Assessing Sensitivity of Coastal Areas to Oil Spills

September 2020

About Us

Clear Seas Centre for Responsible Marine Shipping is an independent, not-for-profit research centre that provides impartial and fact-based information about marine shipping in Canada.

Led by a Board of Directors and advised by a Research Advisory Committee, Clear Seas' work focuses on identifying and sharing best practices for safe and sustainable marine shipping in Canada, encompassing the human, environmental and economic impacts of the shipping industry.

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About this Report

As an element of its Marine Transportation Corridors Initiative, Clear Seas Centre for Responsible Marine Shipping (Clear Seas) commissioned Dillon Consulting to conduct this study, ***Assessing Sensitivity of Coastal Areas to Oil Spills***. This report, authored by Dillon Consulting and edited by Clear Seas, conveys the analysis results.

Board of Directors of Clear Seas Centre for Responsible Marine Shipping

Message from the Executive Director

Canada's Pacific Coast is home to vibrant coastal ecosystems and centres of economic activity that depend on a healthy ocean. It also features busy marine shipping corridors with vessels from small boats to large container ships, all carrying oil for fuel or as cargo. An oil spill could present a risk to the health of the coastal ecosystems and those that rely on the ocean for subsistence.

The results of a Canada-wide opinion poll undertaken in 2016 (view report) and 2018 (view report) by Clear Seas Centre for Responsible Marine Shipping (Clear Seas) in partnership with the Angus Reid Institute indicated that Canadians' top concern related to marine shipping is the potential for an oil spill, with 67% of respondents indicating this as a top concern in 2016 and 54% in 2018.

To support marine spatial planning efforts in Canada with new perspectives on marine shipping risks, Clear Seas launched its Marine Transportation Corridors Initiative: a multi-layered geo-spatial analysis to determine and describe risks related to commercial marine shipping activities. This report forms one part of the initiative by identifying sensitive coastal areas along Canada's Pacific Coast that would be at risk should an oil spill occur as a result of commercial marine shipping activity.

The innovative approach taken in this report considers the aggregate effect of biological, physical and socio-economic factors to understand the overall sensitivity of Canada's Pacific Coast region to the potential impact of a ship-source oil spill. It is not intended as a detailed primary resource for spill response planning, but rather to support marine spatial planning efforts by providing and combining datasets for new perspectives on impacts from shipping activity. While this study focuses on oil spill impacts, this approach could potentially be applied to other marine shipping impacts such as hazardous and noxious substances or air emissions.

This study identified four categories – Biological, Physical, Socio-Economic and Indigenous – to better define the attributes of an area along the coast that could be affected by commercial marine shipping. Three of the categories were analyzed using publicly available data to identify areas along the Pacific coast that are relatively more vulnerable to ship-source oil spills. The fourth, the Indigenous sensitivity category, will need to be developed at a future date in partnership with First Nations who have a deep connection to and stewardship of the lands and waters in the study area as well as rights and interests.

The decision to use publicly available datasets with no licence restrictions is driven by Clear Seas' commitment to disseminate information widely for public benefit. This report supports an interactive web-map created using geographic information system (GIS) databases. The web-map is an integral part of Clear Seas' Marine Transportation Corridors initiative and is intended to be used to inform marine spatial planning discussions by illustrating ways to display and interact with coastal sensitivity information.

This analysis is not static and we hope the results will evolve over time as additional data becomes available, including the vital Indigenous sensitivity data, as a result of consultation and engagement with users and providers of the information.

Executive Summary

Clear Seas Centre for Responsible Marine Shipping (Clear Seas) commissioned Dillon Consulting Limited (Dillon) to identify sensitive coastal areas along most of Canada's Pacific Coast. The identification of sensitive coastal areas is one part of a multi-layered geo-spatial analysis undertaken by Clear Seas to support marine spatial planning by describing risks related to marine shipping activities on Canada's Pacific Coast. This report details the approach to and outcomes of the sensitive coastal areas assessment, displayed in an interactive Geographic Information System (GIS) web-map.

Publicly available data were collected and analyzed to identify areas and regions within the study area that are relatively more vulnerable if an oil spill were to occur near them and a score was assigned based on these data. The assessment was limited to publicly available datasets that could be easily obtained and used without licensing so the results of the assessment could be shared without restriction.

Four categories – Biological, Physical, Socio-Economic and Indigenous – were identified to better define the attributes of an area along the coast that could be affected by commercial marine shipping.

The Biological Sensitivity Score relies upon the BC Marine Conservation Analysis (BCMCA, 2012) that identified marine areas (including habitats and species) of high conservation value. For the purposes of this analysis, these areas of high conservation value were assessed as also being susceptible to negative impacts from oil spills. The Physical Sensitivity Score focuses on key physical attributes of shorelines and seafloor that could support different types of habitats that would be negatively affected if exposed to oil. This score does not consider the level of effort required to clean oil from different types of physical attributes. The Socio-Economic Sensitivity Score qualitatively evaluates the impact an oil spill could have on various human activities in the marine environment such as tourism and fishing.

The Indigenous sensitivity category data will need to be incorporated at a future date in partnership with First Nations who have a deep connection to and stewardship of the lands and waters in the study area as well as rights and interests. The intention with the Indigenous sensitivity data is to highlight the coastal areas within the study area that are identified by First Nations as having high cultural, environmental, spiritual, economical or historical importance.

The individual sensitivity category scores (normalized to the same scale) are combined together with equal weighting to obtain an overall Coastal Sensitivity Score for the area on a per grid-cell basis. The weighting could be modified in the future for specific purposes or to incorporate aspects such as seasonality. The Coastal Sensitivity Score in each grid cell is illustrated using a five-step scale, from very low to very high, to indicate relative sensitivity to an oil spill. The Coastal Sensitivity Score for the Pacific Coast of Canada is presented in Figure 1.

The results of the assessment indicate that the most sensitive areas generally occur close to shore. The interactive web-map displays some of the more sensitive areas as example "Areas of Interest" for each

category to highlight specific areas of the coast that contributed to a higher sensitivity score. Sensitive areas identified during the assessment include:

1. **Haida Gwaii** – The waters surrounding Haida Gwaii are the traditional territory of the Haida Nation and also provide critical habitat and feeding grounds for a wide variety of marine species. Haida Gwaii is an important tourist destination with Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve, and Haida Heritage Site. The shoreline and seafloor of the waters surrounding Haida Gwaii have a very high sensitivity to oil spills.

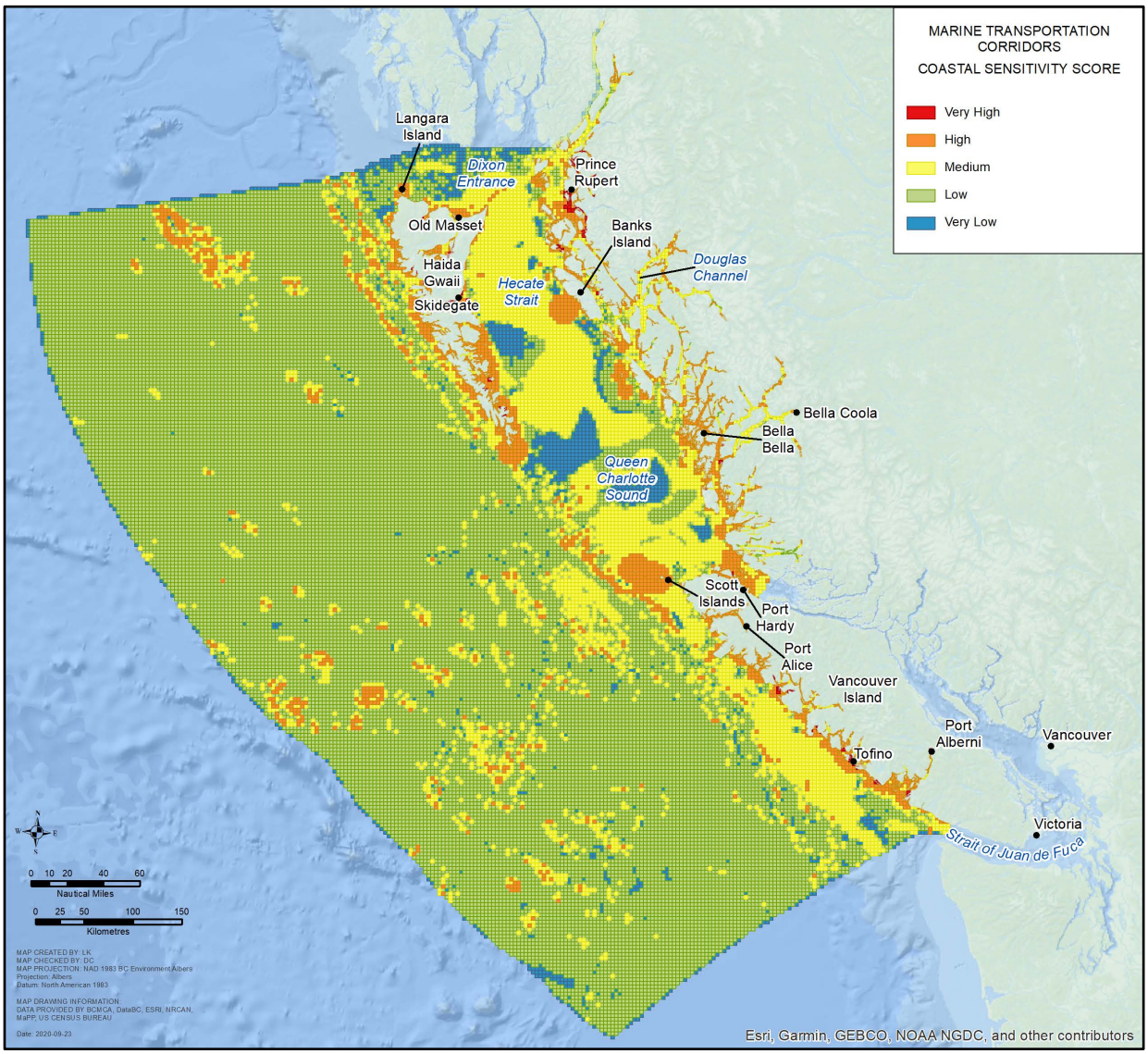

Figure 1. Coastal Sensitivity Score for the Pacific Coast of Canada

2. **Northern and Central Coast** – The Northern and Central Coast includes the waters of the Inside Passage and fjords from Prince Rupert to the northern tip of Vancouver Island. The waters are the traditional territory of the Heiltsuk, Kitasoo/Xai'xais, Nuxalk and Wuikinuxv

First Nations and provide important habitat to a wide range of marine species. There are several important commercial fisheries located in this area as well as log boom storage and tourism and recreational sites. The waters east of Banks Island are an important feeding area for marine mammals and the Marine Plan Partnership (MaPP) North Coast Marine Plan, developed by North Coast First Nations and the Province of B.C. with input from stakeholders, governments, and the public, identified the waters to the west of Banks Island as an important rockfish conservation area.

3. **North and West Coast of Vancouver Island** – The Scott Islands, located just north of Vancouver Island, are Canada's first marine National Wildlife Area under the *Canada Wildlife Act*, designated an Ecologically and Biologically Significant Area by Fisheries and Oceans Canada and have also been identified by the Province of British Columbia as an important biological area with designated Ecological Reserves. As an Important Bird Area (designated by Birdlife International), the islands provide nesting to over two million seabirds, and are also key sea lion rookeries. The region is the ancestral home of the Tlatlasikwala and the Quatsino First Nations. Barkley Sound, west of Port Alberni, provides habitat and feeding grounds to a wide variety of marine birds, mammals and fish. Barkley Sound is also the site of the Pacific Rim National Park Reserve and an important tourist area with visitors participating in eco-tourism activities as well as recreational fishing. The waters at the entrance of Barkley Sound are the traditional territory of the Nuu-chah-nulth First Nations and one of the largest commercial salmon fisheries in B.C.

This coastal sensitivity analysis is part of a broader Marine Transportation Corridors initiative that Clear Seas is undertaking. The first phase of this initiative is focused on Canada's Pacific Region. Within each phase there are a number of geo-spatial components. The findings for the first three research studies, *Vessel Drift and Response Analysis*, *Emergency Towing Vessel Needs Assessment* and *Availability of Tugs of Opportunity* have been made available on the Clear Seas website. The findings of this coastal sensitivity assessment will be considered with the other assessments to provide a summary of findings and recommendations.

This report is intended to support marine spatial planning discussions and is expected to evolve over time as additional data becomes available. Further work by the federal, provincial, and Indigenous governments leading marine spatial planning processes is required to engage in broad consultation with the public, other First Nations, and knowledgeable stakeholders to identify and select additional relevant datasets and also validate this model's approach and the resulting sensitivity scores.

The method used to determine and score sensitive coastal areas is based on an ArcGIS workflow that is easily updated when additional datasets become available, if the scoring methodology is revised, or if a weighting is added to any of the sensitivity categories.

The coastal sensitivity analysis contained within this report is limited to a specific study area determined for the overall Marine Transportation Corridors initiative. The study area was defined to include

geographical areas where risks from disabled and drifting ships could be modeled, which excluded the east side of Vancouver Island and the Strait of Juan de Fuca from the scope of this analysis.

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Acronyms and Abbreviations

B.C.	British Columbia
BCMCA	British Columbia Marine Conservation Analysis
BSS	Biological Sensitivity Score
CF	Commercial Fishing
CSS	Coastal Sensitivity Score
DFO	Fisheries and Oceans Canada
GIS	Geographic Information System
km	Kilometres
km^2	Square kilometres
m^3	Cubic metres
MaPP	Marine Plan Partnership
NM	Nautical mile
PCSA	Parks and Cultural Sensitive Areas
PD	Population Density
PSS	Physical Sensitivity Score
$SEN_{seafloor}$	Seafloor Sensitivity Score
$SEN_{shoreline}$	Shoreline Sensitivity Score
SESS	Socio-Economic Sensitivity Score
$SFEI_n$	Seafloor Exposure Index
TE	Tourism Employment
WRU	Water Resource Use

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Assessing Sensitivity of Coastal Areas to Oil Spills

1.0 Introduction

This report presents the results of an assessment commissioned by Clear Seas Centre for Responsible Marine Shipping (Clear Seas) and completed by Dillon Consulting Limited (Dillon) to identify areas along the Pacific Coast of Canada sensitive to oil spills from commercial marine shipping activity. The work presented here is part of Clear Seas' larger Marine Transportation Corridors initiative. The identification of sensitive coastal areas is one part of a multi-layered geo-spatial analysis to support marine spatial planning and identify risks related to marine shipping activities on Canada's Pacific Coast. This report details the approach to and outcomes of the sensitive coastal areas assessment, displayed in an interactive Geographic Information System (GIS) web-map.

A modified version of the consequence model from the Area Risk Assessment Methodology (Dillon, 2017) was used in this study to identify sensitivities along Canada's Pacific Coast. The Area Risk Assessment Methodology was developed for the Government of Canada to identify locations with higher potential of ship-source oil spills and to evaluate the consequences of these potential spills.

The objective of this assessment is to identify areas along much of Canada's Pacific Coast that are sensitive to oil spills. The overall coastal sensitivity to an oil spill is a reflection of the sum of the following three sensitivity categories:

1. **Biological** – areas that have significant ecological value and high conservation value (including species and habitats).
2. **Physical** – characteristics of the shoreline and seafloor that contribute to biological activity and present resistance to impacts associated with an oil spill incident.
3. **Socio-Economic** – human-use resources that contribute economically to the area.

A fourth sensitivity category concerning Indigenous perspectives is intended to be added at a later date. This category will identify areas identified as having high cultural, environmental, spiritual, economical or historical importance to First Nations people.

1.1 Scope of Assessment

The scope of this assessment was to identify the sensitive coastal areas along the Pacific Coast of Canada. Publicly available data were collected and analyzed to identify vulnerable areas that may be more sensitive to degradation or may require additional protection from oil spills because of their significance for recognized ecological, economic, cultural, or scientific attributes.

The work presented herein is not a risk assessment as it does not attempt to determine the likelihood of an oil spill occurring. The scope of this assessment does not include oil spill fate and trajectory

modelling for a specific oil spill event. Instead this assessment attempts to identify ecological, economic, cultural or scientific areas sensitive to oil spills that are within the study area.

The approximately 443,000 square kilometre (km^2) Pacific Coast of Canada study area, presented in Figure 2, extends from the B.C.-Washington State border in the south to the B.C.-Alaska State border in the north. The eastern boundary of the study area is defined by the Pacific Coast of Canada, including the west coast of Vancouver Island, Haida Gwaii, Dixon Entrance, Queen Charlotte Sound and Hecate Strait. The western boundary of the study area is the 200 nautical mile (NM) Exclusive Economic Zone of Canada.

The study area excludes the east (inside) of Vancouver Island and the Strait of Juan de Fuca, as the study area for the Marine Transportation Corridors initiative was initially geographically defined by areas where risk associated with a drifting vessel as a result of marine causality (disabled vessel) could be modeled. Much of the area east of Vancouver Island features narrow channels, meaning that the potential response time is very short to recover a disabled vessel before it drifts aground. Such areas were therefore excluded from the study area.

The study area was divided into a grid measuring 2 NM by 2 NM. Where the grid cell includes shoreline, the grid cell is aligned to the high water mark of the shoreline.

Publicly accessible data from 441 different federal and provincial government, non-profit and academic sources were gathered for the sensitivity assessment and are detailed in Appendix A.

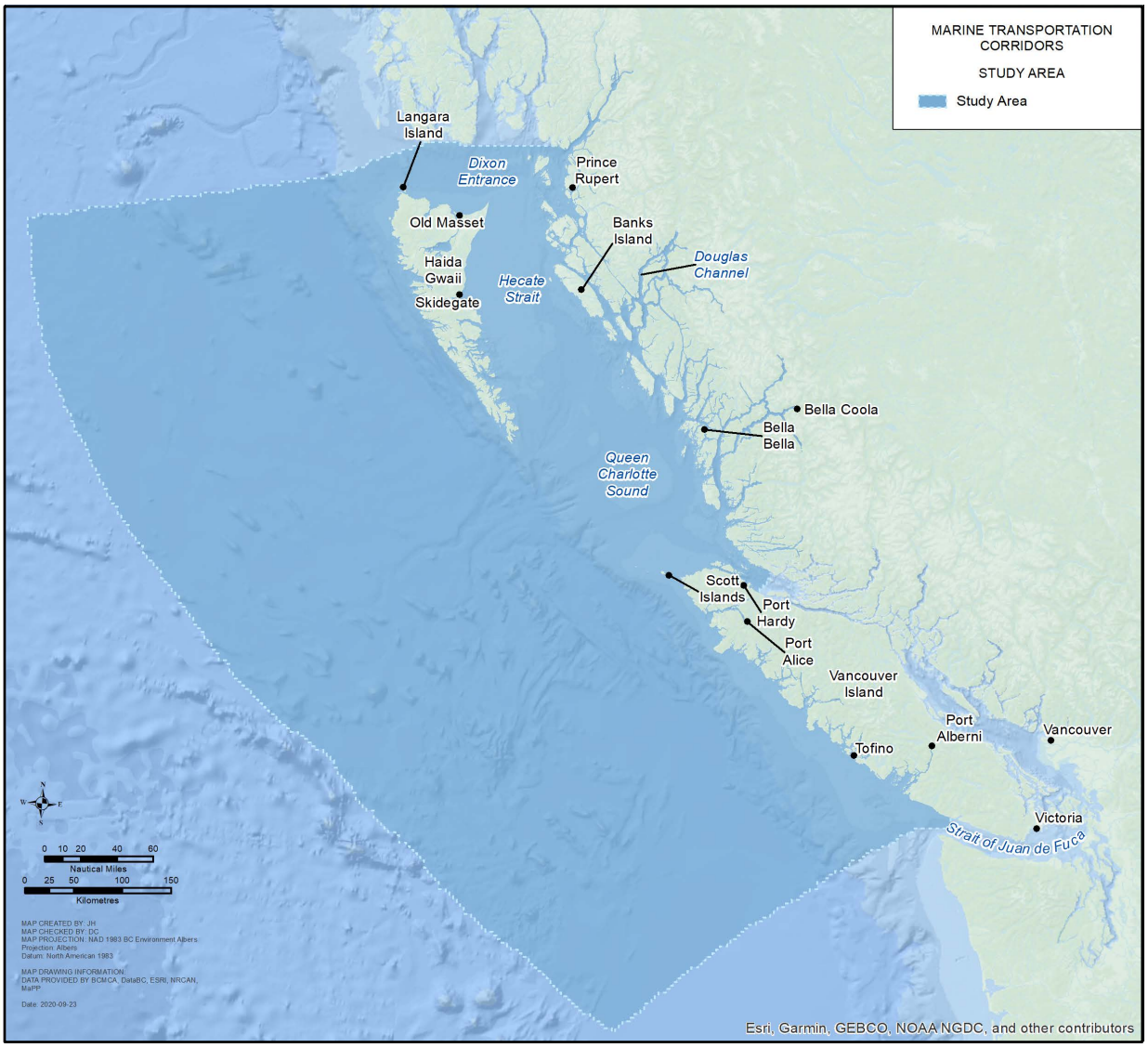

Figure 2. Pacific Coast of Canada Study Area

1.2 Limitations

The methodology for this analysis has the following key limitations and sources of uncertainty:

- The study area is limited to the west coast of British Columbia, including the west coasts of Vancouver Island and Northern B.C., out to the edge of Canada's Exclusive Economic Zone (approximately 200 NM offshore). It includes inlets, bays and fjords along the west coast of B.C. but does not include any lakes or rivers.
- The data used as part of this assessment were obtained from various sources and the creation date of the data varies. No verification of the data was undertaken as part of this assessment.
- The assessment contains 441 different data layers of publicly available data, as detailed in Appendix A. The data used may not represent the most comprehensive or current information. Additional potential data layers exist from different sources, including federal, provincial and

municipal governments, First Nations as well as non-governmental organizations. These additional data sources could not be included in the assessment as they may restrict Clear Seas' ability to make the results publicly available.

2.0 Coastal Sensitivity

A modified version of the Area Risk Assessment consequence model was used to identify the coastal sensitivities within the study area. This modified model is a GIS-based model that classifies and ranks the sensitivity of the three categories if exposed to oil. The model is described in more detail in Appendices B through E.

2.1 Overview of Coastal Sensitivity Score

The Coastal Sensitivity Score identifies areas and regions within the study area that are relatively more vulnerable to harm if an oil spill occurs near them. The Coastal Sensitivity Score is determined for each grid cell within the study area and is an aggregate of the sensitivity score for each of the three sensitivity categories, as depicted in Figure 3. This method does not indicate the extent, level of impact or likelihood that a specific oil spill will occur in the area.

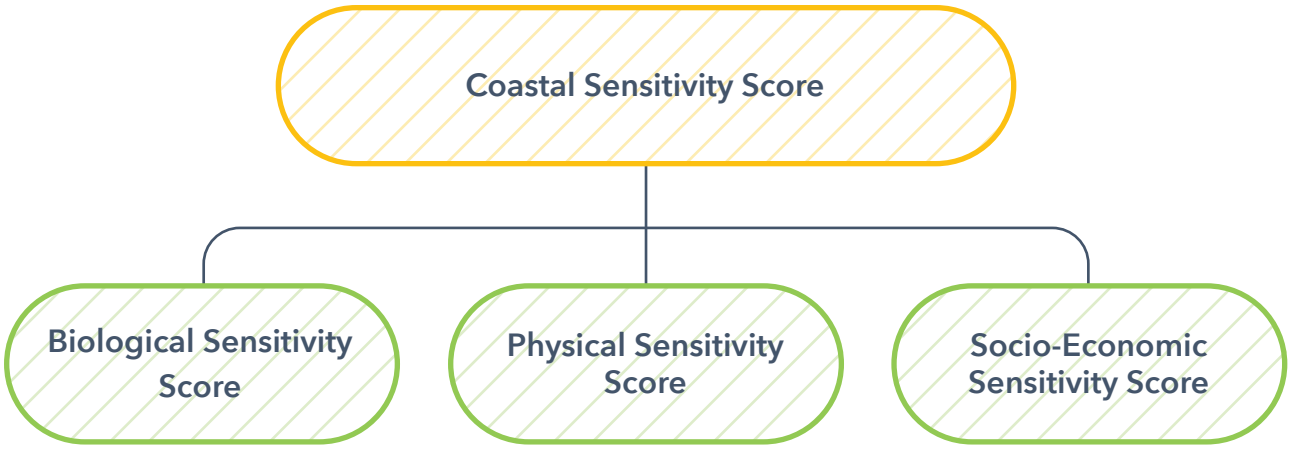

Figure 3. Coastal Sensitivity Score Components

Individual sensitivity category scores were determined before the Coastal Sensitivity Score was calculated. The **Biological Sensitivity Score** was determined using work completed by the British Columbia Marine Conservation Analysis (BCMCA) that identified marine areas (including habitats and species) of high conservation value (BCMCA, 2017). For the purposes of this analysis, these areas of high conservation value were assessed as also being susceptible to negative impacts from oil spills. The BCMCA is widely considered to be the most complete and up-to-date analysis for the Pacific Coast of Canada. Additional information on the Biological Sensitivity Score is provided in Section 4.0 and Appendix B.

The **Physical Sensitivity Score** focuses on key physical attributes that would be negatively affected if exposed to oil. The physical sensitivities cover the shoreline and the seafloor. Each of the two physical sensitivities is given equal weighting in the calculation of the Physical Sensitivity Score. Additional information on the Physical Sensitivity Score is provided in Section 5.0 and Appendix C.

The **Socio-Economic Sensitivity Score** qualitatively evaluates the impact an oil spill could have on certain human activities in the marine environment. There are six categories that contribute equally to the Socio-Economic Sensitivity Score including: commercial fishing, tourism, port facilities, population density, water resource usage and parks and cultural areas. Additional information on the Socio-Economic Sensitivity Score and its six sub-categories is presented in Section 6.0 and Appendix D.

Indigenous sensitivity data has not been included in the sensitivity scores. Future inclusion of this data is intended to identify the coastal areas within the study area that are acknowledged by First Nations as having high cultural, environmental, spiritual, economical or historical importance. At this time, insufficient data was available to assess this aspect of the Coastal Sensitivity Score. The Indigenous Sensitivity Score will need to be developed at a future date in partnership with First Nations communities who have a deep connection to and stewardship of the lands and waters in the study area as well as rights and interests. Additional information on the Indigenous Sensitivity Score is provided in Section 7.0.

To obtain the Coastal Sensitivity Score, each of the three individual Sensitivity Categories Scores are summed together on a per grid-cell basis. Each individual category received a score of 1, 2, 4, 8 or 16 to represent very low to very high sensitivity and provide equal weighting for each of the five levels of sensitivity. The results for each individual category are added together for each grid cell and the cumulative result falls within a range of possible values (e.g., 8.50 to 16.97 represents "medium") which determines whether the cumulative result is very low, low, medium, high or very high. Further detail on scoring and the weighting scale is provided in Appendix E.

The Coastal Sensitivity Score in each grid cell is displayed using a five-step scale that is used to indicate its relative sensitivity to being negatively affected by an oil spill. The five-step scale used to represent Coastal Sensitivity Score is shown in Table 1.

Table 1. Coastal Sensitivity Score Details

Description	Definition	Colour Code
Very High	Attributes within the grid cell show a very high sensitivity to an oil spill	
High	Attributes within the grid cell show a high sensitivity to an oil spill	
Medium	Attributes within the grid cell show a medium sensitivity to an oil spill	
Low	Attributes within the grid cell show a low sensitivity to an oil spill	
Very Low	Attributes within the grid cell show a very low sensitivity to an oil spill	

2.2 Results of Coastal Sensitivity Score

The Coastal Sensitivity Score for the Pacific Coast of Canada is presented in Figure 4. The results of the assessment indicate the most sensitive areas (scored as high or very high) are usually found in close proximity to shore, for example the areas around Haida Gwaii, North and Central Coast and the North and West Coast of Vancouver Island. The rationale for the sensitivity scores for the selected areas are provided below as examples, as it would not be possible to describe the sensitivity rationale for each grid cell in the study area.

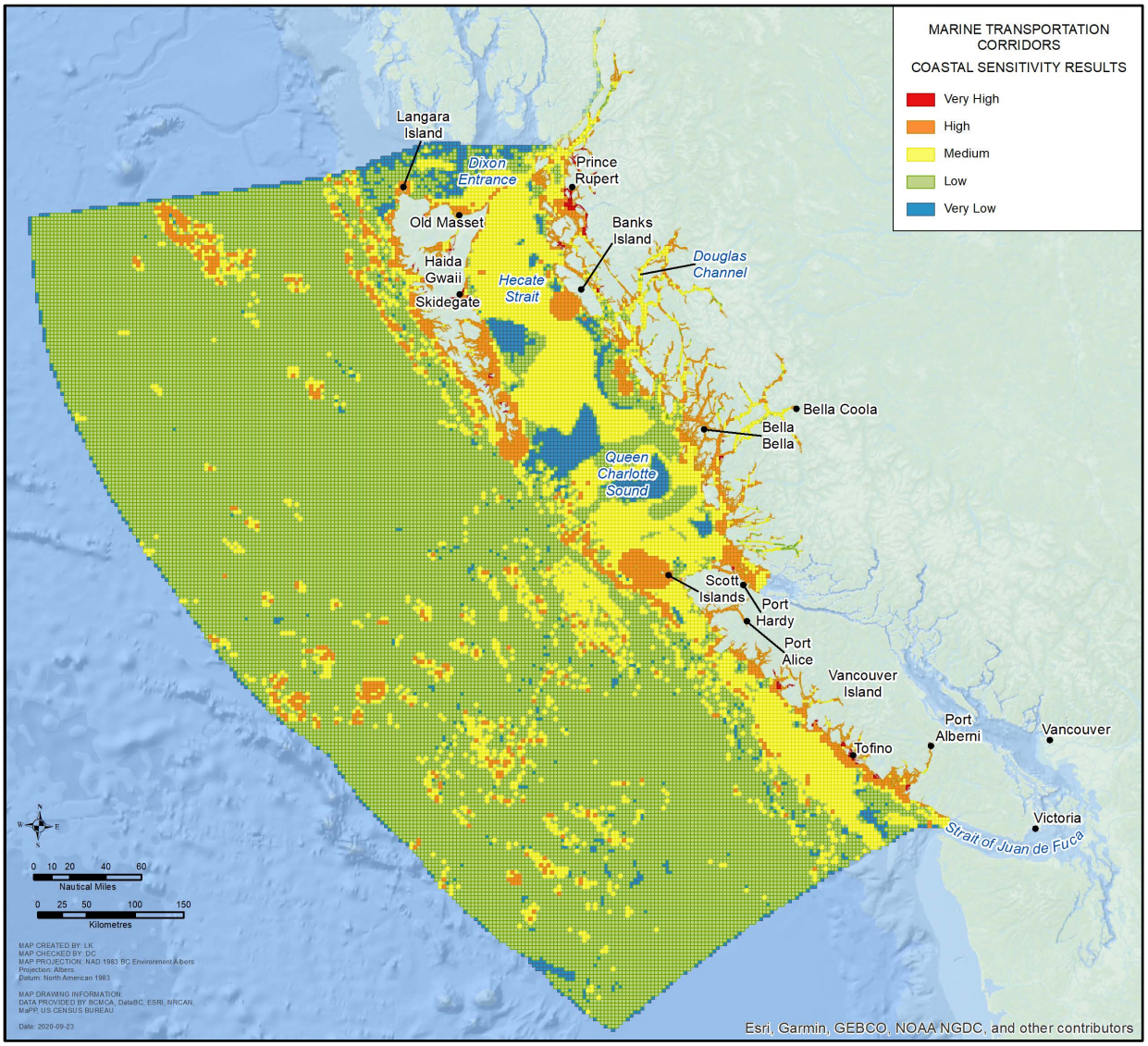

Figure 4. Coastal Sensitivity Results

2.2.1 Haida Gwaii – Sensitive Areas

The waters surrounding Haida Gwaii are the traditional territory of the Haida Nation and have a Coastal Sensitivity score of high to very high. The high sensitivity surrounding southern Haida Gwaii is largely due to very high biological sensitivities. The southern portion of Haida Gwaii is an aggregation area for multiple marine species (including fin, humpback, blue and sei whales, halibut, corals, red urchins and sea cucumbers), an important area for sea lion pupping, contains several important bird areas, a spawning area for herring and an important foraging area for Pacific cod. The waters around Haida Gwaii had a very high physical sensitivity score, due to the seafloor and shoreline being sensitive to oil. Finally, Haida Gwaii is a tourist destination with the presence of Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Sites. A more detailed map of the coastal sensitivities around Haida Gwaii is presented in Figure 5.

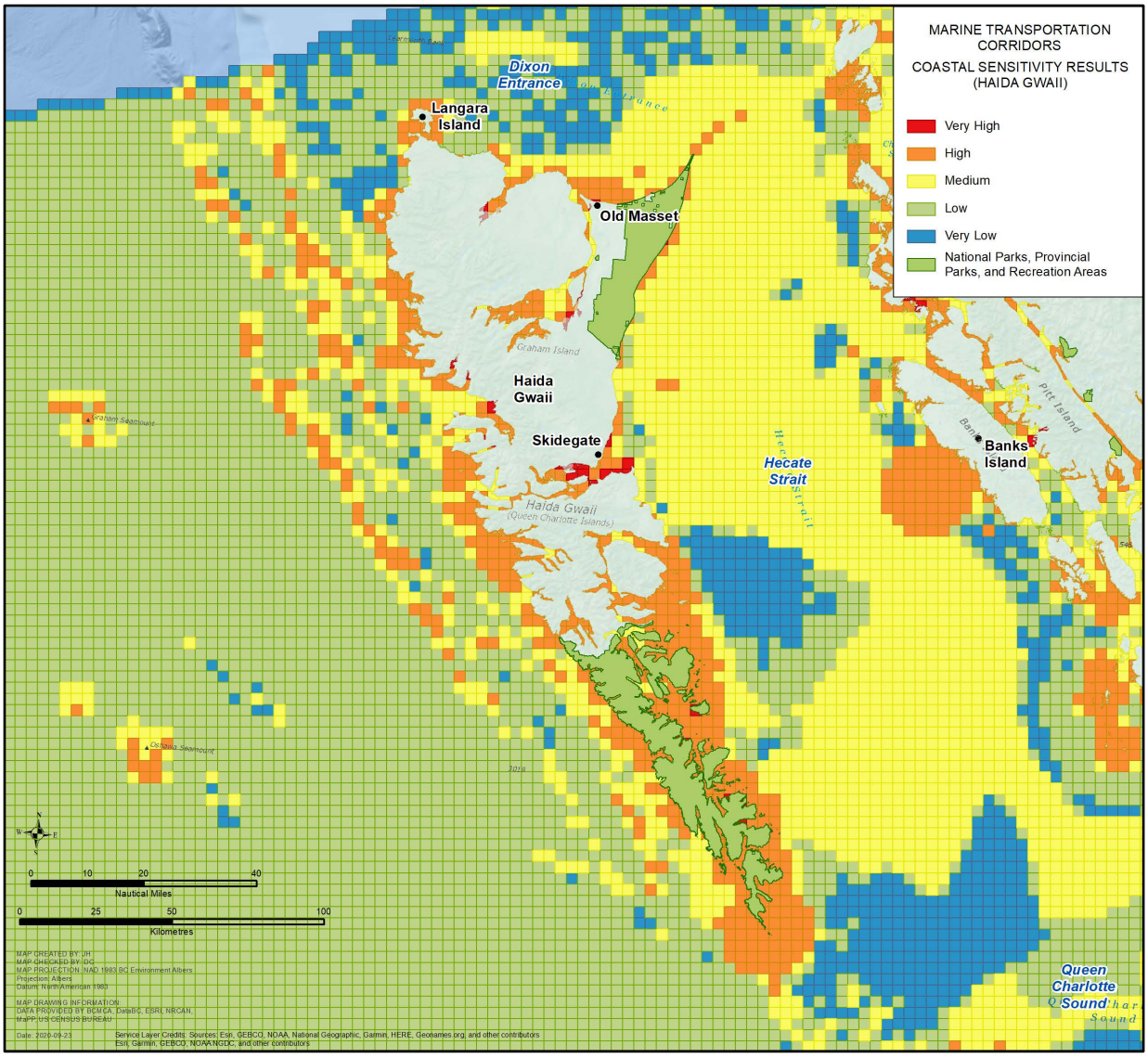

Figure 5. Coastal Sensitivity Results (Haida Gwaii)

2.2.2 North and Central Coast – Sensitive Areas

The waters within the Inside Passage, the fjords and near the Prince Rupert and Bella Bella areas have a sensitivity score of high. These waters are important habitat to a wide range of marine species. The area to the immediate east of Banks Island has a Coastal Sensitivity Score of high as it is a nursery area for sea lions and provides critical habitat to young sea lions. It is also an important feeding area for the northern killer whale, fin and humpback whales and an important migration route for gray whales. The area is a known congregation area for sea otters and provides important habitat for marine birds, specifically the sooty shearwaters (WSP, 2013). The North Coast Marine Plan, developed by North Coast First Nations and the Province of B.C., has identified the waters to the west of Banks Island as important rockfish conservation areas (MaPP, 2015b).

The waters in this area have socio-economic importance as they host significant commercial fisheries, several log boom storage areas, tourism sites and recreational fishing areas and lodges. A detailed map of the north and central coasts from Prince Rupert to the northern tip of Vancouver Island is presented in Figure 6.

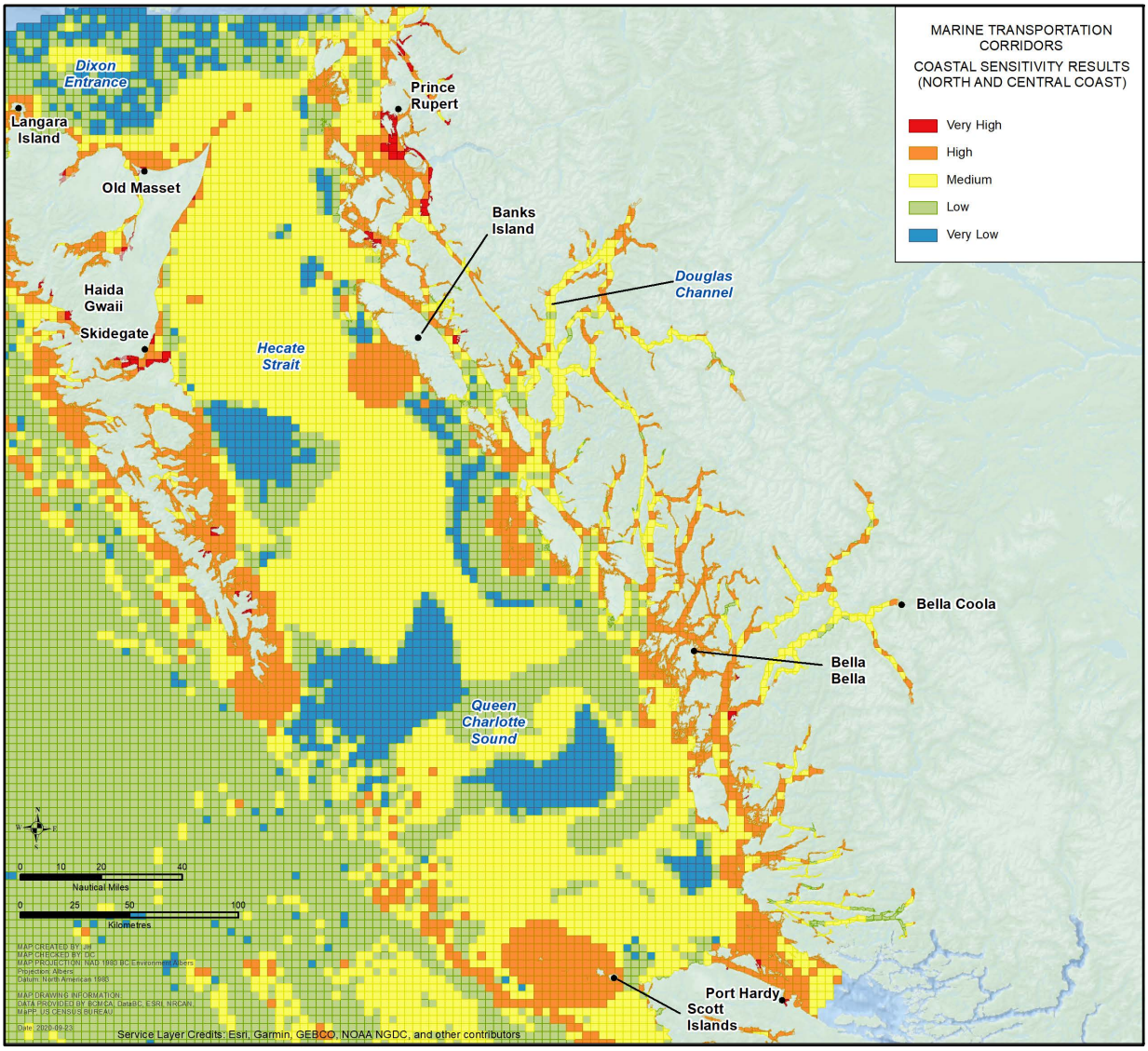

Figure 6. Coastal Sensitivity Results (North and Central Coast)

2.2.3 North and West Coast of Vancouver Island – Sensitive Areas

The Coastal Sensitivity Score along the coast of Vancouver Island covers the area from the Scott Islands in the north to the entrance of the Strait of Juan de Fuca in the south. The Scott Islands are Canada's first marine National Wildlife Area under the *Canada Wildlife Act*, designated an Ecologically and Biologically Significant Area by Fisheries and Oceans Canada and have also been identified by the Province of British Columbia as an important biological area with designated Ecological Reserves. (Government of Canada, 2016; DFO, 2015). The area is home to over two million seabirds and is the most important nesting and breeding area for seabirds in B.C., with about 40% of all breeding seabirds (DFO, 2015). As well, the Scott Islands provide key sea lion rookeries. A detailed map of the west coast of Vancouver Island from the Scott Islands to the entrance of the Strait of Juan de Fuca is shown in Figure 7.

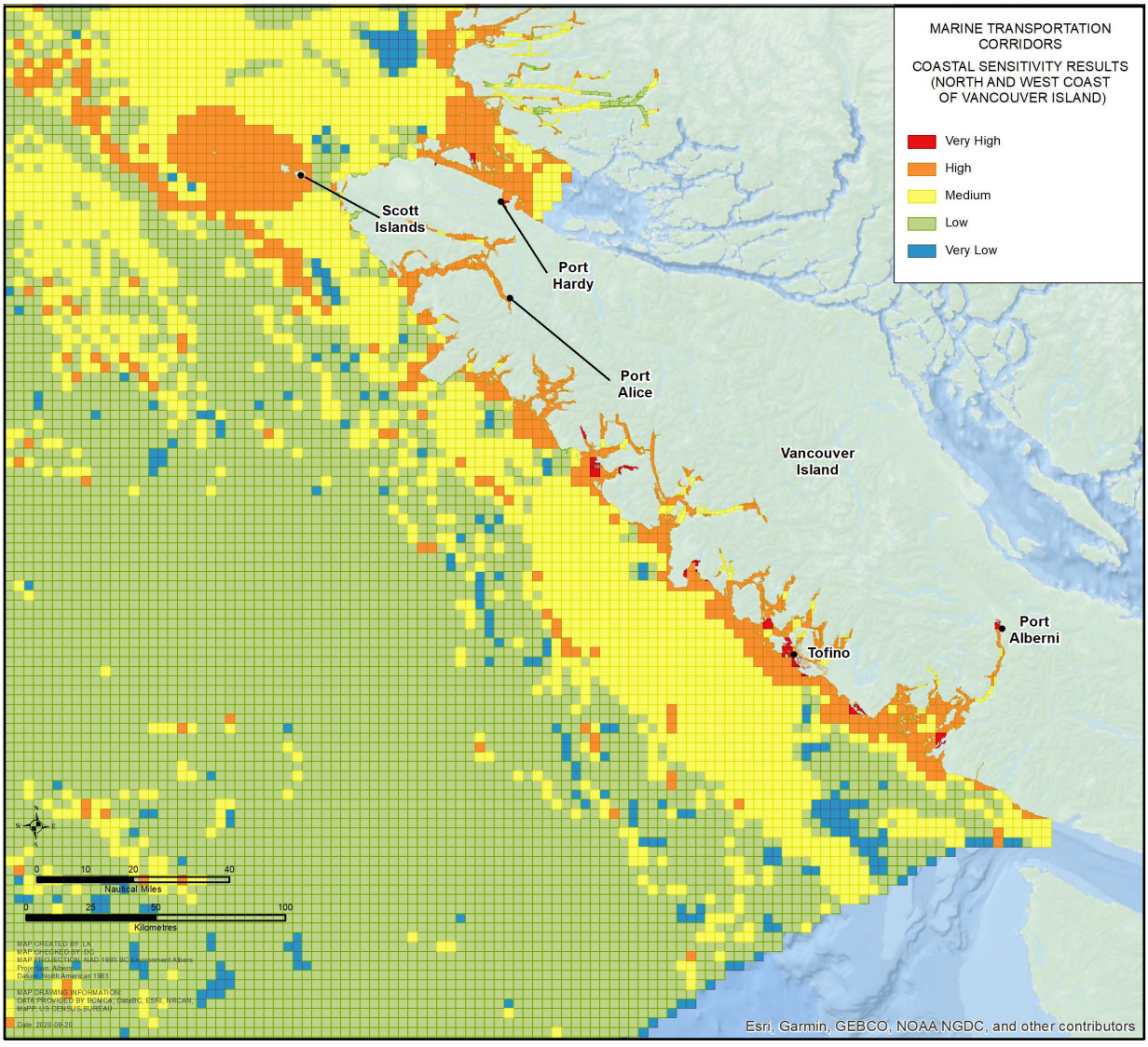

Figure 7. Coastal Sensitivity Results (North and West Coast of Vancouver Island)

The waters in Barkley Sound also had a high sensitivity score due to support for a wide variety of biological species and inclusion in the Pacific Rim National Park Reserve. Barkley Sound provides nesting areas and habitats for birds including Pacific loons and ducks, pelagic seabirds (pigeon guillemots, marbled murrelets), surf scoters, and gull and pelagic cormorants. It also is a foraging area for resident gray and humpback whales, harbour seals and Steller sea lions. A wide variety of socio-economic activities also occur within Barkley Sound such as commercial fisheries at its entrance including a very large salmon fishery. Port Alberni is an important port for the forest industry. Barkley Sound is an important tourist area as it provides good access to Pacific Rim National Park.

3.0 Biological Sensitivity

The biological sensitivity category includes areas that have significant ecological value and high conservation value, which contain receptors such as species and habitats that would be negatively impacted by an oil spill. Areas of high conservation value are defined by the BCMCA as areas that are important to effectively representing and conserving marine biodiversity (BCMCA, 2012).

The interactive GIS web-map includes a separate data layer collecting "Areas of Marine Protection" to indicate those geographic areas that have been designated as Marine Protected Areas under the *Oceans Act*, National Marine Conservation Areas under the *National Marine Conservation Areas Act*, National Wildlife Areas under the *Canada Wildlife Act*, and marine National Parks under the *National Parks Act*.

The data compiled by BCMCA were used to determine biological sensitivity since it was the most complete and current of any of the publicly available datasets at the time of the analysis. The overall purpose of the BCMCA data was to identify marine areas of high conservation value in Canada's Pacific Ocean (BCMCA, 2017). For the purposes of this analysis, these areas of high conservation value were assessed as also being susceptible to negative impacts from oil spills. The BCMCA accomplished this by compiling 200 different layers of mapped biological information, and processing it using a decision support tool called Marxan. The model identifies areas that are considered as having high conservation value; additional details and limitations regarding the Marxan model are provided in Appendix B.

The BCMCA dataset included features such as marine bird colonies, staging areas and nests; marine mammal (e.g., sea otter and sea lion) habitats and range; marine plant locations (e.g., kelp beds, eelgrass, algal habitat, and salt marshes); and productive areas such as seamounts and hydrothermal vents. The results of the biological sensitivity assessment are presented in Figure 8.

As seen in Figure 8, areas of high biological sensitivity are generally located along the shoreline and in areas of the seafloor with seamounts and hydrothermal vents. This correlation is due to the biological habitats and activity that accompany these features. Particularly high biologically sensitive areas include Haida Gwaii, east of Banks Island and the Scott Islands.

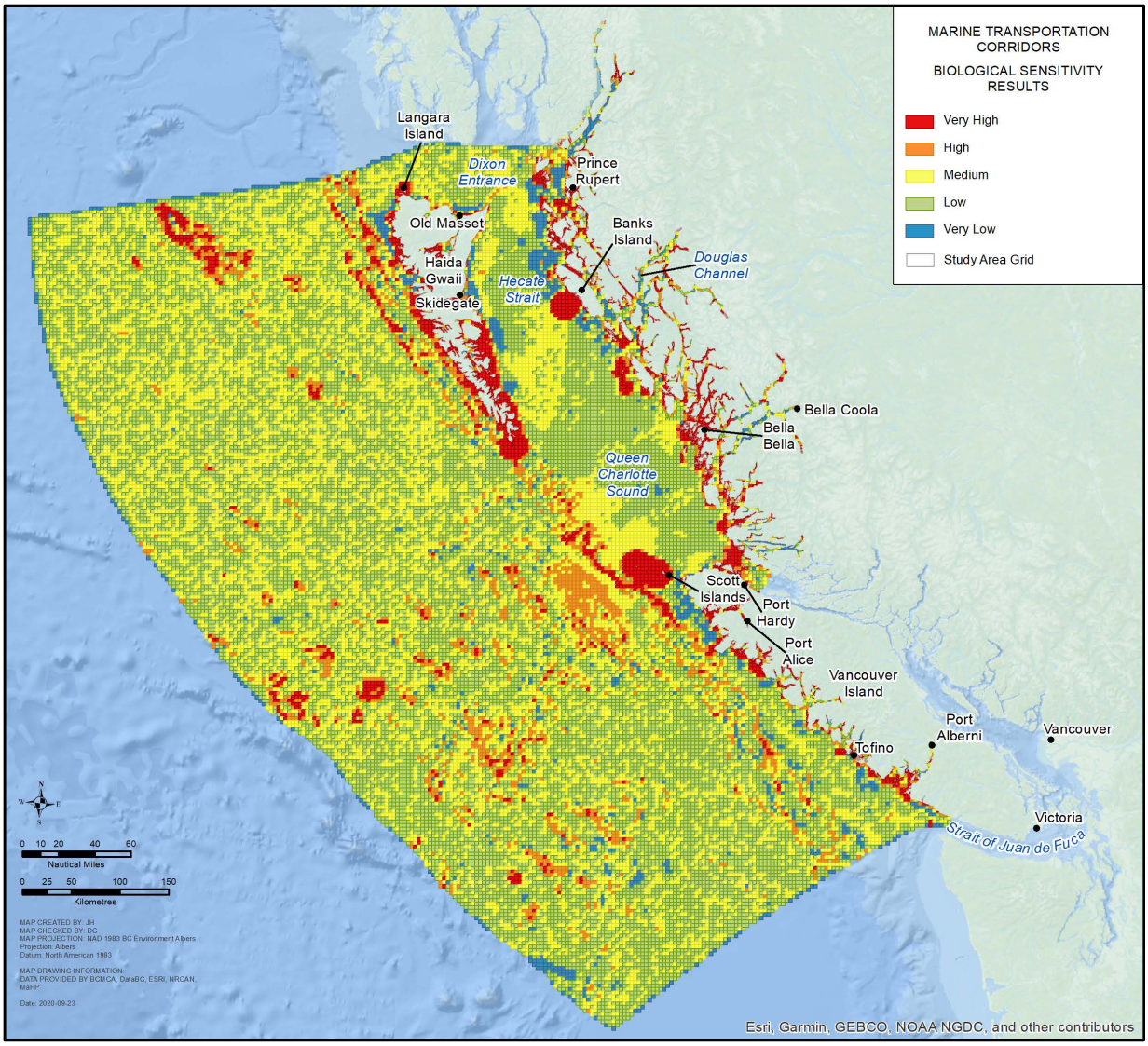

Figure 8. Biological Sensitivity Results

4.0 Physical Sensitivity

The Physical Sensitivity category includes key physical characteristics of shorelines and seafloor that could support different types of habitats and that would be negatively affected if exposed to oil. This score does not consider the level of effort required to clean oil from different types of physical attributes. These characteristics include shoreline type and exposure to wave action as well as seafloor type. An area with multiple physical characteristics that deter biologic activity and limit oil spill impacts, such as minimal habitat on impermeable bedrock, will have a lower physical sensitivity score than an area with high biologic activity, such as eelgrass habitat in a mudflat.

The Physical Sensitivity Score is an aggregation of the shoreline and seafloor sensitivity scores. Detailed scoring information is provided in Appendix C.

4.1 Shoreline Sensitivity Score

The Shoreline Sensitivity Score is determined by shoreline classification and shoreline exposure; together these account for the shoreline's geology, exposure to wave and tidal action, slope, substrate permeability (to oil penetration and burial) and biological productivity, using data obtained from the Province of B.C. The results of the Shoreline Sensitivity Score are presented in Figure 9.

4.1.1 Shoreline Classification

The shoreline classifications are based on the eleven Environment and Climate Change Canada Shoreline Types (Owens and Sergy, 2000; Wynja *et al*, 2015) and their geological makeup. The shoreline classifications shown below are ranked from most sensitive to least sensitive based on their inferred biologic activity due to their geologic structures. Detailed shoreline classification descriptions and their associated scores are presented in Appendix C.

- Marsh
- Mud tidal flats
- Sand tidal flats
- Sand beach or bank
- Mixed sediment beach or bank
- Mixed and coarse sediment tidal flat
- Not classified
- Man-made permeable
- Bedrock sloping/ramp
- Bedrock platform
- Man-made solid
- Bedrock cliff/vertical

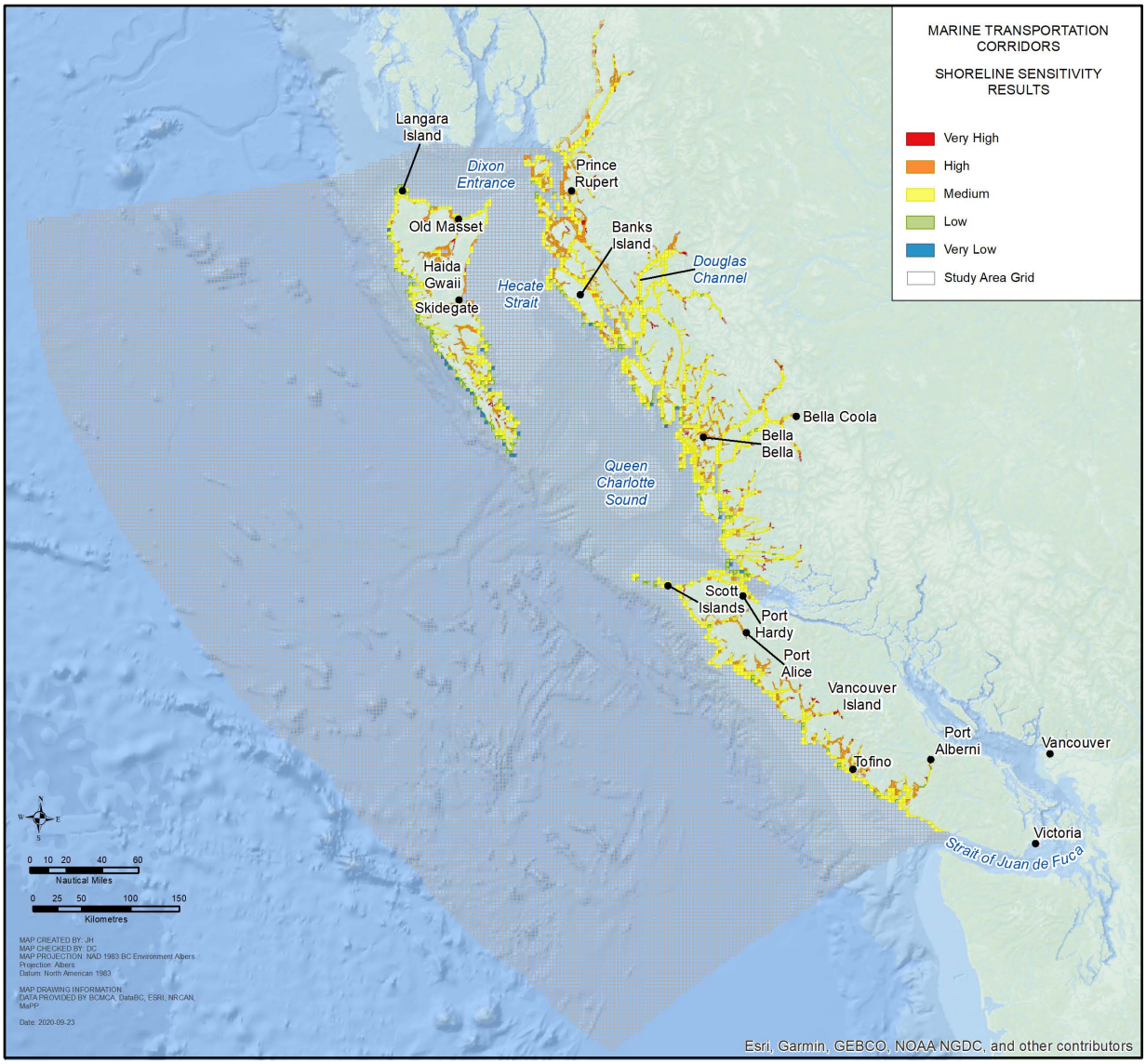

Figure 9. Shoreline Sensitivity Results

4.1.2 Shoreline Exposure

Protected shorelines are favourable for biologic activity while very exposed shorelines experience harsh natural conditions that deter biological activity. Therefore, shoreline exposure is an important element of the sensitivity analysis of coastal areas. The shoreline exposure is based on six different levels of exposure to the environment. Exposure is ranked from very protected to very exposed correlating to very high to very low sensitivity. Areas with unknown exposure were assumed to have medium sensitivity. Detailed exposure calculations are provided in Appendix C.

4.2 Seafloor Sensitivity Score

Similar to shoreline characteristics, seafloor type can promote or deter biologic activity and can provide resistance or have susceptibility to ship-source oil spills. There are three types of seafloor within the study area:

- Soft Bottom – Areas that are predominated by soft substrates such as mud, sand, and mud and sand.
- Mixed Bottom – Areas that have a mixture of hard and soft substrates such as gravels, mixed sediment, and sand and gravel.
- Hard Bottom – Areas that are predominated by hard substrates such as continuous and discontinuous bedrock and boulders.

Data on seafloor classification were obtained from the Province of B.C. Soft bottom areas were assigned very high sensitivity, mixed bottom and unknown substrate were considered medium sensitivity, and hard bottom was considered low sensitivity. The majority of known seafloor type is soft bottom located within the continental shelf. The waters from the continental shelf to the edge of the study area are classified as mixed bottom and thus have a medium sensitivity score. The results of the seafloor sensitivity analysis are presented in Figure 10.

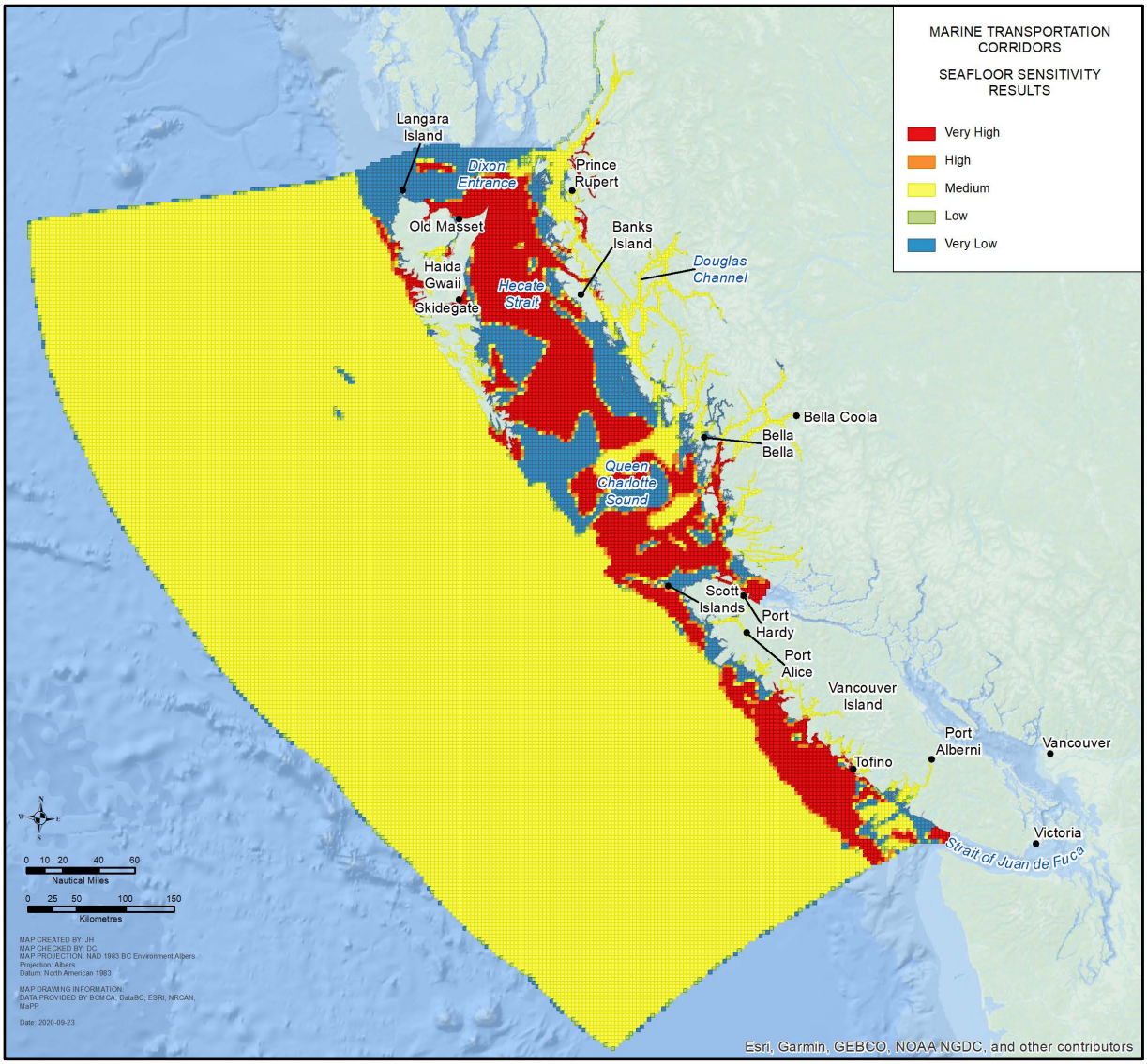

Figure 10. Seafloor Sensitivity Results

4.3 Physical Sensitivity Score

The results of the shoreline and seafloor sensitivity are added to determine the physical sensitivity score, presented in Figure 11. The areas with a very high physical sensitivity score, such as the areas around Haida Gwaii and Prince Rupert, have a seafloor that is classified as soft and a shoreline with low exposure that is very sensitive to oil (classified as Marsh or Tidal Flats).

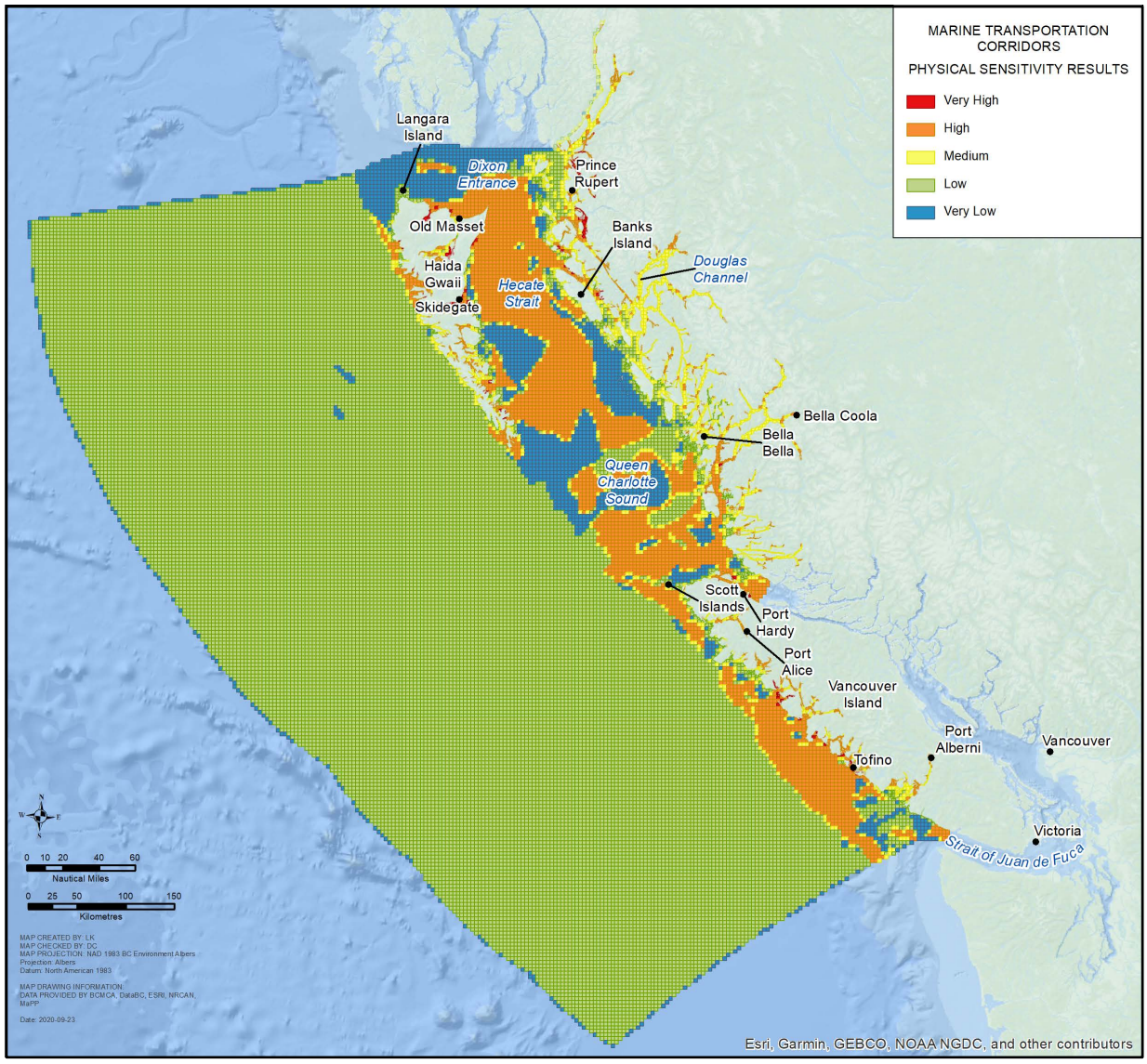

Figure 11. Physical Sensitivity Results

5.0 Socio-Economic Sensitivity

The Socio-Economic Sensitivity category encompasses human use of resources for economic benefit that may be affected by an oil spill. Six sub-categories were identified as contributors to the Socio-Economic Sensitivity category:

1. Commercial Fishing
2. Tourism
3. Port Facilities
4. Water Resources
5. Population Density
6. Parks and Cultural Areas

The Socio-Economic Sensitivity Score is an aggregate of each of the six socio-economic sensitivity sub-category scores for a given grid cell. An area with multiple sub-categories (e.g., port facilities, parks, and commercial fishing) would be considered a higher sensitivity than an area with only one of the sub-categories. All sub-components were weighted equally, thus assuming that an oil spill has the potential to affect each sub-category equally. Additional information regarding the scoring methodology for this category is provided in Appendix D. The following sub-sections detail data used to calculate the sensitivity score for each of the six sub-categories.

5.1 Commercial Fishing Sensitivity Score

The Commercial Fishing Sensitivity Score was calculated by determining the total commercial fishing that occurs within the study area. Commercial fishing data was obtained from Fisheries and Oceans Canada and BCMCA as outlined in Appendix A.

Areas of high sensitivity indicate areas with high relative commercial fish catches. As seen in Figure 12, the majority of fish catch occurs near shore. There are two areas of very high commercial fishing sensitivity: northern B.C. near Prince Rupert and the southern end of Vancouver Island between Cape Beale and Ucluelet. The catches in the area of high sensitivity near Prince Rupert have high volumes of shrimp, halibut, salmon and notable amounts of octopus. Salmon fisheries contributed to the very high sensitivity area between Cape Beale and Ucluelet on the west coast of Vancouver Island.

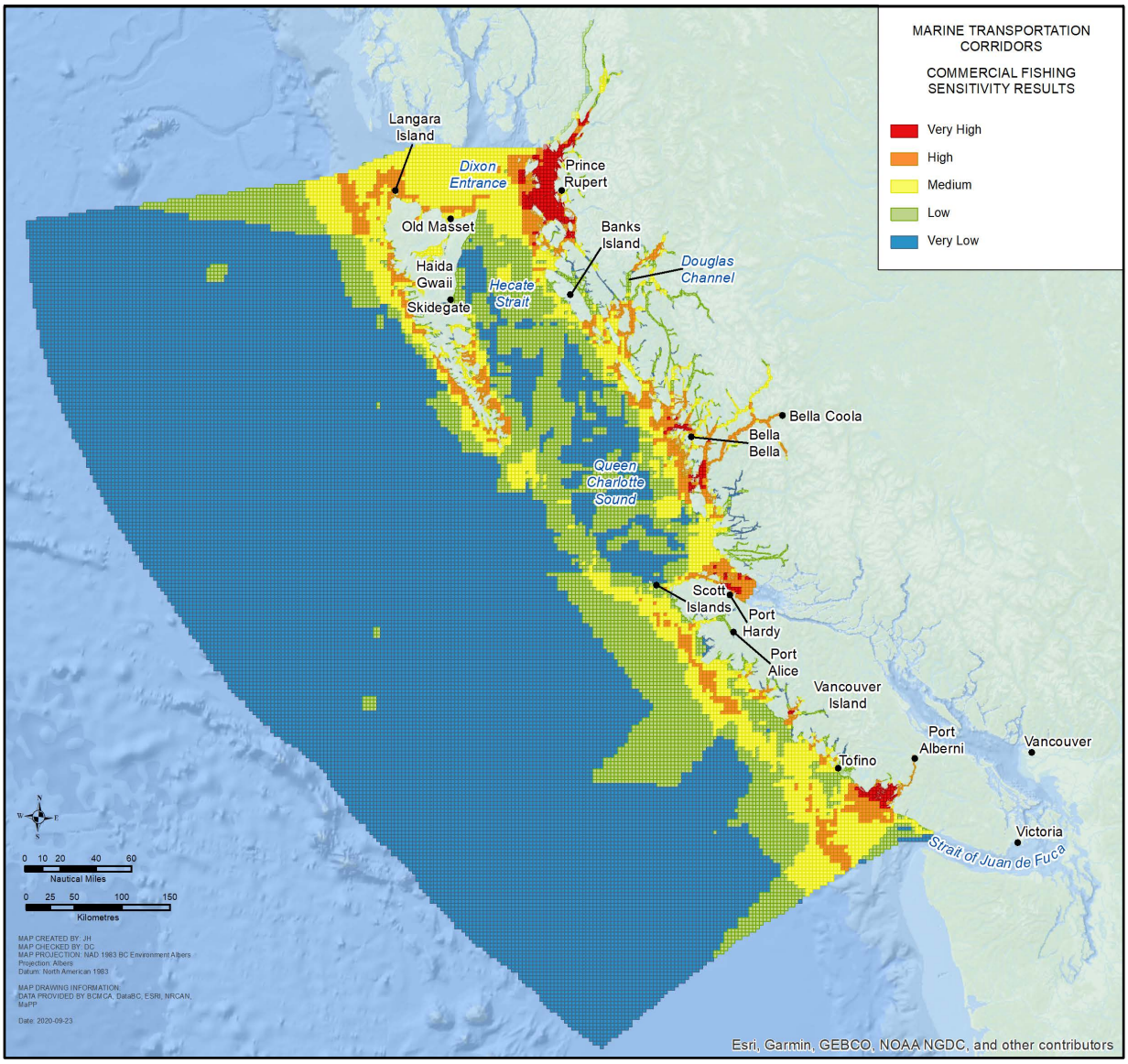

Figure 12. Commercial Fishing Sensitivity Results

5.2 Tourism Sensitivity Score

The Tourism Sensitivity Score accounts for the potential losses the tourist economy within the study area could have due to an oil spill. The score was determined using tourism employment statistics and known tourist sites within the study area. Tourism employment was determined by using the accommodation and food services employment data from the 2019 census as an indicator for overall tourism employment data, indirectly accounting for employment in the tourism sector.

In addition to accommodation and food service employment data, known point features (e.g., dive sites, marinas, coastal campsites, anchorages) and area features (e.g., recreational fishing areas) were also accounted for in the tourism sensitivity analysis.

The results of the combined tourism sensitivity analysis are presented in Figure 13. Areas of high tourism sensitivity are those within close proximity of multiple tourism features and/or an area with high employment in the accommodation and food service industry. The high sensitivity area along the North and Central Coast has numerous tourism point features and contains high or very high employment in accommodation and food services within close proximity to the shore.

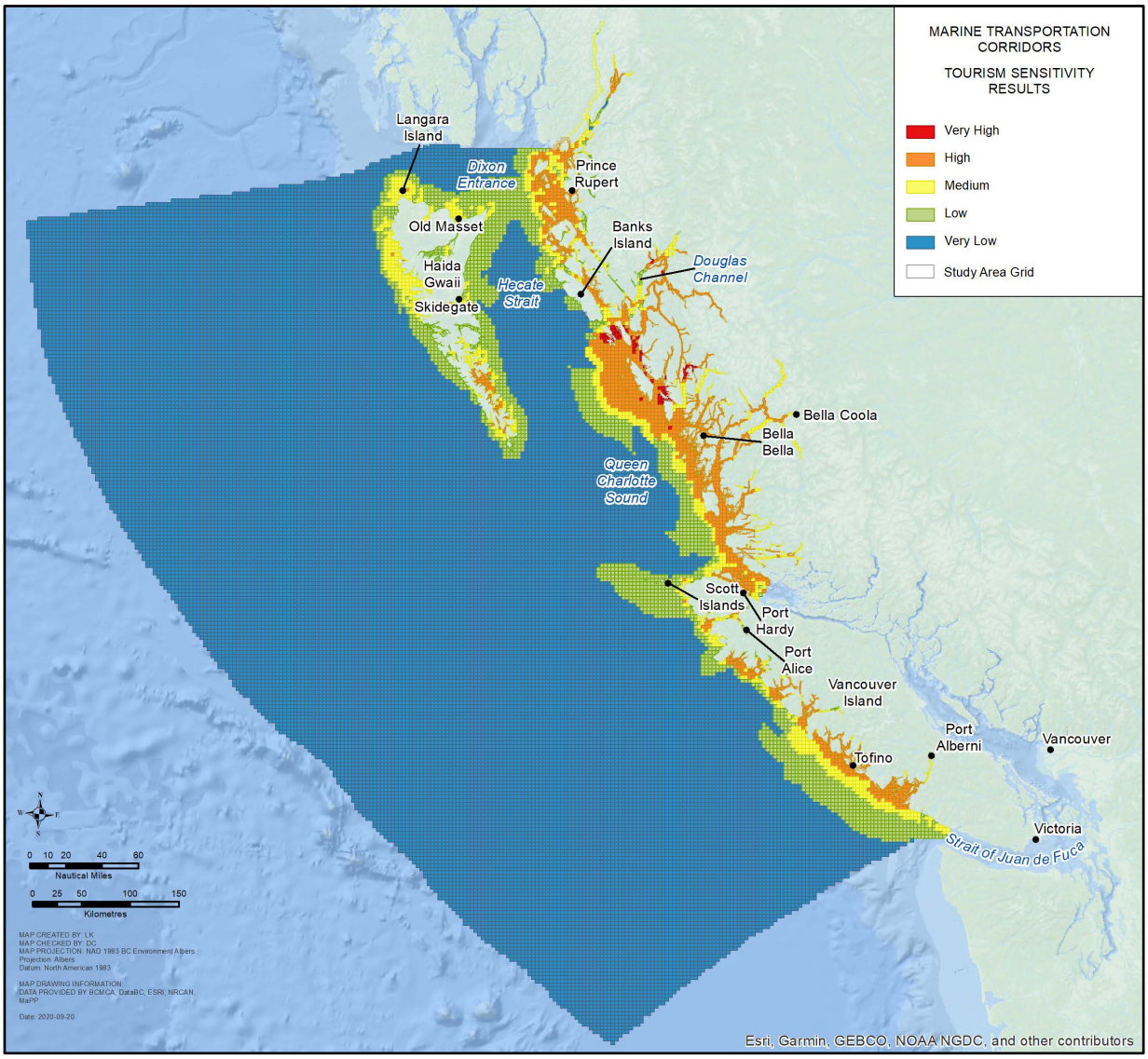

Figure 13. Tourism Sensitivity Results

5.3 Port Facilities Sensitivity Score

The Port Facilities Sensitivity Score accounts for the presence of commercial port and port facilities within the study area including designated ports under the *Canada Marine Act* as well as ports, terminals, shipyards, navigable waters, and harbours as identified by the Province of B.C. (Province of B.C., 2016). The Port Facilities Sensitivity Score was determined by the presence or absence of port

facilities in a grid cell. Grid cells that intersect a port facility were assigned a value of very high while grid cells with no port facilities were not considered applicable to this sensitivity category.

Prince Rupert is the largest port facility within study area handling approximately 21.4 million tonnes of cargo in 2017 (Prince Rupert Port Authority, 2017). Other port facilities within the study area include Bella Bella, Bella Coola, Port Alberni, Queen Charlotte City and Port Hardy. The result of the port facility sensitivity analysis is presented in Figure 14.

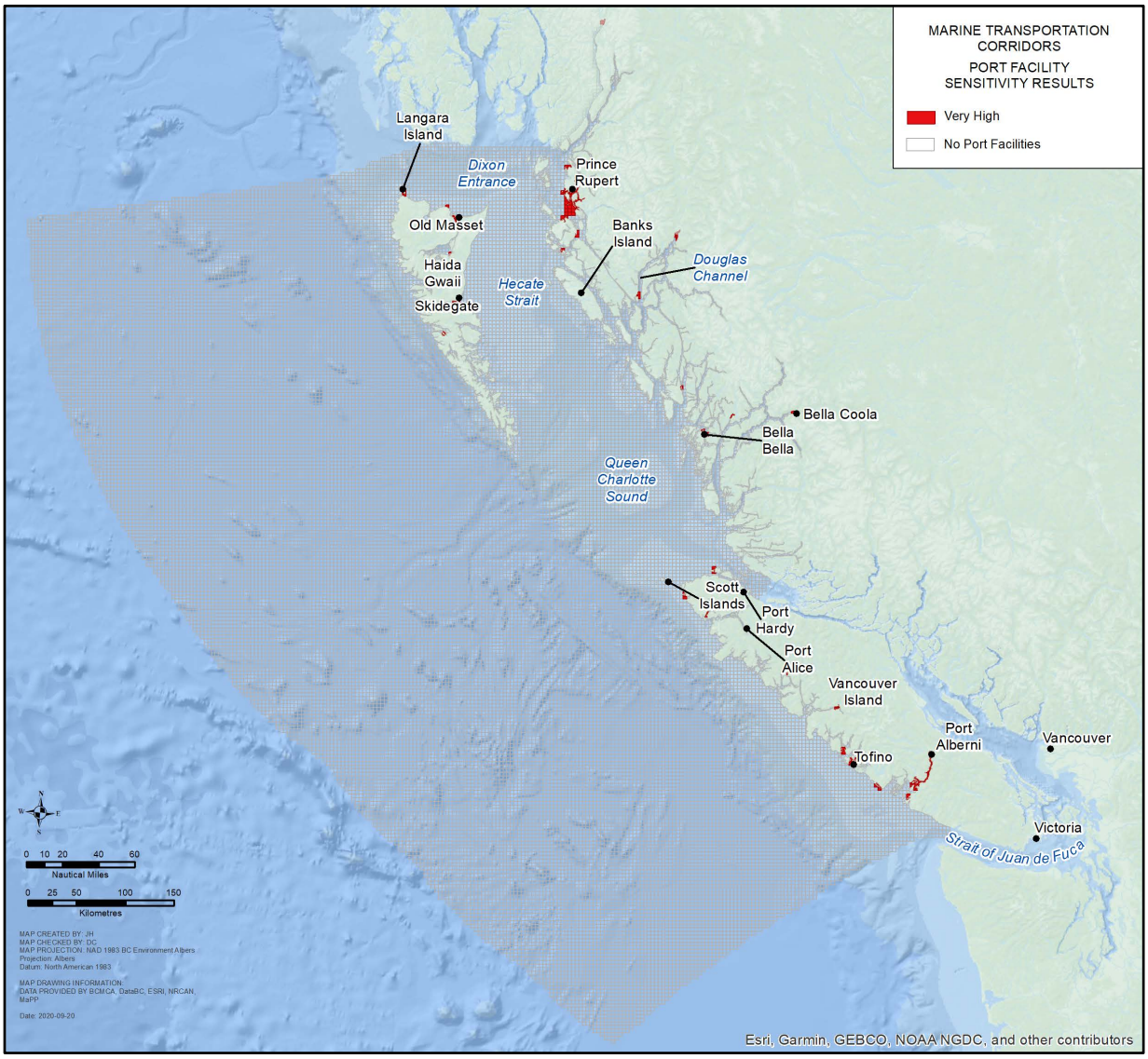

Figure 14. Port Facility Sensitivity Results

5.4 Water Resource Use Sensitivity Score

The Water Resource Use Sensitivity Score accounts for the presence of saltwater intakes within the study area that are used for various purposes including power generation plant cooling, industry intakes, fish processing plants and aquaculture sites. This category also considers industries that rely on water lots to store raw materials (e.g., log booms). A complete listing of the data sets and sources used is provided in Appendix A; locations of water resource features are presented in Appendix D.

Grid cells that contain a water resource feature or are within 4 NM of a water resource feature were scored with a very high sensitivity. Cells 4-8 NM away from a water resource feature were scored as a medium sensitivity, while those at greater than 8 NM were considered not applicable to this sensitivity category. Water resource use is predominantly scored very high within the fjords of northern B.C. and within the bays on the west coast of Vancouver Island. This is due to the presence of numerous aquaculture sites as well as log boom storage areas. Figure 15 presents the results of the Water Resource Use Sensitivity analysis.

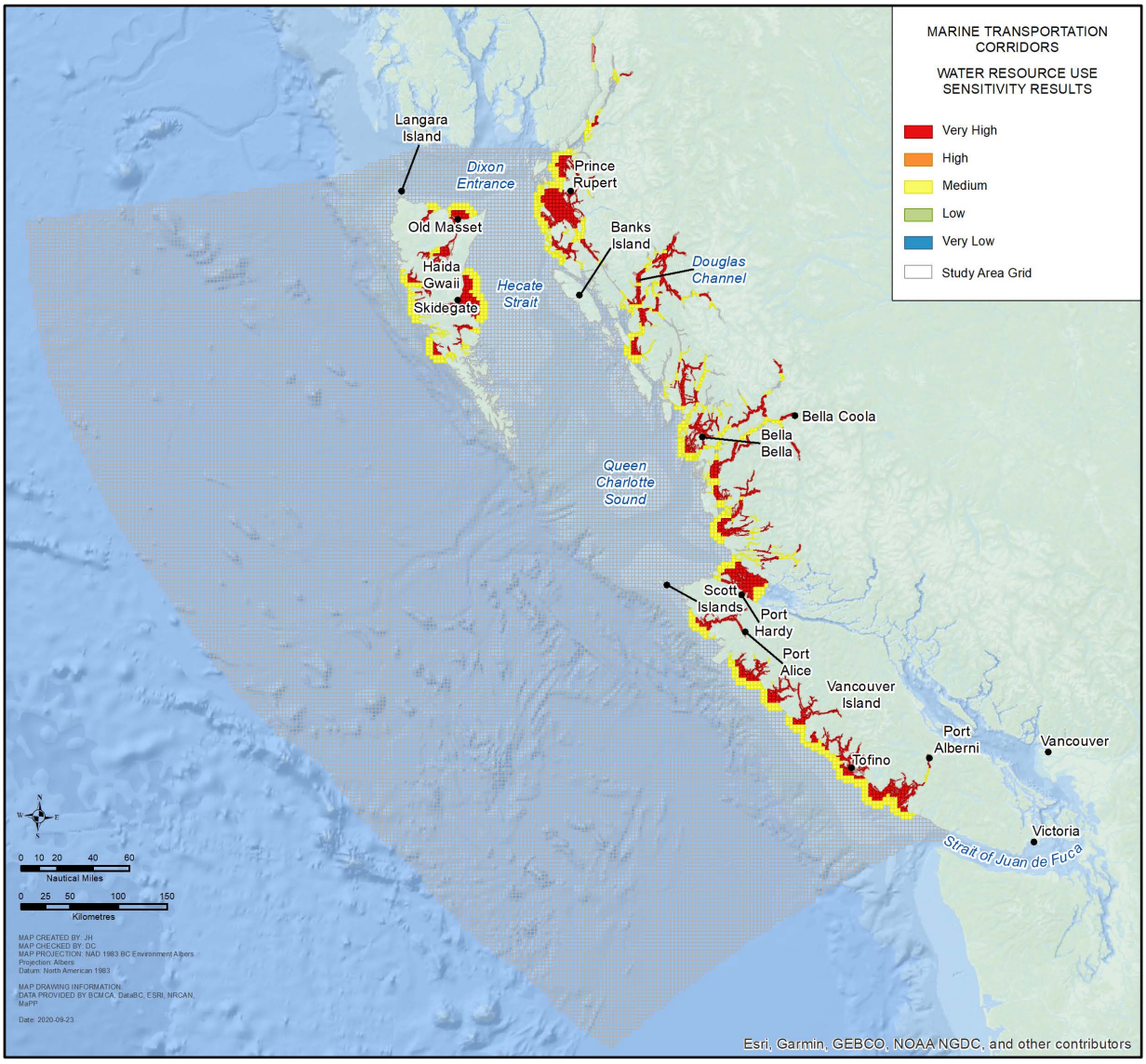

Figure 15. Water Resource Use Sensitivity Results

5.5 Population Density Sensitivity Score

The Population Density Sensitivity Score accounts for the number of people that will be directly affected in the event of a spill. Areas of high population density are likely to have a larger number of people impacted by an oil spill; therefore, areas of high population density are considered more sensitive than areas of low population density. Projected population density data was collected from Environics Analytics for 2019 based on the 2016 Census Dissemination Area for the study area (Environics Analytics, 2019). A distance modifier – the sum of the population density within 60 km of each grid cell – was applied to the data to apply the population data to the coastline. As seen in Figure 16, areas of high population density are located in the vicinity of Prince Rupert, Port Hardy, and the Tofino / Ucluelet area. These three areas have the highest relative population density compared to the rest of the study area.

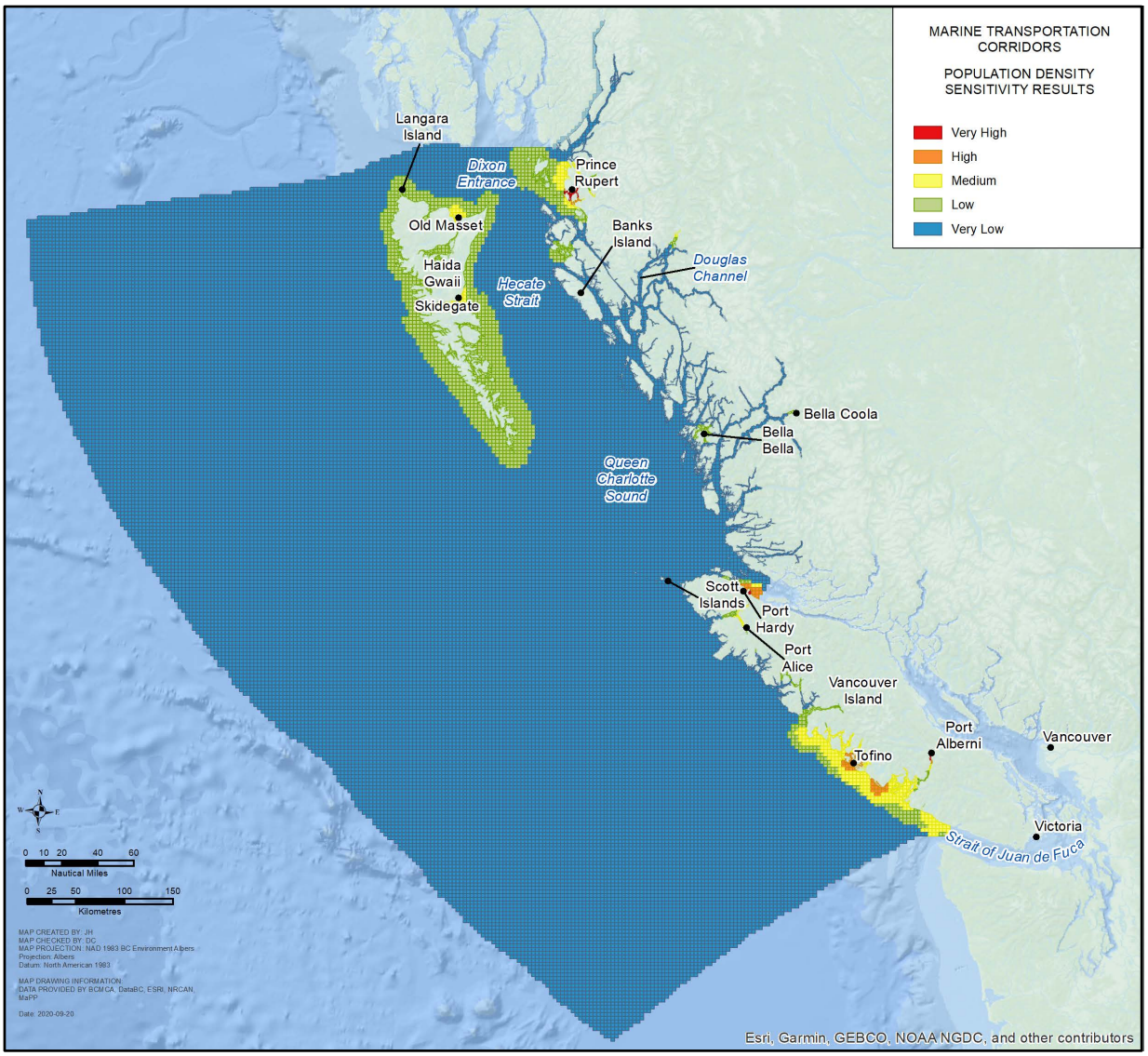

Figure 16. Population Density Sensitivity Results

5.6 Parks and Cultural Areas Sensitivity Score

The Parks and Cultural Areas Sensitivity Score includes national, provincial and municipal parks as well as important cultural areas along the shoreline. Ecological reserves and conservancies are represented in the Biological data layer. This information was obtained from the Natural Resources Canada database and the Province of B.C. Important cultural areas include archeological sites and other historical sites. This sub-category does not include Indigenous cultural areas as these will need to be included in the future Indigenous sensitivity category.

A distance modifier was used to determine park and cultural area sensitivity as oil does not have to actually reach a park to have a negative impact on its use. Grid cells with a park or cultural area within 4 NM were scored with a very high sensitivity while grid cells 4-8 NM away were scored as medium sensitivity. Grid cells located beyond 8 NM from a park or cultural area were considered not applicable to this sensitivity category.

B.C. has a large number of parks and cultural areas but relatively few of them are located along the coast. The majority of coastal parks and cultural areas are located on Vancouver Island and Haida Gwaii. Gwaii Haanas National Park Reserve and Haida Heritage Site are located in southern Haida Gwaii and account for the very high sensitivity in that area. Pacific Rim National Park Reserve is located on the southwest coast of Vancouver Island and contributes to the very high sensitivity in that area. The result of the Park and Cultural Area Sensitivity analysis is presented in Figure 17.

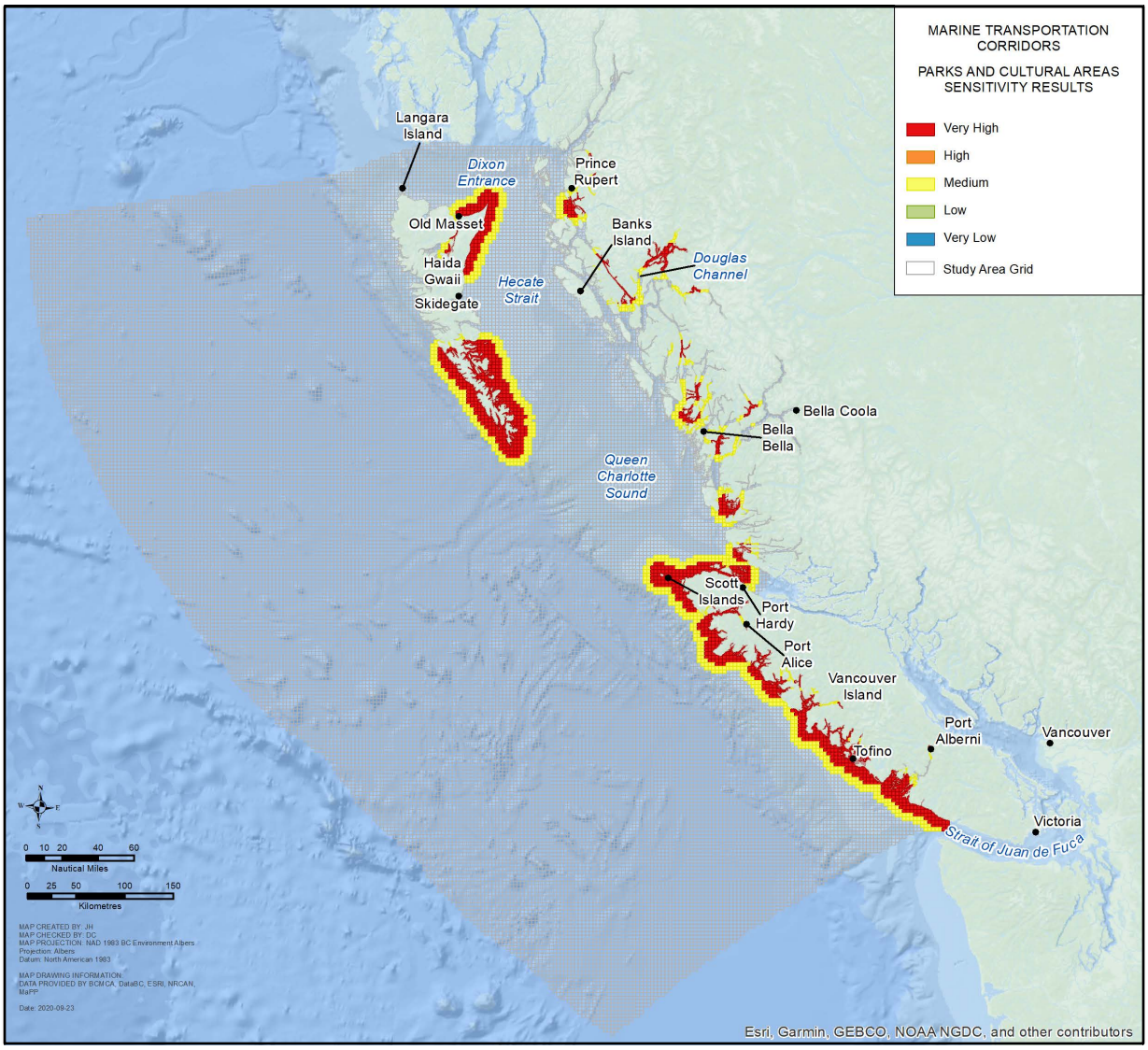

Figure 17. Parks and Cultural Areas Sensitivity Results

5.7 Socio-Economic Sensitivity Score

The Socio-Economic Sensitivity Score is an aggregate of the six sub-categories – commercial fishing, tourism employment, port facilities, water resources, population density, and parks and cultural areas – used to identify areas where an oil spill has the potential to affect economic human-use resource contributors.

A very high sensitivity is located in several grid cells around Prince Rupert. Prince Rupert is the largest port within the study area, has a large population density compared to the rest of the study area, supports a significant tourism sector and has significant water usage. Other areas of high sensitivity include Port Hardy and the Barkley Sound area near Port Alberni. The results of the Socio-Economic Sensitivity analysis are presented in Figure 18.

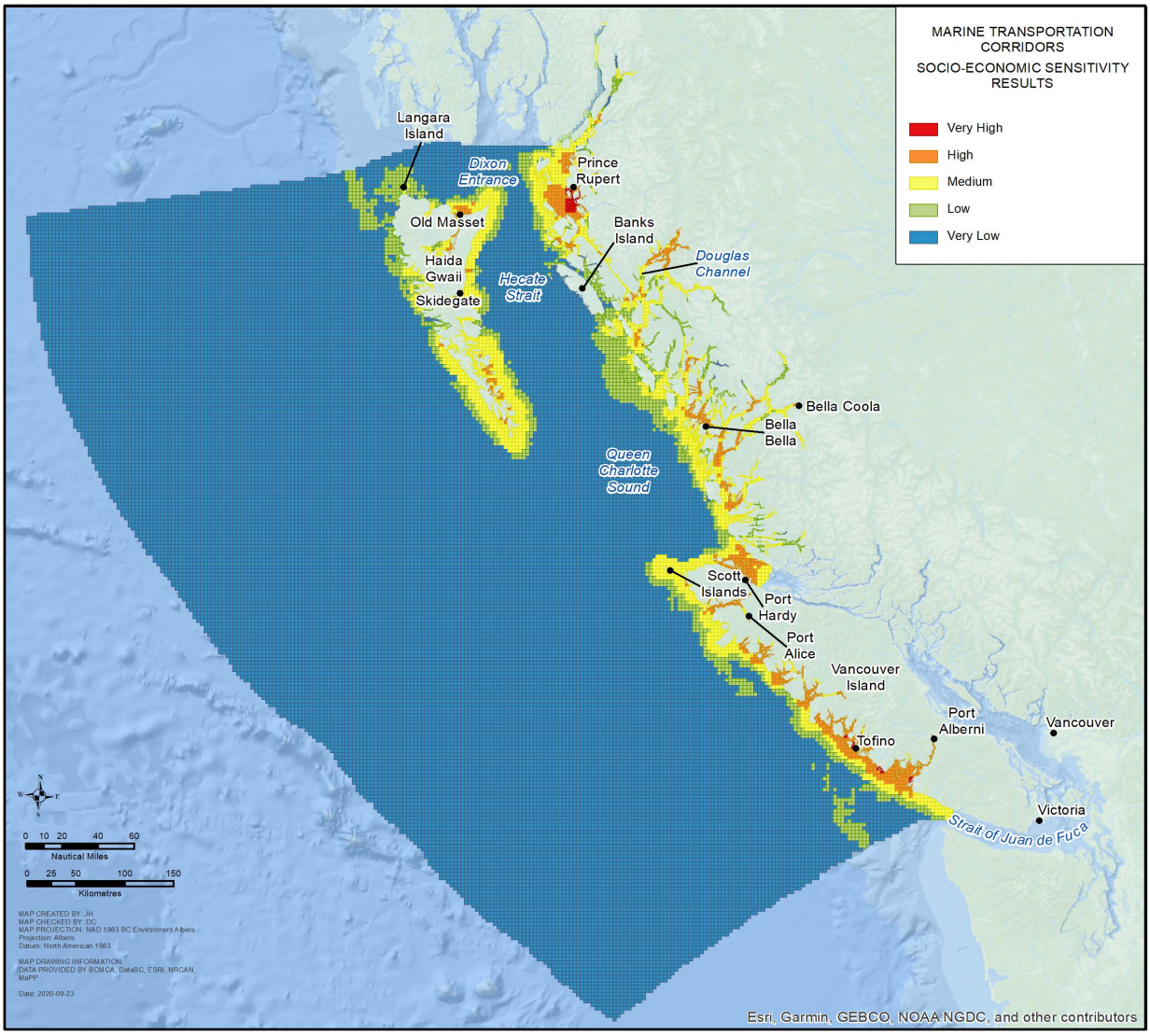

Figure 18. Socio-Economic Sensitivity Results

6.0 Indigenous Sensitivity

The Indigenous Sensitivity category is intended to identify the coastal areas within the study area that are acknowledged by First Nations as having high cultural, environmental, spiritual, economical or historical importance.

At this time, insufficient data was available to assess these aspects of the Coastal Sensitivity Score. Limited information is publicly available for these areas; therefore, Clear Seas is exploring different ways to work with First Nations within the project area to incorporate important Indigenous Knowledge and develop an Indigenous Sensitivity Score.

Clear Seas anticipates developing an Indigenous Sensitivity Score at a future date in partnership with First Nations communities who have a deep connection to and stewardship of the lands and waters in the study area as well as rights and interests.

7.0 Conclusion

Clear Seas commissioned Dillon to identify sensitive coastal areas on the Pacific Coast of Canada as part of the Marine Transportation Corridors Initiative. Sensitive coastal areas are considered areas where sensitivities, in the form of risk receptors, are present and have the potential to be negatively impacted by a ship-source oil spill.

Four sensitivity categories were identified to classify the risk receptors within the study area. The four categories included biological, physical, socio-economic, and Indigenous. The Coastal Sensitivity Score represents the relative magnitude of different risk receptors within an area. Areas where multiple sensitivity categories overlap indicate areas with the potential for an incident to impact multiple receptors. The Coastal Sensitivity Score is an aggregate of the sensitivity scores for three of the sensitivity categories: biological, physical and socio-economic. An Indigenous Sensitivity Score is anticipated to be developed and incorporated at a future date.

The results of the assessment indicate that the most sensitive areas generally occur close to shore. In reviewing the results of the assessment, the three following areas were observed to have elevated sensitives:

1. **Haida Gwaii** – The waters surrounding Haida Gwaii are the traditional territory of the Haida Nation and also provide critical habitat and feeding grounds for a wide variety of marine species. Haida Gwaii is an important tourist destination with Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve, and Haida Heritage Site. The shoreline and seafloor of the waters surrounding Haida Gwaii have a very high sensitivity to oil spills.
2. **Northern and Central Coast** – The Northern and Central Coast includes the waters of the Inside Passage and fjords from Prince Rupert to the northern tip of Vancouver Island. The waters are the traditional territory of the Heiltsuk, Kitasoo/Xai'xais, Nuxalk and Wuikinuxv First Nations and provide important habitat to a wide range of marine species. There are several important commercial fisheries located in this area as well as log boom storage and tourism and recreational sites. The waters east of Banks Island are an important feeding area for marine mammals and the waters to the west of Banks Island are an important rockfish conservation area.
3. **North and West Coast of Vancouver Island** – The Scott Islands, located just north of Vancouver Island, are Canada's first marine National Wildlife Area under the *Canada Wildlife Act*, designated an Ecologically and Biologically Significant Area by Fisheries and Oceans Canada and have also been identified by the Province of British Columbia as an

important biological area with designated Ecological Reserves. As an Important Bird Area (designated by Birdlife International), the islands provide nesting to over two million seabirds and are key sea lion rookeries. The region is the ancestral home of the Tlatlasikwala and the Quatsino First Nations. Barkley Sound, west of Port Alberni, provides habitat and feeding grounds to a wide variety of marine birds, mammals and fish. Barkley Sound is also the site of the Pacific Rim National Park Reserve and an important tourist area with visitors participating in eco-tourism activities as well as recreational fishing. The waters at the entrance of Barkley Sound are the traditional territory of the Nuu-chah-nulth First Nations and one of the largest commercial salmon fisheries in B.C.

The method used to determine and score the sensitivities is based on an ArcGIS workflow that is easily updated when additional datasets become available, when scoring methodology is revised, or if a weighting of various sensitivities is incorporated.

These results are intended to help inform marine spatial planning discussions and are expected to evolve over time as additional data becomes available. It is recommended that the federal, provincial, and Indigenous governments leading the spatial planning processes engage in broad consultation with the public, other First Nations, and knowledgeable stakeholders to identify and select relevant datasets and also validate this model's approach and the resulting sensitivity scores.

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Appendix A: Incorporated Data

Table A1. Data Layers for Sensitivity Analysis

Data Layer	Model Sensitivity	Sub-Sensitivity	Data Source
Marxan Biological Layer	Biological	N/A	BC Marine Conservation Analysis
Shoreline Classification	Physical	Shoreline	Province of B.C. – GeoBC Products
Shoreline Exposure	Physical	Shoreline	Province of B.C. – GeoBC Products
Seafloor Substrate Classification	Physical	Seafloor	BC Marine Conservation Analysis
Canadian Census Dissemination Areas	Socio-Economic	Population Density, Tourism Employment	Statistics Canada
Population Data	Socio-Economic	Population Density	ESRI and Environics Analytics
Employment Data (Accommodation and Food Services Labour Force and Total Population in Labour Force Data)	Socio-Economic	Tourism Employment	ESRI and Environics Analytics
Dive Sites	Socio-Economic	Tourism Employment	Province of B.C. – GeoBC Products
Marinas	Socio-Economic	Tourism Employment	BC Marine Conservation Analysis
Coastal Campsites	Socio-Economic	Tourism Employment	Province of B.C. – GeoBC Products

Data Layer	Model Sensitivity	Sub-Sensitivity	Data Source
Anchorages	Socio-Economic	Tourism Employment	BC Marine Conservation Analysis
Recreational Crab Fishing Areas	Socio-Economic	Tourism Employment	Province of B.C. – GeoBC Products
Recreational Fish Fisheries	Socio-Economic	Tourism Employment	Province of B.C. – GeoBC Products
Recreational Groundfish Fisheries	Socio-Economic	Tourism Employment	Province of B.C. – GeoBC Products
Recreational Prawn Fishing Areas	Socio-Economic	Tourism Employment	Province of B.C. – GeoBC Products
Recreational Scallop Fishing Areas	Socio-Economic	Tourism Employment	Province of B.C. – GeoBC Products
Recreational Fishing Areas (All Types)	Socio-Economic	Tourism Employment	Province of B.C. – GeoBC Products
National Parks	Socio-Economic	Parks and Cultural Areas	Parks Canada
Provincial Parks	Socio-Economic	Parks and Cultural Areas	Province of B.C. – GeoBC Products
Recreation Areas	Socio-Economic	Parks and Cultural Areas	Province of B.C. – GeoBC Products
Crab	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Shellfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Geoduck	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Shellfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Green Sea Urchin	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Shellfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")

Data Layer	Model Sensitivity	Sub-Sensitivity	Data Source
Groundfish Trawl	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Groundfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Halibut	Socio-Economic	Commercial Fishing	BCMCA ("International Pacific Habitat Commission, Living Oceans Society")
Roe Herring Gillnet	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Conservation Biology Section, Pacific Biological Station, Living Oceans Society")
Roe Herring Siene	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Conservation Biology Section, Pacific Biological Station, Living Oceans Society")
Humpback Shrimp	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Shellfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Krill	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Shellfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Pink Shrimp	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Shellfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Prawn	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Shellfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Red Sea Urchin	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Shellfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")

Data Layer	Model Sensitivity	Sub-Sensitivity	Data Source
Rockfish Hook and Line	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Shellfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Sablefish	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Groundfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Sardine	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Sardine Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Schedule II (including lingcod, skates, sole, flounder, tuna, etc.)	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Groundfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Seacucumber	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Shellfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Shrimp (Trawl)	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Shellfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Sidestripe Shrimp	Socio-Economic	Commercial Fishing	BCMCA ("Fisheries and Oceans Canada, Shellfish Stock Assessment Harvest Log Database, Pacific Biological Station, Living Oceans Society")
Marine Industrial Sites	Socio-Economic	Water Resources Use	Province of B.C. – GeoBC Products
Shellfish Hatcheries	Socio-Economic	Water Resources Use	Province of B.C. – GeoBC Products
Salmon Hatcheries	Socio-Economic	Water Resources Use	Province of B.C. – GeoBC Products

Data Layer	Model Sensitivity	Sub-Sensitivity	Data Source
Shellfish Tenures	Socio-Economic	Water Resources Use	Province of B.C. – GeoBC Products
Saltwater Finfish Tenures	Socio-Economic	Water Resources Use	Province of B.C. – GeoBC Products
Ports	Socio-Economic	Port Facilities Sensitivity	Province of B.C. – GeoBC Products
Terminals	Socio-Economic	Port Facilities Sensitivity	Province of B.C. – GeoBC Products
Shipyards	Socio-Economic	Port Facilities Sensitivity	Province of B.C. – GeoBC Products
Harbours	Socio-Economic	Port Facilities Sensitivity	Province of B.C. – GeoBC Products
Port Alberni Port Authority	Socio-Economic	Port Facilities Sensitivity	Canada Gazette, June 26, 1999
Prince Rupert Port Authority	Socio-Economic	Port Facilities Sensitivity	Canada Gazette, May 1, 1999

Appendix B: Biological Sensitivity Analysis

The Biological Sensitivity category highlights sensitive biological areas within the study area. The category includes both species and habitats of marine mammals, marine fish, marine invertebrates, marine birds and marine plants. Data available from the BCMCA was used to determine the sensitivity of biological areas as it was the most complete of any of the publicly available datasets.

The BCMCA compiled over 200 different layers of mapped biological information and then used the Marxan model to determine areas of high biological value.[1] The model identifies areas that are considered as having high conservation value based on biological data. The outputs of the Marxan model were publicly available but the 200 different biological input layers were not publicly available for use. Several other international methods and approaches to assess biological sensitivities were reviewed (French et al., 1996; Schmidt, 2009; WSP, 2013; WSP, 2014a; WSP, 2014b; DNV, 2001; Stevens and Aurand, 2008; Cole and Hasselström, 2013; DNV, 2010; DNV, 2011; Dillon, 2017) but it was determined that these methods could not be used as the necessary biological layers (used as the input layers in the Marxan model) were not publicly available.

The Marxan model is a decision support tool developed by the University of Adelaide (Ball, 2000) that uses a simple statistical analysis, while considering various input layers and set targets, to search millions of potential solutions to determine what areas are of high conservation value. For example, a question that could be posed to Marxan is "which areas contain a representative suite of critical habitat for a specific species (e.g., 70% of the habitat identified for that specific species) in the smallest area?" The model would then conduct millions of runs to determine what area contains at least 70% of the targeted habitat within the smallest footprint. This methodology can then be repeated for any other species or habitat identified.

The model can also be run to combine the results of each individual species or habitat model runs to produce an output that shows where the most sensitive areas are. For example, if you wanted to include 70% of the habitat for specific species and 80% of all the sightings of another species you could program this into the model. In this example, the Marxan model will conduct hundreds to millions of runs to determine the various solutions that will include 70% of the habitat of the specific species and 80% of the sightings of the other species in the smallest area. The results of these runs are then combined to produce a heat map that illustrates the number of times a certain area was selected in the model run meeting the specific criteria.

The BCMCA Marxan results were supplied in a 2 km x 2 km grid and values within each grid cell represented the percentage of selection frequency for each area over the various model runs. For use as a biological sensitivity input for this sensitive coastal areas study, the BCMCA Marxan values (drawn

[1] A further explanation of the approach to the BCMCA effort is available here and more detail about the Marxan model is available here.

from the scenario developed by the expert team with high ecological values and no clumping) were inserted into the study area using GIS tools. The Biological Sensitivity Score for each grid cell was then calculated by creating five equal interval breaks in the data and reclassifying them on a scale from 1-16 to represent very low, low, medium, high and very high sensitivity categories. The results of this reclassification can be found in Table B1.

Table B1. Biological Sensitivity Score (BSS) Details

Classification	BSS Score	Description	Definition (based on % of selection frequency over 100 runs)	Colour Code
BSS – 5	16	Very High	80.1 – 100%	
BSS – 4	8	High	60.1 – 80%	
BSS – 3	4	Medium	40.1 – 60%	
BSS – 2	2	Low	20.1 – 40%	
BSS – 1	1	Very Low	0 – 20%	

Areas with a Very High designation are areas with biological species and habitats that have a high conservation value and as such, are considered highly sensitive to oil spills. The Marxan model selected those areas that best matched the desired outputs of the model run, containing the most biologically sensitive areas based on the input data. The areas with a Very Low designation are the areas that contain species and habitats that have a low conservation value and as such, are considered least sensitive to oil spills.

The data that was used to determine the Biological Sensitivity Score was obtained from the Marxan analysis completed by the BCMCA.

The limitations of the Marxan analysis are as follows:

- While the analysis contained approximately 200 different data layers, as detailed in Appendix A, there are additional data layers available from the federal, provincial, municipal, and First Nations governments as well as non-governmental organizations. These data sources could not be included in the analysis as they require sharing agreements and long lead times to obtain. This study relies entirely on publicly available data.
- The data used in the analysis were collected over a period of many years. Some of the datasets used are older and may not reflect the current biological situation as biological life shifts spatially over time due to stressors and changes in the environment. However, the data used represents the best available data at the time of the analysis.

their results should be used to conduct additional Marxan model runs to update the Biological Sensitivity Score.

The following additional limitations apply to the Biological Sensitivity Score:

- The Biological Sensitivity Score identifies habitats and species of high conservation value. It does not attempt to determine the impacts an oil spill would have on biological receptors. To determine that, a specific oil spill scenario with oil spill fate and trajectory modelling would need to be completed to determine impact for individual species and habitats.
- The Biological Sensitivity Score does not consider seasonality in its calculation as the Marxan analysis did not consider seasonality when it identified species and habitats.

Appendix C: Physical Sensitivity Analysis

The Physical Sensitivity category focuses on key physical attributes that would be negatively affected if exposed to oil. The physical sensitivities consider 1) the shoreline and 2) the seafloor. Each of the physical sensitivities is given equal weighting in the calculation of the Physical Sensitivity Score. The methodology used to determine the Physical Sensitivity Score is described below.

C.1 Shoreline

The Shoreline Sensitivity Score is determined by taking into consideration the shoreline classification and the shoreline exposure. The shoreline classifications are based on the 11 shoreline types defined by Environment and Climate Change Canada (Owens and Sergy, 2000; Wynja *et al*, 2015) and their geological makeup. The shoreline exposure is based on six different levels of exposure the shoreline has to the environment, ranging from very protected to very exposed. The Shoreline Sensitivity Score ($SEN_{shoreline}$) is calculated as shown in Equation C1. It determines the relative percentage of the Shoreline Classification and the Shoreline Exposure within a grid cell.

Equation C1 $$SEN_{shoreline,j} = \left[\sum\left(\frac{LOS_m}{LOS_j}\right)SC_m\right] \; x \; \left[\sum\left(\frac{LOSEx_n}{LOS_j}\right)ExS_n\right]$$

Where:

SC_m	Shoreline Classification for shoreline type 'm' (Table C1) in Grid Cell 'j'
LOS_m	Length of shoreline type 'm' (Table C1) in Grid Cell 'j'
LOS_j	Total length of shoreline in Grid Cell 'j'
ExS_n	Shoreline Exposure Score for exposure class 'n' (Table C2) in Grid Cell 'j'
$LOSEx_n$	Length of shoreline exposure class 'n' (Table C2) in Grid Cell 'j'

The process is twofold. First, the shoreline line data is intersected with the study area grid and a proportional area calculation is performed, where each type of shoreline within the grid cell is weighted by its total length and associated shoreline score. The weighted shoreline scores in each grid cell are then summed together. The process is then repeated in parallel for exposure, and the two scores are multiplied to create the Shoreline Sensitivity Score. The total score was then normalized and used in the Physical Sensitivity Score calculations.

Shoreline Classification

Descriptions of shoreline classifications are outlined in Table C1 while the shoreline classifications are depicted in Figure C1.

Table C1. Shoreline Classifications and Associated Scores

Shoreline Type 'm'	**Description**	**Shoreline Classification (SC_m)**
Bedrock Cliff/Vertical	Impermeable outcrops of native rock with slopes greater than 35°, regular exposure to high wave energy or tidal conditions, attached organisms are hardy and accustomed to wave energy.	1
Man-Made Solid	Anthropogenic structures composed of impermeable materials. Includes docks, wharves, breakwaters and seawalls. Habitat is not as rich as bedrock shores given the steep vertical nature of the structures.	2
Bedrock Platform	Impermeable outcrops of native rock with nearly horizontal platforms with slope of less than 5°.	4
Bedrock Sloping/Ramp	Impermeable outcrops of native rock with ramp slopes from 5° to 35°. Generally, provides good habitat for algae and attached organisms.	8
Man-Made Permeable	Anthropogenic structures composed of permeable materials. Include docks, wharves, breakwaters and seawalls. Habitat is not as rich as bedrock shores given the steep vertical nature of the structures.	16
Not Classified	Shoreline has not been classified so it is scored in the mid-range of the Shoreline Classification Score.	32
Mixed and Coarse Sediment Tidal Flat	Dominant geological material is coarse sediment including pebbles and/or cobbles. Pebbles have diameter of 4-64 mm while cobbles have diameter of 65-256 mm. Permeable to all but heavy sinker oils with mobile surface layers. Supports little habitat due to constant reworking of the geology.	32
Mixed Sediment Beach or Bank	Composed of sands, granules, pebbles, cobbles and boulders. Supports little habitat in exposed shorelines due to wave energy. Habitat can be more prevalent in sheltered waters.	64
Sand Beach or Bank	Beach is composed of sand with a grain-size diameter of 0.0625 to 2.0 mm. Beaches may also contain small amounts of granules, pebbles and cobbles. Permeable for medium evaporator and medium floater oils. Has a very dynamic, mobile and unstable surface layer of sand which supports very little habitat due to the unstable environment.	128

Shoreline Type 'm'	Description	Shoreline Classification (SC_m)
Sand Tidal Flat	Wide flat surface (slope less than 5°) with the dominant substrate being sand. Permeable for medium evaporator and medium floater oils. Generally present in sheltered areas and supports important habitats, especially for birds.	256
Mud Tidal Flat	Wide flat surface (slope less than 5°) with the dominant substrate being silt and clay (grain-size less than 0.0625 mm). Can include organic detritus and small amounts of sand. Water saturated and not permeable to oil. Generally present in sheltered areas and supports important habitats, especially for birds, with very productive biological habitats that contain many different organisms at varying trophic levels.	512
Marsh	Shoreline periodically or permanently under water with strong presence of vegetation. Permeable for medium evaporator oils. Extremely productive habitats in terms of plants, small organisms and birds.	1,024

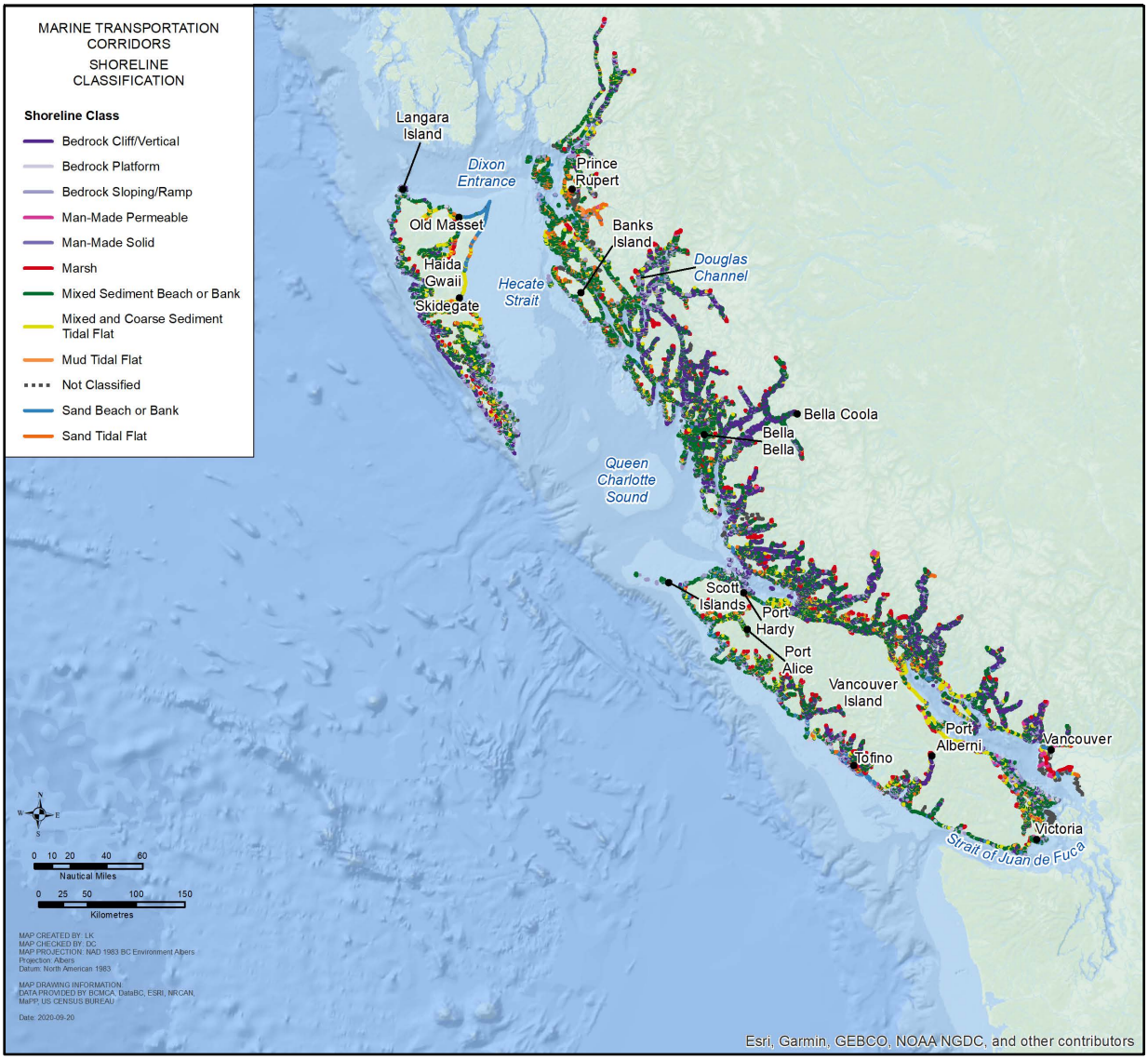

Figure C1. Shoreline Classification

The Shoreline Classification is based on the principle of equal distribution of importance, starting with the Bedrock Cliff/Vertical as having the lowest sensitivity to oil exposure – with a corresponding score of 1. The doubling of the score for the 11 categories results in the shoreline type Marsh having the highest score of 1,024. A proportional calculation was then performed, where the shoreline type score for each grid cell is the sum of the weighted scores present in the grid cell. This value for each grid cell was used in Equation C1 to determine the Shoreline Sensitivity Score.

Shoreline Exposure

The shoreline exposure rankings as assigned by the Province of B.C. are presented in Table C2. A proportional calculation was then performed, where the shoreline exposure score for each grid cell is the sum of the weighted scores present in the grid cell.

Table C2. Exposure Class 'n' for Shoreline Score

Exposure Class 'n'	**Score**
Very Exposed	1
Exposed	2
Semi-exposed	4
Semi-protected / Unknown	8
Protected	16
Very Protected	32

Combined Shoreline Sensitivity Score

The shoreline sensitivity score within the study area was calculated and normalized into five categories as shown in Table C3.

Table C3. Shoreline Sensitivity Score ($SEN_{shoreline}$) Details

Classification	**$SEN_{shoreline}$ Score**	**Description**	**Definition** (based on $SEN_{shoreline}$ Score within study area)	**Colour Code**
$SEN_{shoreline}$ 5	16	Very High	6,144.1 – 32,768.0	
$SEN_{shoreline}$ 4	8	High	768.1 – 6,144.0	
$SEN_{shoreline}$ 3	4	Medium	48.1 – 768.0	
$SEN_{shoreline}$ 2	2	Low	6.1 – 48.0	
$SEN_{shoreline}$ 1	1	Very Low	1.0 – 6.0	

C.2 Seafloor

The $SEN_{seafloor}$ for each Grid Cell 'j' was calculated as shown in Equation C2.

Equation C2 $$SEN_{seafloor\_j} = \sum \left(\frac{Area_n}{Area_j} \right) SFEI_n$$

Where:

$SFEI_n$	Seafloor Exposure Index for seafloor type 'n' in Grid Cell 'j'
$Area_n$	Area of seafloor type 'n' in Grid Cell 'j'
$Area_j$	Total area of Grid Cell 'j'

The Seafloor Exposure Index for each type of seafloor was determined based on the substrate type,[2] its sensitivity to oil and its biological productivity, ranked from 1 to 16, with 1 being the least sensitive and 16 being the most sensitive to oil as shown in Table C4. Seafloor type can be seen on Figure C2.

[2] The seafloor substrate was obtained from the BCMCA analysis, which used data provided by Parks Canada as per the details available here.

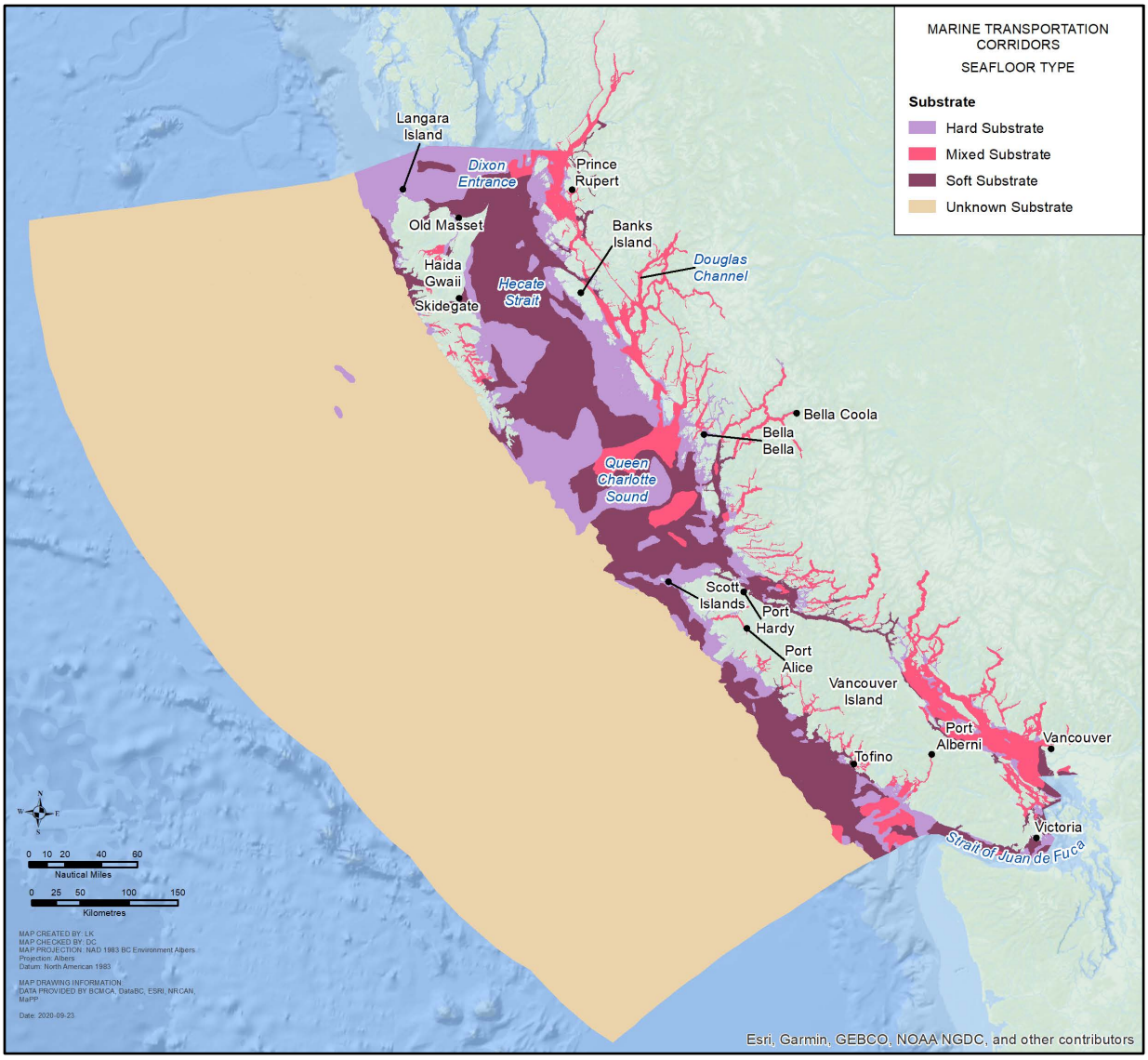

Figure C2. Seafloor Type

Table C4. Seafloor Exposure Index

Seafloor Type 'n'	**Description**	**Exposure Index ($SFEI_n$)**
Soft Bottom	Muds, sand, and mud and sand	16
Mixed/Unknown Bottom	Gravels, mixed sediment, and sand and gravel	4
Hard Bottom	Continuous and discontinuous bedrock and boulders	1

The seafloor sensitivity score within the study area was calculated normalized into five categories as presented in Table C5.

Table C5. Seafloor Sensitivity Score ($SEN_{seafloor}$) Details

Classification	SEN Score	Description	Definition (based on $SEN_{seafloor}$ Score within Study Area)	Colour Code
$SEN_{seafloor}$ 5	16	Very High	11.31 - 16.00	
$SEN_{seafloor}$ 4	8	High	5.67 – 11.30	
$SEN_{seafloor}$ 3	4	Medium	2.84 – 5.66	
$SEN_{seafloor}$ 2	2	Low	1.41 – 2.83	
$SEN_{seafloor}$ 1	1	Very Low	1.00 – 1.40	

C.3 Physical Sensitivity Score

The Physical Sensitivity Score is the sum of the shoreline and seafloor scores in a given grid cell as shown in Equation C3.

Equation C3 $$PSS_j = SEN_{shoreline,j} + SEN_{seafloor,j}$$

Where:

PSS_j The Physical Sensitivity Score in Grid Cell 'j'

$SEN_{shoreline,\ j}$ Shoreline Sensitivity Score in Grid Cell 'j' calculated as per Equation C1.

$SEN_{seafloor,\ j}$ Seafloor Sensitivity Score in Grid Cell 'j' calculated as per Equation C2.

Once the Physical Sensitivity Score is calculated for each grid cell in the study area it is normalized into one of five categories presented in Table C6.

Table C6. Physical Sensitivity Score (PSS) Details

Classification	PSS Score	Description	Definition (based on PSS Score within study area)	Colour Code
PSS 5	16	Very High	22.64 – 32.00	
PSS 4	8	High	11.32 – 22.63	
PSS 3	4	Medium	5.67 – 11.31	
PSS 2	2	Low	2.84 – 5.66	
PSS 1	1	Very Low	2.00 – 2.83	

Appendix D: Socio-Economic Sensitivity Analysis

Identifying the socio-economic sensitivities within the study area is a complex task for which no simple indicator exists (WSP, 2013). The Socio-Economic Sensitivity Score attempts to determine what areas used by humans for economic benefit could likely be affected by an oil spill. The Socio-Economic Sensitivity Score is an aggregate of the following sub-categories:

- Commercial fishing
- Tourism employment
- Port facilities
- Water resource use
- Population density
- Parks and cultural areas

Areas with multiple sub-categories (e.g., port facilities, parks, and commercial fishing) would be considered to have a higher sensitivity than areas with only one sub-category. All sub-components were weighted equally, assuming that an oil spill has the potential to affect each sub-category equally.

The Socio-Economic Sensitivity model developed herein builds on work done by others in Canada, which adapted earlier work done for Australia (DNV, 2011) with modifications to reflect the Canadian economy (WSP, 2013; WSP, 2014a; WSP, 2014b and Dillon, 2017).

D.1 Commercial Fishing Sensitivity Score

Commercial fishing is included in the Socio-Economic Sensitivity Score as an oil spill could limit or eliminate commercial fishing in the area of the oil spill, due to the physical presence of the oil preventing fishing or from consumer pressures such as the public not wanting to eat potentially contaminated fish.

Commercial fishing data was obtained from Fisheries and Oceans Canada and BCMCA as outlined in Appendix A. Table D1 provides a listing of all the commercial fisheries included in the analysis. Data was provided in a number of different formats depending on the species type and the method used to report the catch. The majority of fish were reported in 4 km by 4 km grid cells that represented total catch weight per cell.

Table D1. Commercial Fisheries Included in Analysis

Commercial Fisheries by Catch Weight	Commercial Fisheries by Total Fish Caught
Crab	Pink Salmon caught by gillnet
Geoduck	Pink Salmon caught by seine
Green Sea Urchin	Pink Salmon caught by troll
Groundfish (Trawl)	Chum Salmon caught by gillnet
Halibut	Chum Salmon caught by seine
Roe Herring (Gillnet)	Chum Salmon caught by troll
Roe Herring (Seine)	Sockeye Salmon caught by gillnet
Humpback Shrimp	Sockeye Salmon caught by seine
Krill	Sockeye Salmon caught by troll
Pink Shrimp	Coho Salmon caught by gillnet
Prawn	Coho Salmon caught by seine
Red Sea Urchin	Coho Salmon caught by troll
Rockfish Hook and Line	Chinook Salmon caught by gillnet
Sablefish (Longline)	Chinook Salmon caught by seine
Sablefish (Trap)	Chinook Salmon caught by troll
Sardine	
Schedule II (including lingcod, skates, sole, flounder, tuna, etc.)	
Seacucumber	
Shrimp (Trawl)	
Sidestripe Shrimp	

The salmon fisheries catch data, seen on Figure D1, was total number of fish caught per salmon catch estimate area.

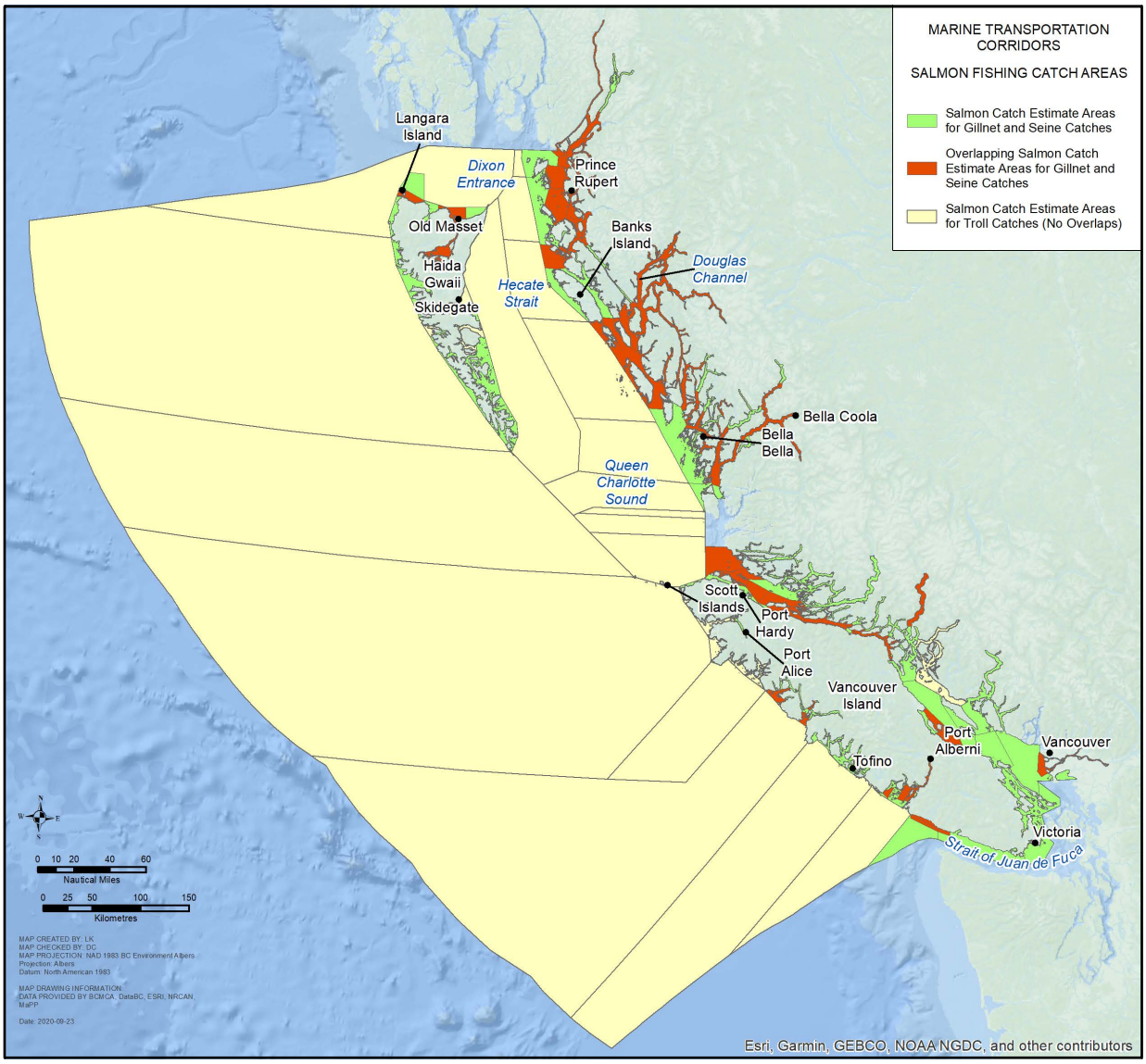

Figure D1. Salmon Fishing Catch Areas

Data for each species was converted from the provided grid (4 km x 4 km grid) or salmon catch estimate area into the project's 2 NM x 2 NM grid. This was accomplished by proportionally summing all the values within the larger project grid cells or subareas. Data for each species were then normalized. Each of the data sets for each study area was scored using the natural break (Jenks function) of ArcGIS.[3] The natural break function divided the data set into five groups as shown in Table D2. The grid cells that report the largest catch totals or largest monetary value caught are scored higher and are assumed to have greater sensitivity than grid cells that report the lowest catch totals by weight or monetary value.

[3] The Jenks Function is a method used to group data that tries to minimize the difference within a group while maximizing the differences between each separate group (de Smith et. al., 2015).

Table D2. Commercial Fishing Score Details

Classification	Commercial Fishing (CF) Score	Description	Definition	Colour Code
CF 5	16	Very High	898 - 1582	
CF 4	8	High	552 – 897	
CF 3	4	Medium	329 – 551	
CF 2	2	Low	154 – 328	
CF 1	1	Very Low	0 – 153	

D.2 Tourism Sensitivity Score

The tourism sensitivity score accounts for the potential loss of tourism in the event of an oil spill. The score identifies both areas where a large number of people are employed in the tourism industry and areas that are tourist sites. Tourism employment was determined by using the percentage of persons employed in the accommodation and food service sectors in an area, while known tourism sites – dive sites, marinas, coastal campsites, recreational fishing areas, and recreational anchorages – were used to identify areas that are regularly visited by tourists. The tourism sensitivity score is determined using a three-step process as follows:

1. The Tourism Employment Sensitivity Score is calculated.
2. The Tourism Sites Sensitivity Score is calculated.
3. The Tourism Sensitivity Score is calculated by combining the results of steps 1 and 2.

Tourism Employment Sensitivity Score

The calculation of the tourism employment sensitivity score for each Grid Cell 'j' is shown in Equation D1. The tourism employment is modified to account for the distance each individual grid cell is from the shoreline as presented in Table D3. This method is adopted from previous studies (WSP, 2013; Dillon, 2017). The ratio of tourism employment to total employment is presented in Figure D2.

Equation D1 $$SEIS_{TE,j} = \frac{\sum Tourism\ industry\ employment\ in\ Dissemination\ Area(s)}{\sum Total\ employment\ in\ Dissemination\ Area(s)} \times DF_{TEI}$$

Where:

$SEIS_{TE,j}$ Tourism Employment Sensitivity Score

DF_{TEI} Distance factor to account for the reduction of tourism activities based on the distance from the shoreline.

Table D3. Tourism Employment Distance Modifiers

Tourism Zone	Distance from Shoreline (NM)	Distance Modifier (DF_{TEI})
Coastal Zone	0 - 4	1.0
Meso Zone	4 - 8	0.8
Nearshore Zone	8 - 12	0.5
Intermediate Zone	12 - 24	0.2
Deep-sea Zone	> 24	0.05

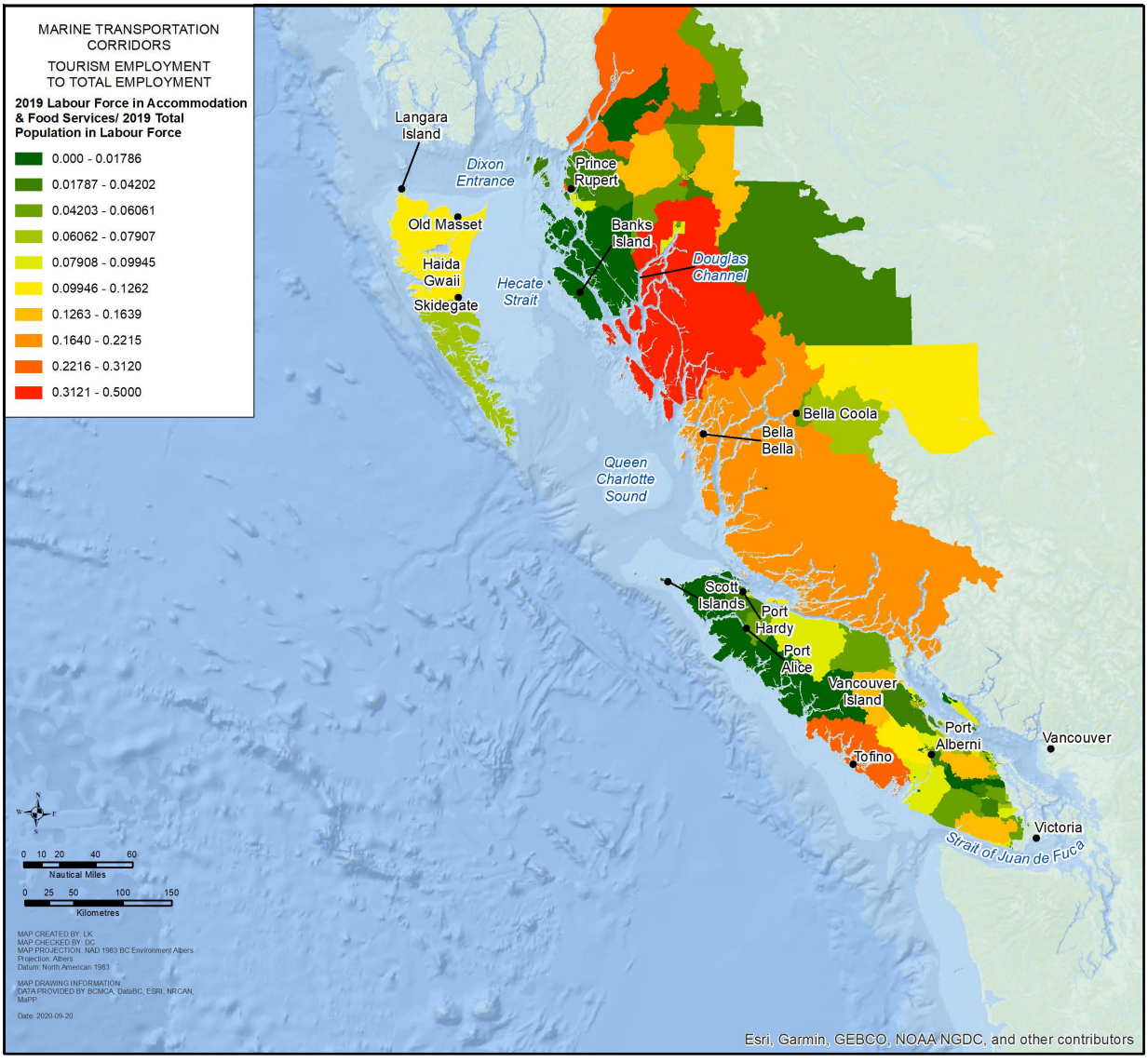

Figure D2. Tourism Employment to Total Employment

Tourism Sites Sensitivity Score

A separate calculation was completed where known tourism areas have been defined within the study area grid. Features in the tourism site layer include:

- Pleasure craft anchorages
- Coastal campsites
- Marinas
- Recreational dive sites
- Recreational fishing areas, including crab, fish, groundfish, prawn, and scallops

These tourism sites are illustrated in Figure D3. Point features were buffered by 20 m and merged with the polygon datasets. Each tourist site within 4 NM of a grid cell was assigned a value of 16. Each tourist site within range of a specific grid cell were summed together. All the grid cells were then distributed into five different categories from Very Low to Very High based on their combined score.

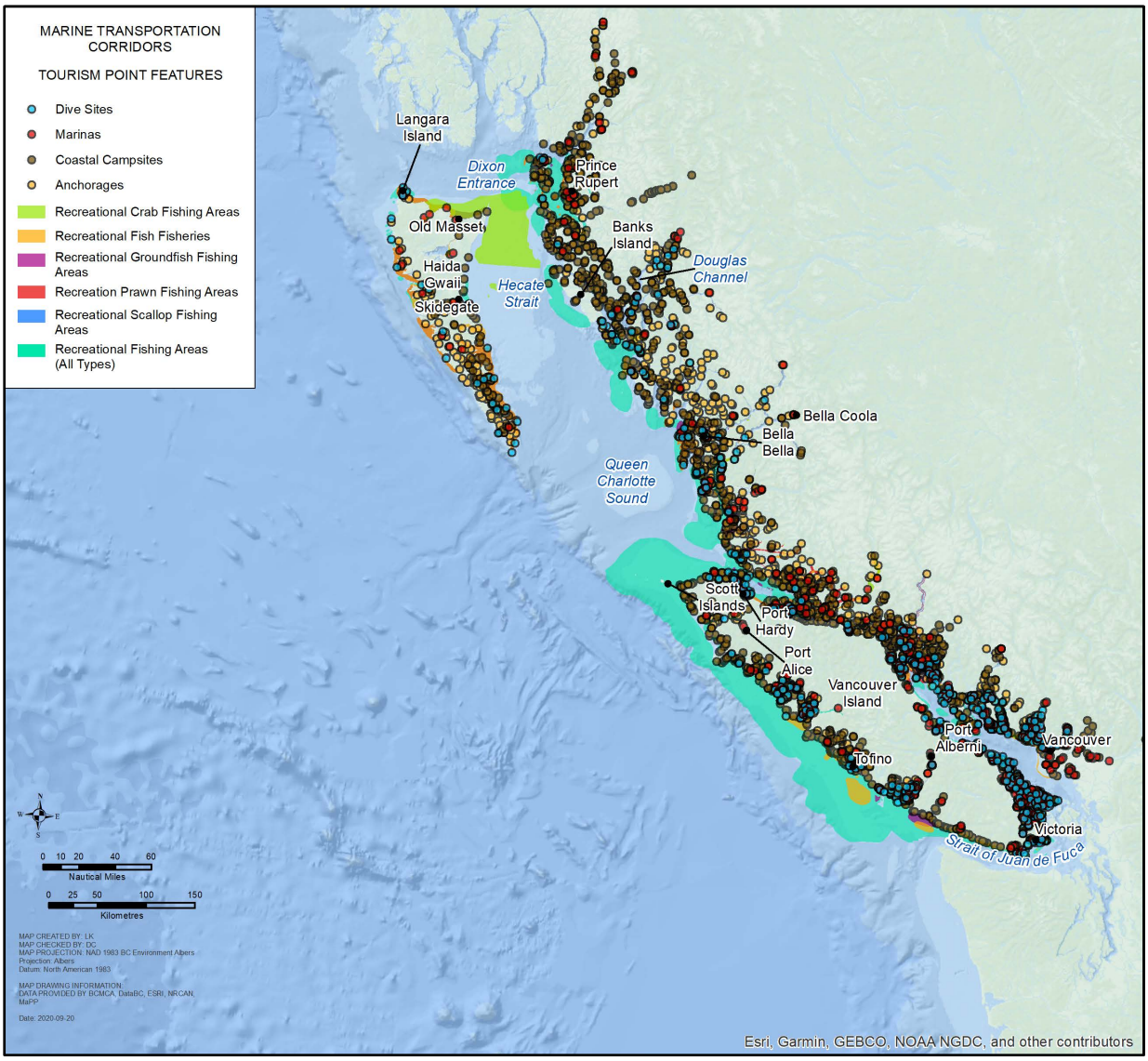

Figure D3. Tourism Point Features

Combined Tourism Sensitivity Score

The final step was to combine the results of the Tourism Employment Sensitivity Score and the Tourism Site Sensitivity Score to yield the Tourism Sensitivity Score. The resultant Tourism Sensitivity Score for each grid was then normalized into five categories using the natural break (Jenks Function)[4] of ArcGIS as shown in Table D4.

[4] The Jenks Function is a method used to group data that tries to minimize the difference within a group while maximizing the differences between each separate group (de Smith et. al., 2015).

Table D4. Tourism Employment (TE) Details

Classification	TE Score	Description	Definition (contribution of tourism to total employment)	Colour Code
TE 5	16	Very High	> 0.318000	
TE 4	8	High	0.160000 – 0.318000	
TE 3	4	Medium	0.082000 – 0.159999	
TE 2	2	Low	0.026000 – 0.081999	
TE 1	1	Very Low	0 – 0.025999	

D.3 Port Facilities Sensitivity Score

The Port Facilities Sensitivity Score addresses the negative socio-economic impact an oil spill could have on a port. An oil spill within or near a harbour could restrict vessel traffic in and out of that harbour, thus negatively affecting the port and the industries relying on the goods moving through the port. For this score, port facilities include designated ports under the *Canadian Marine Act* as well as ports, terminals, shipyards, navigable waters and harbours identified by the Province of B.C

The area of impact associated with the port facilities shown on Figure D4 includes 1 km of surrounding area to ensure potential impacts are adequately accounted for. Port authorities were delineated from legal descriptions of navigable waters. Areas outside of navigable waters and the 1 km buffer zones but within the study area boundary were identified as "Open Water". Grid cells that intersect a port facility were assigned a value of 16. All others were assigned a value of 0.

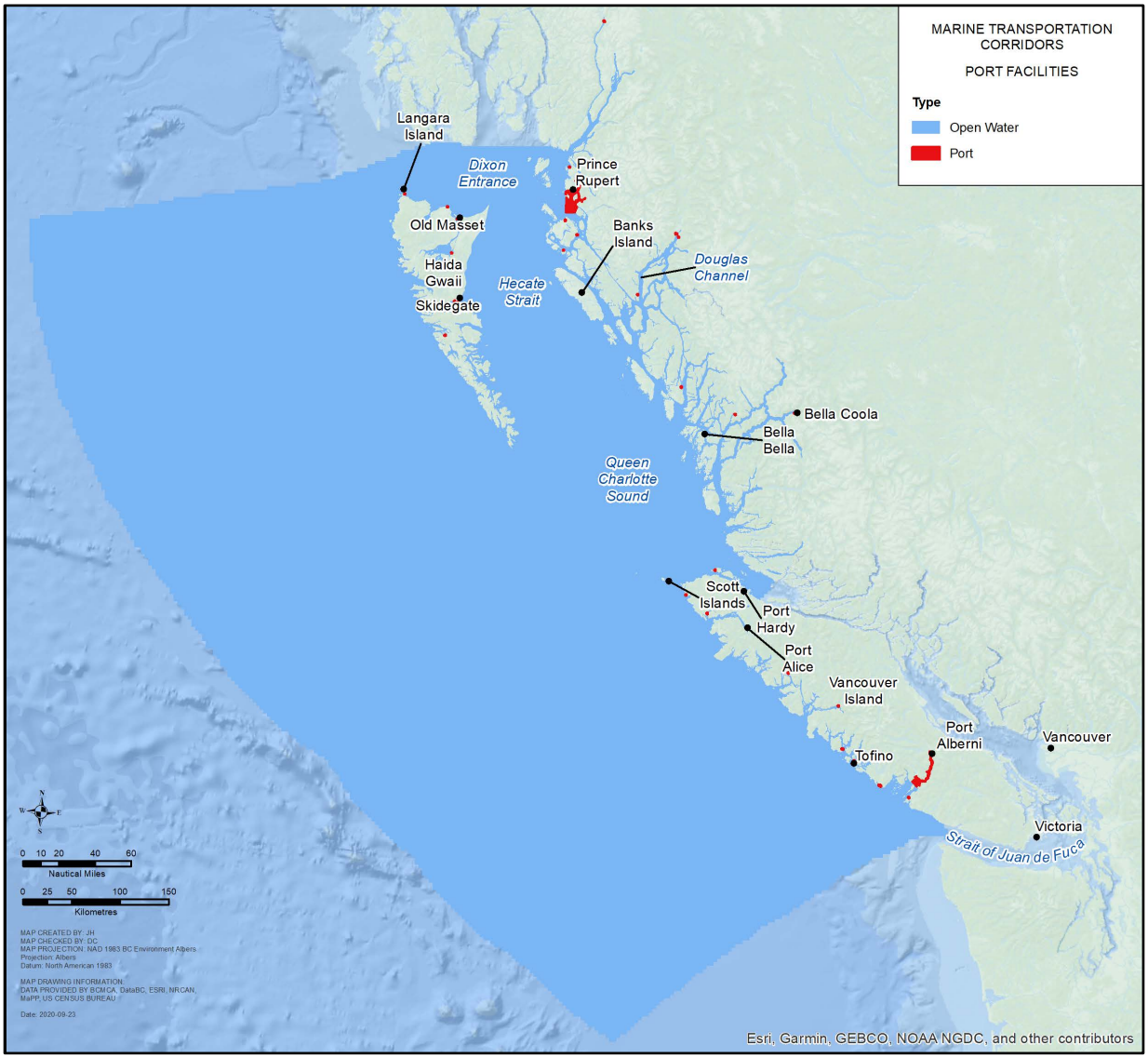

Figure D4. Port Facilities

D.4 Water Resource Sensitivity Score

The Water Resource Sensitivity Score accounts for the impact an oil spill could have on saltwater intakes and aquaculture operations within the study area. An oil spill near a saltwater intake or aquaculture site could require that facility's shutdown which could negatively affect operations. Saltwater intakes could be used for a variety of purposes including power generation and cooling, industry intakes, fish processing plants and aquaculture sites. This score also includes industries that rely on water lots to store raw materials (e.g., log boom storage).

Datasets contained both point and polygon features. The point features were buffered by predefined areas and merged with the polygon features for use in the model. The Water Resource Use input layer is displayed in Figure D5. A complete listing of the data and sources used is provided in Appendix A.

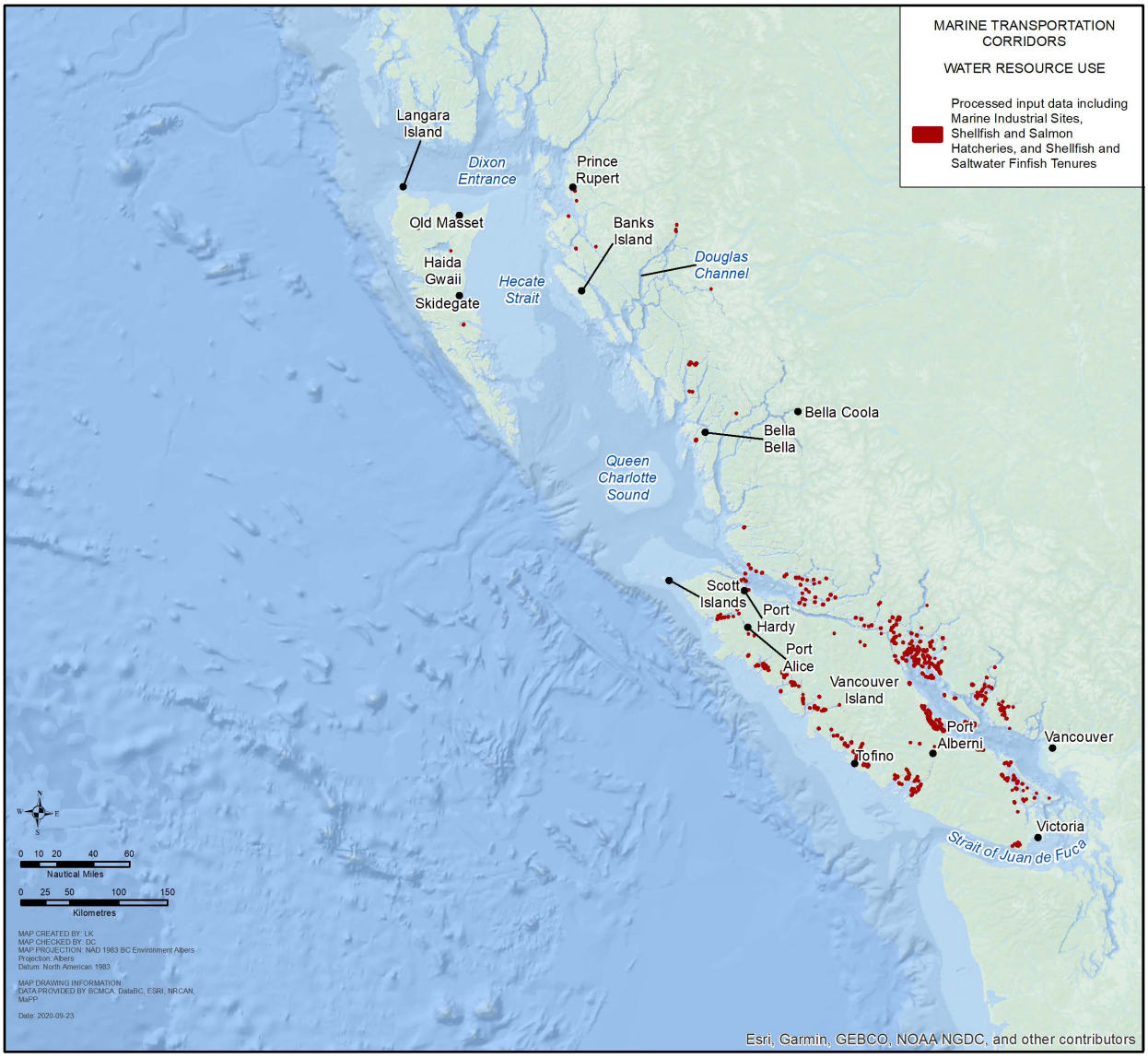

Figure D5. Water Resource Use

Water Resource Use is scored as shown in Table D5, with grid cells where the water resource feature is located scoring Very High and the score decreasing to 0 to represent "no sensitivity" based on the distance from the feature.

Table D5. Water Resource Use (WRU) Details

Classification	WRU Score	Description	Definition (based on oil proximity to WRU Risk Receptor)	Colour Code
WRU Max	16	Very High	< 4 NM	
WRU Mid	4	Medium	4 to 8 NM	
WRU Min	0	Very Low	> 8 NM	

D.5 Population Density Sensitivity Score

The Population Density Sensitivity Score accounts for the number of people that will be affected in the event of a ship-source oil spill. Areas of high population density are likely to have a larger number of people impacted by an oil spill than areas with low population; therefore, areas of high population density are considered more sensitive than areas of low population density within the model.

Projected population density data was collected from Environics Analytics for 2019 based on the 2016 Census Dissemination Area for the study area (Environics Analytics, 2019). The population data was analyzed to determine the maximum population density within any of the dissemination areas, which was 0.00445 people per m^2, within Prince Rupert. Equation D2 was used to determine the Population Density (PD) of each grid cell within the study area.

Equation D2 $$PD_j = \frac{\sum Population\ Density\ in\ Dissemination\ Area(s) within\ 60\ km\ of\ Grid\ Cell}{\sum Total\ Area\ of\ Dissemination\ Area(s)\ within\ 60\ km\ of\ Grid\ Cell} \times DF_{PD}$$

Where:

DF_{pdi} Distance factor to account for decreasing level of risk further from shore

The distance factor goes out to 8 NM from an identified grid cell. The Population Density distance factors used within the study area are:

- 0-4 NM from Grid Cell j = 1.0
- 4-8 NM from Grid Cell j = 0.5
- > 8 NM from Grid Cell j = 0.0

The input population by dissemination area is presented on Figure D6.

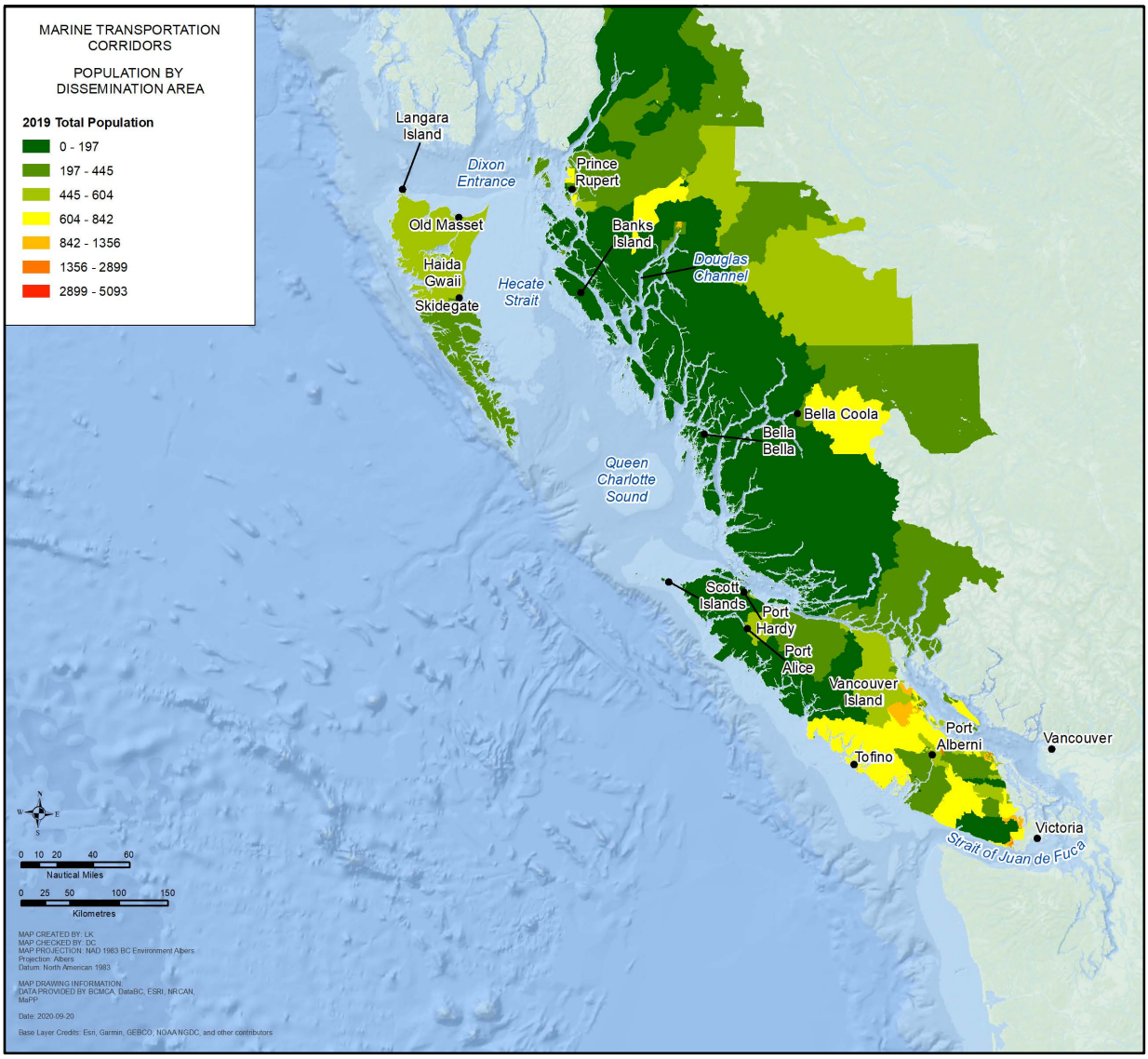

Figure D6. Population by Dissemination Area

Using the natural breaks (Jenks function)[5] available in ArcGIS, the population density was divided into five categories and assigned a score from 1 to 16 based on the grid cell's population density as shown in Table D6. The result of the population density sensitivity is a normalized score that varies from 0 (no human population within the dissemination area) to a maximum value based on the study area.

[5] The Jenks Function is a method used to group data that tries to minimize the difference within a group while maximizing the differences between each separate group (de Smith et. al., 2015).

Table D6. Population Density (PD) Details

Classification	PD Score	Description	Definition (Total Population Per Dissemination Area)	Colour Code
PD 5	16	Very High	> 3.111751	
PD 4	8	High	0.731971 – 3.111751	
PD 3	4	Medium	0.196427 – 0.731970	
PD 2	2	Low	0.046838 – 0.196426	
PD 1	1	Very Low	0 – 0.046837	

D.6 Parks and Cultural Areas Sensitivity Score

The Parks and Cultural Areas Sensitivity Score includes national, provincial and municipal parks as well as important cultural areas along the shoreline. It is included in the Socio-Economic Sensitivity Score due to the value Canadians place on the use of parks. The dataset layers obtained for the parks and cultural areas category were merged into one polygon layer and used for input into the model as shown on Figure D7. Each grid cell in the study area was assigned a value based on distance from a park or cultural site. Cells within 8 NM were assigned a value of 4, while cells within 4 NM were assigned a value of 16. Any cells that did not have an identified site within 8 NM were assigned a value of 0 to indicate no sensitivity as outlined in Table D7.

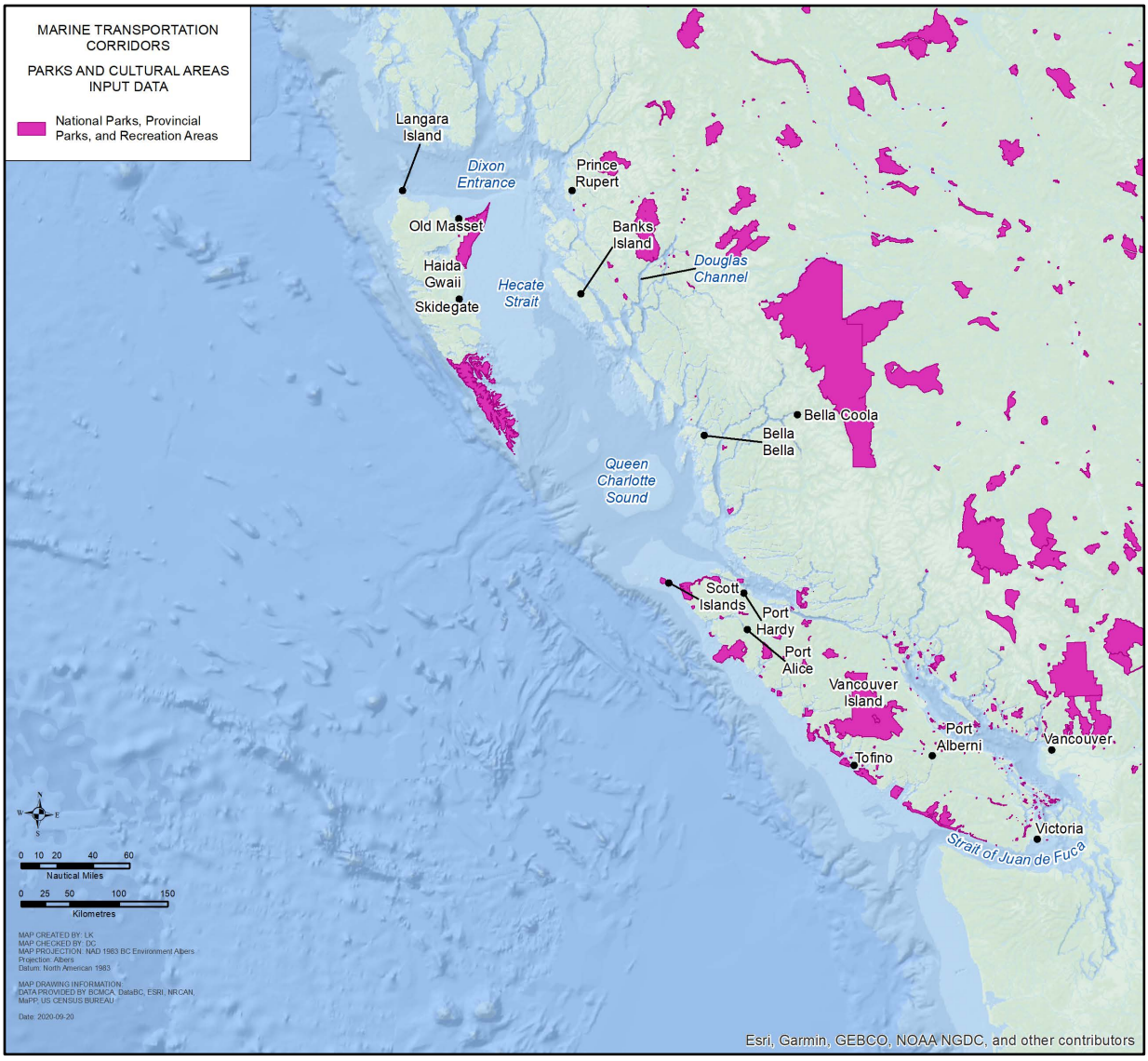

Figure D7. Parks and Cultural Areas Input Data

Table D7. Parks and Cultural Sensitive Areas (PCSA) Details

Classification	PCSA Score	Description	Definition (based on distance from an identified Park or Cultural Area)	Colour Code
PCSA Max	16	Very High	< 4 NM	
PCSA Mid	4	Medium	4 to 8 NM	
PCSA Min	0	Very Low	> 8 NM	

D.7 Socio-Economic Sensitivity Score

The Socio-Economic Sensitivity Score is the sum of each of the socio-economic sensitivity sub-category scores for a given grid cell. All components were assigned equal weighting. The resulting score was then normalized as shown in Table D8 to take into consideration the different values that could be assigned for different sub-categories (e.g., some sub-categories have a "very low" score of 1 while others have a "very low" score of 0 due to the type of features being assessed).

Table D8. Socio-Economic Sensitivity Score (SESS) Details

Classification	SESS Score	Description	Definition	Colour Code
SESS 5	16	Very High	67.89 - 82.00	
SESS 4	8	High	33.95 – 67.88	
SESS 3	4	Medium	16.98 – 33.94	
SESS 2	2	Low	8.50 – 16.97	
SESS 1	1	Very Low	3.00 – 8.49	

Appendix E: Coastal Sensitivity Analysis

The Coastal Sensitivity Score for each grid cell is the sum of the three sensitivity category scores detailed in Equation E1.

Equation E1 $CSS_j = BSS_j + PSS_j + SESS_j$

Where:

CSSj	Coastal Sensitivity Score in Grid Cell 'j'
BSS_j	Biological Sensitivity Score for Grid Cell 'j'
PSS_j	Physical Sensitivity Score for Grid Cell 'j'
$SESS_j$	Socio-Economic Sensitivity Score for Grid Cell 'j'

All layers were weighted equally but the Coastal Sensitivity Score model can include weighted scoring if that feature is desired in the future. Scores were normalized as shown in Table E1.

Table E1. Coastal Sensitivity Score (CSS) Details

Classification	CSS Score	Description	Definition	Colour Code
CSS 5	16	Very High	33.95 – 48.00	
CSS 4	8	High	16.98 – 33.94	
CSS 3	4	Medium	8.50 – 16.97	
CSS 2	2	Low	4.25 – 8.49	
CSS 1	1	Very Low	3.00 – 4.24	

Clear Seas anticipates developing an Indigenous Sensitivity Score at a future date in partnership with First Nations communities who have a deep connection to and stewardship of the lands and waters in the study area as well as rights and interests. The Indigenous Sensitivity category is intended to identify the coastal areas within the study area that are acknowledged by First Nations as having high cultural, environmental, spiritual, economical or historical importance.

At this time, insufficient data was available to assess these aspects of the Coastal Sensitivity Score. Limited information is publicly available for these areas; therefore, Clear Seas will need to explore different ways to work with First Nations within the project area to incorporate important Indigenous Knowledge and develop an Indigenous Sensitivity Score. Once an Indigenous Sensitivity Score is developed, Equation E1 will be modified to incorporate the new score similar to the existing three sensitivity scores.

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