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EVALUATION OF EXISTING FRAMEWORKS AND RECOMMENDATIONS FOR IDENTIFYING SIGNIFICANT BENTHIC AREAS IN THE PACIFIC REGION

1 Context

Benthic ecosystems are diverse, providing habitat and supporting food webs for a wide range of species. They are an important source of biodiversity and a vital part of Canada's ocean environments. In addition to their biological role, they are important from a social, cultural and economic perspective (e.g. supporting fisheries, recreation opportunities) in the lives of many Canadians.

Under the United Nations General Assembly (UNGA[1]) Resolution 61/105 (Food and Agriculture Organization of the United Nations [UNFAO], 2009), Canada is committed to protecting sensitive marine habitats. In response, Fisheries and Oceans Canada (DFO) developed the Policy for Managing the Impacts of Fishing on Sensitive Benthic Area (SeBA) (Government of Canada [GOC] 2009) to directly manage fisheries within Sensitive Benthic Areas. The SeBA policy is designed to mitigate the impacts of fishing on benthic ecosystems (or avoid impacts likely to cause serious and/or irreversible harm). This policy is housed within the DFO Sustainable Fisheries Framework (SFF) as one of its conservation and sustainable use policies. SeBAs can also be considered an 'Other Effective Area-Based Conservation Measure' (OEABCM); a term used to encompass area-based conservation measures other than marine protected areas that meet certain criteria (DFO 2017a).

The first step towards establishing SeBAs is to identify Significant Benthic Areas (SiBAs). A SiBA is defined as an ecologically and biologically significant habitat type, feature, community or species considered intrinsically sensitive to fishing impacts and slow to recover (e.g. coral and sponge dominated habitats). These aspects of vulnerability (sensitivity and ability to recover) can be assessed through consideration of life history characteristics, recovery times, and other relevant factors (e.g. Food and Agriculture Organization of the United Nations (FAO) Guidelines to Vulnerable Marine Ecosystems (VME)). The second step in establishing SeBAs involves assessing exposure of SiBAs to fishing. The SiBAs, or portions thereof, that are likely to be exposed to proposed or ongoing fishing activities, are then considered SeBAs.

It is important to note that there has been confusion in past literature regarding the use of the terms Significant Benthic Areas and Sensitive Benthic Areas. To clearly differentiate these terms we have refrained from using the acronym SBA, and have chosen unique acronyms for each term; in this paper Significant Benthic Areas will be referred to as SiBAs, and Sensitive Benthic Areas as SeBAs.

DFO Fisheries Management (FM) requested advice from the DFO Science Branch to evaluate existing DFO frameworks that may be useful for identifying Significant Benthic Areas (SiBAs) in the Pacific region, and to summarize the best available data that can be used to identify those areas in the Strait of Georgia (SoG) and Southern Shelf Bioregion (SSB)(Figure 1).

[1] A list of abbreviations used throughout this Science Response appear in at the end of this document (Acronyms section).

The assessment and advice arising from this Canadian Science Advisory Secretariat (CSAS) Science Response Process (SRP) will be used to inform decisions regarding fisheries management and to lay the foundation for future work to identify SiBAs. The establishment of fisheries closures to minimize/avoid impacts on SeBAs is also expected to contribute to Canada's Marine Conservation Target[2] to protect 10% of Canada's coast by 2020.

Here we evaluate and outline the best approach for determining which benthic habitat types, features, communities and species qualify as SiBAs (step 1 above). Specifically, this Science Response (SR) will:

1. Evaluate existing frameworks that may be useful for identifying ecologically and biologically Significant Benthic Areas (SiBAs). Provide rationale and supporting evidence as to which one(s) would be most appropriate for identifying future SiBAs.
2. Based on the outputs of the framework, present potential SiBAs identified in the SoG and SSB.
3. Using the best available information, present existing species and habitat data in the SoG and SSB, for use in the identification of SiBAs.
4. Assess data gaps, uncertainties and/or assumptions used to inform the current findings and recommendations; identify future science work, where applicable.

This Science Response results from the Science Response Process of July 11, 2018 on the Evaluation of Existing Frameworks to identify Significant Benthic Areas in the Strait of Georgia and Southern Shelf Bioregions.

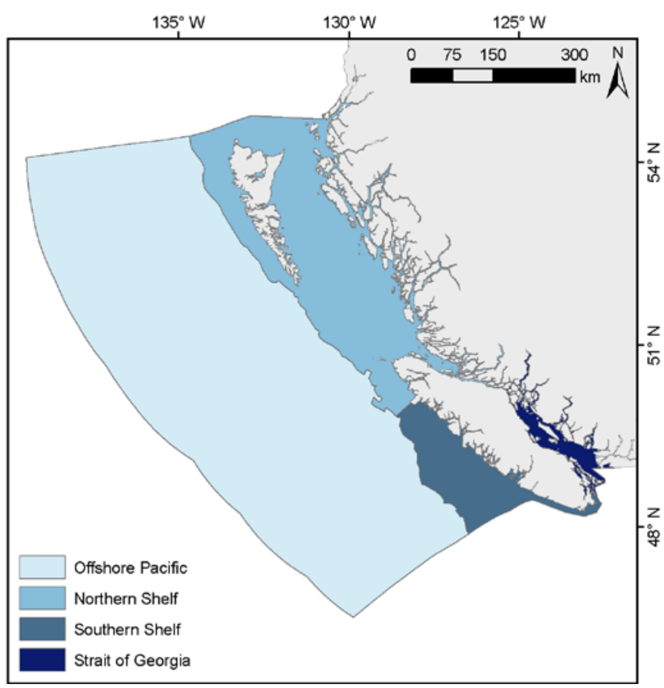

Figure 1. Bioregions in the Pacific region of Canada.

[2] Canada's Marine Conservation Target is an initiative of the federal government to conserve 10% of coastal and marine areas by the year 2020 in order to meet Aichi Target 11, outlined at a 2010 CBD meeting. These areas are to be conserved by way of "well connected systems of protected areas and Other Effective Area-Based Conservation Measures (OEABCMs)".

2 Analysis and Response

2.1 Considerations for determination of significant areas

To identify Significant Benthic Areas, it is first necessary to determine which benthic habitat types, features, communities and species are important from an ecological or biological perspective. This is an important step in implementing the SeBA Policy. To date, SeBA policy implementation has been solely on coral and sponge dominated communities, largely due to the fact that SiBAs were specifically defined as "significant areas of cold-water corals and sponge dominated communities" in DFO (2013). These attributes have been the focus of SeBA policy applications to date because they were selected for priority consideration by management. Because of this focus, the first step in determining important benthic attributes, considering all possible habitats, taxa or features, has not yet been undertaken. It was recognized in DFO (2013) that further work would need to be done to identify other SiBAs, and that efforts to expand upon the advice should be well documented, transparent, and peer-reviewed. Here, we aim to apply a more inclusive definition of important benthic attributes, and expand the focus to include other benthic habitats, features, communities and species.

To this end, we review various DFO frameworks used to prioritize areas for other applications (with a focus on those used in the Pacific region), from which we hope to draw inference for the identification of important benthic attributes in the context of implementing the SeBA policy in the Pacific region. The frameworks that were reviewed include those used to identify:

- Vulnerable Marine Ecosystems (VMEs);
- Ecologically and Biologically Important Areas (EBSAs);
- Ecologically Sensitive Species and Community Properties (ESSs/ESCPs); and
- Significant Ecosystem Components (SECs).

These frameworks are discussed in detail in Section 2.3.

As stated in the context, SiBAs are defined as areas comprised of benthic habitats, features, communities or species that have been identified as ecologically or biologically important (DFO 2013). SiBAs must also be sensitive to fishing, and slow to recover from fishing impacts (Figure 2). To identify SeBAs, fishing effort is then overlain onto these SiBAs to identify areas at risk of exposure to fishing. In this way, all facets of vulnerability are accounted for in the identification of SeBAs, where vulnerability is considered to be a function of sensitivity, recovery potential, and exposure to a stressor. These components of vulnerability are defined as follows: sensitivity considers the magnitude of the impact of fishing; recovery potential considers the resilience or ability to recover following exposure to fishing; and exposure is considered the likelihood of exposure to a fishing activity.

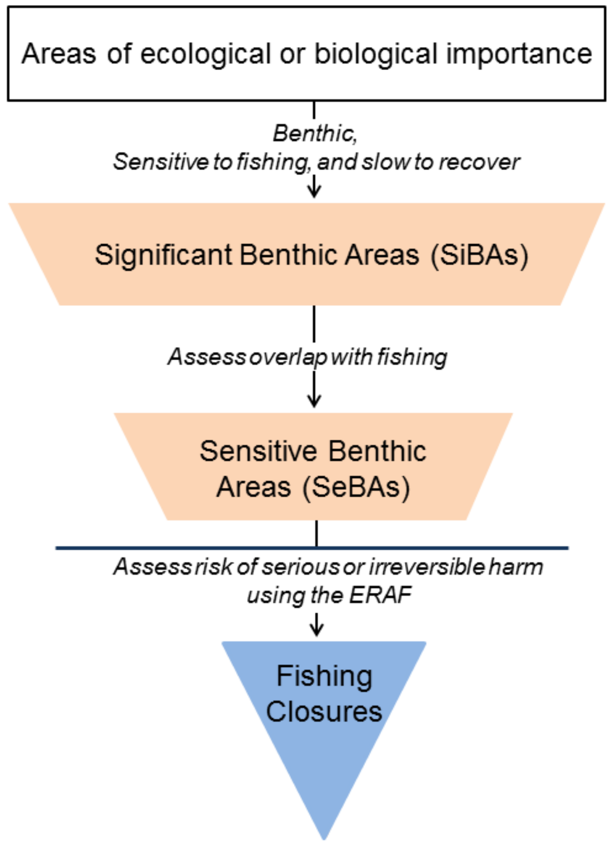

Figure 2. Flowchart outlining the process used to identify SiBAs and SeBAs. Important areas identified by applicable frameworks are screened through a 'benthic' filter to identify those that contain benthic features, and then through a filter to determine whether they are sensitive and slow to recover from fishing impacts. The resulting areas are considered SiBAs. Overlap with fishing is then determined, resulting in SeBAs. Finally, the coral and sponge ERAF (DFO 2013) is applied to SeBAs to determine the risk of serious or irreversible harm by fishing. DFO Science is responsible for all parts of the process in orange (above the horizontal line), while Fisheries Management is responsible for the process in blue.

2.2 Sensitive Benthic Area policy application in Canada

The SeBA policy was developed in 2009 and work towards its implementation can be traced through a series of publications beginning in 2010 and continuing until the present (Table 1).

In 2010, as a first step towards identifying SeBAs, a national science advisory process was held to determine the occurrence, sensitivity to fishing, and ecological function of corals, sponges and hydrothermal vents in Canadian waters (DFO 2010). It was determined that corals and sponges are important because they form complex, three-dimensional habitats that support other invertebrate and fish species, and that they are 'sensitive and susceptible' to damage from fishing activity. The focus for implementing the SeBA policy to date has been on these two habitats, which is in keeping with a parallel process in international waters to reduce damage to sensitive ecosystems from fishing activities (VMEs: Section 2.3.1; DFO 2014). In DFO (2010), known and predicted locations of corals and sponges were determined for the Pacific, Eastern Artic and Atlantic regions, showing that they are present throughout all regions. This publication described what may be considered a nationally consistent approach for defining boundaries for

SiBAs. It reviewed three methodologies (cumulative distribution, areas of aggregation, and species distribution models), that can be used to outline where SiBAs occur. This 2010 peer review process also outlined ecological criteria to identify SiBAs including uniqueness, rarity and species density, richness and diversity. Examples of unique or rare benthic attributes identified in the Pacific region included the Endeavour hydrothermal vent fields, glass sponge reefs, and black corals. It was anticipated that the approach outlined in DFO (2010) would be used to define SiBAs; however, it was recognized that modifications would likely be required for species other than corals and sponges.

In 2013, a national Ecological Risk Assessment Framework (ERAF) for corals and sponges was developed under the SeBA policy (DFO 2013) as a decision making process for identifying:

1. the level of ecological risk associated with fishing activity; and
2. the impacts of fishing activity on Sensitive Benthic Areas (SeBAs).

The advice outlined in the ERAF provides guidance on conducting a risk assessment specifically for corals and sponges; namely to determine the risk of exposure to fishing and, based on the level of assessed risk, to provide management options to avoid Serious or Irreversible Harm (SIH) to SeBAs. While this ERAF was developed for significant cold-water coral and sponge dominated communities, it could be modified for applications to other benthic communities or species.

Building on advice provided in the 2013 coral and sponge ERAF, a document was produced by FM in 2014 (DFO 2014) to provide clarity for several aspects of the SeBA policy (e.g. whether to use an area-based or fishery-based approach when implementing the SeBA policy). Although written specifically for cold-water corals and sponges, it included some advice on how to apply the SeBA policy to other benthic features, namely to gain from the experience of Northwest Atlantic Fisheries Organization (NAFO) in protecting other types of sensitive benthic areas as VMEs.

In 2014, the first application of the SeBA policy was published for the Bay of Fundy (DFO 2015). In this paper, benthic components of two EBSAs were assessed to determine if they met the VME criteria in order to support their consideration under the SeBA policy. Parts of both EBSAs were found to meet many VME criteria, thus warranting consideration for fisheries protection under the SeBA policy.

In 2017 another application of the policy was completed for Canada's Atlantic and Eastern Arctic marine waters to identify the following (DFO 2017b):

1. Areas that contain sponges, gorgonians and/or sea pens as a "dominant and defining feature"); and
2. Where these areas overlap with known fishing activity.

In the 2017 analysis, coral and sponge features were modelled using kernel density estimation (KDE) based on research vessel trawl survey data to identify hot spots, from which polygons of high biomass were created. Results from the KDE analyses were used jointly with species distribution models (SDMs) to delineate potential SiBAs (Kenchington et al. 2016; DFO 2017b). Fishing activity data was then overlaid onto these areas to assess the likelihood of exposure (DFO 2017b; Koen-Alonso et al. 2018). Thirty-five general candidate SeBAs locations were identified in these regions based on this analysis (Koen-Alonso et al. 2018).

Further guidance was required in the Newfoundland region to determine the level of protection required for coral and sponge SeBAs, in order to meet conservation goals laid out in the policy.

To this end, DFO Science was asked to provide advice on the level of protection required to "mitigate impacts of fishing on SeBAs, or to avoid impacts of fishing that are likely to cause serious or irreversible harm to SeBAs". This advice for coral, sponge and sea pen SeBAs in Newfoundland and Labrador waters was provided in the form of a Science Response document (DFO 2017c), and included guidelines such as protecting 100% of SeBAs if possible; prioritizing areas with confirmed (ground-truthed) presence of SeBA features; and ensuring that environmental gradients are contained within SeBAs. It was also advised that proposed boundaries must be open to refinement as new research and information emerges.

The work outlined above for cold-water corals and sponges in the Atlantic and Artic regions is the most comprehensive example of an application of the SeBA policy in Canada. Some SeBAs that meet specific criteria have been delineated as Marine Refuges under the SeBA policy, to help meet Aichi Conservation Targets. In the Pacific Region, the SeBA policy has been applied at a smaller scale to protect glass sponge reefs. Full implementation of the SeBA policy remains a work in progress.

Table 1. History of publications related to the application of the SeBA policy to coral and sponge-dominated waters in Canada. Publications from 2009 to 2015 listed below are national in scope (with the exception of DFO 2015); publications from 2017 onwards are from the Atlantic region.

Year	Publication	Title
2009	Policy (GOC 2009)	Sensitive Benthic Area policy under the SFF
2010	SAR 2010/041 (DFO 2010)	Occurrence, sensitivity to fishing, and ecological function of corals, sponges and hydrothermal vents in Canadian waters
2013	Management Tool (DFO 2013)	Ecological Risk Assessment Framework (ERAF) for cold-water coral and sponge dominated communities
2014	Guidance Document (DFO 2014)	Guidance for implementation of the policy for managing the impacts of fishing on Sensitive Benthic Areas
2014	SR 2014/044 (DFO 2015)	Information on potential sensitive benthic areas in the Bay of Fundy: Head Harbour/West Isles/Passages and the Modiolus Reefs, Nova Scotia shore
2017	SAR 2017/007[3] (DFO 2017b)	Delineation of significant areas of cold-water corals and sponge-dominated communities in Canada's Atlantic and Eastern Arctic marine waters, and their overlap with fishing activity
2017	SR 2017/030 (DFO 2017c)	Guidance on the level of protection for significant areas of cold water corals and sponge-dominated communities in Newfoundland and Labrador waters

[3] This Science Advisory Report accompanies two DFO Research Documents: Kenchington et al. (2016) and Koen-Alonso et al. (2018).

2.3 Overview of existing processes used to define features as ‘important/significant’

According to the SeBA policy, several approaches already exist that can be used to identify significant areas, including “scientific inference from other jurisdictions, available data sets and expert opinion”. Across Canada, ‘important’ or ‘significant’ habitats, features, communities and species have been identified by several other frameworks for the purpose of protecting habitats and species. There are many similarities between these frameworks and the resulting lists of ‘important’ species and habitats that they produce. For instance, the identification of VMEs is considered an analogous process to SiBAs (DFO 2010); therefore, the VME framework is well aligned with the SeBA policy and perhaps the most informative of all the frameworks reviewed here. Additionally, it was suggested in the SeBA policy that the EBSA identification framework may be used to identify SiBAs, as its objectives are closely aligned with the SeBA policy.

The frameworks used to identify VMEs, EBSAs, ESS/ESCPs, and SECs are described in the sections below and summarized in Table 2.This table contains background information and a brief description of each framework, a summary of the intent of the framework, as well as a summary of how the frameworks have been applied to date.

Table 2.Frameworks currently used within DFO science and elsewhere in the scientific community for the identification of ecologically and biologically important habitats, features, communities and species.

Classification	Origin	Purpose	Overview	Applications	References
Vulnerable Marine Ecosystems (VMEs)	Concept came from meetings of the United Nations General Assembly dedicated to building guidelines for the management of fisheries in areas beyond national jurisdiction (outside the EEZ).	Used in fisheries management to identify important and sensitive areas for protection from fishing impacts.	Five criteria for the identification of VMEs were agreed upon internationally. VMEs include species, communities and habitats that are unique/rare, fragile, have functional significance, structural complexity, or are slow to recover from disturbance.	VMEs have been identified by many nations; however, the approach taken has differed between regions. More recently, a 10-step process has been proposed to standardize the identification and protection of VME.	UNFAO 2009; Auster et al. 2010; NAFO 2011
Ecologically and Biologically Significant Areas (EBSAs)	Developed nationally during a DFO workshop in 2004 and internationally by the Convention on Biological Diversity (CBD) in 2010 to facilitate Integrated Management.	A tool for identifying areas with high Ecological or Biological Significance relative to the surrounding area to facilitate provision of a greater-than usual degree of risk aversion in management of activities in the area in accordance with Canada's Ocean Act.	A set of national guidelines (criteria) for evaluating species/ features /habitats by scoring against criteria such as uniqueness and aggregation to identify their ecological and biological significance.	EBSAs have been identified globally and throughout BC (Canada's Offshore Pacific Bioregion, NSB, SSB SoG), and at a finer scale in nearshore habitats in the NSB.	DFO 2004; Clarke & Jamieson 2006a; Clarke & Jamieson 2006b; DFO 2012; Jamieson & Levesque 2014; Ban et al. 2016; DFO 2017[4]; DFO 2018b
Ecologically Significant Species (ESSs)	Developed nationally during a DFO workshop in 2006 to facilitate the creation of Integrated Management Plans for LOMAs.	ESSs are identified to support the creation of Conservation Objectives within Integrated Management Plans for LOMAs.	A set of criteria for identifying species and community properties that are particularly significant for maintaining ecosystem structure and function.	Eelgrass has been evaluated as an ESS in the Atlantic region, and all species in the Bay of Quinte were assessed as ESSs. Criteria for ESS have been adapted	DFO 2006; DFO 2009; Glass et al. 2014; Gale et al. 2018

[4] DFO. 2017. Assessment of nearshore features in the Northern Shelf Bioregion against criteria for determining Ecologically and Biologically Significant Areas. DFO Canadian Science Advisory Secretariat Science Response. *In prep.*

Classification	Origin	Purpose	Overview	Applications	References
				for other ecological frameworks in BC.	
Valued Ecosystem Components (VECs) / Significant Ecosystem Components (SECs)	The term VEC was coined in the 1980s following a series of 10 technical workshops across Canada including representatives from federal and provincial governments, academia, and industry.	To provide focus for environmental impact assessments.	VEC is defined by the Canadian Environmental Assessment Act (CEAA) as an environmental element of an ecosystem that has scientific, social, cultural, economic, historical, archaeological or aesthetic importance. The term SECs has been used to describe VECs of ecological (scientific) importance.	Within DFO, SEC identification occurs as part of the ecological risk assessment framework (ERAF) developed by O et al. (2015) to support ecosystem-based management efforts in the Pacific region.	O et al. 2015; Rubidge et al. 2018; Thornborough et al. 2018; DFO 2018a; Beanlands and Duinker 1983

2.3.1 Vulnerable Marine Ecosystems (VMEs)

The concept of Vulnerable Marine Ecosystems (VMEs) is outlined in United Nations General Assembly (UNGA) Resolution 61/105. This resolution was produced following discussions at the UNGA in 2006 and 2009. The concept of VMEs is used in fisheries management to reduce the impacts of deep sea fisheries and ensure that fisheries are sustainable. The general criteria developed for identifying VMEs and implementing UNGA Resolution 61/105 were agreed upon internationally, and are outlined in the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas (UNFAO 2009). Criteria recommended for identifying VMEs consider aspects such as its relative importance, as well as sensitivity and ability to recover (Table 3).

Table 3. Criteria and descriptions used to identify Vulnerable Marine Ecosystems.

Criteria	Description
Uniqueness or rarity	An area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems including: o habitats that contain endemic species; o habitats of rare, threatened or endangered species that occur only in discrete areas; or o nurseries or discrete feeding, breeding, or spawning areas
Functional significance of the habitat	Discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular early life-history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species.
Fragility	An ecosystem that is highly susceptible to degradation by anthropogenic activities.
Life-history traits of component species that make recovery difficult	Ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics: slow growth rates; late age of maturity; low or unpredictable recruitment; or long-lived.
Structural complexity	An ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms.

VMEs can include groups of species, communities or habitats that meet the criteria, and are at risk of SIH from fishing activities. A process for identifying VMEs was outlined following a 2011 workshop that took place to discuss “Science requirements for effective governance of bottom fisheries in areas beyond national jurisdiction” (Ardron et al. 2014). This process is similar to the steps in the SeBA policy; however, unlike the VME process, the criteria for identifying ‘significant’ areas or species have not been outlined for the identification of SiBAs.

Extensive work has been done by NAFO in recent years to identify and map VMEs and VME elements in international waters of the Northwest Atlantic, and subsequently develop fisheries closures/management measures for them (NAFO 2013; NAFO 2014; NAFO 2015a; NAFO 2016). VME fisheries closure can be large due to the scale of the international regions being managed; recent NAFO fisheries closures are variable in size, ranging from approximately 35 to 170,000 km^2. To date, several species of corals (including pennatulaceans - sea pens and sea whips), sponges, crinoids, tube-dwelling anemones, erect bryozoans and large tunicates have been identified as VME indicator species[5] (NAFO 2012), and dense aggregations of these species are considered VMEs (NAFO 2012). Using the locations of these dense aggregations, NAFO has closed many seamounts within the NAFO Regulatory area to bottom-contact fishing gear, as well as several other areas dominated by corals, sponges and sea pens (NAFO 2011; NAFO 2015b).

Work to identify and protect VMEs has also been started on the Pacific coast by the North Pacific Fisheries Commission (NPFC). This Regional Fishery Management Organization has just begun work in the North Pacific by identifying the locations of VMEs, and assessing whether or not they are at risk from fishing (NPFC 2017).

2.3.2 EBSAs

EBSAs are defined as areas with a relatively high ecological or biological significance, as determined by a set of nationally determined, scientific criteria. Fisheries and Oceans Canada (DFO) developed these criteria in response to the passing of Canada's Ocean Act in 1996 in order to standardize how areas were designated as "significant". The designation of 'significant' can be assigned to an area either for its structural properties, or the function that it serves in an ecosystem (DFO 2004). EBSA designation alone does not mean that an area will be protected; however, it does designate areas as warranting an enhanced level of protection relative to other areas in the region (DFO 2004).

In 2004, DFO developed a set of five criteria for identifying EBSAs (DFO 2004)(Table 4). In addition to these criteria, Canada has also endorsed EBSA criteria developed by the Convention on Biological Diversity (CBD)(Table 4). As shown in Table 4, there is considerable overlap between the DFO and CBD sets of criteria; therefore, recent EBSA evaluations have scored features based on an amalgamated list of eight criteria (Ban et al. 2016; DFO 2018b; DFO 2017[4]). Features are scored as High, Medium or Low for each of the criteria.

Table 4. Combined list of DFO and CBD EBSA criteria that have been used in recent EBSA assessments in the Pacific region. [A] indicates the criteria was developed by DFO, [B] indicates the criteria was developed by the CBD, and [A B] indicates where the two sets of criteria overlap.

Criteria	Description
Uniqueness [AB]	The area contains unique, rare, or distinct features.
Aggregation[A]	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.
Fitness Consequences [AB]	The area is required for a population to survive and thrive (e.g. breeding or nursery grounds, spawning areas, migratory species habitat).
Resilience [AB]	The habitat structures or species present in the area are highly sensitive, easily perturbed, and/or slow to recover.
Naturalness [AB]	The area is relatively pristine, with little to no evidence of human influence.
Importance for threatened, endangered or declining species and/or habitats[B]	The area contains habitat that is critical for the survival and recovery of endangered, threatened, or declining species OR significant assemblages of endangered, threatened, or declining species are found in the area.

[5] Refers to species that signal the occurrence of vulnerable marine ecosystems (NAFO 2015).

Criteria	Description
Biological productivity[B]	The area contains species, populations, or communities with comparatively higher natural biological productivity.
Biological diversity[B]	The area contains comparatively higher diversity of ecosystems, habitats, communities, or species OR comparatively higher genetic diversity is observed in the area.

To be considered an EBSA, features must score High on at least one of three dimensions: Uniqueness, Aggregation or Fitness Consequences, or score Medium across more than one criteria (DFO 2004). The justification for the designation of an EBSA is stronger with higher numbers of criteria scoring 'High'; however, high scores for Resilience and Naturalness alone are not sufficient to designate an area as an EBSA.

The scale of EBSAs depends on the size of the planning area. Whereas the CBD has evaluated EBSAs at a global scale, EBSA identification in the Pacific region was initially completed at a regional scale (e.g. LOMA), and has recently been applied at an even smaller scale to nearshore areas (DFO 2017[4]). To date, EBSAs have been identified in five regions of BC (offshore and nearshore areas of the NSB, West Coast Vancouver Island, SoG, and Offshore Pacific) (Clarke and Jamieson 2006a; Clarke and Jamieson 2006b; Jamieson and Levesque 2014; Ban et al. 2016; DFO 2017[4])(Table 5). For EBSAs in on-shelf regions (NSB, SSB and SoG), experts were asked to identify Important Areas (IAs) for individual species based on the three main EBSA criteria (Uniqueness, Aggregation and Fitness Consequences). The final result of this process was that all on-shelf waters in BC were identified as IAs for at least one species (DFO 2012). Subsequently, three types of important broad scale physiographic features that overlapped with these IAs were assessed as EBSAs in all three regions: physical oceanographic features (e.g. upwelling areas); geographic bottlenecks (e.g. estuaries); and unique areas (e.g. glass sponge reefs).

Since the assessment of on-shelf marine waters, several features in Canada's Offshore Pacific Bioregion have also been assessed as EBSAs through literature reviews and consultation with experts (e.g. hydrothermal vents, seamounts)(Ban et al. 2016). EBSAs were also assessed at a finer scale in five habitat types in nearshore areas of the NSB (eelgrass, kelp, surfgrass, high current areas and estuaries) in 2017 DFO 2017[4]). In this assessment it was found that there was sufficient scientific support to designate kelp forests, eelgrass meadows and estuaries as EBSAs. Finally, the boundaries of previously established EBSAs identified in 2006 for the NSB were recently reassessed using available empirical biological data (DFO 2018b).

Table 5. Summary of EBSA evaluations in BC to date. The processes used to identify EBSAs based on physiographic features in the NSB, SSB and SoG are well summarized in DFO 2012.

Region	Summary	Citation
NSB	Phase I: A Delphic process was used in conjunction with data analyses to identify IAs that met at least one of the three primary EBSA criteria for a broad range of species in the NSB. This resulted in a map where almost all areas were identified as being important for at least 1 species (DFO 2012).	Clarke & Jamieson 2006a
	Phase II: Species specific Important Areas (IAs) were synthesized into spatially distinct EBSAs. Expert knowledge on broad scale physiographic features overlapping with species IAs was used to identify 18 EBSAs in the NSB.	Clarke & Jamieson 2006b
	Reassessment of Ecologically and Biologically Significant Areas (EBSAs) in the Pacific Northern Shelf Bioregion.	DFO 2018b
	Five nearshore habitats (eelgrass meadows, kelp forests, estuaries, surfgrass meadows, and high tidal current passes) were assessed against the full suite of 8 EBSA criteria (DFO + CBD criteria).	DFO 2017[4]
SSB	Same process as for Phase I and II that was completed for NSB. Six EBSAs were identified in the SSB.	Levesque & Jamieson 2014, Jamieson & Levesque 2014
SoG	Same process as for Phase I and II for NSB. Seven EBSAs were identified in the SoG.	Levesque & Jamieson 2014, Jamieson & Levesque 2014
Offshore	Five habitat types (seamounts, hydrothermal vents, continental slope, abyssal/bathypelagic waters and pelagic/surface waters) were assessed against the full suite of 8 EBSA criteria (DFO + CBD criteria). Many features were identified as EBSAs, including all hydrothermal vents, all named seamounts, the continental slope, the Haida Eddy and the North Pacific Transition Zone.	Ban et al. 2016

2.3.3 Ecologically Significant Species and Community Properties

Ecologically Significant Species (ESSs) and Community Properties (ESCPs) are species and community properties that are particularly significant for maintaining ecosystem structure and function (DFO 2006). The concept of ESSs and ESCPs was developed to support the development of Integrated Management Plans (IMPs) for five Large Ocean Management Areas (DFO 2006). The identification of ESSs and ESCPs supports the creation of Conservation Objectives that form part of the ecosystem management objectives within these IMPs (DFO 2007). ESSs and ESCPs are defined as priority species or community properties that have a particularly high ecological significance (DFO 2006). For a species or community property to be considered significant, the ecological consequences following its disturbance needs to be greater than the consequences to most other species or properties in the ecosystem. For this reason, ESSs and ESCPs require enhanced management compared to those that are not considered significant. The scale of management areas for ESS/ESCPs will be variable, but likely smaller than those for VMEs, as they will be developed within individual bioregions.

The selection process for identifying ESS/ESCP criteria involved a scientific review of thirteen candidate criteria to determine their appropriateness for ESS/ESCP identification (Rice 2006). The final list of criteria includes three main categories of criteria related to trophic roles, habitat formation, and community properties (DFO 2006)(Table 6). Unlike the other frameworks reviewed in this document, the ESS/ESCP framework also includes a fourth criteria type to identify species that pose a threat to the ecosystem, requiring management measures to control rather than protect them (Table 6). The ESS/ESCP framework also specifies that the concept of rarity and sensitivity/recoverability should be taken into consideration when identifying ESSs and ESCPs, which is highly applicable to the identification of SiBAs.

Three of these criteria types relate to species (Type 1: trophic roles; Type 2: habitat formation; and Type 4: threatening species), while only one is related to communities (Type 3). Community level criteria (ESCP) have proven difficult to assess in the past (Glass et al. 2014), and are less applicable to the identification of SiBAs. Criteria related to the identification of threatening species are also not relevant to the identification of SiBAs. Thus, this overview, and the comparison of all frameworks in Section 2.3, will focus on ESS criteria including Type 1 and 2 criteria as well as the ‘other considerations’, which is in keeping with other applications of the framework (DFO 2009; Glass et al. 2014).

One of the first applications of the ESS/ESCP framework was in Atlantic Canada. Here, eelgrass was assessed and determined to qualify as an ESS because it is highly productive, exports nutrients to other system, and provides three-dimensional structured used by many species (Type 1 criteria), (Type 2 criterion). The framework has also been applied to identify ESSs in the Bay of Quinte, Lake Ontario (Glass et al. 2014) where expert opinion was used to assess all aquatic species in the ecosystem against species level criteria. In this assessment, thirteen species met at least one criterion and were considered ESSs. In the Pacific Region, ESS criteria have been adapted and incorporated into the ecological conservation priorities framework for marine protected area network design in the NSB (Gale et al. 2018, *in press*). Species known to occur in the NSB were assessed against criteria that included Type 1 and Type 2 criteria, resulting in a list of conservation priorities (CPs) for that bioregion.

Table 6. Criteria and descriptions used to identify Ecologically Significant Species and Community Properties as outlined in DFO 2006. Only Type 1 and 2 criteria and ‘other considerations’ are considered in this review as they are the most relevant for the identification of SiBAs.

Type 1. Species that have important trophodynamic roles:

Criteria	Description
Forage species	Small, schooling marine taxa that serve as an important source of food for marine predators.
Highly influential predators	Species that have high interaction strengths as predators.
Nutrient importing or exporting species	Species that transfer energy or nutrients to or from the spatial boundaries of the ecosystem.

Type 2. Structure providing species:

Criteria	Description
Provision of three-dimensional structure	Structural species that create habitat that is preferentially used by other species.
Size-based properties	Community size spectrum and species accumulation curves.
Frequency distribution of abundance or biomass across species	The pattern of changing abundance or differential commonness and rarity of species within a community, considering all individuals and species in the community.

Type 4. Species that pose a threat to ecosystem structure and function:

Criteria	Description
Invasive species	Introduces species that cause harmful impacts to natural resources in the native ecosystem.
Harmful or toxic species	E.g. toxic phytoplankton and harmful algal blooms.

Other considerations in applying the criteria:

Criteria	Description
Rarity	Existence of a species at a relatively low abundance in an ecosystem.
Sensitivity	A species that is easily depleted by human activities and is slow to recover when impacted.

2.3.4 Significant Ecosystem Components (SECs)

As defined by the Canadian Environmental Assessment Act (CEAA), a Valued Ecosystem Component (VEC) is "an environmental element of an ecosystem that has scientific, social, cultural, economic, historical, archaeological or aesthetic importance." (O et. al. 2015). This term was coined in the 1980s (Beanlands and Duinker 1983) and is being used increasingly in environmental management (Leschine and Petersen 2007). This section focuses on VECs of ecological (scientific) importance, which have been termed Significant Ecosystem Components (SECs) in recent applications in the Pacific region.

Within DFO, SEC identification has occurred as part of the Pacific Ecological Risk Assessment Framework developed by O et. al. (2015) to support ecosystem-based management efforts in the Pacific region. The O et. al. (2015) framework outlines a method for calculating the risk of harm to ecosystems, and offers criteria and guidance to screen ecosystem components and select SECs.

To select SECs, the ecosystem is first structured into subcomponents of species, habitats, and community/ecosystem properties. These initial ecosystem components are then screened through criteria or considerations developed for each ecosystem component category (species, habitats, and communities) to identify those with greater relative significance (or "value"), and to select SECs. For species components, the guidance is that those meeting at least one species criterion (Table 7) are screened in as SECs. For habitat and community/ecosystem property components, the guidance is more general and includes lists of considerations (rather than criteria) for selecting these types of components as SECs (Table 8, Table 9). The scale of SECs depends on their type (species, habitat, or community/ecosystem property), as well as the area under consideration. For example, rockfish species have been identified as SECs within the SGaan-Kinghlas-Bowie Seamount Marine Protected Area (MPA), which covers 6,131 km^2 (Rubidge et al. 2018). In contrast, active and inactive hydrothermal chimney habitats have been identified as SECs within the Endeavour Hydrothermal Vents MPA, with a much smaller footprint of 100 km^2 (Thornborough et al. 2018).

Table 7. Criteria for selecting significant species components (O et al. 2015).

Species Criteria	Description
Nutrient Importer/Exporter	Crucial role in maintaining ecosystem structure and function through the transfer of energy or nutrients that would otherwise be limiting to an ecosystem.
Specialized or keystone role in food web	Species has a highly specialized relationship with another species or guild; has an important food web relationship where an impact to it would cause vertical or horizontal change in food web; species supports a temporally or spatially explicit event important for other species. Examples include highly influential predators and forage species (see glossary for definitions).
Habitat creating species	Species which create habitat for infauna and aerate substrates. Species which create habitat on the seafloor and water column.
Rare, Unique, or Endemic Species	Existence of a species at relatively low abundance or whose populations are globally or nationally significant within the boundaries of the area of interest.
Sensitive Species	Low tolerance and more time needed for recovery from stressors.
Depleted Species	Listed under SARA/COSEWIC/IUCN/BCCDC Target and non-target species impacted beyond their sustainable level by fisheries.

Table 8. Considerations for selecting significant habitat components (O et al. 2015).

Habitat Considerations	Description
Biogenic habitat types	Habitats formed by biogenic species.
Rare or unique habitats	Habitat types with very restricted distribution in the area of interest, or habitats which are globally or nationally significant within the boundaries of the area of interest.
Sensitive habitats	Habitats with low tolerance to disturbance requiring more time to recover, or no tolerance to disturbance. May be fragile habitat, such as biogenic coral. The loss or impairment of habitat integrity can result in direct impacts to species, communities and ecosystem structure and function.
Habitats critical for sensitive species	Habitats supporting species with low tolerance which need more time for recovery from stressors.
Threatened or depleted habitats	Habitats in danger of disappearance in their natural range. Determined from literature reviews, expert review, or relevant conservation lists.
Habitats critical for depleted species	Habitats critical for supporting species listed under SARA/COSEWIC/IUCN/BCCDC and target and non-target species impacted beyond their sustainable level.
Habitats critical for supporting rare, unique or endemic species	Habitats supporting species at relatively low abundance or whose populations are globally or

Habitat Considerations	Description
	nationally significant within the boundaries of the area of interest.
Habitats supporting critical life cycle stages	For example, habitat important for the shelter, feeding, spawning and rearing of seamount associated fish.
Habitats providing critical ecosystem function(s) or service(s)	Habitats that provide critical physical, chemical, and biological processes or functions that contribute to the self-maintenance of an ecosystem. Ecosystem services are the beneficial outcomes, for the natural environment or people, which result from ecosystem functions.

Table 9. Considerations for selecting significant community/ecosystem property components (O et al. 2015).

Community / Ecosystem Property Considerations	Description
Unique communities	Communities (species assemblage) that are unique within the region, or within the area of interest.
Ecologically significant community properties	Communities that are ecologically “significant” because of the functions that they serve in the ecosystem and/or because of features that they provide for other parts of the ecosystem to use (EBSA national document definition).
Functional groups that play a critical role in ecosystem functioning	Biodiversity and productivity of functional groups which are central to the functioning and resilience of the ecosystem.
Ecological processes critical for ecosystem functioning	Ecological processes which are central to the functioning of the ecosystem. Include oceanographic factors critical to ecosystem functioning. Material flows, or the cycling of organic matter and inorganic nutrients (e.g. nitrogen, phosphorus), can mediate how energy travels through the food web.
Sensitive functional groups	Functional groups that are sensitive to disturbance, and if impacted would result in significant effects on community composition and ecosystem function. Includes functional groups with low functional redundancy, and low response diversity. For example, a food web containing several species of herbivores would be considered to have high functional redundancy with respect to the ecosystem function of grazing, if species of herbivores show a differential response to hypoxia, there is also high response diversity.

This framework has been applied in the SGaan-Kinghlas-Bowie Seamount Marine Protected Area (Rubidge et al. 2018), the Endeavour Hydrothermal Vents MPA (Thornborough et al. 2018) and the Hecate Strait and Queen Charlotte Sound Glass Sponge Reefs MPA (DFO 2018a). Lists of SECs were created for each area as part of the process. Benthic SECs identified for SGaan-Kinghlas - Bowie Seamount include species such as rockfish and squat lobster, biogenic habitat such as demosponges and coralline algae, and communities such as benthic invertebrate assemblages and rockfish species assemblages (Rubidge et al. 2018). Benthic SECs identified for the Endeavour Hydrothermal Vents MPA include species such as tubeworms, limpets, and spider crabs, habitats such as active venting and inactive hydrothermal chimneys, and communities such as the benthic clam bed community (Thornborough et al. 2018). Benthic SECs identified for Hecate Strait and Queen Charlotte Sound Glass Sponge Reefs MPA include sponge gardens, reef building glass sponges and squat lobsters (DFO 2018a). SECs have yet to be identified within the Strait of Georgia or Southern Shelf Bioregions.

2.4 Comparison of existing processes for identification of SiBAs

Many options for identifying ecologically and biologically important areas, already in use for other purposes (MPA planning, etc.), have been outlined in the previous section. Here we compare these options and provide recommendations for those that would be most appropriate for identifying Significant Benthic Areas in the Pacific region.

There are many similarities among the VME, EBSA, ESS and SEC frameworks that have been reviewed, and all are relevant to a certain extent to the objectives in the SeBA policy. All frameworks reviewed here are similar in the fact that they score ecosystem components for certain criteria and subsequently screen them, in order to identify ecosystem components with the greatest relative significance; something that is also useful for identifying significant areas from a SeBA perspective. The concepts of VMEs and SiBAs, in particular, are equivalent (DFO 2014; Koen-Alonso 2018). This is driven by the common goal of VMEs and the SBA policy to manage impacts from fishing on vulnerable areas, and the fact that both were developed in response to the same UNGA resolution (2006 UNGA resolution 61/105) (Kenchington et al. 2016); SiBAs are used as a first step in this process domestically, while VMEs are identified to protect areas from fishing in international waters.

Marine protected area planning and the delineation of SiBAs are also highly linked. There are significant overlaps in the definitions, criteria and implementation timelines for the SeBA policy and MPA network planning (Lawton et al. 2012), and the end results of both processes include area-based closures. It is also recognized that fishery closures to protect SeBAs qualify as “other effective area-based conservation measures” under the MPA objectives of Aichi Target 11 (DFO 2014), further emphasizing the link between the two processes. EBSAs have been used as a first step in the MPA planning process, and are inherently linked with SiBAs because they are defined as areas with a relatively high ecological or biological significance. The parallels between EBSA identification and SeBA policy implementation are discussed in Lawton et al. (2012), where it is stated that the final areas outlined by the SeBA policy are a subset of benthic EBSAs that are at risk to fishing (Figure 2 in Lawton et al. 2012). ESSs are also linked to the MPA planning process, as ESS criteria have been adapted and incorporated into the ecological conservation priorities framework that is being used in marine protected area network design in the NSB.

Finally, the criteria used in the frameworks reviewed here are very similar and highly linked. The overlap between all frameworks is exemplified by the fact that there are a combined total of twenty-five criteria among the four frameworks, but only eleven of these are unique (shown in Table 10). The greatest overlap was found for two criteria: ‘sensitivity or poor ability to recover’, and ‘uniqueness or rarity’, which are common between all four frameworks. Five other criteria are shared between at least two frameworks. These overlapping criteria include concepts such as keystone roles in food web (e.g. upper level predator or forage species), structural complexity, supporting critical life stages or threatened, endangered or declining species, and providing critical ecosystem functions (e.g. nutrient cycling). Most criteria outlined in Table 10 have some applicability for the identification of SiBAs. Most importantly for the SBA policy is the sensitivity/slow to recover criterion that is included in all frameworks, as it is a required criterion for the identification of SiBAs (Figure 2).

Given the similar purpose of SiBAs and VMEs, the parallels between the SiBA and MPA processes, and the overlap in criteria used to identify VME, EBSA, ESS and SEC features, it follows that all frameworks described here are applicable for the identification of SiBAs. Habitats, features, communities and species identified by these frameworks would need to be benthic, sensitive to fishing, and slow to recover to fully meet the requirements of a SiBA (see Table 2).

Table 10. Comparison of criteria outlined in four different frameworks used to identify features for conservation purposes. Criteria that are relevant to species([S]), habitats([H]) and communities([C]) are represented by their symbols.

Criteria for species, habitats or communities	VME	EBSA	ESS	SEC
Fragile, sensitive or slow to recover [SHC]	x	x	x	x
Rare, Unique, or Endemic [SHC]	x	x	x	x
Increases structural complexity (e.g. habitat forming) [SHC]	x	-	x	x
Supports critical life history stages [HC]	x	x	-	x
Keystone role in food web (e.g. upper level predator or forage species) [S]	-	-	x	x
Provides critical ecosystem function (e.g. nutrient cycling) [SHC]	-	-	x	x
Threatened, endangered or declining [SH]	x	x	-	x
Biological diversity [SHC]	-	x	-	-
Biological productivity [SHC]	-	x	-	-
Aggregation [S]	-	x	-	-
Naturalness [HC]	-	x	-	-

2.5 Potential SiBAs in the SSB and SoG

The goal of this paper was to review frameworks used to identify ecologically and biologically significant benthic areas in Canada and recommend a process for identifying SiBAs to implement the SeBA policy in the Pacific region. In reviewing these processes, it became apparent that some important benthic habitats, features and species already identified by the frameworks have either already been identified as SiBAs or VMEs in other areas, or are good candidates for SiBAs. These are described below, with a focus on those found in the SSB and SoG.

Firstly, aggregations of corals and sponges are already considered SiBAs in the context of the SeBA policy (DFO 2014, 2017b). These taxa have also been identified as VMEs by Boutillier et al. (2010 - Appendix 1). BC is home to many glass sponge reefs, all of which meet all VME criteria: they are considered unique and globally rare; there is a body of evidence suggesting that sponge habitat supports higher biodiversity and enhanced fish populations; most sponges are known to be fragile; sponges are slow growing and long-lived; and aggregations of sponges form structural habitat. Glass sponge reefs have been mapped within the SSB and SoG, and some have already been closed to fishing under the SeBA policy. Aggregations of cold-water corals meet four VME criteria; they have been found to support higher biodiversity and enhance fish populations; most species are considered fragile; they are long-lived and recover slowly; and they form vertical relief and structural complexity. Aggregations of corals qualify as SiBAs, but currently need to be mapped to complete the SiBA identification process for the SSB and SoG.

Secondly, sea pens and sea whips have also been identified as VME indicator taxa (Convention for the Conservation of Antarctic Marine Living Resources [CCAMLR] 2009), and aggregations of sea pens in the Laurentian channel were identified as SiBAs in Kenchington et al. (2016). Sea pen and sea whip aggregations also exist in the SSB and SoG (Hemmera 2014; S. Jeffery, DFO, pers. obs). These will need to be mapped in order to complete the SiBA identification process for the area (as depicted in Figure 2).

All of the EBSAs identified for the SSB and SoG to date have included IAs for one or more benthic species, as they either contain aggregations of one or more benthic species, or they have fitness consequences for at least one benthic species (e.g. Pacific Herring, Pacific Sand Lance, skates, bivalves, Dungeness Crab, Tanner Crab, shrimp, sole, Pacific Geoduck and Green Sea Urchin) (Jamieson & Levesque 2014). These benthic IAs are candidates for SiBAs; however, their sensitivity and resilience to fishing will need to be assessed. It is important to note that the IA and EBSA identification process for the SoG and SSB occurred at a LOMA scale, and significant area identification at the coastal management area scale would be a valuable next step to identify locally significant areas.

Finally, it was recommended in the SeBA policy that scientific inference from other jurisdictions be used to identify significant or sensitive habitats. Several taxa (e.g. crinoids, tube-dwelling anemones, bryozoans, stalked tunicates, etc) have been assessed as benthic EBSAs in the Maritimes region (Kenchington 2014); those taxa also occurring in the Pacific region should be assessed as SiBAs by screening for sensitivity and resilience to fishing.

2.6 Potential data sources and methods to delineate SiBAs in the SoG and SSB

Existing species datasets from the Pacific region that could be used to delineate SiBAs in the SoG and SSB are presented in Table 11. These data layers are similar to those used in recent planning processes in the Pacific region (e.g. MPA network planning, EBSA delineation and VME identification), and will therefore likely be of use for the delineation of SiBAs.

Many of the frameworks reviewed here are designed to identify important species, rather than habitats or physical features that can be mapped directly. Important species or groups of species identified by relevant frameworks (VME, EBSA, ESS or SEC), that are benthic and sensitive to fishing will be referred to hereafter as SiBA indicator taxa. SiBAs can be delineated from indicator taxa data by mapping areas representative of the taxa (e.g. areas of aggregation) Many of these have not yet been mapped in the SoG and SSB. In these cases, species data, or physical proxies in the absence of species data, will need to be used to delineate SiBAs. The process of delineating SiBAs from indicator taxa data varies based on the type of data available (e.g. point locations versus polygon areas). Methods for delineating SiBAs with a range of data types are presented in Figure 3 and are described below.

If spatial data for SiBA indicator taxa are available, the method for delineating areas, and ultimately SiBAs, depends on the type of data. Polygon data can be used directly to identify the areas representative of indictor taxa. Polygon data is typically available for habitat features that tend to be surveyed using remote sensing applications (e.g. extent of eelgrass beds from aerial photography). Benthic species, as opposed to habitats or features, tend to be sampled at discrete locations resulting in point or line data (e.g. trackline from a longline survey). Discrete observations can be used to model the distribution of the species. Those models can then be used to identify areas representative of the indicator taxa by locating areas with high probability of suitable habitat.

If spatial data for a SiBA indicator taxa are not available, and a known association exists between the taxa and physical feature, the physical feature can be used to map the area where the taxa is expected to occur. Physical proxies have been used in other processes including EBSA and VME applications (e.g. seamounts as proxies for cold-water coral and sponge communities) (Kenchington 2014).

Finally, any area representative of SiBA indicator taxa should be validated and possibly refined in order to be considered a SiBA. If abundance or density data is available, areas can be refined by overlaying them with species hotspots or aggregations (following methods in Kenchington et al., 2016). Additionally, validation and refinement could be accomplished by groundtruthing areas with new data.

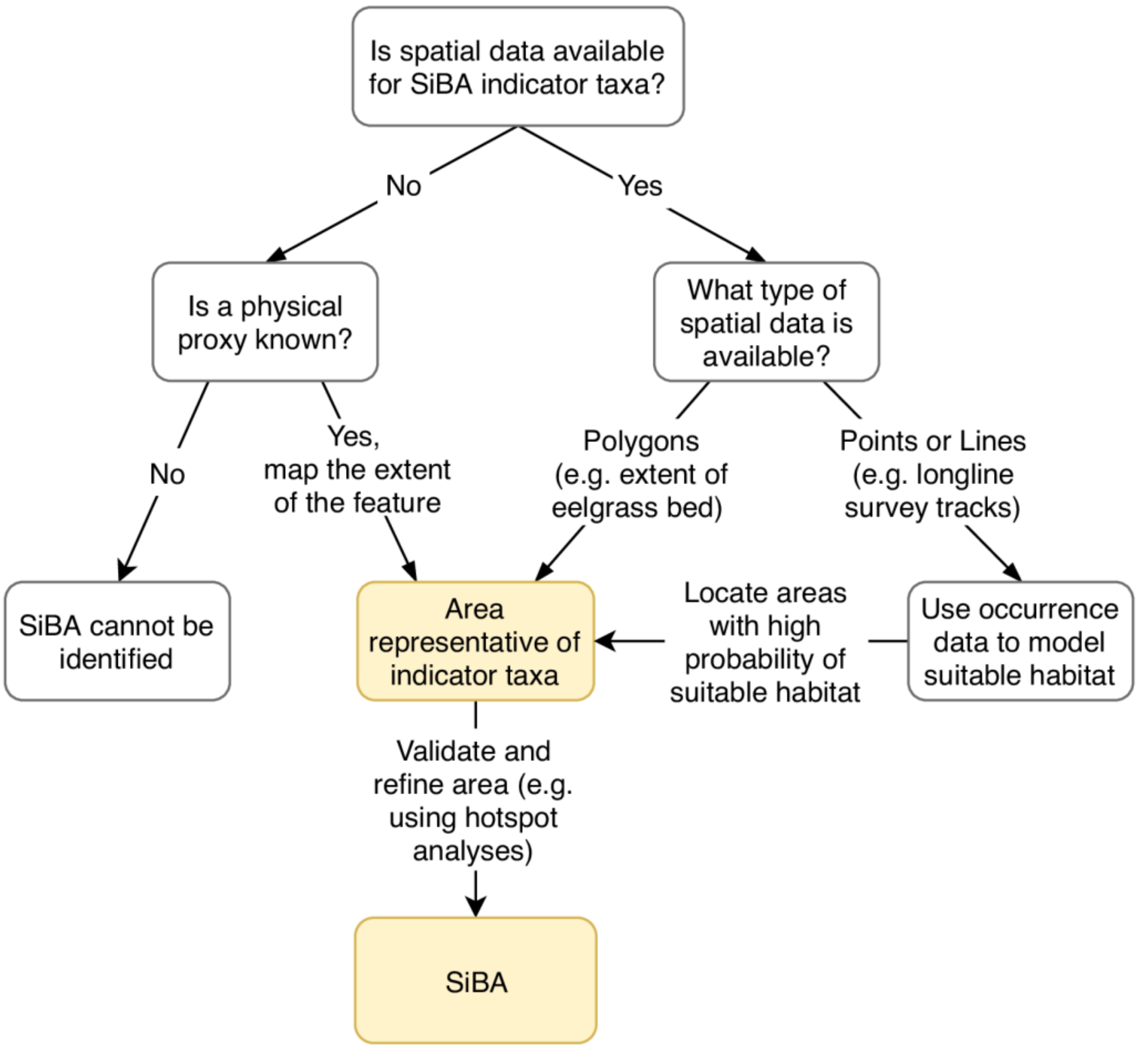

Figure 3. Decision tree to facilitate the creation of Significant Benthic Areas with a range of input data types. SiBA indicator taxa are species or groups of species identified by relevant frameworks (VME, EBSA, ESS or SEC) and that are benthic and sensitive to fishing.

Table 11. List of available data from the Strait of Georgia and Southern Shelf Bioregion for a selection of benthic species identified as indicator taxa by DFO frameworks (i.e. VME, EBSA, CP).The datasets described here are combined from multiple sources. The data type, number of presence or absence records, and temporal range shown here do not necessarily reflect the entirety of the available source data. Months are represented by numbers (e.g. 5 – 10 represents May to October). The spatial data type is represented in 'Feature Name' by the following symbols: polygons representing continuous extents (^), point locations representing occurrence data (*) and track lines representing catch per unit effort (~).

Feature Name	Description	Sources	Years	Months	Common (scientific) name	Region	# Presence Records	# Absence Records
Kelp and Sea Grass Distribution^	Areal extents of kelp and sea grasses	BCMCA, ShoreZone, Burrard Inlet Environmental Action Program and Fraser River Estuary Management Program, Galiano Conservancy Association, Sunshine Coast Regional District	-	-	Bull Kelp *(Nereocystis leutkeana)*	SoG, SSB	-	-
					Giant Kelp *(Macrocystis pyrifera)*	SoG, SSB	-	-
					Eelgrass *(Zostera* spp)	SoG, SSB	-	-
					Surfgrass *(Phyllospadix* spp)	SoG, SSB	-	-
Clam Beds^	Distribution of clam beds	GeoBC	1979 - 2017	-	Clams (Bivalvia)	SoG, SSB	-	-
Corals and Sponges*	Locations of cold water sponge and coral groups	DFO Pacific (research and commercial bottom trawls) and Royal BC Museum records	1914 - 2017	1 - 12	*Black Corals* (Antipatharia)	SSB	9	-
					Hard or Stony Corals (Scleractinia)	SoG	17	-
						SSB	220	-
					Sea Pens (Pennatulacea)	SoG	154	-
						SSB	1425	-
					Soft Corals (Alcyonacea)	SoG	22	-
						SSB	386	-
					Glass Sponges (Hexactinellida)	SoG	70	-
						SSB	618	-
					Demosponges (Demospongiae)	SoG	74	-
						SSB	228	-
Corals and Sponges~	Normalized catch per unit effort	DFO Pacific (research and commercial bottom trawls)	2004 - 2017	1 - 12	Corals (Alcyonacea, Antipatharia, Scleractinia, Anthoathecata)	SSB	58	43209
					Sponges (Porifera)	SSB	569	42698
					Sea Pens (Pennatulacea)	SSB	184	43083

Feature Name	Description	Sources	Years	Months	Common (scientific) name	Region	# Presence Records	# Absence Records
Other Benthic Invertebrates*	Locations of benthic invertebrate species	DFO Pacific (research surveys and commercial shellfish logs)	1963 - 2017	1 - 12	Inshore Tanner Crab *(Chionoecetes bairdi)*	SoG	719	-
					Deepwater Tanner Crab *(Chionoecetes tanneri)*	SSB	29839	-
					Scallop *(Chlamys* spp)	SoG	1240	-
						SSB	145	-
					Cockle *(Clinocardium nuttallii)*	SoG	52	-
						SSB	47	-
					Purple-hinged Rock Scallop *(Crassadoma gigantea)*	SSB	2	-
					Opal Squid *(Doryteuthis opalescens)*	SoG	144	-
						SSB	675	-
					Giant Pacific Octopus *(Enteroctopus dofleini)*	SoG	30514	-
						SSB	7585	-
					Northern Abalone (Haliotis kamtschatkana)	SoG	50	-
						SSB	206	-
					Littleneck Clam *(Leukoma staminea)*	SoG	96	-
						SSB	65	-
					Red Sea Urchin *(Mesocentrotus franciscanus)*	SoG	2208	-
						SSB	1847	-
					Dungeness Crab *(Metacarcinus magister)*	SoG	415893	-
						SSB	161459	-
					Olympia Oyster *(Ostrea lurida)*	SoG	24	-
						SSB	50	-
					Sidestripe Shrimp *(Pandalopsis dispar)*	SoG	64647	-
						SSB	14416	-
					Spiny/Northern Pink Shrimp *(Pandalus borealis)*	SoG	14345	-
						SSB	4667	-
					Coonstripe/Dock Shrimp *(Pandalus danae)*	SoG	3980	-
						SSB	4251	-
					Humpback Shrimp *(Pandalus hypsinotus)*	SoG	3899	-
						SSB	185	-
					Smooth Pink Shrimp *(Pandalus jordani)*	SoG	41848	-
						SSB	24687	-
					Spot Prawn *(Pandalus platyceros)*	SoG	434254	-
						SSB	93277	-

Feature Name	Description	Sources	Years	Months	Common (scientific) name	Region	# Presence Records	# Absence Records
					Geoduck *(Panopea generosa)*	SoG	12990	-
						SSB	20633	-
					Ochre Sea Star *(Pisaster ochraceus)*	SoG	12	-
						SSB	15	-
					Sunflower Sea Star *(Pycnopodia helianthoides)*	SoG	143	-
						SSB	331	-
					Butter Clam *(Saxidomus gigantea)*	SoG	65	-
						SSB	48	-
					Green Sea Urchin *(Strongylocentrotus droebachiensis)*	SoG	1023	-
						SSB	793	-
					Horse Clam *(Tresus spp)*	SoG	1684	-
						SSB	689	-
Demersal Fish and Elasmobranchs ~	Normalized catch per unit effort	DFO Pacific (longline and trawl research surveys)	2003 - 2016	3,5,6,8, 9	Sablefish *(Anoplopoma fimbria)*	SoG	14	520
						SSB	639	669
					Arrowtooth Flounder *(Atheresthes stomias)*	SoG	61	473
						SSB	919	389
					Roughtail Skate *(Bathyraja interrupta)*	SSB	125	1183
					Petrale Sole *(Eopsetta jordani)*	SoG	13	521
						SSB	628	680
					Rex Sole *(Glyptocephalus zachirus)*	SoG	52	482
						SSB	846	462
					Pacific Halibut *(Hippoglossus stenolepis)*	SoG	7	527
						SSB	805	503
					Rock Sole *(Lepidopsetta bilineata)*	SoG	42	492
						SSB	204	1104
					Dover Sole *(Microstomus pacificus)*	SoG	73	461
						SSB	809	499
					Lingcod *(Ophiodon elongatus)*	SoG	134	400
						SSB	794	514
					Big Skate *(Raja binoculata)*	SoG	34	500
						SSB	205	1103
					Longnose Skate *(Raja rhina)*	SoG	126	408
						SSB	707	601

Feature Name	Description	Sources	Years	Months	Common (scientific) name	Region	# Presence Records	# Absence Records
					Rougheye Rockfish *(Sebastes aleutianus)*	SSB	172	1136
					Silvergray Rockfish *(Sebastes brevispinis)*	SoG	4	530
						SSB	278	1030
					Copper Rockfish *(Sebastes caurinus)*	SoG	80	454
						SSB	68	1240
					Darkblotched Rockfish *(Sebastes crameri)*	SSB	173	1135
					Greenstriped Rockfish *(Sebastes elongatus)*	SoG	82	452
						SSB	502	806
					Widow Rockfish *(Sebastes entomelas)*	SSB	89	1219
						SSB	403	905
					Rosethorn Rockfish *(Sebastes helvomaculatus)*	SSB	278	1030
					Quillback Rockfish *(Sebastes maliger)*	SoG	295	239
						SSB	218	1090
					China Rockfish *(Sebastes nebulosus)*	SSB	73	1235
					Tiger Rockfish *(Sebastes nigrocinctus)*	SoG	11	523
						SSB	22	1286
					Canary Rockfish *(Sebastes pinniger)*	SoG	19	515
						SSB	471	837
					Redstripe Rockfish *(Sebastes proriger)*	SSB	204	1104
					Yelloweye Rockfish *(Sebastes ruberrimus)*	SoG	259	275
						SSB	265	1043
					Shortspine Thornyhead *(Sebastolobus alascanus)*	SoG	26	508
						SSB	230	1078
					Spiny Dogfish *(Squalus suckleyi)*	SoG	518	16
						SSB	1034	274

3 Conclusions

We have drawn inference from previous work done on the Atlantic coast related to SiBAs, and from marine planning processes in BC, in order to provide recommendations for how to identify SiBAs in the Pacific region. Aggregations of corals, sponges and sea pens have already been identified as SiBAs in other regions, and are therefore recommended as such in the Pacific region.

SiBAs have yet to be identified for habitats, features, communities and species other than the above mentioned taxa in any region in Canada. Here we have shown that all of the frameworks for identifying ecologically and biologically important habitats, features, communities and species discussed in this paper are applicable for the identification of SiBAs. Many areas of biological and ecological importance already identified by these frameworks are relevant to the SeBA policy, provided that they are also benthic, sensitive to fishing, and slow to recover. We recommend that any habitat, feature, community or species already identified and delineated using these frameworks be screened for these attributes and subsequently considered SiBAs. Significant data sources exist, both within and outside DFO, for benthic species within the SoG and SSB that will be useful for delineating new SiBAs in these regions (outlined in Section 2.6).

There are benefits to incorporating criteria from other frameworks into the process of identifying SiBAs, including better integration of spatial planning approaches and more efficient delineation of protected areas; be they protected under an MPA, designated as EBSAs, or protected specifically from fishing pressure (DFO 2014). In fact, close integration during the planning processes for SeBA policy implementation and MPA network planning has been recommended in order to maximize benefits and efficiency of protected areas (DFO 2014).

3.1 Next Steps for the SSB and SoG

Aggregations of several taxa (corals, sponges, sea pens) have already been identified as significant, sensitive, and slow to recover in the Atlantic region. Therefore, these taxa would serve as a logical starting point for the SeBA policy application in the SSB and SoG. Where sufficient data exists for these taxa, the next step in this application will be to use existing data (outlined in Table 11) to model and map SiBAs. SeBAs could then be identified by determining overlap with fishing activities. The coral and sponge ERAF (DFO 2013) would then need to be applied to these SiBAs to assess their likelihood of SIH from fishing activities.

As a second step for the SSB and SoG, SiBAs should be identified for habitats, species and features other than corals and sponges. As a starting point, it is recommended that areas already identified and delineated by VME, EBSA, ESS and SEC framework applications be considered SiBAs once assessed for benthic components and sensitivity/resiliency to fishing activities. Within the SSB and SoG specifically, we recommend that all IAs delineated for benthic species in Levesque & Jamieson (2014), that are sensitive and slow to recover from fishing impacts, be considered SiBAs once expert derived areas are validated with existing data or models.

Alternatively, where SiBA indicator taxa have been identified by framework applications, but areas representative of those taxa have yet to be mapped, existing data should be used to model and map areas representative of indicator taxa to identify SiBAs. For example, vulnerable, benthic taxa identified with EBSA criteria by Kenchington (2014) occurring in the Pacific region should be considered SiBA indicator taxa and mapped in the SSB and SoG.

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Acronyms

BC	British Columbia
CBD	Convention on Biological Diversity
CEAA	Canadian Environmental Assessment Agency
CP	Conservation Priority
CSAS	Canadian Science Advisory Secretariat
DFO	Fisheries and Oceans Canada
EBSA	Ecologically and Biologically Sensitive Area
ERAF	Ecological Risk Assessment Framework
ESCP	Ecologically Significant Community Property
ESS	Ecologically Significant Species
FM	DFO Fisheries Management
FAO	United Nations Food and Agriculture Organization
IA	Important Area
IMP	Integrated Management Plans for LOMAs
KDE	Kernel Density Estimation
LOMA	Large Ocean Management Area
MPA	Marine Protected Area
NAFO	Northwest Atlantic Fisheries Organization
NSB	Northern Shelf Bioregion
SAR	Science Advisory Report
SDM	Species Distribution Model
SeBA	Sensitive Benthic Area
SEC	Significant Ecosystem Component
SFF	Sustainable Fisheries Framework
SiBA	Significant Benthic Area
SIH	Serious or Irreversible Harm
SoG	Strait of Georgia
SR	Science Response
SSB	Southern Shelf Bioregion
UNGA	United Nations General Assembly
VEC	Valued Ecosystem Component
VME	Vulnerable Marine Ecosystem

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