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Vulnerability Index to Scale Effects of Offshore Renewable Energy on Marine Mammals and Sea Turtles Off the U.S. West Coast (VIMMS)

US Department of the Interior
Bureau of Ocean Energy Management
Pacific OCS Region, Camarillo, CA

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Bureau of Ocean Energy Management

DISCLAIMER

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ABOUT THE COVER

Top left: Leatherback sea turtle with a temporary tracking transmitter; photo by K. Cummins.
Top right: Long-beaked common dolphin; photo by T. Pusser, NMFS permit #14534.
Bottom left: Elephant seal; photo by B. Southall, NMFS permit #14636.
Bottom right: Blue whale fluke; photo by A. Friedlaender, NMFS permit #14534.

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List of Abbreviations and Acronyms

AIS	Automatic Identification System
AK	Alaska
BOEM	Bureau of Ocean Energy Management
CA	California
CalCOFI	California Cooperative Fisheries Investigations
CMSF	California Marine Sanctuary Foundation
DOI	Department of the Interior
DPS	Distinct population segment
ESA	Endangered Species Act
G&G	Geological and geophysical
ESPIS	Environmental Studies Program Information System
IUCN	International Union for the Conservation of Nature
MMPA	Marine Mammal Protection Act
NOAA	National Oceanic and Atmospheric Administration
NMFS	National Marine Fisheries Service
OR	Oregon
PAM	Passive acoustic monitoring
PBR	Potential biological removal
SAR	Stock assessment report
SDM	Species distribution model
SWFSC	Southwest Fisheries Science Center
UME	Unusual mortality event
U.S.	United States
VIMMS	Vulnerability index to scale effects of offshore renewable energy on marine mammals and sea turtles
WA	Washington

1 Overview

With proven advances in offshore energy technology, the ambitious objectives of the U.S. Federal government, and a host of planning and preparation at the state and local levels, there is increasing interest and progress in developing sustainable offshore alternative energy. This includes broad scale implementation of offshore wind energy development and focused implementation of hydrokinetic energy systems harnessing the power of waves and tides. These technologies and their implementation in different areas are being extended, applied, and in some cases substantially modified from earlier developments in other parts of the world, notably Europe. On the U.S. East Coast this is largely taking the form of large wind farms with monopile structures in relatively shallow water. Many lease areas for such wind farms have already been sold and large-scale construction is soon to be underway. For the U.S. West Coast however, the vastly different bathymetry associated with being an active geological margin favors and requires quite different types of industrial developments for transforming the power of offshore wind into electrical energy. Conditions also offer varied and unique opportunities to convert the power of waves and tides into clean and sustainable electrical energy.

Given the novel and nascent nature of these technologies and contexts for industrial developments of offshore sustainable energy, there is considerable uncertainty regarding potential environmental impacts. There have now been several decades of relatively intensive monitoring and impact assessment of myriad issues regarding offshore wind developments in Europe, above and below water for avian and marine taxa. However, the contexts, species, and ecological systems differ substantially from those that will be exposed to offshore sustainable energy in the U.S. More recently, baseline monitoring, modeling, and early stages of evaluating potential impacts, both positive and negative, have been initiated on the U.S. East Coast focused largely on offshore wind with generally similar types of industrial development but a much wider range of species. These include low-frequency sound sensitive species that would be expected to be more susceptible to disturbance from associated low frequency noise, notably baleen whales. Further behind still in the development and deployment of wind and hydrokinetic energy developments is the U.S. West Coast, affording yet another set of unique challenges from both industrial (e.g., floating offshore wind in very deep water) and ecological perspectives (e.g., additional species previously unstudied in terms of impact assessment).

It is early in the development and impact assessment of offshore sustainable energy off the U.S. West Coast. There are myriad acknowledged uncertainties regarding aspects of developments, species that may be exposed to potential impacts, and what those impacts may be. However, the first offshore lease sales in California have already occurred, with designated lease areas off Morro Bay and the Humboldt coast. There are already proven offshore wave energy pilot installations off Oregon. Put simply, we are in the early stages of the deployment of these technologies in most areas off the U.S. West Coast, and we clearly need analytical tools to (1) evaluate potential susceptibility to impacts of disturbance, injury, or mortality, and (2) systematically identify data gaps, research needs, and monitoring and mitigation priorities.

Building on an iterative development of novel relativistic risk assessment methods to evaluate the potential impacts of human disturbance of marine mammals (Ellison et al. 2012; Wood et al. 2012; Southall et al. 2018; 2019; 2021a; 2021b; 2023), an interdisciplinary team of biologists and researchers involved in the current study adapted aspects of this approach to a new setting. While these approaches were relatively novel in their application to behavioral and auditory disturbance of protected marine mammals from offshore industrial activity, similar kinds of semi-quantitative, expert elicitation-based risk assessment methods have been applied in an increasing diversity of contexts. Examples include assessments of marine fisheries management (e.g., Morrison et al. 2015; Johnson et al. 2016), collision and displacement for seabirds associated with offshore wind energy development (Adams et al. 2017), and evaluations of impacts on marine mammals from climate change (Albouy et al. 2020) and disease (Norman et al. 2022).

Most of these earlier assessments focused on specified types, contexts, and strategically selected spatial and temporal patterns of industrial development based on realistic operations, the nature, timing, precise location, and other features of offshore development for this West Coast focused effort were not deliberately specified. Consequently, the objective here was to apply and adapt aspects of earlier risk assessment methods used to consider impacts of seismic surveys and large piling-based wind farms (notably Southall et al. 2023) to evaluate the relative vulnerability of many protected marine species on the U.S. West Coast to disturbance associated with all forms of offshore alternative energy development. The fundamental approach retains the species-specific, spatially- and temporally explicit nature of the earlier risk assessment but focuses, as an initial step, on just the species-specific vulnerability to the kinds of anticipated disturbances based on a structured host of factors. Subsequent analyses are needed, as discussed, to evaluate specific and finer spatial and temporal aspects of exposure magnitude and severity.

The geographic scope is very broad, extending from Point Conception, CA to the U.S.-Canada border off Washington, and coastal (not inshore) to oceanic waters (out to 2,500 m water depth). Specified geographical latitudinal zones and depth regimes with identified through an expert group elicitation process based on both human-centric (e.g., borders) and ecological considerations. Risk assessment methods as applied here for West Coast species also represents the first consideration of non-marine mammal species in this overall effort, specifically Endangered Species Act (ESA)-listed sea turtle species. Further, central to the approach taken in this novel context for the California Current Ecosystem where ecological patterns are so intimately tied with wind-driven upwelling was the designation of oceanographic “seasons” rather than traditional calendar-based ones. What was achieved through this adaptation and a concentrated and structured assessment process involving many subject matter experts and biologists was a systematic assessment of potential vulnerability of all marine mammal and sea turtle species to disturbance in defined geographical areas and oceanographic “seasons” using a structured assessment with population, life history, acoustic, and other environmental factors.

A core team of experts that was centrally involved in developing the earlier risk assessment methods (namely the authors of Southall et al. 2023) partnered with colleagues from an experienced and centrally engaged conservation organization (California Marine Sanctuary Foundation (CMSF)) to convene a series of workshops engaging more than a dozen expert sea turtle and marine mammal biologists and researchers to conduct the vulnerability assessment. These experts, who were invited and engaged in the discussion to varying degrees based on their availability, are identified below. Their mention here does not necessarily imply their personal concurrence, or that of their affiliated employer, with every scoring assessment or conclusion presented below that was developed during the expert scoring process.

Elizabeth Becker (ManTech; NOAA affiliate)
Karin Forney (NOAA)
Elliott Hazen (NOAA)
Scott Benson (NOAA)
Dominic Tollit (SMRU, Consulting)
Jenn Amaral (Marine Acoustics Inc (MAI))
Kristin Reed (Upwell)
George Shillinger (Upwell)
Megan McKenna (SEA, Stanford University)
Daniel Pelacios (Oregon State University)
John Calambokidis (Cascadia Research)
Jeff Moore (NOAA)
Shannon Rankin (NOAA)
William Ellison (MAI)
Chris Clark (Cornell University; MAI)

Two half-day virtual workshops (December 2021 and March 2022) were conducted ahead of the main vulnerability scoring exercise to present the existing vulnerability risk assessment methods, adapt them for this unique assessment, agree on the segregation of the study area and analysis periods, and consider potential species groupings. Through these group processes and interim discussions on key topics, the team concurred on the majority of these parameters and the assessment criteria, setting up the primary action for this project, namely a three-day in-person workshop held 7–9 June 2022 held at the Long Marine Laboratory at the University of California, Santa Cruz in Santa Cruz, CA. The results of the vulnerability scoring assessment and the synthesis conclusions and messages contained in this report were conveyed in a series of sequential virtual webinars conducted from January to March 2023 by the project team for the Bureau of Ocean Energy Management (BOEM), National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service, state scientific and management agencies in California, Oregon, and Washington, and representatives of Native American tribes.

This report summarizes the methods applied (section 2) in the vulnerability scoring process, including specified spatial zones, temporal windows, adapted scoring assessment criteria, species/stocks of marine mammals considered, and approaches to summarizing relative vulnerability (risk) assessments for each species/stock-area-season context. As described below, several different approaches were utilized to characterize and account for uncertainty both within the scoring process, as a separate qualitative assessment, and in gap analyses with specific research needs assessments. Vulnerability scoring results and relativistic risk assessments are then presented (for most but not all applicable combinations) both by species/stock for each zone (area) and season accordingly (section 3) and by zone for each season with relative scores across all species considered (section 4). A synthesis assessment of conclusions, data gaps, and recommended next steps follows (section 5). The raw data components of the vulnerability scores and ratings for each marine mammal and sea turtle species (or species stock) in this report are provided in spreadsheets in the following workbook files:

- Mysticetes, https://opendata.boem.gov/Vulnerability-Scoring-Mysticetes.xlsx
- Odontocetes, https://opendata.boem.gov/Vulnerability-Scoring-Odontocetes.xlsx
- Pinnipeds, https://opendata.boem.gov/Vulnerability-Scoring-Pinnipeds.xlsx
- Sea turtles, https://opendata.boem.gov/Vulnerability-Scoring-SeaTurtles.xlsx

2 Methods

The assessment and scoring approach applied here is derived from selected methods developed by Southall et al. (2023). Here we similarly applied relativistic risk assessment processes, using quantitative metrics and supporting data where available and structured expert elicitation in cases where some information existed, to evaluate the relative species-specific potential impacts of offshore sustainable energy developments. These structured assessments were based on a host of population, behavioral-ecological context, natural history, and environmental parameters. The adaptation and tuning of the earlier methods to contexts specific to U.S. West Coast marine mammal and sea turtle species was done through a series of group processes in two virtual workshops leading to an in-person workshop where the methods were finalized, then applied in assessing species-area-time specific relativistic assessments.

A key aspect of the Southall et al. (2023) approach is its inherent scalability, allowing relativistic means of assessing potential disturbance scenarios, that can be tuned to animal distribution, region, context, and varying spatial-temporal-spectral resolution. That approach has both a quantitative means of calculating the overall severity of exposure and disturbance using a spatial-temporal-spectral 'activity index' that is intersected with a species-specific 'vulnerability' rating score that considers a host of species-typical factors. Given the limited information on key parameters related to offshore energy developments off the West Coast at this stage (e.g., type, magnitude, distribution intensity, service and supply vessel operational parameters), the current project focused entirely on the relative vulnerability assessment, scaling and adapting aspects to fit the broad geographic and taxonomic scope specified by BOEM and integrating key elements into the assessment that had previously not been considered (e.g., potential vessel strikes, entanglement, electromagnetic impacts).

We describe here the approaches and assumptions used in delineating spatial 'zones' within the large overall area considered (section 2.1) and the specification of temporal periods considered (section 2.2: oceanographic "seasons"). The assessment of potential vulnerability includes a systematic appraisal using a combination of quantitative and structured assessment, based on four species-specific factors related to population, life history, and a host of anthropogenic and environmental parameters (section 2.3). Where possible, vulnerability scores are determined for each zone-season-species/stock scenario for each of the following four factors: species population; species habitat use and compensatory abilities; physical impacts; and other environmental stressors. In some instances, there is simply not sufficient information or species/stocks are known to not occur and consequently no scores are provided. The species, stocks, distinct population segments (DPS), and/or aggregate groups of marine mammal and sea turtle species to be considered was determined through a group elicitation process (section 2.4). Finally, a modified set of criteria for relating aggregate vulnerability factor scores with relativistic vulnerability ratings for each context considered was also determined through a group elicitation process (section 2.5). Each of these key methodological elements are presented and discussed below.

2.1 Focal Areas

The vulnerability scoring assessment is based on multiple factors identified above, some of which are relatively static across contexts (e.g., population factors), whereas others are inherently based on spatial and temporal aspects of the distribution of the species/stock being considered (e.g., habitat utilization, exposure to existing anthropogenic or other environmental stressors). Consequently, the segregation of the overall extremely large region considered into a subset of five focal areas, referred to here as geographic or latitudinal 'zones,' was required; this is particularly relevant to the habitat factor assessment as described below. These are further segregated by three depth regimes into a larger number of "spatial zones," which are described in greater detail below.

Previous applications of versions of these risk assessment methods faced similar requirements. For assessments of seismic surveys in the Gulf of Mexico (Southall et al. 2021a), discrete regions for separate analysis were explicitly specified by regulatory management agencies. For assessments of offshore windfarms off the U.S. East Coast (Southall et al. 2021b), the designation of specified zones within a larger region was developed through an expert elicitation process based on more ecologically relevant considerations of known features (e.g., Stellwagen Bank). A combination of these approaches was taken here whereby several specified and known boundary conditions were specified ahead of the project (e.g., not considering areas south of Point Conception or in Canadian waters, recognition of likely jurisdictional differences in California), whereas other ecological considerations (e.g., unique features of the Columbia River region) were also considered. As in each of the previous assessments, depth regimes were recognized as important ecologically, given well documented differences in the distribution and density for a wide range of marine taxa, with segregation related to the continental shelf, slope, and oceanic depths.

Through a group process with subject matter experts ahead of the vulnerability scoring, five distinct geographic zones were identified across the entire region based on latitudes (Figure 1). The basis for designation and boundaries for each of these five zones is described from south to north (as they are numbered) in greater detail below. Within each of these latitudinal zones are three discrete depth regimes: (a) "*Shelf*": < 100 m; (b) "*Slope*": 100–1,000 m; and (c) "*Oceanic*": 1,000–2,500 m. The result is 15 total spatial zones spanning the entire region, each of which is shown by the five geographic zones with each of three specified depth regimes (Figures 2–6).

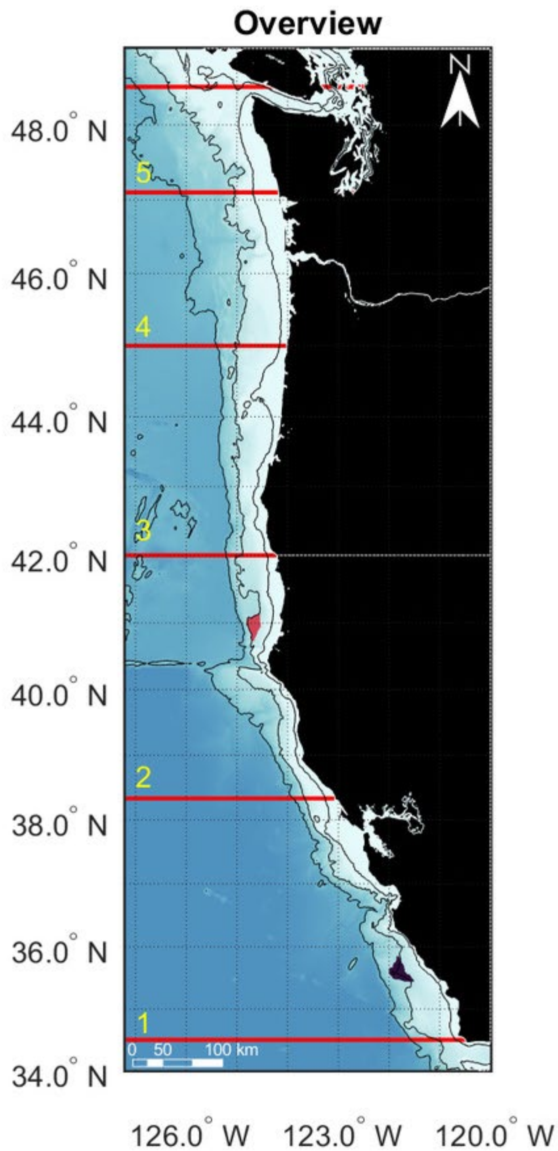


Figure 1. Five latitudinal zones defined from Point Conception to U.S.-Canada border, each with three depth regimes ("Shelf": < 100 m; "Slope": 100–1,000 m; "Oceanic": 1,000–2,500 m). Zone 1 includes wind energy lease areas offshore Morro Bay (in purple); Zone 2 includes wind energy lease areas offshore Humboldt (in red).

2.1.1 Zone 1. Central California

The southern extent of the overall region to be assessed was specified by BOEM as a boundary condition for the analysis as Point Conception in central California, which includes areas being proposed for a national marine sanctuary. Through a group discussion and decision, it was decided to retain the San Francisco Bay and Gulf of the Farallones area within a single latitudinal zone. This ecological consideration resulted in the designation of the northern extent of Zone 1 (which is the largest of the five) as occurring north of these areas. Zone 1 (*Central California*) extends from 34.5° N to 38.33° N. Three defined sub-zones are identified corresponding to each of the depth regimes [*Zone 1a*: *Shelf* (0–100 m); *Zone 1b*: *Slope* (100–1,000 m); *Zone 1c: Oceanic* (1,000–2,500 m)]. The overall zone, sub-zones, and the Morro Bay wind energy lease areas (purple) are shown below (Figure 2).

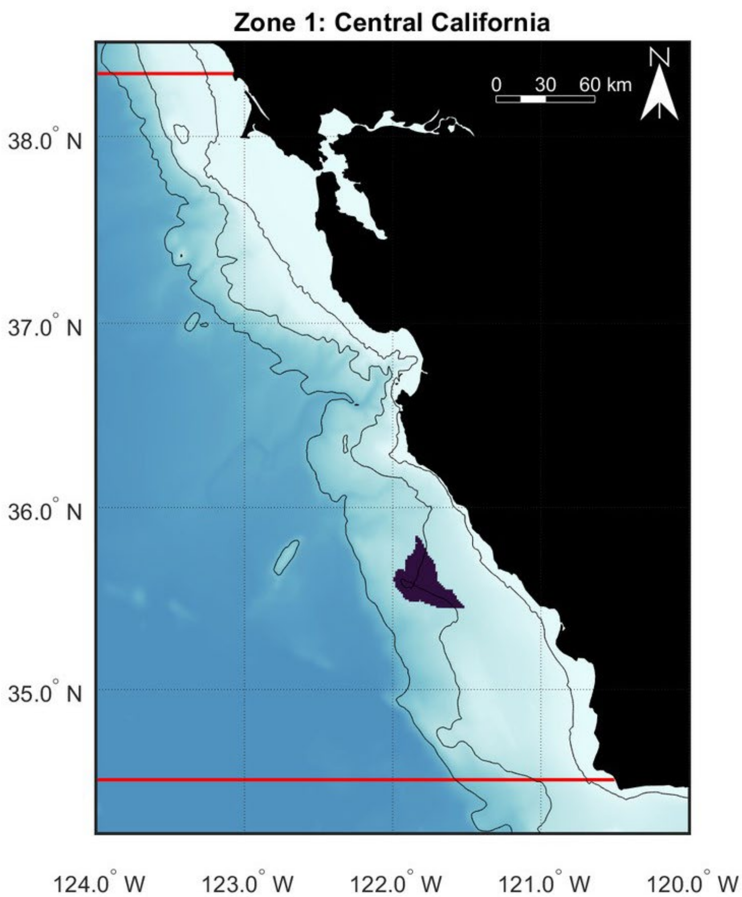


Figure 2. Zone 1: Central California.

2.1.2 Zone 2. Northern California

The next zone moving north was specified to extend from above the ecologically distinct San Francisco Bay and Gulf of the Farallones regions to the human boundary of the CA/OR border. Zone 2 (*Northern California*) thus extends from 38.33° N to 42° N. Three defined sub-zones are identified corresponding to each of the depth regimes [*Zone 2a*: *Shelf* (0–100 m); *Zone 2b*: *Slope* (100–1,000 m); *Zone 2c: Oceanic* (1,000–2,500 m)]. The overall zone, sub-zones, and wind energy lease areas offshore Humboldt (purple) are shown below (Figure 3).

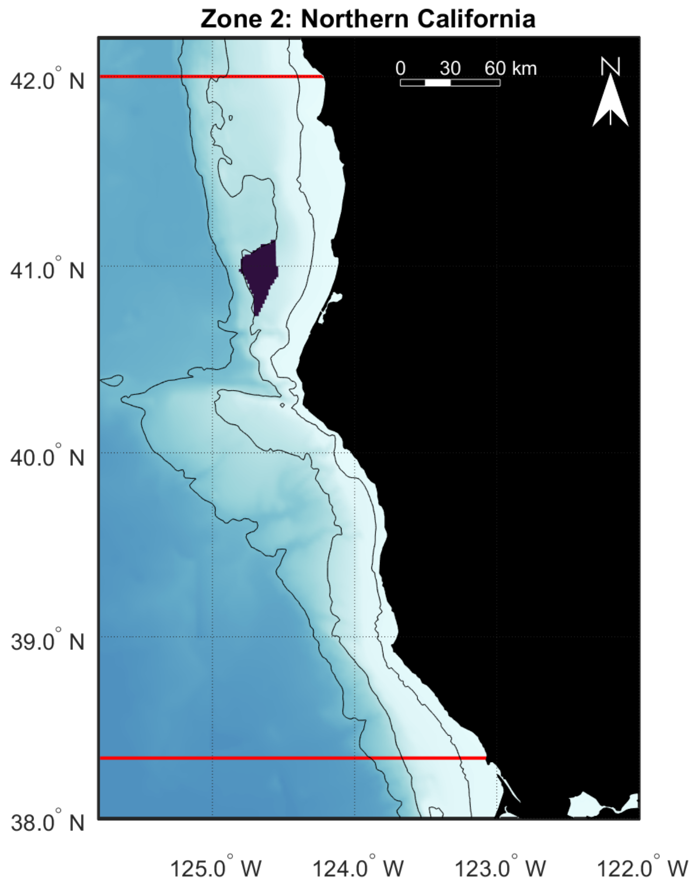


Figure 3. Zone 2: Northern California.

2.1.3 Zone 3. Southern and Central Oregon

The next zone north extends from the human-defined CA/OR border to what was identified through a group elicitation process as the southern extent of the Columbia River plume region. This boundary was identified through a group elicitation process with biologists intimately familiar with these regions and based in part on interpretation of previous ecological assessments of the region (Davis et al. 2014; Phillips et al. 2018). Zone 3 (*Southern and Central Oregon*) thus extends from 42° N to 45° N. Three defined sub-zones are identified corresponding to each of the depth regimes [*Zone 3a*: *Shelf* (0–100 m); *Zone 3b*: *Slope* (100–1,000 m); *Zone 3c: Oceanic* (1,000–2,500 m)]. The overall zone and sub-zones are shown below (Figure 4).

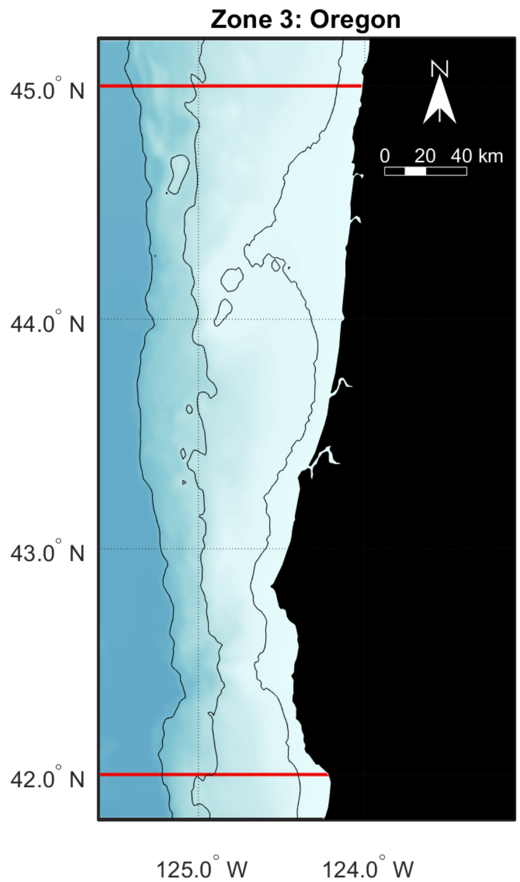


Figure 4. Zone 3: Southern and Central Oregon.

2.1.4 Zone 4. Columbia River Region

The next zone north includes what was determined through the group elicitation process and considering the references given above to comprise the Columbia River plume region with a reasonable amount of spatial buffer (~ 50 nm). Zone 4 (*Columbia River Region*) extends from 45° N to 47.1° N. Three defined sub-zones are identified corresponding to each of the depth regimes [*Zone 4a*: *Shelf* (0–100 m); *Zone 4b*: *Slope* (100–1,000 m); *Zone 4c: Oceanic* (1000–2,500 m)]. The overall zone and sub-zones are shown below (Figure 5).

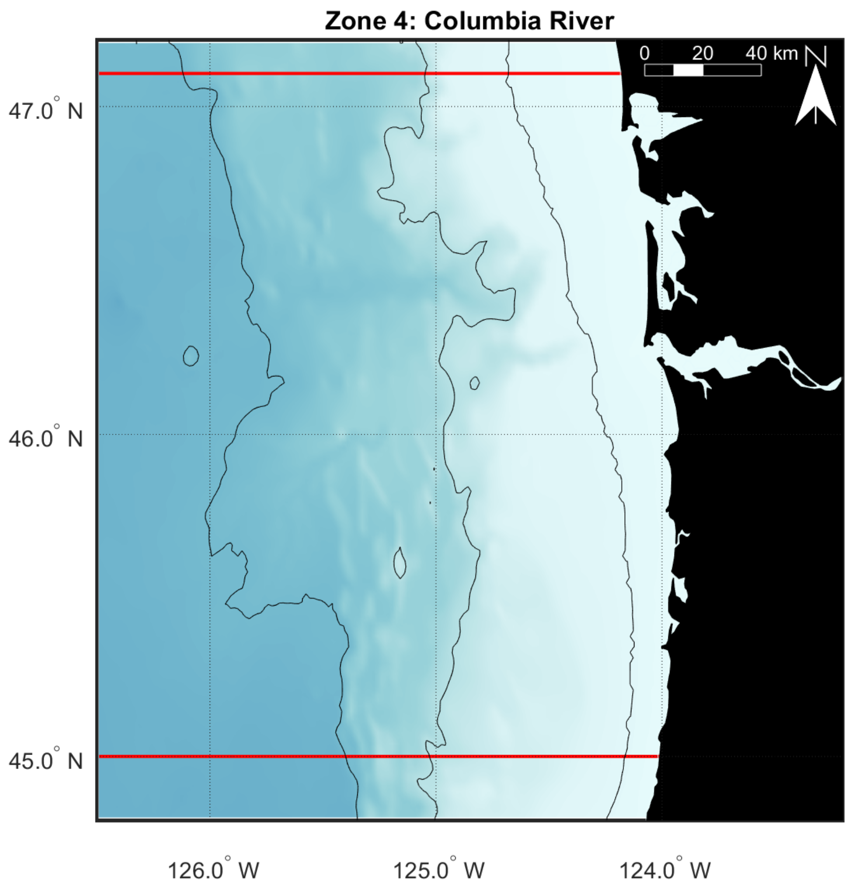


Figure 5. Zone 4: Columbia River Region.

2.1.5 Zone 5. Central and Northern Washington (Offshore)

The northernmost zone extends from above the Columbia River plume region to the human-defined U.S.-Canadian border. Zone 5 (*Central and Northern Washington*) extends from 47.1° N to 48.5° N. Three defined sub-zones are identified corresponding to each of the depth regimes [*Zone 5a*: *Shelf* (0–100 m); *Zone 5b*: *Slope* (100–1,000 m); *Zone 5c: Oceanic* (1,000–2,500 m)]. The overall zone and sub-zones are shown below (Figure 6).

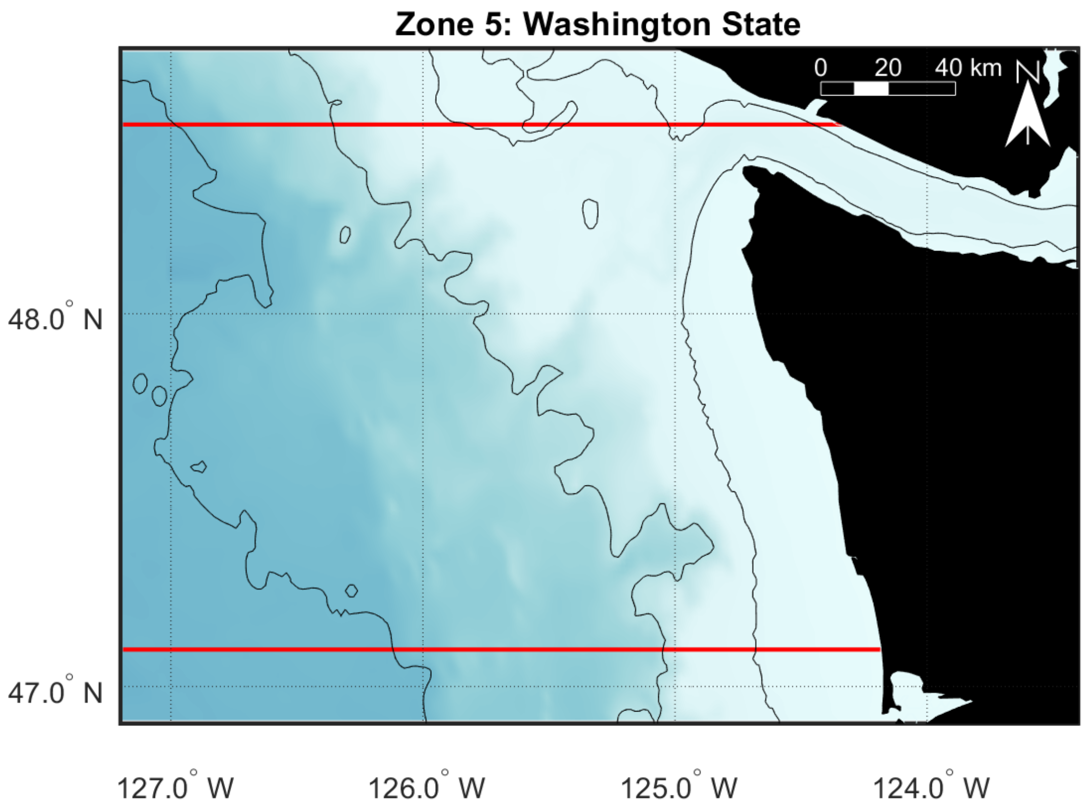


Figure 6. Zone 5: Central and Northern Washington (Offshore).

2.2 Oceanographic "Seasons"

Another key aspect of any spatially-temporally explicit assessment is the windowing of time. A key aspect of the risk assessment methods developed by Southall et al. (2023) is its inherent scalability in space and time. Previous applications of this approach have strategically used relatively conventional windows ranging from months to years to multiple years (Southall et al. 2021a; 2021b).

Through the group elicitation discussions with the expert group in the current effort, it was quickly agreed that the scope in the early stages of assessment here was broader, and the available data with which to conduct the assessments too limited to support a by-month assessment. Given the strong seasonal nature of many of the species being considered, especially highly migratory species, the analysis needed to be finer, however, than annual (although interannual analyses are likely a needed follow-on assessment discussed later). What resulted was a seasonal perspective, although it was also quickly identified that conventional human-defined seasons (spring, summer, etc.) fail to adequately capture key ecological aspects of what drive biological distribution, density, and behavior of marine mammal and sea turtle species on the U.S. West Coast.

While identified as somewhat imperfect and variable both within years across areas and across years depending on oceanographic conditions, the group identified temporal windows based on 'oceanographic' seasons defined around one of the most defining features of the California Current Ecosystem in which this assessment was conducted, namely wind-driven upwelling. Three associated 'seasons' were defined, each with the following identified and associated calendar months:

"*Upwelling*" - March–June

"*Post-Upwelling*" - July–November

"*Winter*" - December–February

2.3 Vulnerability Scoring Criteria

A critical step in the virtual workshops leading up to and the group discussions at the outset of the working group meeting to conduct the vulnerability scoring was agreeing upon the scoring criteria to be applied. The group started from the methods presented in Southall et al. (2023), which include explicit quantitative and expert elicitation criteria for component factors that are evaluated individually and then aggregated to determine a total vulnerability score specific to each species, area, and time period context considered. As was done in earlier adaptations of these risk assessment methods from applications with seismic surveys in the Gulf of Mexico (Southall et al. 2021a) to considerations of offshore wind farms off the U.S. East Coast (Southall et al. 2021b), it was recognized that further modifications were needed for the much different contexts for different kinds of offshore energy developments and a much broader range of species on the U.S. West Coast.

Fundamental aspects and in fact most of the specific sub-factor elements from those presented in Southall et al. (2023) were retained in the adapted vulnerability scoring assessment. Elements related to population parameters, spatial and temporal aspects of distribution and behavior, and susceptibility to variable human and biological stressors were still seen as the logical basis of the assessment. However, several specific modifications were made, which are detailed in the description of criteria for each factor below. One overarching modification was slight changes in the total possible scores for several factors, moving to an overall balanced and equivalent distribution of possible factor scores. Four vulnerability factors were ultimately defined, each containing multiple component sub-factors:

- Population Factor
- Species Habitat and Temporal Factor
- Physical Interactions Factor
- Other Stressors Factor

Each factor is described and specific criteria for all sub-factors and data analyses provided and applied in the scoring process are provided below.

2.3.1 Population Factor

Key considerations for evaluating the potential vulnerability of a species to disturbance include aspects of a species' overall population status and trajectory. The population factor (Table 1) includes three defined sub-factors: conservation status, population trend, and overall population size. Conservation status is clearly defined for the criteria identified for U.S. West Coast marine mammal and sea turtles. Population trend can be more difficult to determine as varying degrees of supporting information exist; criteria specified require some level of expert elicitation, but an explicit score is possible if insufficient information exists. The population size sub-factor was included, using the IUCN criteria specified for identifying small populations, given that not all endangered or listed marine mammal species necessarily have low populations (e.g., Steller sea lions (*Eumetopias jubatus*)). It is noted that population size estimates applied in vulnerability scoring for sea turtles are based on adult females; only sub-adults and adults are encountered in the California Current Ecosystem. Other slight modifications to the population factor score made in the current effort included an increase in the overall weight of the conservation status (to 5) in order to increase the total factor score to an equivalent value (to 9) as each of the other factors.

Table 1. Species population factor scoring criteria (defined for regional population or stock).

Population Factor Elements	Score (max 9)
Population status: • *Endangered* (U.S. Endangered Species Act (ESA)) = **5** • *Threatened (ESA) or depleted* (U.S. Marine Mammal Protection Act (MMPA)) = **3** • *MMPA-listed or Special concern* (various statutes) = **1**	**max = 5**
Population trend: • *Decreasing* (statistically supported trend identified in most recent SAR, status review, or peer-reviewed publication) = **2** • *Unknown* (no population trend analysis performed or data deficient) = **1** • *Stable* (statistically supported trend identified in most recent SAR, status review, or peer-reviewed publication) = **0** • *Increasing* (statistically supported trend identified in most recent SAR, status review, or peer-reviewed publication) = **-1**	**max = 2**
Population size: • *Small* (n < 2,500, as specified by International Union for the Conservation of Nature [IUCN] designation) = **2** • *Unknown* (last three SARs or status reviews) but possibly below 2,500 = **1** • *> 2,500* = **0**	**max = 2**

2.3.2 Species Habitat and Temporal Factor

Baseline data on the distribution and density of species being assessed are central in several ways to the overall spatial-temporal risk assessment framework developed by Southall et al. (2023). Such data, overlaid with the distribution and aspects of potential anthropogenic disturbances, are fundamental to the spatially and temporally explicit exposure index calculations quantifying the relative severity/magnitude of exposure. Baseline density and distribution data are also foundational for the second factor applied in scoring relative species-specific vulnerability, which evaluates the proportion of the overall population occurring in the zone being evaluated in a specified season as well as key biological activities occurring. The species habitat use and compensatory abilities factor aims to quantify the species- and season-specific, biological importance of an area in which potential disturbance will occur, information that is highly pertinent to the extent to which a species might be able to compensate for or offset the effect of the exposure. Relatively higher potential vulnerability is assessed for areas where species have high site fidelity (e.g., Forney et al. 2017), or where there is a higher spatial overlap between anthropogenic, sound-generating activities and seasonally important biological activities (e.g., mating, rearing of offspring, foraging, migrating).

The current analysis, focused exclusively on the vulnerability assessment, maintains the basic structure of this factor, weighted more heavily toward relative distribution and density within a zone (as a proportion of the total area population) than the temporal overlap with key functions (Table 2). However, several adaptations were required and applied given the novel context of this analysis for the West Coast context related to the overall scoring as well as methods developed in assessing the habitat use sub-factor score.

Table 2. Species habitat and temporal factor scoring criteria.

Species habitat and temporal factor elements	Score (max 9)
Habitat use: • Specified zone contains ≥ 20% of total regionwide or estimated population during specified period) = **7** • < 20% and ≥ 5% = **4** • < 5% and ≥ 1% = **1** • < 1% = **0**	max = 7
Temporal overlap: • *High probability* that activity will overlap with concentrated breeding/maternal care periods and/or key feeding or migration periods within specified area = **2** • *Med probability* that activity will overlap with concentrated breeding/maternal care periods and/or key feeding or migration periods within specified area = **1** (also assigned when insufficient data on species biology exists by which to assess potential overlap) • *Low probability* = that activity will overlap with concentrated breeding/maternal care periods and/or key feeding or migration periods within specified area **= 0**	max = 2

As with the population factor, the total score here was increased by two (to nine) such that each factor score has an equivalent overall weight in the total score. We increased the maximum possible score in the habitat use sub-factor (to seven) and re-allocated a coarser delineation of scores associated with each relative proportion of the regionwide population (i.e., across all 15 zones) occurring in the zone being assessed. Most substantively, however, were adaptations of available data sources and analytical approaches to determine the relative proportions by species, zone, and season used to assign the habitat use sub-factor score. Three different approaches were ultimately applied.

The primary objective was to determine the habitat use score based on quantitative metrics of species density in each zone for a specified season. Previous assessments off the U.S. East Coast (Southall et al. 2021a) used existing spatially-temporally explicit density layers in defined grid cells within zones defined in a larger region (Roberts et al. 2020). Similar approaches have recently been applied to quantify species density for a subset of the marine mammal species and/or stocks evaluated here (Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020). These approaches apply sighting data from 1991–2018 systematic ship surveys conducted by NOAA's Southwest Fisheries Science Center (SWFSC), to develop updated species distribution models (SDMs) for summer to autumn months (July–Nov), using well-established modeling methods. These results yield spatially explicit density estimates for 14 cetacean species and a small beaked whale guild (*Mesoplodon* spp. and *Ziphius cavirostris*). Data for the most recent of these surveys (2014 and 2018) during these months were applied, with modifications based on the spatial segregation of zones in this analysis, to determine spatial densities for these species used in directly determining habitat use scores. This was done by determining the relative percentage of species within each zone relative to the total estimated population within the entire region (all 15 zones).

For some species, where density data in other months were not available, the resulting relative proportions of species presence in each zone (again relative to the total estimated population within the entire region) were used for each season. However, for most species for which SDMs were determined, additional data were applied to determine habitat use scores for other seasons. Seasonal SDMs, developed by Becker et al. (in prep.) using data from the above SWFSC surveys and quarterly CalCOFI (California Cooperative Fisheries Investigation) cruises from 2005 to 2020, were applied to the upwelling and winter seasons for eight cetacean species (fin whale (*Balaenoptera physalus*), minke whale (*Balaenoptera* *acutorostrata*), short-beaked common dolphin (*Delphinus delphis*), long-beaked common dolphin (*Delphinus delphis bairdii*), Risso's dolphin (*Grampus griseus*), northern right whale dolphin (*Lissodelphus borealis*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), and Dall's porpoise (*Phocoenoides dalli*)). For two key baleen whale species, additional enhancements were also made. For blue whales (*Balaenoptera physalus*) an ensemble model from Becker et al. (2022) density predictions and Abrahms et al. (2019) probability of occurrence predictions (rescaled to abundance) was used to enhance predictions in the post-upwelling period. For humpback whales (*Megaptera novaeangliae*), predictions in each season determined as described above, were further segregated into relative proportions for three DPSs (Central America, Mexico, Hawaii) based on photo identification and visual resight data (J. Calambokidis, pers comm.). The resulting zone- and season-specific proportions for species for which these respective SDM methods were applied are provided below for selected mysticete (Table 3) and odontocete cetaceans (Table 4).

For the mysticete and odontocete species considered in this vulnerability assessment for which SDM results are not presented above (Tables 3 and 4), expert elicitation was applied to evaluate spatial and temporal distribution patterns. For species where sufficient data were determined to be available for some or all contexts, temporal factor scores were assigned through elicitation; species-specific references, associated data gaps, and implication for confidence scores are discussed in results by species. In some instances, experts determined data limitations related to spatial and temporal patterns in distribution precluded even low-confidence assessments and no scores were assigned. While this precluded an overall vulnerability score, other factor scores were provided for some species to provide some indication of both where other aspects of the assessment were tending and to highlight data gaps. Temporal overlap scores for species for which habitat use scores were assigned were determined through expert elicitation. Lowest possible (0) temporal overlap scores were assigned only in instances where habitat use scores were also 0.

Table 3. Species density model predictions of relative proportions (as percentages) in each zone for selected mysticete cetacean species for each oceanographic season: a. post-upwelling, b. winter, c. upwelling; for humpback whales, assume post-upwelling applies to winter and upwelling.

a. Post-upwellling (Jul.–Nov.)

Stratum	Depth Zone	Blue Whale	Fin Whale	Minke Whale	Humpback Whale Central Amer. DPS	Humpback Whale Mexico DPS	Humpback Whale Hawaii DPS
Zone.1a	<100m	11.5%	3.2%	8.2%	26.1%	16.3%	0.0%
Zone.1b	100-1000m	23.6%	23.0%	16.3%	33.8%	21.1%	0.0%
Zone.1c	1000-2500m	11.7%	27.3%	12.2%	12.9%	8.0%	0.0%
Zone.2a	<100m	5.8%	0.6%	3.3%	2.6%	3.4%	1.8%
Zone.2b	100-1000m	14.4%	4.4%	8.7%	6.6%	8.6%	4.6%
Zone.2c	1000-2500m	6.3%	7.9%	7.4%	2.0%	2.6%	1.4%
Zone.3a	<100m	3.9%	1.5%	3.5%	2.3%	5.3%	3.4%
Zone.3b	100-1000m	8.8%	8.8%	8.3%	6.7%	15.2%	9.7%
Zone.3c	1000-2500m	2.7%	9.9%	4.5%	1.3%	3.0%	1.9%
Zone.4a	<100m	1.8%	0.7%	3.7%	0.5%	1.4%	6.7%
Zone.4b	100-1000m	4.4%	4.0%	7.5%	1.7%	5.0%	23.2%
Zone.4c	1000-2500m	4.1%	6.5%	7.8%	0.6%	1.8%	8.4%
Zone.5a	<100m	0.2%	0.1%	1.8%	0.6%	1.7%	7.8%
Zone.5b	100-1000m	0.2%	0.3%	2.3%	1.4%	4.3%	20.0%
Zone.5c	1000-2500m	0.6%	1.8%	4.6%	0.8%	2.4%	11.1%
Total abundance	(% of peak) 15 strata	100%	100%	100%	100%	100%	100%

b. Winter (Dec.–Feb.)

Stratum	Depth Zone	Blue Whale	Fin Whale	Minke Whale
Zone.1a	<100m	1.2%	0.6%	4.8%
Zone.1b	100-1000m	2.8%	3.3%	9.4%
Zone.1c	1000-2500m	1.6%	4.7%	7.0%
Zone.2a	<100m	0.3%	0.1%	2.4%
Zone.2b	100-1000m	0.9%	0.6%	6.7%
Zone.2c	1000-2500m	0.7%	1.3%	5.5%
Zone.3a	<100m	0.3%	0.0%	2.9%
Zone.3b	100-1000m	0.7%	0.2%	6.4%
Zone.3c	1000-2500m	0.2%	0.3%	3.2%
Zone.4a	<100m	0.3%	0.0%	2.8%
Zone.4b	100-1000m	0.6%	0.1%	5.3%
Zone.4c	1000-2500m	0.3%	0.3%	4.9%
Zone.5a	<100m	0.0%	0.0%	1.6%
Zone.5b	100-1000m	0.0%	0.0%	1.9%
Zone.5c	1000-2500m	0.0%	0.1%	3.4%
Total abundance	(% of peak) 15 strata	10%	12%	68%

c. Upwellling (Mar.–Jun.)

Stratum	Depth Zone	Blue Whale	Fin Whale	Minke Whale
Zone.1a	<100m	1.7%	0.9%	4.6%
Zone.1b	100-1000m	3.2%	3.5%	8.5%
Zone.1c	1000-2500m	1.9%	5.2%	6.6%
Zone.2a	<100m	1.0%	0.2%	2.5%
Zone.2b	100-1000m	2.5%	0.6%	6.4%
Zone.2c	1000-2500m	1.6%	1.0%	5.2%
Zone.3a	<100m	1.0%	0.2%	3.1%
Zone.3b	100-1000m	3.4%	0.7%	6.8%
Zone.3c	1000-2500m	1.3%	0.7%	3.3%
Zone.4a	<100m	0.8%	0.5%	3.5%
Zone.4b	100-1000m	2.6%	1.0%	6.2%
Zone.4c	1000-2500m	2.3%	1.5%	5.6%
Zone.5a	<100m	0.1%	0.2%	1.9%
Zone.5b	100-1000m	0.1%	0.2%	2.2%
Zone.5c	1000-2500m	0.3%	0.7%	3.8%
Total abundance	(% of peak) 15 strata	24%	17%	70%

Table 4. Species density model predictions of relative proportions (as percentages) of selected odontocete cetacean species in each zone in each of 3 oceanographic seasons: a. post-upwelling, b. winter, c. upwelling; for beaked whales, assume post-upwelling applies to winter and upwelling.

a. Post-upwellling (Jul.–Nov.)

Stratum	Depth Zone	Dall's porpoise	Risso's dolphin	Pacific white-sided dolphin	Northern right whale dolphin	Short-beaked common dolphin	Long-beaked common dolphin	Small beaked whales	Baird's beaked whale
Zone.1a	<100m	2.0%	10.5%	1.7%	0.2%	10.6%	17.5%	3.7%	1.7%
Zone.1b	100-1000m	3.2%	15.9%	4.7%	0.6%	52.0%	67.3%	13.2%	11.8%
Zone.1c	1000-2500m	2.6%	6.0%	6.8%	1.9%	34.4%	15.2%	15.9%	42.9%
Zone.2a	<100m	2.5%	1.0%	0.2%	0.1%	0.2%	0.0%	2.2%	0.7%
Zone.2b	100-1000m	8.3%	2.1%	1.4%	0.9%	0.8%	0.0%	9.1%	6.7%
Zone.2c	1000-2500m	7.5%	1.3%	1.9%	1.6%	1.9%	0.0%	13.3%	34.7%
Zone.3a	<100m	2.8%	1.4%	0.0%	0.1%	0.0%	0.0%	1.8%	0.0%
Zone.3b	100-1000m	8.4%	2.3%	0.9%	0.3%	0.1%	0.0%	6.5%	0.3%
Zone.3c	1000-2500m	5.1%	0.8%	3.2%	0.8%	0.1%	0.0%	5.4%	1.2%
Zone.4a	<100m	1.4%	1.3%	0.1%	0.0%	0.0%	0.0%	1.3%	0.0%
Zone.4b	100-1000m	3.5%	2.9%	1.3%	0.2%	0.0%	0.0%	4.2%	0.0%
Zone.4c	1000-2500m	3.7%	4.2%	6.2%	1.8%	0.0%	0.0%	11.5%	0.1%
Zone.5a	<100m	0.5%	1.1%	0.5%	0.0%	0.0%	0.0%	0.7%	0.0%
Zone.5b	100-1000m	0.9%	3.7%	3.3%	0.3%	0.0%	0.0%	1.7%	0.0%
Zone.5c	1000-2500m	2.4%	11.8%	3.2%	11.0%	0.0%	0.0%	9.3%	0.0%
Total abundance	(% of peak) 15 strata	55%	66%	35%	20%	100%	100%	100%	100%

b. Winter (Dec.–Feb.)

Stratum	Depth Zone	Dall's porpoise	Risso's dolphin	Pacific white-sided dolphin	Northern right whale dolphin	Short-beaked common dolphin	Long-beaked common dolphin
Zone.1a	<100m	2.2%	5.6%	0.9%	0.1%	1.0%	14.7%
Zone.1b	100-1000m	8.0%	14.5%	5.2%	0.9%	4.8%	52.0%
Zone.1c	1000-2500m	6.5%	7.2%	6.2%	3.3%	5.0%	10.4%
Zone.2a	<100m	1.2%	3.1%	0.7%	0.1%	0.0%	0.0%
Zone.2b	100-1000m	5.9%	11.0%	6.4%	1.1%	0.3%	0.0%
Zone.2c	1000-2500m	4.9%	6.0%	7.4%	3.8%	0.9%	0.0%
Zone.3a	<100m	1.1%	3.5%	0.8%	0.1%	0.0%	0.0%
Zone.3b	100-1000m	4.8%	9.9%	6.6%	0.6%	0.1%	0.0%
Zone.3c	1000-2500m	3.0%	3.8%	6.8%	2.9%	0.1%	0.0%
Zone.4a	<100m	0.9%	3.3%	0.7%	0.1%	0.0%	0.0%
Zone.4b	100-1000m	5.1%	8.2%	6.6%	1.1%	0.0%	0.0%
Zone.4c	1000-2500m	8.1%	4.7%	12.3%	10.0%	0.0%	0.0%
Zone.5a	<100m	0.5%	1.7%	0.4%	0.0%	0.0%	0.0%
Zone.5b	100-1000m	2.3%	3.1%	2.7%	0.5%	0.0%	0.0%
Zone.5c	1000-2500m	6.9%	3.3%	8.7%	6.4%	0.0%	0.0%
Total abundance	(% of peak) 15 strata	61%				12%	77%

c. Upwelling (Mar.–Jun.)

Stratum	Depth Zone	Dall's porpoise	Risso's dolphin	Pacific white-sided dolphin	Northern right whale dolphin	Short-beaked common dolphin	Long-beaked common dolphin
Zone.1a	<100m	3.8%	6.0%	1.9%	0.3%	0.6%	8.6%
Zone.1b	100-1000m	14.3%	14.8%	8.9%	1.6%	2.2%	31.0%
Zone.1c	1000m-2500m	10.1%	7.5%	8.7%	5.9%	3.1%	7.5%
Zone.2a	<100m	2.2%	3.3%	1.5%	0.3%	0.1%	0.0%
Zone.2b	100-1000m	10.7%	11.9%	10.8%	4.1%	0.2%	0.0%
Zone.2c	1000m-2500m	8.3%	6.8%	11.3%	12.2%	0.4%	0.0%
Zone.3a	<100m	2.6%	3.9%	1.4%	0.5%	0.1%	0.0%
Zone.3b	100-1000m	10.0%	11.4%	8.5%	2.7%	0.3%	0.0%
Zone.3c	1000m-2500m	4.6%	4.5%	8.0%	10.0%	0.2%	0.0%
Zone.4a	<100m	2.8%	3.9%	1.4%	0.5%	0.2%	0.0%
Zone.4b	100-1000m	8.4%	9.9%	8.2%	3.3%	0.4%	0.0%
Zone.4c	1000m-2500m	9.3%	5.9%	14.3%	32.3%	0.6%	0.0%
Zone.5a	<100m	1.6%	2.1%	0.8%	0.3%	0.1%	0.0%
Zone.5b	100-1000m	3.4%	3.8%	3.8%	1.7%	0.1%	0.0%
Zone.5c	1000m-2500m	7.9%	4.2%	10.6%	24.5%	0.2%	0.0%
Total abundance	(% of peak) 15 strata	100%				9%	47%

2.3.3 Physical Interactions Factor

This factor is intended to capture the relative vulnerability of species generally to direct physical impacts associated with offshore sustainable energy facility installation and operations. This was the most substantively modified vulnerability factor from Southall et al. (2023) for which it was entirely focused on noise interference with communication and spatial orientation through auditory masking. Given the very different contexts and potential risks associated with likely features of such installations off the U.S. West Coast (e.g., floating platforms with associated support and electrical transmission cables; substantial support and supply vessels), a wholesale restructuring of this factor was applied. This included retaining the overall maximum factor score as previously used (9) and retaining the consideration of auditory masking but adding equally weighted (each max of 3) relative potential for vessel strike and entanglement. Additionally, this factor was reverted from what was fully quantitative based on empirical data in terms of masking for East Coast risk assessments (Southall et al. 2021b) given the substantial and highlighted data limitations about operational details and potential impacts for these factors on the West Coast. The need for specific measurements and data for key species is highlighted in by-species analyses for key species and it is expected that future adaptations and application of risk assessments for these factors will include explicit quantitative criteria derived from the subjective ones used here. It is noted that this was the case in the adaptation of earlier approaches from the assessment of seismic surveys (Southall et al. 2021a) to those of offshore wind installations where pile driving noise and metrics of ambient noise in those environments were available (Southall et al. 2021b).

Expert elicitation was conducted by species using the subjective criteria described below (Table 5) to assign factor vulnerability scores, with reference to SARs as well as peer-reviewed publications where available as noted by species. A single sub-factor and overall factor score was determined for each species, which was used for each location and season. It is noted that, while information on developments and potential impacts are simply too limited to do so currently, future assessments could and should consider spatially and temporally explicit risk associated with these physical interaction factors.

Table 5. Physical interactions factor scoring criteria.

Physical interactions factor elements	Score (max 9)
Potential Auditory Masking (of communication and orientation signals from low frequency noise associated with survey, installation, and operation of offshore energy facilities) and/or Electromagnetic Interference (esp. for sea turtles): • High masking/electromagnetic potential = **3** • Moderate masking/electromagnetic potential; or high uncertainty = **2** • Low masking/electromagnetic potential = **1** • No masking/electromagnetic potential = **0**	max = 3
Vessel Strike Risk: • High vessel strike potential = **3** • Moderate vessel strike potential = **2** • Low vessel strike potential = **1** • No vessel strike potential = **0**	max = 3
Entanglement Risk: • High entanglement potential = **3** • Moderate entanglement potential = **2** • Low entanglement potential = **1** • No entanglement potential = **0**	max = 3

2.3.4 Other Stressors Factor

The fourth and final vulnerability scoring factor is intended to capture the existing contexts of other stressors, anthropogenic as well and environmental (non-anthropogenic). The overall total score associated with this overall factor was also increased (by 2) for an equivalent overall weight (max 9) as each of the other factors. Greater relative weighting was given to the sub-factor relating to estimated mortality, as well as slightly lower threshold breakpoints for relative scores, from known human impacts relative to estimates of the population's ability to sustain such impacts.

There are three sub-factor elements comprising the other stressors factor, as detailed below (Table 6). A relative, subjective assessment of existing anthropogenic noise sources was conducted using expert elicitation for each zone and season. Information provided in support of this included spatial and temporal distribution of various kinds of vessel traffic (see Figure 7 below), as well as information on the presence and intensity of seismic survey activity and naval training and testing areas. This sub-factor was variable within species by area and season. Estimates of mortality relative to specified criteria for population impacts were used to directly assign a species-specific score for the non-noise human impacts sub-factor of chronic anthropogenic risk; this score was constant across seasons and areas. Expert elicitation was used with available information from SARs, peer-reviewed publications, and other appropriate sources to determine a species-specific score for chronic biological risk factors; this score was constant across seasons and areas.

Table 6. Other stressors scoring criteria.

Other Stressors Factor Elements	Score (max 9)
Chronic anthropogenic noise: Species subject to variable levels of current or known future chronic anthropogenic noise (i.e., dense or overlapping concentrations of industrial activity such as shipping lanes, sonar testing ranges, areas of regular seismic surveys)	Up to 2
Chronic anthropogenic risk factors (non-noise direct anthropogenic impacts): Species subject to variable degrees of current or known future risk from other chronic, non-noise anthropogenic activities (e.g., regular documented cases of fisheries interactions, whale watching, research activities, ship-strike). Total annual known or estimated direct anthropogenic mortality, as documented in last SAR, status review, or peer-reviewed publication, evaluated relative to species-specific potential biological removal (PBR) or other established reference points (e.g., local limit reference points for sea turtle). • Annual mortality ≥ PBR: **5** • Annual mortality ≥ 50% PBR or mortality unknown/unreliable: **3** • Annual mortality ≥ 10% PBR: **1** • Annual mortality < 10%: **0**	Up to 5
Chronic biological risk factors (non-noise environmental impacts): Variable presence of disease, parasites, prey limitation (including indirect climate change related), or high predation pressure (recent SARs, status review, or peer-reviewed publication as reference). • Documented instances of multiple such stressors in recent SARs, status reviews, and/or available recent peer-reviewed literature: **2** • Documented instance of one such stressor in recent SARs, status reviews, or available recent peer-reviewed literature: **1** (also assigned when insufficient data for the species is present) • No documented instances of such stressors where species are sufficiently monitored: **0**	Up to 2

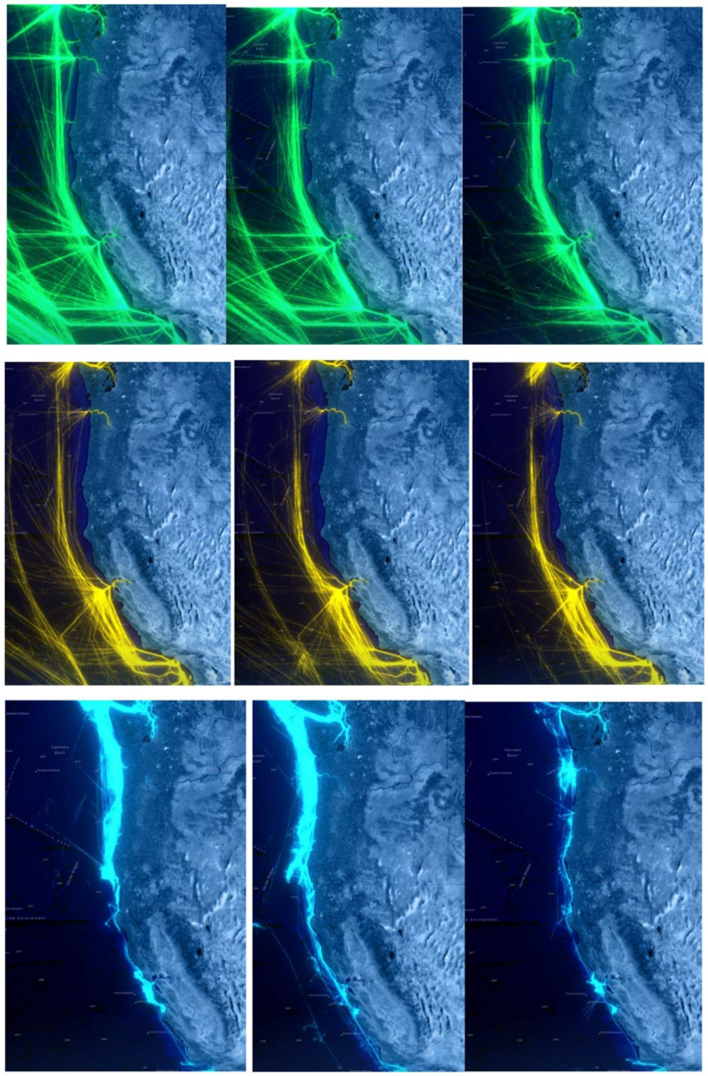


Figure 7. Spatial and temporal distribution of various vessel traffic used in expert elicitation for evaluating chronic anthropogenic noise. Example Automatic Identification System (AIS) data for cargo (top panels), tanker (middle), and fishing (bottom) vessels along the U.S. West Coast for representative months in each season of 2019 (June: left panels; October: center: December right). Note: passenger and 'other' vessel categories were also provided to experts.

2.4 Species, Stocks, and/or Distinct Population Segments Evaluated

Four broad taxonomic groups of marine mammals and sea turtles were defined at the outset of the project, as identified below. The initial aim was to consider all species within these taxa that are known to or could reasonably occur along the West Coast, and to evaluate some related and or ecologically similar species within species groups. However, through extensive debate and discussion at the initial virtual workshops as well as ahead of the scoring processes at the in-person workshop, experts strongly expressed the need to consider the majority of species at the species level and in fact for many species to further break down assessments to the level of stocks and/or distinct population segments (DPSs). This resulted in a total of 42 species, groups, stocks, or DPSs (Tables 7–10). All species were considered across all seasons and spatial zones, with n/a assigned for some contexts for which data were simply unavailable. For some specified stocks that are defined based on their high site fidelity to a specified area (e.g., harbor porpoise), scores are only provided for one or several specified zones. Taxa considered and the associated table with each of the species/stocks evaluated are:

- Mysticete Cetaceans (Table 7)
- Odontocete Cetaceans (Table 8)
- Pinnipeds (Table 9)
- Sea Turtles (Table 10)

Table 7. Mysticete cetacean species/stocks evaluated (n = 11).

SPECIES	*STOCK*	*CONSERVATION STATUS*
BLUE WHALE	Eastern N. Pacific	**ESA-listed (endangered)**
FIN WHALE	CA/OR/WA	**ESA-listed (endangered)**
SEI WHALE	Eastern N. Pacific	**ESA-listed (endangered)**
NORTH PACIFIC RIGHT WHALE	Not specified (AK, W Coast)	**ESA-listed (endangered)**
GRAY WHALE	Western N. Pacific	**ESA-listed (endangered)**
GRAY WHALE	Eastern N. Pacific	**MMPA-listed**
HUMPBACK WHALE	Central American DPS	**ESA-listed (endangered)**
HUMPBACK WHALE	Mexico DPS	**ESA-listed (threatened)**
HUMPBACK WHALE	Hawaii DPS	**MMPA-listed**
BRYDE'S WHALE	Eastern Tropical Pacific	**MMPA-listed**
MINKE WHALE	CA/OR/WA	**MMPA-listed**

Table 8. Odontocete cetacean species/stocks evaluated (n = 20).

SPECIES	*STOCK*	*CONSERVATION STATUS*
SPERM WHALE	CA/OR/WA	**ESA-listed**
KILLER WHALE	Eastern N. Pacific S. Resident	**ESA-listed**
KILLER WHALE	Eastern N. Pacific Offshore	**MMPA-depleted**
KILLER WHALE	Eastern N. Pacific Transient	**MMPA-listed**
DALL'S PORPOISE	CA/OR/WA	**MMPA-listed**
HARBOR PORPOISE	Morro Bay	**MMPA-listed**
HARBOR PORPOISE	Monterey Bay	**MMPA-listed**
HARBOR PORPOISE	SF-Russian River	**MMPA-listed**
HARBOR PORPOISE	Northern Cal/Southern OR	**MMPA-listed**
HARBOR PORPOISE	Northern OR/WA coast	**MMPA-listed**
PYGMY AND DWARF SPERM	CA/OR/WA	**MMPA-listed**
SHORT-FINNED PILOT WHALE	CA/OR/WA	**MMPA-listed**
RISSO'S DOLPHIN	CA/OR/WA	**MMPA-listed**
WHITE-SIDED DOLPHIN	CA/OR/WA	**MMPA-listed**
NORTHERN RIGHT WHALE DOLPHIN	CA/OR/WA	**MMPA-listed**
SHORT-BEAKED COMMON DOLPHIN	CA/OR/WA	**MMPA-listed**
LONG-BEAKED COMMON DOLPHIN	CA	**MMPA-listed**
BOTTLENOSE DOLPHIN	CA/OR/WA (coastal)	**MMPA-listed**
BAIRDS BEAKED WHALE	CA/OR/WA	**MMPA-listed**
OTHER BEAKED WHALES (Cuvier's and Mesoplodont)	CA/OR/WA	**MMPA-listed**

Table 9. Pinniped species/stocks evaluated (n = 8).

SPECIES	*STOCK*	*CONSERVATION STATUS*
GUADALUPE FUR SEAL	Mexico	**MMPA-depleted**
CALIFORNIA SEA LION	U.S.	**MMPA-listed**
STELLER SEA LION	U.S.	**MMPA-listed**
NORTHERN FUR SEAL	California	**MMPA-listed**
NORTHERN FUR SEAL	E. North Pacific	**MMPA-listed**
NORTHERN ELEPHANT SEAL	California Breeding	**MMPA-listed**
HARBOR SEAL	California	**MMPA-listed**
HARBOR SEAL	OR/WA	**MMPA-listed**

Table 10. Sea turtle species/stocks evaluated (n = 4)

SPECIES	*STOCK*	*CONSERVATION STATUS*
LEATHERBACK	W. Pacific DPS (boreal summer nesters)	**ESA-listed (endangered)**
LOGGERHEAD	N. Pacific DPS	**ESA-listed (endangered)**
GREEN		**ESA-listed (threatened)**
OLIVE RIDLEY		**ESA-listed (threatened)**

2.5 Aggregate Vulnerability Score Bins and Relative Vulnerability Ratings

A similar approach as in Southall et al. (2023) was used to aggregate vulnerability scores across factors and sub-factors to provide associated risk probability and relative vulnerability ratings for each zone-season context. However, given the overall changes in factor scores (such that each has a maximum of 9), the associated score bins and probabilities differ slightly here. Aggregate vulnerability scores have a maximum of 36 here. Using a quintile approach to assigning relative overall risk probabilities, relative ratings are assigned as equal proportions, as specified below (Table 11).

Table 11. Aggregate vulnerability score bins and corresponding relative risk probabilities and vulnerability ratings.

Aggregate Vulnerability Score Bins (from factors 1–4)	Relative Risk Probability (% of total possible)	Relative Vulnerability Rating
29–36	80–100%	Highest
22–28	60–79%	High
15–21	40–59%	Moderate
8–14	20–39%	Low
1–7	0–19%	Lowest

3 Vulnerability Risk Assessment Results – By Species

3.1 Vulnerability Risk Assessment – Mysticetes

3.1.1 BLUE WHALE (Eastern N. Pacific stock)

Summary Assessment: Vulnerability scores for eastern north Pacific blue whales were among the highest overall for species evaluated in this study, with generally higher scores in the southern zones. Scores ranged from moderate (low of 21) primarily in winter months when most individuals are on breeding grounds to highest (high of 32), which occurred during the post-upwelling period in non-oceanic areas of Zone 1. Spatial and temporal habitat use scores were based on proportional distribution for each season and zone from habitat modeling approaches described above (section 2.3; Abrahms et al. 2019; Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020). Other key factors driving these relatively high scores for blue whales include: their ESA listing; relatively small (< 2,500) assessed population size (Calambokidis and Barlow 2020); high assessed masking potential (based on low-frequency communication and predominately low frequencies of sounds associated with likely disturbance); high assessed vessel strike risk (Rockwood et al. 2018); moderate assessed risk of entanglement (documented cases of entanglement in SARs but evaluated as less than some other species); moderate scores for chronic biological risk based on potential prey limitations related to climate change (Hazen et al. 2013; 2015; Abrahms et al. 2019); and highest possible score in other stressors/chronic anthropogenic factors based on an estimated mortality of 19.4 individuals relative to PBR of 1.2 (2020 SAR; Carretta et al. 2021). Lower factor scores were assigned in relation to their evaluated stable population trend based on mark-recapture data presented in the 2020 SAR (Carretta et al. 2021). Chronic anthropogenic noise factor scores were consistent with other species as described (section 2.3).

Uncertainty Assessment: Moderate certainty in scores were assigned for most zones/seasons with the exception of high certainty scores in Zones 2 and 3 for the post-upwelling season.

Key Data Gaps: Distribution and density data during winter and finer scale assessment in lease areas, potential for entanglement in floating structures, sustained monitoring of population trend.

Table 12. Blue whale vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	25	25	23	21	23	23	24	25	23	22	24	23	22	23	22
Post-Upwelling	29	32	27	27	27	27	24	28	23	24	24	23	22	23	22
Winter	24	24	23	21	21	21	21	21	21	22	22	22	22	22	21

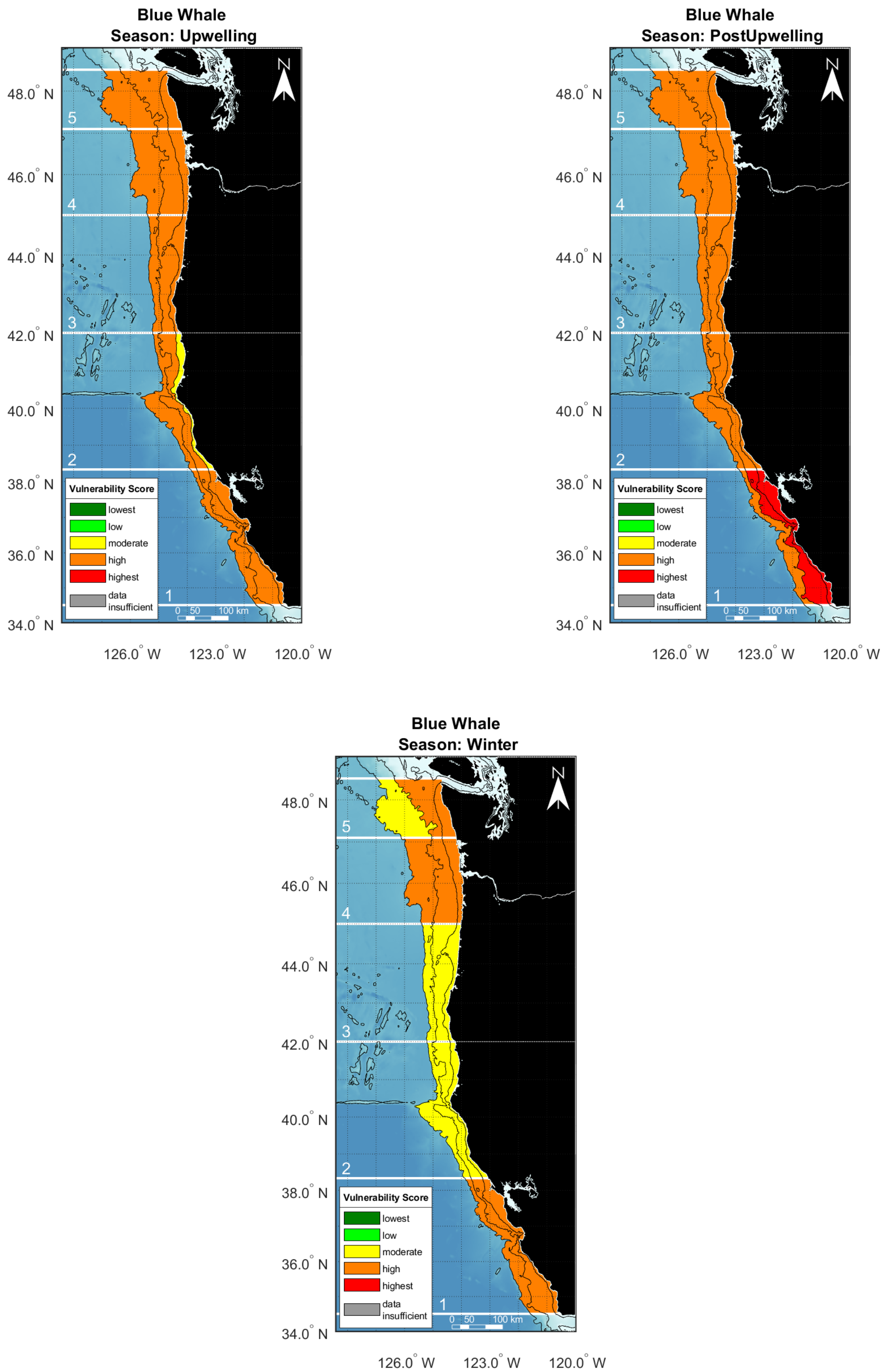


Figure 8. Blue whale vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.1.2 FIN WHALE (CA/OR/WA)

Summary Assessment: Assessed vulnerability scores for fin whales were generally slightly above average for species assessed, with comparable values across zones but higher scores in the post-upwelling season throughout the region. Scores were predominately moderate (low of 16) with several high values (high of 27). Lowest relative scores were reported in winter months when much of the species is in the winter breeding grounds. This stock of fin whales is ESA-listed and was evaluated to have a stable population trend based on Nadeem et al. (2016), though it is noted that there is more recent evidence of population increases (Becker, Forney, et al. 2020; 2021 SAR). With an estimated population size of 9029 (2020 SAR; Carretta et al. 2021), this yields intermediate overall scores in population factors. Factors related to fin whale spatial and temporal habitat use were based on proportional spatial distribution for each season and zone (Scales et al. 2017; Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020; Becker et al. in prep) using the quantitative habitat modeling approaches described above (section 2.3). Physical interaction factor scores were identical and similarly high to blue whales based on high assessed masking potential (based on their low-frequency communication and predominately low frequencies of sounds associated with likely disturbance); high assessed risk of vessel strike (see: Rockwood et al. 2018); and moderate assessed risk of entanglement (documented cases of entanglement in SARs but evaluated as less than some other species). Intermediate scores for other stressors resulted from moderately high scores in chronic anthropogenic (other) factors based on an estimated mortality of 43.7 individuals relative to a PBR of 81 in the 2020 SAR but the lack of documented instances of non-anthropogenic biological stressors in the last three SARs. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3).

Uncertainty Assessment: Moderate certainty was assigned for almost all most zones/seasons with the exception of high certainty scores in Zone 1 for the post-upwelling season.

Key Data Gaps: Distribution and density data during winter and finer scale assessment in lease areas, potential for entanglement in floating structures, sustained monitoring of population trend.

Table 13. Fin whale vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	18	20	22	16	16	18	17	18	16	17	19	18	17	18	17
Post-Upwelling	20	27	25	16	18	22	19	23	22	19	20	22	19	20	20
Winter	17	19	18	16	16	18	16	16	16	17	17	17	17	17	16

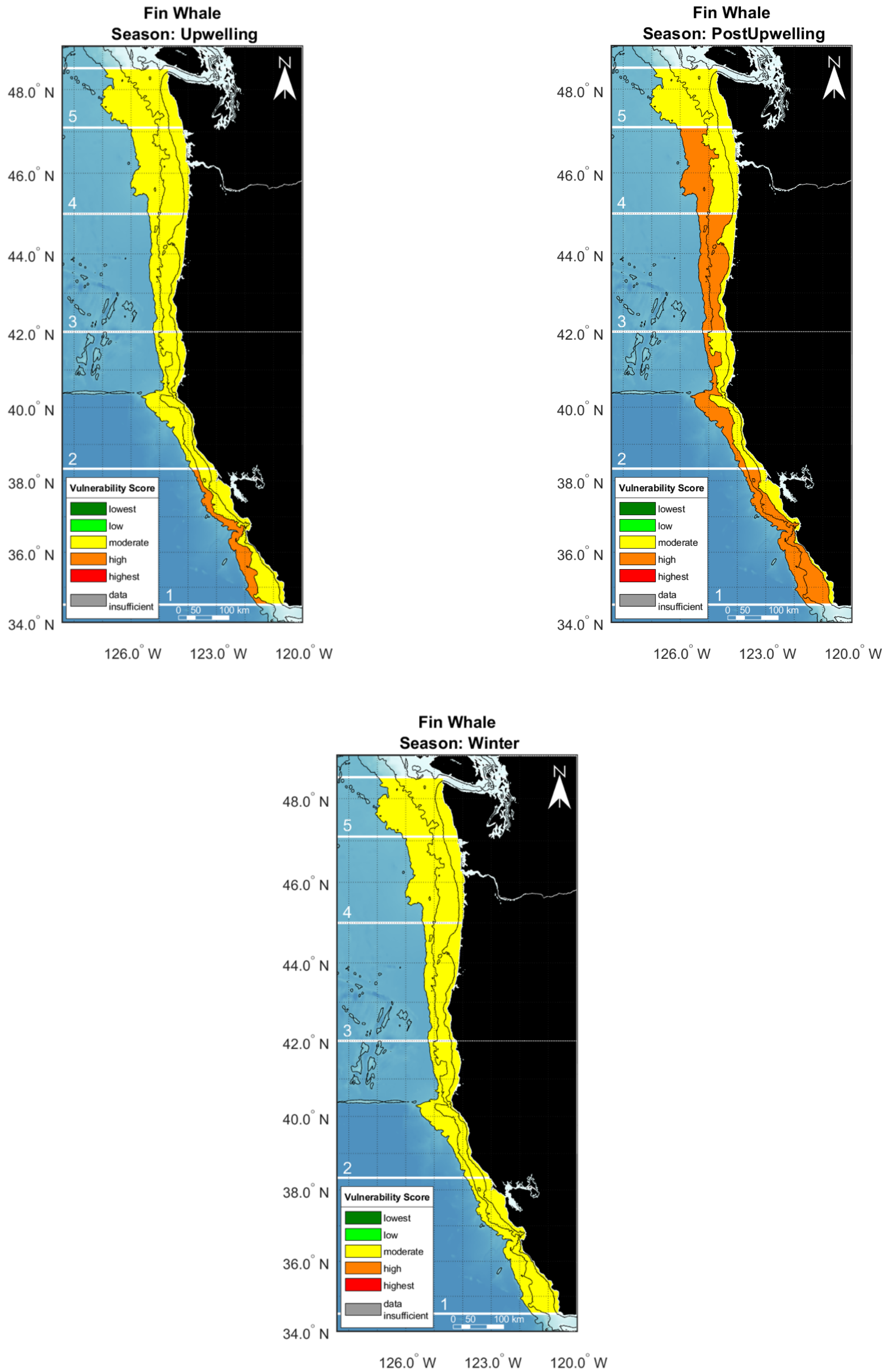


Figure 9. Fin whale vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.1.3 SEI WHALE (Eastern N. Pacific)

Summary Assessment: Given the highly limited information in multiple regards for this species, with the exception of the shelf (< 100 m) portions of each zone in the post-upwelling period, total vulnerability scores for sei whales were not determined. The predominant reason for this was a near total lack of key information on spatial and temporal patterns of their distribution along the U.S. West Coast with which to inform distribution models or elicit expert judgment as to the species habitat and temporal factor scores. Based on limited spatial data presented in the 2020 SAR and expert judgment, zero scores for these factors were assigned in the shelf areas of each zone for the post-upwelling period; these resulted in overall vulnerability scores of moderate (ranging from 15–17). Other factor scores were determined (see https://opendata.boem.gov/Vulnerability-Scoring-Mysticetes.xlsx) to illustrate what vulnerability scores might be when better distribution data are available. Eastern north Pacific sei whales are ESA-listed with an evaluated unknown population trend, and an estimated population size of < 2,500 (n = 519; Barlow 2016). Based on these factors alone, this should be seen as an important species for consideration and future research effort. While considerable uncertainty was noted, physical interaction factor scores were evaluated as lower overall than blue or fin whales with high assessed masking potential (based on their low-frequency communication and predominately low frequencies of sounds associated with likely disturbance), moderate relative assessed risk of vessel strike (see: Rockwood et al. 2018); and no reported instances of entanglement in recent SARs. Relatively lower scores were reported for chronic anthropogenic (other) factors based on an estimated mortality of 0.2 individuals relative to a PBR of 0.75 in the 2020 SAR (Carretta et al. 2021). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3).

Uncertainty Assessment: Low confidence was assigned for all seasons and zones given the lack of key information related to aspects of the vulnerability factors evaluated.

Key Data Gaps: Many, but distribution and density data during all seasons was identified as the most critical data gap, particularly focusing on effort in identified development areas.

Table 14. Sei whale vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Post-Upwelling	17	n/a	n/a	15	n/a	n/a	16	n/a	n/a	16	n/a	n/a	16	n/a	n/a
Winter	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

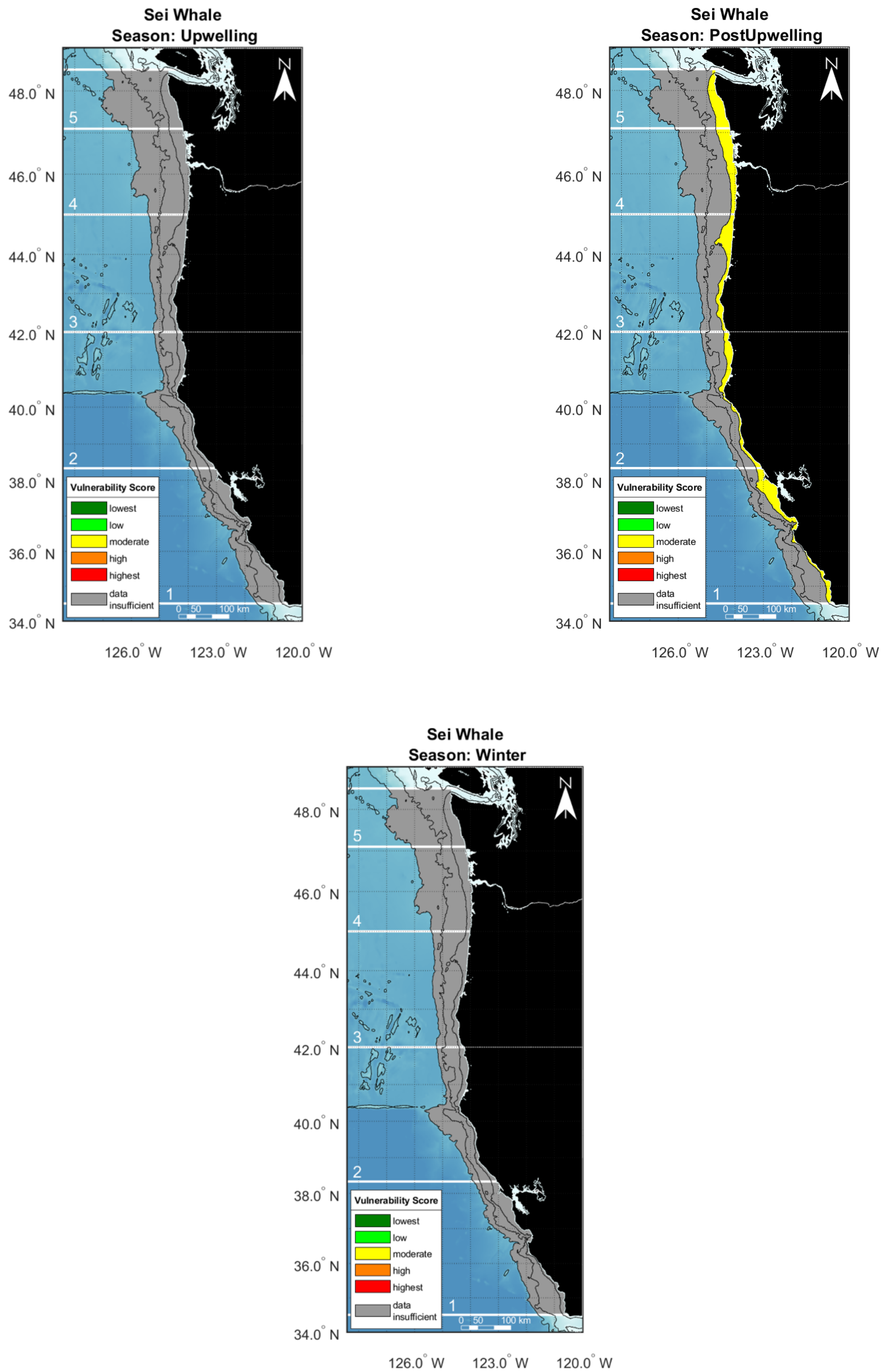


Figure 10. Sei whale vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.1.4 NORTH PACIFIC RIGHT WHALE (Not Specified; AK, U.S. West Coast)

Summary Assessment: Given the highly limited information in all factors, total vulnerability scores for North Pacific right whales were not determined. While individual sightings are reported, there is essentially no systematic data on spatial and temporal patterns of their distribution with which to inform distribution models or elicit expert judgment as to the species habitat and temporal factor scores and none were determined. Other factor scores were determined (see https://opendata.boem.gov/Vulnerability-Scoring-Mysticetes.xlsx) to illustrate what vulnerability scores might be when better distribution data are available, but caution is warranted in considering these given the extent of data limitations. North Pacific right whales are among the most critically endangered marine mammals. They are ESA-listed with an evaluated unknown population trend and an estimated population size of < 2,500 (n = 31; mark-recapture assessment in 2020 SAR). While considerable uncertainty was noted, physical interaction factor scores were at the highest values for each, with high assessed masking potential (based on their low-frequency communication and predominately low frequencies of sounds associated with likely disturbance) and high assessed risk of vessel strike and entanglement based largely on these conservation concerns well documented in north Atlantic right whales. Chronic anthropogenic (other) and chronic biological risk factors were scored as simply unknown. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3).

Uncertainty Assessment: Low confidence was assigned for all seasons and zones given the lack of key information related to aspects of the vulnerability factors evaluated.

Key Data Gaps: Many, but distribution and density data during all seasons was identified as the most critical data gap, particularly focusing on effort in identified development areas. While challenging, given the high level of concern regarding related species (North Atlantic right whales), potential entanglement risk around floating offshore developments should be evaluated.

Table 15. North Pacific right whale vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Post-Upwelling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Winter	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

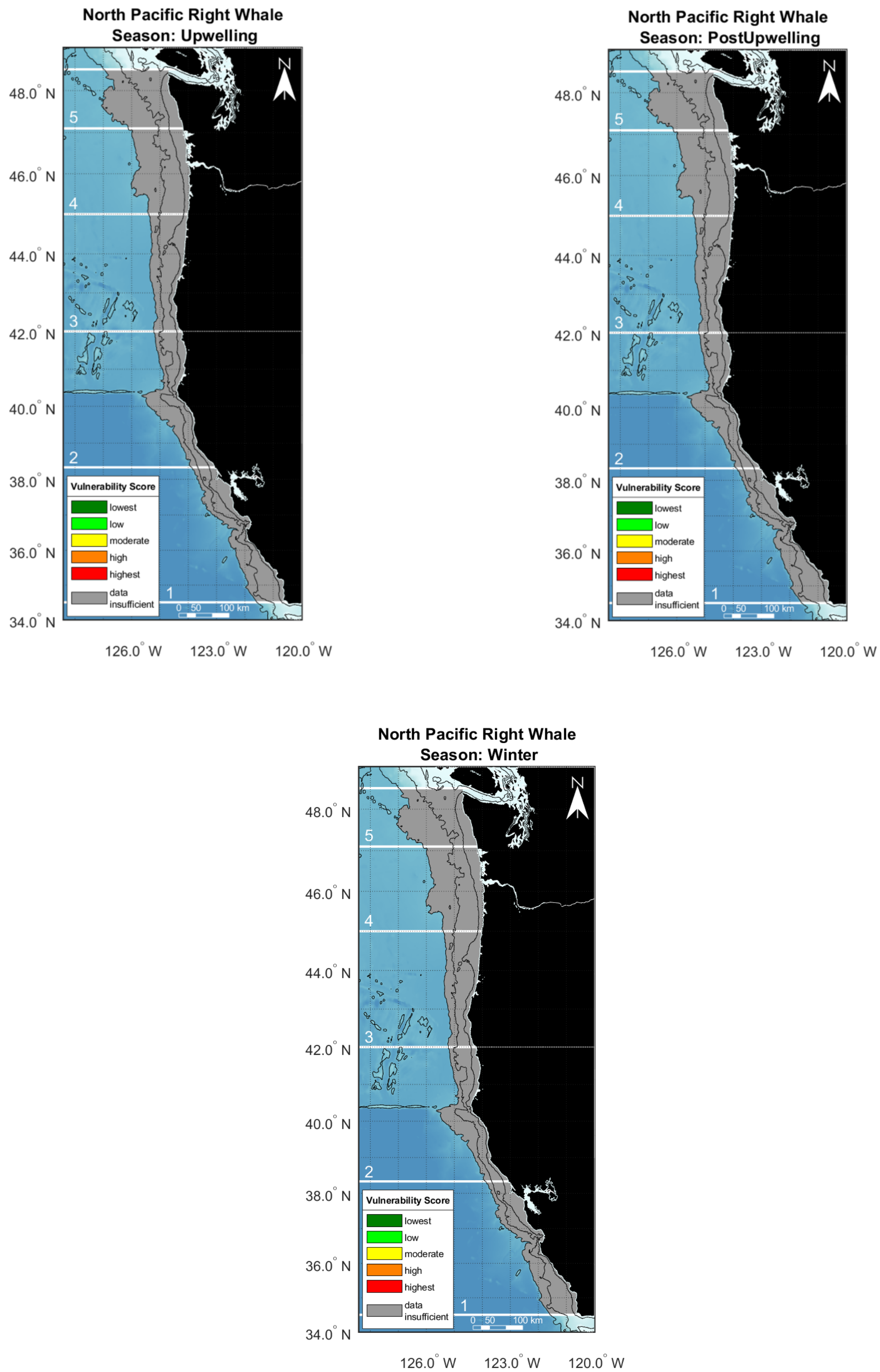


Figure 11. North Pacific right whale vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.1.5 GRAY WHALE (Western N. Pacific)

Summary Assessment: Two distinct populations of gray whales occur along the U.S. West Coast and are considered separately. Recent evidence from tagging and photo ID studies indicates that some proportion of the western North Pacific species believed to feed in the western Pacific spend portions of the year within the region considered here. Assessed vulnerability scores for western north Pacific gray whales included some of the highest relative scores among species evaluated here (max 31), particularly in nearshore areas and during the upwelling season. Lowest scores (min 17) were assigned in offshore areas during the post-upwelling and winter seasons. Western north Pacific gray whales are critically endangered and ESA-listed with an evaluated unknown population trend, and an estimated population size of < 2,500 (n = 290; Cooke 2017; 2020 SAR). Insufficient data exist to inform distribution models; expert judgment using several key sources (Rugh et al. 2001; Calambokidis et al. 2015; Laake et al. 2018) was used to determine to species habitat and temporal factor scores. Considerable uncertainty was noted, but physical interaction factor scores were assessed as relatively high; masking potential was assessed at the highest level (based on their low-frequency communication and predominately low frequencies of sounds associated with likely disturbance) with moderate assessed risks of vessel strike and entanglement based on evaluations of Carretta et al. (2018; 2020). Actual mortality relative to low assessed PBR of 0.12 individuals is unknown but it was noted that many mortalities of likely western gray whales are reported in the 2020 SAR in Russian harvests. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3).

Uncertainty Assessment: Low confidence was assigned for each season in slope (b) and oceanic (c) zones given the lack of key information related to aspects of all of the vulnerability factors evaluated; moderate confidence was assigned for shelf (a) zones.

Key Data Gaps: Many, but distribution and density data during post-upwelling and winter seasons and focused effort around identified development areas were identified. Specific effort including photo ID, visual and acoustic observations needed to distinguish from eastern.

Table 16. Gray whale (Western N. Pacific) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	31	28	20	29	26	20	30	28	20	26	19	16	26	20	17
Post-Upwelling	24	22	20	26	20	20	23	17	16	26	17	16	26	18	17
Winter	30	23	20	26	22	20	22	20	20	23	21	21	23	21	20

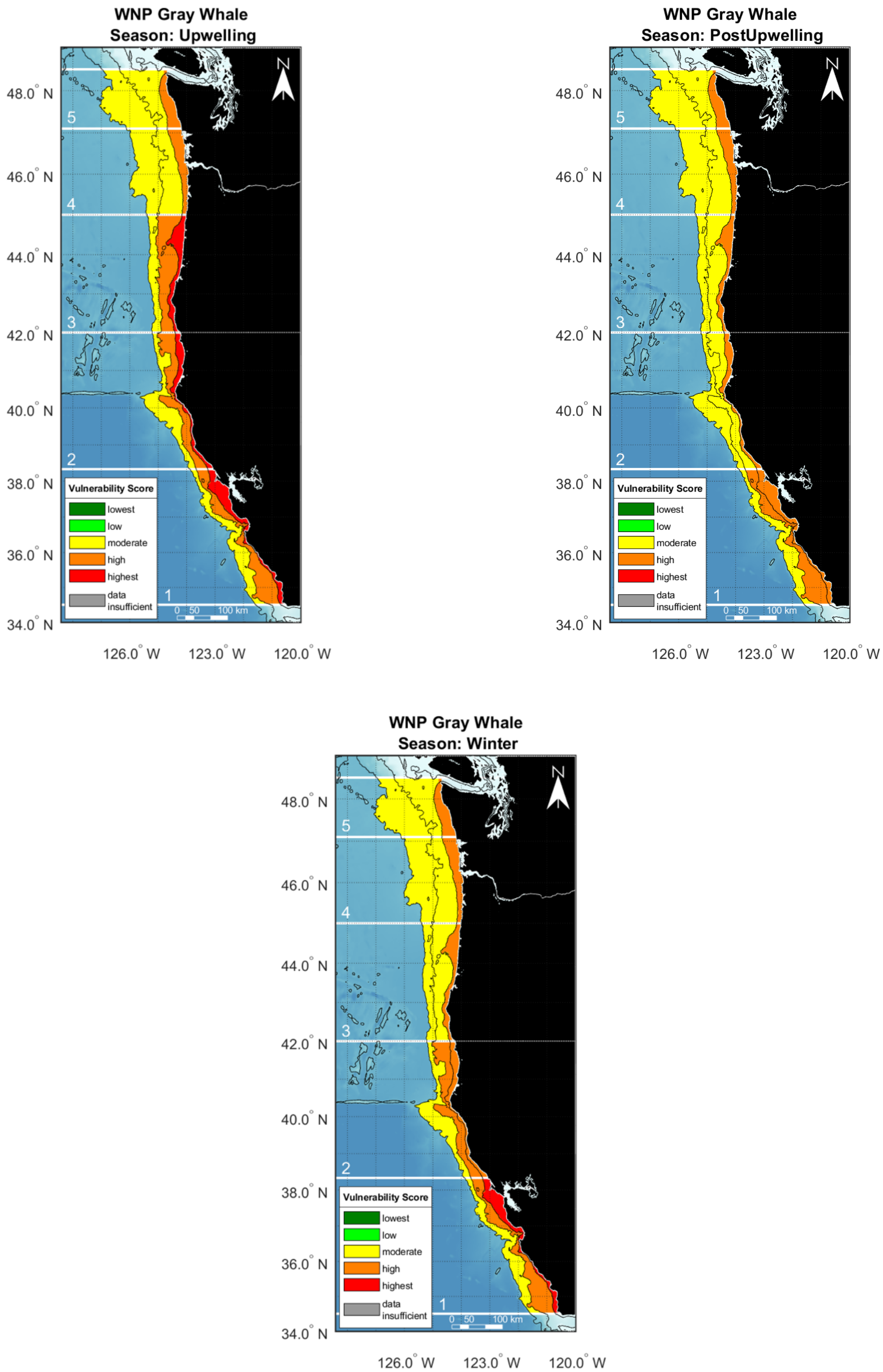


Figure 12. Gray whale (Western N. Pacific) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.1.6 GRAY WHALE (Eastern N. Pacific)

Summary Assessment: Assessed vulnerability scores for the much more commonly occurring and well-studied eastern north Pacific gray whale were much lower overall than western gray whales. Scores ranged from moderate (max 21) in shelf and slope regions to relatively low (min 10) in oceanic areas. Lowest scores occurred during the winter season when large portions of the population likely occur in breeding areas south of the zones considered. Eastern north Pacific gray whales are not endangered or threatened but are protected under the MMPA. A negative score was assigned for population trend factor based on Perryman et al. (2011), Calambokidis (2017), and Durban (2017); it is noted however, that there have been substantial recent population declines and that this assessment could soon differ in subsequent assessments (Stewart and Weller 2021; Eguchi et al. 2022). Estimated population size substantially exceeds 2,500 (n = 26,960; 2020 SAR). Expert judgment using several key sources (Rugh et al. 2001; Calambokidis et al. 2015; Laake et al. 2018) was used to determine to species habitat and temporal factor scores. Physical interaction factor scores were identical to those assessed as relatively high for western gray whales; masking potential was assessed at the highest level (based on their low-frequency communication and predominately low frequencies of sounds associated with likely disturbance) with moderate assessed risks of vessel strike and entanglement based on evaluations of Carretta et al (2018; 2020). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Intermediate scores for other stressors resulted from relatively low scores in chronic anthropogenic (other) factors based on an estimated human-induced mortality of 131 individuals relative to a PBR of 801 in the 2020 SAR, but several documented instances of non-anthropogenic biological stressors (ocean acidification, ongoing UME) were identified in recent SARs.

Uncertainty Assessment: Eastern gray whales are among the most well studied marine mammals in the region, and high confidence was assigned for each season across all zones.

Key Data Gaps: Focused effort in fine-scale distribution, photo ID, tagging, behavioral state around identified development areas as well as potential entanglement risk were identified.

Table 17. Gray whale (Eastern N. Pacific) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	21	18	10	19	16	10	20	18	10	20	13	10	20	14	11
Post-Upwelling	14	12	10	16	10	10	17	11	10	20	11	10	20	12	10
Winter	20	13	10	16	12	10	12	10	10	13	11	11	13	11	10

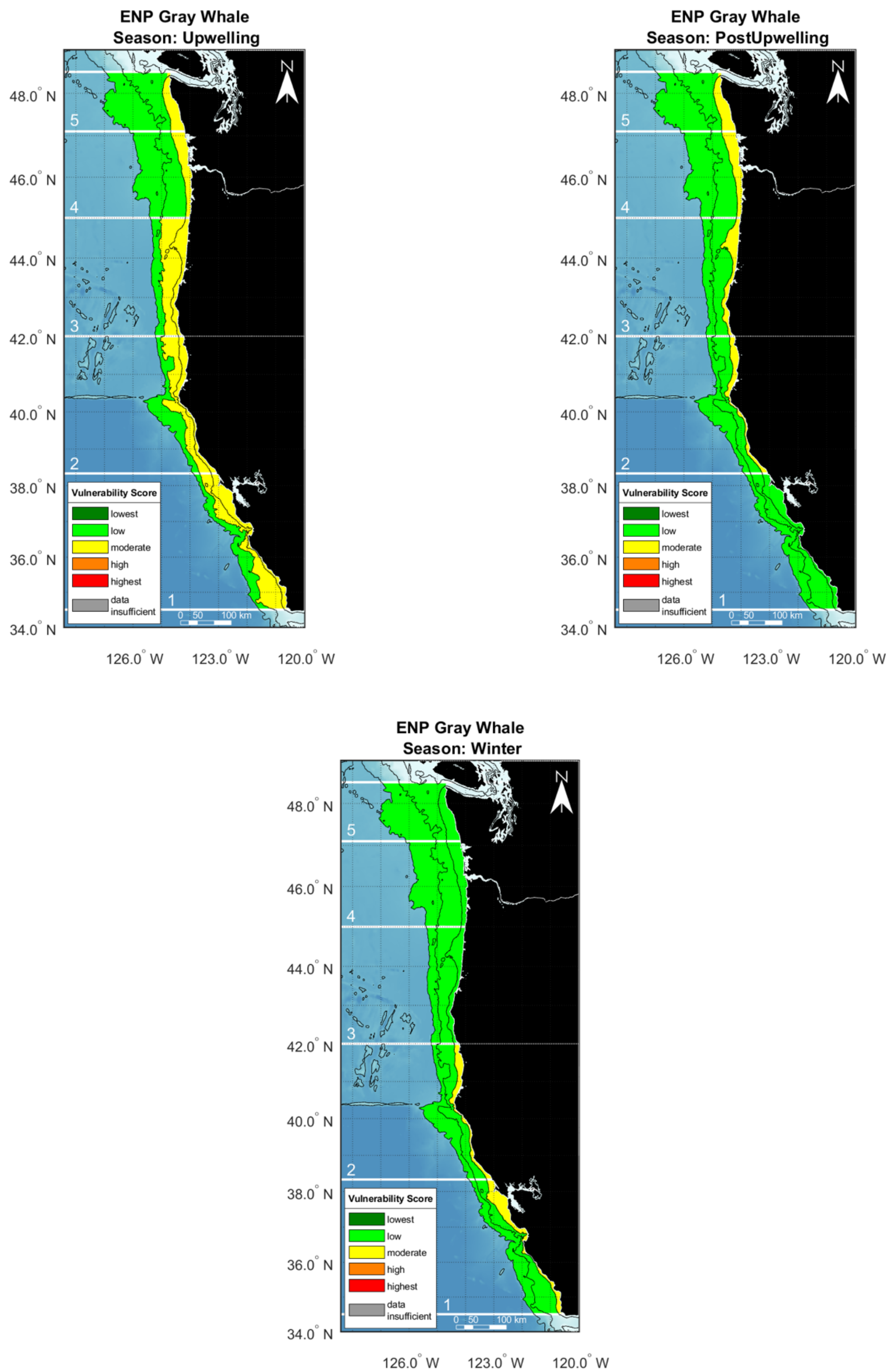


Figure 13. Gray whale (Eastern N. Pacific) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.1.7 HUMPBACK WHALE (Central American DPS)

Summary Assessment: Three distinct humpback whale population segments are identified on the U.S. West Coast, co-occurring in many areas. Their designation is relatively recent; a single SAR existed for the entire species for this assessment (2020 SAR; Carretta et al. 2021). We considered them separately across each DPS because of their different listing status under ESA. As described above, an overall density model estimate for the entire species was developed (Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020; Becker et al. in prep) and photo ID and other field observations provided by researchers contributing to this effort were used to designate proportions in each zone to each of the respective DPS. The highest relative assessed vulnerability scores among the humpback whale DPSs occurred for the ESA-listed (endangered) Central American DPS. Scores ranged from moderate (min 19) to some of the highest overall relative scores (max 31) reported for any species. Relatively lower scores occurred in oceanic zones, more northern zones, and during the winter season. The Central American DPS is ESA-listed as endangered; no DPS-specific population trend is available (though see Curtis et al. 2022 for more recent assessment); and the estimated population size from model estimates using the above process is < 2,500 (Curtis et al. 2022). Physical interaction factor scores were relatively high for each of the humpback DPSs. High masking potential was assessed based on their low-frequency communication and predominately low frequencies of sounds associated with likely disturbance; moderate risk of vessel strike but high risk of entanglement was assessed based on many reported instances in fishing gear interactions (2020 SAR). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Intermediate scores for other stressors resulted from relatively high scores in chronic anthropogenic factors given the limited information on DPS-specific mortality and PBR and the absence of documented instances of non-anthropogenic biological stressors in the last three SARs.

Uncertainty Assessment: Humpback whales are relatively well-studied, but given limited information about DPS-specific spatio-temporal distribution, moderate certainty was assigned for conditions.

Key Data Gaps: Focused effort in fine-scale distribution, photo ID, and behavior (tag studies) around development areas with specific identification of DPS proportions in different seasons as well as potential entanglement risk for offshore infrastructure relative to fishing gear were identified.

Table 18. Humpback whale (Central American DPS) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	31	31	26	22	25	22	23	28	22	21	23	20	21	24	21
Post-Upwelling	30	30	25	21	25	21	22	26	21	20	22	19	20	23	20
Winter	29	29	25	21	25	21	21	25	21	20	22	20	20	22	19

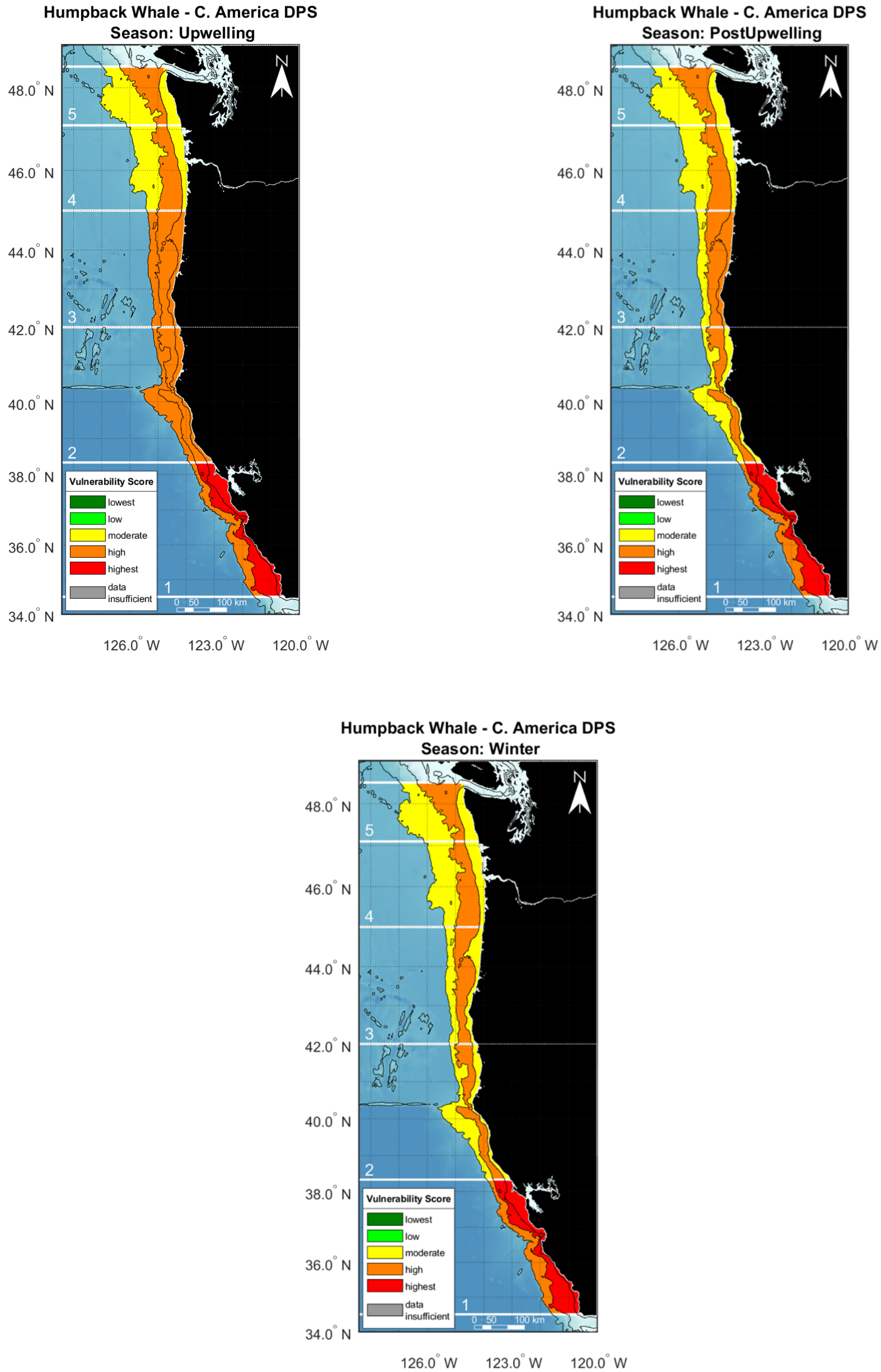


Figure 14. Humpback whale (Central American DPS) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.1.8 HUMPBACK WHALE (Mexican DPS)

Summary Assessment: Three distinct humpback whale population segments are identified on the U.S. West Coast, co-occurring in many areas. Their designation is relatively recent; a single SAR existed for the entire species for this assessment (2020 SAR; Carretta et al. 2021). We considered them separately across each DPS because of their different listing status under ESA. As described above, an overall SDM estimate for the entire species was developed (Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020; Becker et al. in prep) and photo ID and other field observations provided by researchers contributing to this effort were used to designate proportions in each zone to each of the respective DPS. Vulnerability scores for the threatened Mexican DPS were slightly lower than for the Central American DPS, although scores were still relatively higher than for many other species. Scores ranged from moderate (min 19) to relatively highest overall relative scores (max 29). Relatively lower scores occurred in oceanic zones and more northern zones, with less evident seasonality. No DPS-specific population trend is available, and the estimated population size for the overall region from model estimates using the above SDM process for the region evaluated is < 2,500 (but see also recent evaluations in Curtis et al. 2022). Physical interaction factor scores were relatively high for each of the humpback DPSs. High masking potential was assessed based on their low-frequency communication and predominately low frequencies of sounds associated with likely disturbance; moderate risk of vessel strike but high risk of entanglement was assessed based on many reported instances in fishing gear interactions (2020 SAR). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Intermediate scores for other stressors resulted from relatively high scores in chronic anthropogenic factors given the limited information on DPS-specific mortality and PBR and the absence of documented instances of non-anthropogenic biological stressors in the last three SARs.

Uncertainty Assessment: Humpback whales are relatively well-studied, but given limited information about DPS-specific spatio-temporal distribution, moderate certainty was assigned for conditions.

Key Data Gaps: Focused effort in fine-scale distribution, photo ID, and behavior (tag studies) around development areas with specific identification of DPS proportions in different seasons, potential entanglement risk for offshore infrastructure relative to fishing gear identified.

Table 19. Humpback whale (Mexican DPS) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	26	29	24	20	24	20	25	26	20	21	21	20	21	22	21
Post-Upwelling	25	28	23	19	23	19	24	24	19	20	20	19	20	21	20
Winter	24	27	23	19	23	19	23	23	19	20	20	20	20	20	19

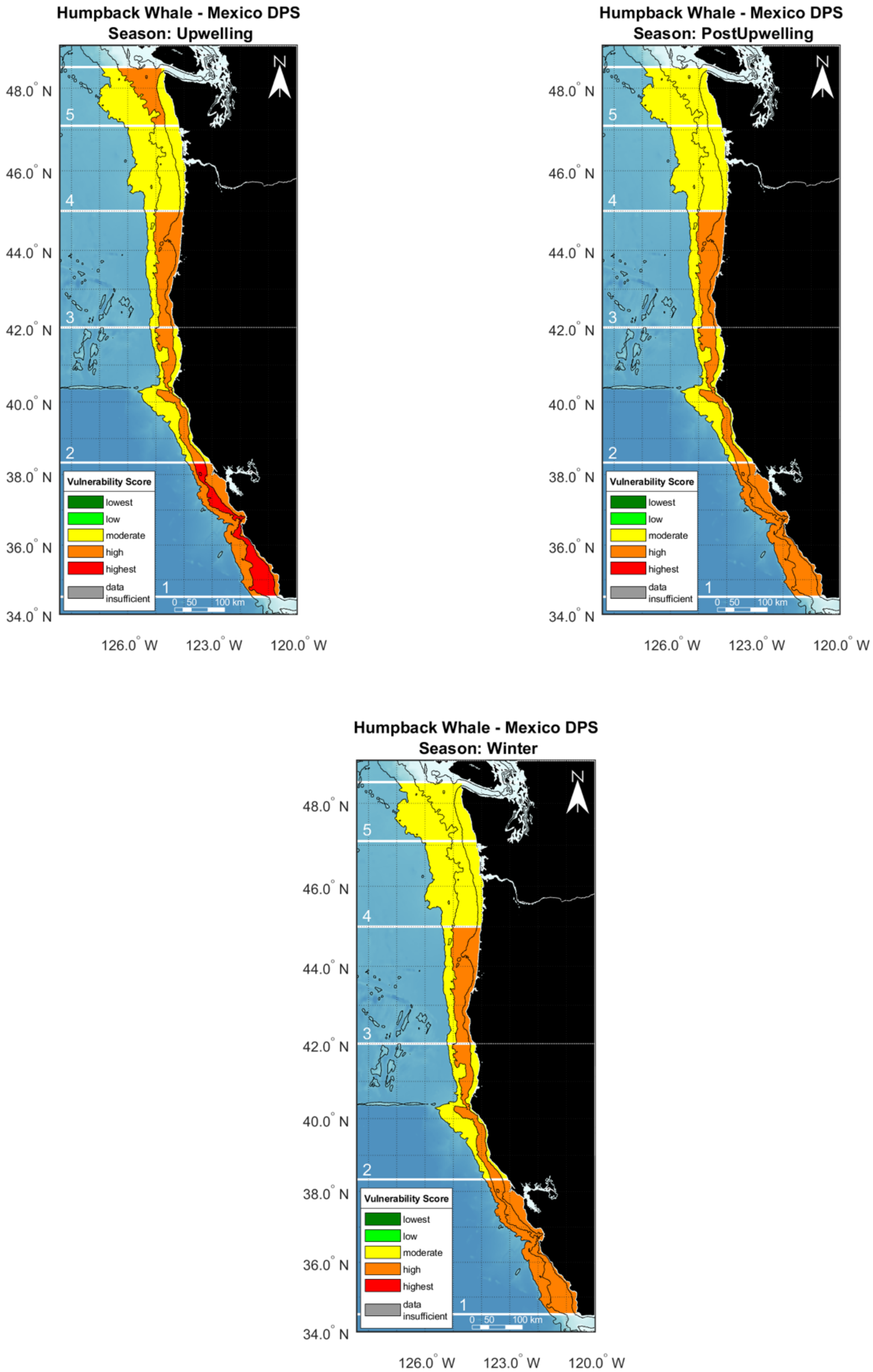


Figure 15. Humpback whale (Mexican DPS) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.1.9 HUMPBACK WHALE (Hawaii DPS)

Summary Assessment: Three distinct humpback whale population segments are identified on the U.S. West Coast, co-occurring in many areas. Their designation is relatively recent; a single SAR existed for the entire species for this assessment (2020 SAR; Carretta et al. 2021). We considered them separately across each DPS because of their different listing status under ESA. As described above, an overall density model estimate for the entire species was developed (Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020; Becker et al. in prep) and photo ID and other field observations provided by researchers contributing to this effort were used to designate proportions in each zone to each of the respective DPS. Relatively lowest (among humpback whales) assessed vulnerability scores occurred for the MMPA-listed Hawaii DPS, although scores were still relatively higher than for many other species. Scores ranged from the low end of moderate (min 15) to relatively high (max 26). Relatively lower scores occurred in oceanic zones and more southern zones, and during winter. No DPS-specific population trend was deemed to be available for the region and the estimated population size (within the overall region considered here) from model estimates using the above process is < 2,500. Physical interaction factor scores were relatively high for each of the humpback DPSs. High masking potential was assessed based on their low-frequency communication and predominately low frequencies of sounds associated with likely disturbance; moderate risk of vessel strike but high risk of entanglement was assessed based on many reported instances in fishing gear interactions (2020 SAR). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Intermediate scores for other stressors resulted from relatively high scores in chronic anthropogenic factors given the limited information on DPS-specific mortality and PBR and the absence of documented instances of non-anthropogenic biological stressors in the last three SARs.

Uncertainty Assessment: Humpback whales are relatively well-studied, but given limited information about spatio-temporal distribution, moderate certainty was assigned for conditions.

Key Data Gaps: Focused effort in fine-scale distribution, photo ID, behavior (tag studies) around development areas with specific identification of DPS proportions in different seasons, potential entanglement risk for offshore infrastructure relative to fishing gear were identified.

Table 20. Humpback whale (Hawaii DPS) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	18	18	16	18	18	18	19	24	18	23	26	22	23	24	23
Post-Upwelling	17	17	15	17	17	17	18	22	17	22	25	21	22	23	22
Winter	16	16	15	17	17	17	17	21	17	22	25	22	22	22	21

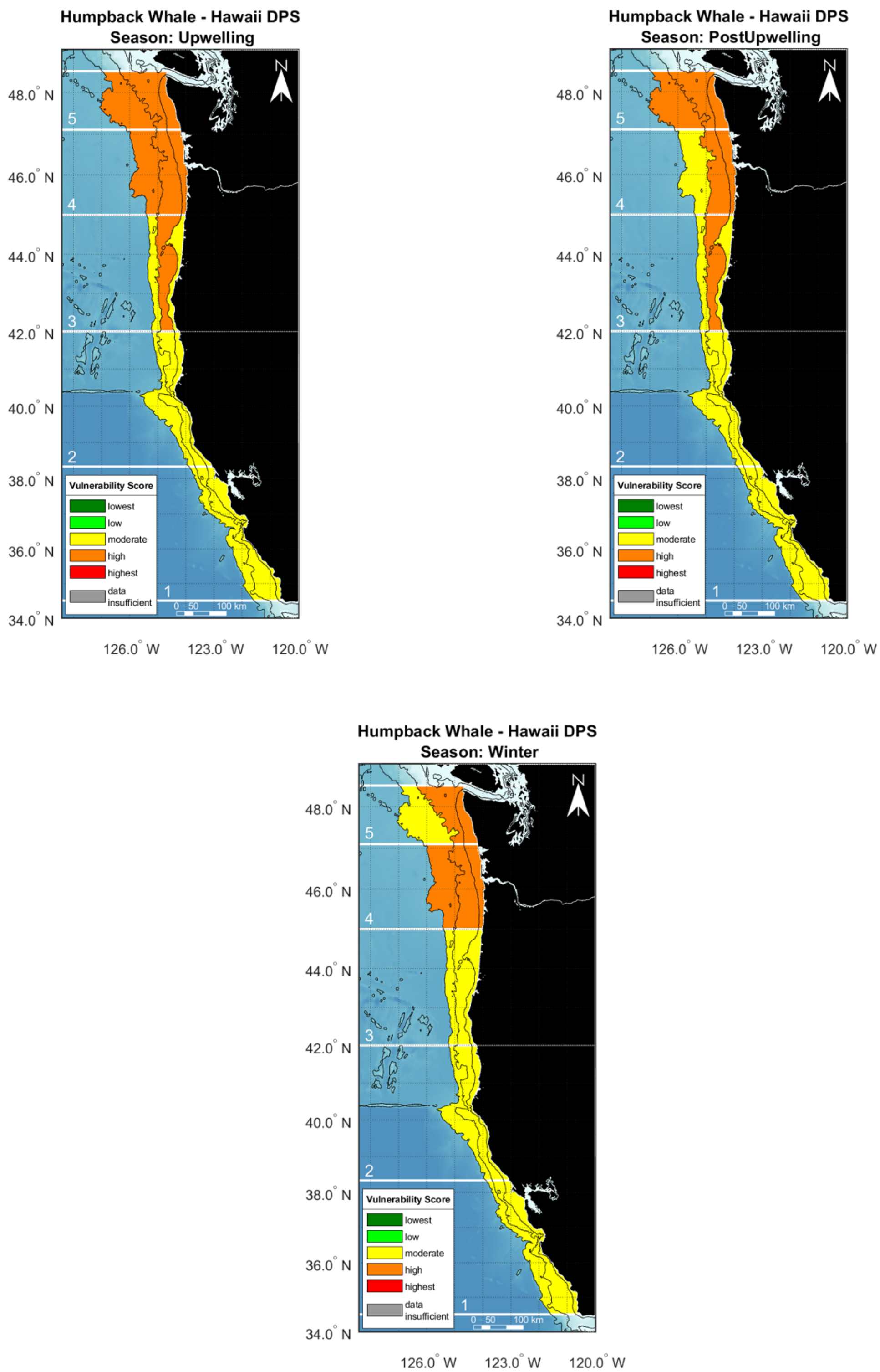


Figure 16. Humpback whale (Hawaii DPS) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.1.10 BRYDE'S WHALE (Eastern Tropical Pacific)

Summary Assessment: Bryde's whales are typically found in areas south of the zones considered here but have increasingly been seen in areas off California (see 2020 SAR; Carretta et al. 2021). Given the limited information on spatial and temporal distribution for this species, complete vulnerability scores were not reported for any areas other than Zone 1 where sufficient evidence (from Barlow 2016) was deemed appropriate to exist to provide a common habitat use score across the depth areas for each season. Scores within Zone 1 ranged from moderate (max 16) in shelf and slope regions to low (min 14) in the oceanic zone and were consistent across seasons. Bryde's whales are not endangered or threatened but are protected under the MMPA; population trends and overall stock size are unknown. Physical interaction factor scores were identical to those assessed for fin whales based on presumed bioacoustic and natural history similarities between the species. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Intermediate scores for other stressors resulted from moderate scores in chronic anthropogenic (other) factors, given the absence of mortality estimates or PBR, and the absence of documented instances of non-anthropogenic biological stressors in the last three SARs.

Uncertainty Assessment: There are extensive data limitations related to every vulnerability factor evaluated here—low confidence was assigned for each season across all zones.

Key Data Gaps: Many although probably secondary priority to most other baleen whales; distribution and movement data particularly around identified development areas in Zone 1, especially where expected to more commonly occur (increasing w/ climate change) identified.

Table 21. Bryde's whale vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	16	16	14	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Post-Upwelling	16	16	14	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Winter	15	15	14	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

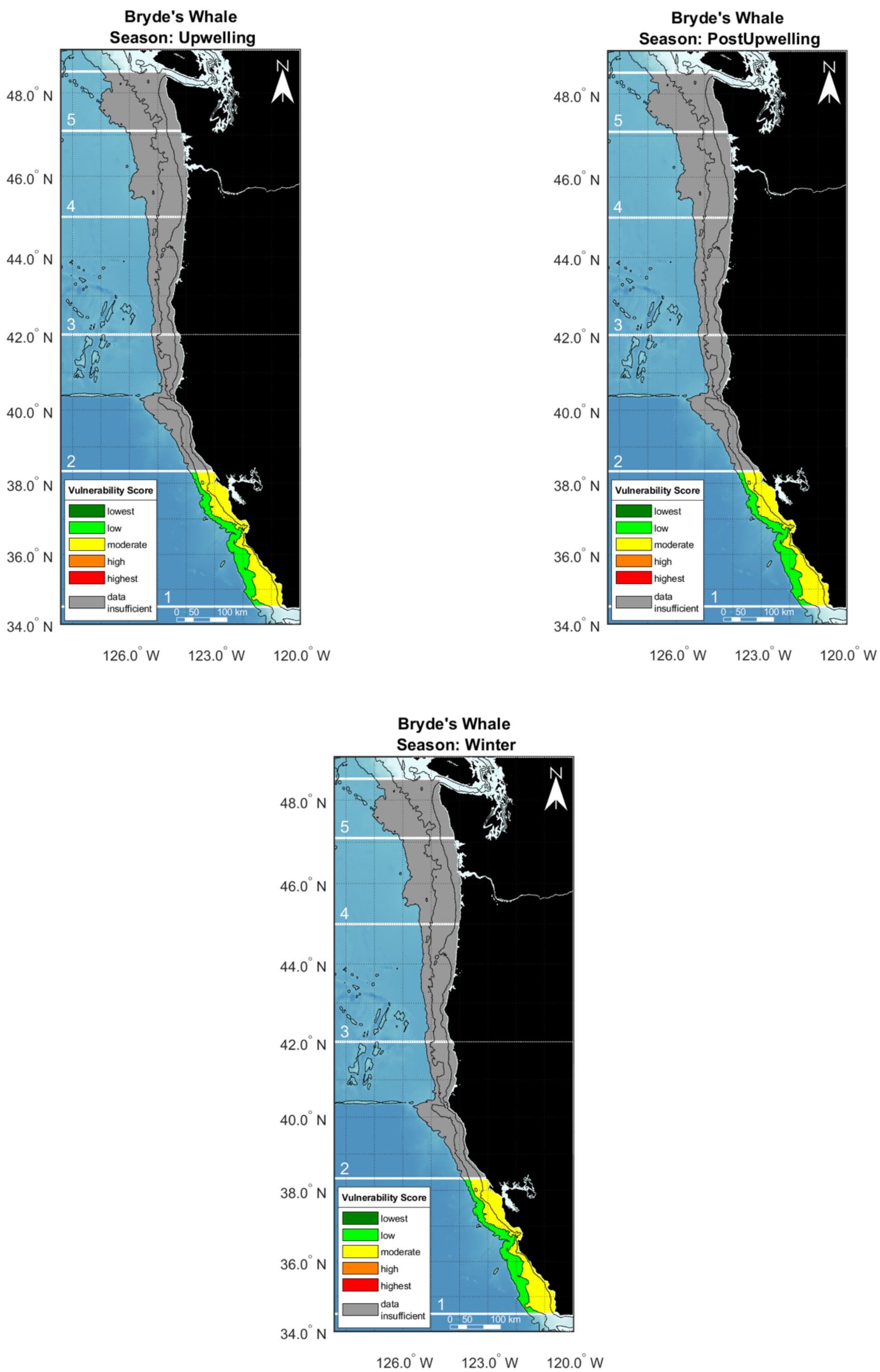


Figure 17. Bryde's whale vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.1.11 MINKE WHALE (CA/OR/WA)

Summary Assessment: Minke whales are among the more well studied baleen whales in the overall region assessed, particularly during summer months, and complete vulnerability scores with habitat factors based on model results presented above (section 2.3) were determined. Scores ranged from relatively low (min 14) to (primarily) moderate (max 20) with relatively comparable scores across both zones and seasons. Minke whales are not endangered or threatened but are protected under the MMPA. Population trends are unavailable but the estimated population size (n = 636 from Barlow 2016, reported in 2020 SAR; Carretta et al. 2021) is < 2,500. Physical interaction factor scores were moderately high; masking potential was assessed at the highest level (based on their low-frequency communication and predominately low frequencies of sounds associated with likely disturbance) relatively low assessed risk of vessel strike (none reported in last five years in 2020 SAR though experts were not scoring this as zero), and moderate risk of entanglement given some limited instances reported within the SAR. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Relatively low scores for other stressors resulted from low scores in chronic anthropogenic (other) factors, given the estimated annual mortality of > 1.3 and PBR estimate of 3.5 and the (1) documented instance of non-anthropogenic biological stressors in recent SARs (domoic acid cases; see: Fire et al. 2010).

Uncertainty Assessment: Most available data for this species relate to distribution and behavior, in summer months; moderate confidence was assigned for all zones in the post-upwelling period and low confidence was consequently assigned for upwelling and winters seasons.

Key Data Gaps: Better data needed to support population trend estimates. Given they may feed on a variety of prey including those types possibly attracted to floating platforms, more information is needed related to possible attraction to these structures and associated entanglement risk as well as potential benefits.

Table 22. Minke whale vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	16	20	18	14	17	17	15	20	14	15	18	17	15	16	15
Post-Upwelling	20	20	18	14	18	18	15	19	14	15	19	18	15	16	15
Winter	15	19	18	14	18	18	14	18	14	15	19	19	15	15	14

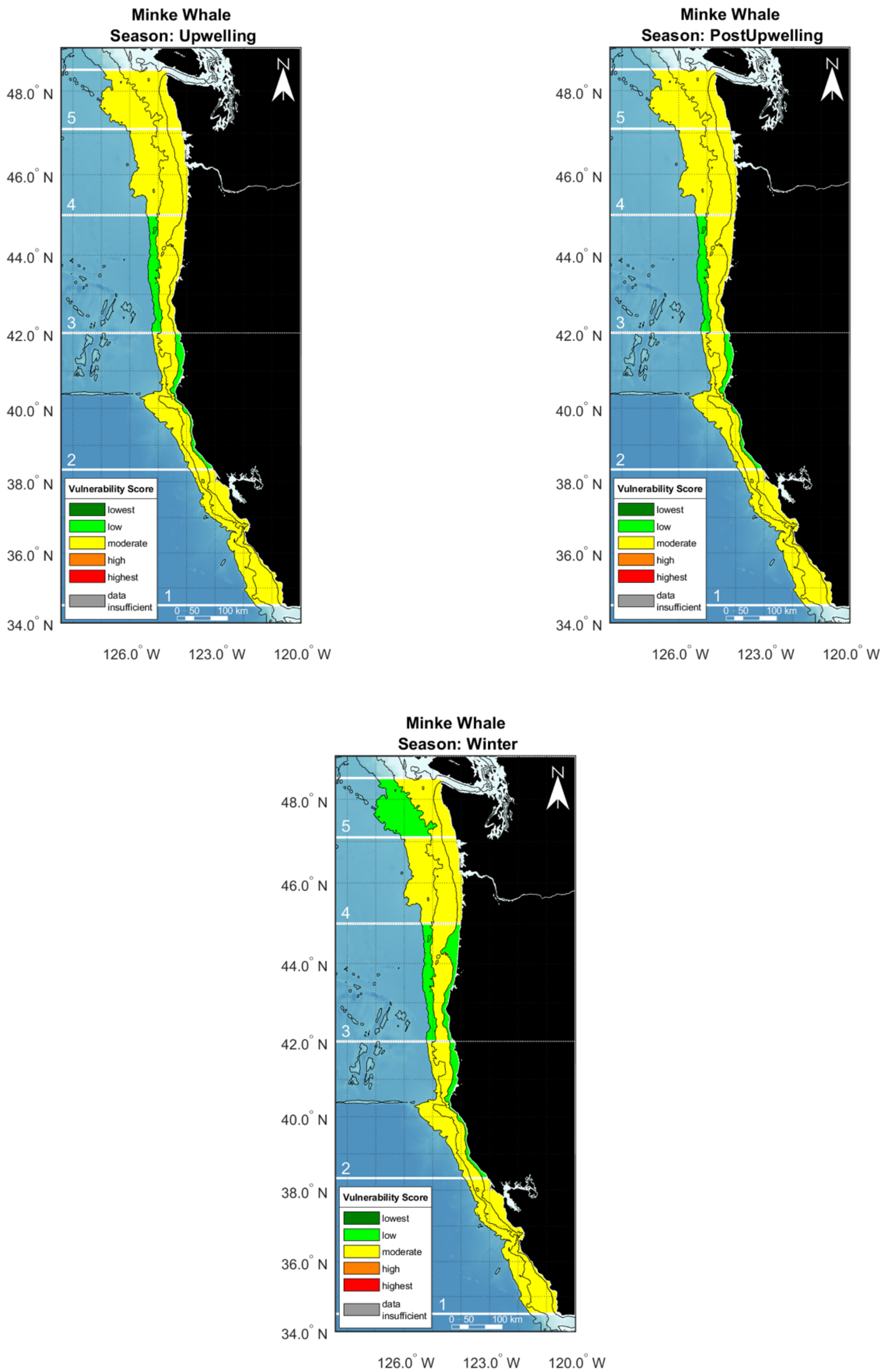


Figure 18. Minke whale vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2 Vulnerability Risk Assessment – Odontocetes

3.2.1 SPERM WHALE (CA/OR/WA)

Summary Assessment: Sperm whales are regularly seen and heard in shelf and oceanic areas throughout the region considered. Assessed vulnerability was among the more spatially and temporally variable for those species assessed. Scores ranged from moderate (min 15) primarily in shelf areas in which they rarely occur to relatively high (max 23) particularly in shelf zones during upwelling and post-upwelling seasons. Lower vulnerability was assessed during the winter. Sperm whales are ESA-listed; reliable population trends are unavailable; and the estimated population size (n = 1997 from 2020 SAR) is < 2,500. Spatial and temporal factor scores were based on expert elicitation using data from Becker, Carretta, et al. (2020), Becker, Forney, et al. (2020), and Rice et al. (2021) rather than modeled density estimates. Physical interaction factor scores were intermediate. Masking potential was assessed as moderate based on the moderately low-frequency components of echolocation signals and aspects of presumed hearing (see: Southall et al. 2019) and predominately low frequencies of sounds associated with likely disturbance. A moderate assessed risk of vessel strike was made (none reported in last five years in 2020 SAR though experts believed these would be unlikely to be detected where they do occur for this species), and relatively low risk of entanglement assessed (although interactions with drift gillnet and longline fisheries was noted). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Moderate scores for other anthropogenic and biological stressors resulted from low scores in chronic anthropogenic (other) factors, given estimated annual mortality of 0.6 and PBR estimate of 2.5 individuals and insufficient data in recent SARs with which to evaluate non-anthropogenic biological stressors.

Uncertainty Assessment: Moderate confidence was assigned for upwelling and winters seasons with high confidence during post-upwelling seasons when many sightings occur.

Key Data Gaps: Distribution, density, population structure data especially during winter and spring months for areas in and around designated lease areas; photo ID, tag studies.

Table 23. Sperm whale vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	17	23	21	15	21	21	16	23	21	16	22	21	16	23	22
Post-Upwelling	17	23	21	15	21	21	16	22	21	18	22	21	18	23	22
Winter	16	22	18	15	21	18	15	18	18	16	19	19	16	19	18

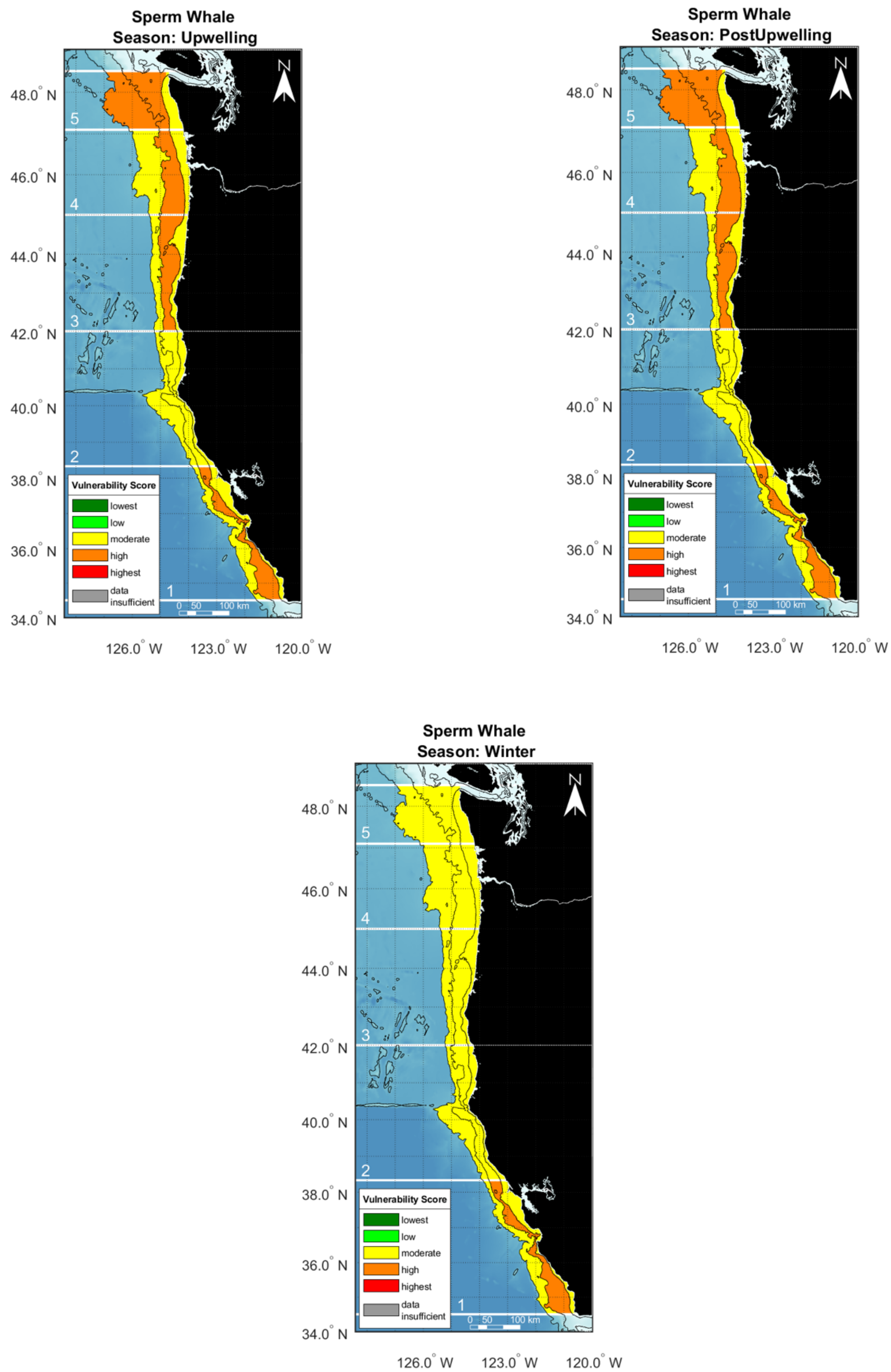


Figure 19. Sperm whale vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.2 KILLER WHALE (Eastern North Pacific Southern Resident)

Summary Assessment: Three distinct killer whale species occur seasonally along the U.S. West Coast and are considered separately here. Southern resident killer whales are the most threatened and least common of these, resulting in relatively high overall vulnerability scores for many zones though with some seasonal variance. Assessed vulnerability scores ranged from moderate (min 21) primarily in oceanic zones in which they less commonly occur to the highest relative risk (max 32), particularly in shelf and slope zones for zones 1 and 5 and especially during winter seasons. Southern resident killer whales are ESA-listed, have a documented declining population and the estimated population size is much < 2,500 (n = 73 from 2020 SAR); these factors equate to the highest possible overall population factor risk score (9). Spatial and temporal factor scores were based on expert elicitation using data from the 2020 SAR (Hanson et al. 2013; 2017; Carretta et al. 2021) rather than modeled density. Physical interaction factor scores were intermediate; masking potential was assessed as moderate based on the moderately low-frequency components of echolocation signals and aspects of presumed hearing (see: Southall et al. 2019) and predominately low frequencies of sounds associated with likely disturbance, moderate assessed risk of vessel strike, and relatively low assessed risk of entanglement. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Highest possible scores were assigned for other anthropogenic and biological stressors, given the estimated annual human-induced mortality of 0.13 and PBR estimate of > 0.4 individuals and multiple documented risk factors, including limitation of preferred Chinook salmon prey, human noise/disturbance especially related to whale watching, resulting in decreased foraging efficiency, and high levels of contaminants, including PCBs and DDT (Clark et al. 2009; Krahn et al. 2009; Lacy et al. 2017; 2020 SAR).

Uncertainty Assessment: Moderate confidence was assigned for upwelling and winters seasons with high confidence during post-upwelling seasons when more sightings occur.

Key Data Gaps: Focused effort in fine-scale distribution, behavior, photo ID, body condition around development areas, especially oceanic. Specific ID of stocks in different seasons.

Table 24. Killer whale (Eastern N. Pacific Southern Resident) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	29	29	23	27	27	23	28	29	23	28	28	21	31	32	22
Post-Upwelling	29	29	23	27	27	23	28	28	23	28	28	21	31	32	32
Winter	31	31	21	30	30	21	30	30	21	31	31	22	31	31	21

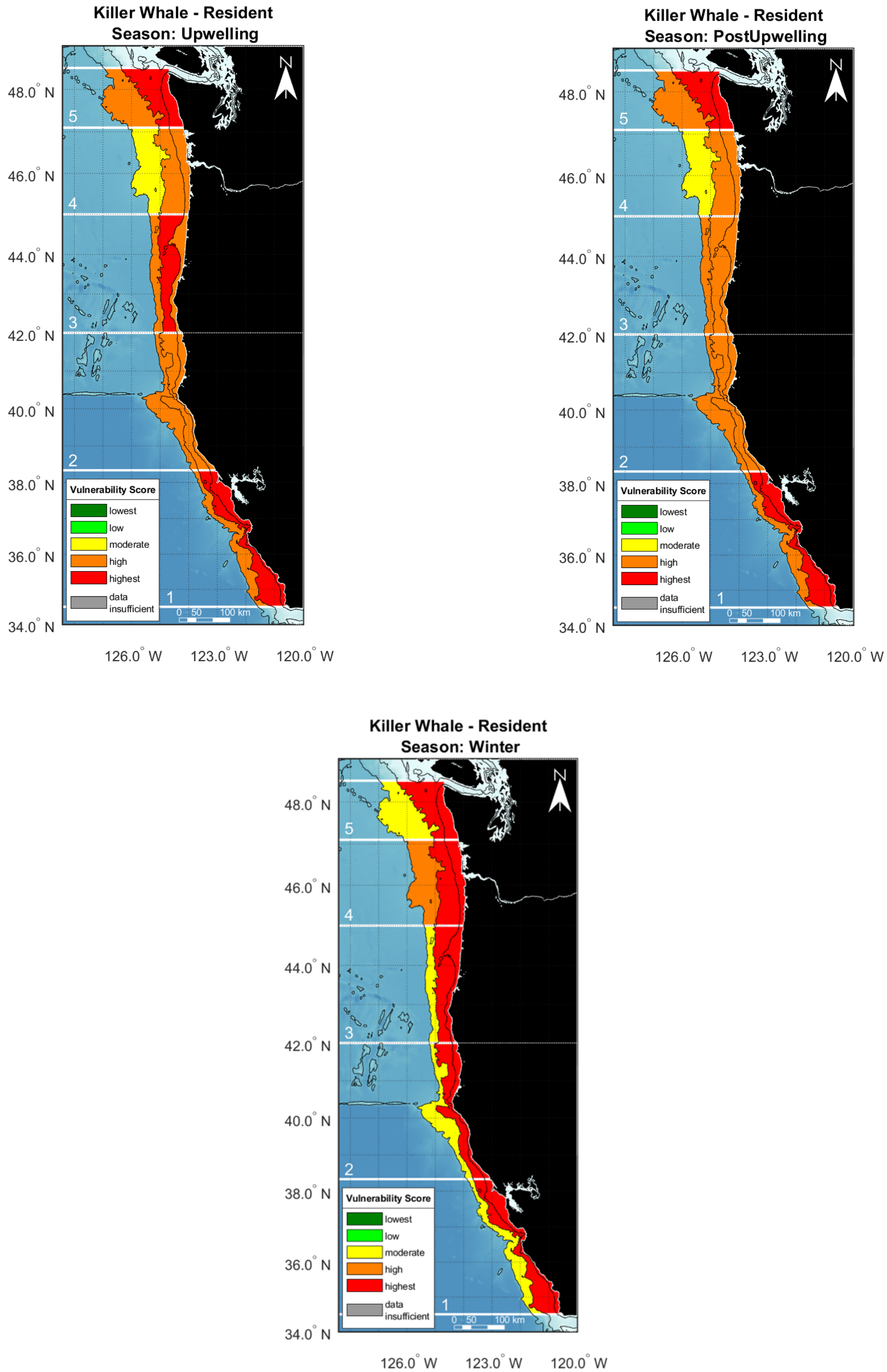


Figure 20. Killer whale (Eastern N. Pacific Southern Resident) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.3 KILLER WHALE (Eastern North Pacific Offshore)

Summary Assessment: Eastern north Pacific offshore killer whales occur throughout the coastal and offshore zones throughout the overall region with relatively limited seasonal variance. Assessed vulnerability scores were among the most consistent across zones and seasons of any species evaluated ranging from relatively low (min 14) to moderate (max 16). Offshore killer whales are MMPA-listed, and while no population trend has been completed, the estimated population size is well below 2,500 (n ~300 individuals from mark-recapture methods (based on Ford et al. (2014) from 2020 SAR)). Spatial and temporal factor scores were based on expert elicitation using data from Ford et al. (2014) rather than modeled density estimates. Physical interaction factor scores were intermediate; masking potential was assessed as moderate based on the moderately low-frequency components of echolocation signals and aspects of presumed hearing (see: Southall et al. 2019) and predominately low frequencies of sounds associated with likely disturbance, relatively low assessed risk of vessel strike (one instance of injury from vessel strikes was reported in Ford et al. 2014) and entanglement risk; experts noted that the lowest possible scores were not reported here despite lack of evidence of effect because of the low probability of such impacts being detected given species life history. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Relatively low scores for other anthropogenic and biological stressors were assigned, given the estimated annual human-induced mortality of 0 and PBR estimate of 2.8 individuals in the 2020 SAR and the absence of documented biological risk factors.

Uncertainty Assessment: Moderate confidence was assigned for all seasons and zones.

Key Data Gaps: Focused effort in fine-scale distribution, behavior, photo ID, body condition around development areas, especially oceanic. Specific ID of stocks in different seasons.

Table 25. Killer whale (Eastern N. Pacific Offshore) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	16	16	14	14	14	14	15	16	14	15	15	14	15	16	15
Post-Upwelling	16	16	14	14	14	14	15	15	14	15	15	14	15	16	15
Winter	15	15	14	14	14	14	14	14	14	15	15	15	15	15	14

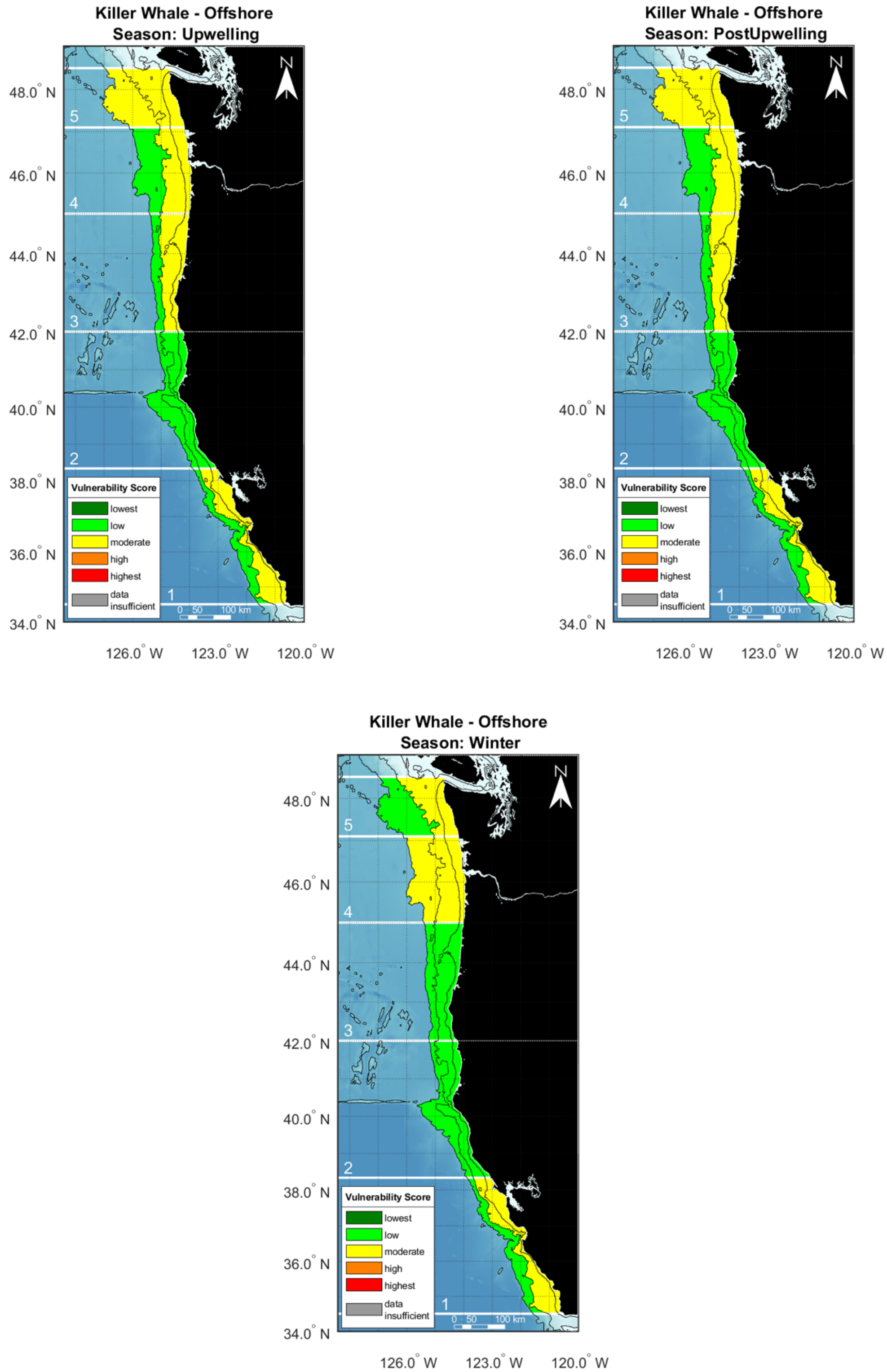


Figure 21. Killer whale (Eastern N. Pacific Offshore) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.4 KILLER WHALE (Eastern North Pacific Transient)

Summary Assessment: Eastern north Pacific transient killer whales occur also throughout the coastal and offshore zones with relatively limited seasonal variance. Assessed vulnerability scores were similar to those of offshore killer whales in being quite consistent across zones and seasons, but were consistently slightly lower ranging from relatively low (min 11) to moderate (max 15) given differences in expert elicitation of distribution and density. Offshore killer whales are protected under the MMPA, and while no population trend has been completed, the estimated population size is well below 2,500 (n ~300 individuals from mark-recapture methods (based on Ford et al. (2014) from 2020 SAR)). Spatial and temporal factor scores were based on expert elicitation using data from Ford et al. (2014) rather than modeled density estimates. Physical interaction factor scores were also intermediate. Masking potential was assessed as moderate, based on the moderately low-frequency components of echolocation signals and aspects of presumed hearing (see: Southall et al. 2019) and predominately low frequencies of sounds associated with likely disturbance. Relatively low risk of vessel strike (one instance of injury from vessel strikes was reported in Ford et al. 2014; see also Raverty et al. 2020) and entanglement risk was assessed; experts noted that the lowest possible scores were not reported here despite lack of evidence of effect because of the low probability of such impacts being detected given species life history. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Relatively low scores for other anthropogenic and biological stressors were assigned, given the estimated annual human-induced mortality of 0 and PBR estimate of 2.8 individuals in the 2020 SAR and the absence of documented biological risk factors.

Uncertainty Assessment: Moderate confidence was assigned for all seasons and zones.

Key Data Gaps: Focused effort in fine-scale distribution, behavior, photo ID, body condition around development areas, especially oceanic. Specific ID of stocks in different seasons.

Table 26. Killer whale (Eastern N. Pacific Transient) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	15	15	13	12	12	12	13	14	12	13	13	12	13	14	13
Post-Upwelling	14	14	12	12	12	12	13	13	12	13	13	12	13	14	13
Winter	13	13	12	12	12	12	12	12	12	13	13	13	13	13	12

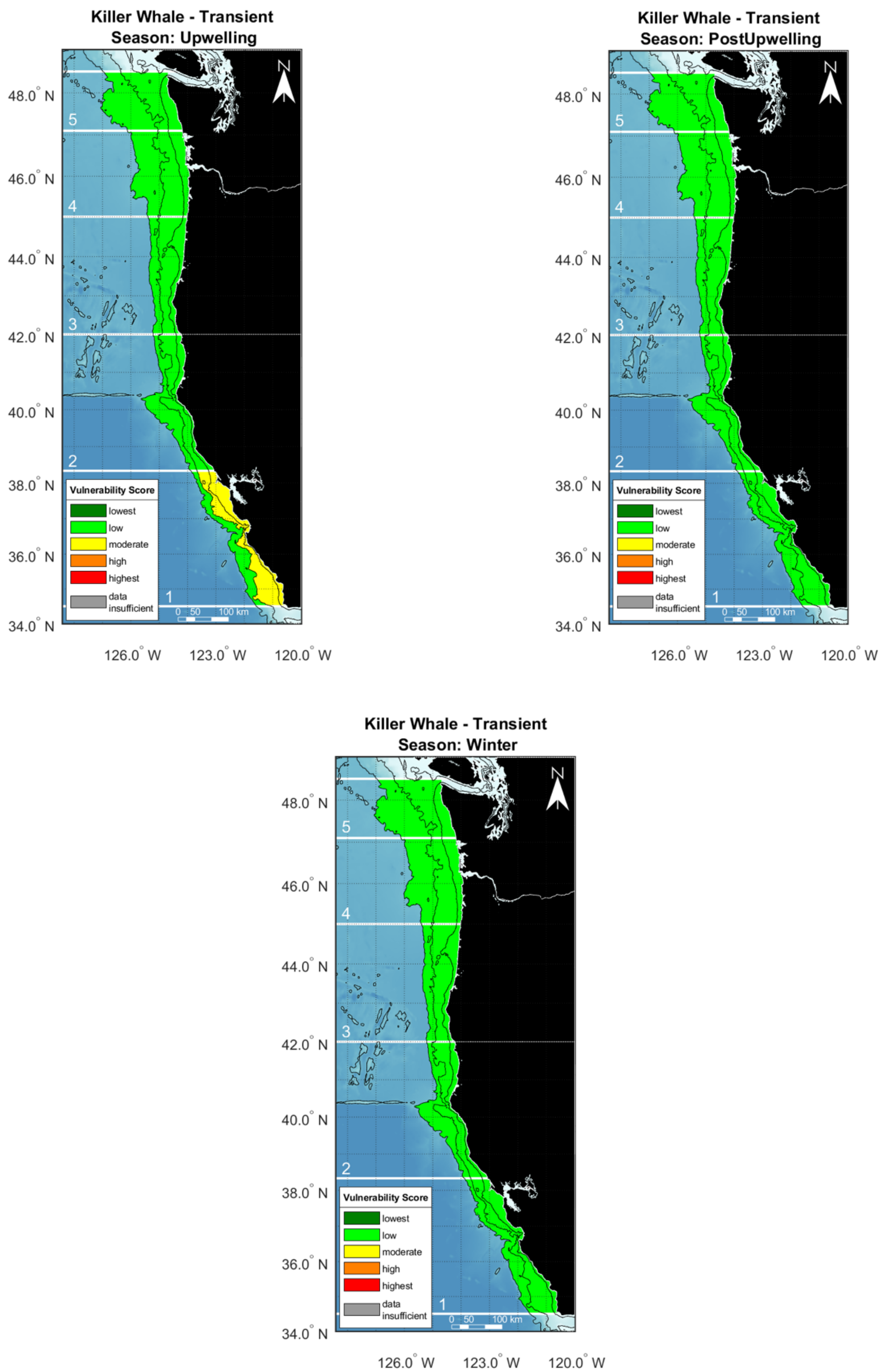


Figure 22. Killer whale (Eastern N. Pacific Transient) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.5 DALL'S PORPOISE (CA/OR/WA)

Summary Assessment: Assessed vulnerability scores for Dall's porpoise were somewhat variable based on zone and season, but were consistently relatively low for all and across all vulnerability factor score elements. Some of the lowest overall vulnerability scores for any species considered here were reported for Dall's porpoise (min 5) and some of the lowest maximum scores (max 12). Scores overall were lowest in the winter season. Dall's porpoise are protected under the MMPA; no systematic population trend has been completed, and the estimated population size is well above 2,500 (n = 25,750 from 2020 SAR). Spatial and temporal factor scores were based on seasonal surveys and quantitative density models for each zone (based on Forney and Barlow 1998; Becker et al. 2017; in prep), as described in section 2.3 (above). Physical interaction factor scores were also very low; masking potential was assessed as low given the very high-frequency nature of echolocation and communication signals for this species, lowest possible risk of vessel strike was assigned, and low but not zero entanglement risk was assigned based on limited evidence of entanglement in longline and gillnet fisheries. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores (0) were assigned for other anthropogenic and biological stressors were assigned, given the estimated annual human-induced mortality of 0.3 and PBR estimate of 173 individuals in the 2020 SAR and the absence of documented biological risk factors.

Uncertainty Assessment: High confidence in vulnerability scores was expressed for seasons and zones.

Key Data Gaps: None specified.

Table 27. Dall's porpoise vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	9	12	10	7	10	10	8	12	7	8	11	10	8	9	11
Post-Upwelling	9	9	7	7	10	10	8	11	10	8	8	7	5	6	8
Winter	8	11	10	7	10	7	7	7	7	5	11	11	5	8	10

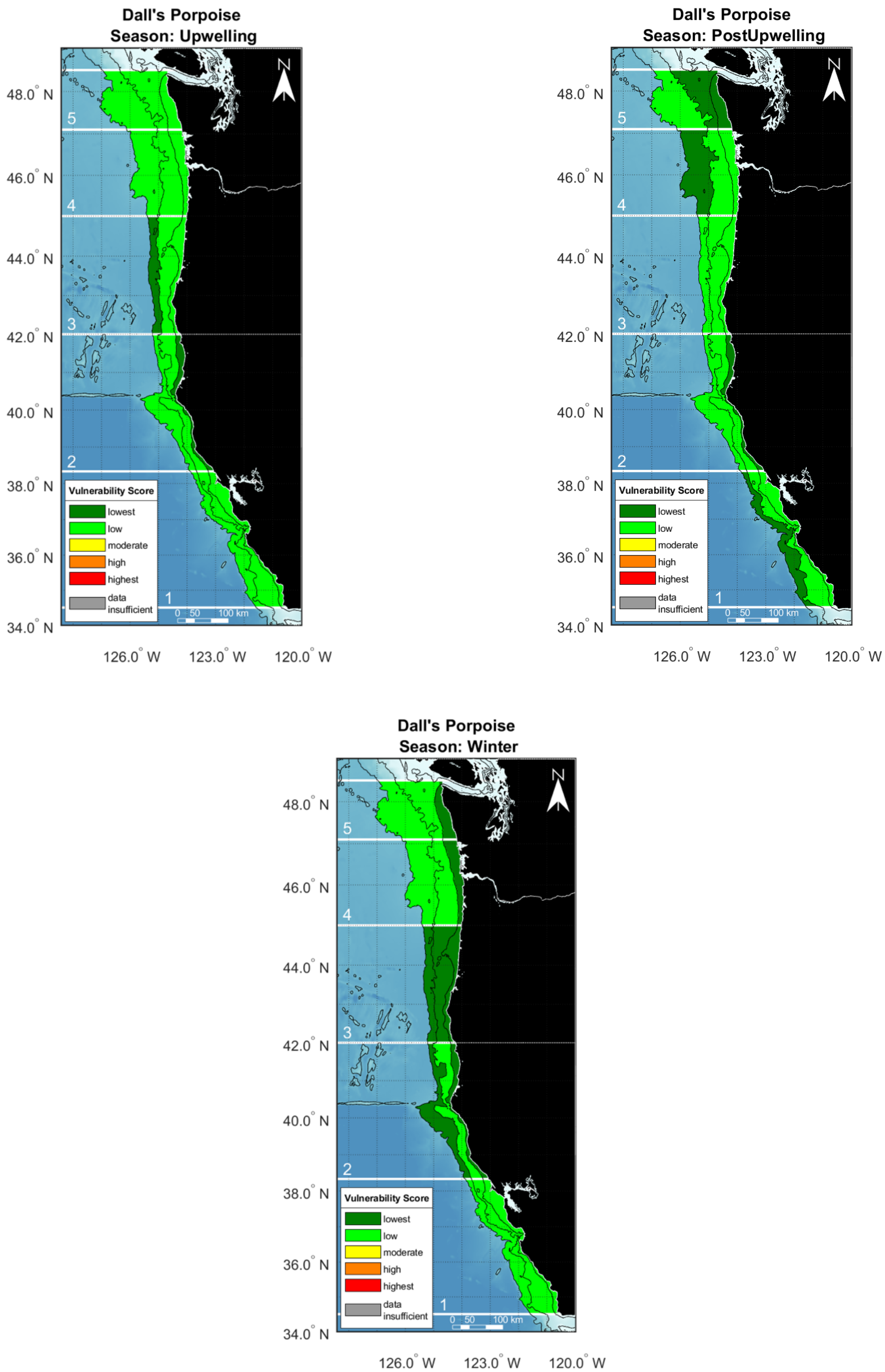


Figure 23. Dall's porpoise vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.6 HARBOR PORPOISE (Morro Bay)

Summary Assessment: Given the high site fidelity and regulatory recognition of five distinct stocks of harbor porpoise within the California Current Ecosystem, each is considered distinctly here within the respective zone(s) in which it occurs. This includes just the shelf (primary habitat) and slope depth zones. Given this high site fidelity across seasons for all stocks, scores were not assigned differentially for each season. The Morro Bay population has high residency for that area. While all Zone 1 is assessed, it should be recognized that when finer scale assessments of this zone are complete, this stock will be almost exclusively vulnerable to disturbance in the areas within and relatively near Morro Bay. Further, it was noted that for disturbance concentrated in their core habitat area that might displace them, they would be subject to a variety of detrimental secondary effects beyond those considered here (see Forney et al. 2017). Vulnerability scores for the Morro Bay stock of harbor porpoise were 20 and 17 for the shelf and slope zones respectively. The Morro Bay stock of harbor porpoise is protected under the MMPA; no population trend was assigned at the time of this analysis based on the 2020 SAR (but see Forney et al. 2021 for evidence of population increase); and the estimated population size exceeds 2,500 (n = 4,255 from 2020 SAR). Spatial and temporal factor scores were based on expert judgment largely from aerial survey data (Forney et al. 2014). Physical interaction factor scores were relatively low; masking potential was assessed as low given the very high-frequency nature of echolocation and communication signals for this species, low possible risk of vessel strike was assessed, and low but not zero entanglement risk was assigned based on limited evidence of documented entanglement. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores (0) were assigned for other anthropogenic and biological stressors, given the estimated annual human-induced mortality of > 0.4 and PBR estimate of 65 individuals, but higher biological risk factor scores were assessed given documented instances of pollutants and mortality from other mammals (Cotter et al. 2012).

Uncertainty Assessment: Moderate confidence in vulnerability scores were assigned.

Key Data Gaps: Distribution, behavior in core habitat near potential development and transit areas for offshore wind; habitat use and behavior in offshore areas; PAM, photo ID for density

Table 28. Harbor porpoise (Morro Bay) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	20	17	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Post-Upwelling	20	17	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Winter	20	17	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

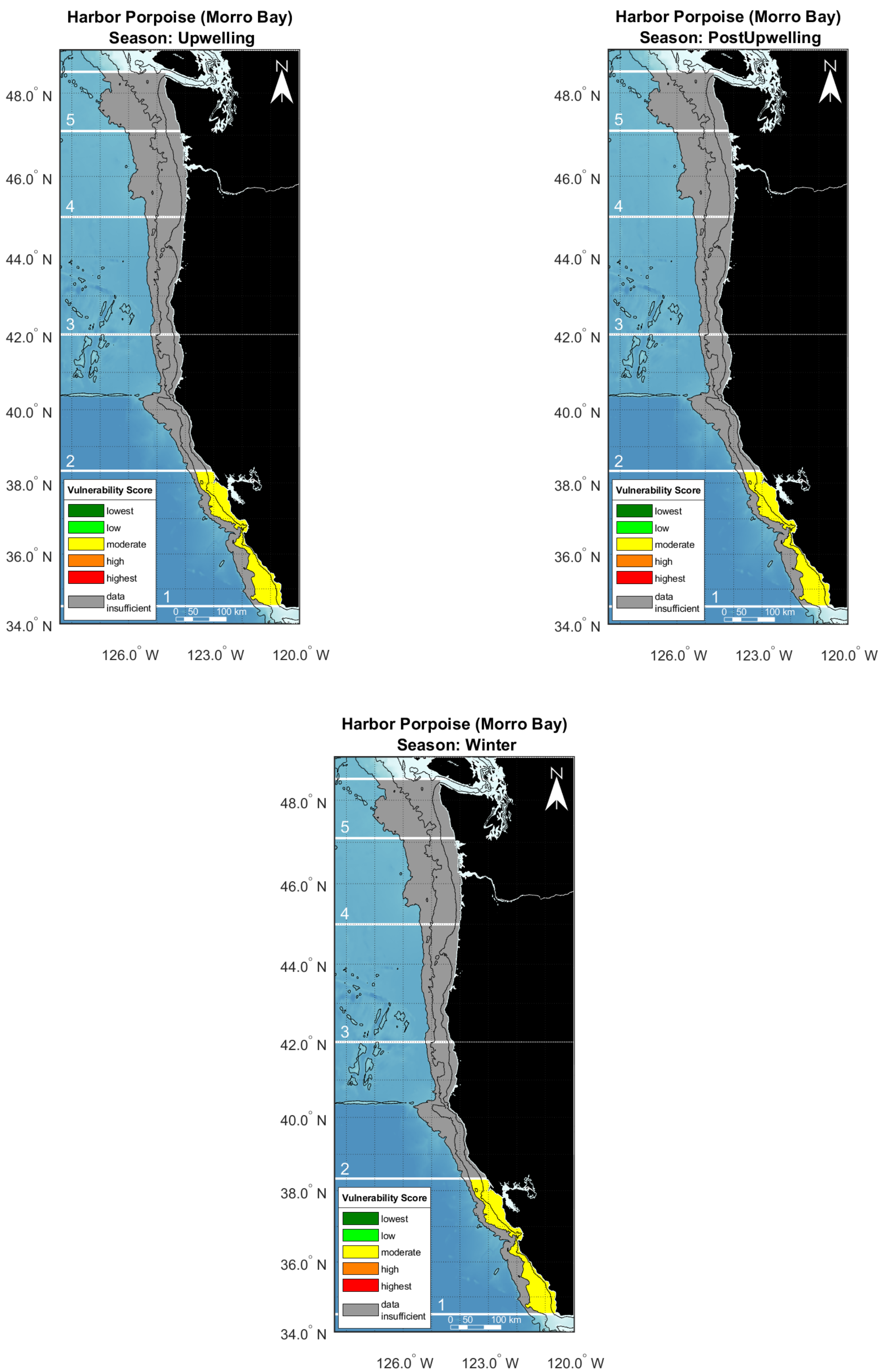


Figure 24. Harbor porpoise (Morro Bay) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.7 HARBOR PORPOISE (Monterey Bay)

Summary Assessment: Given the high site fidelity and regulatory recognition of five distinct stocks of harbor porpoise within the California Current Ecosystem, each is considered distinctly here within the respective zone(s) in which it occurs. This includes just the shelf (primary habitat) and slope depth zones. Given this high site fidelity across seasons for all stocks, scores were not assigned differentially for each season. The Monterey Bay population has high residency for what is only a portion of Zone 1 (from Point Sur to Pigeon Point) and it is similarly noted that the highest vulnerability of this stock is within that core habitat. Vulnerability scores for the Monterey Bay stock of harbor porpoise were 20 for shelf and 20 for slope depths. The Monterey Bay stock is protected under the MMPA; no population trend was assigned at the time of this analysis based on the 2020 SAR (but see Forney et al. 2021 for evidence of population increase); and the estimated population size exceeds 2,500 (n = 3,455 from 2020 SAR). Spatial and temporal factor scores were based on expert judgment largely from aerial survey data (Forney et al. 2014). Physical interaction factor scores were relatively low; masking potential was assessed as low given the very high-frequency nature of echolocation and communication signals for this species, low possible risk of vessel strike was assessed, and low but not zero entanglement risk was assigned based on limited evidence of documented entanglement. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores (0) were assigned for other anthropogenic and biological stressors were assigned, given the estimated annual human-induced mortality of > 0.2 and PBR estimate of 23 individuals, but higher biological risk factor scores were assessed given documented instances of pollutants and mortality from other mammals (Cotter et al. 2012).

Uncertainty Assessment: Moderate confidence in vulnerability scores was assigned.

Key Data Gaps: Population assessments as baseline; potential use of whale-watch, citizen science

Table 29. Harbor porpoise (Monterey Bay) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	20	20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Post-Upwelling	20	20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Winter	20	20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

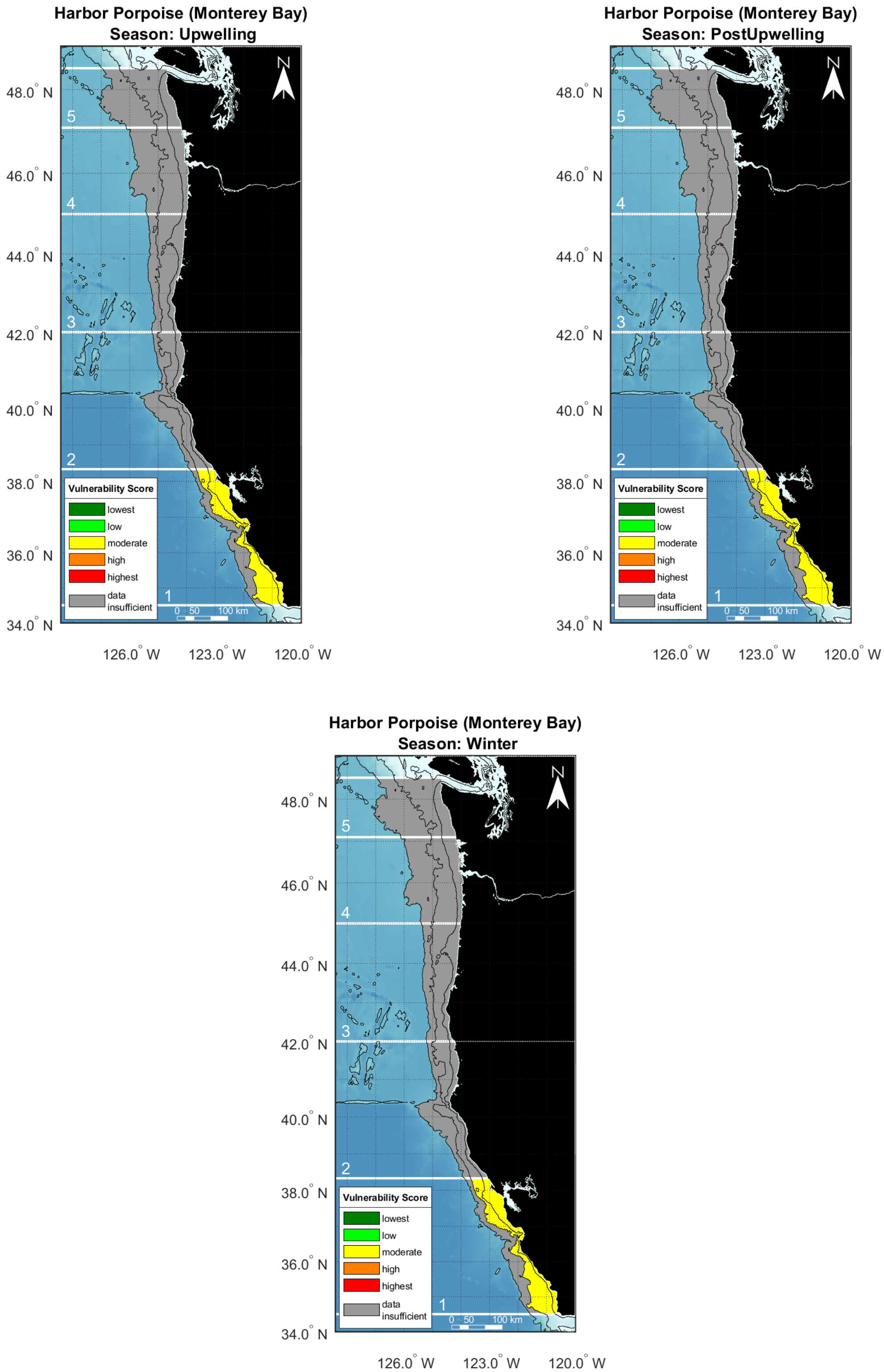


Figure 25. Harbor porpoise (Monterey Bay) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.8 HARBOR PORPOISE (San Francisco-Russian River)

Summary Assessment: Given the high site fidelity and regulatory recognition of five distinct stocks of harbor porpoise within the California Current Ecosystem, each is considered distinctly here within the respective zone(s) in which it occurs. This includes just the shelf (primary habitat) and slope depth zones. Given this high site fidelity across seasons for all stocks, scores were not assigned differentially for each season. The San Francisco-Russian River population has high residency for what are portions of Zones 1 and 2 (from the San Francisco Bay region to areas just north of Point Arena) and it is similarly noted that the highest vulnerability of this stock is within these core habitats. Vulnerability scores for this stock of harbor porpoise were moderate (scores 16-19) for the across the shelf and slope depths in zones 1 and 2. The San Francisco-Russian River stock of harbor porpoise is protected under the MMPA, no systematic population trend has been completed, and the estimated population size exceeds 2,500 (n = 7,524 from 2020 SAR). Spatial and temporal factor scores were based on expert judgment largely from aerial survey data (Forney et al. 2014). Physical interaction factor scores were relatively low; masking potential was assessed as low given the very high-frequency nature of echolocation and communication signals for this species, low possible risk of vessel strike was assessed, and low but not zero entanglement risk was assigned based on limited evidence of documented entanglement. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores (0) were assigned for other anthropogenic and biological stressors were assigned, given the estimated annual human-induced mortality of > 0.2 and PBR estimate of 23 individuals, but higher biological risk factor scores were assessed given documented instances of pollutants and mortality from other mammals (Cotter et al. 2012).

Uncertainty Assessment: High confidence in vulnerability scores was assigned.

Key Data Gaps: None specified

Table 30. Harbor porpoise (SF-Russian River) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	19	16	n/a	19	16	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Post-Upwelling	19	16	n/a	19	16	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Winter	19	16	n/a	19	16	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

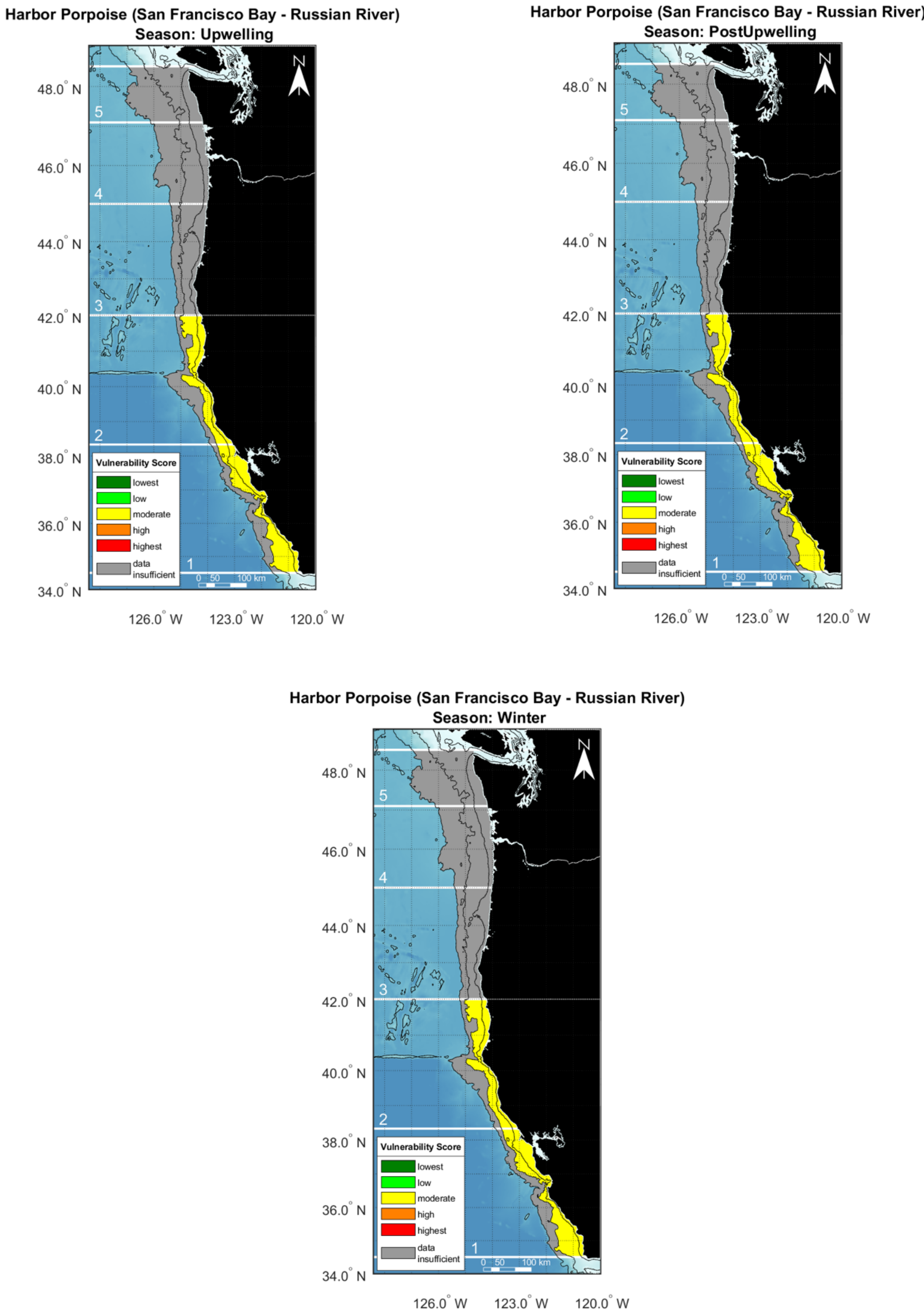


Figure 26. Harbor porpoise (SF-Russian River) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.9 HARBOR PORPOISE (Northern CA/Southern OR)

Summary Assessment: Given the high site fidelity and regulatory recognition of five distinct stocks of harbor porpoise within the California Current Ecosystem, each is considered distinctly here within the respective zone(s) in which it occurs. This includes just the shelf (primary habitat) and slope depth zones. Given this high site fidelity across seasons for all stocks, scores were not assigned differentially for each season. The northern California/southern Oregon stock has high residency for these areas, and it is similarly noted that the highest vulnerability is within and in areas relatively near these core habitats. It is also noted that there is expected to be (for 2023 SARs) a further segregation of this stock, recognizing a genetically-distinct central Oregon stock; this will affect future updates to this assessment. Vulnerability scores for the NorCal/Southern OR stock of harbor porpoise considered in this analysis ranged from relatively low (min 12) to moderate (max 16) for the shelf and slope portions of zones 2 and 3. The NorCal/Southern OR stock of harbor porpoise is protected under the MMPA, no population trend was assigned at the time of this analysis based on the 2020 SAR (but see Forney et al. 2021 for evidence of population stability), and the estimated population size exceeds 2,500 (n = 24,195 from 2020 SAR)). Spatial and temporal factor scores were based on expert judgment largely from aerial survey data (Forney et al. 2014). Physical interaction factor scores were relatively low; masking potential was assessed as low given the very high-frequency nature of echolocation and communication signals for this species, low possible risk of vessel strike was assessed, and low but not zero entanglement risk was assigned based on limited evidence of documented entanglement. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores (0) were assigned for other anthropogenic and biological stressors were assigned, given the estimated annual human-induced mortality of > 0.2 and PBR estimate of 23 individuals, but moderate biological risk factor scores were assessed given documented instances of pollutants and mortality from other mammals (Cotter et al. 2012).

Uncertainty Assessment: Moderate confidence in vulnerability scores was assigned.

Key Data Gaps: Distribution, behavior in core habitat near potential development and transit areas for offshore wind; habitat use and behavior in offshore areas; PAM, photo ID for density

Table 31. Harbor porpoise (Northern CA/Southern OR) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	n/a	n/a	n/a	15	12	n/a	16	13	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Post-Upwelling	n/a	n/a	n/a	15	12	n/a	16	13	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Winter	n/a	n/a	n/a	15	12	n/a	16	13	n/a	n/a	n/a	n/a	n/a	n/a	n/a

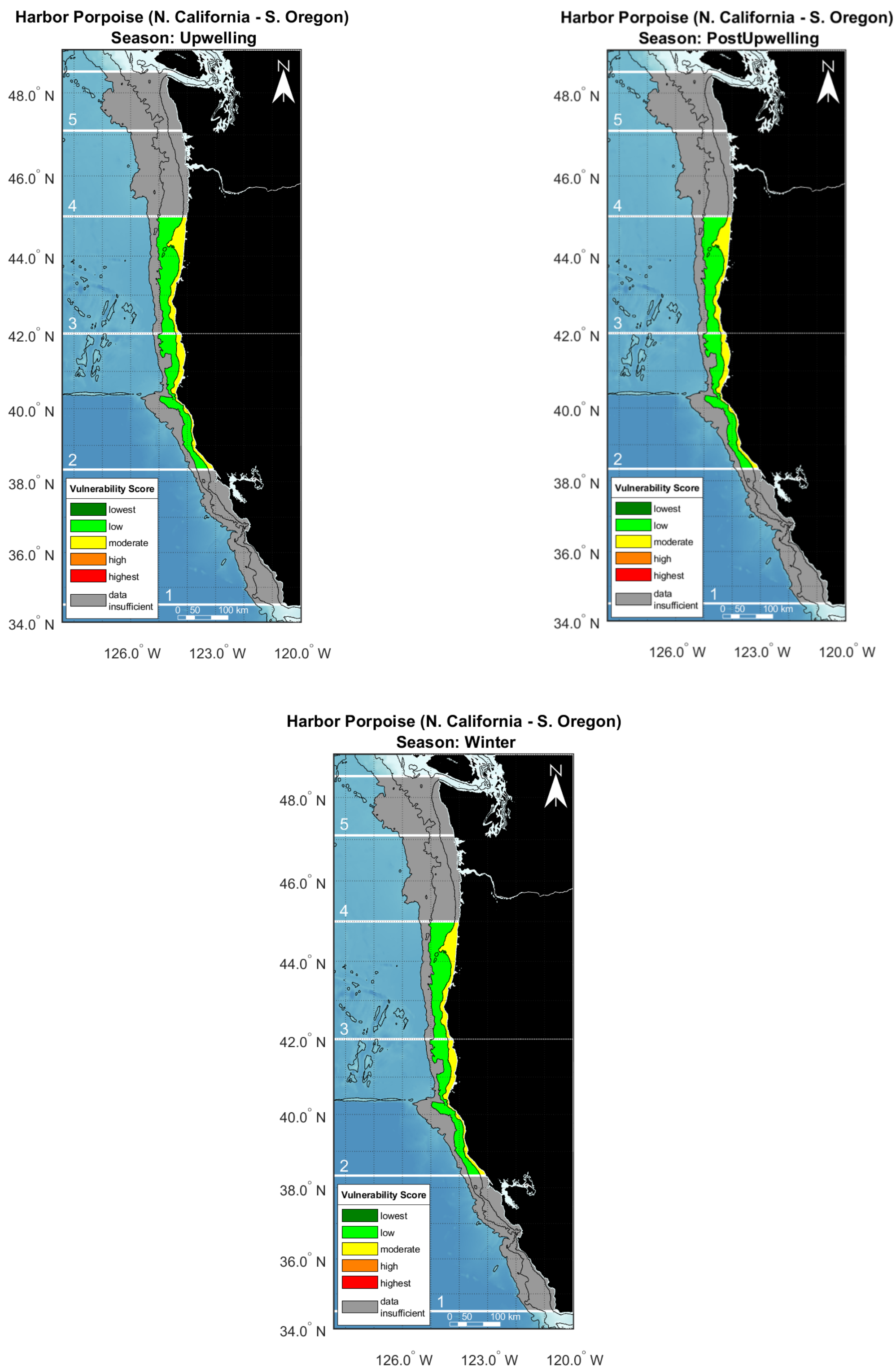


Figure 27. Harbor porpoise (Northern CA/Southern OR) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.10 HARBOR PORPOISE (Northern OR/WA Coast)

Summary Assessment: Given the high site fidelity and regulatory recognition of five distinct stocks of harbor porpoise within the California Current Ecosystem, each is considered distinctly here within the respective zone(s) in which it occurs. This includes just the shelf (primary habitat) and slope depth zones. Given this high site fidelity across seasons for all stocks, scores were not assigned differentially for each season. The northern Oregon/Washington coast stock has high residency for these areas, and it is similarly noted that the highest vulnerability is within and in areas relatively near these core habitats. Vulnerability scores for the northern OR/WA coast stock of harbor porpoise ranged from relatively low (min 12) to moderate (max 17) for the shelf and slope portions of zones 4 and 5. The Northern OR/WA coast stock of harbor porpoise is protected under the MMPA, no systematic population trend has been completed, and the estimated population size exceeds 2,500 (n = 21,487 from 2020 SAR)). Spatial and temporal factor scores were based on expert judgment largely from aerial survey data (Carretta et al. 2001; Forney et al. 2014). Physical interaction factor scores were relatively low; masking potential was assessed as low given the very high-frequency nature of echolocation and communication signals for this species, low possible risk of vessel strike was assessed, and low but not zero entanglement risk was assigned based on limited evidence of documented entanglement. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores (0) were assigned for other anthropogenic and biological stressors were assigned, given the estimated annual human-induced mortality of > 3.0 and PBR estimate of 151 individuals, but moderate biological risk factor scores were assessed given documented instances of pollutants and mortality from other mammals (Cotter et al. 2012).

Uncertainty Assessment: Moderate confidence in vulnerability scores was assigned.

Key Data Gaps: None specified

Table 32. Harbor porpoise (Northern OR/WA Coast) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	17	14	n/a	17	15	n/a
Post-Upwelling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	17	14	n/a	17	15	n/a
Winter	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	17	14	n/a	17	15	n/a

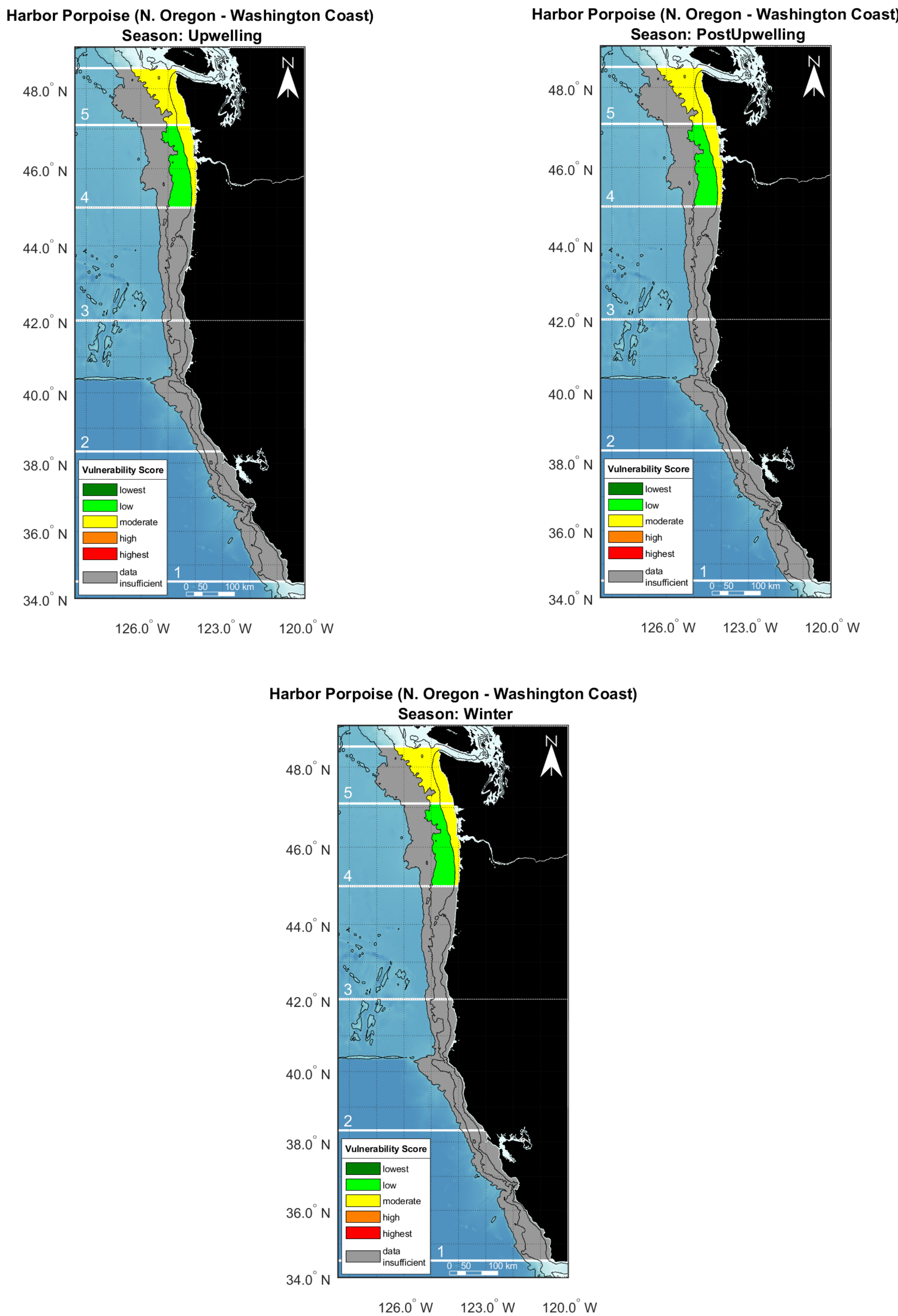


Figure 28. Harbor porpoise (Northern OR/WA Coast) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.11 PYGMY AND DWARF SPERM WHALE (CA/OR/WA)

Summary Assessment: Pygmy and dwarf sperm whales were combined into a species aggregation for the purposes of the analysis here based on taxonomic and life history parameters. Vulnerability scores for this species aggregation ranged from some of the relatively lowest reported scores (min 4) to just barely within the relatively low category (max 9). Few differences were observed across seasons or latitudinally; slightly higher values were typically observed in the oceanic zones given the more offshore distribution of the species. Neither pygmy nor dwarf sperm whales are endangered—both are protected under the MMPA, and while no systematic population trends have been completed, estimated population sizes for pygmy sperm whales are > 2,500 (n = 4,111 from 2020 SAR). Spatial and temporal factor scores were based on expert judgment based on Griffiths et al (2020). Physical interaction factor scores were relatively low; masking potential was assessed as low given the high-frequency nature of echolocation and communication signals for this species, low possible risk of vessel strike was assessed, and low but not zero entanglement risk was assigned (but the absence of this species in gillnet fisheries off California was noted (Carretta et al. 2018)). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores (0) were assigned for other anthropogenic and biological stressors were assigned, based on the estimated annual human-induced mortality of 0 for both species (PBR estimates were 19.2 individuals for pygmy sperm whales, but known for dwarf sperm whales in the 2020 SAR). Low biological risk factor scores were assessed based on the absence of reported concerns in recent SARs for either species.

Uncertainty Assessment: Variable confidence in vulnerability scores was assigned—high confidence in all shelf zones, moderate in all slope zones, and low for all oceanic zones.

Key Data Gaps: None specified

Table 33. Pygmy and dwarf sperm whale vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	7	7	8	5	5	8	6	7	8	6	6	8	6	7	9
Post-Upwelling	7	7	8	5	5	8	6	6	8	6	6	8	6	7	9
Winter	6	6	8	5	5	8	5	5	8	6	6	9	6	6	8

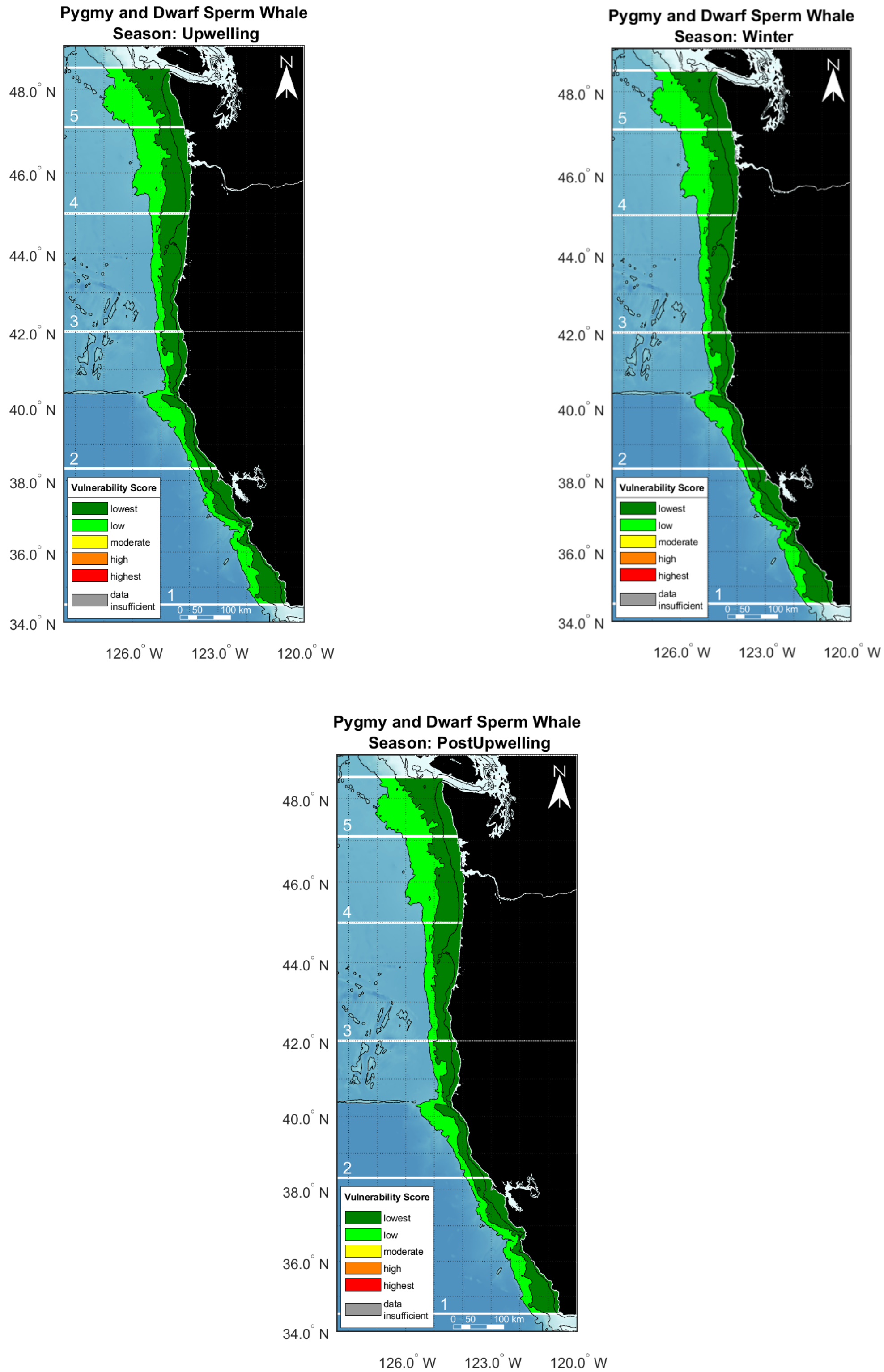


Figure 29. Pygmy and dwarf sperm whale vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.12 SHORT-FINNED PILOT WHALE (CA/OR/WA)

Summary Assessment: Vulnerability scores for short-fined pilot whales were consistently low across zones and seasons. Scores were almost entirely in the low-risk category (min 10) with a few scores in the moderate category (max 15) in slope sub-zones within zones 1 and 3 in non-winter seasons. Short-finned pilot whales are not endangered but are protected under the MMPA; no systematic population trend calculations are available; and the estimated population is < 2,500 (n = 836 from 2020 SAR). Spatial and temporal factor scores suggesting limited distribution in shelf and oceanic areas were based on expert judgment based on survey sightings (Barlow and Forney 2007; Van Cise et al. 2016). Physical interaction factor scores were moderate; masking potential was assessed as intermediate based on some lower frequency components of communication signals for this species relative to some other odontocetes; relatively low possible risk of vessel strike and entanglement was assessed. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Relatively low anthropogenic and biological stressor factor scores were based on the estimated annual human-induced mortality of 1.2, PBR estimates of 4.5 individuals, and the absence of reported concerns regarding other biological stressors in recent SARs.

Uncertainty Assessment: Moderate confidence in vulnerability scores was assigned across all zones for upwelling and winter seasons. High confidence was expressed in the post-upwelling season.

Key Data Gaps: Visual, PAM surveys to identify habitat use in Zone 1, esp. re: Risso's distrib.

Table 34. Short-finned pilot whale vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	12	15	13	10	13	13	11	15	13	11	14	13	11	12	11
Post-Upwelling	12	15	13	10	13	13	11	14	13	11	14	13	11	12	11
Winter	11	15	13	10	13	13	10	13	13	11	14	14	11	11	10

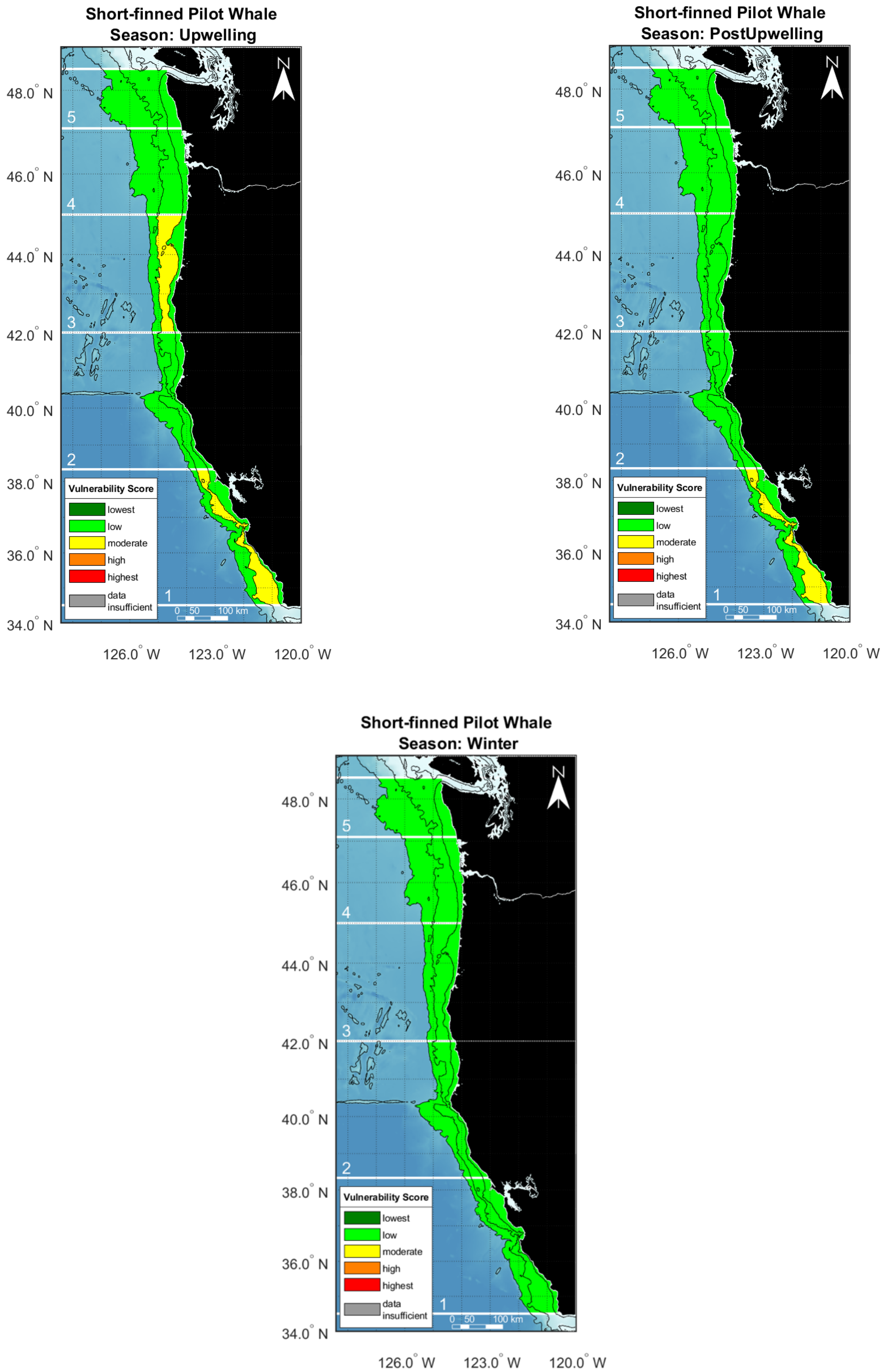


Figure 30. Short-finned pilot whale vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.13 RISSO'S DOLPHIN (CA/OR/WA)

Summary Assessment: Vulnerability scores for Risso's dolphins were also consistently low across zones and seasons. Scores included a single zone (3c - oceanic) during the post-upwelling season in the lowest risk category (min 5), and all other scores within low-risk category (max 14). Risso's dolphins are protected under the MMPA; no systematic population trend calculations are available; and the estimated population exceeds 2,500 (n = 6,336 from 2020 SAR). Spatial and temporal factor scores were based on quantitative model estimates described in section 2.3 above (Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020; Becker et al. in prep). Physical interaction factor scores were relatively low; masking potential was assessed as low based on some generally high-frequency components of echolocation and communication signals; low possible risk of vessel strike and entanglement was assessed. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Very low anthropogenic and biological stressor factor scores were based on the estimated annual human-induced mortality of > 3.7, PBR estimates of 46 individuals, and the absence of reported concerns regarding other biological stressors in recent SARs.

Uncertainty Assessment: Moderate confidence in vulnerability scores was assigned across all zones for upwelling and winter seasons. High confidence was expressed in the post-upwelling season.

Key Data Gaps: Visual, PAM surveys to identify habitat use in Zone 1, esp. re: pil. whale distrib.

Table 35. Risso's dolphin vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	14	14	12	9	12	12	10	14	9	10	13	12	10	11	10
Post-Upwelling	13	13	11	8	8	8	9	9	5	9	9	8	9	10	12
Winter	13	13	12	9	12	12	9	12	9	10	13	10	10	10	9

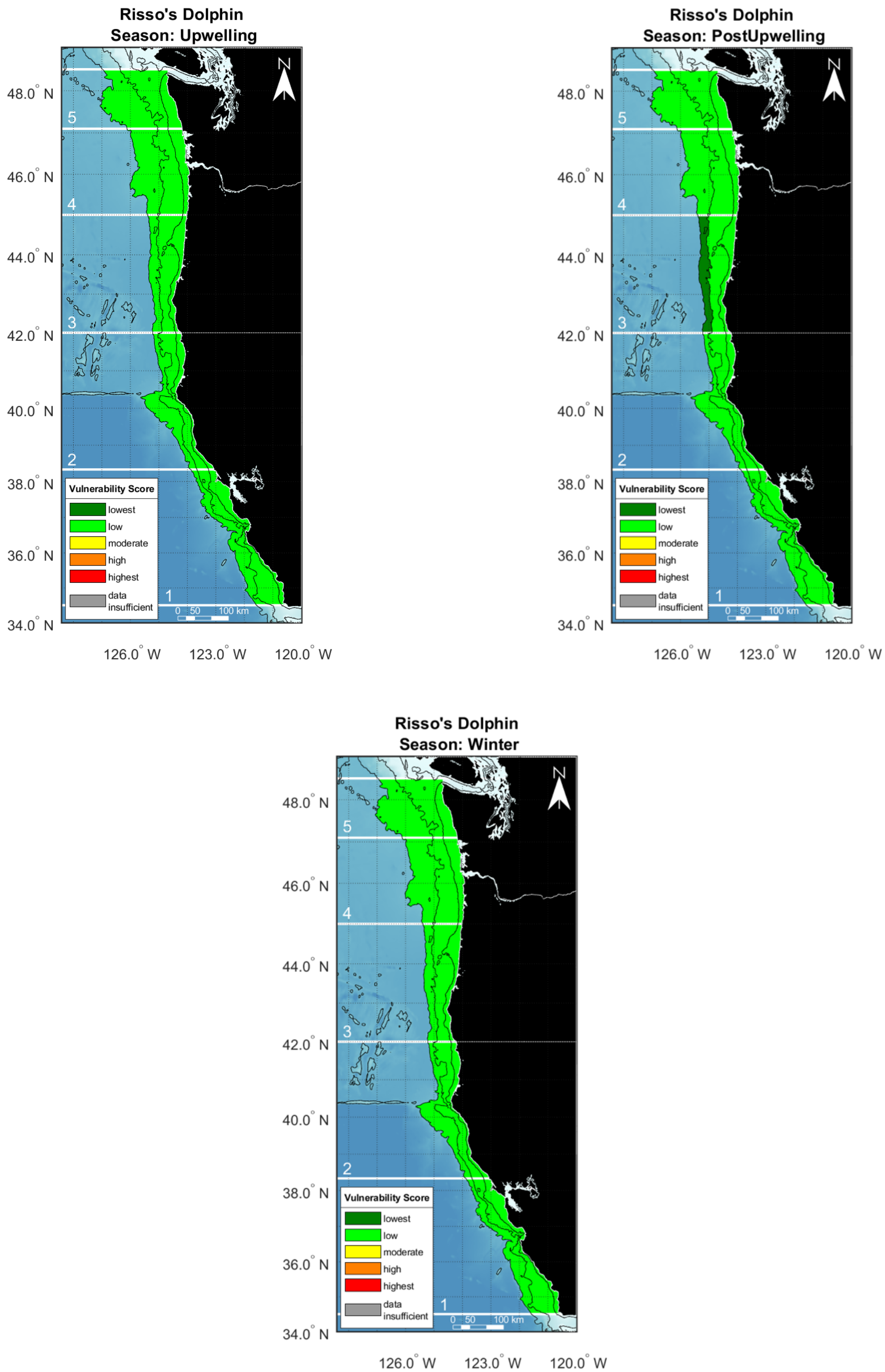


Figure 31. Risso's dolphin vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.14 PACIFIC WHITE-SIDED DOLPHIN (CA/OR/WA)

Summary Assessment: Vulnerability scores for Pacific white-sided dolphins were also consistently low across zones and seasons, particularly in shelf zones given the more offshore nature of this species. Scores ranged from the lowest relative risk (min 5) to low-risk scores (max 13). Pacific white-sided dolphins are protected under the MMPA; no systematic population trend calculations have been reported in recent SARs; and the estimated population exceeds 2,500 (n = 26,814 from 2020 SAR). Spatial and temporal factor scores were based on quantitative model estimates described in section 2.3 (Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020; Becker et al. in prep). Physical interaction factor scores were relatively low; masking potential was assessed as low based on some generally high-frequency components of echolocation and communication signals; low possible risk of vessel strike and entanglement was assessed (though not zero as some bycatch risk in the thresher shark and swordfish fishery was noted). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Very low anthropogenic and biological stressor factor scores for Pacific white-sided dolphins were based on the estimated annual human-induced mortality of 7.5, PBR estimates of 191 individuals, and the absence of reported concerns regarding other biological stressors in recent SARs.

Uncertainty Assessment: Moderate confidence in vulnerability scores was assigned across all zones for upwelling and winter seasons. High confidence was expressed in the post-upwelling season.

Key Data Gaps: None specified

Table 36. Pacific white-sided dolphin vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	10	13	11	8	8	11	9	13	11	9	12	11	6	10	12
Post-Upwelling	10	10	11	5	8	8	6	6	8	6	9	11	6	10	9
Winter	7	13	11	5	11	11	6	12	11	6	12	11	6	10	12

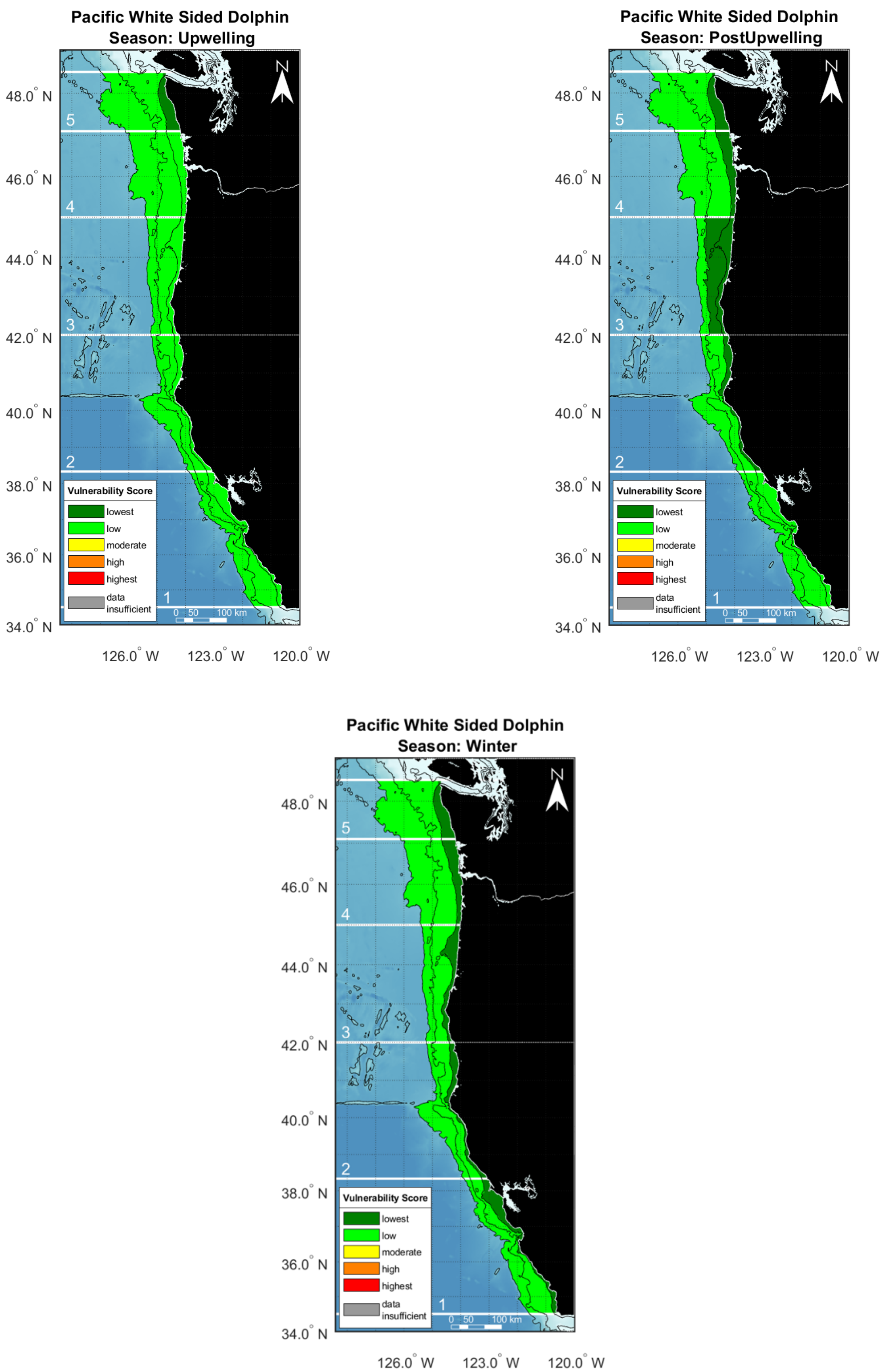


Figure 32. Pacific white-sided dolphin vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.15 NORTHERN RIGHT WHALE DOLPHIN (CA/OR/WA)

Summary Assessment: Vulnerability scores for northern right whale dolphins were also consistently low across zones and seasons, particularly in shelf and slope zones given the more offshore nature of this species. Scores were among the lowest overall across all species, with the majority in the lowest vulnerability rating (min 5), many rated as low vulnerability, and a single zone (5c – oceanic) in the upwelling season rated as moderate (max 15). Northern right whale dolphins are protected under the MMPA; no systematic population trend calculations have been reported in recent SARs; and the estimated population is > 2,500 (n = 26,556 from 2020 SAR)). Spatial and temporal factor scores were based on quantitative model estimates for this species, as described in section 2.3 (Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020; Becker et al. in prep). Physical interaction factor scores were relatively low; masking potential was assessed as low based on some generally high-frequency components of echolocation and communication signals; low possible risk of vessel strike and entanglement was assessed (though not zero as similar to Pacific white-sided dolphins some bycatch risk for this species was noted in the thresher shark and swordfish fishery). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Very low anthropogenic and biological stressor factor scores for northern right whale dolphins were based on the estimated annual human-induced mortality of 3.8 and PBR estimates of 179 individuals and the absence of reported concerns regarding other biological stressors in recent SARs.

Uncertainty Assessment: Similar confidence scores to other more oceanic delphinids was noted with moderate confidence in vulnerability scores assigned across all zones for upwelling and winter seasons and high confidence assigned in the post-upwelling season.

Key Data Gaps: None specified

Table 37. Northern right whale dolphin vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	7	10	11	5	8	11	6	10	11	6	7	14	6	10	15
Post-Upwelling	7	7	8	5	5	8	6	6	5	6	6	8	6	7	12
Winter	7	7	8	5	8	8	6	6	8	6	9	11	6	7	12

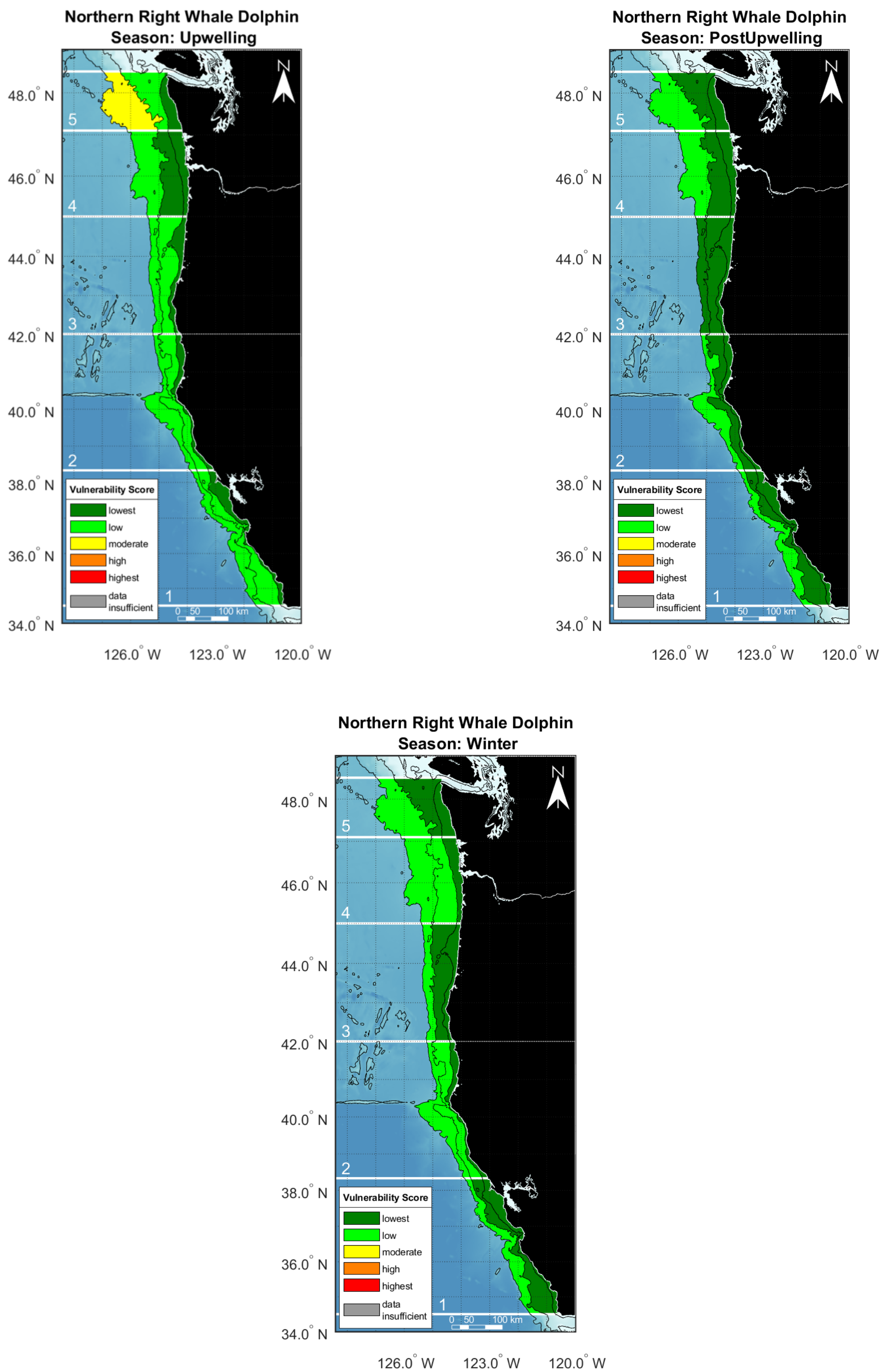


Figure 33. Northern right whale dolphin vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.16 SHORT-BEAKED COMMON DOLPHIN (CA/OR/WA)

Summary Assessment: Short- and long-beaked common dolphins were relatively recently recognized as distinct species and were evaluated as such in this vulnerability assessment, though the obvious similarities and frequent overlap in occurrence was noted. Scores were quite similar between these species accordingly. Vulnerability scores for short-beaked common dolphins were somewhat variable across zones, with higher scores in shelf and oceanic zones and in the southern portion of the overall region. Scores were also variable across seasons, with the highest relative scores in the post-upwelling season and consistently very low scores in the winter. Scores included the lowest overall ratings (min 5), many rated as low vulnerability, and a single zone (1b – shelf) in the post-upwelling season rated as moderate (max 16). Short-beaked common dolphins are protected under the MMPA; no systematic population trend calculations have been reported in recent SARs; and the estimated population substantially exceeds 2,500 (n = 969,861 from 2020 SAR). Spatial and temporal factor scores were based on quantitative model estimates for this species, as described in section 2.3 (Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020; Becker et al. in prep). Physical interaction factor scores were relatively low; masking potential was assessed as low based on some generally high-frequency components of echolocation and communication signals; low possible risk of vessel strike and entanglement was assessed. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Very low anthropogenic and biological stressor factor scores for northern right whale dolphins were based on the estimated annual human-induced mortality of 40 and PBR estimates of 8,393 individuals and the absence of reported concerns regarding other biological stressors in recent SARs.

Uncertainty Assessment: High confidence in vulnerability ratings was assigned across seasons.

Key Data Gaps: None specified

Table 38. Short-beaked common dolphin vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	7	10	8	5	5	5	6	7	5	6	6	5	6	7	6
Post-Upwelling	13	16	14	5	5	7	6	6	5	6	6	5	6	7	6
Winter	6	9	11	5	5	5	5	5	5	6	6	6	6	6	5

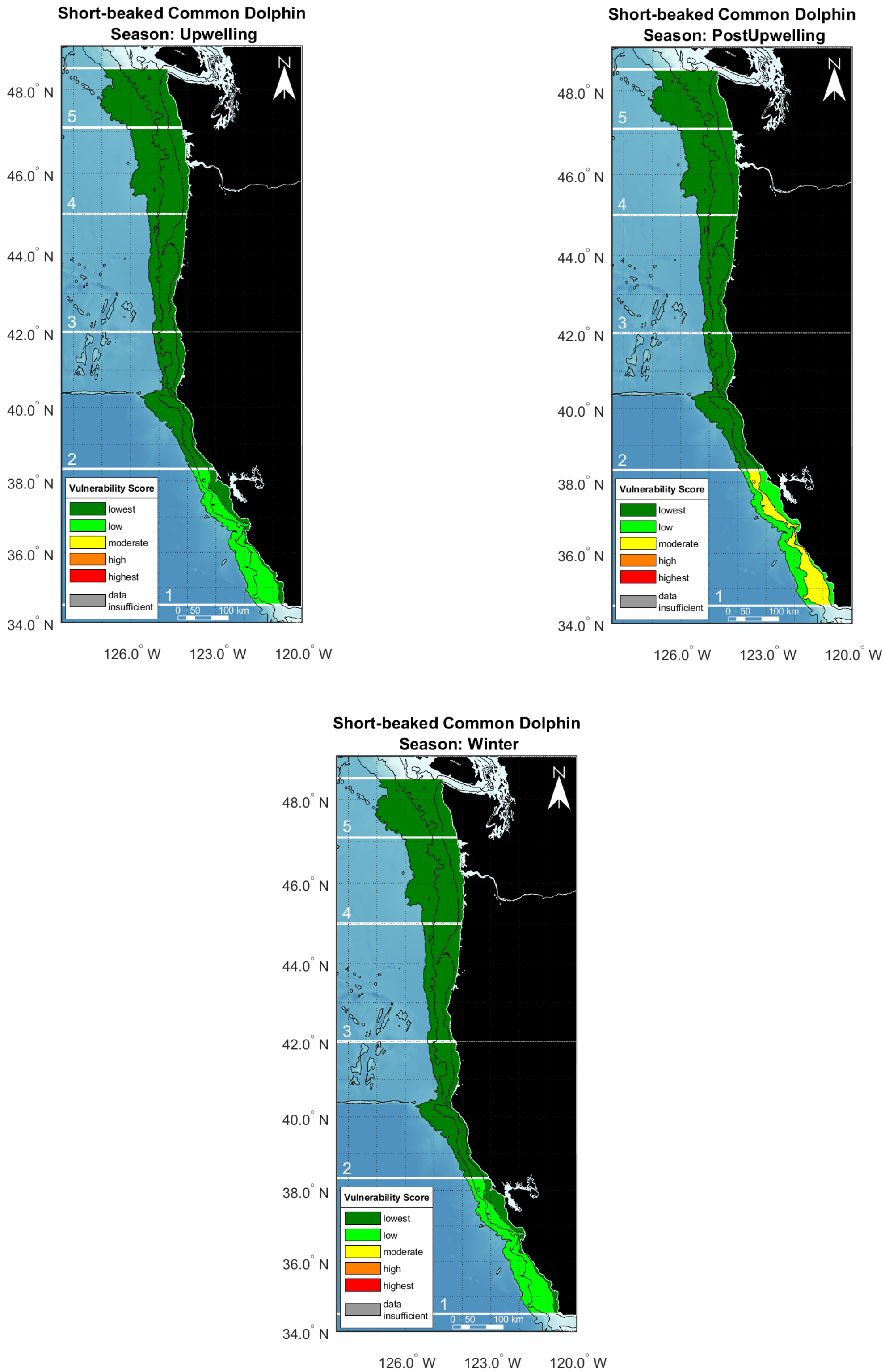


Figure 34. Short-beaked common dolphin vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.17 LONG-BEAKED COMMON DOLPHIN (CA/OR/WA)

Summary Assessment: Short- and long-beaked common dolphins were relatively recently recognized as distinct species and were evaluated as such in this vulnerability assessment, though the obvious similarities and frequent overlap in occurrence was noted. Scores were somewhat similar between these species accordingly. Vulnerability scores for long-beaked common dolphins were even more variable across zones thank for short-beaked dolphins, with higher scores in shelf and oceanic zones especially within Zone 1. Less seasonal variability was observed across seasons. Scores included the lowest overall ratings (min 5 – and many at this level), some rated as low vulnerability, and moderate scores in a single zone (1b – shelf) occurring in each season (max 16). Long-beaked common dolphins are protected under the MMPA; no systematic population trend calculations have been reported in recent SARs; and the estimated population substantially exceeds 2,500 (n = 101,305 from 2020 SAR)). Spatial and temporal factor scores were based on quantitative model estimates for this species as well, as described in section 2.3 (Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020; Becker et al. in prep). Physical interaction factor scores were also relatively low; masking potential was assessed as low based on some generally high-frequency components of echolocation and communication signals; low possible risk of vessel strike and entanglement was assessed. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Very low anthropogenic and biological stressor factor scores for northern right whale dolphins were based on the estimated annual human-induced mortality of > 35.4 and PBR estimates of 657 individuals and the absence of reported concerns regarding other biological stressors in recent SARs.

Uncertainty Assessment: Moderate confidence in vulnerability ratings was assigned for upwelling and winter seasons. High confidence was assigned during the post-upwelling season.

Key Data Gaps: None specified

Table 39. Long-beaked common dolphin vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	13	16	11	5	5	5	6	7	5	6	6	5	6	7	6
Post-Upwelling	13	16	11	5	5	5	6	6	5	6	6	5	6	7	6
Winter	13	16	11	5	5	5	6	6	5	6	6	5	6	7	6

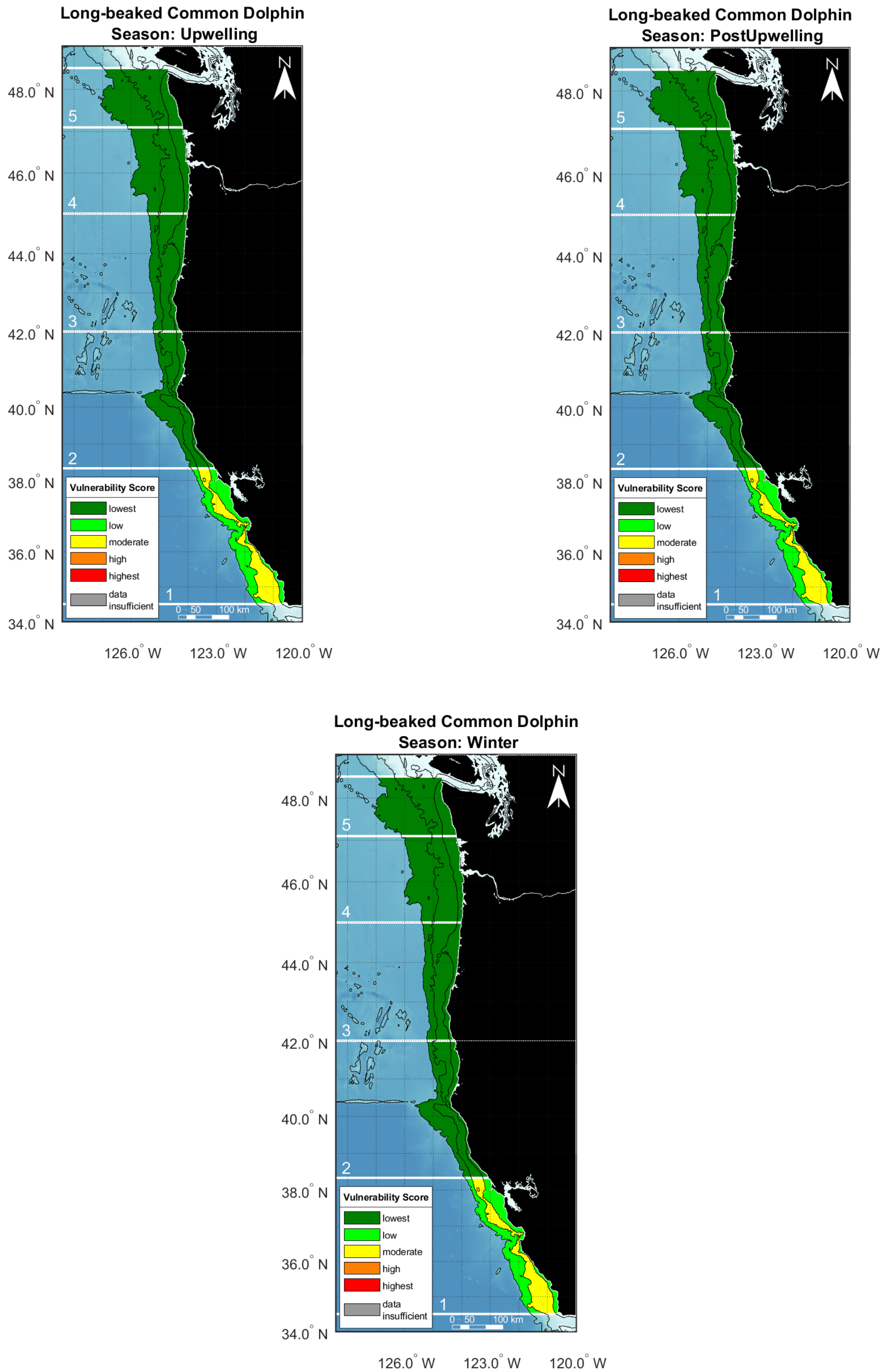


Figure 35. Long-beaked common dolphin vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.18 BOTTLENOSE DOLPHIN (CA/OR/WA Coastal)

Summary Assessment: Given their limited distribution in the overall region, vulnerability scores for California coastal bottlenose dolphins were determined only in Zone 1. Vulnerability scores were quite variable as a function of depth within this zone but consistent across seasons. Scores ranged from relatively low (min 11) to relatively high (max 24). Coastal bottlenose dolphins are protected under the MMPA; no systematic population trend calculations have been reported in recent SARs; and the estimated population is well below 2,500 (n = 453 from 2020 SAR); these contribute to an intermediate score for the population factor. Spatial and temporal factor scores were based on expert elicitation consideration of vessel-based studies and aerial surveys showing a very nearshore, shallow-water distribution (Hansen 1990; Carretta et al. 1998). Physical interaction factor scores were relatively low; masking potential was assessed as low based on some generally high-frequency components of echolocation and communication signals; low possible risk of vessel strike was assessed but a moderate risk of entanglement based on observations with bottlenose dolphins in other contexts and potential attraction to offshore industrial operations. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Relatively high anthropogenic and biological stressor factor scores for coastal bottlenose dolphins were based on the estimated annual human-induced mortality of > 2.0 and PBR estimates of 2.7 individuals and the several reported biological stressors in recent SARs.

Uncertainty Assessment: High confidence in vulnerability ratings was assigned across seasons.

Key Data Gaps: None specified

Table 40. Coastal bottlenose dolphin vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	23	16	12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Post-Upwelling	23	16	12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Winter	25	17	13	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

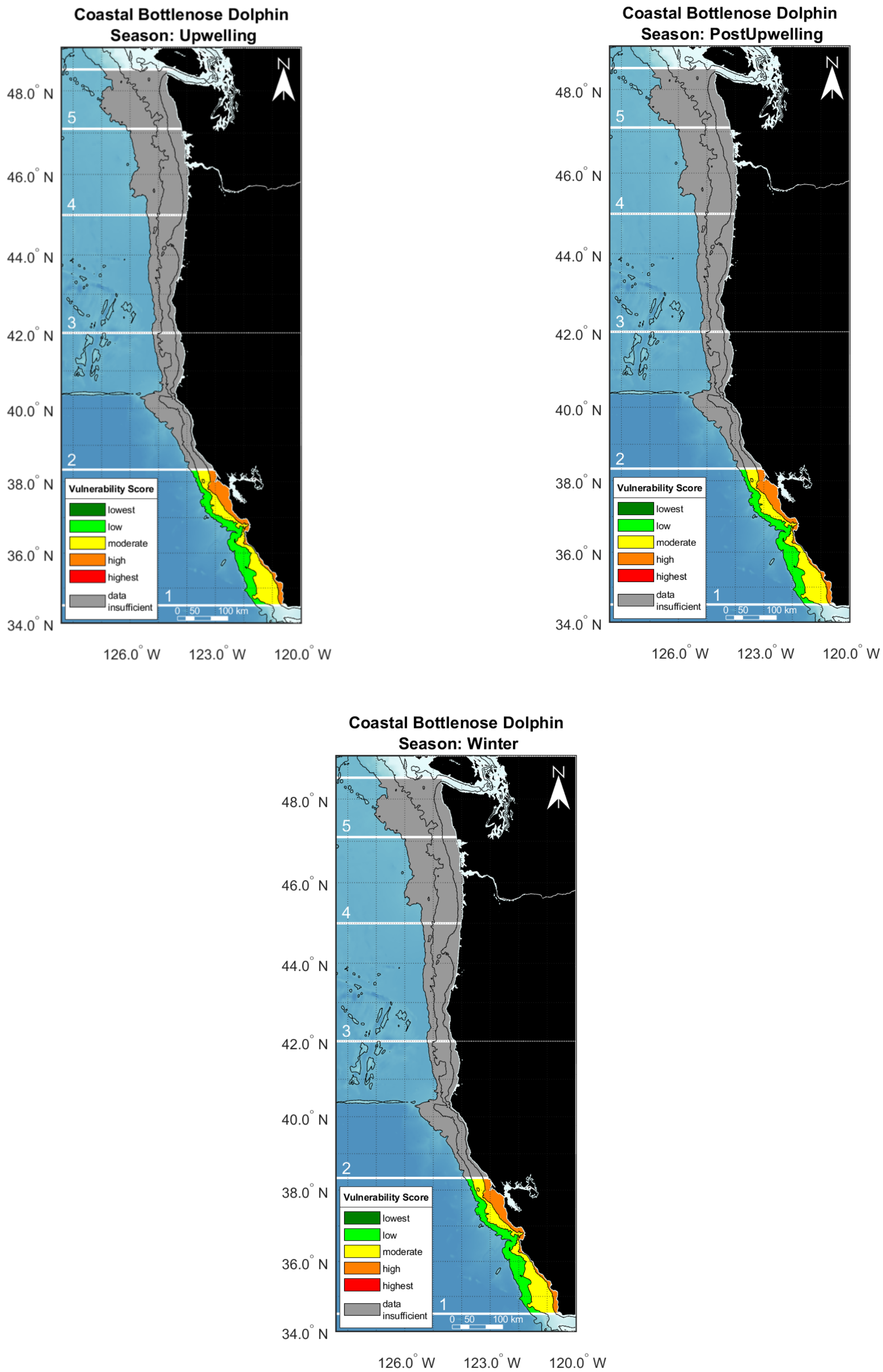


Figure 36. Coastal bottlenose dolphin vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.19 BAIRDS BEAKED WHALE (CA/OR/WA)

Summary Assessment: Vulnerability scores for Baird's beaked whales were variable as a function of both zone and season. Scores ranged from relatively low (min 9) to moderate vulnerability ratings (max 18). Baird's beaked whales are protected under the MMPA—no systematic population trend calculations exist in recent SARs; and the estimated population is just above 2,500 (n = 2,697 from 2020 SAR) but the minimum population estimate is below the IUCN threshold. These contribute to an intermediate score for the population factor. Spatial and temporal factor scores were based on quantitative density modeling estimates for this species described in section 2.3 (Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020; Becker et al. in prep). Physical interaction factor scores were moderate, based on the moderately low-frequency components of echolocation signals and aspects of presumed hearing (see: Southall et al. 2019), predominately low frequencies of sounds associated with likely disturbance, and low possible risk of vessel strike and entanglement. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Relatively high anthropogenic and biological stressor factor scores for Baird's beaked whales were based on the estimated annual human-induced mortality of 0 and PBR estimates of 16 individuals and limited concerns regarding other biological stressors based on recent SARs.

Uncertainty Assessment: Moderate confidence in vulnerability ratings was assigned for upwelling and winter seasons. High confidence was assigned during the post-upwelling season.

Key Data Gaps: Habitat use from PAM, visual surveys, tagging studies focused in Zones 1 and 2 shelf and oceanic areas especially focused around lease areas.

Table 41. Baird's beaked whale vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	13	17	18	9	15	18	10	11	11	10	9	9	10	11	10
Post-Upwelling	13	17	18	9	15	16	10	10	11	10	10	9	10	11	10
Winter	12	16	18	9	15	18	9	9	11	10	10	10	10	10	9

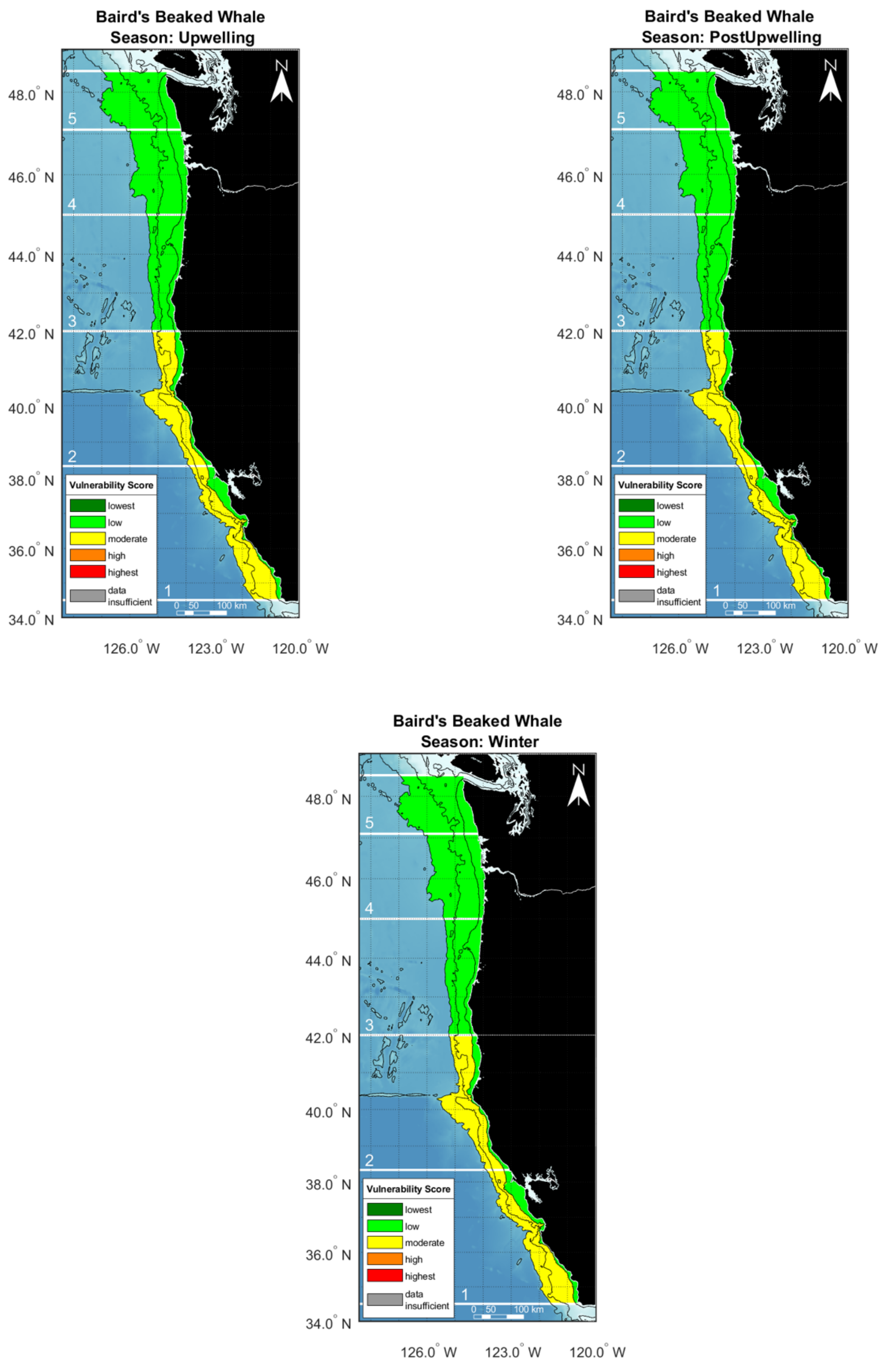


Figure 37. Baird's beaked whale vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.2.20 OTHER BEAKED WHALES (Cuvier's and Mesoplodont)

Summary Assessment: Cuvier's and Mesoplodont beaked whales were combined into a species aggregation for the purposes of the analysis here given the limited information on a number of the species included and based on taxonomic and life history parameters. Vulnerability scores for this species aggregation spanned a relatively narrow range from relatively low (min 10) to moderate (max 17) vulnerability ratings. Few differences were observed across seasons or latitudinally; higher values were consistently observed in oceanic zones given the typically offshore distribution of the species. No species in this aggregation are endangered—all are protected under the MMPA, and no systematic population trends have been completed. Estimated population sizes for both Cuvier's and Mesoplodont beaked whales are both > 2,500 (n = 3,274 and n = 2,697 respectively from 2020 SAR). Spatial and temporal factor scores were based on density modeling predictions described in section 2.3 (Becker, Carretta, et al. 2020; Becker, Forney, et al. 2020; Becker et al. in prep). Physical interaction factor scores were moderate, based on the moderately low-frequency components of echolocation signals and aspects of presumed hearing (see: Southall et al. 2019), predominately low frequencies of sounds associated with likely disturbance, and low possible risk of vessel strike and entanglement. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Relatively low scores were assigned for other anthropogenic and biological stressors, based on the estimated annual human-induced mortality of 0.1 and < 0.1 relative to PBR estimates of 20 and 21 individuals for Cuvier's and Mesoplodont beaked whales respectively. Low biological risk factor scores were assessed based on limited reported concerns related to non-anthropogenic stressors in recent SARs for either species/group.

Uncertainty Assessment: Moderate confidence in vulnerability ratings was assigned for upwelling and winter seasons. High confidence was assigned during the post-upwelling season.

Key Data Gaps: Habitat use from PAM, visual surveys, tagging studies focused in Zones 1 and 2 shelf and oceanic areas especially focused around lease areas.

Table 42. Other beaked whales vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	13	17	15	11	15	15	12	17	15	12	12	15	10	13	16
Post-Upwelling	13	17	15	11	15	15	12	16	15	12	12	15	10	13	16
Winter	12	16	15	11	15	15	11	15	15	11	12	16	10	12	15

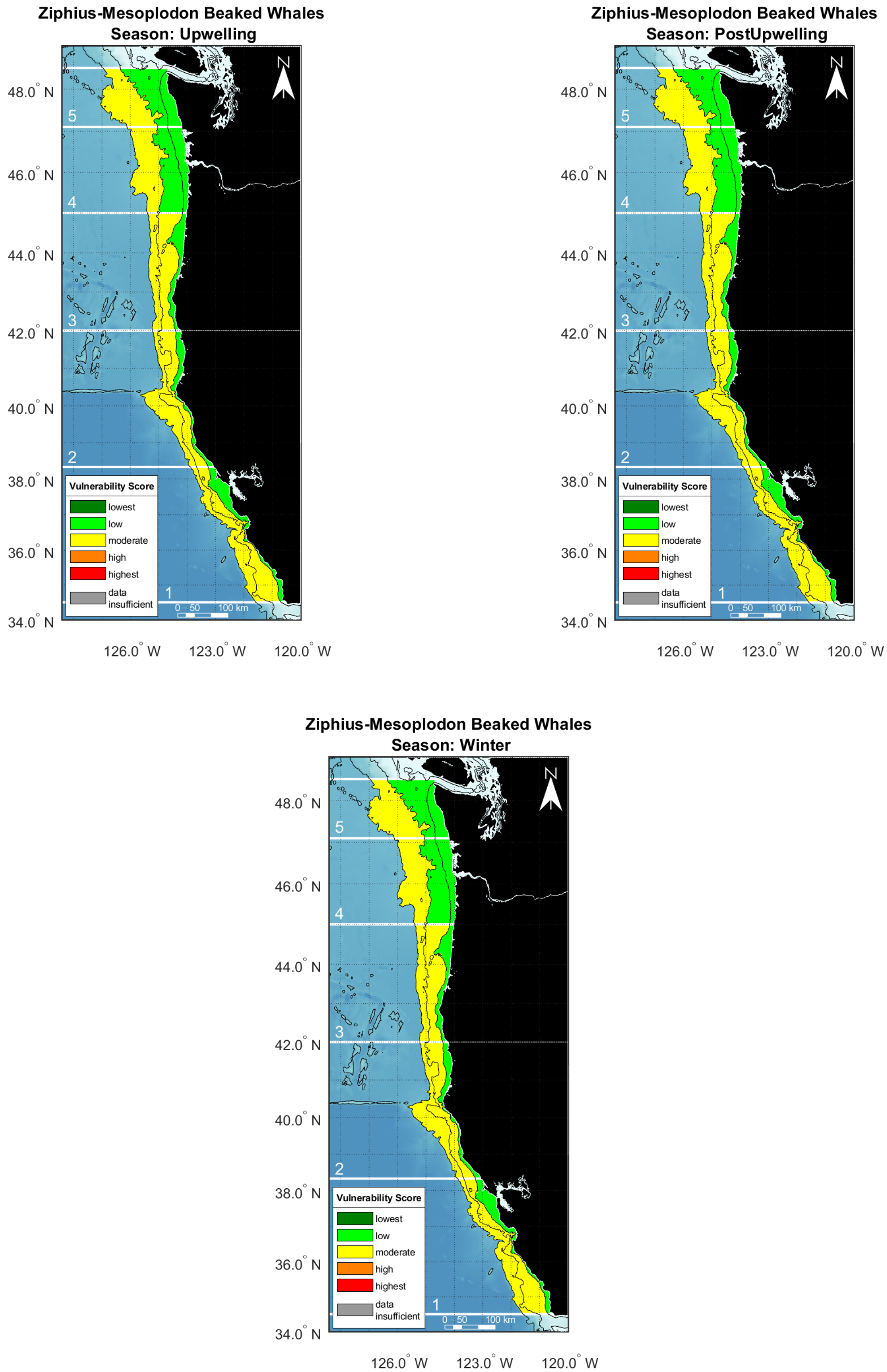


Figure 38. Other beaked whales vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter season.

3.3 Vulnerability Risk Assessment – Pinnipeds

3.3.1 GUADALUPE FUR SEAL (Mexico)

Summary Assessment: Guadalupe fur seals occur primarily off Mexico and southern California but occur in some seasons and zones considered here to some extent. Vulnerability scores for this species were consistently among the lowest for all species evaluated, occurring within a narrow range from lowest relative vulnerability (min 6) to low (max 9) ratings. Few differences were observed across seasons or latitudinally; slightly higher values were observed in oceanic zones based on available distribution data for the species within the overall region. Guadalupe fur seals are listed as MMPA-depleted, resulting in a relatively high population status score, but a negative score for population trend was assigned based on the increasing trend from Garcia-Aguilar (2018; cited in 2020 SAR). Estimated population size in the most recent SAR exceeds 2,500 (n = 34,187). Spatial and temporal factor scores were based on expert elicitation using results from Norris et al. (2019). Physical interaction factor scores were relatively low given less sensitive hearing for otariids (see: Southall et al. 2019) and predominately low frequencies of sounds associated with likely disturbance; low possible risk of vessel strike was assessed, but moderate entanglement risk was assigned (based on Carretta et al. 2016; 2019). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Relatively low scores were assigned for other anthropogenic and biological stressors, based on the estimated annual human-induced mortality of > 3.8 relative to PBR estimates of 1,062 individuals and a single non-anthropogenic stressor (unusual mortality event) reported in the most recent SARs.

Uncertainty Assessment: Relatively little is known about this species in the region; low confidence in vulnerability ratings was assigned accordingly.

Key Data Gaps: None specified

Table 43. Guadalupe fur seal vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	8	8	8	6	6	8	7	8	8	7	7	8	7	8	9
Post-Upwelling	8	8	8	6	6	8	7	7	8	7	7	8	7	8	9
Winter	7	7	8	6	6	8	6	6	8	7	7	9	7	7	8

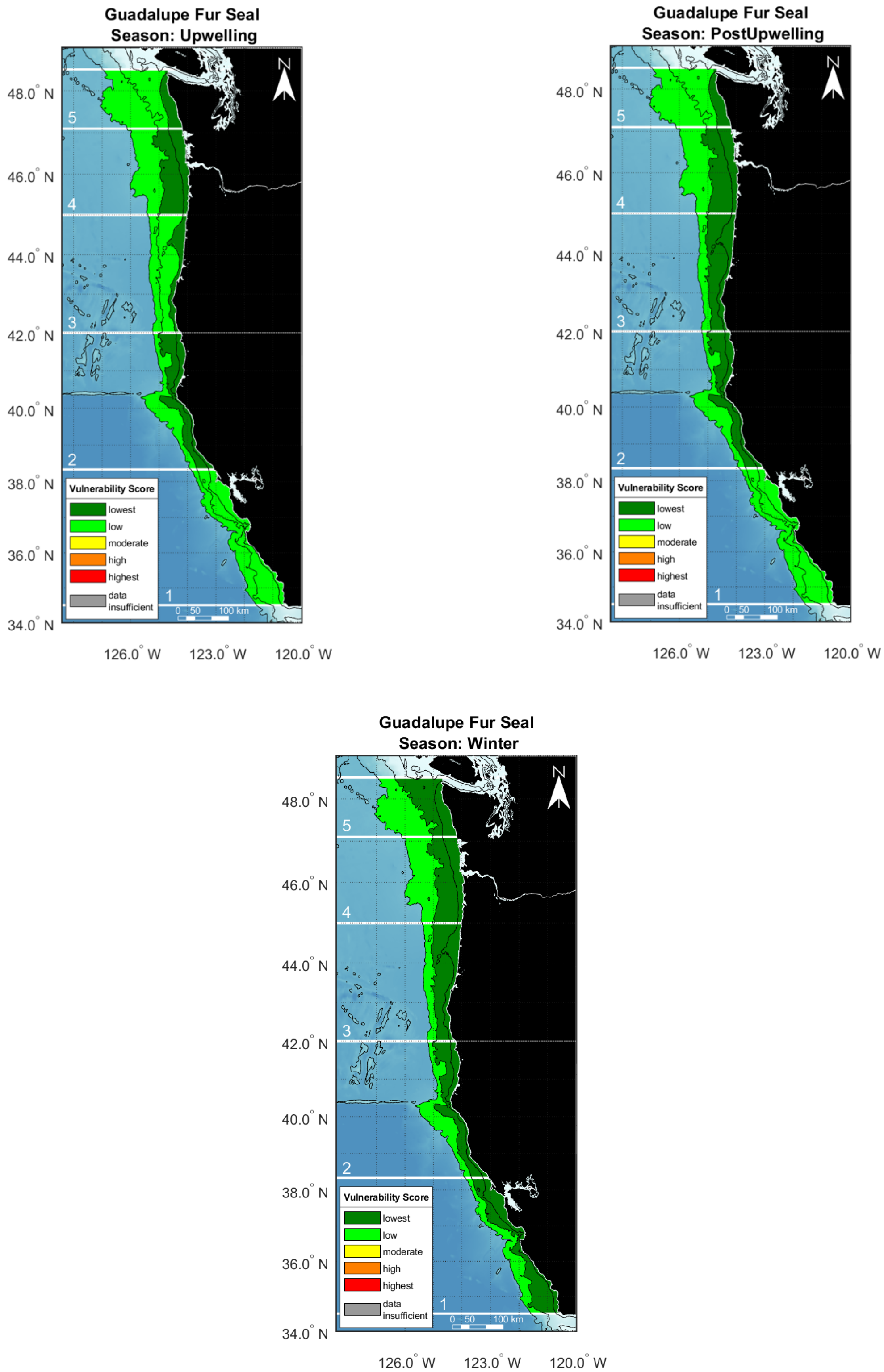


Figure 39. Guadalupe fur seal vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter season.

3.3.2 CALIFORNIA SEA LION (U.S.)

Summary Assessment: California sea lions more commonly occur in the southern portion of the area considered here, particularly in upwelling and post-upwelling season and in shelf and slope depth regimes. Vulnerability scores were consequently variable across seasons and zones, ranging from the lowest relative vulnerability scores (min 5) to moderate (max 16) ratings. Highest relative scores occurred in shelf and slope depth regimes in Zone 1 (a and b respectively) in non-winter seasons. Lowest relative scores occurred in oceanic depth regimes across zones and especially in winter. California sea lions are not endangered or threatened. They are MMPA-depleted, were assigned a negative score for population trend based on a long-term increasing trend from Laake et al. (2018; cited in 2020 SAR). These factors and the estimated population size (from 2020 SAR) greatly exceeding 2,500 (n = 257,606) resulted in the lowest recorded population factor score for any species evaluated in this analysis. Spatial and temporal factor scores were based on expert elicitation using an integration of data from Weise et al (2006), Briscoe et al. (2018), and McHuron et al. (2018). Physical interaction factor scores were relatively low given less sensitive hearing for otariids (see: Southall et al. 2019) and predominately low frequencies of sounds associated with likely disturbance. Low possible risk of vessel strike was assessed but moderate entanglement risk was assigned (based on Carretta et al. 2016; 2019 and some observations of entanglement from stranding facilities). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores for other anthropogenic stressors were based on estimated annual human-induced mortality of 321 and PBR estimates of 14,011 individuals. Higher scores for biological stressors resulted from multiple documented instances, namely impacts of El Niño events and domoic acid poisoning (Weise et al. 2006; 2020 SAR).

Uncertainty Assessment: High confidence in vulnerability ratings was assigned for all seasons.

Key Data Gaps: Better understanding of consequences of prey shifts related to changing conditions, given known vulnerability in El Niño conditions. Data on anticipated attraction to offshore facilities and human impacts from entanglement and/or requisite deterrence methods

Table 44. California sea lion vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	16	16	7	10	10	7	8	9	7	8	8	7	8	9	8
Post-Upwelling	16	16	7	10	10	7	8	8	5	8	8	5	8	9	6
Winter	11	11	7	10	10	7	7	7	7	8	8	8	8	8	7

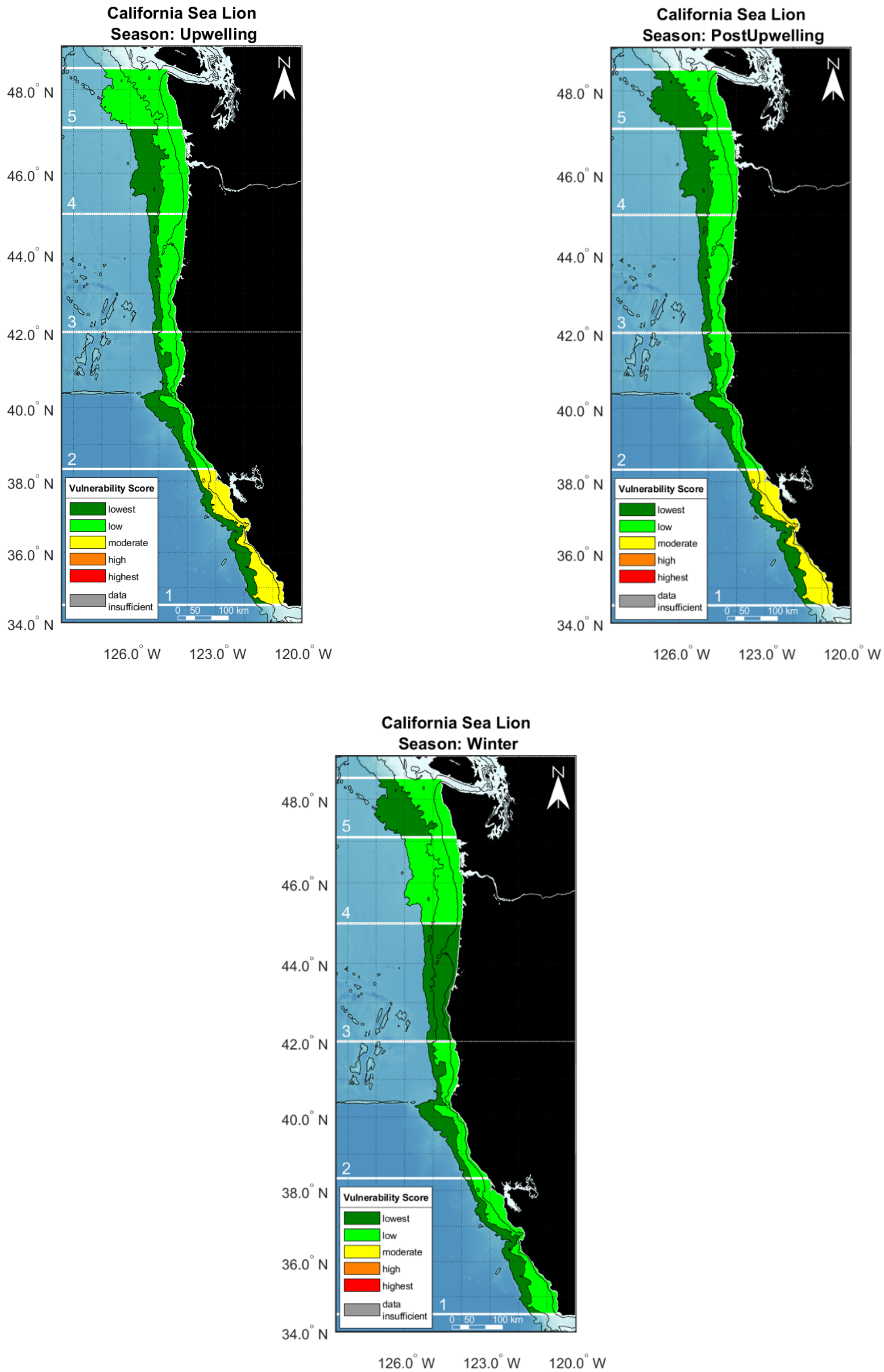


Figure 40. California sea lion vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.3.3 STELLER SEA LION (U.S.)

Summary Assessment: Steller sea lions are broadly distributed across the overall region with limited information on their distribution at sea. Breeding rookeries occur in all five north-south zones and higher distribution in shelf areas is presumed during the breeding season which occurs during upwelling and post-upwelling seasons as defined here. Given this broad distribution and data limitations, vulnerability scores were consequently relatively consistent across seasons and zones. Scores were relatively low overall ranging from a low of 9 to moderate (max 15) ratings for several shelf regions during breeding periods. Steller sea lions are not endangered or threatened but are protected under the MMPA. Like California sea lions, they were assigned a negative score for a long-term increasing population trend based on Calkins et al. (1999), Sweeney et al. (2017), and Fritz et al. (2019) (cited in 2020 SAR). Given the estimated population size (from 2020 SAR) greatly exceeding 2,500 (n = 43,201), this resulted in a population factor score of 0. Spatial and temporal factor scores were based on expert elicitation using limited available information from Kuhn et al. (2017); 2020 SAR. Physical interaction factor scores were relatively low given less sensitive hearing for otariids (see: Southall et al. 2019) and predominately low frequencies of sounds associated with likely disturbance. A comparable assessment was made as in California sea lions; low possible risk of vessel strike was assessed but moderate entanglement risk was assigned (based on Carretta et al. 2016; 2019 and some observations of entanglement from stranding facilities). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores for other anthropogenic stressors were based on estimated annual human-induced mortality of 112 and PBR estimates of 2,572 individuals. A moderate score was assigned for chronic biological risk based on factors identified related to prey limitations in El Niño conditions and potential competition with increasing California sea lion stocks.

Uncertainty Assessment: Low confidence in vulnerability ratings was assigned for all seasons.

Key Data Gaps: Similar data gaps for understanding of consequences of prey shifts related to changing conditions and entanglement and/or requisite deterrence methods.

Table 45. Steller sea lion vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	15	11	9	13	9	9	14	11	9	14	10	9	14	11	10
Post-Upwelling	15	11	9	13	9	9	14	10	9	14	10	9	14	11	10
Winter	10	10	9	9	9	9	9	9	9	10	10	10	10	10	9

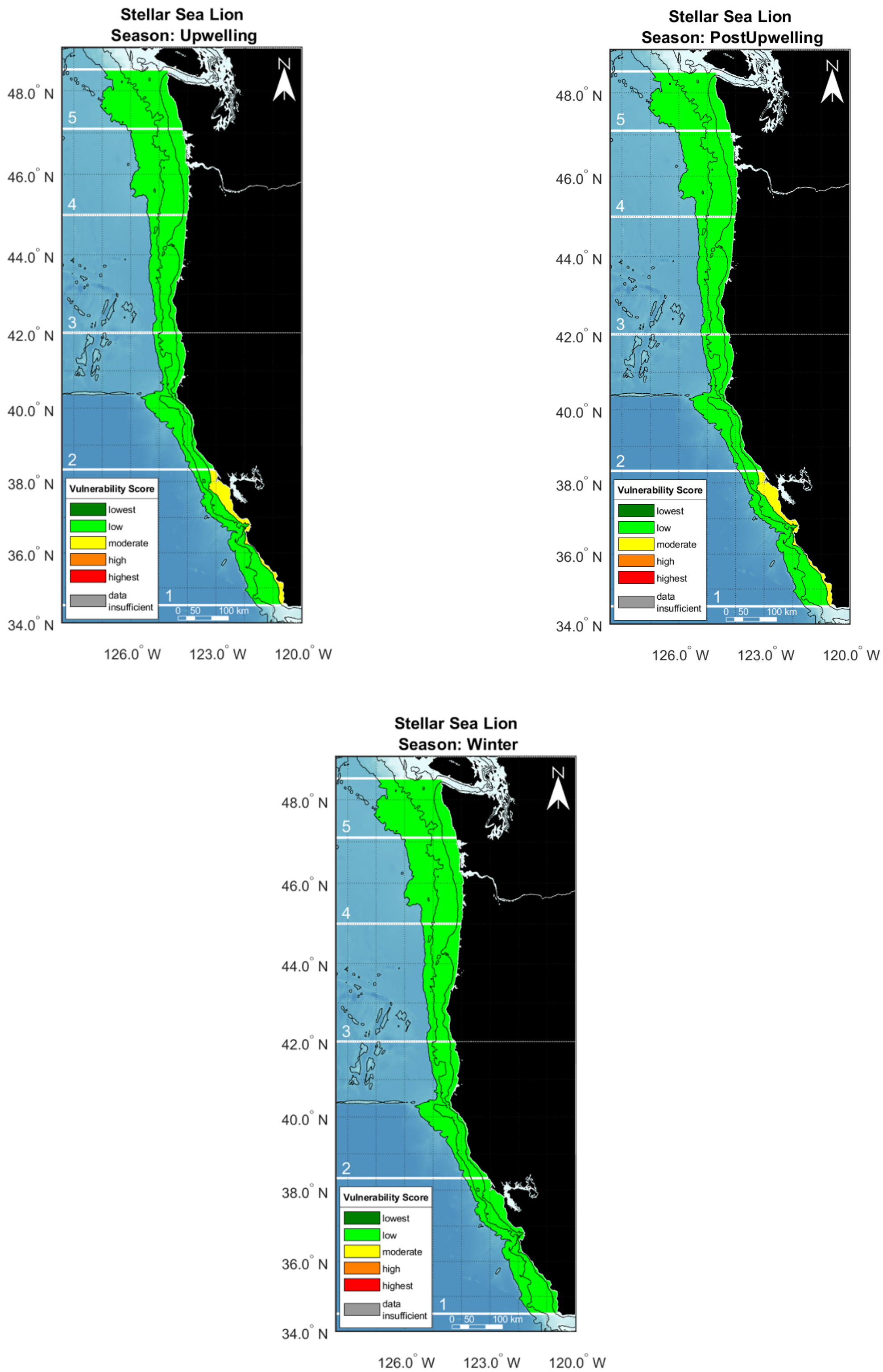


Figure 41. Steller sea lion vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.3.4 NORTHERN FUR SEAL (California)

Summary Assessment: Northern fur seals are distinguished into a California and an eastern North Pacific stock, each with separate SARs and each considered separately here. While there is relatively little data on at-sea distribution, the California stock is likely more abundant in the southern portions of the region and in slope and oceanic zones; little seasonal information is available but higher densities were presumed in known breeding areas (San Miguel Island, Gulf of the Farallones) during breeding periods. Scores were consequently relatively consistent across seasons and zones and ranged from relatively lowest (min 7) to moderate (max 16); moderate scores were limited to two zones during the upwelling period. The California stock of northern fur seals is protected under the MMPA and was assigned a negative score for a long-term increasing population trend reported in the 2020 SAR. The estimated population size (14,050 from 2020 SAR) exceeds 2,500, resulting in a population factor score of 0. Spatial and temporal factor scores were based on expert elicitation using limited available information in Sterling et al. (2014) and the 2020 SAR as well as data from tags deployed at breeding rookeries (Zeppelin et al. 2019). Physical interaction factor scores were relatively low given less sensitive otariid hearing (see: Southall et al. 2019) and predominately low frequencies of anthropogenic sounds. A comparable assessment was made as in California sea lions; low possible risk of vessel strike was assessed but moderate entanglement risk was assigned (based on Carretta et al. 2016; 2019 and some observations of entanglement from stranding facilities). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores for other anthropogenic stressors were based on estimated annual human-induced mortality of 1.8 and PBR estimates of 458 individuals. A moderate score was assigned for chronic biological risk based on factors identified in the 2020 SAR and similarity with other otariids related to prey limitations in El Niño conditions.

Uncertainty Assessment: Moderate confidence in vulnerability ratings was assigned for all zones in upwelling and post-upwelling seasons; low confidence was assigned in the winter season.

Key Data Gaps: None specified

Table 46. Northern fur seal (CA) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	14	14	13	5	6	10	6	8	10	6	7	10	6	8	11
Post-Upwelling	16	16	14	5	7	7	6	8	7	9	11	10	6	9	8
Winter	13	13	13	5	7	11	5	7	11	6	8	12	6	8	11

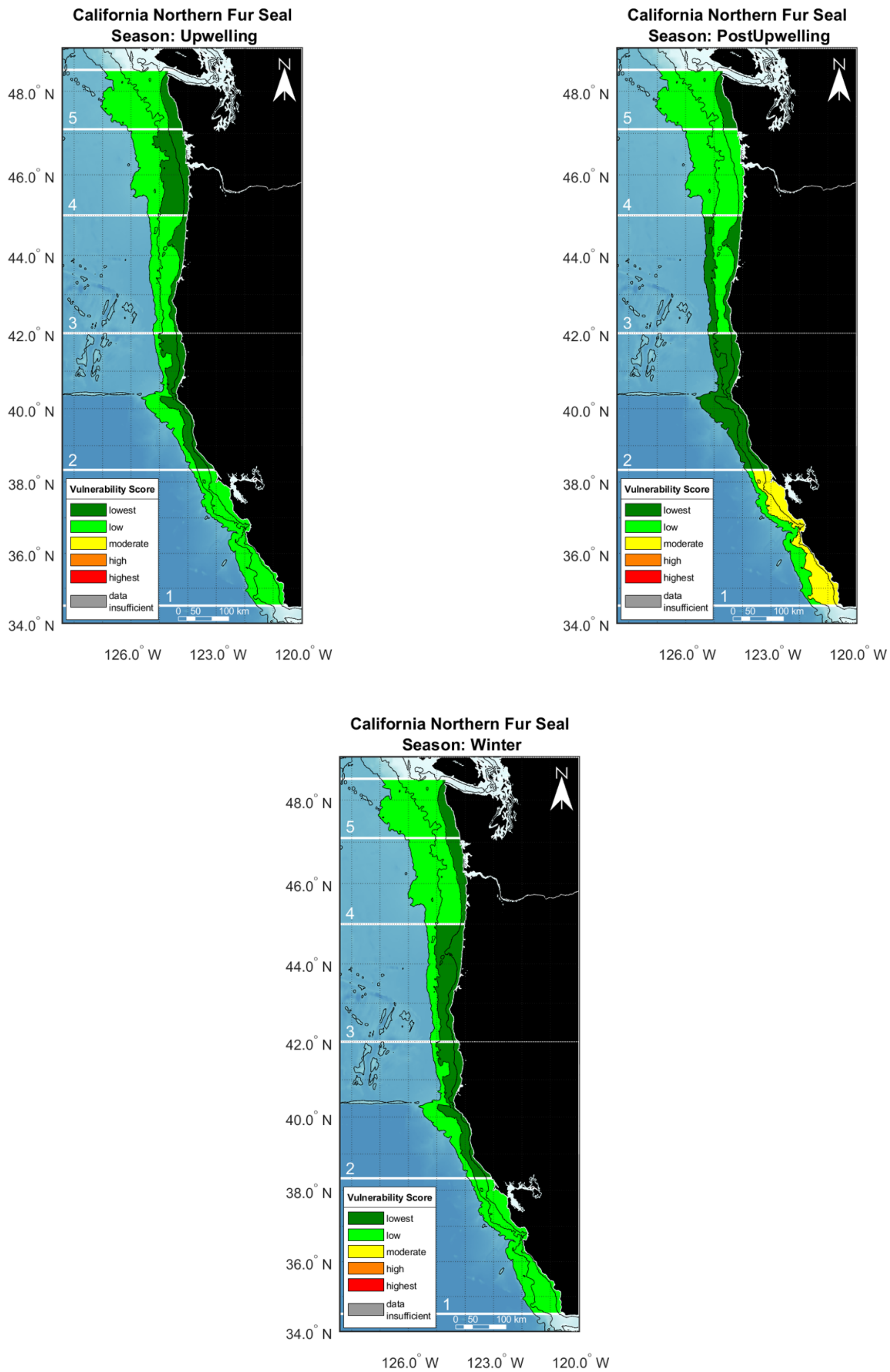


Figure 42. Northern fur seal (CA) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.3.5 NORTHERN FUR SEAL (Eastern N. Pacific)

Summary Assessment: Northern fur seals are distinguished into a California and an eastern North Pacific stock, each with separate SARs and each considered separately here. While there is relatively little data on at-sea distribution, the eastern N. Pacific stock is likely more abundant in the northern slope and oceanic zones, other than during the upwelling period when they may be more likely to occur in more southerly (non-slope) zones. Known breeding areas for this stock are north of spatial zones considered here. Scores ranged from relatively lowest (min 7) to the upper end of relatively low (max 14), with the highest relative scores occurring in slope and oceanic areas during the winter season. The eastern N. Pacific stock of northern fur seals is protected under the MMPA but was determined to have a declining population trend (2020 SAR references Johnson and Fritz (2014) and strongly declining trend at St. Paul rookery but recent evidence of stabilization due to increases at Bogoslof and St. George). The estimated population size (608,143 from 2020 SAR) greatly exceeds 2,500, resulting in a population factor score of 0. Spatial and temporal factor scores were based on expert elicitation using limited available information in the 2020 SAR (see Pelland 2014; Zeppelin et al. 2019). Physical interaction factor scores were relatively low given less sensitive otariid hearing (see: Southall et al. 2019) and predominately low frequencies of anthropogenic sounds. A comparable assessment was made as in California sea lions; low possible risk of vessel strike was assessed but moderate entanglement risk was assigned (based on Carretta et al. 2016; 2019 and some observations of entanglement from stranding facilities). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores for anthropogenic stressors were based on estimated annual human-induced mortality of 387 and PBR estimates of 11,067 individuals. Moderate chronic biological risk scores were based on factors identified in the 2020 SAR related to prey limitations in El Niño conditions.

Uncertainty Assessment: Low confidence in scores was assigned for all seasons and zones.

Key Data Gaps: None specified

Table 47. Northern fur seal (Eastern N. Pacific) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	10	12	13	8	10	13	9	12	13	9	11	13	9	12	14
Post-Upwelling	9	9	8	7	7	8	8	8	8	8	8	8	8	9	8
Winter	8	8	7	7	7	7	7	7	7	8	8	8	8	8	9

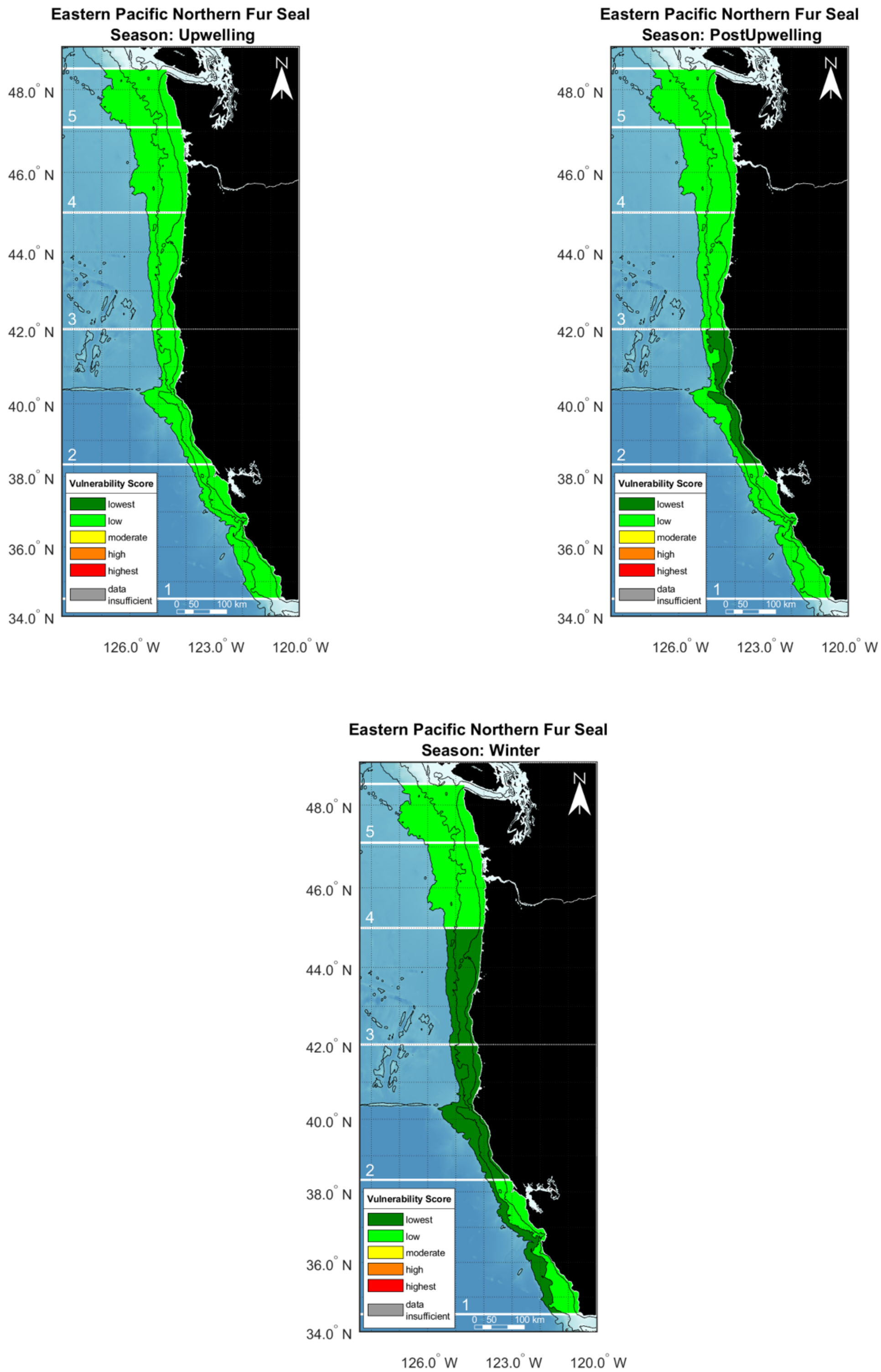


Figure 43. Northern fur seal (Eastern N. Pacific) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.3.6 NORTHERN ELEPHANT SEAL (CA Breeding)

Summary Assessment: Northern elephant seals are one of the best marine mammal conservation success stories recovering from near-extinction to near pre-hunting levels and wide distribution across the Pacific and an increasing (and northward) expansion of breeding areas. They have been extensively studied at many of these breeding rookeries and some of the most detailed and extensive data for marine megafauna exist due to extensive telemetry studies. Vulnerability risk scores were almost exclusively in the lowest (min 6) and low categories with the exception of a moderate score (max 15) in the southern shelf zone (1a) in which most breeding rookeries occur during the winter breeding season. Northern elephant seals are protected under the MMPA, have a long-term increasing population trend (Lowry 2017; 2020 SAR), and the estimated population size (179,000 from 2020 SAR) greatly exceeds 2,500. Spatial and temporal factor scores were based on expert elicitation using extensive empirical field data (LeBoeuf et al. 2000; Robinson et al. 2012; Lowry 2017; Beltran et al. 2022; Kienle et al. 2022). Physical interaction factor scores were relatively high given quite sensitive phocid hearing at low frequencies in general (and specifically measured in this species; see: Southall et al. 2019) and predominately low frequencies of anthropogenic sounds. A moderate possible risk of vessel strike and entanglement was assessed based on documented reports in the SAR (and see Carretta, 2014) including vessel and fishing gear interactions. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores for anthropogenic stressors were based on estimated annual human-induced mortality of 2.8 and PBR estimates of 4,882 individuals. A low biological risk score was based on the absence of documented such instances in the recent SARs.

Uncertainty Assessment: Given the extensive research effort in this species, high confidence scores were assigned for all zones and seasons.

Key Data Gaps: Fine-scale distribution and movement relative to specific lease/development areas

Table 48. Northern elephant seal vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	12	9	10	10	7	10	8	9	10	6	8	10	6	9	11
Post-Upwelling	12	9	7	10	7	7	6	6	7	6	6	7	6	7	8
Winter	15	11	10	14	10	10	5	5	10	6	6	11	6	6	10

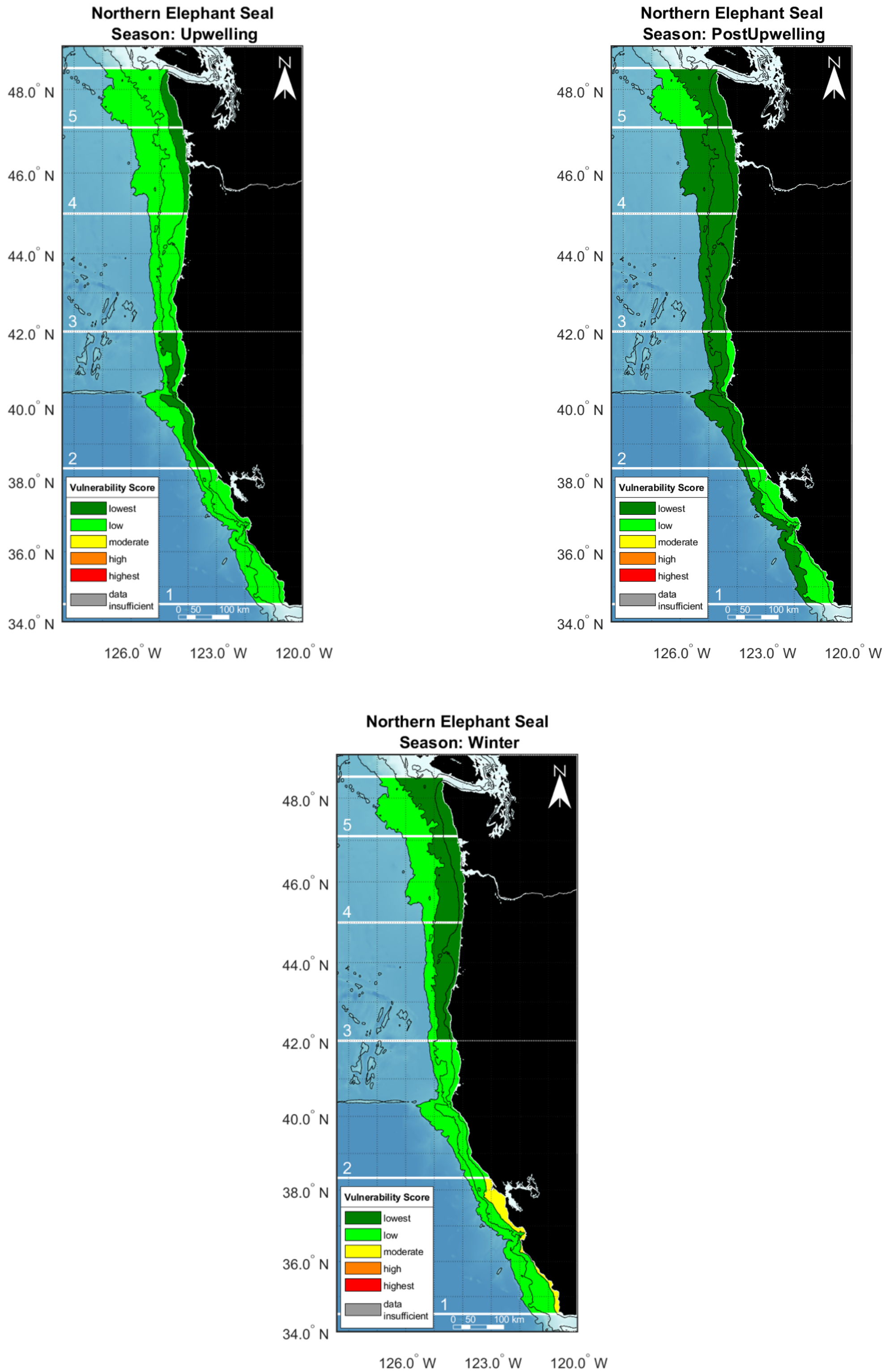


Figure 44. Northern elephant seal vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.3.7 HARBOR SEAL (California)

Summary Assessment: Harbor seals in the California Current Ecosystem are designated into two stocks—California and Oregon/Washington. Separate SARs exist for each stock, and they are considered separately here. The California stock is primarily limited to the southern two zones here and consequently has higher relative risk in these areas, particularly in shelf and slope zones. Vulnerability risk scores ranged from lowest relative risk (min 7) to moderate scores (max 18), which occurred exclusively in the upwelling season coinciding with the primary period of breeding. California stock harbor seals are protected under the MMPA, were interpreted to have a decreasing population trend (based on 2020 SAR), but the estimated population size (30,968 from 2020 SAR) exceeds 2,500. Spatial and temporal factor scores were based on expert elicitation using limited field distribution and movement data (Manugian et al. 2017) as well as foraging patterns in shelf and slope areas (Eguchi and Harvey, 2005). Physical interaction factor scores were relatively high given quite sensitive phocid hearing at low frequencies in general (and specifically measured in this species; see: Southall et al. 2019) and predominately low frequencies of anthropogenic sounds. Moderate possible risk of vessel strike and entanglement was assessed based on documented reports of vessel interactions for harbor seals in general in the 2020 SAR (and see Carretta, 2014) as well as documented instances of entanglement in fishing gear and marine debris and entrainment in power plants (Carretta et al. 2018). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Lowest possible scores for anthropogenic stressors were based on estimated annual human-induced mortality of 43 and PBR estimates of 1,641 individuals. A moderate biological risk score was based on documented instances of morbillivirus in the recent SARs.

Uncertainty Assessment: Moderate confidence in vulnerability risk scores was assigned for all zones and seasons.

Key Data Gaps: Fine-scale distribution and movement relative to specific lease/development areas and especially new vessel corridors during breeding seasons.

Table 49. Harbor seal (CA) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	18	15	10	16	13	10	7	7	7	7	7	7	7	7	7
Post-Upwelling	14	14	9	12	12	9	7	7	7	7	7	7	7	7	7
Winter	13	13	9	12	12	9	7	7	7	7	7	7	7	7	7

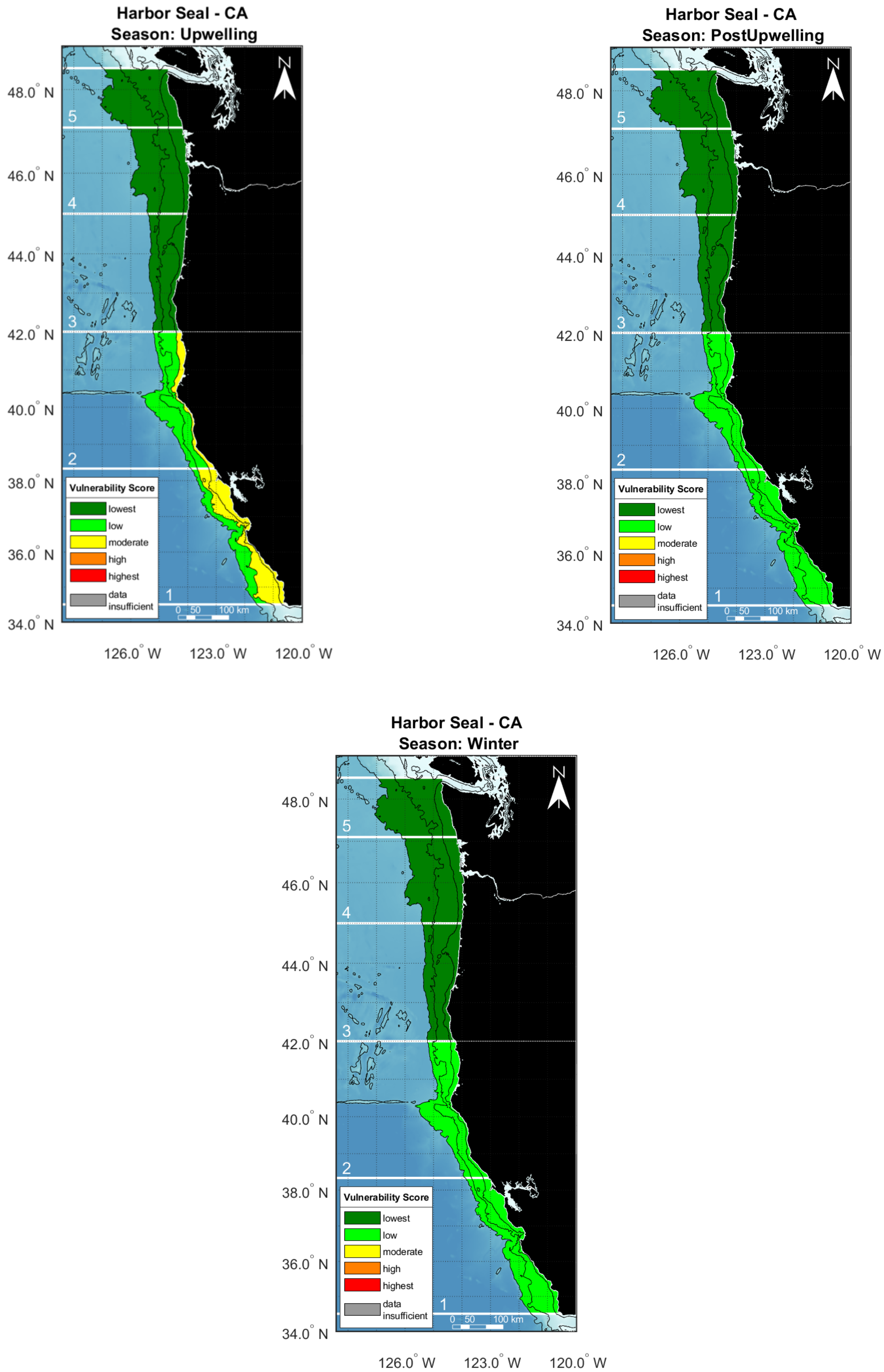


Figure 45. Harbor seal (CA) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter season.

3.3.8 HARBOR SEAL (OR/WA)

Summary Assessment: The OR/WA stock of harbor seals is primarily limited to the northern three zones here and consequently has higher relative risk in these areas, also mainly in shelf and slope zones. Vulnerability risk scores ranged from relatively low risk (min 13) in zones off California to relatively high scores (max 23), which occurred in shelf zones during the upwelling and post-upwelling seasons which overlap the slightly later (relative to CA harbor seals) primary periods of breeding. Harbor seals from the OR/WA stock are protected under the MMPA, but insufficient information exists to determine population trend (based on 2020 SAR). While the most-recently estimated population size (24,732) would suggest this exceeds 2,500, it has not been estimated since the 1999 SAR; an unknown population size was therefore assigned. Spatial and temporal factor scores were based on expert elicitation using limited field distribution and movement data (Steingass et al. 2019) foraging patterns in shelf and slope areas for CA harbor seals (Eguchi and Harvey 2005) were assumed to be applicable for this stock. Physical interaction factor scores were relatively high given quite sensitive phocid hearing at low frequencies in general (and specifically measured in this species; see: Southall et al. 2019) and predominately low frequencies of anthropogenic sounds. Moderate possible risk of vessel strike and entanglement was assessed based on documented reports of vessel interactions in the 2020 SAR (and see Carretta 2014) as well as documented instances of entanglement in fishing gear and marine debris and entrainment in power plants (Carretta et al. 2018). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). A moderate score for anthropogenic stressors was assigned given the absence of an estimated annual human-induced mortality or PBR. While not reported for OR/WA harbor seals a moderate biological risk score was based on documented instances of morbillivirus in recent SARs for CA stock given limited information or investigation.

Uncertainty Assessment: Moderate confidence in risk scores was assigned for all zones/seasons.

Key Data Gaps: Fine-scale distribution and movement relative to specific lease/development areas and especially new vessel corridors during breeding seasons.

Table 50. Harbor seal (OR/WA) vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	13	13	13	13	13	13	23	21	16	23	20	16	23	21	17
Post-Upwelling	13	13	13	13	13	13	23	20	16	23	20	16	23	21	17
Winter	13	13	13	13	13	13	18	18	15	19	19	16	19	19	15

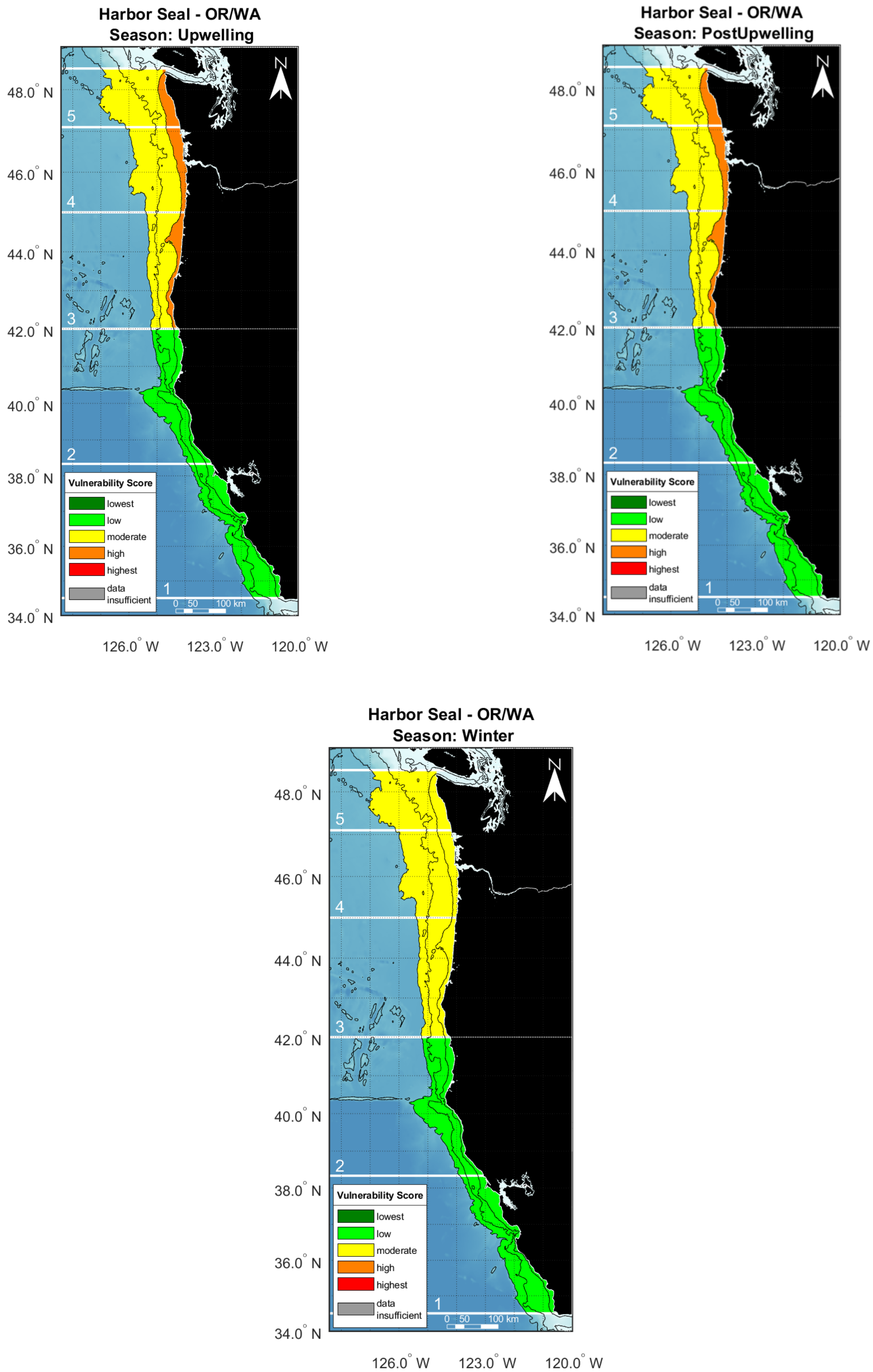


Figure 46. Harbor seal (OR/WA) vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.4 Vulnerability Risk Assessment – Sea Turtles

3.4.1 LEATHERBACK SEA TURTLE (Western Pacific DPS)

Summary Assessment: Leatherback sea turtles are one of the most endangered and ecologically important marine megafauna species on the U.S. West Coast. They have repeatedly been identified as a key species in conservation planning, including the NOAA-NMFS Recovery Plan outlined in 1998, NOAA Species in the Spotlight Action Plan (2021), and NOAA 5-year Review completed in 2020 and 2013 (see also: Avens et al. 2020). Vulnerability risk scores ranged from moderate (min 20) scores in the winter season to the overall highest scores for any species (max 34). Highest scores occurred in the southern zones during the upwelling and post-upwelling seasons. Leatherback sea turtles are ESA-listed (endangered), have a decreasing population trend (Tapilatu et al. 2013; Sato 2017a; Benson et al. 2020), and have an estimated population size of 777 adult females (< 2,500 criteria). Spatial and temporal factor scores were based on expert elicitation using telemetry and aerial survey data (Benson et al. 2007; 2011; 2020). Physical interaction factor scores were relatively high given limited information on their auditory and electromagnetic sensitivity. High risk of vessel strikes wad assigned based on extensive observations and observations from stranding facilities. Entanglement risk was also assessed as highest based on many documented reports of longline interactions (Lewison et al. 2004; Martin et al. 2020; Shamblin et al. 2020). Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Moderate anthropogenic stressor score was assigned given documented instances of human mortality (Curtis et al. 2015) and the absence of an estimated annual human-induced mortality in other areas; PBR is not determined for sea turtles. A moderate biological risk score was based on domoic acid related issues in at least some zones.

Uncertainty Assessment: High confidence for CA zones (1 and 2); moderate for OR/WA zones (3–5).

Key Data Gaps: Additional research and monitoring to determine masking and electromagnetic risks, mortality associated with vessel strikes, better information on profile of cables and protective gear to evaluate entanglement risk, and better information on stressor interactions.

Table 51. Leatherback sea turtle vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	29	29	27	23	23	23	23	24	22	23	23	22	24	25	24
Post-Upwelling	34	31	29	29	29	26	28	28	27	28	28	27	28	29	28
Winter	23	22	21	21	21	21	20	20	20	21	21	21	21	21	20

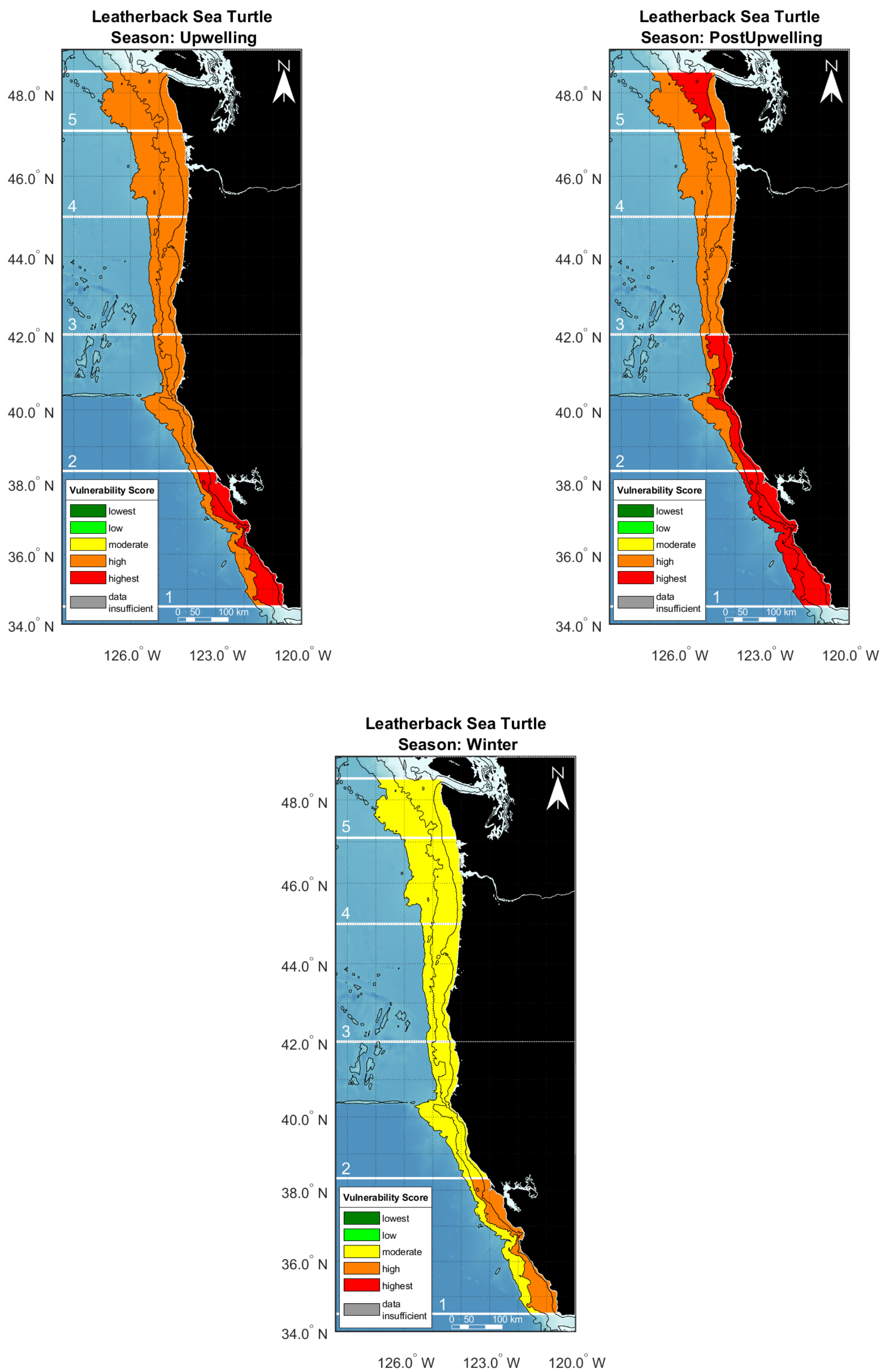


Figure 47. Leatherback sea turtle vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.4.2 LOGGERHEAD SEA TURTLE (North Pacific DPS)

Summary Assessment: Loggerhead sea turtles are also an endangered and ecologically important marine megafauna species. They have a more oceanic distribution than leatherbacks and are similarly less prevalent in the region considered here in the winter season. Vulnerability risk scores for this key species were relatively consistent across seasons and zones, ranging from moderate (min 19) to relatively high (max 22). Loggerhead sea turtles are ESA-listed (endangered), have a decreasing population trend (Sato 2017b; NOAA 2020 5-year review), but have an estimated population size exceeding 2,500 individuals (4,541 adult females; Shamblin et al. 2020). Spatial and temporal factor scores were based on expert elicitation using available data on juveniles and adults coming across the Pacific from Hawaii and during warm-water periods which increase the chances of their occurrence in the region considered here (Dutton et al. 2019; Briscoe et al. 2021). Similar scores and assessments to leatherbacks were made for loggerheads in terms of physical interaction factors, vessel strike, and entanglement risks (also see: Lewison et al. 2004), with similar recommended research needs. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Moderate anthropogenic stressor score was assigned given expected susceptibility to human mortality and the general absence of information; it was noted that a similar approach to leatherbacks was taken but that no specific reference exists, and this score was assigned as a precautionary assessment. Similarly, a moderate biological risk score was based largely on the absence of information.

Uncertainty Assessment: Moderate confidence was assigned for zones and seasons.

Key Data Gaps: More systematic monitoring and observational data. Vessel and satellite tracking, aerial surveys, and environmental data to understand habitat use. More fishermen and whale watcher community science.

Table 52. Loggerhead sea turtle vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	21	21	20	19	19	20	20	21	20	20	20	19	20	21	20
Post-Upwelling	21	22	21	19	19	21	20	20	20	20	20	21	20	21	20
Winter	20	20	19	19	19	19	19	19	19	20	20	20	20	20	19

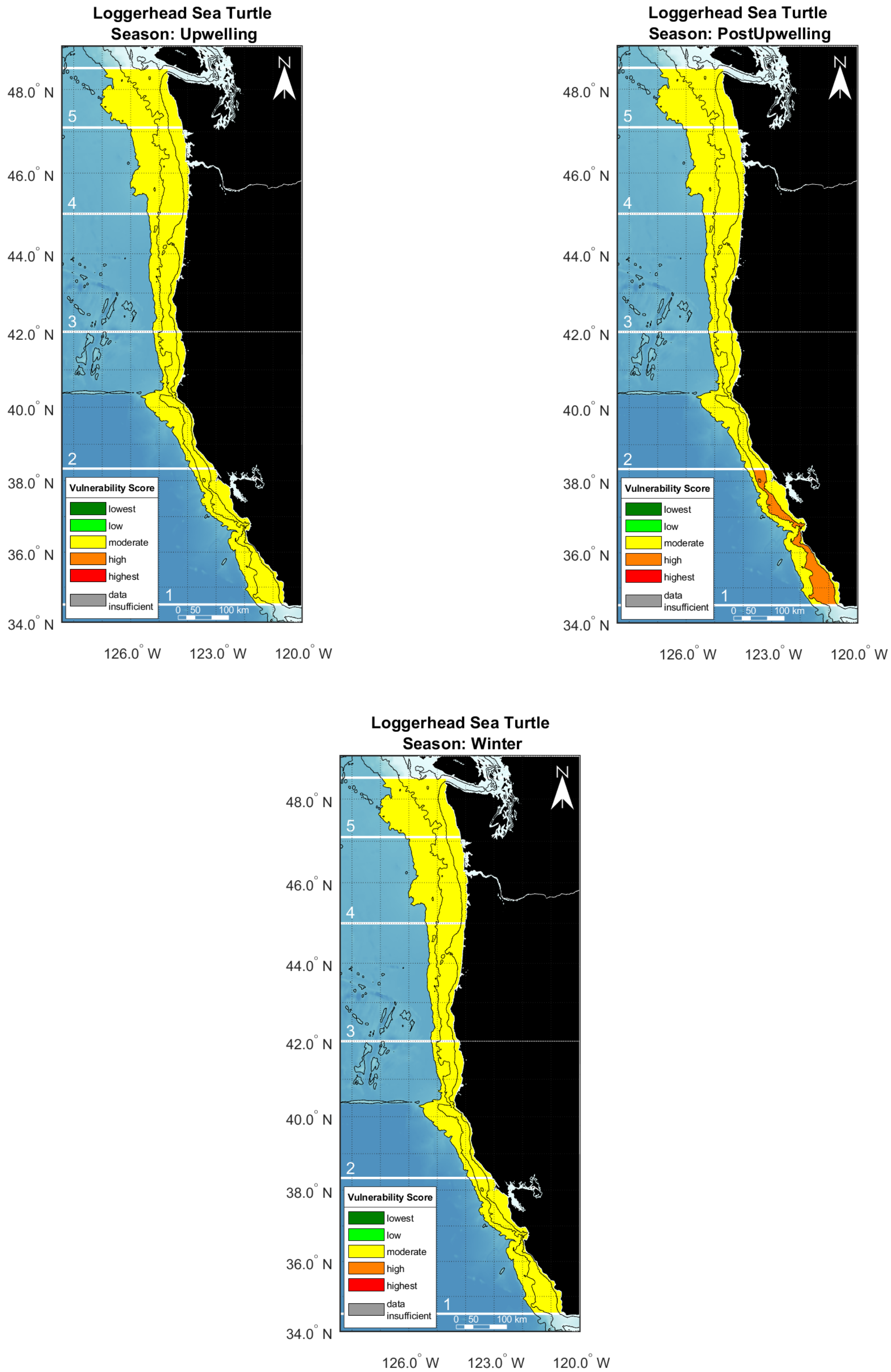


Figure 48. Loggerhead sea turtle vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.4.3 GREEN SEA TURTLE

Summary Assessment: Green sea turtles are ESA-listed (threatened) and rarely but occasionally occur in the region here, most commonly in the shelf zones in the more southerly portion of the region and during post-upwelling seasons. Vulnerability risk scores were relatively consistent across seasons and zones, ranging from relatively low (min 14) to moderate (max 18). Green sea turtles have an increasing population trend (Sato 2017b; NOAA 2020 5-year review) and an estimated population size exceeding 2,500 individuals (20,112 females recorded at 39 nesting sites along the western coast of Mexico (Sato 2017b). Spatial and temporal factor scores were based on expert elicitation using largely observational data from sightings during anomalous events. Similar scores and assessments as for leatherbacks were made for green sea turtles in terms of physical interaction factors (masking and electromagnetic risk; hearing data from Ketten and Bartol (2005) were noted for this species), vessel strike, and entanglement risks (also see: Lewison et al. 2004), with similar recommended research needs. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Moderate anthropogenic stressor score was similarly assigned given expected susceptibility to human mortality and the general absence of information; it was noted that a similar approach to leatherbacks was taken but that no specific reference exists, and this score was assigned as a precautionary assessment. A moderate biological risk score was also based largely on the absence of information.

Uncertainty Assessment: Moderate confidence was assigned for zones and seasons.

Key Data Gaps: More systematic monitoring and observational data. Vessel and satellite tracking, aerial surveys, and environmental data to understand habitat use. More fishermen and whale watcher community science.

Table 53. Green sea turtle vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	16	16	14	14	14	14	15	16	14	15	15	14	15	16	15
Post-Upwelling	18	16	14	14	14	14	15	15	14	16	15	14	15	16	15
Winter	15	15	14	14	14	14	14	14	14	15	15	15	15	15	14

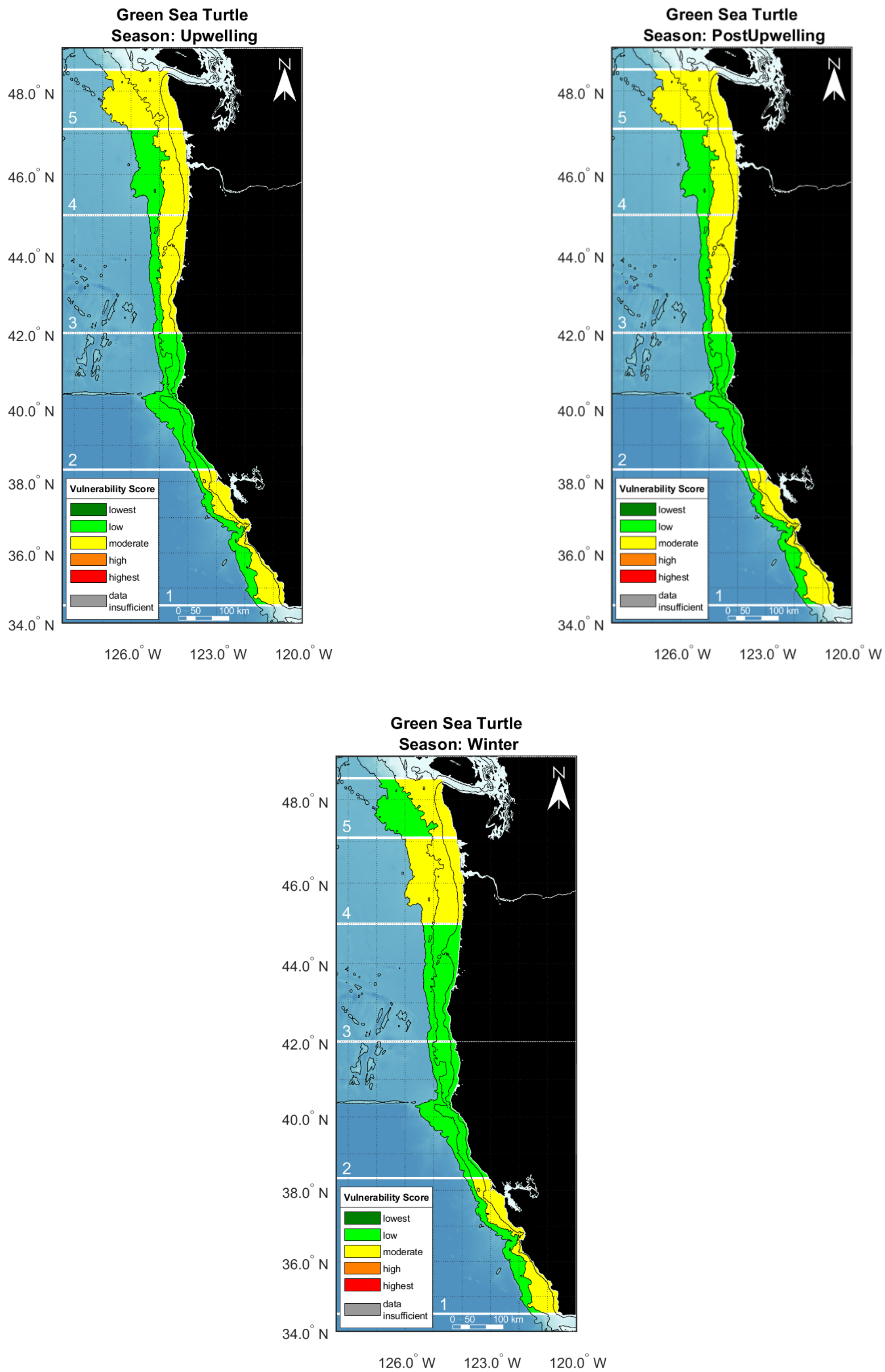


Figure 49. Green sea turtle vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

3.4.4 OLIVE RIDLEY SEA TURTLE (Western Pacific DPS)

Summary Assessment: Olive ridley sea turtles are ESA-listed (threatened) and rarely but occasionally occur in the region here, as with green sea turtles most commonly in the shelf zones in the more southerly portion of the region and during post-upwelling seasons. Vulnerability risk scores were very consistent across seasons and zones, all scored as moderate with a narrow overall range (15-17). Olive ridley sea turtles have a stable evaluated population trend (NMFS and USFWS 2014) and an estimated population size exceeding 2,500 individuals (NMFS and USFWS 2014). Spatial and temporal factor scores were based on expert elicitation using largely observational data from sightings during anomalous events (and see: Richardson et al. 1997). Similar scores and assessments as for leatherbacks were made for Olive ridley sea turtles in terms of physical interaction factors (masking and electromagnetic risk), vessel strike, and entanglement risks (also see: Lewison et al. 2004), with similar recommended research needs. Chronic anthropogenic noise factor scores for each zone were consistent with other species as described above (section 2.3). Moderate anthropogenic stressor score was similarly assigned given expected susceptibility to human mortality and the general absence of information; it was noted that a similar approach to leatherbacks was taken but that no specific reference exists, and this score was assigned as a precautionary assessment. A moderate biological risk score was also based largely on the absence of information.

Uncertainty Assessment: Moderate confidence was assigned for zones and seasons.

Key Data Gaps: More systematic monitoring and observational data. Vessel and satellite tracking, aerial surveys, and environmental data to understand habitat use. More fishermen and whale watcher community science.

Table 54. Olive ridley sea turtle vulnerability scores (out of 36) by geographic zone, depth within geographic zone, and season.

	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
Oceanographic Season	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**
Upwelling	17	17	16	15	15	16	16	17	16	16	16	16	16	17	17
Post-Upwelling	17	17	17	15	15	16	16	16	15	16	16	17	16	17	16
Winter	16	16	16	15	15	16	15	15	15	16	16	16	16	16	15

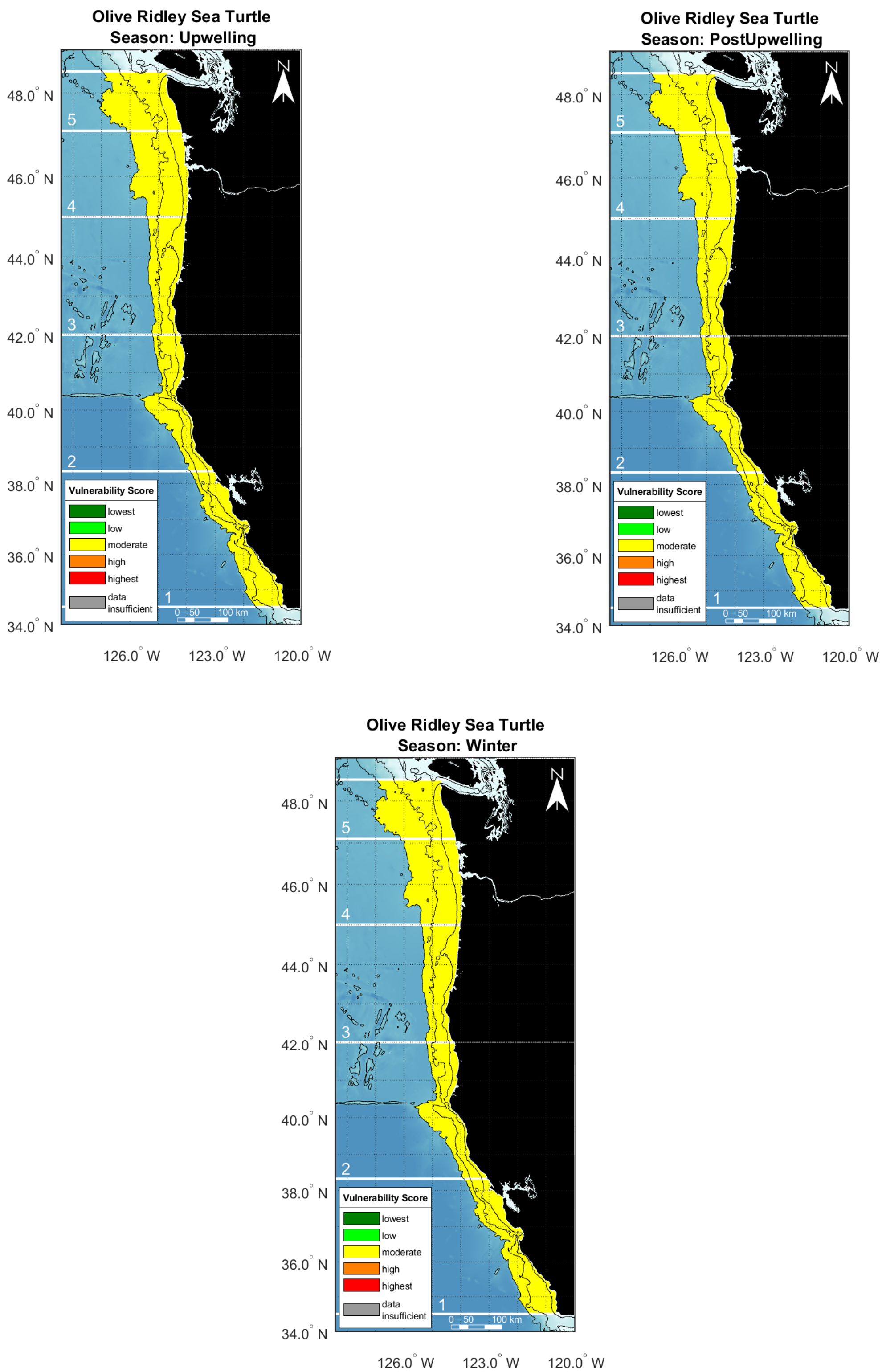


Figure 50. Olive ridley sea turtle vulnerability ratings by geographic zone for upwelling, post-upwelling, and winter seasons.

4 Vulnerability Risk Assessment Results – By Zone Across Species

4.1 Vulnerability Risk Assessment – Zone 1

4.1.1 Zone 1a – Central California: Shelf (< 100 m depth)

Summary Assessment: The shelf zone in central California (Zone 1a) has some of the consistently highest vulnerability assessed overall, with slightly fewer moderate to highest scores assigned during the winter season. Leatherback sea turtles, southern resident killer whales, western north Pacific gray whales, and Central American DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, 4 species had highest relative risk scores, 3 were relatively high, and 17 were moderate. For the post-upwelling, 3 species were highest, 3 were relatively high, and 16 were moderate. For winter, 2 species were highest, 5 were relatively high, and 14 were moderate.

Table 55. Central California shelf (Zone 1a) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		*POST-UPWELLING*		*WINTER*	
Gray whale (Western N. Pacific)	*31*	*Leatherback sea turtle*	*34*	*Killer whale (S. Resident)*	*31*
Humpback whale (Central Amer. DPS)	*31*	*Humpback whale (Central Amer. DPS)*	*30*	*Gray whale (Western N. Pacific)*	*30*
Killer whale (S. Resident)	*29*	*Killer whale (S. Resident)*	*29*	*Humpback whale (Central Amer. DPS)*	*29*
Leatherback sea turtle	*29*	*Blue whale*	*29*	*Blue whale*	*24*
Humpback whale (Mexican DPS)	*26*	*Humpback whale (Mexican DPS)*	*25*	*Coastal bottlenose dolphin*	*24*
Blue whale	*25*	*Gray whale (Western N. Pacific)*	*24*	*Humpback whale (Mexican DPS)*	*24*
Bottlenose dolphin	*22*	*Bottlenose dolphin*	*22*	*Leatherback sea turtle*	*23*
Gray whale (Eastern N. Pacific)	*21*	*Loggerhead sea turtle*	*21*	*Gray whale (Eastern N. Pacific)*	*20*
Loggerhead sea turtle	*21*	*Minke whale*	*20*	*Harbor Porpoise (Morro Bay)*	*20*
Harbor Porpoise (Morro Bay)	*20*	*Harbor Porpoise (Morro Bay)*	*20*	*Harbor Porpoise (Monterey Bay)*	*20*
Harbor Porpoise (Monterey Bay)	*20*	*Harbor Porpoise (Monterey Bay)*	*20*	*Loggerhead sea turtle*	*20*
Harbor Porpoise (SF/Russian River)	*19*	*Fin whale*	*20*	*Harbor Porpoise (SF/Russian River)*	*19*
Fin whale	*18*	*Harbor Porpoise (SF/Russian River)*	*19*	*Fin whale*	*17*
Harbor seal (CA)	*18*	*Green sea turtle*	*18*	*Olive Ridley sea turtle*	*16*
Humpback whale (Hawaii DPS)	*18*	*Sei whale*	*17*	*Humpback whale (Hawaii DPS)*	*16*
Olive Ridley sea turtle	*17*	*Olive Ridley sea turtle*	*17*	*Bryde's whale*	*15*
Bryde's whale	*16*	*Humpback whale (Hawaii DPS)*	*17*	*Minke whale*	*15*
Minke whale	*16*	*Sperm whale*	*17*	*Sperm whale*	*16*
Sperm whale	*17*	*Northern fur seal (CA)*	*16*	*Killer whale (Offshore)*	*15*
Killer whale (Offshore)	*16*	*Killer whale (Offshore)*	*16*	*Northern elephant seal*	*15*
California sea lion	*16*	*California sea lion*	*16*	*Green sea turtle*	*15*
Green sea turtle	*16*	*Bryde's whale*	*16*	*Killer Whale (Transient)*	*13*
Killer Whale (Transient)	*15*	*Steller sea lion*	*15*	*Risso's dolphin*	*13*
Steller sea lion	*15*	*Killer Whale (Transient)*	*14*	*Long-beaked common dolphin*	*13*
Risso's dolphin	*14*	*Harbor seal (CA)*	*14*	*Northern fur seal (CA)*	*13*
Northern fur seal (CA)	*14*	*Gray whale (Eastern N. Pacific)*	*14*	*Harbor seal (CA)*	*13*
Long-beaked common dolphin	*13*	*Short-beaked common dolphin*	*13*	*Harbor seal (OR/WA)*	*13*
Harbor seal (OR/WA)	*13*	*Risso's dolphin*	*13*	*Short-finned pilot whale*	*11*
Short-finned pilot whale	*12*	*Long-beaked common dolphin*	*13*	*Baird's beaked whale*	*11*
Baird's beaked whale	*12*	*Harbor seal (OR/WA)*	*13*	*Other beaked whales*	*11*
Other beaked whales	*12*	*Short-finned pilot whale*	*12*	*California sea lion*	*11*
Northern elephant seal	*12*	*Northern elephant seal*	*12*	*Steller sea lion*	*10*
Pacific White-sided dolphin	*10*	*Baird's beaked whale*	*12*	*Dall's Porpoise*	*8*
Northern fur seal (Eastern N. Pacific)	*10*	*Other beaked whales*	*11*	*Northern fur seal (Eastern N. Pacific)*	*8*
Dall's Porpoise	*9*	*Pacific White-sided dolphin*	*10*	*Pacific White-sided dolphin*	*7*
Guadalupe fur seal	*8*	*Northern fur seal (Eastern N. Pacific)*	*9*	*Northern right whale dolphin*	*7*
Pygmy and dwarf sperm whale	*7*	*Dall's Porpoise*	*9*	*Guadalupe fur seal*	*7*
Northern right whale dolphin	*7*	*Guadalupe fur seal*	*8*	*Pygmy and dwarf sperm whale*	*6*
Short-beaked common dolphin	*7*	*Pygmy and dwarf sperm whale*	*7*	*Short-beaked common dolphin*	*6*
Sei whale	*n/a*	*Northern right whale dolphin*	*7*	*Sei whale*	*n/a*
N. Pacific right whale	*n/a*	*N. Pacific right whale*	*n/a*	*N. Pacific right whale*	*n/a*
Harbor Porpoise (N CA/S OR)	*n/a*	*Harbor Porpoise (N OR/WA Coast)*	*n/a*	*Harbor Porpoise (N CA/S OR)*	*n/a*
Harbor Porpoise (N OR/WA Coast)	*n/a*	*Harbor Porpoise (N CA/S OR)*	*n/a*	*Harbor Porpoise (N OR/WA Coast)*	*n/a*

4.1.2 Zone 1b – Central California: Slope (100–1,000 m depth)

Summary Assessment: The slope zone in central California (Zone 1b) also has consistently elevated vulnerability risk scores overall. For Zone 1b, the greatest number of high and highest scores occurred in the post-upwelling season, but there was again some indication of lower overall risk during winter. Blue whales, leatherback sea turtles, southern resident killer whales, and Central American and Mexican DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, 4 species had highest relative risk scores, 3 were relatively high, and 20 were moderate. For the post-upwelling, 5 species were highest, 4 were relatively high, and 17 were moderate. For winter, 2 species were highest, 5 were relatively high, and 15 were moderate.

Table 56. Central California slope (Zone 1b) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		*POST-UPWELLING*		*WINTER*	
Humpback whale (Central Amer. DPS)	31	*Blue whale*	32	*Killer whale (S. Resident)*	31
Killer whale (S. Resident)	29	*Leatherback sea turtle*	31	*Humpback whale (Central Amer. DPS)*	29
Humpback whale (Mexican DPS)	29	*Humpback whale (Central Amer. DPS)*	30	*Humpback whale (Mexican DPS)*	27
Leatherback sea turtle	29	*Killer whale (S. Resident)*	29	*Blue whale*	24
Gray whale (Western N. Pacific)	28	*Humpback whale (Mexican DPS)*	28	*Gray whale (Western N. Pacific)*	23
Blue whale	25	*Fin whale*	27	*Leatherback sea turtle*	22
Sperm whale	23	*Sperm whale*	23	*Sperm whale*	22
Loggerhead sea turtle	21	*Gray whale (Western N. Pacific)*	22	*Harbor Porpoise (Monterey Bay)*	20
Harbor Porpoise (Monterey Bay)	20	*Loggerhead sea turtle*	22	*Loggerhead sea turtle*	20
Fin whale	20	*Minke whale*	20	*Fin whale*	19
Minke whale	20	*Harbor Porpoise (Monterey Bay)*	20	*Minke whale*	19
Gray whale (Eastern N. Pacific)	18	*Harbor Porpoise (Morro Bay)*	17	*Harbor Porpoise (Morro Bay)*	17
Humpback whale (Hawaii DPS)	18	*Olive Ridley sea turtle*	17	*Coastal bottlenose dolphin*	16
Harbor Porpoise (Morro Bay)	17	*Humpback whale (Hawaii DPS)*	17	*Harbor Porpoise (SF/Russian River)*	16
Olive Ridley sea turtle	17	*Harbor Porpoise (SF/Russian River)*	16	*Olive Ridley sea turtle*	16
Harbor Porpoise (SF/Russian River)	16	*Green sea turtle*	16	*Long-beaked common dolphin*	16
Bryde's whale	16	*Northern fur seal (CA)*	16	*Humpback whale (Hawaii DPS)*	16
Killer whale (Offshore)	16	*Killer whale (Offshore)*	16	*Bryde's whale*	15
California sea lion	16	*California sea lion*	16	*Killer whale (Offshore)*	15
Green sea turtle	16	*Bryde's whale*	16	*Green sea turtle*	15
Long-beaked common dolphin	16	*Short-beaked common dolphin*	16	*Baird's beaked whale*	15
Baird's beaked whale	16	*Long-beaked common dolphin*	16	*Other beaked whales*	15
Other beaked whales	16	*Baird's beaked whale*	16	*Short-finned pilot whale*	14
Bottlenose dolphin	15	*Bottlenose dolphin*	15	*Gray whale (Eastern N. Pacific)*	13
Harbor seal (CA)	15	*Short-finned pilot whale*	15	*Killer Whale (Transient)*	13
Killer Whale (Transient)	15	*Other beaked whales*	15	*Risso's dolphin*	13
Short-finned pilot whale	15	*Killer Whale (Transient)*	14	*Northern fur seal (CA)*	13
Risso's dolphin	14	*Harbor seal (CA)*	14	*Harbor seal (CA)*	13
Northern fur seal (CA)	14	*Risso's dolphin*	13	*Harbor seal (OR/WA)*	13
Harbor seal (OR/WA)	13	*Harbor seal (OR/WA)*	13	*Pacific White-sided dolphin*	13
Pacific White-sided dolphin	13	*Gray whale (Eastern N. Pacific)*	12	*Northern elephant seal*	11
Northern fur seal (Eastern N. Pacific)	12	*Steller sea lion*	11	*California sea lion*	11
Dall's Porpoise	12	*Pacific White-sided dolphin*	10	*Dall's Porpoise*	11
Steller sea lion	11	*Northern elephant seal*	9	*Steller sea lion*	10
Northern right whale dolphin	10	*Northern fur seal (Eastern N. Pacific)*	9	*Short-beaked common dolphin*	9
Short-beaked common dolphin	10	*Dall's Porpoise*	9	*Northern fur seal (Eastern N. Pac.)*	8
Northern elephant seal	9	*Guadalupe fur seal*	8	*Northern right whale dolphin*	7
Guadalupe fur seal	8	*Pygmy and dwarf sperm whale*	7	*Guadalupe fur seal*	7
Pygmy and dwarf sperm whale	7	*Northern right whale dolphin*	7	*Pygmy and dwarf sperm whale*	6
Sei whale	n/a	*Sei whale*	n/a	*Sei whale*	n/a
N. Pacific right whale	n/a	*Harbor Porpoise (N OR/WA Coast)*	n/a	*N. Pacific right whale*	n/a
Harbor Porpoise (N CA/S OR)	n/a	*Harbor Porpoise (N CA/S OR)*	n/a	*Harbor Porpoise (N CA/S OR)*	n/a
Harbor Porpoise (N OR/WA Coast)	n/a	*N. Pacific right whale*	n/a	*Harbor Porpoise (N OR/WA Coast)*	n/a

4.1.3 Zone 1c – Central California Oceanic (1,000–2,500 m depth)

Summary Assessment: The oceanic zone in central California (Zone 1c) has much lower overall predicted risk relative to the shelf (1a) and slope (1b) zones overall, again with a slight indication of reduced risk in the winter season. Leatherback sea turtles, blue and fin whales, and Central American and Mexican DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, 0 species had highest relative risk scores, 6 were relatively high, and 7 were moderate. For the post-upwelling, 1 species was highest, 5 were relatively high, and 7 were moderate. For winter, 0 species were highest, 3 were relatively high, and 10 were moderate.

Table 57. Central California oceanic (Zone 1c) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		*POST-UPWELLING*		*WINTER*	
Leatherback sea turtle	27	Leatherback sea turtle	29	Humpback whale (Central Amer. DPS)	25
Humpback whale (Mexican DPS)	26	Blue whale	27	Humpback whale (Mexican DPS)	24
Humpback whale (Central Amer. DPS)	26	Fin whale	25	Blue whale	23
Killer whale (S. Resident)	23	Humpback whale (Central Amer. DPS)	25	Killer whale (S. Resident)	21
Blue whale	23	Humpback whale (Mexican DPS)	25	Leatherback sea turtle	21
Fin whale	22	Killer whale (S. Resident)	23	Gray whale (Western N. Pacific)	20
Sperm whale	21	Loggerhead sea turtle	21	Loggerhead sea turtle	19
Gray whale (Western N. Pacific)	20	Sperm whale	21	Fin whale	18
Loggerhead sea turtle	20	Gray whale (Western N. Pacific)	20	Minke whale	18
Minke whale	18	Minke whale	18	Sperm whale	18
Baird's beaked whale	17	Olive Ridley sea turtle	17	Baird's beaked whale	17
Olive Ridley sea turtle	16	Baird's beaked whale	17	Olive Ridley sea turtle	16
Humpback whale (Hawaii DPS)	16	Humpback whale (Hawaii DPS)	15	Humpback whale (Hawaii DPS)	15
Bryde's whale	14	Green sea turtle	14	Bryde's whale	14
Killer whale (Offshore)	14	Northern fur seal (CA)	14	Killer whale (Offshore)	14
Green sea turtle	14	Killer whale (Offshore)	14	Green sea turtle	14
Other beaked whales	14	Bryde's whale	14	Other beaked whales	14
Killer Whale (Transient)	13	Short-beaked common dolphin	14	Short-finned pilot whale	13
Short-finned pilot whale	13	Short-finned pilot whale	13	Northern fur seal (CA)	13
Northern fur seal (CA)	13	Other beaked whales	13	Harbor seal (OR/WA)	13
Harbor seal (OR/WA)	13	Harbor seal (OR/WA)	13	Coastal bottlenose dolphin	12
Northern fur seal (Eastern N. Pacific)	13	Killer Whale (Transient)	12	Killer Whale (Transient)	12
Risso's dolphin	12	Long-beaked common dolphin	11	Risso's dolphin	12
Long-beaked common dolphin	11	Bottlenose dolphin	11	Long-beaked common dolphin	11
Bottlenose dolphin	11	Risso's dolphin	11	Pacific White-sided dolphin	11
Pacific White-sided dolphin	11	Pacific White-sided dolphin	11	Short-beaked common dolphin	11
Northern right whale dolphin	11	Gray whale (Eastern N. Pacific)	10	Gray whale (Eastern N. Pacific)	10
Gray whale (Eastern N. Pacific)	10	Harbor seal (CA)	9	Northern elephant seal	10
Harbor seal (CA)	10	Steller sea lion	9	Dall's Porpoise	10
Dall's Porpoise	10	Northern fur seal (Eastern N. Pacific)	8	Harbor seal (CA)	9
Northern elephant seal	10	Guadalupe fur seal	8	Steller sea lion	9
Steller sea lion	9	Pygmy and dwarf sperm whale	8	Northern right whale dolphin	8
Short-beaked common dolphin	8	Northern right whale dolphin	8	Guadalupe fur seal	8
Guadalupe fur seal	8	California sea lion	7	Pygmy and dwarf sperm whale	8
Pygmy and dwarf sperm whale	8	Northern elephant seal	7	California sea lion	7
California sea lion	7	Dall's Porpoise	7	Northern fur seal (Eastern N. Pacific)	7
Sei whale	n/a	Sei whale	n/a	Sei whale	n/a
N. Pacific right whale	n/a	N. Pacific right whale	n/a	N. Pacific right whale	n/a
Harbor Porpoise (N CA/S OR)	n/a	Harbor Porpoise (N OR/WA Coast)	n/a	Harbor Porpoise (N CA/S OR)	n/a
Harbor Porpoise (N OR/WA Coast)	n/a	Harbor Porpoise (N CA/S OR)	n/a	Harbor Porpoise (N OR/WA Coast)	n/a
Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a
Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a
Harbor Porpoise (SF/Russian River)	n/a	Harbor Porpoise (SF/Russian River)	n/a	Harbor Porpoise (SF/Russian River)	n/a

4.2 Vulnerability Risk Assessment – Zone 2

4.2.1 Zone 2a – Northern California Shelf (< 100 m depth)

Summary Assessment: The shelf zone in northern California (Zone 2a) has relatively low vulnerability risk scores overall, with again some indication of slightly lower risk during winter. Southern resident killer whales, leatherback sea turtles, western north Pacific gray whales, blue whales, and Central American DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, 1 species had highest relative risk scores, 3 were relatively high, and 11 were moderate. For the post-upwelling season, 1 species was highest, 3 were relatively high, and 11 were moderate. For winter, 1 species was highest, 1 was relatively high, and 12 were moderate.

Table 58. Northern California shelf (Zone 2a) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		*POST-UPWELLING*		*WINTER*	
Gray whale (Western N. Pacific)	29	*Leatherback sea turtle*	29	*Killer whale (S. Resident)*	30
Killer whale (S. Resident)	27	*Blue whale*	27	*Gray whale (Western N. Pacific)*	26
Leatherback sea turtle	23	*Killer whale (S. Resident)*	27	*Blue whale*	21
Humpback whale (Central Amer. DPS)	22	*Gray whale (Western N. Pacific)*	26	*Leatherback sea turtle*	21
Blue whale	21	*Humpback whale (Central Amer. DPS)*	21	*Humpback whale (Central Amer. DPS)*	21
Humpback whale (Mexican DPS)	20	*Harbor Porpoise (SF/Russian River)*	19	*Humpback whale (Mexican DPS)*	19
Gray whale (Eastern N. Pacific)	19	*Loggerhead sea turtle*	19	*Harbor Porpoise (SF/Russian River)*	19
Harbor Porpoise (SF/Russian River)	19	*Humpback whale (Mexican DPS)*	19	*Loggerhead sea turtle*	19
Loggerhead sea turtle	19	*Humpback whale (Hawaii DPS)*	17	*Humpback whale (Hawaii DPS)*	17
Humpback whale (Hawaii DPS)	18	*Fin whale*	16	*Fin whale*	16
Fin whale	16	*Gray whale (Eastern N. Pacific)*	16	*Gray whale (Eastern N. Pacific)*	16
Harbor seal (CA)	16	*Sei whale*	15	*Harbor Porpoise (N CA/S OR)*	15
Harbor Porpoise (N CA/S OR)	15	*Harbor Porpoise (N CA/S OR)*	15	*Olive Ridley sea turtle*	15
Olive Ridley sea turtle	15	*Olive Ridley sea turtle*	15	*Sperm whale*	15
Sperm whale	15	*Sperm whale*	15	*Minke whale*	14
Minke whale	14	*Minke whale*	14	*Killer whale (Offshore)*	14
Killer whale (Offshore)	14	*Killer whale (Offshore)*	14	*Northern elephant seal*	14
Green sea turtle	14	*Green sea turtle*	14	*Green sea turtle*	14
Steller sea lion	13	*Steller sea lion*	13	*Harbor seal (OR/WA)*	13
Harbor seal (OR/WA)	13	*Harbor seal (OR/WA)*	13	*Killer Whale (Transient)*	12
Killer Whale (Transient)	12	*Killer Whale (Transient)*	12	*Harbor seal (CA)*	12
Short-finned pilot whale	10	*Harbor seal (CA)*	12	*Short-finned pilot whale*	10
Other beaked whales	10	*Short-finned pilot whale*	10	*Other beaked whales*	10
California sea lion	10	*California sea lion*	10	*California sea lion*	10
Northern elephant seal	10	*Northern elephant seal*	10	*Risso's dolphin*	9
Risso's dolphin	9	*Other beaked whales*	9	*Steller sea lion*	9
Pacific White-sided dolphin	8	*Risso's dolphin*	8	*Baird's beaked whale*	8
Baird's beaked whale	8	*Baird's beaked whale*	8	*Dall's Porpoise*	7
Northern fur seal (Eastern N. Pacific)	8	*Dall's Porpoise*	7	*Northern fur seal (Eastern N. Pacific)*	7
Dall's Porpoise	7	*Northern fur seal (Eastern N. Pacific)*	7	*Guadalupe fur seal*	6
Guadalupe fur seal	6	*Guadalupe fur seal*	6	*Pygmy and dwarf sperm whale*	5
Pygmy and dwarf sperm whale	5	*Pygmy and dwarf sperm whale*	5	*Pacific White-sided dolphin*	5
Northern right whale dolphin	5	*Pacific White-sided dolphin*	5	*Northern right whale dolphin*	5
Short-beaked common dolphin	5	*Northern right whale dolphin*	5	*Short-beaked common dolphin*	5
Long-beaked common dolphin	5	*Short-beaked common dolphin*	5	*Long-beaked common dolphin*	5
Northern fur seal (CA)	5	*Long-beaked common dolphin*	5	*Northern fur seal (CA)*	5
Sei whale	n/a	*Northern fur seal (CA)*	5	*Sei whale*	n/a
N. Pacific right whale	n/a	*N. Pacific right whale*	n/a	*N. Pacific right whale*	n/a
Bryde's whale	n/a	*Bryde's whale*	n/a	*Bryde's whale*	n/a
Harbor Porpoise (Morro Bay)	n/a	*Harbor Porpoise (Morro Bay)*	n/a	*Harbor Porpoise (Morro Bay)*	n/a
Harbor Porpoise (Monterey Bay)	n/a	*Harbor Porpoise (Monterey Bay)*	n/a	*Harbor Porpoise (Monterey Bay)*	n/a
Harbor Porpoise (N OR/WA Coast)	n/a	*Harbor Porpoise (N OR/WA Coast)*	n/a	*Harbor Porpoise (N OR/WA Coast)*	n/a
Bottlenose dolphin	n/a	*Bottlenose dolphin*	n/a	*Coastal bottlenose dolphin*	n/a

4.2.2 Zone 2b – Northern California Slope (100–1,000 m depth)

Summary Assessment: The slope zone in northern California (Zone 2b) also has relatively low vulnerability risk scores overall and some indication of slightly lower overall risk during winter. Southern resident killer whales, leatherback sea turtles, western north Pacific gray whales, blue whales, and Central American and Mexican DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, 0 species had highest relative risk scores, 6 were relatively high, and 8 were moderate. For the post-upwelling season, 1 species was highest, 4 were relatively high, and 8 were moderate. For winter, 1 species was highest, 3 was relatively high, and 9 were moderate.

Table 59. Northern California slope (Zone 2b) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		POST-UPWELLING		WINTER	
Killer whale (S. Resident)	27	Leatherback sea turtle	29	Killer whale (S. Resident)	30
Gray whale (Western N. Pacific)	26	Blue whale	27	Humpback whale (Central Amer. DPS)	25
Humpback whale (Central Amer. DPS)	26	Killer whale (S. Resident)	27	Humpback whale (Mexican DPS)	23
Humpback whale (Mexican DPS)	24	Humpback whale (Central Amer. DPS)	25	Gray whale (Western N. Pacific)	22
Leatherback sea turtle	23	Humpback whale (Mexican DPS)	23	Blue whale	21
Blue whale	23	Sperm whale	21	Leatherback sea turtle	21
Sperm whale	21	Gray whale (Western N. Pacific)	20	Sperm whale	21
Loggerhead sea turtle	19	Loggerhead sea turtle	19	Loggerhead sea turtle	19
Humpback whale (Hawaii DPS)	18	Fin whale	18	Minke whale	18
Minke whale	17	Minke whale	18	Humpback whale (Hawaii DPS)	17
Gray whale (Eastern N. Pacific)	16	Humpback whale (Hawaii DPS)	17	Harbor Porpoise (SF/Russian River)	16
Harbor Porpoise (SF/Russian River)	16	Harbor Porpoise (SF/Russian River)	16	Fin whale	16
Fin whale	16	Olive Ridley sea turtle	15	Olive Ridley sea turtle	15
Olive Ridley sea turtle	15	Killer whale (Offshore)	14	Killer whale (Offshore)	14
Killer whale (Offshore)	14	Green sea turtle	14	Green sea turtle	14
Green sea turtle	14	Baird's beaked whale	14	Other beaked whales	14
Other beaked whales	14	Harbor seal (OR/WA)	13	Baird's beaked whale	14
Baird's beaked whale	14	Short-finned pilot whale	13	Harbor seal (OR/WA)	13
Harbor seal (CA)	13	Other beaked whales	13	Short-finned pilot whale	13
Harbor seal (OR/WA)	13	Harbor Porpoise (N CA/S OR)	12	Gray whale (Eastern N. Pacific)	12
Short-finned pilot whale	13	Killer Whale (Transient)	12	Harbor Porpoise (N CA/S OR)	12
Harbor Porpoise (N CA/S OR)	12	Harbor seal (CA)	12	Killer Whale (Transient)	12
Killer Whale (Transient)	12	Gray whale (Eastern N. Pacific)	10	Harbor seal (CA)	12
Risso's dolphin	12	California sea lion	10	Risso's dolphin	12
California sea lion	10	Dall's Porpoise	10	Pacific White-sided dolphin	11
Northern fur seal (Eastern N. Pacific)	10	Steller sea lion	9	Northern elephant seal	10
Dall's Porpoise	10	Risso's dolphin	8	California sea lion	10
Steller sea lion	9	Pacific White-sided dolphin	8	Dall's Porpoise	10
Pacific White-sided dolphin	8	Northern elephant seal	7	Steller sea lion	9
Northern right whale dolphin	8	Northern fur seal (Eastern N. Pacific)	7	Northern right whale dolphin	8
Northern elephant seal	7	Northern fur seal (CA)	7	Northern fur seal (Eastern N. Pacific)	7
Guadalupe fur seal	6	Guadalupe fur seal	6	Northern fur seal (CA)	7
Northern fur seal (CA)	6	Pygmy and dwarf sperm whale	5	Guadalupe fur seal	6
Pygmy and dwarf sperm whale	5	Northern right whale dolphin	5	Pygmy and dwarf sperm whale	5
Short-beaked common dolphin	5	Short-beaked common dolphin	5	Short-beaked common dolphin	5
Long-beaked common dolphin	5	Long-beaked common dolphin	5	Long-beaked common dolphin	5
Sei whale	n/a	Sei whale	n/a	Sei whale	n/a
N. Pacific right whale	n/a	N. Pacific right whale	n/a	N. Pacific right whale	n/a
Bryde's whale	n/a	Bryde's whale	n/a	Bryde's whale	n/a
Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a
Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a
Harbor Porpoise (N OR/WA Coast)	n/a	Harbor Porpoise (N OR/WA Coast)	n/a	Harbor Porpoise (N OR/WA Coast)	n/a
Bottlenose dolphin	n/a	Bottlenose dolphin	n/a	Coastal bottlenose dolphin	n/a

4.2.3 Zone 2c – Northern California Oceanic (1,000–2,500 m depth)

Summary Assessment: The oceanic zone in northern California (Zone 2c) has some of the lowest assessed vulnerability risk scores overall, with lower overall risk assessed during the winter season. Southern resident killer whales, leatherback sea turtles, blue whales, and Central American DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, no species had highest relative risk scores, 4 were relatively high, and 9 were moderate. For the post-upwelling season, no species were highest, 4 were relatively high, and 9 were moderate. For winter, no species were either highest or high, and 13 were moderate.

Table 60. Northern California oceanic (Zone 2c) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		*POST-UPWELLING*		*WINTER*	
Humpback whale (Central Amer. DPS)	*24*	*Blue whale*	*27*	*Killer whale (S. Resident)*	*21*
Killer whale (S. Resident)	*23*	*Leatherback sea turtle*	*26*	*Blue whale*	*21*
Leatherback sea turtle	*23*	*Killer whale (S. Resident)*	*23*	*Leatherback sea turtle*	*21*
Blue whale	*23*	*Fin whale*	*22*	*Humpback whale (Central Amer. DPS)*	*21*
Sperm whale	*21*	*Loggerhead sea turtle*	*21*	*Gray whale (Western N. Pacific)*	*20*
Gray whale (Western N. Pacific)	*20*	*Humpback whale (Central Amer. DPS)*	*21*	*Loggerhead sea turtle*	*19*
Loggerhead sea turtle	*20*	*Sperm whale*	*21*	*Humpback whale (Mexican DPS)*	*19*
Humpback whale (Mexican DPS)	*20*	*Gray whale (Western N. Pacific)*	*20*	*Minke whale*	*18*
Fin whale	*18*	*Humpback whale (Mexican DPS)*	*19*	*Fin whale*	*18*
Humpback whale (Hawaii DPS)	*18*	*Minke whale*	*18*	*Sperm whale*	*18*
Minke whale	*17*	*Baird's beaked whale*	*17*	*Baird's beaked whale*	*17*
Baird's beaked whale	*17*	*Humpback whale (Hawaii DPS)*	*17*	*Humpback whale (Hawaii DPS)*	*17*
Olive Ridley sea turtle	*16*	*Olive Ridley sea turtle*	*16*	*Olive Ridley sea turtle*	*16*
Killer whale (Offshore)	*14*	*Killer whale (Offshore)*	*14*	*Killer whale (Offshore)*	*14*
Green sea turtle	*14*	*Green sea turtle*	*14*	*Green sea turtle*	*14*
Other beaked whales	*14*	*Harbor seal (OR/WA)*	*13*	*Other beaked whales*	*14*
Harbor seal (OR/WA)	*13*	*Short-finned pilot whale*	*13*	*Harbor seal (OR/WA)*	*13*
Short-finned pilot whale	*13*	*Other beaked whales*	*13*	*Short-finned pilot whale*	*13*
Northern fur seal (Eastern N. Pacific)	*13*	*Killer Whale (Transient)*	*12*	*Killer Whale (Transient)*	*12*
Killer Whale (Transient)	*12*	*Gray whale (Eastern N. Pacific)*	*10*	*Risso's dolphin*	*12*
Risso's dolphin	*12*	*Dall's Porpoise*	*10*	*Pacific White-sided dolphin*	*11*
Pacific White-sided dolphin	*11*	*Harbor seal (CA)*	*9*	*Northern fur seal (CA)*	*11*
Northern right whale dolphin	*11*	*Steller sea lion*	*9*	*Gray whale (Eastern N. Pacific)*	*10*
Gray whale (Eastern N. Pacific)	*10*	*Risso's dolphin*	*8*	*Northern elephant seal*	*10*
Harbor seal (CA)	*10*	*Pacific White-sided dolphin*	*8*	*Harbor seal (CA)*	*9*
Dall's Porpoise	*10*	*Northern fur seal (Eastern N. Pacific)*	*8*	*Steller sea lion*	*9*
Northern elephant seal	*10*	*Guadalupe fur seal*	*8*	*Northern right whale dolphin*	*8*
Northern fur seal (CA)	*10*	*Pygmy and dwarf sperm whale*	*8*	*Guadalupe fur seal*	*8*
Steller sea lion	*9*	*Northern right whale dolphin*	*8*	*Pygmy and dwarf sperm whale*	*8*
Guadalupe fur seal	*8*	*California sea lion*	*7*	*California sea lion*	*7*
Pygmy and dwarf sperm whale	*8*	*Northern elephant seal*	*7*	*Dall's Porpoise*	*7*
California sea lion	*7*	*Northern fur seal (CA)*	*7*	*Northern fur seal (Eastern N. Pacific)*	*7*
Short-beaked common dolphin	*5*	*Short-beaked common dolphin*	*7*	*Short-beaked common dolphin*	*5*
Long-beaked common dolphin	*5*	*Long-beaked common dolphin*	*5*	*Long-beaked common dolphin*	*5*
Sei whale	n/a	*Sei whale*	n/a	*Sei whale*	n/a
N. Pacific right whale	n/a	*N. Pacific right whale*	n/a	*N. Pacific right whale*	n/a
Bryde's whale	n/a	*Bryde's whale*	n/a	*Bryde's whale*	n/a
Harbor Porpoise (Morro Bay)	n/a	*Harbor Porpoise (Morro Bay)*	n/a	*Harbor Porpoise (Morro Bay)*	n/a
Harbor Porpoise (Monterey Bay)	n/a	*Harbor Porpoise (Monterey Bay)*	n/a	*Harbor Porpoise (Monterey Bay)*	n/a
Harbor Porpoise (N OR/WA Coast)	n/a	*Harbor Porpoise (N OR/WA Coast)*	n/a	*Harbor Porpoise (N OR/WA Coast)*	n/a
Bottlenose dolphin	n/a	*Bottlenose dolphin*	n/a	*Coastal bottlenose dolphin*	n/a
Harbor Porpoise (SF/Russian River)	n/a	*Harbor Porpoise (SF/Russian River)*	n/a	*Harbor Porpoise (SF/Russian River)*	n/a
Harbor Porpoise (N CA/S OR)	n/a	*Harbor Porpoise (N CA/S OR)*	n/a	*Harbor Porpoise (N CA/S OR)*	n/a

4.3 Vulnerability Risk Assessment – Zone 3

4.3.1 Zone 3a – Southern and Central Oregon Shelf (< 100 m depth)

Summary Assessment: The shelf zone in southern and central Oregon (Zone 3a) has intermediate vulnerability risk scores overall, with a stronger indication of lower risk during winter. Southern resident killer whales, leatherback sea turtles, western north Pacific gray whales, blue whales, and Mexican DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, 1 species had highest relative risk scores, 6 were relatively high, and 10 were moderate. For the post-upwelling season, no species were highest, 7 were relatively high, and 11 were moderate. For winter, 1 species was highest, 2 were relatively high, and 10 were moderate.

Table 61. Southern and Central Oregon shelf (Zone 3a) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		*POST-UPWELLING*		*WINTER*	
Gray whale (Western N. Pacific)	30	*Killer whale (S. Resident)*	28	*Killer whale (S. Resident)*	30
Killer whale (S. Resident)	28	*Leatherback sea turtle*	28	*Humpback whale (Mexican DPS)*	23
Humpback whale (Mexican DPS)	25	*Blue whale*	24	*Gray whale (Western N. Pacific)*	22
Blue whale	24	*Humpback whale (Mexican DPS)*	24	*Blue whale*	21
Harbor seal (OR/WA)	23	*Gray whale (Western N. Pacific)*	23	*Humpback whale (Central Amer. DPS)*	21
Humpback whale (Central Amer. DPS)	23	*Harbor seal (OR/WA)*	23	*Leatherback sea turtle*	20
Leatherback sea turtle	23	*Humpback whale (Central Amer. DPS)*	22	*Loggerhead sea turtle*	19
Gray whale (Eastern N. Pacific)	20	*Loggerhead sea turtle*	20	*Harbor seal (OR/WA)*	18
Loggerhead sea turtle	20	*Fin whale*	19	*Humpback whale (Hawaii DPS)*	17
Humpback whale (Hawaii DPS)	19	*Humpback whale (Hawaii DPS)*	18	*Fin whale*	16
Fin whale	17	*Gray whale (Eastern N. Pacific)*	17	*Harbor Porpoise (N CA/S OR)*	16
Harbor Porpoise (N CA/S OR)	16	*Sei whale*	16	*Olive Ridley sea turtle*	15
Olive Ridley sea turtle	16	*Harbor Porpoise (N CA/S OR)*	16	*Sperm whale*	15
Sperm whale	16	*Olive Ridley sea turtle*	16	*Minke whale*	14
Minke whale	15	*Sperm whale*	16	*Killer whale (Offshore)*	14
Killer whale (Offshore)	15	*Minke whale*	15	*Green sea turtle*	14
Green sea turtle	15	*Killer whale (Offshore)*	15	*Gray whale (Eastern N. Pacific)*	12
Steller sea lion	14	*Green sea turtle*	15	*Killer Whale (Transient)*	12
Killer Whale (Transient)	13	*Steller sea lion*	14	*Short-finned pilot whale*	10
Short-finned pilot whale	11	*Killer Whale (Transient)*	13	*Other beaked whales*	10
Other beaked whales	11	*Short-finned pilot whale*	11	*Risso's dolphin*	9
Risso's dolphin	10	*Other beaked whales*	10	*Steller sea lion*	9
Pacific White-sided dolphin	9	*Risso's dolphin*	9	*Baird's beaked whale*	8
Baird's beaked whale	9	*Baird's beaked whale*	9	*Dall's Porpoise*	7
Northern fur seal (Eastern N. Pacific)	9	*Dall's Porpoise*	8	*California sea lion*	7
Dall's Porpoise	8	*California sea lion*	8	*Northern fur seal (Eastern N. Pacific)*	7
California sea lion	8	*Northern fur seal (Eastern N. Pacific)*	8	*Harbor seal (CA)*	7
Northern elephant seal	8	*Guadalupe fur seal*	7	*Pacific White-sided dolphin*	6
Guadalupe fur seal	7	*Harbor seal (CA)*	7	*Northern right whale dolphin*	6
Harbor seal (CA)	7	*Pygmy and dwarf sperm whale*	6	*Long-beaked common dolphin*	6
Pygmy and dwarf sperm whale	6	*Pacific White-sided dolphin*	6	*Guadalupe fur seal*	6
Northern right whale dolphin	6	*Northern right whale dolphin*	6	*Pygmy and dwarf sperm whale*	5
Short-beaked common dolphin	6	*Short-beaked common dolphin*	6	*Short-beaked common dolphin*	5
Long-beaked common dolphin	6	*Long-beaked common dolphin*	6	*Northern fur seal (CA)*	5
Northern fur seal (CA)	6	*Northern fur seal (CA)*	6	*Northern elephant seal*	5
Sei whale	n/a	*Northern elephant seal*	6	*Sei whale*	n/a
N. Pacific right whale	n/a	*N. Pacific right whale*	n/a	*N. Pacific right whale*	n/a
Bryde's whale	n/a	*Bryde's whale*	n/a	*Bryde's whale*	n/a
Harbor Porpoise (Morro Bay)	n/a	*Harbor Porpoise (Morro Bay)*	n/a	*Harbor Porpoise (Morro Bay)*	n/a
Harbor Porpoise (Monterey Bay)	n/a	*Harbor Porpoise (Monterey Bay)*	n/a	*Harbor Porpoise (Monterey Bay)*	n/a
Harbor Porpoise (SF/Russian River)	n/a	*Harbor Porpoise (SF/Russian River)*	n/a	*Harbor Porpoise (SF/Russian River)*	n/a
Harbor Porpoise (N OR/WA Coast)	n/a	*Harbor Porpoise (N OR/WA Coast)*	n/a	*Harbor Porpoise (N OR/WA Coast)*	n/a
Bottlenose dolphin	n/a	*Bottlenose dolphin*	n/a	*Bottlenose dolphin*	n/a

4.3.2 Zone 3b – Southern and Central Oregon Slope (100–1,000 m depth)

Summary Assessment: The slope zone in southern and central Oregon (Zone 3b) also has intermediate vulnerability risk scores overall, with relatively lower risk during post-upwelling and especially winter seasons. Southern resident killer whales, leatherback sea turtles, blue whales, and Mexican and Central American DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, 1 species had highest relative risk scores, 7 were relatively high, and 10 were moderate. For the post-upwelling season, no species was highest, 8 were relatively high, and 7 were moderate. For winter, 1 species was highest, 2 were relatively high, and 10 were moderate.

Table 62. Southern and Central Oregon slope (Zone 3b) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		POST-UPWELLING		WINTER	
Killer whale (S. Resident)	29	Killer whale (S. Resident)	28	Killer whale (S. Resident)	30
Gray whale (Western N. Pacific)	28	Leatherback sea turtle	28	Humpback whale (Central Amer. DPS)	25
Humpback whale (Central Amer. DPS)	28	Blue whale	28	Humpback whale (Mexican DPS)	23
Humpback whale (Mexican DPS)	26	Humpback whale (Central Amer. DPS)	26	Blue whale	21
Blue whale	25	Humpback whale (Mexican DPS)	24	Humpback whale (Hawaii DPS)	21
Leatherback sea turtle	24	Fin whale	23	Gray whale (Western N. Pacific)	20
Humpback whale (Hawaii DPS)	24	Humpback whale (Hawaii DPS)	22	Leatherback sea turtle	20
Sperm whale	23	Sperm whale	22	Loggerhead sea turtle	19
Harbor seal (OR/WA)	21	Harbor seal (OR/WA)	20	Harbor seal (OR/WA)	18
Loggerhead sea turtle	21	Loggerhead sea turtle	20	Minke whale	18
Minke whale	20	Minke whale	19	Sperm whale	18
Gray whale (Eastern N. Pacific)	18	Gray whale (Western N. Pacific)	17	Fin whale	16
Fin whale	18	Olive Ridley sea turtle	16	Olive Ridley sea turtle	15
Olive Ridley sea turtle	17	Killer whale (Offshore)	15	Killer whale (Offshore)	14
Killer whale (Offshore)	16	Green sea turtle	15	Green sea turtle	14
Green sea turtle	16	Short-finned pilot whale	14	Other beaked whales	14
Other beaked whales	16	Other beaked whales	14	Harbor Porpoise (N CA/S OR)	13
Short-finned pilot whale	15	Harbor Porpoise (N CA/S OR)	13	Short-finned pilot whale	13
Killer Whale (Transient)	14	Killer Whale (Transient)	13	Killer Whale (Transient)	12
Risso's dolphin	14	Gray whale (Eastern N. Pacific)	11	Risso's dolphin	12
Harbor Porpoise (N CA/S OR)	13	Dall's Porpoise	11	Pacific White-sided dolphin	12
Pacific White-sided dolphin	13	Steller sea lion	10	Gray whale (Eastern N. Pacific)	10
Northern fur seal (Eastern N. Pacific)	12	Risso's dolphin	9	Steller sea lion	9
Dall's Porpoise	12	Baird's beaked whale	9	Baird's beaked whale	8
Steller sea lion	11	California sea lion	8	Dall's Porpoise	7
Baird's beaked whale	10	Northern fur seal (Eastern N. Pacific)	8	California sea lion	7
Northern right whale dolphin	10	Northern fur seal (CA)	8	Northern fur seal (Eastern N. Pacific)	7
California sea lion	9	Guadalupe fur seal	7	Harbor seal (CA)	7
Northern elephant seal	9	Harbor seal (CA)	7	Northern fur seal (CA)	7
Guadalupe fur seal	8	Pygmy and dwarf sperm whale	6	Northern right whale dolphin	6
Northern fur seal (CA)	8	Pacific White-sided dolphin	6	Long-beaked common dolphin	6
Harbor seal (CA)	7	Northern right whale dolphin	6	Guadalupe fur seal	6
Pygmy and dwarf sperm whale	7	Short-beaked common dolphin	6	Pygmy and dwarf sperm whale	5
Short-beaked common dolphin	7	Long-beaked common dolphin	6	Short-beaked common dolphin	5
Long-beaked common dolphin	7	Northern elephant seal	6	Northern elephant seal	5
Sei whale	n/a	Sei whale	n/a	Sei whale	n/a
N. Pacific right whale	n/a	N. Pacific right whale	n/a	N. Pacific right whale	n/a
Bryde's whale	n/a	Bryde's whale	n/a	Bryde's whale	n/a
Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a
Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a
Harbor Porpoise (SF/Russian River)	n/a	Harbor Porpoise (SF/Russian River)	n/a	Harbor Porpoise (SF/Russian River)	n/a
Harbor Porpoise (N OR/WA Coast)	n/a	Harbor Porpoise (N OR/WA Coast)	n/a	Harbor Porpoise (N OR/WA Coast)	n/a
Bottlenose dolphin	n/a	Bottlenose dolphin	n/a	Bottlenose dolphin	n/a

4.3.4 Zone 3c – Southern and Central Oregon Oceanic (1,000–2,500 m depth)

Summary Assessment: The oceanic zone in southern and central Oregon (Zone 3c) has among the lowest overall vulnerability risk scores, with a slight indication of lower risk during winter. Southern resident killer whales, leatherback sea turtles, blue whales, and Central American DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, no species had highest relative risk scores, 4 were relatively high, and 8 were moderate. For the post-upwelling season, no species was highest, 4 were relatively high, and 8 were moderate. For winter, no species were highest or high, and 12 were moderate.

Table 63. Southern and Central Oregon oceanic (Zone 3c) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		POST-UPWELLING		WINTER	
Killer whale (S. Resident)	23	Leatherback sea turtle	27	Killer whale (S. Resident)	21
Blue whale	23	Killer whale (S. Resident)	23	Blue whale	21
Leatherback sea turtle	22	Blue whale	23	Humpback whale (Central American DPS)	21
Humpback whale (Central Amer. DPS)	22	Fin whale	22	Leatherback sea turtle	20
Sperm whale	21	Humpback whale (Central Amer. DPS)	21	Gray whale (Western N. Pacific)	20
Gray whale (Western N. Pacific)	20	Sperm whale	21	Loggerhead sea turtle	19
Loggerhead sea turtle	20	Loggerhead sea turtle	20	Humpback whale (Mexican DPS)	19
Humpback whale (Mexican DPS)	20	Humpback whale (Mexican DPS)	19	Sperm whale	18
Humpback whale (Hawaii DPS)	18	Humpback whale (Hawaii DPS)	17	Humpback whale (Hawaii DPS)	17
Harbor seal (OR/WA)	16	Harbor seal (OR/WA)	16	Fin whale	16
Fin whale	16	Gray whale (Western N. Pacific)	16	Olive Ridley sea turtle	15
Olive Ridley sea turtle	16	Olive Ridley sea turtle	15	Harbor seal (OR/WA)	15
Minke whale	14	Minke whale	14	Other beaked whales	14
Killer whale (Offshore)	14	Killer whale (Offshore)	14	Minke whale	14
Green sea turtle	14	Green sea turtle	14	Killer whale (Offshore)	14
Other beaked whales	14	Short-finned pilot whale	13	Green sea turtle	14
Short-finned pilot whale	13	Other beaked whales	13	Short-finned pilot whale	13
Northern fur seal (Eastern N. Pacific)	13	Killer Whale (Transient)	12	Killer Whale (Transient)	12
Killer Whale (Transient)	12	Gray whale (Eastern N. Pacific)	10	Pacific White-sided dolphin	11
Pacific White-sided dolphin	11	Dall's Porpoise	10	Northern fur seal (CA)	11
Northern right whale dolphin	11	Baird's beaked whale	10	Northern elephant seal	10
Gray whale (Eastern N. Pacific)	10	Steller sea lion	9	Gray whale (Eastern N. Pacific)	10
Baird's beaked whale	10	Northern fur seal (Eastern N. Pacific)	8	Baird's beaked whale	10
Northern elephant seal	10	Guadalupe fur seal	8	Steller sea lion	9
Northern fur seal (CA)	10	Pygmy and dwarf sperm whale	8	Risso's dolphin	9
Risso's dolphin	9	Pacific White-sided dolphin	8	Pygmy and dwarf sperm whale	8
Steller sea lion	9	Northern fur seal (CA)	7	Northern right whale dolphin	8
Guadalupe fur seal	8	Harbor seal (CA)	7	Guadalupe fur seal	8
Pygmy and dwarf sperm whale	8	Northern elephant seal	7	Northern fur seal (Eastern N. Pacific)	7
Dall's Porpoise	7	Risso's dolphin	5	Harbor seal (CA)	7
California sea lion	7	California sea lion	5	Dall's Porpoise	7
Harbor seal (CA)	7	Northern right whale dolphin	5	California sea lion	7
Short-beaked common dolphin	5	Short-beaked common dolphin	5	Short-beaked common dolphin	5
Long-beaked common dolphin	5	Long-beaked common dolphin	5	Long-beaked common dolphin	5
Sei whale	n/a	Sei whale	n/a	Sei whale	n/a
N. Pacific right whale	n/a	N. Pacific right whale	n/a	N. Pacific right whale	n/a
Bryde's whale	n/a	Bryde's whale	n/a	Bryde's whale	n/a
Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (SF/Russian River)	n/a
Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (N OR/WA Coast)	n/a
Harbor Porpoise (SF/Russian River)	n/a	Harbor Porpoise (SF/Russian River)	n/a	Harbor Porpoise (N CA/S OR)	n/a
Harbor Porpoise (N OR/WA Coast)	n/a	Harbor Porpoise (N OR/WA Coast)	n/a	Harbor Porpoise (Morro Bay)	n/a
Bottlenose dolphin	n/a	Bottlenose dolphin	n/a	Harbor Porpoise (Monterey Bay)	n/a
Harbor Porpoise (N CA/S OR)	n/a	Harbor Porpoise (N CA/S OR)	n/a	Bottlenose dolphin	n/a

4.4 Vulnerability Risk Assessment – Zone 4

4.4.1 Zone 4a – Columbia River Shelf (< 100 m depth)

Summary Assessment: The shelf zone in the Columbia River region (Zone 3a) has intermediate vulnerability risk scores overall, with a limited indication of lower risk during winter. Southern resident killer whales, western north Pacific gray whales, blue whales, OR/WA stock harbor seals, and Hawaii DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, no species had highest relative risk scores, 6 were relatively high, and 11 were moderate. For the post-upwelling season, no species were highest, 6 were relatively high, and 12 were moderate. For winter, 1 species was highest, 3 were relatively high, and 12 were moderate.

Table 64. Columbia River shelf (Zone 4a) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		*POST-UPWELLING*		*WINTER*	
Killer whale (S. Resident)	28	*Killer whale (S. Resident)*	28	*Killer whale (S. Resident)*	31
Gray whale (Western N. Pacific)	26	*Leatherback sea turtle*	28	*Gray whale (Western N. Pacific)*	23
Harbor seal (OR/WA)	23	*Gray whale (Western N. Pacific)*	26	*Blue whale*	22
Leatherback sea turtle	23	*Blue whale*	24	*Humpback whale (Hawaii DPS)*	22
Humpback whale (Hawaii DPS)	23	*Harbor seal (OR/WA)*	23	*Leatherback sea turtle*	21
Blue whale	22	*Humpback whale (Hawaii DPS)*	22	*Loggerhead sea turtle*	20
Humpback whale (Central Amer. DPS)	21	*Gray whale (Eastern N. Pacific)*	20	*Humpback whale (Mexican DPS)*	20
Humpback whale (Mexican DPS)	21	*Loggerhead sea turtle*	20	*Humpback whale (Central Amer. DPS)*	20
Gray whale (Eastern N. Pacific)	20	*Humpback whale (Central Amer. DPS)*	20	*Harbor seal (OR/WA)*	19
Loggerhead sea turtle	20	*Humpback whale (Mexican DPS)*	20	*Fin whale*	17
Fin whale	17	*Fin whale*	19	*Harbor Porpoise (N OR/WA Coast)*	17
Harbor Porpoise (N OR/WA Coast)	17	*Sperm whale*	18	*Olive Ridley sea turtle*	16
Olive Ridley sea turtle	16	*Harbor Porpoise (N OR/WA Coast)*	17	*Sperm whale*	16
Sperm whale	16	*Sei whale*	16	*Minke whale*	15
Minke whale	15	*Green sea turtle*	16	*Killer whale (Offshore)*	15
Killer whale (Offshore)	15	*Olive Ridley sea turtle*	16	*Green sea turtle*	15
Green sea turtle	15	*Minke whale*	15	*Gray whale (Eastern N. Pacific)*	13
Steller sea lion	14	*Killer whale (Offshore)*	15	*Killer Whale (Transient)*	13
Killer Whale (Transient)	13	*Steller sea lion*	14	*Short-finned pilot whale*	11
Short-finned pilot whale	11	*Killer Whale (Transient)*	13	*Other beaked whales*	11
Other beaked whales	11	*Short-finned pilot whale*	11	*Risso's dolphin*	10
Risso's dolphin	10	*Other beaked whales*	10	*Steller sea lion*	10
Pacific White-sided dolphin	9	*Risso's dolphin*	9	*Baird's beaked whale*	9
Baird's beaked whale	9	*Baird's beaked whale*	9	*California sea lion*	8
Northern fur seal (Eastern N. Pacific)	9	*Northern fur seal (CA)*	9	*Northern fur seal (Eastern N. Pacific)*	8
Dall's Porpoise	8	*Dall's Porpoise*	8	*Guadalupe fur seal*	7
California sea lion	8	*California sea lion*	8	*Harbor seal (CA)*	7
Guadalupe fur seal	7	*Northern fur seal (Eastern N. Pacific)*	8	*Pygmy and dwarf sperm whale*	6
Harbor seal (CA)	7	*Guadalupe fur seal*	7	*Pacific White-sided dolphin*	6
Pygmy and dwarf sperm whale	6	*Harbor seal (CA)*	7	*Northern right whale dolphin*	6
Northern right whale dolphin	6	*Pygmy and dwarf sperm whale*	6	*Short-beaked common dolphin*	6
Short-beaked common dolphin	6	*Pacific White-sided dolphin*	6	*Long-beaked common dolphin*	6
Long-beaked common dolphin	6	*Northern right whale dolphin*	6	*Northern fur seal (CA)*	6
Northern fur seal (CA)	6	*Short-beaked common dolphin*	6	*Northern elephant seal*	6
Northern elephant seal	6	*Long-beaked common dolphin*	6	*Dall's Porpoise*	5
Sei whale	n/a	*Northern elephant seal*	6	*Sei whale*	n/a
N. Pacific right whale	n/a	*N. Pacific right whale*	n/a	*N. Pacific right whale*	n/a
Bryde's whale	n/a	*Bryde's whale*	n/a	*Bryde's whale*	n/a
Harbor Porpoise (Morro Bay)	n/a	*Harbor Porpoise (Morro Bay)*	n/a	*Harbor Porpoise (Morro Bay)*	n/a
Harbor Porpoise (Monterey Bay)	n/a	*Harbor Porpoise (Monterey Bay)*	n/a	*Harbor Porpoise (Monterey Bay)*	n/a
Harbor Porpoise (SF/Russian River)	n/a	*Harbor Porpoise (SF/Russian River)*	n/a	*Harbor Porpoise (SF/Russian River)*	n/a
Harbor Porpoise (N CA/S OR)	n/a	*Harbor Porpoise (N CA/S OR)*	n/a	*Harbor Porpoise (N CA/S OR)*	n/a
Bottlenose dolphin	n/a	*Bottlenose dolphin*	n/a	*Coastal bottlenose dolphin*	n/a

4.4.2 Zone 4b – Columbia River Slope (100–1,000 m depth)

Summary Assessment: The slope zone in the Columbia River region (Zone 3b) is quite similar to the shelf (3a) zone with intermediate vulnerability risk scores overall and a limited indication of lower risk during winter. Southern resident killer whales, blue whales, Hawaii DPS humpback whales, and leatherback sea turtles were among species with the most consistently high scores across seasons. For the upwelling season, no species had highest relative risk scores, 6 were relatively high, and 9 were moderate. For the post-upwelling season, there was an identical distribution of scores with no species receiving highest scores, 6 were relatively high, and 9 were moderate. For winter, 1 species was highest, 3 were relatively high, and 11 were moderate.

Table 65. Columbia River slope (Zone 4b) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		POST-UPWELLING		WINTER	
Killer whale (S. Resident)	28	Killer whale (S. Resident)	28	Killer whale (S. Resident)	31
Humpback whale (Hawaii DPS)	26	Leatherback sea turtle	28	Humpback whale (Hawaii DPS)	25
Blue whale	24	Humpback whale (Hawaii DPS)	25	Blue whale	22
Leatherback sea turtle	23	Blue whale	24	Humpback whale (Central Amer. DPS)	22
Humpback whale (Central Amer. DPS)	23	Humpback whale (Central Amer. DPS)	22	Gray whale (Western N. Pacific)	21
Sperm whale	22	Sperm whale	22	Leatherback sea turtle	21
Humpback whale (Mexican DPS)	21	Harbor seal (OR/WA)	20	Loggerhead sea turtle	20
Harbor seal (OR/WA)	20	Loggerhead sea turtle	20	Humpback whale (Mexican DPS)	20
Loggerhead sea turtle	20	Fin whale	20	Minke whale	19
Gray whale (Western N. Pacific)	19	Humpback whale (Mexican DPS)	20	Harbor seal (OR/WA)	19
Fin whale	19	Minke whale	19	Sperm whale	19
Minke whale	18	Gray whale (Western N. Pacific)	17	Fin whale	17
Olive Ridley sea turtle	16	Olive Ridley sea turtle	16	Olive Ridley sea turtle	16
Killer whale (Offshore)	15	Green sea turtle	15	Killer whale (Offshore)	15
Green sea turtle	15	Killer whale (Offshore)	15	Green sea turtle	15
Harbor Porpoise (N OR/WA Coast)	14	Harbor Porpoise (N OR/WA Coast)	14	Harbor Porpoise (N OR/WA Coast)	14
Short-finned pilot whale	14	Short-finned pilot whale	14	Short-finned pilot whale	14
Gray whale (Eastern N. Pacific)	13	Killer Whale (Transient)	13	Killer Whale (Transient)	13
Killer Whale (Transient)	13	Gray whale (Eastern N. Pacific)	11	Risso's dolphin	13
Risso's dolphin	13	Northern fur seal (CA)	11	Other beaked whales	12
Other beaked whales	12	Steller sea lion	10	Pacific White-sided dolphin	12
Pacific White-sided dolphin	12	Other beaked whales	10	Gray whale (Eastern N. Pacific)	11
Northern fur seal (Eastern N. Pacific)	11	Risso's dolphin	9	Dall's Porpoise	11
Dall's Porpoise	11	Baird's beaked whale	9	Steller sea lion	10
Steller sea lion	10	Pacific White-sided dolphin	9	Northern right whale dolphin	9
Baird's beaked whale	9	Dall's Porpoise	8	Baird's beaked whale	9
California sea lion	8	California sea lion	8	Northern fur seal (CA)	8
Northern elephant seal	8	Northern fur seal (Eastern N. Pacific)	8	California sea lion	8
Guadalupe fur seal	7	Guadalupe fur seal	7	Northern fur seal (Eastern N. Pacific)	8
Harbor seal (CA)	7	Harbor seal (CA)	7	Guadalupe fur seal	7
Northern right whale dolphin	7	Pygmy and dwarf sperm whale	6	Harbor seal (CA)	7
Northern fur seal (CA)	7	Northern right whale dolphin	6	Northern elephant seal	6
Pygmy and dwarf sperm whale	6	Short-beaked common dolphin	6	Pygmy and dwarf sperm whale	6
Short-beaked common dolphin	6	Long-beaked common dolphin	6	Short-beaked common dolphin	6
Long-beaked common dolphin	6	Northern elephant seal	6	Long-beaked common dolphin	6
Sei whale	n/a	Sei whale	n/a	Sei whale	n/a
N. Pacific right whale	n/a	N. Pacific right whale	n/a	N. Pacific right whale	n/a
Bryde's whale	n/a	Bryde's whale	n/a	Bryde's whale	n/a
Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a
Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a
Harbor Porpoise (SF/Russian River)	n/a	Harbor Porpoise (SF/Russian River)	n/a	Harbor Porpoise (SF/Russian River)	n/a
Harbor Porpoise (N CA/S OR)	n/a	Harbor Porpoise (N CA/S OR)	n/a	Harbor Porpoise (N CA/S OR)	n/a
Bottlenose dolphin	n/a	Bottlenose dolphin	n/a	Coastal bottlenose dolphin	n/a

4.4.3 Zone 4c – Columbia River Oceanic (1,000–2,500 m depth)

Summary Assessment: The oceanic zone in the Columbia River region (Zone 3d) has among the lowest overall vulnerability risk scores, with zero highest scores assigned in any season. Unlike many other zones, there is no indication in Zone 4c of lower risk during winter. Blue whales, southern resident killer whales, leatherback sea turtles, and Hawaii DPS humpback whales were among species with the most consistently high scores across seasons. The distribution of scores in the moderate and relatively high vulnerability categories were identical for this zone across each or the three seasons. No species had highest relative risk scores, 3 were relatively high, and 10 were moderate.

Table 66. Columbia River oceanic (Zone 4c) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		*POST-UPWELLING*		*WINTER*	
Blue whale	23	*Leatherback sea turtle*	27	*Killer whale (S. Resident)*	22
Leatherback sea turtle	22	*Blue whale*	23	*Blue whale*	22
Humpback whale (Hawaii DPS)	22	*Fin whale*	22	*Humpback whale (Hawaii DPS)*	22
Killer whale (S. Resident)	21	*Killer whale (S. Resident)*	21	*Gray whale (Western N. Pacific)*	21
Sperm whale	21	*Loggerhead sea turtle*	21	*Leatherback sea turtle*	21
Humpback whale (Central Amer. DPS)	20	*Humpback whale (Hawaii DPS)*	21	*Loggerhead sea turtle*	20
Humpback whale (Mexican DPS)	20	*Sperm whale*	21	*Humpback whale (Central Amer. DPS)*	20
Loggerhead sea turtle	19	*Humpback whale (Mexican DPS)*	19	*Humpback whale (Mexican DPS)*	20
Fin whale	18	*Humpback whale (Central Amer. DPS)*	19	*Minke whale*	19
Minke whale	17	*Minke whale*	18	*Sperm whale*	19
Harbor seal (OR/WA)	16	*Olive Ridley sea turtle*	17	*Fin whale*	17
Gray whale (Western N. Pacific)	16	*Harbor seal (OR/WA)*	16	*Harbor seal (OR/WA)*	16
Olive Ridley sea turtle	16	*Gray whale (Western N. Pacific)*	16	*Olive Ridley sea turtle*	16
Killer whale (Offshore)	14	*Green sea turtle*	14	*Killer whale (Offshore)*	15
Green sea turtle	14	*Killer whale (Offshore)*	14	*Green sea turtle*	15
Other beaked whales	14	*Short-finned pilot whale*	13	*Other beaked whales*	15
Northern right whale dolphin	14	*Other beaked whales*	13	*Short-finned pilot whale*	14
Short-finned pilot whale	13	*Killer Whale (Transient)*	12	*Killer Whale (Transient)*	13
Northern fur seal (Eastern N. Pacific)	13	*Pacific White-sided dolphin*	11	*Northern fur seal (CA)*	12
Killer Whale (Transient)	12	*Gray whale (Eastern N. Pacific)*	10	*Pacific White-sided dolphin*	11
Risso's dolphin	12	*Northern fur seal (CA)*	10	*Gray whale (Eastern N. Pacific)*	11
Pacific White-sided dolphin	11	*Steller sea lion*	9	*Dall's Porpoise*	11
Gray whale (Eastern N. Pacific)	10	*Risso's dolphin*	8	*Northern right whale dolphin*	11
Dall's Porpoise	10	*Baird's beaked whale*	8	*Northern elephant seal*	11
Northern elephant seal	10	*Northern fur seal (Eastern N. Pacific)*	8	*Risso's dolphin*	10
Northern fur seal (CA)	10	*Guadalupe fur seal*	8	*Steller sea lion*	10
Steller sea lion	9	*Pygmy and dwarf sperm whale*	8	*Baird's beaked whale*	9
Baird's beaked whale	8	*Northern right whale dolphin*	8	*Guadalupe fur seal*	9
Guadalupe fur seal	8	*Dall's Porpoise*	7	*Pygmy and dwarf sperm whale*	9
Pygmy and dwarf sperm whale	8	*Harbor seal (CA)*	7	*California sea lion*	8
California sea lion	7	*Northern elephant seal*	7	*Northern fur seal (Eastern N. Pacific)*	8
Harbor seal (CA)	7	*California sea lion*	5	*Harbor seal (CA)*	7
Short-beaked common dolphin	5	*Short-beaked common dolphin*	5	*Short-beaked common dolphin*	6
Long-beaked common dolphin	5	*Long-beaked common dolphin*	5	*Long-beaked common dolphin*	5
Sei whale	n/a	*Sei whale*	n/a	*Sei whale*	n/a
N. Pacific right whale	n/a	*N. Pacific right whale*	n/a	*N. Pacific right whale*	n/a
Bryde's whale	n/a	*Bryde's whale*	n/a	*Bryde's whale*	n/a
Harbor Porpoise (Morro Bay)	n/a	*Harbor Porpoise (Morro Bay)*	n/a	*Harbor Porpoise (Morro Bay)*	n/a
Harbor Porpoise (Monterey Bay)	n/a	*Harbor Porpoise (Monterey Bay)*	n/a	*Harbor Porpoise (Monterey Bay)*	n/a
Harbor Porpoise (SF/Russian River)	n/a	*Harbor Porpoise (SF/Russian River)*	n/a	*Harbor Porpoise (SF/Russian River)*	n/a
Harbor Porpoise (N CA/S OR)	n/a	*Harbor Porpoise (N CA/S OR)*	n/a	*Harbor Porpoise (N CA/S OR)*	n/a
Bottlenose dolphin	n/a	*Bottlenose dolphin*	n/a	*Coastal bottlenose dolphin*	n/a
Harbor Porpoise (N OR/WA Coast)	n/a	*Harbor Porpoise (N OR/WA Coast)*	n/a	*Harbor Porpoise (N OR/WA Coast)*	n/a

4.5 Vulnerability Risk Assessment – Zone 5

4.5.1 Zone 5a – Central and Northern Washington Shelf (< 100 m depth)

Summary Assessment: The shelf zone in central and northern Washington (Zone 5a; not including inshore waters of Puget Sound) has intermediate overall vulnerability risk scores with a limited indication of lower risk during winter. Southern resident killer whales (scoring highest in all seasons in this zone), western north Pacific gray whales, leatherback sea turtles blue whales, OR/WA stock harbor seals, and Hawaii DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, 1 species had highest relative risk scores, 5 were relatively high, and 11 were moderate. For the post-upwelling season, 1 species was highest, 5 were relatively high, and 12 were moderate. For winter, 1 species was highest, 3 were relatively high, and 12 were moderate.

Table 67. Central and northern Washington shelf (Zone 5a) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		POST-UPWELLING		WINTER	
Killer whale (S. Resident)	31	Killer whale (S. Resident)	31	Killer whale (S. Resident)	31
Gray whale (Western N. Pacific)	26	Leatherback sea turtle	28	Gray whale (Western N. Pacific)	23
Leatherback sea turtle	24	Gray whale (Western N. Pacific)	26	Blue whale	22
Harbor seal (OR/WA)	23	Harbor seal (OR/WA)	23	Humpback whale (Hawaii DPS)	22
Humpback whale (Hawaii DPS)	23	Blue whale	22	Leatherback sea turtle	21
Blue whale	22	Humpback whale (Hawaii DPS)	22	Loggerhead sea turtle	20
Humpback whale (Central Amer. DPS)	21	Humpback whale (Central Amer. DPS)	21	Humpback whale (Central Amer. DPS)	20
Humpback whale (Mexican DPS)	21	Humpback whale (Mexican DPS)	20	Humpback whale (Mexican DPS)	20
Gray whale (Eastern N. Pacific)	20	Gray whale (Eastern N. Pacific)	20	Harbor seal (OR/WA)	19
Loggerhead sea turtle	20	Loggerhead sea turtle	20	Fin whale	17
Fin whale	17	Fin whale	19	Harbor Porpoise (N OR/WA Coast)	17
Harbor Porpoise (N OR/WA Coast)	17	Sperm whale	18	Olive Ridley sea turtle	16
Olive Ridley sea turtle	16	Harbor Porpoise (N OR/WA Coast)	17	Sperm whale	16
Sperm whale	16	Sei whale	16	Minke whale	15
Minke whale	15	Olive Ridley sea turtle	16	Killer whale (Offshore)	15
Killer whale (Offshore)	15	Minke whale	15	Green sea turtle	15
Green sea turtle	15	Killer whale (Offshore)	15	Gray whale (Eastern N. Pacific)	13
Steller sea lion	14	Green sea turtle	15	Killer Whale (Transient)	13
Killer Whale (Transient)	13	Steller sea lion	14	Short-finned pilot whale	11
Short-finned pilot whale	11	Killer Whale (Transient)	13	Risso's dolphin	10
Risso's dolphin	10	Short-finned pilot whale	11	Other beaked whales	10
Other beaked whales	10	Risso's dolphin	9	Steller sea lion	10
Baird's beaked whale	9	Baird's beaked whale	9	Baird's beaked whale	9
Northern fur seal (Eastern N. Pacific)	9	Other beaked whales	8	California sea lion	8
Dall's Porpoise	8	California sea lion	8	Northern fur seal (Eastern N. Pacific)	8
California sea lion	8	Northern fur seal (Eastern N. Pacific)	8	Guadalupe fur seal	7
Guadalupe fur seal	7	Guadalupe fur seal	7	Harbor seal (CA)	7
Harbor seal (CA)	7	Harbor seal (CA)	7	Pygmy and dwarf sperm whale	6
Pygmy and dwarf sperm whale	6	Pygmy and dwarf sperm whale	6	Pacific White-sided dolphin	6
Pacific White-sided dolphin	6	Pacific White-sided dolphin	6	Northern right whale dolphin	6
Northern right whale dolphin	6	Northern right whale dolphin	6	Short-beaked common dolphin	6
Short-beaked common dolphin	6	Short-beaked common dolphin	6	Long-beaked common dolphin	6
Long-beaked common dolphin	6	Long-beaked common dolphin	6	Northern fur seal (CA)	6
Northern fur seal (CA)	6	Northern fur seal (CA)	6	Northern elephant seal	6
Northern elephant seal	6	Northern elephant seal	6	Dall's Porpoise	5
Sei whale	n/a	Dall's Porpoise	5	Sei whale	n/a
N. Pacific right whale	n/a	N. Pacific right whale	n/a	N. Pacific right whale	n/a
Bryde's whale	n/a	Bryde's whale	n/a	Bryde's whale	n/a
Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a
Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a
Harbor Porpoise (SF/Russian River)	n/a	Harbor Porpoise (SF/Russian River)	n/a	Harbor Porpoise (SF/Russian River)	n/a
Harbor Porpoise (N CA/S OR)	n/a	Harbor Porpoise (N CA/S OR)	n/a	Harbor Porpoise (N CA/S OR)	n/a
Bottlenose dolphin	n/a	Bottlenose dolphin	n/a	Bottlenose dolphin	n/a

4.5.2 Zone 5b – Central and Northern Washington Slope (100–1,000 m depth)

Summary Assessment: The slope zone in central and northern Washington (Zone 5b) also has intermediate overall vulnerability risk scores with a limited indication of lower risk during winter. Southern resident killer whales (scoring highest in all seasons in this zone), leatherback sea turtles blue whales, and Central American and Hawaii DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, 1 species had highest relative risk scores, 6 were relatively high, and 9 were moderate. For the post-upwelling season, 2 species were highest, 4 were relatively high, and 10 were moderate. For winter, 1 species was highest, 3 were relatively high, and 12 were moderate.

Table 68. Central and northern Washington slope (Zone 5b) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		POST-UPWELLING		WINTER	
Killer whale (S. Resident)	32	Killer whale (S. Resident)	32	Killer whale (S. Resident)	31
Leatherback sea turtle	25	Leatherback sea turtle	29	Blue whale	22
Humpback whale (Central Amer. DPS)	24	Blue whale	23	Humpback whale (Central Amer. DPS)	22
Humpback whale (Hawaii DPS)	24	Humpback whale (Central Amer. DPS)	23	Humpback whale (Hawaii DPS)	22
Blue whale	23	Humpback whale (Hawaii DPS)	23	Gray whale (Western N. Pacific)	21
Sperm whale	23	Sperm whale	23	Leatherback sea turtle	21
Humpback whale (Mexican DPS)	22	Harbor seal (OR/WA)	21	Loggerhead sea turtle	20
Harbor seal (OR/WA)	21	Loggerhead sea turtle	21	Humpback whale (Mexican DPS)	20
Loggerhead sea turtle	21	Humpback whale (Mexican DPS)	21	Harbor seal (OR/WA)	19
Gray whale (Western N. Pacific)	20	Fin whale	20	Sperm whale	19
Fin whale	18	Gray whale (Western N. Pacific)	18	Fin whale	17
Olive Ridley sea turtle	17	Olive Ridley sea turtle	17	Olive Ridley sea turtle	16
Minke whale	16	Minke whale	16	Harbor Porpoise (N OR/WA Coast)	15
Killer whale (Offshore)	16	Killer whale (Offshore)	16	Minke whale	15
Green sea turtle	16	Green sea turtle	16	Killer whale (Offshore)	15
Harbor Porpoise (N OR/WA Coast)	15	Harbor Porpoise (N OR/WA Coast)	15	Green sea turtle	15
Gray whale (Eastern N. Pacific)	14	Killer Whale (Transient)	14	Killer Whale (Transient)	13
Killer Whale (Transient)	14	Gray whale (Eastern N. Pacific)	12	Other beaked whales	11
Short-finned pilot whale	12	Short-finned pilot whale	12	Gray whale (Eastern N. Pacific)	11
Other beaked whales	12	Steller sea lion	11	Short-finned pilot whale	11
Northern fur seal (Eastern N. Pacific)	12	Other beaked whales	11	Pacific White-sided dolphin	10
Steller sea lion	11	Risso's dolphin	10	Risso's dolphin	10
Risso's dolphin	11	Baird's beaked whale	10	Steller sea lion	10
Baird's beaked whale	10	Pacific White-sided dolphin	10	Baird's beaked whale	9
Pacific White-sided dolphin	10	California sea lion	9	Northern fur seal (CA)	8
Northern right whale dolphin	10	Northern fur seal (Eastern N. Pacific)	9	Dall's Porpoise	8
Dall's Porpoise	9	Northern fur seal (CA)	9	Northern fur seal (Eastern N. Pacific)	8
California sea lion	9	Guadalupe fur seal	8	California sea lion	8
Northern elephant seal	9	Harbor seal (CA)	7	Northern right whale dolphin	7
Guadalupe fur seal	8	Pygmy and dwarf sperm whale	7	Guadalupe fur seal	7
Northern fur seal (CA)	8	Northern right whale dolphin	7	Harbor seal (CA)	7
Harbor seal (CA)	7	Short-beaked common dolphin	7	Long-beaked common dolphin	7
Pygmy and dwarf sperm whale	7	Long-beaked common dolphin	7	Northern elephant seal	6
Short-beaked common dolphin	7	Northern elephant seal	7	Pygmy and dwarf sperm whale	6
Long-beaked common dolphin	7	Dall's Porpoise	6	Short-beaked common dolphin	6
Sei whale	n/a	Sei whale	n/a	Sei whale	n/a
N. Pacific right whale	n/a	N. Pacific right whale	n/a	N. Pacific right whale	n/a
Bryde's whale	n/a	Bryde's whale	n/a	Bryde's whale	n/a
Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a	Harbor Porpoise (Morro Bay)	n/a
Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a	Harbor Porpoise (Monterey Bay)	n/a
Harbor Porpoise (SF/Russian River)	n/a	Harbor Porpoise (SF/Russian River)	n/a	Harbor Porpoise (SF/Russian River)	n/a
Harbor Porpoise (N CA/S OR)	n/a	Harbor Porpoise (N CA/S OR)	n/a	Harbor Porpoise (N CA/S OR)	n/a
Bottlenose dolphin	n/a	Bottlenose dolphin	n/a	Bottlenose dolphin	n/a

4.5.3 Zone 5c – Central and Northern Washington Oceanic (1,000–2,500 m depth)

Summary Assessment: The oceanic zone in central and northern Washington (Zone 5c) also has relatively low overall vulnerability risk scores with no species in the highest category and a relatively strong indication of lower risk during winter. Southern resident killer whales, leatherback sea turtles, blue whales, and Hawaii DPS humpback whales were among species with the most consistently high scores across seasons. For the upwelling season, no species had highest relative risk scores, 5 were relatively high, and 11 were moderate. For the post-upwelling season, no species was highest, 5 were relatively high, and 10 were moderate. For winter, no species were either highest or relatively high, and 12 were moderate.

Table 69. Central and northern Washington oceanic (Zone 5c) vulnerability risk assessment scores – all applicable marine mammal and sea turtle species and/or DPS.

UPWELLING		*POST-UPWELLING*		*WINTER*	
Leatherback sea turtle	24	*Leatherback sea turtle*	28	*Killer whale (S. Resident)*	21
Humpback whale (Hawaii DPS)	23	*Killer whale (S. Resident)*	22	*Blue whale*	21
Killer whale (S. Resident)	22	*Blue whale*	22	*Humpback whale (Hawaii DPS)*	21
Blue whale	22	*Humpback whale (Hawaii DPS)*	22	*Gray whale (Western N. Pacific)*	20
Sperm whale	22	*Sperm whale*	22	*Leatherback sea turtle*	20
Humpback whale (Central Amer. DPS)	21	*Loggerhead sea turtle*	20	*Loggerhead sea turtle*	19
Humpback whale (Mexican DPS)	21	*Fin whale*	20	*Humpback whale (Central Amer. DPS)*	19
Loggerhead sea turtle	20	*Humpback whale (Central Amer. DPS)*	20	*Humpback whale (Mexican DPS)*	19
Harbor seal (OR/WA)	17	*Humpback whale (Mexican DPS)*	20	*Sperm whale*	18
Gray whale (Western N. Pacific)	17	*Harbor seal (OR/WA)*	17	*Fin whale*	16
Fin whale	17	*Gray whale (Western N. Pacific)*	17	*Harbor seal (OR/WA)*	15
Olive Ridley sea turtle	17	*Olive Ridley sea turtle*	16	*Olive Ridley sea turtle*	15
Minke whale	15	*Minke whale*	15	*Minke whale*	14
Killer whale (Offshore)	15	*Killer whale (Offshore)*	15	*Killer whale (Offshore)*	14
Green sea turtle	15	*Green sea turtle*	15	*Green sea turtle*	14
Northern right whale dolphin	15	*Other beaked whales*	14	*Other beaked whales*	13
Other beaked whales	14	*Killer Whale (Transient)*	13	*Killer Whale (Transient)*	12
Northern fur seal (Eastern N. Pacific)	14	*Risso's dolphin*	12	*Pacific White-sided dolphin*	12
Killer Whale (Transient)	13	*Northern right whale dolphin*	12	*Northern right whale dolphin*	12
Pacific White-sided dolphin	12	*Gray whale (Eastern N. Pacific)*	11	*Northern fur seal (CA)*	11
Gray whale (Eastern N. Pacific)	11	*Short-finned pilot whale*	11	*Gray whale (Eastern N. Pacific)*	10
Short-finned pilot whale	11	*Steller sea lion*	10	*Short-finned pilot whale*	10
Dall's Porpoise	11	*Baird's beaked whale*	9	*Dall's Porpoise*	10
Northern elephant seal	11	*Pacific White-sided dolphin*	9	*Northern elephant seal*	10
Northern fur seal (CA)	11	*Guadalupe fur seal*	9	*Risso's dolphin*	9
Steller sea lion	10	*Pygmy and dwarf sperm whale*	9	*Steller sea lion*	9
Risso's dolphin	10	*Northern fur seal (Eastern N. Pacific)*	8	*Northern fur seal (Eastern N. Pacific)*	9
Baird's beaked whale	9	*Northern fur seal (CA)*	8	*Baird's beaked whale*	8
Guadalupe fur seal	9	*Northern elephant seal*	8	*Guadalupe fur seal*	8
Pygmy and dwarf sperm whale	9	*Dall's Porpoise*	8	*Pygmy and dwarf sperm whale*	8
California sea lion	8	*Harbor seal (CA)*	7	*California sea lion*	7
Harbor seal (CA)	7	*California sea lion*	6	*Harbor seal (CA)*	7
Short-beaked common dolphin	6	*Short-beaked common dolphin*	6	*Long-beaked common dolphin*	6
Long-beaked common dolphin	6	*Long-beaked common dolphin*	6	*Short-beaked common dolphin*	5
Sei whale	n/a	*Sei whale*	n/a	*Sei whale*	n/a
N. Pacific right whale	n/a	*N. Pacific right whale*	n/a	*N. Pacific right whale*	n/a
Bryde's whale	n/a	*Bryde's whale*	n/a	*Bryde's whale*	n/a
Harbor Porpoise (Morro Bay)	n/a	*Harbor Porpoise (Morro Bay)*	n/a	*Harbor Porpoise (Morro Bay)*	n/a
Harbor Porpoise (Monterey Bay)	n/a	*Harbor Porpoise (Monterey Bay)*	n/a	*Harbor Porpoise (Monterey Bay)*	n/a
Harbor Porpoise (SF/Russian River)	n/a	*Harbor Porpoise (SF/Russian River)*	n/a	*Harbor Porpoise (SF/Russian River)*	n/a
Harbor Porpoise (N CA/S OR)	n/a	*Harbor Porpoise (N CA/S OR)*	n/a	*Harbor Porpoise (N CA/S OR)*	n/a
Bottlenose dolphin	n/a	*Bottlenose dolphin*	n/a	*Bottlenose dolphin*	n/a
Harbor Porpoise (N OR/WA Coast)	n/a	*Harbor Porpoise (N OR/WA Coast)*	n/a	*Harbor Porpoise (N OR/WA Coast)*	n/a

5 Conclusions and Recommendations

The objective of this analysis was to adapt and apply elements of earlier risk assessment methods using quantitative and expert assessment methods, to evaluate relative vulnerability of U.S. West Coast marine mammal and sea turtle species to potential impacts from offshore sustainable energy development. The approach is inherently spatially and temporally explicit, considering a range of biological, environmental, and anthropogenic aspects of defined areas (zones) and time (oceanographic seasons). It is deliberately simple, transparent, repeatable, scalable, and understandable. The structured assessment yields relativistic vulnerability scores and associated ratings across many species, times, and areas with consistent approaches and treatments of the considerable uncertainty that exists for most contexts evaluated. This acknowledged uncertainty is addressed in multiple ways, including explicitly in higher risk scores for some factors, variable levels of assigned confidence in scores, and even instances where no scores are assigned at all. One of the main related outcomes and associated products are specific targeted data needs for key species and context to reduce data gaps.

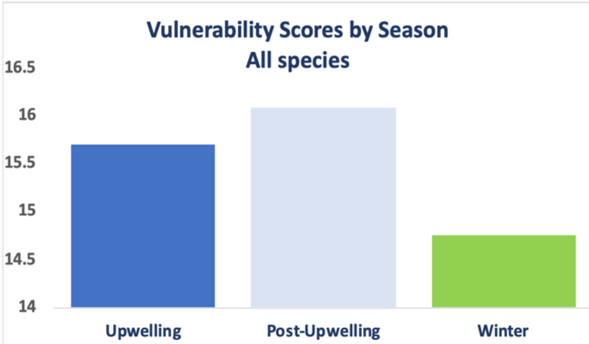
It should be clearly recognized that this analysis is neither intended to be nor presumed to replace fully quantitative impact assessments focused on any specific lease area or proposed development. Rather it is an initial and deliberately broad scale assessment of the relative vulnerability of a wide range of protected species based on a structured assessment of population, habitat distribution, susceptibility to direct impact, and existing anthropogenic stressors, without yet considering the magnitude and severity of new development activities. The resulting vulnerability scores and ratings for each species, zone, and seasonal context that was evaluated are presented here individually by each of the 42 marine mammal and sea turtle species (section 3; see also section 1 for raw data). Relative vulnerability results are also considered for each area and season across all species (section 4). In addition to the specific data needs identified by species and context, the combined results yield a host of key observations that will prove useful in guiding baseline monitoring, strategic research directions, impact assessments, and potential mitigation approaches.

Not surprisingly, extensive variability in assessed vulnerability was observed within and across species and area-time contexts considered. In essence, this is by design based on the structure of the factor and sub-factor scores, which are intended to evaluate differential vulnerability and associated risk based on key population, life history, behavioral, and existing stressor parameters known or expected to influence the relative impacts of future disturbance. That we found relative vulnerability spanning all the relative ratings with clear patterns of spatial, temporal, and taxonomic differences across contexts indicates that adaptations of the vulnerability assessment from very different contexts in other geographic locations (Southall et al. 2023) were effectively implemented for these novel contexts on broad geographic scales for the U.S. West Coast. What is most relevant and appropriate in interpreting these initial variable results, in addition to the specific data gaps identified, are the relative differences that exist among species/stocks overall, within species as a function of space and time, and across species for different zones. Noted again is that these results are intended to guide future finer-scale and more development-specific semi-and fully quantitative analyses focused on more targeted areas, contexts, and species. Synthesis results at this stage, however, provide some clear insights and (in some instances) unsurprising but insightful conclusions.

For instance, certain species-specific population and life history parameters strongly influence assessed vulnerability. This is most evident in key species such as loggerhead sea turtles, blue whales, fin whales, western gray whales, southern resident killer whales, and several humpback whale DPSs with similar confluences of factors. Each of these have both high population factor scores (endangered species with unknown or decreasing population trends, and small or unknown population sizes) and relatively high assessed susceptibility to physical impacts (masking, vessel strike, entanglement) with associated high relative assessed vulnerability. While relative risk for such species was higher for spatial zones and times where these species were known or assessed to be more relatively present and engaged in vital biological functions, their relatively high overall risk in these population and physical impact factor scores meant they remained in at least the moderate relative risk category even if they were assessed to be very rarely present in an area. A key question for these species, given the relatively high overall risk across many contexts including in areas with existing or proposed offshore energy lease areas, is whether through existing or (more likely) targeted monitoring to improve distribution and density data, it can be determined that the probability of their presence, and thus risk, is effectively zero. While some of the vulnerability assessment conducted here effectively made this conclusion for species or stocks with known and documented high site fidelity, we did not do so for many of the migratory species who are known or expected to be rarely present in an area for a given season, but if they are present would be among the most highly vulnerable. In general, mysticete cetaceans and sea turtle species fell in the moderate, high, or highest risk categories for almost all zone-season contexts that were evaluated, although there was considerable variability in which of these categories between different contexts.

An inverse observation may be made for some of the species that are most likely to be encountered and thus most easily monitored and documented in studies and impact assessments. Many of the most common species, and species that may most commonly interact with offshore energy facilities in the lease areas planned for development currently off California, were assessed here to have some of the lowest overall risk. This includes several odontocete cetacean and pinniped species, such as (but not excluded to) common dolphins, Pacific white-sided dolphins, Risso's dolphins, California sea lions, elephant seals, fur seals. Again, there is variability in assessed vulnerability within contexts for these and other odontocete and pinniped species, but they were generally evaluated as having much lower overall risk relative to baleen whales and sea turtles. While there are many data gaps and needed research and monitoring data needs for really all the species evaluated here, and all species considered here are federally protected at some level, these relatively lower vulnerability scores should help inform strategic choices for prioritizing and designing monitoring and baseline studies to inform construction and operational plans. These plans should seek to find reasonable balances between approaches for common (likely lower risk) and rare (likely higher risk) species. Monitoring programs and research studies may be easier and, in some cases, more statistically powerful for species that are commonly present, and thus likely exposed to potential impacts to a greater degree. However, it should be considered that such species are likely have relatively lower overall vulnerability, based on the factors assessed here. Conversely, monitoring and research may be more challenging and/or limited in sample size for rare and/or cryptic species that may be uncommonly present, but when present often have the highest relative risks of impact.

Looking across species to evaluate broader patterns of vulnerability over the very large spatial scales evaluated here, several interesting conclusions emerge. These may also be informative to managers and action proponents considering monitoring, data collection, and ultimately mitigation approaches to strategically minimize impacts generally. For instance, there are clear seasonal differences in vulnerability scores across species and zones (Figure 51). Across all zones, vulnerability scores are generally lowest in winter, highest in the post-upwelling period, and intermediate in the upwelling season. These patterns are particularly evident in baleen whales and sea turtles, while less seasonality is evident in odontocetes and pinnipeds (though average scores are lowest in winter for each of these taxa as well).



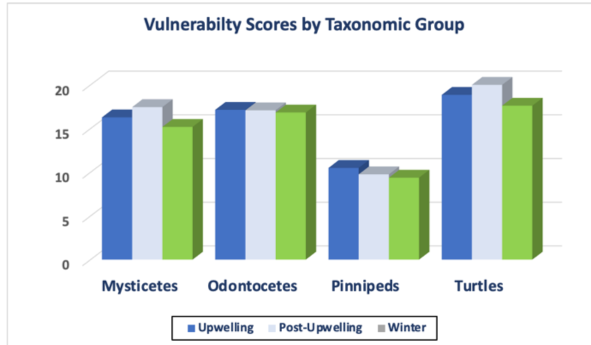
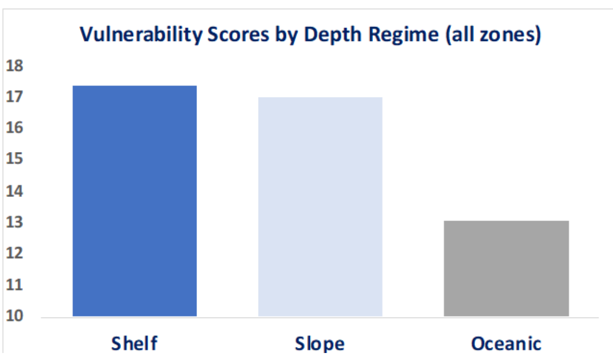


Figure 51. Average vulnerability scores by season for (left panel) all species considered and segregated by taxonomic group (right panel).

Several spatial differences in vulnerability scores are also generally evident across species and seasons. For instance, vulnerability scores were generally highest averaged across all species for shelf (< 100 m) depth regimes, followed by slope depths (100–1,000 m), with oceanic zones (1,000–2,500 m) having the lowest average vulnerability scores (Figure 52). This pattern was observed to different degrees for each of the five latitudinal (north-south) zones other than Zone 1 (central California) where the slope regime had higher scores than the shelf.



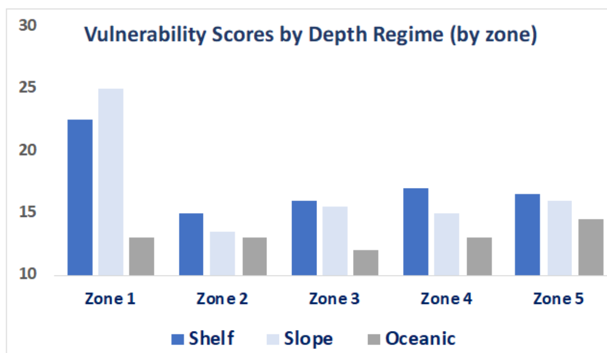


Figure 52. Average vulnerability scores by depth regime (shelf, slope, oceanic) given across all species and all zones (left panel) and segregated by latitudinal zone (right panel).

Latitudinal differences in average vulnerability scores across species are also evident (Figure 53). Average scores are highest overall for all taxonomic groups in Zone 1 (Central California). Zone 2 (Northern California) has the lowest average scores for mysticete and odontocete cetaceans as well as pinnipeds; zone 5 is relatively high for two of these three groups. It is noted that the largest human population and industrial activity centers among these zones are zone 1 and zone 5. For sea turtles, as generally warmer water species, there is a logical decrease in average vulnerability across taxa from southern (zone 1) to northern (zone 5) zones, driven largely by distribution patterns.

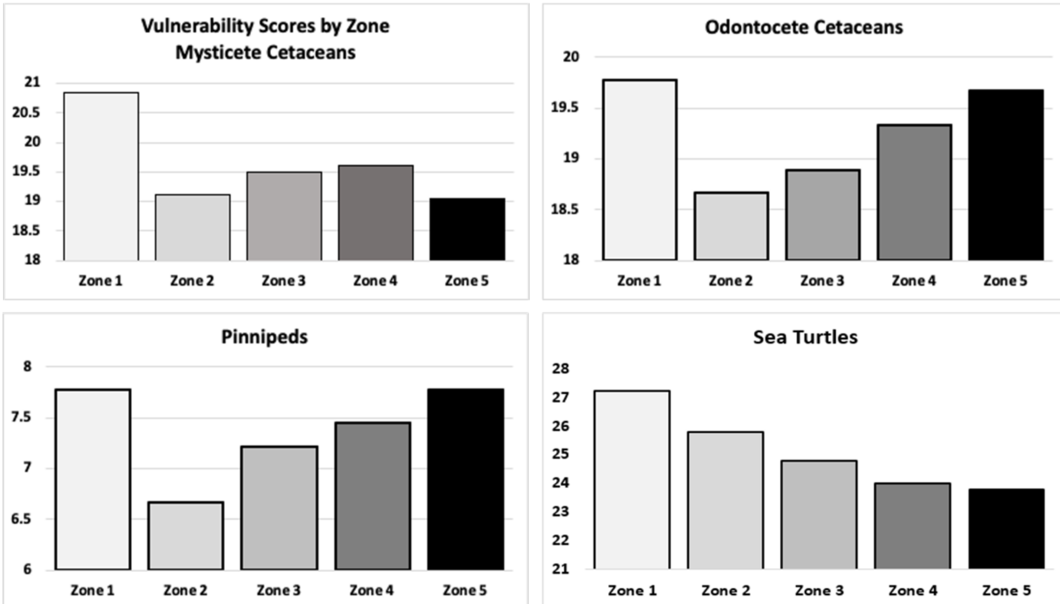


Figure 53. Average vulnerability scores by latitudinal zone (north-south) given across all species for each taxonomic group including mysticete cetaceans (top left panel), odontocete cetaceans (top right), pinnipeds (bottom left), and sea turtles (bottom right).

It was acknowledged at the outset of this project and is again emphasized here that this is neither intended to be nor should be interpreted as a complete risk assessment of potential impacts from any specific industrial development or operation. It is a starting point using semi-quantitative, structured, and consistent methods and assumptions for evaluating relative vulnerability to generalized potential disturbance from offshore energy development over what are quite large spatial areas. Additional steps and analyses (as in Southall et al. 2023) are clearly required and will be informed and guided by the vulnerability analysis conducted here.

While there are many, and many are specified for individual species and areas, some of the greatest sources of uncertainty and data needs include several key recommendations. Much better distribution and density data for key species, notable high vulnerability species, are needed, especially in non-summer seasons in areas in and around known or future lease areas. Key focus areas including analyses of existing and future data collection to identify justifiable criteria by which to determine when effective zero probabilities of occurrence may be assigned for high vulnerability but very rare species. A specific additional data need that is important to note given the differential but often high vulnerability scores in some contexts is both additional and targeted survey effort to support more complex and finer resolution density predictions for humpback whale DPSs across all seasons as well as the development of open population models regarding their respective distribution. Additional key data and analyses are sorely needed on susceptibility to direct human impacts (e.g., entanglement, vessel strike) from offshore wind installations specific to types likely to be deployed off the U.S. West Coast (e.g., floating turbines). More data supporting greater detail, consistency, and recency in SAR assessments for key factors used in this analysis (e.g., population trend, annual mortality, PBR, UME, diseases) are also needed.

Finally, we see several future directions in the analytical approaches used in this vulnerability assessment. Most obviously, comparable assessments focused on finer spatial and potentially temporal scales of species-specific vulnerability are clearly needed. For instance, spatial areas could include smaller areas (sub-zones) of zones considered here, potentially on the scale of lease areas with surrounding sub-zones of comparable sizes. Future analyses could also focus on a subset of species in greater detail and supported by additional, finer-scale quantitative data analyses, informed by the vulnerability analysis here. Experts involved in the scoring process here emphasized the importance of subsequent analyses including some consideration of interannual variability as part of the temporal considerations. The initial vulnerability risk assessment here considered distribution and behavior in a ‘typical’ upwelling year, but given the environmental stochasticity well documented to occur in the California Current Ecosystem, it was clearly noted that multiple scenarios could and should be assessed in more fine-scale vulnerability assessments. Associated temporal scenarios could include strong or weak upwelling years, marine heat waves, anomalously cool years, etc.

In addition to finer-scale, more data driven, and more scenario-driven vulnerability analyses building on the work here, additional quantitative analyses will clearly be required as well. These may include spatially-temporally explicit quantitative methods supporting a full risk assessment, such as the exposure index methods developed for analyses of specific offshore wind developments off the U.S. East Coast (see: Southall et al. 2023). Further information on the specific engineering and operational details of the installation, operation, and servicing of proposed offshore energy facilities is required before such quantitative approaches are possible, however. These kinds of risk assessment methods are intended to guide strategic focus of baseline assessments, impact assessments, effective monitoring and mitigation, and selection of species and context for which fully quantitative population consequence models (e.g., Keen et al. 2021) are needed. Such approaches are unlikely to ever be applied to the geographic or taxonomic breadth of the analysis conducted here. However, they are likely to ultimately be required and informative for a strategic subset of context and species, which may be informed by initial semi-quantitative risk assessments, where sufficient supporting input data are available to parameterize population impact models.

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