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A framework for identification of ecological conservation priorities for Marine Protected Area network design and its application in the Northern Shelf Bioregion

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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.

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ABSTRACT

Conservation priorities (CPs) have been identified as part of systematic conservation planning processes, including Marine Protected Area (MPA) network design, to focus analyses on the most important features (species, habitats, and areas) within a planning area. In this paper, we develop and apply a framework to identify species- and area-based ecological CPs to inform the development of the MPA network in the Northern Shelf Bioregion (NSB) of British Columbia. We focus exclusively on Goal 1 of the Canada – BC Marine Protected Network Strategy (2014): "to protect and maintain marine biodiversity, ecological representation and special natural features". Species-based CPs were identified based on the characteristics of individual species or higher-level taxa, selecting those that are ecologically important, vulnerable, or of conservation concern. Area-based CPs include areas, spatial features, or habitats that directly support the network objectives under Goal 1. Criteria for identifying ecological CPs were developed based on global best practices and were nested under the network objectives associated with Goal 1, then applied to areas and a candidate list of species found in the NSB. Criteria were applied and evaluated using information from the literature then vetted and augmented by expert opinion. Species that were identified as of conservation concern and those that received high scores for either vulnerability or ecological significance were recommended as ecological CPs. The list of 195 species to be considered as ecological CPs for the NSB includes 65 bony fishes and elasmobranchs, 23 marine mammals (including four Orca ecotypes), one sea turtle, 46 invertebrates, five plants and algae, and 55 marine birds. A total of 17 area-based ecological CPs were recommended, including areas and habitats including areas of climate resilience, degraded areas, representative habitats, and features associated with Ecologically and Biologically Significant Areas (EBSAs; e.g., areas of high productivity or diversity). Several types of spatial features were recommended, including Important Areas, to represent species-based CPs in site selection analyses for the MPA network. Ecological CPs identified from this framework will inform subsequent MPA planning steps, including the development of design strategies and design scenarios.

1 INTRODUCTION

Canada has agreed, through several regional, national, and international commitments, to protect marine biodiversity and ocean resources through the establishment of Marine Protected Areas (MPAs) and other effective area-based conservation measures. As a signatory to the Convention on Biological Diversity (CBD), Canada has committed to conserving 10% of coastal and marine area into ecologically representative and well-connected marine protected areas, and to protect ecosystem, species, and genetic diversity (Aichi Target 11 in CBD 2011, DFO 2016). Canada's *Oceans Act* (Government of Canada 1996), Canada's *Oceans Strategy* (DFO 2002), and agreements with the Government of BC[1] and First Nations[2] direct federal departments to coordinate, collaborate, and engage with local, provincial, and First Nations governments and stakeholders to identify areas of interest for potential MPA designation. MPA networks, which are "a collection of individual MPAs that operates cooperatively and synergistically at various spatial scales, and with a range of protection levels, in order to fulfill ecological aims more effectively and comprehensively than individual sites could alone" (IUCN-WCPA 2008), have been identified as an important tool for meeting these commitments.

In the Pacific Region, the Marine Protected Area Technical Team (MPATT), a Federal-Provincial-First Nations technical working group, has been established to coordinate, plan, and implement an MPA network in the Northern Shelf Bioregion (NSB; Figure 1). MPATT includes members from the Government of Canada (Fisheries and Oceans Canada [DFO], Parks Canada, Environment and Climate Change Canada), the Government of BC, and 17 member First Nations (represented by the Central Coast Indigenous Resource Alliance, Council of the Haida Nation, North Coast-Skeena First Nations Stewardship Society, Coastal First Nations - Great Bear Initiative, and Nanwakolas Council).

The MPA network planning process in NSB (Figure 2) builds on guidance provided by the Government of Canada (2011) and the Canada-BC MPA Network Strategy (2014; hereinafter referred to as "the Strategy"). DFO Science has also provided advice on the development of MPA networks and other spatial planning measures, including design and development (DFO 2010), formulating conservation objectives (DFO 2008, 2013a), achieving representativity (DFO 2013b), and identifying conservation priorities (DFO 2007a, 2012).

The goals, objectives, and principles outlined in the Strategy and developed by MPATT inform the identification of conservation priorities (CPs), features to be protected or prioritized during identification of potential sites contributing to the MPA network.

The purpose of this document is to:

1. Develop evaluation criteria for identifying ecological CPs for MPA network design with respect to network goals, principles and objectives.
2. Apply these criteria to ecological attributes (e.g., species, habitats, communities, areas, natural features) to produce a list of conservation priorities for the NSB.
3. Identify the types of spatial information needed to represent CPs in subsequent systematic site selection analyses to achieve MPA network goals and objectives.

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[1] Memorandum of Understanding Respecting Implementation of Canada's Oceans Strategy, 2004

[2] Letter of Intent to Collaborate on Marine Planning and other Fisheries Related Issues in the Pacific North Coast with Coastal First Nations and the North Coast Skeena First Nations Stewardship Society, 2012

4. Discuss uncertainties, gaps, research needs, or limitations for further consideration when identifying CPs for MPA network design in NSB or other bioregions within Canada.

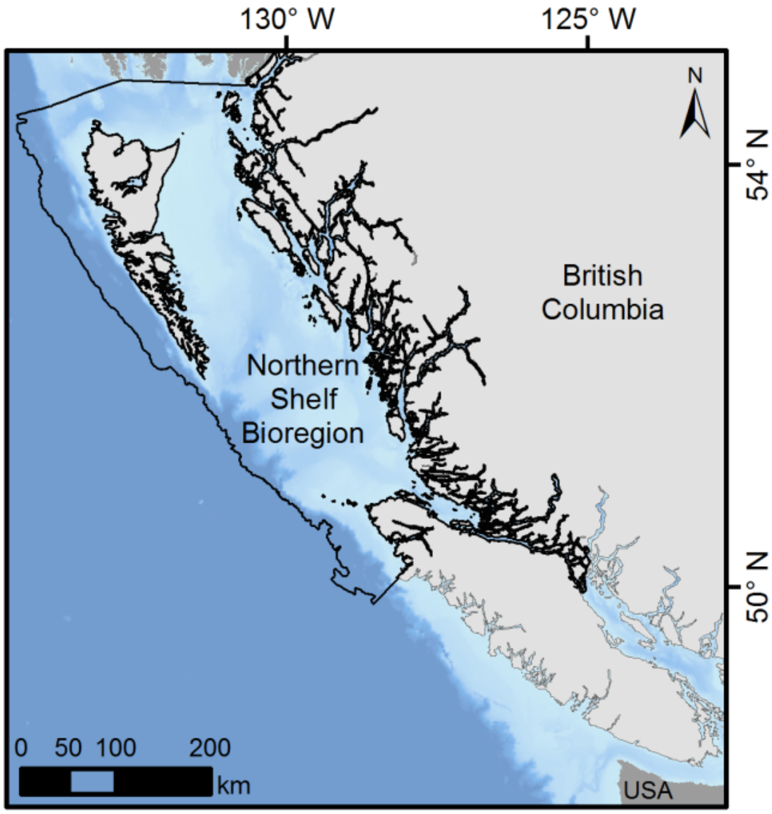

Figure 1. Map of the Northern Shelf Bioregion (NSB), which has the same footprint as the Pacific North Coast Integrated Management Area (PNCIMA).

1.1 NETWORK PLANNING PROCESS

Development of the NSB MPA network is guided by six goals (Canada – BC MPA Network Strategy 2014; Table 1). Goal 1, "to protect and maintain marine biodiversity, ecological representation and special natural features" is of primary importance (Canada – BC MPA Network Strategy 2014). Goal 2 refers to the conservation and protection of fishery resources and their habitats, and Goals 3–6 focus on social, cultural, economic, and educational values. The goals provide the primary means for achieving the vision for the network and are the overarching structure for the development of more specific network objectives (Table 1). The network objectives were developed by members of MPATT based on international best practices and standards, with input from governing bodies, stakeholders, academics, and practitioners. They form the foundation of the MPA network, as they address conservation and sustainability concerns specific to the NSB. Nesting under each of the six network goals, the network objectives identify and focus management priorities, provide a context for resolving issues, a rationale for decisions, and a means for assessing network effectiveness. Consistent with the Strategy, objectives that nest under Goal 1 are of primary importance in network design. Together, the goals and objectives will be used as benchmarks to evaluate the effectiveness of the NSB MPA network for conserving marine biodiversity and other valued features. The NSB MPA network planning process will integrate the outputs of this document, which focuses on Goal 1, with ongoing work related to the remaining goals.

Additional guidance on network design, including connectivity, trade-offs, zoning, configuration, and the types of areas to prioritize is provided in the Strategy's design principles (Canada – BC MPA Network Strategy 2014; Table 2) and through specific design guidelines developed by PacMARA (Pacific Marine Analysis and Research Association) for MPATT (Lieberknecht et al. 2016). Together with the goals and objectives, the design principles identified in the Strategy will help guide site selection and shape the network planning process. The ecological design principles are presented in Table 2. The NSB MPA network planning process builds on and, where appropriate, integrates with other regional spatial planning processes including the ecosystem-based management framework of the Pacific North Coast Integrated Management Area (PNCIMA), the Marine Plan Partnership (MaPP), and First Nations and provincial government spatial planning.

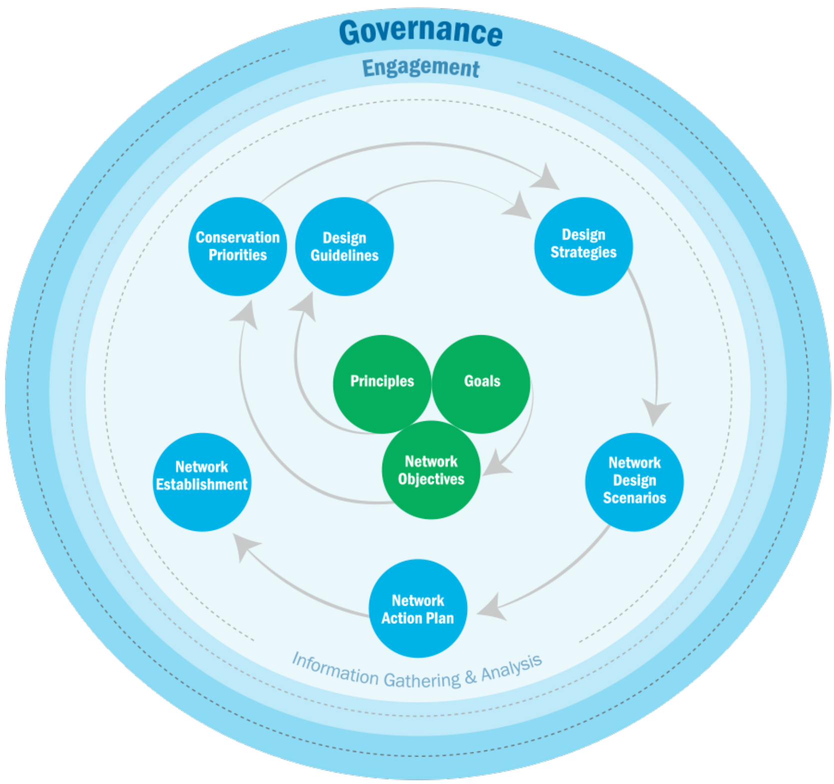

Figure 2. Conceptual diagram of Northern Shelf Bioregion Marine Protected Area planning process developed by the Marine Protected Area Technical Team (MPATT) in the Pacific Region.

1.1.1 Conservation Priorities and Design Strategies

To maximize the benefits of MPAs, identification of conservation priorities is necessary to focus spatial planning towards areas of high conservation value (Margules and Pressey 2000, Micheli et al. 2013). CPs are the features to be prioritized in the MPA network, and can be ecological (e.g., ecologically significant species, species groups, habitats, or areas), cultural (e.g., species or sites of cultural significance), or related to recreation and tourism. Because ecological considerations are of prime importance in MPA network planning (Canada – BC MPA Network Strategy 2014), this document focuses solely on **ecological CPs** that support Goal 1.

DFO's interest in supporting economically prosperous, sustainable fisheries is reflected in Goal 2. Species and areas important for commercial, recreational, and Aboriginal fisheries will be considered in other aspects of the MPA network planning process. Ecological CPs may also have cultural, socioeconomic, or recreational value.

Design strategies describe how the CPs will be spatially incorporated into the network, and will include area-based targets for CPs. Design strategies will also inform key decisions in the technical analyses that influence network design scenarios and the final network configuration, such as the relative weighting of available information and variables such as size, spacing, and replication. Examples of design strategies could be to protect a certain percentage of the area covered by a habitat type (e.g., mudflats); to include a certain number of replicates of a specific habitat in the network; or to protect a proportion of a conservation priority's distribution (e.g., X % of distribution of species A). Design strategies will be developed in a subsequent paper[3] and are not addressed here.

1.2 SCOPE

In this document, we develop and apply a framework to identify species- and area-based ecological CPs to inform the development of the MPA network.

This work:

- Considers only the **ecological objectives** (1.1–1.7, Table 1);
- Focuses on marine ecological components within DFO's mandate;
- Includes a modified scoring framework for marine birds in the NSB;
- Does not consider the availability of spatial data (Martone et al. in revision[3]);
- Does not address targets or other design strategies (Martone et al. in revision[3]); and
- Addresses CPs at the scale of the NSB.

[3] Martone, R., Robb, C., Gale, K.S.P., Frid, A., McDougall, C., Rubidge, E. in revision. Design Strategies for the Northern Shelf Bioregional Marine Protected Area Network. Can. Sci. Advis. Sec. Res. Doc. 2015OCN05b.

Table 1. MPA network goals and objectives for the Northern Shelf Bioregion, as of 7 November 2016.

Goal	Objective
Goal 1: To protect and maintain marine biodiversity, ecological representation and special natural features.	1.1. Contribute to the conservation of the diversity of species, populations, and ecological communities, and their viability in changing environments.
	1.2. Protect natural trophic structures and food webs, including populations of upper-level predators, key forage species, nutrient importing and exporting species, and structure-providing species.
	1.3. Conserve areas of high biological diversity (species, habitat and genetic diversity).
	1.4. Protect representative areas of every marine habitat in the bioregion.
	1.5. Contribute to protection of rare, unique, threatened, and/or endangered species and their habitats.
	1.6. Conserve ecologically significant areas associated with geological features and enduring/recurring oceanographic features.
	1.7. Contribute to conservation of areas important for the life history of resident and migratory species.
Goal 2: To contribute to the conservation and protection of fishery resources and their habitats.	2.1. Maintain or improve stock stability and productivity of species important for commercial, recreational, and Aboriginal fisheries.
	2.2. Maintain within protected areas the natural size and age structure of fished populations.
	2.3. Conserve habitat important to ensuring that the productive capacity and harvestable biomass of commercial, recreational, and Aboriginal fisheries species are maintained within healthy and resilient ecological limits.
Goal 3: To maintain and facilitate opportunities for tourism and recreation.	3.1. Conserve sites compatible with, and of high value for sustainable commercial tourism and recreation.
Goal 4: To contribute to social, community and economic certainty and stability.	4.1. Enable economic development opportunities that are compatible with achievement of conservation objectives contained with Goal 1.
	4.2. Maintain or enhance the long-term productivity, resilience and reliability of marine ecosystem goods and services.
	4.3. Support opportunities for local communities to benefit socially, culturally, and economically from marine protected areas.
	4.4. Strengthen participation and representation of communities and stakeholders in design, establishment and monitoring of the network.

Goal	Objective
	4.5. Ensure that all marine protected areas have clearly defined objectives and effective and adaptive management, including monitoring, evaluation and reporting.
	4.6. Support effective MPA network governance, planning and management that includes monitoring, evaluation and reporting.
	4.7. Establish collaborative approaches to surveillance and compliance monitoring programs.
Goal 5: To conserve and protect traditional use, cultural heritage and archaeological resources.	5.1. Increase awareness and understanding of First Nations use and stewardship of resources and territories.
	5.2. Represent marine areas of high cultural or historical value.
	5.3. Contribute to conservation of species significant to First Nations and coastal communities including those important for cultural use and food security.
Goal 6: To provide opportunities for scientific research, education and awareness.	6.1. Increase awareness, understanding and stewardship of the marine environment.
	6.2. Protect reference sites to support research and management.
	6.3. Monitor and report on effectiveness of management actions across the network

Table 2. Ecological network principles from the Canada-BC MPA Network Strategy (2014).

Principle	Included concepts
1. Include the full range of biodiversity present in Pacific Canada	Representation and replication
2. Ensure ecologically and biologically significant areas are incorporated	Protection of unique or vulnerable habitats Protection of foraging or breeding grounds Protection of source populations
3. Ensure ecological linkages	Connectivity
4. Maintain long-term protection	–
5. Ensure maximum contribution of individual MPAs	Size Spacing Shape

2 FRAMEWORK

Here we present a systematic evaluation framework to identify ecological CPs that are scientifically defensible and that meet the network objectives (Figure 3). We develop evaluation criteria based on and adapted from best practices and planning processes in other regions, and apply these criteria to produce a list of ecological CPs for the NSB. We identify two types of ecological CPs: species-based and area-based. Species-based CPs are identified based on the characteristics of individual species or higher-level taxa, highlighting those that are ecologically significant, vulnerable to fisheries or other perturbations, or of conservation concern. To represent the identified species in MPA network planning and site selection analyses, spatial features delineating important habitats for each species will need to be developed. As such, we recommend the types of spatial features that can be used to represent species-based CPs in the MPA network, including Important Areas (IAs; Objective 1.7). Area-based CPs include areas, spatial features, or habitats that support the network objectives, by contributing to ecosystem resilience, supporting restoration, or acting as surrogates for biodiversity. The identification of ecological CPs is guided by the two relevant ecological design principles, to include the full range of biodiversity present in Pacific Canada, and to ensure ecologically and biologically significant areas are incorporated. The ultimate goal of this framework is to identify areas of high conservation value which warrant spatial protection, by recognizing the ecological importance and conservation needs of species and their habitats.

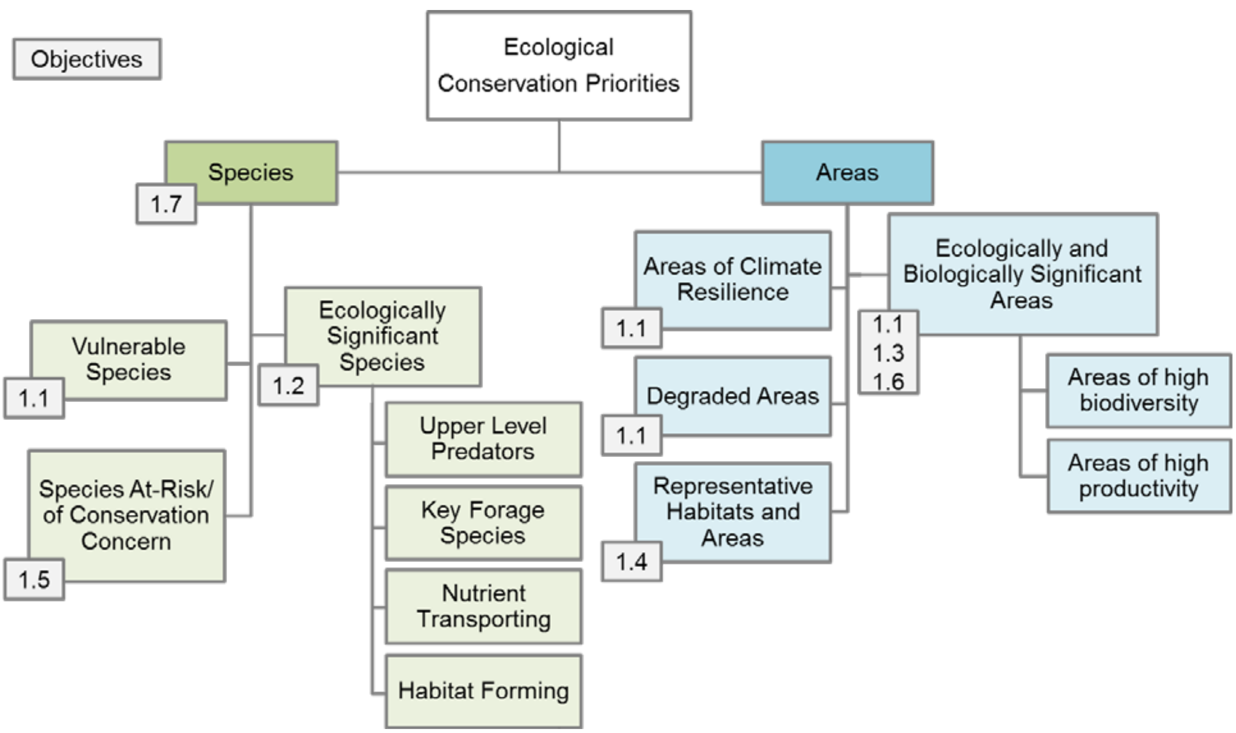

Figure 3. Ecological conservation priority framework. Numbers in grey boxes refer to network objectives in Table 1, and indicate the objectives met by identification of each conservation priority.

2.1 DEVELOPMENT OF CONSERVATION PRIORITY EVALUATION CRITERIA

We developed systematic criteria to identify CPs based on existing national and international guidance (see Appendix 2). Criteria were compiled from marine planning processes in BC (Ban et al. 2013, O et al. 2015), California (Airamé et al. 2003, CDFG 2008a), Australia (ANZECC 1999), Scotland (Howson et al. 2012), England (BRIG 2007, Natural England and JNCC 2010), and other global regions (Eken et al. 2004, IUCN 2016), including those identified in a review of global best practices for MPATT (Ardron et al. 2015). When examining these other processes we sought to identify the criteria used to identify CPs, how those criteria were applied, and the resulting list of CPs. We found that many criteria were similar across planning processes (Table 3) and were consistent with those used to identify Ecologically and Biologically Significant Areas (EBSAs) for the Pacific Coast (Clarke and Jamieson 2006b).

While similar criteria were encountered in many planning processes, the methodology used to apply the criteria and identify CPs varied. Some processes used expert panels to identify the ecological features that meshed with their objectives and criteria (e.g., Dale 1997, Airamé et al. 2003, CDFG 2008a, Ban et al. 2013, DFO 2014). Others used a more explicit evaluation framework, assigning thresholds determined through expert consensus to different criteria to identify CPs more systematically (e.g., Eken et al. 2004, IUCN 2016). Some employed a combination of the two approaches, using explicit thresholds where data were available to support those evaluations (often for criteria related to species at risk) and relying on expert judgement where data were lacking (BRIG 2007, Howson et al. 2012).

The CPs for the NSB MPA network serve as one step towards ensuring that the network's objectives are met. We found that the compiled criteria from the other processes could be nested under the MPA network objectives (Table 3).

Table 3. Other conservation planning processes that included criteria that support the NSB MPA network objectives.

Network Objective	Broad Criteria	1. EBSA	2. Channel Is, CA	3. MLPA, CA	4. PISCO, USA	5. CBD	6. AU Regional	7. GBR, AU	8. DFO ERAF	9. BCMCA	10. Scotland	11. UK BAP	12. NZ	13. IUCN KBAs	14. Gulf MPAs
1.1.	Vulnerability to natural and human impacts	-	X	x	x	x	x	-	-	x	x	x	x	x	x
1.2.	Presence of a particular ecological community or species	x	x	x	x	x	x	-	x	x	x	-	-	x	x
1.3.	Significant biodiversity and/or biological productivity	x	-	-	-	x	x	-	x	-	-	-	-	-	x
1.4.	Representation of all habitat types	-	x	x	x	-	x	x	x	x	-	-	x	-	x
1.5.	Presence of and/or an important area for species at risk	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1.6.	Presence of a particular oceanographic mechanism and/or unique habitats	x	-	x	x	-	-	-	-	x	-	-	-	-	-
1.7.	Presence of condition essential for the development, maintenance, or genetic survival of a population or species	x	x	x	x	x	x	-	-	x	-	x	-	-	x

1. DFO Ecologically and Biologically Significant Areas (EBSAs; Clarke and Jamieson 2006a, 2006b); 2. California Channel Islands (Airamé et al. 2003); 3. California Marine Life Protection Act (CDFG 2008a); 4. Partnership for Interdisciplinary Studies of Coastal Oceans (Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) 2011); 5. CBD EBSAs (CBD 2008); 6. Australia National Representative System of MPAs (ANZECC 1999); 7. Australia Great Barrier Reef Species Conservation Program (Stokes et al. 2004); 8. DFO Ecological Risk Assessment Framework (O et al. 2015); 9. British Columbia Marine Conservation Analysis (Ban et al. 2013); 10. Identification of Priority Marine Features in Scottish Territorial Waters (Howson et al. 2012); 11. UK Biodiversity Action Plan (UKBAP 2008); 12. New Zealand MPA Policy and Implementation Plan (Department of Conservation and Ministry of Fisheries 2005); 13. Identification of Key Biodiversity Areas (IUCN 2016); 14. Methodology for the Development of the Marine Protected Area Network in the Gulf of St. Lawrence Bioregion[4].

[4] Faille, G., Dorion, D., and Pereira, S. unpublished. Methodology for the Development of the Marine Protected Area Network. Draft Document November 2014 for the Technical Committee on the Marine Protected Area Network

3 LINKING OBJECTIVES TO CP IDENTIFICATION

To reflect the objectives and explicitly guide the process of identifying CPs, the broad identification criteria were refined to develop both species-based (Table 4; Section 4) and area-based (Section 5) CPs. MPATT developed the objectives with feedback from experts and stakeholders to reflect the goals of the MPA network. Objectives differ in their specificity and many relate to other objectives under the same goal. For example, Objectives 1.1 and 1.7 (Table 3) contain a broad suite of concepts that underpin the intent and utility of a well-designed MPA network. Objective 1.1 (*Contribute to the conservation of the diversity of species, populations, and ecological communities, and their viability in changing environments)* is linked to all other objectives under Goal 1, and will be achieved when Objectives 1.2–1.7 are fulfilled. CPs supporting the *viability* component of Objective 1.1. relate to species' resilience or vulnerability to change or disturbance. Specific CPs that incorporate all levels of ecological diversity, from species to habitats, are described under Objectives 1.2–1.6.

To *Contribute to conservation of areas important for the life history of resident and migratory species* (Objective 1.7), Important Areas (IAs; Clarke and Jamieson 2006a) can be used to spatially represent the species identified under other objectives (Section 4.4). IAs are areas that are particularly important for species at some life stage, and can include breeding/spawning grounds, areas of feeding aggregations, or important migratory corridors (Clarke and Jamieson 2006a).

4 SPECIES-BASED CONSERVATION PRIORITIES

4.1 MARINE SPECIES (MARINE AND COASTAL BIRDS EXCLUDED)

The species-based CP criteria developed under each objective are described in Table 4. For reference, each criterion is numbered according to its overarching Objective, an S (for Species), and a unique number. For example, the first species-based criterion under Objective 1.2 is criterion 1.2.S1.

Table 4. Species-based ecological conservation priority evaluation criteria under each network objective.

Objective	Criterion
1.1. Contribute to the conservation of the diversity of species, populations, and ecological communities, and their viability in changing environments.	1.1.S1. The species is particularly vulnerable to disturbance and/or slow to recover from perturbations.
1.2. Protect natural trophic structures and food webs, including populations of upper-level predators, key forage species, nutrient importing and exporting species, and structure-providing species.	1.2.S1. The species is an upper level predator.
	1.2.S2. The species is a key forage species.
	1.2.S3. The species is a nutrient importer or exporter.
	1.2.S4. The species is important for forming structure or habitat.
1.5. Contribute to protection of rare, unique, threatened, and/or endangered species and their habitats.	1.5.S1. The species is declining or under threat of decline regionally, nationally, or globally

Unless otherwise stated, all references to species and criteria in Section 4.1 do not include marine and coastal bird species. The criteria and assessment process for species-based CPs were determined not to be applicable to birds; therefore, a modified methodology was developed and applied in collaboration with species experts at Environment and Climate Change Canada. Section 4.2 describes how marine and coastal bird species determined to be regularly occurring in the NSB were assessed for inclusion as CPs.

4.1.1 Identification of Candidate Species

Identifying CPs requires information on the current suite of ecological features found within the study area. To identify priority species or species groups (such as higher-level taxa or functional groups, hereafter "species"), we applied CP criteria to an assembled list of species in the NSB. While a comprehensive analysis of all species present can be feasible for small areas with relatively well-known species lists, it is difficult at the provincial or regional scales (e.g., BC likely has between 5000 and 14,000 species; Archambault et al. 2010, O et al. 2015). Selection and screening criteria relevant to the specific research question can be used to simplify the identification of valued ecosystem components (VECs), including species (e.g., O et al. 2015).

We gathered reports and databases that contained lists of species found in the NSB, aiming to represent the broader ecosystem including bony fishes, elasmobranchs, marine mammals, sea turtles, invertebrates, plants, and algae. We collated all species named in the following sources:

1. Reports on PNCIMA Ecologically and Biologically Significant Areas (EBSAs) and Important Areas (Clarke and Jamieson 2006a, 2006b);
2. PNCIMA Ecosystem Overview report appendices (Fargo et al. 2007, Heise et al. 2007, Hyatt et al. 2007, McFarlane Tranquilla et al. 2007, Pellegrin et al. 2007, Schweigert et al. 2007);
3. An unpublished list of Ecologically Significant Species developed by DFO as part of the PNCIMA process[5]; and
4. A draft list of Culturally Significant Species provided by MPATT First Nations partners[6], which includes a broader range of species than what was identified during the PNCIMA process.

From this list, we identified species that occupy a marine or coastal habitat, were native (i.e., not introduced), and which regularly occur in the NSB. While identification of “regularly occurring” species can be done empirically[7], we did not have range maps or habitat use data available for all of the potential candidate species. Therefore, we compiled information on habitat (marine, coastal, or other) and occurrence in BC and the NSB (regular, accidental, non-native, or unknown) from the above reports, the British Columbia Conservation Data Centre database (BCCDC), DFO fisheries and research catch records, the General Status of Species in Canada database (CESCC 2011), other species-specific literature, and species experts.

Information on species’ conservation status under seven listing agencies was also extracted from the BCCDC database (IUCN Red List, the General Status of Species in Canada,

[5] Jamieson, G.S., Lucas, B.G., Levesque, C. Identification of Ecologically Significant Species and Community Properties in the Pacific Region. Unpublished.

[6] Advice on best practices for MPA network planning recommends also including species identified by local communities and First Nations groups (Burt et al., 2014; Ardron et al., 2015).

[7] An MPA planning process in Scotland assessed species for their “proportional importance”, where a species was only “screened in” as a priority if 20% or more of its extent in the United Kingdom occurred in Scotland (Howson et al. 2012).

NatureServe, BCList, COSEWIC, SARA, and CITES; see page 22 for definitions and descriptions of conservation status). We checked for updates to each species' conservation status under each listing agency in August 2016.

Species named in sources 1–4 above that were determined to be marine, native, and regularly occurring in the NSB (i.e., not accidental) were included in the candidate list of species for in-depth review and scoring. Sei Whales and North Pacific Right Whales, which are currently extremely rare, were retained in the candidate list because of their historic occurrence and current endangered status. Where higher-level groupings (e.g., crabs, shelf rockfish, clams) were mentioned in the above reports, efforts were made to fill in the relevant species or genera that occur in NSB. Higher-level taxa were retained for zooplankton, phytoplankton, amphipods, euphausiids, corals (four orders), sponges (two orders), and coralline algae. Several species were added to the candidate list based on feedback from species experts and through literature review of potentially relevant species.

While all efforts were made to identify species and species groups that could be important or of conservation interest, we recognize that some species may have been missed. Sources 1–4 above were a starting point for the candidate list and some modifications were made as literature review was conducted and as experts were consulted. If at any stage in the process, information was found indicating that a species not on the candidate list fit any criteria, it was added. Upon conducting the literature review for each species, if it became apparent that the species was accidental or undertook vagrant migrations, that species was removed. It is common practice to exclude species that are vagrants or occur only marginally (e.g., Eken et al. 2004). We acknowledge that the species list may not fully reflect future conditions, as some species currently considered accidental may become more common as their ranges shift in response to climate change.

The final list of candidate species contained 190 non-bird species, including 4 Orca ecotypes (Appendix 1). The species identification process for marine birds was conducted separately (Section 4.2).

4.1.2 Scoring Methodology

Following the Design Guideline to "*Ensure the implementation of common and accepted standards of transparency and accountability throughout the process, recording important decisions as they are made*" (Lieberknecht et al. 2016), we developed a systematic framework that provides rationale and evidence for each species' score, and indicates existing uncertainty.

The detailed scoring schemes varied per criterion and are described in Section 4.1.3. In general, the scores were applied following Table 5. A literature review was carried out to assess scores for each species under each criterion. We performed a pre-screening assessment to determine species and species groups that did not require in-depth reviews, based on the traits of the species, the authors' knowledge of the species' biology and ecology, and an early pilot analysis of ecologically significant species[8]. For example, a literature review was not required to determine that forage fish do not form biogenic habitat. All scores under all criteria were reviewed by subject matter experts and revised if necessary (e.g., for species with little available information in the literature). Supporting information for all scores can be found in Appendix 4.

[8] Gale, K.S.P. 2016. Preliminary Identification of Ecologically Significant Species in the Northern Shelf Bioregion. Draft Report Prepared for the Marine Protected Area Team. Unpublished.

Table 5. Description of scores used to assess conservation priority criteria.

Score	Description
2	The species strongly fits or fulfills all aspects of the criterion.
1	The species moderately fits, or fulfills only part of the criterion.
0	The species does not fit the criterion.
–	The species was not assessed for the criterion. This was used in cases where it was reasonably obvious, based on the ecological characteristics of the species, that it would not meet the criterion. For example, schooling fish do not create epibenthic habitat.
*	There is not currently enough information to assess the criterion.
1*	"Uncertain fit". There is some evidence that the species fits the criterion, but there is uncertainty. For interpretation of 1* scores, see score descriptions under each criterion.

Species were scored based on their current and historical roles. Species which are extirpated or are currently at low population sizes compared to historical levels were scored for the known or hypothesized role they used to hold, based on available information. Similarly, some species may have historically held important ecological roles that are not apparent today. For example, commercial exploitation has reduced the size of some species which historically were large-bodied upper-level predators (see text for Objective 1.2, criterion 1.2.S1).

4.1.3 Criteria

Objective 1.1. Contribute to the conservation of the diversity of species, populations, and ecological communities, and their viability in changing environments.

Criteria that address ecological diversity, from species to habitats, are presented under Objectives 1.2, 1.3, 1.4, and 1.6, and considerations regarding climate change are presented in Section 5.1.2. Species' "viability in changing environments" is related to their resilience and capacity to recover, which is addressed in Criterion 1.1.S1.

1.1.S1. The species is particularly vulnerable to disturbance and/or slow to recover from perturbations.

Human activities present a range of threats to marine species and ecosystems at various spatial scales and frequencies, with different levels of impact and timeframes for recovery (Halpern et al. 2008a, Teck et al. 2010). Exploitation (i.e., fishing) and habitat loss (e.g., from environmental contamination, shoreline development, or aquaculture) are considered among the strongest threats to marine ecosystems, and can lead to species extinctions at local and regional scales (Dulvy et al. 2004, Halpern et al. 2008a). Because human activities such as fisheries can exacerbate the impacts of climate change (Harley et al. 2006), spatial protection is important for species vulnerable to exploitation and/or expected to have low resilience to environmental shifts. Regulating or zoning human activities within the boundaries of MPAs can reduce cumulative impacts and help build resilience in communities that are experiencing detrimental effects from climate stressors (Halpern et al. 2008a, Micheli et al. 2012, Green et al. 2014).

An assessment of the interactions between species and human activities in the NSB is currently ongoing[9], and will be used to minimize overlap of harmful human activities and sensitive

[9] Tamburello, N., Cueva-Bueno, P., Olson, E., Grosbeck, A., and Porter, M. 2016. Linking Human uses to Ecosystem Components and Ecosystem Goods and Services in Canada's Northern Shelf Bioregion. Report prepared by ESSA Technologies Ltd. For Fisheries and Oceans Canada. In revision.

ecological CPs during the site-selection phase of network planning. To promote the ability of the MPA network to prevent habitat loss for priority species, Important Areas (Table 18 4.4), including areas of critical habitat, can be included during the site-selection process.

The ability of species to persist through and recover from perturbations, including over-exploitation, is related to life history characteristics and ecological traits (Dulvy et al. 2004, Cheung et al. 2005). In general, species with “slow” life histories (e.g., large, long-lived species with late maturity and low reproductive rates) have lower potential rates of population growth and recovery than small, fast-growing species with high reproductive output (Dulvy et al. 2004, Cheung et al. 2005).

Species’ vulnerability to disturbance and recovery potential were estimated using composite scores of species’ intrinsic vulnerability to fishing developed by Cheung et al. (2005). The scores incorporate available data on each species’ life history characteristics (maximum length, age at first maturity, maximum age, natural mortality, geographic range, fecundity, and aggregation). Details on the fuzzy logic methods used to combine those characteristics into the scores can be found in Cheung et al. (2005). Although developed in the context of recovery from fishing pressures, the inclusion of life history characteristics relevant to population growth makes these scores informative as a general measure of species’ inherent capacity to recover from a range of disturbances. As such, this criterion describes the adaptive capacity component of vulnerability.

Cheung et al. (2005) presented the intrinsic vulnerability scores on a scale from 0–100, which the online databases FishBase and SeaLifeBase converted into ordered categories of low to very high. Each candidate species was queried in FishBase or SeaLifeBase, and the vulnerability category was recorded and converted to a 0–2 score for Criterion 1.1.S1 (Table 6).

FishBase and SeaLifeBase provide vulnerability scores for 125/190 candidate species (marine birds were not assessed for this criterion). For species not included in these databases, scores were assigned based on information available from existing literature, internal reports, and expert knowledge of species’ life history characteristics.

Based on expert feedback, it was determined that the scores from Cheung et al. (2005) do not adequately describe the vulnerability of marine mammal or invertebrate species. Therefore, the following changes were made in the assessment of Criterion 1.1.S1:

- All marine mammals and the sea turtle received a score of *2*.
- Species experts assessed all invertebrate species for relevant life history characteristics. Species that fit two or more of the following characteristics were assigned a score of *2* (high vulnerability), while those that fit one characteristic were assigned a score of *1* (moderate vulnerability). The life history characteristics assessed were:
  - long lived (> 20 years);
  - slow growth rate;
  - unpredictable recruitment;
  - low reproductive output;
  - restricted geographic range in the NSB; and,
  - strong aggregating behaviour.

Table 6. Scoring criteria for species' vulnerability to disturbance from human activities. Scores (0–2) were assigned based on vulnerability rankings presented in FishBase, which were developed using analytical methods developed by Cheung et al. (2005). The life history characteristics for the four ranking levels used by are presented below; FishBase adds intermediate levels (Low to Moderate, Moderate to High, High to Very High). Von Bertalanffy growth function (VBGF) parameter K is highly correlated to natural mortality in fish and was used by Cheung et al. (2005) in combination with estimates of natural mortality.

	Scores for Criterion 1.1.S1						
	0		1		2		
Life History Characteristics	Low	Low to Moderate	Moderate	Moderate to High	High	High to Very High	Very High
Maximum length (cm)	≤ 50	–	50–100	–	100–150	–	>150
Age at first maturity (yr)	≤ 2	–	2–4	–	4–6	–	> 6
Maximum age (yr)	≤ 3	–	3–10	–	10–30	–	> 30
VBGF parameter *K* (yr^{-1})	> 0.8	–	0.5–0.8	–	0.2–0.5	–	≤ 0.2
Natural mortality (yr^{-1})	> 0.5	–	0.35–0.5	–	0.2–0.35	–	≤ 0.2
Geographic range (km^2)	–	–	–	–	3170–5730	–	≤ 3170
Fecundity (egg or pup $individual^{-1}$ yr^{-1})	–	–	–	–	50–100	–	≤ 50
Aggregation (spatial behaviour strength)*	≤ 40	–	40–60	–	60–80	–	> 80

** See Cheung et al. (2005) for description of how values for spatial behaviour strength were determined.*

Objective 1.2. Protect natural trophic structures and food webs, including populations of upper-level predators, key forage species, nutrient importing and exporting species, and structure-providing species.

Protecting species with key trophic roles is important for ecosystem structure, functioning, stability and resilience (Foley et al. 2010). Ecologically Significant Species (ESSs) are species that have particularly high ecological importance and warrant special management measures, such as keystone and other highly influential predators, key forage species, nutrient importing and exporting species, and habitat-forming species (Rice 2006, DFO 2006). While all species have some degree of importance in their communities and ecosystems, ESSs are differentiated by having "controlling influence over key aspects of ecosystem structure and function" (DFO 2007a). The expectation is that disturbance of an ESS has disproportionately greater implications to the community or larger ecosystem than the disturbance of other species. The relative importance of a species may depend on the area and timeframe considered, as well as the state of the ecosystem.

Identifying functionally important species has been recognized as a challenge in identifying CPs (Howson et al. 2012). The problem is that for most species, little empirical data (e.g., experiments or long term data sets) exist to definitively show any "controlling influence". The best available information, often a literature review, must be used, with uncertainties adequately documented. Such information can in some cases be complemented by insights derived from theory and experiments at smaller spatial scales (e.g., contribution of upper-level predators to biodiversity: Heithaus et al. 2008, Terborgh 2015). Further, the extent to which a species meets ESS criteria may vary with spatial and temporal scales and the current state of the ecosystem (Piraino et al. 2002).

1.2.S1. The species is an upper-level predator.

Upper-level predators affect the distribution, behaviour, foraging rates and abundance of herbivores and mesopredators (mid-level predators). Via these mechanisms, they may indirectly influence species diversity, resilience to climate change and other stressors, carbon sequestration and other ecosystem properties (Heithaus et al. 2008, Ling et al. 2009, Atwood et al. 2015, Terborgh 2015, Madin et al. 2016).

For marine fish and other gape-limited predators, however, the strength of these effects depends on body size. Large-bodied species are dangerous to a broader size spectrum of prey and tend to play stronger ecological roles than smaller-bodied species. Similarly, individuals of large-bodied species undergo ontogenetic diet shifts as they grow. At younger age and smaller size they are mesopredators that feed primarily on invertebrates or other small prey that occupy low trophic levels. At older age and larger size they become upper level predators that include mesopredators (e.g., mid to large sized fish) in their diet (Scharf et al. 2000, Beaudreau and Essington 2007, 2009, Heupel et al. 2014). Larger-bodied predators also elicit stronger anti-predator behaviours from prey (Rizzari et al. 2014), including habitat and diet shifts that can have cascading effects on lower trophic levels (Heithaus et al. 2008).

Fisheries, however, truncate size and age structure (i.e., remove old and large individuals) and overfishing can weaken or eliminate the ecological role of upper-level predators (Shackell et al. 2010, Strong and Frank 2010, Madin et al. 2016). This global problem has been documented for Canada's west coast, where there are signs of upper-level predator loss and food web compression: trophic levels of marine fish in BC declined at a significant rate (–0.032 per decade) throughout the 20th century (Pauly et al. 2001). Notably, declines in the average size and age of some rockfishes are currently occurring at rapid rates (McGreer and Frid 2017). Combined with synergistic effects of changing ocean conditions, size truncation by fisheries can alter ecosystem properties (Preikshot et al. 2013, Tolimieri et al. 2013). Rebuilding over-exploited predators to their historical body sizes through spatial protection (Berkeley et al. 2004, Keller et al. 2014, Starr et al. 2015) could restore their former ecological roles and is a conservation priority.

While the importance of upper-level predators is generally understood, identifying the ecological roles and importance of individual species can be difficult when there is limited information on that species' ecology. Trophic levels, which are often calculated from stable isotopes or stomach contents, can be used to identify "apex" predators (i.e., trophic level > 4) that are strongly carnivorous and have few natural predators, such as orcas or large sharks. Interpretations of literature-reported values should consider the context of the study, as estimated trophic levels can vary within a species based on method used, the age and size of individuals studied, and the area and time period considered (Forero et al. 2005, Layman et al. 2012, O'Farrell et al. 2014). Further, trophic levels alone reflect only a predator's direct effects on prey mortality and do not necessarily reflect the full ecological importance of the predator, which includes indirect effects and the extent to which it alters prey distributions and foraging behaviour, particularly for prey types that are rarely consumed (Heithaus et al. 2008, Madin et al. 2016).

We used combinations of size, trophic level, and known ecological role to identify upper-level predators (Table 7). Size was considered for fishes only, which swallow prey whole and therefore their maximum prey size is constrained by their gape size. Because trophic levels are generally lower for invertebrates than for chordates, invertebrate species were scored in relation to each other based on expert knowledge. That is, they scored higher if considered upper-level predators relative to other invertebrate species.

This criterion, originating from DFO guidance on identifying “highly influential predators” (DFO 2007a), specifically focuses on upper-level predators due to their recognized role in stabilizing ecosystems. To limit the scope of assessment, we do not include strongly interacting species in other roles that may be important for maintaining ecosystem structure and function. Future iterations of this framework could explore the utility of including a broader range of species. However, it should be noted that some examples of strong ecological effects of lower trophic level species are the result of destabilized ecosystems released from upper-level predators.

Table 7. Scoring criteria for upper-level predators. Scores for fishes were assigned based on length and trophic level information available from FishBase; in situations where the trophic level or body size information obtained from FishBase seemed inconsistent with the known ecological role of adult individuals, additional information from the literature or from expert knowledge was used to assign the score. Scores for invertebrates were assigned based on available trophic level information from SeaLifeBase, information from the literature, and expert knowledge.

Species Group	Length	Trophic Level (TL)	Scores for Criterion 1.2.S1
Fishes	>90	>4	2
		3-4	1
	55-90	>3	1
	<55	-	0
Marine Mammals and Invertebrates Judgment based on trophic level, diet, and known ecological role	N/A	>4 OR has known important role (e.g., Sea Otter) OR ecologically similar to species with known TL OR is known to be an upper-level predator within the invertebrate community (e.g., Ochre Sea Star)	2
		<4 OR ecologically similar to species with known TL	1

1.2.S2. The species is a key forage species.

Forage species are key trophic components that provide a critical food source for many other species in the ecosystem. In general there is agreement that forage species occupy low (but not the lowest) trophic levels (i.e., often are planktivores), are small in body size, have a very high energy density (i.e., high fat content), and aggregate into very large and dense schools that facilitate capture success by predators (at least seasonally). Given these characteristics, they are critical to energy transfer from plankton to higher trophic levels. Specific definitions of forage species characteristics vary in published literature (Table 8), which can create challenges in identification of key forage species from a management perspective (Rountos 2016).

Key forage species are particularly important in ecosystems where only one or a few species sit at this crucial middle-trophic level position (i.e., “wasp-waisted ecosystems”; Rice 1995, Cury et al. 2000, Smith et al. 2011). However, the northern California Current Ecosystem, which includes much of BC, has a high degree of omnivory (species feeding at multiple trophic levels) and many intermediate-trophic level taxa (Fréon et al. 2009, Szoboszlai et al. 2015, Koehn et al. 2016). The specific roles of individual species and consequences to changes in forage species’ abundance are therefore more difficult to predict (Szoboszlai et al. 2015).

Well-known forage species in the North Pacific include Pacific Herring, smelts, and Pacific Sand Lance. Some species are considered important forage species as juveniles but not as adults (Thayer et al. 2008, Rountos 2016). In a review of forage fish in PNCIMA, which has the same spatial boundary as NSB, Schweigert et al. (2007) included Pacific Herring, Pacific Sand Lance, Osmeridae (smelts), as well as the Embiotocidae (surfperches) and the Bathylagidae (deep-sea smelts, representing mesopelagic fish). DFO’s Forage Fish Policy also includes *Pandalus* shrimps. In their forage species management plan (NPFMC 2013), Alaska’s North Pacific Fishery Management Council includes the families Osmeridae, Ammodytidae (sandlances), Myctophidae (lanternfishes), Bathylagidae, Pholidae (gunnels), Stichaeidae (pricklebacks), Trichodontidae (sandfishes) and Gonostomatidae (Bristlemouths, lightfishes, and anglemouths), as well as the order Euphausiacea. We did not replicate any of these lists, but used combinations of the above criteria to identify important prey species in the NSB (Table 9). We distinguished species known to be forage species as juveniles (e.g., rockfish) from those important at all life stages (e.g., krill). A species had to meet all criteria listed to receive a score of *1* or *2*, otherwise a score of *1** was assigned. In general, forage species had to be important for multiple predators (i.e., the preferred prey species of a specialist predator would not necessarily qualify).

Table 8. Characteristics associated with forage species in the published literature. We used combinations of the listed characteristics to identify important prey species in the NSB.

Forage species characteristics	DFO (2007a)	Guénette et al. (2014)	Springer and Speckman (1997)	Pikitch et al. (2012)	Brodeur et al. (2014)	Smith et al. (2011)
Important for marine predators	X	X	-	X	X	X
Transfer energy to higher trophic levels	-	X	X	X	X	X
Abundant	-	X	X	-	X	X
Fish	X	X	X	-	-	X
Schooling or aggregating	X	-	X	-	X	X
Small size	X	X	-	X	X	
Invertebrates	X	X	-	-	-	X
Preyed on by many species	-	-	X	X	X	-
Feed on zooplankton and phytoplankton	-	-	-	X	-	X
Pelagic	-	-	-	X	X	-
Represented by few species in an ecosystem	-	X	-	-	X	-
Short-lived	-	X	-	-	X	-
Rapid growth / Rapid population turnover	X	X	-	-	-	-
Low-trophic level	-	-	-	-	-	X
Abundance varies in time	-	X	-	-	-	-
Fast response to environmental conditions	X	-	-	-	-	-
High natural mortality	X	-	-	-	-	-
Highly productive	-	X	-	-	-	-
Intermediate size	-	-	-	X	-	-
Juveniles of larger species	-	-	-	-	X	-
Mid-trophic level	-	X	-	-	-	-

Table 9. Scoring criteria for forage species based on available information of ecological roles.

1 (moderate)	1* (uncertain)	2 (high)
Only as a juvenile, species is locally abundant, is aggregating or schooling, has a low trophic level (<3.5), and is important as prey for multiple other species.	Fills most of the criteria for 2, but there is not enough information to confidently score. OR The family or genus fills the criteria for 1, and there is not enough evidence to categorize the species as a 1.	For all life stages, species is locally abundant, is aggregating or schooling, has a low trophic level (<3.5), and is important as prey for multiple other species.

1.2.S3. The species is a nutrient importer or exporter.

Species that transfer limiting nutrients or energy into an ecosystem from sources outside that ecosystem are important for maintaining ecosystem structure and function (DFO 2007a). Mobile consumers are predicted to form energetic links between ecosystems and stabilize food webs (McCann et al. 2005, McCauley et al. 2012). Anadromous species such as Pacific Salmonids hold key roles in transporting nutrients between offshore and coastal areas, and provide important subsidies of marine-derived nutrients to terrestrial and freshwater ecosystems (Schindler et al. 2003, Beamish et al. 2005, Rice 2006, Hyatt et al. 2007). Other species can be important for transporting nutrients from marine to terrestrial areas, such as kelps and seagrasses that wash ashore as wrack (Liebowitz et al. 2016).

Existing DFO guidance recommends identifying species that transfer energy or nutrients from “inside” the focal area (i.e., the marine waters of the NSB) to “outside” (i.e., any marine, freshwater, or terrestrial ecosystems outside the NSB) (DFO 2007a). This includes species that transfer energy by migrating in and out of the NSB (e.g., organisms feeding and emitting waste as they travel (Roman et al. 2014) and organisms that provide nutrient subsidies to transitional ecosystems (e.g., intertidal beaches, streams, or estuaries). There are other important forms of nutrient transfer, such as bentho-pelagic coupling facilitated by diel vertical migrations (movements of species up and down in the water column) (Trueman et al. 2014) and trophic linkages between shallow reef and pelagic habitats (e.g., Andrews et al. 2013). However, following guidance on the identification of ESSs (DFO 2007a), we limit this criterion to species that are documented to provide subsidies across the NSB boundaries, including migratory species, anadromous species, and species that provide subsidies in other ways such as wrack-forming macrophytes. Future sub-regional analyses and management objectives that consider the pelagic and benthic realms separately may determine that other forms of nutrient transfer are important as CPs.

Scores for Criterion 1.2.S3 were applied based on available information regarding species' role in transport of **limiting** nutrients or nutrient/energy subsidies into and out of the marine portion of the NSB (Table 10).

The identification of migratory species is also needed to meet Objective 1.7 (Contribute to conservation of areas important for the life history of resident and migratory species).

Table 10. Scoring criteria for nutrient transporting species. Species that are generally non-migratory but which have occasional large movements (e.g., vagrant individuals) do not fulfil the criterion.

1 (moderate)	1* (uncertain)	2 (high)
The species *consistently* (i.e., every year) migrates from the marine environment of the NSB to marine, freshwater, or terrestrial environments outside of the marine part of the NSB, *but is not known* to transport limiting nutrients or energy to those ecosystems	The species occasionally migrates into or out of the NSB, such as during warm-water years	The species *consistently* (i.e., every year) migrates from the marine environment of the NSB to marine, freshwater, or terrestrial environments outside of the marine part of the NSB, *and is known* to transport limiting nutrients or energy to those ecosystems

1.2.S4. The species is important for forming structure or habitat.

Habitat-forming species (also called structural or foundation species) can provide important habitats for coastal and deep-sea species and promote local diversity by increasing three-dimensional habitat complexity above or below the seafloor (Etnoyer and Morgan 2005, DFO 2007a, Boström et al. 2011, Miller et al. 2012, Seitz et al. 2013). Biogenic habitats such as coastal wetlands, saltmarshes, kelp and seagrass beds, and aggregations of cold-water corals and sponges provide important refuge, nursery, feeding, and spawning habitats and provide food for many species (Stachowicz 2001, Duarte 2002, Etnoyer and Morgan 2005, Fuller et al. 2008, Seitz et al. 2013). Bioturbating species fill this role when their behaviour creates sub-surface habitat, such as burrows or aerated substrates, on which other species depend (DFO 2007a). The scoring system for habitat-forming species (Table 11) highlights species for which a benefit to other species or to diversity has been documented.

The influence of habitat-forming species on local diversity and ecosystem structure and function is also related to the density and extent of the habitat patch they create (Hovel and Lipcius 2001, Boström et al. 2011, Staveley et al. 2016). Therefore, identification of areas that have high densities and large extents of habitat-forming species is recommended (Table 18).

Table 11. Criteria for habitat-forming species based on the importance as habitat for other species or effect on local diversity.

1 (moderate)	1* (uncertain)	2 (high)
The species creates three-dimensional epibenthic or subsurface habitat, but it is not clear if other species benefit.	The species creates three-dimensional epibenthic or subsurface habitat, but there is some level of uncertainty.	The species creates three-dimensional epibenthic or subsurface habitat on which other species are known to rely, or which has been shown to promote local diversity.

Objective 1.5. Contribute to protection of rare, unique, threatened, and/or endangered species and their habitats.

1.5.S1. The species is declining or under threat of decline regionally, nationally, or globally.

Protecting species at risk is a major and consistently applied goal of marine protected areas (Table 3). To capture this important criterion, we used the conservation status assigned to each species by authorities at the global, national, and provincial levels. To account for differences in listing criteria, we identified species considered "at risk" or of conservation concern under multiple listing agencies. While most designations of conservation concern are at the species level, some national and regional listings specify particular populations (e.g., the Interior Fraser River population of Coho Salmon, not the whole species, is COSEWIC-listed as Endangered; the Eastern but not Western population of Harlequin Duck is SARA-listed as Special Concern). In those cases, scores were given only if the populations were relevant to the NSB.

*Table 12. Conservation concern scores and external criteria from global, national, and provincial authorities on which they were derived. * CITES II is not included in the scores for 1.5.S1.*

		NatureServe	**BCList**	**COSEWIC**	**SARA**	**General Status**	**IUCN**	**CITES**
Score for 1.5.S1	**Scale** / **Criteria**	**Global, Provincial**	**Provincial**	**National**	**National**	**National, Provincial**	**Global**	**Global**
-	1. Species no longer exists	–	Extinct	Extinct	Extinct	Extinct	Extinct	–
2	2. Wild populations no longer exist at the scale considered.	Presumed Extirpated Possibly Extirpated	Red	Extirpated	Extirpated	Extirpated	Extinct in the Wild	I
	3. Species extremely rare, or showing steep declines	Critically Imperiled		Endangered	Endangered	At Risk	Critically Endangered	
	4. A species facing imminent extirpation or extinction	Imperiled					Endangered	
	5. Likely to become endangered if limiting factors are not reversed			Threatened	Threatened	May be at risk	Vulnerable	II*
1	6. Species has traits that make it particularly sensitive to human activities or natural events	Vulnerable	Blue	Special Concern	Special Concern	Sensitive	Near Threatened	
0	7. A species that has been evaluated, found to be not at risk	Apparently Secure Secure	Yellow	Not at Risk	Not at Risk	Secure	Least Concern	–
*****	8. Species not evaluated, or lacking necessary data to do evaluation	Unranked, Unrankable, Not Applicable	Unknown, No Status	Data Deficient	Data Deficient	Undetermined Not assessed	Data Deficient, Not Evaluated	–
-	Species not native to given area	–	Exotic	–	–	Exotic	–	–
-	Species occurring infrequently or unpredictably, outside their usual range	–	Accidental	–	–	Accidental	–	–
*****	Species under consideration	–	-	Candidate	–	–	–	–

Species may have different levels of conservation concern depending on the spatial scale and region considered. Differences in conservation status may occur, for example, if a regional population is considered healthy but the species is undergoing more widespread declines globally, or if populations at any scale have not been assessed due to data limitations. We took a precautionary approach and identified species with any designation at any scale (global, national, or regional), as these species may have characteristics that make them more susceptible to population declines at other scales. For each species, a single score for Criterion 1.5.S1 was assigned from the highest score at global, national, and regional scales. For example, a species receiving a *1* regionally, a *** nationally, and a *2* globally would receive an overall score of *2* for Criterion 1.5.S1.

Some species, such as invertebrates and marine fishes, are under-represented on formal lists of conservation status. As such, species experts supplemented scores with their knowledge on population status, which could potentially include information from stock assessments or other unpublished sources of information.

Global: IUCN Red List

The IUCN Red List classifies species at high risk of global extinction (IUCN 2012). IUCN Red List classifications are made using criteria that assess reductions in species' population size and geographic extent (IUCN 2012). Most assessments under the IUCN Red List are at the global scale, but regional assessments exist for some species. Because the regional assessments are carried out with information specific to a given area (e.g., Europe, Gulf of Mexico), a species may have different regional and global classifications. We used the global IUCN Red List assessments for this criterion.

Global and Provincial: NatureServe

The NatureServe Conservation Status Assessment process assigns species scores of conservation concern based on population size and trends, geographic extent, and vulnerability and threats (Master et al. 2012). The BCCDC includes the NatureServe Global ("G" scores) and subnational or provincial ("S" scores) in their database.

National: COSEWIC and SARA

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) provides assessments of the status of species at risk in Canada using scientific, expert, and traditional knowledge (COSEWIC 2015). Status Reports for species are developed and a level of conservation concern is recommended based on species' distribution, extend of occurrence, area of occupancy, abundance, population or habitat trends, and threats (COSEWIC 2015).

Once COSEWIC has designated a species' conservation status, the status report is forwarded to the Minister of the Environment who recommends acceptance or rejection of the listing of the species under the Species At Risk Act (SARA; Environment and Climate Change Canada 2016). Decisions to list species under SARA consider socio-economic factors and consequences that COSEWIC does not. As such, species of conservation concern under COSEWIC may not be listed under SARA.

National and Provincial: General Status of Species in Canada

The General Status of Species in Canada ("General Status") is a conservation classification system developed by the Canadian Endangered Species Conservation Council (CESCC 2011). Using criteria the General Status provides a status score for species at the National (Canada), Provincial (BC), and Regional (Pacific) levels, by gathering available information from institutions, experts, and other listing processes (CESCC 2011). The General Status reports mainly on terrestrial and freshwater species, but includes scores for marine and coastal birds and mammals.

Global: CITES

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) aims to protect species in need of conservation by restricting their international trade. CITES Level I includes species that are at risk of extinction, while CITES II includes species that may be threatened with extinction unless trade is controlled, as well as look-alike species. Because some look-alike species that do not require protection are included under CITES II, only CITES I is considered here.

Other considerations: Rarity and Range Restriction

Species that are endemic, rare, or have narrow distributions are at higher risk of extinction from local impacts, whether their rarity is natural or a result of exploitation (Roberts et al. 2003, Davies et al. 2004) and are often considered a conservation priority (e.g., Piraino et al. 2002, Eken et al. 2004, BCMCA Project Team 2008a). Definitions of what constitutes an endemic, rare, or range-restricted species vary, and are scale-dependent (Piraino et al. 2002, Roberts et al. 2003). For example, range-restricted birds are those that have breeding ranges of less than 50,000 km^2 (Stattersfield et al. 1998), while in marine systems an arbitrary cut-off of 800,000 km^2 has been used (Hawkins et al. 2000). Furthermore, some species that are currently range-restricted might expand their ranges or shift their distributions in response to climate change (Cheung et al. 2015, Weatherdon et al. 2016). Range shifts could potentially be incorporated into network planning through climate envelope models (e.g., Cheung et al. 2009, Pinsky et al. 2013) or risk-based approaches (e.g., Samhouri et al. 2014).

Assessing rarity requires abundance data over a species' range, which is generally only available for larger, well-known species (Roberts et al. 2003). If the species' global range is not known, the footprint of species occurrence in the planning area can be used to assess rarity. For example, a species could be considered regionally or nationally rare if it occurs in less than a given percentage of the planning area (Connor et al. 2002, Derous et al. 2007). Species that only occur in a portion of the planning region may be at the edge of their range and generally should not be prioritized because they are of lower conservation concern (Piraino et al. 2002, Roberts et al. 2003).

Using footprint calculations to assess rarity requires occurrence data with sampling effort over the full study area, and would likely need to be separated based on habitat type (e.g., an ubiquitous intertidal species could be considered rare when assessed over all coastal, shelf, and slope areas). Footprint calculations have been used in spatial planning for sessile or reduced mobility species (e.g., Connor et al. 2002) but additional consideration would be needed for mobile species (e.g., to account for seasonal migrations). In the Scottish MPA process, information on rarity was assessed for potential CPs where available but was not used as a selection criterion (Howson et al. 2012).

We did not explicitly assess rarity, endemism, or range restriction as a scoring criterion for CPs, due in part to difficulties in quantitatively assessing rarity. Other components of rarity, such as population size and vulnerability are included in assessments of conservation status (Criteria 1.5.S1), and vulnerability is directly assessed in Criteria 1.1.S1.

4.2 MARINE AND COASTAL BIRDS

Marine and coastal birds are ecologically significant predators and are important indicators of marine ecosystem functioning (Monaghan 1996, Croxall et al. 2012). The NSB supports 95% of the breeding seabird population in BC and is important for migrating waterfowl and shorebirds (McFarlane Tranquilla et al. 2007)

To determine the marine bird species that should be considered CPs, a modified screening and scoring method was developed in collaboration with subject matter experts from Environment and Climate Change Canada (ECCC) and The Nature Conservancy Canada.

A list of potential candidate species was obtained by querying the BCCDC database (queries for "Bird, All Species"), and removing species categorized as exotic and "accidental/non-regular". Bird species from that list were included as a candidate species if they met one of the following three criteria:

1. Identification as Priority Species for marine or coastal habitats under Environment and Climate Change Canada's Bird Conservation Strategy for Bird Conservation Region (BCR) 5: Northern Pacific Rainforest (Environment Canada 2013). The BCR 5 Bird Conservation Strategy Priority Species list includes
   a. species considered vulnerable or of conservation concern due to population size distribution, population trend, abundance and threats;
   b. widely distributed and abundant "stewardship" species that typify the national or regional avifauna and/or because they have a large proportion of their range and/or continental population in the sub-region; and,
   c. species of management concern that are at (or above) their desired population objectives but require ongoing management because of their socio-economic importance as game species or because of their impacts on other species or habitats.
2. Conservation concern at global, national, and provincial scales (Table 12).
3. Expert opinion of population status, vulnerability, or degree of domestic and international obligations of responsible species stewardship (based on proportion of global population present in BC).

Raptors, passerines, and species considered rare in BC or in the NSB were removed from consideration. The final candidate list contained 80 bird species, which were assigned scores following Table 13. The final CP score for each bird species was the highest score of any criterion.

Table 13. Conservation priority criteria for bird species. ECCC: Environment and Climate Change Canada's Bird Conservation Strategy for Bird Conservation Region 5: Northern Pacific Rainforest (Environment Canada 2013). Expert opinion scores were provided by subject matter experts from ECCC and The Nature Conservancy Canada.

Criterion	Potential Scores
ECCC marine and/or coastal habitat priority species	1
Conservation concern at global, national, and provincial scales	0, 1, or 2 following Table 12
Expert opinion	0, 1, or 2

4.3 RESULTS: SPECIES-BASED CONSERVATION PRIORITIES

Of the 190 non-bird species considered, 177 received a positive score (*1*, *1**, or *2*) for at least one criterion. A summary of the scores across species groups can be found in Table 14 and is shown in Figure 5 (Appendix 2).

Table 14. Number of species by score under each criterion, for all 190 candidate species. Asterisks (*) indicates there was insufficient information to assign a score. "0" and "–" indicate the criterion was not applicable for that species. Explanation of "1", "1", and "2" scores can be found under each criterion in Section 4.1.3.*

Criterion	Score	Bony fishes and Elasmobranchs	Marine Mammals	Sea Turtles	Invertebrates	Plants and Algae
1.1.S1 Vulnerable species	*	0	0	0	2	15
	0 or –	22	0	0	13	0
	1*	0	0	0	0	0
	1	22	0	0	10	0
	2	48	23	1	34	0
1.2.S1 Upper-level predators	*	0	0	0	0	0
	0 or –	30	5	0	53	15
	1*	0	0	0	0	0
	1	36	2	1	2	0
	2	26	16	0	4	0
1.2.S2 Key forage species	*	1	0	0	1	0
	0 or –	37	23	1	32	14
	1*	39	0	0	9	0
	1	6	0	0	2	0
	2	9	0	0	15	1
1.2.S3 Nutrient transporting species	*	51	0	0	0	6
	0 or –	16	4	0	59	2
	1*	4	0	0	0	0
	1	14	19	1	0	7
	2	7	0	0	0	0
1.2.S4 Habitat-forming species	*	1	0	0	0	2
	0 or –	91	23	1	37	2
	1*	0	0	0	2	0
	1	0	0	0	3	7
	2	0	0	0	17	4
1.5.S1 Conservation concern	*	45	0	0	44	9
	0 or –	27	7	0	11	6
	1*	0	0	0	0	0
	1	11	3	0	3	0
	2	9	13	1	1	0

Based on methods used in a similar species scoring process (Hannah et al. 2017), we tested several methods of screening the candidate species based on their scores to identify the final recommended list of species-based CPs (Table 14). Screening alternatives included requiring a certain number of criteria to be met with any score (i.e., *1*, *1**, or *2*) or with only high scores (i.e., *2*) (Table 15). We did not attempt to rank or screen species using additive scores (i.e., summing scores across criteria) due to problems with correlation and interpretation (see discussion).

Table 15. Different methods of sorting and ranking species to obtain a list of recommended conservation priorities for non-bird species. For additive scores, scores of 1 and 1 are worth 1, and a score of 2 is worth 2. "1*" scores indicate a level of uncertainty under 1.2S2 and 1.2.S3. The maximum additive score possible (i.e., a "2" score under each criterion) is 12.*

Method number	Required number of criteria met with any score (*1, 1*,* or *2*)	Required number of criteria met with a strong fit score (*2*)	Number of species retained (/190)
1	1	-	177
2	2	-	143
3	-	1	139
4	-	2	76
5	-	3	14
6	-	1 OR any score under Conservation Concern	140

Method 1, which required that at least one criterion to be met with any score, was not very effective as a screening method as the majority of species (93%, 177/190) were retained. Method 2 required that multiple criteria were met with any score and was somewhat more specific, retaining 75% of species (143/190). However, because scores of *1* and *1** indicate that the species did not fully meet the criteria under each objective, it was decided that methods 1 and 2 were not appropriate, and only high scores should be considered.

Requiring at least one criterion to be met with a high score (method 3) retained 139 (73%) of species. Increasing the number of criteria required to be met reduced the number of species retained to 40% for two criteria (method 4) and 7% for three criteria (method 5). Because the purpose of this framework is to identify species that meet the ecological network objectives, it is not necessary to require species to meet multiple criteria. Method 3 was considered to be an appropriate method for identifying species that fit the framework, and was modified into method 6 by adding any species that has received any score under Criterion 1.5.S1 (conservation concern) criterion. This was done to ensure that all species of conservation concern (i.e., recognized as in need of protection) were included, and because the criterion encompassed several broad considerations including vulnerability, population size, and range restriction.

Our final list of CPs included all species that received a score of *1* or *2* under Conservation Concern (i.e., equivalent to SARA "Special Concern" or higher) at global, national, or regional scales (1.5.S1) and all species that received at least one "2" score under any other criterion (Figure 4). The resulting 140 non-bird CPs are presented in Table 16.

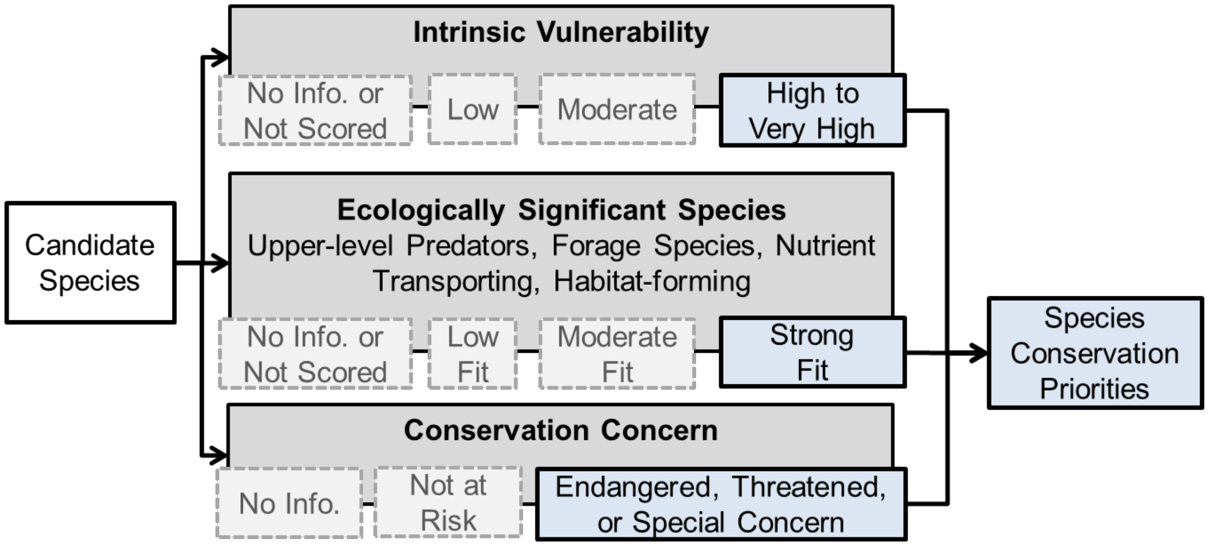

Figure 4. Overview of the framework for identifying non-bird conservation priorities for the MPA network in the Northern Shelf Bioregion.

Of 80 candidate bird species, 55 received scores under the modified bird criteria and are recommended as conservation priorities (Table 17). Of those, 31 are considered high priority, and 24 are of lower priority.

Based on criteria that prioritize protection of vulnerable species, ecologically significant species, and those of conservation concern, we recommend 65 bony fishes and elasmobranchs, 23 marine mammals (including four Orca ecotypes), one sea turtle, 46 invertebrates, five plants and algae, and 55 bird species to be considered as conservation priorities. The scores under each criterion for each of the candidate species are shown in Appendix 1 (Table 22). Additional information supporting each score is provided in Appendix 4.

Table 16. The 140 species, excluding marine birds, recommended as conservation priorities for the NSB MPA Network. † indicates Orca ecotypes (i.e., not separate species).

Higher Group	Species Group	Common Name	Scientific Name
Bony Fishes	Flatfishes	Arrowtooth Flounder	*Atheresthes stomias*
		Dover Sole	*Microstomus pacificus*
		Pacific Halibut	*Hippoglossus stenolepis*
		Petrale Sole	*Eopsetta jordani*
		Rex Sole	*Glyptocephalus zachirus*
		Rock Sole	*Lepidopsetta bilineata*
	Forage Fishes	Capelin	*Mallotus villosus*
		Eulachon	*Thaleichthys pacificus*
		Pacific Herring	*Clupea pallasii*
		Pacific Sand Lance	*Ammodytes hexapterus*
		Pacific Sardine	*Sardinops sagax*
		Surf Smelt	*Hypomesus pretiosus*
	Groundfishes	Lingcod	*Ophiodon elongatus*
		Sablefish	*Anoplopoma fimbria*
		Wolf-Eel	*Anarrhichthys ocellatus*
	Mesopelagic Fishes	Northern Lampfish	*Stenobrachius leucopsarus*
		Northern Smoothtongue	*Leuroglossus schmidti*
	Native Salmonids	Chinook Salmon	*Oncorhynchus tshawytscha*
		Chum Salmon	*Oncorhynchus keta*
		Coho Salmon	*Oncorhynchus kisutch*
		Pink Salmon	*Oncorhynchus gorbuscha*
		Sockeye Salmon	*Oncorhynchus nerka*
		Cutthroat Trout	*Oncorhynchus clarkii*
		Steelhead	*Oncorhynchus mykiss*
		Dolly Varden	*Salvelinus malma lordi*
	Pelagic Fishes	Albacore Tuna	*Thunnus alalunga*
		Ocean Sunfish	*Mola mola*
	Rockfishes	Black Rockfish	*Sebastes melanops*
		Blackspotted Rockfish	*Sebastes melanostictus*
		Bocaccio	*Sebastes paucispinis*
		Canary Rockfish	*Sebastes pinniger*
		China Rockfish	*Sebastes nebulosus*
		Copper Rockfish	*Sebastes caurinus*
		Darkblotched Rockfish	*Sebastes crameri*
		Greenstriped Rockfish	*Sebastes elongatus*
		Pacific Ocean Perch	*Sebastes alutus*
		Quillback Rockfish	*Sebastes maliger*
		Redstripe Rockfish	*Sebastes proriger*
		Rosethorn Rockfish	*Sebastes helvomaculatus*
		Rougheye Rockfish	*Sebastes aleutianus*
		Shortraker Rockfish	*Sebastes borealis*
		Silvergray Rockfish	*Sebastes brevispinis*
		Tiger Rockfish	*Sebastes nigrocinctus*
		Vermilion Rockfish	*Sebastes miniatus*
		Widow Rockfish	*Sebastes entomelas*
		Yelloweye Rockfish	*Sebastes ruberrimus*
		Yellowmouth Rockfish	*Sebastes reedi*
		Yellowtail Rockfish	*Sebastes flavidus*
		Longspine Thornyhead	*Sebastolobus altivelis*
		Shortspine Thornyhead	*Sebastolobus alascanus*
	Roundfishes	Pacific Cod	*Gadus macrocephalus*
		Pacific Hake	*Merluccius productus*
		Walleye Pollock	*Theragra chalcogramma*
	Sturgeons	Green Sturgeon	*Acipenser medirostris*
	Surfperches	Shiner Perch	*Cymatogaster aggregata*

Higher Group	Species Group	Common Name	Scientific Name
Elasmobranchs	Demersal Sharks	Bluntnose Sixgill Shark	*Hexanchus griseus*
		Pacific Sleeper Shark	*Somniosus pacificus*
		Spiny Dogfish	*Squalus suckleyi*
	Pelagic Sharks	Basking Shark	*Cetorhinus maximus*
		Blue Shark	*Prionace glauca*
		Salmon Shark	*Lamna ditropis*
	Skates	Big Skate	*Raja binoculata*
		Longnose Skate	*Raja rhina*
		Roughtail Skate	*Bathyraja trachura*
		Sandpaper Skate	*Bathyraja interrupta*
Marine Mammals	Dolphins and Porpoises	Dall's Porpoise	*Phocoenoides dalli*
		Harbour Porpoise	*Phocoena phocoena*
		Northern Right Whale Dolphin	*Lissodelphis borealis*
		Pacific White-sided Dolphin	*Lagenorhynchus obliquidens*
		Risso's Dolphin	*Grampus griseus*
	Orcas	Northern Resident†	*Orcinus orca*
		Offshore†	*Orcinus orca*
		Southern Resident†	*Orcinus orca*
		Transient†	*Orcinus orca*
	Pinnipeds	California Sea Lion	*Zalophus californianus*
		Harbour Seal	*Phoca vitulina*
		Northern Elephant Seal	*Mirounga angustirostris*
		Northern Fur Seal	*Callorhinus ursinus*
		Steller Sea Lion	*Eumetopias jubatus*
	Sea Otters	Sea Otter	*Enhydra lutris*
	Whales	Blue Whale	*Balaenoptera musculus*
		Common Minke Whale	*Balaenoptera acutorostrata*
		Fin Whale	*Balaenoptera physalus*
		Grey Whale	*Eschrichtius robustus*
		Humpback Whale	*Megaptera novaeangliae*
		North Pacific Right Whale	*Eubalaena japonica*
		Sei Whale	*Balaenoptera borealis*
		Sperm Whale	*Physeter macrocephalus*
Reptiles	Sea Turtles	Leatherback Sea Turtle	*Dermochelys coriacea*
Cnidarians	Cold-water Corals	Black Corals	Antipatharia
		Hard or Stony Corals	Scleractinia
		Sea Pens	Pennatulacea
		Soft Corals	Alcyonacea
Crustaceans	Barnacles	Goose Barnacle	*Pollicipes polymerus*
	Crabs	Dungeness Crab	*Metacarcinus magister*
		Deepwater Grooved Tanner Crab	*Chionoecetes tanneri*
		Inshore Tanner Crab	*Chionoecetes bairdi*
		Puget Sound King Crab	*Lopholithodes mandtii*
	Shrimps	Bay Ghost Shrimp	*Neotrypaea californiensis*
		Coonstripe/Dock Shrimp	*Pandalus danae*
		Humpback Shrimp	*Pandalus hypsinotus*
		Sidestripe Shrimp	*Pandalopsis dispar*
		Smooth Pink Shrimp	*Pandalus jordani*
		Spiny/Northern Pink Shrimp	*Pandalus borealis*
		Spot Prawn	*Pandalus platyceros*
	Zooplankton	Euphausiids	Euphausiacea
		Neocalanus Copepods	*Neocalanus* sp.
		Other Crustacean Zooplankton	Other Crustacean Zooplankton
Echinoderms	Sea Stars	Ochre Sea Star	*Pisaster ochraceus*
		Sunflower Sea Star	*Pycnopodia helianthoides*
	Sea Urchins	Green Urchin	*Strongylocentrotus droebachiensis*
		Red Urchin	*Mesocentrotus franciscanus*

Higher Group	Species Group	Common Name	Scientific Name
Molluscs	Cephalopods	Giant Pacific Octopus	*Enteroctopus dofleini*
		Opal Squid	*Doryteuthis opalescens*
	Clams and Cockles	Butter Clam	*Saxidomus gigantea*
		Cockle	*Clinocardium nuttallii*
		Geoduck	*Panopea generosa*
		Horse Clam/Fat Gaper	*Tresus capax*
		Horse Clam/Pacific Gaper	*Tresus nuttallii*
		Littleneck Clam	*Leukoma staminea*
		Razor Clam	*Siliqua patula*
	Epibenthic Bivalves	California Mussel	*Mytilus californianus*
		Olympia Oyster	*Ostrea lurida*
		Pink Scallop	*Chlamys rubida*
		Purple-hinged Rock Scallop	*Crassadoma gigantea*
		Spiny Scallop	*Chlamys hastata*
		Weathervane Scallop	*Patinopecten caurinus*
	Gastropods	*Littorina* Snail	*Littorina* sp.
		Northern Abalone	*Haliotis kamtschatkana*
Sponges	Sponges	Glass Sponges	Hexactinellida
		Cloud Sponge	*Aphrocallistes vastus*
		Glass Sponge	*Farrea occa*
		Glass Sponge	*Heterochone calyx*
		Demosponges	Demospongiae
Other	Zooplankton	Non-Crustacean Zooplankton	Non-Crustacean Zooplankton
Plants and Algae	Phytoplankton	Phytoplankton	Phytoplankton
	Large Algae	Bull Kelp	*Nereocystis leutkeana*
		Giant Kelp	*Macrocystis* sp.
	Seagrasses	Eelgrass	*Zostera marina*
		Surfgrass	*Phyllospadix* sp.

Table 17. Marine bird species recommended as conservation priorities for the NSB MPA Network.

Score	Family	Common Name	Scientific Name
2	Gaviidae	Yellow-billed Loon	*Gavia adamsii*
	Podicipedidae	Western Grebe	*Aechmophorus occidentalis*
	Diomedeidae	Black-footed Albatross	*Phoebastria nigripes*
		Short-tailed Albatross	*Phoebastria albatrus*
	Procellariidae	Buller's Shearwater	*Ardenna bulleri*
		Pink-footed Shearwater	*Ardenna creatopus.*
	Phalacrocoracidae	Brandt's Cormorant	*Phalacrocorax penicillatus*
		Pelagic Cormorant, *pelagicus* subsp.	*Phalacrocorax pelagicus pelagicus*
	Anatidae	Harlequin Duck	*Histrionicus histrionicus*
		Long-tailed Duck	*Clangula hyemalis*
		Surf Scoter	*Melanitta perspicillata*
		Black Scoter	*Melanitta americana*
		White-winged Scoter	*Melanitta deglandi*
		Barrow's Goldeneye	*Bucephala islandica*
	Haematopodidae	Blackish Oystercatcher	*Haematopus ater bachmani*
	Scolopacidae	Wandering Tattler	*Tringa incana*
		Surfbird	*Calidris virgata*
		Ruddy Turnstone	*Arenaria interpres*
		Black Turnstone	*Arenaria melanocephala*
		Rock Sandpiper	*Calidris ptilocnemis*
		Sanderling	*Calidris alba*
		Red Knot	*Calidris canutus*
		Short-billed Dowitcher	*Limnodromus griseus*
		Red Phalarope	*Phalaropus fulicarius*
	Alcidae	Common Murre	*Uria aalge*
		Pigeon Guillemot	*Cepphus columba*
		Marbled Murrelet	*Brachyramphus marmoratus*
		Ancient Murrelet	*Synthliboramphus antiquus*
		Cassin's Auklet	*Ptychoramphus aleuticus*
		Rhinoceros Auklet	*Cerorhinca monocerata*
		Tufted Puffin	*Fratercula cirrhata*
1	Gaviidae	Pacific Loon	*Gavia pacifica*
		Common Loon	*Gavia immer*
	Podicipedidae	Horned Grebe	*Podiceps auritus*
	Diomedeidae	Laysan Albatross	*Phoebastria immutabilis*
	Procellariidae	Northern Fulmar	*Fulmarus glacialis*
		Short-tailed Shearwater	*Ardenna tenuirostris*
		Sooty Shearwater	*Ardenna grisea*
	Hydrobatidae	Leach's Storm-Petrel	*Hydrobates leucorhous*
		Fork-tailed Storm-Petrel	*Hydrobates furcatus*
	Phalacrocoracidae	Pelagic Cormorant, *resplendens* subsp.	*Phalacrocorax pelagicus resplendens*
		Double-crested Cormorant	*Phalacrocorax auritus*
	Ardeidae	Great Blue Heron, f*annini* subsp.	*Ardea herodias fannini*
		Trumpeter Swan	*Cygnus buccinator*
		Canada Goose (Pacific, residents & migrants)	*Branta canadensis*
		Cackling Goose	*Branta hutchinsii*
		Common Goldeneye	*Bucephala clangula*
	Scolopacidae	Whimbrel	*Numenius phaeopus*
		Dunlin	*Calidris alpina*
		Western Sandpiper	*Calidris mauri*
		Red-necked Phalarope	*Phalaropus lobatus*
	Laridae	California Gull	*Larus californicus*
		Thayer's Gull	*Larus thayeri*
	Alcidae	Thick-billed Murre	*Uria lomvia*
		Horned Puffin	*Fratercula corniculata*

4.4 RECOMMENDED SPATIAL FEATURES FOR SPECIES-BASED CONSERVATION PRIORITIES

Effective MPA planning and implementation requires an understanding of where CPs occur in the planning area. To guide the future collection of data for use in site selection analyses, we are suggesting the types of spatial features and information that can be used to adequately represent species-based CPs in the MPA network (Table 18). Of particular importance is the identification and inclusion of IAs (Objective 1.7), which may include areas of aggregation or importance for spawning, rearing/nursery, feeding, or migrating, or areas otherwise determined to be critical habitat. For habitat-forming species, it is important to identify areas of high density and large spatial extent (see Section 4.1.3, criterion 1.2.S4). Information on observed or modelled distributions and relative abundance can be used to understand species' habitat use, to supplement IAs, or to assess species' representation under different network design scenarios. Identification of areas of high or distinct genetic diversity meets Objective 1.3 (Table 1).

Table 18. Recommended spatial features to represent conservation priorities during site-selection analyses.

Recommended Spatial Feature	Details
Areas of aggregation or importance for spawning, rearing/nursery, feeding, or migrating, or areas otherwise determined to be critical habitat.	May include IAs (e.g., Clarke and Jamieson 2006a), Important Bird Areas (Bird Studies Canada 2015), or Critical Habitat for Species at Risk as areas important to species' life histories (Objective 1.7). Sessile or low mobility species carry out all life history functions where they settle, so may not have specific areas for spawning, feeding, or migrating. However, areas of aggregation should be prioritized. Areas of high density and large extent should be identified for habitat-forming species, as patch density and extent is related to their impact on local diversity (e.g., dense sponge reefs vs. scattered sponges; large vs. small eelgrass beds).
Observed or modelled distribution and relative abundance within the NSB	The full range of a species occurrence is of interest to understand species' habitat requirements and patterns of abundance. It may be appropriate to distinguish among life stages for some species.
Areas of high or distinct genetic diversity.	High genetic diversity promotes resilience and adaptation to disturbance. Populations with distinct genetics are interesting from an evolutionary and ecological perspective. Since some level of population isolation (temporal or spatial) is generally needed to develop genetic differentiation, genetic analyses can provide information on stock/population structure, source-sink populations, and other information relevant to spatially managing species.

5 AREA-BASED CONSERVATION PRIORITIES

To identify area-based CPs, a literature search was carried out to determine if a particular type of feature, habitat, or area was known to fulfill the relevant network objectives (Table 19). We identified area-based CPs as features, habitats, and areas that meet the criteria outlined below (Sections 5.1–5.2) and in Table 20. Many of the areas meet multiple objectives. Unlike the species-based CPs, we did not compile a candidate list of areas or features and did not use a scoring system to assess area-based CPs. Instead, the identified area-based CPs are meant to drive data collection and mapping efforts to delineate ecologically important areas and areas that are representative of the range of habitats that occur in the NSB.

Table 19. Network objectives relevant to area-based conservation priorities.

Network Objective
1.1. Contribute to the conservation of the diversity of species, populations, and ecological communities, and their viability in changing environments.
1.3. Conserve areas of high biological diversity (species, habitat and genetic diversity).
1.4. Protect representative areas of every marine habitat in the bioregion.
1.6. Conserve ecologically significant geological features and enduring/recurring oceanographic features.

5.1 FEATURES ASSOCIATED WITH ECOLOGICALLY AND BIOLOGICALLY SIGNIFICANT AREAS

Incorporating Ecologically and Biologically Significant Areas (EBSAs) is an important design principle laid out in the Canada-BC MPA Network Strategy (2014). An EBSA is an area deemed to be ecologically or biologically “significant” because of its structural properties and/or the function that it serves in an ecosystem (DFO 2004). The EBSA criteria developed by DFO (2004) include areas important for uniqueness, aggregation, fitness consequences, resilience and naturalness. Canada has also endorsed the seven EBSA criteria developed by the Convention on Biological Diversity (CBD 2008), which are internationally accepted for identifying EBSAs and have some overlap with the DFO criteria: uniqueness/rarity, importance for species life history stages, importance for threatened or endangered species, vulnerability, high productivity, high biodiversity, and naturalness. EBSAs have been designated in the NSB through an expert-driven approach (Clarke and Jamieson 2006a, 2006b) and are currently being reassessed to fill identified gaps in the original process (Rubidge et al. 2018). As part of the CP framework, we are focusing on features associated with areas of high biodiversity, areas of high productivity, and areas contributing to ecological resilience. Unique or rare areas will be captured in ecological classifications (Section 5.1.1), and areas important for species’ life history stages and for threatened species are discussed in Section 4.4. We do not address the naturalness criterion of EBSAs, as it is not directly linked to the network objectives (but see Section 5.1.3 on degraded areas).

5.1.1 Areas of High Biodiversity and High Productivity

Protecting and restoring biodiversity, or biological diversity, is a global challenge and a major impetus for the establishment of MPAs (Foley et al. 2010, Klein et al. 2015). Biodiversity is “the full range of variety and variability within and among living organisms and the ecological complexes in which they occur; the diversity they encompass at the ecosystem, community, species and genetic levels; and the interaction of these components” (Government of Canada

2011). Areas that contain comparatively higher diversity of ecosystems, habitats, communities, species, or genes than the surrounding area, are considered EBSAs (CBD 2008). Biodiversity is the basis and the value of our biosphere and there are multiple and complex reasons for protecting it, including environmental, economic and social benefits (Millennium Ecosystem Assessment 2005, Roff and Zacharias 2011). Rich and diverse communities support resilient, productive ecosystems by providing functional redundancy, where multiple species carry out similar roles, which “insures” against loss of any one species (Yachi and Loreau 1999). Areas of high biodiversity are important for evolution and maintaining the resilience of marine species and ecosystems (CBD 2008, Oliver et al. 2015). Examples are features known to be associated with high or distinct biodiversity (e.g., seamounts, tidal channels, see Table 20 for list of features). Analyses can also be conducted on available data to identify areas of high biodiversity (e.g., observed or modelled areas of high species richness; Table 21).

Table 20. Features or areas recommended as conservation priorities, with information supporting their inclusion.

Feature	Justification	References	Examples
Areas of high habitat heterogeneity	There is a positive relationship between species diversity and habitat heterogeneity, and rugosity or other measures of habitat heterogeneity can be used as a surrogate for biodiversity when biological data are lacking.	Risk (1972), Huston (1979), Beck (1998), Levin et al. (2001), Gratwicke and Speight (2005), McArthur et al. (2010)	Areas of high rugosity, rocky reefs, and structurally complex biogenic habitats (sponge reefs, cold water corals, kelp forests, eel grass beds).
Frontal zones	Tidal fronts often define the boundaries of well-mixed regions, and these areas tend to concentrate plankton. The concentration of plankton, in turn, attracts fish, birds and other marine life.	Crawford et al. (2007)	Scott Islands has been identified as an ecologically and biologically significant area (Clarke and Jamieson 2006b) due in part to the high productivity of the surrounding waters as a result of frontal zones in the area (Crawford et al. 2007).
Submarine canyons (relative to surrounding slope) and steep walled troughs	The channeling and concentrating of detrital organic matter and pelagic animal populations leads to increased productivity and biodiversity in canyons. Increased heterogeneity in canyons responsible for enhancing benthic biodiversity and creating biomass hotspots.	De Leo et al. (2010), Vetter et al. (2010), Mackas et al. (2007)	Euphausiids (key forage species) aggregate along steep seabed slopes within and outside NSB, and are associated with the three troughs that cut across the shelf in the Queen Charlotte Sound. These areas are important for groundfish production (Clarke and Jamieson 2006b, Mackas et al. 2007).
Areas of upwelling	Upwelling rise of deep sea water to the surface bringing cold nutrient rich water to the surface. Nutrients brought up to the photic zone nourish the planktonic base of the food web. The influx of nutrients to the surface waters result in areas of high biological productivity.	Crawford et al. (2007), Roff and Zacharias (2011)	Upwelling can occur on large or local scales. Local-scale examples in BC include many BC passes where tidal currents are deflected upward by underwater ridges, shoals, and other bumps on the channel bottom (e.g., Seymour Narrows, Campbell River). Larger scale upwelling occurs off the west coast of Vancouver Island during summer but tends to be more intermittent and less well developed than the upwelling that occurs on the west coast of the United States (Thomson 1981).
Tidal passes and currents	Large tides of BC coast generate strong tidal currents, which dominate the surface flows and result in strong tidal mixing. Tidal and wind-driven mixing are significant factors in the supply of nutrients to the surface and oxygen to bottom waters over the continental shelf.	Crawford et al. (2007)	Areas of strong tidal mixing (e.g., over banks in Queen Charlotte Sound, shallow portions of Hecate Strait, around Cape St. James and Rose Spit in Northern Haida Gwaii and western end of Dixon Entrance (Crawford et al. 2007).

Feature	Justification	References	Examples
Eddies and plumes	Ecologically important features such as eddies or river plumes (and buoyancy currents) are formed by interactions between currents and coastal headlands and submarine canyons, or by the influx of fresh water. The changes in flow patterns that occur with these features can greatly influence upwelling of nutrients, with large associated impacts on phytoplankton and zooplankton retention and growth rates.	Crawford et al. (2007), Mackas et al. (2007), Andrews et al. (2013)	Many zooplankton species aggregate along environmental "edges," either hydrographic (e.g. the margins of the Fraser plume) or bathymetric (banks and shoals in the main basin, sills and lateral margins of both the main basin and adjoining inlets) (Levin et al. 2001). Haida Eddies transport large amounts of shelf water offshore, carrying with them freshwater and organisms, as well as high levels of iron and other trace elements normally depleted in the Alaskan gyre (Crawford et al. 2002, Mackas and Galbraith 2002, Crawford et al. 2007)
Non-tidal currents	Non-tidal currents include wind-driven, runoff/buoyancy driven, bathymetric steering currents. Tidal and wind-driven mixing can bring deeper, nutrient-rich water up to the surface where it is available to phytoplankton increasing productivity.	Crawford et al. (2007)	The central BC shelf region is dominated by a series of banks and troughs, which modify and steer the tidal and non-tidal flows (Crawford et al. 2007). Many of these bathymetric features and resulting currents aggregate zooplankton (Clarke and Jamieson 2006b, Mackas et al. 2007).
Marine areas influenced by freshwater discharges with high oxygen levels (climate refugia)	From Ban et al. 2016: "Low oxygen areas primarily resulting from upwelled oxygen-depleted waters are common and problematic in Canada's Pacific waters (Whitney et al. 2007). Waters with higher oxygen content from freshwater influence can counter the effects of oxygen depleted waters and provide some resilience. In addition, tidal mixing helps redistribute and oxygenate waters, countering impacts of anoxic upwelled water."	Ban et al. (2016)	Strait of Georgia, Haro Strait, Hecate Strait
Underwater banks (climate refugia)	From Ban et al. 2016: "Underwater banks have circulation processes that create retention areas (Boehlert and Genin 1987, Ladd et al. 2005, Rooper and Boldt 2005), and that circulation pattern – driven by bathymetry – is unlikely to change."	Ban et al. (2016)	Moresby and Goose Island Banks

Table 21. Objectives met by features or areas recommended as conservation priorities.

Category	Feature or Area Recommended as Conservation Priority	Obj. 1.1. Diversity and viability in changing environments	Obj. 1.3. Areas of high biological diversity	Obj. 1.4. Representative areas /habitats	Obj.1.6. Ecologically significant geological and oceanographic features
Physical Features	Areas of high habitat heterogeneity (ESBA – biodiversity)	-	x	-	x
	Frontal zones (ESBA – biodiversity)	-	x	-	x
	Submarine canyons (relative to surrounding slope) and steep walled troughs (ESBA – biodiversity)	-	x	-	x
	Areas of upwelling (EBSA – productivity)	-	-	-	x
	Tidal passes and currents (EBSA – biodiversity, productivity)	-	x	-	x
	Eddies and plumes (EBSA – productivity)	-	-	-	x
	Non-tidal currents (EBSA – productivity)	-	-	-	x
	Marine areas influenced by freshwater discharges with high oxygen levels (areas of climate resilience)	x	-	-	x
	Underwater banks (areas of climate resilience)	x	-	-	x
	Areas important for carbon sequestration/"blue carbon" (areas of climate resilience)	x	-	-	-
	Degraded areas	x	-	-	-
Ecological Classifications	Benthic ecological units from PMECS (Rubidge et al. 2016) and future classifications building on PMECS framework - Includes Biophysical Units, Geomorphological Units, Biotopes, and Biological Facies	-	x	x	-
	Benthic ecological units from BCMEC (Harper et al. 1993, Zacharias et al. 1998, AXYS Environmental Consulting Ltd. 2001)	-	-	x	-
	Pelagic ecological units from BCMEC	-	-	x	-
	Pelagic ecological units from Parks Canada Upper Ocean Subregions (BCMCA Project Team 2011)	-	-	x	-
	Shoreline ecological units from ShoreZone (Howes et al. 1994)	-	-	x	-
Modeled or measured areas	Areas of high species abundance, diversity or richness (for appropriate groups of species)	-	x	-	-

In marine systems, several biological and physical processes promote increased biodiversity. These processes are often linked to areas of high productivity, one of the CBD EBSA criteria (2008). Areas of high productivity are considered important for their role in fuelling ecosystems and increasing the growth rates of organisms and their capacity for reproduction. Areas of high productivity are often associated with geological or enduring/recurring oceanographic features (Clarke and Jamieson 2006b), and can be defined by spatial areas that contain species, populations, or communities with comparatively higher natural biological productivity.

Genetic diversity is an important consideration that must be assessed at the species level. Where available, species-specific areas of genetic diversity are being recommended as a type of spatial information used to represent species (see Table 18).

5.1.2 Areas of Climate Resilience

The impacts of climate change on marine organisms are complex and unprecedented (Brierley and Kingsford 2009, Pörtner et al. 2014). The many components of climate change, including rising temperatures, ocean acidification, de-oxygenation, sea level rise, and changes in circulation patterns, can act cumulatively and interactively, with complex results on ecosystems (Brierley and Kingsford 2009, Pörtner et al. 2014). Climate change acts on all levels of the ecological hierarchy (genes, individuals, populations, ecosystems, biomes) and will have direct and indirect impacts on all types of marine ecosystems (Brierley and Kingsford 2009, Pörtner et al. 2014).

Synergistically with fishery impacts, climate change is also expected to affect body sizes of fishes (Cheung et al. 2013) which likely will disrupt predator-prey relationships and other multispecies interactions (Scharf et al. 2000, Madin et al. 2016). Climate change, including warming temperatures and expanding hypoxia, will not affect all species uniformly; differences in functional and life-history traits will lead to re-organization of species relationships and community structure (Vaquer-Sunyer and Duarte 2008, Okey et al. 2014, Pörtner et al. 2014). The responses of species to some climate change components can be predicted with some confidence (e.g., ocean acidification on carbonate shells), but indirect or ecosystem effects are difficult to predict (e.g., changing trophic relationships and cascades due to northward expansion of predators; but also see Marzloff et al. 2016).

While MPAs cannot prevent climate change from progressing, environmental refugia or ‘‘habitats that components of biodiversity retreat to, persist in and can potentially expand from under changing environmental conditions’’ (Keppel et al. 2012), are beginning to be considered in the context of conservation planning (West and Salm 2003, Maina et al. 2015, Ban et al. 2016). Because climate change is occurring faster than most species can adapt, protecting areas that are experiencing less extreme climactic change may promote species’ persistence or recovery by reducing cumulative impacts, maintaining genetic and population diversity, and providing additional time for adaptation (Noss 2002, Game et al. 2008, Heller and Zavaleta 2009, Game et al. 2011). Green et al. (2014) suggest protecting areas with historically variable sea surface temperatures and ocean carbonate chemistry, where habitats and species are more likely to persist under changing environments in the future. They also highlight areas adjacent to undeveloped low-lying inland areas into which coastal habitats could expand as sea level rises (e.g., tidal marshes).

In addition to including climate change refugia identified in our region by Ban et al. (2016), a well-connected MPA network can aid in species’ resilience to climate change, by

1. reducing other stressors in the environment, and
2. protecting areas into which species’ ranges may shift in response to climate change.

Studies have shown that current threats such as habitat degradation, invasive species, and harvest pressure are undermining species' resilience in the face of climate change (e.g., Mackey et al. 2008) and therefore MPA networks play an important role in minimizing local threats (Green et al. 2014). Although network design elements, such as connectivity for climate resilience cannot necessarily be incorporated as an area-based CP, they are important to mention as they are integral to designing an effective MPA network. Areas that directly link to climate resilience are areas that provide an ecosystem service and contribute to sequestration of "blue carbon" (e.g., salt marshes, kelp forests) (McLeod et al. 2011). These areas will be captured as CPs as representative habitats using ecological classification systems (Section 5.2), and in some cases will be identified as species-based CPs under the habitat-forming criterion (Section 4.1.3, criterion 1.2.S4).

5.1.3 Degraded Areas

Degraded areas are those that are unable to carry out their ecosystem functioning such that key ecosystem components (such as ESS, see page 15) are unable to fulfil their ecological roles and functions (DFO 2007a). Degraded areas can also be areas that a "competent regulatory authority" has determined to be in need of rehabilitation (DFO 2007a). Because one of the long-term goals of MPAs is to restore ecosystem structure and function (but not necessarily to some "pristine" state), protection of degraded areas is the first step in a management plan to reduce further impacts.

In practice, identifying degraded areas is difficult, given that at some level, all ecosystems have been altered from their original state (Halpern et al. 2008b). Degraded areas have been recommended as CPs at the national level, but have yet to be identified regionally. A process to identify conservation objectives in Newfoundland (Placentia Bay-Grand Banks Large Ocean Management Area) deferred identification of degraded areas to "some other regulatory agency" (May 1-2, 2007; DFO 2007b) and ultimately, no degraded areas were identified. Stakeholders during that CSAS meeting emphasized that functionally, the entire management area is degraded from its natural state (DFO 2007b). While there are challenges identifying degraded areas at the bioregion scale, this CP may be tractable during finer-scale analyses (e.g., site selection at the sub-regional level). Maps of cumulative impacts in the Pacific region (e.g., Clarke Murray et al. 2015) could potentially be used to identify areas with high relative levels of impact that could be considered degraded.

5.2 REPRESENTATIVE HABITATS AND AREAS

Representativity (Objective 1.4; Table 1) is defined as "relatively intact, naturally functioning examples of the full range of ecosystems and habitat diversity found within a given planning area" (Canada – British Columbia Marine Protected Area Network Strategy 2014). Representativity has been identified as a key factor in network planning because it ensures consideration of species that may have otherwise been missed and accommodates changes in the system due to climate by covering a range of niches for species (IUCN-WCPA 2008, Ardron et al. 2010, Jessen et al. 2011, Roff and Zacharias 2011, Burt et al. 2014, Ardron et al. 2015, Rubidge et al. 2016). Protecting representative features, areas, and habitats also protects the range of biodiversity, including species and communities that occur in those habitats.

To achieve representativity in MPA networks, ecological classifications can be used to identify the types of habitats that occur at various spatial scales within the planning region (Rubidge et al. 2016). Several classification systems have been developed in the Pacific Region to represent different ecological patterns and processes. Following from the proposed design guidelines recommended by PacMARA (Lieberknecht et al. 2016), multiple classification systems can be used to achieve Objective 1.4 (Table 21). The BC Marine Ecological

Classification (BCMEC) includes five classification levels based on physical ocean properties, and includes both pelagic and benthic units at the finest two levels (Harper et al. 1993, Zacharias et al. 1998, AXYS Environmental Consulting Ltd. 2001). ShoreZone is an intertidal classification system that includes information on geological features and biological patterns of zonation (Howes et al. 1994). The Pacific Marine Ecological Classification System (PMECS; Rubidge et al. 2016) is a hierarchical classification system developed to represent biological patterns at multiple scales, from Realms to Microcommunities. Parks Canada has also developed Upper Ocean Subregions (BCMCA Project Team 2011) to represent biophysical patterns of pelagic habitats in BC. The benthic habitat template classification (Gregr et al. 2016), which integrates physical data relating to ecological processes to classify species' functional niches, may also be a useful biodiversity surrogate.

6 DISCUSSION

6.1 OVERVIEW

We developed a framework for identifying CPs for MPA networks and applied the framework to the NSB in British Columbia. The ultimate goal of this framework is to identify areas of high conservation value which warrant spatial protection, by recognizing the ecological importance and conservation needs of species and their habitats.

Species-based CPs were identified based on criteria that prioritize protection of vulnerable species, ecologically significant species, and those of conservation concern. We recommend 65 bony fishes and elasmobranchs, 23 marine mammals (including four Orca ecotypes), 1 sea turtle, 46 invertebrates, five plants and algae, and 55 marine bird species to be considered as CPs. A summary of scores by taxa is presented in Table 14, and the complete scores for each species are presented Table 22 (species other than marine birds) and Table 23 (marine birds). To guide the future collection of data for use in site selection analyses, for each species-based CP we recommend identifying IAs (including areas important for spawning, rearing, feeding, migrating, or aggregation), patterns of distribution and abundance, and areas of high or distinct genetic diversity.

Area-based CPs include 17 types of areas, spatial features, or habitats that support the network objectives, by contributing to ecosystem resilience, supporting restoration, or acting as surrogates for biodiversity. We identified seven types of physical features that are associated with productivity or high biodiversity, three features associated with climate resilience, and five ecological classifications. We also recommend identifying potential degraded areas in the NSB, and to explore modelled or measured areas of abundance, diversity, or richness for appropriate groups of organisms.

6.1.1 Distribution of Scores for Species-based CPs

Marine species (marine and coastal birds excluded)

There were differences in the numbers of high scores (*2*) given across criteria for species other than birds, which influenced the final list of species included as CPs (Table 14, Figure 5).

Vulnerability (1.1.S1) had the most "2" scores of any criterion, with 106 species having "high" to "very high" vulnerability to fishing, based on their life history characteristics. Vulnerability scores from FishBase/SeaLifeBase were available for all fish species, most marine mammal species, and only a portion of invertebrate species: the species for which vulnerability scores were not available were mostly invertebrates (crustaceans, echinoderms, molluscs, and others), as well as plants and algae, and one mammal (North Pacific Right Whale). Based on feedback from species experts at DFO, scores for marine mammals and invertebrates were refined. Vulnerability scores were ultimately given to all but 17 species, most of which were algae. Of those 17 species that did not receive a Vulnerability score, six were retained as CPs based on other criteria, seven received only "1" scores, and four received no score for any criteria.

Forty-six species were identified as upper-level predators (1.2.S1), including Sablefish, Pacific Cod, Arrowtooth Flounder, Albacore Tuna, several skates and rockfish, pelagic and demersal sharks, and marine mammals (16 species, including four Orca ecotypes). Four species of invertebrate (two sea stars and two cephalopods) were also identified as being upper-level predators within the invertebrate community. Identified important forage species (1.2.S.12) included nine species of fish, nine species of crustacean, six species of mollusc, non-crustacean zooplankton, and phytoplankton.

Nutrient transporting species (1.2.S3) had the fewest "2" scores, with seven species (five species of Pacific Salmon, Pacific Herring, and Eulachon) being identified. While migratory species fit this criterion in theory, there is little information on the nutrient transporting role of individual species. As such, most migratory species received scores of 1, while anadromous species that have well documented nutrient transporting roles (e.g., salmon) received scores of 2.

The 21 species that scored highly as habitat-forming species (1.4.S4) included corals, sponges, goose barnacles, California mussels, five species of clams and cockles, two species of large kelp, seagrasses, and ghost shrimp. Because of a lack of published species-specific information regarding habitat creation, scores for many of the habitat-forming species were assigned through consultation with species experts.

Conservation Concern (1.5.S1) had the most "Insufficient Information" (*) scores of any criterion, with 100 species having no ranking among the seven lists of species at risk referenced. Two species of echinoderm were identified by experts as being of concern due to disease and were given scores of 1. Of the remaining 98 species lacking information on conservation status, 45 were fishes or elasmobranchs, 44 were invertebrates, and nine were plants or algae.

There were 38 species that received "1" or "1*" scores but no "2" scores. These were mostly species considered less vulnerable to disturbance (1.1.S1), mesopredators based on their size and trophic levels (1.2.S1), or species which did not meet all the criteria for forage species (1.2.S.2). A total of 13 species did not score for any criteria (three fishes, seven invertebrates, and three plants or algae).

Marine and Coastal Birds

Most of the candidate bird species are identified in ECCC Bird Conservation Region 5 (BCR 5) Conservation Plan (Environment Canada 2013) as priority species for marine or coastal habitats (70 of 80 species). For the remaining species, the NSB is an important migratory stopover or an important foraging area.

Thirty-one species received a CP score of *2* because of either conservation concern (n=14) or high jurisdictional responsibility given the percent of the global population breeding in Canada (n=17). Twenty-four species received a CP score of *1*, either because they were identified as a priority species for BCR 5 marine or coastal habitat and there is conservation concern (n=12); because they were identified as a priority species in BCR 5 marine or coastal habitat (with no conservation concern) (n=8); because there is conservation concern for the species (but it is not a priority species in BCR 5 marine or coastal habitat) (n=2); or because experts identified the NSB as an important area of their range (n=2). Twenty-five species received a CP score of *0*. Nine of these species have some conservation concern and 14 species are identified as priority species in BCR 5 marine or coastal habitat (so originally assigned a score of *1*), but experts reduced the overall CP score to *0* either because of low occurrence in the NSB, or conversely because they are common in the NSB. Two species were included because the NSB provides important habitat during the non-breeding season.

The 80 candidate species selected for this framework can be classified as seabirds (32 species); ducks, geese, herons, and grebes (28 species); shorebirds (11 species); and one falcon.

Of the 32 seabirds, 14 received a CP score of *2* (mostly due to high conservation concern and high jurisdictional responsibility), 14 had a CP score of *1* (mostly because there is some conservation concern or they are a priority species for BCR 5 marine or coastal habitat), and 4 had a CP score of *0* (primarily due to low occurrence in the NSB).

Of the 28 ducks, geese, herons, and grebes, seven had a CP score of *2* (mostly due to high conservation concern and high jurisdictional responsibility), six had a CP score of *1* (mostly because there is some conservation concern or they are a priority species for BCR 5 marine or coastal habitat), 15 had a CP score of *0* (primarily due to low occurrence in the NSB or because they are common throughout the NSB).

Of the 19 shorebirds, 10 received a CP score of *2* (primarily because of high jurisdictional responsibility though a couple have high conservation concern), four had a CP score of *1* (mostly because there is some conservation concern though they are all priority species for BCR 5 marine or coastal habitat), and five had a CP score of *0* (because there is either low occurrence in the NSB, or they are common in the NSB or the NSB is an important migratory stop-over area).

The falcon was assigned a CP score of *0* because although there is some conservation concern and it is a priority species for BCR 5 marine or coastal habitat, it is less reliant on the NSB compared to some of the bird species on our list.

6.2 COMPARISONS WITH OTHER PROCESSES

Other regions in Canada are developing conservation plans for MPAs and Large Ocean Management Areas. The specific conservation objectives and priorities in those processes vary due to differences in species and ecosystems present on the Atlantic and Pacific coasts, but the general priorities are similar. Depleted or at risk species, IAs and EBSAs have been identified in Newfoundland, the Gulf of St. Lawrence, and the Maritimes, and Ecologically Significant Species have been identified in Newfoundland and the Gulf of St. Lawrence (King et al. 2013, DFO 2014, Faille et al. unpublished[4]). The utility of ecological classifications to represent the range of species and habitats has also been consistently recognized as a tool to account for limited species-specific information (BCMCA Project Team 2011, King et al. 2013, DFO 2014, Faille et al. unpublished[4]).

In BC, a comprehensive process to identify priority conservation features in BC was undertaken by the BC Marine Conservation Analysis (BCMCA) through a series of expert workshops and analyses (BCMCA Project Team 2011). In a risk assessment for PNCIMA, Clarke Murray et al. (2016) identified a small number (n=17) of pilot priority species based on data availability. The CPs identified here include all species from Clarke Murray et al. (2016), and are broadly in agreement with the BCMCA results, described below.

Important plants and algae species recognized here and in BCMCA include large kelps (bull, giant, and feather boa kelp), eelgrass, surfgrass, and salt marshes and marsh plants (BCMCA Project Team 2008a). BCMCA also prioritized rare algae species and dune plants; while we do not focus on these species, we anticipate that they will be captured under the recommended ecological classifications such as ShoreZone. Both this work and BCMCA identify all regularly occurring cetaceans, pinnipeds, and marine mustelids (sea otters) as priorities (BCMCA Project Team 2008b). Unlike BCMCA, however, we have excluded False Killer Whale and all beaked whales due to their rarity in NSB.

We scored potential CPs at the lowest taxonomic level possible to highlight their individual ecological roles and distributions, and to focus data collection efforts. Most of the species-level CPs are bony fishes (65 species), many of which are commercially important, while the 46 invertebrate CPs include some higher-level taxa. BCMCA generally did not identify fishes or invertebrates at the species level due to concerns about lack of data for many non-commercial species (BCMCA Project Team 2008c, 2008d). Instead, they focused on habitat surrogates, including areas that support important life history stages (i.e., IAs for spawning, rearing, and migrations, including identified critical habitat) and more easily mappable geological or oceanographic features such as areas of high productivity or strong currents, estuaries, and rocky reefs (BCMCA Project Team 2008d). We have recommended all of these features, as well as several ecological classifications, as CPs to represent the range and diversity of species and habitats in the planning area.

BCMCA identifies a number of foundation (habitat-forming) invertebrate species, some of which (glass sponges, cold-water corals, some bivalves) are also identified here (BCMCA Project Team 2008c). Other foundation species identified by BCMCA were not scored in the context of habitat formation (e.g., tubeworms, barnacles, and brittle stars). Considerations of scale are important when identifying species that increase biodiversity or provide habitat; some species, such as brittle stars, may form fine-scale local habitat, but their overall influence on biodiversity is likely less than that of large foundation species such as reef-forming sponges.

There is broad agreement between the CPs identified here and the BCMCA process. While the level of specificity differs from some of the BCMCA recommendations, the combination of physical ocean features, ecological classifications, and known important areas recommended here should represent the majority of important species, habitats, and features present in the NSB.

6.2.1 Number of Features

We have recommended 195 species-based and 17 area-based CPs, each of which will potentially be represented by multiple spatial features (Table 18). This is roughly in line with the number of spatial features used by BCMCA (169 in site-selection analysis, with another 150 recommended but with insufficient data; BCMCA 2012). A recent analysis in DFO Maritimes Region[10] used units from two ecological classifications, five modelled areas of diversity, 23 functional groups, 14 foundation species, and 20 species at risk (DFO 2018). Conservation processes in the United Kingdom have identified around 20–40 habitat types and up to 90 species (UKBAP 2008, Howson et al. 2012). The final number of features used in site selection analyses will depend on data availability and decisions made during the design strategies process.

6.3 INTERPRETATION OF SCORES

Species-based CPs were identified based on criteria reflecting vulnerability, ecological importance, and conservation concern (Table 22). The scores assigned under this framework

[10] King, M., Gerhartz Abraham, A., Koropatnick, T., Pardy, G., Serdynska, A., Will, E., Breeze, H., Bundy, A., Edmondson, E., Allard, K. 2016. Design Strategies for the Scotian Shelf Bioregional Marine Protected Area Network. DFO Can. Sci. Advis. Sec. Working Paper.

are intended to guide understanding of the different species' ecological roles and conservation needs. The scores should be interpreted with an understanding of their context and should not be used as the only information for prioritizing species in the MPA network design. Any method used to combine or rank scores may not be appropriate for all uses. For example, a high simple additive score (calculated by adding the scores across all criteria for a species) would indicate that the species fits multiple criteria, but may not fully capture the importance of that species under a single criterion. Under a simple additive score, species that are very important under only one criterion would rank lower than species that are moderately important under several criteria. Furthermore, some of the criteria are not independent and are potentially correlated. For example, both Vulnerability and Conservation Concern take population size into account, and formal listings of Conservation Concern may be biased towards large-bodied species that may be more likely to be predators. As such, we do not recommend using additive scores to rank species-based CPs. Similar considerations would have to be taken into account for other methods of combining scores and ranking species. Figure 6 shows the overlap in scores for different criteria among species, and Figure 7 shows an alternative method for understanding the distribution of scores across species.

6.4 UNCERTAINTY IN SCORING

We could not always assign scores to some species and criteria due to a lack of published information. In particular, published information on vulnerability and conservation status of invertebrates was lacking. We also experienced difficulty in assigning scores based on documented ecological effects of predator-prey interactions, as this process generally biased the results towards well-studied species. Information specific to BC was often not available for many species, requiring the use of information from California or Alaska. However, because BC is a biogeographic transition zone between the California Current Ecosystem to the south and the Alaska Current Ecosystem to the north (Lucas et al. 2007), there may be differences in the community structure and environmental conditions among areas that may make it difficult to generalize species' roles. The review and revision of scores by species experts filled some of these knowledge gaps by assigning scores for invertebrate vulnerability and ecological role, although most invertebrates remained data deficient (*) regarding conservation concern. Future applications of this framework should begin with a search for updates to species' conservation status and determine if new information is available to assess the other criteria.

6.5 SUFFICIENCY AND REPRESENTATIVITY OF IDENTIFIED CPS

By developing and applying evaluation criteria specific to the network objectives, we have identified a comprehensive suite of CPs that is relevant to the MPA network planning process in the NSB. Although it is possible that some ecologically important features were missed, the species, habitats, and areas identified here should act as surrogates to capture the range of ecological features that occur in the NSB. While features for species screened out as CPs will not be used as inputs in site selection analyses, they will not be "excluded" from the MPA network. Rather, their habitats are expected to be spatially represented through areas of importance shared with other species, or through ecological classifications. Affording spatial protection measures to the most at-risk species based on their population trends and ongoing threats (1.5.S1) and ability to recover (1.1.S1) should also protect other less-vulnerable species. Protecting species that have at-risk populations and are the most vulnerable to disturbance (e.g., to habitat loss or resource limitation) can provide protection to co-occurring species with similar or less intense conservation requirements (Lambeck 1997).

The inclusion of ecological classifications incorporating representative habitats and communities at multiple spatial scales (Objective 1.4) should also ensure that important species and features are being captured in the network, even if they have not been explicitly identified as CPs. Several ecological classifications are recommended (Table 20) under the representativity criterion (1.4.A1) to capture the range of habitats that occur in NSB. One important unit under the PMECS classification system are the *biological facies,* which include biogenic habitats with key indicator species that act as surrogates for associated communities and species (Rubidge et al. 2016). The indicator species for some of those biological facies have been identified as species-level CPs, including eelgrass, kelp, and sponges that form beds, aggregations, reefs, and other structures that form patches of habitats that can be mapped. Areas of high density (Table 18) for these habitat-forming species can be used to represent the *biological facies* component of the PMECS classification.

We identified and described species- and area-based CPs separately. Because all CPs must ultimately be presented spatially to be included in the network, we recommended several types of spatial features (Table 18) including IAs to represent species-based CPs. In some cases, IAs for species-based CPs will mirror or duplicate priorities identified in the area-based CPs. These areas would not need to be included multiple times during site selection, but rather should be highlighted as areas that meet multiple network objectives and may have broad ecological importance.

7 NEXT STEPS

7.1 SPATIAL DATA AVAILABILITY

Ecological CPs were identified based on the best available information relevant to the proposed framework, without consideration of the availability of data that will be needed to represent those features in the MPA network. Future work will focus on spatial data collection to represent CPs in the MPA network site selection process. Information, including spatial data layers, from experts, communities, stakeholders, governments, First Nations, local knowledge holders, and other sources, will be assessed for use in site selection analyses. For some CPs the data needed to develop the recommended spatial features may not currently be available, which will preclude those CPs from being included in site selection analyses. Specific methods for integrating data into site selection analyses have not been determined.

While some conservation planning processes exclude CPs at the identification stage based on data availability (e.g., BCMCA Project Team 2008c, 2008d, Howson et al. 2012), this can lead to a bias towards well-studied groups. We present the full list to ensure that the ecological importance of all CPs is documented, rather than constraining future processes based on the present state of data. This document provides rationale for future data collection and will aid in identification of data and research gaps. Adaptive management of the MPA network may allow data-limited CPs to be included in the future.

7.2 NON-ECOLOGICAL CONSERVATION PRIORITIES

Non-ecological CPs will be identified using other methods prior to data collection and site selection analyses. MPATT is coordinating with First Nations partners to identify cultural CPs and is developing a strategy to work with agencies and industries that have mandates relating to economics, tourism, and recreation, to identify relevant CPs.

Objectives 2.1, 2.2 and 2.3 refer to the importance of conserving fishery resources. We did not develop species-based CPs for these objectives because the determination of species important for fisheries is a socio-economic and/or cultural consideration. Priority commercial, recreational, and Aboriginal fisheries will be identified at a later date in collaboration with other partners in the MPA network planning process. However, maintenance of species' population size, structure, and viability has an ecological basis. Spatial protection of IAs that support species' life history stages (Clark and Jamieson 2006; Objective 1.7) for fishery species, in addition to fisheries management measures, will help the MPA network meet these objectives.

7.3 DESIGN STRATEGIES

The list of CPs will be used in the development of design strategies for MPA network design. Design strategies will describe how CPs will be spatially incorporated into the network, and will include specific area-based targets to be used in site selection analyses. During the development of design strategies, further prioritization of CPs may occur for socio-economic, cultural, or practical reasons. For example, species identified at a later date to be important cultural CPs may also have high ecological significance and may warrant higher spatial targets. Conversely, targets may not be set for CPs for which no data is available (see Section 7.1). Additional considerations in determining design strategies may relate to the amenability of species to spatial management. Because of differences in mobility, home range, and migratory or aggregating behaviours, all species may not respond equally to spatial protection and may not be suitable for area-based targets. Other measures, such as existing fisheries management tools, may be more appropriate for some species. Methods for determining design strategies, including targets, are under development and have not been finalized.

7.4 DESIGN SCENARIOS

Design scenarios for potential locations for the NSB MPA network will incorporate all stages of the planning process (Figure 2). MARXAN, a decision support tool for marine planning, will be used to identify areas of high conservation value while maximizing potential benefits, and minimizing potential costs. The socio-economic and cultural impacts of the various scenarios will also be assessed. Methods for determining design scenarios are under development and have not been finalized.

7.5 FUTURE APPLICATION OF FRAMEWORK

This document represents CPs at the scale of the NSB and may not reflect finer-scale sub-regional ecological processes and priorities. Using the methods outlined in this paper, identification of CPs can be carried out at the sub-regional level. Some bioregion-scale CPs may not be important (or may not occur) in smaller areas. Conversely, analysis across the sub-regions may reveal broadly important bioregion-scale CPs.

The evaluation framework presented here can also be used to assess if additional species should be considered CPs. For example, future spatial planning processes may identify species that are becoming more common in the NSB or BC (e.g., due to climate change and shifting ranges) and that may have important ecological roles that should be recognized in adaptively managing the MPA network. Additional criteria can also be added in future iterations if management objectives change.

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9 ACRONYMS

ANZECC	Australian and New Zealand Environment and Conservation Council
BC	British Columbia
BCCDC	British Columbia Conservation Data Centre
BCMCA	British Columbia Marine Conservation Analysis
BCR	Bird Conservation Region
BRIG	Biodiversity Reporting and Information Group
CBD	Convention on Biological Diversity
CDFG	California Department of Fish and Game
CESCC	Canadian Endangered Species Conservation Council
CITES	Convention on International Trade in Endangered Species of Wild Fauna & Flora
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CP	Conservation Priority
DFO	Fisheries and Oceans Canada (formerly Department of Fisheries and Oceans)
EBSA	Ecologically and Biologically Significant Areas
ESS	Ecologically Significant Species
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
MAPP	Marine Plan Partnership
MPA	Marine Protected Area
MPATT	Marine Protected Area Technical Team
NSB	Northern Shelf Bioregion
PacMARA	Pacific Marine Analysis and Research Association
PMECS	Pacific Marine Ecological Classification System
PNCIMA	Pacific North Coast Integrated Management Area
SARA	Species At Risk Act
VEC	Valued Ecosystem Component
VBGF	Von Bertalanffy growth function

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APPENDIX 1: SPECIES SCORES

*Table 22. Scores for species, except birds. Trophic level and maximum size, and vulnerability category obtained from FishBase or SeaLifeBase. Vulnerability categories are L, Low; M, Moderate; H, High; VH, Very High; L-M, M-H, and H-VH indicate intermediate scores. * Under Trophic Level indicates that the estimated trophic level from FishBase is inconsistent with what is known of the life history of that species, or which was based on smaller/younger individuals that had yet to undergo size-based ontogenetic diet shifts that would give them a higher trophic level score. An average value was calculated if more than one trophic level value was reported on FishBase or SeaLifeBase (e.g., a range or two values). Scores under 1.1. to 1.5. reflect the scoring schemes described in section 4.1.3. CC: Conservation Concern. Recommended CPs are those that received scores of 2 for any of criteria 1.1 to 1.5. or which received scores of 1 or 2 under 1.5.*

Higher Group	Species Group	Common Name	Scientific Name	Trophic Level	Max Size (cm; Total or standard length); fish only	Vulnerability Category	1.1.S1. Vulnerable Species	1.2.S1. Upper-level Predators	1.2.S2. Forage Species	1.2.S3. Nutrient Transporting Species	1.2.S4. Habitat-forming Species	1.5.S1 Any CC	Global CC	National CC	Regional CC	Recommended CP
Bony Fishes	Flatfish	Arrowtooth	*Atheresthes stomias*	4.2	84	H	2	2	-	*	-	*	*	*	*	X
		Butter Sole	*Isopsetta isolepis*	3.6	55	L-M	0	1	-	*	-	*	*	*	*	-
		Dover Sole	*Microstomus pacificus*	3.2	76	H-VH	2	1	-	*	-	*	*	*	*	X
		English Sole	*Parophrys vetulus*	3.4	57	M	1	1	-	*	-	*	*	*	*	-
		Flathead Sole	*Hippoglossoides elassodon*	3.7	52	M	1	0	-	*	-	*	*	*	*	-
		Pacific Halibut	*Hippoglossus stenolepis*	4.1	267	VH	2	2	-	1	-	*	*	*	*	X
		Pacific Sanddab	*Citharichthys sordidus*	3.5	41	L-M	0	0	-	*	-	*	*	*	*	-
		Petrale Sole	*Eopsetta jordani*	4.1	70	H	2	1	-	0	-	0	0	*	*	X
		Rex Sole	*Glyptocephalus zachirus*	3.3	60	H	2	1	-	0	-	*	*	*	*	X
		Rock Sole	*Lepidopsetta bilineata*	3.2	60	H	2	1	-	0	-	*	*	*	*	X
		Sand Sole	*Psettichthys melanostictus*	4.1	63	M	1	1	-	0	-	*	*	*	*	-
		Slender Sole	*Lyopsetta exilis*	3.5	35	M-H	1	0	-	*	-	0	0	*	*	-
		Speckled Sanddab	*Citharichthys stigmaeus*	3.4	17	L	0	0	-	*	-	*	*	*	*	-
		Starry Flounder	*Platichthys stellatus*	3.6	91	M-H	1	1	-	*	-	0	0	*	*	-
	Forage Fishes	Capelin	*Mallotus villosus*	3.2	25.2	L	0	0	2	*	-	0	0	*	*	X
		Eulachon	*Thaleichthys pacificus*	3.3	34	L-M	0	0	2	2	-	2	0	2	2	X
		Longfin Smelt	*Spirinchus thaleichthys*	3.2	20	L-M	0	0	1*	1*	-	0	0	*	*	-
		Northern Anchovy	*Engraulis mordax*	3.1	24.8	L-M	0	0	1*	*	-	0	0	*	*	-
		Pacific Herring	*Clupea pallasii*	3.2	46	L-M	0	0	2	2	-	*	*	*	*	X

Higher Group	Species Group	Common Name	Scientific Name	Trophic Level	Max Size (cm; Total or standard length); fish only	Vulnerability Category	1.1.S1. Vulnerable Species	1.2.S1. Upper-level Predators	1.2.S2. Forage Species	1.2.S3. Nutrient Transporting Species	1.2.S4. Habitat-forming Species	1.5.S1 Any CC	Global CC	National CC	Regional CC	Recommended CP
Bony Fishes (cont'd)	Forage Fishes (cont'd)	Pacific Sand Lance	*Ammodytes hexapterus*	3.1	30	L-M	0	0	2	0	-	*	*	*	*	X
		Pacific Sardine	*Sardinops sagax*	2.8	39.5	L-M	0	0	1*	1	-	1	*	1	*	X
		Pacific Saury	*Cololabis saira*	3.7	40	L-M	0	0	1*	1*	-	*	*	*	*	-
		Surf Smelt	*Hypomesus pretiosus*	3.4	30.5	L-M	0	0	2	*	-	0	0	*	*	X
	Groundfishes	Cabezon	*Scorpaenichthys marmoratus*	3.6	99	M	1	1	-	0	-	*	*	*	*	-
		Kelp Greenling	*Hexagrammos decagrammus*	3.6	61	M-H	1	0	-	0	-	*	*	*	*	-
		Lingcod	*Ophiodon elongatus*	4.3	152	H	2	2	-	*	-	*	*	*	*	X
		Northern Ronquil	*Ronquilus jordani*	3.1	20	L	0	0	-	*	-	0	0	*	*	-
		Pacific Sandfish	*Trichodon trichodon*	4.0	30.5	L-M	0	0	1	*	*	*	*	*	*	-
		Prowfish	*Zaprora silenus*	3.7	88	M-H	1	1	-	*	-	0	0	*	*	-
		Sablefish	*Anoplopoma fimbria*	3.8*	120	H	2	2	-	1	-	*	*	*	*	X
		Wolf-eel	*Anarrhichthys ocellatus*	3.5	240	VH	2	1	-	*	-	0	0	*	*	X
	Mesopelagic fishes	Northern Lampfish	*Stenobrachius leucopsarus*	3.1	13	L-M	0	0	2	*	-	*	*	*	*	X
		Northern Smoothtongue	*Leuroglossus schmidti*	3.1	20	M-H	1	0	2	*	-	*	*	*	*	X
	Native Salmonids	Chinook Salmon	*Oncorhynchus tshawytscha*	4.4	150	H-VH	2	2	1	2	-	0	*	0	0	X
		Chum Salmon	*Oncorhynchus keta*	3.7	100	M-H	1	1	1	2	-	0	*	0	0	X
		Coho Salmon	*Oncorhynchus kisutch*	4.2	108	M-H	1	2	1	2	-	0	*	0	0	X
		Cutthroat Trout	*Oncorhynchus clarkii*	3.8	99	M	1	2	1*	1	-	0	*	0	0	X
		Pink Salmon	*Oncorhynchus gorbuscha*	4.5	76	M	1	1	1*	2	-	0	*	0	0	X
		Sockeye Salmon	*Oncorhynchus nerka*	3.6	84	L-M	0	1	1	2	-	0	0	0	0	X
		Steelhead	*Oncorhynchus mykiss*	4.1	122	M	1	2	1*	1	-	0	*	0	0	X
		Dolly Varden	*Salvelinus malma lordi*	4.4	127	H-VH	2	2	*	*	-	*	*	*	*	X
	Pelagic Fishes	Albacore Tuna	*Thunnus alalunga*	4.3	140	H	2	2	-	1	-	1	1	*	*	X
		Jack Mackerel	*Trachurus symmetricus*	3.6	81	L-M	0	1	1*	1	-	0	0	*	*	-
		Ocean Sunfish	*Mola mola*	3.7	333	VH	2	1	-	1	-	2	2	*	*	X
		Pacific Chub Mackerel	*Scomber japonicus*	3.4	64	L-M	0	1	1*	1*	-	0	0	*	*	-
		Pacific Pomfret	*Brama japonica*	4.4	61	M	1	1	-	1*	-	*	*	*	*	-

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Bony Fishes (cont'd)	Rockfishes	Black Rockfish	*Sebastes melanops*	4.4	63	H-VH	2	1	1*	*	-	*	*	*	*	X
		Blackspotted Rockfish	*Sebastes melanostictus*	3.9	54	H-VH	2	2	1*	*	-	1	*	1	*	X
		Bocaccio	*Sebastes paucispinis*	3.5*	91	H	2	2	1*	*	-	2	2	2	*	X
		Canary Rockfish	*Sebastes pinniger*	3.8	76	H	2	1	1*	*	-	2	*	2	*	X
		China Rockfish	*Sebastes nebulosus*	3.9	45	H	2	0	1*	0	-	*	*	*	*	X
		Copper Rockfish	*Sebastes caurinus*	4.1	58	H	2	1	1*	0	-	*	*	*	*	X
		Darkblotched Rockfish	*Sebastes crameri*	3.8	58	H-VH	2	1	1*	*	-	1	*	1	*	X
		Dusky Rockfish	*Sebastes variabilis*	3.8	43.1	M-H	1	0	1*	*	-	*	*	*	*	-
		Greenstriped Rockfish	*Sebastes elongatus*	3.7	39	H	2	0	1*	*	-	*	*	*	*	X
		Pacific Ocean Perch	*Sebastes alutus*	3.5	53	H	2	0	1*	0	-	*	*	*	*	X
		Quillback Rockfish	*Sebastes maliger*	3.8	61	H	2	1	1*	0	-	2	*	2	*	X
		Redbanded Rockfish	*Sebastes babcocki*	3.8	64	M-H	1	1	1*	*	-	*	*	*	*	-
		Redstripe Rockfish	*Sebastes proriger*	3.8	61	H	2	1	1*	*	-	*	*	*	*	X
		Rosethorn Rockfish	*Sebastes helvomaculatus*	3.7	41	H-VH	2	0	1*	*	-	*	*	*	*	X
		Rougheye Rockfish	*Sebastes aleutianus*	3.5*	97	H-VH	2	2	1*	*	-	1	*	1	*	X
		Sharpchin Rockfish	*Sebastes zacentrus*	3.7	39	M-H	1	0	1*	*	-	*	*	*	*	-
		Shortraker Rockfish	*Sebastes borealis*	4.3	108	H-VH	2	2	1*	*	-	*	*	*	*	X
		Silvergray Rockfish	*Sebastes brevispinis*	3.8	71	H-VH	2	1	1*	*	-	*	*	*	*	X
		Tiger Rockfish	*Sebastes nigrocinctus*	3.5	61	H-VH	2	1	1*	*	-	*	*	*	*	X
		Vermilion Rockfish	*Sebastes miniatus*	3.9	91	H	2	1	1*	*	-	*	*	*	*	X
		Widow Rockfish	*Sebastes entomelas*	3.7	60	H	2	1	1*	*	-	*	*	*	*	X
		Yelloweye Rockfish	*Sebastes ruberrimus*	4.4	104	H-VH	2	2	1*	*	-	1	*	1	*	X
		Yellowmouth Rockfish	*Sebastes reedi*	3.8	58	H	2	1	1*	*	-	2	*	2	*	X
		Yellowtail Rockfish	*Sebastes flavidus*	4.2	66	H	2	1	1*	*	-	*	*	*	*	X
		Longspine Thornyhead	*Sebastolobus altivelis*	3.3	39	H	2	0	1*	0	-	1	*	1	*	X
		Shortspine Thornyhead	*Sebastolobus alascanus*	3.6	80	H-VH	2	1	1*	0	-	2	2	*	*	X

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Bony Fishes (cont'd)	Roundfishes	Pacific Cod	*Gadus macrocephalus*	4.2	119	M-H	1	2	0	0	-	*	*	*	*	X
		Pacific Hake	*Merluccius productus*	4.4	91	H	2	2	1	1	-	0	0	*	*	X
		Pacific Tomcod	*Microgadus proximus*	3.6	30.5	L-M	0	0	1*	*	-	0	0	*	*	-
		Walleye Pollock	*Theragra chalcogramma*	3.6	91	M-H	1	2	2	*	-	*	*	*	*	X
	Sturgeons	Green Sturgeon	*Acipenser medirostris*	3.5	270	VH	2	1	-	1	-	2	1	1	2	X
	Surfperches	Kelp Perch	*Brachyistius frenatus*	3.5	22	L	0	0	1*	*	-	*	*	*	*	-
		Pile Perch	*Rhacochilus vacca*	3.4	44	L-M	0	0	1*	*	-	0	0	*	*	-
		Shiner perch	*Cymatogaster aggregata*	3.0	20	L	0	0	2	*	-	0	0	*	*	X
		Striped Seaperch	*Embiotoca lateralis*	3.3	38	M	1	0	1*	*	-	*	*	*	*	-
Elasmobranchs	Demersal sharks	Brown Cat Shark	*Apristurus brunneus*	3.6	69	M-H	1	1	-	*	-	*	*	*	*	-
		Bluntnose Sixgill Shark	*Hexanchus griseus*	4.5	482	VH	2	2	-	0	-	1	1	1	*	X
		Pacific Sleeper Shark	*Somniosus pacificus*	4.4	430	VH	2	2	-	*	-	*	*	*	*	X
		Spiny Dogfish	*Squalus suckleyi*	4.4	130	H-VH	2	2	-	1	-	1	0	1	*	X
	Pelagic Sharks	Basking Shark	*Cetorhinus maximus*	3.2	1520	VH	2	1	-	1	-	2	2	2	*	X
		Blue Shark	*Prionace glauca*	4.4	400	VH	2	2	-	1	-	1	1	*	*	X
		Salmon Shark	*Lamna ditropis*	4.5	305	H	2	2	-	1	-	0	0	*	*	X
	Skates	Big Skate	*Raja binoculata*	3.9	244	VH	2	2	-	0	-	1	1	*	*	X
		Longnose Skate	*Raja rhina*	4.0	180	VH	2	2	-	*	-	0	0	*	*	X
		Roughtail Skate	*Bathyraja trachura*	4.0	91	H-VH	2	2	-	*	-	0	0	*	*	X
		Sandpaper skate	*Bathyraja interrupta*	3.4	86	H	2	1	-	*	-	0	0	*	*	X
Marine Mammals	Dolphins and Porpoises	Dall's Porpoise	*Phocoenoides dalli*	4.5	*	M	2	2	-	0	-	0	0	0	0	X
		Harbour Porpoise	*Phocoena phocoena*	4.5	-	M	2	2	-	0	-	1	0	1	1	X
		N. Right Whale Dolphin	*Lissodelphis borealis*	*	-	VH	2	0	-	1	-	0	0	0	0	X
		Pacific White-sided Dolphin	*Lagenorhynchus obliquidens*	*	-	M	2	2	-	1	-	0	0	0	0	X
		Risso's Dolphin	*Grampus griseus*	4.4	-	M	2	2	-	1	-	0	0	*	0	X

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Marine Mammals (cont'd)	Orcas	Northern Resident Orca	*Orcinus orca*	4.6	-	H-VH	2	2	-	1	-	2	*	2	2	X
		Offshore Population Orca	*Orcinus orca*	4.6	-	H-VH	2	2	-	1	-	2	*	2	2	X
		Southern Resident Orca	*Orcinus orca*	4.6	-	H-VH	2	2	-	1	-	2	*	2	2	X
		Transient Orca	*Orcinus orca*	4.6	-	H-VH	2	2	-	1	-	2	*	2	2	X
	Pinnipeds	California Sea Lion	*Zalophus californianus*	4.5	-	VH	2	2	-	1	-	0	0	0	0	X
		Harbour Seal	*Phoca vitulina*	4.5	-	H	2	2	-	0	-	0	0	0	0	X
		Northern Elephant Seal	*Mirounga angustirostris*	*	-	VH	2	2	-	1	-	2	0	0	2	X
		Northern Fur Seal	*Callorhinus ursinus*	4.5	-	M-H	2	2	-	1	-	2	2	2	2	X
		Steller Sea Lion	*Eumetopias jubatus*	4.4	-	H	2	2	-	1	-	1	1	1	1	X
	Sea otters	Sea Otter	*Enhydra lutris*	3.9	-	M-H	2	2	-	0	-	2	2	1	1	X
	Whales	Blue Whale	*Balaenoptera musculus*	3.3	-	VH	2	0	-	1	-	2	2	2	2	X
		Common Minke Whale	*Balaenoptera acutorostrata*	4.3	-	H	2	2	-	1	-	0	0	0	0	X
		Fin Whale	*Balaenoptera physalus*	4.0	-	VH	2	0	-	1	-	2	2	2	2	X
		Grey Whale	*Eschrichtius robustus*	3.3	-	H	2	1	-	1	-	1	0	1	1	X
		Humpback Whale	*Megaptera novaeangliae*	3.9	-	H	2	1	-	1	-	2	0	2	1	X
		North Pacific Right Whale	*Eubalaena japonica*	*	*	-	2	0	-	1	-	2	2	2	2	X
		Sei Whale	*Balaenoptera borealis*	4.0	-	VH	2	0	-	1	-	2	2	2	2	X
		Sperm Whale	*Physeter macrocephalus*	4.5	-	H	2	2	-	1	-	2	2	*	1	X
Reptiles	Turtles	Leatherback	*Dermochelys coriacea*	*	*	VH	2	1	-	1	-	2	2	2	2	X
Cnidarians	Cold-water corals	Black Corals	Antipatharia	*	*	-	2	0	0	0	2	-	-	-	-	X
		Hard or Stony Corals	Scleractinia	*	-	-	2	0	0	0	2	-	-	-	-	X
		Sea Pens	Pennatulacea	*	*	-	2	0	0	0	2	-	-	-	-	X
		Soft Corals	Alcyonacea	*	-	-	2	0	0	0	2	-	-	-	-	X
Crustaceans	Barnacles	Goose Barnacle	*Pollicipes polymerus*	*	-	-	1	0	1	0	2	*	*	*	*	X
	Crabs	Brown Box Crab	*Lopholithodes foraminatus*	*	-	-	*	0	0	0	0	*	*	*	*	-
		Deepwater Grooved Tanner Crab	*Chionoecetes tanneri*	*	-	-	2	0	0	0	0	*	*	*	*	X
		Dungeness Crab	*Metacarcinus magister*	4.0*	-	-	2	1	0	0	0	*	*	*	*	X

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Crustaceans (cont'd)	Crabs (cont'd)	Inshore Tanner crab	*Chionoecetes bairdi*	3.2	-	-	2	0	0	0	0	*	*	*	*	X
		Puget Sound King Crab	*Lopholithodes mandtii*	*	-	-	2	0	0	0	0	*	*	*	*	X
		Red King Crab	*Paralithodes camtschaticus*	3.8	-	L	0	0	0	0	0	*	*	*	*	-
		Red Rock Crab	*Cancer productus*	3.3	-	L	1	1	0	0	0	*	*	*	*	-
	Shrimps	Bay Ghost Shrimp	*Neotrypaea californiensis*	2.4	-	-	0	0	0	0	2	*	*	*	*	X
		Coonstripe/Dock Shrimp	*Pandalus danae*	*	-	-	0	0	2	0	0	*	*	*	*	X
		Humpback Shrimp	*Pandalus hypsinotus*	*	-	-	0	0	2	0	0	*	*	*	*	X
		Sidestripe Shrimp	*Pandalopsis dispar*	*	*	-	0	0	2	0	0	*	*	*	*	X
		Smooth Pink Shrimp	*Pandalus jordani*	3.2	-	-	0	0	2	0	0	*	*	*	*	X
		Spiny/Northern Pink Shrimp	*Pandalus borealis*	3.1	*	-	0	0	2	0	0	*	*	*	*	X
		Spot Prawn	*Pandalus platyceros*	3.7	*	-	0	0	2	0	0	*	*	*	*	X
	Zooplankton	Amphipods	Amphipoda	*	-	-	0	0	*	0	0	-	-	-	-	-
		Euphausiids	Euphausiacea	*	-	-	2	0	2	0	0	-	-	-	-	X
		Neocalanus Copepods	*Neocalanus* sp.	*	-	-	*	0	2	0	0	-	-	-	-	X
		Other Crustacean Zooplankton	Other crustacean zooplankton	*	*	-	2	0	2	0	0	-	-	-	-	X
Echinoderms	Sea Cucumbers	California Sea Cucumber	*Apostichopus californicus*	*	-	-	1	0	0	0	0	*	*	*	*	-
	Sea Stars	Ochre Sea Star	*Pisaster ochraceus*	3.4	-	-	2	2	0	0	0	1	*	*	*	X
		Sunflower Sea Star	*Pycnopodia helianthoides*	*	-	-	1	2	0	0	0	1	*	*	*	X
	Sea Urchins	Green Sea Urchin	*Strongylocentrotus droebachiensis*	2.4	-	-	2	0	1*	0	0	*	*	*	*	X
		Purple Urchin	*Strongylocentrotus purpuratus*	*	-	-	1	0	1*	0	0	*	*	*	*	-
		Red Urchin	*Mesocentrotus franciscanus*	*	-	-	2	0	1*	0	0	*	*	*	*	X
Molluscs	Cephalopods	Giant Pacific Octopus	*Enteroctopus dofleini*	3.3	-	VH	2	2	0	0	0	*	*	*	*	X
		Opal Squid	*Doryteuthis opalescens*	3.9	-	L	2	2	1*	0	0	*	*	*	*	X
	Clams and Cockles	Butter Clam	*Saxidomus gigantea*	*	-	-	2	0	2	0	2	*	*	*	*	X
		Cockle	*Clinocardium nuttallii*	*	-	-	2	-	2	0	2	*	*	*	*	X

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Molluscs (cont'd)	Clams and Cockles (cont'd)	Geoduck	*Panopea generosa*	2	-	-	2	0	0	0	1	*	*	*	*	X
		Horse Clam/Fat Gaper	*Tresus capax*	*	-	-	2	0	0	0	2	*	*	*	*	X
		Horse Clam/Pacific Gaper	*Tresus nuttallii*	2	-	-	2	0	0	0	2	*	*	*	*	X
		Littleneck Clam	*Leukoma staminea*	2	-	-	2	0	2	0	2	*	*	*	*	X
		Razor Clam	*Siliqua patula*	*	-	-	2	0	2	0	1	*	*	*	*	X
	Epibenthic Bivalves	Blue Mussel	*Mytilus edulis*	2	-	M	1	0	1*	-	1*	*	*	*	*	-
		California Mussel	*Mytilus californianus*	2	-	-	2	0	0	0	2	*	*	*	*	X
		Olympia Oyster	*Ostrea lurida*	*	-	-	2	-	1*	0	1	1	*	1	1	X
		Pacific Blue Mussel	*Mytilus trossulus*	*	*	-	1	-	1*	-	1*	*	*	*	*	-
		Pink Scallop	*Chlamys rubida*	*	-	-	2	-	1*	0	0	*	*	*	*	X
		Purple-hinged Rock Scallop	*Crassadoma gigantea*	*	-	-	2	-	0	0	0	*	*	*	*	X
		Spiny Scallop	*Chlamys hastata*	*	-	-	2	-	1*	0	0	*	*	*	*	X
		Weathervane Scallop	*Patinopecten caurinus*	*	-	L-M	2	-	0	0	0	*	*	*	*	X
	Gastropods and Chitons	Black Chiton	*Katharina tunicata*	2	-	L	0	0	0	0	0	*	*	*	*	-
		Black Turban Snail	*Tegula funebralis*	-	-	-	1	0	0	0	0	*	*	*	*	-
		Gumboot Chiton	*Cryptochiton stelleri*	*	-	L	0	0	0	0	0	*	*	*	*	-
		Lewis' Moonsnail	*Neverita lewisii*	*	-	-	0	-	0	0	0	*	*	*	*	-
		Littorina Snail	*Littorina* sp.	*	-	-	1	0	2	0	0	*	*	*	*	X
		Northern Abalone	*Haliotis kamtschatkana*	*	-	-	2	-	1	0	0	2	2	2	2	X
		Red Turban Snail	*Pomaulax gibberosus*	-	-	-	0	0	0	0	0	*	*	*	*	-
Other	Zooplankton	Non-Crustacean Zooplankton	Non-Crustacean Zooplankton	*	*	-	1	0	2	0	0	-	-	-	-	X
Sponges	Glass Sponges	Glass Sponges	Hexactinellida	*	*	-	2	0	0	0	2	-	-	-	-	X
		Cloud Sponge	*Aphrocallistes vastus*	*	*	-	2	0	0	0	2	*	*	*	*	X
		Glass Sponge	*Farrea occa*	*	*	-	2	0	0	0	2	*	*	*	*	X
		Glass Sponge	*Heterochone calyx*	*	*	-	2	0	0	0	2	*	*	*	*	X
	Demosponges	Demosponges	Demospongiae	*	*	-	2	0	0	0	2	-	-	-	-	X

Higher Group	Species Group	Common Name	Scientific Name	Trophic Level	Max Size (cm; Total or standard length); fish only	Vulnerability Category	1.1.S1. Vulnerable Species	1.2.S1. Upper-level Predators	1.2.S2. Forage Species	1.2.S3. Nutrient Transporting Species	1.2.S4. Habitat-forming Species	1.5.S1 Any CC	Global CC	National CC	Regional CC	Recommended CP
Microalgae	Phytoplankton	Phytoplankton	Phytoplankton	*	*	-	*	-	2	-	-	-	-	-	-	X
Plants and algae	Encrusting algae	Corraline Algae	Corallinales	*	-	-	*	-	-	*	1	-	-	-	-	-
	Large algae	Bull Kelp	*Nereocystis leutkeana*	*	-	-	*	-	-	1	2	*	*	*	*	X
		Feather Boa Kelp	*Egregia menziesii*	*	-	-	*	-	-	1	1	*	*	*	*	-
		Giant Kelp	*Macrocystis* sp.	*	-	-	*	-	-	1	2	*	*	*	*	X
		Southern Sea Palm	*Eisenia arborea*	*	-	-	*	-	-	*	1	*	*	*	*	-
		Southern Stiff-stiped Kelp	*Laminaria setchellii*	*	-	-	*	-	-	*	1	*	*	*	*	-
		Woody-stemmed Kelp	*Pterygophora californica*	-	-	-	*	-	-	*	1	*	*	*	*	-
	Small intertidal or subtidal algae	Lavers (red and black)	*Porphyra* sp.	*	-	-	*	-	-	*	*	*	*	*	*	-
		Rockweed	*Fucus* sp.	*	-	-	*	-	-	1	1	-	-	-	-	-
		Sea Cabbage	*Hedophyllum sessile*	*	-	-	*	-	-	*	*	*	*	*	*	-
		Sea Lettuce	*Enteromorpha* sp.	*	-	-	*	-	-	1	1	-	-	-	-	-
	Seagrasses	Eelgrass	*Zostera marina*	*	*	-	*	-	-	1	2	0	*	0	0	X
		Surfgrass	*Phyllospadix* sp.	*	-	-	*	-	-	1	2	*	*	*	*	X
	Terrestrial plants	Cord Grass	*Spartina* sp.	*	-	-	*	-	-	-	-	-	-	-	-	-

Table 23. Scores for birds. Conservation Concern scores were assigned as described in Table 12. Overall Conservation Priority scores of 1 were applied when the highest Conservation Concern score was 1, or when the species was identified as marine or coastal Priority Species by Environment Canada (Environment Canada 2013). Overall Conservation Priority scores of 2 were applied when the highest Conservation Concern score was 2.

Family	Common Name	Scientific Name	Any CC	Global CC	National CC	Regional CC	EC BCR5 Marine or Coastal Priority Species	Expert opinion	CP Score
Gaviidae	Pacific Loon	*Gavia pacifica*	1	0	0	1	0		1
	Common Loon	*Gavia immer*	0	0	0	0	1		1
	Yellow-billed Loon	*Gavia adamsii*	1	1	0	2	1		2
Podicipedidae	Horned Grebe	*Podiceps auritus*	2	2	1	0	1	1	1
	Western Grebe	*Aechmophorus occidentalis*	1	0	1	2	1		2
Diomedeidae	Black-footed Albatross	*Phoebastria nigripes*	1	1	1	1	1	2	2
	Laysan Albatross	*Phoebastria immutabilis*	1	1	1	1	1		1
	Short-tailed Albatross	*Phoebastria albatrus*	2	2	2	2	1		2
Procellariidae	Northern Fulmar	*Fulmarus glacialis*	1	0	1	2	1	1	1
	Buller's Shearwater	*Ardenna bulleri*	2	2	0	1	1		2
	Short-tailed Shearwater	*Ardenna tenuirostris*	0	0	0	0	0	1	1
	Sooty Shearwater	*Ardenna grisea*	1	1	0	*	0	1	1
	Pink-footed Shearwater	*Ardenna creatopus*	2	2	2	2	1		2
Hydrobatidae	Leach's Storm-Petrel	*Hydrobates leucorhous*	0	0	0	0	1		1
	Fork-tailed Storm-Petrel	*Hydrobates furcatus*	0	0	0	0	0	1	1
Phalacrocoracidae	Brandt's Cormorant	*Phalacrocorax penicillatus*	2	0	2	2	1		2
	Pelagic Cormorant, *resplendens* subsp.	*Phalacrocorax pelagicus resplendens*	0	0	0	0	1		1
	Pelagic Cormorant, *relagicus* subsp.	*Phalacrocorax pelagicus pelagicus*	2	*	*	2	1		2
	Double-crested Cormorant	*Phalacrocorax auritus*	1	0	0	1	1		1
Ardeidae	Great Blue Heron, *fannini* subsp.	*Ardea herodias fannini*	1	0	1	2	1	1	1
Anatidae	Tundra Swan	*Cygnus columbianus*	1	0	0	1	1	0	0
	Trumpeter Swan	*Cygnus buccinator*	0	0	0	0	1		1

Family	Common Name	Scientific Name	Any CC	Global CC	National CC	Regional CC	EC BCR5 Marine or Coastal Priority Species	Expert opinion	CP Score
Anatidae (cont'd)	Greater White-fronted Goose	*Anser albifrons*	0	0	0	0	1	0	0
	Lesser Snow Goose	*Chen caerulescens caerulescens*	0	0	0	0	1	0	0
	Canada Goose (Pacific, residents & migrants)	*Branta canadensis*	0	0	0	0	1		1
	Cackling Goose	*Branta hutchinsii*	0	0	0	0	1		1
	Brant	*Branta bernicla*	1	0	0	1	1	0	0
	Mallard	*Anas platyrhynchos*	0	0	0	0	1	0	0
	Northern Pintail	*Anas acuta*	0	0	0	0	1	0	0
	American Wigeon	*Anas americana*	0	0	0	0	1	0	0
	Northern Shoveler	*Anas clypeata*	0	0	0	0	1	0	0
	Blue-winged Teal	*Anas discors*	0	0	0	0	1	0	0
	Green-winged Teal	*Anas crecca*	0	0	0	0	1	0	0
	Lesser Scaup	*Aythya affinis*	0	0	0	0	1	0	0
	Greater Scaup	*Aythya marila*	0	0	0	0	1	0	0
	Canvasback	*Aythya valisineria*	0	0	0	0	1	0	0
	Harlequin Duck	*Histrionicus histrionicus*	1	0	0	1	1	2	2
	Long-tailed Duck	*Clangula hyemalis*	2	2	0	2	0		2
	Surf Scoter	*Melanitta perspicillata*	1	0	0	1	1	2	2
	Black Scoter	*Melanitta americana*	1	1	0	0	1	2	2
	White-winged Scoter	*Melanitta deglandi*	0	0	0	0	1	2	2
	Common Goldeneye	*Bucephala clangula*	0	0	0	0	1		1
	Barrow's Goldeneye	*Bucephala islandica*	0	0	0	0	1	2	2
	Bufflehead	*Bucephala albeola*	0	0	0	0	1	0	0
	Red-breasted Merganser	*Mergus serrator*	0	0	0	0	0	0	0
Falconidae	Peregrine Falcon, *pealei* subsp.	*Falco peregrinus pealei*	1	1	1	1	1	0	0
Charadriidae	Black-bellied Plover	*Pluvialis squatarola*	1	0	1	0	1	0	0
	American Golden-Plover	*Pluvialis dominica*	1	0	1	1	1	0	0

Family	Common Name	Scientific Name	Any CC	Global CC	National CC	Regional CC	EC BCR5 Marine or Coastal Priority Species	Expert opinion	CP Score
Haematopodidae	Blackish Oystercatcher	*Haematopus ater bachmani*	0	0	0	0	1	2	2
Scolopacidae	Whimbrel	*Numenius phaeopus*	1	0	1	0	1		1
	Marbled Godwit	*Limosa fedoa*	0	0	0	0	1	0	0
	Wandering Tattler	*Tringa incana*	1	0	1	1	1	2	2
	Surfbird	*Calidris virgata*	1	0	1	0	1	2	2
	Ruddy Turnstone	*Arenaria interpres*	1	0	1	0	1	2	2
	Black Turnstone	*Arenaria melanocephala*	0	0	0	0	1	2	2
	Rock Sandpiper	*Calidris ptilocnemis*	0	0	0	0	1	2	2
	Sanderling	*Calidris alba*	1	0	1	0	1	2	2
	Red Knot	*Calidris canutus*	2	0	2	2	1		2
	Dunlin	*Calidris alpina*	1	0	1	0	1		1
	Semipalmated Sandpiper	*Calidris pusilla*	1	0	1	0	0	0	0
	Western Sandpiper	*Calidris mauri*	0	0	0	0	1		1
	Long-billed Dowitcher	*Limnodromus scolopaceus*	1	0	1	0	0	0	0
	Short-billed Dowitcher	*Limnodromus griseus*	2	0	0	2	1		2
	Red Phalarope	*Phalaropus fulicarius*	1	0	1	0	0	2	2
	Red-necked Phalarope	*Phalaropus lobatus*	1	0	1	1	1		1
Laridae	Sabine's Gull	*Xema sabini*	0	0	0	0	0	0	0
	California Gull	*Larus californicus*	2	0	0	2	1	1	1
	Thayer's Gull	*Larus thayeri*	1	0	1	0	1		1
	Heermann's Gull	*Larus heermanni*	1	1	0	0	1	0	0
	Caspian Tern	*Hydroprogne caspia*	1	0	1	1	1	0	0
	Common Tern	*Sterna hirundo*	0	0	0	0	1	0	0
Alcidae	Common Murre	*Uria aalge*	2	0	0	2	1		2
	Thick-billed Murre	*Uria lomvia*	2	0	0	2	1	1	1
	Pigeon Guillemot	*Cepphus columba*	0	0	0	0	1	2	2

Family	Common Name	Scientific Name	Any CC	Global CC	National CC	Regional CC	EC BCR5 Marine or Coastal Priority Species	Expert opinion	CP Score
Alcidae (cont'd)	Marbled Murrelet	*Brachyramphus marmoratus*	2	2	2	2	1		2
	Ancient Murrelet	*Synthliboramphus antiquus*	1	0	1	2	1		2
	Cassin's Auklet	*Ptychoramphus aleuticus*	1	1	1	1	1	2	2
	Rhinoceros Auklet	*Cerorhinca monocerata*	0	0	0	0	1	2	2
	Tufted Puffin	*Fratercula cirrhata*	1	0	1	2	1		2
	Horned Puffin	*Fratercula corniculata*	2	0	2	2	1	1	1

APPENDIX 2. FIGURES SHOWING SCORES FOR SPECIES-BASED CPS

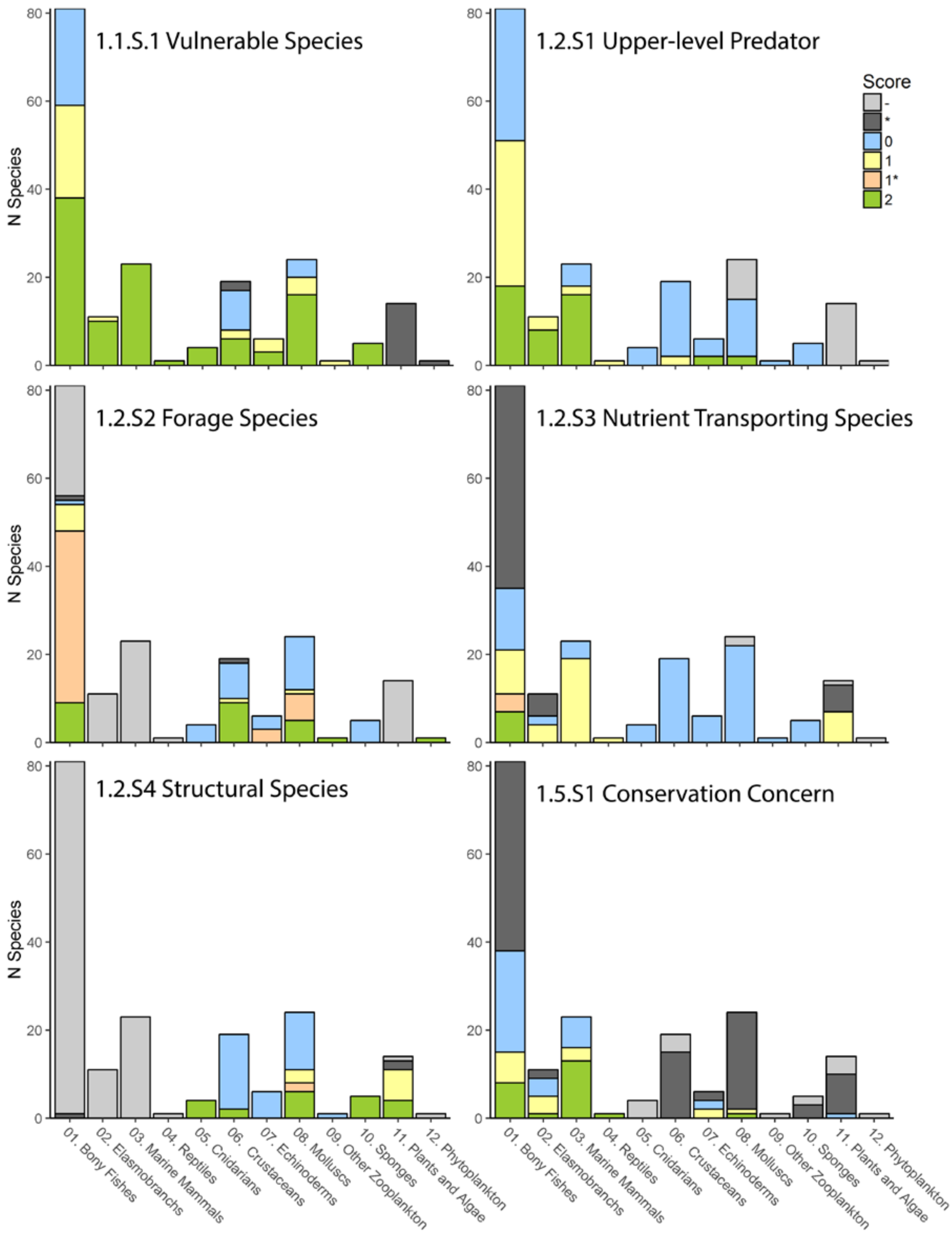

Figure 5. Number of species, by higher taxonomic group, receiving each score under each species-based CP criterion. The total number of species represented in each graph (each criterion) equals the number of candidate species (n=190).

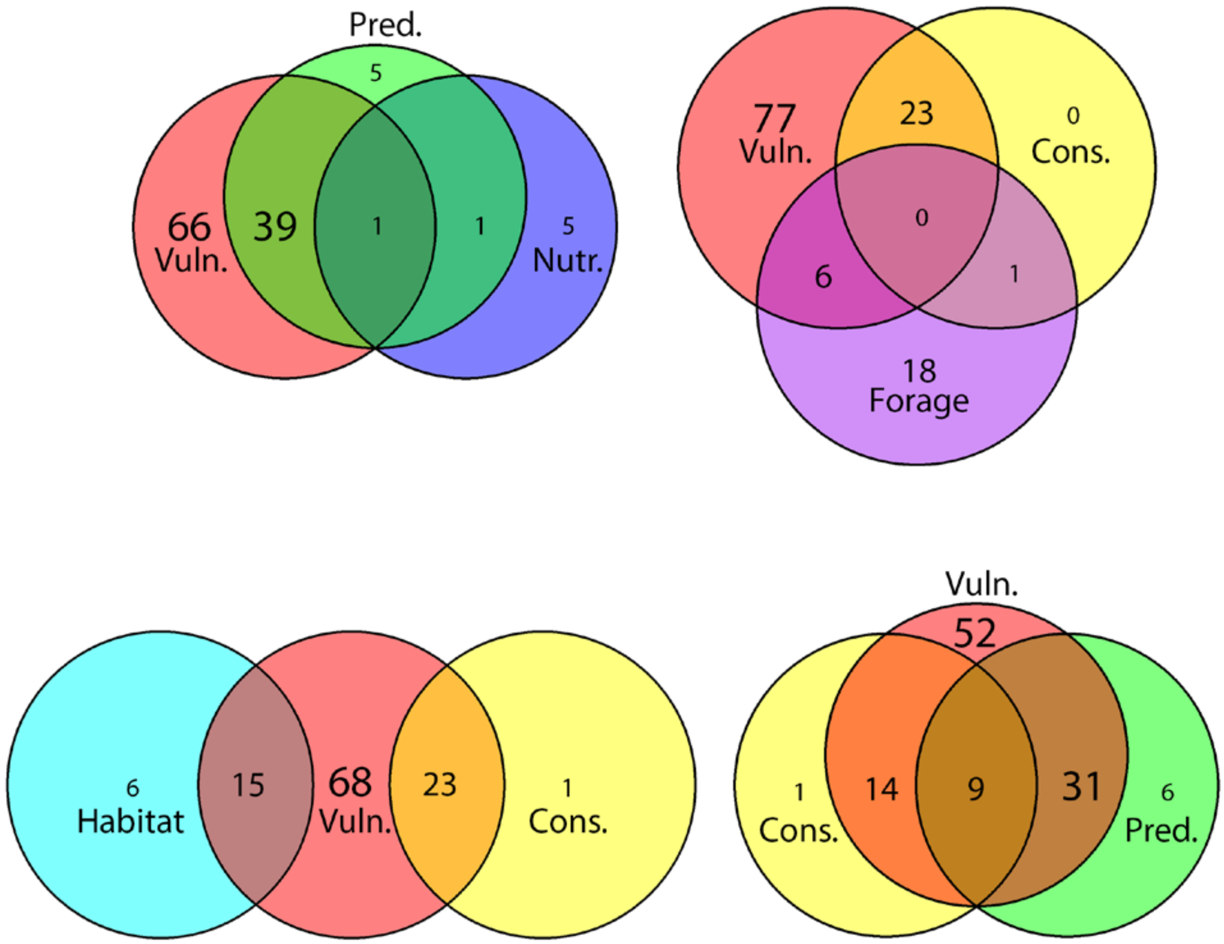

Figure 6. Venn diagrams showing number of species assigned scores of 2 under different species-based CP criteria. Each circle represents the total number of species scoring highly under that criterion; overlapping areas indicates species scoring highly under multiple criteria. Vuln.= 1.1.S1 Vulnerable Species; Pred = 1.2.S1 Upper-level Predator; Forage = 1.2.S2 Forage Species; Nutr. = 1.2.S3 Nutrient Transporting Species; Habitat = 1.2.S4 Habitat-forming Species; Cons. = 1.5.S1 Conservation Concern.

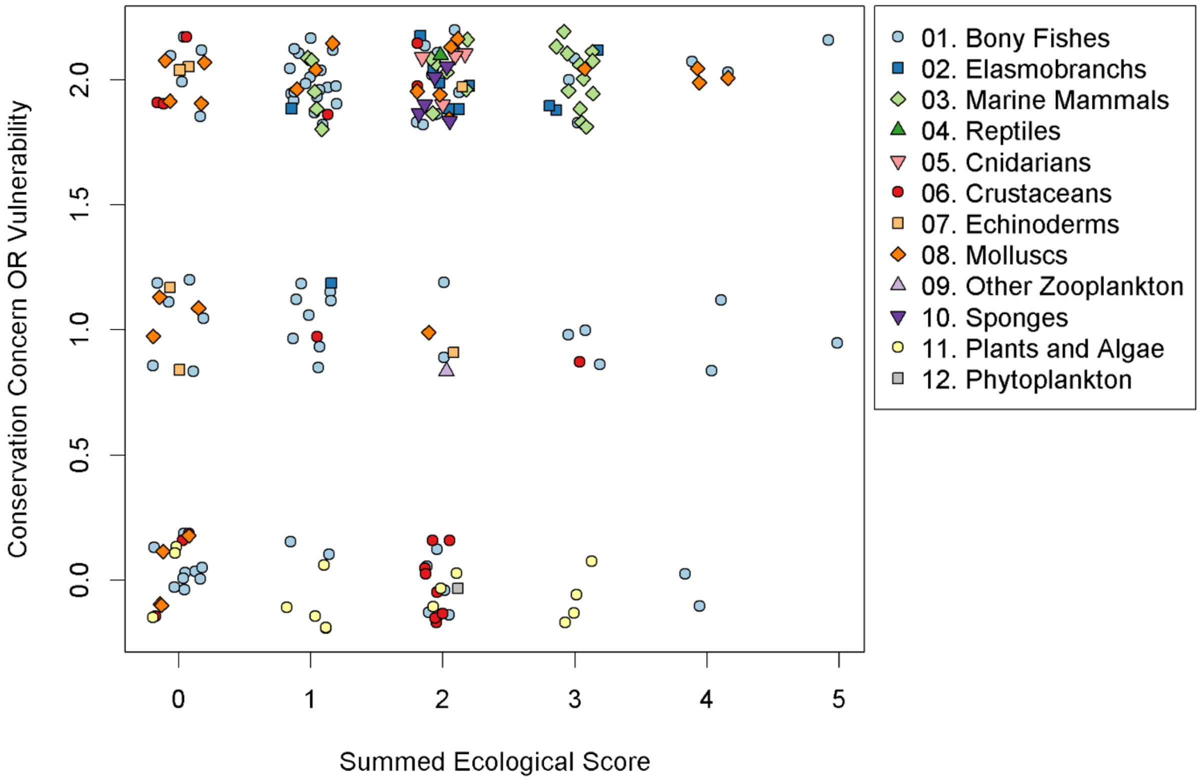

Figure 7. Distribution of scores received by species in different taxonomic groups. The y-axis shows the higher score of either the Conservation Concern or Vulnerability criteria. The summed ecological score is the additive score under Criteria 1.2.S1–1.2.S4 (i.e., upper-level predators, key forage species, nutrient transporting species, and habitat-forming species). Species with a higher ecological score fulfil more criteria. The points are jittered (randomly offset) to allow visualization of overlapping points.

APPENDIX 3: CONSERVATION PRIORITY IDENTIFICATION IN OTHER JURISDICTIONS

This section includes an overview of evaluation strategies and conservation criteria used to identify conservation priorities in marine spatial planning processes in other jurisdictions, including supporting rationale, methods for applying evaluation strategies, and case study examples when available.

The focus is on international examples, as well as available resources from other MPA processes led by DFO in other marine bioregions. We do not address criteria and guidance for identifying ecologically significant areas, species, and community properties from other federal or provincial departments (e.g., Environment Canada Marine Wildlife Areas and National Wildlife Areas; Parks Canada National Marine Conservation Areas; or Provincial and Territorial marine protected areas).

IUCN Key Biodiversity Areas

The International Union for Conservation of Nature (IUCN) Standard for the Identification of Key Biodiversity Areas (KBAs) (IUCN 2015) was developed to consolidate criteria and methodology for identifying sites that contribute significantly to the global persistence of biodiversity in terrestrial, inland water, and marine environments. It specifically aims to harmonize existing approaches; support the identification of important sites not considered in existing approaches; provide a system that can be applied consistently and in a repeatable manner; ensure that KBA identification is objective, transparent and rigorous through application of quantitative thresholds; and provide decision-makers with improved understanding of why particular sites are important for biodiversity.

Quantitative thresholds were used to ensure site identification is transparent, objective and repeatable. Thresholds were "informed by the history of experience in applying quantitative thresholds to identify important sites for biodiversity (i.e., Important Bird Areas and Alliance for Zero Extinction sites), calibrated with complementarity-based quantitative calculations of irreplaceability, as used in systematic conservation planning" (IUCN 2015). Thresholds were developed through technical workshops, consultation, and expert consensus, and were tested with data covering diverse taxonomic groups, regions, and environments.

Thresholds associated with each sub-criterion were designed for KBA identification at the global level. Sites of regional importance can be identified as KBAs if they use the same criteria and meet appropriate regional thresholds. In applying the criteria, individual countries and institutions are encouraged to establish and apply thresholds for national significance, if doing so is considered to be valuable within a given country.

KBA criteria, sub-criteria and thresholds are organized using a hierarchical alphanumeric numbering system similar to that used for the IUCN Red List, and include

1. Threatened biodiversity (threatened taxa; threatened ecosystem types);
2. Geographically restricted biodiversity (individual geographically restricted species; co-occurring geographically restricted species; geographically restricted assemblages; geographically restricted ecosystem types);
3. Ecological integrity;
4. Biological processes (demographic aggregations; ecological refugia; source populations);
5. Irreplaceability through quantitative analysis.

The rationale and justification provided for how thresholds were established is very high level, and is based on experience through previous processes, technical workshops, and expert consensus. No case studies are presented, although some guidance is provided outlining the metrics that can be applied to assess each KBA criterion. For example, when population data is not available, alternative metrics such as number of mature individuals or geographic range can be used to estimate or infer thresholds.

Scotland

A process was developed and applied to identify a list of priority marine habitats and species in or Scotland's territorial seas, on which to focus marine conservation efforts. From an existing long list of important features in Scottish marine waters, this work identified a priority features on which to focus future conservation work. Priority Marine Features were identified in two processes, one in territorial waters (Howson et al. 2012) and one in offshore waters (JNCC 2012).

A criteria-based approach was developed to refine the initial long-list of species. Six 'importance criteria' were initially considered:

1. proportional importance,
2. decline/threat of decline,
3. functional importance,
4. rarity,
5. data deficiency, and
6. international commitment.

Only the first three criteria were applied territorial waters and only the first two criteria in offshore waters, with different thresholds established for each assessment. The criteria used were evaluated using descriptive or semi-quantitative descriptors on a pass/fail basis. Assessment of 'decline/threat of decline' relied on previous assessments results from national and international authorities.

The assessments used existing importance criteria developed during previous UK conservation processes, which were reviewed and assessed through an internal workshop for applicability or suitability in Scottish territorial waters (documented in an unpublished document; Howson et al. 2012). The final criteria were based primarily on those used for the UK's Nationally Important Marine Features list and the Biodiversity Action Plan.

An initial set of criteria were applied, tested and refined using a pilot set of species and habitats, then used to assess remaining features. The approach of filtering the list further by assessing against a set of 'management criteria' was initially considered, however in practice this was determined to be impractical at that stage of the project. A detailed description of criteria application is provided in Howson et al. (2012). Proportional importance and decline/threat criteria were applied first. Because there was insufficient knowledge of the functional importance of species in offshore ecosystems, this criterion was not used to screen out species. Rarity was determined to be a poor criterion. Features that were data deficiency were screened out and flagged for future reassessment.

Assessments were carried out using judgement based on best available information. The process took advantage of previous UK assessments where available, and information for some features was more robust than others. Existing information was updated when possible, and it was noted that assessments for some features may change as new information becomes available. A summary of the information used in assessment of the priority recommended features is referenced (Howson et al. 2012), but is not provided in the report. Although the list is expected to be updated, no formal review process has yet been established.

United Kingdom (UK)

In the UK, Marine Conservation Zones (MCZs) were identified during the development of an MPA network (Natural England and JNCC 2010). "Features of Conservation Importance" (FOCI) in this process included threatened, rare or declining species and habitats. FOCI identification relied on existing assessments, including the OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic) List of Threatened and/or Declining Species and Habitats (species or habitats under threat or decline, considering rarity and sensitivity), and Schedule 5 of the Wildlife and Countryside Act (species that are endangered in Great Britain and likely to become extinct if conservation measures are not taken). The UK List of Priority Species and Habitats (BRIG 2007, UK Biodiversity Action Plan (UKBAP) 2008) included species of international importance, at high risk, or undergoing rapid decline, as well as habitats important for key species.

The marine UK BAP criteria were designed and modified from the Review of Marine Nature Conservation criteria (BRIG 2007). These criteria include some quantitative thresholds for evaluating international threat and decline of species, but are mostly qualitative and provide descriptive guidance rationalizing prioritization of species or habitats. Application of the criteria relied on expert opinion and working groups, with contribution from over 50 coordinators and experts to the review of marine species and habitats. Quantitative data to support criteria were used where as possible, recognising data limitations and considering for best available information that could pass an accepted level of scientific scrutiny.

No rationale for how criteria were developed was documented, but may be detailed in the earlier processes from which the UK developed its criteria. The criteria used in this process were mainly qualitative and descriptive. No examples or case studies of criteria application were provided in the reviewed resources. Additional resources not reviewed herein may be available through the JNCC website.

California

The California Department of Fish & Game (CDFG) draft Marine Life Protection Act (MLPA) Master Plan for Marine Protected Areas identifies a broad list of species which could benefit from conservation measures (2008a, 2008b). The MPLA also calls for protecting representative types of habitat in different depth zones and environmental conditions. CDFG prepared a list of key species to be considered for protection, then worked with a Science Advisory Team to refine this list for each region of the California coast (CDFG 2008b).

In the Central Coast Study Region, CDFG focused on protecting species that were in direct need of protection and would benefit from MPAs, and developed criteria regarding population size, vulnerability, ecological significance, geographic range, and population size structure (CDFG 2008b). Under each criterion, species were given binary (pass-fail) scores. It is not clear how scores were combined for final consideration, as the report only says the criteria were "not equally weighted".

In the North Coast Study region (California MLPA Master Plan Science Advisory Team 2010), pass/fail scores were assigned under criteria such as vulnerability to human impacts, geographic range, habitat specificity, population size, larval dispersal, and ecological importance. There were several essential criteria required for a species to be "screened in". Scores from a subset of the criteria were summed to give an overall score for each species' potential benefit from MPAs. The remaining criteria were not used in the summed score, but were presented to indicate how a species might respond to MPAs. No criteria were weighted to reduce potential bias to well-studied species.

While CDFG (2008a) recommends that MPA networks should include "key" marine habitat types that provide have particular characteristics or benefits, comprehensive guidance is not provided. Key habitats and features that warrant specific consideration and protection were identified following descriptive guidance rather an explicit evaluation strategy, and include habitats (e.g., specific types of kelp forests) and oceanic features (e.g., upwelling currents). It was also recommended to include habitats with unique or rare features; those that are educationally, ecologically, archeologically, anthropologically, culturally, or spiritually important; and oceanographic features that are uniquely productive, aggregative, or sustain distinct use patterns.

No further detail on how the framework or criteria were developed was provided for the overall MLPA Master Plan or for the sub-regional study areas were provided. Criteria were only reported on for key species, with no evaluation strategy or criteria found for habitat and features. Additional information and resources are available through the California Department of Fish and Wildlife website: MPA Planning Process Historical Information.

Australia – Great Barrier Reef (GBR)

Stokes et al. (2004) provides a compendium of information on the fauna and flora of the Great Barrier Reef (GBR) World Heritage Area and explains the rationale behind the work priorities of the Species Conservation Program of the GBR MPA, which focuses on the management of threatened species. No explicit evaluation framework or criteria for the selection of conservation priorities is provided in this resource. Ward and Stewart (2016) note that development of Australia’s National Representative System of Marine Protected Areas program came at a time when the science of conservation planning was “undergoing a renaissance”, when there was limited guidance regarding the selection of areas for biodiversity conservation.

Species of conservation interest included ‘Listed Threatened, or Migratory or Marine Species’ and species of special interest based on the *Environment Protection and Biodiversity Conservation Act,* other marine species of conservation concern, and non-marine island flora and fauna. The information considered for each species included extent of knowledge, conservation status, human related threats to populations, and current or proposed conservation actions. However, it unclear as to how this information was applied or evaluated.

Elements that are considered for in developing and prioritizing the Species Conservation Program of the Great Barrier Reef Marine Park Authority work program are: conservation status (existing obligation), knowledge (of biology, life history, human related threats, etc.), environmental indicator status (i.e. indicator of ecosystem health), likelihood of management success, community perception (public or political interest), and resources. Consideration was also given to having heritage value, however this is descriptive and no systematic evaluation or assessment criteria are provided.

Although Stokes et al. (2004) describes the key priorities considered in identifying conservation priorities, no clear evaluation framework, supporting rationale, application details or example case studies were provided.

Quebec: Gulf Of St. Lawrence

Internal draft materials, prepared for the Technical Committee on the Marine Protected Area Network (TCMPAN), were provided in draft form by MPA practitioners in the Quebec Region[11]. These materials include a draft working paper presenting TCMPAN's work to develop an MPA network for the Gulf of St. Lawrence bioregion, which describes the methodology selected for integrating ecological and socioeconomic considerations into the future network.

Conservation priorities, termed 'ecological features' (EFs) were identified for each strategic conservation objective. Strategic conservation objectives and EFs were defined following national (DFO) and internationally recognized guidelines (IUCN-WCPA), and were based largely on EBSAs and representativity. EFs included

1. Ecologically and biologically significant areas (EBSAs);
2. Representative ecosystems; and
3. Potential ecologically significant species (ESS), Key species (trophic species), and other ecologically significant species not taken into account by EBSAs defined by DFO.

Other important considerations were also taken into account as selection criteria, including quality, availability, and spatial coverage of data..

A full list of selected and excluded EFs is provided in supporting Excel tables. These tables include references, types of data and units of measure, the spatial scale, a brief description of the data. The selection/rejection tables each include rationale for EF selection or omission. However, the rationale behind EF selection is descriptive only, with no explicit evaluation strategy or thresholds defined.

Explanations are provided both for EFs that were and were not selected, including replacement of some layers by others, where applicable) in the supporting excel tables. Reasons EFs were rejected were often listed as having incomplete or insufficiently accurate data, were too general, were redundant to other data sets, or were better represented by other data types (i.e., focus on important areas rather than presence for migratory species). Documentation is given for supporting information used in the evaluation of each EF.

A matrix table showing the relationships between the selected EFs and the conservation objectives is also provided. This table reports the number of linkages for each EFs, however it is noted that even if an EFs could be linked to more than one conservation objective, it was included only once in the analyses.

[11] Faille, G., Dorion, D., Pereira, S. Methodology for the Development of the Marine Protected Area Network. Draft Document November 2014 for the Technical Committee on the Marine Protected Area Network. Unpublished.

Maritimes Region: Scotian Shelf

Considerations for identifying conservation priorities for the Scotian Shelf are presented in an internal slide deck prepared for a DFO MPA Practitioners Meeting held in November 2015[12]. No explicit evaluation framework or criteria were provided. High level considerations included

1. Ecological features associated with Strategic Objectives;
2. Previous national science advice, including identifying conservation priorities and formulating conservation objectives for LOMAs (Large Ocean Management Areas), which used EBSAs, Ecologically Significant Species, and Depleted Species; and
3. Previous Regional Science advice, including advice on objectives and data considerations for network planning and identification of EBSAs.

A report on MPA Network Analysis for the Maritimes Region of Canada (Horsman et al. 2011), describes work to identify a network of MPAs using the criteria of uniqueness, diversity, importance for threatened, endangered or declining species and/or habitats, sensitive habitat, and abundance of key species. No key species were identified, but five design principles to assist in achieving inclusion of EBSAs were adopted for the network process:

1. areas of persistently higher abundance of important fish species (including species identified as at risk by COSEWIC);
2. high biodiversity;
3. areas known to support vulnerable or sensitive structure providing species (e.g., hard coral);
4. areas identified as critical habitat for species at risk; and
5. areas with high topographic roughness.

A list of the species and features targeted in site selection analyses is presented, but there is no information provided regarding how those species or features were selected as priorities.

[12] Internal slide deck: Identifying Conservation Priorities and Operational Objectives and developing Design Strategies: Scotian Shelf, MPA Practitioners Meeting, November 18, 2015

APPENDIX 3 REFERENCES

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APPENDIX 4: SPECIES PROFILES

PURPOSE AND FORMAT

This document contains supporting information used to assess how well species fit criteria used to identify ecological conservation priorities in the Northern Shelf Bioregion. Each species was assigned a score for its ecological role (upper-level predators, forage species, nutrient transporting species and habitat-forming species), conservation status, and vulnerability to human activities using criteria laid out in the body of the research document.

Briefly, the scores are as follows:

Score	Description
(2)	The species strongly fits or fulfills all aspects of the criterion.
(1)	The species moderately fits, or fulfills only part of the criterion.
(0)	The species does not fit the criterion.
(-)	The species was not assessed for the criterion. This was used in cases where it was reasonably obvious, based on the ecological characteristics of the species, that it would not meet the criterion. For example, schooling fish do not create epibenthic habitat. Here, no report or summary is given if the species was not assessed.
(*)	There is not currently enough information to assess the criterion.
(1*)	"Uncertain fit". There is some evidence that the species fits the criterion, but there is uncertainty. For interpretation of 1* scores, see score descriptions under each criterion.

Where applicable, conservation status is listed under each species name (up to date as of August 2016).

Trophic level and maximum length were obtained when available from FishBase or SeaLifeBase. An asterisk (*) next to a trophic level indicates that the reported trophic level is inconsistent with what is known of that species' feeding ecology, and may represent small/juvenile individuals or be derived from limited information. An average value was calculated if more than one trophic level value was reported on FishBase or SeaLifeBase (e.g., a range or two values).

BIRDS

Species profiles for birds contain details on conservation status under the various listing authorities consulted, if the status is equivalent to SARA "Least Concern" or higher (i.e., for species that received a score of 1 or 2 under the conservation concern criterion). Notes from species experts at Environment and Climate Change Canada and The Nature Conservancy Canada are listed if available.

GAVIIDAE

Common Loon (*Gavia immer)*

EC Marine Priority Species (Stewardship criteria)

Pacific Loon (*Gavia pacifica*)

NatureServe (BC): S4B,S3S4N (Apparently Secure Breeding; Vulnerable to Apparently Secure Non-Breeding)

Yellow-billed Loon (*Gavia adamsii*)

IUCN: Near Threatened
NatureServe (BC): S2S3N (Imperiled to Vulnerable Non-Breeding)
BC List: Blue
EC Marine Priority Species (At Risk)

PODICIPEDIDAE

Horned Grebe (*Podiceps auritus*)

IUCN: Vulnerable A2abce+3bce+4abce
COSEWIC: Special Concern (Western population: YT, NT, NU, **BC**, AB, SK, MB, ON)
EC Marine & Coastal Priority Species (At Risk)

Note: BC population stable.

Western Grebe (*Aechmophorus occidentalis*)

NatureServe (BC): S1B,S2N (Critically Imperiled Breeding, Imperiled Non-Breeding)
BC List: Red
COSEWIC: Special Concern
General Status (BC): 2 – May Be At Risk
EC Marine Priority Species (At Risk; Stewardship criteria)

DIOMEDEIDAE

Black-footed Albatross (*Phoebastria nigripes*)

IUCN: Near Threatened
NatureServe (Global): G3G4 (Vulnerable to Apparently Secure)
NatureServe (BC): S3S4N (Vulnerable to Apparently Secure Non-Breeding)
BC List: Blue
COSEWIC: Special Concern
SARA: Schedule 1 - Special Concern
General Status (Canada): 3 - Sensitive
General Status (BC): 3 - Sensitive
EC Marine Priority Species (At Risk; of Conservation Concern; Stewardship criteria)

Note: Known bycatch in longline fisheries on shelf and break.

Laysan Albatross (*Phoebastria immutabilis*)

IUCN: Near Threatened
NatureServe (Global): G3 (Vulnerable)
NatureServe (BC): S3N (Vulnerable Non-Breeding)
BC List: Blue
General Status (Canada): 3 - Sensitive
General Status (BC): 3 - Sensitive
EC Marine Priority Species (At Risk; of Conservation Concern; Stewardship criteria)

Short-tailed Albatross (*Phoebastria albatrus*)

IUCN: Vulnerable D2
NatureServe (Global): G1 (Critically Imperiled)
NatureServe (BC): S1N (Critically Imperiled Non-Breeding)
BC List: Red
COSEWIC: Threatened
SARA: Schedule 1 - Threatened
General Status (Canada): 1 – At Risk
General Status (BC): 1 – At Risk
EC Marine Priority Species (At Risk; of Conservation Concern)

PROCELLARIIDAE

Buller's Shearwater (*Ardenna bulleri*)

IUCN: Vulnerable D2
NatureServe (Global): G3 (Vulnerable)
NatureServe (BC): S3?N (Uncertain – Vulnerable Non-Breeding)
BC List: Blue
EC Marine Priority Species (At Risk)

Northern Fulmar (*Fulmarus glacialis*)

NatureServe (BC): S1B,S4N (Critically Imperiled Breeding, Apparently Secure Non-Breeding)
BC List: Red
General Status (Canada): 3 - Sensitive
EC Marine & Coastal Priority Species (At Risk)

Note: Common in NSB.

Pink-footed Shearwater (*Ardenna creatopus*)

IUCN: Vulnerable D2
NatureServe (Global): G3 (Vulnerable)
NatureServe (BC): S3N (Vulnerable Non-Breeding)
BC List: Blue
COSEWIC: Threatened
SARA: Schedule 1 - Threatened
General Status (Canada): 1 - At Risk
General Status (BC): 1 - At Risk
EC Marine Priority Species (At Risk; of Conservation Concern)

Short-tailed Shearwater (*Ardenna tenuirostris*)

Note: Common in NSB; known bycatch in longline fishery.

Sooty Shearwater (*Ardenna grisea*)

IUCN: Near Threatened

Note: NSB, in particular Hecate Strait, has important foraging areas for this species during non-breeding periods; known bycatch in longline fishery.

HYDROBATIDAE

Fork-tailed Storm-petrel (*Hydrobates furcatus*)

Note: Although small colonies in NSB, could be an important part of their range.

Leach's Storm-petrel (*Hydrobates leucorhous*)

EC Marine & Coastal Priority Species (of Conservation Concern)

PHALACROCORACIDAE

Brandt's Cormorant (*Phalacrocorax penicillatus*)

NatureServe (BC): S1B,S4N (Critically Imperiled Breeding, Apparently Secure Non-Breeding)
BC List: Red
General Status (Canada): 2 - May Be At Risk
General Status (BC): 2 - May Be At Risk
EC Marine & Coastal Priority Species (At Risk; of Conservation Concern; Stewardship criteria)

Double-crested Cormorant (*Phalacrocorax auritus*)

NatureServe (BC): S3S4B (Vulnerable to Apparently Secure Breeding)
BC List: Blue
General Status (BC): 3 - Sensitive
EC Marine & Coastal Priority Species (At Risk)

Pelagic Cormorant, resplendens subspecies (*Phalacrocorax pelagicus respendens*)

Species
EC Marine & Coastal Priority Species (of Conservation Concern; Stewardship criteria)

Pelagic Cormorant, pelagicus subspecies (*Phalacrocorax pelagicus pelagicus*)

While the Pelagic Cormorant, *pelagicus* subspecies is listed as “Red” Status on BCCDC, there is little information available on the status or risks to this species.

Species
EC Marine & Coastal Priority Species (of Conservation Concern; Stewardship criteria)

Subspecies
NatureServe (BC): S2B (Imperiled Breeding)
BC List: Red

ARDEIDAE

Great Blue Heron, *fannini* subspecies (*Ardea herodias fannini*)

There are two subspecies of Great Blue Heron: *Ardea herodias herodias* occurs east of the coastal mountains of BC, and *A. herodias fannini* occurs west of the coast mountains (COSEWIC 2008c).

Species
NatureServe (BC): S3B (Vulnerable Breeding)

Subspecies
NatureServe (BC): S2S3B,S4N (Imperiled to Vulnerable Breeding, Apparently Secure Non-Breeding)
BC List: Blue
COSEWIC: Special Concern
SARA: Schedule 1 - Special Concern
EC Coastal Priority Species (At Risk)

ANATIDAE

Trumpeter Swan (*Cygnus buccinator*)

EC Coastal Priority Species (North American Waterfowl Management Plan priority)

Tundra Swan (*Cygnus columbianus*)

NatureServe (BC): S3N (Vulnerable Non-Breeding)
BC List: Blue
General Status (BC): 3 - Sensitive
EC Coastal Priority Species (At Risk; North American Waterfowl Management Plan priority)

Note: Low occurrence in NSB.

Brant (*Branta bernicla*)

NatureServe (BC): S3M (Vulnerable Migrant)
BC List: Blue
General Status (BC): 3 - Sensitive
EC Coastal Priority Species (At Risk; North American Waterfowl Management Plan priority)

Note: Neither Black Brant or Western High Arctic Brant winter or stage in large numbers on the north coast. A few (100) Brant winter on Haida Gwaii, but that number is still not significant.

Cackling Goose (*Branta hutchinsii*)

EC Coastal Priority Species (At Risk; North American Waterfowl Management Plan priority)

Canada Goose (*Branta canadensis*) – Pacific, residents and migrants

EC Coastal Priority Species (North American Waterfowl Management Plan priority)

Greater White-fronted Goose (*Anser albifrons*)

EC Coastal Priority Species (North American Waterfowl Management Plan priority)

Note: Low occurrence in NSB.

Lesser Snow Goose (*Chen caerulescens caerulescens*)

EC Coastal Priority Species (North American Waterfowl Management Plan priority)

Note: Low occurrence in NSB.

American Wigeon (*Anas americana*)

EC Coastal Priority Species (North American Waterfowl Management Plan priority)

Note: Common in NSB.

Mallard (*Anas platyrhychos*)

EC Coastal Priority Species (North American Waterfowl Management Plan priority)

Note: Common in NSB.

Northern Pintail (*Anas acuta*)

EC Coastal Priority Species (North American Waterfowl Management Plan priority)

Note: Common in NSB.

Northern Shoveler (*Anas clypeata*)

EC Coastal Priority Species (North American Waterfowl Management Plan priority)

Note: Low occurrence in NSB.

Blue-winged Teal (*Anas discors*)

EC Coastal Priority Species (North American Waterfowl Management Plan priority)

Note: Low occurrence in NSB.

Green-winged Teal (*Anas crecca*)

EC Coastal Priority Species (North American Waterfowl Management Plan priority)

Note: Common in NSB.

Canvasback (*Aythya valisineria*)

EC Coastal Priority Species (North American Waterfowl Management Plan priority)

Note: Low occurrence in NSB.

Lesser Scaup (*Aythya affinis*)

EC Marine Priority Species (North American Waterfowl Management Plan priority)

Note: Low occurrence in NSB.

Greater Scaup (*Aythya marila*)

EC Marine Priority Species (North American Waterfowl Management Plan priority)

Note: Common in NSB.

Harlequin Duck (*Histrionicus histrionicus*)

COSEWIC and SARA list the Eastern Population (NU, QC, NB, NS, NL) of Harlequin Duck as Special Concern, but populations in BC are not listed.

NatureServe (BC): S4B,S3N (Apparently Secure Breeding; Vulnerable Non-Breeding)
General Status (Canada): 3 - Sensitive
General Status (BC): 3 - Sensitive
EC Coastal Priority Species (North American Waterfowl Management Plan priority)

Note: BC coast supports the large majority of Pacific Harlequin Duck population; vulnerable to oil spills (long recovery from Exxon Valdez impacts in Alaska); slow to recover (all sea ducks are K-selected, adult survival most important); migratory species, migrates to interior BC, Alberta, and Yukon.

Long-tailed Duck (*Clangula hyemalis*)

IUCN: Vulnerable A4bce
NatureServe (BC): S2S3B,S4N (Imperiled to Vulnerable Breeding; Apparently Secure Non-Breeding)
BC List: Blue

Black Scoter (*Melanitta americana*)

IUCN: Near Threatened
NatureServe (BC): S3S4N (Vulnerable to Apparently Secure Non-Breeding)
BC List: Blue
EC Marine & Coastal Priority Species (North American Waterfowl Management Plan priority)

Note: Species has been declining over the past several decades, high level of concern from the Sea Duck Joint Venture; vulnerable to oil spills; slow to recover (all sea ducks are K-selected, adult survival most important); migratory species, migrates to Alaska to breed; Dogfish Bank is a very important staging area and supports Black Scoters from wintering areas in the south for 5-6 weeks during spring migration.

Surf Scoter (*Melanitta perspicillata*)

NatureServe (BC): S3B,S4N (Vulnerable Breeding, Apparently Secure Non-Breeding)
BC List: Blue
General Status (BC): 3 – Sensitive
EC Marine Priority Species (At Risk; North American Waterfowl Management Plan priority)

Note: Species has been declining over the past several decades, high level of concern from the Sea Duck Joint Venture; vulnerable to oil spills; slow to recover (all sea ducks are K-selected, adult survival most important); migratory species, migrates to Northwest Territories and Nunavut to breed; Surf Scoters forage on / depend on herring spawn sites during spring migration.

White-winged Scoter (*Melanitta deglandi*)

EC Marine Priority Species (North American Waterfowl Management Plan priority)

Note: Species has been declining over the past several decades, high level of concern from the Sea Duck Joint Venture; vulnerable to oil spills; slow to recover (all sea ducks are K-selected, adult survival most important); migratory species, migrates to Northwest Territories and Nunavut to breed; Dogfish Bank is a very important staging area and supports White-winged Scoters from south wintering areas for 5-6 weeks during spring migration.

Barrow's Goldeneye (*Bucephala islandica*)

EC Marine Priority Species (North American Waterfowl Management Plan priority)

Note: Nests in cavities in areas devastated by the mountain pine beetle; BC has a huge portion of the world population.

Common Goldeneye (*Bucephala clangula*)

EC Marine Priority Species (North American Waterfowl Management Plan priority)

Bufflehead (*Bucephala albeola*)

COSEWIC and SARA list the Eastern Population (QC, NB, PE, NS, NL) of Bufflehead as Special Concern, but populations in BC are not listed.
EC Marine Priority Species (North American Waterfowl Management Plan priority)

Note: Common in NSB.

Red-Breasted Merganser (*Mergus serrator*)

Note: Marine habitat important during non-breeding periods.

CHARADRIIDAE

American Golden-plover (*Pluvialis dominica*)

NatureServe (BC): S3S4B (Vulnerable to Apparently Secure Breeding)
BC List: Blue
General Status (Canada): 3 - Sensitive
General Status (BC): 3 - Sensitive
EC Coastal Priority Species (At Risk; Stewardship criteria)

Note: Low occurrence in NSB with stable populations, migrates through.

Black-bellied Plover (*Pluvialis squatarola*)

General Status (Canada): 3 - Sensitive
EC Coastal Priority Species (Stewardship criteria)

Note: Relatively common in NSB, migrates through.

HAEMATOPODIDAE

Blackish Oystercatcher (*Haematopus ater bachmani*)

EC Coastal Priority Species (Of Conservation Concern; Stewardship criteria)

Note: Rocky intertidal species, Canadian responsibility moderate.

SCOLOPACIDAE

Black Turnstone (*Arenaria melanocephala*)

EC Coastal Priority Species (Of Conservation Concern; Stewardship criteria)

Note: Very high jurisdictional responsibility; rocky intertidal species; sensitive to oil spills.

Ruddy Turnstone (*Arenaria interpres*)

General Status (Canada): 3 – Sensitive
EC Coastal Priority Species (Of Conservation Concern)

Note: Rocky intertidal species; migrates through; population in strong decline.

Dunlin (*Calidris alpina*)

General Status (Canada): 3 - Sensitive
EC Coastal Priority Species (Stewardship criteria)

Red Knot (*Calidris canutus*)

NatureServe (BC): S1S2M (Critically Imperiled to Imperiled Migrant)
BC List: Red
COSEWIC: Endangered / Threatened / Special Concern (3 subspecies)
SARA: Schedule 1 - Special Concern
General Status (Canada): 1 - At Risk
EC Coastal Priority Species (At Risk; Of Conservation Concern; Stewardship criteria)

Rock Sandpiper (*Calidris ptilocnemis*)

EC Coastal Priority Species (Stewardship criteria)

Note: Rocky intertidal species.

Sanderling (*Calidris alba*)

General Status (Canada): 3 - Sensitive
EC Coastal Priority Species (Of Conservation Concern)

Note: Canada has very high jurisdictional responsibility during winter; population in decline.

Semipalmated Sandpiper (*Calidris pusilla*)

General Status (Canada): 3 - Sensitive

Note: Relatively rare in NSB; migrates through; intertidal species.

Surfbird (*Calidris virgata*)

General Status (Canada): 3 - Sensitive
EC Coastal Priority Species (Of Conservation Concern)

Note: Rocky intertidal species in winter; sensitive to oil spills.

Western Sandpiper (*Calidris mauri*)

EC Coastal Priority Species (Stewardship criteria)

Marbled Godwit (*Limosa fedoa*)

EC Coastal Priority Species (Of Conservation Concern)

Note: Low occurrence in NSB, migrates through.

Long-billed Dowitcher (*Limnodromus scolopaceus*)

General Status (Canada): 3 - Sensitive

Note: Intertidal areas used by this species; migratory stopover.

Short-billed Dowitcher (*Limnodromus griseus*)

NatureServe (BC): S2S3B (Imperiled to Vulnerable Breeding)
BC List: Blue
General Status (BC): 3 - Sensitive

Whimbrel (*Numenius phaeopus*)

EC Coastal Priority Species (Of Conservation Concern)
General Status (Canada): 3 - Sensitive

Red Phalarope (*Phalaropus fulicarius*)

General Status (Canada): 3 - Sensitive

Note: Seen on the north coast during migration; strong link to ocean conditions.

Red-necked Phalarope (*Phalaropus lobatus*)

NatureServe (BC): S3S4B (Vulnerable to Apparently Secure Breeding)
BC List: Blue
COSEWIC: Special Concern
General Status (BC): 3 - Sensitive
EC Marine Priority Species (At Risk)

Wandering Tattler (*Tringa incana*)

NatureServe (BC): S3B (Vulnerable Breeding)
BC List: Blue
General Status (Canada): 3 - Sensitive
General Status (BC): 3 – Sensitive
EC Coastal Priority Species (At Risk)

Note: Canada has moderate (20-50% of species) jurisdictional responsibility; species can nest right on the coast.

LARIDAE

California Gull (*Larus californicus*)

NatureServe (BC): S2S3B (Imperiled to Vulnerable Breeding)
BC List: Blue
EC Marine & Coastal Priority Species (At Risk; Stewardship criteria)

Note: Common in NSB; regular migrant.

Heermann's Gull (*Larus heermanni)*

IUCN: Near Threatened
EC Marine & Coastal Priority Species (Stewardship criteria)

Note: Low occurrence in NSB.

Sabine's Gull (*Xema sabini*)

Note: Common in NSB.

Thayer's Gull (*Larus thayeri*)

General Status (Canada): 3 - Sensitive
EC Marine & Coastal Priority Species (Stewardship criteria)

Caspian Tern (*Hydroprogne caspia*)

NatureServe (BC): S3B (Vulnerable Breeding)
BC List: Blue
General Status (Canada): 3 - Sensitive
General Status (BC): 3 - Sensitive
EC Marine & Coastal Priority Species (At Risk)

Note: Low occurrence in NSB.

Common Tern (*Sterna hirundo*)

EC Marine & Coastal Priority Species (Stewardship criteria)

Note: Low occurrence in NSB.

ALCIDAE

Pigeon Guillemot (*Cepphus columba*)

EC Marine & Coastal Priority Species (Stewardship criteria)

Note: BC supports high proportion of global population on a small number of colonies, so species is vulnerable.

Ancient Murrelet (*Synthliboramphus antiquus*)

NatureServe (BC): S2S3B,S4N (Imperiled to Vulnerable Breeding; Apparently Secure Non-Breeding)
BC List: Blue
COSEWIC: Special Concern
SARA: Schedule 1 - Special Concern
General Status (Canada): 3 - Sensitive
General Status (BC): 3 – Sensitive
EC Marine Priority Species (At Risk, of Conservation Concern; Stewardship criteria)

Marbled Murrelet (*Brachyramphus marmoratus*)

IUCN: Endangered A2bc+3bc+4bc
NatureServe (Global): G3 (Vulnerable)
NatureServe (BC): S3B,S3N (Vulnerable Breeding, Vulnerable Non-Breeding)
BC List: Blue
COSEWIC: Threatened
SARA: Schedule 1 - Threatened
General Status (Canada): 1- At Risk
General Status (BC): 1 – At Risk
EC Marine Priority Species (At Risk, of Conservation Concern; Stewardship criteria)

Cassin's Auklet (*Ptychoramphus aleuticus*)

IUCN: Near Threatened
NatureServe (BC): S3B,S4N (Vulnerable Breeding, Apparently Secure Non-Breeding)
BC List: Blue
COSEWIC: Special Concern
General Status (Canada): 3 - Sensitive
General Status (BC): 3 - Sensitive
EC Marine & Coastal Priority Species (At Risk; Stewardship criteria)

Note: BC supports high proportion of global population on a small number of colonies, so species is vulnerable.

Rhinoceros Auklet (*Cerorhinca monocerata*)

EC Marine & Coastal Priority Species (Stewardship criteria)

Note: BC supports high proportion of global population on a small number of colonies, so species is vulnerable.

Common Murre (*Uria aalge*)

NatureServe (BC): S2B,S3S4N (Imperiled Breeding; Vulnerable to Apparently Secure Non-Breeding)
BC List: Red
General Status (BC): 2 - May Be At Risk
EC Marine & Coastal Priority Species (At Risk; Stewardship criteria)

Thick-billed Murre (*Uria lomvia*)

NatureServe (BC): S1B (Critically Imperiled Breeding)
BC List: Red
General Status (BC): 2 - May Be At Risk
EC Marine & Coastal Priority Species (At Risk; Stewardship criteria)

Note: Small population in BC, most are north of NSB.

Tufted Puffin (*Fratercula cirrhata*)

NatureServe (BC): S2S3B,S4N (Imperiled to Vulnerable Breeding; Apparently Secure Non-Breeding)
BC List: Blue
General Status (Canada): 3 - Sensitive
General Status (BC): 3 - Sensitive
EC Marine & Coastal Priority Species (At Risk; Stewardship criteria)

Horned Puffin (*Fratercula corniculata*)

NatureServe (BC): S2B (Imperiled Breeding)
BC List: Red
General Status (Canada): 2 - May Be At Risk
General Status (BC): 2 - May Be At Risk
EC Marine & Coastal Priority Species (At Risk; of Conservation Concern; Stewardship criteria)

Note: Small population in BC, most are north of NSB.

BONY FISHES

FLATFISHES

Arrowtooth Flounder (*Atheresthes stomias*)

Trophic level=4.2, Max length=84 cm

Upper-level Predator: 2

Arrowtooth Flounder are high-level predators that occur from California to Alaska, and usually sit at slightly lower trophic levels than Pacific Halibut (Buckley et al. 1999, Haggan et al. 1999, Lee et al. 2010). Both adults and juveniles are piscivorous, although larger Arrowtooth take more fish in their diet (Buckley et al. 1999, Gaichas et al. 2010). Arrowtooth feed primarily on pelagic prey (Kabata and Forrester 1974, Buckley et al. 1999). Pacific Herring, Pacific Hake, Eulachon, and Pacific Sand Lance are common in the diet, while shrimp and euphausiids may be less important (Kabata and Forrester 1974, Buckley et al. 1999). Arrowtooth predation on young Walleye Pollock may impact that species' population dynamics in the Gulf of Alaska (Bailey 2000, Hollowed 2000).

Nutrient Transfer: *

Arrowtooth migrate from shallow areas on the continental shelf to the deeper continental slope to spawn in winter (NOAA 1990 in McCain et al. 2005), and may gradually move deeper as they get larger (Zimmermann and Goddard 1996). However, it's not clear if there is significant movement into and out of NSB.

Butter Sole (*Isopsetta isolepis*)

Trophic level=3.6, Max length=55 cm

Upper-level Predator: 1

Butter Sole feed on polychaete worms, crabs, shrimp, amphipods, and echinoderms, as well as Pacific Herring, Pacific Sand Lance, and some flatfish (Forrester and Thomson 1969, Smith 1936 in Hart 1973, Wakefield 1984). In the Columbia estuary, mysids are an important dietary component (Bottom and Jones 1990), and in Hecate Strait they feed on forage fish and meiofauna (Pearsall and Fargo 2007).

Nutrient Transfer: *

Butter Sole migrate in winter to deeper waters relative to their shallower summer range (Hart 1973). Large migrations in BC are not known.

Dover Sole (*Microstomus pacificus*)

Trophic level=3.2, Max length=76 cm

Upper-level Predator: 1

Dover Sole are benthic feeders that feed on a large variety burrowing invertebrates, particularly polychaetes and brittle stars (Hart 1973, Pearcy and Hancock 1978, Buckley et al. 1999). Other benthic invertebrates such as sea pens, anemones, bivalves, gastropods, shrimp (including *Pandalus jordani*), gammarid amphipods, and other crustaceans may also be taken (Hart 1973, Pearcy and Hancock 1978, Buckley et al. 1999).

Nutrient Transfer: *

Dover Sole migrate to deeper water in the winter to spawn, returning to shallower areas on the continental in the summer (Low 1993). However it is not clear if these migrations span the NSB boundary.

English Sole (*Parophrys vetulus*)

Trophic level=3.4, Max length=57 cm

Upper-level Predator: 1

English Sole are benthic feeders, with diets that include clams, annelids, small crabs and shrimps, and ophiuroids (Hart 1973, Ambrose 1976, Low 1993). In the Columbia estuary, mysids are important in their diet (Bottom and Jones 1990).

Nutrient Transfer: *

English Sole undergo seasonal migrations from shallow water to deeper water in the winter (Low 1993). In Puget Sound, English Sole were recorded moving almost 400 km in a year as they left coastal areas to spawn, then returned (Moser et al. 2013). It is not clear if seasonal migrations span the NSB boundary.

Flathead Sole (*Hippoglossoides elassodon*)

Trophic level=3.7, Max length=52 cm

Upper-level Predator: 0

Flathead Sole in the Bering Sea system are lower- to mid-level predators (Lee et al. 2010). In Puget Sound, Flathead Sole eat clams, worms, and some crustaceans (Smith 1936 in Hart 1973). In the Bering Sea, smaller fish mostly eat crustaceans and larger fish mostly eat ophiuroids; some juvenile Walleye Pollock, rockfish, gunnels, and flatfish were also eaten (Pacunski et al. 1998).

Nutrient Transfer: *

In the Bering Sea, Flathead Sole occur near the continental slope in the winter for spawning, and move towards the mid and outer shelf in the spring and summer (Stockhausen et al. 2010). There is little information on their migration patterns in BC, and it is not known if they move in and out of NSB.

Pacific Halibut (*Hippoglossus stenolepis*)

Trophic level=4.1, Max length=267 cm

Upper-level Predator: 2

Pacific Halibut are among the highest trophic level fish in NE Pacific ecosystems, where they have been referred to as “keystone” species (Pauly and Christensen 1996, Haggan et al. 1999, Gaichas et al. 2010, Lee et al. 2010). Juvenile Halibut are also high-level predators (Gaichas et al. 2010). In Hecate Strait, Halibut eat Pacific Sand Lance, Pacific Herring, and crabs (Best and St-Pierre 1986). In the Gulf of Alaska, juvenile Halibut start out feeding on small crustaceans but become highly piscivorous as they grow, taking large crustaceans and fish such as Pacific Sand Lance, Walleye Pollock, and Pacific Sandfish (Best and St-Pierre 1986, Trumble et al. 1993). Best and St-Pierre (1986) note that “When the biomass of halibut is large, their voracious feeding can have a temporary local effect on prey species”.

Nutrient Transfer: 1

Juvenile Halibut likely have substantial migrations eastward from Alaska to BC, to counteract the westward drift of eggs (Skud 1977, Deriso and Quinn 1983). These migrations could potentially transfer nutrients or energy into NSB from more northerly areas, although it is unclear if this has been studied from an ecosystem perspective. Adult Pacific Halibut undergo seasonal migrations across the shelf, from shallower summer feeding grounds to deeper winter spawning grounds on the slope (inshore to offshore), usually within IPHC statistical areas (IPHC 2014).

Pacific Sanddab (*Citharichthys sordidus*)

Trophic level=3.5, Max length=41 cm

Upper-level Predator: 0

Sanddabs are mid-trophic level carnivores (Young and Mearns 1980), that are likely generalist or opportunistic predators (Hulberg and Oliver 1978 in Rackowski and Pikitch 1989). In Oregon, Pacific Sanddab primarily eat pelagic crustaceans such as crab larvae, calanoid copepods, and euphausiids (Pearcy and Hancock 1978), although juvenile rockfish and razor clams have been found in their stomachs (Hulberg and Oliver 1978 in Rackowski and Pikitch 1989). In California, Pacific Sanddab feed on benthic polychaetes, epibenthic crustaceans, and small midwater fish (Young and Mearns 1980). In Hecate Strait, Pacific Sanddab feed on euphausiids and epibenthic organisms (Pearsall and Fargo 2007).

Nutrient Transfer: *

Sanddabs are not highly migratory (Chamberlain 1979 in Rackowski and Pikitch 1989). There are some migrations from summer feeding to winter spawning grounds (Pearcy 1978 in McCain et al. 2005), but they are poorly understood (McCain et al. 2005). There is no information on Sanddab movement in BC.

Petrale Sole (*Eopsetta jordani*)

Trophic level=4.1, Max length=70 cm

Upper-level Predator: 1

Petrale Sole is a high level predator with a diet similar to Arrowtooth flounder, dogfish, Pacific Cod, Sand Sole, and some rockfish (Starr 2009). The diet of Petrale Sole in BC may include euphausiids, Pacific Sand Lance, Pacific Herring, shrimps, and other fish and invertebrates (Hart 1973). In Hecate Strait, Petrale Sole feed on Pacific Herring, other fish, and epibenthic organisms (Pearsall and Fargo 2007).

Nutrient Transfer: 0

Petrale Sole have seasonal movement patters between shallow feeding grounds in the summer to deeper spawning grounds in the winter (McCain et al. 2005). There is limited north-south movement, although movements over 600 km have been reported (Hart 1973, Garrison and Miller 1982 in McCain et al. 2005).

Rex Sole (*Glyptocephalus zachirus*)

Trophic level=3.3, Max length=60 cm

Upper-level Predator: 1

Rex Sole are primarily benthic feeders, eating primarily polychaetes and gammarid amphipods, other crustaceans such as crab larvae and cumaceans, and *Oikopleura* (Pearcy and Hancock 1978).

Nutrient Transfer: 0

Rex sole move seasonally between inshore and offshore areas (Love 2011), but appear to have limited movement overall (Hosie and Horton 1977).

Rock Sole (*Lepidopsetta bilineata*)

Trophic level=3.2, Max length=60 cm

Upper-level Predator: 1

Rock Sole in the Bering Sea system are lower- to mid-level predators (Lee et al. 2010) that feed on meiobenthic and macrobenthic organisms, including bivalves, polychaetes, shrimps, crabs, brittle stars, and fish such as Pacific Sand Lance (Roedel 1948, Forrester and Thomson 1969 in Hart 1973, Pearsall and Fargo 2007). Although previous studies suggested that smaller Rock Sole in Hecate Strait (< ~ 29 cm) do not feed on fish (Forrester and Thomson 1969), forage fish were found to be an important dietary component in more recent studies of juvenile Rock Sole in Hecate Strait (Pearsall and Fargo 2007).

Nutrient Transfer: 0

Rock Sole are sedentary, although they have seasonal movements to deeper waters to spawn in the winter (Garrison and Miller 1982, McCain et al. 2005). Their large-scale movement patterns are not clear.

Sand Sole (*Psettichthys melanostictus*)

Trophic level=4.1, Max length=63 cm

Upper-level Predator: 1

Juvenile and small sand Sole feed on small crustaceans (mysids, amphipods, decapods) and polychaetes (Ambrose 1976, Nybakken et al. 1977), while larger sand Sole are strongly piscivorous, taking fish such as Pacific Herring, Speckled Sanddabs, Pacific Tomcod, and Northern Anchovy (Miller 1967, Wakefield 1984). In Hecate Strait, Sand Sole feed on forage fish, Rock Sole, shallow-water benthic and other flatfish (Pearsall and Fargo 2007). Adults may also feed on mysids, decapods, shrimp, worms, squid, and other molluscs (Miller 1967, Ambrose 1976, Wakefield 1984, Barry et al. 1996).

Nutrient Transfer: 0

Sand Sole are non-migratory, although they have seasonal movements to shallower waters to spawn (McCain et al. 2005).

Slender Sole (*Lyopsetta exilis*)

Trophic level=3.5, Max length=35 cm

Upper-level Predator: 0

Slender Sole primarily eat pelagic crustaceans, including euphausiids and Smooth Pink Shrimp *Pandalus jordani*, as well as some polychaetes (Pearcy and Hancock 1978).

Nutrient Transfer: *

Little information is available on any migrations of Slender Sole.

Speckled Sanddab (*Citharichthys stigmaeus*)

Trophic level=3.4, Max length=41 cm

Upper-level Predator: 0

Speckled Sanddabs feed on epibenthos (Pearsall and Fargo 2007), including crustaceans, polychaetes, and some fish (Johnson et al. 1994). Juvenile Speckled Sanddabs feed on small crustaceans (e.g., copepods, amphipods, mysids), while adults feed on larger organisms (Ford 1965 in Rackowski and Pikitch 1989, Ambrose 1976). In Hecate Strait, Speckled Sanddab are grazers that feed on mostly epibenthic organisms, with some forage fish (Pearsall and Fargo 2007).

Nutrient Transfer: *

Sanddabs are not highly migratory (Chamberlain 1979 in Rackowski and Pikitch 1989). There is no information on sanddab movement in BC.

Starry Flounder (*Platichthys stellatus*)

Trophic level=3.6, Max length=91 cm

Upper-level Predator: 1

Starry Flounder feed on benthic organisms, such as clams and other molluscs, crabs and shrimp, worms, sand dollars, and brittle stars (Miller 1967, Hart 1973, Wakefield 1984). In the Columbia estuary, and on the Oregon shelf, amphipods are an important dietary component (Wakefield 1984, Bottom and Jones 1990).

Nutrient Transfer: *

There is little information available on the migrations of Starry Flounder.

FORAGE FISHES

Capelin (*Mallotus villosus*)

Trophic level=3.2, Max length=25 cm

Forage Species: 2

Capelin is found on both the Atlantic and Pacific coasts of Canada (Coad 1995). They form large schools and tend to only occur nearshore for spawning (Love 2011). Capelin are very fatty before spawning (Coad 1995) and are food for a large number of fish, seabird, and mammal predators (Love 2011).

Nutrient Transfer: *

They form schools to spawn, and deposit eggs in shallow waters with fine gravel (Schweigert et al. 2007, Love 2011). There is little information on migrations of this species in the Pacific.

Eulachon (*Thaleichthys pacificus*)

Provincial: S2S3 (Imperiled to Vulnerable)
BC List: Blue
COSEWIC: Endangered (Fraser River, Central Pacific Coast Populations), Special Concern (Nass/Skeena Rivers populations)

Trophic level=3.3, Max length=34 cm

Forage Species: 2

Eulachon are an important forage species in ecosystems from California to Alaska (Springer and Speckman 1997, Field et al. 2006, Therriault et al. 2009, Brodeur et al. 2014). During migration and after spawning eulachon are an important prey species for birds (eagles, gulls), mammals (sea lions, seals, porpoises, orcas), and fish (salmon, Pacific Halibut, sturgeon, Pacific Hake, Spiny Dogfish, Pacific Cod) (Hay and McCarter 2000, Eulachon Conservation Society 2001 in Stoffels 2001). Eulachon have exceptionally high lipid content (~20%) compared to other fish (COSEWIC 2011a), which contributes to their importance as a forage species.

Nutrient Transfer: 2

Eulachon are small anadromous fish that migrate from offshore areas to coastal rivers to spawn (Stoffels 2001). During spawning runs, aggregations of marine and terrestrial predators including sea lions, seals, Humpback Whales, gulls, Bald Eagles, ducks, and sandpipers feed on Eulachon (Marston et al. 2002). Eulachon spawning runs bring a substantial amount of energy into the rivers and surrounding terrestrial ecosystem (Stoffels 2001), and it has been suggested that Eulachon may play a similar ecological role as salmon with regards to nutrient and energy subsidies to terrestrial ecosystems (Marston et al. 2002).

Longfin Smelt (*Spirinchus thaleichthys*)

Trophic level=3.2, Max length=20 cm

Forage Species: 1*

Longfin Smelt are an important forage species. They are rare in the Salish Sea, although there are populations in Puget Sound (Penttila 2007, Therriault et al. 2009). They also occur in the NSB (Schweigert et al. 2007). There is little information on the biology of Longfin Smelt. Because Longfin Smelt are not locally abundant in the NSB, a score of 1* has been assigned.

Nutrient Transfer: 1*

Longfin Smelt are anadromous and spawn in the lower parts of streams in the late fall or early winter (Coad 1995, Penttila 2007). It is not clear if they provide nutrient subsidy to estuaries/terrestrial habitats during spawning. There is no information about migrations in BC.

Northern Anchovy (*Engraulis mordax*)

Trophic level=3.1, Max length=25 cm

Forage Species: 1*

Northern Anchovy are an important schooling forage fish in the North California Current, with almost 60 documented predators (Coad 1995, Field et al. 2006, Enticknap et al. 2011, Brodeur et al. 2014, Szoboszlai et al. 2015). They rarely occur in the Salish Sea, and the northern limit to their distribution is likely on the central coast of BC around Fitzhugh Sound (Therriault et al. 2009, Therriault et al. 2012). Because Northern Anchovy are not locally abundant in the NSB, a score of 1* has been assigned.

Nutrient Transfer: *

The migratory and spawning patterns of Northern Anchovy in BC are not clear, and it is not known if spawning occurs locally or if Northern Anchovy migrate from southern locations (Therriault et al. 2012). In Oregon and Washington, adult Northern Anchovy move offshore during the summer, while both juveniles and adults remain in nearshore coastal areas in the summer; however, this separation of adult and juvenile Northern Anchovy may not occur in BC (Laroche and Richardson 1980).

Pacific Herring (*Clupea pallasii*)

Trophic level=3.2, Max length=46 cm

Forage Species: 2

Pacific Herring are among the most important prey species in BC and are an essential part of the coastal marine food web (Schweigert et al. 2007, Therriault et al. 2009). They are “classic” forage fish in the Gulf of Alaska (Springer and Speckman 1997) and are an important forage species in the California Current Ecosystem (Enticknap et al. 2011). Their high lipid content (Logerwell and Schaufler 2005) and abundance make them important during all their life stages. Eggs and juveniles provide food for birds, and juveniles and adults are prey for groundfish, salmonids, and marine mammals (Hourston and Haegele 1980, Olesiuk et al. 1990, Tanasichuk 1997, Anderson et al. 2009). In the Northern California Current Ecosystem, at least 52 species are known to feed on Pacific Herring (Szoboszlai et al. 2015).

Nutrient Transfer: 2

Pacific Herring move from offshore feeding areas in Hecate Strait and Queen Charlotte Sound to inshore spawning grounds (Clarke and Jamieson 2006b, Lucas et al. 2007). Eggs are deposited in intertidal and shallow subtidal substrates and vegetation (Coad 1995, Schweigert et al. 2007). Because the migrations of Pacific Herring occur within the boundaries of NSB, their movements do not meet the criterion for nutrient transfer. However, Pacific Herring spawn provides marine-derived nutrients to terrestrial ecosystems. Pacific Herring spawn and the macrophytes on which it is deposited provides energy and nutrients (omega-3 fatty acids) to terrestrial ecosystems when fed on by semiterrestrial detritivores (e.g., *Traskorchestia* spp. amphipods) and scavengers including black bears (Fox et al. 2014, Fox et al. 2015). Pacific Herring spawn may represent a significant seasonal marine-terrestrial trophic linkage that has not been investigated in detail.

Pacific Sand Lance (*Ammodytes hexapterus*)

Trophic level=3.1, Max length=30 cm

Forage Species: 2

Pacific Sand Lance are found in all 3 Canadian oceans, where they occur either in schools or dug into sand (Coad 1995). Pacific Sand Lance are recognized as one of the most important forage species in the North Pacific due to their importance in the diets of other species and effects on other trophic levels (Springer and Speckman 1997, Robards et al. 1999, Therriault et al. 2009, Enticknap et al. 2011). Pacific Sand Lance have high lipid content (Logerwell and Schaufler 2005), and in the Northern California Current Ecosystem, are found in the diets of at least 32 species (Szoboszlai et al. 2015).

Nutrient Transfer: 0

Pacific Sand Lance do not undergo seasonal migrations (Robards et al. 1999).

Pacific Sardine (*Sardinops sagax*)

SARA: Schedule 3 - Special Concern

Trophic level=2.8, Max length=40 cm

Forage Species: 1*

Pacific Sardine are an important forage species in the California Current Ecosystem, where they are eaten by at least 32 species (Enticknap et al. 2011, Szoboszlai et al. 2015). Pacific Sardine are important prey for many marine species, including groundfish, pelagic fish, salmon, sharks, seabirds, and marine mammals (COSEWIC 2002a, Emmett et al. 2005, Schweigert et al. 2007).

Pacific Sardine are an important forage species, but rarely occur in the Salish Sea (Therriault et al. 2009). Sardine populations expand and contract with some regularity (~60 year cycles) based on environmental conditions (Schweigert et al. 2007). In the most recent contraction, Sardine were absent from BC from 1947 until returning in 1992 (Hargreaves et al. 1994). Although the commercial sardine fishery has been open since 2002, Pacific Sardine has not been observed in BC at all in 2013 or 2014 (DFO 2015). Because Pacific Sardine are not locally abundant in the NSB, a score of 1* has been assigned.

Nutrient Transfer: 1

Sardine migrate from southern spawning grounds off Baja and Southern California northward in spring, and return in the fall (Ware 1999, Beamish et al. 2005). They do not generally spawn in BC (Schweigert et al. 2007). The annual migration of sardine into BC consists of about 10% of the total sardine population (Ware 1999, Schweigert et al. 2007).

Pacific Saury (*Cololabis saira*)

Trophic level=3.7, Max length=40 cm

Forage Species: 1*

In the Northern California Current Ecosystem, at least 33 species are known to feed on Pacific Saury (Szoboszlai et al. 2015). They are known to be important food for albacore, marlins, seabirds, and marine mammals (Coad 1995). In BC, there are multiple reports of Pacific Saury as prey for seabirds, whales, and fish, but relatively few fishery and research catch records exist (Wade and Curtis 2015). Pacific Saury have been reported as important prey for Rhinoceros

Auklets, particularly in years with cool spring sea surface temperatures (Hedd et al. 2006). Because Pacific Saury are not locally abundant in the NSB, a score of 1* has been assigned.

Nutrient Transfer: 1*

There is little information on Pacific Saury in BC (Wade and Curtis 2015). Saury are offshore pelagic fish that occur in NSB when oceanic conditions permit (Schweigert et al. 2007). Saury migrate northward in the summer to feed, and move south to California in the winter to spawn (Love 2011).

Surf Smelt (*Hypomesus pretiosus*)

Trophic level=3.4, Max length=31 cm

Forage Species: 2

Surf smelt are an important forage species in nearshore ecosystems of the NE Pacific, including the Salish Sea and the Northern California Current Ecosystem (Therriault et al. 2002, Therriault et al. 2009, Brodeur et al. 2014). They are important prey for fish, including salmon, as well as seabirds, eagles and marine mammals (Coad 1995, Therriault et al. 2002, Love 2011).

Nutrient Transfer: *

Surf smelt are marine fish, but may be found in estuaries and sometimes in freshwater (Coad 1995, Love 2011). Juveniles and adults school in eelgrass and kelp beds, and adults may occur offshore as well (Love 2011). There does not seem to be much information on predation on surf smelt eggs; terrestrial predation on marine eggs would constitute nutrient transfer between ecosystems.

GROUNDFISHES

Cabezon (*Scorpaenichthys marmoratus*)

Trophic level=3.6, Max length=99 cm

Upper-level Predator: 1

Cabezon are epibenthic carnivores that feed mainly on crabs and shrimps, with small amounts of other benthic organisms such as small flatfish, gastropods, and mysids (Simenstad et al. 1979, Wakefield 1984).

Nutrient Transfer: 0

Adult Cabezon have no known significant migrations, although they may make some movements following the tide (citations in McCain et al. 2005).

Kelp Greenling (*Hexagrammos decagrammus*)

Trophic level=3.6, Max length=61 cm

Upper-level Predator: 0

Kelp Greenlings are considered mesopredators (Frid et al. 2012). They are generalist carnivores that feed at mid-trophic levels on benthic crustaceans, particularly amphipods and crabs, as well as echinoderms, molluscs, annelids, and small fish (Simenstad et al. 1979, Bingham and Braithwaite 1986, Nemeth 1997).

Nutrient Transfer: 0

Adult Kelp Greening do not undergo migrations (McCain et al 2005), although larvae move from estuaries and shallow nearshore areas to open waters (Garrison and Miller 1982 in McCain et al. 2005).

Lingcod (*Ophiodon elongatus*)

Trophic level=4.3, Max length=152 cm

Upper-level Predator: 2

Lingcod are high-level piscivorous predators in rocky habitats (Simenstad et al. 1979 in Haggan et al. 1999, Wallace 1999, Pearsall and Fargo 2007, Beaudreau and Essington 2010). They are generalist predators that feed on demersal fish and invertebrates, as well as pelagic forage fish (Tinus 2012). In Washington and Oregon, Lingcod mostly eat fish, including rockfish, Pacific Sand Lance, clupeids, gadids, Pacific Hake, flatfish, octopus, and shrimp (Wakefield 1984, Beaudreau and Essington 2007, Tinus 2012). In Hecate Strait, Lingcod eat Pacific Herring and English Sole (Pearsall and Fargo 2007).

Larger Lingcod feed on larger prey (Beaudreau and Essington 2009, Frid et al. 2013). If spatial protection restores large size structure, then Lingcod predation on rockfish could, potentially, be greater inside than outside marine protected areas (Beaudreau and Essington 2009). It is unclear, however, the extent to which large Lingcod may limit rockfish population recovery inside protected areas. Field experiments suggest that rockfish actively avoid Lingcod and therefore might be killed infrequently (Frid et al. 2012). Anti-predator behaviour, however, reduces feeding rates of prey, which in turn could hamper growth and reproduction for rockfish and other prey of Lingcod (Heithaus et al. 2008; Frid et al. 2012).

Nutrient Transfer: *

Adult Lingcod are considered non-migratory (Cass et al. 1990). They are generally sedentary and have strong site fidelity, usually staying within 10 km of the reef where they were tagged (Freiwald 2012). However, some individuals, particularly those that are immature, may move up to 1 km/day, or up to several hundred km over longer time periods (Cass et al. 1990, Smith et al. 1990). Little information is available for migrations of Lingcod in NSB, and it is not known if the movements of juvenile Lingcod to areas out of NSB are significant.

Northern Ronquil (*Ronquilus jordani*)

Trophic level=3.1, Max length=20 cm

Upper-level Predator: 0

There is no information on the diet of Northern Ronquil, but given its size and estimated trophic level, it has been assigned a 0.

Nutrient Transfer: *

There is no information on migrations of Northern Ronquil.

Pacific Sandfish (*Trichodon trichodon*)

Trophic level=4.0, Max length=31 cm

Upper-level Predator: 0

Pacific Sandfish feed on plankton, decapods, and fish (gadids), although the importance of each of these prey types varies depending on availability (Thedinga et al. 2005). Sandfish diets in the North California Current are not well documented (Brodeur et al. 2014). In southeast Alaska, they are strongly piscivorous, with Pacific Herring being an important prey species (Sturdevant et al. 2012). Pacific Sandfish may prey heavily on Walleye Pollock in the Bering Sea and Gulf of Alaska (Brodeur and Livingston 1988), which is unlikely to be the case in SE Alaska (Guénette and Christensen 2005), and therefore potentially unlikely in BC. In SE Alaska, schooling young Pacific Sandfish may prey on fish that co-occur in those schools (Thedinga et al. 2005).

Forage Species: 1

Many species feed on Pacific Sandfish, including Chinook and Coho Salmon, sculpins, Pacific Cod, Pacific Halibut, many seabirds, harbour seals, sea lions, mink, and river otter (Best and St-Pierre 1986, Coad 1995, Love 2011). They are nutritious and may be important prey (e.g., for Steller Sea Lion) at certain times of the year (Anthony et al. 2000, Logerwell and Schaufler 2005). Juvenile and larval Pacific Sandfish school with other forage species, including young-of-the-year Walleye Pollock, Pacific Herring, and Pacific Cod, as well as Chum Salmon juveniles and Pink Salmon fry (Bailey et al. 1983, Thedinga et al. 2005).

Nutrient Transfer: *

No information is available on migrations of Pacific Sandfish.

Habitat-Forming Species: *

Pacific Sandfish burrow into sand in nearshore waters (Marliave 1980, Thedinga et al. 2005), but it is not known if other species use the burrows as habitat.

Prowfish (*Zaprora silenus*)

Trophic level=3.7, Max length=88 cm

Upper-level Predator: 1

Adult Prowfish feed mainly on gelatinous zooplankton such as jellyfish, ctenophores, and pelagic tunicates, as well as amphipods, mysids, fish larvae, larvaceans, and polychaetes (Coad 1995, Smith et al. 2004, Love 2011).

Nutrient Transfer:*

There is little information available on any migrations in Prowfish.

Sablefish (*Anoplopoma fimbria*)

Trophic level=3.8*, Max length=120 cm

Upper-level Predator: 2

Sablefish are high trophic level predators throughout BC and Alaska (Pauly and Christensen 1996, Haggan et al. 1999, Gaichas et al. 2010). Sablefish adults and juveniles are opportunistic predators, with diets that vary in time and space depending on local prey availability (Buckley et al. 1999, Coutré et al. 2015). Small Sablefish, which occur on the continental shelf, have similar diets to those of Pacific Hake, feeding on midwater fish, such as myctophids and bathylagids, and crustaceans such as euphausiids, amphipods, and mysids (Laidig et al. 1997, Buckley et al.

1999). Pacific Herring are important prey for juvenile Sablefish in BC and Alaska (McFarlane and Beamish 1983, in Coutré et al. 2015). Larger Sablefish, which occur in deeper slope waters, feed heavily on demersal fish such as thornyheads, as well as cephalopods (Laidig et al. 1997, Rutecki and Varosi 1997). Other fish species eaten by Sablefish include juvenile salmon, rockfish, Pacific Hake, clupeids, smelt, hagfish, and fishery offal (Laidig et al. 1997, Buckley et al. 1999, Sturdevant et al. 2012, Coutré et al. 2015).

Nutrient Transfer: 1

Sablefish spawn on the continental slope; juveniles migrate from the slope to nearshore waters to mature (Beamish et al. 2006) before returning to the slope as adults (Beamish et al. 2006). While many adult Sablefish, particularly those from Vancouver Island, have limited migrations, some from Haida Gwaii may migrate as far as the Gulf of Alaska (Beamish and McFarlane 1988). There is evidence that Sablefish move on and off seamounts from coastal areas, and that recruitment of Sablefish to seamounts may be due to such movements of juveniles (Whitaker and McFarlane 1997, Beamish and Neville 2002).

Wolf-eel (*Anarrhichthys ocellatus*)

Trophic level=3.5, Max length=240 cm

Upper-level Predator: 1

Wolf-eels feed on hard-shelled prey, such as large gastropods, sea urchins, sand dollars, and crabs, with strong prey preferences depending on local prey availability (Hulberg and Graber 1980 in Marliave 1987, Marliave 1987). While mated pairs of adult Wolf-eels are relatively sedentary, juveniles and subadults forage actively and could put pressure on local invertebrate populations; captive subadult Wolf-eel can eat 24 Dungeness crabs in a day (Marliave 1987). However, little information is available showing a controlling influence of Wolf-eels on their prey species.

Nutrient Transfer: *

While mated pairs of adult Wolf-eel are relatively sedentary, juveniles and subadults forage actively (Marliave 1987). However, they likely do not move large distances.

MESOPELAGIC AND BATHYPELAGIC FISHES

Deep-sea smelts (*Bathylagidae*)

Bathylagids are important links in oceanic food webs (Cailliet and Ebeling 1990).

Northern Smoothtongue (*Leuroglossus schmidti*)

Trophic level=3.1, Max length=20 cm

Forage Species: 2

Northern Smoothtongue and other mesopelagic fish have been identified as potentially important forage species in NSB (Schweigert et al. 2007). They are common to coastal waters in Alaska and the Strait of Georgia, and are eaten by species such as Pacific Herring, Eulachon, Pacific Sand Lance, and Chinook Salmon (Coad 1995, Abookire et al. 2002). Northern Smoothtongue are common along the continental slope, but also occur in deep nearshore waters (Mason and Phillips 1985, Abookire et al. 2002).

Nutrient Transfer: *

Smoothtongue do not appear to undergo vertical migrations (Mason and Phillips 1985), and it is not clear if horizontal movement takes place.

Lanternfish (*Myctophidae*)

Myctophids are abundant mesopelagic fish that are important forage fish in oceanic ecosystems (Catul et al. 2010). In the Northern California Current Ecosystem, at least 40 species are known to feed on lanternfish (Szoboszlai et al. 2015).

Northern Lampfish (*Stenobrachius leucopsarus*)

Trophic level=3.1, Max length=13 cm

Forage Species: 2

Lampfish and other myctophids are "classic" forage fish in the Gulf of Alaska (Springer and Speckman 1997) and are an important component in oceanic food webs (Cailliet and Ebeling 1990). They have high lipid contents (Anthony et al. 2000) and are eaten by many species including Sablefish, Walleye Pollock, skates, porpoises, and sea lions (Yang and Nelson 1999, Rinewalt et al. 2007, Tollit et al. 2015).

Nutrient Transfer: *

Northern Lampfish are common along the continental slope, but also occur in deep nearshore (Taylor 1969). Like Smoothtongue, Lampfish migrate from the mesopelagic zone in the day to the epipelagic zone at night (Sobolevsky et al. 1996 in Abookire et al. 2002). However, vertical migrations do not fit the nutrient transfer criterion, and it is not clear if horizontal movement also takes place.

NATIVE SALMONIDS

General overview

Pacific Salmon undergo important migrations between coastal waters and open-ocean ecosystems, and hold key roles in transporting nutrients between offshore, coastal, and terrestrial areas (Hocking and Reimchen 2002, Reimchen et al. 2003, Beamish et al. 2005, Hyatt et al. 2007).

All life stages (eggs, juveniles, and adults) of salmonid fishes are important prey (Hocking and Reimchen 2002, Nelitz et al. 2006, Hyatt et al. 2007). In the marine environment, squid are often a very important part of the diet of salmon, but they also prey on zooplankton, larval crabs, amphipods, polychaetes, euphausiids, and other crustaceans (Quinn 2005). Large salmon prey on Pacific Herring, Pacific Sand Lance, and Eulachon, although these same species can be competitors or even predators when salmon are small (Quinn 2005).

Chinook Salmon (*Oncorhynchus tshawytscha)*

Trophic level=4.4, Max length=150 cm

Upper-level Predator: 2

Chinook are strongly piscivorous and are top predators in the California current ecosystem, where they are known to feed on almost 40 species of fish, crustaceans, and cephalopods (Sturdevant et al. 2012, Szoboszlai et al. 2015). The most commonly reported prey for Chinook was Pacific Herring, Northern Anchovy, and *Sebastes* spp. (Szoboszlai et al. 2015).

Forage Species: 1

Pacific salmon are considered forage fish in the Gulf of Alaska (Springer and Speckman 1997). Juvenile *Oncorhynchus* spp. can be important forage species in the Salish Sea (Therriault et al. 2009), and are eaten by seabirds such as Rhinoceros Auklets at several colonies in BC (Burger et al. 1993, Hedd et al. 2006). Chinook salmon are eaten by Rhinoceros Auklets at several colonies in BC (Burger et al. 1993).

Northern Resident Orcas are highly dependent on Chinook Salmon, which is the least abundant but most energy-rich salmon species (Ford and Ellis 2006, Hilborn et al. 2012, O'Neill et al. 2014).

Nutrient Transfer: 2

Anadromous species such as Pacific Salmon hold key roles in transporting nutrients between offshore and coastal areas, and provide important subsidies of marine-derived nutrients to terrestrial and freshwater ecosystems (Schindler et al. 2003, Beamish et al. 2005, Rice 2006, Hyatt et al. 2007). Chinook salmon are strongly associated with the coastal environment and are not usually found more than 200 miles offshore (Gritsenko 2002 in Beamish et al 2005).

Chum Salmon (*Oncorhynchus keta*)

Trophic level=3.7, Max length=100 cm

Upper-level Predator: 1

Salmon are trophic generalists that show considerable dietary variation. Some of this variation is a consequence of the variation in prey availability, but it is also a consequence of underlying patterns related to fish size and species (Quinn 2005). When Chum Salmon fry first enter the marine environment, their diet is dominated by harpacticoid copepods and gammarid amphipods (reviewed by Salo 1991). The rapid growth rate of salmon in the sea is attests to their intensive and effective feeding behaviour. Chum do not appear to eat as much fish and squid as other species of salmon, and are known to feed on amphipods, euphausiids, pteropods, copepods, fish and squid larvae (Salo 1991). Based on their size and trophic level, they have been given a 1.

Forage Species: 1

Pacific salmon are considered forage fish in the Gulf of Alaska (Springer and Speckman 1997). Juvenile *Oncorhynchus* spp. can be important forage species in the Salish Sea (Therriault et al. 2009), and are eaten by seabirds such as Rhinoceros Auklets at several colonies in BC (Burger et al. 1993, Hedd et al. 2006). Chum Salmon are eaten by Rhinoceros Auklets at several colonies in BC (Burger et al. 1993), and are the second-most important prey for Resident Orcas (Ford and Ellis 2006).

Nutrient Transfer: 2

Pacific Salmon undergo important migrations between coastal waters and open-ocean ecosystems, and hold key roles in transporting nutrients between offshore, coastal, and terrestrial areas (Hocking and Reimchen 2002, Reimchen et al. 2003, Beamish et al. 2005, Hyatt et al. 2007). This transfer of nutrients is reciprocal: Chum Salmon fry have terrestrial-derived carbon in their tissue (Romanuk and Levings 2010).

Coho Salmon (*Oncorhynchus kisutch*)

Trophic level=4.2, Max length=108 cm

Upper-level Predator: 2

Coho Salmon are strongly piscivorous and are known to feed on more than 30 species of fish, crustaceans, and squids (Sturdevant et al. 2012, Szoboszlai et al. 2015). The most commonly reported prey for Coho Salmon in a review of the Northern California Current Ecosystem were Pacific Herring, Euphausiids, and *Sebastes* spp. (Szoboszlai et al. 2015). Based on their size and trophic level, they are assigned a score of 2.

Forage Species: 1

Pacific salmon are considered forage fish in the Gulf of Alaska (Springer and Speckman 1997). Juvenile *Oncorhynchus* spp. can be important forage species in the Salish Sea (Therriault et al. 2009), and are eaten by seabirds such as Rhinoceros Auklets at several colonies in BC (Burger et al. 1993, Hedd et al. 2006).

Nutrient Transfer: 2

Pacific Salmon undergo important migrations between coastal waters and open-ocean ecosystems, and hold key roles in transporting nutrients between offshore, coastal, and terrestrial areas (Hocking and Reimchen 2002, Reimchen et al. 2003, Beamish et al. 2005, Hyatt et al. 2007). Coho are mostly a costal species that do not move as far offshore as other Pacific salmon species during their migrations (Beamish et al. 2005). They are less abundant than other Pacific salmon species (Beamish et al. 2005).

Pink Salmon (*Oncorhynchus gorbuscha*)

Trophic level=4.5, Max length=76 cm

Upper-level Predator: 1

Salmon are trophic generalists that show considerable dietary variation. Some of this variation is a consequence of the variation in prey availability, but it is also a consequence of underlying patterns related to fish size and species (Quinn 2005). Juvenile Pink Salmon in coastal waters gradually shift to larger prey including larvaceans, copepods, euphausiids, arrow worms, and amphipods (Heard 1991). As they get larger, they select larger prey that include squid and fish, though the relative importance of specific foods eaten varies great with the time and area (Heard 1991). Based on their size and trophic level, they have been given a 1.

Forage Species: 1

Pink Salmon are the most abundant Pacific Salmon in NSB (Hyatt et al. 2007). Pacific Salmon are considered forage fish in the Gulf of Alaska (Springer and Speckman 1997). Juvenile *Oncorhynchus* spp. can be important forage species in the Salish Sea (Therriault et al. 2009), and are eaten by seabirds such as Rhinoceros Auklets at several colonies in BC (Burger et al. 1993, Hedd et al. 2006).

Nutrient Transfer: 2

Pacific Salmon undergo important migrations between coastal waters and open-ocean ecosystems, and hold key roles in transporting nutrients between offshore, coastal, and terrestrial areas (Hocking and Reimchen 2002, Reimchen et al. 2003, Beamish et al. 2005, Hyatt et al. 2007).

Sockeye Salmon (*Oncorhynchus nerka*)

As a species, Sockeye Salmon are not listed as Conservation Concern. However, about 1/3 of the global populations are at risk of extinction (Rand et al. 2012). Two populations in NSB (Skeena-Alastair and Hecate Strait-Queen Charlotte Sound) are Endangered under IUCN.

Trophic level=3.6, Max length=84 cm

Upper-level Predator: 1

Salmon are trophic generalists that show considerable dietary variation. Some of this variation is a consequence of the variation in prey availability, but it is also a consequence of underlying patterns related to fish size and species (Quinn 2005). During the initial marine period of Sockeye Salmon's life history, they forage actively on a variety of organisms including copepods and insects, amphipods, euphausiids, and fish larvae when available (Healy 1980). Maturing Sockeye eat larger crustaceans, squid and fish (Quinn 2005). Fish eaten include lanternfish (Myctophidae) and juvenile Pacific Cod, Pacific Sand Lance, Pacific Herring, Walleye Pollock, and Capelin (reviewed in Burgner 1991). Welch and Parsons (1993) show Chinook Salmon are the highest trophic-level Pacific salmon, followed by Coho, Sockeye, and Pink Salmon. Based on their size and trophic level, they have been given a 1.

Forage Species: 1

Pacific salmon are considered forage fish in the Gulf of Alaska (Springer and Speckman 1997). Juvenile *Oncorhynchus* spp. can be important forage species in the Salish Sea (Therriault et al. 2009), and are eaten by seabirds such as Rhinoceros Auklets at several colonies in BC (Burger et al. 1993, Hedd et al. 2006). Fledgling mass of Rhinoceros Auklets at Triangle Island, BC is strongly correlated with marine survival of Sockeye (Borstad et al. 2011).

Nutrient Transfer: 2

Pacific Salmon undergo important migrations between coastal waters and open-ocean ecosystems, and hold key roles in transporting nutrients between offshore, coastal, and terrestrial areas (Hocking and Reimchen 2002, Reimchen et al. 2003, Beamish et al. 2005, Hyatt et al. 2007).

Steelhead (*Oncorhynchus mykiss*)

Trophic level=4.1, Max length=122 cm

Upper-level Predator: 2

Steelhead feed on many fishes and invertebrates, including crustacean larvae, squids, polychaetes, and pteropods (Love 2011). Based on size and trophic level, Steelhead are assigned a 2.

Forage Species: 1*

Pacific salmon are considered forage fish in the Gulf of Alaska (Springer and Speckman 1997). Juvenile *Oncorhynchus* spp. can be important forage species in the Salish Sea (Therriault et al. 2009), and are eaten by seabirds such as Rhinoceros Auklets at several colonies in BC (Burger et al. 1993, Hedd et al. 2006). Coastal Cutthroat Trout and Steelhead, both also *Oncorhynchus* sp.*,* have been given 1* to indicate they may be important forage species as juveniles, reflecting the lack of species-specific information. Seals in the Strait of Georgia do feed on Steelhead or Coastal Cutthroat (Olesiuk et al. 1990).

Nutrient Transfer: 1

Steelhead, which are the anadromous form of Rainbow Trout, are much less abundant than Pacific salmon species (Beamish et al. 2005). Steelhead have extensive migrations that extend west and south of the Aleutian Islands (Gritsenko 2002 in Beamish et al 2005). After spawning, Steelhead return to the ocean; most Steelhead only spawn once but some return to freshwater to spawn a second time.

Coastal Cutthroat Trout (*Oncorhynchus clarkii*)

Trophic level=3.8, Max length=99 cm

Upper-level Predator: 2

At sea, Coastal Cutthroat Trout feed mostly on small fish like Pacific Sand Lance, stickleback, Northern Anchovy, and rockfish, as well as amphipods, isopods, euphausiids and shrimp (Trotter 1989, Love 2011). Based on their size, trophic level, and expert judgement, they have been given a score of 2.

Forage Species: 1*

Pacific salmon are considered forage fish in the Gulf of Alaska (Springer and Speckman 1997), and juvenile *Oncorhynchus* spp. can be important forage species in the Salish Sea (Therriault et al. 2009), and are eaten by seabirds such as Rhinoceros Auklets at several colonies in BC (Burger et al. 1993, Hedd et al. 2006). Coastal Cutthroat Trout and Steelhead, also *Oncorhynchus* sp., have been given 1* to indicate they may be important forage species as juveniles, reflecting the lack of species-specific information. *O. clarkii* was not present in the diets of Orca that fed on all other *Oncorhynchus* species (Ford and Ellis 2006), although seals in the Strait of Georgia do feed on Steelhead or Cutthroat Trout (Olesiuk et al. 1990).

Nutrient Transfer: 1

Some Cutthroat are anadromous, inhabiting coastal areas and estuaries during the summer (Love 2011). Unlike other salmon, Cutthroat are iteroparous (Trotter 1989) and do not die in the streams after spawning. Coastal Cutthroat generally stay in coastal or estuarine areas during their marine phase (Trotter 1989), and do not have a large offshore migration like other salmon species.

Dolly Varden (*Salvelinus malma lordi)*

Trophic level=4.4, Max length=127 cm

Upper-level Predator: 2

Dolly Varden feed on fish such as capelin, Pacific Sand Lance, Pacific Herring, and juvenile salmon, as well as a wide range of epibenthic and planktonic invertebrates (Love 2011).

Forage Species: *

There are two subspecies of Dolly Varden; *Salvelinus malma malma* occurs north of the Aleutian Islands, while *S. m. lordi* occurs south of the Aleutians (COSEWIC 2010a). Dolly Varden are anadromous fish that occupy coastal marine waters during the summer (Love 2011). It is not clear how important Dolly Varden are as a forage species.

Nutrient Transfer: *

There is not much information on sea-run Dolly Varden in British Columbia, including its migration patterns or its role as a forage species.

PELAGIC FISHES

Albacore Tuna (*Thunnus alalunga*)

IUCN: Near Threatened

Trophic level=4.3, Max length=140 cm

Predator: 2

Albacore Tuna are high-level predators in the open-ocean ecosystem of the central and North Pacific (Kitchell et al. 1999, Dambacher et al. 2010). Albacore Tuna feed on forage fish (Pacific Herring, Northern Anchovy, sauries), as well as lanternfish, rockfish, squid, and euphausiids (Coad 1995). In the California Current system (from California to BC), Albacore Tuna predation on Northern Anchovy recruits may influence Northern Anchovy population and dynamics (Glaser 2011). Their ecological role when feeding in more coastal areas of BC is not clear, but they are likely an important seasonal component of the pelagic ecosystem.

Nutrient Transfer: 1

Albacore Tuna are offshore species that usually reside in the open ocean, but some migrate inshore and northward during the summer months, particularly during warm years (Beamish et al. 2005). Albacore prefer temperatures around 14-16ºC (Hart 1973, Coad 1995). In the summer they occur in surface waters around the continental shelf break of BC, including off of West Coast Vancouver Island and Haida Gwaii (Hannah and McKinnell 2016). Albacore Tuna may feed in coastal areas during these migrations, contributing to nutrient transfer between nearshore and offshore ecosystems (Beamish et al. 2005).

Jack Mackerel (*Trachurus symmetricus*)

Trophic level=3.6, Max length=81 cm

Predator: 1

Jack mackerel are mid-trophic level feeders that eat zooplankton and juvenile fish such as Northern Anchovy, Pacific Herring, sardine, whitebait smelt, and Pacific Hake (Coad 1995, Emmett et al. 2005, Emmett and Krutzikowsky 2008, Miller et al. 2010). The amount of fish in their diets varies annually and seasonally; zooplankton such as euphausiids are the primary prey most years (Brodeur et al. 1987, Miller and Brodeur 2007).

Forage Species: 1*

Jack Mackerel are common schooling species around southern Vancouver Island in the fall (Coad 1995). They occur in open ocean as well as around reefs and kelp beds (Coad 1995). Juveniles in particular form large schools around kelp beds, oil platforms, banks, and islands close to shore (Love 2011). Jack Mackerel are an important forage species in the California Current Ecosystem as prey for pelagic predators such as toothed whales, seals, sea lions, porpoises, large fish (e.g., pelagic sharks, halibut, tunas), and seabirds (Coad 1995, Enticknap et al. 2011, Love 2011). The abundance of Jack Mackerel fluctuates in response to environmental conditions and the abundance of competitors such as Sardine (Kawasaki and Omori 1995, MacCall 1996).

Nutrient exporter: 1

Jack Mackerel migrations follow the expansion of warm waters from spawning grounds in California northward throughout the summer, eventually reaching the Gulf of Alaska (Love 2011).

Ocean Sunfish (*Mola mola*)

IUCN: Vulnerable A4bd

Upper-level Predator: 1

Trophic level=3.7, Max length=333 cm

Ocean Sunfish are large (up to 4 m) pelagic fish that are found in BC in the summer (Coad 1995). They feed primarily on gelatinous zooplankton, as well as fish, squid, and molluscs, as well as some benthic invertebrates (Coad 1995, Love 2011). They hold a unique trophic position, along with Leatherback Sea Turtles, as jellyfish specialists (Houghton et al. 2006).

Nutrient Transfer: 1

Although Ocean Sunfish can travel about 30 km a day, they are not thought to make large-scale migrations (Dewar et al. 2010, Love 2011). They usually occur in offshore oceanic habitats (Schweigert et al. 2007), but aggregations have been observed on the northern continental shelf, for example in a productive area in Queen Charlotte Sound (Williams et al. 2010).

Pacific Chub Mackerel (*Scomber japonicus*)

Trophic level=3.4, Max length=64 cm

Upper-level Predator: 1

Chub Mackerel occurs in coastal waters, often schooling in kelp beds but also occuring deeper than 300 m (Coad 1995). In the northern California Current Ecosystem, Chub Mackerel are mid-trophic level fish (Miller et al. 2010) that feed on schooling fish such as Pacific Sand Lance and Pacific Herring, as well as crustaceans, squid, and *Velella velella* (Hart 1973, Coad 1995, Miller et al. 2010). Older, larger individuals feed more heavily on fish than do smaller individuals (Castro 2010).

Forage Species: 1*

Chub Mackerel are schooling pelagic forage fish that are important for pelagic predators such as tunas and toothed whales, as well as Boccacio, Lingcod, Thornyhead, sharks, pinnipeds, and seabirds (Coad 1995, Alder and Pauly 2006, Enticknap et al. 2011, Love 2011). Populations of Chub Mackerel fluctuate significantly, which has been linked to environmental conditions and the abundance of competitors and prey such as Sardine (Sinclair et al. 1985, Kawasaki and Omori 1995, Tang 1995, MacCall 1996, Crone et al. 2009). Because Pacific Chub Mackerel are not locally abundant in the NSB, a score of 1* has been assigned.

Nutrient Transfer: 1*

Chub Mackerel undertake northward migrations following temperature gradients along the North American coast (Coad 1995). They are highly migratory between Baja California and Washington, with the summer range extending further north into BC during El Niño events (Roedel 1938 in Hart 1973, Roedel 1949 in Crone et al 2009, MBC Applied Environmental Sciences 1987 in Crone et al 2009).

Pacific Pomfret (*Brama japonica*)

Upper-level Predator: 1

Trophic level=4.4, Max length=61 cm

Pacific Pomfret feed on fish, squids, crustaceans, and pteropods (Love 2011). In the Gulf of Alaska, gonatid squids were the dominant prey (Pearcy et al. 1993).

Nutrient Transfer: 1*

Pacific Pomfret are very abundant in the offshore North Pacific, where they undertake a large migration between subarctic areas in the spring to subtropical waters in the fall (Pearcy et al. 1993, Love 2011). They care caught occasionally in nearshore waters and are "not uncommon" in BC (Coad 1995) and are found in the NSB under certain ocean conditions (Schweigert et al. 2007).

ROCKFISHES

General overview

Forage Species: 1*

Juvenile rockfish are often considered forage species because of their importance the diets of many species, including predatory fish (e.g., salmon, Lingcod, adult rockfish, greenling), marine birds, and mammals (Brodeur 1991, Hobson et al. 2001, Miller and Sydeman 2004, Beaudreau and Essington 2007, Mills et al. 2007, Field et al. 2010, Enticknap et al. 2011, Szoboszlai et al. 2015). In BC, juvenile rockfish are important in the diet of Rhinoceros and Cassin's Auklets (Burger et al. 1997 in Harfenist 2003, Thayer et al. 2008, Sorensen et al. 2009). However, juvenile rockfish may be lower quality food for breeding seabirds, in comparison with energetically superior copepods (Sorensen et al. 2009). In the Northern California Current Ecosystem, at least 61 species are known to feed on rockfish (Szoboszlai et al. 2015).

It is difficult to identify juvenile rockfish, so most dietary studies report only *Sebastes* spp. Therefore all rockfish were given the score of 1* for their importance as forage species.

Black Rockfish (*Sebastes melanops*)

Trophic level=4.4, Max length=63 cm

Upper-level Predator: 1

Black Rockfish are piscivorous opportunistic predators that feed on a range of water column fish and zooplankton, such as Pacific Herring, Pacific Sand Lance, young-of-the-year rockfish, and crab larvae, as well as some benthic invertebrates (Lea et al. 1999, Love et al. 2002, Sturdevant et al. 2012).

Nutrient Transfer: *

Black Rockfish are among the more mobile rockfish species, although it is not clear what proportion of the population undertakes substantial migrations (Love et al. 2002). While some tagging studies have reported fish moving between Washington and Oregon, others have shown limited movement and high site fidelity (Love et al. 2002, Green and Starr 2011). Black Rockfish in California undertake diel migrations, moving to deeper waters during the day and returning to coastal waters in the day (Green and Starr 2011). Green and Starr (2011) estimate that between 10-40% of small Black Rockfish are highly mobile. However, the extent of migration and the degree to which it occurs in BC is not known.

Blackspotted Rockfish (*Sebastes melanostictus*)

COSEWIC: Special Concern†
SARA: Schedule 1 - Special Concern†

† Rougheye Rockfish was assessed under COSEWIC and SARA in 2007 as "Rougheye Rockfish type I and II", which are now recognized as *Sebastes melanostictus* (Blackspotted Rockfish) and *S. aleutianus* (Rougheye Rockfish) (Orr and Hawkins 2008).

Trophic level=3.9 , Max length= 54 cm

Scores for Blackspotted Rockfish are the same as for Rougheye Rockfish.

Bocaccio (*Sebastes paucispinis*)

IUCN: Critically Endangered A1abd+2d
COSEWIC: Endangered

Trophic level=3.5*, Max length=91 cm

Upper-level Predator: 2

Bocaccio are highly piscivorous (Pearsall and Fargo 2007). Adult Bocaccio feed on rockfish, Pacific Hake, Sablefish, Northern Anchovy, lanternfish, and squid, while juveniles feed on fish larvae and crustacean zooplankton (Love et al. 2002). Young-of-the-year Bocaccio may feed on smaller Bocaccio (Love 2011).

Nutrient Transfer: *

Juvenile Bocaccio move long distances into deeper waters as they age, while adults have small movements between habitat patches (Love et al. 2002). Younger individuals move more than older fish, which are more sedentary (Love 2011). It is not clear the extent to which fish move in and out of NSB.

Canary Rockfish (*Sebastes pinniger*)

COSEWIC: Threatened

Trophic level=3.8, Max length=76 cm

Upper-level Predator: 1

Adult Canary Rockfish feed on krill, small fish (e.g., lanternfish, Northern Anchovy, sanddabs, adult Shortbelly Rockfish), and gelatinous zooplankton (Love et al. 2002). Pacific Herring and Pacific Sand Lance may be important prey species in BC (COSEWIC 2007a), while crustaceans (euphausiids, mysids, and shrimps) were common in California (Lea et al. 1999). Euphausiids were the dominant prey in a study from California to BC, with some myctophid and stomiatoid fish (Brodeur and Pearcy 1984).

Nutrient Transfer: *

No tagging studies have been done on Canary Rockfish in BC, although there is some evidence of seasonal migrations to deeper water in the winter (COSEWIC 2007a). Lea et al. (1999) states that Canary Rockfish have the capacity for moving "great distances". Some individuals have been recorded to move hundreds of km (DeMott 1983, Love et al. 2002). It is not clear if substantial north-south migrations take place that might have fish moving in and out of NSB

China Rockfish (*Sebastes nebulosus*)

Trophic level=3.9, Max length=45 cm

Upper-level Predator: 0

The diet of China Rockfish includes benthic invertebrates such as ophiuroids, shrimps, crabs, and chitons, abalones, and other molluscs (Lea et al. 1999, Love et al. 2002). Fish, including Northern Clingfish, have also been reported in their diet in smaller amounts (Lea et al. 1999).

Nutrient Transfer: 0

China Rockfish are territorial and tend not to move from their home territory (Love et al. 2002).

Copper Rockfish (*Sebastes caurinus*)

Trophic level=4.1, Max length=58 cm

Upper-level Predator: 1

Copper Rockfish are opportunistic carnivores (McCain et al. 2005). Small pelagic fish (e.g., Pacific Herring, Pacific Sand Lance, perch, small rockfish, and other nearshore fish) are important prey in the diets of adults, which are more piscivorous than juveniles (Murie 1995, Lea et al. 1999, Love et al. 2002, McCain et al. 2005). Adults also feed on *Pandalus* and other shrimps, mysids, crabs, dogfish, greenlings, and sculpins (Murie 1995, Lea et al. 1999, Love et al. 2002).

Nutrient Transfer: 0

Copper Rockfish are relatively resident and do not tend to migrate once they settle (Love et al. 2002, McCain et al. 2005).

Darkblotched Rockfish (*Sebastes crameri*)

COSEWIC: Special Concern

Trophic level=3.8, Max length=58 cm

Upper-level Predator: 1

Darkblotched Rockfish feed on midwater species such as krill, amphipods, copepods, and salps, with occasional fish and octopus (Love et al. 2002). In a study from California to BC, Darkblotched Rockfish fed mostly on euphausiids, with some amphipods and copepods (Brodeur and Pearcy 1984).

Nutrient Transfer: *

Darkblotched Rockfish adults do not often rise from the seafloor, where they are often observed resting (Love et al. 2002). They may move to deeper waters as they age (Love 2011). There seems to be little information available on the migration patterns of Darkblotched Rockfish.

Dusky Rockfish (*Sebastes ciliatus*[13])

Trophic level=3.8, Max length=43 cm

Upper-level Predator: 0

Dusky Rockfish are planktivorous fish that feed mainly on euphausiids, but also on mysids, amphipods, copepods, crab larvae, salps, larvaceans, and fish (Love et al. 2002, Love 2011). The dominant prey might vary over time; euphausiids were the most important prey species in the Gulf of Alaska in 1990 (Yang 1993), but Pacific Sand Lance was found to be the dominant prey in 2001 (Yang et al. 2006).

Nutrient Transfer: *

Little information is available on the migrations of Dusky Rockfish.

Greenstriped Rockfish (*Sebastes elongatus*)

Trophic level=3.7, Max length=39 cm

Upper-level Predator: 0

Greenstriped Rockfish feed on euphausiids, fish, shrimps, copepods, squid, and amphipods (Love et al. 2002). Some small fish such as Pacific Hake, Northern Anchovy, and lanternfish are also taken (Allen 1982 in McCain et al. 2005). Given their small body sizes, they are considered mesopredators.

Nutrient Transfer: *

Greenstriped Rockfish are mostly sedentary, lying right on the seafloor (McCain et al. 2005, Love 2011). Little other information is available on Greenstriped Rockfish migration.

Pacific Ocean Perch (*Sebastes alutus*)

Trophic level=3.5, Max length=53 cm

Upper-level Predator: 0

Pacific Ocean Perch feed heavily on euphausiids, and also feed on mysids, amphipods, larvaceans, copepods, and midwater fishes such as deep-sea smelts and lanternfish (Love et al. 2002, Yang et al. 2006). Juveniles feed on copepods and larger individuals feed more heavily on fish (Love 2011). In the Gulf of Alaska, euphausiids were the dominant prey species (40-90% by weight), while fish were a very small part of the diet (~2% by weight) (Yang 1993, Yang et al. 2006). Euphausiids were also the dominant prey in a study from California to BC, with few fish observed in the diets (Brodeur and Pearcy 1984).

Nutrient Transfer: *

Female and some male Pacific Ocean Perch undertake seasonal onshore-offshore migrations from shallower waters in the summer to deeper waters for larval release, followed by a return to shallower waters (Love et al. 2002). These migrations do not generally include movement along the coast (north-south), only by depth (Love et al. 2002).

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[13] The accepted common name for *Sebastes ciliatus* is either “Dusky Rockfish” (DFO 2011) or “Dark Rockfish” (Orr and Blackburn 2004). “Dusky Rockfish” can also refer to *S. variabilis* (Orr and Blackburn 2004).

Quillback Rockfish (*Sebastes maliger*)

COSEWIC: Threatened

Trophic level=3.8, Max length=61 cm

Upper-level Predator: 1

Quillback Rockfish have a more generalist diet than do other rockfish (Rosenthal et al. 1988 in McCain et al. 2005). In Saanich Inlet, they feed primarily on Pacific Herring (Murie 1995). Other prey include crabs, squat lobsters, *Pandalus* shrimp, amphipods, isopods, fish eggs, and pelagic tunicates and crustaceans (Murie 1995, Love et al. 2002, Love 2011).

Nutrient Transfer: 0

In general, Quillback Rockfish do not migrate from their home reef (Love et al. 2002).

Redbanded Rockfish (*Sebastes babcocki*)

Trophic level=3.8, Max length=64 cm

Upper-level Predator: 1

The life history of this species is poorly known, with few reports on its diet (Love et al. 2002, McCain et al. 2005). In the Gulf of Alaska (Yang et al 2006), copepods were the most important prey item. Isopods and euphausiids were also found in Redbanded Rockfish stomachs, but sample sizes were very low (only 3 individuals; Yang et al 2006).

Nutrient Transfer: *

There does not appear to be any information on migrations in Redbanded Rockfish (McCain et al. 2005).

Redstripe Rockfish (*Sebastes proriger*)

Trophic level=3.8, Max length=61 cm

Upper-level Predator: 1

Little is known about the life history of Redstripe Rockfish. They have been reported to feed on euphausiids, shrimp, and small fish (Love et al. 2002).

Nutrient Transfer: *

Little information is available on the migrations of Redstripe Rockfish.

Sharpchin Rockfish (*Sebastes zacentrus*)

Trophic level=3.7, Max length=39 cm

Upper-level Predator: 0

Sharpchin Rockfish feed on euphausiids, shrimp, amphipods, copepods, small fish, and cephalopods (Love et al. 2002, Love 2011). In the Gulf of Alaska, the dominant prey species varied by year between calanoid copepods, euphausiids, and shrimp *Pandalus borealis* (Yang et al. 2006).

Nutrient Transfer: *

There does not appear to be any information on the migrations of Sharpchin Rockfish (McCain et al. 2005).

Rosethorn Rockfish (*Sebastes helvomaculatus*)

Trophic level=3.7, Max length=41 cm

Upper-level Predator: 0

Limited diet information has shown that Rosethorn Rockfish feed heavily on crabs, and also feed on euphausiids, gammarid amphipods, squids and fishes (Love et al. 2002, Love 2011). In California, euphausiids and other crustaceans are important (McCain et al. 2005).

Nutrient Transfer: *

There does not appear to be information on the migration of Rosethorn Rockfish (McCain et al. 2005).

Rougheye Rockfish (*Sebastes aleutianus*)

COSEWIC: Special Concern†
SARA: Schedule 1 - Special Concern†

† Rougheye Rockfish was assessed under COSEWIC and SARA in 2007 as "Rougheye Rockfish type I and II", which are now recognized as *Sebastes melanosticus* (Blackspotted Rockfish) and *S. aleutianus* (Rougheye Rockfish) (Orr and Hawkins 2008).

Trophic level=3.5*, Max length=97 cm

Upper-level Predator: 2

Rougheye Rockfish feed on pandalid shrimps, as well as amphipods, mysids, crabs, and fish (Love et al. 2002). Shrimps and euphausiids are important for smaller individuals in the Gulf of Alaska (Yang and Nelson 2000, Yang et al. 2006). The amount of fish in the diet of Rougheye Rockfish in the Gulf of Alaska varies over time, from about 20% of the diet in 1990 to 1% in 2001 (Yang and Nelson 2000, Yang et al. 2006). Fish eaten include Walleye Pollock, Pacific Herring, eulachon, Pacific Sand Lance, and other species (Yang and Nelson 2000). There is evidence of age and size truncation in Rougheye Rockfish (COSEWIC 2007b).

Nutrient Transfer: *

No information is available for migration of Rougheye Rockfish (McCain et al. 2005, COSEWIC 2007b)

Shortraker Rockfish (*Sebastes borealis*)

Trophic level=4.3, Max length=108 cm

Upper-level Predator : 2

The diet of Shortraker Rockfish in Alaska has been reported to include lanternfish, squid, shrimps, crabs, euphausiids, and octopus (Yang 1993, Love et al. 2002). In Prince William Sound, Shortraker Rockfish have among the highest trophic level of any fish (Kline 2006). Shrimp, myctophids, and squid were the most important prey species in the Gulf of Alaska (Yang et al. 2006),

Nutrient Transfer: *

Little information appears to be available on the migrations of Shortraker Rockfish.

Silvergray Rockfish (*Sebastes brevispinis*)

Trophic level=3.8, Max length=71 cm

Upper-level Predator: 1

In Hecate Strait, Silvergray Rockfish are high-level predators that feed on fish, including Walleye Pollock, and euphausiids (Pearsall and Fargo 2007). Copepods, crab larvae, shrimp, and chaetognaths are also eaten (Love 2011).

Nutrient Transfer: *

Little information is available on migrations of Silvergray Rockfish (McCain et al. 2005). Most are caught on the edge of the continental shelf or on the edges of deep troughs, and may move to shallower water in spring before returning deeper in fall (Love 2011).

Tiger Rockfish (*Sebastes nigrocinctus*)

Trophic level=3.5, Max length=61 cm

Upper-level Predator: 1

Tiger Rockfish are benthic feeders that eat crabs and shrimp (Love et al. 2002), as well as amphipods and small fishes such as Pacific Herring and juvenile rockfish (Rosenthal et al. 1988 in McCain et al. 2005).

Nutrient Transfer: *

Little information is available on the migrations of Tiger Rockfish.

Vermilion Rockfish (*Sebastes miniatus*)

Trophic level=3.9, Max length=91 cm

Upper-level Predator: 1

Vermilion Rockfish feed on fish (e.g., Northern Anchovy and lanternfish), squid, euphausiids, copepods, mysids, and cephalopods, as well as other pelagic and benthic invertebrate prey (Lea et al. 1999, Love et al. 2002).

Nutrient Transfer: *

Vermilion Rockfish in California have strong site fidelity and do not migrate (Lea et al. 1999). Some movement may occur between reefs, perhaps following food, but the extent is unknown (McCain et al. 2005). The migrations of Vermilion Rockfish are poorly understood; although a number of studies suggest limited movement, younger individuals may move quite a bit (Love 2011).

Yelloweye Rockfish (*Sebastes ruberrimus*)

COSEWIC: Special Concern (Pacific inside and outside waters populations)
SARA: Schedule 1 - Special Concern

Trophic level=4.4, Max length=104 cm

Upper-level Predator: 2

Yelloweye Rockfish are high-trophic level predators that feed on a variety of fish including rockfish, Pacific Herring, juvenile gadids, Pacific Sand Lance, and flatfish, as well as shrimps and crabs (Rosenthal et al. 1988 in COSEWIC 2008a, Love et al. 2002, McCain et al. 2005, Kline 2006). Puget Sound Rockfish may be an important prey species (Rosenthal et al. 1988).

In BC, there is evidence of age truncation associated with higher rates of fishery exploitation (Kronlund and Yamanaka 2001, Yamanaka and Logan 2010). In nearshore areas of the NSB, recent data suggests larger body sizes inside Rockfish Conservation Areas and farther from ports, where fishery pressure likely is lower (Frid et al. 2016).

Nutrient Transfer: *

Yelloweye Rockfish are not known to make diel movements (O'Connell and Carlile 1993). Other information on migrations is not available (McCain et al. 2005).

Yellowmouth Rockfish (*Sebastes reedi*)

COSEWIC: Threatened

Trophic level=3.8, Max length=58 cm

Upper-level Predator: 1

Little is known about the life history of this species (Love et al. 2002, COSEWIC 2010b). Limited diet information indicates Yellowmouth Rockfish feed on midwater fishes, shrimps, and squids (Love 2011)

Nutrient Transfer: *

Little is known about the life history of this species, with no migratory information (Love et al. 2002, McCain et al. 2005, COSEWIC 2010b).

Yellowtail Rockfish (*Sebastes flavidus*)

Trophic level=4.2, Max length=66 cm

Upper-level Predator: 1

Yellowtail Rockfish feed opportunistically, primarily on pelagic species such as euphausiids, gelatinous zooplankton, hyperiid amphipods, as well as benthic shrimp (Love et al. 2002, Love 2011). The dominant prey species varies regionally, with krill being important in some areas and fish being important in others (Love et al. 2002). Mesopelagic fish, juvenile fish, Pacific Herring, and smelts have been reported in diets of Yellowtail Rockfish from California to BC (Brodeur and Pearcy 1984). In Queen Charlotte Sound, diets include euphausiids and benthic and pelagic fish (Lorz et al. 1983 in McCain et al. 2005).

Nutrient Transfer: *

Migration patterns of Yellowtail Rockfish are unclear, as there are likely variations among individuals. There have been records of a Yellowtail Rockfish travelling from Alaska to Washington, but a number of studies indicate little movement of most fish (Love et al. 2002). Lea et al. (1999) record movement of almost 200 km by Yellowtail Rockfish. However, it is not clear if substantial north-south migrations take place that might have fish moving in and out of NSB.

Widow Rockfish (*Sebastes entomelas*)

Trophic level=3.7, Max length=60 cm

Upper-level Predator: 1

Widow Rockfish adults have seasonally and regionally variable diets, and have been recorded feeding on salps, jellyfish, small fish (e.g., myctophids, young Pacific Hake), crabs, shrimp amphipods, and krill (Adams 1987, Love et al. 2002).

Nutrient Transfer: *

Although Widow Rockfish move between habitat patches, the extent of their movements it is not known (Love 2011).

Shortspine Thornyhead (*Sebastolobus alascanus*)

IUCN: Endangered A2d

Trophic level=3.6, Max length=80 cm

Upper-level Predator: 1

Shortspine Thornyhead feed on epibenthic crustaceans (mysids, hyperiids, shrimps) in BC (Buckley et al. 1999), with other reported prey species including amphipods, fishes, eggs, crabs, and euphausiids (Love et al 2002, Yang et al 2006). In Prince William Sound, Shortspine Thornyhead have among the highest trophic level of any fish (Kline 2006). In the Gulf of Alaska, the relative importance of fish and invertebrates varies annually (Yang and Nelson 2000, Yang et al. 2006). In years where fish is important, prey species include Shortspine Thornyhead, zoarcids, gadids, and myctophids (Yang et al. 2006). Shortspine Thornyhead may also feed on Longspine Thornyhead (McCain et al. 2005).

Nutrient Transfer: 0

Shortspine Thornyhead spent most of their time on the seafloor with minimal movement (Love et al. 2002). The move into deeper water as they age and get larger (Jacobson and Vetter 1996), but do not appear to undergo seasonal or other large-scale migrations.

Longspine Thornyhead (*Sebastolobus altivelis*)

COSEWIC: Special Concern
SARA: Schedule 1 - Special Concern

Trophic level=3.3, Max length=39 cm

Upper-level Predator: 0

Longspine Thornyhead are opportunistic predators that feed on demersal/benthic crustaceans and fish (Buckley et al. 1999). They are tertiary consumers that feed on fish fragments, crustaceans, bivalves, and polychaetes (McCain et al. 2005). Adult Longspine Thornyhead may cannibalize juveniles that settle into their habitats (McCain et al. 2005).

Nutrient Transfer: 0

Longspines spend most of their time on the seafloor and do not spend much time off bottom (Love et al. 2002). Unlike Shortspine Thornyhead, Longspines do not appear to have ontogenetic migrations (Jacobson and Vetter 1996), and there do not seem to be other seasonal or other large-scale migrations

ROUNDFISHES

Pacific Cod (*Gadus macrocephalus*)

Trophic level=4.2, Max length=119 cm

Upper-level Predator: 2

Pacific Cod are large generalist predators that feed on benthic invertebrates (e.g., northern shrimp, Tanner crab, and polychaetes), as well as fish such as Pacific Herring, Pacific Sand Lance, and flatfish (Albers and Anderson 1985, Coad 1995, Yang 2004, Love 2011). In Hecate Strait, invertebrates are more often eaten by juvenile than adult Pacific Cod (Pearsall and Fargo 2007). In the Aleutian Islands, Pacific Cod have been reported feeding on dead and live seabirds (Ulman et al. 2015)

In Hecate Strait, population patterns for Pacific Cod and Pacific Herring populations are related: Pacific Cod predation likely influences Pacific Herring recruitment, and Pacific Herring abundance is correlated with Pacific Herring recruitment (Walters et al. 1986). Pacific Cod may compete with Sablefish, Arrowtooth, and Spiny Dogfish for resources (Allen 1982 in McCain et al. 2005, Pearsall and Fargo 2007).

Forage Species: 0

Pacific Cod are preyed on by many species, including Arrowtooth, Chinook Salmon, Irish lords, Pacific halibut, lampreys, Sablefish, Walleye Pollock, eagles, puffins, auklets, seals, sea lions, whales, river otters, and Orcas (Love 2011).

Nutrient Transfer: 0

Pacific Cod generally show site fidelity, with limited directed migrations (Cunningham et al. 2009). There is little movement of Pacific Cod between Strait of Georgia, Hecate Strait, Queen Charlotte Sound, and West Coast Vancouver Island (Westrheim 1982). Pacific Cod in the Bering Sea and Aleutian Islands occur on the shelf in summer for feeding, and move towards the shelf break in the winter for spawning (Albers and Anderson 1985, Shimada and Kimura 1994).

Pacific Hake (*Merluccius productus*)

Trophic level=4.4, Max length=91 cm

Upper-level Predator: 2

Due to their abundance, Pacific Hake are "one of the most ecologically important fish species on the west coast of North America" (Love 2011) and are potentially important both as a predator and a prey species (Taylor et al. 2015). Pacific Hake are strongly piscivorous, and tend to target species that aggregate, such as schooling fish (e.g., Eulachon, Pacific Herring) and euphausiids (Livingston and Bailey 1985, Rexstad and Pikitch 1986, Sturdevant et al. 2012). Pacific Herring, Pacific Saury, and pink shrimp *Pandalus jordani* are important prey species off of Vancouver Island, with fish more often eaten by larger Pacific Hake (Buckley and Livingston 1997). Cannibalism of small individuals may also occur (Buckley and Livingston 1997). Euphausiids are the most common food item of Pacific Hake throughout its range, particularly in the spring and summer (Livingston and Bailey 1985, Tanasichuk et al. 1991).

Pacific Hake prey heavily on and may affect populations of pandalid shrimp, juvenile salmon, krill, Pacific Herring, and other forage fish, and may compete with salmon, rockfish, and other groundfish (Rexstad and Pikitch 1986, Hannah 1995, Robinson and Ware 1999, Emmett and Brodeur 2000). Pacific Hake predation has had a significant effect on Pacific Herring abundance

(Ware and McFarlane 1995) and may influence the abundance of Northern Anchovy, whitebait smelt, and Pacific Herring of Oregon and Washington (Emmett and Krutzikowsky 2008).

Forage Species: 1

Young-of-the-year and juvenile Pacific Hake are an important component of the energy flow in the California current ecosystem and are important forage species (Buckley et al. 1999, Enticknap et al. 2011). Both adult and juvenile Pacific Hake are an important prey resource for many large piscivorous fish, sharks, rays, mammals, and birds (Livingston and Bailey 1985). Larger Pacific Hake are fed on by larger predators; Pacific Hake may be preyed on less often by fish and more often by marine mammals in the northern part of their range since that is where larger, older Pacific Hake aggregate. Almost 60 species feed on Pacific Hake, including Walleye Pollock, Pacific Cod, Spiny Dogfish, many other fish, cetaceans, pinnipeds, and Humboldt squids (Coad 1995, Love 2011). In the Northern California Current Ecosystem, at least 35 species are known to feed on Pacific Hake (Szoboszlai et al. 2015). In BC and southeast Alaska, documented predators include rhinoceros auklet, harbour seal, Spiny Dogfish, Steller Sea Lion, Northern Fur Seal, and Coho Salmon (Spalding 1963, Olesiuk et al. 1990, Tanasichuk et al. 1991, King and Beamish 2000, Hedd et al. 2006, Tollit et al. 2015). Historically, sperm whales also fed on Pacific Hake (Flinn et al. 2002).

Nutrient Transfer: 1

Pacific Hake are highly migratory. Juveniles live in nearshore areas, while older individuals move to deeper water (NOAA 1990 in McCain et al. 2005). Older fish undertake northerly migrations northward into shallower waters, and can reach southern Alaska in some warm (El Niño) years (Taylor et al. 2015). Because Pacific Hake migrate from outside of NSB, they are likely importing nutrients and biomass into NSB. The ecosystem effects of this migration are unclear.

Pacific Tomcod (*Microgadus proximus*)

Trophic level=3.6, Max length=31 cm

Upper-level Predator: 0

Pacific Tomcod are epibenthic planktivores that feed on shrimps, mysids and larval crabs, as well as molluscs and small fishes (Simenstad et al. 1979, Wakefield 1984, Coad 1995, Love 2011).

Forage Species: 1*

Pacific Tomcod are schooling fish that tolerate brackish and marine waters (Love 2011). As juveniles they live in shallow nursery grounds in bays, estuaries, and coastal waters, including eelgrass beds, and can be found near the seafloor or in middle or surface waters (Love 2011). Adults can be found in slightly deeper waters (Love 2011). Predators of Pacific Tomcod include larger fish (Albacore, Black Rockfish, Lingcod, Arrowtooth, Sand Sole, Spotted Ratfish, and Spiny Dogfish), birds (cormorants, common murres, and puffins) and marine mammals (harbour seals, fur seals, sea lions, porpoises, and river otters) (Coad 1995, Love 2011, Szoboszlai et al. 2015). Tomcod are considered forage fish by some authors, and have relatively low lipid and low energy content (Anthony et al. 2000)

Nutrient Transfer: *

There appears to be little information on migrations of Pacific Tomcod.

Walleye Pollock (*Theragra chalcogramma*)

Trophic level=3.6, Max length=91 cm

Upper-level Predator: 2

The diet of Walleye Pollock includes crustaceans, squid, and fish such as Pacific Sand Lance, Pacific Hake, Pacific Herring, deep-sea smelts, and some salmon (Coad 1995, Love 2011). Larger Walleye Pollock feed more heavily on fish (Love 2011). In the Gulf of Alaska, Walleye Pollock prey heavily on shrimp and juvenile salmon, potentially affecting those species' population dynamics and leading to competition with humans (Bailey and Ciannelli 2007). In the eastern Bering Sea, large Walleye Pollock feed mainly on euphausiids and fish; cannibalism on young fish is also prevalent (Dwyer et al. 1987). The diet of Walleye Pollock varies seasonally with prey abundance, with fewer euphausiids and more fish eaten in the fall and winter (Dwyer et al. 1987). Given their abundance in the NSB, Walleye Pollock have been assigned a score of 2.

Forage Species: 2

Juvenile Walleye Pollock are "classic" forage fish in the Gulf of Alaska (Springer and Speckman 1997). At least 78 species eat Walleye Pollock, including marine mammals (e.g., seals, sea lions, and porpoises), sea birds, and fish (Coad 1995, Love 2011). Walleye Pollock is an important predator and prey in many North Pacific ecosystems from Puget Sound to the Korean Peninsula (Bailey and Ciannelli 2007), but a full understanding of their influence on ecosystem dynamics is complicated by long-term environmental change (Springer 1992). Large declines in the populations of several bird and marine mammal populations in the Bering Sea and Gulf of Alaska since the 1970s have been linked to Walleye Pollock dynamics (Springer 1992, Fritz and Hinckley 2005). The declines of Steller Sea Lions, which feed heavily on Walleye Pollock, have been proposed to be related to either not enough (Springer 1992) or too much (Rosen and Trites 2000) Walleye Pollock in their diet. The cause of Steller Sea Lion population declines has not been resolved may have more to do with reduced dietary diversity (Merrick et al. 1997) and large-scale ecosystem changes. Given their importance as prey, they have been assigned a score of 2.

Nutrient Transfer: *

Walleye Pollock move to deeper waters as they age (Love 2011).There may also be seasonal migrations, where Walleye Pollock adults move deeper in the summer (Love 2011). The extent of north-south migrations that take Walleye Pollock into or out of NSB are unclear.

STURGEONS

Green Sturgeon (*Acipenser medirostris*)

Global: G3 (Vulnerable)
Provincial: S1N (Critically Imperiled Non-Breeding)
BC List: Red
COSEWIC: Special Concern
SARA: Schedule 1 - Special Concern

Trophic level=3.5, Max length=270 cm

Upper-level Predator: 1

Green Sturgeon fed on mostly on benthic invertebrates including mysids, amphipods, other crustaceans, and mollusc, although Pacific Sand Lance has also been reported in their diets (Coad 1995, COSEWIC 2004a, Love 2011).

Nutrient Transfer: 1

Green Sturgeon are anadromous, migrating from the ocean into streams in Washington, Oregon, and California to spawn in the fall (Coad 1995, Love 2011). Green Sturgeon aggregate in Canadian rivers, and off Vancouver Island, but do not spawn in BC (COSEWIC 2004a, Love 2011). Green Sturgeon may migrate from summer grounds in Washington, Oregon, and California, to winter areas north of Vancouver Island and Southeast Alaska (Lindley et al. 2008).

SURFPERCHES

General overview

The Embiotocidae have been described as forage fish in the Northern Shelf Bioregion (Schweigert et al. 2007), in BC (Beattie 2001), and in the Northern California Current (Szoboszlai et al. 2015). Although many species have been documented feeding on embiotocid species, little detailed information is available on their ecological roles and importance as a prey species. Therefore these species are being given a 1* for forage species, indicating that they may fulfil the criteria of forage species but lack enough information to be scored as a 2.

Kelp Perch (*Brachyistius frenatus*)

Trophic level=3.5, Max length=22 cm

Forage Species: 1*

Kelp Perch occur in kelp beds, where they feed on crustaceans (Coad 1995). They are abundant in kelp and seagrass beds, and form small and large schools (Love 2011). Many species of fish, seabirds, and harbour seals feed on Kelp Perch (Love 2011).

Nutrient Transfer: *

The habitat of Kelp Perch is restricted to kelp beds (Lane et al. 2002), so it is unlikely they have significant migrations in and out of NSB.

Shiner Perch (*Cymatogaster aggregata*)

Trophic level=3.0, Max length=20 cm

Upper-level Predator: 0

Feeds on crustaceans, barnacles, mussels, and algae (Coad 1995).

Forage Species: 2

Shiner Perch form schools in many coastal habitats, including eelgrass, kelp beds, or areas with freshwater (Coad 1995, Love 2011). Many species of demersal fish, seabirds, and marine mammals feed on Shiner Perch (Love 2011). Because Shiner Perch are locally abundant and an important prey for birds and fishes, they have been assigned a score of 2.

Nutrient Transfer: *

Shiner Perch move from shallow to deeper water in the winter (Lane et al. 2002), but it is not clear if they move in and out of NSB.

Striped Seaperch (*Embiotoca lateralis*)

Trophic level=3.3, Max length=38 cm

Forage Species: 1*

Striped Surfperch inhabit rocky coasts, kelp beds, wharves, and pilings, where it is an important recreational fish (Coad 1995). They feed on amphipods, bryozoans, mussels, and fish eggs (Coad 1995). A number of fish and seabirds, as well as harbour seals, feed on Striped Seaperch (Love 2011).

Nutrient Transfer: *

There is little information on migrations of Striped Seaperch.

Pile Perch (*Rhacochilus vacca*)

Trophic level=3.4, Max length=44 cm

Upper-level Predator: 0

Pile Perch occur on rocky shores, kelp beds, pilings and jetties, where they feed on molluscs, crabs, brittle stars, and barnacles (Coad 1995).

Forage Species: 1*

Pile Perch are abundant in eelgrass and other coastal habitats (Love 2011). They form schools and are eaten by fish, seabirds, and marine mammals (Love 2011).

Nutrient Transfer: *

Pile Perch move from shallow to deeper water in the winter (Lane et al. 2002), but the extent of their migratory behavior is unknown (Love 2011). It is not clear if they move in and out of NSB.

ELASMOBRANCHS

SKATES

Big Skate (*Raja binoculata*)

IUCN: Near Threatened

Trophic level=3.9, Max length=244 cm

Upper-level Predator: 2

Big Skates are common in BC (McFarlane et al. 2010). They are high-level predators in the Gulf of Alaska, similar to Pacific Halibut (Gaichas et al. 2010), and feed on decapod crustaceans, particularly *Crangon* shrimp and *Cancer* crabs, with some fish such as Pacific Sand Lance, Speckled Sanddabs, and other flatfish (Hart 1973, Wakefield 1984, Pearsall and Fargo 2007, Yang 2007). In the Aleutian Islands, flatfish made up over half the stomach content weight (Yang 2007). In Hecate Strait, shrimps and *Cancer* crabs were the most abundant prey, with some Pacific Sand Lance and other fish also taken (Pearsall and Fargo 2007). A large Big Skate in Oregon was found to have eaten a Sablefish (Wakefield 1984). Although the estimated trophic level of Big Skate is less than 4 (3.9), given their diet and size they have been assigned a 2.

Nutrient Transfer: 0

Tagging studies in BC show that in general, most Big Skates do not migrate, although a few individuals from BC were recorded moving to Alaska, Washington, and Oregon (King and McFarlane 2010). A tagging study in Alaska showed half of the tagged individuals moved large horizontal distances along the coast (113-278 km), while the other half moved much less (6-21 km) (Farrugia et al. 2016).

Longnose Skate (*Raja rhina*)

Trophic level=4.0, Max length=180 cm

Upper-level Predator: 2

Longnose Skates are common in BC (McFarlane et al. 2010). Big skates are high-level predators in the Gulf of Alaska, where they feed on flatfish, Walleye Pollock, capelin, and Pacific Sand Lance (Gaichas et al. 2010). Longnose Skates in Oregon feed on bony fish, including Pacific Sanddab, Rex Sole, and Butter Sole, as well as some *Crangon* shrimp (Wakefield 1984). In Hecate Strait, their diets mostly contained *Cancer* crabs, with moderate amounts of flatfish and Pacific Sand Lance (Pearsall and Fargo 2007).

Nutrient Transfer: *

There does not appear to be much information on migrations of Longnose Skates.

Sandpaper Skate (*Bathyraja interrupta*)[14]

Trophic level=3.4, Max length=86 cm

Upper-level Predator: 1

Sandpaper Skates are small skates common in BC (McFarlane et al. 2010, Love 2011). Their diets are dominated by small crustaceans, including decapods, amphipods, euphausiids, and mysids (Ebert and Bizzarro 2007, Rinewalt et al. 2007). Less important prey items are polychaetes, cephalopods, and some small fish (Rinewalt et al. 2007, Love 2011). Sandpaper Skates in Oregon were found to feed on *Crangon* shrimp and juvenile Pacific Sanddab (Wakefield 1984), while their diet in Kamchatka was primarily amphipods as well as some oligochaetes (Orlov 1998). In Hecate Strait, Sandpaper Skates fed mostly on *Crangon* shrimp, small crabs, and polychaetes (Pearsall and Fargo 2007).

Nutrient Transfer: *

Sandpaper Skates move into deeper waters in the winter (Csepp et al. 2011), but there is little information on migrations in and out of NSB.

[14] Although the common name "Black Skate" has been used for *Raja/Bathyraja kincaidi* (now synonymized with Sandpaper Skate *Bathyraja interrupta*) (Hart 1973), the synonym "Black Skate" should only refer to *Bathyraja trachura* (Roughtail skate) (McFarlane et al. 2010).

Roughtail Skate (*Bathyraja trachura*)[14]

Trophic level=4.0, Max length=91 cm

Upper-level Predator: 2

In the Aleutian Islands Roughtail Skates feed mainly on polychaetes, as well as some myctophids, cephalopods, and benthic crustaceans (Yang 2007). In California, Oregon, and Washington they feed heavily on crustaceans including euphausiids and tanner crabs, with smaller amounts of fish, such as Longspine Thornyhead (Boyle 2010).

Nutrient Transfer: *

Roughtail Skates are infrequently recorded in BC, occurring in deep waters of the slope and troughs of the continental shelf (McFarlane et al. 2010). It is not clear if they undertake migrations.

DEMERSAL SHARKS

Bluntnose Sixgill Shark (*Hexanchus griseus*)

IUCN: Near Threatened
COSEWIC: Special Concern
SARA: Schedule 1 - Special Concern

Trophic level=4.5, Max length=482 cm

Upper-level Predator: 2

Sixgill Sharks are active, high-level predators that feed in deep demersal, midwater, and nearshore habitats (Ebert 1994) and are commonly recorded from coastal and shelf areas across BC (McFarlane et al. 2010). Sixgill Sharks are generalist scavenger-predators, feeding on cephalopods, elasmobranchs, fish, and marine mammals including dolphins (Ebert 1994, Ebert 2003 in Barnett et al. 2012). Off Vancouver Island, their diet was reported to contain salmon and squid (Benson et al. 2001). They have been identified as a high priority for future research because of a general lack of information on their biology (McFarlane et al. 2010)

Nutrient Transfer: 0

The limited tagging studies of Sixgill Sharks in BC and Washington indicate limited movement or migrations, although mature individuals do migrate to shallow areas to give birth (COSEWIC 2007c).

Brown Cat Shark (*Apristurus brunneus*)

Trophic level=3.6, Max length=69 cm

Upper-level Predator: 1

Brown Cat Sharks feed primarily on shrimps and other crustaceans, as well as some small fish (e.g., myctophids), and squid (Jones and Geen 1977b in Cross 1988, Cross 1988, Coad 1995, Love 2011). A lack of information on this species in BC has led to it being identified as a species of research priority (McFarlane et al. 2010).

Nutrient Transfer: *

Brown Cat Sharks are small sharks common in BC, occurring on the continental shelf to about 1000 m (Hart 1973, Cross 1988). Reports of Brown Cat Sharks in BC are concentrated on the edge of the continental shelf and slope, and are also reported from Strait of Georgia, particularly in the winter (McFarlane et al. 2010). Although thought of as a demersal species, they have been taken in midwater trawls and feed on some pelagic prey (Cross 1988). They may be mesopelagic as juveniles and demersal as adults (Cailliet 1981 in Cross 1988), but there does not appear to be information on any migrations.

Spiny Dogfish (*Squalus suckleyi*)

COSEWIC: Special Concern

Trophic level=4.4, Max length=130 cm

Upper-level Predator: 2

Spiny Dogfish are small, schooling sharks that are common in BC (Love 2011). They are opportunistic feeders on midwater and benthic species including fish, euphausiids, shrimps, crabs, and other demersal invertebrates (Simenstad et al. 1979, Love 2011). Large individuals feed heavily on fish such as Pacific Herring, salmon, Pacific Sand Lance, Capelin, and Pacific Hake (Jones and Geen 1977a, Love 2011).

Nutrient Transfer: 1

Most Spiny Dogfish do not undertake substantial migrations, but a small number of individuals from Canada have been recorded travelling to Japan, California, and Mexico (McFarlane and King 2003). The majority of Dogfish tagged in BC were recaptured in BC or Washington, with some movement into and out of NSB evident (McFarlane and King 2003). Part of the dogfish population may undergo seasonal migrations between Oregon and northern BC (Ketchen 1986).

Pacific Sleeper Shark (*Somniosus pacificus*)

Trophic level=4.4, Max length=430 cm

Upper-level Predator: 2

Pacific Sleeper Sharks are apex predators known to feed on squids, fish, and octopus, as well as marine mammals (Love 2011). They are known to scavenge on whale falls and also feed on benthic invertebrates (Love 2011).

Nutrient Transfer: *

Pacific Sleeper Sharks tagged in the Gulf of Alaska continuously move up and down throughout the day, usually occurring between 150 and 450 m (Hulbert et al. 2006). Diel vertical migrations (up to surface at night, down below photic zone during the day) were also observed (Hulbert et al. 2006). Individual sharks show differences in horizontal movements; while 65% were within 50 km of their initial site, about 25% of tagged sharks moved more than 100 km over 0-336 days (Hulbert et al. 2006). Although it appears that Pacific Sleeper Sharks have the capacity to move large distances, tagging studies have not been carried out on individuals in BC, so it is not known if they move in and out of NSB.

PELAGIC SHARKS

Basking Shark (*Cetorhinus maximus*)

IUCN Status: Vulnerable A2ad+3d; North Pacific subpopulation Endangered A2ad
COSEWIC: Endangered (Pacific population)
SARA: Schedule 1 – Endangered

Trophic level=3.2, Max length=1520 cm

Upper-level Predator: 1

Basking Sharks are large surface filter feeders of plankton, and sit at a middle trophic level (Pauly et al. 1998, Fisheries and Oceans Canada 2011).

Nutrient Transfer: 1

Basking Sharks are thought to be migratory between California and Canada (McFarlane et al. 2009, Fisheries and Oceans Canada 2011). Basking Sharks were once common in coastal areas throughout BC in the summer, but were depleted through an eradication program in 1960s and 1970s. They are now considered rare (McFarlane et al. 2010, Fisheries and Oceans Canada 2011), with only 13 confirmed sightings in BC between 1996 and 2010 (Fisheries and Oceans Canada 2011).

Blue Shark (*Prionace glauca*)

IUCN: Near Threatened
COSEWIC: Special Concern (Atlantic population only)

Trophic level=4.4, Max length=400 cm

Upper-level Predator: 2

Blue Sharks are pelagic, oceanic sharks that are common in BC, particularly in the summer (McFarlane et al. 2010). Blue Sharks are top predators in the Central North Pacific (Kitchell et al. 1999) and are highly piscivorous, but also feed on euphausiids (Miller et al. 2010). Over its global range, the diet of Blue Sharks in deep, oceanic waters tends to include more pelagic cephalopods and myctophid fish than the diet of those inhabiting coastal waters, which they feed on Pacific Hake, Pacific Herring, and other fish (Brodeur et al. 2014). Because of their important role as a predator and scavenger, heavy fishing and bycatch of Blue Shark could influence or destabilize oceanic ecosystems (Markaida and Sosa-Nishizaki 2010). In Washington and Oregon, Blue Shark are likely not abundant enough to have large effect on forage fish abundance (Brodeur et al. 2014).

Nutrient Transfer: 1

Blue Sharks are highly migratory, following warming waters from California to Alaska (Love 2011). Adults feed in coastal areas and contribute to nutrient transfer when they move to open ocean areas to spawn (McKinnell and Seki 1998, Beamish et al. 2005),

Salmon Shark (*Lamna ditropis*)

Trophic level=4.5, Max length=305 cm

Upper-level Predator: 2

Salmon Sharks are top predators in subarctic ecosystems (Brodeur 1988 in Nagasawa 1998). They are opportunistic feeders that feed mainly on fish. In subarctic waters, their diet is primarily

Pacific Salmon, but can include other fish including forage fish, Spiny Dogfish, Sablefish, and rockfish, as well as squids (Nagasawa 1998, Hulbert et al. 2005). In the western North Pacific, Pink Salmon are the most often eaten salmon species (Nagasawa 1998). Oceanic Pacific salmon mortality from Salmon Shark predation is significant (Nagasawa 1998).

Nutrient Transfer: 1

Salmon Sharks undergo large migrations that span much of the North Pacific (Nagasawa 1998, Love 2011). After mating in the Gulf of Alaska, females migrate as far as Baja California and Hawaii (Love 2011). Salmon Sharks occur throughout the Northeast Pacific and are common in BC; while most reports are in the Strait of Georgia and offshore, they have been reported in Queen Charlotte Sound, Hecate Strait, and off West Coast Vancouver Island (Weng et al. 2008, McFarlane et al. 2010).

MARINE MAMMALS

BALEEN WHALES

Baleen whales generally have lower trophic levels than toothed whales (Pauly et al. 1998). During the extensive migrations of baleen whales, they excrete urea (nitrogen) which represents energy and nutrients transported from high latitudes and delivered to low latitudes (Roman et al. 2014).

Blue Whale (*Balaenoptera musculus*)

IUCN: Endangered A1abd ssp. *musculus* North Pacific stock Lower Risk/conservation dependent
NatureServe Global: G3G4 (Vulnerable to Apparently Secure)
NatureServe (BC): S1N (Critically Imperiled Non-Breeding)
BC List: Red
COSEWIC: Endangered (Pacific population)
SARA: Schedule 1 - Endangered (Pacific Population)
General Status (Canada): 1 - At Risk
General Status (Pacific Ocean): 1 - At Risk
CITES: I

Trophic level=3.3

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 0

Blue Whales are middle-trophic level feeders that primarily feed on euphausiids (Pauly et al. 1998, Perry et al. 1999, Ford et al. 2010).

Nutrient Transfer: 1

Blue Whales are rare in the North Pacific, but have been observed 16 times in BC (between 2002 and 2013) during surveys to the south and west of Haida Gwaii (Ford 2014). The majority of records are in deep waters, but there have also been a few sightings in Hecate Strait and Dixon Entrance (Ford 2014).

Blue Whales generally move between high-latitude summer feeding areas and low-latitude breeding areas in winter, but detailed migration patterns are not well known (COSEWIC 2002b, Ford 2014). Individuals from BC have been sighted in California, indicating at least some BC Blue Whales undertake that particular migration route (Ford 2014). Some of the individuals in BC may also move to Alaska to feed in the summer (COSEWIC 2002b). During their migrations, Blue Whales transport large amounts of nitrogen (in the form of urea) between their summer and winter habitats (Roman et al. 2014).

Common Minke Whale (*Balaenoptera acutorostrata*)

Trophic level=4.3

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Minke Whales are middle-trophic level feeders that feed on forage fish (e.g., Pacific Herring, Pacific Saury, Northern Anchovy, Walleye Pollock, and Pacific Sand Lance) and euphausiids (Pauly et al. 1998, Ford 2014). A large portion of their diet is forage fish (Pikitch et al. 2012, Pikitch et al. 2014).

Nutrient Transfer: 1

Minke Whales occur over the whole BC coast, with most sightings taking place in July and August (Ford 2014). Most Minke Whales migrate of BC in the winter to southern breeding areas (Ford 2014). They have been documented to move up to 400 km during migrations between south areas (West Coast Vancouver Island and the Salish Sea) and more northerly areas (Queen Charlotte Strait and the Central Coast) (Towers et al. 2013).

Fin Whale (*Balaenoptera physalus*)

IUCN: Endangered A1d
NatureServe Global: G3G4 (Vulnerable to Apparently Secure)
NatureServe (BC): S2N (Imperiled Non-Breeding)
BC List: Red
COSEWIC: Threatened (Pacific population)
SARA: Schedule 1 - Threatened
General Status (Canada): 3 - Sensitive
General Status (Pacific Ocean): 1 - At Risk
CITES: I

Trophic level=4.1

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 0

Fin Whales are middle-trophic level feeders (Pauly et al. 1998). While there are reports that Fin Whales may be highly dependent on forage fish (Pikitch et al. 2014), historical records from BC indicate their diets contained almost exclusively euphausiids, with some copepods present in some years (Flinn et al. 2002). Very small amounts of other species (cephalopods, ragfish, and other fish such as Pacific Herring) were also recorded in some years (Flinn et al. 2002, Ford 2014).

Nutrient Transfer: 1

The migration patterns of fin whales are poorly known, but they generally move from high latitudes for feeding in the summer to low latitudes for breeding in the winter (Ford 2014). BC is likely a migration corridor for most Fin Whales, but there is evidence that BC may be the summer feeding destination for some of the population (Gregr et al. 2000, COSEWIC 2005, Ford 2014).

Grey Whale (*Eschrichtius robustus*)

NatureServe (BC): S3
BC List: Blue
COSEWIC: Special Concern (Eastern North Pacific population)
SARA: Schedule 1 – Special Concern
General Status (Canada): 3 - Sensitive
General Status (Pacific Ocean): 3 - Sensitive

Trophic level=3.3

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 1

Grey Whales are middle-trophic level bottom feeders that primarily eat benthic and epibenthic invertebrates such as amphipods, polychaetes, ghost shrimp, mysids, and molluscs (Pauly et al. 1998, Ford et al. 2010, Gaichas et al. 2010, Ford 2014). They occasionally feed in surface waters on pelagic zooplankton, particularly crab larvae (Ford 2014). Although Grey Whales are not high-level predators, their feeding mode of sieving large amounts of sediments is very disruptive, causing mixing and resuspension of sediments and influencing benthic community structure (diversity, composition, and abundance) (Johnson and Nelson 1984, Oliver and Slattery 1985, Coyle et al. 2007, Feyrer and Duffus 2011, Burnham and Duffus 2016).

Nutrient Transfer: 1

Grey Whales are highly migratory, moving between winter breeding areas off Baja California and summer feeding areas in the North Pacific (Bering, Chukchi and Beaufort seas) (Ford 2014). BC is a migration corridor for most Grey Whales, although there are about 100 “summer resident” individuals that do not follow the normal migration patterns (Ford 2014).

Humpback Whale (*Megaptera novaeangliae*)

NatureServe (BC): S3 (Vulnerable)
BC List: Blue
COSEWIC: Special Concern (North Pacific population)
SARA: Schedule 1 - Threatened
General Status (Pacific Ocean): 1 - At Risk
CITES: I

Trophic level=4.0

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 1

Humpback Whales are middle-trophic level feeders (Pauly et al. 1998). Their diets are more varied than many other baleen whales, taking many schooling fish in addition to their main prey of euphausiids (Ford 2014). Other zooplankton including copepods and crab larvae may also be commonly eaten in some areas (Ford 2014). Pacific Herring are important in northern BC, Pacific Sand Lance are regularly eaten around Langara Island, and sardines are important off the west coast of Vancouver Island (Ford 2014).

In BC and Alaska, predation by Humpback Whales may be a minor contributor to the delayed recovery of Pacific Herring stocks (NMFS 2014, Surma and Pitcher 2015).

Nutrient Transfer: 1

Humpback Whales are highly migratory between temperate summer feeding areas and warm winter breeding areas (Ford 2014). Humpbacks observed feeding in BC in summer use Hawaiian or Mexican waters as breeding areas (Ford 2014). Most individuals from northern BC migrate to Hawaii, whereas most individuals from southwestern Vancouver Island go to Mexico (Ford 2014).

North Pacific Right Whale (*Eubalaena japonica*)

IUCN: Endangered D Northeast Pacific subpopulation Critically Endangered D
NatureServe Global: G1 (Critically Imperiled)
BC List: Red
COSEWIC: Endangered
SARA: Schedule 1 - Endangered
General Status (Canada): 1 - At Risk
General Status (Pacific Ocean): 1 - At Risk
CITES: I

Trophic level=*

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 0

Although historically abundant, North Pacific Right Whales are rarely sighted today and are extremely rare in BC (Ford 2014). There have been two confirmed sightings of North Pacific Right Whales in BC since 1951, one off the west coast of Graham Island, Haida Gwaii, and one near the Strait of Juan de Fuca (Ford 2014). They are low to middle-trophic level feeders that feed only on zooplankton, mostly calanoid copepods (Pauly et al. 1998, Ford 2014). Given their low trophic level and current low populations, their impacts to BC ecosystems is likely minimal.

Nutrient Transfer: 1

North Pacific Right Whales probably undertook a winter migration to the south from summer feeding grounds around Haida Gwaii (Ford 2014).

Sei Whale (*Balaenoptera borealis*)

IUCN: Endangered A1ad
NatureServe Global: G3 (Vulnerable)
NatureServe (BC): SHN
BC List: Red
COSEWIC: Endangered (Pacific population)
SARA: Schedule 1 - Endangered
General Status (Pacific Ocean): 1 - At Risk

Trophic level=4.0

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 0

Sei Whales are middle-trophic level feeders (Pauly et al. 1998) that can have large amounts of fish in their diets (Pikitch et al. 2014). Their historical diets in BC were made up mostly of copepods and euphausiids, with fish (Pacific Saury, Pacific Hake, lantern fish, Pacific Herring, and others) being important only in some years (Flinn et al. 2002). Given their current rarity, they are unlikely to be ecologically important in NSB.

Nutrient Transfer: 1

Historical records indicate that Sei Whales are an oceanic species that rarely occur in coastal waters, with almost all records occurring in areas more than 1000 m deep (Workman et al. 2007, Ford 2014). While Sei Whales historically occurred in the deep slope areas of NSB (Heise et al. 2007), there have only been two recent sightings in BC, both of which were in deep offshore areas (Ford 2014). The eastern North Pacific population is estimated at only 46 individuals (Carretta et al. 2009). Sei Whales spend winters in warm areas, and move to temperate to subpolar areas in summer (Ford 2014). However given their current rarity, they are unlikely to be contribute significantly to nutrient transport into or out of NSB.

DOLPHINS AND PORPOISES

Dall's Porpoise (*Phocoenoides dalli*)

Trophic level=4.5

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Dall’s Porpoises are found year-round in oceanic and coastal waters of BC, where they are high-level predators on schooling fish (e.g., Pacific Herring, Walleye Pollock, Northern Anchovy, Pacific Saury, and sardine), myctophids (lanternfish), and squid (Pauly et al. 1998, Ford 2014). In general they feed on deeper-water species than do Harbour Porpoises (Ford 2014). In offshore, oceanic areas, Dall’s Porpoises are important predators on mesopelagic species such as squids and myctophid fish (Ohizumi et al. 2003).

Nutrient Transfer: 0

In BC, Dall’s Porpoises may shift inshore during summer and offshore during winter but little information is available supporting this (Ford 2014). Overall there does not appear to be enough information to understand the contribution of Dall’s Porpoises to nutrient transferring.

Harbour Porpoise (*Phocoena phocoena*)

NatureServe (BC): S3 (Vulnerable)
BC List: Blue
COSEWIC: Special Concern (Pacific population)
SARA: Schedule 1 - Special Concern
General Status (Canada): 3 - Sensitive
General Status (Pacific Ocean): 3 - Sensitive

Trophic level=4.5

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Harbour Porpoises are predominately found in less than 150 m of water, where they are high trophic level predators on a range of squid and fish, including Pacific Herring, eelpout, Walleye Pollock, eulachon, Pacific Sand Lance, Pacific Hake, and Northern Anchovy (Pauly et al. 1998, Ford 2014).

Nutrient Transfer: 0

Harbour Porpoises are found year-round in BC, and there is little evidence of migrations (Baird and Guenther 1996, COSEWIC 2003a, Ford 2014). However, there has been little research focused on Harbour Porpoises outside of the Salish Sea (COSEWIC 2003a)

Northern Right Whale Dolphin (*Lissodelphis borealis*)

Trophic level=*

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Northern Right Whale Dolphins feed at high trophic levels on fish (primarily myctophids) and squid (Pauly et al. 1998, Ford 2014). They occur in large schools in deep oceanic waters, usually beyond the continental slope, and there are only a few records of them on the continental shelf in BC (Ford 2014). Although they may be high-level predators, given their oceanic habitat, they are unlikely to be a consistently important component of the NSB ecosystem.

Nutrient Transfer: 1

Northern Right Whale Dolphins are probably more common in offshore BC waters during the summer and during warm-water years (Ford 2014).

Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)

Trophic level=*

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Pacific White-sided Dolphins are high-trophic level opportunistic predators that feed on a wide range of fish and cephalopods (Pauly et al. 1998, Ford 2014). In BC they have been recorded feeding on Pacific Herring, adult and juvenile salmon (Sockeye, Pink, Chum, and Coho), Capelin, Sablefish, Walleye Pollock, squid, and shrimp (Morton 2000, Ford 2014). They are one of the most abundant cetacean species in the North Pacific and BC, where they occur in offshore, shelf, and inshore habitats (Ford 2014). In the past 30 years, Pacific White-sided Dolphins have been occurring more often in the inshore waters of BC (Ford 2014).

Nutrient Transfer: 1

Pacific White-sided Dolphins may move offshore or into deeper waters in the summer, as they are less common in nearshore areas during that time (Morton 2000, Ford 2014).

Risso's Dolphin (*Grampus griseus*)

Trophic level=4.4

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Risso's Dolphins feed almost entirely on squid (Pauly et al. 1998, Ford 2014), and are likely not abundant or frequently occurring enough to have a strong ecological role in BC.

Nutrient Transfer: 1

Risso's Dolphins are relatively uncommon in BC, occurring mostly in the summer deep waters around the shelf break off Vancouver Island, and around Langara Island (Ford 2014). The occurrence of Risso's Dolphins in BC may be related to oceanographic conditions, particularly the expansion of warm water, as most sightings in BC have been in summer (Baird and Stacey 1991, Forney and Barlow 1998, Ford 2014).

TOOTHED WHALES

Orca (*Orcinus orca)*

NatureServe (BC): S3 (Vulnerable)
COSEWIC: see ecotypes
SARA: see ecotypes
General Status (Canada): 3 - Sensitive
General Status (Pacific Ocean): 1 - At Risk

Trophic level=4.6

As a species, Orca are apex predators found worldwide in all oceans (Ford 2014). There are three ecotypes in BC: the residents (northern and southern populations), transients, and offshores, each with their own feeding ecology and social structure (Ford 2014).

Northeast Pacific Northern Resident Orca

NatureServe (BC): S2 (Imperiled)
BC List: Red
COSEWIC: Threatened
SARA: Schedule 1 - Threatened

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Resident Orcas feed primarily on Chinook Salmon, with some Chum Salmon and other demersal fish (Ford and Ellis 2006, Ford 2014). Northern Residents are highly dependent on Chinook Salmon, which is the least abundant but most energy-rich salmon species (Ford and Ellis 2006, Hilborn et al. 2012, O'Neill et al. 2014). Northern Residents feed on Chinook during the summer, and partly switch to Chum Salmon in the fall (Ford and Ellis 2006).

Nutrient Transfer: 1

Northern residents occur often in Johnstone Strait, Dixon Entrance, eastern Hecate Strait, Caamaño Sound, and Queen Charlotte Strait (Ford 2014). Their critical habitat and potential critical habitat is in the northern shelf bioregion, in Caamaño Sound, Fitz High Sound, and Johnstone Strait, and they occur throughout the whole BC continental shelf (COSEWIC 2008b). Resident orcas move to coastal areas to feed on spawning salmon in summer and fall, and in the winter they travel along the outer coast (Ford 2014). Their known range is from Alaska to Washington (COSEWIC 2008b).

Northeast Pacific Southern Resident Orca

NatureServe (BC): S1 (Critically Imperiled)
BC List: Red
COSEWIC: Endangered
SARA: Schedule 1 - Endangered

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Resident Orcas feed primarily on Chinook Salmon, with some Chum Salmon and other demersal fish (Ford and Ellis 2006, Ford 2014). Southern Residents are highly dependent on Chinook salmon, which is the least abundant but most energy-rich salmon species (Ford and Ellis 2006, Hilborn et al. 2012, O'Neill et al. 2014). Southern Residents feed on Chinook during the summer, and partly switch to Chum Salmon in the fall (Ford and Ellis 2006).

Nutrient Transfer: 1

Resident Orcas move to coastal areas to feed on spawning salmon in summer and fall, and in the winter they travel along the outer coast (Ford 2014). Southern Residents have critical habitat in the Strait of Juan de Fuca, Haro Strait, the southern Strait of Georgia, Boundary Pass, and Active Pass (Ford 2014). The Southern Residents occur over much of the continental shelf of BC, and their full range is from Haida Gwaii to California (COSEWIC 2008b).

West Coast Transient Orca

NatureServe (BC): S2 (Imperiled)
BC List: Red
COSEWIC: Threatened
SARA: Schedule 1 - Threatened

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Transient Orcas are apex predators in BC ecosystems (Pauly and Christensen 1996, Haggan et al. 1999, Wallace 1999), where they feed on marine mammals, particularly Harbour Seals, Harbour Porpoises, and Dall's Porpoises (Ford 2014). Steller Sea Lions, Pacific White-sided Dolphins, Minke Whales, California Sea Lions, and Northern Elephant Seals are also sometimes eaten (Ford 2014). Mammal-eating Orcas may be reducing the populations or preventing the recovery of pinnipeds and sea otters in some areas (Springer et al. 2003, Springer et al. 2008).

Nutrient Transfer: 1

The West Coast Transient population ranges from Alaska to Oregon, including all coastal areas of BC to an unknown distance offshore (COSEWIC 2008b, Ford 2014).

Northeast Pacific Offshore Orca

NatureServe (BC): S2 (Imperiled)
BC List: Red
COSEWIC: Threatened
SARA: Schedule 1 - Threatened

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Offshore Orcas feed on sharks, other elasmobranchs, and bony fish (Ford 2014). Pacific Sleeper Sharks appear to be a common prey species, with Blue Sharks and Spiny Dogfish also taken (Ford 2014). Fish prey in BC includes Pacific Halibut and Chinook Salmon (Ford 2014).

Nutrient Transfer: 1

Because they occur mostly in deeper water around the continental slope, Offshore Orcas are less often observed than the residents or transients (Ford 2014). They do occur occasionally in inside waters, and have been recorded to travel as far south as California (COSEWIC 2008b)

Sperm Whale (*Physeter macrocephalus*)

IUCN: Vulnerable A1d
NatureServe Global: G3G4 (Vulnerable to Apparently Secure)
NatureServe (BC): S3S4 (Vulnerable to Apparently Secure)
BC List: Blue

Trophic level=4.5

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Sperm Whales feed on a wide variety of large mesopelagic and bathypelagic squid, as well as some deep-sea fish (Flinn et al. 2002, Ford 2014). Other fish in the diet include ragfish, rockfish, Spiny Dogfish, lamprey, skates, and Pacific Hake (Flinn et al. 2002). Sperm Whales are top predators with a high trophic level in many ecosystems (e.g., in the Northern California Current and in the Bering Sea) (Pauly et al. 1998, Field et al. 2006, Lee et al. 2010).

Nutrient Transfer: 1

In BC, Sperm Whales occur mainly along the continental shelf break, although there are occasional sightings (particularly of males) on the shelf (Ford 2014). Female Sperm Whales have ranges of about 1000 km, while males migrate much further from high-latitude feeding grounds to tropical breeding areas (Ford 2014). The oldest male sperm whales have the largest migrations (Ford 2014).

PINNIPEDS

California Sea Lion (*Zalophus californianus*)

Trophic level=4.5

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

California Sea Lions feed at high trophic levels (Pauly et al. 1998). They feed opportunistically on a wide range of fish and cephalopods, including Pacific Hake, Pacific Herring, Northern Anchovy, Pacific Mackerel, Jack Mackerel, Pacific Sardine, squid, octopus, rockfish, and salmon (Ford 2014).

Nutrient Transfer: 1

Male California Sea Lions migrate northward to BC and southeast Alaska to overwinter between late fall and spring, and then return south to southern California and Baja California, Mexico to breed (Mate 1975 in Bigg 1985, Bigg 1985, Ford 2014).

Harbour Seal (*Phoca vitulina*)

Trophic level=4.5

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Harbour Seals are high-trophic level generalist predators, with diets focused on locally abundant prey (Pauly et al. 1998, Ford 2014). Schooling fish such as Pacific Herring and Pacific Hake are important (Olesiuk et al. 1990, Ford 2014). Other common prey include salmonids, squid, rockfish, and flatfish, while weaned pups feed on benthic crustaceans such as *Crangon* shrimp (Ford 2014).

Nutrient Transfer: 0

Harbour Seals are very common in BC, with many coastal haulouts (Ford 2014). They are non-migratory but may have seasonal movements (e.g., moving to estuarine areas to feed on salmon), and have been observed foraging up to 100 km offshore (Heise et al. 2007, Ford 2014).

Northern Elephant Seal (*Mirounga angustirostris*)

NatureServe (BC): S1B (Critically Imperiled Breeding)
BC List: Red

Trophic level=*

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Northern Elephant Seals feed at high trophic levels (Pauly et al. 1998). They have a broad diet including deepwater squid, Pacific Hake, rockfish, small sharks, rays, hagfish, and lampreys (Ford 2014).

Nutrient Transfer: 1

Northern Elephant Seals mostly breed off California and Mexico, although recently a small breeding colony has been established at Race Rocks (Ford 2014). They are a migratory species, ranging from their breeding colonies northward to feed as far as Alaska (Ford 2014). They forage primarily in deep, oceanic areas and are not often seen in shallow waters, except near haulouts used for moulting (Ford 2014). In BC Northern Elephant Seals usually moult between December and May on beaches on Southern Vancouver Island, Triangle Island (northern Vancouver Island), and Rose Spit (Haida Gwaii) (Ford 2014).

Northern Fur Seal (*Callorhinus ursinus*)

IUCN: Vulnerable A2b
NatureServe Global: G3 (Vulnerable)
NatureServe (BC): S2M (Imperiled Migrant)
BC List: Red
COSEWIC: Threatened
General Status (Canada): 1 - At Risk
General Status (Pacific Ocean): 1 - At Risk

Trophic level=4.5

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Northern Fur Seals are the most abundant pinniped in BC, but prefer pelagic, offshore habitats and are rarely observed within 20 km of shore (Ford 2014). They are high trophic level predators that feed on schooling fish and squid (Pauly et al. 1998, Gaichas et al. 2010, Ford 2014). Important fish prey species include Walleye Pollock, Pacific Herring, Northern Anchovy, Capelin, Pacific Hake, Eulachon, rockfish, myctophids, salmonids, and Pacific Sardines (Ford 2014).

Nutrient Transfer: 1

Northern Fur Seals migrate north in the summer to breeding colonies in Alaska and Russia (Ford 2014). Fur seals pass through BC between December and July, and mostly occur off the west coast of Vancouver Island. Fewer animals are observed in Queen Charlotte Sound and Hecate Strait, and some young individuals occur in protected coastal areas (Ford 2014). There are no breeding colonies or haulouts in BC (Ford 2014).

Steller Sea Lion (*Eumetopias jubatus*)

IUCN: Near Threatened *E. j. monteriensis* Least Concern [includes Canadian population]
NatureServe Global: G3 (Vulnerable)
NatureServe (BC): S3B,S4N (Vulnerable Breeding, Apparently Secure Non-Breeding)
BC List: Blue
COSEWIC: Special Concern
SARA: Schedule 1 - Special Concern
General Status (Canada): 3 – Sensitive
General Status (Pacific Ocean): 3 - Sensitive

Trophic level=4.4

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Steller Sea Lions are high trophic level predators that feed on a variety of fish and invertebrates (Pauly et al. 1998, Gaichas et al. 2010, Ford 2014). Important prey in BC include Pacific Herring, Pacific Hake, Pacific Sand Lance, Spiny Dogfish, Eulachon, Pacific sardine, and salmon (COSEWIC 2003b, Ford 2014). Demersal fish (rockfish, Arrowtooth, skates), cephalopods, seal and fur seal pups, and gulls are also eaten (Ford 2014).

Nutrient Transfer: 1

Although Steller Sea Lions are considered non-migratory, males undertake northward seasonal movements from California and Oregon into BC and Alaska (Mate 1975 in Bigg 1985, COSEWIC 2003b). Individuals can move up to 200 km offshore from their haulout sites to feed, and some individuals, such as one recorded travelling almost 1700 km between the Gulf of Alaska and Douglas Channel, may move substantial distances (Bigg 1985, COSEWIC 2003b, Ford 2014).

SEA OTTERS

Sea Otter (*Enhydra lutris*)

IUCN: Endangered A2abe
NatureServe (BC): S3 (Vulnerable)
BC List: Blue
COSEWIC: Special Concern
SARA: Schedule 1 - Special Concern
General Status (Canada): 3 - Sensitive
General Status (Pacific Ocean): 3 - Sensitive
CITES: I

Trophic level=4.0

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for marine mammals, all marine mammal species were conservatively assigned a score of 2.

Upper-level Predator: 2

Sea Otters feed on benthic invertebrates such as clams, crams, sea urchins, abalone, and snails (Pauly et al. 1998, Ford 2014). In BC, geoduck, littleneck clams, horse clams, butter clams, cockles, and mussels are also important (Ford 2014). Although fish are eaten by some populations of Sea Otter in Alaska, fish predation has not been observed in BC (Ford 2014).

Sea Otters are known to be a keystone species that strongly influence rocky reef and kelp forest ecosystems through top-down predation effects (Estes et al. 2010). By feeding on herbivorous sea urchins, Sea Otters maintain kelp forests and their associated communities; in the absence of otters, “urchin barrens” can occur as herbivory is left unchecked (Estes and Palmisano 1974). In addition to maintaining the diversity and community composition of kelp-associated fish and invertebrates, Sea Otter control of herbivores contributes to increased primary productivity and carbon storage (Wilmers et al. 2012). Scrap material from sea urchins fed on by Sea Otters provides food for seabirds such as Harlequin Ducks (Rechsteiner and Olson 2016).

Nutrient Transfer: 0

Sea Otters mainly inhabit shallow coastal waters and are regularly found in BC from Ucluelet north to the Scott Islands and Port Hardy, and in several areas of the central coast (Ford 2014). They are non-migratory and have strong site fidelity, with some seasonal movements observed (Garshelis and Garshelis 1984, Jameson 1989). In California, males are known to move almost 200 km to maintain their breeding territories (Jameson 1989), but the extent of seasonal movements are not known in BC.

REPTILES

SEA TURTLES

Leatherback Sea Turtle (*Dermochelys coriacea*)

IUCN: Vulnerable A2bd; West Pacific subpopulation Critically Endangered A2bd+4bd
NatureServe Global: G2 (Imperiled)
NatureServe (BC): S1S2N (Critically Imperiled to Imperiled Non-Breeding)
BC List: Red
COSEWIC: Endangered (Pacific population)
SARA: Schedule 1 - Endangered
General Status (Canada): 1 - At Risk
General Status (Pacific Ocean): 1 - At Risk

Trophic level=*

Vulnerability: 2

Because the intrinsic vulnerability scores from Cheung et al. 2005 were determined not to be appropriate for sea turtles, the Leatherback Sea Turtle was conservatively assigned a score of 2.

Upper-level Predator: 1

Leatherback Sea Turtles feed primarily on pelagic gelatinous prey such as scyphozoans, pelagic tunicates, and siphonophores (Bjorndal 1996). Leatherbacks and Ocean Sunfish *Mola mola* are the only known top-level medusivore, a unique trophic role (Hendrickson 1980).

Nutrient Transfer: 1

The Leatherback is a highly pelagic, migratory species that can travel over 10,000 km in a year (COSEWIC 2012). They are relatively rare in Pacific Canada, but have been observed off Vancouver Island and Haida Gwaii in the summer (Spaven et al. 2009). Leatherbacks observed in BC are likely from the South Pacific (Indonesia and Solomon Islands), Mexico, or Costa Rica (Benson et al. 2011, COSEWIC 2012).

INVERTEBRATES

CRUSTACEANS

Brown Box Crab (*Lopholithodes foraminatus*)

Upper-level Predator: 0

There is not much information on the feeding behavior of Brown Box Crab. They may feed by filtering sediment and digging for small clams (Jensen 2014).

Deepwater Grooved Tanner Crab (*Chionoecetes tanneri)*

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits three life history criteria: low reproductive output, restricted geographic range in the NSB (only found on continental slope), and strong aggregating behavior.

Dungeness Crab (*Metacarcinus magister*)

Trophic level: 4.0*

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: low reproductive output and strong aggregating behavior.

Upper-level Predator: 1

Dungeness crabs are opportunistic feeders specializing on hard-shelled prey such as gastropods, bivalves, barnacles, and shrimps (Stevens et al. 1982, Lawton and Elner 1985, Behrens Yamada and Boulding 1998). They also feed on fish including Lingcod, Pacific Sanddab, Pacific Tomcod, and Longfin Smelt (Stevens et al. 1982).

Inshore Tanner Crab (*Chionoecetes bairdi*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: low reproductive output, and strong aggregating behavior (during mating).

Puget Sound King Crab (*Lopholithodes mandtii*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: unpredictable recruitment and low reproductive output.

Red Rock Crab (*Cancer productus*)

Vulnerability: 1

This vulnerability score was assigned based on expert judgement. This species fits one life history criterion: low reproductive output.

Upper-level Predator: 1

This score was assigned based on expert judgement.

Pandalid Shrimp (Sidestripe Shrimp, *Pandalopsis dispar*; Spiny/Northern Pink Shrimp, *Pandalus borealis*; Coonstripe/Dock Shrimp, *Pandalus danae*; Humpback Shrimp, *Pandalus hypsinotus*; Smooth Pink Shrimp, *Pandalus jordani*; Spot Prawn, *Pandalus platyceros*)

Trophic level=3.1-3.7

Forage Species:2

Pandalid shrimp are important prey for many fish species. including flatfish, rockfish, Pacific Hake, and skates (Pearcy and Hancock 1978, Buckley and Livingston 1997, Love et al. 2002, Yang et al. 2006, Brown et al. 2012).

Bay Ghost Shrimp (*Neotrypaea californiensis*)

Trophic level =2.4

Forage species: *

Ghost shrimp can form dense aggregations (Posey 1986) and are known to be fed on by grey whales (COSEWIC 2004b). They have also been reported in the diet of Pacific Hake (Rexstad and Pikitch 1986). However, it is not clear if they are a broadly important prey species.

Habitat-forming species: 2

Ghost shrimp form burrows which have been reported as providing habitats for other species (e.g., BCMCA Project Team 2008c). However, responses to ghost shrimp may be taxon-specific: there is evidence that the bioturbation of ghost shrimp may be detrimental for sedentary organisms such as some polychaetes, bivalves, and tanaids and positive for other polychaetes and cumaceans (Posey 1986, Ferraro and Cole 2007). Ghost shrimp are also known to reduce seagrass growth (Dumbauld and Wyllie-Echeverria 2003). Overall, ghost shrimp may have little effect on species richness and may reduce diversity (Posey 1986, Ferraro and Cole 2007).

Euphausiids (Euphausiacea; 2 species)

Trophic level=*

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. These species fit three life history criteria: slow growth rate, unpredictable recruitment, and strong aggregating behavior.

Forage Species:2

In the Northern California Current Ecosystem, at least 56 species are known to feed on euphausiids (Szoboszlai et al. 2015). They are consistently considered to be forage species based on their importance in many species' diets and for energy transfer through the food web (Field and Francis 2006, Rice 2006, Enticknap et al. 2011, Smith et al. 2011, Pikitch et al. 2012).

Copepods (*Neocalanus* spp.)

Trophic level=*

Forage Species: 2

Neocalanus copepods dominate zooplankton biomass after the spring bloom and through the summer and are important prey item for planktivorous seabirds, fish, and whales (Mackas et al. 2007, Pellegrin et al. 2007, Bertram et al. 2009, Hipfner 2009). Changes in the timing of *Neocalanus* production led to the reproductive failure of Cassin's Auklets in 2010 (Borstad et al. 2011).

Other Crustacean Zooplankton

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. These species fit two life history criteria: low reproductive output and strong aggregating behavior.

Forage Species: 2

This score was assigned based on expert judgement.

Goose Barnacle (*Pollicipes polymerus*)

Vulnerability: 1

This vulnerability score was assigned based on expert judgement. This species fits three life history criteria: unpredictable recruitment, low reproductive output, and strong aggregating behavior. The maximum age for Goose Barnacles is 12 years (Bernard 1988).

Forage Species: 1

This score was assigned based on expert judgement.

Habitat-forming Species: 2

This score was assigned based on expert judgement.

ECHINODERMS

Ochre Sea Star (*Pisaster ochraceus*)

Conservation Concern based on expert judgement: 1 (recent population declines due to disease)

Trophic level=3.4

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: unpredictable recruitment and strong aggregating behavior.

Upper-level Predator: 2

Pisaster ochraceus is considered a keystone species in wave-exposed rocky intertidal communities, where they maintain diversity and zonation of encrusting species by preferentially feeding on mussels (Paine 1966, Menge et al. 1994). Because *P. ochraceus* is known to be an important predator within the invertebrate community, it has been assigned a score of 2.

Sunflower Sea Star (*Pycnopodia helianthoides*)

Conservation Concern based on expert judgement: 1 (recent population declines due to disease)

Trophic level=*

Vulnerability: 1

This vulnerability score was assigned based on expert judgement. This species fits one life history criterion: unpredictable recruitment.

Upper-level Predator: 2

By preying on herbivorous sea urchins (*Strongylocentrotus* spp.), *Pycnopodia helianthoides* helps maintain the abundance and diversity of algae and associated species (Dayton 1972, Schultz et al. 2016). Because *P. helianthoides* is known to be an important predator within the invertebrate community, it has been assigned a score of 2.

Green Sea Urchin (*Strongylocentrotus droebachiensis*)

Trophic level=2.4

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits three life history criteria: long-lived, unpredictable recruitment, and strong aggregating behavior.

Forage Species: 1*

Sea urchins are important prey species as juveniles for many species, and throughout their lives for Sea Otters.

Purple Sea Urchin (*Strongylocentrotus purpuratus*)

Trophic level=*

Vulnerability: 1

This vulnerability score was assigned based on expert judgement. This species fits one life history criterion: unpredictable recruitment.

Forage Species: 1*

Sea urchins are important prey species as juveniles for many species, and throughout their lives for Sea Otters.

Red Sea Urchin (*Mesocentrotus franciscanus*)

Trophic level=*

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits four life history criteria: long-lived, slow growth rate, unpredictable recruitment, and strong aggregating behavior.

Forage Species: 1*

Sea urchins are important prey species as juveniles for many species, and throughout their lives for Sea Otters.

California Sea Cucumber (*Apostichopus californicus*)

Vulnerability: 1

This vulnerability score was assigned based on expert judgement. This species fits one life history criterion: unpredictable recruitment.

MOLLUSCS

California Mussels (*Mytilus californianus*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits three life history criteria: long-lived, unpredictable recruitment, and strong aggregating behavior. The maximum age for California mussels is 50-100 years (Gillespie 1999).

Habitat-Forming Species: 1*

On soft substrates, mussels can form hard, complex habitats that influence macrofaunal abundance and diversity (Commito et al. 2008, Seitz et al. 2013). In the rocky intertidal, *Mytilus californianus* form complex beds composed of live mussels, dead shells, shell debris, and organic material that host a high diversity of associated species (Suchanek 1992). However, if left unchecked by predators (e.g., *Pisaster ochraceus*), mussels can spread and reduce overall diversity through competitive exclusion (Paine 1966). Because of this contrasting influence, a score of 1* is being applied to all mussels.

Mussels (Blue Mussels, *M. edulis*; Pacific Blue Mussels, *M. trossulus*)

Vulnerability: 1

This vulnerability score was assigned based on expert judgement. These species fit one life history criterion: strong aggregating behavior.

Habitat-Forming Species: 1*

On soft substrates, mussels can form hard, complex habitats that influence macrofaunal abundance and diversity (Commito et al. 2008, Seitz et al. 2013). In the rocky intertidal, *Mytilus californianus* form complex beds composed of live mussels, dead shells, shell debris, and organic material that host a high diversity of associated species (Suchanek 1992). However, if left unchecked by predators (e.g., *Pisaster ochraceus*), mussels can spread and reduce overall diversity through competitive exclusion (Paine 1966). Because of this contrasting influence, a score of 1* is being applied to all mussels.

Forage Species: 1*

This score was assigned based on expert judgement.

Olympia Oyster (*Ostrea lurida*)

COSEWIC: Special Concern
SARA: Special Concern
BCList: Blue

Trophic level=*

Vulnerability: 2

Olympia Oysters are only found on the west coast of North America, and are vulnerable to overharvesting (COSEWIC 2011b). Additional information for this vulnerability score was provided based on expert judgement. This species fits four life history criteria: unpredictable recruitment, low reproductive output, restricted geographic range in the NSB, and strong aggregating behavior.

Habitat-Forming Species: 1

Olympia Oysters are known to form beds and reefs in some areas (COSEWIC 2011b, Finney et al. 2012). Oyster reefs are generally known as an important biogenic habitat (Seitz et al. 2013). Although there is little historic information is available on the ecological importance of Olympia Oyster reefs, they likely could contribute to local diversity and ecosystem health (Pritchard et al. 2015).

Forage Species: 1*

This score was assigned based on expert judgement.

Giant Pacific Octopus (*Enteroctopus dofleini*)

Trophic level=3.3

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: unpredictable recruitment and low reproductive output.

Upper-level Predator: 2

This score was assigned based on expert judgement. The diet of the Giant Pacific Octopus in the Salish Sea is dominated by decapod crustaceans (mostly *Cancer productus*), as well as bivalves (Scheel and Anderson 2012).

Opal Squid (*Loligo opalescens*)

Trophic level=3.9

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits three life history criteria: unpredictable recruitment, low reproductive output, and strong aggregating behavior.

Upper-level Predator: 2

This score was assigned based on expert judgement.

Forage Species: 1*

In the Northern California Current Ecosystem, at least 51 species are known to feed on opal squid (Szoboszlai et al. 2015). They are an important dietary component for California sea lions (Lowry and Carretta 1999) and are sometimes considered forage species because of their importance in the diet of so many species including birds, fish, and mammals (Walthers and Gillespie 2002, Enticknap et al. 2011).

Nutrient Transfer: *

Opal squid are common in coastal BC, although they are less abundant north of Vancouver Island (Walthers and Gillespie 2002). They move inshore to span, but in general the movements and distribution of non-spawning opal squid are poorly known (Maupin 1988 in Walthers and Gillespie 2002).

Northern Abalone (*Haliotis kamtschatkana*)

IUCN : Endangered A2abd
NatureServe (Global) : G3G4 (Vulnerable to Apparently Secure)
NatureServe (BC): S2 (Imperiled)
BC List: Red
COSEWIC: Endangered
SARA: Schedule 1 - Endangered

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits four life history criteria: long-lived, slow growth rate, unpredictable recruitment, and strong aggregating behavior.

Forage Species: 1

This score was assigned based on expert judgement.

Black Turban Snail (*Tegula funebralis*)

Vulnerability: 1

This vulnerability score was assigned based on expert judgement. This species fits one life history criterion: strong aggregating behavior.

Littorina snails (*Littorina* sp.)

Vulnerability: 1

This vulnerability score was assigned based on expert judgement. This species fits one life history criterion: strong aggregating behavior.

Forage Species: 2

This score was assigned based on expert judgement.

Pink Scallop (*Chlamys rubida*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: unpredictable recruitment and strong aggregating behavior.

Forage Species: 1*

This score was assigned based on expert judgement.

Spiny Scallop (*Chlamys hastata*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: unpredictable recruitment and strong aggregating behavior.

Forage Species: 1*

This score was assigned based on expert judgement.

Purple-hinged Rock Scallop (*Crassadoma gigantea*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits three life history criteria: long-lived, slow growth rate, and unpredictable recruitment.

Weathervane Scallop (*Patinopecten caurinus*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: unpredictable recruitment and restricted geographic range in the NSB.

Butter Clam (*Saxidomus gigantea)*

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: unpredictable recruitment and strong aggregating behavior.

Forage Species: 2

This score was assigned based on expert judgement.

Habitat-forming Species: 2

This score was assigned based on expert judgement.

Cockle (*Clinocardium nuttallii*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: unpredictable recruitment and strong aggregating behavior.

Forage Species: 2

This score was assigned based on expert judgement.

Habitat-forming Species: 2

This score was assigned based on expert judgement.

Littleneck Clam (*Leukoma staminea*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: unpredictable recruitment and strong aggregating behavior.

Forage Species: 2

This score was assigned based on expert judgement.

Habitat-forming Species: 2

This score was assigned based on expert judgement.

Geoduck (*Panopea generosa*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits three life history criteria: long-lived, unpredictable recruitment, and strong aggregating behavior.

Habitat-forming Species: 1

This score was assigned based on expert judgement.

Horse Clam/Fat Gaper (*Tresus capax*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: long-lived and unpredictable recruitment.

Habitat-forming Species: 2

This score was assigned based on expert judgement.

Horse Clam/Pacific Gaper (*Tresus nuttallii*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits two life history criteria: long-lived and unpredictable recruitment.

Habitat-forming Species: 2

This score was assigned based on expert judgement.

Razor Clam (*Siliqua patula*)

Vulnerability: 2

This vulnerability score was assigned based on expert judgement. This species fits four life history criteria: slow growth rate, unpredictable recruitment, restricted geographic range in the NSB, and strong aggregating behavior.

Forage Species: 2

This score was assigned based on expert judgement.

Habitat-forming Species: 1

This score was assigned based on expert judgement.

SPONGES

Sponges are known to provide habitats for other species and are recognized as vulnerable marine ecosystems (Fuller).

Glass Sponges (Hexactinellida including *Aphrocallistes vastus*, *Heterochone calyx*, and *Farrea occa*)

Vulnerable: 2

Sponges, including sponge reefs, are vulnerable to fishing and benthic disturbance. Physical impacts from fishing gear can damage long-lived sponges (Kahn et al. 2016). As filter feeders, glass sponges are sensitive to sedimentation (e.g., from bottom contact activities) because it clogs their filtration system and limits respiration and feeding (Leys 2013). Additional information for this vulnerability score was provided based on expert judgement. This species fits four life history criteria: long-lived, slow growth rate, unpredictable recruitment, and strong aggregating behavior.

Habitat-Forming Species: 2

British Columbia is home to globally unique glass sponge reefs (Conway et al. 2001) that are associated with higher local diversity and provide important habitat for rockfish and other organisms (Cook et al. 2008, Chu and Leys 2010). The three species that are reported to form reefs in NSB (*Aphrocallistes vastus, Heterochone calyx*, and *Farrea occa*) can occur singly, in large aggregations (e.g., in "sponge gardens"), or in true reef form where live sponges settle and grow upon the silica skeletons of dead sponges (Leys et al. 2004). Both sponge reefs and large sponge aggregations are important as biogenic habitat for other species.

Demosponges (*Demospongiae*)

Vulnerable: 2

Sponges are vulnerable to sedimentation, such as that from bottom contact fishing, because their filtration system gets clogged (Leys 2013).They are also vulnerable to physical damage, for example from fishing gear (Heifetz et al. 2009).

Habitat-Forming Species: 2

By providing three-dimensional structure, sponges provide habitat and shelter for fish and other species (Brancato et al. 2007, Fuller et al. 2008, Miller et al. 2012). Demosponges increase abundance of rockfish at Learmonth Bank, Dixon Entrance (Du Preez and Tunnicliffe 2011).

CORALS

Cold-water Corals (orders Scleractinia, Antipatharia, Alyconacea, and Pennatulacea)

Vulnerable: 2

Cold-water corals form key vulnerable marine ecosystems (Fuller et al. 2008) that are sensitive to the effects of bottom fishing activities (Heifetz et al. 2009). Scleractinians (stony corals) are particularly ecologically important and vulnerable to fishing activities (Fuller et al. 2008). Black corals (Antipatharia) and soft corals (Alcyonacea, including Gorgonians) also have traits that make them vulnerable to disturbance: they have slow growth rates, low fecundity, low recruitment, and low natural mortality (Grigg 1989 in Fuller et al. 2008, Fuller et al. 2008). Additional information for this vulnerability score was provided based on expert judgement. Antipatharia and Alyconacea fit two life history criteria: long-lived and slow growth rate, and Pennatulacea fits three life history criteria: long-lived, slow growth rate, and strong aggregating behavior.

Habitat-Forming Species: 2

By providing three-dimensional structure, cold-water corals increase local diversity and provide nursery, feeding, and spawning habitat for fish and invertebrates (Auster 2005, Etnoyer and Morgan 2005, Fuller et al. 2008, Buhl-Mortensen et al. 2010, Miller et al. 2012). For example, sea pens (Pennatulacea) have recently found to be important as nursery habitat for fish including redfish (*Sebastes* sp.) (Baillon et al. 2012), and tall corals such as red tree coral *Primnoa* provide shelter for rockfish (*Sebastes* sp.) and crustaceans, and are used by suspension feeders (e.g., basket stars, anemones, and sponges) as perches into higher-flow waters (Krieger and Wing 2002). In Washington, many species (crabs, echinoderms, fish) are associated with corals such as *Primnoa,* and have been used as substratum for shark egg sacs (Brancato et al. 2007). Corals including *Primnoa* increase rockfish abundance at Learmonth Bank, Dixon Entrance (Du Preez and Tunnicliffe 2011).

Cold-water corals are not known to form reefs in BC. Remnants of the reef-forming species *Lophelia* have been found in the Strait of Georgia, but no live reefs have been found in BC (Conway et al. 2007).

OTHER

Non-crustacean Zooplankton

Including other taxa such as gelatinous zooplankton (Cnidaria, Ctenophora), pelagic tunicates, pteropods, and protozoa.

Vulnerability: 1

This vulnerability score was assigned based on expert judgement. This species fits one life history criterion: strong aggregating behavior.

Forage Species: 2

This score was assigned based on expert judgement.

PLANTS AND ALGAE

Wrack (dead material from seagrasses and algae) provides food and habitat for intertidal and semi-terrestrial organisms, and provides a marine-terrestrial nutrient link (Heerhartz et al. 2013). Marine input of wrack can increase productivity in otherwise unproductive terrestrial habitats such as islands and coastal areas (Polis and Hurd 1996).

ALGAE

Phytoplankton

Forage species: 2

Although not a traditional forage species, phytoplankton are uniquely important as the base of the food web, and areas of phytoplankton concentration should be prioritized.

Kelps (Laminariales, including Giant Kelp, *Macrocystis pyrifera*[15]; Bull Kelp, *Nereocystis luetkeana)*

Nutrient Transfer: 1

Wrack from kelp, including giant kelp and bull kelp) is common on cobble beaches in BC (Orr et al. 2005) and may contribute to nutrient transfer between marine and terrestrial ecosystems. In BC, wrack from *Macrocystis pyrifera* is important in the diet of semi-terrestrial detritivores *Traskorchestia* spp. (Fox et al. 2014). Black bears seasonally feed on the amphipods, Pacific Herring spawn, kelp, and seagrasses, representing an important marine-terrestrial transfer of nutrients (Fox et al. 2015).

Habitat-Forming Species: 2

Aggregations of kelp (e.g., beds or forests) provide food and habitat for a multitude of other species (Steneck et al. 2003). Kelp beds provide habitat for many species and support important, productive food webs (reviewed in Smale et al. 2013). Kelp holdfasts (particularly with coralline algae present) may be important habitat for northern abalone (Rogers-Bennett et al. 2011). Kelp has general importance as habitat for fishes in temperate ecosystem (Dean et al. 2000), and are used as substrate for spawn on kelp (Council of the Haida Nation 2011, Fox et al. 2014).

Feather Boa Kelp (*Egregia menziesii*)

Nutrient Transfer: 1

Egregia forms wrack on gravel beaches (Orr et al. 2005), and may contribute to nutrient transfer between marine and terrestrial ecosystems.

Habitat-forming species: 1

Aggregations of kelp (e.g., beds or forests) provide food and habitat for a multitude of other species (Steneck et al. 2003).

[15] prev. *M. integrifolia* (Demes et al. 2009)

Other kelps (Woody-stemmed Kelp, *Pterygophora californica*; Southern Sea Palm, *Eisenia arborea;* Southern Stiff-stiped Kelp, *Laminaria setchellii*)

Nutrient Transfer: *

Little information is available on the contribution of these species to wrack and nutrient subsidy. They may play a role depending on local abundance.

Habitat-forming species: 1

Aggregations of kelp (e.g., beds or forests) provide food and habitat for a multitude of other species (Steneck et al. 2003).

Small Non-coralline Red Algae (e.g., Lavers, *Porphyra* spp.)

Nutrient Transfer: *

Little information is available on the contribution of these species to wrack and nutrient subsidy. They may play a role depending on local abundance.

Rockweed (*Fucus* sp.)

Nutrient Transfer: 1

Fucus wrack is common on cobble and gravel beaches in BC (Orr et al. 2005). In BC, wrack from *Fucus* spp. is important in the diet of semi-terrestrial detritivores *Traskorchestia* spp. (Fox et al. 2014). Black bears seasonally feed on the amphipods, Pacific Herring spawn, kelp, and seagrasses, representing an important marine-terrestrial transfer of nutrients (Fox et al. 2015). *Fucus* is only found in trace amounts in the diets of black bears (Fox et al. 2015).

Habitat-forming species: 1

Algae in the Fucaceae increase local species diversity and abundance by providing habitat (Schmidt et al. 2011).

Other Small Brown Algae (e.g., Sea Cabbage, *Hedophyllum sessile*)

Nutrient Transfer: *

Little information is available on the contribution of these species to wrack and nutrient subsidy. They may play a role depending on local abundance.

Green String Lettuce (*Ulva (Enteromorpha)* sp.)

Nutrient Transfer: 1

Ulva dominates the wrack at sandy beaches (Orr et al. 2005).

Habitat-Forming Species: 1

Ulva lactuca increases fish and decapod density relative to unvegetated substrate and may be important habitat in areas where eelgrass is absent (Sogard and Able 1991).

Coralline Algae (e.g., *Corallinales*)

Nutrient Transfer: *

Coralline algae can be found in wrack at cobble beaches, but is not very abundant (Orr et al. 2005). Little information is available on the contribution of these species to wrack and nutrient subsidy. They may play a role depending on local abundance.

Habitat-forming species: 1

Coralline algae and their associated biofilms promote settling by larval echinoderms, annelids, molluscs, corals, sponges (citations in Fisher and Martone 2014); coralline algae covered rocks are preferred habitat for northern abalone (Rogers-Bennett et al. 2011).

PLANTS

Eelgrass (*Zostera marina*)

Nutrient Transfer: 1

Seagrasses are known to provide a subsidy of organic matter to coastal (terrestrial and estuarine) ecosystems through deposition of washed up material (wrack), which is broken down by herbivores and detritivores (Heck et al. 2008). While *Zostera marina* is present in wrack communities in BC (Orr et al. 2005), surfgrass *Phyllospadix* is more abundant.

Habitat-Forming Species: 2

Eelgrass beds form important habitat for algae, invertebrates, and fish, and increases local diversity and abundance (DFO 2009, Barbier et al. 2011, Schmidt et al. 2011) Eelgrass is also used as a substrate for Pacific Herring spawn-on-kelp (Council of the Haida Nation 2011).

Surfgrass (*Phyllospadix* sp.)

Nutrient Transfer: 1

Seagrasses are known to provide a subsidy of organic matter to coastal (terrestrial and estuarine) ecosystems through deposition of washed up material (wrack), which is broken down by herbivores and detritivores (Heck et al. 2008). Phyllospadix wrack is common on gravel and sandy beaches in BC (Orr et al. 2005). In BC, wrack from *Phyllospadix serrulatus* is important in the diet of semi-terrestrial detritivores *Traskorchestia* spp. (Fox et al. 2014). Black bears seasonally feed on the amphipods, Pacific Herring spawn, kelp, and seagrasses, representing an important marine-terrestrial transfer of nutrients (Fox et al. 2015).

Habitat-Forming Species: 2

Phyllospadix surfgrass can grow in rocky habitats (unlike eelgrass) (Duarte 2002) and is important habitat for nearshore fishes (Galst and Anderson 2008). Pacific Herring use surfgrass as substrate for spawning (Fox et al. 2014).

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