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Pacific Region

Identification of Representative Seamount Areas in the Offshore Pacific Bioregion, Canada

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ABSTRACT

The Offshore Pacific Bioregion (OPB) is a dense cluster of ecologically and biologically significant areas, most of which are underwater mountain ranges known as seamounts. Seamounts support a range of ecosystems, depending on a suite of physical and biological characteristics. The Fisheries and Oceans (DFO) Science Branch was asked to develop an ecological assessment to identify representative seamount areas to detect changes within the OPB (i.e., areas that capture examples that reasonably reflect the full range of ecosystems present at the scale of assessment). The focus of the assessment is an Area of Interest (AOI) in anticipation of a proposed Large-Scale Marine Protected Area.

Historically little is known about the variety of ecosystems and species supported by the OPB seamounts. Before 2017, research on the OPB seamounts was limited to information from the relatively small fisheries and rare scientific surveys. Since then, the Deep Sea Ecology program (DFO Pacific Region) has led three intensive seamount surveys. Herein we identify and describe representative seamount areas primarily using models, classification systems, habitat-level surrogates, and ground-truthing with the new survey data. We also identify new seamounts, new seamount classes, natural seamount boundaries, the ecological uniqueness and ecosystem functions provided by each seamount, species found on seamounts, existing knowledge, and anticipated environmental changes.

There are 62 seamounts in the OPB, 47 of which are in the AOI, and dozens that are newly discovered and unnamed. We found that depth- and nutrient-related seamount characteristics are often indicative of enhanced ecological characteristics, where seamounts with shallower summits and higher potential flux of particulate organic carbon support regionally unique or rare species or habitats, higher biomass, higher biological diversity, and more ecosystem functions. Shallower, more productive seamounts are also more likely to have pre-existing data, have attracted previous research, and are more likely to suffer anthropogenic impacts, now and in the future (e.g., fishing and climate change). The evaluation herein determined all seamounts provide rare shallow offshore ecosystems and support ecologically important species (e.g., cold-water corals and sponges). However, Union, Dellwood, and Explorer seamounts are *unique* or rare within the AOI (and the OPB). The establishment of the proposed Marine Protected Areas (MPAs) will significantly enhance the representativity of offshore ecosystems and species within conservation areas. Together with the existing SG̲aan K̲inghlas-Bowie Marine Protected Area, all regional seamount classes will be protected within conservation areas—with only a few examples of notably different seamounts occurring outside of a conservation area (e.g., SAUP 5494 and Tuzo Wilson). SK-B, Union, Dellwood, and Explorer seamounts are also identified as good candidates for representative seamount areas (i.e., reference sites) to detect changes.

The ecological assessments within this Research Document are intended to support ongoing adaptive ecosystem management, to be re-examined as questions that arise regarding management and monitoring.

1. INTRODUCTION

1.1. CONTEXT

Canada's Oceans Act provides the legislative framework for an integrated ecosystem approach to manage oceans, particularly in areas considered ecologically or biologically significant. To guide management efforts, in 2015, Canada adopted international and domestic 2020 Biodiversity Goals and Targets. The United Nations Convention on Biological Diversity (CBD) Aichi Biodiversity Target 11 (reformatted as Target 1 of the 2020 Biodiversity Goals and Targets for Canada) called for the conservation of 10% of coastal and marine areas by 2020 (CBD 2011, DFO 2016). The Government of Canada has since announced it will join the European Union Biodiversity Strategy for 2030, committing to protect 25% of its land and seas by 2025 and 30% by 2030. Under the Oceans Act, Fisheries and Oceans Canada (DFO) is legislated to provide protection to areas of the oceans and coasts through the establishment of Marine Protected Areas (MPAs), where the identification of an Area of Interest (AOI) is the first step in this process.

In 2017, DFO identified the southern portion of the Offshore Pacific Bioregion (OPB) as an AOI, in anticipation of a proposed Marine Protected Area (MPA; Figure 1). The proposed Offshore Pacific MPA would contribute to the protection and conservation of the region's unique seamounts and hydrothermal vents. These features are Ecologically and Biologically Significant Areas (EBSAs) and Vulnerable Marine Ecosystems (VMEs) that are unique within Canada to the OPB, with the majority located inside the AOI (Ban et al. 2016; DFO 2019a).

Seamounts are underwater volcanic mountains that rise abruptly ≥1 km above the deep abyssal and bathyal plains, dramatically altering environmental conditions. The OPB seamounts are uniquely shallow habitats offshore and are known to provide important habitat and food for species of conservation concern, as well as socially, culturally, and commercially valuable species, including cold-water corals and sponges, rockfish, halibut, whales, and seabirds (Ban et al. 2016; DFO 2019a).

Representative ecosystems are considered a collection of areas that capture examples of different biogeographic subdivisions that reasonably reflect the full range of ecosystems present at the scale of assessment, including the biotic and abiotic diversity of those ecosystems (CBD 2008; DFO 2013). EBSA management and monitoring places particular emphasis on the role of representativity in protecting sites of high biodiversity value, such as seamounts (DFO 2013).To assess the representation of ecosystems in protected areas, accurate and informative spatial baseline information is essential (DFO 2013).

DFO Oceans Management Branch has requested that DFO Science Branch develop an assessment, based on ecological criteria, to identify representative seamount areas in the Offshore Pacific AOI, to identify natural seamount boundaries, and to assess the ecological uniqueness and ecosystem functions provided by each seamount. This advice will guide management and monitoring decisions for seamount conservation and protection within the OPB and AOI, and will inform the future application of the Ecological Risk Assessment Framework (ERAF; similar to DFO 2015) (details on ERAFs provided under Objective 6).

1.2. OBJECTIVES

The purpose of this Research Document is to evaluate the representative seamount areas in the OPB, with a focus on the AOI for the proposed Offshore Pacific MPA.

For this Research Document and the accompanying Science Advisory Report (SAR), the objectives presented in the Terms of Reference were reworded and reorganized for clarity (Table 1). In particular, the original Objective 1 was split in two, and Objective 4 was reworded to clarify the use of the term “important seamount area” (see Scope section below).

Table 1. The Terms of Reference objectives were reworded for presentation in the Science Advisory Report (SAR) and Research Document.

Objectives in the Terms Of Reference	Objectives in SAR and Research Document
1. Update information for the nomenclature, location and systematic classification of seamounts in the OPB	1. Update information for the nomenclature and location of OPB seamounts
2. Identify natural boundaries or zones within the OPB	2. Identify natural boundaries or zones within the OPB
	3. Update information for the systematic classification of OPB seamounts
3. Assess the uniqueness and ecosystem functions provided by each seamount within the OPB	4. Assess the uniqueness and ecosystem functions provided by each OPB seamount
4. Identify important seamount areas within the OPB, focusing on the AOI related to the proposed Offshore Pacific MPA	5. Identify representative seamount areas to detect changes within the OPB
5. Inform the future application of the Ecological Risk Assessment Framework (ERAF)	6. Inform the future application of the ERAF to the AOI
6. Examine and identify uncertainties in the data and methods	7. Examine and identify uncertainties in the data and methods

1.3. SCOPE

The Research Document:

- Assesses all 62 known Canadian seamounts (at the time of the 2020 CSAS meeting), including those in the AOI, SḴ-B MPA, and those in the OPB but outside conservation areas.
- Focuses on benthic ecosystems and their associated species, such as large cold-water corals and sponges.

Does not address the concept of “Important Areas” under the EBSA framework. “Important Areas” is a DFO term used to communicate a specific concept under the EBSA framework (i.e., important areas are considered those with regionally rare, significant, or functionally important species; Clarke et al. 2006) and that the similar wording of “important seamount areas” had inadvertently misrepresented the working paper. The terminology used was changed from “important seamount areas” in the Science Request and Terms of Reference to “representative seamount areas” in all subsequent documents.

1.4. BACKGROUND

1.4.1. Offshore Pacific Bioregion (OPB)

The OPB is one of four biogeographic units within Canada's Pacific Ocean based on the DFO classification system (Figure 1) (DFO 2009a). The other three biogeographic units are the Northern Shelf, Southern Shelf, and Strait of Georgia bioregions (DFO 2009a). The OPB extends outward from the continental slope (DFO 2019a), covering approximately 316,000 km^2, overlaying the transitional area of the Alaska and California coastal currents (DFO 2009a, 2019a). Below the water, the OPB overlays a tectonically active and heterogeneous environment. The OPB seafloor is made up of the Pacific, Juan de Fuca, and Explorer oceanic plates and the Cascadia subduction zone of the North American continental plate. The resulting terrain is a remarkably dense cluster of seamounts (underwater volcanic mountains), hydrothermal vents (orifices extruding superheated geothermal fluids), faults, rifts, valleys, ridges, hills, knolls, channels, and bathyal plains. This seafloor complexity is more pronounced in the southern half of the OPB (DFO 2019a) (Figure 2).

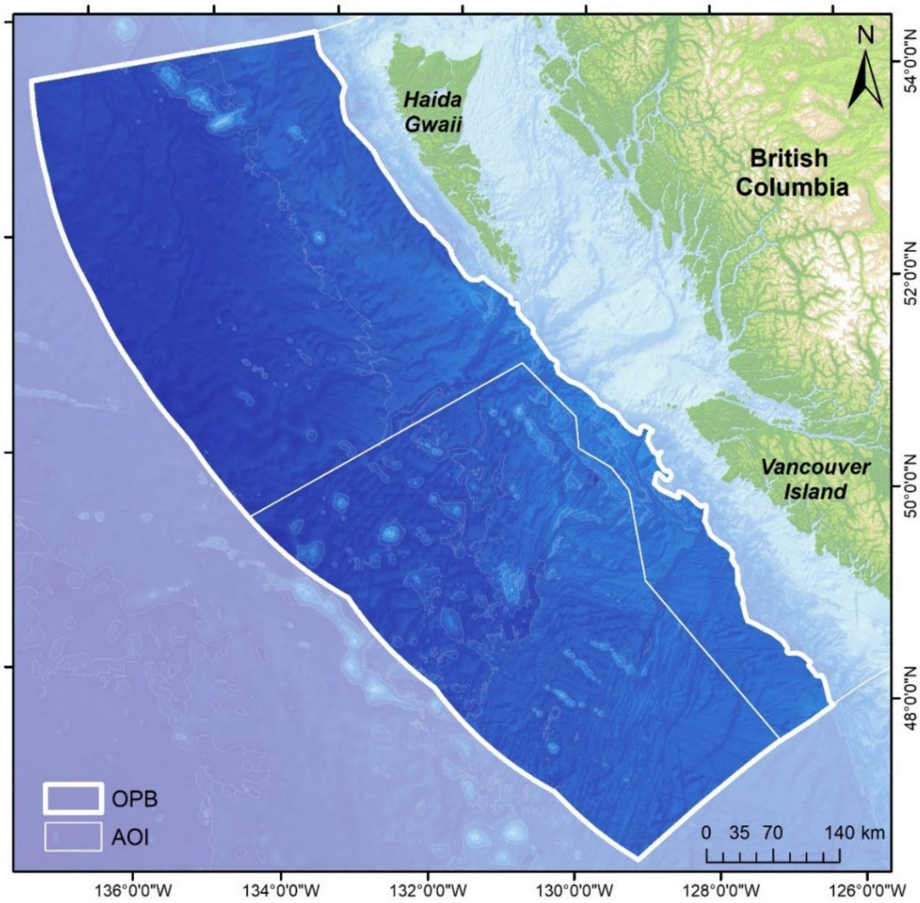

Figure 1. Location of the Offshore Pacific Bioregion (OPB; study area) and the Area of Interest (AOI; focus area) seaward of Pacific Canada's continental slope.

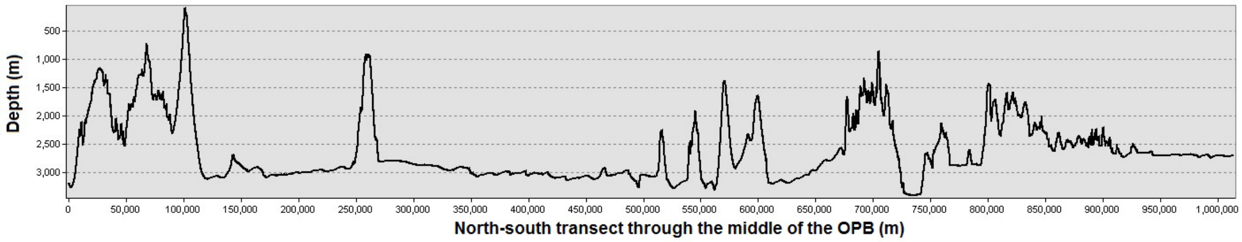

Figure 2. Bathymetry profile north to south through the middle in the Offshore Pacific Bioregion (OPB). The Area of Interest (AOI) covers the second half of the profile (southern half of the OPB; ~500,000 to 1,000,000 m along the transect), where the seafloor is more heterogeneous.

1.4.2. Area Of Interest (AOI) for the proposed Offshore Pacific Marine Protected Area (MPA)

In 2017, following the conclusion of a regional AOI selection process, the southern portion of the OPB, an area covering approximately 133,000 km^2, was announced as an AOI for the potential establishment of the Offshore Pacific MPA (Figure 1). Based on its size, the AOI meets the criteria for Large-Scale Marine Protected Areas (LSMPAs >100 km^2; Lewis et al. 2017). The AOI interim conservation objective is to “Contribute to the protection and conservation of the unique seafloor features (i.e., seamounts and hydrothermal vents) and the ecosystems they support in Canada’s [OPB].” Where an ecosystem is considered a dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit (DFO 2019a). The identification of EBSAs in Canada’s OPB informed the area selection (Ban et al. 2016; DFO 2019a). Ban et al. (2016) used the seamount Ecosystem Evaluation Framework (initially developed by Pitcher and Bulman 2007 and Pitcher et al. 2007) to systematically assess the current level of knowledge regarding the range of seamount ecosystems within the OPB. At this time, only 19 named seamounts were included in the assessment (Figure 3), although as many as 36 were thought to potentially exist.

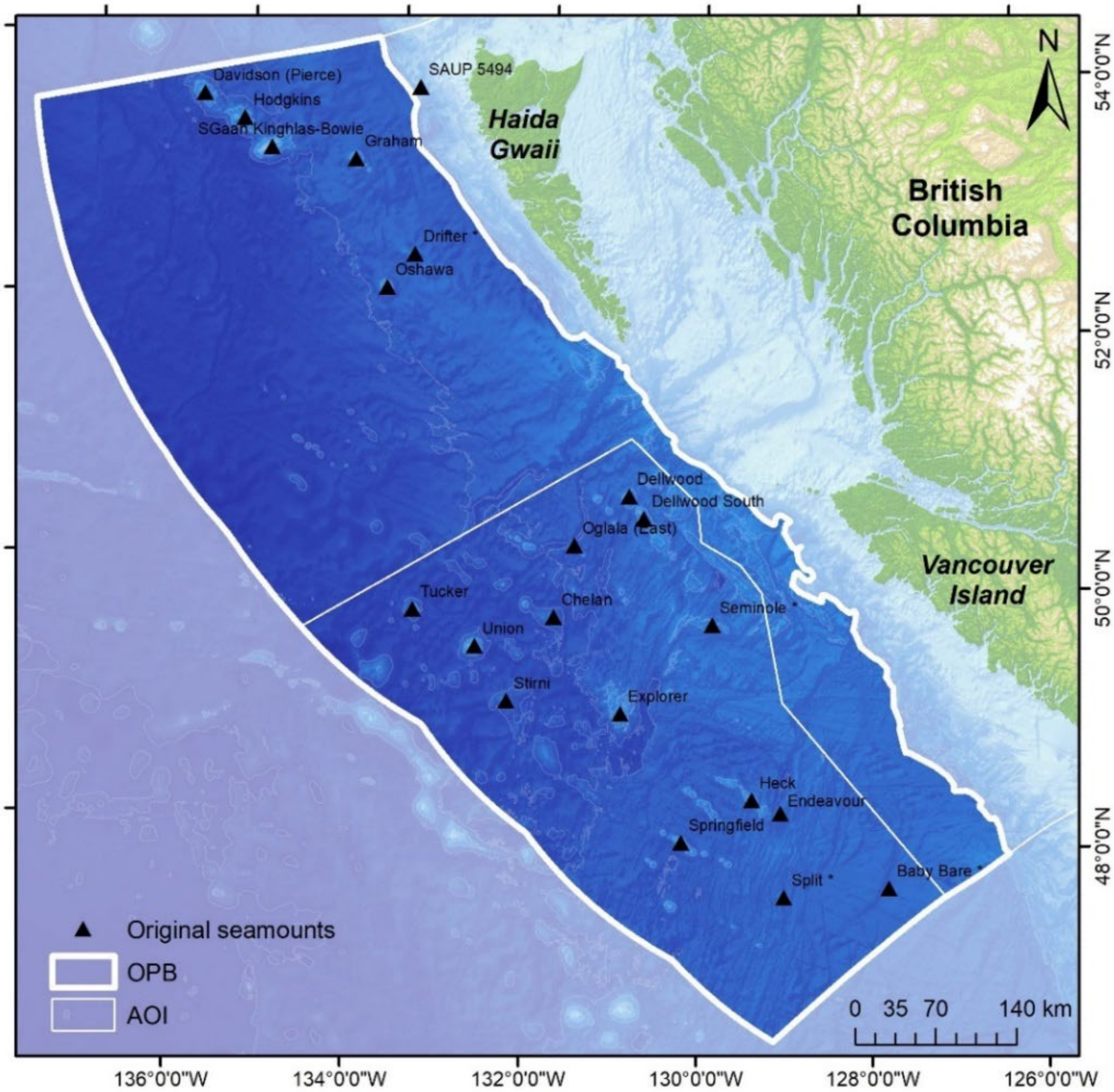

Figure 3. Locations of the original 19 named seamounts identified within the Offshore Pacific Bioregion (OPB) (Ban et al. 2016), plus Endeavour Seamount (DFO 2019a) and Drifter seamount (Cousens et al. 1999) (historically known). An asterisks marks features that have common names that include the word "seamount" (i.e., Drifter Seamount, Baby Bare Seamount, Grizzly Bare Seamount, Seminole Seamount, and Split Seamount) but that are technically knolls or hills (smaller than a seamount, <1 km elevation). Also shown: the Offshore Pacific Bioregion (OPB) and the Area of Interest (AOI).

A biophysical and ecological overview was completed to assist in formulating and refining conservation objectives, delineating the AOI boundary for the proposed MPA (and zones if required), and contribute to completing an ecological risk analysis to inform the development of the regulatory approach for the MPA (DFO 2019a). A systematic review of seamount models was used to generate a comprehensive list of known and predicted seamounts in the OPB. At this point, 52 seamounts were identified within the OPB, 32 of which were new. This overview was also the first application of the global seamount classification scheme to OPB seamounts (Clark et al. 2011). Since the overview publication, zoning consultation has begun, and the AOI boundary has been refined.

Following the announcement of the AOI, the temporary Offshore Pacific Seamounts and Vents (OPSVC) Closure was initiated (Figure 4). The Fisheries Act closure covers approximately 82,500 km^2 or 62% of the AOI and encompasses all known hydrothermal vent fields and the majority of known seamounts. The interim closure prohibits “human activities that are incompatible with the conservation of the ecological components of interest that may occur or be foreseeable within the area.” This includes “all bottom-contact commercial and recreational fishing activities.” Prior to the closure, the shallower seamounts were fished for sablefish (*Anoplopoma fimbria*), rockfish (*Sebastes* spp.), Pacific halibut (*Hippoglossus stenolepis*), and other groundfish, using bottom-contact long-line trap and hook gear. Bottom-contact gear can be extremely harmful to habitat-forming[1] cold-water corals and sponges, taxa listed as ecological components of interest, along with endemic hydrothermal vent species (DFO 2019a). When established, the MPA will be permanent and, at a minimum, will prohibit four key industrial activities: oil and gas activities, mining, dumping, and bottom trawling (DFO 2018).

In addition to containing the OPSV Closure, the AOI also encompasses the Endeavour Hydrothermal Vents Marine Protected Area (EHV MPA)—Canada’s first MPA and the world’s first hydrothermal vent MPA (DFO 2009b; Figure 4). This 100 km^2 MPA, designated in 2003, encompasses four vent fields. Its conservation objective is to “ensure that human activities contribute to the conservation, protection, and understanding of the natural diversity, productivity and dynamism of the ecosystem and are managed appropriately such that the impacts remain less significant than natural perturbations (e.g., magmatic, volcanic or seismic)” (DFO 2009b).

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[1] Habitat-forming cold-water corals and sponges are structural habitats, which refers to the presence of abiotic and biotic physical structures in a system to the degree that influences ecological patterns and processes. Structural habitat creates heterogeneity and complexity, providing niches, access to food and other resources, and refuge from predators. As a result, the presence of structural habitat often supports a higher abundance and richness of organisms in the system.

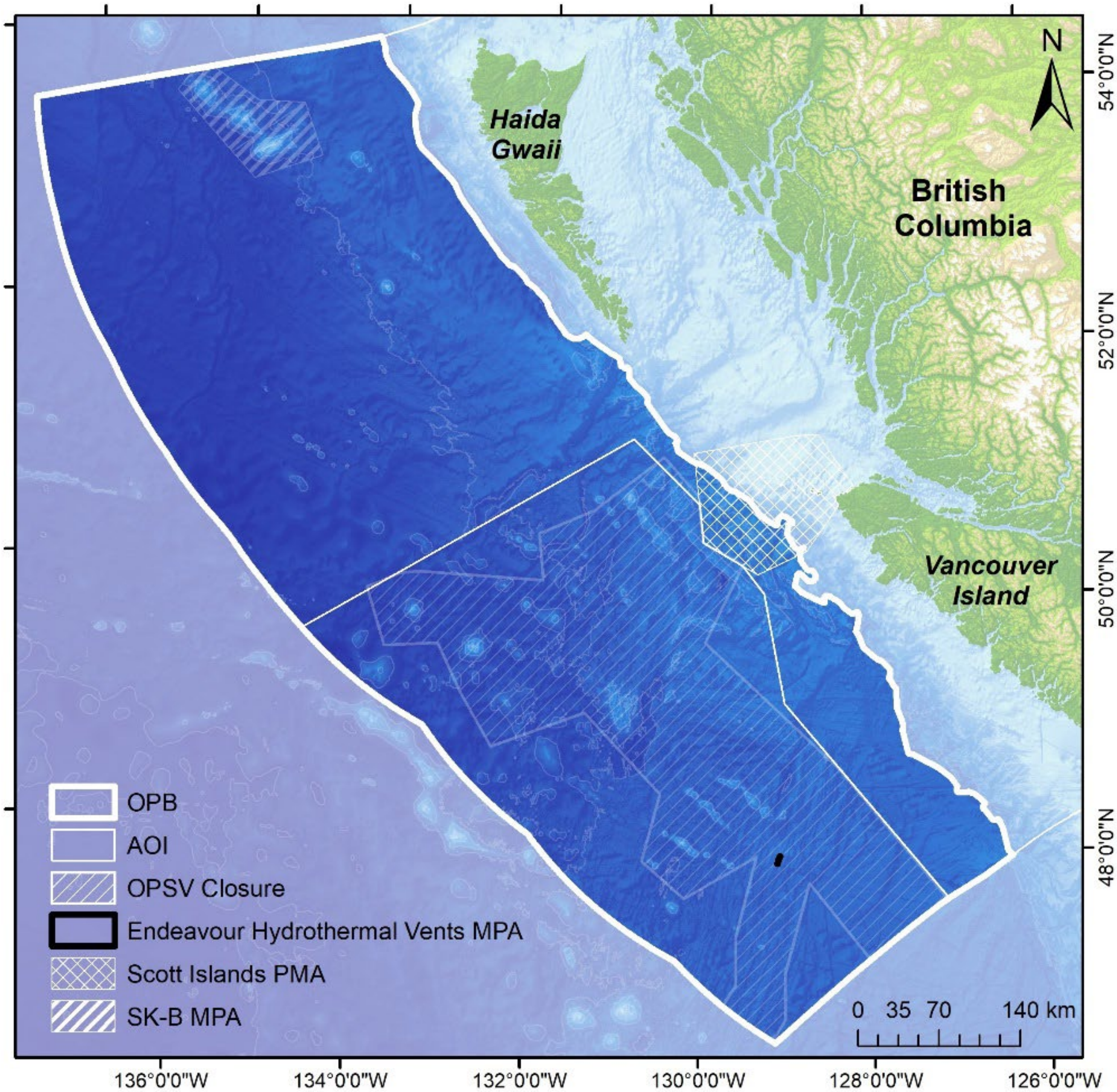


Figure 4. Locations of the existing conservation areas within the Offshore Pacific Bioregion (OPB): the Area of Interest (AOI), the Offshore Pacific Seamounts and Vents (OPSV) Closure (within the AOI), the Endeavor Hydrothermal Vents Marine Protected Area (EHV MPA; within the AOI), the Scott Islands Protected Marine Area (PMA), and the S<u>G</u>aan <u>K</u>inghlas-Bowie Seamount Marine Protected Area (S<u>K</u>-B MPA).

1.4.3. Other offshore conservation areas

There are two conservation areas in the OPB outside the AOI, Scott Islands Protected Marine Area (SIPMA) and S<u>K</u>-B MPA (Figure 4). The SIPMA extends outwards from the Scott Islands (Government of Canada 2020), partially overlapping 4,200 km^2 of the OPB where it shares a boundary with the AOI. This area does not overlap with any known seamounts or hydrothermal vents (DFO 2019a). On the other hand, at 6,100 km^2, S<u>K</u>-B MPA, was designed to encompass the three most northern OPB seamounts, S<u>G</u>aan <u>K</u>inghlas (also called Bowie), Hodgkins, and Davidson (also called Pierce) seamounts (CHN and DFO 2019). S<u>K</u>-B is the shallowest seamount in Canada, an important cultural site of the Haida Nation, and one of the most unique and well-studied seamounts in the world (CHN and DFO 2019).

The major conservation objective of SK-B MPA is to ensure “the unique biodiversity, structural habitat and ecosystem function of the SK-B MPA are protected and conserved” (CHN and DFO 2019). There are three operational (sub) objectives: (1) Populations of rare, localized, endemic and vulnerable species are protected and conserved; (2) habitats that are essential for life-history phases of species within the MPA are protected and conserved; and (3) ecosystem food webs are protected and conserved. The first and second operational objectives specifically call for the conservation and protection of: “cold-water corals and sponges” and “sensitive benthic habitats” (habitats that are vulnerable to proposed or ongoing human activities, which includes cold-water coral and sponge habitats), with references to other organisms (e.g., “other invertebrates” and “fishes”).

1.4.4. Representative seamount areas

Seamounts are classified by the Government of Canada and the CBD as EBSAs (Ban et al. 2016; CBD 2016; DFO 2019a). Seamounts are also among the physiographic indicators of a VME under the language within the United Nations General Assembly Resolution 61/105 (FAO 2009; Watling and Auster 2017). DFO recognizes many of the frameworks and criteria used within DFO science and elsewhere in the scientific community are equivalent concepts, especially in the case of EBSAs and VMEs (Koen-Alonso et al. 2018, DFO 2019a,b) and DFO recently identified all Canadian Pacific seamounts and hydrothermal vents as EBSAs and VMEs (Ban et al. 2016, DFO 2019b). The EBSA and VME designations of seamounts are predominately owing to the benthic ecosystems they support, specifically those created by the physical structures of cold-water corals, sponges, and other habitat-forming invertebrates. That said, it is also widely known that the surface and mid-waters over seamounts host an enhanced abundance and diversity of transient life, such as seabirds, whales, sharks, oceanic fishes, etc. (DFO 2019a). Because of the large sphere of influence seamounts are known to have on surrounding ocean health and ecological functions and services, seamount EBSAs are considered to include up to 30 km of the surrounding ocean (DFO 2019a).

While the official seamount conservation objectives of the Offshore Pacific MPA are still being developed, the condition and abundance of cold-water corals and sponges will likely be important elements, based on the precedent set by the national and international designations of seamounts, the interim AOI and OPSV Closure objectives, and the SK-B MPA management plan. It then follows that representative seamount areas that support regionally rare, significant, or functionally important cold-water corals and sponges will be among the most important seamount areas this evaluation can aim to identify. Cold-water corals and sponges are important components of benthic ecosystems, especially seamounts. They are often used as indicators of ecosystem integrity and biological diversity because they are long-lived, slow-growing, and form large, fragile biogenetic structures which provide habitat heterogeneity, substrate for settlement and shelter, nurseries, enhanced foraging opportunities, nutrients, etc.—changing the ecosystem itself (i.e., as foundation species and/or ecosystem engineers) (Buhl-Mortensen et al. 2010). These characteristics qualify cold-water corals and sponges as ecologically significant species essential to maintaining ecosystem structure and function (Boutillier et al. 2010).

Extrapolating benthic visual survey data to identify important areas is common practice in landscape ecology (species distribution models, habitat suitability models, etc.). However, because of the dearth and coverage limitation for deep-sea visual surveys (remote, costly, logistically challenging, and finite), the data are limited in what they can show us in time and space. Visual surveys are an invaluable snapshot of a discrete area but of a relatively limited footprint in comparison to the size of a seamount. For example, Union Seamount is one of the most well-explored seamounts in the OPB, with five benthic visual transects completed. These dives occurred over a 4-day window, from July 21st to 24th, 2017. The dives were to a maximum depth of 2,100 m (equipment depth limit) and covered roughly 23.3 km or 0.09 km^2 (area calculation based on a generous camera field of view 4-m wide). However, Union Seamount starts at 3,239 m depth and covers 680 km^2. So although we have successfully surveyed the top two-thirds of its height, our visual surveys have covered only 0.013% of its area. In comparison, we have environmental data (i.e., remotely sensed data) that has interpolated full coverage over the OPB (e.g., maps of seafloor bathymetry, slope, chlorophyll-a maps, etc.). Benthic visual survey data extraction (annotation) is ongoing, and our intention is to generate species distribution models in the future.

To assess the representative seamount areas, we leveraged the best available data by focusing our analyses on environmental data and then ground-truthing these findings using the species distribution data (predominately cold-water coral and sponge data). In other words, we provisionally identify representative seamount areas using ecological principles, proxies or surrogates, informed by existing empirical data and observations. We also identify natural seamount boundaries and assess the ecological uniqueness and ecosystem functions provided by each seamount. We focus on identifying regionally rare habitats because they are the most likely to support regionally rare species (habitat diversity promotes biological diversity; Foley et al. 2010). Rare species are vulnerable to human-induced disturbances and contribute disproportionately to the functional structure of species assemblages and the overall integrity of the ecosystem (Mouillot et al. 2013; Leitão et al. 2016;). Using habitat-level surrogates is a highly cost-effective method for the initial identification of high-priority areas to manage marine biological diversity (e.g., Clark et al. 2011; Ward et al. 1999; Visalli et al. 2020). In addition to ecologically significant species, other types of significant species considered herein are species of conservation concern and socially, culturally, and commercially important species. Because the OPB and AOI are large, remote, and difficult to survey, we also offer some pragmatic variables to consider when identifying representative areas for monitoring and protection, such as anticipated changes and existing baseline data.

2. ASSESSMENT

2.1. OBJECTIVE 1: SEAMOUNT IDENTIFICATION AND NAMING

2.1.1. Methods

The OPB seamounts were identified using published locations of seamounts (Canadian Gazetteer, NRC 2015; Ban et al. 2016; DFO 2019a), a compilation of bathymetric maps (e.g., new data from research cruises; Figure 5), a systematic review of six seamount models (four listed in DFO 2019a: Kitchingman and Lai (2004), Manson (2009), Kim and Wessel (2011), and Yesson et al. (2011); plus Harris et al. (2014) and Yesson et al. 2020; Figure 6), and geophysical criteria (Figure 7).

2.1.1.1. Mapping and geoprocessing

We performed all mapping and geoprocessing in ArcGIS 10.8. Distances and surface areas were measured in two-dimensional space projected in UTM 8N and 9N (west and east of 132° longitude, respectively; if a measurement crossed 132° longitude, the UTM containing the majority of the distance measured was used).

2.1.1.2. Bathymetry data

The OPB has limited coverage of high-resolution bathymetric mapping. We generated a ‘best available data’ mosaic map by stacking a high-resolution Global Multi-Resolution Topography (GMRT) v3.7 (Ryan et al. 2009) map of the entire region (gridded at 244 m resolution) with recently collected multi-beam bathymetry (30-m resolution; collected on Pac2018-103 expedition; available on the Marine Geoscience Data System, and interpolated bathymetry for Union Seamount (100-m resolution) (Figure 5). Bathymetric data collected by submersible vehicles during benthic visual surveys were also used for ground-truthing seafloor profiles (DFO seamount expeditions: Pac2017-036, Pac2018-103, Pac2019-014)—such as single-beam sonar (<25-m resolution) (Figure 5) and submersible-mounted sensors (see section 2.2.1.3 for details on benthic visual surveys). The interpolated bathymetry for Union Seamount was generated from roughly a dozen summit crossings with single-beam sonar, data from five benthic visual surveys, and decades of fisheries depth-related data, resulting in a higher resolution bathymetric raster than the GMRT (courtesy of Jessica Nephin, Institute of Ocean Sciences). General Bathymetric Chart of the Oceans (GEBCO), another source of bathymetry, was not included in the ‘best available data’ mosaic due to low spatial resolution (continuous global terrain model but relatively low spatial resolution at 15 arc seconds, 450 m).

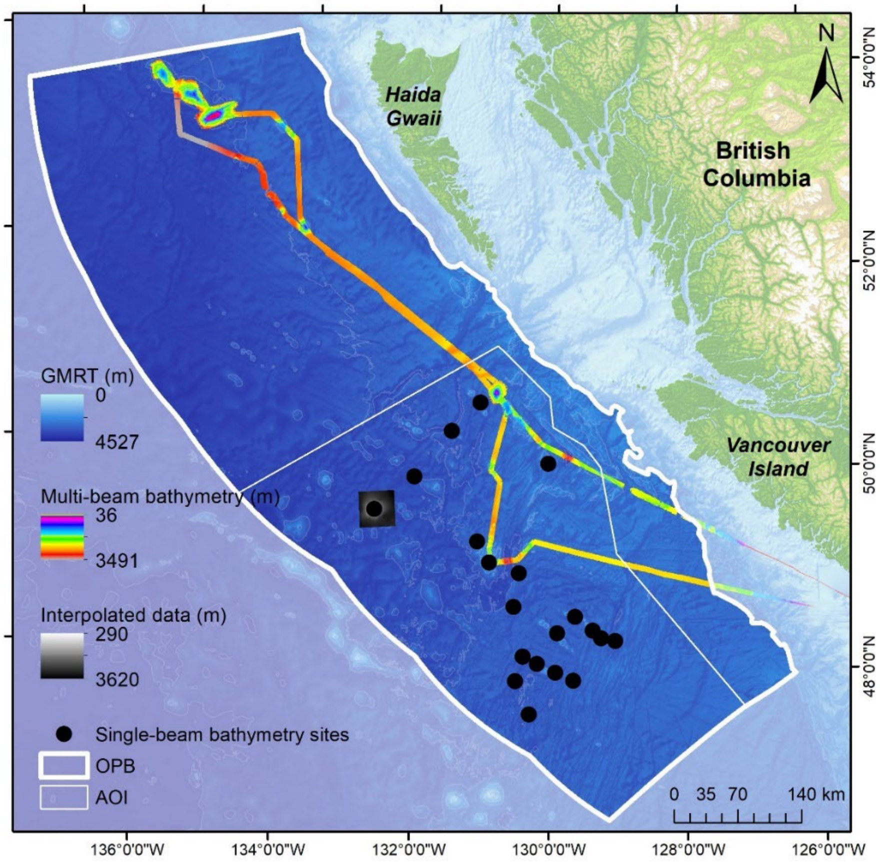


Figure 5. Bathymetric data used in this report includes a mosaic of the Global Multi-Resolution Topography (GMRT) synthesis (gridded at 244-m resolution; base map), multi-beam bathymetry collected during the Northeast Pacific Seamounts Expedition 2018 (30-m resolution; colourful transects), an interpolation of high-density bathymetric data from fishing and scientific surveys (100-m resolution; grey patch over Union Seamount) and single-beam bathymetry transects at 20 sites collected during Northeast Pacific Seamounts expeditions 2017 and 2019 (<25-m resolution; black dots). Also shown: the Offshore Pacific Bioregion (OPB) and the Area of Interest (AOI).

2.1.1.3. Systematic assessment for identifying seamounts

The systematic assessment for identifying seamounts was initially developed to overview the AOI (DFO 2019a). This repeat analysis serves to update the previous inventory by including higher resolution bathymetry maps and additional models. Here we consolidated six seamount models (predictions of summit locations; Figure 6) to create a single dataset by eliminating (i) non-seamount features (elevations <1 km) and (ii) duplicate predictions (e.g., multiple pinnacles of the same mountain identified as individual seamounts).

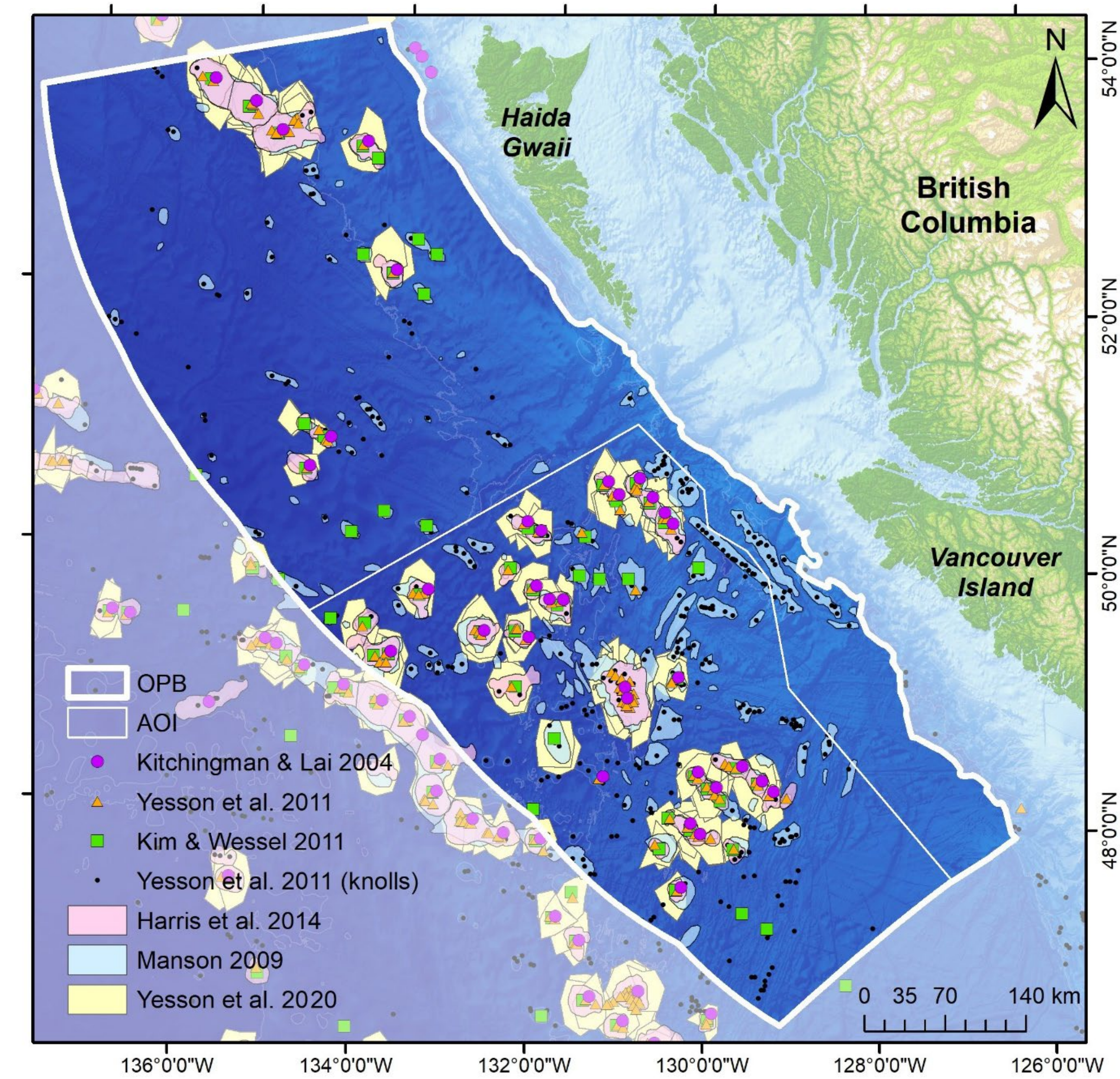
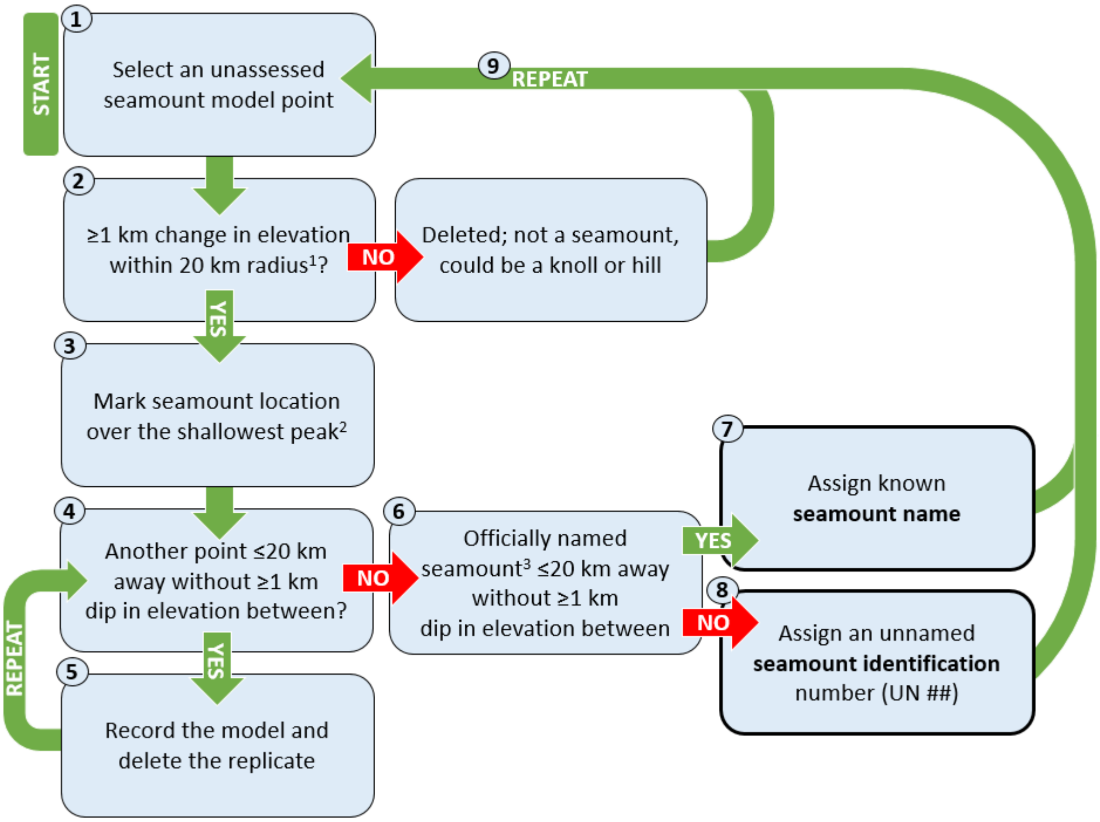


Figure 6. The six models predicting the location of seamount summits by Kitchingman and Lai (2004) (purple circles), Yesson et al. (2011) (orange triangles), Kim and Wessel (2011) (green squares), as well as knoll summits by Yesson et al. (2011) (black dots; seamount-like features); and the location of seamount boundaries by Harris et al. 2014 (pink polygons), Manson (2009) (blue polygons), and Yesson et al. (2020) (yellow polygons). Also shown: the Offshore Pacific Bioregion (OPB) and the Area of Interest (AOI).

Steps for systematically assessing and consolidating the six seamount models (illustrated in Figure 7):

1. We started by selecting any one predicted summit point or polygon centroid from a model, and
2. determined if the bathymetric feature met the pinnacle-to-base ≥1 km elevation criteria (Yesson et al. 2011) using the best available bathymetry. If not, the point was deleted (a knoll or hill if between 500 to 1,000 m elevation or <500 m elevation, respectively; United States Board of Geographic Names 1981).

3. If the feature qualified as a seamount, we marked its summit location (latitude, longitude, depth of the shallowest peak).
4. We then assessed if there were multiple predictions for the same seamount. A point was considered a replicate prediction if it was within 20 km without a ≥1 km dip in elevation.
5. We recorded which models had predicted the seamount and deleted the replicates.
6. We cross-referenced the marked summit location with the location of officially named seamounts.
7. If the marked summit location was within 20 km of a seamount listed in the Canadian Gazetteer or GEBCO, without a ≥1 km dip in elevation between, we assigned the official seamount name to the summit.
8. If the marked summit location was unlisted, we assigned an unnamed seamount identification number (i.e., UN ##).
9. Steps 1 through 8 were repeated for all predicted summit points or centroids.



¹Elevation of ≥1 km between pinnacle-to-base distance (Yesson et al. 2011). ²Seamount summit location recorded as the latitude, longitude, and depth of the shallowest peak. ³Official names as listed in the Canadian Gazetteer (CG) or the General Bathymetric Chart of the Oceans (GEBCO).

Figure 7. Steps for systematically assessing and consolidating six previously published seamount models. These steps were repeated until the prediction locations of seamounts from all six models were assessed to be a known seamount, an unnamed seamount, or deleted as a knoll, hill, or replicate.

2.1.1.4. Quantifying seamount coverage

Seamounts cover vast areas and vary in shapes and sizes, but these characteristics can be overlooked when seamounts are mapped as summit-point locations. To generate a boundary (polygon) of each identified seamount, we analyzed the average slope of the seafloor in the OPB, excluding seamount areas (i.e., within 20 km of a summit). We derived slope (Figure 8) from bathymetry (Figure 5). We calculated the average slope and standard deviation for 10,000 randomly distributed points to characterize the OPB seafloor and to differentiate it from the relatively steep flanks of a seamount. We used a change in slope direction (i.e., aspect; derived from bathymetry) to mark the boundary between two adjacent seamounts (e.g., seamounts in a chain). Simple polygons (e.g., 30-km EBSA buffer and model polygons listed) have been used in the past (e.g., DFO 2019a) can cause a suite of problems (e.g., if they overlap and if the area does not cover the seamount extent, as is the case with EBSA buffers and large OPB seamounts).

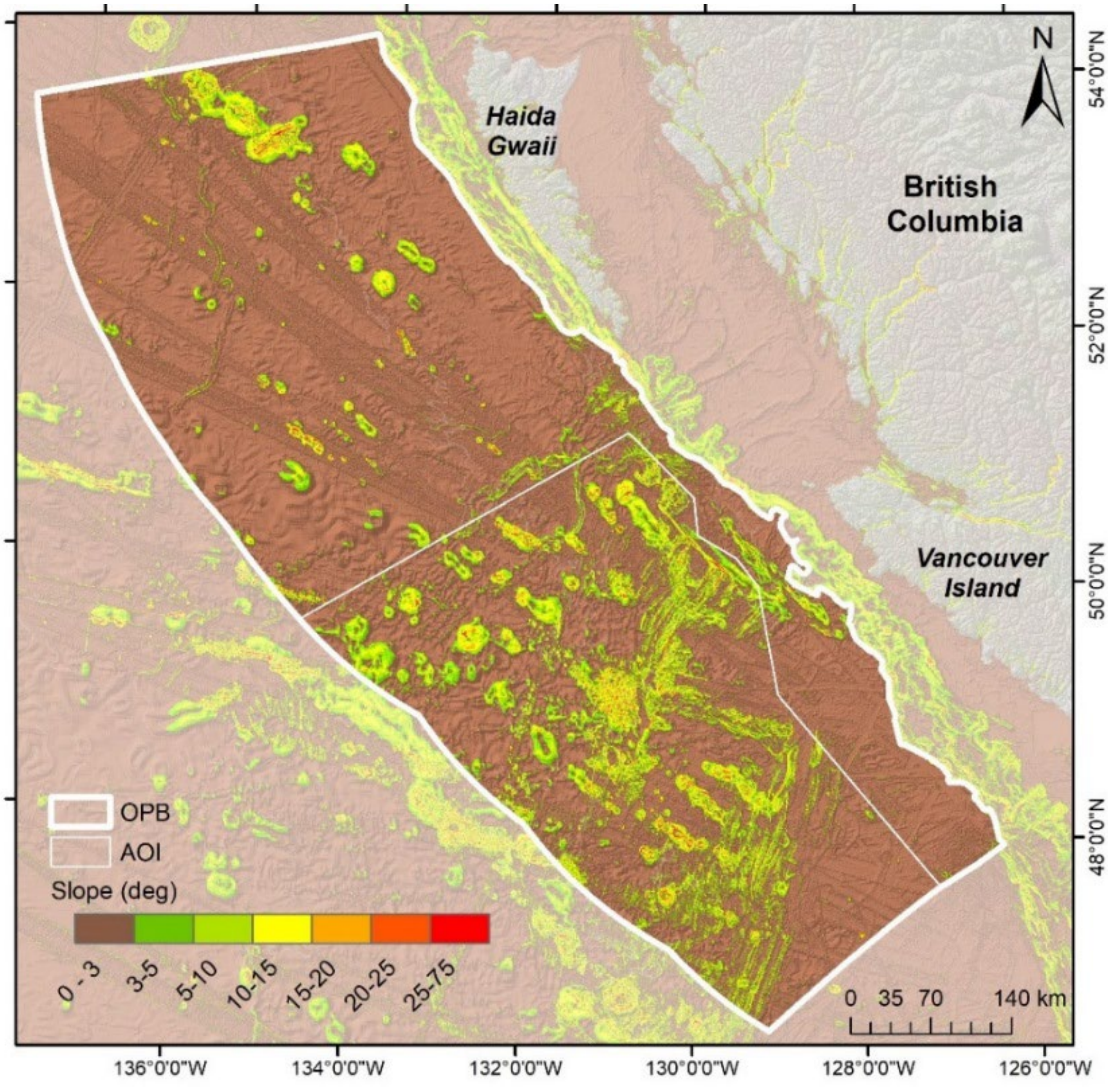


Figure 8. Slope (degrees) of the seafloor in the Offshore Pacific Bioregion (OPB; thick white line) and the Area of Interest (AOI; thin white line). Slope data derived from the bathymetry mosaic (Figure 5). Also shown: the Offshore Pacific Bioregion (OPB) and the Area of Interest (AOI).

2.1.2. Results and discussion

2.1.2.1. Identification and nomenclature

There are now 62 seamounts known or predicted to occur in the OPB (Table 2; Appendix A: Table A1 and A2 contains additional information; shapefiles in Open Maps, DFO 2021), of which 43 are newly identified and unnamed (UN)—ten more since the last inventory: four seamounts listed in DFO 2019a were removed from the inventory (for various reasons) and 14 new UN seamounts were discovered (denoted with * in Table 2). The tripling of seamounts in the OPB since the 2016 count (Figure 3) is a function of increased survey and research efforts within the region. In total, 65% of those found in the OPB are newly identified, unnamed seamounts, predicted by combining multiple bathymetric seamount models and the best available bathymetry.

Table 2. Seamount inventory: summary information for each of the 62 seamounts within the Offshore Pacific Bioregion (OPB). Seamounts included exceed 1 km elevation and are either listed in the Canadian Gazetteer (NRC 2015), predicted by one or more of six published models, are well-known (k), mapped and confirmed (c) during recent expeditions, or a combination thereof. UN = unnamed. Asterisks denote new seamounts (not identified in DFO 2019a)[1]. Seamounts are either within the Area of Interest (AOI), SGaan Kinghlas-Bowie Marine Protected Area (SK-B MPA), or outside conservation areas. Classes are based on a system by Clark et al. (2011), productivity export to summit (low: ≤9.85 C m^{-2} d^{-1}, medium: 9.85-18.78 C m^{-2} d^{-1}, high: ≥18.78 C m^{-2} d^{-1}), summit depth (deep: 3500-801 m, medium: 800-201 m, shallow: ≤200 m), and dissolved oxygen concentration at summit (high: >1 ml/l, low: ≤1 ml/l). Seamounts are listed by summit depth, from deepest to shallowest. Additional seamount information provided in Appendix A: Table A1 and A2.

Seamount name	Summit coordinates (in AOI or SK-B, or outside of conservation areas)	Summit depth (m)	Class	Export productivity	Summit depth	Oxygen conc.
UN 41*	49.818072, -135.10177 (out)	2538	L1	low	deep	high
UN 15	49.532589, -134.12852 (AOI)	2472	L1	low	deep	high
UN 29	50.720553, -134.93982 (out)	2374	L1	low	deep	high
UN 28	50.322715, -133.37737 (out)	2282	L1	low	deep	high
UN 42*	51.069157, -135.03183 (out)	2268	L1	low	deep	high
UN 30	50.95286, -134.72759 (out)	2264	L1	low	deep	high
UN 37*	48.196964, -131.98435 (AOI)	2263	L1	low	deep	high
UN 11	49.323195, -131.30008 (AOI)	2238	L1	low	deep	high
UN 36*	47.729444, -131.36738 (AOI)	2232	L1	low	deep	high
UN 44*	50.193009, -132.70401 (AOI)	2198	L1	low	deep	high
UN 9	48.680612, -131.72344 (AOI)	2138	L1	low	deep	high
UN 34[c]	52.90045, -135.24855 (out)	2103	L1	low	deep	high

Seamount name	Summit coordinates (in AOI or SK-B, or outside of conservation areas)	Summit depth (m)	Class	Export productivity	Summit depth	Oxygen conc.
UN 35[c]*	48.961435, -130.48991 (AOI)	2091	L1	low	deep	high
UN 39[c]*	48.627632, -130.56134 (AOI)	2064	L1	low	deep	high
UN 48*	49.573221, -132.2902 (AOI)	2057	L1	low	deep	high
UN 13	49.49516, -132.18185 (AOI)	2035	L1	low	deep	high
UN 38*	48.406989, -131.20749 (AOI)	1940	M1	medium	deep	high
UN 21	50.007095, -131.54815 (AOI)	1934	M1	medium	deep	high
UN 32[c]	52.426189, -134.42527 (out)	1878	M1	medium	deep	high
UN 45*	50.035884, -132.39638 (AOI)	1866	M1	medium	deep	high
UN 33[c]	53.188725, -134.37533 (out)	1799	M1	medium	deep	high
UN 19[c]	50.001045, -130.95969 (AOI)	1765	M1	medium	deep	high
UN 20	49.994295, -131.30997 (AOI)	1711	M1	medium	deep	high
Stirni[k]	49.130001, -132.30000 (AOI)	1710	M1	medium	deep	high
UN 24	50.537792, -131.07229 (AOI)	1659	M2	medium	deep	low
UN 14	49.329736, -133.82917 (AOI)	1600	M2	medium	deep	low
UN 10[c]	49.262697, -131.13065 (AOI)	1599	M2	medium	deep	low
UN 27[c]	50.046051, -130.07153 (AOI)	1597	M2	medium	deep	low
Endeavour[k,c]	48.299028, -129.04386 (AOI)	1583	M2	medium	deep	low
UN 18[c]	49.939332, -130.90524 (AOI)	1550	M2	medium	deep	low
Oglala[k,c]	50.34853, -131.56642 (AOI)	1543	M2	medium	deep	low
UN 3[c]*	47.980455, -129.92416 (AOI)	1542	M2	medium	deep	low
UN 23[c]	50.635828, -131.13464 (AOI)	1541	M2	medium	deep	low
UN 2[c]	47.89141, -130.51808 (AOI)	1529	M2	medium	deep	low
UN 49[k]*	50.343684, -132.13711 (AOI)	1498	M2	medium	deep	low
UN 5[c]	48.371081, -129.90449 (AOI)	1493	M2	medium	deep	low
UN 43*	50.389046, -132.25022 (AOI)	1486	M2	medium	deep	low

Seamount name	Summit coordinates (in AOI or SK-B, or outside of conservation areas)	Summit depth (m)	Class	Export productivity	Summit depth	Oxygen conc.
UN 12[c]	49.188381, -130.42872 (AOI)	1465	M2	medium	deep	low
Chelan	49.794911, -131.77235 (AOI)	1459	M2	medium	deep	low
UN 4[c]	48.137436, -130.41024 (AOI)	1426	M2	medium	deep	low
Tuzo Wilson (east)[k]	51.458095, -130.84638 (out)	1388	H2	high	deep	low
UN 40[c]*	47.904917, -129.65888 (AOI)	1344	M2	medium	deep	low
Heckle[k]	48.47019, -130.13644 (AOI)	1316	M2	medium	deep	low
Tucker[k]	49.8044, -133.47484 (AOI)	1217	M2	medium	deep	low
Graham[k,c]	53.263312, -134.54856 (out)	1201	M2	medium	deep	low
UN 22	50.725383, -131.28219 (AOI)	1170	H2	high	deep	low
UN 8[c]	48.32499, -129.25247 (AOI)	1158	M2	medium	deep	low
UN 16[c]	49.88355, -132.11363 (AOI)	1097	M2	medium	deep	low
UN 25[c]	50.44943, -130.54107 (AOI)	1089	H2	high	deep	low
Davidson (Pierce)[k,c]	53.66385, -136.58949 (SK-B)	1079	H2	high	deep	low
UN 7[c]	48.534491, -129.6396 (AOI)	1065	H2	high	deep	low
Heck[k,c]	48.400701, -129.37674 (AOI)	1015	H2	high	deep	low
Springfield [k,c]	48.06795, -130.19647 (in)	922	H2	high	deep	low
SAUP 5494[k]	53.852354, -133.77998 (out)	902	H2	high	deep	low
Oshawa[k,c]	52.285469, -134.03283 (out)	896	H2	high	deep	low
UN 1[c]	47.567004, -130.30425 (AOI)	895	H2	high	deep	low
Dellwood South [k,c]	50.580251, -130.71313 (AOI)	821	H2	high	deep	low
Explorer [k,c]	49.058736, -130.94218 (AOI)	795	H3	high	medium	low
Hodgkins [k,c]	53.506186, -136.03632 (SK-B)	611	H3	high	medium	low
Dellwood [k,c]	50.748881, -130.89797 (AOI)	535	H3	high	medium	low

Seamount name	Summit coordinates (in AOI or SK-B, or outside of conservation areas)	Summit depth (m)	Class	Export productivity	Summit depth	Oxygen conc.
Union [k,c]	49.546481, -132.70242 (AOI)	271	H4	high	medium	high
SGaan Kinghlas-Bowie[k,c]	53.299792, -135.65106 (SK-B)	24	H5	high	shallow	high

[1] Fourteen seamounts are new, while four seamounts listed in DFO 2019a were removed from the inventory (UN 17, 26, 31 and Oglala west seamounts) for various reasons (e.g., recently collected bathymetric maps provided better resolution and indicated seamounts initially identified as two are likely one large seamount).

According to the Canadian Gazetteer (CG) (NRC 2015), of the 62 seamounts listed above, only 15 are named *seamounts*, two are named *features* (i.e., not *seamounts*), and five are within named *chains* but are not themselves not identified or named (Appendix A: Table A1).

Place names are anchors, helping to ensure the legacy of the scientific and traditional knowledge of a region. A place name is also an important capsule of history and language in and of itself, celebrating social and cultural values. To mark the significance of seamounts as part of our geographical and cultural environment, DFO Science is working in partnership with 17 coastal First Nations (Nuu-chah-nulth, Quatsino, Haida, and Pacheedaht First Nations) to name the new discoveries and update the Canadian Gazetteer (interim nomenclature: “UN” followed by two numerical digits). DFO is providing the scientific information for each seamount and a committee representing the First Nations will provide the names, all of which will then be submitted to the Advisory Committee on Undersea Feature Names (ACUFN), cataloguing the names nationally and internationally. This unprecedented opportunity to assist coastal First Nations with naming new underwater features observes and honours Article 13 of the United Nations Declaration on the Rights of Indigenous Peoples, whereby indigenous peoples have the right to designate and retain their own names for communities, places, and persons.

In addition to naming new seamounts, data will be submitted to the ACUFN to correct existing seamount information in the CG (e.g., incorrect coordinates). For example, according to the best available bathymetric data and other undersea features databases (e.g., the GEBCO.net gazetteer, the online Seamount Catalog by Earthref.com), the CG has incorrectly recorded Chelan Seamount to be 18 km east of its true location, over bathyal planes, and Oglala Seamount to be 43 km west of its true location, over an unnamed chain of seamounts (the location of UN 49).

2.1.2.2. Seamount mapping and ground-truthing

Using recently collected bathymetry (single- and multi-beam; varying degrees of accuracy; Figure 5), the location and depth of 34 seamounts (21 newly identified) have been confirmed (Table 2) (examples of seamount bathymetric profile data in Appendix B). Thirteen well-known seamounts were mapped with increased accuracy and resolution than previously accomplished. That leaves 28 unmapped seamounts, 6 of which are well-known and 22 of which remain unnamed and unconfirmed. Since 21 out of 21 predicted seamounts recently surveyed were ground-truthed and confirmed to be such (i.e., 100% predictive power thus far), it is reasonable to expect all 22 unnamed and unconfirmed seamounts to exceed the 1 km summit elevation criteria, qualifying them as *seamounts*.

Newly collected bathymetric data have demonstrated that the seamount models and the once ‘best available data’ do well at predicting the general location of features but consistently underestimate summit depth. According to our systematical assessment, we found seamount models tend to underestimate the number of seamounts (exceptions: Manson (2009) and Kim and Wessel (2011)). Therefore, it is likely that as we collect better bathymetry (only a small fraction of the OPB is mapped in high-resolution), we will find many more features that are *seamounts* that are presently misidentified as tall *knolls*. That is to say, it is very likely there are more than 62 seamounts in the OPB (e.g., preliminary analyses of unpublished Pac2021-036 data already indicates three additional seamounts for a potential new total of 65).

While bathymetric data limitations underestimate seamount counts, misleading nomenclature has historically had the opposite effect. There are OPB features named as “seamounts” with known elevations under 1 km: Baby Bare Seamount, Grizzly Bare Seamount, Seminole Seamount, Split Seamount, and Drifters Seamount (the first four are inside the AOI) (Figure 3). *Knolls* and *hills* are comparable features to seamounts but with summit elevations between 500 m and 1 km, and under 500 m, respectively.

The elevation criteria that define and differentiate *seamounts*, *knolls*, and *hills* are somewhat arbitrary thresholds, and it is not uncommon for features >100 m elevation to be referred to as “seamounts” or seamount-like features (e.g., Pitcher et al. 2007; Wessel et al. 2010). For example, at 747 m elevation, Seminole “Seamount” is the tallest named knoll in the OPB and is thought to exhibit similar biophysical properties to a seamount and could potentially be considered functionally equivalent (DFO 2019a) (preliminary analyses of unpublished Pac2021-036 supports this hypothesis). Within the OPB, there are ~350 *knolls* predicted (Yesson et al. 2011) and an untold number of *hills*, many of which may provide a significant amount (area) of additional seamount-like ecosystems. These ecosystems are poorly studied within the OPB, with the exception of Baby Bare and Grizzly Bare outcrops (hills), which have been intensely studied for their hydrothermal vent activity (detailed in DFO 2019a), and are EBSAs under the hydrothermal vent criteria (Ban et al. 2016; DFO 2019).

2.1.2.3. Distribution of seamounts

Forty-seven seamounts are in the AOI (76%), three are in the SK-B MPA (5%), and 12 seamounts are outside of the conservation areas (19%) (Table 2; Figure 9). There are no seamounts in the Scott Islands Protected Marine Area or the Endeavor Hydrothermal Vent MPA. Thirty-six of the 47 AOI seamounts are currently protected by a fisheries closure (77%). There are additionally hundreds to thousands more seamount-like knolls and hills in the OPB that do not meet the seamount criteria of ≥1 km elevation (e.g., Seminole “seamount”; DFO 2019a).

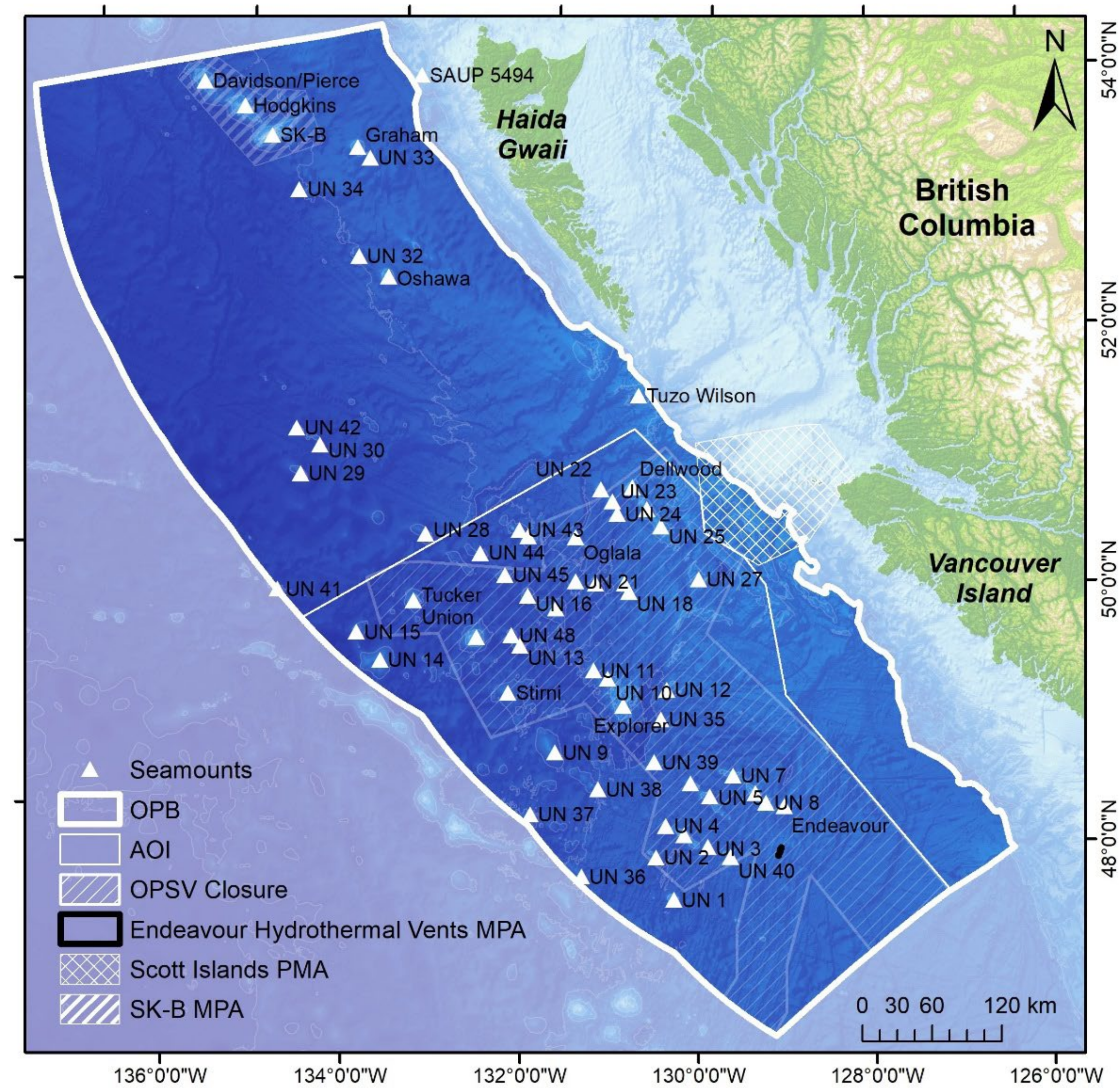


Figure 9. The location of the 62 seamounts in the Offshore Pacific Bioregion (OPB; thick white line) and its different conservation areas: 47 in the Area of Interest (AOI), 36 of which are in the Offshore Pacific Seamounts and Vents (OPSV) Closure (in the AOI), none in the Scott Islands Protected Marine Area (PMA), and three in the SGaan Kinghlas-Bowie Seamount Marine Protected Area (SK-B MPA). Two seamounts are only partially in the OPB (the majority of SAUP 5494 is in the Northern Shelf Bioregion and half of UN 41 in is the High Seas); neither are in a conservation area. See DFO 2021 for shapefile.

2.1.2.4. Seamount coverage

We determined the first contour of 3° slope marks the transition from surrounding basin to seamount flanks, the seamount boundary (i.e., average slope plus standard deviation: 1.186 + 1.934° = 3.120°; n = 10,000) (Figure 10; shapefile available in Open Maps, DFO 2021). Three degrees is similar to the slope of the seafloor along the Offshore Bioregion, which marks the transition (boundary) between the offshore and shelf bioregions (approximately 3° or 2311±388 m depth; based on bathymetry at n = 402 evenly spaced samples). Mason (2009) also identified 3° as the boundary to create the seamount polygons. As shown in Figure 10, our derived polygons align well with the Mason (2009), Harris et al. (2014), and Yesson et al. (2020) polygons (note: other models predicted summit point locations, not boundaries), but outline a considerably smaller area consistently. That said, Manson (2009) tends to over predict the number and the extent of seamounts, Harris et al. (2014) boundaries are very smoothed, and Yesson et al. (2020) are very blocky.

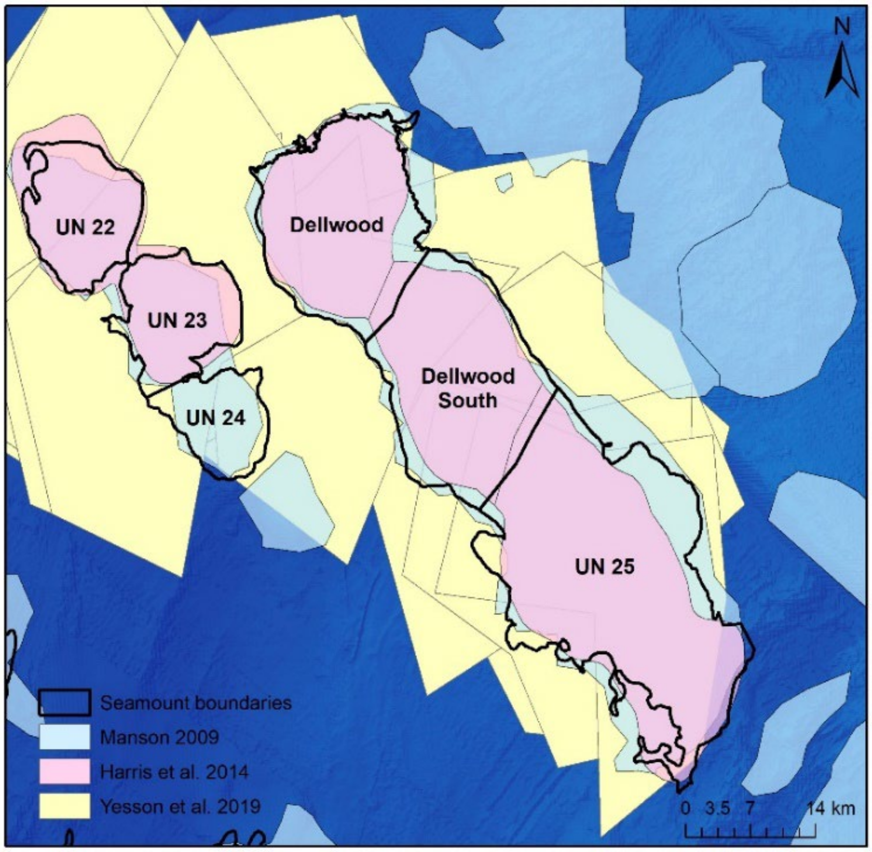


Figure 10. Close-up of seamount boundaries demonstrating the similarities and dissimilarities between the four seamount boundary layers: the seamount polygons generated by Mason (2009; blue polygons), Harris et al. (2014; pink polygons), Yesson et al. (2020; yellow polygons), and this study, 3° slope contour (black lines).

Based on the newly defined seamount boundaries (Figure 11), we can resolve that (i) over half of the OPB seamounts share boundaries (34), forming seamount chains, and (ii) seamounts cover 6.5% of the OPB and 11.2% of the AOI (Table 3). It is difficult to compare the OPB and AOI coverage to other seamount hotspots because of the differences in seamount qualifying criteria (e.g., elevation threshold of 100 m rather than 1 km) and a lack of high-resolution mapping enabling detection and surface area estimates (e.g., global abundance of seamounts published nine years apart: ~33,000 to ~44,000; Yesson et al. 2011, 2020). However, the area calculations indicate the OPB and AOI seamounts are dense in comparison to current regional and global estimates (e.g., 3.97% and 2.2% for the North Pacific and the world's oceans, respectively; Harris et al. 2014). The high density in the OPB and AOI may have implications for connectivity among the seamounts and biogeographical boundaries (or a lack thereof).

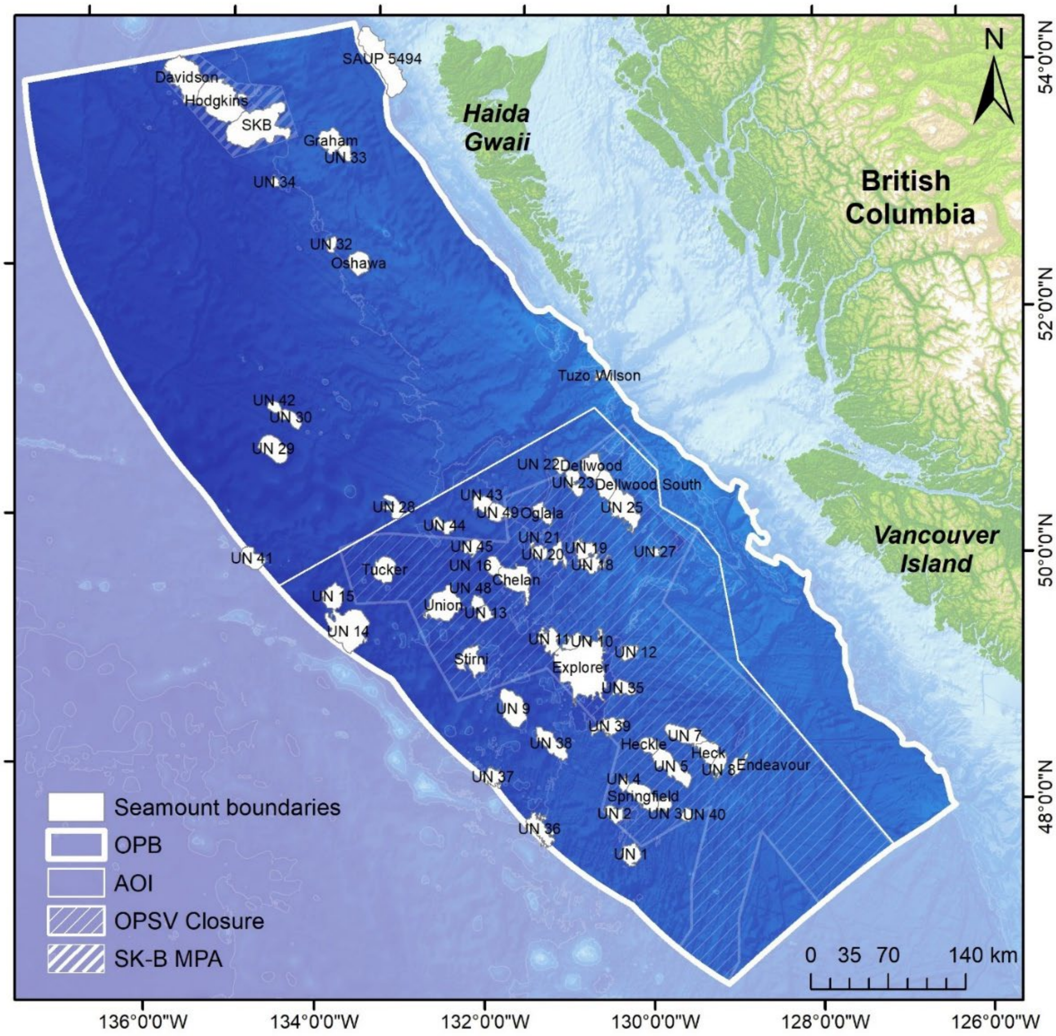


Figure 11. The boundaries of the 62 seamounts in the Offshore Pacific Bioregion (OPB). Two of the seamounts outside of the conservation areas are only partially in the OPB: the majority of SAUP 5494 is in the Northern Shelf Bioregion and half of UN 41 is in the High Seas. Also shown: the Area of Interest (AOI), Offshore Pacific Seamounts and Vents (OPSV) Closure, and the SGaan Kinghlas-Bowie Marine Protected Area (SK-B MPA). See DFO 2021 for shapefile.

Table 3. The proportion of surface area (km^2) covered by seamounts within each conservation area: in the present Offshore Pacific Seamounts and Vents (OPSV) Closure, in the Area of Interest (AOI) (includes the aforementioned closure area), the SGaan Kinghlas-Bowie Marine Protected Area (SK-B MPA), and outside of conservation areas of the OPB (Outside).

Seafloor	OPSV	AOI (incl. closure)	SK-B MPA	Outside	Total OPB
Seamount*	10,941 (13.2%)	14,879 (11.2%)	3,443 (56.5%)	2,108 (1.2%)	20,430 (6.5%)
Non-seamount	71,807 (86.8%)	118,006 (88.8%)	2,656 (43.5%)	174,968 (98.8%)	295,630 (93.5%)
Total	82,748	132,885	6,099	177,076	316,060

*Not included: the majority of SUAP 5494 Seamount and half of UN 41 Seamount.

Several seamounts around the edges of the OPB cross into the Northern Shelf Bioregion (SAUP 5494) and the High Seas (UN 41, 14, 36, and 37) (Figure 11). Our summary stats in Table 3 do not include the complete area covered by two of the seamounts. SUAP 5494 Seamount (1,120 km^2) is in the Northern Shelf Bioregion (on the slope), and approximately half of UN 41 (half of 292 km^2, or 146 km^2) is in the High Seas, only half is in the OPB. If included, these two seamounts raise the total cover of seamounts to 21,696 km^2. In addition, a small area of the western bases of UN 14, 36 and 37 slightly transition into the High Seas.

There is almost a 50-fold difference in area between Tuzo Wilson (east) and Explorer, the smallest and largest of the OPB seamounts, respectively (38 to 1,841 km^2; Figure 12). Explorer Seamount is giant (e.g., over three times the size of the famous Davidson Seamount off the coast of California; NOAA 2019). Explorer is technically a supervolcano made up of multiple volcanoes (USGS 2021; Botros and Johnson 1988). There is geological evidence that at one point, Explorer Seamount was even bigger; that UN 35 was a part of the supervolcano, formed and then split in two over the millennia by rift-related volcanisms and spreading from major plate boundary readjustment (Botros and Johnson 1988).

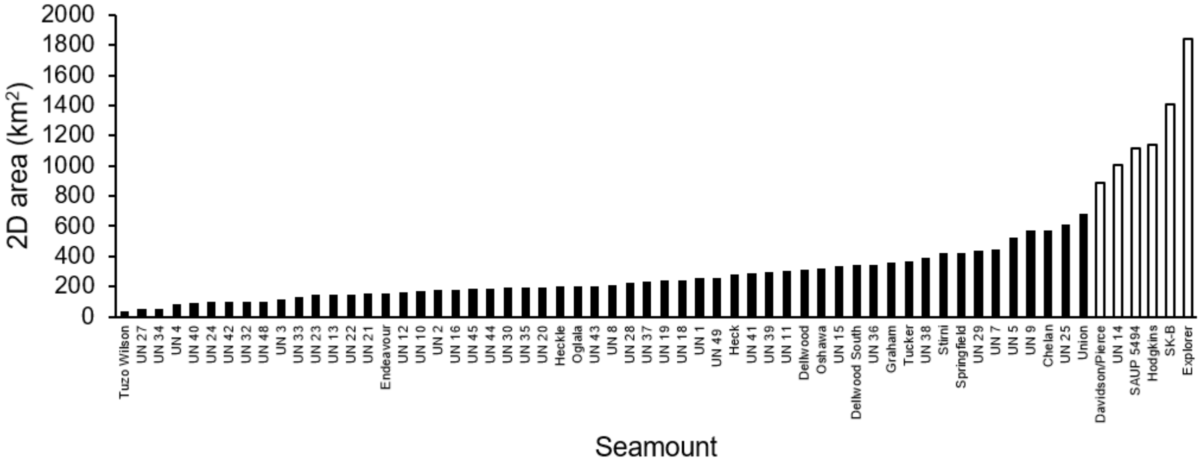


Figure 12. The two-dimensional surface area of each seamount. Seamounts in order of increasing size, with bar colour denoting the two seamount clusters (see section 2.2.1.2 on clustering), where the group of smaller-sized seamounts is in black and the group of larger-sized seamounts is in white. Numerical values provided in Appendix A: Table A1.

2.1.3. Summary of findings

The following summarizes the findings for objective 1: update information for the nomenclature and location of OPB seamounts.

- There are 62 seamounts known to occur in the OPB (10 more than the 2019 inventory).
- Forty-three seamounts are newly identified and unnamed (65% of OPB seamounts). Twenty-one of these seamounts were recently mapped and are considered confirmed by bathymetric data. DFO and the Advisory Committee on Undersea Feature Names (ACUFN) are assisting a committee of coastal First Nations with the process to name these newly identified features.
- Forty-seven seamounts are in the AOI (76%; 36 of which are presently protected by a fisheries closure), three seamounts (5%) are in the SK-B MPA, and 12 seamounts (19%) are outside of the conservation areas. There are additionally hundreds to thousands more

"seamount-like" knolls and hills in the OPB that do not meet the seamount criteria of ≥1 km elevation.

- The newly identified OPB seamount boundaries (marked by the outer 3° slope contour) align with the literature but result in considerably smaller seamount areas than those predicted by the published seamount models.
- Seamounts cover 11.2% of the AOI (14,879 km^2 of the 132,885 km^2), indicating the region is relatively dense in comparison to the rest of the OPB (6.5%) and the world's oceans (2.2%).
- Over half of the OPB seamounts are part of seamount chains and share boundaries. Several of the OPB seamounts around the edges of the OPB cross into the Northern Shelf Bioregion (SAUP 5494) and the High Seas (UN 41, 14, 36, and 37).
- At 1,841 km^2, Explorer is Canada's largest seamount.

2.2. OBJECTIVE 2: NATURAL BOUNDARIES

2.2.1. Methods

Natural boundaries within the OPB were assessed by reviewing the regional geography (tectonic plate boundaries, oceanographic zones, and spatial clustering and proximities) and by assessing regional depth zonation and ecological bathymetric trends on the seamounts.

2.2.1.1. Mapping and geoprocessing

We performed all mapping and geoprocessing in ArcGIS 10.8. Distances were measured in two-dimensional space projected in UTM 8N and 9N. Proximity was calculated as the shortest distance between the seamount and its nearest neighbour (i.e., two seamount boundaries) and the seamount and the edge of the Offshore Bioregion (i.e., transition to the continental slope).

Shapefiles of seamount summits and seamounts boundaries were Objective 1 deliverables. Tectonic plate boundaries and ocean currents shape files were courtesy of the U.S. Geological Survey and DFO (work ongoing; Appendix C) (DFO 2019a; pers comm Rick Thomson, Institute of Ocean Sciences).

2.2.1.2. Spatial clustering

Clustering was performed in R Studio version 1.2.5033 using nearest neighbour distances (proximity described above), a similarity matrix, and hierarchical clustering (hclust function, 'cluster' R package; Euclidean distance) and two analyses for determining the optimal numbers of clusters, average silhouette and within within-cluster cluster sums of square (fviz_nbclust function, 'factoextra' R package).

2.2.1.3. Synthesis of bathymetric boundaries information

Depth-related environmental and ecological patterns for OPB seamounts were synthesized into a model seamount system based on a literature review and data (published and unpublished) from visually surveying the benthos on Northeast Pacific Seamounts Expeditions (Pac2017-036, Pac2018-103, and Pac2019-014).

Benthic visual surveys

Visually surveying the benthos was the primary objective of all three Northeast Pacific Seamounts Expeditions, Pac2017-036, Pac2018-103, and Pac2019-014 (Figure 13; Appendix D: Table A3). These surveys yielded benthic imagery (video and still), bathymetric data, specimen collections, and sensor data (e.g., conductivity, temperature, depth; CTD)—all of which we incorporated into this study. In 2017 and 2019, the DFO drop camera Bathyal Ocean

Observation and Televideo System (BOOTS) was deployed off the CCGS John P. Tully, and in 2018, the remotely operated vehicle Hercules was deployed off the E/V Nautilus. In total, 12 seamounts within the OPB have been visually surveyed at the time of this CSAS process (additional seamounts visited in 2021 are not included here). Dive videos and dive logs available on Ocean Networks Canada Seatube Pro.

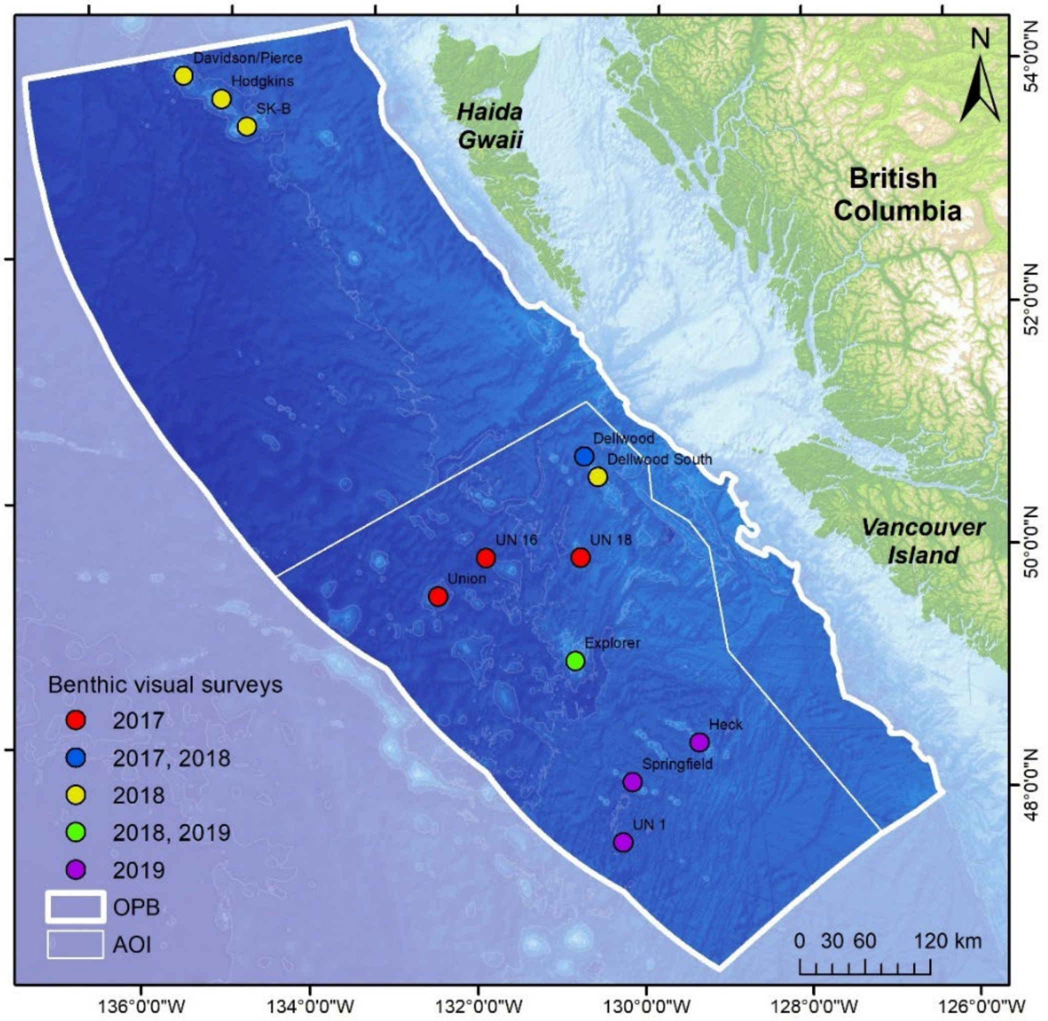


Figure 13. Location of the 12 seamounts visually surveyed during the Northeast Pacific Seamounts Expeditions in 2017, 2018, and 2019. Video and still imagery of the benthos to depths of 2,150 m were collected during these dives, as well as sensor data (some of which was used to ground-truth the bathymetric profiles of the seamounts). Also shown: the Offshore Pacific Bioregion (OPB) and the Area of Interest (AOI). Summary information on the 31 benthic visual survey dives provided in Appendix D: Table A3.

Benthic ecological data for analyses were collected by annotation of the imagery using the DFO in-house software VideoMiner (Curtis et al. 2015) and the web server Biigle (Langenkämper et al. 2017)—this work is still in process at the time this report was written. Relevant ecological datasets included in this section: abundance data for glass sponges (Hexactinellids) on the 2017 survey seamounts, species-specific density data on the 2017 seamounts presented in Ross et al. (2020) (other datasets used in subsequent sections will be described in those sections). Other ongoing and future analyses and uses for annotation data—beyond the scope of this Research Document—include species distribution models, species and community responses to changing conditions, temporal variability of assemblage structure and health, species-specific research projects, distribution of substrate and biotopes, ground-truthing eDNA, etc.

2.2.2. Results and discussion

The OPB and the AOI are massive areas, covering 316,060 and 132,885 km^2 and having an average depth offshore of 2,942±470 m. At approximately 929,850 and 390,950 km^3, the OPB and AOI are over 220 and 95 times the size of the Grand Canyon, respectively. Identifying natural boundaries and zones within the OPB and the AOI help compartmentalize the large area and volume. Large bodies of water can be spatially divided into natural zones using geographic boundaries (e.g., geological and oceanographic), spatial clustering, and/or bathymetric boundaries.

2.2.2.1. Geographic boundaries

The observed species have wide distributions across the seamounts, suggesting there are no biogeographical boundaries between seamounts within the region (e.g., no evidence of regional endemism or dispersal boundaries). This supports the theory of high connectivity associated with the high density of seamounts within the OPB (discussed further in Objectives 5 and 6). That said, more research is required to understand how the spatial distribution and connectivity of geographic zones affect biological pathways for population connectivity, source-sink dynamics, rescue potential, and how this information could inform survey and monitoring planning.

Tectonic plate boundaries

The seafloor offshore of British Columbia is uniquely fractured into some of the world's smallest oceanic plates (Figure 14). There are three plates within the OPB. Plate boundaries and geometry can play a large role in determining the geological and geophysical characteristics of a seamount. However, all OPB seamounts are located within or on the edge (none discrete plate assignment) of just one plate, the Pacific. Although the summit of Tuzo Wilson (east) Seamount is mapped on Explorer plate, it occupies part of the strained seismically active triple junction of the Pacific, Explorer, and North America plates (Carbotte et al. 1989). UN 27 is likely in a similar situation between the Pacific and Explorer plates. There are no seamounts on the Juan de Fuca plate. All OPB seamounts occupy the Pacific plate, at least in part, suggesting that the tectonic plates are not ecologically significant boundaries within the OPB.

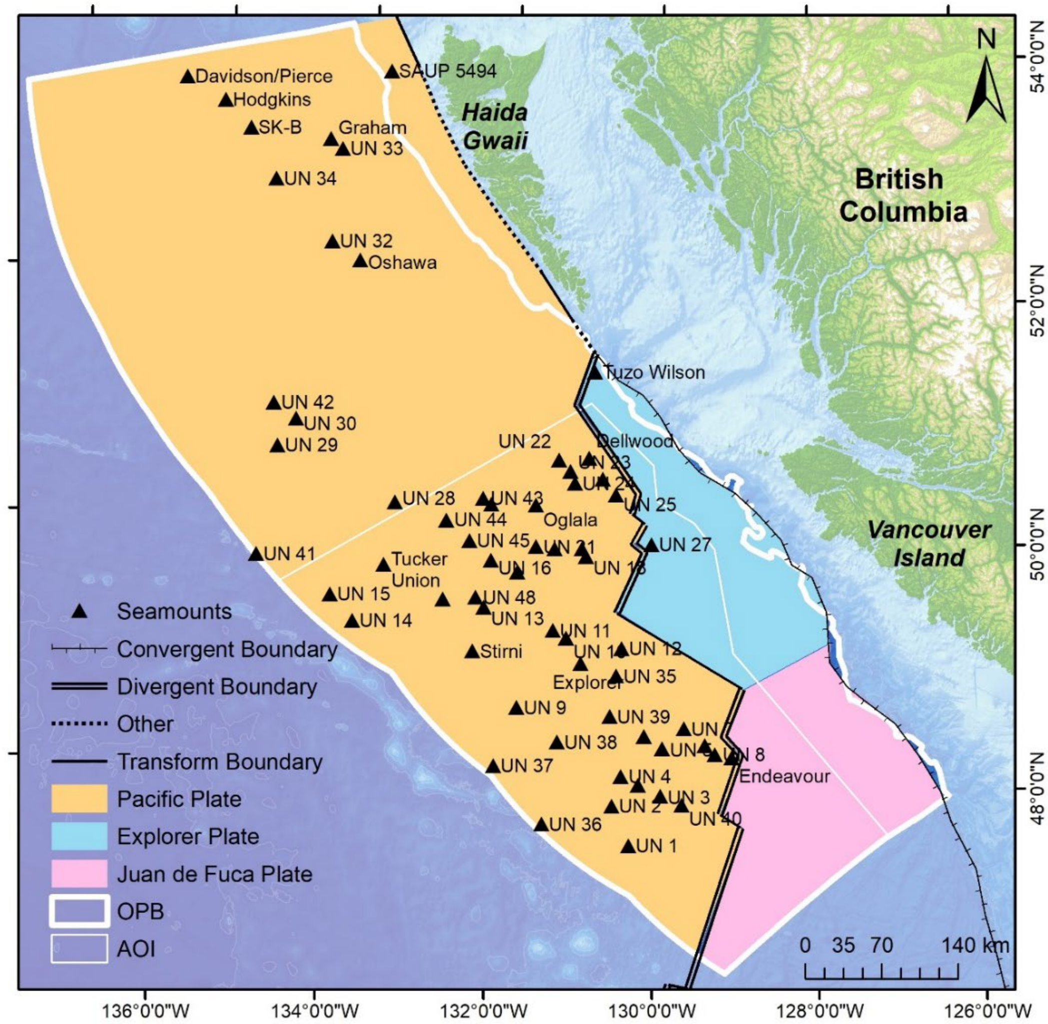


Figure 14. The three oceanic plates and their plate boundaries (four types) within the Offshore Pacific Bioregion (OPB) and Offshore Area of Interest (AOI): the Pacific (orange), Explorer (blue), and Juan de Fuca oceanic plates. Plate boundaries shape files courtesy of the U.S. Geological Survey).

Many of the OPB seamounts are on or adjacent to tectonically active faults, spreading valleys, and ridges within the Pacific plate (details not resolved in Figure 14). The Pacific plate in this region is moving northwards and—offshore of Haida Gwaii—has the fastest moving non-oceanic strike-slip fault on Earth (Brink et al. 2018). The plate's tectonic activity is evident in the region's seismic history (e.g., Hyndman 2015) and the formation of seamounts chains (e.g., Heck, Heckle, SK-B chains; Figure 14). As previously mentioned, there is even evidence Explorer and UN 35 seamount were once a single massive super volcano, formed and then split in two over the millennia by rift-related volcanisms and spreading from major plate boundary readjustment (Botros and Johnson 1988). While the Pacific plate movement and its resulting intera-plate activity are apparent, further research is required to determine if these finer resolution zones translate into ecologically significant boundaries.

Oceanographic zones

There are five major oceanographic zones (features) identified within the OPB: (1) the offshore Alaska current, (2) an offshore bifurcation zone, (3-4) coastal upwelling and downwelling zones with (5) a transition zone in-between (DFO 2009a, 2019a), as well as large-scale eddies (e.g., Haida eddies; tens of kilometers in radius; Crawford 2002).

The region's oceanography is dynamic, with zones changing over time and space (Appendix C; Whitney and Robert 2002; Crawford et al. 2005; DFO 2019a; pers comm Rick Thomson, Institute of Ocean Sciences), making it difficult to develop any static map beyond rough approximations (Figure 15)—further information is required to determine the precise seasonal movement and nature of these oceanographic features over the seamounts (i.e., research is ongoing). In general, it is believed that the transitional (bifurcation) zone shifts north in the summer and south in the winter (Thompson 1981) and shedding of the Haida eddies occurs predominately in winter (Whitney and Robert 2002) (Appendix C).

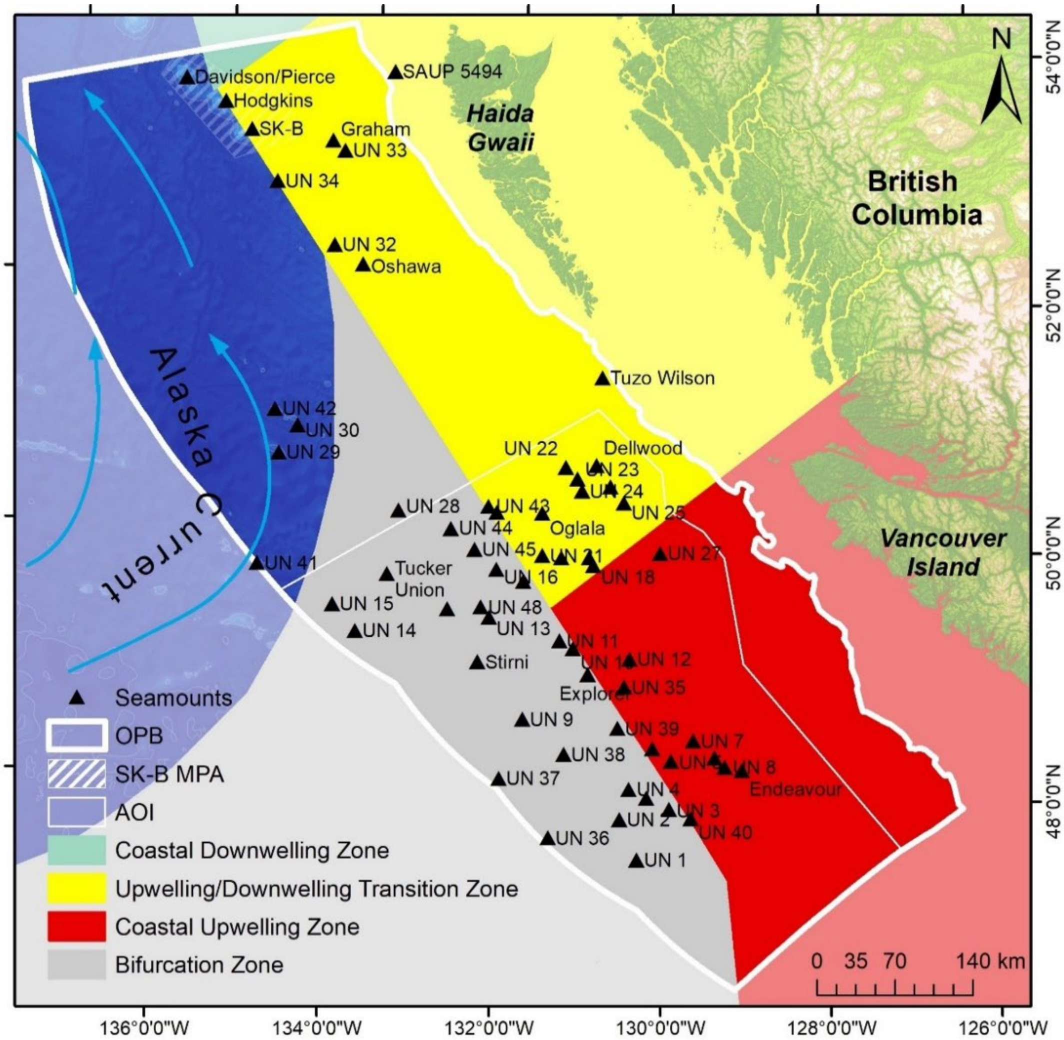


Figure 15. The approximate static representation of the dynamic regional currents within the Offshore Pacific Bioregion (OPB), SGaan Kinghlas-Bowie Seamount Marine Protected Area (SK-B MPA), and Offshore Area of Interest (AOI): the start of the Alaska current (clear) and the Bifurcation Zone (grey) with the California current (south of OPB), and the Coastal Downwelling (green), Transition (Yellow), and Upwelling (Red) zones. Modified from DFO 2019a (Appendix C).

The transitional zones (referred to as the Transitional Pacific in Ban et al. 2016) and the Haida eddies are both identified as EBSAs for, among other reasons, their productivity and diversity (Ban et al. 2016), but little is known about their influence on the seamounts they bath, although it is likely significant. Bifurcation or transitional zones promote mixing and higher biodiversity (i.e., more biotopes). Upwelling zones are typically rich in nutrients and therefore support relatively high productivity. The Haida eddies transport 3,000 to 6,000 km^3 of coastal water up to 1,000 km westward from the coast (Whitney and Robert 2002; discussed further within Objective 4).

Based on the approximate location of the major currents (Figure 15), 26 of the OPB seamounts are in the Bifurcation Zone (grey area), 22 are in the Coastal (Upwelling/Downwelling) Transition Zone (yellow area), nine are in the Coastal Upwelling Zone (red area), and five are in the Alaska Current, there are none in the Coastal Downwelling Zone (green area). Because of their proximity to Haida Gwaii, it is likely the Haida eddies intersect the northern OPB seamounts in the Alaska Current and Coastal Transition Zone (Figure 15; Appendix C). SK-B, Hodgkins, and Davidson seamounts episodically receive coastal water from large-scale Haida eddies (Whitney and Robert 2002), increasing their connectivity with the continental shelf and slope (e.g., delivery of nutrients, migrants, larvae). Based on tracking data, it is likely that eddies also regularly travel over Graham, UN 33, UN 34, and the other seamounts north of the AOI, even some within (Whitney and Robert 2002) (Appendix C). The influence of the eddies is expected to decrease with increasing summit depth of the seamount (eddy core known to reach 500-600 m depth, and possibly 1 km; Whitney and Robert 2002).

Spatial clustering

We resolved four geographic clusters (zones) of seamounts based on the spatial distribution (Figure 16). These horizontal zones are roughly divided by two latitudinal boundaries and one longitudinal boundary. The first latitudinal boundary is in the north, outside the AOI, between Oshawa and UN 42 (~51.75° N). The second occurs in the center of the Offshore Bioregion, within the AOI, between UN 13 and UN 11 (~49.32° N). The longitudinal boundary divides the middle cluster of seamounts into offshore and nearshore seamounts, between UN 28 and Union (~133.06° W). A reduced clustering option is identified by the Silhouette analysis, which resolved two clusters (retains the northern cluster but groups the three southern clusters into one) (dendrogram and within-cluster sum of squares and Silhouette analyses provided in Appendix E).

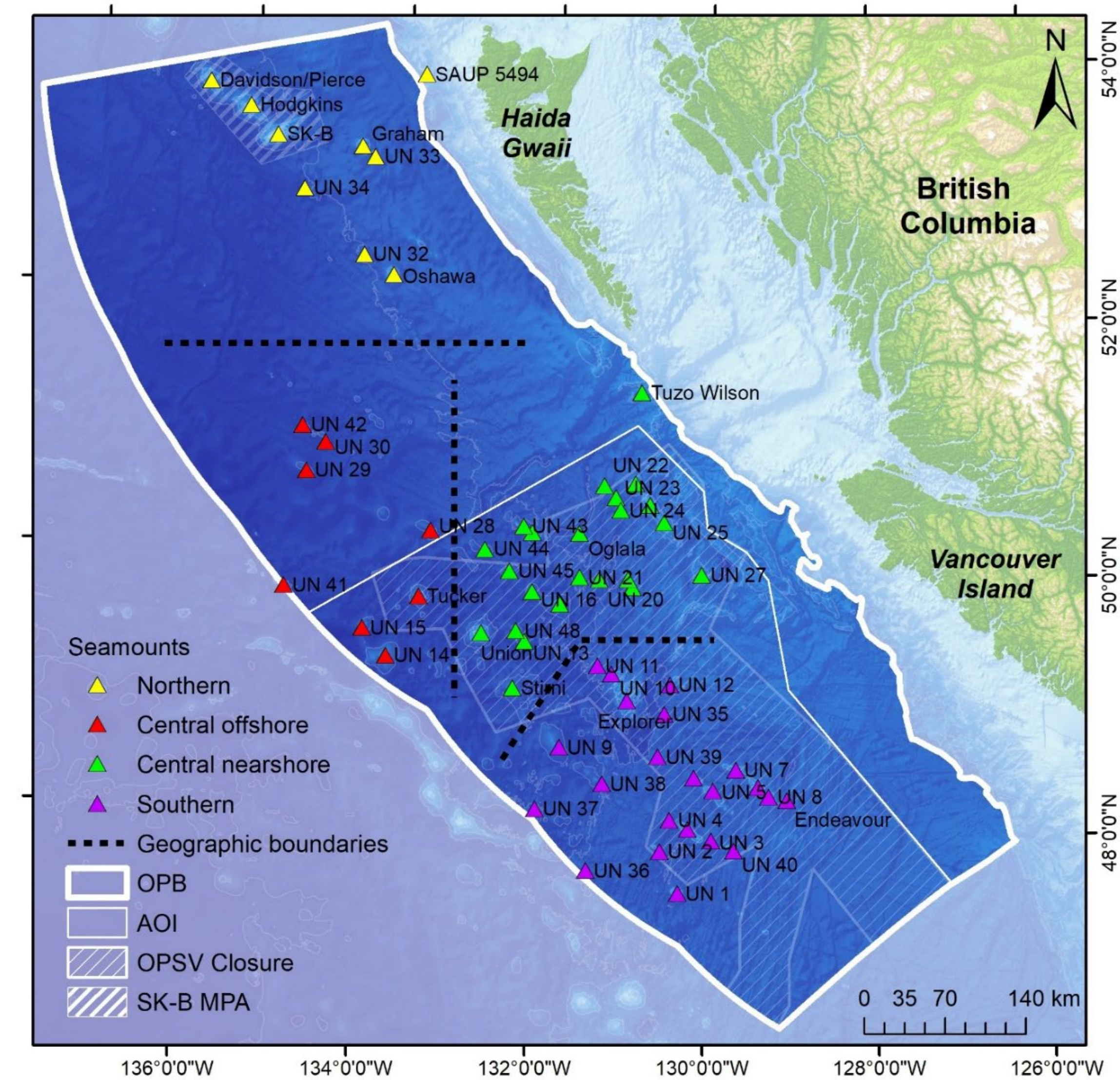


Figure 16. Four spatial clusters divided by three boundaries within the Offshore Pacific Bioregion (OPB) and its conservation areas based on spatial clustering, resulting in four geographic zones: northern, central offshore, central nearshore, and southern. Also shown: the Area of Interest (AOI), Offshore Pacific Seamounts and Vents (OPSV) Closure, and SGaan Kinghlas-Bowie Seamount Marine Protected Area (SK-B MPA).

The AOI contains seamounts from three of the four spatial clusters: 3 of the central offshore seamounts, 22 of the central nearshore seamounts, and all 23 southern seamounts. While the AOI does not contain any of the northern seamounts, SK-B MPA contains 3. Together, these conservation areas contain representative seamounts from all four spatial clusters. That said, while there is only one central nearshore seamount (Tuzo Wilson [east]) outside of conservation areas, the majority of the central offshore (*n* = 5) and northern seamounts (*n* = 6) are beyond the boundaries of the AOI and SK-B MPA.

Proximities

All OPB seamounts are in close proximity to another seamount or the continental slope (≤100 km; a defining category in the seamount classification scheme; Clark et al. 2011), but there is finer-scale variation in the level of isolation, both between seamounts and between the seamounts and the continental slope (Appendix A: Table A1). Regarding the distance between nearest seamounts, 36 seamounts share boundaries (0 km proximity; in seamount chains). Individual seamounts are isolated by an average of only 21 km. All but one seamount (UN 41) is within a mean dispersal distance resolved for deep-sea fauna (≤33 km; Baco et al. 2016). We did not explore alternate proximity thresholds for the classification since there is no evidence of dispersal boundaries or endemism within the OPB, only variations in species relative abundances (e.g., dominant species; discussed further within Objective 5 and 6).

Tuzo Wilson (east) is the most isolated from other seamounts (65 km away); however, it is only 2 km away from the base of the continental slope. With regards to proximity to the continental slope, SAUP 5494 Seamount is uniquely located on the slope, making it the most nearshore seamount. At the opposite end of the scale, at a distance of 330 km, UN 41 is the most offshore seamount in the OPB (half of UN 41 crosses the EEZ; Table 3). The average distance of OPB seamounts offshore is 160 km. There is waning support in the literature that distance from the mainland translates into a dispersal boundary (Mazzei et al. 2021) and is further unsupported by the ecological data in our region.

2.2.2.2. Bathymetric boundaries

Depth-related boundaries are another important means of zoning the OPB and AOI. The seafloor of the OPB transects nearly four vertical kilometers of water, from the rift valley just east of Explorer Seamount (~3,850 m depth) to the sunlit peak of SK-B Seamount (24 m depth). As it rises and falls, the seafloor transitions through ecologically significant bathymetric boundaries.

Environmental conditions

The ecological importance of depth-related gradients on seamounts is evident in the large role depth plays in the global seamount classification scheme (Clark et al. 2011) (the focus of the next section, under Objective 3). The classification identifies important summit-depth boundaries of 200 and 800 m depth. In the OPB, 200 m marks the lower boundary of the euphotic zone (photosynthetic algae observed growing at ≥160 m depth on shallow seamounts in the region; unpublished data and Gauthier et al. 2018a), 800 m marks the lower boundary of the deep scattering layer (likely because it is the upper boundary of the anoxic waters; Ross et al. 2020 and citations therein). In addition, the classification identifies important oxygen concentration (≤1.0 ml/ and >1.0 ml/l) zones which are strongly tied to depth within the OPB owing to a naturally occurring Oxygen Minimum Zone (OMZ; ≤1.0 ml/l oxygen), which contains some of the lowest oxygen levels in the global ocean (Ross et al. 2020). The upper and lower boundaries of the OMZ are at 480 and 1700 m depth and a severely hypoxic zone (<0.5 ml/l) extends from 800 to 1200 m depth (Ross et al. 2020). While the anoxic zone is not included in the seamount classification scheme, it is an extreme environmental condition, intolerable to many animals (or, on the other hand, is a specialized niche), and so is ecologically significant within the OPB (aligns with the 800 m boundary already mentioned). Based on these environmental data, we resolve six bathymetric boundaries (representing vertical zonation): 0 m, 200 m, 480 m, 800 m, 1200 m, and 1700 m (Figure 17).

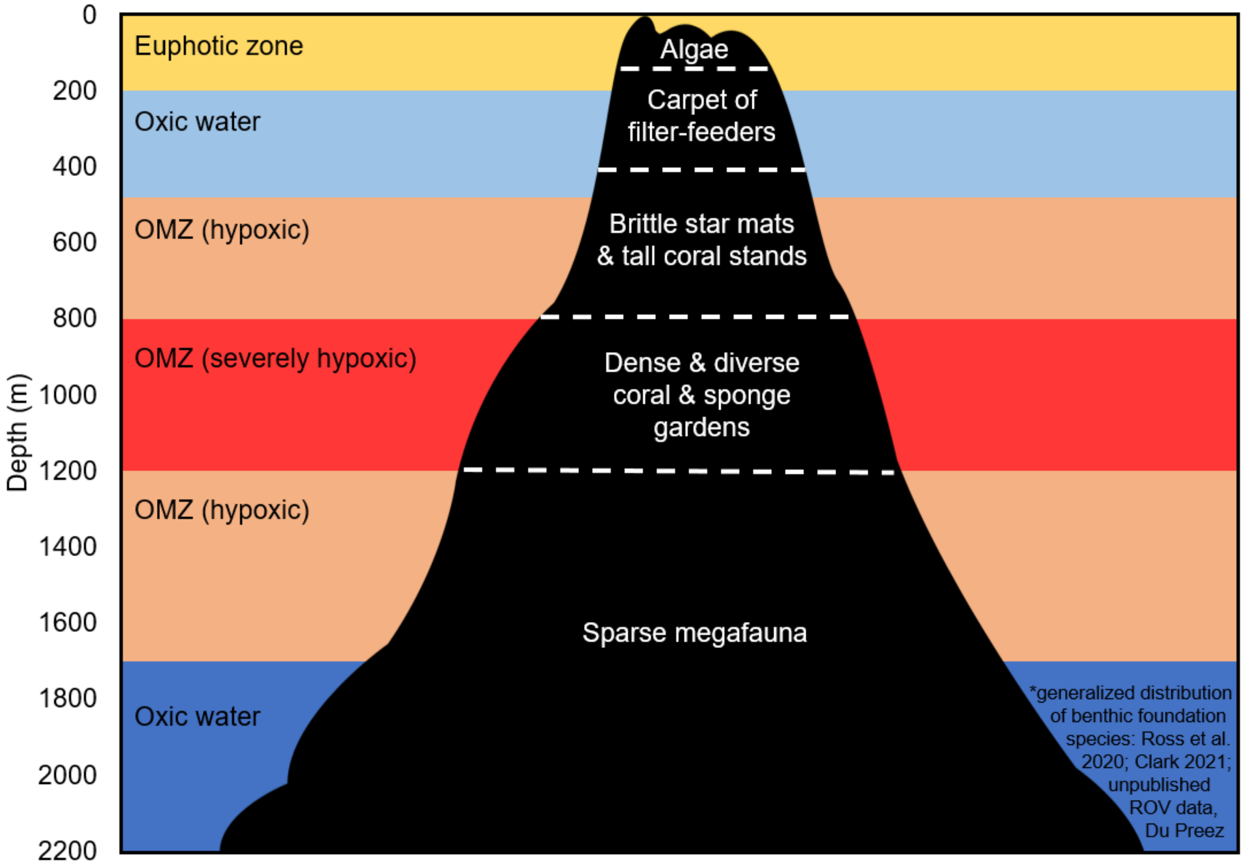


Figure 17. The vertical spatial alignment of bathymetric boundaries (zones) and generalized distributions of benthic foundation species (Ross et al. 2020; Clark 2021; unpublished ROV data, Du Preez) on seamounts within the Offshore Pacific Bioregion. For example biological data see Appendix F (2017 glass sponge data). The maximum depth shown (2,200 m) reflects the depths visually surveyed and not the depth of any particular OPB seamounts.

It should be noted that there are temporal and spatial variations expected to cause deviations from the model seamount generalization. Over time, climate change is causing the OMZ to expand and lose oxygen and it is predicted these chemically-defined bathymetric boundaries within the OPB will drastically change in the near future (15% loss in the last 60 years; Ross et al.2020) (discussed in detail under Objective 5). Within a spatial context, the community structure and/or assemblage may differ depending on the relative location of the depth zone (e.g., if the zone contains the gentle slope of the seamount base, steep flank, or current swept summit) and the intra-seamount variability within a depth zone (discussed under Objective 7: Limitations and uncertainties).

The carbonate saturation horizons are another type of ecologically significant bathymetric boundaries and affect the distribution of animals that build calcium-carbonate structures out of aragonite or calcite (e.g., skeletons and shells of animals such as cold-water corals and snails). The aragonite and calcite saturation horizon ($\Omega = 1$) are at roughly 185 and 340 m, respectively (Ross et al. 2020). Other saturation levels that occur deeper ($\Omega < 1$) are also known to be ecologically significant (Ross et al. 2020 and references therein). Because of the shallow nature of these horizons, they directly influence only the two shallowest OPB seamounts, SK-B and Union seamounts (24 and 271 m depth, respectively). For largely this reason, the saturation horizons are not included in the bathymetric boundaries analysis of the seamounts, but they are discussed in regards to monitoring sites and environmental changes (see Objective 5).

Ecological patterns

The significance of the depth-related zones detailed above is supported by species turnover (zonation) observed with benthic survey imagery (i.e., zones characterized by different assemblages; Figure 17) and is similar to the community structuring environmental drivers reported for other seamounts within the region (Du Preez et al. 2016). All OPB seamounts rise from bases below 1,700 m and steeply transition the range of depth-related environmental conditions and boundaries listed above. Independent of the survey location and the specific community structure, the environmental boundaries appear to—either directly or indirectly—separate benthic species into distinct assemblages (2017-2019 visual surveys generalized in Figure 17; data published in Ross et al. 2020 and Clark 2021; unpublished ROV data, Appendix F), affirming the biological relevance of these bathymetric zones. The OPB seamounts can be divided into five major bathymetric zones based on the generalized distribution of key dominant foundation species (Figure 17): (1) algae ≤160 m, (2) carpets of encrusting filter-feeders between 160 and 400 m (e.g., anemones, sessile sea cucumbers, brachiopods), (3) contiguous mats of brittle stars (*Ophiacantha diplasia* and *Ophiopholis* spp.) starting at 400 m and transitioning into tall Gorgonian coral stands (e.g., *Primnoa pacifica* and *Isidella tentaculum*), (4) glass sponge dominated gardens (e.g., *Pinulasma* n. sp. and *Farrea* sp.) between 800 and 1200 m, and a relative decline of animal abundance below 1200 m.

As a class, glass sponges appear to have the strongest depth-distribution pattern corresponding with a bathymetric zone (Appendix F). The anoxic zone covers only one-fifth of the depth range visually surveyed (~400 m) but contains the majority of habitat-forming glass sponges observed, as well as the overall peak abundance and the individual peak abundance for six of the eight taxa (Appendix F). This biological mirroring of the environmental bathymetric zones is also observed in the depth distribution of mobile species, not just sessile and sedentary organisms. For example, rougheye rockfish (*Sebastes aleutianus*; a species of conservation concern and commercial value) are hypoxic-sensitive and appear restricted to the upper oxic zones over OPB seamounts (<450 m), while the crinoids (*Florometra serratissima*; a mobile but habitat-forming species) have a roughly bimodal depth-distribution, appearing to avoid the anoxic zone (a range gap between 700 to 1150 m) (Ross et al. 2020).

While the effects of the bathymetric boundaries on rockfish appear clear (a significant depth-barrier given that their known depth range extends to almost 3,000 m; Ross et al. 2020 and references therein), the effects on other commercially important fish species, like sablefish (*Anoplopoma fimbria*) and Pacific halibut (*Hippoglossus stenolepis*), are not resolved. Visual observations and fisheries records document their distributions are far more widespread and deeper, with sablefish recorded as present across the OPB and on seamounts with depths down to 1,583 m (SK-B, Hodgkins, Union, Dellwood, Dellwood South, Endeavour, UN 25, UN 22, SAUP 5494). Halibut share a similar widespread distribution and have been fished on seamounts with depths down to 1765 m (SK-B, Dellwood, Dellwood South, and UN 7, 19, 20, 25, and 47). Fisheries data provided and discussed under Objective 5: Existing data.

2.2.3. Summary of findings

The following summarizes the findings for objective 2: identify natural boundaries or zones within the OPB.

- There is no evidence of a biogeographic boundary in the OPB (i.e., no apparent barriers to species distributions).
- All OPB seamounts occur on the Pacific plate—with one partially on the Explorer plate (UN 27) and another partially on the Explorer and North America plates (Tuzo Wilson [east]).

Further research is required to resolve the ecological importance, if any, of proximity to intra-plate features, such as faults, spreading valleys and ridges.

- All OPB seamounts occur within a transitional (offshore bifurcation or coastal) zone, an upwelling zone, the pathways of the Haida eddies, or a combination thereof. Little is known about the influence of these major currents on the seamounts they bath, although it is likely significant (e.g., the Hadia eddies are thought to increase regional productivity, biological diversity, resilience, and connectivity on the seamounts within the SK-B MPA, but more research is required).
- The OPB seamounts cluster into four spatial clusters. The AOI overlaps three of these zones and the SK-B MPA overlaps the remaining one.
- There are six bathymetric zones in the OPB based on depth-related environmental gradients with boundaries at 200, 480, 800, 1200, and 1700 m depth. The biological relevance of these bathymetric zones is supported by the distribution of ecologically important species.

2.3. OBJECTIVE 3: SEAMOUNT CLASSIFICATION

2.3.1. Methods

2.3.1.1. Seamount classification scheme

OPB seamounts were classified based on physical and oceanographic characteristics using a global seamount classification system (Clark et al. 2011) and regional data. The seamount classification system was developed to aid the scientific design of MPAs (Clark et al. 2011) and was used to characterize OPB seamounts for an overview of the AOI (DFO 2019a). This repeat analysis serves to update the previous classification by including an additional criterion (export productivity), new data (i.e., net primary productivity, seamount boundaries, and better bathymetry), and newly discovered seamounts (Objective 1).

The classification system uses a decision tree (Figure 18) to assign seamounts to classes based on the following ecologically important criteria:

1. biogeographic province;
2. export productivity (to summit);
3. summit depth;
4. dissolved oxygen concentration at summit; and
5. proximity (distance to nearest seamount).

Seamount shape, listed as a potential consideration by Clark et al. (2011), was investigated as a possible sixth criterion but not included (see Objective 7, Analyses).

Data were sourced or derived from:

1. lower bathyal global biogeographic provinces (Clark et al. 2011);
2. 19 years of sea surface net primary productivity (satellite-based data assembled and analyzed by Andrea Hilborn, Institute of Ocean Sciences), a carbon flux equation (Suess 1980), and summit depth (Table 2);
3. best available bathymetry data for each seamount (see Objective 1, Methods);

4. oxygen concentration from the World Ocean Atlas 2013 data (World Ocean Atlas 2013 data (Garcia et al. 2014) and Line P (a long-term oceanographic time-series; Tetjana Ross, Institute of Ocean Sciences); and
5. distance to nearest seamount or continental slope (based on boundaries; Appendix A: Table A1).

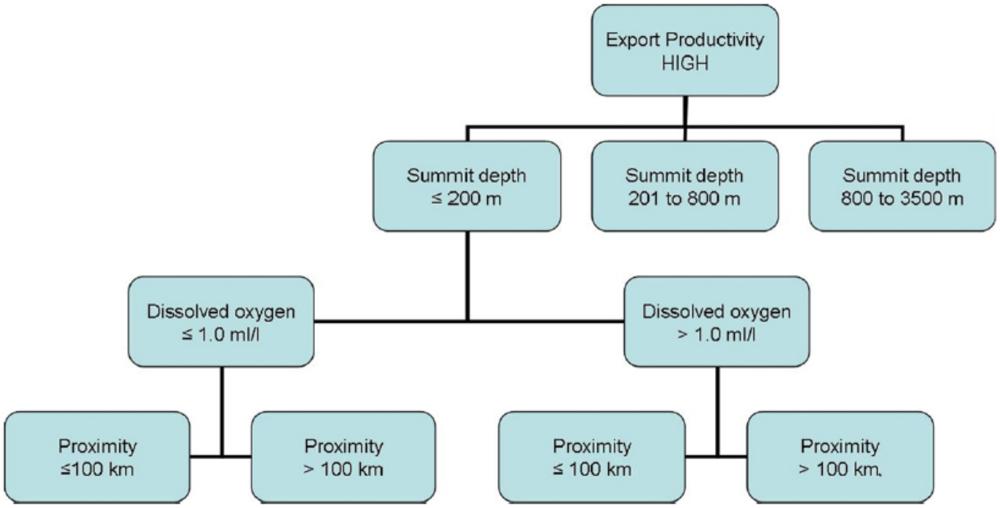


Figure 18. Organization chart of the hierarchical structure showing divisions within a biogeographic province for a high level of organic matter flux (the splits are repeated for Export Productivity MEDIUM and LOW; where HIGH is ≥5 MEDIUM is 1 to 5, and LOW is <1 mol m^{-2} d^{-1} of particulate organic carbon, POC). Figure from Clark et al. (2011).

In the OPB, criteria 1 and 5 are not informative since all seamounts occur in the "North Pacific" biogeographic province, and all occur within "close proximity" (≤100 km; Appendix A: Table A1). The other three criteria are variable.

In the OPB, criteria 3 and 4 numerated thresholds—which are based on global relevant values—are meaningful. Summit depth (≤200, 201-800, >800 m depth): recall that 200 m marks the lower boundary of the euphotic zone and 800 m marks the lower boundary of the deep scattering layer (Objective 2, Ecological patterns). Dissolve oxygen concentration at summit (> or ≤ 1.0 ml/l): recall that 1.0 ml/l oxygen defines the region's mid-water Oxygen Minimum Zone (OMX, hypoxia "low oxygen"; Ross et al. 2020 and citations therein).

We calculated oceanic particulate organic carbon (POC) flux to the seafloor (hereafter referred to as export productivity or $C_{flux(z)}$) as a function of net primary productivity (organic carbon in surface waters or C_{npp}) and summit depth (z) (Suess 1980):

$$C_{flux(z)} = \frac{C_{npp}}{(0.0283z+0.212)}$$

C_{npp} geospatial data was derived from the Carbon-based Production Model (CbPM) monthly over a 19 year period from 01-07-2002 to 31-01-2020, in milligrams of carbon per meter-squared per day (mg C m^{-2} d^{-1}) (Appendix G). Data is integrated down to a depth of 200 m at approximately 9 km pixel resolution over our study region. The CbPM is available online (www.science.oregonstate.edu/ocean.productivity, accessed 7 December 2020). Data used herein were assembled and analyzed by Andrea Hilborn (Institute of Ocean Sciences).

Because of uncertainty associated with POC flux dynamics (e.g., sinking velocity, POC horizontal movement, the efficiency of the biological carbon pump), the monthly C_{npp} and $C_{flux(z)}$

was calculated as a mean value for a 30 km buffer around the summit for each seamount (the breadth of oceanographic influence associated with a well-studied nearby seamount; Dower et al. 1992). Example climatology provided in Appendix G.

We calculated the overall mean $C_{flux(z)}$ for each seamount using CbPM data from February to November. January and December (winter months) were removed owing to lack of high-quality satellite data due to the low sun angle data gaps (Appendix G).

Three export flux categories are included in the global seamount classification system (criterion 2, Clark et al. 2011): low: <1, medium: 1 to 5, high: ≥5 mol m^{-2} d^{-1} of particulate organic carbon, POC. These thresholds are not meaningful at distinguishing OPB seamounts, as all summits receive a “low” level of export flux (<1 mol C m^{-2} d^{-1} or <12,011 mg C m^{-2} d^{-1}). Thus, to use export productivity as a meaningful characteristic, we calculated and reassigned thresholds based on quartiles and the regional seamount conditions:

“Low”, ≤9.85 mg C m^{-2} d^{-1} (1st or lower quartile)

“Medium”, 9.85 to 18.78 mg C m^{-2} d^{-1} (2nd and 3rd quartile)

“High”, ≥18.78 mg C m^{-2} d^{-1} (4th or upper quartile)

These export flux calculations align with published in situ measurements and calculations from the Northeast Pacific of less than 20 mg C m^{-2} d^{-1} to the deep sea (e.g., Smith et al. 2006; Huffard et al. 2020).

The thresholds above correspond with seamount summit depths, whereby seamounts with summits >2,000 m likely receive a low level of export flux, seamounts with summits between 2,000 and ~1,100 m receive a medium amount, and seamounts above ~1,100 m receive a high amount.

2.3.1.2. Seamount classes ground-truth analysis

Ecological information derived from a subset of visual survey data collected from 2017-2019 (see Objective 2, Methods: Benthic visual surveys) was used to assess and ground-truth differences in species composition among the seamount classes (similar to the ground-truth analysis in Clark et al. 2011). We used a presence-absence analysis of large habitat-forming octocorals (Gorgonians) (Figure 19) to regionally ground-truth the biological relevance of the seamount classes. Gorgonian corals were selected for these analyses because they are included in many conservation targets, both nationally and internationally, they are relatively easy to resolve and identify, and they are foundation species and key components of the OPB seamount benthic communities and promote productivity and biological diversity.

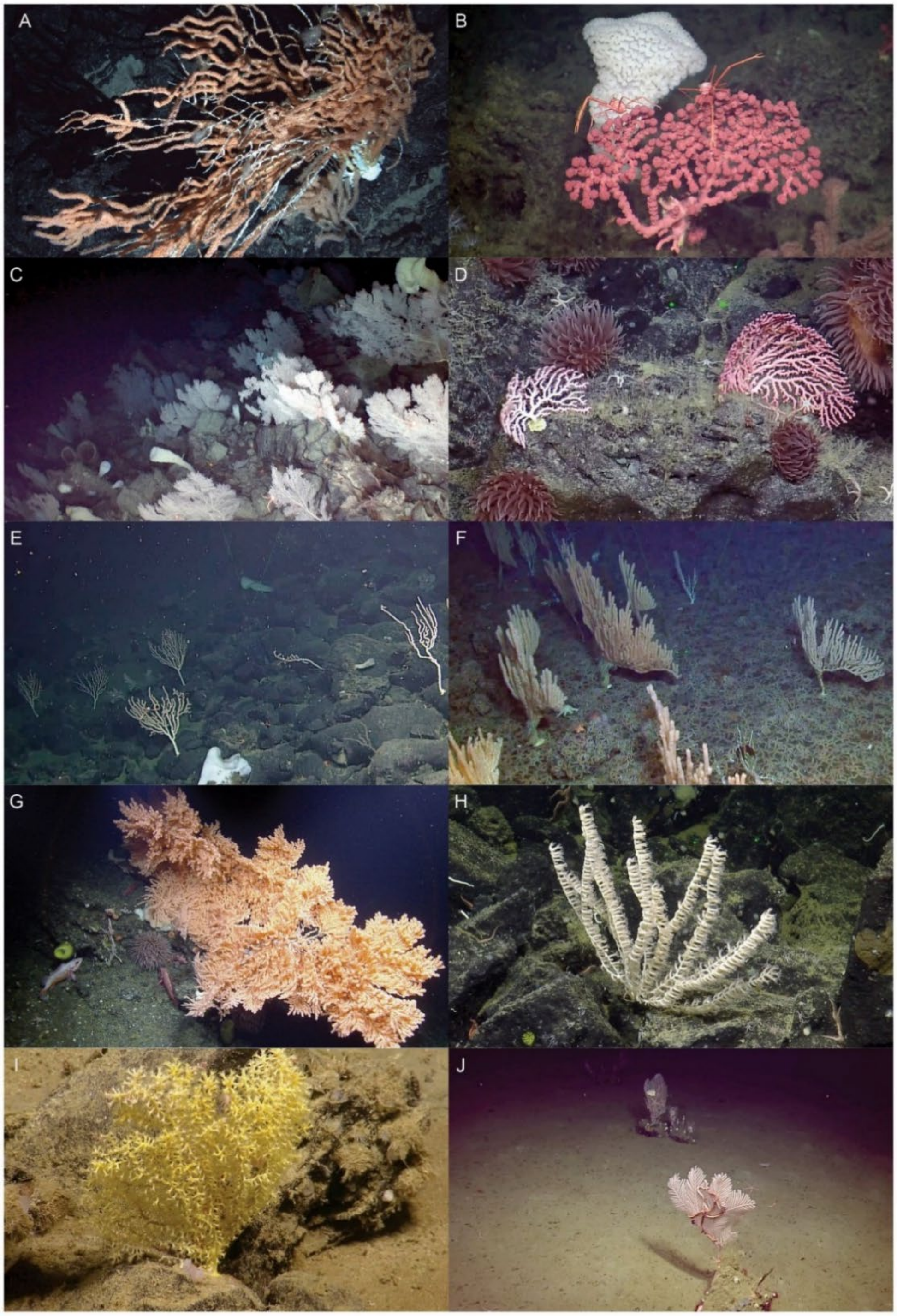


Figure 19. Examples of the large habitat-forming octocorals (Gorgonians) observed on 11 seamounts, above 1400 m depth: (A) the complex structure of Keratoisis sp. A, (B) a Paragorgia pacifica bubble gum coral providing elevation for squat lobsters (Chirostylidae), (C) a dense forest of fan-like Parastenella sp., (D) the glove-shaped Paragorgiidae species, (E) a patch of Paragorgia cf. jamesi, (F) a thicket of some 2-m tall Isidella tentaculum corals, (G) a massive red tree coral, Primnoa pacifica, reaching meters across, providing shelter for resting rockfish (Sebastes sp.), (H) the bushy structure of the Keratoisis sp. B, (I) a Acanthogorgia sp. coral, and (J) a couple of Callogorgia sp. corals creating relief and structural habitat for commensal brittle stars (Ophiuroids) on the otherwise flat and muddy surrounding terrain.

Biological diversity is the variability among living organisms and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems (DFO 2019a). Herein we examined two tiers of biodiversity. We analyzed alpha-diversity (α-diversity) as a count of local species richness for each seamount and beta-diversity (β-diversity) as the Jaccard index pairwise (dis)similarity between seamount assemblages. The Jaccard index is a measure of the intersection over the union or, put another way, the ratio of shared species between two assemblages divided by the total number of species in the assemblages. Corals that are not confidently known to be a single species were excluded to avoid misidentifying assemblages as more similar than they are (i.e, *Swiftia* spp. were grouped as were multiple whip-like Isididae species). Clustering was performed in R Studio version 1.2.5033 using the Jaccard index and hierarchical clustering (hclust function, 'cluster' R package; euclidean distance).

Relevant ecological datasets included in this section: presence-absence data for large habitat-forming Gorgonian corals (Octocorals) (replicating Clark et al. 2011). Existing Gorgonian coral data was readily available for the 2017 and 2018 expedition, and data for the 2019 expedition was specifically annotated for this research. To enable comparability between seamounts: only one straight transect was used to represent each seamount and only at depths ≤1,400 m. Of the 12 seamounts surveyed, 11 qualified for this analysis (Appendix D: Table A3, grey shaded dives); the survey on UN 18—the deepest seamount surveyed to date—ended at 1615 m depth. It was assumed individual transects represented the true assemblage well enough to enable a comparison between seamounts. The lack of observed presence herein is interpreted as evidence of absence, but we can not ascertain absence with certainty. We considered within-transect variability of substrate, but noted variability occurred on the order of meters to tens of meters and hard substrate was readily available throughout the transects (habitat required for Gorgonian corals). We also considered the lack of replicate transects, but noted the length and duration of the individual transect was substantive (i.e., kilometers long with redundancy of depths surveyed and several hours, Appendix D: Table A3), especially in comparison to other regional seamount surveys (e.g., the community structure of Cobb Seamount was resolved from multiple transects which, when combined, were more spatially and temporally limited than our individual transects; Du Preez et al. 2016).

While writing this Research Document, the authors participated in the Pac2021-036 expedition. Owing to the timing, the data is not included in this Research Document, although some comments on observations or preliminary findings are provided. Other sources of data that could have been included but were not are seamount fisheries bycatch data (not consistently recorded and not recorded at the taxonomic level of interest) and eDNA (only collected in 2018, processing still in progress, reliability and sensitivity unknown).

2.3.2. Results and discussion

2.3.2.1. Seamount classes

Seven classes of seamounts were identified in the OPB (Figure 20): L1, M1, M2, H2, H3, H4, and H5; where the letters denote the export productivity categories (low, medium, high) and the numbers denote the summit depth and dissolved oxygen combination categories (comparable with the original five classes produced without considering export productivity, which split classes 1 and 2; DFO 2019a).

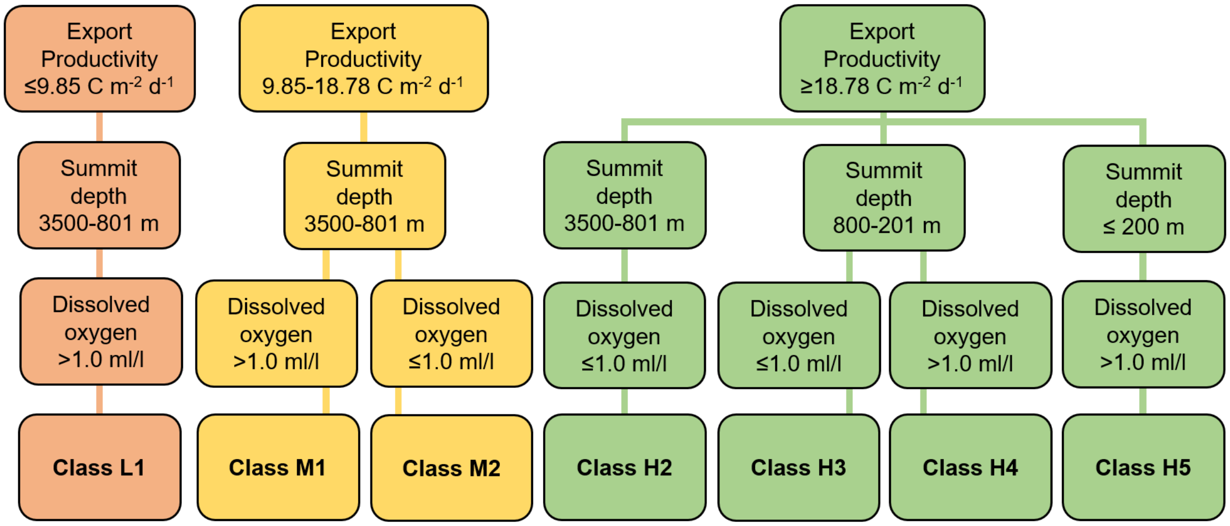


Figure 20. Organization chart of the hierarchical structure showing the seamount classification divisions for the seven combinations that exist in the Offshore Pacific Bioregion (OPB). Environmental conditions illustrated in Figure 6. The significant figures provided for Export Productivity define the categories based on regional seamount conditions estimates and quartiles, and should not be interpreted as an indication of certainty or precision.

The 62 OPB seamounts are classified primarily by the depth of the summit (Table 2), either directly or indirectly (i.e., depth-related environmental gradients). With the deepest criterion of the classification occurring at ~2,000 m (Table 2: the transition between Low Export Productivity) and the shallowest seamount base starting at 2,550 m (Appendix A: Table A1Table 2: Tuzo Wilson (east)), all 62 seamounts experience the deepest of the defining condition. As summit depth decreases, a seamount transitions the subsequent defining depths. The shallower the seamount, the more environmental conditions it passes through (Figure 21-22).

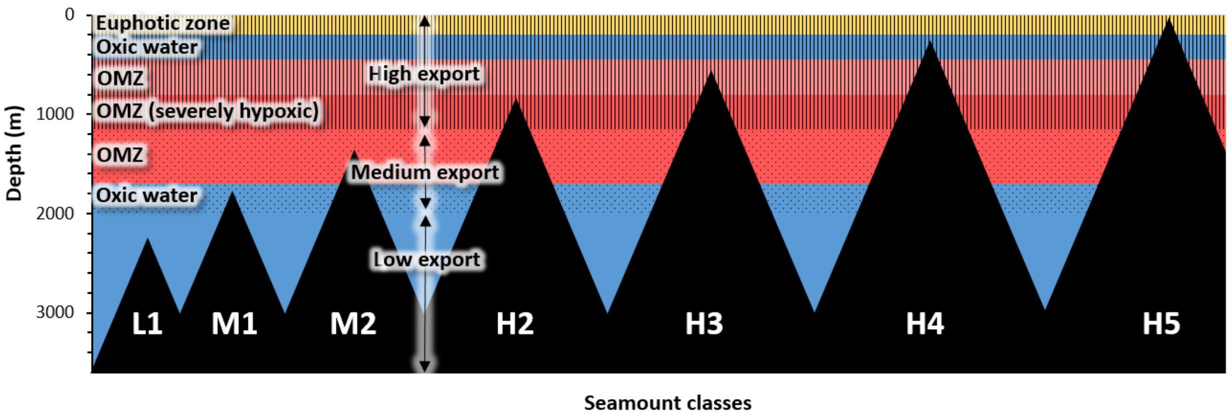


Figure 21. Illustration of the different depth-related environmental conditions (i.e., habitats) each of the seven seamount classes rise through: depth zones delineated by light availability (yellow: euphotic; aphotic below), oxygen concentration (blue: oxic; pink: hypoxic in the Oxygen Minimum Zone, OMZ; red: severely hypoxic in the OMZ), and export productivity from surface waters (vertical lines: high; dots: medium; black: low).

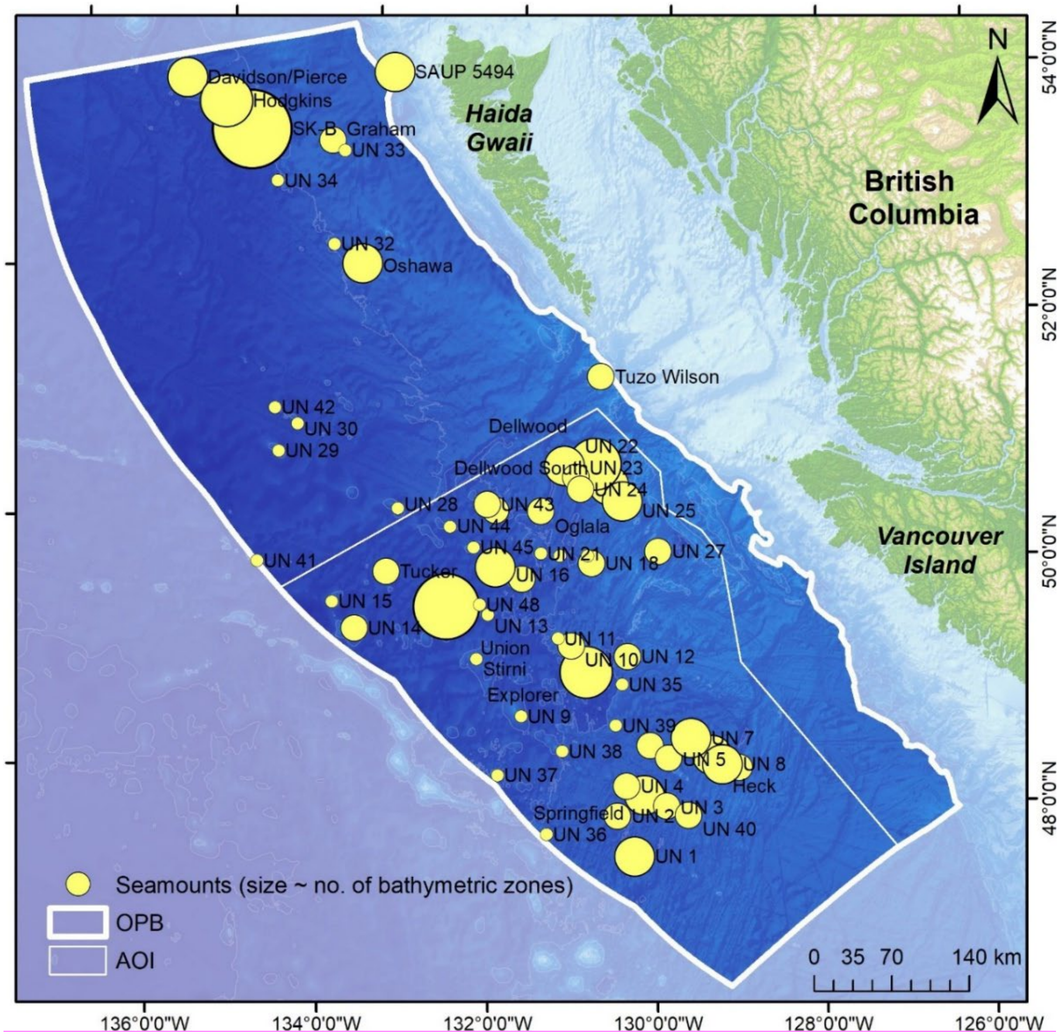


Figure 22. The number of bathymetric zones each seamount transitions, where circle size represents the number of zones (i.e., a larger circle = more zones) (proxy of ecological/biological diversity). Also shown: the Offshore Pacific Bioregion (OPB) and Offshore Area of Interest (AOI).

2.3.2.2. Trends in coral diversity among seamount classes

Alpha diversity case study

Similar to the ground-truth analysis by Clark et al. (2011), our presence-absence analyses of large habitat-forming octocorals (Figure 19) support the biological distinctiveness of the seven seamount classes. Despite the low sample size (*n* 11 of 62 seamounts), mean species richness (α-diversity) varied among classes (Table 4), generally increasing with export productivity and increasing class number (i.e., decreasing summit depth), which aligns with the habitat-heterogeneity hypothesis (MacArthur and MacArthur 1961) that an increase in the number of different habitats can lead to an increase in species diversity (illustrated in Figure 21).

Table 4. The observed presence (P) and local richness (α-diversity) of large habitat-forming octocorals (Gorgonians) on 11 surveyed seamounts representing all but one class (Class 1) (see Figure 13 for seamount locations, Figure 19 for example images of the species, and Appendix D: Table A3 for survey dive details). Data is from a single benthic visual survey, starting at 1,400 m and ending on the seamount summit (but not necessarily the shallowest pinnacle; i.e., summit depth). The lack of observed presence is a dash and should be interpreted as evidence of absence. Astericks denote exceptions to the trend of increasing richness with decreasing summit. Seamounts ordered by ascending class, then summit depth.

	UN 16	Davidson	Heck	Springfield	UN1	Dellwood South	Explorer	Hodgkins	Dellwood	Union	SK-B
Class	**M2**	**H2**	**H2**	**H2**	**H2**	**H2**	**H3**	**H3**	**H3**	**H4**	**H5**
Max. depth	1,400										
Min. depth	1099	1172	1085	912	917	817	790	599	559	395	240
Summit depth	1097	1079	1015	922	895	821	795	611	535	271	24
Keratoisis sp. A	P	P	P	P	P	P	P	P	P	P	P
Paragorgia pacifica	P	-*	P	P	P	P	P	P	P	P	P
Parastenella sp.	-	P	P	P	P	P	P	P	P	P	P
Paragorgiidae, Unknown	-	P	P	P	P	P	P	P	P	-*	P
Paragorgia cf. *jamesi*	-	-	-	P	-*	P	P	P	P	P	P
Isidella tentaculum	-	-	-	-	-	P	-*	P	P	P	P
Primnoa pacifica	-	-	-	-	-	-	-	-	P	P	P
Keratoisis sp. B	-	-	-	-	-	P*	-	-	P*	-	P
Acanthogorgia sp.	-	-	-	-	-	P*	-	-	P*	-	-
Callogorgia sp.	-	-	-	-	-	P*	-	-	P*	-	-
α-diversity	**2**	**3**	**4**	**5**	**4**	**9**	**5**	**6**	**10**	**6**	**8**

Based on the visual surveys of 11 seamounts within the OPB (one transect per seamount), (i) all seamounts supported Gorgonian corals, (ii) seamounts in the same class tend to support a similar number of species of large Gorgonians (α-diversity), and (iii) the local richness tends to increase with decreasing summit depth (i.e., increasing class number) (Table 4).

No L1 or M1 seamounts have been surveyed, but it is rational to expect, with summit depths below 1200 m, the species richness would be low, similar to UN 16. This expectation fits with the low diversity and sparse distribution of Gorgonian corals observed between 1200 and 2150 m depth on the OPB seamounts (unpublished data from annotations used in this report). M2 seamount supports two species. H2 and H3 seamounts support an average (± StDev) of 5.0±1.0 species (n = 5) and 7.0±1.5 species (n = 3), respectively. The H4 and H5 seamounts support 6 and 8 species, respectively. The trend of increasing richness with decreasing summit depth is a function of accumulating new, shallower species (i.e., the number and characteristics of bathymetric boundaries a seamount transects determines the species turnover and ultimately the total biodiversity; McClain et al. 2010), with few exceptions (Table 4: shaded grey), most notably the presence of *Keratoisis* sp. B, *Acanthogorgia* sp., and *Callogorgia* sp. on the two Dellwood seamounts. This supports the hypothesis that the number of bathymetric zones each seamount transitions is likely a proxy for ecological and biological diversity (Figure 22).

The 11 surveyed seamounts cover a large summit depth range (>1 km) and the full spatial extent of the OPB (Figure 13). It is reasonable to expect the documented biological patterns apply to the other OPB seamounts within the same surveyed depths. There is support for such extrapolation from independent research on two seamounts just west of the AOI (outside the OPB). Warwick and Cobb seamounts qualify as Class H4 and H5, respectively (summit depths of ~490 and 35 m). The presence of *Parastenella* sp. and *Isidella tentaculum* on Warwick Seamount fits with the expected coral assemblage of a H4 seamount, while the presence of *Keratoisis* sp. A, *Parastenella* sp., *I. tentaculum*, *P. pacifica*, and *Keratoisis* sp. B on Cobb Seamount fits with the expected coral assemblage of a H5 seamount. Presence-only data for these seamounts are from the National Oceanic and Atmospheric Administration (NOAA) coral data portal (NOAA 2020) and Du Preez et al. (2015).

It should be noted that the two seamounts with the highest Gorgonian coral α-diversity are both in the AOI (Table 4). Dellwood South (H2) and Dellwood (H3) seamounts support up to twice as many species as the other seamounts in their classes. This may be a function of their high surface productivity (Appendix A: Table A1) and therefore increased POC export flux potential (Pitcher and Bulman 2007; Clark et al. 2011) (Appendix A: Table A1). At 0.88 and 0.87 mg/m^3, their sea surface chlorophyll-a (Chl-a) concentrations are twice that of other seamounts in their numerical classes (Appendix A: Table A1). In general, Chl-a concentration decreases with increasing distance offshore. While Dellwood and Dellwood South are only 40 and 54 km offshore, other seamounts included in this analysis and within their numerical classes are up to 152 and 233 km offshore (Appendix A: Table A1).

Beta diversity case study

A (dis)similarity analysis further demonstrates that the species composition (β-diversity) also varies among classes (Table 5); in general, seamounts in the same classes are more similar (dissimilarity values closer to 1.00) than seamounts in different classes. All seamount pairs share at least one species (dissimilarity value >0). Dellwood and Dellwood South shared the most (0.90). Again, exceptions to the trend mentioned above appear to be linked to high net primary productivity (surface), suggesting the export productivity equation may underestimate its ecological importance.

Table 5. The Jaccard index pairwise (dis)similarity matrix of Gorgonian coral species by seamount for the OPB (see Figure 13 for seamount locations and Figure 19 for examples of corals). Where “0” indicates no shared species and “1” indicates the two seamounts have the same species assemblage (bold) (light to dark green shading reflect the values, 0 to 1). (Dis)similarity matrix illustrated in Figure 23.

Seamount	UN 16	Davidson	Heck	Springfield	UN1	Explorer	Hodgkins	Union	SK-B	Dellwood South
UN 16										
Davidson/Pierce	0.25									
Heck	0.50	0.75								
Springfield	0.40	0.60	0.80							
UN1	0.50	0.75	1.00	0.80						
Explorer	0.40	0.6	0.80	1.00	0.80					
Hodgkins	0.33	0.5	0.67	0.83	0.67	0.83				
Union	0.33	0.29	0.43	0.57	0.43	0.57	0.71			
SK-B	0.25	0.38	0.50	0.63	0.50	0.63	0.75	0.75		
Dellwood South	0.22	0.33	0.44	0.56	0.44	0.56	0.67	0.50	0.70	
Dellwood	0.20	0.30	0.40	0.50	0.40	0.50	0.60	0.60	0.80	0.90

The Jaccard Index pairwise (dis)similarity matrix (Table 5) and tree (dendrogram; Figure 23) demonstrate several important biological trends of the seamount classification scheme (illustrated in Figure 20).

In general:

1. seamounts in the same class tend to support Gorgonian coral assemblages that are more similar than seamounts in different classes;
2. seamounts in sequential classes (i.e., seamounts with similar submit depths) tend to support assemblages that are more similar than seamounts in non-sequential classes;
3. the Dellwoods are outliers to the two generalizations listed above.

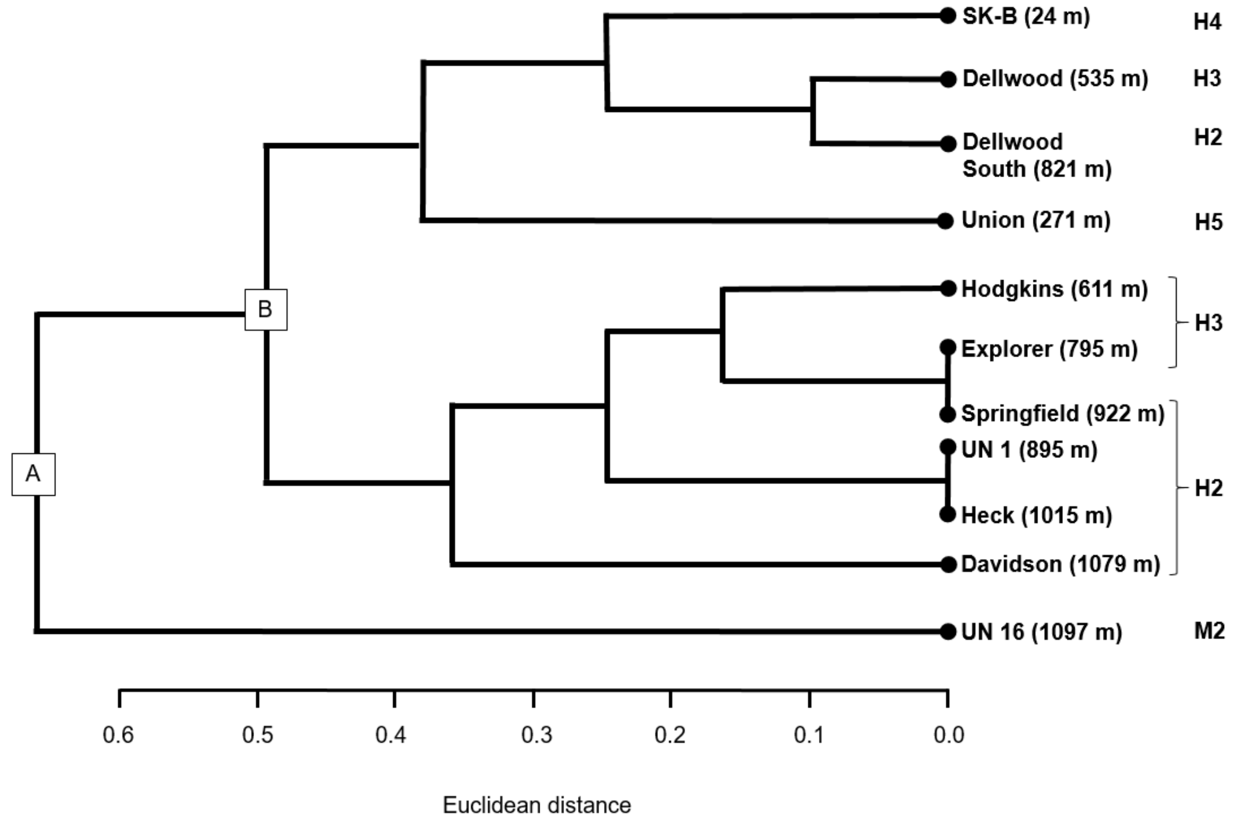


Figure 23. Gorgonian coral (dis)similarity tree between 11 seamounts in the Offshore Pacific Bioregion (OPB) representing 6 of the 7 classes (data in Table 5; seamount locations shown in Figure 13). The first two breaks separate (A) M2 from all other classes and (B) most H2 and H3 seamounts from H4 and H5 seamounts (with the exception of the Dellwood seamounts). Seamounts ordered by (dis)similarity, then summit depth.

To better understand the variations from the trends requires examination of the continuous data for one or more of the variables. For example, Springfield Seamount supports a species richness (Table 4) and assemblage (Table 5) more similar to the H3 seamounts than to the other H2 seamounts. In fact, it supports the exact same assemblage as Explorer Seamount. Springfield is a “shallow” H2 while Explorer is a “deep” H3; consequently, there is only 127 m depth difference between their summits (Figure 23). They also share similar Chl-a and oxygen concentrations (Appendix A: Table A1) and are located in the same general region of the AOI (Figure 9), at similar distances offshore. These findings suggest it may be helpful to consider a multivariate classification approach option, in addition to hierarchical classification and continuous data. Replicate transects from the seamounts, and for other seamounts within classes (including the missed classes, L1 and M1) would be preferable.

2.3.3. Summary of findings

The following summarizes the findings for objective 3: update information for the systematic classification of OPB seamounts.

- Seven classes of seamounts were identified in the OPB: L1, M1, M2, H2, H3, H4, and H5; where the letters denote the export productivity categories (low, medium, high) and the numbers denote the summit depth and dissolved oxygen combination categories (comparable with the original five classes produced without considering export productivity; DFO 2019a).

- The α- and β-diversity trends for the large, habitat-forming Gorgonian corals support the general application and biological meaningfulness of the seamount classification system (similar to Clark et al. 2011). In general, species richness (α-diversity) increases with decreasing summit depth and increasing productivity export, and the species assemblage of a seamount (β-diversity) corresponds to its class. Variations from this trend may be better explained by the export productivity equation underestimating the ecological importance of surface primary productivity and by continuous data rather than the categories.
- All surveyed OPB seamounts support habitat-forming cold-water corals, independent of location, depth, or class—it is highly likely that this applies to all OPB seamounts and that these seamounts support many more species of corals, sponges, and other habitat-forming invertebrates in addition to Gorgonian corals.

2.4. OBJECTIVE 4: UNIQUENESS AND ECOSYSTEM FUNCTIONS PROVIDED BY SEAMOUNTS

2.4.1. Methods

2.4.1.1. Mapping and geoprocessing

We performed all mapping and geoprocessing ArcGIS 10.8 (e.g., 'clipping' and 'select by location' functions to assess depth distribution within and outside of seamount boundaries). Shapefiles of seamount summits and seamounts boundaries (Objective 1 deliverables) and the 'best available bathymetry data' mosaic were products of Objective 1.

2.4.1.2. Assessments

Assessments within this section focus on the OPB seamount classes (Objective 3 results) and ecological criteria defined by the United Nations CBD. The uniqueness assessment is based on the CBD EBSA criteria definitions for *rare* (occurs in only a few locations) and *unique* (the only one of its kind) (CBD 2008). By default, *common* is neither *unique* nor *rare*. The ecosystem function assessment is based on the five biological CBD criteria (i.e. unique or rare, critical habitat, threatened species, productive, diverse) for defining EBSAs as providing important services (natural physical, chemical, and biological processes, attributes, and components) to one or more species, populations, or ecosystems, compared to other surrounding areas or areas of similar ecological characteristics (CBD 2008). Some seamount ecosystem functions are well-demonstrated, while others are rarely observed and/or are theoretical in nature.

2.4.2. Results and discussion

2.4.2.1. Uniqueness provided by seamounts

Uniquely shallow seafloor

Shallow seafloor in the OPB and AOI is rare and almost exclusively limited to on seamounts (Figure 24). The average off-seamount depth in the OPB is ~2,900 m, with only a few nearshore features outliers rising above 1 km depth (834 m is the shallowest).

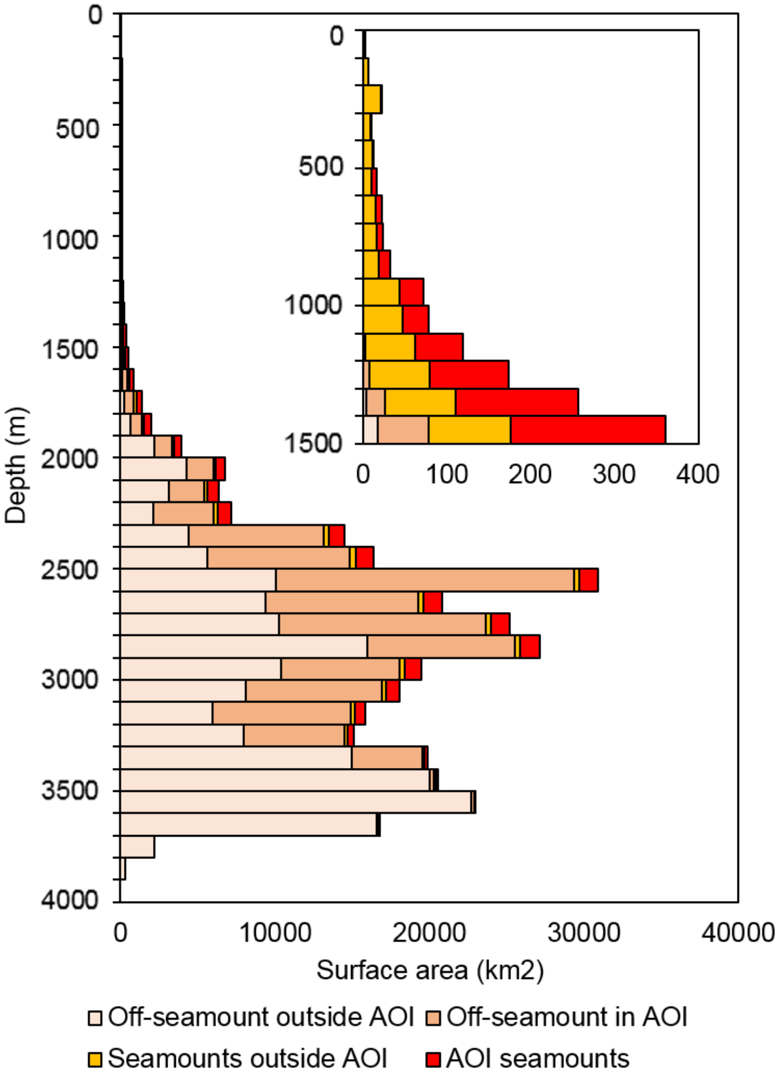


Figure 24. The seafloor depth distribution in the Offshore Pacific Bioregion (OPB), within and outside of the Area of Interest (AOI), both on and off-seamounts. Where the largest area is off-seamount outside the AOI (cream), followed by off-seamount in the AOI (light brow), and on seamounts are relatively small areas, both outside (yellow) and inside (red) the AOI.

Seamounts cover a relatively small area of the OPB and AOI (Table 3: 6.5% and 11.2%; Figure 24) but represent 99% of all “shallow” benthic habitat above 1,200 m depth. The SK-B MPA contains more seafloor above 1,200 m than the AOI, despite containing only three seamounts in comparison to 47 within the AOI (257 km^2 and 156 km^2, respectively). SK-B MPA also contains the only seafloor in the OPB within the “sunlit” euphotic zone (0-200 m) (8 km^2 or 0.0025% of the OPB; Figure 24): the summit plateau and peaks of SK-B Seamount. The shallowest seafloor in the AOI is a small peak on the flat-topped summit of Union Seamount—it has roughly 7 km^2 above 500 m depth, as a relatively small submarine island isolated by 100s of kilometers (Figure 24; Appendix A: Table A1).

Rare or unique classes

Knowing each seamount class's abundance, location, and conservation status is essential for ensuring representativity in conservation and monitoring plans (Table 2). Within the OPB,

- Classes L1, M1, M2, and H2 are *common*, with >10% of the OPB seamounts in each (Table A2: *n* = 16, 8, 22, and 11, respectively),
- Class H3 seamounts are *rare* (Dellwood, Hodgkins, Explorer), and
- Classes H4 and H5 seamounts are *unique* (Union and SK-B, respectively).

The AOI has at least one seamount from six of the seven classes (no Class H5), but the AOI and SK-B MPA combined cover all seven classes (Table 6; Figure 25). Notably, three classes that occur in the AOI or SK-B are the *rare* (H3) and *unique* (H4 and H5), whereas seamounts outside the conservation areas are deep and belong to well-represented *common* classes.

Table 6. The proportion of each seamount class in different Offshore Pacific Bioregion (OPB) conservation areas: the present Offshore Pacific Seamounts and Vents (OPSV) Closure, the Area of Interest (AOI; includes the OPSV Closure), the SGaan Kinghlas-Bowie Seamount Marine Protected Area (SK-B MPA), and outside of conservation areas.

Class	OPSV	AOI (incl. OPSV)	SK-B MPA	Outside	**Total**
L1	5	10 (63%)	0	6 (37%)	**16**
M1	5	6 (75%)	0	2 (5%)	**8**
M2	18	21 (95%)	0	1 (5%)	**22**
H2	5	7 (64%)	1 (9%)	3 (27%)	**11**
H3	2	2 (67%)	1 (33%)	0	**3**
H4	1	1 (100%)	0	0	**1**
H5	0	0	1 (100%)	0	**1**

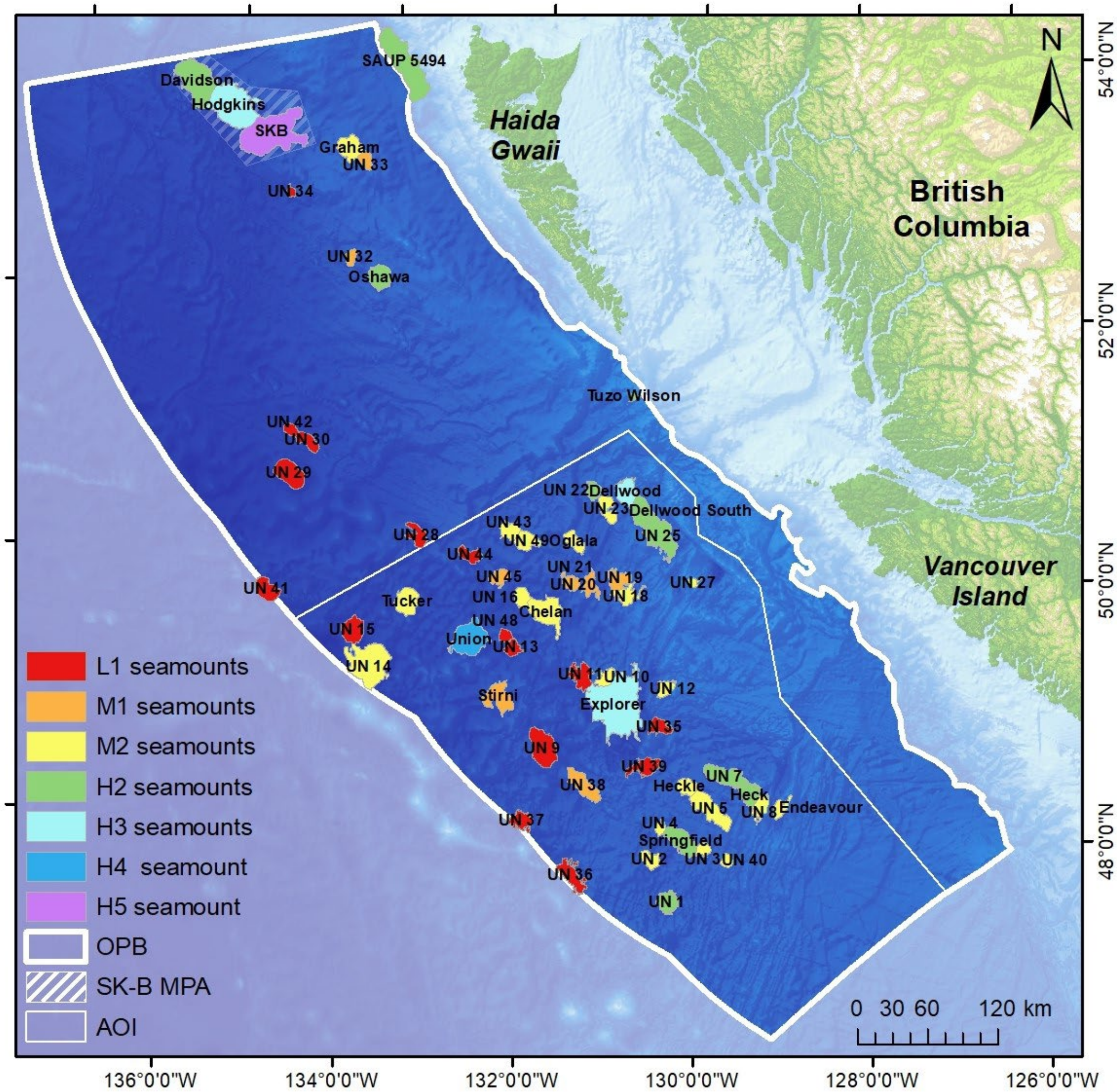


Figure 25. The location of the 62 seamount areas in the Offshore Pacific Bioregion (OPB) coloured by seamount class. Also shown: SGaan Kinghlas-Bowie Seamount Marine Protected Area (SK-B MPA) and the the Area of Interest (AOI).

2.4.2.2. Ecosystem functions provided by seamounts

Seamounts add to the heterogeneity and diversity of the deep sea (Thurber et al. 2014), providing or enhancing a range of ecosystem functions, which often relate to the abrupt presence of shallow physical structures (e.g., Union Seamount rises abruptly from ~3,000 m to less than 300 m depth over 260 km offshore). The steep volcanic flanks and relatively shallow summits of seamounts are in stark contrast to the predominately featureless surrounding deep seafloor and the otherwise uninterrupted waters of the open ocean. The sphere of influence is considered to reach far beyond the spatial scale of the physical seamount (e.g., 30-km EBSA buffer; DFO 2019a), altering conditions for benthic and pelagic species, as well as birds and other migratory animals (regional species list provided and discussed under Objective 6).

All seamounts provide ecosystem functions (Table 7). Some functions are ubiquitous to all OPB seamounts, such as providing relatively shallow benthic habitats which support diverse and distinct species assemblages of cold-water corals and sponges (i.e., rock as shallow as 24 m in comparison to the surrounding muddy basin at ~3 km) (demonstrated by alpha diversity case study, under Objective 3). Other ecosystem functions apply to only a subset of seamounts (e.g., Class H5, higher biological productivity: macroalgae present). In general, the number of ecosystem functions provided by OPB seamounts increases with decreasing summit depth (i.e., Class H5 provides the most).

Table 7. Summary of the seven seamount classes identified for the Offshore Pacific Bioregion (OPB) and the five Ecologically and Biologically Significant Area (EBSA) biological criteria associated ecosystem functions provided by each seamount class. Seamount ecosystem functions listed for OPB by DFO (Ban et al. 2016) and North Pacific by CBD (CBD 2016) include five biological criteria and exclude two anthropogenic associated criteria ("vulnerability" and "naturalness").

Class (*n*): *classification criteria* (Objective 3) • Biological EBSA criteria associated first-order ecosystem functions
L1 (*n* = 16): *export productivity — low, summit depth — deep, oxygen concentration — high* • Support unique or rare species, populations, communities, habitat, ecosystems, geomorphological, or oceanographic features [CBD EBSA criterion 1]; • provide special areas for life-history stages for a population to survive and thrive (i.e., fitness) [criterion 2]; • provide important areas containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species [criterion 3]; • provide areas containing species, populations or communities with comparatively higher natural biological productivity [criterion 4]; • provide areas containing comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity [criterion 5].
M1 (*n* = 8): *export productivity — medium, summit depth — deep, oxygen concentration — high* • All ecosystem functions listed above; • support higher biological productivity[1] (compared to surrounding abyssal waters and plains and other classes listed above): "medium" export productivity to the summits (particulate organic carbon or 'marine snow').
M2 (*n* = 22): *export productivity — medium, summit depth — deep, oxygen concentration — low* • All ecosystem functions listed above; • provide habitat for recovery of endangered, threatened, declining species: offshore refugia for continental slope species (overlapping depth range); • support higher diversity of habitats (compared to other classes listed above)
H2 (*n* = 11): *export productivity — high, summit depth — deep, oxygen concentration — low* • All ecosystem functions listed above; • support higher biological productivity (compared to surrounding abyssal waters and plains and other classes listed above): "high" export productivity to the summits.
H3 (*n* = 3): *export productivity — high, summit depth — medium, oxygen concentration — low* • All ecosystem functions listed above; • provide rare habitat: benthic habitat in the shallow hypoxic zone;

Class (*n*): *classification criteria* (Objective 3) • Biological EBSA criteria associated first-order ecosystem functions
• provide habitat for recovery of endangered, threatened, declining species: offshore refugia for continental shelf species (overlapping depth range). • support higher biological productivity (compared to surrounding abyssal waters and plains and other classes listed above): shallow; the most likely OPB seamounts to advect allochthonous matter and organisms and induce chlorophyll enhancement[1]; • support higher diversity of habitats (compared to other classes listed above): seamounts rise through an additional bathymetric zone (demonstrated by alpha diversity case study, under Objective 3); • provide unique geomorphology of Explorer Seamount: the largest seamount in the OPB (≥1,000 km^3), with the steepest pinnacle.
H4 (Union): *export productivity — high, summit depth — medium, oxygen concentration — high* • All class-based ecosystem functions listed above; • provide rare habitat: benthic habitat in the shallow oxic zone; • provide habitat for recovery of endangered, threatened, declining species: offshore refugia for coastal species (depth range of continental shelf); • support higher diversity of habitats (compared to other classes listed above): seamount rises through an additional bathymetric zone (demonstrated by alpha diversity case study, under Objective 3).
H5 (SK̲-B): *export productivity — high, summit depth — shallow, oxygen concentration — high* • All class-based ecosystem functions listed above; • provide unique habitat: benthic habitat in the euphotic zone; • provide unique geomorphology: submarine beaches, gravel beds, pinnacles, and wave-cut terraces formed by subaerial history (once an island); • provide rare geomorphology: second largest OPB seamount; • provide unique oceanographic features: tallest and therefore most likely OPB seamount to alter local currents; • provide habitat for recovery of endangered, threatened, declining species: offshore refugia for shallow-water coastal species (overlapping depth range); • support higher biological productivity (compared to surrounding abyssal waters and plains and other OPB seamounts): macroalgae present; • support higher diversity of habitats: seamount rises through all bathymetric zones (demonstrated by alpha diversity case study, under Objective 3).

[1] There is uncertainty if and how seamounts directly or indirectly affect local productivity–see Knowledge Gaps under Objective 7.

2.4.3. Summary of findings

The following summarizes the findings for objective 3: assess the uniqueness and ecosystem functions provided by each OPB seamount.

- The majority of the seafloor in the OPB and the AOI is extremely deep—the seamounts within these regions provided almost all shallow benthic habitats in the offshore. The only sunlit seafloor in the OPB is in SK̲-B MPA.
- Classes L1, M1, M2, and H2 seamounts are *common*, H3 seamounts are *rare* (Dellwood, Hodgkins, Explorer), and H4 and H5 seamounts are *unique* (Union and SK̲-B, respectively). In general, deeper seamounts are more common than shallow seamounts.

- The AOI contains 6 of the 7 classes of seamounts, with the 7th missing class, H5, found in SK-B MPA. The AOI and SK-B MPA combined capture all *rare* and *unique* seamounts, as well as the majority of *common* seamounts.
- All seamounts provided ecosystem functions—shallower seamounts tend to provide more than deeper seamounts (i.e., the H5 seamount provides more types of ecosystem functions in comparison to a L1 seamount).

2.5. OBJECTIVE 5: REPRESENTATIVE AREAS TO DETECT CHANGE

2.5.1. Methods

The management and monitoring of an LSMPA is made more challenging if the area is offshore and includes deep-sea ecosystems (Lewis et al. 2017)—such is the case with the proposed (AOI) and existing OPB MPAs. Therefore, to offer valuable information for developing future management and monitoring plans, we combined anticipated environmental changes within the OPB and a review of known existing ecological data for the 62 seamounts in a single portfolio (similar to the portfolio concept used by Taranto et al. 2012).

We assessed the following for each seamount:

1. *anticipated changes score* as the count of anticipated changes, and
2. *existing data score* as the count of known data types.

Eleven possible *changes* were assessed, including those associated with closures to (1) fishing (e.g., recovery) and (2) lost fishing gear (ghost fishing) (unpublished 2007 to 2016 DFO Pac Harv data), (3) ship traffic (2019 Satellite Automatic Identification System (SAIS) data; courtesy of Josephine Iacarella, Insitute of Ocean Sciences; see Appendix H), (4-5) exposure to ocean acidification (for calcite and aragonite) and (6-9) deoxygenation (in four different water masses related to the mid-water oxygen minimum zone: below the OMZ, within the lower boundary, in the OMZ, within the upper boundary; Ross et al. 2020), and (10-11) other environmental and biological effects of climate change (Okey et al. 2014). A comprehensive description of each *anticipated change* is provided in Appendix H: Table A5. The list contains changes that are known to be of immediate concern to the seamount ecosystems within the study region (DFO 2019a), with a focus on the benthos, and is not an exhaustive list.

Twelve possible types of *data* were inventoried for each seamount: (1-3) acoustic (bathymetry, pelagic, passive), (4) benthic collections, (5) fisheries, (6) geological, (7) monitoring sites, (8-9) oceanographic (collections, sensors), (10) visual benthic surveys (photo or video), (11) satellite-based, and (12) time-series (e.g., Line P and Ocean Networks Canada, Appendix I). A comprehensive description of each *existing data* type (with data source references) is provided in Appendix I: Table A6. Existing data sources of baseline ecological information can also be a helpful indication of existing infrastructure for future monitoring plans (e.g., long-term monitoring sites listed in Appendix I: Table A7). Existing baseline data and monitoring infrastructure listed are those available for use to the best of the authors' knowledge.

Scoring inferences were necessary at times and are explained within the appendices. The relative importance of each anticipated change or existing data source will depend on the objectives of the conservation or management action(s) of interest. They do not include all deciding factors and are presented in no particular order. Scoring was not weighted.

Depending on the conservation or management action(s) of interest, it may also be beneficial to consider additional pragmatic elements. This section also contains supplementary information on:

3. potential *control sites* outside of the OPB (i.e., seamounts within the region but outside of conservation areas) (Appendix J: Table A8), and
4. *opportunistic visual observations* of uncommon sites with regionally rare, significant, or functionally important species (identified based on opportunistic visual observations and expert opinion, limited to the 12 visually surveyed OPB seamounts) (Appendix K: Table A9).

2.5.2. Results and discussion

2.5.2.1. Anticipated changes

It is very likely all OPB seamounts will experience environmental change now or in the near future (Table 8). Of the 11 anticipated changes, those associated with climate change will probably impact the most seamounts (*n* = 62), followed by fishing (*n* = 16) and ship traffic (*n* = 5). Fifteen OPB seamounts are likely to experience a change in six or more of the 11 categories considered. Anticipated changes scores ranged from 3/11 (*n* = 21 seamounts) to 9/11 and 10/11 (Union and SK-B, respectively). If we assume a higher number of anticipated changes equates to a higher likelihood of change: 15 seamounts are highly likely to experience change relative to the other 47 (≥6 and ≤5, respectively).

SK-B and Union seamounts are the most heavily impacted by fishing activities (Appendix H: Table A5), thus may have the greatest potential for recovery post-fishing. These seamounts are also likely at the highest risk for ongoing and future impacts from lost gear and climate change (Appendix H: Table A5). They could therefore play an important role in future monitoring plans. In general, shallower seamounts are the most impacted and the most at risk.

2.5.2.2. Existing data

Of the 12 existing data types, satellite and pelagic acoustic are the most readily available (*n* = 62 and 34), while passive acoustic and geological surveys are the least (*n* = 4 each) (Table 9). Only seven OPB seamounts have six or more types of existing data available. Benthic monitoring sites were established in 2018 at six OPB seamounts (positioned in particularly diverse/dense areas and bathymetric transition zones; Appendix I: Table A7). The basic ecological data required for species distribution modeling (i.e., species presence and multibeam bathymetry) are available for roughly a quarter of the OPB seamounts. Seamount existing knowledge scores ranged from 1/12 (*n* = 21 seamounts) to 12/12 (SK-B, Dellwood, and Explorer seamounts). If we assume a higher number of data types equates to more data or knowledge: 7 seamounts have a high level of existing data relative to the other 55 (≥6 and <6, respectively). However, even on the best-studied seamounts, that data is spatially and temporally limited (recall: only 0.013% of Union has been visually surveyed, and it is one of our better-studied seamounts).

Table 8. The anticipated changes score for the 62 Offshore Pacific Bioregion (OPB) seamounts, evaluated as anticipated (1) or not (0). Seamounts with the same evaluations are grouped together. See Appendix H: Table A5, for details on each category. According to the summary, SGaan-Kinghlas Bowie and Union seamounts are the most likely to experience change in the future (scores of 10 and 9 out of a possible 11, respectively).

Seamounts	**Fishing:**		**Ship traffic**	**Ocean acidification:**		**Ocean deoxygenation:**				**Other effects of climate changes:**		***n***	**Score**
	closure	**lost gear**		**calcite**	**aragonite**	**under OMZ**	**OMZ base**	**in OMZ**	**OMZ top**	**enviro.**	**bio.**		
SK-B	1	1	0	1	1	1	1	1	1	1	1	**1**	**10**
Union	1	1	0	1	0	1	1	1	1	1	1	**1**	**9**
Dellwood	1	1	0	1	0	1	1	1	0	1	1	**1**	**8**
UN 7	1	1	1	0	0	1	1	1	0	1	1	**1**	**8**
Dellwood South, Hodgkins, Explorer, SAUP 5494, Endeavor, Oglala, & UN 5, 22, 25	1	1	0	0	0	1	1	1	0	1	1	**9**	**7**
Heck & Heckle	0	0	1	0	0	1	1	1	0	1	1	**2**	**6**
Stirni, & UN 19, 20	1	1	0	0	0	1	0	0	0	1	1	**3**	**5**
Oshawa, Springfield, Davidson, Graham, Tucker, Tuzo Wilson (east), & UN 1, 2, 3, 4, 8, 10, 12, 14, 16, 18, 23, 24, 27, 40, 43	0	0	0	0	0	1	1	1	0	1	1	**21**	**5**
UN 38 & 39	0	0	1	0	0	1	0	0	0	1	1	**2**	**4**
Remaining seamounts	0	0	0	0	0	1	0	0	0	1	1	**21**	**3**
No. of seamounts	**16**	**16**	**5**	**3**	**1**	**62**	**36**	**36**	**2**	**62**	**62**	**-**	**-**

Table 9.The existing data score for the 62 Offshore Pacific Bioregion (OPB) seamounts, evaluated as present (1) or absent (0). Seamounts with the same evaluation are grouped together. See Appendix I: Table A6, for details on each category. According to the summary, SGaan-Kinghlas Bowie, Dellwood, and Explorer seamounts have the most existing data (scores: 12 of 12 data types).

Seamounts	Acoustic			Benthos collection	Fish.	Geo. survey	Monitoring sites	Oceano-graphy		Photo/ video	Satellite	Time-series	*n*	Score
	bathymetry	pelagic	passive					collections	sensors					
SK-B	1	1	1	1	1	1	1	1	1	1	1	1	**1**	**12**
Dellwood	1	1	1	1	1	1	1	1	1	1	1	1	**1**	**12**
Explorer	1	1	1	1	1	1	1	1	1	1	1	1	**1**	**12**
Hodgkins	1	1	0	1	1	0	1	1	1	1	1	0	**1**	**9**
Dellwood South, Davidson	1	1	0	1	1	0	1	1	1	1	1	0	**2**	**9**
Union	0	1	1	0	1	0	0	1	1	1	1	0	**1**	**7**
Springfield, Heck, & UN 1, 16, 23	0	1	0	0	0	0	0	1	1	1	1	0	**5**	**5**
UN 19, 25	1	1	0	0	1	0	0	0	0	0	1	0	**2**	**4**
Endeavor	0	1	0	0	1	0	0	0	0	0	1	1	**1**	**4**
UN 35	0	1	0	0	0	1	0	0	0	0	1	1	**1**	**4**
Oshawa, Graham, & UN 12, 18, 32, 33, 34	1	1	0	0	0	0	0	0	0	0	1	0	**7**	**3**
Oglala, & UN 5, 7	0	1	0	0	1	0	0	0	0	0	1	0	**3**	**3**
UN 8, 40	0	1	0	0	0	0	0	0	0	0	1	1	**2**	**3**
Stirni	0	0	0	0	1	0	0	0	0	0	1	1	**1**	**3**
UN 2, 3, 4, 10, 27, 39	0	1	0	0	0	0	0	0	0	0	1	0	**6**	**2**

Seamounts	**Acoustic**			**Benthos collection**	**Fish.**	**Geo. survey**	**Monitoring sites**	**Oceano-graphy**		**Photo/ video**	**Satellite**	**Time-series**	***n***	**Score**
	bathymetry	**pelagic**	**passive**					**collections**	**sensors**					
SAUP 5494, & UN 20, 22	0	0	0	0	1	0	0	0	0	0	1	0	**3**	**2**
UN 9, 11, 14	0	0	0	0	0	0	0	0	0	0	1	1	**3**	**2**
Remaining seamounts	0	0	0	0	0	0	0	0	0	0	1	0	**21**	**1**
No. of seamounts	**15**	**34**	**4**	**6**	**17**	**4**	**6**	**12**	**12**	**12**	**62**	**11**	**62**	**-**

In recent years, DFO has targeted offshore seamounts during research expeditions specifically to provide science-based information for the management of the OPB and AOI. We have collected high-resolution multibeam bathymetry data for 15 seamounts and single-beam acoustic data for 34 seamounts (Figure 5). Additionally, we have surveyed the benthos and oceanography of 12 seamounts (Figure 13) with in situ specimen collections and the establishment of long-term monitoring sites on 6 seamounts (Appendix I: Table A7) (numbers do not contain the Pac2021-036 expedition which was conducted during the writing of this Research Document).

2.5.2.3. Control sites

Comparable reference sites outside conservation areas provide valuable opportunities for assessing an MPA's effectiveness at achieving its conservation goals (e.g., those pertaining to the closure to bottom-contact fishing and potential recovery). While areas of the continental slope and shelf transect have the same depths as AOI seamounts, significant differences in slope, substrate type, nearshore impacts, and connectivity make comparisons between them difficult.

Of the 12 OPB seamounts outside conservation areas, none are comparable to those identified as *rare* or *unique* areas in the AOI and SK-B MPA (Figure 25: classes H3, H4, and H5); all twelve are much deeper (Figure 25: L1, M1, M2, and H2) and have experienced little to no bottom-contact fishing (i.e., there are no comparative sites within the OPB that will continue to be fished).

There are, however, eight seamounts adjacent to the OPB, within the High Seas, that have depths similar to the *rare* or *unique* OPB seamounts and are still open to bottom-contact fishing (Appendix J: Table A8). All of these seamounts are west of the AOI, with the majority only 20-60 km away. Historical information and future monitoring of fishing efforts and impacts to vulnerable marine ecosystems on these seamounts could provide valuable information on the effectiveness of seamount MPAs. There is relatively good multibeam bathymetry for at least one of these seamounts (Cobb) and visual survey data for at least two (Cobb and Warwick), in addition to the associated fisheries data for all eight seamounts.

2.5.2.4. Opportunistic visual observations of uncommon sites

While there is no evidence of biogeographical boundaries within the OPB seamounts, visual surveys of the benthic communities show high variation in community structure. In total, 12 seamounts have been visually surveyed in recent years (Figure 13: 2017-2019; i.e., older surveys of SK-B or Hodgkins included here). DFO biologists and partners have reviewed the footage for a number of research projects and noted opportunistic visual confirmation of high density, or high diversity of regionally rare, significant, or functionally important species on eight of the twelve seamounts (Appendix K); all are identified as Significant Ecosystem Components (SECs) of OPB seamounts (DFO 2015; herein, Objective 6). Many of these species are also identified as socially, culturally, and commercially valuable species (e.g., coastal fishes). All seamounts support a range of species (including some rare, significant, or functionally important), but not all seamount surveys captured the occurrence of "unique" or "rare" observations in comparison to observations from other areas of the seamount or observations on other seamounts. The summary in Appendix K: Table A9, therefore, does not list any observations from UN 16 and 18, Springfield, and Heck.

2.5.2.5. Portfolio

The six shallowest seamounts score the highest with regards to *anticipated changes* and *existing data* (i.e., good candidate reference sites for monitoring and detecting change) (Figure 26), have nearby control sites (Appendix J: Table A8), and uncommon sites with regionally rare, significant, or functionally important species (Appendix K: Table A9) (i.e., SK̲-B, Union, Dellwood, Hodgkins, Explorer, and Dellwood South). Five of these six seamounts represent seamount classes that are *rare* or *unique* (H3, H4, and H5; see Objective 4 for details).

SK̲-B Seamount has the highest combined portfolio scores, and therefore, it is a strong candidate to detect changes within the OPB and SK̲-B MPA. Dellwood Seamount has the highest combined portfolio scores within the AOI; however, Union, the shallower seamount, is likely to experience more changes, but it has a relatively low existing data score (which suggests Union Seamount is a potentially problematic knowledge gap). Based on previous sections of this Research Document, it is important to note that the highest-scoring seamounts—the shallowest seamounts—are the seamounts with regionally unique species and the highest biological diversity.

The portfolio may be helpful for identifying class-based representative seamount areas for monitoring. For example, the highest combined score within each seamount class are: L1 UN 35 (anticipated changes score = 3, existing data score = 4), M1 UN 19 (5, 4), M2 Endeavour (7, 4), H2 Dellwood South (7, 9), H3 Dellwood (8, 12), H4 Union (9, 7), and H5 SK̲-B (10, 12) (the latter three are labelled in Figure 26). This portfolio was used to plan the Pac2021-036 seamount expedition to visually survey under-represented seamount classes (i.e., the deeper seamounts: classes L1, M1, and M2).

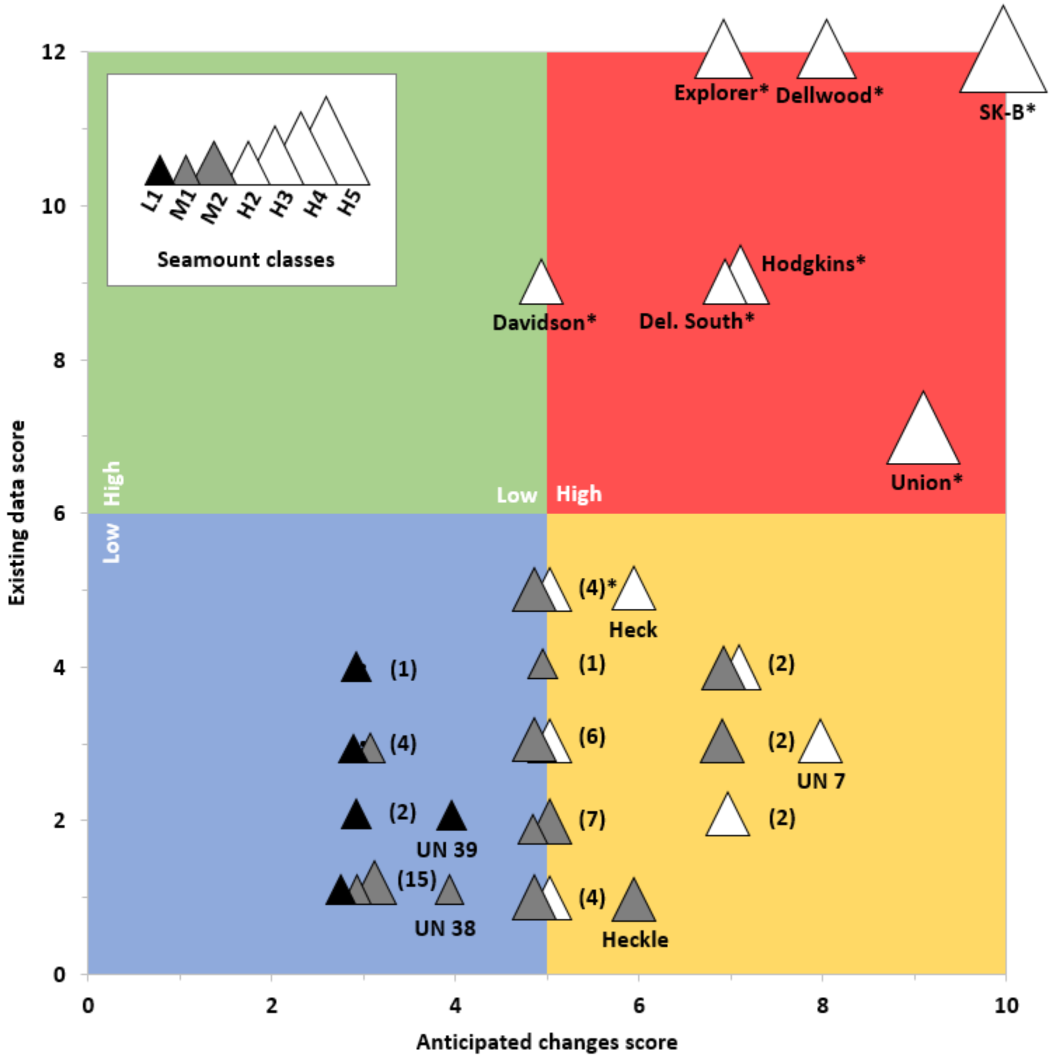


Figure 26. Seamount portfolio plot based on anticipated changes score and existing data score for the 62 seamounts in the Offshore Pacific Bioregion (OPB). The different colours represent four categories. Blue: few anticipated changes with low likelihood to detect (based on existing baseline data). Yellow: few anticipated changes with high likelihood to detect. Green: many anticipated changes with low likelihood to detect. Red: many anticipated changes with high likelihood to detect. If multiple seamounts share the same scores, the count (n) is provided in brackets, otherwise, the individual seamount name is provided. Asterisks denote seamounts with one or more observations of uncommon sites with regionally rare, significant, or functionally important species.

2.5.3. Summary of findings

The following summarizes the findings for objective 5: identify representative seamount areas to detect changes within the OPB.

- All OPB seamounts are known or inferred to be impacted by anthropogenic activities (e.g., bottom-contact fishing and climate change). That said, some are more likely to experience continued or future changes relative to others.
- There are one or more known sources for existing data for roughly half of the OPB seamounts (e.g., multibeam bathymetry, visual surveys, and/or fishing data).

- There is a data bias for shallow, nearshore seamounts. Well-studied seamounts include the three SK-B MPA seamounts, the Dellwood seamounts, and Explorer Seamount.
- The six shallowest seamounts score the highest with regards to anticipated changes and existing data. Conversely, the deepest score the lowest.
- There are several seamounts adjacent to the OPB and within the High Seas that are still open to bottom-contact fishing. These comparable seamounts may be highly valuable to studying the efficacy of fishery closures to seamounts in the OPB.
- The majority of opportunistic visual observations of uncommon sites are on the SK-B MPA seamounts and the shallowest AOI seamounts (Union, the Dellwoods, and Explorer).
- The majority of opportunistic visual observations of uncommon sites stand out as “high density” and “high diversity” observations, usually of cold-water corals and sponges. There were only two listed observations of “regionally unique” species— the tubeworm garden on Dellwood and the algae on the sunlit summit of SK-B.
- The five seamounts that represent *rare* or *unique* seamounts classes (i.e., SK-B [H5], Union [H4], Dellwood, Hodgkins, and Explorer [H5]) are notably the five of the six highest-scoring seamounts with regards to both *anticipated changes* and *existing data* and are therefore good candidate reference sites for monitoring and detecting change. They also have nearby control sites, and support regionally rare, significant, or functionally important species.

2.6. OBJECTIVE 6: INFORMATION FOR THE ECOLOGICAL RISK ASSESSMENT (ERAF)

2.6.1. Methods

The ERAF is a systematic, science-based decision-making structure that is intended to help guide transition from high-level aspirational principles and goals to more tangible and specific operational objectives. When an ERAF is applied, it assesses potential individual and cumulative risk to SECs (prior epithet: valued ecosystem components, VECs[2]) from human activities and their associated stressors. The results of this application inform the identification and prioritization of potential indicators to monitor the impact of human activities on SECs and the achievement of conservation objectives (DFO 2015).

There are two phases to an ERAF: scoping and risk assessment. During the scoping phase, ERAFs assess individual species (taxa), as well as habitats and communities, to resolve a relatively short list of SECs. To inform the scoping phase of the future application of the ERAF to the proposed Offshore Pacific MPA, the SK-B seamount component inventories (DFO 2015) were expanded to include new OPB seamount data (e.g., from recent DFO seamount expeditions). We also provide further information on species, as well as habitat and community, ecosystem components that may be relevant to the second ERAF phase, the risk assessment of SECs. The suggestions are neither comprehensive nor analytical. Instead, they include all species/habitats/communities defined and discussed within the Research Document that were not considered in the SK-B MPA ERAF (e.g., all species and habitats listed or described in Appendix K: Table A9 or Appendix L: Table A10 are summarized here for consideration in the scoping phase of future ERAFs).

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[2] Where a VEC (or SEC) is defined by the Canadian Environmental Assessment Agency as an environmental element of an ecosystem that has scientific, social, cultural, economic, historical, archaeological or aesthetic importance (O et al. 2015).

Data sources reviewed include: Du Preez et al. 2015 (summarizes Cobb Seamount taxa; Cobb Seamount is in the High Seas but extremely close to the OPB), Gauthier 2018a, b, c (summarizes SK-B taxa), DFO 2019a (summary of Dellwood and Union seamounts fisheries catches), unpublished data from benthic visual survey annotation (Pac2017-036, Pac2018-103, Pac2019-014), unpublished data from expert taxonomic identification of the Pac2018-103 specimen collection (by DFO, the Royal British Columbia Museum, Biologica, and other partners), unpublished data from the Barcode of Life Database (BOLD) analysis on the Pac2018-103 specimens, unpublished eDNA from the Pac2018-103 water samples (courtesy of Meredith Everett and partners at NOAA), unpublished internal DFO fisheries records (PacHarv2007-2016), and unpublished data from DFO Pacific Region International Survey of Marine Megafauna (PRISMM) 2018.

2.6.2. Results and discussion

2.6.2.1. Information for the scoping phase

By compiling observations collected over the past three years of surveys, an additional 580 taxa were added to the species inventory, quadrupling the number of taxa identified on OPB seamounts (from 191 to 771) (list provided in Appendix L: Table A10). Dozens of these species are confirmed new to science, collected during the Pac2018-103 expedition and identified by taxonomic experts and DNA barcoding (taxonomic descriptions are in progress). The seamount taxa represent 17 phyla, 46 classes, and 140 orders (Figure 27). There is no evidence of biogeographical boundaries between seamounts within the region within the species inventory dataset—evident in the wide species distributions. Occurrences of conspecifics were documented throughout the region based on visual identifications and collected specimens.

Of the 771 taxa documented for OPB seamounts, nearly a quarter of the taxa identified are chordates (23%), possibly reflecting the capabilities of sampling gear used and/or the taxonomic effort focused on this phylum. Next to chordates, echinoderms and cnidarians are the two most represented phyla, each comprising 14% of the total taxa. Twelve percent of identified taxa are molluscs, followed by arthropods (11%; almost entirely crustaceans), Porifera (9%), annelids (7%; almost entirely polychaetes), and bryozoans (5%). All remaining phyla (Rhodophyta, Ochrophyta, Brachiopoda, Ctenophora, Nemertea, Sipuncula, Chlorophyta, Foraminifera, and Radiozoa) represent <5% of the taxa identified to date.

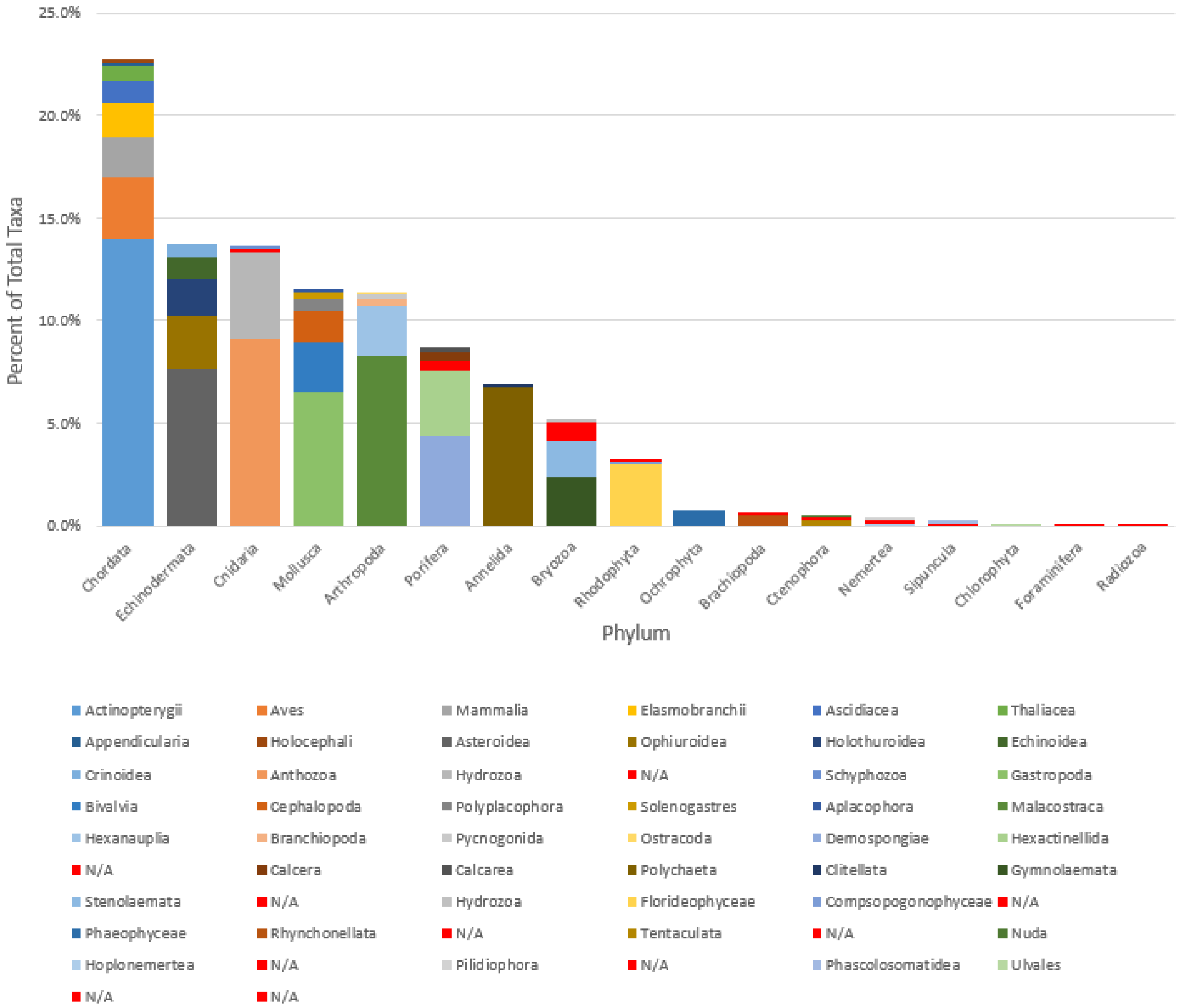

Figure 27. The phyla and classes of taxa listed in the species inventory (Appendix L: Table A10). Where N/A represents morphospecies or taxa that could not be assigned to a class.

The class with the most documented taxa is the ray-finned fishes, Actinopterygii (Figure 28). It composes 14% of all taxa found – more than the representation of most entire phyla – and 62% of the chordates identified. Following Actinopterygii, the most abundant classes are Anthozoa, Malacostraca, Asteroidea (sea stars), Polychaeta, and Gastropoda in descending order, with the remaining classes each representing under 5% of the taxa.

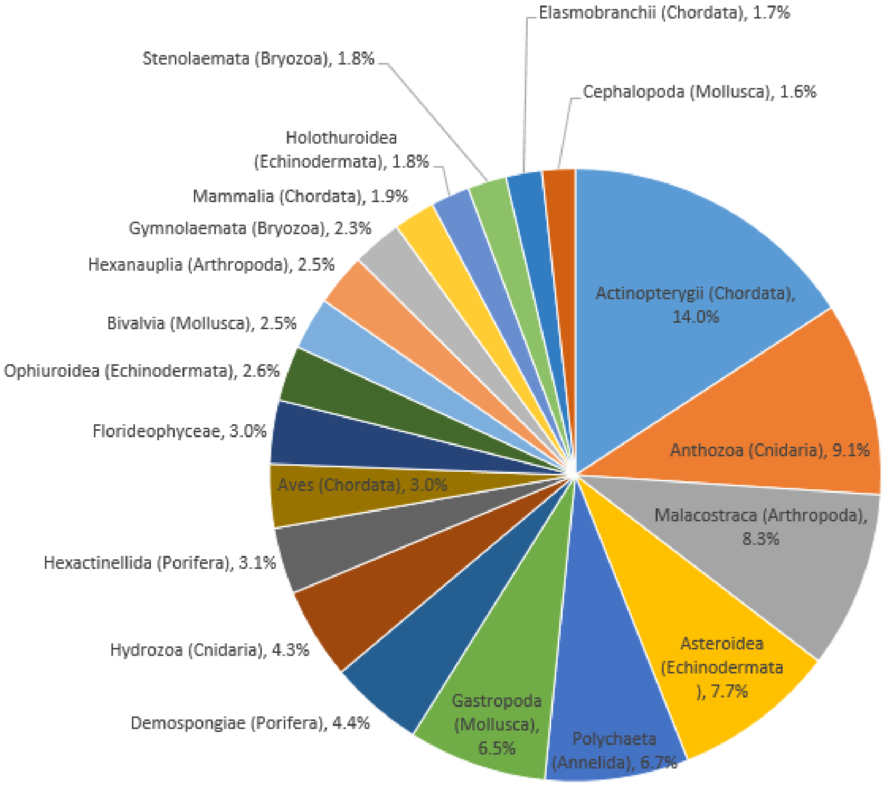

Figure 28. The taxonomic classes of the species inventory (Appendix L: Table A10).

The coral and sponge samples collected during the 2018 ROV seamount survey are of particular taxonomic interest and value. Work is still ongoing at the time of this publication; however, the preliminary results indicate at least 17 new species and one new genus to science. The majority of this work has been focused on the sponges, with corals and associated fauna likely to contain additional new taxa. Of the nine new demosponge species, four are in the family Ancorinidae, 2 in the Polymastiidae, 1 Raspailiidae and 1 Tetillidae, with an additional species in the new Halichondriidae genus. The hexactinellid sponges collected contain seven new species - 2 in the family Farreidae, 2 Tretodictyidae, and one each in Euretidae, Rossellidae, and *Sceptrulophora incertae sedis*.

2.6.2.2. Information for the risk assessment phase

The SK-B MPA ERAF resolved ten species, four habitat, and two community SECs from the relatively small list of potential SECs compiled during the scoping phase (DFO 2015).

- The SK-B MPA ERAF species: *Zaprora silenus* (prowfish), *Anoplopoma fimbria* (sablefish), *Hippoglossus stenolepis* (Pacific halibut), *Sebastes paucispinis* (bocaccio rockfish), *Sebastes ruberrimus* (yelloweye rockfish), *S. aleutianus*/*S. melanostictus* (Rougheye/Blackspotted Rockfish complex), *Sebastes entomelas* (widow rockfish), *Munida quadrispina* (squat lobster), Isidella sp. (bamboo coral), *Primnoa* sp. (coral).
- The SK-B MPA ERAF habitats: Sponges (demosponges), Deep water Alcyonacean corals, macroalgae, coralline algae.
- The SK-B MPA ERAF communities: benthic invertebrate assemblage, rockfish species assemblage.

The OPB seamount species inventory is provided in Appendix L: Table A10. Additions to the species, habitat and community inventories for potential SEC consideration, based on ERAF categories (DFO 2015) and new records added to the inventory and opportunistic visual observations (Appendix K: Table A9), included:

- Species (Appendix L: Table A10): Thornyheads. Brittle stars (species that form continuous mats). Crinoids.
- Habitats (based on depths; Objective 2): Seafloor (i) in the epipelagic euphotic zone (<200 m depth), (ii) in the mesopelagic above the OMZ (200-500 m) and (iii) within the OMZ (500-800 m), in the upper bathypelagic split (in OMZ; 800-1000 m), in the bathypelagic within the OMZ (1000-1700 m) and below the OMZ (>1700 m).
- Habitats (based on slope and substrate; unpublished observations from benthic visual surveys): steep flanks, ridges, cliffs of exposed lava/rocks (often associated with strong currents), gentle slopes with some fine sediment disposition, flat areas covered in fine sediment.
- Habitats (based on proximity to the seamount; unpublished observations from benthic visual surveys): hard-bottom (lava) benthic habitat, soft-sediment benthic habitat (deposition over lava), pelagic directly above the seafloor (meters), pelagic far above the seamount (up to a thousand or more meters), surface waters above the seamount (potential Taylor cone), and the pelagic and surface waters downstream from seamounts (turbulence, eddies).
- Habitats (summit; Objective 4 and Appendix K): plateau (e.g., SK-B), pinnacle (e.g., Union and Dellwood), and caldera (e.g., UN 16).
- Communities (benthic; Appendix K and Appendix L: Table A10): Four hard-bottom and two soft-bottom: species that do not associate with biogenic structures, habitat-forming corals and associate species, habitat-forming sponges and associate species, algae (primary producers) and associate species, fine sediment infauna, and fine sediment epifauna.
- Communities (based on permanence): permanent (sessile and sedentary benthic assemblages) and transient (pelagic fishes, marine mammals, birds).

2.6.3. Summary of findings

The following summarizes the findings for objective 6: inform the future application of the ERAF to the AOI.

- To inform the scoping phase of the future application of the ERAF to the proposed Offshore Pacific MPA, the SK-B seamount component inventories (DFO 2015) were expanded to include new OPB seamount data (from 191 to 771 taxa).
- Additional SEC considerations were made based on the new species inventory as well as findings presented in this Research Document (e.g., SEC species, habitats, and communities).

2.7. OBJECTIVE 7: LIMITATIONS AND UNCERTAINTIES

Limitations and uncertainties with the methods, data, and results were considered and are summarized below.

2.7.1. Data

- The remote nature and vast size (area and volume) of the OPB make gathering comprehensive and/or representative data a challenge (e.g., technical and/or effort limitations).
- There may be more seamounts in the OPB than is presented in this analysis. Because the definition of a seamount is based on depth, the inventory and known summit depth of suspected seamounts may be revised depending on the quality, coverage, and resolution of bathymetry used. High-resolution multibeam bathymetry is preferred but is only available for a small portion of the OPB. The new seamounts were discovered by adding new high-resolution bathymetric maps to the compilation used in DFO 2019a and reassessing the geophysical criteria. For example, a preliminary review of data from the Pac2021-036 has resolved another three seamounts not included in this Research Document (Tuzo Wilson (west) and two more features within the Dellwood complex).
- While remote sensing multi-beam sonar mapping provides the best overall sense of the deep seascape, its ability to resolve fine details (such as peaks and spires) depends on the density of the beams and the post-processing. By nature, multi-beam will bias towards resolving a flatter seafloor. It is, therefore, reasonable to expect that we have underestimated the depths of some seamounts and non-seamount features (i.e., knolls and hills).
- By comparing recent multi-beam surveys with synthesized large-scale maps of the OPB (e.g., GMRT, GEBCO, in-house DFO maps), we have concluded that a non-negligible area of the maps is offset by ~1 km to the east of where it actually is. The data in question is relatively high-resolution multi-beam bathymetry collected for the Explorer Ridge and Seamount area in 1983 by an NOAA led team during the RP-15-SU-83 expedition. This data is the source bathymetry for roughly 12 seamounts in the center of the AOI. We know with some certainty that it is offset by ~1 km to the east over Explorer Seamount because parts of Explorer, including the summit, were resurveyed in 2018. Because the 1983 survey included multiple different survey grids, it is unclear if all grids are offset. This issue was still being examined at the time this report was written with the help of colleagues at the Global Multi-Resolution Topography Data Synthesis. It should also be noted that a new GMRT was released during the time this report was in review (v.3.8).
- The coverage of existing benthic survey imagery is extremely limited and may not necessarily be representative of the seamount, zone, or class in which it was collected. Work is ongoing to determine the variation within and among OPB seamount classes, but preliminary analyses and research from other regions suggests within-seamount variability associated with differences in sedimentation, substrate, current directionality, flow speed, and other environmental variables is common (e.g., Morgan et al. 2019; unpublished 2017-2019 benthic visual surveys observations).
- Data derived from benthic visual surveys is limited to what the annotators can see, resolve, and identify and is strongly tied to what voucher specimens have been collected. From our own collection, we know the OPB seamounts are home to species new to science (though not necessarily endemic), mobile, cryptic species, and rare species.
- The collection of voucher specimens to compare and validate imagery-based identifications is invaluable, but there are limited opportunities to collect such samples.
- In general, there is a data bias for shallow, nearshore seamounts.

- Oceanographic data such as water and phyto- and zooplankton samples are limited within the OPB, and a lack of long-term data (e.g., time-series) makes it difficult to detect change. A notable exception is the DFO Line P Program, which provides a long-term oceanographic dataset at a series of fixed sites through the southern half of OPB (Appendix I: Figure A14).

- Our knowledge of direct anthropogenic impacts by bottom-contact fishing is limited by what has been reported and documented. It is reasonable to expect there are incorrect records, undocumented activities (especially in the early days of seamount fisheries, 1950s and 1960s), and lost or otherwise discarded fishing gear. Deep-sea fishing is also an evolving industry, and it is reasonable to expect new fisheries and gear in the future.

2.7.2. Analyses

- This assessment focused on the benthic habitats; work is ongoing to understand the pelagic realm and surface waters, which are important components of seamount ecosystems. These environments, as well as the air above the ocean, represent far larger habitats and are underrepresented in this report.
- Clark et al. (2011) list potential considerations for additional seamount classification criteria, which would result in a different seamount classification scheme. Seamount summit shape likely has biological relevance and should be considered in future iterations but was not included here because of difficulties integrating bathymetry data of variable resolutions (preliminary analysis and findings summarized in Appendix M).
- The criterion thresholds used in the original seamount classification system were developed based on global conditions. The global thresholds for four of the five criteria were determined to be regionally relevant and were retained. Regional thresholds based on quartile breaks were used for Export Productivity because the global thresholds were found to be too high to be informative.
- Surface chlorophyll-a (chl-a) levels from satellite-based imagery provide information on the local primary productivity which we assume translates into a proxy of particulate organic material export, but this ignores other sources of POC (e.g., remote input or POC from transient animals) and important distribution variables that ultimately affect if the POC enters the seamount benthic food web (e.g., currents at depth and local hydrodynamics) (Smith and Kaufmann 1999).
- Variability in surface productivity is likely important and requires additional *in situ* data to explore to resolve how it affects seamount community structure (and, by extension, how it should be factored into the seamount classification system). Variability between data sources should also be considered (comparison provided in Appendix G: Figure A12).
- Exceptions to the ecological trends associated with the seamount classes appear to be linked to high net primary productivity (surface), suggesting the export productivity equation used in this analysis may underestimate its ecological importance.
- A potentially important oceanographic factor not included in this report under the investigation of natural boundaries in the OPB is dissolved silica availability. The OPB and surrounding regions are known for their anomalously high dissolved silica concentrations (Johnson et al. 2006)—the nature and distribution of which may have significant influence over the distribution and abundance of glass sponges (Leys et al. 2004). These habitat-forming species require silica to build their structural components (spicules). The variability of dissolved silica availability within the OPB may play a large role in the community structure of the seamount benthos by controlling glass sponges.

- The results of the hierarchical cluster analyses (i.e., based on spatial distance and cold-water coral assemblages) in this assessment are likely sensitive to the algorithms to select the optimal number of clusters; alternate methods would likely produce different results.
- The assessments did not incorporate sensitivity analyses.
- Multiple analyses in this assessment focused on cold-water corals and sponges, or a specific group of corals (i.e., Alcyonacea). Sessile long-lived species serve as good proxies (e.g., vulnerable foundation species), but it is uncertain whether the observed ecological trends reflect patterns of other taxa.
- The portfolio scoring does not reflect the anticipated magnitude or duration of the environmental changes nor the quantity or quality of the existing data (e.g., is not weighted). This will be incorporated into future applications of the ERAF.
- Some of the analyses are more qualitative than others. The level of information to include was sometimes based on subjective expert opinion (e.g., the level of detail included for species turnover with depth, ecosystem functions, anticipated changes, existing data types, the opportunistic observations of regionally rare, significant, or functionally important species, and the habitat and ecosystem component inventory suggestions for the future application of the ERAF).

2.7.3. Knowledge gaps

- The analyses presented here are limited to discrete or static oceanographic and geomorphic information to classify seamounts, but the OPB is a dynamic system with multi-scale spatial and temporal variability. For example, there are intra-plate features (faults, spreading valleys and ridges), water bodies are known to be mobile (Appendix C), and new research shows fine-scale variability in water masses around seamounts (Clark 2021). Further research is required to determine if this variability translates into ecologically significant boundaries.
- Line P and Argo float data suggest there is little to no variation in oxygen concentration within the study region as a function of latitude or longitude (Ross et al. 2020); however, research on fine-scale spatial variability (e.g., conditions off-seamount according to Line P data compared with conditions on-seamount according to in situ ROV-based data) are ongoing. It is expected that upwelling forced by the ramp-like shape of seamounts causes an upward shift, or shoaling, of the water masses and, therefore, conditions experienced (e.g., it is expected that the OMZ is slightly shallowest on the seamounts).
- It is beyond the scope of our data and this report to account for daily, seasonal, annual, or decadal variability. That said, Ross et al. (2020) documented the changes captured by a long-term oceanographic time-series (Line P) that strongly suggests the chemistry of the deep ocean around the seamounts is rapidly changing in comparison to our understanding of the "normal" environmental stability of these ecosystems. If trends continue as they have over the past 60 years, it is likely that climate change will cause the seamount conditions and species assemblages to undergo drastic changes, with the potential for local extinctions (Ross et al. 2020). The natural stability and resilience of future benthic boundaries, species distributions, and food webs are uncertain.
- There is uncertainty if and how seamounts directly or indirectly affect local productivity. The concept of a "seamount effect" that causes enhanced local primary productivity above the seamount has been documented in some regions but is still debated (Leitner et al. 2020 and citations therein); the increased local diversity and biomass observed at seamounts may be due to other seamount effects, such as providing shallow habitat in offshore areas, changes

(acceleration) of currents over the bathymetry, local currents advecting or retaining organic material, deep-scattering layer trapping, etc.

- There is limited information on seamount connectivity. Additional research, such as current flow and genetic analyses, is needed to assess the movement/dispersal of organisms between seamounts (Parker and Tunnicliffe 1994). Despite the high density of seamounts, it may be that one obscure seamount is, unknowing to us, the dispersal source or link to seeding other neighbouring or distant seamount communities.
- This Research Document only considers the seamounts; however, as pointed out by Clark et al. (2011), it is uncertain how independent seamount habitat and communities are from the surrounding environments.
- There is limited information available about the substrate, which is an important predictor of species distributions (Morgan et al. 2019). Work is ongoing to extract substrate information from existing imagery.
- There is little research on the ecological characteristics of hills and knolls (defined as features under 500 m and between 500 and 1 km, respectively). Still, these features may support seamount-like ecosystems (preliminary analyses of unpublished Pac2021-036 support this hypothesis).
- Climate change poses multiple stresses to marine ecosystems, including deep-sea and oceanic habitats. Two components of climate change, ocean acidification and deoxygenation, were considered as part of the "anticipated changes," but other aspects such as rising temperature and changes to ocean circulation were not addressed. Given the strong environmental gradients and resulting biological zonation observed at seamounts, the cumulative (potentially synergistic) effects of climate change can be expected to cause changes to species distributions and community structure on seamounts, which in turn will impact ecosystem function provision in ways not yet quantifiable.

3. RESEARCH DOCUMENT SUMMARY

3.1. CONCLUSIONS AND ADVICE

- There are 62 seamounts known or predicted to occur in the OPB, ten more than the 2019 inventory. It is highly likely others will be discovered as high-resolution mapping of the region continues.
- Compared to the surrounding deep seafloor, the relatively shallow habitat provided by all OPB seamounts supports diverse and distinct species assemblages, including habitat-forming cold-water corals, sponges, and hundreds of other benthic and pelagic species.
- The OPB seamounts are a dense cluster of individual seamounts and seamount chains surrounded by hundreds to thousands of smaller seamount-like features (knolls and hills).
- This assessment revealed no evidence of natural biogeographic boundaries (i.e., barriers to dispersal) among the OPB seamounts and no evidence of endemism. However, some seamount classes were assessed to be unique or rare.
- Depth zones on the OPB seamounts delineated by light availability (photic, aphotic) and oxygen concentration (oxic, hypoxic, severely hypoxic) are supported by biological observations of community transition zones.

- OPB seamounts were assigned to one of seven biophysical classes using quantitative thresholds of export productivity (new to this iteration), summit depth, and dissolved oxygen concentration at the summit.
- Assemblages of cold-water corals, sponges, and other benthic species vary across seamount classes and depth zones, supporting the classifications as being biologically relevant. Seamounts with shallower summits span multiple depth zones and support higher species richness. SK-B Seamount, the shallowest in the OPB, supports unique benthic assemblages not represented elsewhere in the OPB (e.g., shallow subtidal communities).
- OPB conservation areas cover at least one representative seamount of each class. Six of the seven classes occur in the AOI for the Offshore Pacific MPA, and the only Class H5 seamount, SK-B, occurs in SK-B MPA.
- Seamounts provide ecosystem functions that enhance regional productivity, biological diversity, resilience, and connectivity. In general, shallower seamounts are thought to provide more ecosystem functions than deeper ones.
- All OPB seamounts are anticipated to experience changes now and in the near future. The amount of existing baseline data by which to detect change varies between OPB seamounts, but, in general, more is known about the shallower seamounts and those closer to shore. SK-B and Dellwood seamounts (the shallowest seamounts in the SK-B MPA and AOI, respectively) are the best candidates for representative seamount areas (i.e., reference sites) to detect changes. Others, such as Union and Explorer seamounts, are also good candidates.
- Within the AOI, Union, Dellwood, and Explorer seamount summits and upper flanks (above ~1200 m) are consistently identified as notable representative seamount areas, whether the assessment is based on boundaries, uniqueness and ecosystem function, anticipated changes, and/or existing baseline knowledge. Within the OPB, SK-B should be counted among these important seamounts. The attributes driving these trends often trace back to their shallow summit depths (e.g., to strong depth-related gradient and depth-stratified attributes like accessibility for fishing or research).
- To support the scoping stage of the ERAF, an inventory of species known to occur on OPB seamounts was compiled and potential SEC were provided. Since the last assessment in 2015, the number of known taxa on OPB seamounts has quadrupled. With increased sampling and examination of voucher specimens, more species are likely to be identified.
- The remote nature, vast size, and range of habitats in the OPB make gathering comprehensive and/or representative data a challenge. The analyses presented here are limited to discrete or static (“snapshot”) information, but the OPB is a dynamic system with multi-scale spatial and temporal variability.
- It is recommended that the methods presented here be used to update/reassess the seamount classifications (classes and zones) as new data becomes available (e.g., improved bathymetry, seamount morphology, substrate, pelagic data).
- It is recommended that this information is suitable for a range of potential applications, such as the ERAF and the development of an MPA management plan, conservation objectives, a monitoring framework and plan, and future survey design and research development.

3.2. OTHER CONSIDERATIONS

The OPB seamounts are part of a larger group of seamounts along the North American continent, ranging from southern Alaska to California and out into Areas Beyond National Jurisdiction. The activities occurring on these seamounts (or lack thereof, where conservation measures are in place) can affect conditions and the health of OPB seamount ecosystems. For example, fishing and deep-sea mining impacts may indirectly influence OPB seamounts through the migration and recruitment of species, and it is predicted that mining plumes will have large-scale direct effects, including reduced fitness and mortality for benthic, pelagic, and surface animals (e.g., Levin et al. 2016). The influence of activities on adjacent seamounts and other stressors, such as noise, light, physical, and chemical pollutions, are important considerations for seamount environmental management and monitoring but are beyond the scope of this report and will be addressed further in the ERAF.

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APPENDIX A. ADDITIONAL SEAMOUNT INFORMATION

Table A1. Extention of Table 2: additional information for each of the 62 seamounts within the Offshore Pacific Bioregion (OPB). Seamounts included exceed 1 km elevation and are listed in the Canadian Gazetteer (CG; NRC 2015), predicted by one or more of six published models, mapped during recent expeditions (confirmed), or a combination thereof. Details on each dataset are provided in Table A2 (heading descriptions) and within the Research Document. Seamounts are listed by summit depth, from deepest to shallowest. This table includes updated records initially published in Table 3 in DFO 2019a.

Seamount name	Name status	Seamount status	Add. Data	Basin depth (m)	Eleva-tion (m)	Sea surface produc-tivity (mg C m^{-2} d^{-1})	Summit export produc-tivity (mg C m^{-2} d^{-1})	[O_2] at summit (ml l^{-1})	Prox. to nearest seamount (km)	Prox. to slope (km)	2-D area (km^2)	Boundary perimeter (km)	Slope (°), average	Slope (°), StDev	Peark ORS, m	Benthic survey, year
UN 41	Unnamed	Predicted: M, KW	-	3696	1158	528.8	7.3	2.124	59	330	292.0	76.71	5.95	0.53	274	-
UN 15	Unnamed	Predicted: M, KW, Y, H	-	3635	1163	537.5	7.7	1.965	0	305	339.8	75.12	5.28	0.51	226	-
UN 29	Unnamed	Predicted: all	-	3664	1290	556.9	8.3	1.917	16	252	439.3	82.33	5.74	0.85	145	-
UN 28	Unnamed	Predicted: M, KW	-	3355	1073	576.9	8.9	1.881	27	212	224.9	85.30	5.46	0.57	180	-
UN 42	Unnamed	Predicted: M, KW, H	-	3575	1307	564.2	8.8	1.779	0	230	102.2	39.03	12.86	1.15	331	-
UN 30	Unnamed	Predicted: all	-	3509	1245	570.0	8.9	1.779	0	226	190.6	60.74	9.32	1.58	313	-
UN 37	Unnamed	Predicted: KW	-	3445	1182	540.9	8.4	1.874	36	300	230.2	116.31	6.01	0.75	297	-
UN 11	Unnamed	Predicted: M	-	3315	1077	576.0	9.1	1.815	0	187	308.3	140.74	7.45	3.43	192	-
UN 36	Unnamed	Predicted: M	-	3260	1028	544.4	8.6	1.801	36	295	347.2	211.45	4.02	0.48	289	-
UN 44	Unnamed	Predicted: M	-	3240	1042	586.3	9.4	1.741	15	190	189.0	71.02	7.17	0.74	307	-
UN 9	Unnamed	Predicted: M, KW	-	3289	1151	552.3	9.1	1.797	11	244	570.8	101.72	3.93	0.59	101	-
UN 34	Unnamed	Confirmed, predicted: M	MB 2018	3305	1202	580.1	9.7	1.555	29	112	52.5	37.09	13.89	1.01	663	-
UN 35	Unnamed	Confirmed, predicted: M	SB 2019	3381	1290	574.2	9.7	1.55	6	63	191.8	86.10	4.96	1.43	324	-
UN 39	Unnamed	Confirmed, predicted: M	SB 2019	3340	1276	558.1	9.5	1.55	15	190	294.5	128.72	4.64	0.51	192	-
UN 48	Unnamed	Predicted: M, KW, Y, H	-	3270	1213	567.0	9.7	1.582	0	214	102.6	42.91	10.70	0.79	388	-
UN 13	Unnamed	Predicted: all	-	3270	1235	566.9	9.8	1.582	0	216	147.2	58.72	9.18	0.60	274	-
UN 38	Unnamed	Predicted: Y, KL	-	3193	1253	550.4	10.0	1.388	11	243	388.7	108.62	5.63	0.96	350	-
UN 21	Unnamed	Predicted: M, KW	-	3096	1162	628.3	11.4	1.382	4	143	154.9	70.93	7.67	0.91	257	-
UN 32	Unnamed	Confirmed, predicted: M, KW	MB 2018	3018	1140	606.9	11.4	1.232	13	101	102.3	50.44	9.55	0.54	445	-

Seamount name	Name status	Seamount status	Add. Data	Basin depth (m)	Eleva-tion (m)	Sea surface produc-tivity (mg C m^{-2} d^{-1})	Summit export produc-tivity (mg C m^{-2} d^{-1})	[O$_2$] at summit (ml l^{-1})	Prox. to nearest seamount (km)	Prox. to slope (km)	2-D area (km^2)	Boundary perimeter (km)	Slope (°), average	Slope (°), StDev	Peark ORS, m	Benthic survey, year
UN 45	Unnamed	Predicted: M, KW, Y, H	-	3244	1378	586.3	11.1	1.389	11	179	186.5	68.36	9.79	0.46	417	-
UN 33	Unnamed	Confirmed, predicted: M, KW, H	MB 2018	2836	1037	619.9	12.1	1.106	0	40	130.8	50.80	6.70	0.70	338	-
UN 19	Unnamed	Confirmed, predicted: M, KW	SB 2017, MB 2018	2950	1185	659.4	13.1	1.218	0	114	240.0	113.26	5.17	0.54	205	-
UN 20	Unnamed	Predicted: M, KW	-	2986	1275	643.4	13.2	1.069	4	128	194.2	97.74	8.53	1.04	21	-
Stirni	CG, GEBCO	Known	-	3320	1610	546.6	11.2	1.069	21	249	423.6	123.77	6.79	0.87	178	-
UN 24	Unnamed; chain in CG	Predicted: M, Y	-	2950	1291	717.5	15.2	0.949	0	77	99.7	43.55	10.95	0.61	314	-
UN 14	Unnamed	Predicted: all	-	3300	1700	538.7	11.8	0.792	0	304	1005.1	187.23	5.41	0.26	115	-
UN 10	Unnamed	Confirmed, predicted: M, Y	SB 2019	3125	1526	575.4	12.7	0.854	0	171	168.5	78.81	8.14	1.16	604	-
UN 27	Unnamed	Confirmed, predicted: M, KW	SB 2017	2939	1342	696.8	15.3	0.959	21	78	51.1	42.02	5.58	0.66	161	-
Endeavour	CG, GEBCO	Known & confirmed	SB 2019	2955	1372	603.9	13.4	0.921	4	106	157.4	70.29	7.19	1.11	304	-
UN 18	Unnamed	Confirmed, predicted: M, Y	SB, VS 2017, MB 2018	2839	1289	651.7	14.8	0.646	0	114	243.9	139.47	6.33	1.11	269	2017
Oglala	GEBCO, Earthref, Seamount Catalog	Known & confirmed	SB 2017	3000	1457	667.1	15.2	0.646	14	113	200.2	70.16	9.77	1.64	122	-
UN 3	Unnamed	Confirmed, predicted: M, Y,H	SB 2017	2881	1339	560.1	12.8	0.802	0	188	117.9	58.41	10.74	0.52	297	-
UN 23	Unnamed; chain in CG	Confirmed , predicted: all	SB 2017	2997	1456	721.1	16.5	0.646	0	71	144.0	60.11	9.86	0.59	289	-
UN 2	Unnamed	Confirmed, predicted: M, KW, Y, H	SB 2019	2977	1448	557.2	12.8	0.88	14	230	181.2	67.12	10.02	0.67	297	-
UN 49	Unnamed; CG: incorrectly “Oglala”	Known	-	3069	1571	631.8	14.8	0.817	0	142	260.3	68.68	8.96	0.86	372	-
UN 5	Unnamed	Confirmed, predicted: all	SB 2019	2883	1390	569.7	13.4	0.789	0	162	526.0	128.33	5.72	1.42	259	-

Seamount name	Name status	Seamount status	Add. Data	Basin depth (m)	Elevation (m)	Sea surface productivity (mg C m^{-2} d^{-1})	Summit export productivity (mg C m^{-2} d^{-1})	[O_2] at summit (ml l^{-1})	Prox. to nearest seamount (km)	Prox. to slope (km)	2-D area (km^2)	Boundary perimeter (km)	Slope (°), average	Slope (°), StDev	Peark ORS, m	Benthic survey, year
UN 43	Unnamed	Predicted: all	-	3126	1640	630.5	14.9	0.817	0	151	201.2	76.14	10.93	0.79	540	-
UN 12	Unnamed	Confirmed, predicted: KL, M, KW, Y	MB 2018	3232	1767	586.2	14.1	0.81	15	133	161.5	76.54	9.15	2.20	289	-
Chelan	CG (incorrect location), GEBCO (18 km east)	Predicted: all	-	3050	1591	596.5	14.4	0.597	0	166	575.6	140.44	6.89	0.61	170	-
UN 4	Unnamed	Confirmed, predicted: M, KW, Y,H	SB 2019	2903	1477	556.6	13.7	0.712	0	217	82.4	41.11	14.16	1.05	605	-
Tuzo Wilson (east)	CG	Known	-	2550	1162	821.7	20.8	0.652	65	2	38.0	42.83	10.51	1.23	239	-
UN 40	Unnamed	Confirmed, predicted: M, KW, Y	SB 2019	2790	1446	565.0	14.8	0.605	11	176	93.1	37.88	12.53	0.65	393	-
Heckle	CG	Known	-	2877	1561	565.1	15.1	0.594	0	182	200.0	63.88	10.40	0.84	427	-
Tucker	CG, GEBCO	Known	-	3342	2125	549.9	15.9	0.521	29	254	370.0	85.40	10.50	0.46	323	-
Graham	CG, GEBCO	Known & confirmed	MB 2018	2800	1599	616.2	18.0	0.618	0	43	357.2	83.28	7.59	0.38	202	-
UN 22	Unnamed; chain in CG	Predicted: KL, M, Y,H	-	2894	1724	719.0	21.6	0.486	0	73	148.4	60.22	11.64	0.72	207	-
UN 8	Unnamed; feature in CG	Confirmed, predicted: KL, M, Y,H	SB 2019	2939	1781	594.8	18.0	0.455	0	126	206.0	99.70	7.85	0.61	380	-
UN 16	Unnamed	Confirmed, predicted: all	SB, VS 2017	3150	2053	586.7	18.8	0.405	0	178	181.8	59.75	14.68	0.53	334	2017
UN 25	Unnamed	Confirmed, predicted: KL, M, Y, H	MB 2018	2601	1512	745.3	24.0	0.419	0	60	611.3	175.30	5.03	0.79	184	-
Davidson	CG, GEBCO (as known as Pierce)	Known & confirmed	MB, VS 2018	3310	2231	577.4	18.8	0.495	0	142	888.9	174.20	6.92	0.41	121	2018
UN 7	Unnamed; feature in CG	Confirmed, predicted: all	SB 2019	2858	1793	588.6	19.4	0.413	0	138	442.6	113.11	8.60	1.26	345	-
Heck	CG, GEBCO (incorrect location)	Known & confirmed	SB, VS 2019	2701	1686	592.9	20.5	0.385	0	129	280.8	86.75	8.47	0.71	260	2019

Seamount name	**Name status**	**Seamount status**	**Add. Data**	**Basin depth (m)**	**Elevation (m)**	**Sea surface productivity (mg C m^{-2} d^{-1})**	**Summit export productivity (mg C m^{-2} d^{-1})**	**$[O_2]$ at summit (ml l^{-1})**	**Prox. to nearest seamount (km)**	**Prox. to slope (km)**	**2-D area (km^2)**	**Boundary perimeter (km)**	**Slope (°), average**	**Slope (°), StDev**	**Peark ORS, m**	**Benthic survey, year**
Springfield	CG, GEBCO	Known & confirmed	SB, VS 2019	3000	2078	557.2	21.2	0.369	0	199	423.7	109.72	9.70	1.16	156	2019
SAUP 5494	Unnamed (but in Ban et al. 2016)	Known	-	2778	1876	668.0	26.0	0.439	56	0	1120.2	190.78	3.34	0.87	14	-
Oshawa	CG, GEBCO	Known & confirmed	MB 2018	2940	2044	621.6	24.3	0.404	13	85	324.0	79.00	10.56	0.29	152	-
UN 1	Unnamed	Confirmed, predicted: M, KW, Y, H	SB, VS 2019	2821	1926	554.4	21.7	0.361	21	233	257.0	90.82	11.97	0.54	484	2019
Dellwood South	Chain in CG, GEBCO	Known & confirmed	MB, VS 2018	2629	1808	747.2	31.9	0.73	0	54	343.5	74.86	8.05	0.90	412	2018
Explorer	CG, GEBCO	Known & confirmed	MB, VS 2018; SB, VS 2019	3300	2505	568.6	25.0	0.41	0	152	1840.7	353.06	4.94	0.52	718	2018, 2019
Hodgkins	CG, GEBCO	Known & confirmed	MB, VS 2018	3315	2704	579.9	33.1	0.53	0	111	1142.9	194.02	7.38	0.52	493	2018
Dellwood	Chain in CG, GEBCO	Known & confirmed	SB, VS 2017; MB, VS 2018	2659	2124	746.9	48.7	0.705	0	44	314.7	112.47	11.33	0.69	307	2017, 2018
Union	CG, GEBCO	Known & confirmed	SB, VS 2017	3239	2968	558.5	70.9	2.653	7	243	680.5	138.63	10.74	0.48	-37	2017
SGaan Kinghlas-Bowie	CG, GEBCO	Known & confirmed	MB, VS 2018	3224	3200	581.2	581.2	6.691	0	85	1411.1	212.66	7.99	1.06	311	2018

Table A2. Heading descriptions for Table A1 (above).

Heading	**Description**
Seamount name	Name used by Fisheries and Oceans Canada (DFO).
Name status	Where the name is officially listed: CG = listed in the Canadian Gazetteer, GEBCO = listed by the General Bathymetric Chart of the Oceans.
Seamount status	The seamount is predicted or confirmed to exist. The six models used to predict the location of the seamounts are: KL = Kitchingman and Lai (2004), M = Manson (2009), KW = Kim and Wessel (2011), Y = Yesson et al. (2011, 2020), and H = Harris et al. (2014). See report for references.
Add. Data	Bathymetry data used is from the Global Multi-Resolution Topography (GMRT) 3.7 synthesis (default) unless higher resolution data was available from single-beam bathymetry, multi-beam bathymetry, or benthic visual surveys (SB, MB, and VS, respectively) performed during the 2017, 2018, and 2019 Northeast Pacific Seamounts expeditions.
Basin depth (m)	The depth of the deepest point within a 20 km radius of the seamount summit, in meters (Yesson et al. 2011 approach). See report for references.
Elevation (m)	Equals the difference between the summit depth (see Table 2) and the basin depth, in meters.
Sea surface productivity (C_{npp}; mg C m^{-2} d^{-1})	Mean net primary production (C_{npp}; organic carbon in surface waters) based on the Carbon-based Production Model (CbPM; www.science.oregonstate.edu/ocean.productivity, accessed 7 December 2020) over a 19 year period from 01-07-2002 to 31-01-2020, in milligrams of carbon per meter-squared per day (generated by Andrea Hilborn).
Summit export productivity ($C_{flux(z)}$; mg C m^{-2} d^{-1})	Mean particulate organic carbon flux ($C_{flux(z)}$) as a function of net primary productivity in surface waters and summit depth (***z***): $C_{flux(z)} = C_{npp} / (0.0283z+0.212)$ (Suess 1980), in milligrams of carbon per meter-squared per day.
$[O_2]$ at summit (ml l^{-1})	Oxygen concentration from the World Ocean Atlas 2013 data (Garcia et al. 2014). See report for references.
Prox. to nearest seamount (km)	The shortest geodesic distance between the seamount boundary and its nearest neighbour seamount boundary, in kilometres.
Prox. to slope (km)	The shortest geodesic distance between the seamount boundary and the edge of the Offshore Pacific Bioregion (i.e., transition to the continental slope; see text for details), in kilometres.
2-D area (km^2)	The two-dimensional surface areas, in squared-kilometers. Area was measured in two-dimensional space to avoid the inherent basis of calculating higher three-dimensional surface areas for areas mapped in higher resolution.
Boundary perimeter (km)	The geodesic distance following the seamount boundary, in kilometres
Slope (°), average	A slope raster was derived from the bathymetry mosaic and averaged for the area within the seamount boundary, in degrees.
Slope (°), StDev	A slope raster was derived from the bathymetry mosaic and the standard deviation was calculated for the area within the seamount boundary, in degrees.
Peak ORS (m)	Peak omnidirectional relief and steepness (ORS; i.e., average height difference between the peak and the seafloor 2-km away in all directions) as a proxy for local current intensification (hydrographic conditions) experienced at the summit, in meters. See Appendix M.
Benthic survey, year	The seamount was visually surveyed using a submersible vehicle in 2017, 2018, or 2019 (Pac2017-036, Pac2018-103, and Pac2019-014).

APPENDIX B. SEAMOUNT BATHYMETRIC PROFILE DATA EXAMPLES

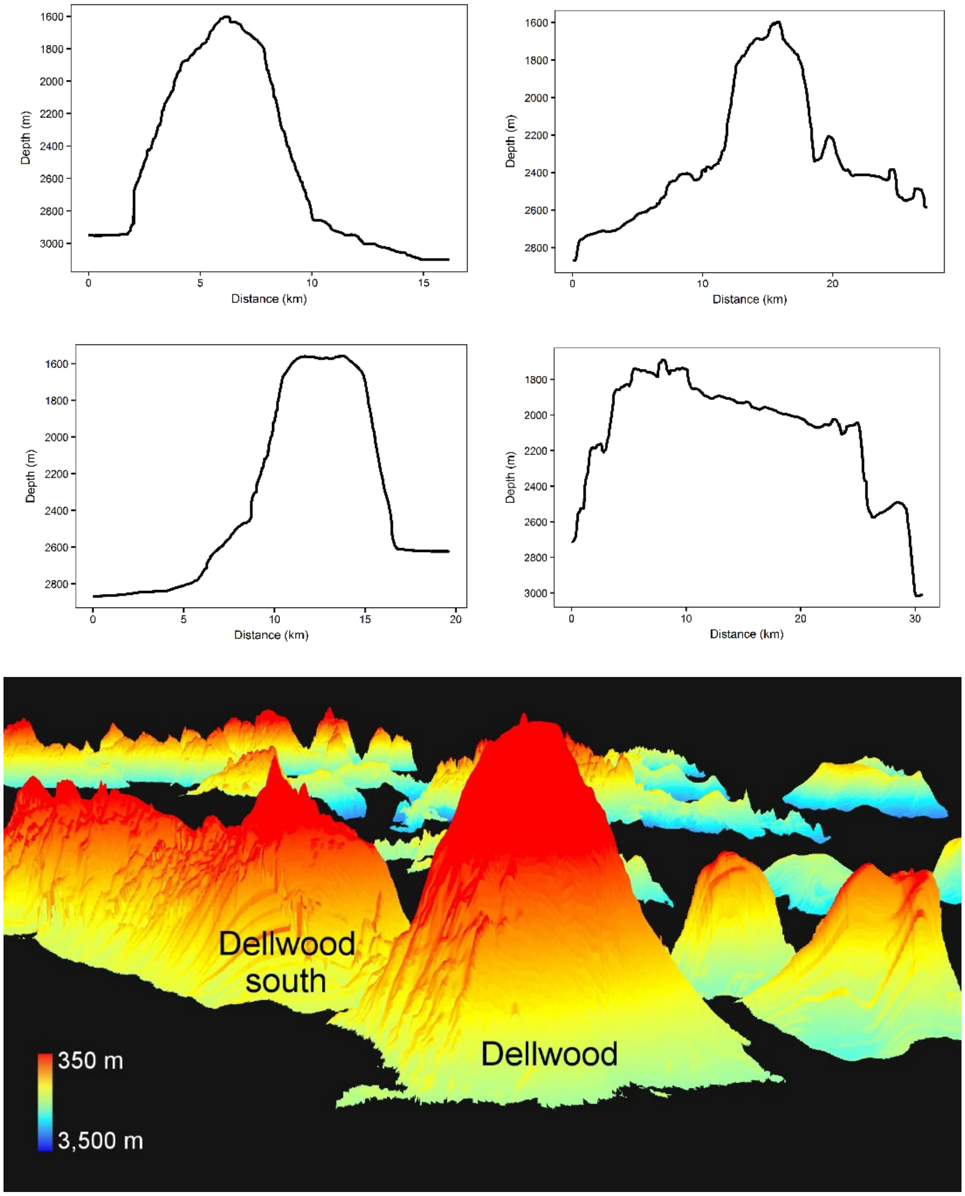


Figure A1. Example profiles of seamounts measured using single-beam sonar in 2017 and multi-beam sonar in 2018. Data used to validate the identification of features as seamounts (e.g., elevation ≥1 km) and document or update information on the seamount (e.g., summit depth, summit location). Bathymetric profiles of (top-left) Oglala, (top-right) UN 18, (bottom-left) UN 23, and (bottom-right) UN 27. Bathymetric maps of Dellwood and Dellwood south, (bottom-photo), (with other Offshore Pacific Bioregion, OPB, seamounts in the background from Global Multi-Resolution Topography Data Synthesis, GMRT, V3.7).

APPENDIX C. REGIONAL OCEANOGRAPHY: CURRENTS AND EDDIES

For map of regional oceanography, see figures below, Whitney and Robert 2002 (tracks of Haida eddies from 1993 to 2001), and Crawford et al. 2005 (composite images of chlorophyll concentrations based on SeaWiFS measurements).

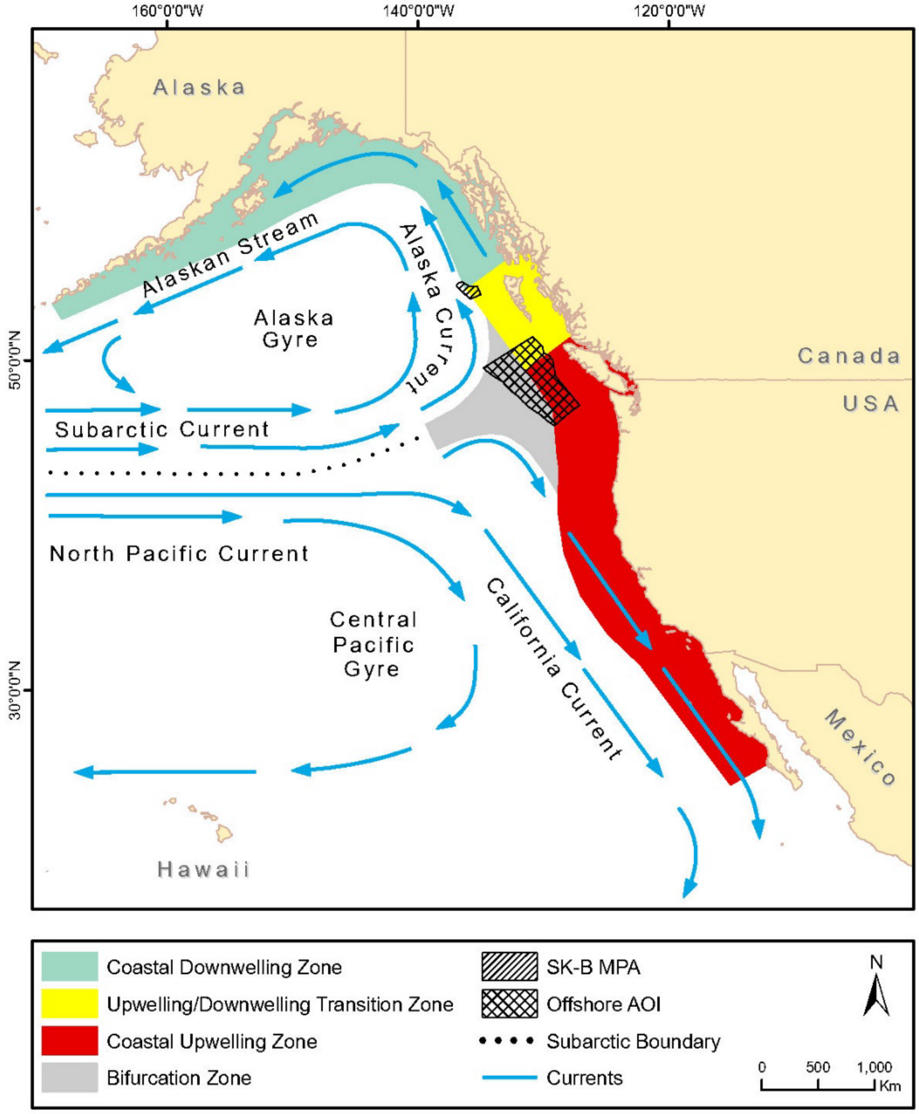
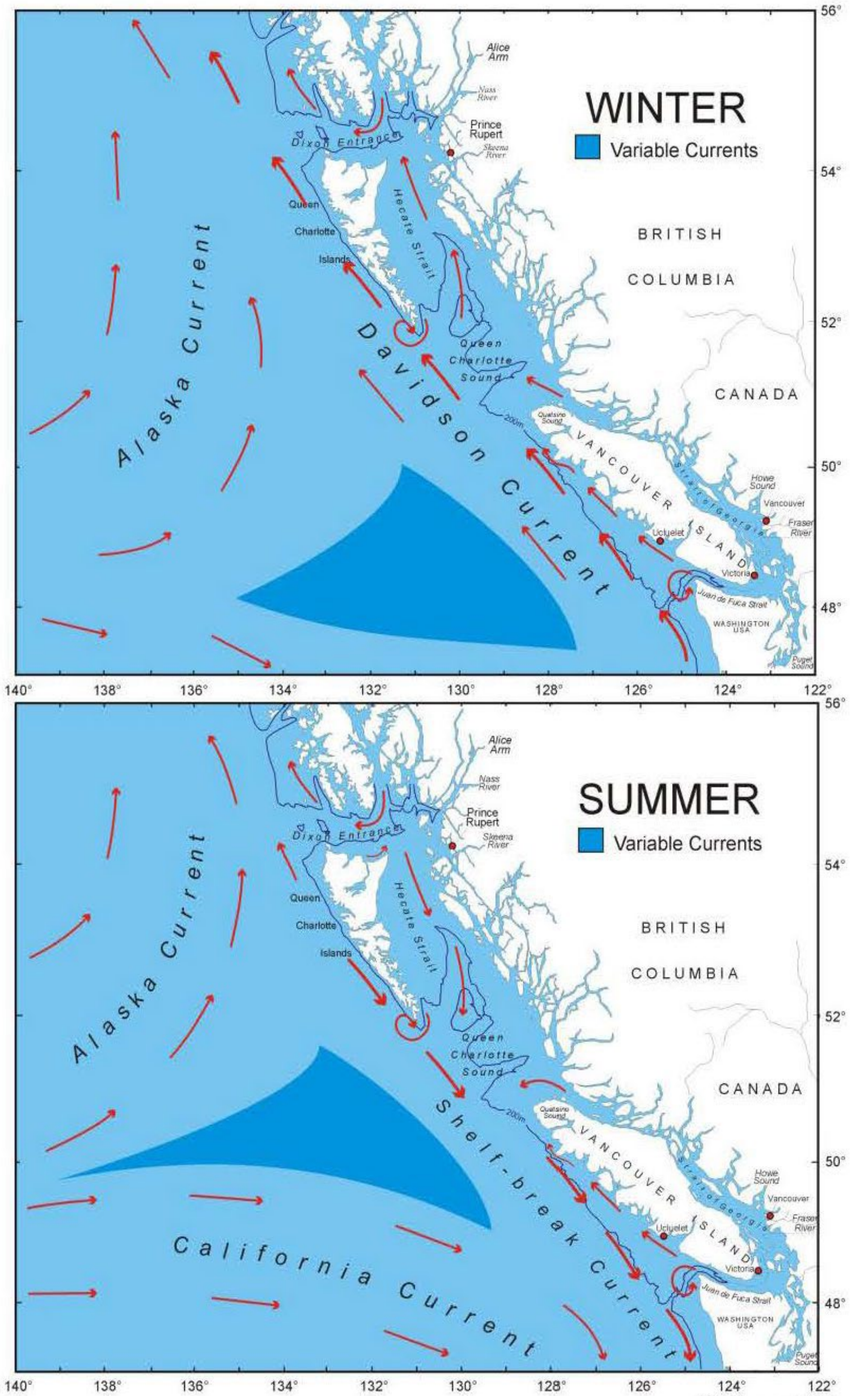


Figure A2. Ocean Circulation in the northeast Pacific. Area 1 Coastal Downwelling Zone, Area 2 Upwelling/Downwelling Transition Zone (transition in wind-generated currents), Area 3 Coastal Upwelling Zone, and Area 4 Bifurcation Zone. Modified from DFO 2019a.



R.E. Thomson, 2003

Figure A3. Generalized seasonal changes of the ocean circulation currents (Bifurcation Zone). Modified from Thomson 1981 and printed in DFO 2019a.

APPENDIX D. SUMMARY OF BENTHIC VISUAL SURVEY DIVES

Table A3. Summaries of 31 benthic visual survey dives on 12 Offshore Pacific Bioregion (OPB) seamounts during Pac2017-036, Pac2018-103, and Pac2019-014. In 2017 and 2019, BOOTS (Bathyal Ocean Observation and Televideo System) was deployed off the CCGS John P. Tully, and in 2018, the remotely operated vehicle (ROV) Hercules was deployed off the E/V Nautilus. See Figure 13 for mapped seamount locations. Dive videos and dive logs available on Ocean Networks Canada Seatube Pro. Information based on raw data; see forthcoming expedition reports for processed data. Astericks: transects used in coral analyses to groundtruth seamount classifications.

Pac2017-036

Dive	Dive date & time (UTC)	Dive duration (hh:mm)	Seamount, location (transect name if applicable)	Depth range (m)[1]	Approximate transect length (km)	Start & end locations (lat.,long.)
B021	19-07-17 16:10	1:26	Strait of Juan de Fuca[2]	112-112	0.3	na
B022	21-07-17 14:51	2:22	Union, southern flank	419-390	0.2	49.52568, -132.7089
						49.52428, -132.71402
B023	21-07-17 20:29	5:05	Union, southern flank	719-410	2	49.52492, -132.69487
						49.52624, -132.70527
B024*	22-07-17 15:02	10:11	Union, southern flank	2080-399	6.2	49.4814, -132.66373
						49.52895, -132.71163
B025	23-07-17 15:09	9:49	Union, northeast flank to summit	1686-300	5.4	49.55536, -132.64259
						49.54603, -132.70064
B026	24-07-17 15:22	11:05	Union, northwest flank to summit	2118-498	7.5	49.57066, -132.82465
						49.55029, -132.72283
B027*	25-07-17 21:16	5:19	UN 16, western flank to summit	2054-1106	2.7	49.87394, -132.14806
						49.88317, -132.11363
B028	26-07-17 21:17	5:29	Dellwood, eastern flank to summit	2054-596	5	50.75157, -130.82274
						50.74421, -130.88262
B029	27-07-17 15:02	10:34	Dellwood, northwest flank to summit	2069-548	6.9	50.78696, -130.93129
						50.75648, -130.88812
B030*	28-07-17 16:23	9:22	Dellwood, southwest flank to summit	2111-561	7.2	50.69273, -130.95674
						50.74226, -130.89467
B031	29-07-17 17:29	6:14	UN 18, northeast flank to summit	2145-1615	3	49.9571, -130.89121
						49.93845, -130.91373
B032	30-07-17 17:01	5:44	Paul Revere Ridge[2]	1993-1666	3.6	49.88737, -129.2299
						49.91073, -129.21393

Pac2018-103

Dive	Dive date & time (UTC)	Dive duration (hh:mm)	Seamount, location (transect name if applicable)	Depth range (m)[1]	Approximate transect length (km)	Start & end locations (lat.,long.)
H1682	07-07-18 16:29	8:02	Dellwood, southwest flank to summit	837-552	5.6	50.72130, -130.92149
						50.73362, -130.89315
H1683	08-07-18 14:08	10:35	Dellwood, northern flank	669-603	4.8	50.75677, -130.88565
						50.75684, -130.88937
H1684*	10-07-18 13:59	10:06	SGaan-Kinghlas Bowie, southern flank to summit	1992-244	12.6	53.25176, -135.60263
						53.29552, -135.64249
H1685*	11-07-18 14:15	10:19	Hodgkins, eastern summit	1408-599	10	53.51053, -135.99835
						53.50645, -136.03534
H1686	12-07-18 14:01	11:38	SGaan-Kinghlas Bowie, northern summit	191-48	6.2	53.30776, -135.68076
						53.30266, -135.65132
H1687*	13-07-18 14:04	10:22	SGaan-Kinghlas Bowie, eastern flank	1258-580	7.6	53.32200, -135.53205
						53.31627, -135.57380
H1688	14-07-18 14:02	10:49	SGaan-Kinghlas Bowie, western flank	1094-175	7.6	53.28961, -135.78207
						53.28071, -135.74295
H1689*	15-07-18 14:30	8:25	Davidson, western summit	2046-1159	10	53.64830, -136.69629
						53.66941, -136.67641
H1690*	18-07-18 14:17	9:56	Dellwood South, eastern flank to summit	1446-808	9.2	50.58028, -130.68077
						50.58016, -130.71248
H1691	19-07-18 14:08	4:09	Explorer, eastern summit	947-787	3.4	49.05676, -130.93686
						49.05844, -130.94158

Pac2019-015

Dive	Dive date & time (UTC)	Dive duration (hh:mm)	Seamount, location (transect name if applicable)	Depth range (m)[1]	Approximate transect length (km)	Start & end locations (lat.,long.)
B064	19-07-19 19:52	3:38	Explorer, east of summit (ES01)	1900-1800	1	49.04998, -130.89345
						49.04992, -130.90837
B065*	20-07-19 17:25	7:43	Explorer, western summit (ES03b)	1690-795	2.6	49.06539, -130.97169
						49.05652, -130.94122
B066	21-07-19 15:13	8:39	Explorer, northern flank (ES04b)	1816-1420	5.3	49.19457, -130.93870
						49.16031, -130.96480
B067	22-07-19 17:16	8:09	Explorer, southeast flank (ES02b)	1965-1600	4.1	48.98025, -130.87254
						48.97968, -130.90026
B068	23-07-19 20:50	5:28	Explorer, north of summit (ES07)	1807-930	2	49.12594, -130.93799
						49.12015, -130.96548
B069	24-07-19 15:50	5:50	Explorer, northwest flank (ES08)	2000-1884	2.6	49.2328, -131.01014
						49.21261, -131.00268
B070*	25-07-19 14:44	7:20	UN 1, northeast flank to summit	1949-918	3.2	47.58506, -130.27227
						47.56589, -130.30734

Dive	Dive date & time (UTC)	Dive duration (hh:mm)	Seamount, location (transect name if applicable)	Depth range (m)1	Approximate transect length (km)	Start & end locations (lat.,long.)
B071*	26-07-19 16:14	9:09	Northern Springfield, eastern flank to summit	2000-925	4.4	47.56616, -130.30675
						48.06664, -130.20189
B072*	27-07-19 15:27	11:09	Heck, south flank to summit	1600-1100	5.4	48.36570, -129.38202
						48.41107, -129.37198

[1] Dives start deep with the vehicle transiting upslope toward the summit

[2] Test dives or other non-seamount dives conducted during the expedition

APPENDIX E. CLUSTER ANALYSES

Statistical analyses for spatial clustering (under Objective 2: Geographic boundaries) were performed in R Studio version 1.2.5033. The following is a dendrogram of seamounts based on a geographic Euclidean distance derived from a similarity matrix and the two analyses used to determine the optimal numbers of clusters: average silhouette and within cluster sums of square (fviz_nbclust function, ‘factoextra’ R package).

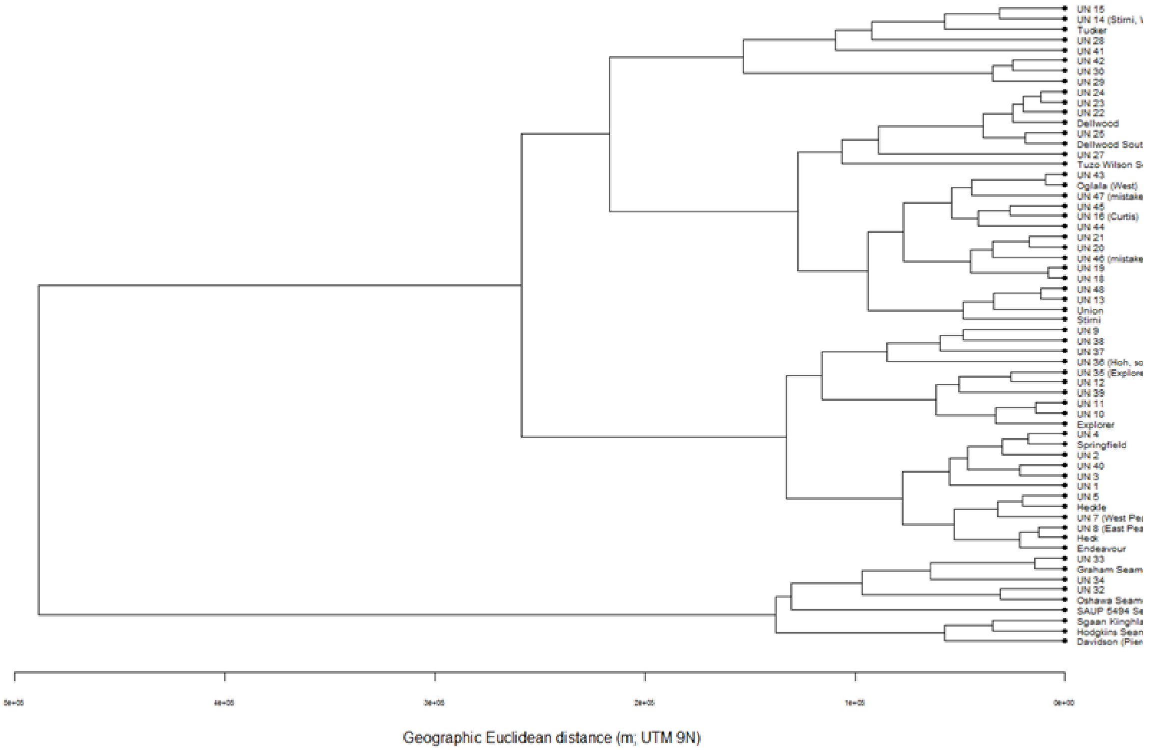


Figure A4. Dendrogram of seamounts based on a geographic Euclidean distance.

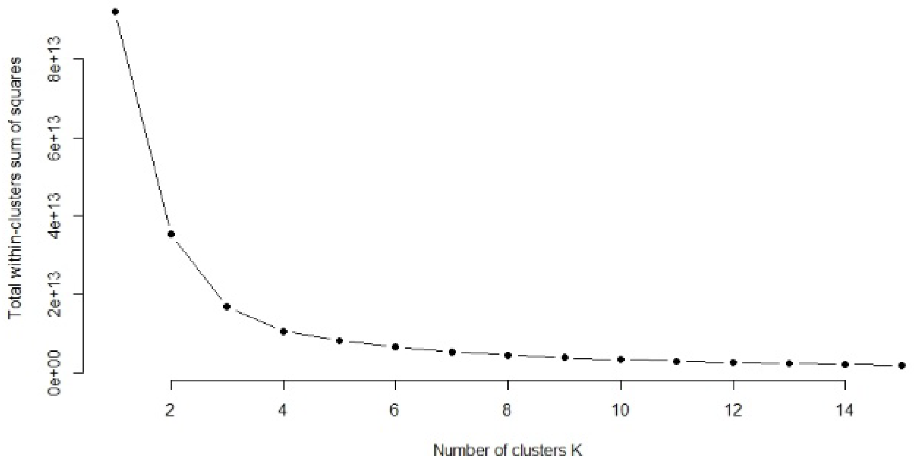


Figure A5. The average silhouette (fviz_nbclust function R package) indicates a possible optimal cluster of four groups based on a geographic Euclidean distance.

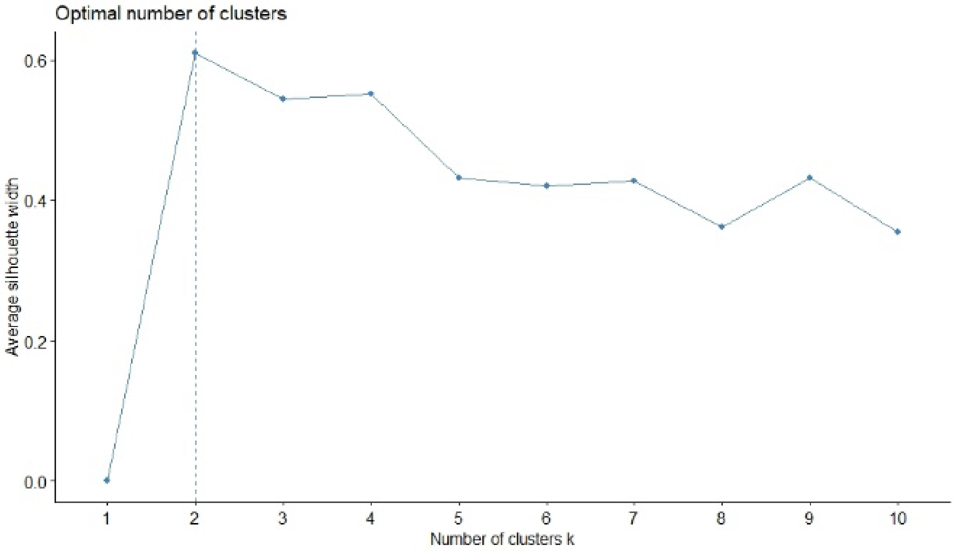


Figure A6. The within-cluster sums of squares ('factoextra' R package) indicate a possible optimal cluster of two groups based on a geographic Euclidean distance.

APPENDIX F. UNPUBLISHED GLASS SPONGE DATA

Table A4. The relative abundance of habitat-forming glass sponges (standardized as occurrence of individuals per survey hour of video annotated) as a function of depth (binned in 50 m intervals). Video of four Area of Interest (AOI) seamounts surveyed during the 2017 expedition (Union, Dellwood, UN 16, and UN 18). Unpublished data from Ross et al. (2020). Graphic of data provided below.

Depth interval (m)	***Chonelasma oreia***	***Farrea* spp. (branching)**	***Tretodictyum* n. sp.**	***Pinulasma* n. sp.**	**Rossellidae**	**Aphrocallistidae**	***Farrea* spp. (mound)**	**Hexactinella n. sp.**
250-300	0	0	0	0	-	0	0	0
300-350	0.412229474	0	0	1.648917898	-	8.244589488	0.824458949	0.412229474
350-400	0	0	0	0.590260698	27.15199213	17.70782095	0	0
400-450	0	0	0	1.14905841	7.660389403	8.043408873	0	0
450-500	0	0	0	0	5.611222445	2.404809619	0	0
500-550	0	0	0	0	4.708344232	3.766675386	0	0
550-600	0	0.222373216	0	0.444746433	5.114583977	0	0.444746433	0
600-650	0	0	0	0.415177027	10.7946027	0	0.830354054	0
650-700	0.464516129	0	0	16.25806452	19.04516129	0	0	0
700-750	0	0	0	16.76948256	36.71156994	0	0.453229258	0
750-800	0	0	0	9.993830969	23.68908081	0	2.961135102	0
800-850	7.310081223	0.860009556	175.4419494	13.76015289	49.88055423	0	24.94027711	1.290014333
850-900	8.688656476	35.91311344	50.97345133	9.847144006	48.65647627	1.15848753	18.53580048	0
900-950	0	4.114957544	2.351404311	6.466361855	24.68974526	0.587851078	24.10189419	0
950-1000	0.595336531	0	2.976682653	16.07408632	27.98081693	0	25.59947081	0
1000-1050	0.378787879	0.757575758	12.12121212	160.9848485	34.84848485	0.757575758	48.48484848	0.378787879
1050-1100	1.505488761	1.129116571	9.409304757	152.0543649	51.18661788	1.129116571	79.41453215	0
1100-1150	5.781584582	0.385438972	3.083511777	58.58672377	34.68950749	0.385438972	43.94004283	0
1150-1200	9.486999297	2.529866479	0.63246662	25.29866479	37.94799719	0	45.53759663	0.63246662
1200-1250	3.75	2.5	0	5.625	21.875	0	29.375	0.625
1250-1300	2.209944751	1.767955801	0	2.209944751	25.19337017	0	7.513812155	0
1300-1350	1.69531434	4.238285849	0	0	51.70708736	1.69531434	12.71485755	0.84765717
1350-1400	2.3914969	3.985828167	0	0	43.84410983	0.797165633	12.75465013	2.3914969

Depth interval (m)	***Chonelasma oreia***	***Farrea* spp. (branching)**	***Tretodictyum* n. sp.**	***Pinulasma* n. sp.**	**Rossellidae**	**Aphrocallistidae**	***Farrea* spp. (mound)**	**Hexactinella n. sp.**
1400-1450	1.727861771	3.455723542	0	3.455723542	19.87041037	1.727861771	7.77537797	0
1450-1500	0.739675365	2.219026094	0	0	19.23155948	0	5.177727553	0.739675365
1500-1550	3.594608088	1.797304044	0	0	8.087868198	1.797304044	15.27708437	2.695956066
1550-1600	0	5.132382892	0.733197556	5.132382892	19.79633401	1.466395112	21.26272912	93.11608961
1600-1650	0.835751596	0.835751596	0.417875798	0.417875798	2.08937899	0	10.44689495	44.29483459
1650-1700	1.228668942	0.491467577	0.491467577	4.66894198	6.389078498	0.245733788	6.389078498	28.50511945
1700-1750	0.403859098	0.807718196	0	0	2.01929549	0	4.442450079	5.250168275
1750-1800	0.393184797	1.965923984	0	0	2.359108781	0	1.179554391	18.87287025
1800-1850	0	6.35551142	0	0.397219464	3.972194638	0	2.780536246	2.383316783
1850-1900	0	4.198600467	0	0	10.7964012	0	4.198600467	3.5988004
1900-1950	0	3.005008347	0	0	9.015025042	0	1.202003339	0.601001669
1950-2000	0.781080495	2.343241484	0	0	5.467563463	0	2.343241484	0
2000-2050	0	0	0	0	25.61334642	0	0	0
2050-2100	0	0	0	0	11.67988464	0	0	0
2100-2150	0	0	0	0	0.925212028	0	0	0

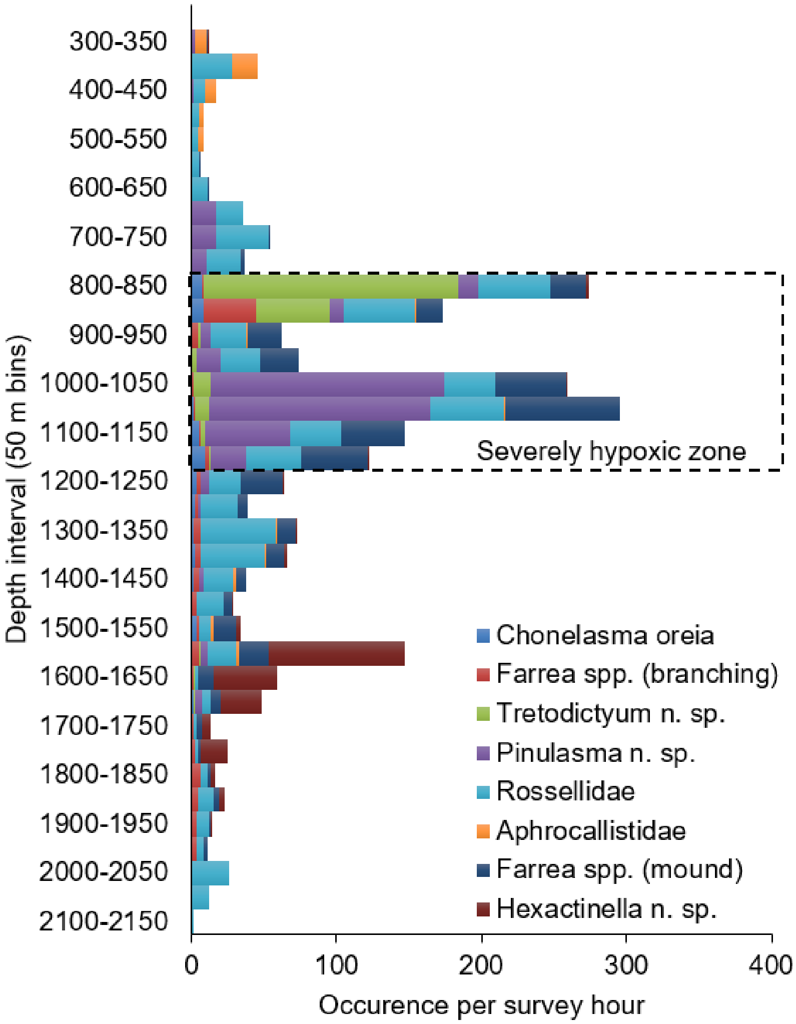


Figure A7. The relative abundance of habitat-forming glass sponges (standardized as occurrence of individuals per survey hour of video annotated) as a function of depth (binned in 50 m intervals). The overlaid dashed box marks the lowest oxygen levels (severely hypoxic zone between 800 and 1200 m depth; Figure 21), which contains the peak abundance of the glass sponges. Video of four AOI seamounts surveyed during the 2017 expedition (Union, Dellwood, UN 16, and UN 18). Unpublished data from Ross et al. (2020) (data available in Appendix A Table A4).

APPENDIX G. REGIONAL OCEANOGRAPHY: NET PRIMARY PRODUCTIVITY

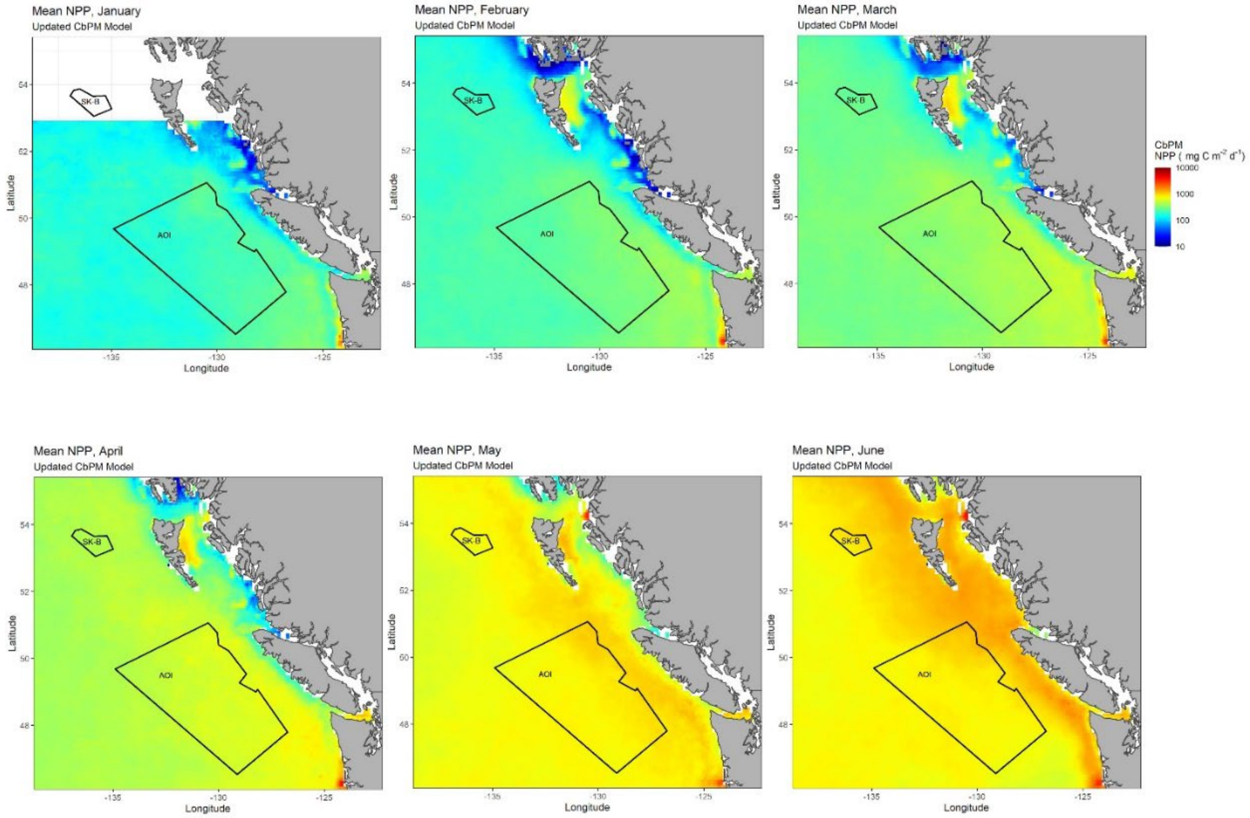


Figure A8. Monthly composite of mean net primary production (C_{npp}; organic carbon in surface waters) based on the Carbon-based Production Model (CbPM; accessed 7 December 2020) over a 19 year period from 01-07-2002 to 31-01-2020, in milligrams of carbon per meter squared per day (mg C m^{-2} d^{-1}). Generated by Andrea Hilborn (Institute of Ocean Sciences). Figure continues on the following page.

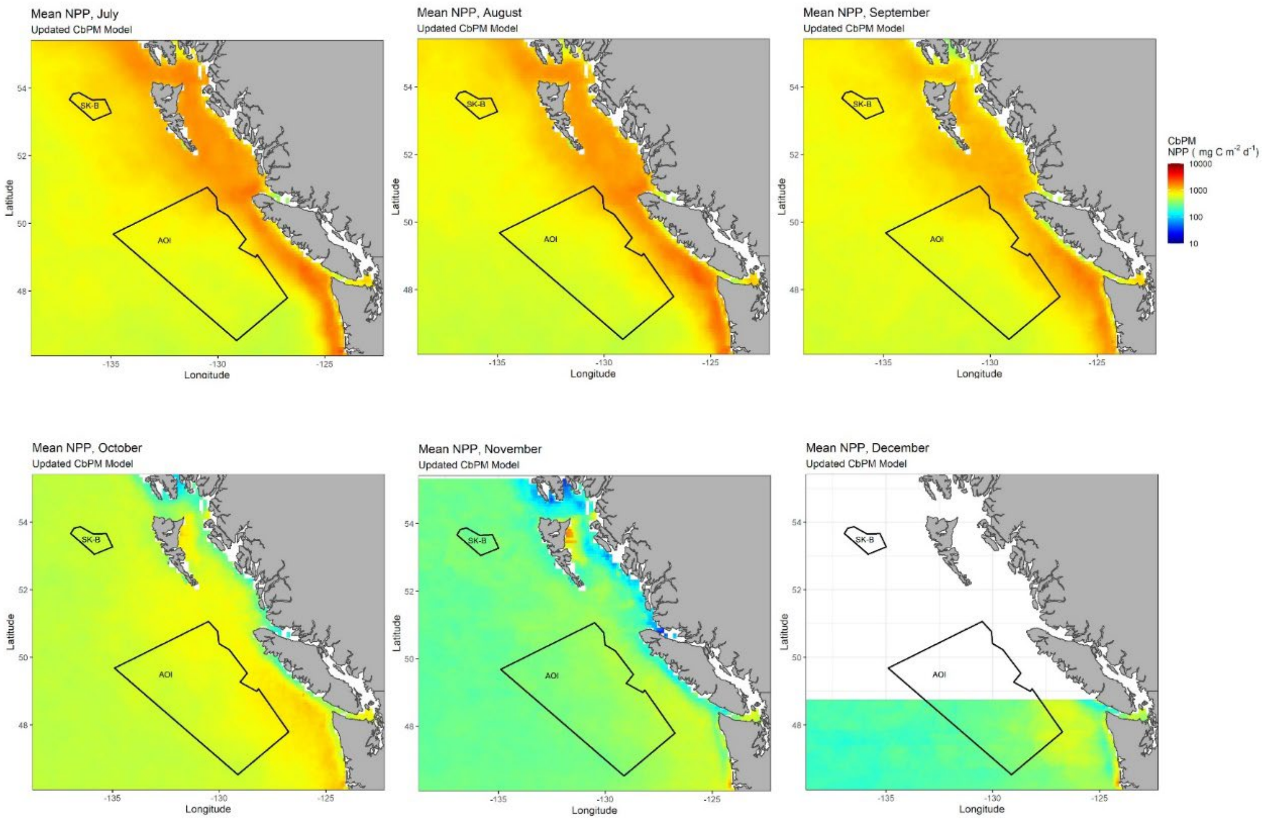


Figure A8. Continued.

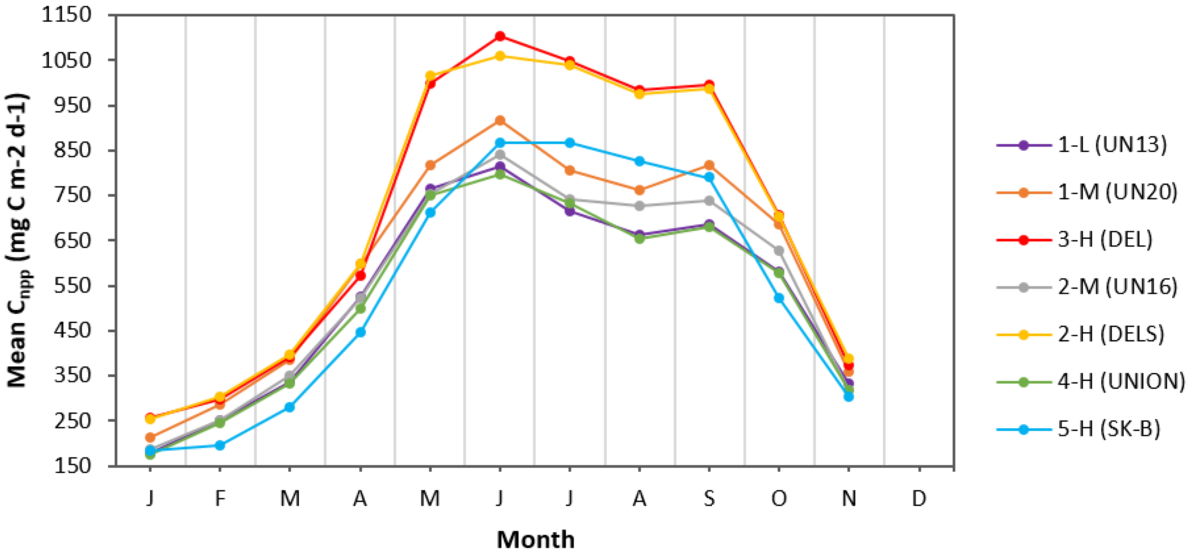


Figure A9. Monthly mean net primary productivity (C_{npp}; organic carbon in surface waters) climatology at seven example seamounts (the seamount with the highest mean export productivity, $C_{flux(z)}$, in each class; Appendix A and Table A1). 1-L, UN13; 1-M, UN20; 2-M, UN16; 2-H, Dellwood South; 3-H, Dellwood; 4-H, Union; 5-H, SGaan Kinghlas-Bowie. Generated by Andrea Hilborn (Institute of Ocean Sciences).

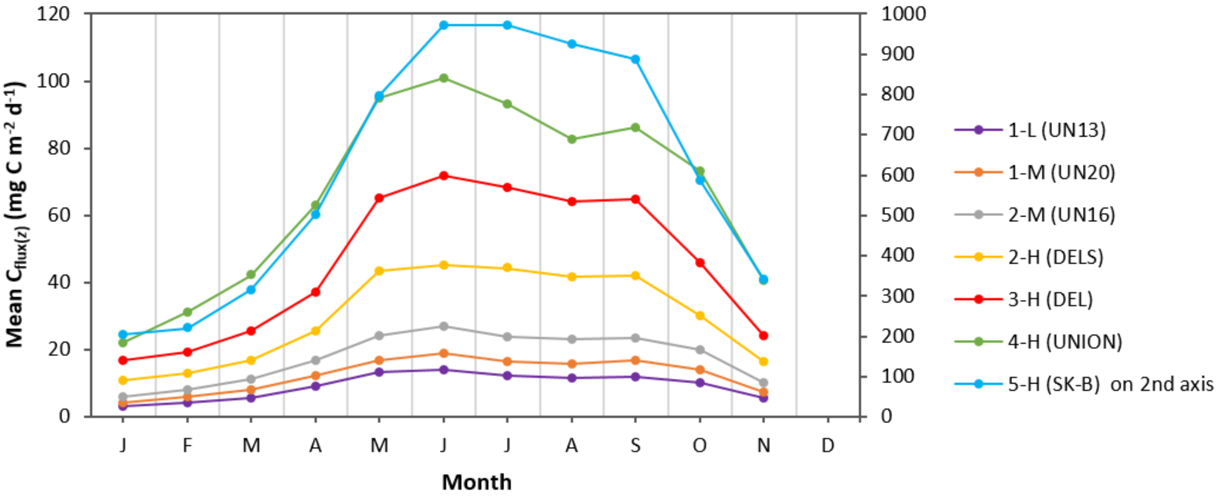


Figure A10. Monthly mean export productivity ($C_{flux(z)}$) climatology at seven example seamounts (the seamount with the highest mean export productivity, $C_{flux(z)}$, in each class; Appendix A; Table A1). 1-L, UN13; 1-M, UN20; 2-M, UN16; 2-H, Dellwood South; 3-H, Dellwood; 4-H, Union; 5-H, SGaan Kinghlas-Bowie. $C_{flux(z)}$ is a function of net primary productivity in surface waters (C_{nnp}) and summit depth (z) (Suess 1980). Note: the second axis (right) for 5-H, SK-B, is a magnitude larger than the first (left). Generated by Andrea Hilborn (Institute of Ocean Sciences).

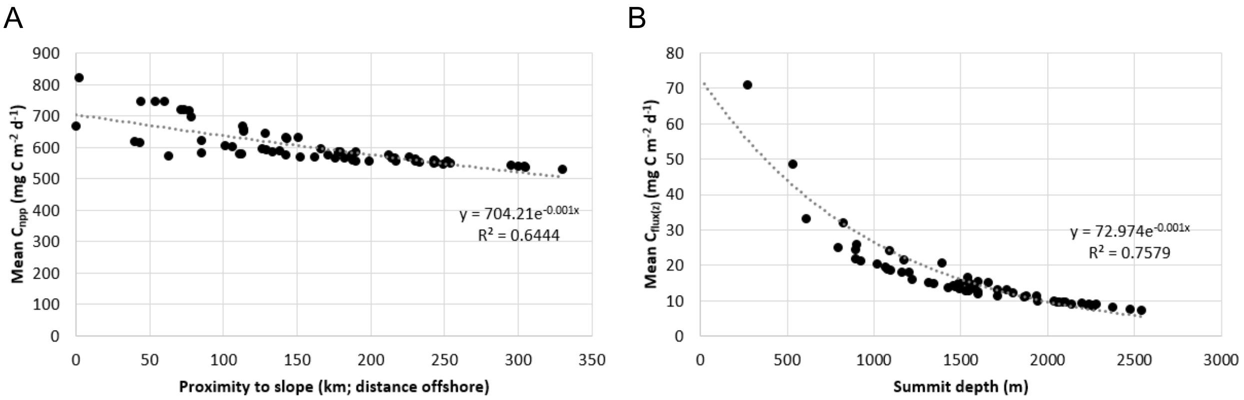


Figure A11. The correlation between productivity values (mg C m^{-2} d^{-1}) at the 62 seamounts and the environmental variable likely driving the distribution pattern: (A) the negative correlation between distance offshore (proximity to slope) and mean net primary productivity (C_{npp}; organic carbon in surface waters) and (B) the negative correlation between summit depth and mean export productivity ($C_{flux(z)}$). Data from Appendix A and Table A1. Note: SK-B $C_{flux(z)}$ not shown (24 m and 581.2 mg C m^{-2} d^{-1}).

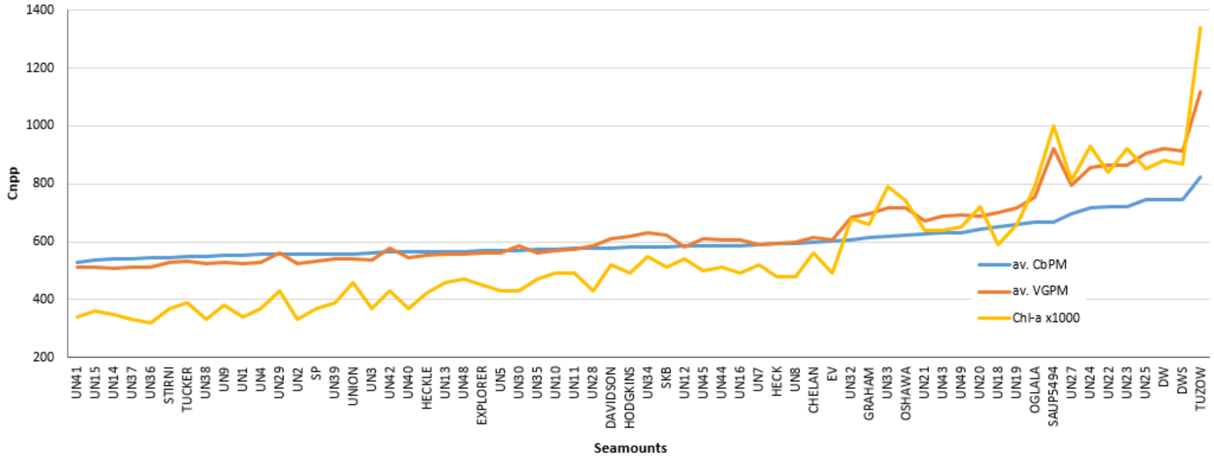


Figure A12. A comparison of three options for net primary production (C_{npp}). The Carbon-based Production Model (CbPM; blue line in mg C m^{-2} d^{-1}) and Vertically Generalized Production Model (VGPM; orange line in mg C m^{-2} d^{-1}) over a 19 year period from 01-07-2002 to 31-01-2020 (Ocean Productivity, accessed 7 December 2020). Chlorophyll-a levels (Chl-a; yellow line in x1000 mg/m^3) from satellite-based mean surface estimates between March and October over a four-year period from 2012 to 2015 (generated by Jessica Nephin, Institute of Ocean Sciences).

APPENDIX H. ADDITIONAL INFORMATION ON ANTICIPATED CHANGES

Table A5. Eleven anticipated changes within the Offshore Pacific Bioregion (OPB) and Area of Interest (AOI). Scoring of the 62 seamounts provided in Table 8.

No.	Anticipated change	Description
1	Recovery following the prohibition of bottom-contact fishing (closure)	The benthic ecosystem has been directly affected by previous bottom-contact fishing (e.g., longline trap or hook, bottom trawling, and/or mid-water trawling which can often make contact with the seafloor). In addition to capturing the target species, bottom contact fishing removes, kills, or damages cold-water corals and sponges (as well as other vulnerable organisms), causing long-term alterations to the benthic ecosystems (e.g., Du Preez et al. 2020). This summary is based on 2007 to 2016 DFO Pac Harv data and its spatial overlap with the seamount areas (data cannot be shared to respect the privacy of commercial fishers).
		o SK-B and Union: heavily fished with bottom-contact gear relative to the other seamounts.
		o SK-B, Hodgkins, Union, and Endeavour: long-line trap or hook for sablefish (Anoplopoma fimbria) (Union also fished for rockfish, Sebastes spp.).
		o Explorer, Stirni, and Endeavour: rare bottom trawl for groundfish.
		o SK-B, Dellwood, Dellwood South, Oglala, and UN 7, 19, 20, and 25: longline hook for Pacific Halibut (Hippoglossus stenolepis), lingcod (Ophiodon elongatus), and other groundfish. The summit of SK-B is shallow enough that ships have anchored on its summit, potentially causing impacts that are similar to bottom-contact fishing.
		o Endeavour and UN 5: mid-water trawls.
2	Ongoing harm caused by lost gear	The benthic ecosystem suffers the ongoing effects of derelict or “lost” fishing gear (e.g., longline trap or hook gear, which can be up to 2-3 km in length, plus the additional anchors and float lines; Du Preez et al. 2020). The presence and visible impacts of lost fishing gear were recorded during visual surveys in 2017, 2018, and 2019. Impacts can include ongoing large-scale habitat alteration and ghost fishing, especially if gear is mobile (Du Preez et al. 2020). Seamounts not yet visually surveyed are inferred to not have lost gear (although the potential is high on previously fished seamounts).
3	Impacts of heavey shipping traffic	The resident and transient species at or around the seamount suffer the ongoing shipping-related effects, such as noise, light, and chemical pollution. For example, shipping noise pollution is known to be harmful to whales that inhabit or migrate through BC waters. For the purpose of this assessment, we only considered shipping frequency and proximity to the seamounts, although there are many other factors at play. We identified seamounts most likely to suffer changes owing to shipping traffic as those underneath the highest density marine route: a ~7 km wide marine route through the OPB for vessels travelling between Canada and Asia (~360 vessels in 2019 or ~1 vessel per day).
-	Ocean acidification (direct impacts):	The seamount transects the shoaling calcite or aragonite saturation horizon, which is rising because of ocean acidification (climate change). This negatively impacts marine organisms (e.g., inhibits the building of coral skeletons and mollusc shells; productivity export barrier). If these trends continue as they have over the last 3 decades, they threaten to diminish regional seamount ecosystem diversity and cause local extinctions—information from Ross et al. (2020).
4	(a) calcite saturation horizon	The seamount transects the shoaling calcite saturation horizon, which is presently at ~340 m depth but is rising at a rate of 1.7±0.8 m/year due to ocean acidification. If these climate change-induced trends continue as they have over the last 3 decades, they threaten to cause local extinctions of vulnerable species living just above this current boundary.
5	(b) aragonite saturation horizo	The seamount transects the shoaling aragonite saturation horizon, which is presently at ~185 m depth but is rising at a rate of 0.8±0.6 m/year due to ocean acidification. If these climate change-induced trends continue as they have over the last 3 decades, they threaten to cause local extinctions of vulnerable species living just above this current boundary.
-	Ocean deoxygenation, in the OMZ:	The seamount in below or transects the expanding and further depleting (15% loss of oxygen since 1960) midwater oxygen minimum zone (OMZ; hypoxic water, <1 ml/l of oxygen). If these climate change-induced trends continue as they have over the last 6 decades, they threaten to diminish regional seamount ecosystem diversity and cause local extinctions—information from Ross et al. (2020).
6	(a) under the OMZ (ceiling)	The seamounts that summit below 1700 m depth have to contend with the OMZ as a descending and worsening chemical ceiling, which is increasingly limiting connectivity with the ocean above (e.g., affecting nutrient flux and population connectivity).

No.	Anticipated change	Description
7	(b) transects the deepening OMZ base	The seamount transects the lower boundary of the OMZ, presently at ~1700 m depth. Climate change deoxygenation is causing the OMZ to become further depleted and the lower boundary to deepen at a rate of 3.0±0.6 m/year. If these climate change-induced trends continue, they threaten to cause local extinctions of vulnerable benthic species living just below this boundary or species living within the OMZ at some preexisting tolerance threshold.
8	(c) in the OMZ	The seamount transects the expanding and further depleting (15% loss of oxygen since 1960) midwater OMZ (hypoxic water, <1 ml/l of oxygen). If these climate change-induced trends continue as they have over the last 6 decades, they threaten to diminish regional seamount ecosystem diversity and cause local extinctions.
9	(d) transects the shoaling OMZ top	The seamount transects the upper boundary of the OMZ, presently at ~480 m depth. Climate change deoxygenation is causing the OMZ to become further depleted and the upper boundary to be variable, shoaling for long periods. If these climate change-induced trends continue, they threaten to cause local extinctions of vulnerable benthic species living just above this boundary or species living within the OMZ at some preexisting tolerance threshold.
10	Other effects of climate changes, environmental	Changes in temperature, precipitation and hydrology, salinity and stratification, sea level, ocean currects, oceanogphic oscillations, storminess and wave heights.
11	Other effects of climate changes, biological	Shifts in species distributions, community composition, and structure; increased occurrence and establishment of new species, changes in favorable conditions and biodiversity; changes due to interactions with other stressors; etc. Climate change can facilitate the spread of alien and/or invasive species, which may have cascading ecological implications. New range extensions of tropical species were documented over the OPB seamounts in 2017, including bottlenose dolphins (*Turiops truncatus*; Halpin et al. 2018) and gelatinous pyrosomes (*Pyrosoma atlanticum*; Archer et al. 2018). The tropical “jelly bloom” altered the deep ocean nutrient flux, with dense “jelly falls” documented on all the seamounts surveyed that year. The pyrosome carcasses were consumed by at least 33 species of seamount benthic organisms at depths up to 2100 m (Archer et al. 2018), providing a substantial and accelerated input of carbon into these deep ecosystems (up to 13 times greater than the average annual flux (Lebrato and Jones, 2009). While the fast-sinking jellies can increase the efficiency of the biological pump to the deep sea, they draw down carbon from the surface waters, causing a deficit in the normal system. The frequency, duration, and the cascading effect of this climate change impact on seamounts is unclear.
-	Other changes	Other potential changes not summarized here include changes caused by: marine noise (sources other than shipping traffic), water movement, marine light pollution, shipping strikes, spills, ballast water, the occurrence of plastics, litter, pollutants and contaminants, dumping, wrecks, research, etc.

For maps of shipping traffic through the OPB, see figure below and Erbe et al. 2014 (a measure of audible acoustic energy from all classes of ships over the summer of 2008 by species on a 5×5 km grid).

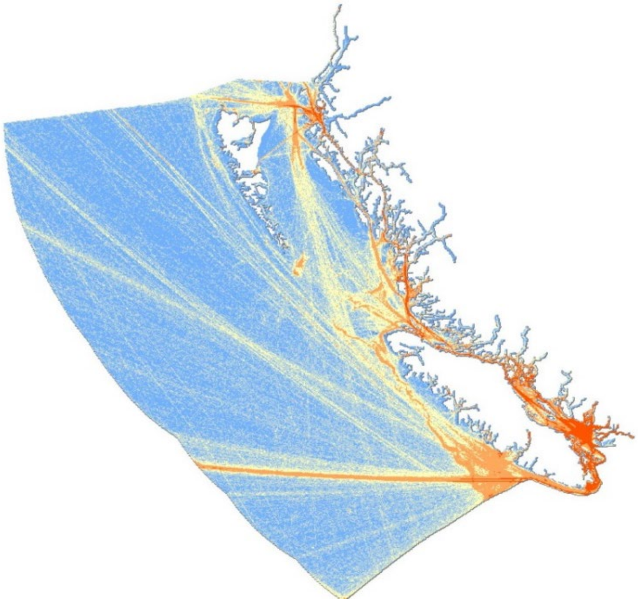


Figure A13. Shipping traffic (vessel density) within the Canadian Pacific Exclusive Economic Zone from 2019 Satellite Automatic Identification System (SAIS) data. Courtesy of Josephine Iacarella (Institute of Ocean Sciences).

APPENDIX I. ADDITIONAL INFORMATION ON EXISTING DATA

Table A6. Twelve existing data types relevant to seamounts within the Offshore Pacific Bioregion (OPB) and Area of Interest (AOI). Scoring of the 62 seamounts provided in Table 9.

No.	Data type	Description	Reference
1	Acoustic data (bathymetry)	The physical structure of the seamount has been mapped, either completely or partially, using a ship-based multibeam echosounder bathymetric system for bathymetry and backscatter (this included sub-bottom profiling in 2018).	Appendix A: Table A1
2	Acoustic data (pelagic)	The pelagic environment was mapped using a ship-based single-beam echosounder bathymetric system. This may also have produced a profile of the seamount bathymetry.	Pac2017-036, Pac2018-103, Pac2019-015 fieldnotes
3	Acoustic data (passive)	The soundscape has been recorded using hydrophone moorings deployed between 50 and 2000 m depth (i.e., marine mammal survey; 2006 to 2019; pers common).	Pers comm Thomas Doniol-Valcroze
4	Benthos collection data	Specimens of the benthos have been collected using a submersible vehicle.	Appendix A Table A1 (2018 submersible survey)
5	Fisheries data	The benthic community has been physically sampled (e.g., commercial fisheries and groundfish research surveys)	2007 to 2016 DFO Pac Harv data; pers comm Lisa Lacko in DFO 2019a
6	Geological survey	Ship-based geological grabs.	Herzer 1970; Bertrand 1972; Botros and Johnson 1988; Canessa et al. 2003
7	Monitoring sites	There is at least one potential long-term monitoring site on the seamount established in 2018 with the deployment of unique physical markers and a comprehensive visual survey of an area approximately 10 m by 10 m. These sites represent potential long-term monitoring sites. SKB and Dellwood have the most sites, with 12 and 7 respectively. The image processing plan is to generate high-resolution 2D and 3D mosaics of the sites using the comprehensive visual survey data. These mosaics can then be georeferenced and analyzed for species presence, counts/densities, and conditions (health). Locations, depths, marker ID, and of all 27 sites are listed in Appendix D Excel sheet 4.	Appendix I: Table A7
8	Oceanography data (collections)	The pelagic environment and community has been sampled using ship-based casts or deployements (e.g., niskin bottles and trawls).	Pac2017-036, Pac2018-103, Pac2019-015 fieldnotes
9	Oceanography data (sensors)	The pelagic environment has been surveyed using ship-based casts with sensors (e.g., CTD and oxygen profiler)	Pac2017-036, Pac2018-103, Pac2019-015 fieldnotes
10	Photographic and video data	The benthic ecosystem has been visually surveyed using a submersible camera system (a remotely operated vehicle or drop camera) and sensors (e.g., mounted CTD).	Appendix A: Table A1
11	Satellite data	Large-scale satellite-collected data sets or products are available online (e.g., sea surface temperature and chlorophyll-a concentration).	e.g., Appendix G
12	Time-series data	The seamount has an associated long-term oceanographic data series. SK-B and Union was home to a Canadian Hydrographic Services of Canada mooring hydrographic mooring (at least one on the summits; Crawford et al. 1981). Dellwood Seamount was home to an underwater autonomous oceanographic mooring from 2018 to 2019 (site: 50.7215502, -130.920556, 833 m depth). Long-term oceanographic data are also derived from stations along line P (a >50 year ongoing oceanographic time-series; Ross et al. 2020), which sample to depths of 2500 m, including some locations over or adjacent to multiple seamounts. Station P11 is 9 km east of UN 35, P12 is over the base of Explorer Seamount, P13 is within 30 km of the bases of Explorer, UN 11, and UN 9, P14 is 11 km west of Stirni, and P15 is adjacent to the base of UN 14. Two of the Ocean Networks Canada NEPTUNE Observatory nodes are near three seamount chains (Heck, Heckle, and Springfield) and within <35 km of three seamounts within these chains, Endeavor, UN 8, and UN 40 (see Appendix G for ONC map). In 2019, the DFO glider program has initiated and repeated a "northern" survey line, which starts on the continental shelf and follows Line P out to the northwest corner of	Crawford et al. 1981; Ross et al. 2020; Ocean Networks Canada ; pers comm Tetjana Ross (Appendix I: Figure A14 and A15)

No.	Data type	Description	Reference
		the AOI. The glider provides additional oceanographic data for the water over the seamounts listed above but only dives to 1000 m depth. A second, “southern” survey line is proposed, which would likely start in the same location (P4 on line P) but run to the southwest corner of the AOI and out. Other long-term (or spatial) oceanographic data (not summarized here) include: current moorings and Argo floats.	
	Other	Other potential data types not summarized here include: marine mammal surveys (e.g., 2018 Pacific Region International Survey of Marine Megafauna) , cultural history/information/records, recreation or tourism (e.g., the 2019 Pacific Wild scuba expedition to SK-B, as well as Pac2017-036, Pac2018-103, Pac2019-015), large-scale models (currents), scientific trawl or drege data (e.g., on Explorer and Dellwood), grab or core sample data, geological survey (e.g. etc.	na

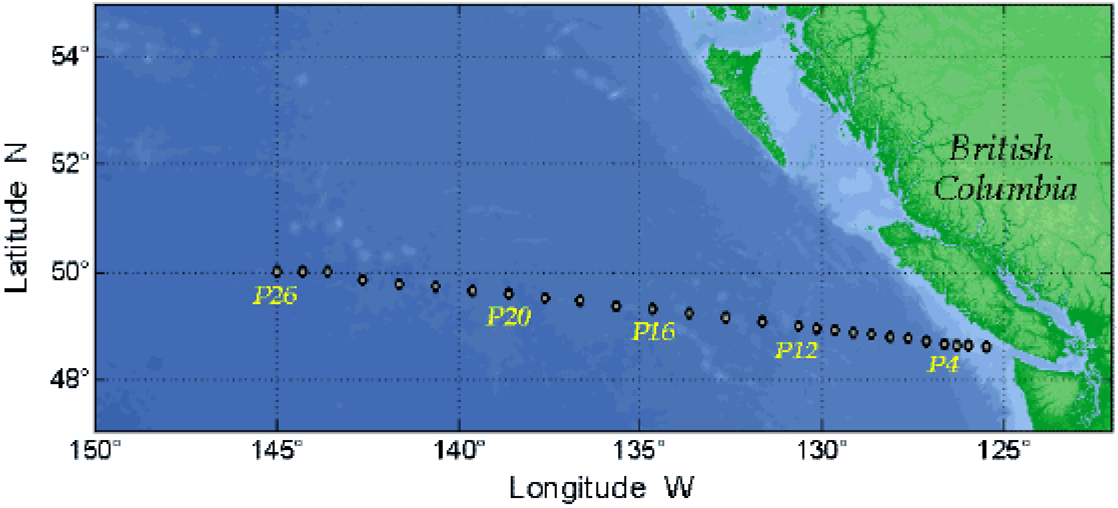


Figure A14. The Line P oceanographic program, which extends into the Offshore Pacific Bioregion (OPB).

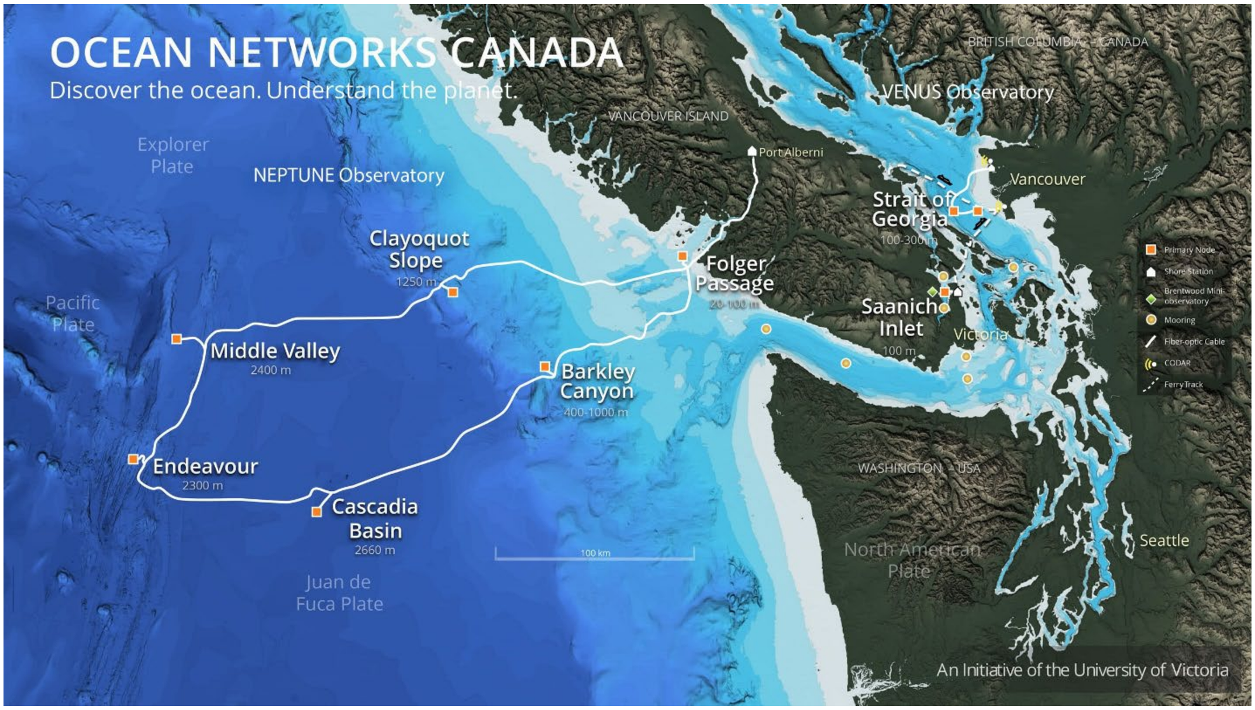


Figure A15. The Ocean Networks Canada (ONC) NEPTUNE cabled observatory, which extends into the Offshore Pacific Bioregion (OPB).

Table A7. Summary information for the 29 long-term monitoring sites established in 2018.Where SK-B is SGaan Kinghlas-Bowie seamount.

Count	Dive	Site Name	Date (UTC)	Marker name	Video Clip Name	UTC Video Time	Date/Timestamp	Latitude	Longitude	Depth (m)
1	H1682	Dellwood seamount	2018-07-07	Dellwood mooring	NA097_H1682_HERC_LOW_20180707T171428Z	18:30	2018-07-07T17:37:56.675Z	50.7215502	-130.920556	833
2	H1682	Dellwood seamount	2018-07-07	A1	NA097_H1682_HERC_LOW_20180707T181428Z	21:24	2018-07-07T18:22:28.692Z	50.72149544	-13.920496	833
3	H1683	Dellwood seamount	2018-07-08	B1	NA097_H1683_HERC_LOW_20180708T182255Z	12:40	2018-07-08T18:34:54.216Z	50.7568615	-130.888173	625
4	H1683	Dellwood seamount	2018-07-08	B2	NA097_H1683_HERC_LOW_20180708T213756Z	22:03	2018-07-08T21:48:01.230Z	50.757104	-130.8861219	640
5	H1683	Dellwood seamount	2018-07-08	B3	NA097_H1683_HERC_LOW_20180708T222256Z	23:25	2018-07-08T23:30:38.117Z	50.7568945	-130.8867171	633
6	H1683	Dellwood seamount	2018-07-08	B4	NA097_H1683_HERC_LOW_20180708T232256Z	16:23	2018-07-08T23:28:03.400Z	50.75691395	130.8873988	630
7	H1683	Dellwood seamount	2018-07-09	B5	NA097_H1683_HERC_LOW_20180709T000756Z	10:24	2018-07-09T00:18:18.268Z	50.7566603	-130.8891552	607
8	H1683	Dellwood seamount	2018-07-09	B6	NA097_H1683_HERC_LOW_20180709T010756Z	13:56	2018-07-09T01:09:52.000Z	50.756671	-130.88896	616
9	H1684	SK-B	2018-07-10	C1	NA097_H1684_HERC_LOW_20180710T180106Z	18:32	2018-07-10T18:09:01.261Z	53.25743088	-130.6070538	1807
10	H1684	SK-B	2018-07-10	C2	NA097_H1684_HERC_LOW_20180710T121460Z	20:00	2018-07-10T21:54:35.925Z	53.27880814	-135.6232077	899
11	H1684	SK-B	2018-07-11	C3	NA097_H1684_HERC_LOW_20180711T011607Z	2:59	2018-07-11T01:17:41.665Z	53.2954585	-135.642676	252
12	H1685	Hodkins Seamount	2018-07-11	A2	NA097_H1685_HERC_LOW_20180711T192955Z	12:02	2018-07-11T19:42:18.785Z	53.507805	-136.024863	945
13	H1685	Hodkins Seamount	2018-07-11	A3	NA097_H1685_HERC_LOW_20180711T214455Z	12:07	2018-07-11T21:57:02.879Z	53.507425	-136.0288555	835
14	H1685	Hodkins Seamount	2018-07-11	C4	NA097_H1685_HERC_LOW_20180711T214455Z	19:40	2018-07-11T23:22:46.693Z	53.50682645	-136.0322265	727
15	H1685	Hodkins Seamount	2018-07-12	C5	NA097_H1685_HERC_LOW_20180712T002955Z	7:19	2018-07-12T00:42:20.618Z	53.50654608	-136.0360255	597
16	H1686	SK-B	2018-07-12	(no marker-used cliff face as site makrer)	NA097_H1686_HERC_LOW_20180712T190107Z	15:00	2018-07-12T19:08:57.624Z	53.3023966	-135.6745988	79
17	H1686	SK-B	2018-07-12	1969 Marker (square_block_with_shackle_and_"1969"_tag)	NA097_H1686_HERC_LOW_20180712T233108Z	17:27	2018-07-12T23:33:24.221Z	53.30036203	-135.6525834	63
18	H1687	SK-B	2018-07-13	E1	NA097_H1687_HERC_LOW_20180713T233108Z	12:16	2018-07-13T17:13:09.835Z	53.3216345	-135.5362925	1111
19	H1687	SK-B	2018-07-13	E2	NA097_H1687_HERC_LOW_20180713T220506Z	15:19	2018-07-13T22:08:30.138Z	53.3214485	-135.5619215	644

Count	Dive	Site Name	Date (UTC)	Marker name	Video Clip Name	UTC Video Time	Date/Timestamp	Latitude	Longitude	Depth (m)
20	H1687	SK-B	2018-07-13	E3	NA097_H1687_HERC_LOW_20180713T185005Z	23:50	2018-07-13T18:56:19.062Z	53.32069303	-135.5446423	828
21	H1687	SK-B	2018-07-14	E4	NA097_H1687_HERC_LOW_20180714T003506Z	3:50	2018-07-14T00:38:40.587Z	53.3162535	-135.5738181	584
22	H1688	SK-B	2018-07-14	G1	NA097_H1688_HERC_LOW_20180714T170210Z	17:21	2018-07-14T17:09:50.124Z	53.2855886	-135.771603	787
23	H1688	SK-B	2018-07-14	G2	NA097_H1688_HERC_LOW_20180714T211711Z	23:18	2018-07-14T21:31:11.987Z	53.2807645	-135.7654307	467
24	H1688	SK-B	2018-07-14	G3	NA097_H1689_HERC_LOW_20180714T224711Z	16:08	2018-07-14T22:52:14.113Z	53.27955438	-135.763261	350
25	H1689	Davidson Seamount/Pierce Seamount	2018-07-15	E5	NA097_H1689_HERC_LOW_20180715T231535Z	19:53	2018-07-15T23:28:46.924Z	53.66913239	-136.6764762	1165
26	H1690	Dellwood South Seamount	2018-07-18	E6	NA097_H1690_HERC_LOW_20180718T215009Z	18:47	2018-07-18T21:57:16.694Z	50.579324	-130.705392	1028
27	H1690	Dellwood South Seamount	2018-07-19	G6	NA097_H1690_HERC_LOW_20180719T003509Z	2:31	2018-07-19T00:38:08.532Z	50.5805005	-130.712886	811
28	H1691	Explorer Seamount	2019-07-19	G4	NA097_H1691_HERC_LOW_20180719T170922Z	18:44	2018-07-19T17:20:38.296Z	49.05814128	-130.9419158	799
29	H1691	Explorer Seamount	2019-07-19	G5	NA097_H1691_HERC_LOW_20180719T153922Z	10:45	2018-07-19T15:51:37.296Z	49.057452	-130.93953	799

APPENDIX J. CONTROL SITES

Table A8. Seamounts within and outside of the Offshore Pacific Bioregion (OPB) that represent the rare or unique OPB seamount classes (plus Dellwood South). Only seamounts outside the OPB that are known to be fished using bottom-contact gear are listed (NPFC 2017).

Class	OPB seamounts and depth	Fished seamounts outside the OPB and depth
H5	SK-B, 24 m	Cobb, 34 m
H4	Union, 271 m	Cobb Far, 362 m; Brown Bear, 461 m
H3	Dellwood, 535 m; Hodgkins, 611 m; and Explorer, 795 m	Warwick, 489 m; Brown Bear North, ~650 m; Eickelberg South, ~750 m; Eickelberg, 775 m
H2	Dellwood South	Cobb South, 863 m

APPENDIX K. UNCOMMON SITES

The location and description of opportunistic visual observations of subjectively uncommon sites are provided in Table A9 and Figures A17-19 (based on ecology).

Table A9. The location and description of opportunistic visual observations of subjectively uncommon sites, regarded as such for the presence, high density, or high diversity of regionally rare, significant, or functionally important species, all of which are identified as Significant Ecosystem Components (SECs) of Offshore Pacific Bioregion (OPB) seamounts (DFO 2015 and herein). Eight of the twelve seamounts visually surveyed in recent years (2017-2019) appear on this list. Example images in Figures A17-19.

Ecosystem component & speices	Location, depth, area/length, & centroid coordinates	Description of uncommon observations of regionally rare, significant, or functionally important species [expedition year]
AOI seamounts (Figure A16 and A17)		
Union (Table 8: 9 of 11 anticipated changes, including fishing closure & lost gear, ocean acidification, deoxygenation, & other climate change impacts)		
Rougheye rockfish, *Sebastes aleutianus*	Shallow summit, 271-500 m, 6.9 km^2, 49.546481, -132.702419	Regionally rare and significant: the only area in the AOI visually confirmed to still support this large, extremely long-lived (up to 200+ years) rockfish, a species of commercial value and conservation concern (documented in Ross et al., 2020). [2017]
Mats of brittle stars (dominated by *Ophiacantha diplasia* with less *Ophiopholis longispina* and *Ophiopholis bakeri*)	Summits & upper flanks, 400-600 m, 11 km^2, 49.546481, -132.702419	Significant and functionally important: these dense mats are very likely to play a significant role in seamount energy transfer, visibly representing a large proportion of the local benthic productivity and biomass (documented in Ross et al., 2020). These species occur in high densities on SK-B and Hodgkins seamounts at similar depths, but are not so dense that they create the same contiguous living mats. [2017]
Cold-water coral & sponge dominated forest (e.g., *Isidella tentaculum*, *Paragorgia* spp., *Chrysopathes* spp., *Chonelasma oreia*, *Pinulasma* n. sp.)	Patches on the flanks & summits, <1,200 m, 64 km^2, 49.546481, -132.702419	Significant and functionally important: these offshore areas support a diverse mosaic of forests, each dominated by one or two large, habitat-forming cold-water corals or sponges (visibly high biomass). [2017]
Dellwood: fishing closure & lost gear, ocean acidification, deoxygenation, & other climate change impacts (Table 8: 8 of 11 anticipated changes)		
Mats of brittle stars	Summits & upper flanks, 400-600 m, 5 km^2, 50.748881, -130.897972	Same information as Union (above). [2017, 2018]
Cold-water coral & sponge mixed gardens (e.g., *Isidella tentaculum*, *Paragorgia* spp., *Chrysopathes* spp., *Chonelasma oreia*, *Pinulasma* n. sp.)	Patches on the flanks & summits, <1,200 m, 43 km^2, 50.748881, -130.897972	Regionally rare, significant, or functionally important: mixed gardens with the highest diversity of cold-water corals (soft, black, sea whips) and glass sponges (compared to presence-absence data from other visually surveyed seamounts). [2017, 2018]
Cold-water coral & sponge dominated forest	Patches on the flanks & summits, <1,200 m, 43 km^2, 50.748881, -130.897972	Same information as Union (above). [2017, 2018]
Tubeworm garden, species unknown	Northern summit break, 610 m, meters-squared, 50.755883, -130.889364	Regionally rare: a field of exposed tubeworms in a mudflat, species (unknown) observed nowhere else. [2017]
Dellwood South (Table 8: 7 of 11 anticipated changes, including fishing closure & lost gear, deoxygenation, & other climate change impacts)		
Cold-water coral and sponge mixed gardens	Patches on the flanks & summits, <1,200 m, 14 km^2, 50.580251, -130.713126	Same information as Dellwood (above). [2018]

Ecosystem component & speices	**Location, depth, area/length, & centroid coordinates**	**Description of uncommon observations of regionally rare, significant, or functionally important species [expedition year]**
Explorer: fishing closure & lost gear, deoxygenation, & other climate change impacts (Table 8: 7 of 11 anticipated changes)		
Dominated by bugle and trumpet-like glass sponges *Pinulasma* n. sp and *Chonelasma oreia*	Eastern side of summit, 790-900 m, <0.5 km transect, 49.057704, -130.939750	Significant and functionally important: nicknamed “Spongtopia”, this city of glass sponges is so dense, the growth of living sponges on dead sponges may qualify as a glass sponge reef in some areas. [2018]
Dominated by the undulating glass sponges *Hexactinella* n. sp. and the wire-coral *Stichopathes* sp.	Western side of summit, 1000-1230 m, <1 km transect, 49.059700, -130.945511	Significant and functionally important: “Coraltropolis” is a dense forest of cold-water corals and sponges. [2019]
UN 1 (Table 8: 5 of 11 anticipated changes, including deoxygenation & other climate change impacts)		
Dominated by the fan coral *Parastenella* sp. and the glass bugle sponge *Pinulasma* n. sp.	Steep summit peak, 1010-920 m, 0.7 km^2 (47.567004, -130.304245)	Significant and functionally important: an incredibly dense forest on the steep flanks of the southern-most seamount in the AOI and the OPB. [2019]
SK̲-B MPA seamounts (Figure A18)		
SK̲-B (Table 8: 10 of 11 anticipated changes, including fishing closure & lost gear, ocean acidification, deoxygenation, & other climate change impacts)		
Seaweeds, kelps, and coastal animals (e.g., diverse assemblage of coastal fishes)	Summit plateau & pinnacles, 24-130 m, 5 km^2, 53.299792, -135.651058	Regionally rare, significant, and functionally important: a diverse assemblage of seaweeds and kelps (i.e., unique in situ primary production) and coastal species, including commercially important fishes and species of conservation concern. [2018]
Squat lobster, *Munida quadrispina*	Summit plateau & pinnacles, 24-190 m, 8 km^2, 53.299792, -135.651058	Regionally rare, significant, and functionally important: the shallow and flat gravel plateau supports a dense population of squat lobsters, which likely play a significant role in seamount energy transfer, and represent a large proportion of the local benthic productivity and biomass. [2018]
Gorgonian coral, *Isidella tentaculum*	Eastern ridge/summit break, 550-600 m, ~100-200 m, 53.319130 -135.567863	Significant and functionally important: dense ticket of large, habitat-forming harp-like corals. [2018]
Red tree coral, *Primnoa pacifica*	Western ridge/summit break, 230-450 m, ~1 km, 53.280786 -135.765201	Regionally rare, significant, and functionally important: large and remarkably dense forest of massive habitat-forming red tree corals, with associated species invertebrates and fish, including *Sebastes* spp. rockfish. This coral has only been recorded on two other seamounts in the OPB (Table 3), and only as individual stands. [2018]
Hodgkins (Table 8: 7 of 11 anticipated changes, including fishing closure & lost gear, deoxygenation, & other climate change impacts)		
Deep sea sole, *Embassichthys bathybius*, & shortspine thornyhead, *Sebastolobus alascanus*	Summit, 600-620 m, 10s m, 53.506531, -136.036048	Significant: potential nursery area a high density of juveniles of both species on rocks and between undulating glass sponges (*Hexactinella* n. sp.). [2018]
Davidson (Table 8: 5 of 11 anticipated changes, including deoxygenation & other climate change impacts)		
Pom-pom anmones, *Liponema brevicorne*, with the black coral *Lillipathes* cf. *wingi* and *Farrea* spp. glass sponges	Summit, 1180-1500 m, 1.5 km^2, 53.667246, -136.677205	Significant and functionally important: a dense field of habitat-forming species on the northernmost seamount in the OPB. [2018]

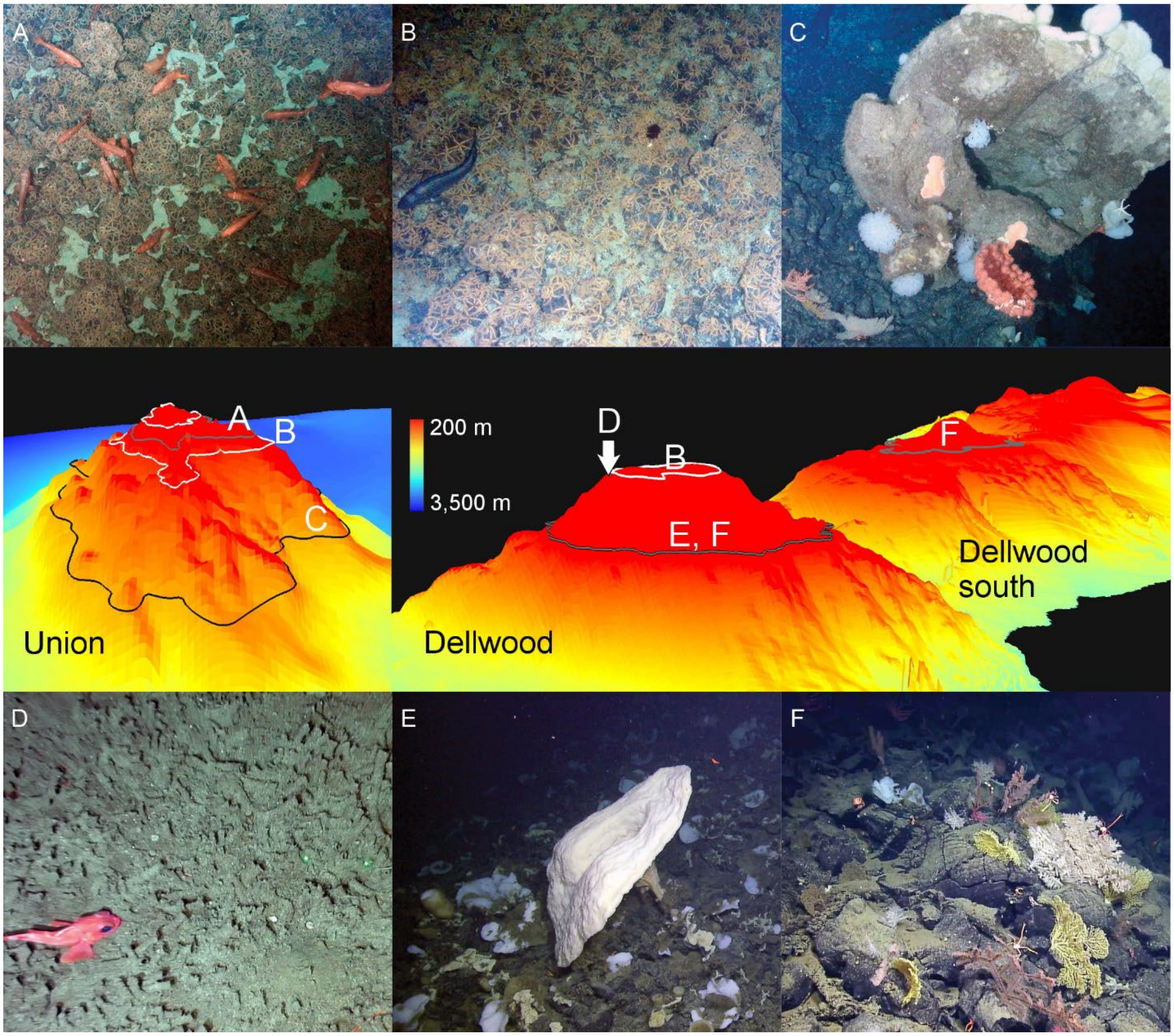


Figure A16. Example images and locations from Union and the Dellwood seamounts of opportunistic visual observations of uncommon sites, regarded as such for the presence, high density, or high diversity of regionally rare, significant, or functionally important species (see Appendix A Table A9 for details), all of which are identified as Significant Ecosystem Components (SECs) of Offshore Pacific Bioregion (OPB) seamounts (DFO 2015 and herein). On Union Seamount, (A) rougheye rockfish (Sebastes aleutianus) are present above 500 m (grey line), (B) living mats of brittle stars are abundant between 400-600 m (white line), and (C) diverse mosaics of forests thrive above 1,200 m (where the dominant cold-water coral and sponge varies between different patches of forests). On Dellwood Seamount, there is (D) a field of exposed tubeworms in a mud flat at a single site; the species (unknown) has not been observed anywhere else. Similar to Union, Dellwood also supports (E) mosaics of forests above 1,200 m. These cold-water coral and sponge grounds can also be extremely diverse (i.e., not dominated by a single species). In fact, above 1,200m, Dellwood and Dellwood South, support (F) the most diverse mixed gardens of corals and sponges observed in the OPB to date (e.g., Table 4).

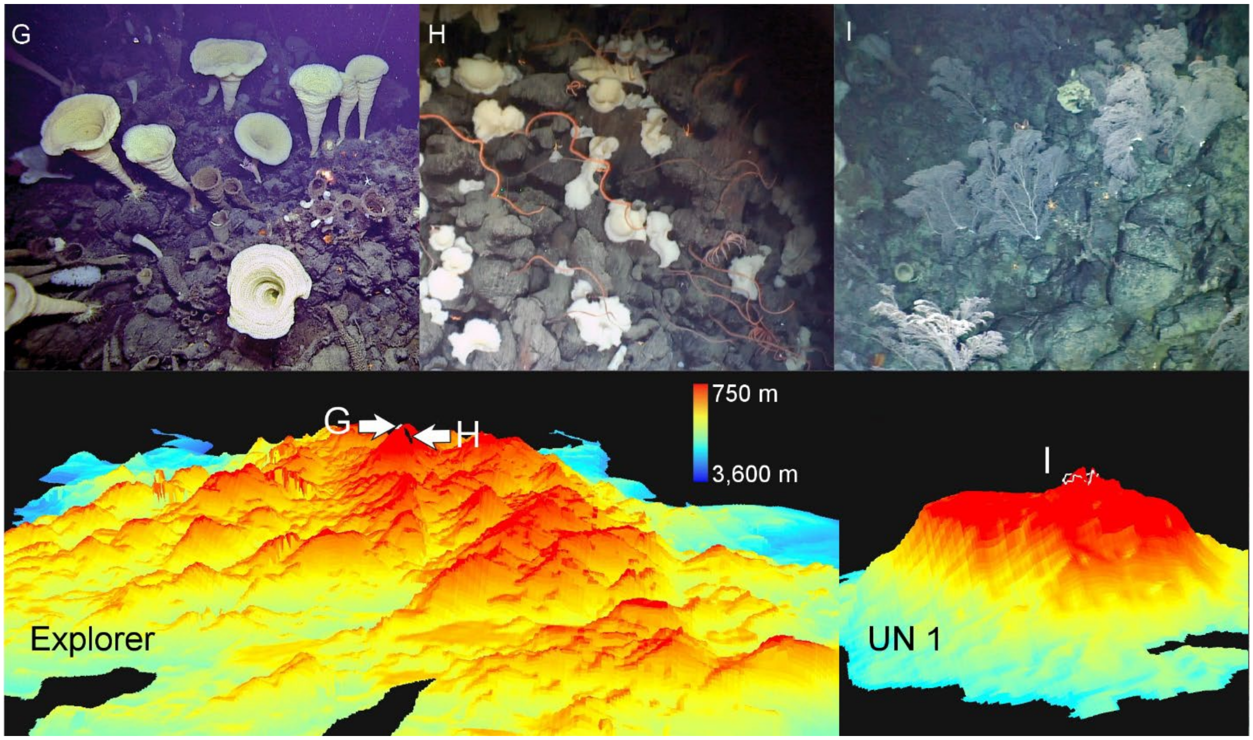


Figure A17. Example images and locations from Explorer and UN 1 seamounts of opportunistic visual observations of uncommon sites, regarded as such for the presence, high density, or high diversity of regionally rare, significant, or functionally important species (see Appendix A Table A9 for details), all of which are identified as Significant Ecosystem Components (SECs) of Offshore Pacific Bioregion (OPB) seamounts (DFO 2015 and herein). Explorer Seamount, the largest seamount in the OPB, supports the densest assemblages of cold-water corals and sponges observed in the OPB to date, with (G) "Spongtopia" (the city of glass sponges) on the west-facing side of its shallowest summit and (H) "Coraltropolis" (the coral city) on the east-facing side. On the steep summit peak of the newly identified seamount UN 1, one of the most remote seamounts in the OPB is a dense mixed garden dominated by fan-like corals and bugle sponges. The summit shape and resulting flow conditions of these two seamounts are discussed in detail in Table 4.

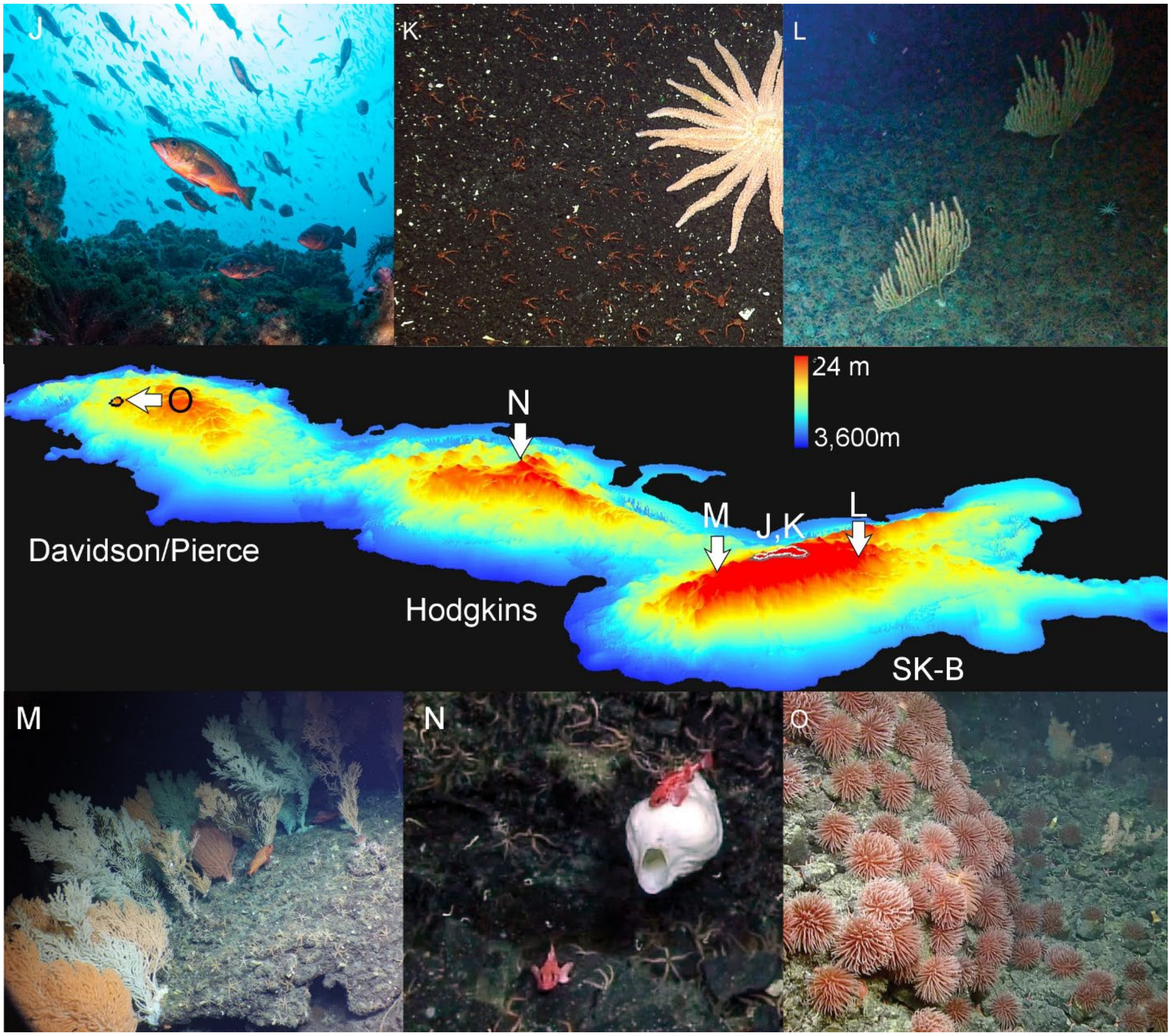


Figure A18. Example images and locations from SGaan Kinghlas-Bowie Seamount Marine Protected Area (SK-B MPA) seamounts of opportunistic visual observations of uncommon sites, regarded as such for the presence, high density, or high diversity of regionally rare, significant, or functionally important species (see Appendix A Table A9 for details), all of which are identified as Significant Ecosystem Components (SECs) of Offshore Pacific Bioregion (OPB) seamounts (DFO 2015 and herein). SK-B Seamount is the shallowest seamount in the OPB—its sunlit summit supports regionally unique species and habitats, such as (J) seaweeds, kelps, and coastal animals (diverse assemblages of rockfish, Sebastes spp.) above 130 m depth (white line) and (K) extensive and dense casts of squat lobsters (Munida quadrispina) above 190 m depth (grey line). SK-B is also home to regionally rare deeper species and habitats, such as dense forests of the tall Gorgonian coral (L) Isidella tentaculum and (M) the red tree coral Primnoa pacifica between 550-600 and 230-450 m depth, respectively. The two other sister seamounts of the SK-B Marine Protected Area (MPA) also support uncommon assemblages deep on their summits. (N) Dense assemblages of benthic fishes—many appearing to be juveniles—were present on summit of Hodgkins, ~600 m (e.g., shortspine thornyhead, Sebastolobus alscanus). (O) Dense gardens of pom-pom anemones (Liponema brevicorne), black corals, and glass sponges were present on the summit of Davidson between 1180-1500 m depth (black line). Image J courtesy of Pacific Wild.

APPENDIX L. SEAMOUNT SPECIES INVENTORY

Table A10. A species inventory for all of the Offshore Pacific Bioregion (OPB) combined. See report for sources.

Taxon	Category	Sub-category	Common name	Feeding/Ecological Guild
Alcidae (Family)	Birds	Migratory seabird	Unidentified alcids, auks	N/A
Cerorhinca monocerata	Birds	Migratory seabird	Rhinoceros auklet	Tertiary consumer
Fulmarus glacialis	Birds	Migratory seabird	Northern fulmar	Tertiary consumer/Scavenger
Pterodroma ultima	Birds	Migratory seabird	Murphy's petrel	Unknown
Puffinus bulleri	Birds	Migratory seabird	Buller's shearwater	Tertiary consumer
Puffinus creatopus	Birds	Migratory seabird	Pink-footed Shearwater	Tertiary consumer
Puffinus griseus	Birds	Migratory seabird	Sooty shearwater	Tertiary consumer
Puffinus tenuirostris	Birds	Migratory seabird	Short-tailed shearwater	Tertiary consumer
Rissa tridactyla	Birds	Migratory seabird	Black-legged kittiwake	Tertiary consumer
Stercorarius longicaudus	Birds	Migratory seabird	Long-tailed jaeger	Tertiary consumer/Scavenger
Stercorarius maccormicki	Birds	Migratory seabird	South polar skua	Tertiary consumer/Scavenger
Synthliboramphus antiquus	Birds	Migratory seabird	Ancient murrelet	Tertiary consumer
Xema sabini	Birds	Migratory seabird	Sabine's gull	Tertiary consumer
Calidris mauri	Birds	Migratory shorebird	Western sandpiper	Secondary consumer
Phalaropus fulicarius	Birds	Migratory shorebird	Red phalarope	Secondary consumer/Scavenger
Phalaropus lobatus	Birds	Migratory shorebird	Red-necked phalarope	Secondary consumer/Scavenger
Fratercula cirrhata	Birds	Pelagic seabird	Tufted puffin	Tertiary consumer
Fratercula corniculata	Birds	Pelagic seabird	Horned puffin	Tertiary consumer
Oceanodroma furcata	Birds	Pelagic seabird	Fork-tailed storm petrel	Secondary consumer
Oceanodroma leucorhoa	Birds	Pelagic seabird	Leach's storm petrel	Secondary consumer
Phoebastria nigripes	Birds	Pelagic seabird	Black-footed albatross	Tertiary consumer
Ptychoramphus aleuticus	Birds	Pelagic seabird	Cassin's auklet	Secondary consumer
Larus glaucescens	Birds	Shorebird	Glaucous-winged gulls	Tertiary consumer/Scavenger
Bothrocara molle	Fish	Bathydemersal fish	Soft eelpout	-
Psychrolutes phrictus	Fish	Bathydemersal fish	Giant blob sculpin, blob sculpin	Secondary consumer
Sebastes alutus	Fish	Bathydemersal fish	Pacific ocean perch	Secondary consumer
Sebastes melanostomus	Fish	Bathydemersal fish	Blackgill rockfish	-
Sebastes zacentrus	Fish	Bathydemersal fish	Sharpchin rockfish	Tertiary consumer
Xeneretmus latifrons	Fish	Bathydemersal fish	Blacktip poacher	Secondary consumer
Avocettina sp.	Fish	Bathypelagic fish	Snipe eels	Secondary consumer
Lestidiops ringens	Fish	Bathypelagic fish	Slender barracudina	Secondary consumer

Taxon	Category	Sub-category	Common name	Feeding/Ecological Guild
Lycodapus mandibularis	Fish	Bathypelagic fish	Pallid eelpout	-
Gadus chalcogrammus	Fish	Benthopelagic fish	Walleye pollock, Alaska pollock	Secondary consumer
Sebastes melanostictus	Fish	Benthopelagic fish	Blackspotted rockfish	Tertiary consumer
Agonidae (Family)	Fish	Demersal fish	Poachers	Secondary consumer
Agonopsis vulsa	Fish	Demersal fish	Northern spearnose poacher	Secondary consumer
Albatrossia pectoralis	Fish	Demersal fish	Giant grenadier, pectoral rattail	Tertiary consumer
Anarrhichthys ocellatus	Fish	Demersal fish	Wolf eel	Tertiary consumer
Anoplopoma fimbria	Fish	Demersal fish	Sablefish	Tertiary consumer
Antimora microlepis	Fish	Demersal fish	Pacific flatnose, finescale mora	Secondary consumer
Bathymaster caeruleofasciatus	Fish	Demersal fish	Alaskan ronquil	Tertiary consumer
Bothrocara brunneum	Fish	Demersal fish	Twoline eelpout	Scavenger
Bothrocara remigerum	Fish	Demersal fish	Longsnout eelpout	Scavenger
Brama japonica	Fish	Demersal fish	Pacific pomfret	Secondary consumer
Careproctus melanurus	Fish	Demersal fish	Blacktail snailfish	Secondary consumer
Chirolophis decoratus	Fish	Demersal fish	Decorated warbonnet	Secondary consumer
Citharichthys sordidus	Fish	Demersal fish	Pacific sanddab	-
Coryphaenoides acrolepis	Fish	Demersal fish	Pacific grenadier	Tertiary consumer
Cottidae (Family)	Fish	Demersal fish	Sculpins	Secondary consumer
Cottus ricei	Fish	Demersal fish	Spoonhead sculpin	Secondary consumer
Erilepis zonifer	Fish	Demersal fish	Skilfish	Tertiary consumer
Gadus macrocephalus	Fish	Demersal fish	Pacific Cod	Tertiary consumer
Hemilepidotus hemilepidotus	Fish	Demersal fish	Red Irish lord	Secondary consumer
Hemilepidotus spinosus	Fish	Demersal fish	Brown Irish lord	Secondary consumer
Hexagrammos decagrammus	Fish	Demersal fish	Kelp greenling	Tertiary consumer
Hydrolagus colliei	Fish	Demersal fish	Spotted ratfish	-
Macrouridae	Fish	Demersal fish	Grenadiers, rattails	-
Merluccius productus	Fish	Demersal fish	Pacific hake	Secondary consumer
Ophiodon elongatus	Fish	Demersal fish	Lingcod	Tertiary consumer
Paricelinus hopliticus	Fish	Demersal fish	Thornback sculpin	-
Parophrys vetulus	Fish	Demersal fish	English sole	Secondary consumer
Pholis sp.	Fish	Demersal fish	Gunnel	-
Podothecus accipenserinus	Fish	Demersal fish	Sturgeon poacher	Secondary consumer
Rhamphocottus richardsonii	Fish	Demersal fish	Grunt sculpin	Secondary consumer
Ronquilus jordani	Fish	Demersal fish	Northern ronquil	Primary consumer
Scorpaenidae (Family)	Fish	Demersal fish	Scorpionfishes	Tertiary consumer
Sebastes aleutianus	Fish	Demersal fish	Rougheye rockfish	Tertiary consumer
Sebastes aurora	Fish	Demersal fish	Aurora rockfish	Tertiary consumer
Sebastes babcocki	Fish	Demersal fish	Redbanded rockfish	Tertiary consumer

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Sebastes borealis	Fish	Demersal fish	Shortraker rockfish	Tertiary consumer
Sebastes brevispinis	Fish	Demersal fish	Slivergray rockfish	Tertiary consumer
Sebastes crameri	Fish	Demersal fish	Darkblotched rockfish	Tertiary consumer
Sebastes diploproa	Fish	Demersal fish	Splitnose rockfish	Tertiary consumer
Sebastes elongatus	Fish	Demersal fish	Greenstriped rockfish	Tertiary consumer
Sebastes emphaeus	Fish	Demersal fish	Puget sound rockfish	-
Sebastes flavidus	Fish	Demersal fish	Yellowtail rockfish	Tertiary consumer
Sebastes goodei	Fish	Demersal fish	Chilipepper rockfish	Tertiary consumer
Sebastes helvomaculatus	Fish	Demersal fish	Rosethorn rockfish	Tertiary consumer
Sebastes jordani	Fish	Demersal fish	Shortbelly rockfish	Secondary consumer
Sebastes maliger	Fish	Demersal fish	Quillback rockfish	Tertiary consumer
Sebastes melanops	Fish	Demersal fish	Black rockfish	Tertiary consumer
Sebastes miniatus	Fish	Demersal fish	Vermillion rockfish	Tertiary consumer
Sebastes mystinus	Fish	Demersal fish	Blue rockfish	Secondary consumer
Sebastes nebulosus	Fish	Demersal fish	China rockfish	Secondary consumer
Sebastes nigrocinctus	Fish	Demersal fish	Tiger rockfish	Tertiary consumer
Sebastes paucispinis	Fish	Demersal fish	Bocaccio	Tertiary consumer
Sebastes pinniger	Fish	Demersal fish	Canary rockfish	Secondary consumer
Sebastes proriger	Fish	Demersal fish	Redstripe rockfish	Tertiary consumer
Sebastes reedi	Fish	Demersal fish	Yellowmouth rockfish	Tertiary consumer
Sebastes rosaceus	Fish	Demersal fish	Rosy rockfish	Tertiary consumer
Sebastes ruberrimus	Fish	Demersal fish	Yelloweye rockfish	Tertiary consumer
Sebastes rufus	Fish	Demersal fish	Bank rockfish	Tertiary consumer
Sebastes variegatus	Fish	Demersal fish	Harlequin rockfish	Tertiary consumer
Sebastes wilsoni	Fish	Demersal fish	Pygmy rockfish	Secondary consumer
Sebastolobus alascanus	Fish	Demersal fish	Shortspine thornyhead	Tertiary consumer
Sebastolobus altivelis	Fish	Demersal fish	Longspine thornyhead	Tertiary consumer
Stichaeidae (Family)	Fish	Demersal fish	Pricklebacks	Secondary consumer
Zaprora silenus	Fish	Demersal fish	Prowfish	Tertiary consumer
Zoarcidae (Family)	Fish	Demersal fish	Eelpouts	-
Atheresthes stomias	Fish	Demersal flatfish	Arrowtooth flounder	Tertiary consumer
Embassichthys bathybius	Fish	Demersal flatfish	Deepsea sole	Tertiary consumer
Eopsetta jordani	Fish	Demersal flatfish	Petrale sole	Tertiary consumer
Glyptocephalus zachirus	Fish	Demersal flatfish	Rex sole	Secondary consumer
Hippoglossus stenolepis	Fish	Demersal flatfish	Pacific halibut	Top-level consumer
Lepidopsetta bilineata	Fish	Demersal flatfish	Rock sole	Secondary consumer
Microstomus pacificus	Fish	Demersal flatfish	Dover sole	Tertiary consumer
Pleuronectidae (Family)	Fish	Demersal flatfish	Dabs, righteye flounder	-

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Actinopterygii	Fish	N/A	Ray-finned fishes	N/A
Lycodapus sp.	Fish	N/A	-	-
Perciformes (Order)	Fish	N/A	Perch-like fishes	N/A
Sebastes spp.	Fish	N/A	Rockfishes	N/A
Sebastolobus spp.	Fish	N/A	Thornyhead	-
Argyropelecus affinis	Fish	Pelagic fish	Pacific hatchetfish	Secondary consumer
Bathophilus flemingi	Fish	Pelagic fish	Highfin dargonfish	Secondary consumer
Bathylagidae (Family)	Fish	Pelagic fish	Deep-sea smelts	Secondary consumer
Bramidae (Family)	Fish	Pelagic fish	Pomfrets	Tertiary consumer
Chauliodus macouni	Fish	Pelagic fish	Pacific viperfish	Secondary consumer
Diaphus theta	Fish	Pelagic fish	California headlightfish	Secondary consumer
Icosteus aenigmaticus	Fish	Pelagic fish	Ragfish	Secondary consumer
Mola mola	Fish	Pelagic fish	Sunfish	Secondary consumer
Myctophidae (Family)	Fish	Pelagic fish	Lanternfishes	Secondary consumer
Nannobrachium regale	Fish	Pelagic fish	Pinpoint lampfish	Secondary consumer
Nannobrachium ritteri	Fish	Pelagic fish	Broadfinlampfish	Secondary consumer
Protomyctophum spp.	Fish	Pelagic fish	-	Secondary consumer
Pseudopentaceros richardsoni	Fish	Pelagic fish	Pelagic armourhead	Secondary consumer
Sebastes entomelas	Fish	Pelagic fish	Widow rockfish	Tertiary consumer
Stenobrachius leucopsarus	Fish	Pelagic fish	Northern lampfish	Secondary consumer
Tactostoma macropus	Fish	Pelagic fish	Longfin dragonfish	Secondary consumer
Tarletonbeania crenularis	Fish	Pelagic fish	Blue lanternfish	Secondary consumer
Thunnus alalunga	Fish	Pelagic fish	Albacore tuna	Top-level consumer
Trachipterus altivelis	Fish	Pelagic fish	King-of-the-salmon	Secondary consumer
Trachurus symmetricus	Fish	Pelagic fish	Jack mackerel, Pacific jack mackerel	Secondary consumer
Melphidippa amorita	Invertebrates	Amphipoda	-	-
Annuloplatidia horni	Invertebrates	Brachiopod	-	Filter/Suspension feeder
Brachiopoda (Phylum)	Invertebrates	Brachiopod	Lamp shells	Filter/Suspension feeder
Laqueus californianus	Invertebrates	Brachiopod	California lamp shell	Filter/Suspension feeder
Podon sp.	Invertebrates	Brachiopod	Water flea	Filter/Suspension feeder
Podon spp.	Invertebrates	Brachiopod	Water fleas, Cladocera	Filter/Suspension feeder
Terebratalia sp.	Invertebrates	Brachiopod	-	Filter/Suspension feeder
Terebratulina unguicula	Invertebrates	Brachiopod	-	Filter/Suspension feeder
Acryptolaria sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Bicrisia edwardsiana	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Bicrisia sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Borgella pustulosa	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Bryozoa (Phylum)	Invertebrates	Bryozoa	Moss animals	Filter/Suspension feeder
Bryozoa (Phylum) sp. A	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Bryozoa (Phylum) sp. B	Invertebrates	Bryozoa	-	Filter/Suspension feeder

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Bryozoa (Phylum) sp. C	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Bryozoa (Phylum) sp. D	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Bryozoa (Phylum) sp. E	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Bryozoa (Phylum) sp. F	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Bryozoan/Hydroid	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Bugula californica	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Bugula sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Bugulina californica	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Caberea ellisii	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Caberea sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Cellaria diffusa	Invertebrates	Bryozoa	Rabit-ear bryozoan	Filter/Suspension feeder
Celleporaria sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
cf. Reginella hippocrepis	Invertebrates	Bryozoa	Green encrusting bryozoa	Filter/Suspension feeder
Cradoscrupocellaria cf. tenuirostris	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Crisia occidentalis	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Crisia sp.	Invertebrates	Bryozoa	Moss animal	Filter/Suspension feeder
Crisulipora sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Dendrobeania longispinosa	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Diaperoforma sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Disporella separata	Invertebrates	Bryozoa	Purple encrusting bryozoa	Filter/Suspension feeder
Filicrisia franciscana	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Filicrisia geniculata	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Filicrisia sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Heteropora sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Lagenicella sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Leieschara sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Lyrula sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Microporella sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Phidolopora sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Rhamphostomella spinigera	Invertebrates	Bryozoa	Moss animal	Filter/Suspension feeder
Schizoporella sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Smittina sp.	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Tricellaria circumternata	Invertebrates	Bryozoa	-	Filter/Suspension feeder
Cnidaria (Phylum)	Invertebrates	Cnidaria	Cnidarians	N/A
Actiniaria sp. 1	Invertebrates	Cnidaria: Anemone	-	Filter/Suspension feeder
Actiniaria sp. 2	Invertebrates	Cnidaria: Anemone	-	Filter/Suspension feeder
Actiniaria sp. 3	Invertebrates	Cnidaria: Anemone	-	Filter/Suspension feeder
Anthopleura xanthogrammica	Invertebrates	Cnidaria: Anemone	Giant green anemone	Filter/Suspension feeder

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cf. Hormathiidae (Family)	Invertebrates	Cnidaria: Anemone	Flytrap anemone	Filter/Suspension feeder
Cribrinopsis fernaldi	Invertebrates	Cnidaria: Anemone	Crimson anemone, fernald brooding anemone	Filter/Suspension feeder
Liponema brevicorne	Invertebrates	Cnidaria: Anemone	Pom-pom anemone, tentacle-shedding anemone	Filter/Suspension feeder
Metridium farcimen	Invertebrates	Cnidaria: Anemone	Tall plumose anemone	Filter/Suspension feeder
Metridium senile	Invertebrates	Cnidaria: Anemone	Plumose anemone	Filter/Suspension feeder
Metridium sp.	Invertebrates	Cnidaria: Anemone	Plumose anemones	Filter/Suspension feeder
Stomphia didemon	Invertebrates	Cnidaria: Anemone	Cowardly anemone, swimming anemone	Filter/Suspension feeder
Urticina crassicornis	Invertebrates	Cnidaria: Anemone	Painted anemone	Filter/Suspension feeder
Urticina lofotensis	Invertebrates	Cnidaria: Anemone	Strawberry anemone	Filter/Suspension feeder
Urticina piscivora	Invertebrates	Cnidaria: Anemone	Fish-eating anemone	Secondary consumer
Antipatharia (Order)	Invertebrates	Cnidaria: Black coral	Black corals	Filter/Suspension feeder
Bathypathes cf. patula	Invertebrates	Cnidaria: Black coral	-	Filter/Suspension feeder
Chrysopathes formosa	Invertebrates	Cnidaria: Black coral	-	Filter/Suspension feeder
Chrysopathes speciosa	Invertebrates	Cnidaria: Black coral	-	Filter/Suspension feeder
Chrysopathes spp.	Invertebrates	Cnidaria: Black coral	-	Filter/Suspension feeder
Lillipathes cf. wingi	Invertebrates	Cnidaria: Black coral	-	Filter/Suspension feeder
Parantipathes sp.	Invertebrates	Cnidaria: Black coral	-	Filter/Suspension feeder
Stichopathes spiessi	Invertebrates	Cnidaria: Black coral	-	Filter/Suspension feeder
Corynactis californica	Invertebrates	Cnidaria: Coral anemone	Strawberry corallimopharian	Filter/Suspension feeder
Acanthogorgia sp.	Invertebrates	Cnidaria: Gorgonian	-	Filter/Suspension feeder
Calcigorgia spiculifera	Invertebrates	Cnidaria: Gorgonian	-	Filter/Suspension feeder
Callogorgia sp.	Invertebrates	Cnidaria: Gorgonian	-	Filter/Suspension feeder
Gorgonacea (former Order)	Invertebrates	Cnidaria: Gorgonian	Gorgonian corals	Filter/Suspension feeder
Isidella sp.	Invertebrates	Cnidaria: Gorgonian	Bamboo coral	Filter/Suspension feeder
Isidella tentaculum	Invertebrates	Cnidaria: Gorgonian	Bamboo coral	Filter/Suspension feeder
Lepidisis sp.	Invertebrates	Cnidaria: Gorgonian	Bamboo coral	Filter/Suspension feeder
Paragorgia cf. jamesi	Invertebrates	Cnidaria: Gorgonian	Bubblegum coral	Filter/Suspension feeder
Paragorgia pacifica	Invertebrates	Cnidaria: Gorgonian	Bubblegum coral	Filter/Suspension feeder
Paragorgia sp.	Invertebrates	Cnidaria: Gorgonian	Bubblegum coral	Filter/Suspension feeder
Paragorgiidae (Family)	Invertebrates	Cnidaria: Gorgonian	-	Filter/Suspension feeder
Primnoa pacifica	Invertebrates	Cnidaria: Gorgonian	Red tree coral	Filter/Suspension feeder
Primnoa sp.	Invertebrates	Cnidaria: Gorgonian	White Primnoa	Filter/Suspension feeder
Primnoidae (Family)	Invertebrates	Cnidaria: Gorgonian	-	Filter/Suspension feeder

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Swiftia pacifica	Invertebrates	Cnidaria: Gorgonian	-	Filter/Suspension feeder
Swiftia simplex	Invertebrates	Cnidaria: Gorgonian	-	Filter/Suspension feeder
cf. Distichopora sp.	Invertebrates	Cnidaria: Hydrocoral	Hydrocorals	Filter/Suspension feeder
Hydrocoral sp. 1	Invertebrates	Cnidaria: Hydrocoral	-	Filter/Suspension feeder
Stylaster campylecus	Invertebrates	Cnidaria: Hydrocoral	-	Filter/Suspension feeder
Stylaster spp.	Invertebrates	Cnidaria: Hydrocoral	Hydrocorals	Filter/Suspension feeder
Stylaster verrillii	Invertebrates	Cnidaria: Hydrocoral	-	Filter/Suspension feeder
Abietinaria sp.	Invertebrates	Cnidaria: Hydroid	Sea fir	Filter/Suspension feeder
Bougainvillia sp.	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Campanulariidae	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
cf. Obelia spp.	Invertebrates	Cnidaria: Hydroid	Wine-glass hydroid	Filter/Suspension feeder
Halecium delicatulum	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Hydrozoa sp. 1	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Hydrozoa sp. 2	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Hydrozoa sp. A	Invertebrates	Cnidaria: Hydroid	Hydroid	Filter/Suspension feeder
Hydrozoa sp. B	Invertebrates	Cnidaria: Hydroid	Hydroid	Filter/Suspension feeder
Lafoea cf. dumosa	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Lafoea gracillima	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Lafoea regia	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Leptothecata (Order)	Invertebrates	Cnidaria: Hydroid	Thecate hydriods, hydromedusae	Filter/Suspension feeder
Obelia longissima	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Plumularia sp.	Invertebrates	Cnidaria: Hydroid	Feather hydroid	Filter/Suspension feeder
Plumularia spp.	Invertebrates	Cnidaria: Hydroid	Little sea bristle, plumed hydroid	Filter/Suspension feeder
Ptychogastria sp.	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Rhizocaulus verticillatus	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Sertularella sp.	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Sertularia tenera	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Thuiaria geniculata	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Tubularia sp.	Invertebrates	Cnidaria: Hydroid	Pink-mouthed hydroids, pink-hearted hydroids	Filter/Suspension feeder
Tubulipora sp.	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Zygophylax convallaria	Invertebrates	Cnidaria: Hydroid	-	Filter/Suspension feeder
Solmissus sp.	Invertebrates	Cnidaria: Hydroid (pelagic)	Dinner plate jelly	Tertiary consumer

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Velella velella	Invertebrates	Cnidaria: Hydroid (pelagic)	By-the-wind sailor	Filter/Suspension feeder
Anthoptilum cf. lithophilum	Invertebrates	Cnidaria: Sea pens	Rock-loving Anthoptilum	Filter/Suspension feeder
Anthoptilum grandiflorum	Invertebrates	Cnidaria: Sea pens	Feather boa sea pen	Filter/Suspension feeder
Anthoptilum spp.	Invertebrates	Cnidaria: Sea pens	-	Filter/Suspension feeder
Halipteris californica	Invertebrates	Cnidaria: Sea pens	Sea whip, California sea pen	Filter/Suspension feeder
Halipteris willemoesi	Invertebrates	Cnidaria: Sea pens	Sea whip, Willemoes's white sea pen	Filter/Suspension feeder
Pennatulacea (Order)	Invertebrates	Cnidaria: Sea pens	Sea pens	Filter/Suspension feeder
Ptilosarcus gurneyi	Invertebrates	Cnidaria: Sea pens	Orange sea pen	Filter/Suspension feeder
Stylatula elongata	Invertebrates	Cnidaria: Sea pens	Slender sea pen	Filter/Suspension feeder
Umbellula cf. lindahli	Invertebrates	Cnidaria: Sea pens	-	Filter/Suspension feeder
Virgularia sp.	Invertebrates	Cnidaria: Sea pens	-	Filter/Suspension feeder
Nanomia bijuga	Invertebrates	Cnidaria: Siphonophore	Siphonophore	Filter/Suspension feeder
Siphonophorae	Invertebrates	Cnidaria: Siphonophore	Apolemiidae	Filter/Suspension feeder
Alcyonacea (Order)	Invertebrates	Cnidaria: Soft coral	Soft corals	Filter/Suspension feeder
Anthomastus sp.	Invertebrates	Cnidaria: Soft coral	Mushroom coral	Filter/Suspension feeder
Clavularia sp.	Invertebrates	Cnidaria: Soft coral	-	Filter/Suspension feeder
Gersemia juliepackardae	Invertebrates	Cnidaria: Soft coral	-	Filter/Suspension feeder
Gersemia sp.	Invertebrates	Cnidaria: Soft coral	-	Filter/Suspension feeder
Heteropolypus ritteri	Invertebrates	Cnidaria: Soft coral	Mushroom coral	Filter/Suspension feeder
Keratoisis spp.	Invertebrates	Cnidaria: Soft coral	Bamboo coral	Filter/Suspension feeder
Narella sp.	Invertebrates	Cnidaria: Soft coral	-	Filter/Suspension feeder
Parastenella cf. ramosa	Invertebrates	Cnidaria: Soft coral	-	Filter/Suspension feeder
Plumarella superba	Invertebrates	Cnidaria: Soft coral	-	Filter/Suspension feeder
Balanophyllia elegans	Invertebrates	Cnidaria: Stony coral	Orange cup coral	Filter/Suspension feeder
Desmophyllum dianthus	Invertebrates	Cnidaria: Stony coral	Cockcomb cup coral	Filter/Suspension feeder
Desmophyllum pertusum	Invertebrates	Cnidaria: Stony coral	Lophelia, spider hazards	Filter/Suspension feeder
Desmophyllum sp.	Invertebrates	Cnidaria: Stony coral	-	Filter/Suspension feeder
Flabellidae (Family); Red	Invertebrates	Cnidaria: Stony coral	Red cup coral	Filter/Suspension feeder
Flabellidae (Family); White	Invertebrates	Cnidaria: Stony coral	White cup coral	Filter/Suspension feeder
Madreporia	Invertebrates	Cnidaria: Stony coral	Stony Corals	Filter/Suspension feeder
Scleractinia (Order)	Invertebrates	Cnidaria: Stony coral	Stony corals	Filter/Suspension feeder
Periphylla sp.	Invertebrates	Cnidaria: True jelly	Helmet jelly	Filter/Suspension feeder

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Epizoanthus scotinus	Invertebrates	Cnidaria: Zoanthid	Orange zoanthid	Filter/Suspension feeder
Zibrowius sp.	Invertebrates	Cnidaria: Zoanthid	Parasitic zoanthid	Filter/Suspension feeder
Zoantharia (Order)	Invertebrates	Cnidaria: Zoanthid	Zoanthids, zoanthid anemones	Filter/Suspension feeder
Caprella alaskana	Invertebrates	Crustacea: Amphipod	Alaskan skeleton shrimp	Grazer
Caprella laeviuscula	Invertebrates	Crustacea: Amphipod	-	Grazer
Caprella sp.	Invertebrates	Crustacea: Amphipod	-	-
Caprellidae (Family)	Invertebrates	Crustacea: Amphipod	Skeleton shrimp	-
Dulichiopsis barnardi	Invertebrates	Crustacea: Amphipod	-	-
Gammaridae spp.	Invertebrates	Crustacea: Amphipod	-	-
Ischyrocerus sp.	Invertebrates	Crustacea: Amphipod	-	-
Melphidippidae (Family)	Invertebrates	Crustacea: Amphipod	-	-
Metacaprella kennerlyi	Invertebrates	Crustacea: Amphipod	-	Primary consumer
Photis pachydactyla	Invertebrates	Crustacea: Amphipod	-	-
Stenothoidae (Family)	Invertebrates	Crustacea: Amphipod	-	-
Themisto pacifica	Invertebrates	Crustacea: Amphipod	Hyperiid amphipod	Primary consumer
Balanus nubilus	Invertebrates	Crustacea: Barnacle	Giant barnacle	Filter/Suspension feeder
Lepas anatifera	Invertebrates	Crustacea: Barnacle	Pelagic goose baracle, smooth gooseneck barnacle	Filter/Suspension feeder
Acartia (Acartiura) longiremis	Invertebrates	Crustacea: Copepod	-	-
Calanus marshallae	Invertebrates	Crustacea: Copepod	-	Zooplankton
Calanus pacificus	Invertebrates	Crustacea: Copepod	Calanoid copepod	Zooplankton
Copepoda (Subclass)	Invertebrates	Crustacea: Copepod	Copepods	N/A
Cyclopoida (Order)	Invertebrates	Crustacea: Copepod	-	N/A
Eucalanus sp.	Invertebrates	Crustacea: Copepod	-	Zooplankton
Euphausiid nauplii	Invertebrates	Crustacea: Copepod	Copepod	Zooplankton
Harpacticoida (Order)	Invertebrates	Crustacea: Copepod	-	N/A
Metridia pacifica	Invertebrates	Crustacea: Copepod	-	Zooplankton
Metridia sp.	Invertebrates	Crustacea: Copepod	-	-
Neocalanus cristatus	Invertebrates	Crustacea: Copepod	-	Zooplankton
Neocalanus flemengeris	Invertebrates	Crustacea: Copepod	-	Zooplankton
Neocalanus plumchrus	Invertebrates	Crustacea: Copepod	-	Zooplankton
Oithona atlantica	Invertebrates	Crustacea: Copepod	-	Zooplankton
Oithona similis	Invertebrates	Crustacea: Copepod	-	Zooplankton
Paracalanus parvus	Invertebrates	Crustacea: Copepod	-	Zooplankton

Taxon	**Category**	**Sub-category**	**Common name**	**Feeding/Ecological Guild**
Pseudocalanus mimus	Invertebrates	Crustacea: Copepod	-	Zooplankton
Scolecthricella minor	Invertebrates	Crustacea: Copepod	-	Zooplankton
Acantholithodes hispidus	Invertebrates	Crustacea: Decapoda	Fuzzy crab, spiny lithode crab	Secondary consumer
Calappa sp.	Invertebrates	Crustacea: Decapoda	Box crab	Secondary consumer/Scavenger
Chionoecetes sp.1	Invertebrates	Crustacea: Decapoda	Queen crab	Secondary consumer/Scavenger
Chionoecetes sp.2	Invertebrates	Crustacea: Decapoda	Snow crab	Secondary consumer/Scavenger
Chionoecetes spp.	Invertebrates	Crustacea: Decapoda	Spider crabs, queen crabs, snow crabs	Secondary consumer/Scavenger
Chionoecetes tanneri	Invertebrates	Crustacea: Decapoda	Tanner crab, grooved tanner crab	Secondary consumer/Scavenger
Chorilia longipes	Invertebrates	Crustacea: Decapoda	Longhorn decorator crab, redclaw crab	Secondary consumer/Scavenger
Decapoda (Order)	Invertebrates	Crustacea: Decapoda	-	N/A
Elassochirus cavimanus	Invertebrates	Crustacea: Decapoda	Purple hermit crab	Scavenger
Epialtinae (Subfamily)	Invertebrates	Crustacea: Decapoda	-	-
Glebocarcinus oregonensis	Invertebrates	Crustacea: Decapoda	Pygmy rock crab	Secondary consumer/Scavenger
Libinia emarginata	Invertebrates	Crustacea: Decapoda	Portly spider crab, common spider crab	Secondary consumer/Scavenger
Lithodes aequispinus	Invertebrates	Crustacea: Decapoda	Golden king crab	-
Lithodes couesi	Invertebrates	Crustacea: Decapoda	Scarlet king crab	-
Lithodidae (Family)	Invertebrates	Crustacea: Decapoda	King crabs	-
Lopholithodes foraminatus	Invertebrates	Crustacea: Decapoda	Brown box crab	Secondary consumer
Lopholithodes spp.	Invertebrates	Crustacea: Decapoda	Box crabs	-
Loxorhynchus crispatus	Invertebrates	Crustacea: Decapoda	Moss crab	Secondary consumer/Scavenger
Majidae (Family)	Invertebrates	Crustacea: Decapoda	Spider crabs	-
Oregonia gracilis	Invertebrates	Crustacea: Decapoda	Graceful decorator crab	Secondary consumer/Scavenger
Paguridae (Family)	Invertebrates	Crustacea: Decapoda	Hermit crabs	Scavenger
Pagurus kennerlyi	Invertebrates	Crustacea: Decapoda	Blue-spine hermit crab	Scavenger
Pandalus amplus	Invertebrates	Crustacea: Decapoda	Deepwater big-eyed shrimp	Secondary consumer
Paralithodes camtschatica	Invertebrates	Crustacea: Decapoda	King crab	Secondary consumer/Scavenger/Top-level invertebrate predator
Paralomis sp.	Invertebrates	Crustacea: Decapoda	-	-
Paralomis verrilli	Invertebrates	Crustacea: Decapoda	-	-
Pilumnus hirtellus	Invertebrates	Crustacea: Decapoda	Bristly (hairy) crab	-
Pugettia gracilis	Invertebrates	Crustacea: Decapoda	Graceful kelp crab	Secondary consumer/Scavenger
Romaleon branneri	Invertebrates	Crustacea: Decapoda	Furrowed rock crab	-
Stenocionops sp.	Invertebrates	Crustacea: Decapoda	Decorator crab	Secondary consumer/Scavenger

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Thoridae (Family)	Invertebrates	Crustacea: Decapoda	Broken-back shrimp, anemone shrimp	-
Aegiochus symmetrica	Invertebrates	Crustacea: Isopod	-	-
Cymothoidae (Family)	Invertebrates	Crustacea: Isopod	-	Parasite (Fish)
Eurycope sp.	Invertebrates	Crustacea: Isopod	-	-
Ianiropsis tridens	Invertebrates	Crustacea: Isopod	-	Detritivore
Isopoda (Order)	Invertebrates	Crustacea: Isopod	Isopods	N/A
Janiridae (Family)	Invertebrates	Crustacea: Isopod	-	-
Munna chromatocephala	Invertebrates	Crustacea: Isopod	-	Detritivore
Munna sp.	Invertebrates	Crustacea: Isopod	-	-
Uromunna ubiquita	Invertebrates	Crustacea: Isopod	-	Detritivore
Euphausiacea (Order)	Invertebrates	Crustacea: Krill	Krill, euphausiids	Primary consumer
Mysida (Order)	Invertebrates	Crustacea: Mysid	-	N/A
Ostracoda (Class)	Invertebrates	Crustacea: Ostracod	Seed shrimps, ostracods	N/A
Heptacarpus moseri	Invertebrates	Crustacea: Shrimp	Alaska coastal shrimp	-
Pandalidae (Family)	Invertebrates	Crustacea: Shrimp	Pandalid shrimp	-
Munida quadrispina	Invertebrates	Crustacea: Squat lobster	-	Secondary consumer/Scavenger
Munidopsis sp.	Invertebrates	Crustacea: Squat lobster	-	-
Sternostylus iaspis	Invertebrates	Crustacea: Squat lobster	-	Primary consumer
Leptochelia sp.	Invertebrates	Crustacea: Tanaid	-	-
Paratanais sp.	Invertebrates	Crustacea: Tanaid	-	-
Tanaidacea (Order)	Invertebrates	Crustacea: Tanaid	Tanaids	-
Beroe sp.	Invertebrates	Ctenophora (Comb jellies)	Melo jelly	Filter/Suspension feeder
Bolinopsis infundibulum	Invertebrates	Ctenophora (Comb jellies)	Common northern comb jelly	Filter/Suspension feeder
Ctenophora (Phylum)	Invertebrates	Ctenophora (Comb jellies)	-	-
Pleurobrachia bachei	Invertebrates	Ctenophora (Comb jellies)	Sea gooseberry	Filter/Suspension feeder
Asteronyx loveni	Invertebrates	Echinodermata: Brittle star	Snake brittle star	Filter/Suspension feeder
Asteroschema sublaeve	Invertebrates	Echinodermata: Brittle star	-	-
Gorgonocephalus eucnemis	Invertebrates	Echinodermata: Brittle star	Basket star	-
Ophiacantha bathybia	Invertebrates	Echinodermata: Brittle star	-	-
Ophiacantha clypeata	Invertebrates	Echinodermata: Brittle star	-	-
Ophiacantha diplasia	Invertebrates	Echinodermata: Brittle star	-	-
Ophiacantha eurypoma	Invertebrates	Echinodermata: Brittle star	-	-
Ophiacantha normani	Invertebrates	Echinodermata: Brittle star	-	-

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Ophiacantha rhachophora	Invertebrates	Echinodermata : Brittle star	-	-
Ophiacantha sp.	Invertebrates	Echinodermata : Brittle star	-	-
Ophiacantha spp.	Invertebrates	Echinodermata : Brittle star	-	-
Ophiopholis aculeata	Invertebrates	Echinodermata : Brittle star	Daisy brittle star	Detritivore
Ophiopholis bakeri	Invertebrates	Echinodermata : Brittle star	Baker's brittle star	-
Ophiopholis longispina	Invertebrates	Echinodermata : Brittle star	Long-spined Ophiopholis	-
Ophiopholis spp.	Invertebrates	Echinodermata : Brittle star	-	-
Ophioscolex corynetes	Invertebrates	Echinodermata : Brittle star	Fleshy brittle star	-
Ophiura leptoctenia	Invertebrates	Echinodermata : Brittle star	-	-
Ophiura sarsii	Invertebrates	Echinodermata : Brittle star	Notched brittle star, common grey brittle star	-
Ophiuroidea (Class)	Invertebrates	Echinodermata : Brittle star	Brittle stars	-
Crinoidea (Class)	Invertebrates	Echinodermata : Crinoid	Feather stars & sea lillies	Filter/Suspension feeder
Florometra asperrima	Invertebrates	Echinodermata : Crinoid	-	Filter/Suspension feeder
Florometra serratissima	Invertebrates	Echinodermata : Crinoid	Common feather star	Filter/Suspension feeder
Psathyrometra fragilis	Invertebrates	Echinodermata : Crinoid	Fragile feather star	Filter/Suspension feeder
Ptilocrinus sp.	Invertebrates	Echinodermata : Crinoid	-	Filter/Suspension feeder
Apostichopus californicus	Invertebrates	Echinodermata : Cucumber	California sea cucumbery, giant sea cucumber	Detritivore
Apostichopus leukothele	Invertebrates	Echinodermata : Cucumber	White-spined sea cucumber	Detritivore
Cucumaria sp.	Invertebrates	Echinodermata : Cucumber	-	-
Elpidiidae (Family)	Invertebrates	Echinodermata : Cucumber	Sea pigs	Detritivore
Eupentacta quinquesemita	Invertebrates	Echinodermata : Cucumber	white sea cucumber, pentamerous sea cucumber	Detritivore
Holothuroidea (Class)	Invertebrates	Echinodermata : Cucumber	Sea cucumber	N/A
Paelopatides confundens	Invertebrates	Echinodermata : Cucumber	-	-
Pannychia moseleyi	Invertebrates	Echinodermata : Cucumber	White sea cucumber	Detritivore
Pseudostichopus mollis	Invertebrates	Echinodermata : Cucumber	-	Detritivore
Pseudostichopus sp.	Invertebrates	Echinodermata : Cucumber	-	Detritivore
Psolidium cf. bullatum	Invertebrates	Echinodermata : Cucumber	-	Filter/Suspension feeder
Psolus chitonoides	Invertebrates	Echinodermata : Cucumber	Creeping pedal sea cucumber	Filter/Suspension feeder
Psolus spp.	Invertebrates	Echinodermata : Cucumber	Pedal sea cucumbers, creeping sea cucumbers	Filter/Suspension feeder
Psolus squamatus	Invertebrates	Echinodermata : Cucumber	Scaled sea cucumber	Filter/Suspension feeder
Ampheraster sp.	Invertebrates	Echinodermata : Seastar	-	-
Asterinidae (Family)	Invertebrates	Echinodermata : Seastar	Cushion stars	-
Asteroidea (Class)	Invertebrates	Echinodermata : Seastar	Sea stars	-

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Benthopecten claviger	Invertebrates	Echinodermata : Seastar	-	-
Benthopectinidae (Family)	Invertebrates	Echinodermata : Seastar	-	-
Brisinga synaptoma	Invertebrates	Echinodermata : Seastar	-	Filter/Suspension feeder
Brisingidae (Family)	Invertebrates	Echinodermata : Seastar	-	Filter/Suspension feeder
Ceramaster arcticus	Invertebrates	Echinodermata : Seastar	Arctic cookie star	Secondary consumer
Ceramaster cf. stellatus	Invertebrates	Echinodermata : Seastar	-	-
Ceramaster patagonicus	Invertebrates	Echinodermata : Seastar	Cookie star	Detritivore
Ceramaster sp.	Invertebrates	Echinodermata : Seastar	Cookie stars	-
cf. Dermasterias sp.	Invertebrates	Echinodermata : Seastar	-	-
Cheiraster (Luidiaster) dawsoni	Invertebrates	Echinodermata : Seastar	-	-
Crossaster papposus	Invertebrates	Echinodermata : Seastar	Rose star	Secondary consumer
Crossaster sp.	Invertebrates	Echinodermata : Seastar	-	-
Ctenodiscus crispatus	Invertebrates	Echinodermata : Seastar	Mud star	Detritivore
Dermasterias imbricata	Invertebrates	Echinodermata : Seastar	Leather star	Secondary consumer
Dipsacaster sp.	Invertebrates	Echinodermata : Seastar	-	-
Evasterias troschelii	Invertebrates	Echinodermata : Seastar	Mottled star	Secondary consumer
Freyellaster fecundus	Invertebrates	Echinodermata : Seastar	-	Filter/Suspension feeder
Gephyreaster swifti	Invertebrates	Echinodermata : Seastar	Gunpowder sea star	Secondary consumer
Goniasteridae (Family)	Invertebrates	Echinodermata : Seastar	Biscuit stars	-
Henricia clarki	Invertebrates	Echinodermata : Seastar	-	Filter/Suspension feeder
Henricia leviuscula	Invertebrates	Echinodermata : Seastar	Blood star	Filter/Suspension feeder
Henricia sanguinolenta	Invertebrates	Echinodermata : Seastar	Fat blood star	Filter/Suspension feeder
Henricia sp.	Invertebrates	Echinodermata : Seastar	Blood stars	Filter/Suspension feeder
Hippasteria heathi	Invertebrates	Echinodermata : Seastar	Heath's spiny star	Secondary consumer
Hippasteria phrygiana	Invertebrates	Echinodermata : Seastar	Spiny red sea star, Trojan star	Secondary consumer
Hippasteria sp.	Invertebrates	Echinodermata : Seastar	-	-
Hymenaster sp.	Invertebrates	Echinodermata : Seastar	-	-
Leptasterias hexactis	Invertebrates	Echinodermata : Seastar	Six-rayed star	-
Leptychaster pacificus	Invertebrates	Echinodermata : Seastar	Pale star, Pacific Leptychaster	-
Lophaster furcilliger	Invertebrates	Echinodermata : Seastar	Pink crested star	Secondary consumer
Mediaster aequalis	Invertebrates	Echinodermata : Seastar	Vermillion star	Secondary consumer
Mediaster sp.	Invertebrates	Echinodermata : Seastar	-	-
Mediaster tenellus	Invertebrates	Echinodermata : Seastar	-	-

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Molpadia sp.	Invertebrates	Echinodermata : Seastar	-	-
Nearchaster aciculosus	Invertebrates	Echinodermata : Seastar	Needle-spined fragile star	-
Orthasterias koehleri	Invertebrates	Echinodermata : Seastar	Rainbow star, long-armed star	Secondary consumer
Pisaster brevispinus	Invertebrates	Echinodermata : Seastar	Giant Pink Star, short-spined star	Secondary consumer
Poraniopsis inflata	Invertebrates	Echinodermata : Seastar	Spiny star	-
Poraniopsis sp.	Invertebrates	Echinodermata : Seastar	-	-
Pseudarchaster alascensis	Invertebrates	Echinodermata : Seastar	Alascena sarstar	-
Pseudarchaster sp.	Invertebrates	Echinodermata : Seastar	-	-
Pteraster cf. militaris	Invertebrates	Echinodermata : Seastar	Wrinkle star	-
Pteraster jordani	Invertebrates	Echinodermata : Seastar	Jordan's cushion star	-
Pteraster sp.	Invertebrates	Echinodermata : Seastar	-	-
Pteraster tesselatus	Invertebrates	Echinodermata : Seastar	Slime star, cushion star	-
Pycnopodia helianthoides	Invertebrates	Echinodermata : Seastar	Sunflower star	Secondary consumer/Top-level invertebrate consumer
Rathbunaster californicus	Invertebrates	Echinodermata : Seastar	California sunstar	Secondary consumer
Solaster cf. endeca	Invertebrates	Echinodermata : Seastar	Northern sunstar	-
Solaster dawsoni	Invertebrates	Echinodermata : Seastar	Morning sunstar	-
Solaster paxillatus	Invertebrates	Echinodermata : Seastar	Orange sunstar	-
Solaster sp.	Invertebrates	Echinodermata : Seastar	-	Secondary consumer
Solaster spp.	Invertebrates	Echinodermata : Seastar	Sunstars	Secondary consumer
Solaster stimpsoni	Invertebrates	Echinodermata : Seastar	Striped sunstar	-
Spinulosida (Order)	Invertebrates	Echinodermata : Seastar	-	-
Stylasterias forreri	Invertebrates	Echinodermata : Seastar	Velcro star, fish-eating star	Secondary consumer
Thrissacanthias sp.	Invertebrates	Echinodermata : Seastar	-	-
Echinoidea (Class)	Invertebrates	Echinodermata : Urchin	Sea urchins	-
Mesocentrotus franciscanus	Invertebrates	Echinodermata : Urchin	Red urchin	Grazer
Sperosoma obscurum	Invertebrates	Echinodermata : Urchin	-	-
Strongylocentrotus droebachiensis	Invertebrates	Echinodermata : Urchin	Green urchin	Grazer
Strongylocentrotus fragilis	Invertebrates	Echinodermata : Urchin	Fragile pink urchin	Detritivore
Strongylocentrotus pallidus	Invertebrates	Echinodermata : Urchin	Pallid urchin	Detritivore
Strongylocentrotus purpuratus	Invertebrates	Echinodermata : Urchin	Purple urchin	Herbivore/Detritivore
Strongylocentrotus sp.	Invertebrates	Echinodermata : Urchin	-	-
Rathbunaster sp.	Invertebrates	Echinoderms: Seastar	-	-

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Foraminifera (Phylum)	Invertebrates	Foraminifera	-	-
Flabellina sp.	Invertebrates	Gastropods	-	-
Aplacophora (Class)	Invertebrates	Mollusca: Aplacophoran worm	Aplacophoran worms	N/A
Macellomenia sp.	Invertebrates	Mollusca: Aplacophoran worm	-	Secondary consumer
Pruvotinidae (Family)	Invertebrates	Mollusca: Aplacophoran worm	-	Secondary consumer
Solenogastres (Class)	Invertebrates	Mollusca: Aplacophoran worm	-	Secondary consumer
Acesta mori	Invertebrates	Mollusca: Bivalve	-	Filter/Suspension feeder
Chlamys behringiana	Invertebrates	Mollusca: Bivalve	Bering scallop	Filter/Suspension feeder
Chlamys hastata	Invertebrates	Mollusca: Bivalve	Swimming scallop	Filter/Suspension feeder
Chlamys rubida	Invertebrates	Mollusca: Bivalve	Pink scallop	Filter/Suspension feeder
Crassadoma gigantea	Invertebrates	Mollusca: Bivalve	Giant rock scallop	Filter/Suspension feeder
Delectopecten vancouverensis	Invertebrates	Mollusca: Bivalve	-	Filter/Suspension feeder
Entodesma navicula	Invertebrates	Mollusca: Bivalve	Rock entodesma	Filter/Suspension feeder
Hiatella arctica	Invertebrates	Mollusca: Bivalve	Arctic hiatella	Filter/Suspension feeder
Hiatellidae (Family)	Invertebrates	Mollusca: Bivalve	-	Filter/Suspension feeder
Limatula subauriculata	Invertebrates	Mollusca: Bivalve	-	Filter/Suspension feeder
Macoma balthica	Invertebrates	Mollusca: Bivalve	-	Filter/Suspension feeder
Modiolus modiolus	Invertebrates	Mollusca: Bivalve	-	Filter/Suspension feeder
Mytilus californianus	Invertebrates	Mollusca: Bivalve	California mussel	Filter/Suspension feeder
Petricolaria pholadiformis	Invertebrates	Mollusca: Bivalve	-	Filter/Suspension feeder
Philobrya setosa	Invertebrates	Mollusca: Bivalve	Hairy Philobrya	Filter/Suspension feeder
Philobryid sp.	Invertebrates	Mollusca: Bivalve	-	Filter/Suspension feeder
Pododesmus macrochisma	Invertebrates	Mollusca: Bivalve	Alaska jingle, green false-jingle	Filter/Suspension feeder
Pododesmus sp.	Invertebrates	Mollusca: Bivalve	-	-
Solemyidae (Family)	Invertebrates	Mollusca: Bivalve	-	Filter/Suspension feeder
Abraliopsis (Pfefferiteuthis) affinis	Invertebrates	Mollusca: Cephalopoda	-	-
Chiroteuthis sp.	Invertebrates	Mollusca: Cephalopoda	-	-
Decapodiformes (Superorder)	Invertebrates	Mollusca: Cephalopoda	Squid	Predator/Scavenger
Enteroctopus dofleini	Invertebrates	Mollusca: Cephalopoda	Giant Pacific octopus	Predator
Galiteuthis phyllura	Invertebrates	Mollusca: Cephalopoda	-	-
Gonatus onyx	Invertebrates	Mollusca: Cephalopoda	Clawed Armhook Squid	-

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Gonatus pyros	Invertebrates	Mollusca: Cephalopoda	-	-
Graneledone boreopacifica	Invertebrates	Mollusca: Cephalopoda	Deepsea octopus	Predator/Scavenger
Octopoda (Order)	Invertebrates	Mollusca: Cephalopoda	Octopus	Predator/Scavenger
Octopus sp.	Invertebrates	Mollusca: Cephalopoda	-	Predator/Scavenger
Taonius borealis	Invertebrates	Mollusca: Cephalopoda	-	-
Taonius sp.	Invertebrates	Mollusca: Cephalopoda	-	-
Chitonida (Order)	Invertebrates	Mollusca: Chiton	Chitons	-
Cryptochiton stelleri	Invertebrates	Mollusca: Chiton	Giant Pacific chiton, gumboot chiton	-
Leptochiton rugatus	Invertebrates	Mollusca: Chiton	Dwarf chiton	Grazer
Placiphorella pacifica	Invertebrates	Mollusca: Chiton	-	-
Amphissa cf. versicolor	Invertebrates	Mollusca: Gastropod	-	-
Amphissa sp.	Invertebrates	Mollusca: Gastropod	Dove snail	Grazer
Anatoma crispata	Invertebrates	Mollusca: Gastropod	-	-
Anatoma sp.	Invertebrates	Mollusca: Gastropod	-	-
Batillaria sp.	Invertebrates	Mollusca: Gastropod	-	-
Bittium sp.	Invertebrates	Mollusca: Gastropod	-	-
Caenogastropoda (Subclass)	Invertebrates	Mollusca: Gastropod	-	-
Calliostoma annulatum	Invertebrates	Mollusca: Gastropod	Purple-ring top snail	-
Calliostoma ligatum	Invertebrates	Mollusca: Gastropod	Blue top snail	-
Calliostomatidae (Family)	Invertebrates	Mollusca: Gastropod	Top snails	-
cf. Depressigyra globulus	Invertebrates	Mollusca: Gastropod	-	-
cf. Paralepetopsis tunnicliffae	Invertebrates	Mollusca: Gastropod	-	-
Dendronotus frondosus	Invertebrates	Mollusca: Gastropod	Frond aeolis	Grazer
Diodora aspera	Invertebrates	Mollusca: Gastropod	Rough keyhole limpet	Grazer
Doris montereyensis	Invertebrates	Mollusca: Gastropod	Monterey sea lemon	-
Doris odhneri	Invertebrates	Mollusca: Gastropod	White night doris	-
Epitonium indianorum	Invertebrates	Mollusca: Gastropod	Money wentletrap	-
Fusitriton oregonensis	Invertebrates	Mollusca: Gastropod	Oregon hairy triton	Secondary consumer/Scavenger
Gastropoda (Class)	Invertebrates	Mollusca: Gastropod	-	N/A
Granulina margaritula	Invertebrates	Mollusca: Gastropod	Pear marginella	-
Homalopoma luridum	Invertebrates	Mollusca: Gastropod	Dark dwarf-turban	-
Limacina helicina	Invertebrates	Mollusca: Gastropod	Sea butterfly	Zooplankton
Lirabuccinum dirum	Invertebrates	Mollusca: Gastropod	Dire whelk	-

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Littorinimorpha (Order)	Invertebrates	Mollusca: Gastropod	-	-
Lottia instabilis	Invertebrates	Mollusca: Gastropod	Unstable limpet	-
Margarites helicinus	Invertebrates	Mollusca: Gastropod	Spiral margarite	-
Margarites olivaceus marginatus	Invertebrates	Mollusca: Gastropod	-	Grazer/Detritivore
Montereina nobilis	Invertebrates	Mollusca: Gastropod	Pacific sea-lemon	-
Muricidae (Family)	Invertebrates	Mollusca: Gastropod	Murex snails, Rock snails	Secondary consumers
Neogastropoda	Invertebrates	Mollusca: Gastropod	Whelks/cone shells	N/A
Neptunea pribiloffensis	Invertebrates	Mollusca: Gastropod	Pribilof whelk	-
Ocinebrina lurida	Invertebrates	Mollusca: Gastropod	Lurid rock snail	-
Opalia wroblewskyi	Invertebrates	Mollusca: Gastropod	Boreal Wentletrap	-
Pleurobranchidae	Invertebrates	Mollusca: Gastropod	Pleurobranchid sea slug	-
Pleurotomaria (Entemnotrochus) sp.	Invertebrates	Mollusca: Gastropod	Slit snail	-
Puncturella sp.	Invertebrates	Mollusca: Gastropod	-	-
Scabrotrophon lasius	Invertebrates	Mollusca: Gastropod	-	-
Solariella obscura	Invertebrates	Mollusca: Gastropod	Obscure solarelle	-
Tritonia tetraquetra	Invertebrates	Mollusca: Gastropod	Giant orange tochui	-
Trophonopsis sp.	Invertebrates	Mollusca: Gastropod	-	-
Dendronotus sp.	Invertebrates	Mollusca: Nudibranch	Light-speckled dendronotid	-
Dirona albolineata	Invertebrates	Mollusca: Nudibranch	White-line dirona	Predator/Grazer
Dorididae (Family)	Invertebrates	Mollusca: Nudibranch	Sea lemons	-
Flabellina verrucosa	Invertebrates	Mollusca: Nudibranch	Red-finger aeolis	-
Hermissenda crassicornis	Invertebrates	Mollusca: Nudibranch	Opalescent nudibranch	Grazer
Janolus fuscus	Invertebrates	Mollusca: Nudibranch	White-and-orange-tipped nudibranch	Grazer
Nudibranchia (Order)	Invertebrates	Mollusca: Nudibranch	Nudibranchs	-
Triopha catalinae	Invertebrates	Mollusca: Nudibranch	Sea clown nudibranch	Grazer
Tritoniidae (Family)	Invertebrates	Mollusca: Nudibranch	Triton nudibranch	-
Hoplonemertea (Class)	Invertebrates	Nemertea (Ribbon worm)	-	-
Lineidae (Family)	Invertebrates	Nemertea (Ribbon worm)	-	-
Nemertea (Phylum)	Invertebrates	Nemertea (Ribbon worm)	Ribbon worms	-
Acrocirridae (Family)	Invertebrates	Polychaeta (Worms)	-	-
Arctonoe fragilis	Invertebrates	Polychaeta (Worms)	Commensal scaleworm	Detritivore
Autolytus (Proceraea) sp.	Invertebrates	Polychaeta (Worms)	-	Secondary consumer
Bathyvermilia eliasoni	Invertebrates	Polychaeta (Worms)	-	Filter/Suspension feeder

Taxon	Category	Sub-category	Common name	Feeding/Ecological Guild
Chaetopterus sp.	Invertebrates	Polychaeta (Worms)	Parchment worm	Filter/Suspension feeder
Chitinopoma serrula	Invertebrates	Polychaeta (Worms)	-	Filter/Suspension feeder
Chone sp.	Invertebrates	Polychaeta (Worms)	-	Filter/Suspension feeder
Cirratulidae (Family)	Invertebrates	Polychaeta (Worms)	-	Detritivore
Crucigera irregularis	Invertebrates	Polychaeta (Worms)	-	Filter/Suspension feeder
Crucigera zygophora	Invertebrates	Polychaeta (Worms)	Yoke-bearer calcareous tubeworm	Filter/Suspension feeder
Ehlersia (Syllis) sp.	Invertebrates	Polychaeta (Worms)	-	Secondary consumer
Eunice sp.	Invertebrates	Polychaeta (Worms)	-	-
Euphrosine bicirrata	Invertebrates	Polychaeta (Worms)	-	-
Euphrosine hortensis	Invertebrates	Polychaeta (Worms)	-	-
Euphrosine sp.	Invertebrates	Polychaeta (Worms)	-	-
Eupolymnia sp.	Invertebrates	Polychaeta (Worms)	-	Detritivore
Halosydna brevisetosa	Invertebrates	Polychaeta (Worms)	-	-
Harmothoe sp.	Invertebrates	Polychaeta (Worms)	-	Secondary consumer
Hirudinea (Subclass)	Invertebrates	Polychaeta (Worms)	Leeches	-
Lepidonotus squamatus	Invertebrates	Polychaeta (Worms)	-	Secondary consumer
Lumbrineris inflata	Invertebrates	Polychaeta (Worms)	-	Scavenger
Lumbrineris sp.	Invertebrates	Polychaeta (Worms)	-	Scavenger
Macellicephala sp.	Invertebrates	Polychaeta (Worms)	-	-
Macellicephalinae (Subfamily)	Invertebrates	Polychaeta (Worms)	-	-
Maera sp.	Invertebrates	Polychaeta (Worms)	-	-
Micropleustes sp.	Invertebrates	Polychaeta (Worms)	-	-
Nereididae (Family)	Invertebrates	Polychaeta (Worms)	-	-
Nereis procera	Invertebrates	Polychaeta (Worms)	-	-
Nothria conchylega	Invertebrates	Polychaeta (Worms)	-	-
Nudisyllis sp.	Invertebrates	Polychaeta (Worms)	-	-
Paradexiospira sp.	Invertebrates	Polychaeta (Worms)	Dwarf calcareous tubeworm	Filter/Suspension feeder
Parapleustes sp.	Invertebrates	Polychaeta (Worms)	-	-
Phyllochaetopterus claparedii	Invertebrates	Polychaeta (Worms)	-	-
Phyllochaetopterus prolifica	Invertebrates	Polychaeta (Worms)	-	-
Phyllodoce maculata	Invertebrates	Polychaeta (Worms)	-	-
Phyllodoce medipapillata	Invertebrates	Polychaeta (Worms)	-	-
Polychaeta (Class)	Invertebrates	Polychaeta (Worms)	Worms	-

Taxon	Category	Sub-category	Common name	Feeding/Ecological Guild
Polychaeta (Class) sp. A	Invertebrates	Polychaeta (Worms)	-	-
Polychaeta (Class) sp. B	Invertebrates	Polychaeta (Worms)	-	-
Polynoidae (Family)	Invertebrates	Polychaeta (Worms)	-	-
Proboloides sp.	Invertebrates	Polychaeta (Worms)	-	-
Proceraea sp.	Invertebrates	Polychaeta (Worms)	-	-
Protula pacifica	Invertebrates	Polychaeta (Worms)	White-crown calcareous tubeworm	-
Sabellidae (Family)	Invertebrates	Polychaeta (Worms)	-	Filter/Suspension feeder
Sedentaria (Subclass)	Invertebrates	Polychaeta (Worms)	-	-
Serpula vermicularis	Invertebrates	Polychaeta (Worms)	-	Filter/Suspension feeder
Serpulidae (Family)	Invertebrates	Polychaeta (Worms)	Tubeworms	Filter/Suspension feeder
Spiochaetopterus cf. costarum	Invertebrates	Polychaeta (Worms)	-	-
Spirorbinae (Subfamily)	Invertebrates	Polychaeta (Worms)	-	Filter/Suspension feeder
Syllis sp.	Invertebrates	Polychaeta (Worms)	-	-
Terebellidae (Family)	Invertebrates	Polychaeta (Worms)	Spaghetti worms	Detritivore
Trichobranchidae (Family)	Invertebrates	Polychaeta (Worms)	-	-
Trypanosyllis aeolis	Invertebrates	Polychaeta (Worms)	-	-
Porifera (Phylum)	Invertebrates	Porifera (Sponges)	Sponges	Filter/Suspension feeder
Porifera (Phylum) sp. A	Invertebrates	Porifera (Sponges)	-	Filter/Suspension feeder
Porifera (Phylum) sp. B	Invertebrates	Porifera (Sponges)	-	Filter/Suspension feeder
Porifera (Phylum) sp. C	Invertebrates	Porifera (Sponges)	-	Filter/Suspension feeder
Calcarea (Class) sp. A	Invertebrates	Porifera: Calcareous sponge	-	Filter/Suspension feeder
Calcarea (Class) sp. B	Invertebrates	Porifera: Calcareous sponge	-	Filter/Suspension feeder
Grantia sp.	Invertebrates	Porifera: Calcareous sponge	-	Filter/Suspension feeder
Leucosolenia sp.	Invertebrates	Porifera: Calcareous sponge	Tube sponge	Filter/Suspension feeder
Sycon sp.	Invertebrates	Porifera: Calcareous sponge	-	Filter/Suspension feeder
Ancorina sp. A	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Ancorina sp. B	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Asbestopluma (Asbestopluma) monticola	Invertebrates	Porifera: Demosponge	-	Secondary consumer
Asbestopluma spp.	Invertebrates	Porifera: Demosponge	Carnivorous sponge	Secondary consumer
Axinellidae (Family)	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder

Taxon	Category	Sub-category	Common name	Feeding/Ecological Guild
cf. Acarnus erithacus	Invertebrates	Porifera: Demosponge	Red encrusting sponge	Filter/Suspension feeder
cf. Auletta sp.	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
cf. Mycale (Mycale) lingua	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Cladorhizidae (Family)	Invertebrates	Porifera: Demosponge	Carnivorous sponges	Secondary consumer
Craniella sp. nov.	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Demospongiae (Class)	Invertebrates	Porifera: Demosponge	Bath sponge	Filter/Suspension feeder
Demospongiae sp. 1	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Demospongiae sp. 2	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Demospongiae sp. 3	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Desmacella spp.	Invertebrates	Porifera: Demosponge	Encrusting sponge	Filter/Suspension feeder
Ecionemia sp.	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Esperiopsis cf. villosa	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Esperiopsis spp.	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Eurypon sp.	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Halichondria panicea	Invertebrates	Porifera: Demosponge	Yellow-green breadcrumb sponge	Filter/Suspension feeder
Hamigera spp.	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Hymeniacidon sp.	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Iophon piceum pacificum	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Isodictya sp.	Invertebrates	Porifera: Demosponge	Finger sponge	Filter/Suspension feeder
Latrunculia (Biannulata) oparinae	Invertebrates	Porifera: Demosponge	Moon sponge	Filter/Suspension feeder
Mycale sp.	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Neopetrosia sp.	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Penares cortius	Invertebrates	Porifera: Demosponge	Gray ridge sponge	Filter/Suspension feeder
Phorbas sp.	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Poecillastra cf. tenuilaminaris	Invertebrates	Porifera: Demosponge	Plate sponge	Filter/Suspension feeder
Polymastiidae (Family)	Invertebrates	Porifera: Demosponge	Nipple sponge	Filter/Suspension feeder
Radiella sp. nov.	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Sphaerotylus capitatus	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Sphaerotylus sp. nov.	Invertebrates	Porifera: Demosponge	-	Filter/Suspension feeder
Acanthascus spp.	Invertebrates	Porifera: Glass sponge	Boot sponges	Filter/Suspension feeder
Aphrocallistes vastus	Invertebrates	Porifera: Glass sponge	Cloud sponge	Filter/Suspension feeder
Aphrocallistidae	Invertebrates	Porifera: Glass sponge	Cloud sponges and goblet sponges	Filter/Suspension feeder
Bathydorus sp.	Invertebrates	Porifera: Glass sponge	Boot sponges	Filter/Suspension feeder

Taxon	Category	Sub-category	Common name	Feeding/Ecological Guild
Chonelasma oreia	Invertebrates	Porifera: Glass sponge	-	Filter/Suspension feeder
Farrea n. sp. A	Invertebrates	Porifera: Glass sponge	Lace sponge	Filter/Suspension feeder
Farrea n. sp. B	Invertebrates	Porifera: Glass sponge	Branching lace sponge	Filter/Suspension feeder
Farrea omniclavata	Invertebrates	Porifera: Glass sponge	-	Filter/Suspension feeder
Farrea spp.	Invertebrates	Porifera: Glass sponge	Lace sponges	Filter/Suspension feeder
Heterochone calyx	Invertebrates	Porifera: Glass sponge	Goblet sponge, chalice sponge, goiter sponge	Filter/Suspension feeder
Hexactinella n. sp. A	Invertebrates	Porifera: Glass sponge	-	Filter/Suspension feeder
Hexactinellida (Class)	Invertebrates	Porifera: Glass sponge	Glass sponges	Filter/Suspension feeder
Hexasterophora (Subclass)	Invertebrates	Porifera: Glass sponge	-	Filter/Suspension feeder
Homoieurete n. sp. 1	Invertebrates	Porifera: Glass sponge	-	Filter/Suspension feeder
Lefroyella sp.	Invertebrates	Porifera: Glass sponge	-	Filter/Suspension feeder
Pinulasma n. sp. A	Invertebrates	Porifera: Glass sponge	Bugle sponge	Filter/Suspension feeder
Rhabdocalyptus dawsoni	Invertebrates	Porifera: Glass sponge	Boot sponge, sharp-lipped boot sponge, chimney sponge	Filter/Suspension feeder
Rhabdocalyptus spp.	Invertebrates	Porifera: Glass sponge	Boot sponges	Filter/Suspension feeder
Rossellidae (Family)	Invertebrates	Porifera: Glass sponge	-	Filter/Suspension feeder
Schaudinnia n. sp.	Invertebrates	Porifera: Glass sponge	-	Filter/Suspension feeder
Staurocalyptus fasciculatus	Invertebrates	Porifera: Glass sponge	-	Filter/Suspension feeder
Staurocalyptus spp.	Invertebrates	Porifera: Glass sponge	Boot sponges	Filter/Suspension feeder
Tretodictyidae n. sp.	Invertebrates	Porifera: Glass sponge	-	Filter/Suspension feeder
Tretodictyum n. sp. A	Invertebrates	Porifera: Glass sponge	-	Filter/Suspension feeder
Pycnogonida (Class)	Invertebrates	Pycnogonid	Sea spiders	-
Pycnogonida (Class) sp. A	Invertebrates	Pycnogonid	Sea spider	-
Radiozoa (Phylum)	Invertebrates	Radiozoa	-	-
Phascolosoma agassizii	Invertebrates	Sipunculid worm	Agassiz's peanut worm	-
Sipuncula (Phylum)	Invertebrates	Sipunculid worm	Peanut worms	-
Battersia norrisii	Macrophytes	Brown algae	-	Primary producer
Desmarestia ligulata	Macrophytes	Brown algae	Flattened acid kelp	Primary producer
Desmarestia viridis	Macrophytes	Brown algae	Stringy acid kelp	Primary producer
Ectocarpus corticulatus	Macrophytes	Brown algae	Filamentous brown algae	Primary producer
Laminaria yezoensis	Macrophytes	Brown algae	Suction cup kelp	Primary producer
Phaeophyceae	Macrophytes	Brown algae	Brown seaweed	Primary producer
Acrochaete apiculata	Macrophytes	Green algae	-	Primary producer
Antithamnion defectum	Macrophytes	Red algae	Dwarf skein	Primary producer
Antithamnion kylinii	Macrophytes	Red algae	-	Primary producer
Callophyllis flabellata	Macrophytes	Red algae	-	Primary producer

Taxon	Category	Sub-category	Common name	Feeding/Ecological Guild
Callophyllus sp.	Macrophytes	Red algae	Red sea fan	Primary producer
Ceramiun sp.	Macrophytes	Red algae	-	Primary producer
cf. Fauchea laciniata	Macrophytes	Red algae	-	Primary producer
cf. Lithophyllum spp.	Macrophytes	Red algae	Crustose coralline algae	Primary producer
cf. Lithothamnion spp.	Macrophytes	Red algae	Crustose coralline algae	Primary producer
Corallinaceae (Family)	Macrophytes	Red algae	Coralline algae	Primary producer
Cryptopleura sp.	Macrophytes	Red algae	-	Primary producer
Delesseria decipiens	Macrophytes	Red algae	Winged rib	Primary producer
Delesseria sp.	Macrophytes	Red algae	-	Primary producer
Fryeella gardneri	Macrophytes	Red algae	-	Primary producer
Hommersandia maximicarpa	Macrophytes	Red algae	Hommersand's seaweed	Primary producer
Mastocarpus jardinii	Macrophytes	Red algae	-	Primary producer
Membranoptera sp.	Macrophytes	Red algae	-	Primary producer
Opuntiella californica	Macrophytes	Red algae	Red optunia	Primary producer
Phycodrys cf. isabellae	Macrophytes	Red algae	-	Primary producer
Polyneura latissima	Macrophytes	Red algae	Network red seaweed	Primary producer
Polysiphonia pacifica	Macrophytes	Red algae	Pretty polly	Primary producer
Polysiphonia spp.	Macrophytes	Red algae	Filamentous red algae	Primary producer
Polysiphonia stricta	Macrophytes	Red algae	-	Primary producer
Porphyropsis sp.	Macrophytes	Red algae	-	Primary producer
Ptilota sp.	Macrophytes	Red algae	-	Primary producer
Rhodophyta (Phylum)	Macrophytes	Red algae	Unknown red algae	Primary producer
Lagenorhynchus obliquidens	Marine Mammals	Dolphin	Pacific white-sided dolphin	Top-level consumer
Lissodelphis borealis	Marine Mammals	Dolphin	Northern right whale dolphin	Filter feeder (Baleen)
Stenella coeruleoalba	Marine Mammals	Dolphin	Striped dolphin	Top-level consumer
Tursiops truncatus	Marine Mammals	Dolphin	Bottlenose dolphin	Top-level consumer
Phocoenoides dalli	Marine Mammals	Porpoise	Dall's porpoise	Top-level consumer
Eumetopias jubatus	Marine Mammals	Sea Lion	Steller sea lion	Top-level consumer
Callorhinus ursinus	Marine Mammals	Seal	Northern fur seal	Top-level consumer
Mirounga angustirostris	Marine Mammals	Seal	Northern elephant seal	Top-level consumer
Balaenoptera acutorostrata	Marine Mammals	Whale	Minke whale, northern minke whale	Filter feeder (Baleen)
Balaenoptera physalus	Marine Mammals	Whale	Fin whale	Filter feeder (Baleen)
Megaptera novaeangliae	Marine Mammals	Whale	Humpback whale	Filter feeder (Baleen)
Orcinus orca	Marine Mammals	Whale	Killer whale	Top-level consumer
Physeter macrocephalus	Marine Mammals	Whale	Sperm whale	Tertiary consumer (Squid)
Pseudorca crassidens	Marine Mammals	Whale	False killer whale	Top-level consumer
Ziphius cavirostris	Marine Mammals	Whale	Cuvier's beaked whale	Tertiary consumer

Taxon	Category	Sub-category	Common name	Feeding/Ecological Guild
Hexanchus griseus	Sharks & Skates	Bathydemersal shark	Bluntnose sixgill shark, cow shark	Top-level consumer
Squalus acanthias	Sharks & Skates	Benthopelagic shark	Spiny dogfish, picked dogfish	Tertiary consumer
Apristurus brunneus	Sharks & Skates	Demersal shark	Brown catshark	Tertiary consumer
Somniosus pacificus	Sharks & Skates	Demersal shark	Pacific sleeper shark	Top-level consumer
Carcharodon carcharias	Sharks & Skates	Epipelagic shark	Great white shark	Top-level consumer
Cetorhinus maximus	Sharks & Skates	Pelagic shark	Basking shark	Filter feeder
Lamna ditropis	Sharks & Skates	Pelagic shark	Salmon shark	Top-level consumer
Prionace glauca	Sharks & Skates	Pelagic shark	Blue shark	Top-level consumer
Bathyraja interrupta	Sharks & Skates	Skate	Sandpaper skate	Secondary consumer
Bathyraja trachura	Sharks & Skates	Skate	Roughtail skate	Tertiary consumer
Raja binoculata	Sharks & Skates	Skate	Big skate	Tertiary consumer
Raja rhina	Sharks & Skates	Skate	Longnose skate	Tertiary consumer
Raja sp.	Sharks & Skates	Skate	Skates	Tertiary consumer
Doliopsidina (Suborder)	Urochordates	Pelagic tunicate	-	Filter/Suspension feeder
Oikopleura dioica	Urochordates	Pelagic tunicate	-	Filter/Suspension feeder
Pyrosoma atlanticum	Urochordates	Pyrosome	Pyrosome	Filter/Suspension feeder
Cyclosalpa sp.	Urochordates	Salp	-	Filter/Suspension feeder
Salpa fusiformis	Urochordates	Salp	Common salp	Filter/Suspension feeder
Thalia democratica	Urochordates	Salp	-	Filter/Suspension feeder
Thetys vagina	Urochordates	Salp	Twin-sailed salp	Filter/Suspension feeder
Ascidia ceratodes	Urochordates	Sessile tunicate	California sea squirt	Filter/Suspension feeder
Ascidiacea (Class)	Urochordates	Sessile tunicate	Tunicates, sea squirts	Filter/Suspension feeder
Ciona savignyi	Urochordates	Sessile tunicate	Pacific transparent sea squirt	Filter/Suspension feeder
Cnemidocarpa finmarkiensis	Urochordates	Sessile tunicate	Orange sea squirt	Filter/Suspension feeder
Distaplia occidentalis	Urochordates	Sessile tunicate	Mushroom ascidian	Filter/Suspension feeder
Megalodicopia hians	Urochordates	Sessile tunicate	Predatory tunicate	Secondary consumer
Ritterella rubra	Urochordates	Sessile tunicate	-	Filter/Suspension feeder
Didemnum albidum	Urochordates	Sessile Tunicates	-	Filter/Suspension feeder

APPENDIX M. SEAMOUNT SUMMIT SHAPE

The thick quiescent benthic boundary layer (slow-moving water above the seafloor) is a common characteristic of featureless deep-sea environments. In contrast, seamounts cause accelerated currents over and around their structures, reducing the benthic boundary layer and amplifying food delivery, causing nutrient upwelling, re-suspending detritus, preventing sedimentation, and increasing vertical mixing (Pitcher and Bulman 2007). The peaks, summits, and upper slope of many seamounts are exposed to strong currents and usually support the greatest abundance of life. For example, strong currents are a common habitat characteristic of sessile filter-feeders, such as cold-water coral habitats, and close proximity to strong flow with shelter for rest is a common habitat characteristic for site-attached fish, such as rockfish (*Sebastes* spp.; Genin and Dower 2007).

We tested a geomorphological measure of peak (summit) omnidirectional relief and steepness (ORS; similar to the benthic position index; i.e., average height difference between the peak and the seafloor 2-km away in all directions) as a proxy for local current intensification (hydrographic conditions) experienced at the summit. Metrics to capture this type of information were initially considered for inclusion in the global seamount classification scheme but were determined to be too hard to come by for use in large-scale analyses (Clark et al. 2011). From the benthic visual surveys, we know some OPB seamount summits are sedimented flat-topped (e.g., eroded guyot, caldera, summit plateau with or without multiple small peaks) while others are rocky, current-swept steep conical- or spire-shaped. We calculated ORS as a means to quantify and compare the diversity of OPB summits, where ORS is a measure of how high the peak rises about the local terrain and how steeply. The ORS was calculated as the average height difference between the peak and 2-km away in all directions. Only the GMRT bathymetry was used in this analysis to avoid overestimating the ORS of seamounts with high-resolution multibeam bathymetry. The distance of 2-km was determined from preliminary review of the terrain to isolate the area directly around the peak of each OPB seamount given their average size and shape. Minor changes to the buffer distance did not change the overall trend of the results.

The 2-km ORS of the OPB seamounts ranges from the slightly indented summit of Union at -37 m to the steep spire-like summit of Explorer Seamount at 718 m (average of 293 m; Figure A19). It then follows that the summit of Explorer likely experiences a relatively high local current intensification as a result of its geomorphology. Evidence of this was documented during the 2018 and 2019 visual surveys of Explorer. The two sides of Explorer's summit supported extreme high-densities of cold-water corals and sponges that they were immediately nicknamed *Coraltropolis* (west-facing) and *Spongetopia* (east-facing) (see Appendix K: Table A9 and Figure A17 for site descriptions and photos). A thick forest of wire-coral *Stichopathes* sp. dominated large steep areas the summit and high densities of *Stichopathes* spp. are known to indicate the occurrence of strong currents at a site (Genin et al. 1986). *Stichopathes* sp. were only observed on three of the other visually surveyed seamounts (of 12 in total) and always on steep substrates: on the summits of UN 1 and Dellwood South (both relatively high ORS values), and on a few of the small peaks rising from the Springfield Seamount plateau (a relatively low 2-km ORS, which captures the nature of the plateau and not its small peaks). In comparison, at the other end of the spectrum, the flat-top of Union Seamount (lowest ORS) supported sparse individuals of tree-like corals (*Primnoa pacifica* and *Paragorgia* spp.).

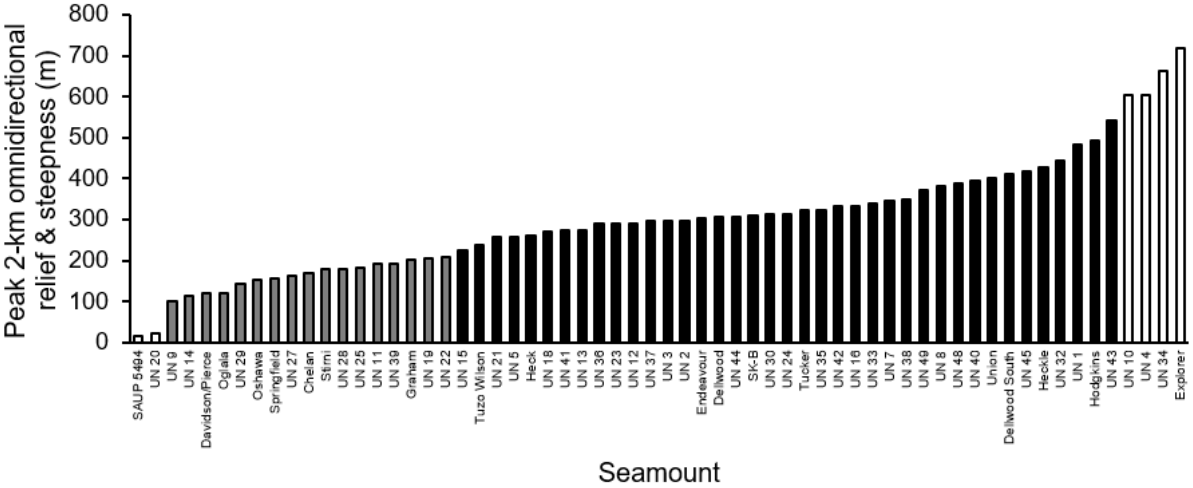

Figure A19. The omnidirectional relief and steepness of each seamount peak (calculated for a 2-km radius). Seamounts in order of increasing sharpness (ORS), with bar colour denoting the four seamount clusters seamounts, where the group of flattest seamount peaks is the first white bars and the group of sharpest seamount peaks (steep and high) is the last white bars.

By analyzing seamount 2-km peak ORS values using a similarity matrix (Figure A21) in R Studio version 1.2.5033 (fviz_nbclust function, ‘factoextra’ R package), the Silhouette and total within-cluster sum of squares analyses both resolve four clusters (Figure A22 and A23). The majority of seamounts fall in the middle two clusters with small clusters on either end of the scale (i.e., rare membership). The two flat-topped seamounts (lowest ORS cluster: SAUP 5494, and UN 20) likely have sedimented peaks and are either eroded guyots, calderas, or summit plateaus with or without small-scale peaks. The four spire-topped seamounts (highest ORS: Explorer, UN 34, UN 4, UN 10) likely have rocky, current-swept steep conical- or spire-shaped peaks. Further research is required to resolve the ecological importance of relief and steepness above the seafloor.

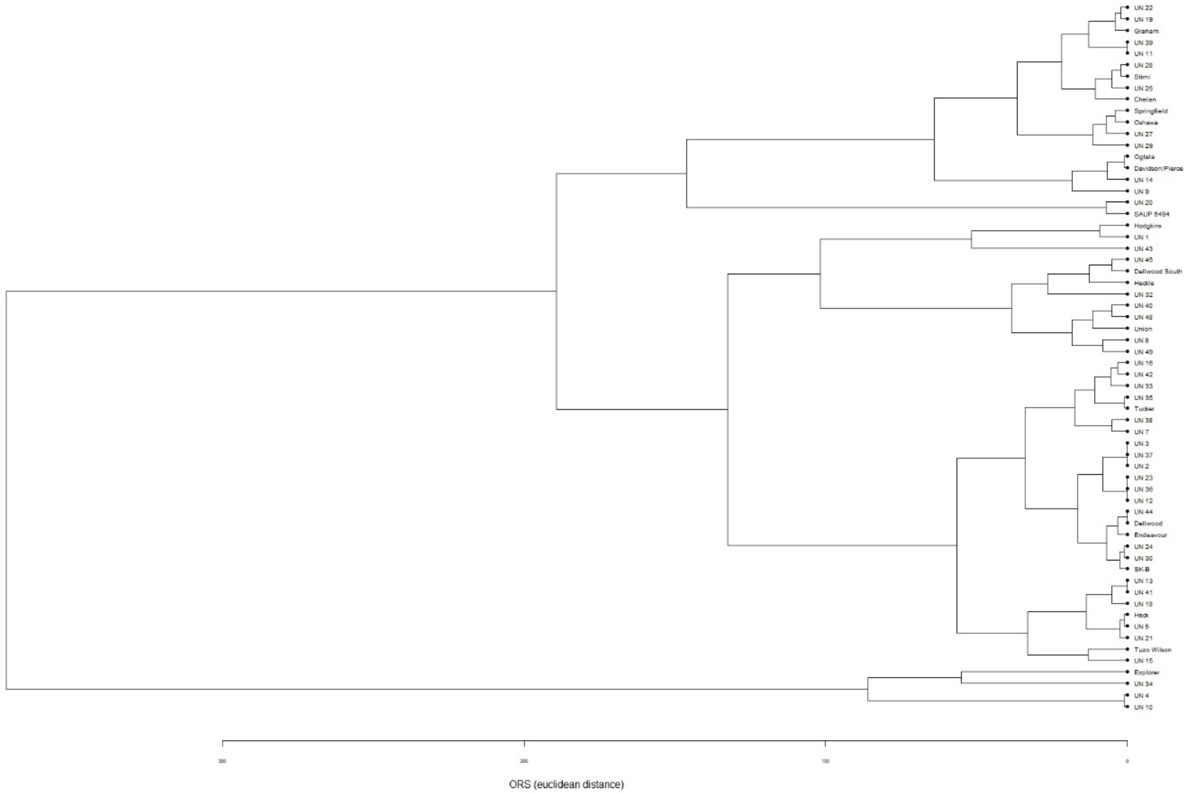

Figure A20. Dendrogram of seamounts based on 2-km omnidirectional relief and steepness (ORS).

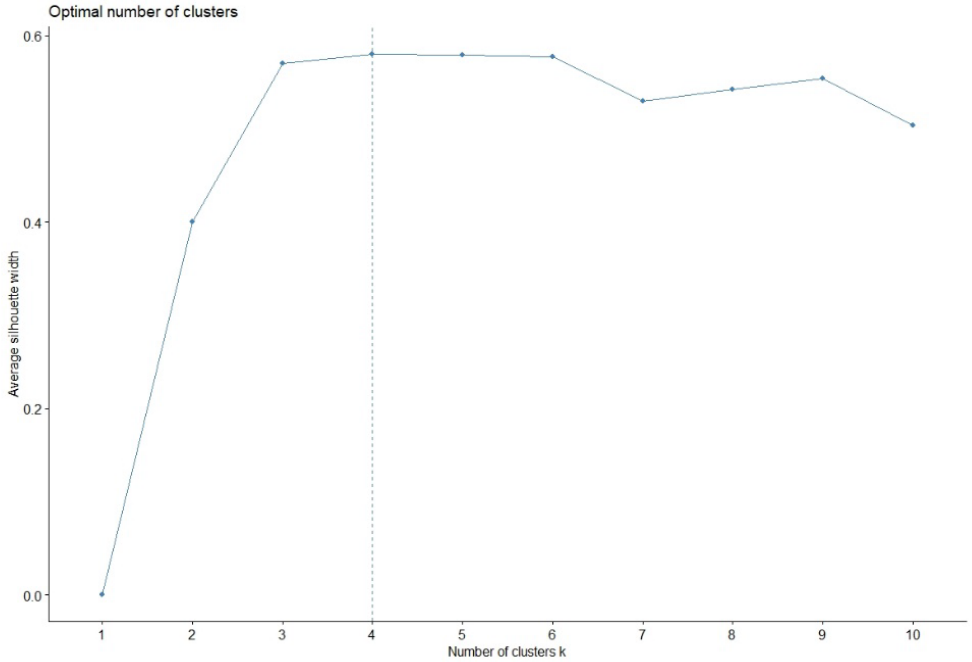

Figure A21. The average silhouette (fviz_nbclust function R package) indicating a possible optimal cluster of 4 groups based on 2-km omnidirectional relief and steepness (ORS).

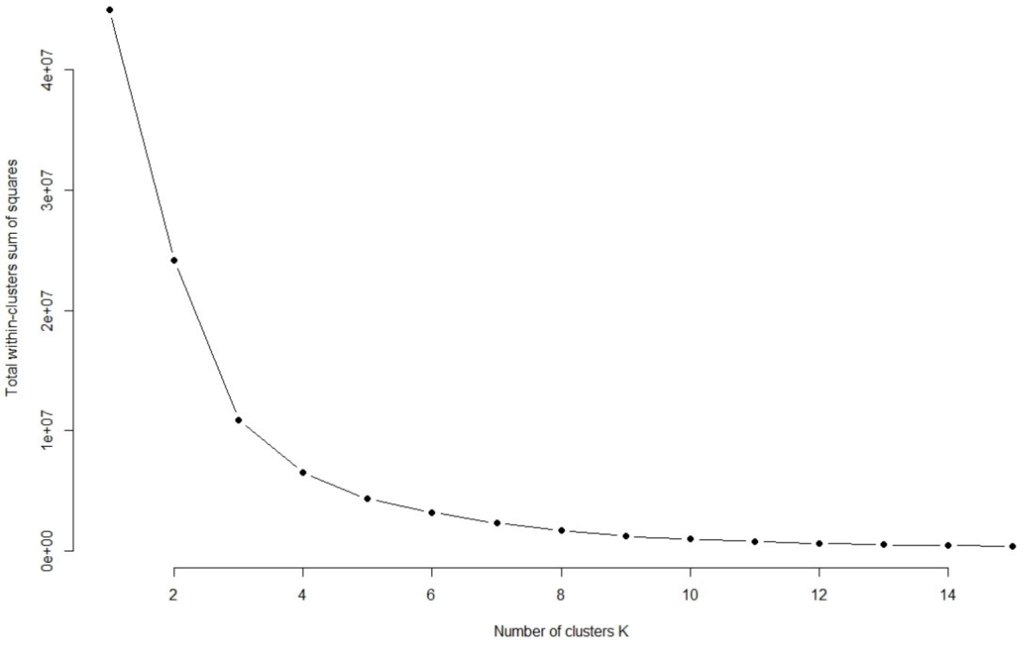

Figure A22. The within-cluster sums of squares ('factoextra' R package) indicating a possible optimal cluster of 4 groups based on 2-km omnidirectional relief and steepness (ORS).