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Pacific Region

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Science Advisory Report 2017/019

# A FRAMEWORK FOR IDENTIFICATION OF ECOLOGICAL CONSERVATION PRIORITIES FOR MARINE PROTECTED AREA NETWORK DESIGN AND ITS APPLICATION IN THE NORTHERN SHELF BIOREGION

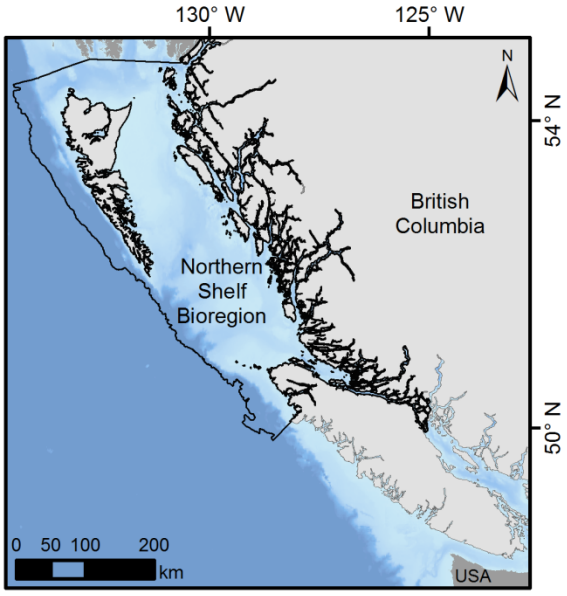


*Figure 1. The Northern Shelf Bioregion.*

## Context:

*Canada has committed to conserving 10% of its coastal and marine areas, and protecting ecosystems, species, and genetic diversity, through the development of ecologically representative and well-connected Marine Protected Areas (MPAs). MPA network development is guided by the 2011 National Framework for Canada's Network of MPAs. The identification of conservation priorities (CPs) helps to focus spatial planning towards areas of high conservation value, maximize the benefits of MPAs, and ensure the goals outlined in the Strategy are met. Specifically, ecological CPs support the achievement of Goal 1 of the 2014 Canada – British Columbia Marine Protected Area Network Strategy.*

*This paper describes the development and application of a framework to identify ecological CPs from broad lists of candidate species and areas in the Northern Shelf Bioregion (NSB; Figure 1), and may be applicable for the development of MPA networks in other areas in the Pacific Region.*

*This Science Advisory Report is from the November 22–24, 2016 meeting on the Framework for identifying ecological conservation priorities for marine protected area (MPA) network design in the Northern Shelf Bioregion. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.*

June 2017 (Errata: October 2018)

Canada

## SUMMARY


- Conservation Priorities (CPs) are the features to be prioritized in Marine Protected Area (MPA) network planning, 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 tourism and recreation.
- CPs will inform the development and design of a MPA network in the Northern Shelf Bioregion (NSB). This framework focuses exclusively on ecological CPs that support the achievement of Goal 1 of 6 from the Canada – BC Marine Protected Network Strategy (2014): "to protect and maintain marine biodiversity, ecological representation and special natural features".
- This framework provides criteria and scoring outputs for identifying ecological CPs nested under the network objectives associated with Goal 1. Criteria were based on global best practices, applied and evaluated using information from literature, then vetted and augmented by expert opinion.
- Framework criteria were applied to species and areas to identify species-based and area-based ecological CPs. Species-based ecological 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 ecological CPs include areas, spatial features, or habitats that directly support the network objectives under Goal 1.
- Species that were identified as of conservation concern and/or received high scores for either vulnerability or ecological significance were recommended as ecological CPs. The list of species includes 65 fishes and elasmobranchs, 23 marine mammals (including four Orca ecotypes), one sea turtle, 46[1] invertebrates, five plants and algae, and 55 marine bird species to be considered as ecological CPs for the NSB.
- Areas and habitats including areas of climate resilience, degraded areas, representative habitats, and Ecologically and Biologically Significant Areas (EBSAs; e.g., areas of high productivity or diversity) were recommended as ecological CPs. A total of 17 area-based ecological CPs were recommended
- Several types of spatial features were recommended, including Important Areas (IAs) to represent species-based ecological CPs in site selection analyses for the MPA network. In some cases, IAs for species-based ecological CPs will mirror or duplicate priorities identified in the area-based ecological CPs. These areas would not need to be included multiple times during site selection, but rather will be highlighted as areas that meet multiple network objectives and may have broad ecological importance.
- To assist in the inclusion of spatial features in MPA network planning, development of accessible and comprehensive spatial databases is recommended as a next step to continue fostering collaboration among DFO programs, other agencies and organizations including governments, First Nations, and stakeholders engaged in marine spatial planning to avoid duplication of efforts and ensure efficiencies.
- While all areas and species have some level of ecological importance, conservation planning is based on the assumption that the ecological CPs identified with this framework


[1] Erratum: 48 now reads 46

will act as biological surrogates. Protecting known features of high conservation value is assumed to also protect unmapped biodiversity and important features. For example, protecting biogenic habitats such as kelp and eelgrass beds will also protect the range of species and communities that are associated with those habitats.

- A review of ecological CPs is recommended for future work prior to the design strategies phase; to determine which ecological CPs are amenable to spatial protection measures within the NSB.
- It was not possible to evaluate all criteria for all candidate species, in some cases due to a paucity of information or data. In particular, there was a lack of vulnerability data for invertebrate species in available literature and the selected criterion was not applicable to birds. Further review by subject matter experts was used to augment the available data from literature. The inclusion of expert evaluation of scoring outputs is an important step to ensure scores are both accurate and appropriate.
- It is recommended that the scores used to assess species under each ecological conservation priority criterion NOT be used for ranking. Scores are additive and will be higher for species that have more data and meet multiple criteria. Comparing species' additive scores across criteria is inappropriate because some of the criteria are correlated.
- It is recommended that future iterations or applications of this framework:
    - incorporate expert input at an early stage to develop criteria that apply generally across groups, classes, or phyla (e.g., invertebrates, fishes, marine birds, marine mammals); and provide expert pre-review of criteria evaluations to ensure applicability to all species and taxa;
    - consider the context of the objectives in each MPA network area for the development of appropriate criteria; and,
    - develop or improve criteria assessment tools and metrics as new information becomes relevant.
- This framework is a scientifically defensible, transparent, and repeatable method to identify ecological CPs that meet the MPA network objectives. This evaluation framework can be used to assess additional species, and be adapted to other planning areas. The list of ecological CPs is expected to inform data collection for future steps in the MPA network planning process.
- Ecological CPs identified from this framework will inform subsequent MPA planning steps, including the development of design strategies and design scenarios. Design strategies will guide how the ecological CPs will be incorporated into the network and will consider data availability and whether species identified as ecological CPs are amenable to spatial management measures.

# BACKGROUND

Canada has made regional, national and international commitments to develop a network of Marine Protected Areas (MPAs). In Pacific Region, the Government of Canada, Province of British Columbia and 17 First Nations are working together as the Marine Protected Area Technical Team (MPATT) to develop a marine protected area network in the Northern Shelf Bioregion (NSB). MPA network objectives have been developed (Table 1) that address conservation and sustainability concerns specific to the NSB.

The MPA network planning process in the NSB (Figure 2) builds on guidance provided by the Government of Canada (2011) and the Canada-BC MPA Network Strategy (2014). 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 2009, 2013a), achieving representativity (DFO 2013b), and identifying conservation priorities (DFO 2007b, 2012).

The goals and principles outlined in the Canada-BC MPA Network Strategy along with the network objectives for the NSB inform the identification of conservation priorities (CPs), which are the features to be protected or prioritized during identification of potential sites contributing to the MPA network.

To maximize the benefits of MPAs, identification of CPs is necessary to focus spatial planning towards areas of high conservation value. 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 tourism and recreation. 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.

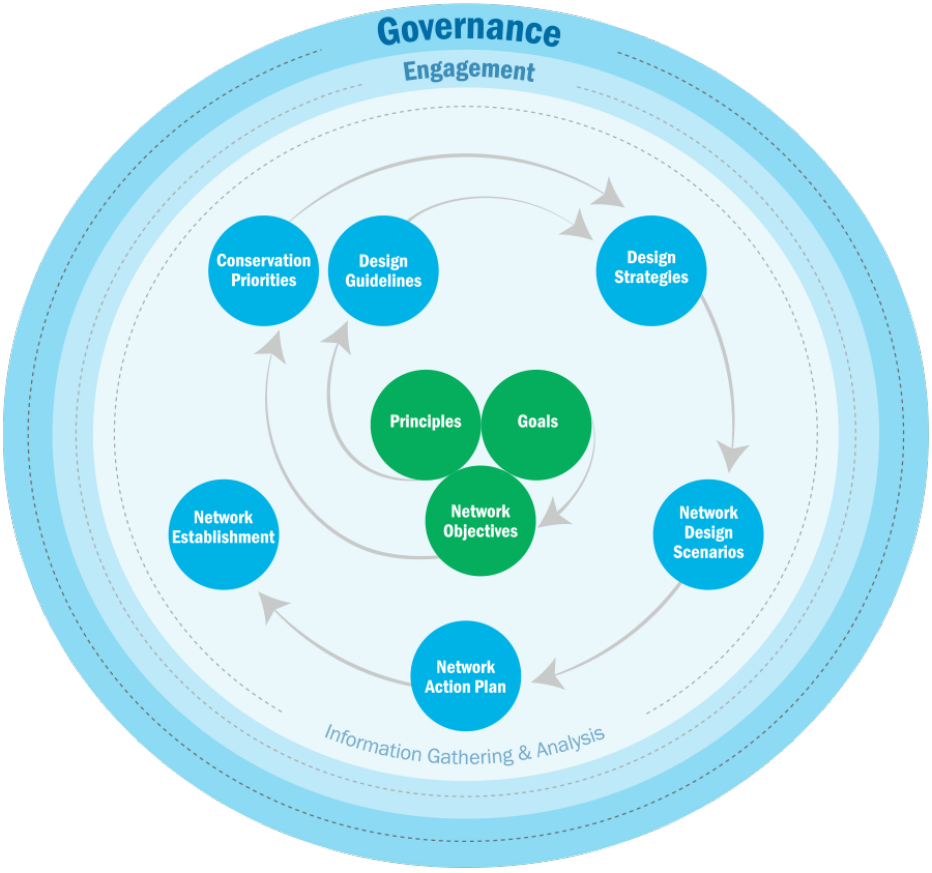


*Figure 2. Conceptual diagram of Northern Shelf Bioregion Marine Protected Area planning process developed by the Marine Protected Area Technical Team (MPATT) in the Pacific Region.*

### Objectives

The main objective of this framework is to identify ecological CPs for MPA network planning in the NSB. Specific objectives of the working paper are 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 ecological CPs for the NSB.
3. Identify the types of spatial information needed to represent ecological CPs in subsequent systematic site selection analyses to achieve MPA network goals and objectives.
4. Discuss uncertainties, gaps, research needs, or limitations for further consideration when identifying ecological CPs for MPA network design in NSB or other bioregions within Canada.

### Scope

The framework:

- considers only the **ecological objectives** outlined in the Canada-BC MPA Network Strategy (Appendix A, Table A 1, 1.1–1.7). The other objectives will be addressed at a later date;
- focuses on marine and coastal ecological components within DFO's mandate;
- includes a modified assessment of marine bird species in the NSB (see page 9);
- does not consider the availability of spatial data;
- does not address targets or other design strategies; and
- addresses ecological CPs at the scale of the NSB.

## ASSESSMENT

Systematic criteria for identifying ecological CPs were developed using existing guidance from past marine spatial planning processes in Canada, the USA, the UK, Australia, New Zealand, and elsewhere. The ecological CP identification strategies and criteria were aligned with the network objectives and nested under the objectives as broad categories. To reflect the objectives and to explicitly guide the process of identifying ecological CPs in the NSB, the broad identification criteria were refined to develop both species-based and area-based ecological CPs (Figure 3).

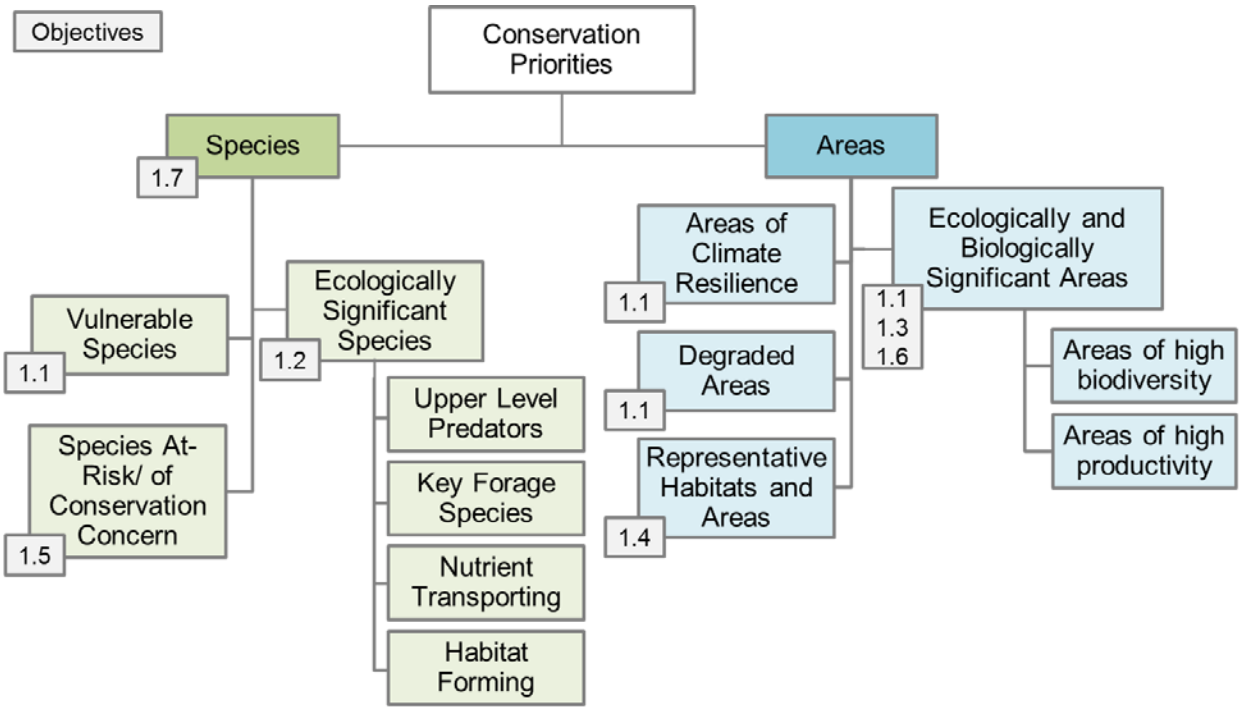


*Figure 3. Ecological conservation priority framework. Numbers in grey boxes refer to network objectives in Table A 1.*

## Species

A set of 190[2] marine and coastal species (excluding marine birds) that regularly occur in the NSB were screened through six species-based ecological CP criteria (Table 1;. A literature review was carried out to assess if each species met each of the criteria. Species were scored based on their current and historical roles, and any uncertainty was documented. Species which are extirpated or are currently at low population sizes compared to historical levels were scored for their known or hypothesized past ecological role(s), 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 body size of some species which historically were large-bodied upper-level predators.

The general scoring scheme for each criterion followed Table 2. The scores assigned through application of the framework and based on the available literature were reviewed and refined by species experts at DFO. All score refinement followed the framework and criteria.

Because the scoring process for many of the selected criteria were not applicable to birds, a modified scoring methodology was used to determine which birds should be considered. A description of how marine and coastal bird species were assessed for inclusion as ecological CPs can be found on Page 9.

[2] Erratum: 192 now reads 190

*Table 1. Species-based ecological conservation priority evaluation criteria under each network objective.*

| Network 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 |

*Table 2. Description of scores used to assess species under each ecological conservation priority criterion.*

| 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. |

### Objective 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.

Species' vulnerability to disturbance and recovery potential was 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). Life history characteristics relevant to population growth provide 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.

Each candidate species was assessed based on their vulnerability category in FishBase or SeaLifeBase, or for species not included in these databases, based on information available

from existing literature, internal reports, and expert knowledge of species' life history characteristics. Based on expert feedback during the peer review meeting, it was determined that the scores from Cheung et al. (2005) did not adequately describe the vulnerability of marine mammal or invertebrate species. As such, 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.

**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.**

Objective 1.2 prioritizes Ecologically Significant Species (ESSs), which are species that have particularly high ecological importance and warrant special management measures, such as upper-level predators, key forage species, nutrient importing and exporting species, and structure-providing (habitat-forming) species (DFO 2007a). 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). To meet Objective 1.2, individual criteria were developed for each of the four ESS categories.

**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). For marine fishes and other gape-limited predators, however, the strength of these effects depends on body size. Combinations of size, trophic level, and known ecological role were used to identify upper-level predators.

**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 in the literature that forage species occupy low trophic levels , are small in body size, have a very high fat content, and aggregate into very large and dense schools. They are critical to energy transfer from plankton to higher trophic levels. Combinations of the above criteria were used to identify key forage species in the NSB.

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

Species that transfer limiting nutrients or energy; either into an ecosystem from sources outside that ecosystem, or from inside an ecosystem to an area outside, are important for maintaining ecosystem structure and functioning (DFO 2007a). Examples include species that transfer energy by migrating in and out of the NSB (e.g., organisms feeding and emitting waste as they travel) and organisms that transport nutrients from marine to transitional ecosystems (e.g., provide nutrient subsidies to intertidal beaches, streams, or estuaries). Following guidance on the identification of ESSs (DFO 2007a), scores for this criterion were limited 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.

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.

**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 (DFO 2007a).

**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. Species of conservation concern were identified using the conservation status assigned to each species by authorities at the global, national, and provincial levels. Species with any level of conservation concern (i.e., equivalent to Species at Risk Act (SARA) "Special Concern" or higher) received scores under this criterion.

**Other considerations: Rarity and Range Restriction**

The framework does not explicitly assess rarity, endemism, or range restriction as a scoring criterion for ecological CPs, due in part to difficulties in quantitatively assessing rarity. 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.

**Marine Birds**

Although marine birds are not the mandate of DFO specifically, they are included here as an important component of an effective MPA network design. To determine the marine bird species that should be considered ecological CPs, a modified screening and scoring method was developed and applied in collaboration with subject matter experts from Environment and Climate Change Canada (ECCC) and The Nature Conservancy Canada.

A set of 80 candidate species were assigned scores based on the following 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 5: Northern Pacific Rainforest (Environment Canada 2013);
2. Level of conservation concern at global, national, and provincial scales;
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).

The final ecological CP score for each bird species was the highest score of any criterion.

## Results: Species-Based Ecological Conservation Priorities

Based on criteria that prioritize protection of vulnerable species, Ecologically Significant Species, and those of conservation concern, the original set of 270[3] marine and coastal species (190[4] non birds + 80 birds) was narrowed to 65 fishes and elasmobranchs, 23 marine mammals

[3] Erratum: 272 now reads 270
[4] Erratum: 192 now reads 190

(including four Orca ecotypes), one sea turtle, 46[5] invertebrates, five plants and algae, and 55 marine bird species identified as ecological CPs for the NSB. The resulting lists of ecological CPs are shown in Table C 1 (all species except marine birds) and Table C 2 (marine birds only).

## Recommended Spatial Features for Species-based Ecological Conservation Priorities

Effective MPA planning and implementation requires an understanding of where CPs occur in the planning area. To guide future data collection, types of spatial features and information were suggested to adequately represent species-based ecological CPs in the MPA network (Table B 1).

Identification and inclusion of Important Areas (IAs), (including areas of aggregation or importance for spawning, rearing/nursery, feeding, or migrating, or areas otherwise determined to be critical habitat), was determined to be of particular importance for meeting network objective 1.7 ('*Contribute to conservation of areas important for the life history of resident and migratory species*').

## Areas

To identify area-based ecological CPs, a literature search was conducted to determine if a particular type of feature, habitat, or area was known to fulfill the relevant network objectives (Table 3). We identified area-based ecological CPs as features, habitats, and areas that meet the criteria outlined below. Unlike the species-based ecological CPs, a candidate list of areas or features was not compiled, and a scoring system was not used to assess area-based ecological CPs. Instead, the identified area-based ecological CPs were 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 3. Network objectives relevant to area-based ecological conservation priorities.*

| 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 areas associated with geological features and enduring/recurring oceanographic features. |

The following categories of areas and habitats were found to fit the network objectives laid out in Table A 1. Specific types of features recommended as area-based ecological CPs are presented in Table D 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

[5] Erratum: 48 now reads 46

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 (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, potential for recovery from disturbance, high productivity, high biodiversity and naturalness. The ecological CP framework focuses 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 (see below), and areas important for species' life history stages and for threatened species are discussed as recommended spatial features. Naturalness is excluded (see section below on Degraded Areas).

#### Areas of High Biodiversity and High Productivity

Areas that contain comparatively higher diversity of ecosystems, habitats, communities, species, or genes than the surrounding area, are considered EBSAs (CBD 2008). Examples are features known to be associated with high or distinct biodiversity (e.g., including seamounts andtidal channels). In marine systems, several biological and physical processes promote increased biodiversity, which are often linked to areas of high productivity. Genetic diversity is also an important consideration that should be assessed at the species level.

#### Areas of Climate Resilience

While MPAs cannot prevent climate change from progressing, environmental refugia are beginning to be considered in the context of conservation planning. 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. Protecting areas that contribute to sequestration of "blue carbon" (e.g., salt marshes) will also contribute to climate resilience.

#### Degraded Areas

Degraded areas are those that are unable to carry out their ecosystem functioning such that key ecosystem components (such as ESSs) are unable to fulfil their ecological roles and functions (DFO 2007b). Degraded areas can also be areas that have been determined to be in need of rehabilitation (DFO 2007b).

In practice, identifying degraded areas is difficult, given that at some level, all ecosystems have been altered from their original state. Degraded areas have been recommended as CPs at the national level, but have yet to be identified regionally. 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).

#### Representative habitats and areas

Representativity 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 may accommodate changes in the system due to climate.

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 (DFO 2013b).

In BC, several classification systems have been developed to represent different ecological patterns and processes.

## Discussion

The ecological CP framework was developed and applied to the NSB in British Columbia. Based on criteria that prioritize protection of vulnerable species, ESSs, and those of conservation concern, we recommend 65 fishes and elasmobranchs, 23 marine mammals, one sea turtle, 48 invertebrates, five plants and algae, and 55 marine bird species to be considered as ecological CPs in the NSB. To guide the future collection of data for use in site selection analyses, it was recommended to identify IAs (including areas important for spawning, rearing, feeding, migrating, or aggregation), patterns of distribution and abundance, and areas of high or distinct genetic diversity for each species-based ecological CP.

Area-based ecological 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. Seven types of physical features were identified that are associated with productivity or high biodiversity, three features associated with climate resilience, and six ecological classifications. It is also recommended to identify potential degraded areas in the NSB, and to explore modelled or measured areas of abundance, diversity, or richness for appropriate groups of organisms.

### Distribution of Scores for Species-based Ecological CPs

*Species Other than Marine Birds*

Differences in the numbers of "strong fit" (*2*) scores given across criteria influenced the final list of species included as ecological CPs.

The highest number of species were identified under the vulnerability criterion (1.1.S1), with 112[6] of 190[7] species considered highly vulnerable to disturbance based on their life history characteristics. 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 ecological CPs based on other criteria.

Forty-six species were identified as upper-level predators (1.2.S1), including 26 species of fish, 16 marine mammals, and four invertebrates. Key forage species (1.2.S.12) included nine species of fish, nine species of crustacean, six[8] species of mollusc, non-crustacean zooplankton, and phytoplankton.

The fewest species were identified under the nutrient transporting criterion (1.2.S3), with only seven species (five species of Pacific Salmon, Pacific Herring, and Eulachon) receiving high scores. 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 only moderately fit the criterion, while anadromous species that have well documented nutrient transporting roles (e.g., salmon) strongly fit the criterion.

[6] Erratum: 115 now reads 112
[7] Erratum: 192 now reads 190
[8] Erratum: eight species now reads six species

Species that scored highly as habitat-forming species (1.4.S4) included corals, sponges, goose[9] barnacles, California mussels, seven[10] 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[11] species having no ranking among the seven lists of species at risk referenced. Four species of echinoderm were identified by experts as being of concern due to disease and were deemed to moderately fulfill this criterion. Of the remaining 96[12] species with lacking information on conservation concern, 45[13] were fishes or elasmobranchs, 42[14] were invertebrates, and nine were plants or algae[15].

Overall, 38[16] species were given moderate or uncertain fit scores but were not a strong fit for any of the criteria. 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[17] species did not fulfill any criteria (three fishes, seven invertebrates, and three[18] plants or algae).

*Marine Birds*

80 species of marine birds were considered for evaluation using the framework. Most of the candidate bird species are identified in the ECCC Bird Conservation Region 5 (; Northern Pacific Rainforest [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 an ecological CP score of *2* because of either conservation concern (14 species) or high jurisdictional responsibility given the percent of the global population breeding in Canada (17 species). Twenty-four species received a score of *1*, either because they were identified as a priority species for BCR 5 marine or coastal habitat and there is conservation concern (12 species); because they were identified as a priority species in BCR 5 marine or coastal habitat (with no conservation concern) (8 species); because there is conservation concern for the species (but it is not a priority species in BCR 5 marine or coastal habitat) (2 species); or because experts identified the NSB as an important area of their range (2 species). Twenty-five species received a 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 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.

[9] Erratum: gooseneck barnacles now reads goose barnacles
[10] Erratum: seven species now reads five species
[11] Erratum: 103 species now reads 100 species
[12] Erratum: 99 species now reads 96 species
[13] Erratum: 46 now reads 45
[14] Erratum: 44 now reads 42
[15] Erratum: inserted "or algae"
[16] Erratum: 37 species now reads 38 species
[17] Erratum: 14 species now reads 13 species
[18] Erratum: four plants now reads three plants

The 80 candidate species selected to be evaluated through this framework can be classified as seabirds (32 species); ducks, geese, herons, and grebes (28 species); shorebirds (19 species); and one falcon.

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

Of the 28 ducks, geese, herons, and grebes, seven had a score of *2* (mostly due to high conservation concern and high jurisdictional responsibility), six had a 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 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 score of *2* (primarily because of high jurisdictional responsibility though a couple have high conservation concern), four had a 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 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 score of *0* because of 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.

#### Comparisons with Similar Efforts Elsewhere in Canada

The methods and general results of this framework align well with other conservation processes in Canada and BC. Processes in Newfoundland, the Maritimes, and the Gulf of St. Lawrence have variously identified depleted or at risk species, ESSs, IAs, EBSAs, and representative ecological classifications for use in conservation planning (e.g. King et al. 2013, DFO 2014).

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

## Challenges and Limitations

A number of challenges, limitations and uncertainties were encountered during the development and application of the framework. These challenges and limitations are incorporated throughout this document in the section most pertinent to each; key limitations are listed below.

- The criteria developed are not equally applicable to all taxa. For example, the intrinsic vulnerability scores used to estimate species' vulnerability to disturbance and recovery potential was designed for fish species and is not necessarily directly transferable to species such as invertebrates and marine birds. Because conservation authorities (e.g., SARA, IUCN Red List) list more fishes, marine mammals and marine birds than invertebrates, there was a taxonomic bias in the number of species being scored as of Conservation Concern.
- The broad effects of climate change (e.g., ocean acidification, warming, changing oxygen levels, sea level rise, extreme weather impacts) are expected to shift species ranges, and

may alter species' vulnerability to natural and anthropogenic effects such as pollutants and other stressors, and may change the distribution of resilient areas.

- The MPA network should be based upon the scale of the underlying processes driving spatial patterns within the NSB. However, it must be acknowledged that spatial protection measures will be implemented at a scale that in some cases may not be relevant for all species, life history stages, and ecological processes.

### Sources of Uncertainty

- The species scores under each criterion reflect the best available knowledge and information. It was not possible to evaluate all criteria for all candidate species, in some cases due to a paucity of information or data. In particular, there was a lack of vulnerability data for invertebrate species in available literature. Further review by subject matter experts was used to augment the available data from literature. The inclusion of expert evaluation of scoring outputs is an important step to ensure scores are both accurate and appropriate.
- A bias towards well-studied species was identified. For example, there is a bias in the level of information available for assessment of fish and/or marine mammal species with high conservation value, while the assessment of invertebrate species was limited by uncertainties and/or lack of data available.
- The vulnerability scores are associated with a level of uncertainty, as they were developed on a scale of 0-100 (Cheung et al. 2005) and have been truncated into three categories (0, 1, 2).
- The trophic levels used in scoring upper-level predators and forage species originated from FishBase. In some cases, such as when trophic levels were calculated on small or juvenile individuals, the trophic levels are not representative of the range of trophic levels that exist in a species.

## CONCLUSIONS AND ADVICE

- This framework is a scientifically defensible, transparent, and repeatable method to identify ecological CPs that meets the network objectives for the NSB. This evaluation framework can be used to assess additional species, and can be adapted to other planning areas. The list of ecological CPs is expected to drive data collection for future steps in the NSB MPA network planning process.
- Two types of ecological CPs were identified: species-based and area-based. Species-based CPs are 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 of the Canada-BC MPA Network Strategy.
- Species that were identified as of conservation concern and/or received high scores for either vulnerability or ecological significance were recommended as ecological CPs. The list of species includes 65 fishes and elasmobranchs, 23 marine mammals (including four Orca ecotypes), one sea turtle, 46[19] invertebrates, five plants and algae, and 55 marine bird species to be considered as ecological CPs for the NSB.

[19] Erratum: 48 invertebrates now reads 46 invertebrates

- Areas and habitats including areas of climate resilience, degraded areas, representative habitats, and EBSAs were recommended as ecological CPs. Seventeen types of area-based ecological CPs were recommended.
- The types of spatial features and information that should be collected in order to adequately represent species-based ecological CPs in the MPA network were recommended, including Important Areas, observed or modelled distributions and relative abundance, and areas of high or distinct genetic diversity.
- A review of ecological CPs is recommended for future work prior to the design strategies phase; to determine which ecological CPs are amenable to spatial protection measures within the NSB.
- It was not possible to evaluate all criteria for all candidate species, in some cases due to a paucity of information or data. In particular, there was a lack of vulnerability data for invertebrate species in available literature and the selected criterion was not applicable to birds. Further review by subject matter experts was used to augment the available data from literature. The inclusion of expert evaluation of scoring outputs is an important step to ensure scores are both accurate and appropriate.
- It is recommended that the scores for ecological CPs NOT be used for ranking. Scores are additive and will be higher for species that have more data and meet multiple criteria. Comparing species' additive scores across criteria is inappropriate because some of the criteria are correlated.
- Development of accessible and comprehensive spatial databases is recommended as a next step to continue fostering collaboration among DFO programs, other agencies and organizations including governments, First Nations, and stakeholders engaged in marine spatial planning to avoid duplication of efforts and ensure efficiencies.
- It is recommended that future iterations or applications of this framework:
    - incorporate expert input at an early stage to develop criteria that apply generally across groups, classes, or phyla (e.g., invertebrates, fishes, marine birds, marine mammals); and provide expert pre-review of criteria evaluations to ensure applicability to all species and taxa;
    - define criteria to be applicable to all candidate species;
    - consider the context of the objectives in each MPA network area for the development of appropriate criteria; and,
    - develop or improve criteria assessment tools and metrics as new information becomes relevant.

## SOURCES OF INFORMATION

This Science Advisory Report is from the November 22–24, 2016 meeting on the Framework for identifying ecological conservation priorities for marine protected area (MPA) network design in the Northern Shelf Bioregion. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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# APPENDIX A. MPA NETWORK GOALS AND NETWORK OBJECTIVES FOR THE NORTHERN SHELF BIOREGION

*Table A 1. MPA network goals and network objectives for the Northern Shelf Bioregion, as of 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 | Objective |
|---|---|
| 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 from marine protected areas. |
| | 4.4. Strengthen participation and representation of communities and stakeholders in design, establishment and monitoring of the network. |
| | 4.5. Ensure that all marine protected areas have clearly defined objectives and effective management and monitoring measures. |
| | 4.6. Support effective MPA network governance, planning and management. |
| | 4.7. Establish modern and collaborative approaches to surveillance and compliance monitoring. |
| 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 public 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 |

# APPENDIX B: RECOMMENDED SPATIAL FEATURES TO REPRESENT SPECIES-BASED ECOLOGICAL CONSERVATION PRIORITIES

*Table B 1. Recommended spatial features to represent species-based ecological 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 Important Areas (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).<br>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.<br>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. |

# APPENDIX C: ECOLOGICAL CONSERVATION PRIORITIES

*Table C 1. The 142 species, excluding marine birds, recommended as ecological conservation priorities. † 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* |

| Higher Group | Species Group | Common Name | Scientific Name |
|---|---|---|---|
| Bony Fishes (cont'd) | Rockfishes (cont'd) | 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* |
| 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 | Coldwater Corals | Black Corals | Antipatharia |
| | | Hard or Stony Corals | Scleractinia |
| | | Sea Pens | Pennatulacea |
| | | Soft Corals | Alcyonacea |
| Crustaceans | Barnacles | Gooseneck 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* |

| Higher Group | Species Group | Common Name | Scientific Name |
|---|---|---|---|
| Crustaceans (cont'd) | 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 Sea Urchin | *Strongylocentrotus droebachiensis* |
| | | Red Sea Urchin | *Mesocentrotus franciscanus* |
| 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[20] | *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. |

[20] Erratum: Two species (Manila and Softshell Clam) removed from table

*Table C 2. Marine bird species recommended as ecological conservation priorities.*

| 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, p*elagicus* 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* |

# APPENDIX D. RECOMMENDED AREA-BASED ECOLOGICAL CONSERVATION PRIORITIES

*Table D 1. Network objectives met by features or areas recommended as ecological conservation priorities (CP).*

| Feature or Area Recommended as Ecological CP | 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[1] and future classifications building on PMECS framework (Rubidge et al. 2016). | | 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 (British Columbia Marine Conservation Analysis 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 | | |

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