



ASSESSMENT OF NEARSHORE FEATURES IN THE NORTHERN SHELF BIOREGION AGAINST CRITERIA FOR DETERMINING ECOLOGICALLY AND BIOLOGICALLY SIGNIFICANT AREAS (EBSAs)

Context

The identification of Ecologically and Biologically Significant Areas (EBSAs) is a step towards meeting Canada's commitments under the Oceans Act (Government of Canada 1997) which provides the legislative framework for an integrated ecosystem approach to management in Canada's oceans. EBSA identification is also a commitment by Canada as a signatory on the Convention of Biological Diversity (CBD). Canada was one of the first CBD signatory countries to develop criteria and guidance for identifying EBSAs (DFO 2004, 2011a), and has also endorsed the scientific criteria used by the CBD for identifying EBSAs¹ (CBD 2008). DFO's science advice recommends identifying EBSAs as a first step to planning networks of marine protected areas (DFO 2010), in accordance with the CBD (2008). This approach was re-emphasized in Canada's National Framework for Canada's Network of Marine Protected Areas (MPAs) (Government of Canada 2011). EBSA identification is an important input into the ongoing MPA network planning process in the Northern Shelf Bioregion (NSB) following guidance outlined in the Canada-British Columbia (BC) MPA Network Strategy (2014). The integration of EBSAs into the network is a key strategy and this work will provide the Marine Protected Area Network Technical Team (MPATT²) guidance for the ongoing MPA network planning process in the NSB.

Areas identified as EBSAs do not automatically trigger new management measures. However, EBSAs are considered special natural areas and are afforded an increased measure of risk aversion in marine spatial management of human activities (DFO 2004, 2011a). The need for management, and the type of management action required to conserve or protect an EBSA, is determined by the ecological characteristics of the EBSA, including why it was designated as an EBSA, the type and extent of human activities occurring in or adjacent to it, and how the ecological components and the stressors associated with the human activity interact.

This Science Response results from the Science Response Process of June 14, 2017 on the Assessment of nearshore features against criteria for determining Ecologically and Biologically Significant Areas (EBSAs) in the Northern Shelf Bioregion.

¹ The Convention on Biological Diversity defines EBSAs as Ecologically or Biologically Significant Marine Areas but we will refer to them as Ecologically and Biologically Significant Areas to keep consistent with DFO language.

² MPATT is the technical team responsible for the design and implementation of the MPA network planning process in the NSB, with representatives from the federal government, the province of British Columbia and 16 partner First Nations.

Background

Defining and Identifying an EBSA

An EBSA is defined as an area of especially high ecological or biological significance where greater risk aversion is required in the management of activities (DFO 2004). In addition, perturbations are expected to cause greater ecological consequences within EBSAs than in surrounding areas exposed to comparable perturbations. Similar to the DFO definition, CBD (2008) defines an EBSA as an area that is important for the healthy functioning of our oceans and the services they provide.

Scientific criteria to identify EBSAs have been established at the national (DFO 2004) and international (CBD 2008) levels (Box 1 & 2 respectively). The DFO and CBD criteria overlap (Table 1), and it is generally accepted that similar areas will be identified by following either set of criteria (Westhead et al. 2013; DFO 2012; Gregr et al. 2012). EBSAs can be identified based on single species (e.g., spawning areas, or species aggregations), or multiple features (e.g., areas of high diversity, productivity, or overlap of many single-species EBSAs). In the Pacific Region, single-species EBSAs are referred to as “Important Areas” or IAs. DFO science advice (DFO 2004) states that features or areas that rank “High” for one or more of uniqueness, fitness consequences, or aggregation, can be designated as an EBSA. A feature or area that ranks above average (Medium or High) across multiple criteria also meets the EBSA criteria (DFO 2004).

Box 1. Summary of the DFO (2004) EBSA criteria, reproduced from Hastings et al. (2014)

1. Uniqueness

- The area contains unique, rare, or distinct features.

2. Aggregation

- Significant numbers of a species are found in the area during some period of the year.
- Significant numbers of a species use the area for a life history function.
- A structural feature or ecological process is observed in high density in the area.

3. Fitness Consequences

- The life history activities of a species or population in the area strongly affect its fitness.

4. Resilience

- The habitat structures or species present in the area are highly sensitive, easily perturbed, and/or slow to recover.

5. Naturalness

- The area is relatively pristine, with little to no evidence of human influence.

Box 2. Summary of the CBD (2008) criteria, reproduced from Hastings et al. (2014)

1. Uniqueness or rarity

- A unique, rare, or endemic species, population, or community is present.
- A unique, rare, or distinct habitat or ecosystem is present.
- A unique or unusual geomorphological or oceanographic feature is present.

2. Special importance for life-history stages of species

- The area is required for a population to survive and thrive (e.g., breeding or nursery grounds, spawning areas, migratory species habitat).

3. Importance for threatened, endangered or declining species and/or habitats

- The area contains habitat that is critical for the survival and recovery of endangered, threatened, or declining species.
- Significant assemblages of endangered, threatened, or declining species are found in the area.

4. Vulnerability, fragility, sensitivity, or slow recovery

- The area contains a high proportion of sensitive habitats, biotopes, or species that are especially susceptible to degradation or depletion, and/or are slow to recover.

5. Biological productivity

- The area contains species, populations, or communities with comparatively higher natural biological productivity.

6. Biological diversity

- The area contains comparatively higher diversity of ecosystems, habitats, communities, or species.
- Comparatively higher genetic diversity is observed in the area.

7. Naturalness

- Exhibits a comparatively higher degree of naturalness resulting from little to no anthropogenic pressure.

Table 1. Overlap between DFO and CBD criteria as indicated in Hastings et al. (2014), Westhead et al. (2013) and Ban et al. (2016). Shading indicates overlap between two criteria.

CBD (2008)	DFO (2004)				
	Uniqueness	Aggregation	Fitness Consequences	Resilience	Naturalness
Uniqueness or Rarity	X				
Special Importance for life history stages of species		X	X		
Importance for threatened, endangered or declining species and/or habitats		X	X		
Vulnerability, fragility, sensitivity, or slow recovery				X	
Biological productivity		X			
Biological diversity					
Naturalness					X

Previous EBSA processes in the Northern Shelf Bioregion

EBSAs in the NSB (Figure 1) were identified in 2006 (Clarke and Jamieson 2006a, 2006b) and reviewed in a Canadian Science Advisory Secretariat (CSAS) Regional Peer Review Process in February 2012 (DFO 2013). However, this process did not include a comprehensive analysis of nearshore areas (defined as 0.25 km from shore, DFO 2013). Consequently, DFO Oceans Sector of the Ecosystems Management Branch requested that DFO Science provide advice regarding nearshore areas in the NSB that meet the EBSA criteria.

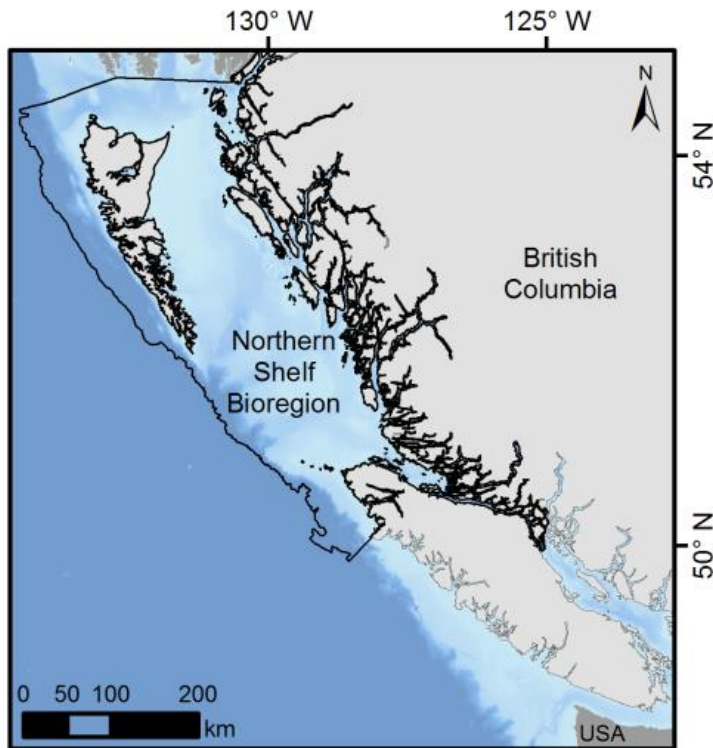


Figure 1. Extent of the Northern Shelf Bioregion (NSB) in British Columbia.

Gregr et al. (2012) defined nearshore as shelf areas shallower than 50 m. However, a depth-based measure includes shallow banks far from shore, and omits deep regions close to shore (e.g., in fjords). For this analysis, we generally follow the nearshore definition described in Rubidge et al. (2018) as areas shallower than 20 m and less than 2 km from shore, plus all semi-enclosed waters (bays, inlets and fjords).

This project assesses five nearshore features (canopy forming kelp forests, eelgrass meadows, estuaries, surfgrass meadows, and high current tidal passages) against the established EBSA criteria. These five features were selected as a preliminary set of potential nearshore EBSAs because they have recognized ecological importance but have not been formally assessed against the EBSA criteria in Pacific Region. Marine plants, including eelgrass meadows and kelp beds, were identified as EBSAs in Maritimes Region (Kenchington 2014); eelgrass was identified as an Ecologically Significant Species (ESS³) in Gulf Region (DFO 2009); and kelp, eelgrass, and surfgrass were identified as conservation priorities in the NSB MPA network process (DFO 2017). In addition, River Mouths and Estuaries were identified as EBSAs in the original EBSA process in the NSB (Clarke and Jamieson 2006b) but were not formally assessed against the CBD criteria and were not mapped.

It is important to note that the five features considered here are just an initial assessment of nearshore features and these are not the only potential nearshore EBSAs. Multiple other nearshore biogenic or physical features can be assessed in the future (e.g., clam beds, mussel beds, rocky reefs).

³ 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 2007a).

The methods used here for assessing EBSAs follow Ban et al. (2016), where the DFO and EBSA criteria were merged into eight criteria based on conceptual overlap (see Table 1, Box 1 & 2 for definitions and a summary of the overlap). The Ban et al. (2016) approach was reviewed and approved through a CSAS Regional Peer Review process in February 2015 (DFO 2016) as a defensible approach for identifying EBSAs. ESSs and conservation priorities identified for the MPA network in the NSB (DFO 2017; Gale et al. 2019; ESSs are considered as those receiving a “strong fit” score for criterion 1.2 in Gale et al. 2019) are also incorporated into this EBSA assessment via known habitat linkages with the five nearshore features assessed. These linkages identify the importance of these habitats to ecologically important species.

Analysis and Response

Following Ban et al. (2016), each feature was assessed against the combined EBSA criteria (refer to Box 1 & 2 for criteria definitions). All criteria for EBSA designation are relative to the surrounding area, which includes the seabed and water column around the feature being assessed. “Feature” refers to the biological structures created by species (e.g., canopy-forming kelp forest) or those created by the physical characteristics of the area (e.g., rocky reef, estuary, high tidal current passage). The EBSA criteria were applied to each feature as follows:

Uniqueness or rarity: This criterion was applied to the feature itself, not to the species that occupy it.

Special importance for life-history stages of species: This criterion is focused on the species that use the feature for specific life history stages.

Importance for threatened, endangered or declining species and/or habitats: This criterion was applied to both the features themselves and the species that inhabit them.

Vulnerability, fragility, sensitivity, or slow recovery: This criterion was applied to the biological components of the feature.

Biological productivity: This criterion was assessed by examining the relative productivity in the vicinity of the feature.

Biological diversity: This criterion was assessed by examining the relative biodiversity within the feature (e.g., the number of species that use the feature as habitat)

Naturalness: This criterion was applied based on the state of the feature being assessed. In all cases, the features in this assessment are found throughout the study area and therefore experience a range of human impacts. An analysis specifically examining the distribution of human impacts across the NSB is needed to identify areas with higher naturalness.

Aggregation: This criterion is related to life history stage and biological productivity, and was applied to both the feature itself, and the species that occupy it.

Canopy Forming Kelp

Introduction

Two species of canopy-forming kelp predominate along the eastern North Pacific coast: the perennial *Macrocystis pyrifera* (Giant Kelp), and the annual *Nereocystis luetkeana* (Bull Kelp). Large patches of Giant and/or Bull Kelp visible at the surface are often called “kelp forests”, and are the focus of this assessment. However, there are many other genera of kelp (e.g., *Laminaria*, *Alaria*, *Pterygophora*) that create mid-water canopies with potentially similar ecological importance. Mid-water kelps should therefore be a priority in future assessments of this feature. Distributed on rocky and mixed substrates in neritic waters (typically to 20 m), kelp forests rank among the most productive ecosystems in the world (Mann 1973; DFO 2009). These forests provide a variety of important ecosystem services, including the creation of coastal habitat (Markel 2011; Markel and Shurin 2015), carbon sequestration (Wilmers et al. 2012), and shoreline protection (Tallis et al. 2012). Both species have been identified as ESSs and as conservation priorities for the MPA network in the NSB (DFO 2017).

Distribution

Bull Kelp and Giant kelp are found from Alaska to Mexico (Druehl 2001) and are broadly distributed in BC. Bull kelp tends to be distributed in moderate to higher energy waters, while giant kelp tends to occur in waters of moderate to low energy. Mixed stands are not uncommon in BC, where bull kelp is often observed forming a fringe in the higher energy zone around giant kelp beds closer to shore (E. Gregr, J. Lessard, and S. Jeffery, pers. obs.⁴). Kelp forests of primarily bull kelp are also commonly observed on suitable substrate in shallow areas further from shore.

Feature description

In general, kelp forest ecosystems support coastal species through two distinct ecological processes (Markel 2011). First, by creating and enhancing habitat (e.g., Trebilco et al. 2015), and second through the provision of primary production (Duggins 1988; Steneck et al. 2002; Markel 2011). Within a kelp forest, the spatially complex three-dimensional structure increases the abundance and diversity of coastal organisms (Duggins 1988; Steneck et al. 2002), with the vertical component known to be used by mid-water reef fishes (Hallacher and Roberts 1985; Ebeling and Laur 1988; Markel and Shurin 2015), and juvenile Coho and Chinook Salmon (Daly et al. 2009). The benthic and edge habitats, and the plants themselves, provide habitats for other species (Duggins 1988). For example, kelps serve as substrate for a diversity of small planktivorous and detritivorous invertebrates (Graham et al. 2008). This high habitat complexity leads to high species diversity (Graham et al. 2007) and trophic complexity (Graham et al. 2008), in part through the provision of refugia from predators (Lee et al. 2016). Increased retention of particulate matter (Graham 2003) may also enhance nursery and rearing habitat, while at broader extents, the size and configuration of kelp forests modifies nearshore hydrodynamics (Eckman et al. 1989; Graham 2003; Wu et al. 2017), potentially affecting recruitment of fishes and invertebrates with a nearshore larval phase (Eckman et al. 1989; Graham 2003; Markel 2011). Many of the species that use and depend on kelp forests for critical stages in their life history have been identified as conservation priorities for NSB MPA network planning (Rubidge et al. 2020).

⁴ Fisheries and Oceans Canada, Victoria/Nanaimo, BC, 2019.

Assessment against EBSA criteria

Characteristics of kelp forests were assessed against the EBSA criteria to evaluate whether they should be included as nearshore EBSAs (Table 2).

Table 2. Assessment of kelp forests against the eight EBSA criteria (Boxes 1 and 2). Insuffic. Info.: insufficient information.

EBSA Criteria	Ranking of criterion relevance			
	Insuffic. Info.	Low	Medium	High
Uniqueness or rarity			X	
<p>Rationale: Kelp forests are a unique, biogenic habitat feature supporting a diversity of coastal species through habitat provisioning and enhanced primary production (Steneck et al. 2002; Markel 2011; Lee et al. 2016). Habitat is enhanced by the complex three-dimensional structure (Duggins 1988; Steneck et al. 2002) and increases species abundance, diversity, and trophic complexity (Graham et al. 2007, 2008). Increased retention of particulate matter (Graham 2003) may also enhance nursery and rearing habitat. Regionally, the size and configuration of kelp forests modifies nearshore hydrodynamics (Eckman et al. 1989; Graham 2003, Wu et al. 2017), potentially improving the recruitment of fishes and invertebrates with a nearshore larval phase (Eckman et al. 1989; Graham 2003; Markel 2011). Despite the unique ability of kelp to build canopy-forming, complex three dimensional structure for multiple species, the criterion is scored as Medium because the feature is widely distributed in BC.</p>				
Special importance for life-history stages of species			X	
<p>Rationale: Kelp forests provide habitat for a variety of fish species including juvenile and adult life stages of rockfish (Hallacher and Roberts 1985; Ebeling and Laur 1988; Markel and Shurin 2015), salmon (Shaffer 2004; Daly et al. 2009), and invertebrates (Krumhansl and Scheibling 2012; Lee et al. 2016). They also serve as substrate for small invertebrates (Graham et al. 2008). Despite this habitat provisioning for a range of species during critical early life history stages, a ranking of Medium is assigned because most species persist in the absence of canopy kelp (though see Graham 2004), perhaps due to a similar contribution by understory kelp in deeper waters.</p>				
Importance for threatened, endangered or declining species and/or habitats			X	
<p>Rationale: Kelp forests create important habitat for a diversity of species, some of which may be declining or listed as species at risk (e.g., endangered Northern Abalone; DFO 2007b; Lee et al. 2016). The importance of kelp forests to many commercial finfish may be quite high, particularly in their early life history stages (e.g., Daly et al. 2009; Markel and Shurin 2015). The nutritional supplement to higher trophic levels from the considerable primary production may also contribute significant nutritional support for declining species and species at risk such as some rockfish species. Despite its likely importance to threatening and declining species, most of these species can occur in alternative habitats in the absence of kelp, so it was scored Medium.</p>				
Vulnerability, fragility, sensitivity, or slow recovery		X		
<p>Rationale: Kelp forests are comprised of fast-growing species that are functionally robust and appear fairly resilient. The most direct threats include rising water temperatures and associated changes in</p>				

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EBSA Criteria	Ranking of criterion relevance			
	Insuffic. Info.	Low	Medium	High
<p>trophic dynamics leading to increased herbivory, and invasive species (Schiel and Foster 2015; Krumhansl et al. 2017), which can lead to permanent loss of kelp forests.</p>				
Biological productivity				X
<p>Rationale: Kelp forests are one of the most productive ecosystems on the planet (Mann 1973; Krumhansl et al. 2016). They provide as much as 30% more biomass than the same rocky reef feature dominated by grazing invertebrates, contributing significantly to the overall productivity of the coastal eastern North Pacific (Gregr 2016). This biomass enhances secondary production by feeding a range of detritivores and grazers (Steneck et al. 2002). Kelp-derived primary production can also supplement filter feeders at places (e.g., Duggins et al. 1989; Salomon et al. 2008) or times (Ramshaw 2012) when planktonic primary productivity is reduced. In addition to their importance as a nutrient importer, kelp forests have been identified with other macroalgae and marine plants for their important role in reducing atmospheric carbon and for carbon sequestration (see Krause-Jensen and Duarte 2016; Wilmers et al. 2012).</p>				
Biological diversity				X
<p>Rationale: The habitat provisioning service provided by kelp forests leads to higher species diversity, unique communities, and higher density of some species and life stages (Steneck et al. 2002; Graham 2004; Koenigs et al. 2015; Gregr 2016).</p>				
Naturalness	Variable			
<p>Rationale: The distribution of canopy-forming kelps, particularly in terms of depth and canopy extent, is strongly influenced by the presence of Sea Otters (Estes and Palmisano 1974; Watson and Estes 2011). In the absence of Sea Otters, the distribution of canopy-forming kelps is reduced by sea urchin grazing to higher energy, shallow waters (Duggins 1980; Steneck et al. 2002). The consumption of herbivores by Sea Otters, when present, can lead to kelp recovery and the formation of large canopy and high biomass kelp forests form, which can be considered their more natural state (Estes and Palmisano 1974; Watson and Estes 2011). Sea Otter populations have not fully recovered from the maritime fur trade, but where they are abundant (e.g., Kyuquot Sound, Central Coast near Bella Bella), kelp forests are often larger, denser, and deeper (Watson and Estes 2011; Lee et al. 2016). The patchiness of kelp forests occupied by Sea Otters results in a patchy distribution of naturalness for canopy-forming kelp in the NSB; therefore, this criterion was scored as Variable.</p>				
Aggregation				X
<p>Rationale: The habitat provisioning service provided by kelp forests leads to higher diversity and higher density of some species and life stages, making it a significant aggregation feature relative to surrounding areas outside the canopy-forming kelp forests (Duggins 1988; Graham et al. 2007).</p>				

Summary

Kelp forests scored High for 3/8 criteria and Medium for 3/8 criteria, demonstrating this feature meets the EBSA criteria. Kelp scored High for Productivity, Biological Diversity, and Aggregation; Medium for Uniqueness, Special Importance to Life History Stages, and Importance to Threatened/Declining Species; Low for Vulnerability and Variable for Naturalness. A more thorough analysis of canopy-extent and biomass, linking ground-truthed remote sensing analysis currently being adapted to the BC coast (e.g., Nijland et al. 2019), with species distribution modelling will aid in identifying rocky reef features likely to support large, canopy-forming kelp forest EBSAs.

Eelgrass Meadows

Introduction

The native eelgrass, *Zostera marina*, is a perennial plant belonging to a group of plants known as seagrasses⁵ that form meadow habitats along the coast of BC. A non-native eelgrass species is also present in BC (*Zostera japonica*), and may form mixed-species meadows with the native species in the NSB. Nearshore areas that support eelgrass meadows (also referred to as eelgrass beds) have not been previously assessed against the EBSA criteria in the NSB. Eelgrass has been identified as an ESS in eastern Canada (DFO 2009), and as an ecological conservation priority for the NSB (DFO 2017), based on its role in providing an important biogenic habitat for numerous species. Eelgrasses are also very important primary producers, ranking among the most productive ecosystems in the world (DFO 2009), and are recognized as important ecosystem service providers (e.g., carbon sequestration, shoreline stability, erosion prevention, water clarity improvement, reduction in pathogens, and fish habitat provisioning) (Orth et al. 1984; Hughes 2002; DFO 2009; Vandermeulen 2009; Barbier et al. 2011; Plummer et al. 2012; Duarte et al. 2013; Lamb et al. 2017).

Distribution

Eelgrass is the dominant seagrass species in BC (BC MSRM 2002), where it forms extensive meadows in shallow subtidal and intertidal areas, especially in estuaries. Eelgrass meadows are most commonly found in wave protected areas, especially covering large areas of embayments, and the shallow estuarine heads of inlets (Pojar and MacKinnon 1994). They are also widely distributed as patchy, fringing beds throughout coastal areas in the NSB. One of the largest eelgrass meadows in the region is located on Flora Bank, in the Skeena River estuary. Flora Bank supports 50–60% of the total eelgrass found in Skeena estuary, and is considered a vital fish rearing area (Hoos 1975; Moore et al. 2015).

Feature description

Eelgrass meadows are highly influential in altering the surrounding marine environment and support several marine ecosystem services. The extensive rhizome network created by seagrasses binds the soft sediments in which they anchor helps to prevent erosion (Duarte 2002). Eelgrass plants also oxygenate both the water column and sediment through photosynthesis and active transport of oxygen into the sediment (Pregnall et al. 1984; DFO 2009). In addition, the high density and three-dimensional structure of the seagrass leaves create friction as currents and waves pass over them, baffling water motion and further reducing

⁵ The term “seagrass” is used to describe vascular plants that grow submerged or partially submerged in marine or estuarine waters, and that have the unique ability to complete sexual reproduction while immersed in a saline environment (Scagel 1971).

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erosion (Peterson et al. 2004). This slowing of water is also beneficial because it increases deposition of sediments and other particles (including larvae), increasing the clarity of the water passing through it (Hemminga et al. 1991; Green and Short 2003). This deposition of larvae due to reduced currents may contribute to the role of eelgrass meadows as nursery habitats. In addition to the provisioning services to fisheries through providing nursery habitats, and the shore stabilization services, eelgrass meadows are also very important in carbon storage and sequestration. On a per area basis, salt marshes and seagrasses can bury carbon in their sediments at levels that exceed storage rates in boreal and temperate forests (Fourqurean et al. 2012).

In BC, eelgrass meadows support a diverse biological community of fish and invertebrates. (e.g., Robinson et al. 2011). Studies have shown that eelgrass meadows support high densities of fishes and invertebrates (Hemminga and Duarte 2000; Murphy et al. 2000; Johnson and Thedinga 2005). Large continuous eelgrass meadows may be particularly important, such as the eelgrass meadow on Flora Bank, near the Port of Prince Rupert, BC. Moore et al. (2015) report that more than twice as many juvenile salmon were found in eelgrass surveys on Flora Bank than in other parts of the Skeena estuary. The Flora Bank eelgrass meadow is also used for spawning by Pacific Herring, rearing for juvenile Dungeness Crabs, and has higher abundances of juvenile Steelhead than other locations in the Skeena estuary (Moore et al. 2015). The three-dimensional structure of eelgrass provides food, shelter and habitat, likely contributing to the high diversity and abundance of fishes in eelgrass meadows (Orth et al. 1984; Jackson et al. 2001). Many species of fish and invertebrates with pelagic larval stages also rely on eelgrass meadows as habitat to bridge their early planktonic existence with later adult habitats (Beck et al. 2001; Smith and Sinerchia 2004).

Eelgrass was identified as a conservation priority for the NSB MPA network (DFO 2017) based on its important role as a habitat-forming species. Many of the species that use and depend on eelgrass meadows for critical stages in their life history have also been identified as ESSs and conservation priorities for NSB MPA network planning, including Pacific salmon species, Pacific Herring, Lingcod, and several species of rockfishes (see associated Research Document, Rubidge et al. 2020).

Assessment against EBSA criteria

Characteristics of eelgrass meadows were assessed against the EBSA criteria to evaluate whether they should be included as nearshore EBSAs (Table 3).

Table 3. Assessment of eelgrass meadows against the eight EBSA criteria (Boxes 1 and 2). Insuff. Info.: insufficient information.

EBSA Criteria	Ranking of criterion relevance			
	Insuff. Info.	Low	Medium	High
Uniqueness or rarity		X		
<p>Rationale: Seagrasses, including eelgrass, are unique among flowering plants because they are the only group of plants capable of completing sexual reproduction while submerged in a marine environment (Scagel 1971). However, because eelgrass meadows are ubiquitous in BC, and not unique to the NSB, they are scored as Low rather than High for this criterion.</p>				
Special importance for life-history stages of species				X
<p>Rationale: Eelgrass is highly important for many species, particularly juvenile fish as it provides nursery habitat for multiple species. Eelgrass plants support high densities of harpacticoid copepods that are the main prey item for outmigrating juvenile salmon (Simenstad et al. 1999); one study in Washington found that the primary prey item for Chum Salmon was largely produced in eelgrass habitat (Hass et al. 2002). Access to these prey items improves the fitness of salmon when they first enter the marine environment (Moore et al. 2015). Eelgrass also provides protection from predation, further improving marine survival for out-migrating salmon (Simenstad et al. 1999); juvenile Chinook Salmon in eelgrass meadows were shown to have increased survival compared to those in nearby unvegetated habitats (Semmens 2008).</p> <p>Studies have also shown that rockfishes rearing in eelgrass have a higher energetic content in their tissues than those rearing in the other vegetated habitats sampled (Byerly 2001; Olson 2017). These rockfishes also had higher measures of stomach fullness, which can result in increased fitness.</p> <p>Eelgrass is also required for the survival of eelgrass-dependent biota such as the Bay Pipefish (de Graaf 2006).</p>				
Importance for threatened, endangered or declining species and/or habitats				X
<p>Rationale: Eelgrass meadows were assessed as High for this criterion because of their importance to several species of conservation concern. For example, Bocaccio have been found in eelgrass meadows as juveniles (Murphy et al. 2000; Jeffery 2008; Robinson et al. 2011), and are currently listed as Endangered by COSEWIC. Juvenile salmon (Pink, Chum, Coho, Chinook and Sockeye) are found in eelgrass in high numbers in the period immediately following emigration from freshwater (Murphy et al. 2000; Moore et al. 2015). More than 160 stocks of these species in the Skeena River system are considered of conservation concern, or at risk of extinction (Morrell 2000; Connors et al. 2018).</p>				
Vulnerability, fragility, sensitivity, or slow recovery				X
<p>Rationale: Eelgrass plants are highly vulnerable to a wide variety of stressors including physical damage and environmental degradation (Short and Wyllie-Echeverria 1996). Entire eelgrass meadows have been lost in coastal areas due to environmental changes such as eutrophication, decreased light penetration or anoxia (Hauxwell et al. 2003; Plus et al. 2003). Extensive damage to meadows has also been documented from dredging and anchoring (Short and Wyllie-Echeverria 1996).</p> <p>Eelgrass meadows can also be slow to recover once damaged or lost (Neckles et al. 2005; Boese et al. 2009), and recovery can be nonexistent where large areas of plants have been completely removed</p>				

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EBSA Criteria	Ranking of criterion relevance			
	Insuff. Info.	Low	Medium	High
<p>(Orth et al. 2006; Duarte et al. 2009). This may be exacerbated by the fact that eelgrass meadows in the Pacific Northwest rely largely on vegetative growth for meadow expansion and maintenance, which is relatively slow and only occurs where eelgrass already exists (Phillips 1983). Restoration efforts for eelgrass meadows have been made in many parts of the world, but success rates are generally low (Eriander et al. 2016). Despite this, some restoration attempts in the Pacific Northwest have been successful where transplant conditions are highly suited to eelgrass growth (Gayaldo et al. 2001).</p>				
Biological productivity				X
<p>Rationale: Eelgrass is an important primary producer, and epiphyte productivity in eelgrass meadows can equal that of the eelgrass itself, thereby doubling the overall productivity of the area (Penhale 1977). Eelgrass meadows rank among the most productive ecosystems in the world (Hemminga and Duarte 2000; DFO 2009). Much of the primary productivity from eelgrass meadows is incorporated into detrital food chains that support higher trophic levels (McConnaughey and McRoy 1979). Eelgrass meadows are also considered nursery habitats for species such as Pacific salmon, thereby supporting the productivity of commercial fisheries (Lucas et al. 2007; Moore et al. 2015). For some tropical species, a reduction in the extent of seagrass vegetation is expected to have direct impacts on commercial fisheries (Hemminga and Duarte 2000), and the same may be true for eelgrass meadows in the NSB.</p>				
Biological diversity				X
<p>Rationale: Eelgrass meadows were scored High for this criterion because many studies have shown that eelgrass meadows support a high diversity of fish and invertebrates. For example, 45 fish species were identified from 44 beach seine hauls in eelgrass meadows in southeastern Alaska (Johnson and Thedinga 2005), and 52 fish species were identified from numerous beach seine hauls at 13 eelgrass locations in Gwaii Haanas, Haida Gwaii, BC (Robinson et al. 2011). Additionally, there are hundreds of locally adapted and genetically distinct salmon populations that use eelgrass meadows as juveniles in the region (Morrell 2000).</p>				
Naturalness	Variable			
<p>Rationale: There are many threats to the health of eelgrass meadows in the NSB, including shoreline development, eutrophication, overhead structures, and log storage (DFO 2005; Hall 2008; Thom et al. 2011). However, there are also many coastal areas in the region where these activities have not occurred, and where eelgrass meadows remain relatively pristine (e.g., much of Haida Gwaii, and the Great Bear Rainforest). Because of this, eelgrass meadows exist in varying states of naturalness throughout the region. A more thorough analysis of human impact across eelgrass meadows within the NSB is needed to highlight more pristine meadows.</p>				
Aggregation				X
<p>Rationale: Many studies have demonstrated that eelgrass meadows support high densities of invertebrates and juvenile and adult fishes (Hemminga and Duarte 2000; Murphy et al. 2000; Johnson and Thedinga 2005), which has led to the score of high for this criterion. More than a thousand juvenile Pink Salmon were captured in a single beach seine haul on Flora Bank in the Skeena River</p>				

EBSA Criteria	Ranking of criterion relevance			
	Insuff. Info.	Low	Medium	High
<p>estuary (Carr-Harris et al. 2015), and more than 20,000 Chum Salmon were captured in a single beach seine haul in an eelgrass bed in southeastern Alaska (Johnson and Thedinga 2005).</p> <p>The high density of many fishes in eelgrass meadows is likely due to the three-dimensional structure of the leaves that provide food, shelter and habitat (Orth et al. 1984; Jackson et al. 2001), and the entrainment of larvae from the plankton due to the slowing of water currents through eelgrass meadows (Jackson et al. 2001).</p>				

Summary

Eelgrass meadows were scored High for all criteria (6/8) except Uniqueness and Naturalness for which they scored Low and Variable, respectively. These scores are sufficient to support the designation of eelgrass meadows as EBSAs. Although all eelgrass meadows are ecologically and biologically significant, they vary in size, degree of human disturbance and/or threats, and the richness of biological communities they support. More research on characterizing BC eelgrass meadows by these attributes will increase our understanding of which eelgrass meadows EBSAs should be prioritized further. The eelgrass meadow highlighted in this assessment is the one on Flora Bank, which is already within the boundary of the Chatham Sound EBSA (Clarke and Jamieson 2006b), and within the Skeena River estuary (see next section). The Flora Bank eelgrass meadow is one of the largest in the NSB and makes up 50–60% of the eelgrass in the entire Skeena Estuary (Hoos 1975). This eelgrass meadow is a very important juvenile habitat for all five species of Pacific salmon (Higgins and Schouwenburg 1973; Carr-Harris et al. 2015; Moore et al. 2015), and is under pressure from human activity and several development proposals. Targeted surveys of other eelgrass meadows will aid in the identification of additional priority eelgrass EBSAs.

Estuaries

Introduction

River mouths and estuaries were previously assessed and designated as EBSAs by Clarke and Jamieson in 2006 under the aggregation and fitness consequences criteria (Clarke and Jamieson 2006a,b; DFO 2013); however, a map of estuaries was not provided in the previous process, and they only assessed using the DFO criteria. Here, we also assessed them under the additional CBD EBSA criteria.

Estuaries are typically defined as a “semi-enclosed body of water with a free connection to the open sea where the seawater is measurably diluted with fresh water derived from land drainages” (Pritchard 1967). Estuaries serve important ecological roles and provide many ecosystem services. In BC, they comprise less than 3% of the province’s coastline but these productive and diverse habitats are seasonally or annually important for multiple taxa including fish, birds, mammals and invertebrates (Ryder et al. 2007).

Feature description

Estuaries are highly productive habitats at the confluence of fresh and saltwater ecosystems. Productivity in estuaries is driven by high nutrient levels delivered via rivers, oceanic sources, and internal detrital sources (Naiman and Sibert 1979). These nutrients fuel both benthic and pelagic primary production (Moore et al. 2015), which supports high densities of fishes and invertebrates, especially juveniles, contributing to the role of estuaries as a nursery habitat. High

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turbidity in estuaries and the abundance of vegetation (salt marsh plants, eelgrass, macroalgae) protect juveniles of species such as Pacific salmon from predators, enhancing the nursery role of estuaries for these species (Macdonald et al. 1988; Semmens 2008).

Clarke and Jamieson (2006b) assessed the biological significance of estuaries and determined that the geographically-restricted nature of estuaries created aggregations of anadromous species (notably salmon and Eulachon) by funnelling these species into a confined space prior to their migration upriver. For instance, at least 448 genetically distinct salmon spawning stocks have been documented in the Skeena River estuary (Morrell 2000). In addition to salmon, the Skeena River, its estuary, and adjacent waters are important for Steelhead, trout, whitefish, Rock Sole, Pacific Cod, Pacific Halibut, Surf Smelt, and Pacific Herring (Hoos 1975).

Clarke and Jamieson (2006b) also noted that estuaries had fitness consequences for salmon smolts. This is supported by studies that have found increased marine survival for juvenile salmon after experiencing higher growth rates resulting from superior feeding opportunities in estuaries (Moulton 1997; Mortensen et al. 2000). The improved fitness afforded by the Skeena River estuary is of paramount importance because many of the salmon stocks rearing there are either “at risk of extinction” or “of some concern” (Morrell 2000).

A variety of habitats comprise estuaries, including salt marshes, eelgrass meadows and mud flats. These habitats provide many ecosystems services including water filtration, nutrient enrichment and recycling, detritus processing, and energy provisioning to support near-shore food-webs (Ryder et al. 2007). Many of these habitats are also important for waterbirds, some of which are of conservation concern, including BC blue-listed Brant, Long-tailed Duck, Tundra Swan, Yellow-billed Loon, Black Scoter, Surf Scoter, Horned Grebe, and Eared Grebe, and BC red-listed Western Grebe (Ryder et al. 2007; BCCDC 2017).

Many of the species that use estuaries for feeding, rearing and migration have been identified as conservation priorities for the MPA network planning process in the NSB (Rubidge et al. 2020).

Assessment against EBSA criteria

Characteristics of estuaries were assessed against the EBSA criteria to evaluate whether they should be included as nearshore EBSAs (Table 4).

Table 4. Assessment of estuaries against the eight EBSA criteria (Boxes 1 and 2). Insuffic. Info.: insufficient information.

EBSA Criteria	Ranking of criterion relevance			
	Insuffic. Info.	Low	Medium	High
Uniqueness or rarity			X	
<p>Rationale: Estuaries are unique among marine habitats because they comprise a transition zone between terrestrial, fresh and marine systems, unlike other coastal features that are strictly marine. However, because estuaries are not globally rare, nor are they rare in the NSB, they are scored as Medium rather than High for this criterion. Individual estuaries in the region may be considered highly unique because they host Eulachon, a species that is found in very few estuaries along the coast of BC, during adult spawning migrations and juvenile outmigration (Lucas et al. 2007).</p>				
Special importance for life-history stages of species				X
<p>Rationale: Estuaries are scored High for this criterion because they are essential to the survival of all anadromous species, which must pass through estuaries as both spawning adults and out-migrating juveniles (Clarke and Jamieson 2006b, previous EBSA process).</p> <p>Estuaries are especially important to the fitness of salmon. Studies have shown that estuaries are valuable stopover locations on the outmigration routes of juvenile Pacific salmonids (Moore et al. 2015) that provide optimal prey resources, protection from predation, and suitable environmental conditions for the physiological transition to a marine environment (Simenstad et al. 1982). Estuaries have been considered critical habitat for Chinook Salmon by some (Moore et al. 2016). The high growth rates afforded by the feeding opportunities in estuaries have been linked to increased marine survival (Moulton 1997; Mortensen et al. 2000). Additionally, the relative magnitude of this increase is proportional to the state (i.e., pristine versus degraded) of the estuary for Chinook Salmon (Magnusson and Hillborn 2003). Enhanced feeding and growth has even been documented in species that pass quickly through estuaries as they migrate seaward (e.g., Pink and Sockeye Salmon) (Weitkamp 2014).</p> <p>Estuaries also support higher growth for juvenile Dungeness Crabs compared to non-estuary habitats due to higher temperatures and greater food supplies (Gunderson et al. 1990). Finally, estuaries support large populations of waterbirds that aggregate for many reasons, including feeding, resting and breeding (Baldwin and Lovvorn 1994; Ganter 2000; Ryder et al. 2007). Other species also use estuaries for certain aspects of their life history (Rubidge et al. 2020).</p>				
Importance for threatened, endangered or declining species and/or habitats			X	
<p>Rationale: Estuaries were assessed as Medium for this criterion because of the importance of certain estuaries to several species of conservation concern. For example, 30 genetically distinct stocks of Chinook Salmon in the Skeena River were identified as either “at risk of extinction” or “of some concern” by Morrell (2000), and it is likely that there are other stocks of conservation concern throughout the NSB that have not yet been assessed. Chinook Salmon rely on estuarine habitats for maximal growth during their first weeks or months in the marine environment (Groot and Margolis 1991; Moore et al. 2015), and estuaries have been considered Chinook critical habitat by some (Moore et al. 2015). It has been found that the state of an estuary (i.e., pristine versus degraded) used by juvenile Chinook Salmon impacts the rate of marine survival (Magnusson and Hillborn 2003).</p> <p>Chum and Pink Salmon in the Skeena River are also of conservation concern (Morrell 2000), and are known to form large schools during early sea life (Groot and Margolis 1991). Juveniles have been found in abundance in the Skeena River estuary (Carr-Harris et al. 2015). It is generally accepted that rapid growth during the early marine stage spent in estuaries reduces the vulnerability of salmonids to</p>				

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EBSA Criteria	Ranking of criterion relevance			
	Insuffic. Info.	Low	Medium	High
<p>predation (Moulton 1997), thus estuarine habitats are likely important for the survival and recovery of these species.</p> <p>Several species of red and blue listed waterbird species are also reported to use estuarine habitats (Ryder et al. 2007; BCCDC 2017). Finally, endangered and special concern populations of Eulachon (endangered- Central coast population; Special Concern- Nass/Skeena populations) pass through certain estuaries as adults and juveniles.</p>				
Vulnerability, fragility, sensitivity, or slow recovery			X	
<p>Rationale: Many studies have documented degradation in estuaries caused by multiple stressors (Borja et al. 2010). For example, it has been shown that diversity and ecological connectivity are reduced in estuaries subjected to cumulative stressors (de Juan et al. 2013), as is species abundance (Ryder et al. 2007). The habitat value of estuarine habitats can also be reduced by anthropogenic disturbances (Hass et al. 2002).</p> <p>Additionally, two dominant habitats that occur in estuaries, salt marshes and eelgrass, are both considered to be highly susceptible to degradation and have slow recovery rates (Hauxwell et al. 2003; Plus et al. 2003; Neckles et al. 2005; Boese et al. 2009; Borja et al. 2010).</p> <p>However, estuaries are inherently dynamic features, highly influenced by changing ocean and riverine conditions (Elliott and Whitfield 2011). Natural physical disturbance within estuaries may contribute to their ecosystem-level resilience to stressors (Boesch 1974; Geden et al. 2011), which lead to their score of Medium rather than High for this criterion.</p>				
Biological productivity				X
<p>Rationale: Estuaries are widely considered to be highly productive (Nixon et al. 1986; Ryder et al. 2007; Elliott and Whitfield 2011). Productivity in estuaries is made possible by high levels of nutrients delivered via rivers, oceanic sources, as well as internally derived nutrients from detrital decomposition (Naiman and Sibert 1979) that fuel both benthic and pelagic primary production (Moore et al. 2015). The microbes and phytoplankton that are produced within estuaries are consumed by zooplankton and benthic invertebrates that, in turn, support an abundance of higher trophic level species and contribute to very high levels of secondary production in estuaries (Moore et al. 2015).</p>				
Biological diversity				X
<p>Rationale: Estuaries comprise a high diversity of habitats, including eelgrass meadows, mud flats, wetlands, tidal marshes (Emmett et al. 2000), containing a diverse array of plant and animal species (Emmett et al. 2000; BC MOE 2006). In BC, it is estimated that, despite their relatively small overall area, estuaries are used by multiple coastal species from all major taxonomic groups at some point in their life history (Lucas et al. 2007), including a large number of marine bird species (Ryder et al. 2007).</p> <p>The Skeena River estuary, for example, is used extensively by six species of salmonids, from populations originating in the Skeena River, its drainages, and surrounding areas, thus integrating diversity from a large area of the north coast of BC (Carr-Harris et al. 2015). At least 448 genetically distinct salmon spawning stocks have been documented in the estuary (Morrell 2000). These factors combine for the overall score of High for this criterion.</p>				

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EBSA Criteria	Ranking of criterion relevance			
	Insuffic. Info.	Low	Medium	High
Naturalness	Variable			
<p>Rationale: Estuaries face many threats, including eutrophication, resource extraction, freshwater diversion, shoreline development, aquatic invasive species, and chemical contamination (Kennish 2002; Ryder et al. 2007). However, there are also many coastal areas in the region where these activities have not occurred, and where estuaries remain relatively pristine; over 40% of mapped estuaries in BC were minimally affected by known threats, and a large proportion of these were in the NSB (Robb 2014). Because of this, estuaries exist in varying states of naturalness throughout the region and thus are scored collectively as Variable for this criterion.</p>				
Aggregation				X
<p>Rationale: All estuaries act as bottlenecks that aggregate anadromous species (e.g., salmon, Eulachon) during adult and juvenile migrations between fresh and marine waters, which is one of the reasons they were previously identified as EBSAs (Clarke and Jamieson 2006b). It is well documented that juvenile Chum and Pink Salmon form large schools during early sea life (Groot and Margolis 1991), and large schools of these species have been observed in the Skeena River estuary (Carr-Harris et al. 2015). High abundances of juvenile Steelhead, Pacific Herring, Surf Smelt and juvenile Dungeness Crabs have also been documented in the Flora Bank region of the Skeena River estuary (Moore et al. 2015). For these reasons, estuaries are scored as High for this criterion.</p>				

Summary

Estuaries were designated as EBSAs in 2012 (DFO 2013). To update and support this designation, a formal assessment against the DFO and CBD criteria is presented here in the standardized template developed by Ban et al. (2016). Estuaries score High on 4/8 criteria and Medium on 3/8 criteria. Estuaries were scored High for Aggregation, Biological Diversity, Special Importance for Life History stage and Productivity, and Medium on Vulnerability, Uniqueness, and Importance for threatened species. The Naturalness criterion was scored as Variable since this assessment was on estuaries as a coastwide feature, rather than on a specific estuary. Our assessment supports the previous designation of estuaries as EBSAs (Clarke and Jamieson 2006b). In addition to the updated assessment, a spatial dataset is provided to represent estuaries in the NSB, which was missing in the previous process. Finally, although individual estuaries were not assessed, given the size and the PECP rankings, the Skeena, the Nass, and the Kitimat estuaries stood out as priority EBSAs in this assessment due to their size, and importance for birds (Ryder et al. 2007) and anadromous fish such as Eulachon and Pacific Salmon. Smaller estuaries of potential sub-regional importance were not highlighted here, but all estuaries meet the EBSA criteria.

Surfgrass Meadows

Introduction

Surfgrasses are species of seagrass⁵ that belong to the phylum *Phyllospadix* (Phillips 1979). Three species within this genus are found in the NSB that differ in phenology, morphology, and zonation within rocky intertidal benthic habitat: *P. torreyi*, *P. scouleri*, and *P. serrulatus* (Phillips 1979; Gabrielson et al. 2000). The three species can dominate the intertidal zone, form extensive meadows with >80% cover, and pre-empt space from other organisms such as algae (Turner and Lucas 1985; Menge et al. 2005). Nearshore areas that support surfgrass meadows have not been previously assessed as EBSAs for the NSB.

Phyllospadix plants are long-lived, and the meadows they form have been shown to be very persistent (Turner 1985). However, *Phyllospadix* beds are also slow to recover from physical disturbance (Turner and Lucas 1985; Menge et al. 2005). Like other seagrasses, surfgrasses are highly productive with high leaf turnover rates (Ramirez-Garcia et al. 1998); abundant surfgrass leaves in the form of wrack provide nutrient subsidies for a variety of other ecosystems from the high intertidal to submarine canyons (Green and Short 2003).

Distribution

Surfgrasses can be found in intertidal and shallow subtidal regions (Druehl and Clarkston 2016). Surfgrass species are ecologically distinct from other seagrasses because they grow on rocky shores, and in high energy environments (Cooper and McRoy 1988). The intertidal distribution of the three species of surfgrasses are somewhat partitioned across depths, with *P. serrulatus* found in the mid-intertidal, *P. scouleri* in the low intertidal, and *P. torreyi* found at low intertidal to high subtidal depths (Phillips 1979).

Feature description

Phyllospadix sp. was identified as an ESS and a conservation priority for the NSB MPA network (DFO 2017) based on its important role as a habitat-forming species. Surfgrass meadows often cover extensive areas, with two or more species coexisting across a gradient of depths (Phillips 1979). They are considered dominant, late successional species that are facilitated by early and mid-successional plants (Turner 1983; Menge et al. 2005). Surfgrass species play important ecological roles in wave-exposed, intertidal habitats. Firstly, surfgrasses have a strong ability to buffer wave energy due to the length and density of their leaves (Phillips 1979), providing sheltered microhabitats within their canopies and root systems (Moulton and Hacker 2011). The root and rhizome systems of surfgrasses also play a role in stabilizing rocky shores and protecting them against erosion (Gibbs 1902). Sediments accumulate under the dense surfgrass canopy, and are bound within the thick rhizome mats, forming sediment layers up to one meter in depth that creates habitat for infaunal invertebrates (Gibbs 1902; Phillips 1979). It is thought that this trapping of sediment can help create terraces on surf swept shorelines (Gibbs 1902). Lastly, surfgrasses are highly productive plants (Ramirez-Garcia et al. 1998), producing over 8000 g dry weight/m²/yr in areas with continuous surfgrass coverage, and annual leaf production rates of 17.8 and 22.6 leaves per shoot for *P. torreyi* and *P. scouleri*, respectively. (Ramirez-Garcia et al. 1998). Much of this productivity is transported out of surfgrass meadows and provides nutrient subsidies to a variety of other ecosystems (Dugan et al. 2011).

Phyllospadix spp. have been considered habitat-forming, foundation species that improve environmental conditions for other species (Shelton 2010). Surfgrasses in the intertidal are important for moderating temperatures within tidepools, and the removal of surfgrass can generate significant shifts in plant and invertebrate community composition (Shelton 2010).

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Surfgrasses also provide habitat and protect macroinvertebrate communities; the leaves and rhizomes of surfgrasses provide protective habitat for macroinvertebrates in high wave energy environments, while the sediment trapped by the roots and rhizomes provides habitat for infaunal organisms that could not otherwise exist on a rocky beach (Moulton and Hacker 2011). Moulton and Hacker (2011) found that while both species were considered important habitat creators, *P. scouleri* provided better habitat for epifaunal species, while *P. serrulatus* accreted more sand and provided better habitat for infaunal species. Finally, *P. scouleri* is unique in its ability to survive in intertidal areas with constantly moving sand, and it is possible that these plants create refuge for other species in this otherwise hostile environment (Littler et al. 1983).

Assessment against EBSA criteria

Characteristics of surfgrass meadows were assessed against the EBSA criteria to evaluate whether they should be considered nearshore EBSAs (Table 5).

Table 5. Assessment of surfgrass against the eight EBSA criteria (Boxes 1 and 2). Insuffic. Info.: insufficient information.

EBSA Criteria	Ranking of criterion relevance			
	Insuffic. Info.	Low	Medium	High
Uniqueness or rarity		X		
Rationale: All seagrasses, including surfgrasses (and eelgrass), are unique among flowering plants because they are the only group of plants capable of completing sexual reproduction while submerged in a marine environment (Scagel 1971). However, because surfgrass meadows are ubiquitous in BC, and not unique to the NSB, they are scored as Low for this criterion.				
Special importance for life-history stages of species			X	
Rationale: <i>Phyllospadix</i> spp. are considered habitat-forming, foundation species, as they are able to modify the surrounding habitat to facilitate the presence of other species. Many species are able to survive on surf-swept shores only because of the presence of surfgrasses. For instance, <i>P. scouleri</i> survives in intertidal areas with constantly moving sand where the plants help to bind the substrate and provide habitat for other species in an otherwise hostile environment (Littler et al. 1983). Surfgrasses baffle wave energy (Phillips 1979) and provide sheltered microhabitats on highly wave exposed shorelines for a variety of intertidal species (Moulton and Hacker 2011). Lastly, surfgrasses trap sediment in their roots and rhizomes, providing habitat for infaunal organisms that could not otherwise exist on a rocky shore (Moulton and Hacker 2011). Surfgrasses are largely understudied, however, due to difficulties accessing intertidal meadows in wave-exposed environments. For this reason, their importance for many species is unknown, resulting in a score of Medium for this criterion.				
Importance for threatened, endangered or declining species and/or habitats	X			
Rationale: No endangered or declining species within the NSB are known to depend on surfgrasses for their survival or recovery. However, surfgrass habitat is largely understudied; thus, surfgrass meadows are scored as having insufficient information for this criterion.				

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EBSA Criteria	Ranking of criterion relevance			
	Insuffic. Info.	Low	Medium	High
Vulnerability, fragility, sensitivity, or slow recovery			X	
<p>Rationale: Surfgrasses are late-successional species whose recruitment is facilitated by primary successional algae species (Turner and Lucas 1985). Surfgrass species have high persistence and meadows are considered to be resistant to some types of disturbance (e.g., storm waves and other forms of mechanical disturbance) (Turner 1985). However, once disturbed, it has been shown that surfgrass species are very slow to recover. Removal experiments showed that rhizomes of <i>P. scouleri</i>, <i>P. torreyi</i> and <i>P. serrulatus</i> grew <8 cm/yr, and seedlings were very slow to establish (Turner and Lucas 1985). Surfgrasses are susceptible to threats such as desiccation and heat stress, sewage and oiling, coastal development, shoreline protection programs, and eutrophication (Foster et al. 1971; Littler and Murray 1975; Ramirez-Garcia et al. 1998; Craig et al. 2008; Honig et al. 2017). Surfgrass meadows would score Low for this criterion because of their stability and resistance to disturbance, but are given a score of Medium because of evidence of slow recovery and vulnerability to some threats.</p>				
Biological productivity				X
<p>Rationale: Surfgrasses are highly productive plants (Ramirez-Garcia et al. 1998) that grow at very high densities (Phillips 1979). As a result of these two factors, meadows with continuous surfgrass coverage can produce over 8000 g dry weight/m²/yr, and annual leaf production rates are estimated at 17.8 and 22.6 leaves per shoot for <i>P. torreyi</i> and <i>P. scouleri</i>, respectively. (Ramirez-Garcia et al. 1998). Much of this productivity is transported out of surfgrass meadows to provide nutrient subsidies to a variety of other ecosystems (Dugan et al. 2011). As with other marine plants, surfgrass has a role in carbon sequestration and transfer (i.e., “Blue Carbon”), highlighting its role as an ecosystem service provider.</p>				
Biological diversity	X			
<p>Rationale: Surfgrass meadows are often cited as being important for a variety of species, and it is well documented that they provide habitat for a variety of invertebrates (Moulton and Hacker 2011). However, no references to specific species, or comparisons with other rocky intertidal habitats could be found in the literature. Surfgrass meadows are thus scored as having insufficient information for this criterion.</p>				
Naturalness	Variable			
<p>Rationale: There are many threats to the health of surfgrass meadows in the NSB, including shoreline armouring (Craig et al. 2008) and sewage (Littler and Murray 1975). However, there are also many coastal areas in the region where these threats are not present, and where surfgrass meadows remain relatively pristine (e.g., much of Haida Gwaii and the Great Bear Rainforest). Because of this, surfgrass meadows exist in varying states of naturalness throughout the region and have been scored as Variable for this criterion.</p>				
Aggregation	X			
<p>Rationale: Surfgrass meadows are extensive and are comprised of dense aggregations of <i>Phyllospadix</i> spp. plants. However, no studies could be found examining whether surfgrass meadows support aggregations of other species. Therefore, there is not enough information to confidently score this criterion at this time.</p>				

Summary

Surfgrass meadows ranked High for Productivity, Medium for Vulnerability and Special Importance, and Low for Uniqueness. There was not enough information to score the other criteria, thus they were scored as Insufficient Information. DFO guidance suggests EBSA designation based on a High score for Uniqueness, Fitness Consequences or Aggregation (DFO 2004) or Medium to High scores on most criteria. There is no specific guidance from DFO on whether a High score on one CBD criteria is sufficient for EBSA designation. Given the limited information on ESSs, other than Pacific Herring, that regularly use surfgrass meadow habitat, there is not enough information to support an EBSA designation for surfgrass meadows at this time. Research is needed to fill these gaps.

High tidal current passages

Introduction

Oceanographic features such as currents, upwelling zones, and eddies are important drivers of ocean productivity and biological diversity (Crawford et al. 2007). Earlier in the EBSA process, the overlap between expert-identified, recurring regional oceanographic features and species' important areas was used to delineate EBSAs (Clarke and Jamieson 2006b); however, such oceanographic features were not assessed for the nearshore. In nearshore areas, high tidal current passages can create both areas of high mixing (e.g., in tidal rapids) and areas of local upwelling, where strong tides regularly bring deeper water to the surface. Such features can play a key role in shaping local productivity (Thomson 1981) and thus species abundance and diversity patterns observed in coastal areas. This section highlights the importance of high tidal current in relation to diversity and productivity patterns in nearshore areas and provides an initial assessment for EBSA designation. Four locations are highlighted where biological information exists that can be used to characterize the ecological and biological importance of such areas.

Distribution

Given the topographic and bathymetric complexity of the NSB coastline, many areas of high tidal current likely occur throughout the nearshore region. High tidal current passages are defined here as areas where tidal flow is constrained by steep bathymetry increasing current. Although not currently comprehensively mapped, a general assessment of these features is provided against the EBSA criteria to evaluate their potential inclusion as nearshore EBSAs.

We identified and mapped four areas of high tidal current with associated biological information highlighting their ecological value relative to the surrounding area. These areas are: Nakwakto Rapids, Hoeya Head Sill in Knight Inlet, Stubbs Island, and Mathieson Narrows.

Feature Description

Nakwakto Rapids

Nakwakto Rapids are located approximately 325 km northwest of Vancouver in the Seymour-Belize Inlet complex (Figure 2). Five interconnected basins within the Seymour-Belize Inlet complex (Belize Inlet, Seymour Inlet, Mereworth Sound, Alison Sound and Frederick Sound) are linked to Queen Charlotte Sound through a single, 300 m wide, 13 m deep passage known as Nakwakto Rapids (Thomson 1981). The rapids are situated at the eastern end of Slingsby Channel, and during extreme spring tides, currents surge at 8 m/s (16 knots) (Thomson 1981). Nakwakto Rapids has one of the fastest navigable tidal currents in the world (Spear and Thomson 2012) making this area globally unique. Nakwakto Rapids is well known within the recreational dive community for its biological diversity. Pacific Marine Life Survey Inc.

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(unpublished data⁶) has recorded over 240 species on dives within the rapids, including 42 species of algae, 16 species of sponges, 52 species of molluscs, and 17 species of fishes. The area is rated as one of the world’s finest cold water dive sites, despite its hazards. Some of the species known to be abundant in the area include: Gooseneck Barnacles, parchment tube worms, rock scallops, demosponges, Plumose Anemones, Giant Pacific Octopus, and multiple species of rockfishes and other fishes (Howell 2012).

A unique subtidal variety of the Gooseneck Barnacle, *Pollicipes polymerus*, forms large aggregations at Nakwakto Rapids (Lamb and Hanby 2005). The “Nakwakto variety” of *P. polymerus*, is bright red as the hemoglobin in the barnacles’ blood is visible. Subtidal populations do not need the black pigment found in the sun-exposed intertidal populations (Lamb and Hanby 2005). The red “Nakwakto variety” of *P. polymerus* has been recently reported in other subtidal areas including a sea cave on Calvert Island⁷ on the central coast and Race Rocks⁸ near Victoria. Because of its slow recovery rate after perturbations and its ecological role as a habitat-forming species, *P. polymerus* was identified as an ESS and conservation priority for the MPA network planning process in the NSB (DFO 2017).

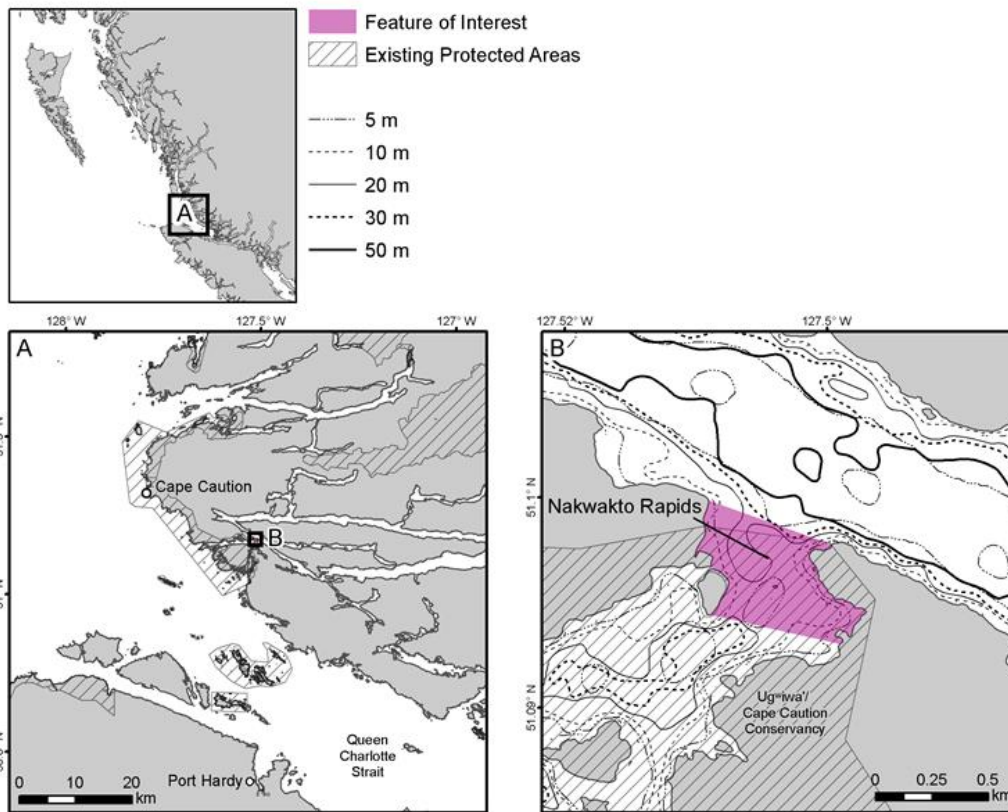


Figure 2. Nakwakto Rapids, an area of high tidal current where evidence suggests high diversity and productivity in the area. Pink areas highlight feature of interest for EBSA assessment. Final boundaries will require additional research.

⁶ A. Lamb and D. Gibbs, Pacific Marine Life Survey Inc., Vancouver, BC, 2017.

⁷ [Biodiversity of the Central Coast – Goose neck barnacle](#)

⁸ [Race Rocks Taxonomy – Goose neck barnacle](#)

Hoeya Head Sill in Knight Inlet

Knight Inlet is a fjord 300 km north of Vancouver, BC stretching 102 km into the mainland from the Queen Charlotte Strait (Figure 3). The inlet is 2–3 km wide with vertical sidewalls (Farmer and Smith 1980). Its average depth is 295 m, with a maximum depth of 540 m (Pickard 1961). There are two sills in the inlet, with the innermost sill off Hoeya Head rising up to a depth of 70 m (Thomson 1981). Hoeya Head Sill has been extensively studied because it generates internal gravity waves (e.g., Farmer and Smith 1980; Thomson 1981; Klymak and Gregg 2003; Chen et al. 2017). In this area, internal waves (waves within the water column rather than at the surface) occur during tidal cycles due to density differences between the fresh surface water and deeper salt water (Thomson 1981). Due to this tidal mixing, there is high biological productivity and diversity in the area surrounding the sill.

A recent review of biological information revealed high biodiversity at the site. Over 240 different species have been recorded on or around the sill, including several ESSs (Boutillier and Davies 2017⁹). For example, the Hoeya Head Sill contains at least 46 different species of corals, sponges and anemones. Of particular interest is the high density of Red Tree Coral, *Primnoa* sp., found here at shallower depths than elsewhere on the coast due to the unique oceanography of the area (Boutillier and Davies 2017⁹). Tall corals such as *Primnoa* sp. 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). Corals including *Primnoa* sp. increase rockfish abundance at Learmonth Bank, Dixon Entrance (Du Preez and Tunnicliffe 2011). Corals and sponges have been identified as ESSs and conservation priorities for the MPA network in NSB (DFO 2017) due to the biogenic habitat they provide. The known aggregations of these vulnerable groups at the Hoeya Head Sill highlight the ecological and biological significance of this area.

The Hoeya Head Sill has been identified by the province of BC and First Nations as an important ecological area in need of enhanced protection in their Marine Plan Partnership Initiative ([MaPP](#)). MaPP has zoned the area as a Protected Marine Zone (PMZ) as part of their marine spatial plan (Marine Planning Partnership Initiative 2015a). This zoning was due to the sill's ecological importance as a representative habitat of shallow-sill ecosystem comprised of coral fans and sponges, and the unique occurrence of deepwater and/or rare species at shallower depths (e.g., gorgonian corals, Soft Goblet Sponge, Cloud Sponge, Townsend Eualid Shrimp and Bigmouth Sculpin). This zoning limits human activities to commercial and public recreation and tourism activities within the Hoeya Head Sill PMZ. Research activities are “conditionally acceptable” as long as they do not impact the sensitive habitat in the area (Marine Planning Partnership Initiative 2015a).

⁹ Boutillier, J. and Davies, S. 2017. Evaluation of Hoeya Head Sill in Knight Inlet, Internal Report to DFO Fisheries Management.

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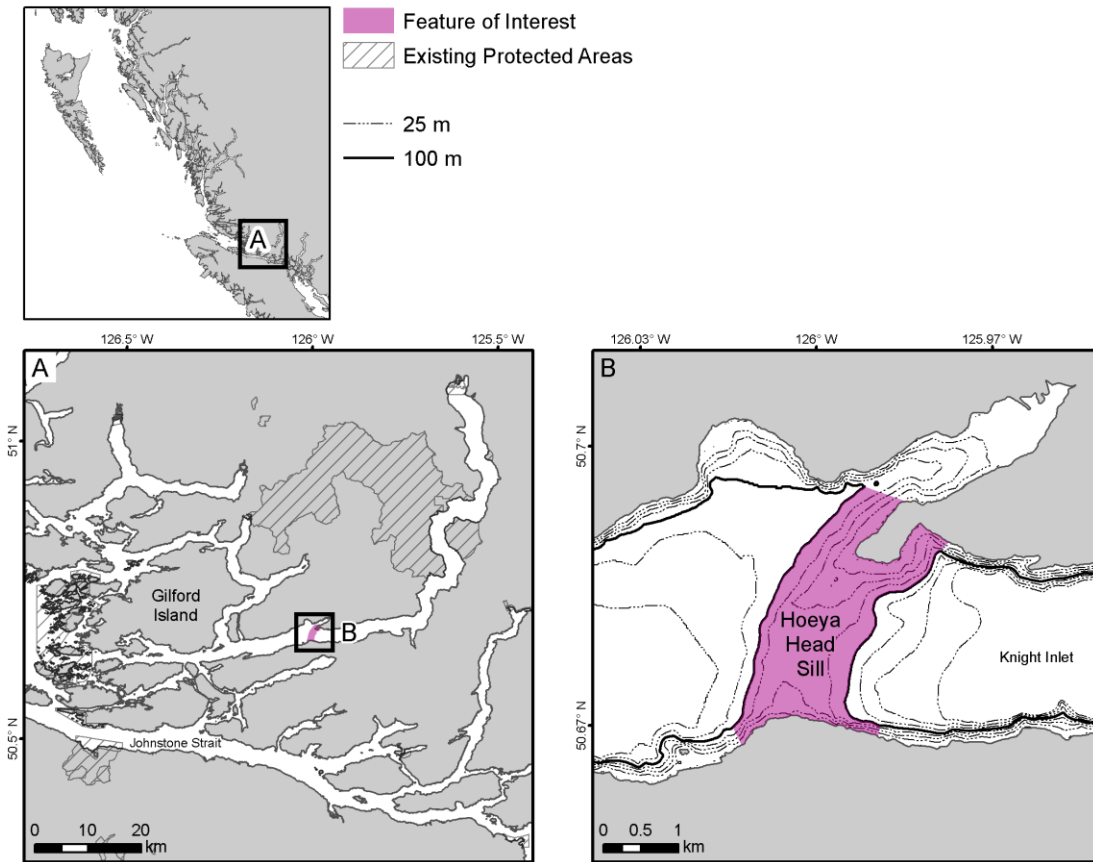


Figure 3. Hoeya Head Sill in Knight Inlet, an area of high tidal current where evidence suggests high diversity and productivity in the area. Pink areas highlight proposed EBSA area of interest. Final boundaries will require additional research.

Stubbs Island

Stubbs Island is situated in the Cormorant Channel Provincial Marine Park within the Pearse and Plumber group of islands at the western end of Johnstone Strait (Figure 4).

The tidal channel near the island is a popular dive site with fringing kelp forests, thousands of Plumose Anemones on the steep slopes, and many soft corals, rockfish species (Dusky, China, Tiger, Quillback) and nudibranchs. Stubbs Island is located in the middle of the tidal flow and the terraced bathymetry surrounding the island forms a series of narrow ledges before a steep drop off to about 70 m (Figure 4). Recreational divers frequent the site for its high diversity of fishes and conspicuous and colourful invertebrates (e.g., soft corals and nudibranchs). Pacific Marine Life Surveys (unpublished data⁶) has recorded 343 marine species in the area, including 54 algae, 26 sponges, 47 cnidarians, 74 molluscs, 33 arthropods, 23 cnidarians, and 28 fishes (including 11 rockfish species). The area of high biological diversity surrounding Stubbs Island is within the boundaries of critical habitat for the northern resident population of Killer Whales (DFO 2011b). The area of high tidal current is also within the boundaries of a larger area selected for a PMZ by MaPP in the North Vancouver Island Marine plan based on its importance to several species and habitats, including Pacific Herring, Humpback Whales and resident Killer Whales. Within the North Vancouver Island Marine Plan several activities and uses were considered inappropriate for this PMZ due to the risk to the ecology of the area,

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including finfish aquaculture, forestry operations, mining operations, wharves and facilities, float homes and lodges, and point source utilities (Marine Planning Partnership Initiative 2015a).

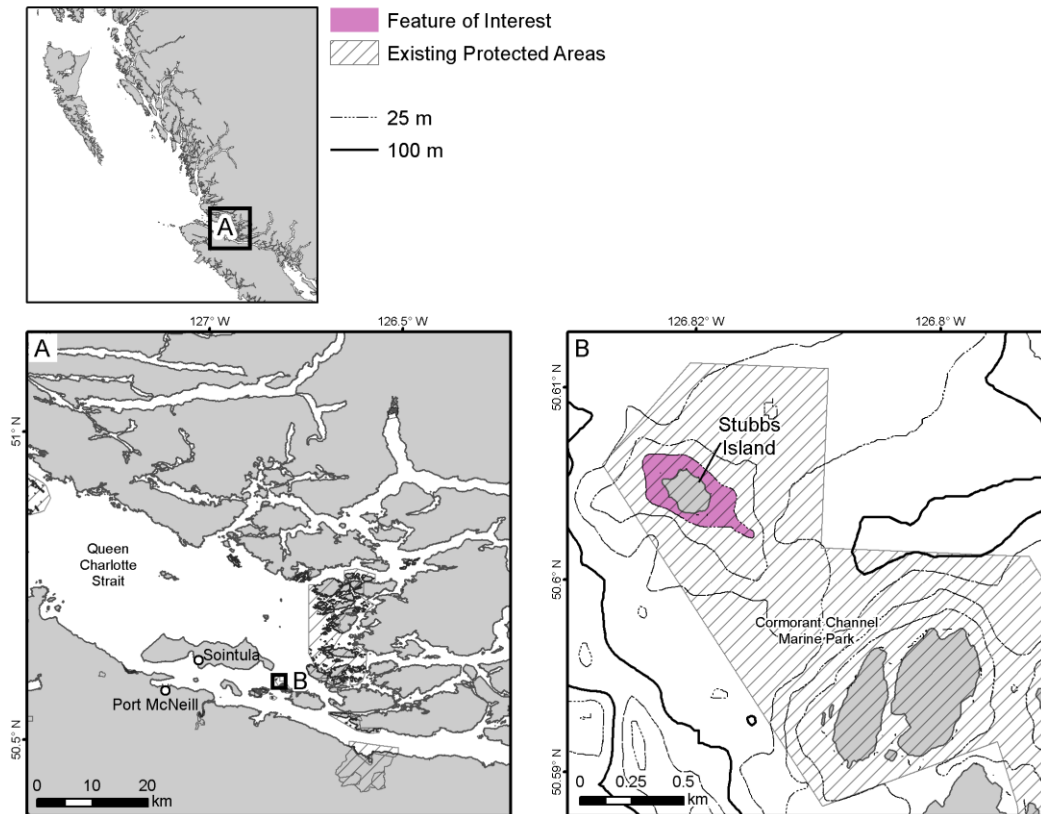


Figure 4. Stubbs Island, an area of high tidal current where evidence suggests high diversity and productivity in the area. Pink areas highlight proposed EBSA area of interest. Final boundaries will require additional research.

Mathieson Narrows

Biological surveys on the Central Coast of BC suggest that the high tidal current passage in the narrows between Pooley Island and the mainland, listed as Mathieson Narrows on marine charts (Figure 5), is important for biodiversity (Frid et al. 2016, 2018, and unpublished data^{10,11}). Beginning in 2006–2007 and annually since 2013, the Heiltsuk, Kitasoo/Xai'xais, Nuxalk and Wuikinuxv First Nations have been collecting data on the population characteristics and habitats of rockfishes and other demersal fishes of the central coast (Frid et al. 2016, 2018). The systematic surveys include hook and line sampling and visual transects using a towed video camera or SCUBA. To date, the surveys have documented a diversity of biological features in Mathieson Narrows, including high abundances of Yelloweye and Quillback Rockfish, large crinoid aggregations, Cloud Sponges, and a Steller Sea Lion haulout

¹⁰ Central Coast Indigenous Resource Alliance, Campbell River, BC, 2019.

¹¹ Frid et al. (2016, 2018) outline data collection and methods and provide a regional assessment of rockfish occurrence and diversity throughout the Central Coast. However, due to concerns from partner First Nations about the sensitivity of spatial data, these papers do not present maps or details specific to Mathieson Narrows. As of 2018, spatial data from these surveys, summarized at the scale of 4-km² planning units (including unit 13213, which encompasses Mathieson Narrows), are viewable on SeaSketch, an online mapping service used to support MPA network planning in the NSB.

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(Frid et al., unpublished data^{10,11}). Other species in the area include Lingcod, Kelp Greenling, and Copper, Dusky, Yellowtail, Black, and China Rockfish (Frid et al. 2016, 2018). Among the species recorded to date, Lingcod, Cloud Sponges, and Steller Sea Lions, as well as Copper, Quillback, and China Rockfish, have been identified as ESSs and conservation priorities for the MPA network in NSB (DFO 2017).

Notably, Mathieson Narrows has been identified by First Nations and the Province of BC as an important ecological area in need of enhanced protection (Marine Planning Partnership Initiative 2015b). Specifically, in the MaPP spatial plan it is part of PMZ 22—a proposed “high protection zone”—due to its high productivity, rich biodiversity and strong cultural significance to First Nations (Marine Planning Partnership Initiative 2015b). Mathieson Narrows is also adjacent to the Pooley Island Conservancy and within Fiordland Conservancy boundaries. Given the preliminary nature of the rich biological dataset in this area, it is recommended that Mathieson Narrows be highlighted as an area of interest for EBSA designation.

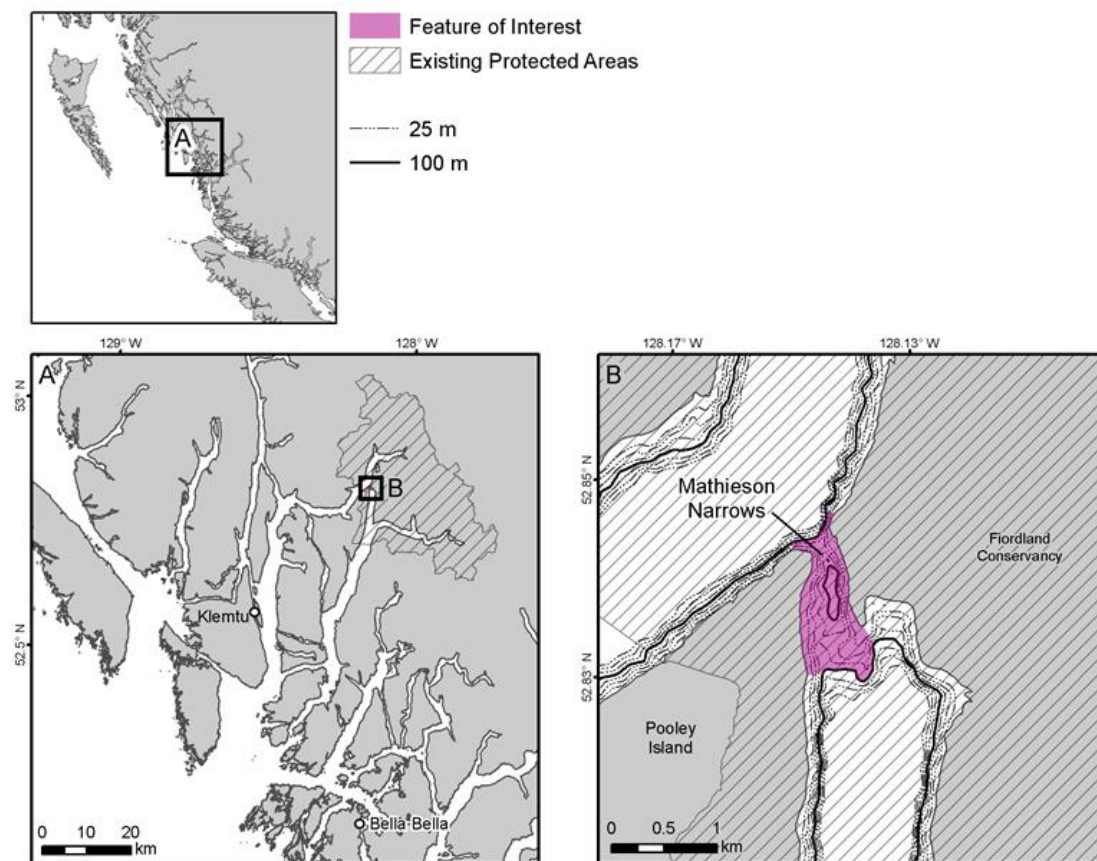


Figure 5. Mathieson Narrows, an area of high tidal current where evidence suggests high diversity and productivity in the area. Pink areas highlight proposed EBSA area of interest. Final boundaries will require additional research.

Assessment against EBSA criteria

Characteristics of high tidal current passages were assessed against the EBSA criteria (Table 6).

Table 6. Assessment of areas with high tidal current passages against the eight EBSA criteria (Boxes 1 and 2). Insuffic. Info.: insufficient information.

EBSA Criteria	Ranking of criterion relevance			
	Insuffic. Info.	Low	Medium	High
Uniqueness or rarity			X	
<p>Rationale: There is evidence to suggest that particular areas of high current meet the Uniqueness criteria. For example, the Hoeya Head Sill in Knight Inlet generates an internal wave. Although internal waves occur throughout the ocean, on the BC coast, they are particularly pronounced in silled inlets and protected basins when they are covered by a thin layer of brackish water. These pronounced internal wave areas occur on Hoeya Head Sill in Knight Inlet and an area in Southern Strait of Georgia (Thomson 1981). Likely due to unique geomorphological structure of the sill and the oceanography of the area, several deepwater species are found at Hoeya Head Sill at shallower depths than normally reported (McDaniel and Swanston 2013; Boutillier and Davies 2017⁹).</p> <p>Nakwakto Rapids have the highest tidal current recorded in the world, making the area globally unique (Thomson 1981). Large aggregations of the “Nakwakto variety” of the Gooseneck Barnacle found at Nakwakto rapids (Lamb and Hanby 2005) also contributes to the uniqueness of this area, despite this variety recently being discovered in other areas.</p> <p>Because our assessment is limited given the lack of information on uniqueness across all the areas with high tidal current, the criterion was scored as Medium, even though Hoeya Head Sill and Nakwakto Rapids would individually score High for this criterion.</p>				
Special importance for life-history stages of species	X			
<p>Rationale: The information to confidently assess this criteria is limited.</p>				
Importance for threatened, endangered or declining species and/or habitats	X			
<p>Rationale: The information to confidently assess this criteria is limited.</p>				
Vulnerability, fragility, sensitivity, or slow recovery			Variable	
<p>Rationale: Not all areas of high tidal current have been surveyed for the presence of sensitive habitats or fragile species. However, high numbers of coral and sponge species, including shallowest known population of <i>Primnoa pacifica</i>, been recorded at Hoeya Head Sill in Knight Inlet (Tunncliffe and Syviski 1983; McDaniel and Swanston 2013; Boutillier and Davies 2017⁹). Although Hoeya Head Sill would score High on this criteria, in general given the uncertainty in regards to unsampled areas, we have scored this as Variable until more information is gathered.</p>				

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EBSA Criteria	Ranking of criterion relevance			
	Insuffic. Info.	Low	Medium	High
Biological productivity				X
<p>Rationale: Large tides on the BC coast generate strong tidal currents (Thomson 1981). These currents 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 (Crawford et al. 2007). Biological surveys in areas associated with tidal passes and high current highlight the rich and diverse communities that thrive in these areas due to their high productivity. This includes the large aggregations of Gooseneck Barnacles at Nakwakto Rapids (Lamb and Hanby 2005), the high densities of large <i>Primnoa pacifica</i> fans at Hoeya Head Sill (Tunncliffe and Syvitski 1983; McDaniel and Swanston 2013; Boutillier and Davies 2017⁹), the crinoid aggregations and high rockfish densities at Mathieson Narrows (Frid et al., 2016, 2018, and unpublished data^{10,11}) and the thousands of Plumose Anemones on the slopes around Stubbs Island. Secondary producers are highly abundant at these sites due to the high primary production at these high current sites.</p>				
Biological diversity				X
<p>Rationale: Areas of high current and local upwelling are highly productive, as described above. This increased productivity supports rich biological communities. Although systematic surveys have not been conducted across the coast, evidence from the four areas assessed support a high score for these areas in terms of biodiversity. Two-hundred and forty species have been reported at Hoeya Head Sill (Boutillier and Davies 2017⁹), and preliminary results of surveys at Mathieson Narrows highlight the area as ecologically important (Frid et al. 2016, 2018, and unpublished data^{10,11}). Around Stubbs island, 343 marine species have been recorded, including 54 algae, 26 different sponges, 47 cnidarians, 74 molluscs, 33 arthropods, 23 cnidarians, and 28 fishes (including 11 rockfish species) (Pacific Marine Life Surveys, unpublished data⁶). Both the area around Stubbs Island and Nakwakto Rapids are popular recreation dive sites due to their colourful and conspicuous diversity of life. Biological surveys will need to be conducted or assessed to confirm this score in areas of high tidal current not assessed here.</p>				
Naturalness	Variable			
<p>Rationale: Many areas of high current are heavily fished because of their productivity. The level of human impact is highly variable. Naturalness could be used as a criterion to prioritize areas for EBSA identification when a more comprehensive map of these areas is compiled. An evaluation of the effects of fishing on the sensitive habitats at Hoeya Head Sill is currently being completed (Boutillier and Davies 2017⁹), as negative impacts on <i>Primnoa</i> sp., have been reported (McDaniel and Swanston 2013). This analysis will be helpful in informing management about the impacts of human activities to the area's ecological community.</p>				
Aggregation			X	
<p>Rationale: Several species aggregate in high tidal current areas. This includes large aggregations of Gooseneck Barnacles at Nakwakto Rapids (Lamb and Hanby 2005), high densities of large <i>Primnoa</i> sp. at Hoeya Head Sill (Tunncliffe and Syvitski 1983; McDaniel and Swanston 2013; Boutillier and Davies 2017⁹), crinoid aggregations and high rockfish densities at Mathieson Narrows (Frid et al. 2016, 2018, and unpublished data^{10,11}), and thousands of Plumose Anemones on the slopes around Stubbs Island (Pacific Marine Life Surveys, unpublished data⁶). These aggregation areas are most likely</p>				

EBSA Criteria	Ranking of criterion relevance			
	Insuffic. Info.	Low	Medium	High
related to the productivity in the area, rather than to a life history function or a seasonal aggregation. For this reason, and because this review is limited to areas where biological surveys or information has been collected, this criterion has been scored as Medium.				

Summary

Areas of high tidal current were assessed against the EBSA criteria by considering select areas that have associated biological information. This was not a comprehensive assessment of all areas of high tidal current passages in BC but rather a starting point to recognize that local tidal currents, topography and bathymetric complexity can play an important role in the creation of nearshore features that enhance biodiversity.

Four specific high tidal current areas were scored as High for Productivity, and Biodiversity; and Medium for Aggregation and Vulnerability. This assessment can be used as the foundation for identifying other high tidal current passages that may qualify for targeted biological surveys leading to EBSA designation. At this time, there is enough evidence to support the designation of Hoeya Head Sill, Nakwakto Rapids and Stubbs Island as nearshore EBSAs, although the boundaries need to be finalized. Mathieson Narrows is an area of interest for EBSA designation, and further analyses are needed to inform this designation.

Conclusions

Upon assessment of the eight combined DFO and CBD EBSA criteria, there is scientific support to designate canopy-forming kelp forests, eelgrass meadows, and estuaries as nearshore EBSAs. There was not enough evidence to designate surfgrass meadows as nearshore EBSAs at this time given the limited targeted biological surveys on this feature. Similarly, there is not enough spatial or paired biological information to designate all high tidal current passages in the NSB as nearshore EBSAs. However, three specific high tidal current areas with associated biological information do have strong support for EBSA designation. These are: Hoeya Head Sill, Nakwakto Rapids, and the waters around Stubbs Island. There is building evidence to support Mathieson Narrows as an EBSA, but analyses are ongoing. It is therefore recommended that Mathieson Narrows be identified as an area of interest for future EBSA assessment. This was an initial effort to identify nearshore EBSAs in the NSB, and other nearshore features such as clam beds, rocky reefs, other high tidal current passages should be assessed against the criteria in the future.

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Table 12. Summary table of nearshore features' score against eight EBSA criteria. DFO science advice (DFO 2004) states that features or areas that rank "High" for one or more of uniqueness, fitness consequences, or aggregation, can be designated as an EBSA. A feature or area that ranks above average (Medium or High) across multiple criteria also meets the EBSA criteria (DFO 2004). ✓: the feature meets the criteria and can be considered an EBSA. ✗: the feature does not meet the criteria, or there is not enough information to complete the EBSA assessment, and at this time is not considered to be an EBSA.

Feature	Uniqueness	Life history	Threatened	Vulnerability	Productivity	Biodiversity	Naturalness	Aggregation	EBSA criteria met?
Canopy Forming Kelp	Medium	Medium	Medium	Low	High	High	Variable	High	✓
Eelgrass	Medium	High	High	High	High	High	Variable	High	✓
Surfgrass	Low	Medium	Insuff. info.	Medium	High	Insuff. info.	Variable	Insuff. Info.	✗
Estuaries	Medium	High	Medium	Medium	High	High	Variable	High	✓
High tidal current	Medium	Insuff. info.	Insuff. info.	Variable	High	High	Variable	Medium	✓*

* These are: Hoeya Head Sill, Nakwakto Rapids, and the waters around Stubbs Island. Other areas of high tidal current, including Mathieson Narrows, require further research and assessment to confirm as EBSAs.

Next Steps

This assessment of nearshore features in BC represents the first step in the nearshore EBSA process by identifying features and areas that meet the EBSA criteria. The next step is to highlight or prioritize these features, based on additional criteria such as extent (or size), local diversity, naturalness/threats, and/or proximity to other nearshore EBSA features (see DFO 2018). These additional criteria require more information about the spatial extent, and biological community of the features, and more extensive analyses (e.g., multiple EBSA overlay, site optimization software or hotspot analyses) to adequately rank areas, or identify areas that support multiple nearshore ecologically important features.

As a starting point for estuaries, we recommend the use of the available rankings for Estuary EBSAs, recognizing the limitations. Estuaries have been ranked by the Pacific Estuary Conservation Program (PECP); based on their size and use by seabirds (Ryder et al. 2007), the Skeena, the Nass, and the Kitimat estuaries stand out as priority estuaries in the NSB. However, further analyses are needed to address spatial gaps and to formally rank estuary importance by taxa in addition to birds. A recent unpublished analysis has ranked estuaries based on their importance to salmon diversity and salmon biomass (C. Robb and E. Rubidge, unpublished data¹²) that also highlighted the importance of the Skeena, the Nass and Kitimat estuaries. However, the regional importance of smaller estuaries on the coast should not be overlooked.

There is currently no system in place for ranking canopy-forming kelp forests and eelgrass meadows into categories based on their ecological importance. Further research on the size (e.g., canopy or meadow extent), productivity (e.g., biomass, stipe or shoot density), diversity (e.g., species richness), and naturalness (e.g., threats, state of degradation, ecosystem intactness) across the NSB will be useful for identifying priority kelp forests or eelgrass meadows. Alternative methods such as habitat diversity hotspots or feature overlay analyses could be used to identify areas where multiple EBSAs occur. Some of these methods were developed and highlighted in the reassessment of the existing NSB EBSAs in a Regional Peer Review Process in October 2017 (DFO 2018; Rubidge et al. 2018).

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¹² Fisheries and Oceans Canada, Victoria, BC, 2019.

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