Potential of wind-energy areas currently-identified off Oregon to adversely impact future groundfish surveys conducted by the NOAA Northwest Fisheries Science Center

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The Fishery Resource Analysis and Monitoring Division (FRAMD) of the NOAA Northwest Fisheries Science Center (NWFSC) conducts three routine surveys of groundfish off the U. S. Pacific coast, two of which operate north of Pt. Conception, California. First, is an annual bottom trawl survey that randomly samples grid cells in accessible areas between Canada and Mexico, in bottom depths between 30 and 700 fm (55-1,280 m). Second, is a joint U.S.-Canada acoustic survey for Pacific hake, which also samples fish using mid-water trawls. This survey generally operates biennially, covering waters from around Pt. Conception to Dixon Entrance, utilizing a latitudinally-aligned transect design, with 10-20 nm spacing between transects. Both surveys provide critical data for conducting stock assessments of the most important commercial groundfish species along the U.S. west coast that are not found exclusively in nearshore waters shoreward of 55 m.

FRAMD staff recently conducted analyses intended to highlight the importance of continued access by these two surveys within either proposed or designated wind energy areas (WEAs) identified by BOEM off Oregon and California, respectively. The first analysis described below examined the annual importance of each BOEM area to each of FRAMD's two groundfish surveys, while the second analysis summarized the relative value of individual bottom trawl survey cells within the two Oregon wind energy call areas.

Historical survey findings in Oregon Call Areas

Bottom Trawl Survey

The west coast groundfish bottom trawl (WCGBT) survey has operated annually since 2003, with the exception of 2020, when COVID prevented safe execution of the survey. In a normal year, roughly 750 cells (of more than 11,000 in the survey frame) are selected for sampling by one of 4 vessels, divided into 2 coastwide passes conducted north-to-south from May-July and August-October. Within each selected cell, the skipper conducts a trawl that remains on-bottom for roughly 15 minutes. If a suitable site for trawling cannot be located within the cell in the designated search time, an alternative, pre-selected cell may be sampled.

For this analysis, the 'best' single location for each WCGBT survey haul, most commonly the midpoint of the gear track on bottom, was used to classify every haul as occurring within or outside of each survey cell intersecting a call area. Since 2003, 80 groundfish species have been caught by the survey within the combined footprint of the Oregon call areas. However, not all of these species are important to fisheries, most are not assessed, and many of the catches were small. Based on a preliminary visual review of the location of survey catch events for major species, 13 were selected to have their survey catch quantified.

Table 1 provides WCGBT survey summary results for both Oregon call areas combined, and individually. The first row of each section reports the percentage of coastwide survey hauls that were conducted in each call area in the specified year. For both areas combined, the percent of survey hauls averaged 4.5% across all years, ranging from 3.4% in 2014 to 5.8% in 2013. Below those values, percentages are shown for each of 13 species, which indicate the share of coastwide catch of the species that occurred in hauls in the specified area and year. Longspine thornyhead has the highest average percentage of total survey catch weight in both call areas combined, across all years, at 9.7% Three other species average more than 7% across the 17 years: sablefish, Dover sole, and shortspine thornyhead. For the first three, the percentage of catch occurring in the combined Oregon call areas exceeds the percentage of hauls conducted in those areas in all 17 years, and that was true in 15 years for Dover sole. All four species had survey catch percentages that exceeded the percentage of survey hauls in each individual area in at least 14 of the 17 years. For two species, darkblotched and widow rockfishes, hauls in the Coos Bay call area produced more than 47% of the coastwide catch of the species in particular years.

Figure 1 displays the 13 individual-species findings for the combined Oregon call areas, and also for all four areas (including the two WEAs from California) combined. For species other than longspine thornyhead, shortspine thornyhead, sablefish, and Dover sole, negligible survey catch has occurred in either of the California areas. The California WEAs include only an annual average of 1.1% of survey hauls, but included an average 4.1% of longspine, 2.5% of shortspine, and 1.8% of sablefish.

Were the WCGBT survey to be precluded from sampling throughout any of the WEAs, future surveys would sample only available cells outside of those areas. For some species, this would likely mean replacing higher-catch per unit effort (CPUE) hauls with lower ones. It is uncertain how existing time series would be affected. Traditionally, when areas that were previously available for surveying became unavailable, all data acquired from those areas has been removed from use in assessments. It is not clear whether this course of action could be repeated with the prospect of losing such a large amount of data. If it were, we would expect assessment uncertainty to increase throughout much of the existing survey period, with the potential for unpredictable changes in population scale or status. If existing data from future inaccessible wind-energy areas were to be used in subsequent assessments, estimated trends across periods might be subject to bias.

Pacific Hake Acoustic-Trawl Survey

For the accompanying analysis of the acoustic survey for Pacific hake, all transects that passed through the latitudinal footprint of one of the call areas were considered to be ‘inside’ it, along with all biomass attributed to any part of the transect. Although hake are migratory, the consistent timing of the survey and the habitat features in the two Oregon call areas and the Humboldt WEA produce circumstances where the biomass estimates associated with transects passing through these areas commonly are much larger than the percentages of total transects assigned to the areas. From 2003 to 2021, the percentage of hake biomass associated with the two Oregon call areas has averaged 12%, nearly double the percentage of all transects assigned to those areas (6.2%) (Table 2 and Figure 2). On average, 10.1% of annual survey transects were assigned to one of the four wind areas, but they account for 17.5% of annual coastwide biomass. Roughly one-third of all the estimated biomass for hake in 2021 arose from transects inside one of the four BOEM-designated areas, with 22% associated with transects in the two Oregon call areas. Transects assigned to the two Oregon call areas accounted for at least 14% of the coastwide biomass estimate in 5 of the 11 years, while all four areas contributed at least 15% in all but two years.

Were the Pacific hake survey to be excluded from the WEAs, the assessment would suffer a substantial information loss. As with the WCGBT survey, it is not clear how historical data from closed areas would be treated in future assessments. Some degree of problems would be expected, whether the historical data continued to be used or not. If future surveys would not provided with latitudinal transect corridors through WEA areas that provided a minimum of 20 nm between transects, and preferably closer to 10 nm, the impacts on future survey estimates of biomass at age would likely be more severe than impacts to the WCGBT survey, given the survey's non-random, transect design and the estimated correlation distance between transects, which is less than 20 nm. Conversely, the availability of suitable passageways through the wind areas could mitigate survey impacts without compromising the ability to meet wind-energy generation objectives for these call areas.

<u>Summary of the importance of Oregon call areas for the WCGBT survey</u>

Review of historical survey activity in the BOEM areas, generally, and the two Oregon ones more specifically, reveals them to be important areas of survey catch for Pacific hake and several other important species. Together hake and sablefish, Dover sole, and shortspine and longspine thornyheads have generated average annual ex-vessel revenues in excess of $84 million over the past 5 years (PacFIN, 2022), including COVID impacts on fishing, which represents roughly 80% of annual, groundfish, ex-vessel revenues generated over that period. The importance of these species to commercial fishing along the west coast underscores the significance of continuing reliable survey sampling of them, which is essential for maintaining high-quality assessments to support sustainable fisheries.

If future survey data are foregone from these areas, it will not be possible to fill in the gaps using prediction models based on prior observations from inside and outside the areas. Even if such modeling were viewed as an acceptable adjunct to real data obtained from survey sampling, the interannual variability in catch in these areas, as a fraction of coastwide survey catch makes it unlikely that a suite of covariates for predicting what future 'foregone observations' in the areas would have been. In addition to the catch-rate sampling that underlies overall biomass estimates from the surveys, the distribution of survey biomass among age and length groups is often equally or more important for assessments. With many species sampled by these surveys living beyond 50 years of age, there would be virtually no chance of predicting with sufficient accuracy what population structure would have been observed in the call areas, had sampling there been possible.

In addition to the development of biomass indices for assessments, which are driven by volumes of survey catch, sampling also provides valuable information about population structure, through the collection of length and age data. This kind of sampling from surveys, using small-mesh nets and random locations provides a less-biased view of population structure than lengths and ages collected from fishing operations, which target marketable sizes of fish and whose site selections may be influenced by other factors such as avoiding bycatch. Evaluation of the Oregon call areas' contributions to overall survey length and age compositions for important species has been beyond the scope of available resources for the current analysis.

Comparative value of survey cells within each Oregon Call Area

The analysis above is intended to illustrate the importance of the Oregon call areas, in total, to the WCGBT Survey. The following analysis will highlight what areas within each of the call areas are of relatively greater importance to the WCGBT survey. Survey cells falling primarily within either call areas, have been sampled by the survey varying numbers of times over the 2003-19 period. Figure 3 shows the number of times each cell has been sampled for the Coos Bay and Brookings call areas, with values ranging from 0 to 6 in the former and 0 to 4 in the latter.

When a survey haul is conducted, the duration and net opening allow the area-swept to be calculated. We have used this measure of effort to calculate the average CPUE of each survey haul with respect to 3 groups of groundfish species (listed in Table 3). The largest group includes all 79 groundfish species (excluding Pacific hake) that were found within one of the call areas in any year. The second group includes 22 species which have higher fishery importance and have generally been assessed multiple times, using survey data. The third group includes the eight species that were observed at the highest and most-consistent levels across the 17 years.

In cases where a cell was sampled multiple times, the individual CPUE values were averaged across years to produce a single cell catch rate for the set of specified species. All other things being equal, cells with higher demonstrated catch rates have the potential to provide more data in future surveys. Per-cell average catch rates for each species group were then transformed (ln) and normalized, on a scale of 0 to 1, based on their position within the range of transformed values for each group of species. Maps of the normalized catch-rate distributions for the large, intermediate, and small numbers of species are presented in Figures 4, 5, and 6, respectively.

Another aspect of an individual cell's value to the survey (and survey data users) is the number of species that can be found there. Each species has preferred depth ranges, and there are many more species found on the continental shelf than in deeper slope areas. However, it is important for the survey to continue to provide useful information for as many managed groundfish as possible. Consequently, we evaluated the species richness of each survey cell within each of the survey's three depth strata: 30-100 fm, 100-300 fm, and 300-700 fm.

Within these large depth zones, individual cells still vary in the maximum number of species that might be expected to be found there, based on the cell's depth range and the depth ranges of individual species. Therefore, we calculated the proportion of possible species (based on depth and latitude) that was reflected in the actual number of species that were caught in the cell. Within a depth stratum, a cell in which 23 of 40 possible species were found can be thought of as a more efficient sampling site than one in which 15 of 38 possible species were found. Within each depth stratum, these proportions were then normalized on a scale of 0 to 1, in the same manner as average catch rates. By separating the calculation of these normalized scores within depth strata, we ensure that sites which are the most important for surveying deep-water species are not undervalued just because fewer species could ever be found there. The normalized scores for this interpretation of species richness are plotted in Figure 7.

As noted at the end of the previous section, one of the major differences between surveys and fisheries is that surveys are not targeting 'marketable' fish sizes. Although fisheries may catch considerable amounts of young fish of some species, in many cases, fish may not appear in fishery catch until they are 5 or 10 years old. One of the most important roles of the WCGBT survey is to provide information about fish that are smaller/younger than those caught by fisheries. Data for these small/young fish provide important information about recruitment success to assessment models. Recent research conducted at the NWFSC evaluated survey cells along the coast for their usefulness in providing information about young fish not commonly sampled on fishing trips. The presence of young fish was summed across the available 13 species for each survey cell, with the normalized aggregate score scaled between 0 and 1. Those scores are plotted for both call areas in Figure 8.

The normalized scores for all five of these factors were summed, and the resulting totals rescaled to a 0-to-1 range. These aggregate scores, which include multiple aspects of survey importance are presented in Figure 9, and provide the best available basis for distinguishing sub-areas within each of the call areas where future survey exclusion would have greater or lesser impact on the information value of future surveys.

As noted at the top of this section, trawl survey sampling is sparse; in any year fewer than 7% of the possible cells in the sampling frame are selected. As a result, even after 17 years of sampling a full third (164) of the cells that are at least partially within the Oregon call areas have not been sampled even once. Roughly 85% of those that have been sampled have been visited fewer than 3 times. Because of this paucity of sampling within these areas, Figures 10 and 11 offer a visual comparison between the aggregate survey-value scores presented in Figure 9 and measures of trawl fishery CPUE (all groundfish species), where logbook data from 2011 to 2019 have been aggregated and partitioned among the same survey cell grid, for the Coos Bay and Brookings call areas, respectively.

Table 1.-- Annual percentages of bottom trawl survey hauls and coastwide amounts of 14 species caught by the survey in the two Oregon wind-energy areas, 2003-19.

Both Oregon areas	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2003-2019	2015-2019
% of BT Survey Hauls	**5.7**	**4.2**	**4.1**	**5.1**	**5.2**	**3.7**	**5.3**	**3.9**	**4.5**	**4.0**	**5.8**	**3.4**	**4.5**	**4.3**	**3.5**	**4.6**	**4.9**	**4.5**	**4.4**
% of species catch wt for:																			
Longspine thornyhead	8.5	9.0	10.6	6.3	11.9	7.0	14.0	13.5	12.0	8.9	11.5	9.1	6.1	9.4	8.4	5.2	13.9	9.7	8.6
Shortspine thornyhead	5.5	5.4	4.6	5.3	4.9	5.5	9.0	5.4	7.6	5.0	14.8	7.4	15.7	13.4	5.3	9.4	16.9	8.3	12.2
Sablefish	5.8	6.7	6.6	8.0	9.3	7.3	8.7	4.6	5.1	5.5	10.2	3.8	15.5	8.4	4.0	9.1	7.4	7.4	8.9
Dover sole	7.6	7.8	4.9	10.9	12.3	6.1	8.7	6.2	7.1	7.6	10.0	6.4	7.7	7.2	4.1	9.6	9.1	7.8	7.6
Darkblotched rockfish	0.4	1.8	0.7	9.6	4.0	1.6	1.7	5.9	3.5	1.3	2.8	4.5	69.4	0.4	0.5	6.3	0.4	6.8	15.4
Longnose skate	6.6	4.8	4.0	8.8	8.0	5.5	6.3	5.1	3.6	3.1	4.8	4.7	8.0	4.3	2.7	7.8	6.5	5.6	5.9
Rougheye rockfish	2.7	1.4	0.4	2.9	6.6	2.1	0.5	10.3	0	1.5	8.8	2.9	6.6	5.2	0.1	6.0	2.8	3.6	4.1
Lingcod	1.9	1.2	5.7	4.9	5.4	10.3	2.8	2.4	1.7	1.0	1.2	1.8	5.0	1.8	1.9	3.3	4.1	3.3	3.2
Widow rockfish	0.3	0	0.8	1.4	2.8	0	6.1	47.4	2.9	0	0.3	0	0.3	0.0	0.1	1.7	54.8	7.0	11.4
Canary rockfish	2.6	0	3.6	0.1	4.7	0.8	0.3	0	2.9	0.3	10.5	0.1	0.5	0.4	0.2	0.2	0.1	1.6	0.3
Splitnose rockfish	1.6	2.5	0.6	2.9	2.4	2.4	0.6	1.0	2.4	0.6	0.4	1.2	2.3	0.2	0.0	0.6	0.8	1.3	0.8
Petrale sole	0.6	0.1	0.4	6.2	0.7	0.5	1.1	0.7	0.4	0.7	0.8	0.1	0.7	0.6	1.0	1.2	1.9	1.0	1.1
Pacific Spiny Dogfish	0.1	0.4	0.1	1.4	3.7	3.3	4.7	0.8	0.2	0.1	0.1	0.2	0.2	0.1	0	1.4	0.0	1.0	0.3
Coos Bay area																			
% of BT Survey Hauls	**3.5**	**2.5**	**2.8**	**4.0**	**3.3**	**2.5**	**4.0**	**2.7**	**3.3**	**3.2**	**4.3**	**2.5**	**3.4**	**3.0**	**2.8**	**3.8**	**3.7**	**3.3**	**3.4**
% of species catch wt for:																			
Longspine thornyhead	4.6	3.0	4.8	3.2	2.3	3.1	6.2	5.3	5.7	4.7	5.4	4.6	1.9	4.7	4.3	4.0	5.0	4.3	4.0
Shortspine thornyhead	4.0	2.5	2.7	4.1	2.7	3.8	6.1	3.6	6.5	4.2	13.2	5.3	14.1	11.0	4.5	7.9	15.4	6.6	10.6
Sablefish	3.5	3.3	4.0	5.5	5.1	2.9	7.1	1.6	3.3	4.0	6.2	2.8	5.3	6.9	3.4	8.1	5.4	4.6	5.8
Dover sole	4.4	3.8	2.6	7.5	5.6	3.2	6.9	4.9	5.0	4.5	6.0	4.5	5.2	4.1	2.8	7.3	7.3	5.0	5.3
Darkblotched rockfish	0.4	1.7	0.7	8.5	3.4	1.6	1.7	5.9	3.5	1.3	2.6	4.5	69.4	0.4	0.5	1.7	0.4	6.4	14.5
Longnose skate	5.7	4.0	3.5	7.8	6.3	3.8	6.0	4.4	3.4	2.8	4.1	4.7	6.8	4.0	2.3	5.7	6.0	4.8	5.0
Rougheye rockfish	2.7	1.4	0.4	2.9	6.6	2.1	0.5	10.3	0	1.5	8.8	2.9	6.6	5.2	0.1	6.0	2.8	3.6	4.1
Lingcod	0.3	1.2	5.7	3.8	4.5	2.5	2.8	1.7	1.7	1.0	0.7	1.8	3.2	1.8	1.9	1.1	4.1	2.3	2.4
Widow rockfish	0	0	0.8	1.4	2.8	0	6.1	47.4	2.9	0	0.3	0	0.3	0.0	0.1	1.1	54.8	6.9	11.2
Canary rockfish	1.9	0	3.6	0.1	4.7	0.8	0.3	0	2.9	0.3	10.5	0.1	0.4	0.4	0.2	0.2	0.1	1.6	0.3
Splitnose rockfish	1.6	2.5	0.6	2.0	2.0	1.8	0.6	1.0	2.4	0.6	0.4	1.2	2.3	0.2	0.0	0.3	0.8	1.2	0.7
Petrale sole	0.4	0.1	0.4	6.1	0.6	0.5	0.8	0	0.4	0.7	0.8	0.1	0.6	0.6	1.0	0.5	1.9	0.9	0.9
Pacific Spiny Dogfish	0.0	0.4	0.1	1.0	3.2	3.0	4.7	0.8	0.2	0.1	0.1	0.2	0.2	0.1	0	1.4	0.0	0.9	0.3
Brookings area																			
% of BT Survey Hauls	**2.2**	**1.7**	**1.3**	**1.1**	**1.9**	**1.2**	**1.3**	**1.3**	**1.2**	**0.9**	**1.5**	**0.9**	**1.0**	**1.3**	**0.7**	**0.7**	**1.1**	**1.2**	**1.0**
% of species catch wt for:																			
Longspine thornyhead	3.9	6.0	5.8	3.1	9.5	3.8	7.8	8.2	6.4	4.3	6.1	4.5	4.2	4.7	4.0	1.2	8.8	5.4	4.6
Shortspine thornyhead	1.5	2.9	1.9	1.1	2.2	1.7	2.9	1.9	1.0	0.9	1.6	2.1	1.6	2.4	0.8	1.6	1.5	1.7	1.6
Sablefish	2.3	3.4	2.6	2.6	4.2	4.4	1.6	3.1	1.7	1.5	4.0	1.0	10.2	1.5	0.6	0.9	2.0	2.8	3.0
Dover sole	3.2	4.0	2.3	3.5	6.7	3.0	1.8	1.3	2.1	3.1	4.0	1.9	2.5	3.1	1.3	2.4	1.8	2.8	2.2
Darkblotched rockfish	0	0.2	0	1.1	0.6	0.0	0.0	0	0	0	0.2	0	0	0	0	4.7	0	0.4	0.9
Longnose skate	0.9	0.9	0.4	1.0	1.7	1.7	0.3	0.8	0.2	0.3	0.8	0.0	1.2	0.3	0.4	2.1	0.4	0.8	0.9
Rougheye rockfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Lingcod	1.7	0	0	1.2	0.8	7.8	0	0.6	0	0	0.5	0	1.8	0	0	2.2	0	1.0	0.8
Widow rockfish	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0.1	0.1
Canary rockfish	0.7	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0.0	0.0
Splitnose rockfish	0.0	0.0	0	0.9	0.4	0.7	0	0	0	0	0.0	0.0	0.0	0	0	0.3	0	0.1	0.1
Petrale sole	0.2	0	0	0.1	0.1	0	0.3	0.7	0	0	0.0	0	0.0	0	0	0.7	0	0.1	0.1
Pacific Spiny Dogfish	0.1	0.0		0.4	0.5	0.2	0	0	0	0	0	0	0	0	0	0.0	0	0.1	0.0

Table 2.--Percentages of hake survey transects passing through either of the two Oregon wind-energy areas or any of the four WEAs, and the percentage of coastwide hake biomass on those transects, for 11 surveys from 2003 through 2021.

	2003	2005	2007	2009	2011	2012	2013	2015	2017	2019	2021	Avg.
Transects intersecting either Oregon WEA												
% of total transects	8%	8%	6%	6%	6%	7%	6%	4%	6%	5%	7%	6.2%
% of hake survey 2+ biomass	20%	8%	11%	17%	4%	7%	6%	18%	6%	14%	22%	12.0%
Transects intersecting any of the 4 WEAs (OR + CA)												
% of total transects	10%	12%	9%	9%	10%	10%	10%	8%	10%	10%	13%	10.1%
% of hake survey 2+ biomass	22%	17%	15%	17%	16%	9%	16%	19%	10%	19%	33%	17.5%

Table 3.— Assignment of species to species-groups, for use in summarizing bottom-trawl survey catch-per-unit-effort in individual survey cells.

Common_Name	Scientific_Name	Group	79 spp	22 spp	8 spp
Darkblotched Rockfish	*Sebastes crameri*	rockfish	X	X	X
Dover Sole	*Microstomus pacificus*	flatfish	X	X	X
Lingcod	*Ophiodon elongatus*	roundfish	X	X	X
Longnose Skate	*Raja rhina*	elasmobranch	X	X	X
Longspine Thornyhead	*Sebastolobus altivelis*	rockfish	X	X	X
Rougheye Rockfish	*Sebastes aleutianus*	rockfish	X	X	X
+ Blackspotted Rockfish	*Sebastes melanostictus*	rockfish	X	X	X
Sablefish	*Anoplopoma fimbria*	roundfish	X	X	X
Shortspine Thornyhead	*Sebastolobus alascanus*	rockfish	X	X	X
Arrowtooth Flounder	*Atheresthes stomias*	flatfish	X	X	
Aurora Rockfish	*Sebastes aurora*	rockfish	X	X	
Big Skate	*Raja binoculata*	elasmobranch	X	X	
Canary Rockfish	*Sebastes pinniger*	rockfish	X	X	
English Sole	*Parophrys vetulus*	flatfish	X	X	
Pacific Ocean Perch	*Sebastes alutus*	rockfish	X	X	
Pacific Spiny Dogfish	*Squalus suckleyi*	elasmobranch	X	X	
Petrale Sole	*Eopsetta jordani*	flatfish	X	X	
Redbanded Rockfish	*Sebastes babcocki*	rockfish	X	X	
Rex Sole	*Glyptocephalus zachirus*	flatfish	X	X	
Splitnose Rockfish	*Sebastes diploproa*	rockfish	X	X	
Widow Rockfish	*Sebastes entomelas*	rockfish	X	X	
Yelloweye Rockfish	*Sebastes ruberrimus*	rockfish	X	X	
Yellowtail Rockfish	*Sebastes flavidus*	rockfish	X	X	
Bank Rockfish	*Sebastes rufus*	rockfish	X		
Black Rockfish	*Sebastes melanops*	rockfish	X		
Blackgill Rockfish	*Sebastes melanostomus*	rockfish	X		
Blue Rockfish	*Sebastes mystinus*	rockfish	X		
Bocaccio	*Sebastes paucispinis*	rockfish	X		
Bronzespotted Rockfish	*Sebastes gilli*	rockfish	X		
Brown Rockfish	*Sebastes auriculatus*	rockfish	X		
Butter Sole	*Isopsetta isolepis*	flatfish	X		
Cabezon	*Scorpaenichthys marmoratus*	roundfish	X		
California scorpionfish	*Scorpaena guttata*	rockfish	X		
Chilipepper	*Sebastes goodei*	rockfish	X		
Copper Rockfish	*Sebastes caurinus*	rockfish	X		
Cowcod	*Sebastes levis*	rockfish	X		
Curlfin Sole	*Pleuronichthys decurrens*	flatfish	X		
Deacon Rockfish	*Sebastes diaconus*	rockfish	X		
Flag Rockfish	*Sebastes rubrivinctus*	rockfish	X		
Flathead Sole	*Hippoglossoides elassodon*	flatfish	X		

Table 3.— Assignment of species to species-groups, for use in summarizing bottom-trawl survey catch-per-unit-effort in individual survey cells. (cont.)

Common_Name	Scientific_Name	Group	79 spp	22 spp	8 spp
Freckled Rockfish	*Sebastes lentiginosus*	rockfish	X		
Gopher Rockfish	*Sebastes carnatus*	rockfish	X		
Greenblotched Rockfish	*Sebastes rosenblatti*	rockfish	X		
Greenspotted Rockfish	*Sebastes chlorostictus*	rockfish	X		
Greenstriped Rockfish	*Sebastes elongatus*	rockfish	X		
Halfbanded Rockfish	*Sebastes semicinctus*	rockfish	X		
Harlequin Rockfish	*Sebastes variegatus*	rockfish	X		
Honeycomb Rockfish	*Sebastes umbrosus*	rockfish	X		
Kelp Greenling	*Hexagrammos decagrammus*	roundfish	X		
Kelp Rockfish	*Sebastes atrovirens*	rockfish	X		
Leopard Shark	*Triakis semifasciata*	elasmobranch	X		
Mexican Rockfish	*Sebastes macdonaldi*	rockfish	X		
Olive Rockfish	*Sebastes serranoides*	rockfish	X		
Pacific Cod	*Gadus macrocephalus*	roundfish	X		
Pacific Sanddab	*Citharichthys sordidus*	flatfish	X		
Pink Rockfish	*Sebastes eos*	rockfish	X		
Pinkrose Rockfish	*Sebastes simulator*	rockfish	X		
Puget Sound Rockfish	*Sebastes emphaeus*	rockfish	X		
Pygmy Rockfish	*Sebastes wilsoni*	rockfish	X		
Quillback Rockfish	*Sebastes maliger*	rockfish	X		
Redstripe Rockfish	*Sebastes proriger*	rockfish	X		
Rock Sole	*Lepidopsetta bilineata*	flatfish	X		
Rosethorn Rockfish	*Sebastes helvomaculatus*	rockfish	X		
Rosy Rockfish	*Sebastes rosaceus*	rockfish	X		
Sand Sole	*Psettichthys melanostictus*	flatfish	X		
Sharpchin Rockfish	*Sebastes zacentrus*	rockfish	X		
Shortbelly Rockfish	*Sebastes jordani*	rockfish	X		
Shortraker Rockfish	*Sebastes borealis*	rockfish	X		
Silvergray Rockfish	*Sebastes brevispinis*	rockfish	X		
Speckled Rockfish	*Sebastes ovalis*	rockfish	X		
Squarespot Rockfish	*Sebastes hopkinsi*	rockfish	X		
Starry Flounder	*Platichthys stellatus*	flatfish	X		
Starry Rockfish	*Sebastes constellatus*	rockfish	X		
Stripetail Rockfish	*Sebastes saxicola*	rockfish	X		
Sunset Rockfish	*Sebastes crocotulus*	rockfish	X		
Swordspine Rockfish	*Sebastes ensifer*	rockfish	X		
Tiger Rockfish	*Sebastes nigrocinctus*	rockfish	X		
Treefish	*Sebastes serriceps*	rockfish	X		
Vermilion Rockfish	*Sebastes miniatus*	rockfish	X		
Whitespotted Rockfish	*Sebastes moseri*	rockfish	X		
Yellowmouth Rockfish	*Sebastes reedi*	rockfish	X		

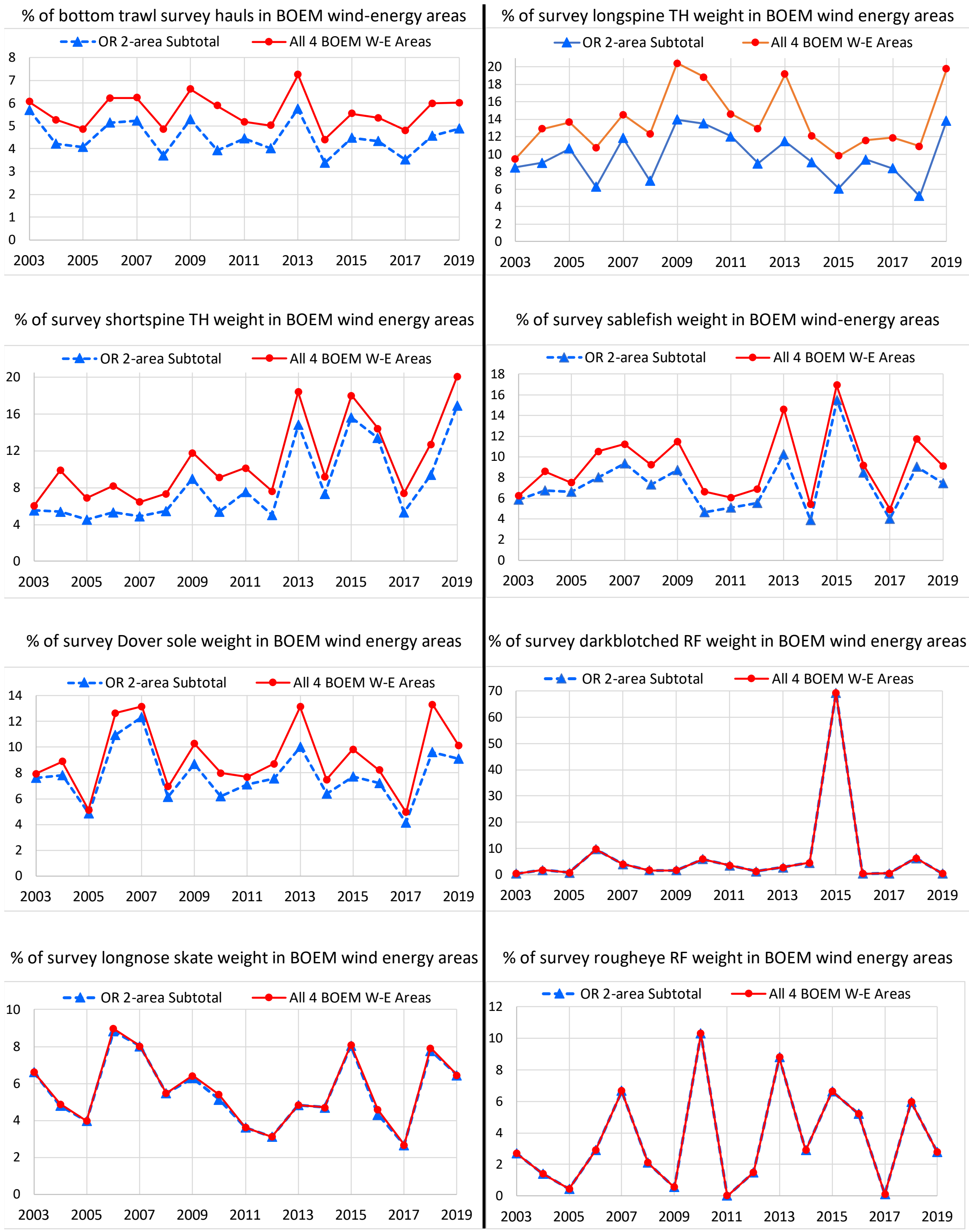

Figure 1.-- Annual percentages of bottom trawl survey hauls and coastwide amounts of 14 species caught by the survey in the two Oregon wind-energy areas and in all four WEAs, 2003-19.

Notes: Scaling of vertical (%) axes varies by figure. "RF" is rockfish; "TH" is thornyhead; "P." is Pacific.

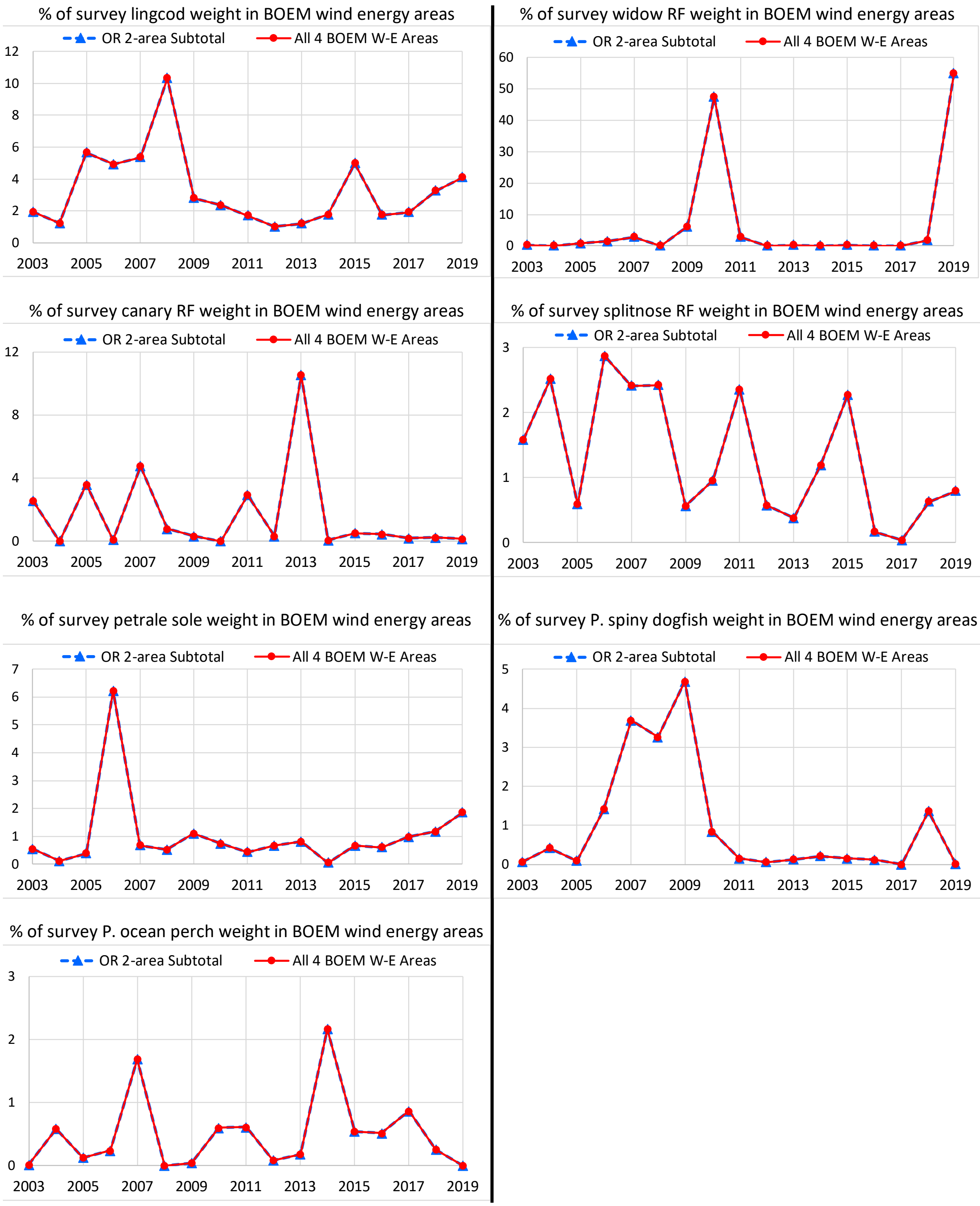

Figure 1.-- Annual percentages of bottom trawl survey hauls and coastwide amounts of 14 species caught by the survey in the two Oregon wind-energy areas and in all four WEAs, 2003-19 (cont.).

Notes: Scaling of vertical (%) axes varies by figure. "RF" is rockfish; "TH" is thornyhead; "P." is Pacific.

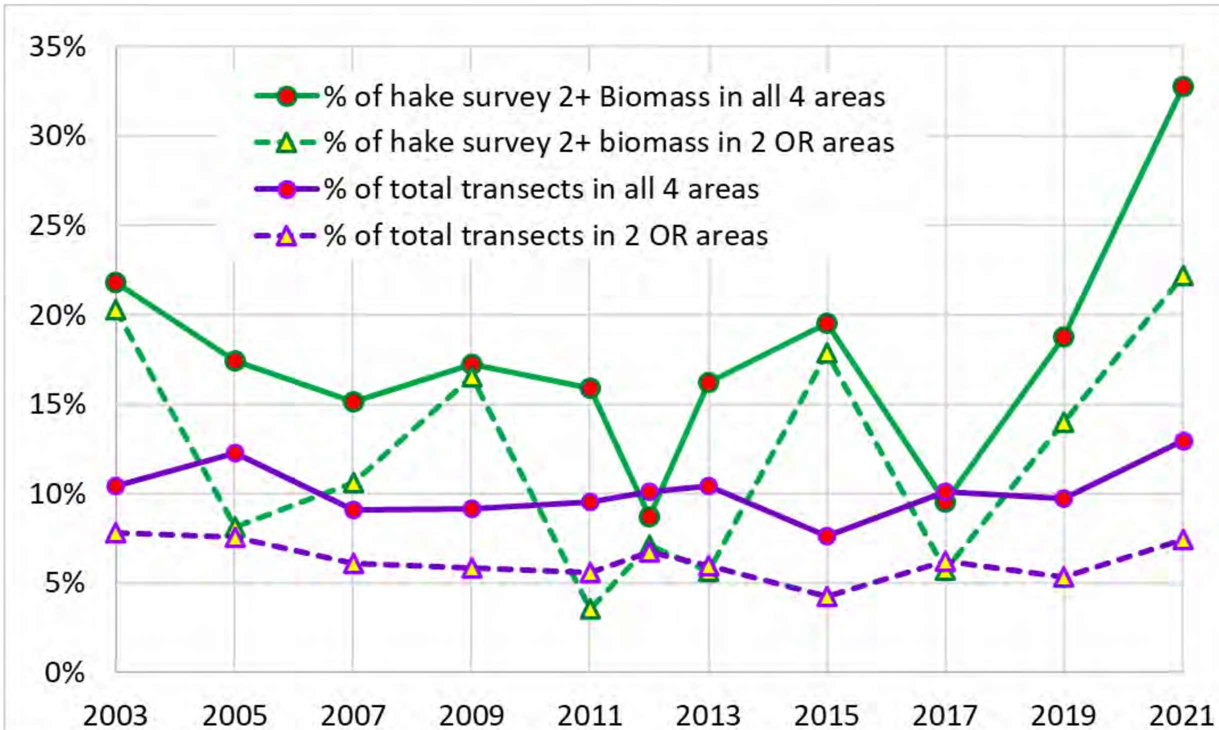

Figure 2.--Percentages of all hake survey transects passing through either of the two Oregon wind-energy areas or any of the four WEAs, and the percentage of coastwide hake biomass on those transects, for 11 surveys from 2003 through 2021.

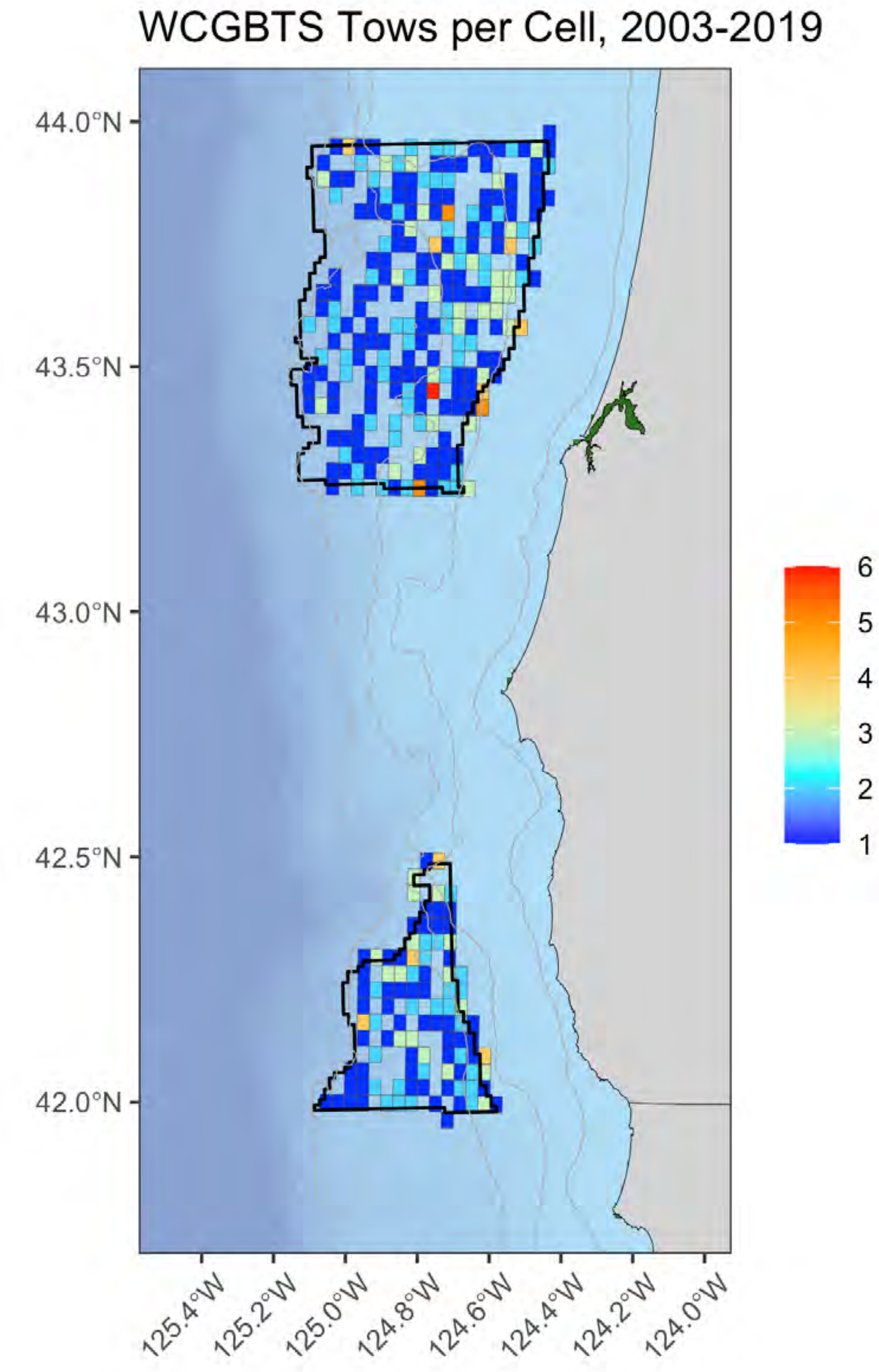

Figure 3,--Numbers of times individual bottom trawl survey cells have been sampled during 2003-2019.

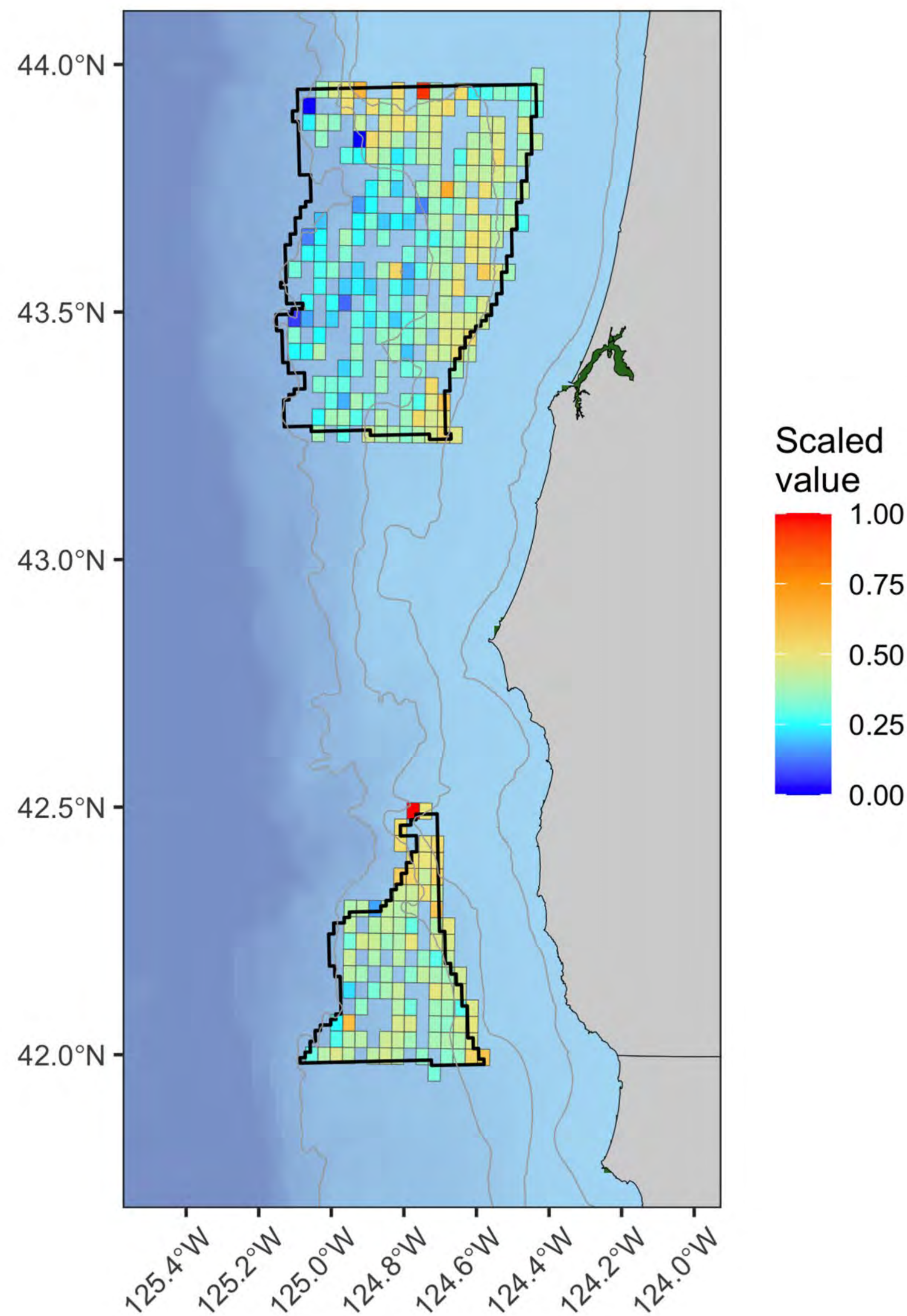

Figure 4,--Normalized **catch-per-unit-effort averages of 79 groundfish species** for individual bottom trawl survey cells, based on sampling during 2003-2019. [see Table 3 for a list of species]

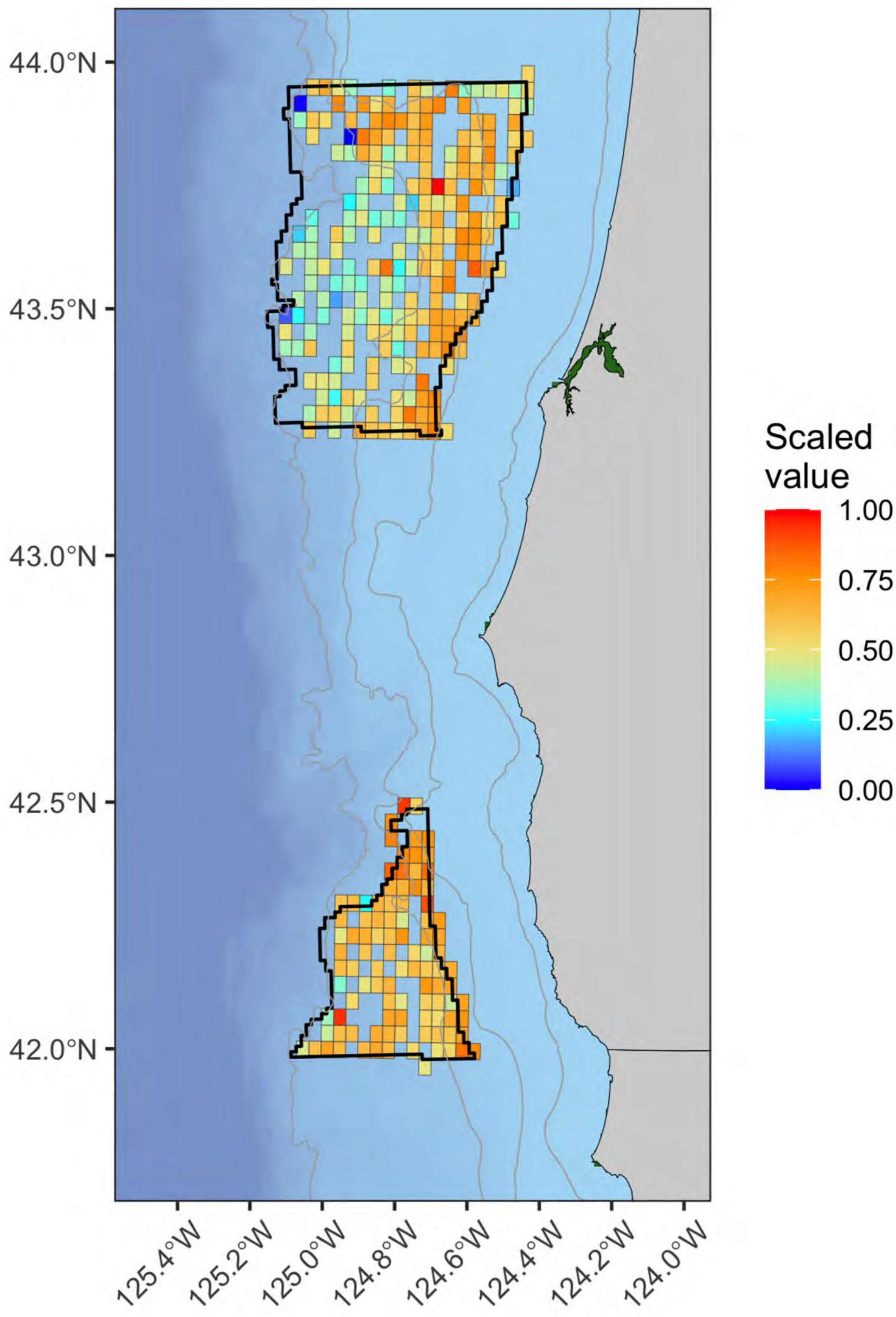

Figure 5,--Normalized **catch-per-unit-effort averages of 22 groundfish species** for individual bottom trawl survey cells, based on sampling during 2003-2019. [see Table 3 for a list of species]

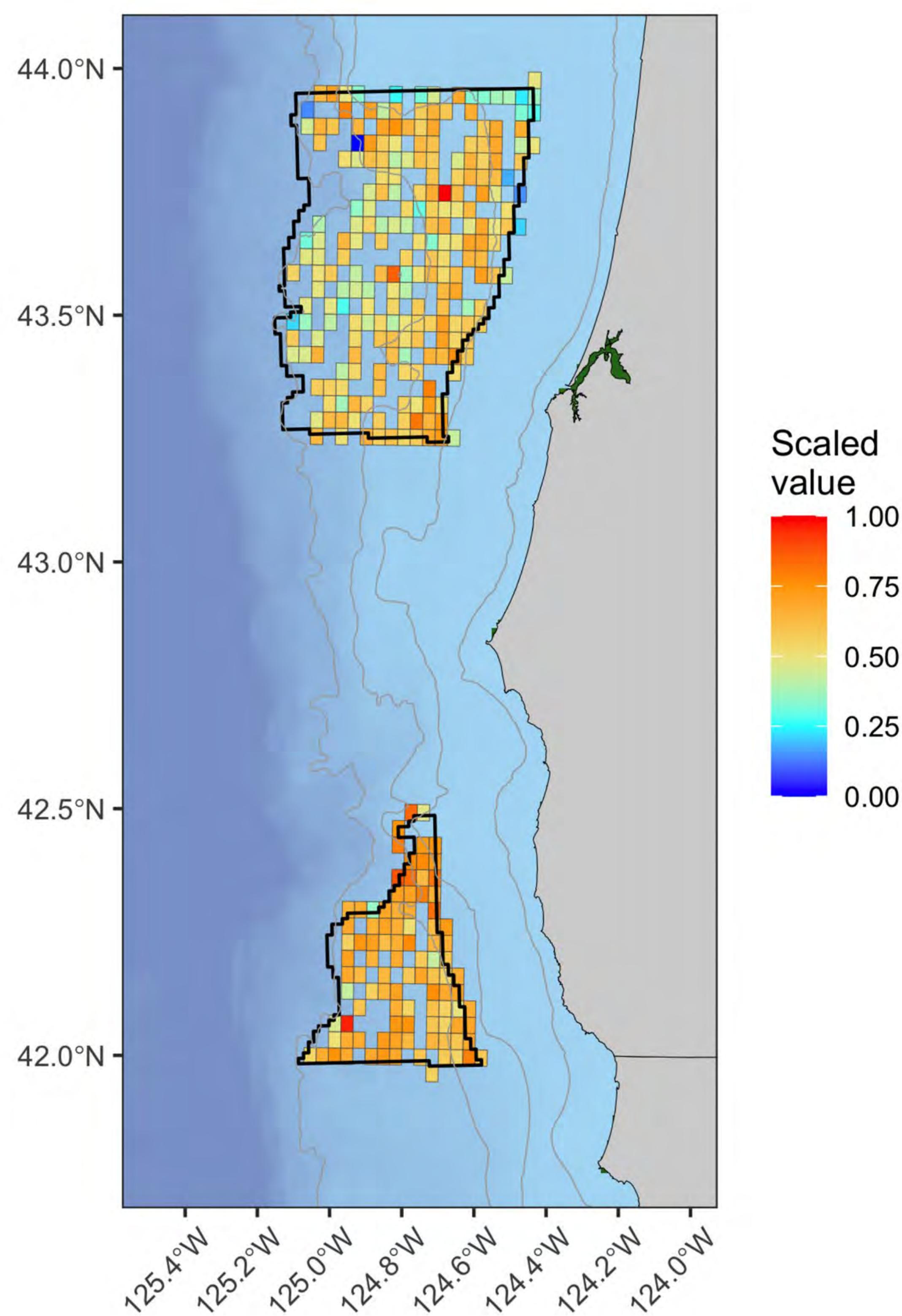

Figure 6,--Normalized **catch-per-unit-effort averages of 8 groundfish species** for individual bottom trawl survey cells, based on sampling during 2003-2019. [see Table 3 for a list of species]

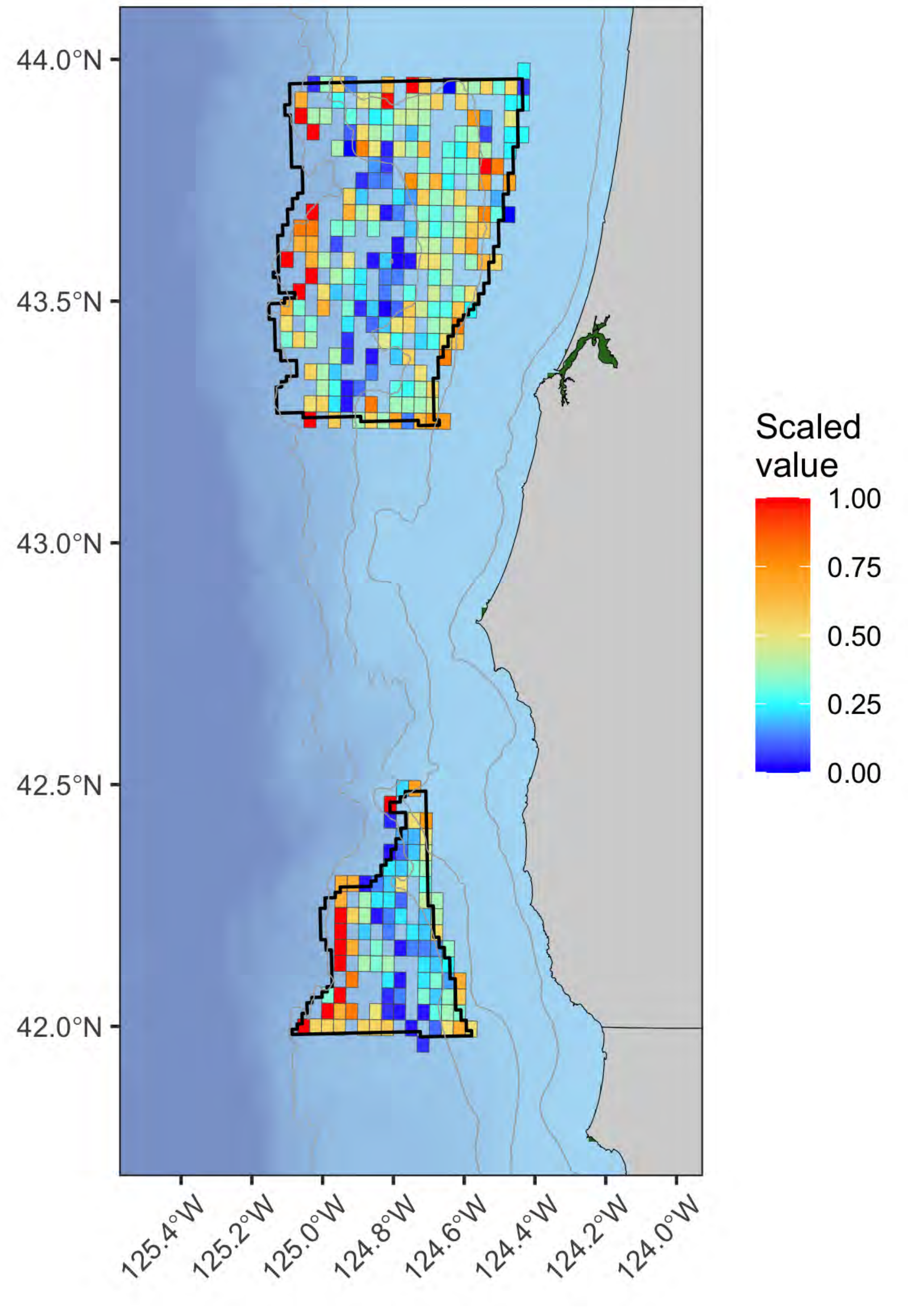

Figure 7,--Normalized measure of depth-zone-specific **species richness**, for individual bottom trawl survey cells, based on sampling during 2003-2019. Higher numbers indicate that a higher percentage of the possible species that might be found in an individual cell were found there. Normalization conducted separately within 30-100 fm, 100-300 fm, and 300-700 fm depth ranges.

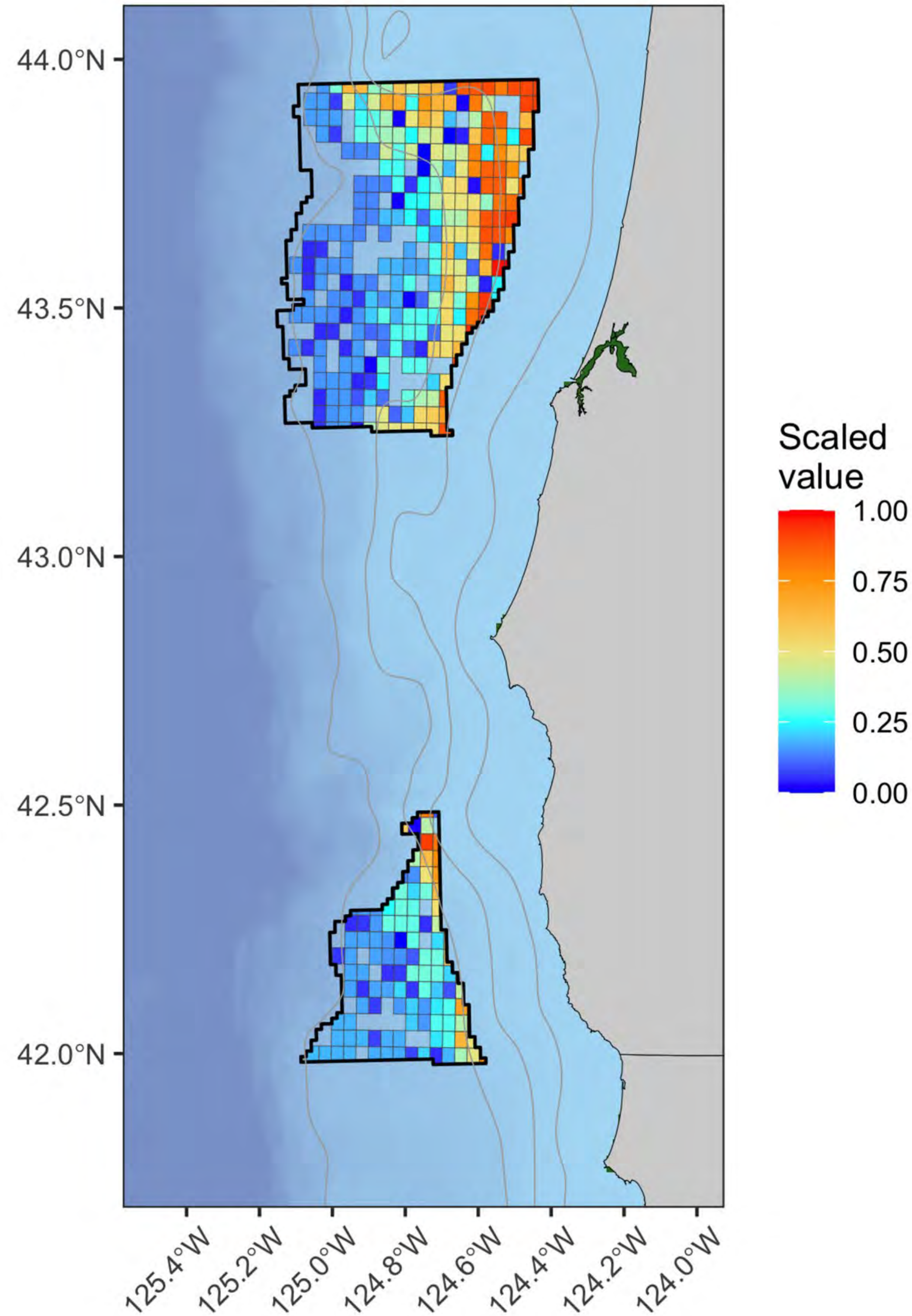

Figure 8,--Normalized measure of the presence of young fish from one of 13 species in individual bottom trawl survey cells, based on sampling during 2003-2019.

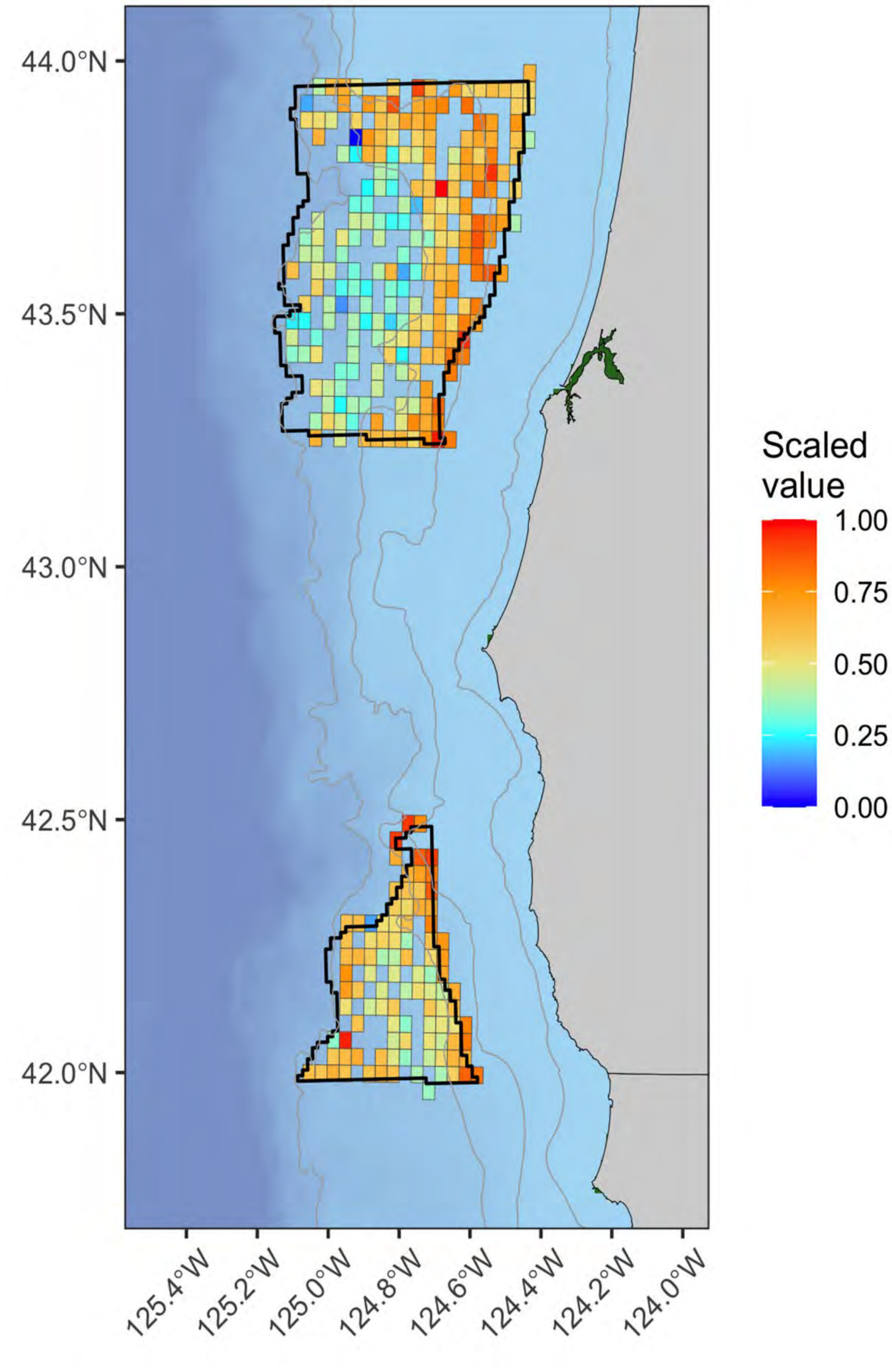

Figure 9,--Normalized aggregated scores of the value of individual survey cells, including all 5 factors portrayed in Figures 4-8, based on sampling during 2003-2019.

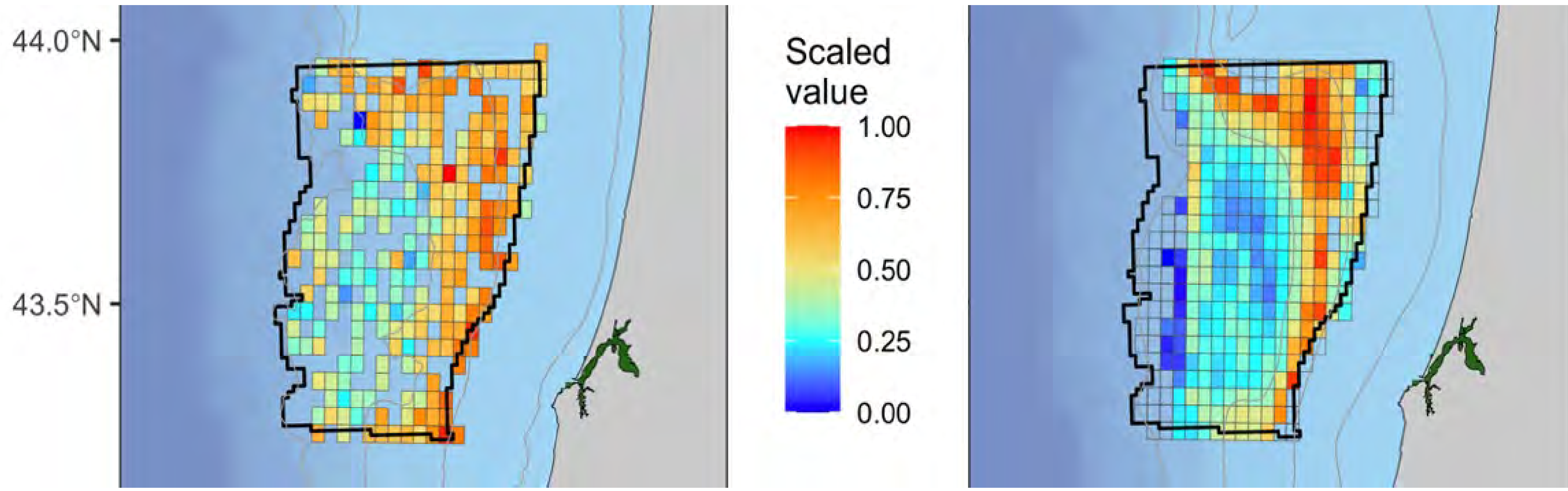

Figure 10,--Comparison of normalized aggregated cell-value scores, based on sampling during 2003-2019 (left, Fig. 9), and mean aggregated trawl logbook catch-per-unit-effort attributed to survey cell areas for the period 2011-19 (right), for the Coos Bay call area.

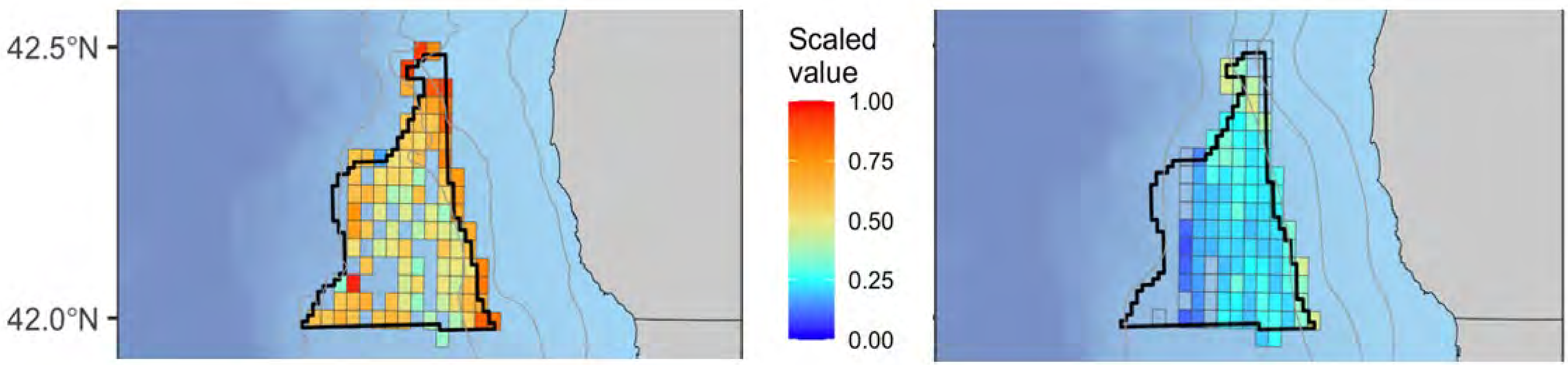

Figure 11,--Comparison of normalized aggregated cell-value scores, based on sampling during 2003-2019 (left, Fig. 9), and mean aggregated trawl logbook catch-per-unit-effort attributed to survey cell areas for the period 2011-19 (right), for the Brookings call area.