PROJECT TEAM REPORT 2 ON ESSENTIAL FISH HABITAT AND ROCKFISH CONSERVATION AREA SUPPLEMENTAL MATERIALS

The essential fish habitat (EFH) and rockfish conservation area (RCA) project team produced an analytical report for the November Council meeting advance briefing book (Agenda Item F.4.a, Project Team Report). This supplemental report provides additional information on several relevant topics. The team notes that socio-economic (S-E) information related to the alternatives described and analyzed in the Project Team report is not yet ready for publication, but will be included at the next stage of Council action on this topic.

The team also notes that an interactive web-based tool to support the analysis and decision making is available, as well as a brief tutorial. This tool allows the user to see maps and associated habitat data of proposed EFH Conservation Areas proposed to be closed or opened. The interactive web tool is at http://www.soundgis.com/efh/efh2016-metrics/, and the video tutorial is at https://youtu.be/pglUTca-tVw

Conservation Value Methodology (page 2)
Listed as Appendix C in the Project Team Report, this describes the approach used to apply a conservation value for particular spatial areas proposed for reopening or closing to bottom trawl activities. It is not in the original report but is included here for reference.

Identifying Spatial Boundaries and Presence of Priority Habitats Methodology (page 16)
Alternative 2b identifies areas within the 2015 trawl RCA based on the presence of priority habitats. Priority habitats were described in Amendment 19 to the Groundfish FMP, and were adopted by the Council for consideration of Amendment 28 alternatives. The presence of priority habitats could help inform new EFH Conservation Areas (EFHCA) within the trawl RCA.

Overfished Species Hotspot Methodology (page 20)
Also appended to this supplemental report is a description of the methodology used to identify "hotspots" for overfished species. These hotspots are used for Alternative 2b, and could be employed to protect specific spatial areas, should the Council choose to remove the RCA.

The Efficacy of Discrete Area Closures Relative to Rockfish Life History Traits and Hotspot Catch Events (page 26)
This section describes basic life history traits of the overfished species of Pacific Coast groundfish, with the goal of identifying which species are most suited for discrete area closures under Alternative 3c.

Mapping Error Correction (page 29)
One of the EFHCAs adopted as part of Amendment 19 is Potato Bank, in the Southern California Bight. However, the coordinates in Amendment 19 and in regulation do not actually encompass Potato Bank. The Council may wish to consider correcting this.

Calculating Conservation Value of Seafloor Habitats for Pacific Groundfish

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Conservation Value: Methods

A coast-wide conservation value metric was developed to quantify how seafloor habitats support diverse and abundant demersal fish assemblages and biogenic habitat, given exposure to certain potential anthropogenic impacts. This metric was the product of the integration of eight datasets from both published and EFH Synthesis Report data (Table 1). Other metrics were considered for inclusion, but we only used those that provided reliable predictions across the area of consideration. We report on the eight data layers individually, and used those eight layers to calculate summary layers of conservation value "mean", "variance", and "data quality".

Table 1: Summary of data layers used to develop the conservation value metric.

Conservation value data layers			**Source data**		**Normalized data**	**Brief description**
			range	units	range	
Groundfish abundance and diversity	1	Adult groundfish HSP	0 - 21	no. species cell^{-1}	0 - 1	Summary of Habitat Suitability Probability (HSP) models for 80 species of adult groundfishes
	2	Juvenile groundfish HSP	0 - 22	no. species cell^{-1}	0 - 1	Summary of HSP models for 58 species of juvenile groundfishes
	3	Groundfish species density	7.8 - 18.8	no. species ha^{-1}	0.7 - 1	Species density model predictions generated from the NOAA U.S. West Coast Groundfish Bottom Trawl Survey data
	4	Groundfish species biomass	16.6 - 670.2	kg ha^{-1}	0.4 - 1	Predicted total biomass of groundfishes caught during the NOAA U.S. West Coast Groundfish Bottom Trawl Survey
Presence of deep-sea corals	5	Deep-sea coral HSP	0 - 6	no. taxa cell^{-1}	0 - 1	Predicted habitat suitability for six taxa of deep-sea corals (Orders: Antipatharia and Scleractinia; Suborders: Alcyoniina, Calcaxonia, Holaxonia and Scleraxonia)
	6	Biogenic occurrence	0.11 - 1.59	-	0.01 - 1	Predicted probability of occurrence for stony corals, soft corals and sponges, generated from NOAA U.S. West Coast Groundfish Bottom Trawl Survey data
Existing impacts	7	Fishing impacts	0 - 3617	-	0 - 1	Cumulative commercial fishing effort for bottom trawl, midwater trawl and fixed gear from 2002-2010
	8	Non-fishing impacts	0 - 0.83	-	0 - 1	Vessel track lines from the World Meteorological Organization Voluntary Observing Ships Scheme and ferries

1.0 Individual Datasets

1.1 Groundfish abundance and diversity

There is a critical need for the development and application of fish-based metrics to generate spatially explicit information on benthic habitat use and associated groundfish assemblages. Equally important is that these data are analyzed on spatial scales relevant to fishery management and habitat protection decisions. The use of fish-based metrics in a coast-wide analysis of seafloor habitat and its function for supporting diverse and abundant assemblages is a valuable tool to help inform managers and researchers of high priority conservation areas. However, because Pacific Groundfish consist of many species with life stages that use different habitats which cannot be readily sampled with standard survey gear, we used several metrics that captured the ability of different seafloor habitats to support a diverse and abundant groundfish community.

1.1.1 Habitat Suitability Probability metrics

We used the 2005 groundfish Habitat Suitability Probability (HSP) model outputs, which are based on information from the Habitat Use Database (HUD), NMFS bottom trawl survey data, and expert opinion (PFMC 2005, Copps et al. 2007). The HUD provides qualitative information on the habitat preferences for different species and life stages of native marine fish and consists of data based on trawl surveys, and for areas in which no trawl survey data was available (0-50 meters), species profiles were completed by expert opinion. HSP provides a measure of the likelihood that a habitat unit with certain features is suitable for groundfish species at varying life stages (i.e., adult, juvenile, larvae and egg). It was calculated by modeling predictions of habitat suitability as functions of substrate type, depth, and latitude for each species/life stage (Copps et al. 2007).

We utilized HSP models for adult and juvenile life stages, which represent the groundfish assemblages most vulnerable to commercial bottom trawling, and for which there was a sufficient amount of data available. HSP profiles for 80 species with adult stages (94% of Groundfish species) and 58 species with juvenile stages (68%) were available. Since these data include information on species-habitat preferences that are based on expert opinion, they provide predictions of species occurrence in shallow-water and untrawlable habitats (i.e., rocky and mixed substrates) which are generally not captured during bottom trawl surveys.

HSP scores have a continuous range of values from 0 to 1, with 1 indicating the highest index of habitat suitability. For each species and life stage, polygon features were converted to a 2x2 km polygon grid. For data layers where multiple values were present within the 2x2 km cell size, the area-weighted values determined the final score of the cell. Since HSP scores can represent different aspects of habitat utilization depending on the species and life stage, a threshold approach was applied, and cells received a score of 1 if they were in the top 50% of the range of values, and 0 if not. The total number of species surpassing this threshold was then calculated in each cell for each life stage (juveniles or adults). The final adult and juvenile groundfish HSP data layers reported total species diversity (number of species) per 2x2 km cell.

1.1.2 Trawl-based metrics

Multi-species demersal fish community metrics from Tolimieri et al. (2015) were utilized to provide empirical summaries of groundfish diversity and abundance. Tolimieri et al. (2015) computed model-based predictions of groundfish species density (number of species/ha) and biomass (kg) of groundfish from the fishery-independent NOAA U.S. West Coast Groundfish Bottom Trawl Survey, conducted annually between May and October, from depths of 55 to 1280 meters. These data are limited in that they only provide information on the assemblage of fishes caught selectively with bottom trawl gear (i.e., small fish and fishes occurring in high relief habitats are generally not observed). Due to these limitations, these data are less accurate in providing predictions for juvenile life stages and for untrawlable habitats, but provide a complement to the habitat suitability models which provide better information for species occurrence in untrawlable habitats. In combination, these metrics reveal areas of high biodiversity or high standing crop, which is valuable information for determining high priority conservation areas.

Data layers of predicted species density (number of species per trawl) and total biomass (sum of the biomass of all species in a haul) per 2x2 km grid cell were included as individual metrics in the conservation value analysis. Each metric reported the mean value for a given grid cell for all surveys conducted between 2003 and 2011.

1.2 Presence of deep-sea corals

Deep sea corals and other structure-forming invertebrates (SFI) are protected under the Magnuson-Stevens Fishery Conservation and Management Act of 2007 (MSA §303 (b)(2)(B)), and have been hypothesized by some as important habitat features for some species of groundfish (NOAA Fisheries 2016). However, there are no systematic surveys of SFI, and observations are limited to incidental catches of SFI, or ROV surveys in limited areas. We used outputs of two models of habitat suitability or probability of presence for SFI. We also considered incorporating a metric of invertebrate biomass and species density based on data collected as part of the trawl surveys, but we determined that these data were not suitable because the sampling design and gear of bottom trawl survey is not designed to monitor biomass or diversity of SFI.

1.2.1 Deep-sea coral HSP

Predicted habitat suitability data layers for six taxa of deep-sea corals (Orders: Antipatharia and Scleractinia; Suborders: Alcyoniina, Calcaxonia, Holaxonia and Scleraxonia) were utilized (Guinotte and Davies 2014). These model outputs were generated for the entire U.S. West Coast exclusive economic zone (EEZ) to help determine priority areas for future research and mapping efforts.

These model outputs have a low level of taxonomic resolution (i.e., coral taxa were binned and modelled at the Suborder and Order levels due to taxonomic limitations in deep-sea coral data sets), a lack of field validation and/or ground truthing, and model only the probability of presence (as opposed to considering presence/absence of corals). Data layers for the six taxa of deep-sea corals have discrete scores ranging from 0 to 4, depending on the number of spatially cross-validated models that indicated habitat suitability. Using the same methodology as groundfish HSP data layers, raster datasets for each taxon were converted to a 2x2 km grid with each cell containing the area-weighted HSP scores. The top 50% of the range of values per taxon (i.e., habitat suitability scores of 3 or 4) received a score of 1, and all cells with values below the threshold received a score of 0. The habitat suitability of the six coral taxa were summarized in a final layer, which reported the number of deep-sea coral taxa per 2x2 km cell.

1.2.2 Biogenic occurrence

Trawl-based biogenic habitat model predictions of three taxon groups: stony corals and relatives (Subclass Hexacorallia, excluding anemones); soft corals, including sea pens (subclass Octocorallia); and sponges (Phylum Porifera) were used (Barnett et al. in review). These data were generated from the NOAA U.S. West Coast Groundfish Bottom Trawl Surveys, and thus only include invertebrates that were selectively caught during bottom trawl surveys (i.e., small invertebrates and those occurring on hard substrates were not well-represented in the data). A predicted probability of occurrence was generated for each taxon group, with a range of values from 0 to 1. These data were from surveys conducted from 2003 to 2012. The final data layer reported the additive sum of the predicted probability of occurrence for all three taxon groups.

1.3 Existing impacts

Understanding the effects of certain existing anthropogenic impacts on seafloor habitat is integral in determining areas of higher and lower conservation value. Seafloor areas that are exposed to higher pressures (fishing or otherwise) are likely more disturbed and would be expected to have lower conservation value. Conversely, seafloor areas that are generally exposed to fewer pressures would likely be less disturbed, and would be expected to provide a higher quality of habitat which could support more abundant and diverse assemblages of groundfish and other species. Inclusion of existing impacts in the conservation value metric will help to elucidate higher (minimal impact) and lower (high impact) priority areas for conservation.

Due to lack of data across time and space, it is extremely difficult to determine the extent to which fishing and non-fishing impacts have affected seafloor habitats. However, existing datasets documenting recent potential effects provide indicators of relative degree of impact across the seafloor of the Pacific coast. Release and retrieval points of trawls and fixed gear provide an indicator of seafloor disturbance from commercial fishing, and track lines of commercial vessels provide a footprint of vessel traffic that may be associated with debris, acoustic noise, and pollution affecting seafloor organisms.

1.3.1 Fishing impacts

Cumulative fishing impacts data layer was obtained from the EFH Synthesis Report. This layer represents the cumulative commercial fishing effort for bottom trawl, midwater trawl and fixed gear from 2002-2010 (McClure et al. 2014, Bellman et al. 2005).

1.3.2 Non-fishing impacts

We used the commercial shipping activity data layer, available from Halpern et al. (2009), to represent the most relevant non-fisheries threat on seafloor areas throughout the U.S. West Coast EEZ, for which data was available. Data represents vessel track lines from the World Meteorological Organization Voluntary Observing Ships Scheme and ferries. Raster features with 1x1 km grid cell resolution were converted to polygon features with a 2x2 km grid resolution, and each cell contained the area-weighted commercial shipping activity value, with original raster product values ranging from 0 to 1.

2.0 Integration of metrics

All data processing was performed using ArcGIS 10 (Environmental System Research Institute, Inc., Redlands, CA), with the Spatial Analyst extension. Data layers were converted from polygon or raster formats to a 2 km by 2 km grid resolution and were projected using a "WGS 1984 Transverse Mercator" coordinate system (Figure 1).

A majority of datasets contained a large number of cells with values of zero as well as a wide range of non-zero values with a log-normal distribution, so for these datasets with a continuous range of values, cells with values greater than zero were log-transformed. All metrics were normalized by the maximum value to get a range of scores from 0 to 1 (Table 1). Final scores for fishing and non-fishing impact metrics were reversed (1-x) to indicate that habitats exposed to fewer impacts would be less disturbed and have a higher conservation value. Each metric received an equal weight in the summary layers.

Since datasets had varying spatial extents, we generated a data quality layer that reported the number of metrics with non-NULL values for a given grid cell. We set the threshold for data quality at four, so only cells with at least four non-NULL metric values (data quality score ≥ 4) were included in the final data layer. We created three summary data products reporting the mean variance and data quality scores for a given grid cell across metrics, and a coast-wide raster format map was developed for each summary score (Figures 2 – 4).

3.0 Results:

Figure 1 illustrates differences in individual datasets (A-H) and summary metrics of mean conservation value, variance in datasets, and data quality (I-K) for an area along the Oregon coast. The juvenile groundfish metric tended to be highest along the nearshore shelf, while metrics that were largely based on adult groundfish (adult groundfish HSP, groundfish species biomass, and groundfish species diversity) tended to be high in offshore shelf and upper slope areas. Biogenic habitat metrics had little correspondence except in deepwater lower slope habitats. Conservation value resulting from bottom contract gear (the inverse of actual cumulative distribution of gear) tended to be highest in the upper slope and in some shelf areas. Conservation value from non-fishing pressures (the inverse of actual impacts) generally tracked distance from shore, with certain lower-score areas reflecting primary shipping lines from key ports.

The resultant mean conservation value of these metrics was highest along the continental shelf and portions of the upper slope, with the lowest values in estuaries like the Columbia River basin. Variance exhibited a bimodal spatial distribution: highest in both nearshore shelf areas and in lower slope areas offshore. Data quality values for this region range from 4 to 8, with the largest spatial extent comprising all 8 datasets.

Overall conservation value was generally highest at and shoreward of the 200-m isobath, from Washington through California (Figure 2). Nearshore areas off the Washington and southern California coasts have intermediate values, whereas Oregon and central California coasts maintain high values closer to the coastline. Smaller clusters of higher values were also offshore of the 1000-m isobath of Washington and Oregon. Areas with the lowest conservation value were concentrated in the Salish Sea, various river basins, San Francisco Bay and at depths farthest offshore starting at the California-Oregon border and continuing south through the southern California bight. An obvious change in the range of conservation value occurred at the California border. This pattern reflects a change in the way benthic habitats were mapped compared to Oregon and Washington, which subsequently affected groundfish HSP values.

Variance among datasets was highest in the Salish Sea, offshore of Washington and parts of the Oregon coast, deeper regions of the southern California bight, as well as along the entire coastline (Figure 3). Regions with the lowest variance coincide with areas of the lowest mean values offshore of the California coast.

The region farthest offshore of California was comprised of the minimum number of datasets that were included in the conservation value metric, along with the Salish Sea, various river basins, San Francisco Bay and portions of the southern California bight. Coast-wide nearshore regions and a narrow band of cells offshore of the 1000-m isobath of California were based on data from 6 datasets, whereas regions offshore of the 1000-m isobath of Oregon and Washington and the southern region of the southern California bight were represented by 5-6 datasets. The largest spatial extent of values was based on data from all 8 metrics.

A coast-wide summary of average conservation values as a function of depth zone and habitat type for the four biogeographic sub-regions is shown in Figure 5. With the exception of the Salish Sea, conservation value was lowest in the lower slope depth zone. Only slight differences were shown between the shelf and upper slope of each sub-region and between the hard, mixed and soft substrate types of each depth zone.

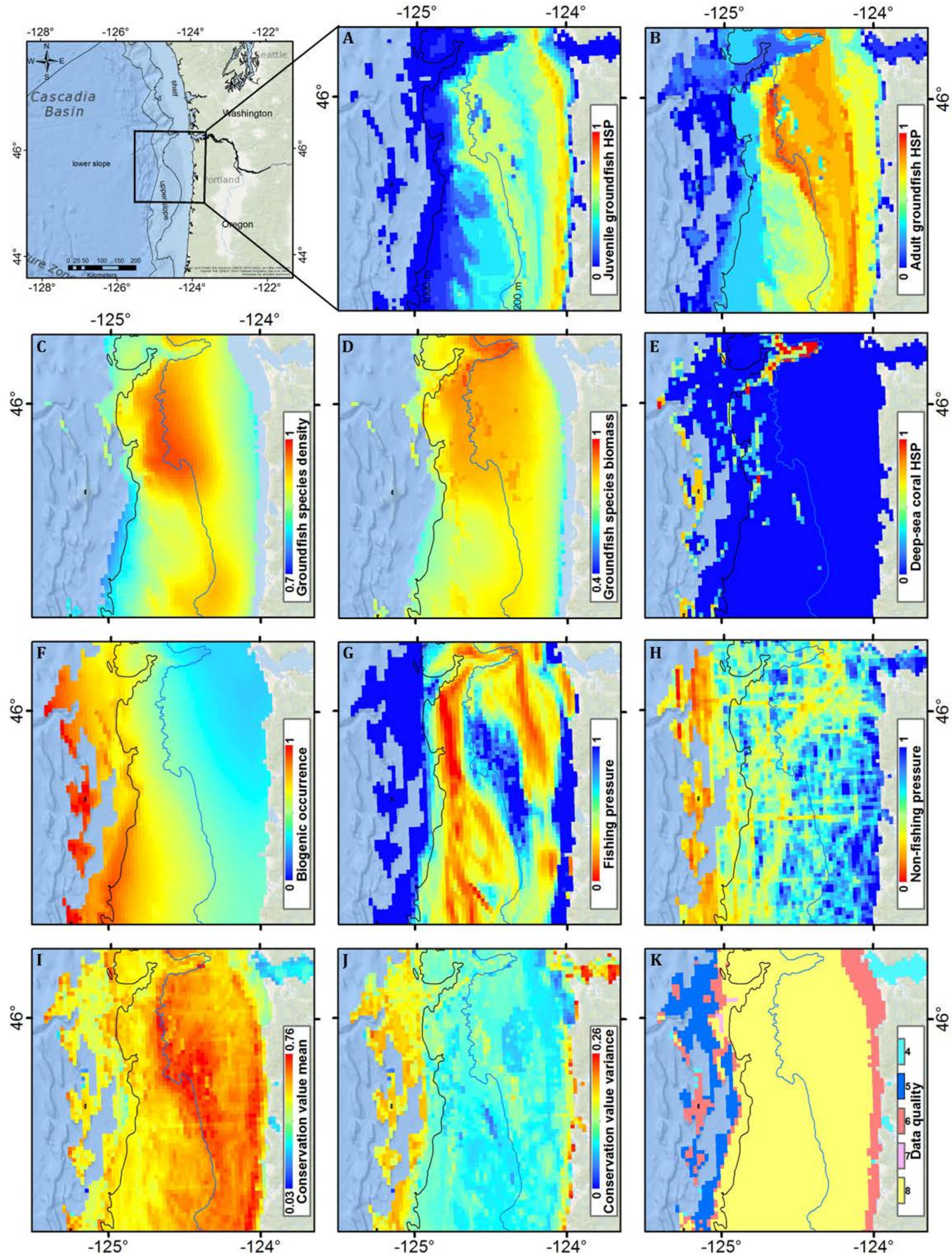

Figure 1. Examples of the normalized scores from the eight datasets and the conservation value mean, variance, and data quality. Fishing and non-fishing pressure scores are the reverse of the actual normalized pressure scores (1-x) to indicate that higher conservation value results from lower pressure scores.

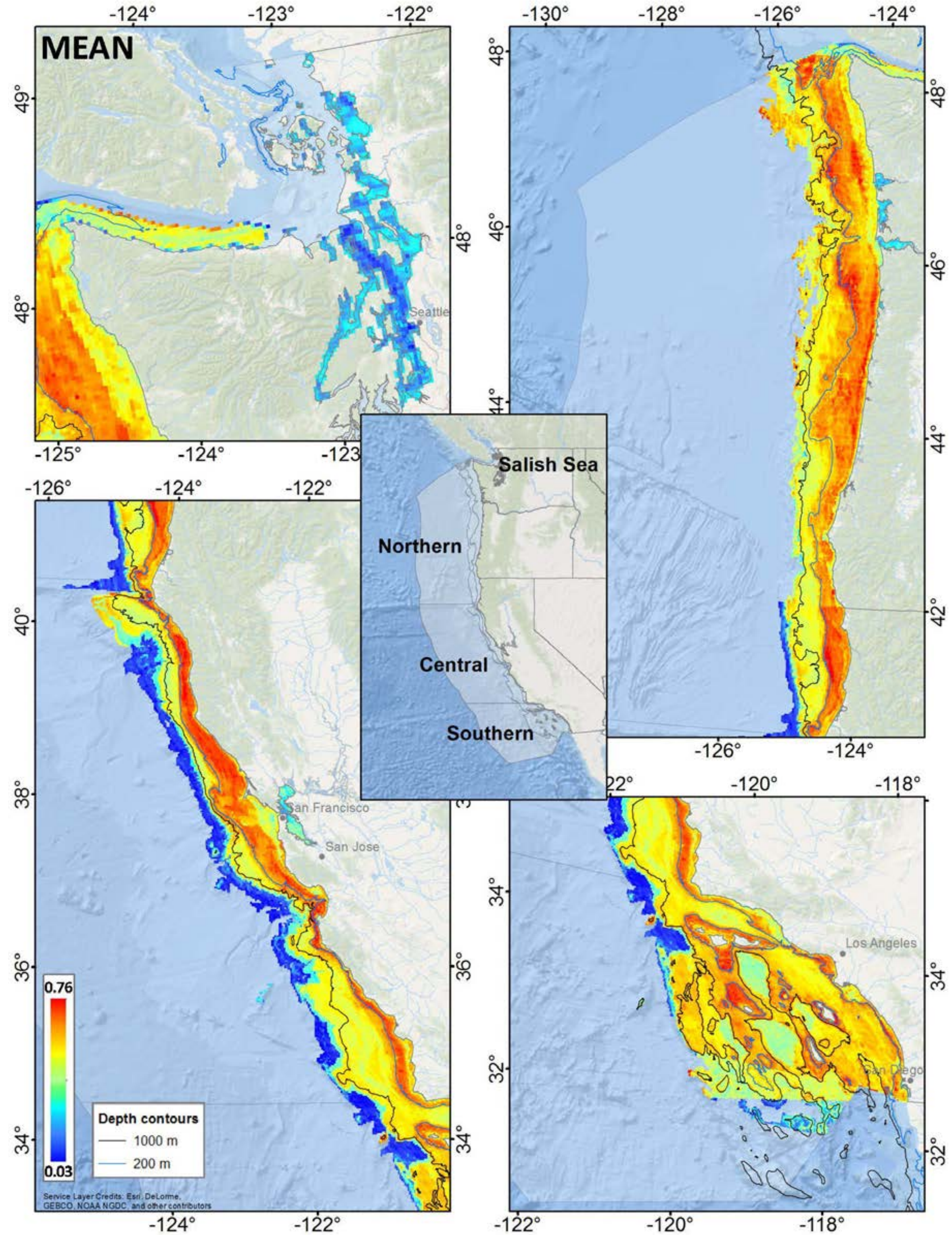

Figure 2. Conservation value for each 2km x 2km grid cell as the unweighted mean of the normalized dataset scores for all datasets that cover that cell.

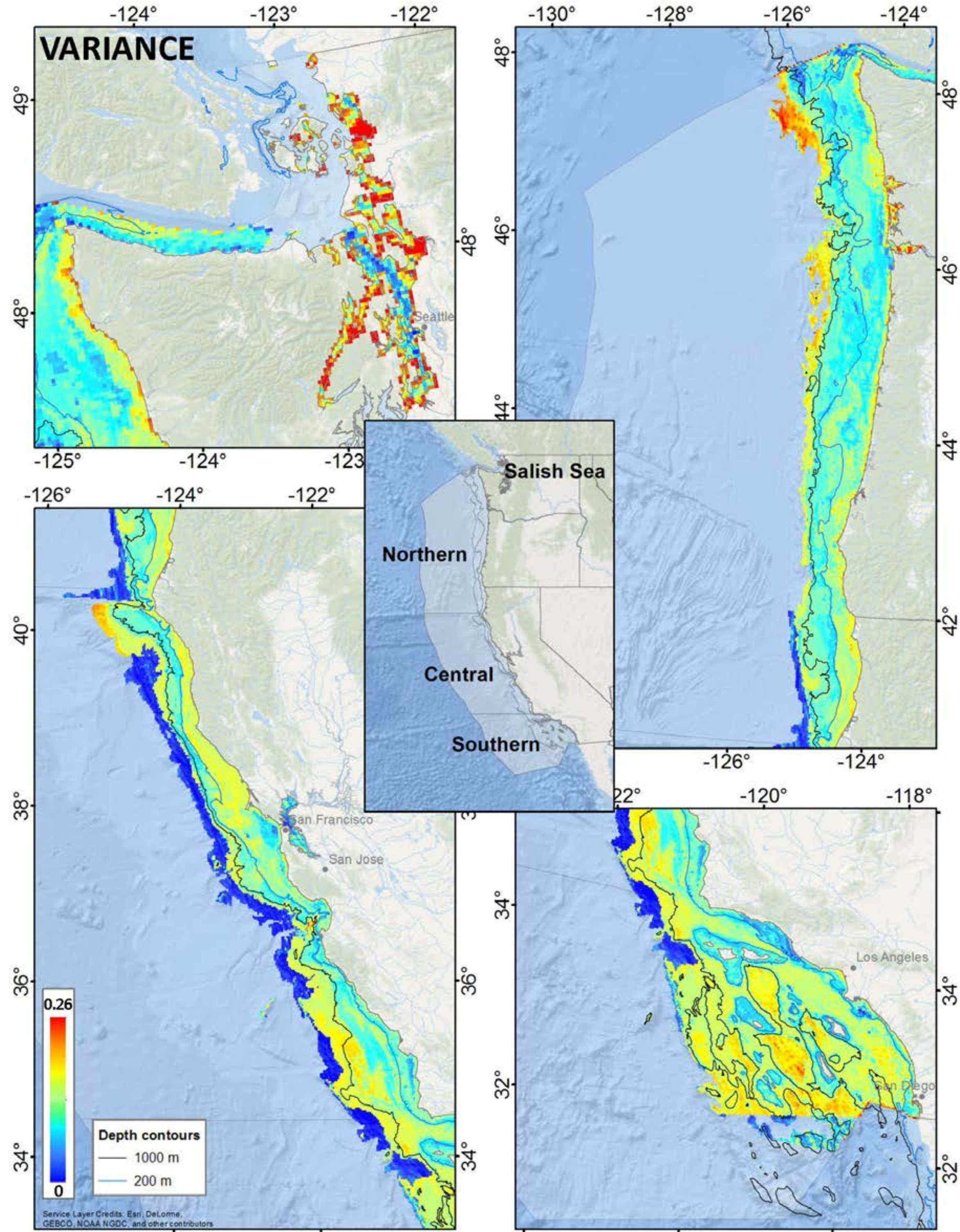

Figure 3. Variance of the dataset normalized scores in each 2km x 2km grid cell.

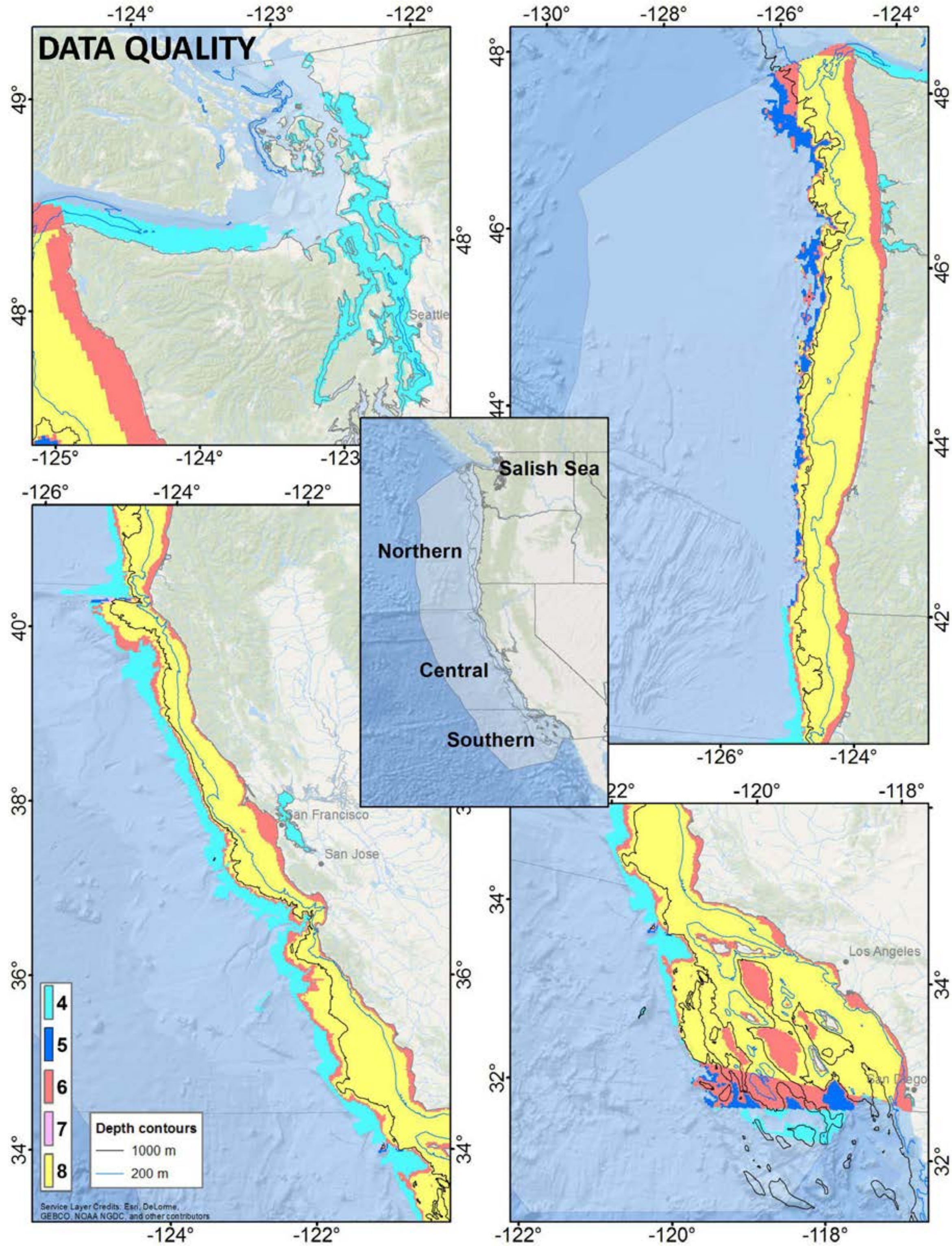

Figure 4. Data quality is calculated for each 2km x 2km grid cell as the number of datasets with non-NULL values in that cell.

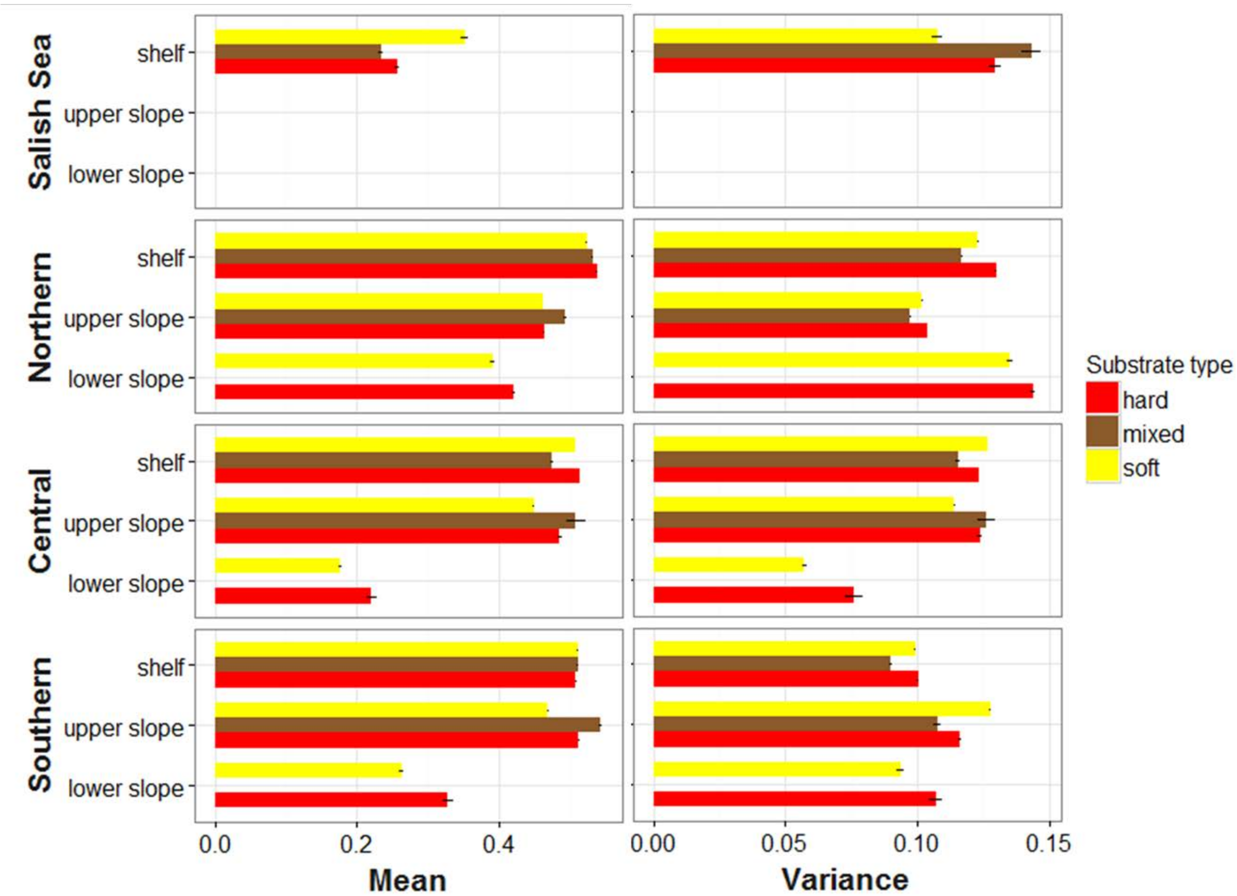

Figure 5. Average conservation value as a function of biogeographic sub-region, depth zone and substrate type.

4.0 References

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Tolimieri, N., A. O. Shelton, B. E. Feist, and V. Simon (2015). Can we increase our confidence about the locations of biodiversity 'hotspots' by using multiple diversity indices? *Ecosphere* 6 (12). doi: 10.1890/es14-00363.1.

Development of Spatial Boundaries for Groundfish EFH Alternative 2.b, New EFHCAs within the Trawl RCA Based on Presence of Priority Habitats

EFH/RCA Team (NMFS & PFMC)

November 2016

Priority habitats for purposes of Pacific Coast Groundfish essential fish habitat (EFH) are described in the Final Groundfish Essential Fish Habitat Environmental Impact Statement (EIS), (http://www.westcoast.fisheries.noaa.gov/publications/nepa/groundfish/final_groundfish_efh_eis.html). In the EIS, priority habitats are referred to as "complex sensitive habitats", (see pages 2-26 to 2-28 in Chapter 2 of the EIS).

Priority Habitats include:

- Hard substrate, including rocky ridges and rocky slopes
- Habitat-forming invertebrates
- Submarine canyons and gullies
- Untrawlable areas (trawl hangs and abandoned trawl survey stations)
- Seamounts
- Highest 20% habitat suitability for overfished groundfish species as defined by NOAA

DATA SOURCES

The most current existing coastwide data sets were compiled to represent the spatial extent of each of these priority habitat areas within the West Coast EEZ.

Hard Substrate

West Coast substrate data were developed or updated as part of the Groundfish EFH Synthesis by Oregon State University (OSU), referred to as v.3.6 (2013). (http://efh-catalog.coas.oregonstate.edu/synthesis/). Version 3.6 was used for areas in Central and Southern California. Some additional updates to these data were made by OSU through work with the Bureau of Ocean and Energy Management (BOEM), referred to as v.4.0 (2014). Version 4.0 was used for areas in Northern California, Oregon, and Washington: (http://bhc.coas.oregonstate.edu/boem_data/V4_0_SGH_WA_OR_NCA.zip). All areas with a value of "hard" for induration were extracted from these data.

Habitat-forming Invertebrates

Point locations of habitat-forming invertebrates (corals, sponges, and sea pens), were extracted, in March 2016, from a database of records of coral, sponge, and sea pen occurrence compiled by NOAA's Deep Sea Coral Research and Technology Program (https://deepseacoraldata.noaa.gov/). The data come from a variety of sources, including visual surveys conducted by private research institutions (e.g., Monterey Bay Aquarium Research Institute, Scripps Institution of Oceanography) and governmental agencies (e.g., NMFS, Sanctuaries). These presence-only data are points that represent individual in situ observations or the mid-point of underwater vehicle transects in which observations were summarized. The lack of absence or abundance data preclude the ability to determine, in a standardized way, the relative importance of individual areas to these invertebrates. In addition, the spatial accuracy of the source locations is highly variable. Given these data limitations, the point locations were generalized into a 1km x 1km grid of known observations (i.e., presence) of habitat-forming invertebrates.

Submarine Canyons and Gullies

Submarine canyons and gullies were delineated as part of the geologic mapping for the Groundfish EFH process in 2005 (http://marinehabitat.psmfc.org/physical-habitat.html) and updated by OSU for areas off of Northern California, Oregon, and Washington (v.4.0 described above). The boundaries for submarine canyon walls, canyon floors, and gullies were extracted from these data sets.

Untrawlable Areas

Because untrawlable areas are used as a proxy for complex rocky habitat types, and, because we have better substrate data than we did in 2005, the EFH team determined that this priority habitat is already encompassed within the hard substrate habitat type. No additional data were incorporated to represent these areas.

Seamounts

Seamounts were delineated as part of the Groundfish EFH process in 2005 (http://marinehabitat.psmfc.org/physical-habitat.html). The boundaries from the 2005 data were supplemented by additional seamounts within the Pacific Coast EEZ that were delineated by GRID-Arendal
http://geonode.grida.no/layers/geonode:seamounts or
http://www.grida.no/publications/story-maps/map/6596.aspx).

Highest 20% habitat suitability for overfished groundfish species

During the Groundfish EFH Synthesis (2013), NOAA (both the Northwest Fisheries Science Center (NWFSC) and the National Centers for Coastal Ocean Science (NCCOS)) developed a set of gridded species models for a select group of groundfish species (http://efh-catalog.coas.oregonstate.edu/synthesis/).
NWFSC developed models for darkblotched rockfish, greenstriped rockfish, longspine thornyhead, petrale sole, sablefish, and yelloweye rockfish. NCCOS developed models for chilipepper rockfish, darkblotched rockfish, Dover sole, greenstriped rockfish, lingcod, longspine thornyhead, Pacific Ocean perch, petrale sole, sablefish, shortspine thornyhead, and yelloweye rockfish. The NWFSC models use a 2km x 2km grid and the NCCOS models use a 1km x 1km grid.

From these models, we used the predicted species occurrence data for the following overfished species: darkblotched rockfish (NWFSC & NCCOS), Pacific Ocean perch (NCCOS), and yelloweye rockfish (NWFSC & NCCOS).

The theoretical range of predicted species occurrence values is between 0 and 1. So, theoretically, the highest 20% habitat suitability areas would be any grid cells that have a value of 0.8 or greater. However, the maximum modeled predicted species occurrence value for the overfished species was always less than 1. Therefore, the threshold for the highest 20% value was based on the maximum for each species and model as shown in the table below.

	NWFSC		NCCOS	
Species	**Modeled max value**	**Highest 20%**	**Modeled max value**	**Highest 20%**
Darkblotched Rockfish	0.717	>= 0.5736	0.522	>= 0.4176
Pacific Ocean Perch	--	--	0.394	>= 0.3152
Yelloweye Rockfish	0.817	>= 0.6536	0.1	>= 0.08

All grid cells meeting the top 20% criteria for any overfished species and from either source (NWFSC or NCCOS) were included as priority habitat.

Detailed References for EFH Synthesis, including species modeling methods:

National Marine Fisheries Service (NMFS). 2013. Groundfish Essential Fish Habitat Synthesis: A Report to the Pacific Fishery Management Council. NOAA NMFS Northwest Fisheries Science Center, Seattle WA, April 2013. 107 p. http://www.pcouncil.org/wp-content/uploads/Groundfish_EFH_Synthesis_Report_to_PFMC_FINAL.pdf

National Marine Fisheries Service (NMFS). 2013. Appendix to Groundfish Essential Fish Habitat Synthesis: A Report to the Pacific Fishery Management Council. NOAA NMFS Northwest Fisheries Science Center, Seattle WA, April 2013. 378p. http://www.pcouncil.org/wp-content/uploads/Appendix_to_Groundfish_EFH_Synthesis_Report_to_PFMC_FINAL.pdf

DATA PROCESSING

Once the data for each priority habitat type was extracted and compiled, all the individual priority habitat layers were compiled, using ArcGIS software, into a single, merged layer. This layer was then subset (clipped) with the maximum extent boundary of the Groundfish Trawl Rockfish Conservation Area (RCA) for 2015. Note that there are no seamounts present within the Trawl RCA.

Because the priority habitat data contain many small areas with complex boundaries that would be difficult to enforce as a fishing closure, we visually delineated simplified area boundaries around the merged priority habitat areas within the RCA.

From these initial polygons, we removed any areas in state waters, Tribal Usual and Accustomed areas off the state of Washington, and any that overlap existing EFH Conservation Areas. Finally, each area was assigned an identifier to indicate which of the four priority habitats it contains,

- H = hard substrate
- I = structure-forming invertebrate
- C = canyon/gully
- O = Overfished species (highest 20% habitat suitability)

as well as a unique integer.

There are a total of 36 areas coastwide, ranging from 0.3 square miles to 350 square miles in size.

"Hotspot Analysis" to Identify Discrete Area Closures for Overfished Species

Background

As part of the Council's review of groundfish Essential Fish Habitat (EFH) designations, changes to trawl Rockfish Conservation Area (RCA) closures are being considered. RCAs were first implemented in 2003 to reduce incidental catch of overfished species. The current RCAs are configured to approximate depth intervals where overfished species occur. The trawl RCA depth-based configuration varies seasonally and geographically based on the expected occurrence of overfished species. In general, the Council is considering a reduction in the total area covered by RCAs both in light of implementation of the groundfish catch shares program and closures to trawl fishing intended to protect groundfish essential fish habitat. One approach would be to close discrete areas to trawl gear instead of the current coastwide depth-based restriction. Fishery dependent and fishery independent data have been used to identify potential closures. In September 2015 the SSC reviewed separate methodologies to identify potential closure areas based on fishery and survey data and found both wanting. In its report to the Council, the SSC noted

> Use of geostatistical methods to map species distributions spatially and seasonally would provide a better way to use both trawl survey and commercial CPUE data to characterize species distributions. Analysis of the trawl survey data should be based on a common set of percentiles, but these data can only provide information on the distribution of species in summer. Spatial and temporal distributions could be estimated using methods such as that developed by Dr. James Thorson (Northwest Fisheries Science Center), which has been used to analyze the trawl survey data for the current round of assessments. This method could be used to account for factors ignored by current approaches such as differences in catchability among vessels. (Agenda Item H.8.a, Supplemental SSC Report, September 2015)

In response a new method, described below, was applied to both fishery dependent and fishery independent data sets. However, the underlying data issues identified by the SSC in 2015 remain unaddressed in this reanalysis.

Data

The same fishery dependent data set was used in the reanalysis. Trawl gear haul level catch data from the shorebased IFQ sector from 2011 to 2014 were obtained from the West Coast Groundfish Observer Program (WCGOP). A catch-per-unit-effort metric was computed as catch (landings plus discards) in metric tons divided tow duration in fractional hours for the following species: bocaccio rockfish, cowcod, darkblotched rockfish, Pacific Ocean perch, and yelloweye rockfish. Trawl survey data were obtained for 2010-2015. This data set includes a column with a derived CPUE of kilograms per hectare, which was used for this analysis. Point feature data layers for each data set were created in ArcMap 10.3.1 to represent the geographic location of each haul. A table with columns listing the CPUE for each of the five species was joined to the two attribute tables for the point feature layers. Data were projected (NAD_1983_Albers) in ArcMap.

Hotspot Analysis

The ArcGIS Optimized Hotspot Analysis tool was applied to each set of CPUE values in the two data sets. The Optimized Hotspot Analysis tool executes the Hot Spot Analysis (Getis-Ord Gi*) tool using parameters derived from characteristics of the input data.[1] The tool employs a fixed distance spatial relationship with the distance automatically computed so each feature has at least one neighbor and corrects for multiple testing and spatial dependence using the False Discovery Rate (FDR) correction method.

This tool creates a new feature class with a z-score, p-value, and confidence level bin (Gi_Bin) for each feature. Figure 1 shows an example of the resulting classification of points based on the Gi_Bin column.

To represent potential discrete closure areas polygons were created for each cluster of points at or above the 90% confidence interval by separately selecting each cluster and using the Convex Hull tool in XTools Pro 12.2 to create a polygon around the selected set of points. A buffer distance of 1,000 meters was arbitrarily applied. Table 1 summarizes the area covered by these polygons including areas where two or more polygons overlapped with each other. This feature data layer was turned over to the project team GIS analysist for further processing including merging overlapping polygons. Table 2 shows the area covered by the resulting 37 polygons.[2]

Table 1. Summary of discrete area coverage (square miles).

	Non-Overlap		Overlap		Grand Total
Species	**Fishery**	**Survey**	**Fishery**	**Survey**	
Bocaccio	90	485	95	85	755
Cowcod	58	217	14		290
Darkblotched	181	309	90	33	613
POP	28	72	28		128
Yelloweye	96	906	2	21	1,024
Grand Total	**454**	**1,989**	**229**	**138**	**2,810**

[1] The Getis-Ord Gi* spatial statistic evaluates whether locations (clustering) of points and the intensity of an associated value are statistically significant against the null hypothesis of a random spatial distribution. The statistic finds both "hot" and "cold" (dispersed) spots although no cold spots were identified in this analysis.
[2] The small difference in the total area in the two tables is likely results due to the different feature layers from which they are derived.

Table 2. Discrete area polygons by species codes (area and count).

Type	Sq. miles	Count
boc	309	6
boc_cow	323	1
boc_dbk	143	2
boc_ylw	69	1
cow	269	8
cow_ylw	33	1
dkb	331	5
dkb_pop	255	6
dkb_ylw	280	1
pop	68	1
pop_ylw	385	1
ylw	340	4
Grand Total	**2,807**	**37**

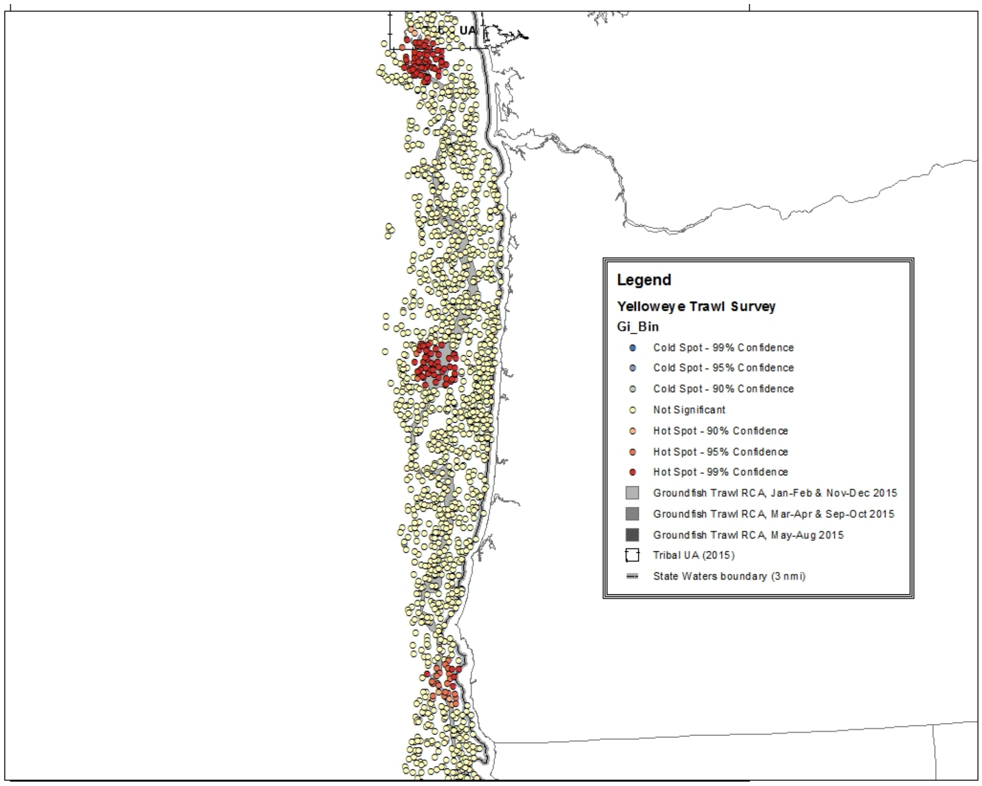

Figure 1. Example of the Optimized Hotspot Tool result with trawl survey data.

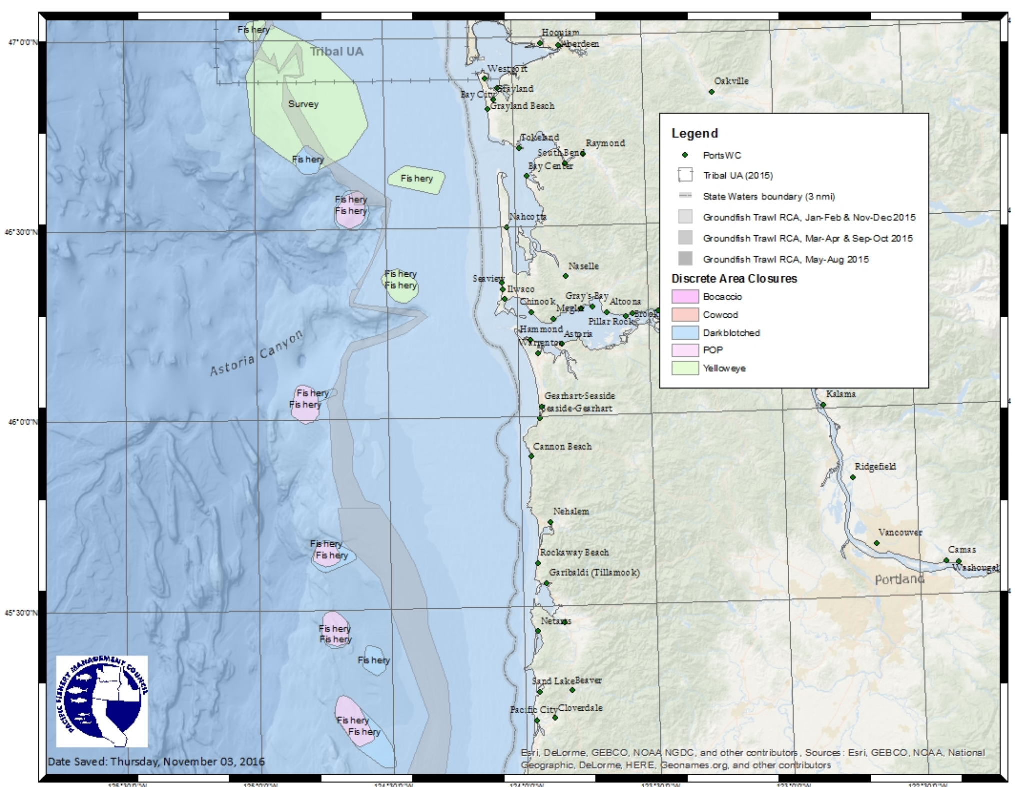

Figure 2. Example of polygons representing closures by species and data source.

Data Issues

The CPUE data from both sources are not normally distributed. There are a large number of zero values as depicted in Table 3 and as shown in. Figure 3 even non-zero values are skewed towards small values.

Table 3. Summary of the number of hauls where overfished species catch occurred (CPUE is not zero), by species. Left: WCGOP data set; right: Trawl Survey data set.

	WCGOP Data			Trawl Survey Data	
Species	**No. Non-zero hauls**	**Non-zero hauls as percent of total hauls**		**No. Non-zero hauls**	**Non-zero hauls as percent of total hauls**
Bocaccio	7,796	18.7%		309	7.4%
Cowcod	409	1.4%		125	3.0%
Darkblotched	15,410	40.1%		632	15.2%
POP	13,134	32.1%		300	7.2%
Yelloweye	261	0.7%		86	2.1%
Total hauls	34,859			4,161	

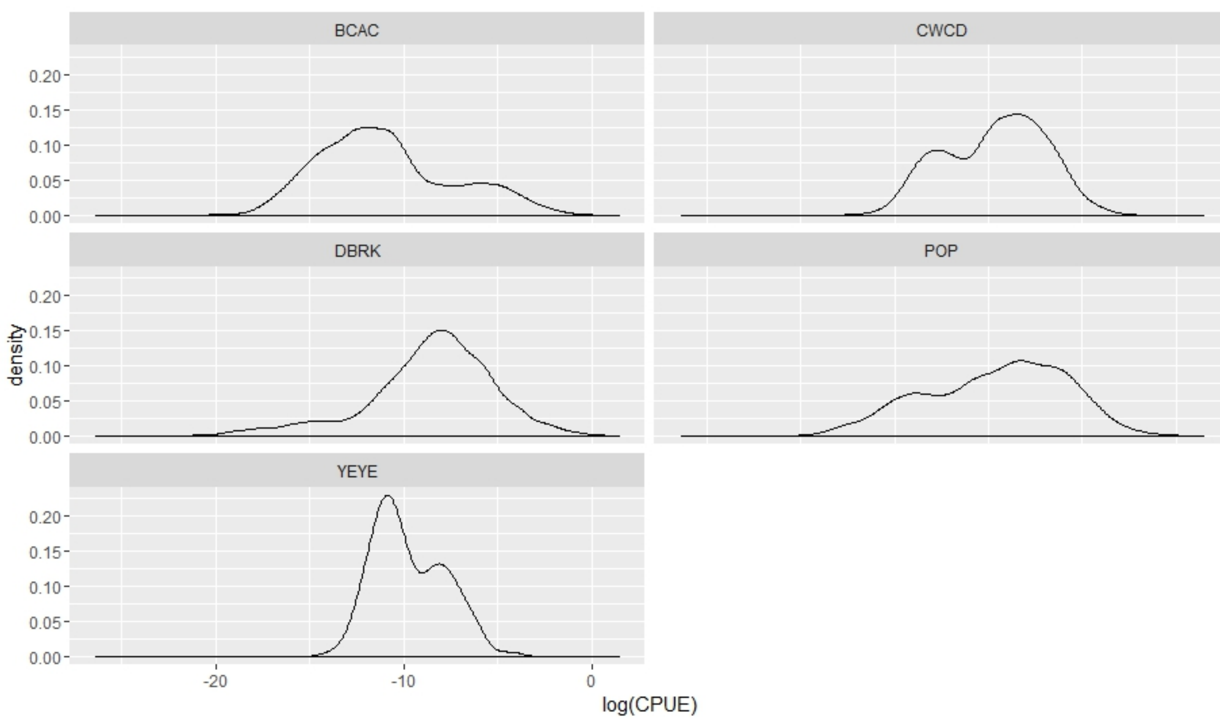

Figure 3. Density plots of log transformed non-zero cpue values from WCGOP data set.

Other effects such as differences among vessel characteristics and temporal variations in catchability were not addressed in this analysis. A post hoc analysis of the WCGOP data set suggests these factors have significant effects. The relationship between overfished species catch represented as a binomial dependent variable (presence/absence in a haul) was tested using a generalized linear model. Presence of the species in a haul was tested against year, month, vessel, and location. Results suggest that factors other than location may influence CPUE.

Conclusion

If the Council chooses to move forward with discrete area closures for overfished rockfish the data issues outlined above should be addressed. This could entail scaling and/or transforming the CPUE data before applying the Geti-Ord Gi* statistic. Also, a complementary analysis could be conducted, for example using the geostatistical delta-GLMM model developed by Jim Thorson, as suggested by the SSC, to determine the reliability of identified hotspots.[3]

After potential area closures are identified a better process is needed to determine actual closure boundaries. Other considerations, such as practicality and enforceability should be taken into account in determining actual closure boundaries. Engagement with others in evaluating the distribution of hotspot points and configuring discrete area closure polygons is somewhat hampered because haul locations in the fishery dependent data are considered confidential.

As an alternative, based on further evaluation, hotspots identification could be used to inform future block area closures proposed under Alternative 3d.

[3] Thorson, J.T., Shelton, A.O., Ward, E.J., Skaug, H.J., 2015. Geostatistical delta-generalized linear mixed models improve precision for estimated abundance indices for West Coast groundfishes. ICES J. Mar. Sci. J. Cons. 72(5), 1297–1310. doi:10.1093/icesjms/fsu243. URL: http://icesjms.oxfordjournals.org/content/72/5/1297)

The Efficacy of Discrete Area Closures Relative to Rockfish Life History Traits and Hotspot Catch Events

The Essential Fish Habitat (EFH) and Rockfish Conservation Area Project Team (Team) considered Alternative 3c - closure of Rockfish Conservation Areas (RCA) and implementation of Discrete Area Closures (DAC) - relative to groundfish distribution, migration patterns, and fishing "hotspots" to determine which of the five overfished species (OFS) (bocaccio, cowcod, darkblotched, Pacific ocean perch [POP], and yelloweye) are suited for discrete area management. Life history characteristics (migratory patterns) for OFS and repeatability of high catch events by area are considered in this report. More information on distribution and life history characteristics can be found in the Draft 2016 Stock Assessment and Fishery Evaluation Document and the Council's Stock Assessment website.

Distribution and Life History Characteristics of the Five Overfished Species

Bocaccio

Bocaccio are most abundant off central and southern California. The southern bocaccio stock is most prevalent in the 54-82 fm depth zone and are found both nearshore and offshore. Young-of-the-Year (YOY) typically recruit to shallow habitats, and subadult bocaccio are more common in shallower water than adults, with average size becoming notably larger at greater depths. As for most rockfish, evidence shows some ontogenetic movement (movement as a fish matures) from shallower to greater depths though adult bocaccio are highly sedentary as adults. In a tagging study conducted by Hartman (1987), 606 of 696 fish tagged were recaptured at or very near the capture site. Of the 90 remaining fish, which comprised only four species, only 12 moved greater than 10 km. Most of these were juvenile bocaccio (which moved as far as 150 km). Adult bocaccio however exhibited no movement, though only a few were tagged. By contrast however, a study of bocaccio movement conducted by Starr et al. (2002) utilizing acoustic transmitters indicated bocaccio only spent a small amount of time within the 12 km^2 study area with frequent small scale movements in both vertical and horizontal planes.

Cowcod

Cowcod are most common from Cape Mendocino, CA to northern Baja CA, Mexico in depths from 27 fm – 164 fm. Larvae develop into a pelagic juvenile stage, settling into benthic habitats after about 3 months. YOY have been observed over a wide depth range (28-151 fm) with juveniles slightly deeper, and adults primarily deeper than 82 fm. Adult cowcod are generally solitary with occasional aggregation (Love et al. 1990) and although typically not migratory, may move to some extent to follow food.

Darkblotched Rockfish

Darkblotched rockfish are most abundant from British Columbia to Central CA with the majority inhabiting depths between 54 fm – 328 fm. Like other rockfish species, darkblotched rockfish exhibit ontogenetic movement with fish migrating to deeper waters as they mature and increase in size and age. No study has been conducted to evaluate movement patterns of darkblotched rockfish within the area of assessment, however, this species are found as bycatch in the at-sea hake fishery indicating they at times are suspended off the bottom.

Pacific Ocean Perch
POP are most abundant in northern British Columbia, the Gulf of Alaska, and the Aleutian Islands, primarily inhabiting the waters of the upper continental slope, and are found along the edge of the continental shelf. POP are most abundant between 109 fm – 246 fm and along submarine canyons and depressions. POP winter and spawn in deeper water (>150 fm) and move to feeding grounds in shallower water (98 fm – 120 fm) during the summer months (June – August). Their seasonal migration is likely related to summer feeding and winter spawning patterns. Most of the population occurs in patchy, localized aggregations though small numbers are dispersed throughout their range. POP exhibit significant diel movement from benthic to pelagic positions, apparently following euphausiid migrations.

Yelloweye Rockfish
Yelloweye rockfish are common from central California to the Gulf of Alaska and most abundant in water depths from 27 fm – 218 fm. Younger yelloweye tend to occur in shallower water, however, they do not exhibit as pronounced an ontogenetic shift as to many eastern Pacific rockfish species. There is little information regarding stock structure for this species off the U.S. and Canadian coasts though yelloweye rockfish are understood to be primarily sedentary and adult movement among major rocky habitat areas is unlikely. Black et al. (2008) conducted a study establishing climate-growth relationships for yelloweye in the northeast Pacific. Synchronous growth of fish was compared among regions during this study and Black notes that "Overall, the high levels of synchrony within sites compared to that among sites indicate that yelloweye rockfish did not migrate long distances". In their analysis, the study group found no outlier fish that failed to cross-date with growth patterns in others, indicating that stocks did not mix over large areas.

Discussion
With the exception of Pacific Ocean Perch which exhibit seasonal migrations from wintering and spawning grounds to shallower feeding grounds, and bocaccio, for which there is some evidence that suggest may move at least to some small extent (though most literature indicates they are relatively sedentary), most adult West Coast groundfishes are thought to be primarily sedentary, exhibiting little migration throughout their life.

With the understanding that groundfish exhibit little spatial migration throughout their life cycles, DACs would likely provide managers with the ability to effectively manage catch while opening grounds that are not currently available to commercial fishermen, allowing them to attain more of the target species allocation while keeping bycatch low.

More information may be needed regarding bocaccio and Pacific Ocean perch, though seasonal changes in DACs for Pacific Ocean perch may be possible based on seasonal movement. Additional to migration/movement patterns, when considering the efficacy of DACs as a management strategy, the possibility of repeat "high catch" events in given areas needs to be addressed. For species with relatively low site fidelity, they may be better managed with inseason or pre-season adjustments to block area closures, rather than relying solely on DACs.

Analysis of data compiled from 2011-2014 (WCGOP) and 2010-2015 (Trawl Surveys) indicates there are areas that have experienced high catch events. However, there is uncertainty as to whether these events, and the resulting "hot-spots" are the result of isolated high catch events, or whether they are likely to be repeated. Additional spatial analysis regarding species distribution over time would be beneficial though this analysis would require additional time to be completed.

References

Black, B. A., G. W. Boehlert, and M. M. Yoklavich. 2008. Establishing climate-growth relationships for yelloweye rockfish (Sebastes ruberrimus) in the northeast Pacific using a dendrochronological approach. Fisheries Oceanography 17:368-379.

Love, M., P. Morris, M. McCrae, and R. Collins. 1990. Life history aspects of 19 rockfish species (Scorpaenidae: Sebastes) from the Southern California Bight. NOAA Technical Report NMFS 87: 38 p.

Hartmann, A.R. (1987) Movement of scorpionfishes (Scorpaenida: Sebastes and Scorpaena) in the Southern California Bight. California Fish and Game 73, 68-79.

Starr, R.M., Heine, J.N. and Cailliet, G.M. 2002. Movements of Bocaccio (Sebastes paucispinis) and greenspotted (S. chlorostictus) rockfishes in a Monterey submarine canyon: implications for the design of marine reserves. Fishery Bulletin 100, 324-337.

New EFH Conservation Area Polygon

Alternative 10b proposes to provide clarifications and correct minor errors from Amendment 19, and was selected by the Council as a preliminary preferred alternative, at its Aril 2016 meeting. Most of these are anticipated to be minor (typos, misspellings, etc), and therefore do not require any analysis under National Environmental Protection Act (NEPA). However, one apparent mistake will require analysis. Incorrect coordinates for the EFHCA identified as Potato Bank were adopted as part of Amendment 19, and carried forward into regulation. The coordinates envelop an area of seafloor near – but not inclusive of – the actual Potato Bank. (See Figure 1 on following page). Because this correction involves a modification of an EFHCA, the best "home" for it is in Subject Area 1, where modifications to EFHCAs are considered.

The impacts of this changes to federally managed groundfish bottom trawling are likely to be negligible, because both areas (the coordinates in regulation and the actual Potato Bank) are entirely within the Cowcod Conservation Area West, and bottom trawling is already prohibited. However, there may be state managed trawl fisheries that would be affected.

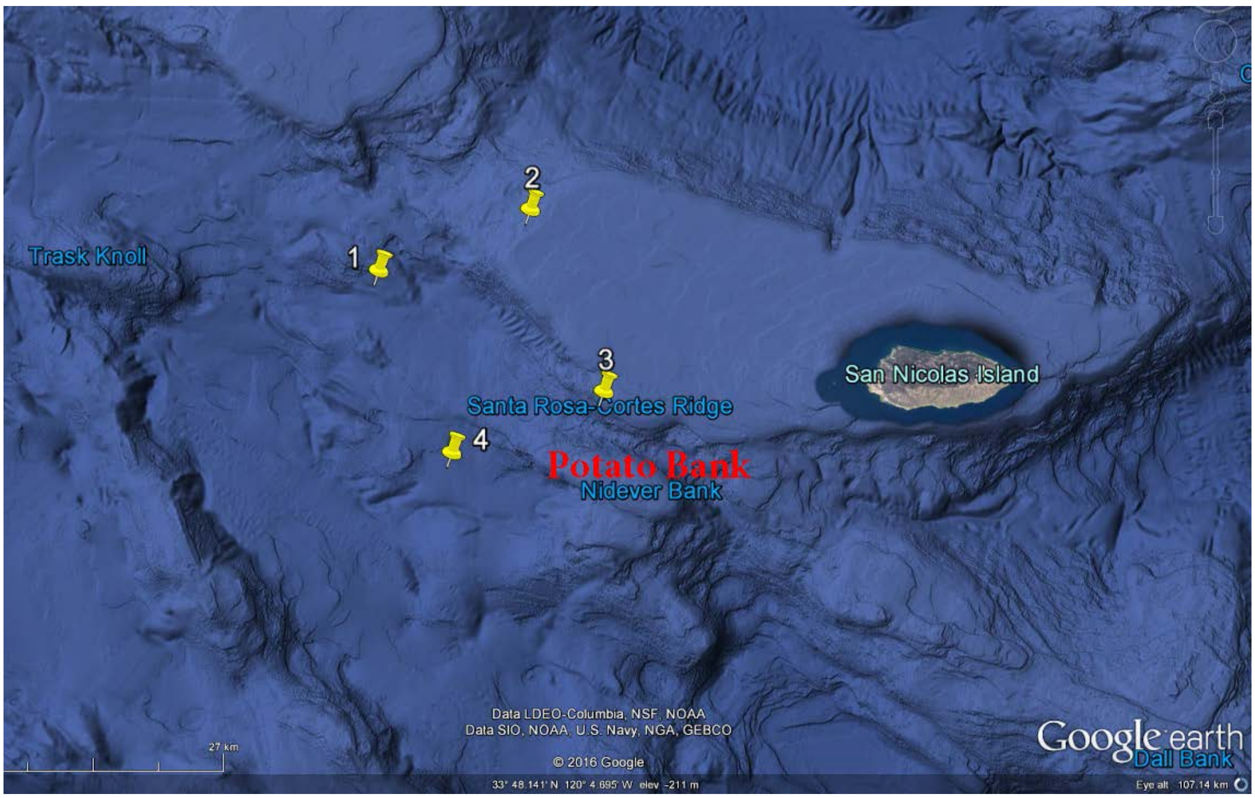

Figure 1: Image depicting the incorrect coordinates that are intended to protect Potato Bank (also known as Nidever Bank).

How the Council addresses this issue depends, in part, on the polygons that the Council ultimately adopts for the preliminary preferred alternative. The Begg Ridge closure that was withdrawn from the Collaborative proposal but was analyzed by the team at the Council's request and the Southern California Bight closure proposed by Oceana, et al. both encompass Potato Bank. Should the Council include either of those in the PPA, further steps to protect Potato Bank would not be necessary, but the Council should consider removing the incorrect mapping coordinates.