Survey data collected by Central Coast First Nations to inform MPA site selection in the Northern Shelf Bioregion

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Introduction

This report synthesizes data from fishery-independent surveys conducted by Central Coast First Nations and their collaborators—the Hakai Institute, DFO, Oceana Canada and Ocean Networks Canada—to inform site selection for the MPA network in the Northern Shelf Bioregion. The data document the relative abundances and distributions of rockfish, thornyheads, glass sponges and structure-forming corals (coral species that reach heights of at least 15 cm) in British Columbia's Central Coast. They are spatially explicit, and therefore highlight locations important to species or species groups formally identified as conservation priorities for the MPA network (DFO 2017).

These surveys are unique. They differ from other fishery-independent surveys for the region—namely DFO synoptic trawl surveys and longline surveys conducted by International Pacific Halibut Commission and the Pacific Halibut Management Association—by extensively sampling fjords, bays and other inside waters, and by covering a broad depth range that includes near-surface waters and depths of 200 to 400 metres. Except for data recently collected in collaboration with DFO and Oceana Canada, all data sets are published (Frid *et al.* 2016, 2018).

The results presented here highlight specific areas in fjords and other inside waters for their biological values. The discussion contextualizes why these data are important for MPA site selection.

Methods

Fieldwork in British Columbia's Central Coast was coordinated by the Heiltsuk First Nation during 2006-7, and by the Central Coast Indigenous Resource Alliance (CCIRA) and collaborators during 2013-18. Data were collected at fine spatial scales (i.e. ≤120 m^2) (Frid *et al.* 2016, 2018). In this report, however, they are presented at the scale of 4-km^2 planning units (PUs), as displayed in SeaSketch[1]. The analyses focus on rockfishes and thornyheads (*Sebastes* spp. and *Sebastolobus alascanus*), glass sponges (data aggregated for Aphrocallistidae, *Farrea* spp., *Rhabdocalyptus dawsoni*, and *Staurocalyptus dowlingi*) and structure-forming corals (data aggregated for Primnoidae (including *Primnoa* spp.), *Antipatharia* spp., *Paragorgia* spp., and *Stylaster* spp.). As described below, two sets of surveys were analyzed separately.

CCIRA surveys

These surveys were conducted from small vessels (≤8 m-long) during 2006-2007 and 2013-2017. They targeted nearshore rocky reefs embedded in a matrix of soft substrates, primarily at depths of 15-150 m, using three methods:

[1] https://www.seasketch.org/#projecthomepage/59767c74bac2eb558ded3d9c

1. *Towed video surveys*: 578 sub-transects, each with a mean area of 120 m^2(range 100-130 m^2) were nested within 119 sites at a mean depth of 73 m (range 2-230 m) (Frid *et al.* 2018). A subset of data was collected collaboratively with the Hakai Institute.
2. *Dive surveys*: 253 transects (120 m^2) were nested within 135 sites at a mean depth of 23 m (range 13-35 m) (Frid *et al.* 2018). A subset of data was collected collaboratively with the Hakai Institute.
3. *Hook-and-line surveys*: 15-min-long samples were conducted at 242 sites and a mean depth of 51 m (6-213 m) (Frid *et al.* 2016)

Estimates of relative abundance within 4-km^2 planning unit (PU) were estimated for different fish species by integrating data from all survey types. For each method, the count-per-unit-effort (CPUE) within each PU was first calculated as the sum of fish counts divided by the sum of effort. Because the three methods differ in metrics and potential biases, CPUE values were converted to a proportion of the maximum values, *Propmax,* obtained by a given method, creating a common metric across methods. For each PU, a mean *Propmax*, weighted by effort from each survey type, was then calculated.

Species diversity of benthic fish (which include species other than rockfish and thornyheads) was estimated with the Shannon diversity index (H') calculated for each sample (tow video sub-transects, 44 species recorded; dive transects, 33 species; and fishing sets, 22 species). To normalize these values across methods, H' values were divided by the maximum H' for that survey, giving H'(norm) which ranged from 0-1. All H'(norm) values were then averaged within each PU. The same approach was used to estimate rockfish species density (the number of species per 120-m^2 sampling unit) per PU (Frid *et al.* 2018). Both diversity and species density, in their normalized form, are equivalent to *Propmax* and reported as such in Appendix 1.

For analyses of cloud sponges and coral, only data from towed video surveys were used. For cloud sponges, relative abundances were analyzed as percent cover categories: 0 (0%), 1 (1-25%), 2 (26-50%), 3 (51-75%), and 4 (76-100%). The average sponge cover category for each sub-transect was calculated by averaging all records within that sub-transect, and these values were used to calculate the average of all sub-transects within each PU. While SeaSketch displays the mean abundance category of glass sponges, here we express glass sponge results as a proportion of maximum values, *Propmax*. Coral values were calculated as presence or absence of coral in any sub-transect within a given PU (i.e., only in this case *Propmax* is either 0 or 1). CCIRA surveys recorded all glass sponges and structure-forming corals (i.e. life and dead individuals).

Vector surveys

These data derive from field research conducted collaboratively between DFO, Central Coast Frist Nations, Oceana Canada and Ocean Networks Canada. In March of 2018, a drop video camera was deployed from the *CCGS Vector* to survey deep habitats (median depth=296 m, range 100-440 m) in fjords and channels of British Columbia's central coast. Surveys encompassed soft and rocky substrates. The relative densities (count/m^2) of corals and glass sponges (living individuals only) and fish were estimated from 826 sub-transects, each covering 90-120 m^2 (2% of sub-transects covered smaller areas). From these values, relative densities at the scale of 4-km^2 PUs were estimated as the sum of counts divided by sum of area surveyed within the given unit. While SeaSketch displays count/m^2, we express results as a proportion of maximum values, *Propmax*.

Results

In the context of these results, "unique records" refer to data collected within 4-km^2 PUs that do not overlap spatially with areas covered by DFO synoptic trawl surveys and longline surveys, as displayed in SeaSketch.

Vector surveys

These surveys encompassed 18 PUs in fjords or other inside waters. Most PUs contained spatially unique records for one or more of the following species (or species groups) considered to be conservation priorities for the MPA network (DFO 2017): Shortraker Rockfish, Rosethorn Rockfish, Shortspine Thornyhead, corals and glass sponges. Additionally, Redbanded Rockfish, a long-lived species with unknown stock status (Edwards *et al.* 2017), also were recorded (Figure 1, Table 1, Appendix 1).

PUs within Mathieson and Finlayson Channels, Sheep Pass, and Kynoch and Mussel Inlets had high relative abundances for Redbanded Rockfish, Rosethorn Rockfish, Shortraker Rockfish and corals. Mid to high values for Rosethorn Rockfish, Shortraker Rockfish and corals overlapped spatially in PU 13050, at the intersection of Sheep Pass and Finlayson Channel (Cluster 1 in Fig. 1).

PUs in Seaforth Chanel and vicinity had high relative abundances for Shortraker Rockfish, Spiny Thornyhead and corals. PU 10369 at the south end of Troup Pass had high values for both Spiny Thornyhead and corals (Cluster 2 in Fig. 1).

PUs in Fitzhugh Sound and vicinity contained corals and Rosethorn Rockfish, and had high relative abundances for Redbanded Rockfish, Shortraker Rockfish, Spiny Thornyhead and glass sponges. PU 9265 contained high abundances for both Redbanded Rockfish and Spiny Thornyhead (Cluster 3 in Fig. 1).

CCIRA surveys

These surveys sampled 176 PUs. Some data spatially complemented findings from DFO trawl and longline surveys, yet many records were spatially unique for species or species groups considered to be conservation priorities (Fig. 2, Table 1, Appendix 1).

Bocaccio, a threatened species of rockfish (COSEWIC 2002), were recorded at 9 PUs (5%). All records were spatially unique. PUs with mid or high relative abundance were in Mussel Inlet (PU 13213), Laredo Sound (PU 12410), Queens Sound (PU 9260) and Hakai Pass (PUs 8314, 8156) (Fig. 2a, Table 1. Appendix 1).

Canary Rockfish, a threatened species (COSEWIC 2007), were detected in 26 PUs (15%). Of PUs with detections, three (12%) were spatially unique; these were in Fitzhugh Sound and vicinity (PUs 7057, 7845, 8318) (Fig. 2b, Table 1. Appendix 1).

Quillback Rockfish, a threatened species (COSEWIC 2009) inherent to First Nation diets, were detected in 144 PUs (82%). Of PUs with detections, 46 (32%) were spatially unique. Unique records with mid to high abundances occurred at the intersection of Mathieson Channel and Kynoch Inlet (PU 12897), southeastern Finlayson Channel (PU 11944), Burke Channel (PU 10381) and Fitzhugh Sound (PUs 7845, 7529) (Fig. 2c, Table 1, Appendix 1).

Yelloweye Rockfish, a species of special concern (COSEWIC 2008) inherent to First Nation diets, were detected in 63 PUs (35%). Of PUs with detections, 18 (29%) were spatially unique. Unique records with mid to high abundances occurred at Mussel Inlet and its intersection with Mathieson Channel (PUs 13213, 13055) and Nowish Inlet (adjacent to Finlayson Channel: PU 11629) (Fig. 2d, Table 1, Appendix 1).

Corals were detected at 8 of 78 (10%) PUs surveyed with towed video. All records were spatially unique and found mostly (though not exclusively) in Hakai Pass and Fitzhugh Sound (Fig. 2e, Table 1, Appendix 1).

Glass sponges were detected at 38 of 78 (49%) PUs surveyed with towed video. Detections at 35 PUs (92%) were spatially unique (Fig. 2, Table 1. Appendix 1). PU 7530 in Fitzhugh Sound and PU 10524 in Seaforth Channel had particularly high relative abundances of sponges. Also, surveys conducted with the Nuxalk Nation recently discovered high relative abundances in Dean Channel near the Kimsquit River (PUs 12916 and 12917).

CCIRA surveys also highlight areas with a high relative abundance of mid-lived rockfishes (maximum age of 50-75 years, including Black, Copper, Greenstriped, Redstripe, Vermillion, Widow, and Yellowtail Rockfish), a high species diversity of benthic fishes, and high species density of rockfishes. Red and orange PUs shown in Fig. 3 represent high values for these features.

Discussion

Our results complement the Marxan analyses for MPA network planning that have been completed to date. Although those analyses included CCIRA surveys, Marxan outputs may not necessarily capture the importance of fjords and other inside waters encompassed by our data from a representativity perspective, particularly because some rockfish populations at heads of fjords could potentially be genetically distinct from those in outside waters (Dick *et al.* 2014). Critically, Vector Surveys for deepwater rockfishes and corals were not completed in time to be incorporated into Marxan analyses and, up to this point, draft designs of the MPA network may have under-utilized the very important data generated by those surveys.

Accordingly, the results presented here highlight spatially unique records in fjords and other inside waters not covered by DFO trawl and longline surveys. From these records, 11 areas listed in Table 2 stand out as ecologically important. Table 2, however, is only a broad guide to be complemented with PU-specific information (Appendix 1; Figs 1-3).

Our unique records for long-lived species of rockfish are important because these species are particularly vulnerable to over-exploitation (Hixon *et al.* 2014), and average size and age (which affect fecundity) are declining for at least some of these species (McGreer & Frid 2017). These records encompass species important to traditional diets of First Nations, such as Yelloweye and Quillback Rockfish, and threatened species, such as Bocaccio and Canary Rockfish. They also encompass species that prefer depths of 200-400 m (Shortraker Rockfish, Rosethorn Rockfish, Redbanded Shortspine Thornyhead) and therefore unlikely to be protected by existing RCAs, which are mandated to protect only species that prefer depths shallower than 200 m (i.e. inshore rockfish).

We also emphasize that our unique records include newly discovered areas for corals and glass sponges (Figs. 1, 2e, 2f), which are vulnerable to bottom contact fishing gear and therefore would strongly benefit from spatial protection. These records are in fjords and inside waters, and therefore not covered by existing protections to sponge reefs in offshore areas.

An important caveat is that although this report emphasizes the importance of PUs that do not overlap spatially with DFO trawl and longline surveys, other areas also are important. Specifically, Figures 2 and 3 contain many high value PUs from CCIRA surveys (i.e., orange or red squares) that are not necessarily spatially unique. For brevity, we have not elaborated on these records and have assumed that Marxan outputs capture some of their importance. Still, it is important that PUs in outside waters with high values for mid-lived rockfish species, species diversity, species richness or other features, as depicted by our data (Figs. 2, 3), are fully considered in the design of the MPA network. Also, to keep this report tractable we did not summarize CCIRA data for several species formally identified as conservation priorities (DFO 2017), such as Lingcod, China Rockfish, Silvergray Rockfish and Tiger Rockfish (Table 1), nor Vector data for species generally found shallower than 200 m, such as Quillback and Yelloweye Rockfish. These data are included in Appendix 1 and available in SeaSketch; they should be considered in the design of the MPA network.

Finally, one of our recent studies concluded that rockfish species richness increases with the structural complexity of rocky habitats. Inferences and data generated from that study can inform MPA network design by ground truthing bathymetric models used to infer habitat structural complexity, and by predicting areas of high species richness where survey data are lacking (Frid *et al.* 2018).

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Table 1. Summary of records for key species and species groups. Number of PUs surveyed by each method were as follows: CCIRA=176, Vector=18, Towed Video (a subset of CCIRA surveys)=78. Maximum ages for rockfish are given to emphasize their fishery vulnerability (see Hixon *et al.* 2014).

Common name	Scientific name	COSEWIC assessment	Max. known lifespan, yrs	Survey method	Total PUs with presence	PUs with presence that are unique
Bocaccio	*Sebastes paucispinus*	Threatened (2002)	50	CCIRA	9 (5%)	9 (100%)
Canary Rockfish	*Sebastes pinniger*	Threatened (2007)	84	CCIRA	26 (15%)	3 (12%)
China Rockfish	*Sebastes nebulosus*	Not assessed	79	CCIRA	76 (43%)	33 (43%)
Quillback Rockfish	*Sebastes maliger*	Threatened (2009)	95	CCIRA	144 (82%)	46 (32%)
				Vector	6 (33%)	6 (100%)
Redbanded rockfish	*Sebastes babcocki*	Not assessed	106	Vector	2 (11%)	2 (100%)
Rosethorn Rockfish	*Sebastes helvomaculatus*	Not assessed	87	Vector	8 (44%)	8 (100%)
				CCIRA	2 (1%)	0 (0%)
Shortraker Rockfish	*Sebastes borealis*	Not assessed	157	Vector	6 (33%)	6 (100%)
Silvergray rockfish	*Sebastes brevispinis*	Not assessed	82	CCIRA	20 (11%)	12 (60%)
Tiger Rockfish	*Sebastes nigrocinctus*	Not assessed	116	CCIRA	49 (28%)	18 (37%)
				Vector	2 (11%)	2 (100%)
Yelloweye Rockfish	*Sebastes ruberrimus*	Special Concern (2008)	121	CCIRA	62 (35%)	18 (29%)
				Vector	3 (17%)	3 (100%)
Shortspine Thornyhead	*Sebastolobus alascanus*	Not assessed	80	Vector	3 (17%)	3 (100%)
Corals	Primnoidae, *Antipatharia*, *Paragorgia*, *Stylaster*	Not assessed		Vector	15 (83%)	15 (100%)
				Towed video	8 (10%)	8 (100%)
Glass sponges	Aphrocallistidae, *Farrea*, *Rhabdocalyptus* *Staurocalyptus*	Not assessed		Vector	18 (100%)	18 (100%)
				Towed video	38 (49%)	35 (92%)

Table 2. General areas (columns) containing 4-km^2 PUs with unique records for important biological features (rows). Asterisks indicate species or species groups with broad distributions for which only mid to high-abundance PUs were incorporated into this table. While shortened common names are given here, Table 1 provides taxonomic details.

	Finlayson Channel	Mathieson Channel	Sheep Pass	Mussel Inlet	Seaforth Channel	Fitzhugh Sound	Laredo Sound	Queens Sound	Hakai Pass	Burke Channel	Dean Channel
Bocaccio				X		X	X	X	X		
Canary						X					
Quillback*	X	X				X				X	
Yelloweye*	X	X		X							
Corals	X	X	X	X	X	X			X		
Glass sponge*					X	X					X
Redbanded		X				X					
Rosethorn	X	X	X	X		X					
Shortraker	X	X			X	X					
Thornyhead					X	X					

Fig. 1. Select results from Vector surveys. The map shows the eighteen 4-km^2 planning units (PUs) sampled and displays relative abundances of Shortraker Rockfish as an example (warmer colours represent higher abundances). Individual graphs show mean relative abundances (i.e., proportion of maximum values for count/m^2) of key species or species groups within PUs, as aggregated into three spatial clusters. While shortened common names are given here, Table 1 provides taxonomic details.

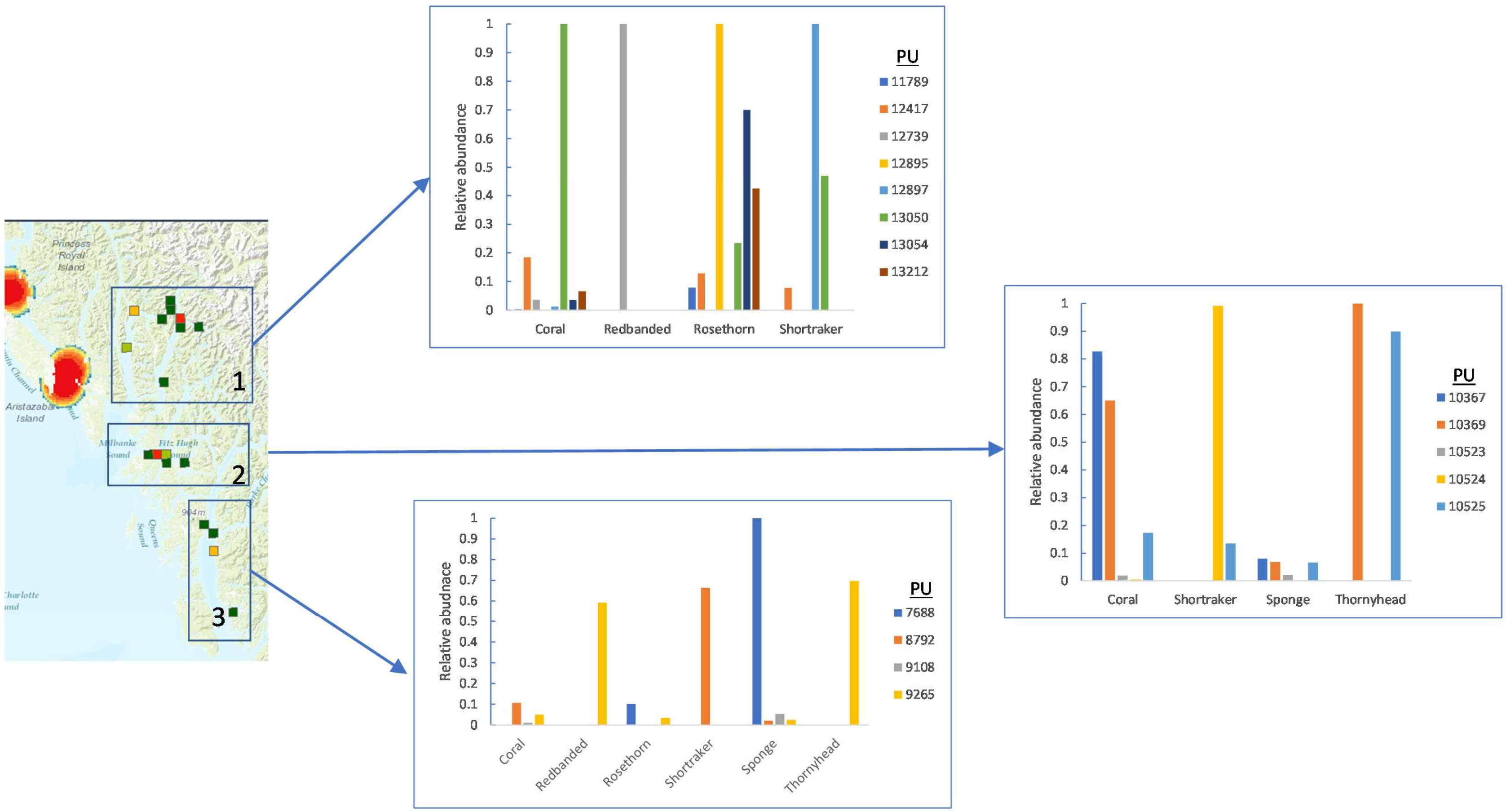


Fig. 2. SeaSketch outputs showing relative abundances (*Propmax*) of keys species or species groups, as depicted by CCIRA surveys (squares representing 4-km^2 PUs) and DFO trawl and longline surveys (kernel densities shown as a heat map). The two survey types are overlaid to discern unique records from CCIRA surveys. For both survey types, warmer colours depict higher relative abundances. For CCIRA surveys, light gray squares indicate species absences. While shortened common names are given here, Table 1 provides taxonomic details. The arrow in panel (f) points to an important glass sponge area recently discovered by CCIRA/Nuxalk Nation.

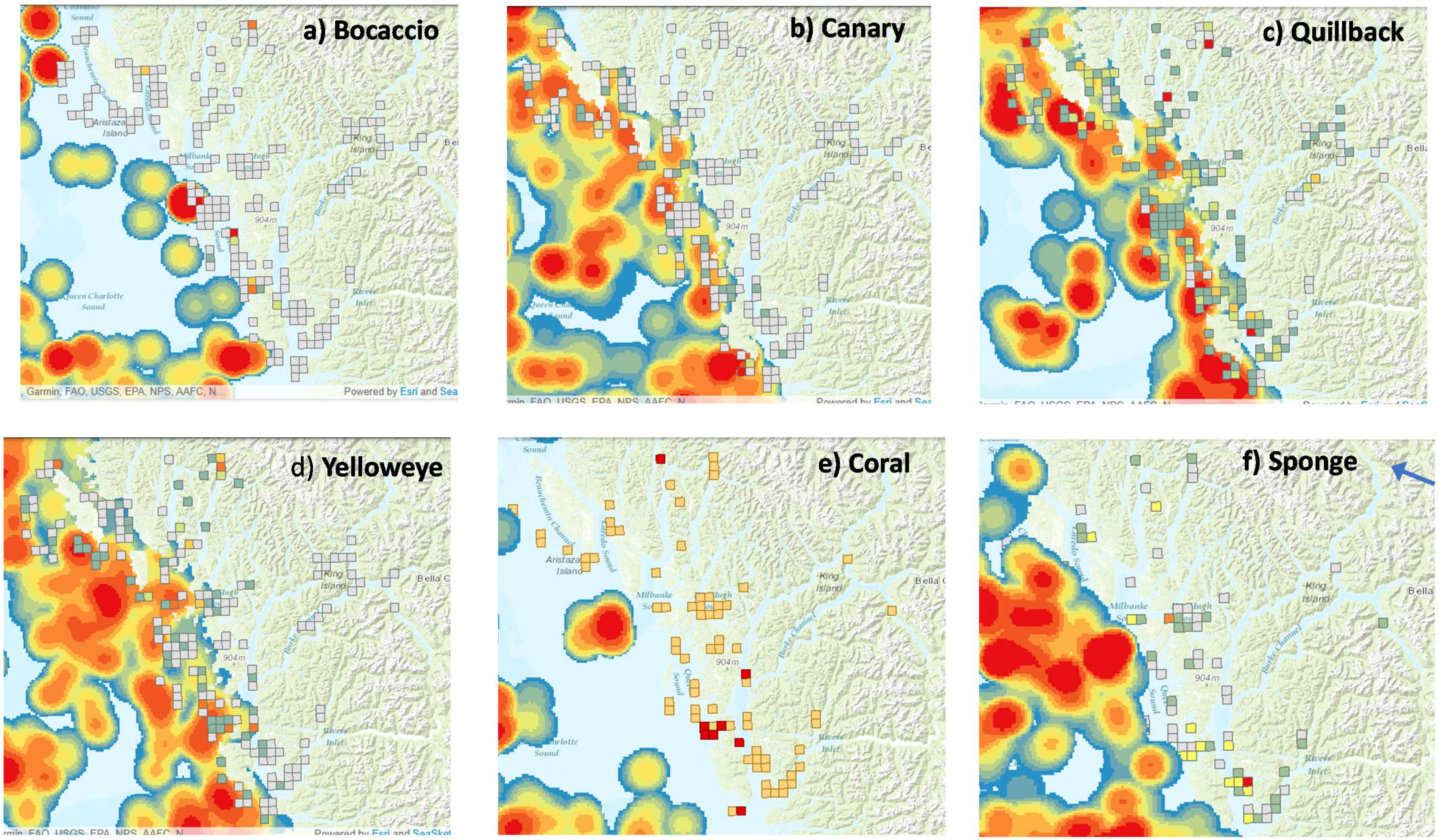
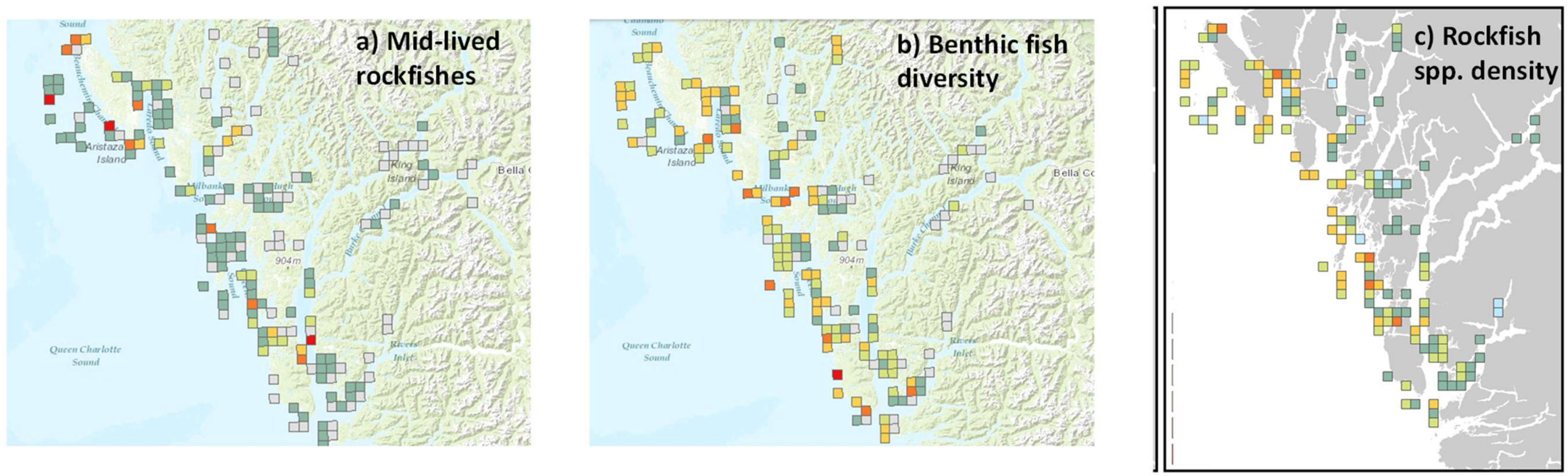


Fig. 3. Mean relative values (*Propmax*) within 4-km^2 PUs for the (a) abundance of mid-lived species of rockfish (Black, Copper, Greenstriped, Redstripe, Vermillion, Widow, and Yellowtail Rockfish aggregated), (b) Shannon diversity of benthic fish species, and (c) species density of rockfishes, as depicted by CCIRA surveys. Warmer colours depict higher. Panels (a) and (b) are SeaSketch outputs; panel (c) is adapted from (Frid *et al.* 2018)



Appendix 1. Raw data used to generate this report.
The spreadsheet contains the following variables, by column:

A. Planning unit (PU) identifier (standardized from MaPP grid).
B. Identifier of Vector Survey PU clusters used to generate Fig. 1.
C. Biological features recorded by surveys. Most shortened names are self-explanatory, and their taxonomic details are in Table 1 of the main text. Additionally:
    a. *Diversity*: Shannon diversity of benthic fishes
    b. *SppDens*: Rockfish species density
    c. *Mid-lived*: Mid-lived species of rockfish (Black, Copper, Greenstriped, Redstripe, Vermillion, Widow, and Yellowtail Rockfish aggregated)
D. Mean *Propmax* value for a given biological feature, as described in methods. Species absences (i.e. zero values) are excluded.
E. Indicates whether data overlap spatially (Complement) or not (Unique) with equivalent data from DFO trawl or longline surveys.