Interaction of trawl survey CPUE, proposed EFH and trawl RCA boundaries for groundfish species of interest

Sean E. Matson Ph.D.[1], Colby Brady[1], and Richard Morse[2]

[1]National Marine Fisheries Service,
Sustainable Fisheries Division, West Coast Region
7600 Sand Point Way
Seattle, WA 98115

[2]National Marine Fisheries Service
Sustainable Fisheries Division, West Coast Region
501 W. Ocean Blvd., Suite 4200
Long Beach, CA 90802

Summary

In order to contribute information to the Council process and support decision making regarding proposed Essential Fish Habitat (EFH) areas and potential future trawl Rockfish Conservation Area (RCA) configurations, we examined the intersection of these factors using fishery-independent catch per unit effort (CPUE) data from the Northwest Fishery Science Center (NWFSC) shelf-slope trawl survey, between 2003 and 2014. We produced Geographic Information Systems (GIS) maps for seven groundfish stocks, overlaying proposed EFH areas and status quo RCAs, with survey haul locations identified by their CPUE range. The results reveal geospatial species distribution trends which should be considered together with other sources, such as fishery-dependent data (e.g. council staff report under Agenda Item H.8.), as well as other data relevant to either additional exploited fish stocks or taxa important to the ecosystem. Many of the groundfish stocks considered here, some of which are currently rebuilding, show their highest CPUE within and closely neighboring currently closed areas of the RCA, most notably darkblotched rockfish (northern area), bocaccio rockfish (southern area) and longnose skate (coastwide). Although Individual Fishing Quotas (IFQ) provide strong incentives for minimizing catch of most of these stocks through individual accountability (except longnose skate), it is worth considering the degree of risk to the entire fleet by opening areas with highest CPUE and abundance. Many of the proposed EFH areas generally show low survey CPUE of these species.

Methods

We used trawl survey data from the NWFSC shelf-slope survey from 2003 through 2014 to show fishery-independent bottom trawl CPUE both inside and outside the status quo RCA for selected species of interest. Histograms and distribution summary statistics are shown in Figure 1 and Table 1 respectively. The GIS maps are shown in Figures 2-15. Fishery-independent survey data represent one important source of information relevant to this agenda item. Advantages of survey data include that they are available for both inside and outside of areas closed to fishing, and are free of several complications of fishery-dependent data such as variation in CPUE according to gear type, target strategy, haul duration

and highly clustered locations of hauls in desirable fishing areas. Freedom from these confounders enables survey data to provide direct insight into geospatial distributional and abundance trends. However, some of these advantages are also limitations; only one gear type (bottom trawl) is used, samples sizes are smaller, and haul duration is much shorter than in actual commercial fishing operations, potentially resulting in less resolution than fishery data. Survey sampling coverage is generally wide but not dense. Cell plot maps in Figures 16 and 17 show the number of survey haul samples taken per 5km grid square coastwide, over the years included (2003-2014); they range between one and nine samples per grid square. By pooling data for the maps, maximum coverage is achieved; however these data should be used to judge general trends rather than fine-scale, discrete locational inferences. These data do not provide a picture of temporal variation in CPUE for each location.

We show data from darkblotched rockfish, yelloweye rockfish, canary rockfish, Pacific ocean perch rockfish, petrale sole, longnose skate, and bocaccio rockfish; they were chosen either because of their current status as rebuilding species, or due to life history traits that make them potentially vulnerable and of conservation interest, as well as suitability of the available data. Species vary in their susceptibility to trawl sampling. We omitted rougheye and blackspotted rockfish from this single-source analysis (grouped together in survey data because of difficulty in separating them from one another in identification), as well as shortraker rockfish because of concerns by the survey team that they are caught infrequently and in clusters. Consequently, their trawl survey sample distributions may not be representative of the underlying actual distributions for these particular stocks. Cowcod rockfish was also not presented here for similar reasons. However, this does not mean they should be absent from any consideration for this agenda item, as clustering within the survey data could also suggest susceptibility to extreme catch events, and warrants further analysis. See the 2014 trawl RCA Environmental Assessment (EA) for additional information, where these species were considered using multiple data sources, with caveats (http://www.westcoast.fisheries.noaa.gov/publications/nepa/groundfish/misc_ea/rca_ea_3_4_14.pdf), pages 104-143. We omitted spiny dogfish from the current analysis as well, due to similar concerns stemming mainly from extreme catch events in two particular years (also considered with caveats and multiple data sources in the 2014 trawl RCA EA). Variation in CPUE was examined by vessel, and varied none to extremely little by this factor, and this factor was often confounded by year; thus CPUE estimates were not adjusted. This is supported by the continued use of unadjusted CPUE estimates in calculation of design-based abundance indices in many groundfish stock assessments.

Survey CPUE was expressed as kilograms per hectare and plotted using a geometric interval classification in ArcGIS Version 10.2 software. This classification (binning) method for visualizing continuous data provides an alternative to the Jenks method, quantiles, or variance minimizing (within classes) methods. It is well suited for non-normal and skewed distributions, with many zero observations (characteristics of these survey data). Geometric coefficients generated by the fitting algorithm for these data are shown in Appendix A.3. This method locates natural breaks within for each species, according to their particular distributions.

We also generated histograms, summary statistics, and summarized distributions by specifying the same percentiles across all species in Figure 1 and Table 1 respectively, so that readers could compare percentiles across species if desired. Percentiles in Appendix A.1. and A.2. exclude, and include zero-catch hauls, respectively. We calculated median CPUE as a measure of central tendency rather than the mean, since distributions are highly skewed. We show Interquartile Range as a measure of variance and

dispersion, and express it in units of the median as Coefficient of Dispersion (COD), for the same reasons. Data distributions and most summary statistics were analyzed in JMP Version 12 software, and Gini coefficients were calculated in R. The Gini coefficient is an index of inequality of distribution, which ranges from 0 being a uniform distribution, and 1 being the most unequal distribution (e.g. one category with high values and the remaining categories with zero). It was developed for use in economics but is widely applied in other disciplines as well, including biology, to describe and compare evenness (or inequality) of continuous distributions such as among trait values in genetics and as a measure of diversity in ecology.

Results and discussion

The map plots of survey CPUE, overlain on RCA and proposed EFH areas are presented in Figures 2-15. The species considered show markedly different geospatial distributions, although most share some common attributes. All are highly skewed with highest frequency of catch toward zero, especially rockfish species. Although longnose skate is a species of interest in conservation-oriented groundfish analyses due to its life history characteristics of low fecundity, long gestation time and low productivity, it is widespread throughout the survey area, throughout the shoreward to seaward sides of the current RCA; it serves here as something of a spatial positive control. Petrale sole is also widespread throughout the survey area, predominantly toward the shoreward side of the RCA, through the dates in which the survey is conducted, from May to October each year. This is notable, since petrale undertakes seasonal migrations to and from spawning and feeding grounds, and a deeper average distribution is expected during the winter months.

Of the species examined, longnose skate showed by far the highest proportion of positive hauls (59 percent), the most even distribution (among positive hauls, Gini=0.74), and the lowest variance among them (COD=185 percent, Table 1). By comparison, petrale sole appeared in a lower proportion of hauls (43%), has a somewhat higher variance among positive hauls (COD=200%), and is more unequally (less evenly) distributed (Gini=0.86). Darkblotched rockfish appears in much fewer hauls (18%), has the second highest variance in positive haul CPUE among those considered here (COD=386%), and is markedly more unequally distributed (Gini=0.98). The remaining rockfish species cluster together in terms of their proportion of positive hauls (2-7 percent) and unevenness of distribution (Gini=0.99). However, POP has the highest variance in positive haul CPUE (445 percent), roughly twice as high as the remaining rockfish species (bocaccio, canary, and yelloweye rockfish).

Species differ in their geospatial abundance trends in relation to the status quo RCA. Many of the groundfish stocks considered here, some of which are currently rebuilding, show their highest CPUE within and neighboring currently closed areas of the RCA, most notably darkblotched rockfish (Figure 6, northern area), bocaccio rockfish (Figure 3, southern area) and longnose skate (Figures 8 and 9). For example, darkblotched rockfish shows a pronounced trend of higher CPUE within and along the RCA, most notably off the Oregon Coast from 45°46', to 42°50' N. latitude, and less so from 36° to 39° N. latitude. Bocaccio rockfish shows a large proportion of its positive hauls within closed southern areas of the current RCA (Figure 3). Canary rockfish, which appears in much fewer hauls, shows a pronounced appearance within and close to the No Action RCA off the Washington coast, and in the area north of 48/10, where many of the highest outlier hauls appear. Canary shows a pronounced but less concentrated distribution in the area shoreward of the RCA along Washington and Oregon (Figure 4),

less so in Northern California, and almost not at all off Southern California. Although longnose skate is widely distributed, it shows a pattern of many hauls with the highest concentrations coming from within currently closed RCA zones, especially along Oregon and Northern California, as well as the area north of 48°10'. Pacific Ocean perch is much more sparsely distributed, but a large proportion of the positive hauls for this stock lie within the RCA off Oregon, Washington, and in the area north of 48°10'. Petrale sole is widely distributed, and during the survey months, this stock appears predominantly shoreward of, as well as within many areas the RCA.

Many proposed EFH areas lie predominantly outside the survey coverage area, and for those that lie inside it, most species appear little in hauls within those areas (compared with the RCA), except the areas proposed by Greenpeace, NRDC, Oceana, and Ocean Conservancy, which are quite expansive. Longnose skate and petrale sole appear within many of the areas, as they are comparatively quite widely distributed along the coast. A notable exception is the proposed bottom trawl closure area that is within the currently closed area north of 48°10'. This area has shown moderate to high survey CPUE of longnose skate, petrale sole and canary rockfish, moderate CPUE of darkblotched rockfish, as well as some bocaccio rockfish.

Figure 1. Histograms of survey CPUE percentiles for each species; zero-catch hauls excluded for enhanced visibility of skewed distributions. See Appendix A.1. and A.2. for complete percentiles, with and without zero hauls.

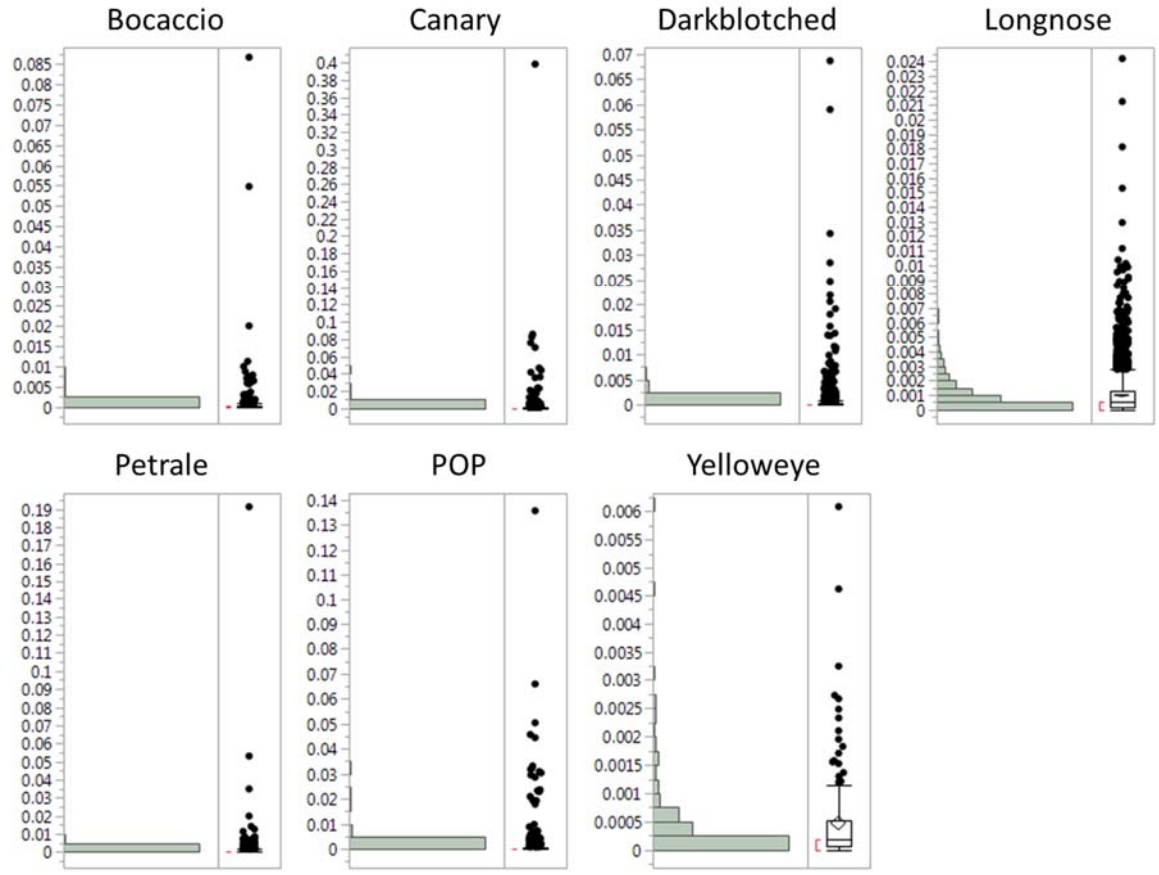

Table 1. Distributional summary statistics of survey CPUE by species (zero hauls excluded). Median CPUE values when including zero hauls were zero for all species except longnose skate (0.0001207kg/ha). See text for description of statistics, and Appendix A.1. and A.2. for complete percentiles, with and without zero hauls.

	Bocaccio	Canary	Darkblotched	Longnose	Petrale	POP	Yelloweye
Median	0.000125	0.0001626	7.129E-05	0.0005617	0.0003081	6.628E-05	0.0001881
IQR	0.0003015	0.0004354	0.0002755	0.0010401	0.0006176	0.000295	0.0004433
IQR/median	241%	268%	386%	185%	200%	445%	236%
Gini	0.9905052	0.9933182	0.97625	0.746173	0.8559165	0.9937522	0.9923784
N pos. hauls	479	555	1338	4518	3234	547	168
Total N	7608	7608	7608	7608	7608	7608	7608
% pos hauls	6%	7%	18%	59%	43%	7%	2%

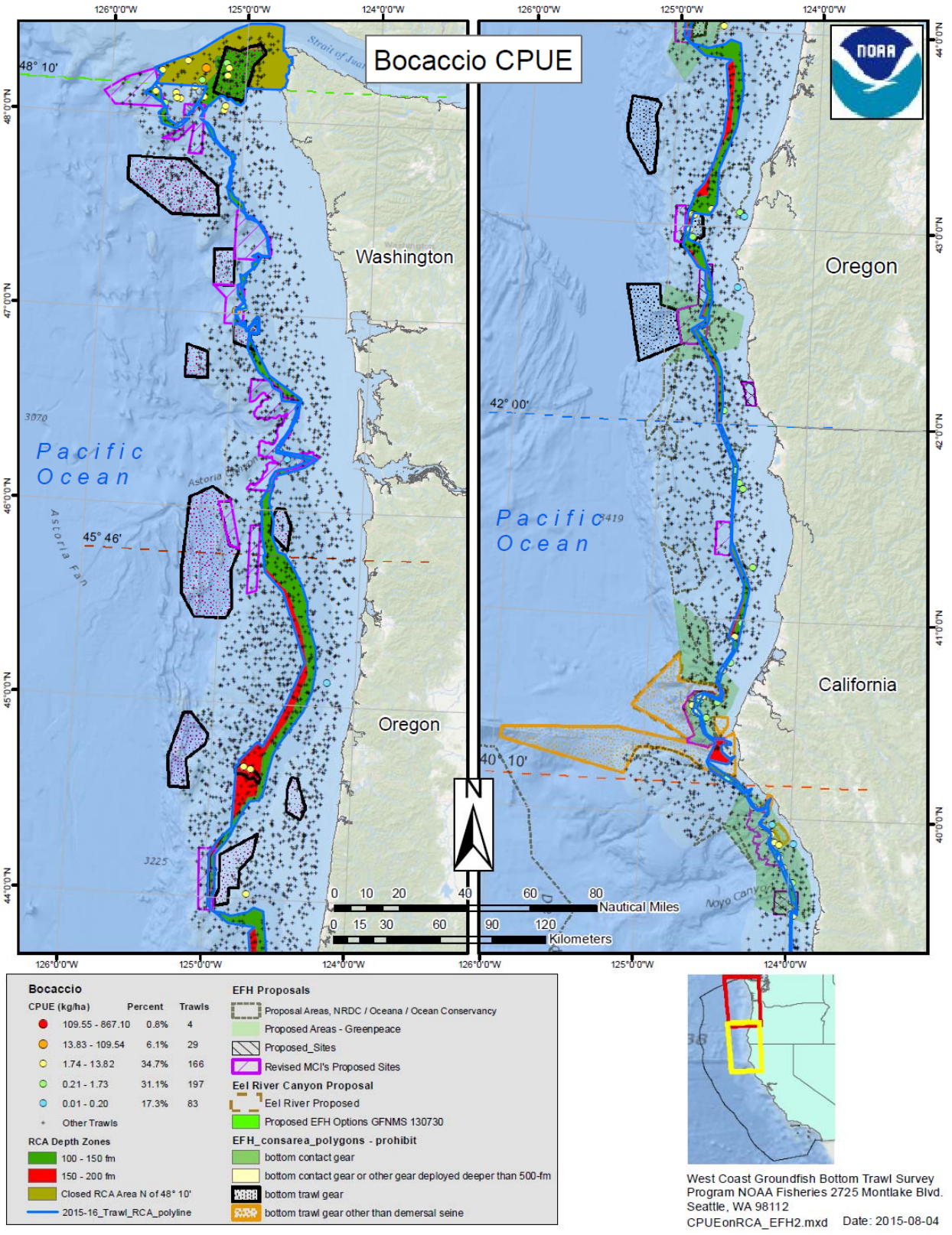

Figure 2. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for bocaccio rockfish in the northern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

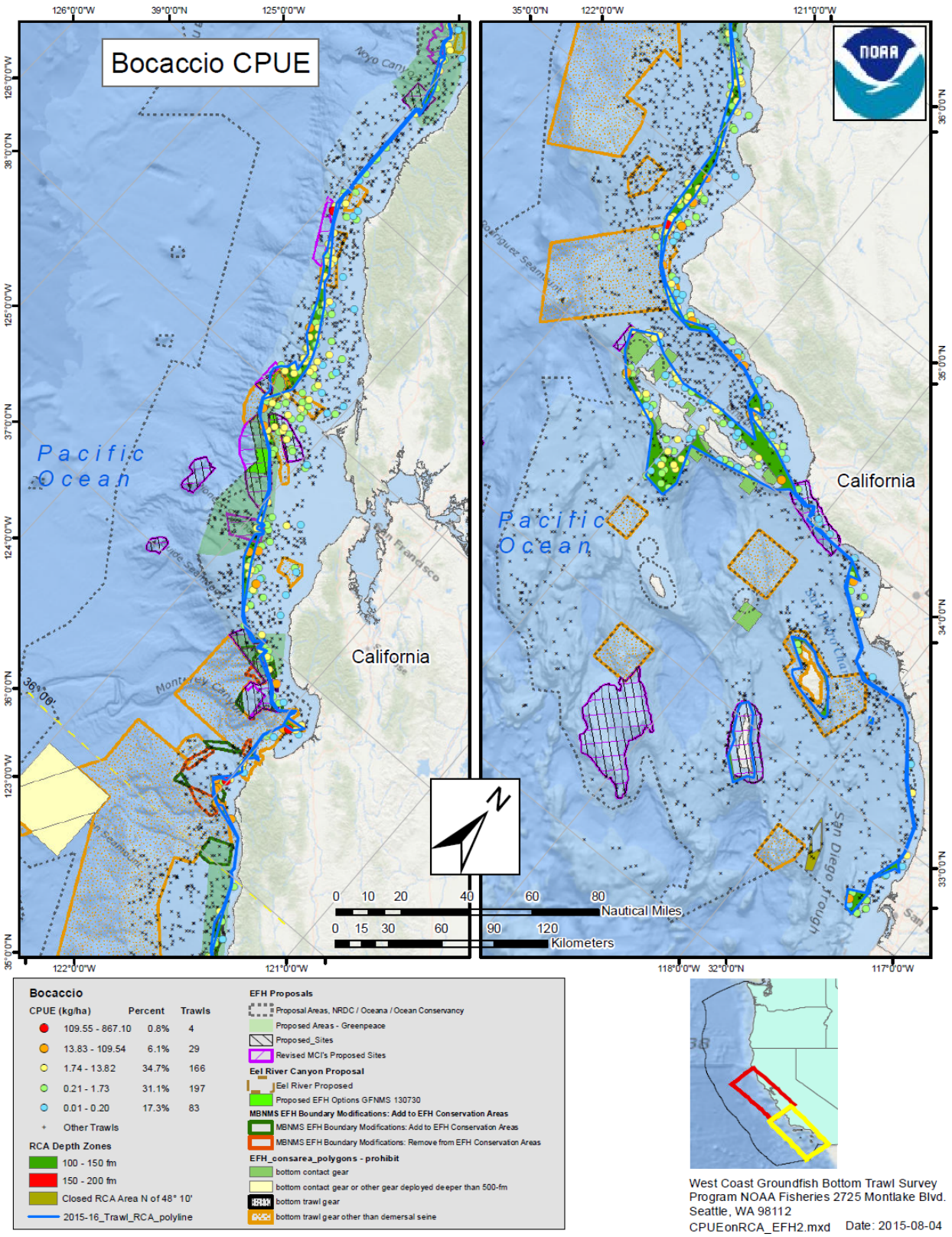

Figure 3. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for bocaccio rockfish in the southern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

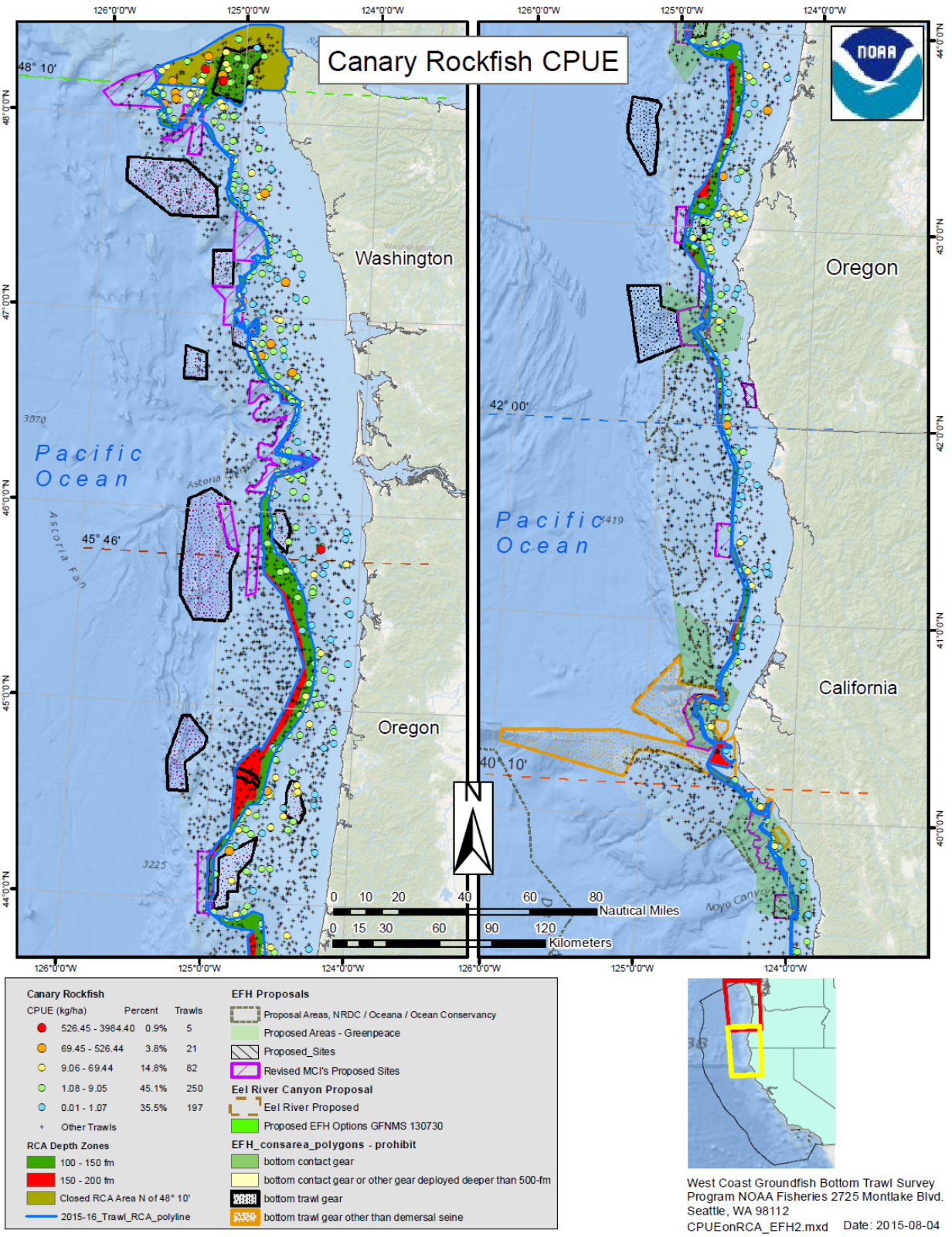

Figure 4. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for canary rockfish in the northern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

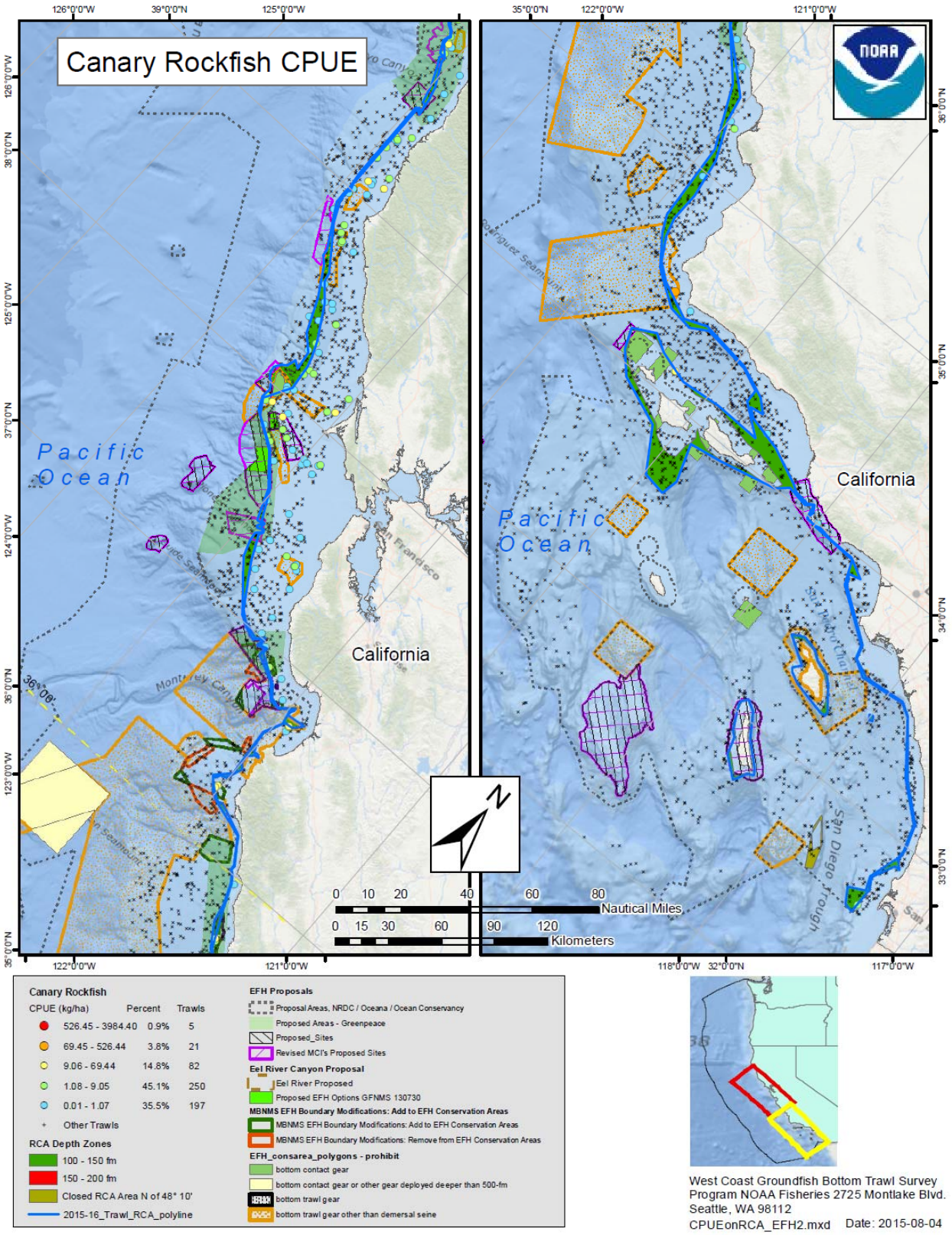

Figure 5. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for canary rockfish in the southern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

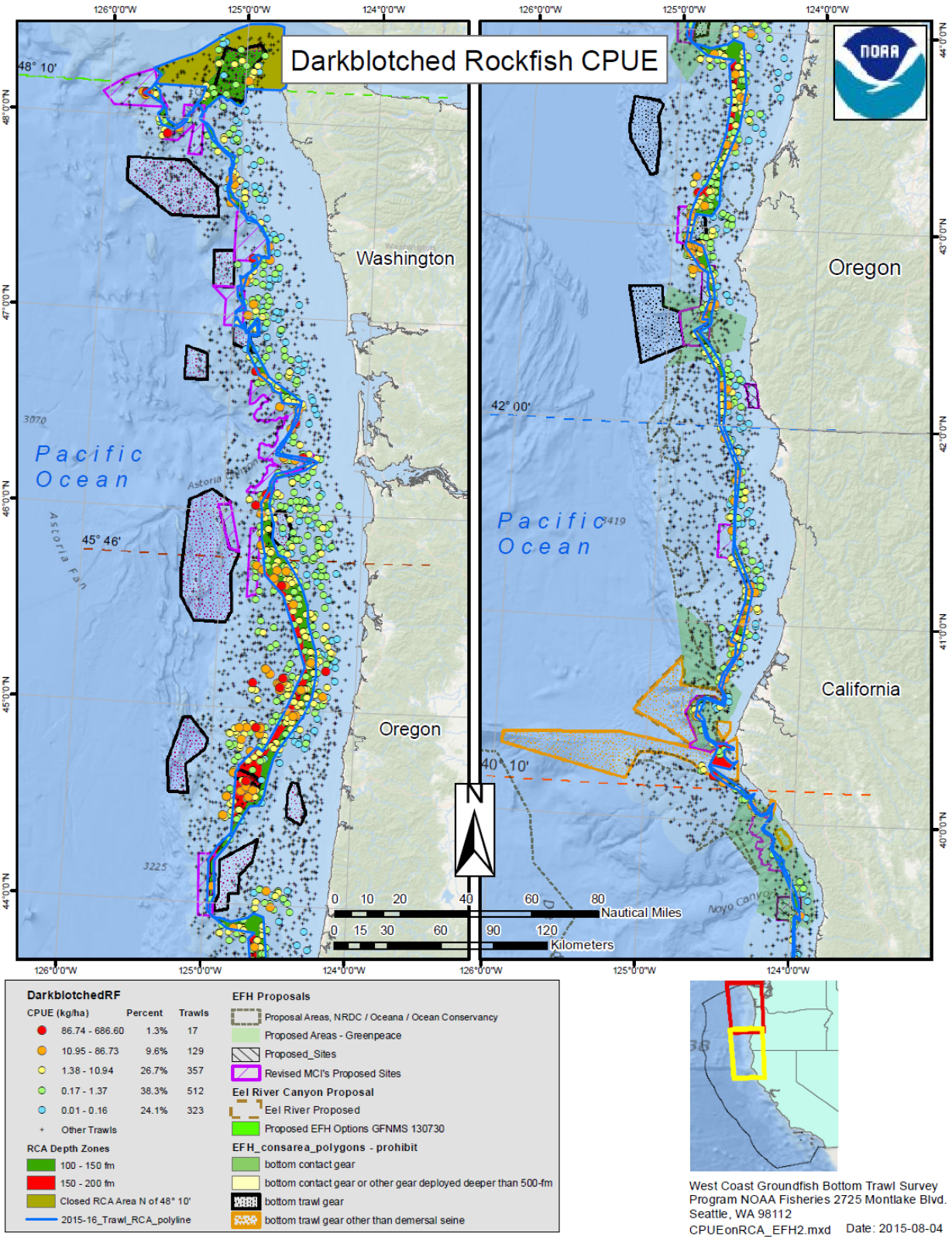

Figure 6. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for darkblotched rockfish in the northern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

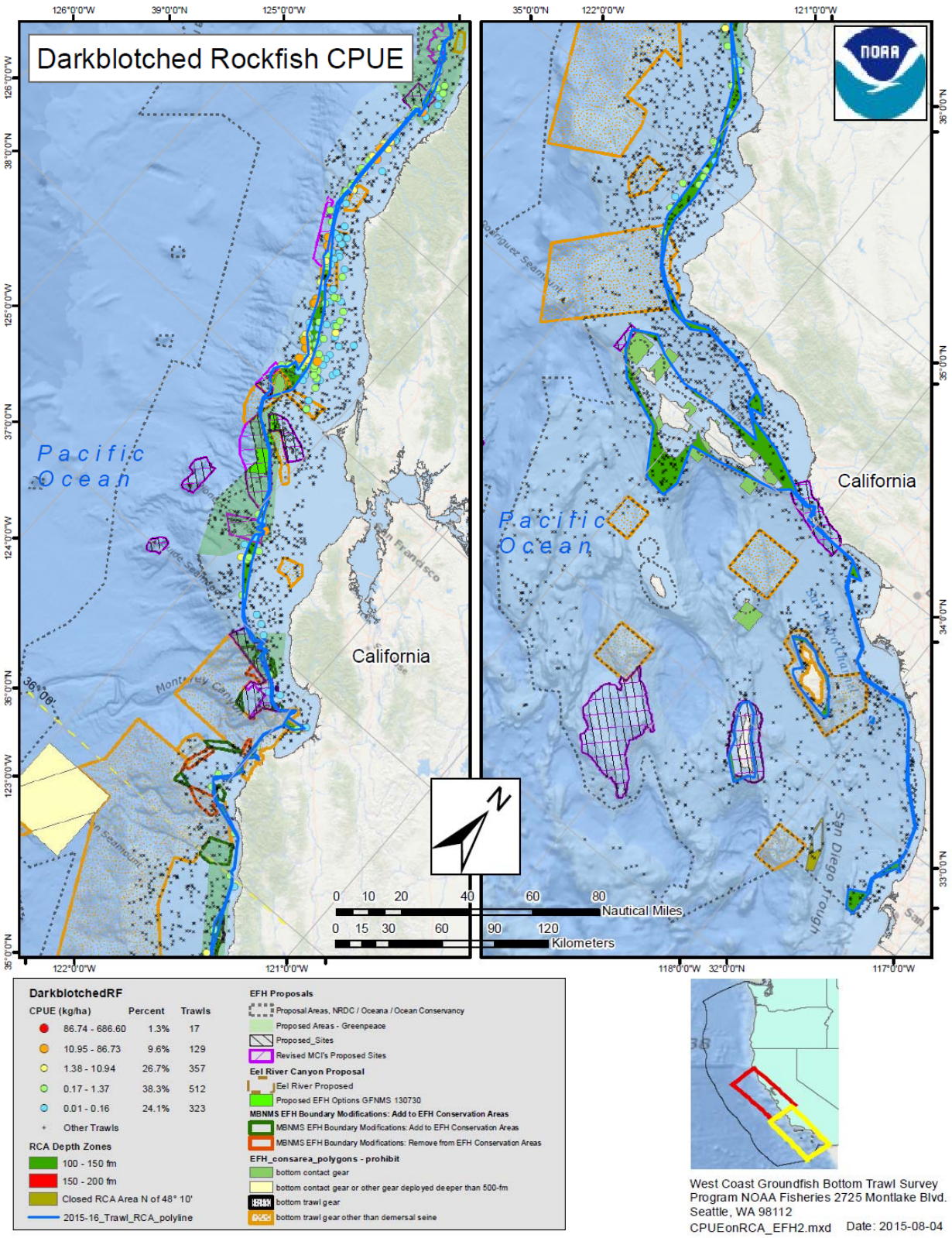

Figure 7. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for darkblotched rockfish in the southern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

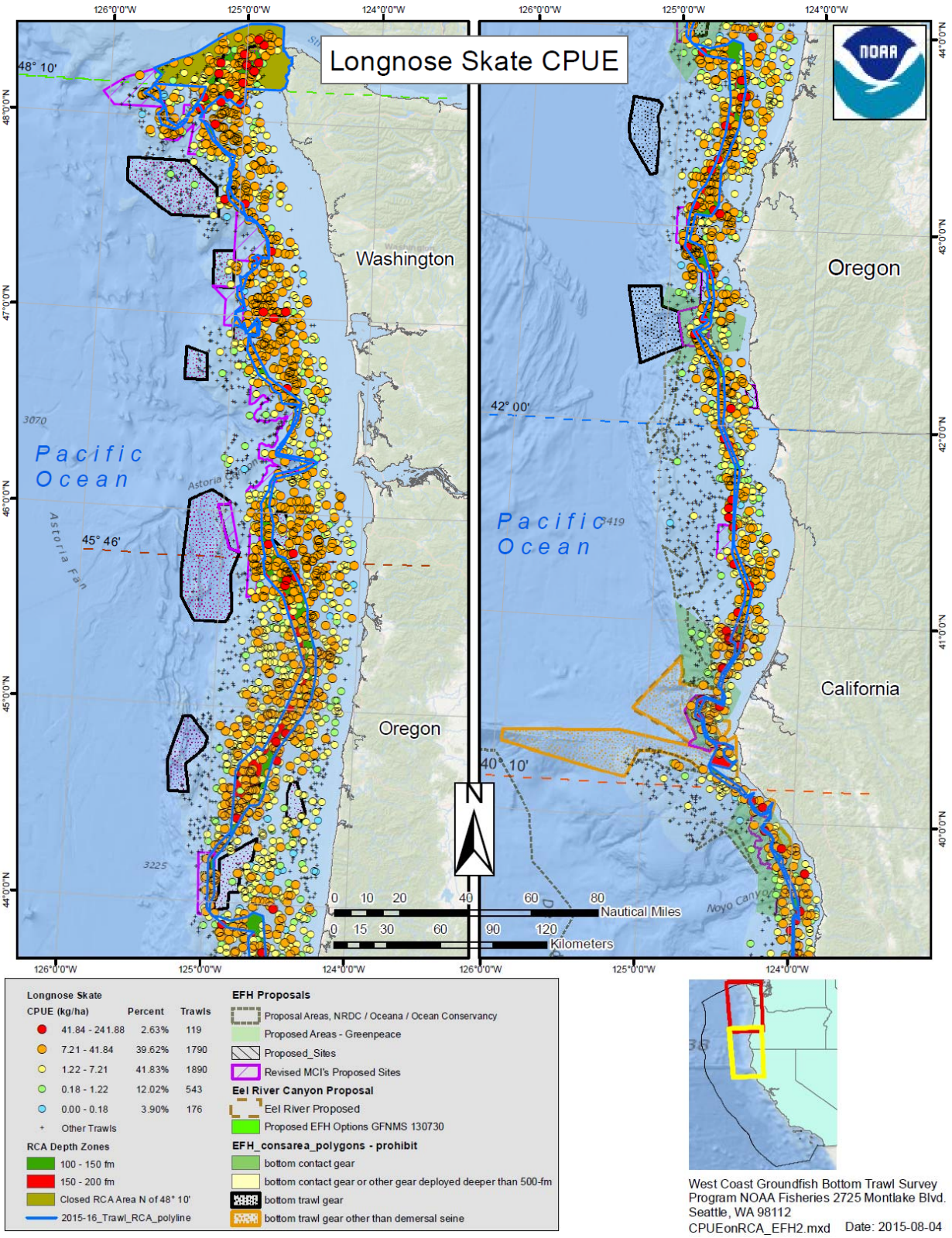

Figure 8. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for longnose skate in the northern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

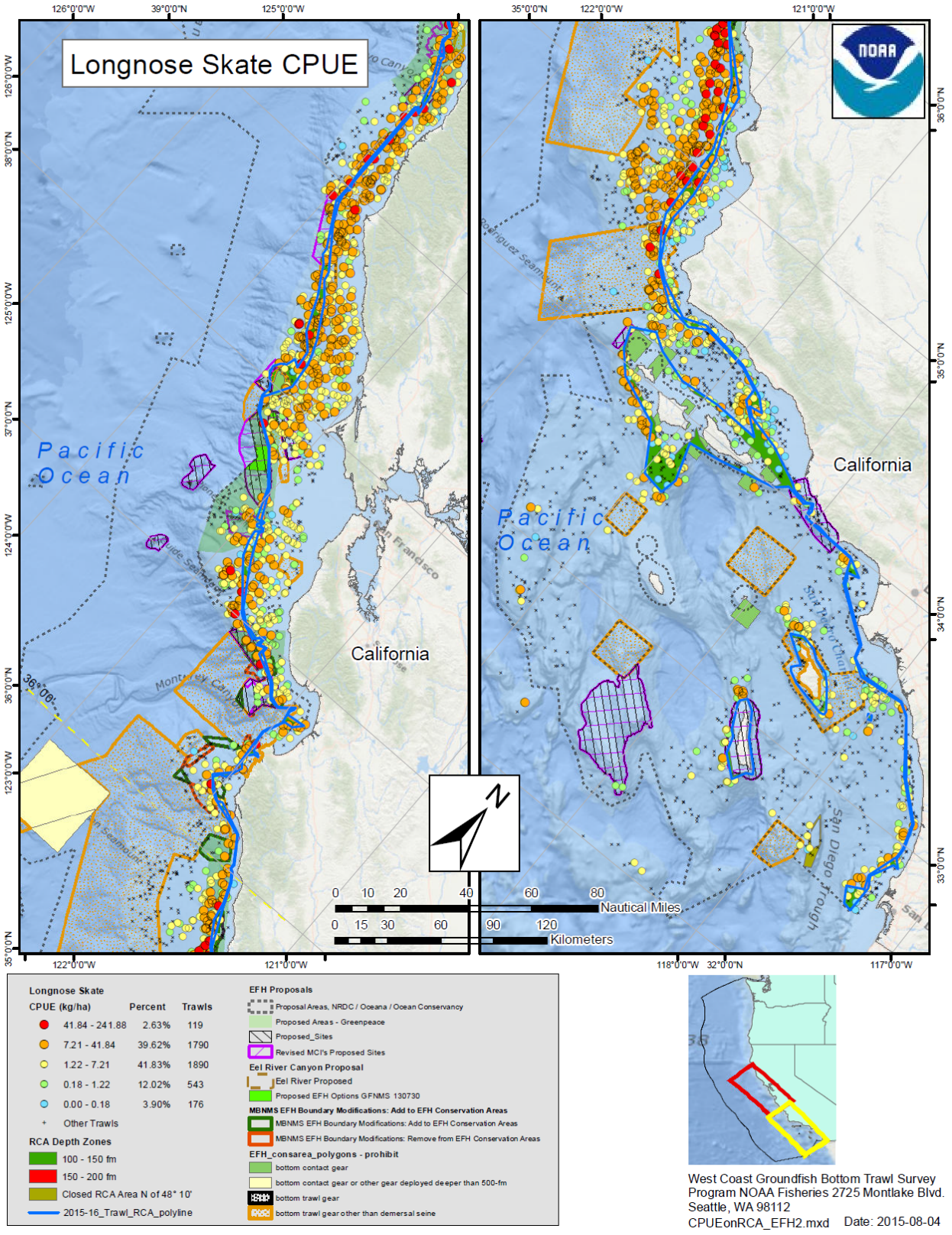

Figure 9. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for longnose skate in the southern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

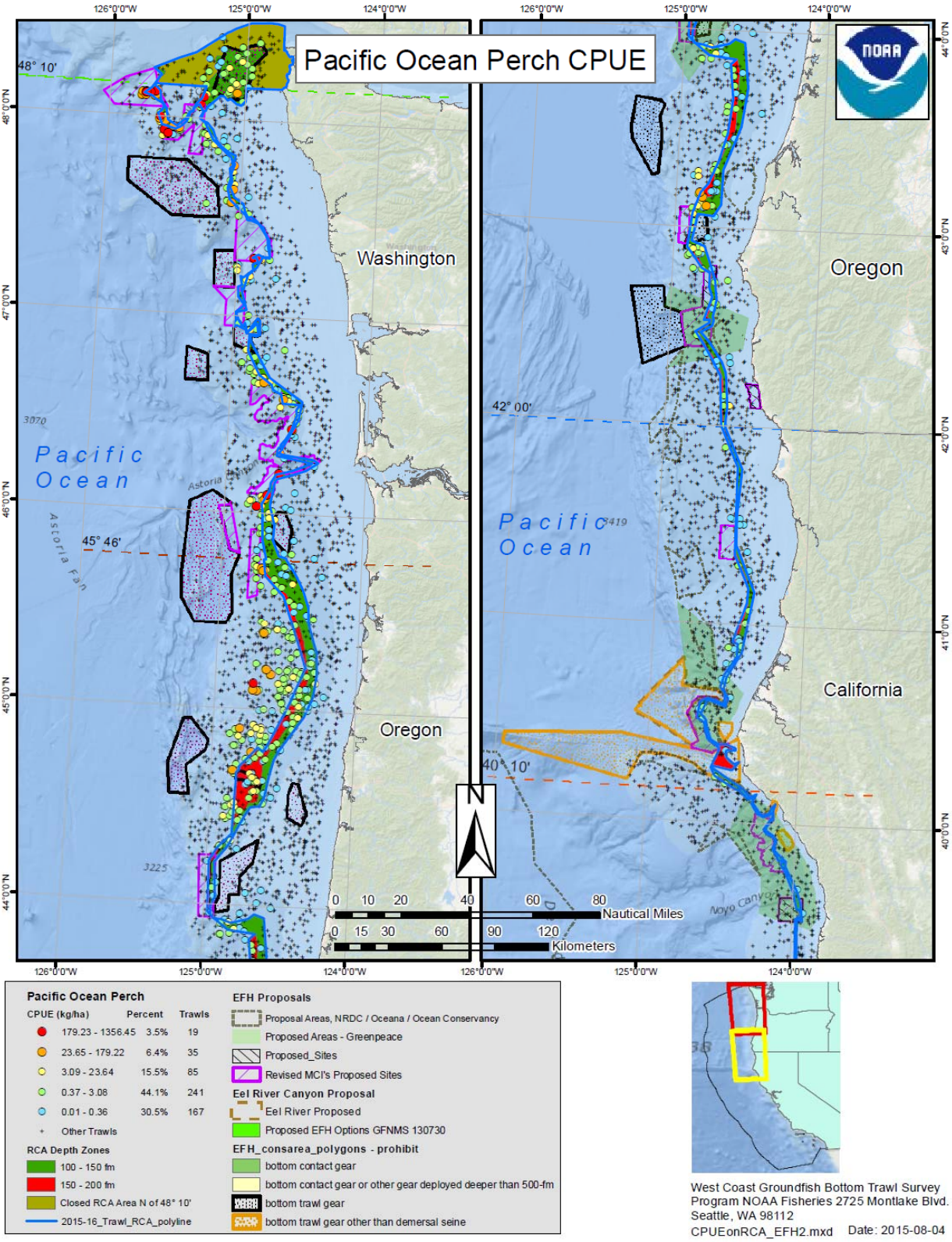

Figure 10. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for Pacific ocean perch in the northern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

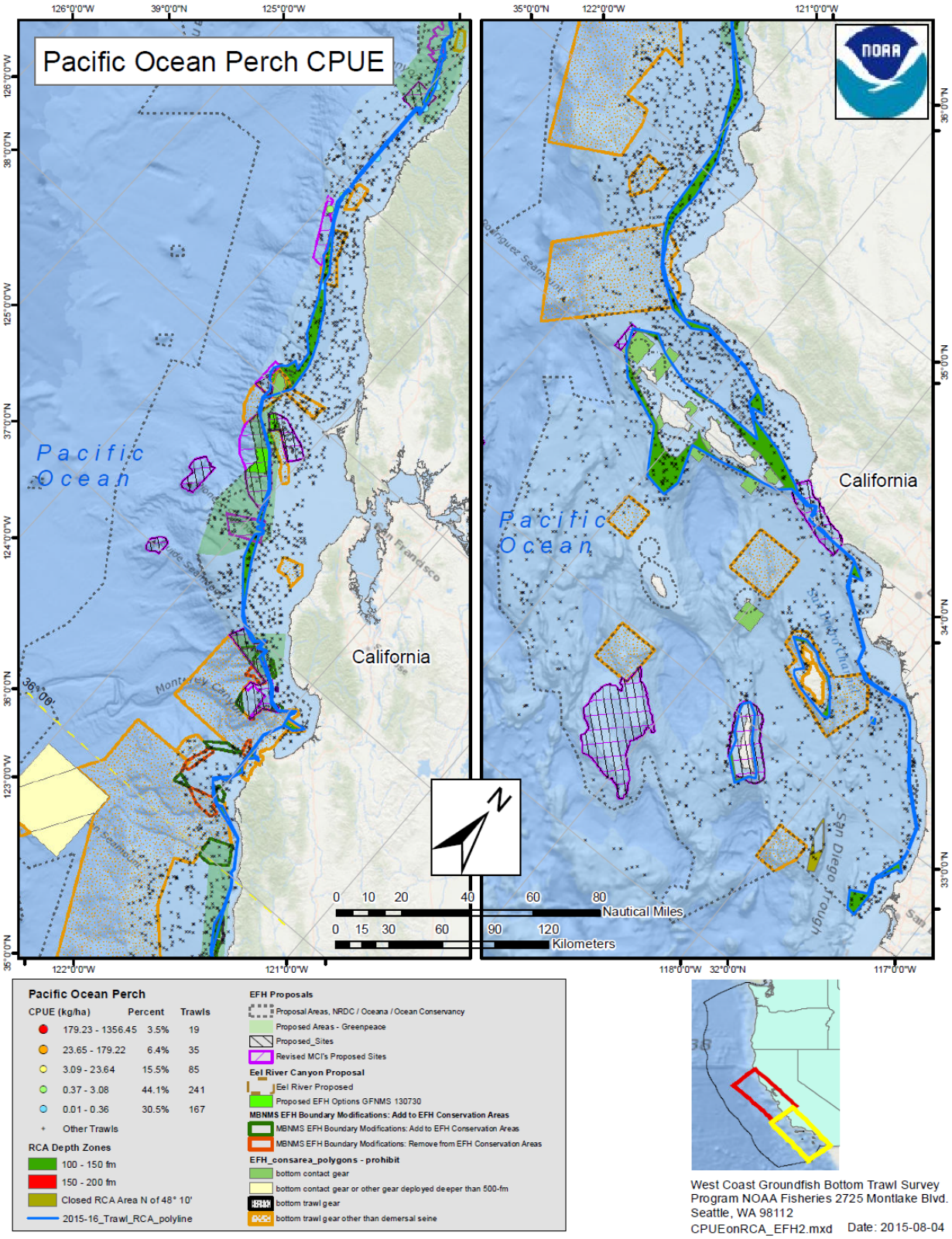

Figure 11. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for Pacific ocean perch in the southern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

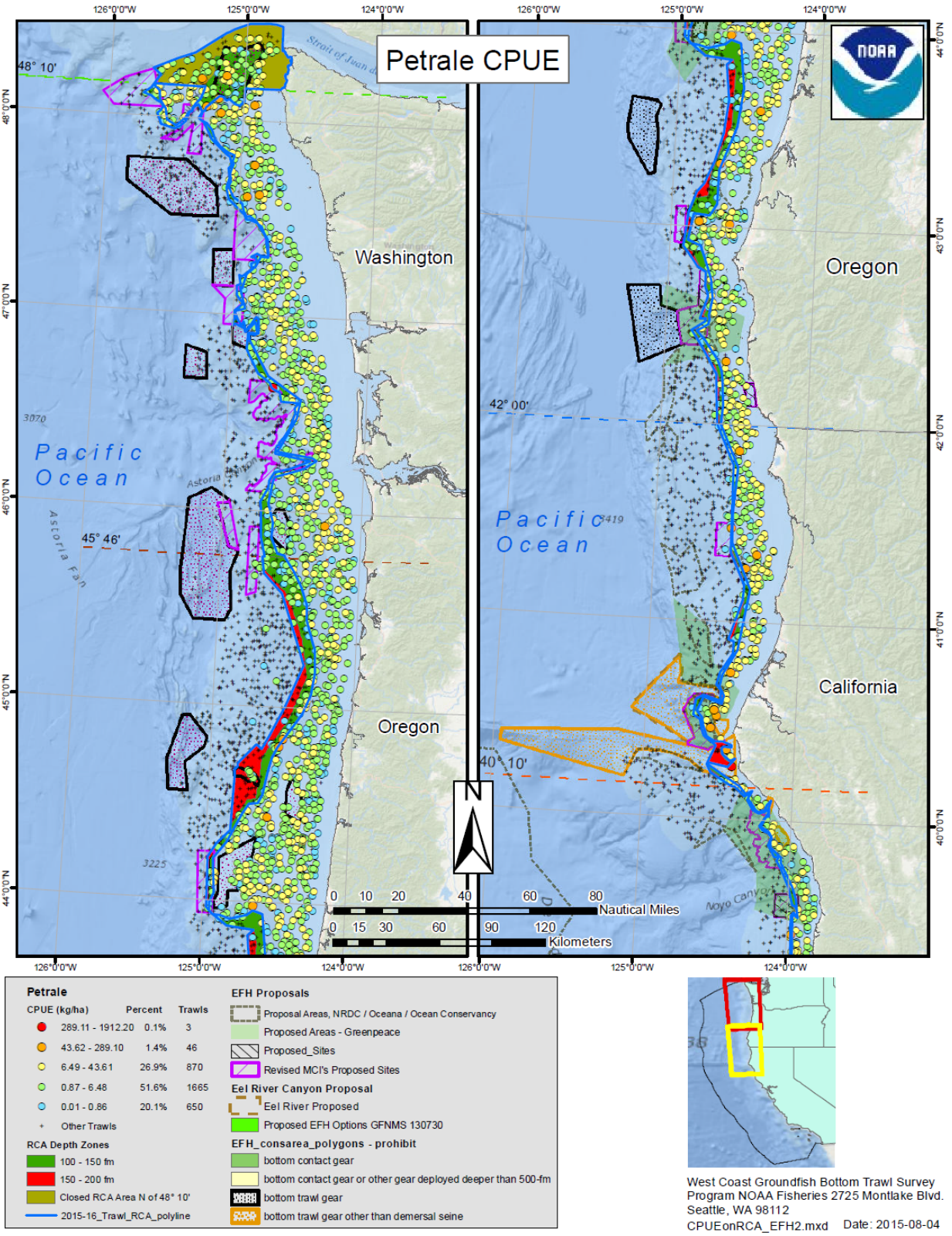

Figure 12. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for petrale sole in the northern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

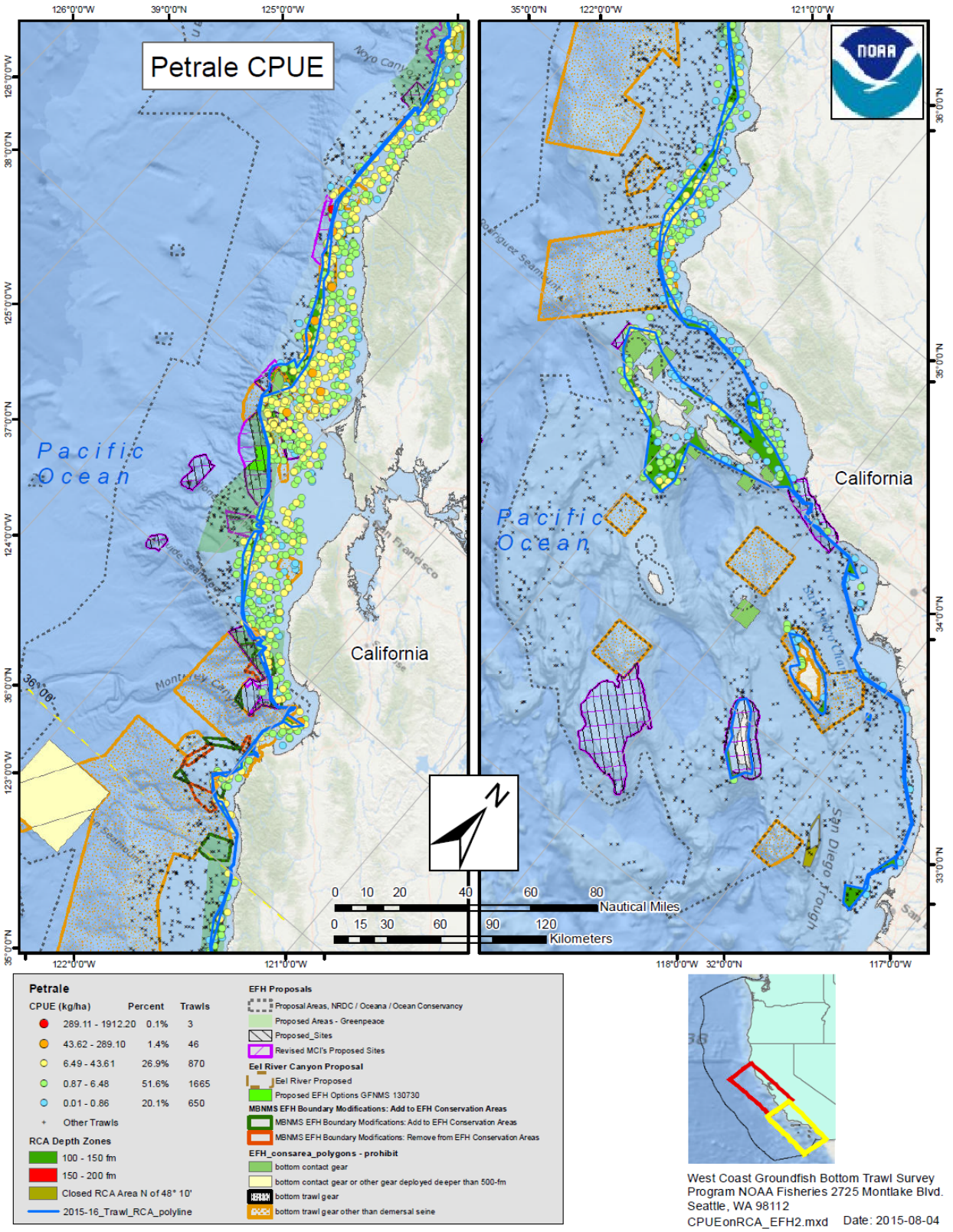

Figure 13. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for petrale sole in the southern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

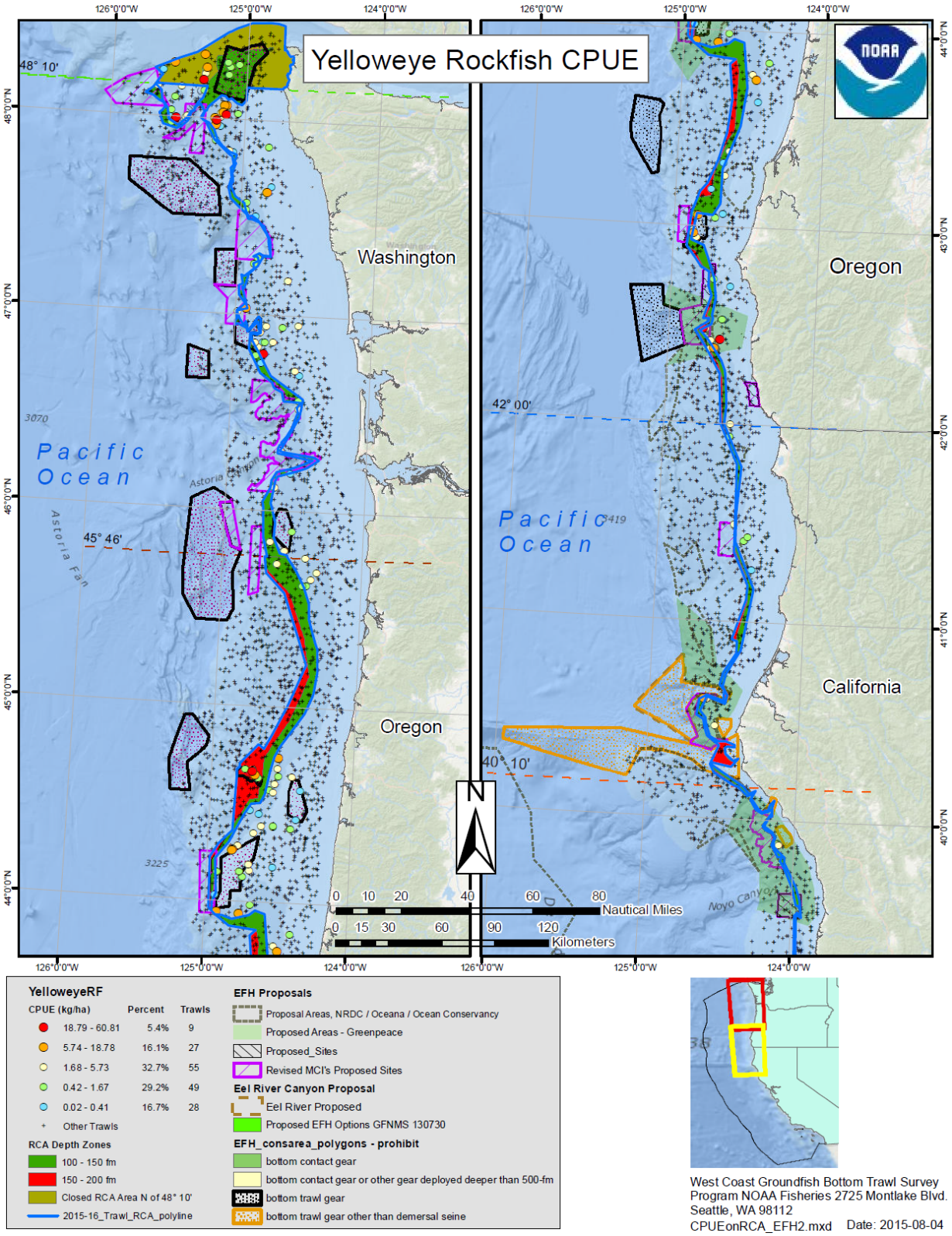

Figure 14. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for yelloweye rockfish in the northern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

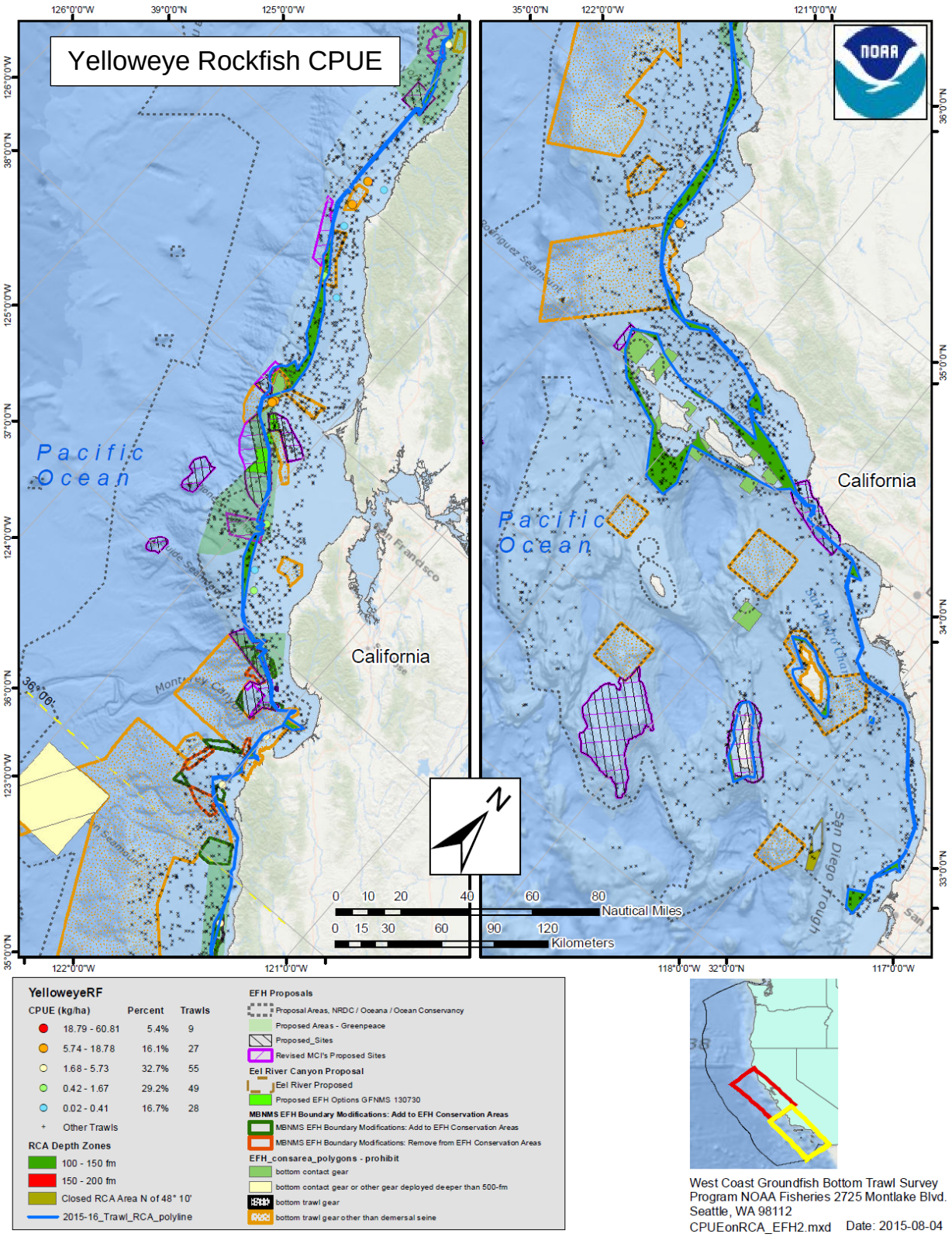

Figure 15. Survey CPUE from the NWFSC shelf-slope bottom trawl survey, for yelloweye rockfish in the southern area, from 2003-2014, proposed EFH areas, and status quo RCA. Key shows percent and number of hauls per CPUE bin, with zero hauls excluded. For complete percentiles and summary statistics with zero-catch hauls included and excluded, see Appendix A.

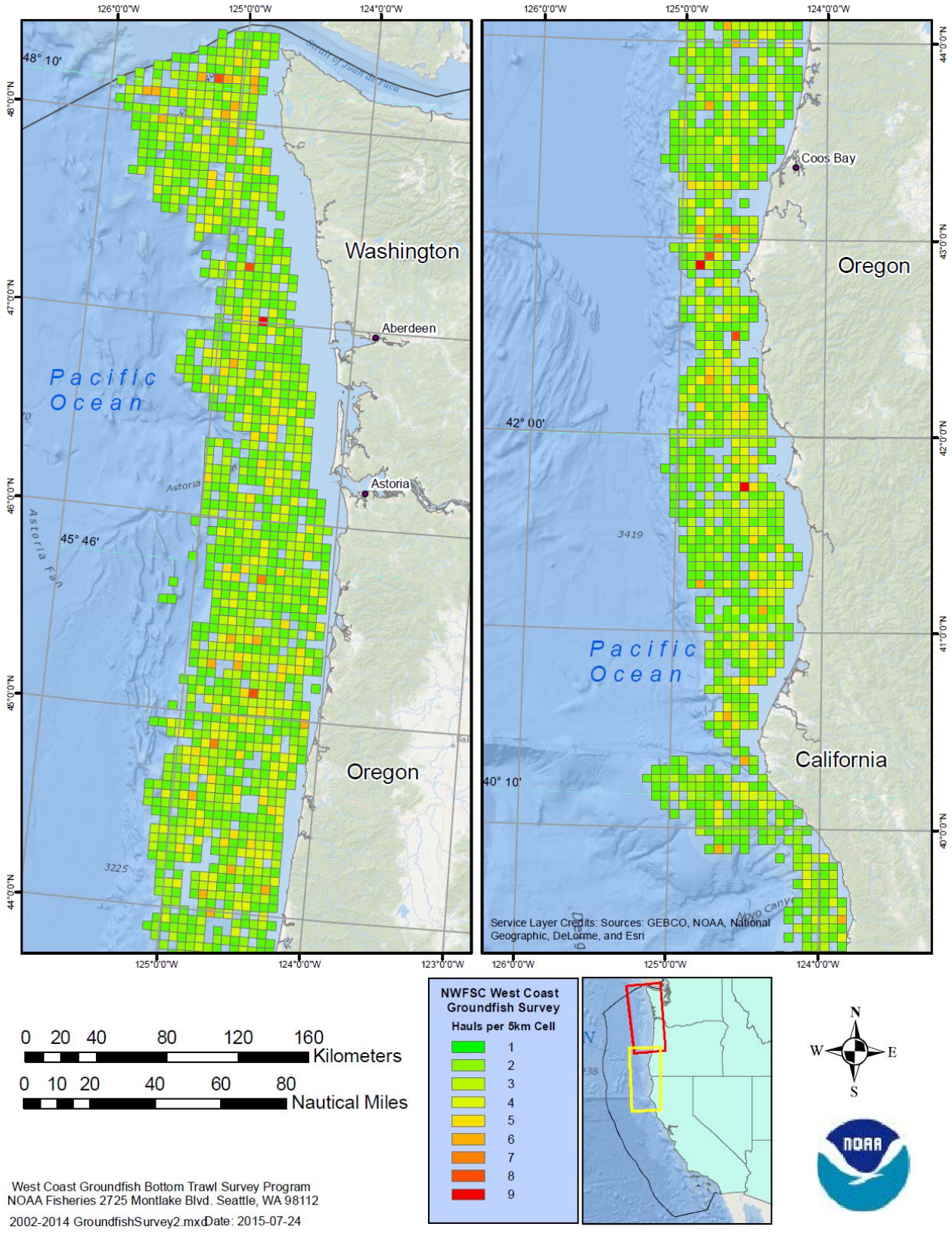

Figure 16. Cell plot showing spatial distribution of NWFSC shelf-slope trawl survey haul density by 5km grid squares for the northern area, including years 2003-2014.

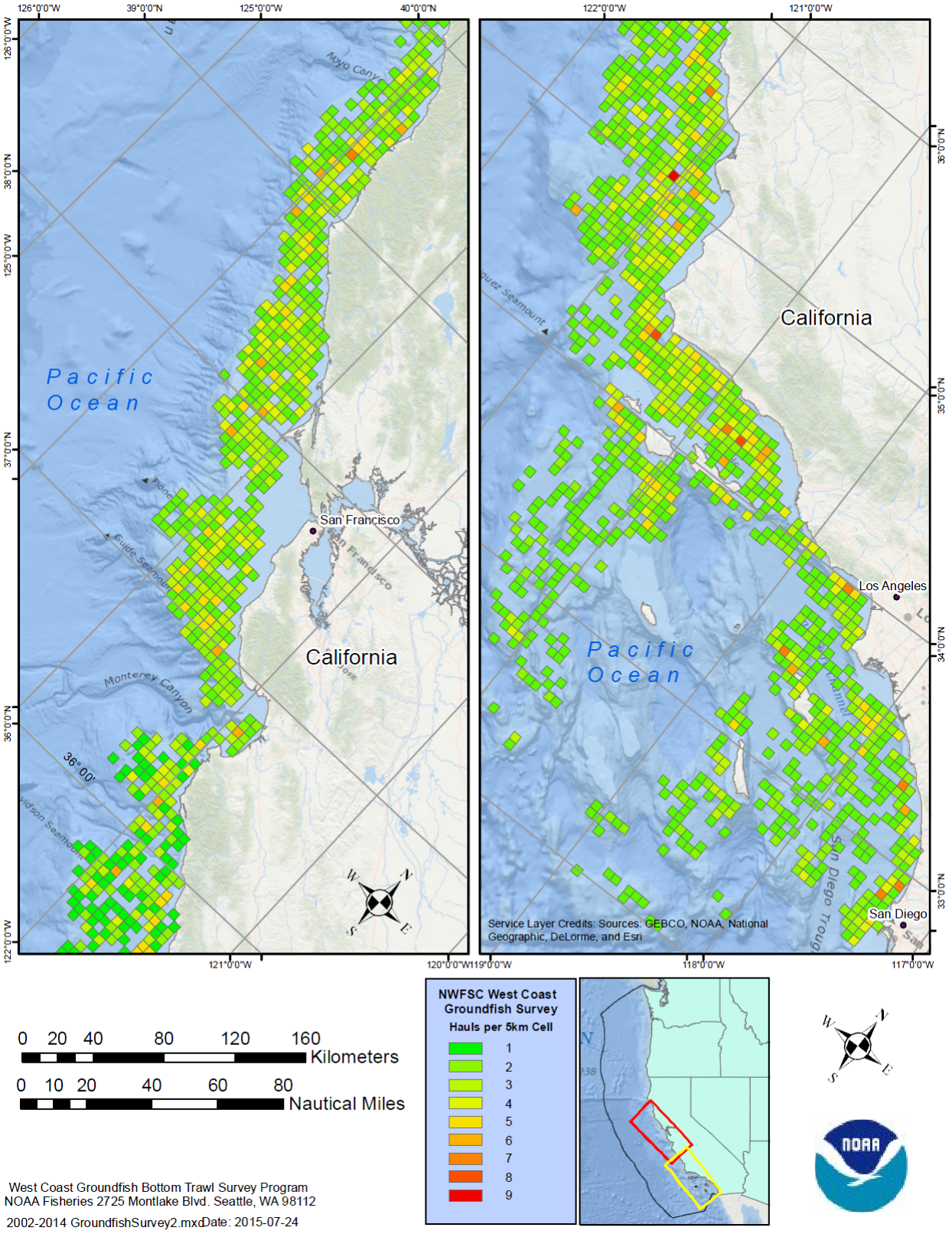

Figure 17. Cell plot showing spatial distribution of NWFSC shelf-slope trawl survey haul density by 5km grid squares for the southern area, including years 2003-2014.

Appendix A.1. Summary statistics of survey CPUE distributions (zero-catch hauls excluded) including percentiles, sample sizes, measures of variation (interquartile range, interquartile range / median), and inequality of distribution (Gini coefficient).

Zero hauls excluded

Percentile	Quartile	Bocaccio	Canary	Darkblotched	Longnose	Petrale	POP	Yelloweye
100.00%	max	0.0867095	0.3984403	0.0686596	0.0241881	0.1912196	0.1356448	0.0060811
99.50%		0.0409154	0.0833325	0.0209661	0.007709	0.0067762	0.0544757	0.0060811
97.50%		0.0062169	0.0190338	0.0056313	0.0042377	0.0033271	0.0233877	0.0027184
90.00%		0.0009684	0.0025266	0.0012544	0.0023815	0.0015098	0.0024098	0.0012218
75.00%	quartile	0.0003463	0.0005217	0.0002939	0.001249	0.000731	0.0003246	0.0005116
50.00%	median	0.000125	0.0001626	7.129E-05	0.0005617	0.0003081	6.628E-05	0.0001881
25.00%	quartile	4.483E-05	8.633E-05	1.845E-05	0.0002088	0.0001134	2.959E-05	6.83E-05
10.00%		1.074E-05	4.615E-05	6.075E-06	6.317E-05	4.417E-05	8.792E-06	2.521E-05
2.50%		2.386E-06	8.041E-06	2.262E-06	1.129E-05	1.79E-05	2.465E-06	7.855E-06
0.50%		9.38E-07	1.826E-06	9.947E-07	2.876E-06	7.447E-06	1.058E-06	2.185E-06
0.00%	min	7.49E-07	1.188E-06	5.98E-07	8.615E-07	1.313E-06	5.699E-07	2.185E-06
	IQR	0.0003015	0.0004354	0.0002755	0.0010401	0.0006176	0.000295	0.0004433
	IQR/median	2.4128329	2.6775592	3.8643191	1.8517387	2.0041157	4.4513808	2.3562508
	N pos hauls	479	555	1338	4518	3234	547	168
	Total N	7608	7608	7608	7608	7608	7608	7608
	Gini	0.9905	0.9933	0.9763	0.7462	0.8559	0.9938	0.9924

Appendix A.2. Summary statistics of survey CPUE distributions (zero-catch hauls included) including percentiles, and sample sizes.

Zero hauls included

Percentile	Quartile	Bocaccio	Canary	Darkblotched	Longnose	Petrale	POP	Yelloweye
100.00%	max	0.0867095	0.3984403	0.0686596	0.0241881	0.1912196	0.1356448	0.0060811
99.50%		0.0011795	0.0051144	0.0049797	0.006592	0.0049513	0.0039986	0.0005687
97.50%		0.0001923	0.0003021	0.0007551	0.0035479	0.0020717	0.0001563	0
90.00%		0	0	4.978E-05	0.0017004	0.0007619	0	0
75.00%	quartile	0	0	0	0.0007248	0.000223	0	0
50.00%	median	0	0	0	0.0001207	0	0	0
25.00%	quartile	0	0	0	0	0	0	0
10.00%		0	0	0	0	0	0	0
2.50%		0	0	0	0	0	0	0
0.50%		0	0	0	0	0	0	0
0.00%	min	0	0	0	0	0	0	0
	N pos hauls	479	555	1338	4518	3234	547	168
	Total N	7608	7608	7608	7608	7608	7608	7608
	% pos hauls	6%	7%	18%	59%	43%	7%	2%

Appendix A.3. Binning information for geometric interval classification used in displaying survey CPUE on maps.

Canary rockfish		Petrale sole		POP kg/ha		Bocaccio	
CPUE kg/ha	Coef.	CPUE kg/ha	Coef.	CPUE kg/ha	Coef.	CPUE kg/ha	Coef.
1.07	-	0.86	-	0.36	-	0.20	-
9.05	8.4579	6.48	7.5349	3.08	8.5556	1.73	8.6500
69.44	7.6729	43.61	6.7299	23.64	7.6753	13.82	7.9884
526.44	7.5812	289.10	6.6292	179.22	7.5812	109.54	7.9262
3984.40	7.5686	1912.20	6.6143	1356.45	7.5686	867.10	7.9158

Longnose skate		Yelloweye		Darkblotched	
CPUE kg/ha	Coef.	CPUE kg/ha	Coef.	CPUE kg/ha	Coef.
0.18	-	0.41	-	0.16	-
1.22	6.7778	1.67	4.0732	1.37	8.5625
7.21	5.9098	5.73	3.4311	10.94	7.9854
41.84	5.8031	18.78	3.2775	86.73	7.9278
241.88	5.7811	60.81	3.2380	686.60	7.9165