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Identification of Ecologically and Biologically Significant Areas in the Strait of Georgia and off the West Coast of Vancouver Island: Phase I - Identification of Important Areas

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Foreword

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

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ABSTRACT

This report details the first phase of the identification process of Ecologically and Biologically Significant Areas (EBSAs) for the two southernmost inshore BC ecoregions, namely the Strait of Georgia (SoG) and off the west coast of Vancouver Island (WCVI). This phase is the description of regional Important Areas (IAs), which are used in the second phase, i.e., the determination of EBSAs. Both phases have been previously described for the northernmost inshore BC ecoregion, the Pacific North Coast Integrated Management Area (PNCIMA), but some additions to these documents are provided in the document presenting the second phase of this process: Designation of EBSAs.

EBSAs are areas worthy of enhanced management or risk aversion. An area is identified as an EBSA if it ranks highly on one or more of three dimensions (Uniqueness, Aggregation and Fitness Consequences), and can be weighted by two other dimensions (Naturalness and Resilience), agreed upon at a national Fisheries and Oceans Canada workshop. Regional scientific experts were surveyed to identify IAs of the SoG and WCVI that met the criteria using a modified Delphic process. Thematic layers produced included species of fish, invertebrates, marine mammals, reptiles and oceanographic features. Experts were also asked to provide rankings of the IAs identified for each species for each of the five EBSA criteria. The final list of species' IAs is identified in 50 thematic layers on the WCVI and 29 layers in the SoG. This report describes how these IAs were identified, discusses issues around the EBSA identification process, and includes maps displaying each individual thematic layer.

When taken together the entire group of species' IAs cover almost the whole area of each of the above ecoregions. This indicates that when viewed at a high level, all areas are likely important in some way for at least one species, species group or habitat feature.

Désignation des zones d’importance écologique et biologique dans le détroit de Georgie et sur la côte Ouest de l’île de Vancouver : Phase I – Désignation des zones d’importance

RÉSUMÉ

Le présent rapport donne une description détaillée de la première phase du processus de désignation des zones d'importance écologique et biologique (ZIEB) pour les deux écorégions côtières les plus méridionales de la Colombie-Britannique, soit le détroit de Georgie et au large de la côte Ouest de l'île de Vancouver. Cette phase consiste en la description de zones importantes à l'échelle régionale, qui serviront à la détermination des ZIEB dans la deuxième phase du processus. Les deux phases ont déjà fait l'objet d'une description pour l'écorégion côtière la plus septentrionale de la Colombie-Britannique, soit la zone de gestion intégrée de la côte nord du Pacifique (ZGICNP), mais certains ajouts à ces documents sont fournis dans le document qui présente la deuxième phase de ce processus : Désignation des ZIEB.

Les ZIEB sont des zones qui méritent une gestion améliorée ou une aversion accrue au risque. Une zone est désignée comme une ZIEB si elle se classe à un rang élevé pour un ou plusieurs des trois aspects étudiés (unicité, concentration et conséquences sur la valeur adaptative) et s'il est possible de la pondérer selon deux autres aspects (caractère naturel et résilience) convenus dans le cadre d'un atelier national de Pêches et Océans Canada. Un suivi des experts scientifiques régionaux a été effectué à l'aide d'une méthode delphique modifiée dans le but de déterminer les zones importantes du détroit de Georgie et de la côte Ouest de l'île de Vancouver qui répondaient aux critères. Les couches thématiques produites comprenaient notamment des espèces de poissons, d'invertébrés, de mammifères marins, de reptiles, ainsi que des caractéristiques océanographiques. On a également demandé aux experts de fournir des classements des zones importantes désignées pour chacune des espèces en fonction de l'ensemble des cinq critères de désignation des ZIEB. La liste finale des zones importantes pour les espèces est répartie en 50 couches thématiques pour la côte Ouest de l'île de Vancouver et en 29 couches pour le détroit de Georgie. Le présent rapport fournit une description du processus ayant servi à désigner ces zones importantes. On y traite également des problèmes éprouvés dans le processus de désignation des ZIEB, et des cartes montrant chacune des couches thématiques y sont présentées.

Prises dans leur ensemble, les zones importantes du regroupement d'espèces couvrent pratiquement toute la superficie des écorégions mentionnées précédemment. Cela indique que lorsqu'elles sont prises en compte à un niveau supérieur, toutes les zones sont probablement importantes d’une certaine façon pour au moins une espèce, un groupe d'espèces ou une composante de l'habitat.

1. INTRODUCTION

Canada's Oceans Act was passed in 1997 and incorporates three important principles in ocean management: sustainable development, integrated management (IM) and the precautionary approach (DFO 2004b). The 2004 Oceans Action Plan (OAP) has four pillars: 1) Effective international leadership, sovereignty and security to advance Canadian and global interests, 2) Action to address health of the oceans (HOTO), 3) Integrated oceans management, and 4) Oceans technology innovation. IM is defined as "an ongoing and collaborative planning process that brings together interested stakeholders and regulators to reach general agreement on the best mix of conservation, sustainable use and economic development of marine areas for the benefit of all Canadians" (DFO 2004a). The 2004 OAP identified five Large Ocean Management Areas (LOMAs) in Canada where Integrated Management is being initially applied: 1) the Gulf of St. Lawrence Integrated Management (GOSLIM), 2) Eastern Scotian Shelf Integrated Management (ESSIM), 3) Beaufort Sea, 4) Placentia Bay/Grand Banks and 5) the Pacific North Coast Integrated Management Area (PNCIMA). These five areas were the first to be evaluated in an IM context, but relevant analyses for other regional areas, such as the West Coast of Vancouver Island (WCVI) and Strait of Georgia (SoG) on the continental shelf in Canada's Pacific region are also now beginning to be initiated. This is particularly relevant to the Pacific Region because of the relatively small size of its ecoregions (Powles *et al.* 2004), at least in comparison with those in Atlantic Canada and the Arctic, and the more significant spatial biological connections thus between them.

The PNCIMA initiative, as the major focus of the Oceans Action Plan in the Pacific Region, marks a shift toward a broader ecosystem approach to resource management. Background documentation produced to support IM in these areas is comprised of numerous parts: an Ecosystem Overview Report (Lucas *et al.* 2007); a Marine Use Analysis report (MacConnachie *et al.* 2007); and initial identification of Ecologically and Biologically Significant Areas (EBSAs) (DFO 2004c; Clarke and Jamieson 2006a,b; Jamieson and Levesque 2011), Ecologically Significant Species and Community Properties (ESSCPs) (DFO 2006, Jamieson et al. Unpublished manuscript), Depleted Species and Degraded Areas (Jamieson et al. Unpublished manuscript). Together, this information will be used to determine conservation objectives (Jamieson, Unpublished manuscript), which represent the science-based recommended minimum thresholds in the development of environmental reference points and indicators for them. "Desirable" thresholds will be derived through consultation with relevant sectors, and to provide a buffer, should be such that the "bottom-line" science thresholds would not likely be reached or exceeded as the result of either human actions or inaction.

While IM is not presently being advanced at this time in the WCVI and SoG on the Pacific Coast of Canada, planning for a functional network of marine protected areas over the entire coast is underway. This process would benefit from determination of both EBSAs and ESSCPs for all three of the region's inshore ecoregions, i.e., PNCIMA, the SoG and off the WCVI. This report details the methodology and data used for identifying species' Important Areas (IAs), which are used for determining EBSAs, in these latter two ecoregions. Another report builds on this one and summarizes the EBSAs identified in all three inshore ecoregions (Jamieson and Levesque 2011). It is emphasized that the identification of an EBSA under the decision model developed nationally and previously used in PNCIMA (Clarke and Jamieson (2006 a,b), based purely on scientific advice available at the time a report was completed, does not confer any legislative protection for identified areas. As was pointed out in the earlier reports, we also note that future consideration could also be given to incorporating additional data and data types (e.g. traditional and local ecological knowledge) to address data gaps and acknowledged shortcomings of the existing science-based EBSA identification process; such considerations are not included here because of time and funding constraints.

Canada's Oceans Act empowers Fisheries and Oceans Canada (DFO) to apply an enhanced level of protection to those areas identified as biologically or ecologically significant. Marine areas can be considered significant based on the life history functions they serve in the ecosystem or because of the structural properties they possess (DFO 2004c). Significance used in this context is purely a relative term, as it is understood that all ecosystems and species functions have some degree of ecological significance. The current initiative seeks to identify those areas known at this time that host ecological structures or functions with greater relative significance. The intent is to facilitate the application of a higher level of protection and/or encourage more cautious risk assessment by managers for activities occurring or planned in identified EBSA areas. Ultimate science definition of EBSAs is simply science advice to managers. Sound ecosystem-based management in any ecoregion will also need to incorporate the nature of impacts under consideration, a specific area's vulnerability to potential impacts, and socio-economic considerations.

A summary of national criteria guidelines (DFO 2004c) are presented in Section 2.

The listing of IAs presented here for BC should be considered as initial steps in an ongoing EBSA identification program, as 1) evaluation time was limited; 2) many experts consulted had collected their data to address other needs, such as stock assessment. Consequently, they may either not have the most appropriate data or have not yet analysed their data in a manner most appropriate for EBSA identification; and 3) data of other types (e.g. traditional and local ecological knowledge) has not yet been included in this process.

Here, we used a modified Delphic process to obtain the opinions of regional scientific experts over a six-month period. As in the determination of EBSAs in the north coast (Clarke and Jamieson 2006a), we recognize that there is inherent bias in the selection of species included here (e.g., mostly commercial species) and the places where data on these species was collected (areas where fisheries occur). Species considered in this analysis were based on the expertise and advice of only those experts that we were able to include (Appendix I) given our timeframe for completion. For many species and habitat features, information desirable for IA identification has either not been collected, analyzed or was unavailable as a result of confidentiality agreements. In some cases, data had been obtained for the determination fishing management options, but had not been analysed for a purpose such as IA identification. Ideally, the identification of IAs would be based on all information, but what we present here is based on the best knowledge available to us. Thus, IAs identified in this report should be considered dynamic, being the first step in an on-going process.

It should also be noted that species considered here and by Clarke and Jamieson (2006a) were only those species that tended to occur in identifiable specific areas for one of the EBSA criteria listed, and for which relevant data were available. Other ecologically important species identified that are wide ranging and that occur over most of the BC coast were considered in the draft report (Jamieson et al. Unpublished manuscript) on Ecologically Significant Species, as for these species (e.g. many marine plants, etc.), no particular areas could be identified that were more important than others for the species. Thus, to obtain a comprehensive evaluation of important habitats and species in BC marine waters, both reports should be considered together. Finally, for some larger species and most smaller sized species, we did not have enough distributional information and do not understand their habitat requirements to consider them in either EBSAs or as ESSs, but these species are too many to list and so are best inferred by their absence in either of these reports,

Surveyed experts suggested IAs for species and habitat features based on the five EBSA dimensions and assigned continuum values to each of the areas identified as important, which operationally meant ranking them as of low, medium or high importance. However, many interviewed experts found this difficult to do, so operationally, all areas indicated by experts were considered to be of high importance. Caveats to our analysis are 1) bycatch data has not been sufficiently captured in the current identification, and focus to date is on exploited or the more obvious marine species; 2) the EBSA identification process should at some point include Traditional and Local Ecological Knowledge; and 3) IA identification is based on a snapshot of information only, i.e., the best available science knowledge at the time of preparation. As new data become available, revisions and additions may need to be considered. Finally, this study was completed by November, 2009, so any research completed after this date has not been included.

2. NATIONAL EBSA CRITERIA GUIDELINES

In order to reduce variation in EBSA identification criteria being used in IM areas across Canada, the decision model that was developed during national workshops (DFO 2004c, 2007a) has been adopted in all IM areas. However, the application of these criteria in each region can be tailored to the needs and specific characteristics of individual regions.

The following is a brief summary of the national EBSA guidelines (DFO 2004c). There are three main dimensions against which IAs for single species and ultimately EBSAs for all species combined are to be evaluated (Uniqueness, Aggregation and Fitness Consequences) and two additional ranking dimensions (Resilience and Naturalness). Uniqueness refers to the degree to which the characteristics of areas are unique, rare, distinct, and have no alternatives. The spectrum of uniqueness increases from regional to national to international scales. Aggregation refers to the extent that a) individuals of a species aggregate for part of the year, b) most individuals use the area for an important life history function or c) where a structural feature or ecological process occurs with relatively high density. Fitness Consequences is the degree to which the area itself contributes to the fitness of a population or species, where the actual life history activity taking place there only makes a marginal contribution to fitness. Two additional influencing dimensions are also to be considered during site evaluations: Resilience and Naturalness. Resilience refers habitat structures or species which are sensitive, easily disturbed, and slow to recover. Naturalness is the degree to which areas are pristine and contain native species. The ranking from one of the first three dimensions can be increased if it ranks low in resilience and high in naturalness.

EBSAs include areas which rank high in any of Uniqueness, Aggregation, or Fitness Consequences. Areas can also be identified as EBSAs if a large number of average ranking areas are overlapping. The justification for an EBSA can be thought of as a continuum where justification becomes stronger with increasing numbers of highly ranked dimensions.

The three dimensions can overlap considerably and the boundaries between them may become blurred. For example, birds moulting in large numbers in a specific site may have a high Aggregation ranking, a high Uniqueness ranking if it is the only site of its kind in the region and a high Fitness Consequences ranking because moulting in that particular area results in lower predation for the birds when flightless.

Considering application of the above IA dimensions to determine suggested EBSAs in an operational sense has proved to be challenging (Clarke and Jamieson 2006a,b). In meetings with experts, EBSA IA dimensions were first defined and then examples given of hypothetical areas that would rank highly for each dimension. Discussion followed to ensure that understanding of the dimensions and how IAs should be identified were fully understood. Each expert(s) was then asked to detail specific areas within each IM area that, according to their experience and knowledge of particular species, stand out in the context of those three dimensions. This resulted in identification of IAs.

3. METHODOLOGY

The objective of this project was to implement the same acceptable and transparent process for identifying EBSAs as was used initially in PNCIMA (Clarke and Jamieson 2006 a,b). It is anticipated that there will be follow-up consultations and extensive discussion during the IM development process. The end-product of this identification exercise is also expected to be refined and modified over time as further data become available.

3.1. DELPHIC IDENTIFICATION

3.1.1. Initial Identification of Important Areas

Identification of IAs for all Pacific marine ecoregions used a modified Delphic method. Delphic approaches have been used in similar projects in the USA, Australia, and by Parks Canada to identify sites for use in marine reserve systems (Muldoon 1995). The Delphic method offers certain advantages over direct data acquisition and analysis. First, the time frame for Pacific IA identification was short compared to initiatives completed in other regions, which did not allow for us to undertake extensive data collection and analysis of our own. Second, possible analyses of unfamiliar data sets could lead to erroneous conclusions since each dataset has unique limitations and issues that need to be considered during analysis. Data must be viewed carefully in light of management restrictions, observer effort, gear selectivity, and species biology; all parameters that can influence the interpretation of spatial and temporal patterns and information that is often difficult and/or time-consuming to acquire or access. Finally, some important data (e.g. logbook and bycatch records) were not readily available for analysis by us due to confidentiality agreements. Therefore, soliciting expert opinions from scientists known to already be intimately familiar with existing datasets was used to eliminate potential errors and facilitate completion of the project within the desired timeline. The experience of regional scientific experts also provided valuable information (Scientific Experiential Knowledge) not captured in existing datasets.

Delphic methods are relatively straightforward to apply and allow easy explanation to a wide audience of user groups and managers. Quantitative approaches may sometimes be more scientifically defensible, but in early discussions, we learned that in many cases, relevant data had either yet to be collected or if present (e.g. distribution by life stage, or trawl bycatch data), may not have been analysed, particularly if it was a side attribute of data collected for other reasons, notably a particular species' stock assessment. Our overall conclusion was that an exhaustive quantitative evaluation of the raw data by us was not justifiable at this time.

Because of the previous work done to determine IAs for PNCIMA (Clarke and Jamieson 2006a), regional experts were already largely familiar with the IA concept. To briefly summarize though, regional experts were approached individually or in small groups (all with knowledge on the same species or species group) between October 2008-October 2009 to gather their expert opinions. IAs from experts were spatially drawn by them on paper maps, mostly at a scale of 1:1,000,000 to 1:3,000,000, although some utilized a larger scale (e.g., some of the sponge garden SOG areas were drawn at 1:100,000). Experts either 1) drew polygons themselves on maps, 2) provided polygons of their analysis or 3) provided places names that we then digitized polygons around to identify areas that were felt met the IA criteria, and experts also detailed their rationale for choosing these areas either verbally to the interviewer or later by written submission. Detailed notes were taken during each interview to document the information given and any concerns the interviewee expressed about the IA identification process. Special attention was given to detailing datasets, publications and personal observations that the expert's opinion was based upon.

The paper map from each expert was digitized in ArcGIS 9.2 to produce a thematic layer for each expert consulted. Each expert's layer was given a unique name that included the expert's name and the area of expertise that the layer referred to. The scale of digitization for each polygon was recorded in the attribute table of each GIS theme. The scale at which areas were identified and digitized is important information for future analyses. It provides an indication of the scale at which area boundaries were created and meant to be utilized. Metadata, a standardized text file that describes the data collection process, references to experts, scale, etc, was produced to accompany each thematic layer. On the WCVI, there were 42 species and eight species group thematic layers, while in the SoG there were 21 species and eight species group thematic layers.

A map of the individual layer produced for each expert was returned to that expert for vetting. This allowed the experts to re-evaluate the layer they created and to check for accuracy and completeness in presentation. Comments were then elicited and any changes requested by an expert were made to their layer of IAs.

The Delphic approach works best with a diversity of expert opinion for a given thematic IA layer and as many experts as possible for each layer were thus consulted in the timeframe available. When more than one expert was consulted about a species or habitat feature, that group of experts was treated as a working group. Maps of the initial layers created by individuals in the group were shared with the other members to allow for discussion and evaluation of the IAs identified. Interim maps of potential areas were returned to the working group members as often as needed until consensus was reached. A final map was then returned to the experts in the working group for confirmation. All layers produced during this process were transferred to the Habitat Enhancement Branch (HEB) GIS unit for storage.

We recognize that there is inherent bias in the selection of species included here (e.g., mostly commercial species) and the places where data on these species was collected (areas where fisheries occur). Implications relating to bias associated with commercially important species, charismatic species, spatial variation, and temporal variation is discussed further in Section 6.4.

3.1.2. Ranking Important Areas

For PNCIMA (Clarke and Jamieson 2006a), each expert was asked to identify IAs for the five EBSA criteria (Uniqueness, Aggregation, Fitness Consequences, Naturalness and Resilience). When more than one expert was surveyed and a difference of opinion occurred, the following decision rules were followed only for PNCIMA (they weren't applied for the WCVI and SOG because most of the IAs weren't ranked, or only one expert ranked the polygons):

- $\geq$3 experts: use the value of the majority (e.g. 9, 6, 9 = 9),
  if all different, take the average (e.g. 9, 4, 7 = 7)
- 2 experts: use the highest value (precautionary) (e.g. 8, 6 = 8)

An area's final score was based on the highest ranking of the three primary criteria (Uniqueness, Aggregation and Fitness Consequences). For example, if Area "X" had been given the following scores: Uniqueness and Fitness Consequences "moderate", and Aggregation "high", the area's final Score would be 'high". Having done this though, these rankings of IAs were not ultimately later used in EBSA determinations, although they are part of each IA's metadata.

Under special circumstances, an area's score could be adjusted for extreme rankings in the two weighting criteria: Naturalness and Resilience. A low ranking in Naturalness would push the score down and a low score in Resilience would push the score up. However, these two criteria were not applicable for any of the species and areas examined here, and were not used to adjust rank values. The most relevant application would have been a low Resilience value for corals and sponges, but rankings here were already "high" for both the Aggregation and Uniqueness dimensions.

However, these decision rules weren't applied for the WCVI and SOG because most of the IAs either could not be easily ranked by the experts, or only one expert ranked the polygons. As a result, it was therefore felt that rankings would contribute little to EBSA analysis in the WCVI and SoG areas.

Experts were also asked to evaluate the quality of information available for each identified area on a scale of 1-3 (Data quality). This allowed the evaluation of the confidence in an area's identification. The highest ranking (3) represents detailed information for the area such as density and spatial locations of life history functions. Areas with a data quality ranking of 2 have information such as the spatial extent and occurrence of life history functions and/or modelling information available for habitat use. A data quality ranking of 1 represents only basic information available, i.e. range or occurrence (sightings) and perhaps an educated guess at habitat use.

3.2. DATABASE STRUCTURE

In total, 24 and 41 IA shapefiles were created for the SoG and WCVI, respectively (Tables 1 and 2), for EBSA determination, each with 16 fields of information in the accompanying data tables. Descriptions of the fields can be found in Table 3.

4. IMPORTANT AREA LAYER CHARACTERISTICS

This section describes IAs identified for species, species groupings and habitat features examined for the WCVI and SoG ecoregions, and some additional ones for PNCIMA; it includes some species for which IAs could not be identified to show that these species were in fact considered. Details used in the rationale for IA identification and the datasets experts based their advice upon are provided. Problems associated with IA identification, if any, in each group and recommendations for future analysis are given. A full list of the expert contributors and the species and habitat features investigated is in Appendices I and II, respectively. A listing of the species maps is given in Appendix III.

4.1. ANADROMOUS FISH

Species here are highly migratory with specialized life history strategies that involve both freshwater and marine habitats. Spawning and nursery functions occur in natal freshwater rivers while juvenile and adult feeding and migration occurs in the marine environment. For anadromous fish that return to a natal stream to reproduce, each stream is essential habitat for its stock, giving a high significance for streams bearing these species. Ardron (2003) used a measure of species richness and stream magnitude so that large streams with a high number of anadromous species present would be given the highest scores. This measure places emphasis on the physical characteristics of the stream rather than its biological characteristics. A more meaningful biological measure might include anadromid species richness and escapement magnitudes. Migration routes can bottleneck species on their way to natal streams, but with increasing distance from their natal streams, routes can increasingly vary temporally, such as often occurs around Vancouver Island during El Nĩno events as salmon try to avoid warmer waters.

4.1.1. Salmon

Six species of Pacific salmon (genus *Oncorhynchus*) reside in BC and within the bounds of the WCVI and SoG ecoregions:

1) Coho (O. kisutch),
2) Sockeye (O. nerka),
3) Steelhead (O. mykiss),
4) Pink (O. gorbuscha),
5) Chum (O. keta), and
6) Chinook (O. tshawytscha).

Salmon are maintained in Pacific Canadian waters by identifying and managing conservation units (CUs) under the Wild Salmon Policy (WSP), which reflect their geographic and genetic diversity (DFO 2005). A CU is a group of wild salmon sufficiently isolated from other groups that if lost is very unlikely to recolonize naturally within an acceptable timeframe. There are 412 Pacific salmon CUs that range widely and depend on a variety of habitats from small streams, rivers, coastal waters and the high seas (K. Hyatt, DFO, Pacific Biological Station, Nanaimo, BC, pers. comm.); therefore, a diverse combination of habitats are used by salmon throughout their life history and should all be considered in the identification of IAs. How these habitats can be evaluated under the EBSA criteria (i.e. uniqueness of an area, importance of an area for aggregations, fitness consequences given losses of specific habitat) using knowledge of wild salmon biodiversity (i.e. spatial distribution of CUs and life history stages at local, regional, national, and international scales) (K. Hyatt, pers. comm.) is described below.

Salmon life history stages (spawning, rearing, juvenile migration, ocean rearing and adult migration) can be evaluated under the Fitness Consequences criteria. Wild salmon have been studied extensively resulting in relatively abundant data on their complex life histories; including fitness metrics at different life history stages in various geographic locations (K. Hyatt, pers. comm.). Fitness Consequences can be evaluated from analysis of growth hormone in juvenile salmon (M. Trudel, DFO, Pacific Biological Station, Nanaimo, pers. comm.), which is an indicator of growth rate. Marine survival is strongly positively correlated with growth rate, and varying environmental conditions in different locations affect growth. Locations of juveniles with high growth rates can thus indicate areas which make a positive contribution to their fitness. Most juvenile salmon mortality occurs in their early marine life (M. Trudel, pers. comm.), and so areas used by salmon during this phase are ranked high in Fitness Consequences.

4.1.1.1. River Mouths and Estuaries

Each river mouth and estuary along the BC and Vancouver Island coast is important habitat for salmon (K. Hyatt, pers. comm.). The constricting geographic characteristics of river mouths and estuaries cause aggregations of both landward returning adult salmon that are staging and heading up their natal rivers to spawn and seaward migrating juveniles. These areas are consistently used seasonally and annually and thus are always important. River mouths and estuaries are not ranked against each other as each is an important area to one or more CUs; all river mouths and estuaries are thus captured as IAs, as was the case in PNCIMA (Clarke and Jamieson 2006a).

If ranking were to be done, salmon habitats could be evaluated under the EBSA criteria differently depending on the level of organization (species, stock, or CU) and scale (local, regional, national and international). Different levels of organization need to be considered at different scales because some individual CUs take up a relatively large area and spawn in multiple rivers while others have a strong site fidelity to a single river and occupy a small area. Each outcome of an evaluation of EBSA criteria at different levels of organization and scales would present a different configuration of areas on a continuum of importance. River mouths and estuaries could be evaluated further under the EBSA criteria, for example the larger the river mouth or estuary the greater the biodiversity of CUs (e.g. Fraser > Skeena > Nass > Squamish > Stikine > Iskut) (K. Hyatt, pers. comm.). This information could be evaluated under either Uniqueness (how many different CUs are present at each river mouth or estuary) or Aggregation (how many individuals of a CU are location at that river mouth) criteria.

4.1.1.2. Marine Habitats: Coastal Waters

Juvenile salmon of all marine species are in general distributed in the upper 20 m of the marine water column to the 300 m depth contour just on the continental shelf break (K. Hyatt; M. Trudel, pers. comm.). These spatial data on juvenile salmon distribution come from DNA markers of individual juveniles that are recaptured in surveys, which provides information on specific areas of habitat used by different species, stocks and CUs (M. Trudel, pers. comm.). This does not mean juveniles are not sometimes found beyond the 300 m bathymetric contour, just that they are not found within 20 m of the surface at the time of day they are sampled past the 300 m depth contour (M. Trudel, pers. comm.). The continental shelf was thus identified both as an important forage area for juvenile salmon and a migratory corridor, as juvenile salmon are well distributed across this area and most move from south to north along the coast before heading off Alaska into the open ocean (M. Trudel, pers. comm.). Most juveniles leave BC coastal waters during the winter; however, there are exceptions including Harrison River Sockeye. Their juveniles do not go into a nursery lake after hatching (unlike most other Sockeye stocks), but instead move into the SoG, where they stay until fall. They then leave through Juan de Fuca Strait and feed on the WCVI continental shelf during the winter (M. Trudel, pers. comm.). Another exception is Fraser River Chinook which stay in the SoG for their first year (M. Trudel, pers. comm.).

The WCVI continental shelf has biophysical conditions that are important to the fitness of the rearing juvenile salmon (K. Hyatt, pers. comm.). Some areas within this region are particularly favorable for juvenile salmon, including the edges of banks and shoals which have upwelling and vertical mixing, which results in high plankton production.

The southern Gulf Islands in the SoG are a particularly important area for juveniles of all five salmon species that utilize SoG rivers and lakes for spawning and rearing, typically to the end of May-June, but numbers will vary throughout the year (D. Beamish, DFO, Pacific Biological Station, Nanaimo, pers. comm.).

4.1.1.3. Bottlenecks

The marine habitats salmon occupy are shared by many species and CUs. All inlets along the mainland coast and Vancouver Island are important nearshore rearing areas that can concentrate both juvenile salmon migrating seaward and landward migrating adults (K. Hyatt, DFO, Nanaimo, pers. comm.). We did not attempt to include these individual areas as IAs but based on Aggregation and Uniqueness as described in the river mouth and estuary section, identified the major Straits through which many stocks passed as “bottleneck” areas. The Juan de Fuca, Johnstone and Queen Charlotte Straits are geographic bottleneck areas for salmon leaving or entering the SoG. Most Fraser River Sockeye juveniles move north through the Johnstone Strait (Welch *et al.* 2009), but an exception is the Harrison River population, which leaves through Juan de Fuca Strait (M. Trudel, pers. comm.).

In summary, all salmon river estuaries are considered an IA for their individual stocks. We have not made an attempt to rank the natal areas against each other and most, if not all, these estuaries are currently managed intensively. However, on-going research (e.g., Chittenden *et al.* 2009, Melnychuk *et al.* 2010, Payne *et al.* 2010, Rechisky 2010) from the Pacific Ocean Shelf Tracking (POST) project (POST 2009) is providing new data to evaluate the relative importance of areas for salmon in the marine habitat. For example, recent data (Rechisky 2010) from 2004-2007 indicate that Cultus Lake smolts displayed four migratory behaviours: northward migration to enter the Pacific Ocean via Johnstone and Queen Charlotte Strait; westward migration through the Strait of Juan de Fuca; migration into Howe Sound before continued the migration north; and migration upstream into Cultus Lake. These are the first direct observations of movement and survival for Fraser River sockeye salmon smolts, and at the least show the complexity of salmon migration routes and patterns. There seems to be many potential holding and bottleneck areas in the marine environment, with the only commonality being that smolts in the marine environment stay on the continental shelf through Canadian waters.

However, caution should be taken when making generalizations about areas that are important for different salmon species, stocks or CUs. There are always exceptions to major patterns and a high degree of variability and diversity in salmon life histories; as another example, some juvenile Chinook stay in the SoG for their first summer while most leave for coastal waters and move north in the fall (K. Hyatt, pers. comm.). Some stocks will utilize different habitats depending on local environmental conditions; for example, some Coho stocks remain in the SoG for the summer and in other years, the same stocks move out right away (K. Hyatt, pers. comm.). Lastly marine adult salmon habitats have not been considered here in detail and are still not well described, although their major migration routes have been.

4.1.2. Sturgeon

The Green sturgeon (*Acipenser medirostris*) is a medium sized anadromous fish that is listed as a species of Special Concern under the SARA and by the COSEWIC. Their distribution extends from southern California to Alaska (Hart 1973). There are four Green sturgeon (extant) populations that spawn in different rivers (the Rogue, Klamath-Trinity, Eel, and Sacramento rivers) and these populations have been grouped into two Evolutionarily Significant Units (ESUs, roughly equivalent to COSEWIC's DUs). The implication is that sturgeon spawning in the different rivers are likely reproductively isolated by homing (i.e., belong to demographically isolated populations), but that the populations in the Rogue, Klamath-Trinity, and Eel rivers are closely related and are not considered evolutionarily distinct from one another (see Adams et al. 2007). California's Sacramento River and Basin population is listed as threatened under the federal Endangered Species Act (ESA), and the others are listed as a Special Concern under the ESA.

Adults and subadults from both U.S. populations were acoustically tagged and movements were observed in 2004-2005 with arrays of automated hydrophones deployed along the West Coast of North America from southeast Alaska to Monterey Bay, California (Lindley *et al.* 2008). The Alaska, BC and Washington array are part of the Pacific Ocean Shelf Tracking program (POST 2009). Large numbers were continuously present near the Brooks Peninsula array during May-June 2004 and 2005 and October-November 2005 (Lindley *et al.* 2008). A single fish was detected in southeast Alaska in December, suggesting that some important overwintering grounds may be north of Vancouver Island and south of Cape Spencer, Alaska. There were only a few individuals observed in Queen Charlotte Strait, Juan de Fuca Strait and the northern Strait of Georgia (Lindley *et al.* 2008). The patterns of detection along the west coast of Canada and the U.S. indicate that many green sturgeons make an annual migration north along the WCVI in the fall where they spend the winter in marine waters along or past northern Vancouver Island and south of southeast Alaska, and then migrate south in the spring to spend summers in the coastal waters, bays and estuaries off of Washington, Oregon and California (Lindley *et al.* 2008).

Green sturgeon typically remain in waters less than 100 m deep and spend time in estuaries and bays in U.S. waters (Moser and Lindley (2007) as cited in Lindley *et al.* 2008). It is inferred that they may potentially occupy similar habitats along the coastal waters of BC (D. Welch, Kintama Research, Nanaimo, pers. comm.).

An important area was identified around Brooks Peninsula as well as along the WCVI, as it is believed they must migrate along the coast to reach Brooks Peninsula from their spawning grounds in the U.S. The important area for these fish extends to the 100 m depth contour and includes bays and estuaries, based on research (Moser and Lindley 2007, Erickson and Hightower 2007) that describes their use of these areas in other regions. The fine detail of green sturgeon's habitat use along the WCVI and in the SoG is not known at this time as current POST arrays are only located in selected areas.

White sturgeon (*Acipenser transmontanus*) movement in the marine environment is just beginning to be documented (Welch *et al.* 2006). POST telemetry data on the marine and freshwater movements of a 188-cm (fork length; probably 30–60 years old) white sturgeon over a 19-month period showed that after being tagged in the Klamath River, California, in May 2002, it remained there until emigrating to the ocean in November 2002. It was next detected more than 1000 km away in the Fraser River, British Columbia, where it made extended in-river movements in September and October 2003. Given the long periods of time spent in at least two very different river systems (one clear and one highly turbid), the home river is uncertain. Large-scale movements of white sturgeon outside the "home river" thus occur. However, current data are too limited to determine if specific marine areas are important for this species.

4.1.3. Eulachon

Eulachon (*Thaleichthys pacificus*) is on the BC provincial conservation status blue list (a species of special concern) (BC Conservation Data Centre 2008). There are a total of 33 spawning rivers on the BC mainland coast, but only 14 are utilized regularly (Hay and McCarter 2000). Three of these rivers are within the SoG where eulachon aggregate and spawn between March and May. There are no current spawning rivers located on Vancouver Island (Hay and McCarter 2000). The largest spawning run in the South Coast region occurs in the Fraser River, where eulachon have been observed to migrate 80 to 110 km upriver to as far as Chilliwack and Agassiz (B. McCarter, DFO, Nanaimo, pers. comm.). Two significantly smaller runs occur in the Squamish River at the northern end of Howe Sound and the Homathko River at the northern head of Bute Inlet (Hay and McCarter 2000). The Homathko River run is larger than the Squamish River run; however both are significantly less than the Fraser River (B. McCarter, DFO, Nanaimo, pers. comm.). All three spawning rivers were identified as important areas characterized by distinct spring freshets (B. McCarter and D. Hay, DFO, Nanaimo, pers. comm.). They were assigned high ranks in Uniqueness, Aggregation and Fitness Consequences.

Eulachon larvae are flushed out of the river after hatching and spend 4 to 5 months in the surrounding areas feeding (Hay and McCarter 2000). Bute Inlet, Howe Sound, the Fraser River estuary and the southern Gulf Islands were identified as important larval rearing habitats based on larval and juvenile surveys in the SoG (B. McCarter, DFO, Nanaimo, pers. comm.). Barkley Sound and the inlets along the WCVI are important rearing areas for young juveniles and were identified as important areas (B. McCarter, DFO, Nanaimo, pers. comm.). All larval rearing areas were assigned high ranks in Uniqueness, Aggregation and Fitness Consequences.

Juan de Fuca Strait was identified as an important migratory corridor for older juveniles returning to spawning rivers in the SoG (T. Therriault and B. McCarter DFO, Nanaimo, pers. comm.). Catch compositions from juvenile, adult herring and multi-species trawl surveys in the SoG suggest that the Juan de Fuca Strait is the main migratory route for eulachon returning from WCVI offshore feeding areas (B. McCarter, DFO, Nanaimo, pers. comm.). The migratory corridor was assigned a high rank in Aggregation.

There is, at minimum, a 2-3 year period between hatching and spawning (Hay and McCarter 2000). Older juveniles (ages 1+ and 2+) typically aggregate near the sea floor at moderate depth (80-180 m) (Hay and McCarter 2000, and B. McCarter, DFO, Nanaimo, pers. comm.). Older juveniles are rarely captured in the Strait of Georgia; however, prespawning adults have been captured in the lower Gulf Islands (Hay and McCarter 2000). A summer feeding area has been identified on the WCVI based on incidental catches from shrimp research surveys and analyses of eulachon stomachs (B. McCarter, J. Schweigert, DFO, Nanaimo, pers. comm.). La Perouse Bank is where the largest concentrations of older juveniles have been observed; however incidental catches are also frequently encountered on the Clayoquot and Nootka offshore fishing grounds (B. McCarter, DFO, Nanaimo, pers. comm.). These feeding areas were assigned high in Aggregation.

4.2. MARINE BIRDS

Birds that utilize the marine environment for some part of their life cycle are collectively called marine birds. Different species carry out different life history processes throughout BC, which can include wintering, staging, breeding, moulting and migration. Wintering or overwintering is the time when birds spend the winter in a region where the temperature is warmer and food is more readily available than on their breeding grounds. Staging is preparing for migration; they will stop and feed, often specific locations to build reserves before long flights, and females also use this energy for egg growth. BC is particularly important for staging marine birds on their way to arctic breeding areas (S. Boyd, CWS, Delta, pers. comm.). Moulting is the periodic replacement of feathers by shedding of old feathers. Migration is the regular movement of some species from a breeding location to a feeding location and vice versa.

Marine birds can be broken up into smaller groups based on similar habitat needs and use of the marine environment. Open water species are often referred to as pelagic seabirds and include tubenoses (albatrosses, fulmar, shearwaters, and storm-petrels); cormorants; jaegers, skuas, gulls, and terns; alcids (murres, guillemots, murrelets, auklets, and puffins); and phalaropes, although the latter may also be categorized as shorebirds (McFarlane Tranquilla *et al.* 2007). Waterfowl and their allies include species that commonly breed inland near fresh water but either migrate along the coast during the spring and fall or use marine habitats for moulting and wintering. This group includes loons, grebes, swans, geese, ducks, and cranes. Ducks are sometimes further divided into dabbling ducks, which tend to stay nearshore and in estuaries, and sea ducks or diving ducks, whose habitats include more open marine waters (McFarlane Tranquilla *et al.* 2007). Shorebirds generally breed inland (mostly in the Arctic) but forage along southern sea coasts during winter and spring and fall migration. These birds include plovers, oystercatchers, and sandpipers. Herons are included in this group because they also use nearshore habitats for foraging (McFarlane Tranquilla *et al.* 2007).

Breeding species of marine birds in BC include Ancient Murrelet, Black Oystercatcher, Brandt's Cormorant, Cassin's Auklet, Common Murre, Double-crested Cormorant, Fork-tailed Storm-Petrel, Glaucous-winged Gull, Great Blue Heron, Horned Puffin, Leach's Storm-Petrel, Marbled Murrelet, Pelagic Cormorant, Pigeon Guillemot, Rhinoceros Auklet, Thick-billed Murre, Tufted Puffin and Xantus Murrelet (McFarlane Tranquilla *et al.* 2007). Birds of prey and scavengers live near the coast and use resources from the marine environment but they are not as dependent on the marine ecosystem as are the seabird, waterfowl and shorebird groups (McFarlane Tranquilla *et al.* 2007). No important areas were identified for them in the PNICMA (Clarke and Jamieson 2006) and they were not considered for the WCVI and SoG. In total, there are 175 marine bird species, excluding birds or prey and scavengers (McFarlane Tranquilla *et al.* 2007).

4.2.1. Strait of Georgia

In the Strait of Georgia, the Fraser River estuary, including Boundary Bay, is the largest estuary in BC and is a wintering ground for many marine bird species, particularly hundreds of Trumpeter Swans, tens of thousands of Snow Geese, tens of thousands of duck species and hundreds of thousands of Western Sandpipers (S. Boyd, CWS, Delta, pers. comm.). There are other species of birds present here as well throughout the spring, fall and winter. This IA ranked high in Uniqueness, Aggregation and Fitness Consequences.

Baynes Sound is a particularly important staging area for tens of thousands of birds during the spring herring spawn. The most common species include Brant and Harlequin Ducks (S. Boyd, CWS, Delta, pers. comm.). This IA ranked high in Uniqueness, Aggregation and Fitness Consequences.

Desolation Sound is home to hundreds of summer breeding populations of Marbled Murrelets, which are listed as Threatened under the SARA and by the COSEWIC. They feed in the coastal waters, and some individuals remain there in the winter when there are also three to four thousand Surf Scoters wintering (S. Boyd, CWS, Delta, pers. comm.). This IA ranks high in Fitness Consequences.

There are two main seabird breeding islands in the SoG: Mitlenatch Island and Mandarte island. Mandarte Island is the largest seabird nesting colony in the Strait of Georgia, with Mittlenatch a close second. Counts and estimates of the breeding seabirds have been sporadic over the last three decades, and caution must be used when comparing these surveys site to site and year to year. However, the most recent surveys show that Mandarte supports more than 2000 pairs of Glaucous-winged Gulls, and the largest colonies of Double Crested Cormorants and Pelagic Cormorants in the Strait of Georgia. Estimates of the former and latter cormorants have been much larger in the past (1980's and 1990's) on all colonies in the Strait of Georgia. Mandarte supports breeding Pigeon Guillemots and Black Oystercatchers as well as a few pairs of Rhinoceros Auklets (Chatwin *et al.* 2002, Vermeer and Devito 1989, M. Lemon, CWS, Delta, BC, pers. comm.).

Mitlenatch Island has the second largest seabird nesting colony in the Strait of Georgia, with predominant nesting seabird species (in decreasing order) being glaucous-winged gulls (more than 3,000 pairs), pelagic cormorants, double-crested cormorants, pigeon guillemots, black oystercatchers and rhinocerous auklets (Mitlenatch Island Nature Provincial Park Purpose Statement and Zoning Plan). The island also serves as an important moulting site for post-breeding harlequin ducks and the marine area around it is foraging habitat during the summer for as many as 300 marbled murrelets, a nationally threatened species.

Marine foraging buffer distances from breeding locations set for the Seabird Colony Inventory dataset were dependant upon the species present in the colony but not on size of the colony. Based upon expert opinion, two (cormorants, gulls, guillemots) and five (burrow nesting alcids) km distances were chosen for buffer distances (M. Hipfner and M. Lemon, CWS, Delta, BC, pers. comm.). For multi-species seabird colonies, the buffer distance chosen should be that of the species with the largest buffer present within the colony. The buffered area may not represent the entire foraging range of a species, as some species are known to forage up to 100 km (e.g. Cassin’s Auklet) or more (e.g. storm-petrels) from the colony. Instead, buffers describe a common use area of birds in waters close to the colony (Kenyon *et al.* 2007).

4.2.2. West Coast of Vancouver Island

Important areas along the WCVI include Solander Island off Brooks Peninsula, which has a major seabird colony (M. Hipfner, CWS, Delta, pers. comm.). Solander Island has been identified as a globally significant Important Bird Area by BirdLife International for its globally significant breeding populations (more than 1% of the global population) of Leach's Storm-Petrels, the third largest colony in BC, and Cassins Auklets, the sixth largest colony in BC Nationally significant (more than 1% of the national population) populations of Pelagic Cormorants, Tufted Puffins, Glaucous-Winged Gulls, and Pigeon Guillemots occur as well (BirdLife International 2009b).

Nootka Sound is a wintering ground for thousands of birds including scoters and pelagic species (S. Boyd, CWS, Delta, pers. comm.). This IA ranks high in Uniqueness.

The Tofino mudflats are important to many species of birds during the winter and spring including shorebirds, Brant geese and pelagic species (S. Boyd, CWS, Delta, pers. comm.). This IA ranked high in Uniqueness. There is a major seabird colony near Tofino on Cleland Island (M. Hipfner, CWS, Delta, pers. comm.). Globally significant breeding populations of American Black Oystercatchers, and nationally significant populations of Glaucous-winged gulls, Pigeon Guillemonts, and Leach's Storm-petrels occur on Cleland Island. It is a diverse seabird colony, as in addition, Cassin's Auklet, Rhinoceros Auklet, Tufted Puffin, and Fork-tailed Storm-Petrel also breed there (BirdLife International 2009a).

Clayoquot Sound hosts large numbers of Black Brant which use eelgrass beds during the spring. In the southeast part of the sound, large numbers of Marbled Murrelet occur during the summer (BirdLife International 2009a).

Barkley Sound is an IA for Surf Scoters wintering and in the spring feeding on herring spawn (S. Boyd, CWS, Delta, pers. comm.). Pacific Loons and ducks winter and stage here (S. Boyd, CWS, Delta, pers. comm.). There are also pelagic seabirds present including Gull colonies, Pigeon Gillmonts, Marbelled Murrelets and Pelagic Cormrants (K. Morgan, CWS/IOS, Sidney, pers. comm.). This area ranked high in Uniqueness, Aggregation and Fitness Consequences.

Surface waters at the shelf break and over La Perouse Bank are important feeding areas for many pelagic seabirds. These areas were determined based on at-sea pelagic survey data, which accounts for all identifiable seabirds encountered three km offshore and seaward (K. Morgan, pers. comm.).

Other organizations that have spatially designated areas of importance are described below that could be useful in the identification of IAs. This is not a comprehensive list of available sources of information on important areas for marine birds, but some similar designation processes that we encountered when asking experts about habitat that fit into the EBSA framework. The Canadian Wildlife Service (CWS) identified Areas of Interest (AOI) for migratory bird species in 1992 to provide input into the British Columbia 1991 Protected Area Strategy (Kenyon *et al.* 2007). Most species of seabird, waterfowl, shorebird, raptor, and scavenger are considered "migratory birds" and as such, are protected under the Migratory Bird Convention Act, and managed by Canadian Wildlife Service (CWS) of Environment Canada (McFarlane Tranquilla *et al.* 2007). Thereafter, additional updates were made involving in-house staff workshops that provided published, unpublished and anecdotal information about marine and terrestrial areas known to have significant migratory bird value in BC. The AOIs were formally used in the BC Protected Areas Strategy process, BirdLife International's Important Bird Areas (IBAs), and in other similar processes (Kenyon *et al.* 2007). CWS has updated their AOIs for migratory birds using the greater spatial rigor provided by Geographic Information Systems (GIS) as well as focusing only on marine habitats, and have updated the name to BC's Marine Bird Areas of Interest (MBAOI) (Kenyon *et al.* 2007).

MBAOIs warrant special attention during marine planning processes due to the underlying ecological value of these areas with respect to marine birds. Ecological value is defined in Kenyon *et al.* (2007) as: 1) an area where an observation of large numbers of marine birds have been recorded exceeding a threshold determined by experts, 2) an area where aggregations of marine birds, regardless of species, are likely to occur based on identified habitat characteristics that are important to birds, including all Pacific Estuary Conservation Program identified estuaries previously mapped in BC (Ryder *et al.* 2007) and herring spawn areas ranking in the top 10% (cut off based on expert opinion) of all records based on a herring spawn index, 3) any breeding colony and adjacent area (radius determined by experts) and 4) pelagic areas having high bird species diversity relative to other areas.

BirdLife International has identified IBAs as an international effort to identify, conserve and monitor a network of sites that provide essential habitat for bird populations. Partners include Bird Studies Canada, Nature Canada and BC Nature. The criteria of an area to be designated as an IBA includes: 1) sites that hold endangered or threatened species, 2) birds with restricted breeding ranges (e.g., endemic species), 3) biome-restricted assemblages or unique natural community type and 4) significant numbers of birds when breeding, wintering, migrating (majority of Canadian sites are within this category) (Important Bird Areas of Canada 2009).

There is overlap between BirdLife International's IBAs and the Canadian Wildlife Service's MBAOIs. The 1990-1993 CWS AOIs were used as a basis for many of the IBAs when they were originally designated in the late 1990s. There are nine marine IBAs that are not considered to be MBAOIs and an additional 14 MBAOIs that have not been designated as IBAs (Kenyon et al., 2007), either because they did not meet the criteria at the time or because they have not been reviewed yet (K. Englund, BC Nature, North Vancouver, pers. comm.). Other differences are that MBAOIs are coastal/marine sites and IBAs include all birds and encompass the terrestrial environment. IBAs are driven by global criteria whereas the MBAOIs have a more regional relevance. Offshore IBAs are planned to be designated in the future by BirdLife International (K. Englund, BC Nature, North Vancouver, pers. comm.).

We have not critically considered the IBAs and MBOAIs here under the EBSA criteria and have not used them in the identification of the proposed EBSAs for the WCVI and SOG. Future EBSA assessments and other marine planning processes should consider ways to incorporate this information.

Species with COSEWIC and/or SARA designation may have species-specific important areas under EBSA criteria in the future. Currently listed marine bird species include:

- Ancient Murrelet: Special Concern under the SARA and by the COSEWIC
- Black-footed Albatross: Special Concern under the SARA and by the COSEWIC Great Blue Heron *fannini* subspecies: Special Concern under the SARA and by the COSEWIC
- Horned Grebe: Special Concern by the COSEWIC
- Marbled Murrelet: Threatened under the SARA and by the COSEWIC
- Pink-footed shearwater: Threatened under the SARA and by the COSEWIC
- Short-tailed albatross: Threatened under the SARA and by the COSEWIC

4.3. MARINE MAMMALS

4.3.1. Cetaceans

There are 25 species of cetaceans that have been sighted in BC waters. The following cetaceans considered for IA identification are BC residents that are common to the region and/or are sighted frequently. Information on cetacean spatial distribution comes from three sources: 1) research survey data, 2) opportunistic sightings that are recorded by BC Cetacean Sightings Network (BCCSN), which is a partnership between the Vancouver Aquarium and DFO, and 3) historical whaling data (held by DFO). The last two databases have not been corrected for effort, and so spatial distributions may reflect regions of higher observer effort, such as in denser human-visited areas, and whaling catches may be biased by proximity to whaling stations. There is currently research underway to account for observer effort distribution in the BCCSN at the Vancouver Aquarium (D. Sandilands, BCCSN, Vancouver, pers. comm.). Calving grounds are known for only a few species; some species calve during their yearly migrations.

4.3.1.1. Toothed Whales

Harbour porpoise

The harbour porpoise (*Phocoena phocoena)* is listed as a Special Concern under both SARA and COSEWIC. There is currently a habitat suitability evaluation underway in the southern Vancouver Island region by Anna Hall (UBC, Vancouver, pers. comm.), which should be used when completed to help outline important areas in future analyses. Harbour porpoises use southern Vancouver Island waters year round (Hall 2004). Currently an area from the eastern waters of Juan de Fuca Strait (JFS) to Haro Strait is identified as an important area for the seasonal influx of harbour porpoise during the summer months of April to October (Hall 2004; A. Hall, pers. comm.). The reason for this change in seasonal distribution is currently unknown, so it may be unique or possibly representative of other areas (Hall 2004 and A. Hall, pers. comm.). This area currently ranks high in Aggregation.

Other areas of high abundance based on reliable sightings include the area surrounding Moresby Island in the SoG-JFS which extends from the south end of Salt Spring Island to South Pender Island and south to the northern tip of Sidney Island (A. Hall, pers. comm.). A second region extends along the southern shore of Saturna Island. A third region occurs west of Race Rocks to Otter Point and extends from shore to a depth of 120 m. Harbour porpoises typically occupy waters to this depth and less (A. Hall, pers. comm.). All three areas have relatively high harbour porpoise abundance from April to October. These regions all rank high in aggregation, but not as high as the first region mentioned. The densities of these animals vary considerably during this time; large groups may be observed on some days and then they break apart and are spread out on others (A. Hall, pers. comm.). It is not known if harbour porpoise migrate but their calves are seen in these regions.

There are also high abundances of harbour porpoise in Clayquot sound (J. Ford, DFO, Nanaimo, per. comm.). Harbour porpoises are observed in other areas in the SoG and WCVI, but the importance of these regions is less well understood for this species and therefore no other areas of importance could be identified at this time.

Other Porpoises/Dolphins

Dall's porpoise (*Phocoenodies dalli*) and Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) are both wide ranging species on the WCVI and in the SoG. There are no known IAs for these species at this time (L. Spaven and J. Ford, DFO, Nanaimo, pers. comm.)

Killer Whale

Killer whales (*Orcinus orca*) are divided into three ecotypes: 1) residents, 2) transients and 3) offshores. Residents are further divided into two distinct populations: northern and southern. The southern residents range includes the WCVI and SoG regions. This population has been designated endangered by both COSEWIC and SARA. An important area was identified for the southern resident killer whales based on the critical habitat identified in the recovery strategy (DFO 2008c; J. Ford, DFO, Nanaimo, pers. comm.). It should be noted that the critical habitat extends into U.S. waters. This area represents a very important concentration area for the southern resident killer whales as well as an important foraging range during the period of salmon migration for the entire southern resident community. This area is typically used by the three southern resident pods (J, K, and L) during June through October. There are also specific areas within this critical habitat range that are especially important for foraging (DFO 2008c). This area was extended to include the Swiftsure Bank region, which also is an area of high concentration. This area ranks high in Uniqueness, Aggregation and Fitness Consequences.

Transient killer whales are wide ranging and constantly moving to surprise and target their prey and therefore no particular areas could be identified as IAs at this time (J. Ford, pers. comm.). No areas were identified for the offshore killer whales as they are less well understood.

Sperm whale

Sperm whales (*Physeter macrocephalus*) are an offshore deep diving species. An important area was identified from the shelf break and offshore to the WCVI boundary (J. Ford; L. Spaven, DFO, Nanaimo, pers. comm.). This area was based on whaling data, sightings from the BCCSN, research survey data and expert opinion. It ranked moderate in Uniqueness, Aggregation and Fitness Consequences

4.3.1.2. Baleen Whales

Grey whale

The eastern North Pacific population of grey whales (*Eschrichtius robustus*) is designated as Special Concern under SARA and COSEWIC. They migrate north from breeding grounds in Baja California, Mexico, along the west coast of Vancouver Island from February to May to their feeding grounds in the Bering Sea (DFO 2008b). Most individuals are seen within five km of the shore (J. Ford, pers, comm.; B. Gisborne, DFO, Nanaimo, pers. comm.). This migratory corridor was identified as an important area and ranked high in Aggregation and Fitness Consequences (J. Ford, pers. comm.). This is northward migration, and the southward migration corridor is not well known, i.e. in terms of mapping it along west coast of Vancouver Island (L. Nichol.,pers. comm.) A summer resident population of grey whales remains in British Columbia along the west and northern coast of Vancouver Island. There are productive foraging habitat areas where individuals of this population are seen annually (B. Gisborne, pers. comm.) and these were identified as IAs. Both populations migrate south again from December to January to their breeding grounds (DFO 2008b). The exact migratory route is not well understood, but evidence suggests they move further offshore during this time (B. Gisborne, pers. comm.).

Humpback whales

The North Pacific population of the humpback whale (*Megaptera novaeangliae*) is listed as Threatened under COSEWIC and SARA. They have a widespread occurrence in BC waters and occupy a range of habitats including narrow channels and straits, inshore areas, waters over the continental shelf, as well as deep oceanic waters (Ford *et al.* 2009). They spend the spring through fall in productive cool waters in high latitudes, such as waters of the WCVI and historically, in the SoG, and then in late fall most humpbacks migrate to their lower latitude breeding areas. There is considerable intra- and inter-annual variation in the distribution of humpbacks in BC waters (Ford *et al.* 2009). Historically they were abundant in the SoG, but were extirpated from there by whaling. While we know whaling occurred in the Strait of Georgia, there are no whaling records from that era with which to identify even historical IAs in the Strait. This is noted because historical whaling data is used to inform IAs for other large whale species and humpback whale IAs on the west coast of Vancouver Island and in PNCIMA (L. Nichol, pers. comm.)

There are areas of concentration, such as the southwestern coast of Vancouver Island (Ford *et al.* 2009). This region includes La Perouse, Swifture and Amphitrite Banks and was identified as a consistently utilized important feeding area with high concentrations of their main prey source euphausiids (J. Ford, pers. comm.). They are also frequently sighted around Tofino and Clayoquot Sound (L. Spaven, pers. comm.) and this region extending offshore is also included in the important area. Since 2004, many animals have been observed in and around Barkley Sound feeding on the sardines (J. Ford, pers. comm.), and so this area was also identified as an important area, and the whole region ranks high in Uniqueness, Aggregation and Fitness Consequences.

Northern right whale

The northern right whale (*Eubalaena japonica*) is listed as Endangered under both COSEWIC and SARA. There has not been a sighting in BC waters for over 50 years (L. Spaven, pers. comm) and due to extreme rarity, no area could be identified as an IA for this sepcies. There is a lack of information and understanding on the habitat use of this species (COSEWIC 2004).

Blue, Sei and Fin Whales

The blue whale (*Balaenoptera musculus*) and sei whale (*Balaenoptera borealis*) are both listed as Endangered by both COSEWIC and SARA, and the fin whale (*Balaenoptera physalus*) is listed as Threatened. Sightings of blue whales are extremely rare in post whaling years. Based on habitat use in the north, historical whaling records and expert opinion, an area of importance for all three species was identified from the shelf break and offshore (J. Ford and L. Spaven, pers. comm.). This area ranks moderate in Uniqueness, Aggregation and Fitness Consequences.

4.3.2. Pinnipeds

Pinnipeds require stable land habitat for haulout purposes for proper skin metabolism and predator avoidance, typically isolated islets or rocks with water access and refuge from adverse weather conditions. The spatial occurrence of pinniped haulouts differs between species and is affected by the size of foraging grounds available around each haulout area. Sea lions and elephant seals undergo significant migrations for feeding, breeding and/or moulting, while harbour seals reside in the same general locations year round.

4.3.2.1. Harbour seal

Harbour seals (*Phoca vitulina*) are non-migratory year round residents of BC and are typically found within 20 km of land. There is a single widely distributed population with lots of mixing of individuals between localized sites, and they do not aggregate to breed. The BC population is part of the eastern Pacific subspecies (*P. v. richardsi*), one of five geographically separated subspecies in the northern hemisphere, which occurs from Baja California to the Aleutian Islands (DFO 2009d). Spatial information on harbour seal distribution comes from aerial survey data, which has covered about 82% of the BC coast, and time-depth recorders deployed on seals (DFO 2009d). Approximately 500 haulout sites occur between the WCVI and in the SoG

(P. Olesiuk, DFO, Nanaimo, pers. comm.). Harbour seals aggregate on haulout sites to rest, moult and give birth. Birthing season varies regionally with most pups being born between early-July and late-August in southern BC. Among all haulout sites, a relatively small proportion makes up the most important haulouts that support most of the harbour seal population in BC (P. Olesiuk, pers. comm.). Individual haulout sites chosen for important area identification include about 10% of all the haulout sites on the WCVI and in the SoG, which generally support about half the total population (27 sites support 48% of the WCVI population and 22 sites support 51% of the SoG population) (P. Olesiuk, pers. comm.). Haulout locations include a ten km foraging buffer, which is the typical foraging range. These areas rank moderate in both Aggregation and Fitness Consequences.

4.3.2.2. Steller sea lion

Steller sea lions (*Eumetopias jubatus*) are widely distributed in the SoG and on the WCVI. They are listed as a Special Concern under the SARA and by the COSEWIC. Spatial information comes from aerial surveys (DFO 2008d). They aggregate at three types of haulout sites: breeding (rookeries), year round and winter haulouts. Males arrive at rookeries in May, and the pregnant cows arrive on rookeries throughout June. During the summer, non-breeding individuals are found at year-round haulout sites. In August, animals disperse from rookeries to feed and begin to occupy numerous winter haulout sites (DFO 2008d). Numbers at haulout sites vary widely seasonally and from year-to-year (P. Olesiuk, pers. comm.). All four rookeries are in the PNCIMA LOMA, which includes the Scott Islands off the north tip of Vancouver Island, Cape St. James off the southern tip of Haida Gwaii (previously called the Queen Charlotte Islands), on the Sea Otter Group off the central coast and on North Danger Rocks off the northern mainland coast (DFO 2008d). Haulout sites that are still currently in use with over 500 animals were identified as important areas, with 17 km of surrounding foraging area (P. Olesiuk, pers. comm.) (note: this is smaller then the 50 km foraging rane used by Clarke and J *lurida lurida lurida lurida* amieson (2008a) for PNCIMA). This includes one site for the SoG and 11 for the WCVI. These areas rank moderate in both Aggregation and Fitness Consequences.

4.3.2.3. Northern fur seal

Northern fur seals (*Callorhinus ursinus*) are pelagic and do not haulout in BC. They are listed as Threatened by the COSEWIC, and have no SARA status. There are six rookeries in the Pacific, all outside of BC and after the breeding season (May to November), they migrate to feeding grounds and remain at sea. Approximately 375,000 northern fur seals winter along the west coast of North America during December to June, with about one-third of those inhabiting coastal waters off British Columbia during peak abundance in May (DFO 2007c). During migration, they range from five to 100 km from shore (P. Olesiuk, DFO, Nanaimo, pers. comm.). The largest concentration of sightings occurs off the southwest coast of Vancouver Island (DFO 2007c); an area around La Perouse Bank encompasses 50% of the research sighting records from 1958-1974, and this area is identified as an important area (P. Olesiuk, DFO, Nanaimo, pers. comm.). Historical data indicated the wintering area was utilized predominantly by adult females that forage primarily on herring (DFO 2007c). This area ranked high in Aggregation and Fitness Consequences.

4.3.2.4. California sea lion

California sea lions (*Zalophus californianus*) are distributed from Baja California to Vancouver Island, BC, but only adult males migrate to BC to over-winter. The current northern limit in the SoG is Campbell River, and on the west coast of WCVI is Nootka Sound (P. Olesiuk, pers. comm.). No important areas are identified at this time.

4.3.2.5. Northern elephant seal

Northern elephant seals (*Mirounga angustirostris*) migrate widely throughout the northeast Pacific but there are no estimates of abundance or distribution in Canadian waters (P. Olesiuk, pers. comm.). They occur mainly offshore beyond the continental shelf and therefore no important areas were identified in BC.

4.3.3. Sea Otter

The sea otter (*Enhydra lutris*) is listed as a Special Concern under the SARA and by the COSEWIC. Sea otters were reintroduced to BC from 1969-72 (Bigg and MacAskie 1978). Distribution from the shore is largely limited by the sea otter's ability to dive to the sea floor for food, which occurs at depths of 40 m or less (Nichol et al. 2009). An important area was identified for their current range along the WCVI to this depth, which typically extends one to two km offshore; however some individuals of the population will move further offshore and dive deeper to feed (Nichol et al. 2009). This area was identified for high Aggregation and Fitness Consequences as sea otters are non-migratory and perform all their life history stages in their range (L. Nichol, DFO, Nanaimo, pers. comm.). Sheltered areas that support soft sediment bivalves may be important to sea otter diets during the winter season (Nichol et al. 2009). The inlet boundaries of the WCVI important area were based on a model of spatial distribution of predicted optimum habitat based on bathymetric complexity (Gregr *et al.* 2006). This model supports expert opinion that the sea otter range will continue to expand and ultimately occupy Barkley Sound and Juan de Fuca Strait. There are currently some sightings of individuals in Barkley Sound (L. Nichol, pers. comm.). Individuals from the BC population as well as the Washington State population around Cape Flattery could also move into these regions (L. Nichol, pers. comm.). There were no important areas identified for the SoG as there are no current or known historic ranges in this region.

4.3.4. Elasmobranchs

There are fourteen species of shark, ten species of skate and three species of ray found in BC waters (Benson *et al.* 2001). Information on the spatial distribution of elasmobranches in BC waters described in the following section comes from research and commercial catch data (trawl and longline) and bycatch data compiled by Sandy McFarlane (DFO, Nanaimo, pers. comm; unpublished data in prep.). Shark bycatch records date back to 1984 and in 1996, there was an improved reporting of catches (Benson *et al.* 2001). Skate catches date back to 1954 and since 1996, big and longnose skates have been targeted by the trawl fishery. Because at-sea observers have now placed on most trawlers, more accurate reports are now available. Species identification has also improved over time. DFO has conducted research surveys approximately every two years since 1984 using bottom and mid-water trawl gear in southern and northern Hecate Strait; some skate species were captured incidentally and biological data was taken (Benson *et al.* 2001).

In the following section, when a species is referred to as rare or common, it means only in terms of catches and therefore does not necessarily mean that the species itself is abundant or rare in the ecosystem. The species that are considered common to BC have important areas identified and mapped based on their distributions of catch data. Species with less than ten data records are considered rare and do not have any distributions mapped. Lastly, if a species is widely distributed across the SoG and WCVI large ocean management areas (LOMAs), then no particular areas stand out and therefore no areas are mapped. However, this does not mean that there are not any important areas for that species under the EBSA criteria.

4.3.5. Sharks

4.3.5.1. Spiny Dogfish

The spiny dogfish (*Squalus acanthias*) is distributed in the eastern Pacific from Baja, California to the Bering Sea, but is most abundant between northern California and northern BC (Hart 1973). They are found from the intertidal down to at least 900 m depth, but are usually near the bottom (Compagno 1984). They are widely distributed in BC's inshore and offshore waters (Wallace *et al.* 2008). It is thought that there is an offshore coastal stock and two inshore stocks, one in the SoG and the other in Puget Sound (Wallace *et al.* 2008). Tagging studies have shown limited movement of fish from the SoG and limited, but also some very extensive migrations of offshore fish (McFarlane and King 2003; Wallace *et al.* 2008). Spiny dogfish are the only targeted commercially fished shark species in BC waters (Benson *et al.* 2001). Two pupping areas are known for the SoG in the late fall (October to November), one around Mitlenatch Island and another off of Thormanby Island extending into the mouth of Malaspina Strait (S. McFarlane, pers. comm.). These two locations were identified as important areas. Dogfish do pup off the WCVI but the exact locations are not known (S. McFarlane, pers. comm.).

4.3.5.2. Basking shark

The basking shark (*Cetorhinus maximus*) is listed as Endangered by the COSEWIC. Historically they were abundant in many areas off the BC coast including the WCVI, SoG and Queen Charlotte Sound (COSEWIC 2007a). Evidence supports their preference for habitats where oceanographic events concentrate zooplankton, typically fronts where water masses meet, headlands and around islands and bays with strong tidal flow. Recent evidence also suggests that they may utilize habitats at greater than 1000 m depth. A decrease in numbers is attributed to fisheries for liver oil (1941-1947) and a government eradication program between 1945 and 1970 (COSEWIC 2007a). Historical centers of concentration and where recent sightings (1999-2008) have occurred on the WCVI include Barkley Sound, and Clayquot Sound (McFarlane *et al.* 2008); these locations are identified as important areas (S. McFarlane, pers. comm.).

4.3.5.3. Bluntnose sixgill shark

The bluntnose sixgill shark (*Hexanchus griseus*) is listed as a Special Concern by the COSEWIC and under the SARA. They are regularly taken as bycatch in BC fisheries (Benson *et al.* 2001). The sixgill shark is a widely distributed deepwater benthic species occurring over the continental and insular shelves and upper slopes associated with areas of upwelling and high biological productivity (Ebert 2003 as cited in COSEWIC 2007b). They occur in BC waters from the surface to 2000 m depth (S. McFarlane, pers. comm; unpublished data in prep.). Young sharks inhabit shallower waters and move into deeper waters once they reach adolescence. Immature sharks regularly come up into shallow waters allowing SCUBA divers to observe them. Flora Islet off Hornby Island in the SoG is one location where this occurs and is globally unique as there are few places where sixgill sharks can be observed regularly in shallow waters (COSEWIC 2007b). In a 1994 study along the WCVI, juveniles of both sexes were tagged and areas around these locations were identified as important areas (S. McFarlane, pers. comm.). They include locations within Barkley, Clayquot, Nootka and Kyuquot Sounds (COSEWIC 2007b). It is suspected by Dunbrack (pers. comm., cited in COSEWIC 2007b) that the SoG and other near-shore areas along the BC coast are primarily nursery areas and that mature sharks are found primarily offshore. This is consistent with the movement pattern proposed by Ebert (2003, as cited in COSEWIC 2007b) for other locations.

4.3.5.4. Other sharks

Most of the information about the following sharks is from S. McFarlane (pers. comm.). The sevengill shark (*Notorynchus cepedianus*) is a resident year-round shark that is found mainly offshore and typically shallow, but is found from the surface to 500 m depth. There have been no sightings in the SoG. Larger individuals range in deeper offshore water and deep channels and bays (Compagno 1984). No important areas were identified for this species at this time.

The brown cat shark (*Apristurus brunneus*) is demersal and common throughout BC waters including the WCVI, SoG, outer Queen Charlotte Sound and northwest of Haida Gwaii. They are found from 300-500 m and an important area was identified in the SOG and the WCVI in this depth range.

The Pacific sleeper shark (*Somniosus pacificus*) is a fairly common bottom shark on the WCVI, the deeper portion of Queen Charlotte Strait, the northwest side of Haida Gwaii, and Dixon Entrance in deep water from 200-700 m. An important area was identified between this depth range and in the deeper portion of the basins off Barkley Sound; no Pacific sleeper sharks have been observed in the SOG.

The following pelagic sharks are commonly found, often near the surface in the summer and are highly migratory. No important areas have been identified at this time as they are so widely distributed.

- The soupfin or tope shark (*Galeorhinus galeus*) used to be very abundant off the WCVI, but is often still caught in surface waters off the WCVI, Queen Charlotte Strait and Hecate Strait;
- The blue shark (*Prionace glauca*) is common on the WCVI, Queen Charlotte Strait, northwest side of Haida Gwaii, Hecate Strait and intermittently in the SoG. They are usually seen in the summer and sometimes during warm winters;
- The salmon shark (*Lamna ditropis*) is seen intermittently in surface waters on the WCVI, Queen Charlotte Strait, northern Hectate Strait and the West coast of Haida Gwaii; and
- The common thresher (*Alopisa vulpinus*) is fairly common off the WCVI, intermittently in Queen Charlotte Strait, Hecate Strait and northwest of Haida Gwaii. and sometimes in the southern SoG.

The following are rare, highly migratory pelagic sharks often found near the surface and only in the summer. Due to their rare occurrence no important areas have been identified:

- The great white shark (*Carcharodon carcharias*) - only a couple records off the WCVI and in Hecate Strait;
- The shortfin mako (*Isurus oxyrinchus*) - only had one record in BC waters;
- The green-eyed shark (*Etmopterus* spp) has a few catch records off the WCVI.; and
- The bigeye thresher (*Alopias superciliosus*) has a few records off the WCVI.

4.3.6. Skates

Skates and rays are dorsal-ventrally flattened cartilaginous fishes that inhabit the benthic environment (Hart 1973). The longnose skate (*Raja rhina*) is commercially caught (Benson *et al*. 2001). All the following information on skates is from S. McFarlane (pers. comm.). It is abundant off the WCVI, Queen Charlotte sound, northwest coast of Haida Gwaii, Hecate Strait, Dixon Entrance and is fairly common in the SoG from 50-700 m, but the majority are caught between 200-300 m. An important area was identified in this depth range for the WCVI and SOG.

The big skate (*Raja binoculata*) is commercially caught (Benson *et al*. 2001). They are abundant off the WCVI, southern Queen Charlotte Sound, west coast of Haida Gwaii, Dixon Entrance and Hecate Strait from 50-1000 m, but the majority are caught between 100-300 m. Their egg cases are seen in Northern Hecate Strait around Dogfish Bank, with some around Goose Island Bank. An important area was identified in this depth range for the WCVI and SoG.

The deepsea or abyssal skate (*Bathyraja abyssicola*) is found from depths of 400-2000 m on the WCVI, Queen Charlotte Sound, the northwest coast of Haida Gwaii and intermittently in the deep waters of Hecate Strait, but none have been observed in the SoG. An important area was identified in this depth range for the WCVI.

The sandpaper skate (*Bathyraja interrupta*) is a common skate found along the entire WCVI, around the Gulf Islands in the SoG, Queen Charlotte Strait, and intermittently in Hecate Strait and Dixon Entrance from 20-1300 m, but the majority are between 300-500 m. An important area was identified around the southern Gulf Island and this depth range for the WCVI.

The roughtail or black skate (*Bathyraja trachura*) is found along the WCVI, Queen Charlotte Strait and the northwest coast of Haida Gwaii from 200-1800 m, but none are found in the SoG. An important area was identified in this depth range for the WCVI.

The Alaska or flathead skate (*Bathyraja rosispinis*) is found on the WCVI, intermittently in the Gulf Islands, Queen Charlotte Strait, northwest coast of Haida Gwaii and Dixon Entrance from 200-1000 m. An important area was identified in this depth range along the WCVI.

The following skates are rare and therefore no important areas were identified:

- The Aleutian skate (*Bathyraja aleutica*) has only a few records off the WCVI, none in the SoG and is found intermittently in southern Hecate Strait and Dixon Entrance;
- The broad skate (*Raja badia*) has only a few records on the WCVI and Queen Charlotte Strait and none in the SoG;
- The whitebrow skate (*Bathyraja minispinosa*) has only one documented record; and
- The California skate (*Raja inornata*) is extremely rare off of BC.

4.3.7. Rays

Most information on BC rays below is from S. McFarlane (pers. comm). The Pacific electric ray (*Torpedo californica*) is fairly common off the WCVI, Queen Charlotte Strait and less common in northern BC and the SoG.

Stingrays are most commonly in the tropics but do venture into temperate waters (Hart 1973). The pelagic stingray (*Dasyatis violacea*) has only a couple of records off the WCVI. There are no official catch records of the diamond stingray (*Dasyatis dipterura*) in BC (Gillespie 1993). They are rarely reported north of southern California (Eschmeye and Herald 1983, as cited in but there is a strong possibility that they could be in southern Canadian waters.

4.4. GROUNDFISH

Groundfish are a diverse group of species that are demersal or benthic. They can be divided into four general groups with similar characteristics: elasmobranches, roundfish, flatfish and rockfish. Elasmobranchs are discussed separately above, and the other groups will be discussed in the following sections, with some species discussed in greater detail with regards to their IAs. Previously during the PNCIMA EBSA process, IAs for groundfish were based on a 1985 map folio published by the West Coast Offshore Exploration Panel (Clarke and Jamieson 2006a). This map folio contains spawning and rearing locations for fifteen groundfish species for only the north coast. This reference could not thus be used for the WCVI and SoG IA identification processes.

Additional research data would help in the application of EBSA criteria to the large groundfish group. There are 77 species landed and 27 different groundfish stocks assessed and subject to annual allocations in six different management areas (Stocker *et al.* 2001). A species by species approach may not be the best approach in the EBSA process given the large numbers of species in this group. Most available information is on adults from catch data, and information is limited on locations of spawning and rearing grounds, migratory pathways and critical habitat for these species (Lucas *et al.* 2007). Research surveys should be utilized in this process as they provide a fishery-independent assessment of groundfish distribution. Other sources of information for groundfish are discussed in the Groundfish ecosystem overview for PNCIMA (Fargo *et al.* 2007), and should be considered further under the EBSA criteria. Given the limited resources in the current IA determination, data from these information sources were not directly incorporated.

Adult groundfish are fished commercially and most available data are relevant only to this life stage. There is little information available on other life history stages (A. Sinclair, DFO, Nanaimo, BC, pers. comm). There has been little work done in the SoG since the 1930's and 40's in groundfish, as there is currently a very limited commercial groundfish fishery there (only 3-4 small trawllers) (J. Fargo, DFO, Nanaimo, BC, pers. comm.). The current mandate is to study fished species where fisheries are occurring and the departmental priority is to do stock assessments on those species. There have been three surveys since 2004 and the information for those could be used (G. Workman, DFO, Nanaimo, BC, pers. comm). Since the PNCIMA EBSA analysis was conducted in 2006, new databases have become available (fishery-independent groundfish survey datasets started off Queen Charlotte Sound in 2003, the WCVI in 2004, Hecate Strait in 2005 and the west coast of Haida Gwaii in 2006) that seem like they could be valuable to the EBSA process, although they haven't been used yet in EBSA identification (A. Sinclair, pers. comm.). A reanalysis of PNCIMA groundfish IAs is not attempted here.

IAs are identified for Pacific Cod (*Gadus macrocephalus*), Walleye Pollock (*Theragra chalcogramma*), Lingcod (*Ophiodon elongatus*), Sablefish (*Anoplopoma fimbria*) and Pacific Halibut (*Hippoglossus stenolepis*) as single species IAs. The other IA maps represent more than one species, such as the 'flatfish' grouping, which consists on the WCVI of Petrale sole (*Eopsetta jordani*), Rock sole (*Lepidopsetta bilineata*), Dover sole (*Microstomus pacificus*), and English sole (*Parophrys vetulus*).

4.4.1. Pacific Cod

Pacific cod are widely distributed across the continental shelf and upper slope of North America and Asia (Westrheim 1996) to 550 m depth (Hart 1973). There are four stocks defined for management purposes on Canada's west coast: SoG, WCVI, Queen Charlotte Sound and Hecate Strait; tagging studies indicate there is very little movement of individuals among areas (Stocker *et al.* 2001). Pacific cod make a seasonal migration between shallow waters in the spring and summer and deeper waters in fall and winter (Stocker *et al.* 2001). Within the SoG, migration patterns indicate there are four stocks: a resident stock in the central and western Strait, Gulf Islands, Juan de Fuca Strait, and a highly migratory stock that spawns in Nanoose Bay (Schmitt *et al.* 1994). Spawning occurs between December and May (Westrheim 1996); and they spawn at depths between 55 and 90 m (Ketchen *et al.* 1983). Spawning locations include southwest Vancouver Island, which is closed to fishing from January to March during the spawning period, defined by the boundaries of the closed area in the Groundfish Integrated Fisheries Management Plan (DFO 2010). Spawning areas in the SoG include Nanoose Bay from which they then disperse mainly to the southern part of the Strait (Westrheim 1981, as cited in Ketchen *et al.* 1983) and may include the Hornby Island-Cape Lazo area and Swanson Channel (Ketchen *et al.* 1983). Pacific cod are broadcast spawners and fertilized eggs are adherent and sink to the bottom where hatching occurs. Juvenile cod are commonly associated with sand-eelgrass habitats (Schmitt *et al.* 1994). The distribution of eggs and larvae are probably limited to the spawning grounds; however it is not known how far larvae drift from their hatching sites. A possible analysis to identify rearing areas could include assessing Groundfish surveys and looking at locations of juvenile size frequency catches to see if any areas stand out (A. Sinclair, pers. comm.).

4.4.2. Rockfish

Rockfish are traditionally divided into three groupings based on their life history characteristics and habitat preferences: Inshore, Shelf and Slope Rockfish. In total there are 35 species in the genus *Sebastes* and two in the genus *Sebastolobus* (Hart 1973). In general they are slow growing, long lived and late maturing; they are primarily benthic and non-migratory (Lucas *et al.* 2007).

Inshore: Inshore rockfish species primarily caught by hook-and-line gear in subsistence, recreational and commercial fisheries include: Yelloweye (*Sebastes ruberrimus*), Quillback (*S. maliger*), Copper (*S. caurinus*), China (*S. nebulosus*) and Tiger rockfish (*S. nigrocinctus*) (Stocker *et al.* 2001). The Yelloweye rockfish is listed as Special Concern by the COSEWIC. Habitat includes any complex rocky bottom between 0 and 200 m in depth; no particular areas within this habitat type stand out at this time in the context of the EBSA criteria (L. Yamanaka, DFO, Nanaimo, pers. comm.). Rockfish Conservation Areas (RCAs) were established along the BC coast in 2002 and there are currently 164 sites. These sites are closed to fishing of rockfish species in order to protect a portion of the inshore rockfish stock (DFO 2007d). It is not known at this time if specific RCAs justifications meet the EBSA criteria.

Shelf: Five species of shelf rockfish: Bocaccio (*S. paucispinis*), Widow (*S. entomelas*), Silvergray (*S. brevispinis*), Canary (*S. pinniger*), and Yellowtail (*S. flavidus*) prefer high relief bottom rocky substrates on the continental shelf and are typically caught at depths from 100 to 300 m around the shelf break (R. Stanley, DFO, Nanaimo, pers. comm.). This region is where most data comes from for adults and late juveniles of these species; the younger juvenile stages are less well understood (R. Stanley, pers. comm.). The Canary rockfish is listed as Threatened by the COSEWIC. Shelf rockfish can also be found in the SoG and likely occur in inlets on Vancouver Island and the mainland coast in areas of deeper water (R. Stanley, pers. comm.). Thus all these regions are important shelf rockfish habitat and, given the available information, there are no particular areas in these regions that currently stand out as being more important based on the EBSA criteria (R. Stanley, pers. comm.).

Slope: Seven species of slope rockfish are assessed by DFO on the WCVI: Pacific Ocean Perch (*S. alutus*), Yellowmouth (*S. reedi*), Redstripe (*S. proriger*), Rougheye (*S. aleutianus*), Shortraker (*S. borealis*), Shortspine thornyhead (*Sebastolobus alascanus*), and Longspine thornyhead (*Sebastolobus altivelis*). Longspine thornyhead and the Rougheye are listed as a Special Concern under both COSEWIC and by the SARA. All these species utilize different depths and have different preferences for bottom type; no particular areas stood out in the context of the EBSA criteria (R. Haigh, DFO, Nanaimo, pers. comm.). Suggestions for sources of information that could be utilized in this process include: contacting the Canadian Groundfish Research and Conservation Society (CGRCS), and looking at integrated management plans, which discuss closed areas (for example, for a spawning season or area of a species); CSAS research documents, which include information on distributions, depth ranges and analyses such as cluster that highlight areas where a lot of different species are occurring; and lastly, COSEWIC reports that examine important habitats (R. Haigh, pers. comm.).

4.4.3. Flatfish

Flatfish are asymmetrical, have both eyes on the same side of their head and are typically found on the bottom but can make forays to the surface (Hart 1973). There are two families, Family Bothidae contains two species in BC with eyes on the left hand side of their head, and Family Pleuronectidae contains 19 species in BC that usually have eyes on the right hand side of their head (Hart 1973). Newly hatched larvae are symmetrical and free swimming as plankton but during development one eye migrates to one side of the head and the transformed fish settles to the bottom, blind side down (Hart 1973). Nursery areas for juveniles include any shallow areas on the coast including bays and inlets from 10-40 m (J. Fargo, pers. comm.). Flatfish spawn in the winter and their eggs incubate and rise in the seawater where after four to six weeks they hatch and drift with other ichthyoplankton before settling out as juveniles on the sea floor.

Species that make up 95% of the landings from the BC trawl fishery include: Rock, English, Petrale, Dover, Butter (*Isopsetta isolepis*), Sand (*Psettichthys melanostictus*), Flathead (*Hippoglossoides elassodon*) and Rex sole (*Glyptocephalus zacharius*), Pacific halibut (*Hippoglossus stenolepis*), and Arrowtooth flounder (*Atherestes stomias*) (Fargo *et al.* 2007). Species that comprise 95% of the landings in the hook and line fishery include three of the above species: Pacific Halibut, Rock sole and Arrowtooth flounder (Fargo *et al.* 2007). Species considered in our analyses include all the above species as well as ones that are caught to a much lesser extent and are not of commercial interest: Curlfin sole (*Pleuronichthys decurrens)*, Deepsea sole *(Embassichthys bathybius),* and Pacific Sanddab (*Citharichthys sordidus*).

During the PNCIMA analyses it was concluded to be difficult to identify IAs based on high densities of catches as a proxy for aggregations (Clarke and Jamieson 2006). This issue also applies on the WCVI for flatfish, but some IAs have nevertheless been identified.

The Uniqueness criterion is difficult to evaluate for flatfish as they are specific to sediment type and we would have to examine the habitat of the species where they are observed and/or caught in surveys (J. Fargo, pers. comm.). The Fitness Consequences criterion is also challenging to evaluate as there is not a lot of information available for most flatfish species on locations of different life history stages. When species are caught in fisheries or surveys, it is not typically known whether the individual was spawning, feeding or in transit (J. Fargo, pers. comm.). Some locations of life history stages are known for certain species and were identified in the PNCIMA process (Clarke and Jamieson 2006a) and are described in more detail in Lucas et al. (2007).

4.4.4. Flounders and Soles

On the WCVI, Petrale sole spawn in waters of 275 to 460 m between December and March, and Dover sole spawn in deeper waters from 460 to 1100 m during the same time (J. Fargo, pers. comm.). Both species move from deeper water in winter to shallow water in the summer. For Rock sole, there is limited quantity on the WCVI and the major stocks are in Hecate Strait and the Queen Charolette Sound; there is no info on spawning areas. For English sole, the major stock is in Hecate Strait and little is known about the life history of this species (J. Fargo, pers. comm.).

Important areas were identified for flatfish on the WCVI based on the distribution of cumulative trawl catch data and catch per unit effort (cpue) from 1996-2007. Locations of more than at least three vessels were examined in order to not break any confidentiality agreements. To determine areas of aggregations, under the Aggregation criteria, locations with the highest density of catches were inferred as aggregations. The locations of the highest catches (cpue) were heads-up digitized (digitized by hand) into polygons. Reproducing the cpue into a different format using this method is not accurate and precise, but for our purposes showed the general locations of where a number of species have been observed. Fishing effort is not evenly distributed along the coast as there are areas that trawlers cannot access due to gear restrictions, such as nearshore areas. There may be other areas along the coast that have high aggregations of flatfish. Many of the less important commercial species will have much broader distributions than indicated in these maps as they are not a target by the fishery, such as Pacific sanddab and curlfin sole which are ubiquitous in shallow water (J. Fargo, pers. comm.). For these species, knowledge on their distributions is limited.

4.4.5. Halibut

Pacific halibut are found along the continental shelf and while they are able to migrate long distances, most adult fish tend to remain on the same grounds year after year, making only a seasonal migration from the more shallow feeding grounds in summer to deeper spawning grounds in winter. As the eggs develop into larvae and grow, they drift slowly upward in the water column, during which time the larvae drift great distances with the ocean currents in a counterclockwise direction around the northeast Pacific Ocean until they settle to the bottom in shallow feeding areas. Following two to three years in nursery areas, young halibut tend to countermigrate and move into more southerly and easterly waters (International Pacific Halibut Commission 1998).

4.4.6. Lingcod

Lingcod (*Ophiodon elongates*) are ubiquitous in rocky reefs from 10-400 m depth, but most are observed from 10-100 m. No areas could be identified at this time based on the EBSA criteria, but life history characteristics are described as follows (J. King, pers. comm.). Lingcod are non-migratory and remain relatively close (1-10 km) to their habitat. Between October to November males move into waters from 10-100 m and establish nesting areas. Egg masses have been observed in areas of active water movement compared to unexposed areas (King *et al.* 2004). Lingcod require areas with rocky crevices for egg deposition and it appears they prefer open spaces with improved visibility for spawning behaviour or for effective nest guarding, or perhaps to provide sufficient water flow for optimal egg development (King *et al.* 2004). From December to February, females move in and deposit eggs at the nesting sites, and the males then take care of the nest until the eggs hatch. In April, larvae move up to the surface and then onto flat sandy areas around eelgrass beds. During the first winter, young-of-the-year move into shallow reefs and presumably as they get older, into deeper waters. Possible future analyses include looking at bathymetry and their habitat characteristics to identify areas where both these features co-exist (J. King, pers. comm.). Information on young-of-the-year lingcod includes annual surveys since 2003 in the SoG, which has both allowed comparison with the same sites from a similar survey in 1991 (Workman *et al.* 1992) and to establish new sites that could be compared with future survey results (Surry *et al.* 2007).

4.4.7. Pacific sand lance

Pacific sand lance (*Ammodytes hexapterus*) require spawning habitat consisting of coarse medium grain sand and a subtidal burying habitat of coarse sand and high bottom currents. The sand must be low in silt and in an area of enough tidal action to keep the sand well aerated to oxygenate interstitial spaces. Sand lance are thought to spawn in the high intertidal in winter (Blaseckie *et al.* 2002).

A GIS-based model combining substrates, tidal current and water depth has been used to identify potential subtidal burying areas in the SoG and Juan de Fuca Strait (C. Robinson, Parks Canada, Vancouver, BC, person. comm.). The model has identified a region from the north of

Sidney Island to Swiftsure Bank as potentially containing the largest surface area of suitable subtidal burying habitats in the SoG and WCVI. In addition, the model has identified smaller pockets of suitable burying habitat as far north as the southern end of Quadra Island. Model development and ground-truthing using a grab sampler continues (C. Robinson, pers. comm.), and should be used to update these regions in future EBSA analysis. Recent field sampling based on snorkel, video and beach seining surveys has confirmed the presence of suitable sand lance habitat along the West Coast Trail of Pacific Rim National Park Reserve (Haynes *et al.* 2007). Various regions of the Broken Group Islands, a unit of Pacific Rim National Park Reserve, in Barkley Sound are also known to contain suitable sand lance habitat (Haynes *et al.* 2008).

4.4.8. Sablefish

Sablefish, or black cod, (*Anoplopoma fimbria*) inhabit shelf and slope waters to depths greater than 1500 m from central Baja California to Japan and the Bering Sea (Stocker *et al.* 2001). They are ubiquitous and highly transient (R. Kronlund, DFO, Nanaimo, pers. comm.). Genetic studies suggest a single population; however recruitment and growth patterns indicate two stocks in Canada's west coast waters (Stocker *et al.* 2001). The spawning period is between January to March along the continental shelf at depths greater than 1000 m; larvae are found in surface waters over the shelf and slope in April to May. Juveniles migrate inshore during the following six months and rear in nearshore and shelf habitats until the age of two to five, when they migrate offshore and into the fishery (Stocker *et al.* 2001) following troughs out to the deeper waters, but some are seen in shallow waters as well (R. Kronlund, pers. comm.). No particular areas along the WCVI stood out in the context of the EBSA criteria. There is no commercial sablefish fishing in the SoG.

4.5. PELAGIC FISH

Pelagic fish live near the surface or in the water column of coastal, ocean waters, but not on the bottom of the sea. They can be contrasted with demersal fish, which do live on or near the bottom. Pelagic fish range in size from small coastal forage fish, such as herring and sardine, to large apex predator oceanic fishes, such as tuna and sharks. They are usually agile swimmers with streamlined bodies, capable of sustained cruising on long distance migrations. Many pelagic fish swim in schools weighing hundreds of tonnes. Others are solitary, like the large ocean sunfish, which sometimes drift passively with ocean currents. Marine pelagic fish can be divided into coastal (inshore) fish and oceanic (offshore) fish, and into epipelagic and deep-water species. Coastal fish inhabit the relatively shallow and sunlit waters above the continental shelf, while oceanic fish (which may well also swim inshore) inhabit the vast and deep waters beyond the continental shelf.

Epipelagic fish inhabit the epipelagic zone. The epipelagic zone is the water from the surface of the sea down to 200 metres. It is also referred to as the surface waters or the sunlit zone, and includes the photic zone.

Coastal fish (also called neritic or inshore fish) inhabit the waters near the coast and above the continental shelf, which is usually less than 200 metres deep. Oceanic fish (also called open ocean or offshore fish) live in the waters that are not above the continental shelf. In the deep ocean, waters extend far below the epipelagic zone and support deep-water pelagic fishes adapted to living in these deeper zones.

4.5.1. Pacific hake

Pacific hake, or Pacific whiting (*Merluccius productus*), have two main stocks on the BC coast, one in the SoG and an offshore stock that is found primarily off the west coast of Vancouver

Island (Beamish and McFarlane 1985). The offshore stock has a larger size-at-age, is migratory, is infected with a muscle parasite *Kudoa paniformis*, and has a different otolith shape and structure. In the spring, offshore hake migrate north to feeding areas from northern California to northern BC and return south in the fall to spawn off southern California between December and March (McFarlane and Beamish 1985). Recent spring surveys of the distribution and abundance of hake larvae have detected increasing numbers of larvae off the Oregon and Washington coats since 2003, supporting the hypothesis that hake spawning is occurring much further north than occurred historically (Phillips *et al.* 2007).

The SoG population spawns in the main deep water basins of the Strait from March to May. A major spawning aggregation occurs southwest of Halibut Bank at depths ranging between 150 and 350 m and a smaller spawning aggregation has been observed northwest of Texada Island near Montgomery Bank (McFarlane and Beamish 1985). Both these spawning locations have been identified as important spawning areas in recent years (K. Cooke, DFO, Nanaimo, pers. comm.). The mainland inlets along the east coast of the Strait are important summer foraging grounds for hake in the Strait (K. Cooke and S. McFarlane, pers. comm.). Within the SoG, there are also other discrete smaller local stocks (McFarlane and Beamish 1985).

Canadian and U.S. scientists collaborate in conducting an acoustic-trawl survey of the offshore hake stock biennially (use to be every three years) northward from California to northern British Columbia. This survey is used to determine the distribution, biomass, and length-at-age composition of the exploitable portion of the hake stock (Fleischer *et al.* 2008) and the data are a key input for the hake stock assessment model which estimates stock status trends and total allowable catch (TAC) for the fishery (J. Holmes, DFO, Nanaimo, pers. comm.). La Perouse Bank hosts large aggregations of hake feeding on euphausiids during the summer and was the most productive fishing grounds in Canadian waters historically (Beamish and McFarlane 1985, Ware and McFarlane 1995). Hake also feed along the shelf break (Ware and McFarlane 1995). The migratory corridor along the shelf break between depths of 80 to 500 m was identified as an important area that hake follow when they spread north during the warmer years to feed (K. Cooke, C. Grandin, DFO, Nanaimo, pers. comm.). There is large inter-annual variability in the spatial distribution of the offshore stock. For example their northern limit is usually Queen Charlotte Sound but in warm El Niño years, they may occur as far north as Dixon Entrance (K. Cooke, pers. comm.). In contrast, during the strong La Niña event in 2000-01, few hake migrated north into Canadian waters (J. Holmes, pers. comm.). Acoustic surveys since 2003 have found hake biomass has decreased substantially on La Perouse Bank and this decline in its importance is reflected by a shift in the fishery to Queen Charlotte Sound (J. Holmes, pers. comm.). Therefore different locations may be important foraging areas depending on the environmental conditions of that year. Hake also occur in Juan de Fuca Strait (Beamish and McFarlane 1985), and these fish are part of the offshore migratory stock (Beamish *et al.* 1982, as cited in Beamish and McFarlane 1985).

There are also smaller resident outer coast stocks along the sounds (and inlets) of the WCVI (Ware and McFarlane 1995); these stocks are distinct from the offshore and SoG stocks (S. McFarlane, pers. comm.) and are relatively small compared to the migratory stock (Beamish and McFarlane 1985).

Currently there is no direct evidence of hake spawning occurring off the BC coast from the migratory stock, but there is a recent presence of smaller and younger hake in Queen Charlotte Sound and northern Vancouver Island (Beamish and McFarlane 1985). King *et al.* (submitted) examine the discreteness of hake stocks in the Canadian zone based on biology, parasites and genetics.

4.5.2. Walleye pollock

Walleye pollock (*Theragra chalcogramma*) are distributed in inlets and open waters along the west coast of BC and in the SoG (Shaw and McFarlane 1986). Their overall eastern Pacific distribution extends continuously around the continental shelf and slope of the North Pacific from the southern Chukchi Sea to southern California (Bakkala *et al.* 1986). Discrete spawning stocks exist in the SoG, off the WCVI, Queen Charlotte Sound and in northern Hecate Strait/Dixon Entrance (Saunders *et al.* 1989). Spawning begins early in March, peaks in mid-March to early April and is completed by early May. Between March and May of 1981 in the SoG, a major spawning aggregation southwest of Halibut Bank and a smaller one between Active Pass and Point Roberts were observed (Shaw and McFarlane 1986), which were identified as an important areas for spawning (Sandy McFarlane, pers. comm.). They are mid water broadcast spawners and prior to spawning, female pollock are found between 50-110 m and males between 137-190 m depth; during spawning, females descend into the deeper layer. Following spawning, most fish are captured at the shallower depth of 80-135 m and by late spring, have dispersed in the central strait region (Shaw and McFarlane 1986). They spawn off the WCVI, but these locations are not known (S. McFarlane, pers. comm.). Young-of-the-year and juveniles are commonly encountered in shallow nearshore areas of the SoG (Bakkala *et al.* 1986). No other important areas could be identified for this species at this time.

4.5.3. Pacific Herring

Important areas were identified for Pacific herring (*Clupea pallasi*) based on four life history stages: spawning, rearing, feeding and migration. Herring aggregate in well known areas along the BC coast during their spawning season in the late winter, between January and April and occasionally as late as early June or July (Hart 1973). There are three major spawning areas (have the top 10% cumulative herring spawn deposition since 1928) on the WCVI and in the SoG (DFO 2008a). The highest ranked cumulative spawning areas of the entire BC coast are located between Cape Lazo and Nanaimo on the east side of Vancouver Island. Adjacent inshore areas between Nanaimo and Ladysmith are also included in this important spawning region as some of the largest spawning aggregations on the coast can occur in these areas as well. The second and third ranked cumulative spawning areas of Vancouver Island are in Barkley Sound and Esperanza Inlet. In some years, there are also significant spawning aggregations between Powell River and Cortez Island (J. Schweigert, DFO, Nanaimo, pers. comm; DFO 2008a). The inshore waters of the WCVI were also identified as having important spawning and juvenile rearing areas (J. Schweigert; B. McCarter, DFO, Nanaimo, pers. comm.). There are also numerous other inshore areas beyond the boundaries of the spawning areas identified where herring do spawn, but in smaller aggregations. In addition a very small but unique spawning area around the Gorge region of Victoria was identified due to the unique genetics of this spawning population (T. Therriault, DFO, Nanaimo, pers. comm.).

Important areas also include inshore juvenile herring rearing areas along the east side of Vancouver Island and the BC mainland shoreline in the SoG that extend five km from the shoreline, as delineated by annual juvenile surveys (J. Schweigert, pers. comm.). The southern Gulf Islands were also identified as an important juvenile rearing area (D. Hay, DFO, Nanaimo, pers. comm.); there are other smaller, scattered populations of herring that remain in the SoG year-round (B. McCarter, pers. comm.). These spawning deposition sites and surrounding juvenile rearing areas have been identified as important areas (J. Schweigert, B. McCarter, and T. Therriault, pers. comm.).

Juvenile herring migrate from nearshore rearing grounds on the WCVI to offshore feeding areas during the fall from August to October (J. Schweigert, pers. comm.). La Perouse Bank is one of the largest summer aggregations or pre-recruit and adult herring on the BC coast (T. Therriault, pers. comm.). There are also finer scale locations and habitats within this region where herring are known to aggregate (B. McCarter, pers. comm.). Summer herring are typically captured along the 90 m (50 fathom) contour line (J. Schweigert, pers. comm.). An important foraging area was identified from La Perouse and Swiftsure Bank to the north ecoregion boundary extending seaward to the 150 m depth contour, as few herring are captured beyond this depth (J. Schweigert, pers. comm.).

In the early fall, around September-October, herring that spawn in the SoG begin migrating through Juan de Fuca Strait (B. McCarter, pers. comm.). This migratory corridor was identified as an important area, as bathymetric boundaries and oceanographic processes create a bottleneck that aggregate herring as they move through the strait. The exact route they follow within this area is not known (T. Therriault, pers. comm.). Swiftsure Bank is a staging area where herring aggregate before they migrate into Juan de Fuca Strait (B. McCarter, pers. comm.). This offshore bank at the entrance to Juan de Fuca Strait is included in the important feeding area surrounding La Perouse Bank. After herring migrate through Juan de Fuca Strait on their way to spawning grounds in the SoG, some aggregate at stop-over areas near Race Rocks and Constance Bank and inside various channels and passages between the lower Gulf Islands to feed and rest (B. McCarter, pers. comm.).

4.5.4. Northern Anchovy

Northern Anchovy (*Engraulis mordax*) range from Baja California to BC with the northern stock ranging at its northern extent into BC wasters (Schweigert *et al*., 2007). No IAs were identified as their occurrence in BC waters is quite sporadic (J. Schweigert, pers. comm.).

4.5.5. Pacific Sardine

Pacific sardine (*Sardinops sagax*) is a migratory fish that breeds in California and Baja California and migrates into BC waters during the spring to feed and returns south in the fall (DFO 2008e). Their whole distribution ranges from northern Mexico to southeastern Alaska but the main centers of concentration range from northern Baja California to southern BC. Their northern distribution depends on the environmental conditions as in warm El Niño years they are distributed further north and it appears they may spawn further north during warm years (DFO 2008e). An important feeding area was identified for the WCVI including inlets and sounds to the 200 m shelf break isobath, and being a surface-oriented species, they are generally found within 30 m of the surface (J. Schweigert, pers. comm.).

4.5.6. Albacore tuna

Albacore tuna (*Thunnus alalunga*) are highly migratory and inhabit open oceanic habitats throughout the North Pacific Ocean and along the North American coast, they range from the Gulf of California and the Revillagigedo Islands off Mexico north to the transition zone between the Alaska gyre and the California Current (Hart 1973). In BC waters, juvenile albacore are found offshore from the continental shelf break and slope into deeper waters and are associated with temperatures of 15-20°C as well as oceanic features including frontal zones between water masses and upwelling areas (J. Holmes, pers. comm.). Logbook records of albacore catch and effort have been compiled by DFO since 1995 and are used to map the distribution of annual catch and effort. However, the quality of these data is poorer prior to 2001 since logbook coverage was less than 95% in this period. Albacore is the only tuna species found in BC waters in sufficient numbers to support a fishery, and they occur here from July through October (J. Holmes, pers. comm.). Other tuna and tuna-like species including skipjack (*Katsuwonus pelamis*), bluefin tuna (*Thunnus thynnus*) and Pacific bonito (*Sarda chiliensis*) have been recorded in BC waters, but are rare visitors. There are currently no known important areas under the EBSA criteria at this time.

4.6. STRUCTURAL HABITAT-FORMING SPECIES

4.6.1. Sponges

There are >250 sponge species in the Pacific Region, apart from the four to six species identified as forming sponge-dominated communities and sponge reefs. Living glass sponge reefs (bioherms) are currently known only to occur in the North Pacific, specifically the Queen Charlotte Basin (QCB) and the SoG (Conway *et al.* 2005, Jamieson *et al.* 2007a), although some may also exist in Alaskan waters. There are 16 glass sponge reefs in the SoG that have been identified and mapped by multibeam bathymetry by the Canadian Hydrographic Service and the Geological Survey of Canada. SoG reef locations (reference number locations are shown in map 44) are: 1: Fraser Ridge; 2-4: McCall Bank (Conway *et al.* 2005); 5: Parksville; 6: Nanaimo; 7-12: Active Pass (Conway *et al.* 2007); 13: "Coulee Bank" (informal name, also called coral knoll, not shown; Conway *et al.* 2007; Cook *et al*. 2008); 14: Howe Sound (Passage Island; Cook *et al.* 2008); 15: Howe Sound (Defence Islands) (Marliave *et al*. 2009); and 16: Ajax Bank (K. Conway, Natural Resources Canada, unpublished data). The reefs are numbered in chronological order of discovery.

The main reef building sponges that comprise these reefs include *Aphrocallistes vastus* and *Heterochone calyx* of the Class Hexactinellida and Order Hexactinosida (Cook *et al*. 2008). The Howe Sound bioherms contain only the *Aphrocallistes vastus* reef building species (Marliave *et al*. 2009). Glass sponge reefs are constructed from sponge larvae attaching to dead sponge skeletons to form new live sponges, which in combination with sponge skeletons trap fine sediment particles in the water, which then act to stabilize the whole reef structure (Krautter *et al.* 2006). The SoG sponge reefs differ from the QCB reefs in their smaller size and that they do not contain the reef building species *Farrea occa* present in the QCB reefs (Conway *et al*. 1991). The sponge species themselves are not unique as they are each common to other locations in BC (Conway *et al*. 1991), but the reef structures they create and hence likely their ecosystem role are globally unique.

Seven out of the 16 glass sponge reefs have been examined by remotely operated vehicles by the Pacific Geoscience Centre and the results indicate three reefs are presently undamaged (reef 1: Fraser River; reef 4: McCall Bank; and reef 7: Active Pass) two are damaged (reef 3: McCall Bank and reef 9: Active Pass South) and another two are damaged but potentially recovering (reef 6: Nanaimo and reef 13: "Coulee Bank") (Conway *et al*. 2005; Cook *et al*. 2008). Reef-building glass sponges are fragile and the damage to the examined SoG reefs appears to be mechanical by mobile fishing gear (Cook *et al.* 2008).

The bioherms are structural habitat as they provide habitat for other species. Cook *et al*. (2008) looked at the relative abundance of megafauna associated with the examined reefs and some results were that the reef at Active Pass (7) had the highest relative abundance of observed taxa including rockfish species, compared to other surveyed reefs. This undamaged reef was compared to a damaged reef nearby and Cook *et al*. (2008) found the former had a higher number of taxa including rockfish species. Rockfish have been the focus of some recent conservation efforts in the SoG, e.g., the establishment of Rockfish Conservation Areas, and undamaged bioherms may be important refugia for these species, as found in the QCB (Cook 2005; Cook *et al*. 2008). The SoG reefs are much smaller than the QCB reefs and may need to be managed at a coastal management scale (CMA).

Sponge gardens (colonies of the cloud sponge *Aphrocallistes vastus*) occur on underwater rock cliffs and ledges in the SoG (Marliave *et al.* 2009). These differ from bioherms in that sponge gardens contain few dead glass sponge skeletons (Krautter *et al.* 2006). Known sponge garden locations include: around the Defence Islands in Howe Sound; in Anderson Bay on Texada Island (Marliave *et al*. 2009); the area around Whytecliff Park, Vancouver; around Hutt Island on the North side of Bowen Island including the channel on the Bowen side to the south; and pinnacles off SE Gambier Island (Pacific Marine Life Surveys; J. Marliave, Vancouver Aquarium, Vancouver, pers. comm.).

The Defence Island sponge gardens were associated with a higher number of taxa than the bioherms at Texada and Defence Islands, and they also had newly recruited juvenile rockfish (Quillback *Sebastes maliger*), while the bioherms had subadult and adult rockfish (Quillback rockfish (*S . maliger*), Yelloweye rockfish (*S. ruberriums*), Redstriped rockfish (*S. proriger*), and Greenstriped rockfish (*S. elongates*) (Marliave *et al*. 2009). There is currently no protection of glass sponge habitats in southern BC. Documenting sponge gardens locations has been suggested as important in the conservation of nursery habitats for inshore rockfishes (Marliave *et al.* 2009).

4.6.2. Corals

Jamieson *et al.* (2007b) summarized the coral species and their locations that have been found, or are likely to be found, in BC coastal waters. Currently, research is being conducted by Jessica Finney, DFO, Nanaimo, to model and hopefully allow the prediction of areas of occurrence of four orders of deep-sea coral in British Columbia using Maxent, a species distribution model (SDM). SDM models have proven to be valuable in the planning of protected areas elsewhere (J. Finney, pers. comm.). These analyses may provide a defensible and quantitative basis for planning when there is limited data on the species or communities that need to be protected. Information on areas of suitable habitat for corals could be assessed under the EBSA criteria and should be in future IA determinations. Examples of how areas of suitable habitat could be evaluated under the EBSA criteria for Uniqueness includes: geographic scale and species composition of the coral assemblage; for Aggregation: density and variety of species; for Fitness Consequences: older/larger individuals provide greater population fecundity and community structure (DFO 2004c).

Some corals are widely dispersed and occur at low density, but may nevertheless provide important habitat structure where little other structure exists. Rating importance of areas by amount of coral in bycatch likely biases results to emphasize areas for aggregated species.

Ardron and Jamieson (2006) analyzed groundfish trawl bycatch data in BC and identified areas of coral and sponge aggregations. Their analysis identified 12 areas that contain 90% of the BC coral and sponge trawl bycatch by weight, and three of these areas occur within the WCVI ecoregion. All were identified as coral IAs for their high Aggregation and Fitness Consequences, as occurred for PNCIMA (Clarke and Jamieson, 2006a). No coral IAs were identified for the SoG. General Status reports are being developed on corals by Palmira Boutillier (DFO, Nanaimo, pers. comm.).

4.6.3. Macrophyte Beds

Kelp and eelgrass beds are generally widespread along the entire coastline, so ecologically significant areas would be those that exhibit higher productivity, higher density of beds or those that are temporally stable. A complete dataset of kelp or seagrass beds does not yet exist for the WCVI or SoG. Data exists at various scales and have varying degrees of accuracy but as of yet, the entire coasts in these ecoregions have not been examined. Some datasets available now may be sufficient for CMA-scale EBSA projects. At a LOMA scale, density analyses may lead in the future to identification of IAs for macrophyte beds, but such analyses are not available at this time.

4.7. INVERTEBRATES

4.7.1. Low Mobility Marine Invertebrates

Species in this group perform all their life history stages in the general area where settlement of their pelagic larvae occurs. Thus, life history events are not performed in separate areas – feeding, reproducing, etc., all must occur at the same location. Dispersal is achieved as planktonic larvae and in most species, dispersal distances have not been investigated and can only be approximated based on larval duration in the water column and presumed depth distribution. These species survive after settlement in areas where a combination of physical factors creates suitable habitat. Some species (e.g. sea cucumber and abalone) have juveniles that exhibit a different suite of behaviours than do adults to make them more cryptic. This cryptic juvenile behaviour, coupled with their smaller sizes, presents problems in identifying significant juvenile habitats and determining population abundance estimates as juveniles are often missed or excluded from survey data.

IAs for this group are typically those beds or habitats that support a high density, full age structure, larger growth, greater productivity, or act as identified source populations (those that produce successful recruits for other areas). However, for those species exploited by fisheries, the current age structure may not be natural and density may be altered, so these measures have been considered in IA identification.

4.7.2. Bivalves

There are over 400 species of bivalves across the British Columbia coast, but only a few are utilized commercially and/or recreationally as food (Jamieson and Francis 1986). Many sometimes harvested species of intertidal clams are present in both the SoG and WCVI but are considered ubiquitous throughout the study area (G. Gillespie, DFO, Nanaimo, pers. comm.), and therefore no IAs were identified for the following species at this time. These include the littleneck clam (*Protothaca staminea*), softshell clam (*Mya arenaria*) and the cockle (*Clinocardium nuttalli*).

IAs have been identified for the following species, as detailed below.

4.7.2.1. Pacific oyster

The Pacific oyster (*Crassostrea gigas*) was introduced from Japan for aquaculture farms between 1912-1913, first in Lady Smith Harbour and Fanny Bay (Jamieson and Francis 1986). It is now considered a naturalized species, which means it is commercially valuable and not considered an invasive species in terms of its introduction causing damage to the host ecosystem, existing species therein, the economy or human well-being (AISTG 2003). The Pacific oyster is widely distributed, with northern limits currently in BC of Brooks Peninsula on the WCVI and Discovery Passage in the SoG (G. Gillespie, DFO, Nanaimo, pers. comm.). Important areas for the Pacific oyster were identified based on habitats with consistent breeding adults and good recruitment as well as seeding populations which produce successful recruits for other regions (G. Gillespie, DFO, Nanaimo, pers. comm.). These areas have the temperature and physical environmental characteristics required for successful reproduction. Important areas in the SoG include Pendrell Sound and Hotham Sound, and on the WCVI, Tlupana Inlet in Nootka Sound and both Pipestem Inlet and Toquart Bay in Barkley Sound (G. Gillespie, DFO, Nanaimo, per. comm.). All areas ranked high in Uniqueness and Aggregation, based on density of populations.

4.7.2.2. Olympia oyster

The Olympia oyster (*Ostrea lurida*) is listed as a Special Concern under the SARA and by the COSEWIC. Habitat that hosts abundant concentrations of Olympia oysters listed in the proposed management plan for the Olympia oyster (DFO 2009c) were identified as important areas. They are distributed in localized spots all along the WCVI and the SoG, some in Queen Charlotte Strait and in some central coast areas (DFO 2009c). They are found all throughout Barkley Sound, but the identified areas of high abundance are in protective inlets and are likely seeding populations for the rest of Barkley Sound (G. Gillespie, DFO, pers. comm.). These areas include: Effingham Inlet, Harris Point, Hillier Island, Lucky Creek, Mayne Bay, Pipestem Inlet, Snowden Island, South Stopper Island, Useless Inlet, and Vernon Bay. Areas of abundance in Clayoquot Sound include: Bottleneck Cove, Mosquito Harbour, Pretty Girl Cove and Sydney Inlet. In Kyuquot Sound there are high numbers in Amai and Cachalot Inlets. In Nootka Sound areas include: Inner Mary Basin, Malksope Inlet and Port Eliza. All areas ranked high in Uniqueness and Aggregation.

4.7.2.3. Manila clam

The Manila clam (*Tapes philipinarum*) is an accidentally introduced species from Japan, which hitchhiked in with imported Pacific Oyster seed (Jamieson and Francis 1986). It is also now considered a naturalized species, commercially valuable and not considered an invasive species in terms of its introduction causing damage to the host ecosystem, existing species therein, the economy or human well-being (DFO 2009b). Its distribution now ranges throughout the SoG with a northern limit of Seymour Narrows and along the WCVI and small populations in Queen Charlotte Strait and around Bella Bella (Jamieson and Francis 1986; Harbo et al 1997a,b). The north shore of Savary Island provides good Manila clam habitat and is a producer of large landings (G. Gillespie, pers. comm.). This area ranked high in Aggregation.

4.7.2.4. Razor clam

Razor clams (*Siliqua patula*) inhabit surf-swept open beaches and are found from the mid-intertidal to subtidal depths of 20 m (Jamieson and Francis 1986). They have a limited distribution in BC. Long Beach is the only area where they are abundantly found on the WCVI. This location was identified as an important area and ranked high in Uniqueness and Aggregation (G. Gillespie, pers. comm.). There are no abundant populations in the SoG. Long Beach has similar habitat to McIntyre Bay on Gwai Haanas, the location where the densest populations are found and which supports a small commercial fishery (Jamieson and Francis 1986).

4.7.2.5. Butter clam

Butter clams (*Saxidomus gigantea*) are one of the most common bivalves of the intertidal in BC and are found throughout the coastal area (Jamieson and Francis 1986). Particularly high densities in the SoG occur at the Seal Islets north of Denman Island (G. Gillespie, pers. comm.), which ranked high in Aggregation.

4.7.2.6. Geoduck

Geoduck clams (*Panopea generosa*) are distributed in the Northeast Pacific from Alaska to the Gulf of California (DFO 2000). They occur in a wide range of habitats from sheltered to moderately exposed in substrates from fine mud to sand and gravel and from brackish inlets to the outer coast. Their vertical range in BC is from the lower intertidal to at least 120 m, but most populations have an upper limit near 8 m in depth (Jamieson and Francis 1986). A small recreational fishery in the intertidal zone and a large subtidal commercial fishery exist for geoduck in BC (Jamieson and Francis 1986). Information on geoduck abundance and spatial distribution comes from catch and survey data and the location of geoduck beds are protected by confidentiality agreements. The Tofino region, Statistical Area 24, hosts both productive growth rates of geoduck and aggregations of high density beds andso was identified as an IA (C. Hand, DFO, Nanaimo, pers. comm.). This area ranked highly in Aggregation.

4.7.2.7. Scallops

There are 13 species of scallop that occur in BC (Jamieson and Francis 1986), but only two species are commercially harvested by small dive and trawl fisheries in the Strait of Georgia, pink (*Chlamys rubida*) and spiny (*Chlamys hastata*) scallops; and two are recreationally harvested, purple-hinged rock scallop (*Crassadoma gigantea*) and the weathervane scallop (*Pathinopecten caurinus*). Weathervane distribution is intermittent with small significant populations occurring only in McIntyre Bay off the northeast coast off Haida Gwai and in the Gulf Islands. There are other scattered smaller populations of weathervanes along the BC coast, and they occur at depths from 20 to 200 m mostly on sand or mud bottom. Spawning occurs in the Gulf Islands in the SoG from May-June (Jamieson and Francis 1986). Purple-hinged rock scallops occur throughout BC's coastal area and are found on rocky shores subtidally from the lowest intertidal level to a depth of 80 m. Spawning in southern waters probably occurs in June-July (Jamieson and Francis 1986). Pink and spiny scallops have a discontinuous distribution along the coast. They can occur in small dense beds and are usually found in areas of strong current on firm, gravel or rock bottom. Pink scallops occur from 5 to 200 m depth while spiny scallops are slightly shallower at 5 to 150 m depth (Jamieson and Francis 1986).

IAs for weathervane and purple hinged rock scallops were identified based on areas of known concentration. In the SoG, weathervane scallop concentrations are in Trincomali Channel within the Southern Gulf Islands and Kanish Bay on Quadra Island (the latter is within the PNCIMA). For the purple-hinged rock scallop, Desolation Sound is an area of concentration (R. Lauzier, DFO, Nanaimo, pers. comm.). High density areas of pink and spiny scallops were identified throughout the SoG based on fishery-dependent and fishery-independent information (Lauzier *et al*. 2005; K. Fong and R. Lauzier, DFO, Nanaimo, pers. comm.). There is less information available on stock distribution outside the survey areas and therefore IAs outside the identified areas here are unknown.

4.7.2.8. Gastropods

Northern abalone

The northern or pinto abalone (*Haliotis kamtschatkana*) is listed as Threatened under the SARA and endangered by the COSEWIC. Any coastline habitat less than 10 m in depth with hard substrate could be considered potential abalone habitat (Lessard et al. 2007). No particular areas could be designated as IAs at this time.

4.7.2.9. Echinoderms

Sea Cucumbers

The giant red sea cucumber (*Parastichopus californicus*) is found from the intertidal to 250 m in depth in a variety of flow conditions and substrate types, but are most abundant in areas of moderate current on cobbles, boulders or crevassed bedrock (Stocker *et al.* 2001). Spawning occurs from spring through summer. *P. californicus* is the only harvested sea cucumber is BC and is the largest of approximately 30 species that exist in BC (Stocker *et al*. 2001). The location of sea cucumber harvest beds are protected by confidentiality agreements. No particular locations stand out as IAs at this time (C. Hand, pers. comm.).

Green sea urchin

The green sea urchin (*Strongylocentrus droebachiensis*) is distributed in the Northeast Pacific from northern Washington to the Aleutian Islands in Alaska. Green sea urchin is a coastal species which occurs on rocky bottom habitats in the intertidal to depths over 140 m (Perry *et al.* 2006). They typically occur at depths of 15 m or less and in areas of strong tidal exchange;

they make seasonal migrations between shallow water in the winter to deep water in the summer (I. Perry, DFO, Nanaimo, pers. comm.). They have patchy distributions and tend to be more mobile than the red sea urchin (*Strongylocentrotus franciscanus*), which they are often found with (Stocker *et al*. 2001). Based on fisheries-dependent and fisheries-independent data, an IA was identified along the east side of Quadra Island, which extends from the important area identified in PNCIMA for Johnstone and Queen Charlotte Straits (Clarke and Jamieson 2006). This area is part of a larger fished area (Perry *et al*. 2006).

A second IA was identified as a fished region around the southern Gulf Islands and a portion of Juan de Fuca Strait for high aggregations of sea urchins (Perry *et al*. 2006; I. Perry, pers. comm.). This area was defined by the 50 m bathymetry contour, as most green sea urchins (approximately 90%) are found nearshore above this depth (I. Perry, pers. comm.). The highest densities of green urchins on the coast occur here; however, northern fishing areas and the rest of the SOG have not been as intensively surveyed and therefore they cannot all be equally compared. The surrounding waters of adult and juvenile urchins are important for distribution of larvae, as there is likely to be mixing between sub populations of a larger metapopulation (I. Perry, pers. comm.). Spawning occurs around February to March and the fishery is open in the winter from November to March (Perry *et al.* 2006). Both areas ranked high in Aggregation. Relatively low densities occur on the WCVI outside of the identified part of Juan de Fuca Strait and there are no other green urchin fisheries there (I. Perry, pers. comm.).

Purple and red sea urchins

The purple sea urchin, *Strongylocentrus purpuratus,* prefers wave swept offshore habitats. There is currently no fishery for this species, and hence little available data.

Red sea urchin, *Strongylocentrotus franciscanus*, are found in a wide range of rocky habitats on exposed and protected areas on the outer coast and in the SOG as well as in tidal passages (Jamieson and Francis 1986). No particular areas fit into the EBSA criteria at this time (D. Leus, DFO, Nanaimo, pers. comm.)

4.7.3. Mobile Marine Invertebrates

Among mobile marine invertebrates, there is a large diversity of life history strategies. Most have a highly dispersive planktonic larval stage, but the degree of adult mobility varies between species, from some crabs and squid that can make long distance seasonal migrations to other species (e.g. red rock crabs) that tend to stay in local areas. Except for commercially exploited species, very little is known about the life histories of the majority of this group. Some species have all their life history stages in the same location, similar to sessile invertebrates, while others have separate areas for different life history stages. Detailed examination of bycatch data, which has yet to be done in BC, may prove useful in identifying IAs for species not commercially exploited.

4.7.3.1. Crabs

Crab resources and their biologies in BC have been summarized by Otto and Jamieson (2003).

Tanner crabs

Over 35 species of crabs are found on BC coast (Jamieson and Francis 1986). Three species are tanner crabs: *Chionoecetes tanneri*, *C. angulatus, and C. bairdi*. *C. tanneri* occupies a depth range between 600 and 1400 m and *C. angulatus* has a partly overlapping depth distribution, but is found deeper from 1200 to 2500 m along the continental shelf break (A. Phillips, DFO, Nanaimo, pers. comm.). An experimental fishery existed for *C. tanneri* between 1988 and 1990 and now they are part of an ongoing fishery potential assessment (Workman *et al*. 2001). An IA was identified for both these species spanning their total depth range of 600 to 2500 m based on research surveys (A. Phillips, pers. comm.); it ranked high in Uniqueness, Aggregation and Fitness Consequences. All the life history activities of these tanner crabs are performed in this region; they spawn in the spring and the larvae can only settle in the narrow depth range of their distribution (A. Phillips, pers. comm.). The range of *C. angulatus* extends offshore of the WCVI ecoregion into deeper water.

Chionoecetes bairdi is an inshore tanner crab, which is present in the entire inlet fjord ecosystem along the BC mainland coast typically from 50 to 200 m, but can be found at depths to 400 m (A. Phillips, pers. comm.). There was a commercial fishery on the northern coast for this species, and while it ceased in 1993, there is an interest now in a new fishery (Fong *et al*. 2004). There are no major populations on the WCVI, although some crab are found in select locations, and there are also not many in the main body of the SoG (A. Phillips, pers. comm.). IAs were identified based on high concentrations; the highest in BC occurs in the northern inlets and fjords of the PNCIMA region, and the next most important are in the Southern Gulf Islands, followed by the northern part of the SoG including Bute Inlet (A. Phillips, pers. comm.).

Neither offshore (*C. tanneri* and *C. angulatus*) or inshore species (*C. bairdi*) are targets of developing fisheries currently, despite personal communications prior to 2006 and publications from 2001 or 2004.

Dungeness crab

Dungeness crab (*Metacarcinus magister*) range from the Alaska to California on sandy bottom depths (Stocker *et al.* 2001) from the intertidal to 200 in depth (A. Phillips, pers. comm.). They are commercially exploited in selected locations off the WCVI, in the SoG and on the north coast (Stocker *et al.* 2001). They release larvae between February to April and settlement occurs between May to August; it occurs later in the season in the north (A. Phillips, pers. comm.). IAs were identified based on concentrations of adult crabs. On the WCVI, locations include Tofino and Long Beach and the southern portion of Vancouver Island from Port Renfrew down Juan de Fuca Strait to the Gulf Islands. In the SoG, crab are abundant in the Fraser River estuary and in Boundary Bay, at a few locations in the Gulf Islands, and in the upper Strait between Cortez island and Powell River (A. Phillips, pers. comm.).

Red rock crab

Red rock crab (*Cancer productus*) are ubiquitous in rocky habitat above 50 m, but can be found deeper. They are excluded from cold inlets, especially near fresh water runoff, and they are not found on sand (A. Phillips, pers. comm.). There are no commercial fisheries but they support a small sport fishery (Jamieson and Francis 1986). No particular areas stood out as IAs.

4.7.3.2. Shrimps and Prawns

There are 85 species of shrimp in BC (Jamieson and Francis 1986). Seven species of shrimp and prawn (Family Pandalidae) are exploited commercially by the trawl and trap fisheries in BC (DFO 2009e). The identification of important areas was based on aggregations of the different species from fishery independent research surveys (D. Rutherford, DFO, Nanaimo, pers. comm.). Shrimp are found on soft bottom habitats at 50 to 200 m depth and prawn (*Pandalus platyceros*) are found on rocky bottom habitats, mostly within a depth range of 50 to 70 m depth (DFO 2008f). The survey areas are defined by depth contours of 50 to 200 m (D. Rutherford, pers. comm.). Shrimp and prawn also spawn usually in late autumn or early winter and the females release their eggs in the spring (DFO 1999a, 1999b). Four areas were identified on the WCVI: offshore areas along the shelf break for smooth pink shrimp (*Pandalus jordani*), 2) Barkley Sound for smooth pink and sidestripe shrimp, (*Pandalopsis dispar*), and 3) Haro Strait for northern (or spiny) pink shrimp (*P. borealis*). Five areas were identified in the SOG: 1) the Southern Haro Strait area has northern pink shrimp (connecting to WCVI area 3 above), 2) the

Southern Gulf Islands for northern pink, sidestripe, and coonstripe (or dock) (*P. danae*) shrimp, 3) the Howe Sound area for smooth pink and northern pink shrimp, 4) the Baynes Sound area for sidestripe and smooth pink shrimp, and 5) South of Cortez Island for sidestripe and smooth pink shrimp. All these areas ranked low for Aggregation, as it is currently unknown which habitats are important for shrimp under the EBSA criteria since the spatial location and densities of species during their different life histories is not known. Prawn are distributed throughout the northeastern Pacific from San Diego, California, to the Unalaska Island, Alaska (DFO 1999b). They are widely distributed in the inlets of the mainland coast and West Coast of Vancouver Island. No particular inlets are known to be an IA at this time for prawn.

4.7.3.3. Euphausiids

Euphausiids, or krill, are found throughout the world's oceans and make up the second largest biomass of all animal life in the ocean, second to copepods (Jamieson and Francis 1986). There are 23 species that have been reported in BC (Jamieson and Francis 1986). BC's euphausiid biomass is dominated by the following five species: *Euphausia pacifica, Thysanoessa spinifera, T. inspinata, T. longipes* and *T. rashii* (Jamieson *et al.* 1990 as cited in DFO 2007b). There is a fishery in the Strait of Georgia mostly around Malaspina Strait and Jervis Inlet from November through March (DFO 2007b). *E. pacifica* accounts for 70 to 100% of the biomass in the SoG where the commercial fishery occurs (Jamieson *et al.* 1990 as cited in DFO 2007b). Their spawning period extends from early May to mid-July (Jamieson and Francis1986). An area of relatively high density of euphausiids was identified around Malaspina Strait and Jervis Inlet, based on sampling between 1990 and 1997. There is a strong seasonal cycle of euphausiid abundance with a maximum in early-mid autumn in this region (D. Mackas, IOS, Sidney, pers. comm.; Romaine *et al.* 2002).

4.8. TURTLES

There are three species of sea turtle known to seasonally inhabit British Columbia waters: Leatherback sea turtle, green sea turtle, and Olive Ridley sea turtle. Only the North Pacific population of the leatherback turtle (*Dermochelys coriacea*) is listed as endangered by COSEWIC and SARA for Pacific Canadian waters.

Leatherback sea turtle breeding and nesting occur in southern latitudes and animals migrate to northern Pacific latitudes to feed on jellyfish and other gelatinous prey (Pacific Leatherback Turtle Recovery Team 2006). Abundance and spatial distribution of leatherback turtles in B.C. waters is unclear as sighting reports remain few (n=119 from 1931 to 2009) (Spaven et al. 2009) and distributional data on their main prey species (primarily large semaestome jellyfish) is sparse (L. Spaven, DFO, pers.comm.). Seasonally, the majority of leatherback turtles are sighted from June through September throughout the Pacific Region, and have most frequently been sighted in waters off western Vancouver Island and Haida Gwaii (Spaven et al., 2009). 52% of sightings (n=63) have occurred within PCNIMA boundaries. Most leatherbacks appear to be adults (L. Spaven, DFO, Nanaimo, pers. comm.). Little is understood about the spatial distribution of juveniles and young adults and it is unknown whether they too migrate as far north as B.C. (Pacific Leatherback Turtle Recovery Team 2006).

Sightings data for leatherback turtles have been collected by DFO in partnership with the Cetacean Sightings Network (BCCSN) at the Vancouver Aquarium over the past several years. Most leatherback turtle occurrence in B.C., and elsewhere off western United States, are consistent with warm sea temperatures on the continental shelf along with areas of upwelling and high productivity (Spaven et al. 2009; Benson et al. 2007; Lutcavage and Lutz 1986; Shoop and Kenney 1992 as cited in the Pacific Leatherback Turtle Recovery Team 2006). A large IA was suggested that includes areas where turtles have been repeatedly sighted (N. Pinnell, VAMSC, Vancouver; L. Spaven, DFO, Nanaimo, pers. comm.) (Map 54). This area was ranked high for Uniqueness and Fitness Consequences. The use of other areas by this species is unclear and the importance of such areas to turtles should not be disregarded. Turtles have also been sighted at lower frequency in other locations within PNCIMA. Surveys and sightings solicitation from the public are ongoing in hopes of filling some of the knowledge gaps for this species. Prey-based modelling studies and habitat classification may yield better data on which to base IA identification for turtles.

Green sea turtles are most commonly seen in southern temperate waters around Mexico and Hawaii, but some may occasionally follow warm currents northward and end up in BC or even Alaska waters (Wild Whales, BCCSN 2009). There have been 34 reports of green turtles in BC, (BC Cetacean Sightings Network 2012). No particular areas can be identified as important at this time for green sea turtles.

Olive Ridley sea turtles have seen in Washington and Alaska waters, but as of 2009 had not been confirmed in BC waters. There are 39 records of unidentified sea turtle from 1965-2012 (BC Cetacean Sightings Network, 2012) that may well have been green or Olive Ridely sea turtles, but this cannot be confirmed. Olive Ridely turtles nest on the beaches of Mexico and Central America and are more typically seen as far north as central California. No particular areas can be identified as important for Olive Ridely sea turtles at this time.

5. OCEANOGRAPHIC FEATURES

Experts identified oceanographic features on the basis of characteristics that concentrate and/or retain productivity. These features have structural properties that result in ecological processes that support high species' densities, thus fitting into the Aggregation criteria. The oceanographic features described in the following section do not have rigid boundaries as depicted in the associated maps because they are dynamic and may change temporally on different time scales (daily, seasonally and/or inter-annually etc.) in response to environmental conditions. Some of the boundaries could be refined more precisely at a finer resolution, but here locations were defined at a LOMA-scale.

Bottlenecks are regions of the marine environment where migrating species passing through are concentrated in density, making them potentially more vulnerable to human actions (e.g., fishing, pollution, ship activity, etc.). These areas are largely determined on the basis of topographic or bathymetric characteristics of the shoreline, such as inlets, straits or river mouths. A narrowing of a water passage is one example of a bottleneck, but around river mouths (apart from the narrowness of the river or stream itself), returning anadramous species such as salmon may be concentrated and occur at a relatively high density while they wait for conditions in the river, particularly water flow rate and water temperature, that are favourable for their survival during their upward migration. The area around a river mouth that would constitute the bottleneck is a function of both the size of the river and the number of salmon that utilize that river, so would be larger for rivers such as the Fraser and Skenna and smaller for rivers such as the Englishman and Squamish, and may perhaps be estimated by the relative sizes of the river estuaries. No specific sizes are available at this time, and because they are relatively small (a few kilometres is radius around the river mouths) in relation to the attached maps, they could not always be mapped for scale discernation reasons.

5.1. WEST COAST OF VANCOUVER ISLAND

5.1.1. Brooks Peninsula Jets

Current jets form off Brooks Peninsula and are areas of high productivity and plankton concentration, which is transported seaward by the jets. These jets are most prominent in the summer, although there is less satellite imagery available during the winter due to clouds and therefore less is known about this feature during that time of year. The jets move in a southern downstream direction, but are highly variable. They separate from the continental shelf around Cape Cook on Brooks Peninsula (B. Crawford, DFO, Sidney, pers. comm.). An area from Cape Cook, extending in southern direction based on satellite images of water temperature from Mackas and Yelland (1999), to a 55 km buffer around the peninsula (D. Mackas, DFO, Sidney, pers. comm.) was identified as important.

5.1.2. Shelf Break

The shelf break was identified as an important area for its high productivity and high aggregation of macrozooplankton (B. Crawford, M. Foreman, and D. Mackas, DFO, Sidney, pers. comm.). The shelf break current (or seasonal reverse current) is driven south by northwest winds which causes an upwelling of nutrient rich water in this region during the summer (Thomson *et al.* 1989). The spring transition in winds from the southeast to the northwest typically occurs in April, with the upwelling winds being strongest in July. Predominant wind direction switches again during the fall transition in October and there is very limited upwelling in the winter months, and combined with less sunlight at this time, makes this region much less productive in the winter (B. Crawford, pers. comm.). Upwellings result in increases in productivity in surface waters which is an important for trophic energy transfers up the food web (Thomson *et al*. 1989). The timing of the spring and fall transitions is variable and can affect species abundances when there is a late spring transition. Increased productivity along the shelf break moves onto the continental shelf during the summer months (M. Foreman, pers. comm.). The shelf break important area extends approximately 20 km offshore of the 200 m shelf break isobath and inshore to approximately the 100 m depth contour (B. Crawford; M. Foreman; D. Mackas; I. Perry, DFO, pers. comm.).

Submarine canyons on the continental slope are also important areas for aggregations of zooplankton and trophic energy transfer (D. Mackas, pers. comm.). During the summer, the shelf break current drives strong vertical velocities through the submarine canyons and causes enhanced upwelling by bringing nutrient rich water onto the shelf (S. Allen, UBC, Vancouver, pers. comm.). This is centred in the large marine canyons that break the shelf, which include the Juan de Fuca Canyon (mostly in U.S. waters); and Barkley, Nitinat and Clayquot Canyons. The strong vertical velocities cause zooplankton to be pushed up against the sides of the canyon, thus aggregating them and thereby facilitating the possibility for trophic transfer from other animals feeding on the zooplankton (S. Allen, pers. comm.). Mesopelagic fish have also been observed being pushed up in marine canyons where they are then preyed upon by pelagic fish (Pereyra *et al*. 1969). During the winter the canyons enhance downwelling, so no nutrient flux is occurring, but strong vertical velocities remain and aggregations of zooplankton are still possible (S. Allen, pers. comm.).

5.1.3. Vancouver Island coastal current

The Vancouver Island coastal current is an extension of the lower density, fresh water runoff out of the Juan de Fuca Strait from the Strait of Georgia. It is confined landward of the 100 m depth contour (Thomson *et al.* 1989). It is an important oceanographic feature for its high nutrient level and transfer of these nutrients up the coast. The Vancouver Island coastal current was not included as an oceanographic feature in this analysis as it does not concentrate productivity to the same extent as other identified features.

5.1.4. Edges of banks and basins

The edges of the banks and basins on the continental shelf across from Barkely Sound include: La Perouse, Swiftsure, Amphitrite and Finger Banks. These areas are productive, aggregate zooplankton and are areas of trophic transfer (D. Mackas, B. Crawford, and I. Perry, pers. comm.).

5.1.5. Juan de Fuca Eddy

The Juan de Fuca Eddy is an area of retention and of high productivity (A. Pena, DFO, Sidney, pers. comm). It forms during the summer months at the southwest side of Vancouver Island near the mouth of the Juan de Fuca Strait. The summer northwest winds cause upwelling that brings deep nutrient rich cooler water to the surface. Cool water with nutrients also comes seaward in Juan de Fuca Strait. The combination of the topography and physical oceanography in the area is rare and responsible for the retention mechanism of this oceanographic feature (Foreman *et al.* 2008). Many other eddies along the BC coast disperse or migrate seaward away from their source (Crawford 2002). However, the Juan de Fuca Eddy is stationary, although it is dynamic and can collapse and reform. The spatial boundary for mapping this feature was determined by satellite images of water temperature and phytoplankton biomass.

5.1.6. Strait of Georgia

5.1.6.1. Vertically Mixed Areas

Discovery Passage is an area of significant tidal exchange and mixing (I. Perry, pers. comm.). This mixing brings deep, nutrient rich water to the surface and likely enhances the productivity of the Strait. Current strength (speed of the water) dissipates with increasing distance from the entrance to Discovery Passage. Haro Strait and Boundary Pass are other areas of significant tidal exchange and mixing (D. Mackas, and I. Perry, pers. comm.). The waters between the Gulf Islands are also tidally mixed but there are areas within the islands that are stratified, particularly on the northwest islands (Parsons *et al.* 1981; D. Mackas and M. Foreman, pers. comm.). Stratified waters within the Gulf Islands are mostly the result of thermal stratification although some are salinity based because of flow from the Cowichan River.

5.1.6.2. Fraser River Plume

The Fraser River Plume provides nutrients to the SoG and thus helps make the whole Strait productive (D. Masson, DFO, Sidney, pers. comm.). The plume extends further out into the Strait during the summer and where the plume reaches the southern Gulf Islands, the water becomes vertically mixed causing the plume boundary to disappear (D. Mackas, pers. comm.).

5.1.6.3. Stratified Waters

Areas of the Strait of Georgia that have not been classified as tidally mixed are considered stratified waters. An exception is Sechelt Narrows which is tidally mixed (M. Foreman, pers. comm.). The southern Strait's vertically stratified waters are largely salinity driven from fresh water output from the Fraser River while the northern Strait's waters are thermally driven from summer warming (D. Mackas, pers. comm.). The Fraser River plume has been included with stratified waters in the Strait for mapping and classification purposes as it does not stand out by itself with EBSA criteria.

5.1.6.4. Biological Fronts

Biological fronts are regions where deep nutrient rich waters are brought up to the euphotic zone to support an increase in productivity (Lalli and Parsons 1993). They are generated at a transition zone between vertically well mixed waters and vertically stratified waters. The frontal boundaries are characterized by high rates of productivity and phytoplankton biomass relative to the rates in the well mixed waters on one side and the stratified waters on the other side of the front (e.g. Parsons *et al.* 1969, 1981, 1983). Different types of fronts can be created via different mechanisms based on the topographic and oceanographic features of the area (Lalli and Parsons 1993). Three biological front types persist throughout the summer months in the SoG: tidal fronts, island mass effects and river plume fronts (T. Parsons, pers. comm.). Tidal fronts are the result of tidal currents moving over a sill creating well-mixed waters that meet with stratified waters (T. Parsons, pers. comm.). Island mass effects occur from a persistent current passing an island or bank creating turbulence which results in upwelling on the leeward side downstream of the island or bank (Lalli and Parsons 1993). River plume fronts are formed when fresh water runoff of a river encounters more turbulent offshore waters and the nutrients are stabilized at the surface (Lalli and Parsons 1993). The stratified waters in all cases may be the result of a halocline or thermal stratification (T. Parsons, pers. comm.).

There can be trophic phasing of phytoplankton with zooplankton, sometimes within the same region (Floodgate *et al*. 1981 and Pingree *et al*. 1974 as cited in Parsons *et al*. 1983) but usually in a related region (e.g. Parsons *et al*. 1969, 1981, 1983). Biological fronts are important for trophic energy transfer up the food web (T. Parsons, pers. comm.), and, for example, can provide foraging areas of high biological productivity for marine birds (Perry and Waddell 1997, Lalli and Parsons 1993).

The presence of frontal zones in the SoG has been investigated because of their probable importance to the nutrition and survival of commercially important larval and juvenile fish (Cochlan *et al*. 1986 and Parsons *et al*. 1984). In the SoG, biological fronts occur in the following locations: the entrance to Discovery Passage (tidal front); between Texada and Lasqueti Islands (island mass effects); and smaller fronts associated with passages in the Gulf Islands such as Porlier and Active Passages (tidal fronts), between Denman and Vancouver Island, and between Denman and Hornby Island (tidal fronts) (Parsons *et al*. 1981). The Denman Island front lacks trophic phasing with migrant zooplankton, and as the water here is too shallow for a large abundance of zooplankton to exist to graze on the phytoplankton, there is consequently an abundance of phytoplankton for bivalves (St. John *et al*. 1992; St. John and Pond 1992; T. Parsons, pers. comm.). There is also a small tidal front in Jervis Inlet (Parsons *et al.*, 1984) and another at the head of Saanich Inlet (Parsons *et al*., 1983). The Saanich Inlet front occurs on the neap tide and is dependent on the 14 day lunar cycle. The front along with the phytoplankton is forced into Saanich Inlet, where the phytoplankton is then grazed on by other animals (Parsons *et al*. 1983). However, fronts arising from sills are not a characteristic of all inlets, and, for example, Cochlan *et al*. (1986) did not find such fronts associated with the entrances of Bute, Toda or Jervis Inlets. The Jervis Inlet front mentioned earlier is not associated with the sill at the entrance to the inlet but is found at the junction of Jervis Inlet, Skookumchuk Narrows and Agamemnon Channel (Parsons *et al.* 1984).

Lastly, the location of the river plume front associated with the Fraser River can vary with flow and wind direction, and sometimes extends into English Bay (T. Parsons, per. comm.). The greatest concentration of phytoplankton occurs closer to the river mouth and the zooplankton are trophically phased further away, closer to the Gulf Islands (Parsons *et al*. 1969).

Biological fronts have seasonal and temporal variations and therefore their mapped “rigid” boundaries do not reflect their real occurrences, but are the approximate areas where the fronts are often occurring. The boundaries can move with tides, currents and winds and they depend on certain properties such as substrate, water velocity, and depth (T. Parsons, pers. comm.). Predominately they are a summer feature but can sometimes form in the winter (T. Parsons, pers. comm.). There may be other small fronts in the SOG that have not been identified yet.

6. PARKS CANADA

Parks Canada is currently undertaking a feasibility study for the proposed Southern Strait of Georgia National Marine Conservation Area (NMCA) Reserve (Parks Canada 2009). This proposed NMCA is part of the National Marine Conservation Area System mandated by the Canada National Marine Conservations Areas Act (2002) that requires a system of NMCAs be created in each of the 29 Parks Canada natural marine regions with the purpose of representing the full range of marine ecosystems found in Canada's oceans and Great Lakes (Parks Canada 2008a). The boundaries of the proposed Southern Strait of Georgia NMCA were based on a different set of criteria (Parks Canada 2008a) than those being used for EBSA determination; therefore the entire NMCA cannot be delineated as an EBSA based on a proposed NMCA alone. However, portions of the southern Strait of Georgia location within the proposed NMCA are considered IAs based on EBSA criteria.

Parks Canada has produced many study publications on the proposed SoG NMCA, such as a representation analysis of habitats in the proposed NMCA relative to the entire Strait of Georgia marine region (Robinson and Royle 2008). Our identification of important oceanographic features that aggregate productivity and/or are especially unique was more challenging for the SoG than for either the WCVI and PNCIMA regions. We decided to adopt a similar method to that used in Robinson and Royle's (2008) representivity analyses which divided the SoG into different oceanographic regions (described in the oceanographic section of this report). On a finer spatial scale, specific areas within the proposed NMCA were identified that captured a broad range of habitat types, distinctive areas and biological features (Parks Canada 2008b). These "hotspots" were identified using both similar and different criteria than used in proposing IAs, as, for example, EBSA criteria do not include representivity or geologic features which the Parks Canada process does, but both processes consider biological and oceanographic features and distinctive (unique) areas.

7. IMPORTANT AREAS

The individual maps for each species' IAs will prove useful in risk management and impact mitigation, even if the IAs are not ultimately incorporated into EBSAs. This dataset could thus be used as a checklist for managers responsible for impact mitigation when planning activities within BC ecoregions. When considered together, the entire set of IAs almost entirely covers SoG and WCVI waters (Figure 1). Therefore, as expected, almost every marine area is potentially significant for at least one species or habitat feature.

7.1. IMPORTANT AREA ANALYSIS

In trying to follow the national guidelines for EBSA determination, it has become obvious to us that a phased approach to EBSA determination is necessary. The first phase, presented here, starts with the compilation of maps relating to habitat and species distributions within a particular region (IAs), as was done above. A Delphic approach was adopted and the opinions of species experts were obtained. Ranking and weighting of IAs within and among species was necessary, since EBSAs are areas of enhanced management and the entire coastal area cannot therefore be EBSAs. Completion of Phase 1 results in maps of ranked IAs for species and habitat features. The second phase, briefly discussed here and presented in detail in

Jamieson and Levesque (2011), involves moving from a set of IAs to identifying a logical and defensible EBSA network. The third step is incorporating the EBSA data with other data and clearly defining overall conservation goals, and the forth step will then be to identify indicators and reference points that will allow managers to assess how goals are being achieved over the long term.

IA overlaps are shown for both the WCVI and SoG together with a common scale (Fig. 2), and for the SoG and WCVI alone, i.e with their own scales (Figs. 3 and 4, respectively).

8. CAVEATS & SPECIAL CONSIDERATIONS

This report is Pacific Region's first attempt at the identification of EBSAs. In the process of trying to do so, we have identified IAs and have encountered significant data gaps. We also discuss here concerns voiced by regional science experts about the overall EBSA identification process.

8.1. DATA GAPS

We first emphasize that the present report represents information and data available as of April 30, 2010. It is based on the expertise and advice of only those experts that we were able to include (Appendix I) given our timeframe for completion. As was the case in Clarke and Jamieson (2006a), for many species and habitat features, information desirable for IA identification has either not been collected, analyzed or was unavailable as a result of confidentiality agreements. In some cases, data had been obtained for the determination fishing management options, but had not been analyzed for a purpose such as IA identification. Ideally, the identification of IAs would be based on all information, but what we present here is based on the best knowledge available to us. While a 'system document' is often needed for resource management decisions, deadlines for report preparation are often set independently of the actual pace of scientific study and data analysis (Muldoon 1995). This was the case here. Thus, IAs identified in this report should be considered dynamic, being the first step in an on-going process. We envision a process that allows changes to be made to existing layers when new information becomes available and the addition of new species and habitat layers not available at the time of publication. IAs therefore may be subject to considerable change over time with the addition of new information. The maps of IAs produced here are thus envisaged as part of an adaptive framework which can be modified.

In light of the above, failure of an area to be declared an IA does not negate its ecological value. There was a great deal of concern expressed to us by experts that areas that did not make the list of IAs would never be given a later chance to become EBSAs or Marine Protected Areas. Some areas may fail to become EBSAs purely because of a present lack of relevant available information about them. Areas may have escaped previous scientific investigation or industry focus as a result of their inaccessibility, poor fishing yields or a myriad of other reasons. All areas, regardless of identification status should be carefully considered in the ecological assessment and management phases of Integrated Management and in the development on a functional marine protected area network.

Experts consulted were sometimes not able to provide information for the identification of IAs, and this created a challenge in ensuring that the best data possible was presented here. Some staff approached had schedules or locations that prevented them from meeting with us, and so input was sometimes obtained via email. Others were unable to do new analyses on their existing data to provide the data interpretations being requested without additional resources. Stock assessment databases are structured with a goal different from that required to support conservation biology queries. In some cases, data needs new analyses to provide the information being requested to address Ecosystem Based Management-related needs. In addition, confidentiality agreements created obstacles to obtaining some analyses.

8.2. OTHER DATA SOURCES

Scientific Ecological Knowledge (SEK) was identified (DFO 2004c) as knowledge that should be included in the EBSA identification process. SEK was the basis of the Delphic process employed here to identify IAs. It is not presently clear how aboriginal knowledge and fishermen's knowledge, commonly referred to as Traditional and Local Ecological Knowledge (TEK and LEK, respectively), will be incorporated into the EBSA identification process. When and what procedure would allow this to occur needs to be addressed. Such data were not included in this process here because of time constraints. Significant effort will be required to obtain TEK and LEK, but this information should prove valuable in adding areas of significance for ecological or biological reasons, particularly at the Coastal Management Area (CMA) scale.

8.3. SCALE

The issue of scale repeatedly came up in conversation during the IA/EBSA identification process. The objective of the project was to identify IAs on an ecoregion (Large Ocean Management Area (LOMA)) scale. However, the scale of IAs/EBSAs must also match the biology and ecology of species being considered. IA identification at the CMA scale would be a logical next step in the identification of locally significant areas. Scale is particularly relevant when considering shallow-water, near shore species, on an ecoregion or LOMA scale map. At the LOMA scale, such areas are typically just a thin line, so to make them visible the widths of such nearshore IAs has been exaggerated. When considering them, managers need to recognize that their outer boundary does not extend beyond the inhabited depth range of the species. Also, for wide-ranging, low mobility or sessile species in this habitat, it is not clear whether they are adequately captured in IA-identification processes. All estuaries are significant, as are eel grass and kelp beds, yet such features are seldom grouped enough at a LOMA-scale to allow their inclusion in mapping. However, such features may be captured at a CMA scale. Regardless, the ecological significance of such features is recognized, and to a large extent whether IAs exists for these species or not, management often already treats these as special features worthy of an enhanced level of management consideration.

As mentioned earlier, EBSA scale also differs between national regions. Most continental shelf ecoregions and LOMAs on the east coast have a much larger area than does any Pacific ecoregion, as shown in comparison with the area of the largest Pacific ecoregion (PNCIMA) (Clarke and Jamieson 2006). Preliminary EBSA identification for GOSLIM included large EBSAs, whose polygon areas on a PNCIMA map would cover most of the WCVI and SoG.

The data collected through the Delphic process was collected at a PNCIMA scale. Experts utilized paper maps of 1:1,000,000 to 1:3,000,000 scales to draw IA polygons. This process is likely to have a high degree of accuracy, in that the same areas would likely be chosen repeatedly by the same expert. However, the level of precision for this methodology is not high as the boundaries may change slightly with repeated attempts. It must be acknowledged therefore that boundaries of the identified IAs are thus approximate and the identified IAs are not meant to be viewed at different resolutions than those at which they were created.

8.4. BIAS

As discussed by Clarke and Jamieson (2006a), a Delphic approach for the identification of IAs contains inherent biases that need to be acknowledged for results to be used appropriately. Species considered in the present analysis are only a very small subset of the species diversity present on the WCVI and in the SOG. In most cases, species considered were macrofauna, and of these, exploited species predominated. It is hoped that habitats of species not directly targeted will be captured in some way by the IAs identified, but the extent to which this has occurred is unknown. Species with economic value have more information collected for them, but they may not necessarily be the most important ecologically in the habitats they occur in. Also, while some aspects of the habitat requirements for some of their life stages may be identified, often the habitat requirements of non-exploited life stages are unknown. There is also a bias towards charismatic species, such as marine mammals. Animals that capture the public's attention have often become the focus of concentrated research effort, meaning we know more about them relative to other species. In many cases, these iconic animals are top predators (e.g. killer whales) that have spatial distributions that are indicative of areas of high ecosystem productivity (e.g. feeding locations of baleen whales), but this has not always been verified.

There is also a spatial bias inherent to this IA identification process. Certain exploited areas, especially those supporting a diversity of commercial species and accessible to fisher and research harvesting gears, have more detailed information about them, and therefore are more likely to be identified as IAs. A major problem is that the IA process does not allow areas lacking information to be flagged. In future stages, data-deficient areas, some of which may be worthy of further study and special consideration under the precautionary principle, could be identified as IAs. With advances in technology, fishers are increasingly able to exploit previously unfished areas, such as deeper habitats. New species and species presence records are continually being described as a result of new surveys or better by-catch monitoring and species identification (J. Boutillier, DFO, pers. comm.). Thus, a lack of information about an area should not exclude its importance, as some of these areas may later be identified as needing enhanced management.

8.5. DATA QUALITY

The species and habitat features examined during the Pacific EBSA identification process are diverse in their data quality. One of the issues that arose was IA identification of data-rich versus data poor species and/or habitat features. The data quality of these groups can be viewed as a continuum with species such as the leatherback turtle on one end of the spectrum (data poor) and species such as herring at the other end (data rich). It became difficult to apply the EBSA dimensions in the same manner for the two levels of data quality, and we suggest that applying the same decision rules to each situation may not be best. For situations with high data quality, application of a qualitative Delphic approach may be less accurate then when highly specific quantitative decision rules could be used. The converse would apply for data poor situations.

9. RECOMMENDATIONS

1. Geographical areas where there is a lack of information available should be flagged as priorities for future research consideration. In particular, bycatch data should be further analyzed. Such areas may contain important species (e.g. corals), even if these species are not presently of commercial importance.
2. The process to identify IAs identified a need for consideration of a science data collection and analysis policy shift so that results more applicable to advancing ecosystem-based management (EBM) rather than just Stock Assessment are provided. Much data held by DFO has only been used to date for species-specific stock assessments, and analyses have yet to be done that could support EBM. Data confidentiality issues typically allow

only specific people to access these data, and their workloads do not include analyses for EBM per se.

3. The IA/EBSA-identification process should be repeated at the CMA-scale, as many areas deemed important for species (e.g., nearshore ones) were too small for mapping inclusion at a LOMA scale.

4. The utility of TEK and LEK information for inclusion in EBSA determination should be assessed and if positive, a process developed to allow its incorporation.

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11.TABLES

Table 1. Important Area (IA) layers and shapefile names for the Strait of Georgia.

Layer	Shapefile Name
Marine Birds	SDE_BIOTA.DFO_BC_MARINE_BIRDS_IA_SOG
Harbour Porpoise	SDE_BIOTA.DFO_BC_HARBOUR_PORPOIS_IA_ SOG
Resident Killer Whale	SDE_BIOTA.DFO_BC_RES_KILLR_WHALE_IA_ SOG
Harbour Seal	SDE_BIOTA.DFO_BC_HARBOUR_SEAL_IA_SOG
Steller Sea Lion	SDE_BIOTA.DFO_BC_STELLER_SEALION_IA_ SOG
Juvenile Salmon	SDE_BIOTA.DFO_BC_SALMON_IA_ SOG
Eulachon	SDE_BIOTA.DFO_BC_EULACHON_IA_ SOG
Herring	SDE_BIOTA.DFO_BC_HERRING_IA_ SOG
Pacific Sand Lance	SDE_BIOTA.DFO_BC_SANDLANCE_IA_ SOG
Dogfish	SDE_BIOTA.DFO_BC_DOGFISH_IA_ SOG
Sixgilled Shark	SDE_BIOTA.DFO_BC_SIXGILLED_SHARK_IA_ SOG
Brown Cat Shark	SDE_BIOTA.DFO_BC_BROWNCATSHARK_IA_ SOG
Longnose Skate	SDE_BIOTA.DFO_BC_LONGNOSE_SKATE_SOG
Big Skate	SDE_BIOTA.DFO_BC_BIGSKAT_IA_ SOG_SOG
Alaska Skate	SDE_BIOTA.DFO_BC_ALASKA_SKATE_IA_SOG
Pacific Cod	SDE_BIOTA.DFO_BC_PACIFIC_COD_IA_SOG
Hake	SDE_BIOTA.DFO_BC_HAKE_IA_SOG
Pollock	SDE_BIOTA.DFO_BC_POLLOCK_IA_SOG
Bivalves	SDE_BIOTA.DFO_BC_BIVALVES_IA_SOG
Scallop	SDE_BIOTA.DFO_BC_SCALLOPS_IA_SOG
Dungeness Crab	SDE_BIOTA.DFO_BC_DUNGENESS_CRAB_IA_SOG
Tanner Crab	SDE_BIOTA.DFO_BC_TANNER_CRAB_IA_SOG
Euphausiid	SDE_BIOTA.DFO_BC_EUPHAUSIIDS_IA_SOG
Shrimp	SDE_BIOTA.DFO_BC_SHRIMP_IA_SOG

Table 2. Important Area (IA) layers and shapefile names for the West Coast of Vancouver Island.

Layer	Shapefile Name
Marine Birds	SDE_BIOTA.DFO_BC_MARINE_BIRDS_IA_WCVI
Harbour Porpoise	SDE_BIOTA.DFO_BC_HARBOUR_PORPOIS_IA_WCVI
Resident Killer Whale	SDE_BIOTA.DFO_BC_RES_KILLR_WHALE_IA_WCVI
Blue Whale	SDE_BIOTA.DFO_BC_BLUE_WHALE_IA_WCVI
Fin Whale	SDE_BIOTA.DFO_BC_FIN_WHALE_IA_WCVI
Sei Whale	SDE_BIOTA.DFO_BC_SEI_WHALE_IA_WCVI
Sperm Whale	SDE_BIOTA.DFO_BC_SPERM_WHALE_IA_WCVI
Grey whale	SDE_BIOTA.DFO_BC_GRAY_WHALE_IA_WCVI
Humpback Whale	SDE_BIOTA.DFO_BC_HUMPBACK_WHALE_IA_WCVI
Harbour Seal	SDE_BIOTA.DFO_BC_HARBOUR_SEAL_IA_WCVI
Steller Sea Lion	SDE_BIOTA.DFO_BC_STELLER_SEALION_IA_WCVI
Northern Fur Seal	SDE_BIOTA.DFO_BC_NRTHRN_FUR_SEAL_IA_WCVI
Sea Otter	SDE_BIOTA.DFO_BC_SEAOTTER_IA_WCVI
Juvenile Salmon	SDE_BIOTA.DFO_BC_SALMON_IA_WCVI
Green Sturegon	SDE_BIOTA.DFO_BC_GREEN_STURGEON_IA_WCVI
Eulachon	SDE_BIOTA.DFO_BC_EULACHON_IA_WCVI
Herring	SDE_BIOTA.DFO_BC_HERRING_IA_WCVI
Pacific Sand Lance	SDE_BIOTA.DFO_BC_SANDLANCE_IA_WCVI
Sardine	SDE_BIOTA.DFO_BC_SARDINE_IA_WCVI
Basking Shark	SDE_BIOTA.DFO_BC_BASKING_SHARK_IA_WCVI
Sixgilled Shark	SDE_BIOTA.DFO_BC_SIXGILLED_SHARK_IA_WCVI
Brown Cat Shark	SDE_BIOTA.DFO_BC_BROWNCATSHARK_IA_ WCVI
Pacific Sleeper Shark	SDE_BIOTA.DFO_BC_PACIFIC_SLEEPER_IA_ WCVI
Longnose Skate	SDE_BIOTA.DFO_BC_LONGNOSE_SKATE_IA_ WCVI
Big Skate	SDE_BIOTA.DFO_BC_BIGSKAT_IA_WCVI
Deepsea Skate	SDE_BIOTA.DFO_BC_DEEPSEA_SKATE_IA_WCVI
Sandpaper Skate	SDE_BIOTA.DFO_BC_SANDPAPER_SKATE_IA_WCVI
Roughtail Skate	SDE_BIOTA.DFO_BC_ROUGHTAIL_SKATE_IA_WCVI
Alaska Skate	SDE_BIOTA.DFO_BC_ALASKA_SKATE_IA_WCVI
Pacific Cod	SDE_BIOTA.DFO_BC_PACIFIC_COD_IA_WCVI
Hake	SDE_BIOTA.DFO_BC_HAKE_IA_WCVI
Arrowtooth Flounder	SDE_BIOTA.DFO_BC_AROWTOTH_FLNDER_IA_WCVI
Curlfin Sole	SDE_BIOTA.DFO_BC_CURLFIN_IA_WCVI
Deepsea Sole	SDE_BIOTA.DFO_BC_DEEPSEA_SOLE_IA_WCVI
Dover Sole	SDE_BIOTA.DFO_BC_DOVER_SOLE_IA_WCVI
English Sole	SDE_BIOTA.DFO_BC_ENGLISH_SOLE_IA_WCVI
Flathead Sole	SDE_BIOTA.DFO_BC_FLATHEAD_SOLE_IA_WCVI
Halibut	SDE_BIOTA.DFO_BC_HALIBUT_IA_WCVI
Juvenile Flatfish	SDE_BIOTA.DFO_BC_JUVENILE_FLATFISH_IA_WCVI
Pacific Sanddab	SDE_BIOTA.DFO_BC_PACIFIC_SANDDAB_IA_WCVI
Petrale Sole	SDE_BIOTA.DFO_BC_PETRALE_SOLE_IA_WCVI
Rex Sole	SDE_BIOTA.DFO_BC_REX_SOLE_IA_WCVI
Rock Sole	SDE_BIOTA.DFO_BC_ROCK_SOLE_IA_WCVI
Sand Sole	SDE_BIOTA.DFO_BC_SAND_SOLE_IA_WCVI
Coral and Sponge	SDE_BIOTA.DFO_BC_CORAL_SPONGE_IA_WCVI

Layer	Shapefile Name
Bycatch	
Bivalves	SDE_BIOTA.DFO_BC_BIVALVES_IA_WCVI
Geoduck	SDE_BIOTA.DFO_BC_GEODUCK_IA_WCVI
Green Sea Urchin	SDE_BIOTA.DFO_BC_GREENSEAURCHIN_IA_WCVI
Dungeness Crab	SDE_BIOTA.DFO_BC_DUNGENESS_CRAB_IA_WCVI
Tanner Crab	SDE_BIOTA.DFO_BC_TANNER_CRAB_IA_WCVI
Shrimp	SDE_BIOTA.DFO_BC_SHRIMP_IA_WCVI
Leatherback turtle	SDE_BIOTA.DFO_BC_LEATHERBACK_IA_WCVI

Table 3. Description of the fields found in the EBSA shapefile attribute tables.

Field	Description
Shape	ArcView shape identifier
ID	The number assigned to the polygon as it was digitized
Map#	Cross-reference number for the hand-drawn polygon on the paper map
Species	The name of the species or habitat feature the polygon describes
Criteria	The EBSA criteria the polygon meets (Uniqueness, Aggregation, Fitness Consequences, Naturalness and/or Resilience)
Notes	Any notes on the polygon
Seasonal	Any seasonal variation for the polygon
Scale	The scale at which the polygon was digitized
Expert	The name of the expert(s) responsible for identification
Unique	Expert's ranking of the area based on the EBSA criterion "Uniqueness". An increasing scale from 1-10.
Aggreg	Expert's ranking of the area based on the EBSA criterion "Aggregation". An increasing scale from 1-10.
Fitness	Expert's ranking of the area based on the EBSA criterion "Fitness Consequences". An increasing scale from 1-10.
Natural	Expert's ranking of the area based on the EBSA criterion "Resilience". An increasing scale from 1-10. This criterion is an inverse where areas with higher resilience will have lower value as EBSAs.
Resil	16 Expert's ranking of the area based on the EBSA criterion "Naturalness". An increasing scale from 1-10.
Data	The expert's opinion of the quality of data on which the area's identification was based. An increasing scale from 1-3.
Score	The area's cumulative value score based on the experts' ranking of the EBSA criteria (Low, Moderate and High value)

Note: When the EBSA criteria field is blank that means a value was not given by the expert for that field.

12.FIGURES

Figure 1. Overlays of all identified species' IA polygons for the West Coast of Vancouver Island and Strait of Georgia.

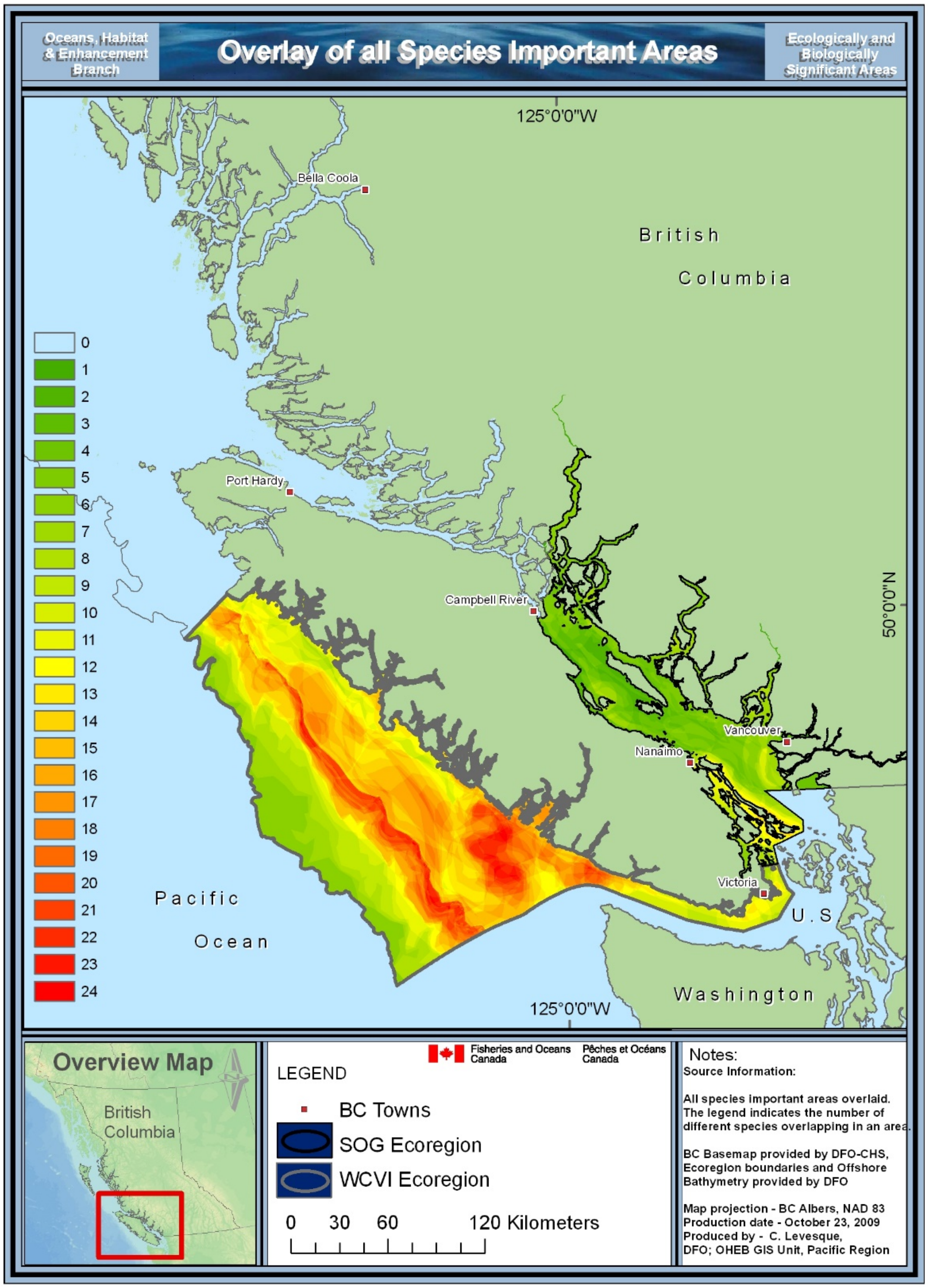

Figure 2. Counts of overlaid species IAs, i.e., the number of IA polygons overlapping, on both the West Coast of Vancouver Island and in the Strait of Georgia.

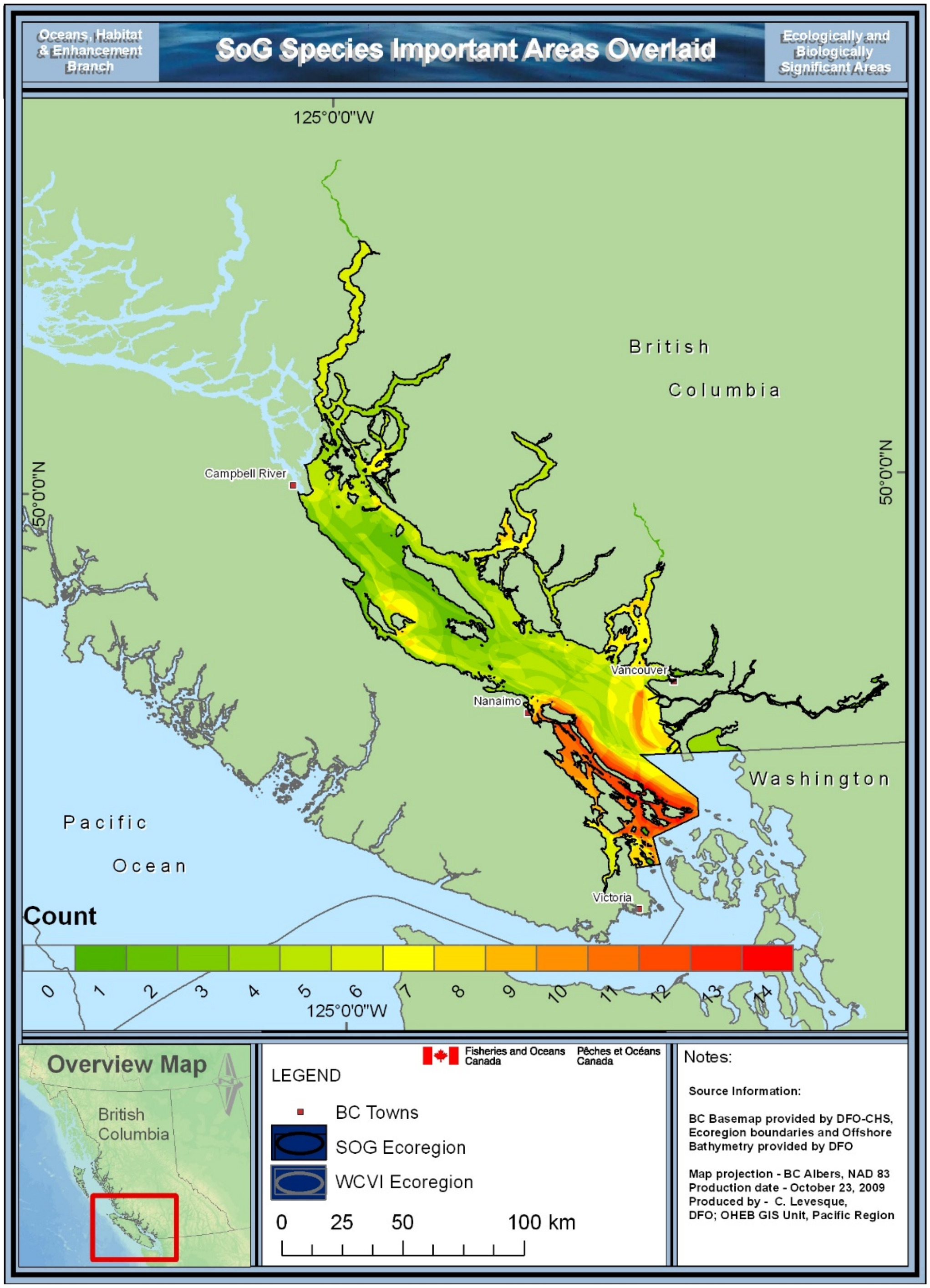

Figure 3. Counts of overlaid species IAs, i.e., the number of IA polygons overlapping, in only the Strait of Georgia. Note: This is a different count scale that in Fig 2 to make more visible the pattern in the SoG because of fewer overlaps.

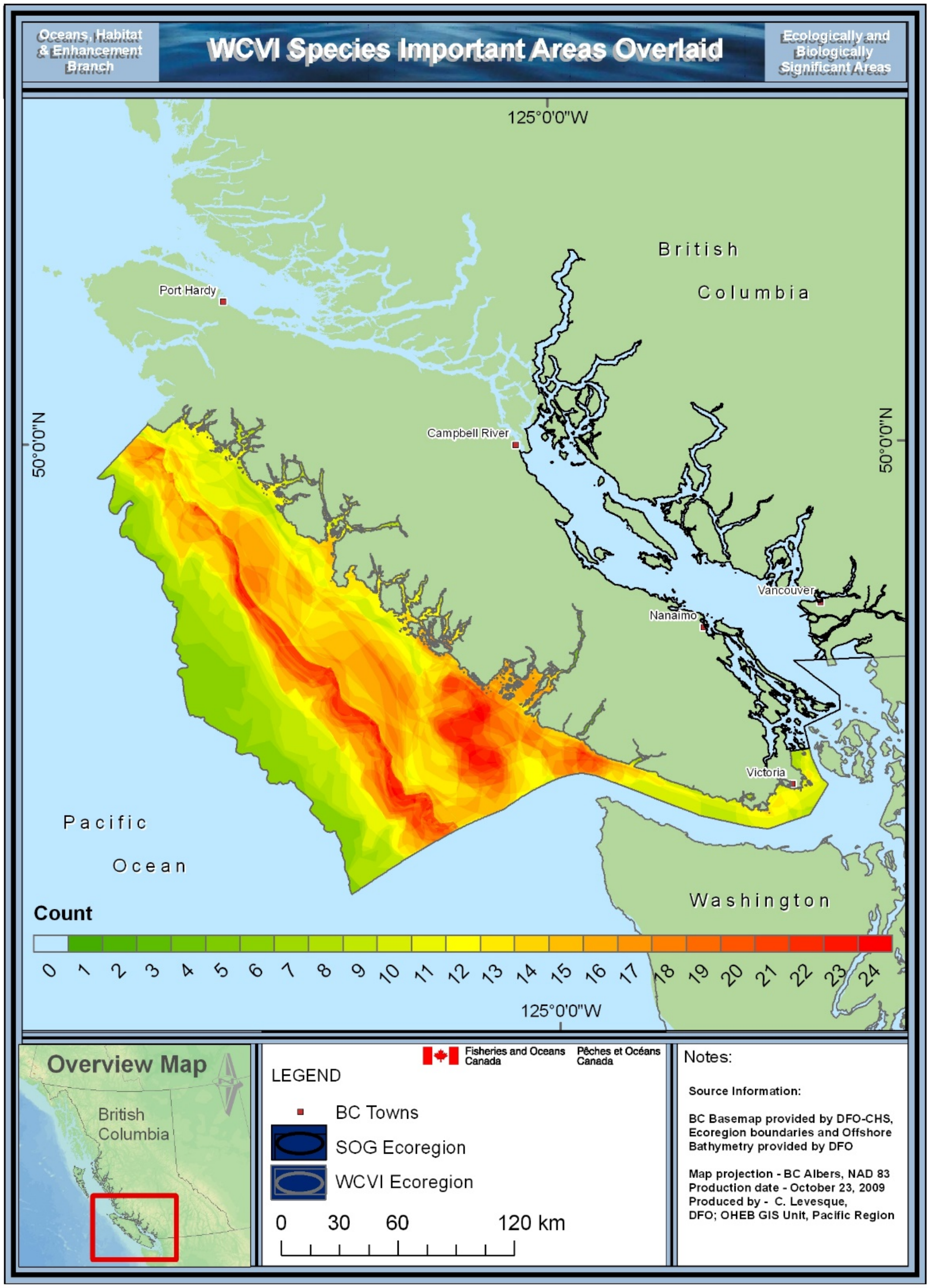

Figure 4. Counts of overlaid species IAs, i.e., the number of IA polygons overlapping, for the West Coast of Vancouver Island.

13. APPENDIX I: LIST OF DELPHIC PARTICIPANTS THAT PROVIDED INFORMATION

Last Name	First Name	Organization	Species/Habitat Feature they provided information on (their expertise)
Allen	Susan	UBC	Oceanography (Marine Canyons)
Austin	Bill	Khoyatan Marine Lab	Sponges
Barton	Leslie	PBS	Shellfish Data Coordinator
Beamish	Dick	PBS	Pacific Salmon
Biffard	Doug	BCGOV	Sponge Gardens
Boutillier	Palmira	PBS	Corals and Sponges
Boutillier	Jim	PBS	Shellfish
Boyd	Sean	CWS	Birds
Conway	Kim	NRCAN	Glass Sponge Reefs
Cooke	Ken	PBS	Hake
Crawford	Bill	IOS	Oceanography
Fargo	Jeff	PBS	Groundfish (Flatfish)
Finney	Jessica	PBS	Corals
Fong	Ken	PBS	Scallops
Ford	John	PBS	Cetaceans
Foreman	Mike	IOS	Oceanography
Gibbs	Donna	PMLS	Sponge Gardens
Gillespie	Graham	PBS	Bivalves
Gisborne	Brian	JDF Express	Cetaceans
Gower	Jim	IOS	Oceanography
Grandin	Chris	PBS	Hake
Haigh	Rowan	PBS	Groundfish (Slope Rockfish)
Hall	Anna	UBC	Harbour Porpoise
Hand	Claudia	PBS	Sea Cucumber, Geoduck
Hay	Doug	PBS	Pelagics (herring, eulachon)
Hipfner	Mark	CWS	Birds
Holmes	John	PBS	Hake, Albacore Tuna
Hyatt	Kim	PBS	Salmon
Jamieson	Glen	PBS	Crab
King	Jackie	PBS	Groundfish (Lingcod)
Kronlund	Rob	PBS	Groundfish (Sablefish)
Lauzier	Ray	PBS	Scallops
Lemon	Moira	CWS	Birds
Lessard	Joanne	PBS	Abalone
Leus	Dan	PBS	Red Sea Urchin
Mackas	Dave	IOS	Plankton, Euphausiids, Oceanography
Marliave	Jeff	VAMSC	Sponge Gardens
McCarter	Bruce	PBS	Pelagics (herring, eulachon)
McFarlane	Sandy	PBS	Elasmobranchs, Hake, Walleye Pollock
Moore	Kathleen	CWS	Birds
Morgan	Ken	IOS/CWS	Birds

Last Name	First Name	Organization	Species/Habitat Feature they provided information on (their expertise)
Nichol	Linda	PBS	Sea Otters, Cetaceans
Olesiuk	Peter	PBS	Pinnipeds
Parsons	Tim	PBS	Oceanography (Biological Fronts)
Pellatt	Marlow	PC	Parks Canada
Peña	Angelica	IOS	Oceanography
Perry	Ian	PBS	Oceanography, Green Sea Urchin
Phillips	Antan	PBS	Crabs
Robinson	Cliff	PC	Sand Lance, Parks Canada NMCAs
Rutherford	Dennis	PBS	Shrimp
Schweigert	Jake	PBS	Pelagics (herring, eulachon, sardine, anchovy)
Sinclair	Alan	PBS	Groundfish (Pacific cod)
Smith	Dave	CWS	Birds
Spaven	Lisa	PBS	Leatherback Turtle, Cetaceans
Stanley	Rick	PBS	Groundfish (Shelf Rockfish)
Tanasichuk	Ron	PBS	Euphausiids, Herring
Therriault	Tom	PBS	Pelagics (herring, eulachon)
Thomson	Rick	IOS	Oceanography
Trudel	Marc	PBS	Pacific Salmon
Welch	David	Kintama Research	Salmon, Green Sturgeon
Workman	Greg	PBS	Groundfish
Yamanaka	Lynn	PBS	Groundfish (Inshore Rockfish)
Zielinski	Amanda	Hornby Island Diving	Sponge Gardens and Sixgilled Sharks

Organization Key	
PC	Parks Canada
CWS	Environment Canada/Canadian Wildlife Service
NRCAN	Natural Resources Canada
VAMSC	Vancouver Aquarium Marine Science Centre
UBC	University of British Columbia
PBS	Department of Fisheries and Oceans/Pacific Biological Station
PMLS	Pacific Marine Life Surveys
IOS	Department of Fisheries and Oceans/Institute of Ocean Sciences
GOVBC	B.C. Provincial Government
JDF Express	Juan de Fuca Express

14. APPENDIX II: IA LAYERS INVESTIGATED

A. Species layers

Marine Mammals and Turtles
Leatherback Turtle

Harbour Porpoise
Dall's Porpoise
Pacific White-Sided Dolphin
Killer Whale - Southern Residents
Killer Whale - Northern Residents
Killer Whale - Transients
Killer Whale - Offshore
Sperm Whale
Humpback Whale
Grey whale
Blue Whale
Sei Whale
Fin Whale

Sea Otter
Harbour Seal
Steller Sea Lion
Fur Seal

Pelagics
Herring
Hake
Pacific Sardine
Albacore Tuna
Northern Anchovy
Sand Lance

Anadromous Fish
Eulachon

Green Sturgeon

Invertebrates

Euphausiids
Giant Red Sea Cucumber
Geoduck
Green Sea Urchin
Red Sea Urchin
Purple Sea Urchin
Manilla Clam
Razor Clam
Butter Clam
Olympia Oyster

Pacific Oyster
King Crab
Dungeness Crab
Tanner Crab
Red Rock Crab
Shrimp
Prawn
Abalone

Groundfish
Pacific cod
Arrowtooth Flounder
Curlfin Sole
Deepsea Sole

Dover Sole

English Sole
Flathead Sole
Sanddab
Petrale Sole
Rex Sole
Rock Sole
Sand Sole
Pacfic Halibut
Lingcod

Sablefish
Walleye Pollock

Elasmobranchs
Spiny Dogfish

Basking Shark
Sixgilled Shark
Sevengill Shark

Brown Cat Shark

Great White Shark
Soupfin Shark
Blue Shark
Salmon Shark
Common Thresher
Shortfin Mako
Bigeye Thresher
Green-eyed Thresher
Pacific Sleeper Shark
Deepsea or Abyssal Skate
Sandpaper Skate
Roughtial Skate
Aleutian Skate
Alaska Skate
Broad Skate
Longnose Skate
Big Skate
Whitebrow Skate
California Skate
Starry Skate
Pacific Electric Ray
Pelagic Stingray
Diamond Stingray

B. Guild layers

Marine Birds
Macrophyte beds
Rockfish
Scallops
Coral and Sponge Bycatch
Sponge reefs
Macrozooplankton
Salmon

C. Physical Features and Organizations

Oceanographic Features
Parks Canada

15. APPENDIX III: MAP FOLIO

Marine Birds
Harbour Porpoise
Resident Killer Whale
Blue, Fin, Sei and Sperm Whales
Grey whale
Humpback Whale
Harbour Seal
Steller Sea Lion
Northern Fur Seal
Sea Otter
Juvenile Salmon
Green Sturegon
Eulachon
Herring
Pacific Sand Lance
Sardine
Dogfish
Basking Shark
Sixgilled Shark
Brown Cat Shark
Pacific Sleeper Shark
Longnose Skate
Big Skate
Deepsea Skate
Sandpaper Skate
Roughtail Skate
Alaska Skate
Pacific Cod
Hake
Pollock
Arrowtooth Flounder
Curlfin Sole
Deepsea Sole
Dover Sole
English Sole
Flathead Sole
Halibut
Juvenile Flatfish
Pacific Sanddab
Petrale Sole
Rex Sole
Rock Sole
Sand Sole
Glass Sponge Reef
Coral and Sponge Bycatch
Bivalves
Scallop
Geoduck
Green Sea Urchin
Dungeness Crab
Tanner Crab
Euphausiid
Shrimp
Leatherback turtle