ECOLOGICAL SPATIAL FEATURES COMPILED TO SUPPORT MARINE PROTECTED AREA NETWORK PLANNING IN THE NORTHERN SHELF BIOREGION

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ABSTRACT

Gale, K.S.P., Robb, C., McDougall C., and Fields, C. 2025. Ecological spatial features compiled to support marine protected area network planning in the Northern Shelf Bioregion. Can. Tech. Rep. Fish. Aquat. Sci. 3706: xiii + 257 p.
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A marine protected area (MPA) network is being collaboratively established by Indigenous, federal, and provincial government partners in the Northern Shelf Bioregion (NSB), an area of 102,000 km^2 along the north and central coasts of British Columbia. A Network Action Plan was released in 2023 that includes a proposed MPA network design and a recommended approach for its establishment, informed by traditional, local, and scientific knowledge. Included within this knowledge base are a large suite of spatial features created or compiled to represent ecological conservation priorities, which are the species, habitats, and special natural features that underpin the MPA network design. This report describes these ecological spatial features, which include species (marine plants, algae, fishes, invertebrates, mammals, and birds), biogenic habitats, ecologically and biologically significant areas (EBSAs), and physical features represented by regional ecological classification systems. While the focus was on spatial features that represent each conservation priority at the scale of the NSB, individual datasets were generated from a wide variety of source data and have varying spatial extents, resolutions, temporal scales, and uncertainties. The metadata presented for each feature provides an overall summary and details on the methods, data sources, accuracy and completeness, uncertainties, use restrictions, and references.

RÉSUMÉ

Gale, K.S.P., Robb, C., McDougall C., and Fields, C. 2025. Ecological spatial features compiled to support marine protected area network planning in the Northern Shelf Bioregion. Can. Tech. Rep. Fish. Aquat. Sci. 3706: xiii + 257 p.
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Les gouvernements autochtones, fédéral et provincial collaborent à l’établissement du réseau d’aires marines protégées (AMP) de la biorégion du plateau Nord, une zone de 102 000 km^2 qui longe le nord et le centre de la côte de la Colombie-Britannique. Un plan d’action publié en 2023 propose une conception pour ce réseau d’AMP et recommande une approche pour son établissement qui est éclairée par des connaissances traditionnelles, locales et scientifiques. Parmi ces connaissances figure un vaste ensemble de caractéristiques spatiales qui on été créés ou compilées en vue de représenter les priorités de conservation écologique, à savoir les espèces, les habitats et les caractéristiques naturelles spéciales qui sous-tendent la conception du réseau d’AMP. Le présent rapport décrit ces caractéristiques spatiales écologiques, à savoir les espèces (plantes marines, algues, poissons, invertébrés, mammifères et oiseaux), les habitats biogènes et les zones d’importance écologique et biologique (ZIEB), ainsi que les caractéristiques physiques représentées par des systèmes régionaux de classification écologique. Bien que l’accent ait été mis sur les caractéristiques spatiales qui constituent des priorités de conservation à l’échelle de la biorégion du plateau Nord, des ensembles de données individuels ont été générés à partir d’une grande variété de données sources et ont des étendues spatiales, des résolutions, des échelles temporelles et des niveaux d’incertitude variables. Les métadonnées présentées pour chaque caractéristique fournissent un résumé et des renseignements détaillés sur les méthodes, les sources de données, l’exactitude, l’exhaustivité, les incertitudes, les restrictions d’utilisation et les références.

INTRODUCTION

As a signatory to the Convention on Biological Diversity (CBD), Canada has committed to protecting 30% of coastal and marine areas in ecologically representative and well-connected marine protected areas (MPAs), and to protect ecosystem, species, and genetic diversity (Convention on Biological Diversity, 2023; DFO, 2023). MPAs, in particular those designed as part of a network, are increasingly recognized as important biodiversity conservation tools that can support sustainable coastal communities and economies (Ban et al., 2019; DFO, 2023; Government of Canada, 2011; Grorud-Covert et al., 2014). In Canada's Pacific Region, Indigenous, federal, and provincial government partners[1] have been collaboratively planning for an MPA network since 2014. The focus of this effort is the Northern Shelf Bioregion (NSB), which encompasses an area of 102,000 km^2 along the north and central coasts of British Columbia (Figure 1).

[1] Governance Partners for the Network include the Gitga'at, Gitxaała, Haisla, Kitselas, Kitsumkalum, Metlakatla, Heiltsuk, Kitasoo Xai'xais, Nuxalk, Wuikinuxv, Mamalilikulla, Kwiakah, Tlowitsis, K'omoks, Da'naxda'xw Awaetlala, and Wei Wai Kum First Nations; Council of the Haida Nation; Province of British Columbia; and Government of Canada.

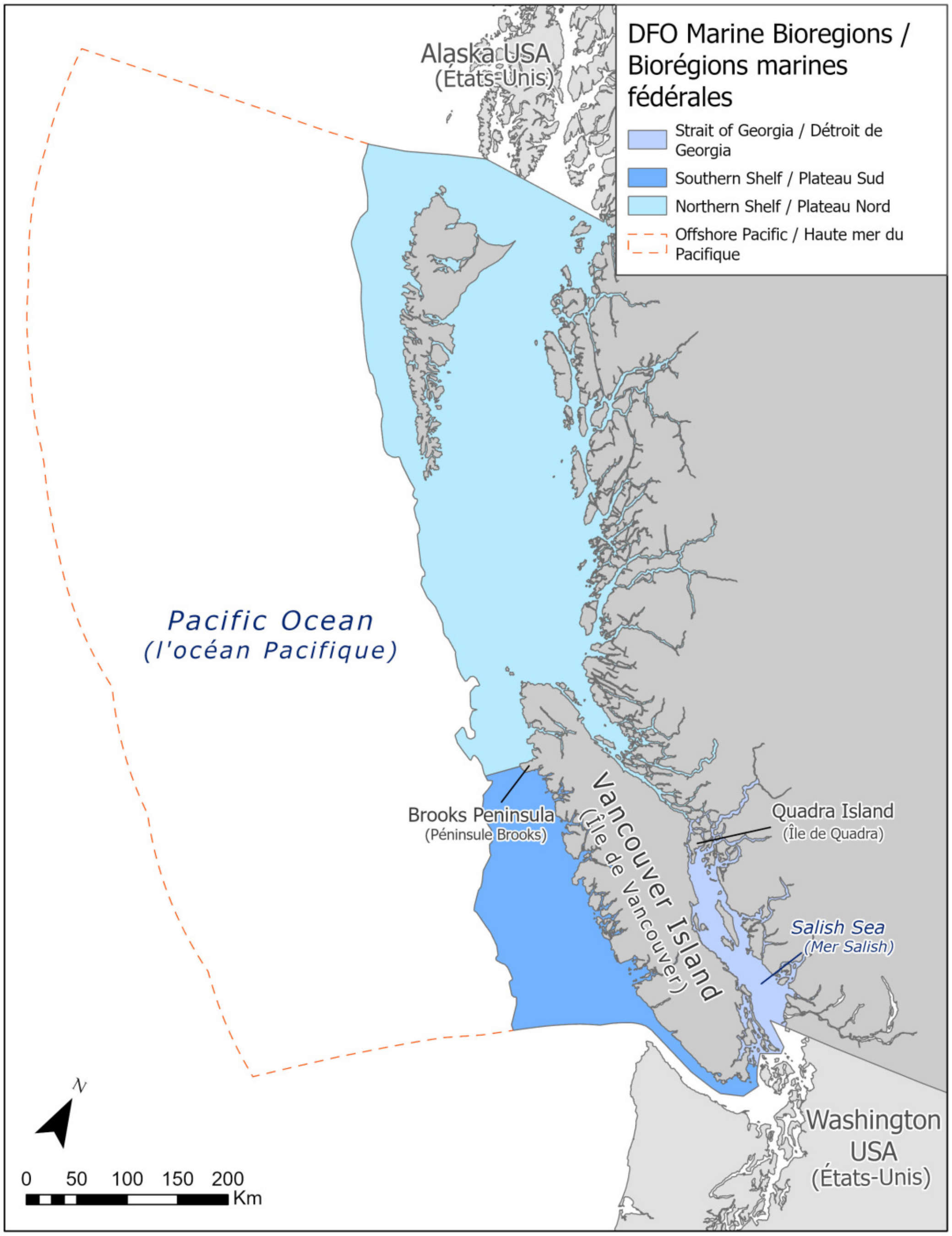

Figure 1: Marine bioregions in Canada's Pacific Region.

Network planning in the NSB was guided by six goals, the primary goal being to protect and maintain marine biodiversity, ecological representation and special natural features (Canada – British Columbia, 2014; MPA Network BC Northern Shelf Initiative, 2023a). Each goal had numerous supporting network objectives that were considered along with a suite of planning principles, design guidelines, and design strategies (DFO, 2017, 2019; MPA Network BC Northern Shelf Initiative, 2023a). Technical work required to progress the network following the network goals and associated guidance was performed by a tripartite working group known as the MPA network technical team (MPATT), with input from network governance partners and stakeholder and expert advisory committees. To help identify areas that could contribute to the network, ecological conservation priorities (E-CPs) were identified following a systematic framework (DFO, 2017; Gale et al., 2019). That work also recommended several types of spatial features to represent the E-CPs. Spatial representation targets were subsequently recommended for each E-CP, along with a workflow for incorporating the most appropriate spatial features into analyses to support the identification of MPA network designs (DFO, 2019; Martone et al., 2021). Using that information, MPATT compiled data and created spatial features to represent the E-CPs, as well as features to represent cultural conservation priorities (C-CPs) and human activities (MPA Network BC Northern Shelf Initiative, 2023b).

The spatial features representing the E-CPs were used by MPATT in a suite of analyses, including site selection analyses performed using the decision support tool Marxan (Ball et al., 2009) to identify areas of high conservation value, as well as iterative assessments of potential network designs using a conservation gaps analysis (CGA) tool[2]. Marxan is a widely used conservation planning software that generates potential conservation plans that meet the targets for conservation features while minimizing overall costs. MPATT performed a suite of Marxan analyses incorporating ecological and/or cultural spatial features, while minimizing costs associated with area (to generate spatially efficient solutions) or human activities (to minimize impacts to human users) to identify areas of high conservation importance as one input into conversations about potential network designs. MPATT also deployed an online interactive mapping portal using SeaSketch (Figure 2) to make viewing the spatial features available to partners and stakeholders. Further, MPATT developed the CGA tool to iteratively assess how well the spatial representation targets for the E-CPs were captured by draft network designs. A desktop version of the CGA tool was utilized by planning partners and an online version was also made available through SeaSketch.

In 2023, the network governance partners released a Network Action Plan (NAP) for the NSB MPA Network that includes a proposed network design (Figure 3; MPA Network BC Northern Shelf Initiative, 2023a). Work is now proceeding on implementation of the MPA network, including the development of monitoring guidance.

[2] Beaty et al. In review. Protected area network design is improved by accounting for how different levels of protection affect representation.

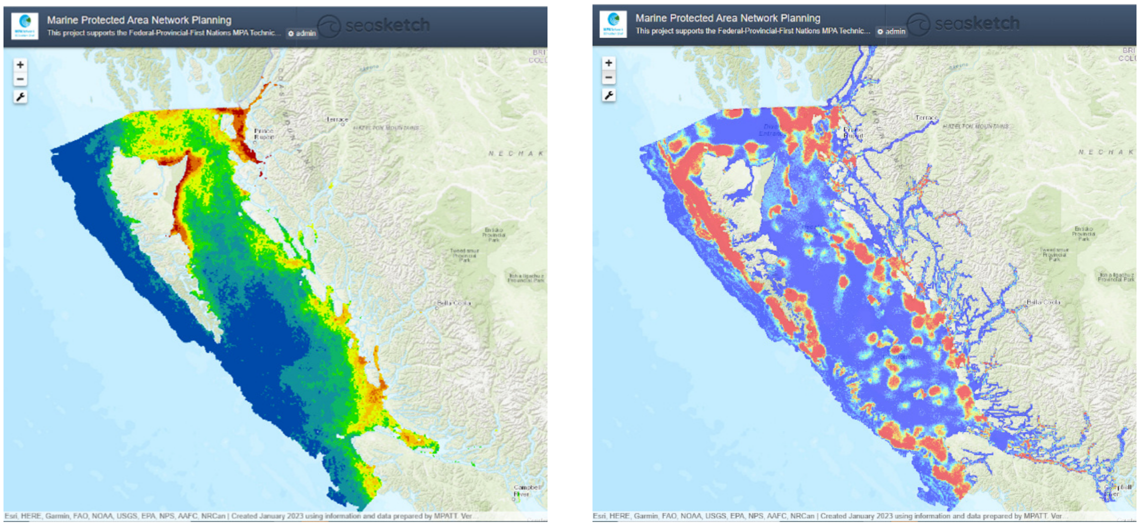

Figure 2: Example of (a) Chlorophyll-a bloom frequency and (b) an example Marxan output displayed in the MPATT SeaSketch portal.

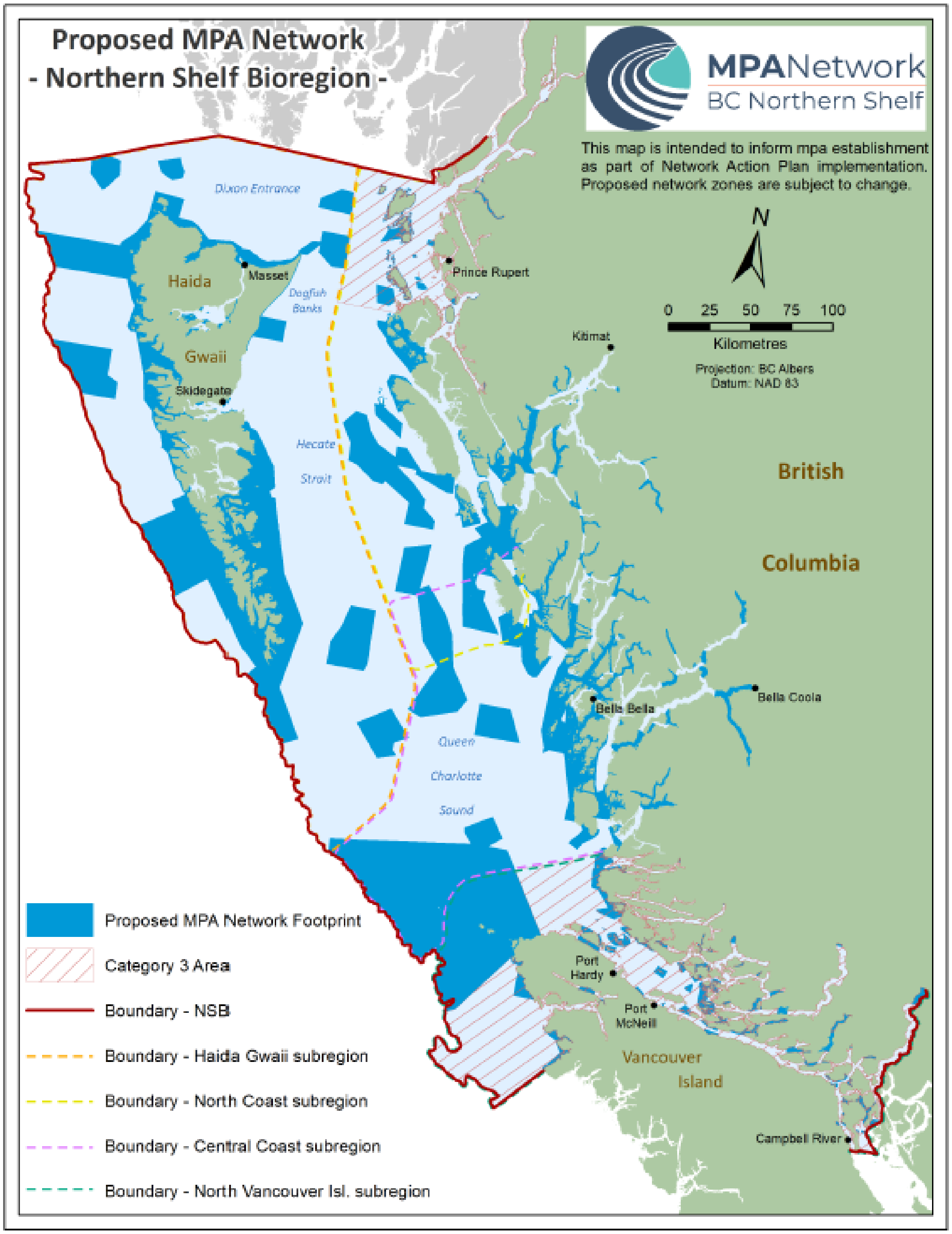

Figure 3: Proposed MPA network design for the Northern Shelf Bioregion (credit: MPA Network BC Northern Shelf Initiative, 2023a).

Report Overview

This report focuses solely on the ecological spatial features collated to represent the E-CPs in site selection analyses. The report begins with an overview of the process followed to identify the E-CPs and compile relevant data, then details the metadata for each spatial feature. The metadata records are organized by taxonomic groups for the species-based E-CPs, followed by the area-based E-CPs organized by the finer-scale habitats and coarse-scale habitat classification systems. For each record, information is provided on data sources, represented time periods, associated uncertainties or limitations, and data process steps undertaken, along with a map of the data within the NSB. Further details on the spatial features used to represent C-CPs and human activities, as well as the analyses that utilized the compiled ecological spatial features can be found in Compendium 2 of the NAP (MPA Network BC Northern Shelf Initiative, 2023b) and in Beaty et al. (2024).

IDENTIFICATION OF APPROPRIATE ECOLOGICAL SPATIAL FEATURES

Ecological Conservation Priorities

The primary goal of the MPA network planning process in the NSB was informed by the identification of E-CPs, which are the species, habitats, and ecological features important to protect within the network (Gale et al., 2019). E-CPs were identified following a systematic framework that was developed collaboratively by MPATT partners and assessed through a Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) regional peer review process (DFO, 2017; Gale et al., 2019). Species-based E-CPs included species of conservation concern, species with high intrinsic vulnerability to disturbance, and species that perform important ecological roles, including upper-level predators, nutrient transporters, forage species, and habitat-forming species. Area-based E-CPs were identified based on their alignment with MPA network objectives, such as areas of climate resilience, degraded areas, representative habitats, and ecologically and biologically significant areas (EBSAs).

The framework for identifying E-CPs also incorporated guidance on the spatial features recommended to represent species-based E-CPs in site selection analyses to identify areas of ecological importance (DFO, 2017; Gale et al., 2019). Recommended spatial features included:

- Areas of aggregation or importance for spawning, rearing/nursery, feeding, or migrating, or areas otherwise determined to be critical habitat (such as Important Areas identified through the EBSA process; Clarke and Jamieson, 2006*a*).
- Observed or modelled distribution and relative abundance within the NSB
- Areas of high or distinct genetic diversity

Detailed information on the methods, rationale, and identification of the E-CPs and guidance on spatial features are presented in Gale et al. (2019).

Ecological Design Strategies

Subsequent to the review of the E-CP framework, a second CSAS regional peer review process was completed focused on ecological design strategies that describe how the E-CPs will be spatially incorporated in the NSB MPA network (DFO, 2019; Martone et al., 2021). The ecological design strategies included ecological conservation targets, which are quantitative estimates of how much of each spatial feature representing each species - and area-based E-CP should be included in the network, as well as key variables for network design. In addition, areas of importance for each species-based E-CP were identified and reviewed by species experts and a decision framework was developed to select the spatial features most appropriate for use in the Marxan site selection analyses. This framework (Figure 4) considered data quality, scale, and completeness for the NSB, as well as feature type, with spatial features representing known areas of importance for a species-based E-CP within the NSB prioritized over broader distribution or range data. Following this framework, spatial features representing the E-CPs were categorized as:

- Marxan feature – data of reasonable spatial coverage and quality
    - Included in Marxan and post-hoc analyses using the target assigned to its associated E-CP

- Non-Marxan feature – data with limitations (e.g., limited spatial extents, low data quality or confidence) such that it was not appropriate for use in Marxan analyses
  - Tracked in Marxan site selection and post-hoc analyses (i.e., assigned a target of zero so that the feature did not influence the analysis outputs)
- Low target feature – data for highly mobile species (ranging greater than 50 km) that did not represent known areas of importance within the NSB
  - Target downgraded to low for Marxan and post-hoc analyses
- Data Gap – to be included in analyses when data become available

Further details on the process to identify representation targets and the decision framework for spatial features can be found in (Martone et al., 2021).

Decision Tree: Identify Appropriate Conservation Priorities for Design Scenarios

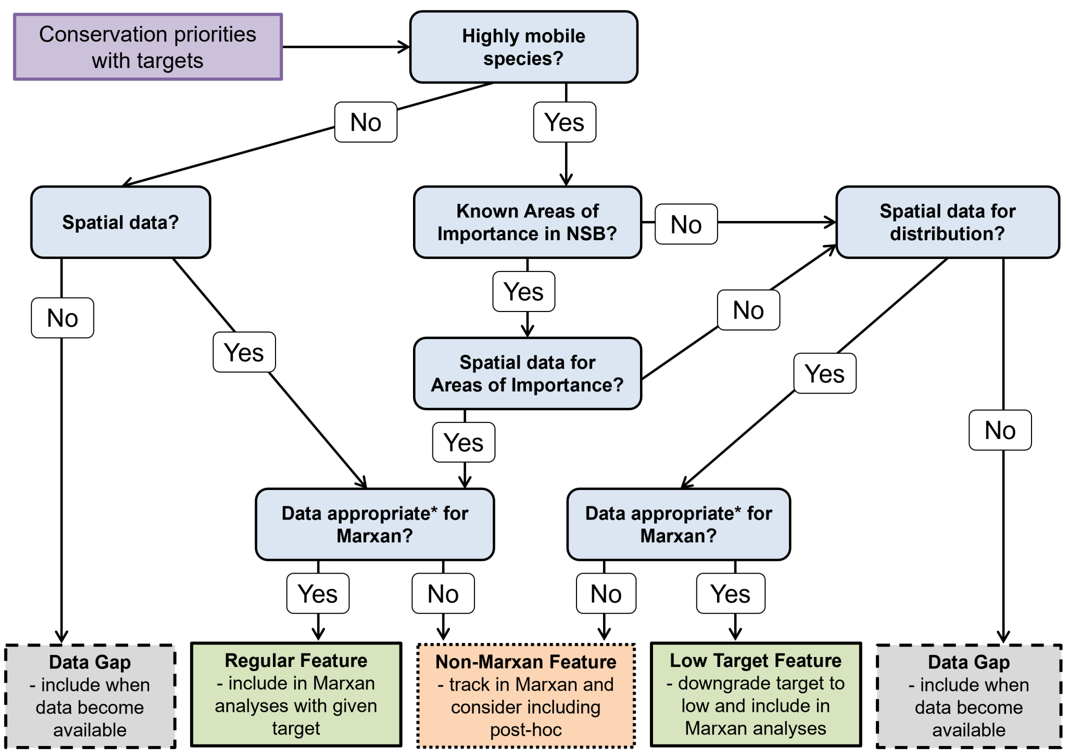

Figure 4: Decision framework for identification of spatial features (credit: DFO, 2019).

Spatial Data Compilation and Review

Potential spatial data sources to represent the E-CPs were solicited from subject matter experts and included as recommendations through the CSAS reviews for the E-CPs and ecological design strategies in 2016 and 2017 (DFO, 2017, 2019). Spatial features were compiled using datasets from a number of sources, with a preference for fishery-independent research survey data that occurred throughout the NSB. In an effort to minimize bias towards areas identified based on socioeconomic importance, systematic/research surveys were used where available and commercial fisheries data such as fishery logs were generally not used to develop ecological features; two exceptions to this are for invertebrate presence-only records, and coral and sponge biomass. Research survey data or features developed by subject matter experts were used for all other ecological features. Where possible and relevant, random-stratified surveys were chosen and were corrected for observer effort.

Subject matter experts within the network governance partner organizations were consulted to review analysis methods and spatial features for their appropriateness for Marxan analyses through emails and in-person review sessions. The spatial features were displayed through SeaSketch. The spatial features were reviewed by stakeholders during an external review period from late 2017 to early 2018.

The recommended spatial features were used subsequently in a variety of iterative analyses to help characterize existing and proposed sites within draft network design scenarios as they were identified by the partners and to inform site selection analyses performed using the decision support tool Marxan. Spatial features that were not recommended for use in Marxan site selection analyses were included in the analyses with no target so that these non-Marxan features would not influence the analyses but their representation in the outputs could be tracked. These non-Marxan features were also included in iterative analyses to assess the representation of features within potential network design scenarios using the conservation gaps analysis tool, as well as reports generated by both partners and stakeholders via SeaSketch (see MPA Network BC Northern Shelf Initiative, 2023b, for more details).

The full list of E-CPS and associated spatial features are listed in the NAP (MPA Network BC Northern Shelf Initiative, 2023b) and included in Appendix A, including information on the spatial features included in spatial analyses.

ECOLOGICAL SPATIAL FEATURES

The identification, creation, processing, and analysis of the spatial features were carried out as part of MPATT to represent the ecological conservation priorities for the MPA network (Gale et al., 2019). Decisions on which data to include, as well as how to process and present each feature, was carried out by DFO Science and MPATT partners, and incorporated feedback from subject matter experts. The data have been used to identify areas of high ecological value (e.g., using the Marxan decision support tool) and are incorporated into 'performance metrics' that describe the ecological attributes of potential sites of interest. The data are intended for use at the scale of the NSB, and caution should be used for finer-scale analyses.

The features are archived in a series of 13 geodatabases on the GIS Hub, an internal service hosted by DFO Science. Metadata records for each ecological spatial feature are presented below following a standard template to provide an overall summary and details on the methods, data sources, accuracy and completeness, uncertainties, use restrictions, and references. The geodatabases on the GIS Hub have been uploaded for archival purposes, and are not intended to be shared or distributed. Not all features in the database are permitted to be shared. A subset of the data that is shareable is available on request.

The records are organized by taxonomic groups for the species-based E-CPs (algae and plants, birds, fishes and invertebrates, mammals and reptiles), followed by the area-based E-CPs organized by the finer-scale habitats and coarse-scale habitat classification systems. Within each section, the metadata for the spatial features may be separated further into subgroups based on the feature type, data sources, and/or the methods used to developed the features. For example, within the section on marine birds spatial features, the features representing seabird colonies are described together as they were generated from the same data sources and represent similar features for a suite of species. Density features representing offshore and nearshore marine bird distribution are also described together, while a third subgroup describes the remaining marine bird spatial features compiled by MPATT.

All features can be viewed on the MPA Network Seasketch portal. Metadata for each feature is linked in the sumamries below, which is embedded in the spatial feature and is also available through Seasketch (right click on feature in the Data Layers window and select "View Description").

Area-Based

NSB MPA Network Ecological Data - Area Features

Summary:

There are 10 features in the 'Area' geodatabase:

- (1) Areas of high rugosity
- (4) Fish and invertebrate diversity and biomass hotspots
- (1) Important Bird Areas
- (1) Nearshore habitat richness hotspots
- (1) Estuaries

- (2) Areas of high tidal current that meet Ecologically and Biologically Significant Area (EBSA) criteria, and those that require further research

Data Creators and Co-creators: Creator: Katie Gale; Co-Creators: Pacific Estuary Conservation Program (estuaries), Emily Rubidge (hotspots), British Columbia Marine Conservation Analysis (rugosity), Bird Studies Canada (Important Bird Areas), MPATT Science Team

Methods and links to metadata:

Areas of high rugosity

- Areas of high rugosity

This feature was obtained from the BCMCA. It was developed from a 75 m bathymetry model (produced by Natural Resources Canada using Canadian Hydrographic Service data) processed using the benthic terrain modeller (BTM) tool. Information on the original data processing dan be found in the BCMCA metadata.

Fish and invertebrate diversity and biomass hotspots:

- Benthic fish diversity
- Shelf fish biomass hotspots
- Shelf invertebrate biomass hotspots
- Shelf invertebrate diversity hotspots

Longline Data: Fish diversity was calculated from count per unit effort (CPUE; count/hook/hr) from Pacific Halibut Management Association (PHMA) surveys (Doherty et al., 2019). PHMA surveys are standardized, depth-stratified random longline surveys that are carried out at depths of 20–260 m. All species caught are weighed or counted and identified to the lowest possible taxonomic level. Data was extracted from DFO's GFBio database on 18 April 2017, limiting the query to records quality-tagged as "fully usable". The PHMA dataset spans August 2006 - August 2016 and includes records taken in the months of August and September. Shannon Diversity (H') was calculated from CPUE of fish species using the diversity function in the R package 'vegan'.

Trawl Data: Fish and invertebrate biomass and diversity was calculated from CPUE (kg/hr) from DFO synoptic groundfish bottom trawl surveys that are carried out at depths of 50–1300 m (Olsen et al., 2009; Workman et al., 2007). DFO synoptic surveys are standardized, depth-stratified random bottom trawl surveys in four regions of BC that cover the continental shelf of BC: West Coast Haida Gwaii, Hecate Strait, Queen Charlotte Sound, and West Coast Vancouver Island. These surveys do not include inlets, enclosed waters, sensitive habitats (e.g., Hecate Strait Glass Sponge reefs, Learmonth Bank Red Tree corals, Rockfish Conservation Areas), areas that are not trawlable or the steep slope off the southwest part of Haida Gwaii (Workman et al., 2007; Olsen et al., 2009). All species caught are weighed or counted and identified to the lowest possible taxonomic level. Data was extracted from DFO's GFBio database on 28 November 2016, limiting the query to records quality-tagged as "fully usable". The synoptic dataset spans July 2003 - June 2016, and includes samples from the months of May to October, but most are from May to July.

Total biomass was calculated from the sum of CPUE from all fish taxa in each fishing event (trawl tow). Shannon Diversity (H') was calculated from CPUE of fish species using the diversity function in the R package 'vegan'.

Biomass and Shannon diversity values were used to detect hotspots using the Getis-Ord G tool. The G statistic represents the local neighbourhood sum compared proportionally to the sum of all features in the study area. When the local sum is significantly different from the expected sum, then that site is identified as a hotspot (Gi_Bin>0), a cold spot (Gi_Bin<0), or neutral (Gi_Bin=0). A 10 km distance value was used as the neighbourhood size. The false discovery rate correction was applied, which accounts for multiple testing and spatial dependence. Absolute Gi_Bin values of 1, 2, and 3 correspond to 90, 95, and 99% confidence, respectively. Using the Minimum Bounding Geometry Tool, convex hull polygons were drawn around groups of hotspot points (confidence ≥90%) containing 10 or more points. The resulting polygons were then buffered by 1 km and manually edited where needed to exclude any large areas of the polygons that did not include hotspot points.

Important Bird Areas

- Important Bird Areas

From Bird Studies Canada: This layer represents generalized boundaries of 'Important Bird Areas (IBA) in Canada. IBAs, in Canada and elsewhere, are evaluated and designated on the basis of internationally recognized and standardized criteria. The polygons contained in the dataset meet these criteria and are therefore deemed significant at the national, continental, or global level.

In Canada, IBAs are not legally recognized entities and therefore do not have any regulatory status. Nevertheless, they are extremely useful for conservation planning for birds. In 2004, polygon boundaries were digitized on-screen in ArcView GIS 3.2 using NTDB 1:50K or 1:250K digital layers for reference. If NTDB coverage was not available (e.g., far north), the Digital Chart of the World (1:1M) was used. The boundaries of IBAs in this dataset are intentionally generalized to reflect the importance of the surrounding ecosystem on the values present within IBAs. For example, small islands supporting colonies of seabirds might be buffered by 1 or 2 km to form an IBA. The boundaries of terrestrial IBAs were "fuzzed" in a similar manner. Boundaries for a very small minority of IBAs were available in paper form as part of IBA conservation plans that had been developed previously. In such cases, we visually estimated their boundaries against the NTDB or other base layers. Many IBAs are already recognized as other types of protected areas, e.g., National Wildlife Areas, National and Provincial Parks, Migratory Bird Sanctuaries, conservation reserves, and so on. In these cases, we used digital boundaries from other sources (e.g., WWF Canada's Designated Areas Database, Environment Canada's Canadian Conservation Areas Database) as reference points when digitizing IBA boundaries. In 2009, Bird Studies Canada began a process to update the boundaries of some of our IBAs and to correct others that had been incorrectly delineated in 2004. The recent advent of tools such as Google Earth and other similar mapping tools, and the availability of better topographic and other base data (e.g., Environment Canada's CARTS database of protected areas), have made the updating process much easier and more accurate. As of 2009, ArcGIS 9.3 or higher is being used to create/adjust IBA polygon boundaries.

The Canadian IBA directory is available here.

Nearshore habitat richness hotspots

- Nearshore habitat richness hotspots

Habitat richness was calculated from eight habitat features: eelgrass, surfgrass, canopy-forming kelp, estuaries, areas of high rugosity, and hard, mixed, and soft substrate.

Layers for eelgrass, surfgrass, canopy-forming kelp, and estuaries were assembled as part of an assessment of nearshore EBSA features (Rubidge et al., 2020).

- The kelp and eelgrass layers consist of polygons and ShoreZone biobands available from the BCMCA.
- The estuary layer is from the Pacific Estuary Conservation Program (PECP), most recently updated in 2018, but originally developed in 2007 (Ryder et al., 2007).

The layer representing areas of high rugosity is from BCMCA, and was developed using the Benthic Terrain Modeller (BTM) ArcGIS tool and a 75 m bathymetry model from Natural Resources Canada. Layers representing hard, mixed, and soft substrate in nearshore waters (0- 50 m) were used from a bottom patch model developed by Gregr et al. (2013).

The nearshore area represents shallow coastal areas (any location 2 km from the coastline or shallower than 20 meters depth) and internal waterways and inlets. The eight layers were clipped to the nearshore area and overlaid with each other in ArcMap 10.4. Habitat richness was calculated by summing the number of features within 1 km x 1 km planning units. Habitat richness values were used to detect hotspots of habitat richness within the nearshore area using the Getis-Ord G tool. The G statistic represents the local neighbourhood sum compared proportionally to the sum of all features in the study area. When the local sum is significantly different from the expected sum, then that site is identified as a hotspot (high values; Gi_Bin>0), a cold spot (low values; Gi_Bin<0), or neutral (Gi_Bin=0). A 1 km distance value was used as the neighbourhood size. The false discovery rate correction was applied, which accounts for multiple testing and spatial dependence. Absolute Gi_Bin values of 1, 2, and 3 correspond to 90, 95, and 99% confidence, respectively. For the purpose of MPA network planning, only 1 km planning units with Gi_Bin values of 3 (99% confidence) were classified as habitat richness hotspots.

Estuaries

- Estuaries

Ryder et al. (2007) describe the methods for identifying and mapping 442 of BC's estuaries on behalf of the PECP using standardized criteria and GIS tools.

The project provided a quantifiable regional overview of estuary habitats that links existing biophysical data and attributes to assist conservation planning. Individual estuaries were ranked for their biological importance to waterbirds (ducks, geese, swans, loons, and grebes) using data and metrics of estuary size, habitat type and rarity, herring spawn occurrence, waterbird use, and intertidal biodiversity.

Areas of high tidal current that meet EBSA criteria, and those that require further research

- Areas of high tidal current

A May 2017 Science Response (DFO, 2020*a*; Rubidge et al., 2020) assessed areas of high tidal current against the EBSA criteria while focusing on select areas that have associated biological information. This was not a comprehensive assessment of all areas that are considered to have high tidal currents on our coast but a starting point to recognize that local tidal currents, topography and bathymetric complexity play an important role in the spatial configuration of nearshore biodiversity patterns. Four specific high tidal current areas were assessed, and at this time, there is enough evidence to support the designation of Hoeya Head Sill, Nakwakto Rapids and Stubbs Island as nearshore EBSAs, although the boundaries of these areas need to be finalized upon further review. Mathieson Narrows is an area of interest for EBSA designation, and further analyses will inform this designation in future EBSA processes.

Temporal Coverage:

2003-01-01 to 2017-01-31

Scripts/Software:

Code used to develop the diversity, biomass, and nearshore habitat richness hotspots can be found at the MSEA GitLab page.

Data Sources:

- **Areas of high rugosity**: Feature obtained directly from the BCMCA.
- **Fish and invertebrate diversity and biomass hotspots**: DFO synoptic trawl and PHMA longline research survey data. Available separately at `https://www.gis-hub.ca/dataset/diversity-richness-biomass-hotspots`, and described in Rubidge et al. (2018).
- **Important Bird Areas**: From Bird Studies Canada/Bird Life International.
- **Nearshore habitat richness hotspots**: Habitat richness was calculated from eight habitat features: eelgrass, surfgrass, canopy-forming kelp, estuaries, areas of high rugosity, and hard, mixed, and soft substrate. Available separately at `https://www.gis-hub.ca/dataset/diversity-richness-biomass-hotspots`, and described in Rubidge et al. (2018).
  - The kelp and eelgrass layers consist of polygons and ShoreZone biobands from the BCMCA.
  - The estuary layer is from the PECP, most recently updated in 2018, but originally developed in 2007 (Ryder et al., 2007).
  - The layer representing areas of high rugosity is from BCMCA.
  - Layers representing hard, mixed, and soft substrate in nearshore waters (0-50 m) were from the Bottom Patch substrate model.
- **Estuaries**: Feature obtained from the PECP (Ryder et al., 2007).
- **Areas of high tidal current that meet EBSA criteria, and those that require further research**: From Rubidge et al. (2020).

Absence Data:

No absence data

Uncertainties:

Each feature has uncertainties based on its input data and processing steps. Notable uncertainties are described in each feature's individual metadata.

Species Data:

n/a

Maps of available datasets:

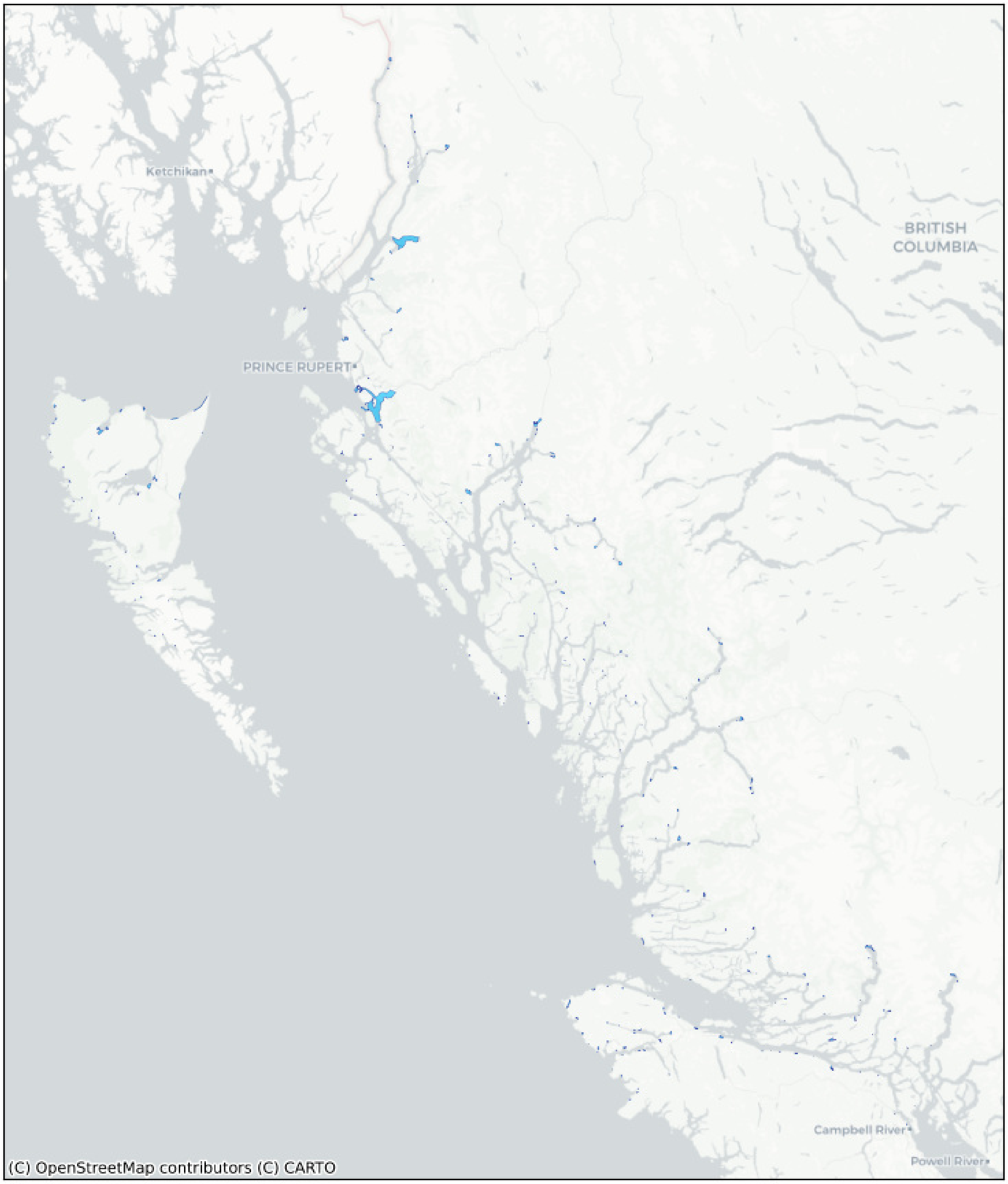

Figure 5: Estuaries delineated by the Pacific Estuary Conservation Program (Ryder et al., 2007).

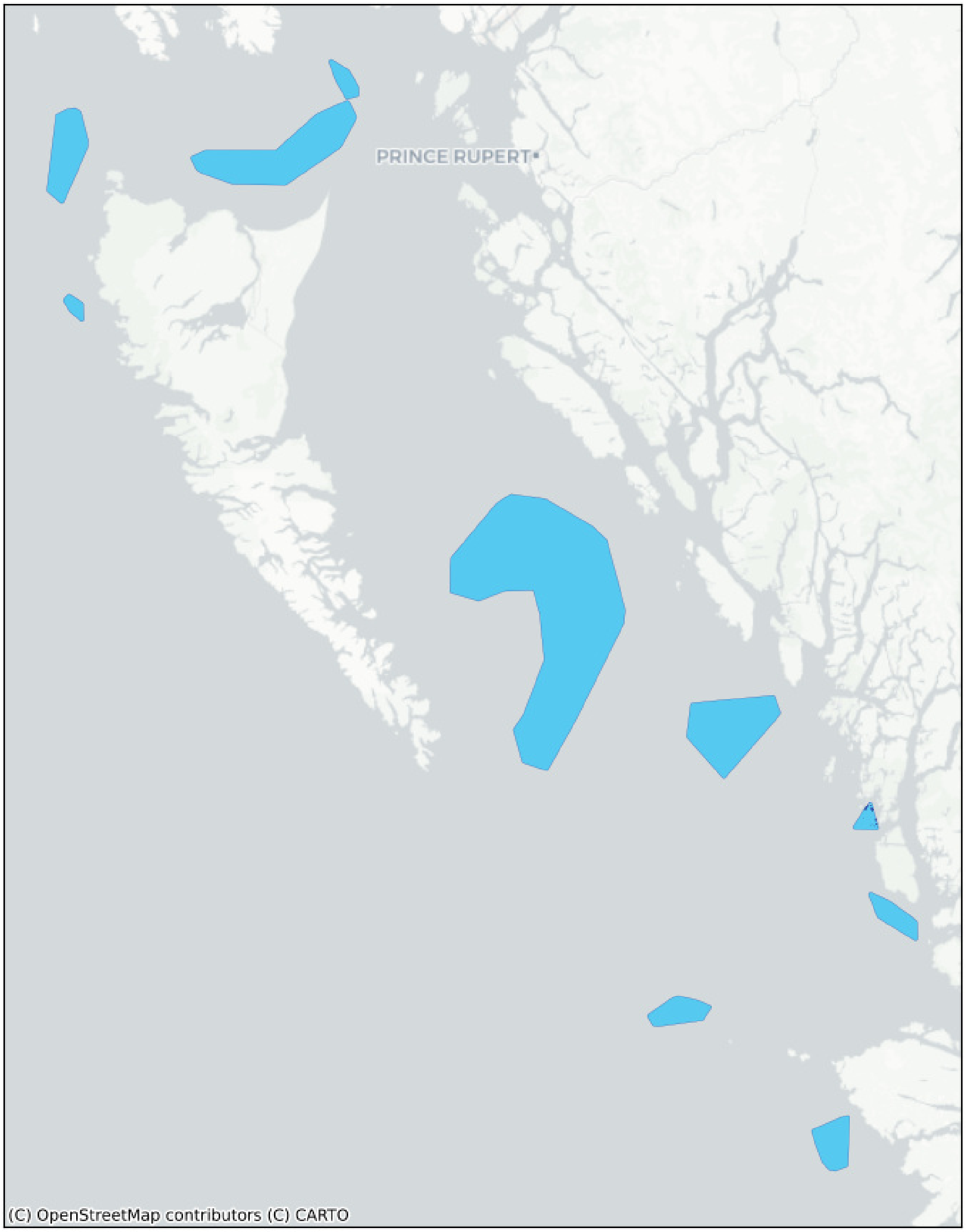

Figure 6: Fish diversity (Shannon Diversity) hotpots in shelf and nearshore areas (Rubidge et al., 2018). Shelf hotspots used DFO groundfish synoptic trawl survey data, and nearshore hotspots used PHMA longline survey data. Hotspots represent areas where groups of points (fishing events) had diversity values higher than expected compared to neighbouring points.

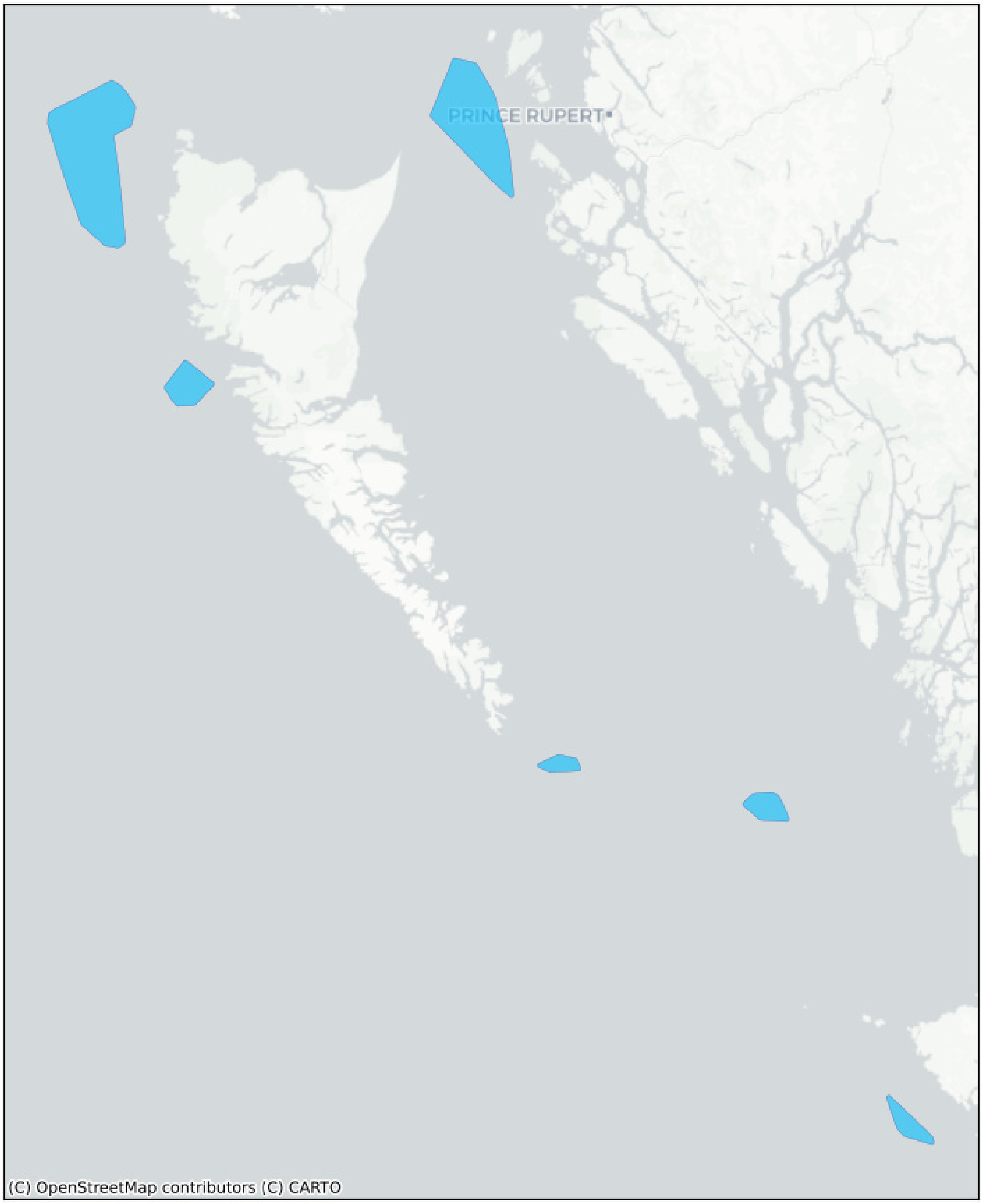

Figure 7: Hotpots of fish biomass from DFO synoptic trawl surveys (Rubidge et al., 2018). Hotspots represent areas where groups of points (fishing events) had biomass values higher than expected compared to neighbouring points.

Figure 8: Areas of high tidal currents that meet Ecologically and Biologically Significant Area criteria (Rubidge et al., 2020). This dataset contains three areas: Nakwakto Rapids, Hoeya Head Sill, and Stubbs Island.

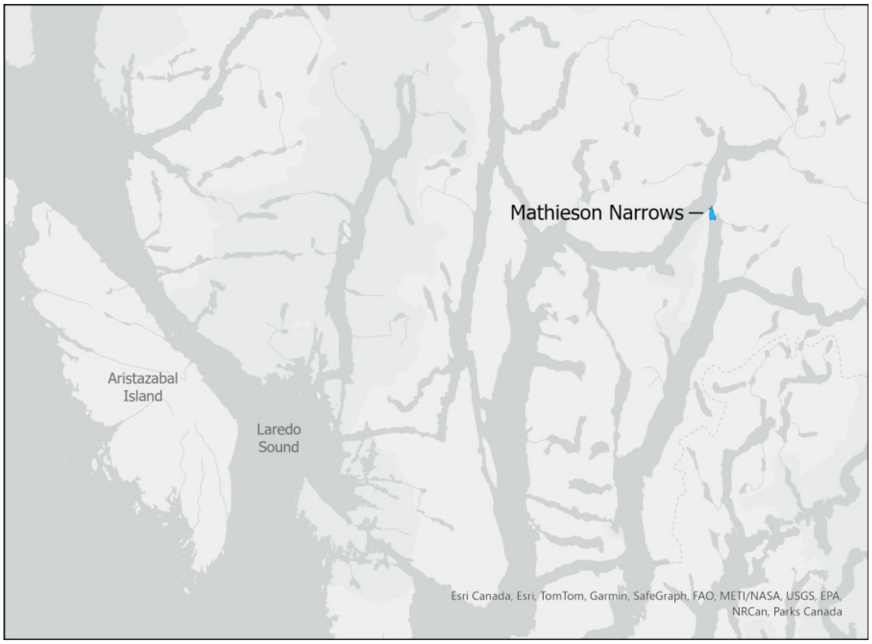

Figure 9: Areas of high tidal current that may meet Ecologically and Biologically Significant Area criteria, but which require additional research (Rubidge et al., 2020). This dataset contains one area: Mathieson Narrows.

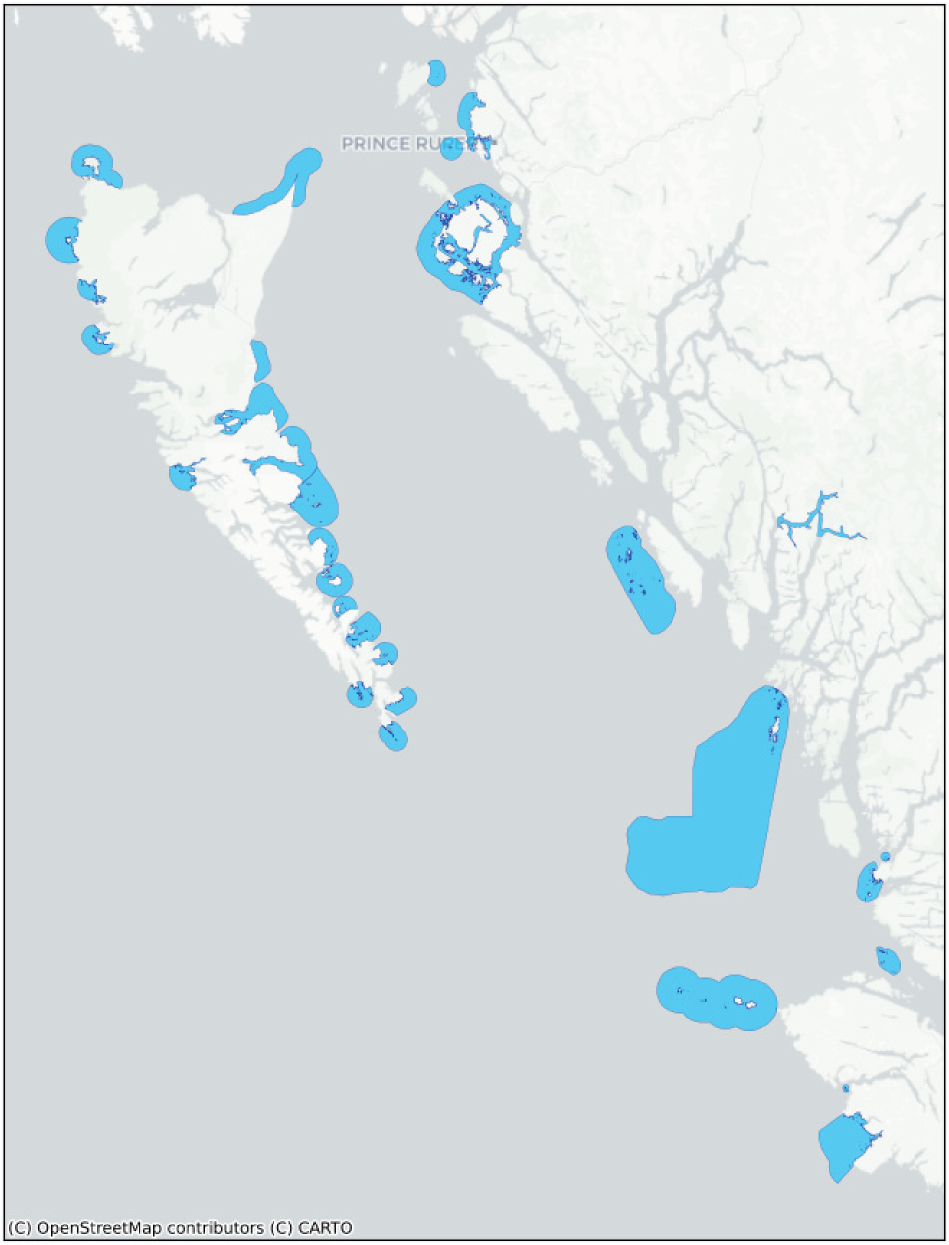

Figure 11: Areas identified as globally important for the conservation of bird populations by BirdLife International.

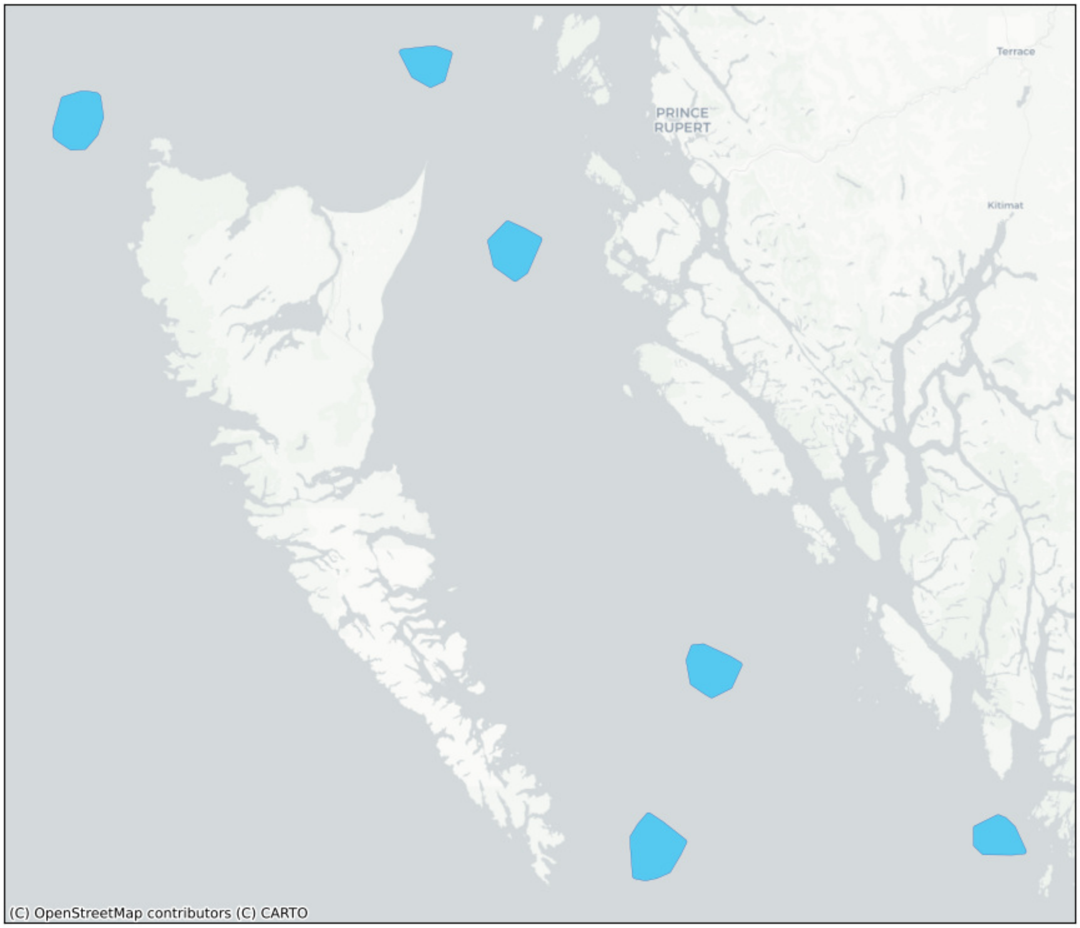

Figure 12: Hotpots of invertebrate biomass from DFO synoptic trawl surveys (Rubidge et al., 2018). Hotspots represent areas where groups of points (fishing events) had biomass values higher than expected compared to neighbouring points.

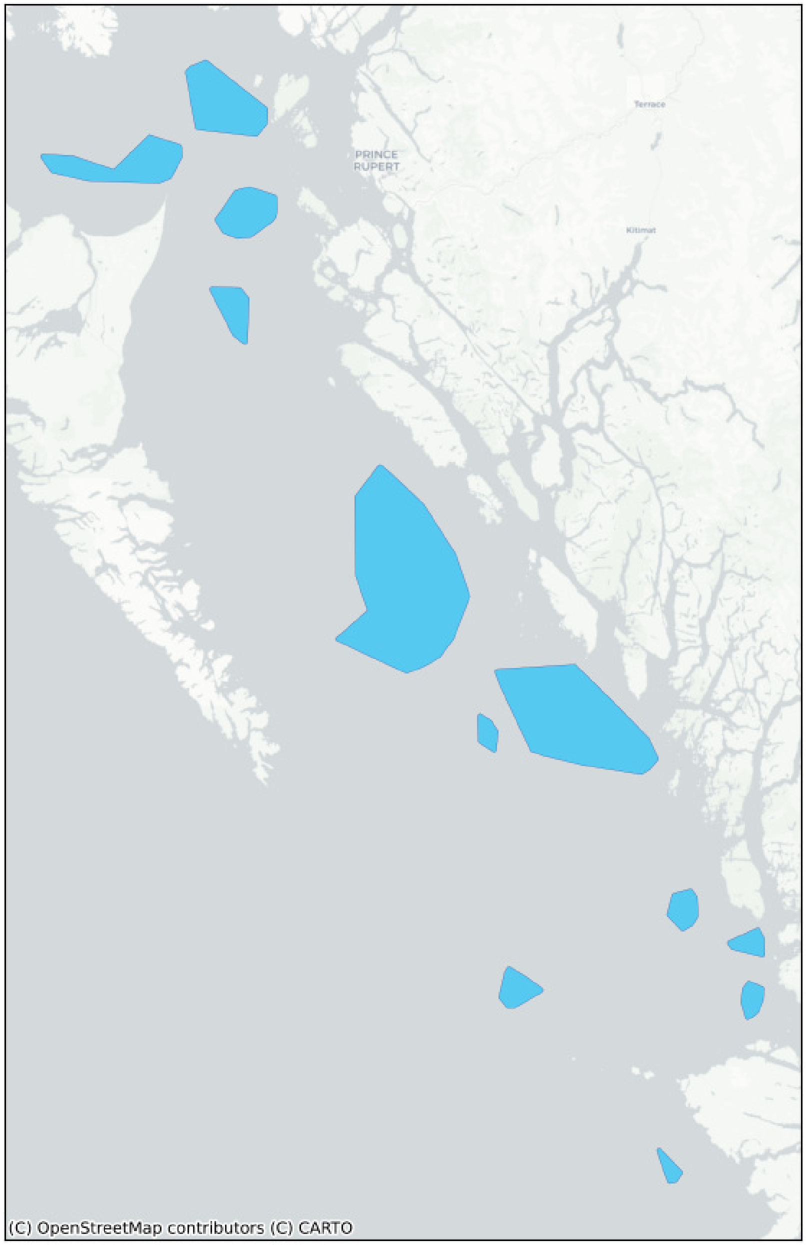

Figure 13: Invertebrate diversity (Shannon diversity) hotpots from DFO synoptic trawl surveys (Rubidge et al., 2018). Hotspots represent areas where groups of points (fishing events) had biomass values higher than expected compared to neighbouring points.

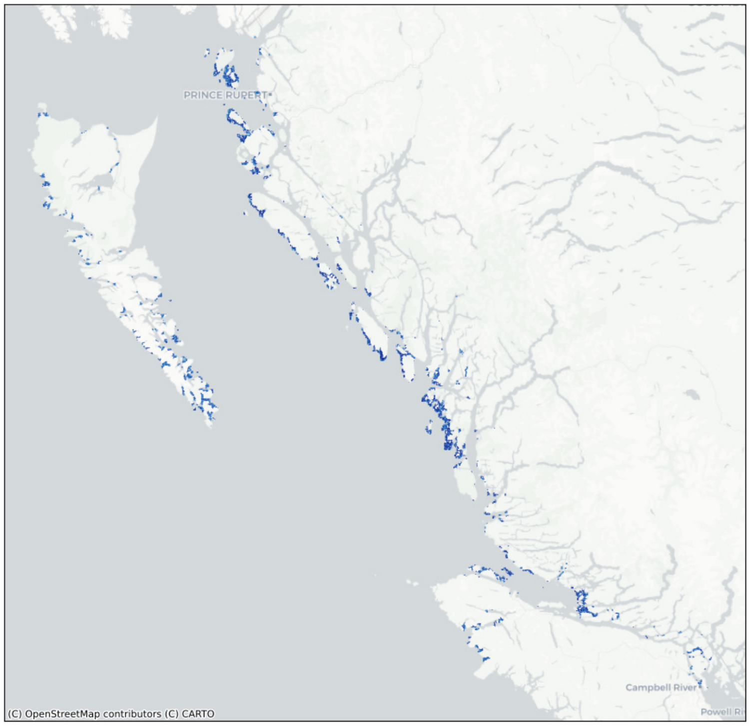

Figure 14: Hotpots of nearshore habitat richness (Rubidge et al., 2018), considering 8 habitat types (eelgrass, surfgrass, kelp, estuaries, high rugosity, soft substrate, mixed substrate, and hard substrate). Hotspots represent areas where 1 km grid cells have more habitat types than expected compared to neighbouring points.

NSB MPA Network Ecological Data - Coarse Features

Summary:

There are 72 features in the 'Coarse' geodatabase, which represent individual classes or divisions in 7 different ecological classifications. The particular analyses carried out by for the MPA Network required the classes to be split out. The features are:

- (5) Pacific Marine Ecological Classification System (PMECS) Biophysical Units
- (3) Bottom Patch substrate type
- (14) Shorezone Coastal Classes
- (13) Ecologically and Biologically Significant Areas
- (8) British Columbia Marine Ecological Classification (BCMEC) Ecosections
- (14) PMECS Geomorphic Units
- (15) Upper Ocean Subregions

Data Creators and Co-creators: Creator: Katie Gale; Co-Creators: Province of BC (coastal classes, ecosections), BCMCA and Parks Canada Agency (upper ocean subregions), Emily Rubidge, Carrie Robb, Karin Bodtker (PMECS), Ed Gregr and Joanne Lessard (Bottom Patches), Cathryn Clarke (EBSAs), MPATT Science Team

Methods and links to metadata:

Pacific Marine Ecological Classification System (PMECS) Biophysical Units

- Biophysical units

Under the Pacific Marine Ecological Classification System (PMECS; DFO, 2016; Rubidge et al., 2016), biophysical units are areas of distinct physiographic and oceanographic conditions and processes that shape species composition at spatial extents of 1000s of km. Rubidge et al. (2016) used a two-step process to identify biophysical units in British Columbia. First, a cluster analysis based on the similarity of species composition was used to group sites with similar species into distinct biological assemblages. Second, a random forest analysis was used to identify environmental correlates of the biological assemblages identified by the cluster analysis and to predict and assign the biological assemblage present in areas with too few biological data. Indicator species for each assemblage (biophysical unit) were also identified.

Five biophysical units were identified: Continental Shelf, Troughs, Dogfish Bank, Other Banks, and the Continental Slope. Depth, salinity, and temperature range were the most important variables for distinguishing the units. Additional details are available at the metadata link above. Full methods are available in Rubidge et al. (2016), and a summary is available in DFO (2016).

Two nearshore grid cells were removed from the published version of the biophysical units for the analyses carried out in the NSB MPA Network planning process.

Bottom Patch substrate type

- Bottom Patches

Bottom patches were created to represent bottom type for the entire Pacific Canadian coast from the high high water line to a depth of 50 m. As a polygon representation, the bottom patches describe patches of similar substrate prescribed by depth classes and the available field observations. In the areas where no observations are available, predicted bottom type values are used. The approach is described in Gregr et al. (2013), as a spatial framework for representing nearshore ecosystems.

Shorezone Coastal Classes

- Shorezone Coastal Classes

This dataset contains a subset of data collected by the provincial government in an effort to map and classify the entire BC coastline. The BC Shorezone Mapping System (Howes et al., 1994) is a systematic methodology for mapping the biophysical character of the entire BC coastline, by way of aerial low tide oblique surveys. The system involves the subdivision of the coastline into along-shore units and across-shore components.

Coastal classes are a summary of shoreunit morphology and substrate in terms of one of 36 different criteria categories defined by a systematic consideration of substrate, sediment, width and slope. Coastal class is an indicator of repeatable collections of across-shore detail on the morphology and sediment components contained within the shoreunit. For the NSB MPA Network planning process, the BCMCA coastal classes layer was dissolved based on the primary component of each coastal class definition to obtain 14 distinct classes: Channel, Estuary (Organics/Fines), Gravel Beach, Gravel Flat, Man made, Mud Flat, Rock Cliff, Rock Platform, Rock Ramp, Sand and Gravel Beach, Sand and Gravel Flat or Fan, Sand Beach, Sand Flat, and Undefined.

Ecologically and Biologically Significant Areas (EBSAs)

-EBSAs

EBSAs are areas of relatively higher ecological or biological significance than surrounding areas, where greater risk aversion is required in the management of activities (DFO, 2004). Within the EBSA boundary, perturbations are also expected to cause greater ecological consequences than in surrounding areas exposed to comparable perturbations. Criteria to identify EBSAs have been established at the national (DFO, 2004) and international (Convention on Biological Diversity, 2008) levels. Areas that rank High for one or more of uniqueness, fitness consequences, or aggregation can be designated as an EBSA. A feature or area that ranks above average (Medium or High) across multiple criteria also meets the EBSA criteria.

In the NSB, broad-scale IAs and EBSAs were identified in Clarke and Jamieson (2006*a*,*b*) and DFO (2013*a*). Species IAs were identified on the basis of species experts' knowledge on the biology of individual species, or groups of species, and the EBSAs were primarily identified on the basis of expert knowledge about physical and oceanographic features that also overlap with IAs for at least one species or species group.

There are 17 broad-scale EBSAs that have been mapped in the NSB: 15 identified in Clarke and Jamieson (2006*b*) and two identified in DFO (2013*a*). These EBSAs are: Hecate Strait Front, McIntyre Bay, Dogfish Bank, Learmonth Bank, Brooks Peninsula, Cape St. James, Shelf Break, Scott Islands, North Island Straits, Sponge Reefs (four separate areas were counted each as separate EBSAs), Chatham Sound, Haida Gwaii Nearshore, Central Mainland (referred to as Caamaño Sound in Clarke and Jamieson, 2006*b*), and Bella Bella Nearshore.

For the NSB MPA Network planning process, the Sponge Reef EBSAs were not included because there is a separate dataset being used to represent the full distribution of known sponge reefs.

British Columbia Marine Ecological Classification (BCMEC) Ecosections

- BCMEC Ecosections

The BCMEC is a hierarchical classification of Provincial marine areas with five nested levels: Ecozones, Ecoprovinces, Ecoregions, Ecosections, and Ecounits (Harper et al., 1993; Zacharias et al., 1998; AXYS Environmental Consulting Ltd., 2000, 2001). The 12 Ecosections were delineated based on ocean mixing and stratification.

For the NSB MPA Network planning process, the Ecosections shapefile from the BCMCA was clipped to the MPA Network coastline. BCMCA had extended the original DataBC Ecosection file onto land to ensure that other spatial data based on different coastlines could be assigned to the correct Ecosection. The official Ecosection file can be obtained from DataBC.

PMECS Geomorphic Units

- Geomorphic units

Under PMECS (DFO, 2016; Rubidge et al., 2016), geomorphic units or geozones are discrete geomorphological structures at the scale of 100s of km that are assumed to have distinctive biological assemblages (e.g., plateaus, ridges, seamounts, canyons). Although the spatial scale of geomorphic units is nested within biophysical units, a single geomorphic unit such as a trough may span more than one biophysical unit.

Rubidge et al. (2016) used the benthic terrain modeller (BTM) tool with broad and fine-scale benthic positioning index (BPI) parameters to define geomorphic units on the continental shelf in the NSB and the continental slope in both the NSB and Southern Shelf Bioregion. The study area was split into three analysis regions: the continental slope, the continental shelf, and the fjordal areas of the continental shelf. Using unit names proposed by Greene et al. (2008), the continental shelf fjords and the continental shelf were each classified into crests, mounds, steeply sloping walls, depressions, and depression floors, and the continental slope was classified into ridges, sloping walls, steeply sloping walls, and canyon floors. The features identified by the BTM were cross-referenced, where possible, against undersea feature names in the Canadian Gazetteer, although the point locations of features named in the gazette are not always accurate or informative, particularly for large features. Methods details, including BPI parameters and classification rules, can be found in Rubidge et al. (2016).

Upper Ocean Subregions

- Upper Ocean Subregions

Oceanographic Regions (also referred to as Upper Ocean Subregions) are part of a classification for the coast of BC with 24 divisions that were derived from expert knowledge, primary literature, satellite imagery, and oceanographic modelling (Robinson and McBlane, 2013). The analysis was restricted to the upper ocean (approximately 20-30 m depth) and to oceanographic processes linked to enhancing nutrient supply to surface waters. This dataset was obtained from the BCMCA, which received the data from Parks Canada. The original source metadata can be viewed here.

Temporal Coverage:
1979-01-01 to 2014-12-31

Scripts/Software:
n/a

Data Sources:

- **Pacific Marine Ecological Classification System (PMECS) Biophysical Units**: From Rubidge et al. (2016). Species data was taken from DFO standardized fisheries-independent research surveys: groundfish trawl and long-line (2003-2013), Tanner Crab trawl and trap (2000–2006), and Dungeness Crab trap (2000–2014). Environmental data came from NASA, the Canadian Hydrographic Service, DFO, Bio-ORACLE, and elsewhere (details in Rubidge et al., 2016).
- **Bottom Patch substrate type**: Available directly at `https://www.gis-hub.ca/dataset/bops.` Input data included bathymetry from the Canadian Hydrographic Service and substrate observations from DFO, Coastal Oceans and Resources, Inc. (CORI; Shorezone Mapping System), the Hakai Institute, and the Central Coast Indigenous Resource Alliance (CCIRA).
- **Shorezone Coastal Classes**: From the BCMCA.
- **Ecologically and Biologically Significant Areas**: From Clarke and Jamieson (2006*b*).
- **British Columbia Marine Ecological Classification (BCMEC) Ecosections**: From DataBC.
- **PMECS Geomorphic Units**: From Rubidge et al. (2016). Input data for the BPI analysis was a 75 m resolution raster produced by Natural Resources Canada using Canadian Hydrographic Service data.
- **Upper Ocean Subregions**: From the BCMCA.

Absence Data:
No absence data

Uncertainties:
Each feature has uncertainties based on its input data and processing steps. Notable uncertainties are described in each feature's individual metadata.

Biophysical units:

- Although the biophysical units are presented as polygons that suggest hard spatial boundaries and a clear distinction between adjacent units, the boundaries between the units should be considered to be transition zones where the biological and environmental conditions are changing over gradients. Rubidge et al. (2016) show that uncertainty in the random forest model is highest at the boundaries between units, particularly at the southern boundary of Dogfish Bank, around the Other Banks unit, and running along the length of the boundary between the Shelf and Slope units. The model also performs poorly in the Strait of Juan de Fuca, possibly because the influences of complex local currents, and because eddies in the area are not accurately captured in the broad-scale environmental data used to predict the biophysical units.

Geomorphic units:

- Although geomorphic units are assumed to have distinctive species assemblages, future work is required to characterize any biological correlations.

Oceanographic regions:

- The boundaries of the Oceanographic Regions should be considered "fuzzy" because of temporal and spatial variability in the location of water masses due to surface winds and tidal currents, but pragmatically, the boundaries are represented on the maps as hard lines to facilitate presentation. The shoreward boundary of the Oceanographc Regions is the kelp zone or "white-strip" (depth of 30 m).

Species Data:
n/a

Maps of available datasets:

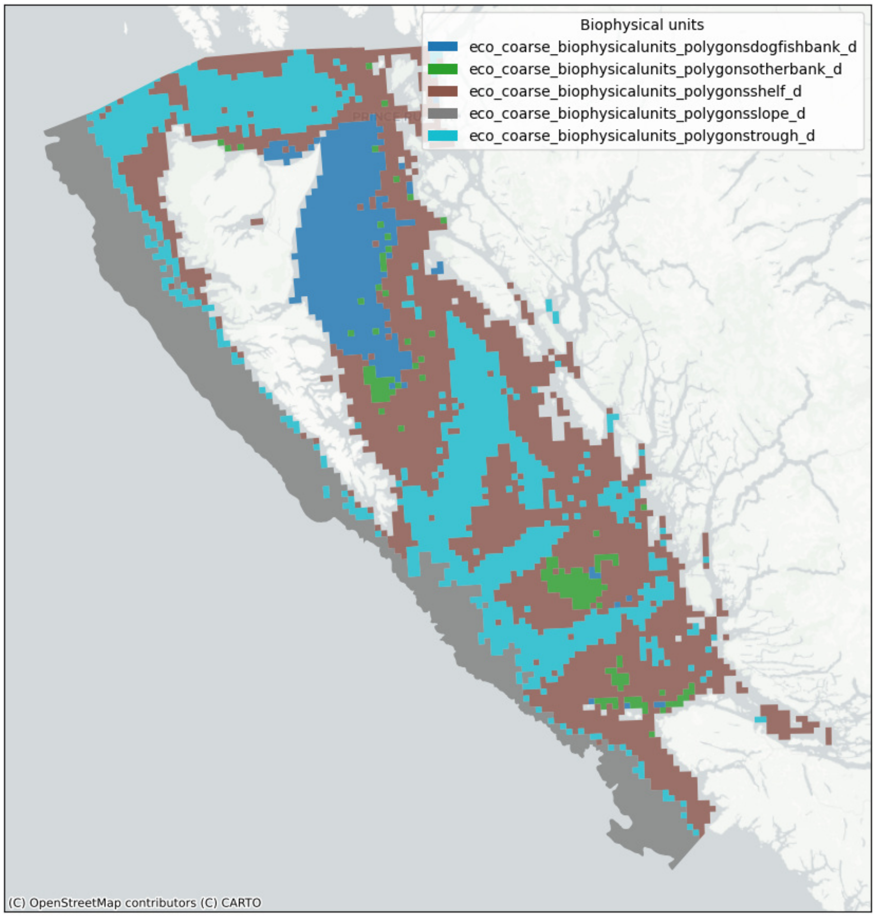

Figure 15: Biophysical units from Pacific Marine Ecological Classification (PMECS; Rubidge et al., 2016).

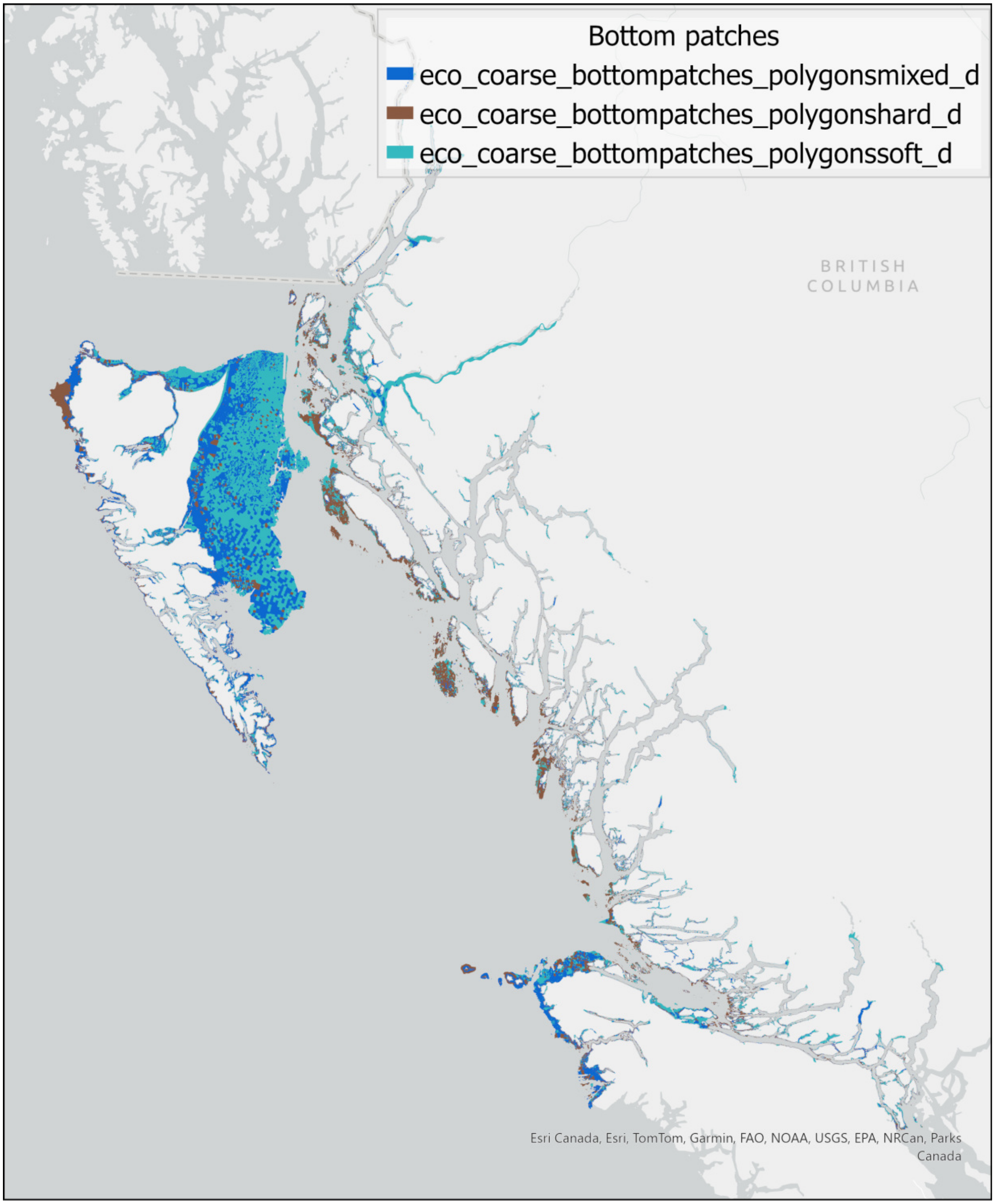

Figure 16: Hard, mixed, and soft components of the Bottom Patch substrate model.

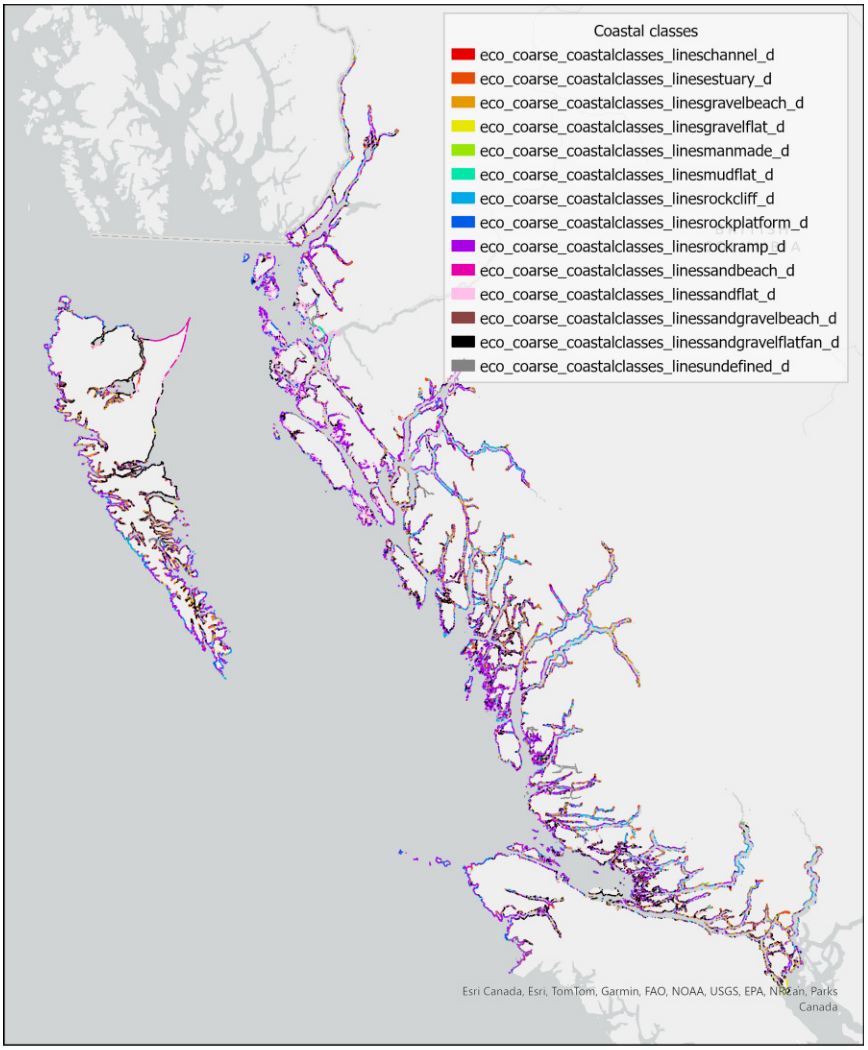

Figure 17: Shorezone Coastal Classes classification.

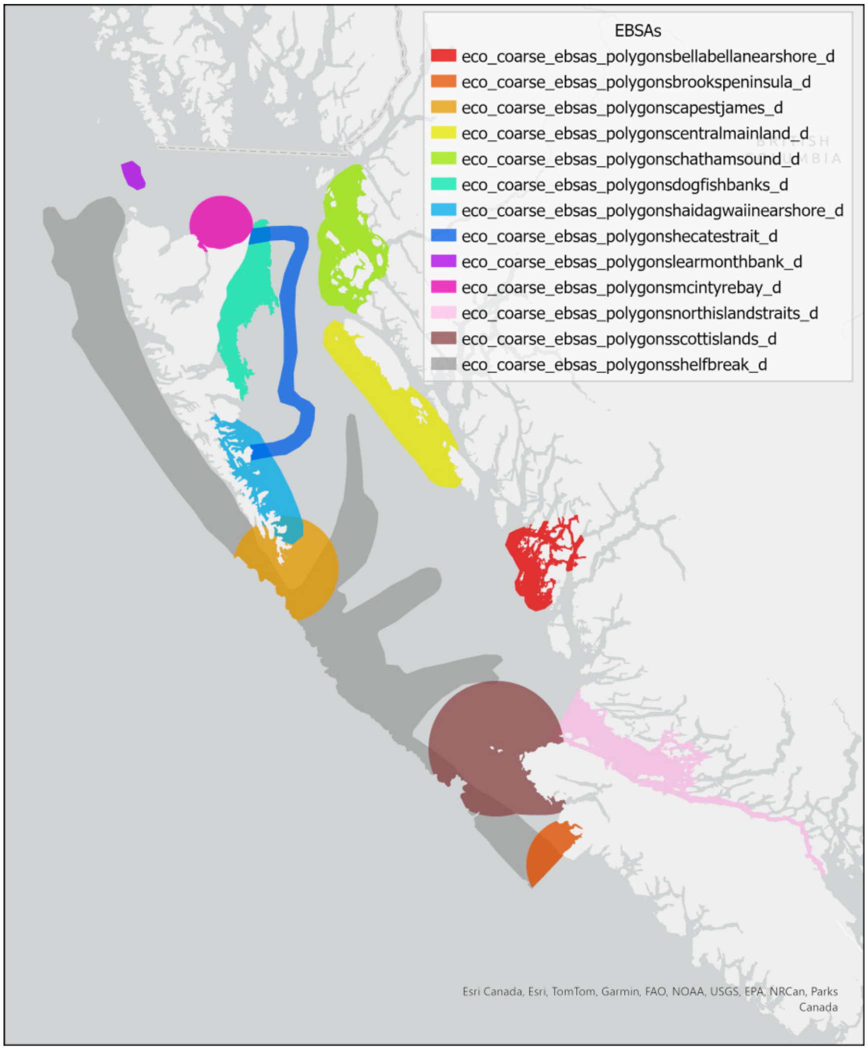

Figure 18: Ecologically and Biologically Significant Areas (EBSAs; Clarke and Jamieson, 2006*b*).

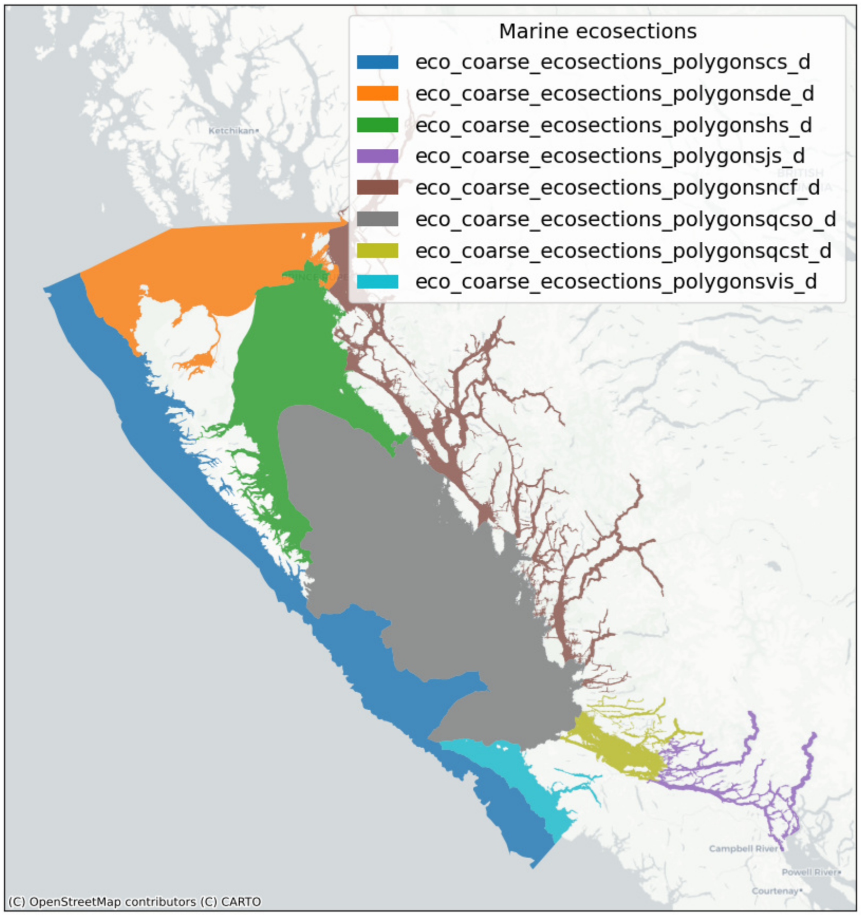

Figure 19: Marine ecosections from the British Columbia Marine Ecological Classification (BCMEC).

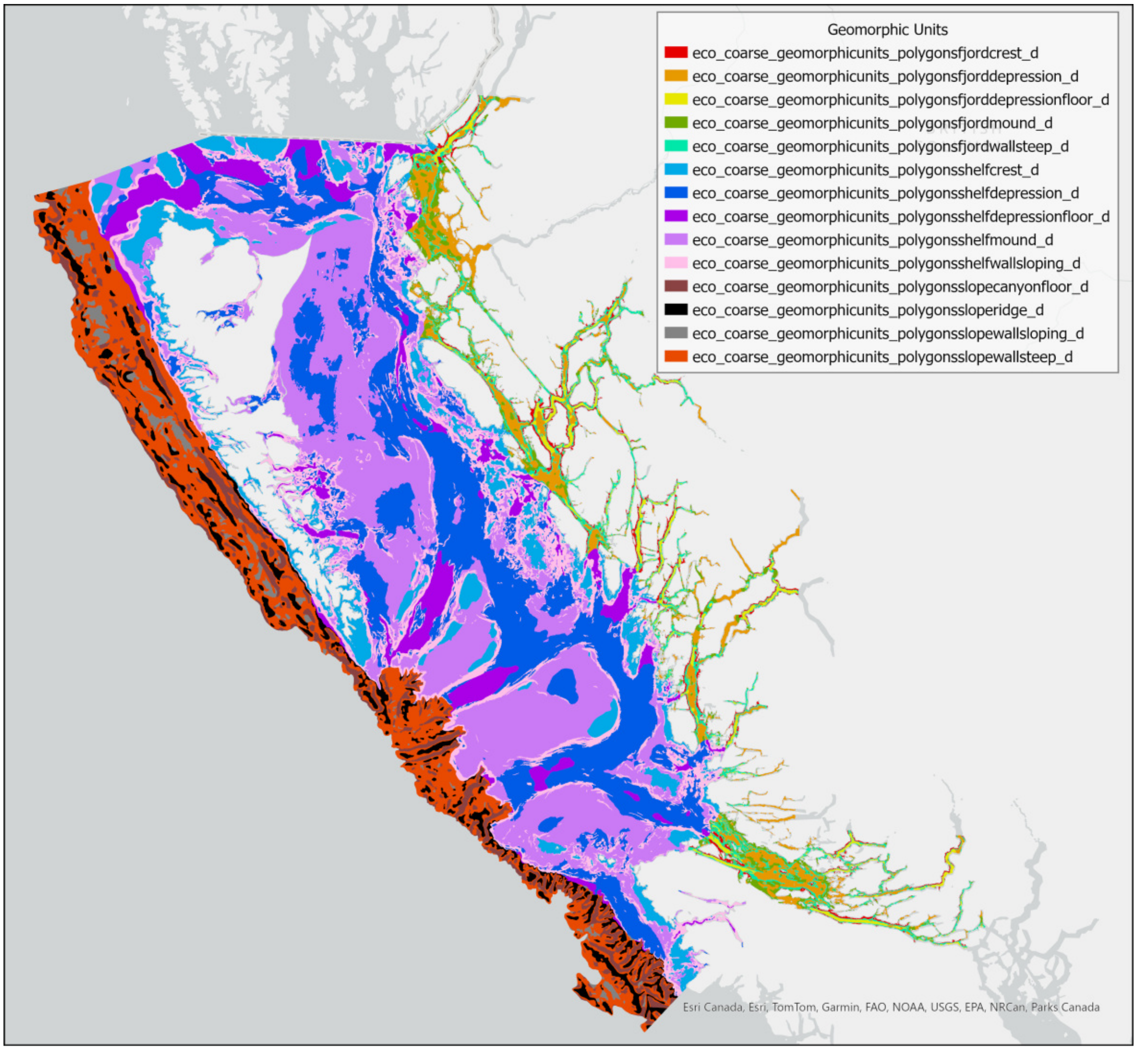

Figure 20: Geomorphic units from the Pacific Marine Ecological Classification System (PMECS; Rubidge et al., 2016).

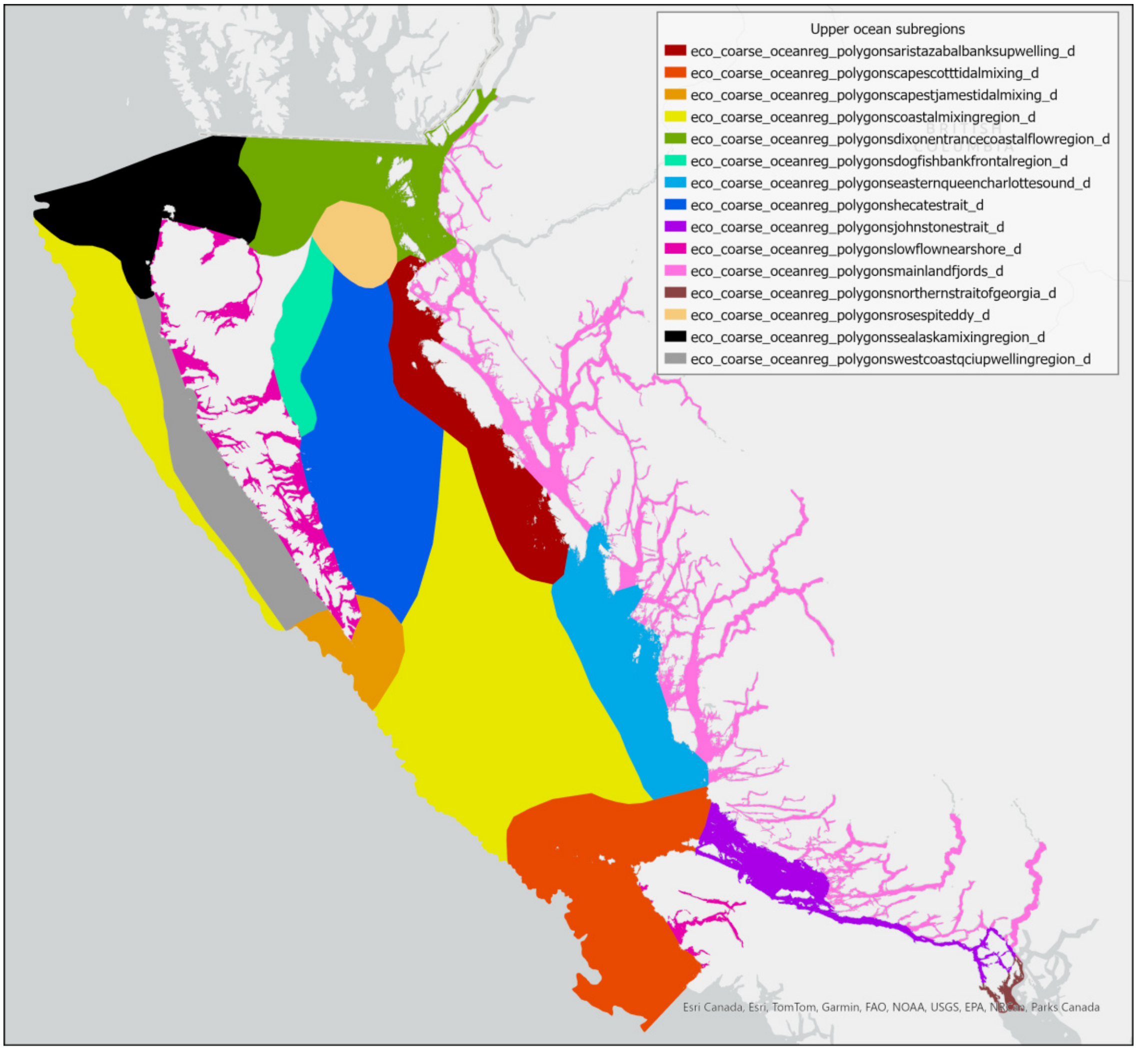

Figure 21: Oceanographic regions from the Upper-ocean Subregion classification.

Birds

NSB MPA Network Ecological Data - Bird Colonies

Summary:

There are 27 features in the 'Bird Colonies' geodatabase. The colonies for most species were assigned 'importance classes', and each importance class has been split into its own feature. The particular analyses carried out by for the MPA Network required the classes to be split out. The features are:

- (3) Ancient Murrelet colonies
- (1) Black Oystercatcher nesting sites
- (1) Brandt's Cormorant colonies
- (3) Cassin's Auklet colonies
- (2) Common Murre colonies
- (1) Great Blue Heron foraging areas
- (1) Horned Puffin colonies
- (3) Pelagic Cormorant colonies
- (2) Pigeon Guillemot colonies
- (3) Rhinoceros Auklet colonies
- (3) Storm-petrel colonies
- (1) Thick-billed Murre colonies
- (3) Tufted Puffin colonies

Data Creators and Co-creators: Creator: Katie Gale; Co-Creators: Canadian Wildlife Service and BCMCA (colonies), Parks Canada BC Heron Working Group (Great Blue Heron nesting sites), MPATT Science Team

Methods and links to metadata:
For all species except Great Blue Heron, colony point locations from the Canadian Wildlife Service, Environment and Climate Change Canada, were buffered (2 or 5 km) to represent some of the adjacent marine habitat used by each species. Buffers followed the methodology used in the Canadian Wildlife Service Marine Birds Areas of Interest database (Kenyon et al., 2007).

Colonies were separated out by Relative Importance (RI) classes for all species except Black Oystercatcher (for which all sites were given a RI value of 2 (moderate) based on expert advice). Relative importance was determined as follows:

- High (3): colony has >5% of the species' total BC population
- Moderate (2): colony has 1-5% of the species' total BC population
- Low (1): colony has <1% of the species' total BC population

Great Blue Heron foraging areas were provided by the BC Heron Working Group at Parks Canada. These areas are buffered estuary areas adjacent to nesting colonies. The estuary data came from the Pacific Estuary Conservation Program (PECP; Ryder et al., 2007).

Each feature has embedded metadata with details on its creation. Links to online versions of each feature's metadata are listed below.

- Ancient Murrelet colonies
- Black Oystercatcher nesting sites
- Brandt's Cormorant colonies
- Cassin's Auklet colonies
- Common Murre colonies
- Great Blue Heron foraging areas
- Horned Puffin colonies
- Pelagic Cormorant colonies
- Pigeon Guillemot colonies
- Rhinoceros Auklet colonies
- Storm-petrel colonies
- Thick-billed Murre colonies
- Tufted Puffin colonies

Temporal Coverage:
1927-01-01 to 2017-12-31

Scripts/Software:
n/a

Data Sources:

- All colony features were obtained directly from the BCMCA, which used input data from the Canadian Wildlife Service, Environment and Climate Change Canada.

  Great Blue Heron foraging areas were provided by the BC Heron Working Group at Parks Canada.

Absence Data:
No absence data.

Uncertainties:
Each feature has uncertainties based on its input data and processing steps. Notable uncertainties are described in each feature's individual metadata.

Species Data:

- SYNTHLIBORAMPHUS ANTIQUUS (ANCIENT MURRELET)
- PHALACROCORAX PELAGICUS (BRANDT'S CORMORANT)
- PTYCHORAMPHUS ALEUTICUS (CASSIN'S AUKLET)
- URIA AALGE (COMMON MURRE)
- FRATERCULA CORNICULATA (HORNED PUFFIN)
- PHALACROCORAX PENICILLATUS (PELAGIC CORMORANT)
- CEPPHUS COLUMBA (PIGEON GUILLEMONT)

- CERORHINCA MONOCERATA (RHINOCEROS AUKLET)
- OCEANODROMA LEUCORHOA (LEACH'S STORM-PETREL)
- URIA LOMVIA (THICK-BILLED MURRE)
- FRATERCULA CIRRHATA (TUFTED PUFFIN)
- OCEANODROMA FURCATA (FORK-TAILED STORM-PETREL)

Maps of available datasets:

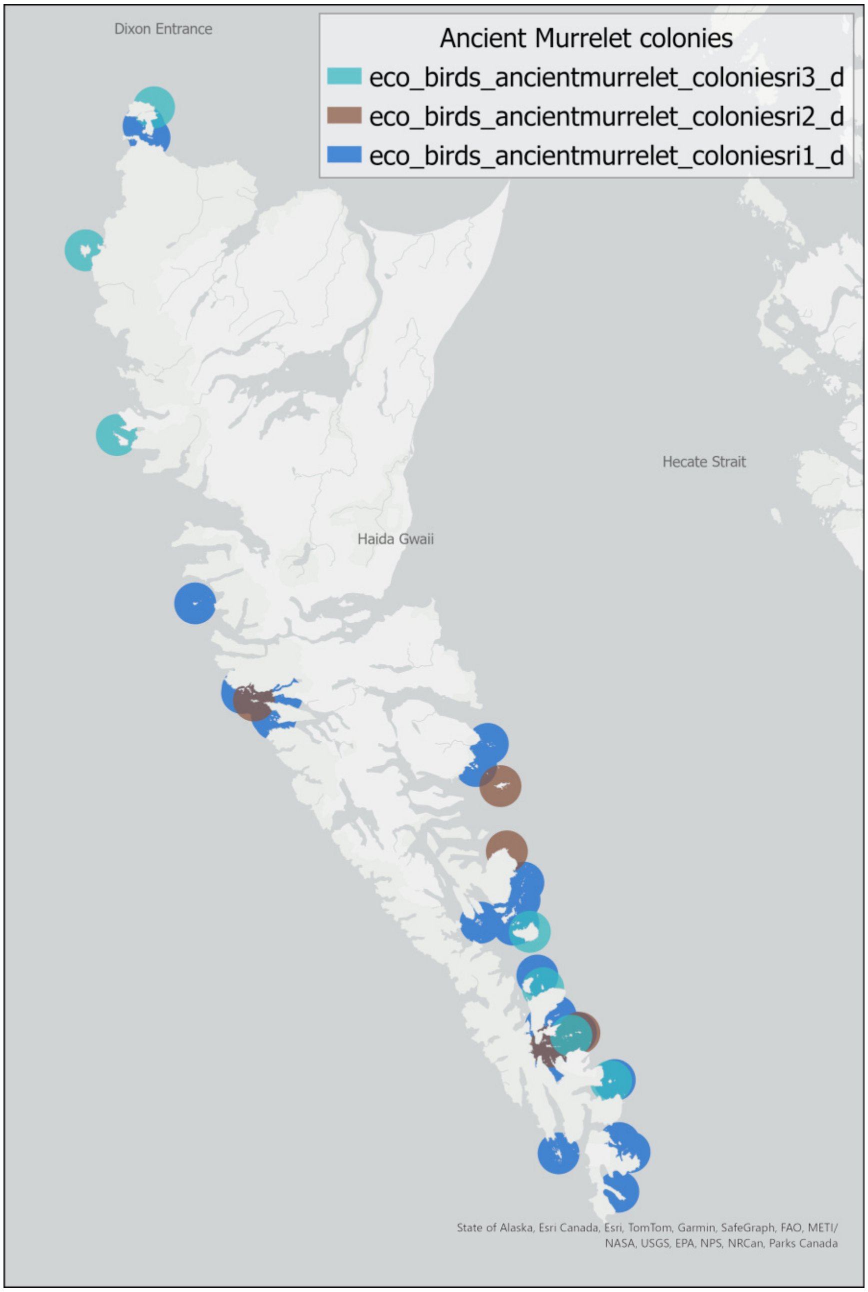

Figure 22: Colony locations for Ancient Murrelets, classified by relative importance.

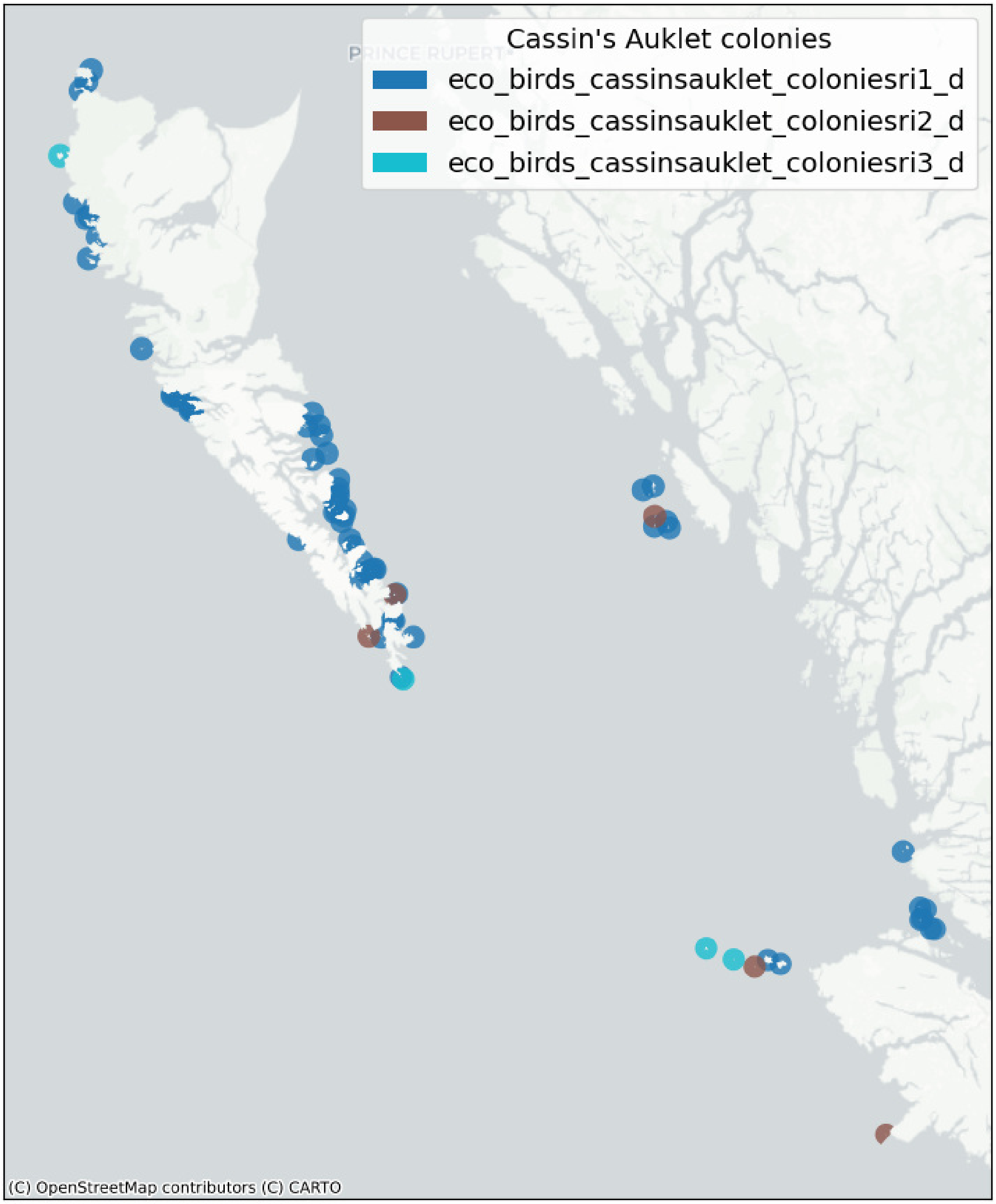

Figure 23: Colony locations for Cassin's Auklets, classified by relative importance.

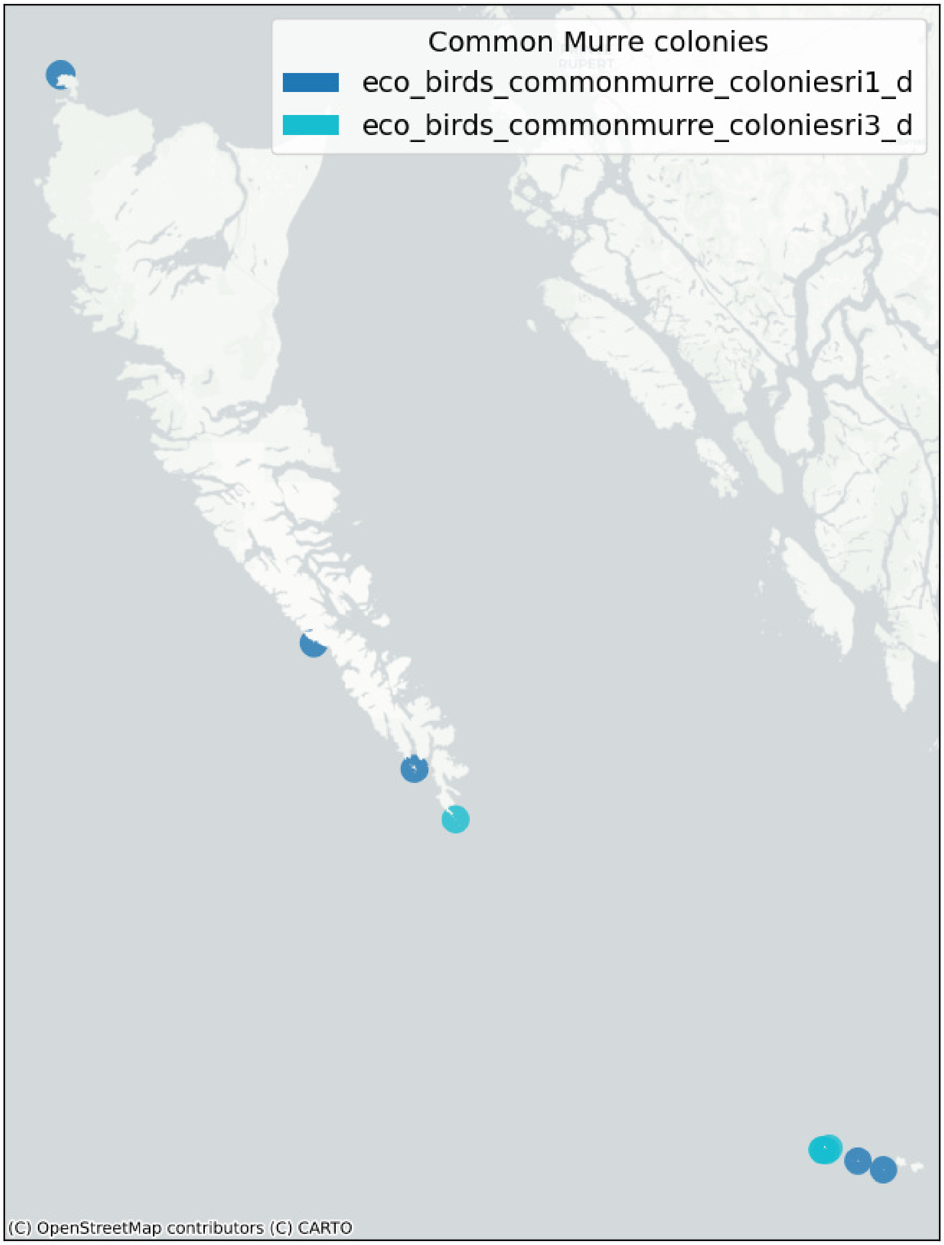

Figure 24: Colony locations for Common Murres, classified by relative importance.

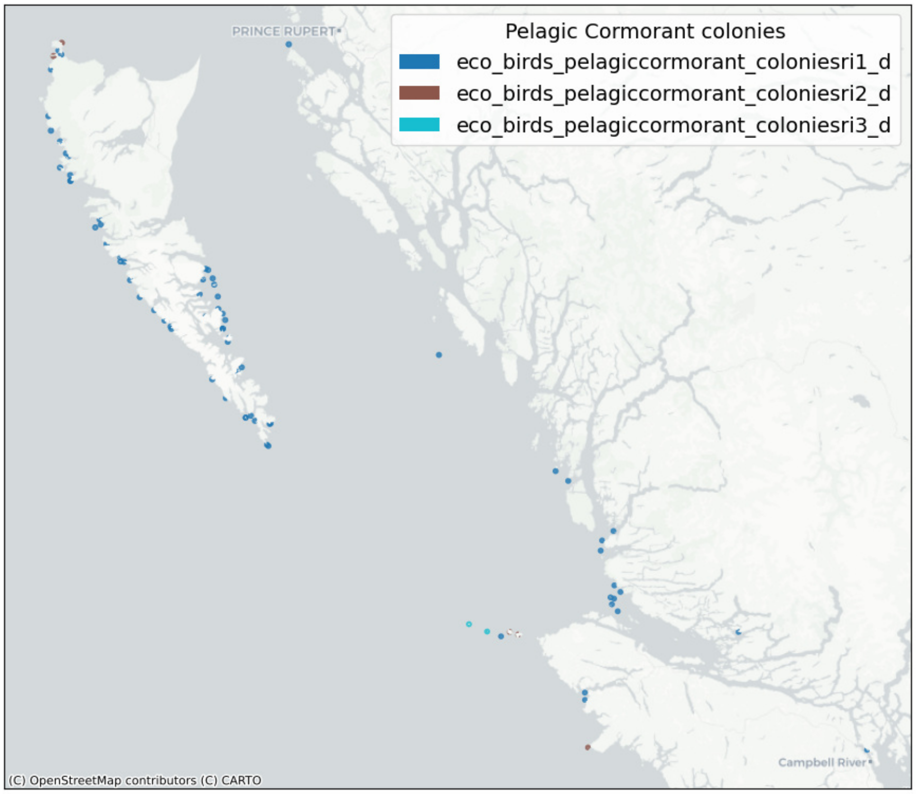

Figure 25: Colony locations for Pelagic Cormorants, classified by relative importance.

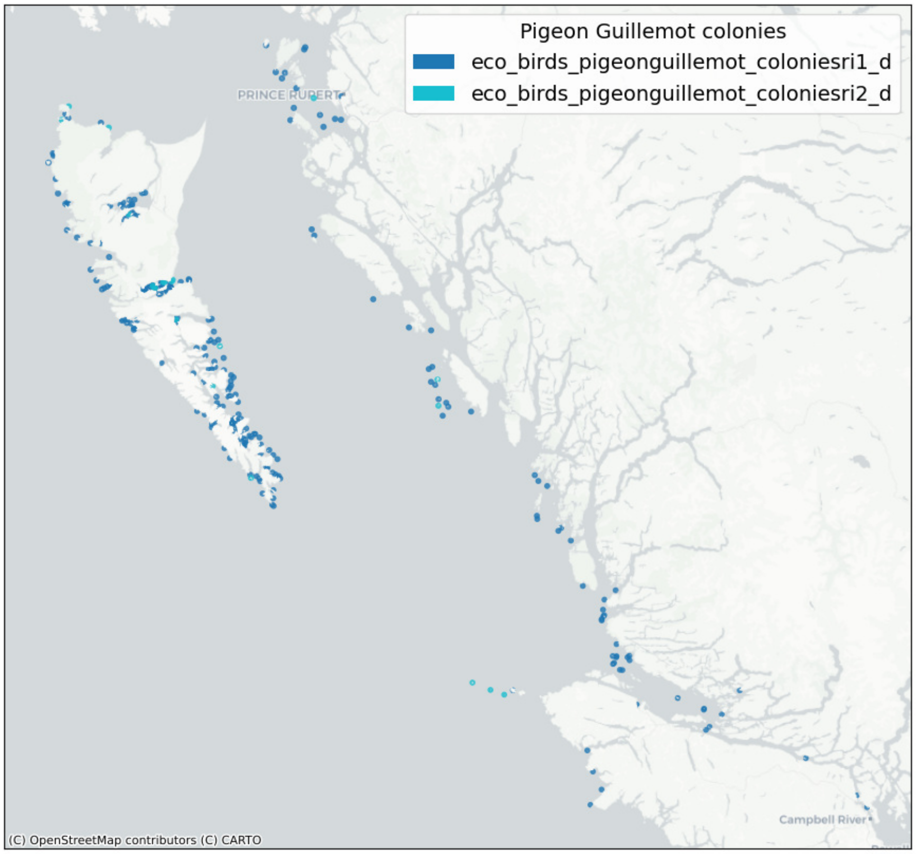

Figure 26: Colony locations for Pigeon Guillemots, classified by relative importance.

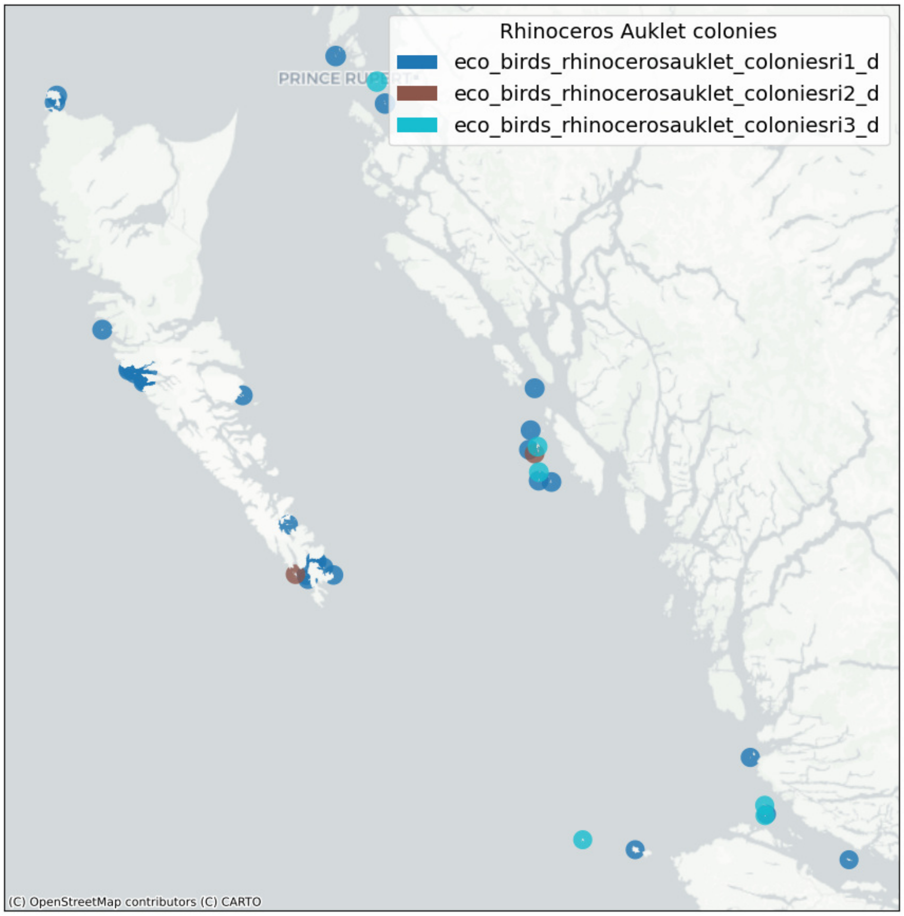

Figure 27: Colony locations for Rhinoceros Auklets, classified by relative importance.

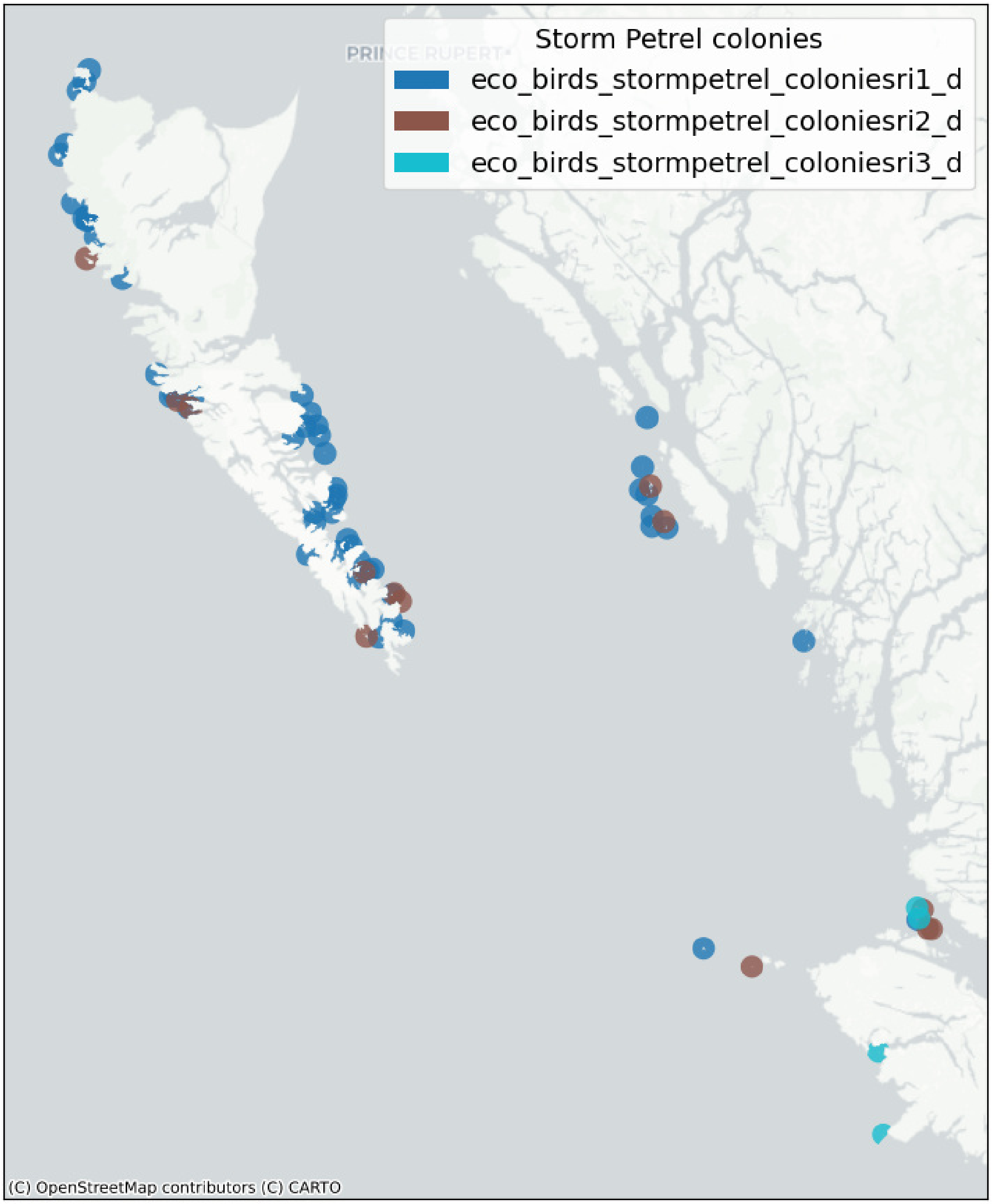

Figure 28: Colony locations for Fork-tailed and Leach's Storm Petrels, classified by relative importance.

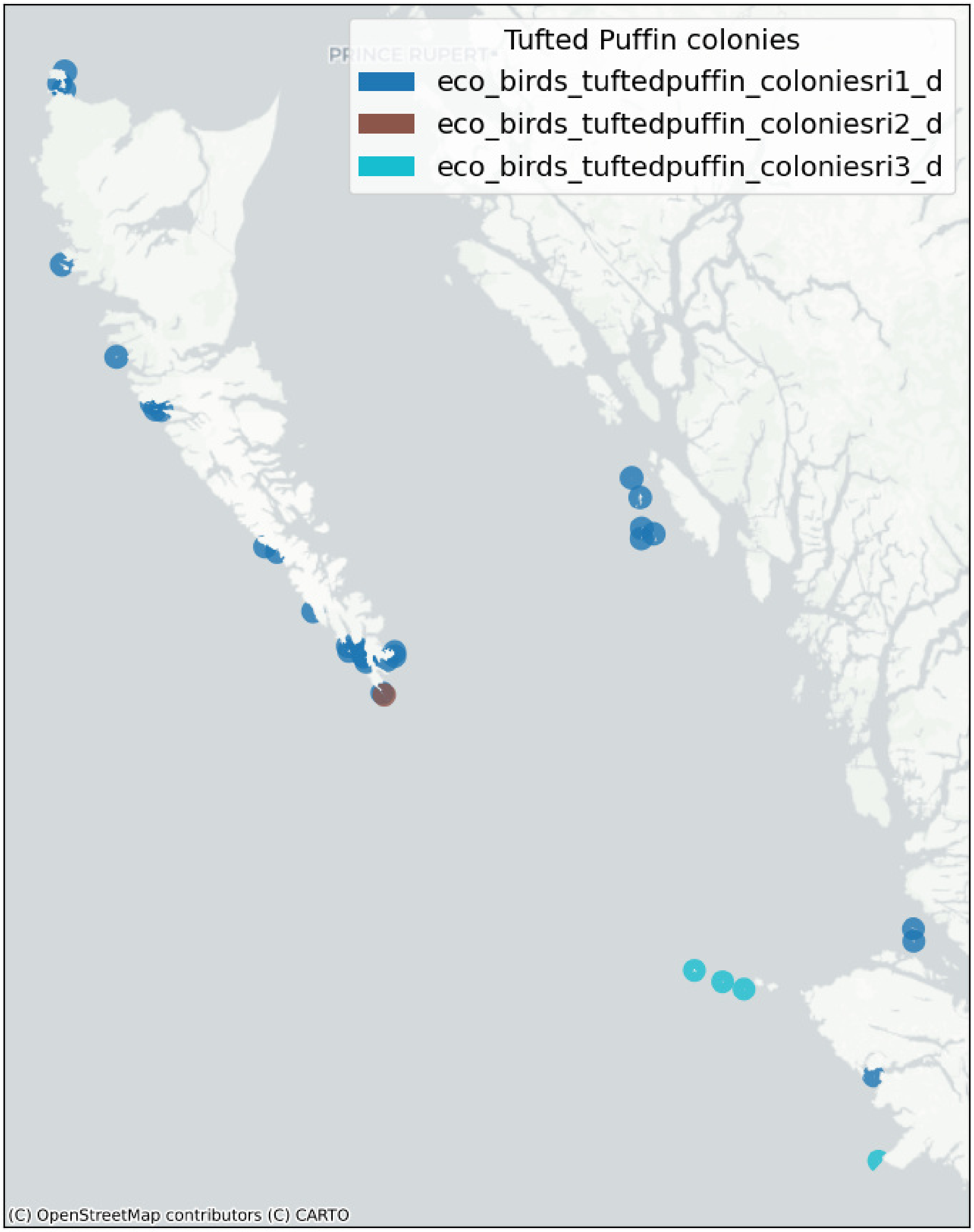

Figure 29: Colony locations for Tufted Puffins, classified by relative importance.

NSB MPA Network Ecological Data - Bird Density Features

Summary:

There are 25 features in the 'Bird Density' geodatabase:

- (1) Albatross density (year-round)
- (2) Cormorant density (year-round and winter)
- (2) Goose and Swan density (year-round and winter)
- (2) Gull density (year-round and winter)
- (1) Great Blue Heron density (year-round)
- (2) Loon and Grebe density (year-round and winter)
- (2) Marbled Murrelet density (year-round and winter)
- (2) Murre and Large Alcid density (year-round and winter)
- (1) Storm-petrel and Phalarope density (year-round)
- (1) Pigeon Guillemot density (year-round)
- (1) Puffin density (year-round)
- (3) Sea duck density (moulting, staging, and winter)
- (1) Shearwater and Fulmar density (year-round)
- (1) Rocky Intertidal Shorebird density (year-round)
- (1) Mud or Sand Flat Intertidal Shorebird density (year-round)
- (2) Small Alcid density (year-round and winter)

Data Creators and Co-creators: Creator: Katie Gale; Co-Creators: Carrie Robb, Canadian Wildlife Service, Melissa Meneghetti (Coastal Resource Mapping, Ltd.), Bird Studies Canada, BCMCA, MPATT Science Team

Methods and links to metadata:
Observations from two types of surveys (strip transects and distance sampling) were compiled separately, normalized, and combined.

Strip transects (all surveys other than Raincoast):

Survey polygons were created based on the transect length and survey width. For each survey polygon, the total number of birds observed from the species in the given species group and for the chosen season were summed and used to calculate the density of birds per sq. km. In addition, the total number of surveys conducted for that polygon and the surveys where the given species were observed were determined. The survey polygons from all datasets were merged and spatially joined to the 1 km x 1 km planning grid and the density and survey totals were summed and used to calculate the average density of birds observed in each grid cell.

Distance sampling (Raincoast surveys): E

stimated density values were calculated by Raincoast using distance sampling. The transect segments pertaining to the appropriate species and season were extracted and spatially joined to the 1 km x 1 km planning grid. The density and total surveys per grid cell were summed and used to calculate the average density of birds observed in each grid cell.

Normalized Densities (field 'densNorm', displayed on Seasketch)

- For each species, the two density datasets were normalized (rescaled) by dividing each value by the maximum value in that dataset. The resulting density index ranged from 0 to 1. Normalizing the data removes differences in the absolute magnitude of density values among the datasets that may have resulted from different survey and data processing methods.
- The normalized values from the two datasets were overlaid onto the MPA Network 1 km planning grid and averaged together within each grid cell by species.

Transformation (field 'densTrans')

- The normalized bird density values ranged from 0-1, but were heavily skewed towards 0. This was constraining the prioritized planning units in Marxan, since the few high values were a much more valuable/efficient solution.
- The species experts at CWS recommended that the lowest quantile be excluded from site selection analysis and subsequent analytics.
- To unskew the distribution of values, the normalized density values were transformed: ln(n)+abs(min(ln(n)))+1. The abs(min(ln(n))) value was calculated only on the top 4 quantiles of data, excluding zeros.
- I.e., to get densTrans for each species:
  - Calculate quantiles (20th percentiles) of densNorm, excluding zeros
  - Calculate ln(densNorm)
  - Identify the minimum ln(densNorm) for the top 4 quantiles, and add it to each ln(densNorm)+1
- Field 'densTransTop' (= 'value') was calculated by setting densTrans values to null/0 for quantile 1. This field was used for Marxan analysis and follow-up analytics.

The above methods apply to all features in this geodatabase. Each feature has embedded metadata with details on its creation. Links to online versions of each feature's metadata are listed below.

- Albatross density (year-round)
- Cormorant density (year-round)
- Cormorant density (winter)
- Goose and Swan density (year-round)
- Goose and Swan density (winter)
- Gull density (year-round)
- Gull density (winter)
- Great Blue Heron density (year-round)
- Loon and Grebe density (year-round)
- Loon and Grebe density (winter)

- Marbled Murrelet density (year-round)
- Marbled Murrelet density (winter)
- Murre and Large Alcid density (year-round)
- Murre and Large Alcid density (winter)
- Storm-petrel and Phalarope density (year-round)
- Pigeon Guillemot density (year-round)
- Puffin density (year-round)
- Sea duck density (moulting)
- Sea duck density (staging)
- Sea duck density (winter)
- Shearwater and Fulmar density (year-round)
- Rocky Intertidal Shorebird density (year-round)
- Mud or Sand Flat Intertidal Shorebird density (year-round)
- Small Alcid density (year-round)
- Small Alcid density (winter)

Temporal Coverage:
1982-01-01 to 2017-12-31

Scripts/Software:
n/a

Data Sources:

- Bird Studies Canada - Coastal Waterbird Survey (Bird Studies Canada, 2008)
- Laskeek Bay Conservation Society Surveys (Laskeek Bay Conservation Society, 2016)
- Raincoast Conservation Foundation Surveys (Fox et al., 2017)
- US Geological Survey - North Pacific Seabird Database (Drew et al., 2015)
- Canadian Wildlife Service, Environment and Climate Change Canada
- Coastal Waterbird Inventory (Canadian Wildlife Service et al., 2007)
- Marine Bird Database (Bertram, 2009)
- Moulting Seaduck Survey (Canadian Wildlife Service, 1998)
- Pelagic Seabird Surveys (Kenyon et al., 2009)

Absence Data:
Zero 'densNorm' values indicate that the species was not observed in the surveys that were used as inputs to this dataset. Areas outside the footprint of each dataset are areas that were unsurveyed.

Uncertainties:
The grid cell boundaries on these maps appear as distinct lines, but in reality they should be displayed as fuzzy lines to represent the fact that densities do not change abruptly

from one grid cell to another. To avoid misinterpretation of these data, grid cell boundaries should not be interpreted literally.

Areas outside the footprint of each dataset have not been surveyed. These are not areas of little importance, but rather represent a knowledge gap.

Each feature has uncertainties based on its input data and processing steps. Notable uncertainties are described in each feature's individual metadata.

Species Data:

- PHOEBASTRIA NIGRIPES (BLACK-FOOTED ALBATROSS)
- PHOEBASTRIA IMMUTABILIS (LAYSAN ALBATROSS)
- PHOEBASTRIA ALBATRUS (SHORT-TAILED ALBATROSS)
- PHALACROCORAX PELAGICUS (BRANDT'S CORMORANT)
- PHALACROCORAX AURITUS (DOUBLE-CRESTED CORMORANT)
- PHALACROCORAX PENICILLATUS (PELAGIC CORMORANT)
- BRANTA CANADENSIS (CANADA GOOSE)
- LARUS THAYERI (THAYER'S GULL)
- LARUS CALIFORNICUS (CALIFORNIA GULL)
- GAVIA IMMER (COMMON LOON)
- GAVIA PACIFICA (PACIFIC LOON)
- GAVIA ADAMSII (YELLOW-BILLED LOON)
- PODICEPS AURITUS (HORNED GREBE)
- AECHMOPHORUS OCCIDENTALIS (WESTERN GREBE)
- BRACHYRAMPHUS MARMORATUS (MARBLED MURRELET)
- URIA AALGE (COMMON MURRE)
- URIA LOMVIA (THICK-BILLED MURRE)
- CERORHINCA MONOCERATA (RHINOCEROS AUKLET)
- CEPPHUS COLUMBA (PIGEON GUILLEMONT)
- FRATERCULA CORNICULATA (HORNED PUFFIN)
- FRATERCULA CIRRHATA (TUFTED PUFFIN)
- HISTRIONICUS HISTRIONICUS (HARLEQUIN DUCK)
- CLANGULA HYEMALIS (LONG-TAILED DUCK (OLDSQUAW))
- MELANITTA NIGRA (BLACK SCOTER)
- MELANITTA PERSPICILLATA (SURF SCOTER)
- MELANITTA FUSCA (WHITE-WINGED SCOTER)
- BUCEPHALA ISLANDICA (BARROW?S GOLDENEYE)
- BUCEPHALA CLANGULA (COMMON GOLDENEYE)

- PUFFINUS BULLERI (BULLER’S OR GRAY-BACKED SHEARWATER)
- PUFFINUS CREATOPUS (PINK-FOOTED SHEARWATER)
- PUFFINUS TENUIROSTRIS (SHORT-TAILED SHEARWATER)
- PUFFINUS GRISEUS (SOOTY SHEARWATER)
- FULMARUS GLACIALIS (NORTHERN FULMAR)
- SYNTHLIBORAMPHUS ANTIQUUS (ANCIENT MURRELET)
- PTYCHORAMPHUS ALEUTICUS (CASSIN’S AUKLET)
- OCEANODROMA FURCATA (FORK-TAILED STORM-PETREL)
- OCEANODROMA LEUCORHOA (LEACH’S STORM-PETREL)
- PHALAROPUS FULICARIUS (RED PHALAROPE)
- PHALAROPUS LOBATUS (RED-NECKED PHALAROPE)

Maps of available datasets:

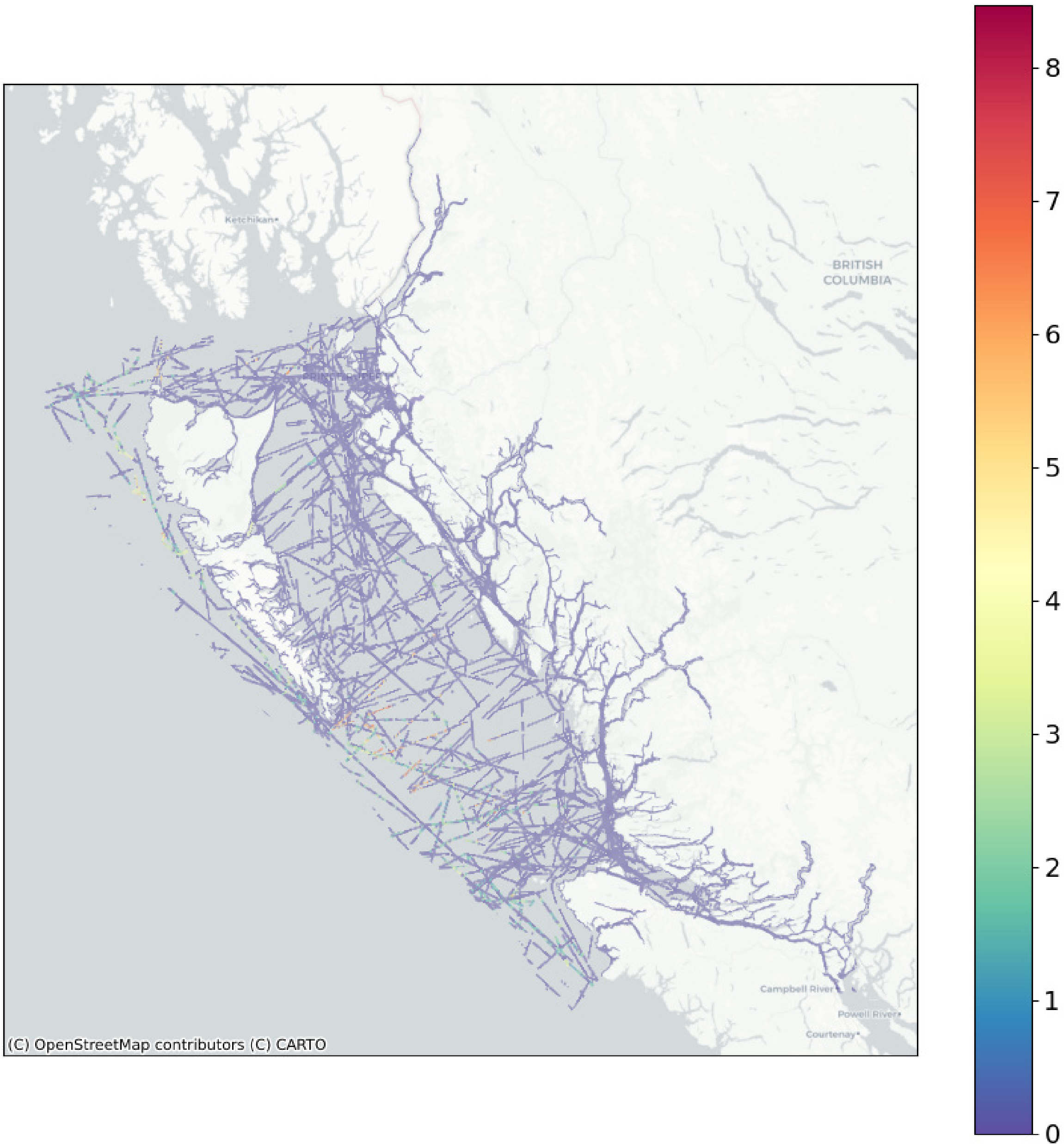

Figure 30: Effort-corrected density of Albatrosses (Black-footed, Laysan, and Short-tailed Albatrosses).

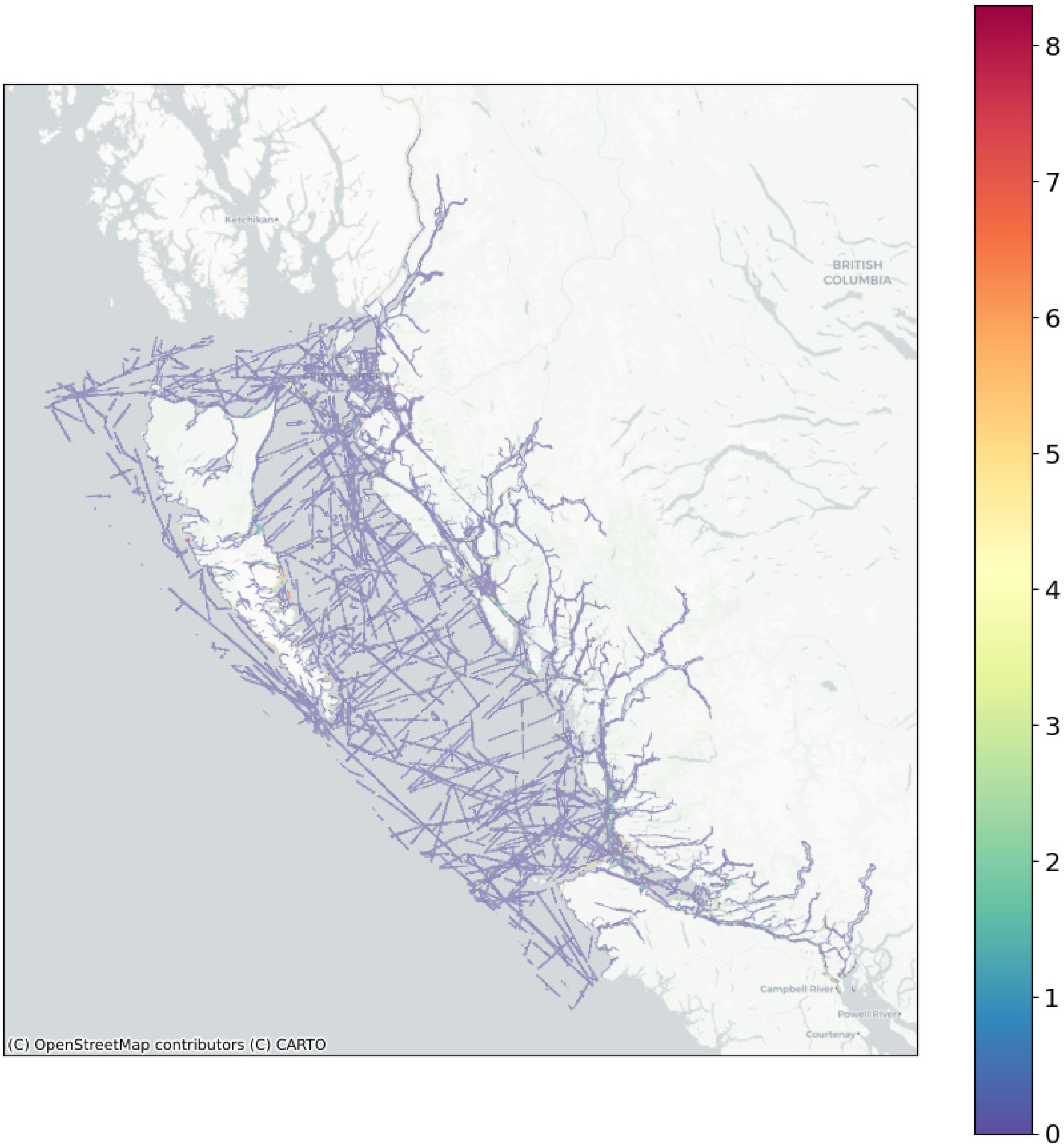

Figure 31: Effort-corrected density of Cormorants (Brandt's, Double-crested, and Pelagic).

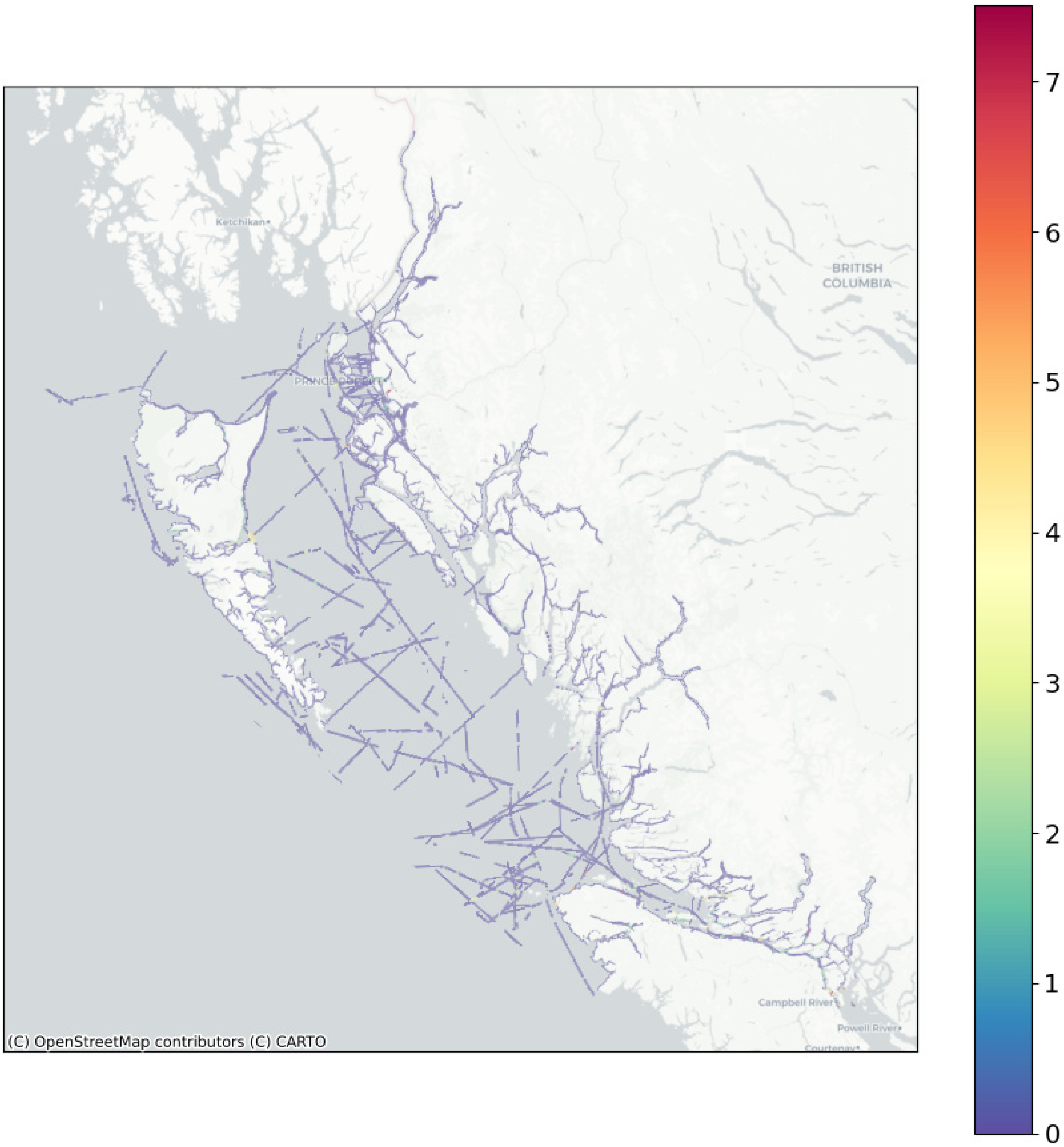

Figure 32: Effort-corrected density of Cormorants (Brandt's, Double-crested, and Pelagic) in winter (Dec - Feb).

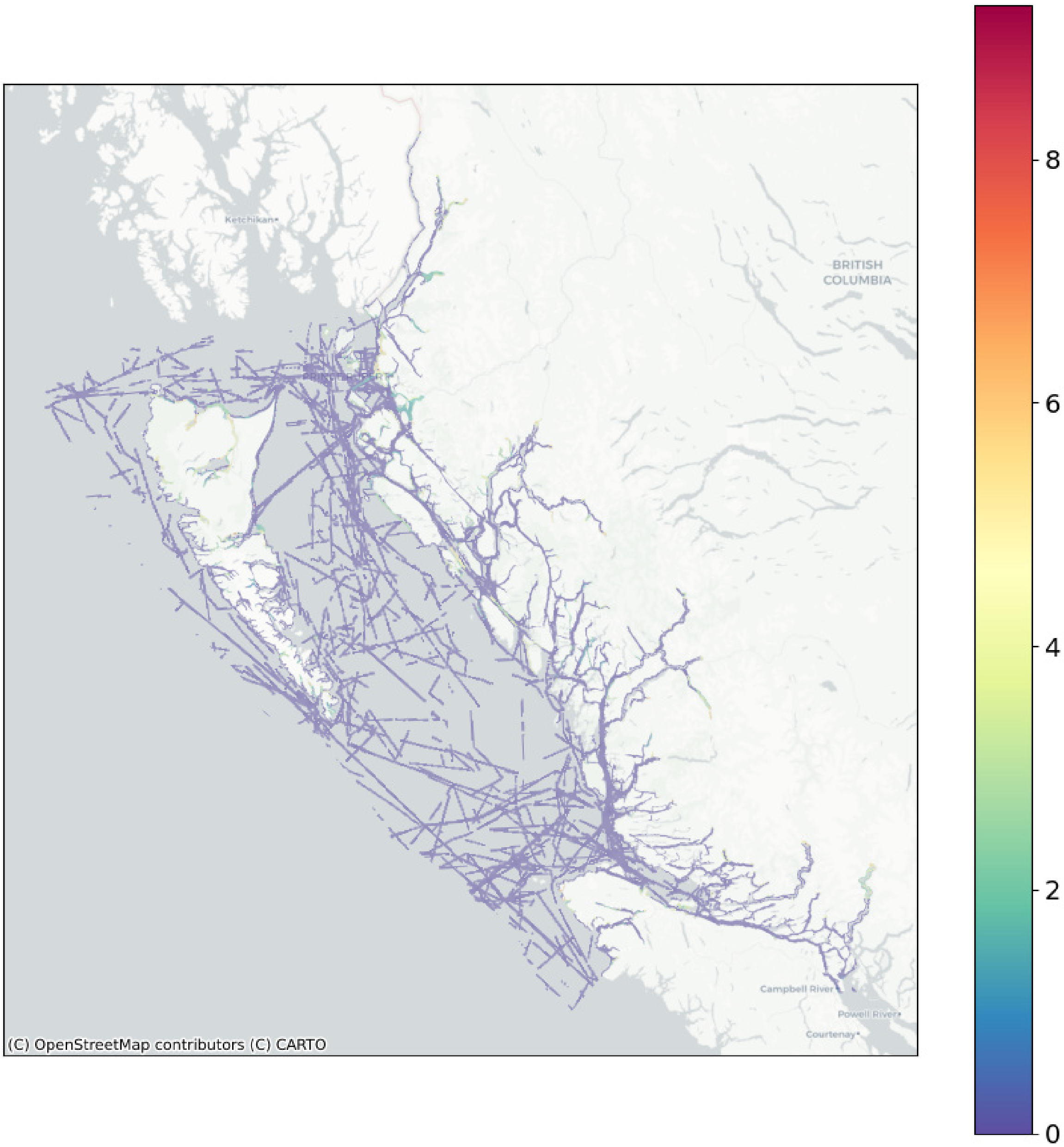

Figure 33: Effort-corrected density of Geese and Swans (Cackling and Canada Geese; Trumpeter Swans).

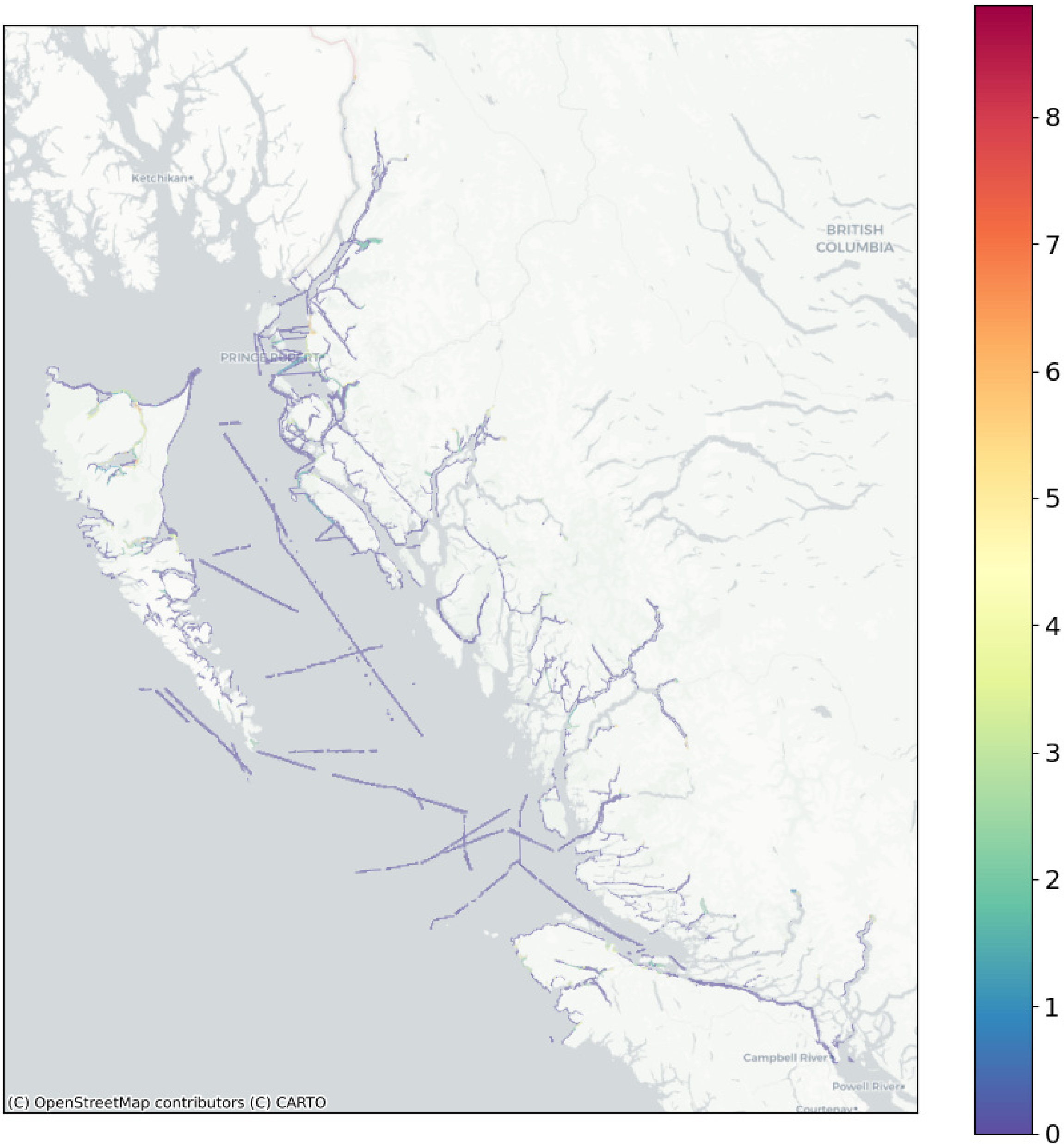

Figure 34: Effort-corrected density of Geese and Swans (Cackling and Canada Geese; Trumpeter Swans) in winter (Dec - Feb).

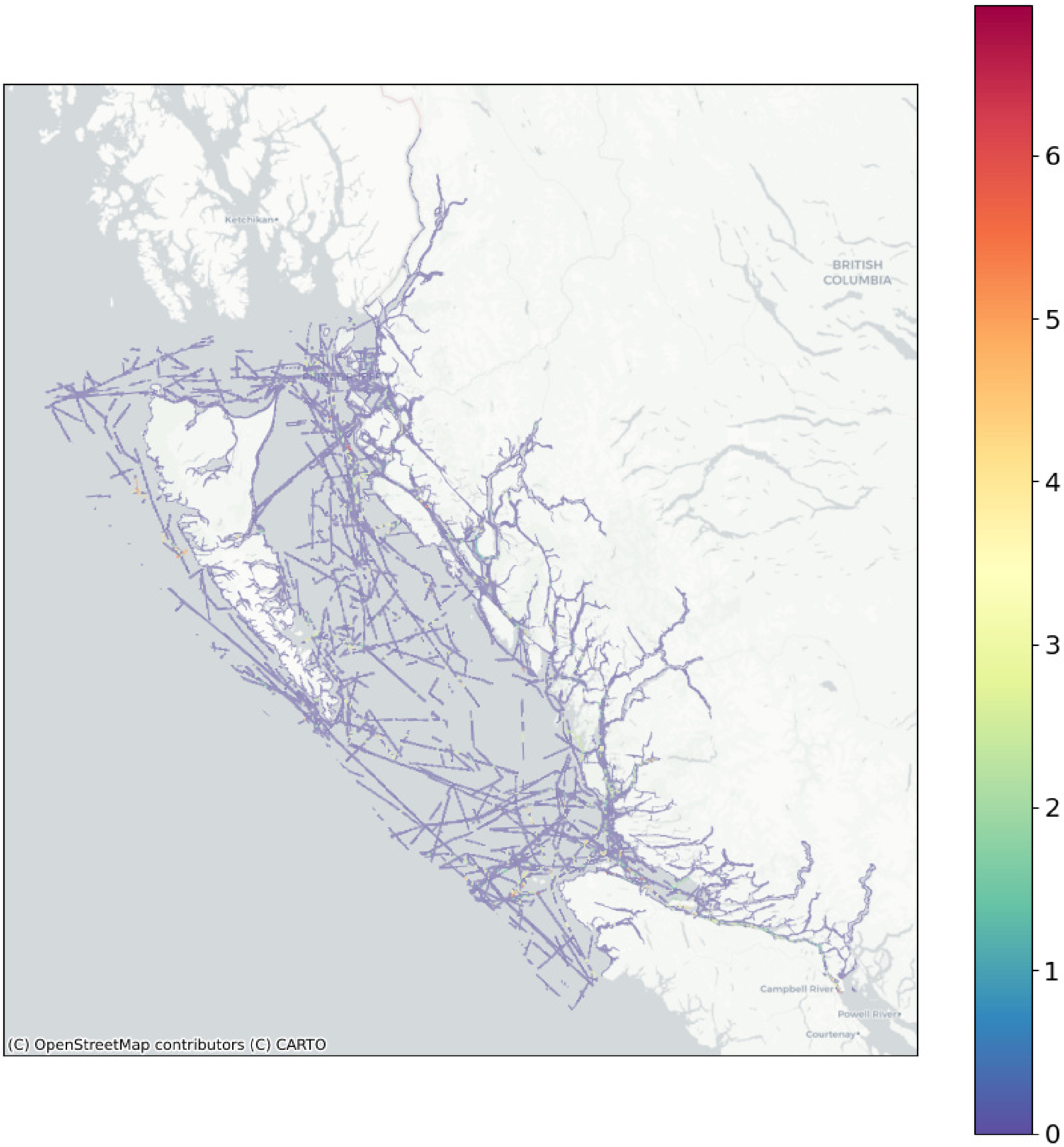

Figure 35: Effort-corrected density of Gulls (California and Thayer's Gulls).

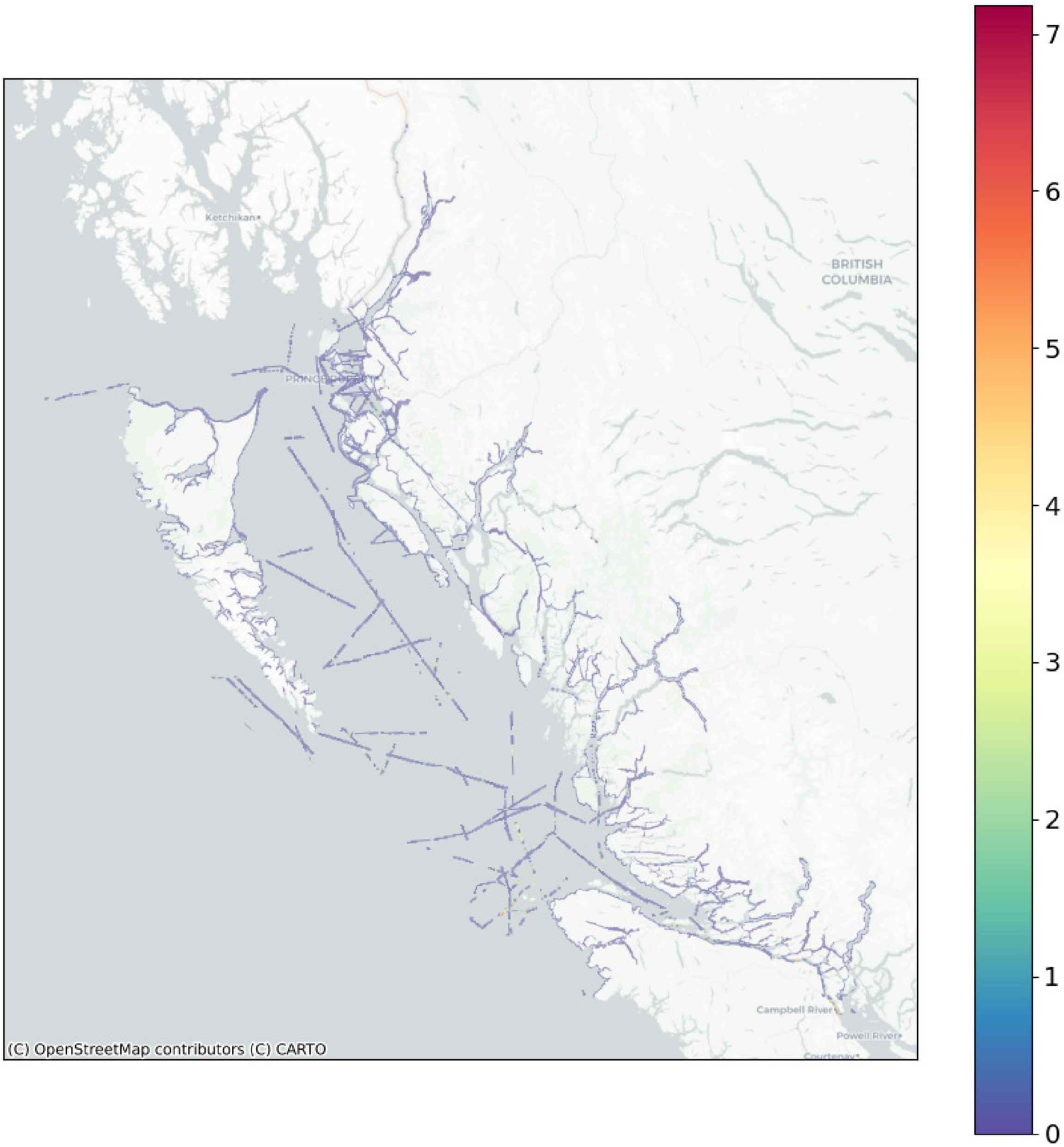

Figure 36: Effort-corrected density of Gulls (California and Thayer's Gulls) in winter (Oct - Feb).

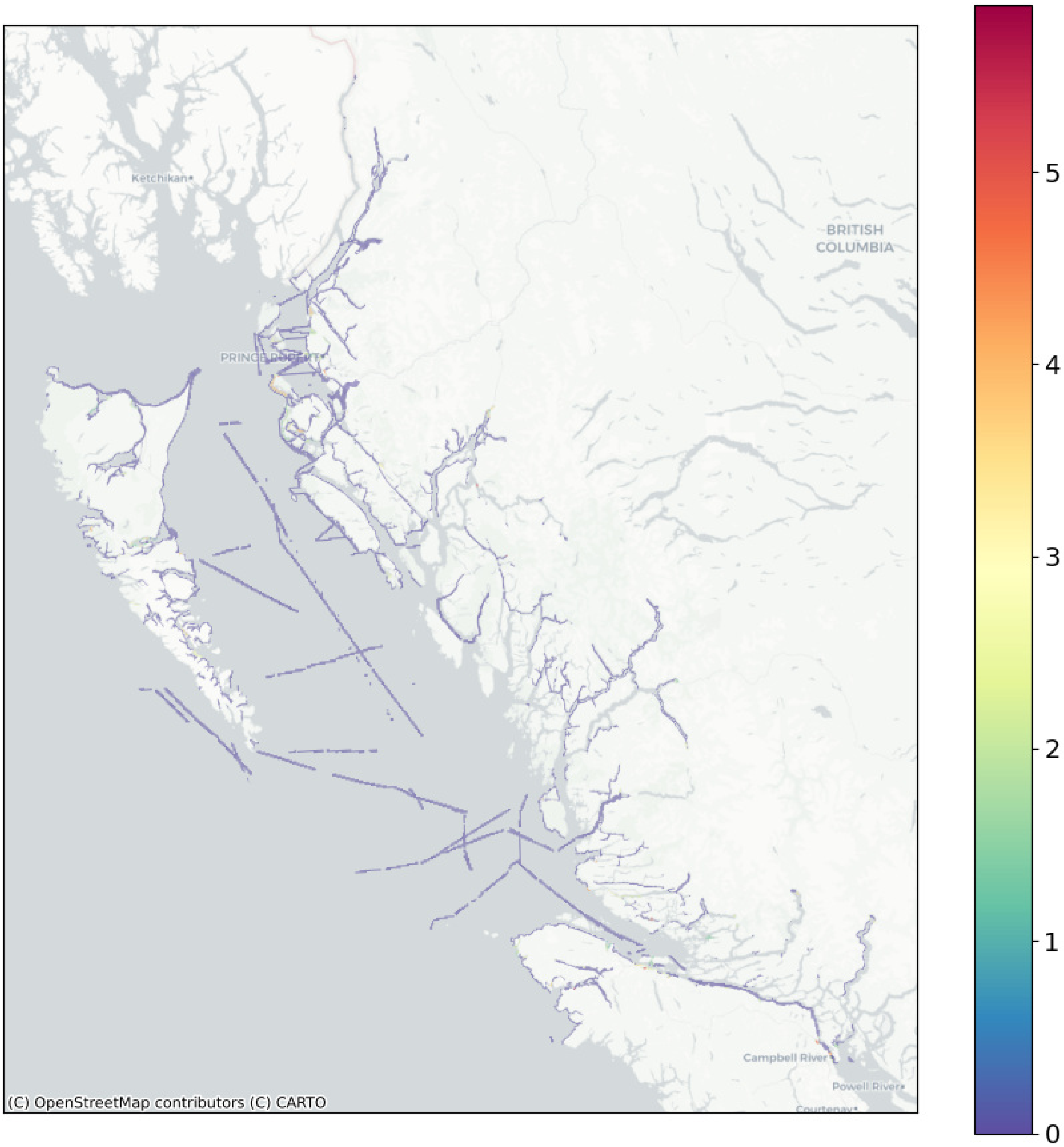

Figure 37: Effort-corrected density of Great Blue Herons in winter (Dec - Feb).

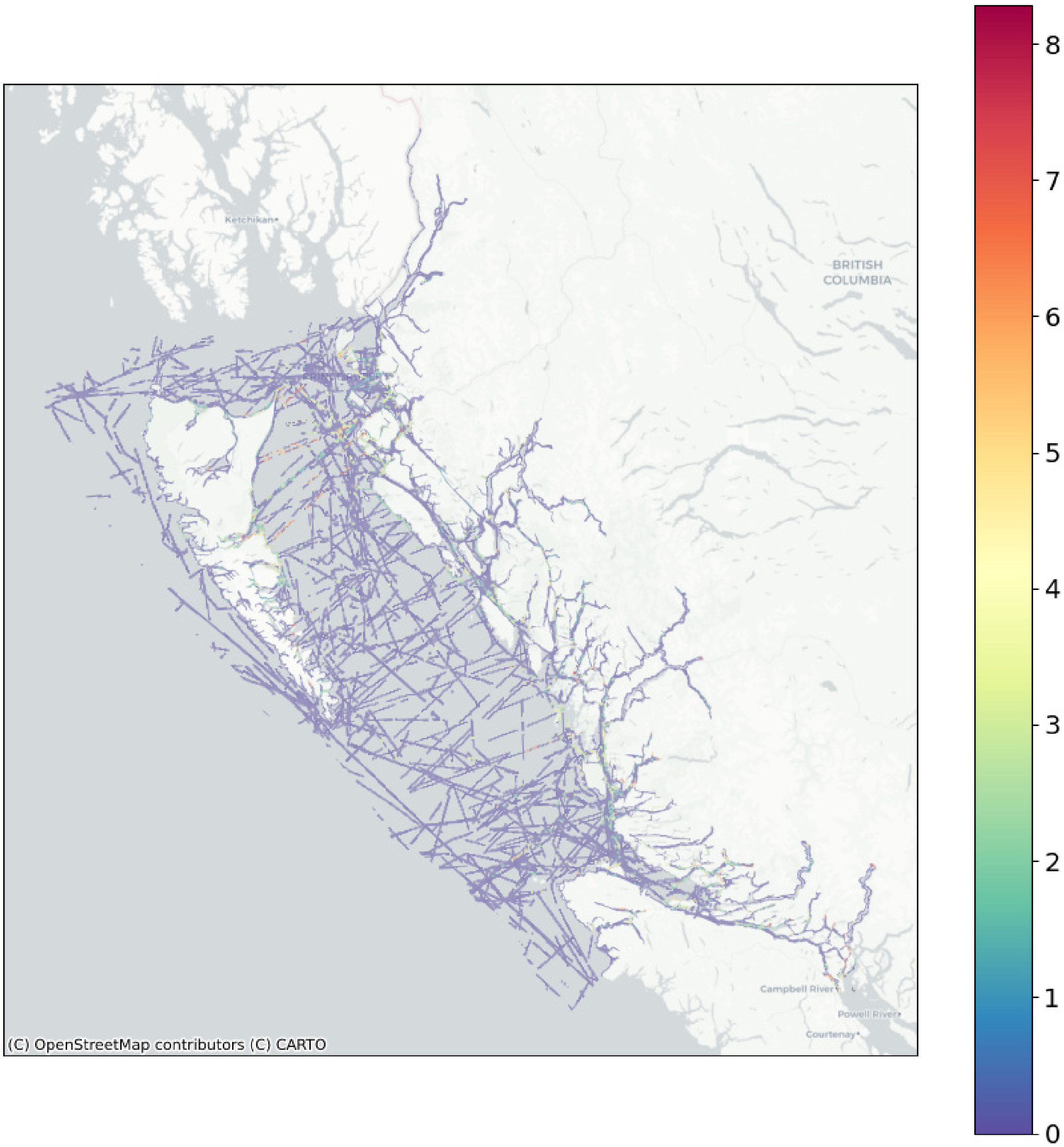

Figure 38: Effort-corrected density of Loons and Grebes (Common, Pacific and Yellow-billed Loons; Horned and Western Grebes).

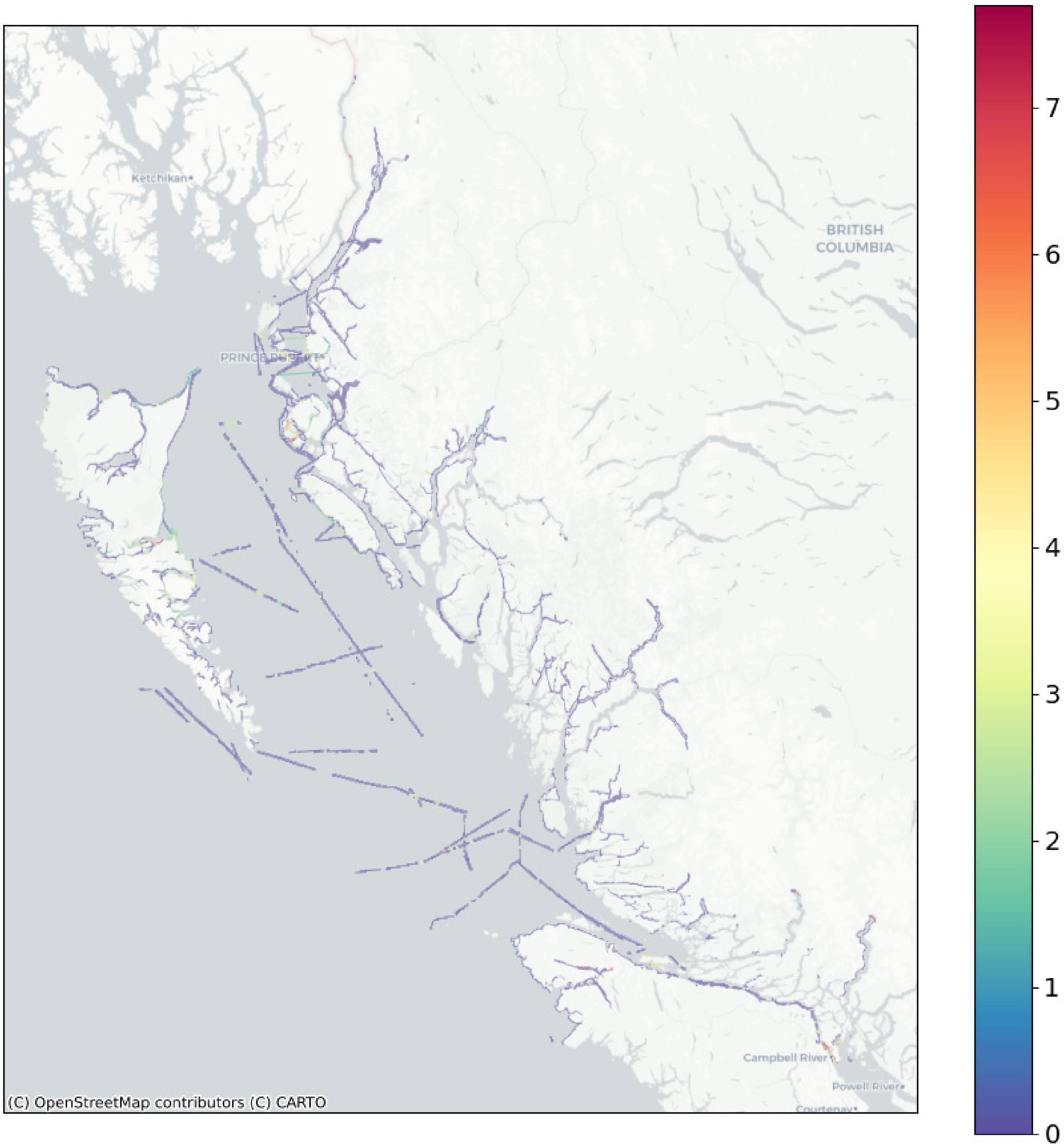

Figure 39: Effort-corrected density of Loons and Grebes (Common, Pacific and Yellow-billed Loons; Horned and Western Grebes) in winter (Dec - Feb).

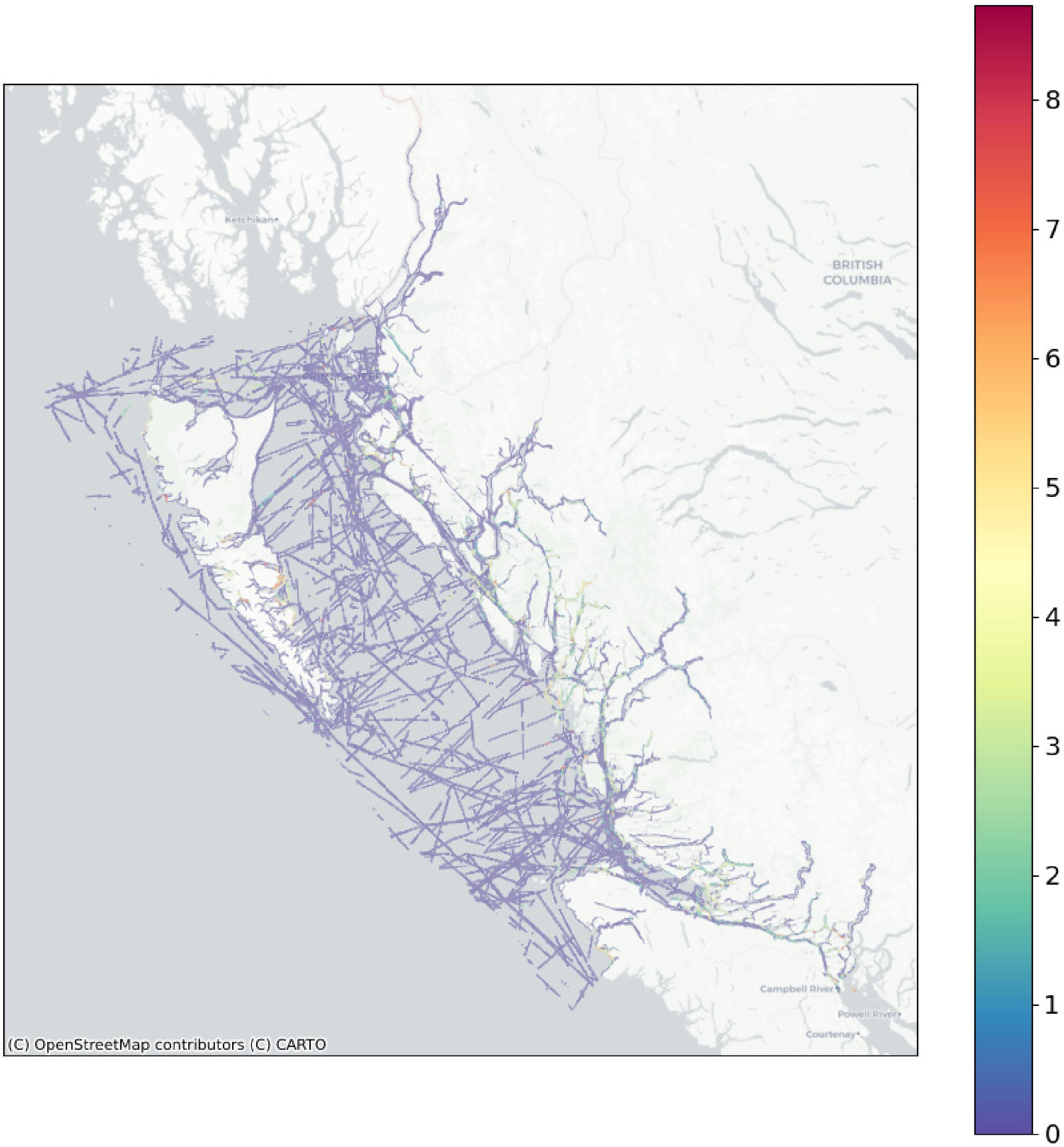

Figure 40: Effort-corrected density of Marbled Murrelet.

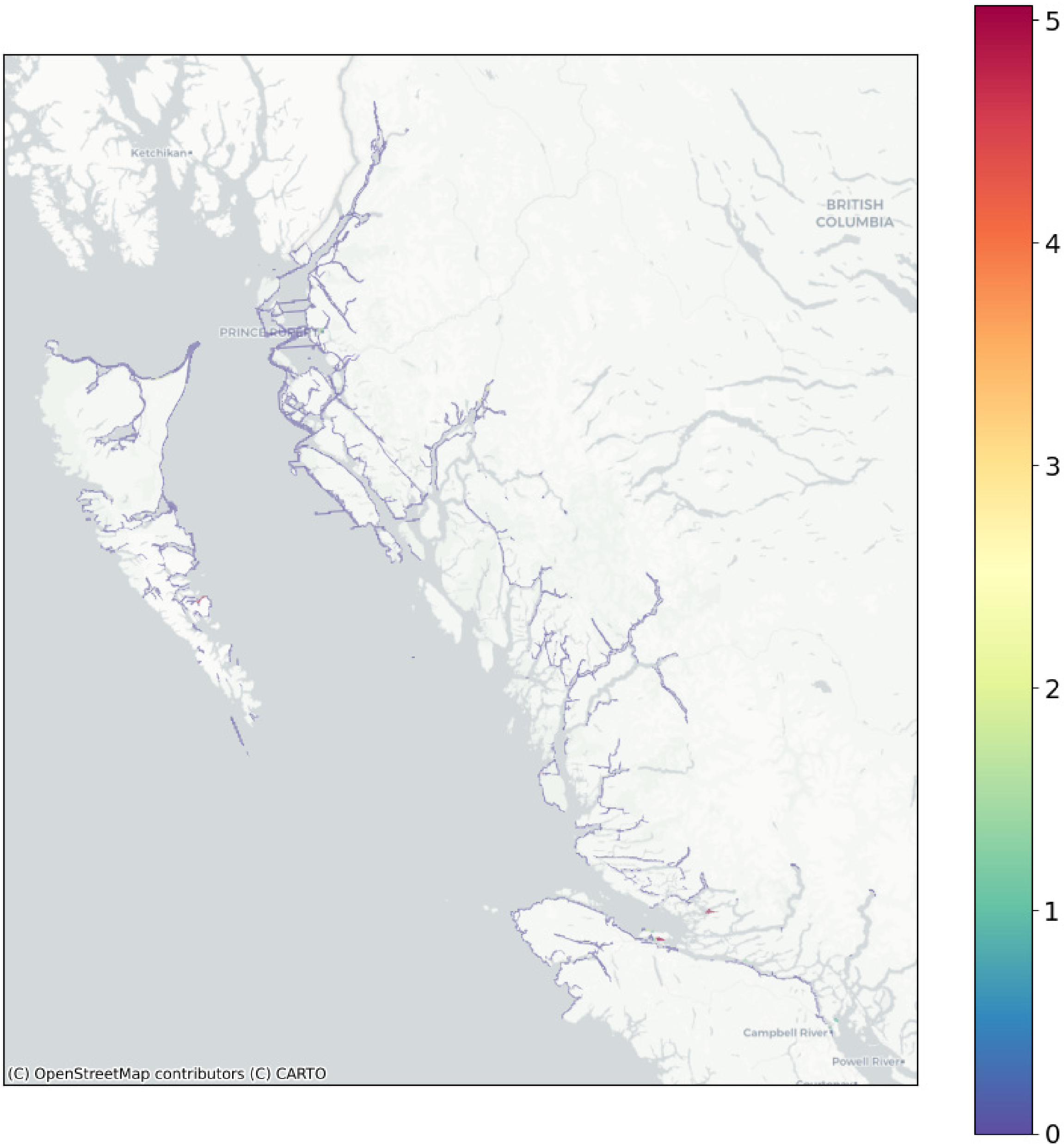

Figure 41: Effort-corrected density of Marbled Murrelet in winter (Dec-Jan).

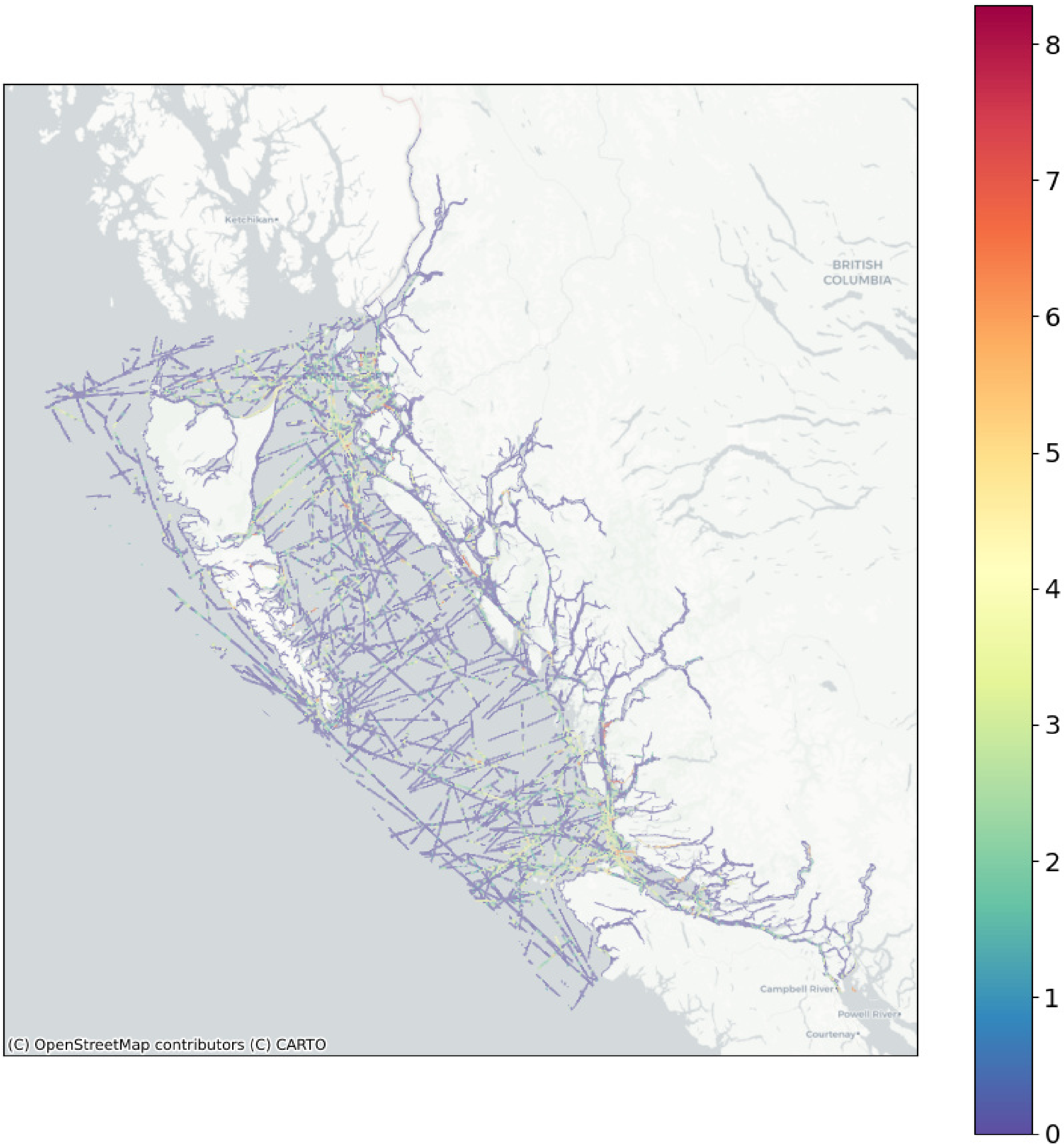

Figure 42: Effort-corrected density of Murres and Large Alcids (Common and Thick-billed Murres; Rhinoceros Auklets).

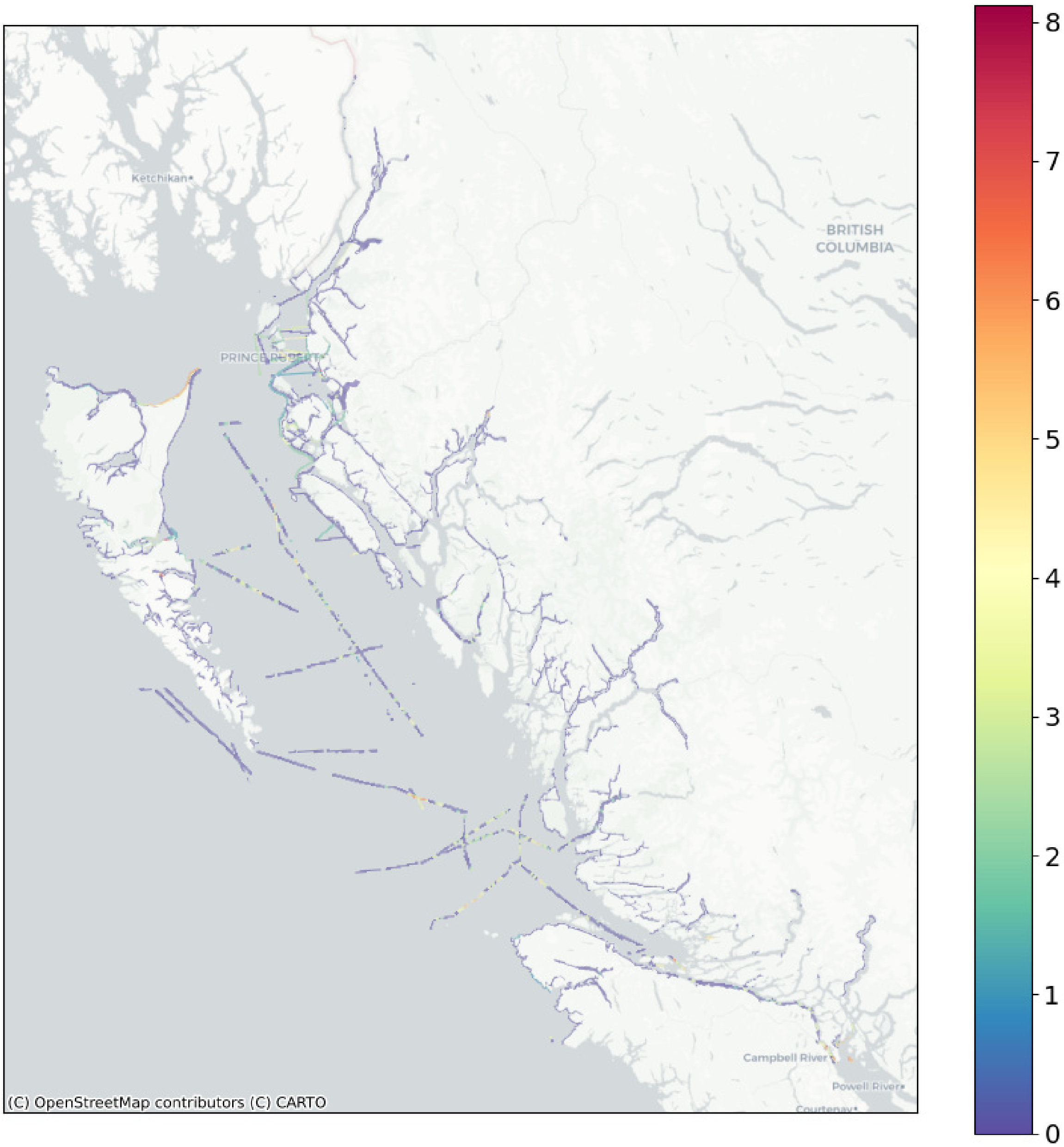

Figure 43: Effort-corrected density of Murres and Large Alcids (Common and Thick-billed Murres; Rhinoceros Auklets) in winter (Dec - Feb).

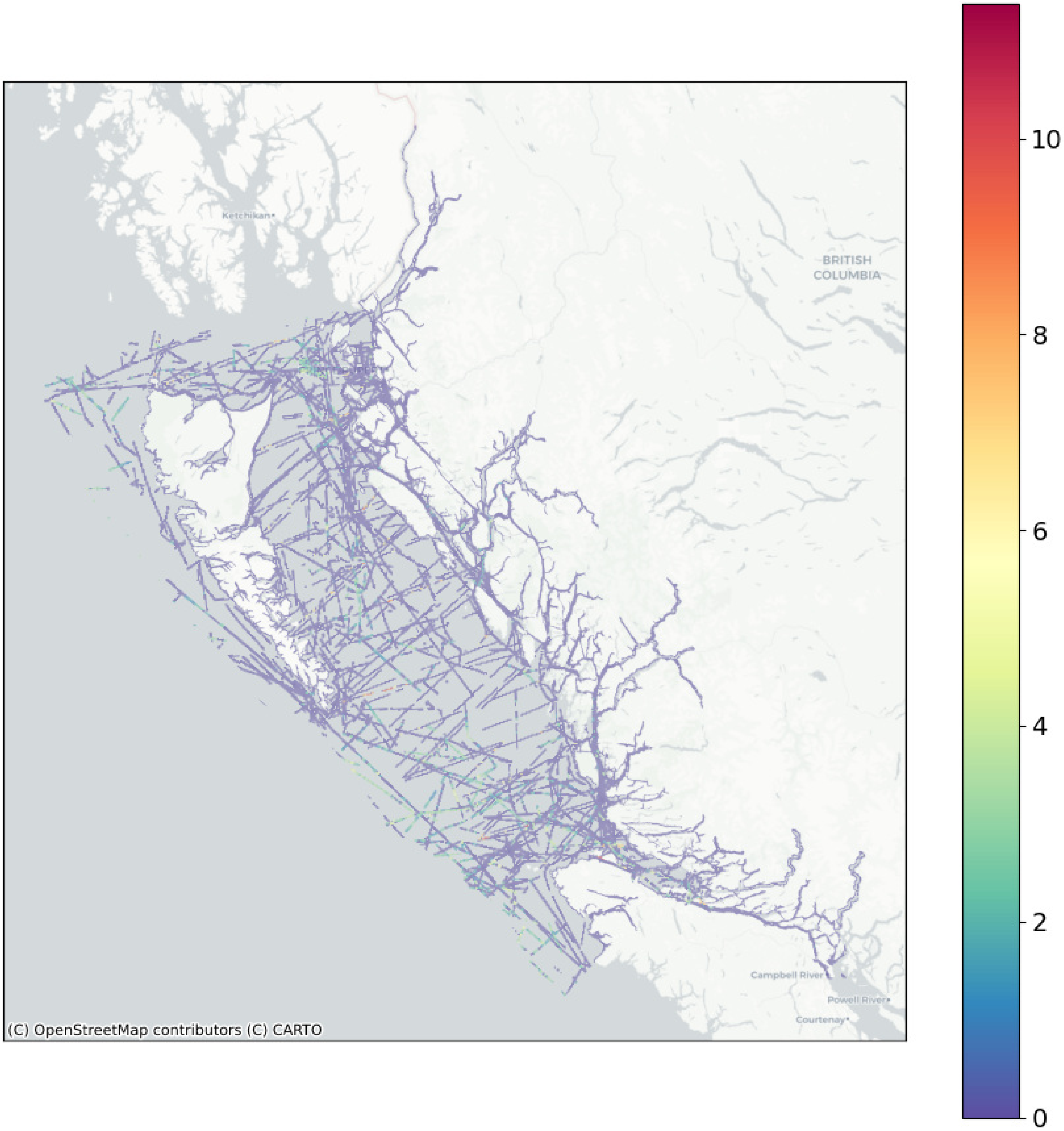

Figure 44: Effort-corrected density of Storm Petrels and Phalaropes (Fork-tailed and Leach's Storm Petrels; Red and Red-necked Phalaropes).

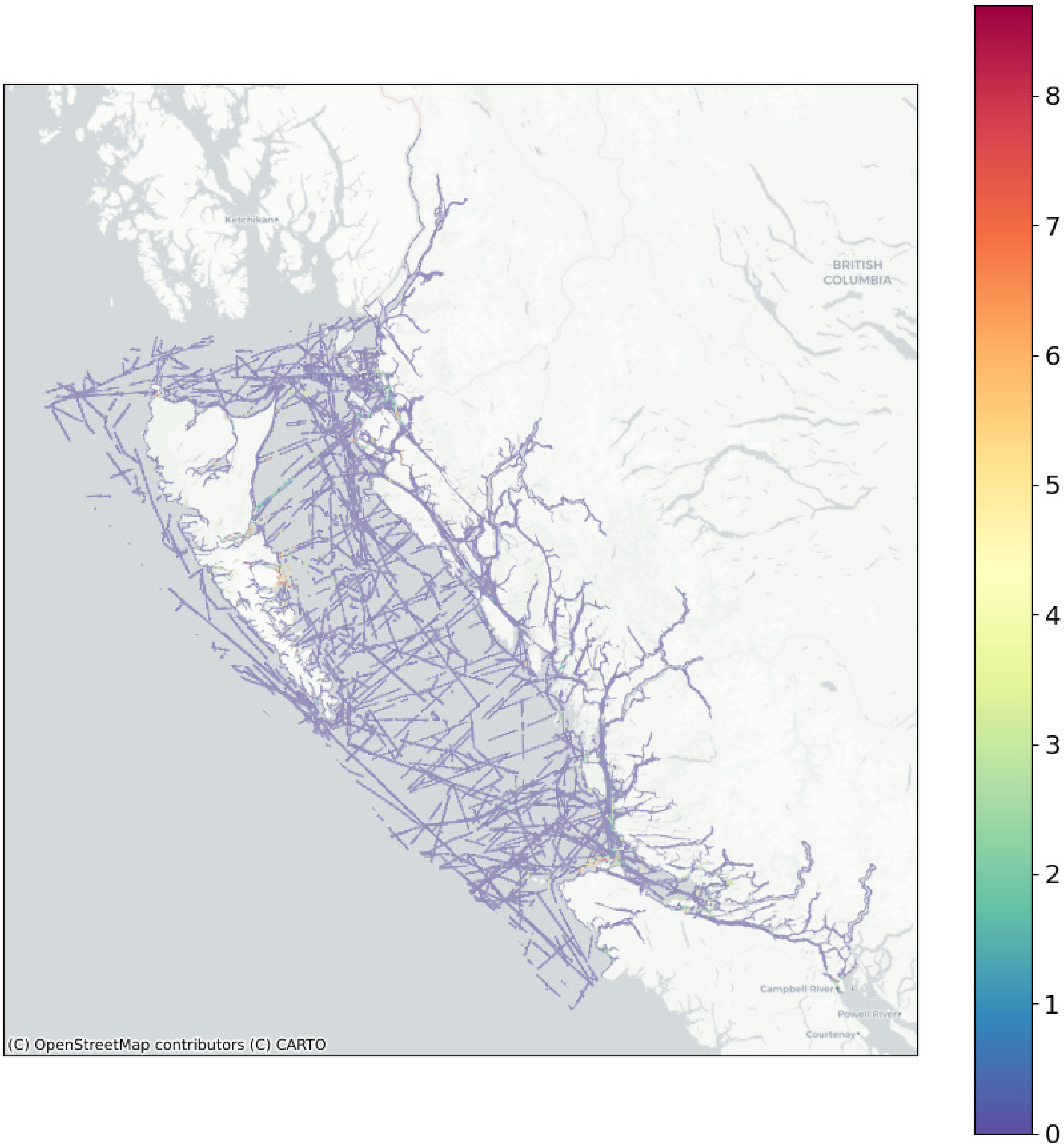

Figure 45: Effort-corrected density of Pigeon Guillemot.

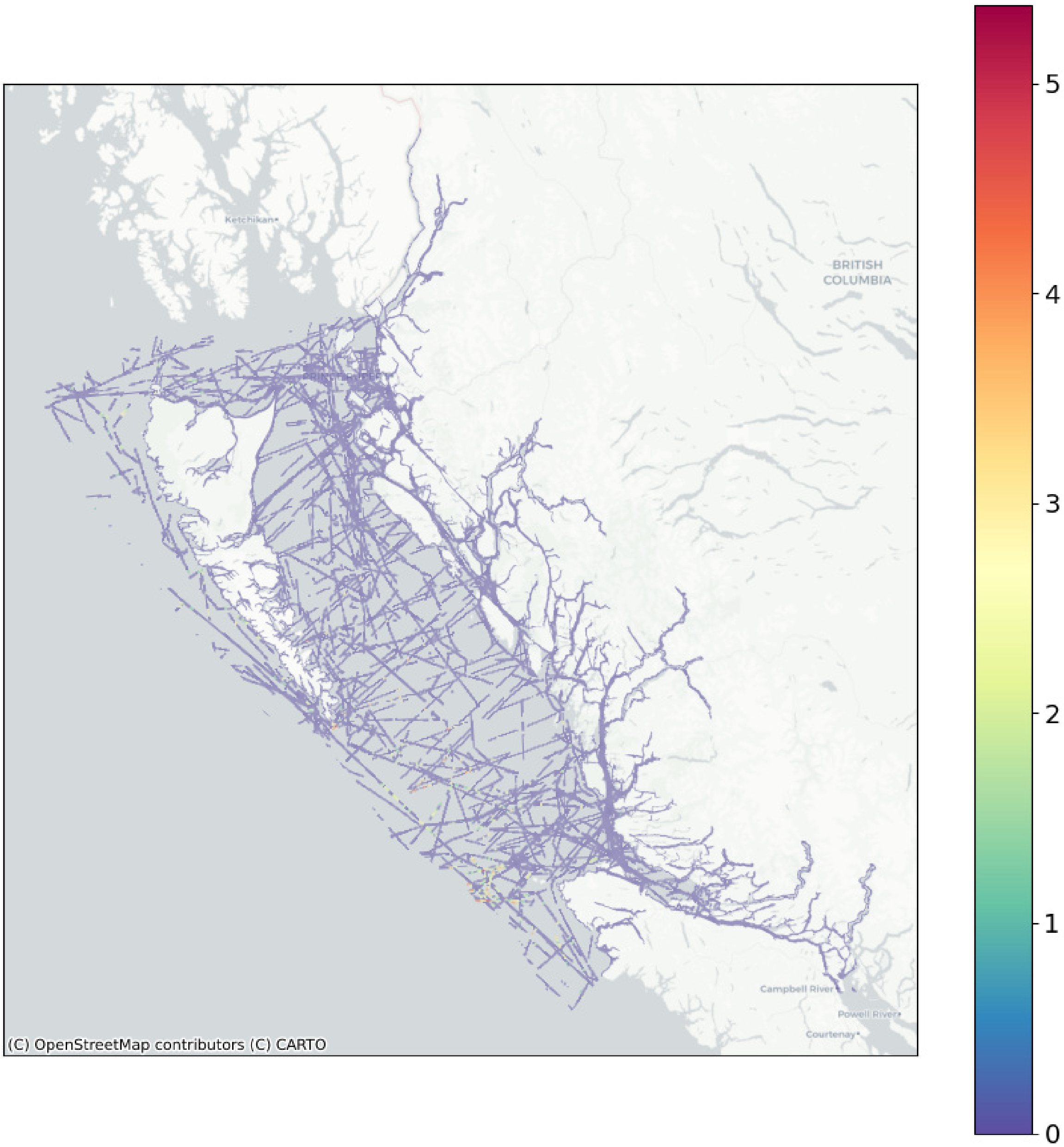

Figure 46: Effort-corrected density of Puffins (Horned and Tufted Puffins).

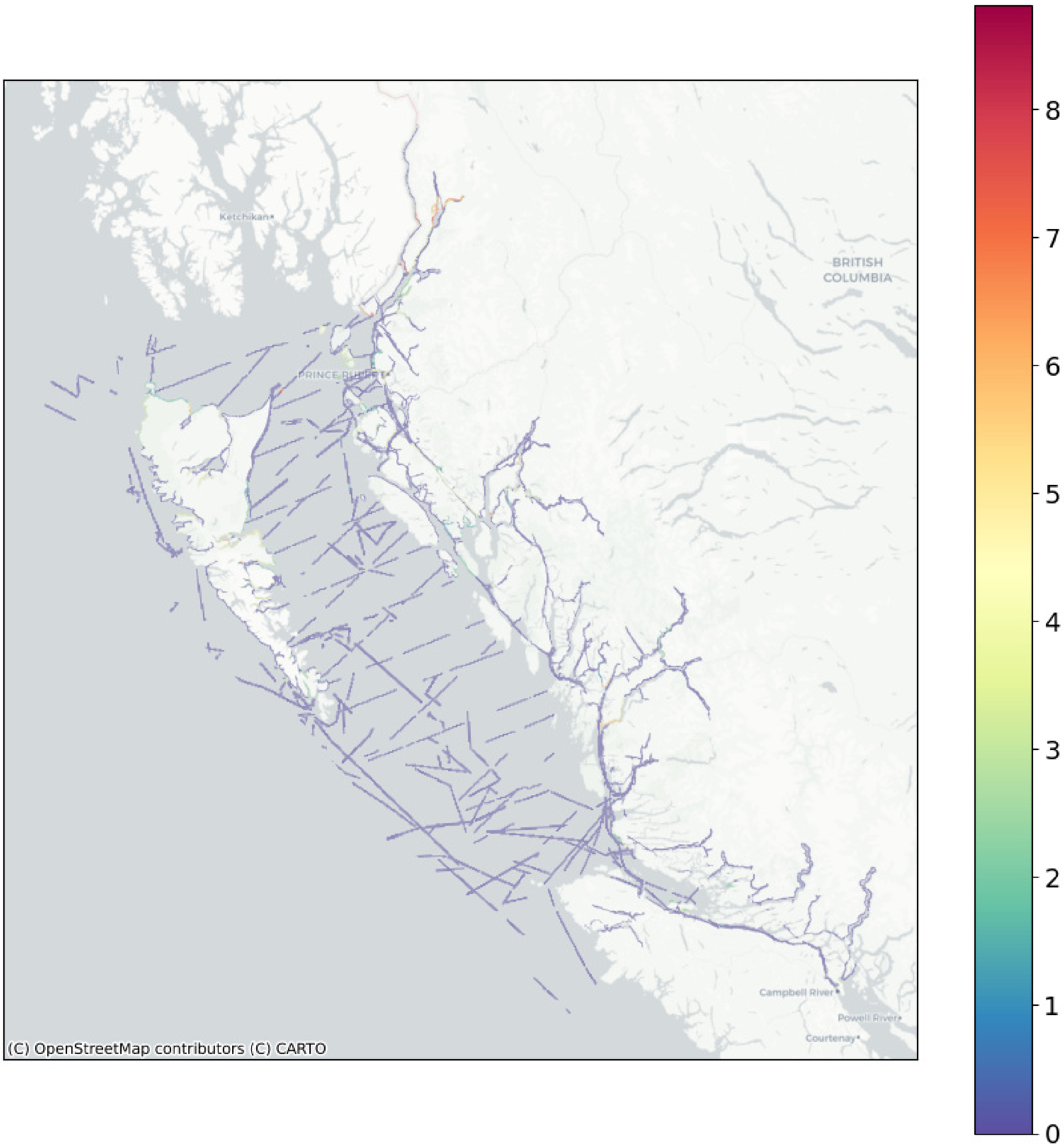

Figure 47: Effort-corrected density of Sea Ducks (Harlequin and Long-tailed Ducks; Black, Surf and White-winged Scoters; Barrow’s and Common Goldeneyes) in moulting season (Aug - Sep).

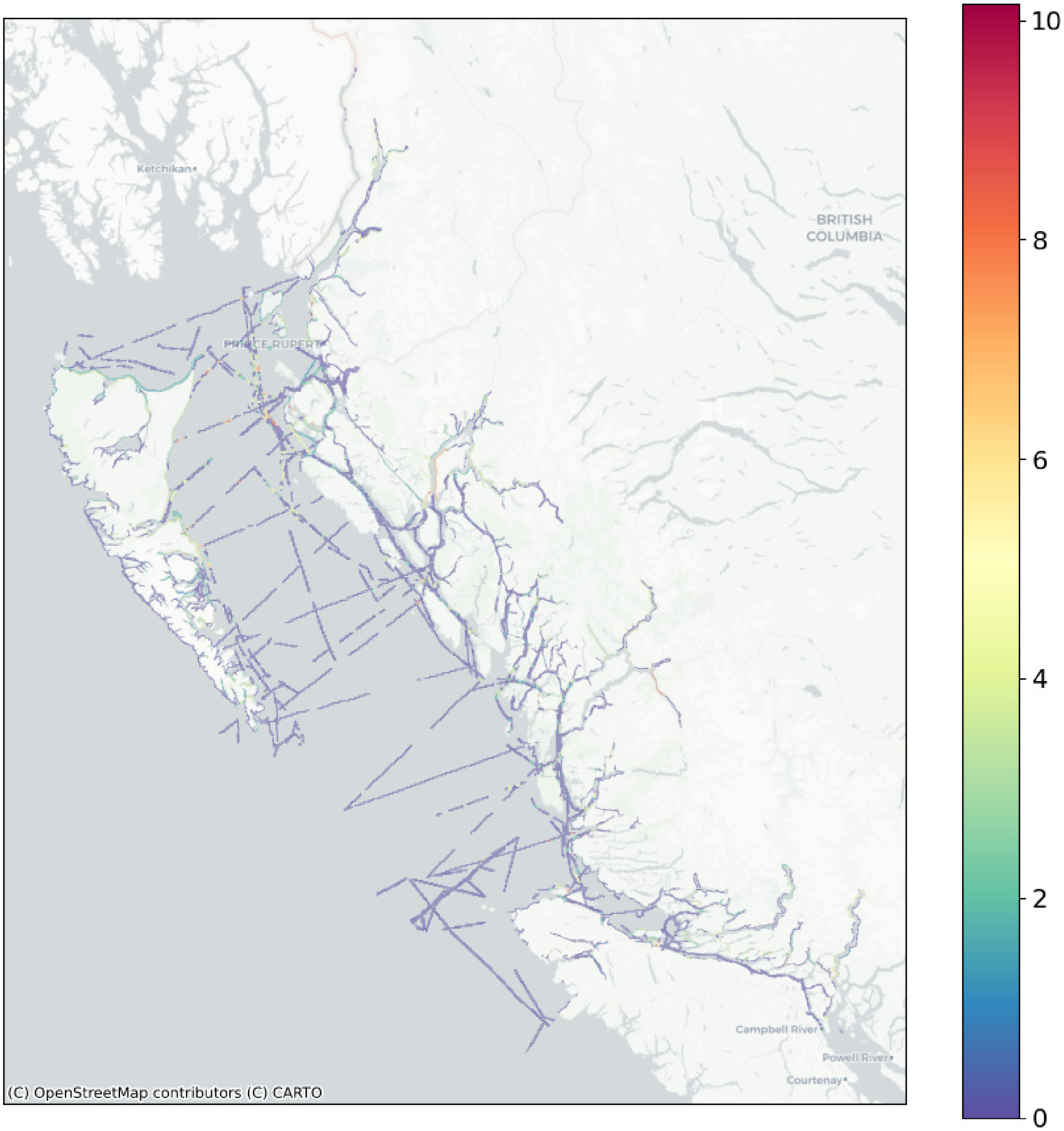

Figure 48: Effort-corrected density of Sea Ducks (Harlequin and Long-tailed Ducks; Black, Surf and White-winged Scoters; Barrow's and Common Goldeneyes) in pre-migration staging season (Mar - May).

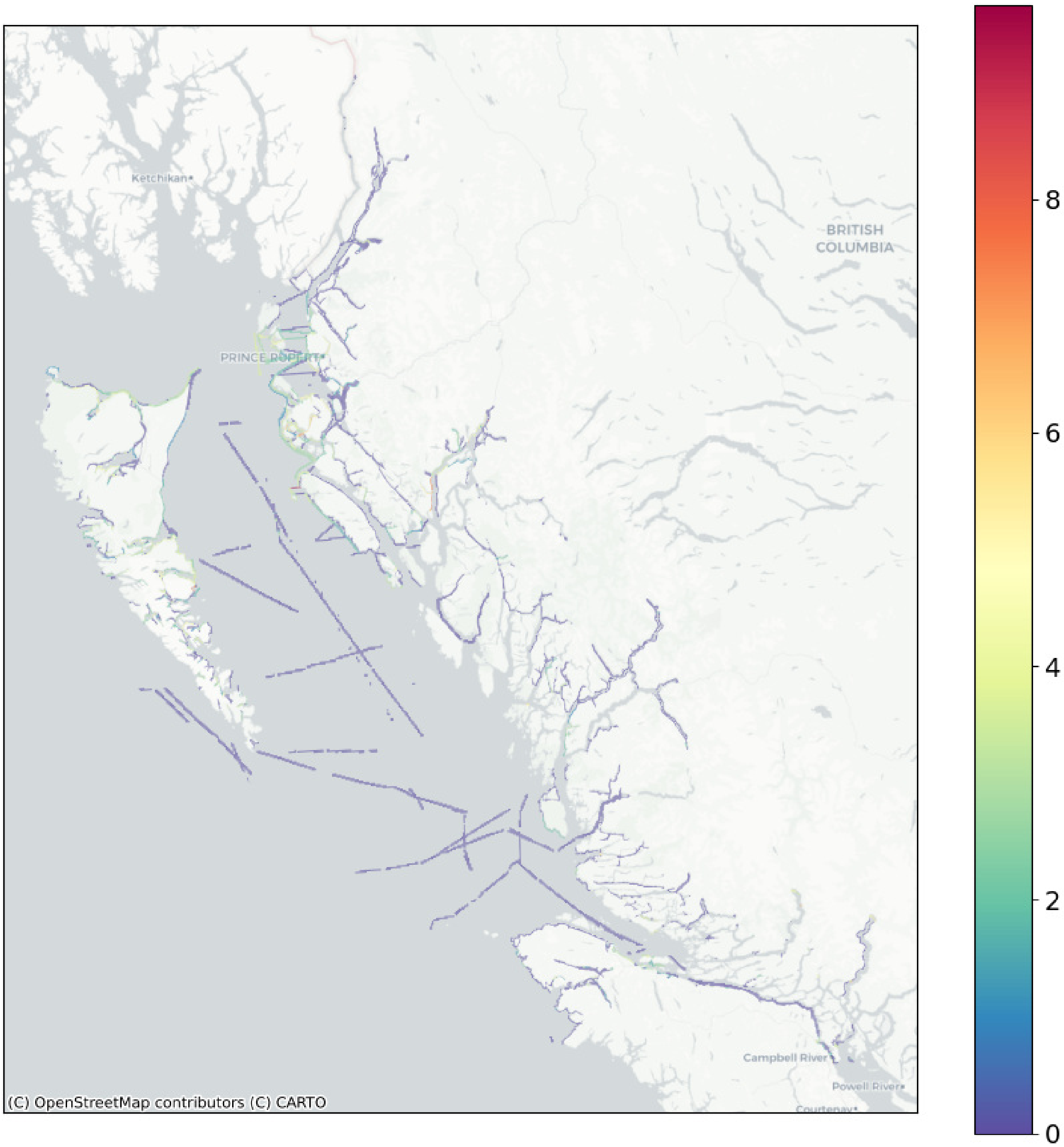

Figure 49: Effort-corrected density of Sea Ducks (Harlequin and Long-tailed Ducks; Black, Surf and White-winged Scoters; Barrow's and Common Goldeneyes) in winter (Dec - Feb).

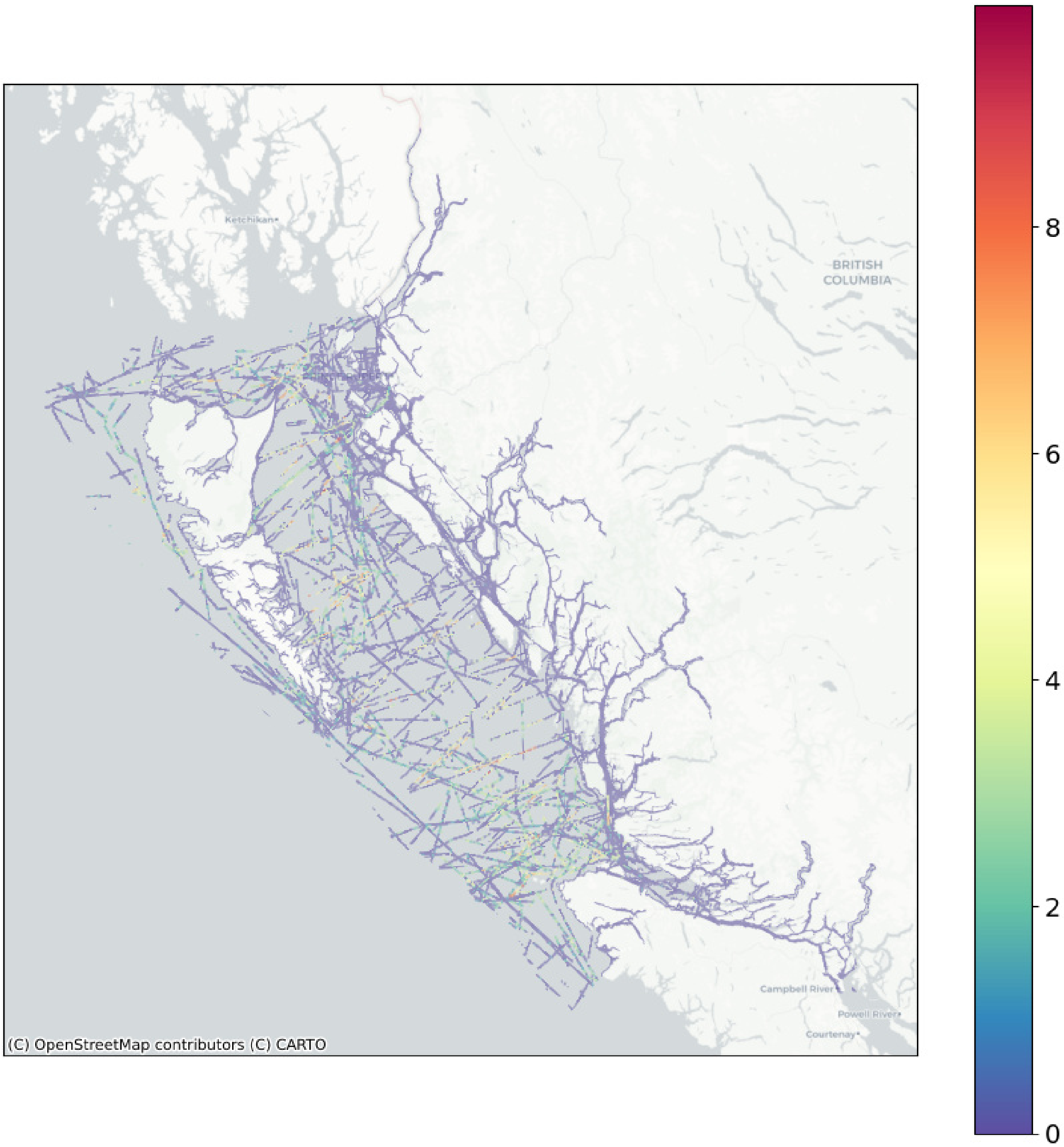

Figure 50: Effort-corrected density of Shearwaters and Fulmars (Buller's, Pink-footed, Short-tailed and Sooty Shearwaters; Northern Fulmars) in winter (Dec - Feb).

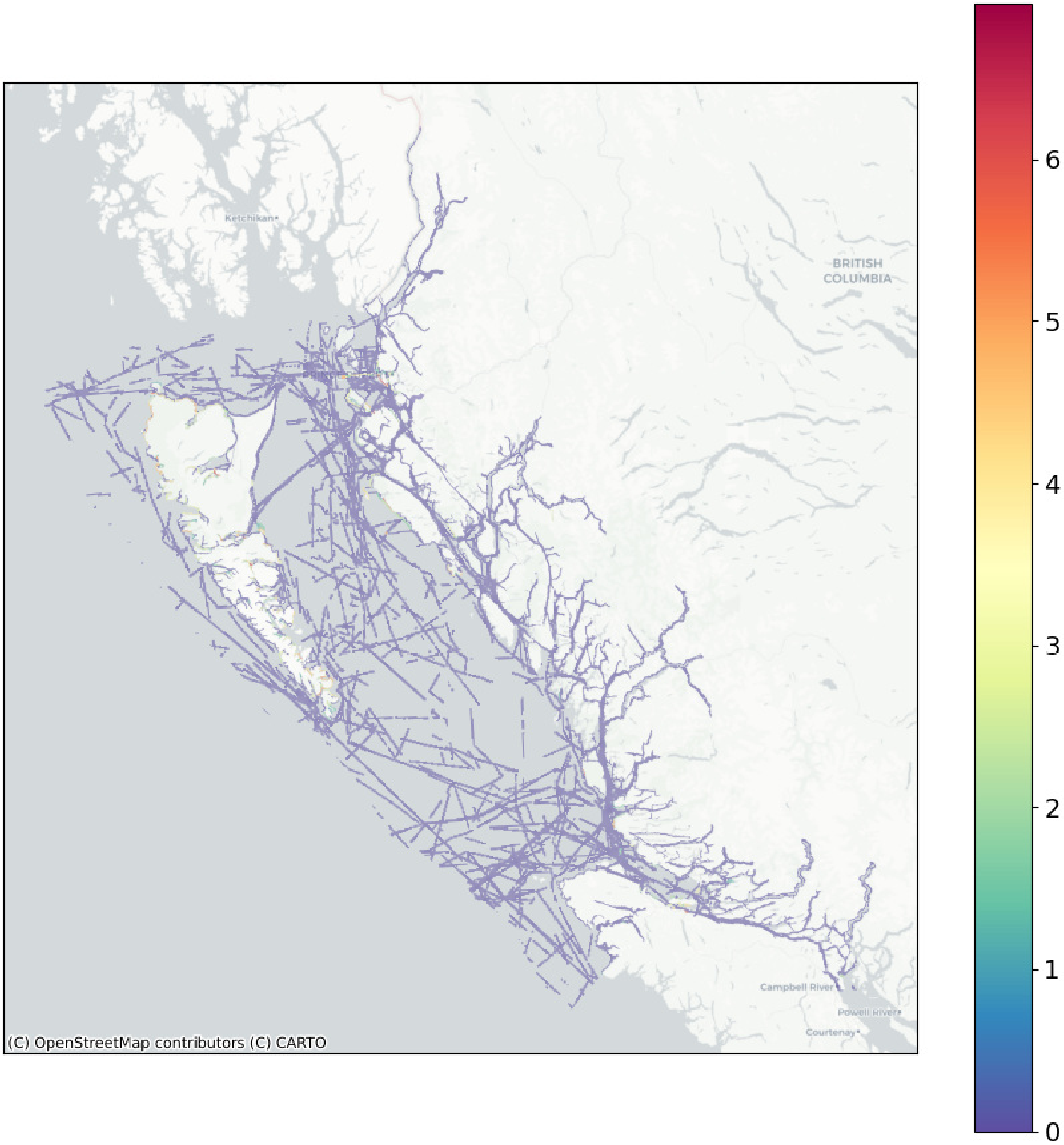

Figure 51: Effort-corrected density of Rocky Intertidal Birds (Black Oystercatchers; Black and Ruddy Turnstones; Rock Sandpipers; Surfbirds).

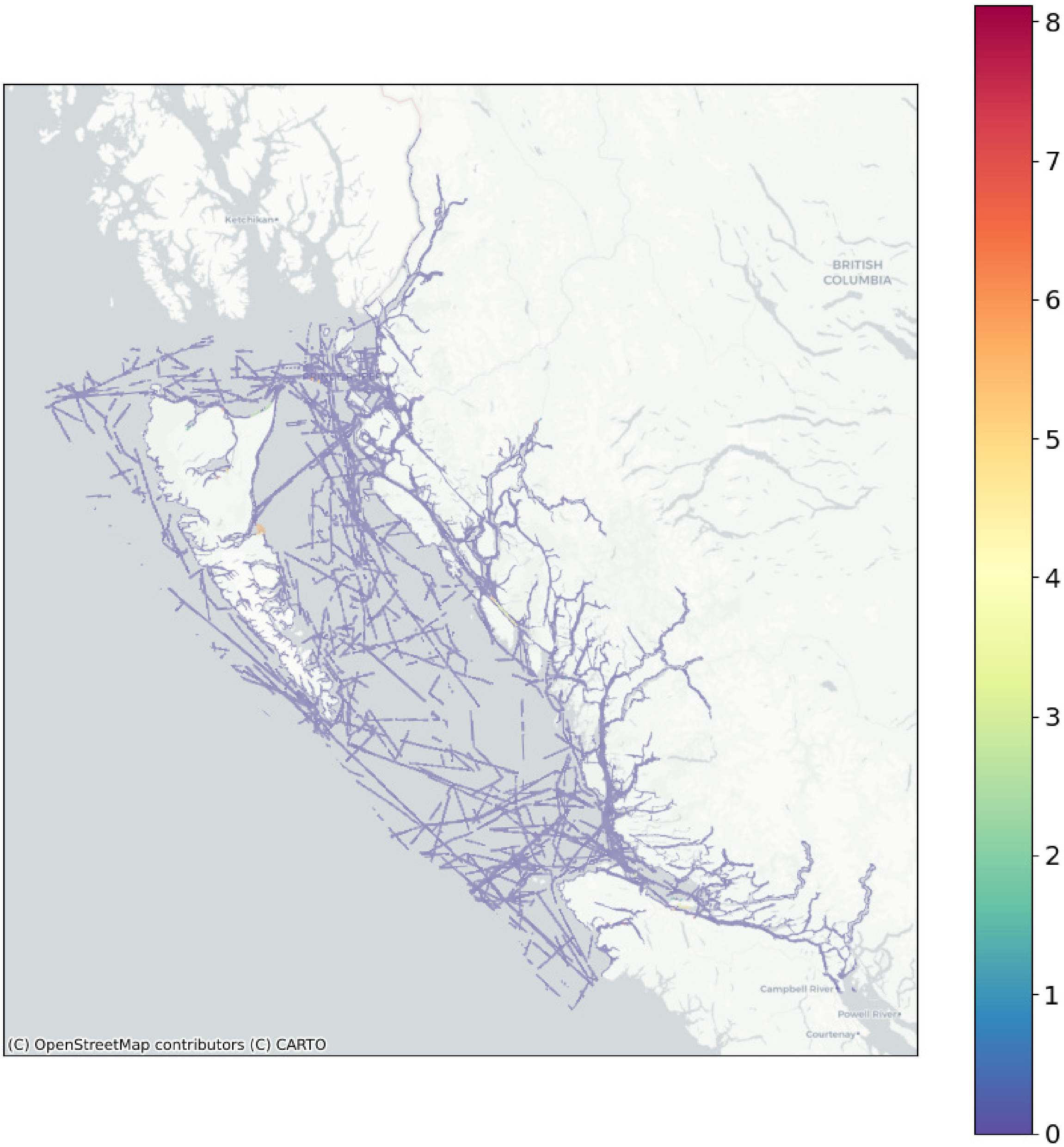

Figure 52: Effort-corrected density of Mud or Sand Flat Intertidal Birds (Dunlin; Red Knots; Sanderlings; Short-billed Dowitchers; Western Sandpipers; Whimbrels).

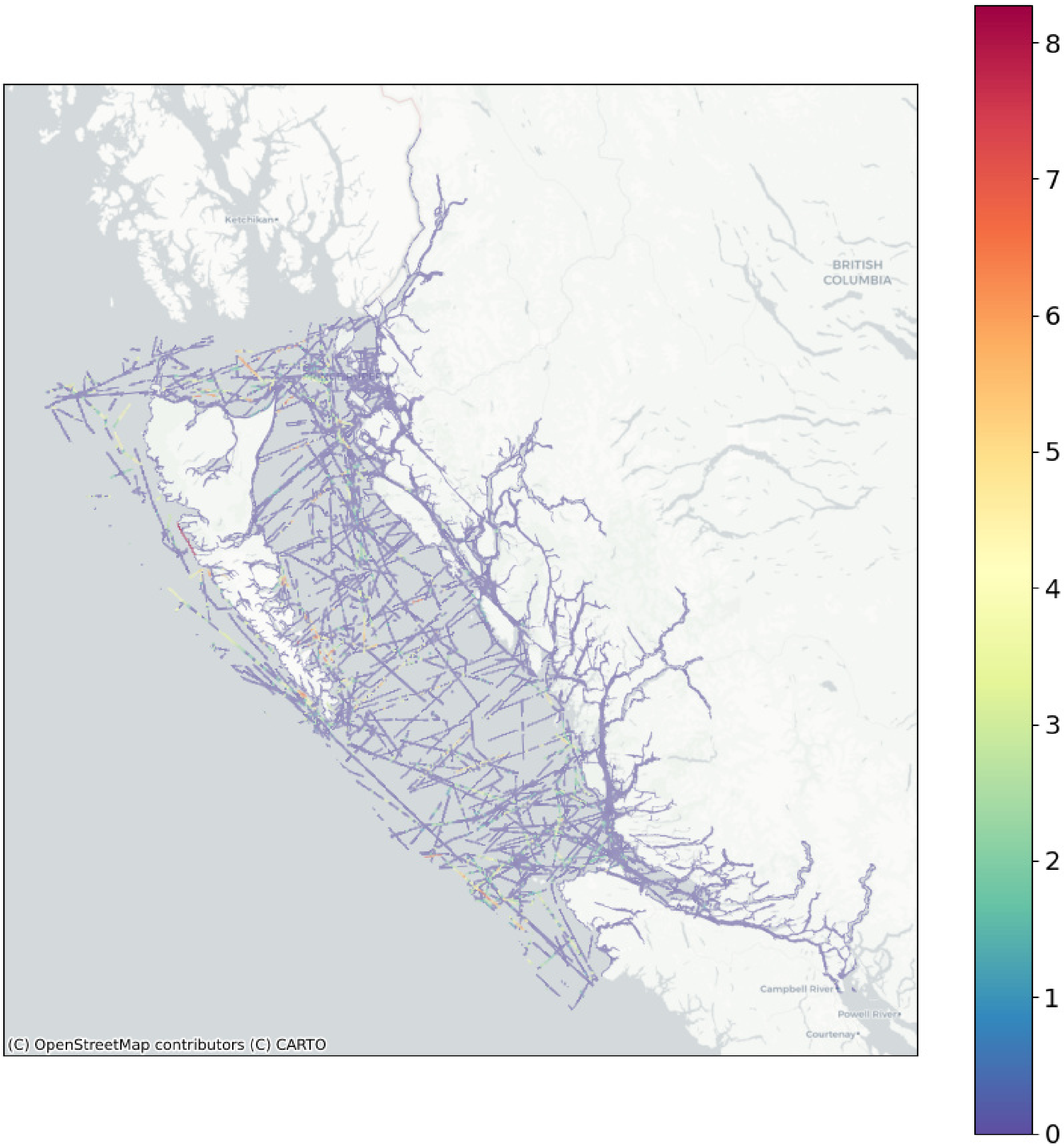

Figure 53: Effort-corrected density of small alcids (Ancient Murrelets; Cassin's Auklets).

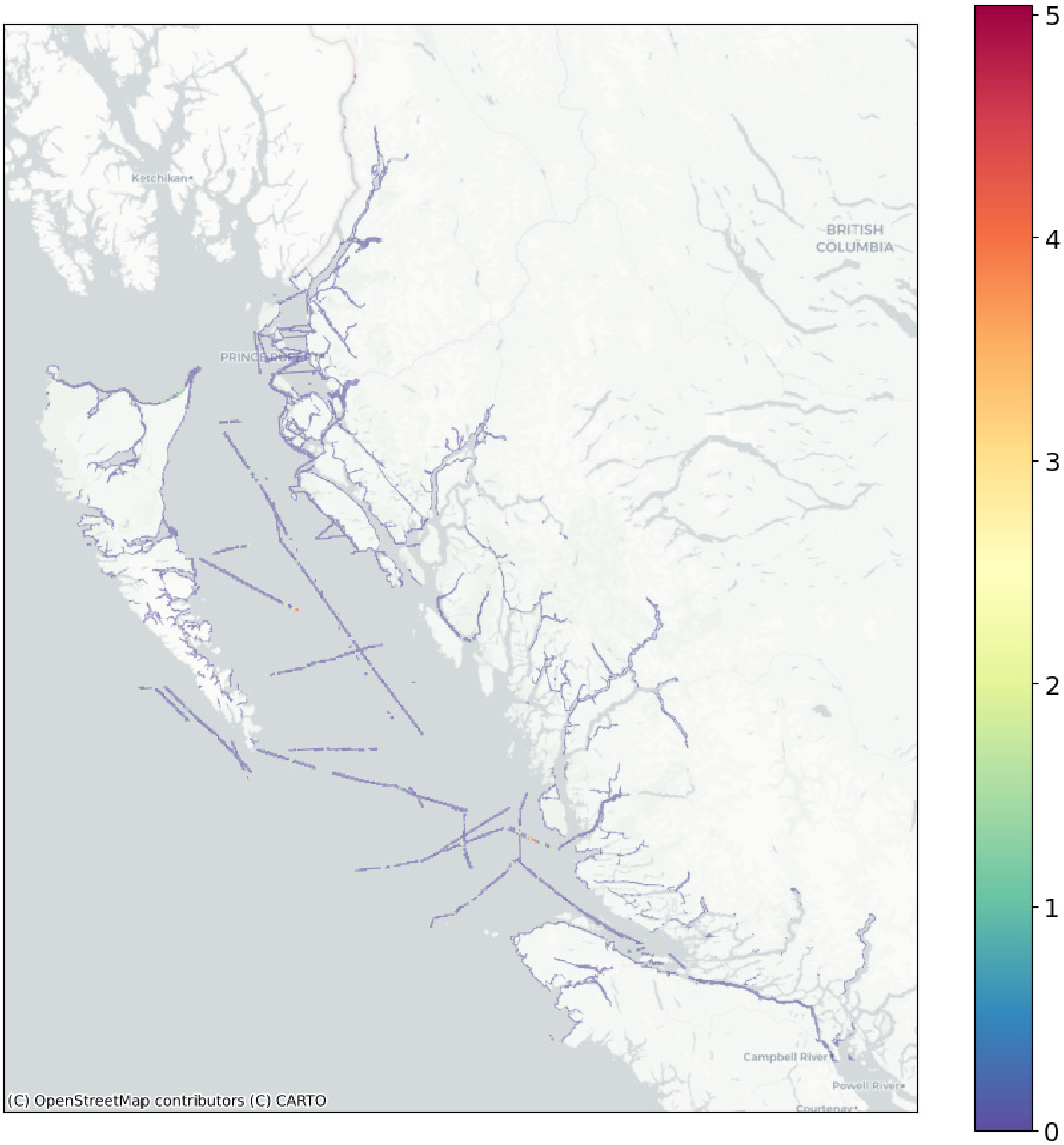

Figure 54: Effort-corrected density of small alcids (Ancient Murrelets; Cassin's Auklets) in winter (Dec - Feb)

NSB MPA Network Ecological Data - Other Bird Features

Summary:

There are 3 features in the 'Other Birds' geodatabase:

- (1) Seabird Important Areas
- (1) Sea Duck Joint Venture key sites
- (1) Shorebird key sites

Data Creators and Co-creators: Creator: Katie Gale; Co-Creators: Cathryn Clarke (Important Areas), Sea Duck Joint Venture (sea duck key sites), Canadian Wildlife Service (shorebird key sites), MPATT Science Team

Methods and links to metadata:

Seabird Important Areas

- Seabird Important Areas

EBSAs are areas of relatively higher ecological or biological significance than surrounding areas, where greater risk aversion is required in the management of activities (DFO, 2004). Within the EBSA boundary, perturbations are also expected to cause greater ecological consequences than in surrounding areas exposed to comparable perturbations.

Criteria to identify EBSAs have been established at the national (DFO, 2004) and international (Convention on Biological Diversity, 2008) levels. Areas that rank High for one or more of uniqueness, fitness consequences, or aggregation can be designated as an EBSA. A feature or area that ranks above average (Medium or High) across multiple criteria also meets the EBSA criteria.

EBSAs can be identified based on single features or species (e.g., spawning areas for a single species, or aggregations of single species), or multiple species or features (e.g., areas of high diversity, productivity, or overlap of many single-feature EBSAs). In the Pacific Region single-feature or taxon-specific EBSAs are referred to as "Important Areas" (IAs)(Clarke and Jamieson, 2006*a*; Levesque and Jamieson, 2015).

In the NSB, broad-scale IAs and EBSAs were identified in (Clarke and Jamieson, 2006*a*,*b*) and (DFO, 2013*a*). Species IAs were identified on the basis of species experts' knowledge on the biology of individual species, or groups of species, and the EBSAs were primarily identified on the basis of expert knowledge about physical and oceanographic features that also overlap with IAs for at least one species or species group.

Sea Duck Joint Venture key sites

-Sea Duck Key Sites

Data displayed as received. Sites that do not fall within the NSB were removed. Further information on the SDJV sites can be found here.

Shorebird key sites

-Shorebird Key Sites

The data are displayed as received from CWS, after removing sites that do not fall within the NSB (marked below with *). Sites were identified in the Pacific Americas Shorebird Conservation Strategy (Senner et al., 2016), but official spatial boundaries are not depicted in that paper nor on the Western Hemisphere Shorebird Reserve Network (WHSRN) website. Spatial extents for the Key Shorebird Sites were therefore delineated by CWS as follows:

- Delkatla Slough is the parcels owned by the village of Masset and under agreement to Ducks Unlimited.
- Queen Charlotte Strait is the Duke of Edinburgh IBA (Important Bird Area; Bird Studies Canada, 2015).
- Hansens Lagoon is the Hansens Inlet portion of Cape Scott Provincial Park.
- *Baynes Sound is the K'omoks IBA.
- *White Islets and Wilson Creek are the White Islets and Wilson Creek IBAs.
- *Tofino Mudflats/Chesterman Beach is the Tofino Mudflats IBA. Note the WHSRN polygon is an underestimation due to a lack of official boundaries.
- *Fraser River Delta is the full Fraser River Estuary IBA.
- *Barkley Sound is the Barkley Sound IBA.

Temporal Coverage:
`2006-01-01` to `2017-12-31`

Scripts/Software:
n/a

Data Sources:

- **Seabird Important Areas**: From Clarke and Jamieson (2006*a*). Available directly at `https://www.gis-hub.ca/dataset/ia-birds-pncima`
- **Sea Duck Joint Venture key sites**: Feature was obtained from Sea Duck Joint Venture; SDJV via Environment and Climate Change Canada (Canadian Wildlife Service).
- **Shorebird key sites**: Feature was obtained from Environment and Climate Change Canada (Canadian Wildlife Service)

Absence Data:
No absence data

Uncertainties:
Each feature has uncertainties based on its input data and processing steps. Notable uncertainties are described in each feature's individual metadata.

Species Data:
n/a

Maps of available datasets:

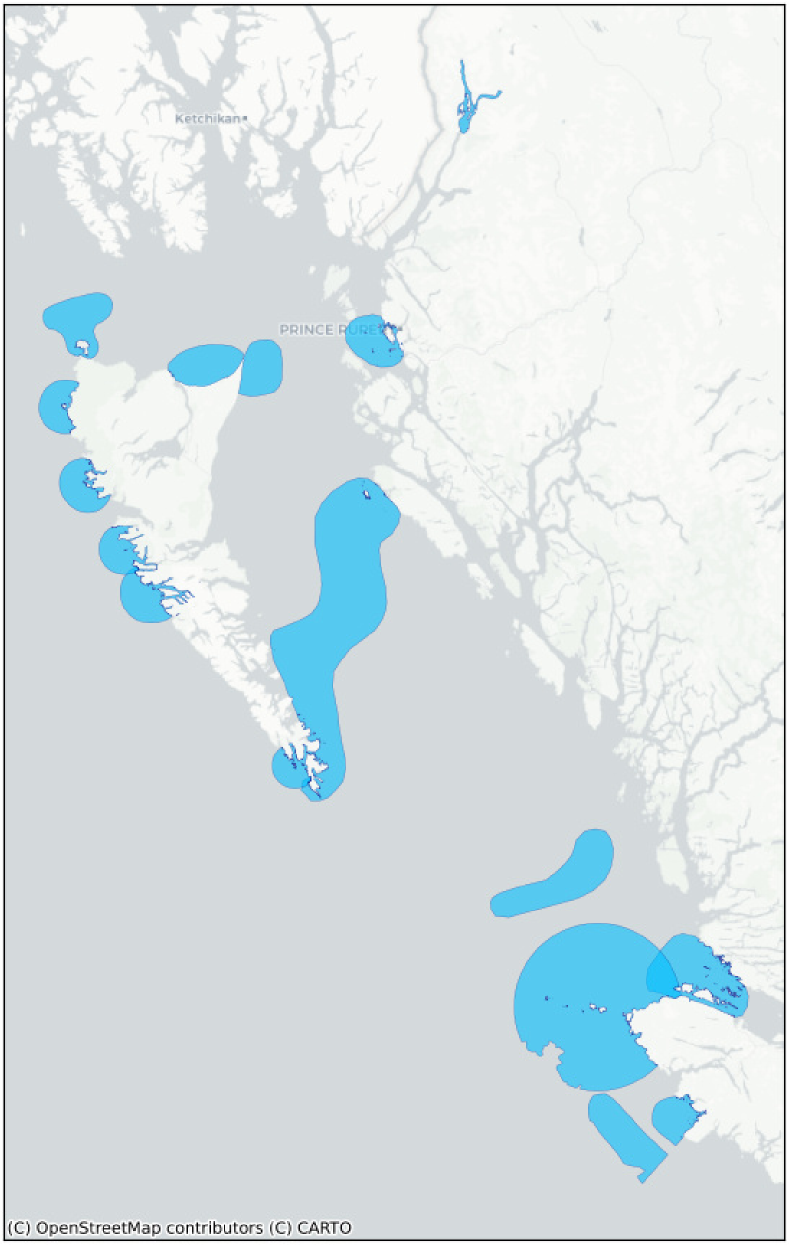

Figure 55: Marine bird "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

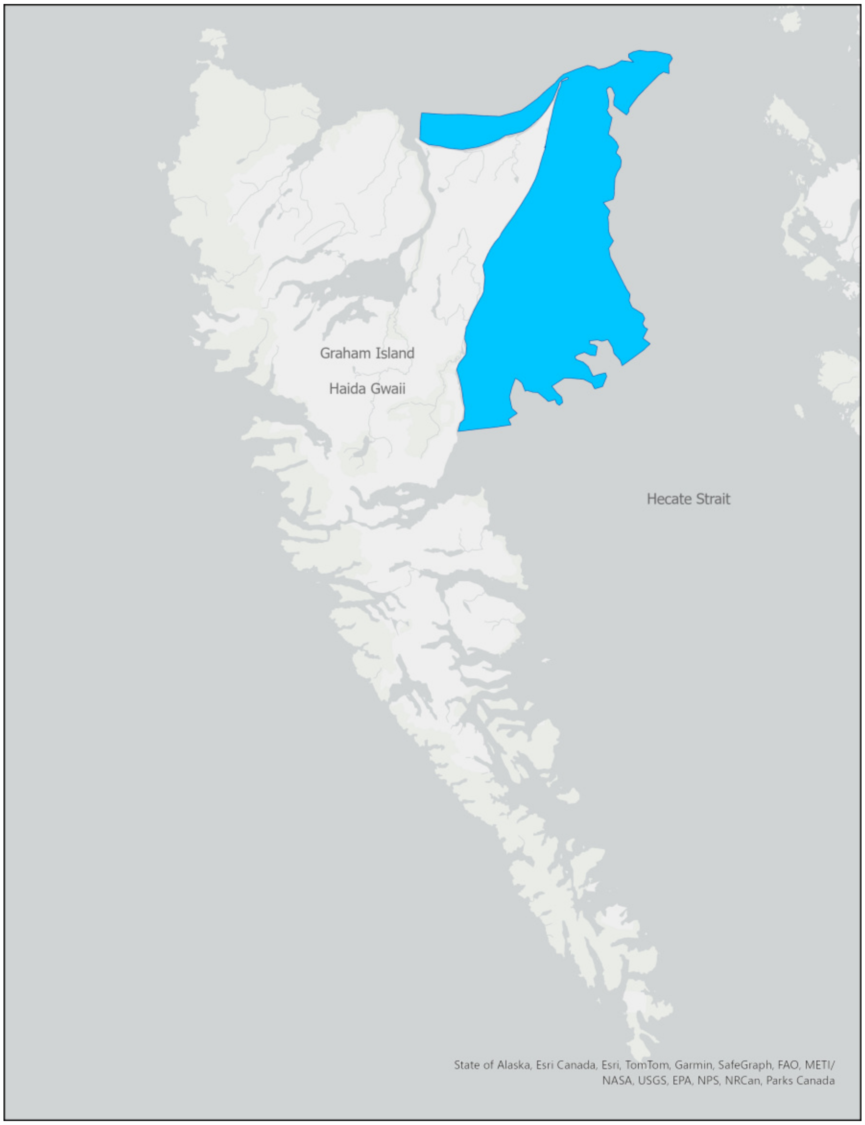

Figure 56: Key sites for sea ducks identified by the Sea Duck Joint Venture. Within the NSB, there is one key site northeast of Haida Gwaii (McIntyre Bay/Dogfish Bank).

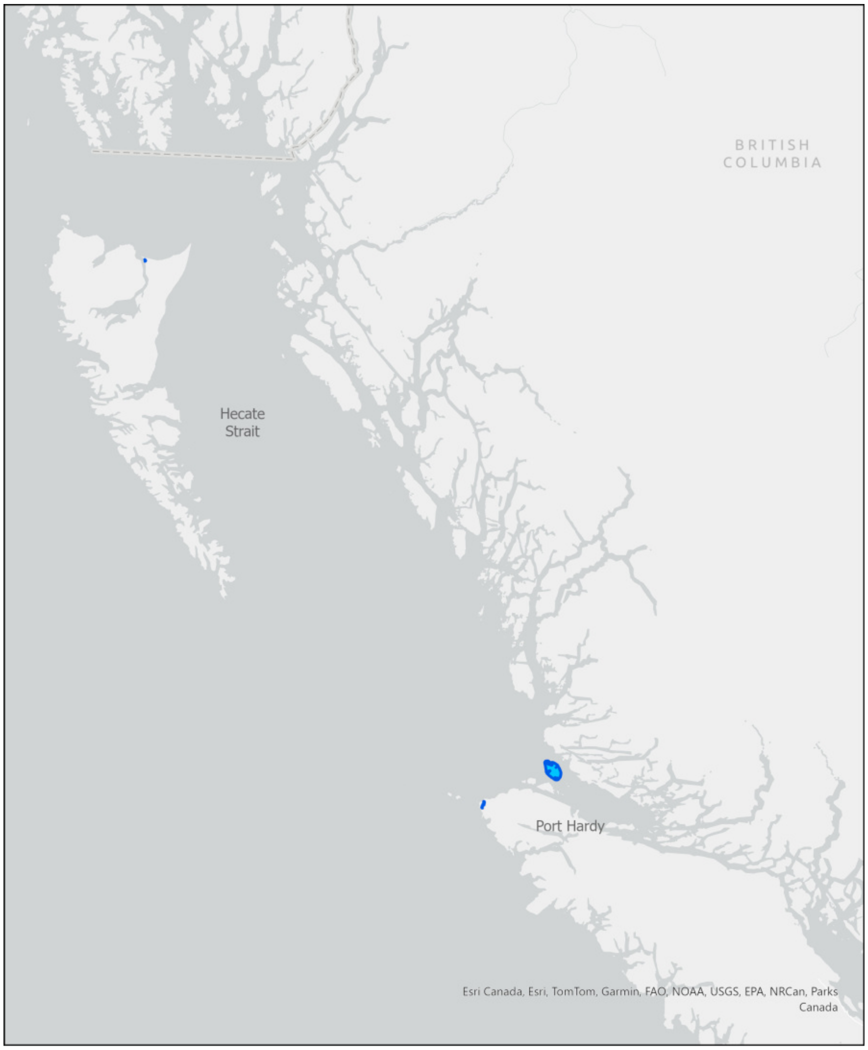

Figure 57: Key sites for shorebirds identified by the Pacific Americas Shorebird Conservation Strategy

Fishes and Invertebrates

NSB MPA Network Ecological Data - CCIRA Features

Summary:
There are 13 features in the Central Coast Indigenous Resource Alliance (CCIRA) geodatabase:

- (1) Benthic fish diversity
- (1) Lingcod catch per unit effort
- (9) Rockfish catch per unit effort
- (1) Coral presence
- (1) Glass sponge cover

Data Creators and Co-creators: Creator: Alejandro Frid (CCIRA); Co-Creators: Katie Gale, MPATT Science Team
Methods and links to metadata:
Data come from Frid et al. (2018). Field surveys of nearshore habitats used three methods:

- Towed video: 578 sub-transects nested within 119 sites at a mean depth of 73 m (range 2-230 m).
- Dive: 253 transects nested within 135 sites at a mean depth of 23 m (range 13-35 m).
- Fishery-independent sampling with hook-and-line gear: 242 sites at a mean depth of 51 m (6-213 m).

CPUE: For each method, the CPUE of each 4 km^2 planning unit (PU) was first calculated as the sum of fish counts divided by the sum of effort.

Because the 3 methods differ in metrics and potential biases, CPUE values were converted to a proportion of the maximum values obtained by a given method, creating a common metric across methods (Propmax).

For each PU, from these metrics a mean Propmax, weighted by effort (NumSurv), was estimated. That is, for methods i, j, k; the weighted average is:

$$\frac{(Propmax_i \times NumSurv_i) + (Propmax_j \times NumSurv_j) + (Propmax_k \times NumSurv_k)}{(NumSurv_i + NumSurv_j + NumSurv_k)}$$

Diversity: The Shannon diversity index (H′) was calculated for each sample (tow video sub-transects, 44 species recorded; dive transects, 33 species; and fishing sets, 22 species).

Because the 3 survey methods differ in potential biases, including the identity and number of species observed, diversity values were normalized (converted to a proportion of the maximum values obtained by a given method, creating a common metric across methods).

For each survey method all 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 4 km^2 planning units.

Coral and sponge: Only the towed video data was used for coral and sponge.

Corals were mainly *Paragorgia pacifica* and *Calcigorgia spiculifera*, with one site containing abundant *Stylaster* sp. Glass sponges were mainly *Aphrocallistes vastus*, *Farrea occa*, *Heterochone calyx*, *Rhabdocalyptus dawsoni*, and *Staurocalyptus dowlingi*.

Video was annotated every 2 seconds for presence of corals and percent cover of glass sponges. Percent cover categories were 0 (0%), 1 (1-25%), 2 (26-50%), 3 (51-75%), 4 (76-100%). The average sponge cover category for each sub-transect was calculated by averaging all annotation records within that sub-transect.

The mean cover category for glass sponges was calculated as the average of all sub-transects within a 4 km^2 planning unit. Coral values were calculated as presence or absence of coral in any sub-transect within the planning unit.

Links to online metadata

The above methods apply to all features in this geodatabase. Each feature has embedded metadata with details on its creation. Links to online versions of each feature's metadata are listed below.

Fish:

- Benthic fish diversity
- Lingod
- Bocaccio
- Canary Rockfish
- China Rockfish
- Mid-lived rockfish
- Quillback Rockfish
- Rosethorn Rockfish
- Silvergray Rockfish
- Tiger Rockfish
- Yelloweye Rockfish

Coral and sponge:

- Coral presence
- Glass sponge cover

Temporal Coverage:
2006-01-01 to 2017-12-31

Scripts/Software:
Scripts to process the CCIRA data files are at the MSEA GitLab page.

Spatial Data Quality:
Data was summarized within 4 km^2 grid cells to retain the confidentiality of the original collection sites.

Data Sources:

- CCIRA surveys, which targeted rocky reefs embedded in a matrix of soft substrate.

Absence Data:
Zero values indicate that the species was not observed the surveys within that grid cell.

Uncertainties:
Each feature has uncertainties based on its input data and processing steps. Notable uncertainties are described in each feature's individual metadata.

Species Data:

- SEBASTES PAUCISPINIS (BOCACCIO)
- OPHIODON ELONGATUS (LINGCOD)
- SEBASTES MALIGER (QUILLBACK ROCKFISH)
- SEBASTES HELVOMACULATUS (ROSETHORN ROCKFISH)
- SEBASTES BREVISPINIS (SILVERGRAY ROCKFISH)
- SEBASTES NIGROCINCTUS (TIGER ROCKFISH)
- SEBASTES RUBERRIMUS (YELLOWEYE ROCKFISH)
- SEBASTES MELANOPS (BLACK ROCKFISH)
- SEBASTES CAURINUS (COPPER ROCKFISH)
- SEBASTES ELONGATUS (GREENSTRIPED ROCKFISH)
- SEBASTES PRORIGER (REDSTRIPE ROCKFISH)
- SEBASTES MINIATUS (VERMILION ROCKFISH)
- SEBASTES ENTOMELAS (WIDOW ROCKFISH)
- SEBASTES FLAVIDUS (YELLOWTAIL ROCKFISH)
- PARAGORGIA PACIFICA
- CALCIGORGIA SPICULIFERA
- STYLASTER (GEN)
- APHROCALLISTES VASTUS
- FARREA OCCA
- HETEROCHONE CALYX
- RHABDOCALYPTUS DAWSONI
- STAUROCALYPTUS DOWLINGI

Maps of available datasets:

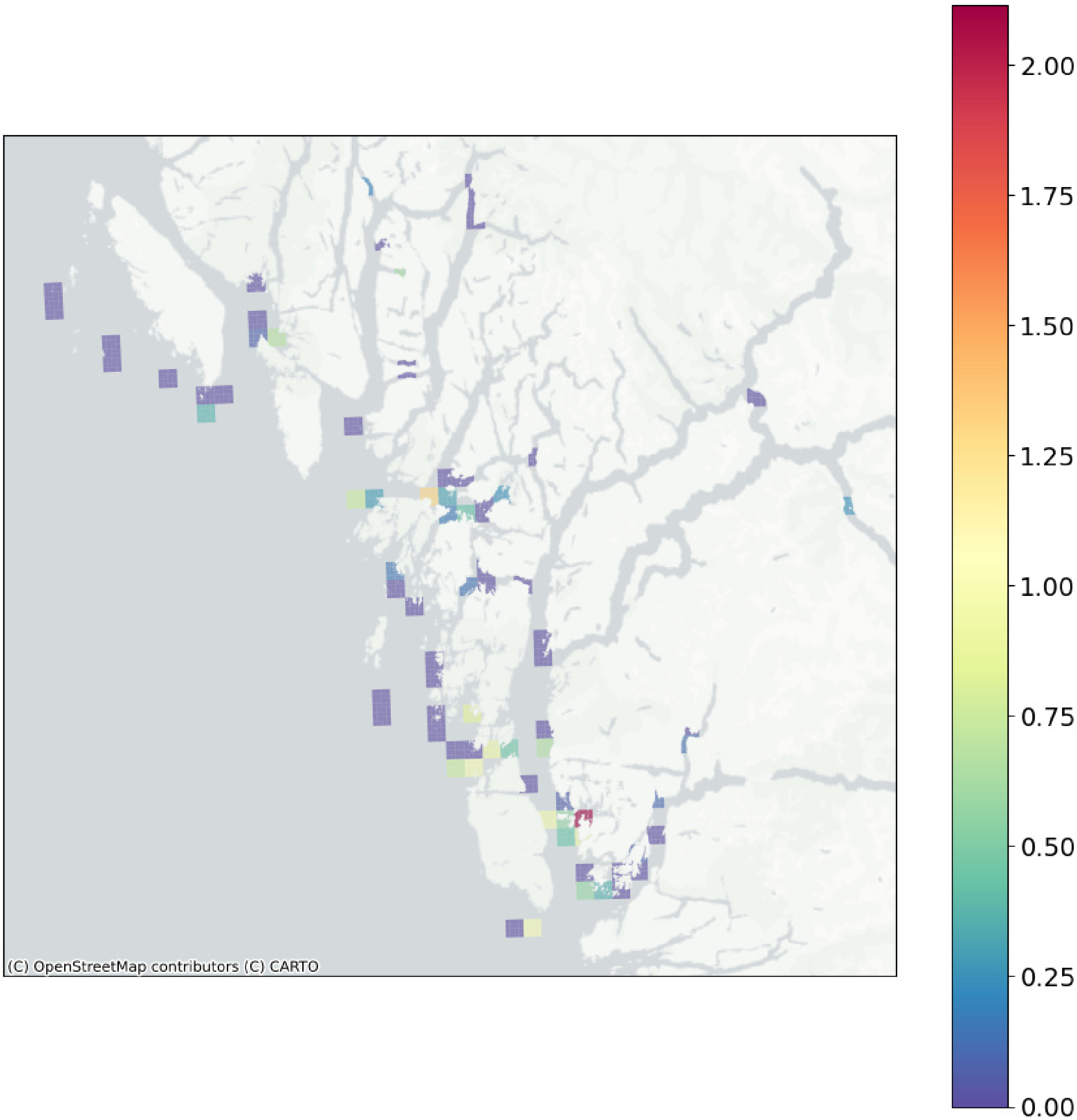

Figure 58: Normalized Shannon diversity of all benthic fish recorded along nearshore areas of British Columbia's central coast (CCIRA surveys).

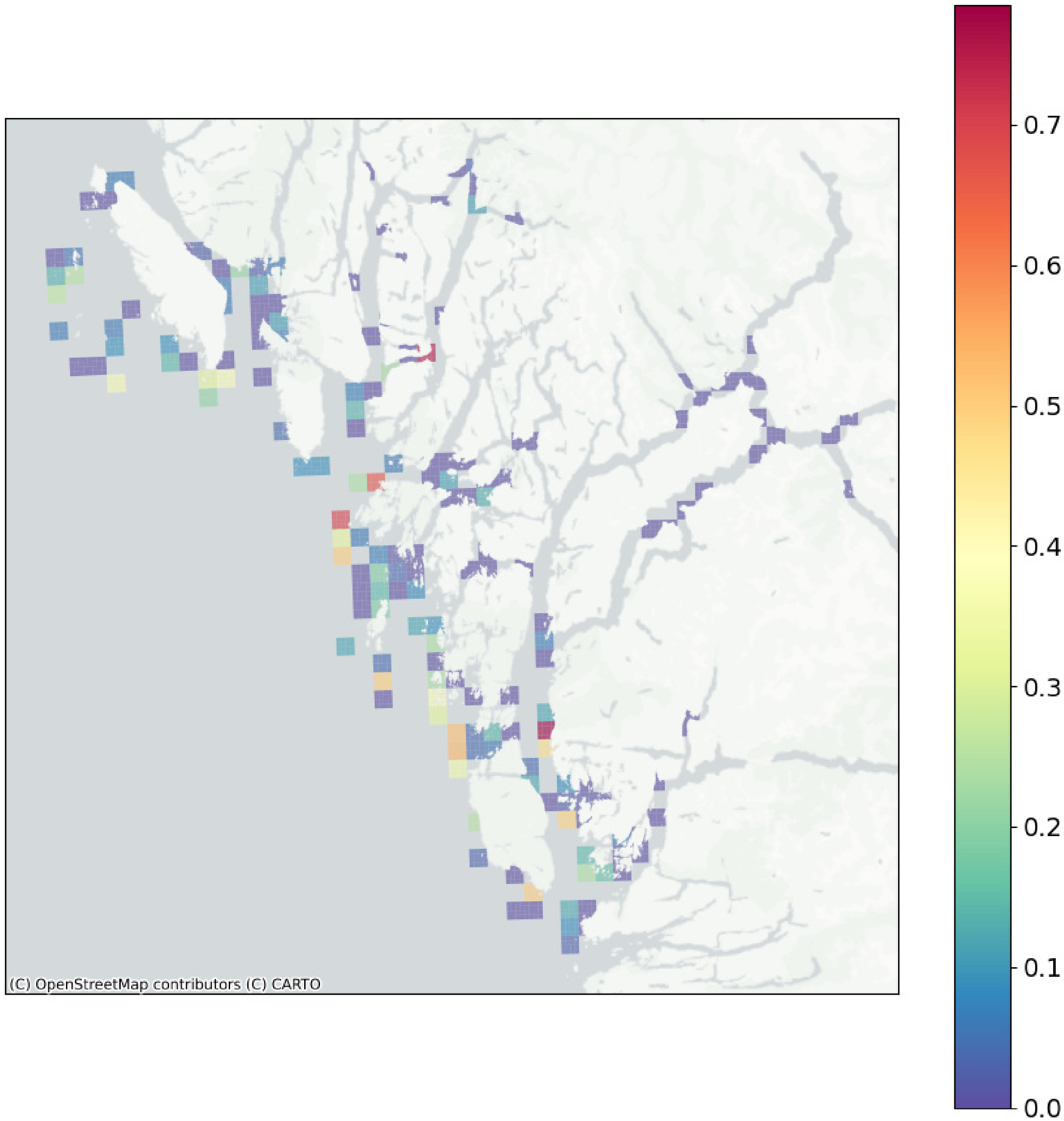

Figure 59: CPUE of Lingcod from CCIRA research surveys, displayed as deciles of catch per unit effort.

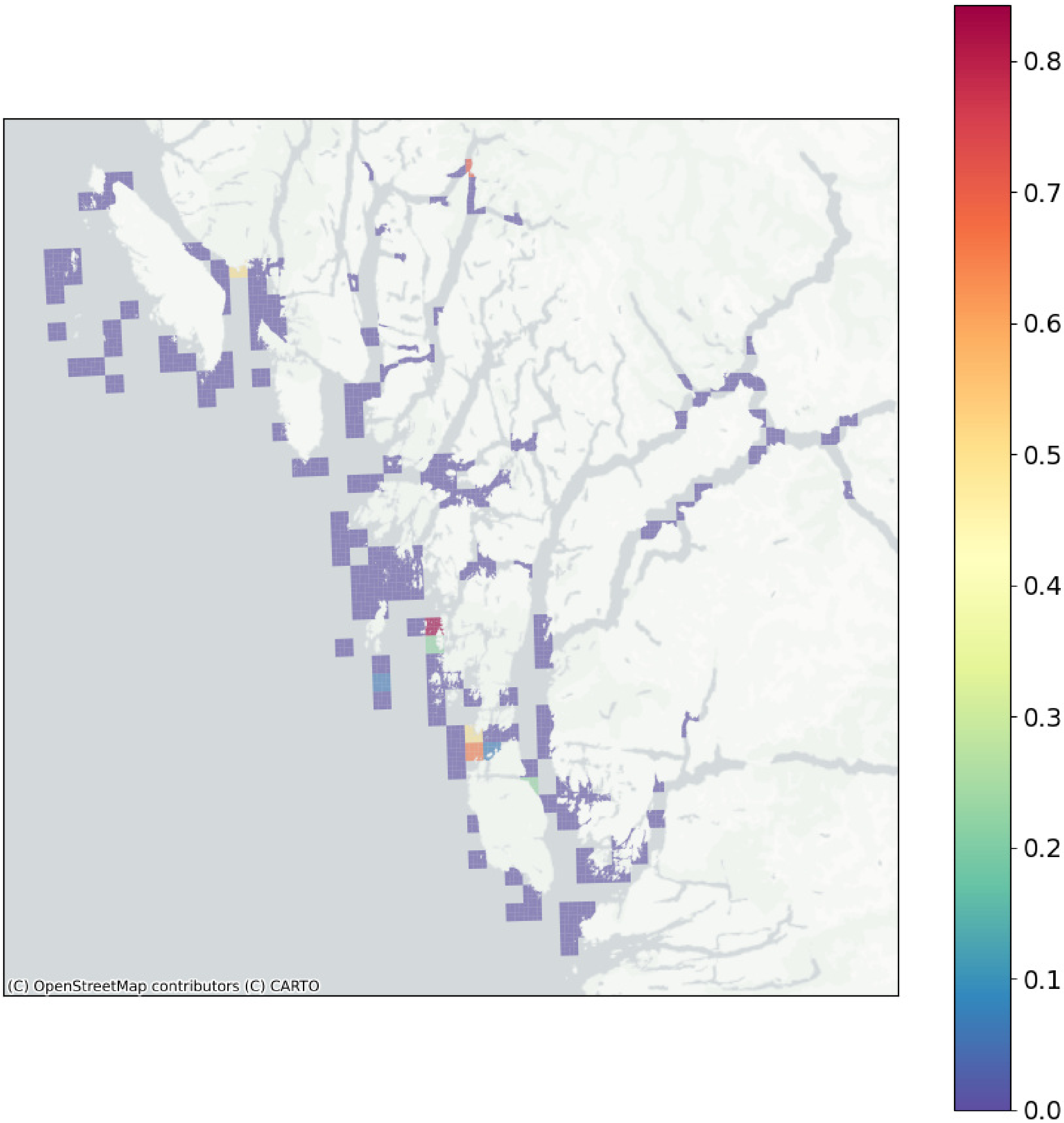

Figure 60: CPUE of Bocaccio from CCIRA research surveys, displayed as deciles of catch per unit effort.

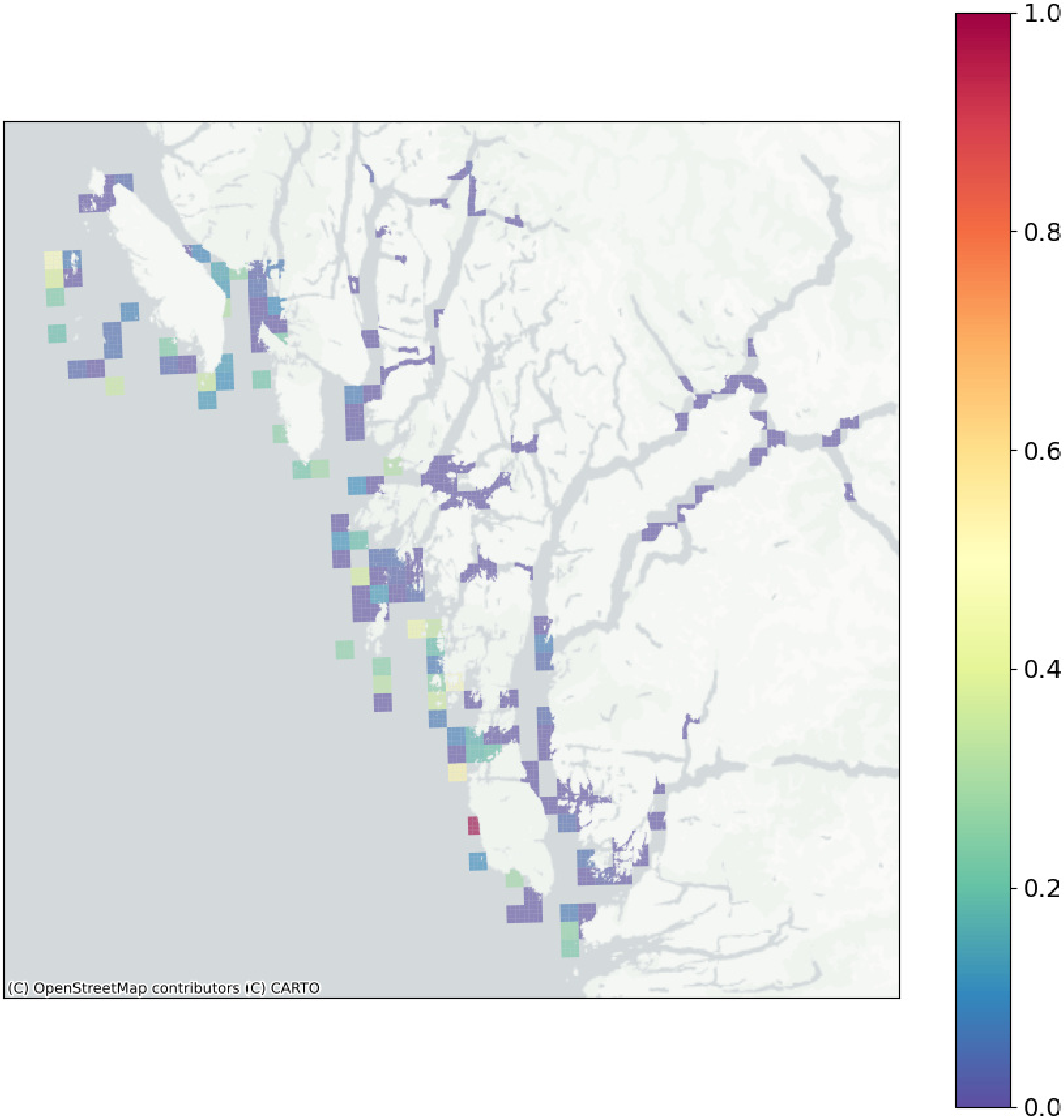

Figure 61: CPUE of Canary Rockfish from CCIRA research surveys, displayed as deciles of catch per unit effort.

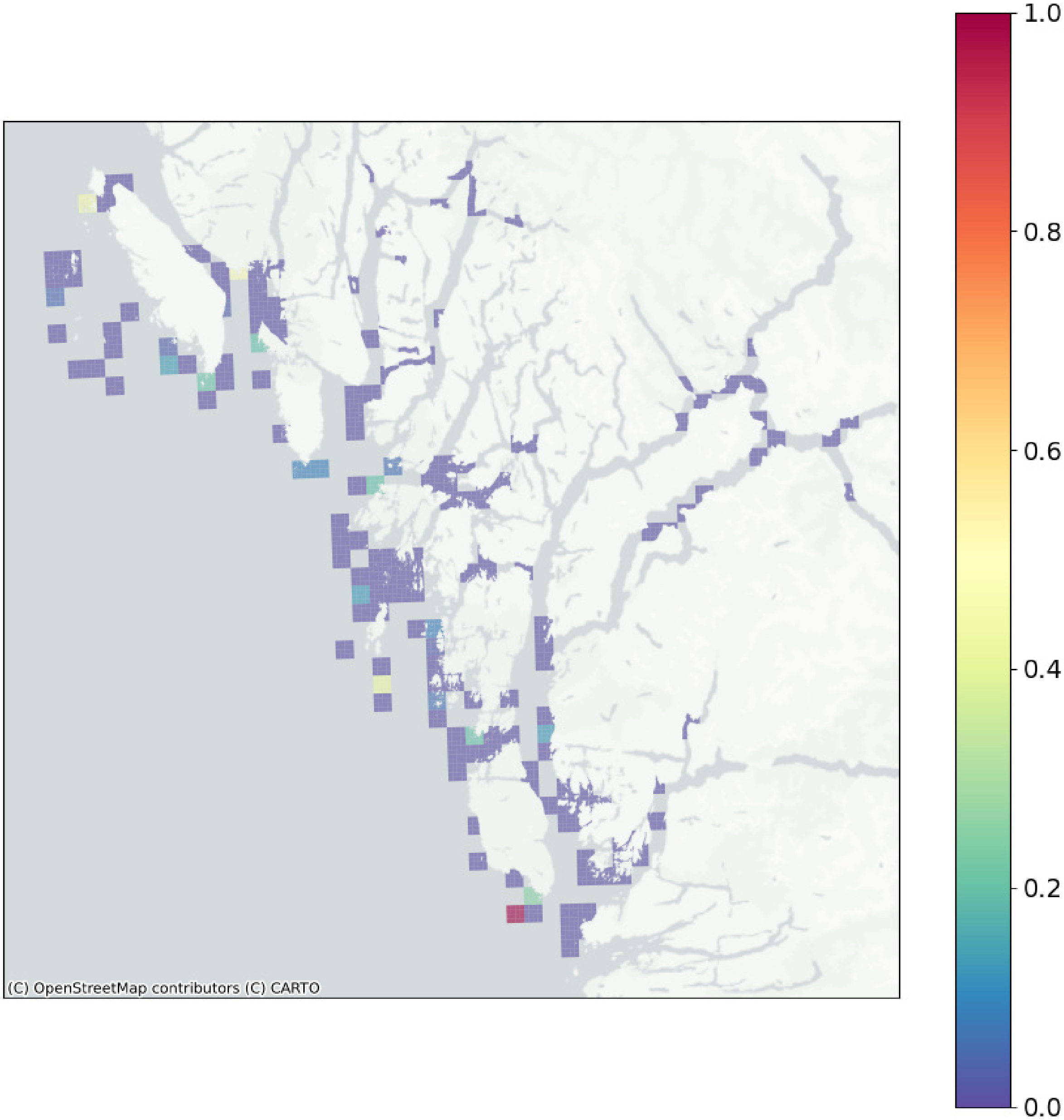

Figure 62: CPUE of China Rockfish from CCIRA research surveys, displayed as deciles of catch per unit effort.

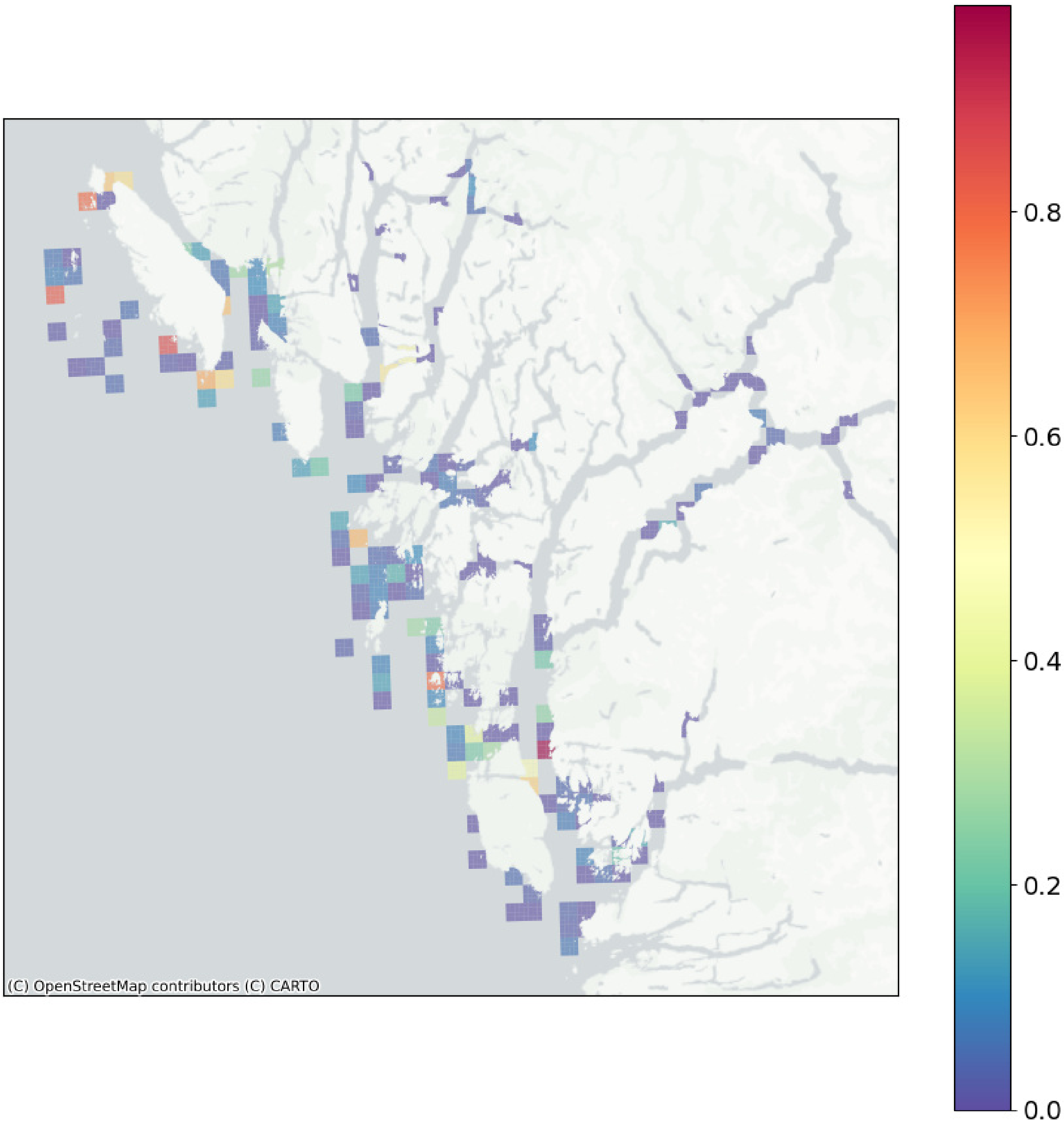

Figure 63: CPUE of mid-lived Rockfish from CCIRA research surveys, displayed as deciles of catch per unit effort. (Black, Copper, Greenstriped, Redstripe, Vermillion, Widow, and Yellowtail Rockfish).

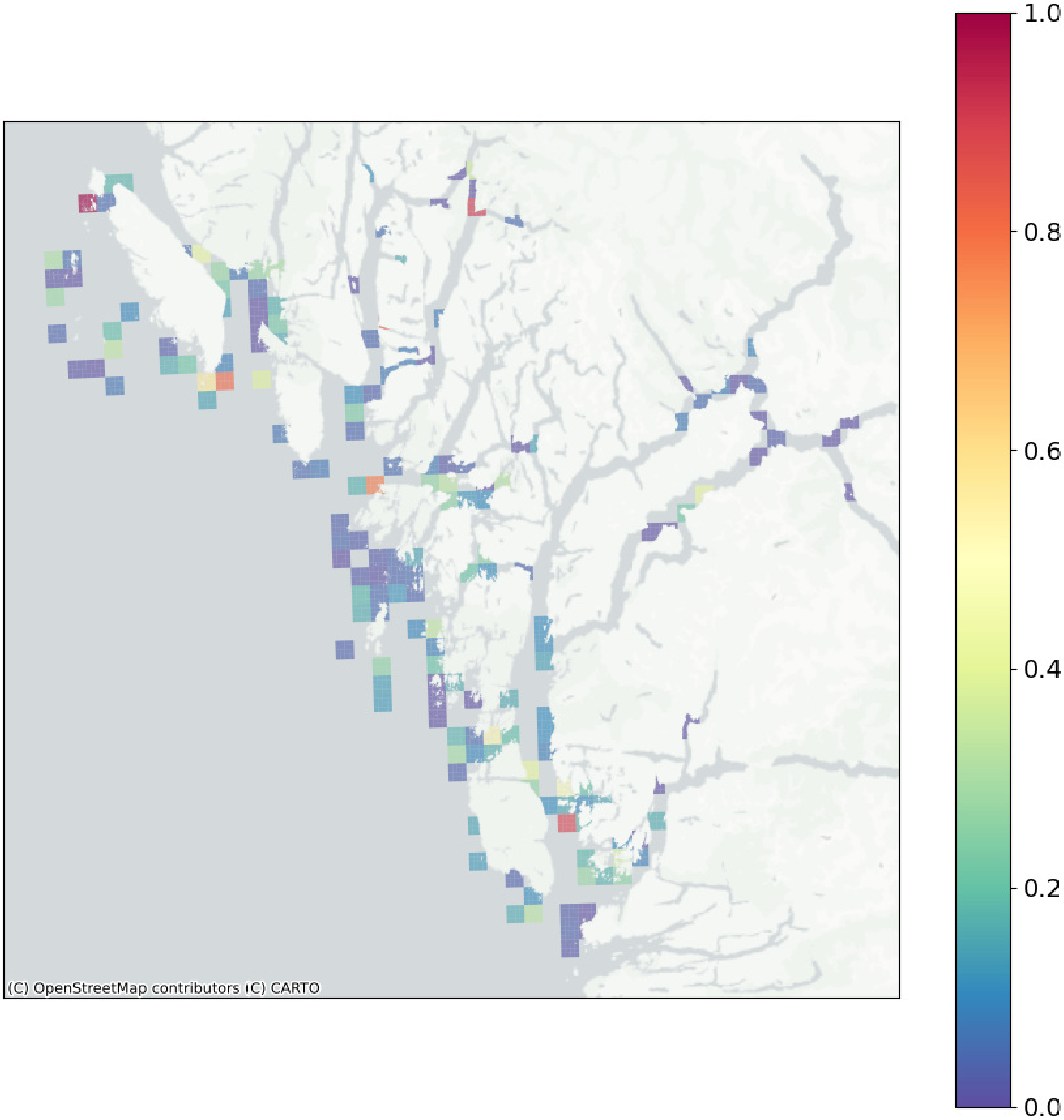

Figure 64: CPUE of Quillback Rockfish from CCIRA research surveys, displayed as deciles of catch per unit effort.

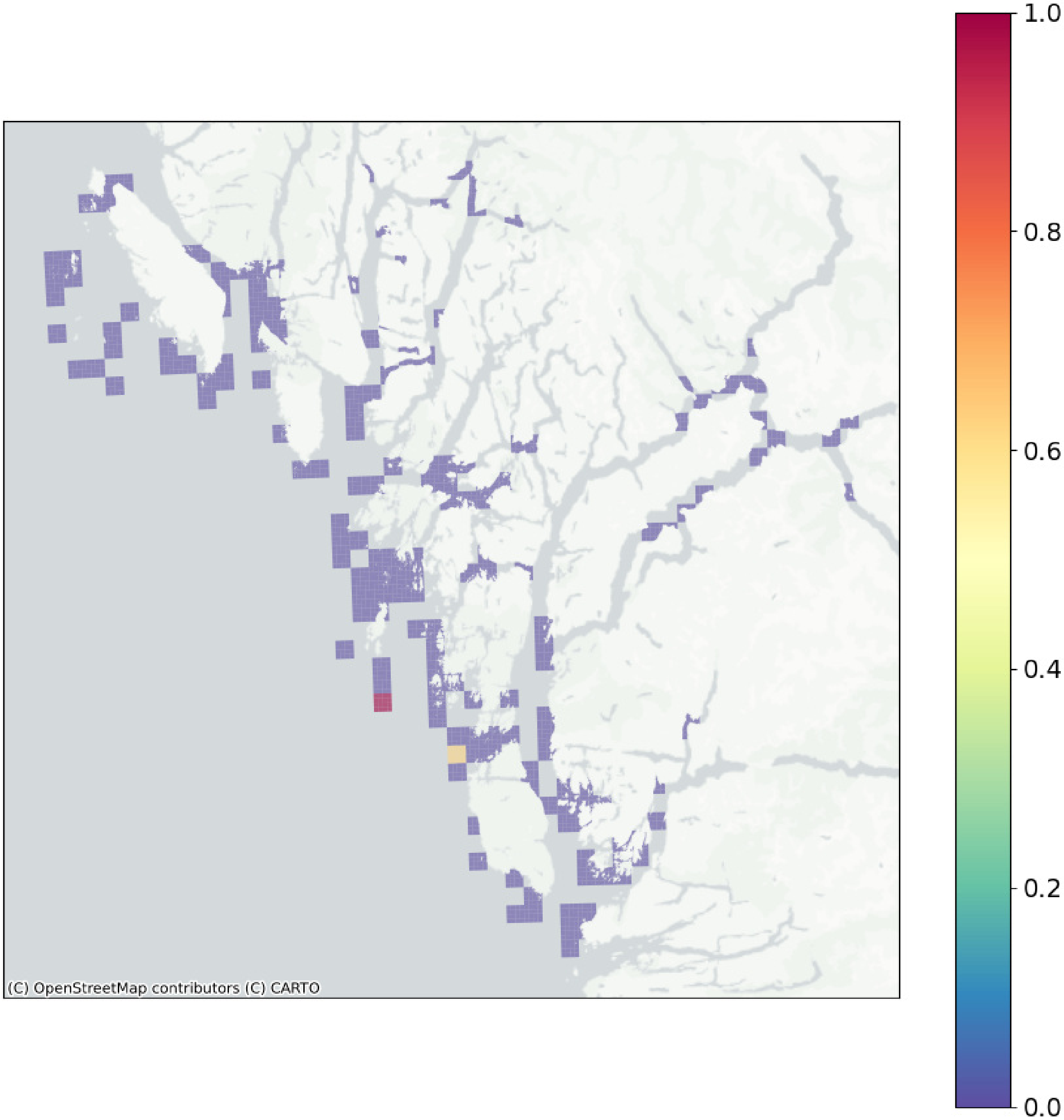

Figure 65: CPUE of Rosethorn Rockfish from CCIRA research surveys, displayed as deciles of catch per unit effort.

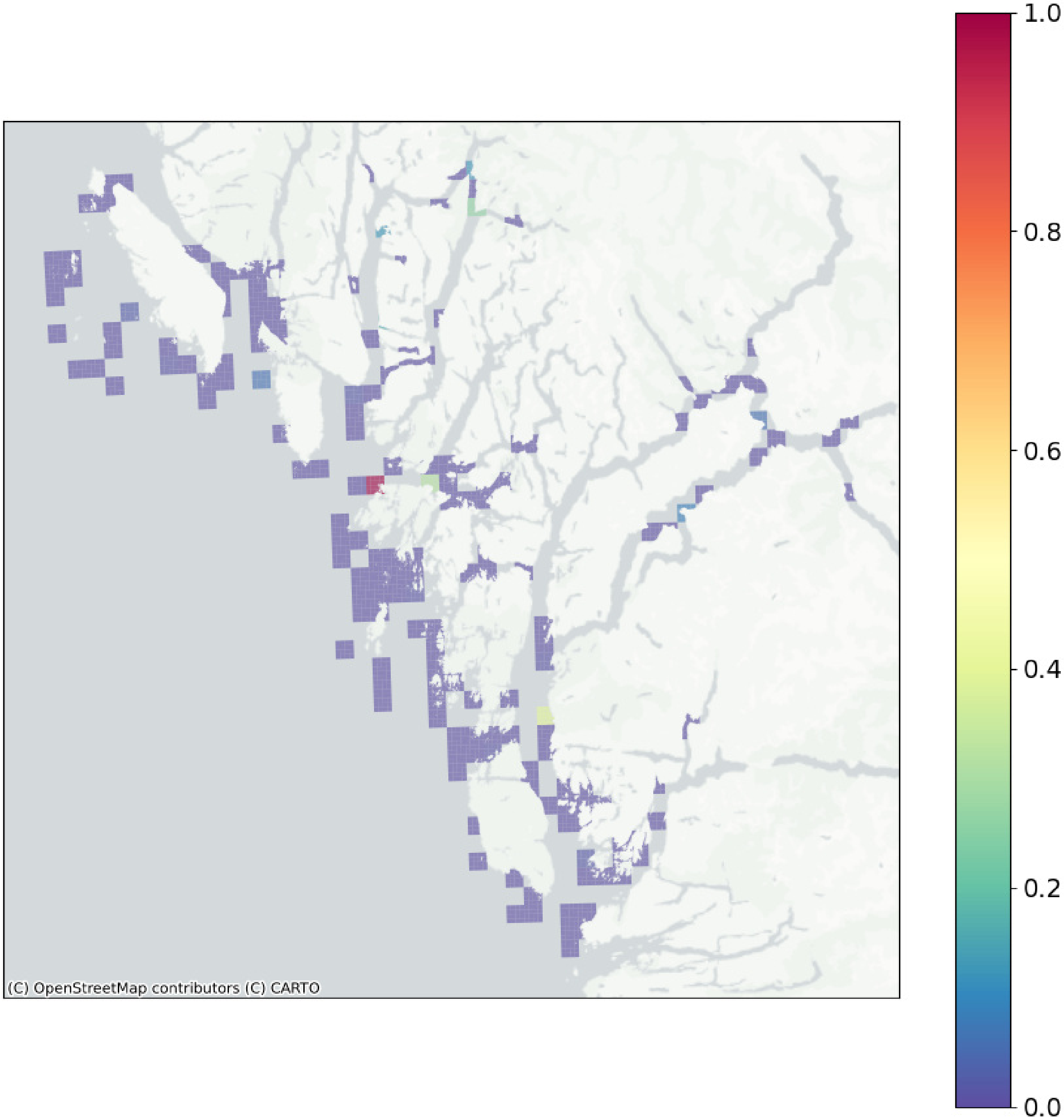

Figure 66: CPUE of Silvergray Rockfish from CCIRA research surveys, displayed as deciles of catch per unit effort.

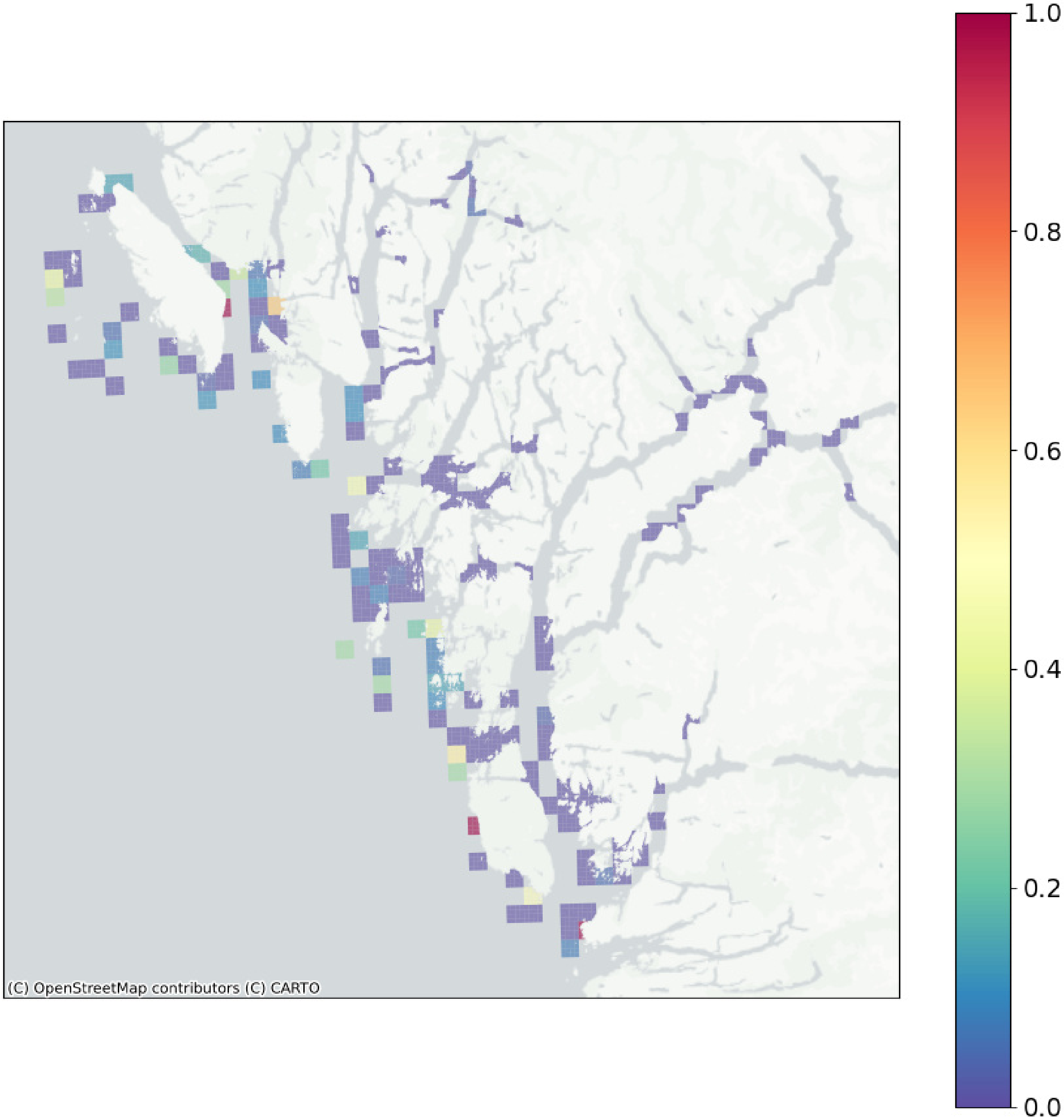

Figure 67: CPUE of Tiger Rockfish from CCIRA research surveys, displayed as deciles of catch per unit effort.

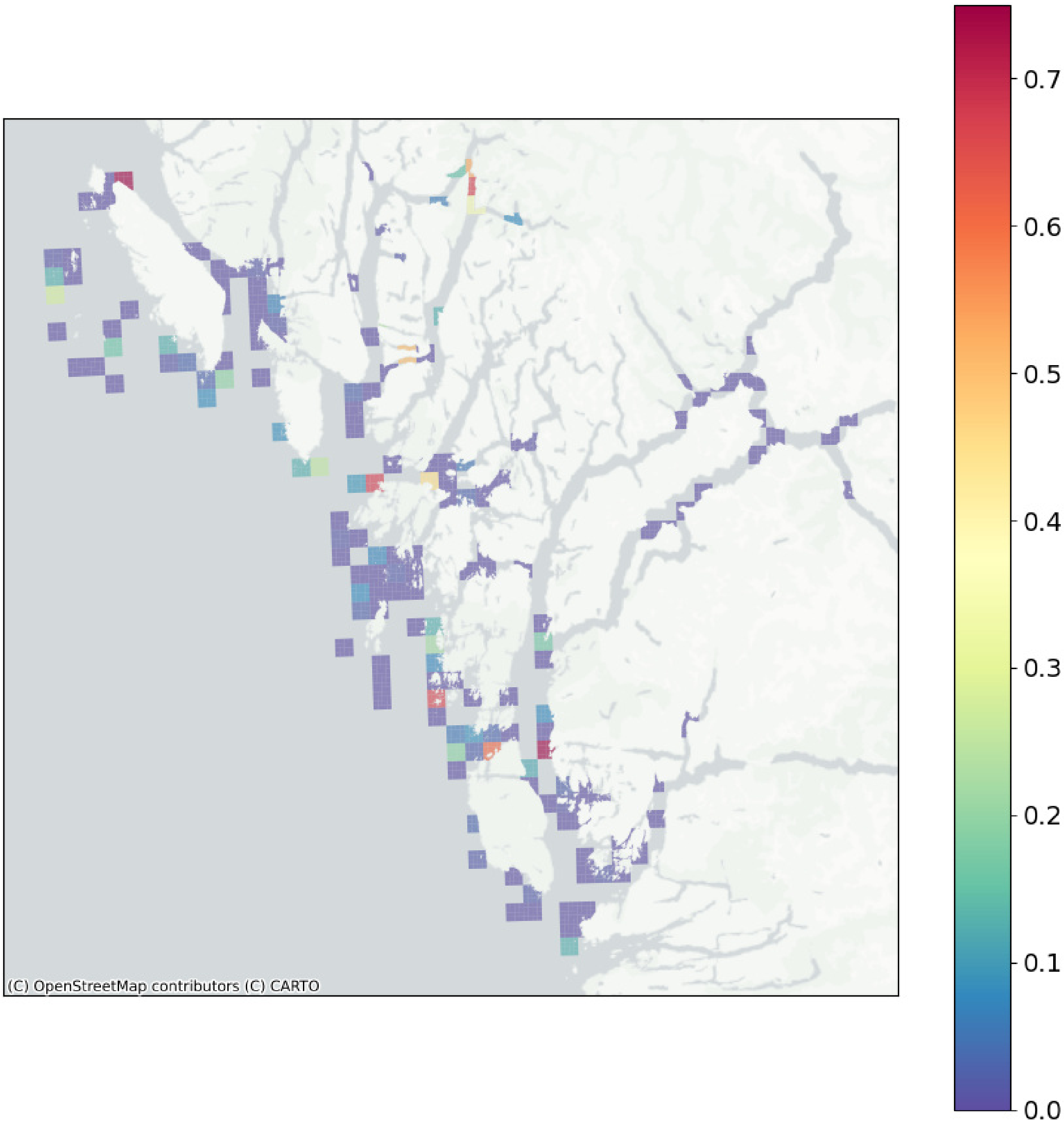

Figure 68: CPUE of Yelloweye Rockfish from CCIRA research surveys, displayed as deciles of catch per unit effort.

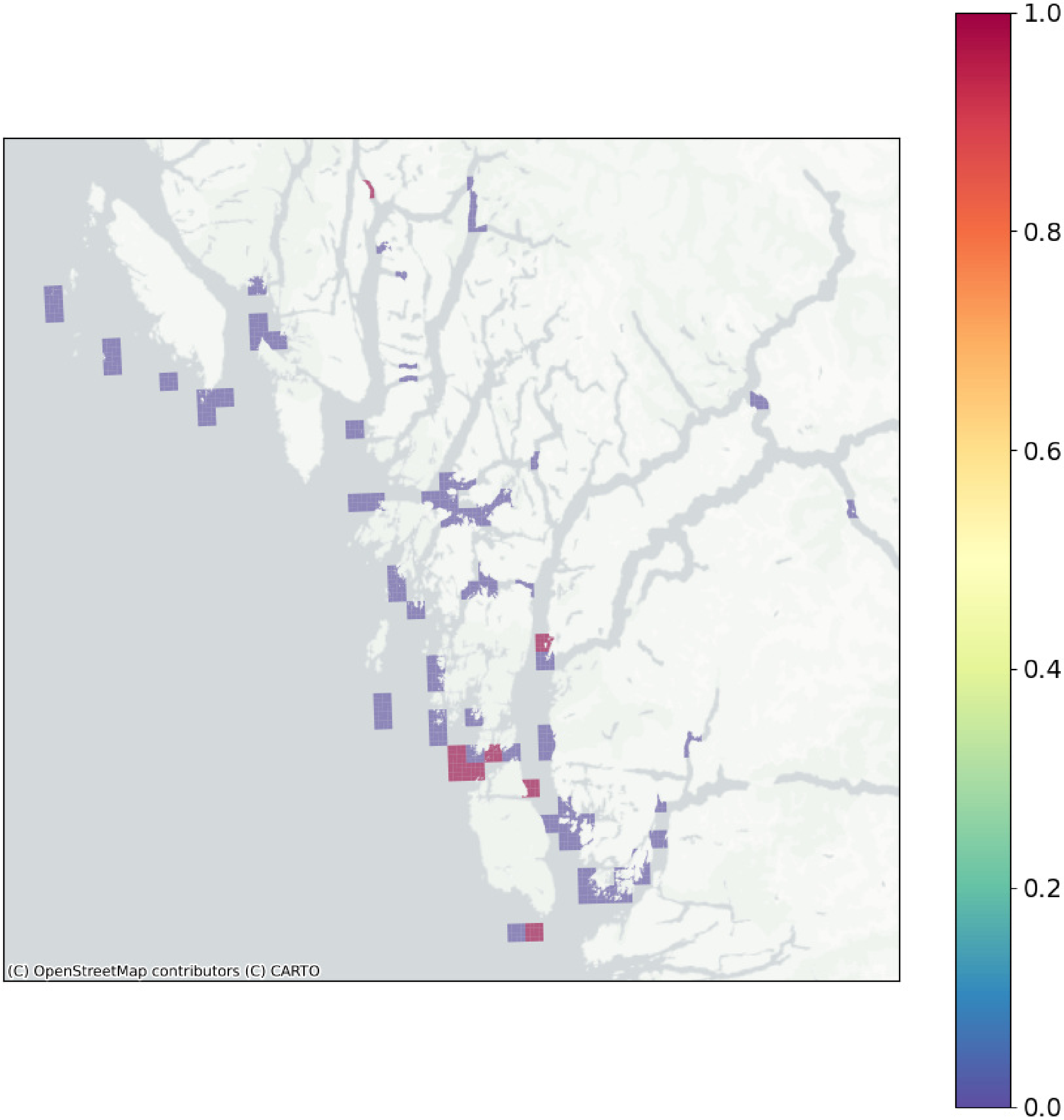

Figure 69: Coral presence in CCIRA research surveys along nearshore areas of British Columbia's central coast. Mainly *Paragorgia pacifica* and *Calcigorgia spiculifera*, with one site containing abundant *Stylaster* sp.

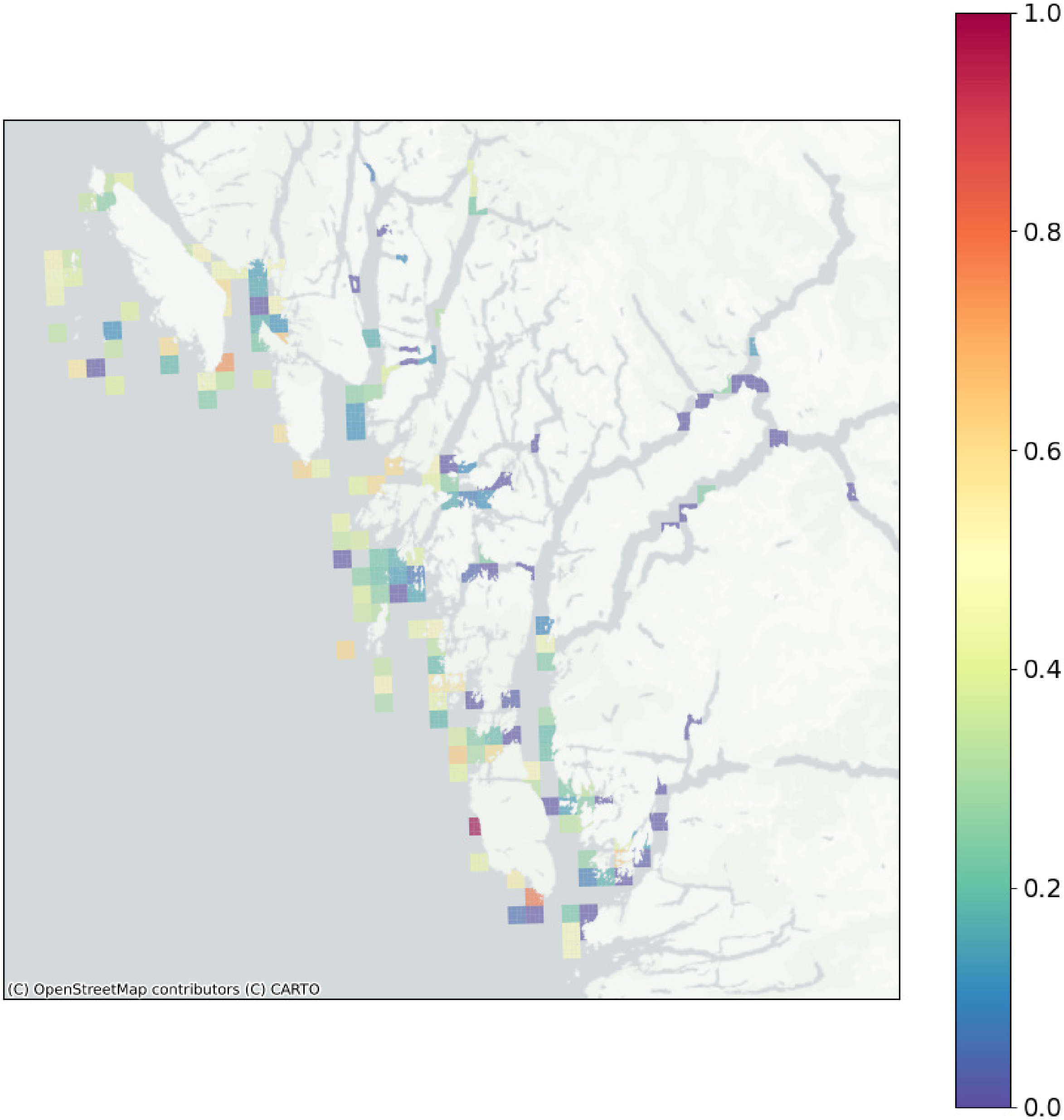

Figure 70: Relative cover of glass sponges in CCIRA research suveys along nearshore areas of British Columbia's central coast (*Aphrocallistes vastus, Farrea occa, Heterochone calyx, Rhabdocalyptus dawsoni, Staurocalyptus dowlingi*)

NSB MPA Network Ecological Data - Fish and Invertebrate Density Features

Summary:

There are 42 features in the 'Fish and Invertebrate Density' geodatabase:

- (37) Fish catch per unit effort (from DFO research surveys)

- (3) Coral and sponge catch per unit effort (from DFO research surveys and commercial catch records)

- (2) Other invertebrate density features (from DFO research surveys)

Data Creators and Co-creators: Creator: Katie Gale; Co-Creators: MPATT Science Team

Methods and links to metadata:

Fish and Invertebrates:

Each feature (except coral and sponge) was developed from up to three research survey data sources, based on how well represented the focal species was in each data source: DFO synoptic trawl surveys (2003-2016) (Workman et al., 2007; Olsen et al., 2009), outside hard-bottom longline surveys (2006-2016) (Doherty et al., 2019), and random-stratified sablefish trap surveys (2003-2016) (Wyeth et al., 2007). The data represent normalized (rescaled) catch per unit effort (CPUE) across the footprint of the surveys.

For each fishing event (trawl tow, longline set, or trap set), the CPUE of all recorded taxa was calculated as kg/hr (trawl), count/hook/hr (longline), or count/trap/hr (trap). Because CPUE is not directly comparable across survey types, species data was normalized (rescaled to the maximum value for each group from each dataset): for each survey, the CPUE values for each species was divided by maximum CPUE for that species in that survey, resulting in values that ranged from 0–1. Values for all survey types were then combined into a single dataset. The fishing event tracklines (start position to end position) were used as input to a kernel density analysis, which creates a smoothed surface of values. 1-km resolution rasters for each species were created using a neighbourhood size of 10 km. The resulting kernel density raster was then categorized into deciles (10th percentiles), excluding zero values, to represent the distribution of CPUE for each species.

Coral and Sponge:

The same general method as above was used for coral and sponge, but the input data sources were DFO synoptic groundfish trawl surveys (2003-2016) and groundfish trawl fishery observations (2007-2017).

For each fishing event (trawl tow), the CPUE of all recorded taxa from the trawl surveys and trawl fishery was calculated as kg/hr. Taxa were classified into three groups: 1) sponges (phylum Porifera); 2) corals, excluding sea pens (orders Alcyonacea, Antipatharia, Scleractinia, and Anthoathecata); or 3) sea pens (order Pennatulacea). CPUE of each of the three groups was summed within fishing events. The summed CPUE of each group in each fishing event was normalized; for each dataset (survey or commercial), the CPUE values for each group were divided by the maximum CPUE for that group in that dataset, resulting in values that ranged from 0–1.

After normalization, the fishing event tracklines from each dataset were combined and used as input to a kernel density analysis. Tracklines over 10 km long were removed.

1-km resolution rasters for each species group were created using a neighbourhood size of 10 km. The resulting kernel density raster was then categorized into deciles (10th percentiles), excluding zero values, to represent the distribution of CPUE for each species group.

Links to online metadata

The above methods apply to all features in this geodatabase. Each feature has embedded metadata with details on its creation. Links to online versions of each feature's metadata are listed below.

Fish:

- Arrowtooth Flounder
- Spiny Dogfish
- Pacific Halibut
- Lingcod
- Pacific Cod
- Pacific Ocean Perch
- Walleye Pollock
- Canary Rockfish
- China Rockfish
- Copper Rockfish
- Darkblotched Rockfish
- Greenstriped Rockfish
- Quillback Rockfish
- Redstripe Rockfish
- Rosethorn Rockfish
- Rougheye-Blackspotted Rockfish
- Shortraker Rockfish
- Silvergray Rockfish
- Tiger Rockfish
- Vermilion Rockfish
- Widow Rockfish
- Yelloweye Rockfish
- Yellowmouth Rockfish
- Yellowtail Rockfish
- Sablefish
- Pacific Sandlance

- Big Skate
- Longnose Skate
- Roughtail Skate
- Sandpaper Skate
- Dover Sole
- Petrale Sole
- Rex Sole
- Rock Sole
- Longspine Thornyhead
- Shortspine Thornyhead

Coral and Sponge

- Coral (excluding sea pens)
- Sea pen
- Sponge

Other Invertebrates

- Scallop
- Deepwater Tanner Crab

Temporal Coverage:
2003-01-01 to 2016-01-31

Scripts/Software:
Code for the fish and invertebrate data processing can be found at the MSEA GitLab page.

Code for coral and sponge can be found here at the MSEA GitLab Page.

Data Sources:

- **Fish and invertebrates, other than coral and sponge**:
  - DFO synoptic trawl surveys (2003-2016),
  - Outside hard-bottom longline surveys (2006-2016),
  - Random-stratified sablefish trap surveys (2003-2016).
- **Coral and Sponge**:
  - DFO synoptic groundfish trawl surveys (2003-2016)
  - Groundfish trawl fishery observations (2007-2017).

Absence Data:
Zero values have been excluded from this dataset. No distinction can be made between surveyed areas with zero catch, and areas that were not surveyed.

Uncertainties:
The rescaled values represent a relative density, intended to show areas of higher occurrence of each species. The kernel density extrapolates from input data points up to the neighbour distance (in this case, 10 km), and can therefore show data values where

no survey was carried out. The interpretation of this extrapolation is most relevant in areas where environmental conditions change rapidly across relatively small distances, such as on the continental slope. Caution should be used when interpreting the data at finer scales than was intended for use (i.e., the scale of the Northern Shelf Bioregion).

Each feature has uncertainties based on its input data and processing steps. Notable uncertainties are described in each feature's individual metadata.

Species Data:

- GLYPTOCEPHALUS ZACHIRUS (REX SOLE)
- LEPIDOPSETTA BILINEATA (SOUTHERN ROCK SOLE)
- SEBASTES HELVOMACULATUS (ROSETHORN ROCKFISH)
- BATHYRAJA TRACHURA (ROUGHTAIL SKATE)
- ANOPLOPOMA FIMBRIA (SABLEFISH)
- BATHYRAJA INTERRUPTA (SANDPAPER SKATE)
- SEBASTES BOREALIS (SHORTRAKER ROCKFISH)
- SEBASTOLOBUS ALASCANUS (SHORTSPINE THORNYHEAD)
- SEBASTES BREVISPINIS (SILVERGRAY ROCKFISH)
- SQUALUS SUCKLEYI (NORTH PACIFIC SPINY DOGFISH)
- ATHERESTHES STOMIAS (ARROWTOOTH FLOUNDER)
- BERINGRAJA BINOCULATA (BIG SKATE)
- SEBASTES PAUCISPINIS (BOCACCIO)
- SEBASTES PINNIGER (CANARY ROCKFISH)
- SEBASTES NEBULOSUS (CHINA ROCKFISH)
- SEBASTES CAURINUS (COPPER ROCKFISH)
- SEBASTES CRAMERI (DARKBLOTCHED ROCKFISH)
- MICROSTOMUS PACIFICUS (DOVER SOLE)
- SEBASTES ELONGATUS (GREENSTRIPED ROCKFISH)
- OPHIODON ELONGATUS (LINGCOD)
- RAJA RHINA (LONGNOSE SKATE)
- SEBASTOLOBUS ALTIVELIS (LONGSPINE THORNYHEAD)
- GADUS MACROCEPHALUS (PACIFIC COD)
- HIPPOGLOSSUS STENOLEPIS (PACIFIC HALIBUT)
- SEBASTES ALUTUS (PACIFIC OCEAN PERCH)
- AMMODYTES PERSONATUS (PACIFIC SAND LANCE)
- EOPSETTA JORDANI (PETRALE SOLE)
- SEBASTES MALIGER (QUILLBACK ROCKFISH)

- SEBASTES PRORIGER (REDSTRIPE ROCKFISH)
- SEBASTES NIGROCINCTUS (TIGER ROCKFISH)
- SEBASTES MINIATUS (VERMILION ROCKFISH)
- GADUS CHALCOGRAMMUS (WALLEYE POLLOCK)
- SEBASTES ENTOMELAS (WIDOW ROCKFISH)
- SEBASTES RUBERRIMUS (YELLOWEYE ROCKFISH)
- SEBASTES REEDI (YELLOWMOUTH ROCKFISH)
- SEBASTES FLAVIDUS (YELLOWTAIL ROCKFISH)
- PHYLUM PORIFERA (SPONGES)
- ALCYONACEA (ORDER) (SOFT CORALS)
- ANTIPATHARIA (ORD) (BLACK CORALS, THORNY CORALS)
- SCLERACTINIA (ORDER) (STONY CORALS)
- ANTHOATHECATAE (ORD) (ATHECATE HYDROIDS)
- PENNATULACEA (ORDER) (SEA PENS)
- CHIONOECETES TANNERI (GROOVED TANNER CRAB)
- CHLAMYS RUBIDA (PINK SCALLOP, (aka REDDISH SCALLOP))
- CHLAMYS HASTATA (SPINY SCALLOP)
- SEBASTES ALEUTIANUS/MELANOSTICTUS COMPLEX (ROUGHEYE/BLACKSPOTTED ROCKFISH COMPLEX)

Maps of available datasets:

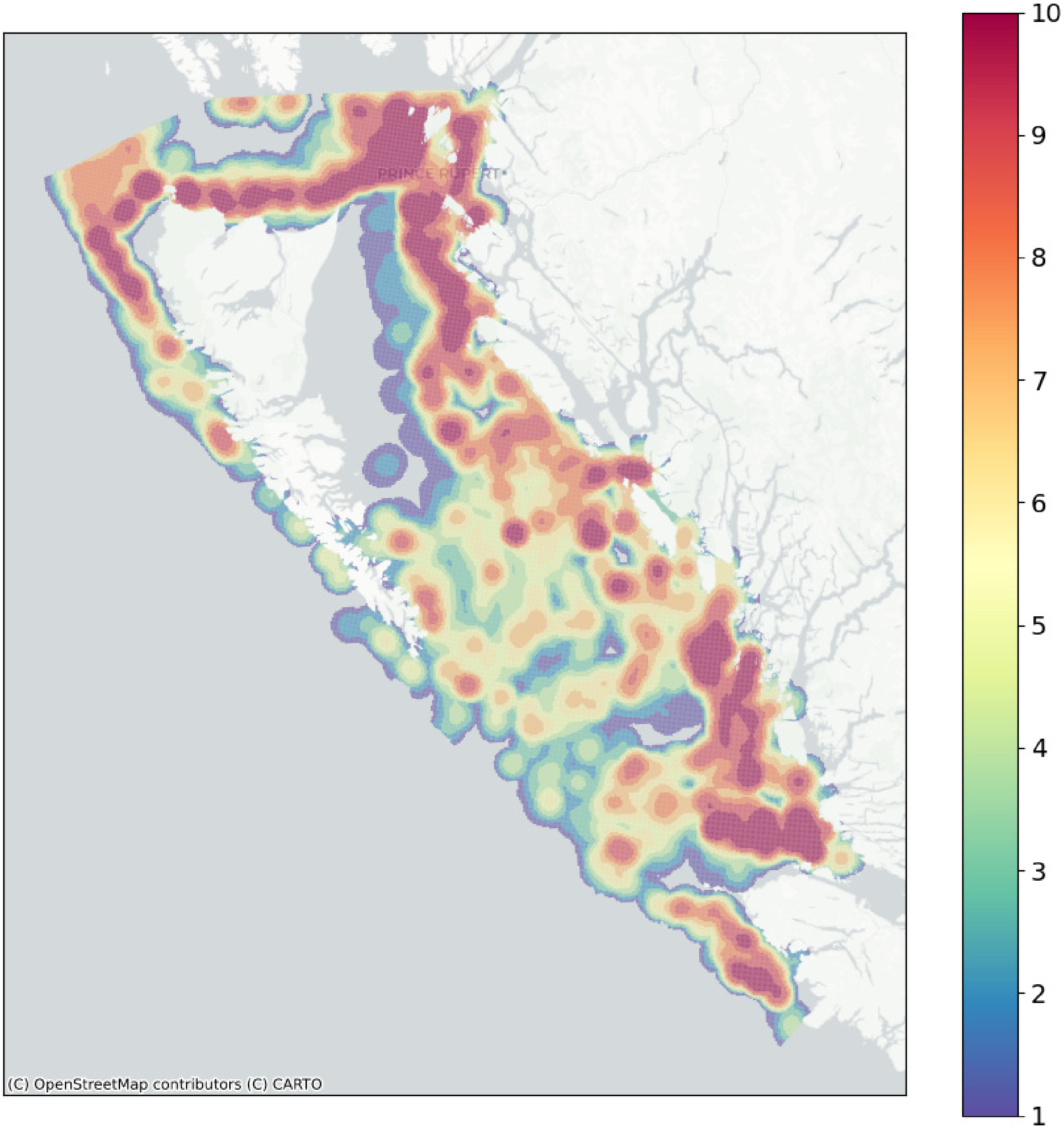

Figure 71: Arrowtooth Flounder catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, DFO sablefish trap, PHMA longline), displayed as deciles of CPUE.

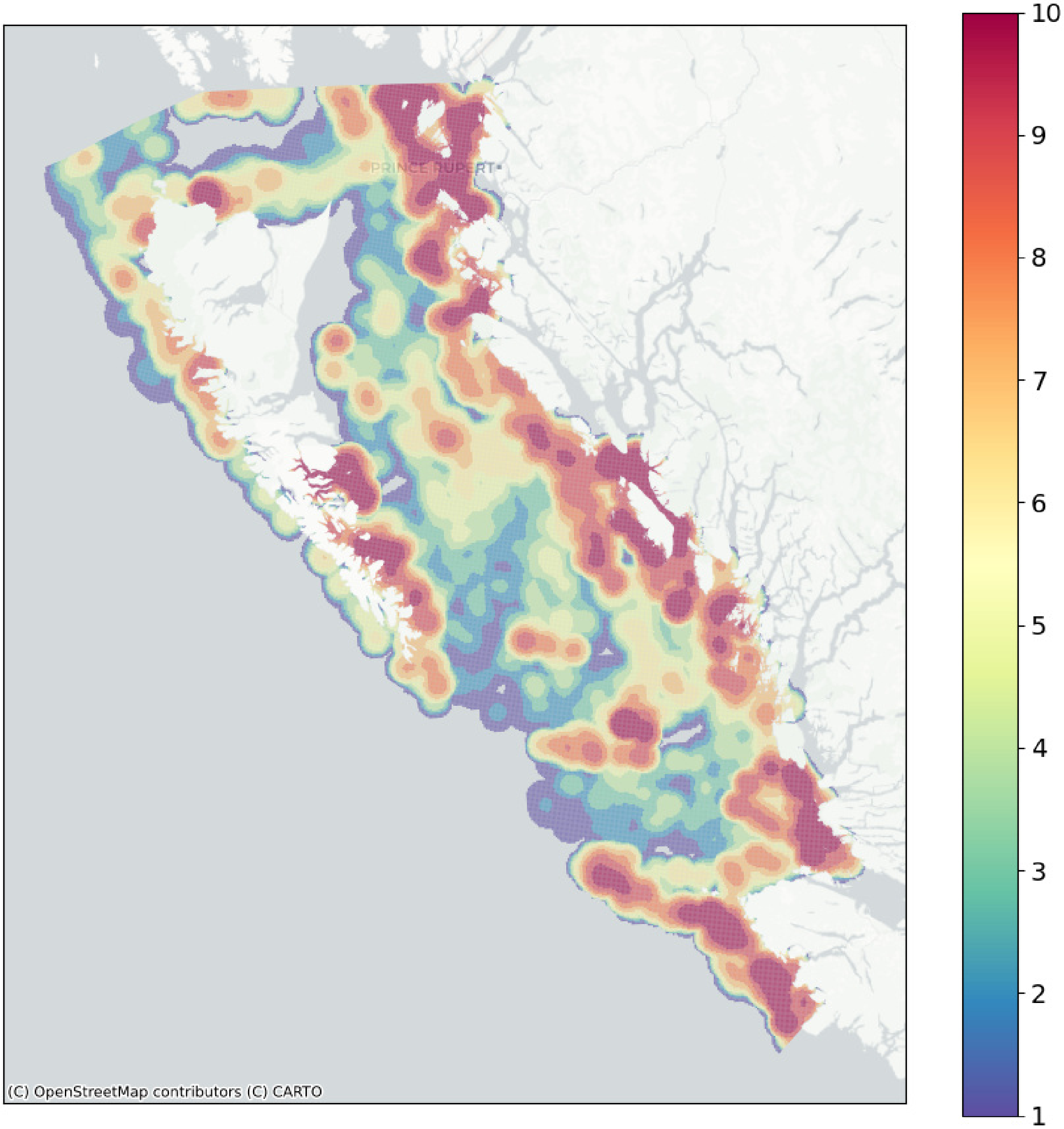

Figure 72: Spiny Dogfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

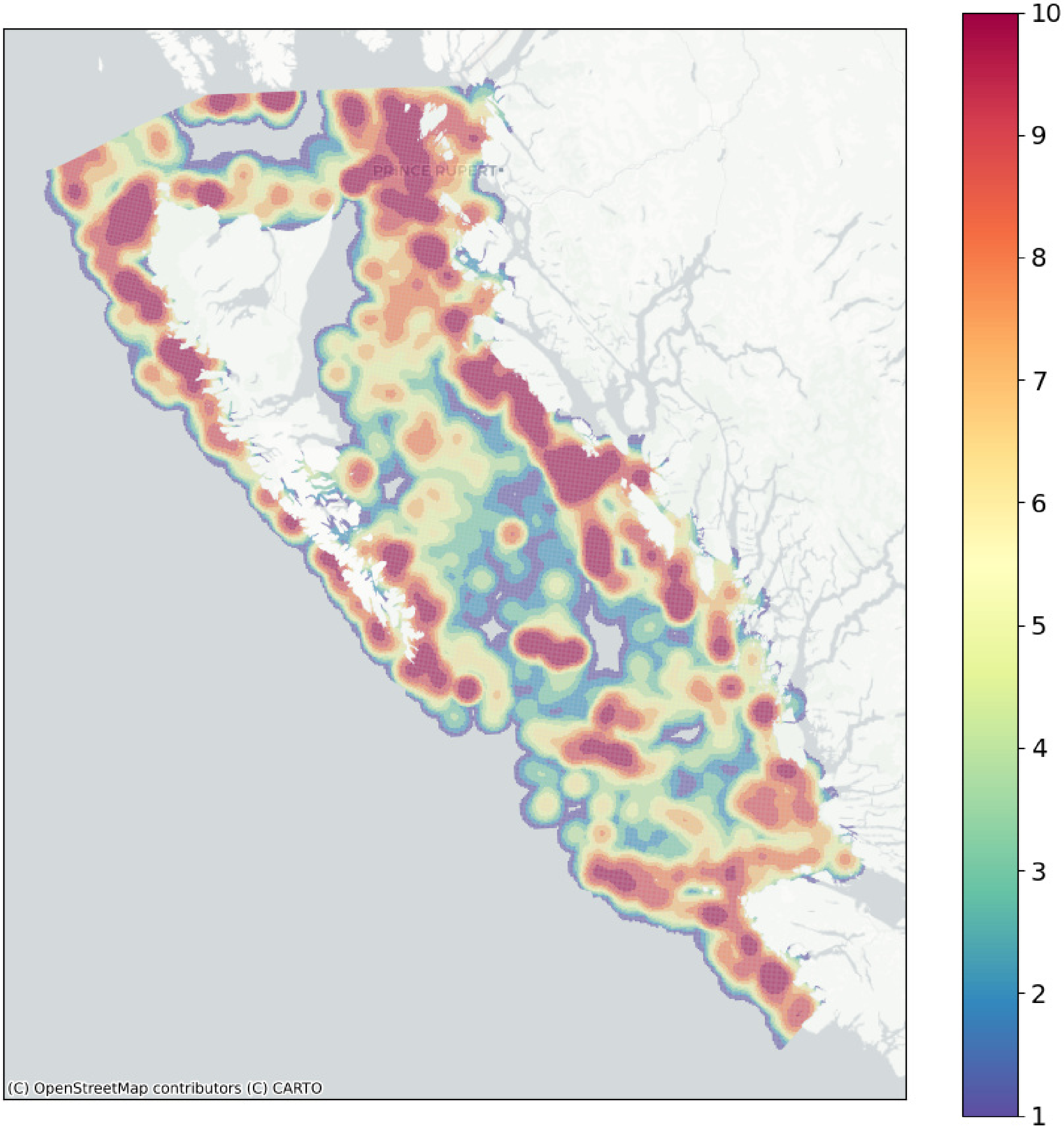

Figure 73: Pacific Halibut catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, DFO sablefish trap, PHMA longline), displayed as deciles of CPUE.

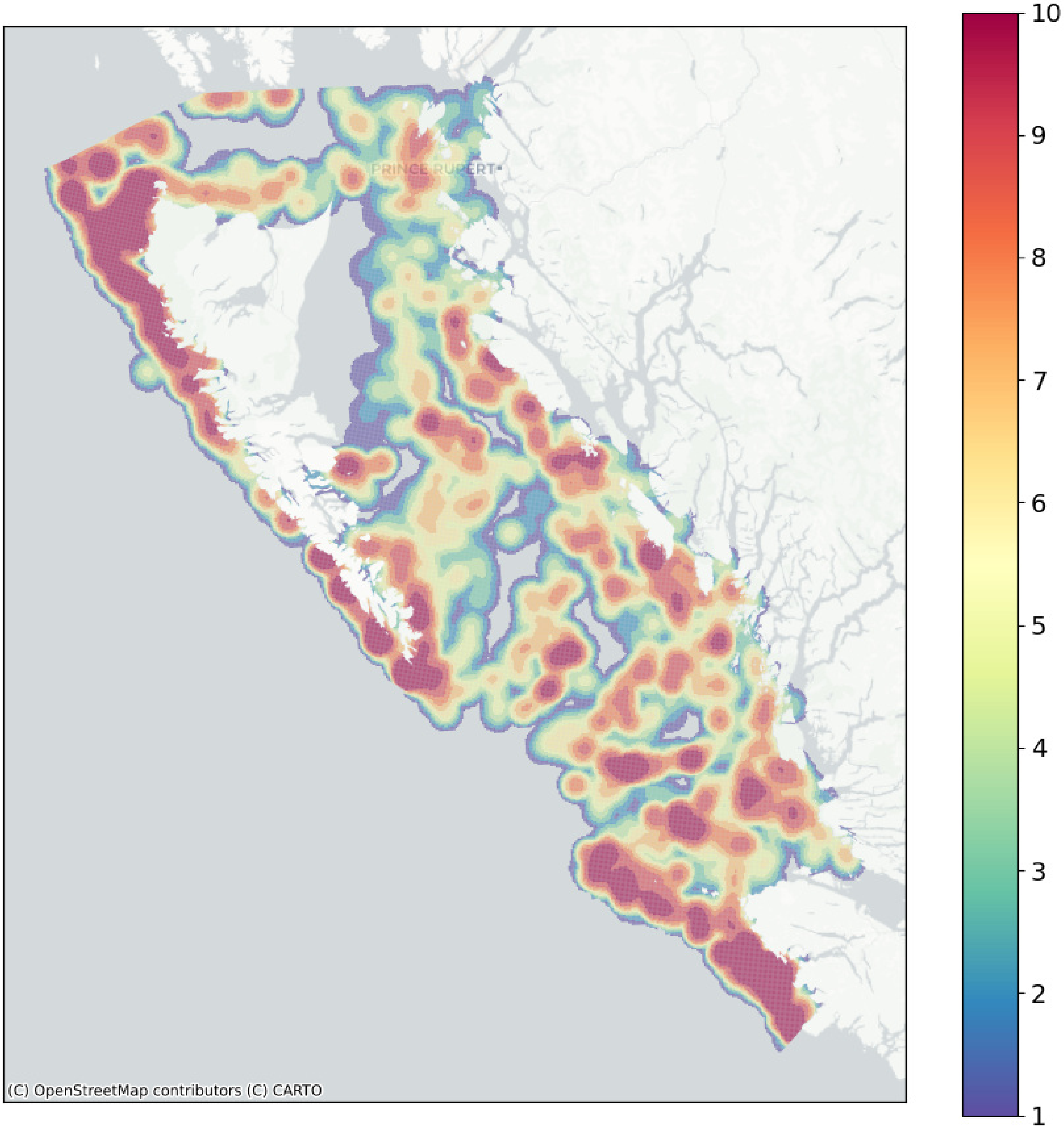

Figure 74: Lingcod catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, DFO sablefish trap, PHMA longline), displayed as deciles of CPUE.

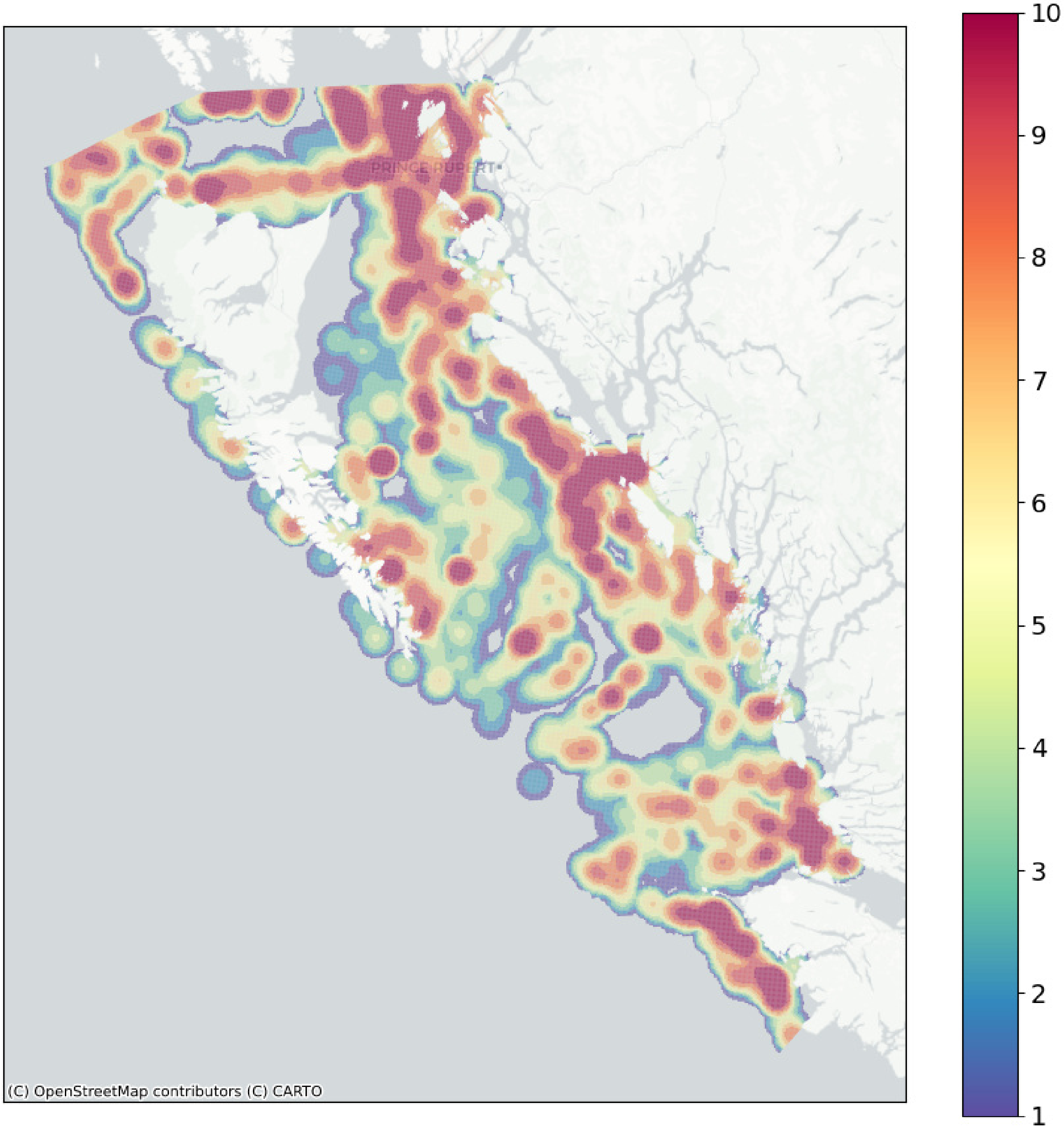

Figure 75: Pacific Cod catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

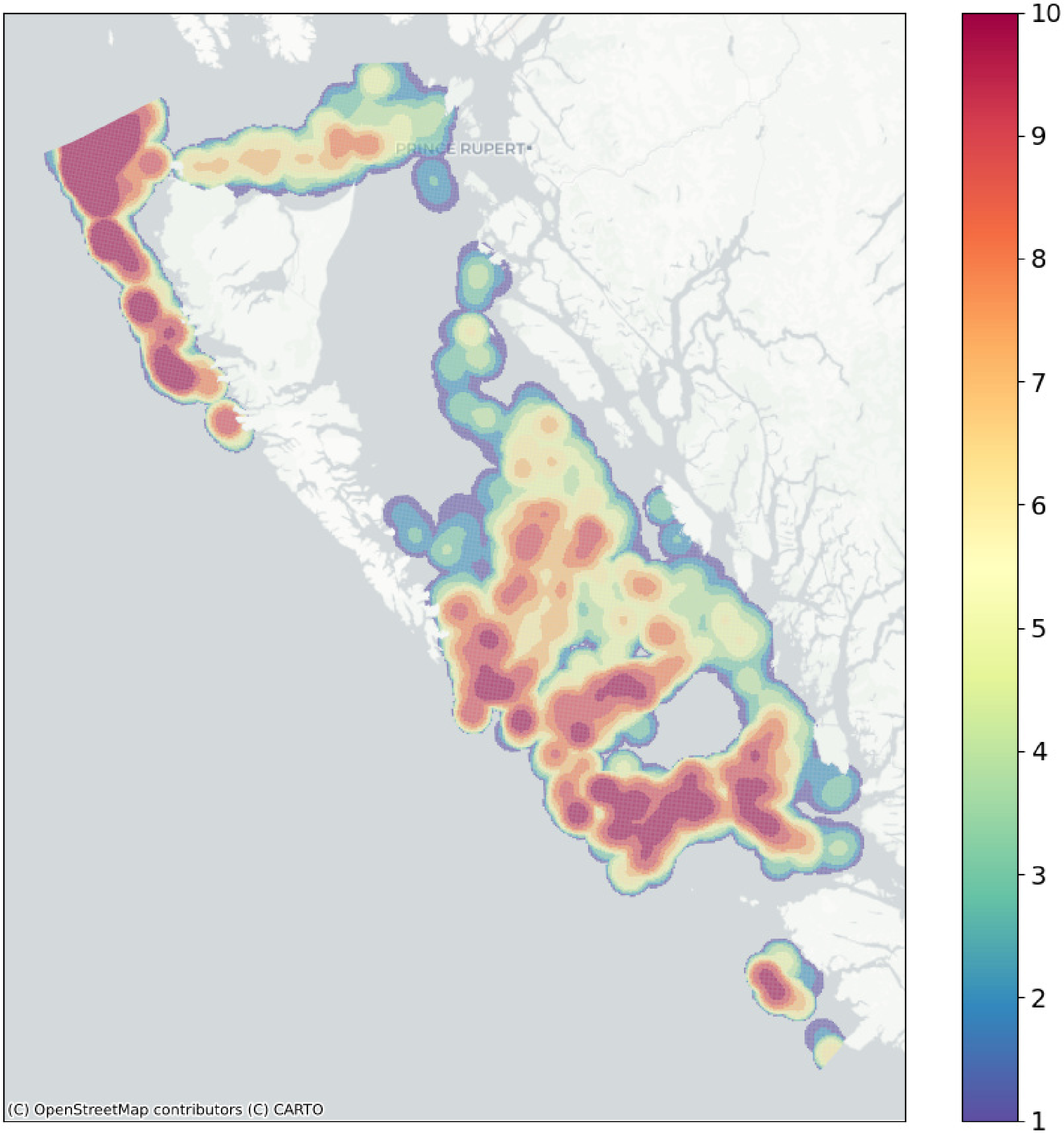

Figure 76: Pacific Ocean Perch catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

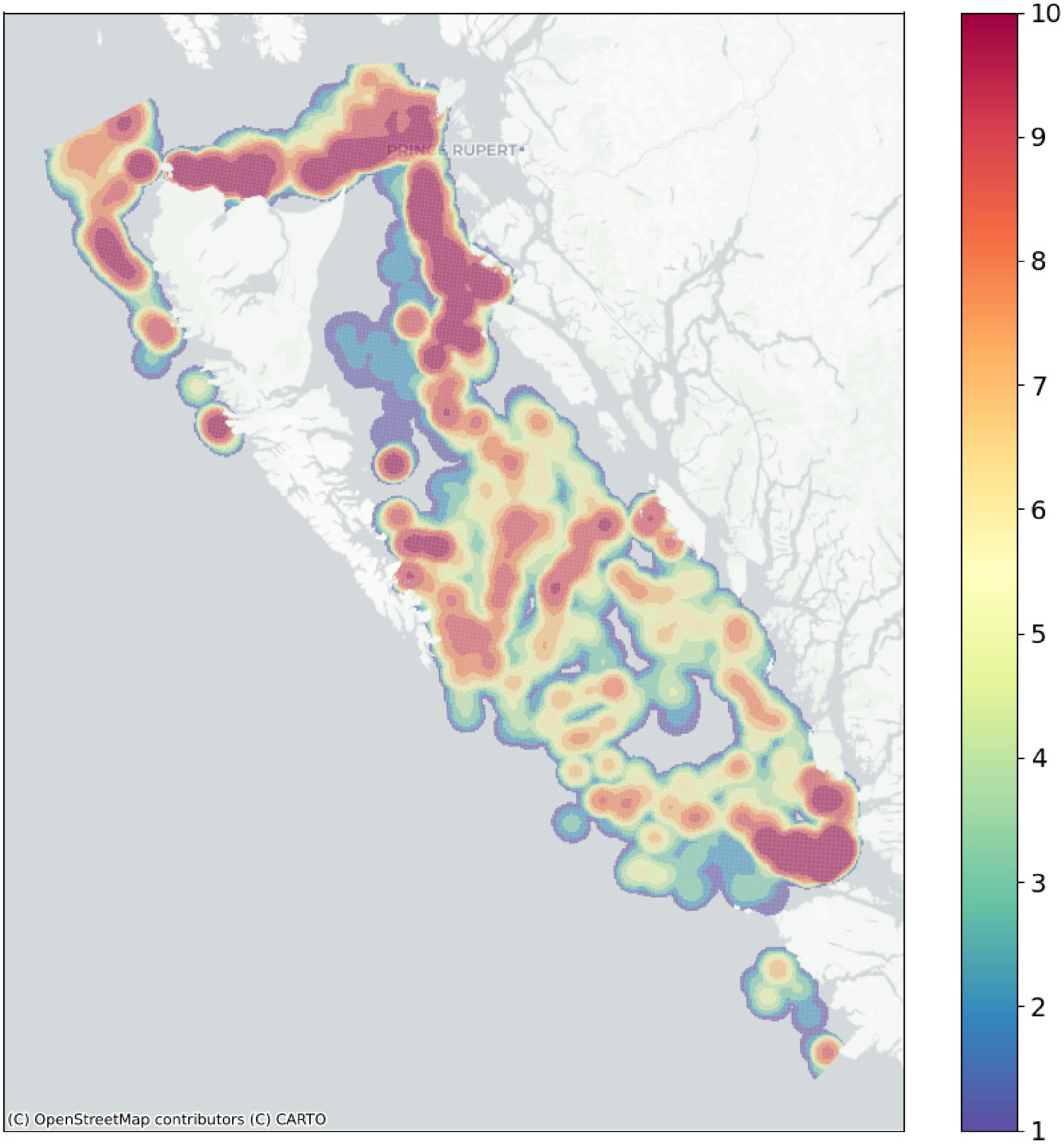

Figure 77: Walleye Pollock catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

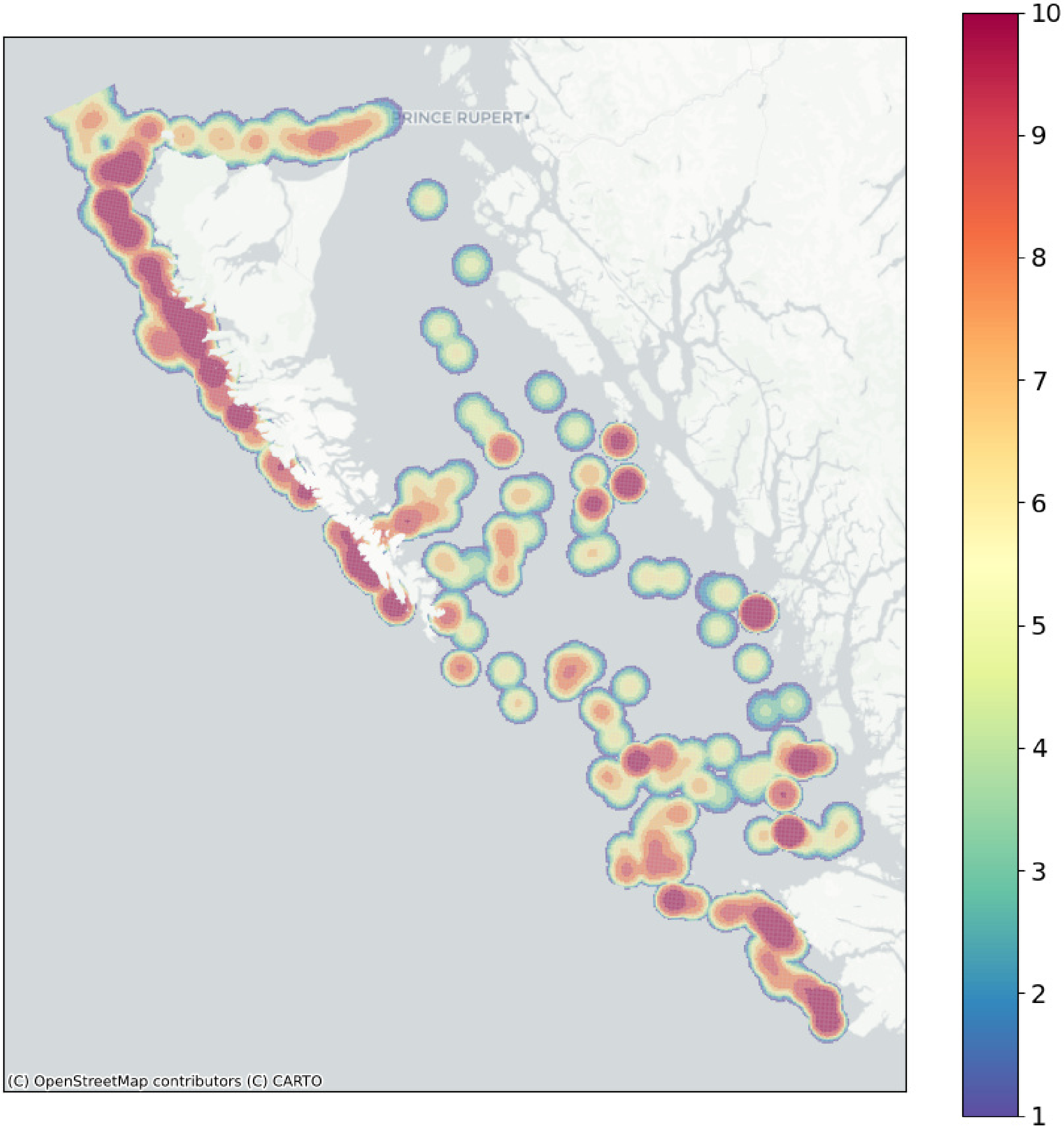

Figure 78: Bocaccio catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

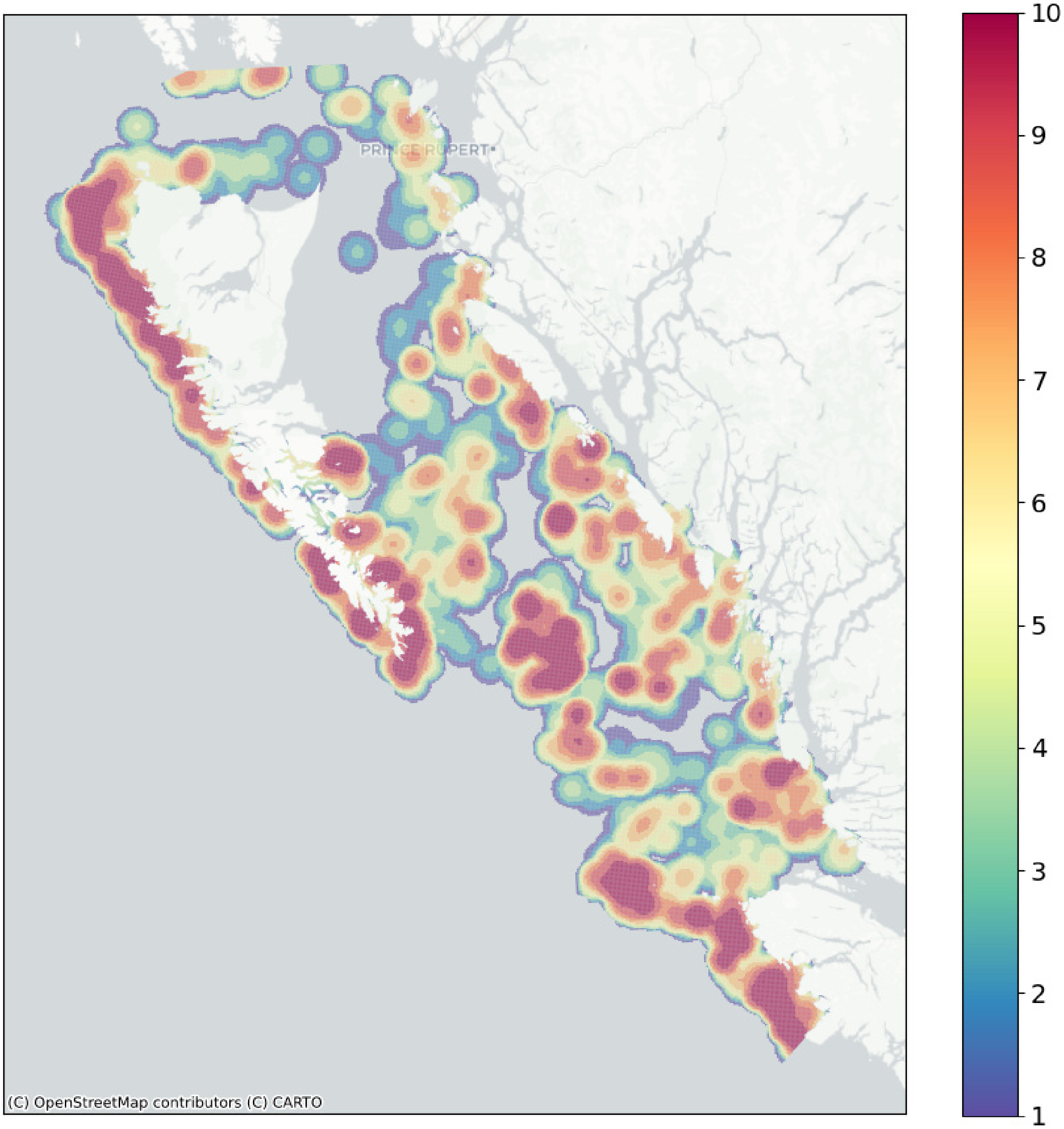

Figure 79: Canary Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

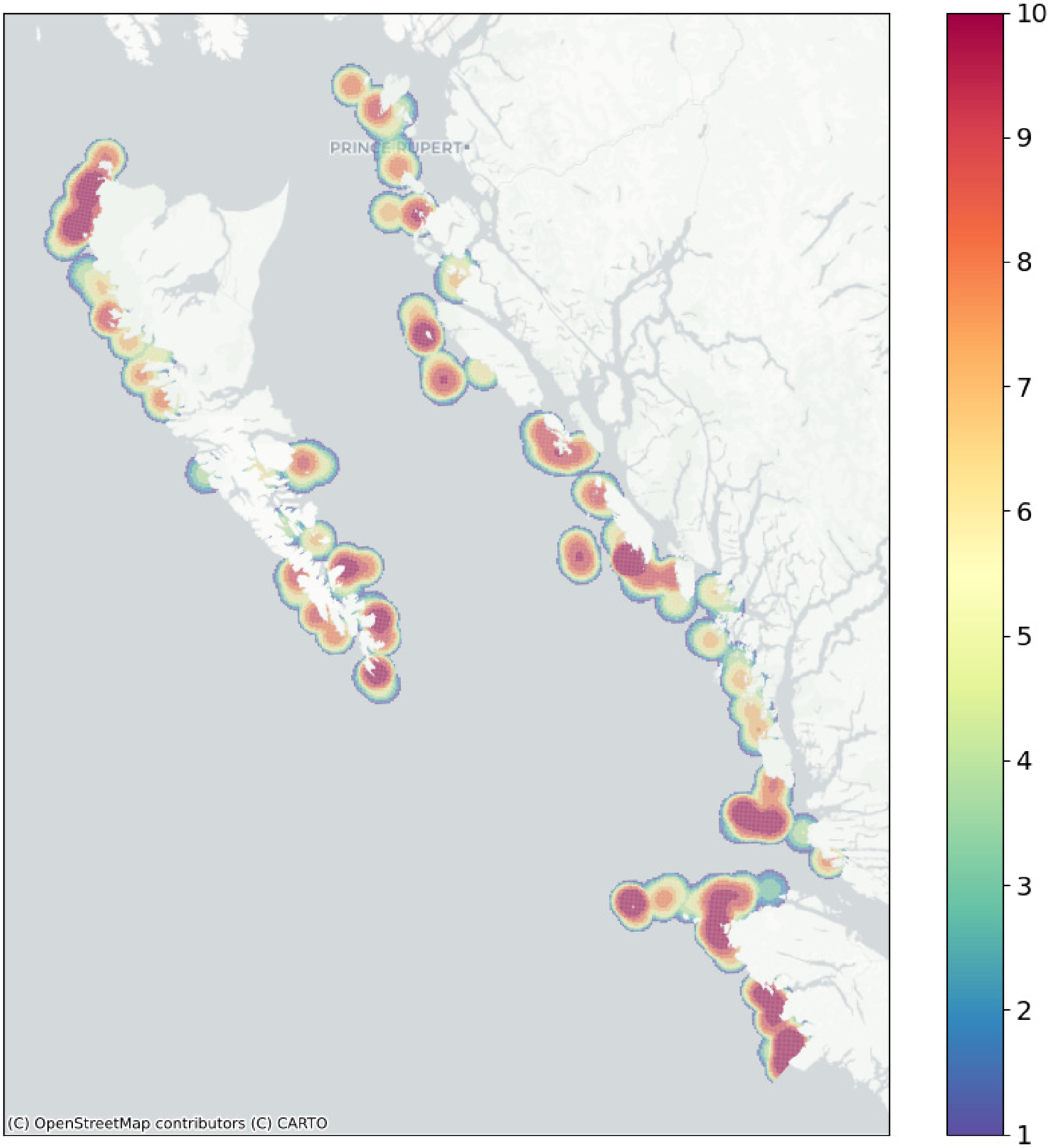

Figure 80: CPUE of China Rockfish from research surveys (PHMA longline), displayed as deciles of catch per unit effort.

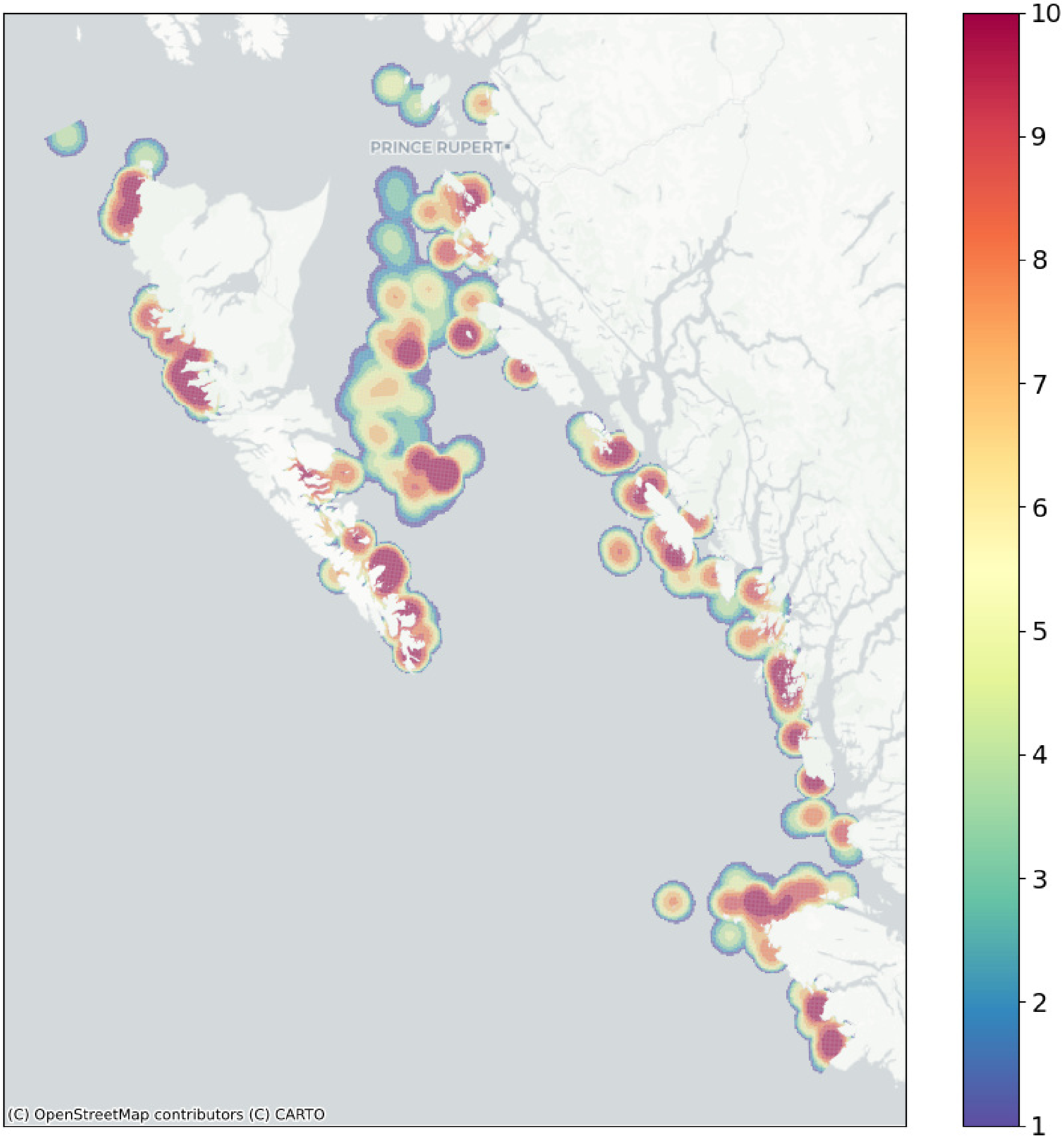

Figure 81: Copper Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

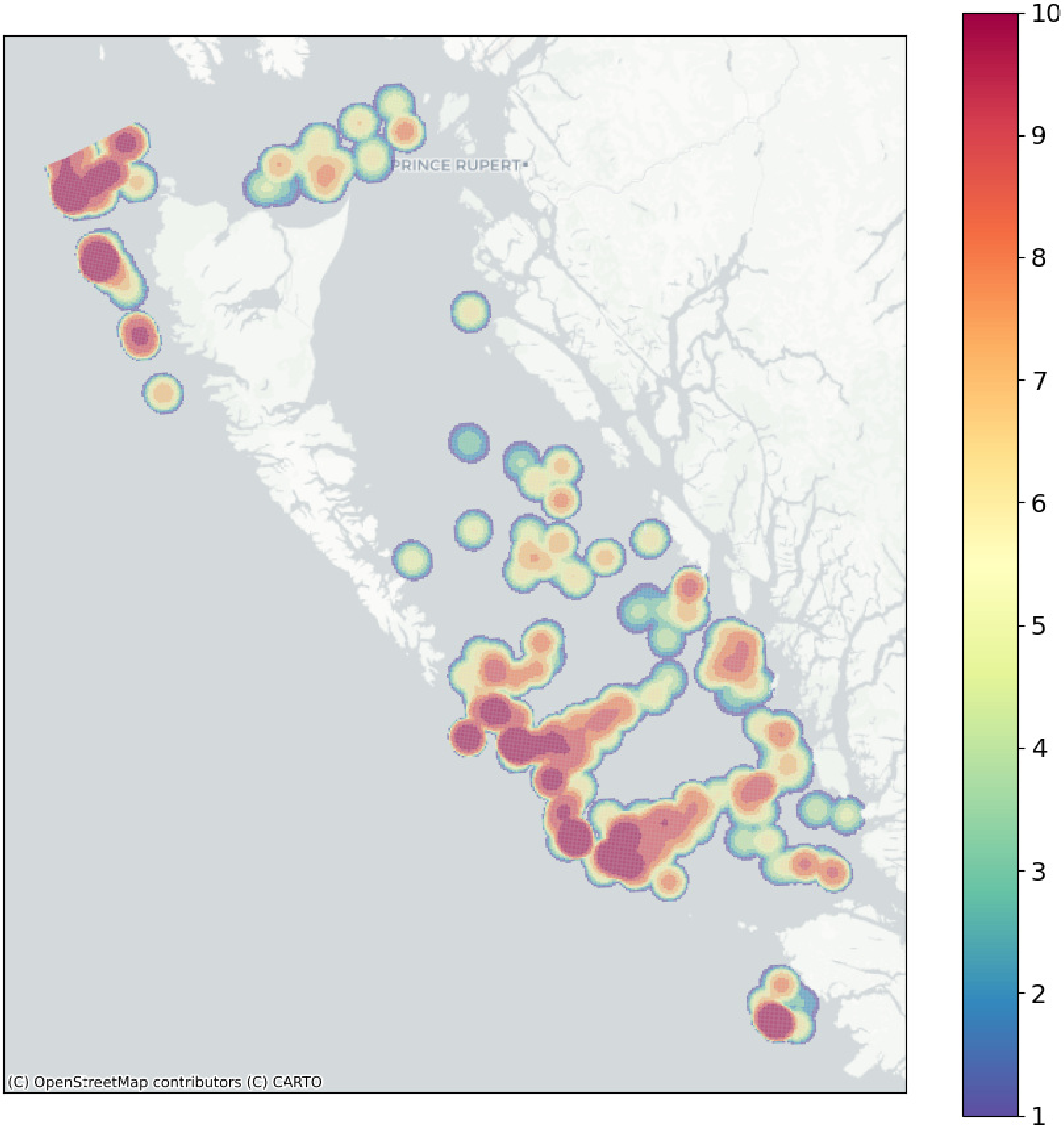

Figure 82: Darkblotched Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

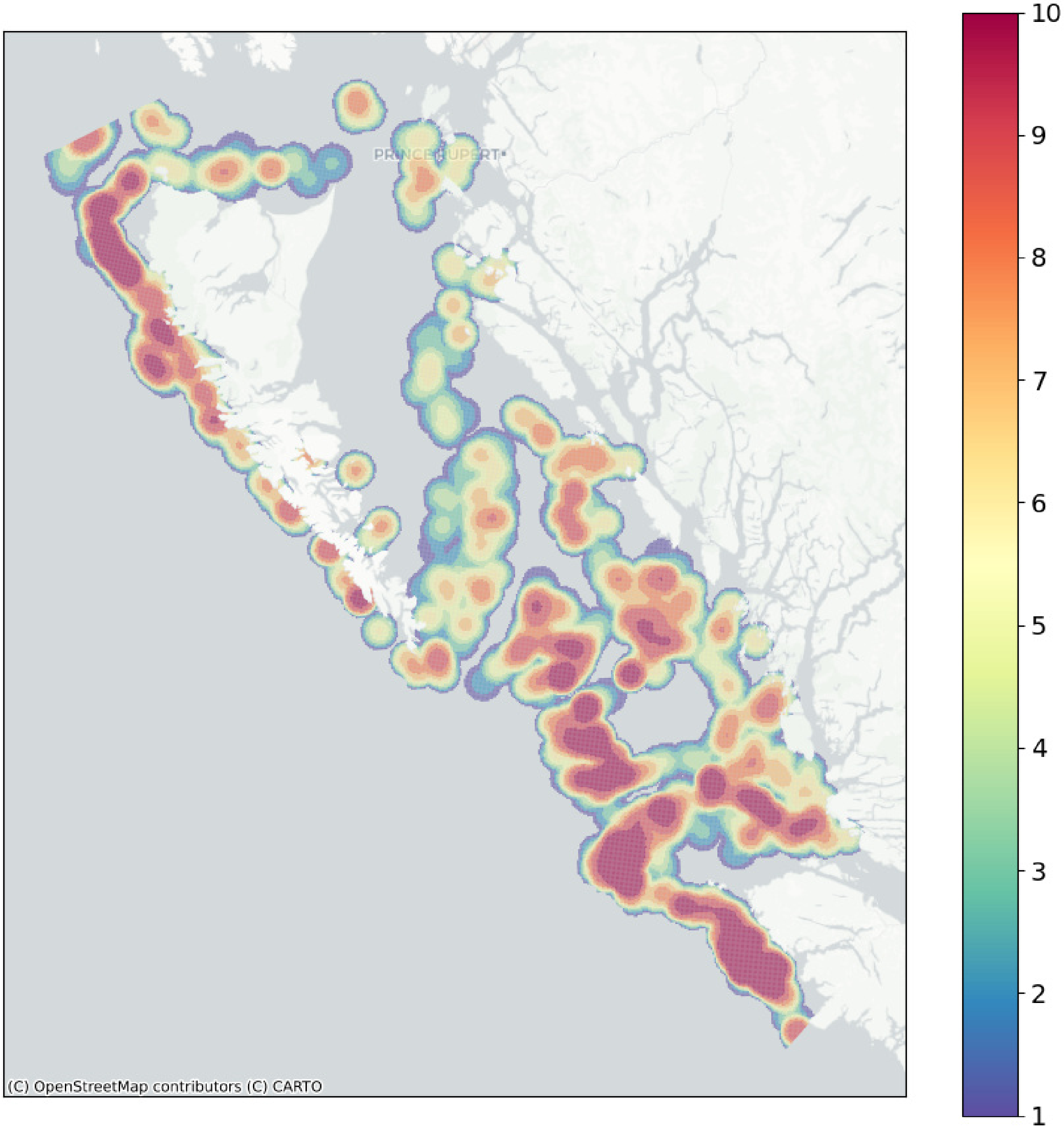

Figure 83: Greenstriped Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

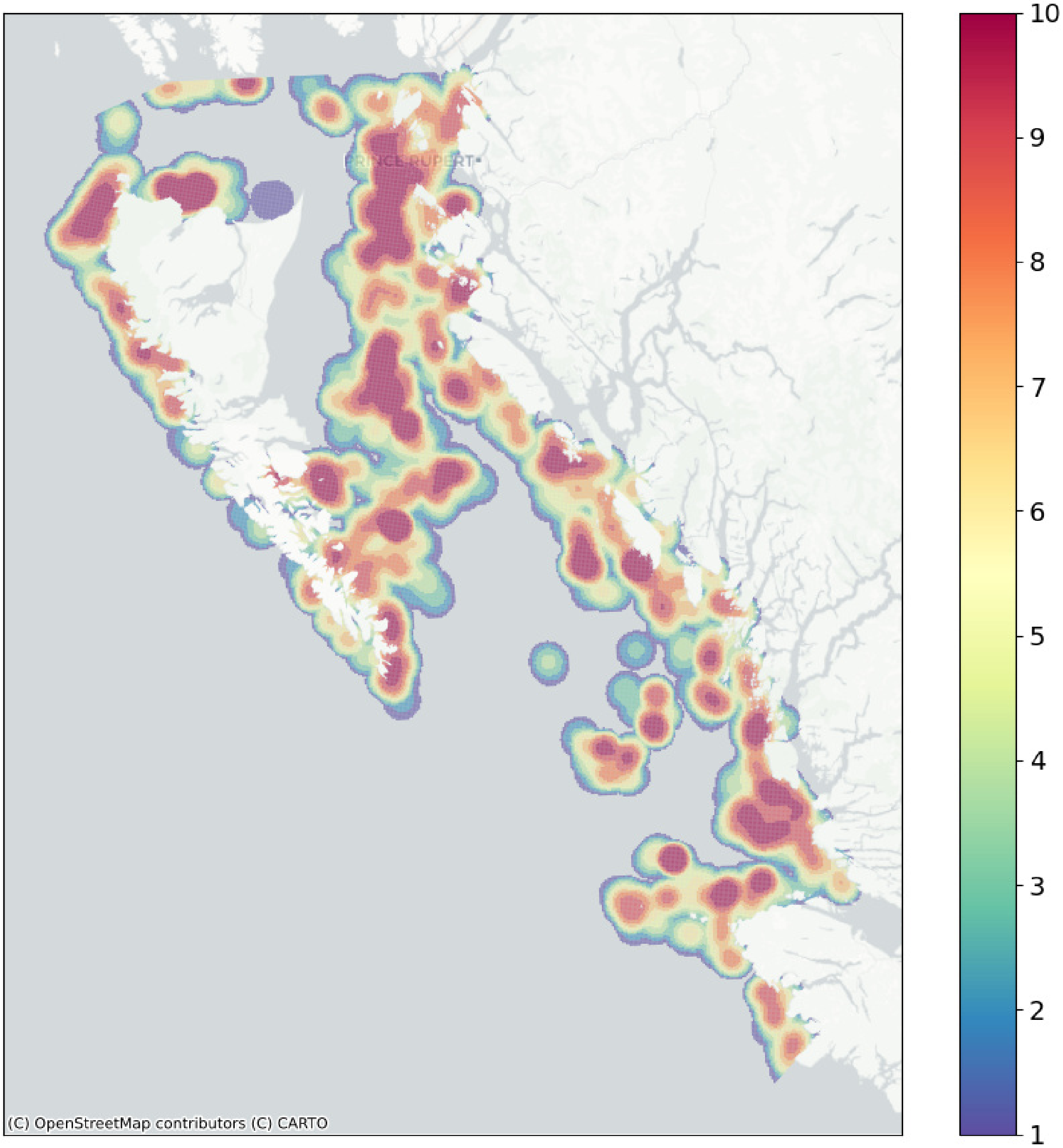

Figure 84: Quillback Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

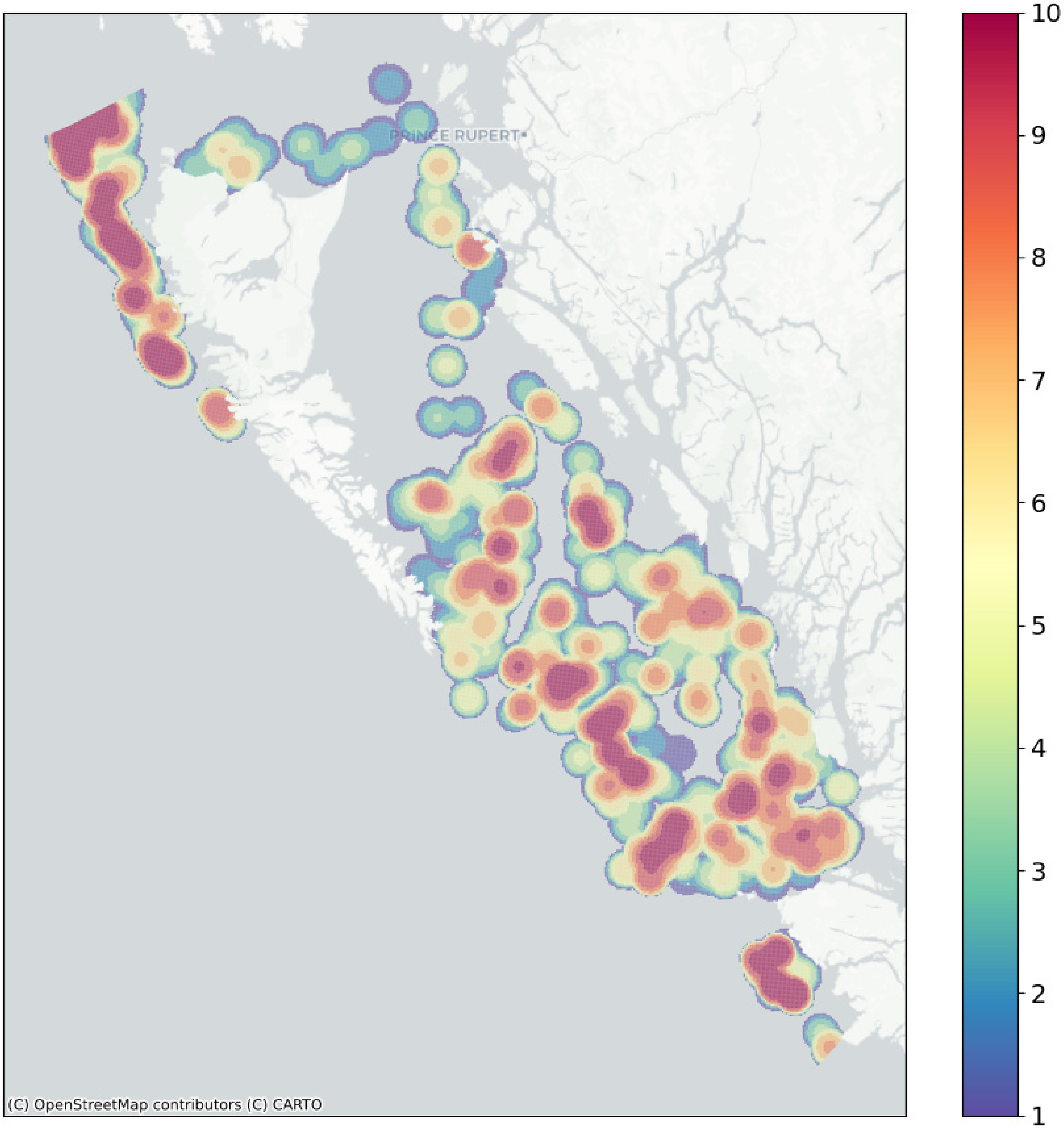

Figure 85: Redstripe Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

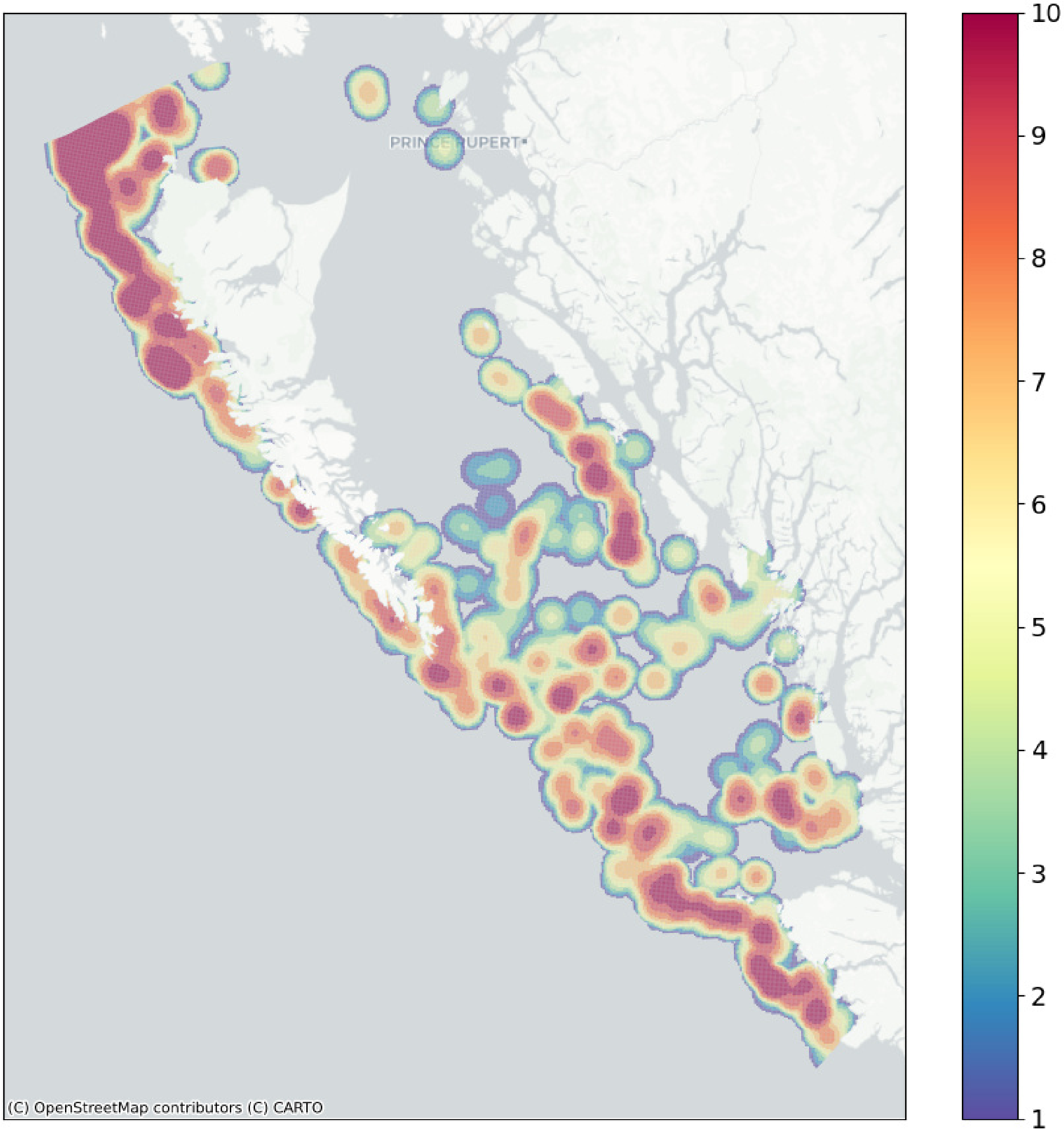

Figure 86: Rosethorn Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

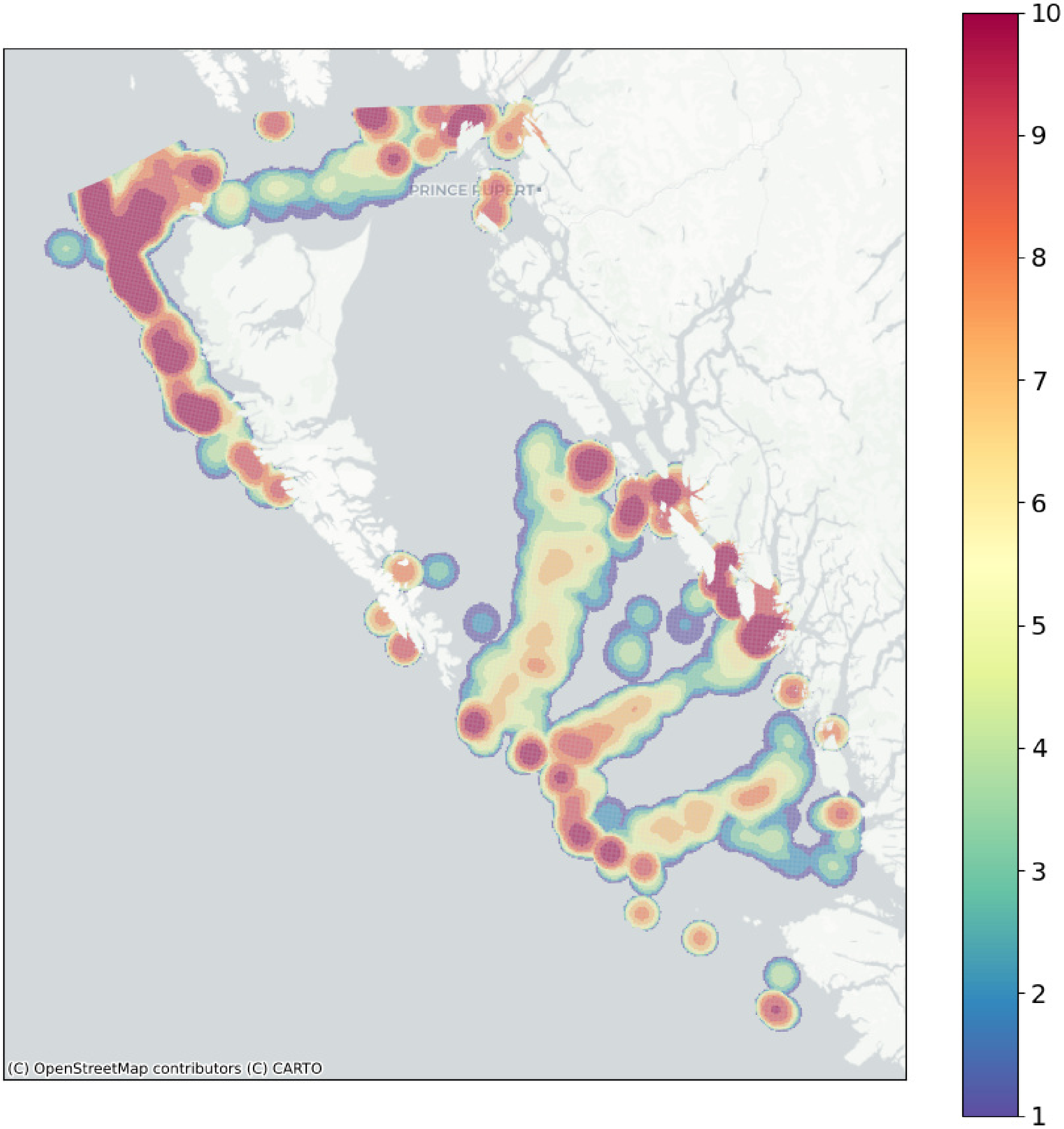

Figure 87: Rougheye-Blackspotted Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

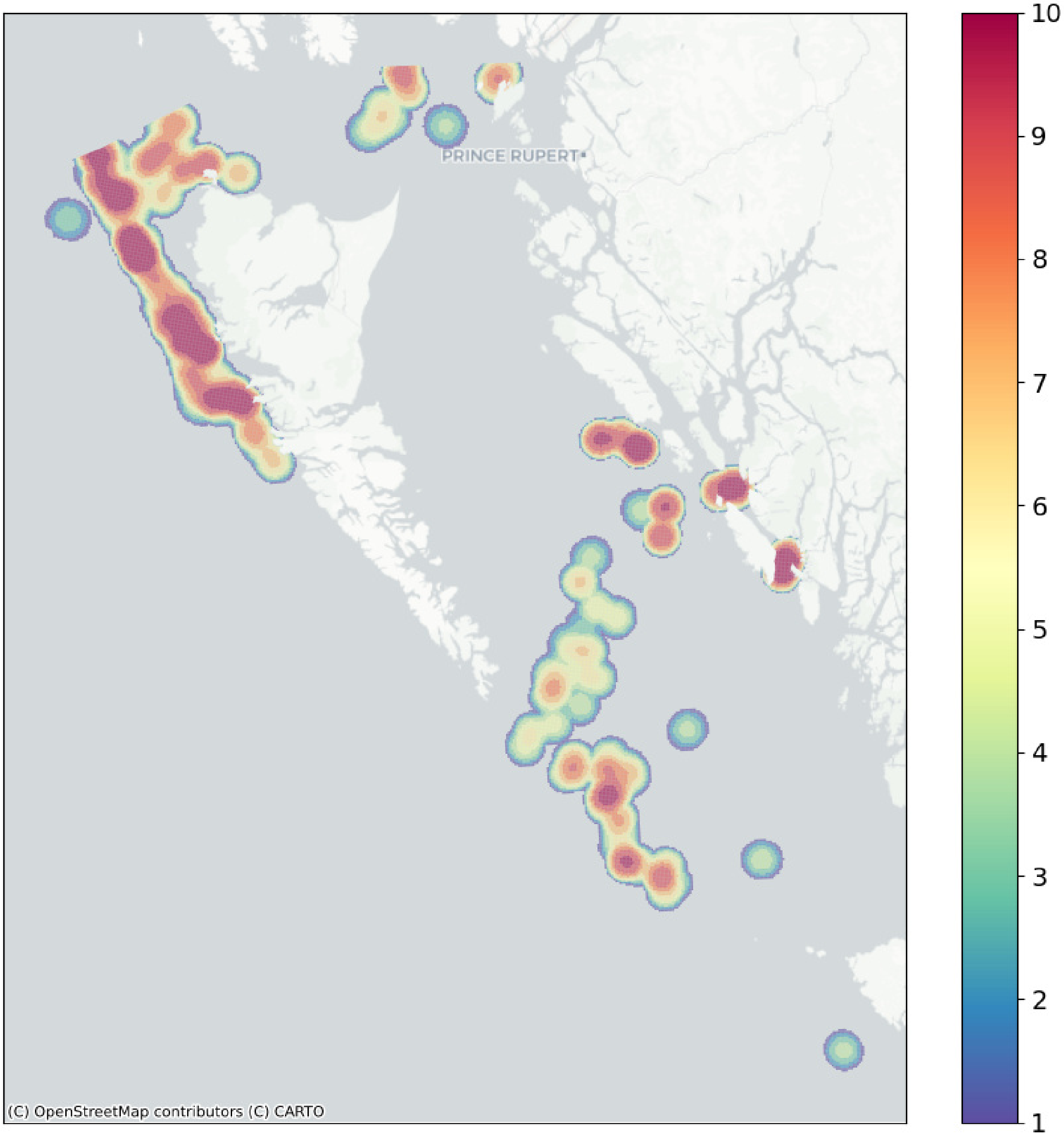

Figure 88: Shortraker Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

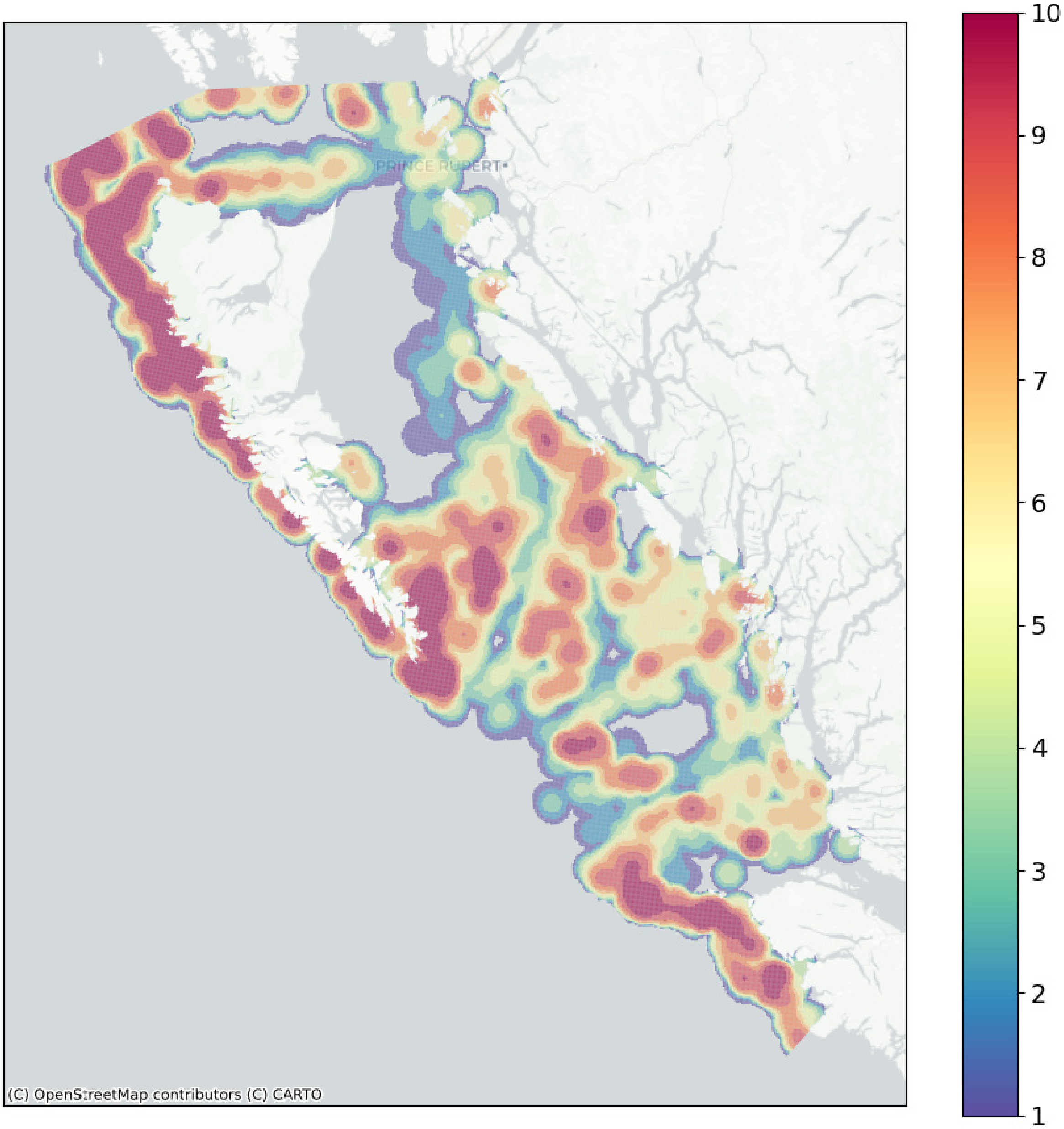

Figure 89: Silvergray Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

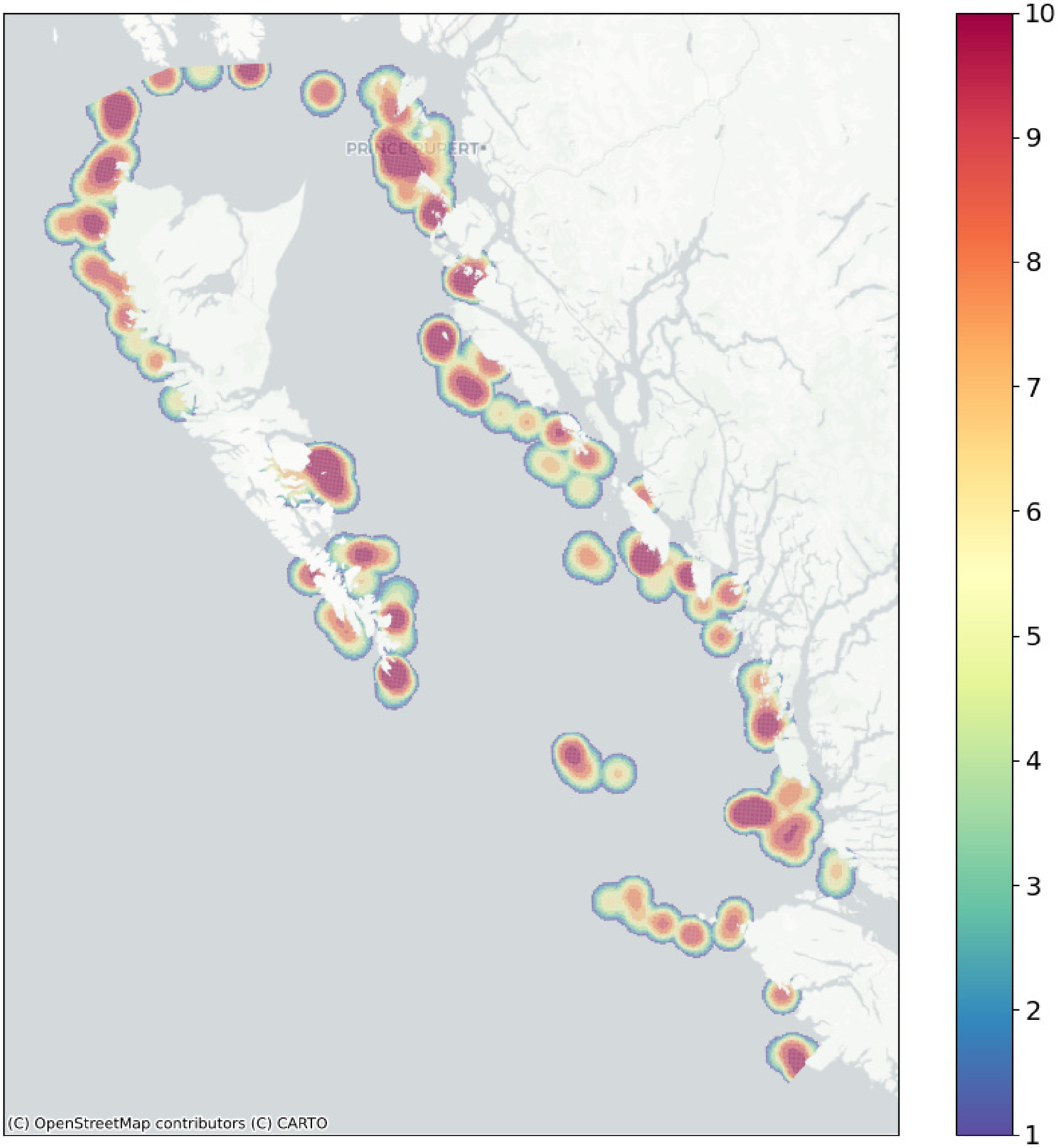

Figure 90: CPUE of Tiger Rockfish from research surveys (PHMA longline), displayed as deciles of catch per unit effort.

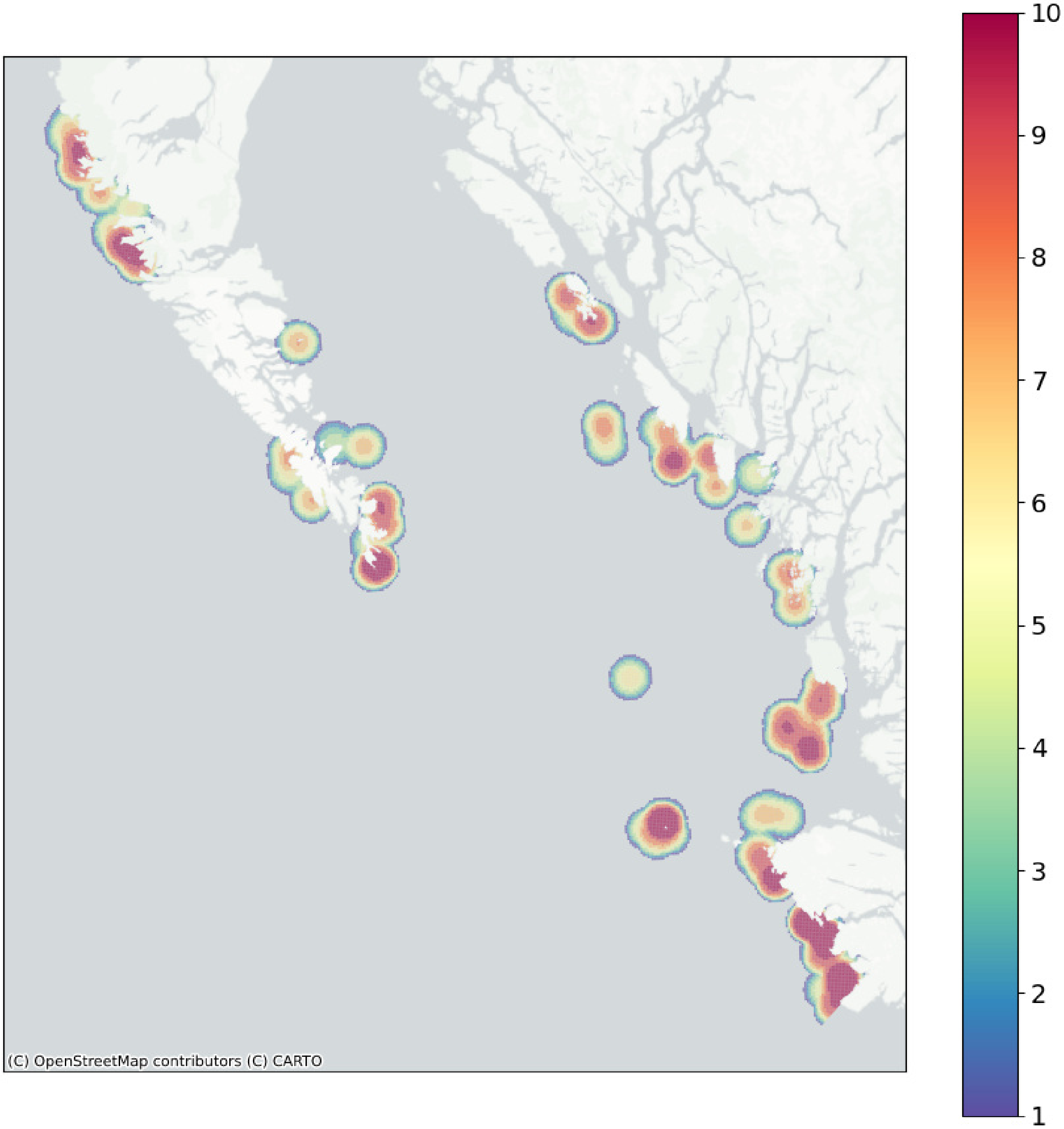

Figure 91: CPUE of Vermilion Rockfish from research surveys (PHMA longline), displayed as deciles of catch per unit effort.

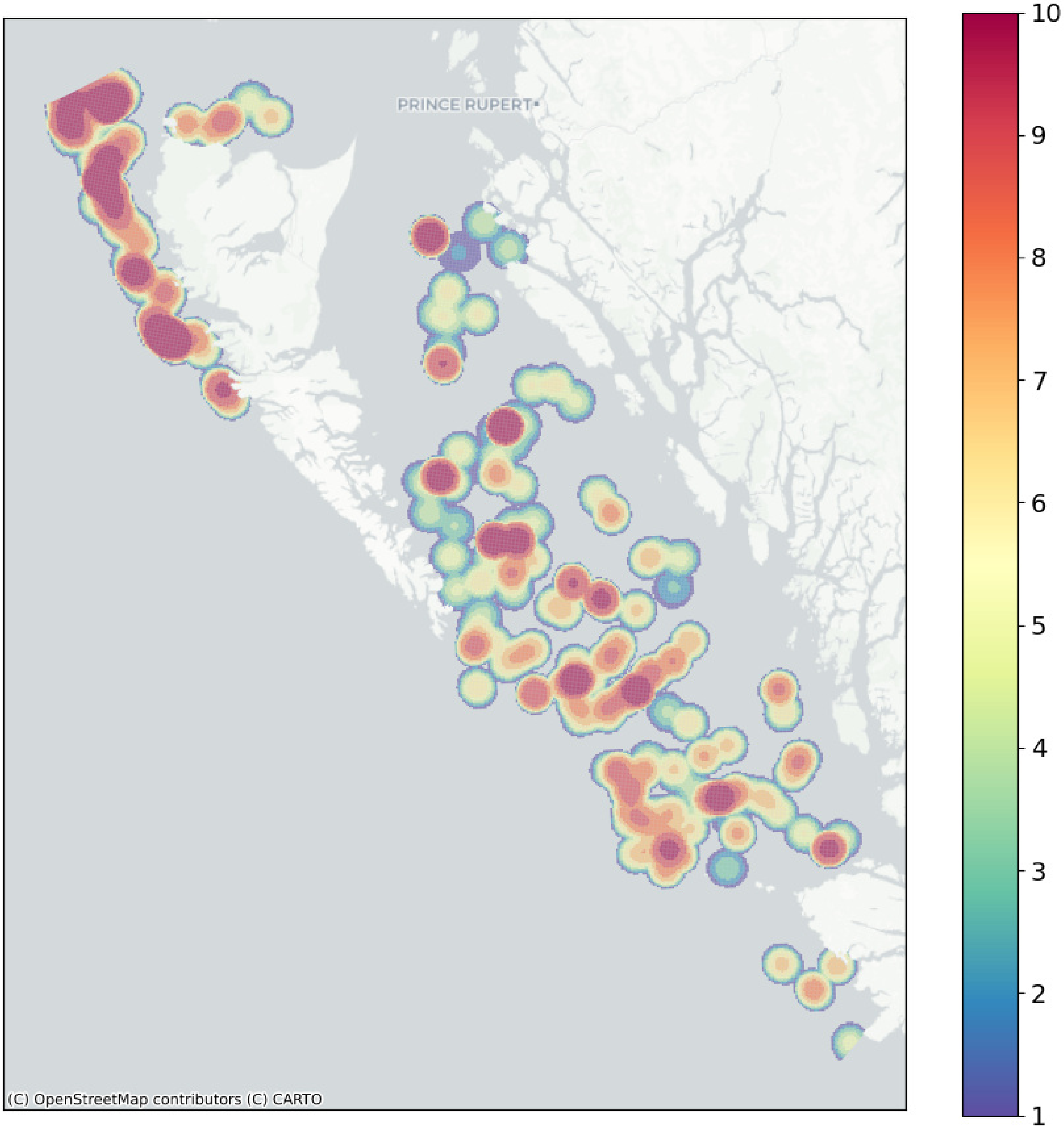

Figure 92: Widow Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

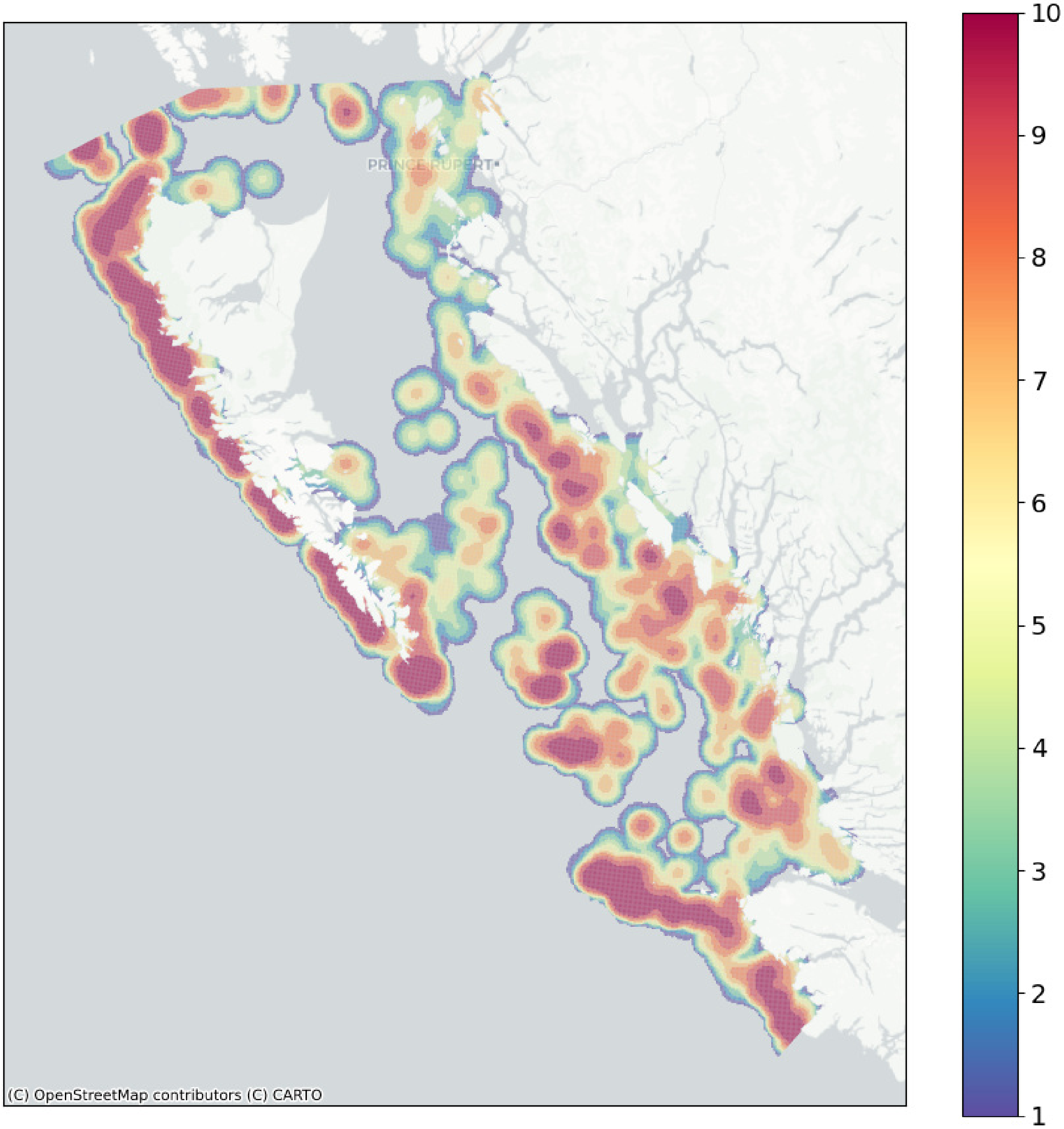

Figure 93: Yelloweye Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

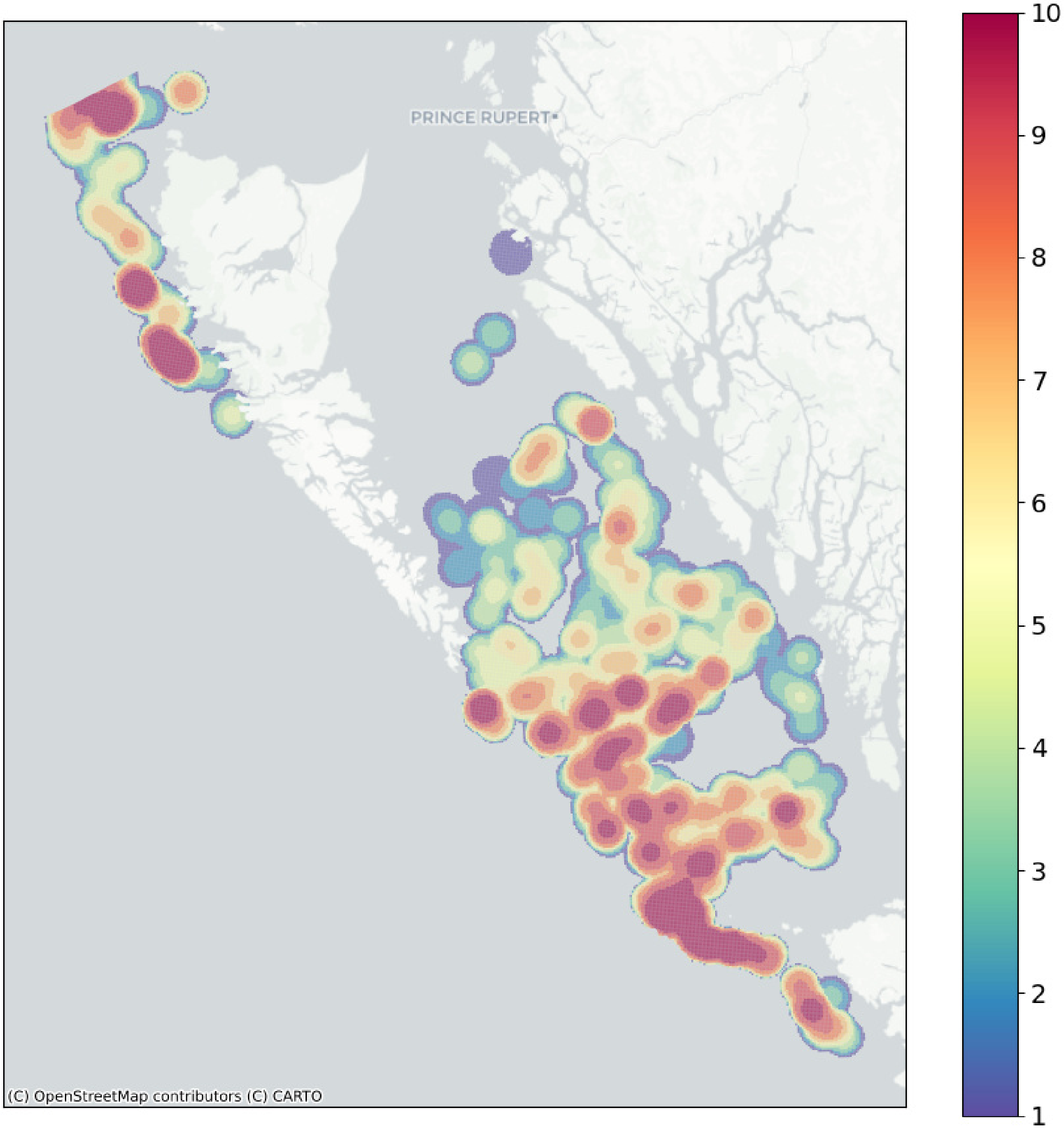

Figure 94: Yellowmouth Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

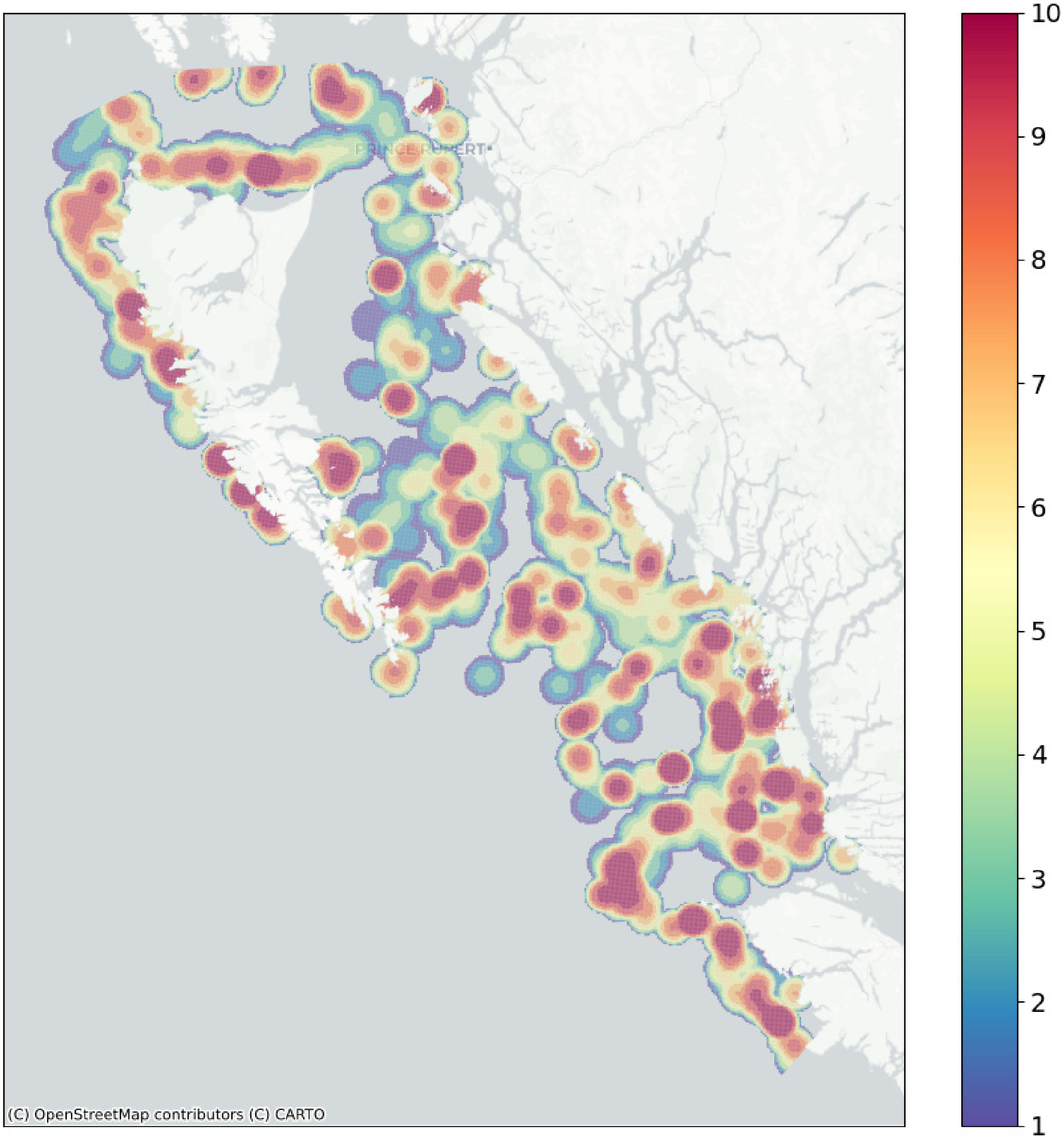

Figure 95: Yellowtail Rockfish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

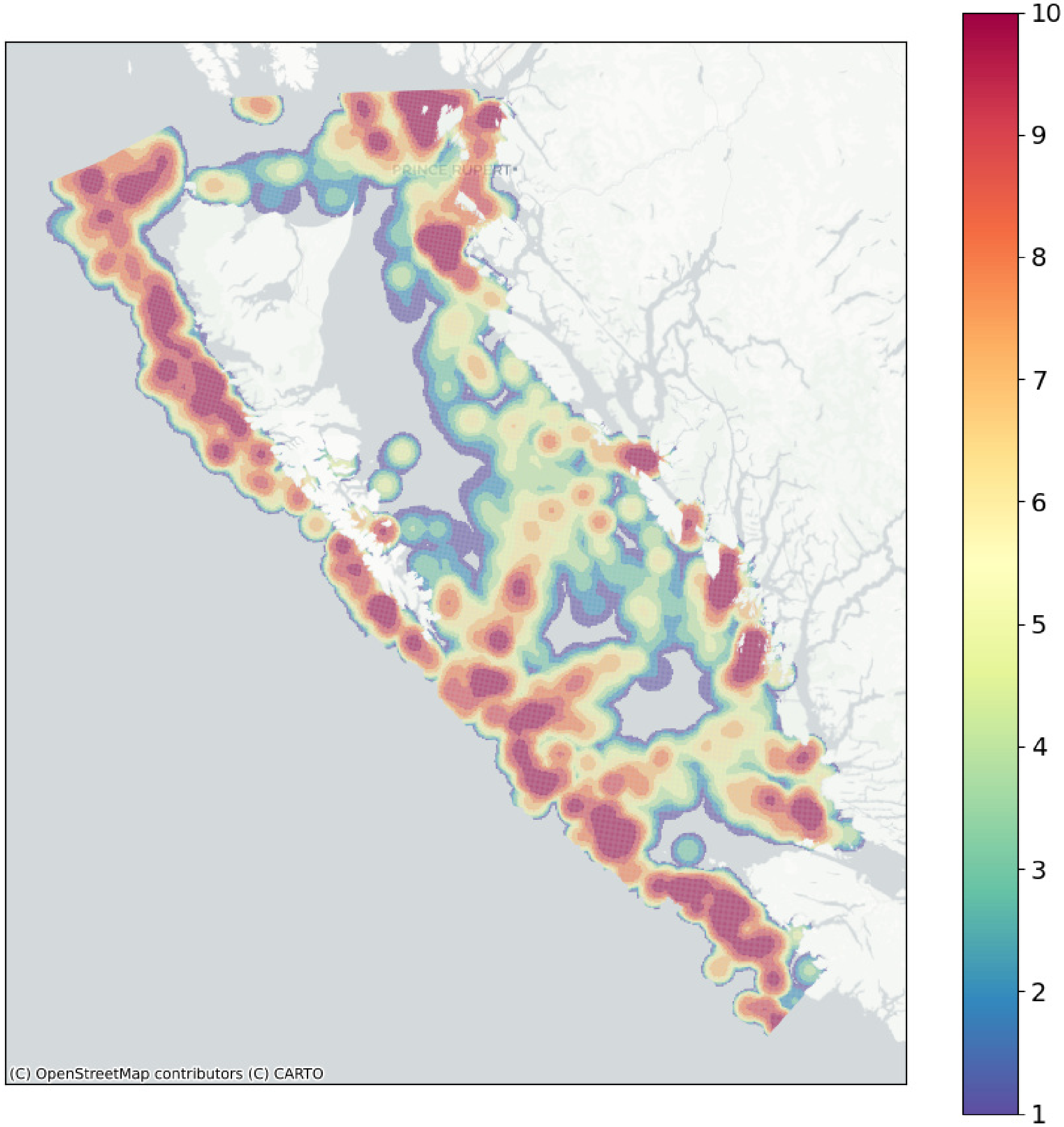

Figure 96: Sablefish catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, DFO sablefish trap, PHMA longline), displayed as deciles of CPUE.

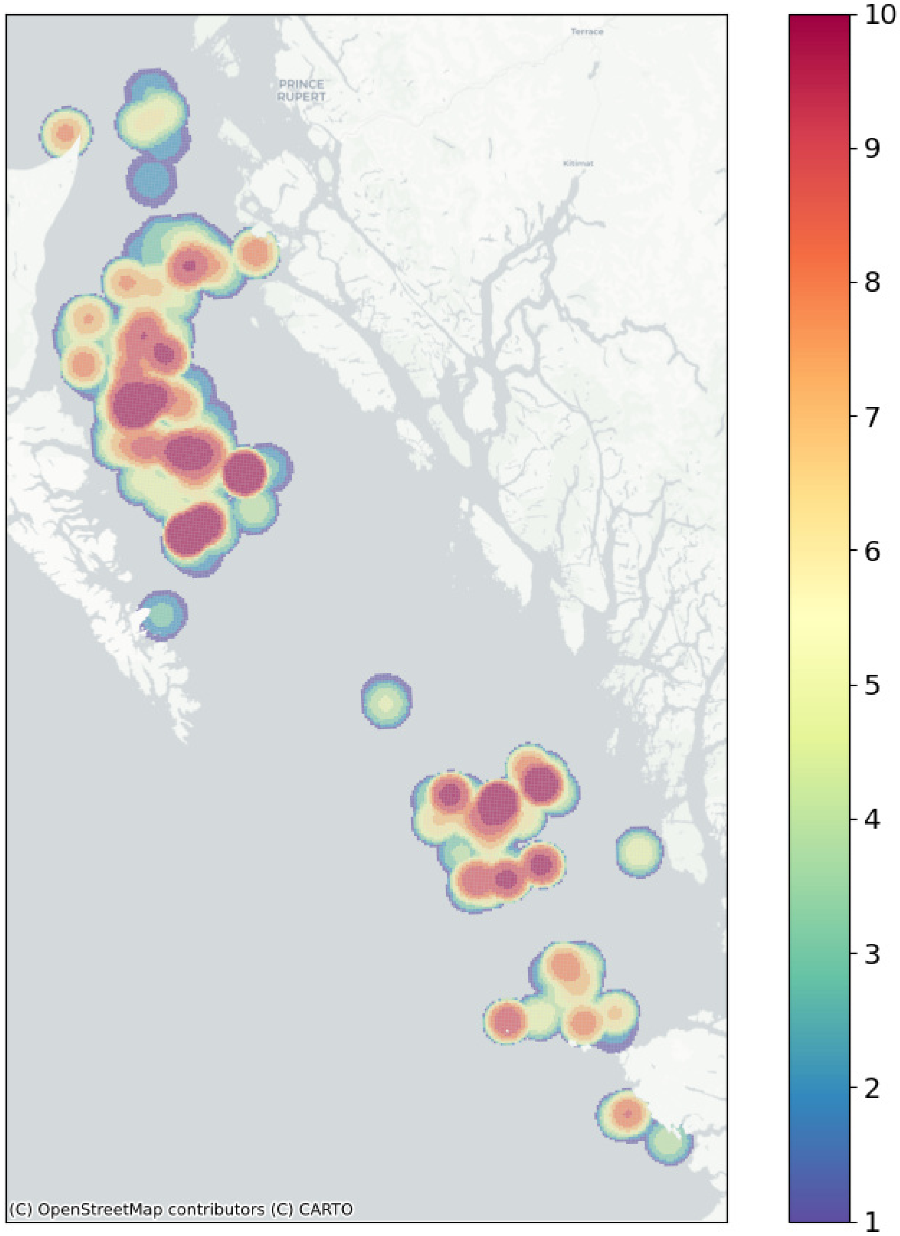

Figure 97: Pacific Sand Lance catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

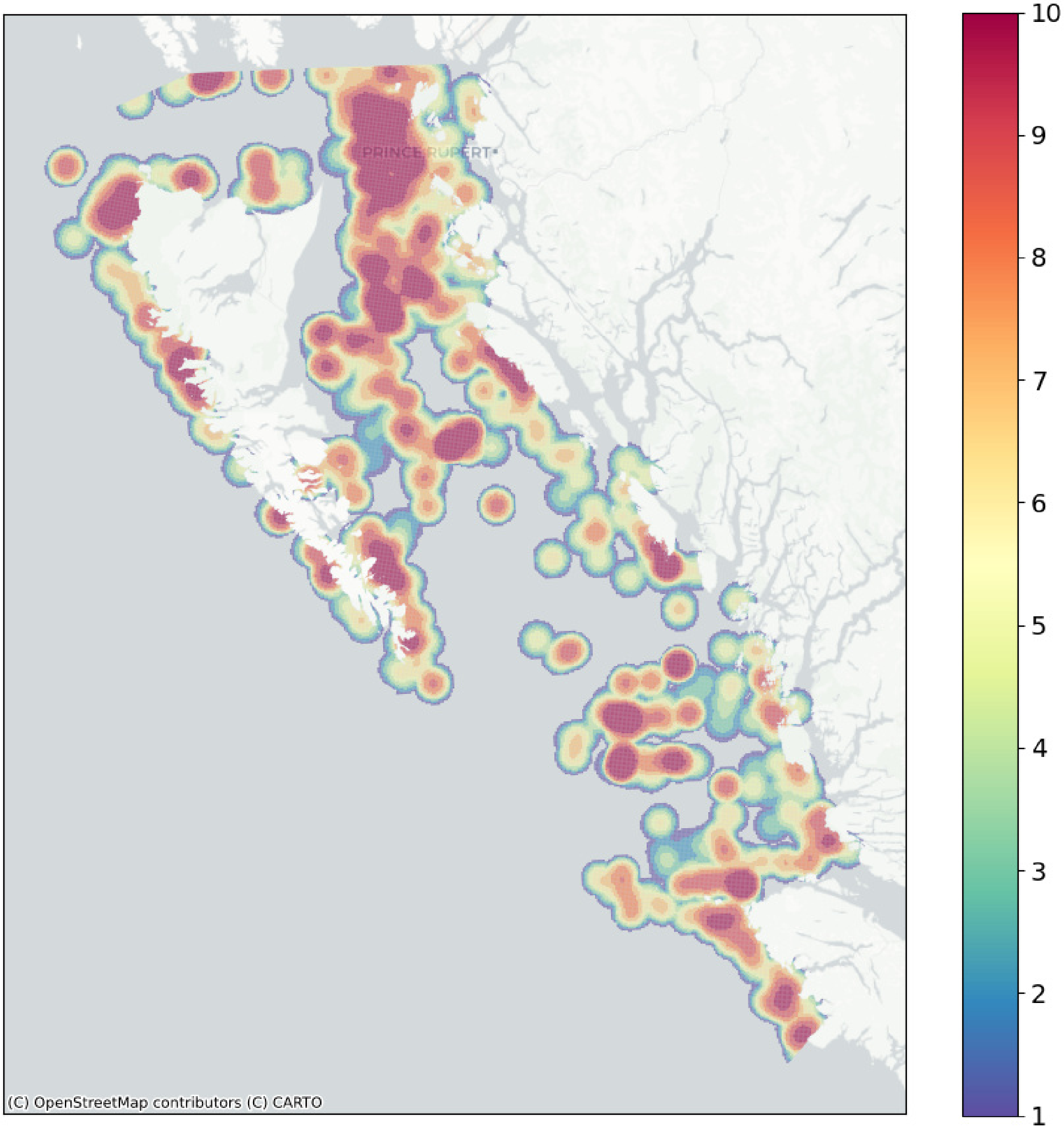

Figure 98: Big Skate catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

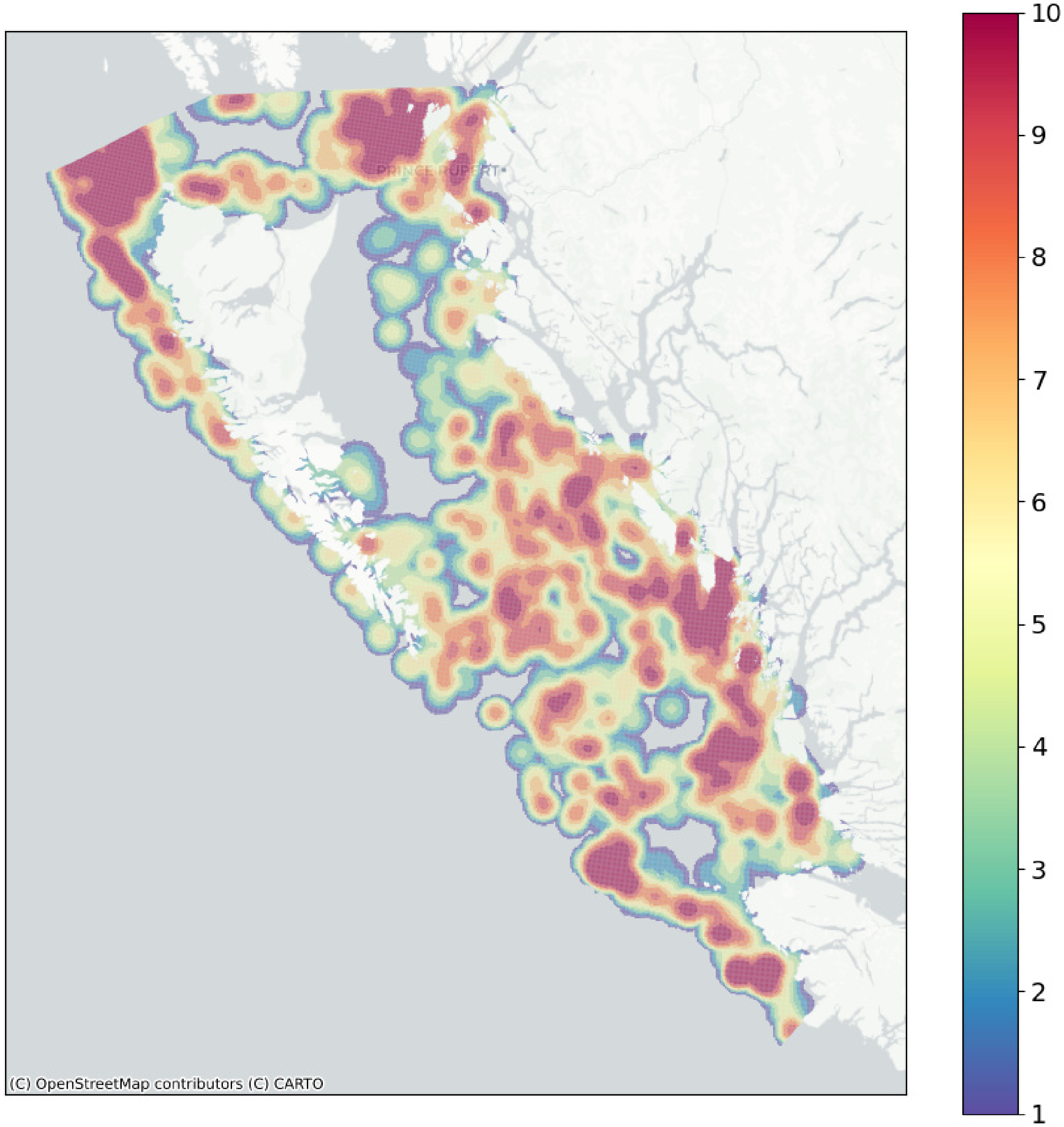

Figure 99: Longnose Skate catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

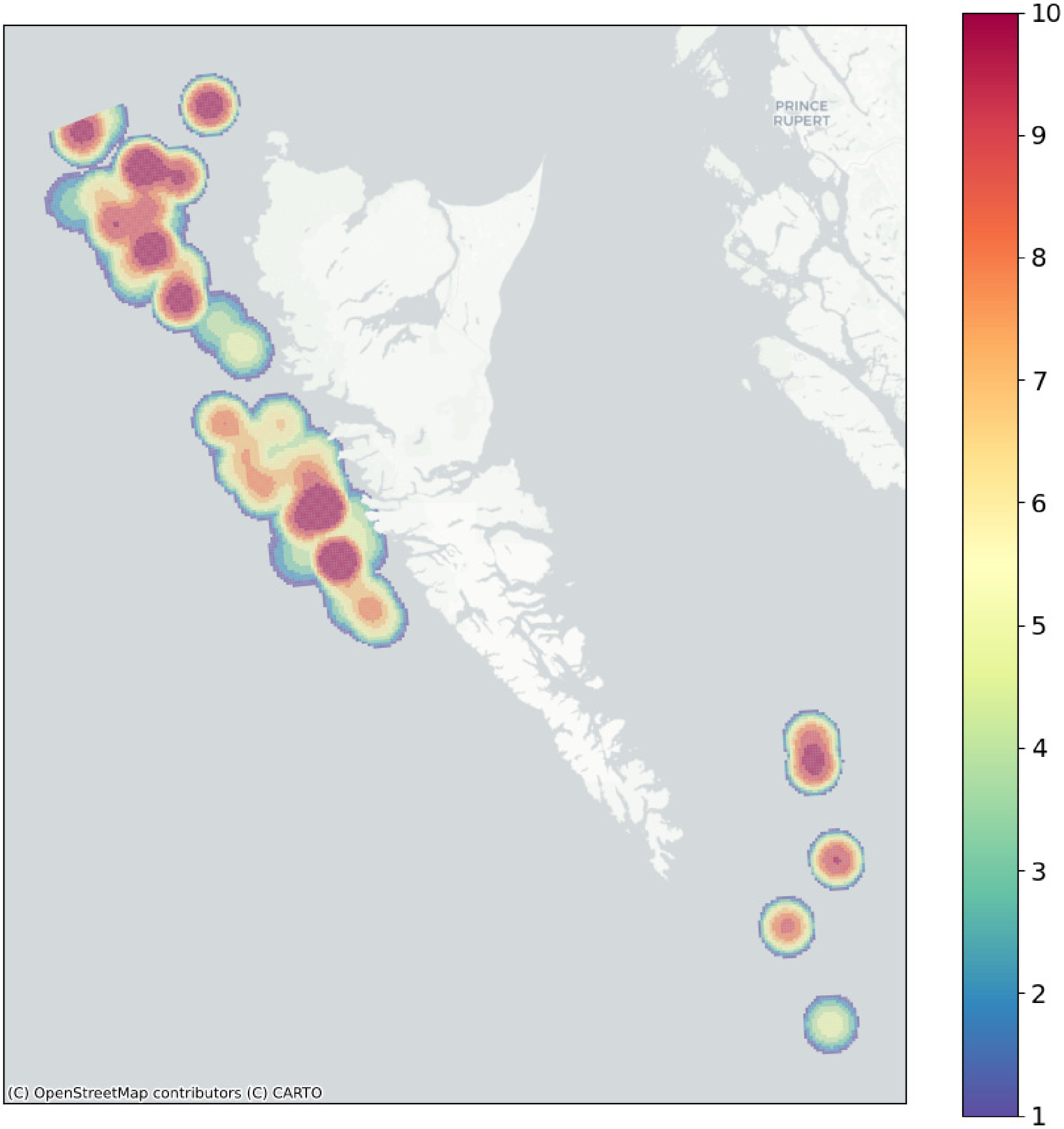

Figure 100: Roughtail Skate catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

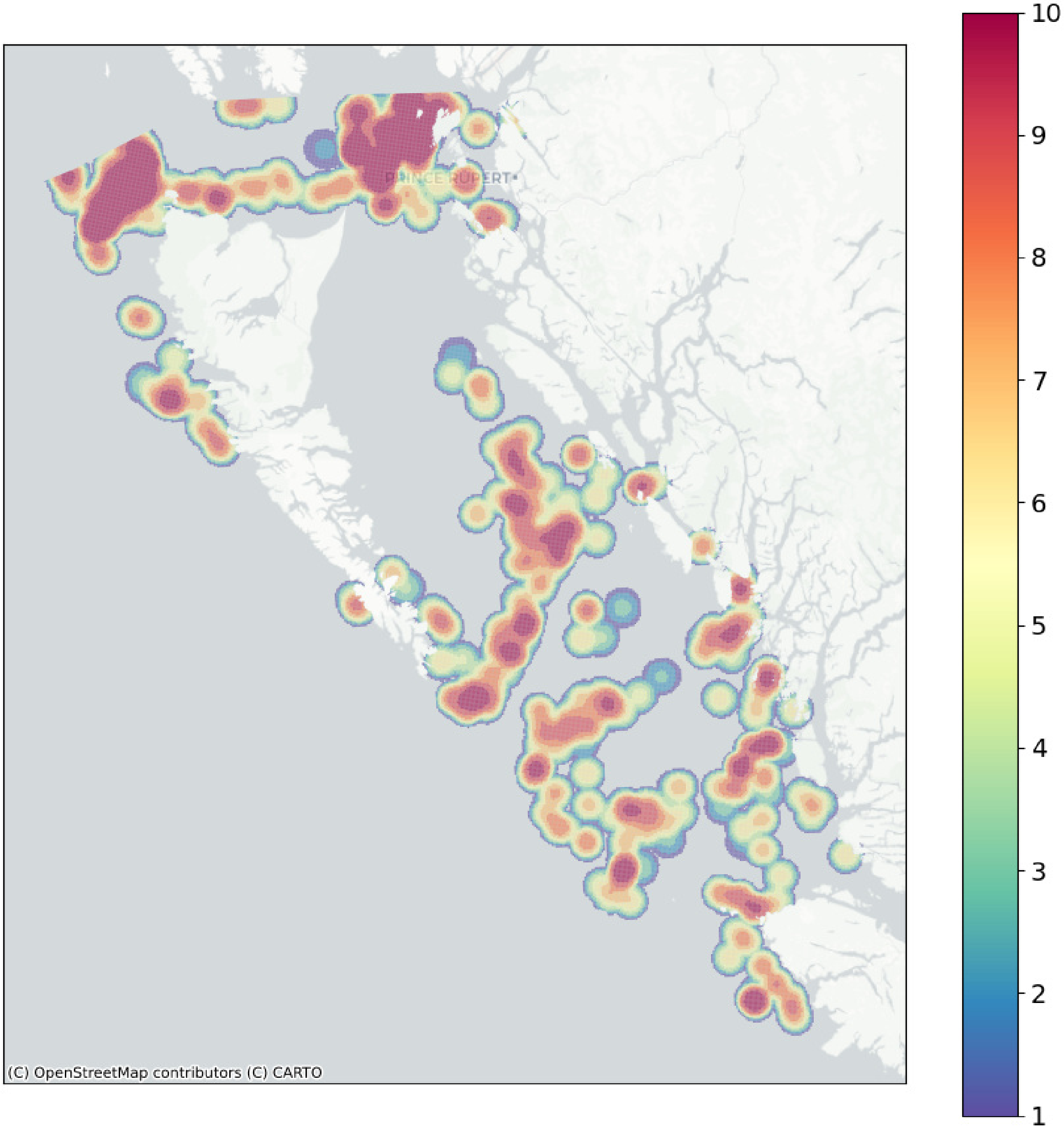

Figure 101: Sandpaper Skate catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

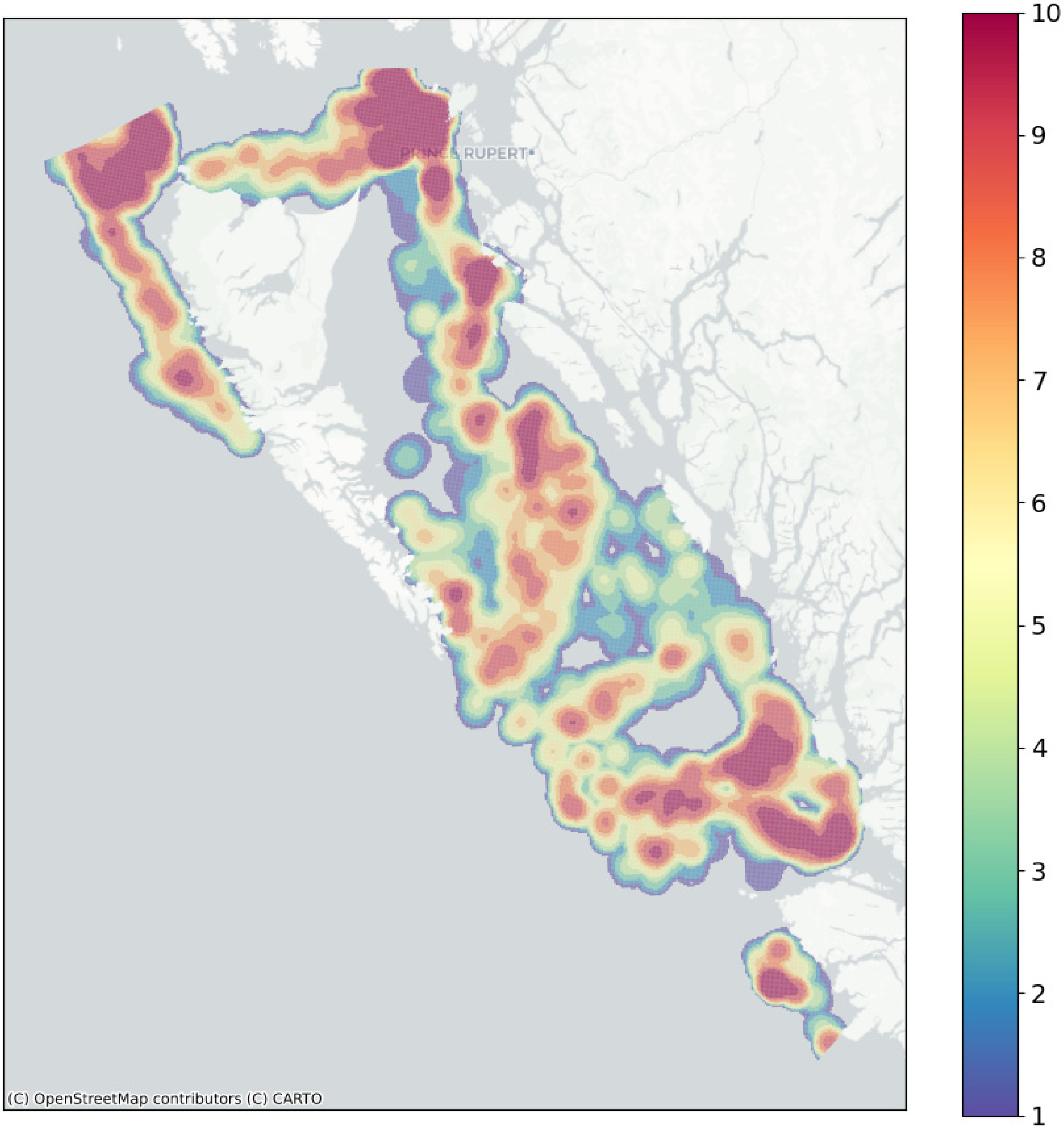

Figure 102: Dover Sole catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

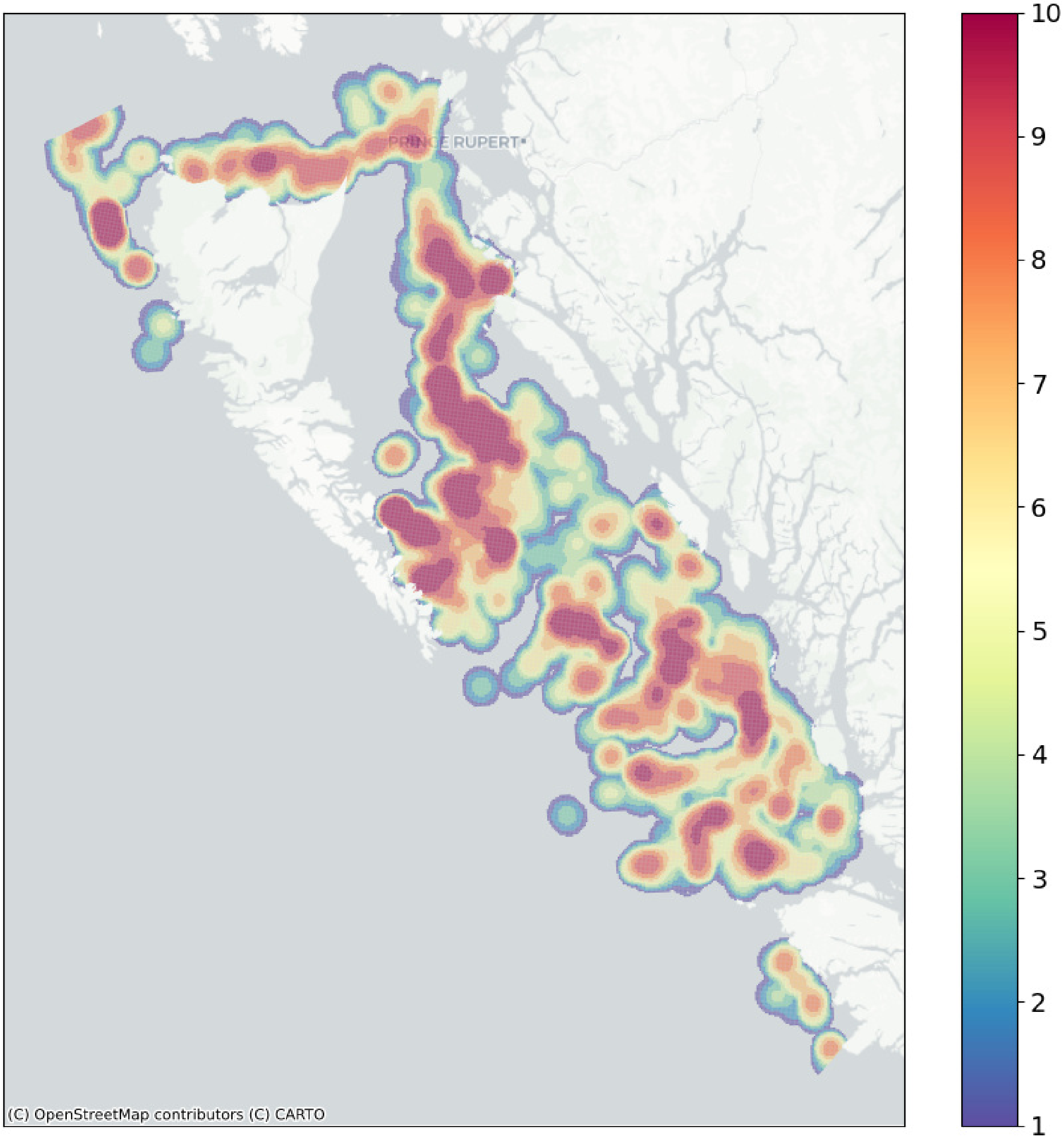

Figure 103: Petrale Sole catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

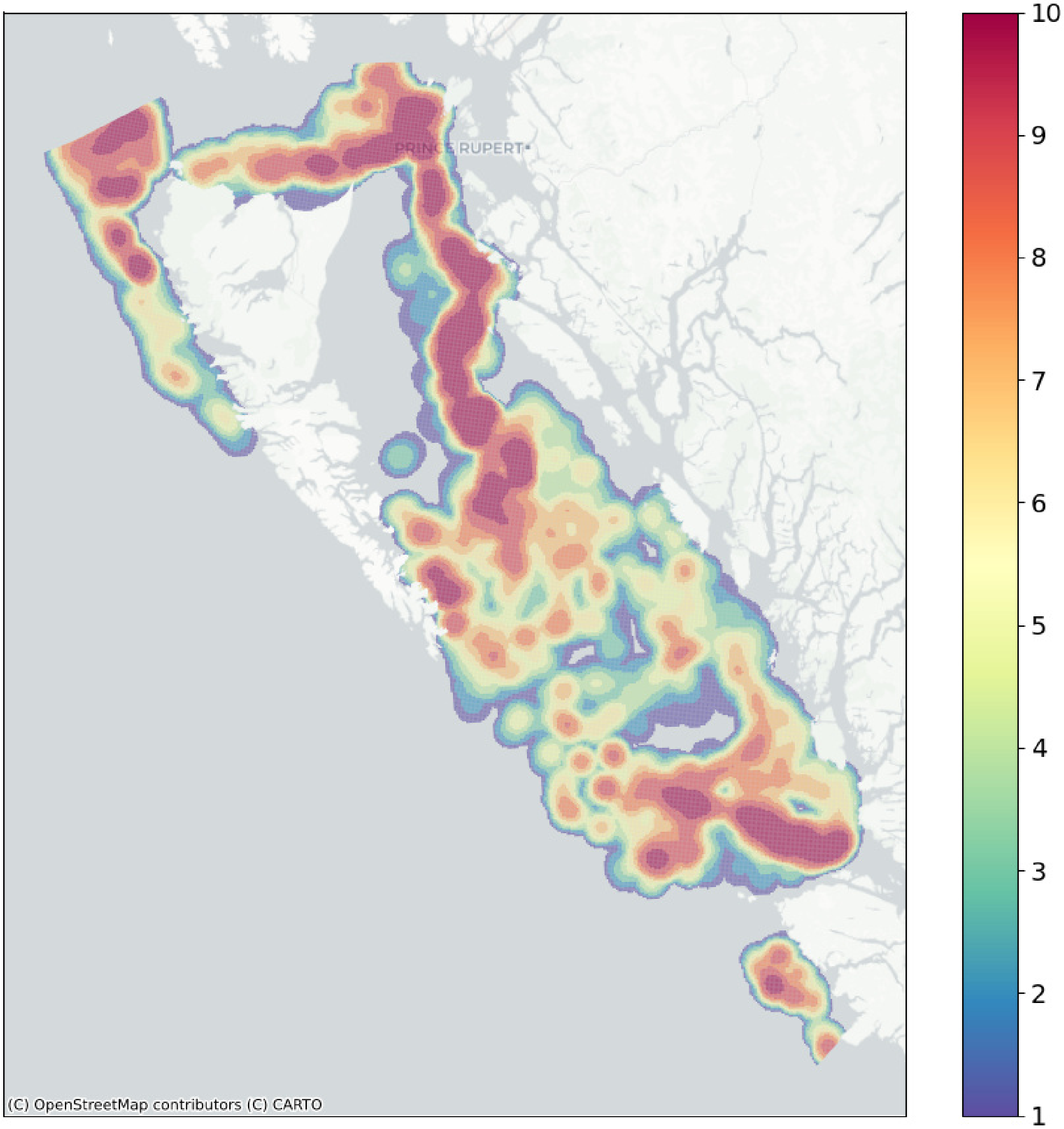

Figure 104: Rex Sole catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

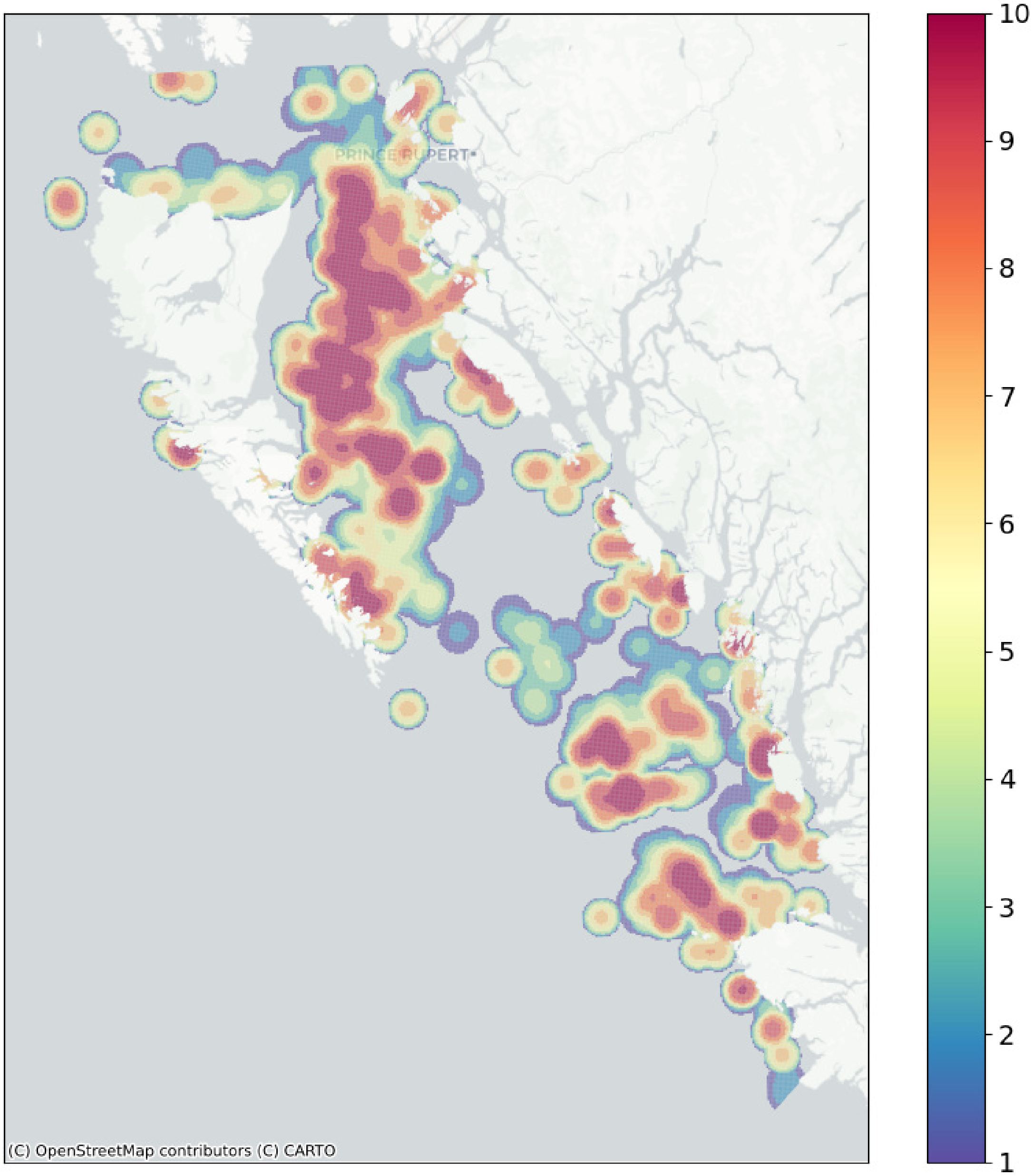

Figure 105: Rock Sole catch per unit effort (CPUE) from research surveys (DFO synoptic trawl, PHMA longline), displayed as deciles of CPUE.

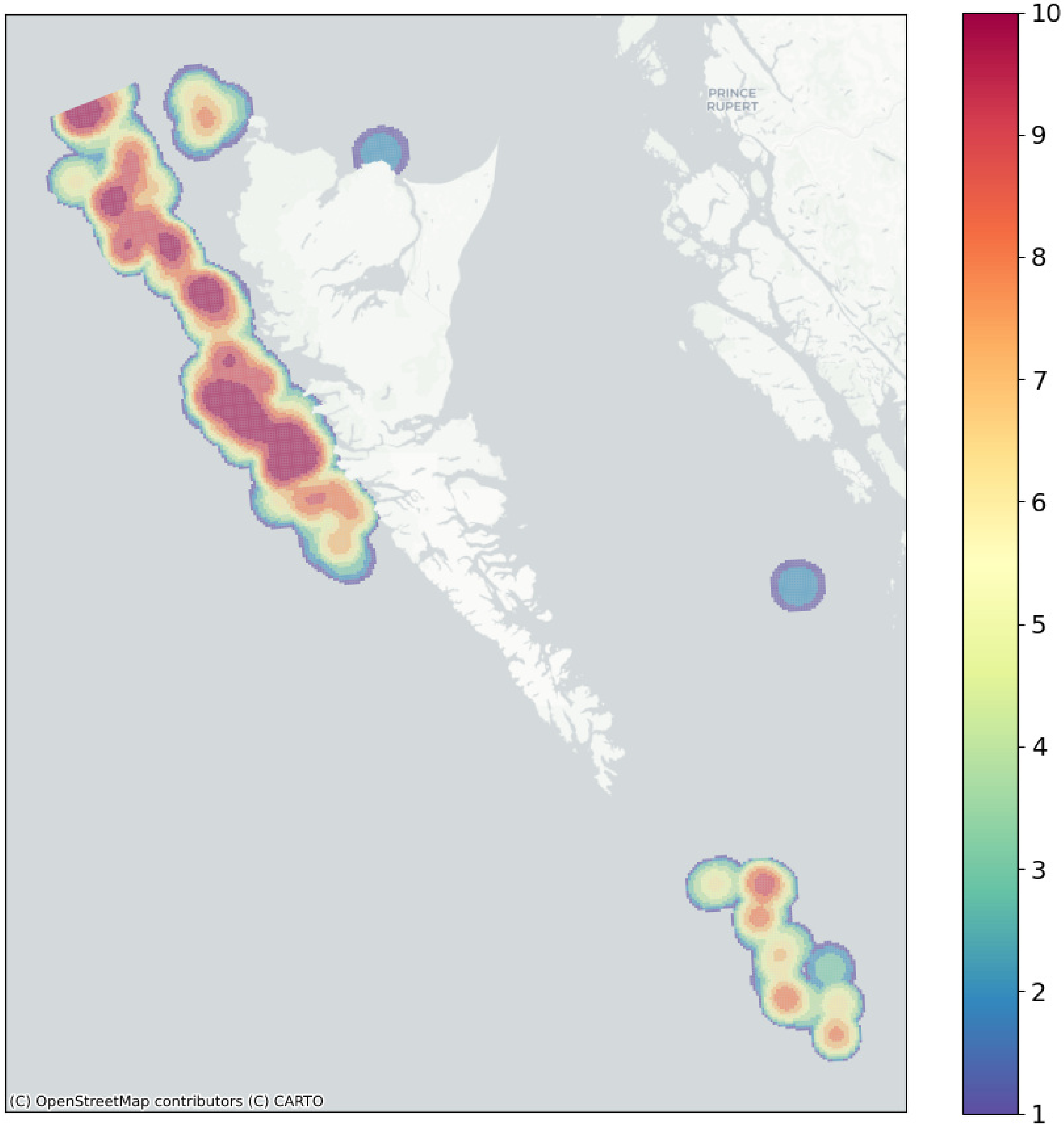

Figure 106: Longspine Thornyhead catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

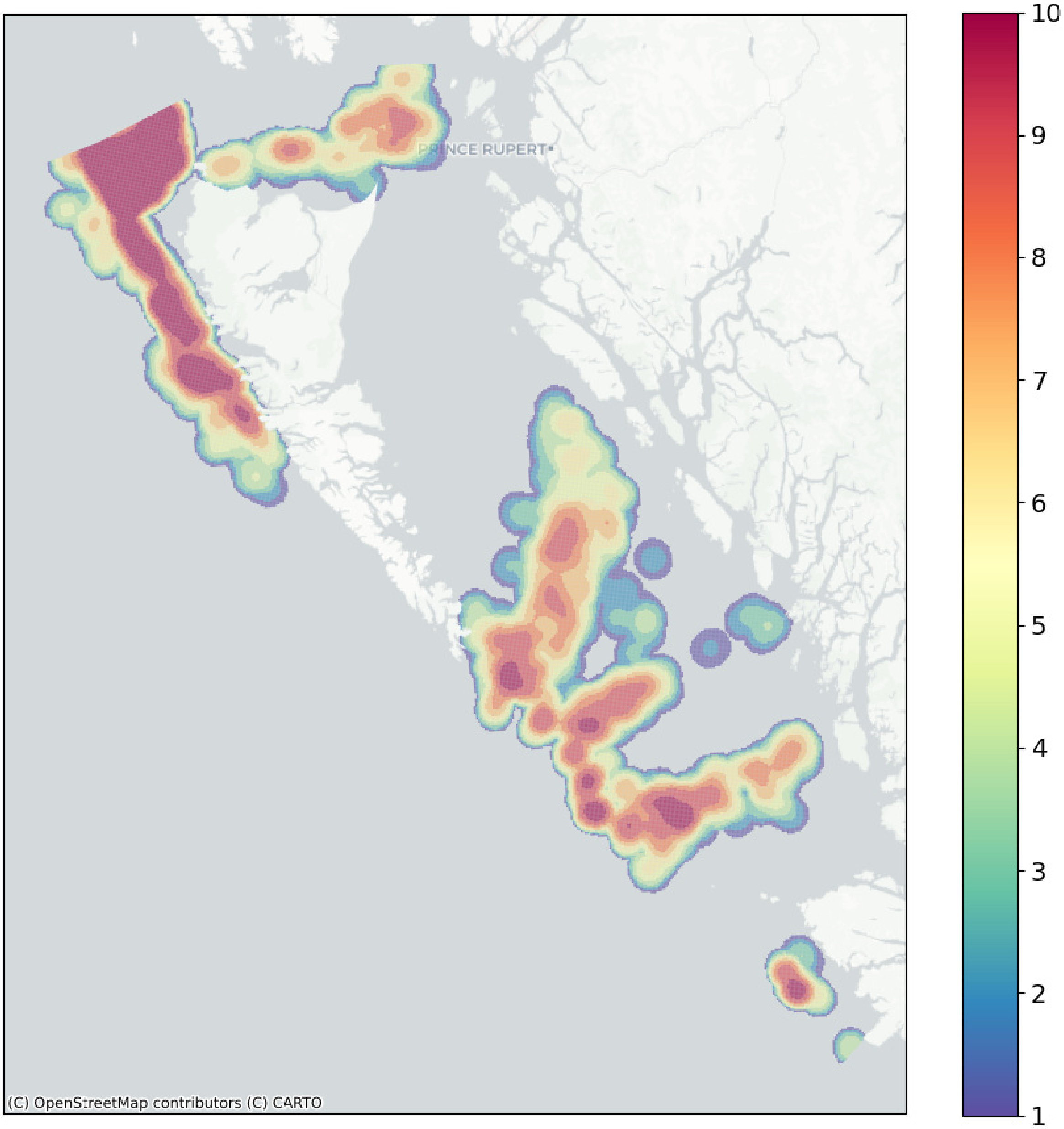

Figure 107: Shortspine Thornyhead catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE.

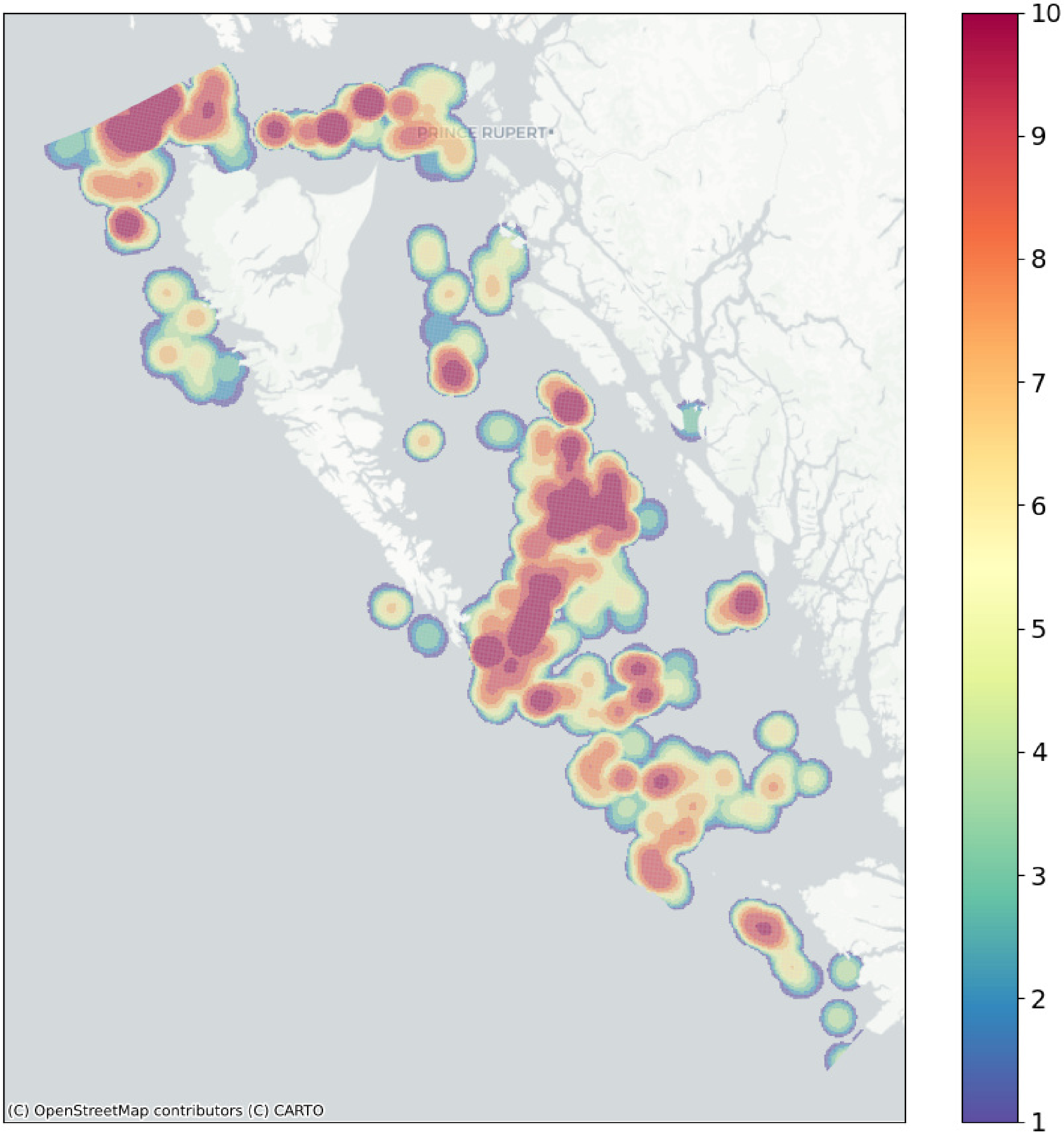

Figure 108: Coral (excluding sea pens) catch per unit effort (CPUE) from DFO synoptic groundfish trawl surveys and groundfish trawl fishery records, displayed as deciles of CPUE.

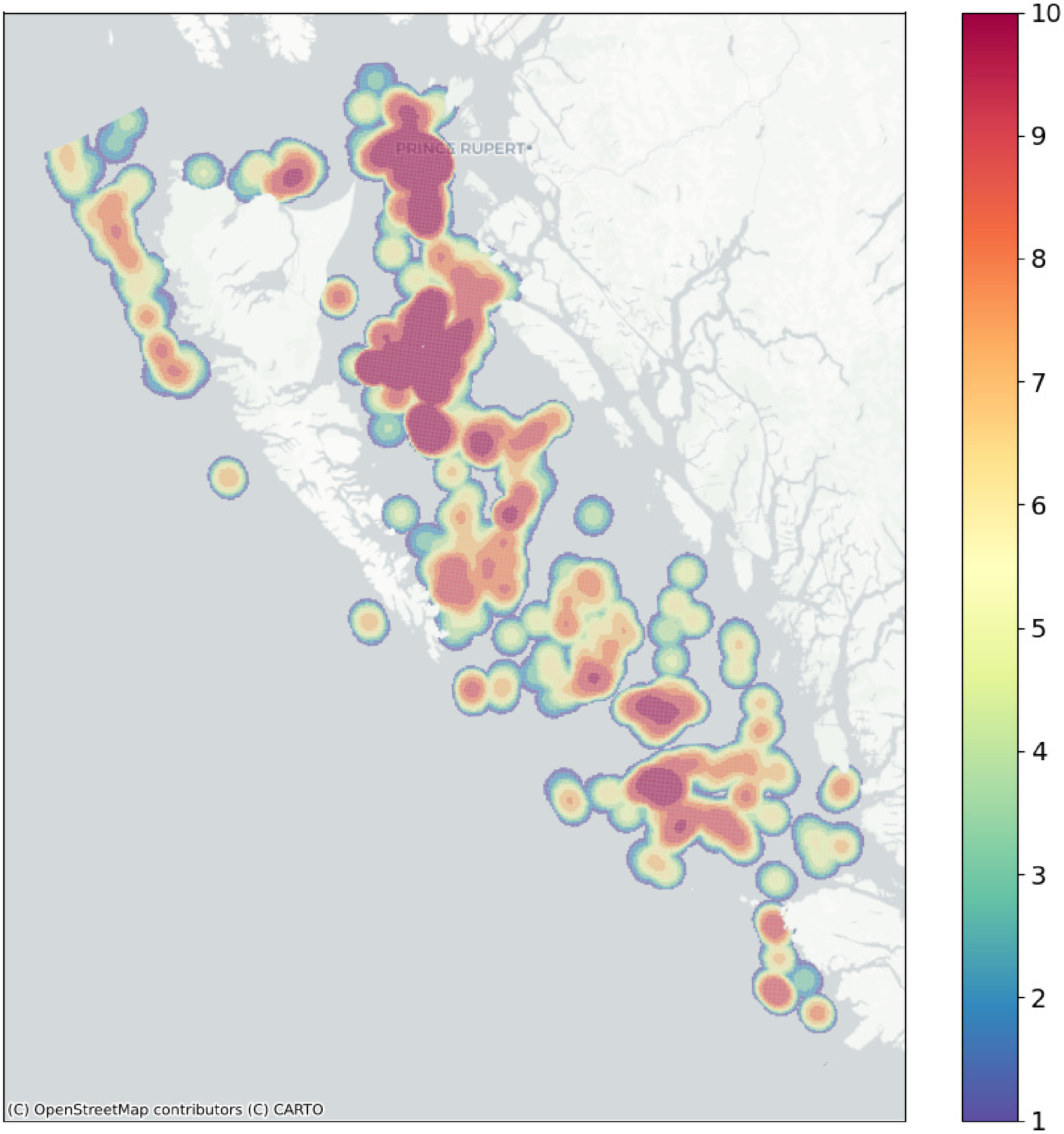

Figure 109: Sea pens catch per unit effort (CPUE) from DFO synoptic groundfish trawl surveys and groundfish trawl fishery records, displayed as deciles of CPUE.

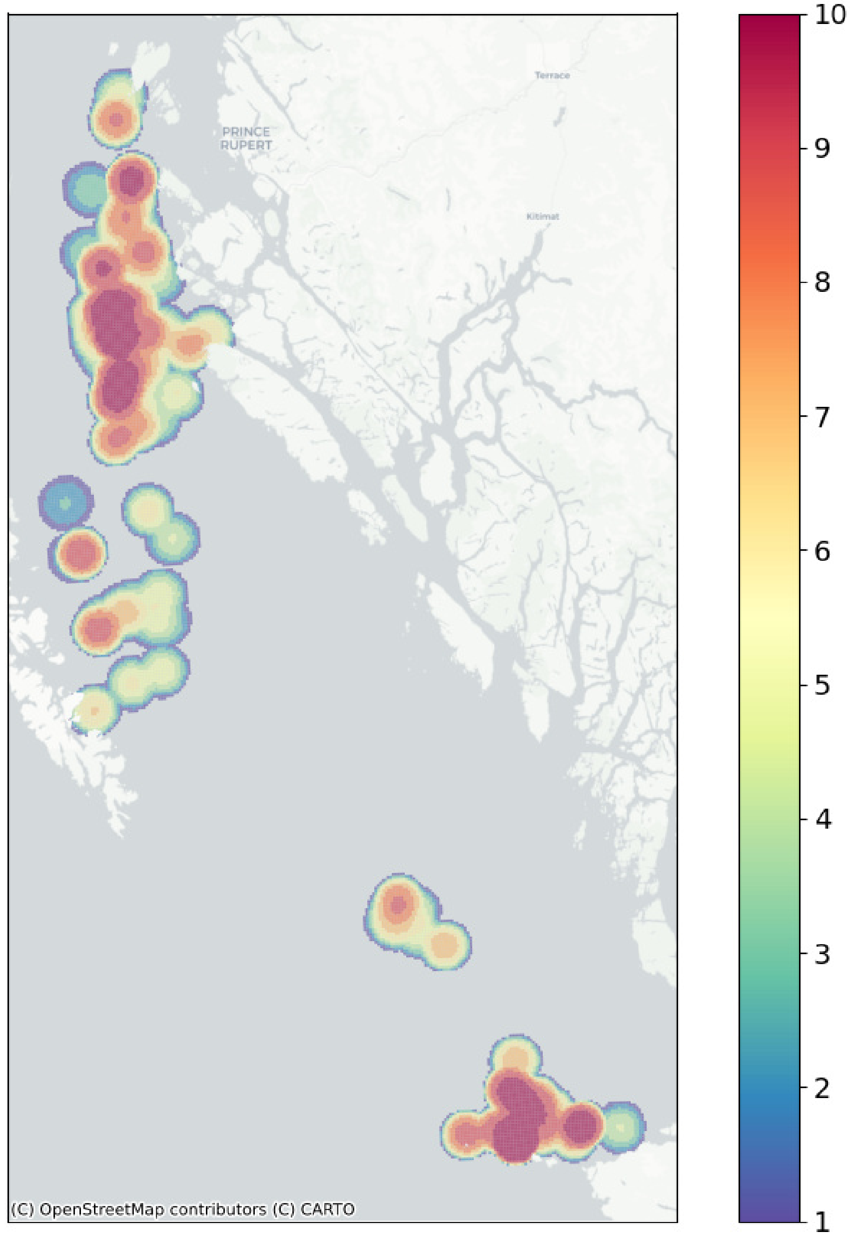

Figure 110: Scallop catch per unit effort (CPUE) from research surveys (DFO synoptic trawl), displayed as deciles of CPUE. (Pink Scallop, Spiny Scallop).

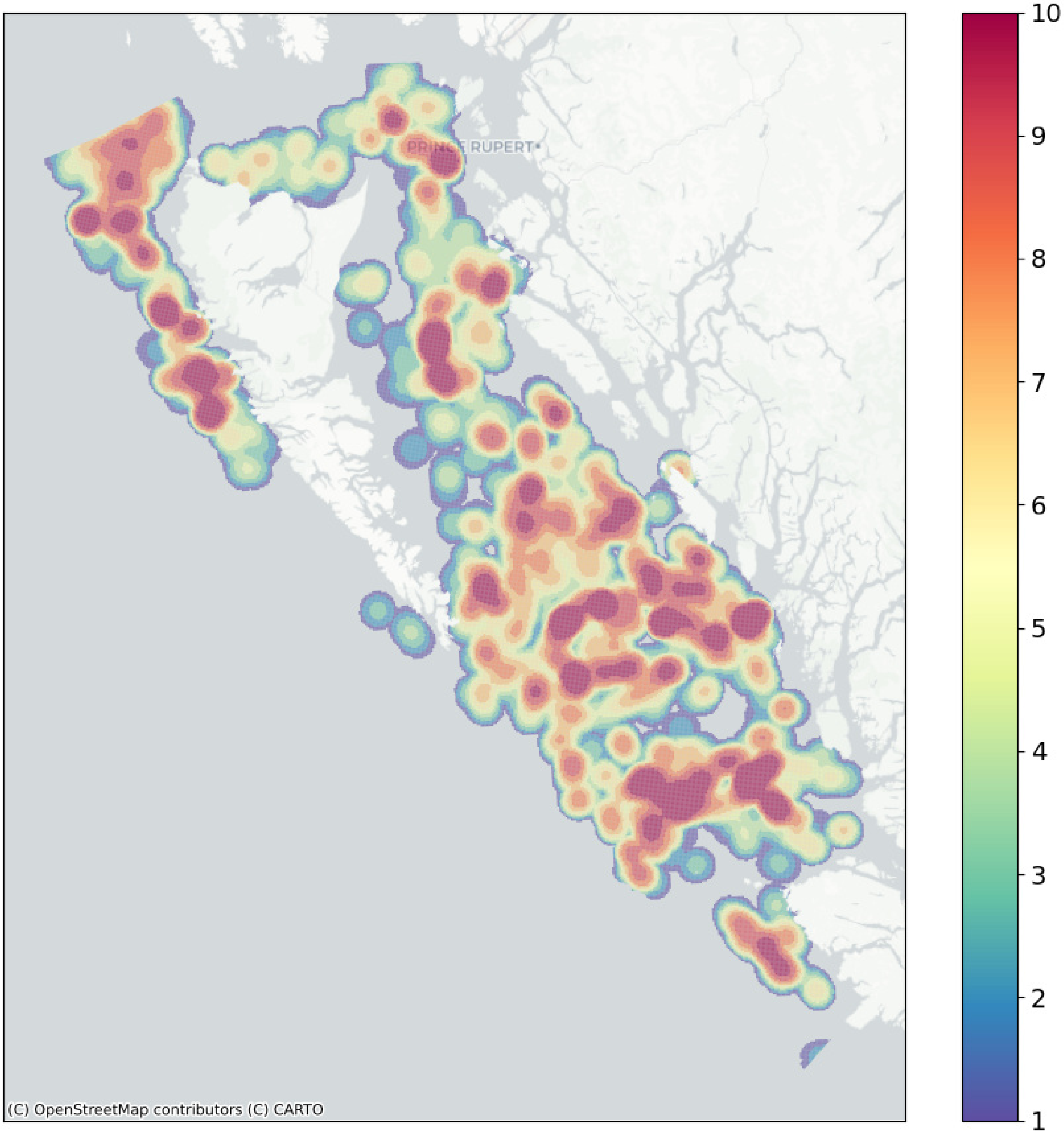

Figure 111: Sponge catch per unit effort (CPUE) from DFO synoptic groundfish trawl surveys and groundfish trawl fishery records, displayed as deciles of CPUE.

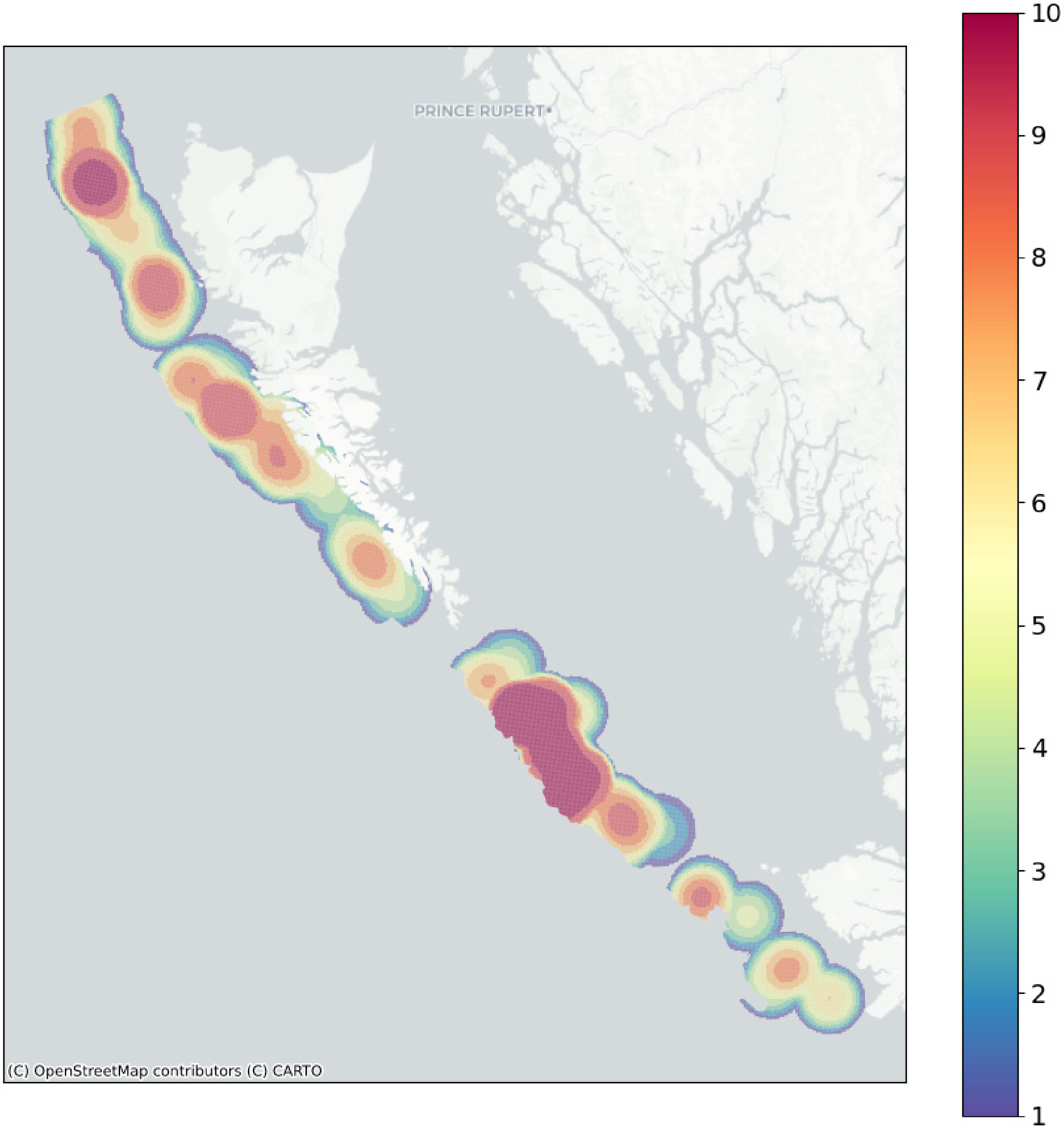

Figure 112: Deepwater Tanner Crab catch per unit effort (CPUE) from research surveys (DFO sablefish trap), displayed as deciles of CPUE

NSB MPA Network Ecological Data - Invertebrate Presence Features

Summary:

There are 21 features in the 'Invertebrate Locations' geodatabase:

- (7) Bivalves
- (2) Crabs
- (6) Prawn and shrimps
- (4) Sea stars and sea urchins
- (2) Squid and octopus

Data Creators and Co-creators: Creator: Katie Gale; Co-Creators: MPATT Science Team

Methods and links to metadata:

Presence records for species of interest were extracted from a number of DFO research surveys and commercial shellfish logs. Planning units (1 km grid cells) shown indicate that at least one presence point for that species occurred in that planning unit. No distinction is made between planning units that have not been sampled (i.e., "no data") and those that have been sampled but in which the species was not found (i.e., "absence").

Not all species were present in each data source. The data sources queried are listed in the following section.

The above methods apply to all features in this geodatabase. Each feature has embedded metadata with details on its creation. Links to online versions of each feature's metadata are listed below.

- Butter Clam
- Horse Clam
- Littleneck Clam
- Cockle
- Puget Sound King Crab
- Dungeness Crab
- Geoduck
- Giant Pacific Octopus
- Olympia Oyster
- Spot Prawn
- Purple Rock Scallop
- Green Urchin
- Red Urchin
- Ochre Sea Star
- Sunflower Sea Star

- Coonstripe Shrimp
- Humpback Shrimp
- Sidestripe Shrimp
- Smooth Pink Shrimp
- Spiny Pink Shrimp
- Opal Squid

Temporal Coverage:
1963-01-01 to 2017-12-31

Scripts/Software:
Code used to create these features is available at the MSEA GitLab page.

Data Sources:

- **Shellfish Fishery Logs**, 2000-2017 (Prawn by Trap; Crab by Trap; Tanner Crab; Scallop by Trawl; Opal Squid; Octopus by Dive; Shrimp by Trawl; Geoduck by Dive; Green Sea Urchin by Dive; Red Sea Urchin by Dive; Intertidal Clam).
- **DFO Shellfish Research Surveys**, 1963-2017 (Green Sea Urchin by Dive; Red Sea Urchin by Dive; Intertidal Clam; Crab by Trap; Sea Cucumber by Dive; Geoduck by Dive; Prawn by Trap; Shrimp by Trawl; Scallop by Trawl; Tanner Crab; World Class Tanker Safety System Dive and ROV).
- **DFO Groundfish and other Research Surveys**, 2003-2016 (Synoptic Trawl; Sablefish Assessment; Hecate Multispecies Trawl; IPHC Longline; Inshore Rockfish Longline; Joint Can–US Hake; Hake Stock Delineation; Hecate Strait Pacific Cod Monitoring; PHMA Longline; High Seas Salmon Survey).

Absence Data:
No absence data. No distinction is made between planning units that have not been sampled (i.e., "no data") and those that have been sampled but in which the species was not found (i.e., "absence").

Uncertainties:
Grid cells shown had at least one observation of the focal species in the data queried, but no information is available on density or frequency of occurrence.

Each feature has uncertainties based on its input data and processing steps. Notable uncertainties are described in each feature's individual metadata.

Species Data:

- SAXIDOMUS GIGANTEA (BUTTER CLAM)
- CLINOCARDIUM NUTTALLII (NUTTALL COCKLE (aka HEART COCKLE))
- PANDALUS DANAE (COONSTRIPE SHRIMP)
- METACARCINUS MAGISTER (DUNGENESS CRAB)
- PANOPEA GENEROSA (PACIFIC GEODUCK)
- ENTEROCTOPUS DOFLEINI (GIANT PACIFIC OCTOPUS)
- STRONGYLOCENTROTUS DROEBACHIENSIS (GREEN URCHIN)

- TRESUS CAPAX (FAT GAPER)
- TRESUS NUTTALLII (PACIFIC GAPER)
- PANDALUS HYPSINOTUS (HUMPBACK SHRIMP)
- LEUKOMA STAMINEA (NATIVE LITTLENECK CLAM)
- PISASTER OCHRACEUS (PURPLE STARFISH)
- OSTREA LURIDA (OLYMPIA OYSTER (aka NATIVE OYSTER))
- DORYTEUTHIS OPALESCENS (OPALESCENT INSHORE SQUID)
- LOPHOLITHODES MANDTII (PUGET SOUND KING CRAB)
- CRASSADOMA GIGANTEA (GIANT ROCK-SCALLOP (aka PURPLEHINGED ROCKSCALLOP))
- STRONGYLOCENTROTUS FRANCISCANUS (RED URCHIN)
- PANDALOPSIS DISPAR (SIDESTRIPE SHRIMP)
- PANDALUS JORDANI (PINK SHRIMP (SMOOTH))
- PANDALUS BOREALIS (PINK SHRIMP)
- PANDALUS PLATYCEROS (PRAWN)
- PYCNOPODIA HELIANTHOIDES (SUNFLOWER STARFISH)

Maps of available datasets:

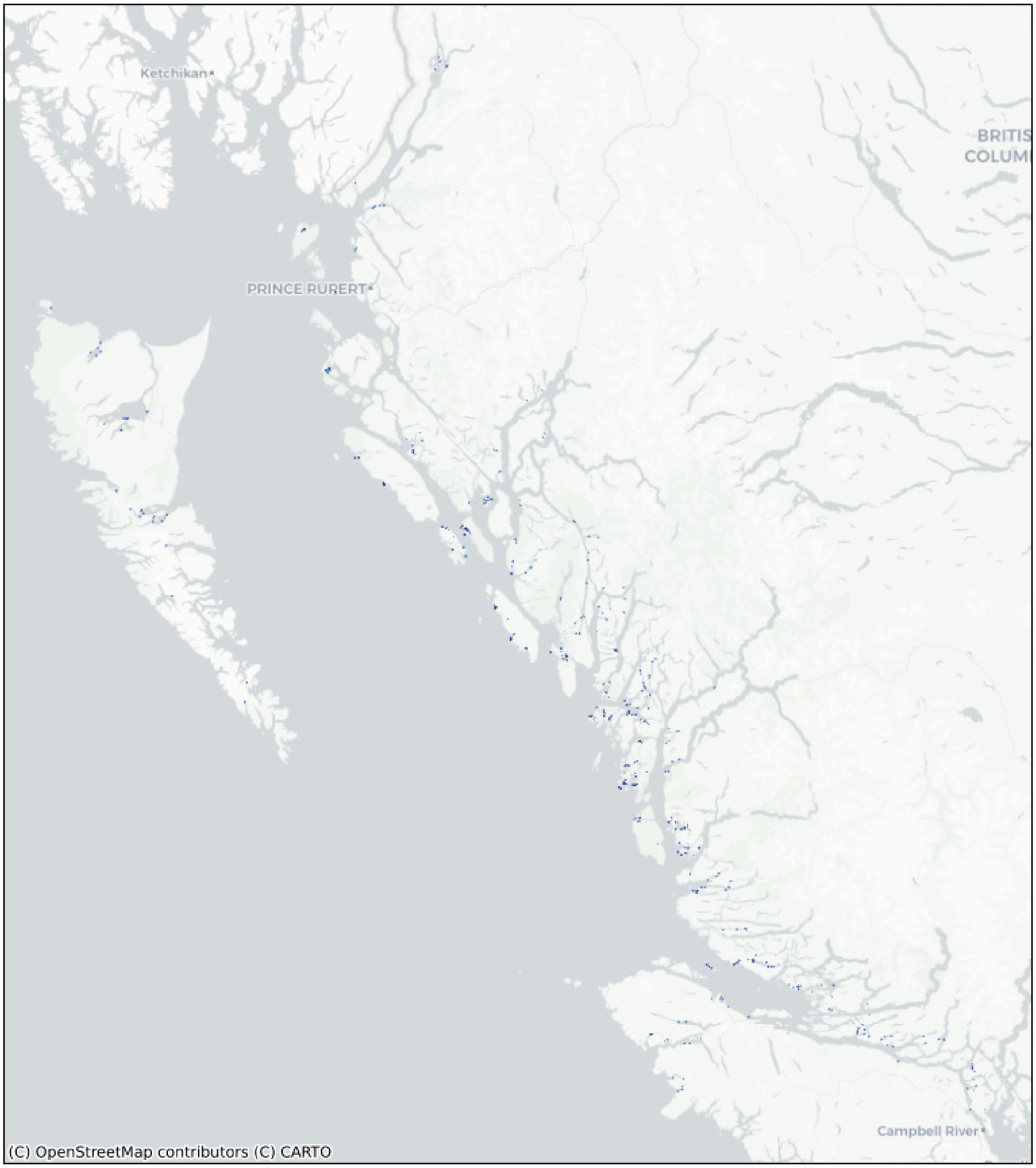

Figure 113: Presence-only records of Butter Clam, collated from a variety of research and commercial sources.

Figure 114: Presence-only records of Horse Clam, collated from a variety of research and commercial sources.

Figure 115: Presence-only records of Littleneck Clam, collated from a variety of research and commercial sources.

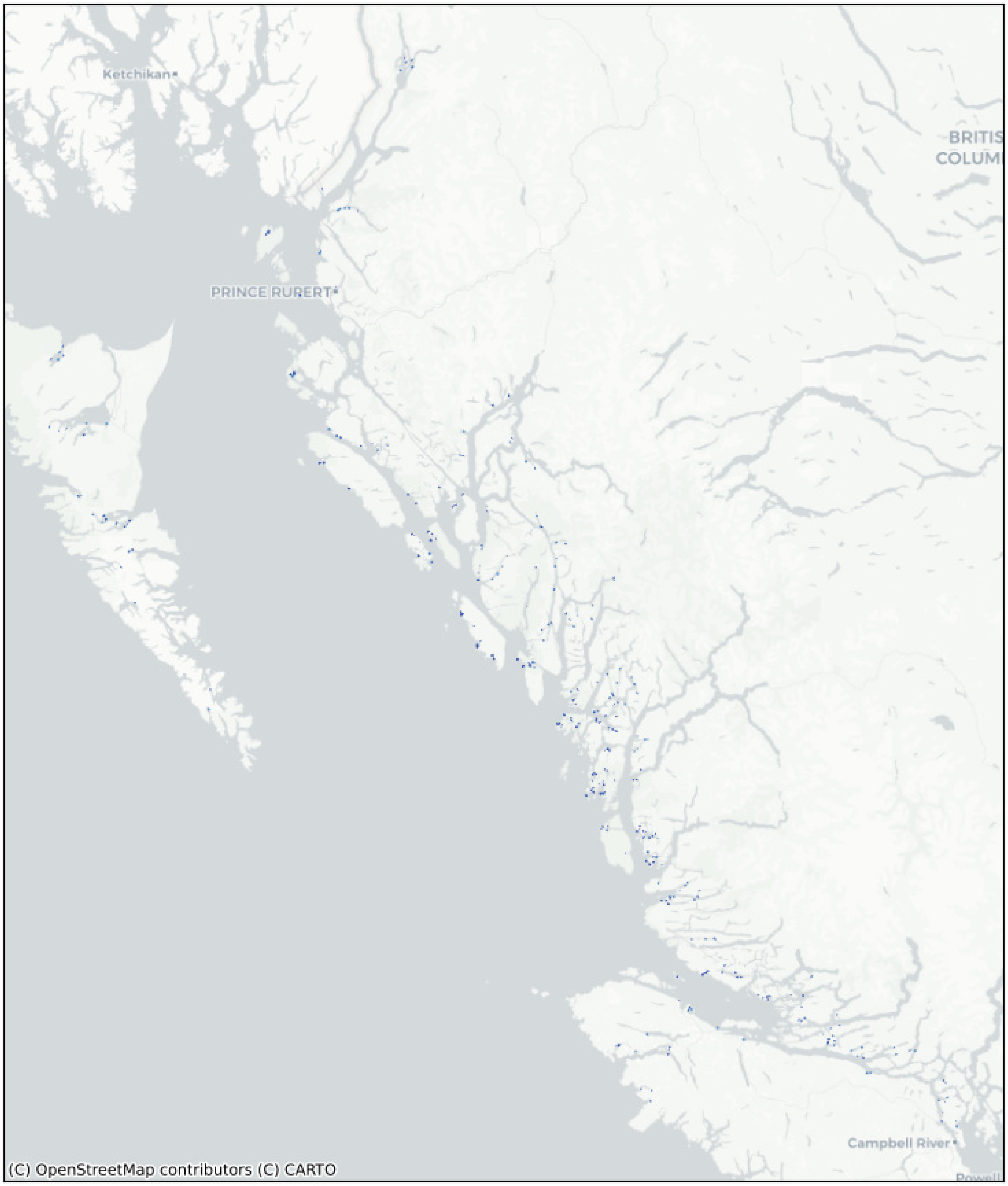

Figure 116: Presence-only records of Cockle, collated from a variety of research and commercial sources.

Figure 117: Presence-only records of Puget Sound King Crab, collated from a variety of research and commercial sources.

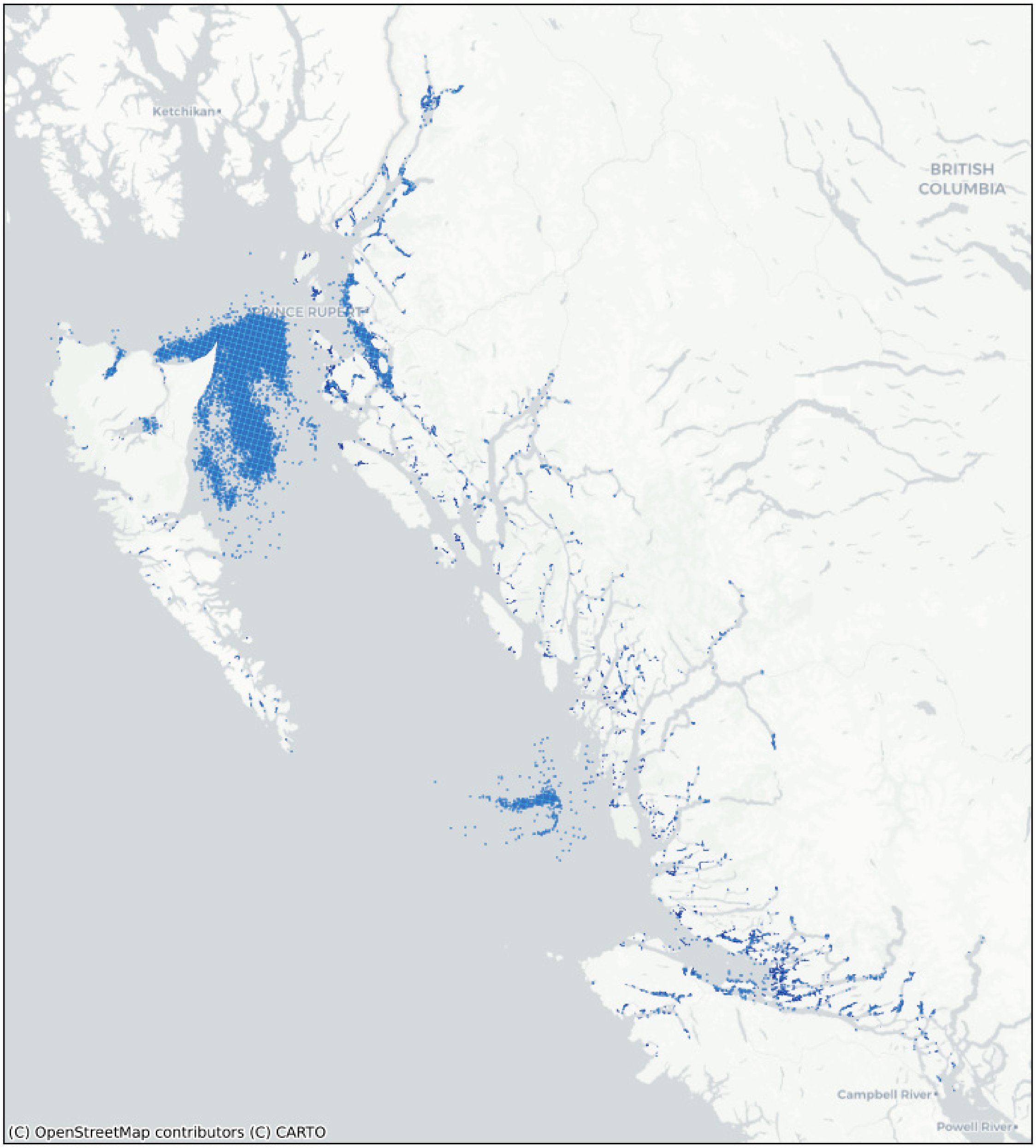

Figure 118: Presence-only records of Dungeness Crab, collated from a variety of research and commercial sources.

Figure 119: Presence-only records of Geoduck, collated from a variety of research and commercial sources.

Figure 120: Presence-only records of Giant Pacific Octopus, collated from a variety of research and commercial sources.

Figure 121: Presence-only records of Olympia Oyster, collated from a variety of research and commercial sources.

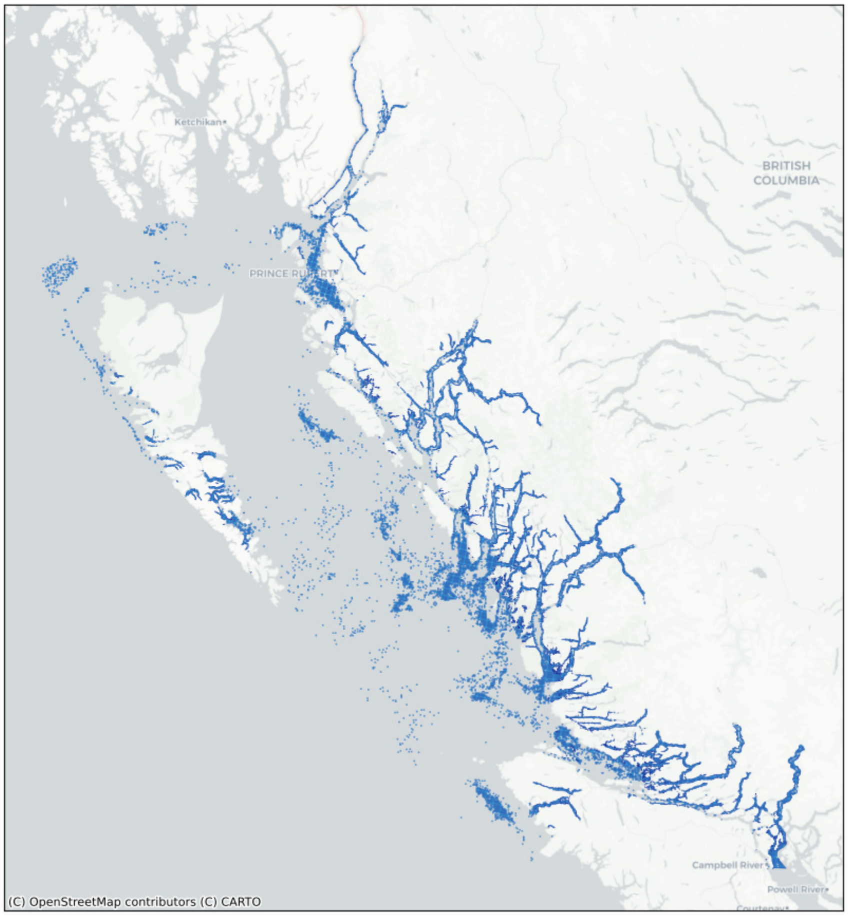

Figure 122: Presence-only records of Spot Prawn, collated from a variety of research and commercial sources.

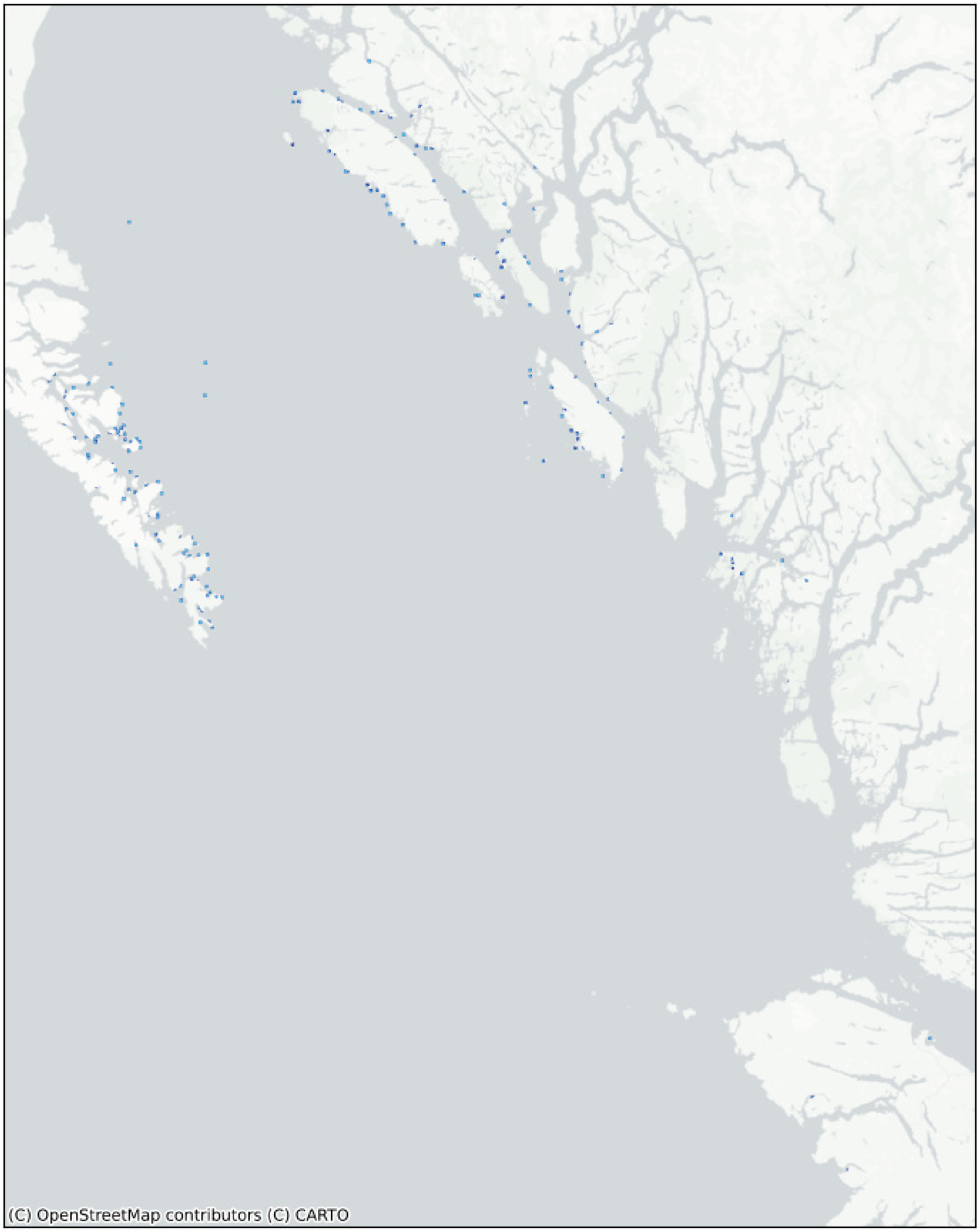

Figure 123: Presence-only records of Purple-hinged Rock Scallop, collated from a variety of research and commercial sources.

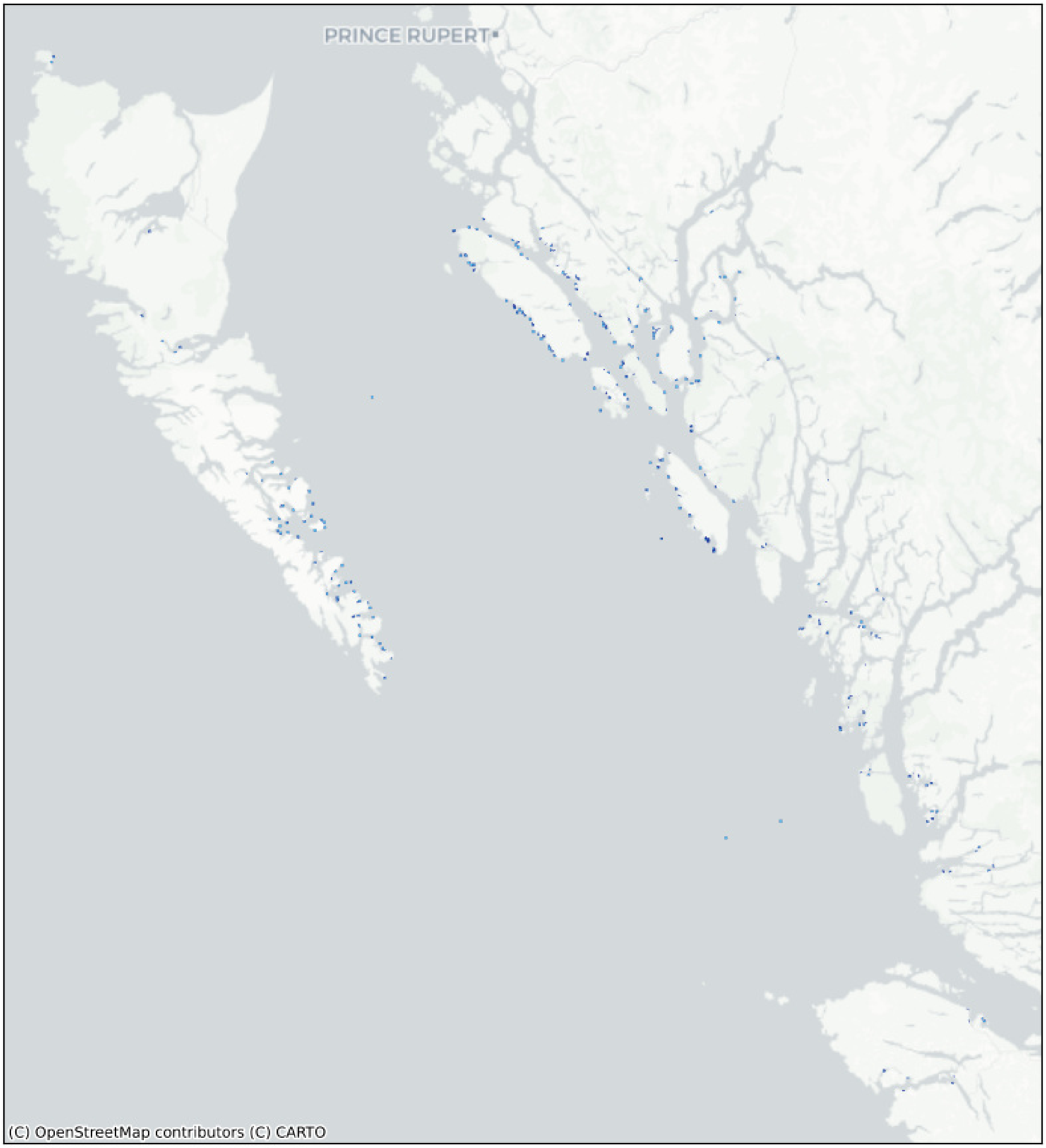

Figure 124: Presence-only records of Ochre Sea Star, collated from a variety of research and commercial sources.

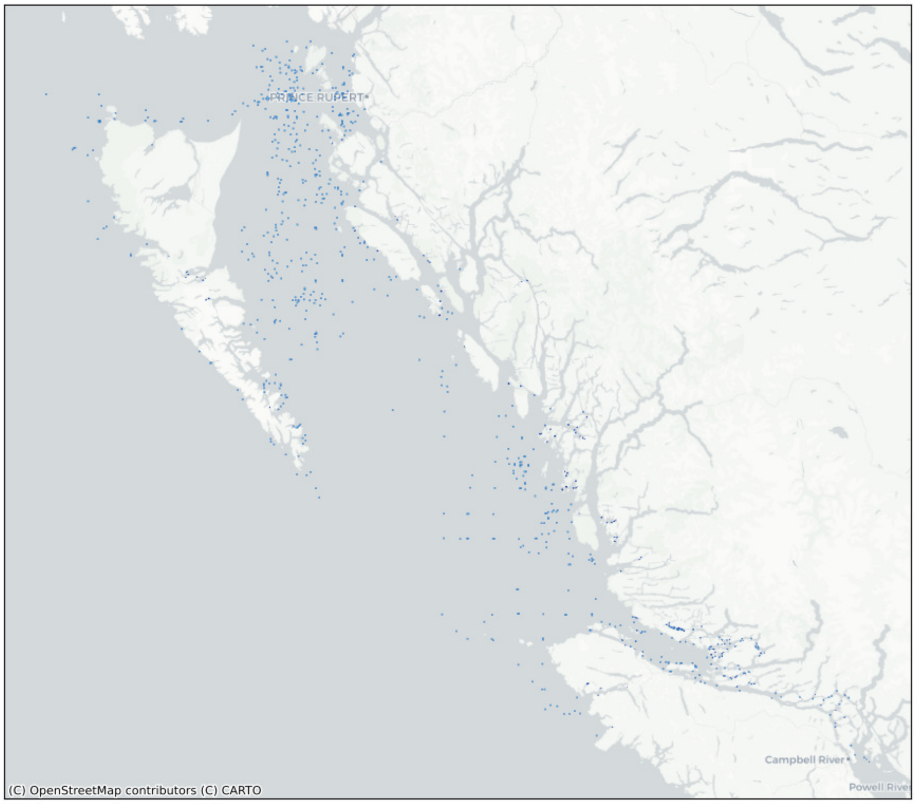

Figure 125: Presence-only records of Sunflower Sea Star, collated from a variety of research and commercial sources.

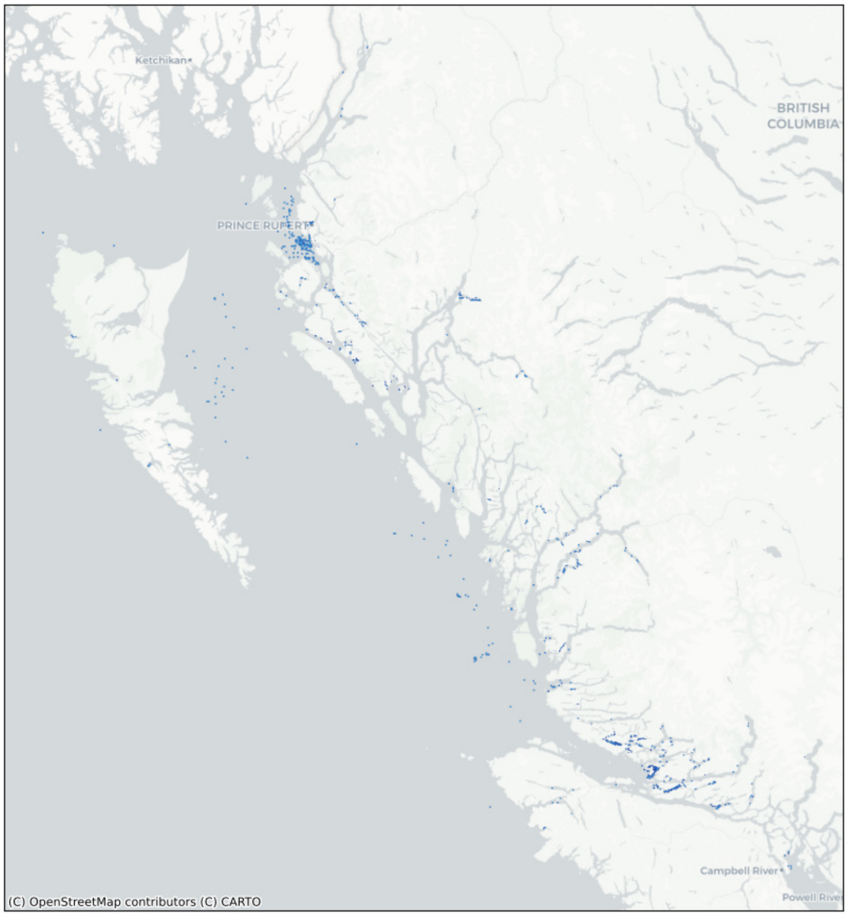

Figure 126: Presence-only records of Coonstripe/Dock Shrimp, collated from a variety of research and commercial sources.

Figure 127: Presence-only records of Humpback Shrimp, collated from a variety of research and commercial sources.

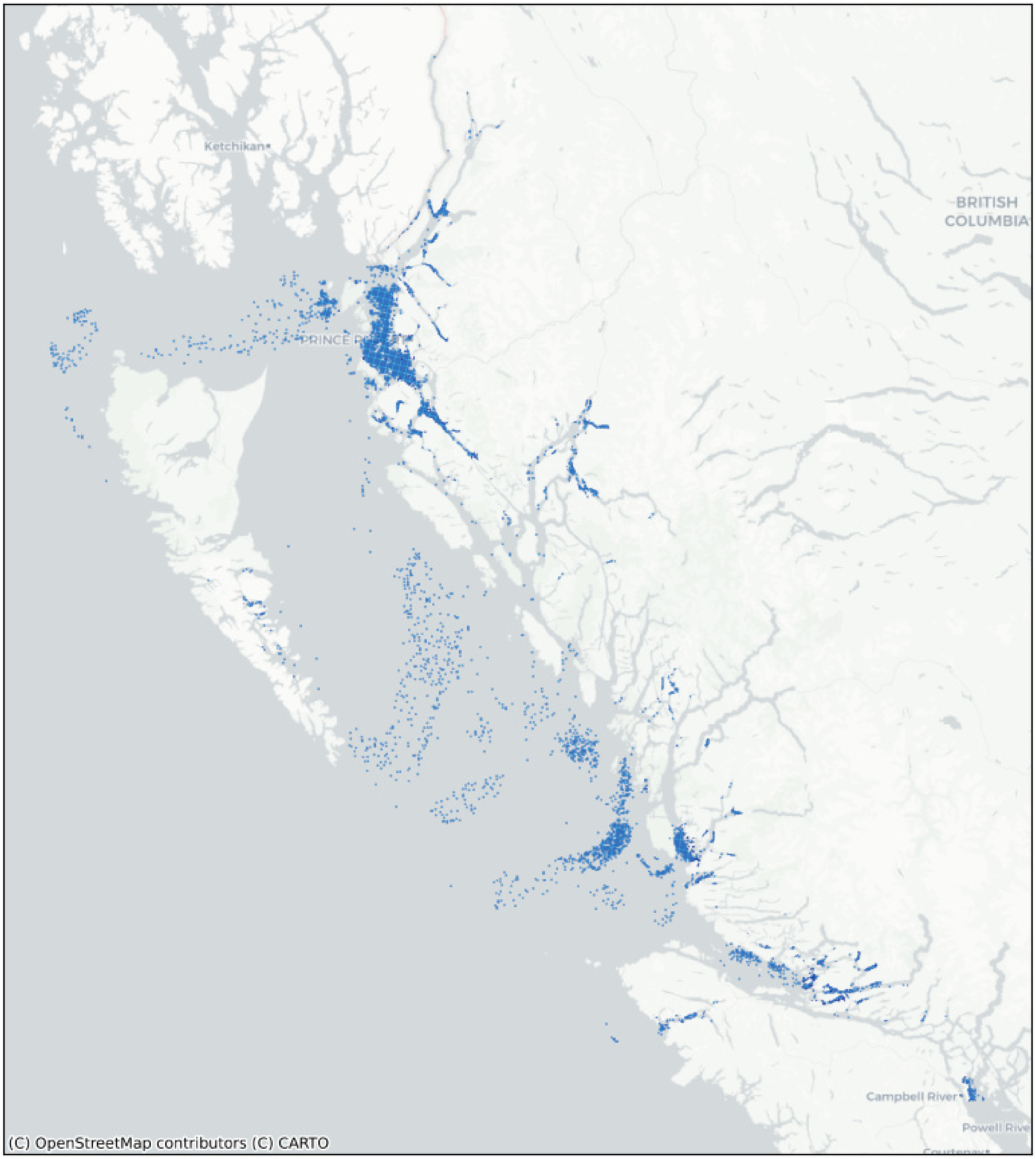

Figure 128: Presence-only records of Sidestripe Shrimp, collated from a variety of research and commercial sources.

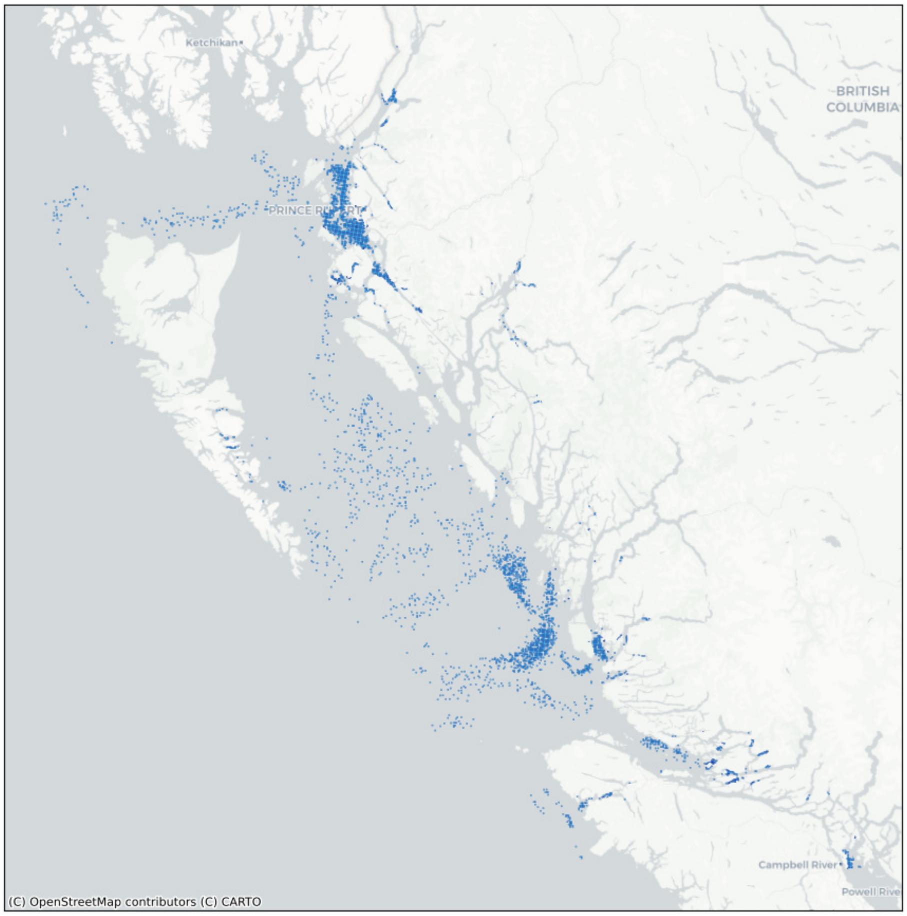

Figure 129: Presence-only records of Smooth Pink Shrimp, collated from a variety of research and commercial sources.

Figure 130: Presence-only records of Spiny Pink Shrimp, collated from a variety of research and commercial sources.

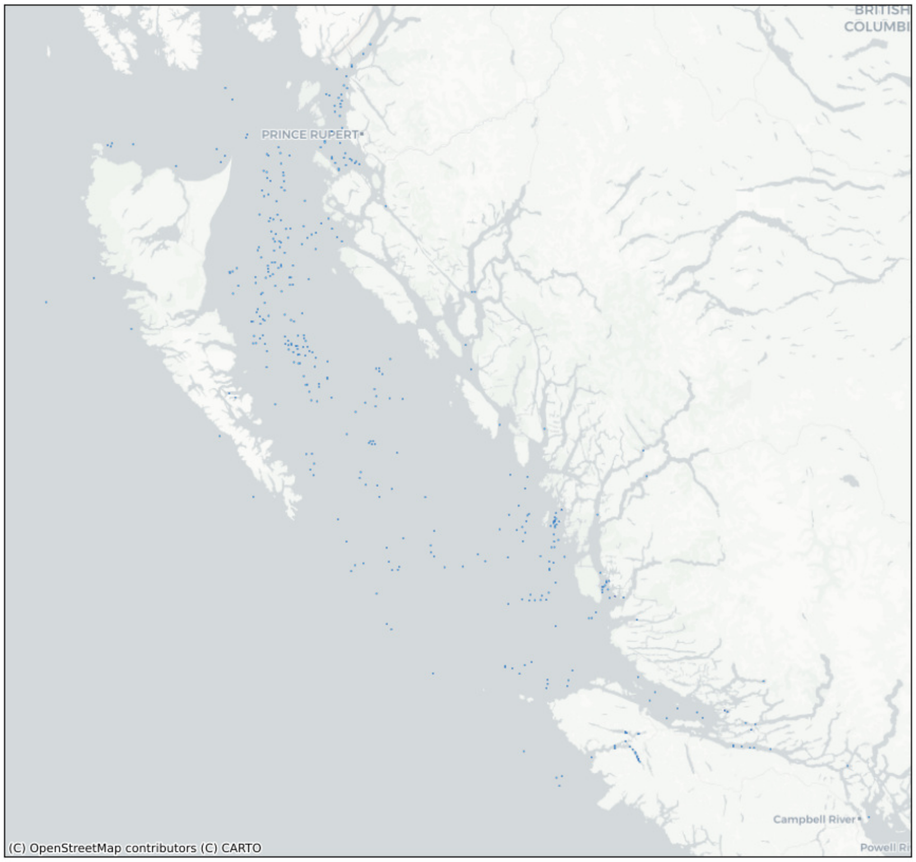

Figure 131: Presence-only records of Opal Squid, collated from a variety of research and commercial sources.

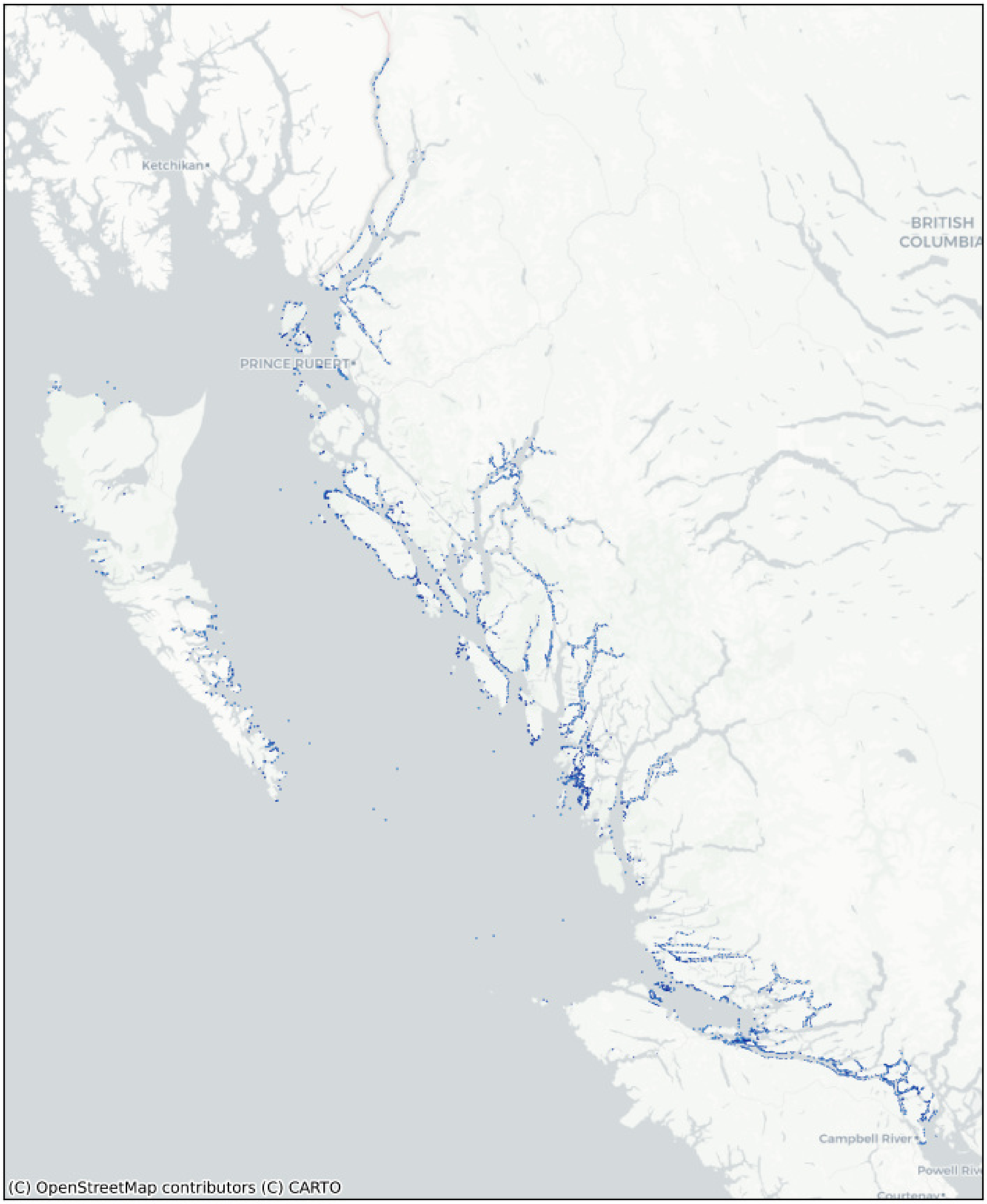

Figure 132: Presence-only records of Green Sea Urchin, collated from a variety of research and commercial sources.

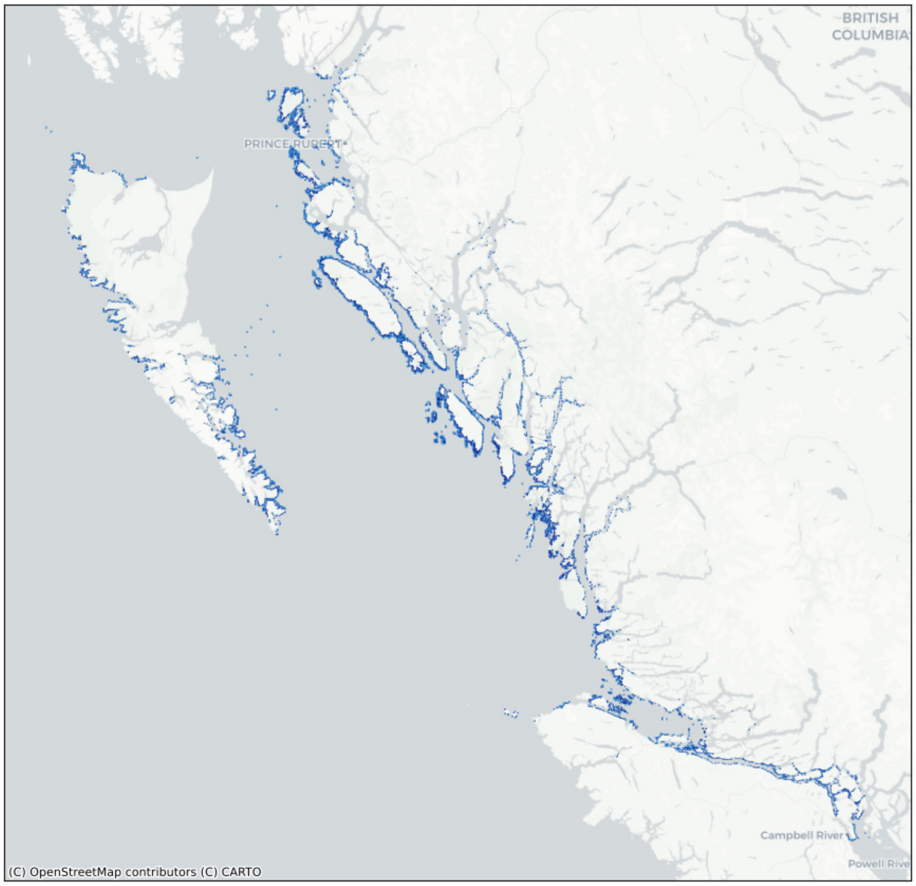

Figure 133: Presence-only records of Red Sea Urchin, collated from a variety of research and commercial sources.

NSB MPA Network Ecological Data - Other Fish Features

Summary:

There are 13 features in the 'Other Fish' geodatabase:

- (2) Eulachon Important Areas
- (1) Pacific Hake biomass index
- (1) Pacific Herring Important Areas
- (1) Pacific Herring Spawn Habitat Index
- (1) Pacific Salmon estuaries of importance (biomass)
- (6) Pacific Salmon estuaries of importance (diversity, 6 species)
- (1) Green Sturgeon Important Area

Data Creators and Co-creators: Creator: Katie Gale; Co-Creators: Cathryn Clarke (Important Areas), Jessica Nephin (Pacific Hake Biomass Index), Carrie Robb (Eulachon Important Areas - spawning, Pacific Herring Spawn Habitat Index, Pacific Salmon estuaries), MPATT Science Team

Methods and links to metadata:

Important Areas (IAs) for Eulachon (summer), Pacific Herring, and Green Sturgeon

- Eulachon summer IA
- Pacific Herring IA
- Green Sturgeon IA

EBSAs are areas of relatively higher ecological or biological significance than surrounding areas, where greater risk aversion is required in the management of activities (DFO, 2004). Within the EBSA boundary, perturbations are also expected to cause greater ecological consequences than in surrounding areas exposed to comparable perturbations.

Criteria to identify EBSAs have been established at the national (DFO, 2004) and international (Convention on Biological Diversity, 2008) levels. Areas that rank High for one or more of uniqueness, fitness consequences, or aggregation can be designated as an EBSA. A feature or area that ranks above average (Medium or High) across multiple criteria also meets the EBSA criteria.

EBSAs can be identified based on single features or species (e.g., spawning areas for a single species, or aggregations of single species), or multiple species or features (e.g., areas of high diversity, productivity, or overlap of many single-feature EBSAs). In the Pacific Region single-feature or taxon-specific EBSAs are referred to as "Important Areas" (IAs) (Clarke and Jamieson, 2006*a*; Levesque and Jamieson, 2015).

In the NSB, broad-scale IAs and EBSAs were identified in Clarke and Jamieson (2006*a*,*b*) and DFO (2013*a*). Species IAs were identified on the basis of species experts' knowledge on the biology of individual species, or groups of species, and the EBSAs were primarily identified on the basis of expert knowledge about physical and oceanographic features that also overlap with IAs for at least one species or species group.

Important Areas for Eulachon spawning

- Eulachon spawning IA

The suite of important areas for eulachon was updated in 2016 for the nearshore to include information on eulachon estuaries collated by the BCMCA. Estuary boundaries from the PECP (Ryder et al., 2007) were were classified into high and low importance for eulachon based on expert feedback from Doug Hay (DFO), Chantal Levesque (DFO) and John Kelson and the following reports: McCarter and Hay (2000, 1999); Moody (2008). Some estuaries are listed as "probable" based on the presence and size of larvae found in nearby waters during ichthyoplankton surveys and the nearby rivers that are suspected of being the source. There are different levels of certainty around those rivers, sometimes many larvae were found in the area (>100's) and sometimes only a few. These possible rivers could have different sized runs as well. Some rivers have been identified based on anecdotal reports; some have tributaries with known spawning, like the Skeena.

Pacific Hake biomass index

- Pacific Hake biomass index

Joint NOAA/DFO hydro-acoustic trawl surveys were conducted on a triennial to annual basis along the Pacific Coast of North America (Berger et al., 2017). The survey covers the summer extent of the migratory Pacific Hake stock from 34 to 58 degree latitude with parallel transects every 10 to 20 nautical miles (nmi) along the coast between 50 and 1,500 metres depth. Acoustic backscatter (38 kHz) representative of adult hake (age 2+) was converted to biomass with target strength equation TS = 20logL - 68, where L represents fork length in centimetres. Along transect biomass was calculated at 0.5 nautical mile resolution with units kilogram per square nautical mile. Biomass was then interpolated through Kriging on a 2.5 by 2.5 nautical mile grid. The interpolated biomass from each of the ten surveys completed between 1998 and 2015 were averaged to produce mean biomass of Pacific Hake. For more details on survey and data processing methodology, see Berger et al. (2017).

Pacific Herring Spawn Habitat Index

- Pacific Herring spawn habitat index

DFO has computed a cumulative spawn habitat index (SHI) to represent the combined, long-term frequency and magnitude of Pacific Herring spawns along each kilometre of coastline over time. Long-term cumulative spawn data covers 1928 to 2016. The index is calculated by the sum of the product of each measured length of spawn (metres along the shoreline) and the median of the product of spawn width and egg layers adjusted by percent cover and pooled geographically.

The data for all of BC were clipped to the NSB planning area, and the categories (vital, major, high, medium, low, minor) were designated by calculating the relevant percentiles on the Spawn Habitat Index value. For MPA network analyses (e.g., Marxan), the SHI values were used directly.

Pacific Salmon estuaries of importance - biomass and diversity

- Estuaries of Importance for Pacific Salmon

Data from the DFO NuSEDS escapement database (v 2.0; DFO, 2018) and DFO Conservation Units for salmon species (Holtby and Ciruna, 2007) were used to assess the biomass and diversity of mapped estuaries available from the PECP (Ryder et al., 2007) and Riparian Fish Forest (Broadhead, 2009) estuary databases.

To determine salmon biomass for each estuary, the average maximum escapement for each salmon population (1990-present) was summed by population for the principle drainages and coastal rivers in the Freshwater Atlas stream network. For each estuary, biomass was then calculated as the average escapement, by species, of the population originating from all feeder streams, multiplied by the average weight for the species (J. Irvine, personal communication). The total biomass was obtained by summing the species-specific values.

Genetic diversity was assessed separately for each species by summing the number of overlapping Conservation Units within each estuary. If a Conservation Unit overlapped multiple estuaries, the diversity value was divided by the number of estuaries overlapping the same Conservation Unit. Diversity values were retained only for the estuaries that had recorded species presence in any year in the NuSEDS escapement database.

Temporal Coverage:
1928-01-01 to 2018-12-31

Scripts/Software:
n/a

Data Sources:

- **Important Areas for Eulachon (summer), Pacific Herring, and Green Sturgeon**: From Clarke and Jamieson (2006*a*). Available directly at https://www.gis-hub.ca/dataset/ia-fish-pncima.
- **Important Areas for Eulachon spawning**: Important Areas from Clarke and Jamieson (2006*a*) were updated with estuary boundaries from the PECP (Ryder et al., 2007) as well as new expert and literature information.
- **Pacific Hake biomass index**: Joint NOAA/DFO acoustic surveys (Berger et al., 2017).
- **Pacific Herring Spawn Habitat Index**: Spawn Habitat Index data available at http://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagic-pelagique/herring-hareng/herspawn/kilometr-eng.html.
- **Pacific Salmon estuaries of importance (biomass and diversity)**: DFO NuSEDS escapement database, DFO conservation units, PECP estuaries, and Riparian Fish Forest estuaries.

Absence Data:
Important Areas: No absence data.

Pacific Hake Biomass Index: No data is shown in unsurveyed areas.

Pacific Herring Spawn Habitat Index: Zero 'Avg_SpawnHabit' values indicate a site was surveyed and no spawn was found. However, not all sites are surveyed every year, and given this is a long-term database (1928-2016) some sites may not have been surveyed for quite some time. Zero values indicate that no spawn has been recorded at a site, not that spawning has never or could never occur there.

Pacific Salmon estuaries of importance: Zero 'biomass_allSpecies' values indicate that no escapement of any species has been recorded for that estuary. The six diversity features represent each individual salmon species, and only estuaries where that species occurs are shown.

Uncertainties:

Each feature has uncertainties based on its input data and processing steps. Notable uncertainties are described in each feature's individual metadata.

Species Data:

- THALEICHTHYS PACIFICUS (EULACHON)
- MERLUCCIUS PRODUCTUS (PACIFIC HAKE)
- CLUPEA PALLASII (PACIFIC HERRING)
- ONCORHYNCHUS TSHAWYTSCHA (CHINOOK SALMON)
- ONCORHYNCHUS KETA (CHUM SALMON)
- ONCORHYNCHUS KISUTCH (COHO SALMON)
- ONCORHYNCHUS GORBUSCHA (PINK SALMON)
- ONCORHYNCHUS NERKA (SOCKEYE SALMON)
- ACIPENSER MEDIROSTRIS (GREEN STURGEON)

Maps of available datasets:

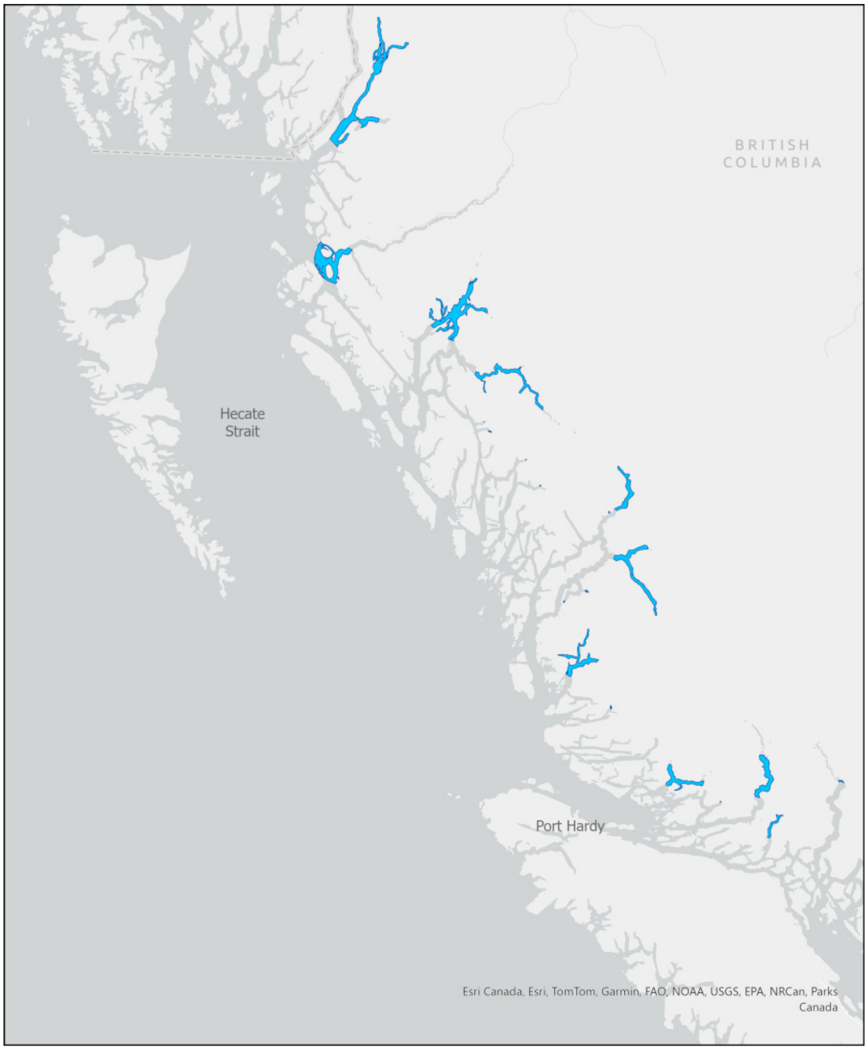

Figure 134: "Important Areas" for Eulachon spawning, identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*) and updated using information from PECP estuaries (Ryder et al., 2007) and from McCarter and Hay (1999, 2000); Moody (2008).

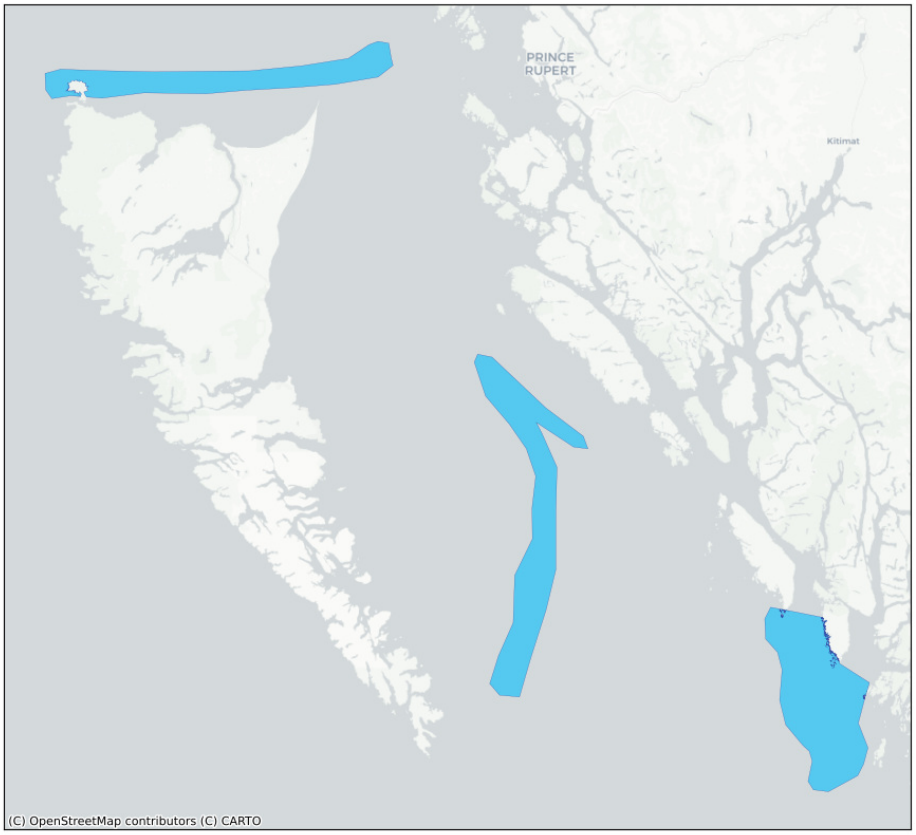

Figure 135: "Important Areas" for Eulachon during the summer, identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

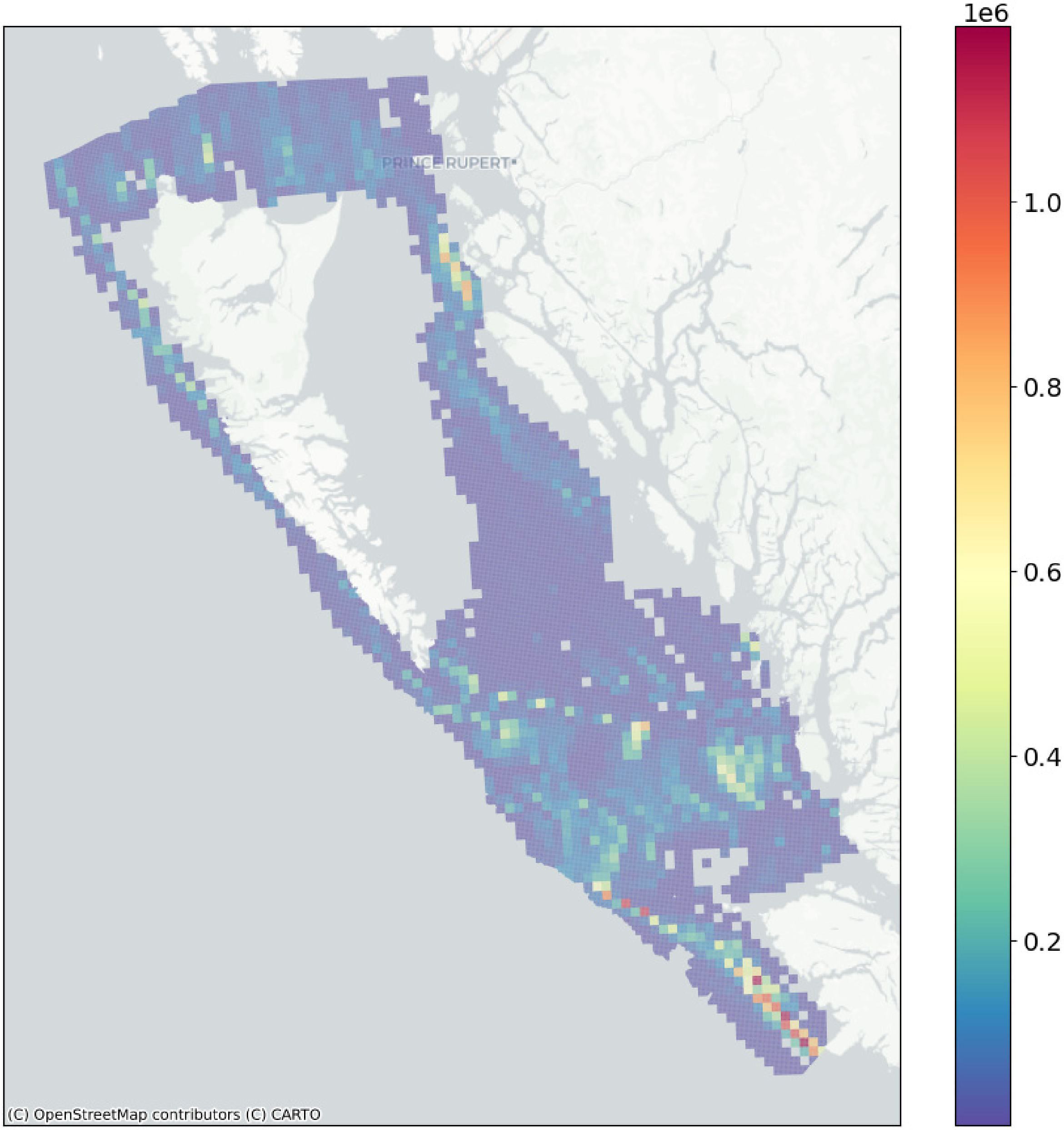

Figure 136: Mean biomass of Pacific Hake (Berger et al., 2017) during their summer feeding migration within the Northern Shelf Bioregion.

Figure 137: Pacific Herring "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

Figure 138: Point locations of Herring Spawn areas within the Northern Shelf Bioregion, ranked by magnitude and frequency of spawning. The "Spawn Habitat Index" value for original points were aggregated and averaged within 1 km planning units.

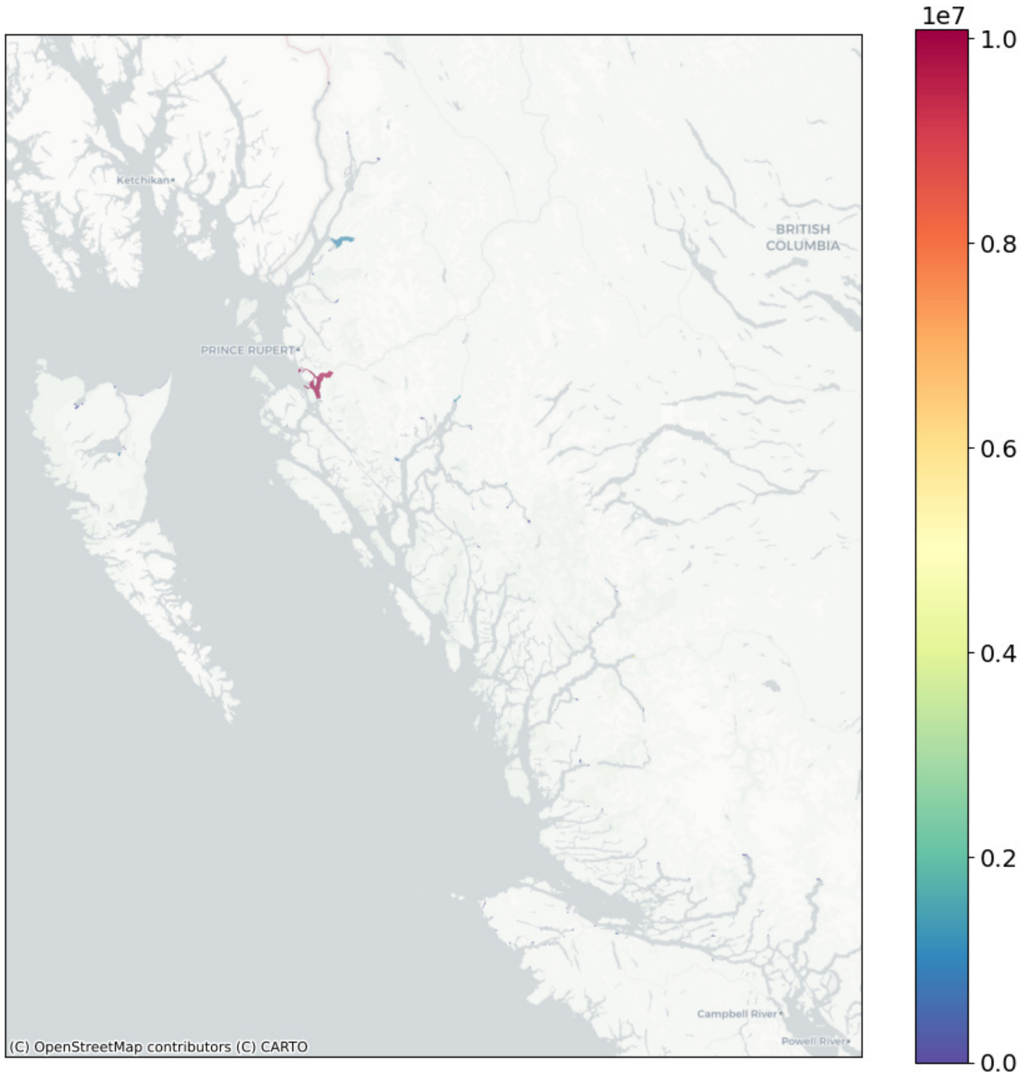

Figure 139: Estuaries ranked for importance for Pacific salmon biomass (Chinook, Chum, Coho, Pink, Sockeye Salmon).

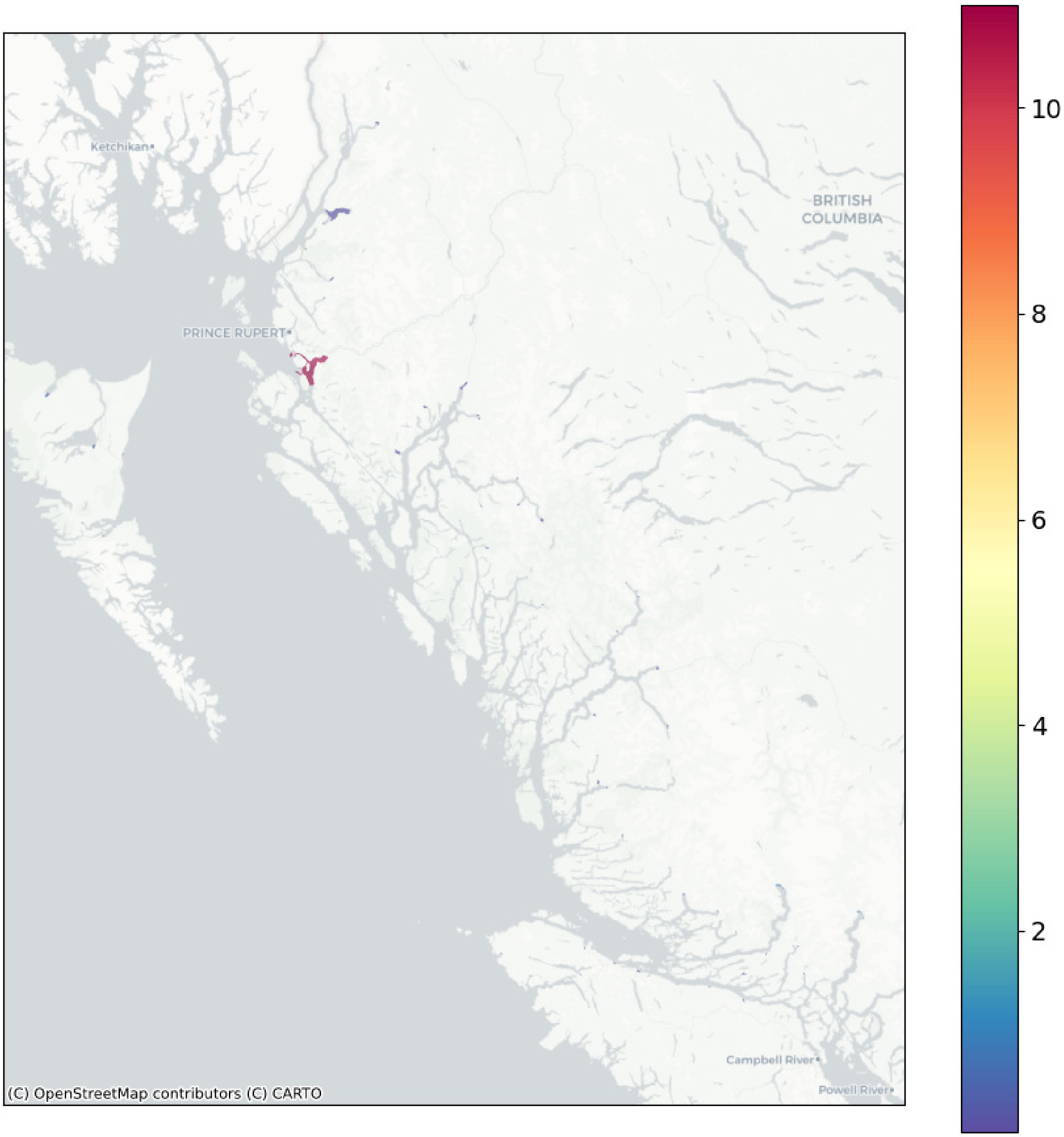

Figure 140: Estuaries ranked for importance for Chinook Salmon diversity.

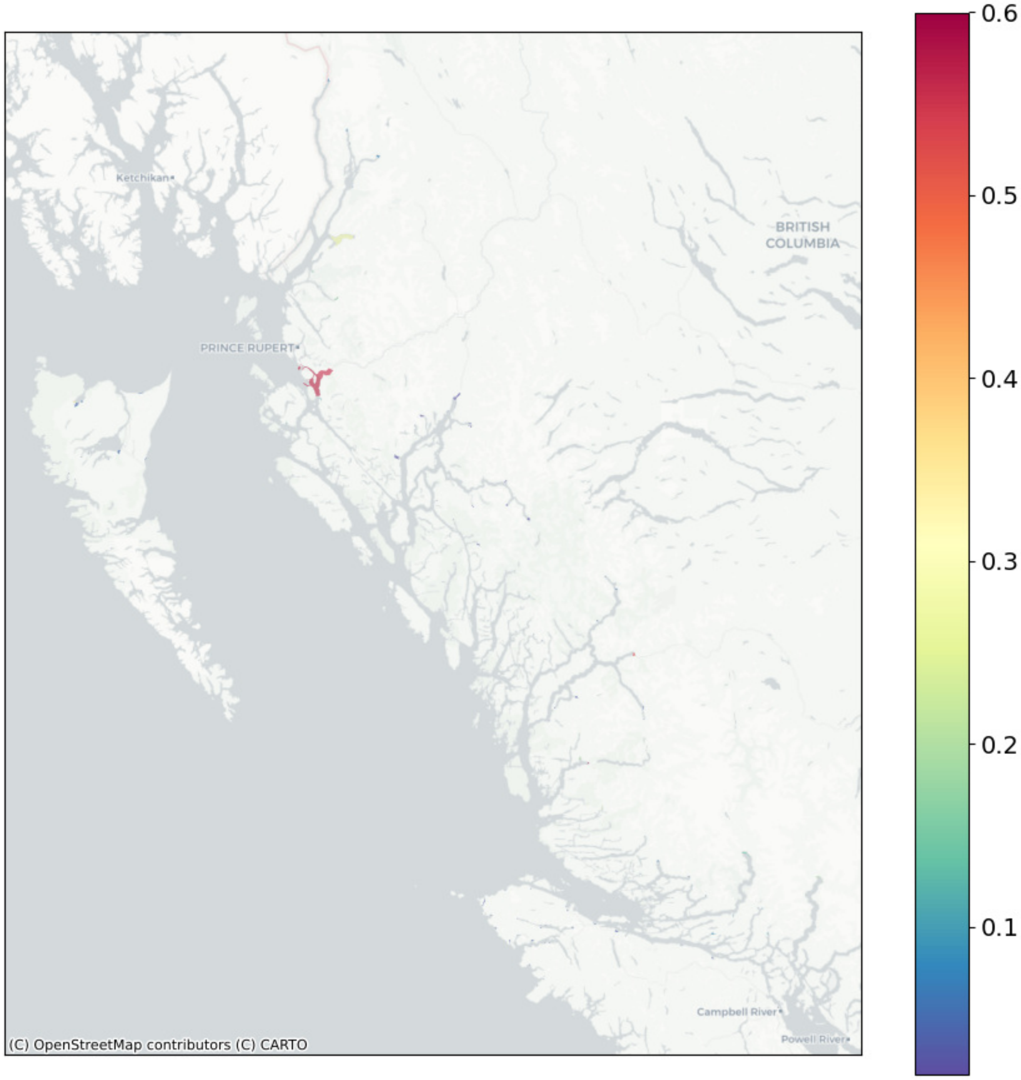

Figure 141: Estuaries ranked for importance for Chum Salmon diversity.

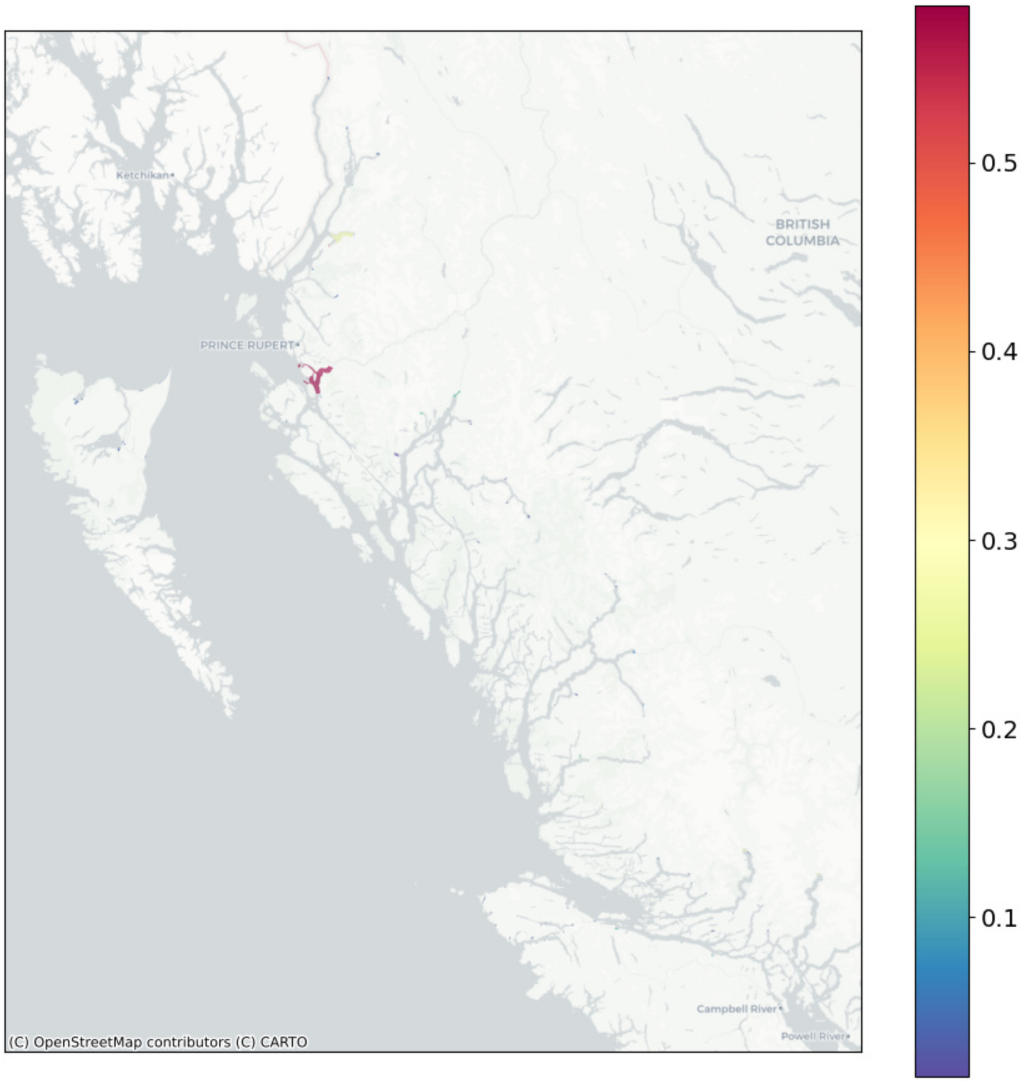

Figure 142: Estuaries ranked for importance for Coho Salmon diversity.

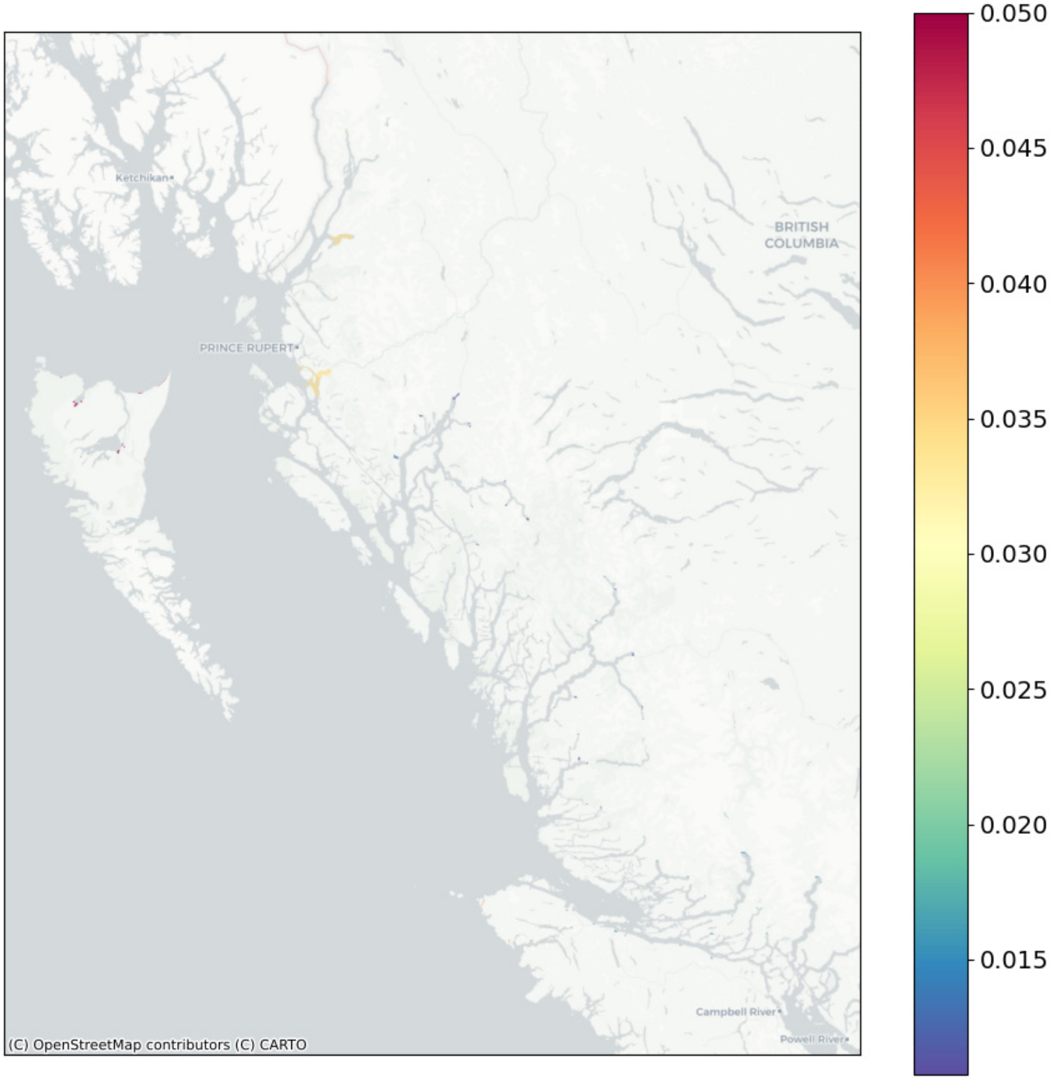

Figure 143: Estuaries ranked for importance for Pink Salmon diversity (even years).

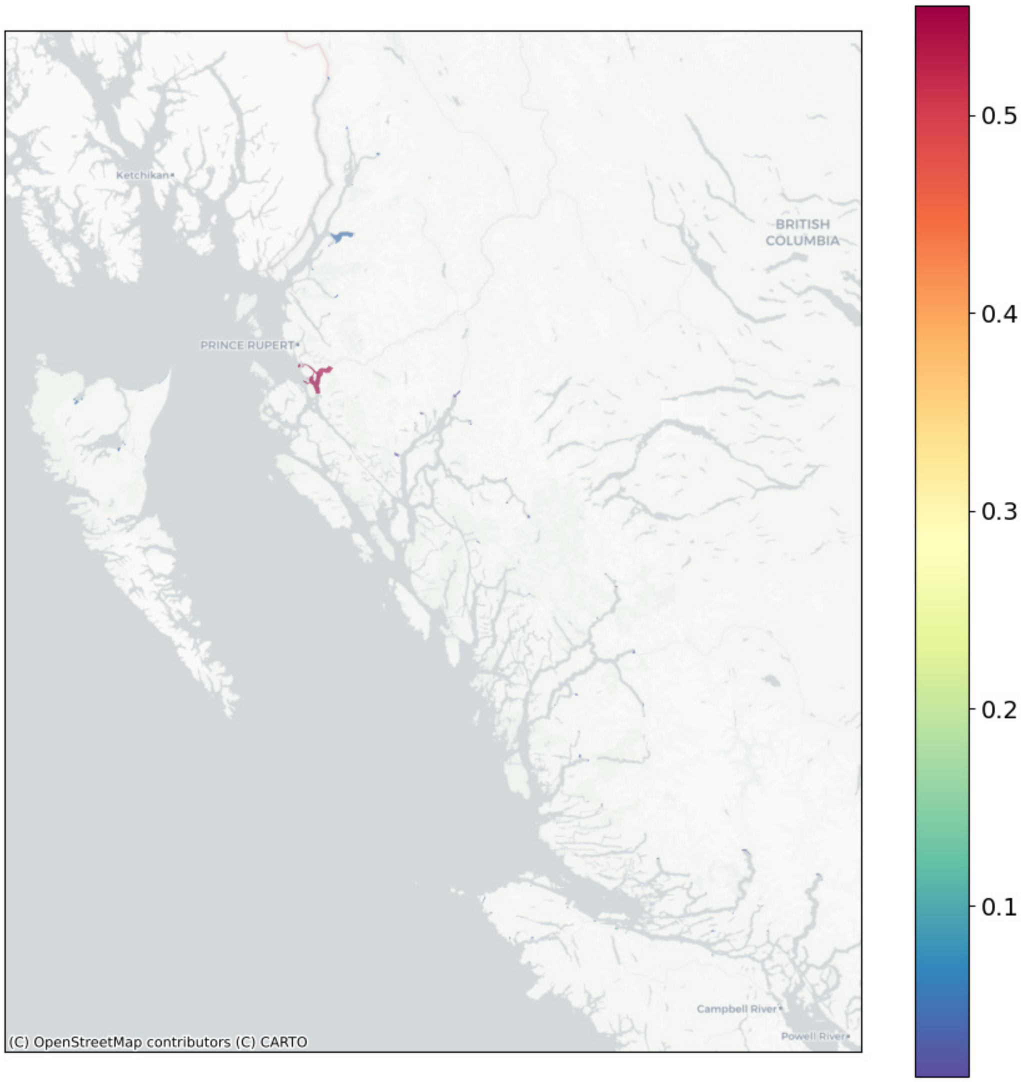

Figure 144: Estuaries ranked for importance for Pink Salmon diversity (odd years).

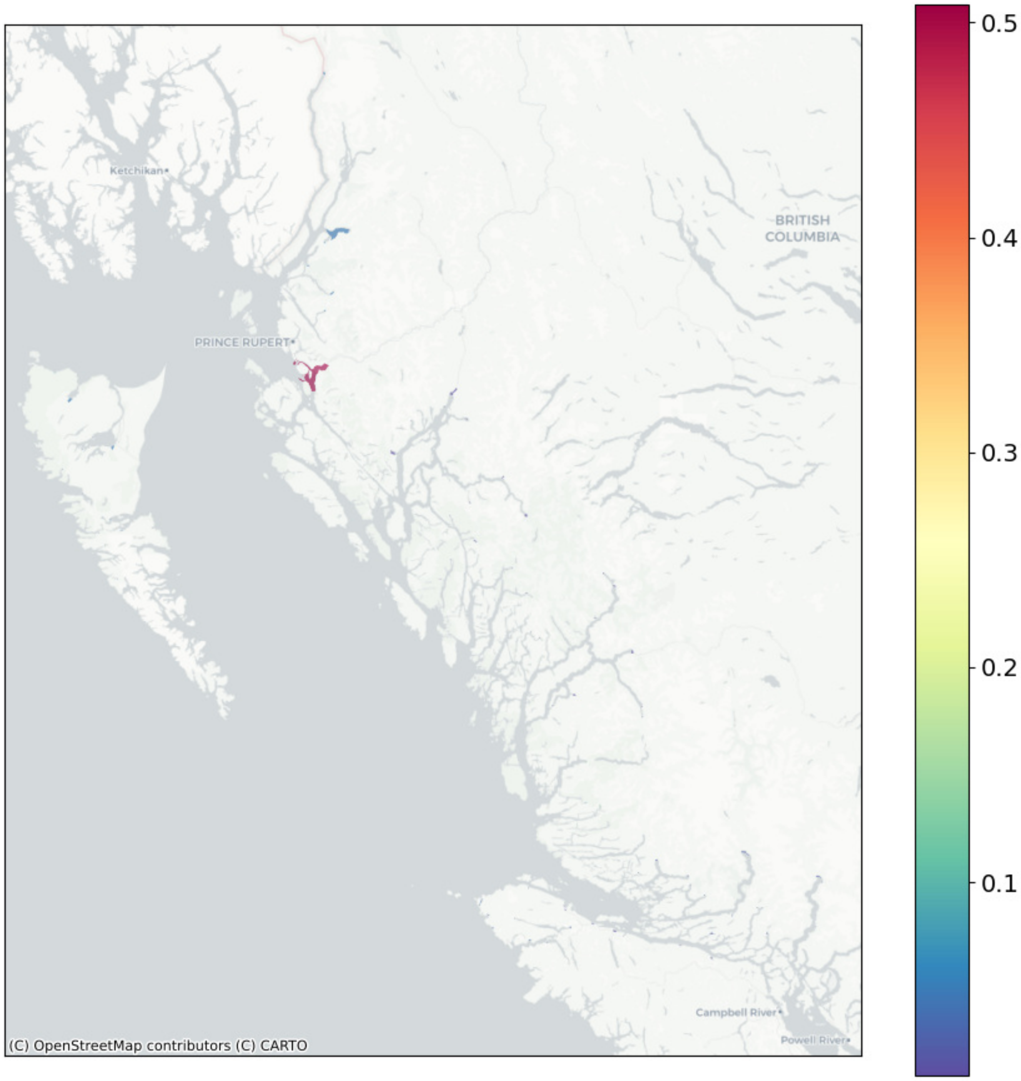

Figure 145: Estuaries ranked for importance for Sockeye Salmon diversity.

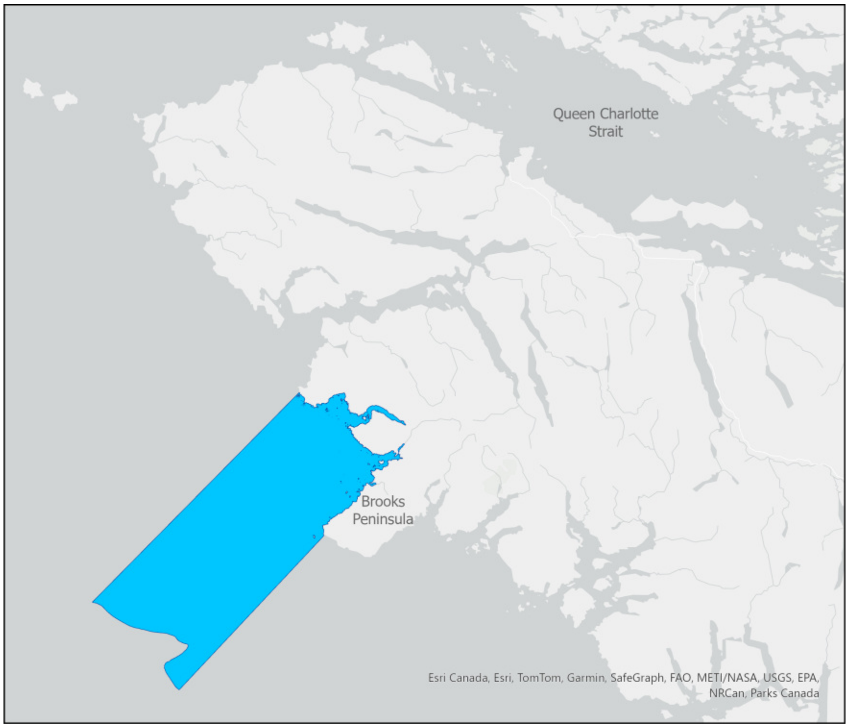

Figure 146: Green Sturgeon "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

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NSB MPA Network Ecological Data - Other Invertebrate Features

Summary:

There are 7 features in the 'Other Invertebrates' geodatabase:

- (4) Coral species distribution models
- (1) Razor Clam Important Area
- (1) Dungeness Crab Important Area
- (1) Sponge Reef distribution based on geological signature

Data Creators and Co-creators: Creator: Katie Gale; Co-Creators: Jessica Finney (coral species distribution models), Cathryn Clarke (Important Areas), Natural Resources Canada (sponge reef), MPATT Science Team

Methods and links to metadata:

Coral species distribution models

- Alcyonacea
- Antipatharia
- Pennatulacea
- Scleractinia

Records of species presence used for the predictive modelling were originally obtained as part of research surveys, other scientific studies, and from bycatch in commercial fisheries that were sent to museums and identified by experts.

These layers represent predicted habitat suitability for soft corals (Alcyonacea), black corals (Antipatharia), sea pens (Pennatulacea), and stony corals (Scleractinia) resulting from a Maxent model. Full methods can be found in Finney (2010).

Important Areas (IAs) for Dungeness Crab and Razor Clam

- Dungeness Crab IA
- Razor Clam IA

EBSAs are areas of relatively higher ecological or biological significance than surrounding areas, where greater risk aversion is required in the management of activities (DFO, 2004). Within the EBSA boundary, perturbations are also expected to cause greater ecological consequences than in surrounding areas exposed to comparable perturbations.

Criteria to identify EBSAs have been established at the national (DFO, 2004) and international (Convention on Biological Diversity, 2008) levels. Areas that rank High for one or more of uniqueness, fitness consequences, or aggregation can be designated as an EBSA. A feature or area that ranks above average (Medium or High) across multiple criteria also meets the EBSA criteria.

EBSAs can be identified based on single features or species (e.g., spawning areas for a single species, or aggregations of single species), or multiple species or features (e.g., areas of high diversity, productivity, or overlap of many single-feature EBSAs). In the Pacific Region single-feature or taxon-specific EBSAs are referred to as "Important Areas" (IAs) (Clarke and Jamieson, 2006*a*; Levesque and Jamieson, 2015).

In the NSB, broad-scale IAs and EBSAs were identified in Clarke and Jamieson (2006*a*,*b*) and DFO (2013*a*). Species IAs were identified on the basis of species experts' knowledge on the biology of individual species, or groups of species, and the EBSAs were primarily identified on the basis of expert knowledge about physical and oceanographic features that also overlap with IAs for at least one species or species group.

The Razor Clam IA was used as received, but based on feedback from subject matter experts only the Hecate Strait portion of the IA for Dungeness Crab was used (the Prince Rupert Harbour portion of the IA was excluded).

Sponge reef distribution based on geological signature

- Sponge reef distribution

Sponge reefs were originally mapped using multibeam imagery collected using a Simrad EM1002 multibeam swath bathymetry system mounted on the CCGS Vector between 2000 and 2002. The GIS coverage was created using ArcInfo software at the Pacific Geoscience Centre in March, 2005. The presence of sponge reefs was confirmed in most cases by use of remote operated vehicles, sampling or underway acoustic methods such as high resolution seismic on several scientific surveys between 2002 and 2005. Several of these reef locations are described in detail in (Conway et al., 2005).

Additional multibeam surveying and groundtruthing has taken place since these the original reef locations were described. For MPA Network planning in the NSB, polygons representing areas with known sponge reef geological signatures up to 2010 were obtained from NRCan in early 2017. Additional polygons were added for reef signatures recently identified in Chatham Sound (Shaw et al., 2018), and for a reef observed with video by the CCIRA in Dundavin Inlet near Seaforth Channel.

Polygons were buffered by 1 km to indicate the importance of sedimentation risk to sponges from nearby activities. However, the buffer size needed will vary greatly based on the area of live sponge on the reef, the substrate type surrounding the live sponge, and the currents (Tompkins-MacDonald and Leys, 2008; Boutillier et al., 2013; Leys, 2013).

This version of the sponge reef data, excluding Dundavin Reef, matches that presented in Rubidge et al. (2018). This is the version useed in all MPA Network analysis and analytics.

The version of the sponge reef data presented on Seasketch as of 2020 is not buffered, and includes additional polygons in Pearse Canal (outside the MPA Network planning area) and Goletas Channel. It can be downloaded from the Government of Canada Open Data portal.

Temporal Coverage:
1882-01-01 to 2018-12-31

Scripts/Software:
n/a

Data Sources:

- **Coral species distribution models**: From Finney (2010)
- **Dungeness Crab and Razor Clam Important Areas**: From Clarke and Jamieson (2006*a*). Available directly at https://www.gis-hub.ca/dataset/ia-invert-pncima.
- **Sponge Reef distribution based on geological signature**: Feature obtained from Natural Resources Canada.

Absence Data:
Coral species distribution models: Areas outside the model footprint do not indicate absence of the species.

Important Areas: No absence data.

Sponge reefs: No absence data.

Uncertainties: Coral species distribution models: The models do not cover many inshore/coastal areas.

Sponge reefs: The sponge reef geological signature represented in this dataset may not represent or reflect the distribution of live or dense sponge. In situ video surveys are required to determine the extent and density of live, reef-forming sponge within areas identified as having sub-surface structure using multibeam imagery (e.g., DFO, 2020*b*)
Species Data:

- METACARCINUS MAGISTER (DUNGENESS CRAB)
- SILIQUA PATULA (PACIFIC RAZOR)
- PENNATULACEA (ORDER) (SEA PENS)
- ALCYONACEA (ORDER) (SOFT CORALS)
- ANTIPATHARIA (ORD) (BLACK CORALS, THORNY CORALS)
- SCLERACTINIA (ORDER) (STONY CORALS)
- HEXACTINELLIDA (CLASS) (GLASS SPONGES)

Maps of available datasets:

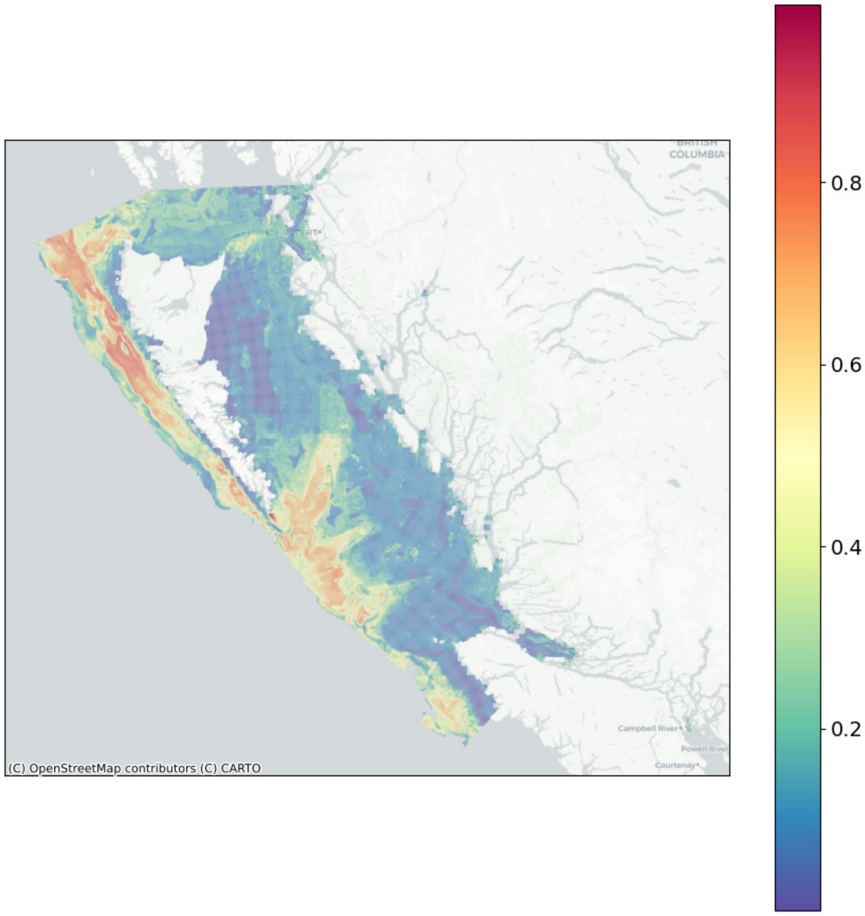

Figure 147: Predicted habitat suitability for soft corals (Alyconacea) from Finney (2010).

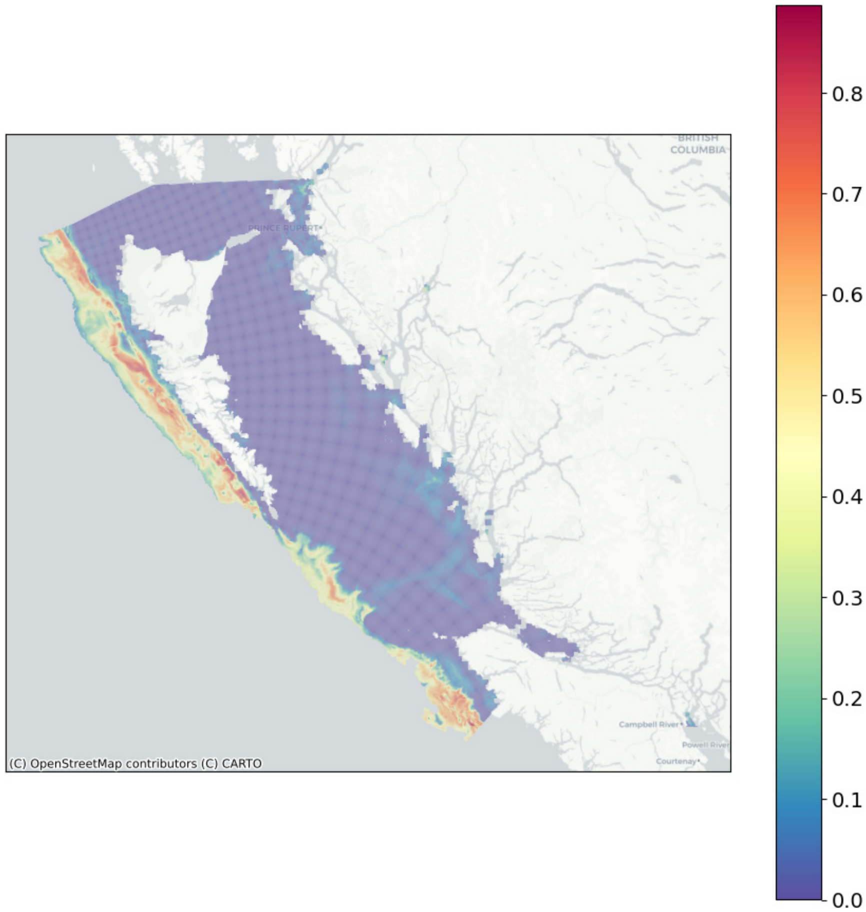

Figure 148: Predicted habitat suitability for black corals (Antipatharia) from Finney (2010).

Figure 149: Razor clam "Important Area" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

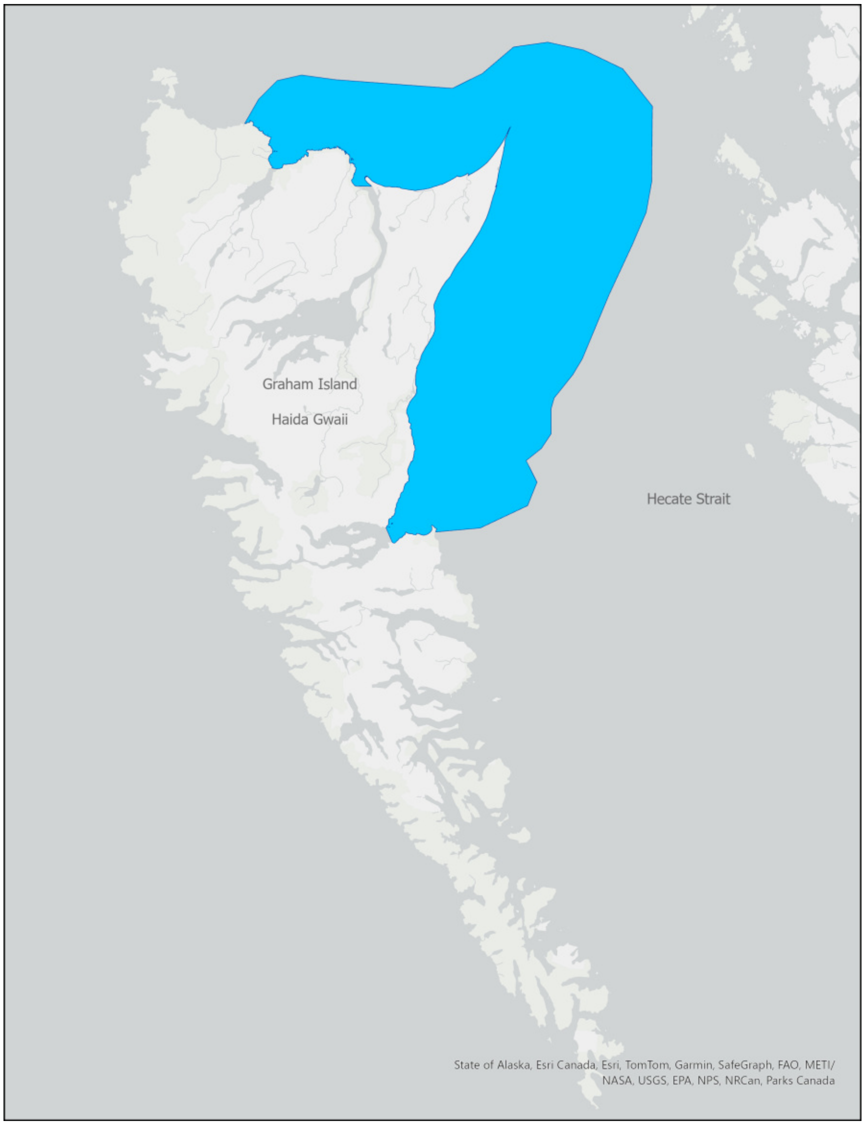

Figure 150: Dungeness crab "Important Area" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

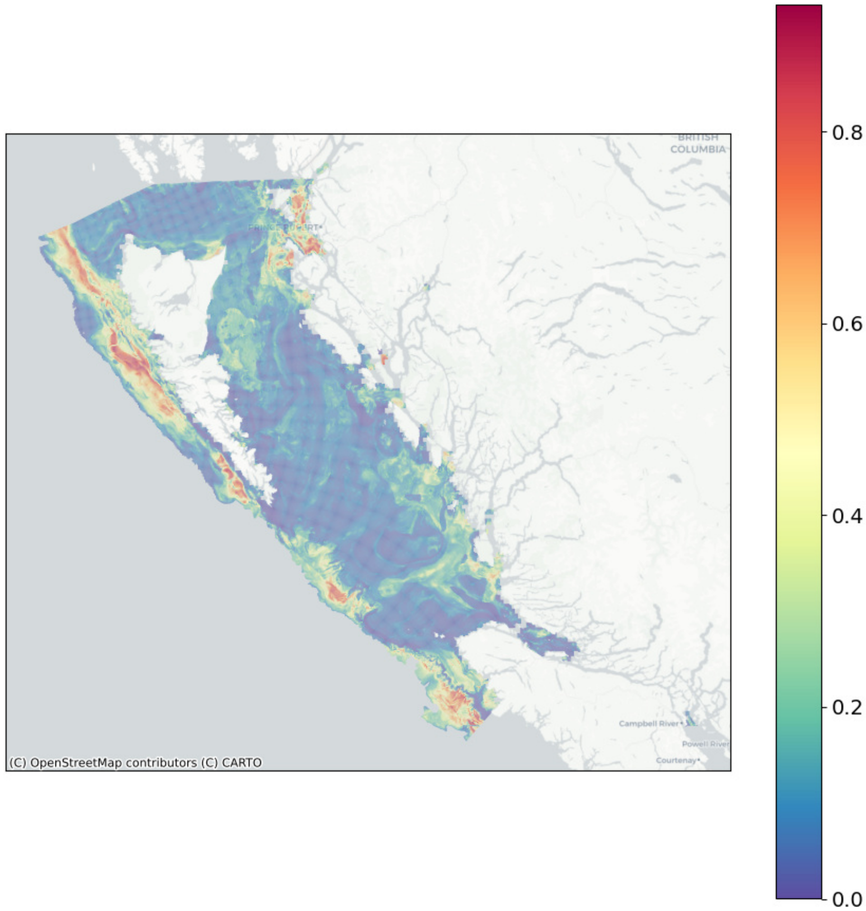

Figure 151: Predicted habitat suitability for sea pens (Pennatulacea) from Finney (2010).

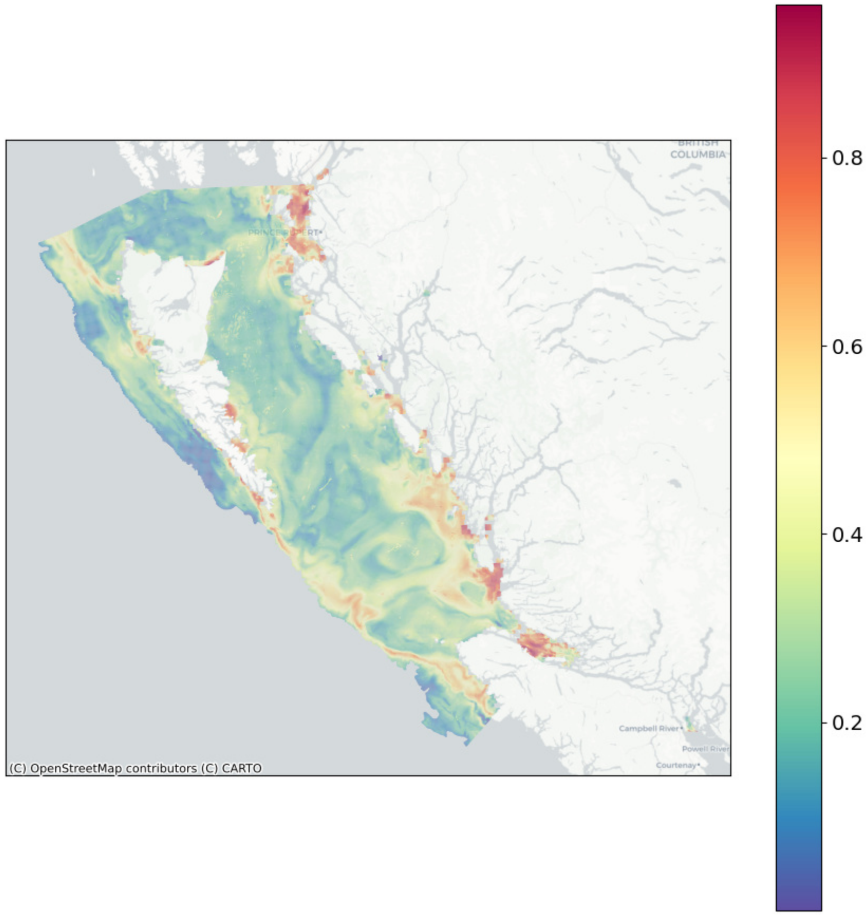

Figure 152: Predicted habitat suitability for stony corals (Scleractinia) from Finney (2010).

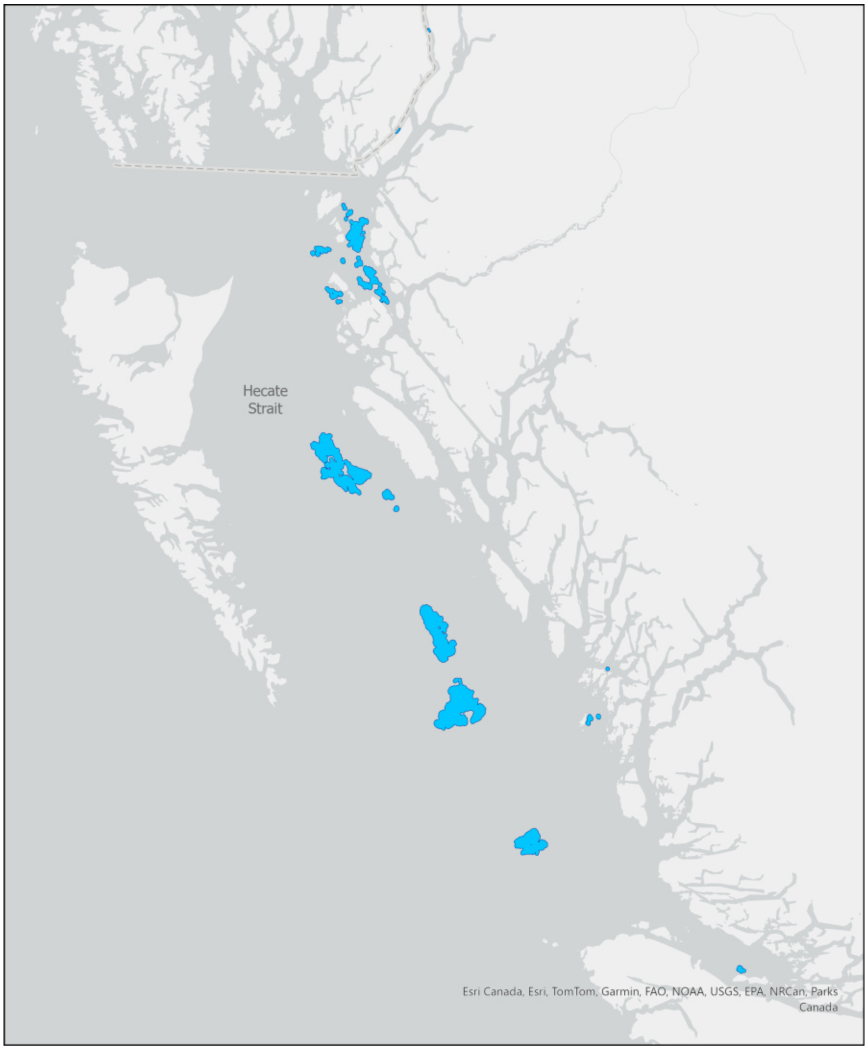

Figure 153: Sponge reef distribution based on geological signature

Mammals and Reptiles

NSB MPA Network Ecological Data - Mammal Density Features

Summary:

There are 9 features in the 'Mammal Density' geodatabase:

- Dall's Porpoise density
- Fin Whale density
- Grey Whale density
- Harbour Porpoise density
- Minke Whale density
- Northern Right Whale density
- Pacific White-sided Dolphin density
- Sperm Whale density

Data Creators and Co-creators: Creator: Jessica Nephin; Co-Creators: Katie Gale, MPATT Science Team

Methods and links to metadata:

- **Data sources**:

Density estimates were derived from DFO and Raincoast Conservation Foundation surveys, as well as those housed in the North Pacific Pelagic Seabird Database (NPPSD). Estimated densities were extracted directly from the Raincoast and NPPSD datasets.

Fisheries and Oceans Canada Dataset:

DFO sightings from 48 surveys carried out from 2002 to 2017 were converted to number of individuals by species per km^2 by dividing the number of individuals observed by the area sampled using a 5×5 km grid. The sampled area was estimated by buffering the transect line by the sampling width (the estimated visible range from the vessel), which was estimated for each vessel based on the elevation of the observation deck above the waterline, the prevailing weather conditions by vessel and weather condition. The total area sampled was calculated by summing the sample area within each 25 km^2 grid cell from all surveys. For the version of this data used in MPA Network planning in the NSB, no threshold for a minimum number of surveys per grid cell was applied.

North Pacific Pelagic Seabird Dataset:

The NPPSD 2.0 contains observations of marine birds and mammals within the North Pacific (Drew et al., 2015). The database is a collection of survey data from a number of different sources collated by the U.S. Geological Survey (USGS). We extracted 2,435 records of the cetacean species of interest from the database from surveys between 1975 and 2012. Density estimates (number of individuals per km^2) were provided. For this dataset, density estimates were derived by dividing the number of individuals sighted by the area sampled, which was calculated by multiplying the transect length (1 km segments) by the sampling width. The data is available from USGS.

Raincoast Conservation Foundation Dataset:

The Raincoast dataset (Harvey et al., 2018) provided statistical estimates of species density calculated using distance sampling methods. Distance sampling uses the sightings obtained on line transect surveys as a sample in a detection function to estimate the number of animals missed by the observers as a function of distance from the transect line (Buckland et al., 2001). These density estimates (estimated abundance of individuals per km^2 at every nautical mile along transect) were calculated using a Multiple Covariate Distance Sampling method from surveys carried out from 2004 to 2008 (Best et al., 2015). This method differs from the simple uncorrected sightings per unit effort method used to process DFO and NPPSD data because the Raincoast densities values include statistically derived estimates of the true abundance of animals (those sighted as well as those present but missed by the observer).

- **Combining and transforming data**:

Combining datasets (field ‘densNorm’, displayed on Seasketch)

The three cetacean density datasets were normalized by dividing by the maximum value in each dataset before they were combined. The resulting density index ranged from 0 to 1. Normalizing the data removes differences in the absolute magnitude of density values among the datasets that may have resulted from different survey and data processing methods. The normalized density estimates from the three cetacean datasets were overlaid onto a 5×5 km polygon grid and averaged together within each grid cell by species. The large grid size (5×5 km) was recommended by DFO marine mammal experts to account for the highly mobile nature of marine mammals (R. Abernethy and L. Nichol, pers. comm.). We retained no detection (“absence”) values from the Raincoast and DFO dataset, but not from the NPPSD dataset where cetacean observations were only opportunistically recorded.

Transforming density data (field ‘densTransf’, used in Marxan and other MPA Network analyses)

The normalized mammal density values ranged from 0-1, but were skewed towards 0. This was constraining the prioritized planning units in Marxan, since the few high values were a much more valuable/efficient solution. To unskew the distribution of values, the normalized density values were transformed: ln(n)+abs(min(ln(n)))+1. I.e., to get densTrans for each species:

- Calculate quantiles (20th percentiles) of densNorm, excluding zeros
- Calculate ln(densNorm)
- Identify the minimum ln(densNorm), and add it to each ln(densNorm)+1

Temporal Coverage:
1975-01-01 to 2017-12-31

Scripts/Software:
n/a

Spatial Data Quality: The grid cell boundaries on these maps appear as distinct lines, but in reality they should be displayed as fuzzy lines to represent the fact that mammal densities do not change abruptly from one grid cell to another. To avoid misinterpretation of these data, grid cell boundaries should not be interpreted literally.

Data Sources:

- DFO, Raincoast Conservation Foundation, and the North Pacific Pelagic Seabird Database (NPPSD)

Absence Data:

Zero values indicate that the species was not observed in the surveys used as input data. Areas outside the data footprint were not surveyed.

Uncertainties:
The DFO surveys were carried out from large ships for the primary purpose of surveying humpback, fin whales, and killer whales. Although effort was made to maintain systematic survey coverage and all cetacean species encountered were recorded using standard line-transect survey methods, systematic coverage was not always the case because of additional research efforts underway that emphasized photo-identification techniques to estimate abundance of certain species. This necessitated the need to maximize the number of different individuals photographed and thus areas of expected aggregations were often emphasized during surveys. Therefore, the coverage is not consistent over the range and thus may not represent the distribution of all species presented here.

The survey data used to build this map represents snapshots of distribution at times in the recent past (see date range of each dataset). Many of these cetacean species are recovering from prior exploitation, thus their distribution can be expected to change over time. Further, these species feed on mobile prey and changes in ocean conditions can and do influence distribution. Therefore their distribution may reasonably be expected to change in the future and as such the utility of these maps may decrease over time. Ideally, for emergency response planning such as assessing oil spill risk these maps should be updated every 5 years.

The grid cell boundaries on these maps appear as distinct lines, but in reality they should be displayed as fuzzy lines to represent the fact that mammal densities do not change abruptly from one grid cell to another. To avoid misinterpretation of these data, grid cell boundaries should not be interpreted literally.

Finally it is important for users to note that cells with 'NULL' values areas where there has been little or no survey effort. These are not areas of little importance, but rather represent a knowledge gap.

Species Data:

- PHOCOENOIDES DALLI (DALL PORPOISE)
- BALAENOPTERA PHYSALUS (FIN OR FIN-BACKED WHALE)
- ESCHRICHTIUS ROBUSTUS (GREY WHALE)
- PHOCOENA PHOCOENA (HARBOUR PORPOISE)
- MEGAPTERA NOVAEANGLIAE (HUMPBACK OR HUMP-BACKED WHALE)
- LISSODELPHIS BOREALIS (NORTHERN RIGHT-WHALE DOLPHIN)
- LAGENORHYNCHUS OBLIQUIDENS (PACIFIC WHITE-SIDED DOLPHIN)
- PHYSETER MACROCEPHALUS (SPERM WHALE)

Maps of available datasets:

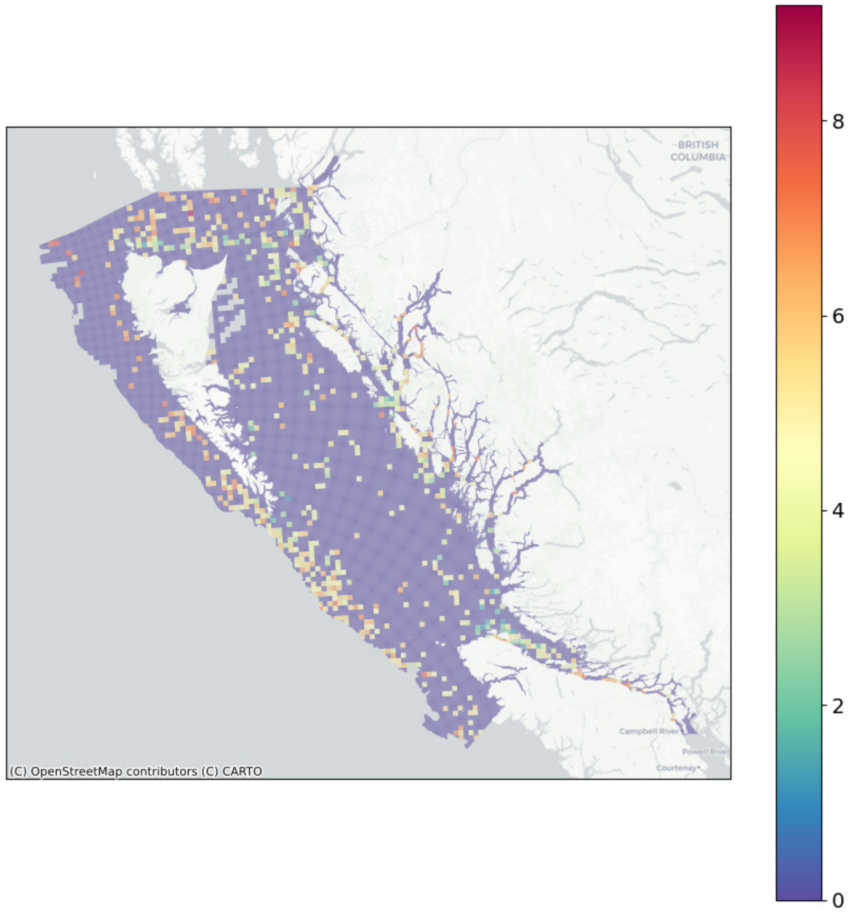

Figure 154: Effort-corrected density of Dall's Porpoise derived from surveys conducted by DFO, Raincoast Conservation Foundation, and those in the North Pacific Pelagic Seabird Database.

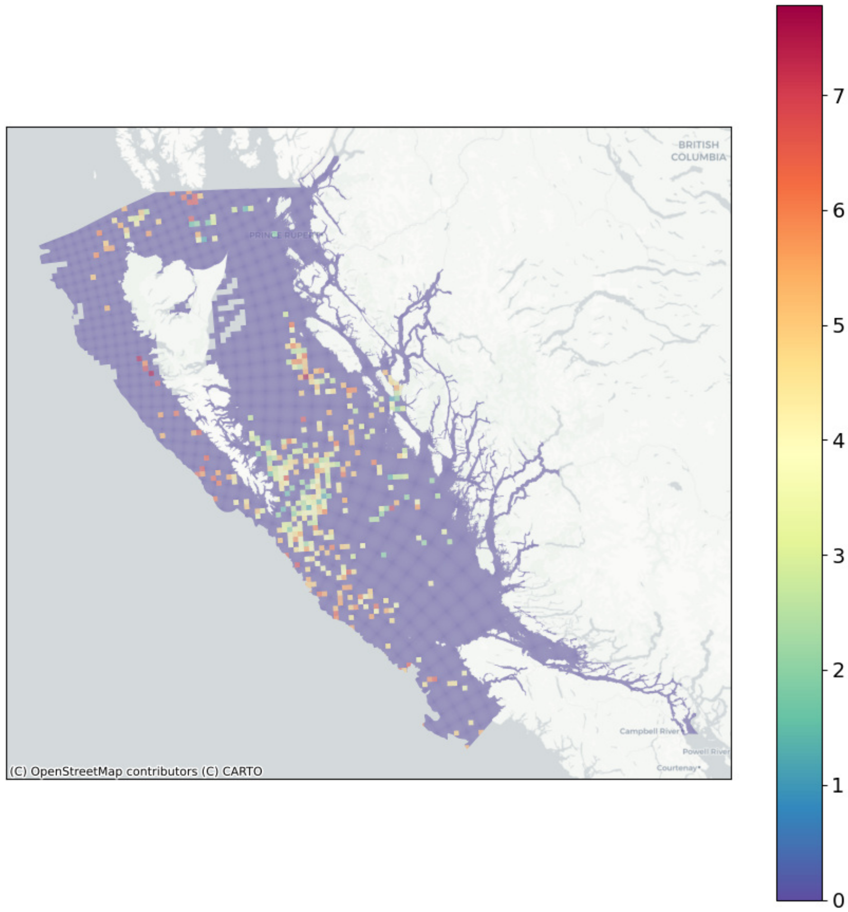

Figure 155: Effort-corrected density of Fin Whale derived from surveys conducted by DFO, Raincoast Conservation Foundation, and those in the North Pacific Pelagic Seabird Database.

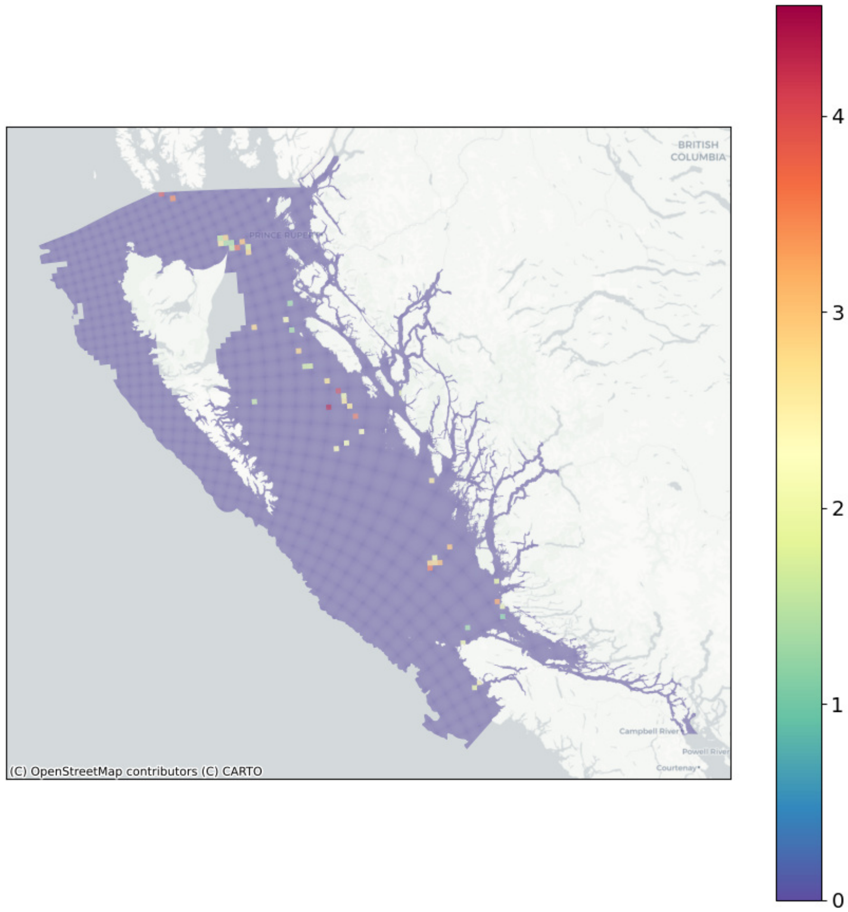

Figure 156: Effort-corrected density of Grey Whale derived from surveys conducted by DFO, Raincoast Conservation Foundation, and those in the North Pacific Pelagic Seabird Database.

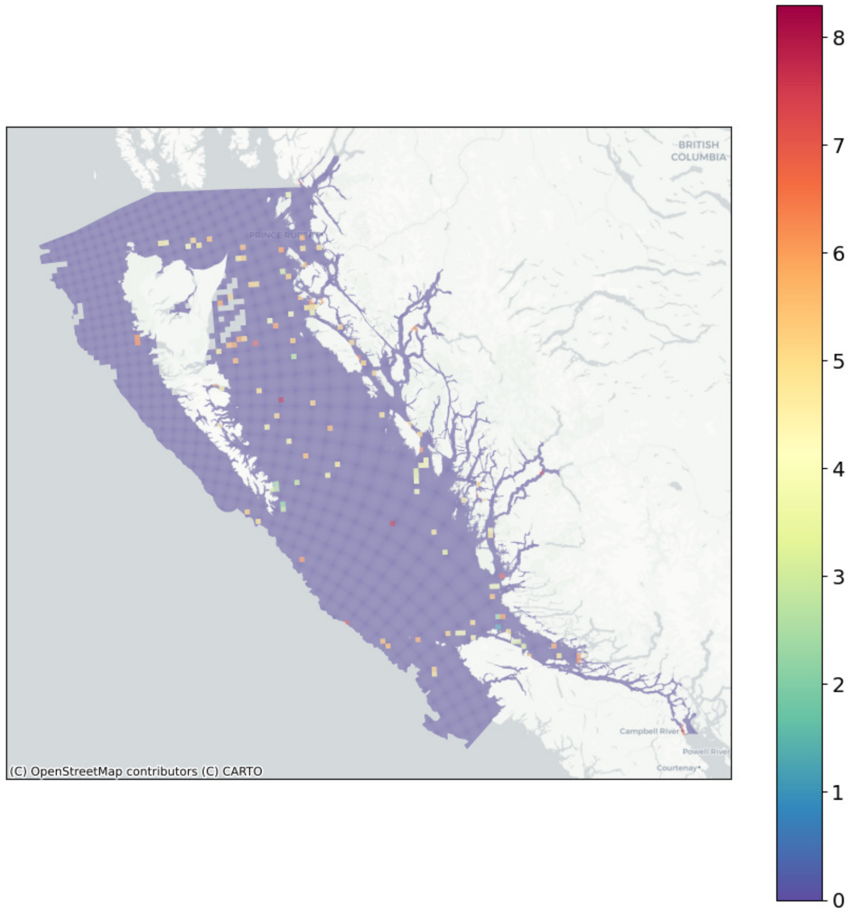

Figure 157: Effort-corrected density of Harbour Porpoise derived from surveys conducted by DFO, Raincoast Conservation Foundation, and those in the North Pacific Pelagic Seabird Database.

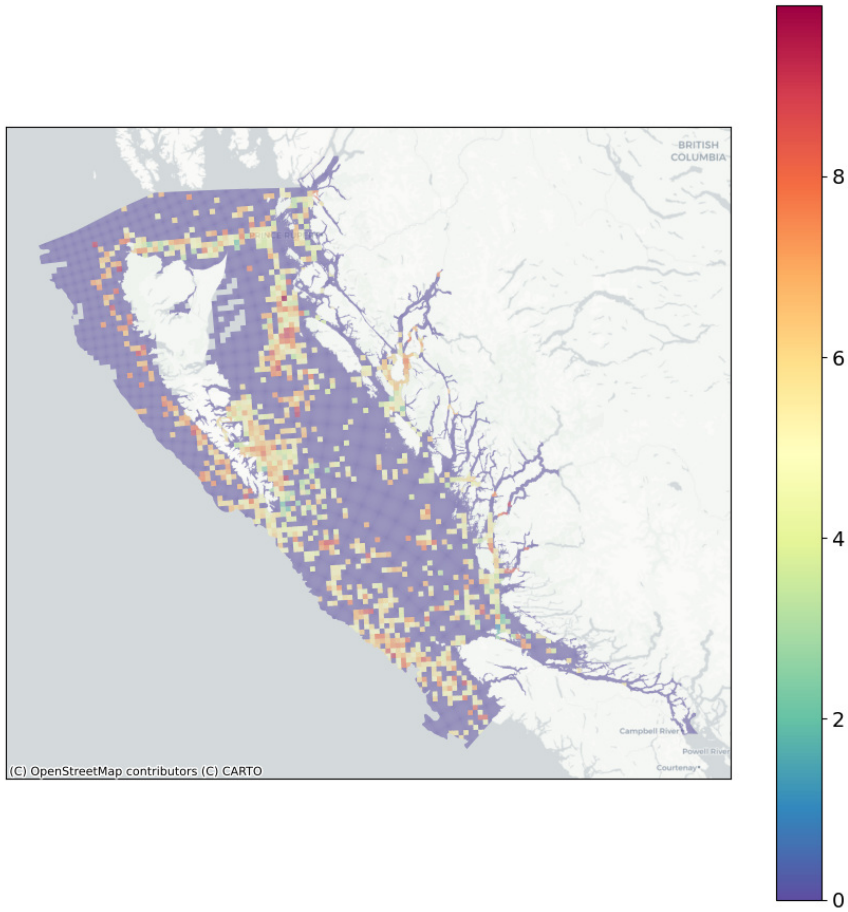

Figure 158: Effort-corrected density of Humpback Whale derived from surveys conducted by DFO, Raincoast Conservation Foundation, and those in the North Pacific Pelagic Seabird Database.

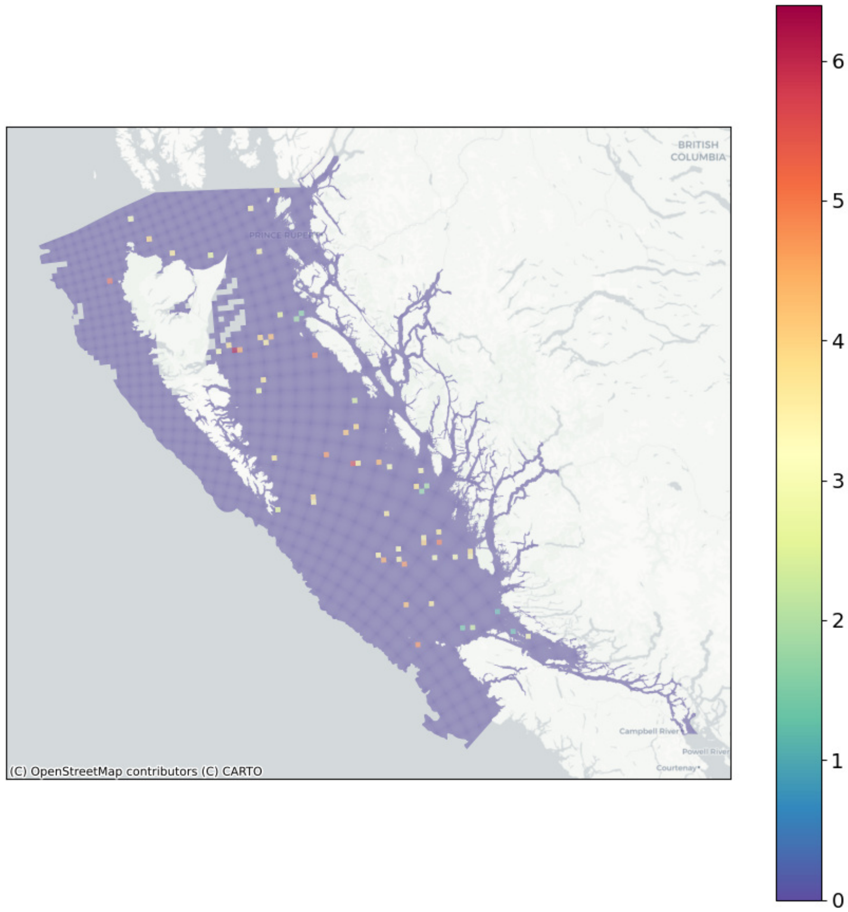

Figure 159: Effort-corrected density of Minke Whale derived from surveys conducted by DFO, Raincoast Conservation Foundation, and those in the North Pacific Pelagic Seabird Database.

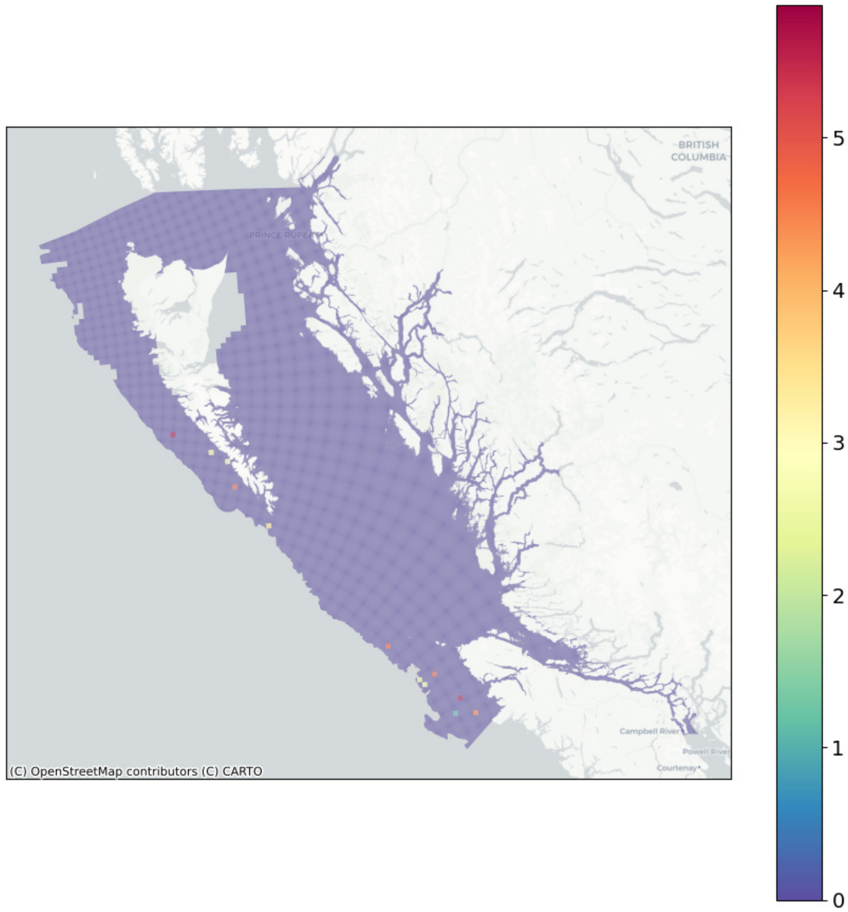

Figure 160: Effort-corrected density of Northern Right Whale Dolphin derived from surveys conducted by DFO, Raincoast Conservation Foundation, and those in the North Pacific Pelagic Seabird Database.

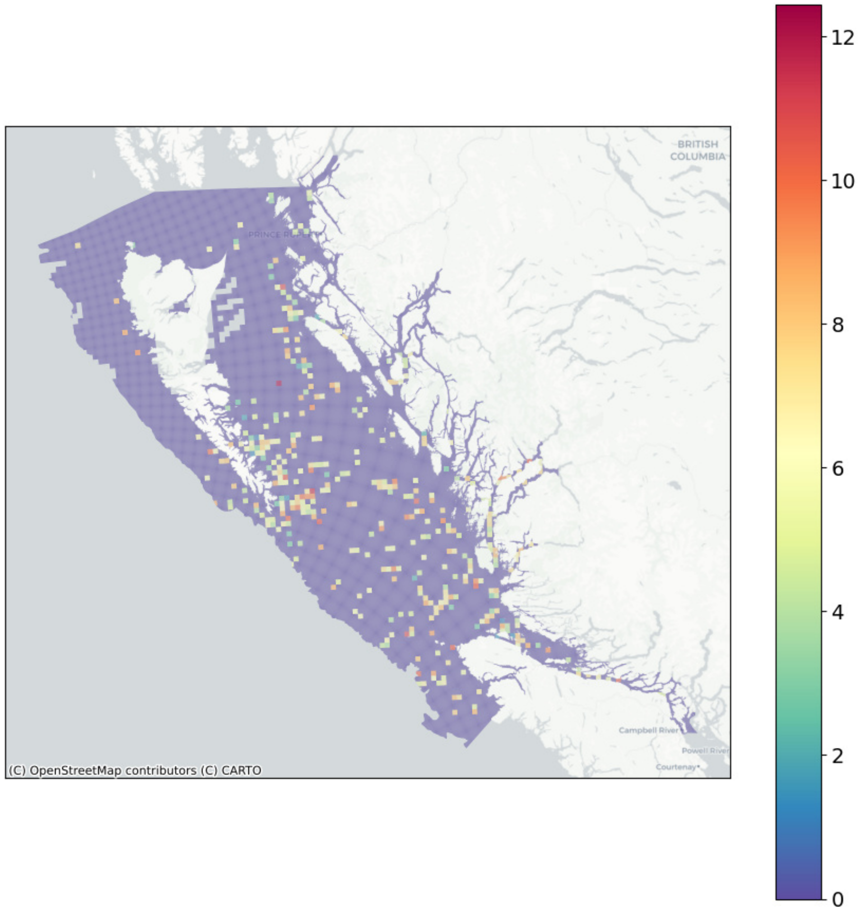

Figure 161: Effort-corrected density of Pacific White-sided Dolphin derived from surveys conducted by DFO, Raincoast Conservation Foundation, and those in the North Pacific Pelagic Seabird Database.

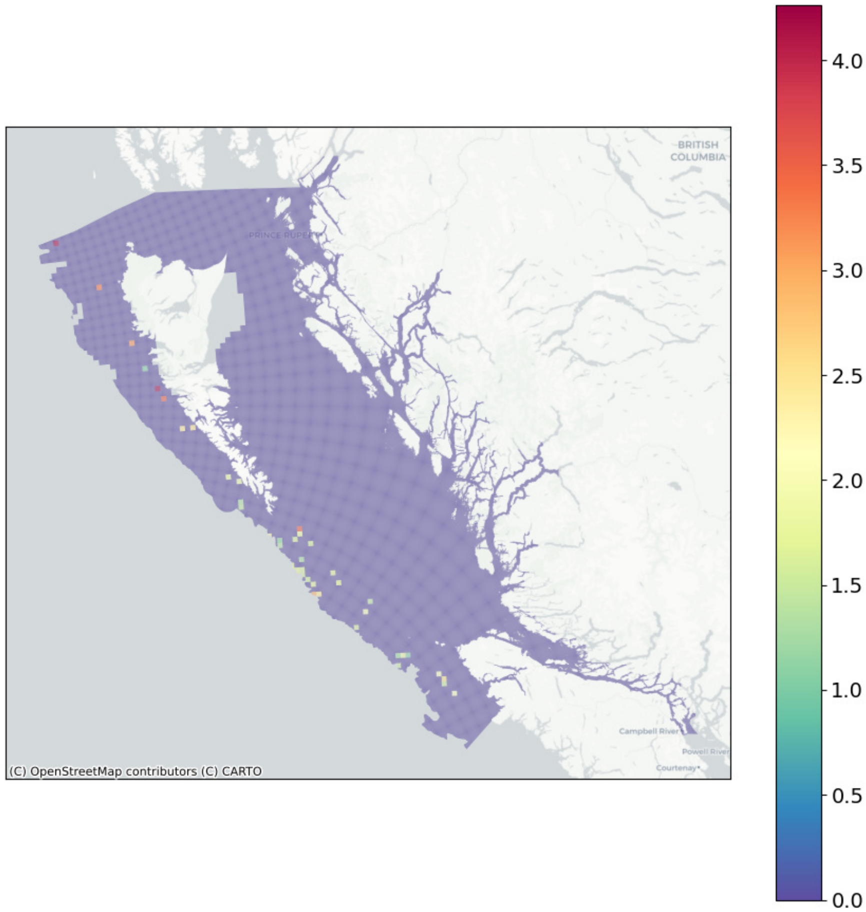

Figure 162: Effort-corrected density of Sperm Whale derived from surveys conducted by DFO, Raincoast Conservation Foundation, and those in the North Pacific Pelagic Seabird Database

NSB MPA Network Ecological Data - Other Marine Mammal and Reptile Features

Summary:

There are 21 features in the 'Other Marine Mammals and Reptiles' geodatabase:

- (8) Important Areas for whales, Fur Seal, Sea Otter, and Leatherback Turtle
- (4) Haulouts for California Sea Lion, Harbour Seal, and Steller Sea Lion
- (1) Rookeries for Steller Sea Lion
- (1) Grey Whale migration routes
- (2) Critical Habitat for Humpback Whale and Northern Resident Killer Whales
- (3) Habitats of Special Importance for Fin Whales, Northern Resident Killer Whales, and Transient Killer Whales
- (1) Potential Critical Habitat for Northern Resident Killer Whales
- (1) Modeled habitat for Sea Otter

Data Creators and Co-creators: Creator: Katie Gale; Co-Creators: Cathryn Clarke (Important Areas); DFO Marine Mammals group, Carrie Robb, and BCMCA (haulouts and rookeries); Carrie Robb (Grey Whale migration route, habitats of special importance); DFO Species at Risk (critical habitat), Ed Gregr and BCMCA (sea otter modeled habitat); MPATT Science Team

Methods and links to metadata:

Important Areas for whales, Fur Seal, Sea Otter, and Leatherback Turtle

- Blue Whale IA
- Fin Whale IA
- Fur Seal IA
- Resident Killer Whale IA
- Sea Otter IA
- Sei Whale IA
- Sperm Whale IA
- Leatherback Sea Turtle IA

EBSAs are areas of relatively higher ecological or biological significance than surrounding areas, where greater risk aversion is required in the management of activities (DFO, 2004). Within the EBSA boundary, perturbations are also expected to cause greater ecological consequences than in surrounding areas exposed to comparable perturbations.

Criteria to identify EBSAs have been established at the national (DFO, 2004) and international (Convention on Biological Diversity, 2008) levels. Areas that rank High for one or more of uniqueness, fitness consequences, or aggregation can be designated as an EBSA. A feature or area that ranks above average (Medium or High) across multiple criteria also meets the EBSA criteria.

EBSAs can be identified based on single features or species (e.g., spawning areas for a single species, or aggregations of single species), or multiple species or features (e.g., areas of high diversity, productivity, or overlap of many single-feature EBSAs). In the Pacific Region single-feature or taxon-specific EBSAs are referred to as "Important Areas" (IAs) (Clarke and Jamieson, 2006*a*; Levesque and Jamieson, 2015).

In the NSB, broad-scale IAs and EBSAs were identified in Clarke and Jamieson (2006*a*,*b*) and DFO (2013*a*). Species IAs were identified on the basis of species experts' knowledge on the biology of individual species, or groups of species, and the EBSAs were primarily identified on the basis of expert knowledge about physical and oceanographic features that also overlap with IAs for at least one species or species group.

Haulouts and Rookeries

- Calfornia Sea Lion haulouts

- Harbour Seal haulouts

- Steller Sea Lion winter haulouts

- Steller Sea Lion year-round haulouts

- Steller Sea Lion rookeries

California Sea Lion haulouts were obtained from the BCMCA, which obtained the point locations from the Province of British Columbia and marine mammal biologist Wendy Szaniszlo.

Point location for Steller sea lion year-round haulouts, winter haulouts, and rookeries were collected from DFO surveys (Olesiuk, 2018). See Majewski (2021*b*) for an updated version of the Steller Sea Lion haulouts.

Point locations of harbour seal haulouts were identified from DFO marine mammal surveys, based on coordinates provided by Sheena Majewski (DFO Marine Mammals group; see Majewski, 2021*a*, for an updated version).

Point locations of all species' haulouts were buffered by 200 m to represent the habitat associated with the haulout site. Point locations of rookeries were digitized and buffered by 15 km to account for foraging behaviour of females feeding their young.

Grey Whale migration routes

- Grey Whale migration routes

Positions of five satellite-tagged grey whales were recorded migrating northbound between Vancouver Island and southeastern Alaska (Ford et al., 2013). The location points of the satellite-tagged grey whales (Figure 1 in Ford et al., 2013) that fell within the NSB planning area were enclosed in a spatial polygon and digitized to illustrate the migratory corridor for grey whales in the peak of northern migration.

Critical Habitat for Humpback Whale

- Humpback Whale Critical Habitat

North Pacific Humpback Whale was listed as Threatened under SARA in 2005, but was changed to Special Concern in 2017 based on a reassessment carried out by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2011. SARA Critical Habitat is not identified for species listed as Special Concern, so the areas previously identified as Critical Habitat for North Pacific Humpback Whale are no longer included in the Critical Habitat database available on the Government of Canada's Open Data portal. However, these areas were still used to represent areas important for

Humpback Whale as part of the NSB MPA Network planning process, and are included here for archival purposes.

In January 2009, a meeting of experts in the field of Humpback Whale research was convened to critique information presented in the draft Recovery Strategy (final version: DFO, 2013*b*) and to ensure it incorporated all available knowledge and addressed priority research, management, and other actions to promote recovery of North Pacific humpback whales in Canadian waters (DFO, 2010). Discussions on the available data and potential critical habitat designations were also conducted. Based on weight of evidence from the data and information presented, it was clear that there are predictable, seasonal aggregations of Humpback Whales in BC and four areas were identified as candidates for Critical Habitat designation.

These areas included:

- the waters surrounding Langara Island;
- coastal waters along the south eastern side of Moresby Island and Kunghit Island;
- the mainland channels around Gil Island and Gribbel Island;
- and waters off southwest Vancouver Island including Barkley Sound, La Perouse Bank, Swiftsure Banks and Barkley Canyon.

Critical Habitat for Northern Resident Killer Whales

- Northern Resident Killer Whale Critical Habitat

Northern Resident Killer Whale Critical Habitat was initially identified in Johnstone Strait and southeastern Queen Charlotte Strait and their adjoining channels (Ford, 2006) due to the area's use by Northern Residents during summer and fall. This area was designated as critical habitat for Northern Residents in 2009 (Government of Canada 2009). New areas were subsequently proposed as habitats of special importance for Northern Residents (Ford et al., 2017): western Dixon Entrance, which is used by Northern Residents year-round, and southwestern Vancouver Island, which is used by both Southern and Northern Residents year-round. These two new areas were designated as critical habitat for Northern Resident Killer Whales in 2018 (DFO, 2018).

Though not shown in this layer, the transboundary waters of Haro Strait and Boundary Pass are designated critical habitat for Southern Resident Killer Whales, due to the area's year-round importance for Southern Residents (DFO, 2018). The Recovery Strategy for Northern and Southern Resident Killer Whales notes that additional key areas may exist but information is not yet sufficient for designation of critical habitat. Ford (2006) identified some additional areas as potential critical habitat for Northern Resident Killer Whales.

Habitats of Special Importance for Fin Whales

- Fin Whale Habitat of Special Importance

The habitat of special importance for Fin Whales encompasses Hecate Strait, Queen Charlotte Sound and Greater Caamaño Sound, and was identified as important for foraging/feeding, as well as possible courtship/mating and calving habitat (DFO, 2017). This feature was digitized from Figure 1 in DFO (2017) for use in MPA Network planning.

Habitats of Special Importance for Northern Resident Killer Whales

- Northern Resident Killer Whale Habitat of Special Importance

Northern Resident Killer Whale Critical Habitat was initially identified in Johnstone Strait and southeastern Queen Charlotte Strait and their adjoining channels (Ford, 2006) due to the area's use by Northern Residents during summer and fall. This area was designated as critical habitat for Northern Residents in 2009 (Government of Canada, 2009). New areas were subsequently proposed as habitats of special importance for Northern Residents (Ford et al., 2017): western Dixon Entrance, which is used by Northern Residents year-round, and southwestern Vancouver Island, which is used by both Southern and Northern Residents year-round. These two new areas were designated as critical habitat for Northern Resident Killer Whales in 2018 (DFO, 2018).

This feature represents the Dixon Entrance part of the "Habitat of Special Importance" described in Ford et al. (2017), which was identified based on the high use of the area by Northern Resident Killer Whales in March-May. As of 2018, Dixon Entrance is formally considered Critical Habitat (DFO, 2018), but is presented independently here for archival purposes. The extent of this polygon was digitized from coordinates provided in Ford et al. (2017), with coordinates for Jorey Point taken from the BC Gazeteer.

Habitats of Special Importance for Transient Killer Whales

- Transient Killer Whale Habitat of Special Importance

Based on frequency of occurrence and distribution of photo-identifications, Ford et al. (2013) defined two putative subpopulations of West Coast Transient Killer Whales: a well-known inner coast subpopulation and a more poorly-known outer coast subpopulation. Ford et al. (2013) suggest that a habitat area that includes Pacific coast marine waters up to 3 nautical miles (5.56 km) from shore is of sufficient extent to provide for the population and distribution objectives described in the West Coast Transient Killer Whale Recovery Strategy (DFO, 2007), at least for the inner coast subpopulation. The area encompasses 92% of all identifications of inner coast individuals, and 64% of identifications of outer coast individuals.

For the NSB MPA Network planning process, a 3 nm (5.56 km) buffer was generated around a polygon of British Columbia's coastline, dissolved into a single feature, and clipped to the Canadian Hydrographic Service high water coastline using ArcGIS software. The dataset was subsequently clipped to the NSB for display in SeaSketch.

Potential Critical Habitat for Northern Resident Killer Whales

- Northern Resident Killer Whale potential Critical Habitat

Northern Resident Killer Whale Critical Habitat was initially identified in Johnstone Strait and southeastern Queen Charlotte Strait and their adjoining channels (Ford, 2006) due to the area's use by Northern Residents during summer and fall. This area was designated as critical habitat for Northern Residents in 2009 (Government of Canada, 2009). New areas were subsequently proposed as habitats of special importance for Northern Residents (Ford et al., 2017): western Dixon Entrance, which is used by Northern Residents year-round, and southwestern Vancouver Island, which is used by both Southern and Northern Residents year-round. These two new areas were designated as critical habitat for Northern Resident Killer Whales in 2018 (DFO, 2018).

Ford (2006) identified three additional areas as potential critical habitat for Northern Resident Killer Whales, but there was insufficient information to meet Species At Risk Act (SARA) requirements. These areas are Chatham Sound, Caamano Sound and Fitz Hugh Sound, where northern residents congregate seasonally. These three areas are shown here as "potential critical habitat".

Modeled habitat for Sea Otter

- Sea Otter modelled habitat

The habitat model (Gregr et al., 2008) was developed by characterizing and mapping the complexity of nearshore intertidal and sub-tidal bathymetric contours (i.e., the shape and depth of the seafloor). Known habitat, occupied by sea otters in Checleset Bay and Kyuquot Sound during spring and summer was identified a priori as important habitat because sea otters had occupied at carrying capacity - based on sea otter counts and distribution data for the area from 1995 to 2005. Thus the areas occupied by sea otters in Checleset Bay and Kyuoqut Sound were characterized by these physical parameters and used to build the model. The model was projected to Vancouver Island and then to the whole BC coast to identify similar habitat, both occupied by sea otters and areas as yet unoccupied by sea otters.

Temporal Coverage:
1996-01-01 to 2018-12-31

Scripts/Software:
n/a

Data Sources:

- **Important Areas**: From Clarke and Jamieson (2006*a*). Available directly at `https://www.gis-hub.ca/dataset/ia-cetaceans-pncima` and `https://www.gis-hub.ca/dataset/ia-othervert-pncima.`
- **Haulouts for California Sea Lion**: Feature obtained from the BCMCA.
- **Haulouts for Harbour Seal, and Steller Sea Lion, and rookeries for Steller Sea Lion**: From Olesiuk (2018) and the DFO Marine Mammals group (see Majewski, 2021*b*,*a*, for updated versions of the Harbour Seal and Steller Sea Lion haulouts).
- **Grey Whale migration routes**: From Ford et al. (2013).
- **Critical Habitat for Humpback Whale and Northern Resident Killer Whales**: from DFO Species at Risk (SARA). Northern Resident Killer Whale critical habitat available directly from the Government of Canada's Open Data portal. Because Critical Habitat is not identified for species listed as Special Concern, the areas previously identified as Critical Habitat for North Pacific Humpback Whale are no longer included in the Critical Habitat database on Open Data.
- **Habitats of Special Importance for Fin Whales**: From DFO (2017).
- **Habitats of Special Importance for Northern Resident Killer Whales**: From Ford et al. (2017).
- **Habitats of Special Importance for Transient Killer Whales**: From Ford et al. (2013).
- **Potential Critical Habitat for Northern Resident Killer Whales**: From Ford (2006).
- **Modeled habitat for Sea Otter:** Feature obtained from the BCMCA.

Absence Data:
No absence data.

Uncertainties:
Each feature has uncertainties based on its input data and processing steps. Notable uncertainties are described in each feature's individual metadata.

Sea Otter modeled habitat: The sea otter population continues to increase and its range has expanded since the habitat model was created. More recent information on sea otter distribution based on surveys by DFO are presented in Nichol et al. (2015) but no updated validation of the model has occurred. Gregr et al. (2008) noted that the model may not fully capture the characteristics of sea otter habitat in the north coast, central coast, and particularly on Haida Gwaii, possibly reflecting limitations of the bathymetric data that was available but varied in resolution over the coast.

Species Data:

- BALAENOPTERA MUSCULUS (BLUE OR SULPHUR-BOTTOMED WHALE)
- ZALOPHUS CALIFORNIANUS (CALIFORNIA SEA LION)
- BALAENOPTERA PHYSALUS (FIN OR FIN-BACKED WHALE)
- CALLORHINUS URSINUS (NORTHERN FUR SEAL)
- ESCHRICHTIUS ROBUSTUS (GREY WHALE)
- PHOCA VITULINA (HARBOUR SEAL)
- MEGAPTERA NOVAEANGLIAE (HUMPBACK OR HUMP-BACKED WHALE)
- ORCINUS ORCA (KILLER WHALE)
- ENHYDRA LUTRIS (SEA OTTER)
- BALAENOPTERA BOREALIS (SEI WHALE)
- PHYSETER MACROCEPHALUS (SPERM WHALE)
- EUMETOPIAS JUBATUS (STELLER SEA LION)
- DERMOCHELYS CORIACEA (LEATHERBACK TURTLE)

Maps of available datasets:

Figure 163: Blue Whale "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

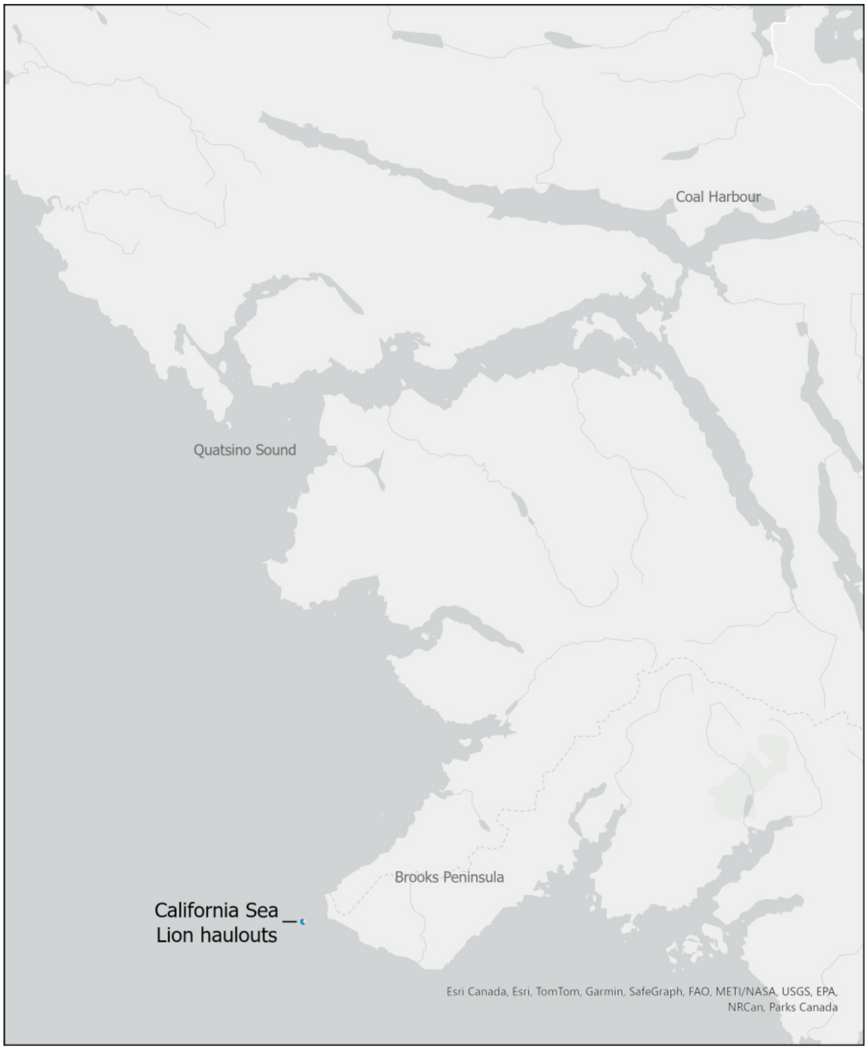

Figure 164: Locations of haulouts used by California Sea Lions (BCMCA).

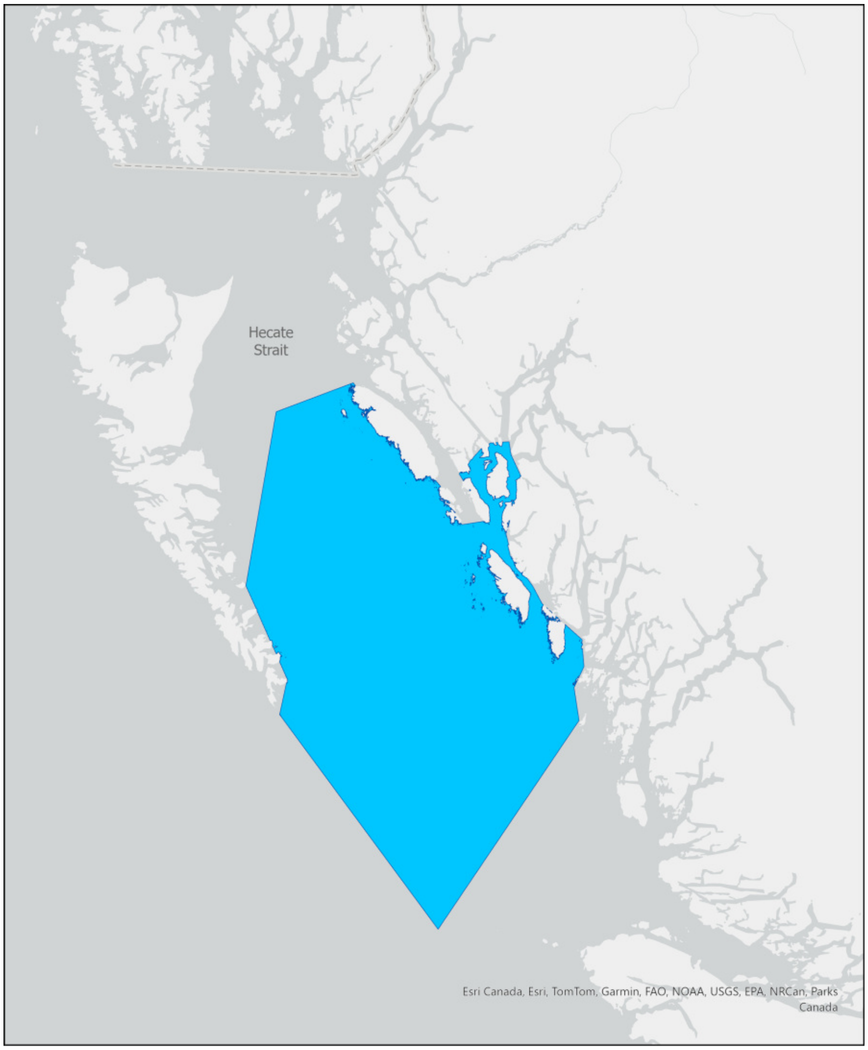

Figure 165: Habitat of special importance for Fin Whales (DFO, 2017).

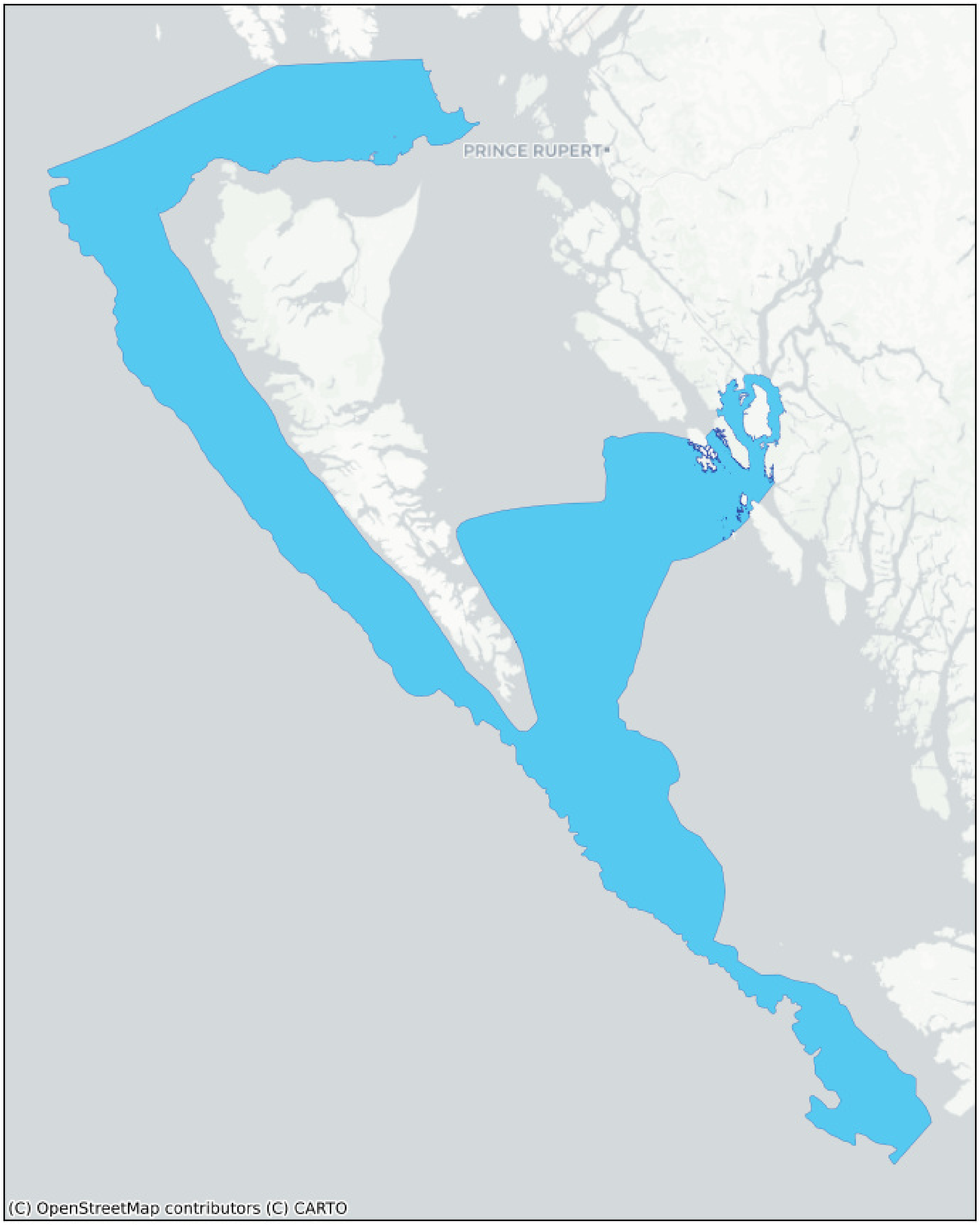

Figure 166: Fin Whale "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

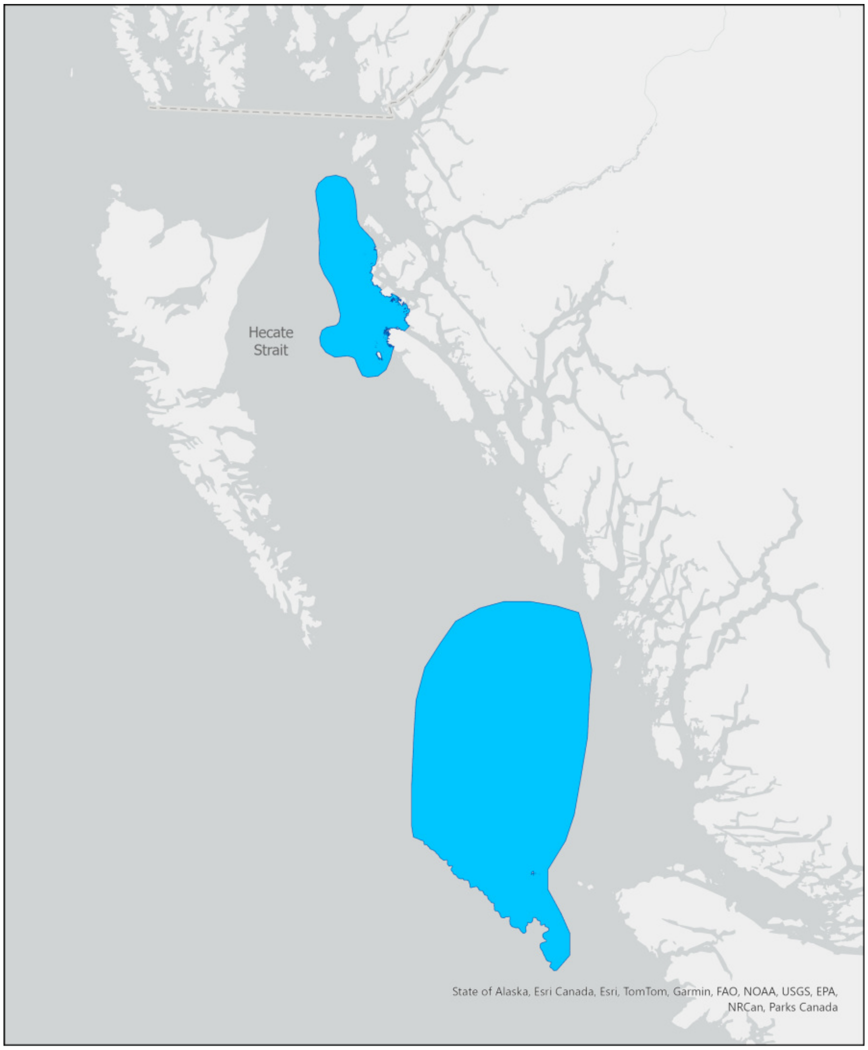

Figure 167: Northern Fur Seal "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

Figure 168: Migration routes identified for Grey Whales (Ford et al., 2013).

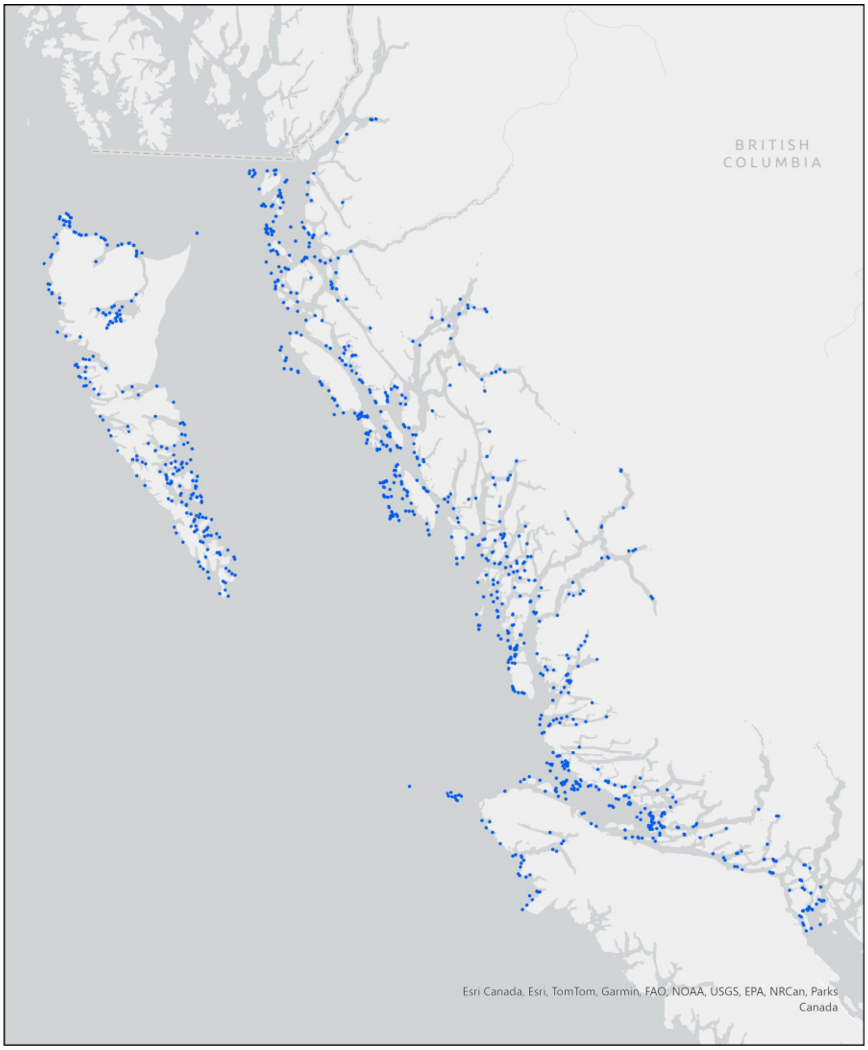

Figure 169: Locations of haulouts used by Harbour Seals (DFO Marine Mammals group).

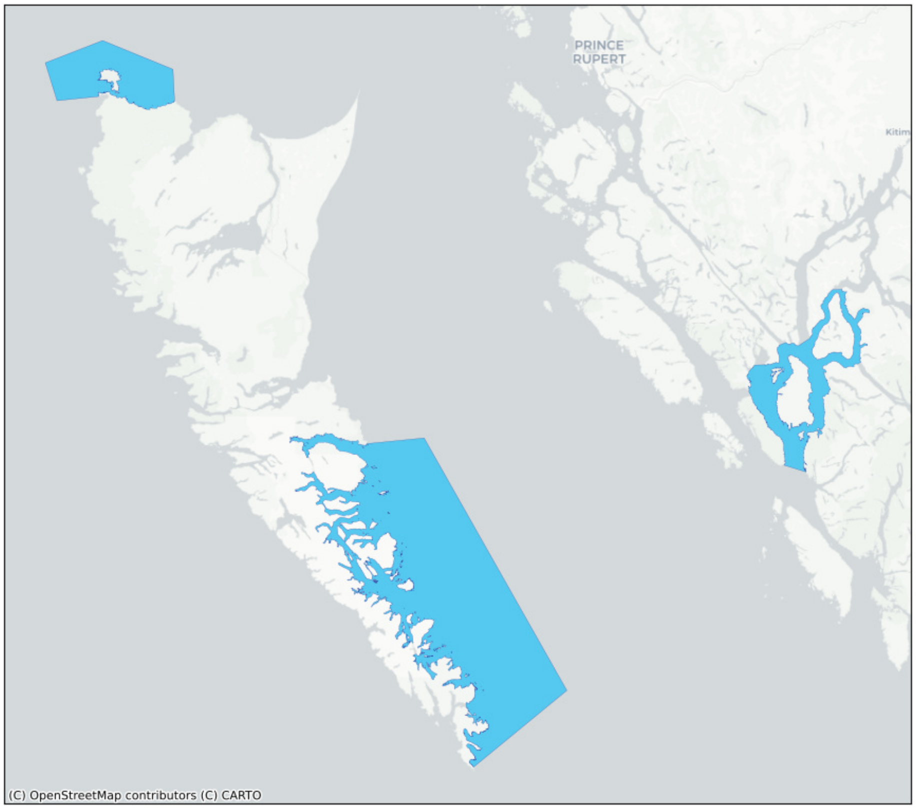

Figure 170: SARA Critical Habitat for Humpback Whales (2009-2013). Critical Habitat in the Northern Shelf Bioregion includes: 1) the waters surrounding Langara Island; 2) coastal waters along the south eastern side of Moresby Island and Kunghit Island; 3) the mainand channels around Gil Island and Gribbel Island. An additional area outside the NSB (waters off southwest Vancouver Island including Barkley Sound, La Perouse Bank, Swiftsure Banks and Barkley Canyon) is not included in this version of the layer.

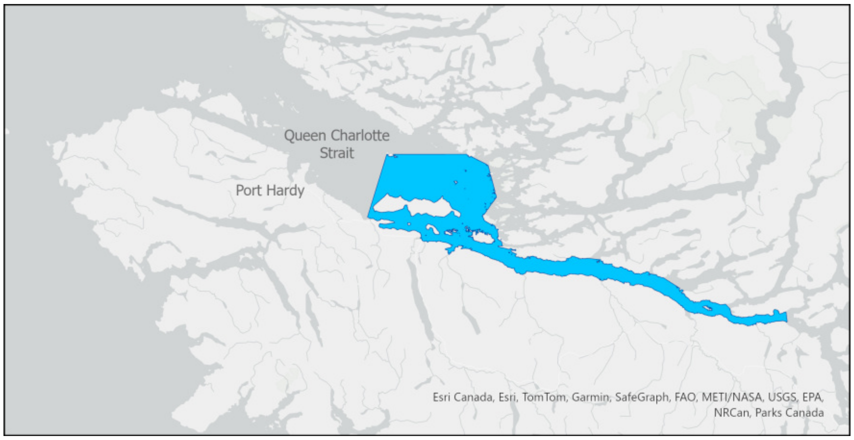

Figure 171: SARA Critical Habitat for Northern Resident Killer Whales.

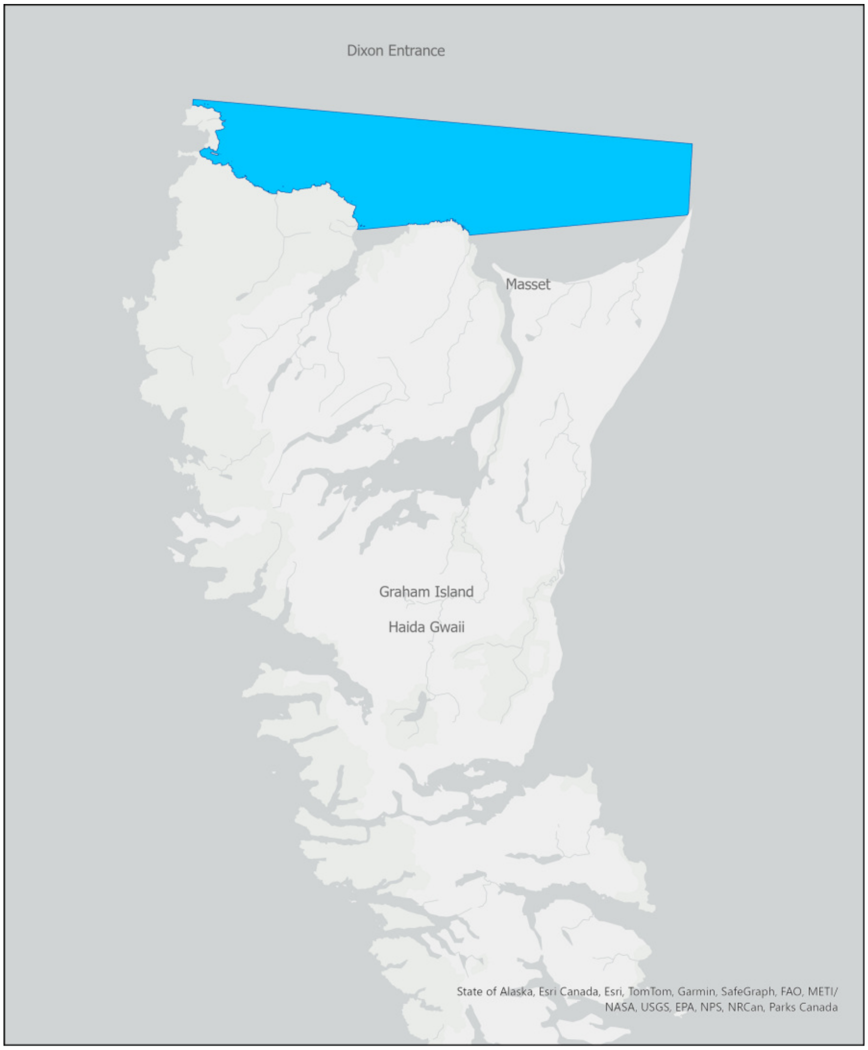

Figure 172: This feature represents the Dixon Entrance part of the "Habitat of Special Importance" described in Ford et al. (2017), which was identified based on the high use of the area by Northern Resident Killer Whales in March-May. As of 2018, Dixon Entrance is formally considered Critical Habitat (DFO, 2018), but is presented independently here for archival purposes.

Figure 173: Resident Killer Whales "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

Figure 174: Potential critical habitat for Northern Resident Killer Whales (Chatham Sound, Caamano Sound, Fitz Hugh Sound) from Ford (2006).

Figure 175: Habitat of special importance for Transient Killer Whales (3 nm / 5.56 km buffer around full coastline of BC) from Ford et al. (2013).

Figure 176: Sea Otter "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

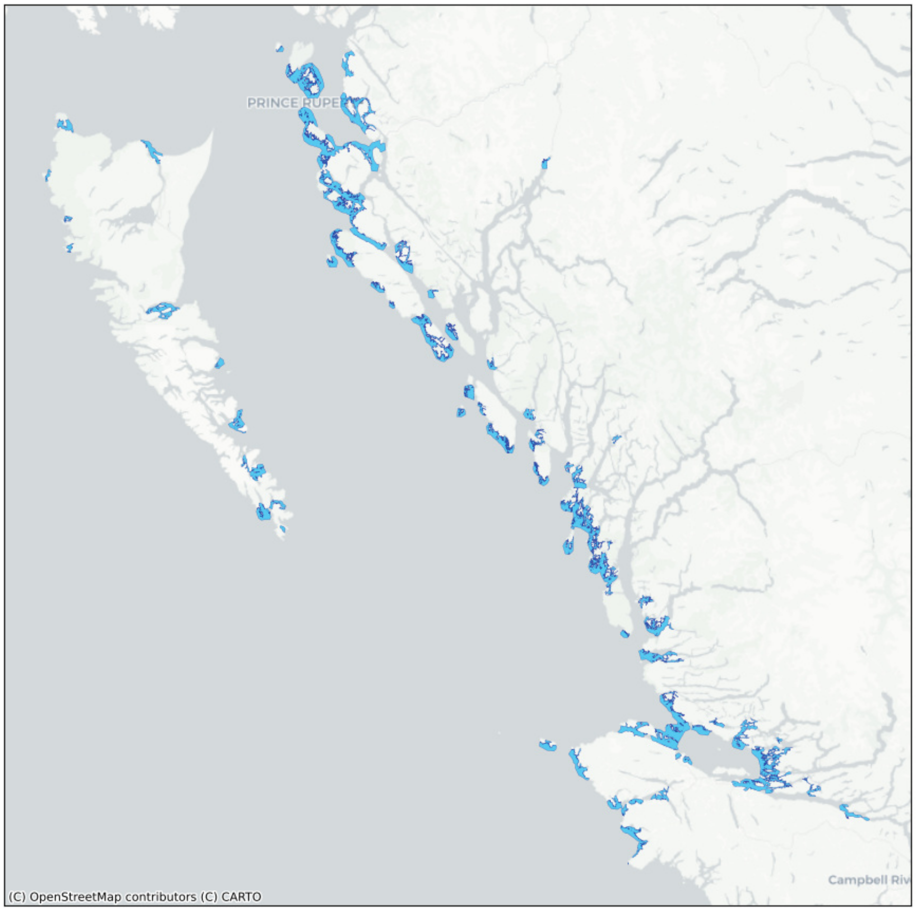

Figure 177: Modeled habitat for Sea Otters.

Figure 178: Sei Whale "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

Figure 179: Sperm Whale "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

Figure 180: Locations of haulouts used by Steller Sea Lions in winter months (Olesiuk, 2018, and the DFO Marine Mammals group).

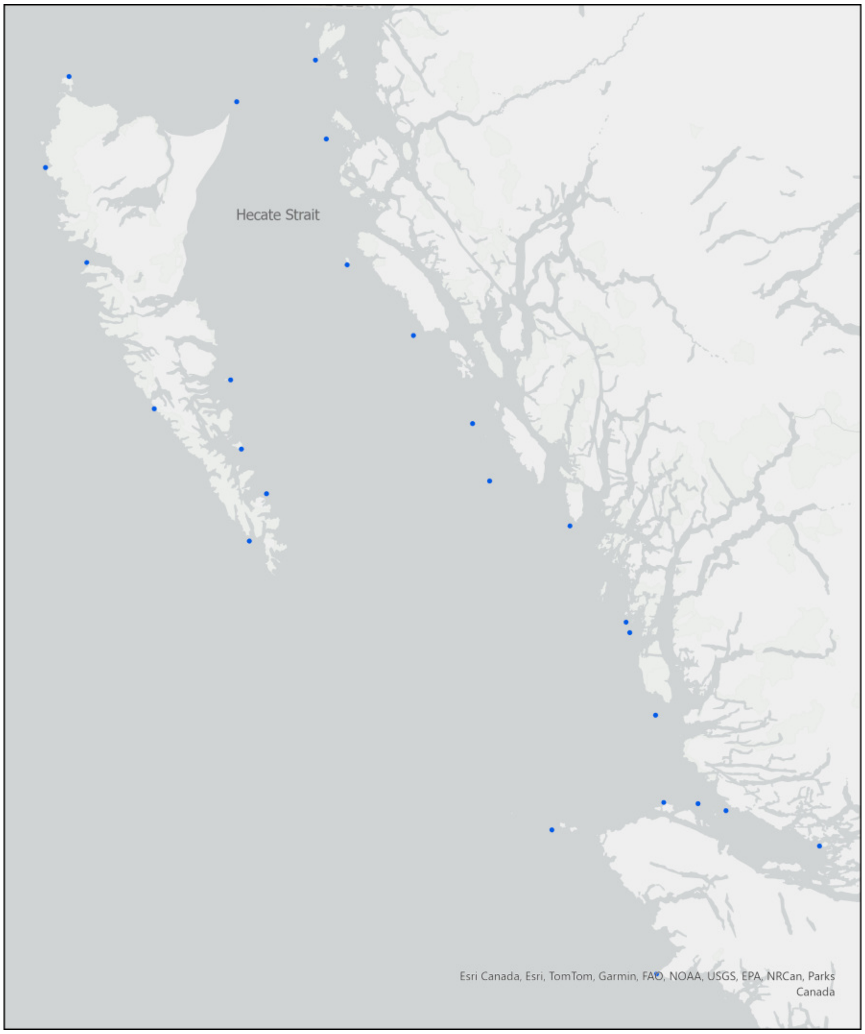

Figure 181: Locations of haulouts used by Steller Sea Lions year-round (Olesiuk, 2018, and the DFO Marine Mammals group).

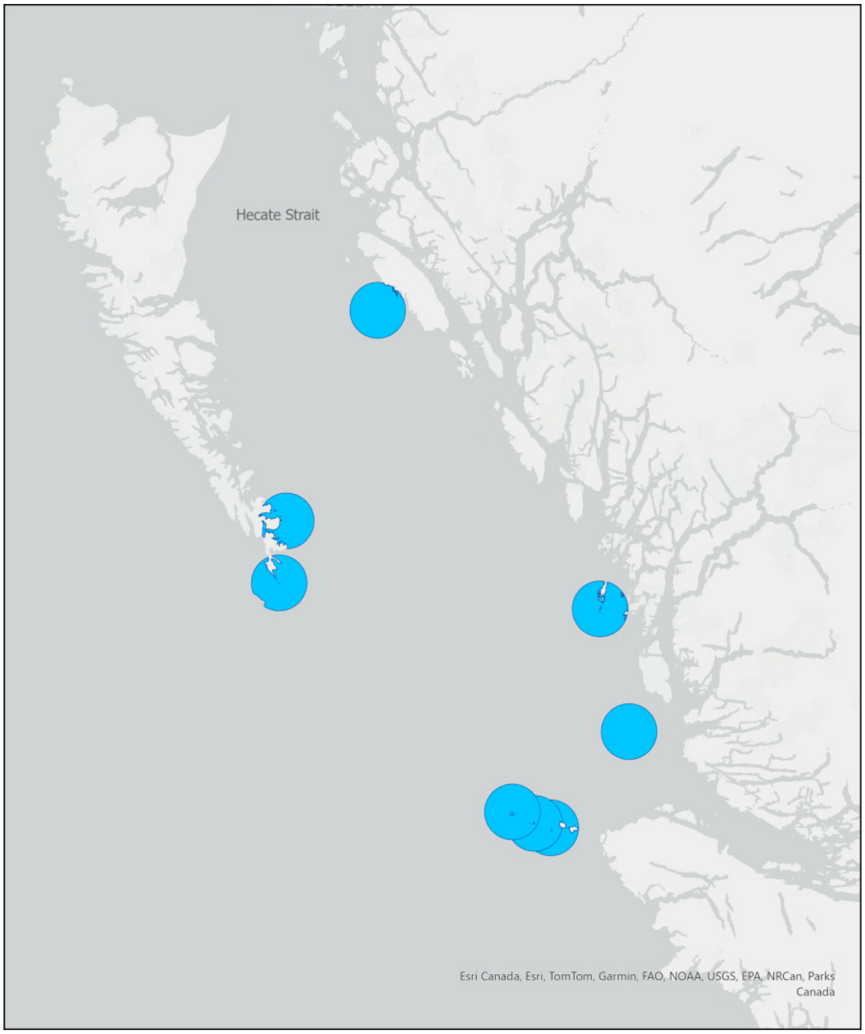

Figure 182: Locations of rookeries used by Steller Sea Lions (Olesiuk, 2018, and the DFO Marine Mammals group).

Figure 183: Leatherback Turtle "Important Areas" identified as part of the Ecologically and Biologically Significant Areas process (Clarke and Jamieson, 2006*a*).

Plants and Algae

NSB MPA Network Ecological Data - Plants and Algae

Summary:

There are 11 features in the 'Plants and Algae' geodatabase:

- Bull kelp biobands
- Bull kelp polygons
- Chlorophyll *a* bloom frequency
- Chlorophyll *a* concentration
- Eelgrass biobands
- Eelgrass polygons
- Eelgrass priority polygons
- General kelp polygons
- Giant kelp biobands
- Giant kelp polygons
- Surfgrass biobands

Data Creators and Co-creators: Creator: Katie Gale; Co-Creators: Province of British Columbia (biobands), Jessica Nephin (chlorophyll), British Columbia Marine Conservation Analysis (BCMCA; kelp and eelgrass polygons), Carrie Robb (eelgrass priority polygons), MPATT Science Team

Methods and links to metadata:

Biobands:

- Bull Kelp Biobands
- Eelgrass Biobands
- Giant Kelp Biobands
- Surfgrass Biobands

This dataset contains a subset of data collected by the provincial government in an effort to map and classify the entire BC coastline. The BC Shorezone Mapping System (Howes et al., 1994) is a systematic methodology for mapping the biophysical character of the entire BC coastline, by way of aerial low tide oblique surveys. The system involves the subdivision of the coastline into along-shore units and across-shore components. The marine flora and fauna visible within a shore unit are described in terms of common species assemblages known as biobands. The biobands are defined by the dominant cover species.

These feature display the shoreline units where kelp, eelgrass, or surfgrass was observed and coverage was rated as either "patchy" (visible in less than 50% of the shore unit) or "continuous" (visible in greater than 50% of the shore unit).

The BCMCA metadata (e.g., for Bull Kelp) describes how the biobands were extracted from the original Shorezone database.

Bull Kelp, Giant Kelp, and Eelgrass polygons:

- Bull Kelp polygons
- General Kelp polygons
- Giant Kelp polygons
- Eelgrass polygons

BCMCA compiled spatial data from a variety of sources (described in the above metadata and listed in the 'data sources' section below) to create these polygon datasets, which represent the distribution of kelp and eelgrass beds in the study area. 'General kelp' represents records of kelp for which no species name was recorded.

The Eelgrass data used in the NSB MPA Network planning process was created by updating the original BCMCA Eelgrass polygon data with several new datasets (described in 'data sources' section below). The datasets were reviewed for duplicates, merged, the attributes for survey date and decade were updated, and the data was clipped to the NSB.

Eelgrass priority polygons:

- Eelgrass priority polygons

This feature is an updated version of that presented by BCMCA. The original BCMCA 'priority eelgrass habitat' data was not used as an input to create this updated feature, but the metadata describes the general methods followed.

This 'Priority Eelgrass Polygon' feature is meant to represent Eelgrass beds with information regarding habitat use by other species, and was created by identifying Eelgrass beds that overlapped with data for those species.

Spatial data for Pacific Herring, Great Blue Heron, estuaries, Dungeness Crab, and Brant, which was compiled specifically for the MPA network planning process, was used to select priority Eelgrass habitats from the full Eegrass bed feature. Polygons within 100 m of herring spawn survey (using only top 30% of values), or those that intersect with Great Blue Heron nests and foraging areas, estuaries, Dungeness Crab Important Areas and Dungeness Crab locations, and Brant spring staging density and Brant winter density were selected as priority habitat. Selected polygons were then exported to a new feature class.

Chlorophyll *a* bloom frequency and concentration:

- Chlorophyll *a* bloom frequency
- Chlorophyll *a* concentration

Chlorophyll *a* (ChlA) data was sourced from the AquaMODIS satellite. NASA derived ChlA values from reflectances using the OC4 and CI algorithm (for more details see Hu et al., 2012). The MODIS chlorophyll a (mg m^{-3}) band has a resolution of 1 by 1 km.

Daily swath data was downloaded for all months between March and October from 2012 to 2015. Swath data was projected into BC Albers (EPSG:3005) and the following quality flags were masked (LAND, ATMFAIL, HIGLINT, HILT, HISATZEN, CLDICE, COCCOLITH, HISOLZEN, LOWLW,NAVFAIL, MAXAERITER, ABSAER). The STRAYLIGHT flag was not masked to retain more data in the coastal region. Projecting and masking operations were carried out using the command line tool gpt from Sentinel Application Platform (SNAP).

Daily swath data were then mosaicked by month. Months from November to February were excluded as cloud cover is persistent during that period. Mosaicking was performed using bilinear interpolation at the native resolution 1 x 1 km. When daily swaths were overlapping during mosaicking the mean value was returned. The monthly ChlA rasters (1 by 1 km) were then interpolated spatially using Spline with Barriers (ArcGIS 10.4) and a smoothed coastline to fill in any gaps that remained after mosaicking. These gaps were typically located nearshore and in coastal inlets.

Two indices of productivity were created from the monthly ChlA data:

- Mean ChlA concentration: calculated by averaging the monthly surface ChlA concentration (mg m^{-3}) across the time period.
- Bloom frequency: calculated following (Gregr et al., 2016), by classifying ChlA concentration greater than 3.0 mg m^{-3} as blooming. The 3.0 mg m^{-3} chlorophyll bloom threshold was reported for the study area (Mackas et al., 2007). For each month, each 1 by 1 km raster cell was classified as either blooming (1) or not blooming (0). Monthly bloom rasters were summed to calculate bloom frequency which ranged from 0 to 32. Values of 32 represent areas where monthly ChlA concentrations exceeded the bloom threshold for all months from March to October over a 4 year period (2012-2015).

Temporal Coverage:

1950-01-01 to 2015-12-31

Scripts/Software:

Scripts used to create the ChlA layers are available at https://www.gis-hub.ca/dataset/chlorophyll-a.

Data Sources:

Further details on the input data sources for each feature are available in the metadata links above.

- **Biobands**: Feature obtained directly from the BCMCA which used input data from the BC Shorezone Mapping System (Howes et al., 1994).
- **Bull kelp polygons**: Feature obtained directly from BCMCA, which used input data from the Province of British Columbia, Living Oceans Society, Parks Canada, and the Capital Region District.
- **Chlorophyll *a* bloom frequency and concentration**: NASA AquaMODIS satellite data. Available separately at https://www.gis-hub.ca/dataset/chlorophyll-a, and described in Rubidge et al. (2018)..
- **Eelgrass polygons**: Feature from BCMCA, which used input data from the Province of British Columbia, DFO, Parks Canada, and Community Mapping Network, was updated with several datasets from ASL Environmental Sciences, Ocean Ecology, and World Wildlife Fund (Forsyth et al., 1998; World Wildlife Fund Canada, 2009; Ocean Ecology, 2013).
- **Eelgrass priority polygons**: The above Eelgrass polygon feature was overlaid with the MPA Network spatial data for Pacific Herring (this document, page 170), Great Blue Heron (page 37), estuaries (page 13), Dungeness Crab (pages 145 and 186, and Brant (BCMCA).
- **General kelp polygons**: Feature obtained directly from BCMCA, which used input data from the Province of British Columbia, Living Oceans Society, Parks Canada, and the Capital Region District.

- **Giant kelp polygons**: Feature obtained directly from BCMCA, which used input data from the Province of British Columbia, Living Oceans Society, and Parks Canada.

Absence Data: No absence data

Uncertainties: Each feature has uncertainties based on its input data and processing steps. Notable uncertainties are described in each feature's individual metadata.

Bull Kelp, General Kelp, Giant Kelp, and Eelgrass polygons:

- Survey effort is not consistent across all planning units or across all areas of the coast and some species tend to be underrepresented by some survey methods. Areas with no data may not have been surveyed and these data gaps are not necessarily indicative of an absence of the species. Some locations may still be important but currently lack associated data to confirm their value.
- These features are a compilation of data collected by many people, for different purposes, using different survey techniques with different methodologies within each technique and, therefore, considerable care must be taken when using the data. Please refer to the original metadata document for data limitations and usage.

Kelp polygons:

- Sub-surface marine plant distribution has not been comprehensively mapped.

Eelgrass polygons:

- Please also note that because data for all years was retained, the same eelgrass bed may be represented more than once if mapped in multiple years.

General kelp polygons:

- This feature includes observations of stalked kelp (*Pterygophora californica*) and bladed kelp (*Laminaria* spp.) from the Capital Regional District Harbours Atlas. These two species groups may be more appropriate as a separate feature.

Chlorophyll:

- Raster layers are more uncertain in the coastal nearshore areas where cloud cover is greater and thus data gaps were present that required some spatial interpolation.
- An uncertainty layer is provided, which represents the extent to which the mean chlorophyll a concentration and bloom frequency layers were interpolated or extrapolated.

Species Data:

- NEREOCYSTIS LUETKEANA (BULL KELP)
- MACROCYSTIS PYRIFERA (SMALL PERENNIAL KELP)
- ZOSTERA MARINA (EEL GRASS)
- PHYLLOSPADIX (GEN) (SURFGRASS)

Maps of available datasets:

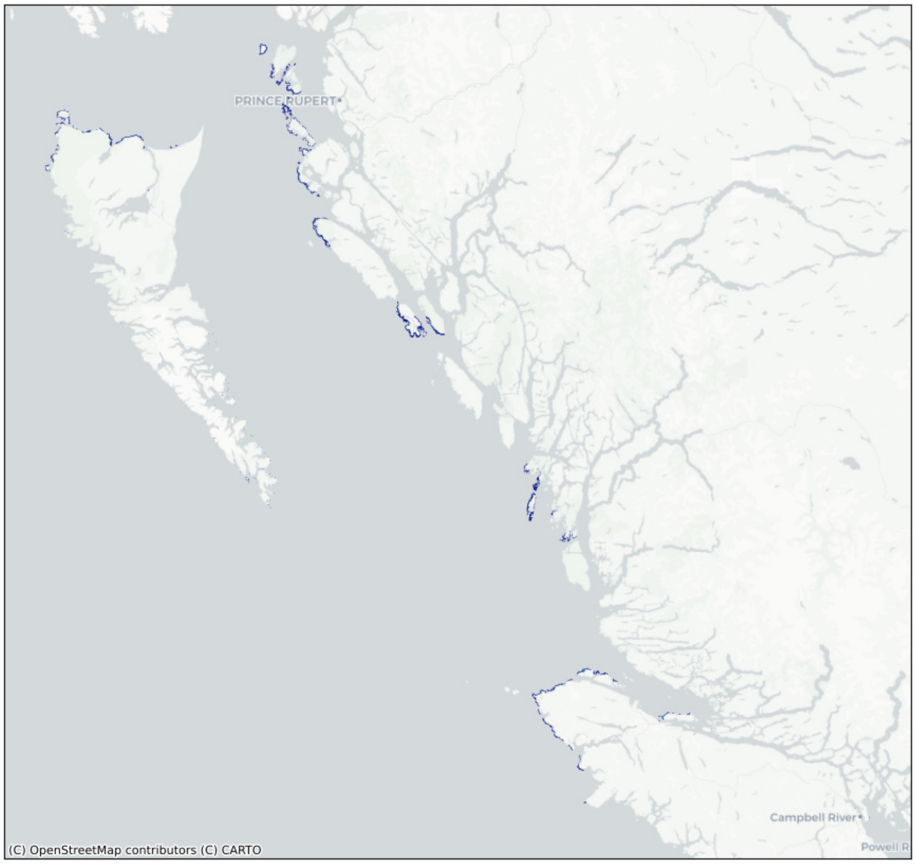

Figure 184: Polygons delineating Bull Kelp beds compiled by the BCMCA.

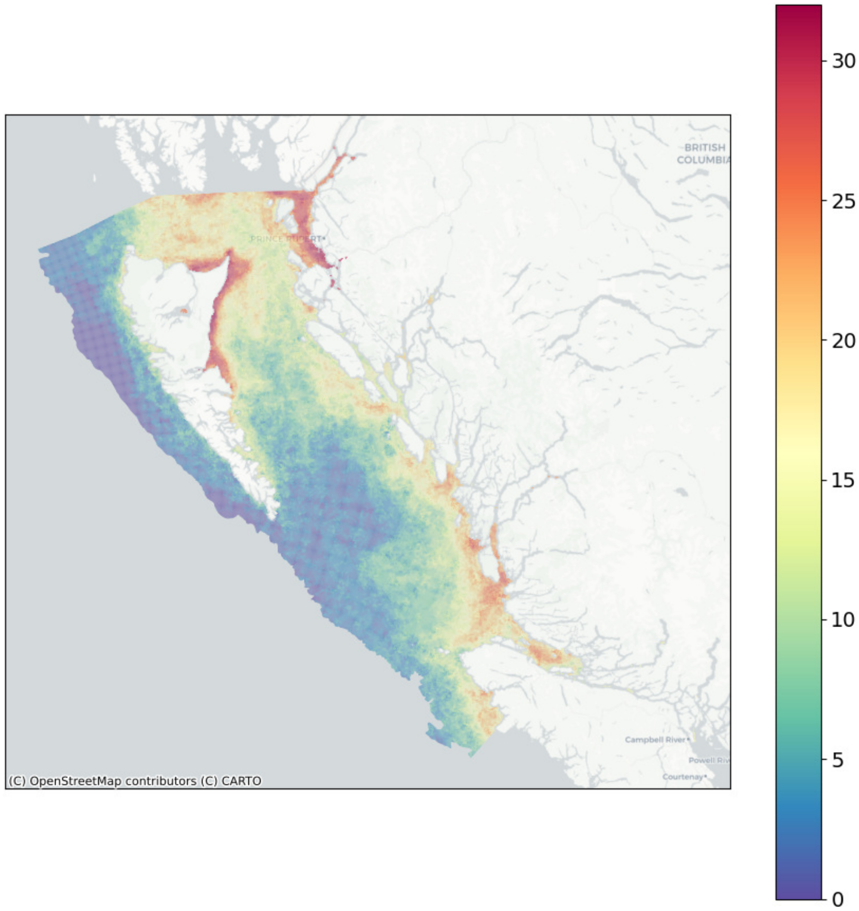

Figure 185: Near-surface Chlorophyll *a* bloom frequency.

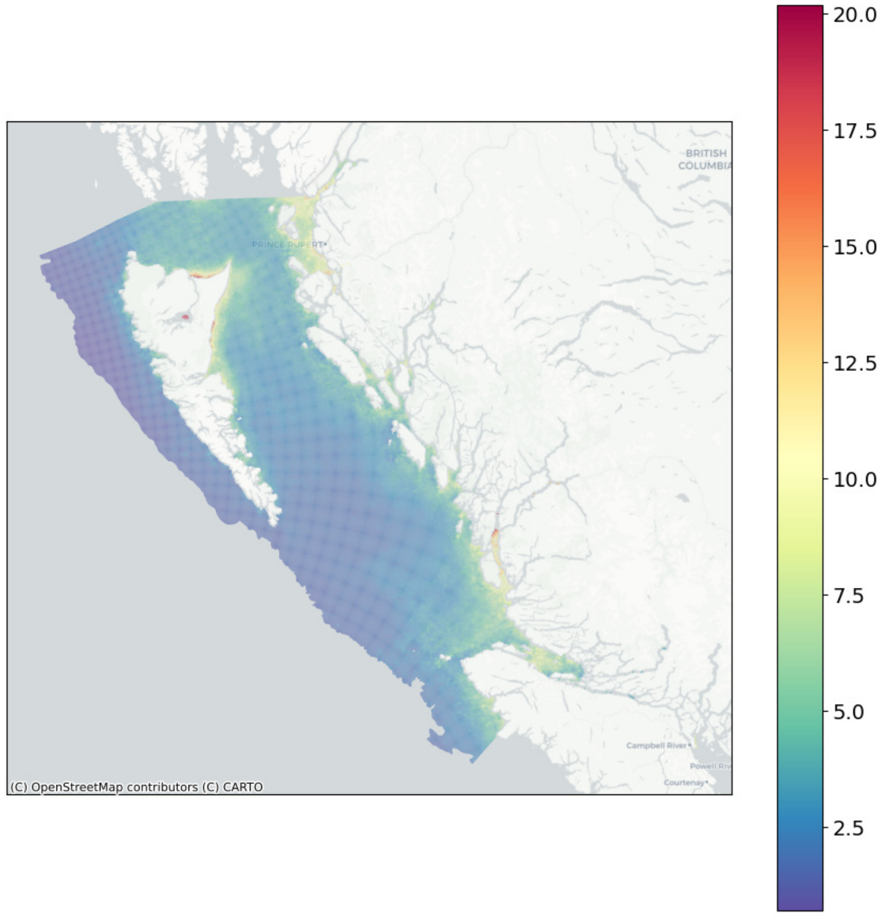

Figure 186: Near-surface Chlorophyll *a* concentration.

Figure 187: Coastline segment surveyed for patchy or continuous presence of eelgrass.

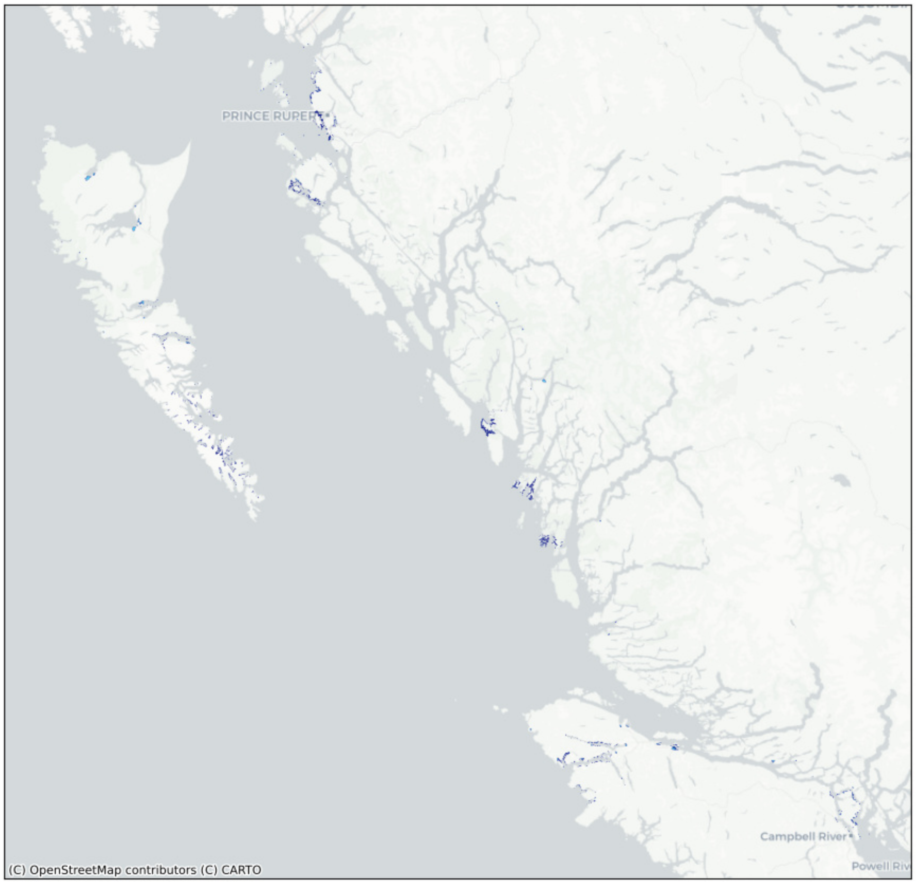

Figure 188: Polygons delineating eelgrass beds compiled by the BCMCA, with updates.

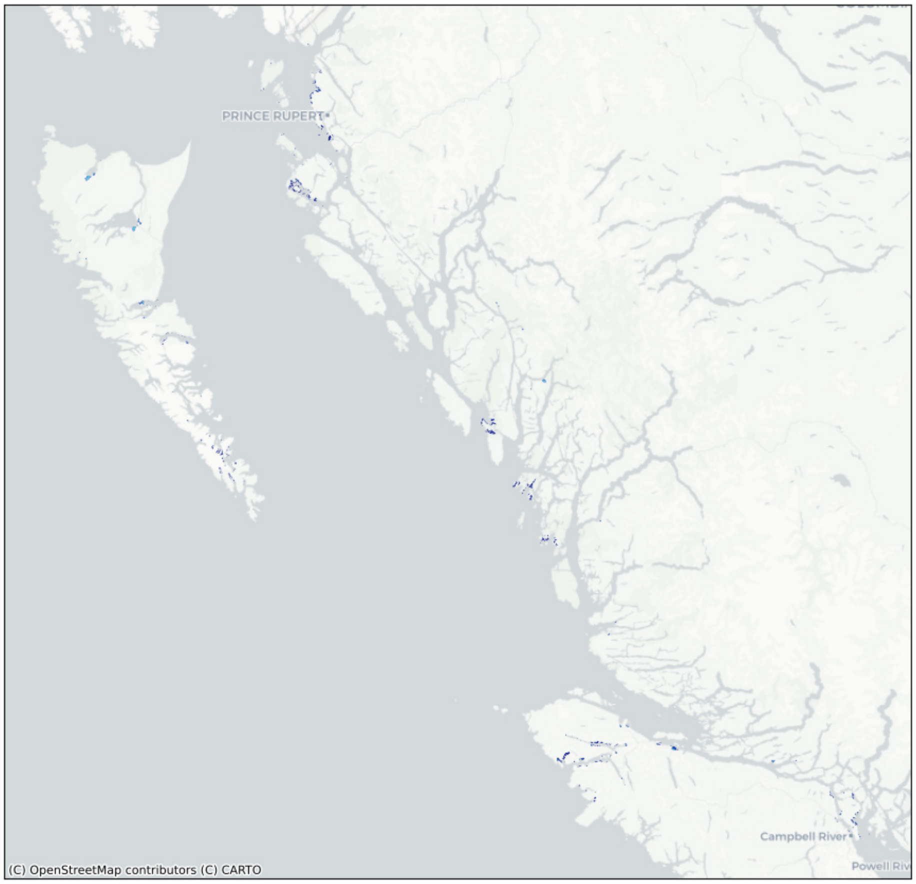

Figure 189: Polygons delineating eelgrass beds compiled by the BCMCA, with updates, and prioritized based on their association with key marine species (Pacific Herring, Great Blue Heron, Dungeness Crab, Brant, estuaries).

Figure 190: Polygons delineating kelp beds where species was not identified, compiled by the BCMCA.

Figure 191: Coastline segment surveyed for patchy or continuous presence of Giant Kelp.

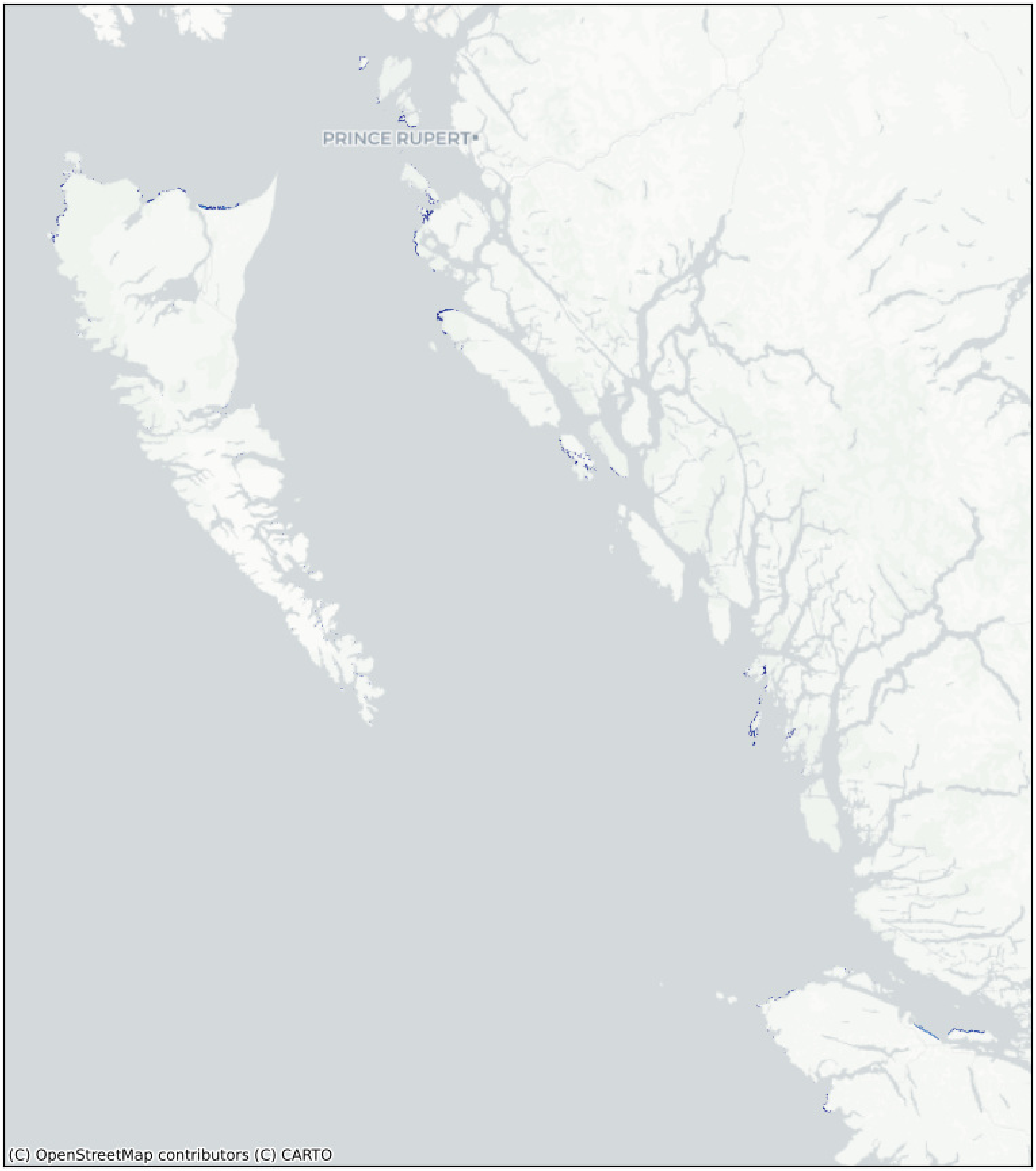

Figure 192: Polygons delineating Giant Kelp beds compiled by the BCMCA.

Figure 193: Coastline segment surveyed for patchy or continuous presence of surfgrass.

CONCLUSION

This report summarizes the details for ecological spatial features compiled by MPATT to support the NSB MPA network planning process following guidance from CSAS peer-review meetings held in 2016 and 2017. The spatial features displayed in the report are the result of a collaborative effort by staff from across the planning partner organizations. While the focus was on spatial features representative at the scale of the NSB, the individual datasets were generated from a wide variety of source datasets using a variety of methods and, as such, have varying spatial extents, resolutions, temporal scales, and uncertainties. Further information can be obtained through the MPATT SeaSketch Portal or from the data custodians.

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