Preliminary Draft Marine Spatial Plan

Sunrise at Rialto Beach

An interagency team of state agencies, including Washington departments of Ecology, Natural Resources and Fish and Wildlife, developed the preliminary draft Marine Spatial Plan with input from local, federal and tribal governments, and stakeholders including the Washington Coastal Marine Advisory Council.

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Comments on the preliminary draft Marine Spatial Plan by **March 17, 2017**.

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Marine Spatial Plan for Washington's Pacific Coast

A Marine Spatial Plan (MSP) is currently under development for Washington's Pacific Ocean coast. The MSP provides:

- Guidance for new ocean uses along Washington's Pacific coast, such as renewable energy projects and offshore aquaculture.
- Baseline data on coastal uses and resources to capture current conditions and future trends.
- Requirements and recommendations for evaluating new ocean uses through the different phases of project review consistent with existing laws and regulations.
- Recommendations to protect important and sensitive ecological areas and existing uses like fishing.

Preliminary Review

A preliminary draft is now available for review by key stakeholders and tribes. A more formal draft plan is targeted for release for public comment in May 2017. While not required, a preliminary draft:

- Assists state agencies by getting early input from groups that have been engaged in the process for several years.
- Helps better prepare the draft plan for public comment by refining how plans and regulations fit together, identifying missing information and addressing concerns about recommendations.
- Enables the state meet a target for completing the MSP by June 2017.

Please see instructions for commenting on the preliminary draft MSP in the box at left.

Marine Spatial Plan for Washington's Pacific Coast

Section 3: Spatial Analyses

3.1. Seabird and Marine Mammal Modeling

3.2. Ecologically Important Areas Analysis

3.3. Use Analysis

Chapter 3: Introduction

As part of the Marine Spatial Planning process, the interagency team commissioned several analyses to provide additional information relevant to present and potential future conditions in the study area. Analyses were selected fill known data gaps, and to fulfill several of the requirements outlined in RCW 43.372.040(6)(c). Results of these analyses include data products, previously not available through empirical datasets alone, that inform and support many of the spatial and management recommendations outlined in the plan.

This chapter will not provide specific recommendations, which are described in detail in the management framework presented in Chapter 4. Rather, it briefly describes the data, tools and methods used to perform analyses that have contributed to the development of these recommendations and the planning process as a whole. In addition, each section also provides a brief overview of important results, and highlights some of the products from three projects completed to support the Marine Spatial Planning process in Washington:

1) Ecological modeling of seabird and marine mammal distribution by NOAA

2) Ecologically Important Areas (EIA) modeling by WDFW

3) A use analysis comparing the location and intensity of existing uses with technical suitability for offshore renewable energy

3.1: Seabird and Marine Mammal Modeling

The National Centers for Coastal and Ocean Science (NCCOS) at NOAA conducted several analyses for the state planning process, including developing ecological models of predicted seabird and marine mammal distribution within the study area. It is important to note that this process did not predict abundance but rather relative density. The resulting maps show where in the study area one would expect to find the highest density of each species, rather than predicting the number of animals actually present in the planning area or comparing abundance numbers across species.

NCCOS produced ecological models for eight species of birds and six species of marine mammals. Species were selected for analysis by the Washington Department of Fish and Wildlife (WDFW) because they are either of management concern (such as threatened or endangered species), or are representative of groups of species with important life history strategies or ecological functions. Seabird species included the Marbled Murrelet (*Brachyramphus marmoratus*), Tufted Puffin (*Fratercula cirrhata*), Common Murre (*Uria aalge*), Black-footed Albatross (*Phoebastria nigripes*), Northern Fulmar (*Fulmarus glacialis*), Pink-footed Shearwater (*Puffinus creatopus*), Sooty Shearwater (*Puffinus griseus*), and Rhinoceros Auklet (*Cerorhinca monocerata*). An analysis for Short-tailed Albatross, also a listed species, could not be completed because of insufficient data.

Maps of marine mammals included two species of pinniped, the Steller Sea Lion (*Eumetopias jubatus*) and Harbor Seal (*Phoca vitulina*), and four species of cetaceans: the Humpback Whale (*Megaptera novaeangliae*), Gray Whale (*Eschrichtius robustus*), Harbor Porpoise (*Phocoena phocoena*) and Dall's Porpoise (*Phocoenoides dalli*). Insufficient observations were available to produce models for the Sei Whale (*Balaenoptera borealis*), Blue Whale (*Balaenoptera musculus*), Fin Whale (*Balaenoptera physalus*), Southern Resident Killer Whale (*Orcinus orca*) or Sperm Whale (*Physeter macrocephalus*).

This section summarizes the data and general methods used to create the relative density maps, and highlights some key results. Reports from NCCOS covering additional technical details and maps for all species are available (Menza et al. 2016).

Data Sources

NCCOS staff and other contributors synthesized information from eleven existing monitoring programs that have collected data on sightings of species within the planning area (Table 3.1). While all of these programs overlap with the study area, they vary in geographic extent and years of operation. For this study, data collected between 2000 and 2013 within or just beyond the study area boundary was used. All observations were made at sea from ships or aircraft, typically along transects ranging in length from 25 kilometers to several hundred kilometers.

Table 3.1: Summary of seabird and mammal survey data compiled by NCCOS for the distribution analysis.

Survey Name	Data Collectors	Data Category
Harbor porpoise surveys	Cascadia Research Collective, NOAA Alaska Fisheries Science Center	Mammals
Leatherback turtle aerial survey	NOAA Southwest Fisheries Science Center	Mammals
Pacific Continental Shelf Environmental Assessment (PaCSEA)	USGS Western Ecological Research Center, Bureau of Ocean Energy Management	Birds and Mammals
California Current Ecosystem Surveys (includes ORCAWALE and CSCAPE surveys)	NOAA Southwest Fisheries Science Center	Birds and Mammals
Northwest Fisheries Science Center Northern California Current Seabird Surveys	NOAA Northwest Fisheries Science Center	Birds
Olympic Coast National Marine Sanctuary Seabird and Marine Mammal Surveys	Cascadia Research Collective, Olympic Coast National Marine Sanctuary, NOAA Southwest Fisheries Science Center	Birds and Mammals
Pacific Coast Winter Sea Duck Survey	Sea Duck Joint Venture, Washington Dept of Fish and Wildlife	Birds
Pacific Orcinus Distribution Survey (PODS)	NOAA Northwest Fisheries Science Center	Mammals
Large whale surveys off Washington and Oregon	Cascadia Research Collective, Washington Dept of Fish and Wildlife, Oregon Dept of Fish and Wildlife	Mammals
Northwest Forest Plan Marbled Murrelet Effectiveness Monitoring Program	US Forest Service, US Fish and Wildlife Service, Washington Dept of Fish and Wildlife	Birds and Mammals
Seasonal Olympic Coast National Marine Sanctuary seabird surveys	NOAA Olympic Coast National Marine Sanctuary	Birds

Figure 3.1 provides an overview of the spatial coverage of bird, cetacean, and pinniped surveys used in modeling. Through additional analysis of the location and timing of transects, NCCOS also identified seasonal patterns in survey effort for the study period. Effort per square kilometer was more concentrated in the northern section of the study area for birds and mammals during the summer, whereas winter bird survey effort was more evenly distributed from north to south.

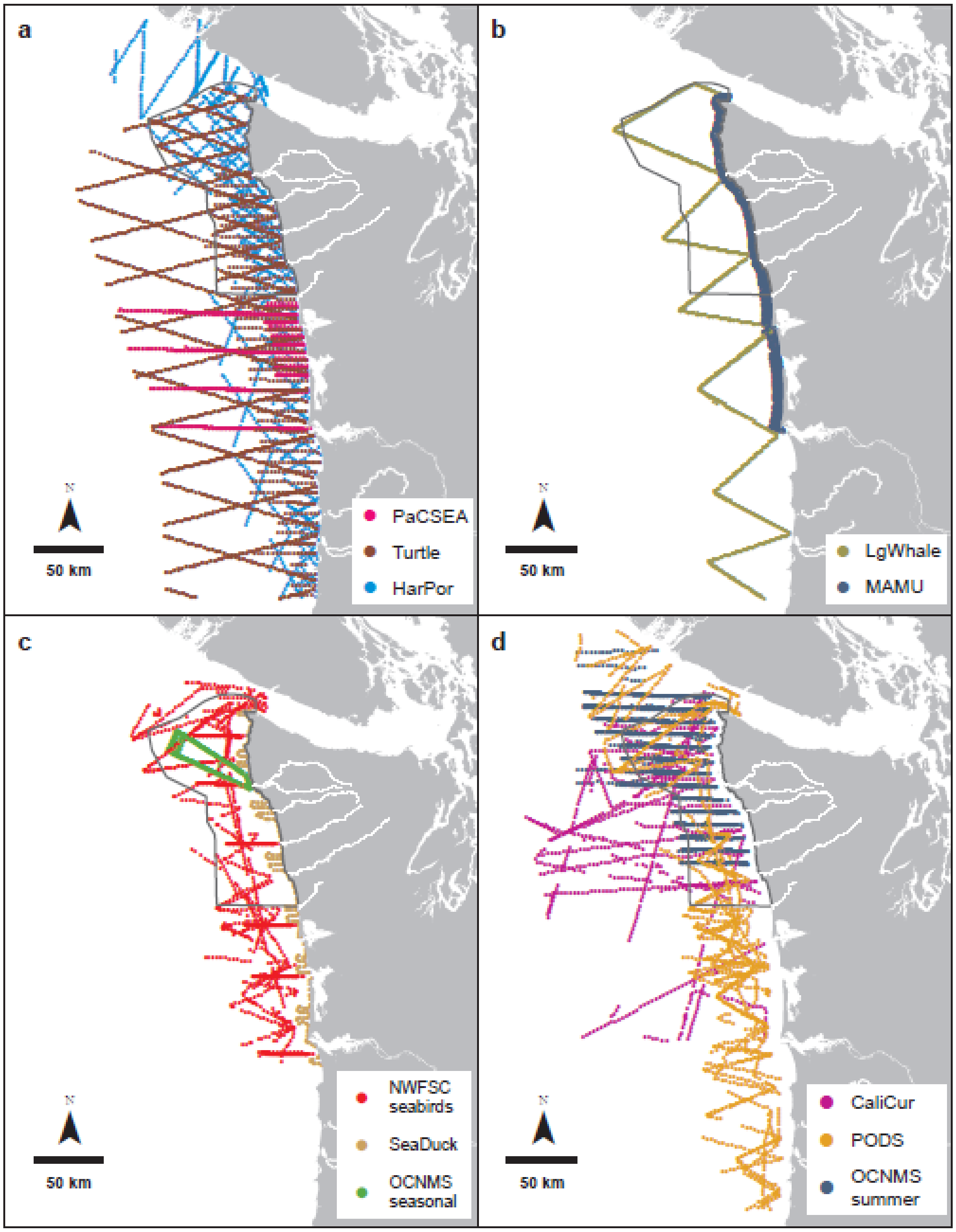


Figure 3.1: Spatial distribution of surveys from 11 programs used in bird and mammal models. The gray line in each frame indicates the boundaries of the Olympic Coast National Marine Sanctuary. Additional details on this figure and its source data provided in the final NCCOS report (Menza et al 2016).

Numerous datasets describing environmental and temporal parameters were used as predictor variables in the modeling process. Environmental predictors examined included geographic, topographic, oceanographic, and biological information, either collected as part of survey data or acquired by NCCOS from other sources. Table 3.2 summarizes the full list of predictor variables assessed. For analysis, all spatial datasets were averaged or extrapolated to a resolution of 3km. Additional details about data sources, data selection, and processing steps for individual predictor variables are provided in the final report (Menza et al. 2016).

Table 3.2: Summary of ecological predictor variables incorporated into distribution models.

Geographic variables	Topographic Variables	Temporal Variables	Oceanographic Variables	Survey Variables
• Coordinates (X,Y) • Distance to key habitats like colonies or haul-outs for: - Tufted Puffin - Common Murre - Marbled Murrelet - Steller sea lion - Harbor seal	• Depth • Bathymetric position indices • Profile curvature • Planform curvature • Slope	• Julian Day • Year • Upwelling index • Indices for: - El Niño-Southern Oscillation - North Pacific Gyre Oscillation - Pacific Decadal Oscillation	• Probability of cyclonic and anticyclonic eddy rings • Sea surface salinity • Sea surface temperature • Probability of sea surface temperature front • Surface chlorophyll *a* • Frequency of chlorophyll peaks index	• Survey platform • Beaufort Sea State (marine mammals only) • Survey ID • Transect ID

Methods

In order to standardize and synthesize information from programs with diverse procedures for recording and collecting observations, datasets were first processed using a series of steps outlined in detail in the final project report (Menza et al. 2016) Data was sorted into summer (April to October) or winter (November to March) seasons based on the assumption that distribution patterns are affected by seasonal differences in environmental conditions or animal behavior. Statistical modeling was used to identify the ecological variables from Table 3.2 that best predict density for each species and season combination. To account for variations in observations due to survey methods and timing, the models also incorporated variables related to survey methods and conditions, such as weather and whether a survey was done from a boat or from aircraft. For most species, sufficient data was not available to conduct analysis for the winter period. Models and maps were produced for the Common Murre, Rhinoceros Auklet, and Black-footed Albatross for both seasons, and for summer only for all other bird and mammal species.

NCCOS produced multiple models for each species and season, and then used various diagnostic tools to assess and compare model performance before making a final selection. After identifying the best available model, further diagnostic steps included identifying limitations and caveats applicable to the results for each species.

After selecting a final model for each season and species combination, the outputs of each model were mapped to illustrate the areas of highest and lowest long-term relative predicted density. NCCOS also generated maps showing where in the planning area the coefficient of variation is highest for each species based on data inputs and model evaluations. These maps provide a mathematical and spatial representation of uncertainty. Areas with higher coefficients had a greater amount of variability in results, and therefore have a higher amount of uncertainty associated with how well model predictions align with the actual distribution of species. For detailed performance results and uncertainty information for each model, please refer to Appendix C of the final report (Menza et al. 2016).

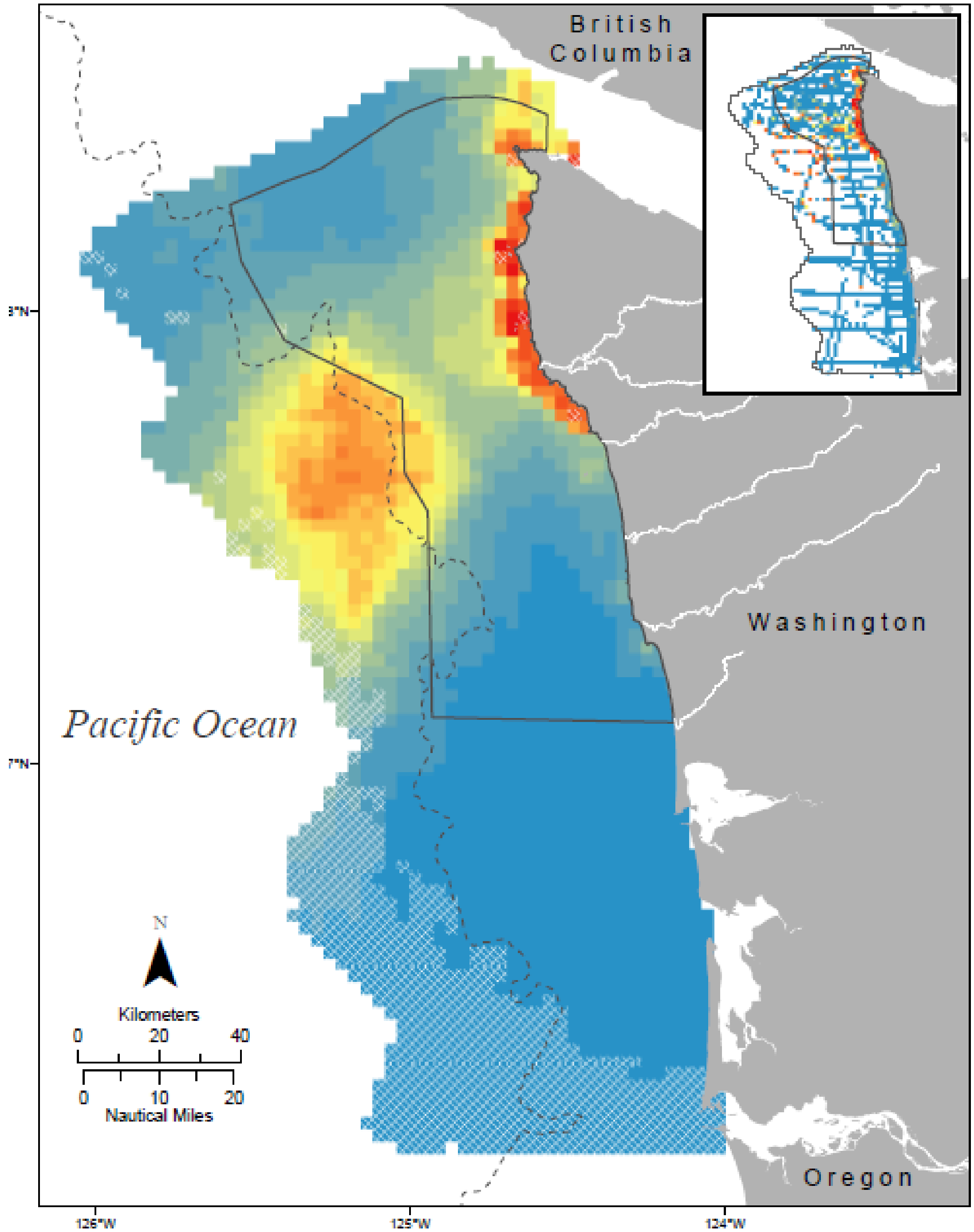
Results

The output maps from NCCOS provide general predictions for areas of highest and lowest density of the selected species at a broad scale using extensively evaluated models. However, all models have inherent uncertainties and limitations. While each model was assessed to ensure that it provides the best possible representation of relative density at the planning scale based on available data, all maps should be considered in the context of uncertainty and other available data and expertise.

Figures 3.2 and 3.3 provide examples of maps produced for each species and season combination. The species presented in this chapter are of particular interest because of their conservation status, or because they represent datasets that are particularly robust or can be representative of patterns seen in other species. Figure 3.2 illustrates the best long-term density prediction for Tufted Puffin, a nearshore species, in summer. This best prediction model represents the median of predicted values, and is shown with an overlay depicting uncertainty and an inset showing survey coverage and species density for actual field observations. Uncertainty varied greatly by species, and any interpretation of distribution information from a specific model should include careful consideration of areas with high coefficients of variation, particularly if assessing a specific site.

In addition to the best prediction median map (a), Figure 3.3 presents a spatial representation of uncertainty based on the coefficient of variation (b), and two quantile maps (c and d). The quantile maps show two additional potential distributions based on different levels of statistical confidence, which could be of interest in cases where a more or less conservative approach to predictions is desired. NCCOS produced each of these images for all models.

Tufted Puffin (*Fratercula cirrhata*): April to October



Relative density Min Max

Figure 3.2: Long-term predicted relative density for Tufted Puffin, summer. White cross-hatching indicates areas where the model has a coefficient of variation greater than 0.5 (relatively higher uncertainty). Gray line indicates the boundaries of the Olympic Coast National Marine Sanctuary, and inset shows observed density from surveys. Original figure and additional detail provided in the NCCOS final report (Menza et al 2016).

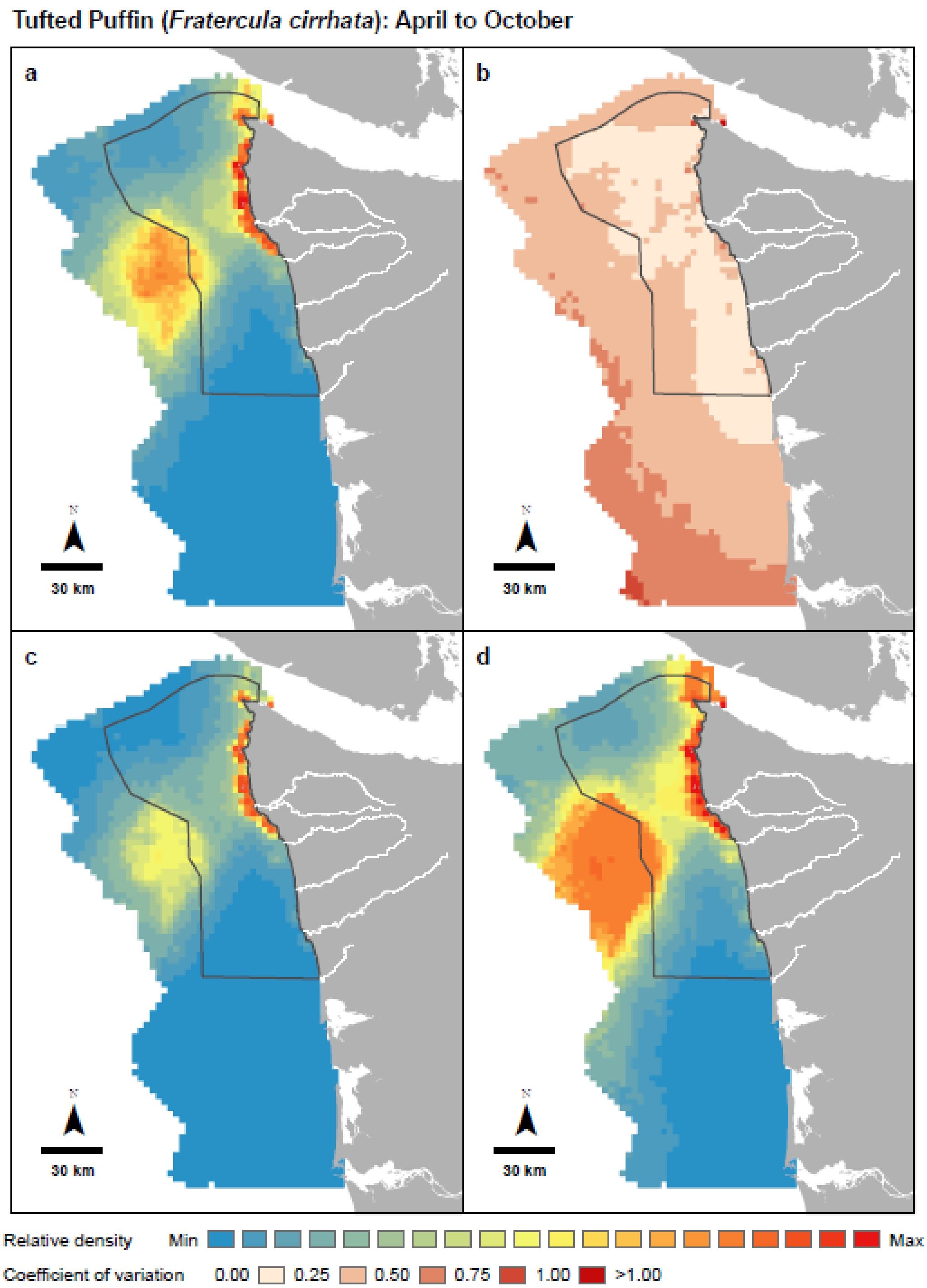


Figure 3.3: Predicted long-term relative density for Tufted Puffin, summer, based on a) the median of predictions, c) a 5% quantile, and d) a 95% quantile. b) a spatial illustration of coefficients of variation for the model (a measure of uncertainty). Original figure and additional explanation of quantiles provided in the NCCOS final report (Menza et al 2016).

The predicted relative density of pelagic species was generally highest in the northern part of the study area; nearshore species such as the Tufted Puffin and Marbled Murrelet (Figures 3.2 - 3.4) were generally predicted to be concentrated within 10 to 15km from shore during summer, but with greater variation in north to south distribution. Patterns for pelagic species tended to be associated with the continental shelf or other geological features such as submarine canyons. Models for some species, such as the Gray Whale (Figure 3.5), may have been affected by the relationship between survey timing and migration patterns. Possible anomalies of note for several specific species are discussed in the full NCCOS report (Menza et al. 2016).

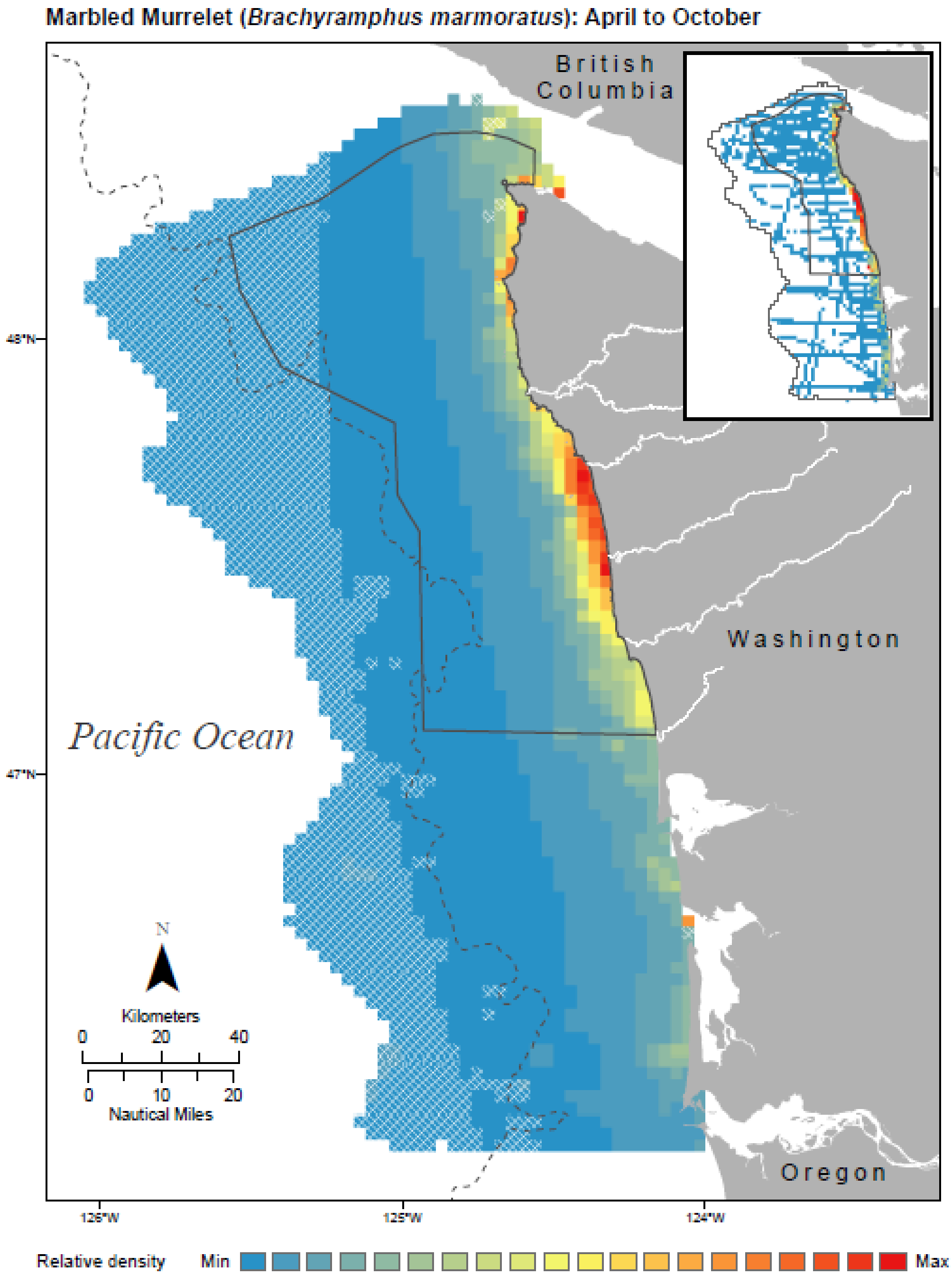


Figure 3.4: Predicted long-term relative density for Marbeled Murrelet, summer. White cross-hatching indicates areas where the model has a coefficient of variation greater than 0.5 (relatively higher uncertainty). Gray line indicates the boundaries of the Olympic Coast National Marine Sanctuary, and inset shows observed density from surveys. Original figure and additional detail provided in the NCCOS final report (Menza et al 2016).

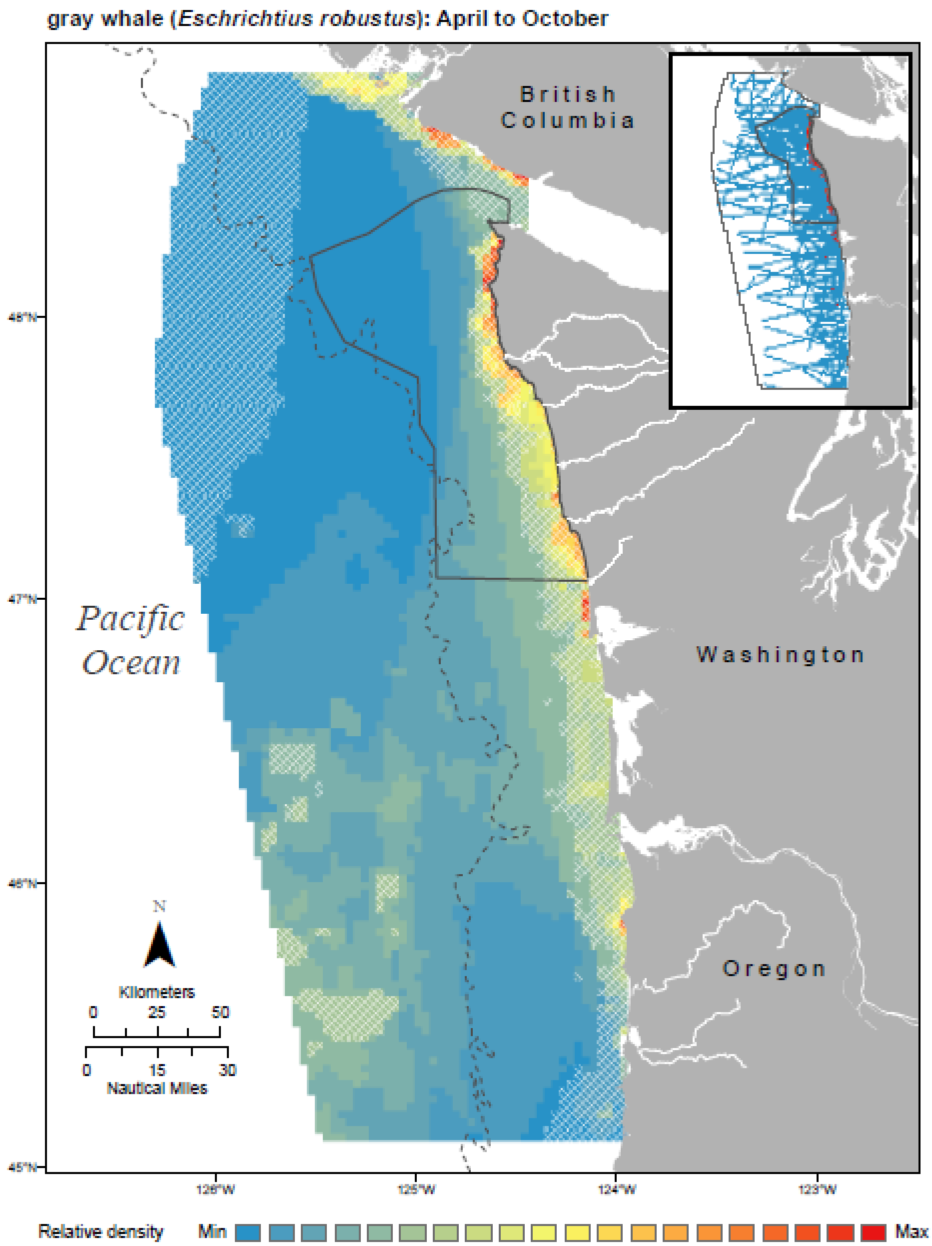


Figure 3.5: Predicted long-term relative density for Gray Whale, summer. White cross-hatching indicates areas where the model has a coefficient of variation greater than 0.5 (relatively higher uncertainty). Gray line indicates the boundaries of the Olympic Coast National Marine Sanctuary, and inset shows observed density from surveys. Original figure and additional detail provided in the NCCOS final report (Menza et al 2016).

Areas of high predicted density are often associated with known patterns of upwelling and high productivity, or located near breeding colonies or haul-outs. The Marine Spatial Plan provides additional detail on productivity patterns and the location of bird colonies and mammal haul-outs in the study area in Section 2.1.

For species with sufficient data available to model both summer and winter, areas of greatest density were further offshore in winter than in the summer. Figure 3.6 provides an example of this pattern as seen in the results for the pelagic Black-footed Albatross. While insufficient data was available to model predictions for Short-tailed Albatross in the planning area, the maps for Black-footed Albatross can provide an indication of likely areas for greatest Short-tailed density due to similarities in the ranges and life history traits of these two species.

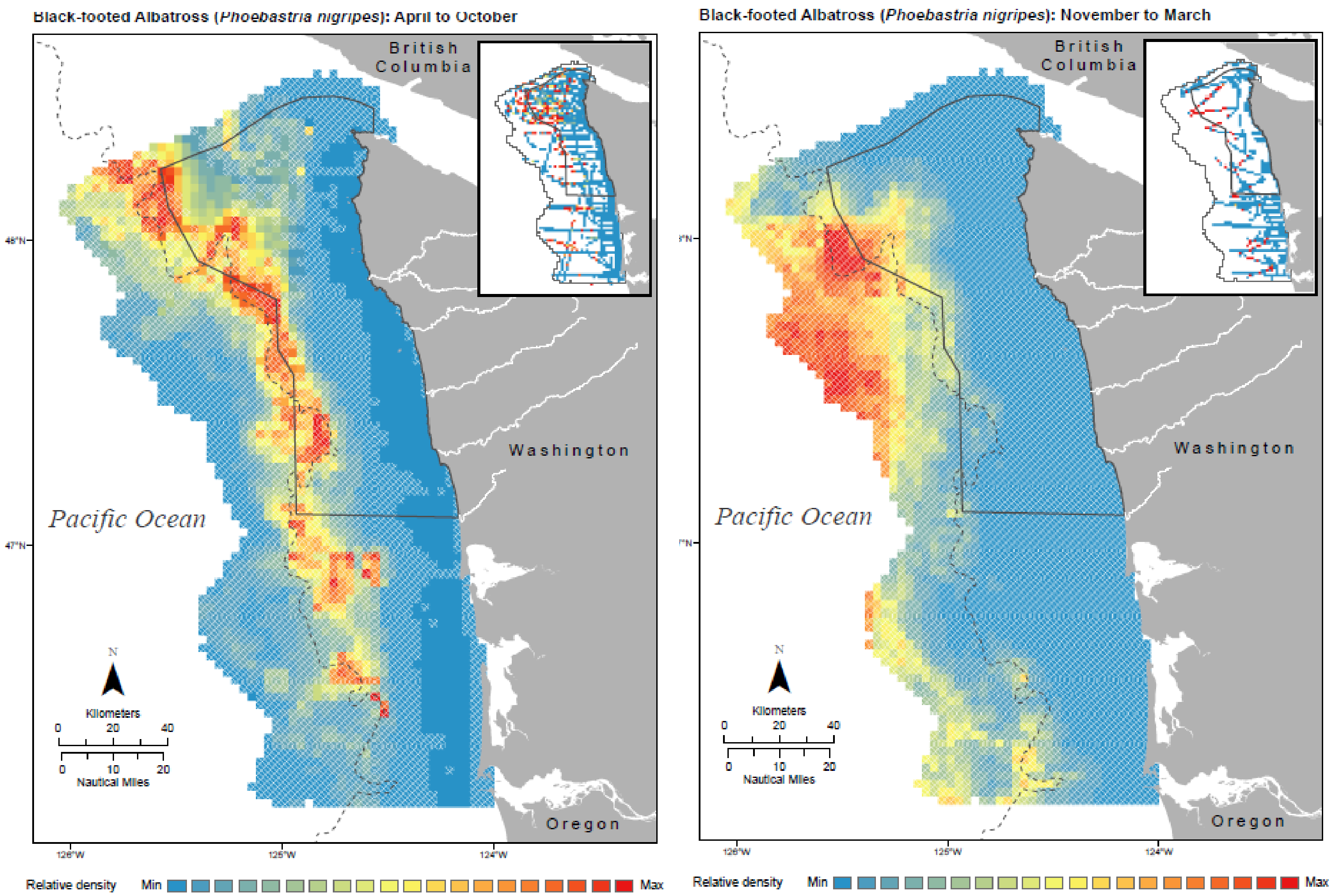


Figure 3.6: Predicted long-term relative density for Black-footed Albatross, summer (left) and winter (right). White cross-hatching indicates areas where the model has a coefficient of variation greater than 0.5 (relatively higher uncertainty). Gray line indicates the boundaries of the Olympic Coast National Marine Sanctuary, and insets show observed density from surveys. Original figure and additional detail provided in the NCCOS final report (Menza et al 2016).

The full research report by NCCOS also provides detailed results from evaluations of each final species model. This includes an in-depth statistical analysis of model performance and visual representations of fit and potential bias using marginal and residual plots. A comparison of variable importance between models shows that some predictors, such as depth and surface chlorophyll *a* concentration, were relatively more important in final models for many species. Full discussion of model fit and performance is available in Appendix E of the report (Menza et al. 2016). In cases where the highest relative importance was assigned to random variables, such as Transect ID number, models may benefit from the inclusion of additional ecological predictor variables which more strongly correlate with that species' distribution.

Overall, performance was strong for all models, though variable across species and seasons. While the strength of a model represents how well it fits the input data, it does not necessarily describe the quality of the original data, fully assess accuracy of results, or give a clear indication of how well the model predicts density in areas far from all input data points. As shown in Figure 3.1, there are also known gaps in survey coverage for modeled species, particularly in offshore areas. This may have a particular effect on the results for pelagic species which frequent these areas (Menza et al. 2016).

It is also important to note that because of data limitations, NCCOS could not analyze the full list of species identified by WDFW as priorities for ecological modeling. In some cases the models discussed here highlight areas that may also contain a higher density of species that were not modeled, by illustrating general patterns common to many birds, cetaceans, or pinnipeds. However, a lack of available data for a species does not imply that it plays a less important ecological role in the study area. The species with insufficient sighting data are all listed at the state or federal level. They may be of interest when prioritizing future monitoring and modeling projects, and despite not being included in these results are important to consider in any finer-scale assessments of current conditions of a specific site within the planning area.

Output layers from the NCCOS marine mammal and bird distribution analyses were used in combination with other ecological datasets to support the Ecologically Important Areas assessment described in Section 3.2.

3.2: Ecologically Important Areas

The Washington Department of Fish and Wildlife's (WDFW) Ecologically Important Areas (EIA) project was completed to contribute to the series of maps required by RCW 43.372.040(6)(c). The statute requires the series of maps to among other things, "summarize available data on:

> The key ecological aspects of the marine ecosystem, including on its biological characteristics and on areas that are environmentally sensitive or contain unique or sensitive species or biological communities that must be conserved and warrant protective measures."

The EIA analysis contributes to the summary of key ecological aspects in two main ways. First, the project analyzed and produced 39 maps of the ecological distribution of various species, species groups, and habitat features. These individual maps, a.k.a. "layers", provide a substantial summary of how biological communities are distributed throughout the Study Area. The state interagency team considered these maps when developing various components of the plan, such as the designation of Important, Sensitive, and Unique (ISU) areas, discussed in the management framework (Section 4.3).

The project's second main contribution involved combining the individual maps (or "overlaying" the maps) to explore broader ecological patterns in the study area. Due to data limitations, the individual EIA maps can only cover a subset of the biological communities in the study area. Therefore, one goal of the analysis was to use the patterns seen in their combined distribution to differentiate some regions of the study area as being more ecologically important than others.

This section provides an overview of the individual maps that were produced in the EIA analysis and the methods used to overlay them. Further discussion of how various combinations of EIA layers were incorporated into the use analysis is provided in Section 3.3, and full details on the individual map layers and the project will be available in a separate report (WDFW 2017a). .

Data Sources: Individual Map Layers

WDFW used a variety of data sources and methods to produce the individual EIA maps, such as the NCCOS models described in Section 3.1, survey data, and fisheries logbooks. Many maps, particularly those for wildlife species, were based on surveys conducted by WDFW. Others were based on data provided by outside groups. Table 3.3 lists all of the individual layers or layer groups for which maps were completed. This table described the species within each layer, the data source or methodology used to collect or synthesize the data, the data timespan, and the CMECs zones that the layer can be found in (further description of the CMECs zones can be found in (WDFW 2017a)). For some layer groups, individual maps were produced for all species in the group (e.g. groundfish), while other layers may include multiple species (e.g. seabird colonies) in one map.

Table 3.3: EIA Layers

Layer Title or Group	Species Included	Methods	Timespan	Zone/ Strata
Snowy plover	Snowy plover	Transects and nest searches	2006-2013	Beach
Streaked horned lark	Streaked horned lark	Transects and nest searches	2006-2013	Beach
Seabird Colonies	- Ancient Murrelet - Arctic Tern - Black Oystercatcher - Caspian Tern - Cassin's Auklet - Common Murre - Cormorants - Gulls - Storm-petrels - Pigeon Guillemot - Rhinoceros Auklet - Tufted Puffin	Colony counts	1970s -2013	Beach, Nearshore
Seal/Sea Lion haulouts	- Harbor Seal - California Sea Lion - Steller Sea Lion - Northern Elephant Seal	Aerial observations	1998-2013	Beach, Nearshore
Nearshore seabirds and marine mammals	- Cassin's Auklet - Ancient Murrelet - Rhinoceros Auklet - Brandt's Cormorant - Double-Crested Cormorant - Pelagic Cormorant - Pigeon Guillemot - Harbor Seal - Harbor Porpoise.	Boat-based line transects	2009-2013	Nearshore
Sea otter	Sea otter	Aerial observations	2012-2013	Nearshore
Seabird Abundance	- Black-footed Albatross (winter/summer) - Northern Fulmar (summer) - Sooty Shearwater (summer) - Common Murre (winter/summer) - Tufted Puffin (summer) - Marbled Murrelet (summer)	Modelled abundance surface using environmental variables and results from boat and aerial surveys	1996-2013	Nearshore, Offshore, Oceanic

Layer Title or Group	Species Included	Methods	Timespan	Zone/ Strata
Marine Mammal Abundance	- Steller Sea Lion - Harbor Seal - Humpback Whale - Gray Whale - Harbor Porpoise - Dall's porpoise	Modelled abundance using a compilation of at-sea observations from multiple survey programs. Each program collected spatially-explicit observations of pinnipeds, and/or cetaceans within a sampling domain which overlapped, and in some cases extended well beyond the study area.	Data time series ranged from 11-22 years; 1995 to 2014	All zones and strata
Razor Clams	Razor Clams	Beach survey locations	1997-2014	Beach, Nearshore
Dungeness Crab	Dungeness Crab	Fishery logbooks	2009/10 - 2012/13	Nearshore, Oceanic, Offshore
Groundfish	- Darkblotched Rockfish - Dover Sole - Greenspotted Rockfish - Longspine Thornyhead - Pacific Ocean Perch - Petrale Sole - Sablefish - Shortspine Thornyhead - Yelloweye Rockfish	Modeled abundance or probability of occurrence using bottom trawl survey information with covariates.	2003-2012	Offshore, Oceanic
Pacific Whiting	Pacific Whiting	Fishery logbooks and observer records	2001-2014	Oceanic, Offshore
Pink Shrimp	Pink Shrimp	Fishery logbooks	2003-2012	Oceanic, Offshore
Intertidal spawning forage fish spawning sites	- Surf Smelt - Night Smelt - Pacific Sand Lance	Locations of beach spawning surveys	2003-2012	Oceanic, Offshore
Deep Sea Coral	Any species in the taxonomic orders Antipatharia or Scleractinia or the suborders Alcyoniina, Calcaxonia, Filifera, Holaxonia, Scleraxonia, Stolonifera.	Maxent species distribution model	Several	Oceanic, Offshore
Rocky Reefs/Hard benthic substrate types	Rocky reefs/hard benthic substrate types	Various	Several	Nearshore, Oceanic, Offshore
Kelp	- Bull Kelp - Giant Kelp	Polygons representing floating kelp beds derived from annual aerial photos.	1989-2012	Nearshore

1

Methods

The source data for the EIA maps was measured in a variety of different ways, including counts of animals present, the probability of occurrence as estimated by a model, or total commercial fisheries catch in weight as reported in logbooks. To facilitate comparison and create the map overlays, WDFW analysts converted the original measurement units for each map to a relative ranking using a quantile method. Within each layer, ranking scores were assigned on a scale of 1 to 5, with 1 representing the areas of greatest relative ecological importance and 5 the lowest. Table 3.4 shows the quantile values that correspond to each ranking.

Table 3.4: EIA scoring metrics

EIA score	1 (Highest Importance)	2	3	4	5 (Lowest Importance)
Quantile	> 0.90	0.75-0.90	0.25-0.75	0.10-0.25	< 0.10

As one example of how this quantile method was applied, consider the Blackfooted Albatross EIA layer, which was based on modelled abundance values from the NCCOS model described previously. For this particular layer, each hexagon was associated with a modelled abundance value. To calculate a score, this value was compared to that of all other hexagons in the map and assigned a relative ranking. For example, a hexagon with a modelled abundance value greater than 80% of the values in the entire map would be called the 0.80 quantile, and would be assigned a rank of 2 based on Table 3.4. More detail about this process is available in WDFW's final report (2017a).

In addition to being based on different units of measurement, EIA source data was also provided in various spatial resolutions and formats. Some datasets were created using grids of varying cell sizes (e.g. 500 square meters), while others used precise point coordinates. To attain a common spatial resolution, the EIA analysis used a grid in which each cell ("hexagon") is 1 square mile in area. For each individual map, an EIA score was assigned to all relevant hexagons. If the original spatial resolution of a map layer was finer than that of the EIA grid, it was possible to have multiple scores per hexagon. In such cases, the general approach was to score the hexagon based on the score closest to 1.

Not every map layer could be scored using the quantile approach. Some map layers, such as those for kelp and rocky areas, simply describe whether a feature is present or absent from an area. For those maps, the available data was not adequate to rank the relative quality of one area against another, as would be needed for the quantile approach. In these cases, the EIA scores were assigned based on other considerations, such as general knowledge that the areas have high ecological importance. While the scores of 1 assigned in this manner are not equivalent in meaning to those assigned using the quantile method, they are comparable for the purposes of the project.

In general, care should be taken when interpreting the EIA scores. The scores are not precise, quantitative measures of ecological quality. They are instead intended more as qualitative measures, and while they are easy to tabulate, must be interpreted in context. The scoring system would be no different if text labels were used instead of a 1 to 5 ranking. To best interpret the significance of the EIA, individual scores should be interpreted by closely assessing the source data and methods for each map, as well as other relevant information.

Furthermore, the EIA scoring approach has the same issue as many "binning" approaches where hard lines need to be drawn. For example, the difference between a score of 2 and 3 is the difference between information being included in the hotspot map described below or not. For an individual species map, the difference between a 2 and a 3 could be as minor as the difference between the 74.9th percentile and the 75th percentile. The latter would be a 2 and the former a 3, yet on the original measurement scale the difference between the two could be very small and not ecologically meaningful. This issue is not a major one in the context of the EIA project's aim to explore broad patterns in the study area, but could be a flaw if used for a different purpose.

The EIA analysis team also produced relative uncertainty scores for many of the individual maps on a scale from 1 to 3, with 3 being the highest uncertainty. The meaning of these uncertainty scores differs for each map and is meant to qualitatively show the relative confidence in the EIA score. For instance, the WDFW analysts have more confidence that a hexagon with an EIA score is 1 if the uncertainty score is a 1 than if it is a 2 or a 3. More detail is given in the final analysis report (WDFW 2017a).

Results

Again, the overall goal of the EIA was analyze the ecological distribution of individual species and habitats and to evaluate the combined "overlay" patterns throughout the study area. There are several different ways to combine layers, and no one result can provide a single "best" view of ecological importance. This section provides examples of some of the main maps considered and interpretations. Other examples and interpretations are further described in the full report (WDFW 2017a).

As described in the previous section, the EIA scores provide a unit of measure that can be compared across all individual layers. For each map, an EIA score of 1 conveys the highest importance or an important feature (e.g. rocky areas), and a score of 2 indicates lower, but still above average, importance. One of the first overlays highlighted in the EIA analysis is shown in Figure 3.7. This map evaluates which parts of the Study Area show up as important to at least one of the individual EIA maps. In other words, this map shows the score from each hexagon that was closest to 1 (the greatest importance ranking); this score could be from one or multiple layers. The result shows little contrast within the Study Area, as all but a small percentage of the hexagons have a score of 1 or 2. None of the hexagons in the Study Area are shown as a 4 or 5 in this map, because all cells had at least one layer ranked 1, 2, or 3. Based on this result and the fact that the EIA maps only cover a small subset of species in the marine ecosystem, it would appear that every part of the Study Area could be considered important to at least one species.

After considering several overlays, the interagency team chose two for inclusion in the Use Analysis (see Section 3.3) The "hotspot map" shows the number of 1s and 2s that appear in each hexagon (Figure 3.8). Hexagons that are important across multiple individual EIA maps may indicate higher ecological activity than those that are important to just a few. Consistent with marine ecology literature, the hotspot map shows the highest scores along the continental shelf break and at the heads of submarine canyons, particularly in the Juan de Fuca Canyon area off northern Washington. Further interpretations of the patterns seen in the hotspot map are given in WDFW (2017a). The hotspot map incorporated into the use analysis (see Section 3.3) differs slightly from Figure 3.8. Instead of using a count of importance scores across all 39 layers, the hotspot map included in the use analysis combined scores from several subsectors covering key layers or groups of layers. This was done to account for the fact that the amount of layers in the EIA outweighed the other existing use data. However, the overall patterns of ecologically important hotspots are very similar.

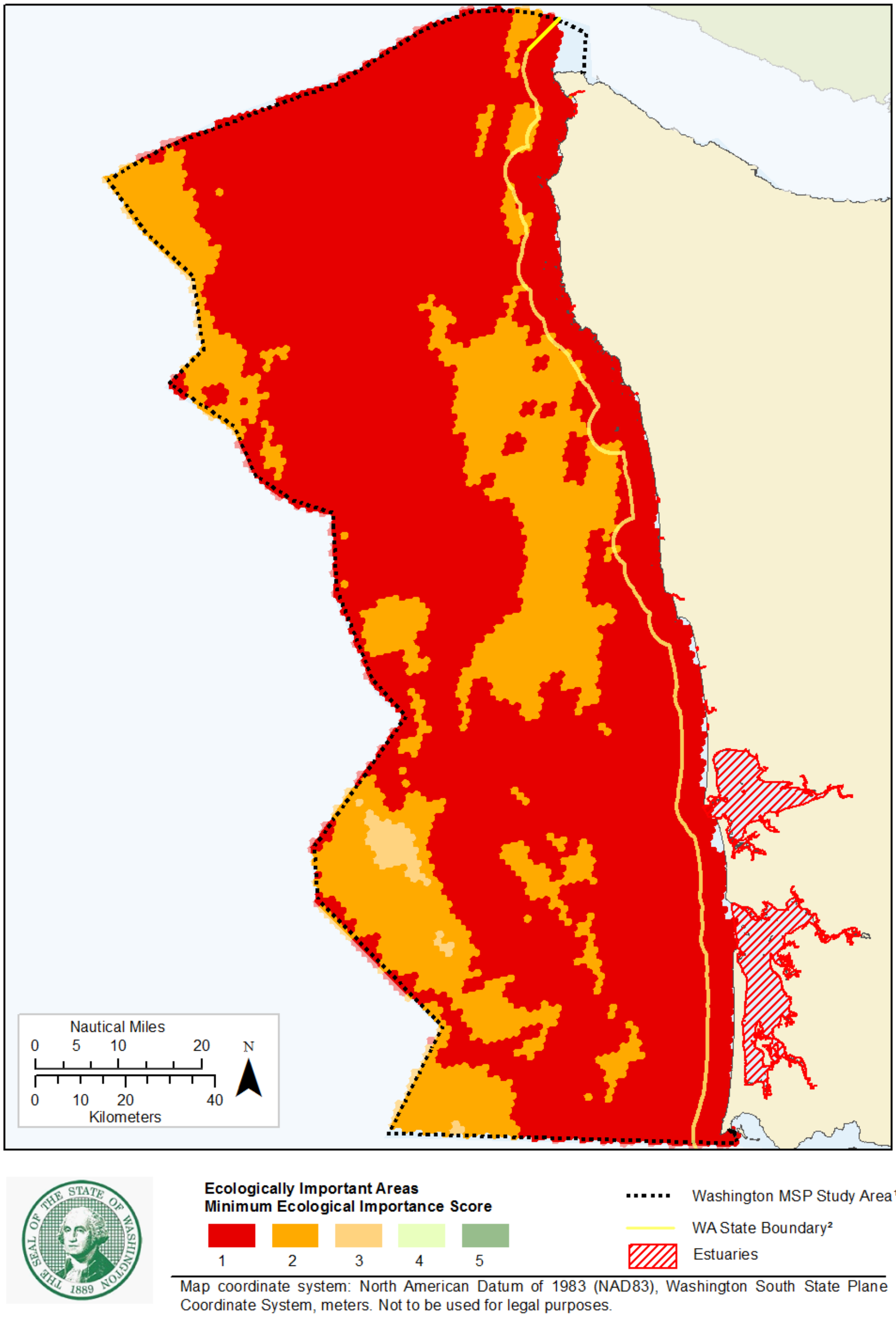


Figure 3.7: Score closest to 1 (indicating the greatest relative importance) for each hexagon in the planning area.

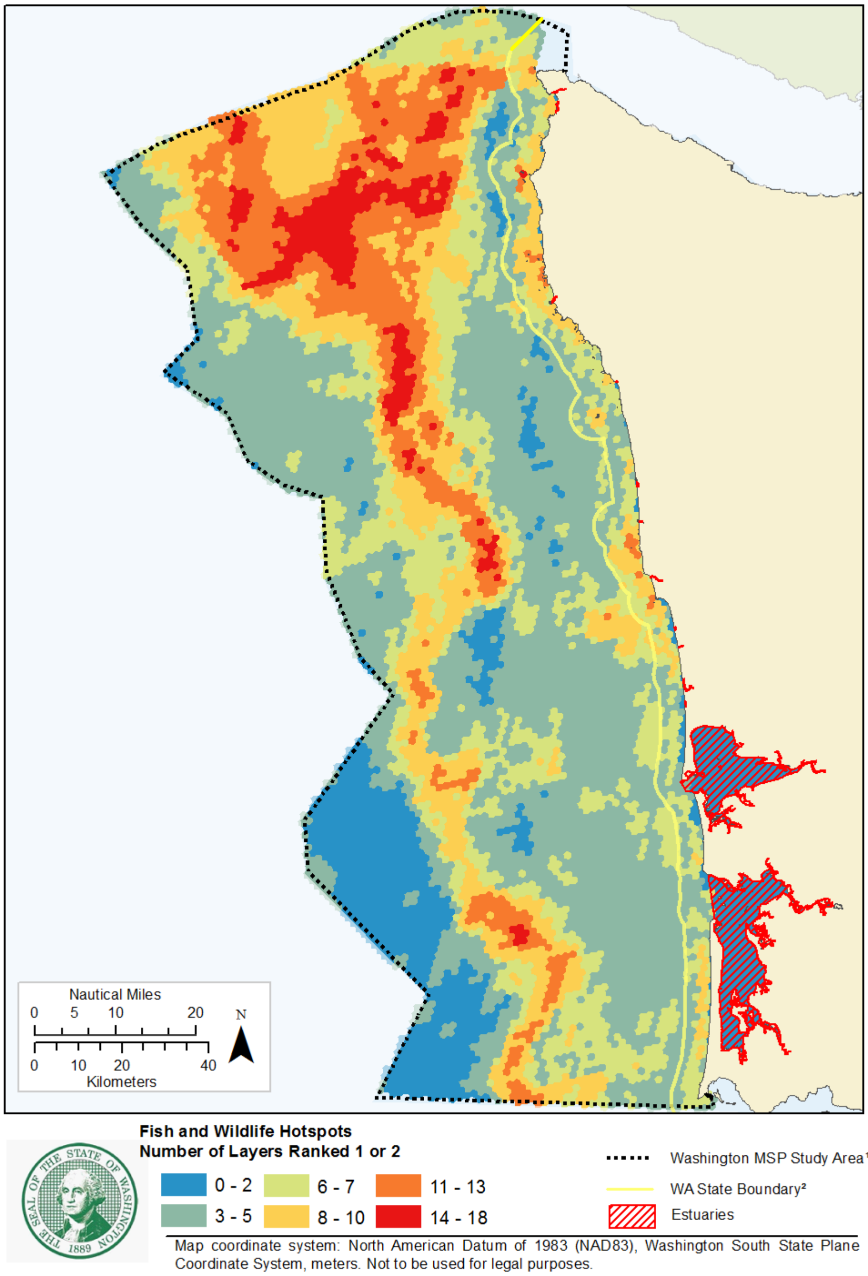


Figure 3.8: Hotspots for all combined EIA layers. Each hexagon's value is the number of layers with an importance score of 1 or 2 in that location (the scores indicating greatest ecological importance).

The second map incorporated into the Use Analysis is similar to the hotspot map but only includes species of high conservation concern (e.g. threatened or endangered species), or layers that have a presumed sensitivity to the physical displacement that might accompany renewable energy development (Figure 3.9). Sensitive species and habitats include kelp and rock areas, Snowy Plover nesting areas, Marbled Murrelet, and all large whales, among others.

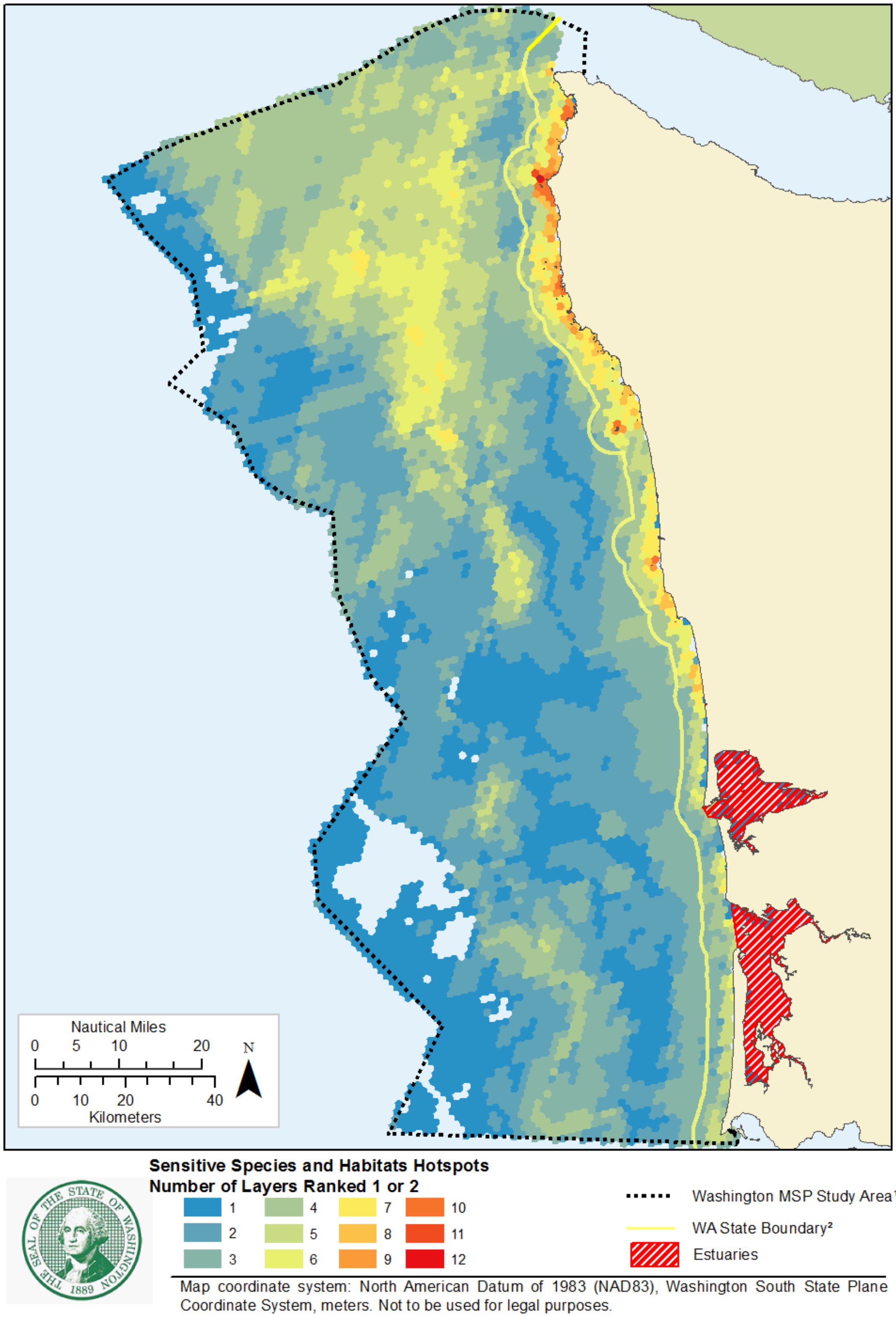
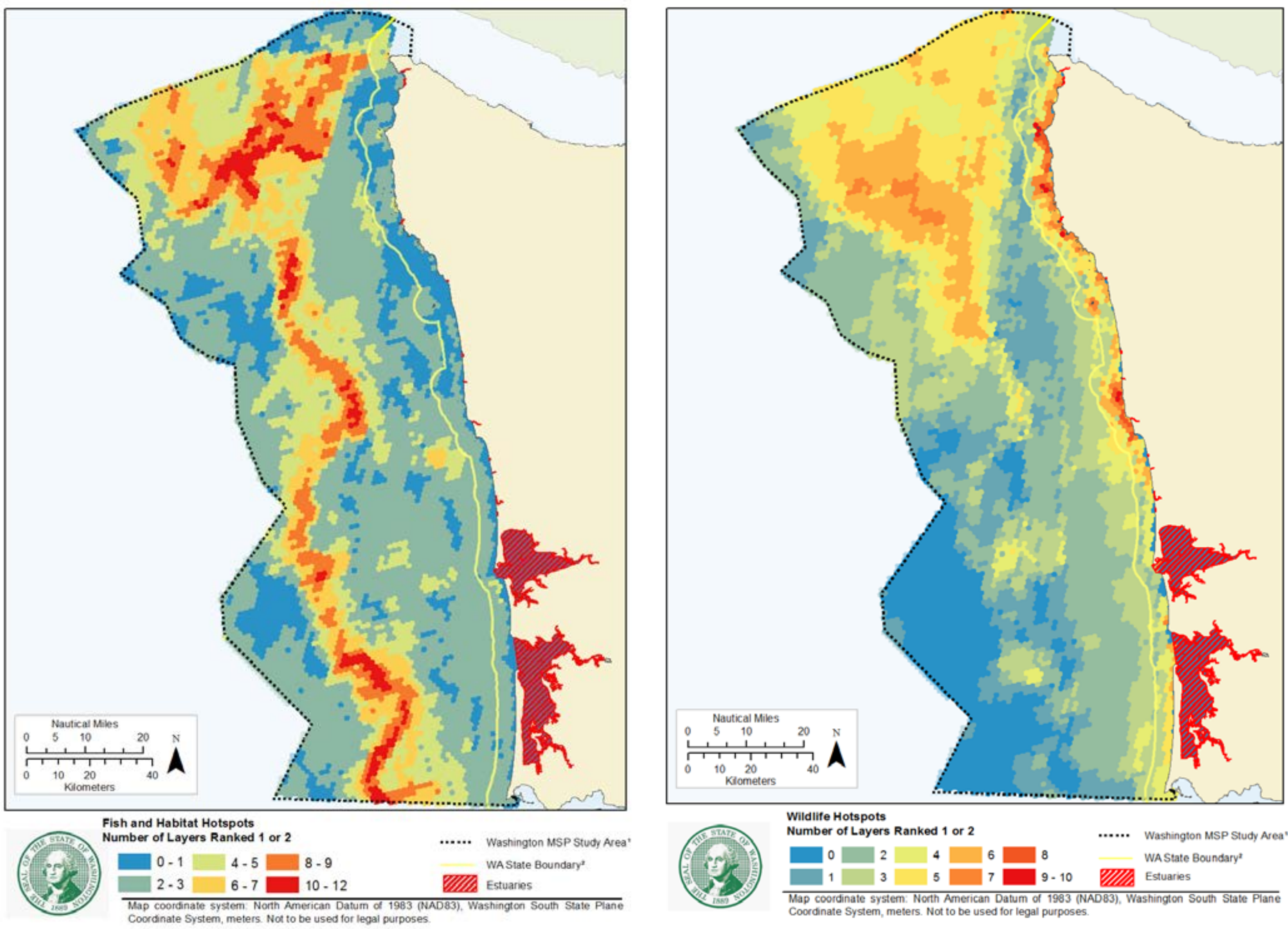


Figure 3.9: Hotspots for sensitive species and habitats. Each hexagon's value is the number of layers with an importance score of 1 or 2 in that location (the scores indicating greatest ecological importance).

While the subsector hotspot and sensitive species maps were chosen for the Use Analysis, this does not mean that they are the only outputs worth investigating. For example, Figures 3.10 and 3.11 show hotspots for fish and wildlife, respectively. While the fish hotspot map shows the highest scores clustered along the shelf break and the Juan de Fuca Canyon area (similar to the overall hotspot map), the wildlife hotspots tend to be found in the northern part of the study area, including in the nearshore.

Alternatively, the "coldspot" map shows the number of 4s and 5s (below average importance scores) that are found within a hexagon (Figure 3.12). While these areas may have a large proportion of layers that are ranked lower in importance, the underlying individual layers may contain certain species or habitats with scores of 1 or areas of great importance. For example, the southeast portion of the planning area contains a large amount of "coldspots", but is ranked as highly important habitat for Dungeness Crab, one of the most important commercial fisheries in Washington.

Many other analysis outputs are discussed in the final report (WDFW 2017a). Again, the intent of the overlay maps is to explore high-level patterns of ecological importance in the study area. Further interpretation requires looking to the individual maps and the data that supports them in the context of the question being evaluated.



Figures 3.10 (hotspots for all fish and habitat layers) and 3.11 (hotspots for all wildlife layers). Each hexagon's value is the number of layers with an importance score of 1 or 2 in that location (the scores indicating greatest ecological importance). Note that the color scales are not identical for the two figures, because each map incorporated a different number of layers.

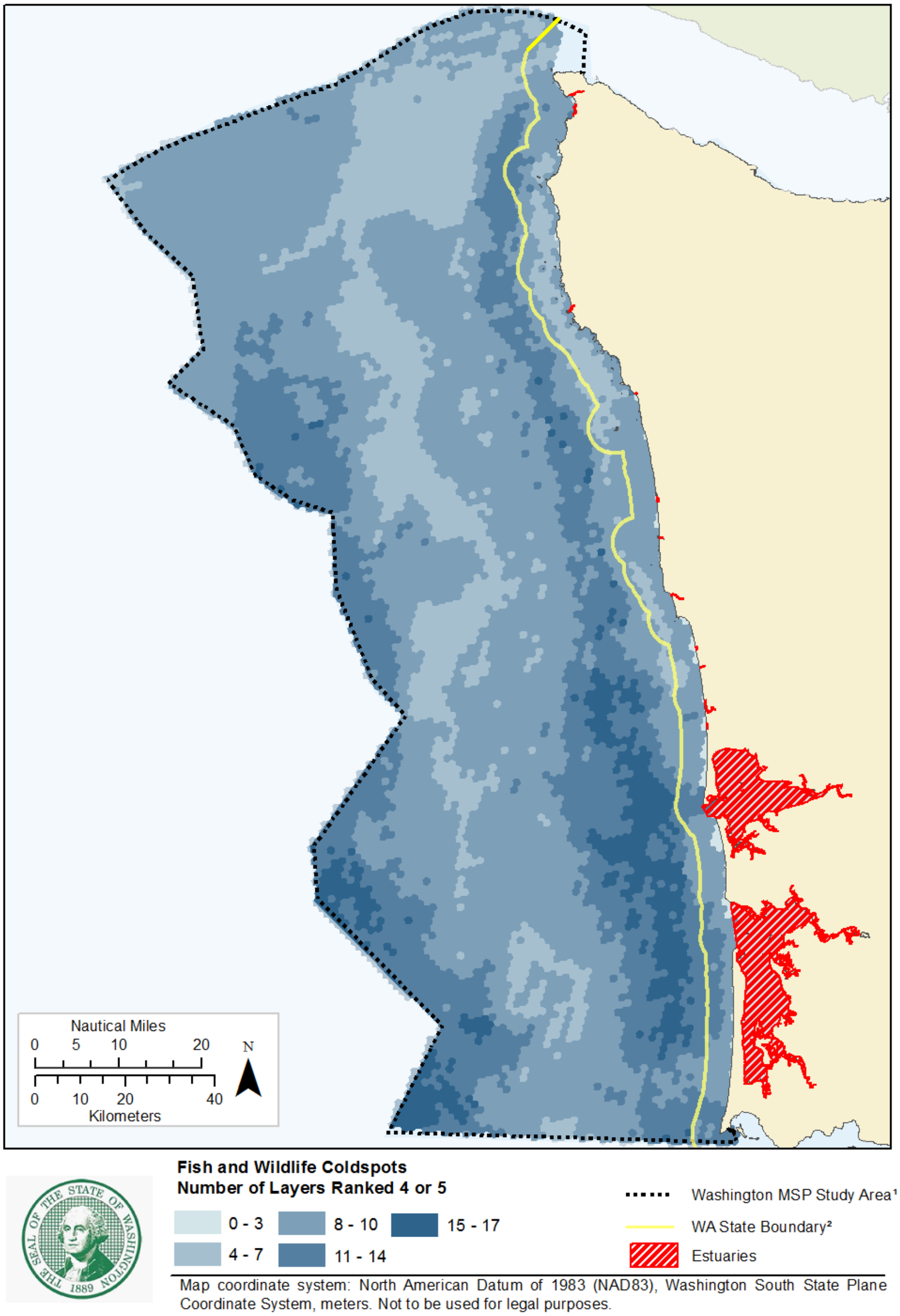


Figure 3.12: Fish and wildlife coldspots. Each hexagon's value is the number of layers with an importance score of 4 or 5 in that location (the scores indicating least relative ecological importance).

Limitations, Data Gaps, and the Treatment of Estuaries

As discussed in the EIA introduction, the primary purpose of the EIA was to summarize available data on key biological aspects of the marine ecosystem using maps. However, while the EIA analysis makes a strong contribution toward this goal, summarizing available data is a long way from definitively mapping the ecology of the Study Area.

The perfect EIA analysis would involve knowing the full “time budget” of, at a minimum, a set of key species that are representative of greater ecological activity. This “time budget” would describe which parts of the Study Area each species uses and how often. To be comprehensive, it would need to account for the changes that happen over seasonal, annual, and long-term time scales in the highly dynamic California Current marine ecosystem.

Such perfection is of course not possible. Survey work in the Study Area’s coastal and marine environment is logistically difficult and expensive. In addition, resources for ecological surveys are limited. As an example, most of the surveys in the Study Area happen during the spring and summer when conditions such as visibility and wave height are more conducive to research. Because of this, there are many unknowns about how the species included in the EIA use the Study Area in the winter. In general, limited survey resources mean that the EIA maps are biased towards the species of highest conservation and management interest to the mandates of WDFW and partner agencies. Therefore, many species that live in the Study Area are not surveyed regularly at all.

Even for the species included in the EIA project, the maps should be recognized as uncertain. Many of the surveys conducted in the Study Area are used to monitor population abundance. Monitoring abundance is a different objective than monitoring for the “time budget” of a species. The abundance of a species can be reliably estimated by only partially sampling the area that the species occupies. Statistical techniques, such as the ones described in Section 3.1, can be used to extrapolate survey observations to un-surveyed areas, yet these methods are inherently limited in the certainty they can provide. More on the caveats involved with each map are given in WDFW (2017a), including discussion of using commercial fisheries data as a proxy for ecological distribution of fish species.

The quality of data needed to estimate the spatial patterns is so high that even relatively well studied species lack sufficient data to make statistical estimates of their use the Study Area. This includes species of high conservation interest like Chinook Salmon, Guadalupe and Northern Fur Seals, Green Sturgeon and Leatherback Sea Turtles, among others. The latter two species even have Critical Habitat designated under the Endangered Species Act located in the Study Area. For Leatherback Sea Turtles, the Critical Habitat covers the entire Study Area, yet there is just insufficient information to call out areas that are of lesser and greater importance.

Another limitation is that the focus of the EIA analysis primarily describes where animals use the Study Area. The idea is that ecological importance in one sense is proportional to where these animals spend their time. However, the word “ecological” can have much broader meaning and can encompasses many interacting physical, chemical, and biological features. The marine ecosystem of the Study Area is a product of all these interacting features, some of which happen over broad areas and may even happen far from the Study Area. Therefore, the EIA project’s view of the key ecological aspects of this area should be considered in conjunction with information on these key features.

Lastly, one major data gap in the EIA project involves the estuaries, especially the two large estuaries in the Study Area: Willapa Bay and Grays Harbor. While some individual EIA maps cover features inside the estuaries (e.g. marine mammal haulouts), there is not enough data to perform the same EIA overlay method used in the marine areas of the Study Area. Despite being unable to produce

EIA overlay maps for the estuaries, the EIA recognized the high ecological importance of estuaries. As with kelp and rocky areas, the scientific evidence well establishes the importance of these areas. For instance, it is well-known that estuaries provide important habitat to juvenile Pacific salmon, Dungeness Crab, Green Sturgeon, migrating shorebirds and waterfowl, and many other species. However, analogous to the Leatherback Sea Turtle example, the available spatial data is just not available to differentiate which areas within the estuaries are relatively more important than others. An EIA-type project for the estuaries would likely require using a finer-scale spatial scale (i.e. a grid using cells of less than one square mile in area) as well as new survey and mapping efforts to complete. Additional discussion of how estuaries are considered in the Marine Spatial Plan is provided in Section 4.3.3 of the management framework.

SECTION 3.3: Use Analysis

The state agencies performed a use analysis designed to compare the extent and intensity of existing uses and ecologically important areas within the planning area to the potential for renewable energy production in the region. Coordinated by the interagency team and implemented by the Department of Fish and Wildlife, the Use Analysis was structured to illustrate outputs for renewable energy at various scales and for different energy types and technologies. Specifically, the outputs sought to illustrate areas that had higher energy production, but contained fewer uses or less heavily used areas.

In particular, the use analysis:

- Provides an objective tool to use best available scientific, spatial data to develop a series of maps that meet the requirement of RCW 43.372.040(6)(c)[1].
- Uses spatial extent and intensity data (where available) for existing uses to identify the spatial overlaps between existing uses and potential new uses. Specifically, the analysis can:
    - Identify areas that have the most or more existing uses, including areas that are used more frequently than other areas, versus areas that have fewer existing uses, including areas that are relatively less frequently used.
    - Explore complex spatial relationships between existing use and ecological data and information on renewable energy potential through map scenarios.
    - Provide a method to visualize complex data and relationships.
    - Use a series of maps to inform discussions regarding spatial recommendations for the MSP.

The Use Analysis relied on several important assumptions that are critical to interpreting the outputs:

- No one map scenario can be used on its own to make a decision about a particular use.
- All uses have equal potential for conflict.
- Specific scenarios can explore particular spatial relationships or overlaps, but not tradeoffs.
- Existing use data and analysis cannot assess the degree of impact from a new use. This type of assessment would be project-specific.
- Areas of fewer existing uses do not indicate no or low impact, or a lack of conflict.

[1] RCW 43.372.040(6)(c) requires that the plan provide maps including those showing "… appropriate locations with high potential for renewable energy production with minimal potential for conflicts with other existing uses or sensitive environments."

- Existing use data does not represent the value of areas, but rather potentially where and how heavily they are used.
- The confidence in model outputs is dependent on the amount and quality of data.

The results of the use analysis were used to inform many of the recommendations outlined in Part 4 of the Marine Spatial Plan.

Data Sources

Two major categories of data were used as inputs in the Use Analysis: 1) existing uses in the planning area, including ecologically important areas, and 2) technical suitability models for future development of renewable energy.

Spatial models describing renewable energy suitability in the planning area were provided by the Department of Energy's Pacific Northwest National Laboratory (PNNL). In a 2013 study, PNNL produced models of expected technical suitability off the Washington coast using three categories of information: site quality, grid connection, and shore-side support. These categories incorporated data relating to depth, energy resource potential, benthic substrate, and distance to relevant infrastructure. PNNL completed analyses for three types of offshore wind technology, four types of wave technology, and one type of tidal energy technology. Please see Maps 42 - 49 in the Maps Section for examples of the final outputs from these analyses. More detail on methods and data for the modeling process will be provided in a Data Appendix, or is available in the final report from PNNL (Van Cleve et al. 2013).

Current uses in the planning area were represented by a variety of data layers falling into five categories: cultural and archaeological uses, shipping, fisheries (non-tribal), recreation, and ecological uses (fish, wildlife, and habitat). Table 3.4 lists all of the data layers in used in each of these categories, though every layer was not used in all analysis scenarios.

Table 3.4: Data layers used to represent existing uses and Ecologically Important Areas. For more information about individual uses or data layers, please refer to the referenced plan chapter and maps, or information in the data summary appendix [not available for preliminary draft].

DATA CATEGORY	LAYERS	DATA SOURCE
Cultural and Archaeological Uses *Section 2.2*	Cultural risk model	Washington Department of Archaeology and Historic Preservation
Shipping *Section 2.6* *Maps 35 - 38*	Density of shipping activity: • Cargo Vessels • Passenger Vessels • Tanker Vessels • Tug and Tow Vessels Location of tug and tow lanes	Olympic Coast National Marine Sanctuary (NOAA) Washington Sea Grant (tow lanes)

Non-Tribal Fisheries *Section 2.4* *Maps 17 - 28*	Commercial fishing intensity: • Albacore tuna • Dungeness crab • Sablefish (fixed gear) • Groundfish (bottom trawl) • Pacific whiting • Pink shrimp • Salmon • Pacific Sardine Recreational fishing intensity: • Albacore tuna • Bottomfish and lingcod • Pacific halibut • Salmon	Washington Department of Fish and Wildlife

Fish and Wildlife / Ecological Uses
Sections 2.1 (Ecology) and 3.2 (Ecologically Important Areas Analysis)
Maps 5, 8, 9, 12, and Section 3.2
	Ecologically Important Areas analysis
	• Overall ecological hotspots, showing combined high use information from various "subsectors" (groups of layers), including:
	    • Marine mammals
	    • Pinniped haulouts
	    • Habitats
	    • Shorebird areas
	    • Seabird abundance
	    • Seabird colonies
	    • Invertebrates
	    • Fish Abundance
	• Hotspots for selected sensitive species and habitats
		Washington Department of Fish and Wildlife

Recreation *Section 2.6* *Maps 32 - 34*	Participatory recreation data for: • Diving Activities • Shore-Based Activities • Surface Water Activities • Wildlife Viewing & Sightseeing	Surfrider Foundation

Some additional data layers discussed elsewhere in the Marine Spatial Plan were considered or used to illustrate some specific scenarios, but ultimately not included in the later stages of use analysis. For example, aquaculture occurs primarily within estuaries (which were not included in the use analysis) and is associated with other data limitations. Military use was not included because available data indicates that the entire planning area is a low-intensity use area for military operations, which would not provide any contrast within the use analysis process. The boundary of the Olympic Coast National Marine Sanctuary was also used in some phases of analysis to assess how its inclusion would affect results, but is not represented in the outputs provided in this chapter.

Methods

The interagency team focused primarily on wind energy in these analyses rather than on tidal or wave energy technologies. PNNL did provide technical suitability maps for tidal and wave energy, but wind is a more established industry. Therefore, more information is available about the technical requirements and viability of offshore wind development, and the interagency team expected wind to be the most likely proposed use of the three in the near term. There is also significant overlap in areas that were shown to be suitable for all three types of energy based on PNNL's analysis, due in part to correlation between the availability of these resources in marine environments. Assessment of the potential for wave or tidal energy production must be done on a case-by-case basis, but these maps can provide a general understanding of energy resource patterns.

To complete the Use Analysis, WDFW used Marxan, a decision-support tool designed for marine planning applications. This tool allows the user to set a series of targets and limitations, and generates potential spatial solutions which optimize each scenario's goals within a given set of parameters. For this project, the interagency team explored several different scenarios illustrating the relationship between renewable energy suitability (as represented by PNNL's technical suitability analysis), and the number and frequency of existing uses (Table 3.4). Each scenario provided a look at how analysis results might change if certain existing uses or energy targets were prioritized.

Various data layers from Table 3.4 were combined into maps called cost surfaces, which represent the multiple uses occurring in each 1-square mile hexagon of the planning area. To create these cost surfaces, each individual dataset was weighted based on factors including the goal of that particular scenario, the relative intensity of a given use, the number of layers being incorporated for that category of use, stakeholder input, and review by experts familiar with each sector. Throughout the Use Analysis process, WDFW produced cost surfaces for many different scenarios, which were refined through an iterative process that included several workshops with the Washington Coast Marine Advisory Council and other stakeholders. In the outputs for each scenario, Marxan attempts to minimize "cost," or number and intensity of existing uses, based on the quantity assigned to each hexagon from weighted input data. Note that this only accounts for the amount of use occurring in an area, not use value or potential for conflict with new uses. An example is shown in Figure 3.13, which presents a cost surface incorporating all of the uses described in Table 3.4.

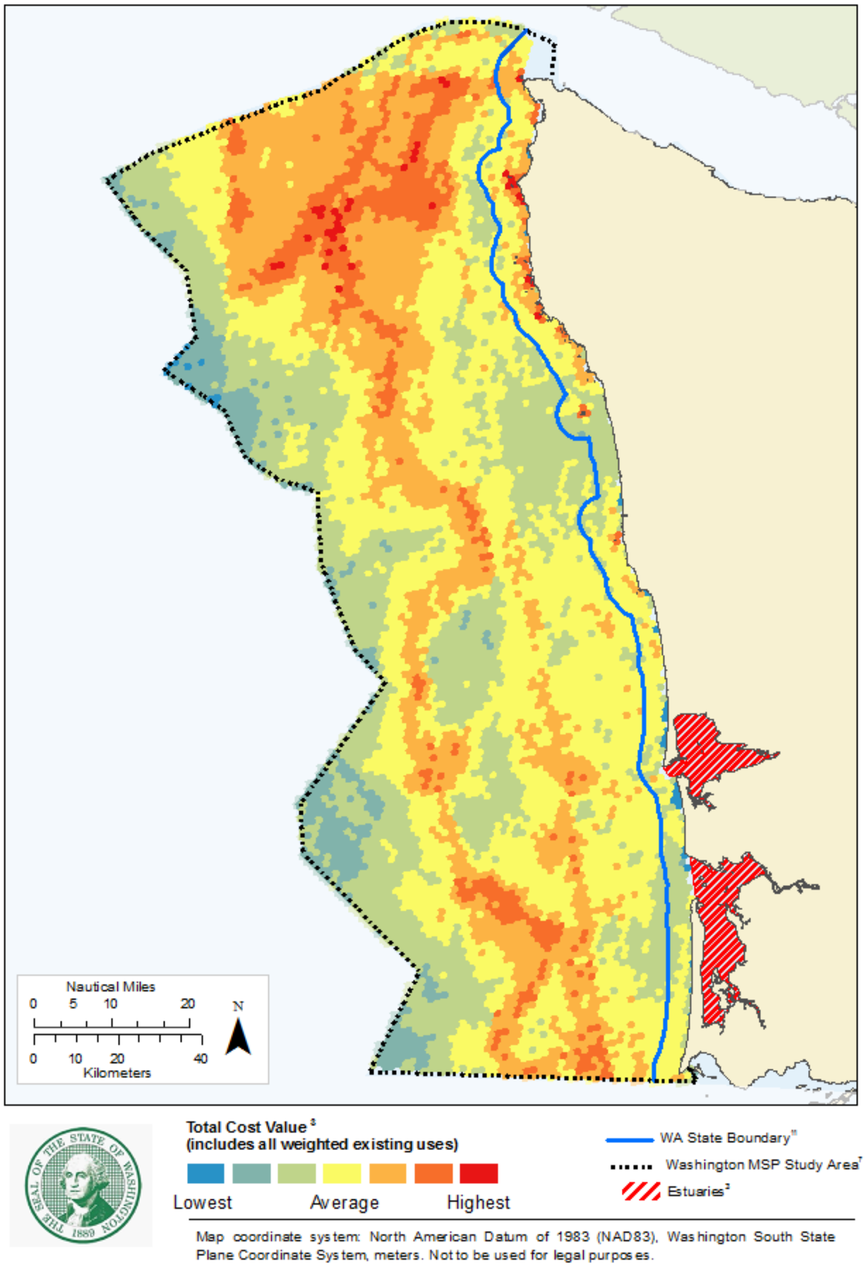


Figure 3.13: Combined map of existing uses incorporated into Use Analysis.

To illustrate how different weighting choices would affect the outcome of the use analysis, many other scenarios were assessed in which certain categories of uses were weighted more heavily. These included (but were not limited to) prioritizing avoiding:

- Areas with species, habitats, and cultural resources known to be particularly vulnerable to disturbance, such as endangered and threatened species (as discussed in Section 3.2)
- Important Dungeness Crab areas, including fishing grounds and habitats
- The boundaries of regions with special concerns including the Olympic Coast National Marine Sanctuary, tug and tow lanes, and Special Management Areas for fisheries

For some scenarios, WDFW performed analyses based on a "cost threshold." That is, Marxan was directed not to select any areas that exceeded a certain level of existing uses, based on the cost surface. For others, the analysis focused on renewable energy targets (measured in MW) that minimized overlap with existing uses, without setting a specific cost limit. Parameters for renewable energy potential were also determined using an iterative process resulting in multiple variations of scenarios. Marxan allows the user to set goals for how much of a particular resource is included in analysis outputs, and optimizes those outputs based on goals and cost (i.e. existing use) limitations. In this case, renewable energy goals were set based on the footprint that would be required for industrial- or community-scale wind projects, measured by the number of 1 square mile hexagons these projects would need to cover to produce a certain amount of energy. These footprint sizes were calculated based on knowledge of renewable energy technology at the time of the analysis, parameters of comparable renewable energy projects proposed or constructed in other states, and consultation with industry and agency experts. Analyses were done for two types of renewable energy footprints: unclumped and clumped. Unclumped outputs identify areas that meet total energy production goals without concern for whether they are all adjacent to each other. Clumped outputs prioritized identifying areas where the total amount of desired energy could be achieved in a single site composed of multiple connected hexagons.

As discussed in Section 3.2, estuaries were not included in these analysis scenarios because of challenges associated with the scale of available data and density of existing uses in these areas. Estuaries are known to be highly important areas for many human and ecological uses, and are addressed more fully in Section 4.3.3 of the Management Framework.

Results

Overall, the results of the Use Analysis provide a spatial illustration of the great number and intensity of existing uses occurring in the study area, and shows how these relate to areas of possible renewable energy potential. There is no single final solution in this type of analysis, as each scenario prioritizes different factors and produces different outputs. The interagency team considered many different outputs and results from the use analysis when developing the recommendations and guidelines presented in the Management Framework, which also defines the distinction between industrial- and community-scale projects for the purposes of the Marine Spatial Plan (Section 4.3.4).

As discussed in the project assumptions, it is important to highlight that while the following maps offer a way to visualize existing uses and potential future uses, this type of analysis does not assess potential conflict or impacts that could occur from the introduction of new uses such as renewable energy production. The input layers give a measure of the current number of existing uses in a given area and the intensity of those uses relative to other areas based on recent data. However, this does not imply that fewer or less frequent existing uses would equate to less conflict in an area, or mean that any area is less valuable than another. In addition, changes in the environment or regulations may lead to changes in existing use patterns. Any evaluation of conflict or value would need to be done on a case-by-case basis for any potential projects.

What the outputs of the use analysis can provide are several different types of spatial comparisons between existing and potential new uses. Figure 3.14 demonstrates one approach. This output shows a simple count of the existing number of uses categorized as "high uses" and how this overlaps with the overall wind energy potential throughout the planning area. So, for example, the darkest green hexagons show areas identified as having the fewest number of high intensity uses, and the greatest amount of wind energy potential. While there is potential for conflict even in the case of one existing use, the red hexagons show areas that may present particular planning or permitting challenges due to a greater number of existing uses that would need to be addressed for a proposed project.

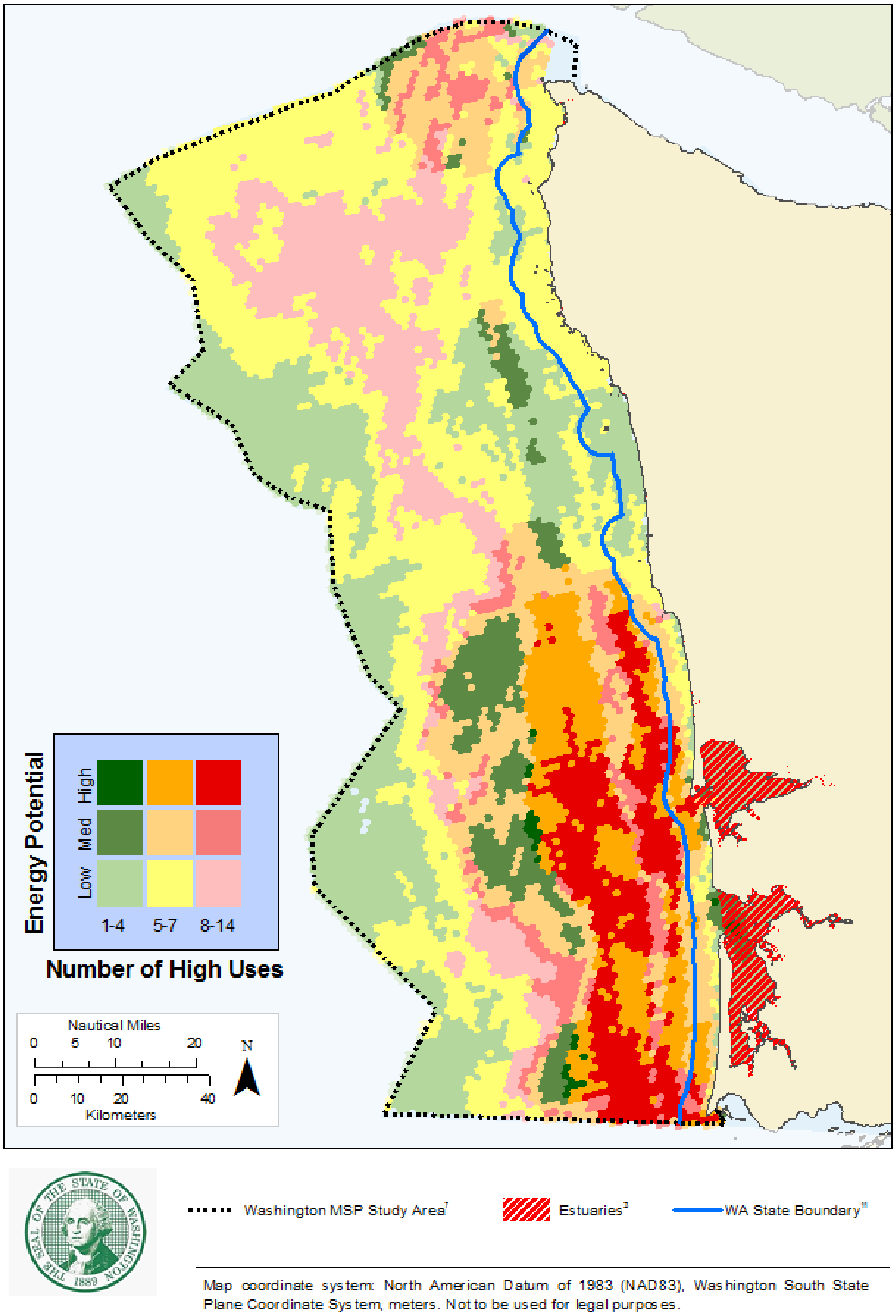


Figure 3.14: Comparison of renewable energy potential and the number of high intensity uses in each hexagon of the planning area.

Figure 3.15 shows another type of output. The results of this scenario identify clumped groups of hexagons that would fulfill the expected energy requirements of three different types of industrial-scale wind operations: monopole, tripod, and floating platform turbines (see Section 2.10.1 for more information on the differences between these technologies). Clumped outputs are presented because these results prioritized a single larger site over several smaller, scattered ones. While unclumped sites may provide more flexibility in avoiding areas with the most existing uses, based on industry input the interagency team expects the clumped approach to best reflect what developers might be looking for when assessing potential sites for offshore renewable energy in Washington.

The gradients shown for each type of wind technology represent how frequently Marxan selected each hexagon as part of a possible solution for the given scenario. During each analysis, the software performs hundreds of runs, creating many possible solutions. The regions outlined in Figure 3.15 are the areas identified by Marxan as the most frequently selected cells out of all the runs for that scenario given the settings used for energy requirements, clumping, and avoidance of existing uses.

It is important to note that these outputs are not meant to be recommendations for areas where renewable energy projects should be sited. The outputs are simply the product of the knowledge of existing uses, our understanding of current renewable wind technology, and the data limitations that are present with both. Additionally, the technical suitability analysis conducted by PNNL and the use analysis outputs do not address any of the broader market or energy policy factors that may impact the feasibility or desirability of the study area for renewable energy development, and there are many measures of potential impact that would need to be considered for any proposed projects. Advances in technology or other changes in the industry would   Instead, these results provide quantitative and visual representations of the overlap with existing uses that any offshore renewable energy development in the study area would encounter, based on current knowledge. The outputs displayed in this chapter and many other iterations and scenarios examined by the interagency team throughout the use analysis process guided the development of the recommendations in Section 4.3.4.

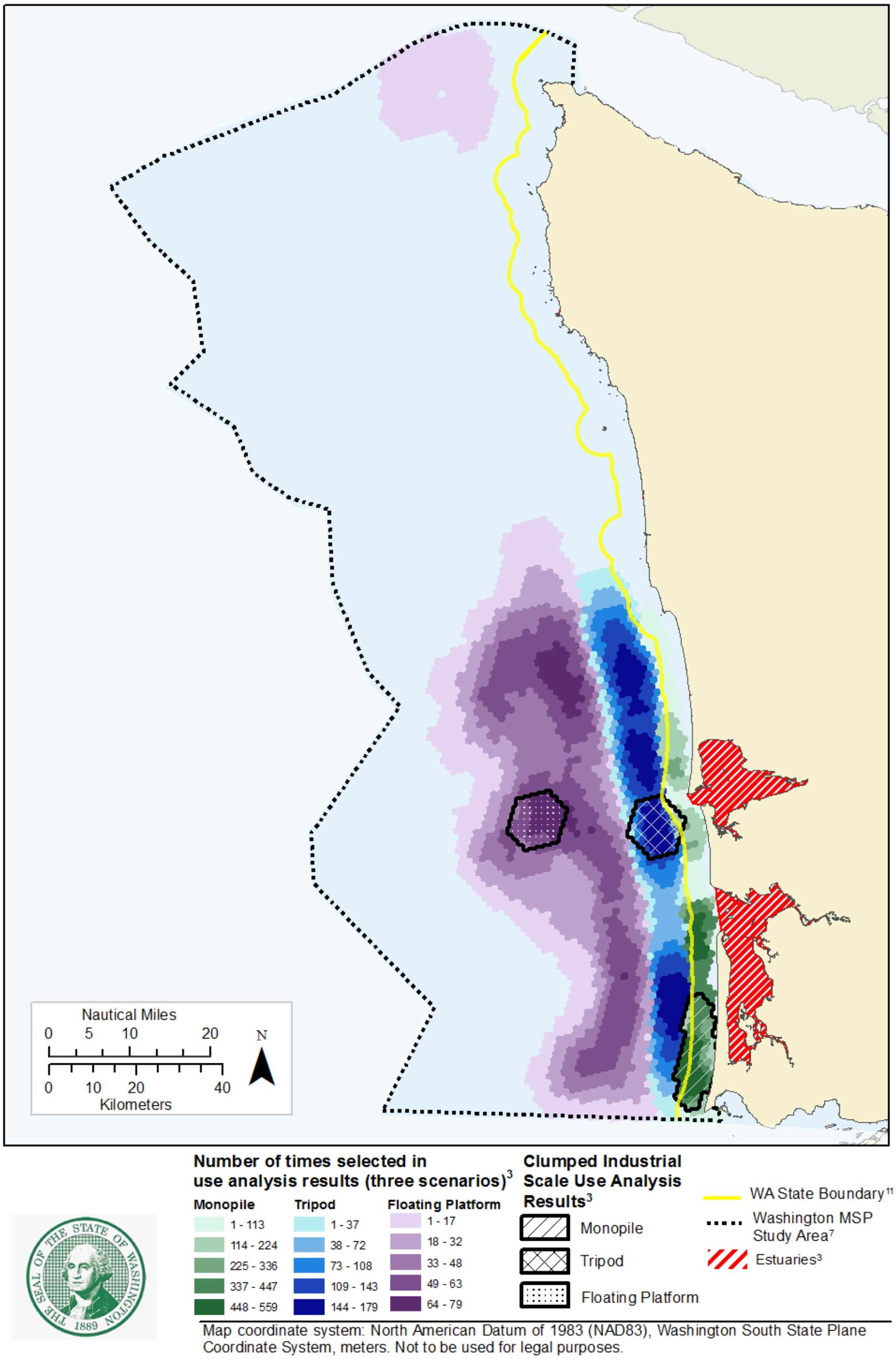


Figure 3.15: Use Analysis outputs for clumped, industrial-scale wind energy (three types).

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