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Identification of Ecologically and Biologically Significant Areas (EBSAs) in Canada's Offshore Pacific Bioregion

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Canada

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

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ABSTRACT

Canada has committed to identifying and protecting Ecologically and Biologically Significant Areas (EBSAs) within its territorial waters. Five habitat types (hydrothermal vents, seamounts, the continental slope, abyssal/bathypelagic waters, and pelagic/surface waters) in Canada's Offshore Pacific Bioregion were assessed against eight EBSA criteria established by Fisheries and Oceans Canada and the Convention on Biological Diversity. All known or inferred active and inactive hydrothermal vent fields and their associated structures, vent fluids, gases, and biological communities ranked as highly unique, vulnerable, productive, diverse, natural, and important for life history stages, species and species aggregation. All named seamounts, including the seafloor, substrata, and associated water column, were identified as EBSAs, as well as the Baby Bare – Grizzly Bare complex. Seamounts ranked highly as unique, vulnerable, diverse, natural, and important for species aggregation. The continental slope was assessed as a whole and ranked highly as vulnerable, diverse, and important for life history stages/species, threatened, endangered or declining species or habitats, and for species aggregation. Two EBSAs in the pelagic/surface waters were identified: the Haida Eddy and the North Pacific Transition Zone (NPTZ). The Haida Eddy was ranked as high for uniqueness and medium in terms of productivity, diversity, naturalness, and importance for life history stage or species, and species aggregation. The NPTZ ranked highly as productive, diverse, and important for life history stages or species, threatened, endangered or declining species or habitats, and for species aggregation. The abyssal/bathypelagic habitats did not meet EBSA criteria. The hydrothermal vents and NPTZ EBSAs in Canada's Offshore Pacific Bioregion are contiguous with corresponding EBSAs identified in international waters of the North Pacific Ocean, and seamount EBSAs in Canada are consistent with eight EBSAs identified in the northeast Pacific Ocean.

Désignation de zones d’importance écologique et biologique dans la biorégion du Pacifique située en mer au Canada

RÉSUMÉ

Le Canada s'est engagé à désigner et à protéger les zones d'importance écologique et biologique (ZIEB) dans ses eaux territoriales. Cinq types d'habitats (cheminées hydrothermales, monts sous-marins, pente continentale, eaux abyssales/bathypélagiques et eaux superficielles/pélagiques) de la biorégion du Pacifique située en mer au Canada ont été évalués par rapport à huit critères des ZIEB établis par Pêches et Océans Canada et la Convention sur la diversité biologique. Tous les champs connus ou présumés de cheminées hydrothermales actives ou inactives et leurs structures, fluides, et gaz connexes, et les communautés biologiques des cheminées classées comme étant très uniques, vulnérables, productives, diverses, naturelles et importantes pour les stades du cycle biologique, les espèces et les concentrations d'espèces. Tous les monts sous-marins, y compris le fond marin, le substrat et la colonne d'eau connexe, et le complexe de monts sous-marins Baby Bare-Grizzly Bare ont été désignés comme des ZIEB. Les monts sous-marins classés comme étant très uniques, vulnérables, divers, naturels et importants pour des concentrations d'espèces. La pente continentale a été évaluée dans son ensemble et classée comme étant très vulnérable, diverse et importante pour des espèces et des stades du cycle biologique, les espèces ou les habitats menacés, en péril ou en déclin, et des concentrations d'espèces. Deux ZIEB ont été désignées dans les eaux superficielles/pélagiques : le tourbillon Haïda et la zone de transition du Pacifique Nord. Le tourbillon Haïda a été classé élevé en ce qui a trait à l'unicité et moyen en ce qui concerne la productivité, l'état naturel et l'importance pour des espèces et des stades du cycle biologique, et des concentrations d'espèces. La zone de transition du Pacifique Nord a été classée comme étant très productive, diverse et importante pour des espèces ou des stades du cycle biologique, les espèces ou les habitats menacés, en péril ou en déclin, et des concentrations d'espèces. Les habitats abyssaux/bathypélagiques ne répondaient pas aux critères des ZIEB. Les ZIEB des cheminées hydrothermales et de la zone de transition du Pacifique Nord dans la biorégion du Pacifique située en mer au Canada sont contigües aux ZIEB correspondantes désignées dans les eaux internationales du Pacifique Nord, et les ZIEB des monts sous-marins au Canada correspondent aux huit ZIEB désignées dans le Pacifique Nord-Est.

1 INTRODUCTION

Signatory countries to the Convention on Biological Diversity (CBD), including Canada, have committed to identifying ecologically and biologically significant areas (EBSAs) and establishing marine protected areas (MPAs) within their waters. An EBSA is an area deemed to be ecologically or biologically "significant" because of either its structural properties and/or the function that it serves in an ecosystem (DFO 2004). Identification of EBSAs is one way for countries to prioritise areas for potential protection (Gregr et al. 2012) with MPAs, a key principle of the Canada-British Columbia Marine Protected Area Network Strategy[1].

Identification of an area or feature as an EBSA does not confer or imply any degree of specific protection; rather, it is a means of recognizing an area with special features where threats and risks should be more carefully scrutinized when undertaking management of activities in that area. To this end, identification of an area as an EBSA is the first of three steps. The second step is to consider societal values and potential threats in setting management objectives; the third step is for managers and regulators to devise and implement a management plan for each area (DFO 2004). Conversely, an area need not be identified as an EBSA in order to be designated as a Marine Protected Area or to be protected under the National Marine Conservation Areas Act (DFO 2004).

EBSA criteria were developed by Fisheries and Oceans Canada (DFO) in response to the passing of Canada's Oceans Act in 1996 as a way to operationalize and standardize the process of identification of areas deemed "significant" and to support an ecosystem-based approach towards integrated management (DFO 2004). This guidance stated that an area was an EBSA if it either scored high on at least one of three primary criteria (uniqueness, aggregregation, or fitness consequences for species or life history stages), or if it scored above average (medium or high) across a range of criteria (i.e., cumulative importance). In addition, resilience and naturalness were also deemed important attributes of EBSAs but insufficient on their own to designate an area as an EBSA. DFO guidance (2004, 2011) recommended that data analyses or expert-driven processes be used to evaluate areas.

In Pacific Region, the DFO criteria were applied previously to identify EBSAs in the Northern Shelf Bioregion, Southern Shelf Bioregion and Strait of Georgia Bioregion (Clarke and Jamieson 2006a, Clarke and Jamieson 2006b, Jamieson and Levesque 2014) (Figure 1.1). These EBSA evaluations employed a modified Delphic (i.e., expert consultation) process in conjunction with limited data analyses to generate important areas (IAs) for a broad range of species (Clarke and Jamieson 2006a, Clarke and Jamieson 2006b, Jamieson and Levesque 2014). The authors also used a similar modified Delphic approach to identify significant physiographic features that overlapped with species IAs to produce a list of candidate EBSAs and define their boundaries (Clarke and Jamieson 2006a, Clarke and Jamieson 2006b). Areas within these three bioregions, particularly in shallow coastal areas (<50 m depth), were not systematically evaluated against the DFO EBSA criteria, nor were areas in Canada's Offshore Pacific Bioregion (DFO 2012a).

In addition to DFO's (2004) EBSA criteria, Canada endorsed the seven EBSA criteria developed by the Convention on Biological Diversity (CBD) in Annex 1 of Decision IX/20 of COP IX. These CBD criteria are internationally accepted for identifying EBSAs: uniqueness/rarity, importance for species' life history stages, importance for threatened or endangered species, potential for recovery from disturbance, productivity, diversity, and naturalness (CBD 2008). While there is

[1] Canada - British Columbia Marine Protected Area Network Strategy. 2014. (Accessed 06 February 2016)

considerable overlap in the DFO and CBD criteria (Table 1.1), the CBD criteria also include biological diversity, biological productivity, and importance for threatened, endangered, or declining species or habitats. Here we assume a correspondence between DFO's criterion of fitness consequences and CBD's criterion of special importance for life history stages or species. We also assumed correspondence between DFO's criterion of resilience and CBD's criterion of vulnerability, fragility, sensitivity, or slow recovery (Table 1.1).

Table 1.1 Correspondence between DFO (2004) and CBD (2008) EBSA criteria.

DFO (ESR2004/006)	**CBD (Annex 1 of Decision IX/20 of COPIX)**
Uniqueness	Uniqueness or rarity
Aggregation	
Fitness consequences	Special importance for life history stages or species
Resilience	Vulnerability, fragility, sensitivity, or slow recovery
Naturalness	Naturalness
	Importance for threatened, endangered or declining species and/or habitats
	Biological productivity
	Biological diversity

The CBD criteria were applied during a workshop to areas in the North Pacific Ocean and led to the identification of twenty EBSAs, including the northeast Pacific seamounts, the northeast Pacific hydrothermal vents, the Emperor Seamount Chain, the North Pacific Transition Zone (NPTZ), and important seabird foraging areas (CBD 2014). The CBD workshop also relied on expert knowledge whereby scientists were invited to develop proposals for EBSA identification using a standard template provided by the CBD Secretariat in advance of the meeting (CBD 2014). The EBSA evaluation included a literature review, relevant data analyses, and a means of structuring information used to assess areas against each of the CBD criteria. The template included space for an abstract, introduction, description of the location, the feature description, its condition and future outlook and an assessment table. Once populated with information, each template was reviewed and revised as needed by workshop participants. Consensus was then achieved on the relative rankings of each criterion and the overall merits of the feature as an EBSA. No formal rules were adopted for determining whether or not a feature was ecologically or biologically significant (as in DFO 2004) beyond noting that a feature could be an EBSA if it ranked highly on any of the seven criteria, but confidence in the evaluation was strengthened when multiple criteria were scored high. Insufficient time and information meant that not all areas within the North Pacific Ocean were evaluated systematically against the CBD criteria and the workshop participants identified several priorities for further evaluation including complexes of seamounts (CBD 2014). Participants also noted that some of the EBSAs, including the northeast Pacific seamounts and hydrothermal vents, were contiguous with features in domestic waters that had not been identified as EBSAs through national processes and were beyond the scope of the CBD assessment.

The purpose of this research document was to assess features and areas in Canada's Offshore Pacific Bioregion using criteria established by the CBD and DFO. We evaluated five types of features in the Offshore Pacific Bioregion, including the seafloor and water column, against the seven CBD and five DFO EBSA criteria. Specifically, this included hydrothermal vents, seamounts, the continental slope, abyssal/bathypelagic waters, and pelagic/surface waters. For each of these, we defined the known marine features and their associated fauna, reviewed the processes that create or maintain these features, evaluated these features with respect to each of the EBSA criteria, giving each criterion a rank in terms of importance (high, medium, low, or no information), and proposed the boundaries of features or areas that meet EBSA criteria. In the case of the continental slope, although portions of this area were evaluated by Clarke and Jamieson (2006b) and Jamieson and Levesque (2014), we re-evaluated the slope in terms of its benthic attributes because previous analyses had focussed predominantly on oceanographic (pelagic) features. Features within the Offshore Pacific Bioregion were evaluated against 8 criteria using a template modified from the CBD (Table 1.2).

Table 1.2 The CBD evaluation template, modified to include DFO criteria.

CBD EBSA Criteria (Annex I to decision IX/20)	**Description** (Annex I to decision IX/20)	**Ranking of criterion relevance** (please mark one column with an X)			
		No information	**Low**	**Medium**	**High**
Uniqueness or rarity	Area contains either i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or ii) unique, rare or distinct, habitats or ecosystems; and/or iii) unique or unusual geomorphological or oceanographic features.				
Rationale:					
Special importance for life-history stages of species	Areas that are required for a population to survive and thrive. Areas that have important fitness consequences.				
Rationale:					
Importance for threatened, endangered or declining species and/or habitats	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.				

CBD EBSA Criteria (Annex I to decision IX/20)	Description (Annex I to decision IX/20)	Ranking of criterion relevance (please mark one column with an X)			
		No information	**Low**	**Medium**	**High**
Rationale:					
Vulnerability, fragility, sensitivity, or slow recovery	Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.				
Rationale:					
Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.				
Rationale:					
Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.				
Rationale:					
Naturalness	Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.				
Rationale:					
Importance for species aggregation (DFO criterion)	Area where species aggregation for important life cycle functions (breeding/spawning, rearing, feeding, migrating, etc).				
Rationale:					

In accordance with guidance by DFO (2004, 2011), the significance of each criterion was evaluated relative to other adjacent or surrounding areas in the bioregion. For example, biodiversity supported by hydrothermal vents was evaluated in relation to the surrounding seafloor, while the productivity of seamounts was evaluated relative to the surrounding seafloor plains and pelagic waters. In the case of the continental slope, because the area being evaluated was large and diverse, the surrounding areas were considered to be the continental shelf at the upper edge of the slope and the abyssal plain at the lower edge. The criterion of uniqueness was evaluated at both regional and global scales as recommended by DFO (2004, 2011). Once all of the criteria were ranked, we determined which features/areas were EBSAs according to DFO (2004) criteria. This paper is organized according to templates developed for each of the five types of features evaluated. These templates serve as the basis for developing science advice to address the terms of reference for the Pacific Regional Science Advisory Process to identify ecologically and biologically significant areas (EBSAs) in the Offshore Pacific Bioregion from 11-12 February 2015.

1. Provide evidence and justification indicating which areas or features in the Pacific Offshore Ecoregion from the shelf break to Canada's EEZ, including the seafloor and water column, meet EBSA criteria, using the best available information and the criteria defined by DFO (DFO, 2004) and the CBD.
2. For the Pacific Offshore Ecoregion areas or features identified in Objective 1: propose EBSA boundaries (including maps), and indicate the level of confidence associated with the delineation of identified EBSAs, including sources of uncertainty.

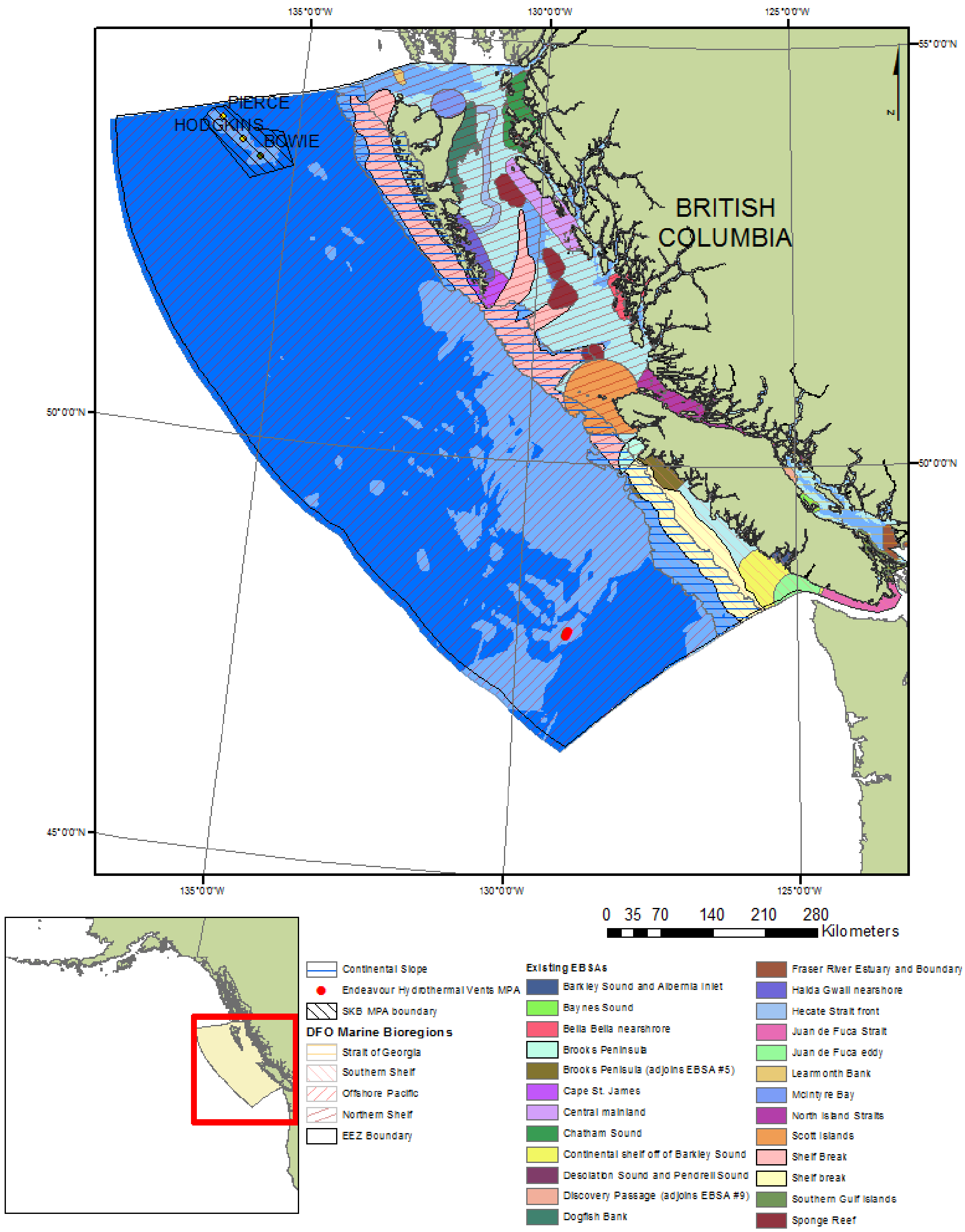


Figure 1.1. Map of study area and previously-identified EBSAs and MPAs. Note: Actual boundaries of the Endeavour Hydrothermal Vents MPA are too small to be seen at this scale. (DataBc 2014)

2 HYDROTHERMAL VENTS

2.1 INTRODUCTION

Hydrothermal vents are chemosynthetically driven ecosystems that support a diverse array of unique organisms. Globally, they are a relatively rare and unique geological feature associated with the spreading of tectonic plates (Figure 2.1). The hydrothermal fluid, which vents from cracks in the oceanic crust, is rich in hydrogen sulphide and a variety of metal oxides, allowing for multiple different pathways for primary production by chemosynthetic bacteria. Sulphides and metals precipitating from the hydrothermal fluid accrete to create elaborate sulphide structures capable of supporting immense biomass.

Hydrothermal vents vary in size, structure, fluid chemistry, and thermal properties (Tsurumi and Tunnicliffe 2003), and are associated with diverse, unique and endemic faunal assemblages. Faunae associated with hydrothermal vents are distinct over short and long distances and vary according to the physical, chemical, and thermal properties of the vents. Faunae associated with hydrothermal vents are adapted to dynamic and extreme habitats and exhibit unusual life history strategies and physiologies, including the capacity for chemosynthesis and tolerating extremely warm or saline water. McArthur and Tunnicliffe (1998) estimate that 82% of vent animals are endemic to hydrothermal vent environments, not occurring in any other marine setting.

The hydrothermal vents in Canada’s Offshore Pacific Bioregion are located on the northeast Pacific ridge system, a mid-ocean spreading ridge off the west coast of Vancouver Island, Canada. Endeavour Hydrothermal Vents were first discovered in 1982. Active vents and vent fields in Canadian waters range in depth from 1850 m (Magic Mountain) to 3000 m (West Valley) (Beaulieu 2010). The northeast Pacific ridge system is a medium activity location that spreads an average of 56 mm yr^{-1}, compared with the highly active East Pacific Rise (77-194 mm yr^{-1}), and the relatively inactive Gakkel Ridge (10 mm yr^{-1}) found in the Arctic Ocean (Beaulieu 2010). Hydrothermal vent fields are located in rift valleys and arranged linearly along the ridge axis at irregular intervals (Tunnicliffe et al. 1998). The ridge valleys host current dynamics that are distinct from those on surrounding abyssal plains.

Models available for the geology and oceanography of the hydrothermal vents in the area describe different vents and vent fields with respect to hydrothermal vent fluid formation, circulation, and physical characteristics; formation and physical properties of hydrothermal structures; and current dynamics of ambient seawater at multiple scales, among other characteristics (Speer and Rona 1989). Species distribution models have been used to describe different sets of biogeographic provinces in the world’s oceans (e.g., Tunnicliffe 1997, Bachraty et al. 2009). The majority of these models use biotic features (e.g., species distribution, richness) together with abiotic features to construct ecologically reasonable distributions. On a local scale, models describe local patterns of community composition, succession, biomass, and richness, among other characteristics (e.g., Sarrazin and Juniper 1999).

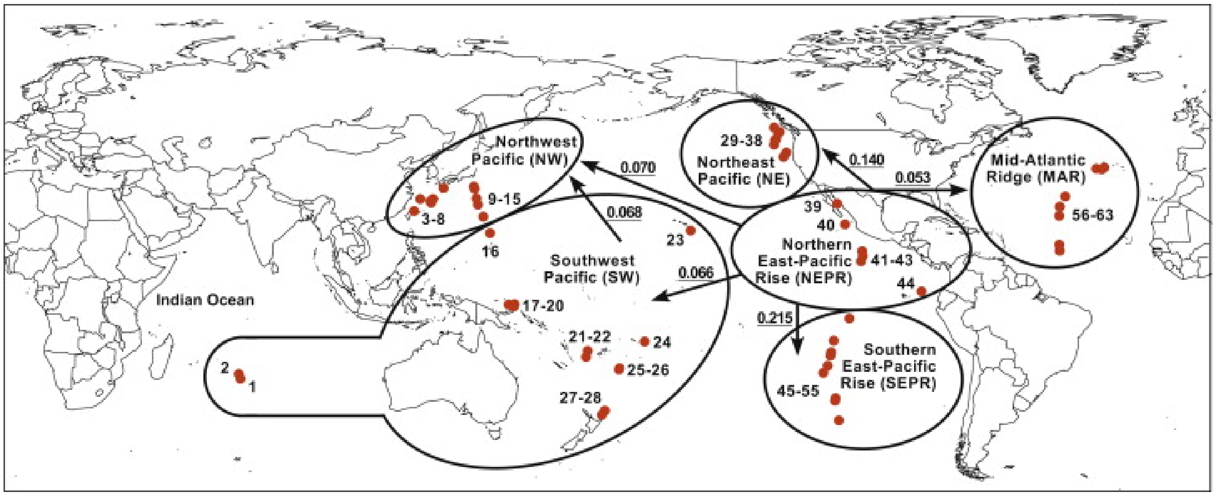


Figure 2.1. Global biogeographic model of the 6 hydrothermal vent provinces proposed by (Bachraty et al. 2009). Used with permission.

2.2 LOCATION

The northeast Pacific ridge system ranges from 52-41°N latitude and from 185-280 km off the west coast of Vancouver Island (Table 2.1, Figure 2.2a). The system is made up of three ridge segments separated by two offset faults (Figure 2.3). The northernmost Explorer Ridge and a portion of the Juan de Fuca Ridge are located in Canadian waters, while the southernmost Gorda Ridge is located in American waters. Of the 37 hydrothermal vent fields found along the Northeast Pacific ridge system (Beaulieu 2010), 18 are within Canadian jurisdiction, 12 are in international waters, and 7 are under the jurisdiction of the USA (Figure 2.2a). The vent fields are arranged mostly linearly along the ridge axes (Tunnicliffe et al. 1998), with the exception of the Baby Bare-Grizzly Bare Seamount complex in Canadian waters, which is an off-axis volcano. Within each vent field multiple sulphide structures form a complex of interconnected hydrothermal vents. Of the vent fields in Canadian waters, 11 are confirmed active, 4 are inferred active, and 3 are inactive sulphide deposits (Beaulieu 2010) (Figure 2.2b). Only vents that fall within Canadian waters were evaluated with respect to EBSA criteria here. However, given that the tectonic processes giving rise to the hydrothermal vents along the Explorer, Juan de Fuca, and Gorda Ridges are related, that these vent fields are similar in terms of structures, biological communities, and degree of endemism (Tunnicliffe et al. 1986), and that they are spatially proximate, the whole set of hydrothermal vents that fall along these ridges can be considered a meta-community. This feature straddles international waters, and the jurisdictions of Canada and the USA. With the exception of the Baby Bare-Grizzly Bare Seamount complex, all known hydrothermal vent fields in the northeast Pacific Ocean occur within 33 km of the main ridge and fault axes (Lavelle et al. 2003, Beaulieu 2010). Baby Bare Seamount is located roughly 100 km east of the Endeavour segment of the Juan de Fuca Ridge and measures 1 km x 0.5 km x 70 m (Becker et al. 2000). Fluid input for hydrothermal venting at Baby Bare Seamount comes from downdrafting of water from Grizzly Bare Seamount, located 52 km to the south-southwest (Jungbluth et al. 2013). The Baby Bare-Grizzly Bare Seamount complex is also included in this EBSA as an off-axis volcano complex with an active vent field.

Table 2.1. Location and feature information for hydrothermal vent fields within Canada's Offshore Pacific Bioregion (Beaulieu 2010). Data source available at InterRidge Vents Database 2.2)

Hydrothermal vent field	Latitude	Longitude	Maximum or single reported depth (m)
Dellwood Seamount	50.8579	-129.3515	800
Explorer Deep	50.0833	-129.7500	3200
Magic Mountain	49.7500	-130.2667	1850
Magic Mountain, 3 km south	49.7250	-130.2667	1850
West Valley Segment	48.4833	-129.0417	3000
Middle Valley, Dead Dog Vent Field	48.4567	-128.7083	2450
Middle Valley, Bent Hill Massive Sulphide	48.4500	-128.6783	2400
Middle Valley, ODP Mound	48.4300	-128.6816	2440
ET	48.1993	-128.9257	2500
Sasquatch Field	47.9970	-129.0660	2200
Salty Dawg Field	47.9820	-129.0760	2200
High Rise Field	47.9667	-129.0900	2200
Raven	47.9583	-129.0833	2180
Main Endeavour Field	47.9500	-129.1000	2220
Mothra Field	47.9230	-129.1090	2270
Baby Bare Seamount	47.7100	-127.7870	2600
Split Seamount	47.6400	-128.9667	2350
Not Dead Yet	46.6899	-129.3772	2419

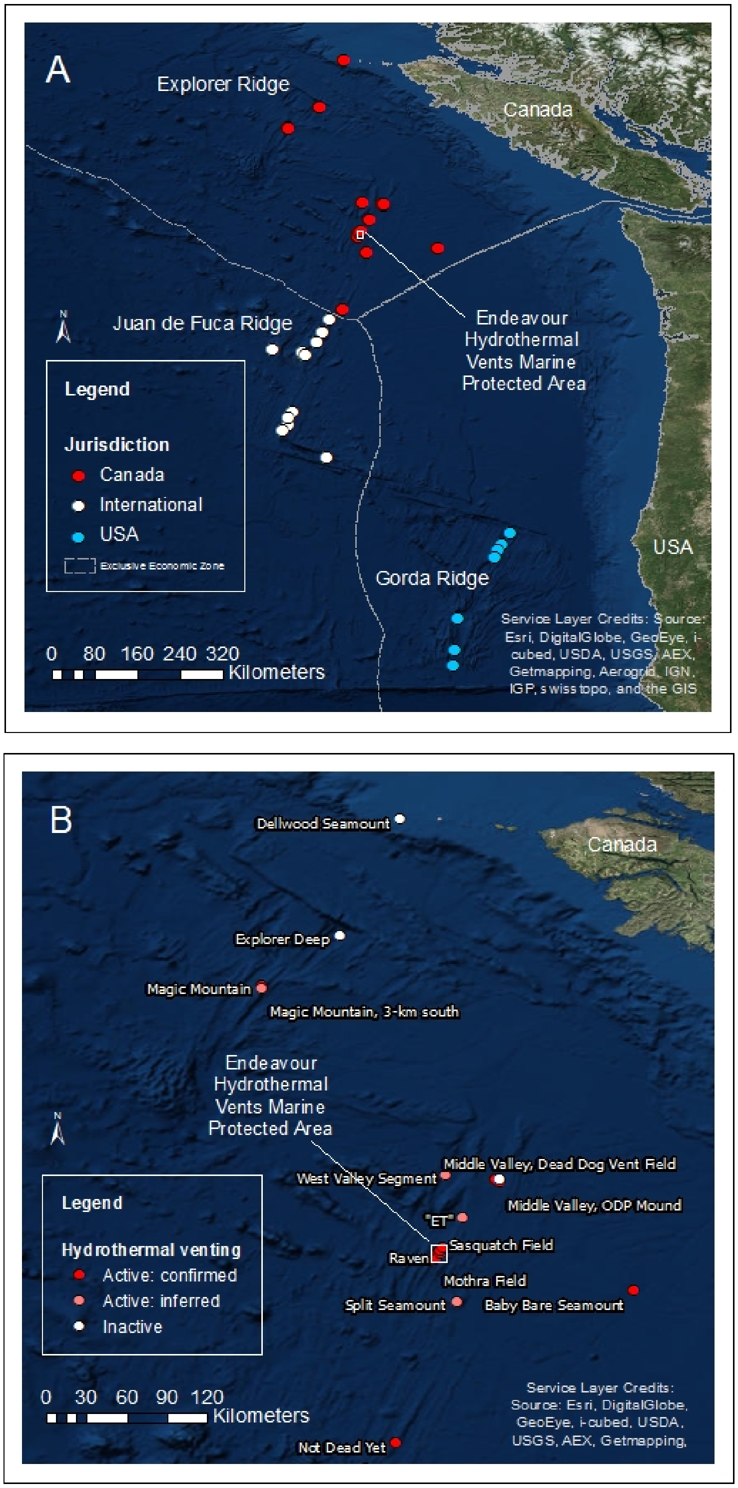


*Figure 2.2. Map of the hydrothermal vent fields in the northeast Pacific Ocean (A) and within the Canadian Exclusive Economic Zone (B). *Note: some hydrothermal vent site names are not shown. See Table 2.1 for a complete list of Canadian vent field names. The EBSA will encompass all of the hydrothermal vent fields within Canada's Offshore Pacific Bioregion (Beaulieu 2010): Data source available at InterRidge Vents Database 2.2); (Claus et al. 2014): Data source available at Marineregions).*

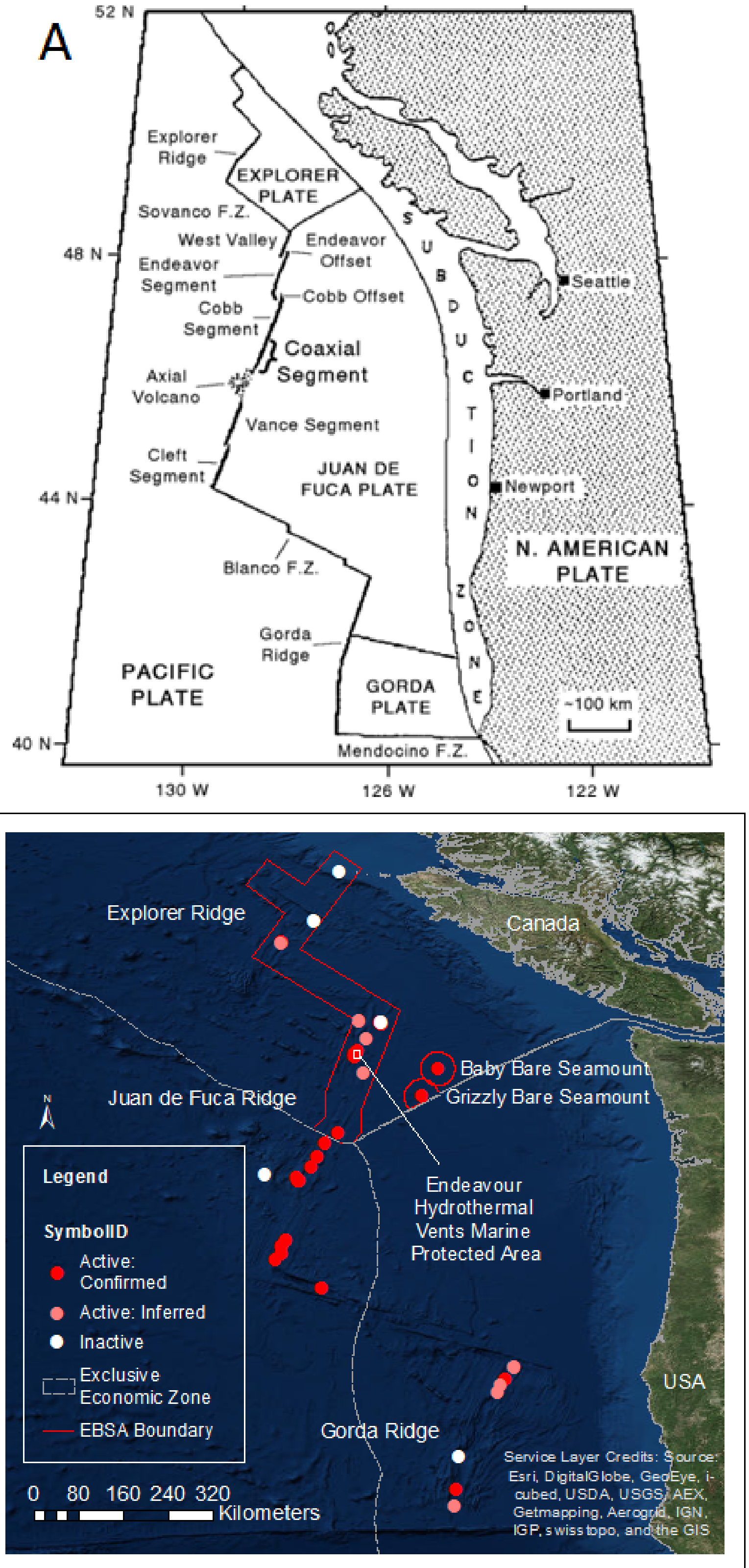


Figure 2.3. Representative map of all ridge segments in the northeast spreading ridge system (top) and topographic map outlining the boundaries of the Hydrothermal Vents EBSA (bottom) within Canada (Claus et al. 2014): Data source available at Marineregions.

2.3 FEATURE DESCRIPTION OF THE EVALUATED AREA

Sulphide structures, which form from a buildup of sulphides and metals precipitating from hydrothermal vent fluids and gases, vary in structure and composition within and among hydrothermal vent fields and ridges. Within the Offshore Pacific Bioregion, three types of vents are found on Explorer Ridge and Juan de Fuca Ridge: vents rich in abiotic iron and zinc; high temperature vents rich in H_2S, and vents associated with lower temperatures (Tunnicliffe et al. 1986). Despite a common source of hydrothermal vent fluid, sulphide structures within a vent field can vary in fluid composition (Butterfield et al. 1994), flow (Delaney et al. 1992), and temperature (Delaney et al. 1992). Venting temperatures up to 400 °C are reported from black smoker chimneys (Butterfield et al. 1994), but temperatures from diffuse venting in the same Endeavour vent field can range as low as 8-15 °C (Delaney et al. 1992). Vigorously venting hydrothermal fields can produce large (e.g. 1000 m^3), steep-sided deposits of sulphide-sulfate-silica (Delaney et al. 1992) that can attain diameters >30 m and heights >25 m (Tunnicliffe et al. 1986, Delaney et al. 1992). High densities of sulphide structures and associated fauna can occur on small scales (e.g., 200m x 400m; Delaney et al. 1992) and be surrounded by many smaller inactive sulphide structures (e.g., Delaney et al. 1992). Kelley et al. (2001) observed structures spaced 40-200 m apart that were awash in venting fluids ranging from 30-200 °C that supported diverse macrofaunal and microbial communities. Fluid flow and temperature patterns show decimeter scale variability, creating patchiness in the resources available for chemosynthesis and ecological interactions within hydrothermal vent communities (Sarrazin and Juniper 1999).

Within Canada's Offshore Pacific Bioregion there are some fundamental geological differences between hydrothermal vent sites. Canadian hydrothermal vent systems are primarily driven by tectonic processes rather than volcanic ones, as in the Axial volcano system. This difference makes Canadian hydrothermal vent systems relatively more stable than their international counterparts. Middle Valley on the Juan de Fuca Ridge is a heavily sedimented ridge that is covered in 200 to over 1000 m of turbidite sediment (Hannington et al. 2005). This sedimentation retains heat and precipitated metals and protects the sulphide deposits from seafloor weathering and oxidation, which promotes the formation of some of the world's largest polymetallic sulphide (PMS) deposits (Hannington et al. 2005). Another site with large PMS deposits, Explorer Ridge, is characterized by old pillow basalt with large sulphide spires coalescing to form sulphide mounds up to 25 m in height (Tunnicliffe et al. 1986). Similar to Explorer Ridge, the Endeavour segment of the Juan de Fuca Ridge hosts large sulphide structures, some over 30 m tall. Endeavour segment is one the most active hydrothermal area on the mid-ocean ridge system (Kelley et al. 2002) with greater than 800 chimneys over 15 km. In contrast to the hydrothermal vent fields on or close to ridge axes, the Baby Bare-Grizzly Bare Seamount complex is an off-axis volcano located on the eastern flank of the Juan de Fuca Ridge. Grizzly Bare is a recharge seamount where water is drawn down through the seamount into the igneous basement then travels from Grizzly Bare to Baby Bare, where it vents out as hydrothermal vent fluid (Wheat et al. 2000). Despite differences in the geological setting between individual vent sites, the Canadian hydrothermal vents as group contrast starkly with the surrounding abyssal plain, and will be evaluated as one large EBSA.

The microbial communities associated with hydrothermal vents in the northeast Pacific Ocean are diverse, rare, and unique in terms of physiologies, metabolism, thermal tolerance, and halotolerance. At hydrothermal vents in the northeast Pacific Ocean, microbes are ubiquitous, being found in hydrothermal fluids, in mats covering vent substrates, on the tubes and bodies of vent organisms and in elaborate symbioses with hydrothermal vent invertebrates. The extreme temperatures of hydrothermal fluids support a variety of hyperthermophiles, and the hydrogen sulfilde and reduced metal compounds support a diverse array of chemoautotrophs. Among the metabolic pathways supported are methanogenesis, aerobic and anaerobic methane oxidation, nitrification, denitrification, sulfate reduction, and degradation of complex carbon substrates (Wang et al. 2009). Microbes are highly variable in density and composition among hydrothermal vent sites, which can support dense microbial communities of archaebacteria, Thiobacilli, and barophilic eubacteria (Hedrick et al. 1992). In a study by Zhou et al. (2009), high microbial diversity at the Dudley hydrothermal site included clones belonging to *Thermococcales* and deep-sea hydrothermal vent *Euryarchaeota* (DHVE). The associated microbes were characterized by thermophilic or hyperthermophilic physiologies. Sulphur-related metabolism by thermophilic archaea and mesophilic bacteria was common at the Dudley hydrothermal site (Zhou et al. 2009). Kaye and Baross (2000) found halotolerant bacteria from Endeavour (Juan de Fuca Ridge), and in the same area, De Angelis et al (1993) found evidence that microbial methane oxidation can play an important role in productivity. The most notable metabolic pathway, due to its varied use by numerous taxa and its large contribution to the primary production of hydrothermal vents, is sulphide oxidation. Unique vent organisms, such as the polychaete worm, *Ridgeia piscesae*, live in symbiosis with sulphide oxidizing bacteria, providing hydrogen sulphide, carbon dioxide, and oxygen to the symbionts and receiving fixed carbon in return.

Hydrothermal vent macrofaunal species characteristic of hydrothermal vents include the tubeworm *Ridgeia piscesae*, common to >50 vents in the northeast Pacific Ocean, including Gorda Ridge (Southward et al. 1995). Another tubeworm species, *Lamellibrachia barhami,* was found at the sedimented Middle Valley on Juan de Fuca Ridge (Southward et al. 1996) but is rare in comparison to *R. piscesae*. More generally, vent communities in the northeast Pacific Ocean include terebellids, vestimentifera, phyllodocids, vetigastropods, caenogastropods, pycnogonids, capitellids, solenogasters, and crustaceans (Sarrazin and Juniper 1999).

Axial Volcano exhibits the highest richness and diversity in a comparison of sites in three segments of the Juan de Fuca Ridge, but the density of fauna associated with vestimentiferan tubeworm bushes was similar across sites (Tsurumi and Tunnicliffe 2003). Thus, community structure may be more influenced by substratum, vent flow characteristics and the structure of the tubes of tubeworms, than by location. Fauna associated with tubeworm tube bushes were dominated by four taxa: two gastropods (*Lepetodrilus fucensis* and *Depressigyra globulus*) and two polychaetes (*Paralvinella pandorae* and *Amphisamytha galapagensis*) (Tsurumi and Tunnicliffe 2003). Vestimentiferan worms were found on small sulphide mounds whereas high temperature vents appeared to attract alvinellid polychaetes (Tunnicliffe and Juniper 1990) and larger structures were inhabited by more species, potentially reflecting greater diversity of habitats. *Lepetodrilus fucensis*, *Depressigyra globulus* and *Provanna variabilis* were most abundant at varying distances (0-75 cm) from vent flows with temperatures varying on average from 3-10°C (Bates et al. 2005).

Endemic species and distinct macrofaunal assemblages are noted from surveys of Juan de Fuca Ridge (e.g. Chase 1985, Tunnicliffe 1988), although they are generally lower in diversity than East Pacific Rise vents to the south (Tunnicliffe 1988). (Tunnicliffe et al. 1993) describe a new polychaete, *Paralvinella sulfincola*, which inhabits tubes on the sides of active smoker chimneys venting fluids in excess of 300 °C. Fourteen vent animals previously unreported from the caldera of Axial Seamount were noted by Chase (1985), including a new vestimentiferan with intracellular bacteria, two alvinellid polychaetes in the genus *Paralvinella*, a tropical vent polychaete species, *Amphysamytha galapagensis*, two new polynoid polychaetes, three gastropods in new subfamilies, a copepod found in a tubeworm tube, and a few tiny bivalves that appear to be related to mussels and clams from other vents.

More mobile species, such as the Majid crab (*Macroregonia macrochira*) are also associated with hydrothermal vents. The majid crab is a predator of hydrothermal vent species, occurs in greater densities around vent sites in the northeast Pacific Ocean, and plays a role in transferring production from chemosynthesis to the surrounding deep-sea environment (Tunnicliffe and Jensen 1987). High mortality rates of vestimentiferan tubeworms were associated with falling sulphate/sulphide spires and predation by rattail fish and polynoid polychaetes (Tunnicliffe 1990). Distinct and more abundant assemblages of vertically migrating zooplankton occupy the water column above the hydrothermal plume of the main vent field on Endeavour Ridge (Burd and Thomson 1994), thereby linking the deep sea vent communities to pelagic ecosystems.

On a global scale, barriers to dispersal causing isolation may result in different sets of hydrothermal vent species that evolve separately, but fill the same niches (Tunnicliffe et al. 1996, Tunnicliffe et al. 1998). Vestimentiferans are genetically structured within the northeast Pacific Ocean indicating limited gene flow over long distances (Southward et al. 1996). There appears to be significant larval retention on the scale of vent fields and ridge segments (Metaxas 2004) in the NE Pacific Ocean, possibly because the location of hydrothermal vents within mid-ocean ridges shields them from currents (Thomson et al. 2003, Metaxas 2004). To illustrate distribution patterns at the global scale, Tunnicliffe (1997) proposed the first biogeographic model for hydrothermal vents, which outlined 7 biogeographic provinces. Since then, several authors have proposed revised models, with the number of provinces in each model ranging from 4 to 9 (Mironov et al. 1998, Tunnicliffe et al. 1998, Tyler and Young 2003). Desbruyeres et al. (2006) created a database containing presence-absence data for 592 species and 332 genera in 63 hydrothermal vent fields around the world. Bachraty et al. (2009) used these data to update the biogeographic model for hydrothermal vents and also modeled dispersal direction between provinces. These authors outlined 6 different biogeographic provinces and stressed the need for genetic analysis to support proposed biogeographic models. Interestingly, all but one of the proposed models designates the Northeast Pacific as its own separate biogeographic province, indicating that this area is unique among the hydrothermal vents of the world.

On a local scale, spatio-temporal distribution of communities on sulphide structures has been described in several studies and models (e.g., Fustec et al. 1987, Tunnicliffe and Juniper 1990, Hannington and Juniper 1992, Segonzac et al. 1993), but few models have focused exclusively on vents in the Northeast Pacific Ocean, and few have been based on time-series observations. Sarrazin *et al.* (1997) created a community successional model based on 4 years of time series video imagery. Sarrazin and Juniper (1999) refined this model after quantifying species composition, richness, and biomass for each of the community types as well as for the entire sulphide structure under examination. This was the first quantitative community succession model for hydrothermal vents in the Northeast Pacific Ocean. The authors identified 6 different succession assemblages and found that, as the succession sequence progressed, species richness, biomass, and density increased. Comparable community succession models, with different species composition, have been proposed for hydrothermal vents in other bigeographic areas (e.g, Shank et al. 1998 - East Pacific Rise).

2.4 FEATURE CONDITION AND FUTURE OUTLOOK OF THE EVALUATED AREA

The Endeavour Hydrothermal Vents Marine Protected Area (MPA) was identified as Canada's first MPA on March 4, 2003. The MPA is managed by DFO and aimed at conserving a highly productive and unique habitat. In the MPA, there are designated areas for scientific sampling as well as no-take, no-disturbance areas that remain relatively untouched. This MPA falls within the boundaries of the EBSA (Figure 2.3). In 2013, a risk assessment for the Endeavour Hydrothermal vents MPA found that the main stressors within the MPA were research activities, including vessel traffic and equipment installation and abandonment (K. Thornborough, DFO, Sidney, B.C., personal communication, 2014).

Hydrothermal vents that fall outside the MPA may be affected by deepsea commercial fishing activities or research surveys that employ fishing gears that contact the seafloor. While several studies discuss the destructive effects of bottom-contact fishing gears on benthic habitat (e.g. review for deep-sea coral communities in Roberts and Hirshfield (2004), there are no data on the impacts of these fisheries on the hydrothermal vents in the EBSA. Given that bottom-contact fisheries can cause extensive mechanical damage, the main impacts of fishing would likely be defaunation and damage or collapse of sulphide edifices, having similar impacts as tectonic disturbances and scientific sampling, but possibly on a much larger scale. Most commercial bottom-contact fishing within Canada's Offshore Pacific Bioregion has taken place in areas that are shallower than the depth of known hydrothermal vent fields (Driscoll et al. 2009). Only 0.05% of commercial catch records from this bioregion between 2006 and 2014 were from gear set deeper than 1850 m, which is shallower than the depth of most (17/18) of the known vent fields in Canadian waters. However, with its relatively shallow summit (800m), the delicate structures within the vent fields at Dellwood Seamount may be vulnerable to damage by fishing gears that contact the seafloor. Approximately 9% of commercial fishing records from this bioregion were from gear set deeper than 800m and Dellwood Seamount is known to have been commercially fished for Sablefish (*Anoplopoma fimbria*) since 1983. It is possible that fishers avoid known hydrothermal vent fields because of the risk of gear entanglement. The extent of the threat to hydrothermal vents from commercial fishing as well as illegal and unreported fishing in Canadian waters is currently unknown.

The polymetallic sulphide (PMS) deposits that form hydrothermal vent structures contain metals such as copper, zinc, silver, and gold, that are of interest to the mining industry. Currently there are several mining companies investigating the possibilities of mining seafloor massive sulphides (Scott 2001). In 2011, Nautilus Minerals was granted the world's first polymetallic sulphide deposit mining lease by the government of Papua New Guinea and mining operations will commence in 2018. The PMS deposits of the Solwara 1 project in Papua New Guinea contain much higher concentrations of gold and silver than do the PMS deposits in the Northeast Pacific Ocean, but the PMS deposits on the Southern Explorer Ridge in the Northeast Pacific Ocean are some of the largest in the world (Hannington et al. 2011). Estimates of gold and silver content in 10 of the largest PMS deposits on the Southern Explorer Ridge range from 2.0-3.4 tonnes of gold and 255-396 tonnes of silver (Hannington and Scott 1989).

There are 3 stages in the mining process: prospecting, exploration, and exploitation and all have associated impacts on the surrounding ecosystem. To date, no commercial PMS deposit mining has occurred, which makes it difficult to predict potential impacts. Several studies (e.g. Van Dover 2007, 2011; Gwyther 2008) have outlined the potential impacts of PMS mining, which include alteration of seafloor structure and hydrothermal fluid flow and smothering of the surrounding communities by sediment plumes from mining operations, among others. It is unknown if or when PMS deposit mining would occur in Canadian waters.

Other potential future threats to hydrothermal vents in the northeast Pacific Ocean include bioprospecting, geothermal exploitation, and eco-tourism. It is unknown if and when these may become threats and what the impacts might be.

2.5 ASSESSMENT OF THE AREA AGAINST CBD EBSA CRITERIA

<table>
<tr><th rowspan="2">CBD EBSA Criteria
(Annex I to decision IX/20)</th><th rowspan="2">Description
(Annex I to decision IX/20)</th><th colspan="4">Ranking of criterion relevance
(please mark one column with an X)</th></tr>
<tr><th>No information</th><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><td>Uniqueness or rarity</td><td>Area contains either
i) unique (“the only one of its kind”), rare (occurs only in few locations) or endemic species, populations or communities, and/or
ii) unique, rare or distinct, habitats or ecosystems; and/or
iii) unique or unusual geomorphological or oceanographic features.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">The EBSA hosts numerous species that are only found at the hydrothermal vents in the northeast Pacific Ocean. Among the endemic macrofaunal species are Paralvinella sulfincola, a pioneer species that is first to colonize newly formed habitat, and Ridgeia piscesae, a primary producing symbiotic keystone species whose tubes increase available surface area for colonization). Other endemic macrofaunal species include Paralvinella palmiformis, Lepetodrilus fucensis, and Depressigyra globulus. In a study of macrofaunal biogeography, Tunnicliffe (1988) estimated that 50% of the macrofaunal species observed at sampling sites on the Juan de Fuca Ridge were endemic to hydrothermal vents of the northeast Pacific Ocean.

In the northeast Pacific Ocean, colonization patterns are characterized by 5 to 6 different assemblages colonizing in succession, with a patchy distribution of local populations in various stages of succession at any given point in time (Sarrazin and Juniper 1999). Hydrothermal vents on the East Pacific Rise show similar community succession processes (Shank et al. 1998), but the species involved are different as vents of the northeast Pacific Ocean host an endemic assemblage of vent fauna (Tunnicliffe 1988). In multiple bigeographic models of global hydrothermal vent systems, the northeast Pacific Ocean was designated as its own, separate biogeographic province, further supporting a unique faunal distribution.

Given that hydrothermal vents host unique species and community structure, as well as unique geological processes and features, and that primary production is chemosynthetic (rare), the area is highly unique.</td></tr>
<tr><td>Special importance for life-history stages of species</td><td>Areas that are required for a population to survive and thrive. Areas that have important fitness consequences.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">The sessile benthic invertebrates as well as most of the mobile benthic invertebrates at hydrothermal vents rely on bacterial chemosynthetic primary production, which requires the hydrogen sulphide and other reduced compounds found in hydrothermal vent fluid. With the high degree of endemism found in the EBSA, the absence of hydrothermal vents in the Northeast Pacific Ocean would result in a significant loss of unique species from multiple taxonomic and trophic levels. Even non-hydrothermal vent species that are not directly dependent on hydrothermal vents for nutrition require these environments as breeding and nursery grounds. The life histories of these non-vent species would be significantly altered without this crucial habitat.</td></tr>
<tr><td>Importance</td><td>Area containing habitat for the survival</td><td>X</td><td></td><td></td><td></td></tr>
</table>

for threatened, endangered or declining species and/or habitats	and recovery of endangered, threatened, declining species or area with significant assemblages of such species.				
There is insufficient information available at this time to evaluate hydrothermal vents on the basis of this criterion.					
Vulnerability, fragility, sensitivity, or slow recovery	Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.				X
The elaborate structure of sulphide edifices creates large surface areas for colonization by hydrothermal vent fauna. After the first year of community succession, dense forests of vestimentiferan tubeworms have colonized, the surfaces of their tubes creating additional surface area for colonization (Sarrazin et al. 1997). However, hydrothermal communities are highly susceptible to frequent tectonic events (Tunnicliffe and Juniper 1990), which can cause large fluctuations in hydrothermal fluid flow and alter habitat structure. Within minutes of a disturbance event at the northeast Pacific hydrothermal vents, mobile species begin to move into denuded areas (Sarrazin et al. 1997), but it can take much longer (5 to 10 years at the East Pacific Rise) for a community to recover to the late stages of succession (Shank et al. 1998). Also, sessile organisms, such as *Ridgeia piscesae*, are not able to maintain their populations once disturbed (Tunnicliffe and Juniper 1990). Furthermore, in extreme cases tectonic activity can cut off the fluid supply to an area or cause the collapse of entire sulphide structures. When a vent structure collapses, not only are most of the animals either crushed or starved, but the surface area that has developed over decades is no longer available for recolonization. To a lesser degree, the hydrothermal vents in the EBSA are also susceptible to human activity through scientific sampling. In an observational study conducted over 4 years at hydrothermal vents on the Juan de Fuca Ridge, Tunnicliffe and Juniper (1990) found that vents that had been sampled the most showed the greatest differences in visual changes to community structure. They list excavation, removal of sulphides, animal sampling, and accidental damage by submersible as common types of scientific sampling disturbances but caution that this was not an experimental study, rather a series of incidental observations. Hydrothermal vents are highly variable areas that experience frequent natural disturbance events and may also be affected by human activities. Though primary succession is rapid for a given area, recovery from disturbance events is slow, and in many cases complete recovery is not possible.					
Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.				X
In relation to the surrounding marine benthic habitat, hydrothermal vents are well known oases of high animal density and biomass (e.g., Corliss et al. 1979, Grassle 1985). Sarrazin et al. (1999) estimated biomass for an entire sulphide structure in the northeast Pacific Ocean and found the values comparable to those of the most productive marine environments, including photosynthetic environments as well as other hydrothermal vents and cold seeps. In the absence of active venting, biological productivity would be significantly reduced, as the food web structure and flow of energy depend almost exclusively on chemosynthesis.					

<table>
<tr><td>Biological diversity</td><td>Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">While species diversity at hydrothermal vents in the northeast Pacific Ocean is relatively low compared to other hydrothermal vent systems, the diversity of community types is higher than in the surrounding abyssal plain environment. Sarrazin and Juniper (1999) report 5-6 dominant faunal assemblages, which are present in a mosaic structure with decimeter-scale patchiness at hydrothermal vents in the northeast Pacific Ocean. Hydrothermal vents in the Offshore Pacific Bioregion are noted for their exceptionally diverse microbial communities.</td></tr>
<tr><td>Naturalness</td><td>Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Hydrothermal vents are at least 200 million years old, but they weren’t discovered until 1977. As of 1998, over 500 new animal species had been described from the hydrothermal vent environment and greater than 80% of these species were new to science. Most activities involving vent fields are related to scientific research, meaning that hydrothermal vents are relatively untouched environments. The degree to which vent fields on Dellwood Seamount have been affected by fishing activities is not known, but 17/18 of the known vent fields in Canada’s Offshore Pacific Bioregion generally fall outside the areas usually commercially fished. In 2003, Canada identified the Endeavour Hydrothermal Vents Marine Protected Area (MPA) on the Endeavour segment of the Juan de Fuca Ridge. The MPA has designated no-take, no disturbance areas aimed at conserving a highly productive and unique habitat (DFO 2009b).

Hydrothermal vents, in general, have a high degree of naturalness due to their relatively recent discovery and remote location and the EBSA includes a Marine Protected Area.</td></tr>
<tr><td>Importance for species aggregation (DFO criterion)</td><td>Area where species aggregation for important life cycle functions (breeding/spawning, rearing, feeding, migrating, etc).</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">All of the hydrothermal vent organisms rely on hydrothermal vent chemosynthetic primary productivity for survival, which means that all of these species spend their lives aggregated on or around hydrothermal vents.</td></tr>
</table>

2.6 SUMMARY

Hydrothermal vents score as “high” on all EBSA criteria except for importance for threatened or endangered species, for which insufficient information exists to evaluate the criterion. The EBSA includes all active and inactive hydrothermal vents within Canada’s Offshore Pacific Bioregion, the hydrothermal plume above them, the substrate and hydrothermal cells beneath them, the rift valleys within which new vents may form with tectonic movement, and all of the fauna associated with these features. Inactive vent fields were included as part of the EBSA as they host novel assemblages and geomorphic features even though venting has ceased. The EBSA boundaries (Figure 2.3) include all areas within 33 km of the main ridge and fault axes (i.e., the maximum distance at which a vent has been found from the ridge) and 300 m above the valley floor, which encompasses the hydrothermal plume. This EBSA boundary is intended to capture the potential emergence of any new hydrothermal vents in the Offshore Pacific Bioregion. The hydrothermal vent EBSA boundary also includes a 30 km radius around the summits of Baby

Bare and Grizzly Bare Seamounts and the water column above these footprints (see section 3.6 for further detail on seamount boundaries). There may be other hydrothermal vent fields associated with seamounts not included in the seamounts EBSA (Section 3) that have yet to be discovered.

3 SEAMOUNTS

3.1 INTRODUCTION

Globally, very little information exists regarding seamounts considering their uniqueness and targeted use by commercial fishing. Within Canada's Offshore Pacific Bioregion, Bowie Seamount has been the subject of most scientific studies; although commercial fishery catch records and geological data exist from other seamounts, data regarding the biota and oceanographic characteristics of other seamounts in Canadian waters are relatively scant, and much more is known about shallower seamounts (e.g., Cobb and Bowie Seamounts) than deeper ones (Table 3.1). Therefore, we evaluate seamounts in the Offshore Pacific Bioregion collectively by drawing inferences from studies and surveys conducted on Bowie Seamount and other seamounts in the northeast Pacific Ocean, including Cobb Seamount approximately 500 km west of the Oregon coast.

Seamounts are features of considerable biological and oceanographic interest because of their often distinct species assemblages and enhanced biological productivity. A seamount is an underwater mountain that has an elevation of more than 1,000 m from the seafloor (Yesson et al. 2011). Features between 500 m and 1,000 m from the seafloor are designated as knolls and those under 500 m as hills (United States Board of Geographic Names 1981). The Pacific Ocean has a large number of seamounts over 1,000 m – likely more than 30,000 – far more than in the Atlantic Ocean, with only ~800 (Epp and Smoot 1989). In the northeast Pacific specifically, the Cobb-Eickelberg Seamount chain stretches from ~500 km off the west coast of Oregon to the Aleutian Islands. Within Canadian waters, there are 18 named seamounts and perhaps as many as 36 seamounts in total (Kitchingman and Lai 2004) (Figure 3.1). Bowie, Cobb and Union Seamounts are three of only five shallow (i.e. summit depth < 500 m) seamounts in the northeast Pacific Ocean (Canessa et al. 2003). Northeastern Pacific seamounts – including those in Canada's Offshore Pacific Bioregion, the focus of this report – are the result of volcanic activity along the Cascadia subduction zone, and thus are geologically young, ranging from 27.6 to 33 million years in age (Desonie and Duncan 1990).

Seamounts have varying effects on local and even regional circulation patterns, depending on their height, shape, and position relative to other seafloor features. At the local scale, these effects include the production of eddies and Taylor columns (Roden 1991), the formation of trapped waves (Eriksen 1991), and the amplification of tidal currents (Noble and Mullineaux 1989). At broader scales, seamounts can deflect major oceanic currents (Vastano and Warren 1976, Zhang and Boyer 1991).

Although the flow patterns around Canada's Pacific seamounts remain largely unstudied, observations from Cobb Seamount (25 m summit depth) in international waters, which has a similar summit depth to Bowie Seamount (28 m), may provide some insight into general oceanographic patterns at shallow seamounts. At Cobb Seamount, a dome of cold, upwelled water was observed over the seamount, as well as a persistent closed eddy that lasted nearly a month (Dower and Fee 1999).

Seamounts are biologically productive and diverse. The circulation patterns associated with seamounts often result in increased biological productivity and may entrain propagules and other planktonic particles over a seamount for weeks or months, thus producing biological communities that are unique or endemic to particular seamounts (Rogers 1993). In addition, seamounts typically offer hard substrates and hydrothermal or biogenic sediments that support deep water corals (Stone and Shotwell 2007); models of habitat suitability and species distribution indicate that northeastern Pacific seamounts should provide suitable habitat for cold water octocorals (Davies and Guinotte 2011, Yesson et al. 2012). The community composition of some pelagic species also tends to differ over seamounts, particularly that of nektonic and micronektonic organisms (Boehlert and Seki 1984). Other studies have found higher diversity and abundance of demersal and benthopelagic fish species associated with seamounts (Parin and Prut'ko 1985, de Forges et al. 2000, Muhlia-Melo et al. 2003, Morato and Clark 2008). Seamounts contain aggregations of higher trophic-level species, but it is unclear whether these aggregations are directly attributable to increased primary productivity, or whether seamounts attract predators for other reasons, such as increased access to, or vulnerability of, vertically migrating zooplankton (Marshall 1979).

Table 3.1. Ecosystem evaluation framework (EEF) for Cobb Seamount, Bowie Seamount, Dellwood, Heck and Union Seamounts, and all other seamounts in the Offshore Pacific Bioregion. Modified from Pitcher et al (2007) and updated with data from Fisheries and Oceans Canada (DFO). Colours indicate level of knowledge: red – unknown; orange – inferred; blue – known; green – well-known. Information from Cobb Seamount in international waters is provided for comparison. - depth dependent.*

	Seamount attributes	Cobb Seamount	Bowie, Hodgkins and Davidson Seamounts	Dellwood, Heck, and Union Seamounts	All other Offshore Pacific Bioregion Seamounts
Physical and Oceanographic factors	Depth of Peak (summit depth)	Well-known	Well-known	Well-known	Well-known
	Depth of Surrounding Ocean	Well-known	Well-known	Well-known	Well-known
	Height of Peak	Well-known	Well-known	Well-known	Well-known
	Slope of seamount	Well-known	Well-known	Known	Known
	Proximity to shelf	Well-known	Well-known	Well-known	Well-known
	Proximity to neighbouring seamounts	Well-known	Well-known	Well-known	Well-known
	Ocean currents link to shelf	Known	Known	Inferred	Inferred
	Ocean currents to neighbor seamounts	Well-known	Known	Inferred	Inferred
	Taylor cap forms	Well-known	Inferred	Unknown	Unknown
	Presence of hydrothermal vent fields	Known	Known	Known	Known

	Seamount attributes	Cobb Seamount	Bowie, Hodgkins and Davidson Seamounts	Dellwood, Heck, and Union Seamounts	All other Offshore Pacific Bioregion Seamounts
Ecological factors	Macrophytes present	Well-known	Well-known	Unknown	Inferred
	Corals present	Known	Known	Known	Inferred*
	Larval settlement regime	Known	Known	Unknown	Unknown
	Nutrient upwelling occurs	Well-known	Known	Inferred	Inferred*
	Phytoplankton enhancement	Well-known	Known	Inferred	Inferred*
	Zooplankton enhancement	Known	Known	Inferred	Inferred*
	Deep scattering layer organisms entrapped	Unknown	Unknown	Unknown	Unknown
	Settled filter feeders	Well-known	Known	Inferred	Inferred*
	Zooplankton migrates in feeding range	Unknown	Unknown	Unknown	Unknown
	Predators/grazers present	Well-known	Known	Known	Inferred
	Detritus build-up present	Known	Inferred	Inferred	Inferred
	Detritivores present	Well-known	Well-known	Known	Inferred
	Small resident invertebrate predators	Well-known	Known	Known	Inferred
	Small resident fish predators	Well-known	Known	Known	Inferred
	Resident cephalopods	Known	Known	Known	Inferred
	Aggregating deep sea fish	Unknown	Unknown	Unknown	Unknown

Seamount attributes	Cobb Seamount	Bowie, Hodgkins and Davidson Seamounts	Dellwood, Heck, and Union Seamounts	All other Offshore Pacific Bioregion Seamounts
Visiting fish predators	Well-known	Well-known	Known	Inferred*
Visiting elasmobranch predators	Well-known	Well-known	Known	Inferred*
Visiting marine turtles	Unknown	Unknown	Unknown	Unknown
Visiting mammal predators	Known	Well-known	Inferred	Inferred*
Visiting seabird predators	Well-known	Well-known	Inferred	Inferred*
COSEWIC/IUCN-listed species present	Well-known	Well-known	Known	Inferred*
Endemic fauna	Known	Known	Unknown	Unknown

Detailed oceanographic profiles of Canada's Pacific seamounts are limited; however, coarse-scale datasets indicate that all have very similar surface salinity and dissolved oxygen profiles. A north-south gradient in surface temperature means that northern seamounts experience cooler surface temperatures than the southern ones (Figure 3.4). The conditions at-depth, however, vary considerably. Temperature and oxygen at-depth have been estimated using data from the World Ocean Atlas that were collated from ship transect, buoy, and Argo float data (Locarnini et al. 2013, Zweng et al. 2013, Garcia et al. 2014) and are summarized in Table 3.2.

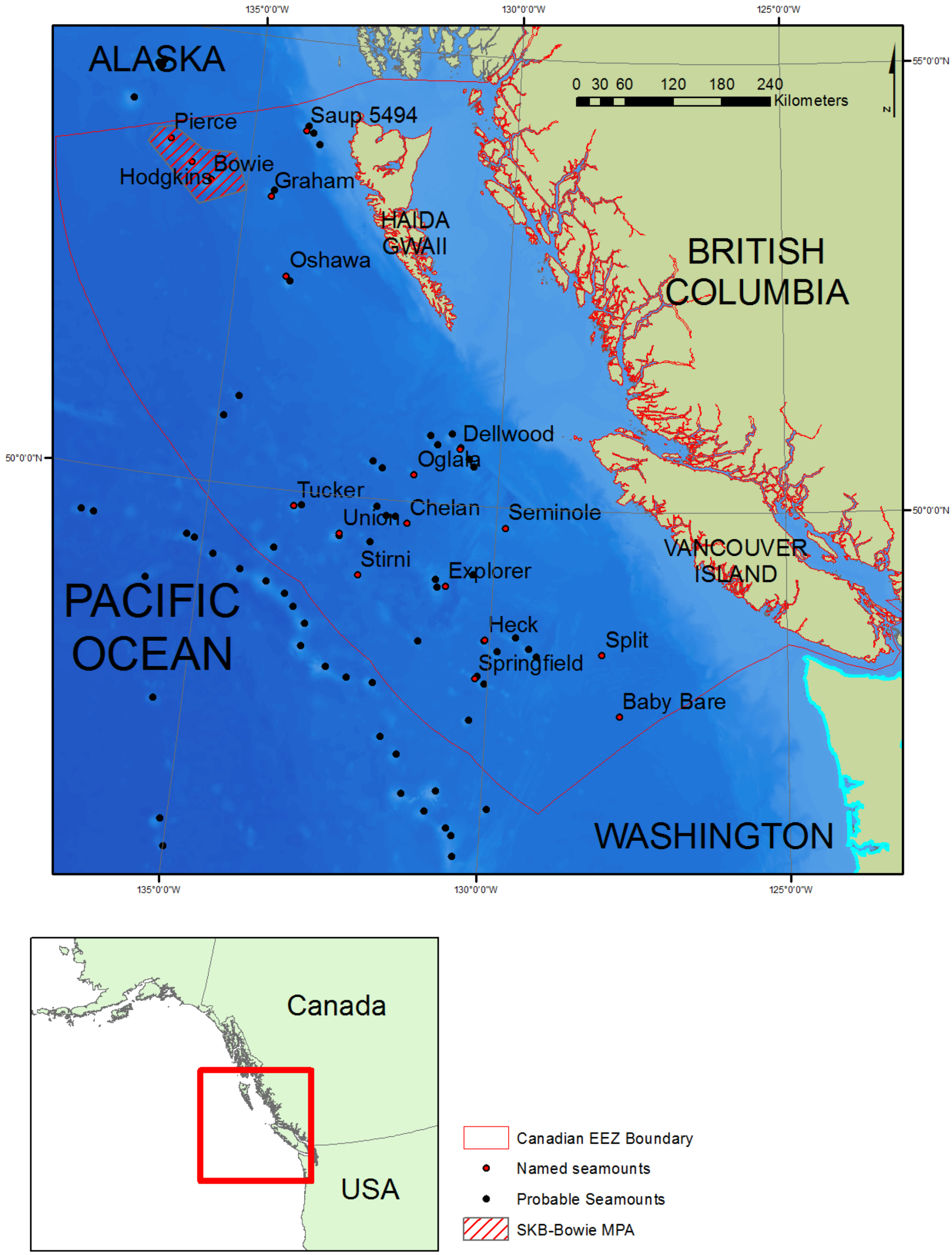
Table 3.2. Temperature and oxygen at-depth of named seamounts estimated from World Ocean Atlas (2013) data. Summit depths from (British Columbia Marine Conservation Analysis Project Team 2011), (Canessa et al. 2003), and (Barr 1974a).

Seamount	Estimated temp. at depth (°C)	Estimated Oxygen Conc. at depth (mL/L)	Lat.	Long.	Summit depth below surface (m)	Depth zone
Baby Bare	1.8	1.8	47.71	-127.79	2600	Abyssalpelagic
Bowie	9.8	6.7	53.33	-135.67	24-28	Photic/Epipelagic
Chelan	2.4	0.6	49.75	-131.53	1459	Bathypelagic
Dellwood	2.9	0.5	50.73	-130.90	300	Mesopelagic
Dellwood South	2.6	0.5	50.60	-130.72	1218	Bathypelagic
Explorer	3.6	0.4	49.08	-130.80	830	Mesopelagic
Graham	2.4	0.7	53.23	-134.52	1474	Bathypelagic

Seamount	Estimated temp. at depth (°C)	Estimated Oxygen Conc. at depth (mL/L)	Lat.	Long.	Summit depth below surface (m)	Depth zone
Heck	2.8	0.5	48.51	-130.07	1080-1320	Bathypelagic
Hodgkins	3.7	0.5	53.50	-136.08	790	Mesopelagic
Oglala	2.6	0.5	50.30	-131.47	1372	Bathypelagic
Oshawa	1.9	1.5	52.37	-134.08	2127	Abyssalpelagic
Pierce (Davidson)	2.2	0.6	53.73	-136.53	1809	Bathypelagic
Saup 5494	?	?	54.00	-134.00	?	?
Seminole	2.2	1.0	49.77	-129.83	1653	Bathypelagic
Split	1.8	1.9	47.64	-128.97	2350	Abyssalpelagic
Springfield	3.5	0.4	48.07	-130.20	938	Bathypelagic
Stirni	2.4	0.7	49.13	-132.30	1710	Bathypelagic
Tucker	2.6	0.5	49.83	-133.50	1242	Bathypelagic
Union	5.3	3.0	49.58	-132.67	290-293	Mesopelagic

3.2 LOCATION

Within the Exclusive Economic Zone (EEZ) of Canada's Pacific waters, there are 18 named seamounts (Figure 3.1), with summit depths ranging from 28 metres below the surface to 2.6 km (Table 3.2). Kitchingman and Lai (2004) modeled (based on changes in relief using medium-resolution (2 arc-minute) bathymetry) up to 36 potential seamounts within Canada's EEZ, of which at least 13 correspond to named seamounts. Canada's Pacific waters contain what are likely two seamount complexes, and several isolated seamounts. The first is the Kodiak-Bowie Seamount complex which lies along the northwestern edge of the EEZ, and contains the Pierce (also known as Peirce or Davidson), Hodgkins, and Bowie Seamounts.



Probable seamount locations from Kitchingman and Lai (2004)
Named seamounts from BC Marine Conservation Analysis (2011) and InterRidge Vents Database 2.2 (2010)

Figure 3.1. Location of named and unnamed seamounts within Canada's Pacific waters. Yellow line denotes continental margin; red line denotes extent of Canada's Exclusive Economic Zone (EEZ).

The second chain occurs on the Explorer ridge where Explorer, Union, and Heck (or Heckle) Seamounts are located. Isolated seamounts include Chelan, the Dellwood Seamount chain (also known as the Dellwood Knolls), Graham, Oglala, Oshawa, Seminole, Springfield, Stirni, and Tucker Seamounts. One unnamed seamount appears in the Seamounts Online database (Seamount Biogeosciences Network 2014) as Saup 5494, with depth unreported.

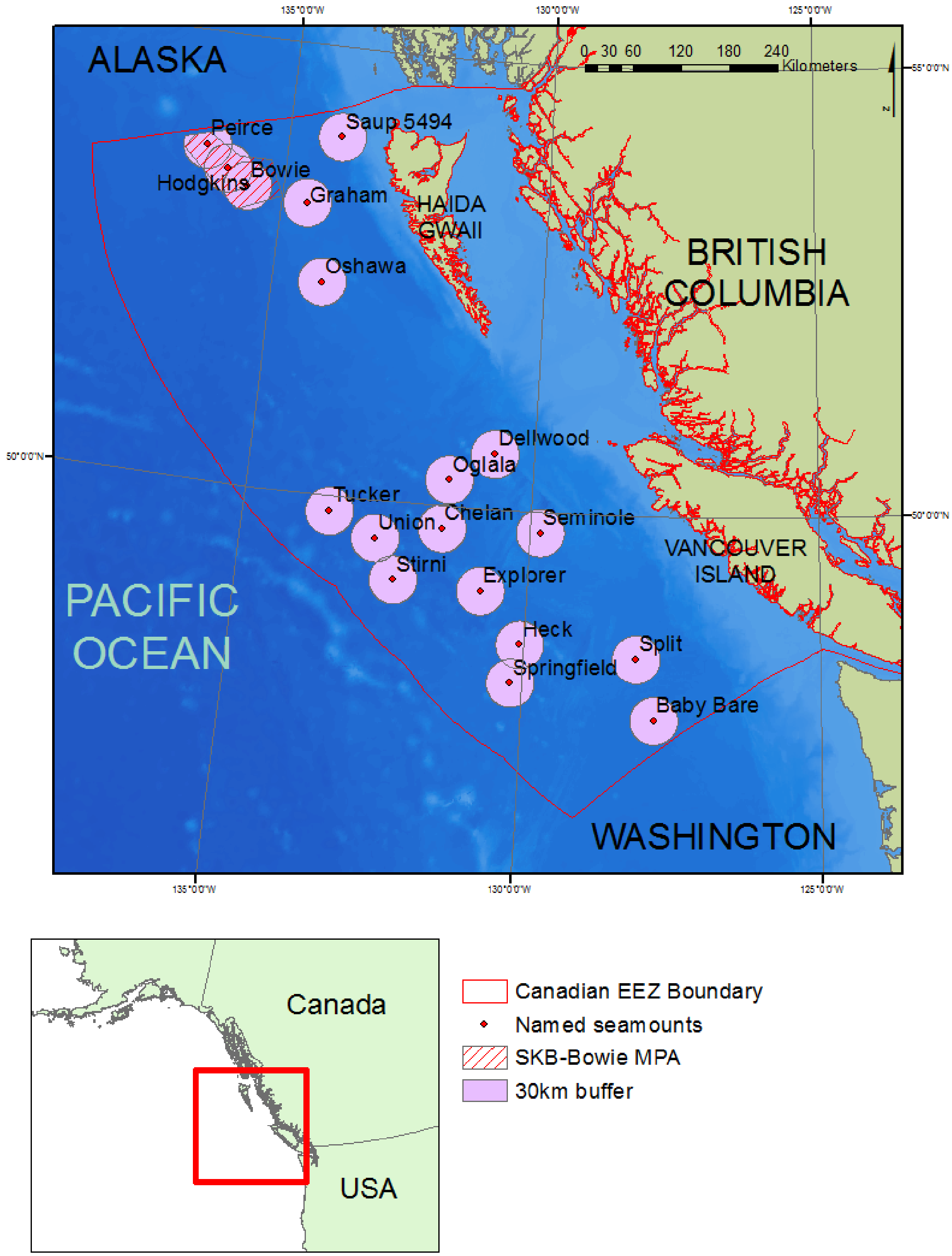
3.3 FEATURE DESCRIPTION OF THE EVALUATED AREA

While few of the seamounts in Canada's Offshore Pacific Bioregion have been surveyed, it is possible that each location supports distinct and discrete biological communities, unique assemblages, and endemic species (Tunnicliffe et al. 1998, McClain et al. 2009). The overall level of biodiversity on seamounts is likely similar to that on the continental margin (O'Hara 2007, Lundsten et al. 2009, McClain et al. 2009). Seamounts generally have a varied and complex topography of pinnacles, plains, and ridges that create numerous habitat types which support distinct communities (DFO 2011). For example, surveys of Cobb Seamount (outside of Canada's EEZ, but in a similar oceanographic setting) have counted 269 taxa from 14 phyla and 27 orders (Budinger 1967, Birkeland 1971, Du Preez et al. 2015). Limited surveys have also been conducted on Bowie, Dellwood, and Union Seamounts (Appendix Table A 1-Table A 3), but these species lists are unlikely to be complete given the relatively low sampling effort – particularly at Dellwood and Union Seamounts. Generally, Crustacea are the most common taxonomic group found on seamounts, but this may be an artifact of sampling bias. Other common groups include anthozoans, gastropods, bivalves, echinoids, ophiuroids, asteroids, polychaetes, hexactinellids, bony fishes, and elasmobranchs (Birkeland 1971, Morato and Pauly 2004, Du Preez et al. 2015).

Seamounts provide important habitats for many species of conservation concern, as well as commercially and recreationally valuable species. In particular, rockfish species, halibut, sablefish, marine mammals, sea birds, alcyonancean corals and others are known to be associated with seamounts. Because Bowie Seamount has been the site of most ecological surveys in the Canada's Offshore Pacific Bioregion, much of our understanding of seamounts draws on available information from this seamount. However, Bowie Seamount is particularly unique because it is the only seamount with a summit within photic depths; all of the other seamounts within this bioregion range from mesopelagic (<1,000m) to abyssalpelagic (>2,000m) in depth (Table 3.2). Surveys of the Kodiak-Bowie Seamount chain have indicated that both deepwater and coastal species can be found in this area (Canessa et al. 2003).

Vulnerable marine ecosystem (VME) indicator species adopted by the North Pacific Fisheries Commission (NPFC) in 2009 include three orders of coldwater corals: Alcyonacea[2], Antipatharia, and Scleractinia. To date, 17 species belonging to these orders have been identified on Cobb Seamount (Du Preez et al. 2015); Table 3.3). Bowie Seamount is also known to support populations of VME indicator species in the orders Alcyonacea and Scleratinia, but few invertebrates at Bowie Seamount have been identified to lower taxonomic levels (Canessa et al. 2003). Both Cobb and Bowie Seamounts support dense populations of *Stylaster* spp. A detailed list of species observed during submersible surveys carried out on Bowie Seamount in 2011 are not yet available for inclusion in this working paper. However, Yamanaka (2005) and McDaniel et al. (2003) list species observed during underwater surveys carried out in the shallow zone of Bowie Seamount, <250m depth.

[2]Gorgonacea was also adopted by the NPFC as a VME indicator, but this order is synonymous with Alcyonacea (Mees et al, 2015).



Named seamounts from BC Marine Conservation Analysis (2011) and InterRidge Vents Database 2.2 (2010)

Figure 3.2. Locations of seamount EBSAs, derived using a 30 km buffer around each named seamount pinnacle.

Table 3.3. Indicator species of vulnerable marine ecosystems (VMEs) observed on or collected from Cobb Seamount during the past five decades (Du Preez et al. 2015). Species are grouped according to the three orders of coral identified as VME indicators by the North Pacific Fisheries Commission (NPFC) in 2009.

Alcyonacea	Antipatharia	Scleractinia
Gersemia sp.	Antipatharia sp. (unidentified)	*Desmophyllum dianthus*
Heteropolypus ritteri	*Bathypathes* sp.	*Lophelia pertusa*
Isidella sp.	*Lillipathes* cf *lillei*	
Keratoisis sp.	*Parantipathes* sp.	
Lepidisis sp.	*Stichopathes* sp.	
Narella sp.		
Paragorgia sp.		
Plumarella superba		
Primnoa cf pacifica		
Swiftia simplex		

Nine of the coldwater coral species observed on Cobb Seamount belong to two orders (Antipatharia, Scleractinia) and one family (Stylasteridae) that are listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Table 3.4). CITES Appendix II is used to manage the international trade of listed taxa to ensure sustainable use. While the conservation status of corals known to occur on Cobb Seamount has not been assessed by the International Union for the Conservation of Nature (IUCN), nor by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), four elasmobranchs and four rockfishes are listed by CITES, IUCN or COSEWIC due to conservation concerns (Table 3.4). Shortspine Thornyhead (*Sebastolubus alascanus*), listed as Endangered by the IUCN (IUCN 2014), was captured annually in the Sablefish fishery on Cobb Seamount from 2007-2011 (Appendix Table A 1). Longspine Thornyhead (*S. altevelis*), assessed as Special Concern by COSEWIC (COSEWIC 2015), are also captured by the fishery. Other species captured in the groundfish surveys for the Bowie/Hodgkins, Dellwood, and Union Seamounts are listed in Appendix Table A 2 - Table A 4.

Table 3.4. Taxa observed on Cobb Seamount and included on CITES (Convention on International Trade of Endangered Species of Wild Fauna and Flora) Appendix II or the IUCN (International Union for the Conservation of Nature) Red List. Where relevant, the present status in Canada as assessed by COSEWIC (Committee on the Status of Wildlife in Canada) is also included (COSEWIC 2015).

Classification	Species	CITES	IUCN	COSEWIC
Class Elasmobranchii	*Prionace glauca* Blue Shark	-	Near Threatened	Data Deficient
Class Elasmobranchii	*Hexanchus griseus* Bluntnose Sixgill Shark	-	Near Threatened	Special Concern
Class Elasmobranchii	*Carcharodon carcharias* Great White Shark	Appendix II	Vulnerable (A2cd+3cd)	Data Deficient
Class	*Raja binoculata*	-	Near Threatened	Not at Risk

Classification	Species	CITES	IUCN	COSEWIC
Elasmobranchii	Big Skate			
Class Actinopterygii	*Sebastes paucispinis* Bocaccio Rockfish	-	Critically Endangered (A1abd+2d)	Endangered
Class Actinopterygii	*Sebastes ruberrimus* Yelloweye Rockfish	-	-	Special Concern
Class Actinopterygii	*Sebastolobus altivelis* Longspine Thornyhead	-	-	Special Concern
Class Actinopterygii	*Sebastolobus alascanus* Shortspine Thornyhead	-	Endangered (A2d)	-
Class Anthozoa Order Antipatharia (Black corals)	Antipatharia sp.(unidentified)	Appendix II	-	-
Class Anthozoa Order Antipatharia (Black corals)	*Bathypathes* sp.	Appendix II	-	-
Class Anthozoa Order Antipatharia (Black corals)	*Lillipathes lillei*	Appendix II	-	-
Class Anthozoa Order Antipatharia (Black corals)	*Parantipathes* sp.	Appendix II	-	-
Class Anthozoa Order Antipatharia (Black corals)	*Stichopathes* sp.	Appendix II	-	-
Class Anthozoa Order Scleractinia (Stony corals)	*Desmophyllum dianthus*	Appendix II	-	-
Class Anthozoa Order Scleractinia (Stony corals)	*Lophelia pertusa*	Appendix II	-	-
Class Anthozoa Family Stylasteridae (Hydrocorals)	*Stylaster verrillii* *Stylaster campylecus*.	Appendix II	-	-

In total, more than 158 taxa have been observed at Bowie Seamount (See full species list in Canessa et al. 2003) and 269 at Cobb Seamount (Du Preez et al. 2015). Numerous species of commercial and conservation importance are known to occur on seamounts in Canada's Pacific waters. The following taxa are highlighted in the following sections: rockfish, Pacific Halibut, Sablefish, marine mammals, seabirds, and deepwater corals.

Rockfish: Bowie, Dellwood, and Union Seamounts are known to provide suitable rockfish habitat. Individuals from the the Rougheye/Blackspotted Rockfish complex, Redbanded Rockfish (*S. babcocki*), Silvergray Rockfish (*S. brevispinis*), and Yelloweye Rockfish (*S. ruberrimus*) were captured on Dellwood Seamount (Table A 3), while Aurora Rockfish (*S. aurora*), Canary Rockfish (*S. pinniger*), Chilipepper (*S. goodei*), Pacific Ocean Perch (*S. alutus*), Redbanded Rockfish, Rosethorn Rockfish (*S. helvomaculatus*), Rougheye/Blackspotted Rockfish complex (*Sebastes aleutianus, S. melanostictus*), Shortraker Rockfish (*S. borealis*), Widow Rockfish (*S. entomelas*), Yelloweye Rockfish and Yellowmount Rockfish (*S. reedi*) were reportedly captured on Union Seamount (Table A 4). At least 25 rockfish species have been observed at Bowie Seamount (Table 3.5), of which Rougheye Rockfish, Yelloweye Rockfish (*Sebastes ruberrimus*), and Widow Rockfish (*Sebastes entomelas*) were the most abundant (Canessa et al. 2003, McDaniel et al. 2003, Yamanaka 2005). Of these species, one (Boccacio (*Sebastes paucispinis*)) is listed as Endangered by COSEWIC, three are listed as Threatened, and four are listed as Special Concern. Bowie Seamount also likely supports a self-sustaining population of Widow Rockfish that may be prey for halibut, Sablefish, and other rockfish (Beamish and Neville 2003, Yamanaka 2005). In contrast, the observed age structure (Canessa et al. 2003) and lack of genetic differentiation from coastal populations (Siegle et al. 2013) of Yelloweye Rockfish at Bowie Seamount suggests that they may be immigrating from elsewhere. In addition, the apparent lack of small pelagic fish and the presence of top predators suggests Rougheye Rockfish may be a keystone species at Bowie Seamount, the loss of which were hypothesized to have the potential to lead to a decline or disappearance of Sablefish and halibut (Beamish and Neville 2003).

Depth is believed to be the single most important predictor of rockfish distribution (Young et al. 2010), with abundance and species number generally increasing from depths of 151 to 250 m and decreasing beyond this depth. Some species, however, are found at much greater depths; recent observations from Cobb Seamount have found individuals from the Rougheye/Blackspotted Rockfish complex down to 373 m, Blackgill Rockfish (*Sebastes melanostomus*) down to 556 m, and other unidentified rockfish down to 555 m (Du Preez et al. 2015).

Halibut: Halibut (*Hippoglossus stenolepis*) may be found at depths of up to 1200 m on various bottom types (Eschmeyer et al. 1983), and thus may be expected to occur on Hodgkins, Explorer, Springfield, Union, Dellwood, and possibly Tucker Seamounts.

Sablefish: Sablefish (*Anoploma fimbria*), a demersal species endemic to the North Pacific Ocean, can be found from depths of 175 m to as much as 2700 m, and tend to favour muddy substrates (Eschmeyer et al. 1983). Thus, although all of the seamounts considered here are potential Sablefish habitat in terms of depth range, further benthic classification would be necessary to make a more definitive judgment. Catch data from groundfish surveys show that Sablefish are found at the Bowie, Union, Heck, and Dellwood Seamounts (Lisa Lacko, DFO, Nanaimo, B.C., personal communication, 2015), and they were observed on Cobb Seamount at depths ranging from 903-927 m (Table 3.5). While initially it was thought that Sablefish at Bowie Seamount may be a distinct population from the coast, the weight of evidence suggests that there is continuous movement back and forth between the coast and the seamount (Kabata et al. 1988, Whitaker and McFarlane 1997, Kimura et al. 1998, Beamish and Neville 2003), and that Sablefish form a single biological population throughout their range in the northeastern Pacific Ocean (DFO 2013). The age structure of Sablefish at Bowie Seamount suggests that the population there is not self-sustaining, and it is unknown whether they spawn there (Canessa et al. 2003).

Table 3.5. List of rockfish species observed at Bowie Seamount. Compiled from Canessa et al (2003), McDaniel et al (2003), and Yamanaka (2005).

Common name	Scientific Name	Comments[3]	Number Caught[4]
Rougheye Rockfish	*Sebastes aleutianus*	-	497
Pacific Ocean Perch	*Sebastes alutus*	-	1
Aurora Rockfish	*Sebastes aurora*	-	-
Redbanded Rockfish	*Sebastes babcocki*	-	4
Shortraker Rockfish	*Sebastes borealis*	-	6
Slivergrat Rockfish	*Sebastes brevispinis*	-	3
Darkblotched Rockfish	*Sebastes crameri*	-	-
Splitnose Rockfish	*Sebastes diploproa*	-	-
Greenstriped Rockfish	*Sebastes elongatus*	-	1
Widow Rockfish	*Sebastes entomelas*	"Abundant, schooling over reef"	3
Yellowtail Rockfish	*Sebastes flavidus*	-	-
Rosethorn Rockfish	*Sebastes helvomaculatus*	-	229
Quillback Rockfish	*Sebastes maliger*	-	-
Vermillion Rockfish	*Sebastes miniatus*	-	-
China Rockfish	*Sebastes nebulosus*	-	-
Tiger Rockfish	*Sebastes nigrocinctus*	"Solitary in crevices"	-
Bocaccio Rockfish	*Sebastes paucispinis*	-	-
Canary Rockfish	*Sebastes pinniger*	-	-
Redstripe Rockfish	*Sebastes proriger*	-	-
Yellowmouth Rockfish	*Sebastes reedi*	-	-
Yelloweye Rockfish	*Sebastes rubberrimus*	"Abundant, schooling near bottom"	219
Harlequin Rockfish	*Sebastes variegatus*	"Abundant, schooling over reef"	1
Shortspine	*Sebastolobus*	-	5

[3] From McDaniel, N., D. Swanston, R. Haight, D. Reid and G. Grant (2003). Biological Observations at Bowie Seamount. Preliminary report prepared for Fisheries and Oceans Canada.

[4] From Yamanaka, K.L. 2005. Data report for the research cruise onboard the CCGS John P. Tully and the F/V Double Decker to Bowie Seamount and Queen Charlotte Islands July 31st to August 14th 2000. Can. Data. Rep. Fish. Aquat. Sci. 1163: vii + 46 p.

Common name	Scientific Name	Comments[3]	Number Caught[4]
Thornyhead Rockfish	*alascanus*		
Longspine Thornyhead Rockfish	*Sebastolobus altivelis*	-	-
Longfin Dragonfish	*Tactostoma macropus*	-	-

Marine mammals: Although quantitative data are lacking, the prey aggregation effect of seamounts is likely to attract both piscivorous and planktivorous marine mammals, but this association must be inferred on the basis of habitat suitability monitoring (Kaschner 2008). Seamount density also appears to be a better predictor of marine mammal habitat suitability than the presence of individual seamounts (Kaschner 2008). Steller Sea Lions (*Eumetopias jubatus*), Sperm Whales (*Physeter macrocephalus*), Killer Whales (*Orcinus orca*), Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*), Northern Right Whale Dolphin (*Lissodelphis borealis*), and possibly Striped Dolphins (*Stenella coeruleoabla*) have been observed in the vicinity of Bowie Seamount (Canessa et al. 2003). Pacific White sided Dolphins, Dall's Porpoises (*Phocoenoides dalli*), and Elephant Seals (*Mirounga angustirostris*) have also been seen in the vicinity of Cobb Seamount (Curtis et al. 2015; Ken Morgan, pers. Comm., Environment Canada, Institute for Ocean Sciences, Sidney BC).

Seabirds: Seamounts also act as aggregation points for seabirds (Thompson 2008). Bird species observed at Cobb Seamount which may also be indicative of species likely to be found at shallower seamounts such as Bowie Seamount include Black-footed Albatross (*Phoebastria nigripes*), Sooty Shearwater (*Puffinus griseus*), Fork-tailed Storm Petrel (*Oceanodroma furcata*), Beal's Petrel, and Western Gull (*Larus occidentalis*) or herring gull (*Larus argentatus smithsonianus*), Buller's shearwater (*Puffinus bulleri*), Leach's storm petrel (*Oceanodroma leucorhoa*), red phalarope (*Phalaropus fulicarius*), long-tailed jaeger (*Stercorarius longicaudus*), Arctic tern (*Sterna paradisaea*), rhinoceros auklet (*Cerorhinca monocerata*), and unidentified storm petrels and phalarope species (Thompson 2008) (Curtis et al. 2015; Ken Morgan, pers. Comm, Environment Canada, Institute for Ocean Sciences, Sidney BC). Elsewhere, numerous shearwater species have been found associated with seamounts in both Alaskan and British Columbian waters. The Canadian Wildlife Service has identified Bowie Seamount as an Area of Interest for Migratory Birds, and two SARA-listed species, the Black-footed Albatross (*Phoebastria nigripes*) and Ancient Murrelet (*Synthliboramphus antiquus*), which are known to occur in the Sgaan Kinghlas-Bowie (SK-B) MPA area (Yamanaka 2005). Black-footed albatross, Sooty Shearwater, and Buller's Shearwater are also Red-Listed by the IUCN. However, the degree to which these seabird species aggregate around or depend on seamounts in Canadian Pacific waters is unknown.

Deepwater corals: Coldwater corals are highly diverse and widely distributed on seamounts in the northeast Pacific Ocean (Canessa et al. 2003, Stone and Shotwell 2007, Du Preez et al. 2015). One alcyonacean (soft coral) species known to occur at Bowie Seamount may also be regionally endemic: *Isidella tentaculum* (DFO 2015a). This newly-described bamboo coral species is typically found at depths between 720-1050 m (Etnoyer 2008); at Bowie Seamount it was recovered from a depth of ~750m (DFO 2015a). *Isidella* sp. is a large (up to ~132 cm in height), habitat-forming species, thought to be extremely long-lived, with a lifespan on the order of centuries (Andrews et al. 2005, Etnoyer 2008, Andrews et al. 2009). Also, *Primnoa* sp. is mainly distributed in the protected zone at Bowie Seamount above 457 m.

Seamounts at depths of less than 1500 m are more likely to be suitable habitat for cold-water corals (Davies and Guinotte 2011). Submersible surveys on Bowie and Cobb Seamounts have ranged from the pinnacle to maximum depths of approximately 1150 m. Coldwater corals were found spanning the entire depth range surveyed on Cobb Seamount, from the pinnacle to 1154 m (Figure 3.3). Dense aggregations of *Stylaster* sp., and large bioherms of *Lophelia pertusa* were observed on Cobb Seamount down to depths of approximately 220 m. At depths greater than 446 m, the 10 most abundant taxa included the bamboo coral *Lepidisis* sp., the antipatharian corals *Bathypathes* sp. and *Lillipathes* cf *lillei*, an unknown antipatharian species (Antipatharia sp. 1), and the alcyonacean coral *Heteropolypus ritteri* (Curtis et al. 2015). Groundfish survey data collected from 1963-2014 (DFO 2014a) indicate that at least 15 coldwater coral taxa are distributed along the continental slope at depths between 400-1500 m, including *Primnoa* sp., *Isadella* sp., *Paragorgia* sp., *Lillipathes* sp., *Bathypathes* sp., and several species of antipatharians, sea pens, and hydrocorals.

Deep water corals are also widespread on seamounts in Alaskan waters, including seamounts in the Bering and Beaufort Seas (Stone and Shotwell 2007) and are likely to be found on deeper (i.e. summit depth below photic zone) seamounts elsewhere. Antipatharians and Alcyonaceans have been observed to depths of 4784 m on Gulf of Alaska seamounts and deep water corals are found on all the habitat types defined by Greene et al.(1999), including seamount tops, flanks, and bases. Within Alaskan waters, coral assemblages exhibit high diversity in six major taxonomic groups including true or stony corals (Order Scleractinia), black corals (Order Antipatharia), true soft corals (Order Alcyonacea) including the stoloniferans (Suborder Stolonifera) and sea fans/sea pens (Order Pennatulacea), and stylasterids (Order Anthoathecatae) (Stone and Shotwell 2007). In a review of the state of deep coral ecosystems in the Alaska Region, Stone and Shotwell (2007) documented the distribution of 141 coral taxa in Alaskan waters, including 11 species of stony corals, 14 species of black corals, 15 species of true soft corals (including six species of stoloniferans), 63 species of alcyonaceans, 10 species of sea pens, and 28 species of stylasterids.

Given the broad depth distribution and diversity of coldwater corals known and predicted to occur on northeast Pacific Ocean seamounts, we can infer that these habitat-forming species are likely to occur on all seamounts within Canadian waters.

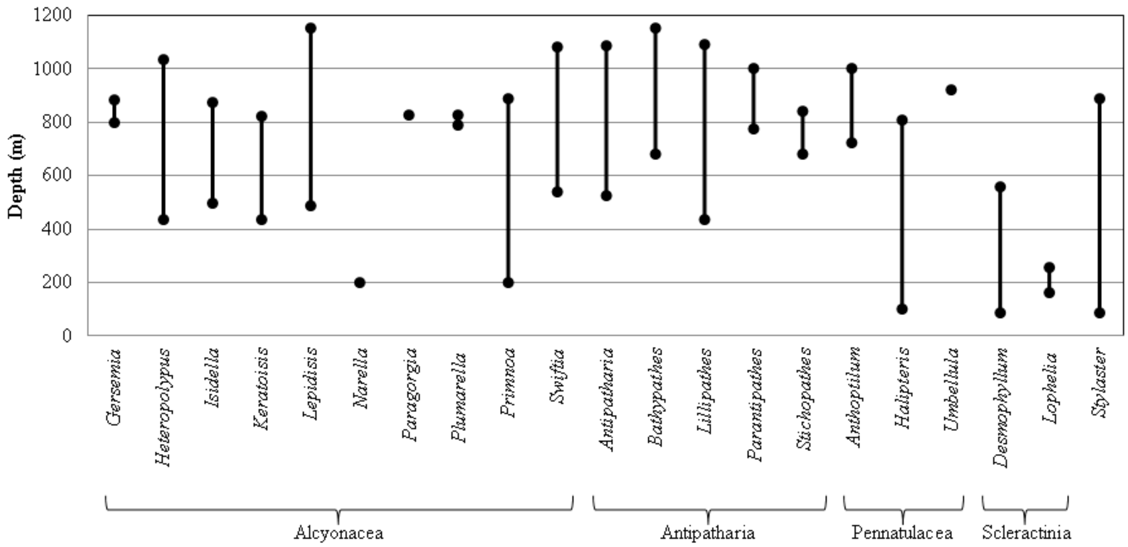


Figure 3.3. Depth distribution of coldwater coral species observed on Cobb Seamount in 2012.

In addition to corals, sponges are highly diverse and widely distributed on seamounts in the northeast Pacific Ocean (Canessa et al. 2003, Leys et al. 2004, Hoff and Stevens 2005, Du Preez et al. 2015). Grey Ridge Sponges (*Penares cortius*) and other encrusting sponges were common at Bowie Seamount (McDaniel et al. 2003), and other unidentified calcareous sponge species have also been observed (Canessa et al. 2003). Hexactinellid (glass) sponges are also known to occur in Canada's Pacific waters (Leys et al. 2004). Although typically found at depths of 500-3000 m, glass sponges have been discovered in much shallower waters in Hecate Strait and the Strait of Georgia (Leys et al. 2004). Hexactinellid sponges were commonly observed on Cobb Seamount from approximately 450–1150 m, while demosponges dominated the sponge community on the shallower plateau and pinnacle (Du Preez et al. 2015). During a survey of Patton Seamount, researchers observed more than 17,680 sponges between 151-3200 m (Hoff and Stevens 2005) (Figure 3.4). Assuming that Hexactinellid and demosponges have similar depth distributions in Canadian waters, we can infer that these important biogenic habitats are also common on seamounts within the Offshore Pacific Bioregion.

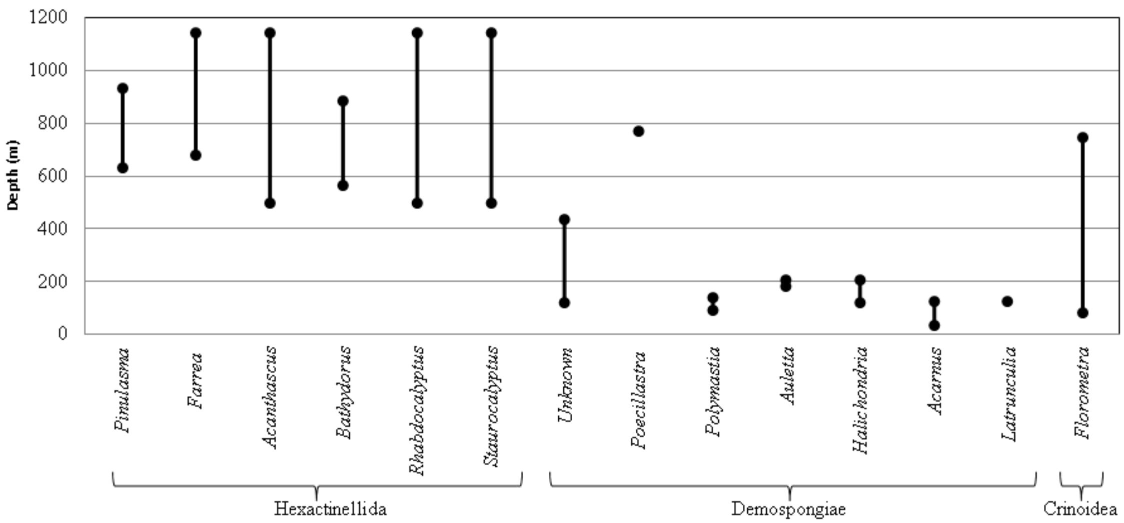


Figure 3.4. Depth ranges of vulnerable marine ecosystem indicator sponge species, and a crinoid observed on Cobb Seamount in 2012.

Other species: Seamounts may also be important habitat for sea turtles (Santos et al. 2008) and pelagic sharks (Litvinov 2008). Furthermore, other important species groups found at Bowie Seamount include primary producers (phytoplankton, macroalgae), detritivores such as squat lobsters (*Munida quadrispina*), sediment reworkers (sea cucumbers) and benthic filter/suspension feeders such as molluscs and barnacles.

3.4 FEATURE CONDITION AND FUTURE OUTLOOK OF THE EVALUATED AREA

The Bowie, Hodgkins and Peirce/Davidson Seamounts were designated as an MPA under the Oceans Act in 2008 (Sgaan Kinghlas Bowie (SK-B) Seamount MPA), but a management plan for this area is still under development (DFO 2011). The MPA is divided into three zones, with Zone 1 in the area immediately surrounding Bowie Seamount from the surface to the bottom of the photic zone at 457m, Zone 2 in the southern portion of the area surrounding Zone 1 containing the remainder of Bowie Seamount, and Zone 3 to the north, comprising the Davidson and Hodgkins seamounts (DFO 2011). A detailed ecological risk assessment was recently completed for the SK-B MPA (DFO 2015a). There have been directed fisheries for halibut, rockfish, and Sablefish within this area; the Sablefish fishery is ongoing, but is currently restricted to Zone 2 at one vessel per month using longline trap gear (DFO 2011). Recreational fishing is permitted within the MPA. Effective management measures for seamounts in general range from area-based closures such as MPAs to activity-based restrictions (such as fishing gear-type restrictions), and may involve recovery and restoration efforts in cases where damage has already occurred (Probert et al. 2007). MPAs may include both conventional horizontal zoning as well as vertical (depth-based) zoning, although the latter is discouraged under IUCN marine protected area guidelines (Day et al. 2012).

Shallow seamounts such as Bowie Seamount are vulnerable to direct physical damage from ship groundings and anchoring as well as indirect vessel traffic impacts such as noise, spills, and potentially invasive species from ballast water (DFO 2015a). Five large vessel groundings have occurred within 200 km of the Bowie Seamount MPA between 1994 and 1999; although none of these groundings involved tankers, tanker companies have stated that they keep a distance of at least 18 km from Bowie Seamount (Canessa et al. 2003). In 2006, under the

Ballast Water and Management Regulations of the Canadian Shipping Act, a 50-nautical mile buffer zone was established around Bowie Seamount that prohibits ballast water exchange. Furthermore, while a voluntary tanker exclusion zone extends out to approximately 250 km offshore for much of the coast, nearly all seamounts (with the exception of Graham, Oshawa, and Dellwood Seamounts) fall outside of this exclusion zone.

Seamounts are often targeted by fishing vessels due to their tendency to aggregate fish (Da Silva and Pinho 2007, Watson et al. 2007). Currently, at least five seamounts within this area are exposed to some degree of fishing pressure (Table 3.5; Hodgkins, Bowie, Dellwood, Union, and Heck Seamounts;DFO 2014a); only the Zone 1 of Bowie Seamount is currently off-limits to commercial fishing; a small portion of Hodgkins Seamount and the remainder of Bowie Seamount are within Zone 2 of SK-B MPA where fishing is permitted as long as it complies with subsection 7(1) of the Fisheries Act (Government of Canada 2008). Remote areas that are currently unfished may also be exposed to future fishing pressure if and when more accessible seamounts become depleted.

Fishing gear may also have adverse effects on seamount habitats, with the type and extent of damage depending on the type of gear being used and the substrate type of the seamount (Clark and Koslow 2008). Bottom trawls are among the most destructive gears, but longlines, traps/pots, longline traps, and gillnet can also cause damage during deployment and hauling. For example, pots and traps can damage fragile species (e.g., corals) in the footprint of the gear, and have the potential for “ghost-fishing.” Groundlines and/or longlines can also topple or become entangled in biogenic structures (Curtis et al. 2015). Biogenic habitats such as corals and sponges are among the most vulnerable to damage from fishing gear, particularly from bottom trawls (Roberts et al. 2000, Fosså et al. 2002, Barnes and Thomas 2005, Reed et al. 2005). Studies from seamounts in New Zealand and Australia found no evidence of megafaunal recovery 5-10 years after trawling had ceased, although individual taxa had increased in abundance (Williams et al. 2010). Fishing can also have indirect effects on seamount habitats, including sediment re-suspension leading to smothering of filter feeders, chemical and nutrient release from disturbed sediments, and bycatch and offal discards potentially reducing oxygen levels and altering community composition (Clark and Koslow 2008). The delicate structures associated with hydrothermal vent fields on Dellwood and Baby Bare Seamounts would be highly vulnerable to damage or destruction by bottom-contact fishing gears. Most seamounts in Canada’s Offshore Pacific Bioregion are not currently subject to fishing, with the exception of Bowie, Union, Heck, and Dellwood Seamounts, which are fished for Sablefish with longlines and longline traps for Sablefish. Expansion of commercial fisheries to other seamounts could cause serious adverse impacts to biogenic habitats that occur within the depth ranges fished.

Table 3.6. Seamounts where commercial fishing activity was known to have occurred (X) between 1983 and 2014. Source: L. Lacko (DFO, Nanaimo, B.C., personal communication, 2014).

Seamount group name	1983	1985	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Bowie/ Hodgkins		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dellwood	X		X			X					X	X										X	X		X	X		X	X	
Union	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Heck				X				X																						

There are numerous potential impacts of vessel traffic on seamounts and associated species (reviewed in (DFO 2015a). While the remaining seamounts in Canadian Pacific waters are sufficiently deep that neither anchoring nor groundings are likely to be issues of concern, vessel traffic along the British Columbia coast quadrupled since 1970, with more than 2,500 vessels transiting the coast in 1998-1999 (Canessa et al. 2003). Increasing vessel traffic not only increases the risk of collisions between vessels (and thus, resulting spills), but also collisions between ships and wildlife – particularly marine mammals. Increased ship traffic also increases potential noise exposure. Chronic noise exposure has been demonstrated to have adverse effects on fish populations, including reduced growth and reproduction, impaired predator avoidance, and interference with communication (Slabbekoorn et al. 2010). Anthropogenic noise has also been linked with deleterious effects on marine mammals, including behavioural changes, increased stress, avoidance, changes in migration paths, strandings and – in extreme cases – hearing damage and death (Weilgart 2007). The effects of chronic noise exposure on other taxonomic groups, however, are largely unknown.

Another potential threat to seamount habitats is resource extraction (e.g., oil and gas exploration, mining exploration), and subsequent development. Although past exploration has focused on the Queen Charlotte Basin and west coast of Vancouver Island, nearly all of the seamounts considered here fall outside current oil and gas exploration leases. Due to their volcanic origins and unique geological features, seamounts may be the focus of future seabed mining operations; such mining operations could have larger impacts on benthic communities than fishing gear (Halkyard 1985, Grigg et al. 1987, Glasby 2000, Hein et al. 2010). Figure 3.5 portrays past oil and gas exploration activity.

In summary, seamounts are distinctive geological features with associated and possibly unique biological and oceanographic characteristics; although very few seamounts have been surveyed in any detail, the limited information we do have suggests that seamounts can be unique, productive environments. However, these same features also make them the focus of current and future exploitation such as fishing and mining.

3.5 ASSESSMENT OF THE AREA AGAINST CBD EBSA CRITERIA

<table>
<tr><th rowspan="2">CBD EBSA Criteria
(Annex I to decision IX/20)</th><th rowspan="2">Description
(Annex I to decision IX/20)</th><th colspan="4">Ranking of criterion relevance
(please mark one column with an X)</th></tr>
<tr><th>No information</th><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><td>Uniqueness or rarity</td><td>Area contains either
i) unique (“the only one of its kind”), rare (occurs only in few locations) or endemic species, populations or communities, and/or
ii) unique, rare or distinct, habitats or ecosystems; and/or
iii) unique or unusual geomorphological or oceanographic features.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Seamounts are, by definition, distinct and unique features; while they are globally numerous, there are relatively few in Canadian waters, and shallow seamounts like Bowie Seamount are rare. Additionally, the Bowie Seamount complex is the shallowest submarine volcano in the Northeast Pacific Ocean, and contains a unique combination of deepwater and coastal species (DFO 2015a). While insufficient information exists to determine whether each seamount in the Offshore Pacific Bioregion supports</td></tr>
</table>

<table>
<tr><td colspan="6">distinct, unique, or endemic assemblages, limited submersible surveys on Bowie and Cobb Seamounts have each recorded the presence of unknown species, including corals, sponges, and a cottid fish (Du Preez et al., 2015; Bob Stone, pers. Comm. Alaska Fisheries Science Center, Juneau, Alaska), as well as unusual assemblages of species. Globally, seamounts are undersampled and new species are likely to be found with each subsequent survey (Samadi et al. 2007). Seamounts are generally thought to have high levels of endemism for benthic species, ranging from 12% to more than 50% (Stocks 2004), while pelagic species endemism is low or uncommon. For example, Patton Seamount in the Gulf of Alaska is noted for its high degree of endemism. Hoff and Stevens (2005) describe this seamount as having a unique subset of the nearshore fauna but it maintains distinct assemblage characteristics. Cobb Seamount supports an unusually high abundance of rock scallop, which are otherwise scarce in the Pacific Ocean (Curtis et al., 2015). The degree of endemism for seamounts will vary according to several factors, including the method and duration of larval dispersal, and the oceanography of the waters surrounding the seamount. In general, however, it does not appear that the hydrological features associated with seamounts are a strong barrier to dispersal (Samadi et al. 2007).

Within Canadian waters, Dellwood and Baby Bare Seamounts are also unusual in that they are associated with hydrothermal vents. While little is known of the endemic fauna associated with the hydrothermal vents of Baby Bare Seamount in Canadian waters, Axial Seamount features three known fields of regionally unique and rare hydrothermal vents – some of which are enriched with helium - which support locally abundant populations of globally rare and unique fauna (e.g. Ridgea piscesae), many of which are chemosynthetic. The Baby Bare-Grizzly Bare complex merits special consideration because it represents a unique geomorphological feature (Fisher et al. 2003, Engelen et al. 2008, Fisher and Wheat 2010), with characteristics of both the hydrothermal vent EBSA and the seamount EBSA.</td></tr>
<tr><td>Special importance for life-history stages of species</td><td>Areas that are required for a population to survive and thrive. Areas that have important fitness consequences.</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Because many Pacific seamounts are formed through volcanic activity, it is likely that hydrothermal vents will occur on, or in the vicinity of seamounts. These vents support an association of rare, unique, or endemic species (see Hydrothermal Vent template).

In general, however, there is limited evidence to suggest that most seamounts in Canadian waters are a necessary part of any species' life-history stages, although they may act as stepping-stones for populations of coastal or migratory species. Shallower seamounts such as Bowie Seamount may be particularly important in this regard for pelagic species and shallow water benthic species because they provide rare patches of offshore benthic habitat within the photic zone. The importance of deeper seamounts for life-history stages or species is not well known. For endemic species and communities, seamounts may indeed be critical habitat. Some fish species are known to aggregate around seamounts for spawning, including serranids, jacks, and eels (Morato and Clark 2008). One of the migration patterns of Sablefish includes moving from the continental slope to seamounts before returning to the continental slope; the other is a north-south migration between the Bering Sea and California (Moser et al. 1994, Kimura et al. 1998).</td></tr>
<tr><td>Importance for threatened, endangered or declining species and/or habitats</td><td>Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.</td><td></td><td></td><td>X</td><td></td></tr>
</table>

<table>
<tr><td colspan="6">Seamounts in this area have not been surveyed extensively enough to determine whether threatened, endangered or declining species or habitats are dependent on seamounts, although a number of listed species are present on or near Canadian seamounts, including two SARA-listed seabird species Black-footed Albatross (Phoebastria nigripes) - Special Concern, and Ancient Murrelet (Synthliboramphus antiquus) – Special Concern, and COSEWIC and/or SARA-listed rockfish species: Rougheye (Sebastes aleutianus Type I and II) – Special Concern, Yelloweye (Sebastes ruberrimus), Bocaccio (Sebastes paucispins) – Endangered, Canary (Sebastes pinniger) – Threatened, Darkblotched (Sebastes crameri) – Special Concern, Quillback (Sebastes maliger) – Threatened, Yellowmouth (Sebastes reedi) – Threatened, Longspine thornyhead (Sebastolobus altivelis) – Special Concern. Seamounts in and adjacent to the Offshore Pacific Bioregion also support diverse and abundant populations of coldwater coral taxa which serve as indicators of vulnerable marine ecosystems, including species in the orders Alcyonacea, Antipatharia, Pennatulacea, and Scleractinia (Curtis et al. 2015; DFO 2015a). Shallow seamounts are more likely to provide important habitat for threatened or endangered epipelagic and mesopelagic species than deep seamounts because of their oceanographic characteristics.</td></tr>
<tr><td>Vulnerability, fragility, sensitivity, or slow recovery</td><td>Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Fauna associated with seamounts are vulnerable to disturbance (Pitcher et al. 2007). Seamounts are vulnerable to human impacts for four reasons:
1. their limited size;
2. the longevity and slow growth of associated species;
3. limited recruitment between seamounts; and
4. the localized distribution of many benthic seamount species (Samadi et al. 2007).

Based on species distribution modelling (Davies and Guinotte 2011, Yesson et al. 2012) and submersible surveys (e.g. (Hoff and Stevens 2005, Du Preez et al. 2015), many seamounts are suitable habitat for diverse and abundant cold water coral and sponge assemblages, which are particularly susceptible to physical damage from activities that contact the seafloor, including trawling and anchoring. Cold water corals are known to be vulnerable, fragile, sensitive, and are slow-growing and thus will take considerable time to recover following disturbance. Fish species that aggregate at seamounts also tend to be K-selected species that are long-lived and slow growing, with low fecundity (Probert et al. 2007, Morato and Clark 2008).

Most coldwater coral and sponge species thrive on hard substrates, including bedrock and boulders, which are common on Bowie and Cobb Seamounts, and inferred to be common on other seamounts in Canadian waters. Given that the substrate composition in surveyed areas on the continental slope is largely soft sediments (sands and clays) with some exposed mudstones and siltstones in the Scott Islands area (Pearcy et al. 1982, Bornhold and Yorath 1984), seamounts may provide important hard substrata needed for settlement, growth and survival of deepwater corals and sponges in Canada’s Offshore Pacific Bioregion. Furthermore, seamounts may provide potential refugia from acidification for stony corals (Tittensor et al. 2010).

Baby Bare and Dellwood Seamounts have known hydrothermal vent fields which are delicate and could be easily damaged or destroyed by bottom-contact fishing gears (DFO 2015a) or other activities that contact the seafloor.</td></tr>
<tr><td>Biological productivity</td><td>Area containing species, populations or communities with comparatively higher natural biological productivity.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Compared to the surrounding abyssal waters and plains, as well as surrounding pelagic waters, seamounts are hotspots of biological productivity (White et al. 2007). Biological productivity is commonly</td></tr>
</table>

<table>
<tr><td colspan="6">enhanced at seamounts due to alterations in local currents, upwelling, and entrainment of eddies; however, such enhanced productivity is not a universal feature of seamounts due to wide variations in physical processes associated with differences in seamount topography (White et al. 2007). Shallow seamounts such as Bowie Seamount may also sustain higher densities of predators by aggregating or trapping prey near the surface. Bowie Seamount also supports a commercial fishery for Sablefish. Although the oceanographic patterns of Bowie Seamount have not been studied in detail, we can infer from studies at Cobb Seamount of a closed eddy and Taylor cone that Bowie Seamount is likely to have similar characteristics. Regional eddies known as “Haida eddies” transport nutrients such as nitrate and iron from coastal waters to the Bowie Seamount area. The waters over Bowie Seamount also have exceptional clarity, allowing greater light penetration and thus greater algal abundance at deeper depths (Canessa et al. 2003). Less is known about the characteristics of deeper seamounts and although likely more productive than surrounding waters, they are likely to be less biologically productive than shallow seamounts because they are below the photic zone and would not trap prey near the surface.</td></tr>
<tr><td>Biological diversity</td><td>Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Seamounts generally have higher diversity than the surrounding abyssal seafloor (Pitcher et al, 2007) and surrounding pelagic waters, although there is evidence from the Atlantic Ocean that this may not be true of all seamounts (Howell et al. 2010) and that seamount diversity may be similar to that of the continental slope (O’Hara 2007, Lundsten et al. 2009, McClain et al. 2009). Although biological surveys of most of the seamounts within Canadian waters are lacking, 269 taxa have been identified from various surveys of Cobb Seamount to date, which may be representative of the diversity likely to be found on seamounts in this region (Du Preez et al. 2015). These species include bony fishes, sharks, corals, sponges, and other invertebrates. In Alaskan waters, more than 140 coral taxa are reported and broadly distributed throughout the Eastern and Western Gulf of Alaska, in all habitat types down to depths exceeding 4000 m on seamounts (Stone and Shotwell 2007). Given the proximity of the Alaskan seamounts in the northeast Pacific Ocean, it is reasonable to infer that similar levels of biological diversity exist across the series of seamount complexes in this EBSA.</td></tr>
<tr><td>Naturalness</td><td>Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">The remoteness (and in some cases, depth) of many seamounts in the northeast Pacific Ocean have meant that they are generally exposed to less human disturbance than inshore and coastal areas; however, seamounts are also specifically targeted by fisheries (e.g. Bowie, Dellwood, Heck, and Union Seamounts within Canadian waters) and thus biogenic habitats on seamounts may have already suffered some damage from trawling or other fishing activities that contact the seafloor. There are some indications from Cobb Seamount that rockfish populations have been depleted due to overexploitation which may have altered ecosystem structure and function and 95 incidences of abandoned gear or observable fishery impacts were documented on Cobb Seamount (Curtis et al. 2015). Compared to inshore and coastal areas, seamounts are less disturbed by human activities; however, relative to other pelagic environments, they are more disturbed because they are often targeted by fishing and research activities and are slower to recover. Shallow seamounts are also more likely to be disturbed by human activities than deeper seamounts because of their accessibility. Seamounts that are deeper and further offshore would tend to be less exposed to human impacts due to their inaccessibility.</td></tr>
<tr><td>Importance for species aggregation (DFO criterion)</td><td>Area where species aggregation for important life cycle functions (breeding/spawning, rearing, feeding, migrating, etc).</td><td></td><td></td><td>X</td><td></td></tr>
</table>

Research from Cobb Seamount found that the majority of invertebrate species there had direct or short larval dispersal modes (Parker and Tunnicliffe 1994), suggesting that much of the recruitment is local, perhaps due to entrainment by eddies. Shallow seamounts in particular tend to aggregate prey species and are used as feeding grounds by many predators, including fish, seabirds, and marine mammals (Kaschner 2008, Santos et al. 2008, Thompson 2008).

3.6 SUMMARY

All named seamounts in Canada's Offshore Pacific Bioregion meet the criteria for EBSA identification, and Baby Bare and Dellwood Seamounts in particular, are also identified as hydrothermal vent EBSAs. Seamounts were ranked as high on the criteria of uniqueness or rarity, vulnerability, productivity, importance for life history stages, and biological diversity. They were ranked medium on importance for species aggregation, naturalness, and importance for threatened and endangered species. Seamounts may differ in their importance for some of these criteria (e.g. shallow versus deep; seamounts with and without hydrothermal vents). In its identification of EBSAs in international waters of the North Pacific Ocean, the CBD Secretariat specified that the boundaries of seamount EBSAs encompass the entire seamount footprint area from the abyssal plain to the summit as well as the water column above the seamount footprint. In Canadian waters, there is a paucity of detailed, high resolution bathymetric data to define the area of seamount footprints. Thus, we used the breadth of oceanographic influence (i.e., the Taylor cone) associated with Cobb Seamount, which is 30 km (Dower et al. 1992, Dower and Mackas 1996, Dower and Perry 2001) as a buffer around each named seamount summit in the Offshore Pacific Bioregion (Figure 3.2)(Dower et al. 1992, Dower and Mackas 1996, Dower and Perry 2001). Note that this buffer distance may overestimate the zone of influence for small or deep seamounts, and underestimate it for very large or shallow ones. These boundaries should be adjusted as more information about the individual characteristics of each seamount become available. The lack of high resolution bathymetry data also means that we are unable to confirm the existence of the unnamed seamounts proposed by Kitchingman and Lai (2004), which have not been included here.

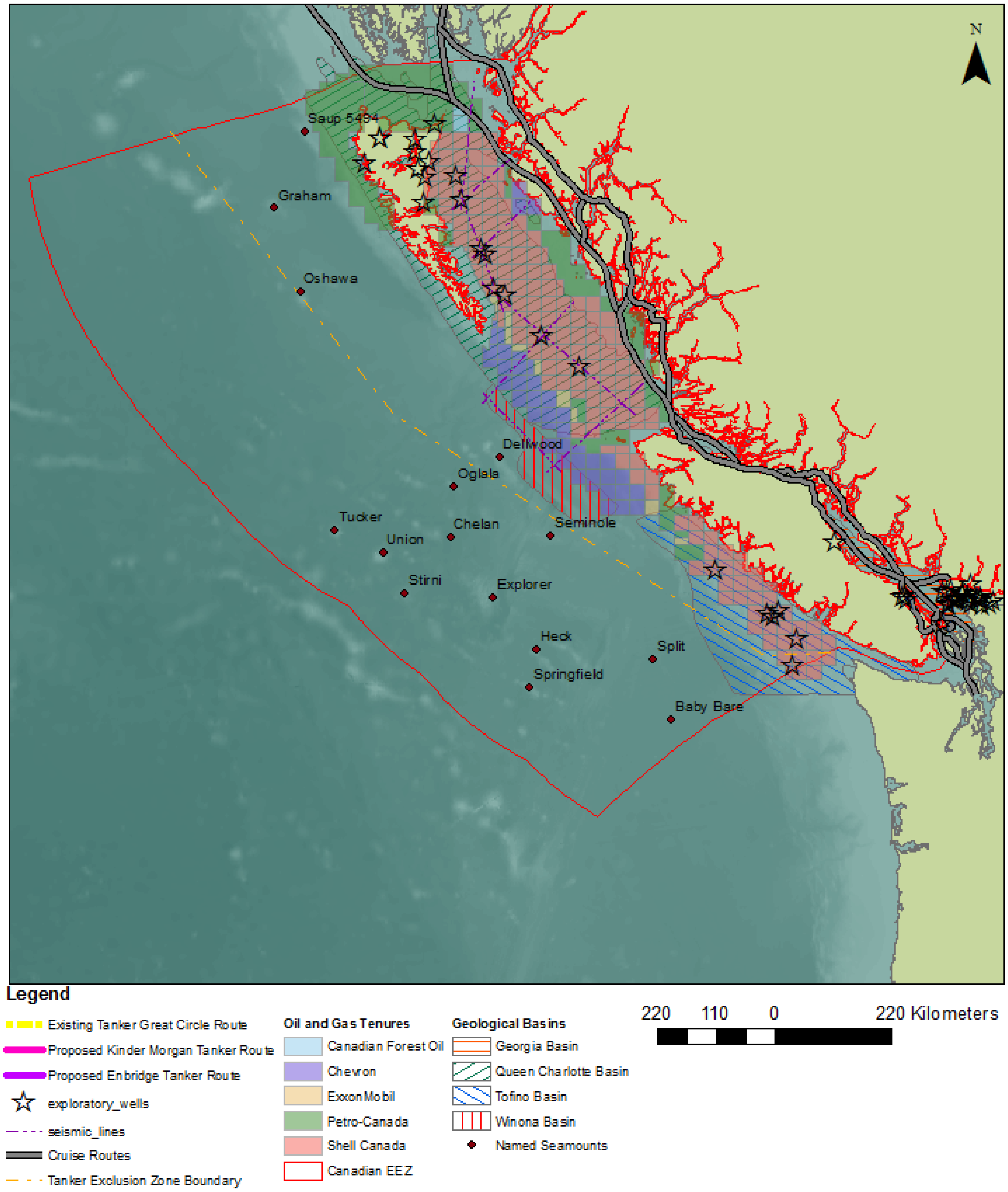


Figure 3.5. Oil and gas exploration areas, tenures, exploratory well locations, geological basins, seismic exploration lines, and current cruise ship routes (DataBC 2014).

4 CONTINENTAL SLOPE

4.1 INTRODUCTION

Upper portions of the continental slope were assessed against EBSA criteria by Clarke and Jamieson (2006a) and Jamieson & Levesque (2014). However, because these previously-identified EBSAs focused on water-column characteristics rather than benthic features, we re-examined the entire continental slope area, paying particular attention to its benthic habitat characteristics.

The continental slope is the area of the continental margin that lies between the continental shelf with typical depths of less than 200 m and the abyssal plains of the Cascadia basin, with depths of ~2500 m (Barr 1974b) (Figure 4.1). No delineation of the continental slope has been universally accepted, and thus different organizations have employed different boundaries (Zacharias et al. 1998, Ardron 2003, DFO 2009a). We define the continental slope as the area that falls between the shallow (upper) edge of the continental slope from British Columbia's Ecosections (Zacharias et al. 1998), and the deep (lower) edge from Ardron (Ardron 2003); a generalized form of which was used by DFO (2009a) in its definition of bioregions. In the Offshore Pacific Bioregion, the shelf edge varies between 190-225 m in depth, being deepest west of the Scott Islands (Bornhold and Yorath 1984). The slope is a mix of abyssal, deep, and shallow depth habitats that transition between the Subarctic Pacific and Transitional Pacific Ecosections, and the Pacific Marine Shelf Ecosection (Zacharias et al. 1998). The gradient of the slope area is generally quite shallow, averaging 10-15° (Tiffin et al. 1972), but is near-vertical in certain areas. In the Strait of Juan de Fuca area, the continental slope is 50-70 km wide (Fofonoff and Tabata 1966, Barr 1974b); at its widest point (about midway between Vancouver Island and Haida Gwaii, the slope is about 100 km wide. The narrowest point is approximately 9 km wide, near Cape Cook (Dodimead 1984). In the area near Vancouver Island, several marine canyons have been identified, including Clayoquot, Father Charles, Loudoun, Barkley, Nitinat, and Juan de Fuca (Barr 1974b); Bornhold and Yorath (1984) list 16 major canyons and numerous smaller ones on the slope south of the Scott Islands. Below the Barkley, Nitinat, and Juan de Fuca Canyons, several fans caoalesce into the Nitinat Fan (Barr 1974b)(Figure 4.1).

The Vancouver Island portion of the slope is transitional between the narrower, steeper faulted slope to the north, and the more gradual slope to the south (Tiffin et al. 1972, Barr 1974b). The majority of survey effort to date has been concentrated on the portion of the continental slope adjacent to Vancouver Island; areas beyond the northern tip of Vancouver Island are poorly characterized beyond basic bathymetric measurements. The substrate composition in areas surveyed to date is largely soft sediments (sands and clays) with some exposed mudstones and siltstones in the Scott Islands area (Pearcy et al. 1982, Bornhold and Yorath 1984). Remotely-operated vehicle (ROV) transects on the lower continental slope off southern Vancouver Island also found a muddy or sandy seabed with occasional boulders (Gauthier 2012).

Oceanographic fronts are a general feature of continental slopes (Kinder and Coachman 1978, Dickson et al. 1980, Dodimead 1984). Local features on the slope such as ridges and canyons also enhance upwelling by interacting with along-shelf Kelvin waves (Dickson et al. 1980). The Juan de Fuca Canyon in particular is suspected to play a role in enhancing the effect of upwelling (Dodimead 1984). Increased biological productivity may also result from the interaction of currents and cyclonic eddies along the west coast of Vancouver Island (Dodimead 1984). Here, the eastward-flowing Subarctic Current is the dominant influence. This current splits into the northward-flowing Alaska Current and the southward-flowing California Current upon reaching the shelf boundary (Bornhold and Yorath 1984). In winter, the California Current generally flows northwards, while in the summer it reverses direction and flows south (Mackas and Galbraith 2002).

Non-tidal current speeds in the northern Vancouver Island region range from 10-30 cm/s in the fall to less than 20 cm/s in the summer (Bornhold and Yorath 1984). Upwelling tends to prevail from May through August off southern Vancouver Island, while downwelling occurs from October to March (Dodimead 1984). Off northern Vancouver Island, the predominant flow is onshore (downwelling) from October to April, and offshore (upwelling) from June to August (Dodimead 1984). Changes in the timing and intensity of these shifts from upwelling to downwelling likely influence the distribution and abundance of slope-associated species such as groundfish, shellfish, and salmonids (Dodimead 1984).

Numerous submarine canyons also originate in the continental shelf, crossing the continental slope and terminating in the abyssal plains in this area (Table 4.1). Submarine canyons are fairly common in the northeast Pacific Ocean, with 20% of the shelf containing canyons and over 50% of the shelf containing canyons north of 45° latitude (Kunze et al. 2002). An analysis of bathymetric data using a bathymetric position index (Manson 2009) also identified additional, unnamed potential canyons along the continental slope.

Table 4.1. Submarine canyon names and locations in Canadian waters. Adapted from De Leo et al (2010).

Canyon Name	Approx. Latitude	Approx. Longitude
Barkley	48.23	-126.17
Clayoquot	48.98	-126.62
Crowther	49.79	-127.75
Esperanza	49.65	-127.50
Father Charles	48.65	-126.50
Kyuquot	49.65	-127.80
Loudoun	48.57	-126.33
Nitinat	48.15	-125.83
Oucukinsh	49.99	-128.00
Quatsino	50.15	-128.17

4.2 LOCATION

The region of the continental slope under consideration lies entirely within Canada's Pacific EEZ, with its deeper edge generally being less than 100 km offshore (Figure 4.1). The width of the slope varies from between 9 and 100 km wide, with depths ranging from approximately 200-2500 m.

Clarke and Jamieson (2006a) and Jamieson & Levesque (2014) identified several EBSAs based on physiographic features that overlap partially or completely with the continental slope area (Table 4.2,Figure 4.2). Many of these areas have common features of biological importance, such as containing known or suspected aggregations of marine mammals, seabirds, and groundfish, flatfish, and rockfish spawning areas.

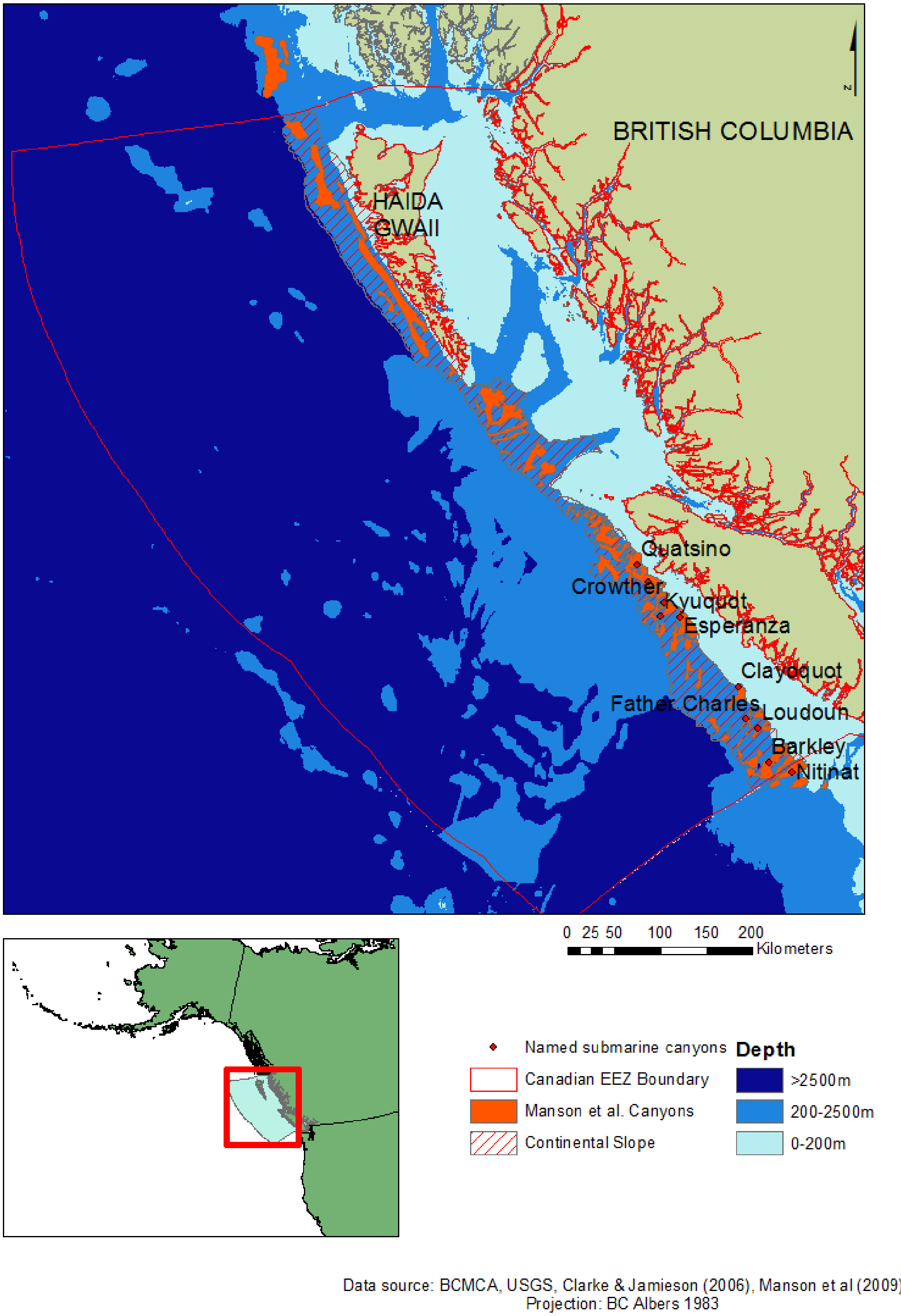


Figure 4.1. Location of the continental slope and submarine canyons within Canada's Offshore Pacific Bioregion. Additional un-named canyons are also depicted as defined by Manson (2009).

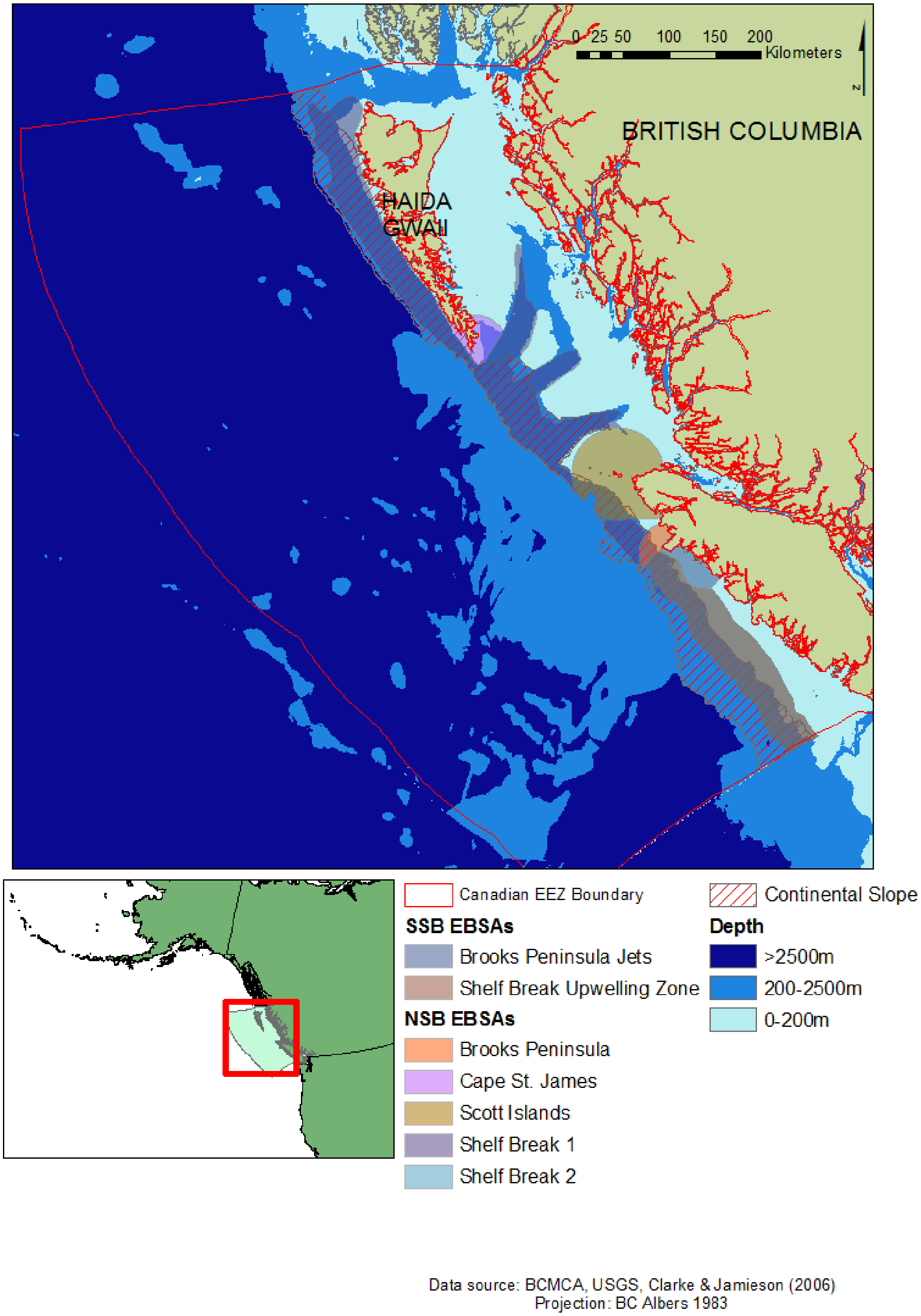


Figure 4.2. Overlap of previously-identified EBSAs with the deeper boundary of the continental slope as defined by Ardron (2003) and the shallow boundary defined by the British Columbia provincial Bioregions (Zacharias et al. 1998, DeMarchi 2011).

4.3 FEATURE DESCRIPTION OF THE EVALUATED AREA

In general, the slope habitat is characterized by low bottom temperatures (3-6°C), low oxygen concentrations (0.27-0.36 mL/L) and low light (Jacobson and Vetter 1996, Stepien 1999). Somewhat more research has been conducted on slope habitats off the coast of Oregon and California, and we can infer some likely characteristics of unsurveyed areas based on this information.

Much of the continental slope in Canada's Offshore Pacific Bioregion has not been studied in great detail in terms of benthic fauna, particularly at depths greater than 1500 m, although several hundred thousand catch records from commercial fisheries and fisheries-independent research surveys led by DFO span the entire length of the continental slope. Species census data have varied considerably with time, survey methodology, and area. Groundfish research surveys spanning 1963-2014 from depths between 400-2500 m using a range of fishing gears (midwater and bottom trawls, longlines, and traps) captured more than 530 taxa from 13 phyla on the continental slope (Appendix Table A 5). However, the species lists generated from these surveys should not be assumed to be complete or representative of the species found on the continental slope. The greatest numbers of records were obtained for Sablefish, Shortspine Thornyhead, Arrowtooth Flounder (*Reinhardtius stomias*), Giant Grenadier (*Albatrossia pectoralis*), Dover Sole, Grooved Tanner Crab, Pacific Grenadier, Rougheye Rockfish, Pacific Flatnose, and Longspine Thornyhead. In the deepest part of the slope, (>1500 m) king crab (*Lithodes couesi*) and Pacific Hake were also frequently captured. Notably, species of conservation concern (i.e., COSEWIC, SARA, or IUCN-listed) found on the slope in these surveys were Shortspine and Longspine Thornyheads, Bocaccio, Eulachon, Blue Shark, Chinook and Coho Salmon, Big Skate, and Canary, Darkblotched, Yelloweye, and Yellowmouth rockfishes. From 1999-2006, the greatest biomasses captured in the Tanner Crab survey dataset were from bony fishes, elasmobranchs, malacostracans, and sea cucumbers (Table 4.3), but cnidarians (corals, anemones, and jellyfishes) were also frequently captured. By contrast, recent ROV surveys along two transects of the upper continental slope off Vancouver Island showed the benthic macrofauna was dominated by holothurians and ophiuroids (Gauthier 2012).

Cutting through the continental slope and many abyssal plains, submarine canyons (Figure 4.1) provide linkages between the continental shelf and deep ocean basins, and are known to be hotspots of benthic production (Vetter 1994), possibly due to their greater habitat heterogeneity, funneling and concentrating detrital organic matter (Yoklavich et al. 2000), or by creating or enhancing oceanographic phenomena such as upwelling, mixing, and internal tidal bores (Klinck 1996, Vetter and Dayton 1999, Kunze et al. 2002).

4.3.1 Fish species

The continental slope off the Oregon coast is dominated by Pleuronectidae, Scorpaenidae, Lipariididae, Zoarcidae, and Bothidae fish families (Day and Pearcy 1968, Pearcy et al. 1982). Day and Pearcy (1968) identified a total 67 fish species belonging to 21 families; Pearcy et al (1982) found 104 fish species in 22 families. Alverson et al. (1964) reported that Pacific ocean perch (*Sebastes alutus*), North Pacific hake (*Merluccius productus*), and spiny dogfish (*Squalus acanthias*) were the most common species in this area, but Day and Pearcy (1968) found Greenstriped rockfish (*Sebastes elongatus)* to be the most abundant.

These species were almost evenly split between the upper slope (400-1,000 m) and the lower slope (1,000-2,500 m), but the depth classes with the highest species diversity were between 600-700 m and 2,000-2,100 m. Others have found a general pattern of diversity declining with increasing depth (Rex 1981), although studies from the east coast of the United States have found that species diversity tended to be higher on the slope than on the continental shelf (Haedrich et al. 1975, Haedrich et al. 1980). Many slope fish species found off the Oregon coast had broad depth ranges of up to 1,000 m, with some having depth ranges of as much as 2,800 m (Pearcy et al. 1982). Continental slope habitats are likely to be important habitats for both seasonal and continuous-spawning bathyal fish species (Stein 1980).

4.3.1.1 Gadiformes

Gadiformes are an important predator of euphausiids and micronekton on the continental slope, and are the most speciose order of deepwater fishes (Koslow et al. 2000, Brodeur and Yamamura 2005). Within this order, Moridae, Brotulidae, and Merlucciidae are the dominant piscivores, linking the near-surface and deep-water foodwebs, while Macrouridae tend to feed near the bottom of flatter habitats (Koslow et al. 2000).

Pacific hake (*Merluccius productus*) are a species of ecological and commercial importance that are particularly prominent within the California Current and Gulf of Alaska ecosystems. More hake are caught than all other groundfish species combined. Hake tend to form dense aggregations in areas of steeply sloping bathymetry, likely following aggregations of euphausiids in regions of upwelling (Mackas et al. 1997). Commercial fisheries target hake at depths ranging from 50-500 m (Alverson and Larkins 1969); they are currently managed as a single stock that is co-managed between the United States and Canada (DFO 2014d). Commercial landings of hake have averaged 221,000 mt between 1966 and 2009, with a low of 90,000 mt in 1980 and a high of 361,000 mt in 2006 (Stewart and Hamel 2010). Female spawning biomass peaked in 1984 at 3.78 million mt and has declined to under 1.5 million mt since (Stewart and Hamel 2010). Adults are normally found in the waters overlying the continental slope, but may move further out to sea during the spawning season (Alverson and Larkins 1969). In Oregon waters, hake were the dominant demersal-pelagic species over the continental shelf (Alverson and Pereyra 1969). Threadfin hakeling (*Laemonema longipes*) are a dominant species over the upper slope (Brodeur and Yamamura 2005).

4.3.1.2 Pleuronectiformes

Pacific halibut (*Hippoglossus stenolepis*) is widely distributed across the North Pacific Ocean, and may use deeper waters along the continental slope during winter spawning from December to March (Clark et al. 1999, Loher and Seitz 2008) at depths between 180-460 m (Seitz et al. 2005). There is some evidence that at least some portion of the halibut population may remain resident on the continental slope year-round (Loher and Seitz 2008).

4.3.1.3 Scorpaeniformes

Surveys of the continental slope off the Oregon and Washington coasts have reported as many as 22 species of rockfish (Alverson et al. 1964), but abundance and diversity estimates have varied depending on the gear type used. At least 23 species were captured in groundfish research surveys on the continental slope in Canadian waters from 1963-2014 (Table 4.2), and all were captured at depths shallower than 1500 m, except individuals in the Rougheye/Blackspotted complex which were also recorded at depths >1500 m.

Juvenile Longspine Thornyhead (*Sebastolobus altivelis*) are known to settle on the continental slope between 600-1200 m, while Shortspine Thornyhead (*Sebastolobus alascanus*) juveniles settle in shallower waters (~100 m) initially and move downslope with age (Stepien et al. 2000). The depth distributions of these two species likely overlap significantly, as both species range between 400-1400 m in Californian waters (Jacobson and Vetter 1996). In Canadian waters, Longspine Thornyhead were also captured at depths >1500m in groundfish research surveys from 1963-2014.

Sablefish (*Anoplopoma fimbria*) are known to reach peak spawning densities in February at depths beyond 300 m, and appear to remain fairly localized (McFarlane and Beamish 1992), although spawning may occur anytime between October and April (Schirripa and Colbert 2007). Sablefish are also thought to migrate along the continental slope (Mason et al. 1983, Heifetz and Fujioka 1991, McFarlane and Beamish 1992, Kimura et al. 1998). On the continental slope in Canadian waters, Sablefish were captured down to 2500 m in groundfish research trawls.

4.3.1.4 Other species

Copepods are known to spawn in large numbers at depths exceeding 700 m (McFarlane and Beamish 1992). Marine mammals and seabirds may also be attracted to the continental slope to take advantage of areas of upwelling and plankton aggregation (Selzer and Payne 1988, Gregr and Trites 2001, Shelden et al. 2005, Clarke and Jamieson 2006a). Due to the prevalence of soft bottom substrates, corals and hexactinellid sponges may be found on the continental slope in low abundances; because historical and current trawling is likely to have destroyed or disturbed corals and sponges, they are more likely to be found in greater abundances within areas undisturbed by trawling activity (Clark and Rowden 2009, Gauthier 2012).

Table 4.2. Previously-identified EBSAs that overlap the continental slope.

EBSA name[5]	Biological Significance	Oceanographic feature(s)
Brooks Peninsula	1. High diversity of breeding and migrating bird species 2. Abundant sea otters 3. Possible green sturgeon staging area during migration 4. Lingcod spawning and rearing area	Offshore flow
Cape St. James	1. Humpback whale aggregation 2. Steller sea lion rookery on Kerouard Islands 3. Spawning area for Pacific halibut 4. Cold water coral community	Haida eddy formation
Scott Islands	1. Sea bird breeding and foraging 2. Humpback whale aggregation 3. Summer resident gray whale feeding area 4. Steller sea lion rookery and fur seal feeding area 5. Established sea otter colony. 6. Pacific cod spawning and rearing area 7. Lingcod spawning and rearing area 8. Sablefish spawning and rearing area 9. Flatfish spawning and rearing area 10. Hake feeding area (May-September) 11. Herring summer feeding area	Tidal mixing
Shelf break	1. Sperm, fin, blue, fin, and sei whale aggregation area. 2. Humpback whale feeding area 3. Grey whale migration route	Upper continental shelf and canyons

[5] DFO (2012a)

EBSA name[5]	Biological Significance	Oceanographic feature(s)
	4. Fur seal feeding area 5. Sablefish spawning and rearing area 6. Dover sole spawning area 7. Rockfish spawning area 8. Hake feeding area 9. Coral sponge habitat 10. Tanner crab habitat 11. Possible leatherback turtle aggregation area	

4.4 FEATURE CONDITION AND FUTURE OUTLOOK OF THE EVALUATED AREA

The complex topography in some areas of the continental slope may preclude the use of trawl or other mobile fishing gears; however, in some areas of the continental slope, fishing effort has been extensive. For example, 97% of the waters between 150-1,200 m off the west coast of Vancouver Island have been trawled (Sinclair et al. 2005, Wallace 2007). Several fisheries operate in the northeastern Pacific Ocean for species such as Shortspine and Longspine Thornyheads, Dover Sole, Pacific Cod, Flounder, rockfish, Spiny Dogfish, skates, Lingcod, and Sablefish (Jacobson and Vetter 1996, Wallace 2007, Driscoll et al. 2009). Little is known about the demographic characteristics of some of these targeted species, but thornyheads, like many other continental slope species, are thought to be long-lived and slow-growing (Ianelli et al. 1994). The Longspine Thornyhead fishery began in 1996, with peak catches occurring only 3 years later, with 86% of catches taking place in continental slope waters (Wallace 2007). Fishing pressure on hake may cause (or already has caused) changes in slope species assemblages (Jay 1996). Pacific Ocean Perch were also heavily fished and depleted in some areas of the northeastern Pacific Ocean during the 1960s and 1970s, with catches peaking at 450,000 mt in 1965 (Koslow et al. 2000). Some populations have recovered, but the species continues to be fished, with Canadian catches averaging 5700 mt between 1980 and 1996 (Westrheim and Foucher 1985), and fishing effort has shifted to deeper waters and targeting other species such as scorpaenids (Koslow et al. 2000). As of 2000, the Washington-Oregon stock of Pacific Ocean Perch was at 13% of the 1960 level, and the depletion of older year-classes may be preventing a broad recovery (Koslow et al. 2000). Since 1996, the number of bottom-trawling vessels and annual area trawled in Canada's Pacific waters has decreased as a result of increased regulation, increased fuel costs, and decreased profitability (Wallace 2007). Bycatch from bottom trawl fisheries is also an issue with up to 20% of the total catch being composed of non-target species (Driscoll et al. 2009). The fish portion of this bycatch is predominantly composed of rockfish, hake, flatfish, and gadoids, wherease the nonfish component is largely corals and sponges (Driscoll et al. 2009). The highest densities of always-discarded bycatch species occurs in continental slope waters off the west coast of Vancouver Island (Driscoll et al. 2009). Within Canadian waters, most of the records of commercial catches (99.6%) on the slope from 2006-2015 between 400-2500 m were taken above 1500 m; 98.7% of catch records were from shallower than 1000 m (Table 4.3). Both the Tanner Crab and groundfish surveys recorded occurrences of many species of conservation concern (IUCN and/or COSEWIC listed, Figure 4.3), nearly all of which occur throughout the continental slope.

Climate change also poses a threat to continental slope species and communities, mainly in the form of ocean acidification (Feely et al. 2008, Denman et al. 2011) and increased areas of depleted oxygen due to changes in ocean circulation and stratification (Whitney et al. 2007, Falkowski et al. 2011). Hypoxia has increased in the eastern North Pacific, including off Oregon where there has been lethal consequences for benthic species (Grantham et al. 2004). The shoaling of this continental hypoxic zone has reduced habitat for a number of species, including some commercially important ones. Species ranges and distributions are also expected to change with changing ocean temperatures (Ainsworth et al. 2011, Okey et al. 2014, Cheung et al. 2015).

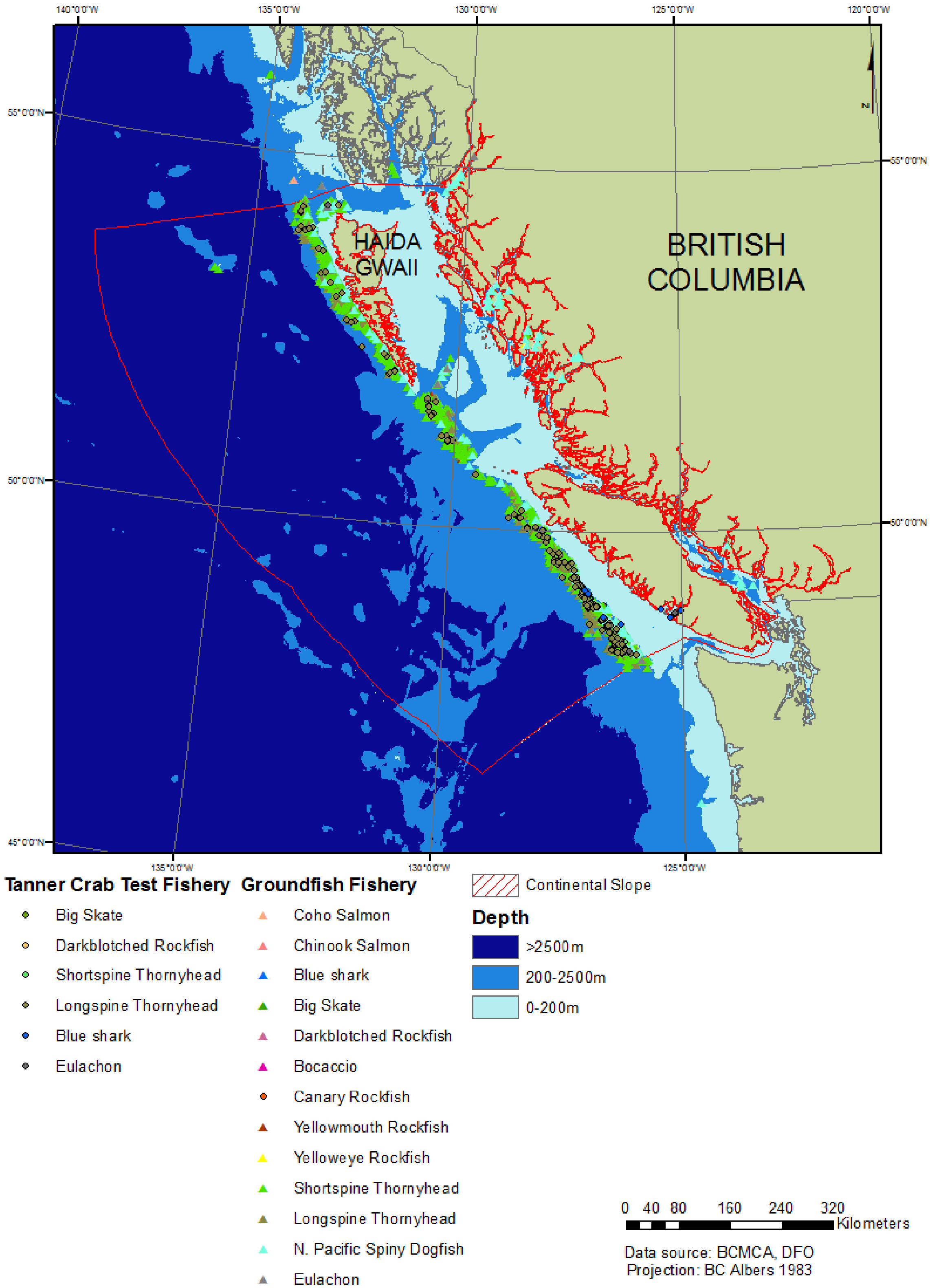


Figure 4.3. Locations of Threatened (COSEWIC), Near Threatened (IUCN), Vulnerable (IUCN), Endangered (COSEWIC/IUCN), or Special Concern (COSEWIC) species caught in the Tanner Crab test fishery surveys (1999-2006) and groundfish surveys (1963-2014).

Table 4.3. Tanner Crab survey catches (kg) by taxonomic class, 1999-2006. Source: L. Lacko (DFO, Nanaimo, B.C., personal communication, 2014).

Taxonomic Class	1999	2000	2001	2002	2003	2004	2005	2006	Total Catch (kg)
Actinopterygii	9015.16	5298.662	6801.425	4512.11	9137.61	10751.25	6125.56	4098.21	55739.99
Anthozoa	101.15	23.761	147.13	57.39	146.39	119.87	64.22	94.45	754.36
Aplacophora	-	-	-	0.45	-	0.04	0.07	0.03	0.59
Ascidiacea	-	2	0.2	8.4	-	9.42		0.62	20.64
Asteroidea	42.06	11.909	60.3	7.08	133.33	71.98	30.37	85.64	442.67
Aves	-	-	-	-	-	-	-	-	0.00
Bivalvia	-	-	0.5	0.2	0.25	0.49	0.14	0.03	1.61
Branchiopoda	-	-	0.1	0.3	-	-	0.09	-	0.49
Calcarea	-	-	-	-	-	-	-	-	0.00
Cephalaspidomorphi	0.86	-	-	-	-	-	-	-	0.86
Cephalopoda	145.13	33.207	107.02	110.5	154.12	159.13	62.04	208.5	979.65
Crinoidea		2.378	1.13	6.7	0.06	0.66	0.09	0.32	11.34
Echinoidea	13.44	0.98	8.69	0.7	13.87	1.75	0.85	7.5	47.78
Elasmobranchii	232.86	86.66	240.25	222.08	272.19	272.2	204.55	189.05	1719.84
Gastropoda	27.97	0.703	27.6	2.9	30.81	28.49	6.37	6.46	131.30
Hexactinellida	-	9.5	1	72.9	86.64	-	-	-	170.04
Hirudinea	-	-	-	-	-	-	-	-	0.00
Holocephali	2.4	-	0.6	12.3	-	-	385.35	-	400.65
Holothuroidea	2.34	6.106	140.31	5.11	423.07	521.49	20.26	169.26	1287.95
Hydrozoa	-	-	-	-	-	-	-	-	0.00
Malacostraca	743.417	585.384	720.88	104.13	415.81	251.45	290.19	99.93	3211.19
Mammalia	-	-	-	0.2	-	-	-	-	0.20
Maxillopoda	-	-	-	-	-	-	-	-	0.00
Mollusca	-	-	-	-	0.1	0.09	0.07	-	0.26
Myxini	33.63	13.25	72.21		7.03	16.06	4.85	-	147.03
Ophiuroidea	26.23	13.716	62.78	5.3	152.86	75.39	36.18	138.05	510.51
Polychaeta	0.28	-	1.44	0.4	0.16	3.27	0.3	1.65	7.50

Taxonomic Class	1999	2000	2001	2002	2003	2004	2005	2006	Total Catch (kg)
Polyplacophora	-	-	-	0.1	-	-	-	-	0.10
Pycnogonida	-	-	-	0.2	1.55	-	0.05	0.57	2.37
Rhabditophora	-	-	-	-	-	0.02	-	-	0.02
Scaphopoda			-	-	-		-	-	0.00
Scyphozoa	24.26	6.939	29.04	0.4	6.03	114.44	3.32	89.7	274.13
Thaliacea	-	4.1	5.12	-	-	-	0.32	6.13	15.67
Other/Unspecified	-	33.444	39.61	11.7	15.7	237.12	14.71	63.29	415.57
Total Catch (kg)	11577.63	7460.26	9395.345	6930.81	11891.63	13419.28	8499.35	6696.81	75871.11

4.5 ASSESSMENT OF THE AREA AGAINST CBD EBSA CRITERIA

<table>
<tr><td rowspan="2">CBD EBSA Criteria
(Annex I to decision IX/20)</td><td rowspan="2">Description
(Annex I to decision IX/20)</td><td colspan="4">Ranking of criterion relevance
(please mark one column with an X)</td></tr>
<tr><td>No information</td><td>Low</td><td>Medium</td><td>High</td></tr>
<tr><td>Uniqueness or rarity</td><td>Area contains either
i) unique (“the only one of its kind”), rare (occurs only in few locations) or endemic species, populations or communities, and/or
ii) unique, rare or distinct, habitats or ecosystems; and/or
iii) unique or unusual geomorphological or oceanographic features.</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Insufficient data exist regarding criteria (i) and (ii), but the southern portion of the continental slope off the coast of Vancouver Island does have some unusual oceanographic features due to the complex and varied circulation patterns caused by the splitting of the Subarctic Current into the California and Alaska Currents. Seasonal changes in upwelling and downwelling along the continental slope in this area are also a distinct feature. The continental slope contains several large marine canyons and the special local ocean circulation patterns and biological assemblages associated with them.</td></tr>
<tr><td>Special importance for life-history stages of species</td><td>Areas that are required for a population to survive and thrive.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">In comparison to other offshore areas, the continental slope is relatively data-rich in terms of knowledge about species distributions and habitat use. Clarke and Jamieson (2006a) note that parts of the continental slope are important aggregation areas for large whales and possibly leatherback turtles; a critical feeding area for gray and humpback whales, fur seals, seabirds, herring, and hake; an important spawning/breeding area for Sablefish, Dover Sole, Rockfish, Hake, lingcod, Pacific Cod and seabirds; and an important habitat for corals, sponges, and Tanner crabs. Both halibut (Clark et al. 1999) and Sablefish (Mason et al. 1983, Heifetz and Fujioka 1991, McFarlane and Beamish 1992) are known to use slope habitats during spawning and migration. Juvenile Pacific salmon may also use the shelf-slope region during migrations (Welch et al. 2002).</td></tr>
<tr><td>Importance for threatened, endangered or declining species and/or habitats</td><td>Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Trawl surveys have found that the continental slope provides habitat for numerous species of conservation concern. COSEWIC Endangered: Coho Salmon (Interior Fraser Population), Sockeye Salmon (Sakinaw Population), Bocaccio, and Eulachon. COSEWIC Special Concern: Darkblotched Rockfish, Yelloweye</td></tr>
</table>

<table>
<tr><td colspan="6">Rockfish, Longspine Thornyhead, and North Pacific Spiny Dogfish. COSEWIC Threated Species: Chinook Salmon (Okanagan Population), Quillback Rockfish, Canary Rockfish, and Yellowmouth Rockfish (DFO 2015b). IUCN Endangered: Shortspine Thornyhead. IUCN Near Threatened: Steller Sea Lion, Blue Shark, Big Skate. IUCN Vulnerable: Sperm whale, Spiny Dogfish. Some seabird Important Areas (IAs) (e.g., Cape Scott, Brooks Peninsula) overlap with the continental slope (Bird Studies Canada 2015). Bird species of conservation concern that are either known or may occur along the continental slope include: COSEWIC/SARA Threatened: Short-tailed albatross (also IUCN Vulnerable), Marbled Murrelet (also IUCN Endangered), Pink-footed shearwater (also IUCN-Vulnerable). COSEWIC/SARA Special Concern: Black-footed albatross (also IUCN Near-threatened), Ancient Murrelet (also IUCN Endangered). IUCN Endangered: White-winged Scoter. IUCN Vulnerable: Long-tailed duck (IUCN Vulnerable). IUCN Near-threatened: Yellow-billed loon, Laysan albatross, Mottled petrel Buller’s shearwater, Sooty Shearwater.</td></tr>
<tr><td>Vulnerability, fragility, sensitivity, or slow recovery</td><td>Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Slope-associated and other deepwater fish species are either known or suspected to be long-lived and slow-reproducing; some fish species (e.g., Pacific Ocean Perch) have already been depleted due to intense fishing pressure nearly half a century ago and have yet to fully recover (Koslow et al. 2000, Stepien et al. 2000). Deepwater macrourids may be attracted to areas disturbed by bottom trawling (Pearcy et al. 1982); other opportunistic species may take advantage of disturbed areas, changing community composition. Recovery time following disturbance is dependent upon bottom type, stability, and the intensity and frequency of a disturbance (Newell et al. 1998). Communities in muddy sand habitats tend to have very slow recovery times following disturbance (Dernie et al. 2003). Cold-water corals and sponges are also known to occur along the continental slope (Finney and Boutillier 2010), and are generally susceptible to disturbance and damage due to their life history characteristics. Climate change also poses a threat to continental slope species in the form of ocean acidification, changed patterns of circulation and upwelling, and increases in oxygen-depleted zones (Whitney et al. 2007, Feely et al. 2008, Denman et al. 2011, Falkowski et al. 2011). Changes in species distributions and ranges are also likely to occur (Ainsworth et al. 2011, Okey et al. 2014, Cheung et al. 2015).</td></tr>
<tr><td>Biological productivity</td><td>Area containing species, populations or communities with comparatively higher natural biological productivity.</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">The continental slope is typically an area of enhanced biological productivity due to upwelling and submarine features such as canyons and ridges. In comparison to both the abyssal waters at the foot of the slope, and the continental shelf waters at the top, the continental slope is a moderately productive area.</td></tr>
<tr><td>Biological diversity</td><td>Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Diversity on the continental slope is generally higher than on the continental shelf or the abyssal plains. It has been suggested that macrofaunal diversity has a parabolic relationship with depth (Snelgrove 1998).</td></tr>
<tr><td>Naturalness</td><td>Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.</td><td></td><td></td><td>X</td><td></td></tr>
</table>

Although commercial fisheries span the length of the continental slope from Alaska to Washington State, the varied bottom topography and extreme depths of the lower portions of the slope have likely kept some areas untrawled and relatively intact (Jacobson and Vetter 1996), while the vast majority of the continental slope has been subjected to trawling (Wallace 2007, Driscoll et al. 2009) and other fishing activities. The vast majority (>98%) of catch records are from gear set at less than 1000 m, suggesting that the deeper portions of the slope may be more natural than shallower zones.					
Importance for species aggregation (DFO criterion)	Area where species aggregation for important life cycle functions (breeding/spawning, rearing, feeding, migrating, etc).				X
Clarke and Jamieson (2006a) identified the continental slope as an area of aggregation of macrozooplankton, as well as containing discrete areas of aggregation for seabirds (Nur et al. 2011), baleen whales (Gregr and Trites 2001), fur seals (Springer et al. 1996), adult eulachon (Hay and McCarter 2000), Sablefish (Beamish and McFarlane 1988), Dover Sole (Stepien 1999), rockfish (Pearcy et al. 1982), hake (Mackas et al. 1997), Tanner crabs (Jamieson 1990), and possibly leatherback turtles (Block et al. 2002) (see Table 4.2).					

4.6 SUMMARY

Previous assessments (Clarke & Jamieson 2006a,b; Jamieson and Levesque 2014) in this area focused on waters that overlie the continental slope; in this assessment, we focused primarily on benthic and demersal habitats and species. While some features contained within the slope warrant future re-assessment and identification as EBSAs (e.g. canyons, ridges, valleys), here, the entire continental slope is identified as an EBSA. It scores as high on the Importance for Species Aggregation, Special Importance for Life History Stages, Biological Diversity, Importance for Threatened/Endangered Species, and Vulnerability/Sensitivity. It scores as medium for Uniqueness, Biological Productivity, and Naturalness.

5 BATHYPELAGIC AND ABYSSAL ZONE

5.1 INTRODUCTION

This section focuses on the waters beyond the continental slope, with the bathypelagic zone starting at depths greater than 1,000 m and transitioning to the abyssalpelagic zone deeper than 2,000 m. However, there is no sharp delineation between the abyssal zone and the bathyal zone (Ekman 1953). These waters are generally poorly characterized in terms of community composition and structure, with most information about biota coming from net tows (Robison et al. 2010). The features evaluated in this zone include the abyssal plain and habitats and features not already considered in previous sections (e.g., hydrothermal vents, seamounts, etc.).

The abyssal plain is the area of the ocean floor and adjoining water column that lies between depths of 3,500-6,000 m and typically has slope angles of less than 0.001^{o} (Hannides and Smith 2003). Globally, abyssal plains cover between half and two-thirds of the seabed (depending on the definition used) (Menard and Smith 1966, Hannides and Smith 2003). Except for the southeast Pacific Ocean, where the East Pacific Rise segregates the Peru and Chile Basins, the rest of the abyssal seafloor within the Pacific Ocean is essentially contiguous. In the northeast Pacific Ocean, there are at least four named abyssal plain areas: the Cascadia, Tufts, Juan de Fuca, and Alaskan Abyssal Plains (Table 5.1). Nearly all of the biological sampling effort in this area has focused on the Cascadia and Tufts Abyssal Plains; therefore, we must infer general characteristics about this habitat from a few, limited studies.

Table 5.1. Named abyssal plain habitats in the Northeast Pacific Basin.

Name	Maximum depth	Area (km^2)
Cascadia Plain	2,800-3,000 m	170,000
Tufts Plain	5,300 m	36,260
Alaskan Abyssal Plain	~4,500 m	?
Juan de Fuca Plain	?	?

Abyssal waters (i.e., deeper than 2,000 m) are thought to generally be an area of low biological productivity, due to their dependence on particulate organic carbon (POC) flux from overlying waters or exports from hydrothermal vent communities as a source of energy (Tunnicliffe and Jensen 1987, Rex et al. 2006, Smith et al. 2008a). As a consequence, growth, reproduction, and recolonization rates of taxa tend to be very low (Gage and Tyler 1992, Smith et al. 2006). However, given the low level of knowledge about the abyssal zone and the expansive area involved, this habitat could represent a substantial reservoir of biodiversity (Snelgrove and Smith 2003, Bouchet and Duarte 2006); typically, more than 90% of the polychaetes, copepods, isopods, and nematodes in a given sample taken from abyssal waters are new to science (Smith et al. 2006). In general, biomass of both plankton and animals decreases exponentially with increasing depth, although the near-bottom region often has more organic material than higher in the water column (Wishner 1980).

Differences in productivity between abyssal habitats are likely attributable to differences in sediment input (from both overlying waters and terrestrial sources) and resuspension from bottom currents (Carey Jr 1981). There is no primary production in abyssal habitats, except for those areas with hydrothermal vents where chemosynthetic bacteria fulfil this role (Rex 1981). Generally, community abundances (particularly of mollusks) in oligotrophic abyssal habitats are only a fraction of that on the continental slopes, which has led to formulation of the slope-abyss source-sink (SASS) hypothesis (Smith et al. 2008a). If true, this hypothesis suggests that abyssal plains are areas of low biodiversity; however, it is unclear whether it applies to all taxa and whether it applies to the Pacific Ocean, where larval transport distances from the slope are much greater and the area of the abyssal plain is much larger (Smith et al. 2008a).

Submarine canyons are likely to be relative hotspots of productivity and biodiversity compared to other abyssal habitats, as they tend to create areas of enhanced turbulent mixing, upwelling, and internal waves (Vetter 1994, Klinck 1996, Vetter and Dayton 1999, Yoklavich et al. 2000, Kunze et al. 2002, De Leo et al. 2010, Robison et al. 2010). While data are scarce for canyons in Canada's Pacific waters, research in similar canyons off the California coast has found canyons to serve as natural refuges for rockfish (Yoklavich et al. 2000), and that a substantial organic carbon reservoir exists within gelatinous predators (Robison et al. 2010).

5.2 LOCATION

The bathypelagic and abyssalpelagic zones generally lie seaward of the continental shelf and slope along the entire Pacific coast (Figure 5.1). The only named Pacific abyssal plains that lie within Canada's Offshore Pacific Bioregion are Cascadia and Juan de Fuca, but the abyssal plain habitat extends across nearly the entire breadth of the Pacific basin (Figure 5.1– only

Cascadia and Tufts Plains shown). The Cascadia Basin lies at the foot of the continental slope just west of Vancouver Island, interrupted by the Juan de Fuca ridge. West of the Cascadia Basin is the Tufts Abyssal Plain, which grades into the Alaskan Abyssal Plain at approximately the latitude of Haida Gwaii (Carter 1988). The Alaskan plain extends from the eastern edge of the Aleutian Trench to the southern tip of Haida Gwaii (Menard and Dietz 1951).

While the Tufts Abyssal Plain falls entirely within international waters, it is linked to the Cascadia Abyssal Plain by the Cascadia Channel (Heezen and Laughton 1963) in the south. We discuss it in this section to provide information on the types of communities and habitats that potentially occur on the abyssal plain habitat that occurs in the Offshore Pacific Bioregion. The Tufts Abyssal Plain is separated from the Alaskan Abyssal Plain by a chain of seamounts and ridges at approximately 50^{o}N latitude, forming its northern boundary (Heezen and Laughton 1963). The Mendocino Rise forms the southern boundary; on the west is an oceanic rise that also delineates the western side of the Alaskan Abyssal Plain. The eastern portion contains the Astoria Channel (Griggs 1968). The eastern boundary is formed by ridges, hills, and seamounts. Maximum depths of the Tufts Abyssal plain are approximately 5,300 m (Pearcy et al. 1982).

The Cascadia Abyssal Plain lies immediately adjacent to the continental slope between Vancouver Island and Cape Mendocino. Submarine ridges of the Blanco Fracture Zone and Juan de Fuca and Gorda Ridges form its southern and western boundaries. Depths on the Cascadia Abyssal Plain range from 2,100-3,000 m (Pearcy et al. 1982). The Cascadia Plain has been divided into four ecological zones: the Slope-Base, the Eastern Plain, the Cascadia Deep-Sea Channel, and the Western Plain, with the Tufts Abyssal Plain forming a separate zone (Carey Jr 1981).

Globally, very little of the abyssal plains have been surveyed in any detail; in the North Pacific Ocean specifically, most research has focused on the Cascadia and Tufts Plains. In general, the abyssal plains habitat is characterized by low temperatures (-1 to 2°C), low current speeds and little or no light (Smith et al. 2006). Based on low-resolution bathymetric data, much of the area between the continental slope and Canada's Pacific EEZ boundary (excluding seamounts and hydrothermal vents) - although unnamed - is likely abyssal plain habitat (Figure 4.3). The importance of other less prominent terrain features such as hills, knolls, trough, ridges, and areas of high rugosity within these abyssal areas is unknown. Areas along the western margin of the Pacific Ocean and those adjoining undersea canyons and other topographic features such as seamounts may experience higher bottom current speeds (Smith and Demopoulos 2003). The major determining factor of habitat characteristics on the abyssal plain is POC flux, which is in turn determined by surface primary productivity and sinking time (Field et al. 1998). Thus, the abyssal waters of the northeast Pacific Ocean can be divided into three zones: eutrophic, mesotrophic, and oligotrophic. The eutrophic abyss extends from the equator to 5°N; the mesotrophic abyss from 5°N to 15°N, and waters north of 15°N latitude and underlying the North Pacific gyre are considered to be oligotrophic, with POC fluxes of less than 0.5g C m^{-2} y^{-1} (Hannides and Smith 2003).

Below depths of 3,000 m, the cold (0.5-1.5°C), saline Antarctic Bottom Water (ABW) mass exerts a strong influence in Pacific waters, even north of the equator, as this is the only source of deep water in the Pacific (Knauss 1962). Above this water mass, at depths of 1,000-3,000 m is the oxygen-poor Pacific Deep Water, formed by mixing of the ABW with North Atlantic Deep Water and Intermediate Deep Water from depths shallower than 1000 m (Smith and Demopoulos 2003). Although much of the deep water within the North Pacific Ocean is above the critical oxygen threshold of 0.5 mL/L, certain areas such as those off the California slope may have near-zero oxygen concentrations (Smith and Demopoulos 2003). The combination of waterbody characteristics and substratum type are two of the key variables driving habitat variations in the deep-sea Pacific Ocean; the other two are vertical POC flux and near-bottom current velocities (Smith and Demopoulos 2003). In comparison to the abyssal zones in other oceans, the Pacific Ocean's abyssal areas have fairly thin (<100 m deep) sediments and limited inputs from terrigenous sedimentation (Smith and Demopoulos 2003). Across much of the north Pacific Ocean, the surface sediment is either fine-grained red clay with low organic content (<0.25%), or lacks deposits completely (Smith and Demopoulos 2003). The structural complexity of abyssal habitats is also typically very low, although small terrain features may exist (Smith et al. 2006).

5.3 FEATURE DESCRIPTION OF THE EVALUATED AREA

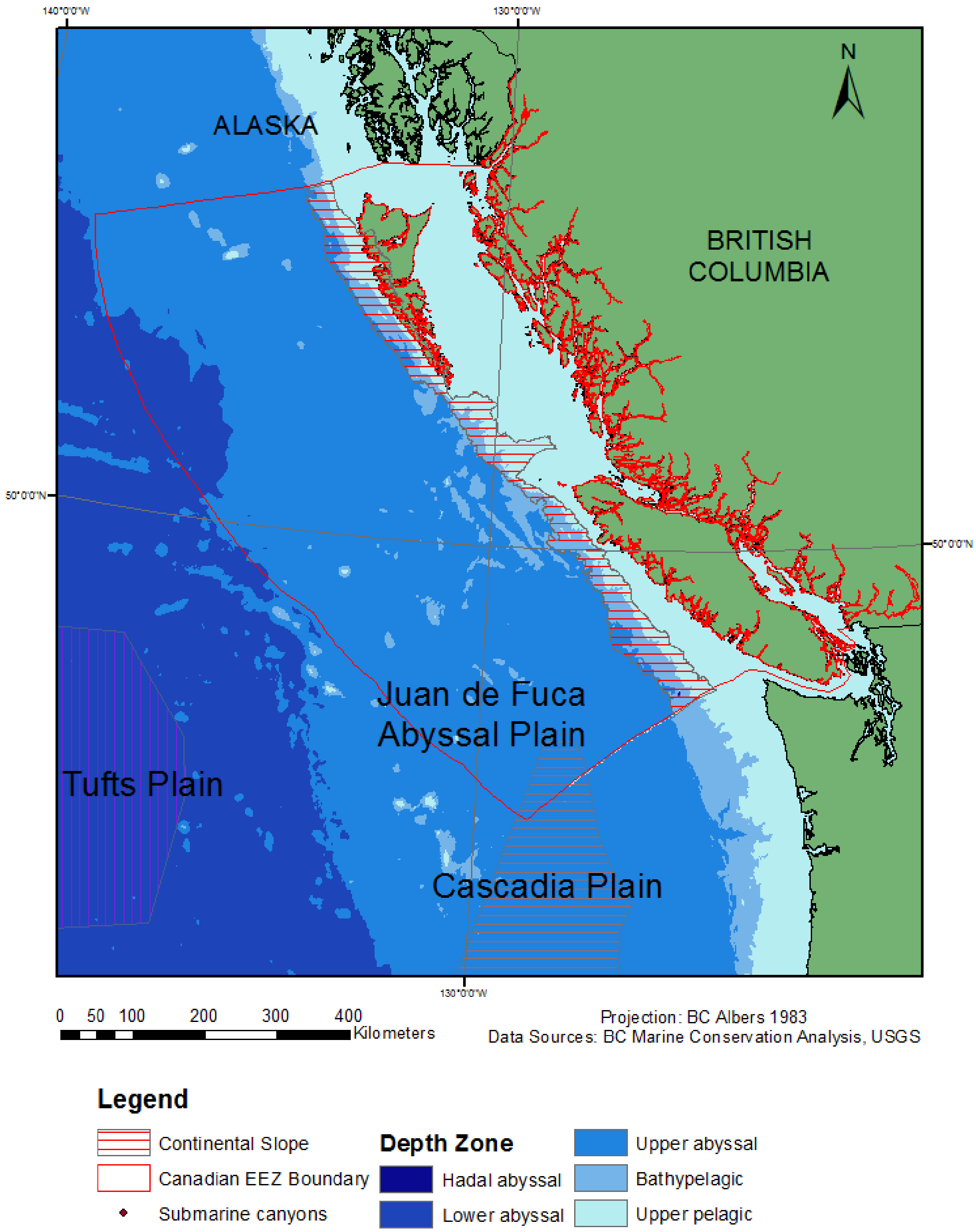


Figure 5.1. Named abyssal plain habitats in and adjacent to Canada's Pacific Offshore waters. Note that the position of the Juan de Fuca Plain is approximate. Alaskan Plain also not depicted.

5.3.1 Fish assemblages

Macrourids (grenadiers) are the dominant fish assemblage in abyssal waters, with abundances estimated to range between 7.8 and 15.4 fish per 10^5 m^3 (Smith Jr et al. 1992). Although there are more than 300 known species in this family, only nine species are known to occur below 3,000 m; two of these occur globally (*C. armatus* and *C. leptolepis*), and one is confined to the North Pacific Ocean (*C. yaquinae*). Generally, macrourids have very broad distributions within oceanic basins, and may exhibit either seasonal or continuous reproduction (Stein 1980). Due to their wide-ranging distribution within the water column, Macrourids are thought to contribute to the vertical transport of organic matter (Priede et al. 1990). In groundfish research surveys carried out from 1969-1980 at depths greater than 2500 m within Canadian waters, fish fauna in catches included eelpouts, myctophids, grenadiers, viperfish, ragfish, Sablefish, and Finescale Mora (*Antimora microlepsis*) (Table 5.2). Groundfish records from the Offshore Pacific Bioregion, however, are scant.

At least 13 species of liparids (Snailfishes) are also known to occur and reproduce both seasonally and continually in abyssal habitats in Oregon waters (Stein 1980). Continual spawners include *Careproctus longifilis, C. microstomus,* Smallfin Snailfish *(C. oregonensis),* Bigtailed Snailfish *(Osteodiscus cascadiae),*Spiny Snailfish (*Acantholiparis opercularis)*, *Paraliparis megalopus*, and Bigpored Snailfish (*P. latrifons*). Seasonal or periodic spawners include Blacktail Snailfish (*Careproctus melanurus)*, Abyssal snailfish (*C. ovigerum)*, *Paraliparis mento* and Pink Snailfish (*P. rosaceus)* (Stein 1980).

Other fish taxa found on the Cascadia Abyssal Plain include Zoarcidae and Rajidae (Table 5.3).

Table 5.2. Species captured in DFO research surveys using midwater trawls and traps from 1969 - 1980 at depths >2500m (n = 45 records) in PFMA 127, PFMA 142, and an unspecified PFMA (Pacific Fishery Management Area) (DFO, Nanaimo, B.C., personal communication, 2014).

Phylum	Common name	Scientific name	Area 127	Area 142	Area unspecified
Annelida	Leeches	Hirudinea		X	
Arthropoda	Amphipod			X	
Arthropoda	Copepods	Copepoda			X
Arthropoda	Glass shrimp	*Pasiphaea pacifica*	X		
Arthropoda	King crab	*Lithodes couesi*		X	
Arthropoda	Shrimp	Hymenodora		X	
Arthropoda	Tanner crabs	Chionoecetes		X	
Chordata	Ascidians and tunicates	Ascidiacea		X	
Chordata	Bigeye flashlightfish	*Protomyctophum thompsoni*	X		
Chordata	Blue lanternfish	*Terletonbeania crenularis*	X		
Chordata	California headlightfish	*Diaphus theta*	X		
Chordata	Dover sole	*Microstomus pacificus*	X		
Chordata	Eelpouts	Zoarcidae		X	X
Chordata	Finescale mora	*Antimora microlepsis*		X	X
Chordata	Northern lampfish	*Stenobrachius leucopsarus*	X		
Chordata	Pacific grenadier	*Coryphaenoides acrolepis*		X	X

Phylum	Common name	Scientific name	Area 127	Area 142	Area unspecified
Chordata	Pacific viperfish	*Chauliodus macouni*	X		X
Chordata	Prowfishes	Zaproidae		X	
Chordata	Ragfishes	Icosteidae			X
Chordata	Rex sole	*Glyptocephalus zachirus*	X		
Chordata	Sablefish	*Anoplopoma fimbria*		X	
Chordata	Slender barracudina	*Lestidiops ringens*	X		
Chordata	Smooth abyssal grenadier	*Coryphaenoides armatus*		X	X
Chordata	Threadfin grenadier	*Coryphaenoides filifer*		X	X
Cnidaria	Jellyfish	Scyphozoa	X	X	
Cnidaria		Anthozoa		X	
Cnidaria	Coelenterates	Coelenterata		X	
Echinodermata	Brittle stars	Phrynophiurida		X	
Echinodermata	Sea cucumbers	Holothuroidea		X	
Echinodermata	Sea lilies and feather stars	Crinodea		X	
Echinodermata	Starfish	Asteroidea			X
Mollusca	Octopus	Octopoda		X	X
Mollusca	Squids	Teuthida	X		
Porifera	Sponges	Porifera		X	

5.3.2 Other species

Species from seven phyla have been captured in DFO groundfish research surveys at depths greater than 2500 m (Table 5.2), including Annelida, Arthropoda, Chordata, Cnidaria, Echinodermata, Mollusca, and Porifera. Arthropods included Tanner and king crabs, glass shrimp and copepods, while echinoderms included brittle stars, crinoids, sea cucumbers and seastars. Squid and octopus were also captured at these depths. Given scant data from within Canadian waters, inferences about species composition must be drawn from other studies.

The dominant taxa within the abyssal plain are infaunal and epifaunal invertebrates, including nematodes, copepods, and foraminiferan protozoa (Table 5.3). Nematodes in particular exhibit considerable diversity within this environment (Lambshead and Boucher 2003). Rotifera, Polychaeta, and Acarina may also be found (Renaud-Mornant and Gourbault 1990). Hard substrata are typically dominated by suspension feeders; soft sediments are dominated by filter feeders (Hannides and Smith 2003). Elasipod holothurians constitute a major portion of the invertebrate megafauna within the abyssal plains, with more than 40 species found at abyssal depths, 18 of which are restricted to single oceans basins (Smith et al. 2006). No holothurian species endemic to the North Pacific Ocean have yet been identified.

The most diverse and abundant group of fauna within the abyssal plains is the macrofauna (organisms between 300µm and 2 cm) (Smith et al. 2006). Isopods in particular are well-represented, with more than 500 species collected from abyssal depths, and estimates of more than 10,000 species total (Poore and Wilson 1993). Polychaetes are also highly diverse, with more than 200 species collected and estimates of more than 100,000 species in total (Smith et al. 2006). Rates of endemism in this group may be high, but again these estimates are confounded by low sampling effort and low taxonomic knowledge. Neogastropods may also be found in abyssal plain habitats, but are thought to be representatives of shelf or slope species (Rex et al. 2005). The biomass of benthic macrofauna on the Cascadia Plain has been observed to be higher than on the Tufts Plain, likely due to its proximity to land and the consequent higher levels of sediment and nutrient inputs (Carey Jr 1981).

Common meiofaunal (<300-500µm, >42-62µm) taxa in abyssal habitats include nematode worms, harpacticoid copepods, and protozoan foraminifera. There may be as many as 1,000 deep-sea foraminiferan species, but distributions are suspected to be broad and estimates of endemism are likely to be inflated (Smith et al. 2006). Nematodes and harpacticoid copepods appear to be similarly diverse, but are also undersampled (Smith et al. 2006). Patchiness in distribution of these copepods and of foraminiferans has been noted at varying scales ranging from centimetres to hundreds of metres (Rex 1981).

In summary, due to chronic undersampling of bathyal and abyssal habitats and numerous cryptic species, estimates of species richness for numerous taxa are likely underestimates in these areas. Additionally, the factors that drive the distribution and abundance of benthic fauna remain unknown.

Table 5.3. Comparison of number of species found on the continental slope of Oregon vs. the Cascadia Abyssal Plain. Adapted from Pearcy et al (1982).

	Continental Slope	Cascadia Abyssal Plain
Liparididae	19	11
Zoarcidae	13	8
Macrouridae	6	6
Pleuronectidae	6	0
Rajidae	8	1
Scorpaenidae	12	0

5.4 FEATURE CONDITION AND FUTURE OUTLOOK OF THE EVALUATED AREA

The depth and inaccessibility of abyssal habitats provides some protection from anthropogenic pressures; however, seabed mining for manganese nodules, methane hydrate extraction, and other mineral exploration could increase impacts on this area. Because the habitat for benthic organisms is within the top few centimetres of sediment, the benthic community of the abyssal plain is highly sensitive to physical disturbance (Hannides and Smith 2003). Slow growth rates, low macrofaunal recolonization rates, and low sediment accumulation rates also make recovery from disturbance very slow (Table 5.4; Hannides and Smith 2003). Preliminary studies on the potential effects of seabed mining have shown that although polychaetes recovered fairly quickly (within 3 years), macrofaunal biodiversity remained depressed seven years after disturbance (Hannides and Smith 2003). Also, regeneration of the manganese nodules themselves, which are the target of deepsea mining, takes millions of years (Ghosh and Mukhopadhyay 2000, McMurtry 2009).

Additionally, climate change may affect deep sea habitats more than many other areas due to their tight coupling with, and dependence on, surface productivity (Brodeur et al. 2003). Climate change can affect primary productivity directly through physiological effects on phytoplankton;

and indirectly, through changes in regional climatic conditions that in turn result in changes in community structure (Hannides and Smith 2003). Abyssal fauna also show decadal-scale cycles in abundance that have been linked to climate change (Rex et al. 2005, Bailey et al. 2006). Changes in ocean circulation patterns and deep water circulation may also have unpredictable effects in abyssal habitats (Stouffer and Manabe 1999).

There is some evidence that body size increases with increasing depth across many taxa, particularly crustaceans, and bathypelagic invertebrates are likely to live much longer than epipelagic species as growth rates are correspondingly slower (Mauchline 1972). The lower density, increased longevity, and lower fecundity of bathypelagic species means that they are more susceptible to, and slower to recover from, exploitation and other disturbances (Mauchline 1972).

Due to their bottom-up structuring, abyssal habitats are also acutely sensitive to changes in phytoplankton community structure (Drazen et al. 2008), and could be heavily impacted by iron-fertilization experiments (Smith et al. 2008). Additionally, because of low population densities, many species are vulnerable to Allee effects and thus face a higher extinction risk (Rex et al. 2005). Expansion of commercial fishing into deeper waters and nutrient inputs from discards could also affect these areas.

Table 5.4. Reported values for various habitat metrics. Adapted from Hannides and Smith (2003).

Habitat parameter	**Mean values for Northeast Pacific oligotrophic abyssal environments**
Sedimentary POC flux (g C m^{-2} yr^{-1})	0.04-0.76
Megafaunal abundance (ind m^{-2})	0.15
Megafaunal biomass (g wet wt m^{-2})	>12.4-12.6
Macrofaunal abundance (ind m^{-2})	12-160
Macrofaunal biomass (mg wet wt m^{-2})	2.1-137
Meiofaunal abundance (10^3 ind m^{-2})	10-232
Meiofaunal biomass (mg wet wt m^{-2})	0.24-243
Microbial abundance (10^{12} ind m^{-2})	0.56-2.4
Microbial biomass (mg wet wt m^{-2})	95-172
Manganese nodule faunal abundance (10^3 ind. $0.25m^{-2}$	0.7-1.0

5.5 ASSESSMENT OF THE AREA AGAINST CBD EBSA CRITERIA

<table>
<tr><th rowspan="2">CBD EBSA Criteria
(Annex I to decision IX/20)</th><th rowspan="2">Description
(Annex I to decision IX/20)</th><th colspan="4">Ranking of criterion relevance
(please mark one column with an X)</th></tr>
<tr><th>No information</th><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><td>Uniqueness or rarity</td><td>Area contains either
i) unique (“the only one of its kind”), rare (occurs only in few locations) or endemic species, populations or communities, and/or
ii) unique, rare or distinct, habitats or ecosystems; and/or
iii) unique or unusual geomorphological or oceanographic features.</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td colspan="6">Abyssal habitats are generally poorly sampled, which can lead to an inflated number of novel species being discovered with increased effort. Undersampling may also lead to overestimates of endemicity, as sampling efforts are often patchy and non-systematic. The limited available information suggests that abyssal endemicity is low compared to other open-ocean habitats (e.g., shallower pelagic waters, seamounts). The sheer size of the abyssal area means that it is not a rare habitat, but it may contain as-yet undiscovered patches of heterogeneity and diversity.</td></tr>
<tr><td>Special importance for life-history stages of species</td><td>Areas that are required for a population to survive and thrive.</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Insufficient data exist on whether abyssal habitats are important for various species; however, many species are confined to specific depth ranges and may rely on or be adapted to specific abyssal areas or conditions.</td></tr>
<tr><td>Importance for threatened, endangered or declining species and/or habitats</td><td>Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Insufficient data exist on whether abyssal habitats are important for threatened, endangered or declining species and/or habitats.</td></tr>
<tr><td>Vulnerability, fragility, sensitivity, or slow recovery</td><td>Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.</td><td>X</td><td></td><td></td><td></td></tr>
</table>

The low biological productivity of abyssal habitats means that they would likely be slow to recover from disturbance (Smith et al. 2006); however the low structural complexity of abyssal plains also make them less susceptible to the types of disturbances that would disrupt other fragile and biogenic habitats such as sponge reefs and hydrothermal vents, so vulnerability to physical disturbance is assumed to be lower than other habitats that have higher structural complexity.					
Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.		X		
Being too deep for photosynthesis, biological productivity of abyssal plain habitats is typically very low (Hannides and Smith 2003). Primary productivity in abyssal habitats is absent outside of chemosynthetic environments such as hydrothermal vents.					
Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.		X		
Although abyssal habitats are generally poorly sampled, research to date indicates that biological diversity is fairly low. However, local diversity – particularly for invertebrates such as amphipods – can be quite high (Smith et al. 2008a). Considerable bacterial and microbial diversity may exist, but has not been extensively sampled to date (Scheckenbach et al. 2010).					
Naturalness	Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.				X
The extreme depths of the abyssal waters means that they are relatively undisturbed by current activities (e.g., fishing), but remain susceptible to future human activities such as seabed mining and ocean dumping (Rex et al. 2005). Currently, there is limited dumping and no mining in this area.					
Importance for species aggregation (DFO criterion)	Area where species aggregation for important life cycle functions (breeding/spawning, rearing, feeding, migrating, etc).	X			
Insufficient data exist to evaluate whether abyssal habitats are important for species aggregation.					

5.6 SUMMARY

Abyssal habitats were ranked as high on naturalness, primarily due to their extreme inaccessibility. All other criteria were ranked as low or as insufficient information to assess. Thus, abyssal habitats do not currently meet criteria for identification as an EBSA. We recommend a reassessment of this area as more information becomes available given its future outlook.

6 PELAGIC AND SURFACE WATERS

6.1 INTRODUCTION

Globally, pelagic waters have more than twice the surface area and over 150 times the habitable volume of all terrestrial biomes (Ardron et al. 2011), with a total volume of over one billion km^3 (Webb et al. 2010). The pelagic zone is formally defined as "the physical, chemical, and biological features of the marine water column of the open oceans or seas rather than waters adjacent to land or inland waters (Game et al. 2009).

Classification of pelagic waters generally falls into two categories: taxonomic and physiognomic (UNESCO 2007). The former type relies on similarities and differences in organisms and communities; the latter relies on similarities and differences in habitat or function. McGowan (1974) and Voronina (1978) both subdivided the Pacific Ocean into ecotones based on oceanic gyres and species distributions. Many systems since then have divided the world's oceans into different zones at varying levels of organization using different methodologies (Table 6.1). Using existing biogeographic classification systems - including Large Marine Ecosystems (Sherman and Alexander 1986), Marine Ecosystems of the World (MEOW; Spalding et al. 2007), Marine Ecosystems of North America (MECNA; Commission for Environmental Cooperation 1997), the Global Open Oceans and Deep Seabeds Biogeographic Classification (GOODS: Vierros et al. 2009), and Longhurst's Biogeochemical Provinces (BGCP: Longhurst 2010) - DFO (2009a) delineated the waters between the shelf break and the EEZ boundary as the Offshore Pacific Bioregion, which includes waters within the Alaska Gyre, California Gyre, and a transition zone between these two areas (Figure 6.1). Four of the classification systems used a qualitative verification of their classification (MEOW, MECNA, Environment Canada and Parks Canada) and two of these systems used a quantitative verification process (GOODS and BGCP) (O'Boyle 2010).

Depending on the system of classification used, the pelagic zone within Canada's Offshore Pacific Bioregion has been considered as encompassing one (e.g., Vierros et al. 2009), two (e.g., Zacharias et al. 1998), or three biogeographic zones (e.g., Longhurst 2010). However, these classification systems do not always distinguish between coastal and pelagic areas; thus, the most useful zoning schemes for the purposes of this report are those that consider and subdivide the pelagic zone separately from on-shelf regions (Zacharias et al. 1998, Longhurst 2010).

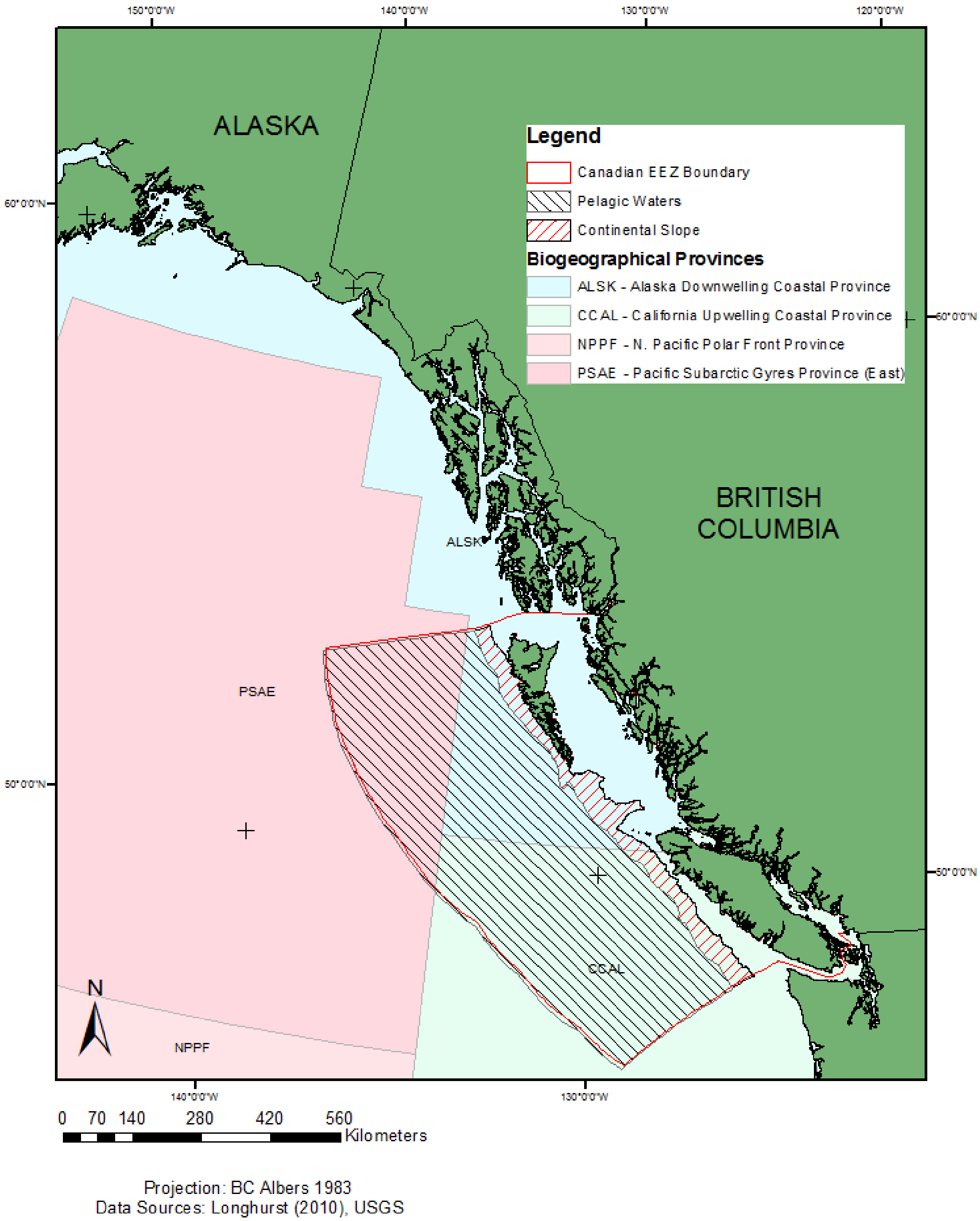


Figure 6.1. Location of pelagic zone showing the Biogeographical Provinces (Longhurst 2010) system of classification.

Given the vast size of the pelagic realm, it remains relatively poorly sampled. Most records within the Ocean Biogeographic Information System (OBIS), for example, are from either the surface or the first 1,000 m of the water column (Figure 6.2). Because of this chronic undersampling, deep pelagic systems have been estimated to contain up to one million undescribed species (Robison 2004). Much of the biomass (up to 25%) in deeper waters is likely contained in gelatinous zooplankton, such as siphonophores, ctenophores, and medusae (Robison 2004). Large populations of deep megafauna, especially bathypelagic squid, are also thought to exist (Robison 2004). Biological and oceanographic information has come predominantly from fishing data throughout the Canadian region and from ship sampling of the transect along Line P to Ocean Station Papa at 50°N and 145°W, which has occurred at least twice per year since 1981, with some data going back to 1949 (Whitney and Freeland 1999). However, this transect represents only a very small portion of the total pelagic area within Canada's Offshore Pacific Bioregion.

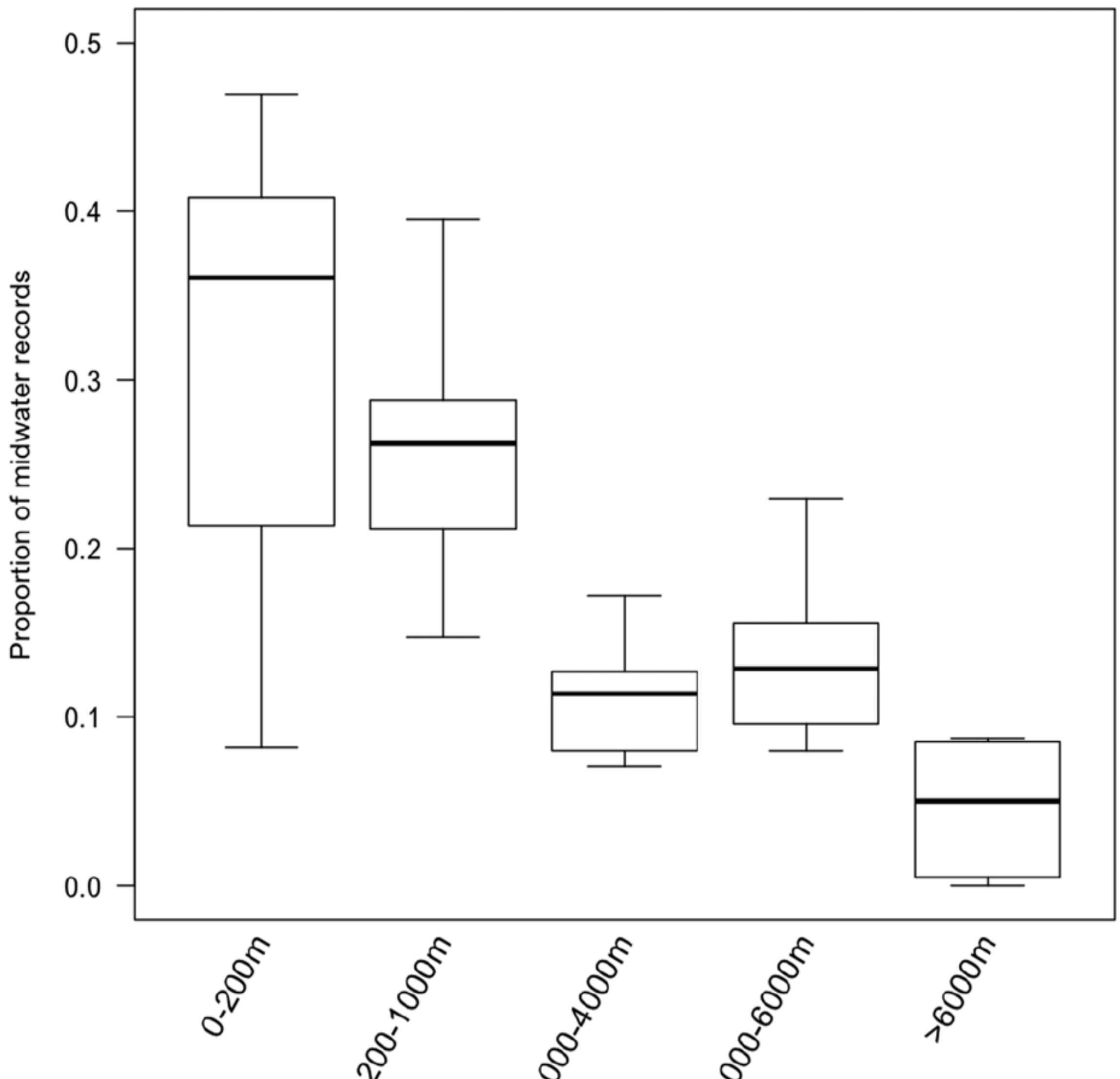


Figure 6.2. Proportion of marine biodiversity records from midwater pelagic ecosystems for the global ocean. Midwater is defined as the entire water column, minus the 10m closest to the surface. Plots show median, interquartile range, and total range of observed proportions. From (Webb et al. 2010).

The areas of highest diversity in pelagic systems tend to coincide with oceanographic front and boundary regions, and to depths of around 1,000 m (Angel 1993). Eleven phyla exist in pelagic waters globally, with only one (Ctenophora) being endemic to the pelagic environment (Angel 1993). Oceanic pelagic communities are widely distributed horizontally – on the order of thousands of kilometres, but may have depth distributions that vary between tens to thousands of metres (Angel 1993). For example, most pelagic fish species within the North Pacific Ocean are trans-Pacific in distribution (Parin 1970). Horizontal distributions of species are determined by two main factors: the climate (predominantly changes in water temperature) and the features of a water mass, mainly nutrient and chemical composition. The depth distribution of a given species is typically determined by water temperature, pressure, and light availability (Van der Spoel 1994). Surface water masses will also show seasonal changes in properties such as salinity, light attenuation, nutrient levels, dissolved oxygen, and biological productivity which will in turn influence species distributions (Norris 2000). For example, the North Pacific Transition Zone (Figure 6.4) is a particularly productive oceanic system, and within this zone diversity of epipelagic fishes appears to be highest on the eastern side due to the direction of prevailing currents (Brodeur et al. 1999).

Table 6.1. Marine classification systems and corresponding zone(s) for pelagic waters within Canadian Pacific waters.

Classification system	Zone(s)	Reference
Pacific Upper Zone Domains	Central Subarctic Domain, Transitional Domain	(Dodimead et al. 1963)
Large Marine Ecosystems	Gulf of Alaska	(Sherman and Alexander 1986)
Environment Canada Ecoprovinces	Northeast Pacific, Transitional Pacific	(Wiken 1986)
Marine Ecoregion Classification of North America	Alaskan/Fjordland Pacific Ecoregion	(Commission for Environmental Cooperation 1997)
British Columbia Marine Ecosystem Classification (Ecosections)	Subarctic Pacific, Transitional Pacific	(Zacharias et al. 1998)
Marine Ecosystems of the World	North American Pacific Fjordland, Oregon, Washington, Vancouver Coast and Shelf	(Spalding et al. 2007)
Global Open Oceans and Deep Seabeds Biogeographic Classification	North Pacific Current	(Vierros et al. 2009)
Biogeographic Classification of Marine Areas	Offshore Pacific	(DFO 2009a)
Biogeographical provinces	Alaska Downwelling Coastal Province, Westerlies – Pacific Subarctic Gyres Province (East), Coastal – California Upwelling Coastal Province	(Longhurst 2010)
Canadian Council of Resource	West Coast Vancouver Island,	(Rankin et al. 2012)

Classification system	Zone(s)	Reference
Ministers Ecozones	North Coast and Hecate Strait	
Pelagic Provinces of the World	California Current, North Pacific Current, Subarctic Pacific	(Spalding et al. 2012)
Parks Canada National Marine Conservation Areas Plan	Queen Charlotte Shelf, Queen Charlotte Sound, Vancouver Island Shelf	(Parks Canada 2013)

6.2 LOCATION

The pelagic waters within Canada's Offshore Pacific Bioregion extend from the edge of the shelf break westward to the EEZ boundary (Figure 6.1). Although different classification systems subdivide this area differently (Table 6.1), most agree that at least two (if not three) distinct biogeographical zones exist within these waters. For example, under the Pelagic Provinces of the World system (Spalding et al. 2012), these waters are predominantly within the California Current province, with northern portions falling within the subarctic Pacific and offshore regions being within the North Pacific Transitional province. However, in practice the oceanographic features that define the boundaries between these zones are not static, and shift on multiple timescales.

6.3 FEATURE DESCRIPTION OF THE EVALUATED AREA

Important oceanographic features within this zone include gyres, upwelling zones, and convergence and divergence areas. Often these features are ephemeral and dynamic, making the drawing of static boundaries difficult; however, species distributions typically match large-scale circulation patterns. Another complicating factor with species distributions is that many pelagic species either actively migrate seasonally, or are passively advected outside of their typical range (Angel 1993). Globally, pelagic waters have a relatively low species richness compared to other habitats such as benthic and coastal habitats (Angel 1993). Portions of the Pacific Ocean, particularly in subarctic waters, are known as high nutrient-low chlorophyll (HNLC) areas. Even though these waters have high nutrient (e.g., nitrate, phosphate) concentrations, biological productivity in terms of phytoplankton is often low (Whitney et al. 2005). Nutrients such as iron (Maldonado et al. 1999) and silicate (Whitney et al. 2005) are thought to be the limiting factors for phytoplankton growth in these waters.

Oceanographic features such as fronts, eddies, and gyres can create biological hotspots in the ocean (Palacios et al. 2006). Some of these features are persistent in both space and time while others are ephemeral, or may move over the course of days, weeks, or months. One such feature that has been identified in Canada's Pacific waters is the Haida eddy (Figure 6.3; Crawford 2002, Whitney and Robert 2002, Di Lorenzo et al. 2005, Miller et al. 2005). Haida eddies form in the late winter near the islands of Haida Gwaii from buoyant plumes flowing out of Hecate Strait (Miller et al. 2005). These eddies entrain waters with temperature, salinity, and chemical profiles typical of coastal waters at depths between 150-600 m, while surface waters within the eddy tend to mix with surrounding waters.

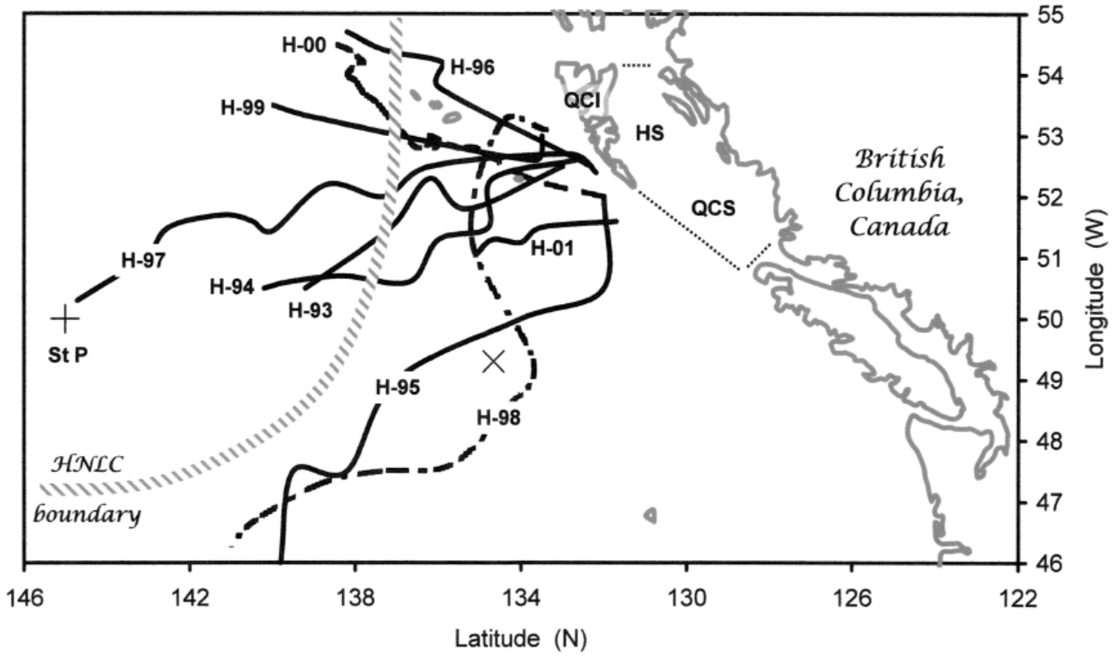


Figure 6.3. Location and tracks of Haida eddies formed between 1993 and 2001. From Whitney and Robert (2002).

The zooplankton communities within eddy waters have been observed to be distinct from those outside, and thus such eddies may be an important mechanism for dispersing planktonic organisms (Miller et al. 2005). Haida eddies are generated more frequently in El Niño years (Miller et al. 2005). Given the associations between species and their ecological communities, and these dynamic oceanographic features, the use of dynamic delineations rather than static EBSA boundaries has been suggested (Ardron et al. 2011).

Another significant oceanographic feature within this region is the North Pacific Transition Zone (Figure 6.4). This 9,000 km wide upper water column oceanographic feature is bounded by thermohaline fronts, the Subarctic Frontal Zone in the north (40-43°N) and the Subtropical Frontal Zone in the south (28-34°N), thereby establishing a highly productive habitat that aggregates prey resources, attracts a number of pelagic predators, and serves as a migratory corridor. The position of these fronts varies seasonally and interannually, being furthest north in July-August and furthest south in January-February (Polovina et al. 2008).

The number and diversity of species found in this dynamic area make it impractical to enumerate the importance of this area for each species – for example, more than 1,000 fish species have been reported for the Pacific coast of the Americas (Croom et al. 1995). Thus, an overview of species assemblages found in this area is presented below. These assemblages include plankton, other invertebrates, myctophid fishes, salmon, marine mammals, and seabirds. Commercially important species caught in pelagic waters such as tuna, squid, and sablefish also tend to have more available data than other taxa. We also used available data from species tagged in the Tagging of Pacific Pelagics (ToPP) project (Block et al. 2002), which provides detailed information about habitat usage by these species.

6.3.1 Plankton

There are an estimated 3500-4500 species of oceanic phytoplankton globally (Angel 1993); however, genetic diversity within plankton species is generally low (Bucklin and Wiebe 1998). This low genetic diversity may leave populations susceptible to pathogens and changes in habitat characteristics (Norris 2000), and most pelagic species (80-90%) are rare (McGowan 1990). However the total number of phytoplankton species is probably underestimated (Norris 2000). Within the northeastern Pacific Ocean, zooplankton is distributed patchily, but by volume sergestid shrimp typically dominate macroplankton sampling catches, followed by euphausiids and amphipods (Aron 1962).

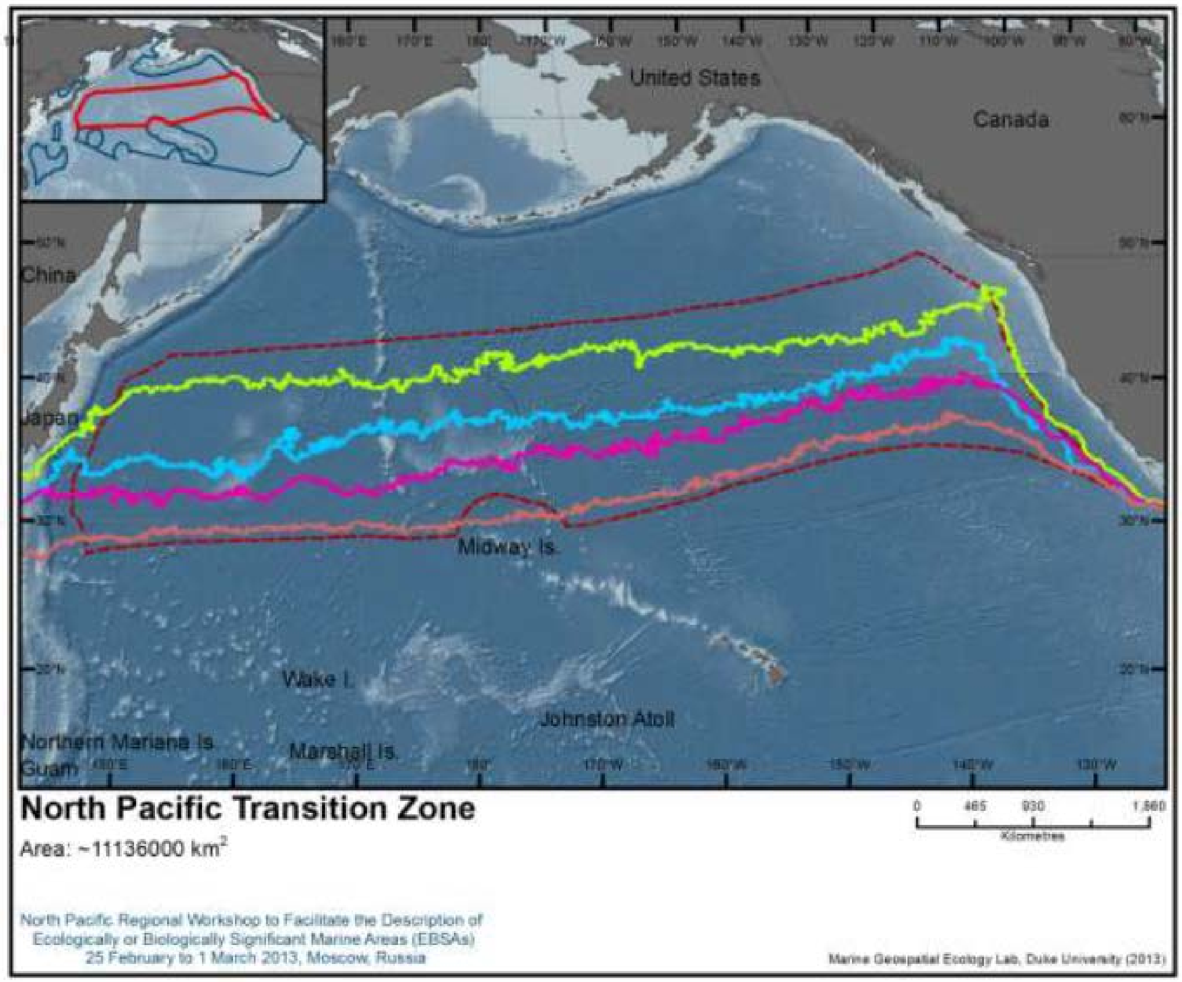


Figure 6.4. Position of the North Pacific Transition Zone; coloured lines represent the seasonal position of the chlorophyll front, which serves as a proxy for the location of the transition between the subtropical and subarctic gyres. The dashed red line represents the boundaries of the Transition Zone EBSA in international waters. From CBD (2014).

Copepods have been well-sampled in both the California Current and Gulf of Alaska ecosystems (Batten and Walne 2011, Francis et al. 2012). Copepods exhibit a strong response to changes in the Pacific Decadal Oscillation (PDO) and El Niño Southern Oscillation (ENSO) on seasonal, interannual, and multidecadal scales, which typically manifest as changes in regional ocean temperatures, upwelling strength, and salinity (Francis et al. 2012). In the eastern Pacific Ocean, copepods can be categorized by their affiliation with water masses: cold neritic, subarctic, warm neritic, warm oceanic, and other (Peterson and Keister 2003, Hooff and Peterson 2006). The cold neritic and subarctic groups would be more typical in Canada's Pacific waters, including species such as *Acartia hudsonica, Acartia longiremis, Calanus marshallae, Centropages abdominalis, Epilabidocera amphitrites, Pseudocalanus mimus, Tortanus discaudatus, Metridia pacific, Microcalanus pusillus, Neocalanus plumchrus, and Scolecithricella minor* (Hooff and Peterson 2006). Further, euphausiids (*Euphausia pacifica* and *Thysanoessa spinifera*) form an important part of the diet for many pelagic fishes, including hake and salmon (Mackas et al. 1997).

Within the North Pacific Transition Zone, zooplankton show a gradient from nearshore to oceanic species, but both types may be found throughout the transition zone due to physical transport processes (Mackas and Coyle 2005). Over the continental margin, larvae of demersal fish and shallow-water benthic species dominate; over the continental shelf, ctenophores and cnidarians dominate (Mackas and Coyle 2005). Offshore, migratory micro-nekton and chaetognaths are more common (Mackas and Coyle 2005).

6.3.2 Other invertebrates

Over 6,000 invertebrate species have been estimated to occur in the northeastern Pacific Ocean (Austin 1985); although many of these species are benthic, these species also typically have a planktonic life phase during which they may be found in pelagic waters. Invertebrates are particularly data-sparse in the region under consideration, with little information on abundances or distributions for non-commercial species. Additionally, cephalopods such as neon flying squid (*Ommastrephes bartrami*) and robust clubhook squid (*Onykia robusta*) form an important part of the pelagic food web both as predators and as prey, especially for marine mammals (Pauly et al. 1998b, Hunt et al. 2000, Sinclair and Zeppelin 2002) and seabirds (Hunt et al. 2000), and some squid species have commercial value both as bait and for human consumption.

A range expansion of Humboldt squid (*Dosidicus gigas*) into northeastern Pacific waters may also be occurring with rising ocean temperatures (Litz et al. 2011, Gilly and Field 2012, Stewart et al. 2012, Ruiz-Cooley et al. 2013) and changes in the depth of the oxygen minimum layer. Neon flying squid and clubhook squid exhibit different temperature preferences as they migrate north from spawning areas in more southern waters, with flying squid preferring warmer waters (15-22°C) than clubhook squid (10-15°C) (Gillespie 1997). Higher temperatures appear to induce significant increases in growth during their paralarval phase (Gillespie 1997).

A test fishery for Neon Flying Squid was conducted between 1996-1998 to determine the distribution and abundance of this species as well as for Boreal Clubhook (*Onychoteuthis borealijaponica*), Eight-armed (*Gonatopsis borealis*) and Schoolmaster Gonate (*Berryteuthis magister*) squid (Gillespie 1997); these latter species are less commercially valuable than neon flying squid and tend to form only a small portion of bycatch in flying squid fisheries. Because these squid are annual semelparous reproducers, they are susceptible to population collapses in years of poor productivity or other reproductive failures. However, their short generation time also enables them to recover quickly from these collapses (Gillespie 1997). Although the last formal stock assessment for Neon Flying Squid was in 1999 (DFO 1999), more recent studies (Ichii et al. 2011) indicate that populations are relatively low but stable, probably due to a regime change in the North Pacific Ocean. At the peak of the fishery for Neon Flying Squid in 1989, 375,000 mt were landed (DFO 1999).

6.3.3 Fishes

Two fish assemblages are highlighted here due to their commercial and/or ecological importance: Myctophid fishes and salmon. Other species such as tuna and sharks are reviewed in a separate section focusing on top predators.

6.3.3.1 Myctophid fishes

Myctophid fishes (lanternfish) are one species assemblage that has been used to delineate water masses within the northeastern Pacific Ocean (Aron 1962, Beamish et al. 1999). *Lampanyctus leucopsarus* was commonly found north of 45˚N in waters shallower than 30 m (Aron 1962). Other diagnostic myctophid species of the Subarctic water mass in this area include *Diaphus theta*, *Tarletonbeania crenularis*, *Electrona arctica*, *Electrona crockeri*, *Ceratoscopelus townsendi*, and *Lampanyctus ritteri* (Aron 1962). These fish also form an important part of the diet for pelagic predators such as northern fur seals (Yonezaki et al. 2008), storm petrels (Vermeer and Devito 1988), kittiwakes (Hatch 2013), salmon (Pearcy et al. 1984), and blue sharks (LeBrasseur 1964).

6.3.3.2 Salmon

Although habitat usage differs by species, many Pacific salmon species make use of pelagic habitats during part of their life cycle (Welch et al. 2002, Myers et al. 2007). Specifically, Pacific salmon species tend to occur north of the boundary between the Subarctic Domain and the Subtropical Domain (i.e., north of the North Pacific Transition Zone) (Myers et al. 2007). At-sea survival of salmon appears to be strongly linked with climatic regimes, although the effect of these regime shifts probably affects salmon on the continental shelf more than in pelagic waters (Welch et al. 2000). In the Gulf of Alaska, where temperature variations have been linked to the timing of sockeye returns (Hodgson et al. 2006), water temperatures have been increasing while salinities have been decreasing and the mixed-layer depth has been getting shallower (Myers et al. 2007).

6.3.4 Marine mammals

Predictive models (informed by sightings data) indicate that these pelagic waters are likely habitat for at least 24 cetacean species and four pinniped species (Table 6.2); additional data from satellite tags has provided more detailed information on animal movements and habitat use (Harrison 2012). Marine mammals such as elephant seals have been observed to forage within frontal zones (Crocker et al. 2010) as well as within Haida eddies (Simmons et al. 2007). Other cetaceans have also been associated with oceanographic fronts (Bluhm et al. 2007, Dalla Rosa et al. 2012, Murase et al. 2014). Although both phocids (true seals) and otariids (sea lions) may be found in pelagic environments, phocids tend to have longer at-sea foraging migrations (Harrison 2012). Northern elephant seals (*Mirounga angusirostris*) are particularly notable, with females spending as long as 10 months of the year at sea (Robinson et al. 2012). California sea lions (*Zalophus californianus*) typically forage over the continental shelf, but may forage considerably farther offshore (up to 450 km) in years of decreased coastal productivity (Weise and Harvey 2008). Blue whales (*Balaenoptera musculus*), once severely depleted by whaling, appear to have recovered to near pre-exploitation levels (Monnahan et al. 2014) and may now be regularly migrating between Mexico and Alaska, passing through Canadian waters in the process (Calambokidis et al. 2006). Habitat models informed by historic whaling data indicate that fin, sei, and male sperm whales (male and female sperm whales were modeled separately due to behavioural differences) historically occurred in waters along the entire shelf break out to approximately 75-100 km offshore (Gregr and Trites 2001). Other habitat models informed by sightings data show that much of the region from the shelf break seawards is likely habitat for nearly all of the marine mammal species found in this region (Figure 6.5; Kaschner et al. 2013).

6.3.5 Seabirds

Short-tailed (*Phoebastria albatrus*), black-footed (*Phoebastria nigripes*), and Laysan (*Phoebastria immutabilis*) albatrosses all have foraging ranges that overlap with pelagic waters in this area, although their breeding sites are all located much further south and west (Cousins et al. 2000). Ship transect surveys have detected seabird aggregations along much of the continental slope (Figure 6.6; Kenyon 2009); subsequent modeling work based on these and other surveys have created maps of seabird “hotspots” (Nur et al. 2011, Figure 6.7; Sydeman et al. 2012). Nur et al. (2011) found that static bathymetric features (depth and proximity to shore) were the best predictors of seabird hotspots, and were fairly stable from season to season and year to year. Seabirds are also known to associate with oceanic frontal systems such as those found at the edge of eddies, which typically aggregate phytoplankton and hence attract potential prey (O’Hara et al. 2006).

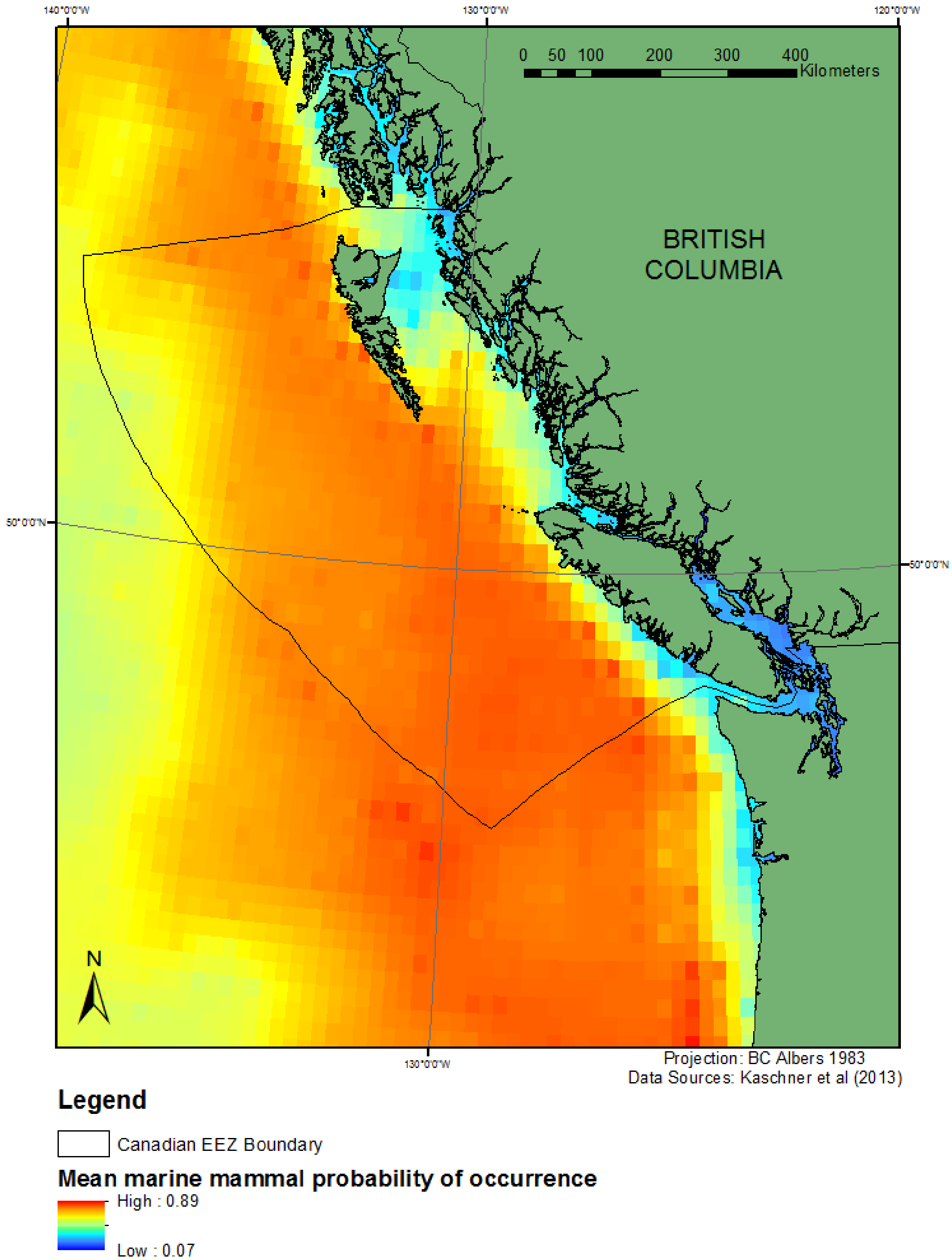


Figure 6.5. Composite average of predicted probability of occurrence for 20 of the most common marine mammal species found in the northeast Pacific. Data from Kaschner et al (2013).

O'Hara et al. (2006) also found that northern fulmars (*Fulmaris glacialis*), black-legged kittiwakes (*Rissa tridactlya*), tufted puffin (*Fratercula cirrhata*), and several phalarope species (*Phalaropus* spp.) were all significantly associated with sea surface temperature (SST) gradients in the pelagic domain. Seabirds also represent a significant component of the marine food web, with one estimate putting consumption by marine birds in the Gulf of Alaska at 18 kg of biomass per km^2 per day (DeGange and Sanger, 1986 as cited in Hunt et al. 2000).

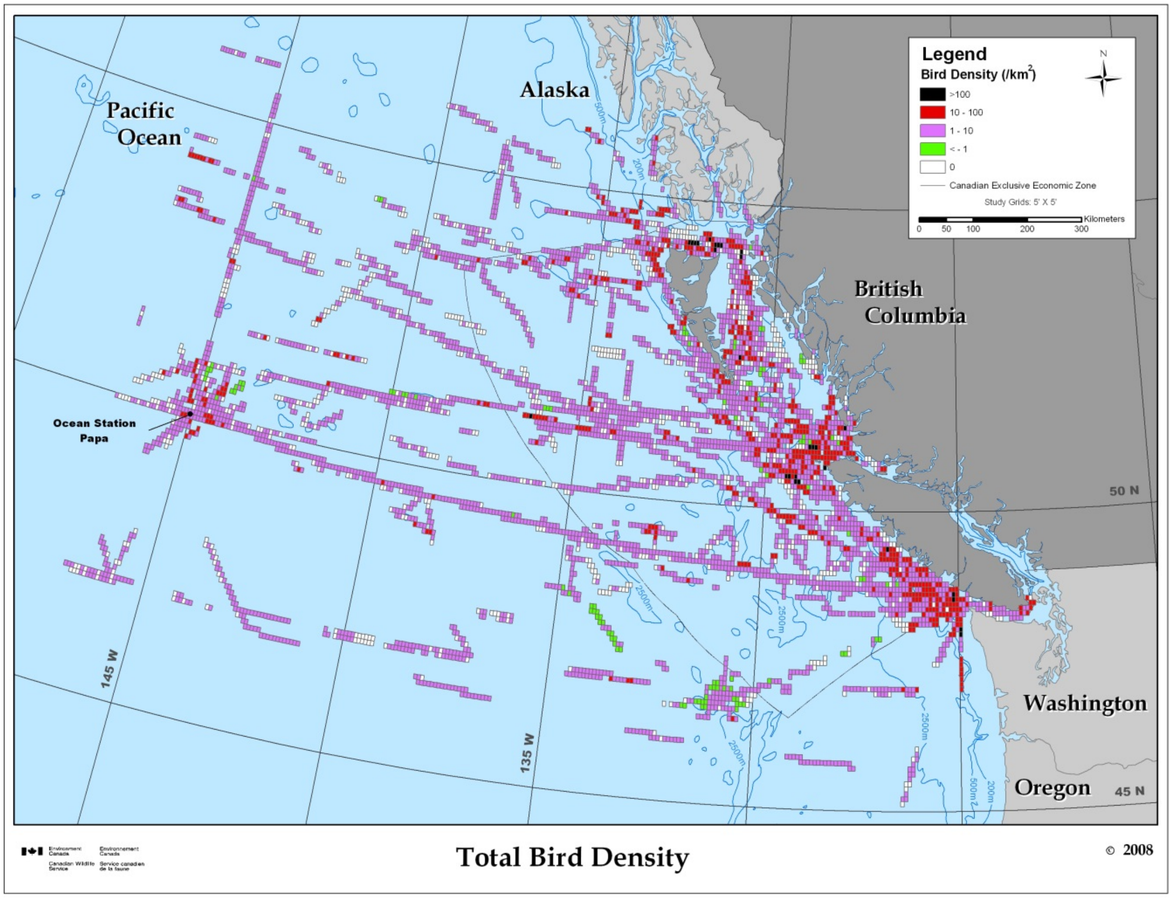


Figure 6.6. Total seabird density encountered on ship transect surveys from 1982-2005. From Kenyon (2009).

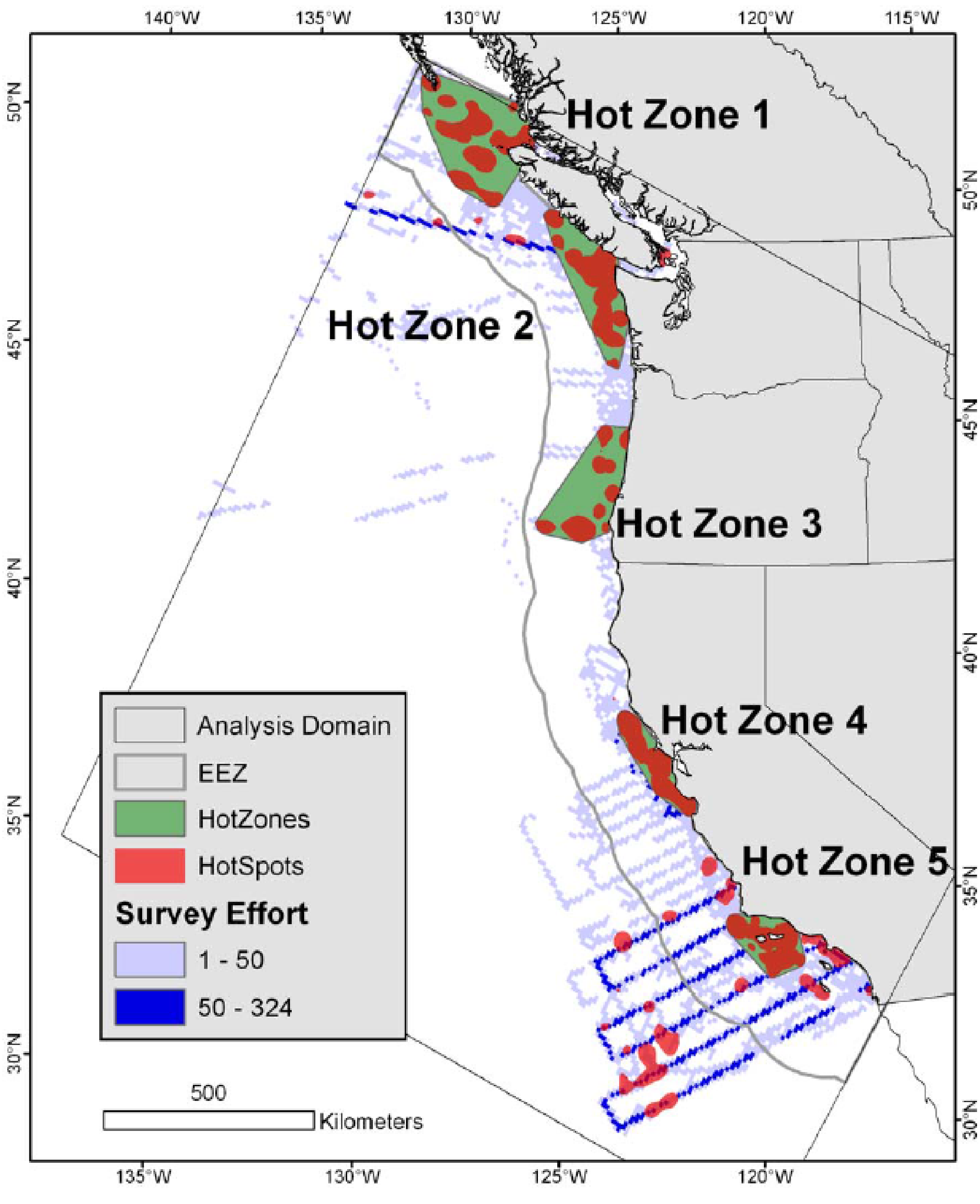


Figure 6.7. Seabird hotzones and hotspots along the California Current. A hotspot is a species-specific aggregation. A hotzone is a cluster of hotspots. From Sydeman et al (2012).

6.3.6 Top predators

Although the ranges and depth distributions of pelagic predators are not well-known, recent tagging efforts have revealed some of the movement and migration patterns of top predators such as tuna, sharks, pinnipeds, cetaceans, and marine turtles (Table 6.3; Block et al. 2002, Harrison 2012). Juvenile Pacific albacore tuna (*Thunnus alalunga*) occur in these waters and are targeted by both U.S. and Canadian fishing vessels (Holmes 2014). Juvenile Pacific bluefin tuna (*T. orientalis*) also reside in California Current waters for several years after spawning in the western Pacific before returning (Kitagawa et al. 2007, Boustany et al. 2010).

Salmon sharks (*Lamna ditropis*), for example, undergo a seasonal migration from subtropical waters near Hawaii to Prince William Sound in Alaska, with some occasionally overwintering in Alaskan waters (Weng et al. 2005). At least 28 elasmobranchs have ranges which potentially overlap with the pelagic waters of Canada's Offshore Pacific Bioregion (Kaschner et al. 2013), although some are considered benthic or neritic species. Of the 21 known pelagic shark and ray species worldwide, most have life history characteristics that make them vulnerable to overexploitation; many are also globally Red Listed (Table 6.4; Dulvy et al. 2008); of these, seven are likely to be found in Canadian waters (Kaschner et al. 2011) and five of these are listed as Vulnerable by the IUCN. Blue sharks (*Prionace glauca*) are widely distributed in both pelagic and coastal waters, and are commonly caught as bycatch in pelagic longline fisheries (Harrison 2012).

Table 6.2. Marine mammals found or predicted to be found within Canada's Pacific pelagic waters. From Kaschner et al. (2013) and IUCN (2014). A1: Listed due to reduction in population size >70% over the last 10 years; a – data from direct observation; b – derived from index of abundance; d – derived from actual or potential levels of exploitation.

Common name	Scientific name	IUCN Red list status	COSEWIC Status	SARA
Balaenidae				
North Pacific right whale	*Eubalaena japonica*	Endangered	Endangered	Endangered
Balaenopteridae				
Northern minke whale	*Balaenoptera acutorostrata*	Least concern	Not at risk	Not at risk
Humpback whale	*Megaptera novaeangliae*	Least concern	Special concern	Threatened
Sei whale	*Balaenoptera borealis*	Endangered A1ad	Endangered	Endangered
Bryde's whale	*Balaenoptera brydei*	Data deficient	n/a	Not listed
Blue whale	*Balaenoptera musculus*	Endangered A1abd	Endangered	Endangered
Fin whale	*Balaenoptera physalus*	Endangered A1d	Threatened	Threatened
Delphinidae				
Dall's porpoise	*Phocoenoides dalli*	Least Concern	Not at Risk	Not listed

Common name	Scientific name	IUCN Red list status	COSEWIC Status	SARA
Bottlenose dolphin	*Tursiops truncatus*	Least Concern	Not at Risk	Not listed
Common dolphin	*Delphinus delphis*	Least Concern	Not at Risk	Not listed
Risso's dolphin	*Grampus griseus*	Least Concern	Not at Risk	Not listed
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	Least Concern	Not at Risk	Not listed
Northern right-whale dolphin	*Lissodelphis borealis*	Least Concern	Not at Risk	Not listed
Killer whale	*Orcinus orca*	Data Deficient	Threatened/Endangered[6]	Threatened/Endangered
False killer whale	*Pseudorca crassidens*	Data Deficient	Not at Risk	Not at Risk
Striped dolphin	*Stenella coeruleoalba*	Least Concern	Not at Risk	Not listed
Eschrichtiidae				
Gray whale	*Estrichius robustus*	Least Concern	Special Concern	Special Concern
Kogiidae				
Pygmy sperm whale	*Kogia breviceps*	Data Deficient	Not at Risk	Not listed
Otariidae				
Steller's sea lion	*Eumetopias jubatus*	Near Threatened	Special Concern	Special Concern
Northern fur seal	*Callorhinus ursinus*	Vulnerable	Threatened	Not listed
California sea lion	*Zalophus californianus*	Least Concern	Not at Risk	Not listed
Phocidae				

[6] Southern resident population endangered; northern resident population threatened; offshore population threatened; transient population threatened

Common name	Scientific name	IUCN Red list status	COSEWIC Status	SARA
Northern elephant seal	*Mirounga angustirostris*	Least Concern	Not at Risk	Not listed
Physeteridae				
Sperm whale	*Physeter macrocephalus*	Vulnerable	Not at Risk	Not listed
Ziphiidae				
Baird's beaked whale	*Berardius bairdii*	Data Deficient	Not at Risk	Not listed
Hubb's beaked whale	*Mesoplodon carlhubbsi*	Data Deficient	Not at Risk	Not listed
Blainville's beaked whale	*Mesoplodon densirostris*	Data Deficient	Not at Risk	Not listed
Perrin's beaked whale	*Mesoplodon perrini*	Data Deficient	n/a	Not listed
Stejneger's beaked whale	*Mesoplodon stejnegeri*	Data Deficient	Not at Risk	Not listed
Cuvier's beaked whale	*Ziphius cavirostris*	Least Concern	Not at Risk	Not listed

Table 6.3. Percentage of TOPP tagged species that visited U.S. and Canadian EEZs and the high seas. Initial tag deployment locations varied; see Winship et al (2012) and Block et al (2011) for details. Adapted from Harrison (2012). Species codes: PBT, Pacific Bluefin tuna; YFT, yellowfin tuna; ALT, albacore tuna; MS, mako shark; BS, blue shark; SS, salmon shark; TS, thresher shark; WHS, white shark; NELE, northern elephant seal; CSL, California sea lion; NFS, northern fur seal; BLWH, blue whale; HUWH, humpback whale; LET, leatherback turtle; LOT, loggerhead turtle; BFAL, black-footed albatross; LAAL, Laysan albatross; SOSH, sooty shearwater.

EEZ	PBT	YFT	ALT	MS	BS	SS	TS	WS	NELE	CSL	NFS	BLWH	HUWH	LET	LOT	BFAL	LAAL	SOSH	% All Ind.	Spp.
Canada	<10	0	0	0	8	58	0	0	27	0	33	6	0	0	0	23	4	25	11	9
Alaska		0	0	0	0	100	0	0	15	0	100	0	0	0	0	17	21	38	13	6
U.S. (non-Alaskan waters)	71	10	82	97	83	44	100	98	97	84	33	92	100	19	0	23	24	25	60	17
High seas	24	7	55	39	56	67	7	85	85	2	78	27	0	89	12.5	70	65	100	47	17

Table 6.4. Elasmobranch species either known or likely to inhabit the pelagic waters of Canada's Pacific EEZ. Source: Kaschner et al. (2013) and IUCN (2014). A1 – Observed or estimated population size reduction of more than 30% over the last 10 years; A2 - observed or estimated population size reduction of more than 30% where the causes are ongoing, not understood, or may not be reversible; A3 – population size reduction expected to be more than 30% in the next 10 years; a – based on direct observation; b – based on an index of abundance; d – based on actual or potential levels of exploitation.

Common name	Scientific name	IUCN Status	COSEWIC Status (n/a = not in database)	SARA Schedule 1 listing	Habitat
Tiger shark	*Galeocerdo cuvier*	Near Threatened	n/a	Not listed	Neritic/Epipelagic/ Mesopelagic
Blue shark	*Prionace glauca*	Near Threatened	Data Deficient	Not listed	Neritic/Epipelagic/ Mesopelagic
Brown catshark	*Apristurus brunneus*	Data Deficient	Data Deficient	Not listed	Epipelagic
Smooth hammerhead	*Sphyrna zygaena*	Vulnerable A2bd+3bd+ 4bd	n/a	Not listed	Neritic
Tope shark	*Galeorhinus galeus*	Vulnerable A2bd+3bd+ 4bd	n/a	Not listed	Neritic/Epipelagic
Bluntnose sixgill shark	*Hexanchus griseus*	Near Threatened	Special Concern	Special Concern	Neritic/Benthic
Broadnose sevengill shark	*Notorynchus cepedianus*	Data Deficient	n/a	Not listed	Neritic
Common thresher shark	*Alopias vulpinus*	Vulnerable A2bd+3bd+ 4bd	n/a	Not listed	Neritic/Epipelagic/ Mesopelagic
Basking shark	*Cetorhinus maximus*	Vulnerable A2ad+3d	Endangered	Endanger ed	Neritic/Epipelagic
Great white shark	*Carcharodon carcharias*	Vulnerable A2cd+3cd	Data Deficient	Not listed	Neritic/Epipelagic/ Mesopelagic
Shortfin mako	*Isurus oxyrinchus*	Vulnerable A2abd+3bd +4abd	n/a	Not listed	Epipelagic/Mesopel agic
Salmon shark	*Lamna ditropis*	Least Concern	n/a	Not listed	Neritic/Epipelagic
Pelagic stingray	*Pteroplatytryg on violacea*	Least Concern	n/a	Not listed	Neritic

Common name	Scientific name	IUCN Status	COSEWIC Status (n/a = not in database)	SARA Schedule 1 listing	Habitat
Sixgill stingray	*Hexatrygon bickelli*	Least Concern	n/a	Not listed	Benthic
Arctic skate	*Amblyraja hyperborea*	Least Concern	n/a	Not listed	Benthic
Deepsea skate	*Bathyraja abyssicola*	Data deficient	n/a	Not listed	Neritic/Benthic
Aleutian skate	*Bathyraja aleutica*	Least Concern	n/a	Not listed	Benthic
Bering skate/Sandpaper skate	*Bathyraja interrupta*	Least Concern	Not at risk	Not listed	Benthic
Alaska skate	*Bathyraja parmifera*	Least Concern	n/a	Not listed	Neritic/Benthic
Roughtail skate	*Bathyraja trachura*	Least Concern	n/a	Not listed	Neritic/Mesopelagic/Bathypelagic/Benthic
Big skate	*Raja binoculata*	Near Threatened	Not at risk	Not listed	Epipelagic/Mesopelagic
California skate	*Raja inornata*	Data deficient	n/a	Not listed	Neritic/Benthic
Longnose skate	*Raja rhina*	Least concern	Not at risk	Not listed	Neritic/Benthic
Starry skate	*Raja stellulata*	Least concern	n/a	Not listed	Neritic/Benthic
Prickly shark	*Echinorhinus cookei*	Near Threatened	n/a	Not listed	Epipelagic
Pacific sleeper shark	*Somniosus pacificus*	Data deficient	n/a	Not listed	Neritic/Epipelagic/Mesopelagic/Bathypelagic/Benthic
Pacific angel shark	*Squatina californica*	Near threatened	n/a	Not listed	Epipelagic
Apron ray	*Discopyge tschudii*	Near threatened	n/a	Not listed	Epipelagic

6.4 FEATURE CONDITION AND FUTURE OUTLOOK OF THE EVALUATED AREA

Currently, offshore pelagic waters experience fewer direct impacts from human activity than pelagic waters that are coastal and on-shelf due to their distance from shore. However, increasing ship traffic and human use of the high seas and underlying seabed poses an emerging threat. Increased ship traffic can result in increased noise that may affect marine mammal behavior and disrupt migration and feeding (Erbe 2002, Gordon et al. 2003, Weilgart 2007, Tyack 2008, Richardson et al. 2013). Undersea resource exploitation can result in metal contaminants from deep-sea mining that may affect plankton distribution (Omori et al. 1994). The effects of pollutants are most significant in areas of oceanic fronts and convergences, where concentrations may be elevated by natural oceanographic processes. These areas also tend to aggregate floating debris such as plastics. However, the largest effects on pelagic systems are likely to be from two main stresses: climate change and fishing. Climate change may also interact with fishing and pollution to result in synergistic impacts, which are often unpredictable (Strömberg 1997, Winder and Schindler 2004, Schiedek et al. 2007).

6.4.1 Climate change

Climate change impacts include increased ocean temperatures, which may lead to less vertical mixing and reduced productivity through effects on metabolism and food requirements (Table 6.5; Omori et al. 1994). Regional sea surface temperature trends in the northeast Pacific Ocean have been variable over the period 1982-2006, with temperatures increasing 0.27°C in the Eastern Bering Sea, 0.37°C in the Gulf of Alaska, and decreasing 0.07°C in the California Current (Belkin 2009). Overall, sea surface temperatures are expected to increase by up to 1.5°C by 2050 (Overland and Wang 2007). Species distributions have already begun to shift polewards (or deeper) as waters warm, with phytoplankton, bony fish, and invertebrate zooplankton showing the greatest movement, ranging from 142 to 470 km per decade (Poloczanska et al. 2013). These shifts in zooplankton distribution may result in significant changes in community structure and thus potentially profound changes to the base of pelagic food chains (Francis et al. 2012). Further, changes in species assemblages as warmer water species invade and expand (at a pace of 45.4 ± 6.33 km per decade), and potentially even local extinctions have been predicted to occur in the North Pacific Ocean under the IPCC A2 emissions scenario (Cheung et al. 2015). Monitoring stations on the Pacific North Coast have observed a warming trend of 0.5-0.6°C over the past 80 years, with increases of up to 1°C in an El Niño year (Freeland 1990, Freeland et al. 1997, DFO 2012).

Another effect of climate change is an increase in hypoxic areas. Generally, global climate models predict that global warming will lead to deoxygenation of the deep ocean because warmer surface waters will hold less oxygen and will be more stratified, resulting in less ventilation of the deep ocean (Sarmiento et al., 1998; Keeling et al., 2010). Oxygen levels have been observed to have decreased in Pacific sub-surface waters over the past few decades (Whitney et al. 2007, DFO 2012a).

Ocean acidification also poses a threat to organisms that rely on the formation of carbonate shells or tests, such as shellfish, corals, and phytoplankton. Acidified waters can reduce growth rates of these organisms and/or increase mortality rates. Water upwelled from deeper depths tends to be more acidic, and the already-shallow aragonite saturation depth (~100 m) in the northeastern Pacific is becoming even more shallow, having decreased by 30-50 m over the past century (DFO 2012a). Large portions of shelf waters in the California Current region are already sufficiently acidic to erode pteropod shells, which are principally composed of aragonite and thus more susceptible to decreased pH (Bednaršek et al. 2014). Pteropods occur in high abundance in the California Current ecosystem, and represent an important prey item for many species, including salmon (Armstrong et al. 2005).

6.4.2 Fishing

The widespread removal of predators from the oceans by fishing has resulted in changes in the structure and function of marine ecosystems (Figure 6.8); these changes include species replacements, changes in biomass at lower trophic levels, and reductions in nutrient cycling from the water column to the benthos (Pauly et al. 1998a, Verity et al. 2002, Myers and Worm 2003, Heithaus et al. 2008, Baum and Worm 2009). Small pelagic fish species are particularly vulnerable to overfishing due to their shoaling behavior, but are also quick to recover once fishing pressure is reduced (Beverton 1990, Hutchings 2000). Trawling, gillnetting, and longline fishing poses a threat to many pelagic bird species, such as albatrosses (Cousins et al. 2000, Bull 2007) and sea turtles (Kleiber 1998). Although the exact number of albatrosses killed incidentally in North Pacific longline fisheries is unknown, estimates range from 0.24-0.57 birds caught per tonne of fish, depending on the fishery (tuna or swordfish) and albatross species (Cousins et al. 2000). Data from both the Tanner Crab and groundfish survey datasets (L. Lacko, DFO, Nanaimo, B.C., personal communications, 2014, 2015) show that birds are occasionally (rarely) caught or entangled even in these bottom trap and trawl fisheries. Numerous mitigation measures exist for fisheries that could reduce or eliminate seabird mortality, including improved offal management and seasonal or area fishery closures (Bull 2007). Current fisheries management plans for pelagic species include Pacific herring (DFO 2014c), sardine (DFO 2014c), albacore tuna (DFO 2014b, Holmes 2014), and eulachon (DFO 2014a), although most of these species (with the exception of tuna) are likely to occur over the shelf and slope regions. The 2013 Canadian albacore tuna catch was 5,090 mt, and has ranged between 1,761 mt (1995) and 7,857 mt (2004) (Holmes 2014). Both yellowtail and bluefin tuna are caught as bycatch in this fishery (albeit in small quantities) and typically retained (Holmes 2014). A growing recreational fishery is also targeting albacore tuna, although at present there are no catch or effort data for this fishery (Holmes 2014). For eulachon, there are insufficient data to determine what the appropriate catch levels and conservation measures are; both the Fraser River and Central Coast eulachon stocks were assessed as endangered by COSEWIC in 2011 (DFO 2014a).

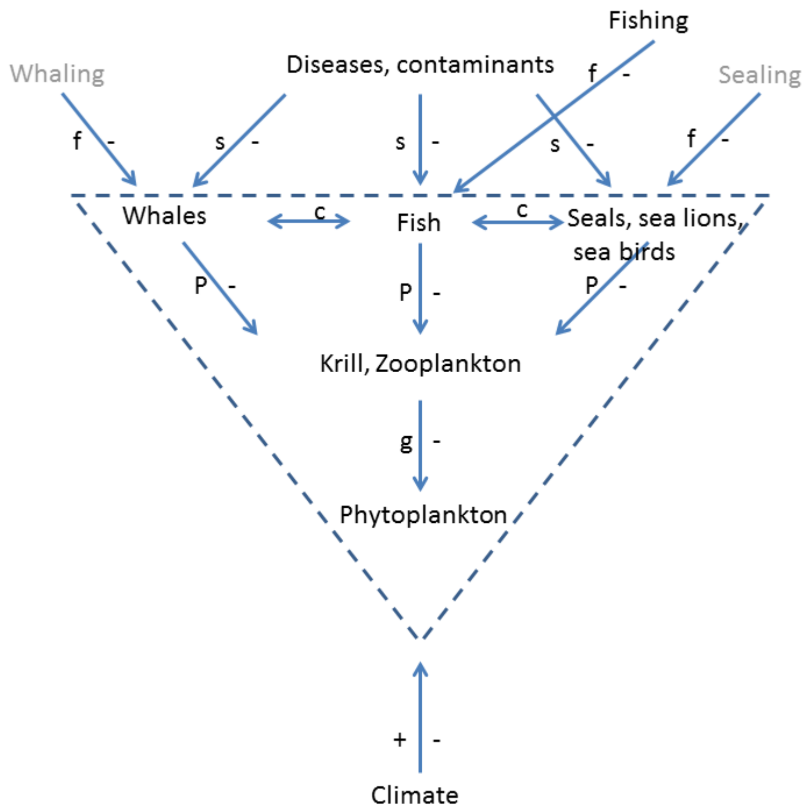


Figure 6.8. Conceptual model of a simplified pelagic ecosystem food web. Whaling and sealing are greyed-out because they are no longer a significant factor in this area, although they have had a historic influence. Key to symbols: f = fishing or extractive use, s = stresses, c = competition, p = prey, g = grazing, + = positive impact, - = negative impact. Adapted from Verity et al. (2002).

Table 6.5. Effects of temperature increases/decreases on oceanographic conditions. Reproduced from Omori et al (1994).

Effect on	**Temperature**	
	Increase	**Decrease**
(Sub)tropical belt	**Broader**	**Smaller**
(Sub)polar belts	**Smaller**	**Broader**
Deepwater supply	**Less**	**More**
Temperature		
N-S gradients	**Less steep**	**Steeper**
Vertical stratification	**More stratified**	**More mixed**
Convergences	**Break down**	**Stronger**
Water level	**Higher**	**Lower**

Table 6.6. Effects of increases/decreases in temperature on species distributions. Adapted from Omori et al (1994).

Effect on	Temperature	
	Increase	**Decrease**
Diversity of epipelagic species	**Increase**	**Decrease**
Diversity at greater depth	**Decrease**	**Increase**
N and S subtropical taxa	**Separation**	**Fusion**
E and W subtropical taxa	**Fusion**	**Separation**
Boundaries shift	**Polewards**	**Equatorwards**

6.5 ASSESSMENT OF THE AREA AGAINST CBD EBSA CRITERIA

i. Haida eddies

CBD EBSA Criteria (Annex I to decision IX/20)	**Description** (Annex I to decision IX/20)	**Ranking of criterion relevance**			
		No information	**Low**	**Medium**	**High**
Uniqueness or rarity	Area contains either i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or ii) unique, rare or distinct, habitats or ecosystems; and/or iii) unique or unusual geomorphological or oceanographic features.				X
The Haida eddy itself is a unique oceanographic feature in Canadian waters responsible for moving nearshore coastal waters offshore (Crawford 2002, Di Lorenzo et al. 2005), but globally eddies are not unique features.					
Special importance for life-history stages of species	Areas that are required for a population to survive and thrive.			X	
Evidence shows that eddies can entrain and transport larvae from coastal to offshore environments (Haury et al. 1986, Lobel and Robinson 1986, Bailey et al. 1997). The importance of eddies specifically for life history stages of species is unknown, but there is some evidence that these eddies accumulate plankton and may therefore be important for life history processes such as reproduction (e.g. Mackas et					

al. 2005).					
Importance for threatened, endangered or declining species and/or habitats	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.	X			
The importance of the Haida Eddy specifically for endangered or threatened species is not known. While Canada's offshore Pacific waters are habitat for numerous species of conservation concern, the utilization and importance of the eddy specifically is unknown. Relatively good habitat utilization data do exist for species that have been tagged (Block et al. 2002). These data suggest that species aggregate within oceanographic features such as the Alaskan and North Pacific gyres, but usage of the Haida eddy specifically has not been demonstrated.					
Vulnerability, fragility, sensitivity, or slow recovery	Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.		X		
As the eddy exists as a feature of an open-water environment, there are no physical structures that are subject to damage, and offshore, pelagic systems in general tend to experience fewer human impacts than coastal systems (Halpern et al. 2008). However, little is known about the sensitivity or resilience of this habitat to other forms of degradation such as chemical pollution and the effects of climate change (e.g., warming, changes in pH).					
Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.			X	
Primary productivity in this area is limited by nutrients such as iron and silicate (Maldonado et al. 1999, Whitney et al. 2005), but experiences seasonal and ephemeral bursts of productivity due to changes in circulation patterns and transient oceanographic features such as eddies.					
Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.			X	
The biodiversity of the Haida Eddy itself is likely to be similar to that of the region overall. Although species richness of offshore ecosystems is lower compared to coastal and certain benthic habitats (Angel 1993), this dynamic feature can contain a variable mix (spatially and temporally) of both coastal and offshore species.					
Naturalness	Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.			X	
As an open-water environment relatively far from shore that lacks easily-damaged physical features, this feature is less directly affected by human activities than many other areas. However, the Haida Eddy is subject to the influences of climate change, microplastic pollution, and accumulation of other pollutants,					

primarily in surface waters (Moore et al. 2001).					
Importance for species aggregation (DFO criterion)	Area where species aggregation for important life cycle functions (breeding/spawning, rearing, feeding, migrating, etc).			X	
The importance of the Haida eddy specifically for species aggregation is unknown, but pelagic waters in this region are a crucial migratory pathway for many species, including humpback whales, blue whales, and numerous waterfowl and seabirds. Many coastal species also rely on pelagic waters at some point in their life cycle, such as salmon (Welch et al. 1995, Welch et al. 1998, Welch et al. 2002), elephant seals (Crocker et al. 2010), and Steller sea lions (Benson and Trites 2002). Eddies in general are known to be aggregation points for many species (Polovina et al. 2000, Orlov 2003, Mackas et al. 2005, Lavaniegos and Hereu 2009, Bailleul et al. 2010, Jaine et al. 2014).					

ii. North Pacific Transition Zone (this table is modified from (CBD 2014))

CBD EBSA Criteria (Annex I to decision IX/20)	**Description** (Annex I to decision IX/20)	**Ranking of criterion relevance**			
		No information	**Low**	**Medium**	**High**
Uniqueness or rarity	Area contains either i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or ii) unique, rare or distinct, habitats or ecosystems; and/or iii) unique or unusual geomorphological or oceanographic features.			X	
The NPTZ is a unique oceanographic feature within the North Pacific Ocean. However, transition zones are not unique features within the global oceans.					
Special importance for life-history stages of species	Areas that are required for a population to survive and thrive.				X
A large number of species migrate from the subtropical frontal zone (e.g., albacore tuna), or from the subarctic domain (e.g., saury, pomfret, flying squid) and spend their critical life stages in the NPTZ (Brodeur et al. 1999). This transition zone also provides an important foraging area for many seabird species, such as Laysan and black-footed albatross (Hyrenbach et al., 2002), marine mammals, and sea turtles.					
Importance for threatened, endangered or declining	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.				X

<table>
<tr><td>species and/or habitats</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">The NPTZ provides a transoceanic migration corridor for Pacific Bluefin Tuna (Thunnis orientalis; IUCN: Vulnerable) (Boustany et al. 2010), and appears to be important habitat for Loggerhead (Caretta caretta) and Leatherback (Dermochelys coriacea; IUCN: Vulnerable, COSEWIC: Endangered) turtles, Northern Fur Seals (Callorhinus ursinus; IUCN: Vulnerable; COSEWIC: Threatened), Elephant Seals (Mirounga angustirostris; IUCN: Least Concern; COSEWIC: Not at Risk), and seabirds (Ayers and Lozier 2010).</td></tr>
<tr><td>Vulnerability, fragility, sensitivity, or slow recovery</td><td>Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td colspan="6">The NPTZ is a dynamic feature that by definition shifts spatially and temporally. Although the specific position of this feature may change with climate change, it is assumed that the feature itself would retain its relative physical properties within the range of variablility observed for the foreseeable future. However, the degree of variation in position, the intensity of currents, and biological responses to these changes are uncertain (PICES 2004). Vulnerability of the associated biological communities was not assessed under this criterion.</td></tr>
<tr><td>Biological productivity</td><td>Area containing species, populations or communities with comparatively higher natural biological productivity.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">The transition zone chlorophyll front (TZCF), which indicates higher concentrations of chlorophyll a relative to the subtropical gyre, migrates from south to north over 1000 km annually (Polovina et al. 2001). The NPTZ is the area between the southern and northern extremes of the TZCF. Ocean productivity estimates derived from models and satellite observations (Behrenfeld and Falkowski 1997) indicate high annual average phytoplankton production throughout the NPTZ. Chlorophyll concentrations in the subtropical gyre surface are usually <0.15 mg/m^3 whereas in the subarctic gyre and NPTZ they can be >0.25 mg/m^3; a chlorophyll density of 0.2 mg/m^3 has been used as an indicator of the position of the chlorophyll front (Polovina et al. 2001). In combination with the adjacent Subarctic domain, which provides seasonally high productivity in the spring, the NPTZ forms a highly productive area in the oceanic North Pacific. It supports many higher trophic level species and commercially important ones such as albacore tuna (Polovina et al. 2001, Harrison 2012) and flying squid (Ichii et al. 2011).</td></tr>
<tr><td>Biological diversity</td><td>Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">The NPTZ includes the edges of two different water domains such that this feature represents a juxtaposition of two different water masses, each containing different species. Thus, this area is highly diverse. Further, it has distinct endemic species of zooplankton and micronekton species (Pearcy 1991).</td></tr>
<tr><td>Naturalness</td><td>Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Due to the presence and aggregation of commercially valuable species, this area has been consistently utilized by humans and thus more impacted than adjacent offshore areas of the North Pacific Ocean. The populations of several of the species using this region have been exploited, perturbed, and in some cases</td></tr>
</table>

depleted. Introduced species and other pollutants (oil, floating plastics, etc) are also a concern.					
Importance for species aggregation (DFO criterion)	Area where species aggregation for important life cycle functions (breeding/spawning, rearing, feeding, migrating, etc).				X
The NPTZ forms part of a crucial migration and foraging pathway for many species, including humpback whales, blue whales, and numerous waterfowl and seabirds, and sea turtles (PICES 2004).					

6.6 SUMMARY

Within Canada's Pacific pelagic waters, we propose two distinct EBSAs: the North Pacific Transition Zone, and the Haida Eddy (Figure 6.9). Both of these EBSAs are intended to capture dynamic features, and thus are bounded within a box where these phenomena can be expected to occur. The Haida Eddy scored high on uniqueness, but not on importance for life history stages or species, or importance for species aggregation. A medium score was assigned for five of eight criteria. In accordance with DFO guidance (DFO 2004), we therefore identified the Haida Eddy as an EBSA. The NPTZ scored high on all criteria except uniqueness (medium), naturalness (medium) and vulnerability (low) and therefore also meets the EBSA criteria.

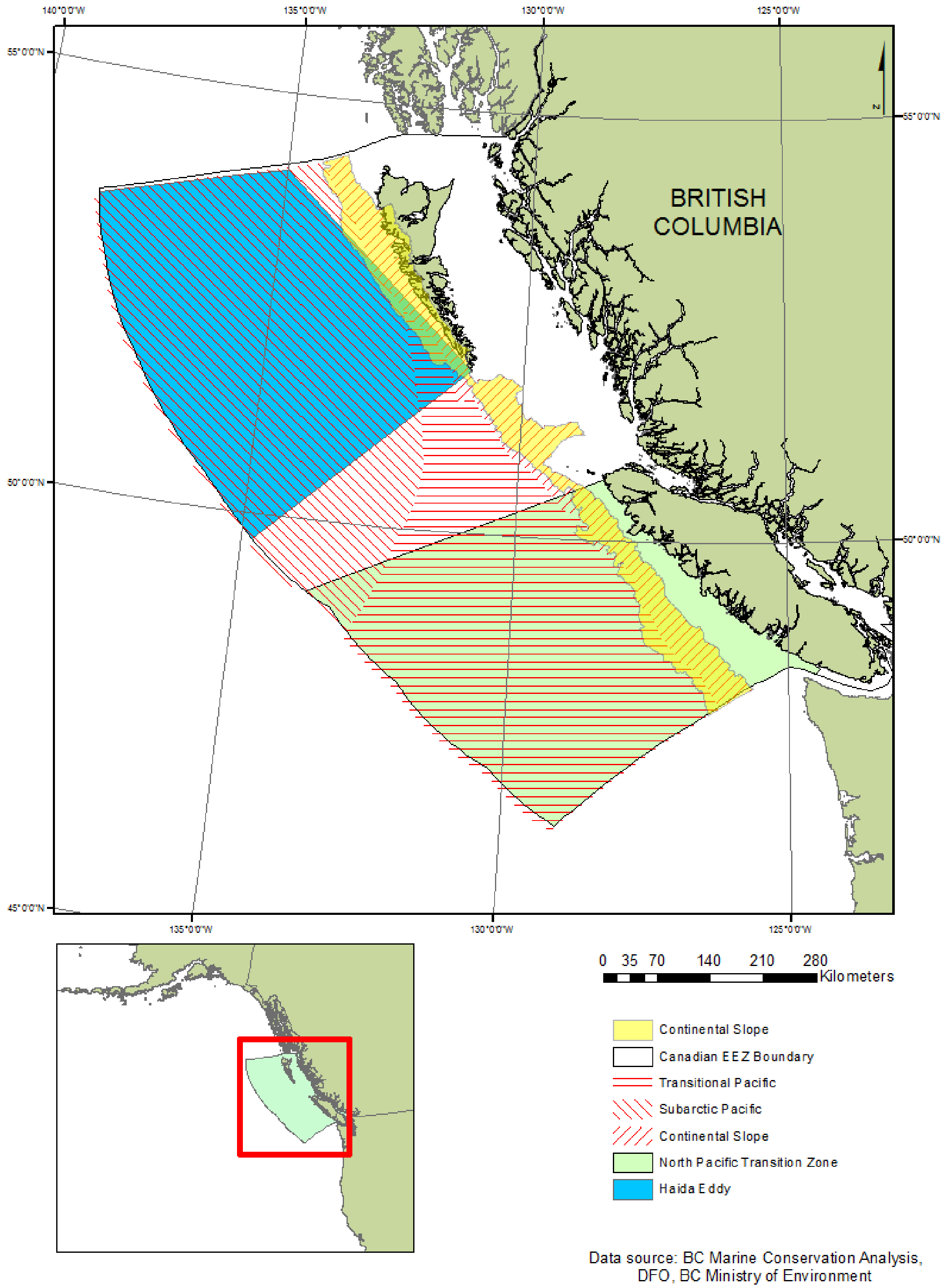


Figure 6.9. North Pacific Transition Zone EBSA and Haida Eddy EBSA. Note that these are boundaries intended to capture the normal range of movement of these ephemeral features, not the boundaries of the features themselves.

7 SUMMARY OF IDENTIFIED EBSAS

This document examined evidence for possible EBSAs within five different habitat types: hydrothermal vents, seamounts, the continental slope, the bathypelagic/abyssal zone, and the pelagic/surface water zone (Figure 7.1). Within these areas, these are the potential EBSAs that have been identified:

Hydrothermal vents: All currently identified hydrothermal vents within Canada's Pacific EEZ. Baby Bare and Grizzly Bare are also identified as unique features

Seamounts: All currently named seamounts within Canada's Pacific EEZ, with a 30 km buffer around the pinnacle to account for oceanographic effects.

Continental slope: The entire continental slope, including submarine canyons and previously identified EBSAs that overlap the slope: Brooks Peninsula, Cape St. James, Scott Islands, and the shelf break.

Bathypelagic/abyssalpelagic zone: no EBSAs were identified in this zone, mainly due to limited data availability

Pelagic/surface water zone: Dynamic boundary areas encompassing the Haida eddy region and the North Pacific Transition Zone.

7.1 CONNECTIVITY BETWEEN EBSAS

With the ocean being a fluid, 3-dimensional environment, no habitat or oceanic ecosystem is ever truly isolated from another. Species may migrate both vertically and horizontally on timescales ranging from daily to seasonally to annually, and may use different habitats at different stages in their life cycle. Thus, the role that any given EBSA has in terms of providing connectivity between other EBSAs should be considered in addition to the intrinsic qualities of that EBSA itself. Thus, the following provides an overview of the potential connectivity roles of EBSAs evaluated in this document.

Both hydrothermal vents and seamounts are associated with tectonic movements and seafloor spreading zones; given their often close proximity, it should be expected that motile organisms may move between these areas, or pass through both at some stage of their life cycle. There may also be linkages in terms of nutrients and productivity between hydrothermal vents and seamounts due to oceanographic features (e.g. Taylor cones) associated with seamounts.

The abyssal and bathypelagic zones rely on nutrients and biological productivity inputs from overlying waters as well as from coastal and shelf waters, which may be transported in eddies or through submarine canyons and channels. Hydrothermal vents may also export chemosynthetic production to abyssal environments and surrounding waters, potentially enhancing productivity.

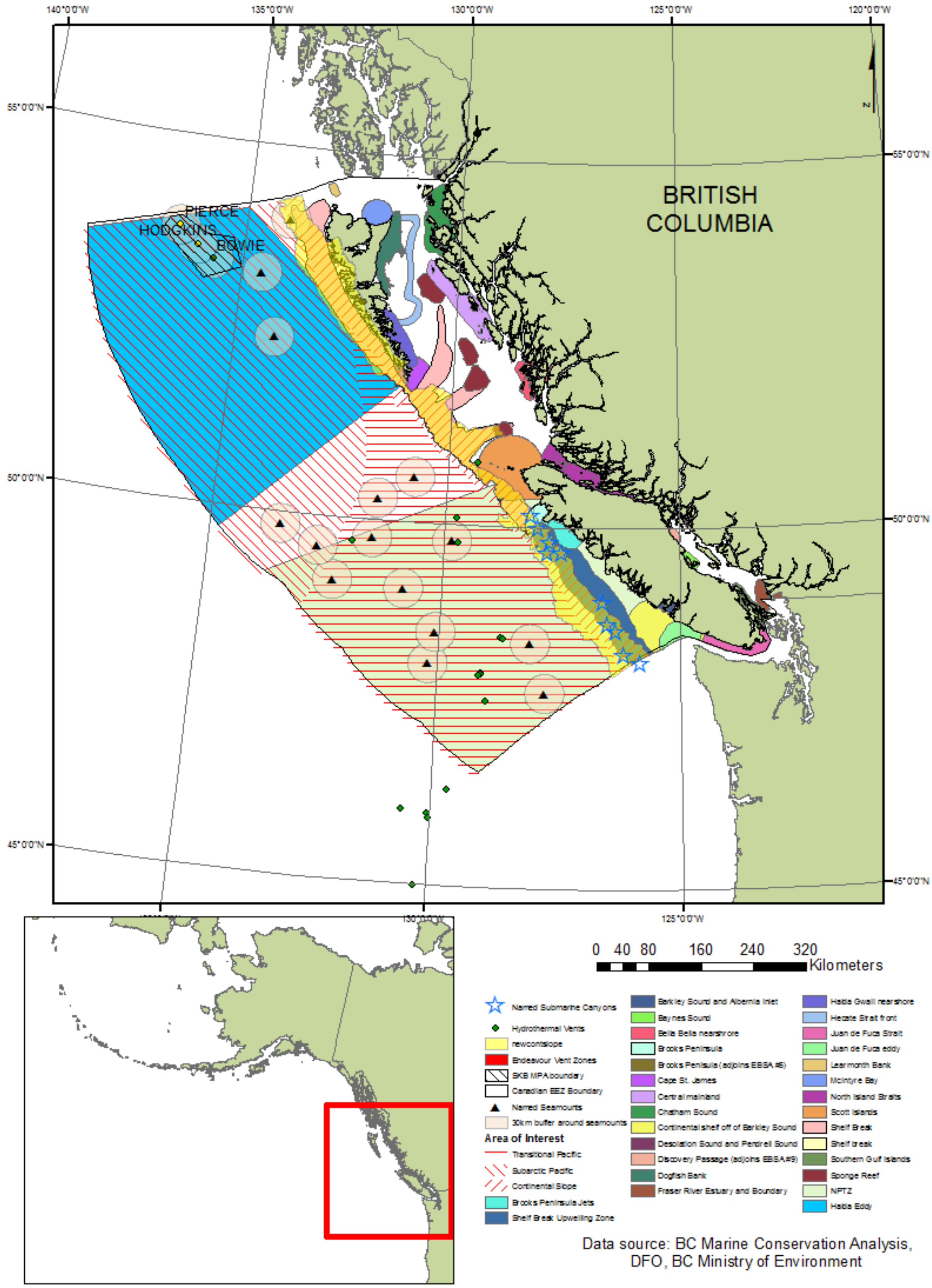


Figure 7.1. EBSAs identified in this document. Note that the boundaries for the Haida Eddy and North Pacific Transition Zone (NPTZ) are approximate.

8 ACKNOWLEDGMENTS

Lisa Lacko and Kate Rutherford provided fisheries catch data for the seamounts, slope and abyss sections. Ken Morgan (DFO/CWS) provided figures and references for seabird surveys in the pelagic section. Katie Gale and Ken Wong (DFO) provided data from the Tanner Crab surveys. Karin Bodtker, Michelle Greenlaw, Emily Rubidge, Verena Tunnicliffe and participants in the CSAP workshop provided comments that significantly improved the working paper.

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APPENDIX

Table A 1. List of taxa observed during the 2012 Cobb Seamount survey at 15 ROV and four AUV transects. Depth ranges are given for each taxon (Du Preez et al. 2015).

Phylum	Class	Order	Genus and species	Depths (m)
Ochrophyta	Phaeophyceae	Desmarestiales	*Desmarestia viridis*	34-49
Rhodophyta	Florideophyceae	Ceramiales	*Polysiphonia* spp.	40
Rhodophyta	Florideophyceae	Corallinales	cf *Lithophyllum* spp.[1]	34-191
Rhodophyta	Florideophyceae	Corallinales	cf *Lithothamnion* spp.[1]	34-191
Porifera	Hexactinellida	Hexactinosida	*Pinulasma fistulosom*	635-934
Porifera	Hexactinellida	Hexactinosida	*Farrea omniclavata* sp. nov.	681-1147
Porifera	Hexactinellida	Lyssacinosida	*Acanthascus* spp.[2]	501-1147
Porifera	Hexactinellida	Lyssacinosida	*Bathydorus* sp.	567-887
Porifera	Hexactinellida	Lyssacinosida	*Rhabdocalyptus* spp[2].	501-1147
Porifera	Hexactinellida	Lyssacinosida	*Staurocalyptus* spp.[2]	501-1147
Porifera	Demospongiae		Demospongiae sp. 1	127-436
Porifera	Demospongiae		Demospongiae sp. 2	124-210
Porifera	Demospongiae		Demospongiae sp. 3	123-138
Porifera	Demospongiae	Astrophorida	*Poecillastra* sp.	772
Porifera	Demospongiae	Hadromerida	*Polymastia* sp.	94-141
Porifera	Demospongiae	Halichondria	cf *Auletta* sp.	183-210
Porifera	Demospongiae	Halichondria	*Halichondria panicea*	63-212
Porifera	Demospongiae	Poecilosclerida	cf *Acarnus erithacus*	35-127
Porifera	Demospongiae	Poecilosclerida	*Latrunculia* (*Biannulata*) *oparinae*	122-126
Cnidaria	Anthozoa	Actiniaria	Actiniaria sp. 1	615
Cnidaria	Anthozoa	Actiniaria	Actiniaria sp. 2	785
Cnidaria	Anthozoa	Actiniaria	Actiniaria sp. 3	619-939
Cnidaria	Anthozoa	Actiniaria	*Cribrinopsis fernaldi*	196-259
Cnidaria	Anthozoa	Actiniaria	cf Hormathiidae sp.	527-1090
Cnidaria	Anthozoa	Actiniaria	*Metridium senile*	116-220
Cnidaria	Anthozoa	Actiniaria	*Stomphia didemon*	121-187
Cnidaria	Anthozoa	Actiniaria	*Urticina crassicornis*	193-259
Cnidaria	Anthozoa	Alcyonacea	*Gersemia* sp.	800-885
Cnidaria	Anthozoa	Alcyonacea	*Heteropolypus ritteri*	436-1036
Cnidaria	Anthozoa	Alcyonacea	*Isidella* sp.	495-875
Cnidaria	Anthozoa	Alcyonacea	*Keratoisis* sp.	436-819

Phylum	Class	Order	Genus and species	Depths (m)
Cnidaria	Anthozoa	Alcyonacea	*Lepidisis* sp.	488-1154
Cnidaria	Anthozoa	Alcyonacea	*Narella* sp.	198
Cnidaria	Anthozoa	Alcyonacea	*Paragorgia* sp.	825
Cnidaria	Anthozoa	Alcyonacea	*Plumarella superba*	788-826
Cnidaria	Anthozoa	Alcyonacea	*Primnoa cf pacifica*	198-888
Cnidaria	Anthozoa	Alcyonacea	*Swiftia simplex*	536-1083
Cnidaria	Anthozoa	Antipatharia	*Antipatharia* sp.	524-1086
Cnidaria	Anthozoa	Antipatharia	*Bathypathes* sp.	681-1153
Cnidaria	Anthozoa	Antipatharia	*Lillipathes* cf *lillei*	436-1088
Cnidaria	Anthozoa	Antipatharia	*Parantipathes* sp.	775-1003
Cnidaria	Anthozoa	Antipatharia	*Stichopathes* sp.	681-840
Cnidaria	Anthozoa	Corallimorpharia	*Corynactis californica*	34-95
Cnidaria	Anthozoa	Pennatulacea	*Anthoptilum* spp.	723-1003
Cnidaria	Anthozoa	Pennatulacea	*Halipteris willemoesi*	99-807
Cnidaria	Anthozoa	Pennatulacea	*Umbellula lindahli*	920
Cnidaria	Anthozoa	Scleractinia	*Desmophyllum dianthus*	91-557
Cnidaria	Anthozoa	Scleractinia	*Lophelia pertusa*	162-254
Cnidaria	Anthozoa	Zoantharia	*Epizoanthus* sp.	198
Cnidaria	Hydrozoa		Hydroid sp. 1	58-209
Cnidaria	Hydrozoa		Hydroid sp. 2	84
Cnidaria	Hydrozoa	Anthoathecata	*Stylaster* spp.[3]	91-886
Cnidaria	Hydrozoa	Leptothecata	cf *Obelia* spp.	40-220
Annelida	Polychaeta	Eunicida	*Nothria conchylega*	89-191
Annelida	Polychaeta	Sabellida	*Crucigera zygophora*	83
Annelida	Polychaeta	Sabellida	*Paradexiospira* sp.	58-221
Annelida	Polychaeta	Sabellida	*Protula pacifica*	84-224
Annelida	Polychaeta	Spionida	*Phyllochaetopterus prolifica*	34-69
Annelida	Polychaeta	Spionida	*Spiochaetopterus* cf *costarum*	84-223
Anthropoda	Malacostraca	Amphipoda	*Caprella* sp.	84
Anthropoda	Malacostraca	Decapoda	*Chionoecetes tanneri*	619-1138
Anthropoda	Malacostraca	Decapoda	*Chirostylidae* sp.	562-1145
Anthropoda	Malacostraca	Decapoda	*Chorilia longipes*	40-1140
Anthropoda	Malacostraca	Decapoda	*Elassochirus cavimanus*	194
Anthropoda	Malacostraca	Decapoda	*Lithodes couesi*	623-1141
Anthropoda	Malacostraca	Decapoda	*Oregonia gracilis*	167

Phylum	Class	Order	Genus and species	Depths (m)
Anthropoda	Malacostraca	Decapoda	*Pagurus kennerlyi*	46-259
Mollusca	Bivalvia	Pectinoida	*Crassadoma gigantea*	35-84
Mollusca	Cephalopoda	Octopoda	*Graneledone pacifica* (*boreopacifica*)	1145
Mollusca	Cephalopoda	Octopoda	*Octopus* sp.[4]	436
Mollusca	Gastropoda	Archaeogastropoda	*Calliostoma annulatum*[5]	34-187
Mollusca	Gastropoda	Archaeogastropoda	*Calliostoma ligatum*[5]	34-187
Mollusca	Gastropoda	Neogastropoda	*Fusitriton oregonensis*	139-223
Mollusca	Gastropoda	Neogastropoda	*Ocinebrina lurida*	83-198
Mollusca	Gastropoda	Nudibranchia	*Doris montereyensis*	35
Mollusca	Gastropoda	Nudibranchia	Tritoniidae sp.	485-1000
Mollusca	Polyplacophora	Lepidopleurida	*Leptochiton rugatus*	34-84
Brachiopoda	Rhynchonellata	Terebratulida	*Laqueus californianus*	90-224
Bryozoa			Bryozoa sp.	180-207
Bryozoa	Gymnolaemata	Cheilostomatida	cf *Reginella hippocrepis*	41-84
Bryozoa	Stenolaemata	Cyclostomatida	*Disporella separata*	75-84
Echinodermata	Asteroidea	Brisingida	Brisingidae sp.	536-1139
Echinodermata	Asteroidea	Forcipulatida	*Ampheraster* sp.	544-944
Echinodermata	Asteroidea	Forcipulatida	*Leptasterias hexactis*	37-195
Echinodermata	Asteroidea	Forcipulatida	*Orthasterias koehleri*	196
Echinodermata	Asteroidea	Forcipulatida	*Pycnopodia helianthoides*	84-177
Echinodermata	Asteroidea	Forcipulatida	*Rathbunaster californicus*	102-617
Echinodermata	Asteroidea	Forcipulatida	*Stylasterias forreri*	180-202
Echinodermata	Asteroidea	Paxillosida	*Asteroidea* sp.	194-255
Echinodermata	Asteroidea	Paxillosida	*Pseudarchaster* sp.[6]	436-790
Echinodermata	Asteroidea	Paxillosida	*Thrissacanthias* sp.	436-562
Echinodermata	Asteroidea	Spinulosida	*Henricia leviuscula*	37-91
Echinodermata	Asteroidea	Spinulosida	*Henricia sanguinolenta*	111-726
Echinodermata	Asteroidea	Valvatida	*Ceramaster patagonicus*	110-217
Echinodermata	Asteroidea	Valvatida	*Ceramaster cf stellatus*	172-218
Echinodermata	Asteroidea	Valvatida	*Crossaster papposus*	84-220
Echinodermata	Asteroidea	Valvatida	*Hippasteria phrygiana*	162-855
Echinodermata	Asteroidea	Valvatida	*Lophaster furcilliger*	95-154
Echinodermata	Asteroidea	Valvatida	*Solaster cf endeca*	123-255
Echinodermata	Asteroidea	Valvatida	*Solaster stimpsoni*	91
Echinodermata	Asteroidea	Velatida	*Pteraster* sp.	539-930

Phylum	Class	Order	Genus and species	Depths (m)
Echinodermata	Crinoidae	Comatulida	*Florometra serratissima*	84-749
Echinodermata	Echinoidea	Camarodonta	*Mesocentrotus franciscanus*	35-95
Echinodermata	Echinoidea	Camarodonta	*Strongylocentrotus pallidus*	160-208
Echinodermata	Holothuroidea	Aspidochirotida	*Apostichopus leukothele*	93-259
Echinodermata	Holothuroidea	Aspidochirotida	*Molpadia* sp.	678
Echinodermata	Holothuroidea	Dendrochirotida	*Psolus squamatus*	527-943
Echinodermata	Holothuroidea	Elasipodida	*Pannychia* cf *moseleyi*	533-937
Echinodermata	Ophiuroidea	Euryalida	*Asteronyx loveni*	165-259
Echinodermata	Ophiuroidea	Ophiurida	*Ophiopholis bakeri*	102-707
Echinodermata	Ophiuroidea	Ophiurida	*Ophiura sarsii*	166-259
Chordata	Ascidiacea		Ascidiacea sp.	34-209
Chordata	Actinopterygii	Gadiformes	*Antimora microlepis*	720-1118
Chordata	Actinopterygii	Gadiformes	cf *Coryphaenoides acrolepis*	608-1154
Chordata	Actinopterygii	Perciformes	*Chirolophis decoratus*	132-196
Chordata	Actinopterygii	Pleuronectiformes	*Citharichthys sordidus*	194-198
Chordata	Actinopterygii	Pleuronectiformes	*Embassichthys bathybius*	436-932
Chordata	Actinopterygii	Pleuronectiformes	*Glyptocephalus zachirus*	194-645
Chordata	Actinopterygii	Pleuronectiformes	*Lepidopsetta bilineata*	84-244
Chordata	Actinopterygii	Pleuronectiformes	*Microstomus pacificus*	199-627
Chordata	Actinopterygii	Scorpaeniformes	*Agonopsis vulsa*	137
Chordata	Actinopterygii	Scorpaeniformes	*Anoplopoma fimbria*	903-937
Chordata	Actinopterygii	Scorpaeniformes	Cottidae sp.	91-223
Chordata	Actinopterygii	Scorpaeniformes	*Hemilepidotus spinosus*	90-126
Chordata	Actinopterygii	Scorpaeniformes	*Paricelinus hopliticus*	91-256
Chordata	Actinopterygii	Scorpaeniformes	*Rhamphocottus richardsonii*	184
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes* spp.	84-555
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes aleutianus*[7]	107-373
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes alutus*	164-258
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes elongatus*	214-215
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes emphaeus*	93-222
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes entomelas*	37-198
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes helvomaculatus*	84-259
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes melanostictus*[7]	107-373
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes melanostomus*	556
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes mystinus*	84

Phylum	Class	Order	Genus and species	Depths (m)
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes rosaceus*	35-219
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes ruberrimus*	84-221
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes variegatus*	91-258
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes wilsoni*	110-221
Chordata	Actinopterygii	Scorpaeniformes	*Sebastes zacentrus*	92-258
Chordata	Actinopterygii	Scorpaeniformes	*Sebastolobus* spp.	436-1147
Chordata	Elasmobranchii	Carcharhiniformes	*Apristurus brunneus*	883
Chordata	Elasmobranchii	Hexachiformes	*Hexanchus griseus*	185
Chordata	Elasmobranchii	Rajiformes	*Raja rhina*	196-242

Table A 2. Species captured at Bowie/Hodgkins Seamounts during groundfish surveys, 1991-2014 (summary of catch data courtesy of Lisa Lacko).

Phylum	Class	Order	Family	Scientific Name	Common Name	Caught weight (kg)	Number caught	COSEWIC Status	SARA Listed	IUCN Status
Arthropoda	Malacostraca	Decapoda	Lithodidae	Lithodes aequispinus	Golden King Crab	29.1	1	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda	Lithodidae	Lopholithodes sp.	Box Crabs	8	-	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda	Lithodidae	Paralithodes camtschaticus	Red King Crab	103.3	-	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda	Lithodidae	Paralithodes sp./Lithodes sp.	Alaskan King Crab	10	-	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda	Oregoniidae	Chionoecetes bairdi	Tanner Crabs	2143	-	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda	Oregoniidae	Chionoecetes japonicus	Red Queen Crab	6755.9	-	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda	Oregoniidae	Chionoecetes tanneri	Grooved Tanner Crab	3346.4	-	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda		Decapoda	Decapods	4	-	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda		Reptantia spp.	Reptantia	49.8	1746	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda			Anomura	82.4	-	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda			Crabs	547.8	-	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda			True Crabs	1704.7	-	n/a	n/a	n/a
Chordata	Actinopterygii	Anguilliformes	Nemichthyidae	Nemichthyidae spp.	Snipe Eels	1	-	n/a	n/a	n/a
Chordata	Actinopterygii	Anguilliformes		Anguilliformes sp.	Eels		1	n/a	n/a	n/a
Chordata	Actinopterygii	Gadiformes	Gadidae	Gadus microcephalus	Pacific Cod		9	n/a	n/a	n/a
Chordata	Actinopterygii	Gadiformes	Macrouridae	Albatrossia pectoralis	Giant Grenadier	1063.9	-	n/a	n/a	n/a

Phylum	Class	Order	Family	Scientific Name	Common Name	Caught weight (kg)	Number caught	COSEWIC Status	SARA Listed	IUCN Status
Chordata	Actinopterygii	Gadiformes	Macrouridae	Coryphaenoides acrolepis	Pacific Grenadier	2317.7	-	n/a	n/a	n/a
Chordata	Actinopterygii	Gadiformes	Macrouridae	Coryphaenoides liocephalus	Bearded Rattail		3	n/a	n/a	n/a
Chordata	Actinopterygii	Gadiformes	Macrouridae	Macrouridae sp.	Grenadiers	6818.4	1111	n/a	n/a	n/a
Chordata	Actinopterygii	Gadiformes	Moridae	Antimora microlepis	Pacific Flatnose	30.9	-	n/a	n/a	Data Deficient
Chordata	Actinopterygii	Perciformes	Anarhichadidae	Anarrhichthys ocellatus	Wolf Eel	88	-	Not at Risk	n/a	n/a
Chordata	Actinopterygii	Perciformes	Bathymasteridae	Bathymaster signatus	Blue-Eyed Searcher	2	-	n/a	n/a	n/a
Chordata	Actinopterygii	Perciformes	Bathymasteridae	Bathymasteridae	Ronquils	-	2	n/a	n/a	n/a
Chordata	Actinopterygii	Perciformes	Bathymasteridae	Ronquilus jordani	Northern Ronquil	8	-	n/a	n/a	n/a
Chordata	Actinopterygii	Perciformes	Icosteidae	Icosteus sp.	Ragfishes	4.7	-	n/a	n/a	n/a
Chordata	Actinopterygii	Perciformes	Zaproridae	Zaprora silenus	Prowfish	104	-	n/a	n/a	n/a
Chordata	Actinopterygii	Perciformes	Zoarcidae	Bothrocara brunneum	Twoline Eelpout	0.5	-	n/a	n/a	n/a
Chordata	Actinopterygii	Pleuronectiformes	Pleuronectidae	Atheresthes stomias	Arrowtooth Flounder	-	1	n/a	n/a	n/a
Chordata	Actinopterygii	Pleuronectiformes	Pleuronectidae	Embassichthys bathybius	Deepsea Sole	13		n/a	n/a	n/a
Chordata	Actinopterygii	Pleuronectiformes	Pleuronectidae	Hippoglossus stenolepis	Pacific Halibut	14852.6	8	n/a	n/a	n/a
Chordata	Actinopterygii	Pleuronectiformes	Pleuronectidae	Microstomus pacificus	Dover Sole	14.1	5	n/a	n/a	n/a
Chordata	Actinopterygii	Pleuronectiformes		Pleuronectiformes	Flatfishes	-	12	n/a	n/a	n/a

Phylum	Class	Order	Family	Scientific Name	Common Name	Caught weight (kg)	Number caught	COSEWIC Status	SARA Listed	IUCN Status
				sp.						
Chordata	Actinopterygii	Salmoniformes	Salmonidae	Oncorhynchus tshawytscha	Chinook Salmon	8	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Anoplopomatidae	Anoplopoma fimbria	Sablefish	1837403.1		n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Anoplopomatidae	Erilepis zonifer	Skilfish	-	9	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Cottidae	Hemilepidotus hemilepidotus	Red Irish Lord	64	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Cottidae	Hemilepidotus spinosus	Brown Irish Lord	6	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Cottoidei	Cottoidea spp.	Sculpins	8	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Hexagrammidae	Hexagrammidae sp.	Greenlings	1	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Hexagrammidae	Ophiodon elongatus	Lingcod	206.4	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Liparidae	Careproctus gilberti	Smalldisk Snailfish	2.3	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Liparidae	Careproctus melanurus	Blacktail Snailfish	1.4	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Liparidae	Liparidae spp.	Snailfishes	-	3	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Psychrolutidae	Psychrolytes phrictus	Giant Blobsculpin	0.9	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Scorpaenidae	Scorpaenidae spp.	Scorpionfishes	65171.3	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes aleutianus	Rougheye Rockfish	751088.2	n/a	Special Concern	Special Concern	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes alutus	Pacific Ocean Perch	43.1	1	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes aurora	Aurora Rockfish	33.6	n/a	n/a	n/a	n/a

Phylum	Class	Order	Family	Scientific Name	Common Name	Caught weight (kg)	Number caught	COSEWIC Status	SARA Listed	IUCN Status
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes babcocki	Redbanded Rockfish	6197.7	365	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes borealis	Shortraker Rockfish	1493.2	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes brevispinis	Silvergray Rockfish	4286	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes caurinus	Copper Rockfish	2	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes diploproa	Splitnose Rockfish	1	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes elongates	Greenstriped Rockfish	1.1	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes entomelas	Widow Rockfish	865	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes flavidus	Yellowtail Rockfish	6.9	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes helvomaculatus	Rosethorn Rockfish	3769.8	1	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes maliger	Quillback Rockfish	69.8	n/a	Threatened	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes miniatus	Vermilion Rockfish	14.3	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes nebulosus	China Rockfish	49.5	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes nigrocinctus	Tiger Rockfish	79.1	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes paucispinis	Bocaccio	22.9	n/a	Endangered	n/a	Critically Endang ered
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes pinniger	Canary Rockfish	161.4	n/a	Threatened	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes proriger	Redstripe Rockfish	13	n/a	n/a	n/a	n/a

Phylum	Class	Order	Family	Scientific Name	Common Name	Caught weight (kg)	Number caught	COSEWIC Status	SARA Listed	IUCN Status
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes reedi	Yellowmouth Rockfish	798.2	n/a	Threatened	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes ruberrimus	Yelloweye Rockfish	103022.1	n/a	Special concern	Special Concern	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes variegatus	Harlequin Rockfish	24.8	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastolobus	Thornyheads	1277.6	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastolobus alascanus	Shortspine Thornyhead	1810.2	n/a	n/a	n/a	Endangered
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	Sebastolobus altivelis	Longspine Thornyhead	0.5	n/a	Special Concern	Special Concern	n/a
Chordata	Actinopterygii	Stomiiformes	Stomiidae	Chauliodus macouni	Pacific Viperfish	3	n/a	n/a	n/a	n/a
Chordata	Actinopterygii	Stomiiformes	Stomiidae	Chauliodus sp.	Viperfishes	0.5	1	n/a	n/a	n/a
Chordata	Chondrichthyes				Unidentified Shark	70	n/a	n/a	n/a	n/a
Chordata	Elasmobranchii	Carcharhiniformes	Carcharhinidae	Prionace glauca	Blue Shark	54	n/a	Special Concern	n/a	Near Threatened
Chordata	Elasmobranchii	Rajiformes	Rajidae	Raja binoculata	Big Skate	3	n/a	Not At Risk	n/a	Near Threatened
Chordata	Elasmobranchii	Rajiformes	Rajidae	Raja rhina	Longnose Skate	334.2	n/a	Not At Risk	n/a	Least Concern
Chordata	Elasmobranchii	Rajiformes	Rajidae	Rajella bathyphila	Abyssal Skate	4	n/a	n/a	n/a	n/a
Chordata	Elasmobranchii	Rajiformes	Rajidae	Rajidae spp.	Skates	344.2	n/a	n/a	n/a	n/a
Chordata	Elasmobranchii	Squaliformes	Somniosidae	Somniosus pacificus	Pacific Sleeper Shark	1464.3	n/a	n/a	n/a	Data Deficient
Chordata	Elasmobranchii	Squaliformes	Squalidae	Squalus acanthias	Spiny Dogfish	2	0	Special	n/a	n/a

Phylum	Class	Order	Family	Scientific Name	Common Name	Caught weight (kg)	Number caught	COSEWIC Status	SARA Listed	IUCN Status
								Concern		
Chordata	Holocephali	Chimaeriformes	Chimaeridae	Hydrolagus colliei	Spotted Ratfish	n/a	362	n/a	n/a	Least Concern
Chordata	Osteichthyes				Unknown Fish	90	6	n/a	n/a	n/a
Cnidaria	Anthozoa	Actinaria			Anemone	1	n/a	n/a	n/a	n/a
Cnidaria	Anthozoa	Alcyonacea		Alcyonacea spp.	Gorgonian Corals	7.9	n/a	n/a	n/a	n/a
Cnidaria	Anthozoa	Antipatharia		Antipatharia sp.	Black Corals, Thorny Corals	0.5	n/a	n/a	n/a	n/a
Cnidaria	Anthozoa	Scleratinia		Scleratinia spp.	Stony Corals	6	n/a	n/a	n/a	n/a
Cnidaria	Hydrozoa			Hydrozoa spp.	Hydroid	0.5	n/a	n/a	n/a	n/a
Cnidaria				Medusozoa spp.	Jellyfish	77.9	n/a	n/a	n/a	n/a
Echinodermata	Asteroidea	Forcipulatida	Pycnopodiidae	Pycnopodia helianthoides	Sunflower Starfish	n/a	86	n/a	n/a	n/a
Echinodermata	Asteroidea			Asteroidea spp.	Starfish	824.4	n/a	n/a	n/a	n/a
Echinodermata	Crinoidea			Crinoidea spp.	Sea Lilies And Feather Stars	5.5	56	n/a	n/a	n/a
Echinodermata	Echinoidea			Echinoidea spp.	Sea Urchins	0.5	n/a	n/a	n/a	n/a
Echinodermata	Ophiuroidea	Euryalida		Euryalina sp.	Basket Stars	4	n/a	n/a	n/a	n/a
Echinodermata	Ophiuroidea			Ophiuroidea spp.	Ophiurae	3	168	n/a	n/a	n/a
Mollusca	Cephalopoda	Octopoda	Enteroctopodidae	Enteroctopus dofleini	Giant Pacific Octopus	4.5	n/a	n/a	n/a	n/a

Phylum	Class	Order	Family	Scientific Name	Common Name	Caught weight (kg)	Number caught	COSEWIC Status	SARA Listed	IUCN Status
Mollusca	Cephalopoda	Octopoda	n/a	Octopoda spp.	Octopus	9.5	16	n/a	n/a	n/a
Mollusca	Cephalopoda	n/a	n/a	Cephalopoda sp.	Cephalopods	0.9	n/a	n/a	n/a	n/a
Mollusca	Gastropoda	n/a	n/a	Gastropoda	Gastropods	3	n/a	n/a	n/a	n/a
Mollusca	Gastropoda	n/a	n/a	n/a	Seaslugs	1	n/a	n/a	n/a	n/a
Porifera	Calcarea	n/a	n/a	Calcarea sp.	Calcareous Sponges	0.5	n/a	n/a	n/a	n/a
Porifera	n/a	n/a	n/a	Porifera sp.	Sponges	4.4	3	n/a	n/a	n/a

Table A 3. Species captured at Dellwood Seamount during groundfish surveys, 1991-2014 (summary of catch data courtesy of Lisa Lacko).

Phylum	Class	Order	Scientific name	Species	Caught weight (kg)	Number caught	COSEWIC Status	SARA Status	IUCN Status
Chordata	Actinopterygii	n/a	n/a	Unknown Fish	-	29	n/a	n/a	n/a
Chordata	Actinopterygii	Pleuronectiformes	Atheresthes stomias	Arrowtooth Flounder	-	790	n/a	n/a	n/a
Chordata	Actinopterygii	Pleuronectiformes	Hippoglossus stenolepis	Pacific Halibut	21054.2	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Ophiodon elongatus	Lingcod	139	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes babcocki	Redbanded Rockfish	467.1	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes aleutianus	Rougheye Rockfish	265	-	Special Concern	Special Concern	n/a
Chordata	Actinopterygii	Scorpaeniformes	Anoplopoma fimbria	Sablefish	24764.4	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastolobus alascanus	Shortspine Thornyhead	76.1	-	n/a	n/a	Endangered
Chordata	Actinopterygii	Scorpaeniformes	Sebastes brevispinis	Silvergray Rockfish	28.6	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes ruberrimus	Yelloweye Rockfish	373.1	-	Special Concern	Special Concern	n/a
Chordata	Elasmobranchii	Rajiformes	Raja binoculata	Big Skate	79.9	7	Not at Risk	n/a	Near Threatened
Chordata	Elasmobranchii	Rajiformes	Raja rhina	Longnose Skate	806.8	-	Not at Risk	n/a	Least Concern
Chordata	Elasmobranchii	Rajiformes		Sandpaper Skate	-	2	Not at Risk	n/a	Data Deficient
Chordata	Elasmobranchii	Squaliformes	Squalus acanthias	Spiny Dogfish	534.1	415	Special Concern	n/a	n/a

Table A 4. Species captured at Union Seamount during groundfish surveys, 1991-2014 (summary of catch data courtesy of Lisa Lacko).

Phylum	Class	Order	Scientific Name	Species	Caught weight (kg)	Number caught	COSEWIC Status	SARA Status	IUCN Status
Actinopterygii	Pleuronectiformes	Pleuronectidae	Hippoglossus stenolepis	Pacific Halibut	112.1	2	n/a	n/a	n/a
Actinopterygii	Scorpaeniformes	Sebastidae	Sebastes alutus	Pacific Ocean Perch	-	1	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda	Paralithodes sp./Lithodes sp.	Alaskan King Crabs	2316	-	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda		Crabs	369.6	248	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda		Red Queen Crab	257.5	402	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda		Tanner Crabs	188.1	638	n/a	n/a	n/a
Arthropoda	Malacostraca	Decapoda		True Crabs	3454.4	-	n/a	n/a	n/a
Chordata	Actinopterygii			Unknown Fish	108.3	2	n/a	n/a	n/a
Chordata	Actinopterygii	Gadiformes	Albatrossia pectoralis	Giant Grenadier	10	-	n/a	n/a	n/a
Chordata	Actinopterygii	Gadiformes	Macrouridae spp.	Grenadiers	64	260	n/a	n/a	n/a
Chordata	Actinopterygii	Gadiformes	Gadus microcephalus	Pacific Cod	-	1	n/a	n/a	n/a
Chordata	Actinopterygii	Perciformes	Zaprora silenus	Prowfish	-	1	n/a	n/a	n/a
Chordata	Actinopterygii	Pleuronectiformes	Embassichthys bathybius	Deepsea Sole	1	-	n/a	n/a	n/a
Chordata	Actinopterygii	Pleuronectiformes	Microstomus pacificus	Dover Sole	2.8	1	n/a	n/a	n/a
Chordata	Actinopterygii	Pleuronectiformes	Pleuronectiformes sp.	Flatfishes	4.1	1	n/a	n/a	n/a
Chordata	Actinopterygii	Pleuronectiformes	Lepidopsetta bilineata	Rock Sole	21	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes aurora	Aurora Rockfish	0.3	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes pinniger	Canary Rockfish	-	2	Threatened	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes goodei	Chilipepper Rockfish	-	2	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes babcocki	Redbanded Rockfish	173.5	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes helvomaculatus	Rosethorn Rockfish	175.2	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes aleutianus	Rougheye Rockfish	879780.7	-	Special Concern	Special Concern	n/a
Chordata	Actinopterygii	Scorpaeniformes	Anoplopoma fimbria	Sablefish	219788.9	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Scorpaenidae spp.	Scorpionfishes	10333.8	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes borealis	Shortraker Rockfish	533.5	1	n/a	n/a	n/a

Phylum	Class	Order	Scientific Name	Species	Caught weight (kg)	Number caught	COSEWIC Status	SARA Status	IUCN Status
Chordata	Actinopterygii	Scorpaeniformes	Sebastolobus alascanus	Shortspine Thornyhead	193.4	-	n/a	n/a	Endangered
Chordata	Actinopterygii	Scorpaeniformes	Erilepis zonifer	Skilfish	1.3	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes entomelas	Widow Rockfish	19.5	-	n/a	n/a	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes ruberrimus	Yelloweye Rockfish	185.1	-	Special Concern	Special Concern	n/a
Chordata	Actinopterygii	Scorpaeniformes	Sebastes reedi	Yellowmouth Rockfish	1.8	-	Threatened	n/a	n/a
Chordata	Elasmobranchii	Carcharhiniformes	Prionace glauca	Blue Shark	-	1	Special Concern	n/a	Near Threatened
Chordata	Elasmobranchii	Squaliformes	Somniosus pacificus	Pacific Sleeper Shark	50	1	n/a	n/a	Data Deficient
Cnidaria				Jellyfish	44	-	n/a	n/a	n/a
Cnidaria	Anthozoa	Scleratinia		Stony Corals	1	-	n/a	n/a	n/a
Echinodermata	Asteroidea			Starfish	-	20	n/a	n/a	n/a
Echinodermata	Ophiuroidea			Ophiurae	6	-	n/a	n/a	n/a
Mollusca	Cephalopoda	Octopoda	Enteroctopus dofleini	Giant Pacific Octopus	6.3	-	n/a	n/a	n/a
Mollusca	Cephalopoda	Octopoda		Octopus	3	13	n/a	n/a	n/a
Mollusca	Gastropoda			Gastropods	11.9	2	n/a	n/a	n/a
Porifera				Sponges	-	1	n/a	n/a	n/a

Table A 5. Species captured in groundfish research surveys with midwater and bottom trawls, traps, and longline gears from 1963 - 2104 from 400 – 1500m and 1500-2500m depth ranges (n = 32514 records in total). N denotes the number of records in the database query for each taxon.

Phylum	**Scientific Name**	**Common Name**	**Status**	**400-1500 m**	**1500-2500 m**	**N**
Annelida	Aphrodita	Sea mouse		X	X	38
Annelida	Echiura	Spoon worm		X	X	5
Annelida	Polychaeta	Polychaete worms		X	X	35
Annelida	Polynoe	Scale worms		X		2
Annelida	Sedentaria	Tube worms		X		3
Arthropoda	*Acanthephyra curtirostris*	Peaked shrimp		X	X	7
Arthropoda	Acanthonychinae			X		3
Arthropoda	*Argis lar*	Northern argid		X		2
Arthropoda	*Argis ovifer*	Split-eye argid		X		1
Arthropoda	Bentheogennema borealis	Northern blunt-tailed shrimp		X	X	15
Arthropoda	Brachyura	True crabs		X		9
Arthropoda	Branchiopoda	Branchiopods		X		3
Arthropoda	*Calastacus stilirostris*			X		1
Arthropoda	Caprellidae	Skeleton shrimp		X		1
Arthropoda	*Chionoecetes angulatus*	Triangle tanner crab		X	X	25
Arthropoda	*Chionoecetes bairdi*	Inshore tanner crab		X		23
Arthropoda	*Chionoecetes tanneri*	Grooved tanner crab		X	X	886
Arthropoda	Chirostylidae			X		2
Arthropoda	*Chorilia longipes*	Redclaw crab		X		11
Arthropoda	Cirripedia	Barnacles		X		1
Arthropoda	*Crangon dalli*	Ridged crangon		X	X	5
Arthropoda	Dendrobranchiata	Shrimp		X		27
Arthropoda	*Eualus barbatus*	Barbed eualid		X		4
Arthropoda	*Eualus biunguis*	Deepsea eualid		X	X	54
Arthropoda	*Eualus macropthalmus*	Large eyed eualid		X		70
Arthropoda	*Euphausia pacifica*	Pacific krill		X		1
Arthropoda	Galatheoidae			X		2
Arthropoda	Gnathiidea			X		2
Arthropoda	Gnathophausia			X	X	8
Arthropoda	*Heptacarpus moseri*	Alaska coastal shrimp		X		4
Arthropoda	Hyale			X		1
Arthropoda	*Hyas lyratus*	Pacific lyre crab		X		1
Arthropoda	*Hymenodora frontalis*			X	X	37
Arthropoda	*Labidochirus splendescens*			X		1

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
Arthropoda	*Lebbeus washingtonianus*	Slope lebbeid		X		4
Arthropoda	Lepadomorpha	Pedunculate barnacles		X		1
Arthropoda	*Lithodes aequispinus*	Golden king crab		X	X	18
Arthropoda	*Lithodes couesi*			X	X	506
Arthropoda	*Lophaxius rathbunae*			X		3
Arthropoda	Lopholithodes	Box crabs		X		
Arthropoda	Majidae	Majidae		X		2
Arthropoda	*Metacarcinus magister*	Dungeness crab		X		1
Arthropoda	*Metacrangon variabilis*	Deepsea spinyhead		X		1
Arthropoda	Munida			X	X	8
Arthropoda	Mysidae			X	X	5
Arthropoda	*Neocrangon abyssorum*	Abyssal crangon		X	X	8
Arthropoda	*Neognathophausia gigas*			X	X	8
Arthropoda	*Neognathophausia ingens*			X		2
Arthropoda	*Notostomus japonicus*	Spiny ridge shrimp		X	X	49
Arthropoda	Oplophoridae	Pelagic shrimp		X		1
Arthropoda	*Oregonia bifurca*	Deepwater decorator crab		X		7
Arthropoda	*Oregonia gracilis*	Graceful decorator crab		X	X?	25
Arthropoda	Paguridae	Right-handed hermits		X	X	13
Arthropoda	*Paguristes turgidus*	Furry hermit		X		1
Arthropoda	Paguroidea			X		1
Arthropoda	*Pagurus confragosus*			X		8
Arthropoda	*Pandalopsis ampla*				X	1
Arthropoda	*Pandalopsis dispar*	Sidestripe shrimp		X		25
Arthropoda	*Pandalopsis glabra*				X	3
Arthropoda	*Pandalus borealis*	Pink shrimp		X		4
Arthropoda	*Pandalus danae*	Coonstripe shrimp		X		2
Arthropoda	*Pandalus hypsinotus*	Humpback shrimp		X		4
Arthropoda	*Pandalus jordani*	Pink shrimp (smooth)		X		5
Arthropoda	*Pandalus platyceros*	Prawn		X		19
Arthropoda	*Pandalus tridens*	Yellowleg shrimp		X		39
Arthropoda	Paralithodes	Alaskan king crabs		X		6
Arthropoda	*Paralithodes brevipes*	Brown king crab		X		20
Arthropoda	*Paralithodes camtschaticus*	Red king crab		X		32
Arthropoda	*Paralomis multispina*			X	X	143
Arthropoda	*Paralomis verrilli*			X	X	10

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
Arthropoda	Parapagurus			X		3
Arthropoda	*Parapasiphae sulcatifrons*	Grooved-back shrimp		X		3
Arthropoda	*Pasiphaea pacifica*	Glass shrimp		X	X	150
Arthropoda	*Pasiphaea tarda*	Crimson pasiphaeid		X	X	37
Arthropoda	Pasiphaeidae			X		
Arthropoda	*Pugettia producta*	Northern kelp crab		X		1
Arthropoda	Pycnogonida	Seaspider		X	X	6
Arthropoda	*Sergestes similis*	Pacific sergestid		X	X	32
Arthropoda	*Sergia tenuiremis*	Ocean sergestid		X		1
Arthropoda	*Spirontocaris arcuata*	Rathbun's bladed shrimp		X		1
Arthropoda	*Spirontocaris holmesi*	Slender bladed shrimp		X		1
Arthropoda	*Spirontocaris lamellicornis*	Dana's bladed shrimp		X		6
Arthropoda	Stegocephalidae			X		1
Arthropoda	*Systellaspis braueri*	Quayle's spinytail		X	X	14
Brachiopoda	Brachiopoda	Lampshells		X	X	19
Bryozoa	Bryozoa			X		1
Chordata	Agonidae	Poachers		X		24
Chordata	*Albatrossia pectoralis*	Giant grenadier		X	X	946
Chordata	Alepisauridae	Lancetfishes		X		3
Chordata	*Alepocephalus tenebrosus*	California slickhead		X		3
Chordata	Ammodytidae	Sand lances		X		8
Chordata	*Anarrhichthys ocellatus*	Wolf eel		X		2
Chordata	*Anoplogaster cornuta*	Longhorn fangtooth		X		1
Chordata	*Anoplopoma fimbria*	Sablefish		X	X	3133
Chordata	Anotopteridae	Daggertooths		X		2
Chordata	*Anotopterus nikparini*	North pacific daggertooth		X	X	7
Chordata	*Antimora microlepis*	Pacific flatnose		X	X	598
Chordata	*Apodichthys fucorum*	Rockweed gunnel		X		1
Chordata	*Apristurus brunneus*	Brown cat shark		X		206
Chordata	*Aptocyclus ventricosus*	Smooth lumpsucker		X		1
Chordata	*Arctozenus risso*	White barracudina		X		11
Chordata	Argentinidae	Argentines		X		3
Chordata	*Argyropelecus affinis*	Pacific hatchetfish		X		
Chordata	*Argyropelecus sladeni*	Lowcrest hatchetfish		X		6
Chordata	*Aristostomias scintillans*	Shining loosejaw		X	X	30

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
Chordata	Artedius			X		1
Chordata	Ascidiacea	Ascidians and tunicates		X	X	52
Chordata	*Avocettina infans*	Closespine snipe eel		X	X	26
Chordata	*Bathophilus flemingi*	Highfin dragonfish		X	X	31
Chordata	*Bathyagonus nigripinnis*	Blackfin poacher		X	X	94
Chordata	*Bathyagonus pentacanthus*	Bigeye poacher		X		9
Chordata	*Bathylagus pacificus*	Pacific blacksmelt		X	X	27
Chordata	*Bathyraja abyssicola*	Abyssal skate		X	X	62
Chordata	*Bathyraja aleutica*	Aleutian skate		X		27
Chordata	*Bathyraja interrupta*	Sandpaper skate		X		138
Chordata	*Bathyraja minispinosa*	Whitebrow skate		X		3
Chordata	*Bathyraja parmifera*	Alaska skate		X		2
Chordata	*Bathyraja trachura*	Roughtail skate		X	X	118
Chordata	*Benthalbella dentata*	Northern pearleye		X	X	32
Chordata	*Benthalbella linguidens*	Longfin pearleye		X	X	4
Chordata	Boltenia	Tunicate		X		6
Chordata	*Bothrocara brunneum*	Twoline eelpout		X	X	214
Chordata	*Bothrocara molle*	Soft eelpout		X		1
Chordata	*Bothrocara remigerum*	Longsnout eelpout		X	X	10
Chordata	*Careproctus colletti*	Alaska snailfish		X		4
Chordata	*Careproctus cypselurus*	Falcate snailfish		X		2
Chordata	*Careproctus furcellus*	Emarginate snailfish		X		14
Chordata	*Careproctus gilberti*	Smalldisk snailfish		X		13
Chordata	*Careproctus melanurus*	Blacktail snailfish		X	X	132
Chordata	*Ceratoscopelus townsendi*	Dogtooth lampfish		X		5
Chordata	*Chaenophryne melanorhabdus*	Smooth dreamer		X		2
Chordata	*Chauliodus macouni*	Pacific viperfish		X	X	256
Chordata	Chimaeridae	Ratfishes		X		3
Chordata	*Citharichthys sordidus*	Pacific sanddab		X		
Chordata	*Clidoderma asperrimum*	Roughscale sole		X		2
Chordata	*Clupea pallasii*	Pacific herring		X		2
Chordata	*Cololabis saira*	Pacific saury		X		1
Chordata	Congridae	Conger eels		X		
Chordata	*Coryphaenoides acrolepis*	Pacific grenadier		X	X	844
Chordata	*Coryphaenoides*	Smooth abyssal		X	X	8

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
	armatus	grenadier				
Chordata	*Coryphaenoides cinereus*	Popeye		X	X	113
Chordata	*Coryphaenoides filifer*	Threadfin grenadier		X	X	141
Chordata	*Coryphaenoides leptolepis*	Ghostly grenadier		X	X	9
Chordata	*Coryphaenoides liocephalus*	Bearded rattail		X		2
Chordata	*Coryphaenoides yaquinae*	Rough abyssal grenadier			X	1
Chordata	*Cottus rhotheus*	Torrent sculpin		X		1
Chordata	*Cryptacanthodes aleutensis*	Dwarf wrymouth		X		1
Chordata	Cyclopteridae	Lumpfishes and snailfishes		X	X	36
Chordata	*Cyclosalpa affinis*			X		16
Chordata	*Cyclothone atraria*	Black bristlemouth		X	X	6
Chordata	*Cyema atrum*	Black bobtail eel		X		1
Chordata	*Derepodichthys alepidotus*	Cuskpout		X	X	17
Chordata	*Diaphus theta*	California headlightfish		X	X	108
Chordata	*Elassodiscus caudatus*	Humpback snailfish		X		29
Chordata	*Eopsetta jordani*	Petrale sole		X		37
Chordata	*Eptatretus deani*	Black hagfish		X		74
Chordata	*Eptatretus stoutii*	Pacific hagfish		X		30
Chordata	*Erilepis zonifer*	Skilfish		X		9
Chordata	*Gadus macrocephalus*	Pacific cod		X		19
Chordata	*Glyptocephalus zachirus*	Rex sole		X		348
Chordata	Gonostomatidae	Lightfishes		X		
Chordata	*Halargyreus johnsonii*	Slender codling		X		2
Chordata	*Hemitripterus bolini*	Bigmouth sculpin		X		1
Chordata	*Hippoglossoides elassodon*	Flathead sole		X		2
Chordata	*Hippoglossus stenolepis*	Pacific halibut		X		494
Chordata	*Hydrolagus colliei*	Spotted ratfish		X	X	120
Chordata	*Icelinus borealis*	Northern sculpin		X		4
Chordata	*Icelinus burchami*	Dusky sculpin		X		1
Chordata	*Icelinus filamentosus*	Threadfin sculpin		X		2
Chordata	*Icichthys lockingtoni*	Medusafish		X		
Chordata	*Icosteus aenigmaticus*	Ragfish		X		9
Chordata	*Lamna ditropis*	Salmon shark		X		1
Chordata	Lampadena	Lanternfish		X	X	9

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
Chordata	*Lampanyctus jordani*	Brokenline lanternfish		X		1
Chordata	*Lampetra tridentata*	Pacific lamprey		X		10
Chordata	*Lepidopsetta bilineata*	Southern rock sole		X		
Chordata	*Lestidiops ringens*	Slender barracudina		X		12
Chordata	*Leuroglossus schmidti*	Northern smoothtongue		X		8
Chordata	*Leuroglossus stilbius*	Southern smoothtongue		X		1
Chordata	Liparis	Snailfishes		X	X	29
Chordata	*Lipariscus nanus*	Pygmy snailfish		X		1
Chordata	*Lipolagus ochotensis*	Popeye blacksmelt		X		2
Chordata	*Lycenchelys camchatica*	Kamchatka eelpout		X		1
Chordata	*Lycenchelys crotalinus*	Snakehead eelpout		X	X	42
Chordata	*Lycenchelys micropora*	Manytoothed eelpout		X		2
Chordata	*Lycodapus dermatinus*	Looseskin eelpout		X	X	3
Chordata	*Lycodapus endemoscotus*	Deepwater eelpout		X		8
Chordata	*Lycodapus fierasfer*	Blackmouth eelpout		X	X	83
Chordata	*Lycodapus mandibularis*	Pallid eelpout		X	X	34
Chordata	*Lycodapus pachysoma*	Stout eelpout			X	1
Chordata	*Lycodes cortezianus*	Bigfin eelpout		X		37
Chordata	*Lycodes diapterus*	Black eelpout		X		172
Chordata	*Lycodes pacificus*	Blackbelly eelpout		X		7
Chordata	*Lyopsetta exilis*	Slender sole		X		48
Chordata	*Macropinna microstoma*	Barreleye		X	X	5
Chordata	*Magnisudis atlantica*	Duckbill barracudina		X		2
Chordata	*Malacocottus aleuticus*	Whitetail sculpin		X		4
Chordata	*Malacocottus kincaidi*	Blackfin sculpin		X		27
Chordata	*Malacocottus zonurus*	Darkfin sculpin		X		29
Chordata	*Malacosteinae*	Loosejaws		X		3
Chordata	*Melamphaes lugubris*	Highsnout bigscale		X	X	22
Chordata	*Melanostigma pammelas*	Pacific softpout		X		5
Chordata	*Merluccius productus*	Pacific hake		X	X	362
Chordata	*Microstomus bathybius*	Deepsea sole		X		264
Chordata	*Microstomus pacificus*	Dover sole		X	X	888
Chordata	Molgula	Tunicate		X		1
Chordata	Moridae	Deepsea cods			X	1
Chordata	Myctophidae	Lanternfishes		X	X	71

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
Chordata	Myxinidae	Hagfishes		X		30
Chordata	*Nannobrachium regale*	Pinpoint lampfish		X	X	59
Chordata	*Nannobrachium ritteri*	Broadfin lampfish		X		9
Chordata	*Nansenia candida*	Bluethroat argentine		X		21
Chordata	*Nectoliparis pelagicus*	Tadpole snailfish		X		3
Chordata	*Nemichthys scolopaceus*	Slender snipe eel		X		6
Chordata	*Nezumia stelgidolepis*	California grenadier		X		1
Chordata	*Notacanthus chemnitzii*	Snubnosed spiny eel			X	1
Chordata	*Notoscopelus japonicus*	Japanese lanternfish		X		
Chordata	*Oncorhynchus gorbuscha*	Pink salmon		X		2
Chordata	*Oncorhynchus keta*	Chum salmon		X		
Chordata	*Oncorhynchus kisutch*	Coho salmon	EN - COSEWIC	X		1
Chordata	*Oncorhynchus tshawytscha*	Chinook salmon	TH - COSEWIC	X		3
Chordata	*Oneirodes bulbosus*	Bulbous dreamer		X		5
Chordata	*Oneirodes thompsoni*	Spiny dreamer		X		3
Chordata	Ophidiidae	Cuskeels			X	1
Chordata	*Ophiodon elongatus*	Lingcod		X		28
Chordata	*Opisthoteuthis californiana*	Flapjack devilfish		X	X	99
Chordata	Osmeridae	Smelts		X		2
Chordata	Paralepididae	Barracudinas		X		8
Chordata	*Paraliparis cephalus*	Swellhead snailfish		X	X	3
Chordata	*Paraliparis rosaceus*	Pink snailfish		X	X	32
Chordata	*Paraliparis ulochir*	Broadfin snailfish		X		
Chordata	*Parophrys vetulus*	English sole		X		1
Chordata	*Pegea confederata*			X		2
Chordata	Petromyzontidae	Lampreys		X		1
Chordata	Pholidae			X		1
Chordata	Platytroctidae	Tubeshoulders		X		4
Chordata	*Polyacanthonotus challengeri*	Longnose tapirfish			X	1
Chordata	*Poromitra crassiceps*	Crested bigscale		X	X	100
Chordata	*Prionace glauca*	Blue shark	NT - IUCN	X		5
Chordata	*Protomyctophum thompsoni*	Bigeye flashlightfish		X	X	21
Chordata	*Pseudobathylagus milleri*	Stout blacksmelt		X	X	100

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
Chordata	*Psychrolutes phrictus*	Giant blobsculpin		X	X	18
Chordata	*Pyrosoma atlanticum*	Pyrosome		X		
Chordata	*Raja binoculata*	Big skate	NT - IUCN	X		3
Chordata	*Raja rhina*	Longnose skate		X		226
Chordata	Rajidae	Skates		X	X	122
Chordata	*Reinhardtius hippoglossoides*	Greenland halibut		X		3
Chordata	*Reinhardtius stomias*	Arrowtooth flounder		X		1132
Chordata	*Rhinoliparis attenuatus*	Slim snailfish		X		1
Chordata	*Rhinoliparis barbulifer*	Longnose snailfish		X		1
Chordata	*Sagamichthys abei*	Shining tubeshoulder		X	X	23
Chordata	*Salmo salar*	Atlantic salmon		X		2
Chordata	*Salpa maxima*			X		7
Chordata	Scomberesocidae	Sauries		X		2
Chordata	*Scopelengys tristis*	Pacific blackchin		X		1
Chordata	*Scopelosaurus harryi*	Scaly waryfish		X	X	14
Chordata	Scyliorhinidae	Cat sharks		X		6
Chordata	*Scytalina cerdale*	Graveldiver		X		1
Chordata	*Sebastes aleutianus*	Rougheye rockfish		X	X	775
Chordata	*Sebastes alutus*	Pacific ocean perch		X		200
Chordata	*Sebastes aurora*	Aurora rockfish		X		120
Chordata	*Sebastes babcocki*	Redbanded rockfish		X		179
Chordata	*Sebastes borealis*	Shortraker rockfish		X		497
Chordata	*Sebastes brevispinis*	Silvergray rockfish		X		17
Chordata	*Sebastes crameri*	Darkblotched rockfish	SC - COSEWIC	X		55
Chordata	*Sebastes diploproa*	Splitnose rockfish		X		43
Chordata	*Sebastes elongatus*	Greenstriped rockfish		X		3
Chordata	*Sebastes emphaeus*	Puget sound rockfish		X		
Chordata	*Sebastes entomelas*	Widow rockfish		X		4
Chordata	*Sebastes flavidus*	Yellowtail rockfish		X		10
Chordata	*Sebastes goodei*	Chilipepper		X		
Chordata	*Sebastes helvomaculatus*	Rosethorn rockfish		X		20
Chordata	*Sebastes melanostomus*	Blackgill rockfish		X		7
Chordata	*Sebastes paucispinis*	Bocaccio	EN - COSEWIC	X		7
Chordata	*Sebastes pinniger*	Canary rockfish	EN - COSEW	X		2

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
			IC			
Chordata	*Sebastes proriger*	Redstripe rockfish		X		7
Chordata	*Sebastes reedi*	Yellowmouth rockfish	VU - COSEWIC	X		9
Chordata	*Sebastes ruberrimus*	Yelloweye rockfish	SC - COSEWIC	X		18
Chordata	*Sebastes semicinctus*	Halfbanded rockfish		X		1
Chordata	*Sebastes variegatus*	Harlequin rockfish		X		4
Chordata	*Sebastes zacentrus*	Sharpchin rockfish		X		22
Chordata	*Sebastolobus alascanus*	Shortspine thornyhead	EN - IUCN	X		1386
Chordata	*Sebastolobus altivelis*	Longspine thornyhead	SC - COSEWIC	X	X	549
Chordata	*Serrivomer jesperseni*	Crossthroat sawpalate		X	X	2
Chordata	*Somniosus pacificus*	Pacific sleeper shark		X		47
Chordata	*Squalus suckleyi*	North pacific spiny dogfish		X		176
Chordata	*Stenobrachius leucopsarus*	Northern lampfish		X	X	300
Chordata	*Stenobrachius nannochir*	Garnet lanternfish		X		37
Chordata	Sternoptychidae	Marine hatchetfishes		X		
Chordata	Stomiidae	Scaleless black dragonfishes		X		2
Chordata	Stomiiformes	Lightfish/hatchetfish/dragonfish/etc		X		3
Chordata	Styelidae			X		2
Chordata	*Symbolophorus californiensis*	Bigfin lanternfish		X		20
Chordata	*Symphurus atricaudus*	California tonguefish		X		
Chordata	*Synchirus gilli*	Manacled sculpin		X		1
Chordata	*Tactostoma macropus*	Longfin dragonfish		X	X	90
Chordata	*Talismania bifurcata*	Threadfin slickhead		X		29
Chordata	*Tarletonbeania crenularis*	Blue lanternfish		X	X	86
Chordata	*Thaleichthys pacificus*	Eulachon	EN - COSEWIC	X		6
Chordata	*Theragra chalcogramma*	Walleye pollock		X		49
Chordata	*Trachipterus altivelis*	King-of-the-salmon		X		
Chordata	*Trachurus symmetricus*	Jack mackerel		X		1
Chordata	*Xeneretmus latifrons*	Blacktip poacher		X		12

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
Chordata	*Xeneretmus leiops*	Smootheye poacher		X		3
Chordata	*Xeneretmus triacanthus*	Bluespotted poacher		X		1
Chordata	*Zaprora silenus*	Prowfish		X		3
Chordata	*Zesticelus profundorum*	Flabby sculpin		X		1
Chordata	Zoarcidae	Eelpouts		X	X	110
Cnidaria	Acanthoptilum			X		1
Cnidaria	Actiniaria	Anemone		X	X	428
Cnidaria	Aequorea			X		1
Cnidaria	Alcyonacea	Soft corals		X		10
Cnidaria	Anthomastus			X		2
Cnidaria	*Anthoptilum grandiflorum*			X		1
Cnidaria	Anthozoa			X	X	16
Cnidaria	Antipatharia	Black corals, thorny corals		X		1
Cnidaria	Atolla			X		2
Cnidaria	Aurelia aurita	Moon jelly		X		3
Cnidaria	*Balticina septentrionalis*	Sea whip		X	X	70
Cnidaria	*Bathypathes patula*			X		3
Cnidaria	Callogorgia			X		1
Cnidaria	*Cyanea capillata*	Lions mane		X		9
Cnidaria	*Dimophyes arctica*	Siphonophore		X		1
Cnidaria	Gorgonacea	Gorgonian corals		X	X	32
Cnidaria	Hexacorallia			X		16
Cnidaria	Hormathiidae			X		4
Cnidaria	Hydrozoa	Hydroid		X		4
Cnidaria	Isidella			X		12
Cnidaria	Keratoisis			X		1
Cnidaria	Lillipathes			X		5
Cnidaria	*Paractinostola faeculenta*			X		2
Cnidaria	Paragorgia			X		2
Cnidaria	*Paragorgia arborea*	Bubble gum coral		X		1
Cnidaria	*Paragorgia pacifica*			X		6
Cnidaria	Pennatulacea	Sea pens		X	X	31
Cnidaria	Periphylla			X		2
Cnidaria	*Periphylla periphylla*			X		29
Cnidaria	Primnoa			X		17
Cnidaria	*Ptilosarcus gurneyi*	Sea pen		X		5
Cnidaria	Scleractinia	Stony corals		X		2

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
Cnidaria	Scyphozoa	Jellyfish		X	X	218
Cnidaria	*Sertularella tanneri*			X		1
Cnidaria	Stomphia	Stomphia		X		13
Cnidaria	*Stylaster campylecus*			X		1
Cnidaria	*Swiftia pacifica*			X		1
Cnidaria	Virgulariidae	Virgulariidae		X		2
Ctenophora	Ctenophora	Ctenophora		X		8
Echinodermata	Acanthasteridae			X		1
Echinodermata	*Acantholiparis opercularis*	Spiny snailfish		X		1
Echinodermata	*Allocentrotus fragilis*	Fragile urchin		X		155
Echinodermata	*Ampheraster marianus*			X		3
Echinodermata	Amphiodia			X		1
Echinodermata	*Amphiophiura ponderosa*			X		27
Echinodermata	*Amphiophiura superba*			X		11
Echinodermata	Antedonidae			X		2
Echinodermata	Asteroidea	Starfish		X	X	346
Echinodermata	Asteronychidae			X		1
Echinodermata	*Asteronyx loveni*			X		5
Echinodermata	*Asteroschema sublaeve*			X		6
Echinodermata	*Astropecten armatus*			X		1
Echinodermata	*Benthopecten claviger*				X	1
Echinodermata	Benthopectinidae			X		2
Echinodermata	*Brisaster latifrons*	Heart urchin		X		2
Echinodermata	Ceramaster	Ceramaster		X		1
Echinodermata	*Ceramaster clarki*			X		1
Echinodermata	*Ceramaster patagonicus*	Cookie star		X		13
Echinodermata	*Cheiraster dawsoni*			X	X	22
Echinodermata	Crinoidea	Sea lilies and feather stars		X	X	97
Echinodermata	*Crossaster papposus*	Rose starfish		X	X	32
Echinodermata	*Cryptopeltaster lepidonotus*			X		2
Echinodermata	*Ctenodiscus crispatus*	Mud star		X	X	59
Echinodermata	*Dasycottus setiger*	Spinyhead sculpin		X		1
Echinodermata	*Diplopteraster multipes*			X		3
Echinodermata	Dipsacaster			X		2
Echinodermata	*Dipsacaster borealis*			X		2
Echinodermata	Echinacea	Sea urchins		X		83
Echinodermata	Elasipodida	Elasipodida		X		2

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
Echinodermata	*Eupentacta quinquesemita*	White sea cucumber		X		2
Echinodermata	Euryalina			X	X	45
Echinodermata	*Florometra asperrima*			X		1
Echinodermata	Goniasteridae			X	X	3
Echinodermata	Goniopectinidae			X	X	2
Echinodermata	Gorgonocephalidae			X		2
Echinodermata	*Gorgonocephalus eucnemis*	Basket star		X		10
Echinodermata	Henricia			X	X	9
Echinodermata	*Henricia aspera*			X		3
Echinodermata	*Henricia asthenactis*			X		3
Echinodermata	*Henricia longispina*			X		3
Echinodermata	*Henricia polyacantha*			X		2
Echinodermata	*Henricia sanguinolenta*			X		3
Echinodermata	*Heterozonias alternatus*			X		30
Echinodermata	*Hippasteria californica*			X		36
Echinodermata	*Hippasteria spinosa*	Spiny red sea star		X	X	72
Echinodermata	Holothuroidea	Sea cucumbers		X	X	110
Echinodermata	*Leptychaster anomalus*			X	X	2
Echinodermata	*Leptychaster pacificus*			X		1
Echinodermata	*Lophaster furcilliger*			X		1
Echinodermata	*Lophaster furcilliger* vexator			X	X	12
Echinodermata	*Luidia foliolata*	Sand star		X		29
Echinodermata	Luidiidae			X	X	3
Echinodermata	Mediaster			X	X	5
Echinodermata	*Mediaster aequalis*	Vermillion starfish		X		8
Echinodermata	*Mediaster tenellus*			X		24
Echinodermata	*Molpadia intermedia*	Sweet potato sea cucumber		X		11
Echinodermata	Myxasteridae			X		2
Echinodermata	*Myxoderma sacculatum*			X		11
Echinodermata	*Nearchaster aciculosus*			X		10
Echinodermata	*Nearchaster variabilis*			X		15
Echinodermata	Notacanthidae	Spiny tapirfishes			X	4
Echinodermata	Ophiacantha			X		26
Echinodermata	Ophiacanthidae			X		2
Echinodermata	Ophiactidae			X		2
Echinodermata	Ophiopholis			X		1

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
Echinodermata	*Ophiopholis aculeata* japonica			X		1
Echinodermata	*Ophiopthalmus normani*			X		5
Echinodermata	*Ophioscolex corynetes*			X		1
Echinodermata	*Ophiosphalma jolliense*			X		1
Echinodermata	*Ophiura sarsi*			X		7
Echinodermata	Ophiuridae			X		12
Echinodermata	Ophiuroidea			X		45
Echinodermata	*Pannychia moseleyi*			X	X	5
Echinodermata	*Parastichopus leukothele*	Whitespotted sea cucumber		X		2
Echinodermata	Phrynophiurida	Brittle stars		X	X	186
Echinodermata	*Poraniopsis inflatus inflatus*			X		3
Echinodermata	*Pseudarchaster alascensis*			X		10
Echinodermata	*Pseudarchaster dissonus*			X	X	2
Echinodermata	*Pseudostichopus mollis*	Soft sea cucumber		X	X	66
Echinodermata	*Psilaster pectinatus*				X	1
Echinodermata	*Psolus chitinoides*	Armoured sea cucumber		X		5
Echinodermata	*Psolus squamatus*	Scaly sea cucumber		X	X	29
Echinodermata	*Pteraster jordani*			X		4
Echinodermata	*Pteraster militaris*	Winged sea star		X		2
Echinodermata	*Pteraster tesselatus*	Cushion star		X		20
Echinodermata	Pterasteridae			X	X	8
Echinodermata	*Pycnopodia helianthoides*	Sunflower starfish		X		3
Echinodermata	*Rathbunaster californicus*			X		21
Echinodermata	*Solaster borealis*	Northern sun star		X	X	63
Echinodermata	*Solaster dawsoni*	Morning sun starfish		X		5
Echinodermata	*Solaster endeca*	Smooth sun star		X		1
Echinodermata	*Solaster paxillatus*			X		5
Echinodermata	*Solaster stimpsoni*	Striped sun starfish		X		1
Echinodermata	Solasteridae			X	X	64
Echinodermata	*Strongylocentrotus droebachiensis*	Green urchin		X		
Echinodermata	*Strongylocentrotus franciscanus*	Red urchin		X		3
Echinodermata	*Strongylocentrotus pallidus*	Pallid urchin		X		2
Echinodermata	*Strongylocentrotus*	Purple sea urchins		X		1

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
	purpuratus					
Echinodermata	*Stylasterias forreri*	Fish-eating star		X		14
Echinodermata	*Synallactes challengeri*	Papillose sea cucumber		X	X	11
Echinodermata	Synallactidae			X		1
Echinodermata	*Tarsaster alaskanus*			X		7
Echinodermata	*Zoroaster evermani*			X	X	22
Mollusca	*Abraliopsis felis*			X		3
Mollusca	Aeolidiidae			X		1
Mollusca	Aplacophora			X		18
Mollusca	*Architeuthis martensi*	Giant squid		X		1
Mollusca	Arctomelon			X		1
Mollusca	*Barleeia subtenuis*	Fragile barleysnail		X		1
Mollusca	*Bathybembix bairdii*			X		2
Mollusca	*Belonella borealis*			X		5
Mollusca	*Benthoctopus leioderma*	Smoothskin octopus		X	X	9
Mollusca	*Berryteuthis anonychus*	Smallfin gonate squid		X		15
Mollusca	*Berryteuthis magister*	Schoolmaster gonate squid		X		273
Mollusca	Cephalopoda	Cephalopods		X	X	11
Mollusca	*Dallicordia alaskana*	Alaskan verticordid		X		1
Mollusca	*Delectopecten vancouverensis*	Vancouver scallop		X		9
Mollusca	*Dermatomya tenuiconcha*	Smooth poromya		X	X	2
Mollusca	*Doryteuthis opalescens*	Opalescent inshore squid		X		13
Mollusca	*Dosidicus gigas*	Humboldt squid		X		7
Mollusca	*Enteroctopus dofleini*	Giant pacific octopus		X		7
Mollusca	*Fusitriton oregonensis*	Oregontriton		X		213
Mollusca	*Galiteuthis phyllura*			X	X	30
Mollusca	Gastropoda	Gastropods		X	X	263
Mollusca	*Gonatopsis borealis*	Boreopacific gonate squid		X		2
Mollusca	Gonatus	Squid		X	X	40
Mollusca	*Gonatus onyx*	Clawed armhook squid		X		1
Mollusca	*Graneledone boreopacifica*			X	X	11
Mollusca	*Haliphron atlanticus*	Seven armed octopus		X		1
Mollusca	*Histioteuthis heteropsis*			X		1
Mollusca	*Histioteuthis hoylei*	Jewel squid		X		3

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
Mollusca	*Idas washingtonius*	Washington combmussel		X		1
Mollusca	*Japetella diaphana*			X	X	26
Mollusca	Loligo			X		1
Mollusca	*Malletia faba*	Bean malletia		X		2
Mollusca	Margarites			X		6
Mollusca	*Moroteuthis robusta*	Robust clubhook squid		X	X	16
Mollusca	Mytilidae	Mussels		X		1
Mollusca	Nassariidae	Dogwhelks		X	X	14
Mollusca	Neomeniidae			X		1
Mollusca	Neptuneidae			X	X	314
Mollusca	*Nucula carlottensis*	Charlotte nutclam		X		1
Mollusca	*Nuculana leonina*	Lion nutclam		X		1
Mollusca	Flabellina	Nudibranch		X		1
Mollusca	Nudibranchia	Seaslugs		X	X	41
Mollusca	Octopoda			X	X	83
Mollusca	Octopodidae			X		2
Mollusca	*Octopoteuthis deletron*			X	X	49
Mollusca	*Octopus rubescens*	East pacific red octopus		X		5
Mollusca	*Ommastrephes bartramii*	Neon flying squid		X		2
Mollusca	*Onychoteuthis borealijaponicus*	Boreal clubhook squid		X		3
Mollusca	Opisthobranchia			X		1
Mollusca	Opisthoteuthidae	Umbrella octopus		X		1
Mollusca	Polyplacophora	Chitons		X		5
Mollusca	*Rossia pacifica*	Pacific bobtail squid		X		4
Mollusca	Solemyidae	Awningclams			X	1
Mollusca	Solemyoida			X		1
Mollusca	*Taonius pavo*			X		
Mollusca	Teredinidae	Shipworm		X		1
Mollusca	*Triopha catalinae*	Sea-clown triopha		X		1
Mollusca	*Tritonia diomedea*	Rosy tritonia		X		2
Mollusca	Trochidae	Topshells		X		2
Mollusca	Vampyromorpha	Vampire squid		X		18
Mollusca	*Vampyroteuthis infernalis*	Vampire squid		X		3
Mollusca	*Barleeia haliotiphila*	Abalone barleysnail		X		1
Mollusca	Benthoctopus			X	X	52
Mollusca	*Benthoctopus robustus*			X		2
Mollusca	Benthoctopus sp a			X		1

Phylum	Scientific Name	Common Name	Status	400-1500 m	1500-2500 m	N
Mollusca	Benthoctopus sp b			X	X	5
Mollusca	Benthoctopus sp c			X	X	6
Mollusca	*Chiroteuthis calyx*			X	X	27
Mollusca	Cirrata	Octopus		X		14
Mollusca	Cranchiidae	Glass squid		X		2
Mollusca	Dendronotidae	Nudibranch		X		4
Mollusca	*Panomya ampla*	Ample roughmya		X		1
Nemertea	Nemertea	Proboscis worm		X		1
Platyhelminthes	Allocoels			X		2
Porifera	Calcarea	Calcareous sponges		X		1
Porifera	Demospongiae	Bath sponges		X		5
Porifera	Hexactinellida	Glass sponges		X	X	93
Sipuncula	Sipuncula	Peanutworms		X	X	11