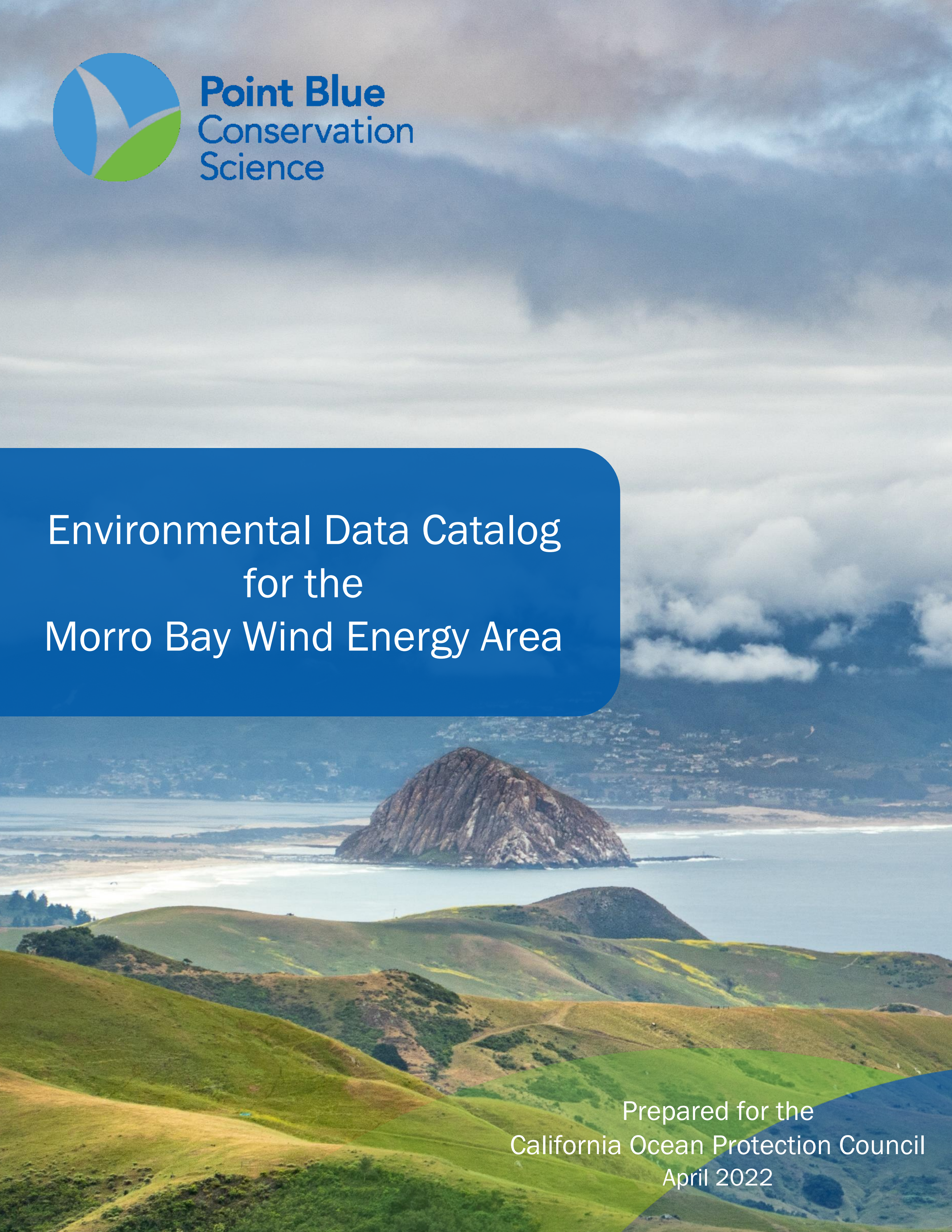

Point Blue Conservation Science

Environmental Data Catalog for the Morro Bay Wind Energy Area

Prepared for the
California Ocean Protection Council
April 2022

Environmental Data Catalog for the Morro Bay Wind Energy Area

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Point Blue Conservation Science – Point Blue's 160 scientists work to reduce the impacts of climate change, habitat loss, and other environmental threats while developing nature-based solutions to benefit both wildlife and people.

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TABLE OF CONTENTS

LIST AND DEFINITIONS OF ACRONYMS[1]

3-D…………………three-dimensional

AIS…………………Automatic Identification System

Anadromous…..describes fish that move from marine waters back to natal freshwater rivers and streams to spawn; salmon is an anadromous species

ASV……………….. Autonomous Surface Vehicle

AUV……………….. Autonomous Underwater Vehicle

BIAs……………….. Biologically Important Areas are based on expert opinion of the best available science to help inform regulatory and management decisions

BIOS………………. Biogeographic Information and Observation System

BOEM……………. Bureau of Ocean Energy Management, which is responsible for energy and mineral resources (including renewable resources such as offshore wind) in federal Outer Continental Shelf waters (i.e., beyond 3 nautical miles [**nm**] or 5.6 km from shore)

BRUVs……………. Baited Remote Underwater Video Systems

Cal DIG…………... California Deepwater Investigations and Groundtruthing I Project

CBI.................... Center for Biological Diversity

CESA……………... California Endangered Species Act is a state law of California that conserves and protects plant and animal species at risk of extinction

CCS………………... California Current System is a cold-water Pacific Ocean current that moves southward along the western coast of North America, beginning off southern British Columbia and ending off southern Baja California Sur

CDFW…………….. California Department of Fish and Wildlife, formerly known as the California Department of Fish and Game (CDFG)

CMECS.............. Coastal and Marine Ecological Classification Standard

CPS………………... Coastal Pelagic Species

Critical Habitat..specific areas that have physical or biological features essential to the conservation of the species and which may require special management considerations or protection, as defined by the **Endangered Species Act**

CSMP…………….. California Seafloor Mapping Program

CSV…………………Comma-separated values

CTD………………. Conductivity, temperature, and depth

[1] Additional emboldened words found in the descriptions are also defined in this list.

CV………………….. Coefficient of Variation for modeling is a way to measure the dispersion of data values relative to the mean and how well the model fits the data; a lower CV means that the predicted values are closer to the actual data

DDT……………….. Dichlorodiphenyltrichloroethane was developed as an insecticide in 1939, but was banned by many countries by the 1970s because of its environmental impacts

DECA…………….. Deep-sea Ecosystem Conservation Area

Deepwater……..Generally defined by **BOEM** as waters greater than 300 m (1,000 ft); other agencies (such as **NOAA Fisheries**) may consider 200 m (656 ft) to be deepwater

DOI………………... United States Department of the Interior; **BOEM** and **USFWS** are agencies within DOI

DPS................. Distinct Population Segment

DSCRTP………….. Deep-Sea Coral Research and Technology Program

DSMZ............... Davidson Seamount Management Zone

EEZ………………... The Exclusive Economic Zone offshore California extends from 12 nm (22 km) to 200 nm (370 km), and grants the U.S. sovereign rights to the exploration and use of marine resources such as fisheries, as well as energy production from water and wind resources

EFH………………... Essential Fish Habitat

EFHCA…………….. Essential Fish Habitat Conservation Area

ENSO……………... El Niño-Southern Oscillation is a large-scale climate event that occurs when sea surface temperatures in the eastern equatorial Pacific region along the coasts of Peru and Ecuador increase significantly above the average temperature for three or more months; the ENSO phase has a return period of every four to five years resulting in a slowdown of the prevailing winds and increased rainfall off the West Coast

EOSDIS............. Earth Observing System Data and Information System

ESA……………….. Endangered Species Act is a federal law of the United States to conserve and protect endangered and threatened species and the ecosystems upon which they depend

ESU................. Evolutionarily Significant Unit

EXPRESS………... Expanding Pacific Research and Exploration of Submerged Systems

FAO……………….. Food and Agriculture Organization of the United Nations

fm...................fathom; one fathom is 6 ft or 1.8 m

FMP……………….. Fishery Management Plan

FOWF................ Floating Offshore Wind Facility

FRAM…………….. Fishery Resource Analysis and Monitoring Division within **NOAA**

GAP................. Gap Analysis Program

GIS.................. Geographic Information System

HAPC……………... Habitat Areas of Particular Concern

HMS………………. Highly Migratory Species

High Seas……….. All parts of the sea that are not included in the jurisdictional waters of a state and which are open to all nations

Hotspots………..Ecologically significant areas with persistently elevated biomass

HWEA……………..Humboldt Wind Energy Area is an area that **BOEM** is considering holding a commercial lease sale for some or all of this 206 mi^2 or 534 square-kilometers km^2 area, which would grant exclusive rights to the lessee(s) to submit a construction and operations plan on their particular leasehold

IATTC……………... Inter-American Tropical Tuna Commission

IODE………………. International Oceanographic Data and Information Exchange

IUCN…………….... International Union for the Conservation of Nature

KUDs.................kernel utilization densities

La Niña…………...A La Niña event is the return of colder ocean temperatures that is the opposite phase of an **El Niño-Southern Oscillation**

LiDAR…………….. Light Detection and Ranging is a remote sensing technology that uses pulsed laser from an aircraft to measure distance (range) to the earth's surface, which are then combined with position and orientation data to obtain accurate, **3-D** spatial maps

Live Bottom…….Marine habitat areas that consist of biological assemblages such as seagrass beds, sponges, and coral attached to exposed hard substrate

MBARI............. Monterey Bay Aquarium Research Institute

MBWEA…………Morro Bay Wind Energy Area, an area that **BOEM** is considering holding a commercial lease sale for some or all of this 1,034 km^2/399 mi^2 area, which would grant exclusive rights to the lessee(s) to submit a construction and operations plan on their particular leasehold

MODIS............. Moderate Resolution Imaging Spectroradiometer

MPA………………. Marine Protected Area

MSA………………. Magnuson-Stevens Conservation and Management Act

NASA................ National Aeronautics and Space Administration

NEPA……………... National Environmental Policy Act

nm………………... nautical mile; one nm is equal to 1.85 km or 1.15 mi

NMFS…………….. National Marine Fisheries Service (also known as **NOAA Fisheries**)

NMS………………. National Marine Sanctuary

NOAA Fisheries…National Oceanic and Atmospheric Administration (NOAA) Fisheries or **NMFS**

NREL……………... National Renewable Energy Laboratory

OBPG............... Ocean Biology Processing Group (within NASA)

PacFIN……………Pacific Fisheries Information Network

PARS................ Port Access Route Study

PCBs………………polychlorinated biphenyls are man-made organic chemicals that were used in a variety of industrial and commercial applications (such as transformers and cable insulation) that were manufactured from 1929 until they were banned in 1979

PFMC…………….. Pacific Fishery Management Council is one of eight regional entities that manages fisheries for approximately 119 species of salmon, groundfish, coastal pelagic species (sardines, anchovies, and mackerel), and highly migratory species (tunas, sharks, and swordfish) on the West Coast of the U.S.

PSMFC………….. Pacific States Marine Fisheries Commission

ROMS.............. Regional Ocean Modeling System

ROV……………….. Remotely Operated Vehicle

SAFE………………Stock Assessment and Fishery Evaluation

SHP...................shapefile; the form of vector data used by **GIS** applications

SMCA…………….. State Marine Conservation Area

SMI................... Standard Mapped Image

SMR.................. State Marine Reserve

SSH………………... Sea Surface Height

SST………………... Sea Surface Temperature

SWFSC............. Southwest Fisheries Science Center

TOPP................. Tagging of Pacific Predators

USFWS………….. United States Fish and Wildlife Service

USGS................. United States Geological Survey

VMS.................. Vessel Monitoring System

WCPFC……………Western and Central Pacific Fisheries Commission

WEA………………Wind Energy Area is an offshore location that **BOEM** has assessed as most suitable for commercial wind energy leasing and possible development

YOY……………….. Young-of-the-Year (or Age-0) refers to animals that are younger than one year old within the population

SECTION 1. INTRODUCTION

The Bureau of Ocean and Energy Management (BOEM) is preparing an Environmental Assessment pursuant to the National Environmental Policy Act (NEPA) to assess a proposed Morro Bay Wind Energy Area (MBWEA) for floating offshore wind leasing, and potentially, development activities, in federal jurisdictional waters offshore San Luis Obispo County, California (Figure 1.1). BOEM is considering two options. MBWEA Option 1 includes the original "Call Area" plus an "East Extension" and a "West Extension," encompassing approximately 255,487 acres (1,034 km^2/399 mi^2). MBWEA Option 1 is located approximately 27 km (17 mi) at its closest point from shore. MBWEA Option 2 also includes the original "Call Area" and only the "West Extension," totaling around 240,898 acres (975 km^2/376 mi^2) and located approximately 32 km (20 mi) at its closest point from shore. The MBWEA lies west of the continental shelf break on the gently sloping shelf in water depths ranging from 800 to 1,300 meters (m; 2,625 to 4,265 feet [ft]). For the purposes of this report when referring to "the MBWEA" and also when its footprint is depicted on the figures, it will encompass the area being considered under Option 1 (Figure1.1).

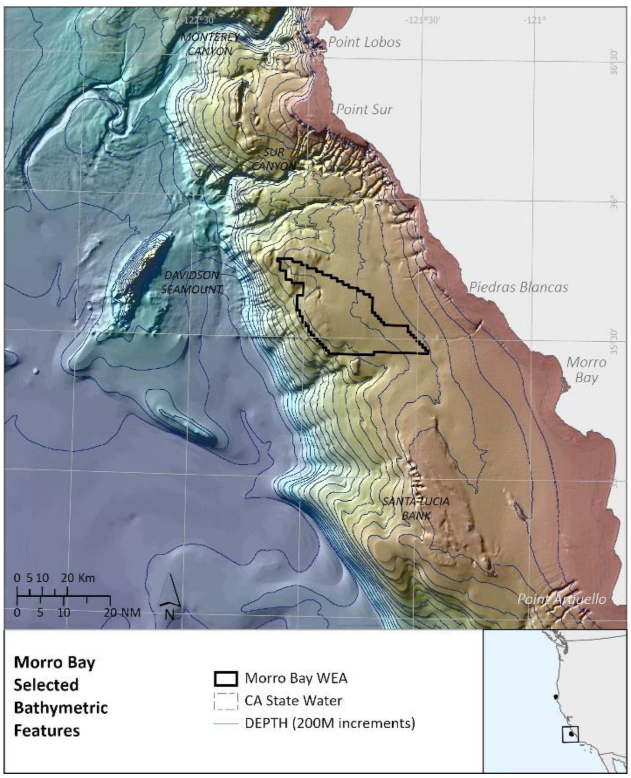

Figure 1.1. Selected bathymetric features within and around the MBWEA.

Following publication of the Environmental Assessment, BOEM has proposed conducting an offshore wind lease sale in fall 2022 (BOEM 2021). The California Coastal Commission, through its consultation responsibilities under Section 307 of the Coastal Zone Management Act, is to decide whether to concur with the federal consistency determination that will be prepared by BOEM as part of the issuance of the Environmental Assessment and the action to hold a lease sale along with subsequent site characterization assessments. The Coastal Commission will assess and base its decision on whether the consistency determination, as well as other information and data provided, meet the state's enforceable policies, which are documented in Chapter 3 of the California Coastal Act of 1976.

As part of this process, Point Blue Conservation Science (Point Blue) was tasked with developing a data catalogue and to synthesize the most relevant environmental datasets that are known within the MBWEA or vicinity, including the nearshore coastal areas of San Luis Obispo County. The intent of this report is to identify the best sources of data currently available on California's marine resources, particularly in and around the proposed wind energy area. An important next step that would enhance this data catalogue effort is to ensure that a single repository for West Coast data includes regular updates of the datasets and a process to ensure that information has been peer-reviewed and verified. One site that has begun to address this data need is the California Offshore Wind Energy Gateway. This gateway was built on the Data Basin platform, which provides open access to biological, physical, and socioeconomic datasets (Conservation Biology Institute [CBI] 2022). The California Offshore Wind Energy Gateway includes geospatial information on ocean wind resources, ecological and natural resources, ocean commercial and recreational uses, and community values that are intended to assess the siting of offshore wind energy in federal waters.

This report summarizes certain marine resources and associated datasets that are available for the MBWEA site and vicinity and may not currently be included in the California Offshore Wind Energy Gateway. The report also includes information on potential gaps in the current knowledge base on data associated with identified resources.

Understanding Dynamic Marine Systems

While datasets are static, the animals in the California marine system are not and environmental conditions can change greatly between seasons, year to year, or from one decade to the next. Many factors affect species and their movements along the length of California's 1,770 km (1,100 mi) coastline and its offshore waters. The California Current System (CCS) defines this coastal upwelling ecosystem that exists along the eastern basin of all major ocean basins. In simple terms, the CCS acts as a conveyor belt bringing cold, nutrient-rich waters of the California Current that interact with the warmer counterflow of the Davidson Current. Predominantly northwesterly winds put stress on surface waters and with the earth's rotational pull, this creates the energy and motion needed to force upwelling of deep, cold waters toward the coast. The upwelling influences food resources and larval transport thereby affecting one of the most productive marine systems in the world. The upwelling helps to sustain a wide range of marine predators, including whales, seals, sharks, tuna and other fish, and pelagic seabirds. This ecosystem, in turn, supports socioeconomic goods and services from managed fisheries and tourism to marine transportation.

Changes to upwelling intensity and magnitude have corresponding significant effects (both positive and negative) on ocean productivity. The upwelling tends to be stronger and colder during spring and summer months, then weaker in the fall and winter when offshore winds subside. Phytoplankton (consisting of bacteria to plant-like diatoms) is the driver for the trophic food chain that supports this diverse array of marine life from microscopic zooplankton (e.g., krill and copepods) to the largest whales. The productivity of phytoplankton can be remotely measured by satellites based on the color intensity (i.e., concentration) of the green pigment called chlorophyll. Phytoplankton productivity varies depending on numerous environmental factors from climate variability to seabed topographic features, which influence local upwelling. Other water quality conditions that are linked to the productivity of this marine system include, but are not limited to, dissolved oxygen levels, nitrogen, water temperature, and salinity.

In addition to the location and abundance of food sources, the physical properties or topography of the seabed as well as water depth are other helpful predictors of species' habitat preferences. Hard structure such as rocky reefs and underwater volcanos provide important habitat for many fish and other animals in an otherwise featureless, soft habitat area. Depth, grain size, sediment composition, and presence of methane gas (also called cold seeps) are some of the physical factors that influence biota, particularly those that live on the seabed. Water depth influences the type of species that may be present on the seabed as well as throughout the water column and even the seabirds above.

Predictive models are a way to assess potential anthropogenic pressures on many species that can be difficult to survey, where it may not be possible to count every animal, and where information about uncommon species is lacking. However, biodiversity of marine species is extremely complex and there are inherent uncertainties in any modeling system that need to be understood when using predictive models for planning and management decisions. For example, the biggest uncertainty in any modeling effort is capturing the dynamic nature of the marine environment in conjunction with often highly mobile species. The level of effort during observational surveys, as well as when and where these surveys were conducted, can create gaps in the underlying data that the models must fill. Modeling accuracy is also affected by the spatial resolution of the grid that is used for analysis and presentation of the results.

Real-time data on oceanic and atmospheric conditions is also becoming more widely available with greater use of satellite technology, remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), and autonomous surface vehicles (ASVs). These technologies will eventually allow for greater collection of biotic and abiotic information that can be conducted more frequently in deep, offshore waters, and during times of the year when crewed vessels do not venture offshore.

Different methods between data collected from human observers and autonomous devices still need to be evaluated to determine how information can best be integrated with existing, long-term datasets. In January 2022, BOEM and the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS; also known as NOAA Fisheries) signed a Memorandum of Understanding to ensure the continuity of long-term data collection efforts and to maintain scientific support for sustainable fisheries.

A new tool called baited remote underwater video systems (BRUVS) can be used on the seabed or in mid-water as a non-lethal sampling method to identify species, determine relative abundance, and measure individual animal size. FishBase, which provides information on 33,000 fish species (Froese and Pauly 2021), has a new BRUVS tool feature that provides publicly available geo-referenced data from global fish surveys that are based on this new tool, although none is available at this time from marine waters of the United States. Other technologies such as passive acoustic monitoring, infrared cameras, floating multi-instrument arrays, and high-definition digital imaging are also becoming more frequently used in offshore studies to obtain more information, and often more accurate information, which is particularly useful for rarely seen or difficult to observe species. A current study by researchers at University of California Santa Cruz and Cornell University involves a novel passive acoustic recorder attached to elephant seals, which remain at sea for about nine months at a time, to record whale calls (Coastside State Parks Association, 2021). This is an example of the kind of data that will be available in the future that could help inform presence and abundance of deepwater or cryptic species.

Summary of Modeling and Survey Efforts to Assess Species Presence and Preferences

The physical and biological structure and composition of the benthos in and around the MBWEA is highly complex and variable as described in Section 2. Initial seafloor habitat mapping of the continental slope and shelf has been conducted by the California Deepwater Investigations and Groundtruthing I (Cal DIG) project. Other habitat mapping data is available from deepwater coral surveys. Demersal/benthic habitat within MBWEA appears to consist mainly of soft sediment and muddy sea bottom. The Santa Lucia Bank, a submarine feature south of the MBWEA, rises to 400 m (1,312 ft) from the surface and is part of a persistent upwelling cell that may influence habitat and species in the MBWEA region. An interesting feature of the seafloor in the MBWEA is one of the largest known pockmark fields in North America, although it not known how they were formed (Walton et al., 2021). Additional information about potential benthic habitat and faunal assemblages in the MBWEA can be found in Kuhnz et al. (2021).

Nearshore marine areas generally out to the 200-m isobath (656 ft) have been well characterized over the years, but site-specific benthic surveys of the MBWEA in water depths over 800 m (2,625 ft) have not yet been required or conducted. Information is available, however, that can be used to conduct preliminary assessments of the potential macrofauna that are likely to exist in the area. Section 3 describes BOEM-funded remotely operated video surveys that can be used to assess likely faunal assemblages in the MBWEA and vicinity. Other surveys that have collected data on deep ocean corals and sponges, which form important biogenic ("live bottom") habitats, have also been compiled to infer patterns in habitat suitability across taxa in depths up to 1,200 m (3,937 ft).

The MBWEA also contains numerous invertebrates such as crab, shrimp, and squid (Section 3) and bony fish and shark species (Section 4). Many of these are important to commercial and recreational fishing, which are detailed in their relevant Fishery Management Plans (Pacific Fishery Management Council [PFMC] 2021a). Additional information on the best available data of managed stocks and fisheries can be found in the Stock Assessment and Fishery Evaluation (SAFE) documents, which are also available at the PFMC's website (PFMC 2021b). There are, however, difficulties in using fishery information for other purposes such as trying to combine datasets that cover varying spatial and temporal scales. Fishery surveys have also been designed to answer specific management questions, such as how much of each species is being landed to measure catch totals, but this information may have limited usefulness for other purposes or questions.

Marine mammals, birds, and turtles utilize habitats in and adjacent to the MBWEA. Section 5 describes many species of marine mammals and their potential likelihood of presence in the region via species density models. These models are based on the collection of shipboard and aerial observer data as well as extrapolating information collected from observational surveys to help determine habitat preferences. Distribution modeling has been done for many of the marine mammals listed in Section 5, which is based on a current understanding of life history traits that are known for these species. Many pelagic bird species could also potentially occur in the vicinity of the MBWEA. These include highly abundant populations of common murres and sooty shearwaters as well as less common pelagic seabirds that remain at sea for long periods of time. Section 6 describes the current understanding of those species that are likely to occur in the region. Seabird density models have also been developed from seabird observational data to predict habitat preferences when fine-scale, long-term, monitoring data are not yet available. Four sea turtle species that may occur offshore California are described in Section 7, all of which are protected under the U.S. Endangered Species Act (ESA). The area offshore central California provides critical foraging area and is a migratory corridor for some sea turtles.

Science-based Mapping and Analysis Platforms

As competing demands for ocean resources rise and climate change creates greater uncertainty for predictions of habitat preferences, the need for collating marine data into large spatial databases becomes ever more important. Ideally, these datasets would be accessible in a single repository, but this is useful only if the datasets are maintained and updated regularly, particularly to incorporate new biological information and protected habitat designations. There are nearly 700 datasets currently in the California Offshore Wind Energy Gateway mapping tool; however, some are incomplete or need to be updated. All portals have varying levels of data and ease of use. Many thousands of datasets can be found for West Coast resources in portals from organizations and national and international bodies. Hourigan et al. (2015) describe a process and schema toward the development of an integrated database for deep-sea corals. This is an example of the type of guide that might be useful in developing a system for standardizing data collection efforts, ensuring the continuity of collected data, and developing an interface for data visualization. Another example, described in Van De Putte et al. (2021), used data from the Southern Ocean to generate indicators and undertake assessments to advise decision-makers.

Ocean marine resources do not obey state, national, or international jurisdictional boundaries. Many species in the CCS might also be found latitudinally between Alaska and Mexico or longitudinally from the West Coast to Asia; some species migrate as far as the Antarctic. The main concern about the various data aggregation sites and portals is the need to have continuous updates with current data and information, as well as a constant review to ensure that corrupted links or files are regularly fixed. The inaccessibility of information, confusing user interfaces, as well as the presence of outdated data diminishes the user's experience and limits the accuracy and usefulness of these products. In general, these sites and associated datasets can be: a) difficult to navigate for the general public, b) not regularly updated, and c) scattered and not accessible within a single website/URL.

Synthesis of the Datasets Identified for the MBWEA and Vicinity

Assessing seafloor structure is a key predictor related to marine species' habitat preferences. Data exists for shallow geohazards and benthic habitats (Dataset Table 2.1), as well as surveys to collect marine geology and geomorphology data along the continental shelf and upper slope in the vicinity of the MBWEA (Dataset Table 2.2). Closer to shore, comprehensive seafloor maps have been produced for high-resolution bathymetry, marine benthic habitats, and geology in California state waters (Dataset Table 2.3). Coastal fault lines (Dataset Table 2.4) and offshore fault lines in and around the MBWEA (Dataset Table 2.5) help describe the potential seismic activity in the region. Additional surveys have been completed to map surficial geology and benthic habitats (Dataset Table 2.6). Biological datasets include satellite ocean biology data from the National Aeronautics and Space Administration's (NASA's) Earth Observing System (Dataset Table 2.7), and corresponding conductivity, depth, and temperature data (Dataset Table 2.8) can be used to assess potential habitat for living marine resources. Efforts have been taken to conserve and minimize effects on important habitat with a tool that can be used to identify areas of Essential Fish Habitat (EFH; Dataset Table 2.9). A similar tool showing the locations of critical habitat (Dataset Table 2.10) and a Nearshore Marine Protected Areas mapping tool (Dataset Table 2.11) perform similar functions.

One source of information that can be used to understand invertebrate presence in or near the MBWEA is the Deep-Sea Coral Research and Technology Program national database of observational data, images, and technical reports on deep-sea corals and sponges (Dataset Table 3.1). Observations of invertebrate species in benthic habitat from ROV underwater video surveys (Dataset Table 3.2) and data queries to understand oceanic and invertebrate hotspots (Dataset Table 3.3) are also available. Krill are an essential resource in marine ecosystems, and models relating geomorphic features and oceanographic conditions to the distribution and abundance of krill species in the central CCS are available (Dataset Table 3.4). Data pertaining to commercially important invertebrate species, such as market squid, are compiled annually by the California Department of Fish and Wildlife (CDFW; Dataset Table 3.5).

Observational data for fish that are likely to be found in the MBWEA and vicinity during recent ROV video surveys are available (Dataset Table 4.1). The Southwest Fisheries Science Center (SWFSC) had also conducted a sonar survey to assess biological abundance, identify species, and characterize habitats (Dataset Table 4.2), as well as trawl surveys to collect information on Coastal Pelagic Species (CPS; Dataset

Table 4.3). The nation's first regional fisheries data network, called the Pacific Fisheries Information Network (PacFIN), combines federal and state fishery data to provide accurate estimates of commercial catch and value for West Coast fisheries (Dataset Table 4.4). There are two types of studies to assess historical information to show spatial distribution of fishing effort (Dataset Tables 4.5 and 4.6). A novel fishery sustainability tool that uses real-time ocean data to reduce fishing bycatch impacts is the EcoCast Map product (Dataset Table 4.7). While NOAA observed fishing effort derived from VMS data for groundfish fisheries may be limited due to confidentiality requirements, it is valuable in providing information about spatial distribution of certain groundfish species (Dataset Table 4.8).

Forty-five species of marine mammals are known to occur in the CCS between Canada and Mexico that can have a presence off California, from the largest cetaceans to sea otters. Because many marine mammal species prefer deep, offshore waters, and can be difficult to observe, predictive models are used to determine approximate abundance and range. By combining oceanic variables with observational data on marine mammals, predictions can be made about where they are likely to be seen. The most current and best available information on these some of these species and sources exists (Dataset Table 5.1), although it is limited to certain cetaceans and does not include any of the pinnipeds. In addition to observation-based models, general habitat use areas have been identified as Biologically Important Areas (BIAs) for cetaceans (Dataset Table 5.2). A summary dataset of marine mammal and seabird research projects and data collected in the U.S. Pacific Ocean, which provides broad spatial and species coverage, (Dataset Table 5.3) was assembled for the purpose of compiling data useful for the assessment of offshore energy development impacts.

Predictive density and distribution modeling efforts have been made for seabirds, which number at least 80 species off California from nearshore to far offshore. Survey data from multiple cruises have been combined with predictor variables derived from bathymetric and remotely sensed oceanographic data as well as climate indices (Dataset Table 6.1). A similar mapping effort shows model-derived predicted density of where 30 species of birds (many the same as Dataset Table 6.1) may be more or less abundant (Dataset Table 6.2). A comprehensive database can be used (and modified or updated) to quantify marine bird vulnerability to offshore renewable energy developments (Dataset Table 6.3). Dataset Table 5.3 in Section 5 is also applicable to seabirds, as it includes seabird research projects and data. In very general terms, jaegers, skuas, pelicans, terns, and gulls have high vulnerability to collision with offshore wind infrastructure, whereas loons, grebes, sea ducks, and alcids have high habitat displacement vulnerability.

Sea turtle observational data have been collected from aerial surveys, nesting beach surveys, and in-water capture efforts to estimate marine turtle abundance, stock structure, habitat use, and movement patterns. Leatherback turtle occurrence has been described based on a deductive process of their habitat preferences (Dataset Table 7.1), while another predictive modeling effort uses satellite and light-based geolocation data from the tracking of tagged leatherback sea turtles has been synthesized to determine their distribution and habitat preferences (Dataset Table 7.2). Coarse spatial data illustrating global relative probabilities of occurrence for less locally common sea turtle species are currently the best available data for these species in the CCS (Dataset Table 7.3). An index of how sensitive certain habitats along the California shoreline might be should an oil or other hazardous material spill occur includes a sea turtle sensitivity index (Dataset Table 7.4).

Overall Synthesis of Science Gaps

Gaps and deficiencies in available data fall into several broad categories including temporal weaknesses, spatial coverage shortfalls, and quality or applicability issues. These different types of gaps are distributed unevenly across the various classes of data covered in this report. Deficiencies also stem from different root causes including technical hurdles, funding shortfalls, and disparity in historical drivers of research for different taxa and physical components of the marine environment. Here, we first describe some of the overarching differences and drivers of data quantity and quality, and we then identify patterns of temporal, spatial, and data applicability gaps specific to each data type covered in the report. We finish with a discussion of three key research gaps that are poorly addressed across nearly all data types covered in this report: 1) prediction of future change, especially resulting from climate change scenarios, 2) quantification of sensitivity to offshore wind impacts, and 3) development of a well-organized, easily accessible, well-maintained data repository with maintained links to source data.

Data Quality and Quantity

One key disparity in data quality and quantity is its availability, which is constrained by the logistics of data collection. Surface and near-surface ocean waters are sampled using visual methods and remote sensing, so significantly more upper-ocean data is available covering a greater area and finer time steps. In comparison, midwater and bottom data are largely collected at widely spaced, specific sampling points by research cruises or automated systems such as vertical profiling floats. These focused point data lead to a relatively poor picture of mid-, deep- and benthic physical and biological processes because they are limited in spatial and temporal extent. The lower coverage and availability of subsurface marine data limits the understanding of ecosystem level interactions between species and their environment. It also increases the difficulty in constructing good models of species that spend the majority of their time in deeper waters. For example, the authors of Dataset Table 5.1 state that the two lowest-performing models of marine mammals are for sperm whales and the small beaked whale guild, partially due to limited environmental data in their most frequented habitat.

Another broad pattern of data disparity is between abundant versus rare species. Distributions of abundant species are more readily studied and modeled, frequently leaving gaps in information covering rare (and often at-risk) species such as the north Pacific right whale (*Eubalaena japonica*), Guadalupe fur seal (*Arctocephalus townsendi*), California least tern (*Sterna antillarum browni*), or leatherback sea turtle (*Dermochelys coriacea*). Solving these deficiencies may require targeted approaches such as tagging and tracking to better understand the distribution and habitat use patterns of species that might be at disproportionate risk of population impacts.

Third, winter conditions can be prohibitive or dangerous for at-sea observations and these conditions frequently preclude data collection. The available information on species distribution is skewed toward summer and fall months and may be reduced or lacking in winter months. The data that are available may also be limited in accessibility (e.g., geographic information system [GIS] software and analysts are needed to manipulate the data) or requests must be made to state agencies or researchers to obtain the datasets. For the portals that do exist, they are scattered in numerous online sites, have varying levels of updated information, and different levels of ease of use.

Fourth, because most at-sea studies cover broad areas and are conducted seasonally or annually at best, there is a lack of site-specific data on the variability of presence and abundance of species in the development area. Given the high levels of strong interannual physical and biological variation in the CCS, multi-year and cross-season data is usually important for a comprehensive assessment of impact. In addition, because of longer-term changes (e.g., the increase in warm water events in recent years or changes in fisheries regulations), it is important to have recent data that represents current conditions to compare with historical patterns that may no longer be relevant. High resolution seasonal data is most important for very mobile species like seabirds, marine mammals, or highly migratory fish. Interannual data is key for mobile species that may alter habitat use annually as well as for shorter-lived species like krill, forage fish, or squid that can have large population fluctuations (natural "boom-bust" cycles) over relatively short timeframes.

Habitat and Species-Specific Gaps

The inherent nature of the benthic environment leads to difficulty in understanding it. Data collecting and processing require highly specialized equipment, high levels of training, complex logistics, significant staff resources, and large server capacity to store and manage. In general, benthic data is collected at two scales: extremely fine spatial scale over a small area, or as a series of well-dispersed points from which unsampled areas are extrapolated. Both result in limited spatial coverage of data, which restricts applicability for site-specific projects like offshore wind development. Focused, fine-scale data collection in the project area will improve the understanding of the importance of these features and their biological associations. Developments in automated sampling platforms like subsurface gliders and continuing improvements to three-dimensional ocean models like the Regional Ocean Modeling System (ROMS) are beginning to increase data availability for sub-surface habitats, offering the prospect for improved understanding and modeling of deeper waters and the species that reside there. Increased use of high-resolution acoustic sampling and new analytical techniques are also improving quantification of midwater species distributions and benthic features. Regular sampling would allow categorization of faunal groups across deepwater habitats that exist beyond the shelf.

Marine invertebrates are one of the most difficult groups of organisms to investigate. Monitoring changes in invertebrate communities requires collecting multiple samples at several locations and across seasons, and post-cruise laboratory work to identify and quantify the species caught. Obtaining ship time and the appropriate gear for sampling can be expensive, and sampling is often deficient at both spatial and temporal scales. For example, sampling benthic invertebrates on the seafloor is logistically challenging and is focused on small areas and species groups (e.g., deepwater corals and sponges). Sampling pelagic invertebrates is also inadequate, as spatial coverage is poor, and sampling is not frequent enough to capture the dynamic nature of these populations that fluctuate rapidly with changing ocean conditions. Ample time and expertise are needed for laboratory analysis of the samples collected. Site-specific sampling is necessary to understand the invertebrate communities that inhabit the MBWEA site. Benthic invertebrate communities identified could be linked to the benthic data and features, and this would be helpful in modeling approaches for this and future potential offshore wind sites.

Fish and fishery data are some of the most complex datasets that are at least available in high or specific spatial or temporal detail. Studies that collect data on fish are often species or group specific, tend to focus on species that have an economic value, and are highly localized. Exclusion of less-studied fish species may skew analysis of data to the point of overlooking the influence those species have on the ecosystem. The highly mobile and wide-ranging nature of some fish species increases the challenge of collecting population and distribution data. Fishery data can be used as a proxy for fish population information, but the intrinsic lack of random spatial and temporal sampling will lead to bias. In addition, fishery information is not easily available to the public mainly because of legal restrictions that preclude reporting of individually identifiable data. There are certain types of vessels or vessels targeting certain species that are required to carry tracking devices called Automatic Identification System (AIS) and VMS. AIS and VMS data that are currently available are problematic because they are not standardized across the whole fishing fleet, especially the smaller vessels or those targeting less sensitive species. VMS information would be particularly useful data because it would more precisely allow an assessment of the location and duration of fishing activity, and it would be in near real-time because the data are automatically transmitted every two hours to satellites. Such precise spatial information on fishing activities could be used to create bio-economic models that would allow better understanding of the dependencies between coastal communities and their fishing grounds.

Marine mammals are one of the better studied and data-rich groups, although they can be difficult to monitor due to variability in their spatial and temporal distribution, as well as the fact that they spend most of their time at sea underwater and out of view. The strong legal protections and regulatory monitoring requirements for marine mammals have led NOAA to collect long-term data that spans two and a half decades. These data underlie the high-quality models in Dataset Table 5.1, most of which have strong statistical fits and have been thoroughly validated with independent data. Since the predictions represent the average densities over the dataset timeframe, they are an excellent representation of long-term patterns. Spatial coverage is good though because the shipboard surveys cover the whole Exclusive Economic Zone (EEZ; i.e., out to 200 nm or 370 km). With the exception of pinnipeds, there is good taxonomic coverage of marine mammals, although the statistical strength of the sperm and beaked whale model predictions is low and needs to be considered when assessing model strength, especially at the scale of the MBWEA. Species distribution models of pinniped species that have good tracking data would offer a way to improve data for that group. In addition, recent advances in acoustic monitoring are likely to improve data on beaked and sperm whales, as well as for other vocal species during seasonal periods where coverage is currently lacking. While long-term coverage is good for marine mammals overall, seasonal representation is lacking, with most species only having models for summer and fall combined.

Datasets for seabirds are the most complete for spatial, temporal, seasonal, and taxonomic coverage of all the habitat and species groups. Their need to breed on land combined with the propensity to be more readily observed at-sea and most species having large populations allow for the collection of robust data in all environments they utilize. As with other species, however, the logistics of collecting data at sea limits the quantity of data available. Also, these data tend to be coarse, generalized over large areas and time scales of many months. For the purposes of wind energy development, it would be beneficial to have more information on the differential species reaction to and potential interaction with offshore wind infrastructure, including seasonality of habitat use, flight behavior, and local foraging habits. Rare, threatened, endemic, and locally breeding species all deserve extra attention, in that they may be disproportionately affected by changes in the local environment. Studies that provide fine spatial and temporal scale data on seabird movement patterns and habitat utilization in and around the MBWEA itself are important for understanding the potential impacts of offshore wind energy development and operation.

Sea turtles are one of the more data-poor groups, lacking in spatial, temporal, and taxonomic coverage. The highest-quality data available is for leatherback turtles and derives from tracking studies. These have been processed into kernel utilization densities (KUDs, Dataset Table 7.1), but the tracked animals were not representative of the broader population, and there were known behavioral effects of the tagging process. For these reasons, the KUDs are only suitable as a general indication of where leatherback turtles may be found but should be treated with caution because some areas that species actually use may be missing. While potentially of some use, the Gap Analysis Program (GAP) distribution models only identify areas of potentially suitable habitat and thus should not be treated as a reliable indicator of presence or absence. Green and loggerhead turtles have no distribution data available. Research is currently under way to construct a statistical model fit to an expanded tracking dataset of leatherback turtles, based on EcoCast modeling (Hazen et al. 2018). This data should be more useful for evaluating offshore wind conflicts**,** once available.

Key Research Gaps

There is a growing field of study following the impact of changes in climate and the increasing frequency of marine heat waves. These events will cause changes in distribution and migratory patterns, potentially deviating from model predictions that are widely used to assess distribution and abundance. Abrupt shifts in oceanic conditions can cause a cascade of changes in distribution and migratory patterns for different species, many of which are described in this report. This is a recently expanding area of intense study and new research findings. Publicly available data on ocean heat content and temperature anomalies over different time scales going back to 1955 can be found at the NOAA National Center for Environmental Information (NOAA NCEI 2021). This can be useful when trying to compare whether population shifts in marine species might be due to oceanic and climatic conditions or anthropogenic inputs. Also, an International Working Group on Marine Heatwaves tracks marine heat waves and consolidates publications on this topic (Marine Heatwaves International Working Group 2021). Improving the information on likely future scenarios will be important for effective and durable assessments of offshore wind development impacts.

Another important information gap for most of the resources covered in this report is a thorough understanding of the vulnerability of each species or habitat to offshore wind development and operation impacts. Though generally not spatial in nature, this data plays a key role in translating exposure (as determined by spatial and temporal patterns) into impact. The sensitivity of seabirds to collision and displacement has been evaluated (Dataset Table 6.3), and there is some research quantifying noise impacts for marine mammals. However, sensitivities for most of the species and habitats at risk are not well known, especially to floating turbine development, which is relatively new technology and has not been well studied.

Lastly, the challenges of data accessibility for impact analysis are daunting. Data has been collected that is not available in the public domain or it remains behind an agency firewall. One example of this is InPort, a centralized repository of documentation for NOAA Fisheries data and the tools to access that data. Other data must be requested directly from their sources, which may be complicated by difficulty in making contact or timeliness of response. For data that are publicly available online, the large diversity of data gateways and repositories can increase the effort required to find and acquire the data. Online data may not be updated regularly or at all; web addresses may be changed, outdated, or broken; and the data itself may not be clearly linked to peer-reviewed studies. An additional important factor that can greatly enhance research use of data is the availability of programmatic access to data which allows researchers to harvest the newest data sources and use them efficiently in statistical models. This type of access is sparsely implemented across existing data repositories. Once acquired, data may not be in a useful format, or they may require specialized analysis software or skills. All of these factors apply to data described in this document and influence the quality and usefulness of data for project-specific purposes such as offshore energy development.

SECTION 2. GEOLOGY, BATHYMETRY, AND HABITAT

Marine benthic habitats are often defined by their geological structure as well as depth (or bathymetry) and chemistry. For this reason, geophysical techniques (high-resolution seismic and sub-bottom profiling, side scan sonar, multibeam surveying) are critical for determining bathymetric features, habitat structure, and substrate type. Depth is often a feature of habitat preference from the intertidal zone to the deep ocean. The continental shelf (from 0 to 200 m [656 ft]) delineates the submerged part of the continental landmass that extends from the coastline to the shelf break. From the 200-m (656 ft) isobath, which delineates the shelf break, a long continuous continental slope descends slowly to the ocean floor (depths to approximately 2,000 m [6,562 ft]). Other features along the slope include deep trenches that form at areas of subduction that occur between tectonic plates, while submarine canyons (formed by ancient fluvial processes during lower sea levels) are common across both the continental shelf and slope.

Submarine canyons have complex bathymetry with high, ridge-like features that provide habitat for a variety of species and can also affect local bottom currents. Seamounts, which are typically found in the deeper continental slope region, are underwater ridges that can rise more than 1,000 m (3,300 ft) above the seafloor. Other topographic features on the continental slope that often resulted from volcanic activity include smaller knolls, hills, and mounds. Steep topographic structures and rock provide exposed relief above the seabed that serve as important habitats for both pelagic and benthic species including habitat for deepwater branching corals and sponges, which are a biogenic source of structural habitat. These features also create regionalized upwelling that are beneficial to benthic and pelagic marine life in an otherwise silty or muddy seabed. Pockmarks are deep depressions in the seabed that are known to occur around the world, generally as the result of fluids escaping from the sediment; however, the large pockmark field in the MBWEA region does not appear to be from active seepage.

As part of efforts to protect commercially and recreationally important fish populations, federal and state agencies have taken measures to protect, enhance, and restore a variety of habitats, including inshore and offshore areas. NOAA Fisheries and the PFMC identify, map, and manage certain fish-specific habitat designations along the West Coast. Offshore habitats that have been determined to be particularly important for certain fish are protected under numerous designations with different regulations. Some areas are off limits to fishing entirely, sometimes all year but often on a seasonal basis or in certain fishing blocks at certain times to avoid critical spawning or migration, or other factors. Other areas are off limits to certain gear types, most often commercial bottom trawling that directly contacts the seafloor.

Geological and Bathymetric Data in the MBWEA or Vicinity

Nearshore and inner shelf deposits of the region are predominantly sand (Watt et al. 2015) while mud likely dominates the MBWEA (Bakhsh et al. 2020; refer to Figure 41 of that report). Scour depressions are common along this area because of low sediment supply to fill the depressions as well as sediment transport that occurs during large northwest winter swells. The outer shelf and slope deposits shift to mud and sand in water depths below 70 m (230 ft) but the point at which this shift occurs can change depending on sediment supply, sediment transport, and wave climate (Watt et al. 2015). As part of the Cal DIG I project, backscatter survey data was collected to assess the area of the MBWEA in water depths of 400 to 1,500 m (1,312 to 4,921 ft; Walton et al. 2021). The multibeam acoustic-backscatter and bathymetry data were used to map surficial geology and benthic habitat (Dataset Table 2.1). Backscatter data provides information on the ‘hardness’ of the sea floor and is used to differentiate between different types of sea floor, such as hard rock or soft sediment.

Offshore geology and geomorphology along the continental shelf and upper slope between Point Piedras Blancas and Pismo Beach have been mapped by the U.S. Geological Survey (USGS; Dataset Table 2.2). Similarly, nearshore geological and habitat mapping information is available from the California Seafloor Mapping Program (CSMP), which includes California’s state waters out to 3 nm (3.6 mi or 5.6 km; Dataset Table 2.3).

The Hosgri Fault extends along the coast from about 6 km (3.7 mi) offshore Cambria to 5 km (3.1 mi) northwest of Point Pedernales. This fault zone is a component of the Pacific Plate/North American Plate margin. To the west of the Hosgri Fault Zone is the Santa Maria Basin (Willingham et al. 2013). There is no distinct topographic break between the shelf and slope from approximately 170 km (106 mi) from Point Sur to the vicinity of Point Conception as the shelf merges seaward with the Santa Lucia Bank at a depth of about 550 m (1,800 ft). West of Santa Lucia Bank is the steep Santa Lucia Bank Escarpment (McCulloch et al. 1980). Nearshore faults have been identified in the coastal region between Point Sur to Point Arguello based on interpretation of seismic reflection profile data collected by the USGS between 2008 and 2014 (Dataset Table 2.4). An interactive, web-based portal that shows a more expanded view of potential earthquake, landslide, tsunami, and geo-hazards in the MBWEA and other wind energy areas has been prepared by BOEM as part of the Bakhsh et al. (2020) report (Dataset Table 2.5).

The Cal DIG I project created baseline geologic interpretations of the MBWEA to improve regional models of shallow geologic hazards and sedimentary processes. The geophysical and geological information included comprehensive, high-resolution sub-bottom data (multi-channel and Chirp seismic reflection profiles), seafloor (bathymetry), and sampling (piston, gravity, and vibracore) collected during surveys in 2018 and 2019. This report provides: 1) interpretation of subsurface geologic structure from the geophysical data; 2) preliminary core analysis results related to fluid, gas, and sediment transport activity; 3) interpretations of the current geohazards in the area; and 4) suggestions on next steps for improving interpretations of geohazard processes (Walton et al. 2021; Dataset Table 2.6).

An interesting feature of the seafloor in the MBWEA region, although common around the world, are thousands of distinct “pockmarks” averaging around 5 m (16 ft) deep and approximately 175 m (574 ft) in diameter. These pockmarks were found across two physiographic regions near the MBWEA in water depths ranging from about 500 to 1,400 m (1,640 to 4,593 ft). The pockmarks cover an area that totals nearly 1,300 km^2 (579 mi^2) making this one of the largest known pockmark fields in North America (Walton et al. 2021). It is not known how the pockmarks were formed, but it does not appear they were caused by fluid venting from the depressions (Walton et al., 2021). Three times as many “micro-depressions,” measuring an average of 11 m (36 ft) wide and 1 m (3 ft) deep, were also found. Many of these micro-depressions contained marine debris including garbage bags, derelict fishing gear, rocks, bones, and kelp holdfasts (Lundsten et al. 2019).

Chemistry data, including chlorophyll, temperature, salinity, oxygen, and nutrients are important factors that influence marine life along the whole California Current ecosystem. A good source of ocean biology data that is collected by satellite is available from NASA's Earth Observing System Data and Information System (EOSDIS; Dataset Table 2.7). Additional efforts to collect in situ water quality data for certain variables (including salinity, dissolved inorganic nutrients, pH, total alkalinity, and dissolved inorganic carbon), as well as conductivity, temperature, and depth, have been collected at selected depth by the USGS in 2018 and 2019 at various sites offshore of California (Dataset Table 2.8). This effort is part of the Expanding Pacific Research and Exploration of Submerged Systems (EXPRESS) project (NOAA, BOEM, and USGS, 2019; Kennedy et al. 2021) to assess living marine resources and habitats, inform ocean energy and mineral resource decisions, and improve offshore hazard assessments including areas of the shelf and slope offshore California. More detail on how environmental predictor data is used to create species distribution models can be found in Schulien et al. (2020).

Essential Fish Habitat and Other Conservation Areas Data in the MBWEA or Vicinity

Essential Fish Habitat (EFH) is a designation under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) to protect waters and substrate that are necessary for spawning, breeding, feeding, or growth to maturity of fish. There is an EFH designation for nearly all federally managed species, and this habitat can be thought of as being essential to the survival of those fish. An EFH designation does not regulate fishing activity specifically. It is determined, described, and mapped based on the array of available species information. EFH locations and information can be found in the relevant Fishery Management Plans, as well as in the EFH Mapper tool (Dataset Table 2.9; Figure 2.1). EFH is also available as a data layer in the California Offshore Wind Energy Gateway tool. All waters within and around the MBWEA are designated as EFH for Pacific Coast groundfish, coastal pelagic species, salmon, and highly migratory species (PFMC 2021c; also refer to Sections 3 and 4 for more detail on these managed species).

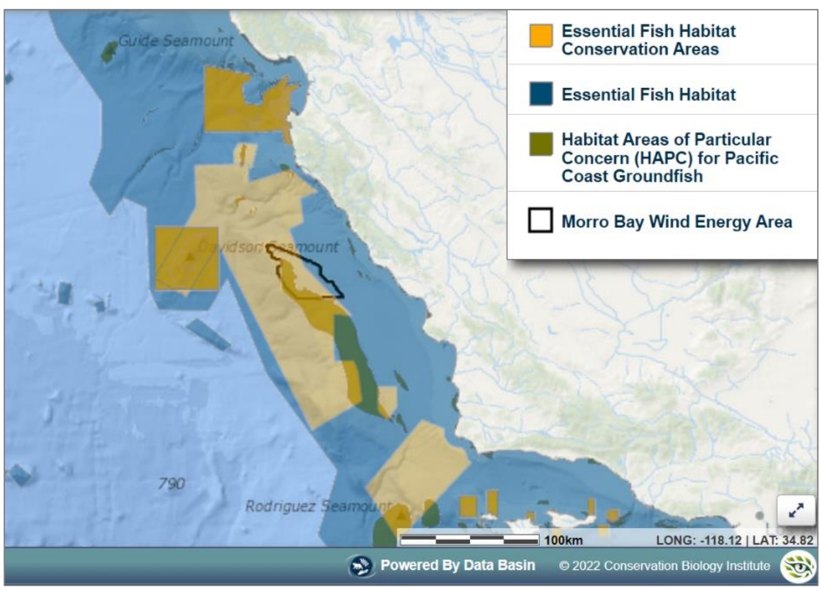

Figure 2.1. Essential Fish Habitat, EFH Conservation Areas, and Habitat Areas of Particular Concern in and near the MBWEA

Habitat Areas of Particular Concern (HAPC) are a subset of EFH in which spatially discrete habitat areas are considered to be especially important ecologically or particularly vulnerable to degradation. HAPCs offshore California are designated through actions by the PFMC and are intended to provide additional focus for conservation efforts, but they do not convey additional restrictions or protections. HAPCs can cover a specific location (e.g., a bank, ledge, or seamount, or a spawning location) or they can cover habitat that is important for a specific function that is found at many locations such as nearshore nursery areas (NOAA Fisheries 2021a). On the U.S. West Coast, HAPCs have been designated for Pacific coast groundfish, which overlaps with the MBWEA (Figure 2.1). These features correspond to areas of rocky reefs and other hard substrate.

Essential Fish Habitat Conservation Areas (EFHCAs) are a component of EFH that are designated by rulemaking. Only EFHCAs may be closed to specific types of fishing (NOAA Fisheries 2019a). As a precautionary measure to mitigate the adverse effects of fishing on groundfish EFH, there is an EFHCA that occurs seaward of a line approximating the 700-fathom (fm) isobath (1,280 m or 4,200 ft), which is closed to bottom trawling to prevent the expansion of bottom trawling into areas where groundfish EFH has not historically been adversely affected by bottom trawling. Starting in 2020, a Deep-sea Ecosystem Conservation Area (DECA) was established that prohibits fishing with any gear that makes contact with the seabed to protect deepwater habitats, including deep sea corals (NOAA Fisheries 2019a). This closure includes all federal waters (from 3 to 200 nm) south of Mendocino Ridge, and west of approximately 1,900 fm (3,500 m or 11,483 ft). These and other EFHCAs are partially defined by depth-based boundary lines that are intended to approximate particular depth contours. The boundary lines are typically defined coast-wide and around islands, with a few exceptions, but may be used to define a closed area off just a part of the coast. The Groundfish EFHCA is closed to bottom trawling and other types of bottom contact gear to protect these habitat features (Dataset Table 2.8).

Included in the DECA is the Davidson Seamount, which is an underwater volcano and the only known seamount in the vicinity of the MBWEA, but also one of the largest in U.S. waters. It is located about 121 km (75 mi) from the coast and west of the MBWEA. From base to crest, the seamount is 2,280 m (7,480 ft) tall, yet its summit is still 1,250 m (4,101 ft) below the surface. The seamount has also been designated as the Davidson Seamount Management Zone (DSMZ), which is part of the Monterey Bay National Marine Sanctuary. This 2,007 km^2-area (775 mi^2) supports coral and sponge habitat as well as deep-sea crabs, fish, shrimp, basket stars, and other rare and unidentified benthic species (Monterey Bay National Marine Sanctuary 2019).

Critical Habitat

Critical habitat is a designation under the ESA, defined by NOAA Fisheries as “areas that contain essential physical or biological features important to the conservation of listed species and that may require special management and protection.” Critical habitat may also be designated in areas outside of the geographic boundaries of a species if the agency determines that these are also necessary for conservation. Federal agencies must consult with NOAA Fisheries if they are to undertake or allow any action, such as the development of offshore wind infrastructure, that may affect listed species or their designated critical habitat. A Protected Resources App has been created to see where critical habitat has been designated for an area (Dataset Table 2.10). The Protected Resources App displays spatial data for marine and anadromous species listed under the ESA. The core datasets include the listed species’ ranges and associated critical habitat. For this region around the MBWEA, the waters from Point Arena and southward are critical habitat for leatherback sea turtles (Section 7). There is critical habitat for black abalone (Section 3) and South-Central Coast steelhead salmon (see Section 4) in areas closer to shore

State of California Marine Protected Areas

San Luis Obispo County marine waters contain a number of California State Marine Reserves (SMR) and State Marine Conservation Areas (SMCA; CDFW 2016). These are coastal marine protected areas (MPAs) in state waters (within 3 nm or 5.5 km from shore) with various levels of protection. The SMR designation prohibits damage or take of all marine resources (living, geologic, or cultural) except under a scientific collecting permit. The SMCA designation may allow some recreational and/or commercial take of marine resources (restrictions vary). One visualization tool to show these MPAs and other fishing-restricted areas is CDFW's marine and coastal data viewer called Marine Biogeographic Information and Observation System (BIOS; Dataset Table 2.11). MarineBIOS also provides a data layer that shows CDFW's administrative boundaries for kelp canopy harvest leases in state waters. Kelp beds provide critical habitat for many species of invertebrates, fish, and marine mammals. A nice feature of MarineBIOS is the ability to add a user's own data to products created in the portal.

General Status and Threats to Geology, Bathymetry, and Habitats

Earthquakes, landslides, liquefaction, tsunamis, slope instability, and biogenic gas are some of the hazards that can impact the MBWEA site. The risks associated with these geologically hazardous and active regions are mainly to the mooring and anchorage systems, as well as buried cables that would transmit power to shore.

In a ranking of human-caused impacts on benthic habitats worldwide, Harris (2020) found the greatest threat from fishing followed by pollution and litter, aggregate mining, oil and gas, coastal development, tourism, cables, shipping, invasive species, climate change, and construction of wind farms.

In a recent benthic survey conducted inside and adjacent to the MBWEA, more than 255 pieces of anthropogenic debris were seen dispersed throughout the 46.8 km (29 mi) of seafloor that was observed. The items included metal, plastic, drinking containers, paint buckets, fabric, a shoe, fishing nets, fish traps, rope, and a shipwreck (Kuhnz et al. 2021).

Data Gaps and Limitations

Fluid and gas hazards in the MBWEA remain difficult to assess. Additional analyses and sampling of existing core data is needed to better understand pockmark formation processes and potential gas accumulations in the area. Further analyses of the core data, including radiocarbon dating, stable isotope analysis, and compositional analysis, are also needed to better understand the timing and sources of the numerous sand deposits found throughout the area, which may have been transported downslope due to mass wasting and/or earthquake shaking processes (Walton et al. 2021).

Very little detailed soil information is available and targeted site-specific seabed sampling is needed for the MBWEA. Seabed sediment boundaries have also not been defined and correlated to known benthic communities. Proposed wind energy projects would also need to collect core samples to assess the ability of various substrates to retain anchor systems and other mooring configurations. Any rocky terrain or steep slopes (greater than 10 degrees) would be difficult for anchor placements. These areas are often found in the transition between the 1,000 m (3,281 ft) and 2,000 m (6,562 ft) isobaths (Bakhsh et al. 2020).

Summary Tables of Selected Geological, Bathymetric, and Habitat Datasets

Dataset Table 2.1. Bathymetry and seismic data offshore south-central California

Dataset Title	Donated AUV bathymetry and Chirp seismic-reflection data collected during Monterey Bay Aquarium Research Institute cruises in 2018-2019 offshore of south-central California
Species/Resource	Bathymetry

Abstract	This data release consists of donated AUV bathymetry and Chirp seismic-reflection data collected using an autonomous underwater vehicle (AUV) in 2018 and 2019. The collection of these data was funded entirely by the Monterey Bay Aquarium Research Institute (MBARI), and the data have been donated to the U.S. Geological Survey (USGS). The data were collected in collaboration with the USGS and the Bureau of Ocean Energy Management (BOEM) and they are located in the same study area as the collaborative California Deepwater Investigations and Groundtruthing I (Cal DIG I) project. The purpose of the overall Cal DIG I study is to assess shallow geohazards, benthic habitats, and thereby the potential for alternative energy infrastructure (namely floating wind turbines) offshore south-central California due to the study area's proximity to power grid infrastructure associated with the Morro Bay power plant.
Strength/Weakness	The AUV mapping navigation data has not been accurately positioned and is considered as only partially processed. Users are advised to read the rest of the metadata record carefully for additional details.
File Name	2021-604-DD_chirp_[various cruise dates]m1.zip 2021-603-DD_bathy_[various cruise dates]m1.zip
Data Type	GeoTIFF raster file
Spatial Extent	West_Bounding_Coordinate: -121.918415 East_Bounding_Coordinate: -121.251260 North_Bounding_Coordinate: 35.826141 South_Bounding_Coordinate: 35.326362
Time Scale	Data Collected: April 25, 2018 – May 11, 2019 Published: Aug. 23, 2021 (updated as needed)
Contact/Source	Guy R Cochrane, PhD, Research Geophysicist, USGS Pacific Coastal and Marine Science Center, (831) 460-7554; gcochrane@usgs.gov
License/Use Restrictions	USGS-authored or produced data and information are in the public domain from the U.S. Government and are freely redistributable with proper metadata and source attribution. Please recognize and acknowledge the U.S. Geological Survey and Monterey Bay Aquarium Research Institute (MBARI) as the originator(s) of the dataset and in products derived from these data.
Citation Info	Kennedy, D.J., Walton, M.A.L., Cochrane, G.R., Paull, C., Caress, D., Anderson, K., and Lundsten, E., 2021, Donated AUV bathymetry and Chirp seismic-reflection data collected during Monterey Bay Aquarium Research Institute cruises in 2018-2019 offshore of south-central California: U.S. Geological Survey data release, https://doi.org/10.5066/P97QM7NF
Online Link	Data Release 10.5066/P97QM7NF - Data Releases - Coastal and Marine Geoscience Data System (usgs.gov)
Metadata Link	Metadata files are provided in the online link (above) and were divided by cruise.

Dataset Table 2.2. USGS Nearshore Geology and Geomorphology

Dataset Title	Offshore Geology and Geomorphology from Point Piedras Blancas to Pismo Beach, San Luis Obispo County, California
Species/Resource	Geology
Abstract	Marine geology and geomorphology were mapped along the continental shelf and upper slope between Point Piedras Blancas and Pismo Beach, California. The map area is divided into the following three (smaller) map areas, listed from north to south: San Simeon, Morro Bay, and Point San Luis. Each smaller map area consists of a geologic map and the corresponding geophysical data that support the geologic mapping. Each geophysical data sheet includes shaded-relief multibeam bathymetry, seismic-

	reflection-survey tracklines, and residual magnetic anomalies, as well as a smaller version of the geologic map for reference. Offshore geologic units were delineated on the basis of integrated analysis of adjacent onshore geology, seafloor-sediment and rock samples, multibeam bathymetry and backscatter imagery, magnetic data, and high-resolution seismic-reflection profiles. Although the geologic maps are presented here at 1:35,000 scale, map interpretation was conducted at scales of between 1:6,000 and 1:12,000. Sea level was approximately 120 to 130 m lower during the Last Glacial Maximum (about 21 ka). This approximate depth corresponds to the modern shelf break, a lateral change from the gently dipping (0.8° to 1.0°) outer shelf to the slightly more steeply dipping (about 1.5° to 2.5°) upper slope in the central and northern parts of the map area. South of Point San Luis in San Luis Bay, deltaic deposits offshore of the mouth of the Santa Maria River (11 km south of the map area) have prograded across the shelf break and now form a continuous low-angle (about 0.8°) ramp that extends to water depths of more than 160 m. The shelf break defines the landward boundary of slope deposits. North of Estero Bay, the shelf break is characterized by a distinctly sharp slope break that is mapped as a landslide headscarp above landslide deposits. Multibeam imagery and seismic-reflection profiles across this part of the shelf break show evidence of slope failure, such as slumping, sliding, and soft-sediment deformation, along the entire length of the scarp. Notably, this shelf-break scarp corresponds to a west splay of the Hosgri Fault that dies out just north of the scarp, suggesting that faulting is controlling the location (and instability) of the shelf break in this area.
Strength/Weakness	Data extends only from the shelf to the upper slope
File Name	PointPiedrasBlancasToPismoBeachGIS.mxd.zip
Data Type	TIFF and ESRI Shape file
Spatial Extent	North Latitude: 35° 42' 3" N (35.7008) South Latitude: 35° 4' 0" N (35.0667) East Longitude: 120° 36' 0" W (-120.6000) West Longitude: 121° 22' 0" W (-121.3667)
Time Scale	Data First Posted: May 19, 2015 ; Page Last Modified: December 1, 2016
Contact/Source	U.S. Geological Survey, Pacific Coastal and Marine Science Center; 888-275-8747; http://walrus.wr.usgs.gov/
License/Use Restrictions	These data are intended for science researchers, students, policy makers, and the general public. These data can be used with geographic information systems or other software to aid in assessments and mitigation of geologic hazards in the central California coastal region and to provide sufficient geologic information for land-use and land-management decisions both onshore and offshore.
Citation Info	Watt, J.T., Johnson, S.Y., Hartwell, S.R., and Roberts, M., 2015, Offshore geology and geomorphology from Point Piedras Blancas to Pismo Beach, San Luis Obispo County, California: U.S. Geological Survey Scientific Investigations Map 3327, pamphlet 6 p., 6 sheets, scale 1:35,000, https://dx.doi.org/10.3133/sim3327.
Online Link	https://pubs.usgs.gov/sim/3327/sim3327_data.html
Metadata Link	https://pubs.usgs.gov/sim/3327/sim3327_metadata.html

Dataset Table 2.3. California Seafloor Mapping Program

Dataset Title	California State Waters Map Series Data Catalog--Point Sur to Point Arguello Region
Species/Resource	Geological information

Abstract	In 2007, the California Ocean Protection Council initiated the California Seafloor Mapping Program (CSMP), designed to create a comprehensive seafloor map of high-resolution bathymetry, marine benthic habitats, and geology within the 3-nautical-mile limit of California's State Waters. The CSMP approach is to create highly detailed seafloor maps and associated data layers through the collection, integration, interpretation, and visualization of swath sonar data, acoustic backscatter, seafloor video, seafloor photography, high-resolution seismic-reflection profiles, and bottom-sediment sampling data. CSMP has divided coastal California into 110 map blocks, each to be published individually as USGS Scientific Investigations Maps (SIMs) at a scale of 1:24,000. The map products display seafloor morphology and character, identify potential marine benthic habitats, and illustrate both the seafloor geology and shallow (to about 100 m) subsurface geology. This part of DS 781 presents data for the transgressive contours of the Point Sur to Point Arguello, California, region. The vector data file is included in the "TransgressiveContours_PointSurToPointArguello.zip," which is accessible from https://doi.org/10.5066/P97CZ0T7. As part of the USGS's California State Waters Mapping Project, a 50-m grid of sediment thickness for the seafloor within the 3-nautical mile limit between Point Sur and Point Arguello was generated from seismic-reflection data collected between 2008 and 2014, and supplemented with geologic structure (fault and fold) information following the methodology of Wong (2012). Water depths determined from bathymetry data were added to the sediment thickness data to provide information on the depth to base of the post-LGM unit. Reference Cited: Wong, F. L., Phillips, E.L., Johnson, S.Y., and Sliter, R.W., 2012, Modeling of depth to base of Last Glacial Maximum and seafloor sediment thickness for the California State Waters Map Series, eastern Santa Barbara Channel, California: U.S. Geological Survey Open-File Report 2012-1161, 16 p. (available at https://pubs.usgs.gov/of/2012/1161/).
Strength/Weakness	None noted
File Name	PointSurToPointArguelloGIS.mxd.zip
Data Type	TIF files
Spatial Extent	West_Bounding_Coordinate: -121.986979 East_Bounding_Coordinate: -120.063148 North_Bounding_Coordinate: 36.363842 South_Bounding_Coordinate: 34.352666
Time Scale	Data first posted July 15, 2019; Collection and processing beginning from June 9, 2009 and ending on August 2, 2014 (progress is complete)
Contact/Source	U.S. Geological Survey, Pacific Coastal and Marine Science Center (PCMSC) Science Data Coordinator; 831-427-4747; pcmsc_data@usgs.gov
License/Use Restrictions	SGS-authored or produced data and information are in the public domain from the U.S. Government and are freely redistributable with proper metadata and source attribution. Please recognize and acknowledge the U.S. Geological Survey as the originator of the dataset and in products derived from these data.
Citation Info	Johnson, Samuel Y., Stephen R. Hartwell, Janet T. Watt, Jeffrey W. Beeson, and Peter Dartnell. 2018. Offshore Shallow Structure and Sediment Distribution, Point Sur to Point Arguello, Central California. Open-File Report 2018-1158. https://doi.org/10.3133/ofr20181158
Online Link	https://cmgds.marine.usgs.gov/data/csmp/PointSurToPointArguello/data_catalog_PointSurToPointArguello.html
Metadata Link	https://pubs.usgs.gov/of/2018/1158/ofr20181158_metadata.html

Dataset Table 2.4. Coastal Faults from Point Sur to Point Arguello

Dataset Title	Faults—Point Sur to Point Arguello, California
Species	Geological information in state waters only
Abstract	Faults in the Point Sur to Point Arguello region are identified on seismic-reflection data based on abrupt truncation or warping of reflections and (or) juxtaposition of reflection panels with different seismic parameters such as reflection presence, amplitude, frequency, geometry, continuity, and vertical sequence. Faults were primarily mapped by interpretation of seismic reflection profile data collected by the U.S. Geological Survey between 2008 and 2014. This information is to support assessments and mitigation of geologic hazards in the Point Sur to Point Arguello coastal region and to provide sufficient geologic information for land-use and land-management decisions both onshore and offshore.
Quality/Value	The data points from seismic-reflection profiles are dense along tracklines (about 1-2 m apart) and sparse between tracklines (typically 800-1,000 m apart).
File Name	https://www.sciencebase.gov/catalog/file/get/5c91388de4b09388245480d7?facet=Faults_PointSurToPointArguello
Data Type	Vector data file
Spatial Extent	West_Bounding_Coordinate: -121.017950 East_Bounding_Coordinate: -120.480933 North_Bounding_Coordinate: 36.241228 South_Bounding_Coordinate: 34.483508
Time Scale	2008 - 2014
Contact/Source	U.S. Geological Survey, Pacific Coastal and Marine Science Center (PCMSC) Science Data Coordinator (831) 427-4747; pcmsc_data@usgs.gov
License/Use Restrictions	The public domain data from the U.S. Government are freely redistributable with proper metadata and source attribution. Please recognize the U.S. Geological Survey as the originator of the dataset.
Citation Info	Johnson, S.Y., Hartwell, S.R., Watt, J.T., Beeson, J.W., Dartnell, P., and Cochran, S.A., 2019, Faults—Point Sur to Point Arguello, California, in Golden, N.E., compiler, 2013, California State Waters Map Series Data Catalog
Online Link	https://pubs.usgs.gov/ds/781/
Metadata Link	https://www.sciencebase.gov/catalog/file/get/5c91388de4b09388245480d7?name=Faults_PointSurToPointArguello_metadata.txt&allowOpen=true

Dataset Table 2.5. Potential Earthquake, Landslide, Tsunami and Geo-hazards

Dataset Title	Potential Earthquake, Landslide, Tsunami and Geo-hazards for the U.S. Offshore Pacific Wind Farms
Species/Resource	Benthic geo-hazards
Abstract	This study/website was developed by RPS and was funded by the Bureau of Ocean Energy Management (BOEM), U.S. Department of the Interior, Washington, D.C., under Contract 140M0119C0004. Earthquakes, landslides, liquefaction, tsunamis, slope instability, and biogenic gas are some of the hazards that can impact the floating offshore wind farms located off the coasts of California, Oregon, and Hawaii, as they are located in geologically hazardous and active regions. The risks are mainly to the mooring and anchorage systems, as well as buried cables that transmit the power to shore. The BOEM funded Solicitation No. E17PS00128 to assess the potential threats to wind energy development off the U.S. Pacific coast, including catastrophic geohazards (e.g., seismic activities, landslides, and tsunamigenic earthquakes), gas plumes, liquefaction, and turbidity currents, and the effect on the mooring and anchorage system and buried cable

	due to geohazards. This evaluation of geohazards is designed to aid in selecting suitable sites for Floating Offshore Wind Farms (FOWF) with the focus on areas already designated as potential lease sites using the best available science, so that potential impacts are understood to the greatest extent possible. The main goal of the study is to provide an understanding of geohazards risks in areas under analysis for the development of FOWF using a geospatial planning approach by providing a guideline on most important geohazards and how they might affect the performance of FOWF. This website provides publicly available datasets of geological and geophysical seabed and soil conditions, ground acceleration and bathymetry slope in the region that are analyzed in form of geospatial raster maps and used in the study. These spatially varying datasets are then weighted and overlaid to determine suitability of the area and define exclusive area that might have more risk for installation of FOWF. It should be noted these maps serve just as a guideline based on publicly available datasets. BOEM strongly encourages review of the full report including current practices regarding the geologic hazards posing risks to components of FOWF, a literature review on approaches and standards applicable to the siting and engineering processes associated with floating offshore structures, and the geohazards off the U.S. West Coast and Hawaii that may directly or indirectly affect the FOWF, and the data analysis for developing geospatial indexing of suitability maps.
Strength/Weakness	No legend appears on the mapping product, so the color-coding schema is not known for geology and seabed type.
File Name	N/A
Data Type	The geospatial data are not available, but visualizations of the different wind energy areas can be generated online through BOEM's interactive mapping interface.
Spatial Extent	Five floating offshore wind farm areas in Hawaii (Oahu North and Oahu South) and California (Humboldt, Morro Bay and Diablo Canyon).
Time Scale	Various dates depending on the data source. See Appendix A in: http://boem-oceansmap.s3-website-us-east-1.amazonaws.com/reports/final_report.pdf
Contact/Source	Jennifer Miller, BOEM Office of Renewable Energy Program; (805) 384-6306; jennifer.miller@boem.gov
License/Use Restrictions	Publicly accessible
Citation Info	Bakhsh T, Monim M, Simpson K, Lapierre T, Dahl J, Rowe J, Spaulding M. 2020. Potential earthquake, landslide, tsunami, and geohazards for the U.S. offshore Pacific Wind Farms. Kingstown, RI: U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2040-040. 127 p.
Online Link	http://boem-oceansmap.s3-website-us-east-1.amazonaws.com/reports/final_report.pdf
Metadata Link	Various sources. See Appendix A in: http://boem-oceansmap.s3-website-us-east-1.amazonaws.com/reports/final_report.pdf

Dataset Table 2.6. Multibeam Acoustic Backscatter and Bathymetry Data

Dataset Title	Multibeam acoustic-backscatter and bathymetry data from offshore of south-central California in support of the Bureau of Ocean Energy Management Cal DIG I, offshore alternative energy project
Species/Resource	Bathymetry and habitat
Abstract	Coastal and Marine Ecological Classification Standard (CMECS) geoform, substrate, and biotic component (also known as "biotope") GIS products were developed for the U.S. Exclusive Economic Zone of south-central California motivated by interest in

	development of offshore wind energy capacity and infrastructure. The lead agency responsible for planning and leasing in the Exclusive Economic Zone, the U.S. Bureau of Ocean Energy Management (BOEM), funded the acquisition of these data to assess baseline conditions of the seafloor environment. The surveys for the multibeam acoustic-backscatter and bathymetry data were conducted to map surficial geology and benthic habitat as part of the USGS/BOEM Interagency Agreement M17PG0021 titled California Deepwater Investigations and Groundtruthing I (Cal DIG I). These data are intended to provide regional surficial geology and benthic habitat information in an area of interest for offshore wind energy development. These data are also intended for science researchers, students, policy makers, and the general public. These data can be used with geographic information systems or other software to help identify geomorphologic features and surficial lithology.
Strength/Weakness	None noted
File Name	Cal_DIG_I_Backscatter_10m.zip Cal_DIG_I_Bathymetry_10m.zip
Data Type	TFW
Spatial Extent	West_Bounding_Coordinate: -121.996378 East_Bounding_Coordinate: -120.792132 North_Bounding_Coordinate: 35.901422 South_Bounding_Coordinate: 34.516318
Time Scale	Published: Jan. 8, 2022; Data Collected: Aug. 27, 2018 – Sept. 27, 2019
Contact/Source	Guy R Cochrane, PhD, Research Geophysicist, Pacific Coastal and Marine Science Center (831-460-7554; gcochrane@usgs.gov) or Peter Dartnell, Physical Scientist, Pacific Coastal and Marine Science Center (831-460-7415; pdartnell@usgs.gov)
License/Use Restrictions	USGS-authored or produced data and information are in the public domain from the U.S. Government and are freely redistributable with proper metadata and source attribution. Please recognize and acknowledge the U.S. Geological Survey and the Alaska Department of Fish and Game as the originators of the dataset and in products derived from these data. This information is not intended for navigation purposes.
Citation Info	Walton MAL, Paull CK, Cochrane G, Addison J, Caress D, Gwiazda R, Kennedy D, Lundsten E, Papesh A. 2021. California Deepwater Investigations and Groundtruthing (Cal DIG) I, Volume 2: Fault and Shallow Geohazard Analysis Offshore Morro Bay. Camarillo (CA): U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2021-044. 56 p.California Deepwater Investigations and Groundtruthing (Cal DIG) I, Volume 2: Fault and Shallow Geohazard Analysis Offshore Morro Bay (boem.gov)
Online Link	https://cmgds.marine.usgs.gov/data-releases/datarelease/10.5066-P9QQZ27U/
Metadata Link	Multibeam acoustic backscatter: https://cmgds.marine.usgs.gov/data-releases/media/2021/10.5066-P9QQZ27U/e584c0900e534eb38ef5e78d8a9c5b3c/Cal_DIG_I_Backscatter_10m_Metadata.txt Multibeam acoustic bathymetry: https://cmgds.marine.usgs.gov/data-releases/media/2021/10.5066-P9QQZ27U/92382a17a34b4b1c81ab96f7c23524c7/Cal_DIG_I_Bathymetry_10m_Metadata.txt

Dataset Table 2.7. Ocean Color Data

Dataset Title	NASA Ocean Color Data
Species/Resource	Ocean Biology

Abstract	NASA's Ocean Biology Processing Group (OBPG) supports the collection, processing, calibration, validation, archive and distribution of ocean-related products from a number of space missions that are supported within the framework and facilities of the NASA Ocean Data Processing System (ODPS) which has been successfully supporting operational, satellite-based remote-sensing missions since 1996. The OBPG serves as a Distributed Active Archive Center (OB.DAAC), responsible for archiving satellite ocean biology data produced or collected under NASA's Earth Observing System Data and Information System (EOSDIS). Ocean Level-3 Standard Mapped Image (SMI) products are image representations of binned data products. The standard SMI products are generated from binned data products, one for each of the following geophysical parameters: chlorophyll a concentration, angstrom coefficient, normalized water-leaving radiance at each visible wavelength, aerosol optical thickness, epsilon, and diffuse attenuation coefficient at 490 nm. For MODIS, products are generated for sea surface temperature (SST), 4 micron SST (SST4) and nighttime SST (NSST). MODIS Chlorophyll-a Concentration Level 3 data can be found at http://oceancolor.gsfc.nasa.gov/cgi/l3.
Strength/Weakness	Searching for data requires users to login to the OceanColor Web's data access points using their Earthdata Login credentials in order to download any products. Although this extra step has been imposed on download operations, OB.DAAC data remains free and open to the public.
File Name	The Area of Interest appears to be called "OCDryTrt" when bounded by the parameters of 35.8N and 34.5N and 121.9W and 121.0W
Data Type	Varies
Spatial Extent	Worldwide
Time Scale	Varies
Contact/Source	Sean Bailey, NASA OceanColor Webmaster, webadmin@oceancolor.gsfc.nasa.gov
License/Use Restrictions	This dataset is intended for public access and use.
Citation Info	Refer to data files (see: https://oceancolor.gsfc.nasa.gov/citations/)
Online Link	https://oceandata.sci.gsfc.nasa.gov/
Metadata Link	https://oceancolor.gsfc.nasa.gov/docs/obpg_dmp.pdf

Dataset Table 2.8. Conductivity, Depth and Temperature Data

Dataset Title	CTD profiles and discrete water-column measurements collected off California and Oregon during NOAA cruise SH-18-12 (USGS field activity 2018-663-FA) from October to November 2018 (ver. 2.0, September 2021)
Species/Resource	Water quality
Abstract	These data were collected as part of the on-going Expanding Pacific Research and Exploration of Submerged Systems (EXPRESS) project, a multi-year, multi-institution cooperative research campaign in deep sea areas of California, Oregon, and Washington, including the continental shelf and slope. EXPRESS data and information are intended to guide wise use of living marine resources and habitats, inform ocean energy and mineral resource decisions, and improve offshore hazard assessments. The ultimate goal of EXPRESS is to develop comprehensive digital elevation models, habitat maps, and geologic maps, which are needed to address important issues associated with marine spatial planning, ecosystem assessments, geohazards, and the impact on sensitive ecosystems of offshore infrastructure development. This particular NOAA cruise focused on deep-sea corals, sponges, and associated habitats.
Strength/Weakness	None noted

File Name	SH-18-12_BTL_CTD_v.2.0_data.csv
Data Type	CSV
Spatial Extent	West boundary: -124.9152 East boundary: -119.3453 North boundary 44.6653 South boundary 33.1300
Time Scale	Beginning date: October 12, 2018; Ending date: November 7, 2018
Contact/Source	PCMSC Science Data Coordinator, Miranda C Baker, PCMSC Science Data Coordinator; mbaker@usgs.gov
License/Use Restrictions	USGS-authored or produced data and information are in the public domain from the U.S. Government and are freely redistributable with proper metadata and source attribution. Please recognize and acknowledge the U.S. Geological Survey, Bureau of Ocean Energy Management (BOEM), and the National Oceanic and Atmospheric Administration (NOAA) as the originators of the dataset and in products derived from these data.
Citation Info	Prouty, N.G., and Baker, M.C., 2021, CTD profiles and discrete water-column measurements collected off California and Oregon during NOAA cruise SH-18-12 (USGS field activity 2018-663-FA) from October to November 2018 (ver. 2.0, September 2021): U.S. Geological Survey data release, https://doi.org/10.5066/P99DIQZ5
Online Link	https://www.sciencebase.gov/catalog/item/5ed8182382ce7e579c670060
Metadata Link	https://www.sciencebase.gov/catalog/item/5ed8182382ce7e579c670060

Dataset Table 2.9. Essential Fish Habitat Mapper

Dataset Title	Essential Fish Habitat (EFH) Mapper
Species/Resource	Habitat areas essential for fish and areas protected from fishing
Abstract	This mapping application provides an interactive platform for viewing spatial boundaries of EFH, or those habitats that NOAA Fisheries and the regional fishery management councils have identified and described as necessary to fish for spawning, breeding, feeding, or growth to maturity. Data layers available for viewing in the EFH Mapper include: • Essential Fish Habitat (EFH) • Habitat Areas of Particular Concern (HAPCs) • EFH areas protected from fishing This data uses methodologies that reflected regional differences in both source data and management needs. Because of the variability in quality and intended use of these GIS data layers, each should be considered individually when interpreting the accuracy and utility of the information they provide. Please be sure to view the EFH data inventory and read the information under Data Quality, to fully understand the usage constraints for each data layer and the completeness and accuracy of the information the EFH Mapper provides.
Strength/Weakness	The EFH Mapper contains areas of EFH and other areas that are protected from fishing as well as certain base maps, but it does not appear to have a method for uploading other datasets, such as the wind energy areas, into the EFH Mapper. The data for Deep-Sea Ecosystem Conservation Areas (established in 2020) do not appear to be available yet on the EFH Mapper tool. The EFH Mapper includes other data disclaimers such as that data for the Pacific Region are based on previous compilation efforts (e.g., groundfish data are from 2006) and do

	not necessarily reflect current habitat conditions. It is especially important to be aware of the data limitations when viewing HAPC boundaries. As a result, the data as represented in the Mapper, should not be relied upon for impact assessments related to individual projects.
File Name	https://www.habitat.noaa.gov/application/efhinventory/index.html (select download button under the West Coast region)
Data Type	SHP file
Spatial Extent	The boundaries of each area are defined by straight lines connecting a series of latitude and longitude coordinates and other regulatory boundaries.
Time Scale	Not specified
Contact/Source	EFH.Mapper@noaa.gov
License/Use Restrictions	Publicly available information as long as information obtained from the use of the site is used for general reference purposes only
Citation Info	NOAA Fisheries, 2021. Essential Fish Habitat. https://www.fisheries.noaa.gov/national/habitat-conservation/essential-fish-habitat.
Online Link	https://www.habitat.noaa.gov/apps/efhmapper/
Metadata Link	XML documents containing the metadata are located at: https://www.habitat.noaa.gov/application/efhinventory/index.html. Then click on the "download data" button for the West Coast region.

Dataset Table 2.10. Protected Resources App

Dataset Title	Protected Resources App
Species/Resource	Endangered species
Abstract	The Protected Resources App displays spatial data for marine and anadromous species listed under the Endangered Species Act (ESA). The core datasets, managed by the Protected Resources Division of NOAA Fisheries' West Coast Region, are ESA-listed species' ranges and critical habitat. These datasets are intended to assist the public and our partners with visually interpreting federal regulations. However, these data do not constitute legal definitions. Please refer to NOAA Fisheries' Federal Register rules and the Code of Federal Regulations for legal definitions of threatened or endangered species and critical habitat. Under the Endangered Species Act, the term "species" can refer to a taxonomic species, subspecies, Distinct Population Segment (DPS), or an Evolutionarily Significant Unit (ESU) for a DPS of Pacific salmon. Salmon ESUs and steelhead DPSs are depicted as ranges using watershed polygons that circumscribe important spawning, rearing, and migration habitats. ESA critical habitat is depicted as lines to represent protected rivers and streams and as polygons to represent protected waterbodies, marine areas, estuaries, marshes, etc. There are habitat areas displayed in these data that are excluded from critical habitat due to overlaps with tribal lands, Department of Defense lands, Habitat Conservation Plans, or they were economic exclusions. Exclusions were not always clipped out of the data. For an exact description of exclusions and any other areas not included in critical habitat, please refer to Federal Register final rules.
Strength/Weakness	Strengths – the app allows CSV datasets to be uploaded as additional layers. Attributes Tables provide additional information and notes on such things as the Federal Register notices, the dates of publication, and description of the area designated as critical habitat. Weaknesses – not all ESA-listed species and critical habitat under the jurisdiction of NOAA Fisheries are displayed. Only those within the West Coast Region that have available data are displayed. Also, it does not appear that the colors given for each data

	layer can be changed so it can be difficult to discern overlapping coverage of different species.
File Name	NMFS_WCR_ESA_Critical_Habitat_20211221_gdb
Data Type	Vector and text data
Spatial Extent	W° Bound:-129.2 E° Bound:-117 N° Bound:48.6 S° Bound:30.4
Time Scale	Published December 21, 2021. Update frequency: as needed.
Contact/Source	Shanna Dunn National Marine Fisheries Service (NMFS), West Coast Region; shanna.dunn@noaa.gov
License/Use Restrictions	These spatial data are not the official legal definitions of critical habitat. Proposed rules, final rules, and the Code of Federal Regulations (50 CFR 226) are the official sources of critical habitat.
Citation Info	Not applicable
Online Link	https://www.webapps.nwfsc.noaa.gov/portal/apps/webappviewer/index.html?id=7514c715b8594944a6e468dd25aaacc9
Metadata Link	https://www.fisheries.noaa.gov/inport/item/21151

Dataset Table 2.11. Marine Protected Areas

Dataset Title	MarineBIOS (Biogeographic Information and Observation System)
Species/Resource	Marine Protected Areas
Abstract	The California Department of Fish and Wildlife offers an interactive map for referencing relevant marine resource planning data. This tool, which is built on the latest version of **BIOS**, is a great place for looking up the boundaries and regulations of marine protected areas or investigating the attributes of benthic and intertidal habitat information. BIOS integrates GIS, relational database management, and ESRI's ArcGIS Server technology to create a statewide, integrated information management tool that can be used on any computer with access to the Internet.
Strength/Weakness	In addition to the data in the viewer, users may add external data services for use within the map viewer.
File Name	Not applicable
Data Type	Digital map
Spatial Extent	West -124.632018 East -116.738089 North 42.074041 South 32.494430
Time Scale	Publication date February 24, 2016; data include all of California's marine protected areas (MPAs) as January 1, 2019
Contact/Source	Biogeographic Data Branch, BIOL Lead Joel Boros; (916) 445-2438; BIOS@wildlife.ca.gov
License/Use Restrictions	The State makes no claims, promises or guarantees about the absolute accuracy, completeness, or adequacy of the contents of this web site and expressly disclaims liability for errors and omissions in the contents of this web site. No warranty of any kind, implied, expressed or statutory, including but not limited to the warranties of non-infringement of third-party rights, title, merchantability, fitness for a particular purpose and freedom from computer virus, is given with respect to the contents of this web site or its hyperlinks to other Internet resources. Reference in this web site to any specific commercial products, processes, or services, or the use of any trade, firm or corporation name is for the information and convenience of the public, and does not constitute

	endorsement, recommendation, or favoring by the State of California, or their employees or agents.
Citation Info	State of California Department of Fish and Wildlife, Marine Region GIS Lab
Online Link	https://apps.wildlife.ca.gov/marine
Metadata Link	https://wildlife.ca.gov/Data/BIOS/Dataset-Index

SECTION 3. INVERTEBRATES INCLUDING LIVE BOTTOM HABITAT

The structure and composition of deepwater marine benthic invertebrates vary widely depending on a number of factors including substrate type and depth. Soft sediments generally have a low diversity and contain a more resilient biological community comprised of opportunistic species. Depth is considered the primary variable to determine macrofaunal invertebrate species distribution with subsequent distinctions related to grain size, while the number of species per grab (richness) and the number of organisms per grab (abundance) also tend to decline with depth (Henkel et al. 2020). The following describes the types of benthic and pelagic organisms that are likely to occur in deepwater regions offshore California, some of which are commercially and recreationally harvested.

Deep-sea corals and sponges form important but sparse live bottom habitats in deep oceanic waters. Octocorals, black corals, and sponges off the West Coast create structure for numerous invertebrate species and are strongly associated with rockfishes (Poti et al. 2020). The most abundant are the soft corals called pennatulaceans or "sea pens," which include 28 species that are known to occur along the U.S. West Coast. They range from the slender sea pen (*Stylatula elongata*) in very shallow waters, to the droopy sea pen (*Umbellula lindahli*) that can be found in water depths to 4,000 m (13,123 ft; Poti et al. 2020). Whitmire et al. (2020) provide a listing of deep-sea coral taxa known to occur off California along with their depth distributions.

Euphausiid crustaceans (krill) form the key food source for much of the marine life along the U.S. West Coast. Krill are well-known indicators of population demographics for many top predators of birds, marine mammals, and fishes. Two species of krill (*Euphausia pacifica* and *Thysanoessa spinifera*) form particularly large aggregations, while another six species are typically more dispersed. Krill growth and reproduction are closely linked with changes in upwelling and large-scale transfer of ocean waters to the shelf (Fiechter et al. 2020). Areas along the shelf break and within submarine canyons have been found to be krill "hotspots," primarily for *E. pacifica* (Santora et al. 2018, Cimino et al. 2020).

Spot prawn (*Pandalus platyceros*) range from Alaska to San Diego, California, in depths from 46 to 488 m (150 to 1,600 ft). A spot prawn trap fleet operates from just north of Monterey Bay to southern California. Traps are set in water depths of 122 to 305 m (400 to 1,000 ft) along submarine canyons or along shelf breaks.

Pink shrimp (*Pandalus jordani*), also called ocean shrimp, are generally found in depths of 46 to 366 m (150 to 1,200 ft) in muddy-sand habitats. Young-of-the-year (YOY) shrimp drift in plankton for up to eight months before settling to the bottom. Adults aggregate near the seabed during the day and ascend the water column at night to feed. High concentrations of pink shrimp annually occur in well-defined areas, or beds, which are generally in areas of sandy mud bottoms. It is believed that high fluctuations of pink shrimp abundance are largely caused by environmental conditions (CDFW 2021a). In the California fishery, pink shrimp are generally caught between 91 and 183 m (300 and 600 ft) with an average reported depth of 135 m (444 ft) based on information contained in commercial fishing logbooks (CDFW 2021a).

Dungeness crab (*Metacarcinus magister*) is typically found on sand or mud bottoms from the intertidal zone out to depths of generally less than 230 m (755 ft; CDFW 2013). Their natural life span is not well understood, but they are estimated to live between eight and ten years, reaching sexual maturity within two to three years. Larvae are pelagic until March, at which time they move closer inshore and settle on the seabed. Larval abundance has also been correlated with periods of colder upwelling (CDFW 2013).

They are fished from Crescent City to the Morro Bay-Avila area, and rarely found south of Point Conception. Most traps are fished at depths ranging from 18 to 73 m (60 to 240 ft), but some traps are fished in shallower or deeper waters.

California spiny lobster (*Panulirus interruptus*) range from Monterey to Baja California. They live up to 30 to 50 years with maturation estimated around five years. Sub-adults and adults are commonly found at depths ranging from intertidal to 64 m (210 ft), while the planktonic larvae have been found offshore as far as 530 km (330 mi) and at depths to 137 m (450 ft; California Department of Fish and Game [CDFG] 2001). The commercial spiny lobster fishery ranges from Point Conception to the U.S.-Mexico border. The recreational fishery extends slightly farther north to Monterey County. Recreational fishing generally occurs in water depths shallower than 30 m (100 ft; California Ocean Science Trust, 2015).

Squid are important prey for many fish, seabirds, and marine mammals in the California Current Ecosystem. Important pelagic squid include the families of *Cranchiidae*, *Gonatidae*, *Histioteuthidae*, *Octopoteuthidae*, and *Ommastrephidae*, *Onychoteuthidae*, and *Thysanoteuthidae*. These groups contain numerous genera and species mostly with poor distributional records. Similar to pink shrimp in the open ocean, squid make vertical (diel) migrations with some swimming to depths of 1,200 m (3,937 ft) or more during the day, and then returning near the surface (at or above 200 m [656 ft]) at night. Other squid species are more mixed throughout the water column (Roper and Young 1975). **California market squid** (*Doryteuthis (Loligo) opalescens*) is one of the largest and most highly valued commercially-targeted species in California. It is short-lived (six to nine months) and ranges from the continental shelf to depths of 700 m (2,300 ft). Adults and juveniles are most abundant at temperatures between 10 to 16 ^{o}C (50 to 61 ^{o}F). Market squid are extremely sensitive to warm water during El Niño-Southern Oscillation (ENSO) conditions, resulting in decreases of fishery catches, but they rebound when colder water increases upwelling intensity (CDFG 2005). Different spawning seasons between central and southern California are believed to be due to variations in ocean bottom temperatures rather than biological differences.

The current range of **Kellet's whelk** (*Kelletia kelletii*) spans from Monterey to Baja California. Most Kellet's whelk are harvested from Point Conception to the U.S.-Mexico border, while a minor fishery also exists in Morro Bay (CDFW 2020a). Much is still unknown about its life cycle. Their growth rates have not been well studied but are thought to be slow at 0.75-1 cm (0.3 to 0.4 in) per year until sexual maturity; and only 9 cm (3.5 in) after 20 years. They are usually found in depths from 0 to 69 m (0 to 226 ft; Hubbard 2008).

Eight species of **abalone** (*Haliotidae spp*) have been found in California coastal waters, five of which (red, black, white, green, and pink) have reduced population numbers. White abalone is currently listed as endangered, but its historical range was from Point Conception and southward to Mexico. Black abalone is listed as endangered and is known to occur along the central California coast on rocky substrates in intertidal and shallow subtidal reefs to about 5 m or 18 ft deep (NOAA Fisheries 2021b). Critical habitat has been established in state waters from Del Mar Landing (Sonoma County) to the Palos Verdes Peninsula (Los Angeles County), and on the offshore islands (NOAA 2011). Given the preference of abalone for shallow coastal waters, they are not discussed further in this report.

Invertebrates and Live Bottom Habitat Data in the MBWEA or Vicinity

One source of information that can be used to understand invertebrate presence in or near the MBWEA includes NOAA's Deep-Sea Coral Research and Technology Program (DSCRTP). The DSCRTP has developed a national database of observational data, images, and technical reports on deep-sea corals and sponges

(Hourigan et al. 2015; Dataset Table 3.1). Deep-sea corals and sponges that have been observed inside the boundaries of the MBWEA are primarily sea pens, but a few instances of black and gorgonian coral, and glass sponge have also been seen.

A comprehensive listing of the datasets that were available (as of 2017) in the DSCRTP database is also provided in Poti et al. (2020). This was a recent study that compiled and synthesized available deep-sea coral and sponge data as well as other macrofauna survey data to better define the physical and environmental characteristics of the MBWEA. Information from NOAA's National Deep-Sea Coral and Sponge Database indicates that it was last updated in 2021, and it seems to be continually updated as more information from deep-sea surveys are received.

In addition to being able to map general locations from observations, Poti et al. (2020) used the coral and sponge data to develop statistical models to predict and map the distribution of deep-sea taxa, including at unexplored locations, based on their relation to other environmental variables. Predicted habitat suitability maps were created for 46 coral and sponge species that occur along the West Coast. The maps include figures to show the coefficient of variation (CV) associated with the modeling effort. The CV figures are indicators of the level of uncertainty related to the confidence in the predictions. The use of CV maps (or values) with maps of predicted probability of occurrence allows for a better understanding of when there are low values in the probability of occurrence (i.e., higher CV values) while high probability of occurrence with corresponding low CV values suggest a good fit of the model. In general, the highest habitat potential can be found on the shelf and upper slope around offshore banks, submarine canyons, and other areas of topographic complexity (Poti et al. 2020). The model output from Poti et al. (2020) may be available by request from the author.

Further details about deepwater biota in these areas can be derived from ROV underwater video surveys (Cochrane et al. 2022) which involve physical, environmental, and biotic observations collected offshore Morro Bay (Dataset Table 3.2). Additional modeling efforts have used this data to assess habitat suitability across the deeper parts of the continental slope (Kuhnz et al. 2021). Generally occurring macrobenthic fauna found in water depths from 300 m to more than 900 m (984 to 2,953 ft) in and around the MBEWA include marine segmented worms (mostly of the family *Sabellidae*, but also *Polynoidae*); amphipods, tunicates, Caridean shrimp (*Caridae*), tanner shrimp (C*hionoecetes tanneri*), longhorn decorator crab (*Chorilia longipes*), big-eyed shrimp (*Eualus macrophthalmus*), scarlet king crab (*Lithodes couesi*), squat lobster (*Munida* spp.), king crab (*Neolithodes diomedeae*), and deepwater bigeye shrimp (*Pandalopsis ampla*; Cochrane et al. 2022).

Understanding the location of hotspots (i.e., oceanic processes that concentrate zooplankton and forage fish) is another factor that can be used to determine potentially important areas of enhanced species abundance, diversity and/or trophic interactions. Messié et al. (in prep) recently completed a study that combined remote sensing products, ecosystem models, and in situ data to investigate zooplankton hotspots along the U.S. West Coast and their relationship with environmental forcing, as well as lower and higher trophic levels. The simulations were evaluated against in situ observations of krill from fisheries surveys and distributions of krill predators (e.g., seabirds and marine mammals). The results show the importance of the upwelling process and oceanic circulation in shaping mesoscale distribution of biological hotspots. These data are also available for downloading as a NetCDF file (1993-present) in a monthly retrospective and near real-time modeled zooplankton concentrations (Dataset Table 3.3). The data were obtained using the growth-advection method described in Messié et al. (in prep). Cimino et al.

(2020) have also related geomorphic features and oceanographic conditions to the distribution and abundance of krill species in the central CCS (Dataset Table 3.4). These Spring season (May-June) models indicate krill species distribution was influenced by bathymetric features, primary productivity, upwelling conditions, surface currents and winds. Overall, the model showed a high abundance of krill from the nearshore to over the continental slope, especially between Cape Mendocino and Point Conception.

Of the top commercial invertebrate landings (by revenue) that were reported from Morro Bay (Table 3.1) most are targeted in nearshore waters. Dungeness crab and shrimp, in particular, are typically targeted over sandy bottom habitats from Monterey Bay to southern California (CDFW 2021b). However, these and other species (or their larval stages) are likely to spend part of their lives over deeper water. Table 3.1 also shows how landings can vary over the years. An example of this variation can be seen in an online visual created by CDFW that shows the catch data (in short tons) of market squid from the 1999-2000 season to the 2020-2021 season (Dataset Table 3.5).

Table 3.1. Ranking of Top Invertebrate Landings by Value in the Port Areas of Morro Bay (2019 and 2020; CDFW 2022a).

Top Commercial Landings and Revenues at Morro Bay (2019 and 2020)				
Species Caught	**Total Landings (pounds)**		**Total Revenue**	
	2019	**2020**	**2019**	**2020**
Dungeness crab	87,852	31,335	$411,309	$131,552
Spot prawn	6,851	9,598	$108,505	$159,066
Ocean (pink) shrimp	71,572	---	$78,729	---
Market squid	79,017	192,341	$39,503	$111,319
Red rock crab	12,474	19,023	$20,654	$34,715
California spiny lobster	2,694	---	$16,152	---
Yellow rock crab	4,895	5,563	$8,422	$9,793
Rock crab (unspecified)	79	11	$121	$22
Spider crab	87	15	$83	$26
Brown rock crab	---	339	---	$713
Top Commercial Landings and Revenues at Avila/Port San Luis (2019 and 2020)				
Species Caught	**Total Landings (pounds)**		**Total Revenue**	
	2019	**2020**	**2019**	**2020**
Dungeness crab	35,026	---	$160,762	---
Spot prawn	3,044	---	$48,589	---
Brown rock crab	14,496	---	$29,567	---
Red rock crab	13,285	11,540	$27,711	$20,624
Ridgeback prawn	4,460	---	$13,380	---
Spider crab	2,986	537	$6,738	$1,146
Rock crab (unspecified)	1,375	201	$3,094	$402
Kellet's whelk	1,674	2,108	$2,511	$1,283
California spiny lobster	100	---	$1,300	---
Yellow rock crab	530	820	$795	$1,366

General Status and Threats to Invertebrates and Live Bottom Habitat

Benthic macroinvertebrates are the types of communities that would most likely be directly impacted by offshore energy development because of disturbances to the seafloor (Poti et al. 2020). Deep-sea corals can be affected by anthropogenic effects because some species grow very slowly and can live for thousands of years. Because of their distance from shore, deep-sea benthic communities have not been as heavily exploited as shelf and coastal habitats.

Population dynamics of krill and other zooplankton are affected by climate variability. Hotspots of krill over the continental shelf are also directly linked with hotspots of other wildlife, particularly for blue whales, although this linkage was more variable for humpback (Rockwood et al. 2020). Predicting hotspots is important for vessel traffic management along routing corridors, which tend to be static, while krill hotspots are dynamic. If real-time forecasting can be developed to better predict where these hotspots might occur, this could help in establishing temporary and dynamic management areas for vessel traffic routing to reduce environmental effects.

Data Gaps and Limitations

Qualitative and quantitative information such as abundance, density, size, and condition remain lacking for most deep-sea benthic ecosystems such as corals and sponges. This information is necessary to understand differences in habitat quality or vulnerability such as large, healthy aggregations versus small, marginal, or already impacted deep-sea biota (Hourigan et al. 2015). Furthermore, the spatial resolution of the current mapping data is out of scale for the MBWEA. Specific geophysical assessments are needed before the full extent of suitable habitat for deep-sea corals and sponges can be determined.

Another gap is the need to define “associated taxa” when conducting surveys on deep-sea corals and sponges. There is no consensus among researchers about what types of associations should be included or how to measure associations. Currently, researchers are not recording associated taxa in the deep-sea coral and sponge database. A null value does not reliably indicate that no associated taxa were present, which is information that could help ascertain their habitat value for other species (Hourigan et al. 2015).

Based on the new data from Messié et al. (in prep), the California Offshore Wind Energy Gateway’s dataset entitled, “Krill Hotspots Along California Coast, 2004–2009” should be updated to reflect this new information when it becomes available.

Summary Tables of Selected Invertebrate Datasets

Dataset Table 3.1 Deepsea Coral and Sponge Occurrences

Dataset Title	NOAA Deep-Sea Coral and Sponge Map Portal
Species/Resource	Various corals, cnidarians, anthozoans
Abstract	NOAA’s Deep-Sea Coral Research and Technology Program (DSCRTP) is compiling a national geodatabase of the known locations of deep-sea corals and sponges in U.S. territorial waters and beyond. The database will be comprehensive, standardized, quality controlled, and networked to outside resources. The database schema accommodates both linear (trawls, transects) and point (samples, observations) data. The structure of the database is tailored to occurrence records of all the azooxanthellate corals, a subset of all corals, and all sponge species. Records shallower than 50 m are generally excluded in order to focus on predominantly deep-water species – the mandate of the DSCRTP. The intention is to limit the overlap with light-dependent (and mostly shallow-water) corals. The current data reflects DSCRTP Database Version 20210414-0. To query, visualize, and download data in its native format, please visit our map portal: https://www.ncei.noaa.gov/maps/deep-sea-corals/mapSites.htm For advanced data query and data download, please visit our ERDDAP data access form:

	https://www.ncei.noaa.gov/erddap/tabledap/deep_sea_corals.html To learn more about deep sea coral and sponge habitats, please visit our website: https://deepseacoraldata.noaa.gov/
Strength/Weakness	Apparently regularly updated
File Name	dwca-noaa_dsc_rtp-v1.12.zip
Data Type	Darwin Core Archive (DwC-A)
Spatial Extent	N: 76.12 S: -77.8664 E: 179.994 W: -180
Time Scale	August 1, 1842, to October 15, 2021 (data complete and updated as needed)
Contact/Source	Tom Hourigan, NOAA Deep-Sea Coral Chief Scientist; (228) 688-2936; tom.hourigan@noaa.gov
License/Use Restrictions	To the extent possible under law, the publisher has waived all rights to these data and has dedicated them to the Public Domain (http://creativecommons.org/publicdomain/zero/1.0/legalcode). Users may copy, modify, distribute and use the work, including for commercial purposes, without restriction.
Citation Info	Hourigan T (2020). NOAA Deep Sea Corals Research and Technology Program. Version 1.6. United States Geological Survey. Occurrence dataset https://doi.org/10.15468/aqbftj
Online Link	https://www.ncei.noaa.gov/archive/archive-management-system/OAS/bin/prd/jquery/accession/download/145037
Metadata Link	https://www1.usgs.gov/obis-usa/ipt/eml.do?r=noaa_dsc_rtp&v=1.12

Dataset Table 3.2 Cal DIG I, Volume 1: Biological Site Characterization Offshore Map

Dataset Title	Physical, environmental, and biotic observations derived from underwater video collected offshore of south-central California in support of the Bureau of Ocean Energy Management Cal DIG I offshore alternative energy project
Species/Resource	Marine invertebrates
Abstract	Physical, environmental, and biotic observations were derived from underwater video collected by the Monterey Bay Aquarium Research Institute (MBARI) using remotely operated vehicles (ROVs) offshore of Morro Bay, California. The data were acquired during three separate surveys in 2019 in support of the U.S. Geological Survey (USGS)/Bureau of Ocean Energy Management (BOEM) California Deepwater Investigations and Groundtruthing I (Cal DIG I) project. Transect information developed to analyze the data for biotopes (as described in Kuhnz and others, 2021) and the resulting biotope numbers are included in the point data. A joint USGS-BOEM-MBARI cruise, which took place from 19-26 September 2019 on the R/V Bold Horizon (USGS field activity 2019-642-FA), focused on conducting biological surveys using MBARI's MiniROV (dives M137-148). Additional surveys were conducted from 02-14 February 2019 (dives D1120-1131) and from 01-11 November 2019 (dives D1202-1217) using MBARI's R/V Western Flyer and ROV Doc Ricketts. The ROV-video surveys were designed and conducted to collect video ground-truth information about substrate and biota.
Strength/Weakness	None noted
File Name	Cal_DIG_I_Biotic_Component.csv
Data Type	Comma-delimited text format
Spatial Extent	West_Bounding_Coordinate: -121.932892

	East_Bounding_Coordinate: -121.057812 North_Bounding_Coordinate: 35.760889 South_Bounding_Coordinate: 34.574724
Time Scale	Publication date: January 8, 2022; data collected from February 2, 2019 to January 26, 2020 (data are complete)
Contact/Source	U.S. Geological Survey, Pacific Coastal and Marine Science Center (PCMSC) Science Data Coordinator (831-427-4747; pcmsc_data@usgs.gov)
License/Use Restrictions	USGS-authored or produced data and information are in the public domain from the U.S. Government and are freely redistributable with proper metadata and source attribution. Please recognize and acknowledge the U.S. Geological Survey and the Alaska Department of Fish and Game as the originators of the dataset and in products derived from these data. This information is not intended for navigation purposes.
Citation Info	Cochrane, G.R., Kuhnz, L.A., Dartnell, P., Gilbane, L., and Walton, M.A., 2022, Multibeam echosounder, video observation, and derived benthic habitat data offshore of south-central California in support of the Bureau of Ocean Energy Management Cal DIG I, offshore alternative energy project: U.S. Geological Survey data release, https://doi.org/10.5066/P9QQZ27U.
Online Link	https://cmgds.marine.usgs.gov/data-releases/datarelease/10.5066-P9QQZ27U/
Metadata Link	https://cmgds.marine.usgs.gov/data-releases/media/2021/10.5066-P9QQZ27U/1d7a00f1936d44c0b16792b99cb38ae2/Cal_DIG_I_Biotic_Component_Metadata.txt

Dataset Table 3.3. Krill Hotspots in the California Current

Dataset Title	Krill hotspots in the California Current
Species/Resource	Euphausiid crustaceans
Abstract	Oceanic processes that concentrate zooplankton and forage fish in so-called hotspots (areas of enhanced species abundance, diversity and/or trophic interactions) have remained elusive. Zooplankton including euphausiids (krill) and copepods are important grazers of phytoplankton and prey species for a diverse array of predators; therefore, they represent a key link in marine food webs. The distribution of zooplankton is patchy and often decoupled from phytoplankton in space and time. Consequently, it has been difficult to predict the abundance and distribution of fish, seabirds and marine mammals, which depend directly on zooplankton for growth and reproduction, from remotely sensed variables such as chlorophyll or primary production. A NASA-funded project (80NSSC17K0574) combined remote sensing products, ecosystem models and in situ data to investigate zooplankton hotspots along the U.S. West Coast and their relationship with environmental forcing, lower and higher trophic levels. We simulated the distribution of hotspots using two different, complementary approaches: 1) a high-resolution coupled biophysical model (Fiechter et al., 2020), and 2) a simple combination of satellite-based winds and currents with plankton growth and grazing equations (Messié et al., in prep). Our simulations were evaluated against in situ observations of krill from fisheries surveys and distributions of krill predators (e.g., seabirds and marine mammals). Our results highlight the importance of the upwelling process and oceanic circulation in shaping the mesoscale distribution of biological hotspots. Here we present routine products for the prediction of zooplankton hotspots along the U.S. West Coast from remotely sensed variables. A toolbox is also available that contains the Matlab programs necessary to run the growth-advection method to predict zooplankton hotspots from nitrate supply in upwelling systems (https://www.mbari.org/science/upper-ocean-systems/biological-oceanography/krill-hotspots-in-the-california-current/).

	The method was primarily funded by NASA (80NSSC17K0574) with additional support from Horizon 2020 (Marie Skłodowska-Curie grant agreement SAPPHIRE No. 746530) and the David and Lucile Packard Foundation. Trajectories are computed using a custom 2D version of the Lagrangian computational tool Ariane (http://stockage.univ-brest.fr/~grima/Ariane/). The programs are written for Matlab running on Linux.
Strength/Weakness	The toolbox uses a custom version of Ariane specifically designed for surface (2D) trajectories, used in previous studies. This version is available upon request to Nicolas Grima or Bruno Blanke (see section "Contact us" on the Ariane website http://stockage.univ-brest.fr/~grima/Ariane/).
File Name	Zbig_CCMP3km_GlobCurrent_monthly(1).nc
Data Type	NetCDF file
Spatial Extent	U.S. West Coast from 28°N to 48°N
Time Scale	1993 to present (near real-time data is accessible)
Contact/Source	Monique Messié, Monterey Bay Aquarium Research Institute (MBARI); (831) 775-1700; monique@mbari.org
License/Use Restrictions	Refer to the paper (listed below and available upon request) when using the toolbox. Also refer to the listed publications when using these products. For use in publications, authors should obtain written permission from MBARI's Director of Information and Technology Dissemination Heidi Cullen. MBARI should be acknowledged as the data source in those publications and reprints should be provided to the MBARI library.
Citation Info	Messié, M., D. A. Sancho-Gallegos, J. Fiechter, J. A. Santora, and F. P. Chavez (submitted). Satellite-based Lagrangian model reveals how upwelling and oceanic circulation shape krill hotspots in the California Current System. Frontiers in Marine Science.
Online Link	https://bitbucket.org/messiem/toolbox_growthadvection/src/master/
Metadata Link	https://bitbucket.org/messiem/toolbox_growthadvection/get/3cd043b10fb1.zip

Dataset Table 3.4 Total Krill Abundance, 2002-2018

Dataset Title	Total Krill Abundance, 2002-2018
Species/Resource	Euphausiid krill spp
Abstract	Krill (euphausiids) are important prey for many mid and upper-trophic level marine organisms due to their global distribution, high biomass, and high energy content. Understanding drivers of krill habitat is essential for forecasting species range shifts, and to better understand how krill predators respond to climate change. Cimino et al. hypothesized that the distribution and abundance of krill species derived from ecosystem surveys in spring and summer relate to geomorphic features, coastal upwelling during the preceding winter, and spring mesoscale oceanographic conditions. For each year from 2002 to 2018, Cimino et al. predicted their "Full model" onto environmental data in May from the core sampling region and the U.S. West Coast to compare the distribution and abundance of krill species. The "Full model" was tuned to the Spring season (May-June) and included a combination of important variables that were selected following three separate models that were hypothesized drivers of krill distribution: 1) geomorphology (Geomorphic model), 2) preceding winter upwelling dynamics (Winter model), and 3) ocean conditions during the survey (May model). The authors found that the total krill model, in general, showed a high abundance of krill from the nearshore to over the continental slope. These maps summarize the annual "total krill" full model outputs to the temporal mean, maximum, and minimum total krill abundance across 2002-2018. The annual 2002-2018 data rasters were processed in Python using the xarray package to summarize the data. In these maps, krill abundance

	is measured in ln(CPUE+1), which is "the abundance of all krill species in log-transformed catch-per-unit-effort".
Strength/Weakness	Wide spatial coverage, relates data to drivers of distribution, lacks temporal specificity/assessment of distribution change
File Name	Cimino2020_mean_tkrill_NAD83.tif, Cimino2020_min_tkrill_NAD83.tif, Cimino2020_max_tkrill_NAD83.tif
Data Type	Raster (.tif), 9.8km cells
Spatial Extent	UL -134.037761 W 47.965033 N; LR -116.030222 W 30.040098 N
Time Scale	2002-2018
Contact/Source	Megan Cimino, UC Santa Cruz/NOAA, megan.cimino@noaa.gov
License/Use Restrictions	This work is licensed under a Creative Commons Attribution 3.0 License
Citation Info	Cimino, M.A., Santora, J.A., Schroeder, I., Sydeman, W., Jacox, M.G., Hazen, E.L. and Bograd, S.J. (2020), Essential krill species habitat resolved by seasonal upwelling and ocean circulation models within the large marine ecosystem of the California Current System. Ecography, 43: 1536-1549. https://doi.org/10.1111/ecog.05204
Online Link	https://caoffshorewind.databasin.org/datasets/19c98618fae348ea98bd60f0f369eb21/
Metadata Link	https://caoffshorewind.databasin.org/datasets/19c98618fae348ea98bd60f0f369eb21/

Dataset Table 3.5 Commercial Market Squid Landings Visual (2019 through 2021)

Dataset Title	California Commercial Market Squid Landing Receipt Data
Species/Resource	Market squid (Doryteuthis (Loligo) opalescens)
Abstract	California processors of commercial market squid landings submit receipts to the California Department of Fish and Wildlife (CDFW) as required by Fish and Game Code Section 8046. Receipts contain catch location (CDFW blocks) and catch information (pounds landed) for each landing. Catch data (in short tons) have been mapped by CDFW block and fishing season, from the 1999-2000 season to the 2020-2021 season. A table of California commercial landings and seasonal catch limits (in short tons) and ex-vessel value corresponding to each season is included here. No confidential commercial market squid landings data are listed. Vessel activity was not disclosed where less than three vessels set per block, per season. Some seasons may appear to contain no data to protect the confidentiality of vessel location information.
Strength/Weakness	The URL to more information for the Pacific Fishery Management Council's Coastal Pelagic Species website is no longer valid.
File Name	N/A
Data Type	N/A
Spatial Extent	CDFW fisheries landings data are summarized in 10 x 10 nautical mile blocks.
Time Scale	1999-2001 (ongoing)
Contact/Source	CDFW Marine Region (Region 7), Dr. Craig Shuman Regional Manager; (831) 649-2870
License/Use Restrictions	The State makes no claims, promises, or guarantees about the absolute accuracy, completeness, or adequacy of the contents of this web site and expressly disclaims liability for errors and omissions in the contents of this web site. No warranty of any kind, implied, expressed or statutory, including but not limited to the warranties of non-infringement of third-party rights, title, merchantability, fitness for a particular purpose and freedom from computer virus, is given with respect to the contents of this web site or its hyperlinks to other Internet resources. Reference in this web site to any specific commercial products, processes, or services, or the use of any trade, firm or corporation name is for the information and convenience of the public, and does not constitute

	endorsement, recommendation, or favoring by the State of California, or their employees or agents.
Citation Info	California Department of Fish and Wildlife. 2022. California Commercial Market Squid Landing Receipt Data. Website accessed February 5, 2022
Online Link	https://wildlife.ca.gov/Conservation/Marine/Pelagic/Market-Squid-Landing
Metadata Link	Not available

SECTION 4. BONY AND CARTILAGINOUS FISH

Bony fish and cartilaginous fish (sharks, skates, and rays) occur widely throughout the CCS as well as inshore in bays and river systems during different stages of their life cycles. Habitat preferences and locations during each life history stage vary based on the species' morphology and physiology. Fish eggs and larvae of many groups (particularly anchovy, herring, jacks, sculpins, and sand lances) may spend days to a year or more adrift as plankton that are driven far offshore by coastal winds. Other fish that produce eggs attached to substrate are more likely to be closely associated with the areas in which they were spawned while other fish species give birth to live young that may also drift as plankton for long periods.

The peak period of spawning for most species in the California Current ecosystem is winter, which generally supports retention of larvae near the coastal zone (Doyle 1992). Some fish larvae will settle out in estuarine and nearshore waters where they remain their whole lives. At a certain size class, typically after one year or more, juveniles of other species such as rockfish will move offshore and/or to deeper water where they mature into adults. Variations in these life history stages and locations are dependent on the species and are also influenced by oceanographic conditions such as upwelling intensity, wind-driven currents, water temperature, and other factors. Other fish, namely salmon, are anadromous, moving from freshwater streams out to the ocean and then back to the freshwater to spawn.

Small pelagic fish and the larvae of larger fish form critical food web links between phytoplankton and other marine predators. Understanding fish life histories and their ecological traits can help predict their habitat preferences. This type of information is also used to support management efforts to maintain sustainable populations of targeted species. Growth rate, fecundity, feeding strategy, mobility, and size at maturity are some of the data that are routinely collected to help understand and manage important commercially and recreationally harvested marine fish populations.

For this report, fish have been generally categorized in the same format as they are listed in the Fishery Management Plans that are used to manage targeted species as well as those species that are considered significant for the ecosystem. The PFMC manages fisheries for groundfish (including rockfish, sole, whiting, shark, and various skates), coastal pelagic species (sardines, anchovies, and mackerel), highly migratory species (tunas, other sharks, and swordfish), and salmon throughout the EEZ. The International Pacific Halibut Commission manages the Pacific halibut fisheries because halibut crosses national and international jurisdictions. The CDFW manages those species that occur in states waters although some of these species co-occur and may also be fished in federal waters.

Life Histories of Select Managed Species

Pacific Coast Groundfish

There are more than 90 different species of managed Pacific Coast groundfish including more than 64 rockfish species such as bocaccio (*Sebastes paucispinis*), yelloweye (*Sebastes ruberrimus*), thornyheads (*Sebastolobus* spp.); six species of roundfish including lingcod (*Ophiodon elongatus*), and sablefish (*Anoplopoma fimbria*); 12 species of flatfish such as flounder and Pacific sanddab (*Citharichthys sordidus*). Leopard shark (*Triakis semifasciata*), spiny dogfish (*Squalus suckleyi*), soupfin shark (*Galeorhinus galeus*), and skates are part of the "other fish complex" with the groundfish fisheries. Other species include the ratfish, grenadiers, and finescale codling, which are being monitored but are also not actively managed such as with catch limits (PFMC 2020a). With a few exceptions, Pacific Coast groundfish live on or near the bottom of the ocean in sandy bottom habitats, sometimes adjacent to rock or other structures.

Rattails, of which there are approximately 300 species, are the dominant fish in deeper waters of the continental slope.

Rockfish

Many rockfish species are vulnerable to exploitation because they do not begin to reproduce until they are five to 20 years old, and few of their young survive to adulthood. However, because of their large size and age at reproduction, rockfish benefit from what is known as the "storage effect" in which they can outlive periods that are not favorable for reproduction, but then have strong periods of successful recruitment during good environmental conditions (Gertseva and Cope 2017). Rockfish are further managed by the habitat in which they are most frequently encountered (i.e., shallow nearshore, deeper nearshore, shelf, and slope). In some years, there may be as many as 40 different species of rockfish targeted offshore Morro Bay (CDFW 2022b).

Bocaccios are one of the largest Pacific coast rockfish. They are moderately slow growing, late to mature, and long-lived. Bocaccios are most common between Oregon and northern Baja California with adults found over rocky reefs to depths of 476 m (1,562 ft) but also common on open bottoms to about 320 m (1,050 ft). Juveniles are pelagic and settle in nearshore nursery areas then move to deeper habitats (Froesse and Pauly 2021). Bocaccios mature and begin to reproduce between four and seven years old and can live to be 50 years old. Bocaccios are generally landed in all months offshore Morro Bay (CDFW 2022b).

Yelloweye rockfish are among the longest-lived rockfish with a maximum reported age of 147 years (Love 2011). This species also is very slow growing and late to mature. Adults are found along the continental shelf, generally shallower than 400 m (1,312 ft). They are typically found in deeper, rocky-bottomed areas although smaller yelloweye tend to occur in shallower water. They are large, slow growing, and mature late in life (50% reported mature at 22 years old; Gertseva and Cope 2017). A small amount of yelloweye is reported in the commercial fishery landings from July through October (CDFW 2022b).

Shortspine thornyhead (*Sebastolobus alascanus*) and **longspine thornyhead** (*S. altivelis*) grow and mature relatively slowly and may live for 80 to 100 years. They are generally found in deep, soft bottom habitats. Shortspine thornyheads spawn between December and late May along the West Coast, while longspine generally spawn during February, March, and April (Fay 2020). Unlike rockfish in the genus *Sebastes* that give birth to live young, thornyheads are oviparous, producing a gelatinous mass consisting of 20,000-450,000 eggs (NOAA Fisheries 2021b) that are fertilized at depth. The mass then floats to the surface where final development and hatching occurs (Fay 2020). Juvenile longspine settle on the continental slope at depths between 600 and 1,200 m (1,969 and 3,937 ft). Longspine are better adapted to deep water than shortspine. Thornyheads (mostly shortspine) are targeted throughout the year in this region (CDFW 2022b).

Lingcod

Lingcod occur from the western Gulf of Alaska to northern Baja California but are most abundant from northern California and northward because of their preference for colder waters of 7 to 10 ^{o}C (44 to 50 ^{o}F). They are typically taken from water depths of 305 m (1,000 ft) or less but occur from the intertidal zone out to 494 m (1,620 ft). In more southerly or warmer waters, they do not typically occur in water depths less than 30 m (100 ft). Small juveniles (less than 8 cm [3 in]) are pelagic and can be attracted to the surface by lights at night, while larger juveniles live on the bottom in nearshore waters out to 61 m

(200 ft). Adults are bottom dwelling and mostly solitary. Spawning varies by location, generally taking place from November to April in California, peaking in late December to early February. Lingcod are voracious predators, and feed on almost any fish within their vicinity, along with squid and octopus (Love 2011). They are commercially landed throughout much of the year in Morro Bay (CDFW 2022b).

Pacific Hagfish

There are four species of hagfish off California: black hagfish (Eptatretus deani), Pacific hagfish (E. stoutii), shorthead hagfish (E. mcconnaugheyi) and whiteface hagfish (Myxine circifrons). The Pacific hagfish is primarily targeted by commercial fishing generally for live export to South Korea although there is a small domestic market for live and fresh, dead hagfish (CDFW 2021c). Considered scavengers, hagfish are found over deep, muddy habitat at depths from 9 to 732 m (30 to 2,402 ft), but most are caught in depths less than 549 m (1,800 ft; CDFG 2010a). Based on the landings data for Morro Bay area, it is one of the largest (in weight) of commercial catches and they are targeted during all months of the year (CDFW 2022b).

Sablefish

Sablefish (commonly called blackcod) are schooling fish that typically live on or near the seafloor, usually over sand or mud. They are sedentary, not making extensive movements, with exceptions. Sablefish eggs and larvae have been found as far as 278 km (173 mi) offshore, but YOY are found near the surface along the coast, especially in summer. Juveniles usually occur shallower than 182 m (600 ft), including sheltering within floating kelp rafts, while adults are typically found from 182 to 1,000 m (600 to 3,000 ft). They have been known to shift downslope into cooler waters on a seasonal basis, seeming to prefer temperatures from 3 to 8 °C (37 to 46 °F). Sablefish occur from east-central Honshu Island, Japan north into the Bering Sea and southeast along the U.S. West Coast down to Baja. Historically, they were abundant from at least southern California northward with the largest concentrations north of Cape Mendocino (Love 2011). Sablefish spawn in batches, three to four times per season. The spawning season tends to be highly variable; one study indicated August to November along the Washington to California coast; another off Central California indicated October to February (Love 2011). Commercial harvest of sablefish occurs during all months of the year off Morro Bay with highest numbers (in pounds) during May through November (CDFW 2022b).

Pacific Halibut

The **Pacific halibut** (*Hippoglossus stenolepis*) is migratory, crossing state boundaries off the U.S. West Coast as well as internationally from Japan to Russia. Halibut occur from Santa Barbara, California to Nome, Alaska, along the edge of the continental shelf at depths from about 182 to 488 m (600 to 1,600 ft). Adults congregate on spawning grounds in British Columbia and Alaska from November to March (International Pacific Halibut Commission 2021). A small amount (in pounds) of Pacific halibut are reported landed offshore the Morro Bay port area during all months of the year but are highest from July through November (CDFW 2022b).

Bottom Dwelling Shark Species

Leopard sharks are common in California waters, primarily in shallow water areas less than 18 m (59 ft), although they have been found as deep as 83 m (272 ft). They are abundant in central and northern California bays and estuaries, then leave for the open coast in the winter months (CDFW 2020b). Pacific angel sharks (*Squatina californica*) tend to be found in shallow, warmer waters during the summer before moving back out into the deep ocean for winter to depths of 1,460 m (4,789 ft). Angel sharks range in depth from 1 m to more than 183 m (3 ft to more than 600 ft) with most catch effort between 30 and 71 m (100 and 300 ft; CDFW 2020b). Small quantities of leopard, Pacific angel, sevengill (*Notorynchus cepedianus*), soupfin, and spiny dogfish sharks are targeted offshore Morro Bay at various times over the year (CDFW 2022b).

Coastal Pelagic Species

Pelagic fish encompass species that live in the water column, but not near or on the bottom. The coastal pelagic species offshore California are found throughout the water column from the surface down to 1,000 m (3,281 ft), and generally above the continental shelf. These species, which are also referred to as forage fish, include Pacific sardine (*Sardinops sagax caerulea*), chub mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), and northern anchovy (*Engraulis mordax*). These small coastal pelagics are a critical part of the food web in the California Current ecosystem for many other species of fish, marine mammals, and seabirds. While these species are described here because they are expected to occur in and around the MBWEA site and are important prey species, they do not appear to be landed at Morro Bay ports (CDFW 2022b).

The **Pacific sardine** is a small, fast growing, schooling fish that typically lives for five years or so, though can reach up to 13 years. They occur from southeastern Alaska to Baja and possibly off Peru and Chile. A large amount of spawning occurs nearshore, while some takes place as far out as 483 km (300 mi) or more (Love 2011). The highest concentrations of sardine larvae occur in warmer, more southern waters. The population size varies naturally, which leads to large fluctuations in abundance – a phenomenon known as a boom-bust population cycle, which is typical of small pelagic species that have relatively short life spans and high reproduction rates.

Chub mackerel are fast-growing fish that can live up to 18 years but are able to reproduce by age four, and sometimes as early as one year. Although the stock ranges from southeastern Alaska to southern Baja California, they are more common from Monterey Bay to Cabo San Lucas. Over the last few decades, Pacific mackerel are occurring more often in the northernmost portions of its range in response to warmer oceanographic conditions during El Niño events. Pacific mackerel usually occur within 30 km (19 mi) of shore but have been captured as far as 400 km (249 mi) offshore, and from the surface to 300 m (984ft) depth. Adults are commonly found near shallow banks. Juveniles are found off sandy beaches, around kelp beds, and in open bays. They often school with other small pelagic species, particularly jack mackerel and Pacific sardine (*Sardinops sagax*; Crone et al. 2019). Pacific mackerel also naturally experience boom-bust cycles of abundance (NOAA Fisheries 2021b).

Jack mackerel are a long-lived fish found throughout the northeastern Pacific Ocean. They are active predators of copepods, squid, anchovy, and other fishes. Jack mackerel are prey for larger tuna, billfish, and marine mammals. They are occasionally caught in both recreational and commercial fisheries (CDFW 2020b). Jack mackerel eggs and larvae are distributed widely in the northeastern Pacific but the largest known concentrations of YOY jack mackerel are found in the Southern California Bight (MacCall and Stauffer 1983).

Northern anchovy are small, short-lived pelagic fish found across the eastern Pacific Ocean. Anchovy eat various types of plankton and play an important role as common prey for many species of birds, mammals, and fish. Northern anchovy are primarily caught in commercial fisheries but are also used as recreational bait.

Highly Migratory Species

While many types of fish tend to spend most of their lives in one general location (such as reef fish on hard bottom habitat, many groundfish in sandy areas, or other fish in kelp forests), highly migratory species are open water fish that travel vast distances across oceans and along coastlines generally making seasonal migrations between temperate waters where they feed, and tropical waters where they spawn. Some of the highly migratory species that occur in the CCS include tunas, many sharks, mahi-mahi (or dolphinfish; *Coryphaena* spp.), swordfish (*Xiphias gladius*), marlin (*Tetrapturus* spp. and *Makaira* spp.), and sailfish (*Istiophorus* spp.). These fish are known to have extensive ranges, often crossing international borders. Although they predominantly live in the open ocean, they may also spend part of their life cycle in nearshore waters.

Tunas

Tunas are fast-moving pelagic fish that often form large schools. Tunas that occur off California include **North Pacific albacore** (*Thunnus alalunga*), **Pacific bluefin** (*T. thynnus* and *T. orientalis*), **bigeye** (*T. obesus*), **skipjack** (*Katsuwonus pelamis*), and **yellowfin** (*T. albacares*). Yellowfin and bigeye are found mid-ocean while albacore, Pacific bluefin, and skipjack are found in both coastal and mid-ocean areas (FAO 2021). Tunas can thermoregulate through a process in which arterial blood is warmed by venous blood that flows through red swimming muscles. This enables them to repeatedly forage in cold waters to depths of hundreds of feet and then ascend to rewarm their tissues spending time relatively near the surface (above 50 m [165 ft]; FAO 2021). Vertical distribution is also influenced by dissolved oxygen levels such that some tuna species may concentrate along the edges of continental shelves and deeper water canyons (PFMC 2018). Another benefit of thermoregulation is that it allows tuna to maintain high activity levels with some of the fastest swimming speeds of all fish. However, varying sea surface temperatures affect tuna migration, which may vary seasonally and from year-to-year (PFMC 2018). Albacore and Pacific bluefin tend to be found in more temperate waters as cold as 10 °C (50 °F; Hino et al. 2021). Offshore the Morro Bay area, both albacore and bluefin are targeted in the fall and winter months (CDFW 2022b).

Oceanic Sharks

Migratory, oceanic sharks (as opposed to bottom-dwelling sharks described in the section on Pacific Coast Groundfish) are **common threshers** (*Alopias vulpinus*), **shortfin mako** (*Isurus oxyrinchus*); **blue shark** (*Prionace glauca*); **great white shark** (*Carcharodon carcharias*), **megamouth** (*Megachasma pelagio*), **basking shark** (*Cetorhinus maximus*), among others. Threshers and shortfin mako are two of the oceanic shark species that are targeted offshore Morro Bay by the drift gillnet fishery, which occurs at varying distances from shore depending on the season. Shark species that cannot be actively targeted but occur in California state and federal waters include the great white shark, basking shark, and megamouth shark. These sharks tend to occur in greatest numbers in the Eastern Pacific in autumn and winter months. The north Pacific stock of basking shark is also listed as endangered by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2021).

Swordfish

Swordfish (*Xiphias gladius*) have round bodies and long, flat, pointed bills. Adults do not have scales and may grow up to 4.5 m (15 ft) in length and weigh up to 536 kg (1,182 lb), although the average size caught in the fishery is much smaller (PFMC 2018). Swordfish are mid-ocean fishes that can be found from surface level (around 100 m [328 ft]) during the night then diving to depths of 600 m (1,969 ft) with occasional descents below 900 m (2,953 ft), and sometimes deeper, for prolonged periods during the day. These depths are habitats that contain very low oxygen and temperature (Abascal et al. 2010). It is believed that swordfish can control their rate of heat loss or gain during these vertical movements by altering the route of blood flow supplying the red muscle, which allows them to prey on species that are not accessible for most other active, pelagic fish (Stoehr et al. 2018). Historically, swordfish were more commonly caught in waters off central and especially southern California, but have been recently caught offshore of the San Francisco region. As water temperatures warm, distribution and habitat preferences for swordfish and many other species are expected to change.

Other predatory fish

Another type of billfish that occurs off California is the **striped marlin** (*Kajikia audax*), which ranges as far north as Oregon, but is more common south of Point Conception. Striped marlins prefer water temperatures between 20 to 25 °C (68° and 78 °F). Their prey sources include northern anchovy, Pacific sardine, jack mackerel, and squid (PFMC 2018). Other highly migratory species include **dolphinfish** (also called mahi-mahi; *Coryphaena hippurus*), which occurs in the more tropical waters of southern California. Dolphinfish are highly productive and widely distributed throughout the tropical/subtropical Pacific. They are mostly commercially taken on the high seas, outside of U.S. waters, but are recreationally taken in California primarily in the Southern California Bight (CDFW 2020b).

Salmonids

Pacific salmon (Oncorhynchus spp.) are native to coastal regions of northeastern Asia (Japan, Korea and Russia) and western North America from California to Alaska. Salmon are anadromous fish that begin their lives in streams, tributaries, and rivers, emigrate down river through estuaries and out to sea where they grow to maturity, then return to spawn in their natal freshwater streams. Pacific salmon are most abundant offshore of California in the summer months of June, July, and August. **Steelhead** (*O. mykiss*) are unique in that some stay in freshwater all their lives and are called rainbow trout, while others migrate to the ocean. One distinct population segment (DPS) of steelhead in San Luis Obispo County is the South-Central California Coast DPS, which is listed as threatened species under the Endangered Species Act (ESA; NOAA Fisheries 2021b). **Chinook** or king (*O. tshawytscha*) salmon generally spend two to five years at sea before returning to spawn in their natal streams. If the regulations allow, they are primarily targeted offshore at depths of 10 to 361 ft (3 to 110 m). It is prohibited to retain ocean steelhead salmon.

Availability of Fisheries Data Near and Within the MBWEA

Many species of fish are likely to occur in and around the MBWEA including those that are actively targeted in commercial and recreational catches as well as many others that are not. Table 4.1 depicts a list of key fish and their depth ranges based on life history data of known populations, landings data provided by the State of California, survey data that is accessible in the California Offshore Wind Energy Gateway, and other information. Fish that have been directly observed in the MBWEA and vicinity during recent remotely operated video surveys can be found in Dataset Table 4.1 (Kuhnz et al 2021). The list includes thornyheads, hagfish, snakehead eelpout (*Lycenchelys crotalinus)*, blackmouth eelpout (*Lycodapus fierasfer*), and blackgill rockfish (*Sebastes melanostomus*). Taken together, this information provides a useful, but not exhaustive, base of understanding about the types of fish species that may be occur in the MBWEA.

Table 4.1. Depth Preferences and Range of Select Fish Species Likely or Known to Occur In or Near the MBWEA

Type	Name	Depth and/or Offshore Range (for adults)*
Pacific Coast Groundfish Fishery Management Plan		
Rockfish	Gopher Rockfish	Found in depths from the intertidal zone to 86 m (282 ft), but are more commonly found between 9-37 m (30-121 ft)
	Bocaccio	Found in depths from 20 to 475 m (66 to 1,558 ft), but tend to be most abundant from 95 to 225 m (312 to 738 ft)
	Thornyheads	From 26 - 1,524 m (85 to 5,000 ft) or more
Groundfish	Sablefish (blackcod)	Occurs in water depths from 57 to 1,524 m (187 to 5,000 ft)
	Lingcod	From 0 to 494 m (0 to 1,620 ft) deep
Flatfish	California halibut	Usually between 1.5 and 54 m (5 and 180 ft), but also as deep as 83 m (600 ft)
Skate	Longnose skate	From 9 to 1,069 m (29 to 3,507 ft)
International Pacific Halibut Commission		
Flatfish	Pacific halibut	Summer feeding grounds on the continental shelf in water depths to 500 m (1,640 ft); occurs farther offshore during winter spawning
Pelagic Fisheries of the Western Pacific Region		
Coastal Pelagic	Pacific sardine	Spawns from surface waters to at least 50 m (165 ft); ranges up 483 km (300 mi) offshore
	Pacific (chub) mackerel	Surface oriented, but retreats down to 300 m (990 ft); spawns up to 322 km (200 mi) offshore
	Pacific herring (a state-managed fishery)	Depth varies with season, generally surface oriented to 478 m (1,568 ft)
	Northern anchovy	Surface to 305 m (1,000 ft) and usually within 161 km (100 mi) of shore, but can be found out to 483 km (300 mi)
Highly Migratory Species		
Tuna	Albacore tuna	Within 16-24 km (10 to 15 mi), sometimes closer; generally, ranges more than 55 km (34 mi) from shore
Shark	Shortfin mako	Occurs primarily near surface, down to 152 m (500 ft)
	Common thresher	Occurs from the surface down to 368 m (1,208 ft) or more, ranging offshore to 80 km (50 mi) or more
Salmonids		
Salmon	Chinook Salmon	Occurs from 3 - 110 m (10 - 361 ft) and ranges 46 km (0 to 28 mi) from shore

*Approximate depth and offshore ranges for individual species listed above were based on life history information obtained from the CDFW Marine Species Portal, Froese and Pauly (2021), and Love (2011).

The SWFSC conducted 3-D sonar surveys of fish schools and other mid-water marine organisms in 2016 to assess biological abundance, identify species, and characterize habitats (Dataset Table 4.2). SWFSC notes that this information could also be used to map underwater gas seeps and remotely monitoring undersea oil spills.

Similarly, SWFSC conducted trawl surveys to collect information on Coastal Pelagic Species (Dataset Table 4.3). These data are listed as line items in a CSV file, which can be grouped by latitude and longitude (North/South 35º to East/West -121º to –122º) to determine which species were caught in the MBWEA and vicinity. For this area of interest, the data came from surveys conducted in 2004 and annually from 2006 to 2015. The data show that northern anchovy, Pacific hake (*Merluccius productus*), sardine , chub mackerel (*Scomber japonicus*), California lanternfish (*Symbolophorus californiensis*), and Pacific jack mackerel were the most commonly encountered species in the deepwater region around the MBWEA. Infrequently caught species (from one to eight individuals) that were also found in and near the MBWEA included sablefish, Pacific pomfret (*Brama japonica*), Medusa fish (*Icichthys lockingtoni*), eared blacksmelt (*Lipolagus (Bathylagus) ochotensis*), Chinook salmon, curlfin sole (*Pleuronichthys decurrens*), blue shark, and ribbonfish (*Trachipterus altivelis*).

For commercial catch information, the Pacific Fisheries Information Network (PacFIN) is a collaboration between state and federal fishery agencies to supply information needed to effectively manage fish stocks on the U.S. West Coast. The PacFIN APEX reporting system provides summary data based on commercial landings ("trip tickets") reported by fishermen (i.e., species caught, total weight) as well as other information such as revenue estimates and price per pound of commercially caught species (Dataset Table 4.4). The data can be sorted by certain landings type (groundfish, albacore, all highly migratory species, or all fisheries), by the gear type used, by the port where the landings were reported, by the catch area and other categories. Customized queries can also be developed from the raw (non-aggregated, non-confidential) data in PacFIN (Edwards 2020).

Each year, CDFW presents the Commercial Landings data as well as landings from Commercial Passenger Fishing Vessels (CPFV) in summary tables that show commercial fisheries catches by month, by port, and by area of California. Some information may be listed as confidential when there are less than three dealers conducting business to prevent disclosure of a particular business's activity, or the information is not released at all. Table 4.2 shows the top 10 fish landings (by value) in San Luis Obispo County ports (listed as Morro Bay and Avila/Port San Luis). CPFV landings are not reported here as they only include broad regions of California (southern versus northern). Invertebrates (crabs, shrimp, squid) are among the top 10 of landings by value, and are presented in Section 3 (Table 3.1).

Table 4.2. Ranking of Top Ten Landings of Fish by Value in the Port of Morro Bay and surrounding Area (2019-2021)

Total Fish Landings and Revenues at Morro Bay and Avila/Port San Luis						
Species Caught	**Total Landings (in metric tons)**			**Total Revenue**		
	2019	**2020**	**2021**	**2019**	**2020**	**2021***
Chinook salmon	76.8	11.8	18.4	$2,426,945	$230,587	$443,425
Sablefish	153.9	106	126.7	$666,804	$469,094	$489,833
Pacific hagfish	177.1	97.6	---	$429,485	$231,586	---
Gopher rockfish	11.4	12.0	14.4	$187,937	$183,864	$223,965
Brown rockfish	10.7	13.4	13.1	$163,816	$203,558	$195,844
California halibut	11.9	13.3	17.3	$149,934	$173,956	$221,925

Total Fish Landings and Revenues at Morro Bay and Avila/Port San Luis						
Species Caught	**Total Landings (in metric tons)**			**Total Revenue**		
	2019	**2020**	**2021**	**2019**	**2020**	**2021***
Shortspine thornyhead	7.5	4.1	5.0	$132,205	$71,706	$89,843
Black and yellow rockfish	7.3	2.4	10.1	$122,167	$35,321	$170,071
Cabezon	9.0	3.4	11.4	$111,301	$50,425	$148,080
Grass rockfish	5.1	5.5	6.0	$119,420	$118,150	$133,971

*Data from Pacific Fisheries Information Network (2022) *In 2021, $494,931 in revenues were reported withheld due to confidentiality of the landings data.*

The commercial fisheries self-reported logbook data allows various assessments to be conducted of catch levels and the types of fish that are targeted in a region. The logbook data contain three main types of features: a) characteristics specific to a fishing trip (such as departure and return port), b) characteristics specific to a tow (such as set and retrieval locations of the gear), and c) characteristics specific to a particular species or market grade (Mamula et al. 2020). The logbooks are required as soon as the catch is landed at port to verify that the fish were caught with appropriate methods and in approved areas. This information is then compiled so each fishery has a complete data set of all the fishing locations reported for a given time with detailed information on hot spots of fishing activity and high catch areas. NOAA Fisheries receives these logbooks and then compiles the data into an in-house database. This is an important source of data on commercial fishing effort and species. The logbooks can also provide a historical record of the spatial distribution of fishing effort. This type of data has been compiled for public use, such as in the California Offshore Wind Energy Gateway (Dataset Table 4.5; Miller et al. 2014); however, the information is not regularly updated. This is also seen in the BOEM and NOAA MarineCadastre.Gov National Viewer, which provides interactive mapping of certain data that can look at certain concerns between fishing and renewable energy such as the potential for space-use conflicts (Dataset Table 4.6). As more information like this becomes available in a publicly accessible format and is regularly maintained, then new types of mapping tools could be built on these data such as determining where to fish for swordfish to avoid bycatch of protected species (Dataset Table 4.7). Limited spatial distribution data current to 2017 for some groundfish species and gear types are available from the NOAA based on observed fishing effort in the U.S. Pacific Coast groundfish fisheries (Dataset Table 4.8; Somers et al. 2020). These tools, which are similar to the ecosystem modeling predictive efforts that were described earlier, can be used to make predictions about where fishing effort should be allocated based on known habitat preferences of sensitive species.

General Status and Threats to Fish

Primary threats to bony and cartilaginous fish include habitat loss, water quality degradation, and climate change. Over-harvesting is also a threat to some species, though U.S. fishery management efforts have enabled the recovery of most stocks to sustainable levels.

Many shark species, as well as some groundfish and deepwater bony fish species have a later maturation age and lower reproductive rates, which may contribute to their vulnerability. Other impacts such as the bioaccumulation of mercury is a particular threat to fish that feed higher on the food chain such as pelagic sharks and tunas.

Primary threats to salmon have been associated with the degradation and loss of fresh and brackish water spawning, rearing, and feeding habitats (PFMC 2016). Effects on long-term ocean temperature trends due to climate change are also expected to alter fish habitat preferences and abundance levels both positively and negatively, depending on species and location yet their ocean migrations are not well known.

Data Gaps and Limitations

There are numerous spatially discrete datasets related to commercial fishing in the California Offshore Wind Energy Gateway, MarineCadastre, and others such as the catalogs in www.Data.Gov, that also need to be updated to reflect current commercial and recreational fishing data. NOAA Fisheries, the Pacific Fishery Management Council, and the Pacific States Marine Fisheries Commission, along with numerous academic and research institutions, collect, maintain, and analyze a significant amount of fishery data. Much of the raw data (e.g., survey data and geo-spatial data for individual species occurrence and abundance); however, is not easily available (or made available) to the public. The SAFE reports contain information on abundance, population trends, landings, and more that are in report form and generally have not been adapted to a visualized format.

For other fisheries, relatively little area-specific data are available such as for sharks and billfish. More information is needed to assess stock distribution, status, and habitats at different life stages. Information is also needed to identify important habitat areas such as for thresher and mako shark pupping areas, key migratory routes, feeding areas, and areas where large adult female sharks congregate (PFMC 2018). Some of these data deficiencies are changing as more tuna, billfish, and sharks are electronically tagged and monitored remotely such as with the Tagging of Pelagic Predators program at Stanford University Hopkins Marine Station. This type of dataset can provide a baseline for monitoring and forecasting seasonal patterns and assessing shifts in abundance for highly migratory species.

Relatively little information is known for many deepwater fish species such as Pacific hagfish. Knowledge of its maturation and fecundity is limited but improving. The status or biomass of Pacific hagfish stocks is also unknown, although the population is considered to be substantial based on catch amounts (CDFG 2010a).

For fishery landings data, the available summaries only show non-confidential landing statistics. Federal statutes prohibit public disclosure of landings (or other information) that would allow identification of the data contributors and possibly put them at a competitive disadvantage. Most summarized landings are non-confidential, but whenever confidential landings occur, they have been combined with other landings and are usually reported as "Withheld for Confidentiality." Total landings by state include confidential data and will be accurate, but landings reported by individual species may, in some instances, be misleading due to data confidentiality.

Except for certain fisheries with required reporting requirements, landings data do not actually indicate the physical location of harvest but the location at which the landings either first crossed the dock or the general area in which they were reported as being caught.

Summary Tables of Selected Fish Datasets

Dataset Table 4.1. Video Observations of Deepwater Fish and Other Species

Dataset Title	Physical, environmental, and biotic observations derived from underwater video collected offshore of south-central California in support of the Bureau of Ocean Energy Management Cal DIG I offshore alternative energy project

Species/Resource	Chordates and invertebrates
Abstract	Physical, environmental, and biotic observations were derived from underwater video collected by the Monterey Bay Aquarium Research Institute (MBARI) using remotely operated vehicles (ROVs) offshore of Morro Bay, California. The data were acquired during three separate surveys in 2019 in support of the U.S. Geological Survey (USGS) / Bureau of Ocean Energy Management (BOEM) California Deepwater Investigations and Groundtruthing I (Cal DIG I) project. Transect information developed to analyze the data for biotopes (as described in Kuhnz and others, 2021) and the resulting biotope numbers are included in the point data. A joint USGS-BOEM-MBARI cruise, which took place from 19-26 September 2019 on the R/V Bold Horizon (USGS field activity 2019-642-FA), focused on conducting biological surveys using MBARI's MiniROV (dives M137-148). Additional surveys were conducted from 02-14 February 2019 (dives D1120-1131) and from 01-11 November 2019 (dives D1202-1217) using MBARI's R/V Western Flyer and ROV Doc Ricketts. The ROV-video surveys were designed and conducted to collect video ground-truth information about substrate and biota.
Strength/Weakness	None noted
File Name	Cal_DIG_I_Biotic_Component.csv
Data Type	Comma-separated values (point data)
Spatial Extent	West_Bounding_Coordinate: -121.932892 East_Bounding_Coordinate: -121.057812 North_Bounding_Coordinate: 35.760889 South_Bounding_Coordinate: 34.574724
Time Scale	2019 (in three surveys; data are complete)
Contact/Source	U.S. Geological Survey, Pacific Coastal and Marine Science Center (PCMSC) Science Data Coordinator (831-427-4747; pcmsc_data@usgs.gov)
License/Use Restrictions	USGS-authored or produced data and information are in the public domain from the U.S. Government and are freely redistributable with proper metadata and source attribution. Please recognize and acknowledge the U.S. Geological Survey and the Bureau of Ocean Energy Management as the originator(s) of the dataset and in products derived from these data.
Citation Info	Kuhnz, L.A., Gilbane, L., Cochrane, G.R., and Paull, C.K., 2021, California Deepwater Investigations and Groundtruthing (Cal DIG) I, Volume 1: Biological site characterization offshore Morro Bay: U.S. Department of the Interior, Bureau of Ocean Energy Management, OCS Study, BOEM 2021-037, 72 p.
Online Link	https://cmgds.marine.usgs.gov/data-releases/media/2021/10.5066-P9QQZ27U/8676dd1cde47458caefd834bb3ed8a87/Cal_DIG_I_Biotic_Component.csv
Metadata Link	https://cmgds.marine.usgs.gov/data-releases/media/2021/10.5066-P9QQZ27U/1d7a00f1936d44c0b16792b99cb38ae2/Cal_DIG_I_Biotic_Component_Metadata.txt

Dataset Table 4.2. Coastal Pelagic Species in Water Column Sonar Data (2016)

Dataset Title	ME70 Water Column Sonar Data Collected During 2016 Summer California Current Ecosystem Coastal Pelagic Species (CPS) Survey (RL1606, ME70).
Species/Resource	Pacific sardine, northern anchovy, herring, and Pacific mackerel, jack mackerel, krill, and other CPS
Abstract	The objectives of the survey were to: 1) acoustically map the distributions and estimate the abundances of CPS, including, but not limited to Pacific sardine (Sardinops sagax), northern anchovy (Engraulis mordax), herring (Clupea pallasii), and Pacific (Scomber

	japonicus) and jack mackerel (Trachurus symmetricus); and krill (euphausiid spp.); 2) characterize the biotic and abiotic environments of these species, and investigate linkages; and 3) gather information regarding the animals' life history parameters, schooling and diel vertical migration (DVM) behaviors, and potential avoidance reactions to the survey vessel. The cruise sampled the California Current Ecosystem from San Diego, CA to Vancouver Island, BC, CA. Multi-frequency (18-, 38-, 70-, 120-, 200-, and 333-) General Purpose Transceivers and Wide Band Transceivers (Simrad EK60 GPTs and EK80 WBTs), were configured with split-beam transducers (ES18-11, ES38B, ES70-7C, ES120-7C, ES200-7C, ES333-7c, respectively). The transducers were mounted on the bottom of a retractable keel called a "centerboard". The keel was retracted (~ 5-m depth) during calibration, and in the intermediate position (~7-m depth) throughout the survey. Exceptions were made during shallow water operations, when the keel was retracted; or during times of heavy weather, when the keel was extended (~9-m depth) to provide extra stability. In addition, the Simrad ME70, MS70, and SX90 were used to sample the water column simultaneously using K-sync to sequence pinging between sounders and sonars. The EK80s were removed from the ship halfway through the survey on August 19 and reinstalled on September 19. EK80 data was collected in CW mode.
Strength/Weakness	Data are raw and not mapped in a visualization yet
File Name	arn:aws:s3:::noaa-wcsd-pds
Data Type	Simrad ME70 raw (.raw) format (Version: 1)
Spatial Extent	West Bound Longitude: -129.46203 East Bound Longitude: -117.15315 South Bound Latitude: 32.59865 North Bound Latitude: 50.76075
Time Scale	Creation: June 28, 2016; Publication: September 24, 2017-09-24. According to the metadata, the dataset is complete and no further updates are planned, but the Amazon Web Service (AWS) archive notes that "New water-column sonar data are added regularly as they are provided to the archive."
Contact/Source	NOAA National Centers for Environmental Information, Water Column Sonar Data Manager; (303) 497-4742; wcd.info@noaa.gov
License/Use Restrictions	These data are considered raw and have not been subjected to the NOAA's quality control or quality assurance procedures. They are released for limited public use as preliminary data to be used only with appropriate caution. NOAA cannot assume liability for any damages caused by any errors or omissions in the data, nor as a result of the failure of the data to function on a particular system. NOAA makes no warranty, expressed or implied, nor does the fact of distribution constitute such a warranty. Not subject to copyright protection within the United States.
Citation Info	Southwest Fisheries Science Center. 2016. 'ME70 Water Column Sonar Data Collected During RL1606'. NOAA National Centers for Environmental Information, doi:10.7289/V5XP7342. Accessed February 10, 2022
Online Link	https://registry.opendata.aws/ncei-wcsd-archive/
Metadata Link	https://data.noaa.gov/waf/NOAA/NESDIS/NGDC/MGG/Sonar_Water_Column//iso/xml/RL1606_ME70.xml https://www.fisheries.noaa.gov/inport/item/20873

Dataset Table 4.3. Coastal Pelagic Fish Trawl Survey

Dataset Title	Coastal Pelagic Fish Trawl Survey
Species/Resource	Pacific sardine, northern anchovy, herring, and Pacific mackerel, jack mackerel, krill, and other species

Abstract	Fish captured in trawls by the Southwest Fisheries Science Center (SWFSC) Fisheries Resources Division during surveys for coastal pelagic species. Most tows were targeted for sardine using a Nordic trawl on the surface at night. The database includes identification to various taxonomic levels depending on species, length frequencies, biomass data, and some age data for sardine based on analysis of otoliths. These data have been collected primarily for use in the Pacific sardine stock assessment to estimate adult parameters for the daily egg-production method, and to quantify species compositions for acoustic estimates.
Strength/Weakness	Data are in a spreadsheet and have not been mapped in a visualization yet. The database is available from a queryable gui interface in a variety of file formats at: http://oceanview.pfeg.noaa.gov/erddap/search/index.html?page=1&itemsPerPage=1000&searchFor=CPS+Trawl
File Name	CPS_Trawl_Life_History_Specimen_Data.csv
Data Type	CSV point data
Spatial Extent	Data from spreadsheet were sorted to only include latitude 35 and by longitude -121 to -122
Time Scale	Website was last updated by Southwest Fisheries Science Center on January 22, 2022
Contact/Source	NOAA SWFSC, Gu, Yuhong; (858) 546-7053; Yuhong.Gu@noaa.gov
License/Use Restrictions	NOAA makes no warranty, expressed or implied, nor does the fact of distribution constitute such a warranty. Not subject to copyright protection within the United States.
Citation Info	SWFSC Data on the NOAA Big Data Program (BDP) https://console.cloud.google.com/storage/browser/_details/nmfs_odp_swfsc/Fisheries%20Resources%20Division/CPS_Trawl_Life_History_Specimen_Data.csv?project=noaa-gcs-public-data
Online Link	https://storage.cloud.google.com/nmfs_odp_swfsc/Fisheries%20Resources%20Division/Sea_Survey-_Station1.csv?_ga=2.53752616.-1679975315.1644511630
Metadata Link	https://www.fisheries.noaa.gov/inport/item/20693

Dataset Table 4.4. Pacific Fisheries Information Network (PacFIN) APEX reporting system

Dataset Title	Pacific Fisheries Information Network (PacFIN) APEX reporting system
Species/Resource	Managed fisheries
Abstract	The nation's first regional fisheries data network, PacFIN is a joint federal and state data collection and information management project. Cooperative agency and industry partners supply data from commercial fisheries off the coasts of Washington, Oregon, and California. PacFIN combines the collected information to provide accurate estimates of commercial catch and value for the West Coast. Member agencies include California Department of Fish & Wildlife, Oregon Department of Fish & Wildlife, Washington Department of Fish & Wildlife, National Oceanic and Atmospheric Administration, Pacific States Marine Fisheries Commission, Pacific Fisheries Management Council
Strength/Weakness	Landing summaries are compiled from databases that overlap in time and geographic coverage and come from both within and outside of NOAA Fisheries. Although numerous checks have been made to verify their completeness and accuracy, discrepancies are always possible.
File Name	ALL005 - Species Report: Monthly Commercial Landed Catch by Port Group: Metric-Tons (mt), Revenue, and Price-per-pound (Price/lbs)
Data Type	No data available except in a report that is generated in Microsoft Excel
Spatial Extent	Landings by port group

Time Scale	Depending on the type of data received, the information is updated weekly, monthly, or annually. The California fish ticket data are updated twice each month (refer to: https://pacfin.psmfc.org/data/faqs/).
Contact/Source	A Contact Us form is available at: https://pacfin.psmfc.org/contact/contact-us/
License/Use Restrictions	Not described
Citation Info	Pacific Fisheries Information Network (PacFIN) 2022
Online Link	https://reports.psmfc.org/pacfin/f?p=501:1000:
Metadata Link	https://reports.psmfc.org/pacfin/f?p=501:826:11678925069201:INITIAL:::F_SELECTED_NODE:146&cs=3IQ4bqnVRHobEHev2_B88HsOtSCZtHfuqBv_4SsO5JilSQnRNmLS8HO-R7dOifVlUA33bW0pZXi-dQUwzs4wrTQ The "metadata" is only the fishery codes, but custom queries can be created from the raw data (see Edwards 2020).

Dataset Table 4.5. Historical catch of California commercial marine fisheries 1981-2005

Dataset Title	Catch of California commercial marine fisheries 1981-2005
Species/Resource	Commercial marine fisheries
Abstract	This data summarizes California Fish and Wildlife commercial fisheries catches from 1981-2005. The purpose of the dataset was to identify historically important fishing grounds and quantify an associated relative ecosystem service and benefit measured over time and space for a suite of commercially important species. Catches are reported on landing receipts (also known as 'fish tickets') and are recorded by fish dealers or processors at the port of landing. Summary catch statistics include market category, year, pounds landed, and spatial block. The time series includes species that are historically and/or currently important to the California fisheries economy and were binned into 10 broad taxonomic groups: groundfish, coastal pelagic species, salmonids, game fish, highly migratory species, abalone, market squid, echinoderms, Dungeness crab and other crustaceans. To improve the spatial accuracy of the catches, a bathymetric criterion was used for each taxonomic group based on depth range in which the species is most often encountered. For all taxonomic groups, total catch for 25 years for each block was summarized and converted pounds to metric tons. To normalize the catch, the total catch was divided by the area of the grid block or depth contour. Note that no catch-related effort information available with this dataset.
Strength/Weakness	The latest data, which are collected annually from logbook data, were last updated in 2005; the dataset was scientifically peer reviewed
File Name	Catch of California commercial marine fisheries 1981-2005
Data Type	Raster data layer
Spatial Extent	California
Time Scale	1981-2005
Contact/Source	Rebecca Miller, National Marine Fisheries Service Fisheries Ecology Division Groundfish Analysis Team, Santa Cruz, CA 95060; (831) 420-3966; rebecca.miller@noaa.gov
License/Use Restrictions	This work is licensed under a Creative Commons Attribution 3.0 License.
Citation Info	Miller, R.R., J. Field, J. Santora, Monk, M.H., R. Kosaka, C. Thomson. 2014. Spatial valuation of California marine fisheries as an ecosystem service. Canadian Journal of Fisheries and Aquatic Sciences. doi.org/10.1139/cjfas-2016-0228
Online Link	https://caoffshorewind.databasin.org/maps/new/#datasets=49ad0ad50e5b49339b8f0774f039a774
Metadata Link	https://caoffshorewind.databasin.org/datasets/49ad0ad50e5b49339b8f0774f039a774/layers/834a3fdb7d7d4a2d9c1757e4680ec507/metadata/fgdc/

Dataset Table 4.6. West Coast Renewable Energy Space Use Conflict Study

Dataset Title	West Coast Fishing Ethnography
Species/Resource	Commercial and recreational fishing
Abstract	Created as part of a 2012 BOEM study on OCS renewable energy space-use conflicts, this data contains the commercial and recreational fishing locations off the Pacific coast of Washington, Oregon and California. The purpose is to support ocean planning activities pursuant to the Executive Order Regarding the Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States, the Energy Policy Act, the National Environmental Policy Act, the Rivers and Harbors Act, and the Coastal Zone Management Act. Three components of the scientific research included a literature review, a geospatial database, and ethnographic research. The literature review surveyed the professional, grey, and peer-reviewed literature on spatial conflicts in the marine environment. Summaries of the literature tracked how stakeholders resolved, mitigated, and addressed space use conflicts. A geospatial database was developed to include available GIS data and new GIS data produced by the study team. The ethnographic data collection occurred by engaging individuals and small groups in one-on-one guided discussions. In addition, the study team convened larger group meetings to describe the study and to develop contacts for further research.
Strength/Weakness	Older dataset; needs updating to ensure it is still relevant
File Name	FinalSpaceUseConflict20130426.zipx
Data Type	Shapefile and TIFF geospatial data
Spatial Extent	W° Bound:-129.163395 E° Bound:-117.311065 N° Bound:49.085369 S° Bound:30.542094
Time Scale	Published: January 1, 2012; data collection began in 1972 and ended on July 3, 2011 (data complete)
Contact/Source	Jonathan Blythe, BOEM
License/Use Restrictions	Generally, materials produced by federal agencies are in the public domain and may be reproduced without permission. However, not all materials appearing on this web site are in the public domain. Some materials have been donated or obtained from individuals or organizations and may be subject to restrictions on use.
Citation Info	Industrial Economics, Inc. 2012. Identification of Outer Continental Shelf renewable energy space-use conflicts and analysis of potential mitigation measures. U.S. Department of the Interior, Bureau of Ocean Energy Management, Herndon, VA. OCS Study BOEM 2012-083. 414 pp. https://caseagrant.ucsd.edu/sites/default/files/BOEM_Renewable_Energy_Space_Use_Conflicts_Report_for_CA.pdf
Online Link	https://www.fisheries.noaa.gov/inport/item/48944
Metadata Link	https://www.sciencebase.gov/catalog/item/51547afee4b030c71ee0688d

Dataset Table 4.7. EcoCast Map Bycatch Predictions Relative to Swordfish Catch

Dataset Title	EcoCast Map Bycatch Predictions Relative to Swordfish Catch
Species/Resource	Fishery sustainability
Abstract	The EcoCast Map product is a novel fishery sustainability tool that helps fishers and managers better evaluate how to allocate fishing effort to optimize the catch of target species (e.g., swordfish) while minimizing the accidental bycatch of blue sharks and protected species (leatherback sea turtles, California sea lions).

Strength/Weakness	This is an experimental product and is currently only available only for the California drift gill net fishery. The data are housed in ERRDAP, which anyone can use to build a personal web page to display graphs with the latest data (or other images or HTML content). ERRDAP is NOAA Fisheries Environmental Research Division's Data Access Program.
File Name	See below
Data Type	The environmental data used to create the EcoCast Map product can be downloaded from the CoastWatch dataserver and the COPERNICUS Copernicus Marine Environmental Monitoring Service at following the links: • NOAA/NCDC Blended Daily Global 0.25° Sea Surface Winds https://coastwatch.pfeg.noaa.gov/erddap/griddap/ncdcOwDly_LonPM180.graph • GHRSST Global 1-km Sea Surface Temperature https://coastwatch.pfeg.noaa.gov/erddap/griddap/jplG1SST.graph • Multi-scale Ultra-high Resolution SST Analysis https://coastwatch.pfeg.noaa.gov/erddap/griddap/jplMURSST41.graph • Global ocean gridded L4 sea surface heights and derived variable nrt https://marine.copernicus.eu/services-portfolio/access-to-products/?option=com_csw&view=details&product_id=SEALEVEL_GLO_PHY_L4_NRT_OBSERVATIONS_008_046
Spatial Extent	lat_max 47.0653 lat_min 29.652364600000002 lon_max -115.67100192 lon_min -131.5914
Time Scale	The tool was developed to be updated with real-time data
Contact/Source	Elliott Hazen or Heather Welch
License/Use Restrictions	The information on this page may be used and redistributed freely, but is not intended for legal use. Neither the data contributors, EcoCast partner organizations, CoastWatch, NOAA SWFSC, nor any of their employees or contractors, makes any warranty, express or implied, including warranties of merchantability and fitness for a particular purpose, or assumes any legal liability for the accuracy, completeness, or usefulness of this information. Although it is distributed by the NOAA CoastWatch West Coast Regional Node, this product is solely the responsibility of the EcoCast project (.pdf) and is not associated with NOAA CoastWatch.
Citation Info	String contributors are: Elliott L. Hazen, Dana K. Briscoe, Heather Welch, Steven J. Bograd, Dale Robinson, Tomo Eguchi, Heidi Dewar, Suzy Kohin, Daniel P. Costa, Scott R. Benson (NOAA Southwest Fisheries Science Center / University of California Santa Cruz), Rebecca Lewison (San Diego State University), Helen Bailey (University of Maryland Center for Environmental Science), Sara M. Maxwell (Old Dominion University), and Larry B. Crowder (Stanford University)
Online Link	https://coastwatch.pfeg.noaa.gov/ecocast/map_product.html
Metadata Link	The EcoCast product data were downloaded from the ERD/CoastWatch West Coast ERDDAP server: • EcoCast Map product as a data file https://coastwatch.pfeg.noaa.gov/erddap/griddap/ecocast.graph https://coastwatch.pfeg.noaa.gov/erddap/info/ecocast/index.html • Animal weighting factors and the dates of the environmental data used for each map https://coastwatch.pfeg.noaa.gov/erddap/tabledap/ecocast_inputs.graph https://coastwatch.pfeg.noaa.gov/erddap/info/ecocast_inputs/index.html

Dataset Table 4.8. NOAA Observed Fishing Effort in the U.S. Pacific Coast Groundfish Fisheries

Dataset Title	NOAA Observed Fishing Effort in the U.S. Pacific Coast Groundfish Fisheries
Species/Resource	Non-catch Shares Pot (2002-2017); Non-catch Shares Hook-and-Line (2002-2017); Limited-entry Bottom Trawl (2002-2010); Catch Shares Pot (2011-2017); Catch Shares Hook-and-Line (2011-2017)
Abstract	The main purpose of these data layers is to help inform the National Marine Fisheries Service Biological Opinion on Continuing Operation of the Pacific Coast Groundfish Fishery (NMFS 2012). In 2011, new regulations governing the limited entry bottom trawl and midwater trawl fisheries led to the induction of individual fishing quotas (IFQs). Primary goals of IFQ management included decreased bycatch and increased catch accountability, profitability, and efficiency. In the shoreside bottom trawl fishery, permit holders with IFQ and a trawl endorsement can use multiple gear types (although not within the same trip), including bottom trawl, midwater trawl, hook-and-line gear, and pot gear. These management changes could impact fishing effort in trawl sectors, as well as alter fixed gear fishing effort by providing a new opportunity for fixed gear fishing activity and potential competition between IFQ and other fixed gear sectors. These data layers display fishing effort to assess these potential changes.
Strength/Weakness	Wide area coverage; data quality limited by confidentiality
File Name	Datawarehouse.gdb (layers are stored in geodatabases in the various packages)
Data Type	Raster
Spatial Extent	UL -126.7 W 48.4 N; LR -116.8W 32.5N; 100m cell size
Time Scale	Varies, 2002-2017
Contact/Source	Curt Whitmire, NOAA Fisheries, Northwest Fisheries Science Center, curt.whitmire@noaa.gov
License/Use Restrictions	This work is licensed under a Creative Commons Attribution 3.0 License
Citation Info	Somers, K. A., C. E. Whitmire, K. Richerson, J. E. Jannot, V. J. Tuttle, and J. T. McVeigh. 2020. Fishing Effort in the 2002–17 Pacific Coast Groundfish Fisheries. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-153. https://doi.org/10.25923/8y7r-0g25
Online Link	https://caoffshorewind.databasin.org/datasets/c9bf92d374544e6399306a1ea9383d50/ https://caoffshorewind.databasin.org/datasets/a9fc4bdc7dcd46f49a5daf1c0a4a0418/ https://caoffshorewind.databasin.org/datasets/bc58d82502314fc08e94d0bd1fcd1c64/ https://caoffshorewind.databasin.org/datasets/5fd58e97906943ae80f290c2e42b63e2/ https://caoffshorewind.databasin.org/datasets/c3f95644734f4992a61307e566c891e0/ https://caoffshorewind.databasin.org/datasets/661a84e632224a3f8a982868defe71b5/ https://caoffshorewind.databasin.org/datasets/8b0d742d072746cca3bb98be0c9c49d8/
Metadata Link	Same as Online Links

SECTION 5. MARINE MAMMALS

Forty-five species of marine mammals are known to occur in the CCS between British Columbia, Canada and Baja California Sur, Mexico. Marine mammals discussed in this section fall into two taxonomic groups: cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals and sea lions). Cetaceans are further divided into two groups consisting of baleen whales (mysticetes) and toothed whales (odontocetes). Seven species of baleen whales are known to occur off California. Toothed whales known to occur offshore California include sperm whales (three species), orca (also known as "killer whales" from three morphologically distinct groups), beaked whales (15 species that are difficult to distinguish at sea), dolphins (19 species), and porpoises (two species). Pinnipeds include the eared seals (otariids) and the earless or true seals (phocids). Southern sea otters (*Enhydra lutris nereis,* mustelids) inhabit a limited portion of the CCS from Pigeon Point to Gaviota State Beach. Population estimates for marine mammals are compiled on a regular basis by NOAA in the form of stock assessments (NOAA Fisheries 2021c), with some Central California specific data for cetacean abundance last compiled in 2007 (Barlow and Forney 2007; Table 5.1). All marine mammals in U.S. waters are protected under the Marine Mammal Protection Act, and some have additional protections such as under the U.S. ESA and the International Convention on Trade in Endangered Species of Wild Fauna and Flora (CITES).

The nutrient-rich upwelling season of the California Current is strongest in spring and summer, which is when prey is likely to be most abundant. When the California Current upwelling relaxes from August to October, whales and pinnipeds will follow the warmer surface waters. The northward flowing Davidson Current dominates in winter, and from November to February warm water species such as dolphins will move north from southern California. The distribution of cetaceans and pinnipeds is also influenced by the edge of the continental shelf at the 200-m (656-ft) isobath along the West Coast (Becker et al. 2020).

Many of the baleen whale species that are seen in California waters in the spring and then later in the fall are passing through to their foraging or breeding and calving grounds. In the summer, they can be found in cold water feeding areas north of Oregon (Würsig, 1988; Calambokidis et al. 2009). In winter, most baleen whales are found in tropical waters off Mexico, Costa Rica, and Hawaii where they mate and calve (Würsig, 1988; Heithaus and Dill 2009). Baleen whale foraging locations and patterns can change depending on oceanographic conditions in their search for better feeding areas (Calambokidis et al. 2009).

Toothed whales occur in a diverse range of habitats from nearshore to far offshore in a variety of temperature regimes and bottom structure preferences. Some examples include Dall's porpoise (*Phocoenoides dalli*), which occurs in upwelling-influenced waters along the shelf-slope break. Risso's dolphins (*Grampus griseus*) prefer bathymetrically complex regions with warm water. Short-beaked common dolphins (*Delphinus delphis*) are found in warmer offshore waters while Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) are found on the cooler shelf-slope areas. Harbor porpoises (*Phocoena phocoena*) concentrate nearshore on the shelf in areas of cool ocean temperatures (Pelagic Working Group 2002; Allen et al. 2011).

Because of their connection to land, pinnipeds follow a predictable and synchronous annual cycle between terrestrial sites for hauling out and rearing young, and ocean foraging sites. They often exhibit breeding site fidelity, returning to the same site annually. Haul out site selection and overall seasonal distribution may be driven by proximity to foraging opportunities. Otariids are also known to float on the surface of the ocean to warm themselves, sometimes in large rafts. The sea lion species are more likely to remain closer to shore, as they haul out frequently to rest and thermoregulate. Fur seals utilize habitat in a similar fashion to the phocids, in that they spend most of their lives at sea, hauling out primarily for breeding. The phocids depend on their higher levels of subcutaneous fat stores to thermoregulate while at sea, allowing them to spend less time on land.

Based on distinct habitat preferences that are generally closely linked to seasonal oceanic conditions, cetacean distribution models have been developed to help assess which animals might be in an area and at which time. Becker et al. (2020) created predicted density distribution models for several species of cetaceans (Dataset Table 5.1). These models combine information on animal observations in the field with the ocean's physical and chemical attributes (e.g., topography, temperature, salinity, depth, chlorophyll concentration, etc.) to determine how environmental drivers influence the distribution of marine species. Known information about habitats and food sources can be used to predict their preferences and form a picture of where marine animals are likely to occur at different times of their biological life histories. The seasonal patterns between cold and warm water, which create generally predictable occurrences in the food web, are altered during abrupt climatic shifts. The shift to an ENSO event occurs about every four to ten years, when the usual westerly trade winds cease, and upwelling is reduced. This affects the whole food chain with corresponding impacts to marine mammal distribution and health.

Table 5.1. Marine mammal species commonly observed in the CCS. Cetacean abundance estimates are based on Barlow and Forney (2007). Minimum population estimates are based on NOAA Marine Mammal Stock Assessment Reports with final survey year, specific stock, and report year identified (NOAA Fisheries 2021c) except for southern sea otter, which is based on a USFWS report (USFWS 2021a).

Common Name	Scientific Name	Est. Abundance Central CA (34.5°- 38° N)	Minimum Population Estimate	IUCN Status; Global Pop. Trend
Mysticetes (Baleen Whales)				
Blue whale	*Balaenoptera musculus*	528	1,050 (2014) East. N. Pacific 2019	Endangered; increasing
Humpback whale	*Megaptera novaeangliae*	586	2,784 (2014) CA/OR/WA 2019	Least Concern; increasing
Gray whale	*Eschrichtius robustus*	----	25,849 (2015/16) East. N. Pacific 2020	Least Concern; stable
Minke whale	*Balaenoptera acutorostrata*	284	369 (2014) CA/OR/WA 2016	Least Concern; unknown
Fin whale	*Balaenoptera physalus physalus*	992	8,127 (2014) CA/OR/WA 2020	Vulnerable; increasing
Sei whale	*Balaenoptera borealis*	14	374 (2014) East. N. Pacific 2018	Endangered; increasing
Odontocetes (Toothed Whales)				
Sperm whale	*Physeter macrocephalus*	143	1,270 (2014) CA/OR/WA 2019	Vulnerable, unknown
Dwarf or pygmy sperm whale	*Kogia spp*	710	1,924 (K. breviceps, 2014) CA/OR/WA 2016	Least Concern; unknown

Common Name	Scientific Name	Est. Abundance Central CA (34.5°- 38° N)	Minimum Population Estimate	IUCN Status; Global Pop. Trend
Killer Whale	*Orcinus orca*	116	75 (2020) SRKW East. N. Pacific 2020 349 (2018) W. Coast Transient 2020 276 (2014) Offshore 2018	Data Deficient; unknown; U.S. ESA Endangered
Baird's beaked whale	*Berardius bairdii*	159	1,633 (2014) CA/OR/WA 2018	Least Concern; unknown
Cuvier's beaked whale	*Ziphius cavirostris*	2,647	2,059 (2014) CA/OR/WA 2017	Least Concern; unknown
Other beaked whales	*Mesoplodon spp*	269	1,967 (2014) CA/OR/WA 2017	Data Deficient; unknown
Bottlenose dolphin (offshore)	*Tursiops truncatus*	61	1,255 (2014) CA/OR/WA Offshore 2016	Least Concern; unknown
Dall's porpoise	*Phocoenoides dalli*	8,870	17,954 (2014) CA/OR/WA 2016	Least Concern; unknown
Harbor Porpoise	*Phocoena phocoena*	----	2,737 (2012) Morro Bay 2019	Least Concern; unknown
Long-beaked common dolphin	*Delphinus capensis*	4,375	68,432 (2014) CA 2016	Least Concern; unknown
Short-beaked common dolphin	*Delphinus delphis*	115,200	839,325 (2014) CA/OR/WA 2016	Least Concern; unknown
Northern right whale dolphin	*Lissodelphis borealis*	2,032	18,608 (2014) CA/OR/WA 2016	Least Concern; unknown
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	9,486	21,195 (2014) CA/OR/WA/No/So 2016	Least Concern; unknown
Risso's dolphin	*Grampus griseus*	3,197	4,817 (2014) CA/OR/WA 2016	Least Concern; unknown
Striped dolphin	*Stenella coeruleoalba*	2,389	24,782 (2014) CA/OR/WA 2016	Least Concern; unknown
Phocids (True Seals)				
Harbor seal	*Phoca vitulina*	----	27,348 (2012) CA 2014	Least Concern; unknown
Northern elephant seal	*Mirounga angustirostris*	----	81,368 (2010) CA Breeding 2014	Least Concern; increasing
Otariids (Eared Seals)				
Northern fur seal	*Callorhinus ursinus*	----	7,524 (2013) CA 2015	Vulnerable; decreasing
California sea lion	*Zalophus californianus*	----	233,515 (2014) U.S. 2018	Least Concern; increasing
Steller sea lion	*Eumetopias jubatus*	----	43,201 (2017) U.S. portion E. Stock 2019	Near Threatened; increasing
Sea Otters				
Southern sea otter	*Enhydra lutris nereis*	-----	2,962 (2019) (USFWS 2021a)	Endangered; decreasing

Marine Mammals With Potential to Occur in the Wind Energy Area or Vicinity

Based on the distribution models of Becker et al. (2020, Dataset Table 5.1), the cetacean species most likely to occur in or near the MBWEA are fin whale, Baird's beaked whale, Pacific white-sided dolphin, and northern right whale dolphin. Humpback and blue whales and Dall's porpoises are also broadly and seasonally distributed in the region but have lower predicted densities due to lower overall population numbers and distribution patterns. The highest density of baleen whales in the vicinity of the MBWEA is most likely to occur in the summer and fall.

Baleen Whales

The current best estimate on the number of **humpback whales** that occur along the U.S. West Coast is 2,900 animals in the California/Oregon/Washington stock (Carretta et al. 2020). They are most abundant off California from spring to fall although a small number remain to feed along the Pacific coast between Kodiak Island, Alaska, and northern California. Becker et al. (2020) estimates that the highest density of humpback whales in the MBWEA occurs in the summer/fall, which is considered low to moderate compared to the maximum density in the CCS (Figure A.1). The distribution pattern indicates that the whales concentrate closer to shore over the continental shelf and are more common off Monterey and San Francisco Bays during these seasons. Based on density modeling data and survey sightings, a Biologically Important Area (BIA) for feeding has been delineated from Morro Bay to Point Sal between April and November (Calambokidis et al. 2019; Van Parijs et al. 2015; Dataset Table 5.2). In addition to the BIA, the area of the MBWEA is encompassed by a Critical Habitat designation for the Mexico and Central American Humpback Whale DPSs (NOAA Fisheries 2021d).

The best estimate of the number of **blue whales** in the eastern North Pacific is between 1,767 and 2,038 individuals (Calambokidis and Barlow, 2020). Recent modelling efforts have found that blue whale habitat preferences are strongly influenced by water temperature, seafloor topography and subsurface water properties (Abrahms et al. 2019). Blue whale abundance estimates from line-transect surveys over the years have been highly variable, which is attributed to a more recent northward shift in their distribution to waters off Oregon and Washington because of warming ocean temperatures (Calambokidis et al. 2009). Blue whales are most likely to be found off California between summer and fall after which they leave U.S. West Coast waters from November to March (Carretta et al. 2020). Becker et al. (2020) estimates that the highest density of blue whales in the MBWEA occurs in the summer/fall, which is considered low relative to the CCS (Figure A.2). The distribution pattern indicates that the whales concentrate over the shelf and shelf break, and more offshore in the southern California area. BIAs for blue whales have also been predicted through similar modeling efforts. The closest BIA to the MBWEA extends from Point Conception to Point Sal, for feeding blue whales from June through October (Van Parijs et al. 2015; Dataset Table 5.2).

The California/Oregon/Washington stock of **fin whales** is estimated to be 9,029 individuals, but this is probably an underestimate because it excludes some fin whales that could not be identified during the surveys, so they were recorded as "unidentified rorqual" or "unidentified large whale" (Carretta et al. 2020). The population structure and movements of fin whales are not well known, but they are generally present year-round off California, occurring both nearshore and offshore, with the highest densities in the summer and fall. High densities have been predicted in modeling efforts in offshore waters centered about 185 km (115 miles) west of the Gulf of the Farallones (Calambokidis et al. 2015). Not all fin whales undergo long-range seasonal migrations with some making only short-range seasonal movements in spring and fall (Calambokidis et al. 2015). In research conducted in the North Atlantic, fin whale distribution was likely influenced by depth and more complex bottom topography. Becker et al. (2020) estimates that the highest density of fin whales in the MBWEA could occur in the summer/fall. These densities are high compared to northern California, as the whales are concentrated south of Monterey Bay to the northern Channel Islands ranging from coastal to offshore habitats (Figure A.3).

Two distinct populations of **gray whales** inhabit the Pacific Ocean, with the Eastern North Pacific population's range extending from Alaska to Baja California, Mexico. Recent abundance estimates for this population indicate there are 26,960 individuals (Carretta et al. 2020). Gray whales are in greatest abundance off California from spring to fall but can be observed almost year-round (Calmbokidis et al. 2015). The migration corridors for most gray whales are within 10 km (6 mi) of the U.S. West Coast although some may deviate farther offshore. This proximity to shore makes them relatively easy to count using land-based observers. These numbers show there is a spike in the number of individuals seen per day from December to March when they are on their southbound migration and again from April to July when they are traveling northward. After these peaks, the numbers moderate for a few weeks until slowly tapering off (Calambokidis et al. 2015). Given their nearshore foraging and travel habitat preferences, gray whales are considered unlikely to occur within the MBWEA. Because of the lack of broad temporal scale at-sea observation data due to their seasonality and nearshore migration tendencies, there is currently no known California Current-wide predictive distribution model for gray whales. However, raw NOAA survey data from cetacean surveys and CalCOFI may be able to provide some information regarding potential presence in the MBWEA. Two gray whale BIAs exist in the vicinity of the MBWEA: a migration BIA, from January to July, and again from October to December overlaps the boundaries of the MBWEA; a second migration BIA, from March to July, is closer to shore, but incorporates the second phase of gray whale northbound migration (Van Parijs et al. 2015; Dataset Table 5.2).

Toothed Whales

The largest member of the toothed whale family is the **sperm whale**. They are also one of the large whales that cannot go without feeding for long periods of time. They routinely dive to depths of 610 m (2,000 ft) for up to 40 minutes or longer in search of squid, their primary prey, and have been known to dive as deep as 3,048 m (10,000 ft; NOAA Fisheries 2021c). Female groups migrate up to 683 mi (1,100 km) as part of a strategy for surviving in a variable habitat with low local food abundance and poor foraging success. It is believed this tactic may be the reason that female sperm whales form permanent social bonds as they may benefit from the experience of older females during migrations (Heithaus and Dill 2009). The 2,000m (6562 ft) isobath is a potential predictor of sperm whale habitat, generally delineating the shift from the continental slope to the continental rise (Becker et al. 2020). Becker et al. (2020) predicted low densities of sperm whales in the MBWEA compared to the CCS as a whole, but there is a substantial increase in predicted density immediately west of the MBWEA along and beyond the shelf slope (Figure A.4). The sperm whale habitat-based density models matched poorly to actual sightings, possibly due to limited sampling of deep offshore waters where sperm whales are usually found combined with low detectability at the ocean surface. It is expected that sperm whales can be found in California waters year-round, with higher abundance in mid-May and mid-September off Central California due to migration patterns (Allen et al. 2011). Given the water depths and distance from shore, it is expected that sperm whales are likely to occur west of and potentially within the MBWEA.

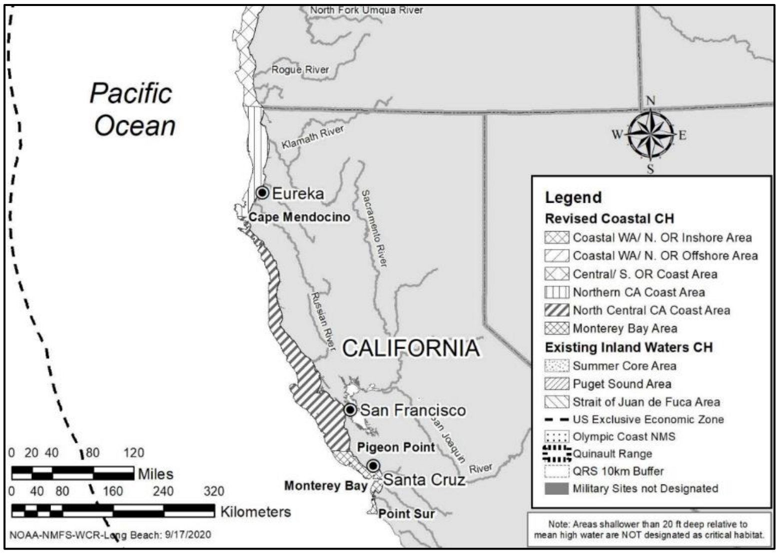

Figure 5.1. Southern resident killer whale DPS critical habitat (NOAA Fisheries 2021c).

Southern resident killer whales spend nearly all their time on the continental shelf within 34 km (21 mi) from shore in water less than 200 m (656 ft) deep (Hanson et al. 2017). They depend on different prey species and habitats throughout the year, but their movements also seem to be influenced by the seasonal timing of salmon returns to different river systems (NOAA Fisheries 2021c). In August 2021, NOAA Fisheries revised critical habitat of the Southern Resident Killer Whale Distinct Population Segment (DPS) which is listed as Endangered under the U.S. ESA. In addition to the original inland waters of Washington State that are listed as critical habitat, the new rule included marine waters in depths of 6 to 200 m (20 to 656 ft) from the U.S. border with Canada south to Point Sur (Figure 5.1; NOAA Fisheries 2021c). There is currently no known California Current-wide predictive distribution model for killer whales. As the southern end of the current known range of this DPS is Point Sur, it is unlikely that killer whales from this population will occur in the MBWEA.

Because **Baird's beaked whales** are larger than other beaked whales, and are also more social, they are the most easily identified species of the beaked whale family during at-sea surveys. They are commonly found in deep, cold waters but are also occasionally observed over the continental slope and shelf along the CCS in summer and fall (NOAA Fisheries 2021c). The California/Oregon/Washington stock population abundance estimate is 2,697 whales (Carretta et al. 2020). Becker (et al. 2020) indicated that predicted densities of Baird's beaked whales in the MBWEA in spring and summer are moderate compared to the CCS. Predicted densities in the area increase as distance from shore increases, with high densities adjacent to the MBWEA to the west. Densities were predicted to be highest offshore over the shelf slope from Cape Mendocino to Pigeon Point, and again from Point Piedras Blancas to Point Arguello (Figure A.5).

The **small beaked whale guild** offshore California includes **Cuvier's beaked whale** (*Ziphius cavirostris*) and six species of Mesoplodonts: **Blainville's beaked whale** (*Mesoplodon densirostris*), **Perrin's beaked whale** (*M. perrini*), **lesser beaked whale** (*M. peruvianus*), **Stejneger's beaked whale** (*M. stejnegeri*), **gingko-toothed beaked whale** (*M. gingkodens*), and **Hubb's beaked whale** (*M. carlhubbsi*). These species are grouped into a guild because they are difficult to distinguish at sea and are rarely observed, resulting in insufficient sighting records to create accurate estimates of distribution and density for any given species (Carretta et al. 2020). The 2014 California/Oregon/Washington stock of mesoplodont whale abundance is estimated to be 3,044 animals (Carretta et al. 2020). Density models from Becker et al. (2020) for these species indicated higher predicted density well beyond the shelf-slope, with low values in the MBWEA compared to the CCS as a whole (Figure A.6). Predicted densities are higher directly adjacent to the

MBWEA, increasing with depth offshore to the west and south. The mesoplodont whale habitat-based density model data matched poorly to actual sightings, possibly due to limited sampling of deep offshore waters where these species are usually found. The 2,000-m (6,562-ft) isobath is a useful predictor for beaked whale habitat preference because this depth represents the transition from the continental slope to the continental rise (Becker et al. 2016).

The **Dall's porpoise** is a common and easily identifiable cetacean in California offshore waters. Although much of its life history is unknown, it is reasonably abundant (NOAA Fisheries 2021c) in temperate to boreal waters that are more than 183 m (600 ft) deep and with temperatures between 2 and 17 ^{o}C (36 and 63 °F). They can be found in offshore, inshore, and nearshore oceanic waters. Dall's porpoises occur in higher abundance near the shelf break. Their migration patterns are based on geography and seasonality (NOAA Fisheries 2021c) and may be linked to movement of prey (Allen et al. 2011). The average abundance estimate for the outer coast of California, Oregon, and Washington waters is 17,954 (Carretta et al. 2020). Becker et al. (2020) estimates that the highest density of Dall's porpoise in the MBWEA could occur in the summer/fall months (Figure A.7), a low density compared to the CCS overall. Local densities are predicted to be higher between the MBWEA and the coast, and highest overall are predicted north of Cape Mendocino.

Harbor porpoise populations in the eastern Pacific are distributed from Point Conception in California to Alaska and are thought to have more restricted movement patterns than other harbor porpoise populations (Carretta et al. 2020). Within California and southern Oregon, the population is divided into four stocks, one of which is the Morro Bay stock which extends from Point Conception to Point Sur. This species is known to inhabit coastal waters and is most often observed alone or in small groups of two to ten animals (NOAA Fisheries 2021b). Their seasonal movements are likely influenced by prey availability. Because this species is known to not approach or surface near vessels (NOAA Fisheries 2021b), they are rarely observed during at-sea surveys. There is currently no known California Current-wide predictive distribution model for harbor porpoises; however, due to their preference for coastal habitats, it is unlikely that they would occur within the MBWEA. Two year-round BIAs for harbor porpoise extend from Pigeon Point to Point Sur, and from Point Sur to Point Conception, the latter of which is adjacent to the MBWEA (Van Parijs et al. 2015; Dataset Table 5.2).

Pacific white-sided dolphins are offshore pelagic species that are unlikely to be found close to shore. Individuals are most common over the continental shelf and along the shelf break to 1,000 m (3,281 ft) or in areas of submarine canyons (Allen et al. 2011). Changes in their distribution off California are likely in response to seasonal and interannual oceanographic changes. The minimum population estimate for the California, Oregon, and Washington stock of Pacific white-sided dolphins is believed to number 21,195 individuals (Carretta et al. 2020). Becker et al. (2020) estimates that the highest density of Pacific white-sided dolphins in the MBWEA could occur in the summer/fall, with moderate densities compared to the CCS overall (Figure A.8).

Northern right whale dolphins range from deep, cold water to warm temperate waters of the Pacific Ocean. They usually travel in groups of 100 to 200 individuals but sometimes travel in groups of up to 3,000. There are an estimated 26,000 individuals in the California/Oregon/Washington stock (Carretta et al. 2020). They are most common on the continental shelf and shelf break to depths of 1,000 m (3,300 ft). Based on stomach contents of four carcasses found on California beaches, the most common prey (75%) was lanternfish (Myctophidae), a small mesopelagic fish, followed by California smoothtongue

(*Leuroglossus stilbius*), a deep-sea smelt that occurs from the surface to 690 m (2,300 ft; Allen et al. 2011). Becker et al. (2020) estimates that the highest density of Northern right whale dolphins in and around the MBWEA could occur in the summer/fall, especially just north of the MBWEA, with moderate to high densities compared to the overall CCS average density (Figure A.9).

The population of **short-beaked common dolphins** that inhabit offshore waters from California to Washington is believed to number 969,861 (Carretta et al. 2020). At sea, short-beaked common dolphin co-occurs with Pacific white-sided dolphin, striped dolphin, and common bottlenose dolphin, which can be confused by observers. These dolphin species commonly ride the bow wakes of vessels. During the day, they are known to form large schools of 2,000 to 10,000 individuals that break into smaller feeding groups of 20 to 200 later in the afternoon and nighttime. This behavior is believed to be in response to the patchy distribution of prey in oceanic waters when they feed at night on fish, squid, and some crustaceans, and then mostly rest and socialize during the day. They usually forage at 9 to 50 m (30 to 164 ft) but will pursue prey down to 280 m (920 ft; Allen et al. 2011). Becker et al. (2020) estimates that the highest density of short-beaked common dolphins in the MBWEA could occur in the summer/fall, but this value is low compared to areas further offshore and off of southern California where densities are predicted to be highest (Figure A.10).

Long-beaked common dolphins often mix with other species including common bottlenose dolphin and Pacific white-sided dolphin. They will form small schools of ten to 30 during the night and larger schools of up to several thousand, but more often 100 to 500, during the day. A regional concentration occurs from Central California to Baja generally in water depths to 183 m (600 ft) and in areas of high relief and local upwelling. They are rarely seen in Northern California, preferring warm temperate and tropical coastal waters (Allen et al. 2011). It is likely that long-beaked common dolphins would be uncommon in the MBWEA. Becker et al. (2020) estimates that the highest density of long-beaked common dolphins in the MBWEA could occur in the summer/fall months, but this value is very low compared to areas offshore to the south in the Southern California Bight, where densities are predicted to be highest (Figure A.11).

Common bottlenose dolphins are found offshore, beyond and over the continental shelf, as well as nearshore, including in bays, estuaries, and harbors. They prefer tropical or temperate waters and consume a wide range of prey including crustaceans, squid, and fish. They travel and hunt in small groups, using cooperative behavior and sound to concentrate and capture prey (Allen et al. 2011). Becker et al. (2020) estimates that the summer/fall density of bottlenose dolphins in the MBWEA is very low compared to offshore areas to the south around the Channel Islands, where densities are predicted to be highest (Figure A.12).

Risso's dolphins are often seen off California on the continental shelf edge and slope, in deeper offshore temperate waters. These dolphins are visually distinct, with prominent white scars covering their gray or nearly white bodies. They travel in small groups of tens of animals, although are sometimes observed in pods of hundreds of animals. While foraging, they can dive more than 333 m (1,000 ft) to hunt cephalopods, especially squid, as well as fish and krill (Allen et al. 2011). Becker et al. (2020) estimates that the summer/fall density of Risso's dolphins in the MBWEA is low compared to areas to both the north and south, namely in the Southern California Bight, where densities are predicted to be highest close to shore (Figure A.13).

The habitat preferences for **striped dolphin** (*Stenella coeruleoalba*) fluctuate substantially because of changing ocean conditions, which results in large fluctuations of the number of animals that may be sighted in the study area in any single year (Becker et al. 2020). Becker (et al. 2020) predicted very low densities of striped dolphins in the MBWEA compared to the overall CCS (Figure A.14). These models indicate this species is distributed very far offshore in the southwest portion of the CCS.

Rare or Data Deficient Marine Mammal Species

Baleen Whales

North Pacific right whales were distributed broadly throughout California before being decimated by whaling operations. Their habitat preferences are cool temperate waters in depths ranging from 100 to 225 m (328 to 738 ft). Despite this, almost all observations of North Pacific right whales south of Canada over the past 30 years have occurred close to shore (Allen et al. 2011). They are listed as Endangered throughout their range under the U.S. ESA, and there are no reliable estimates of current abundance or population trends (NOAA Fisheries 2021b).

Whaling records suggest **sei whales** occurred in nearshore California waters from March to May, then traveled offshore to more than 100 km (62 mi) from July to September. It is not known if this pattern still exists today. Sightings are extremely rare, but when they do occur, they are from aerial observations in pelagic waters between California and Washington (Allen et al. 2011).

Pinnipeds

Spatially explicit distribution data for pinnipeds is limited in availability, and is often restricted to local scales. Some at-sea surveys, both boat-based and aerial, collect pinniped observation data as well as counts of cetaceans and seabirds, but these data have not been utilized to create discrete distribution models. Telemetry studies have also provided data on individual animals, but the volume of data is potentially insufficient for distribution analysis.

Northern fur seals (*Callorhinus ursinus*) are small, solitary, pelagic species that spend 80% of their time at sea, coming ashore primarily to breed (NOAA Fisheries 2021b). These eared seals forage on fish and cephalopods in deep waters over and beyond the continental shelf (Allen et al. 2011). Only two sites support breeding rookeries off the coast of California: Southeast Farallon Island and San Miguel Island. However, their pelagic range extends from Baja California, Mexico to Alaska and west to Japan. They have additional protections under the Fur Seal Act (NOAA Fisheries 2021b).

California sea lions (*Zalophus californianus*) are also eared seals. This charismatic species is well-known due to its propensity to haul out on rocks, beaches, docks, and buoys, and their boisterous, vociferous nature. They eat fish and cephalopods and are known for interacting with commercial and recreational fishing vessels. They are commonly observed in shallow waters over the continental shelf, especially in areas where upwelling has concentrated their prey. California sea lions are common in Morro Bay, and along the coast and offshore rocks from Santa Barbara county to Monterey county. California sea lions do not breed in San Luis Obispo or Monterey counties, as their main breeding range extends south from the Channel Islands to Mexico (NOAA Fisheries 2021b). However, they do utilize haul out sites in the Morro Bay area that they share with other pinniped species. A dock in Morro Bay has been dedicated as a haul out for sea lions as a tourist draw and educational opportunity. Juveniles may remain in the bay year-round, but adults travel to the Channel Islands in the summer to breed (MBNEP 2022).

The largest of the otariids, the **Steller sea lion** (*Eumetopias jubatus*), feeds on many species of fish and cephalopods, and is usually observed over the continental shelf and seaward. Split into two distinct population segments (DPS), the Eastern DPS ranges from southeast Alaska to central California (NOAA Fisheries 2021b). These animals do not breed on the coasts of San Luis Obispo or Monterey counties, as the Año Nuevo Island rookery in Santa Cruz County is currently the southernmost breeding site (Allen et al. 2011), with occasional observations as far south as Point Conception. Critical habitat for Steller sea lion in California has been established at Sugarloaf Island and Cape Mendocino, the Farallon Islands, and Año Nuevo Island, which includes a protected aquatic zone that extends 914 m (3,000 ft) seaward as well as an air zone 914 m (3,000 ft) above these rookeries.

Harbor seals (*Phoca vitulina*) are phocids, or earless seals. They spend a large portion of their lives at sea, but haul out to breed, thermoregulate, and molt. They consume fish, crustaceans, and shellfish, and forage in coastal habitats landward of the continental shelf break. They tend to remain relatively resident in a given area but will travel great distances to follow prey resources (NOAA Fisheries 2021b). This species breeds and hauls out in San Luis Obispo and Monterey counties on isolated beaches, mudflats, and in Morro Bay, where young pups can be seen in spring.

Northern elephant seals (*Mirounga angustirostris*) are also phocids. They live 80 to 95% of their lives at sea (Allen et al. 2011). They pursue a variety of different foraging strategies but are most often found at the mid-water (91-213 m [300-700 ft]) mixing zone between the California Current and the Davidson Current where upwelling drives a robust food web and concentration of prey (Robinson et al. 2012). Female elephant seals may also feed along the continental shelf or near areas such as seamounts (Robinson et al. 2012). Males more often forage on the bottom along the continental margin (Allen et al. 2011). Because they can be prey to white sharks and Southern Resident killer whales, elephant seals do most of their feeding at night, when their prey are closer to the surface. They tend to rest in the early morning around sunrise, after a long night of foraging (Beltran et al. 2021). Female northern elephant seals make two foraging trips every year. After the breeding season (December to March), they head out to sea for two months before returning to the rookery to molt (March to August). Then they leave on a long post-molting migration that often lasts eight months, from June to January. Juveniles will haul out from September to November (Allen et al. 2011). In proximity to the MBWEA, Point Piedras Blancas and San Simeon State Beach host one of the largest rookeries in California, with 18,000 seals returning annually (California Department of Parks and Recreation 2022). Other large California rookeries include Año Nuevo Island and the Farallon Islands.

Sea Otters

Although **southern sea otters** once ranged throughout California, their slow recovery from being hunted for the fur trade has resulted in a reduction of their range. Currently, the species is listed as Threatened under the U.S. Endangered Species Act. Their breeding range and distribution extends from north of Santa Cruz to the northwestern California Bight (Hatfield et al. 2019, USFWS 2021b). They tend to congregate in coastal waters and estuaries, as they forage in shallow water for prey living on kelp or the ocean floor. They are common inhabitants the coastal region of San Luis Obispo and Monterey counties, and of the sheltered waters of Morro Bay, which they use as a nursery as well as foraging grounds. Their popularity with tourists in the area has led to community-based research and outreach efforts such as Sea Otter Savvy (2022) to educate observers and kayakers about the role otters play in the ecosystem and reducing disturbance. Because of their affinity for near-coastal environments, they are unlikely to be observed in the MBWEA and its immediate vicinity. However, they do utilize the coastal waters along San Luis Obispo and Monterey counties, and forage, rest, give birth, and raise their pups within Morro Bay, which hosts a population of up to 60 individuals.

Availability of Marine Mammal Data

Becker et al. (2020) created species distribution models using ship-based survey data that were collected between 1991 and 2018. Most of the surveys extended approximately 200 to 300 nm (370 to 556 km) offshore. The models include additional sighting data over the continental shelf and slope that were surveyed more sparsely in previous years, providing better representation of these habitat regions, and improvements were made to more accurately account for uncertainty based on methodological improvements. The figures used in this section are from Becker et al. (2020; Dataset Table 5.1). Becker et al. (2017) also created winter/spring density and distribution estimates for short-beaked common dolphin, Dall's porpoise, and humpback whale for the area from Point Reyes to south of the U.S.-Mexico border. These models illustrate the high degree of seasonal variability in the distribution of these species in the area of the MBWEA. They also emphasize the difficulties in having enough data to create the models: although the study included data from 20 surveys over 11 years, there was only enough data for three species in the winter/spring to create models.

Woodman et al. (2019) have also created an R package called eSDM that can create species distribution models from a variety of data sources, such as ship-based surveys (as described in Becker et al. 2020) and satellite tagging surveys (as described in Hazen et al. 2017). The data ensemble approach to species distribution modeling is a weighted or unweighted average (or combination) of the data to provide an established method for resolving differences between individual models. It also has options for incorporating or calculating uncertainty. This is an additional tool to assist users in identifying spatial uncertainties and making informed conservation and management decisions.

Pinniped data are often only available on limited temporal or spatial scales. The Tagging of Pacific Predators (TOPP) program has collected multiple years of location data for northern fur seals (two years), California sea lions (eight years), and northern elephant seals (~17 years). These data have been used to assess cumulative impacts of human influence on marine predators (Maxwell et al. 2013) and may have some utility in other marine resource use planning contexts. One product created using these data are Kernel Utilization Distribution (KUD) maps, which indicate the probability of an animal being found in a given location. This can provide information on the distribution and key habitat of the tagged individuals, which serve as a conservative (and possibly underestimated) proxy of habitat use. These data are available by direct request to TOPP (TOPP 2021).

Adams et al. (2019) have compiled information on programs that collect marine mammal data that may be useful in completing environmental risk assessments for offshore energy activities. The Point Conception to Point Sur area covers the MBWEA and is split between the southern portion of the Central California region and the northern half of the southern California region. The database created from the survey information contains 51 marine mammal research and monitoring records for this area. The records were collected from colleges and universities, NGOs, and government agencies. It includes boat-based, shoreline, and acoustic surveys, as well as genetic, aerial, and tagging studies to a lesser extent. This compilation also lists other sources of marine mammal data that did not meet the criteria to be included in the initial survey effort but represent consistent and standardized long-term programs. For marine mammals, data on abundance, distribution, and threat risk (e.g., strikes and entanglement) were determined to be of highest value to inform potential impacts of offshore energy development on those species (Adams et al. 2019). While updates are not currently planned, the database format allows for inclusion of additional datasets. The complete database is available online (Lafferty et al. 2019; Dataset Table 5.3).

In response to a BOEM request for comments on proposed extensions to the MBWEA, Flick et al. (2021) compiled a list of potential impacts of offshore wind development and operation in the MBWEA to select biological resources including marine mammals. The document describes and assesses the existing biological conditions in the MBWEA, as well as potential disturbance and environmental effects. For marine mammals, it summarizes critical considerations, BIAs and their limitations, potential climate change impacts, and some species-specific impacts for cetaceans, with limited information on pinnipeds. Noting existing uncertainties of the interactions between marine mammals and wind energy operations and maintenance, extensive monitoring may be required, as well as flexibility in program operations.

General Status and Threats to Marine Mammals

Marine mammals are susceptible to injury or death from many anthropogenic sources including fisheries conflicts (entanglement, prey population reduction), contaminants (oil spills, pollution, plastic ingestion and entanglement, organochlorines and heavy metals, and industrial and agricultural runoff), vessel impacts (strikes, disturbance, noise), and alteration of and disturbance at haul out and breeding sites for pinnipeds. Climate change may also impact marine mammal populations, through ocean acidification, sea temperature changes, shifts in distribution and abundance of prey species, sea level rise (for pinnipeds), increased susceptibility to illness and disease, and increased occurrence and extent of harmful algal blooms (NOAA Fisheries 2021b).

Noise disturbance can affect all species of marine mammals by causing disruption to natural behaviors such as feeding or masking vocal communication among individuals. In addition, toothed whales, which use echolocation, can experience tissue trauma from energetic anthropogenic sound sources such as high-frequency sonar (Southall et al. 2019).

Humpback and gray whales are highly susceptible to entanglement in fishing gear, although there are also records of blue and sperm whales being entangled. The marine heatwaves that occurred from 2014 to 2016 resulted in a significant increase in whale entanglements, mainly humpback whales, with Dungeness crab fishing gear because they caused a narrowing of the zone where food was most available (Santora et al. 2020). Blue whale populations are impacted by fishing gear entanglements particularly from Dungeness crab and other gear types, estimated at 1.44 blue whales annually (NOAA Fisheries 2021c). Shipping channels off California overlap with baleen whale migration routes, resulting in ship strikes. Because gray whales occur primarily on or near the continental shelf and in coastal waters during much of the year, they are particularly susceptible to strikes from vessels (Silber et al. 2021). Since 2007, 12 ship strikes to blue whales have been documented, resulting in an estimated mortality of 0.4 ship strike deaths per year (NOAA Fisheries 2021c).

Data Gaps and Limitations

While species distribution models can be effective for generalizing over large areas, the scale may be too coarse to forecast fine-scale distribution patterns required for some dynamic management applications such as ship-strike risk (Becker et al. 2016) as well as the level of activities that could be expected during construction and operation of a wind farm. More refinement of the models can be expected as more sightings are collected over a wider range of oceanographic and atmospheric conditions. The researchers, too, could also assess whether finer scale distribution patterns and density estimates can be captured by the modeled data. One method to do this is a tool called WhaleWatch (Hazen et al. 2017) that uses satellite data from tagged blue whales to predict where they are likely to occur in near real-time. This information was then combined with other environmental data such as sea surface temperature, chlorophyll concentrations, and wind speed. The relationship between whales and these environmental data can be used to predict the likelihood of blue whale presence across the modeled areas.

As in most ocean research, deepwater and rare marine mammals are likely under-represented in the data. Environmental deoxyribonucleic acid (eDNA) is an emerging tool that uses DNA fragments from soil and water samples to monitor biodiversity. eDNA is becoming a well-established tool for monitoring biodiversity that could potentially be used to assess the presence of rare, cryptic, or vulnerable cetacean species in conjunction with acoustic and visual cues (Baker et al. 2018). There is also a need to obtain additional genetic data to identify population differences among marine mammal species because of differences in habitat preferences and other behaviors.

Acoustic monitoring is another tool that is increasingly being used to detect and quantify cetacean distribution and abundance. Recently, NOAA Fisheries and BOEM developed recommendations for the use of passive acoustic listening systems for monitoring and mitigation programs associated with offshore wind energy developments in the U.S. Northeast (Van Parijs et al. 2021).

Summary Table of Selected Marine Mammal Datasets

Dataset Table 5.1: Seasonal Cetacean Density Models

Dataset Title	Seasonal Cetacean Density Models
Species/Resource	Summer/Fall: Baird's Beaked Whale; Bottlenose Dolphin; Dall's Porpoise; Long-Beaked Common Dolphin; Northern Right Whale Dolphin; Pacific White-sided Dolphin; Risso's Dolphin; Short-beaked Common Dolphin; Short beaked whale guild; Sperm Whale; Striped Dolphin. Summer_Fall/Winter_Spring: Blue Whale; Fin Whale; Humpback Whale
Abstract	Includes density, area, and abundance for each species and cell. Species distribution models (SDMs) are important management tools for highly mobile marine species because they provide spatially and temporally explicit information on animal distribution. Two prevalent modeling frameworks used to develop SDMs for marine species are Generalized Additive Models (GAMs) and Boosted Regression Trees (BRTs), but comparative studies have rarely been conducted; most rely on presence-only data; and few have explored how features such as species distribution characteristics affect model performance. Since the majority of marine species BRTs have been used to predict habitat suitability, we first compared BRTs to GAMs that used presence/absence as the response variable. We then compared results from these habitat suitability models to GAMs that predict species density (animals/km^2) because density models built with a subset of the data used here have previously received extensive validation. We compared both the explanatory power (i.e., model goodness-of-fit) and predictive power (i.e., performance on a novel dataset) of the GAMs and BRTs for a taxonomically diverse suite of cetacean species using a robust set of systematic survey data (1991-2014) within

	the California Current Ecosystem. Both BRTs and GAMs were successful at describing overall distribution patterns throughout the study area for the majority of species considered, but when predicting on novel data, the density GAMs exhibited substantially greater predictive power than both the presence/absence GAMs and BRTs, likely due to both the different response variables and fitting algorithms. Our results provide an improved understanding of some of the strengths and limitations of models developed using these two methods. These results can be used by modelers developing SDMs and resource managers tasked with the spatial management of marine species to determine the best modeling technique for their question of interest.
Strength/Weakness	These data and analyses are updated periodically as new data become available. No planned updates are scheduled, but updates are expected. Data current to 2018 covering a larger area than prior analyses. Incorporates and accounts for measures of uncertainty. The maps/data represent model-derived spatial predictions of long-term average density. They do not provide predictions of the actual number of individuals of a given species or taxonomic group that would be expected in a given area; they only indicate where a given species/group may be more or less abundant. Also, the maps do not provide predictions of density at a specific time; they only indicate seasonal distributions averaged across the timeframe of the survey dataset.
File Name	NOAA_2020_CetaceanSDM_Data-Becker_etal2020.gdb
DataType	vectorized rasters in geodatabase
Spatial Extent	U.S. Contiguous West Coast; 48.506100 -131 -117.097556 30; 0.1 degree cell size
Time Scale	1991-2014; published in 2020
Contact/Source	https://cetsound.noaa.gov; Karin A. Forney; karin.forney@noaa.gov
License/Use Restrictions	Creative Commons License
Citation Info	Becker, E.A., J.V. Carretta, K.A. Forney, J. Barlow, S. Brodie, R. Hoopes, M.G. Jacox, S.M. Maxwell, J.V. Redfern, N.B. Sisson, H. Welch, E.L. Hazen. 2020. Performance evaluation of cetacean species distribution models developed using generalized additive models and boosted regression trees. Ecology and Evolution, 10, 5759-5784. For Blue_whale_winter_spring: Hazen, E. L., Palacios, D. M., Forney, K. A., Howell, E. A., Becker, E., Hoover, A. L., Bailey, H. (2017). WhaleWatch: A dynamic management tool for predicting blue whale density in the California Current. Journal of Applied Ecology, 54(5), 1415–1428. https://doi.org/10.1111/1365-2664.12820. For Humpback_whale_winter_spring and Fin_whale_winter_spring: U.S. Department of the Navy. (2019). U.S. Navy Marine Species Density Database Phase III for the Northwest Training and Testing Study Area. NAVFAC Pacific Technical Report. Naval Facilities Engineering Command Pacific, Pearl Harbor, HI. 262 pp.
Metadata Link	https://www.fisheries.noaa.gov/inport/item/63298
Online Link	https://noaa.maps.arcgis.com/home/item.html?id=96ae05c033a540bf83e0f6c00a25cf5a

Dataset Table 5.2: Biologically Important Areas for Cetaceans within U.S. Waters

Dataset Title	Biologically Important Areas for Cetaceans within U.S. Waters
Species/Resource	Cetaceans including fin whale, gray whale, north Pacific right whale, Bryde’s whale, bottlenose dolphin, minke whale, harbor porpoise, sei whale, Blainville’s beaked whale, Cuvier’s beaked whale, dwarf sperm whale, blue whale, humpback whale
Abstract	Biologically important areas (BIAs) for cetaceans were defined by compiling the best available information from scientific literature (including books, peer-reviewed articles, and government or contract reports), unpublished data (sighting, acoustic, tagging, genetic, photo identification), and expert knowledge. This information was then used to

	create written summaries and maps highlighting areas shoreward of the U.S. Exclusive Economic Zone that are biologically important to cetacean species (or populations), either seasonally or year-round. This collection contains the data displayed by BIA type, including feeding, migratory corridors, reproduction, and small and resident populations. Feeding BIAs include areas and months within which a particular species or population selectively feeds. These may either be found consistently in space and time, or may be associated with ephemeral features that are less predictable but can be delineated and are generally located within a larger identifiable area. Migratory Corridor BIAs include areas and months within which a substantial portion of a species or population is known to migrate. Reproduction BIAs include areas and months within which a particular species or population selectively mates, gives birth, or is found with neonates or other sensitive age classes. Small and Resident Population BIAs include areas and months within which small and resident populations occupy a limited geographic extent.
Strength/Weakness	Updates irregular; coarse spatial scale
File Name	cetsound.noaa.gov/Assets/cetsound/data/CetMap_BIA_WGS84.zip
DataType	vector
Spatial Extent	UL 72.265057 -179.726956 LR 18.59151 -66.19249
Time Scale	Published 07/2016
Contact/Source	NOAA Data Catalog http://data.noaa.gov/
License/Use Restrictions	Use Constraints: These data are available for public use. At least one of the following citations must be included in any publication or report that uses this data. The first citation covers the entire dataset and special issue publication, other citations are specific to each regional dataset (East Coast, Gulf of Mexico, West Coast, Hawaii, Gulf of Alaska, Aleutian Islands and Bering Sea, Arctic). Van Parijs, S. M., Curtice, C., & Ferguson, M. C. (Eds.). (2015). Biologically important areas for cetaceans within U.S. waters. Aquatic Mammals (Special Issue), 41(1), 1-128. Other citations available at https://data.noaa.gov/dataset/dataset/biologically-important-areas-for-cetaceans-within-u-s-waters
Citation Info	Van Parijs, S. M., Curtice, C., & Ferguson, M. C. (Eds.). (2015). Biologically important areas for cetaceans within U.S. waters. Aquatic Mammals (Special Issue), 41(1), 1-128.
Metadata Link	https://services2.arcgis.com/C8EMgrsFcRFL6LrL/ArcGIS/rest/services/CetMap_BIA/FeatureServer/0
Online Link	https://data.noaa.gov/dataset/dataset/biologically-important-areas-for-cetaceans-within-u-s-waters

Dataset Table 5.3: Database of Marine Mammal and Seabird Research Activity in the Pacific (U.S.)

Dataset Title	Database of Marine Mammal and Seabird Research Activity in the Pacific (U.S.)
Species/Resource	Information on datasets of marine mammal and seabird research in the U.S. Pacific Ocean, including California, Oregon, Washington, Alaska, and Hawaii.
Abstract	This database is a compilation of marine mammal and seabird information collected along the Pacific coast of the United States and U.S. territories in the Pacific from surveys that were solicited among regional research communities and persons. Information from standardized surveys was gathered from 2015 to 2018 and includes programs and researchers who collected information regarding seabirds since 1960. Information collected to synthesize the researcher network (people and organizations), marine bird and mammal taxa studied, parameters measured, and spatial coverage for research activities in areas of Bureau of Ocean Energy Management (BOEM) oversight.
Strength/Weakness	Broad spatial and species data coverage; focus on data useful for assessment of offshore energy development impacts. These data can be updated periodically as new data

	become available. No planned updates are scheduled. Information about datasets, not observation data.
File Name	BOEMmonitoringDatabase1.7.2.csv
DataType	Digital attribute table (.csv file)
Spatial Extent	UL 71.600091 -179.999989; LR -0.622502 179.999989
Time Scale	1960-2018, published 09/09/2019
Contact/Source	U.S. Geological Survey, Western Ecological Research Center
License/Use Restrictions	The authors of these data require that users direct any questions pertaining to appropriate use or assistance with understanding limitations and interpretation of the data to the individuals/organization listed in the Point of Contact section.
Citation Info	Lafferty, K.D., Adams, J., Johnston, C.A., and Kelsey, E.C., 2019, Database of marine mammal and seabird research activity in the Pacific (U.S.): U.S. Geological Survey data release, https://doi.org/10.5066/F7X0669S; Report: Adams, J., Lafferty, K.D., Kelsey, E.C., and Johnston, C.A. 2019. Synopsis of Research Programs that can Provide Baseline and Monitoring Information for Offshore Energy Activities in the Pacific Region: Seabird and Marine Mammal Surveys in the Pacific Region. U.S. Department of the Interior, Bureau of Ocean Energy Management, Pacific OCS Region, Camarillo, CA. OCS Study BOEM 2019-042. 14 Figures, 20 Tables, 54 p. https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Pacific-Region/Studies/BOEM-2019-042.pdf
Metadata Link	https://www.sciencebase.gov/catalog/file/get/5a7c8fb1e4b00f54eb231ae6?f=__disk__73%2Fdb%2F67%2F73db67d5a9d9e7de7c7958de39eefa00dcdc1bd0&transform=1&allowOpen=true
Online Link	https://doi.org/10.5066/F7X0669S

SECTION 6. SEABIRDS

At least 80 species of seabirds occur along the California coast of which five species (sooty shearwater, western gull, common murre, California gull, and Cassin's auklet) comprise 70% of all individuals seen during surveys (Dick 2016). Of these 80 species, 28 breed in California and 52 are migratory. Distribution and abundance of seabirds vary widely depending on species and season. Their distribution is also highly variable due to prey availability, subsurface features, marine climate, and oceanographic characteristics.

Predicted seabird distribution data presented in this catalog are based on Leirness et al. (2021), in a report produced by BOEM (Dataset Table 6.1). This report contains seasonal density distribution models and accompanying statistical uncertainty based on data from 21 projects including at-sea and aerial surveys conducted from 1980 to 2017. These models describe the density distribution of 33 individual species and 13 species groups along the California, Oregon, and Washington coasts. This report provides observed count totals limited to those species observed in at least 100 survey segments in a given season over the entire raw dataset; therefore rare, out of range, migratory, or difficult to observe species may be underrepresented. The models are based on 48 predictor variables including survey, temporal, geographic, bathymetric, oceanographic, and atmospheric variables and derivatives such as time lags or scale variations. The relationship of seasonal species observations to these variables is described in this report, as well as sources of variability in the models and uncertainty resulting from extrapolation of data. Leirness et al. (2021) urge caution in inferring ecological or spatial relationships between the environmental predictors and the distribution of marine birds due to limitations of the modelling procedure.

Each species/group has predicted density data for one to four seasons (Winter, Spring, Summer, and/or Fall), as well as an accompanying presentation of the spatial coefficient of variation. For mapping purposes in this document, the predicted density model for one season per species is selected based on the season with the highest average predicted density for a given species/group in and around the MBWEA (Appendix B). Models for species with only one season of data are shown for that species by default. General density ranks relative to the entire model dataset are provided for each season where data are available (Table 6.1). Species mentioned in this report but not included in Leirness et al. (2021), are included in this document in species descriptions but not in graphics or maps.

Additional CCS-wide seabird distribution data models are available, including those done by Dick (2016) and Nur et al. (2011). Dick (2016, Dataset Table 6.2) used 15 years (1997-2012) of at-sea seabird survey data in the CCS to create mean predicted density models for 30 seabird species along the California, Oregon, and Washington coasts. This work expands on similar analyses done by Nur et al. (2011).

Marine bird densities at sea are known to be influenced by features of the seabed and oceanographic conditions. In an analysis of survey data from regions greater than 50 km (31 mi) from shore, Dick (2016) found that areas consisting of seamounts, ridges, and other bathymetric features tended to have higher seabird use than other pelagic regions. Overall, highest seabird abundance occurred nearshore, peaking during the spring and summer (May-July) inshore of the 200-m isobath and especially near river mouths (Dick 2016). Leirness et al. (2021) found that, in general, day of year, distance to land, depth, chlorophyll-a concentration, current speed, and mean temperature were the most important predictor variables for two model components, and mean salinity and mean mixed layer depth for one component. Other variables were important seasonally or for individual species. Dick (2016) found that species that are year-round residents and breed in the CCS would be more sensitive to changes in SST, SSH, and chlorophyll-a than migratory species. Seabird colonies are frequently located near areas with reliably high productivity to sustain the energetic requirements of breeding and chick provisioning. A change in timing or location of upwelling-induced productivity could reduce nesting success and alter local population distributions.

There have been multiple studies indicating potential and actual impacts of offshore wind development on seabirds. In the CCS, vulnerability of marine bird populations to collision and habitat displacement due to the presence of offshore wind infrastructure was discussed in Adams et al. (2017) and Kelsey et al. (2018). They incorporated metrics such as population size, monthly presence, survival, breeding status, threat status, and flight information such as nocturnal and diurnal flight activity, macro-avoidance of turbines, and flight height. Kelsey et al. (2018) indicated that jaegers, skuas, pelicans, terns, and gulls have high vulnerability to collision with offshore wind infrastructure, whereas loons, grebes, sea ducks, and alcids have high habitat displacement vulnerability. These metrics lack an explicit spatial component and are best utilized in concert with reliable spatial distribution or density data as part of a model incorporating vulnerability. Adams et al. (2017) also provides a useful literature review of other studies based in the Atlantic Ocean in the U.S. and Europe, including Garthe and Hüppop (2004), Desholm (2009), Furness and Wade (2012), Furness et al. (2013), and Robinson Willmott et al. (2013). A database related to Adams et al. (2017, Dataset Table 6.3) includes vulnerability scores and is updatable as new information becomes available.

Seabirds With Potential to Occur in the MBWEA or Vicinity

Albatross

Three species of albatross occur on the U.S. West Coast, two of which are likely to occur in the MBWEA: Laysan albatross (*Phoebastria immutabilis*) and black-footed albatross (*P. nigripes*). The third species, short-tailed albatross (*P. albartrus*), is rare and has a low potential for occurrence in the MBWEA, although the area does encompass foraging habitat (see the next section for species with low potential). These species are long-distance migrants and foragers, visiting the U.S. West Coast year-round with greater abundances during spring and summer. Albatross are known for their large wingspans and ability to glide and fly for large distances over multiple days. Their methods of flight and foraging may increase their risk of collision with turbine infrastructure, and the presence of turbines may result in their displacement from foraging or transit areas.

Major threats for these species include introduced predators and sea-level rise at their colonies, ingestion of plastic and lead, and by-catch in fisheries, particularly longline fishing. The three species are listed by the IUCN, the United States, and the State of California as being at various levels of risk (Table 6.2). Per sighting data on eBird (2021), black-footed albatross observations are most common in the MBWEA, followed by Laysan albatross. At-sea survey data off California indicates the ratio of Laysan to black-footed albatross sightings is 1:32 on average (Dick 2016). There are no short-tailed albatross sightings in the at-sea dataset, and eBird (2021) has no records of short-tailed albatross within the boundaries of the MBWEA.

Laysan albatross nest primarily in the northwestern Hawaiian island archipelago, with small colonies on the western main Hawaiian Islands, islands off Japan, and islands west of Baja California and Baja California Sur in Mexico. The Laysan albatross population is estimated at 2.5 million birds, of which 1.6

million make up the breeding population (Birds of the World 2021). An estimated 90% of the population breeds on Midway Atoll.

In the MBWEA, Leirness et al. (2021) predicts that Laysan albatross density in the MBWEA is very low to low in winter and spring, with no data available for summer and fall (Table 6.1). These birds tend to be pelagic, spending the majority of their time well offshore in colder waters in winter and spring, moving closer to shore when nearshore waters are cooler. In general, these predictions indicated higher densities far offshore, beyond the continental slope (Leirness et al. 2021). Predicted average density values within the MBWEA were highest in spring, but low compared to the highest predicted density value in the CCS for that season (Figure B.1). Dick (2016) predicted densities in and around the MBWEA to be similarly low in winter and spring, and moderate in summer and fall, with higher densities to the north and offshore.

Black-footed albatross nest primarily in the northwestern Hawaiian island archipelago, with small colonies on the western main Hawaiian Islands, as well as islands off Japan. An effort is currently underway on Guadalupe Island off Baja California, Mexico, to reintroduce this species to their historic nesting areas there. Black-footed albatross global populations are estimated at 240,000 individuals (Birds of the World 2021). Black-footed albatross are a pelagic species but tend to forage closer to the coast than Laysan albatross.

These birds can commonly be found along the coast and offshore of northern California, Oregon, and Washington, with a more dispersed at-sea distribution in the fall and winter months. Leirness et al. modeled predicted densities for winter and spring, as data were insufficient to assess density estimates for summer and fall. In spring, Black-footed albatross predicted density values in the MBWEA are low compared to areas to the north in the CCS (Leirness et al. 2021; Table 6.1; Figure B.2), with average densities in the MBWEA higher in spring than in winter. Dick (2016) predicted densities of this species in and around the MBWEA to be low to moderate year-round, with highest values also in the spring.

Alcids

There are eleven species of alcids on the U.S. West Coast, all of which are known to occur along the California coast. Seven species breed in California: common murre (*Uria aalge*), pigeon guillemot (*Cepphus columba*), Scripps's murrelet (*Synthliboramphus scrippsi*), marbled murrelet (*Brachyramphus marmoratus*), Cassin's auklet (*Ptychoramphus aleuticus*), rhinoceros auklet (*Cerorhinca monocerata*), and tufted puffin (*Fratercula cirrhata*). The others are migrants observed during at-sea surveys including Guadalupe murrelet (*S. hypoleucus*), Craveri's murrelet (*S. craveri*), ancient murrelet (*S. antiquus*), and horned puffin (*F. corniculata*). Alcids are heavy-bodied, short-winged birds that forage by diving after prey, propelled by their wings. The majority prey on small schooling fishes, with some species also foraging on cephalopods and zooplankton.

Major threats for these species include habitat loss, introduced predators for island nesting species, human attracted predators such as corvids and domestic animals, oil spills and wildfires, entanglement in fishing gear, and loss of prey base due to overfishing. Murrelet populations are all decreasing, with marbled and Guadalupe murrelets listed as endangered by the IUCN (2021), Scripps's and Craveri's as threatened, and Ancient Murrelets as Least Concern. Marbled murrelets are also listed as Threatened by the U.S. and Endangered by the State of California, with Scripps's and Guadalupe murrelets listed as Threatened by California. Cassin's auklet is listed as Near Threatened by the IUCN because of a decreasing global population trend. Tufted puffins are identified as a California Species of Special Concern during their breeding season, as that is when they are most common in the state (Table 6.2).

The **common murre** is one of the most numerous seabirds in California and is a resident species, accounting for 63% of alcid observations during at-sea surveys (Dick 2016). As of 2002, Castle Rock and Hurricane Point Rock were the closest breeding sites to the MBWEA for common murres, supporting nearly 1,700 breeding birds (CDFG 2010b). On the U.S. West Coast, common murres breed from south of Monterey Bay to central Oregon and Washington. Common murres feed primarily over the continental shelf (H.T. Harvey & Associates 2020). They tend to congregate in large, dispersed rafts at sea, and may travel in sizable flocks. In all seasons, common murres are distributed very close to the coast and are central place foragers during the breeding season. Because this species prefers nearshore waters, predicted density values in the MBWEA are consistently very low compared to the surrounding areas and the CCS as a whole (Table 6.1). Highest predicted densities in the wind energy area occur in the winter (Figure B.3), but nearshore densities greatly exceed these in the north.

Pigeon guillemots are rarely observed during at-sea surveys, representing only 1% of observations of alcids and 0.2% of all observations (Dick 2016). However, they are common breeders along the U.S. West Coast, from Point Conception in California to northern Washington. Most of the California population is presumed to migrate to British Columbia outside of the breeding season. As of 2002, 30 of the 52 seabird colonies within 30 nm (56 km) of the MBWEA supported populations of pigeon guillemots, with a total of 1,000 birds, approximately 8% of the state’s population (CDFG 2010b). Leirness et al. (2021) created spring and summer predicted density models for pigeon guillemots indicating very low densities in and around the MBWEA compared to coastal areas to the north (Table 6.1, Figure B.4). Given their propensity to remain close to shore and low population numbers in the area, densities within the MBWEA are likely very low year-round.

Scripps's murrelet, **Guadalupe murrelet**, and **Craveri’s murrelet** can be difficult to distinguish at sea. Until 2012, These three murrelet species represent 1.1% of the total number of individuals of alcids observed during at-sea surveys, with the majority of observations made south of Cape Mendocino (Dick 2016). Scripps's and Guadalupe murrelets were previously considered a single species: Xantus's murrelet (*S. hypoleucus*). Scripps's and Guadalupe murrelets overlap in their breeding range from the California Channel Islands to islands along the Pacific coast of Baja California, Mexico. The Guadalupe murrelet’s breeding range continues into Baja California Sur, and overlaps with Craveri’s murrelets to the southern end of the Baja Peninsula. Craveri’s murrelets also breed on islands in the Gulf of California. The migration range of Scripps's and Guadalupe murrelets is similar, extending north into British Columbia, Canada, whereas Craveri’s murrelets tend to remain south of Cape Mendocino in California (Birds of the World 2021). Leirness et al. (2021) grouped the three species and only modeled density distribution for spring due to low observation numbers during the other seasons. The predicted densities in the MBWEA were very low compared to areas to the south in the Southern California Bight where they breed (Table 6.1, Figure B.5). The migratory range of all three species overlaps with the MBWEA but all three species tend to congregate closer to shore. Dick (2016) modeled Xantus’s murrelet predicted densities, with highest densities in winter in the MBWEA, and densities relative to the CCS being moderate over all seasons, likely due to the proximity of the MBWEA to the Channel Islands.

Marbled murrelets nest inland in old-growth conifer trees, leading to high population sensitivity to habitat modification and loss. These birds forage for small fish and invertebrates in nearshore waters, primarily within 5 km (3 mi) of the coast. Forests in northern California as well as between San Francisco and Monterey Bays are within the breeding range for this species. Leirness et al. (2021) created predicted density models using spring and summer surveys data limited to the coast north of San Francisco Bay. These models indicate that at-sea marbled murrelet densities are highest near shore and to the north. Predicted densities in the MBWEA and immediate vicinity would be very low, but slightly higher in summer. (Table 6.1, Figure B.6)

Ancient murrelets (*Synthliboramphus antiquus)* nest in burrows, crevices, or under rocks, and forage in shallow waters. Their North American breeding range extends from Alaska to British Columbia. Birds found offshore of California are likely migrants/wintering. Leirness et al. (2021) includes a density distribution map for spring only, which is driven by observations offshore of the Olympic Peninsula in Washington. Densities in the MBWEA are likely to be very low, as this species concentrates in the northern portion of the CCS, prefers to forage near shore, and does not breed in the area (Table 6.1; Figure B.7).

Cassin's auklets are the second most numerous alcid observed in California at-sea surveys, representing 29% of all alcids observed (Dick 2016). This species does not breed in San Luis Obispo or Monterey counties, but the MBWEA is almost equidistant from the two closest breeding sites in the Channel Islands and the Farallon Islands. These birds are primarily planktivores and tend to feed over the shelf (H.T. Harvey & Associates 2020). Because of this foraging strategy, there is an increased likelihood of this species being found in and around the MBWEA. Overall, relative densities within the MBWEA are low to very low compared to the CCS, with highest predicted densities in winter, when birds are not concentrated in breeding areas (Leirness et al. 2021; Table 6.1; Figure B.8).

Rhinoceros auklets are less common in California at-sea surveys and represent 6% of all alcids observed (Dick 2016). These birds are primarily piscivores and will readily kleptoparasitize other birds such as pigeon guillemots and murres to obtain their prey. They tend to congregate in small flocks and remain close to shore. As of 2002, one of the 52 seabird colonies within 30 nm (56 km) of the MBWEA supported rhinoceros auklets; three breeding pairs were observed at Piedras Blancas (CDFG 2010b). Relative densities of rhinoceros auklets in the MBWEA are low to very low year-round, with highest predicted densities in winter (Leirness et al. 20212; Table 6.1, Figure B.9), increasing to the north and toward shore.

Tufted puffins are resident breeders along the California coast but are not commonly observed during at-sea surveys, making up less than 1% of all alcid observations. These wing-propelled divers forage for fish and invertebrates and characteristically carry multiple fish aligned in their bills when feeding chicks. Two pairs were documented breeding at Hurricane Point north of the MBWEA as of 2002 with the majority breeding to the north on the Farallon Islands and at Castle Rock in Del Norte county (CDFG 2010b). During the breeding season, these birds tend to forage nearshore and over the continental shelf but are found well away from shore in deep pelagic environments the remainder of the year, usually well to the north of the MBWEA. Leirness et al. (2021) used data from spring and summer to create predicted density models that indicate higher densities to the north around breeding areas; data were insufficient for fall and winter models. Within and around the MBWEA, the predicted density of tufted puffins is very low, but higher in summer (Table 6.1, Figure B.10). These relative density predictions are supported by Dick (2016), where models indicated very low densities in the MBWEA year-round.

Cormorants

There are three species of cormorant in the CCS, all three of which reside along the California coast: Brandt's cormorant (*Urile penicillatus*), pelagic cormorant (*U. pelagicus*), and double-crested cormorant (*Nannopterum auritum*). According to Adams et al. (2014), the three resident cormorant species can be difficult to distinguish at sea, especially outside the breeding season. All three species are piscivores, diving from the ocean's surface using their feet to propel themselves. Brandt's and pelagic cormorants are found exclusively in marine environments, whereas double-crested cormorants can be found in all aquatic environments. During migration, all three species can travel in large flocks, usually in straight lines or delta shapes at low altitudes to reduce wind resistance. Threats to these species include human disturbance at breeding and roosting sites, extreme climate events such as heat waves and sea temperature change, entanglement in fishing gear, and exotic/invasive species. The IUCN lists the three species as of Least Concern, but populations of Brandt's and pelagic cormorants are decreasing globally (Table 6.2).

Brandt's cormorants roost on rocky headlands and islets but will also roost on artificial structures at sea (Kelsey et al. 2018). This species feeds at sea away from its roost site, commuting as much as 10 mi (16 km) away. Along central California, breeding occurs from March to August, with egg laying from April to July (CDFG 2005). Brandt's cormorants are the most numerous cormorant species observed during at-sea surveys, making up 88% of all cormorants observed. The majority of these observations occur nearshore or around islands. As of 2002, 19 of the 52 seabird colonies within 30 nm (56 km) of the MBWEA supported populations of Brandt's cormorants, for a total of 7,235 birds, approximately 12% of the state's breeding population (CDFG 2010b). Leirness et al. (2021) modeled predicted densities for spring and summer, showing higher densities in the MBWEA in spring, although these were very low relative to nearshore areas (Table 6.1, Figure B.11). These relative densities were supported by Dick (2016), with very low values year-round, although the highest local density was predicted in winter.

In spite of their name, **pelagic cormorants** are uncommon away from shore, and observations comprise only 1.5% of at-sea observations of cormorants in California (Dick 2016). The smallest of the cormorants in the CCS, this species forages on fish and other demersal prey in shallow waters over the shelf. As of 2002, 33 of the 52 seabird colonies within 30 nm (56 km) of the MBWEA supported populations of pelagic cormorants, for a total of 739 birds, approximately 6% of the state's population (CDFG 2010b). Leirness et al. (2021) predicted highly coastal CCS-wide densities of pelagic cormorants for spring and summer and indicated slightly higher densities in spring in the MBWEA, with very low densities in both seasons relative to the CCS (Table 6.1, Figure B.12).

At-sea observations of **double-crested cormorants** off California make up 10% of all cormorants observed (Dick 2016). This is the most common cormorant species in the United States, with the majority of the population residing in freshwater habitats such as lakes and rivers. However, coastal populations exist along the entirety of the CCS. As of 2002, six of the 52 seabird colonies within 30 nm (56 km) of the MBWEA supported populations of double-crested cormorants, for a total of 393 birds, approximately 8% of the state's coastal breeding population (CDFG 2010b). Leirness et al. (2021) predicted coastal double-crested cormorant densities during spring and summer to be very low overall, with densities in the MWBEA higher in spring (Table 6.1, Figure B.13).

Leirness et al. (2021) also created fall and winter density models for the three cormorant species combined due to low counts of the individual species during these seasons. These models indicate similar distribution and relative densities to the individual species for spring and summer. All species combined tend to have higher densities near the coast/islands, and densities in and around the MBWEA are very low for both seasons (Table 6.1, Figure B.14).

Shearwaters and Fulmars

Shearwaters and fulmars are members of the family Procellaridae, the tubenoses. Shearwaters are highly migratory species; those that are observed in the California Current breed in South America, Australia, New Zealand, as well as Mexico. There are six species that have been observed during at-sea surveys: sooty shearwater (*Adrenna grisea*), pink-footed shearwater (*A. creatopus*), short-tailed shearwater (*A. tenuirostris*), flesh-footed shearwater (*A. carneipes*), Buller's shearwater (*A. bulleri*), and black-vented shearwater (*Puffinus opisthomelas*). They generally forage on small fish, crustaceans, zooplankton, and squid, pursuing their prey by diving from low-level flight and using their wings to propel themselves underwater or by dipping their heads to capture prey at the surface (Birds of the World 2021). The flight pattern of shearwaters is distinct as they are adept at using surface winds and ground effect to travel great distances with minimal effort. Northern fulmars (*Fulmarus glacialis*) are a northern hemisphere species. They breed in Alaska and Canada and disperse south after breeding season. They forage where their prey--fish, squid, and zooplankton--are concentrated, typically over the continental slope and seamounts in upwelling areas. They are also known to eat carrion and other floating refuse, especially from vessels. This species feeds by picking items at or below the surface and making shallow feet- and wing-propelled dives (Birds of the World 2021).

Sooty, flesh-footed, and black-vented shearwaters are listed as Near Threatened by the IUCN (2021), pink-footed and Buller's shearwaters are Vulnerable, and short-tailed shearwaters and northern fulmars are considered to be of Least Concern (Table 6.2). Most shearwater populations are either decreasing or have unknown growth status, with only Buller's shearwaters having a stable population. Northern fulmar populations are growing globally but have experienced notable mortality events along the California coast in the last two decades. Threats to these birds include entanglement in fishing gear, alteration and loss of nesting and foraging habitat, invasive predators at their nesting colonies, plastic and contaminant ingestion, and temperature extremes.

Leirness et al. (2021) grouped **sooty shearwaters, short-tailed shearwaters,** and **flesh-footed shearwaters** into a combined species density model. This model was dominated by observations of sooty shearwaters, but these species share similar habitat use patterns in the CCS as well as transequatorial migration from breeding grounds in South America (sooty), Australia (all three), and New Zealand (sooty and flesh-footed). Their northern hemisphere distribution appears to be related to food availability, and they tend to travel, forage, and rest in very large mixed-species flocks, sometimes made up of thousands of birds. While mostly pelagic, these flocks can occasionally be observed from shore when prey are concentrated over the shelf. Sooty shearwaters are the most numerous shearwater species observed along the California coast, representing 85% of at-sea observations of shearwaters (Dick 2016), with the other two species making up less than 1% of shearwater observations. Density models of these three species predict the highest concentrations in or near the MBWEA in summer, with densities decreasing moving seaward across the continental shelf (Figure B.15). Overall, relative densities year-round of this species in and around the MBWEA are very low to low compared to the CCS as a whole (Table 6.1).

Pink-footed shearwaters migrate to the CCS from breeding grounds in Chile. Like other shearwaters, this highly pelagic species is usually found beyond the continental shelf during migration in the CCS but can be observed in flocks with other shearwater species over the shelf and closer to shore. Nearly 7% of shearwaters observed during at-sea surveys were pink-footed (Dick 2016). Compared to the CCS as a whole, the predicted density of pink-footed shearwaters in and around the MBWEA is low from spring to fall; data were insufficient to create a model for winter (Leirness et al. 2021, Table 6.1). Within the MBWEA, densities were highest in summer (Figure B.16). Dick (2016) also predicted the highest densities of this species to occur in summer in and around the MBWEA, but predicted values were slightly greater relative to the CCS as a whole year-round.

Buller's shearwaters breed in New Zealand and migrate to the CCS. During at-sea surveys, this species is not commonly seen, making up 1% of shearwater observations (Dick 2016). In survey data used by Leirness et al. (2021), Buller's shearwaters make up 4% of all shearwater observations, and are available for only summer and fall. This species is also highly pelagic and is rarely observed close to shore. Predicted densities in the MBWEA are highest in the fall but are very low in summer and low in fall compared to the CCS as a whole (Leirness et al. 2021, Table 6.1, Figure B.17).

Black-vented shearwaters are a northern hemisphere species, breeding in northwestern Mexico, and migrating north through the CCS outside of their breeding season. They represent 6% of the shearwaters observed during at-sea surveys (Dick 2016). This species is an exception to the extreme pelagic nature of shearwaters, as they tend to remain relatively closer to shore and generally do not range north of San Francisco Bay. Leirness et al. (2021) modeled predicted densities for this species for summer through winter; data were insufficient to create a model for spring. In the MBWEA, overall densities were very low for all three seasons compared to the CCS as a whole, but were highest in fall, when birds have dispersed from their breeding grounds (Table 6.1, Figure B.18).

In California, **northern fulmars** are uncommon south of Point Conception, and represent only 1.5% of the birds observed during at-sea surveys in the shearwater and fulmar group (Dick 2016). Their predicted density is highest in and around the MBWEA in winter (Figure B.19). Compared to the CCS as a whole, it is low in winter and spring, and very low in summer and fall (Table 6.1), with higher, more dispersed concentrations predicted to the north, off Washington and British Columbia, Canada. This species is most common over the continental shelf and slope in the MBWEA area in all seasons but is likely to be more pelagic in winter and spring.

Grebes and Loons

Grebes and loons are migratory species in the CCS and are not commonly observed during at-sea surveys, representing 0.6% of birds observed. In spite of this rarity during surveys, these birds gather and travel in large flocks during migration, with the larger grebe species resting on the water during the day, and loons traveling in miles-long skeins when wind conditions are optimal. Species that can be observed off the California coast include western grebes (*Aechmophorus occidentalis*), Clark's grebes (*A. clarkii*), Pacific loons (*Gavia pacifica*), common loons (*G. immer*), red-throated loons (*G. stellata*), and Arctic loons (*G. arctica*). Both grebe species breed in inland fresh- and brackish water wetlands. The loons breed in Arctic and sub-Arctic wetlands, and winter in coastal waters, including bays and estuaries. Both loons and grebes are foot-propelled divers, foraging for fish in marine environments, and fish, aquatic and terrestrial invertebrates, and occasionally amphibians in their freshwater breeding phase.

Population status varies by species, with western grebe and common loon populations stable, Pacific loon populations increasing, and the other three loon species decreasing. The two grebe species and three of the loon species are listed as Least Concern by the IUCN (2021); only yellow-billed loons are listed as Near

Threatened (Table 6.2). Threats to these species include pollution and contaminants, fisheries conflicts, and habitat shifts or alterations due to development or climate change.

Common loons are the largest of the loon species and **red-throated loons** are the smallest. They comprise 20% and 2% of at-sea observations of loons respectively (Dick 2016). Leirness et al. (2021) modeled predicted densities for both species separately in spring and summer; data were insufficient for modeling purposes in the fall and winter. Predicted densities in the MBWEA for both species were very low in both seasons compared to the CCS, with densities predicted to be higher in spring than summer (Table 6.1, Figures B.20 and B.21).

Pacific loons and **Arctic loons** are found in California waters in spring and fall during their migration to nesting areas in the Arctic and Alaska, and wintering grounds in Mexico. The majority of the birds occur within a couple of miles of the coastline (Adams et al. 2014). During at-sea surveys, Pacific loons are the most common loon species observed representing 64% of loon observations, with Arctic loons representing 14% of all loons observed. For modeling purposes, Leirness et al. (2021) combined counts of Arctic and Pacific loons with those of common and red-throated loons as well as unidentified loons to create a four-species predicted density model. Numbers of Pacific and Arctic loons dominated the model for all seasons, ranging from 51% to 81% of observations. These models predicted loon densities in the MBWEA to be very low from winter to summer, but moderately high in the fall compared to the CCS (Table 6.1), when they were also highest (Figure B.22). This pattern resembles that calculated by Dick (2016) for Pacific loons alone, with low to moderate densities year-round compared to the CCS overall. Loons tend to concentrate in coastal waters; however, migratory flight patterns for Pacific loons and other loons are not well documented, and this information may clarify the potential impact of development in the MBWEA on this and other loon species.

Leirness et al. (2021) also modeled predicted densities for **western grebes** and **Clark's grebes** combined, although the model is driven by the numerically dominant western grebe. These models, created for winter, spring, and fall, show that densities are predicted to be highest in the CCS during the winter but dispersed slightly more offshore in the spring. Both species congregate close to shore over the shelf, and generally have very low predicted densities in the MBWEA compared to the CCS as a whole (Table 6.1). Densities within the MBWEA are predicted to be highest in winter (Figure B.23). Similar to the loons, the flight and migratory patterns of grebes are not well documented and additional data will be necessary to ascertain the impact of offshore wind development on these species.

Larids, Jaegers, and Skuas

The larids, jaegers, and skuas make up the most observed species group in the CCS. A total of 26 species have been observed during at-sea surveys, seven of which breed on the California coast, the remainder of which are migrants. Larids comprise the gulls and terns, both of which are sometimes further classified based on their size (large/medium/small).

Larids

Fourteen gull species were observed during at-sea surveys, including California breeding species western gull (*L. occidentalis*), and California gull (*L. californicus*); California migrant species Bonaparte's gull (*Chroicocephalus philadelphia*), herring gull (*L. argentatus*), glaucous-winged gull (*L. glaucescens*), Iceland gull (formerly Thayer's gull-2017; *L. glaucoides thayeri*), Heermann's gull (*L. heermanni*), Sabine's gull (*Xema sabini*), and black-legged kittiwake (*Rissa tridactyla*). Less common migrant species will be covered in the Rare or Data Deficient Seabirds section below: ring-billed gull (*L. delawarensis*), short-billed gull (formerly mew gull-2021; *L. brachyrhynchus*), glaucous gull (*L. hyperboreus*), Franklin's gull (*Leucophaeus pipixcan*), and kelp gull (*L. dominicanus*). Most of the medium and large gull species are opportunistic omnivores, foraging on marine food sources, kleptoparasitizing other seabirds, scavenging carrion, ship scraps, and garbage, consuming eggs and chicks of other birds, and, for inland species, consuming terrestrial invertebrates, small vertebrates, and raiding garbage dumps. Species that are more limited in dietary preferences are described below.

All gulls described here are listed by the IUCN (2021) as Least Concern except for Heermann's gulls which are listed as Near Threatened, and black-legged kittiwakes which are Vulnerable due to recent steep population declines in European colonies. None of these gull species are listed by the U.S. or the State of California as being at risk (Table 6.2). While individual species may be more strongly influenced by some threats, gull species in general are impacted by the threats of oil spills and pollution, loss of nesting habitat, human disturbance, climate change resulting in sea-level rise or shifting foraging and breeding habitat, and human encroachment at inland nesting and roosting areas.

Western gulls are the second-most numerous seabird observed off California, and the most numerous resident breeding larid species, representing 11% of all seabirds observed during at-sea surveys, and 54% of all gulls observed (Dick 2016). Although this species is common in the coastal CCS, it has a smaller overall population than other North American gulls, as its distribution is restricted to the Pacific coast from British Columbia to Baja California Sur. High at-sea densities are seen throughout the year, and birds remain resident year-round travelling locally to follow food sources. They are not usually observed far from shore but will follow ships and fishing vessels. This large gull has adapted to coastal development and will readily establish breeding colonies within urban coastal areas. As of 2002, 38 of the 52 seabird colonies within 30 nm (56 km) of the MBWEA supported populations of western gulls, for a total of 799 birds, approximately 2% of the state's coastal breeding population (CDFG 2010b).

Glaucous-winged gulls are less common during at-sea surveys, representing only 0.26% of gulls observed in the CCS. However, this species readily hybridizes with western, glaucous, and herring gulls, so many hybrid gulls may be difficult to identify at sea. This northern transpacific species breeds from the Kamchatka Peninsula, Russia to British Columbia, Canada. It is a strictly coastal species and overwinters off the California coast. As with other gull species, it is generally found close to shore, often in mixed species flocks.

Leirness et al. (2021) created a combined predicted density model for western and glaucous-winged gulls, including western x glaucous-winged gull hybrids, with the majority of observations in all seasons being of western gulls. These models indicate that the relative density of these species in and near the MBWEA are very low in all seasons, relative to the CCS (Table 6.1). As these species generally utilize nearshore and onshore, their distribution decreases with distance from land. Density values in the MBWEA are highest in spring, prior to the start of the breeding season (Figure B.24).

Herring gulls are large gulls that breed in Canada and Alaska but migrate and overwinter along the west coast of North America as well as inland. They represent 3.6% of gulls observed during at-sea surveys in the CCS (Dick 2016). In the Pacific, they are commonly found coastally in shallow water, near beaches, estuaries, and bays. **Iceland gulls** are extremely uncommon during at-sea surveys in the CCS, representing only 0.02% of gulls observed (Dick 2016). This medium-sized gull breeds in the Arctic and migrates to northern coasts in the Pacific and Atlantic. In California, they are a coastal species, usually observed in low numbers in flocks of other gulls. Leirness et al. (2021) created a combined predicted density model for herring and Iceland gulls, with the majority of observations in all seasons being of herring gulls. Relative to the CCS, these models indicate low predicted densities of these species in the MBWEA in winter and spring, and very low densities in summer and fall (Table 6.1). Local densities are highest in winter, when birds are overwintering away from their breeding sites to the north (Figure B.25).

California gulls are an inland breeding species, with a transcontinental range in Canada and the U.S.. Some birds winter in coastal areas, but a large number also winter inland. This medium-sized gull represents 25% of gulls observed during at-sea surveys in the CCS, and 5% of seabirds overall (Dick 2016). Coastal wintering birds concentrate in shallow waters nearshore, estuaries, beaches, and mudflats, often in large flocks with other species. Predicted density models indicate California gull densities are very low in and near the MBWEA year-round, with most of the predicted distribution highly associated with the coast (Leirness et al. 2021; Table 6.1). As with other non-California coastal breeding species, density values in the MBWEA were highest in the winter (Figure B.26).

Heermann's gulls are medium-sized gulls that breed in the winter on islands off the Pacific and Gulf of California coasts of Mexico. In the CCS, they represent 4% of all gulls observed during at-sea surveys (Dick 2016). They are highly associated with brown pelicans, and breed, migrate, and roost in the same seasons and locations. Strictly coastal, they migrate from spring to fall from central Mexico to British Columbia, Canada. They forage by surface feeding for fish, kleptoparasitizing brown pelicans, and scavenging carrion. They are rare inland, and are usually found in shallow coastal waters, beaches, and estuaries. Predictive density models created by Leirness et al. (2021) indicate very low density values in and near the MBWEA from summer to winter; data were insufficient to create a model for spring (Table 6.1). Predictive models from Dick (2016) indicated very low densities in the MBWEA in spring. Average predicted density values are highest in the MBWEA in the summer (Leirness et al. 2016; Figure B.27).

Bonaparte's gulls represent 7% of gulls observed during at-sea surveys in the CCS, and 1.5% of all seabirds (Dick 2016). The population of this small gull is transcontinental, breeding in Alaska and Canada, migrating over both inland and coastal areas. The Pacific wintering population is coastal with some birds overwintering at the Salton Sea. This species has a more limited diet, foraging in the marine environment by surface feeding, kleptoparasitism, and taking terrestrial invertebrates at inland sites. Leirness et al. (2021) found the highest predicted density of this species in and around the MBWEA in the spring, but that densities in the MBWEA relative to the CCS were low in spring and very low in fall and winter (Table 6.1, Figure B.28). There were insufficient data to create a model for summer. Models from Dick (2016) indicate that this species had low relative predicted densities in and near the MBWEA in summer as well.

Sabine's gull is another small gull with a limited foraging strategy, taking fish and invertebrates from the water's surface, as well as foraging in shallow water and mudflats. In the CCS, observations of this species represent 2% of gull observations. It breeds in the Arctic tundra and migrates coastally and over the open ocean to overwintering sites in Central America. Predicted density values from Leirness et al. (2021) in and near the MBWEA are highest in spring but are low from spring to fall compared to the remaining coastwide distribution of this species (Table 6.1, Figure B.29). Data were insufficient to create a model for winter.

Black-legged kittiwakes represent 3% of gulls observed during at-sea surveys (Dick 2016). This small gull is a migrant in the CCS; it breeds in coastal areas of Alaska and northern Canada. It feeds on fish and zooplankton, foraging by surface feeding or plunge diving often in large groups of other kittiwakes and gulls where food is abundant. These birds prefer to forage over the continental shelf and slope in areas where upwelling is concentrated. This species is one of the few gulls that are not well adapted to human environments and are not opportunistic foragers of trash or landfills. Because this species forages and overwinters offshore, it is more likely to be found in the MBWEA and vicinity. Density models of black-legged kittiwakes predict the highest concentrations of this species in or near the MBWEA in winter, with higher densities to the north than in the MBWEA itself (Leirness et al. 2021; Figure B.30). Overall, relative densities of this species in and around the MBWEA are very low in spring and fall and low in winter compared to the CCS as a whole (Table 6.1). Data were insufficient to create a model for summer, although predicted density models from Dick (2016) indicate low relative densities in summer.

Eight tern species were observed during at-sea surveys in the CCS including California breeding species elegant tern (*Thalasseus elegans*), and Caspian tern *(Hydroprogne caspia*), and migrant species Arctic tern (*Sterna paradisaea*), royal tern (*T. maximus*), common tern (*S. hirundo*). Less common breeding species will be included in the Rare or Data Deficient Seabirds section below: least tern (*Sternula antillarum browni*), Forster's tern (*Sterna forsteri*), and black skimmer (*Rynchops niger*). These species represent 0.8% of all seabird observations (Dick 2016).

The species described below are plunge-divers, foraging on fish and large zooplankton in surface waters, concentrating in coastal areas including nearshore, estuarine, and bay habitats. They are often seen foraging and roosting in mixed species flocks, including other terns, gulls, and pelicans. Only elegant terns are listed by the IUCN (2021) as Near Threatened, although their global population is stable. The other five species are listed as Least Concern, with variable population trends (Table 6.2). Because these species use a variety of marine and inland habitats, threats range widely from human and introduced species disturbance at nest and roost sites, climate change and inundation of nest sites, and loss of habitat.

Two species of large terns were observed during at-sea surveys in the CCS, one of which is the **Caspian tern**, representing 15% of all terns observed (Dick 2016). Caspian terns are the largest bodied of the tern group, with an increasing global population. They breed in coastal and inland areas; in California they are mostly coastal from the San Francisco Bay area to Monterey Bay. The Pacific population migrates and overwinters along coastal California and eastern and central Mexico. Leirness et al. (2021) modeled predicted relative density in and near the MBWEA as being very low in spring and summer; of those two seasons, local density was highest in summer (Table 6.1, Figure B.31). Data were insufficient to create models for fall and winter. Dick (2016) found that predicted relative density for this species in and near MBWEA was very low year-round.

Royal terns are another large tern and represent 8% of all terns observed (Dick 2016) and have a stable global population. They have a small breeding population in southern California as well as in Baja California, Baja California Sur, and Nayarit, Mexico. The non-breeding distribution extends as far north as Morro Bay, California. These birds are a marine species, and tend to concentrate in coastal areas, although they can forage far offshore even during breeding season. **Elegant terns** are medium-sized terns, representing 43% of terns observed in the CCS, 0.3% of seabirds (Dick 2016). They breed in southern California and islands off both coasts of Baja California and Baja California Sur Mexico. They migrate both north and south from their breeding range, with the northern range extending to southern Oregon. When migrating and foraging, they tend to congregate in nearshore and in upwelling areas, within 16km (10 mi) of the coast. Leirness et al. (2021) created a predicted density model for royal and elegant terns combined, including terns that could not be clearly identified as royal or elegant. Numerically, elegant terns were predominant from spring to fall, with unidentified royal/elegant terns observed most often in the winter, followed by royal terns. These models indicate very low predicted density values in and near the MBWEA relative to the CCS from spring to fall (Table 6.1). Data were insufficient to create a winter model. Local densities were highest in summer, when the distribution of the two species is expanding from southern California (Figure B.32).

Common terns are medium-sized terns and represent 7% of terns observed during at-sea surveys in the CCS (Dick 2016). The status of their global population is currently unknown due the extent of their breeding range but is increasing in the European population. They breed at inland sites in the north of the U.S. and Canada and migrate both inland and along the coast to sites in southern Mexico, Central America, and the Gulf Coast. Offshore of California, they tend to forage over the shelf and shelf slope. **Arctic terns** are a small-bodied tern species which exhibit one of the greatest migratory ranges of all birds. They breed in northern Canada and Alaska and migrate over the sea transequatorially to the Southern Ocean. Their global population is decreasing; however, they represent 19% of terns observed during at-sea surveys in the CCS. Because this species migrates away from land, densities nearshore are likely to be very low. Leirness et al. (2021) created predicted seasonal density models for common and Arctic terns combined, including undifferentiated common/Arctic terns although data were insufficient for a winter model. For spring through fall, these models are driven by Arctic tern numbers, whereas in the winter, the majority of observations are undifferentiated between the two species. Relative to the CCS, predicted densities were low in spring and fall, and very low in summer in and around the MBWEA (Table 6.1). Local densities were highest in fall when the density distribution of the two species extends offshore and to the south (Figure B.33).

Jaegers and Skuas

Jaegers are migrants in the CCS and represent 0.4% of seabirds observed during at-sea surveys (Dick 2016). Three species have been observed in California: pomarine jaeger (*Stercorarius pomarinus*), parasitic jaeger (*S. parasiticus*), and long-tailed jaeger (*S. longicaudus*). All three species are kleptoparasites, actively stealing prey from other seabirds, but will also forage on fish, carrion, and ship discards. They breed in the Arctic, and “winter” in the Southern Ocean. They all have stable global populations and are listed by the IUCN (2021) as Least Concern (Table 6.2). As Arctic breeders, they are subject to the impacts of climate change, sea level rise, disturbance at nesting sites, and loss of forage and breeding habitat. Their populations may also be impacted by oil spills, pollutants, and heavy metal contamination.

Pomarine jaegers represent 48% of jaegers observed during at-sea surveys in the CCS (Dick 2106). This species tends to migrate and forage over the continental shelf and slope and is not common nearshore. This was the only jaeger species with sufficient observations to warrant model development for all four seasons using single-species data. Predicted density models indicate low density winter through summer, but moderate density in fall in and near the MBWEA compared to the remainder of the CCS (Leirness et al. 2021; Table 6.1). For the MBWEA, predicted density values are an order of magnitude greater in the fall than the other seasons, greatest near the shore coast-wide and decreasing with distance from land (Figure B.34).

Parasitic jaegers and **long-tailed jaegers** are less commonly observed during at sea surveys in the CCS, representing 28% and 18% of jaegers observed respectively (Dick 2016). Parasitic jaegers migrate and overwinter closer to shore than the other two species and may be observed from shore. Long-tailed jaegers are the most pelagic of the three species, migrating at or beyond the shelf slope. Leirness et al. (2021) combined these two species to create models for spring, summer, and fall. Observation data for winter and spring were dominated by parasitic jaegers, with long-tailed jaegers making up the majority of observations in summer and fall. Predicted density models for these seasons indicate low density in and near the MBWEA compared to the remainder of the CCS (Table 6.1). Highest density values are predicted in and near the MBWEA in the fall, with densities increasing to the north and offshore (Figure B.35). Dick (2016) predicted winter densities of both species in the MBWEA would be similar to spring and summer.

Leirness et al. (2021) also created a combined jaeger species model, including observations of the three species as well as undifferentiated parasitic and long-tailed jaegers, and unidentified jaegers in general. In these models, pomarine jaeger dominated observations in spring, fall, and winter, whereas long-tailed jaeger was most numerous in summer. Highest predicted density values in the MBWEA were in the fall, similar to the single and dual species models (Figure B.36). Compared to the CCS, predicted densities of the combined jaeger species in the MBWEA are low year-round (Table 6.1). In winter and spring, distributions were predicted to be denser over and just beyond the continental shelf, whereas offshore areas had higher values in summer and fall.

South polar skuas breed in the Antarctic and migrate over an extremely wide range including the North Pacific in spring and fall. They are more common offshore past the shelf break and slope. Similar to jaegers, they forage on fish during migration, but are known for being kleptoparasites and scavengers. Data availability for this species was limited to fall, and the predicted density model indicates low densities in and near the MBWEA, with higher densities to the west of the shelf break from San Francisco to northern Washington (Leirness et al. 2021, Table 6.1, Figure B.37).

Pelicans

California brown pelicans (*Pelecanus occidentalis californicus*) are year-round species in the CCS although local population sizes vary due to seasonal migration and breeding patterns. The majority of pelicans breed on islands off Baja California, Baja California Sur, Sonora, and Nayarit, Mexico, with the remainder breeding on Anacapa and Santa Barbara Islands in California. In central California, it is common to see pelicans from April to November, then it becomes rare to uncommon in December to March or April during which time adults and some sub-adults are concentrated at their breeding grounds (CDFG 2005). The brown pelican feeds almost entirely on fish that are caught by diving from heights of 6-12 m (20-40 ft) and occasionally from up to 20 m (66 ft) in the air (CDFG 2005). These birds can travel in large, dispersed flocks and are known to participate in dense, multi-species foraging flocks when prey species are concentrated at the surface, sometimes by co-foraging marine mammals and large predatory fish. In general, this species is coastal, foraging at or within the edge of the continental shelf.

Brown pelicans are considered a species of Least Concern by the IUCN (2021) and were removed from the U.S. Endangered Species list in 2009 after having been listed as endangered since 1970 (Table 6.2). The global population is thought to be increasing; however, recent Pacific coast breeding declines and nesting failures may have future impacts on the local population. Risks to the population include oil spills and pollution, loss of forage due to fishing and harvesting, and human disturbance at breeding and roosting sites.

Leirness et al. (2021) found that densities of this species were consistently very low in and around the MBWEA compared to the CCS overall (Table 6.1), as the MBWEA is located over the shelf break, and this species tends to concentrate near shore. The highest predicted densities of pelicans in the MBWEA were in the fall (Figure B.38), as birds are gathering to return to their breeding grounds from northern foraging areas. In general, the models indicate a wider distribution over the Southern California Bight than in any other area along the contiguous U.S. west coast, although this varies seasonally.

Phalaropes

Phalaropes are shorebirds that migrate and forage in aquatic marine environments. While they are shorebirds, they have lobed toes which allow them to swim on the surface of bodies of water. They occur commonly off the California coast as they migrate from Arctic nesting areas to their wintering areas in South and Central America. Two species are observed during at-sea surveys in the CCS: **red-necked phalaropes** (*Phalaropus lobatus*) and **red phalaropes** (*P. fulicarius*). A third species, **Wilson's phalarope** (*P. tricolor*), is a resident of coastal marshes and wetlands but is almost never observed at sea. The red phalarope tends to be more concentrated over the continental slope than the red-necked phalarope, which is found relatively closer to shore. In ocean environments, these birds are surface gleaners, foraging for zooplankton and fish eggs or larvae while they float on the water's surface.

Red and red-necked phalaropes are considered species of Least Concern by the IUCN (2021), although the global population trend of red phalaropes is unknown, and of red-necked phalaropes is decreasing (Table 6.2). Populations of these birds are threatened by breeding and migration habitat alteration due to climate change, and oil exposure and pollution in the marine environment.

Due to the nature of the data used, Leirness et al. (2021) combined observations of the three phalarope species, as well as unidentified phalaropes, to create seasonal predicted density models. These birds are commonly observed during at-sea surveys: red-necked phalaropes represent 3.6% of all birds observed, whereas red-phalaropes make up 2.8% of observations (Dick 2016). Phalaropes can be difficult to differentiate at sea, especially in non-breeding plumage, such that anywhere from 41% (spring) to 71% (fall) of phalaropes were unidentified in datasets in Leirness et al. (2021). When species were identified, red-necked phalarope represented the majority of identified phalaropes in spring and summer, whereas red phalarope made up more of the observations in fall and winter. The proportion of Wilson's phalaropes observed during surveys was negligible. The combined phalarope species models indicate that predicted densities in and near the MBWEA are moderate in winter and spring, and low in summer and fall compared to the CCS as a whole (Table 6.1). Overall, local densities are highest in the spring, with all seasonal models illustrating nearshore concentrations contrasted with widely dispersed offshore distribution patterns (Figure B.39).

Petrels

Petrels are migrants in the CCS and are not commonly observed during at-sea surveys because they tend to utilize habitats that are greater than 100 nm (185 km) from shore. Five species were observed during surveys, with total counts representing 0.1% of the total number of birds observed (Dick 2016). Most common was Cook's petrel (*Pterodroma cookii*), followed by mottled petrel (*P. inexpectata*, one observation, multiple individuals), Murphy's petrel (*P. ultima*), black petrel (*P. parkinsoni*, one individual), and Stejneger's petrel (*P. longirostris*, one individual). Murphy's and Cook's petrels are most likely to be seen far offshore of northern California during the spring, and rarely during the remainder of the year (Leirness et al. 2021). These species tend to breed on a limited number of small, isolated islands in the south or south-western Pacific. They are vulnerable to sea level rise, introduced predators, entanglement in fishing gear, and habitat loss. Only Murphy's petrels are considered by the IUCN (2021) to be of Least Concern; mottled petrels are listed as Near Threatened, and the remaining species are considered Globally Endangered with Cook's, Parkinson's, and Stejneger's petrels listed as Vulnerable (Table 6.2).

Leirness et al. (2021) were able to incorporate additional survey data with adequate counts to create seasonal models for Cook's and Murphy's petrels. **Cook's petrel** densities were predicted to be very low in the MBWEA compared to the CCS as a whole from spring through fall and were highest in the MBWEA in spring (Table 6.1, Figure B.40). Data were insufficient to create a model for winter. Data were only sufficient to create a model for **Murphy's petrel** in spring, when densities in the MBWEA were predicted to be low compared to the CCS (Table 6.1, Figure B.41). Because these birds are highly pelagic and generally occur far offshore beyond the continental shelf, they are likely uncommon in the MBWEA.

Storm-Petrels

There are seven species of storm-petrels that have been observed during at-sea surveys, comprising 4.4% of all seabirds observed: Leach's storm-petrel (*Hydrobates leuchorhous*), fork-tailed storm-petrel (*H. furcatus*), ashy storm-petrel (*H. homochroa*), black storm-petrel (*H. melania*), least storm-petrel *(H. microsoma*), wedge-rumped storm-petrel (*H. tethys*), and Wilson's storm-petrel (*Oceanites oceanicus*). Least, wedge-rumped, and Wilson's storm-petrels are included in the section on Rare or Data Deficient Seabirds below. Storm-petrels are surface feeders, foraging on zooplankton and nekton, and occasionally small fish. They commonly forage in areas above and beyond the continental shelf where upwelling supports their prey populations. Almost all storm-petrels are nocturnal at their breeding sites, presumably to avoid predators.

The four more commonly documented storm-petrel populations are all listed as being potentially in decline. Ashy storm-petrels are listed by the IUCN (2021) as Endangered and are a California Species of Special Concern (breeding, 2nd priority), as their global population is small (estimated at 3,500-6,700 birds) and decreasing. Leach's storm-petrel is listed by the IUCN (2021) as Vulnerable, with a decreasing global population. Fork-tailed and black storm-petrels are both listed as Least Concern by the IUCN (2021), but are California Species of Special Concern (breeding, 3rd priority). The global populations of fork-tailed storm-petrels are increasing, whereas black storm-petrels are decreasing (Table 6.2). These species are threatened by pollution and oil spills, overfishing, habitat degradation, human disturbance, and habitat modification in breeding areas, and introduced predators and disease.

Leach's storm-petrel is the most common storm-petrel observed during at-sea surveys in the CCS; they represent 86% of storm-petrels observed, and 3.8% of all seabirds (Dick 2016). This species breeds in the North Pacific and Atlantic oceans, with the North American population occupying isolated island colonies extending from Alaska to northern Mexico. As with Cassin's auklets, this species does not breed in San Luis Obispo or Monterey counties, but the MBWEA is almost equidistant from the two closest breeding sites in the Channel Islands and the Farallon Islands (CDFG 2010b). Outside of the breeding season, they tend to disperse widely into the tropics of the central and eastern Pacific, although they can be observed foraging over the continental slope west of California. Leirness et al. (2021) predicts densities of Leach's storm-petrels are highest in and near the MBWEA in summer, but densities are very low year-round compared to the entire CCS where densities are higher well offshore and to the north (Table 6.1, Figure B.42).

Observations of **fork-tailed storm-petrels** represent 3.6% of all storm-petrels observed during at-sea surveys (Dick 2016). The majority of breeding habitat for this species is in the North Pacific but terminates in northern California. Breeding occurs on six small islets off Del Norte and Humboldt counties (CDFG 2010b). Outside of the breeding season, these birds are highly pelagic, foraging beyond the continental shelf and usually well north of California. Predicted density models indicate fork-tailed storm petrels have very low densities in and near the MBWEA year-round compared to the CCS as a whole (Leirness 2021; Table 6.1). Local densities are highest in the fall, up to an order of magnitude greater than the other seasons (Figure B.43). Regardless of season, the predicted density models indicate a concentration of the distribution of this species offshore to the north of the MBWEA.

Ashy storm-petrels have a relatively restricted range extending from Cape Mendocino to the northern portion of western Baja California Sur. They represent 3.3% of storm-petrels observed during at-sea surveys in the CCS (Dick 2016). The vast majority of the population breeds on the Farallon Islands and the Channel Islands. None of the seabird colonies within 30 nm (56 km) of the MBWEA supported populations of ashy storm-petrels in 2002 (CDFG 2010b). During the breeding season, they forage near the edge of the continental shelf near their nesting areas. In winter, they concentrate over deep waters, especially in Monterey Bay (Birds of the World 2021). This species does not exhibit the long-distance, open-ocean migration strategy of other storm-petrels and tends to remain within the southern CCS during the non-breeding season. Leirness et al. (2021) found that predicted ashy storm-petrel density in the MBWEA was highest in summer (Figure B.44), when densities in central and southern California waters are highest, even though populations are concentrated around breeding areas in the Channel Islands and Farallon Islands. Relative to the CCS, the modeled values in and near the MBWEA were low in spring and very low in summer and fall (Table 6.1). Data were insufficient to create a model for winter.

Black storm-petrel is a warm-water species which inhabits the west coast of North, Central, and South America. It represents 5.6% of storm-petrels observed during at-sea surveys in the CCS, with the majority of these observations occurring south of San Francisco Bay. This species breeds in the Channel Islands and islands on the Pacific and Gulf of California coasts of Baja California, Mexico. It is uncommon north of Monterey Bay during the breeding season. However, in fall and winter it disperses offshore over the shelf slope, with a portion of the population traveling north to the vicinity of Point Arena. Leirness et al. (2021) modeled predicted density for this species for spring through fall, indicating very low densities in the MBWEA relative to the CCS in spring and summer, and low densities in fall (Table 6.1). Data were insufficient to create a model for winter. Densities within the MBWEA were predicted to be highest in summer, similar to ashy storm-petrels (Figure B.45).

Sea ducks and geese

Scoters are migratory in California and concentrate in coastal areas as they forage in sub- and inter-tidal waters. They often travel over the shallower portions of the continental shelf in long skeins of multiple birds. Leirness et al. (2021) created a combined predicted density model for three species including **surf scoter** (*Melanitta perspicillata*), **white-winged scoter** (*M. deglandi*), and **black scoter** (*M. americana*). These models also included unidentified scoters which made up from 17-31% of scoter observations depending on the season. Black scoters are listed as Near Threatened by the IUCN (2021), with a decreasing population trend; both surf and white-winged scoters are listed as being of Least Concern although their populations are also decreasing (Table 6.2). Observations of surf scoter were predominant in fall and winter, whereas white-winged scoter was the more commonly observed species in spring and summer; each species likely drove the density models for those seasons respectively. In all seasons, especially summer, scoter densities in the MBWEA are likely to be very low, as this species prefers to forage near shore, and does not breed in the area. Compared to the other seasons, the predicted density of scoters is highest during fall in the MBWEA (Table 6.1, Figure B.46).

*Table 6.1. Local residency status and average predicted density ranks (based on Leirness et al. 2021) for select seabird species in and near the MBWEA. Average predicted density ranks are compared to the maximum predicted density in the CCS for a given season. Ranks were calculated as follows: local average density/CCS max ≤ 0.01 = very low, >0.01 and ≤0.1 = low, >0.1 and ≤0.5 = moderate, >0.5 = high. Bold text indicates the season with the highest average predicted density value (not rank) in or near the MBWEA. * indicates no model data were generated.*

Species	Local Residency Status	Average Predicted Density Rank			
		Winter	Spring	Summer	Fall
Laysan albatross	migrant	very low	**low**	*	*
Black-footed albatross	migrant	very low	**low**	low	very low
Common murre	resident	**very low**	very low	very low	very low
Pigeon guillemot	resident	*	**very low**	very low	*
Scripps's/Craveri's/ Guadalupe murrelet	migrant	*	**very low**	*	*
Marbled murrelet	migrant	*	very low	**very low**	*
Ancient murrelet	migrant	*	**very low**	*	*
Cassin's auklet	resident	**low**	very low	very low	very low
Rhinoceros auklet	resident	**low**	very low	very low	low
Tufted puffin	resident	*	very low	**very low**	*
Brandt's cormorant	resident	*	**very low**	very low	*
Pelagic cormorant	resident	*	**very low**	very low	*
Double-crested cormorant	resident	*	very low	**very low**	*
Cormorant spp	resident	**very low**	*	*	very low
Sooty/short-tailed/flesh-footed shearwater	migrant	low	very low	**very low**	very low
Pink-footed shearwater	migrant	*	low	**low**	low
Buller's shearwater	migrant	*	*	very low	**low**
Black-vented shearwater	migrant	very low	very low	*	**very low**
Northern fulmar	migrant	**low**	low	very low	very low
Common loon	migrant	*	**very low**	very low	*
Red-throated loon	migrant	*	**very low**	very low	*
Loon spp (4)	migrant	very low	very low	very low	**moderate**
Western/Clark's Grebe	migrant	very low	very low	*	**very low**
Western/glaucous-winged Gull	resident	very low	**very low**	very low	very low
Herring/Iceland gull	migrant	**low**	low	very low	very low
California gull	migrant	**very low**	very low	very low	very low
Heermann's gull	migrant	very low	*	**very low**	very low

Species	Local Residency Status	Average Predicted Density Rank			
		Winter	Spring	Summer	Fall
Bonaparte's gull	migrant	very low	**low**	*	very low
Sabine's gull	migrant	*	**low**	low	low
Black-legged kittiwake	migrant	**low**	very low	*	very low
Caspian tern	migrant	*	very low	**very low**	*
Royal/elegant tern	migrant	*	very low	**very low**	very low
Common/Arctic tern	migrant	*	low	very low	**low**
Pomarine jaeger	migrant	low	low	low	**moderate**
Parasitic/long-tailed jaeger	migrant	*	low	low	**low**
Jaeger spp (3)	migrant	low	low	low	**low**
South polar skua	migrant	*	*	*	**low**
Brown pelican	migrant	very low	very low	very low	**very low**
Phalarope spp (3)	migrant	moderate	**moderate**	low	low
Cook's petrel	migrant	*	**very low**	very low	very low
Murphy's petrel	migrant	*	**low**	*	*
Leach's storm-petrel	resident	very low	very low	**very low**	very low
Fork-tailed storm-petrel	resident	very low	very low	very low	**very low**
Ashy storm-petrel	resident	*	low	**very low**	very low
Black storm-petrel	resident	*	very low	**very low**	low
Scoter spp (3)	migrant	very low	very low	very low	**very low**

Rare or Data Deficient Seabirds

Albatross

Short-tailed albatross (*P. albartrus*) breed on two isolated Japanese islands, with one known pair successfully breeding on Midway Atoll in the northwestern Hawaiian island archipelago. They are rare visitors to the West Coast and are not commonly seen during at-sea seabird surveys. The population of short-tailed albatross is estimated to be 1,734 birds (Birds of the World 2021). The IUCN lists this species as Vulnerable, and it is Endangered under the U.S. ESA (Table 6.2). This species is occasionally observed offshore in the CCS, but there are no current records in or near the MBWEA (eBird 2021). Because of their low population numbers, there is no predicted density model for this species for the MBWEA. However, the MBWEA does encompass the shelf break and slope, which is suitable foraging habitat for this species.

Alcids

Horned puffins (*F. corniculata*) are migrants and are rarely observed during at-sea surveys, representing 0.04% of alcids observed (Dick 2016). Breeding sites are found on islands and coastal areas off northern British Columbia, Canada, and Alaska. Their non-breeding distribution is similar to that of tufted puffins in that they disperse to deep pelagic environments well away from the coast outside of the breeding season. Horned puffins are listed as Least Concern by the IUCN (2021) although they are experiencing global population declines (Table 6.2).

Larids

Two species of large gull, the **glaucous gull** (*L. hyperboreus*) and the **kelp gull** (*L. dominicanus*) are rarely observed during at-sea surveys. Glaucous gulls breed in the Arctic and overwinter in the northern CCS, rarely traveling south of Cape Mendocino. Kelp gulls breed and winter in the southern hemisphere and are highly vagrant in the CCS. Both are coastal species and are opportunistic omnivores that have adapted well to human development for the purposes of foraging, similar to many other large gull species. Both species are listed as Least Concern by the IUCN, although global glaucous gull populations are decreasing, while kelp gull populations are increasing. Because of their limited distribution in the area, both species are uncommon in the MBWEA or vicinity.

The **ring-billed gull** (*L. delawarensis*) is a mid-sized gull which represents 1% of gulls observed during at-sea surveys in the CCS. This species is also a migrant in the CCS where it overwinters, although the majority of the population breeds and lives year-round in inland areas across Mexico, the U.S., and Canada. When overwintering, it is highly coastal, commonly found in harbors and estuaries and is rarely observed far from shore. Like other gulls, it has adapted to human development and is omnivorous, congregating at feeding sites whether they are bays, farm fields, or garbage dumps. The global population of this species is increasing, and the IUCN lists it as Least Concern. Due to this species' affinity for nearshore and inland environments, it is uncommon in the MBWEA or vicinity.

Two small gull species, the **short-billed gull** (*L. brachyrhynchus*, formerly **mew gull** until 2021) and **Franklin's gull** (*Leucophaeus pipixcan*), are also rarely observed during at-sea surveys in the CCS. Both species migrate through the CCS and breed in coastal and inland environments, short-billed gulls in Alaska and western Canada, Franklin's gulls in central Canada and the north-central U.S. During migration they inhabit coastal and inland habitats, and are rarely observed away from shore. Short-billed gulls overwinter in the CCS, and their abundance decreases south of Point Conception. Franklin's gulls overwinter along the west coast of South America. As with other gulls, both species are opportunistic omnivores, but short-billed gulls are less likely to utilize anthropogenic food sources. Both species are listed by the IUCN as Least Concern, with global populations of Franklin's gull increasing, whereas the population trend of short-billed gulls is unknown (Table 6.2). Because of their affinity to nearshore and inland habitats, both species are uncommon in the MBWEA and vicinity. For short-billed gull, this is supported by predicted density models which indicate very low densities of this species in and near the MBWEA in all seasons relative to the CCS as a whole (Dick 2016).

The **black skimmer** (*Rynchops niger*) is a large tern with a unique appearance: the lower mandible is much longer than the upper. This facilitates the skimmer's foraging strategy, as it drags the bottom mandible through the water while flying low over the surface, snapping the bill closed when it comes in contact with a prey item. Skimmers represent 0.2% of terns observed during at-sea surveys, as they tend to concentrate in shallow water areas nearshore and in estuaries and bays. In the U.S., they are a coastal species, except for a colony at the Salton Sea, with their northernmost breeding colony in the San Francisco Bay area. The IUCN (2021) lists this species as Least Concern, although the global population is decreasing. The State of California lists it as a Species of Special Concern, 3rd priority (breeding). Because these birds are rarely observed at sea it is likely uncommon in or near the MBWEA.

California least tern (*Sternula antillarum browni*) represents 5.6% of terns observed at-sea in the CCS. This small tern is a colonial nester, breeding in coastal areas from San Francisco Bay area to western Mexico. It is considered a vagrant north of Cape Mendocino. West Coast populations are thought to overwinter in Central America. These birds are commonly observed nearshore, although they will travel some distance from breeding sites to acquire food if resources are limited nearby. They forage in any aquatic habitat, from shallow coastal waters, bays, estuaries, and coastal lakes. At the species level, least terns are listed as Least Concern by the IUCN (2021) although their global population trend is decreasing. The California least tern is listed by the U.S. ESA and by the State of California as Endangered. While this population is heavily monitored, little is known of its non-breeding distribution or at-sea density.

Forster's tern (*Sterna forsteri*) represents 2.6% of terns observed during at-sea surveys in the CCS. They are listed by the IUCN (2021) as Least Concern with an increasing global population. This medium-sized tern has a transcontinental distribution, breeding in the north central U.S., central Canada, and scattered locations throughout the intermountain west. In California, they breed in the greater San Francisco Bay area. The portion of the population that winters on the Pacific coast is common south of Cape Mendocino to Mexico and Central America. Like most terns, these medium-sized birds are piscivorous plunge-divers and are highly social, foraging and roosting in large flocks. At present there are no predicted density distribution models for this species in the CCS.

Storm-petrels

Least storm-petrel, wedge-rumped storm-petrel, and **Wilson's storm-petrel** represent less than 0.08% of all species and 1.8% of storm-petrels observed off California during at-sea surveys. Least storm-petrels nest on islands off western Mexico, and range into California, and are rarely observed north of San Francisco Bay (eBird 2021). This species tends to concentrate over and beyond the continental shelf south of Point Conception. Wedge-rumped and Wilson's storm-petrels are vagrants on the Pacific coast of the U.S. as they are predominantly southern hemisphere species; wedge-rumped storm-petrels nest off the west coast of South America; Wilson's storm-petrels nest in Antarctica and Southern Ocean islands along the west coast of southern Chile. They tend to winter in the open ocean far offshore of their breeding grounds or, in the case of the Wilson's storm-petrel, also off the U.S. Atlantic coast where it is extremely common (Birds of the World 2021). Both species are very uncommon in California waters, with a few observations offshore over the shelf break and beyond, mostly south of San Francisco Bay (eBird 2021). All three species are listed by the IUCN (2021) as being of Least Concern, although the population trend of wedge-rumped storm-petrels is decreasing.

Sea ducks and geese

Black brant (*Branta bernicla nigricans*) is a Pacific coast subspecies of a goose that breeds in the high Arctic. Much of the population migrates and winters along the west coast of the U.S. and northern Mexico, and sometimes travels in large flocks. These birds are primarily herbivores and are therefore limited to feeding in shallow waters when on the ocean or in estuaries or bays. Because of this, they are unlikely to be found far offshore in or near the MBWEA. However, they are common in nearby Morro Bay during fall and winter, an area that supports their preferred forage, eelgrass. From 2007 to 2013, the extent of eelgrass beds in the bay declined 95%, with a corresponding 90% decrease in the overwintering black brant population (MBNEP 2021). Two multi-year eelgrass bed restoration efforts have taken place since 2012. As of 2020, eelgrass coverage in the bay totals 146 acres, 42% of the amount present in 2007 with black brant numbers also tripling to 15% of their high use-day count in 2002 (MBNEP 2021).

Table 6.2. Listing status for seabirds under the IUCN Red List (IUCN 2021). When applicable, status under the U.S. ESA and the California ESA/list of Species of Special Concern is included. IUCN population values are provided where available and indicate the

*number of mature individuals. * indicates species that are included in Leirness et al. 2021 only. ^ indicates species that are included in Dick 2016 only. ~ indicates species that are not included in Leirness et al. (2021) or Dick (2016).*

Common Name	Scientific Name	Population Status	Global Population Trend
Laysan albatross	*Phoebastria immutabilis*	IUCN: Near Threatened	Stable 1,600,000
Black-footed albatross	*Phoebastria nigripes*	IUCN: Near Threatened	Increasing 139,800
Short-tailed albatross~	*Phoebastria albartrus*	IUCN: Vulnerable U.S. ESA: Endangered CA CESA/SSC: Species of Special Concern year round	Increasing 1,734
Common murre	*Uria aalge*	IUCN: Least Concern	Increasing
Pigeon guillemot*	*Cepphus columba*	IUCN: Least Concern	Stable
Marbled murrelet*	*Brachyramphus marmoratus*	IUCN: Endangered U.S. ESA: Threatened CA CESA/SSC: Endangered	Decreasing 240,000-280,000
Scripps's murrelet	*Synthliboramphus scrippsi*	IUCN: Vulnerable CA CESA/SSC: Threatened	Decreasing 10,000-20,000
Guadalupe murrelet	*Synthliboramphus hypoleucus*	IUCN: Endangered CA CESA/SSC: Threatened	Decreasing 5,000
Craveri's murrelet*	*Synthliboramphus craveri*	IUCN: Vulnerable	Decreasing 8,000
Ancient murrelet*	*Synthliboramphus antiquus*	IUCN: Least Concern	Decreasing
Cassin's auklet	*Ptychoramphus aleuticus*	IUCN: Near Threatened CA CESA/SSC: Species of Special Concern - breeding, 3rd priority	Decreasing 3,600,000
Rhinoceros auklet	*Cerorhinca monocerata*	IUCN: Least Concern	Decreasing
Tufted puffin	*Fratercula cirrhata*	IUCN: Least Concern CA CESA/SSC: Species of Special Concern - breeding, 1st priority	Stable 2,300,000
Horned puffin	*Fratercula corniculata*	IUCN: Least Concern	Decreasing 800,000
Brandt's cormorant	*Urile penicillatus*	IUCN: Least Concern	Decreasing
Pelagic cormorant*	*Urile pelagicus*	IUCN: Least Concern	Decreasing
Double-crested cormorant*	*Phalacrocorax auritus*	IUCN: Least Concern	Increasing
Sooty shearwater	*Ardenna grisea*	IUCN: Near Threatened	Decreasing 8,800,000
Pink-footed shearwater	*Ardenna creatopus*	IUCN: Vulnerable	Unknown 59,146
Short-tailed shearwater*	*Ardenna tenuirostris*	IUCN: Least Concern	Decreasing
Flesh-footed shearwater*	*Ardenna carneipes*	IUCN: Near Threatened	Decreasing 148,000
Buller's shearwater*	*Ardenna bulleri*	IUCN: Vulnerable	Stable

Common Name	Scientific Name	Population Status	Global Population Trend
Black-vented shearwater*	*Puffinus opisthomelas*	IUCN: Near Threatened	Unknown 82,000
Northern fulmar	*Fulmarus glacialis*	IUCN: Least Concern	Increasing 7,000,000
Western grebe*	*Aechmophorus occidentalis*	IUCN: Least Concern	Stable 80,000-90,000
Clark's grebe*	*Aechmophorus clarkii*	IUCN: Least Concern	Decreasing 7,300-14,000
Pacific loon	*Gavia pacifica*	IUCN: Least Concern	Increasing
Common loon*	*Gavia immer*	IUCN: Least Concern	Stable
Red-throated loon*	*Gavia stellata*	IUCN: Least Concern	Decreasing
Arctic loon*	*Gavia arctica*	IUCN: Least Concern	Decreasing
Surf scoter*	*Melanitta perspicillata*	IUCN: Least Concern	Decreasing
White-winged scoter*	*Melanitta deglandi*	IUCN: Least Concern	Decreasing
Black scoter*	*Melanitta americana*	IUCN: Near Threatened	Decreasing 350,000-560,000
Black brant~	*Branta bernicla nigricans*	IUCN: Least Concern	Unknown
Long-tailed jaeger	*Stercorarius longicaudus*	IUCN: Least Concern	Stable 250,000-750,000
Parasitic jaeger	*Stercorarius parasiticus*	IUCN: Least Concern	Stable 400,000-600,000
Pomarine jaeger	*Stercorarius pomarinus*	IUCN: Least Concern	Stable 400,000
South polar skua*	*Stercorarius maccormicki*	IUCN: Least Concern	Stable 6,000-15,000
Bonaparte's gull	*Chroicocephalus philadelphia*	IUCN: Least Concern	Increasing
Short-billed/Mew gull^	*Larus brachyrhynchus*	IUCN: Least Concern	Unknown
California gull	*Larus californicus*	IUCN: Least Concern	Decreasing
Herring gull	*Larus argentatus*	IUCN: Least Concern	Decreasing
Iceland gull*	*Larus glaucoides*	IUCN: Least Concern	Stable
Glaucous-winged gull	*Larus glaucescens*	IUCN: Least Concern	Increasing
Western Gull	*Larus occidentalis*	IUCN: Least Concern	Increasing
Heermann's gull	*Larus heermanni*	IUCN: Near Threatened	Unknown 350,000
Sabine's gull	*Xema sabini*	IUCN: Least Concern	Stable 340,000
Black-legged kittiwake	*Rissa tridactyla*	IUCN: Vulnerable	Decreasing
Caspian tern	*Hydroprogne caspia*	IUCN: Least Concern	Increasing
Common tern*	*Sterna hirundo*	IUCN: Least Concern	Unknown
Arctic tern*	*Sterna paradisaea*	IUCN: Least Concern	Decreasing
Royal tern*	*Thalasseus maximus*	IUCN: Least Concern	Stable
Elegant tern*	*Thalasseus elegans*	IUCN: Near Threatened	Stable
Brown pelican	*Pelecanus occidentalis*	IUCN: Least Concern	Increasing
Red phalarope	*Phalaropus fulicarius*	IUCN: Least Concern	Unknown
Red-necked phalarope	*Phalaropus lobatus*	IUCN: Least Concern	Decreasing

Common Name	Scientific Name	Population Status	Global Population Trend
Wilson's phalarope*	*Phalaropus tricolor*	IUCN: Least Concern	Increasing
Cook's petrel*	*Pterodroma cookii*	IUCN: Vulnerable	Increasing 670,000
Murphy's petrel*	*Pterodroma ultima*	IUCN: Least Concern	Unknown
Mottled petrel	*Pterodroma inexpectata*	IUCN: Near Threatened	Decreasing
Parkinson's/black petrel	*Pterodroma parkinsoni*	IUCN: Vulnerable	Stable 5,500
Stejneger's petrel	*Pterdroma longirostris*	IUCN: Vulnerable	Decreasing 262,000
Leach's storm-petrel	*Hydrobates leuchorhous*	IUCN: Vulnerable	Decreasing 6,700,000-8,300,000
Fork-tailed storm-petrel	*Hydrobates furcatus*	IUCN: Least Concern CA CESA/SSC: Species of Special Concern - breeding, 3rd priority	Increasing 4,000,000
Ashy storm-petrel*	*Hydrobates homochroa*	IUCN: Endangered CA CESA/SSC: Species of Special Concern - breeding, 2nd priority	Decreasing 3,500-6,700
Black storm-petrel*	*Hydrobates melania*	IUCN: Least Concern CA CESA/SSC: Species of Special Concern - breeding, 3rd priority	Decreasing 600,000

Availability of Data on Seabirds

For the California Current in general and the MBWEA in particular, seabird density distribution models (spatial data) are available from Leirness et al. (2021) and Dick (2016). There are several long-term observational datasets available from multiple sources, a number of which are utilized and cited in both of these studies. However, raw observational data alone may be insufficient to determine population size, distribution, seasonality, and the influence of wind energy development on local seabird populations.

Adams et al. (2019) have compiled information on programs that collect seabird (and marine mammal) data that may be useful in completing environmental risk assessments for offshore energy activities. The Point Conception to Point Sur area covers the MBWEA and is split between the southern portion of the Central California region and the northern half of the southern California region. The database created from the survey information contains 202 seabird research and monitoring records for this area. The records were collected from colleges and universities, NGOs, and government agencies. This compilation also lists other sources of seabird data that did not meet the criteria to be included in the initial survey effort but represent consistent and standardized long-term programs. For seabirds, data on at-sea behavior and distribution were determined to be of highest value to inform potential impacts of offshore energy development on those species (Adams et al. 2019). The complete database is available online (Lafferty et al. 2019, Dataset Table 5.3, Marine Mammal section of this document).

For seabird life history data, one of the most complete assemblages of information available is Birds of the World, https://birdsoftheworld.org, a compilation of comprehensive data for over ten thousand bird species. Access requires a subscription. Some of these data are available in summarized or limited form on related sites including All About Birds, https://allaboutbirds.org, another Cornell Lab of Ornithology product, the Audubon Field Guide, https://www.audubon.org, and eBird, https://ebird.org.

General Status and Threats to Seabirds

Fisheries bycatch directly impacts some seabird species, and human exploitation of fish prey (fisheries competition) indirectly affects some species. Pollution, including oil, chemical, and sewage spills, plastics, and contaminants affect survival and reproduction of many seabird species. Exposure to or ingestion of pollutants and plastics is increasingly common in seabird populations. Habitat alteration and human disturbance along coastlines affects seabird breeding, roosting and foraging locations, as does the introduction of exotic species. Introduced or human-attracted predators can cause partial or complete breeding failure as well as loss of members of the adult breeding population. Introduced species may also cause displacement of roosting or breeding seabirds or introduce novel diseases that can impact the population. Finally, climate related influences, such as marine heat waves, sea temperature extremes and shifts, and sea-level rise may cause shifts or loss of breeding, roosting, or migratory habitat (IUCN 2021, Birds of the World 2021).

HT Harvey and Associates (2020) compiled a list of potential impacts to seabirds of offshore wind development and operation in the Humboldt Wind Energy Area (HWEA), north of the MBWEA. While the document content focuses on the HWEA and surrounding area, the overall potential disturbance and environmental effects are applicable to the MBWEA. For seabirds, it summarizes the risks of collision or avoidance, artificial lighting, and habitat alteration. Noting existing uncertainties of the interactions between seabirds and wind energy operations and maintenance, extensive monitoring may be required, as well as flexibility in program operations.

Data Gaps and Limitations

Spatially explicit data illustrating local species-specific migratory patterns and data flight behaviors (flight height, etc.) of seabirds is rare or highly localized. At-sea survey data may not be capturing important migratory pathways or routes that are intensively used such as during foraging to and from breeding and nesting sites. Collision risk from wind turbines is related to flying or soaring height, which is not currently captured in at-sea surveys. Data on the distribution of flying height needs to be collected by categorizing the altitude of birds that are seen in flight. For the MBWEA, this is especially important for pelagic species which are not easily observed from shore such as albatrosses, loons, grebes, shearwaters, and petrels. Shearwaters and loons in particular may experience an acute risk from offshore wind energy installations due to their flight and travel behaviors as well as their tendency to migrate in large flocks.

At-sea surveys are generally conducted on a coarse scale over a large area. To improve information about species that utilize the area in and around the MBWEA, future surveys will need to be done on a finer spatial and temporal scale than they are currently. There may also be a lag time between collection and release of observation data, and additional time before the data are compiled and standardized in models which cover large areas and time scales. It is inherent in the data collection process that the data may not be available or analyzed for a few years after it is collected. Due to the nature of at-sea data collection, data discontinuity is inherent in many datasets due to funding and logistics. This, coupled with delays in publishing or analyzing data may result in oversight of short-term trends or alterations in behavior or populations of birds that utilize an area.

Summary Tables of Selected Seabird Datasets

Dataset Table 6.1: Modeling at-sea density of marine birds

Dataset Title	Modeling at-sea density of marine birds to support renewable energy planning on the Pacific Outer Continental Shelf of the contiguous United States.
Species/ Resource	Surf Scoter, White-Winged Scoter, Black Scoter, Western Grebe, Clark's Grebe, Wilson's Phalarope, Red-necked Phalarope, Red Phalarope, South Polar Skua, Parasitic Jaeger, Long-tailed Jaeger, Pomarine Jaeger, Common Murre, Pigeon Guillemot, Marbled Murrelet, Scripps's Murrelet, Guadalupe Murrelet, Craveri's Murrelet, Ancient Murrelet, Cassin's Auklet, Rhinoceros Auklet, Tufted Puffin, Black-legged Kittiwake, Sabine's Gull, Bonaparte's Gull, Heermann's Gull, California Gull, Western Gull, Glaucous-winged Gull, Herring Gull, Iceland Gull, Caspian Tern, Common Tern, Arctic Tern, Royal Tern, Elegant Tern, Red-throated Loon, Arctic Loon, Pacific Loon, Common Loon, Yellow-billed Loon, Laysan Albatross, Black-footed Albatross, Fork-tailed Storm-Petrel, Leach's Storm-Petrel, Ashy Storm-Petrel, Black Storm-Petrel, Northern Fulmar, Murphy's Petrel, Cook's Petrel, Buller's Shearwater, Pink-footed Shearwater, Short-tailed Shearwater, Sooty Shearwater, Flesh-footed Shearwater, Black-vented Shearwater, Brandt's Cormorant, Pelagic Cormorant, Double-crested Cormorant, Brown Pelican
Abstract	This report describes the at-sea spatial distributions of marine birds in Pacific OCS waters off the contiguous U.S. to inform marine spatial planning in the region. The goal was to estimate long-term average spatial distributions for marine bird species using all available science-quality transect survey data and numerous bathymetric, oceanographic, and atmospheric predictor variables. We developed seasonal habitat-based spatial models of the at-sea distribution for 33 individual species and 13 taxonomic groups of marine birds throughout the study region. A statistical modeling framework was used to estimate numerical relationships between bird sighting data (i.e., standardized counts) and a range of temporal (e.g., Pacific Decadal Oscillation [PDO] index), spatially static (e.g., depth), and spatially dynamic (e.g., sea surface chlorophyll-a concentration) environmental variables. The estimated relationships were then used to predict spatially explicit long-term average density (individuals per km2) throughout the study area for each species/group in each of four seasons. Bird sighting data came from multiple scientific survey programs and consisted of at-sea counts of birds collected between 1980 and 2017 using boat-based and fixed-wing aerial transect survey methods. Spatial environmental variables were derived from remote sensing satellite data and an ocean dynamics model.
Strength/ Weakness	The maps represent model-derived spatial predictions of long-term average density. They do not provide predictions of the actual number of individuals of a given species or taxonomic group that would be expected in a given area; they only indicate where a given species/group may be more or less abundant. Also, the maps do not provide predictions of density at a specific time; they only indicate seasonal distributions averaged across the timeframe of the survey dataset. In addition to density estimate models, model performance metrics and estimated uncertainty were calculated for each species/season model. It is important to recognize that the model performance metrics mainly reflect the statistical fit of the models to the existing real-world data. They reflect only the data that were analyzed, and they do not reflect the quality of model predictions away from the original data. As with the model performance metrics, the estimated uncertainty in the model predictions is conditional on the model and the data. It does not capture all of the uncertainty associated with our model predictions. Nevertheless, the

	estimated uncertainty is an important indication of the precision of the model predictions, and it should be an integral consideration when using the model predictions.
File Name	Model_input_predictors.zip; model_output_predictions.zip
Data Type	Raster
Spatial Extent	Northern Baja California to Vancouver Island; UL 49 -131, LR 29.8 -117.1; 2 km cells
Time Scale	Data from 1980-2017; products are seasonal (winter, spring, summer, fall); published in 2021
Contact/Source	Jeffrey Leirness, jeffery.leirness@noaa.gov, Bureau of Ocean Energy Management Data and Information Systems
License/Use Restrictions	Public data. Cite as: Leirness, Jeffery B.; Adams, Josh; Ballance, Lisa T.; Coyne, Michael; Felis, Jonathan J.; Joyce, Trevor; Pereksta, David M.; Winship, Arliss J. (2022). NCCOS Assessment: Modeling at-sea density of marine birds to support renewable energy planning on the Pacific Outer Continental Shelf of the contiguous United States (NCEI Accession 0242882). [indicate subset used]. NOAA National Centers for Environmental Information. Dataset. https://www.ncei.noaa.gov/archive/accession/0242882. Accessed [date].
Citation Info	Report citation: Leirness JB, Adams J, Ballance LT, Coyne M, Felis JJ, Joyce T, Pereksta DM, Winship AJ, Jeffrey CFG, Ainley D, Croll D, Evenson J, Jahncke J, McIver W, Miller PI, Pearson S, Strong C, Sydeman W, Waddell JE, Zamon JE, Christensen J. 2021. Modeling at-sea density of marine birds to support renewable energy planning on the Pacific Outer Continental Shelf of the contiguous United States. Camarillo (CA): U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2021-014. 385 p. https://espis.boem.gov/final%20reports/BOEM_2021-014.pdf
Online Link	https://doi.org/10.25921/xqf2-r853
Metadata Link	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:0242882;view=iso

Dataset Table 6.2: Seabird Distribution Models in the California Current System

Dataset Title	Seabird Distribution Models in the California Current System
Species/ Resource	Black-footed Albatross, Laysan Albatross, Cassin's Auklet, Common Murre, Rhinoceros Auklet, Tufted Puffin, Scripps's Murrelet/Guadalupe Murrelet, Brandt's Cormorant, Northern Fulmar, Pink-footed Shearwater, Sooty Shearwater, Pacific Loon, Black-legged Kittiwake, Bonaparte's Gull, California Gull, Caspian Tern, Glaucous-winged Gull, Heermann's Gull, Herring Gull, Long-tailed Jaeger, Mew Gull, Parasitic Jaeger, Pomarine Jaeger, Sabine's Gull, Western Gull, Brown Pelican, Red Phalarope, Red-necked Phalarope, Fork-tailed Storm-Petrel, Leach's Storm-Petrel
Abstract	Marine conservation measures such as marine protected areas (MPAs) rely on a robust understanding of the relationships between species and their environment. We developed species-specific, spatially explicit seabird-habitat association models to identify multispecies foraging aggregations (hotspots) in the California Current System. Using negative binomial regression, we built and validated models for 30 species using 15 years (1997-2012) of seabird survey data from multiple cruises spanning the California Current combined with predictor variables derived from bathymetric and remotely sensed oceanographic data as well as climate indices. We predicted species-specific abundances during four focal months (February, May, July, and October). Predicted abundances were averaged by month across all years and by year and standardized. Standardized predicted means for all species were averaged for each focal month, for each year, and across all months/years to create scenario-specific multispecies hotspot maps for relative abundance and species richness (number of species).

	Average depth and sea surface temperature (SST) were the most important explanatory variables in our models, while no distance related variables were included in any final models. Model outputs yielded similar results - where there was high relative abundance there was also high species richness. Peak values of both measures were found along most of the coast, both within and outside National Marine Sanctuaries. Results also predicted high habitat use by seabirds in association with offshore bathymetric features, especially north of the Mendocino Ridge where seafloor complexity increases. Our use of seabirds as indicator species combined with a multispecies approach provides an example of using at-sea seabird data combined with remotely sensed data and spatial modeling techniques to help prioritize protected area designation in the CCS. This approach can be used in other regions of the world where similar data exist, as well as explore the possible effects of climate change on seabird at-sea distribution.
Strength/ Weakness	These data are finalized and will not be updated as new data become available. The maps represent model-derived spatial predictions of long-term average density of nearshore and pelagic seabird species. They do not provide predictions of the actual number of individuals of a given species or taxonomic group that would be expected in a given area; they only indicate where a given species/group may be more or less abundant. Also, the maps do not provide predictions of density at a specific time; they only indicate seasonal distributions averaged across the timeframe of the survey dataset. While models were validated, these data do not include spatially explicit model performance metrics or estimated uncertainty values.
File Name	FNStudyArea.shp; AllSpp_AllMonths_PredictedMeans.csv; AllSpp_AllMonths_PredictedMeans_Standardized.csv
Data Type	Vectorized raster with related .csv tables
Spatial Extent	Northern Baja California to southern British Columbia; 52.3 -139.167, 29.75 -116.917; 1/12 degree cells (~9km)
Time Scale	Data from 1997-2012; products are seasonal (winter, spring, summer, fall); published in 2016
Contact/ Source	Dori Dick; https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/mg74qp30b
License/Use Restrictions	Permission from data owner.
Citation Info	https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/mg74qp30b
Online Link	Unavailable. Contact data owner.
Metadata Link	Unavailable. Contact data owner.

Dataset Table 6.3: Marine bird population, collision and displacement vulnerability

Dataset Title	Data for calculating population, collision and displacement vulnerability among marine birds of the California Current System associated with offshore wind energy infrastructure (ver. 2.0, June 2017)
Species/ Resource	81 seabird species known to occur in the CCS, including: sea ducks and geese, loons, grebes, albatross, fulmars, petrels, shearwaters, storm-petrels, cormorants, pelicans, phalaropes, jaegers, skuas, murrelets, guillemots, auklets, puffins, kittiwakes, gulls, terns, and skimmers.
Abstract	The U.S. Geological Survey, Western Ecological Research Center (USGS-WERC) was requested by the Bureau of Ocean Energy Management (BOEM) to create a database for marine birds of the California Current System (CCS) that would allow quantification and species ranking regarding vulnerability to offshore wind energy infrastructure (OWEI). This was needed so that resource managers could evaluate potential impacts associated with siting and construction of OWEI within the California Current System section of the Pacific Offshore Continental Shelf, including California, Oregon, and Washington. Along with its accompanying Open File Report (OFR), this

	comprehensive database can be used (and modified or updated) to quantify marine bird vulnerability to OWEIs in the CCS at the population level. For 81 marine bird species present in the CCS, we generated numeric scores to represent three vulnerability indices associated with potential OWEI: population vulnerability, collision vulnerability, and displacement vulnerability. The metrics used to produce these scores includes global population size, proportion of the population in the CCS, threat status, adult survival, breeding score, annual occurrence in the CCS, nocturnal and diurnal flight activity, macro-avoidance behavior, flight height, and habitat flexibility; values for these metrics can be updated and adjusted as new data become available. The scoring methodology was peer-reviewed to evaluate if the metrics identified, and the values generated were appropriate for each species considered. The numeric vulnerability scores in this database can readily be applied to areas in the CCS with known species distributions and where offshore renewable energy development is being considered. We hope that this information can be used to assist meaningful planning decisions that will impact seabird conservation.
Strength/ Weakness	This is not spatial data. For all metrics, preference was given to more recently published sources when multiple literature sources were available. If no sources were available to generate a metric score, data from a similar species was used. The scoring methodology was peer reviewed to evaluate if the metrics identified, and the values generated, were representative for the species considered. Scores given for each species are relative values generated for the purpose of this database, and should not be interpreted as an absolute value of vulnerability for the species. The values generated for most of the metrics in this database have inherent uncertainty. Therefore the level of uncertainty for each metric was determined to be low (10%), medium (25%), or high (50%) depending on the number of data sources, how current the data sources were, and the range of values published in those data sources. When appropriate, expert opinion also was used to determine values and uncertainty. The uncertainties given for each metric and species are relative values generated for the purpose of this database and should not be interpreted as an absolute uncertainty value of vulnerability for the species or metric. No planned updates are scheduled, but updates may occur.
File Name	Population Vulnerability: CCS_vulnerability_FINAL_VERSION_v9_PV.csv; Collision Vulnerability: CCS_vulnerability_FINAL_VERSION_v10_CV.csv; Displacement Vulnerability: CCS_vulnerability_FINAL_VERSION_v10_DV.csv;
Data Type	Tabular text (.csv) files
Spatial Extent	California Current System, northern Washington to southern Baja California Sur; no explicit spatial component to data
Time Scale	Current to 2017 with updates possible; no explicit temporal component to data.
Contact/Source	U.S. Geological Survey, Pacific Region; Josh Adams, josh_adams@usgs.gov
License/Use Restrictions	The authors of these data require that users direct any questions pertaining to appropriate use or assistance with understanding limitations and interpretation of the data to the individuals/organization listed in the Point of Contact section in the metadata.
Citation Info	Adams, J., Kelsey, E.C., Felis J.J., and Pereksta, D.M., 2017, Data for calculating population, collision and displacement vulnerability among marine birds of the California Current System associated with offshore wind energy infrastructure (ver. 2.0, June 2017): U.S. Geological Survey data release, https://doi.org/10.5066/F79C6VJ0.
Online Link	https://www.sciencebase.gov/catalog/item/58f7fadae4b0b7ea5451fc5c
Metadata Link	https://www.sciencebase.gov/catalog/file/get/58f7fadae4b0b7ea5451fc5c?f=__disk__d5%2F05%2F3b%2Fd5053b4c093be6660b8f0ab4c69ef359d577209f&transform=1&allowOpen=true

SECTION 7. SEA TURTLES

Although sea turtles live most of their lives in the ocean, adult females must come back to land to lay their eggs. Sea turtles migrate hundreds to thousands of miles every year between their feeding grounds and nesting beaches. There are four species of sea turtle found in U.S. West Coast waters, all of which are protected under the U.S. ESA. Three turtle species are more commonly found off California: green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), and olive ridley (*Lepidochelys olivacea*). Loggerheads (*Caretta caretta*) are labelled as rare in California, but juveniles may sometimes forage off southern California during warm water years (Welch et al. 2019) and the animals are sometimes found as bycatch in the swordfish and thresher shark drift gillnet fishery off southern California (NOAA and USFWS 2020). To reduce this bycatch, NOAA Fisheries implemented seasonal closures and additional closures during El Niño events (NOAA and USFWS 2020, NOAA Fisheries 2021e). Sea turtles may become more common in California waters if ocean temperatures continue to increase.

Sea Turtles With Potential to Occur in the Wind Energy Area or Vicinity

Figure 7.1. Leatherback sea turtle critical habitat in relation to the MBWEA (CBI 2022)

Leatherback sea turtles are among the most highly migratory animals on earth, traveling as many as 10,000 miles or more each year. They are the most pelagic of the four sea turtle species that may occur along the California coast. They are globally distributed but return to tropical or subtropical beaches for nesting. Leatherbacks are highly migratory, some swimming more than 10,000 km (6,213 mi) in a year between nesting and foraging grounds (NOAA Fisheries 2019b). They are also deep divers, with the deepest recorded dive at nearly 1,219 m (4,000 ft) deep (NOAA Fisheries 2021b). Leatherbacks have unique physiological and behavioral traits that enable it to inhabit cold water, unlike the other sea turtle species. These include a countercurrent circulatory system, a thick layer of insulating fat, large body size that limits heat loss, and the ability to elevate body temperature through increased metabolic activity (NOAA Fisheries 2019b). Leatherback sea turtle critical habitat has also been designated on the U.S. West Coast. This includes approximately 43,800 km^2 (16,200 mi^2) from Point Arena to Point Arguello east of the 3,000-m (9,850-ft) depth contour (Figure 7.1). A Pacific Leatherback Conservation Area (Benson and Dewar 2009) was also established in 2001 that prohibits drift-gillnet fishing for swordfish in leatherback foraging grounds off California, Oregon, and Washington from August 15 to November 15 each year.

Leatherback turtles tagged after nesting in July in Indonesia were found in waters off California and Oregon during July-August of the following year coinciding with the development of seasonal aggregations of jellies (NOAA Fisheries 2019b) and when SST warms to 15-16 °C (59-61 °F). Their habitat preferences also suggest that they could be present around the MBWEA during certain times of the year depending on the presence of certain prey. Their primary food source are cnidarians such as jellies and siphonophores and, to a lesser extent, tunicates such as pyrosomes and salps (NOAA Fisheries 2019b). Annual abundance of leatherback turtles in the California Current Ecosystem is affected by local oceanographic events such that their arrival and departure can be predicted using upwelling indices at various latitudes with time lags. Sightings and incidental capture data indicate that this species is found as far north as Alaska but is most frequently encountered off the coast of central California. Benson et al. (2007) estimated that the average leatherback sea turtle abundance in South Central California and Monterey Bay was 17 individuals based on aerial surveys conducted from 1990 to 2003 from Point Conception to the California/Oregon border. Given its global distribution, it is assumed that leatherback sea turtles may occur in or near the MBWEA from summer to early fall depending on local conditions.

Rare or Data Deficient Sea Turtles

Olive ridley are the smallest and most abundant sea turtle species in the eastern Pacific Ocean. They have been found in the open ocean more than 3,862 km (2,400 mi) from shore, but they also inhabit coastal areas (NOAA Fisheries 2021b). Since individuals may live far offshore for the majority of their lives, their life history is generally unknown to researchers. It is believed that they exploit persistent but dynamic oceanographic features as distinct food webs (Peavey et al. 2017). The common range of this species extends to the California/Baja California border, but individuals have been sighted south of the MBWEA in southern San Luis Obispo County and central Santa Barbara County. They have been known to travel as far north as British Columbia in warm water years (Nafis 2020).

Green sea turtles have a slightly wider at-sea range than olive ridley sea turtles but have a similar distribution in coastal California. They have been found as far north as the Farallon Islands, but are most common in coastal areas off Santa Monica and San Diego, and they are long-term residents in San Diego Bay. There are occasional sightings of green sea turtles reported along the coasts of Washington and Oregon. Because of the limited geographic scope of these data, they are likely very rare in the MBWEA (Nafis 2020).

Loggerhead sea turtles are the largest hard-shelled turtle in existence. They are rarely observed and have no known nesting sites on the west coast of North or South America, although their common range covers the tropical and temperate east coast of those continents, as well as coasts of Africa, Europe, Australia, and Asia. In California, most observations occur south of Point Conception, with the closest observation to the MBWEA occurring in Santa Barbara County (Nafis 2020). NMFS established the Pacific Loggerhead Conservation Area in 2003, an area extending offshore and to the south from Santa Barbara to San Diego. The drift gillnet fishery is closed in this area from June 1 to August 31 during forecasted or occurring El Niño events in southern California. Unlike the other three sea turtle species, their nesting sites are more often found in temperate rather than tropical locations. They share their pelagic range with the other sea turtle species.

Availability of Data on Sea Turtles

Observer data have been collected by NOAA Fisheries for the California deep-set pelagic longline fishery beyond the EEZ since 2005 to document the incidental capture of sea turtles. In a report documenting observations from 8,956 California drift gillnet fishery sets between 1990 and 2017, one olive ridley and

25 leatherbacks were found as bycatch (Carretta et al. 2019). The SWFSC Marine Mammal and Turtle Division also conducts research on sea turtles in all oceans of the world, with an emphasis on the Pacific. The Marine Turtle Ecology and Assessment Program collects data on the ecology, demography, human threats, and conservation status of marine turtles from ships, planes, and shore-based stations. These data are not easily accessible and require contacting the SWFSC directly.

The California Offshore Wind Energy Gateway contains modeled leatherback utilization distribution data from 2003 to 2009 (Dataset Table 7.1). This is based on satellite and light-based geolocation tracking data from the TOPP project. TOPP (2021) uses electronic tagging technologies to study migration patterns of large open-ocean animals and the oceanographic factors controlling these patterns. Utilization Distribution is the probability of an animal being found in a given location. The tagging data in this project were used to model the distribution and key habitats of eight protected predator species across three taxa groups within the U.S. CCS. In addition to leatherback sea turtles, other tagged animals included marine mammals, Laysan albatrosses, sooty shearwaters, and black-footed albatrosses. Distributions and potential risks to key species were then modeled and examined in relation to marine sanctuaries. Study findings suggest that the highest potential impact regions are on the continental shelf and in the sanctuaries, with utilization probabilities ranging from 0-0.4 in the MBWEA. The TOPP data are not accessible online but can be requested.

The USGS has an extensive database on vertebrate species and plants as part of their Gap Analysis Project (GAP) to support national and regional assessments (Dataset Table 7.2). This information primarily covers terrestrial-based animals, but it also includes five species of sea turtles as well as sea otter, six species of seals and sea lions (fur seals, elephant seal, harbor seal, and California sea lion), and several seabird species (mainly gulls, terns, pelicans, grebes, shearwaters, jaegers, and murres). The work focuses on the spatial patterns of richness derived from species' habitat distribution models. These species level models were spatially combined to show variation in richness across the conterminous United States at a spatial resolution of 30 m (98 ft). Since these models are logically linked to mapped data layers that constitute habitat suitability, the suite of data can also provide an intuitive data system for further exploration of biodiversity and implications for change at ecosystem and landscape scales (Gergely et al. 2019). Additional coarse scale datasets are available illustrating the relative probabilities of occurrence of green, olive ridley, and loggerhead sea turtles along the U.S. West Coast at AQUAMAPS (Kaschner et al. 2019; Dataset Table 7.3).

General Status and Threats to Sea Turtles

Long standing man-made threats to sea turtles include by-catch in fishing nets, gear entanglements, beach loss from coastal developments, collection of eggs, oil spills, and ship strikes. More recent threats are likely to occur due to climate change, which could be particularly problematic to sea turtles because the sex ratios in the populations are temperature-dependent, and their nesting beaches may be impacted by sea level rise (Hawkes et al. 2009).

Data Gaps and Limitations

Spatially explicit population and distribution data for sea turtle species on the U.S. west coast is rare or difficult to obtain. This may be because there are not many turtles in this area of their range, they are difficult to observe at-sea even when they might be present, and observational data is often not recorded or publicly available online. Data that do exist are limited in geographic scope or are highly generalized and may be of limited use to offshore wind planning and operation. Leatherbacks are most common along the U.S. west coast and are best represented in the datasets that are described although the ability to access the data may be limited.

In general, data for sea turtle species (leatherback, green, and loggerhead) do not exist for the MBWEA except for a narrow coastal strip of Environmental Sensitivity Index data for leatherback sea turtles (Dataset Table 7.4). Loggerhead and green sea turtles are only represented in geographically generalized Environmental Sensitivity Index data for southern California, outside of the range of the MBWEA. The general range of green and loggerhead sea turtles on the west coast of North America extends from Mexico to Canada, but they are considered less common north of Mexico, whereas leatherback sea turtles are considered more common in this range (Nafis 2020).

Other sources of potential sea turtle data include Welch et al. (2019), which used fisheries dependent and independent datasets to determine loggerhead bycatch events (n = 16 turtles) in the California Drift Gillnet Fishery. This type of information has been recorded since 1990 through the observer program managed by the NOAA Fisheries West Coast Regional Office. Independent datasets (i.e., "sighted turtles") include data from an aerial line-transect survey during September and October 2015 (n = 215 turtles, see details of survey methodology in Eguchi et al. 2018), a citizen science loggerhead sighting hotline from April 2015 to July (Briscoe et al. 2017), and a satellite telemetry study conducted by NMFS's SWFSC in 2015 and 2016 (n = 3 tagged turtles). All of this information, even if it is older data, would be helpful as a start toward mapping potential distribution and habitat preferences for sea turtles off the Northern California coast.

For sea turtle data that is mapped, such as on the California Offshore Wind Energy Gateway, it is incumbent on the users to understand the underlying data, if certain assumptions are being made. For example, the map viewer for the "Leatherback Sea Turtle Distribution Model" in the California Offshore Wind Energy Gateway shows "known or probable occurrence, year-round (both winter and summer)." This appears to be a compilation of two USGS datasets for both their "range" and the habitat model data that shows clusters of leatherback sea turtle distribution, one of which includes the MBWEA region (Dataset Table 7.4).

Summary Tables of Selected Sea Turtle Datasets

Dataset Table 7.1. Leatherback Sea Turtle Utilization Distribution, California Current

Dataset Title	Leatherback Sea Turtle Utilization Distribution, California Current
Species/Resource	Leatherback sea turtles
Abstract	These data have been post-processed and clipped to the Exclusive Economic Zone for the Pacific Coast. Leatherback Sea Turtle (Dermochelys coriacea) utilization distribution (UD) in the California Current. Utilization Distribution is the probability of an animal being found in a given location. In this study, satellite and light-based geolocation tracking data from the Tagging of Pacific Predators (TOPP) project were used to determine the distribution and key habitats of eight protected predator species across three taxa groups within the U.S. waters of the California Current System.
Strength/Weakness	While the webpage indicates that the site September was last modified in September 2017, which is when the page might have been created, it appears that the latest tracking

	data was from January 2009. It is not known if there has been additional leatherback sea turtle data collected by TOPP since 2009.
File Name	file://\\MOREL\G$\CA_Offshore_Wind\Data\Sara_Maxwell_data\Layer_packs\Leatherback_Sea_Turtle_EEZ\v103\masked_sm_rasters.gdb
Data Type	Raster
Spatial Extent	West Boundary -129.163686 East Boundary -117.163686 North Boundary 49.042098 South Boundary 30.542098
Time Scale	June 2003 to January 2009
Contact/Source	Rebecca Degagne, Geospatial Scientist, The Conservation Biology Institute (541-368-5811) or Sara Maxwell, Associate Professor, University of Washington - Bothell Campus (smmax@uw.edu)
License/Use Restrictions	Data Basin, by the Conservation Biology Institute (CBI), is a public resource of user-contributed data about conservation issues. Any content including datasets, files, logos, and documents contributed by the user and any resulting data generated by such user belongs to the user, and CBI makes no claim to this content, nor does CBI provide any warranty to this content whatsoever. The Data Basin platform itself, and all related documentation, design, and graphic elements (the website as a whole) are the proprietary property of CBI, and CBI possesses all right and title. All of these Data Basin platform rights are reserved.
Citation Info	Maxwell, S. M. et al. Cumulative human impacts on marine predators. Nat. Commun. 4:2688 doi: 10.1038/ncomms3688 (2013)
Online Link	https://caoffshorewind.databasin.org/datasets/9bdddb86c6e04c13963bf0b421cc4027/
Metadata Link	https://caoffshorewind.databasin.org/datasets/9bdddb86c6e04c13963bf0b421cc4027/layers/9919230e0a2a43c58a8472bc9b5611f8/metadata/original/

Dataset Table 7.2. Leatherback Sea Turtle Distribution Model

Dataset Title	Leatherback Sea Turtle Distribution Model
Species/Resource	Leatherback sea turtles
Abstract	GAP distribution models represent the areas where species are predicted to occur based on habitat associations. GAP distribution models are the spatial arrangement of environments suitable for occupation by a species. In other words, a species distribution is created using a deductive model to predict areas suitable for occupation within a species range. To represent these suitable environments, GAP compiled existing GAP data, where available, and compiled additional data where needed. Existing data sources were the Southwest Regional Gap Analysis Project (SWReGAP) and the Southeast Gap Analysis Project (SEGAP) as well as a data compiled by Sanborn Solutions and Mason, Bruce and Girard. Habitat associations were based on land cover data of ecological systems and--when applicable for the given taxon--on ancillary variables such as elevation, hydrologic characteristics, human avoidance characteristics, forest edge, ecotone widths, etc. Distribution models were generated using a python script that selects model variables based on literature cited information stored in a wildlife habitat relationship database

	(WHRdb); literature used includes primary and gray publications. Distribution models are 30-meter raster data and delimited by GAP species ranges. Distribution model data were attributed with information regarding seasonal use based on GAP regional projects (NWGAP, SWReGAP, SEGAP, AKGAP, HIGAP, PRGAP, and USVIGAP), NatureServe data, and IUCN data.
Strength/Weakness	The map viewer for this dataset in the California Offshore Wind Energy Gateway shows that leatherback sea turtles are spread widely along the California coast, which is actually the "range" depicted by USGS in their range map (https://www.sciencebase.gov/catalog/item/imap/59f5ec32e4b063d5d307e4f5). Another report on this data is the USGS Species Habitat Model Report for leatherback sea turtles, which shows clusters of leatherback sea turtle's distribution. The Habitat Model Report can be downloaded at: https://gapanalysis.usgs.gov/apps/species-data-download/. Most of the links that are listed for this dataset in the California Offshore Wind Energy Gateway are no longer valid. For example, the Gateway notes that a full report documenting the parameters used in the Leatherback Sea Turtle model can be found at: http://dingo.gapanalysisprogram.com/SpeciesViewer/ModelReport.ashx?species=rleatx, but this link is no longer accessible. The USGS provides a recommendation that the user should acquire these data directly from the USGS Gap Analysis Program server, and not indirectly through other sources, which may have modified the data in some way. USGS also strongly recommends that careful attention be paid to the contents of the metadata file associated with these data. Other recommendations on data uses can be found in the "Use Constraints" section of this dataset on the California Offshore Wind Energy Gateway.
File Name	Leatherback Sea Turtle Distribution Model
Data Type	Raster shape files. Species habitat and range maps are also available in an Open Geospatial Consortium (OGC) Web Map Service (WMS) at: http://gis1.usgs.gov/ArcGIS/rest/services/NAT_Species_Reptiles/rleatx/MapServer
Spatial Extent	U.S. West Coast
Time Scale	Not specified in the California Offshore Wind Energy Gateway, but the USGS report the state date of the data as 2008 and the end date is 2013
Contact/Source	Dr. Alexa J. McKerrow, Biologist, USGS Science Analytics and Synthesis; (571) 218-5474; amckerrow@usgs.gov
License/Use Restrictions	Data Basin, by the Conservation Biology Institute (CBI), is a public resource of user-contributed data about conservation issues. Any content including datasets, files, logos, and documents contributed by the user and any resulting data generated by such user belongs to the user, and CBI makes no claim to this content, nor does CBI provide any warranty to this content whatsoever. The Data Basin platform itself, and all related documentation, design, and graphic elements (the website as a whole) are the proprietary property of CBI, and CBI possesses all right and title. All of these Data Basin platform rights are reserved.
Citation Info	U.S. Geological Survey Gap Analysis Program (USGS-GAP). 2013. National Species Distribution Models.
Online Link	https://www.sciencebase.gov/catalog/item/58fe19e6e4b0f87f0854ad61 for the Habitat Map and https://www.sciencebase.gov/catalog/item/59f5ec32e4b063d5d307e4f5 for the Range Report
Metadata Link	https://www.usgs.gov/programs/gap-analysis-project/science/species-data-download

Dataset Table 7.3. Global Sea Turtle Occurrence Models

Dataset Title	Aquamaps Standardized Distribution Maps
Species/Resource	Sea turtles and other marine animals
Abstract	AquaMaps is a tool for generating model-based, large-scale predictions of natural occurrences of marine species. The model uses estimates of environmental preferences with respect to depth, water temperature, salinity, primary productivity, dissolved oxygen, and association with sea ice or coastal areas. These estimates of species preferences, called environmental envelopes, are derived from large sets of occurrence data available from online collection databases such as GBIF (gbif.org) and OBIS (obis.org), and from independent knowledge from the literature about the distribution of a given species and its habitat usage that are available in FishBase (www.fishbase.org) and in SeaLifeBase (www.sealifebase.org). The environmental envelopes are matched against local environmental conditions to determine the suitability of a given area in the ocean for a particular species. Predictions of relative probabilities of species occurrence are shown as color-coded species range maps in a global grid of half-degree latitude and longitude cell dimensions. The maps are displayed on the web through the use of C-squares Mapper developed at CSIRO Marine and Atmospheric Research in Australia (Rees, 2002, 2003).
Strength/Weakness	Covers multiple sea turtle and other marine animal species; coarse spatial scale (1/2 degree cell size); modeled data
File Name	Dependent on species selected
Data Type	.csv text file of spatially referenced relative probability of occurrence
Spatial Extent	Global
Time Scale	Unknown
Contact/Source	www.aquamaps.org
License/Use Restrictions	Please cite data when used. AquaMaps generates standardized computer-generated and fairly reliable large scale predictions of marine and freshwater species. Although the AquaMaps team and their collaborators have obtained data from sources believed to be reliable and have made every reasonable effort to ensure its accuracy, many maps have not yet been verified by experts and we strongly suggest you verify species occurrences with independent sources before usage. We will not be held responsible for any consequence from the use or misuse of these data and/or maps by any organization or individual.
Citation Info	Kaschner, K., Kesner-Reyes, K., Garilao, C., Segschneider, J., Rius-Barile, J. Rees, T., & Froese, R. (2019, October). AquaMaps: Predicted range maps for aquatic species. Retrieved from https://www.aquamaps.org. Kesner-Reyes, K., Garilao, C., Kaschner, K., Barile, J., & Froese, R. (2020). AquaMaps: algorithm and data sources for marine organisms. In: R. Froese & D. Pauly. (Eds.), FishBase. https://www.fishbase.org, version (10/2019).
Online Link	https://www.aquamaps.org/search.php, search by and select species name
Metadata Link	https://www.aquamaps.org/main/AquaMaps_Algorithm_and_Data_Sources.pdf#page=1

Dataset Table 7.4. Leatherback Sea Turtle Resource Data

Dataset Title	Sensitivity of Coastal Environments and Wildlife to Spilled Oil: Central California: REPTILES (Reptile and Amphibian Polygons)
Species/Resource	Sea turtles (Cheloniidae and Dermochelyidae)
Abstract	This data set contains sensitive biological resource data for amphibians and reptiles in Central California. Vector polygons in this data set represent sea turtle distribution and rare reptile and amphibian species occurrences. Species-specific abundance, seasonality, status, life history, and source information are stored in relational data tables (described below) designed to be used in conjunction with this spatial data layer. This data set comprises a portion of the Environmental Sensitivity Index (ESI) data for Central California. ESI data characterize the marine and coastal environments and wildlife by their sensitivity to spilled oil. The ESI data include information for three main components: shoreline habitats, sensitive biological resources, and human-use resources. See also the REPTILEL (Reptile and Amphibian Lines) data layer, part of the larger Central California ESI database, for additional amphibian and reptile information.
Strength/Weakness	Spatial extent indicates that the data extend throughout California but the abstract only references Central California. Also, based on information in the metadata file, the sea turtle data are based on personal information and unpublished sources. This is also a dataset in the California Offshore Wind Energy Gateway that is entitled, "Leatherback Sea Turtle Presence, Northern California ESI," but there is limited granularity; the map shows that leatherback sea turtles are present all months of the year along the California coast.
File Name	https://response.restoration.noaa.gov/sites/default/files/esimaps/gisdata/CentralCal_2006_GDB.zip
Data Type	Vector (polygon) with associated tables
Spatial Extent	Northern Baja California to southern British Columbia; 38.125 -123.5 -120.375 34.217
Time Scale	Data from 1999-2006; published in 2006
Contact/Source	National Oceanic and Atmospheric Administration (2006) National Ocean Service, Office of Response and Restoration, Hazardous Materials Response Division, Seattle Washington
License/Use Restrictions	There are restrictions and legal prerequisites for using the data set after access is granted.
Citation Info	NOAA Office of Response and Restoration (2006). Sensitivity of Coastal Environments and Wildlife to Spilled Oil: Central California: ESI (Environmental Sensitivity Index Shoreline Types – Lines and Polygons). 2nd Edition.
Online Link	https://response.restoration.noaa.gov/sites/default/files/esimaps/gisdata/CentralCal_2006_GDB.zip
Metadata Link	https://response.restoration.noaa.gov/sites/default/files/esimaps/gisdata/CentralCal_2006_Meta.pdf (starting on page 272)

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APPENDIX A: MARINE MAMMAL MAPS (Becker et al. 2020)

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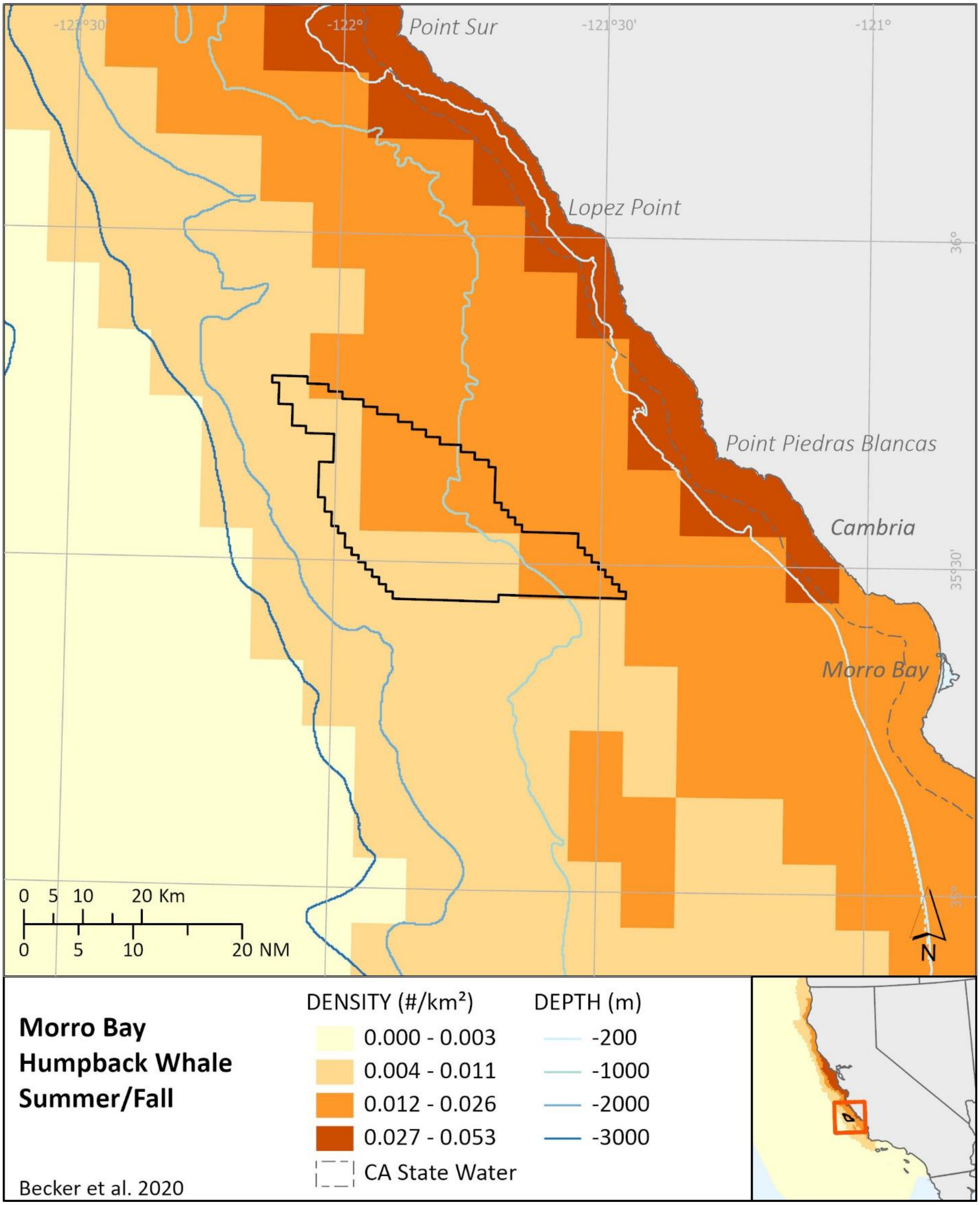

Figure A.1. Humpback whale summer/fall predicted density/distribution in/near the MBWEA.

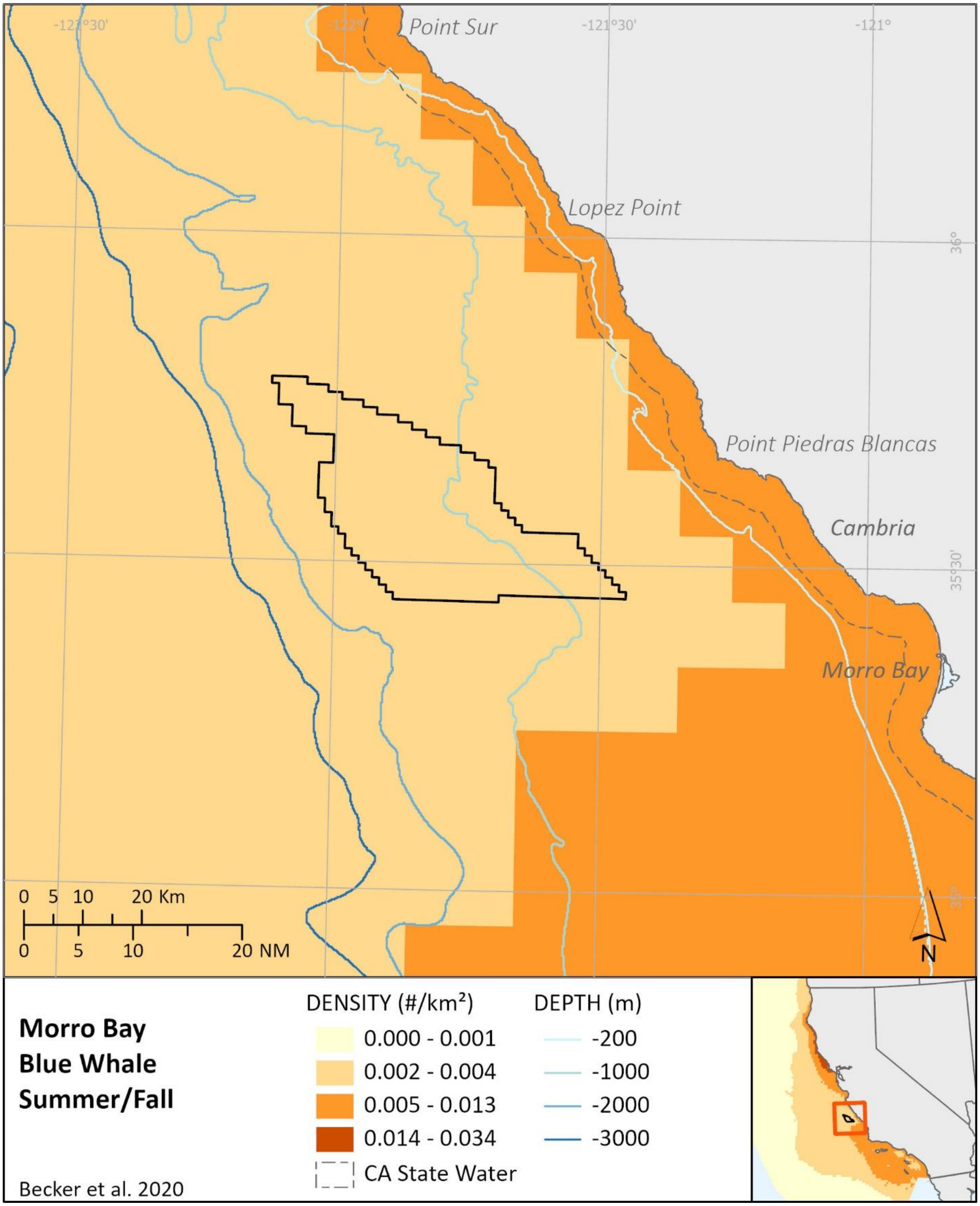

Figure A.2. Blue whale summer/fall predicted density/distribution in/near the MBWEA.

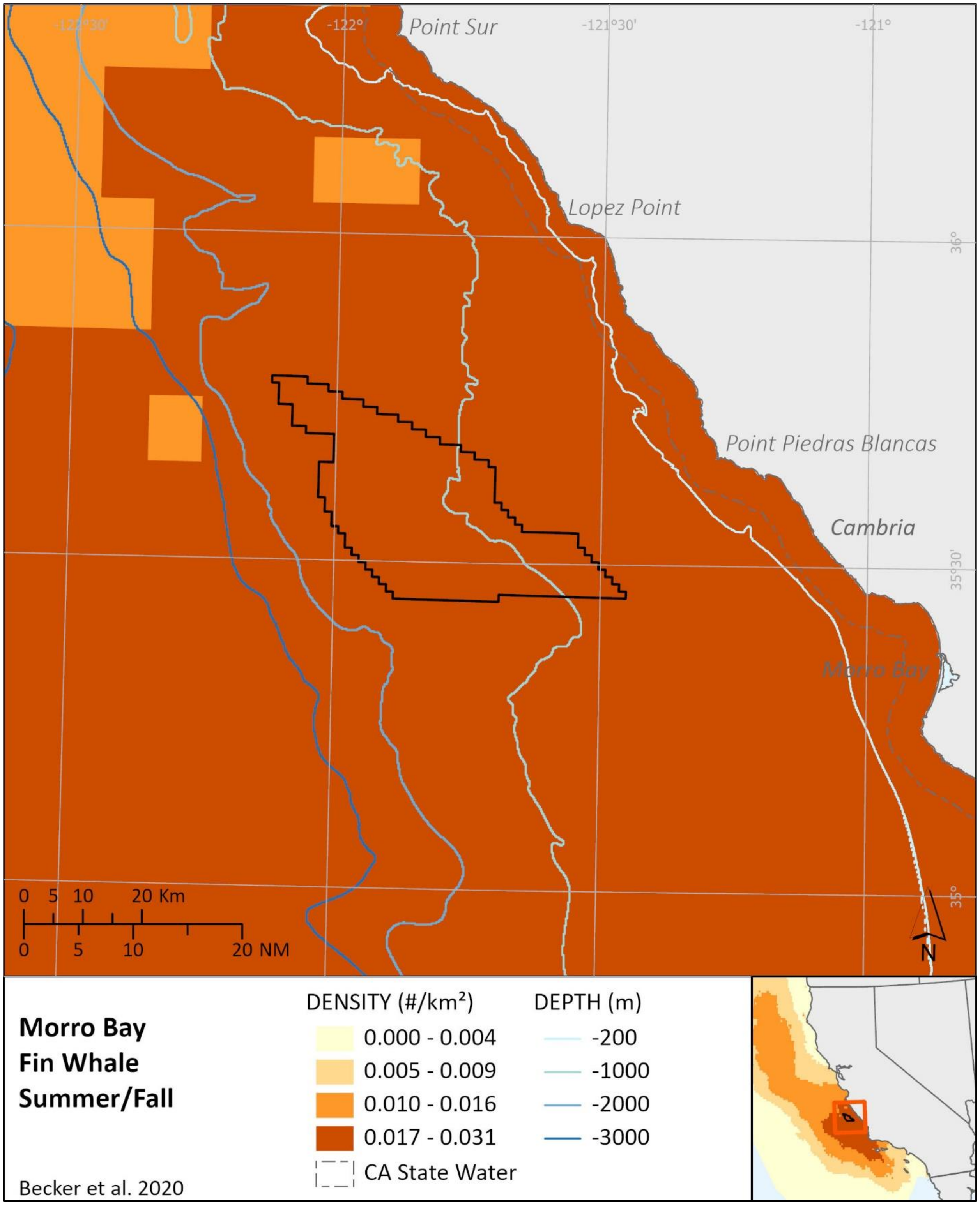

Figure A.3. Fin whale summer/fall predicted density/distribution in/near the MBWEA.

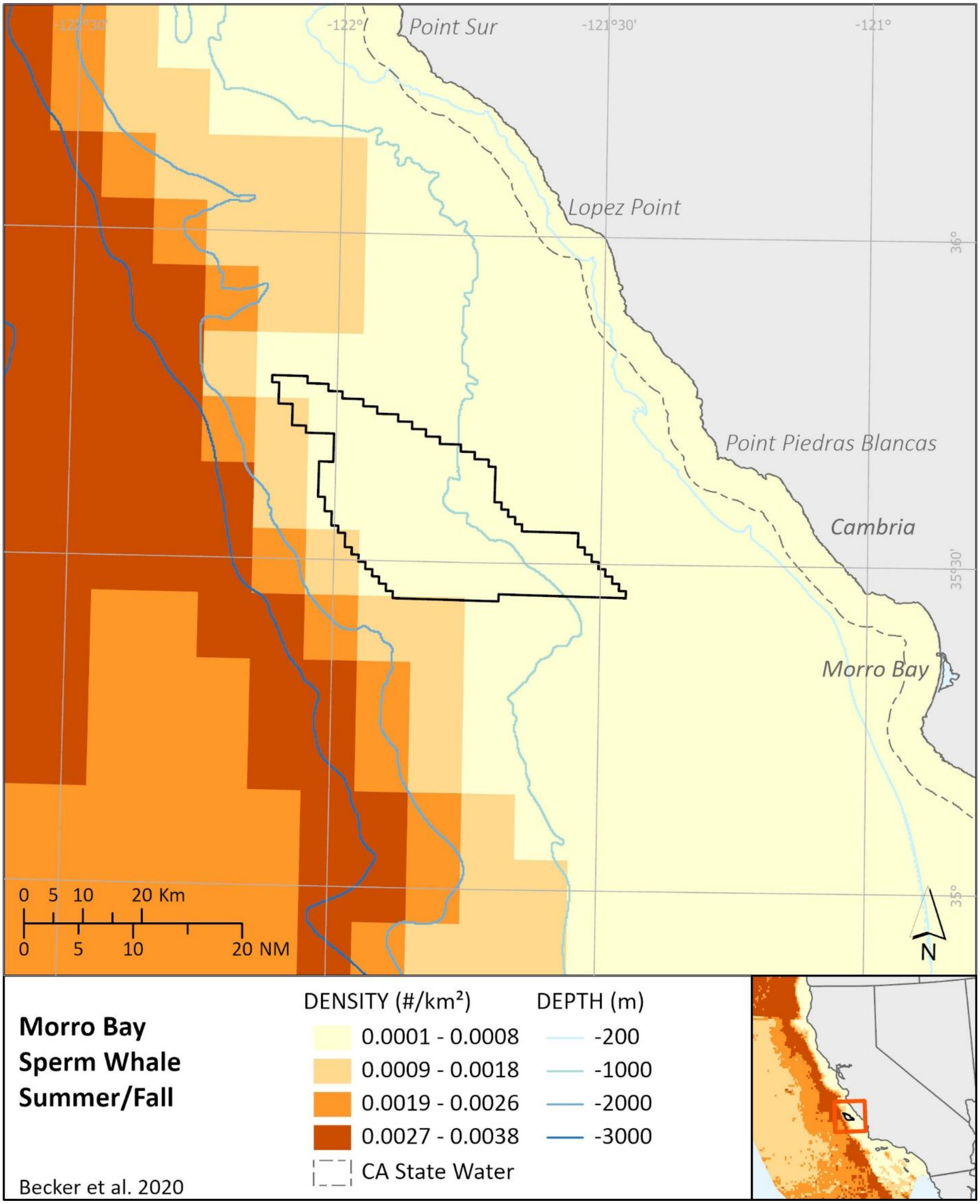

Figure A.4. Sperm whale summer/fall predicted density/distribution in/near the MBWEA.

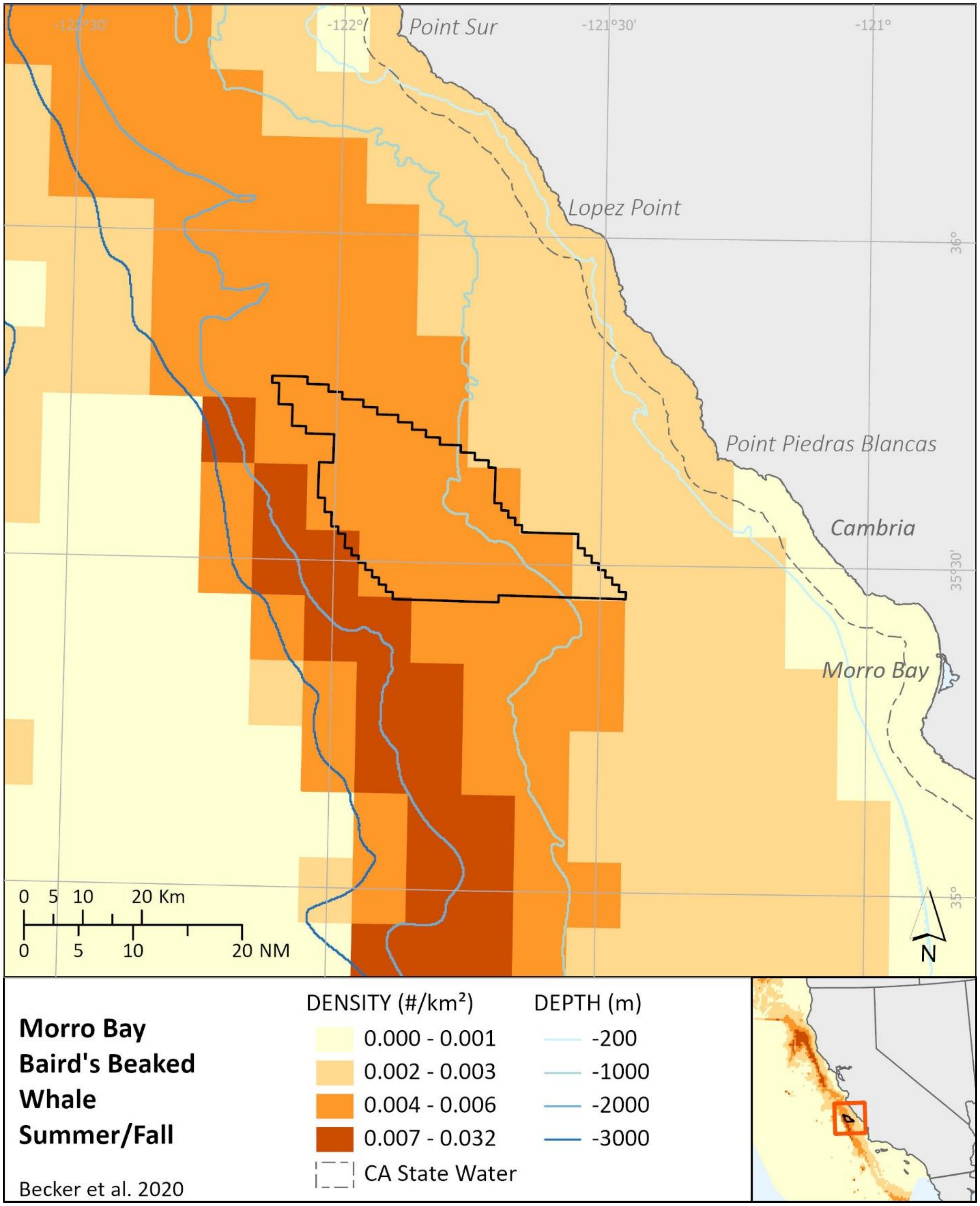

Figure A.5. Baird's beaked whale summer/fall predicted density/distribution in/near the MBWEA.

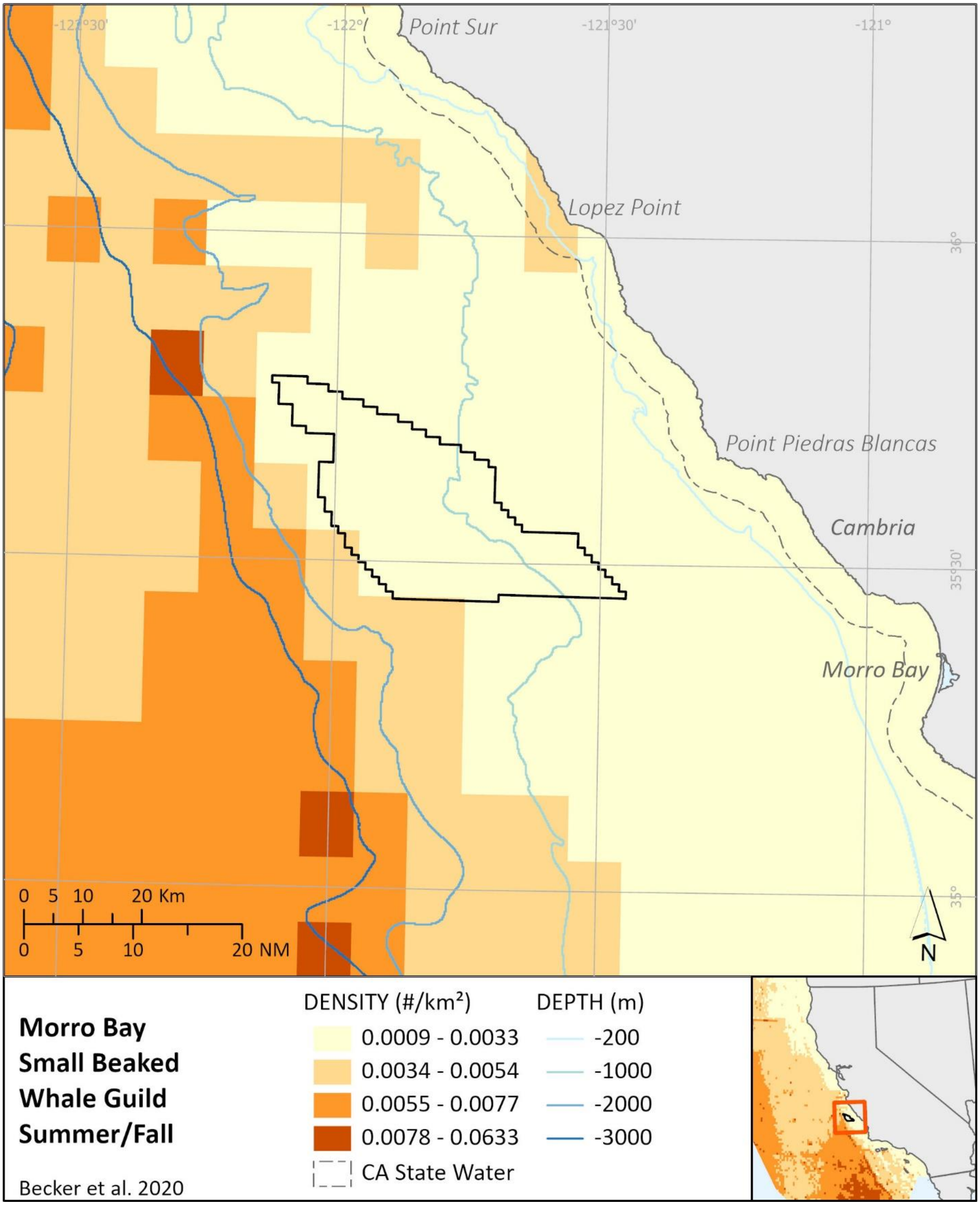

Figure A.6. Small beaked whale guild summer/fall predicted density/distribution in/near the MBWEA.

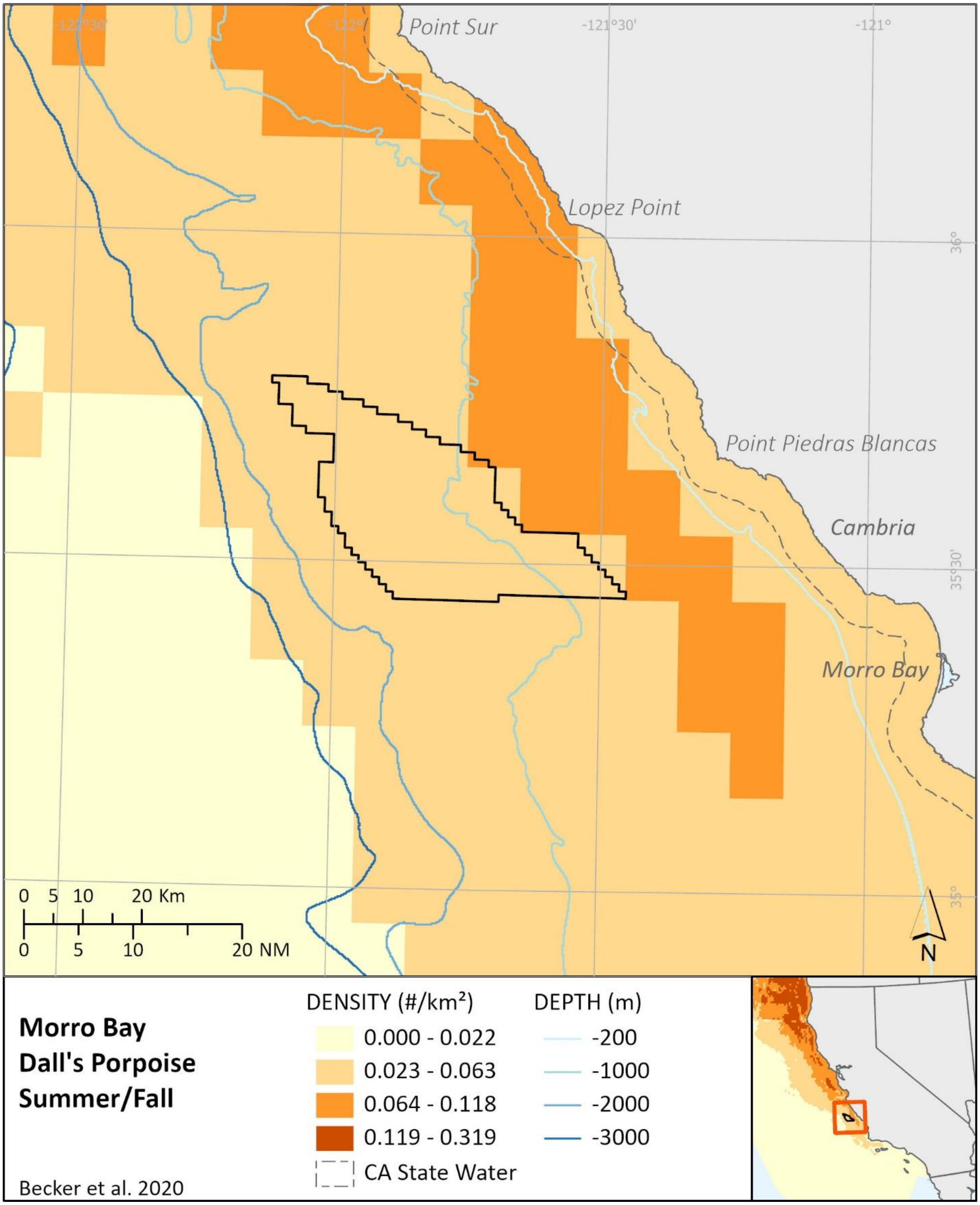

Figure A.7. Dall's porpoise summer/fall predicted density/distribution in/near the MBWEA.

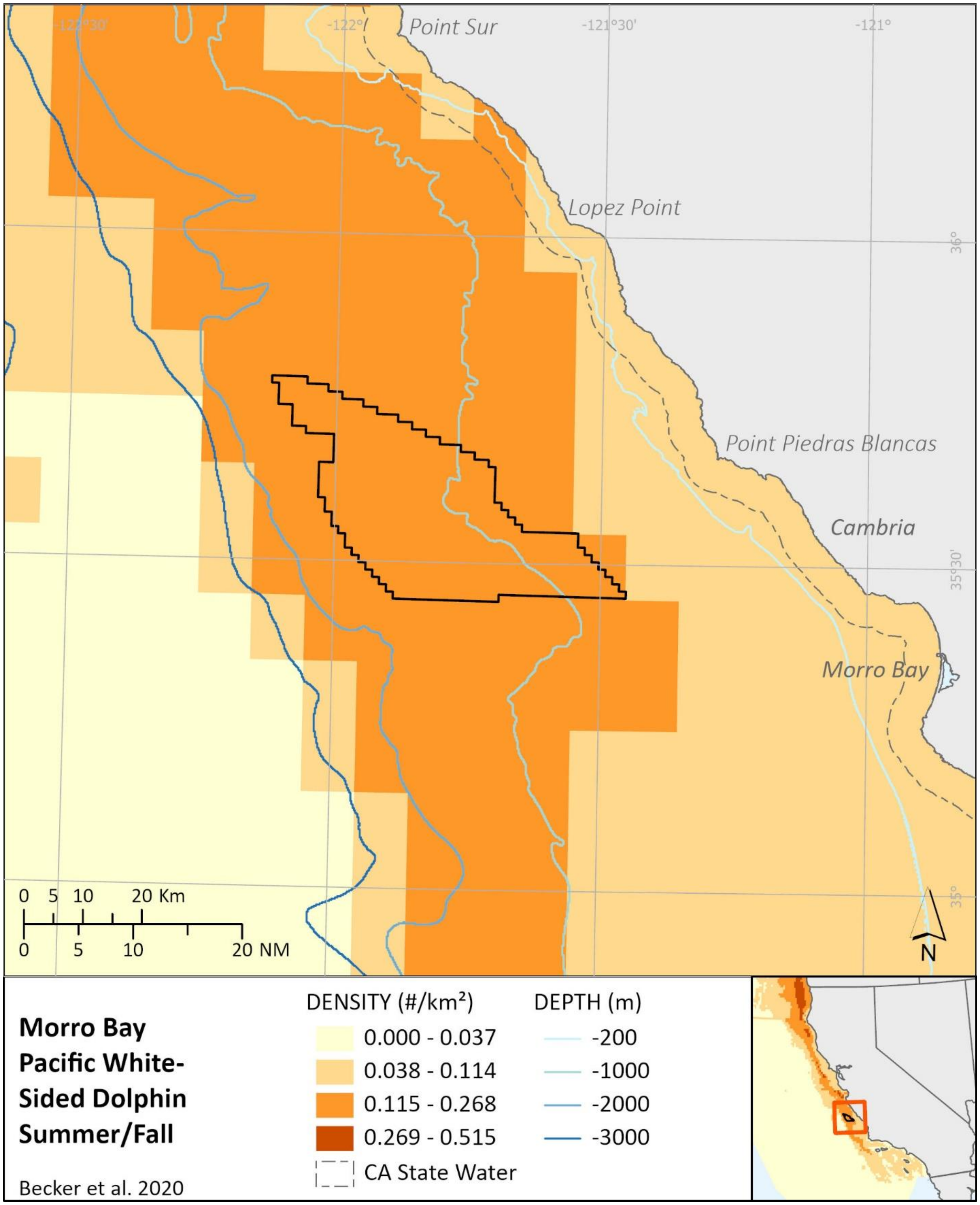

Figure A.8. Pacific white-sided dolphin summer/fall predicted density/distribution in/near the MBWEA.

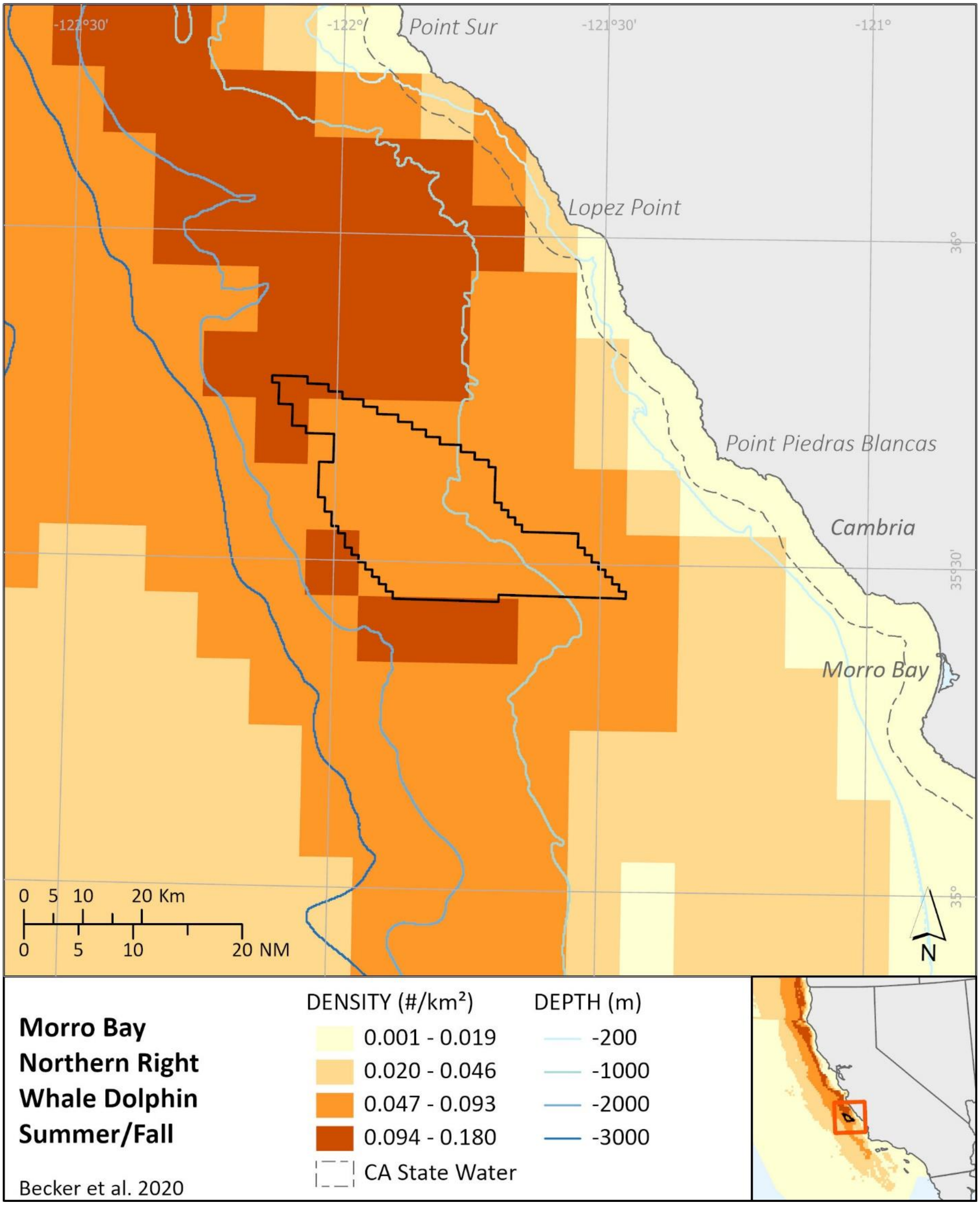

Figure A.9. Northern right whale dolphin summer/fall predicted density/distribution in/near the MBWEA.

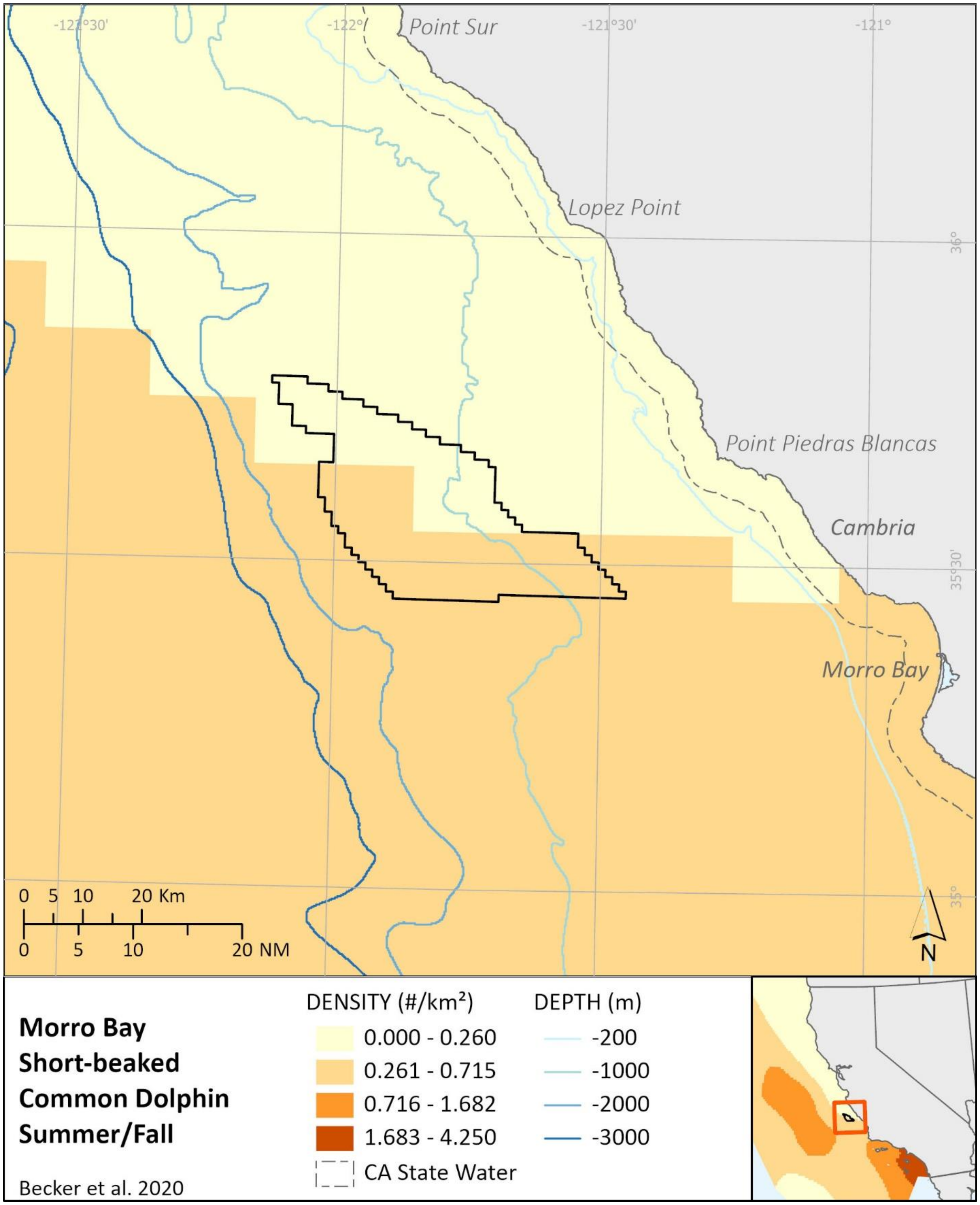

Figure A.10. Short-beaked common dolphin summer/fall predicted density/distribution in/near the MBWEA.

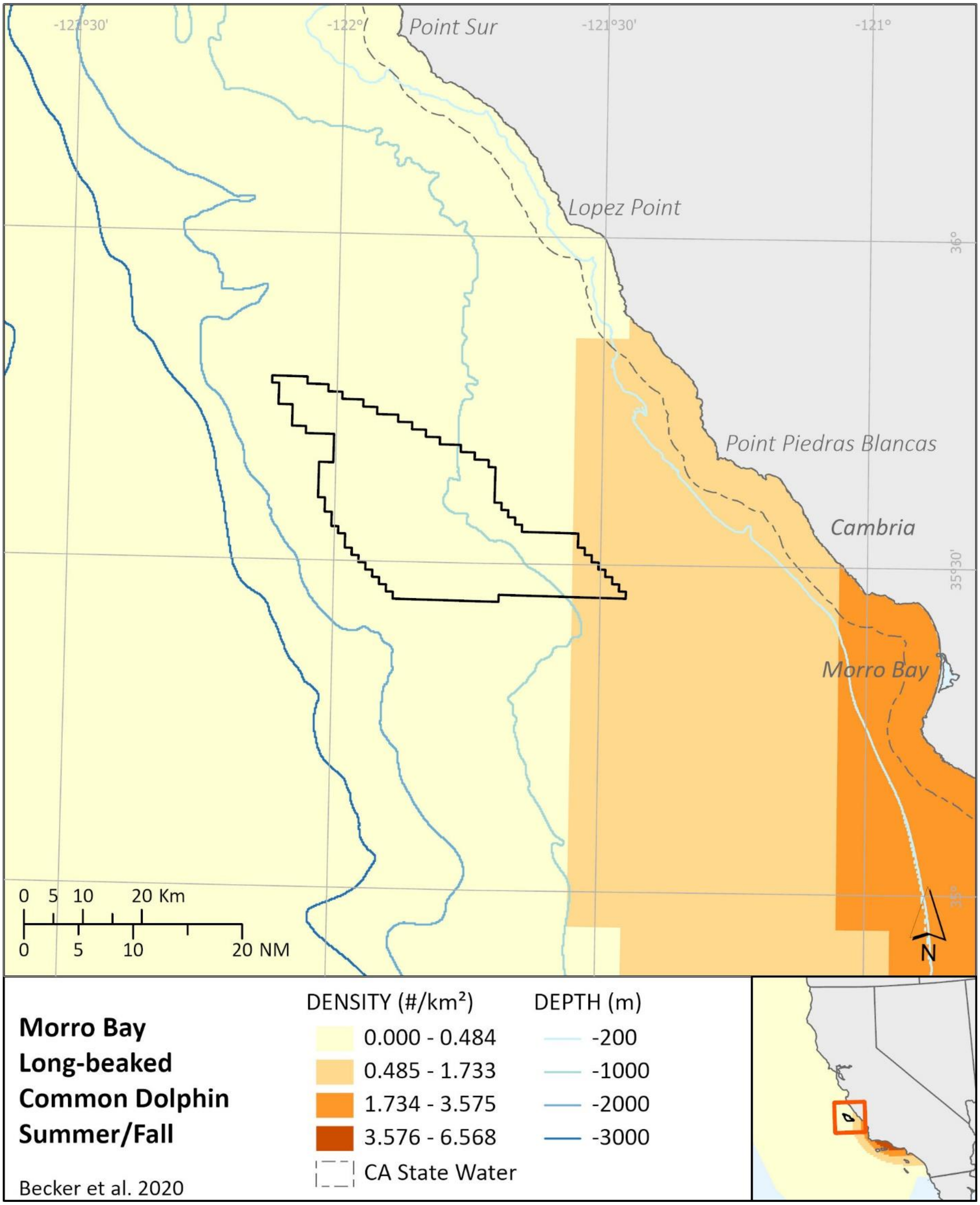

Figure A.11. Long-beaked common dolphin summer/fall predicted density/distribution in/near the MBWEA.

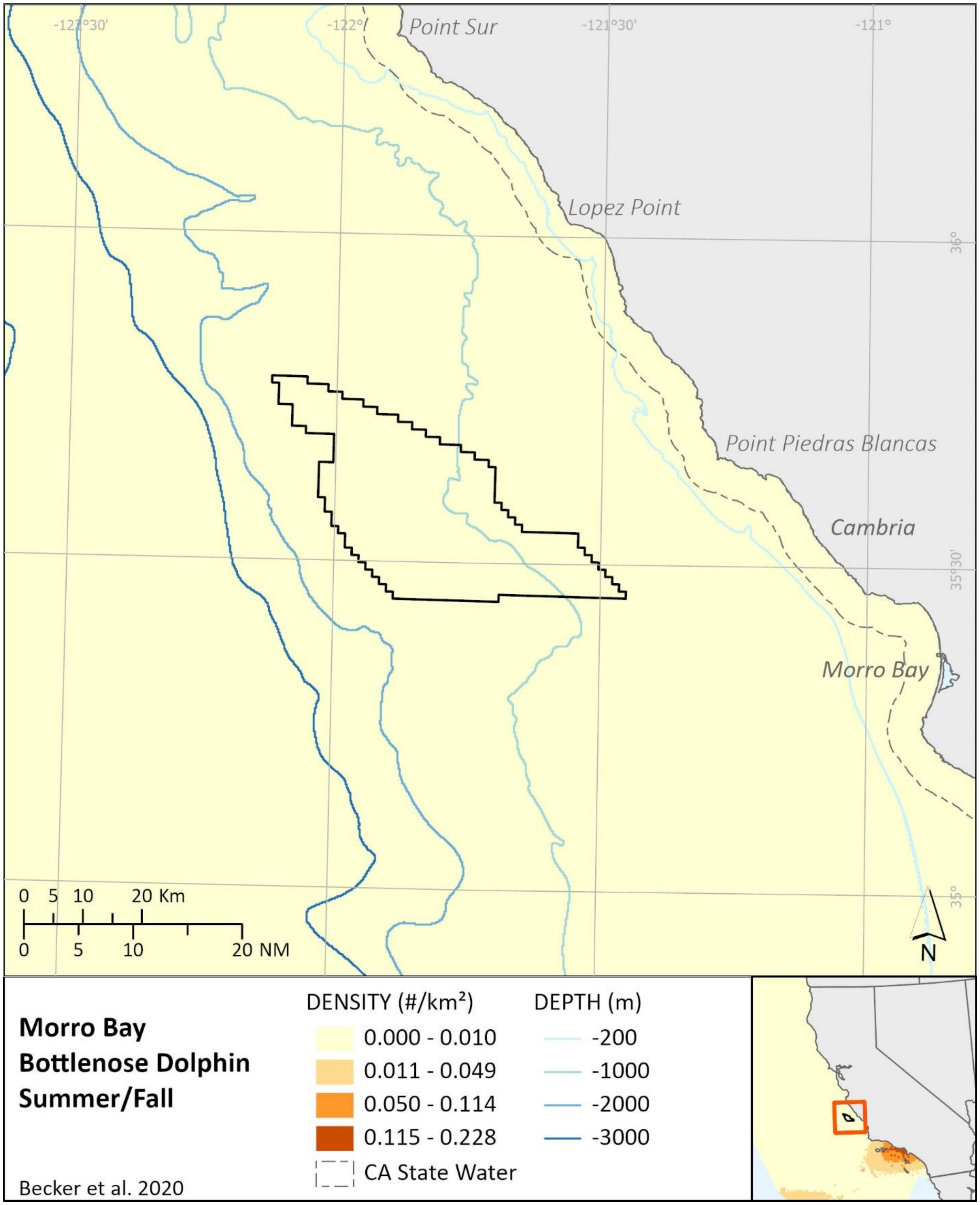

Figure A.12. Bottlenose dolphin summer/fall predicted density/distribution in/near the MBWEA.

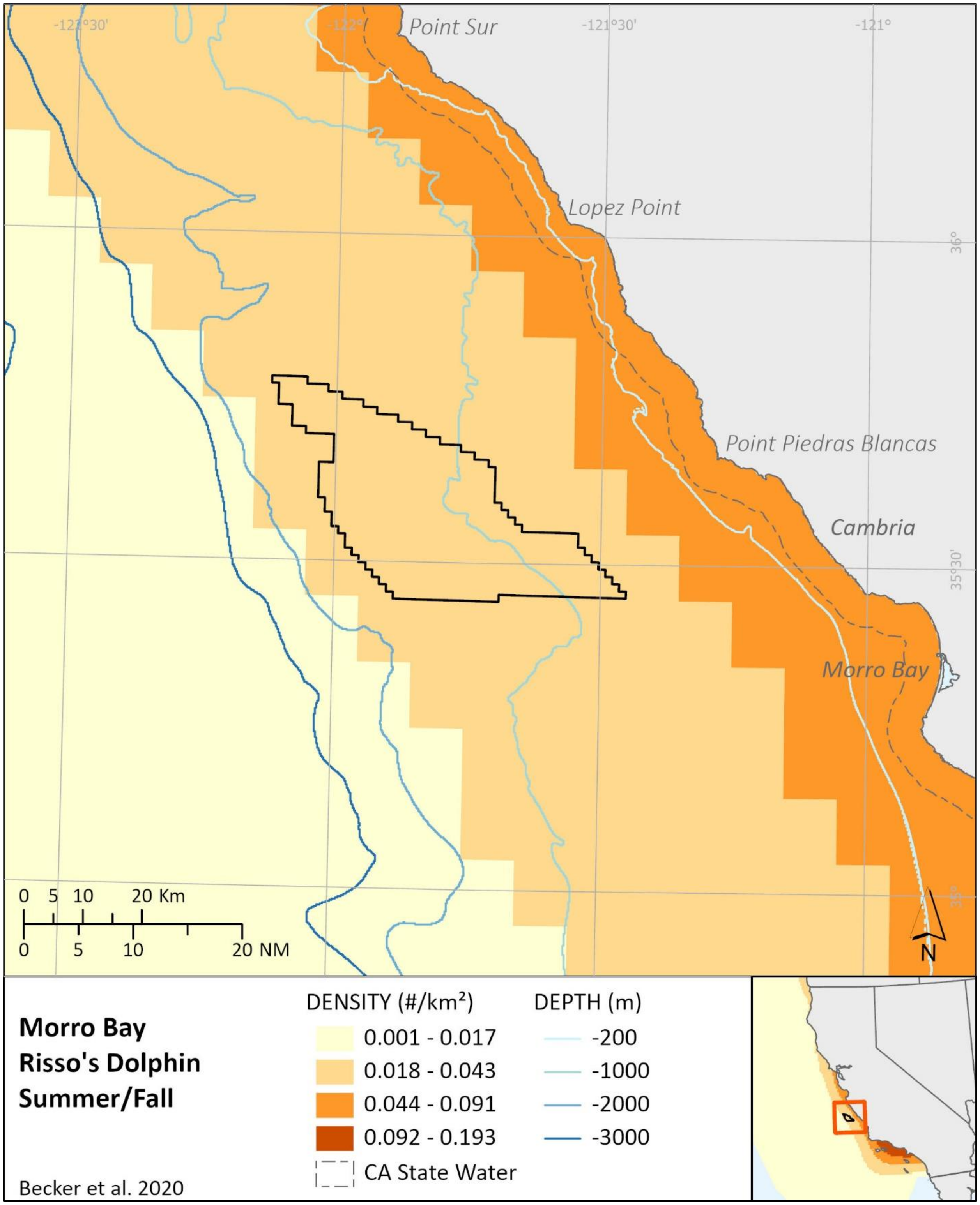

Figure A.13. Risso's dolphin summer/fall predicted density/distribution in/near the MBWEA.

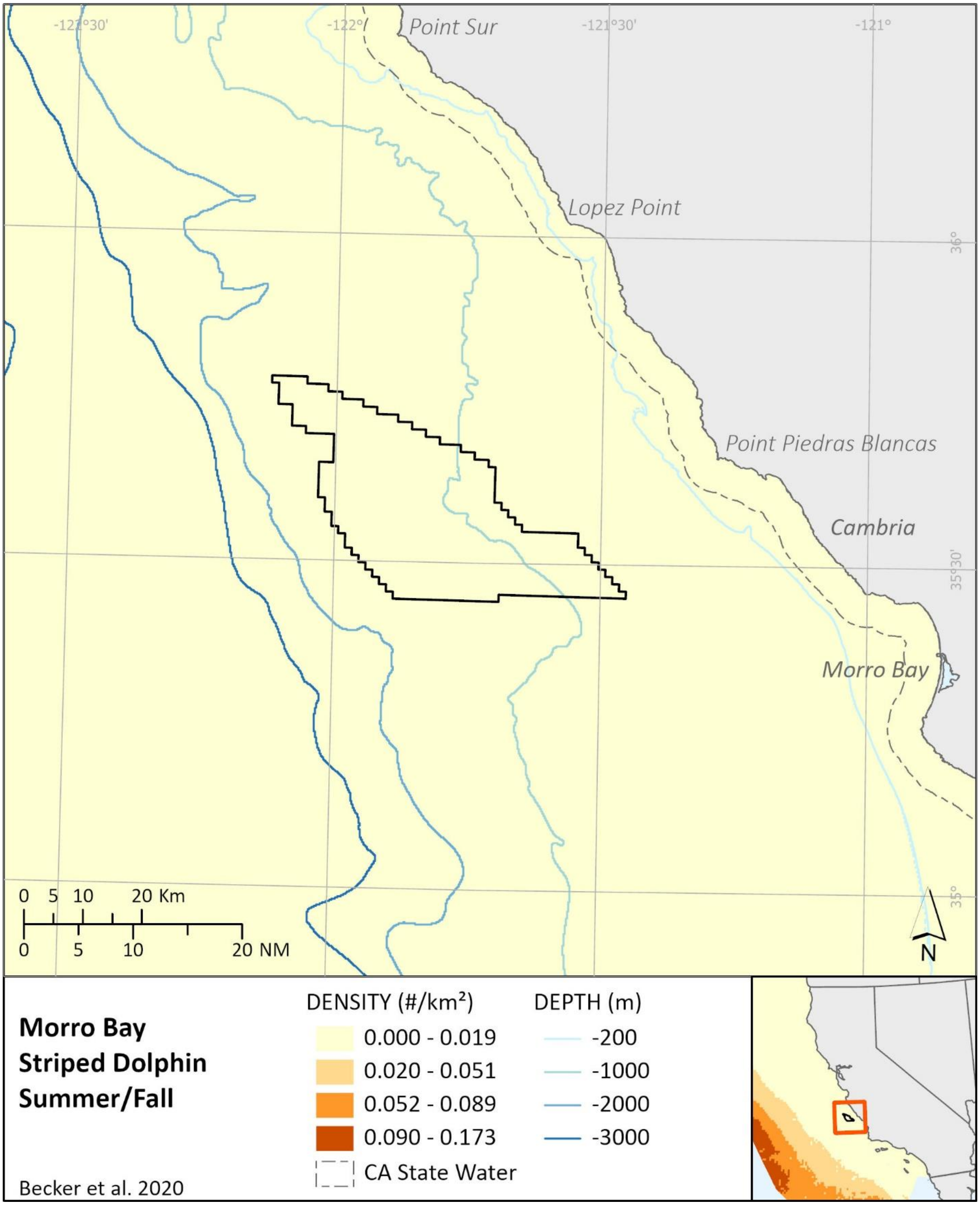

Figure A.14. Striped dolphin summer/fall predicted density/distribution in/near the MBWEA.

APPENDIX B: SEABIRD MAPS (Leirness et al. 2021)

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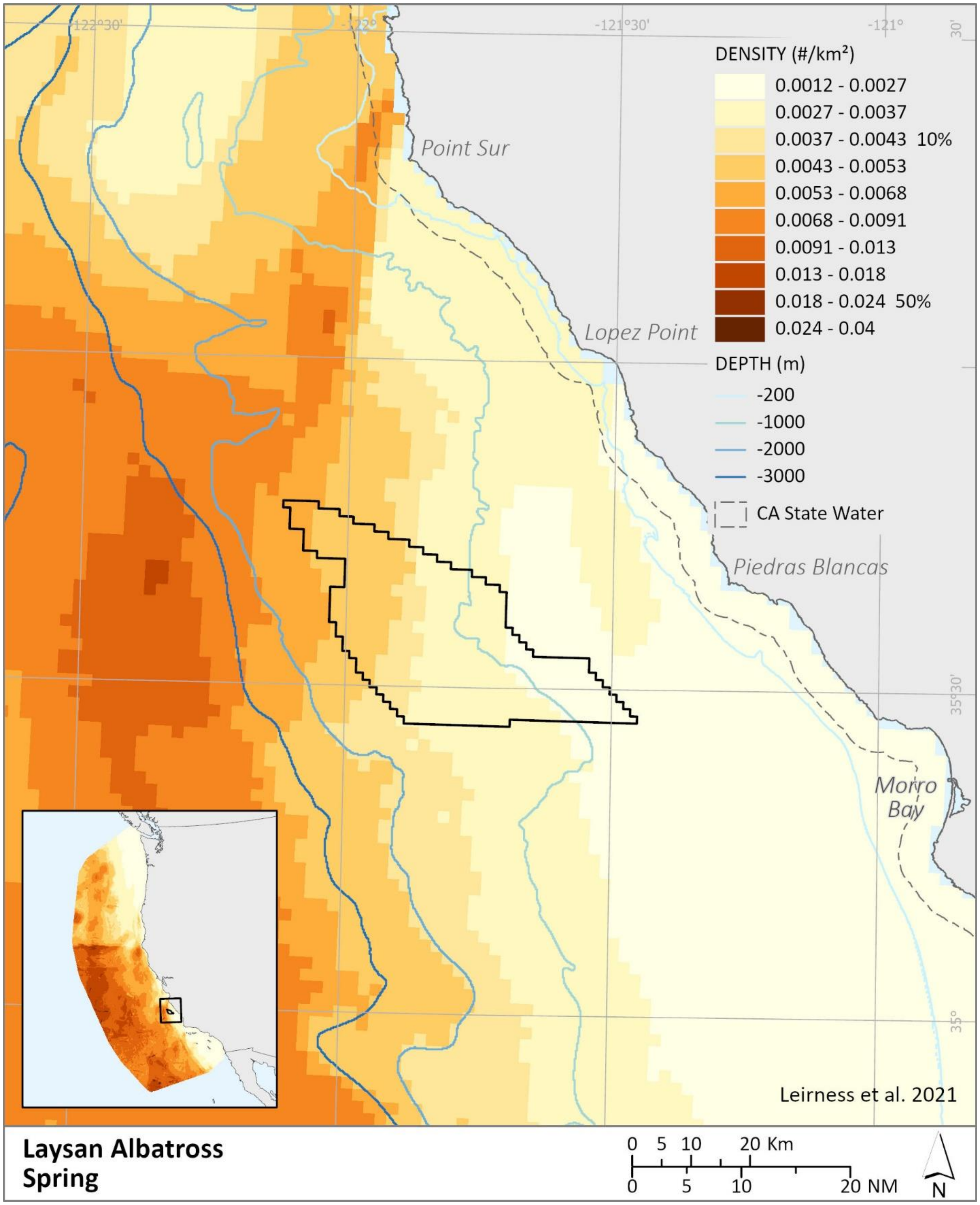

Figure B.1. Laysan albatross winter predicted density/distribution in/near the MBWEA.

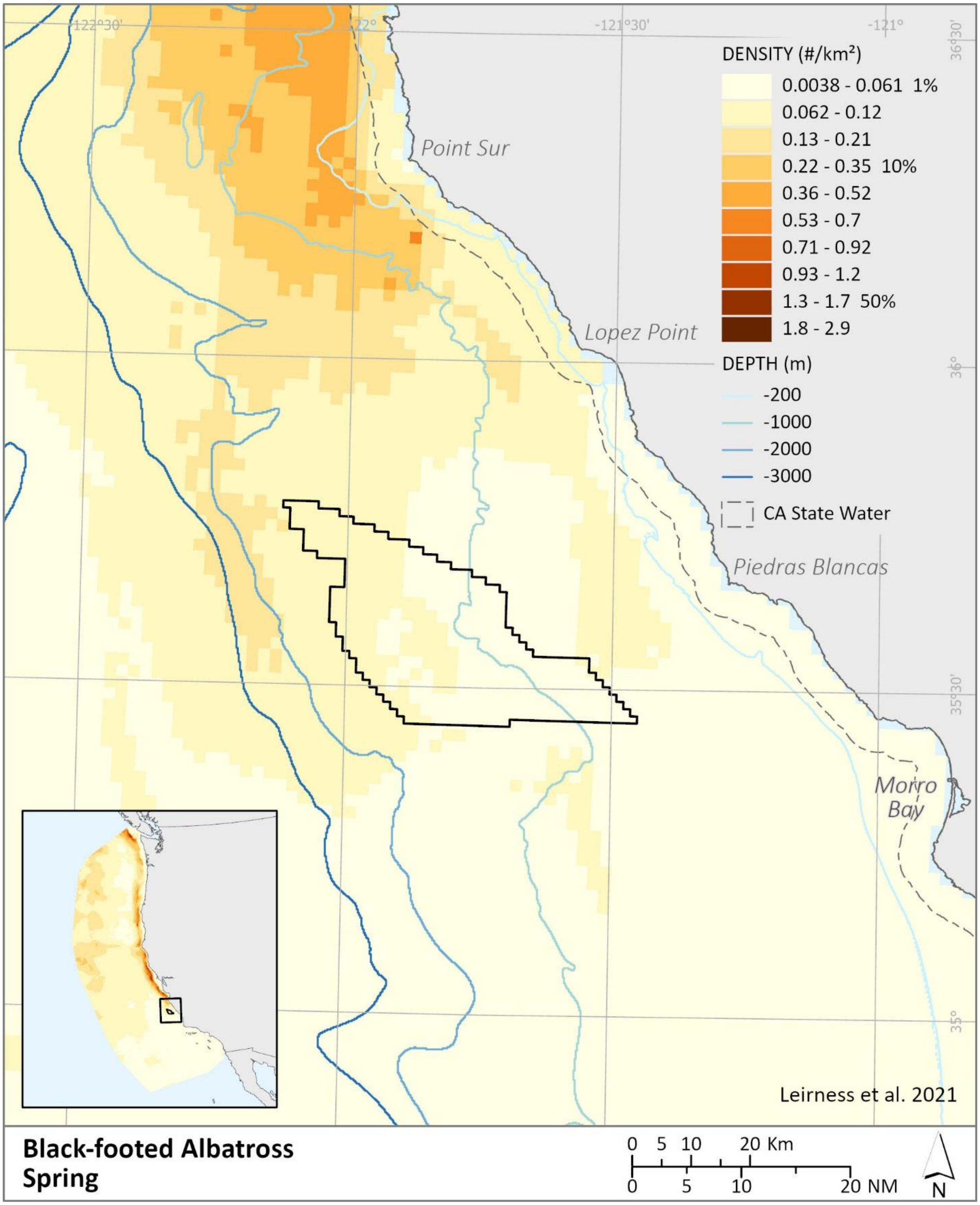

Figure B.2. Black-footed albatross summer predicted density/distribution in/near the MBWEA.

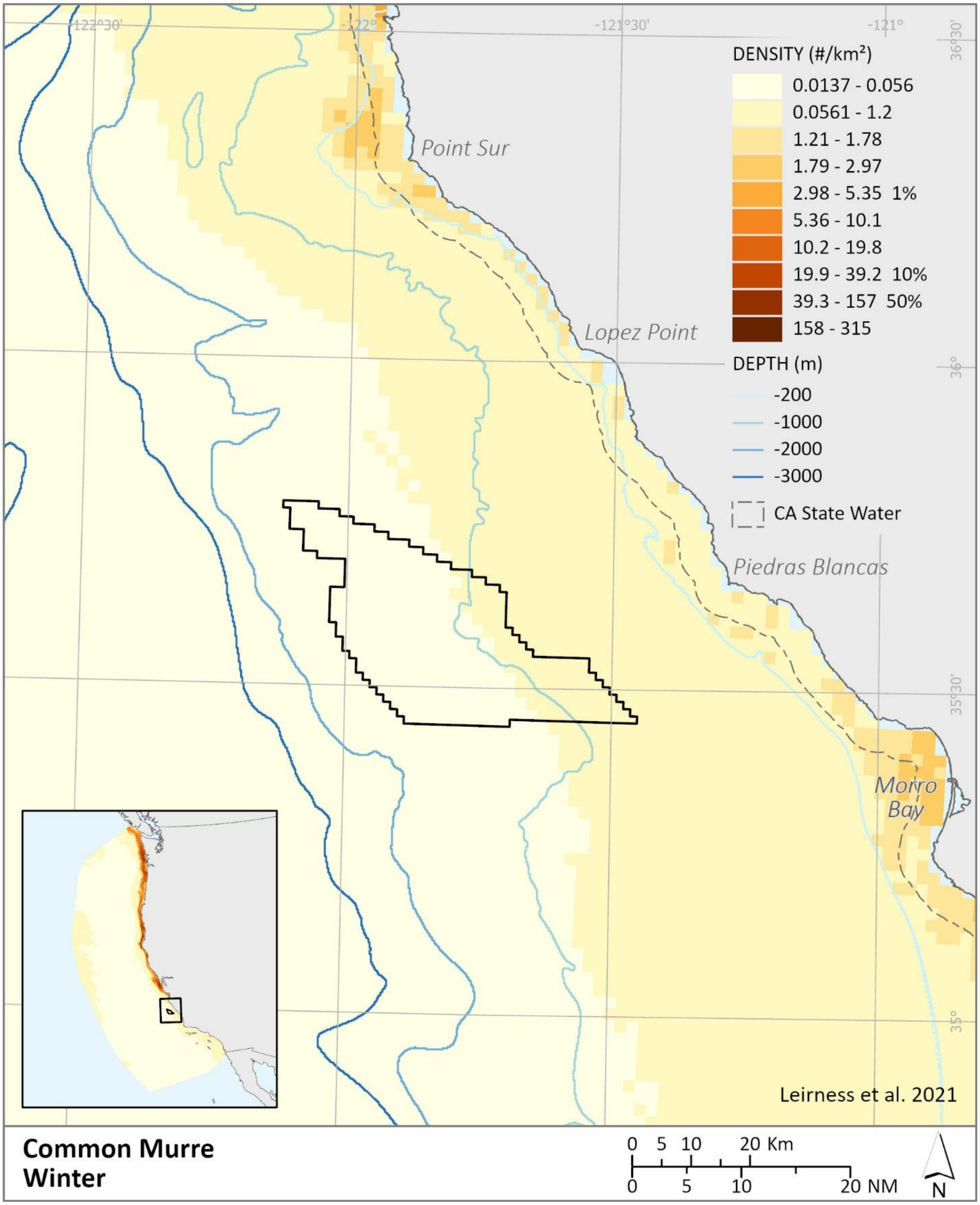

Figure B.3. Common murre winter predicted density/distribution in/near the MBWEA.

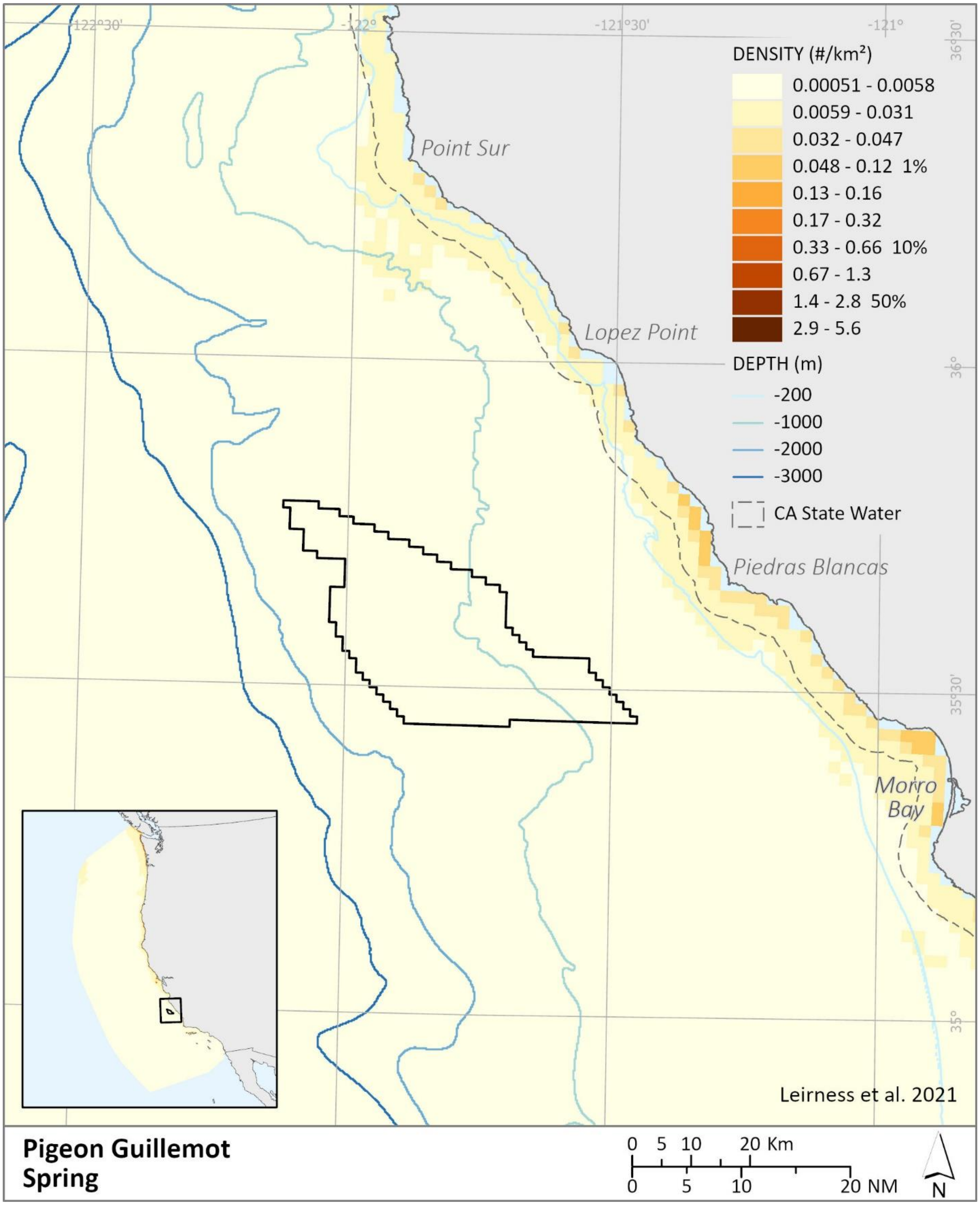

Figure B.4. Pigeon guillemot spring predicted density/distribution in/near the MBWEA.

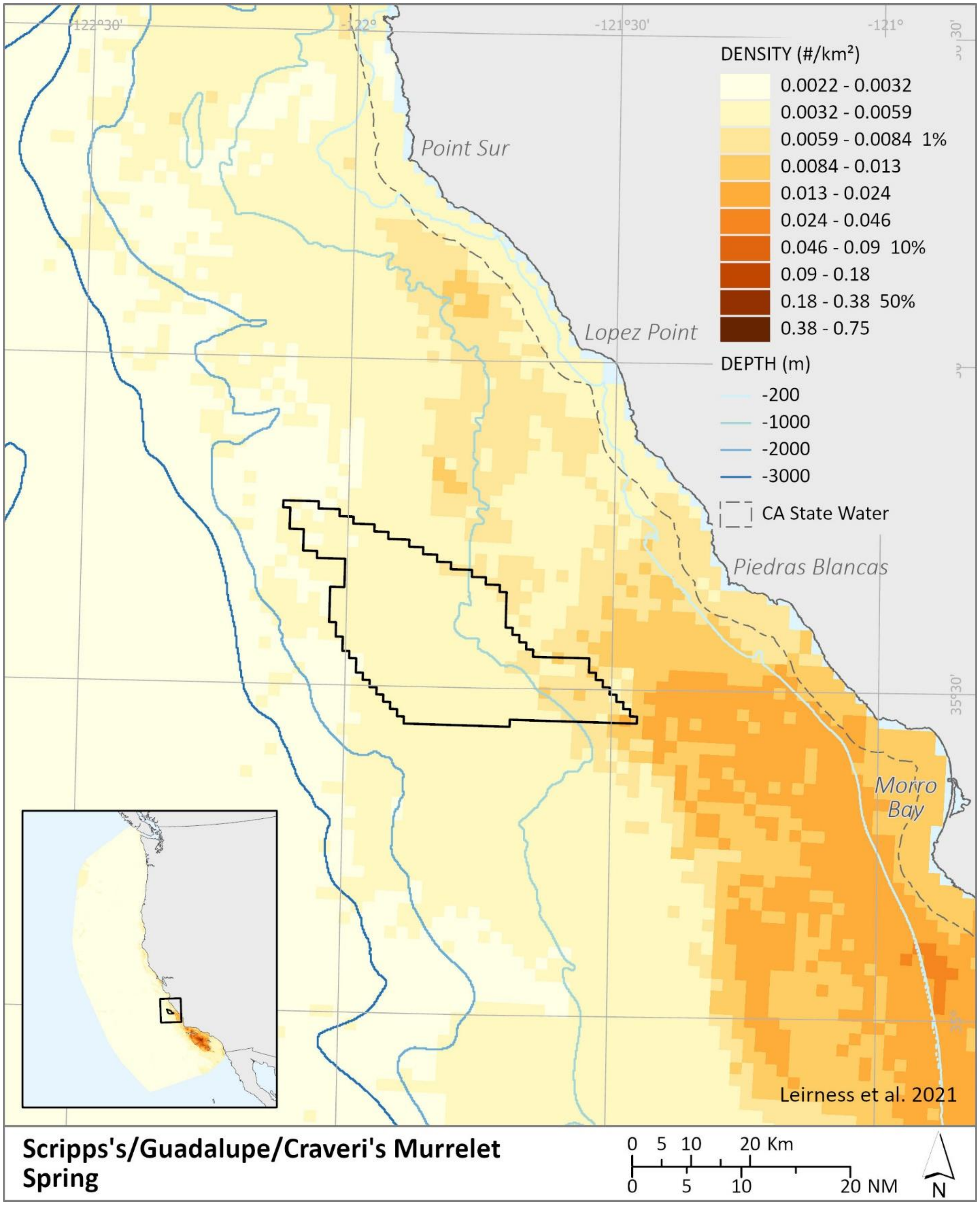

Figure B.5. Scripps's/Guadalupe/Craveri's murrelet spring predicted density/distribution in/near the MBWEA.

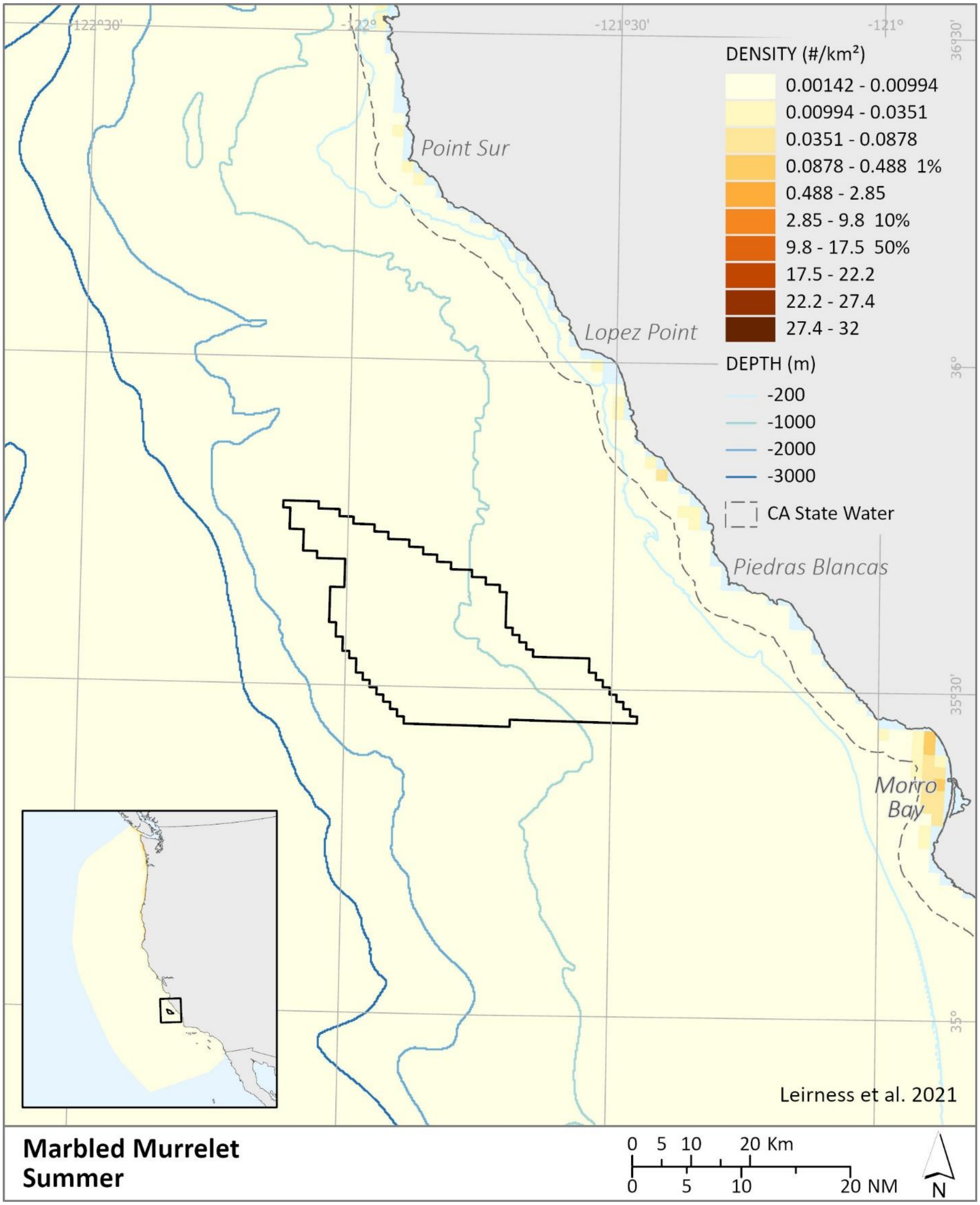

Figure B.6. Marbled murrelet summer predicted density/distribution in/near the MBWEA.

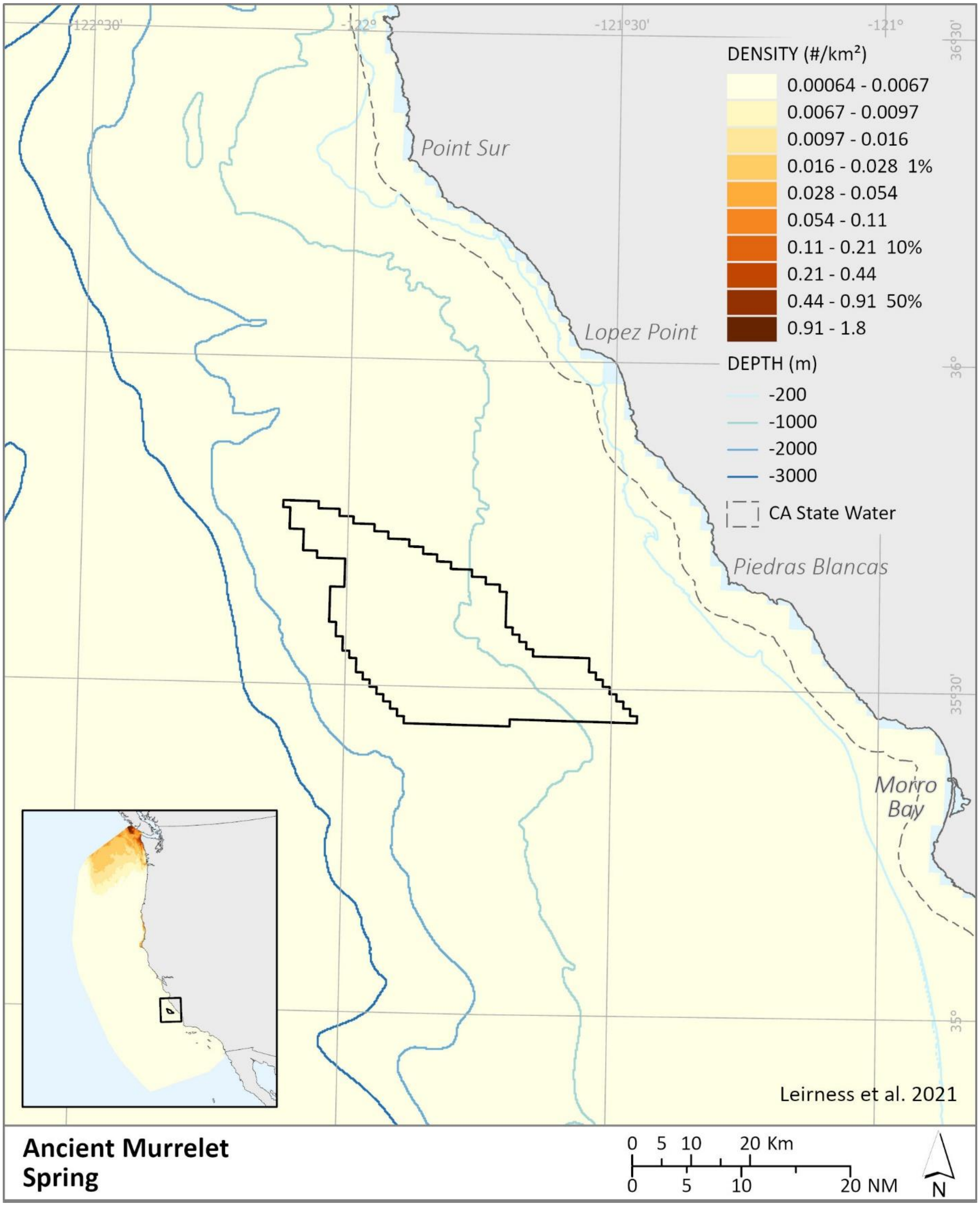

Figure B.7. Ancient murrelet spring predicted density/distribution in/near the MBWEA.

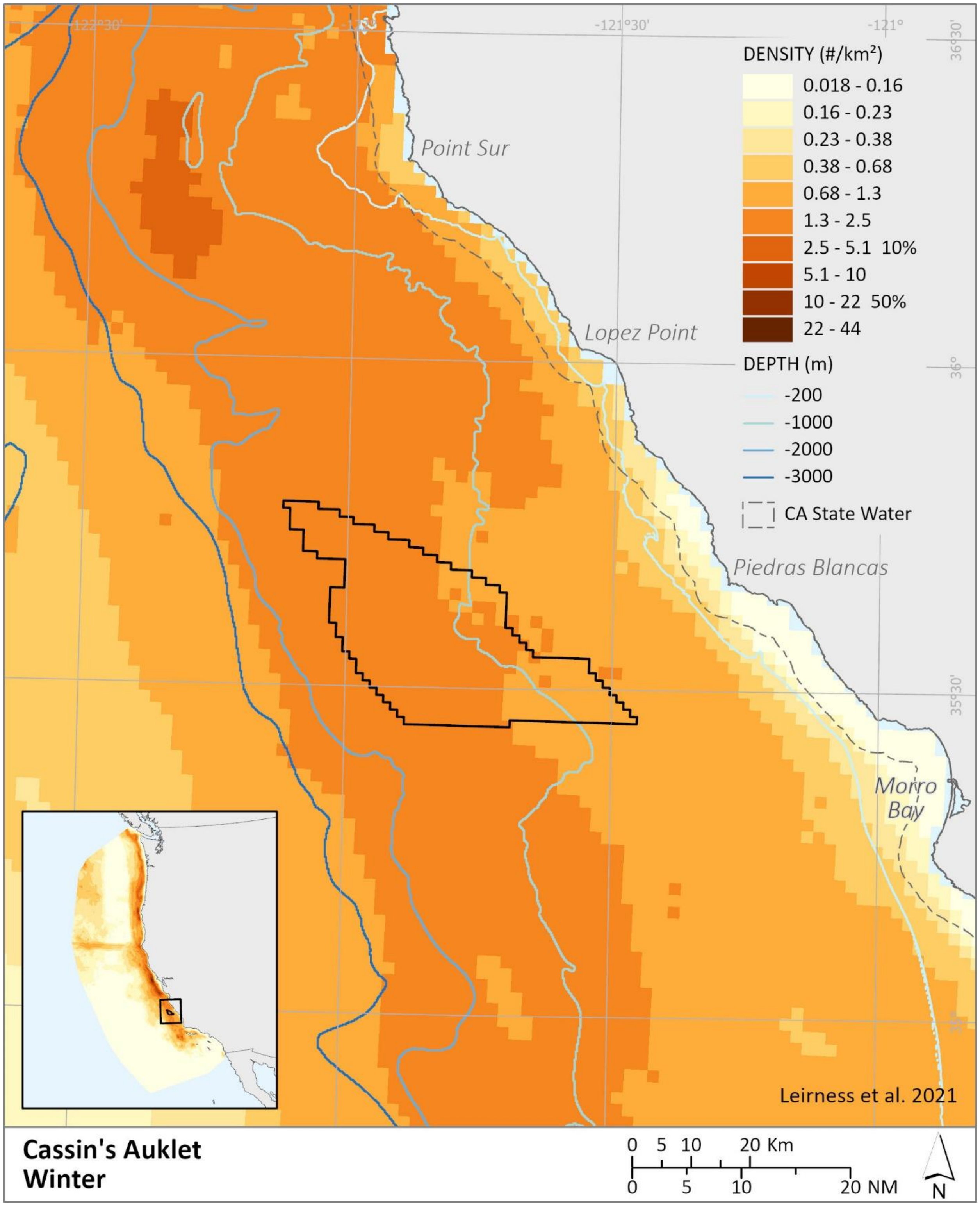

Figure B.8. Cassin's auklet winter predicted density/distribution in/near the MBWEA.

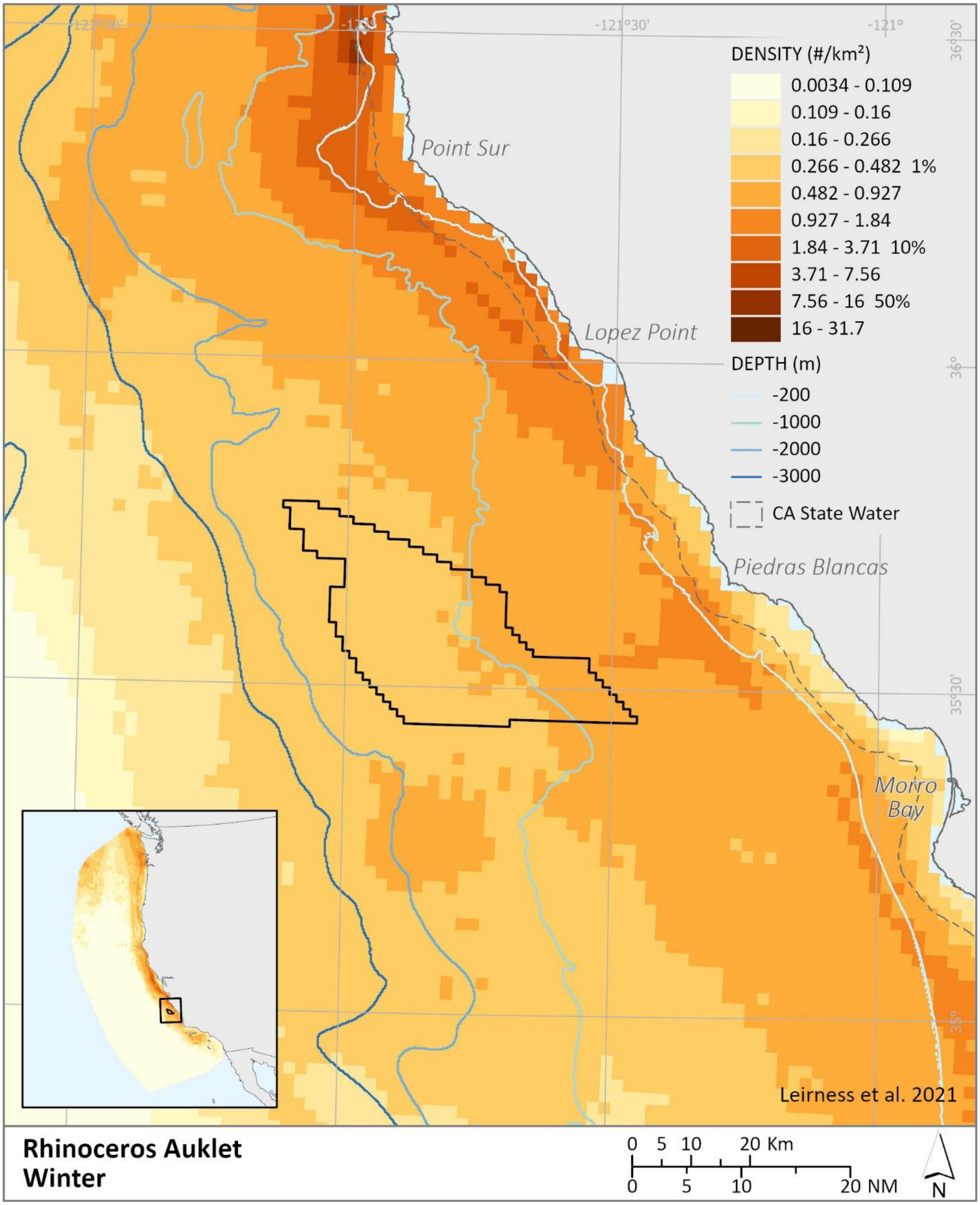

Figure B.9. Rhinoceros auklet winter predicted density/distribution in/near the MBWEA.

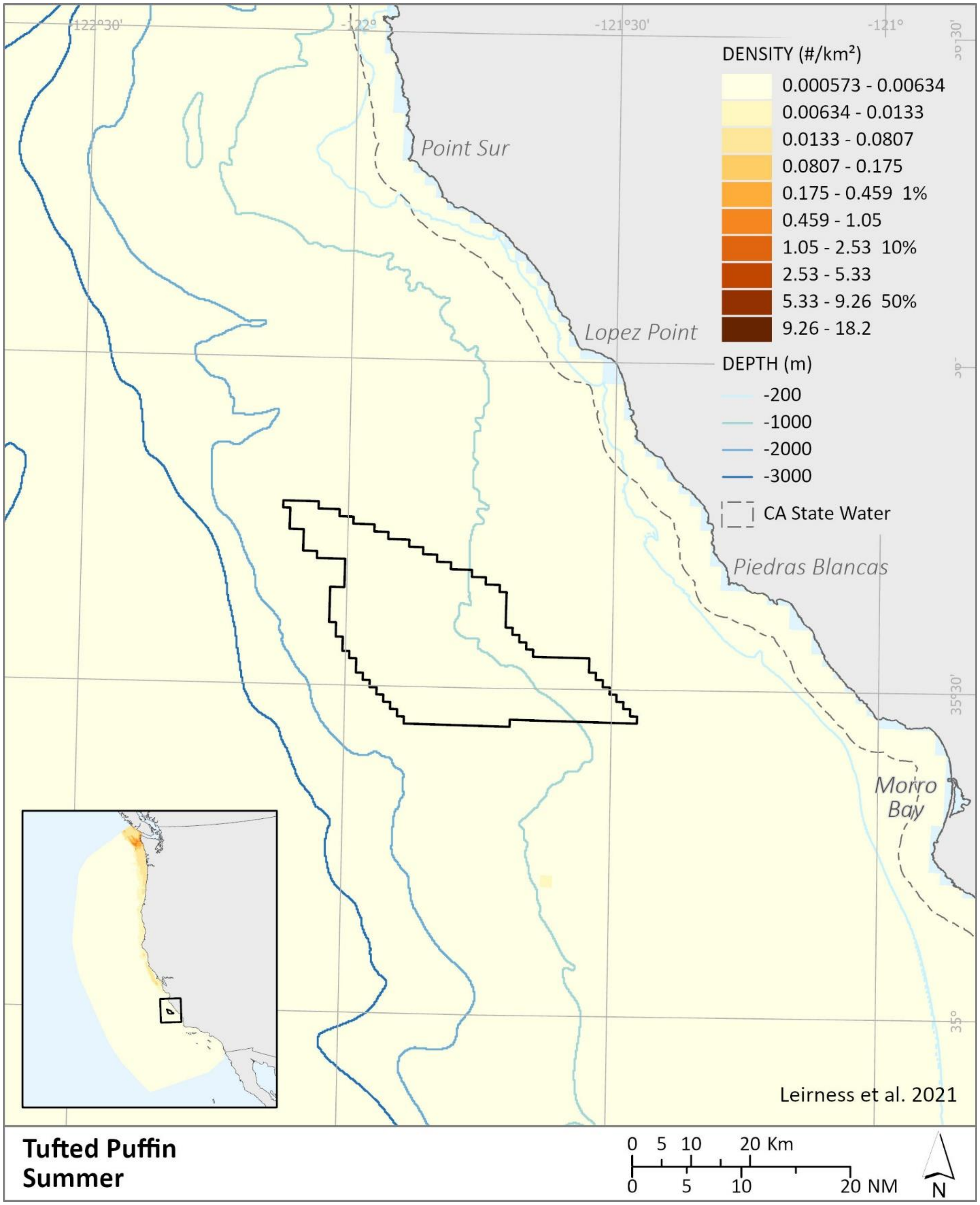

Figure B.10. Tufted puffin summer predicted density/distribution in/near the MBWEA.

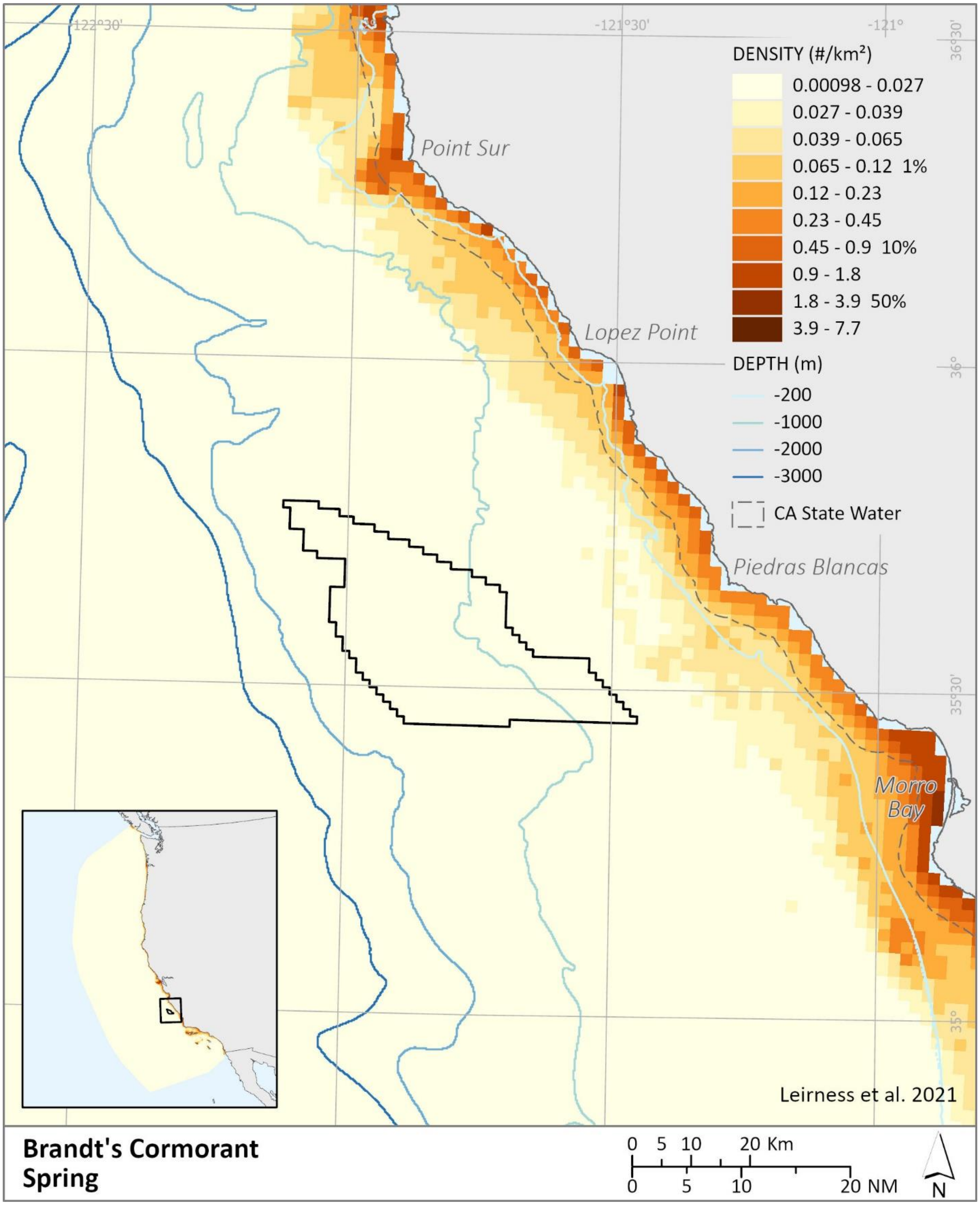

Figure B.11. Brandt's cormorant spring predicted density/distribution in/near the MBWEA.

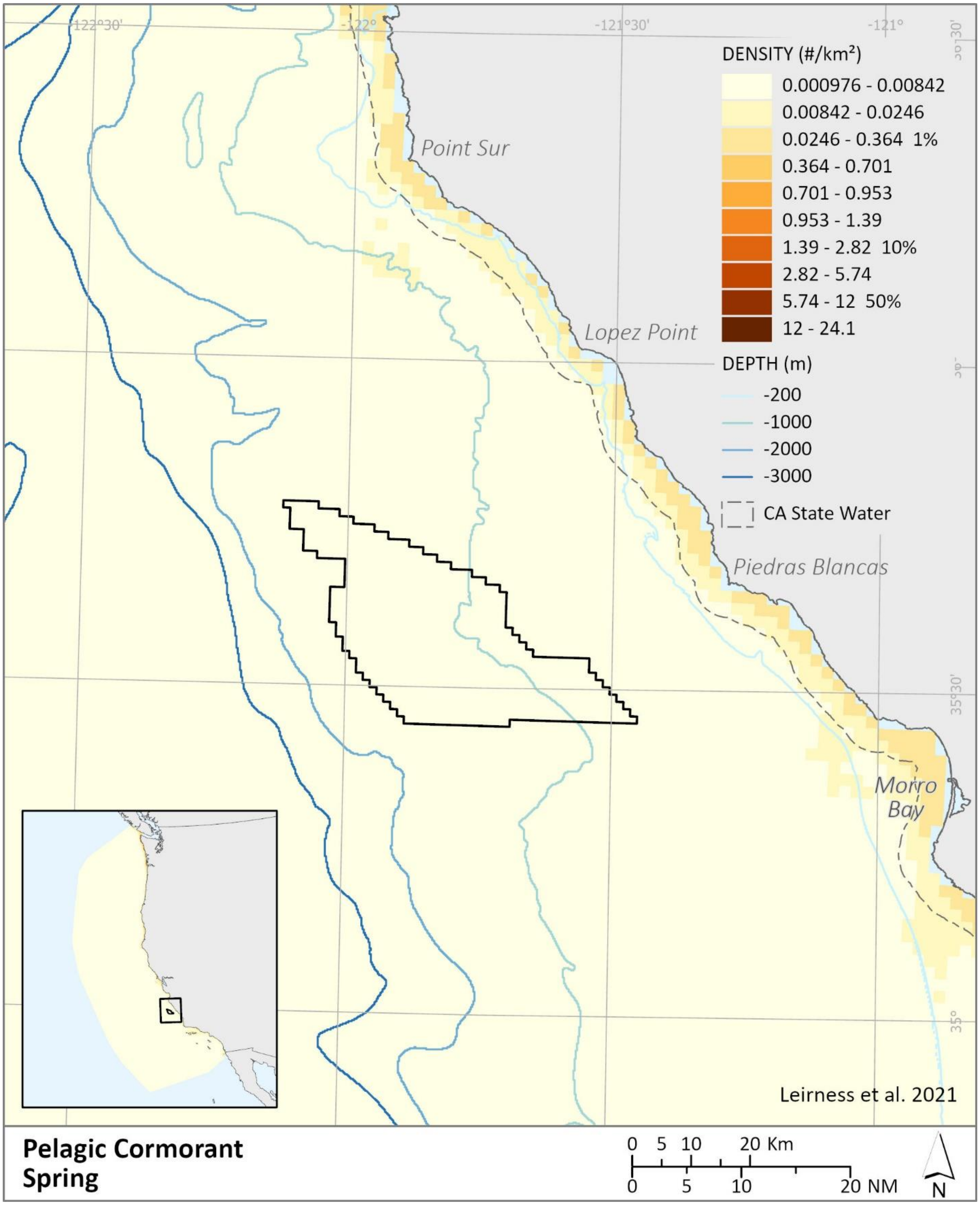

Figure B.12. Pelagic cormorant spring predicted density/distribution in/near the MBWEA.

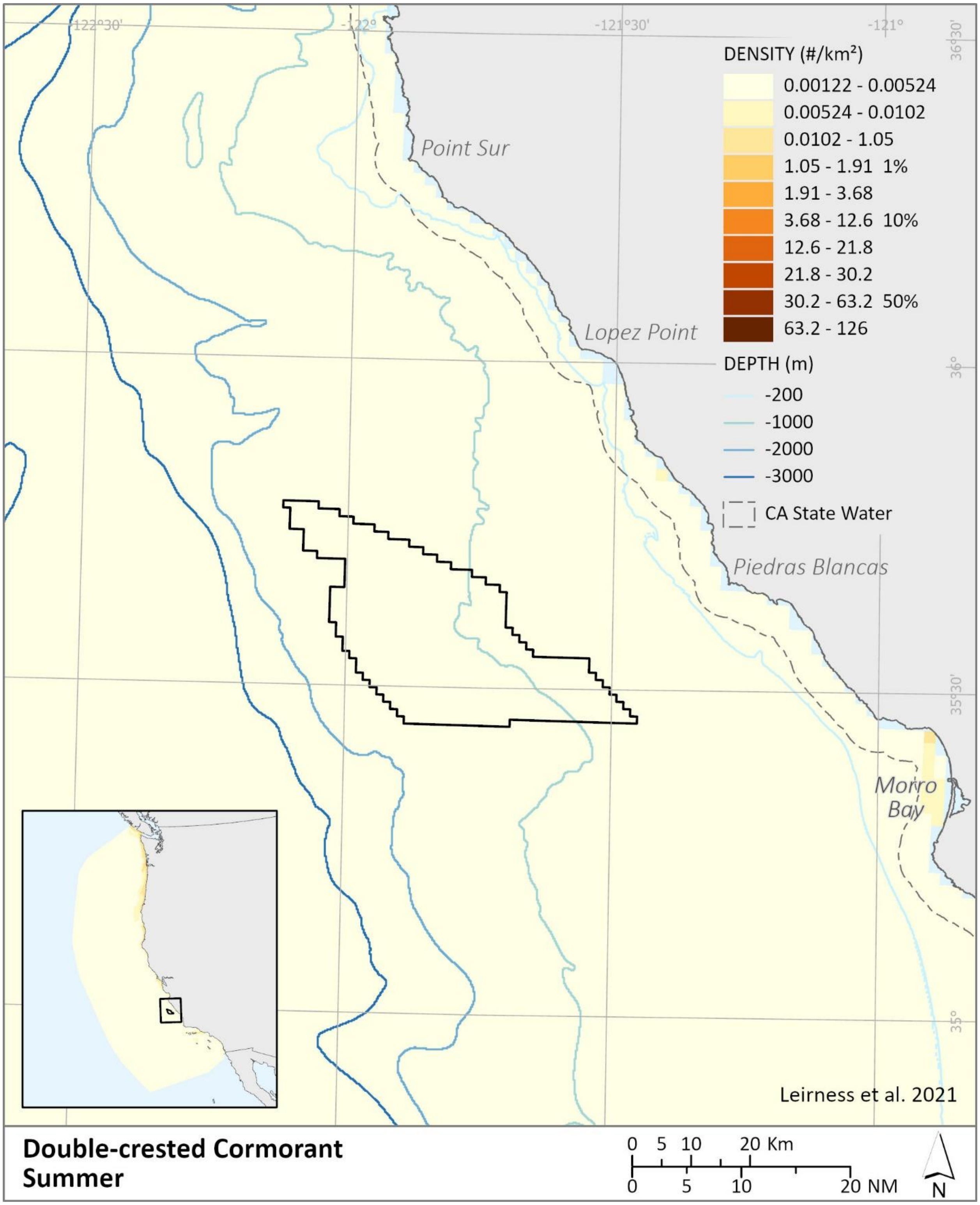

Figure B.13. Double-crested cormorant summer predicted density/distribution in/near the MBWEA.

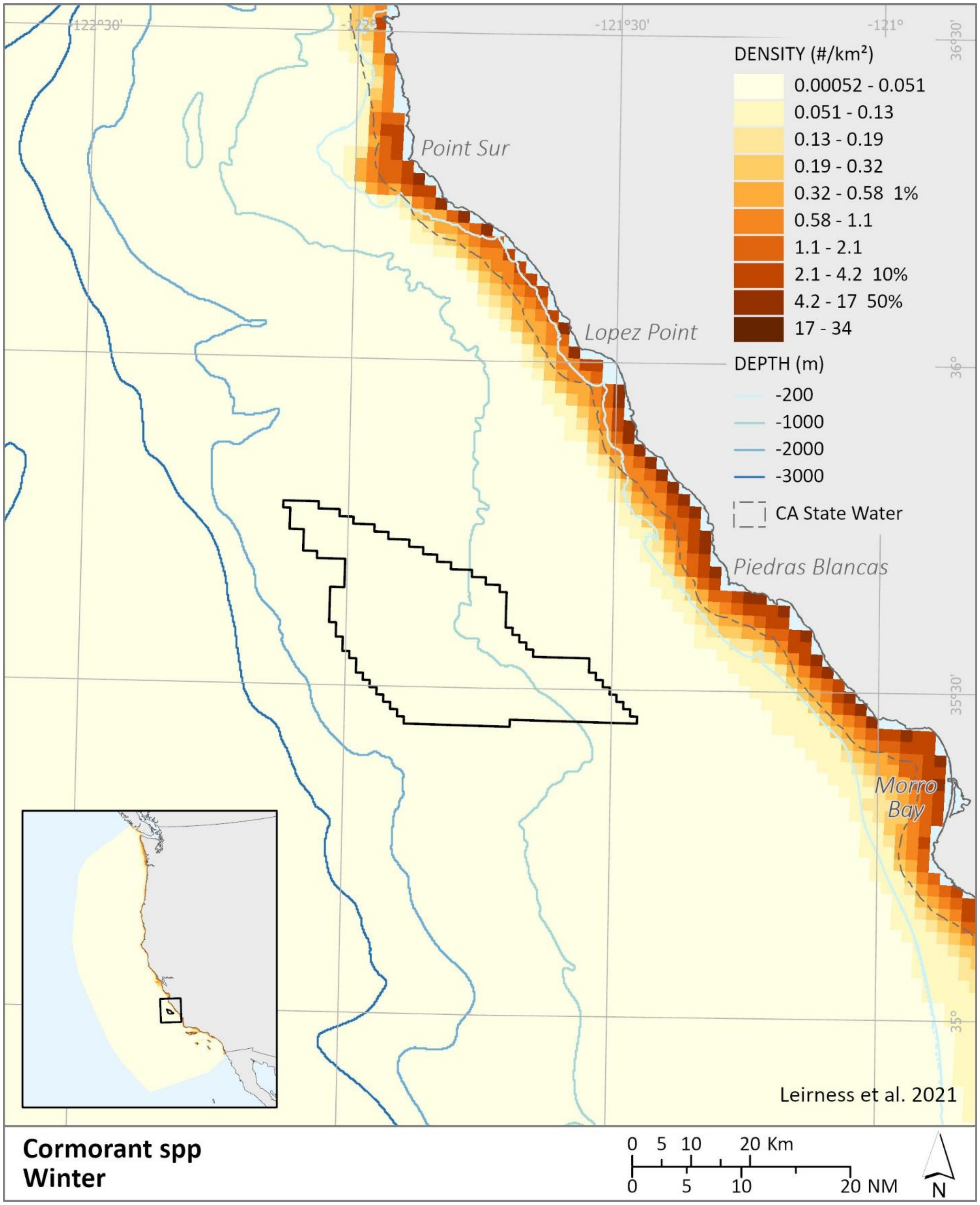

Figure B.14. Cormorant spp winter predicted density/distribution in/near the MBWEA.

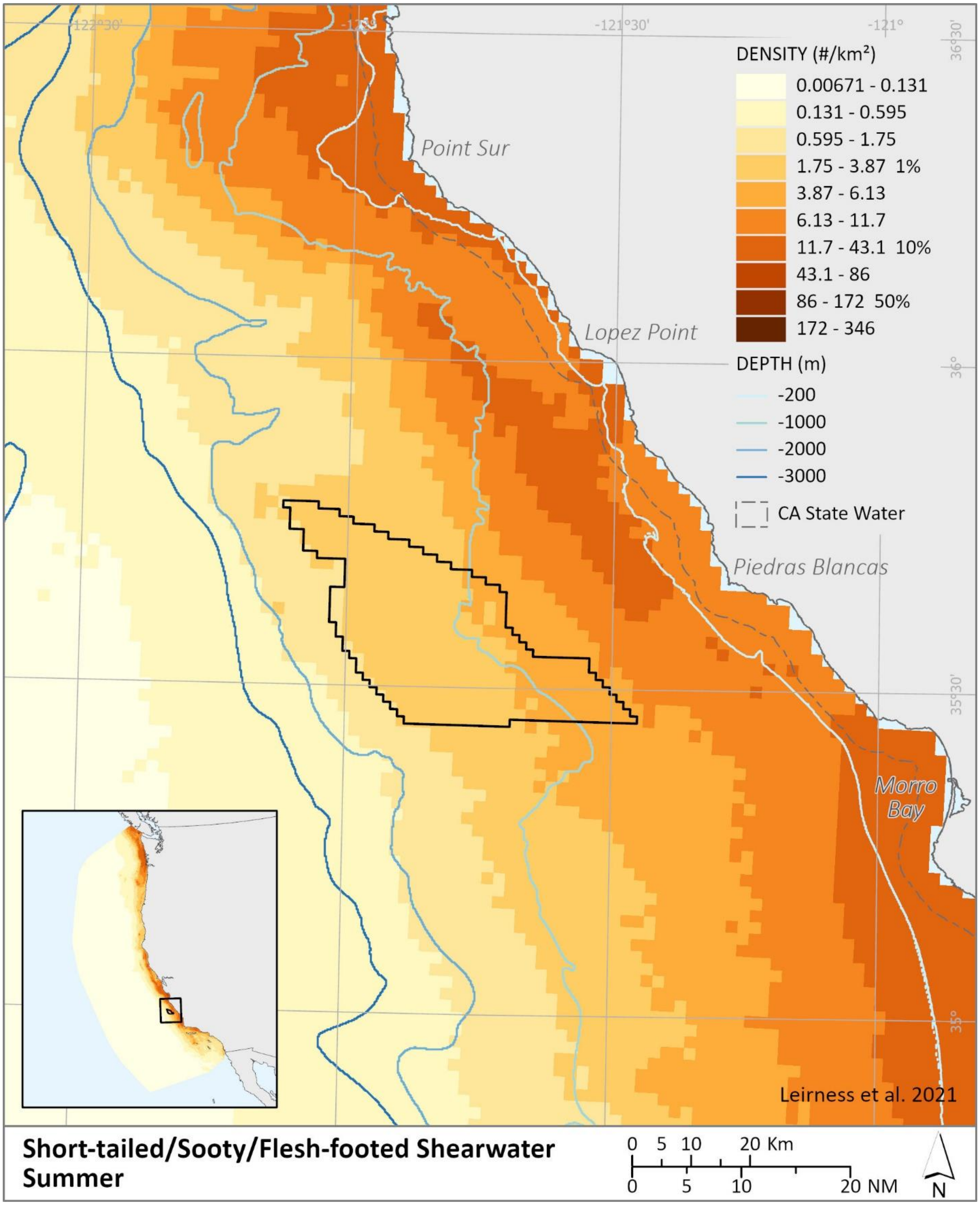

Figure B.15. Short-tailed/sooty/flesh-footed shearwater summer predicted density/distribution in/near the MBWEA.

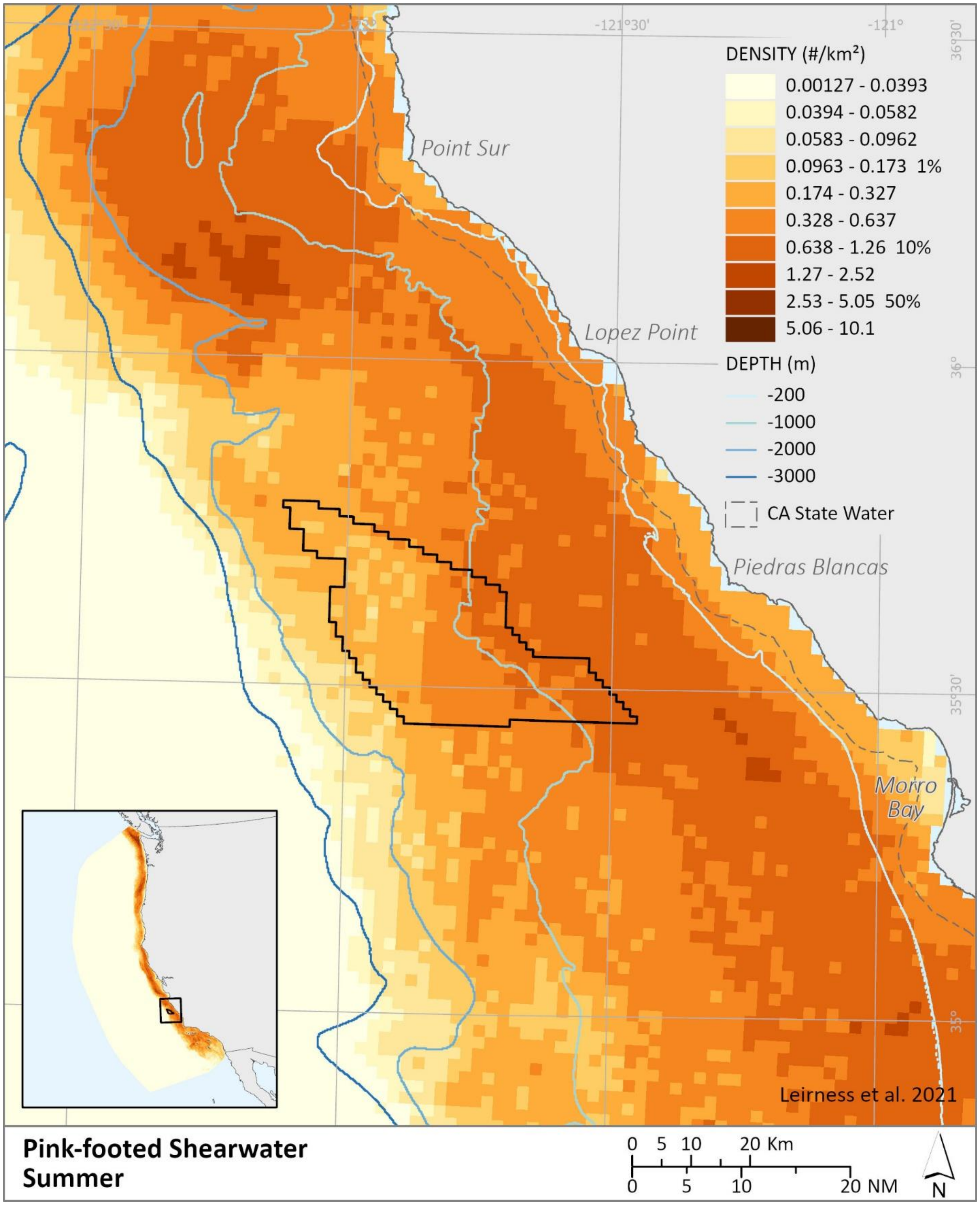

Figure B.16. Pink-footed shearwater summer predicted density/distribution in/near the MBWEA.

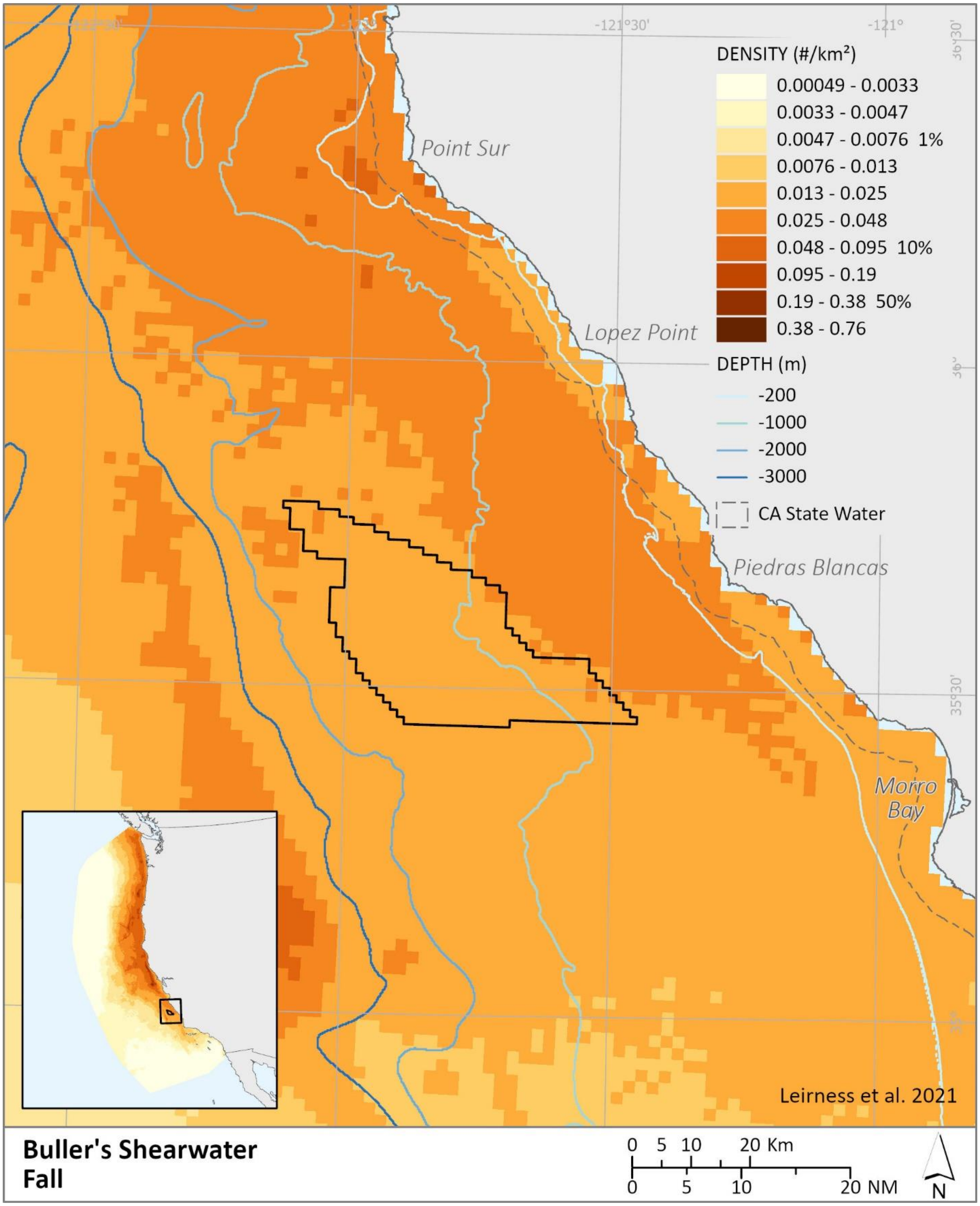

Figure B.17. Buller’s shearwater fall predicted density/distribution in/near the MBWEA.

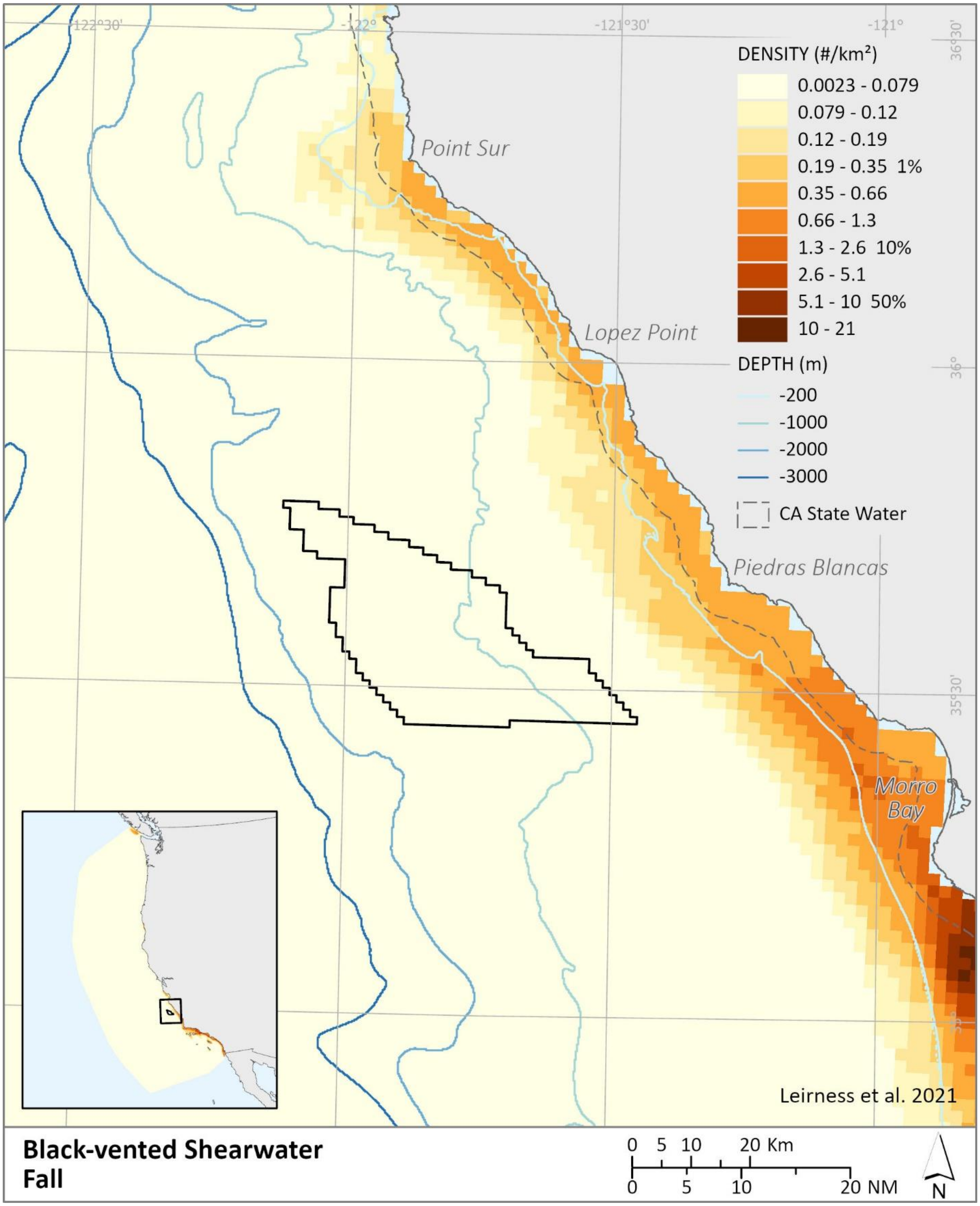

Figure B.18. Black-vented shearwater fall predicted density/distribution in/near the MBWEA.

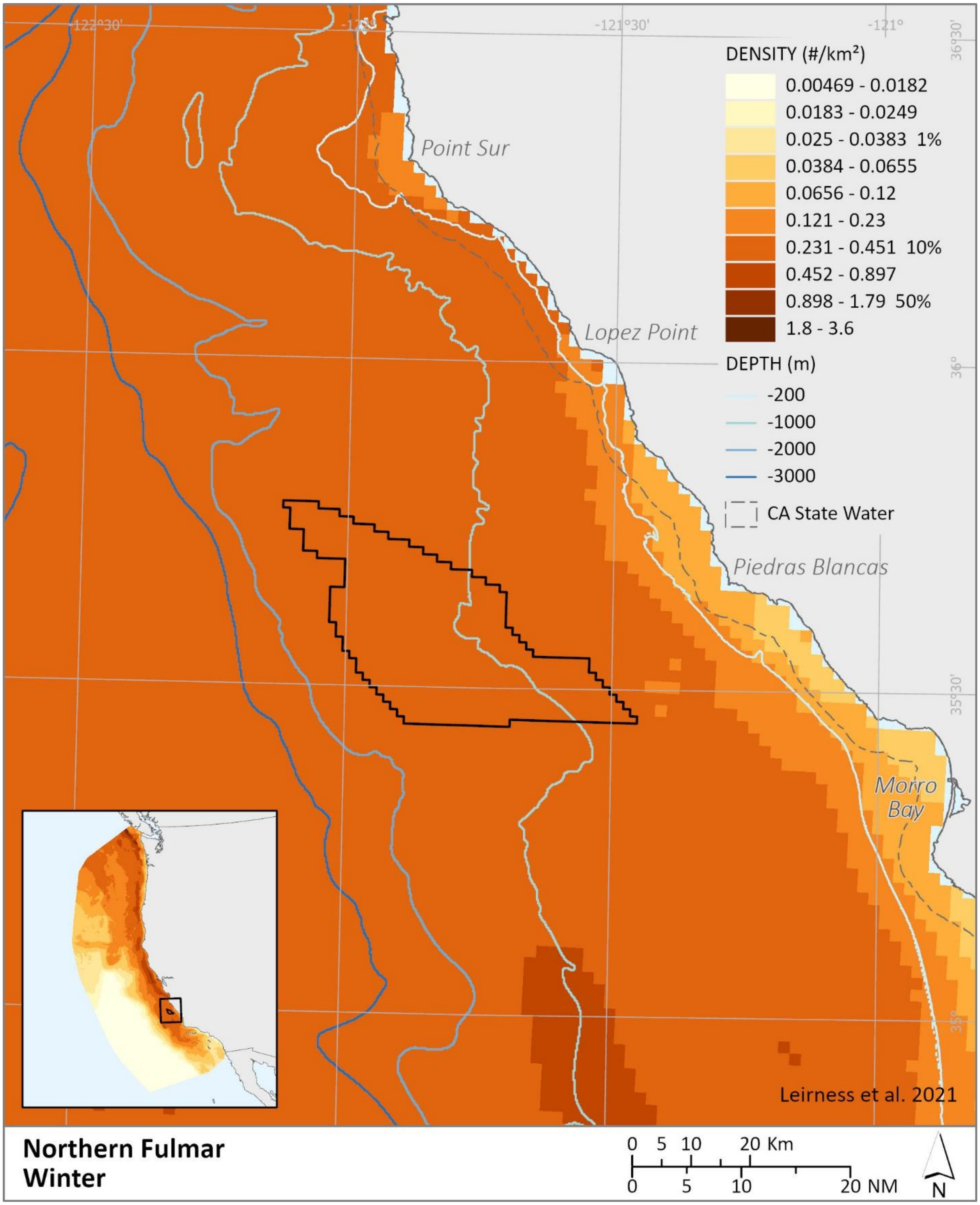

Figure B.19. Northern fulmar winter predicted density/distribution in/near the MBWEA.

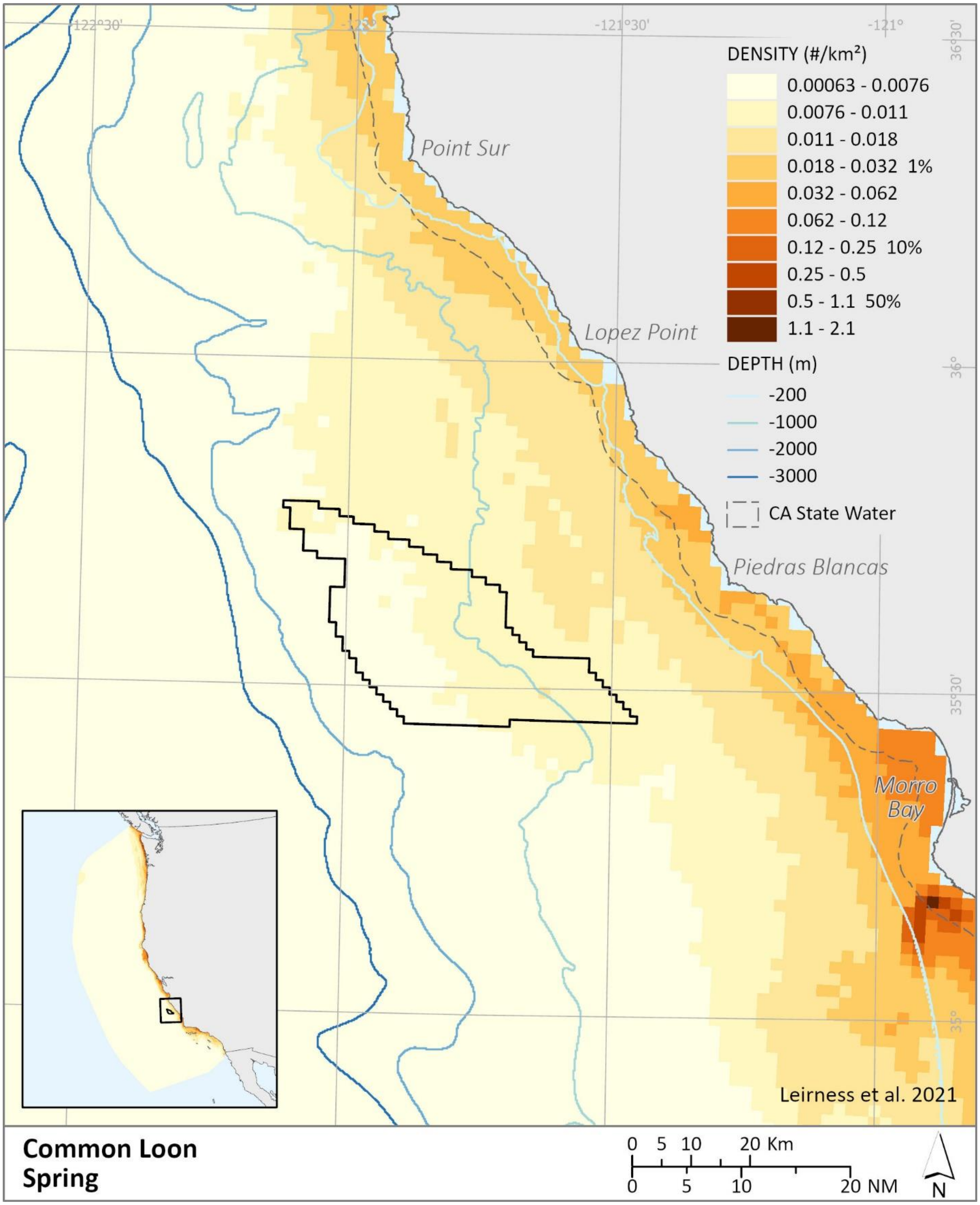

Figure B.20. Common loon spring predicted density/distribution in/near the MBWEA.

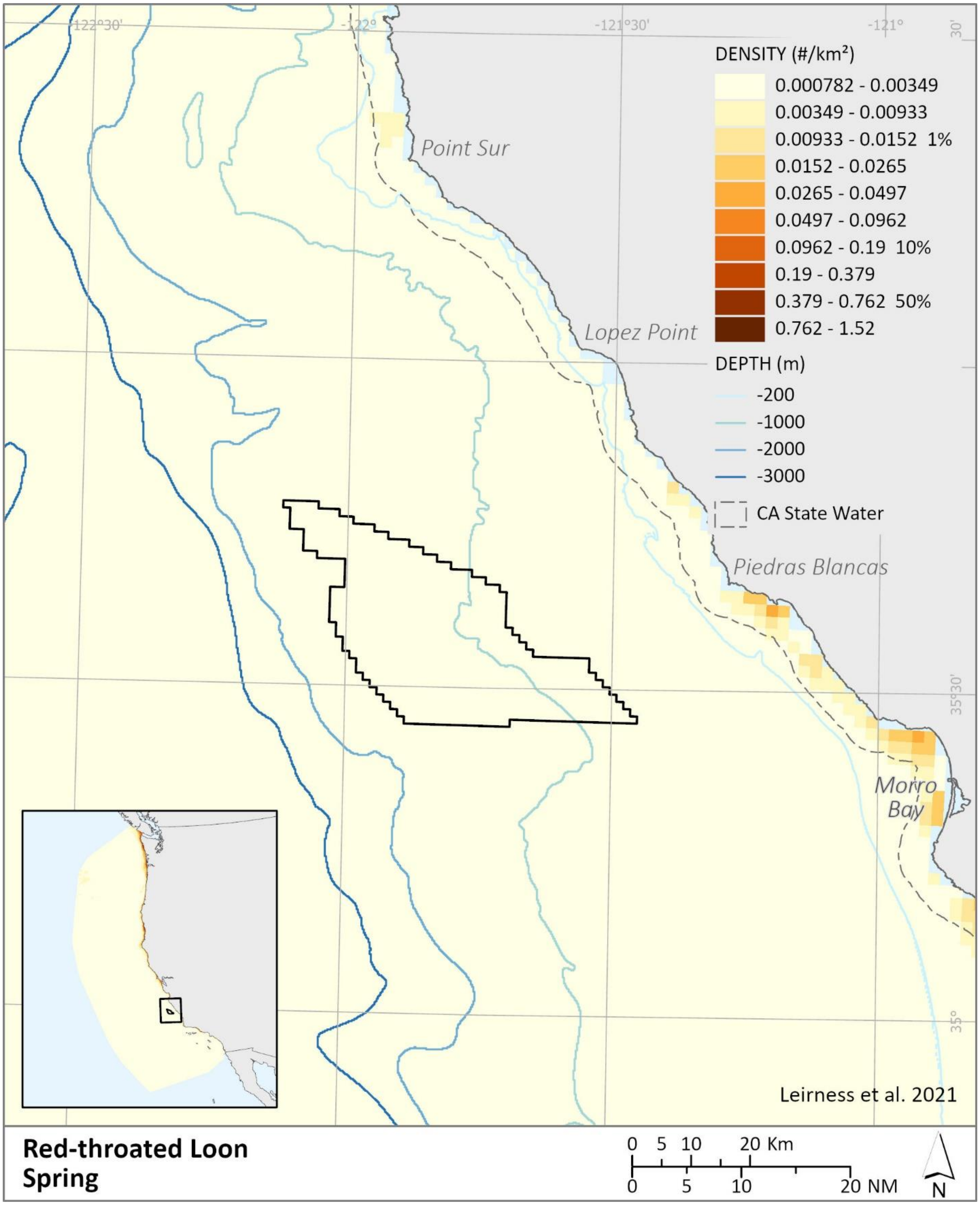

Figure B.21. Red-throated loon spring predicted density/distribution in/near the MBWEA.

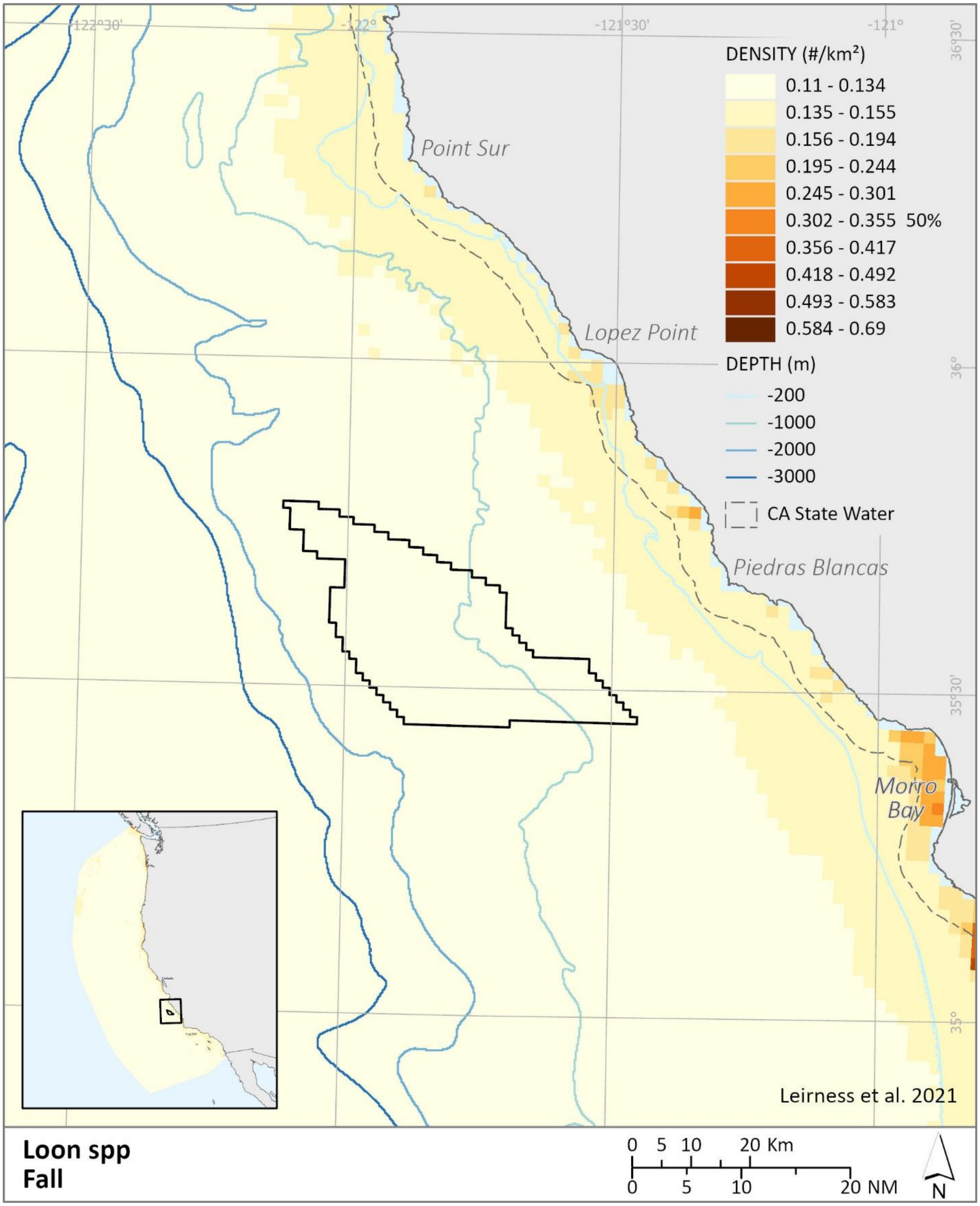

Figure B.22. Loon spp fall predicted density/distribution in/near the MBWEA.

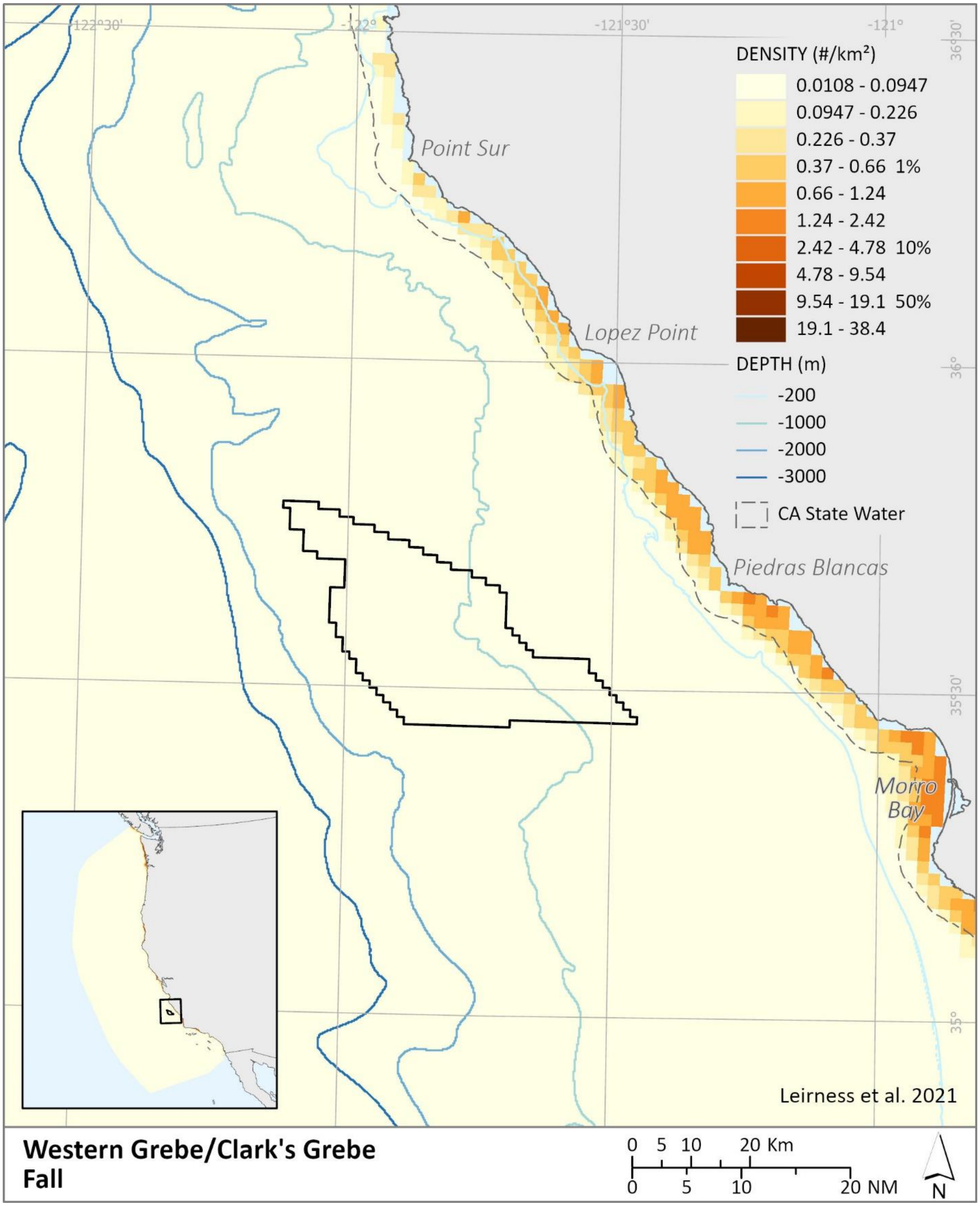

Figure B.23. Western grebe and Clark's grebe fall predicted density/distribution in/near the MBWEA.

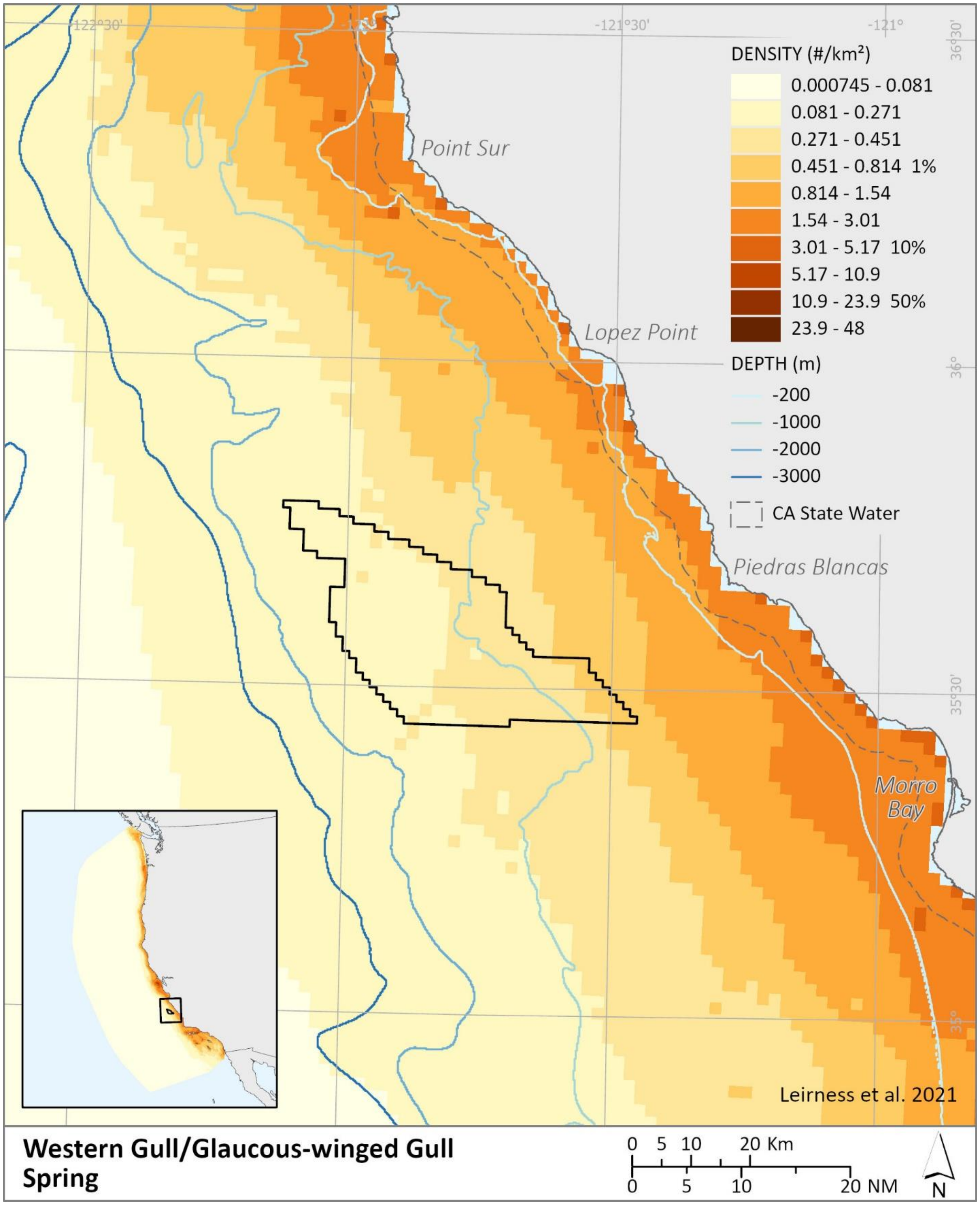

Figure B.24. Western gull and glaucous-winged gull spring predicted density/distribution in/near the MBWEA.

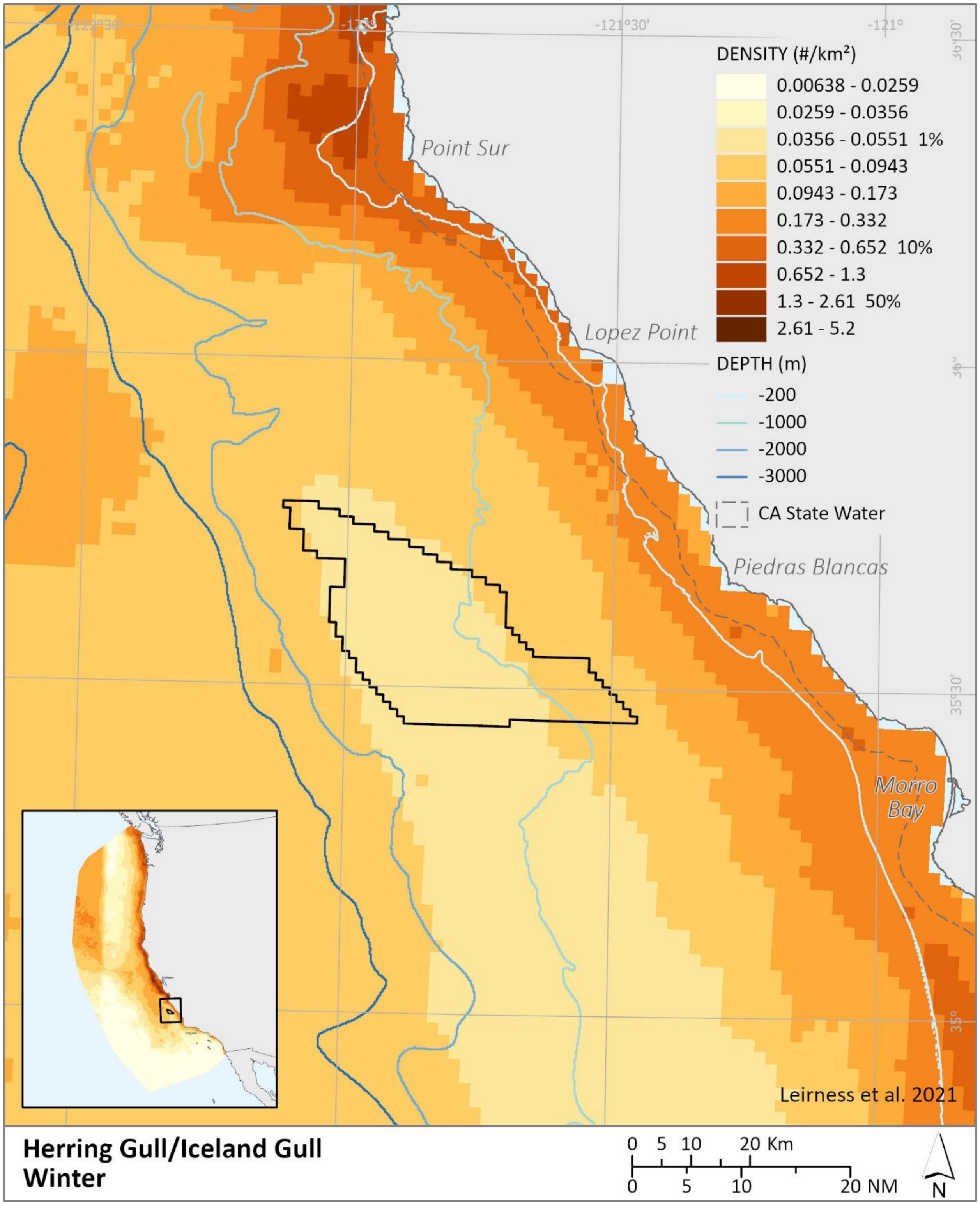

Figure B.25. Herring gull and Iceland gull winter predicted density/distribution in/near the MBWEA.

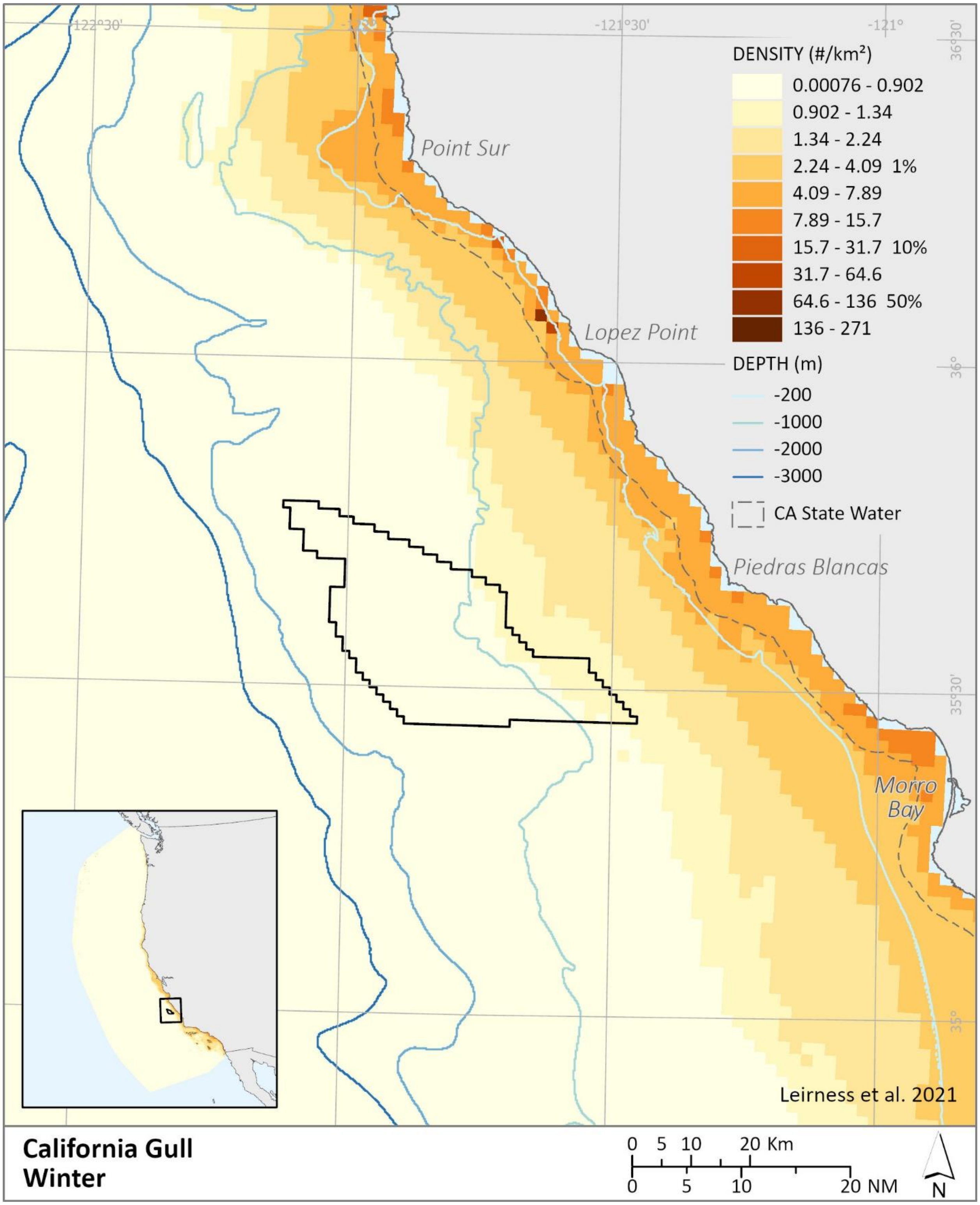

Figure B.26. California gull winter predicted density/distribution in/near the MBWEA.

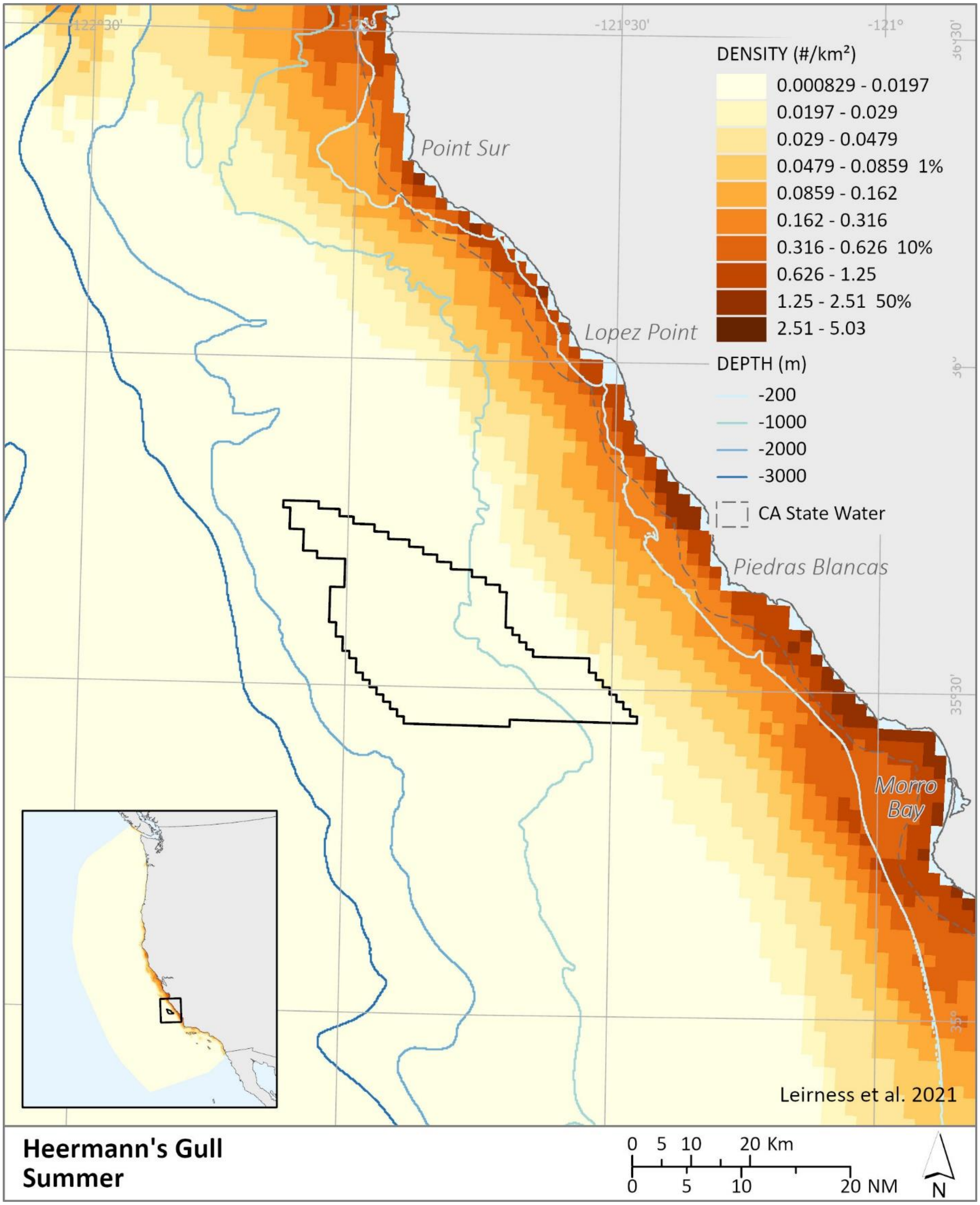

Figure B.27. Heermann's gull summer predicted density/distribution in/near the MBWEA.

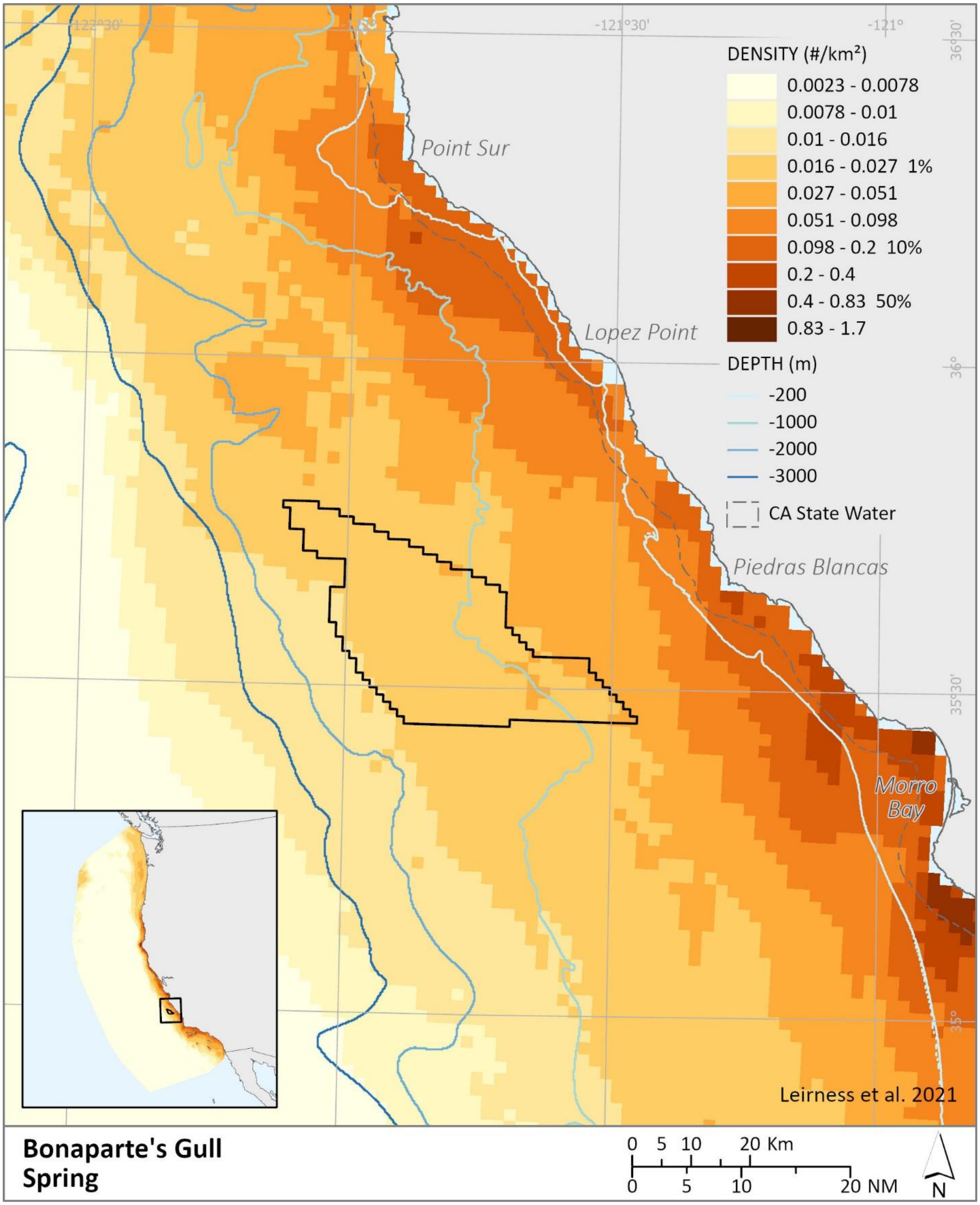

Figure B.28. Bonaparte's gull spring predicted density/distribution in/near the MBWEA.

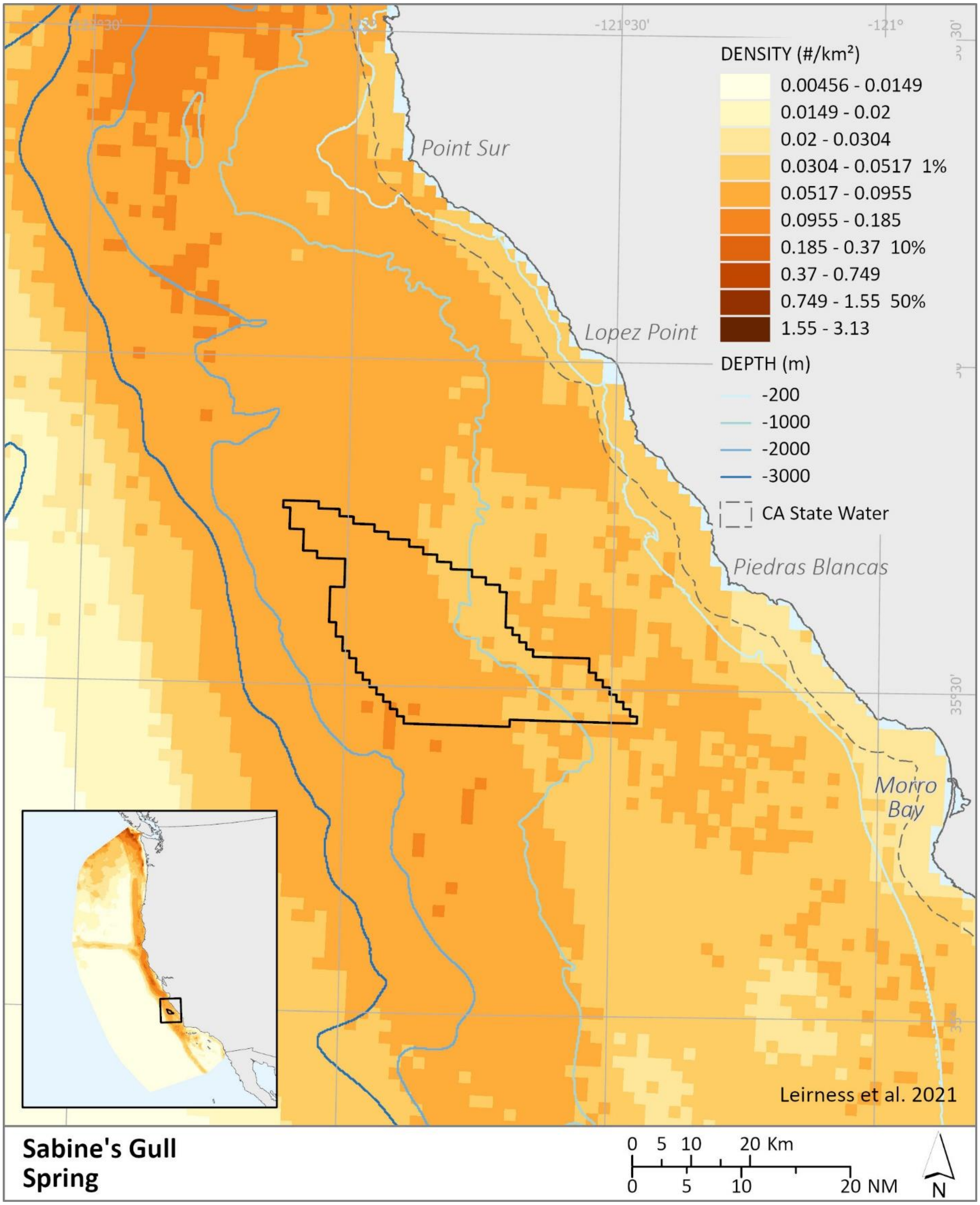

Figure B.29. Sabine's gull spring predicted density/distribution in/near the MBWEA.

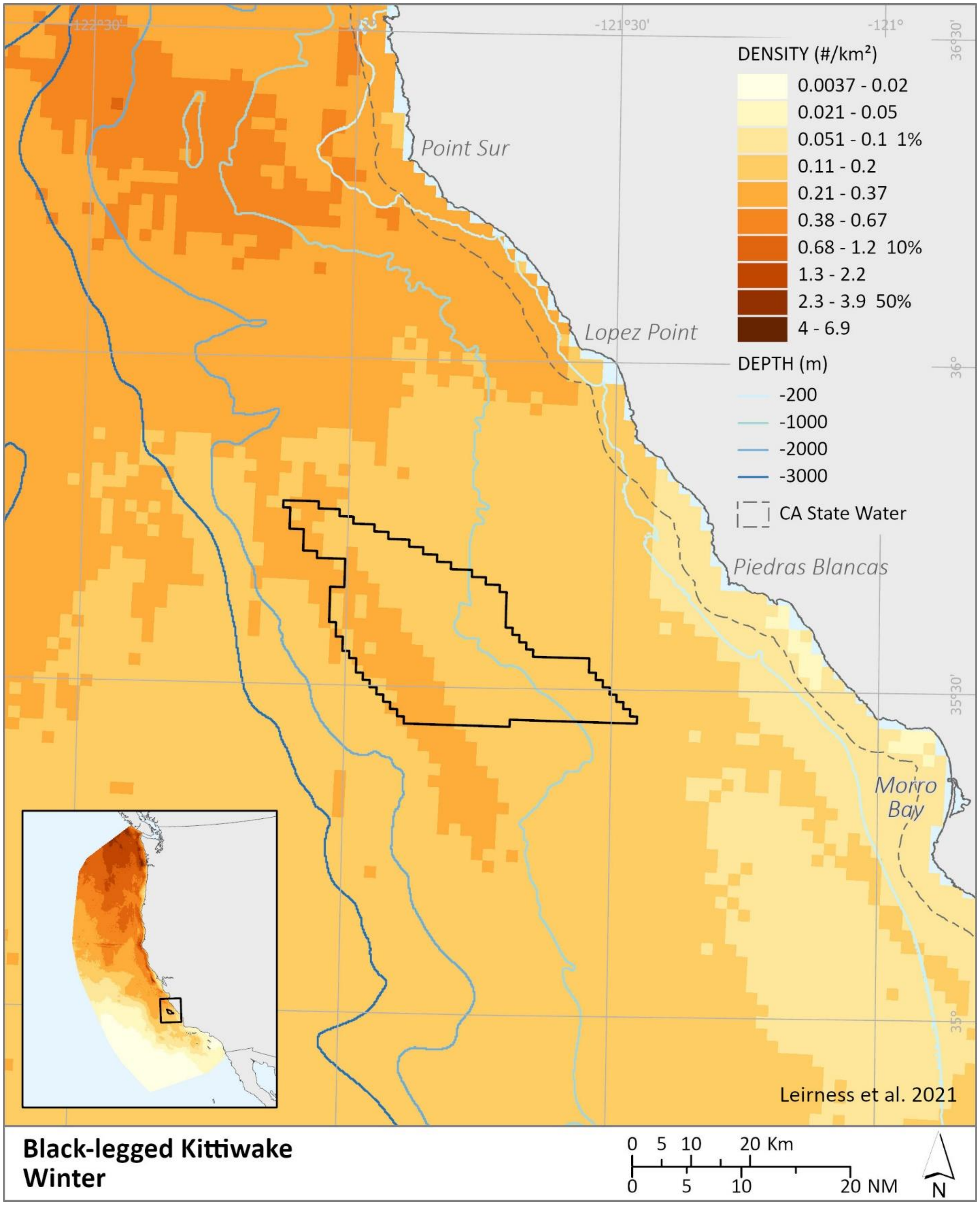

Figure B.30. Black-legged kittiwake winter predicted density/distribution in/near the MBWEA.

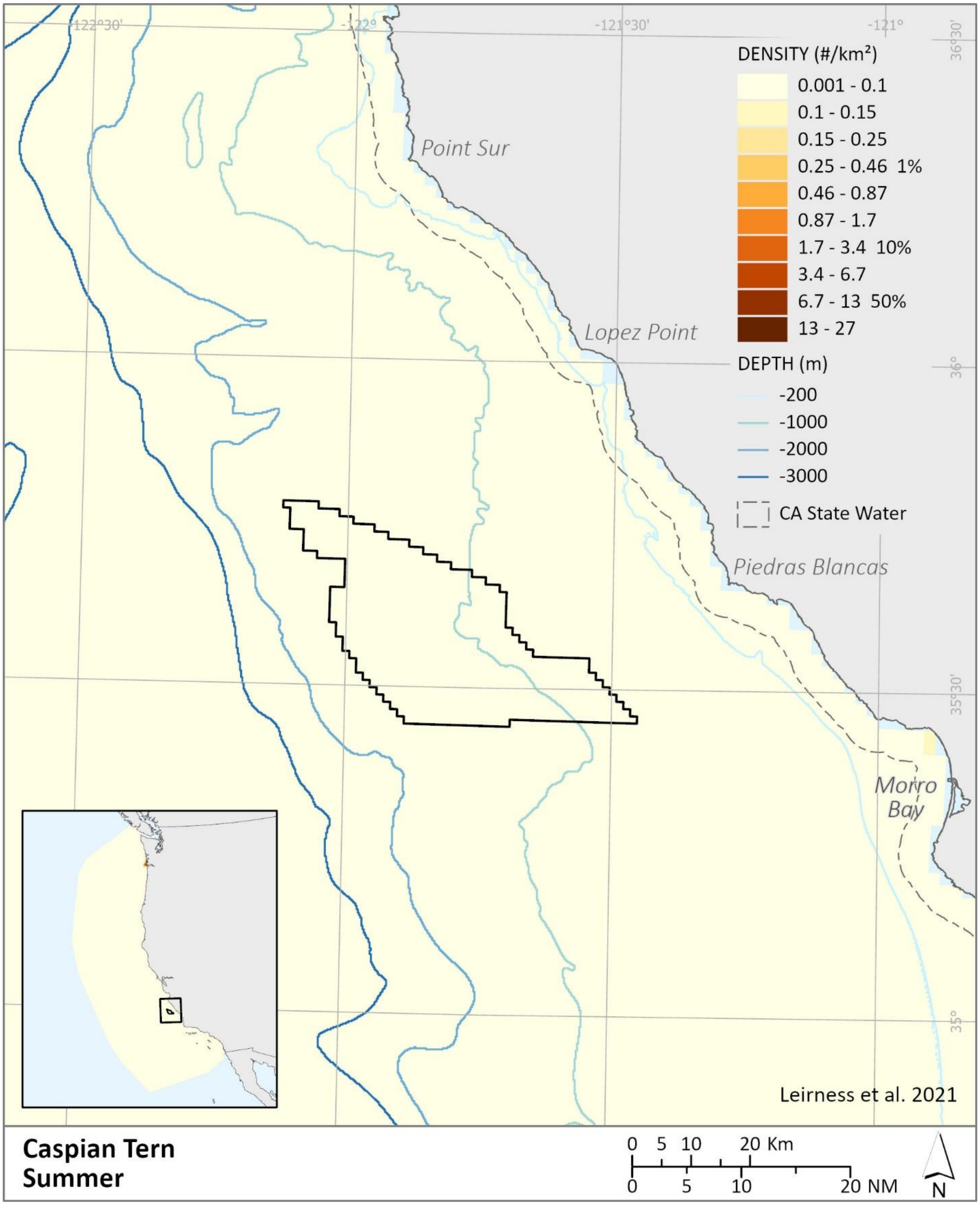

Figure B.31. Caspian tern summer predicted density/distribution in/near the MBWEA.

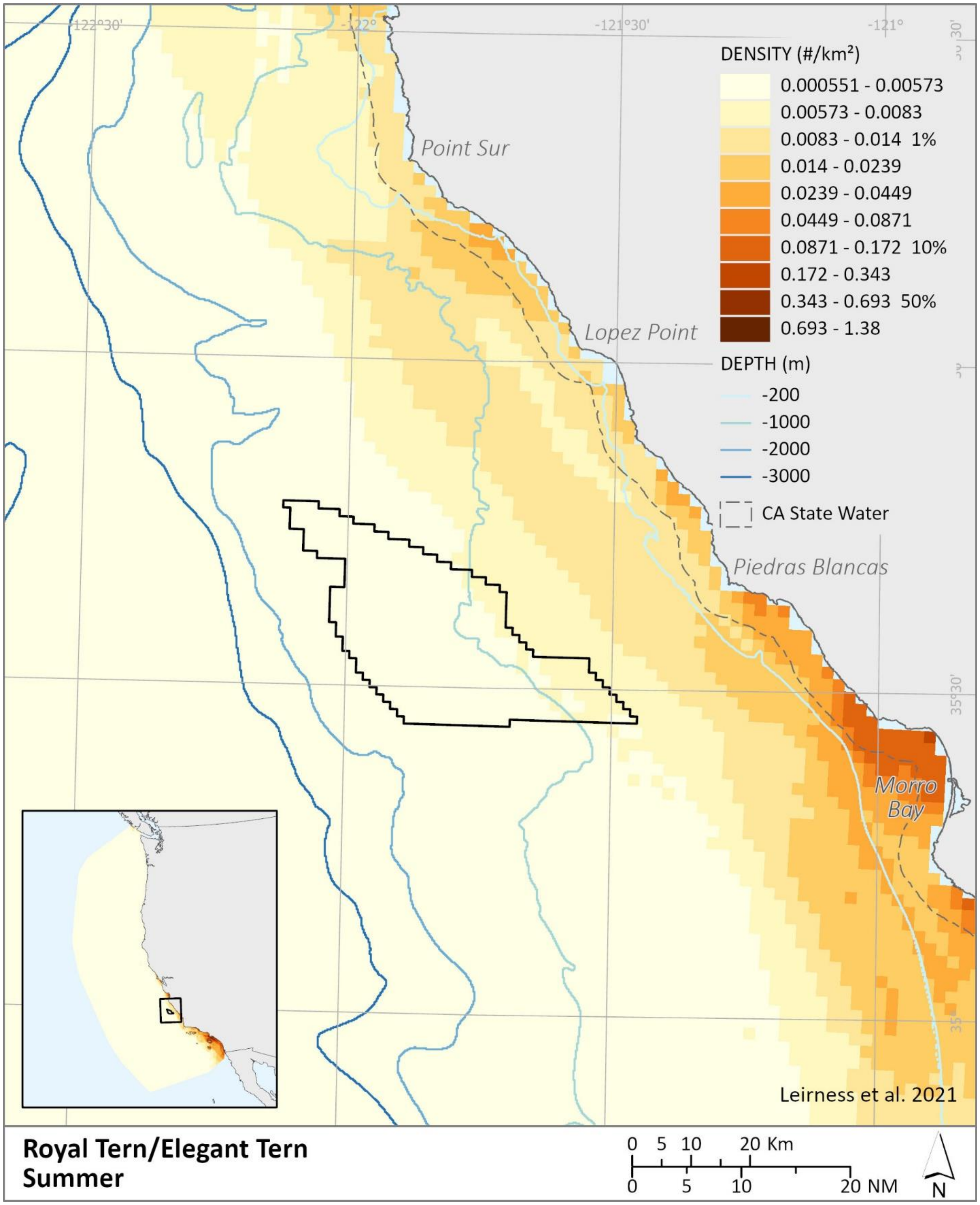

Figure B.32. Royal tern and elegant tern summer predicted density/distribution in/near the MBWEA.

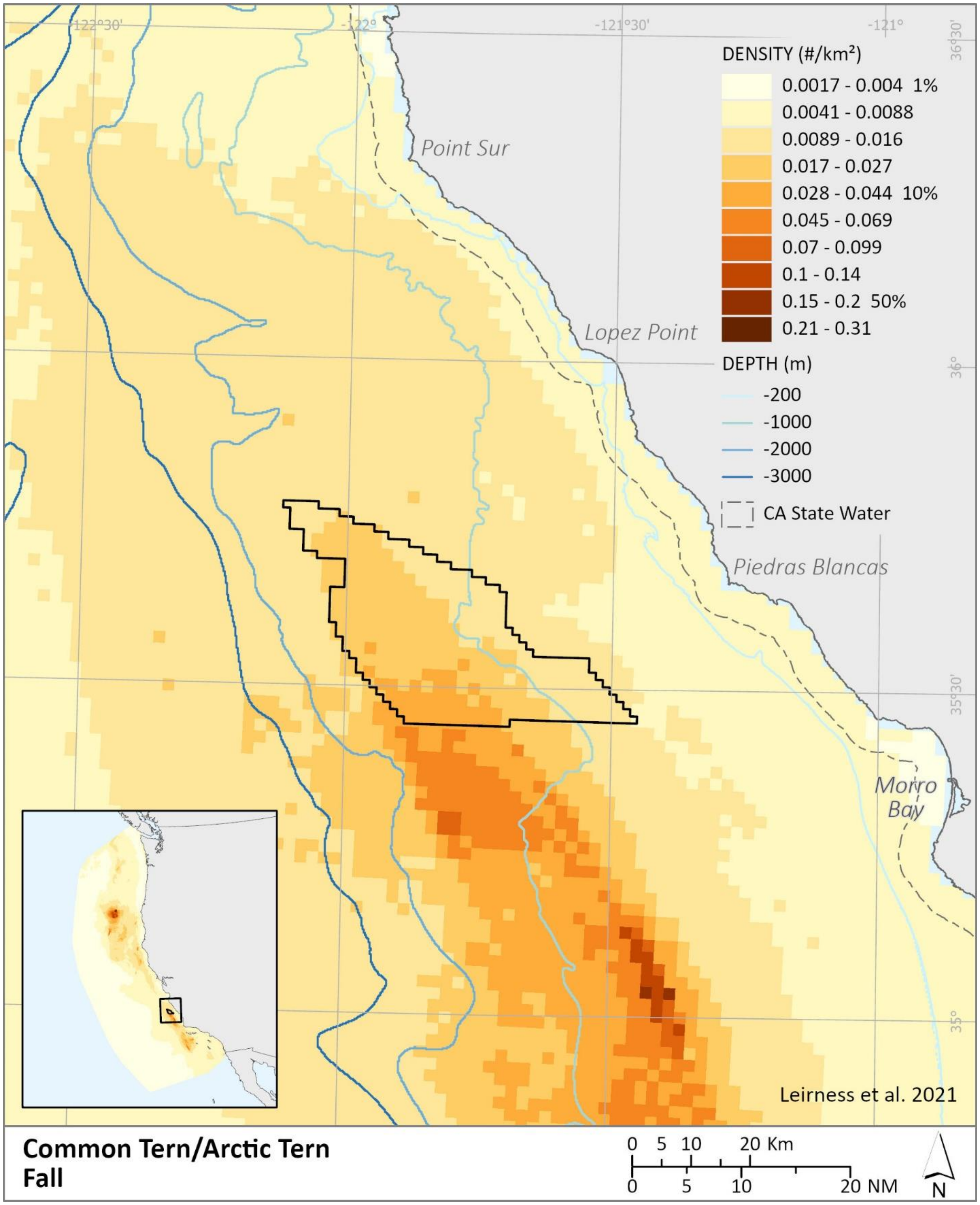

Figure B.33. Common tern and Arctic tern fall predicted density/distribution in/near the MBWEA.

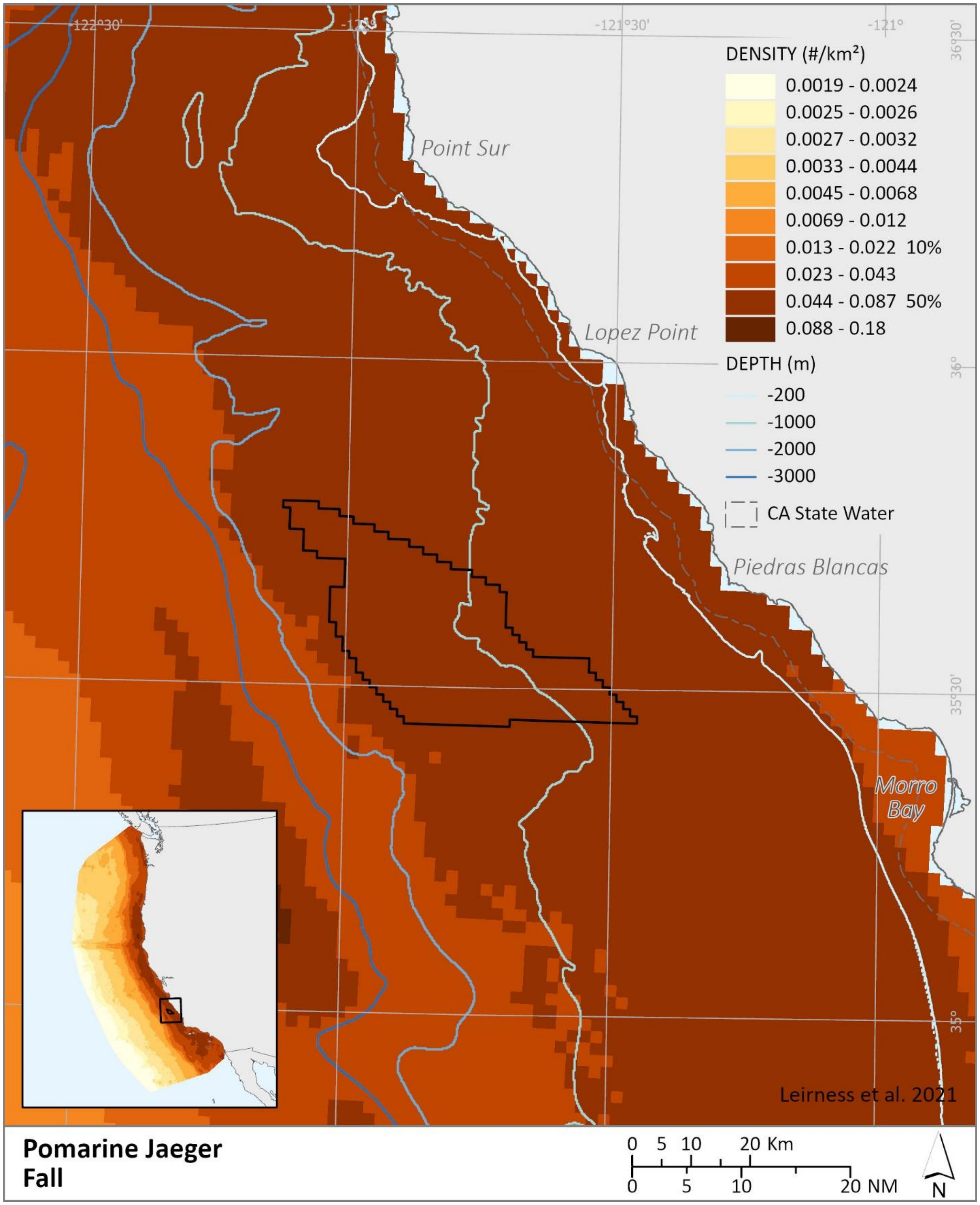

Figure B.34. Pomarine jaeger fall predicted density/distribution in/near the MBWEA.

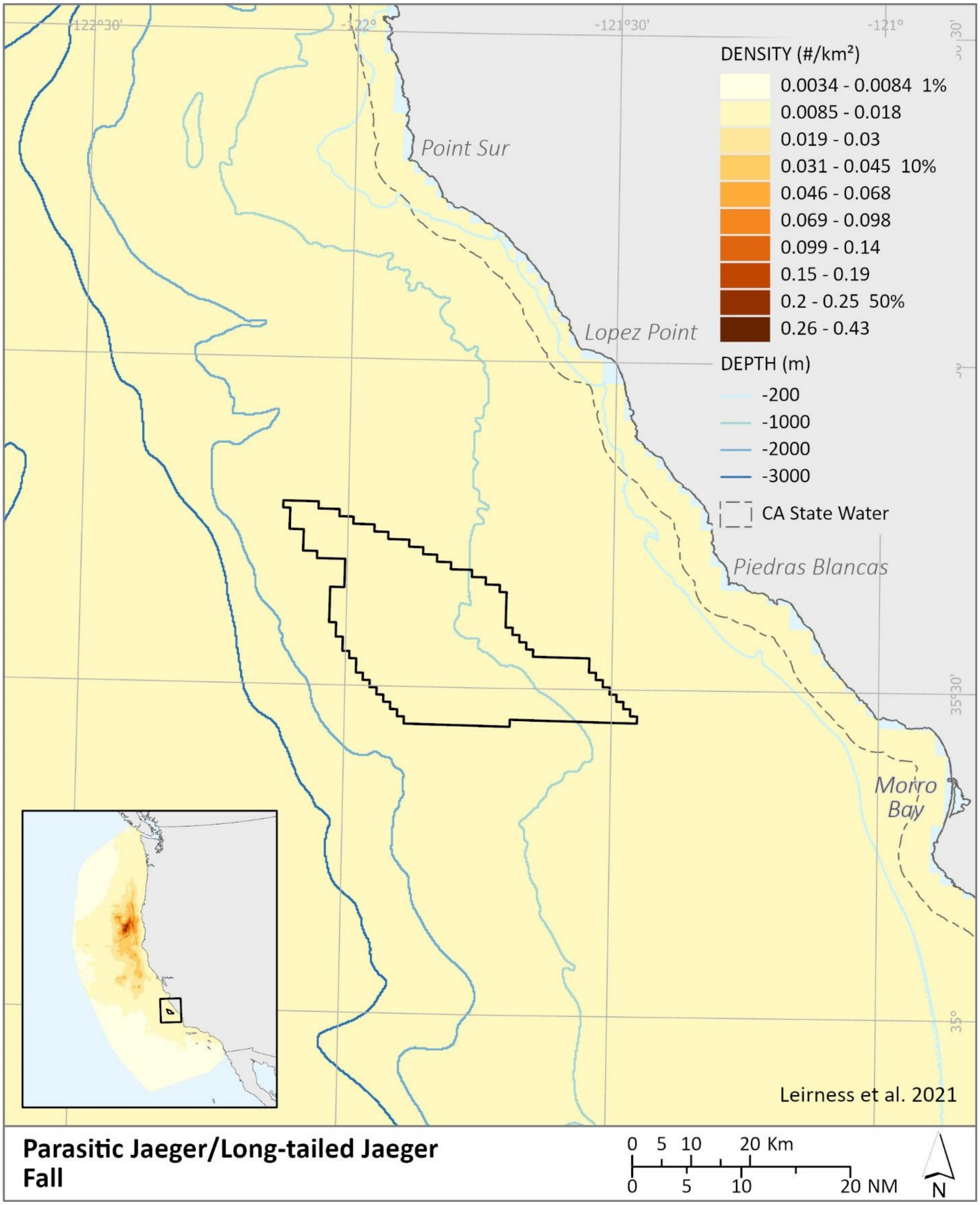

Figure B.35. Parasitic jaeger and long-tailed jaeger fall predicted density/distribution in/near the MBWEA.

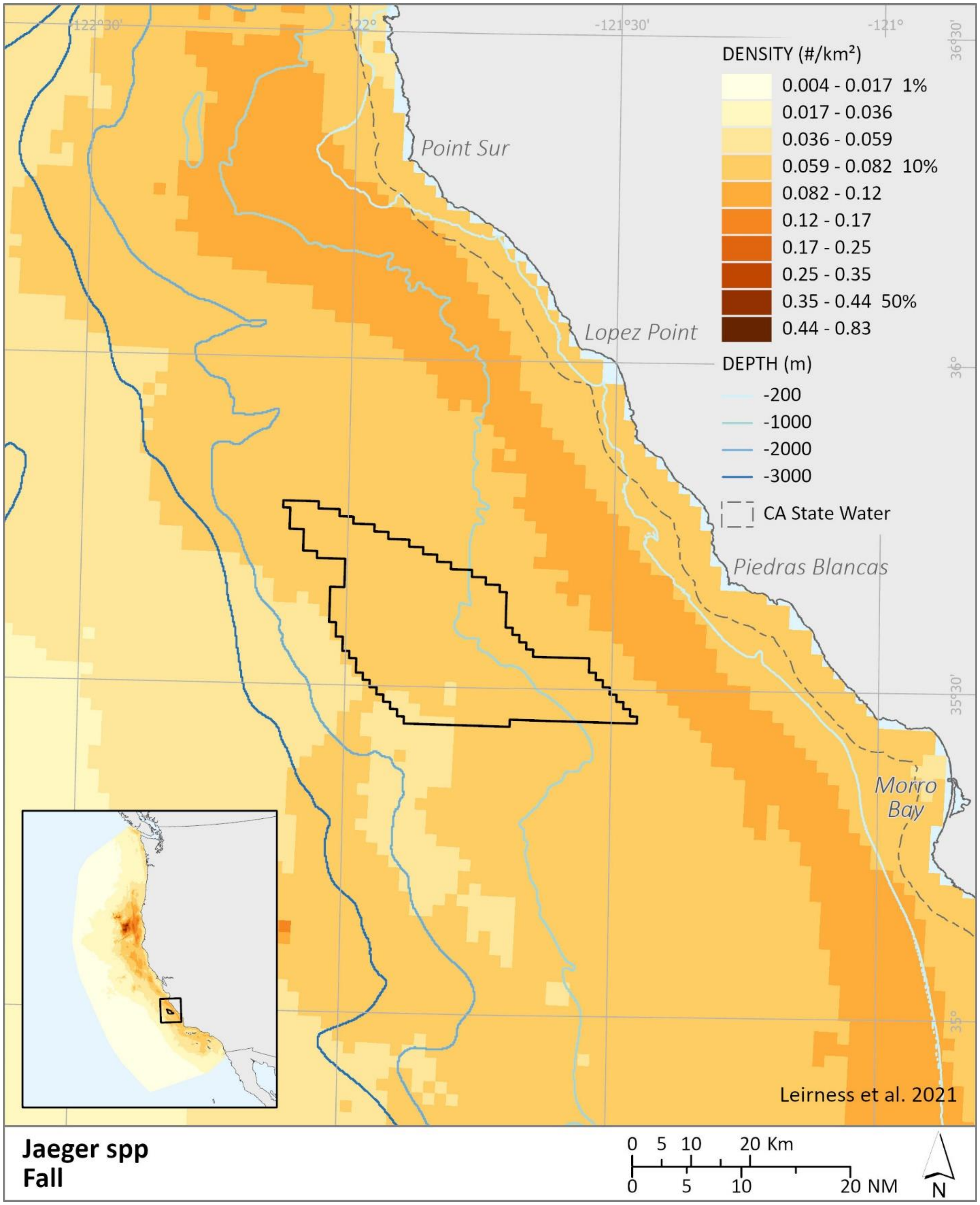

Figure B.36. Jaeger spp fall predicted density/distribution in/near the MBWEA.

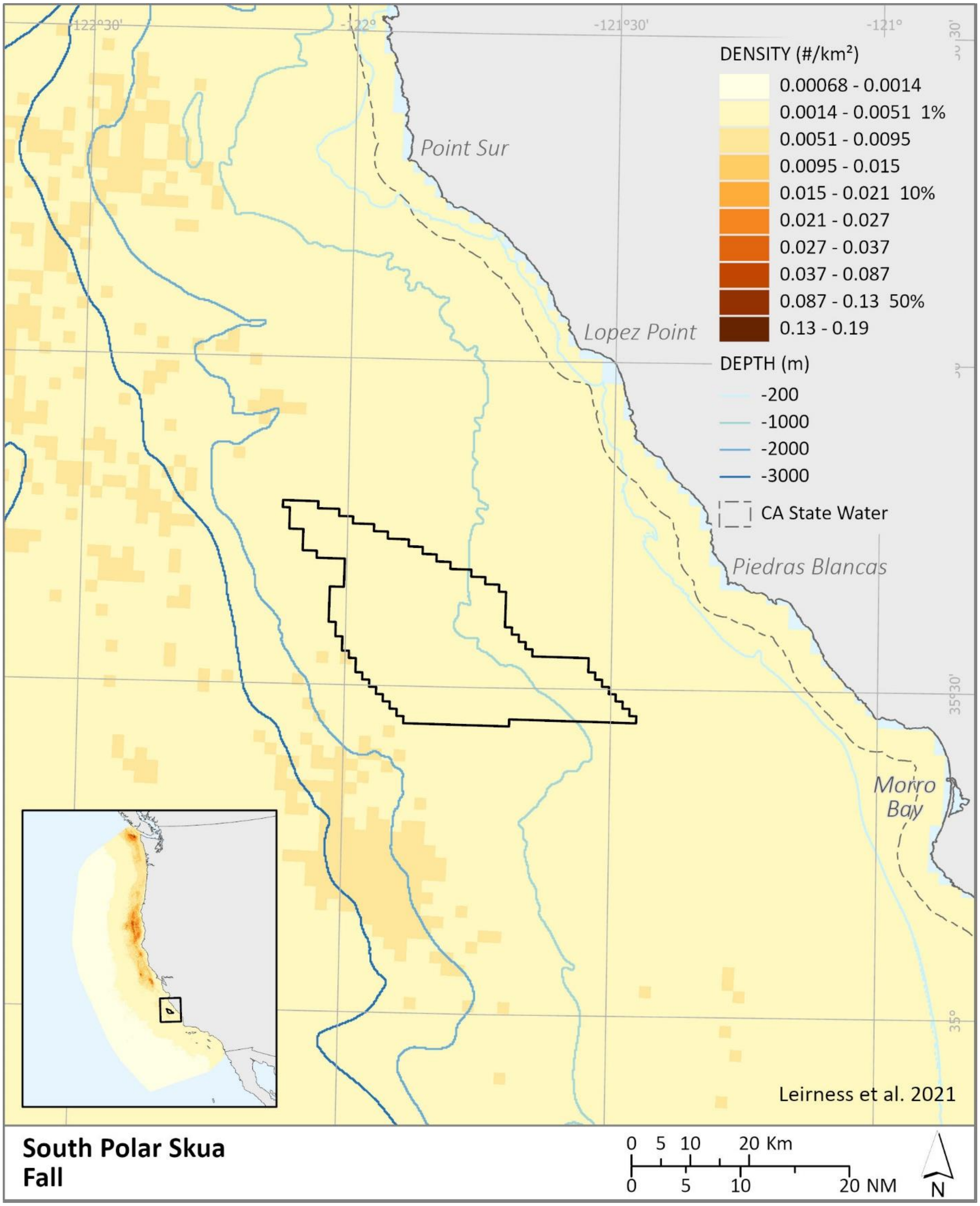

Figure B.37. South polar skua fall predicted density/distribution in/near the MBWEA.

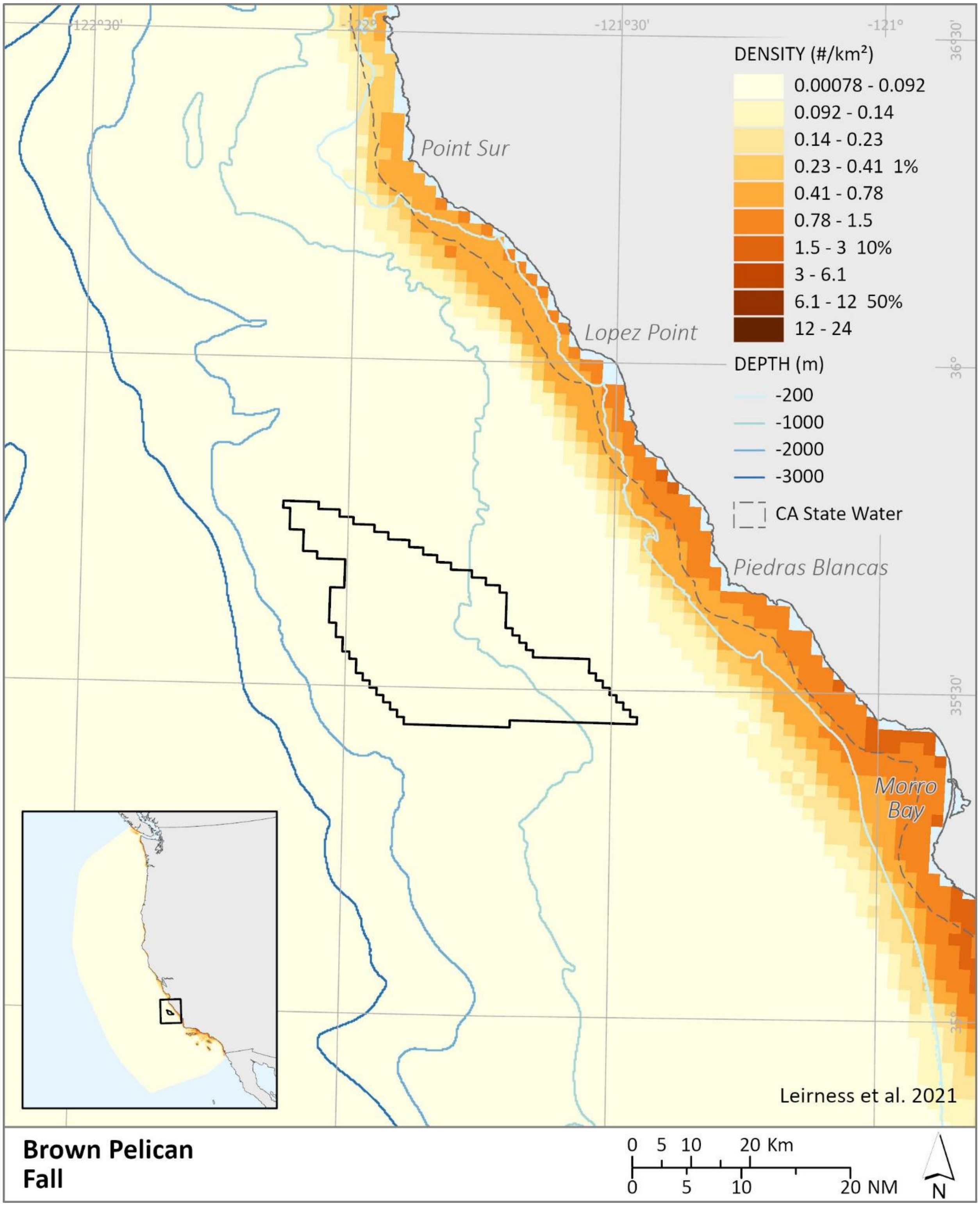

Figure B.38. Brown pelican fall predicted density/distribution in/near the MBWEA.

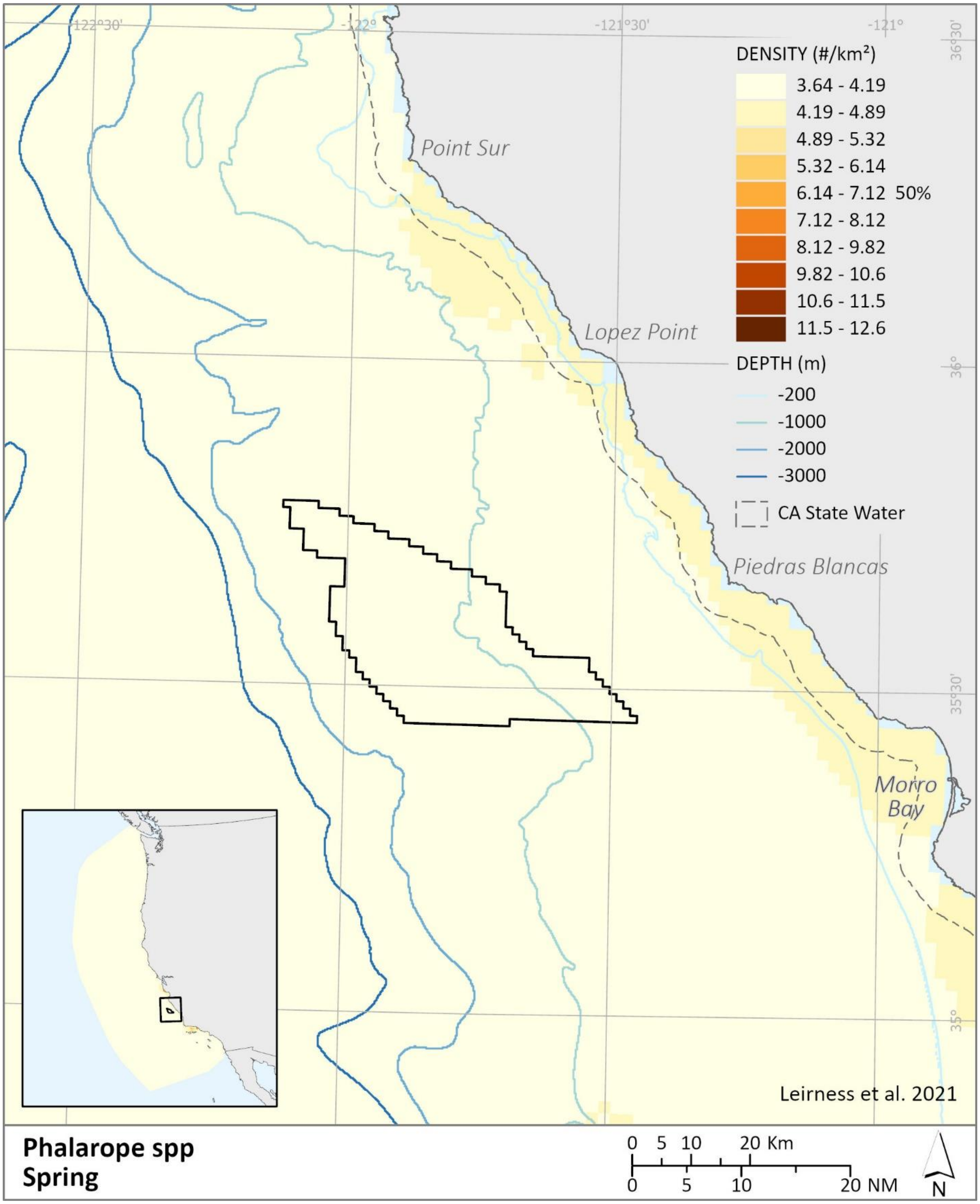

Figure B.39. Phalarope spp spring predicted density/distribution in/near the MBWEA.

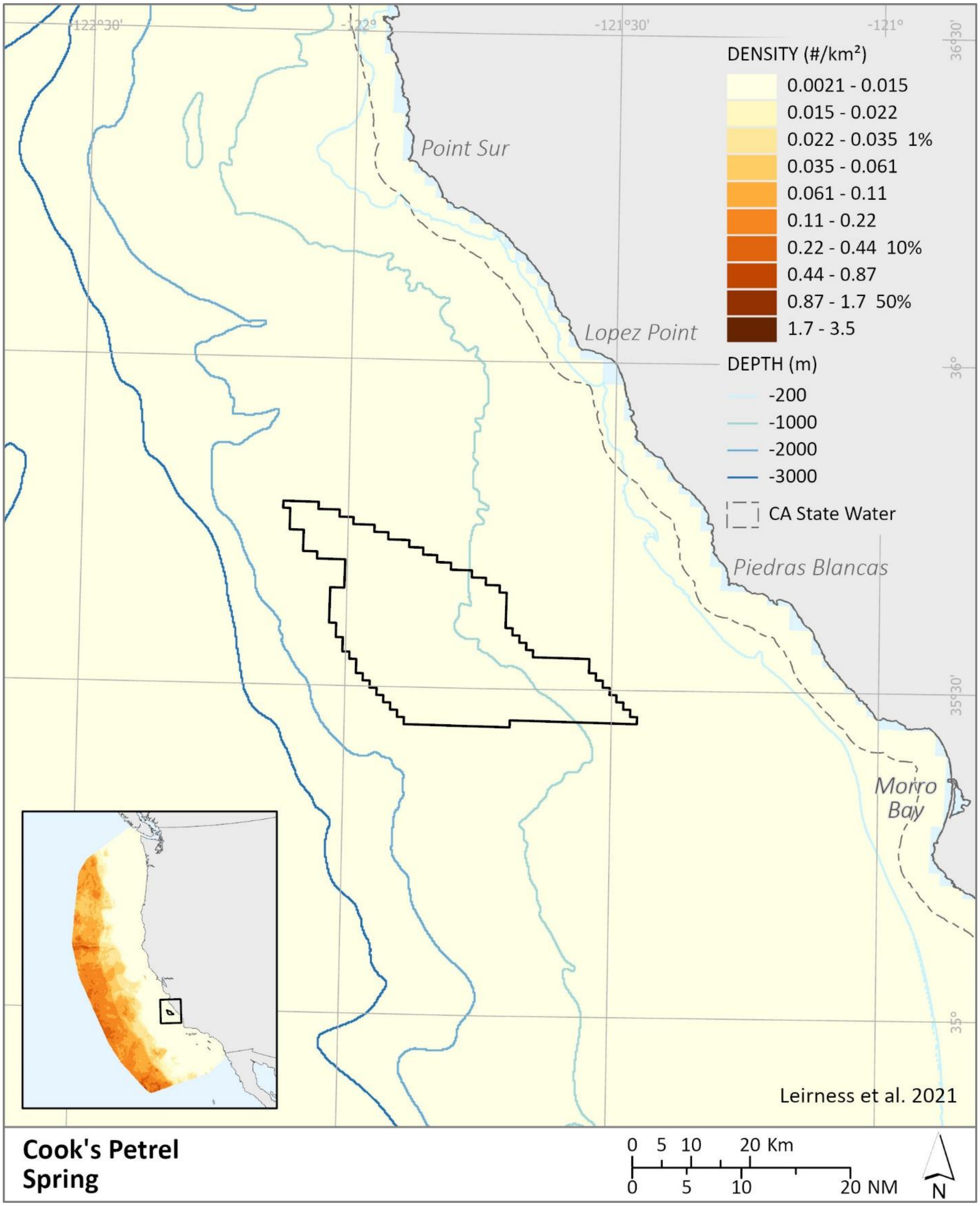

Figure B.40. Cook's petrel spring predicted density/distribution in/near the MBWEA.

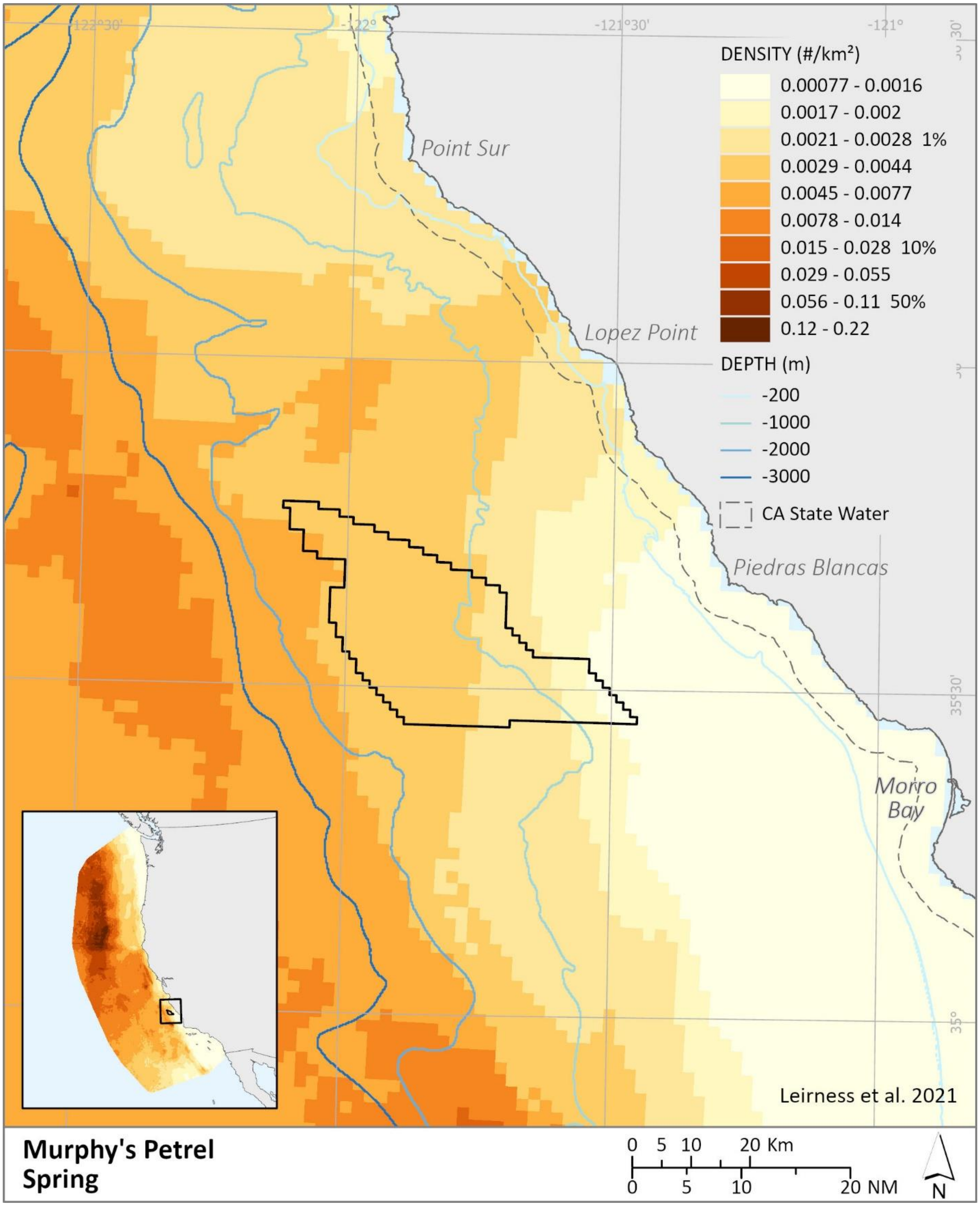

Figure B.41. Murphy's petrel spring predicted density/distribution in/near the MBWEA.

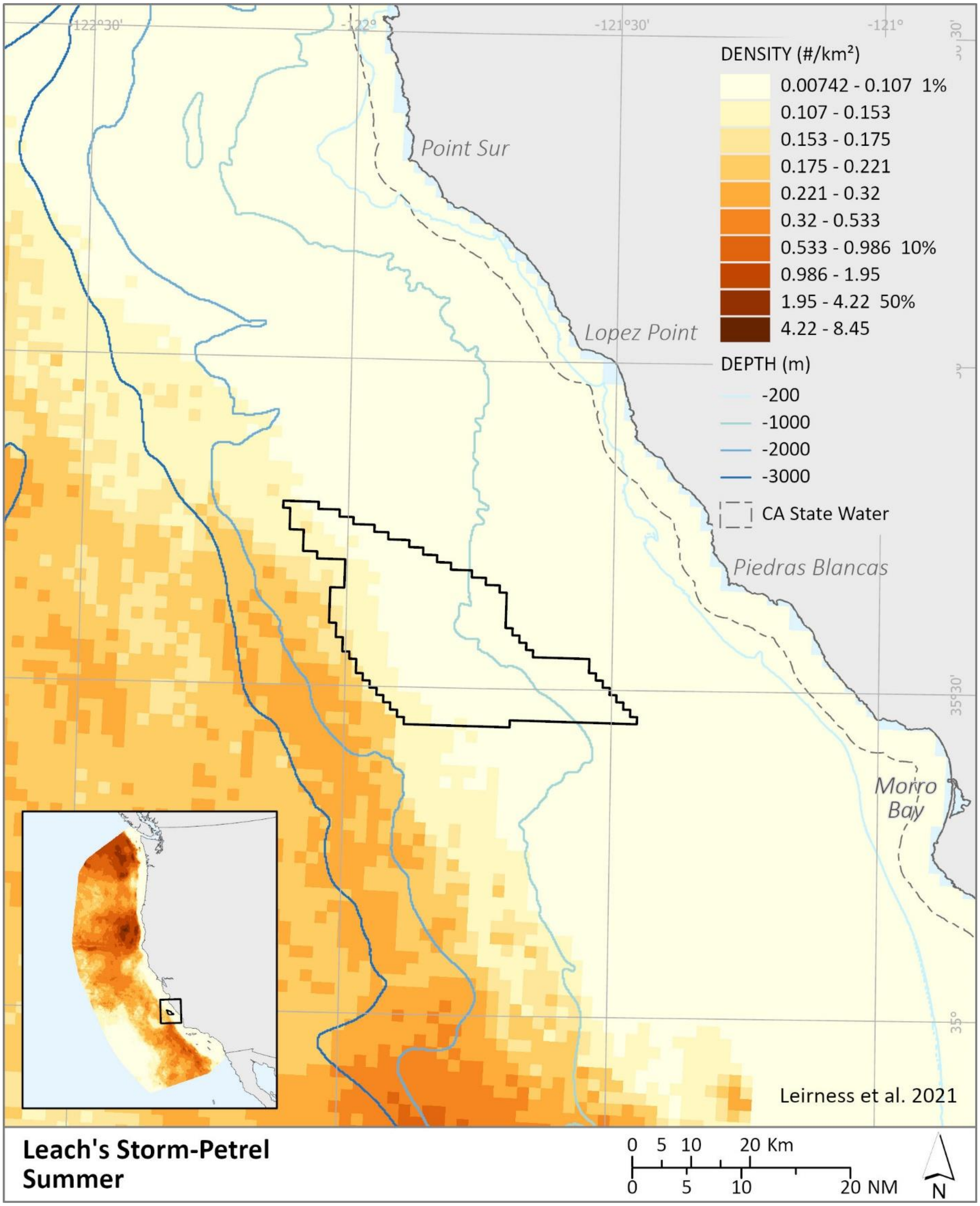

Figure B.42. Leach's storm-petrel summer predicted density/distribution in/near the MBWEA.

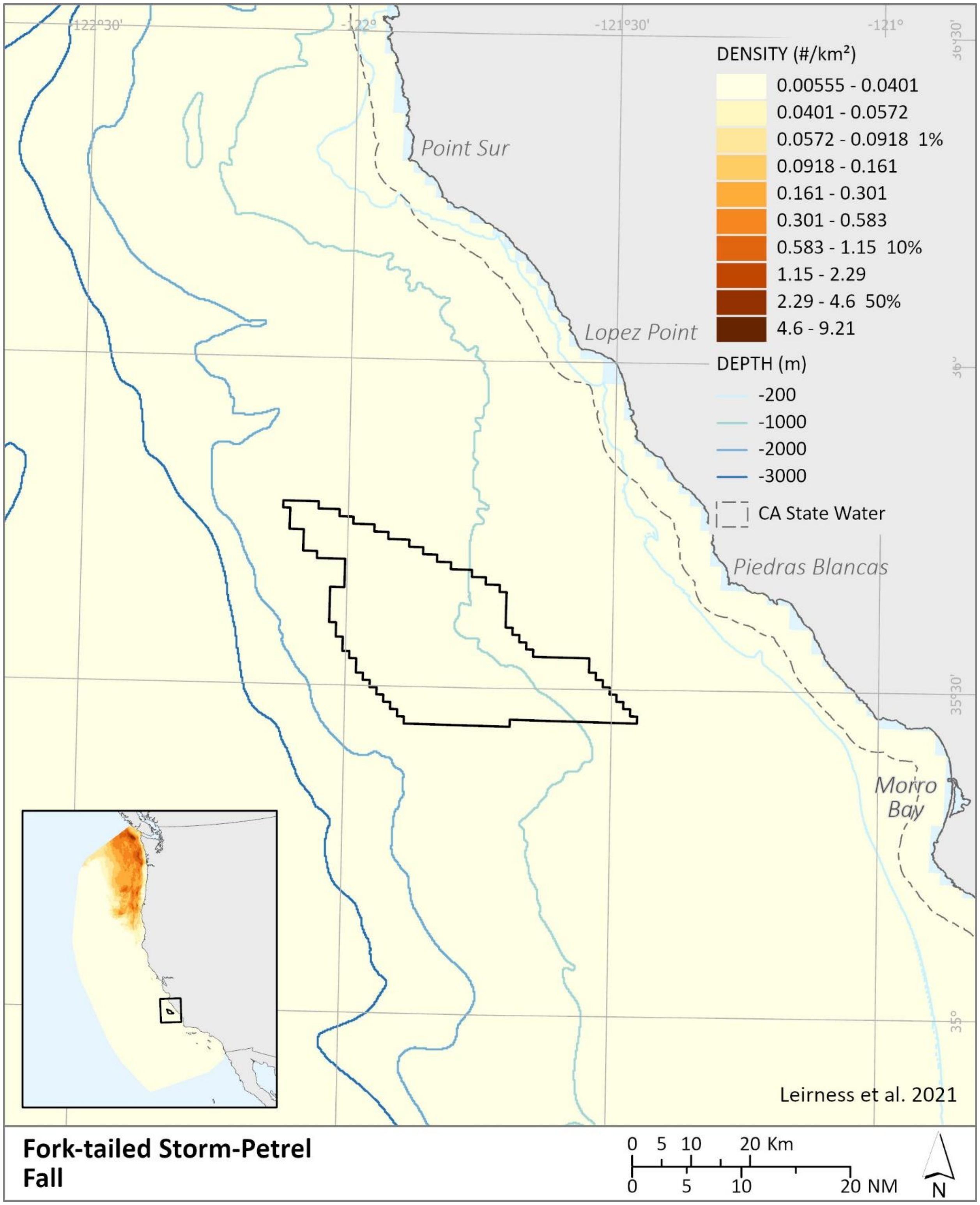

Figure B.43. Fork-tailed storm-petrel fall predicted density/distribution in/near the MBWEA.

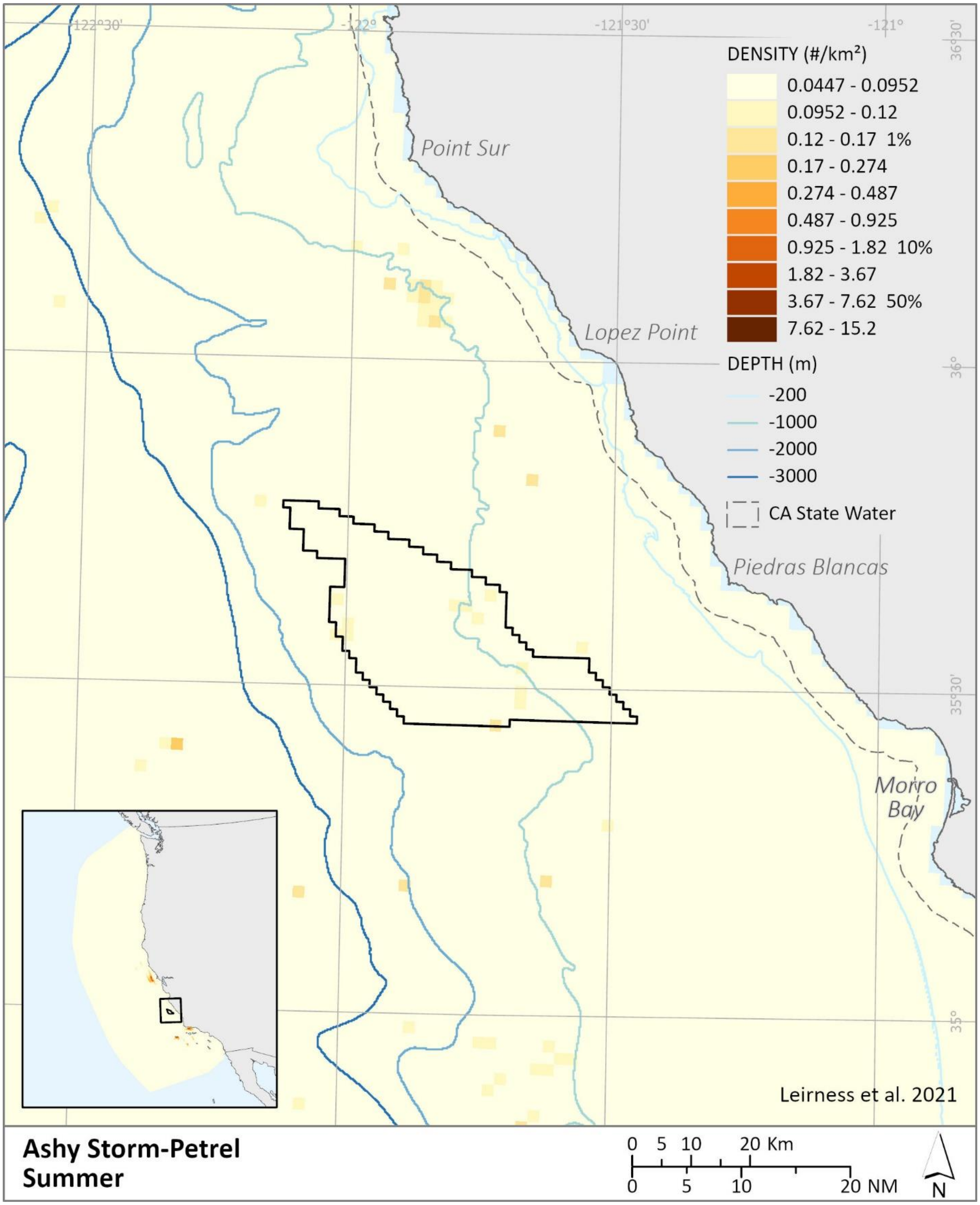

Figure B.44. Ashy storm-petrel summer predicted density/distribution in/near the MBWEA.

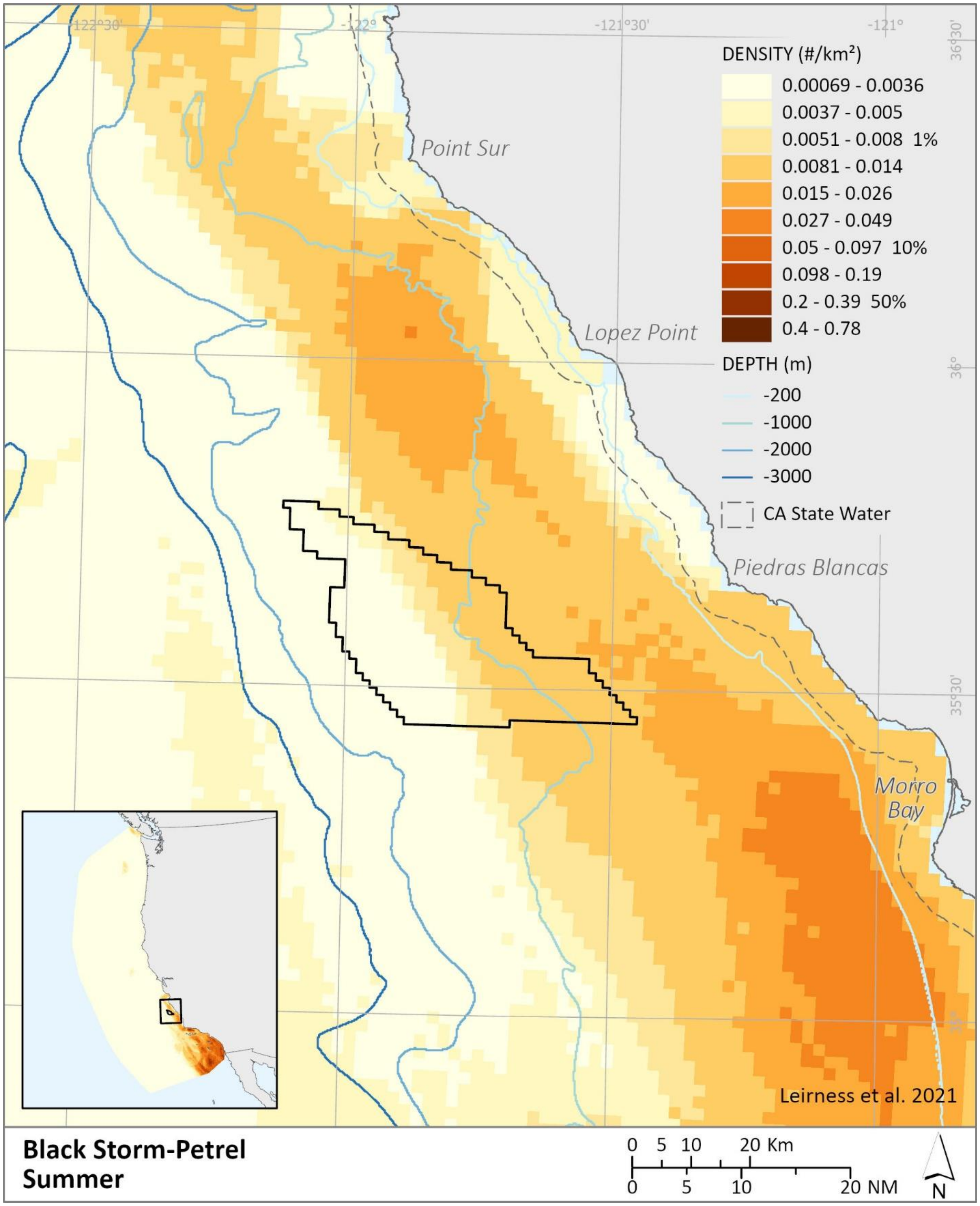

Figure B.45. Black storm-petrel summer predicted density/distribution in/near the MBWEA.

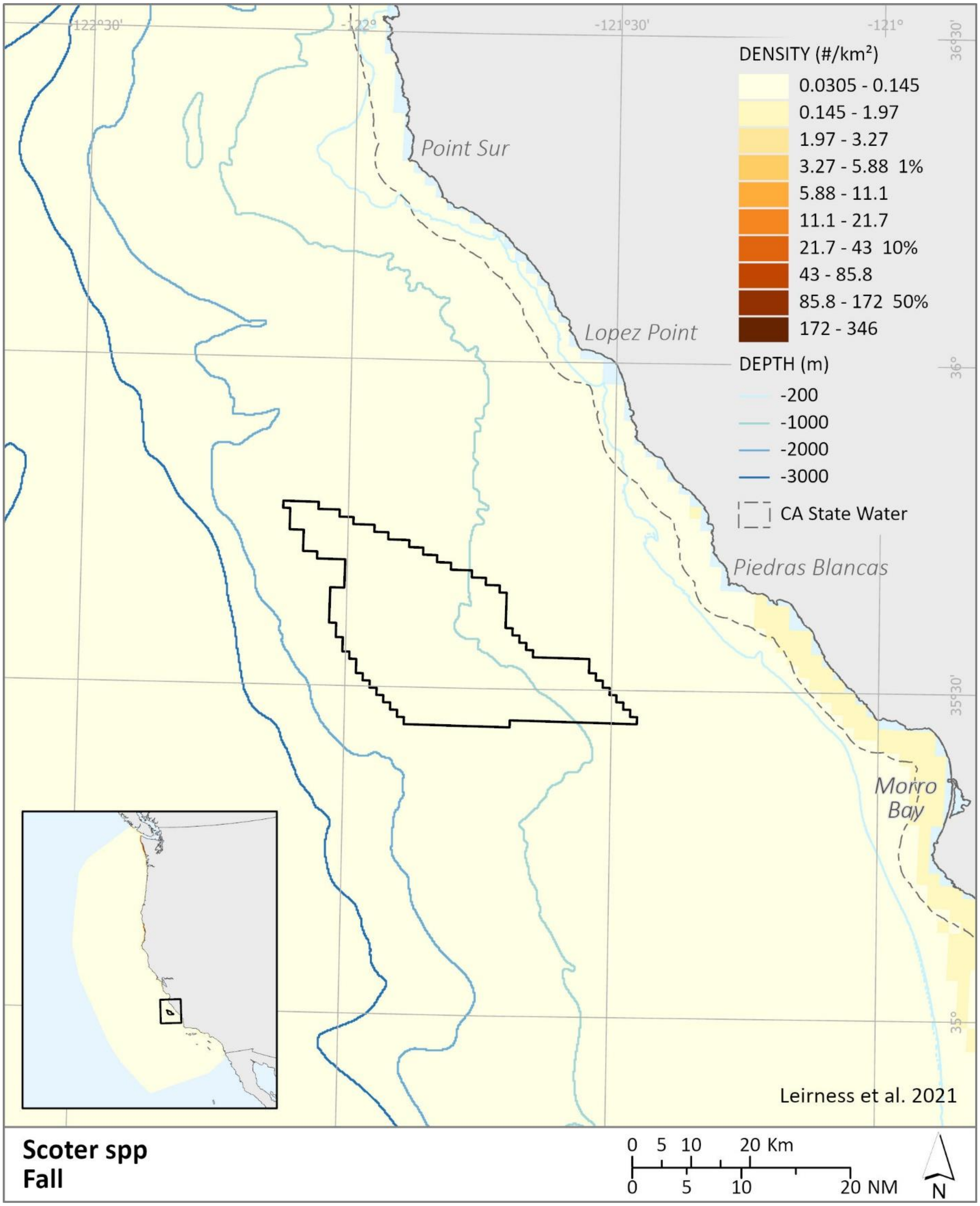

Figure B.46. Scoter spp fall predicted density/distribution in/near the MBWEA.