Green Island Lighthouse, Chatham Sound

Whaling Station Bay, Hornby Island

SHOREZONE COASTWIDE SUMMARY REPORT for British Columbia

September 2023

Prepared For
Department of Fisheries and Oceans
Coastal Environmental Baseline Program

Prepared By
Coastal and Ocean Resources and
SeaChange Marine Conservation Society

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37,083 KM OF SHORELINE IMAGED AND MAPPED FROM **1982-2022**

89,552 SHORELINE UNITS CLASSIFIED

AVERAGE UNIT LENGTH IS **415 M**

Prescott Island

Squamish Harbour

35 DISTINCT SPECIES ASSEMBLAGES, CALLED **BIOBANDS,** WERE OBSERVED IN THE SUPRATIDAL, INTERTIDAL AND SUBTIDAL ZONES

Wilcox Group

69% OF THE INTERTIDAL IS CLASSIFIED AS **ROCK** OR **ROCK AND SEDIMENT** DOMINATED

58% OF THE SHORELINE HAS A **HIGH OIL RESIDENCE INDEX** VALUE (RESIDENCE OF MONTHS TO YEARS)

Table of Contents

LIST OF FIGURES AND TABLES

1 INTRODUCTION

ShoreZone is an imaging and habitat classification system for the coastal nearshore margin including the shallow subtidal, intertidal shoreline and supratidal fringe. The objective of ShoreZone is to produce a georeferenced, searchable inventory of the physical and biological attributes of coastal habitats. ShoreZone imagery and habitat mapping attributes can provide a useful baseline from which to study change over time, while the attributes mapped (such as shoreline sediments, predicted oil residence and biotic communities) provide an important resource for scientists, managers, and responders. The ShoreZone mapping system provides a decision support tool with many potential uses including community planning, scientific research, conservation planning, research and fisheries management, emergency planning and response, search and rescue, education, and species and habitat modelling. To date, ShoreZone data is available for ~122,000 km of coastline in the Pacific Northwest, including Oregon, Washington State, British Columbia, and Alaska (Figure 1).

In British Columbia, coastal resource inventory data was being collected in the late 1970's, and programs collecting oblique aerial imagery of the shoreline specifically for geomorphological characterization began soon after (Owens, E.H. 1983), starting with the Strait of Georgia (Salish Sea) and southern Vancouver Island. It was recognized that biological features were a fundamental component of coastal habitats, prompting the addition of a biologist to over-flight survey teams in 1991. Video imagery was augmented with continuous, simultaneous commentary by both the geologist and the biologist. As well, the biologist instituted the process of acquiring oblique 35mm slide film still image photographs of the shoreline. Interpretation of the imagery and narration was conducted by geomorphologists and biologists with extensive experience and knowledge of coastal environments. At first, aircraft flightlines were a combination of visually estimated positions recorded on paper topographic maps or hydrographic charts, and data-logging files recorded by instrumentation using the LORAN-C ground-based navigational aid system. Initially, resource data was recorded in hard-copy tabular form, linked to paper maps, charts and vertical air photographs.

As the sophistication of personal computers and applications software increased, the use of electronic database, spreadsheet, word processing, and GIS, was readily adopted, leading to improved dataset production, accessibility, and visual presentation. In 1994, the provincial Coastal Task Force, under the Resources Inventory Committee, formalized the physical shoreline mapping system begun in 1979, developing a standardized methodology for both the imagery collection, and the subsequent interpretation, geomorphological classification, and data management including spatial frameworks (Howes, et al. 1994). This was quickly followed in 1995 by the development of a biological shoreline mapping system, designed to integrate with the physical mapping system (Searing and Frith, 1995). This combined system of coastal habitat classification and mapping became known as ShoreZone. Surveying and mapping programs continued to add imagery and classification data, completing the initial imaging of the entire coastline of British Columbia in 2000. Re-imaging and ShoreZone mapping of some British Columbia shorelines using the 1994-1995 protocols was conducted 2004-2007, resulting in updated datasets for those areas.

Technological advances (including digital imaging, satellite navigational positioning, electronic data management, and spatial framework GIS platforms), along with ShoreZone mapping initiatives in Washington State, Alaska, and Oregon, led to modifications of methodologies. Updated protocols had additional and expanded attribute lexicons that afforded enhanced coastal habitat characterizations (Berry, 2004; Howes, 2001; Harper and Morris, 2004; Harney et al. 2008; Harper and Morris 2014). The most recent and currently used ShoreZone protocol (Cook et al., 2017) introduced additional shoreline characterization parameters: video imagery processing for ortho-photos to better estimate shoreline feature widths, revised species assemblage (Bioband) classification, estimation of wave energy dissipation in the intertidal, expanded shoreline flooding and stability indices and a new comprehensive coastal vulnerability index for sea level rise effects.

Coinciding with the compilation of an updated protocol in 2014, surveys in British Columbia began to re-image shorelines in the vicinity of Prince Rupert. Some portions of that imagery were mapped under the 2014 protocol. Remaining imagery, and additional surveys around Prince Rupert and other areas of the province from 2015 to present, were mapped using the 2017 protocol.

This data summary report provides information of geomorphological and biological features for the shoreline of British Columbia, which totals **37,083 kilometers** (Figure 2). The habitat inventory consists of **89,552 along-shore segments** (units), averaging 415 m in length, as mapped using the best available digital shoreline at the time. The British Columbia coast-wide dataset summary presented here comprises many volumes of imagery and coastal habitat mapping data compiled over 4 decades (1979-2022), that used several iterations of mapping protocols. Newer datasets (post-2014) have more complex spatial and relational database structures, with modified and expanded lexicons. Where possible, earlier datasets were upgraded to current protocol (2017) specifications, and more recent datasets were retrofitted where necessary to be compatible with and comparable to earlier (pre-2007) data, facilitating analysis and a cohesive presentation of the data over the entire coast.

This report first examines two regions where coastal re-imaging and mapping projects produced updated datasets: the North Coast near Prince Rupert, and specific areas of the Salish Sea. It presents a thorough analysis of selected attribute data for the multiple mapping overlays within each of these areas, along with an exploration of differences revealed through the analysis. Following this, the report provides a historical perspective of ShoreZone in British Columbia, with an overview of the coastal habitat mapping system and its key attribute hierarchy as well as summaries of specific physical and biological attributes pertaining to the characterization of the British Columbia shoreline.

The final section covers advances in the presentation of spatial data (GIS) that now allows improved, explicit, and detailed display of areal extents (polygons) for ShoreZone physical and biological attributes, with selected examples.

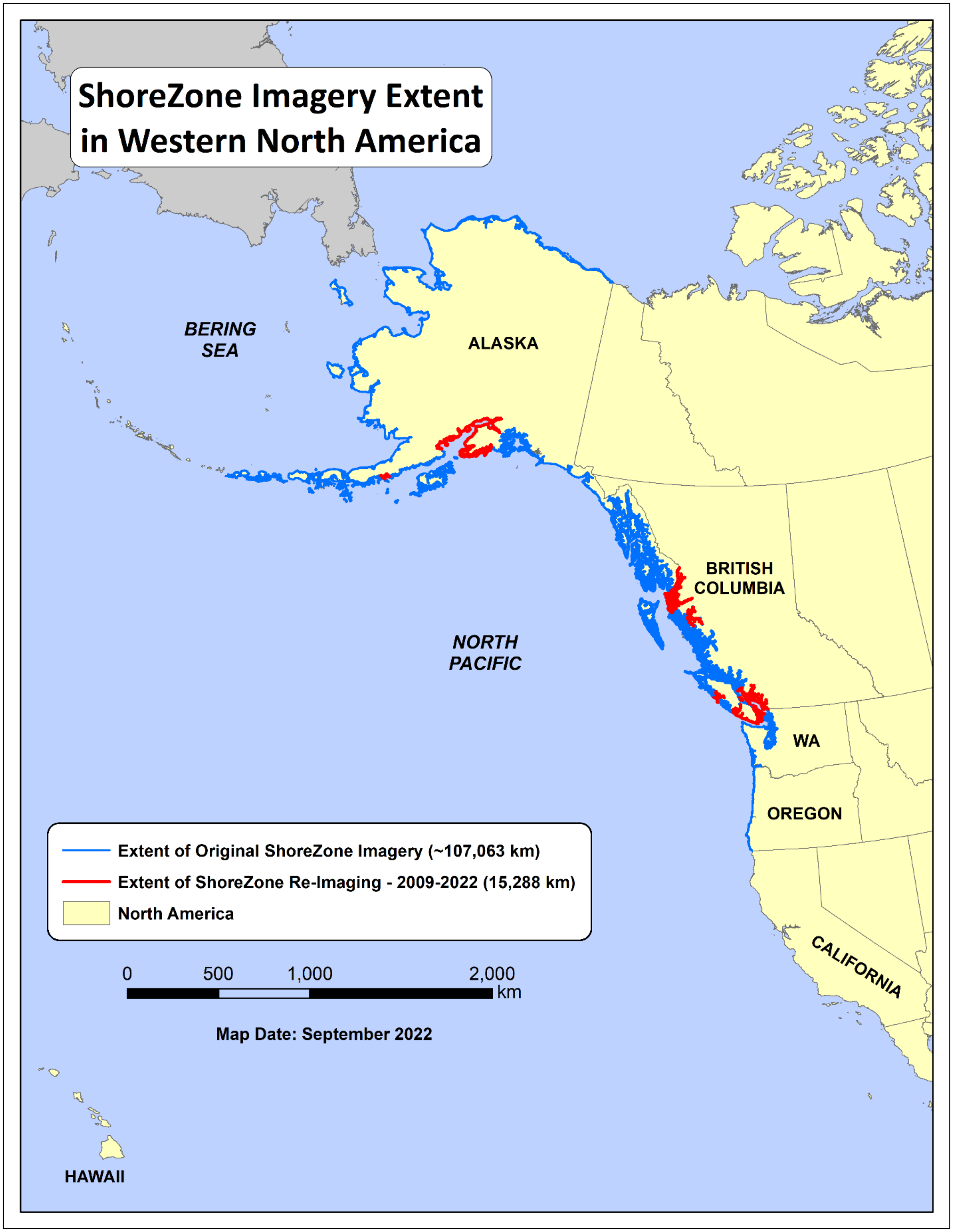

Figure 1. Extent of ShoreZone imagery in Alaska, British Columbia, Washington, and Oregon as of October 2022.

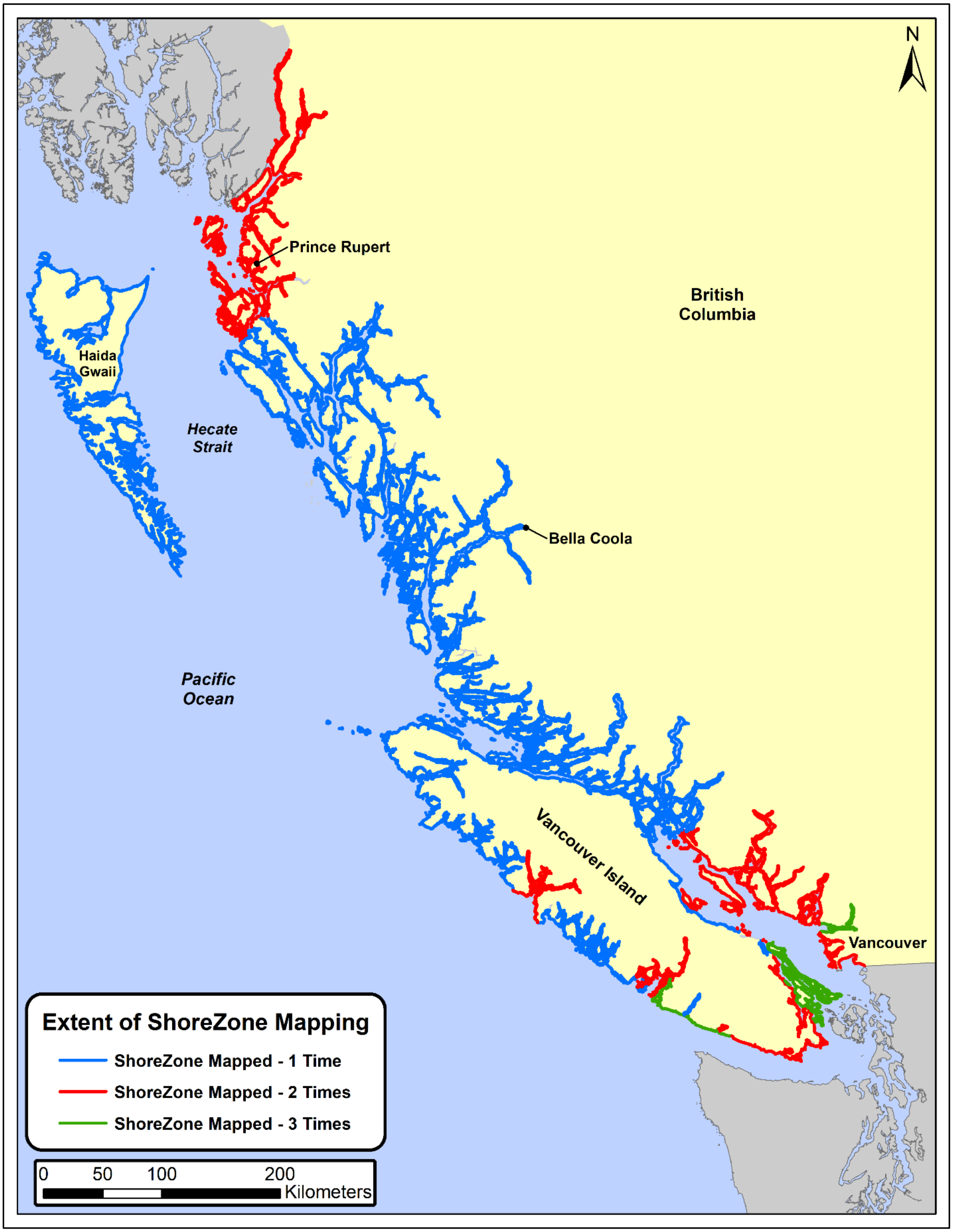

Figure 2. Extent of British Columbia ShoreZone mapping covered in this report and how many times each area has been imaged and mapped.

2 IMAGERY

2.1 Introduction

ShoreZone gathers information on the biology and geology of coastal areas and makes maps of important characteristics. These maps describe coastal habitats and are used in many ways, including oil spill preparedness and response, coastal science and planning, search and rescue, and coastal trip planning. Some people simply use ShoreZone's photos and videos to appreciate the beauty and diversity of the coast.

The mapping is done using video and still photos taken from the air, usually from a helicopter flying at low altitude. Coastal geologists and biologists onboard the helicopter describe the terrain and vegetation they see. Together the images and narration help the ShoreZone mappers classify and map the coast. ShoreZone mapping has been completed for over 90% of Alaska and all of Oregon, Washington, and British Columbia. In British Columbia, ShoreZone has a repository of nearly **115,000 photos** and **400 hours** of video.

2.2 Examples of Imagery

All photographic and video imagery collected by ShoreZone can be found here: Interactive ShoreZone Maps - ShoreZone.

The following are examples of imagery collected with ShoreZone to show current resolution of photography and the biological and physical features that can be seen in them (Figures 3-9).

Figure 3. Dundas Island, photo bc19_dd_00047.

Figure 4. Dundas Island, photo bc19_dd_00124.

Figure 5. Dundas Island, photo bc19_dd_00216.

Figure 6. Sunshine Coast, photo bc20_sc_09661.

Figure 7. Bamfield area, photo bc21_bf_02018.

Figure 8. Nootka Sound area, bc21_nk_00268.

Figure 9. Nootka Sound area, bc21_nk_00797.

3 NORTH COAST OF BRITISH COLUMBIA

3.1 Introduction

Except for the area immediately around the Port of Prince Rupert, the North Coast was originally mapped in the late 1990's/early 2000's. ShoreZone imaging surveys were again conducted around the north coast of British Columbia in June 2014, June 2015, August 2018, and July 2019 and aerial video and digital still images of the coast during minus tides (zero-meter tide levels and lower) were acquired. The imagery and associated audio commentary were used to map the physical and biological attributes of the shoreline. Over the latter surveys (2014, 2015, 2018, 2019), the ShoreZone protocol was updated. Approximately three quarters of the shoreline was mapped according the most recent ShoreZone coastal habitat mapping protocol (Cook et al., 2017) and a quarter was mapped according the to 2014 ShoreZone protocol (Harper et al., 2014).

3.2 Coastal Class

The Coastal Class is used to define along-shore coastal units based on the dominant process, geomorphic features, and other attributes such as substrate type, across-shore width, and slope (Cook et al., 2017 after Howes et al., 1994). The principal characteristics of each along-shore unit are used to assign one of 39 overall unit classifications that have been grouped into various substrate types. The description for each Coastal Class category in the survey area is given in Table 1. Rock and sediment shorelines (41.1%) were prominent along with Rock shorelines (27.4%) and Sediment shorelines (26.2%) in the North Coast of BC survey area. Riparian, Anthropogenic, Lagoon, and Current shorelines all comprised the rest of the coast (Figures 10-19).

Table 1. Summary of Coastal Classes for the North Coast of British Columbia.

Substrate Type	Shore Type		Sum of Unit Length (km)	# of Units	% Occurrence (by length)	Cumulative Occurrence (%, km)
	No.	Description				
Rock	1	Rock Ramp, wide	29	161	1	**27% 1,127 km**
	2	Rock Platform, wide	23	125	1	
	3	Rock Cliff	917	3,736	22	
	4	Rock Ramp, narrow	159	1,036	4	
	5	Rock Platform, narrow	1	3	<1	
Rock & Sediment	6	Ramp w gravel beach,	65	321	2	**41% 1,695 km**
	7	Platform w gravel beach,	26	107	1	
	8	Cliff with gravel beach	293	1,542	7	
	9	Ramp with gravel beach	210	1,242	5	
	10	Platform with gravel beach	1	4	<1	
	11	Ramp w gravel & sand	366	1,647	9	
	12	Platform with G&S beach,	349	1,020	9	
	13	Cliff with gravel/sand beach	91	614	2	
	14	Ramp with gravel/sand	241	1,570	6	
	15	Platform with gravel/sand	1	5	<1	
	16	Ramp w sand beach, wide	27	96	1	
	17	Platform w sand beach,	11	36	<1	
	18	Cliff with sand beach	10	43	<1	
	19	Ramp with sand beach,	6	34	<1	
	20	Platform w sand beach,	<1	2	<1	
Sediment	21	Gravel flat, wide	20	78	1	**26% 1,080 km**
	22	Gravel beach, narrow	63	401	2	
	24	Sand & gravel flat or fan	602	1,912	15	
	25	Sand & gravel beach,	193	966	5	
	26	Sand & gravel flat or fan	3	20	<1	
	27	Sand beach	1	6	<1	
	28	Sand flat	137	244	3	
	29	Mud flat	52	95	1	
	30	Sand beach	10	23	<1	
Organics	31	Organics/Estuarine	158	243	4	**4% 158 km**
Man-made	32	Man-made, permeable	42	133	1	**1% 43 km**
	33	Man-made, impermeable	1	6	<1	
Current	34	Channel	5	23	<1	**<1% 5 km**
Lagoon	36	Lagoon	5	24	<1	**<1% 12 km**
Totals:			***4,121***	***17,518***	***100***	***100%***

Note: This table only includes Coastal Classes observed in the survey area.

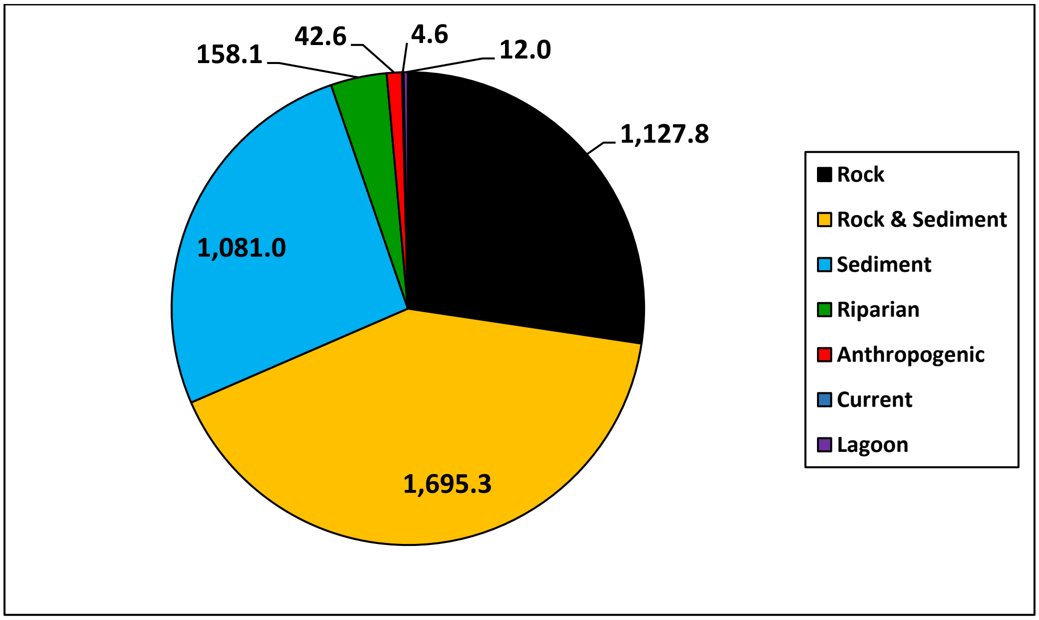

Figure 10. Grouped Coastal Class categories by shoreline length (km).

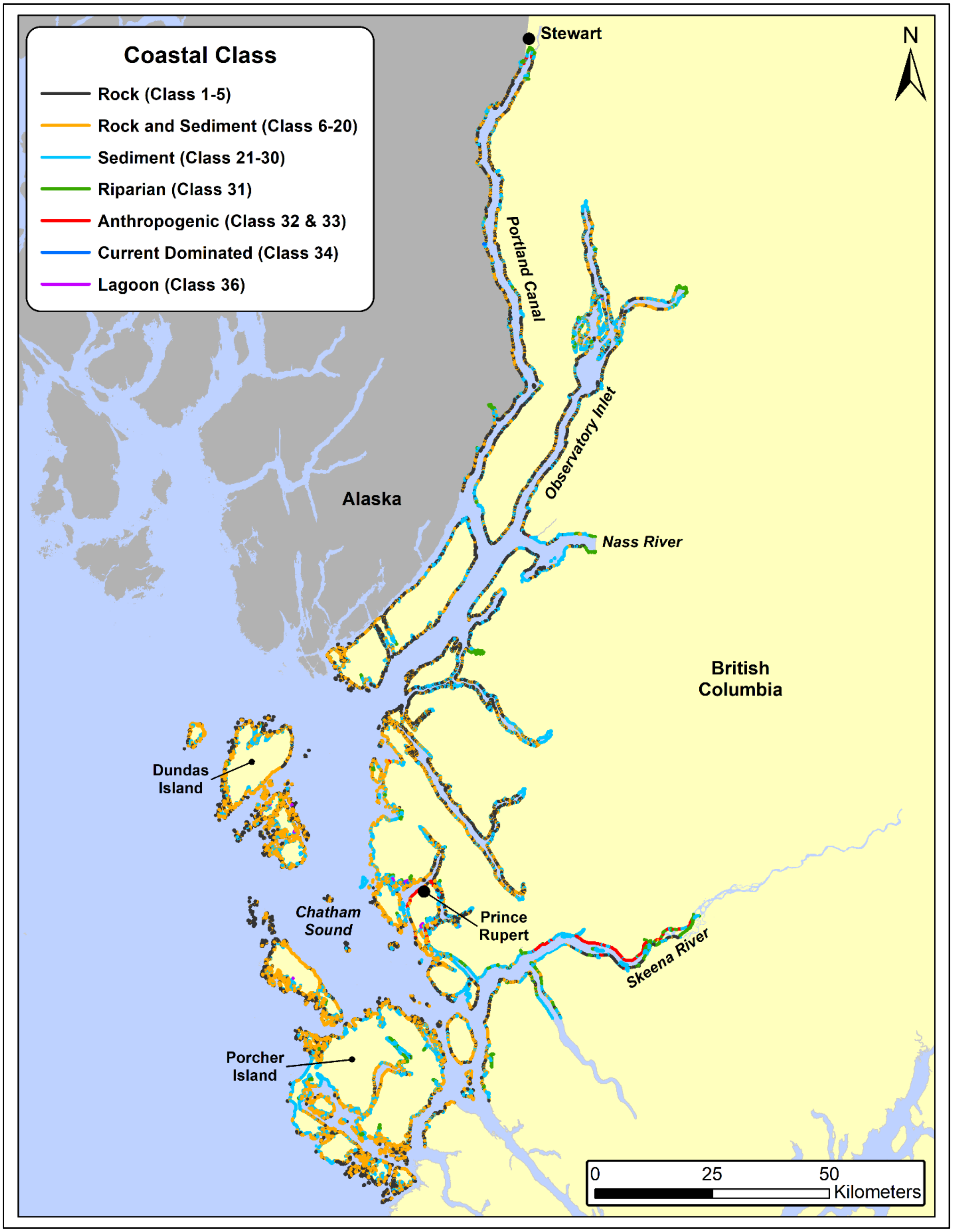

Figure 11. Map of the Coastal Class categories for the North Coast grouped by type (also known as Shore Type).

Figure 12. Example of Coastal Class 3; Rock Cliff. Stephens Island, photo bc15_sh_09996.

Figure 13. Example of Coastal Class 6; Ramp with gravel beach, wide. Goschen Island, photo bc14_pr_15974.

Figure 14. Example of Coastal Class 9; Ramp with gravel beach. Goschen Island, photo bc14_pr_15854.

Figure 15. Example of Coastal Class 14; Ramp with gravel & sand beach. Porcher Inlet, photo bc15_sh_08533.

Figure 16. Example of Coastal Class 21; Gravel flat, wide. Goschen Island, photo bc14_pr_15925.

Figure 17. Example of Coastal Class 22; Gravel beach, narrow. Porcher Island, photo bc14_pr_15349.

Figure 18. Example of Coastal Class 31; Organics/Fines. Big Bay, Chatham Sound, photo bc14_pr_07294.

Figure 19. Example of Coastal Class 36; Lagoon. Metlakatla, photo bc14_pr_01509.

3.3 Environmental Sensitivity Index (ESI)

The NOAA Environmental Sensitivity Index (ESI) is a shoreline classification system developed to characterize coastal regions based on sensitivity to potential oil spills (Petersen et al., 2002). The ESI system uses wave exposure and principal substrate type to assign a rank of 1 to 10 (with 10 being the most sensitive to oil) to alongshore units. Up to three ESI numbers can be assigned to each ShoreZone unit (high, mid, and low intertidal) if applicable. The highest ESI number for each unit, which is the most sensitive, is used in this analysis.

Much of the North Coast of BC coastline is represented by the grouped High and Very High categories (65.4% of shoreline length). These sections of the shoreline have a potentially high sensitivity to oil. At the other end of the spectrum, only 26.2% of the shoreline was mapped with a potentially low sensitivity to oil (Figures 20 and 21). The summary of Coastal Class by ESI class can be seen in Table 2.

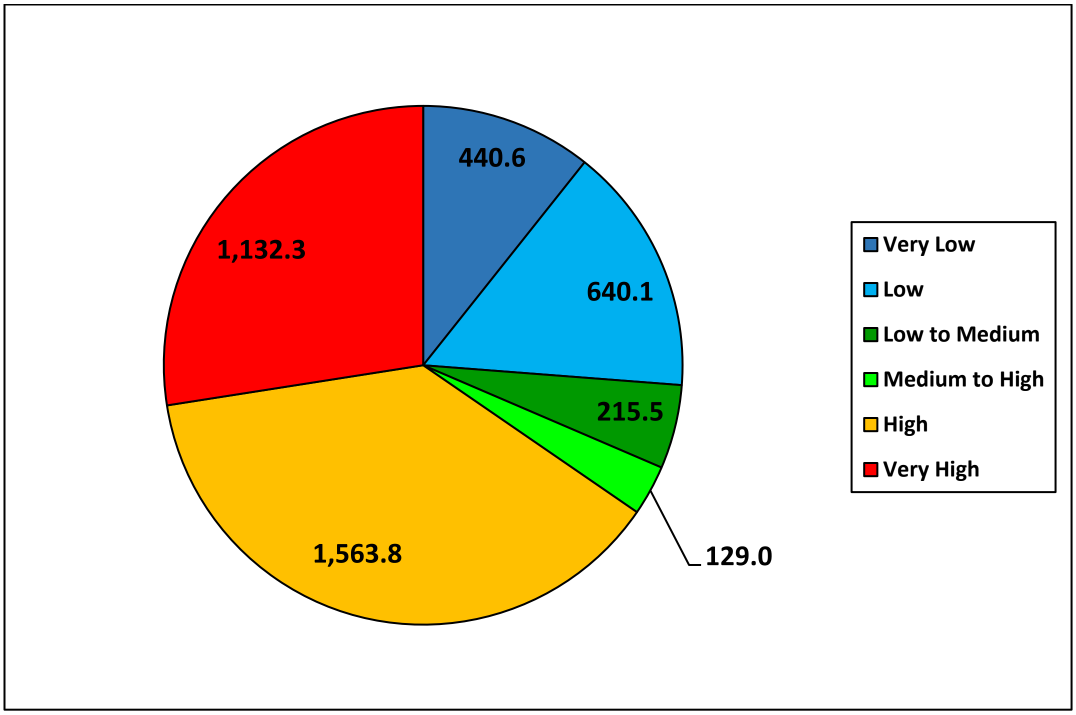

Figure 20. Grouped most sensitive ESI categories by shoreline length (km).

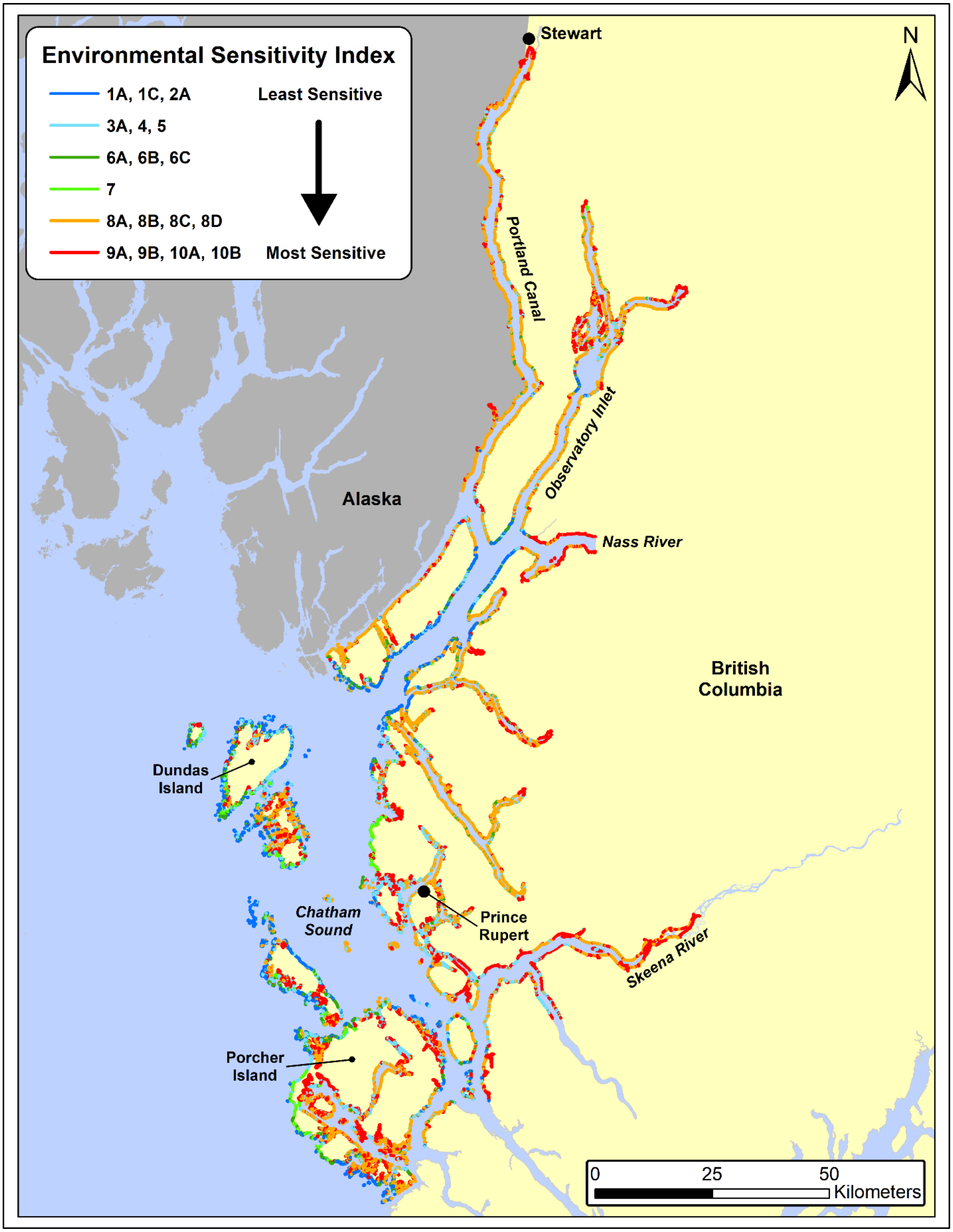

Figure 21. Distribution of the grouped ESI categories from least to most sensitive to oiling.

Table 2. Summary of Coastal Classes by ESI Class for the North Coast of BC.

Environmental Sensitivity Index (ESI)		Sum of Unit Length (km)	# of Units	% of Total Shoreline Length
No.	**Description**			
1A	Exposed rocky shores; Exposed rocky banks	250	1,107	6
1C	Exposed rocky cliffs with boulder talus base	32	163	1
2A	Exposed wave-cut platforms in bedrock, mud, or clay	160	896	4
3A	Fine- to medium-grained sand beaches	34	153	1
4	Coarse-grained sand beaches	5	26	<1
5	Mixed sand and gravel beaches	601	2,894	15
6A	Gravel beaches (granules and pebbles)	2	12	<1
6B	Gravel beaches (cobbles and boulders)	212	1,163	5
6C	Rip rap	1	6	<1
7	Exposed tidal flats	129	321	3
8A	Sheltered scarps in bedrock, mud, or clay; sheltered rocky shores (impermeable)	918	4,416	22
8B	Sheltered, solid, man-made structures; sheltered rocky shores (permeable)	42	178	1
8C	Sheltered Rip Rap	36	111	1
8D	Sheltered rocky rubble shores	569	3,148	14
9A	Sheltered tidal flats	519	1,354	13
9B	Vegetated low banks	15	25	<1
10A	Salt- and brackish-water marshes	586	1,533	14
10B	Freshwater marshes	13	12	<1
	Totals:	***4,121***	***17,518***	***100***

Note: ESI Classes not observed in this survey area were not included in the table.

3.4 Oil Residence Index (ORI)

The Oil Residence Index (ORI) is a rating between 1 and 5 with a value of 1 indicating a relatively short oil residence (days to weeks) while a value of 5 reflects potentially very long oil residence times (years). An ORI value is applied to each alongshore unit and to each across-shore component based on sediment texture and wave exposure (Cook et al., 2017). The ShoreZone ORI was developed by Dr. John Harper based on his many years of experience with cleaning up oiled shorelines, starting with the Exxon Valdez spill in Prince William Sound in Alaska. Lower wave exposures and mobile sediments lead to higher ORI values for 68.5% of the shore segments in the North Coast of BC Sound survey area, indicating oil residence times are on the order of months to years (Figures 22 and 23).

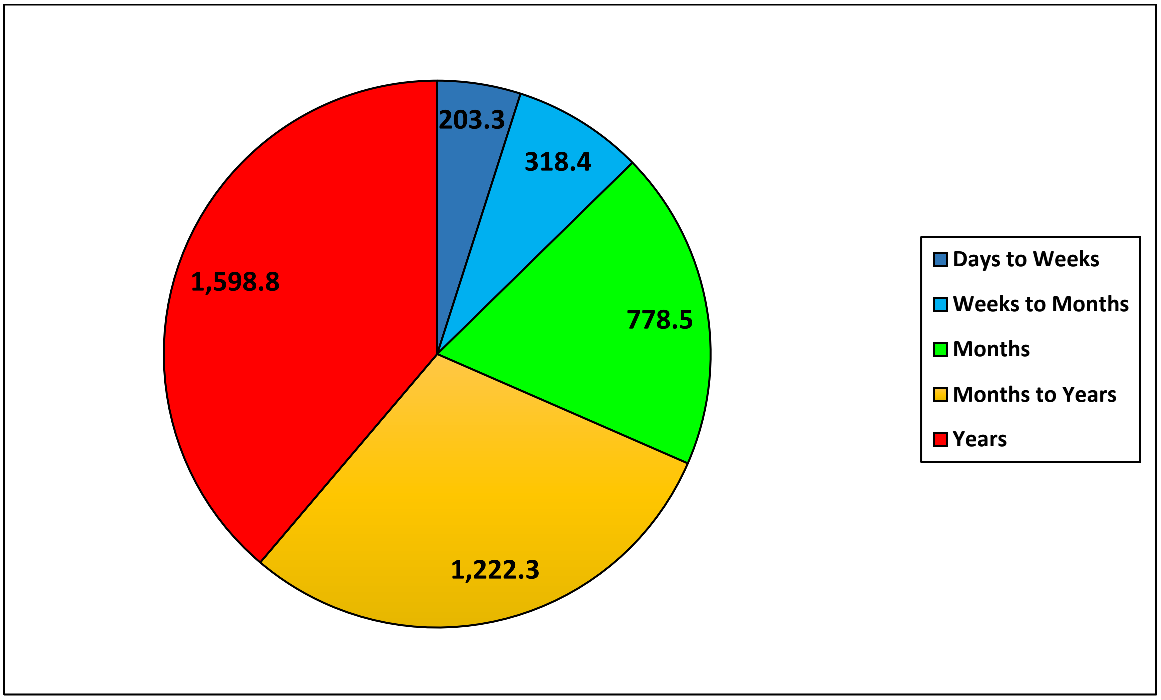

Figure 22. Oil Residence Index (ORI) categories by shoreline length (km).

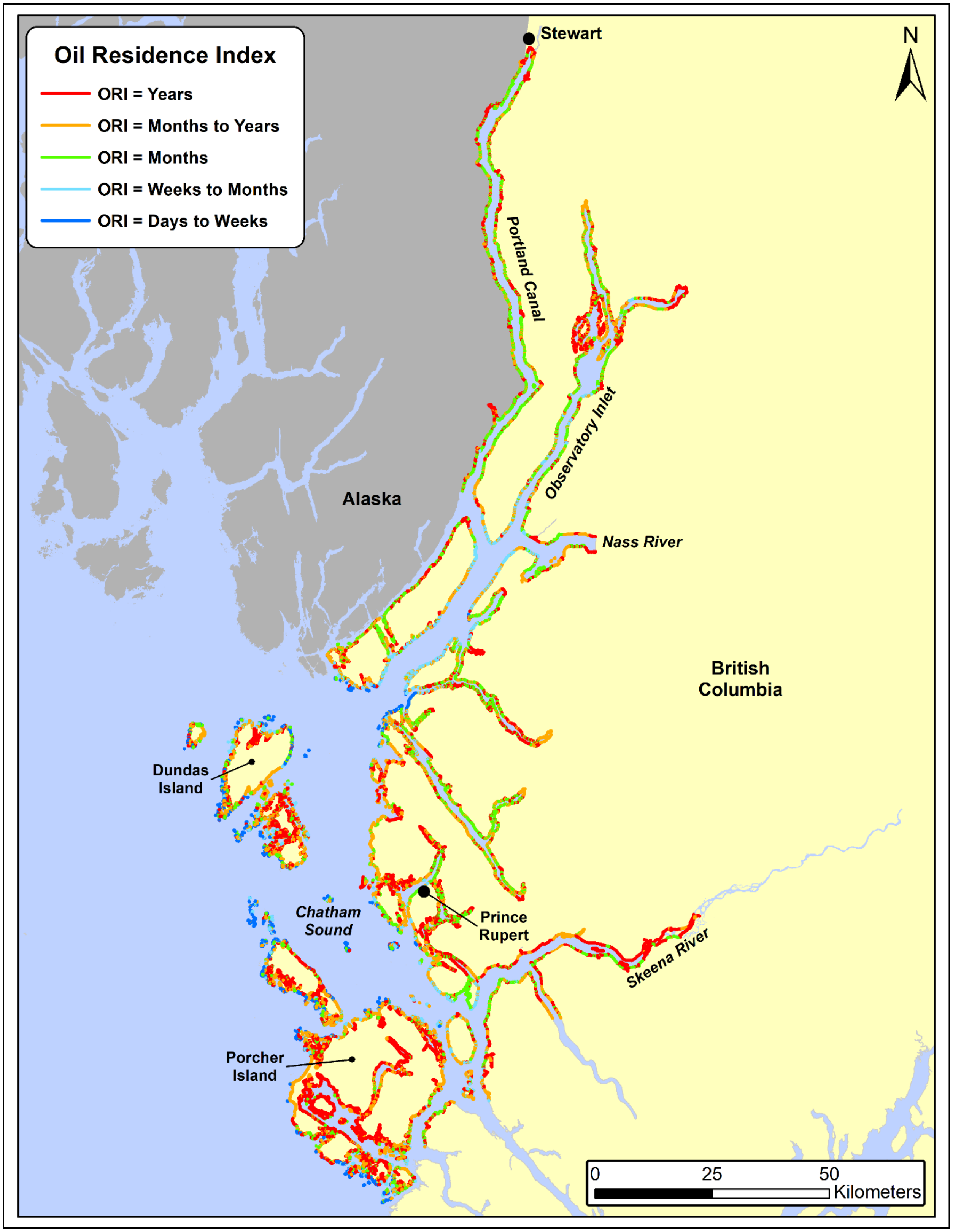

Figure 23. Distribution of the Oil Residence Index (ORI) categories.

3.5 ShoreZone Coastal Vulnerability

The Coastal Vulnerability Module (CVM) includes a classification of flooding sensitivity based on the across shore profile and photographic evidence of historical flooding such as an unambiguous marine debris line. The Flooding Class is an estimate of vulnerability to inundation of the terrestrial area beyond the supratidal. The distance to the debris line is measured and used to classify the flooding potential. Flat shorelines with very low gradients that show evidence of historical flooding have a higher risk of being inundated by storm surges. Potential for damage due to flooding is generally low in the North Coast of BC study area, with 84.9% of the shoreline at a low risk of flooding less than 5m from the MHW (Mean High Water line) (Figures 24 and 25). The flooding class is a parameter of the Coastal Vulnerability Index. Note that 16% of the North Coast Shoreline was not mapped under the new ShoreZone protocol (2017) and is not included in this data analysis.

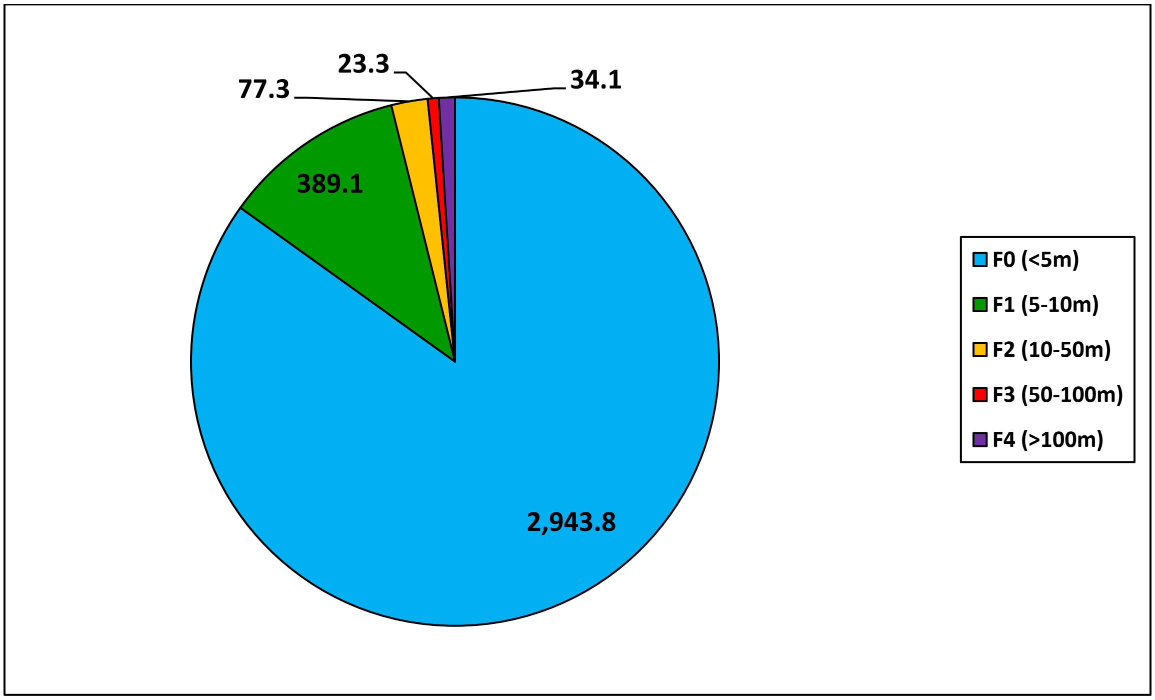

Figure 24. Flooding Class categories by shoreline length (km).

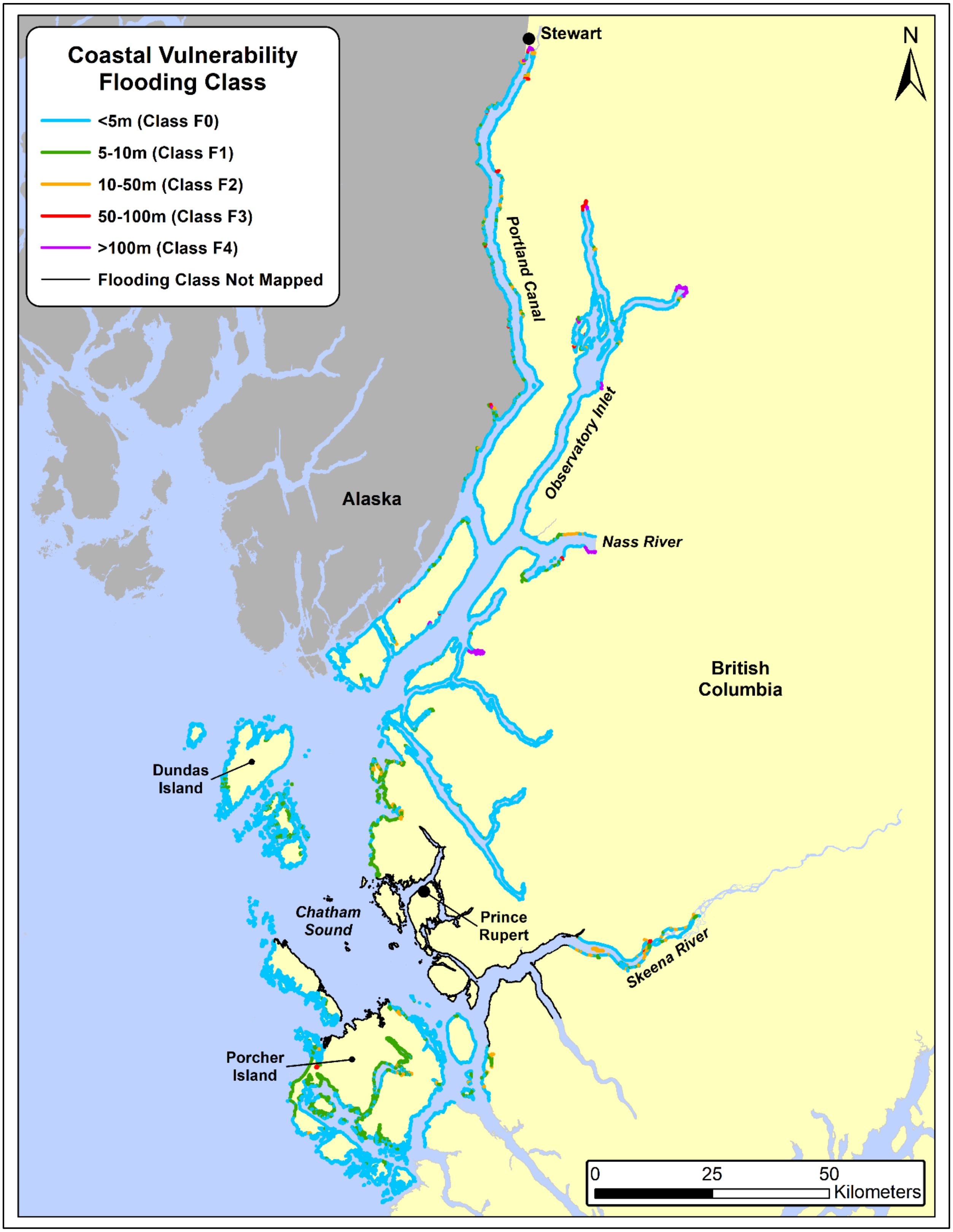

Figure 25. Distribution of the Coastal Vulnerability Flooding Class.

3.6 Anthropogenic Shore Modifications

The Shoreline Modification attribute provides a thorough catalogue of the specific types of anthropogenic modification in each unit (Cook et al., 2017). This includes as many modifications as are observed within a given unit. For example, if both riprap and a pile-supported wharf occur, both are catalogued in the appropriate zone of that unit with an estimate of the alongshore length of the unit that modification covers. A total of 3.0% of the shoreline (taking the estimated length of that modification within the unit into account) exhibits shore modifications in the North Coast of BC study area (Figure 26). Rip Rap was the most recorded observation (48.0%) with Landfill (43.0%) and Concrete Bulkhead (4.2%) rounding out the top three shoreline modifications along the coast. The associated map (Figure 27) shows the distribution of primary shore modifications, though it should be noted that any given modification is possible along the entire length of the indicated shore unit. The Geodatabase delivered with this report displays each shore modification with a specific length category (meters) along the shoreline pertaining to each unit as well as the specific zone (supratidal or intertidal) the modification occurs in.

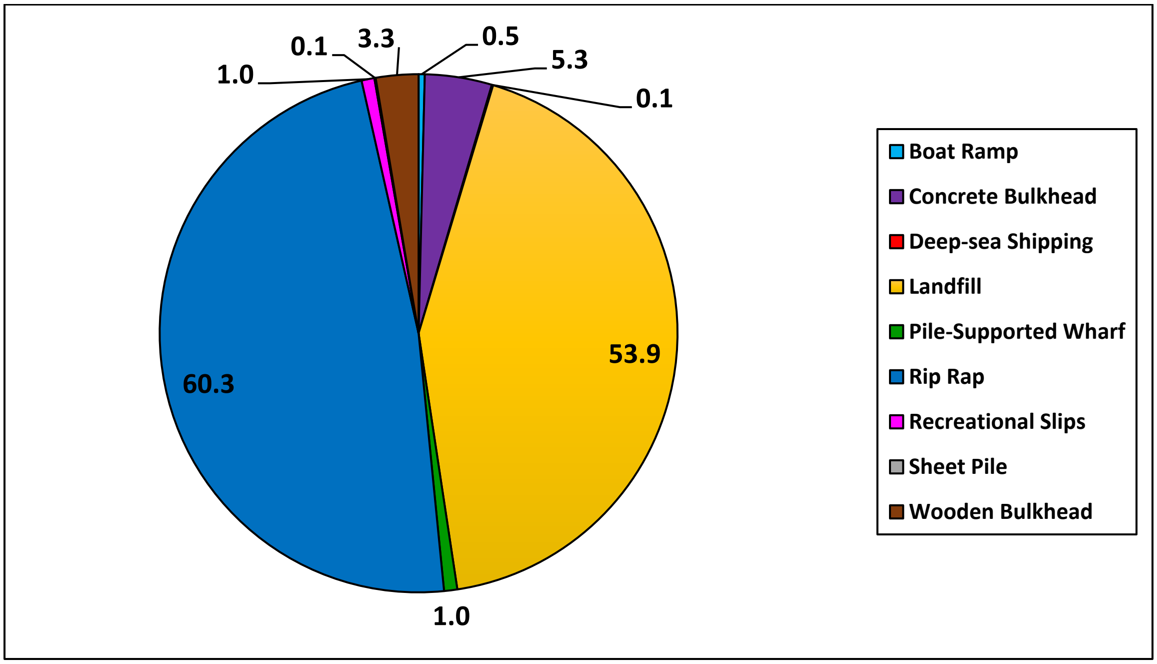

Figure 26. Shore Modifications by estimated shoreline length (km) of each modification type.

Figure 27. Distribution of types of the primary Shore Modifications.

3.7 Biological Wave Exposure

Biological wave exposure categories range from Very Protected (VP) to Very Exposed (VE) and are usually defined in ShoreZone based on a typical set of biobands. When present, the relative abundance of biota in each alongshore unit is used as a proxy to determine the wave exposure at that site. For definitions of the Biological Wave Exposures and the exposure ranges of the biobands see the most recent ShoreZone protocol (Cook et al., 2017).

The distribution of the wave exposure categories mapped on the North Coast of BC are summarized in Figure 28 and a distribution map of the categories is shown in Figure 29. Most of the coastline (91.4%) was in the lower to moderate wave exposures (Very Protected to Semi-Protected), with most of that Protected (64.7%).

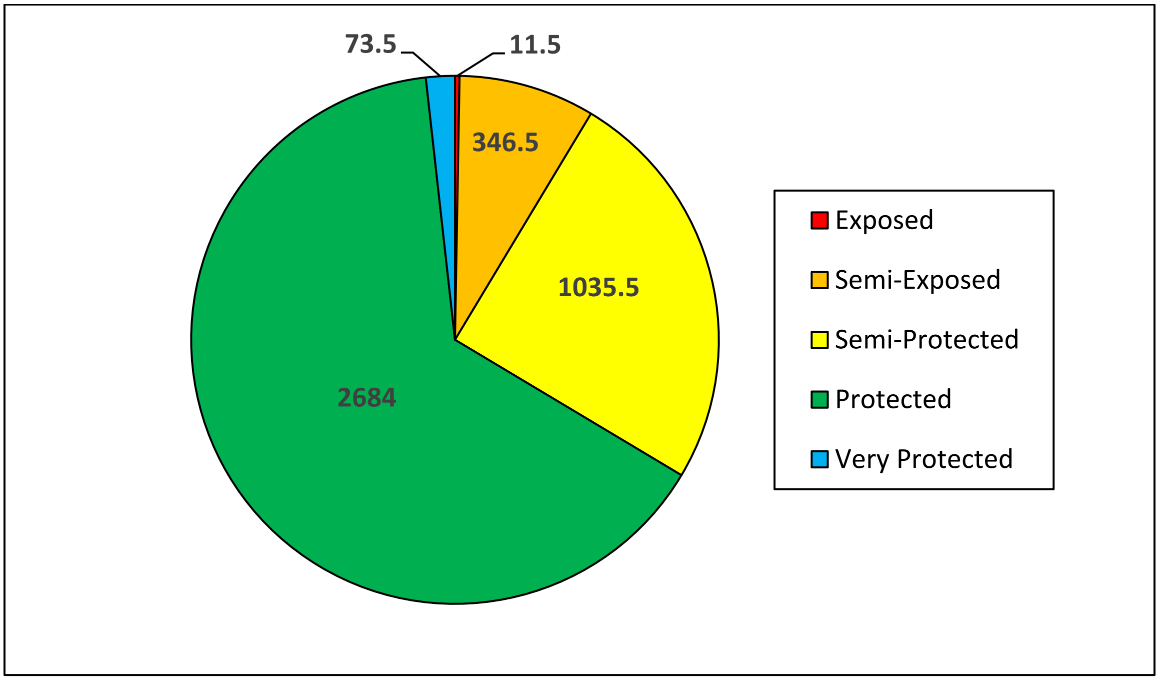

Figure 28. Distribution of Biological Wave Exposures mapped on the North Coast of BC by shoreline length (km).

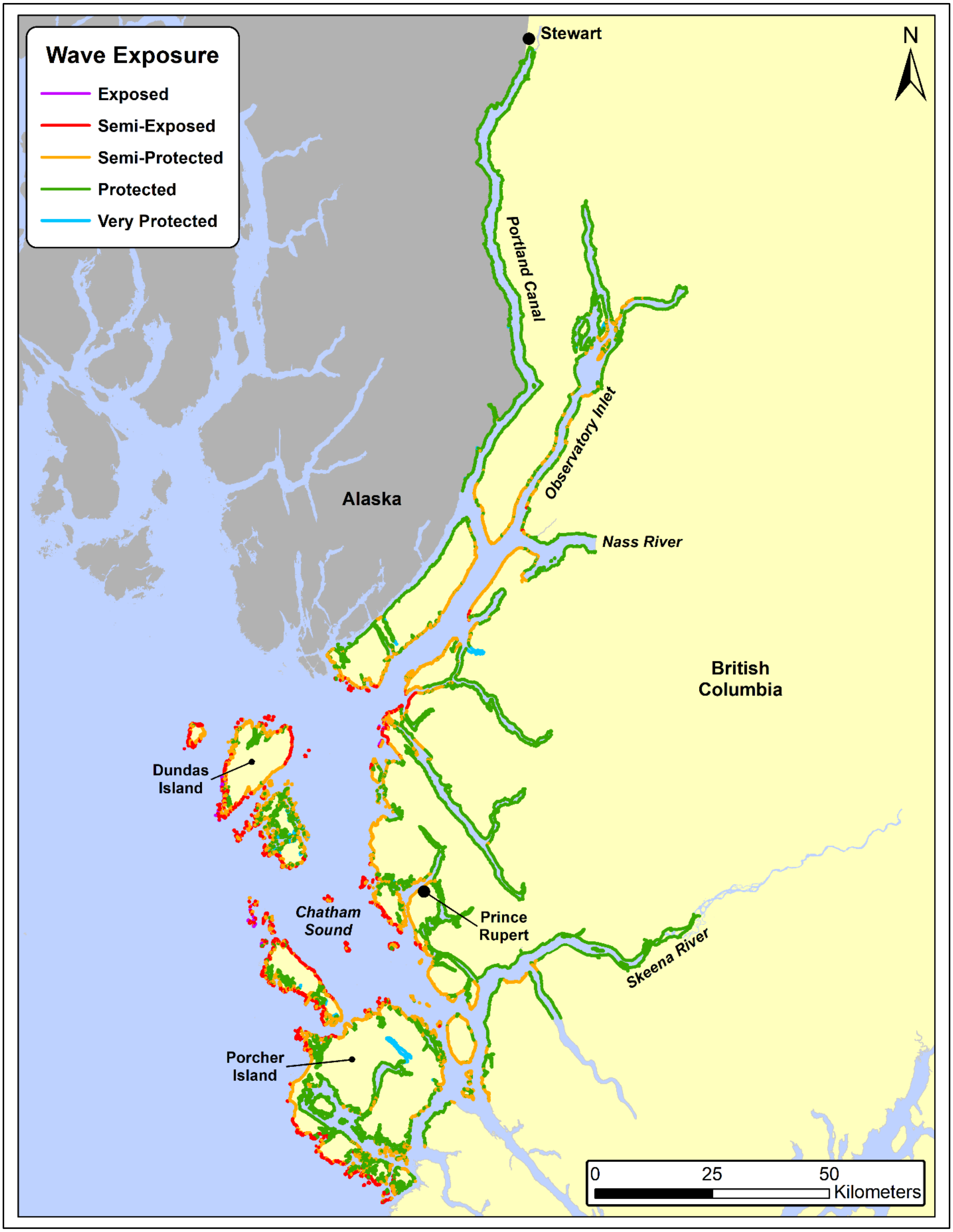

Figure 29. Distribution of the Biological Wave Exposure in the North Coast of BC.

3.8 Habitat Class

Habitat Class is a classification based on wave exposure and geomorphic characteristics observed in an alongshore unit. The habitat class is intended to provide a single attribute to characterize the biophysical features of each unit. The habitat class is assigned by the biological mapper and weighted according to the dominant structuring process. Wave action is the most common structuring process with less commonly observed habitats being those structured by current, estuarine/fluvial processes, and anthropogenic structures. For habitat classes structured by wave action substrate mobility determines the presence of epibenthic biota. Where the substrate is highly mobile, biota is sparse or absent, and where the substrate is stable, biota can be abundant. For further definitions and explanations of Habitat Class codes please see the most recent ShoreZone protocol (Cook et al., 2017).

The distribution of the Habitat Class categories mapped on the North Coast of BC are summarized in Figure 30 and a distribution map of the categories is shown in Figure 31. Partially mobile substrate is the dominant shoreline type (60.8%). Estuaries are not very common in this area with only 5.5% of the shoreline in that classification. The estuary habitat class is associated with spawning and nursery habitats for fish as well as breeding and foraging grounds for birds and other wildlife. However, although individual units may not have been classed as estuaries, the Skeena River is a significant influence in the area and much of the southern portion of the area surveyed could be considered estuarine in nature. The same could be said of the northern-most inlets due to the influence of large rivers like the Nass. The Anthropogenic habitat occurred in 1.6% of units as the only majorly developed areas are the Port of Prince Rupert and Port Edward.

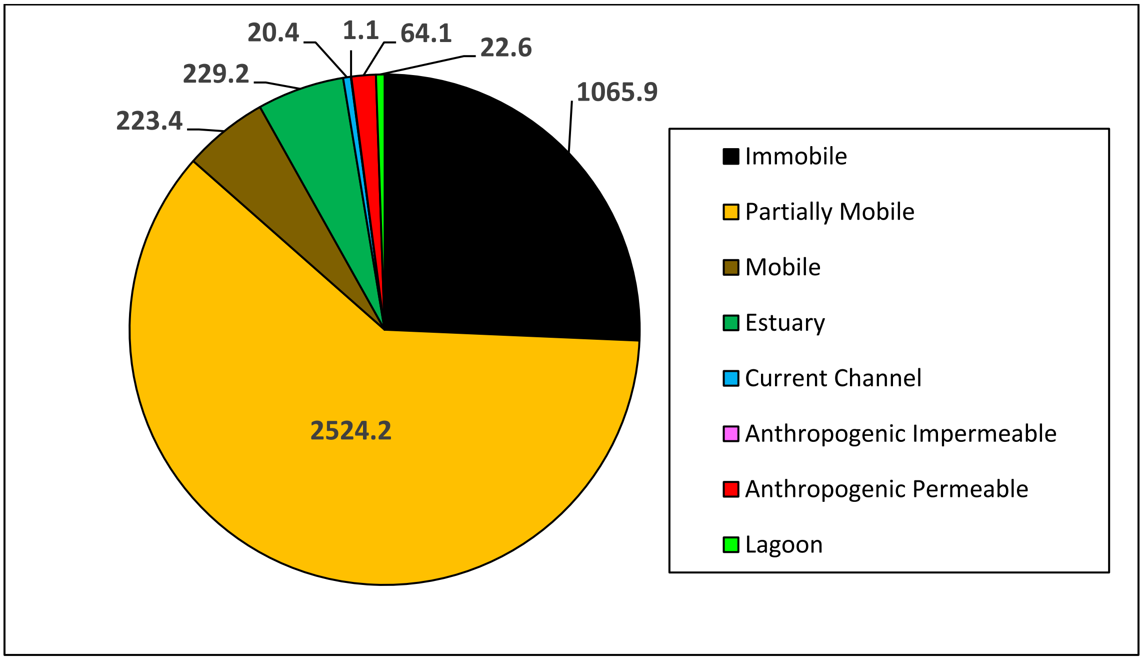

Figure 30. Distribution of Habitat Class categories on the North Coast of BC by shoreline length (km).

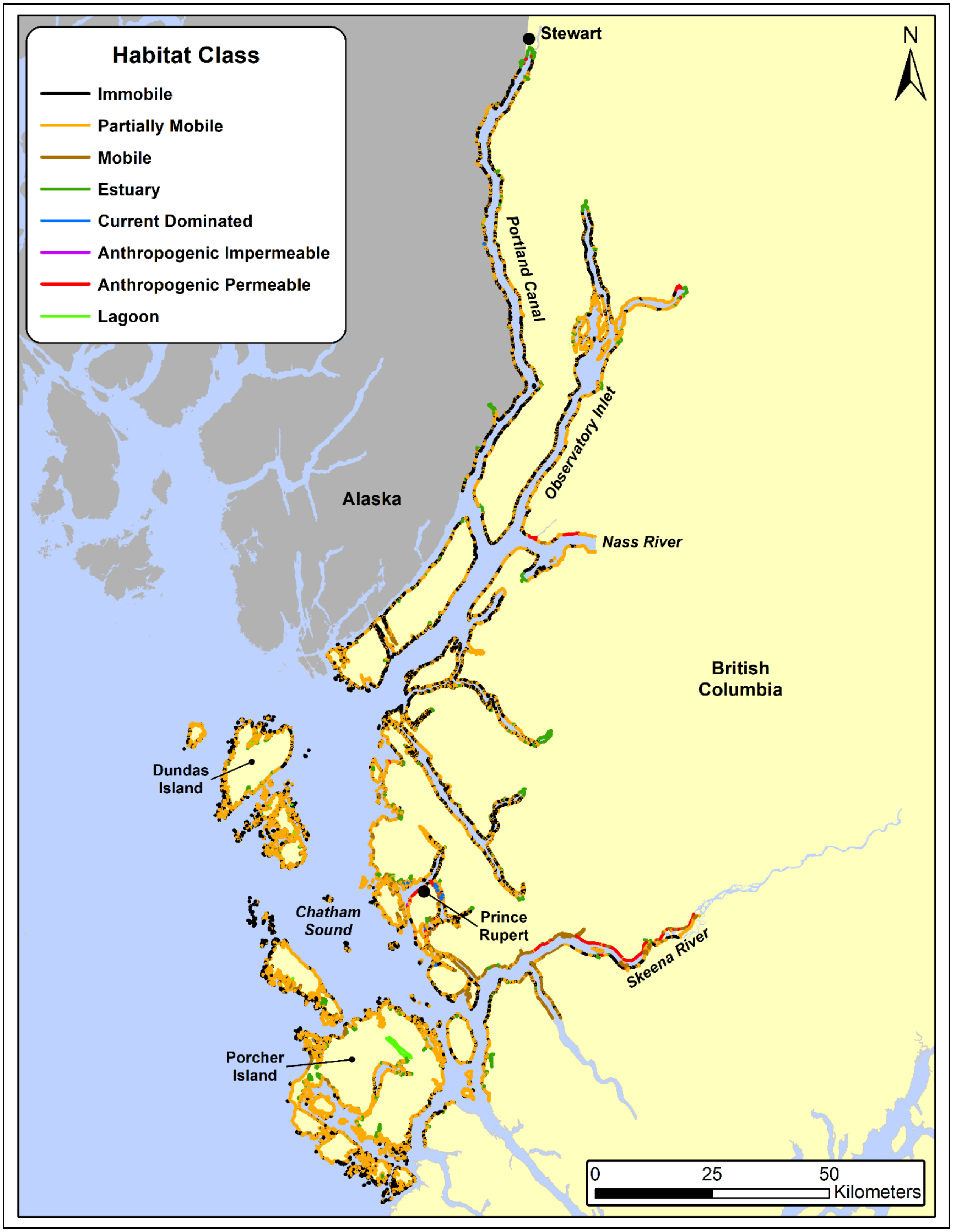

Figure 31. Distribution of Habitat Class categories on the North Coast of BC.

3.9 Biobands

Biobands represent assemblages of coastal biota found on the shoreline at characteristic wave exposures, substrate conditions and typical across-shore elevations. Biobands are spatially distinct, with alongshore and across-shore patterns of color and texture that are visible in aerial imagery. Biobands are generally named for the dominant species or group that best describes the entire assemblage. Some Biobands are named for a single indicator species (such as the Blue Mussel Bioband), while others represent an assemblage of co-occurring species (such as the Red Algae Bioband). Full descriptions of all biobands, including indicator and associated species can be found in the ShoreZone protocol (Cook et al., 2017).

It is important to note that a nested bioband classification was developed and applied to all ShoreZone mapping completed after 2015. Changes to the bioband definitions include the application of a consistent naming convention and new four-digit codes for each bioband. A number of new biobands were added and some were split to better describe the banding that has been observed as ShoreZone continues to move into new and unique areas. The mapping completed for DFO that is incorporated into this report was completed under the 2017 protocol while the mapping for the Port of Prince Rupert and Metlakatla First Nation was completed under the 2014 ShoreZone protocol (Harper and Morris, 2014) so did not include the new biobands.

In the 2014 ShoreZone protocol, only two descriptors were used for the distribution of biobands within each unit: Patchy (in <50% of the length of the unit) or Continuous (in >50% of the length of the unit). In the 2017 protocol, the specific elevation or zone of the shoreline determined how the bioband attributes were described. For example, biobands found in the supratidal (A Zone) and subtidal (C Zone) are described by percent of alongshore length of unit and a width category. The intertidal (B zone) biobands are described by percent of alongshore length of the unit and percent cover of the zone. All metrics are described in the 2017 ShoreZone protocol (Cook et al., 2017). The data presented in this report uses Patchy and Continuous as metrics as that is consistent across the two datasets. Coastal and Ocean Resources Inc. (CORI) has translated the mapping completed under the 2014 ShoreZone protocol to the 2017 protocol format in the geodatabase that accompanies this report. All bioband names are therefore now consistent across the datasets but other fields, such as % length and % cover will be blank for the older mapping.

Biobands mapped in the Prince Rupert area to date are summarized in Tables 3 and 4. Some examples of biobands from the North Coast are shown in Figures 32-39. The most commonly occurring intertidal biobands in the survey areas were Rockweed which was found in 89% of units while Green Algae and Barnacles were found in 79% and 72% of units, respectively. The most common supratidal bioband was Black Lichen, occurring in 82% of the units, while the supratidal/high intertidal Salt Marsh bioband was found in 54% of units. The most common low intertidal/subtidal biobands were Brown Bladed Kelps (75%), Eelgrass (24%) and Bull Kelp (24%). All the most common biobands were typically associated with Semi-Protected to Protected partially mobile shorelines, which is a good description of much of this area.

Distribution maps, statistics, and observations about some specific biobands are found in the following pages.

Table 3. Bioband abundances for non-splash zone biobands mapped on the North Coast of BC.

Bioband		Patchy		Continuous		Total (km)	% of Total Mapped
Name	Code	(km)	%	(km)	%		
Trees and Shrubs	TRSH	2	<1	110	3	112	3
Wetland Vegetation	WEVE	19	<1	53	1	73	2
Dune Grass	DUGR	265	6	36	1	301	7
Sedges	SEDG	8	<1	55	1	62	1
Salt Marsh	SAMB	958	23	1269	31	2228	54
Barnacle	BARN	798	19	2198	53	2996	72
Rockweed	ROCK	755	18	2954	71	3709	89
Green Algae	GRAL	1508	36	1774	43	3282	79
Blue Mussel	BLMU	364	9	497	12	861	21
Echinoderms	ECHI	92	2	0	0	92	2
Bleached Red Algae	BRAL	52	1	12	<1	65	2
Filamentous and Foliose Red Algae	FFRA	894	22	1382	33	2276	55
Coralline Red Algae	CORA	116	3	52	1	168	4
Alaria	ALAR	3	<1	23	1	26	1
Soft Brown Kelp	SOBK	310	7	636	15	946	23
Dark Brown Kelp	DABK	17	<1	189	5	206	5
Brown Bladed Kelps	BRBA	1182	28	1925	46	3107	75
Anemones	ANEM	2	<1	0	0	2	<1
Cnidarians	CNID	<1	<1	0	0	<1	<1
Sponges	SPON	1	<1	0	0	1	<1
Surfgrass	SURF	192	5	92	2	285	7
Eelgrass	EELG	489	12	491	12	980	24
Urchin Barrens	URBA	155	4	368	9	523	13
Giant Kelp	GIKE	216	5	299	7	515	12
Bull Kelp	BUKE	540	13	439	11	979	24
Canopy Kelp	BRCA	7	<1	7	<1	13	<1

Table 4. Bioband abundances for splash zone biobands mapped on the North Coast of BC.

Bioband		Narrow (<1m)		Medium (1-5m)		Wide (>5m)		Total (km)	% of Total Mapped
Name	Code	(km)	%	(km)	%	(km)	%		
Black Lichen	BLLI	1932	47	1305	31	149	4	3385	82
Splash Zone	SPZO	34	1	38	1	1	<1	72	2
White Lichen	WHLI	560	13	663	16	96	2	1319	32
Yellow Lichen	YELI	1	<1	3	<1	1	<1	4	<1

Figure 32. Good example of the Black Lichen (BLLI) bioband which is a black band in the supratidal zone, usually caused by the lichen *Verrucaria* sp. Dundas Island, photo bc19_dd_00111.

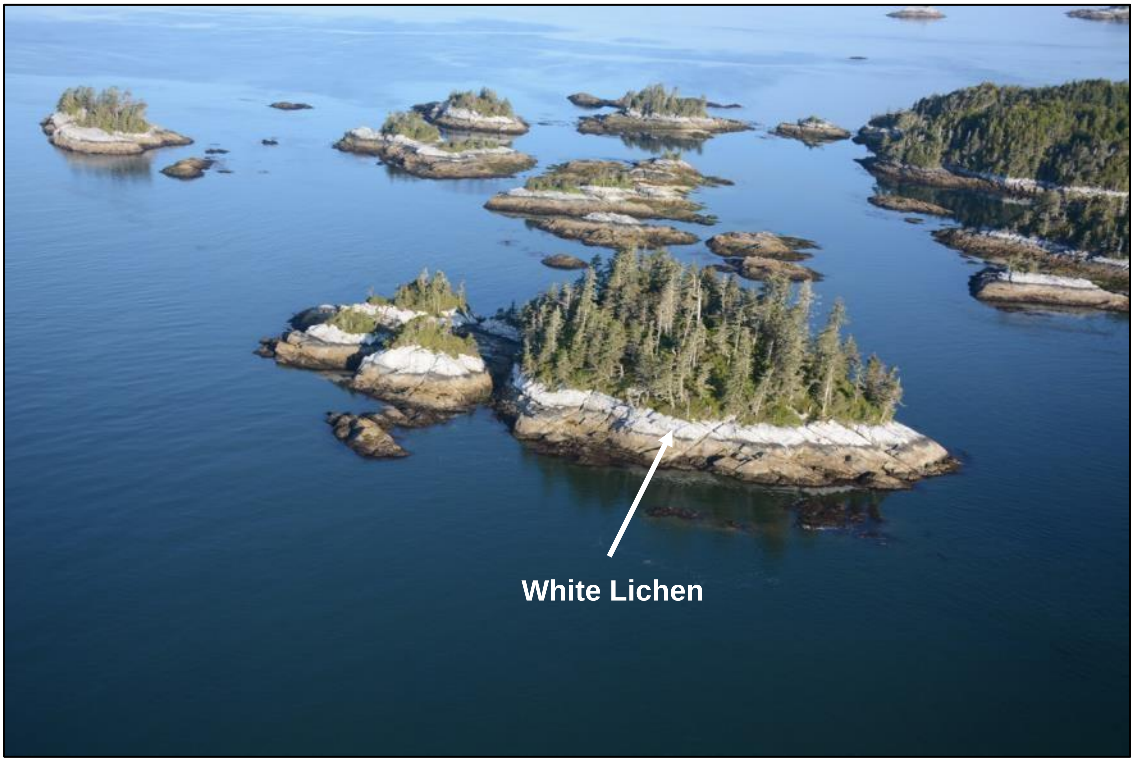

Figure 33. Good example of White Lichen (WHLI) bioband in the supratidal zone, above the Black Lichen band. Tree Nob Island group, photo bc15_sh_09244.

Figure 34. Good example of the blue-green Dune Grass (DUGR) bioband. Dundas Island, photo bc19_dd_01573.

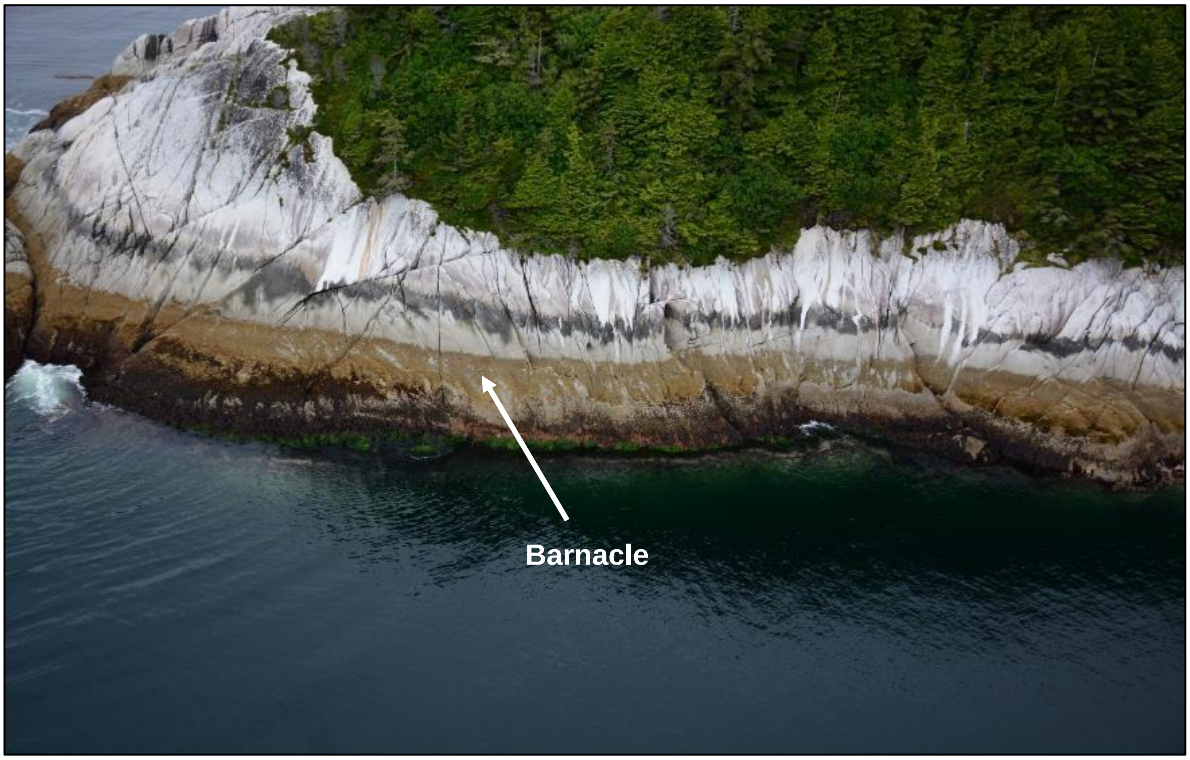

Figure 35. Good example of the beige Barnacle (BARN) bioband in the high intertidal zone. Dundas Island, photo bc19_dd_00610.

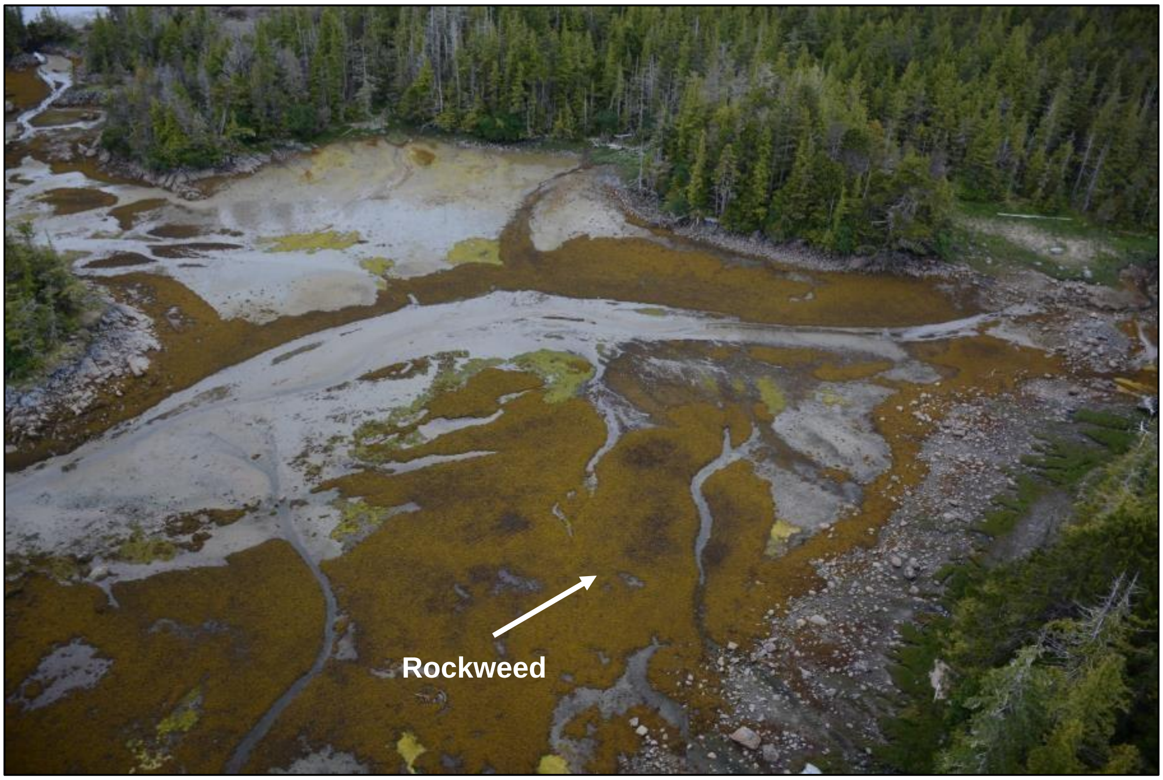

Figure 36. Good example of the golden-brown Rockweed (ROCK) bioband. Porcher Inlet, photo bc14_pr_16606.

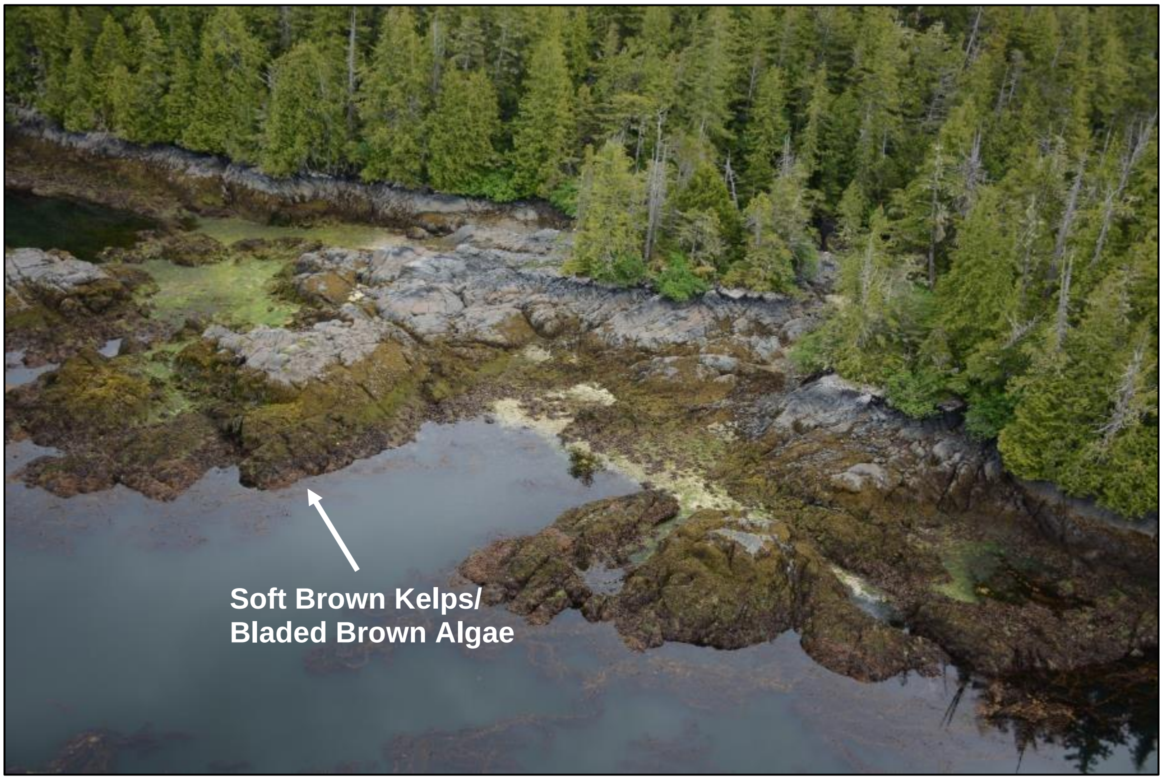

Figure 37. Good example of kelps at the waterline (BRBA and SOBK biobands). Porcher Island, photo bc14_pr_16766.

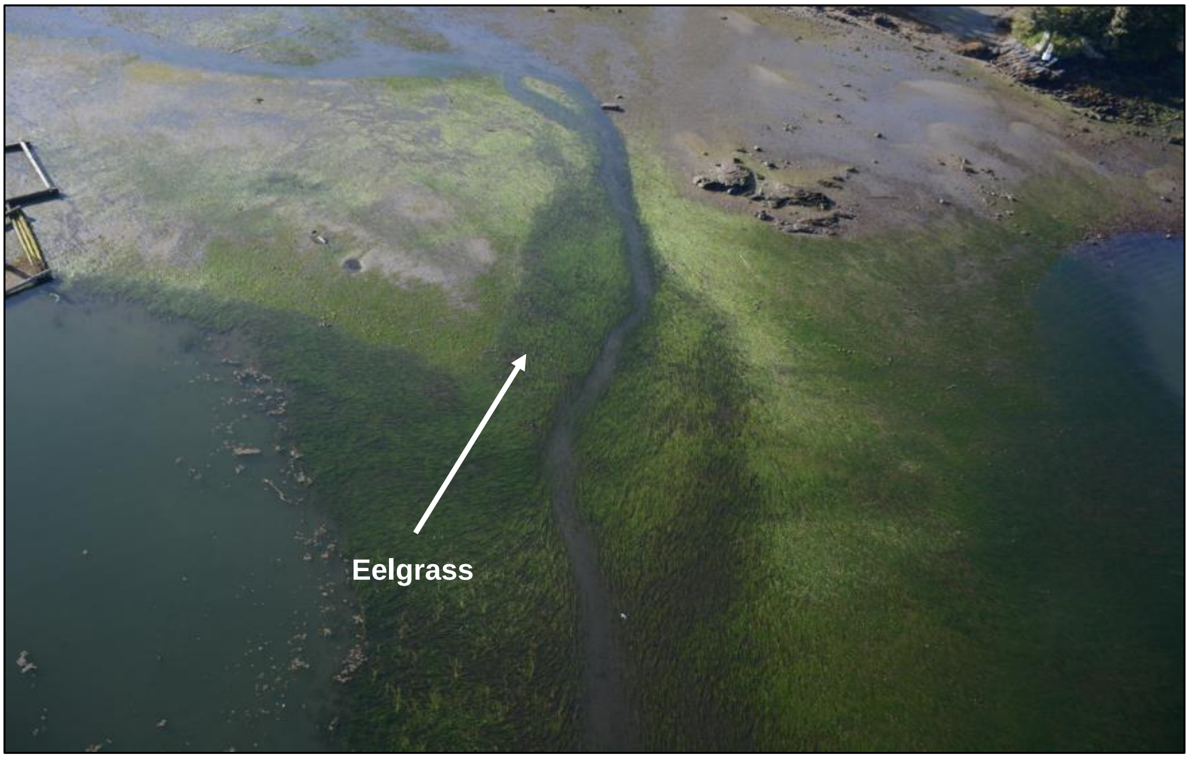

Figure 38. Example of the Eelgrass (EELG) bioband in the lower intertidal/subtidal. Metlakatla Pass, photo bc14_pr_01538.

Figure 39. Good example of the bright green Surfgrass (SURF) bioband in the lower intertidal. Stephens Island, photo bc15_sh_10623.

Salt Marsh (SAMB) was the most commonly occurring supratidal, non-splash zone bioband and was found in 54% of units (Figure 40). Salt Marsh can occur either in the supratidal or upper intertidal; both occurrences are incorporated here. Salt Marsh was ubiquitous along the shoreline, mostly as a narrow strip of vegetation between the trees and intertidal zone (Figures 41 and 42).

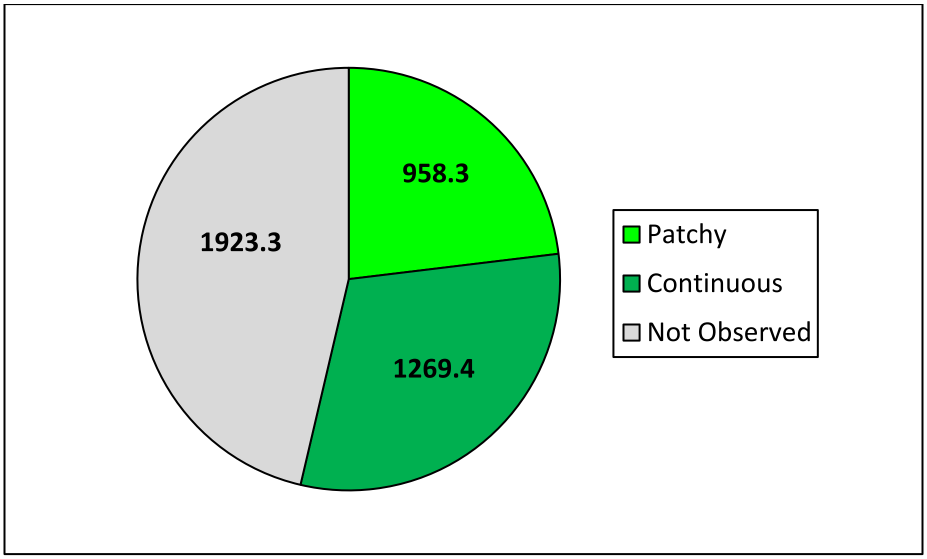

Figure 40. Proportion of shoreline length (km) of the supratidal/intertidal Salt Marsh (SAMB) bioband by category.

Figure 41. Photo of a narrow strip of Salt Marsh bioband on Gurd Island in Porcher Inlet (bc_15_sh_11051).

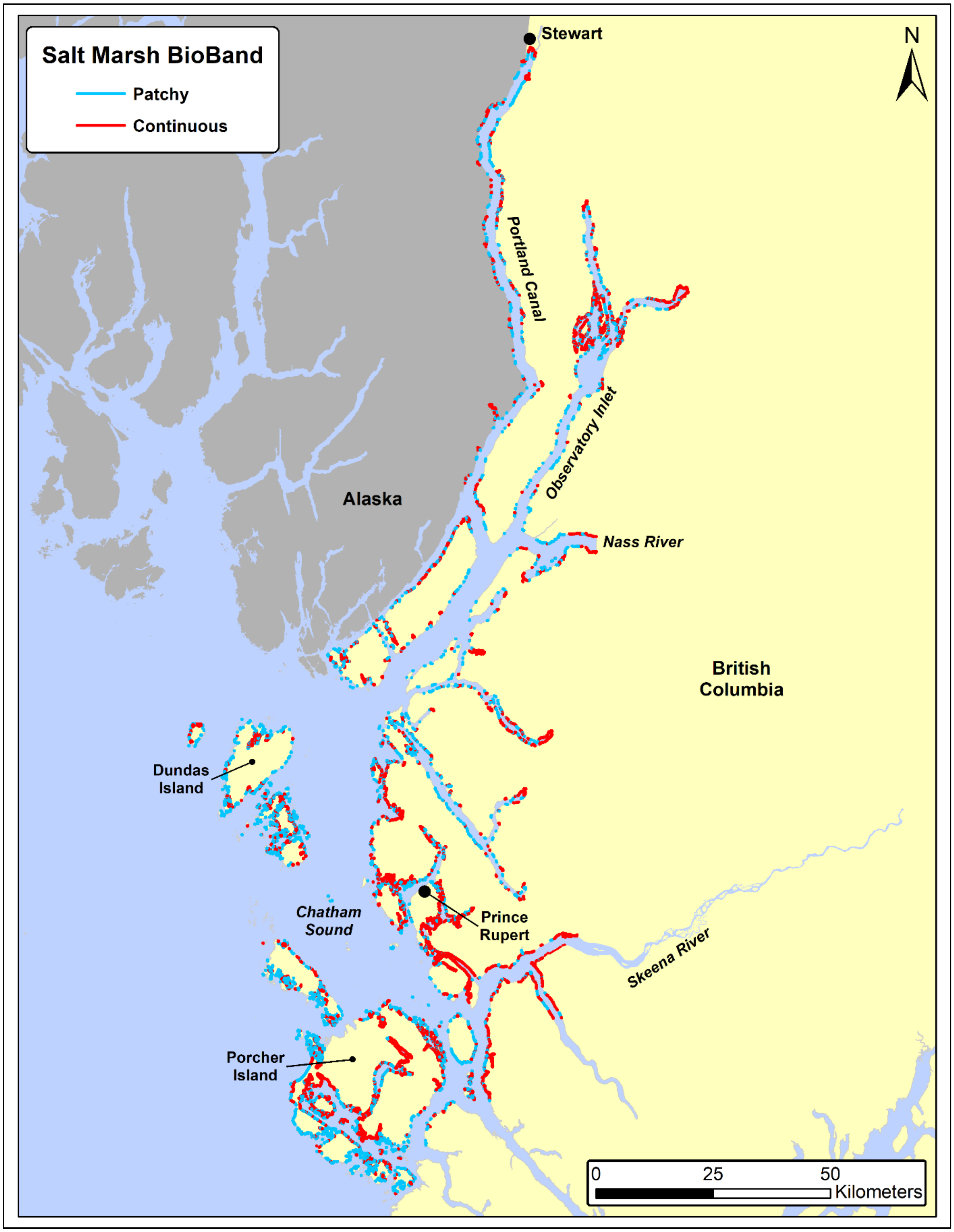

Figure 42. Distribution of the Salt Marsh (SAMB) bioband on the North Coast of BC.

Urchin Barrens (URBA) are subtidal areas where the lack of predators, such as Sea Otters over the long term and sea stars in the shorter term (Schultz et al., 2016) has allowed sea urchins to proliferate. This bioband occurs in 13% of the mapped units (Figures 43 and 44). The urchins graze down the kelp and expose the underlying substrate, which is often covered by coralline red algae. Bladed Kelp and Canopy Kelp biobands can also co-occur with the Urchin Barrens bioband as a narrow strip in the upper subtidal. This narrow strip is the zone where wave action prevents the urchins from grazing; however, around Dundas Island (which was imaged in 2019) the Urchin Barrens were extending up into the intertidal and piles of urchins were even noted out of the water (Figure 45). The density of urchins in the subtidal around Dundas Island appeared to be higher than along other parts of the coastline, although it should be noted that other areas were imaged before the worst effects of the sea star wasting disease were likely to have been felt. Urchin Barrens were ubiquitous along the outer portions of the coast, generally in Semi-Protected and higher exposures.

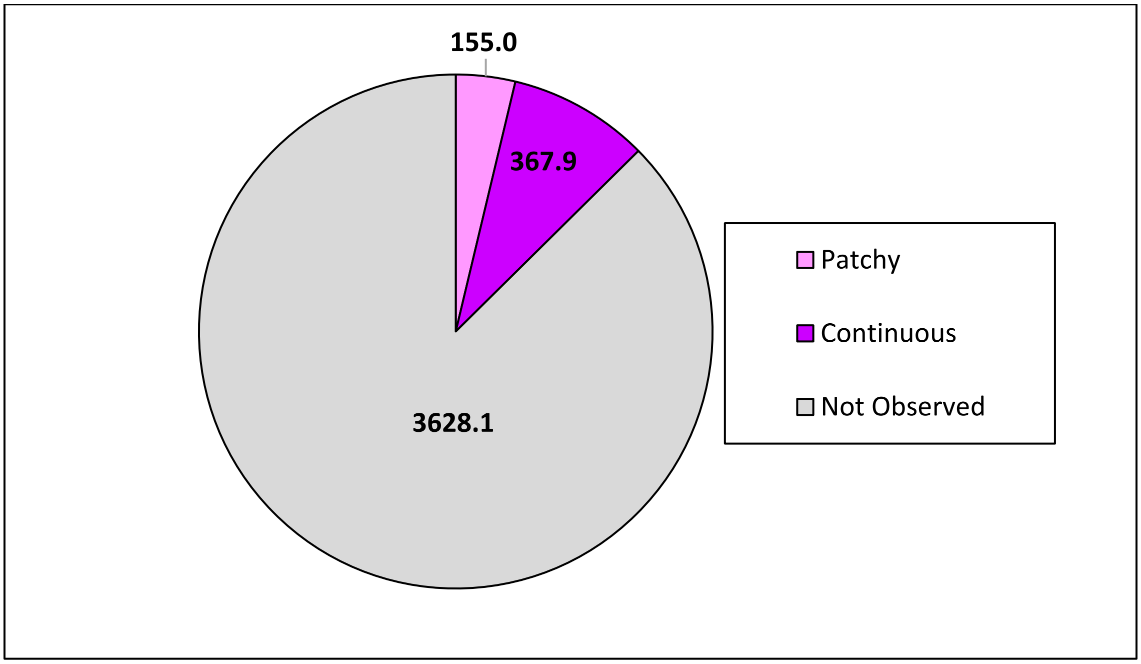

Figure 43. Distribution of the subtidal Urchin Barrens bioband by shoreline length (km).

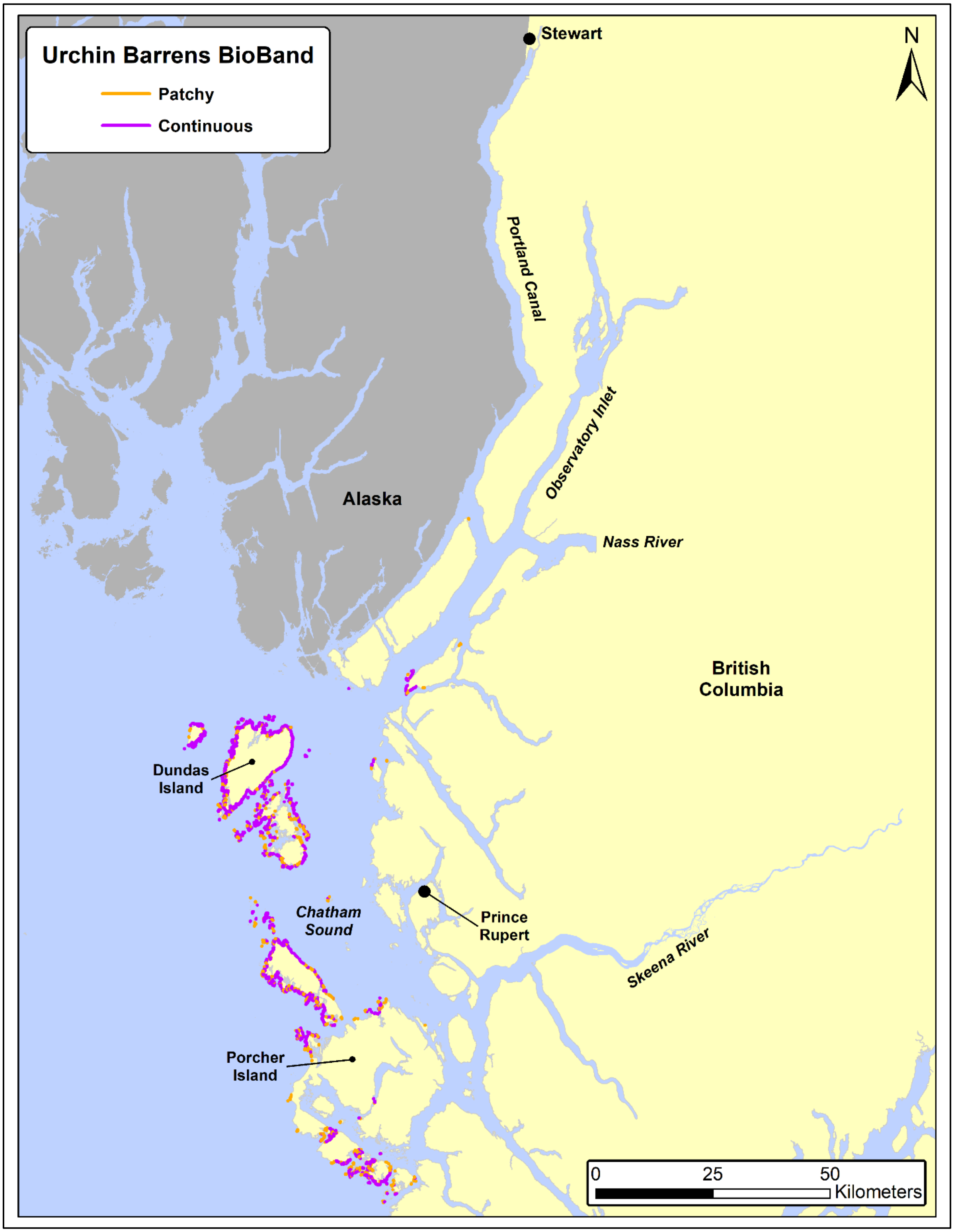

Figure 44. Distribution of the Urchin Barrens (URBA) bioband on the North Coast of BC.

Figure 45. Example of the Urchin Barren bioband extending into the intertidal on Dundas Island (bc19_dd_01224).

Two canopy kelps were observed on the North Coast of BC, Bull Kelp (BUKE) and Giant Kelp (GIKE). Canopy kelps form valuable habitat for fish, invertebrates, and other algae and are an important part of a healthy coastline and healthy fisheries. Bull Kelp was found along more varied parts of the coastline, while Giant Kelp tended to be found in areas that were Semi-Protected/Protected. Where the two canopy kelps co-occurred, the Giant Kelp was generally found inshore of the Bull Kelp bed, although they were also noted mixed together. Giant Kelp is also less tolerant of lower salinity so was not found in the area around the mouth of the Skeena River, to the south of Prince Rupert, or in the fjords and inlets north of Work Channel likely due to the influence of the Nass River among others large rivers in the area. See Figures 46 and 47 for statistics on the distribution of the individual canopy kelp biobands and a distribution map for both in Figure 48.

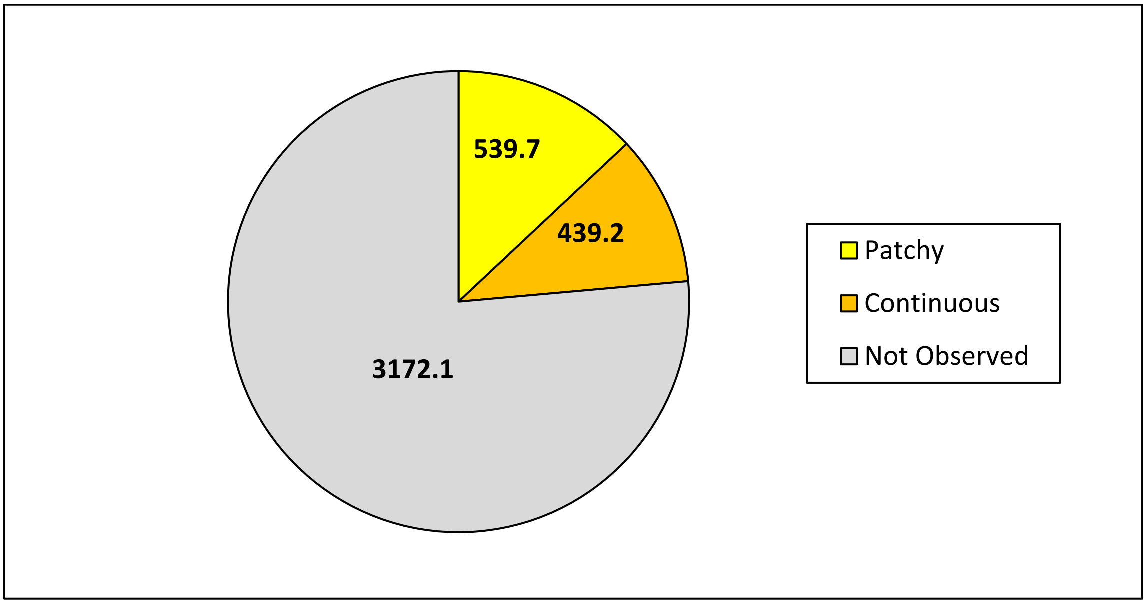

Figure 46. Distribution of the subtidal Bull Kelp (BUKE) bioband by shoreline length (km).

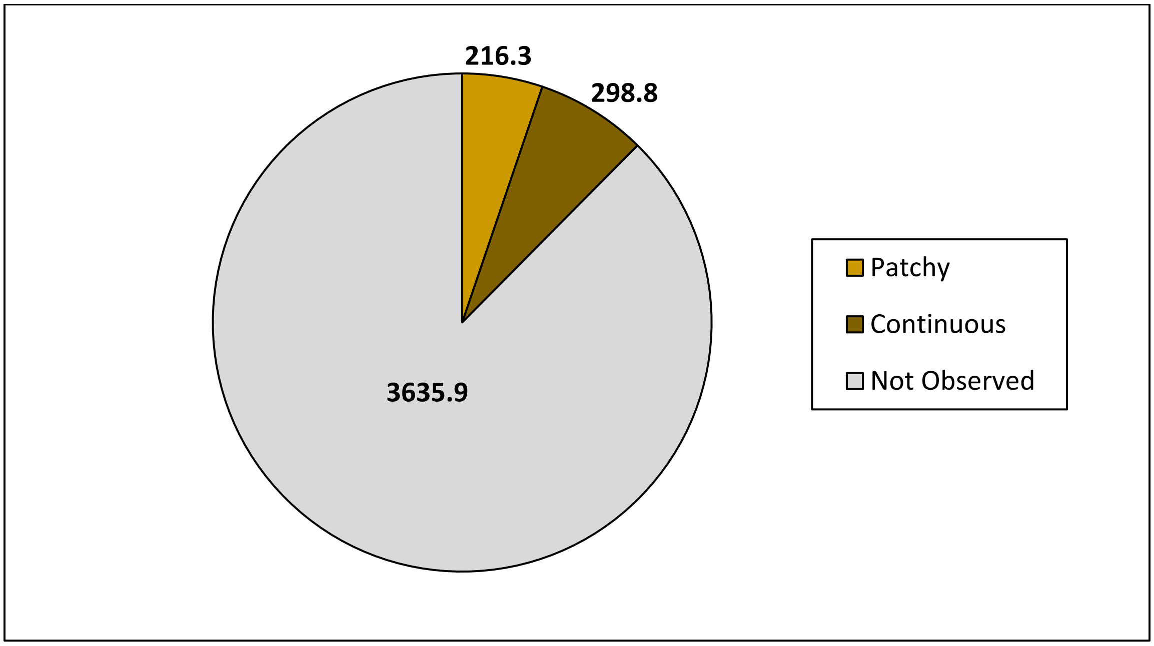

Figure 47. Distribution of the subtidal Giant Kelp (GIKE) bioband by shoreline length (km).

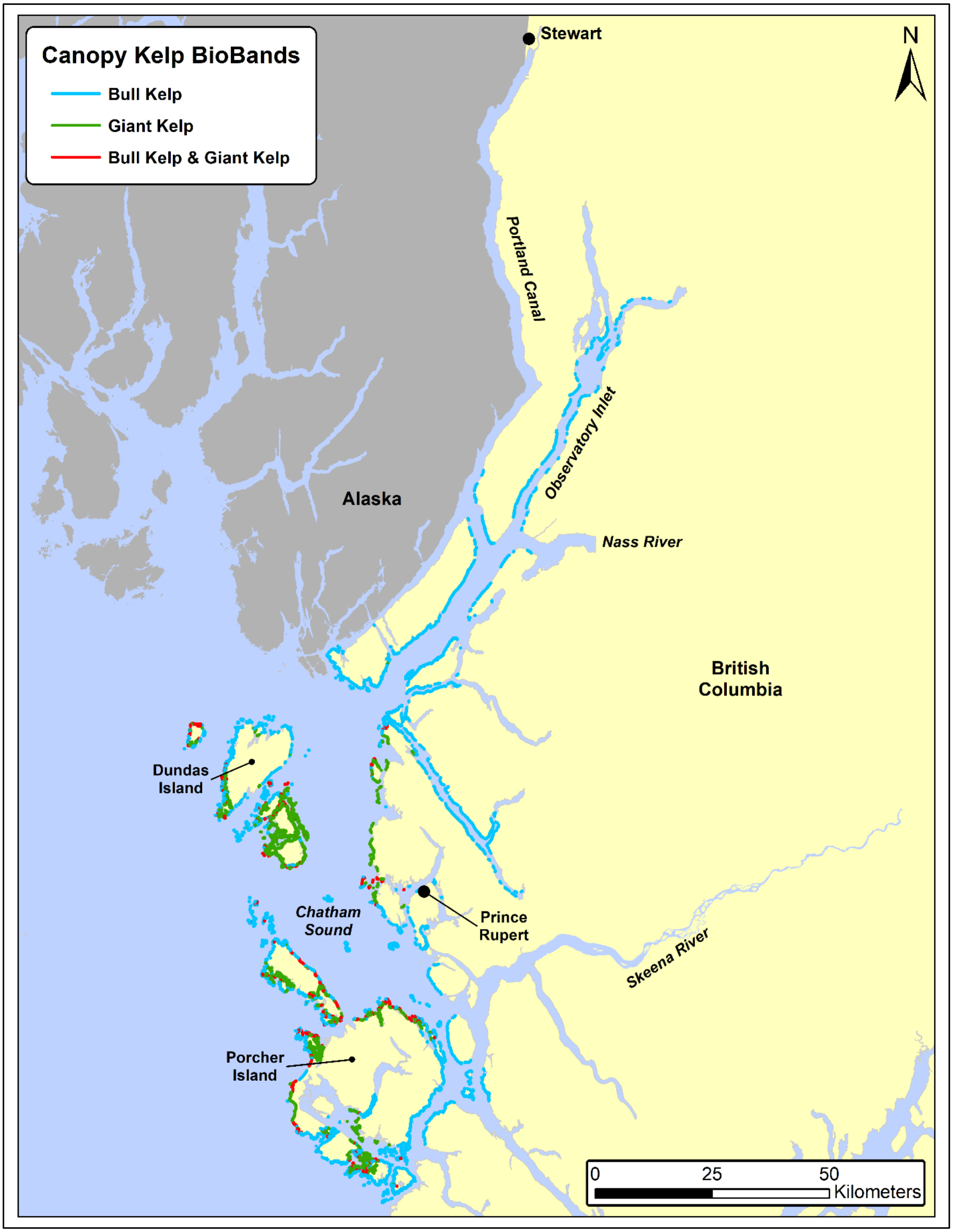

Figure 48. Distribution of the canopy kelp biobands, Bull Kelp (BUKE) and Giant Kelp (GIKE) on the North Coast of BC.

Two seagrass biobands were observed on the North Coat of BC: Eelgrass (EELG) and Surfgrass (SURF). Seagrasses are an important component of coastal ecosystems with Eelgrass beds forming in sandy substrate at Semi-Protected and lower exposures while Surfgrass generally attaches to hard substrate on Semi-Protected or Semi-Exposed beaches. See Figures 49 and 50 for statistics on the distribution of the individual seagrass biobands and a distribution map for both in Figure 51.

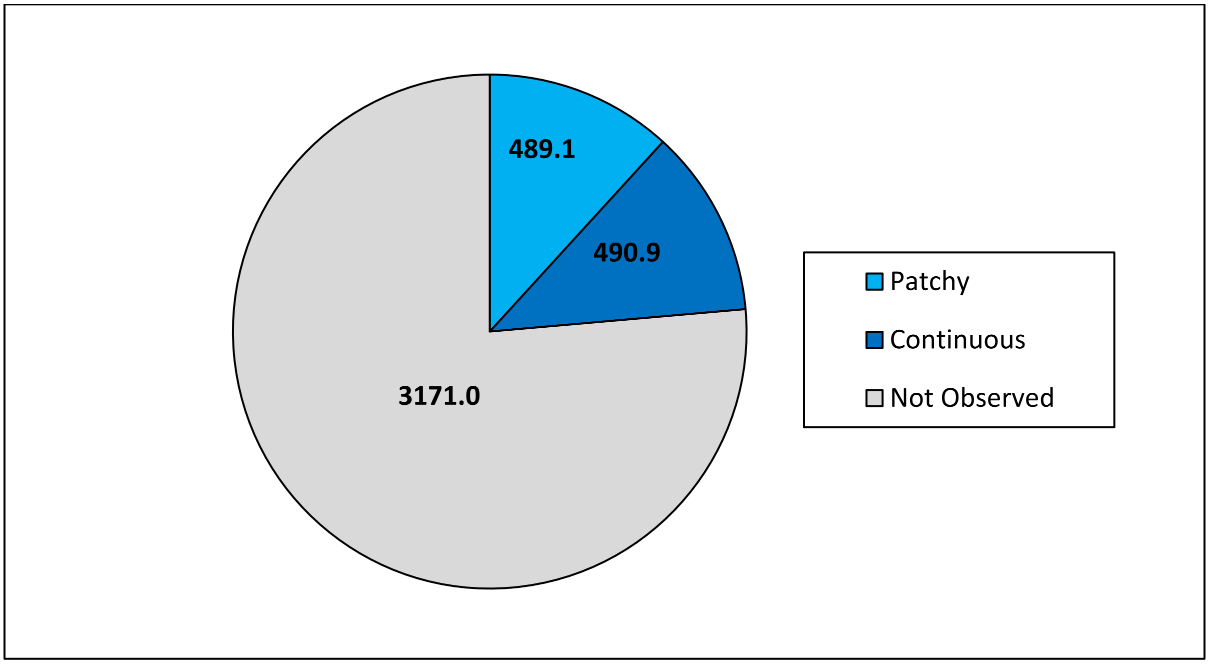

Figure 49. Distribution of the lower intertidal/subtidal Eelgrass (EELG) bioband by shoreline length (km).

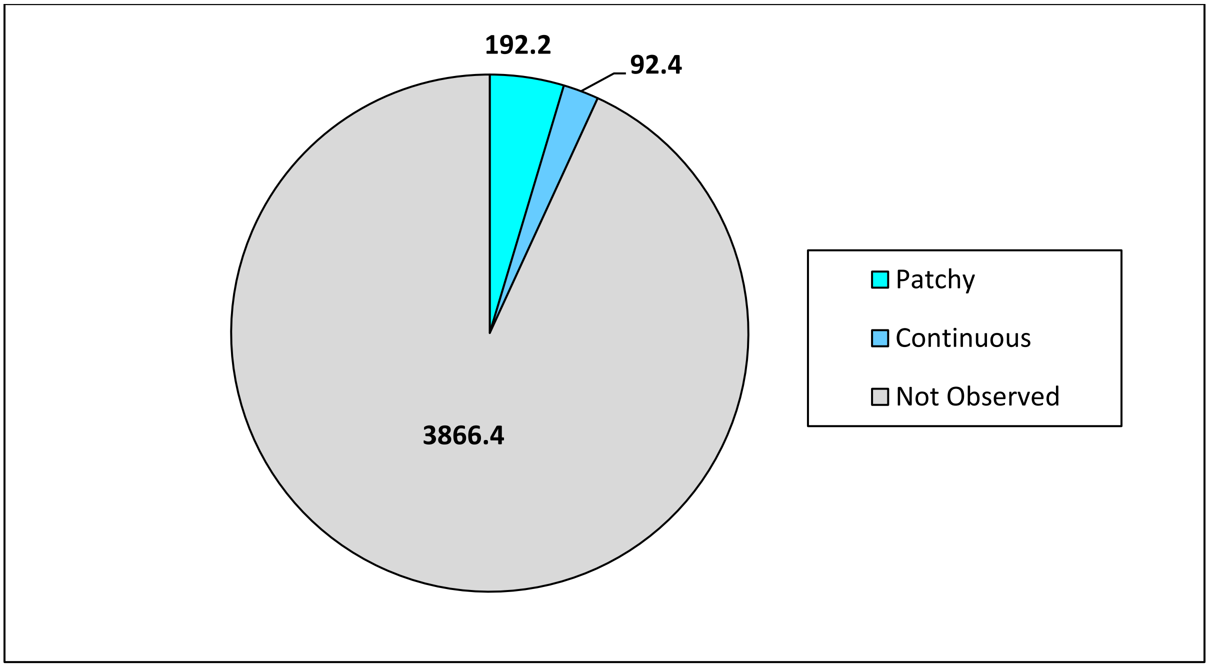

Figure 50. Distribution of the intertidal/subtidal Surfgrass (SURF) bioband by shoreline length (km).

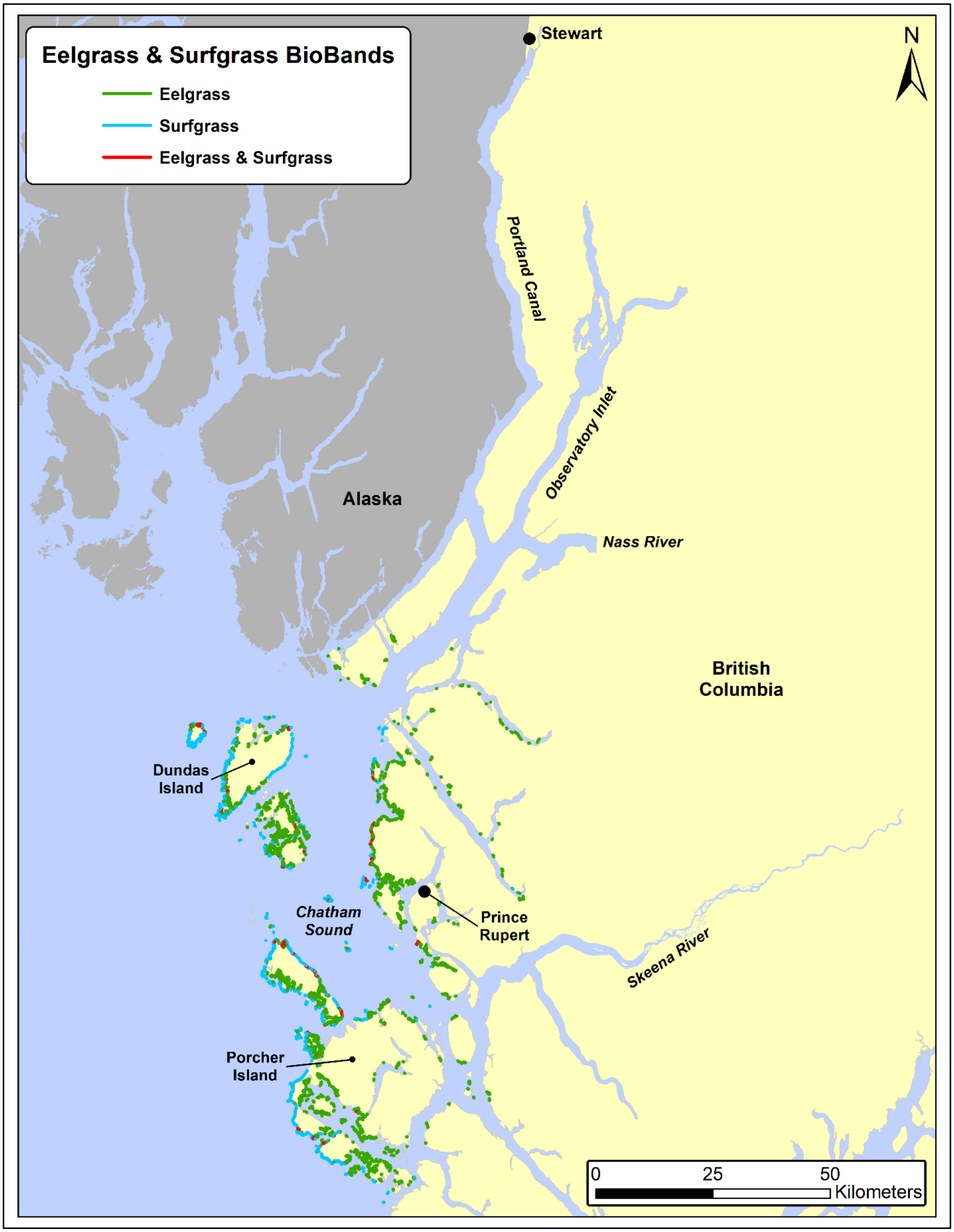

Figure 51. Distribution of the seagrass biobands, Eelgrass (EELG) and Surfgrass (SURF), on the North Coast of BC

4 SALISH SEA, BRITISH COLUMBIA

4.1 Introduction

The Gulf Islands were first imaged and mapped in the 1990s with the Southern Gulf Islands and the Victoria shoreline being re-imaged and re-mapped in 2004. In August 2021, the Gulf Islands in the Strait of Georgia were re-imaged again. Those surveys acquired aerial video and digital still images of the coast during minus tides (zero-meter tide levels and lower). The imagery and associated audio commentary were used to map the physical and biological attributes of the shoreline.

4.2 Coastal Class

Sediment shorelines (30.9%) were prominent along with Rock and sediment shorelines (29.9%) and Rock shorelines (29.6%) in the Salish Sea survey area. Anthropogenic, Riparian, Lagoon, and Current shorelines all comprised the rest of the coast (Figures 52-68). The description for each Coastal Class category in the survey area is given in Table 5.

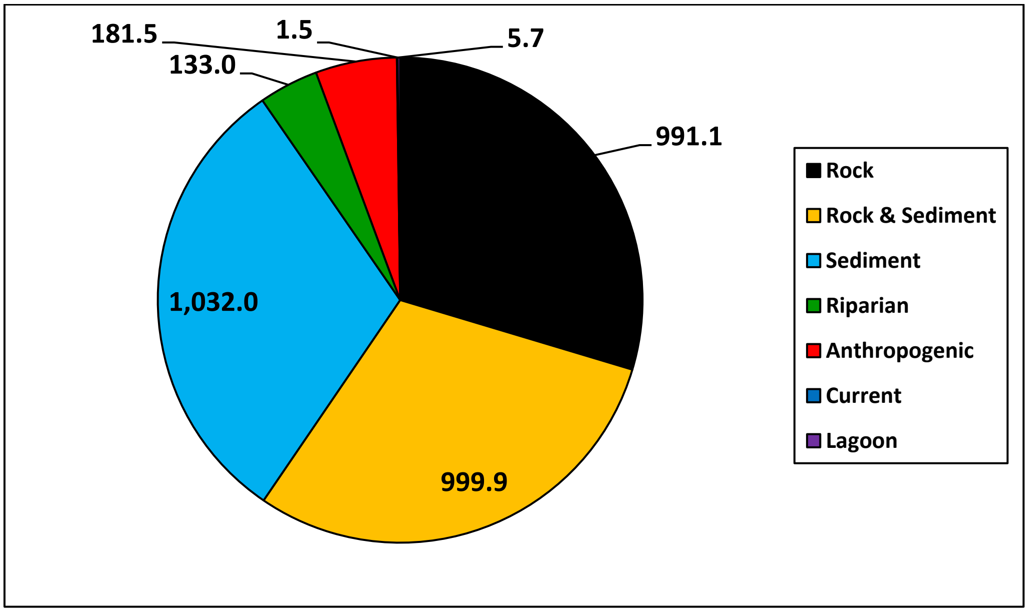

Figure 52. Grouped Coastal Class categories by shoreline length (km)

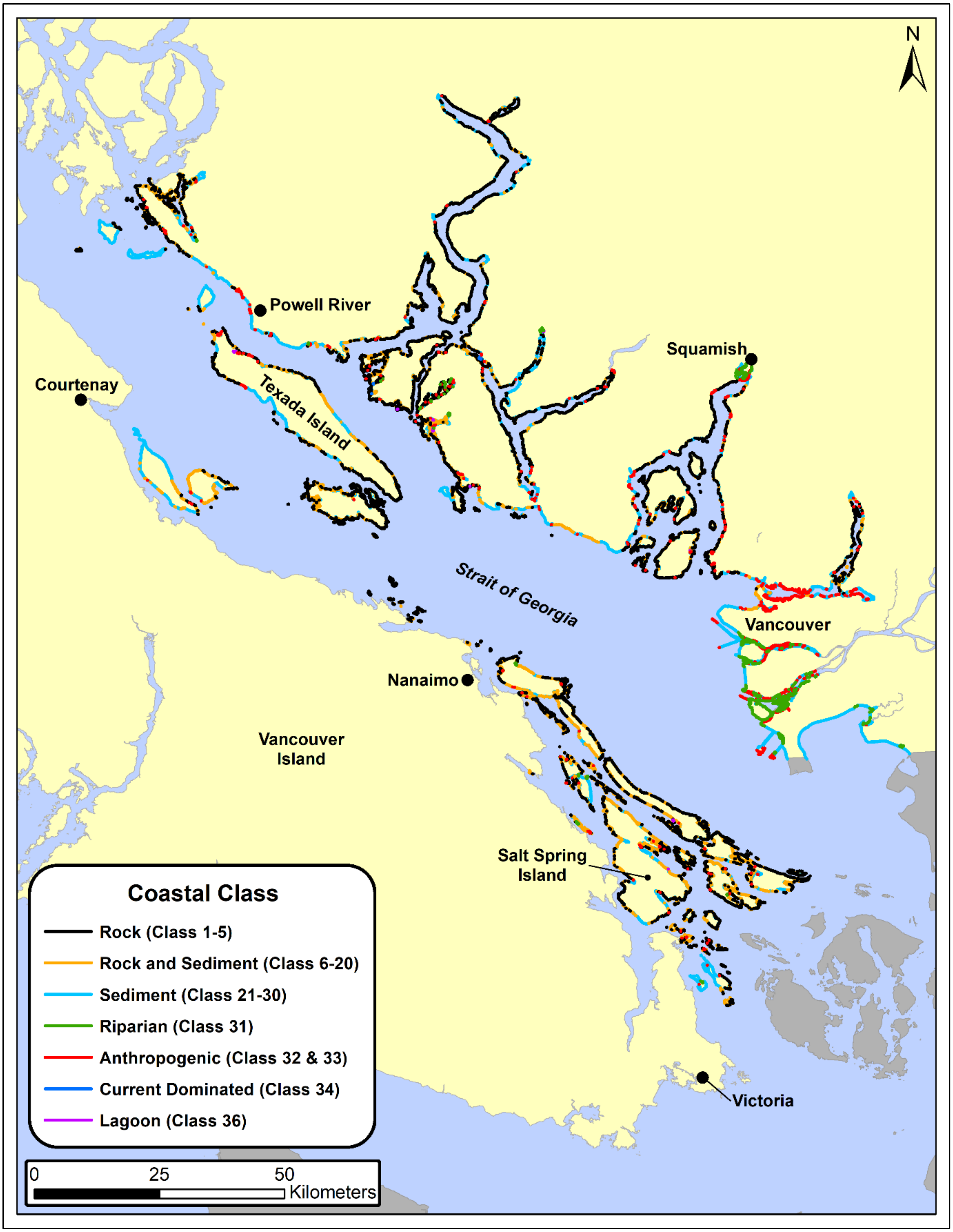
N
Powell River
Squamish
Courtenay
Texada Island
Strait of Georgia
Vancouver
Nanaimo
Vancouver Island
Salt Spring Island
Victoria
Coastal Class
Rock (Class 1-5)
Rock and Sediment (Class 6-20)
Sediment (Class 21-30)
Riparian (Class 31)
Anthropogenic (Class 32 & 33)
Current Dominated (Class 34)
Lagoon (Class 36)
0
25
50
Kilometers

Figure 53. Map of the Coastal Class categories grouped by type (also known as Shore Type).

Figure 54. Example of Coastal Class 2; Rock Platform, wide. Tumbo Island, photo bc21_gi_01306

Figure 55. Example of Coastal Class 4; Rock Ramp. Lasqueti Island, photo bc20_sc_15815.

Figure 56. Example of Coastal Class 7; Platform with gravel beach, wide. Tribune Bay, Hornby Island, photo bc21_gi_08552.

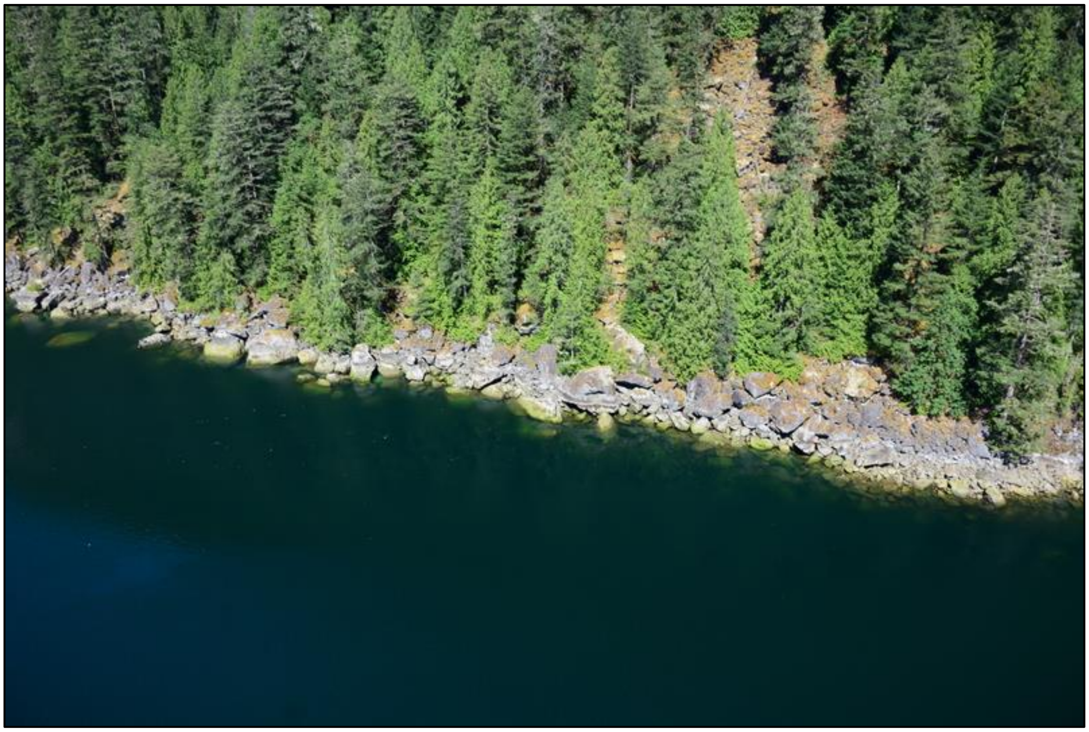

Figure 57. Example of Coastal Class 8; Cliff gravel beach. Princess Louisa Inlet, photo bc20_sc_08778.

Figure 58. Example of Coastal Class 11; Ramp with gravel & sand beach. Keats Island, photo bc18_vr_00315.

Figure 59. Example of Coastal Class 12; Platform with gravel & sand beach, wide. Trail Bay, photo bc20_sc_14778.

Figure 60. Example of Coastal Class 13; Cliff with gravel & sand beach. Welcome Passage, photo bc20_sc_14628.

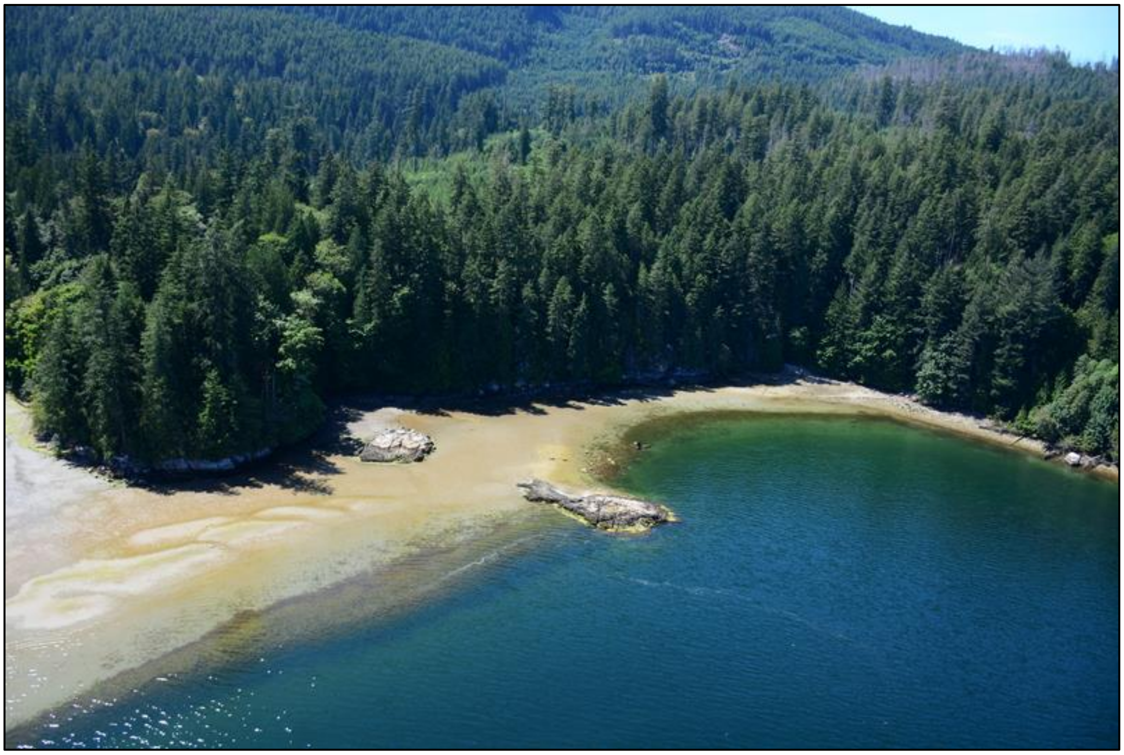

Figure 61. Example of Coastal Class 17; Ramp with sand beach, wide. Snake Bay, photo bc20_sc_10955.

Figure 62. Example of Coastal Class 25; Sand & gravel beach, narrow. Gibsons, photo bc18_vr_00399.

Figure 63. Example of Coastal Class 28; Sand flat. Semiahmoo Bay, photo bc18_vr_07364.

Figure 64. Example of Coastal Class 29; Mudflat. Ewen Slough, photo bc18_vr_08606.

Figure 65. Example of Coastal Class 30; Sand beach. James Island, photo bc21_gi_10492.

Figure 66. Example of Coastal Class 32; Permeable man-made structures. Twin Creeks, photo bc18_vr_00627.

Figure 67. Example of Coastal Class 33; Impermeable man-made structures. South Fraser River, photo bc18_vr_08718.

Figure 68. Example of Coastal Class 34; Channel. Sechelt Rapids, photo bc20_sc_09787.

Table 5. Summary of Coastal Classes for the Salish Sea.

Substrate Type	**Shore Type**		**Sum of Unit Length (km)**	**# of Units**	**% Occurrence (by length)**	**Cumulative Occurrence (%, km)**
	No.	**Description**				
Rock	1	Rock Ramp, wide	16	75	1	**30% 991 km**
	2	Rock Platform, wide	13	96	<1	
	3	Rock Cliff	794	3,504	24	
	4	Rock Ramp, narrow	166	1,049	5	
	5	Rock Platform, narrow	3	15	<1	
Rock & Sediment	6	Ramp w gravel beach,	10	60	<1	**20% 1000 km**
	7	Platform w gravel beach,	11	38	<1	
	8	Cliff with gravel beach	287	1,607	9	
	9	Ramp with gravel beach	188	1,301	6	
	10	Platform with gravel	2	8	<1	
	11	Ramp w gravel & sand	89	572	3	
	12	Platform with G&S beach,	97	481	3	
	13	Cliff with gravel/sand	69	616	2	
	14	Ramp with gravel/sand	230	1,728	7	
	15	Platform with gravel/sand	3	19	<1	
	16	Ramp w sand beach, wide	3	10	<1	
	17	Platform w sand beach,	7	38	<1	
	18	Cliff with sand beach	2	14	<1	
	19	Ramp with sand beach,	1	8	<1	
	20	Platform w sand beach,	<1	1	<1	
Sediment	21	Gravel flat, wide	1	9	<1	**31% 1,032 km**
	22	Gravel beach, narrow	51	313	2	
	24	Sand & gravel flat or fan	401	1,462	12	
	25	Sand & gravel beach,	321	1,931	10	
	26	Sand & gravel flat or fan	2	8	<1	
	27	Sand beach	1	5	<1	
	28	Sand flat	131	261	4	
	29	Mud flat	73	172	2	
	30	Sand beach	51	168	2	
Organics	31	Organics/Estuarine	133	270	4	**4% 133 km**
Man-made	32	Man-made, permeable	158	683	5	**5% 182 km**
	33	Man-made, impermeable	24	83	1	
Current	34	Channel	2	13	<1	**<1% 2 km**
Lagoon	36	Lagoon	6	16	<1	**<1% 6 km**
Totals:			***3,345***	***16,634***	***100***	***100%***

Note: This table only includes Coastal Classes observed in the survey area.

4.3 Environmental Sensitivity Index (ESI)

The majority of the Salish Sea coastline is represented by the grouped High and Very High categories (59.5% of shoreline length). These sections of the shoreline have a potentially high sensitivity to oil. At the other end of the spectrum, only 29.9% of the shoreline was mapped with a potentially low sensitivity to oil (Figures 69 and 70). The summary of Coastal Class by ESI class can be seen in Table 6.

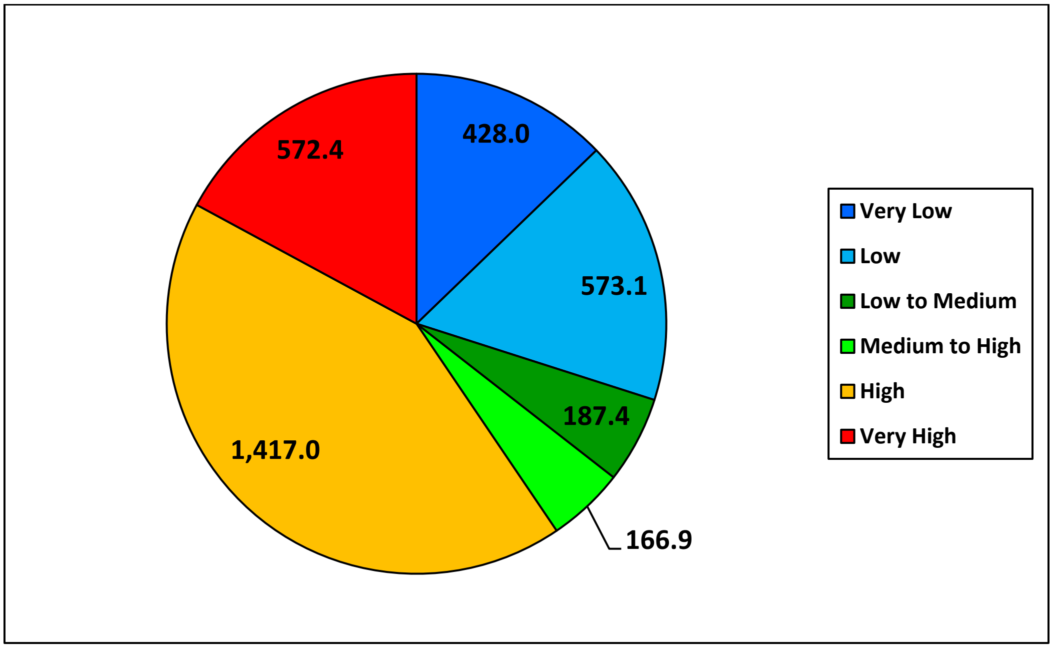

Figure 69. Grouped most sensitive ESI categories by shoreline length (km).

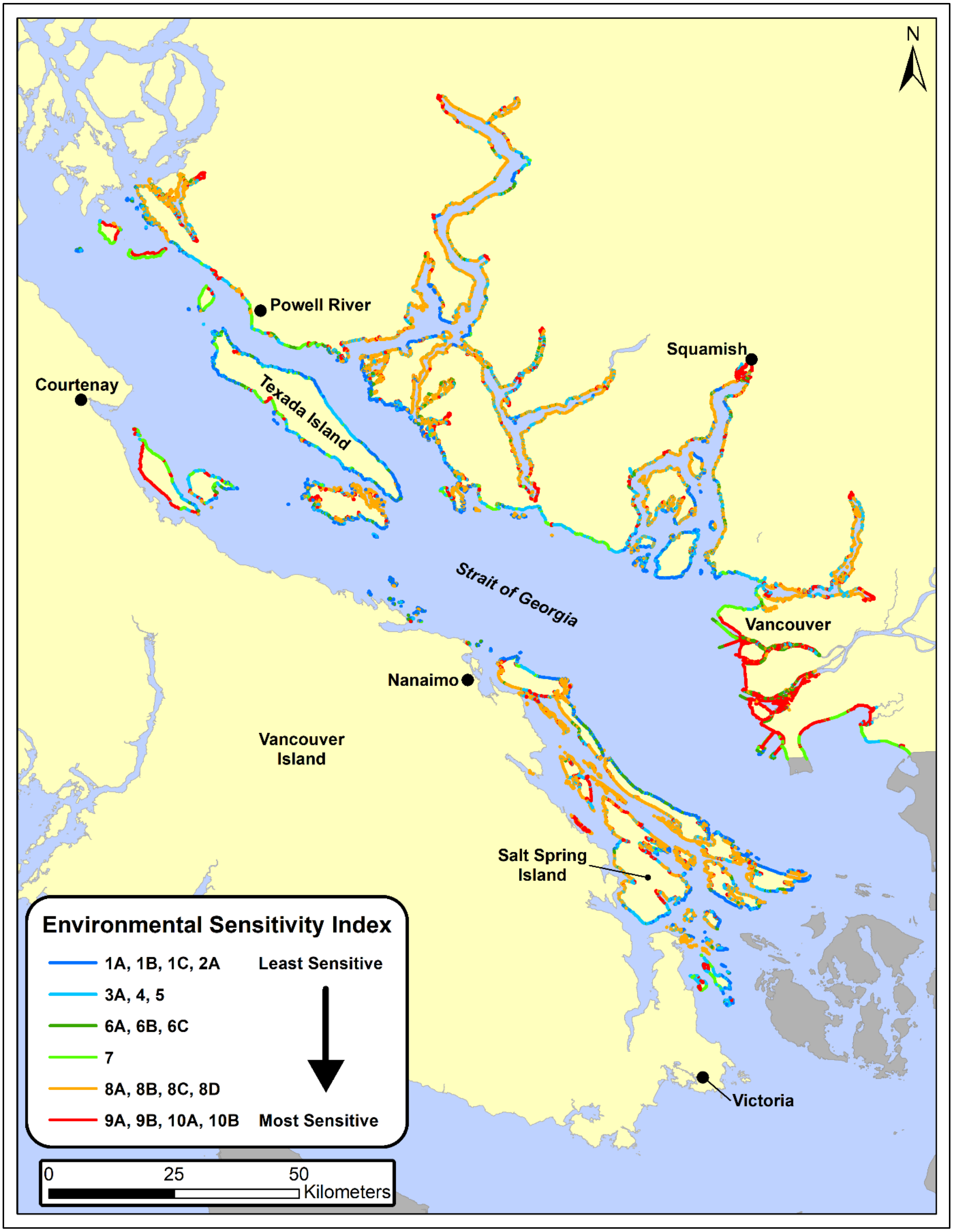

Figure 70. Distribution of the grouped ESI categories from least to most sensitive to oiling.

Table 6. Summary of Coastal Classes by ESI Class for the Salish Sea.

Environmental Sensitivity Index (ESI)		Sum of Unit Length (km)	# of Units	% of Total Shoreline Length
No.	**Description**			
1A	Exposed rocky shores; Exposed rocky banks	238	1,211	7
1B	Exposed, solid man-made structures	4	12	<1
1C	Exposed rocky cliffs with boulder talus base	44	259	1
2A	Exposed wave-cut platforms in bedrock, mud, or clay	142	820	4
3A	Fine- to medium-grained sand beaches	14	56	<1
4	Coarse-grained sand beaches	1	11	<1
5	Mixed sand and gravel beaches	559	3,344	17
6A	Gravel beaches (granules and pebbles)	2	5	<1
6B	Gravel beaches (cobbles and boulders)	116	737	4
6C	Rip rap	70	299	2
7	Exposed tidal flats	167	441	5
8A	Sheltered scarps in bedrock, mud, or clay; sheltered rocky shores (impermeable)	821	4,331	25
8B	Sheltered, solid, man-made structures; sheltered rocky shores (permeable)	78	308	2
8C	Sheltered Rip Rap	55	274	2
8D	Sheltered rocky rubble shores	464	2,878	14
9A	Sheltered tidal flats	245	914	7
10A	Salt- and brackish-water marshes	325	715	10
10B	Freshwater marshes	2	19	<1
	Totals:	***3,345***	***16,634***	***100***

Note: ESI Classes not observed in this survey area were not included in the table.

4.4 Oil Residence Index (ORI)

Lower wave exposures and mobile sediments lead to higher ORI values for 65.4% of the shore segments in the Salish Sea survey area, indicating oil residence times are on the order of months to years (see Figures 71 and 72 for distribution and summary statistics).

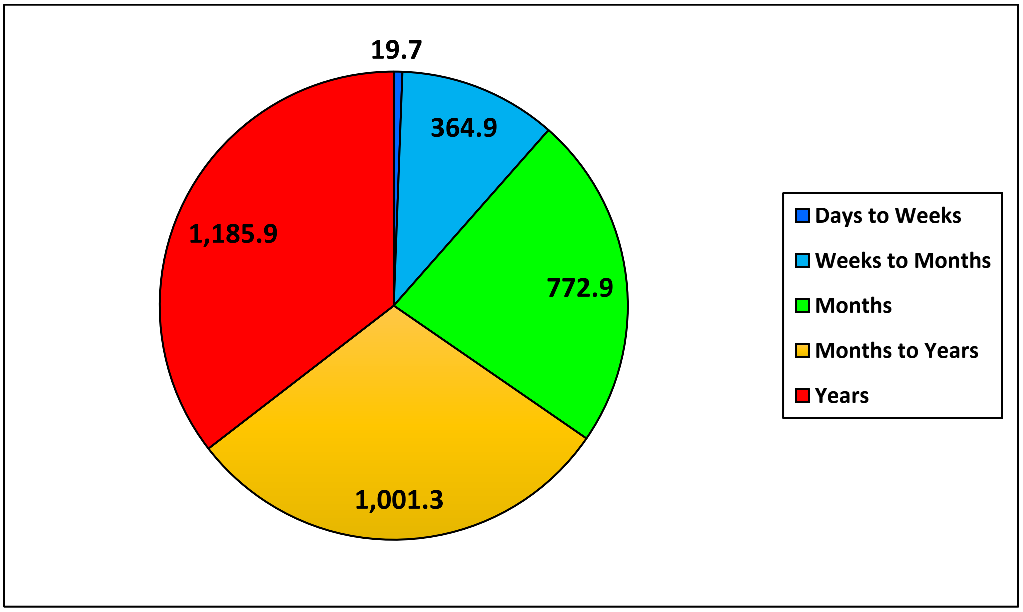

Figure 71. Oil Residence Index (ORI) categories by shoreline length (km).

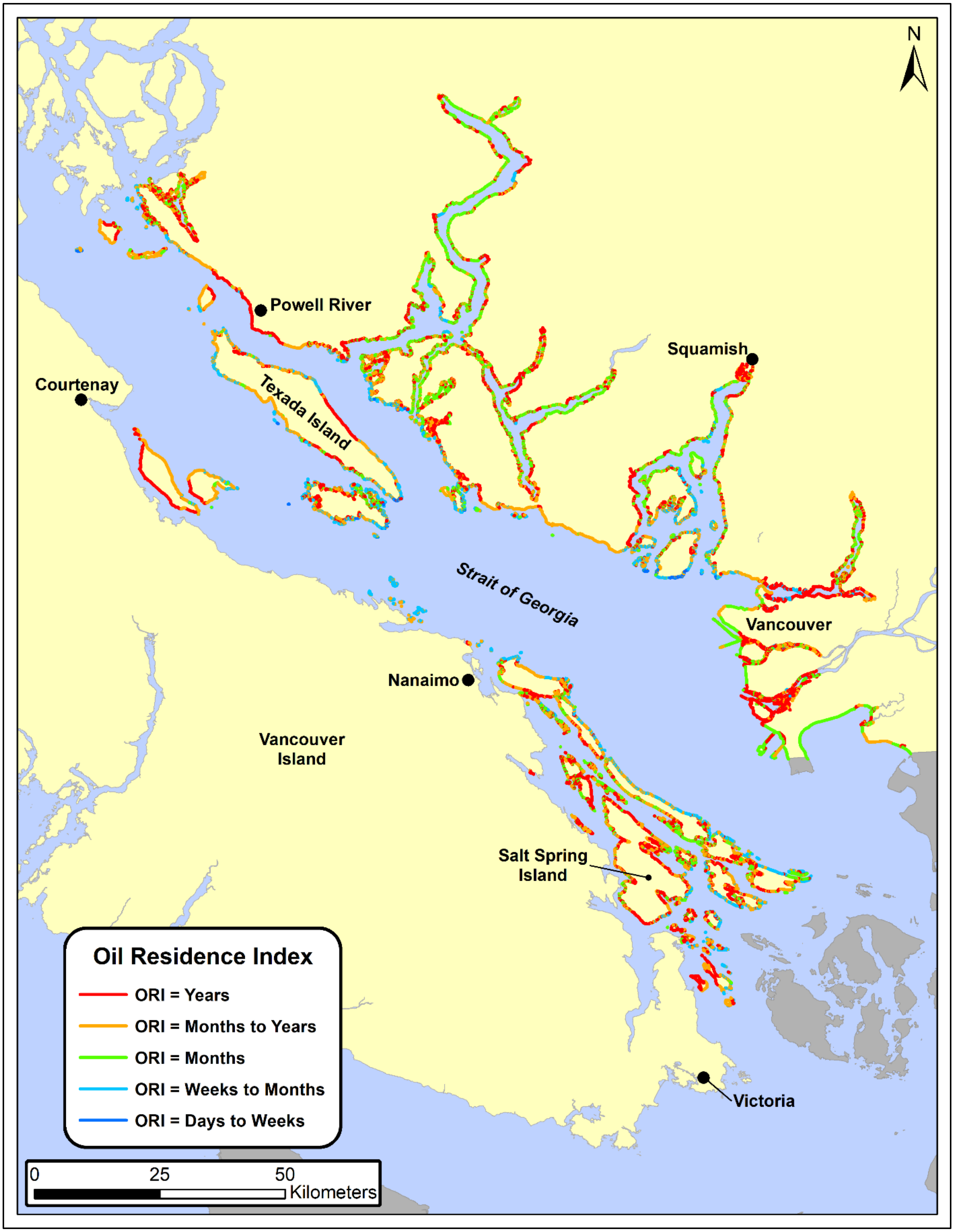

Figure 72. Distribution of the Oil Residence Index (ORI) categories.

4.5 ShoreZone Coastal Vulnerability

In the Salish Sea study area, potential for damage due to flooding is generally low with 84.6% of the shoreline at a low risk of flooding less than 5m from the MHW (Figures 73 and 74).

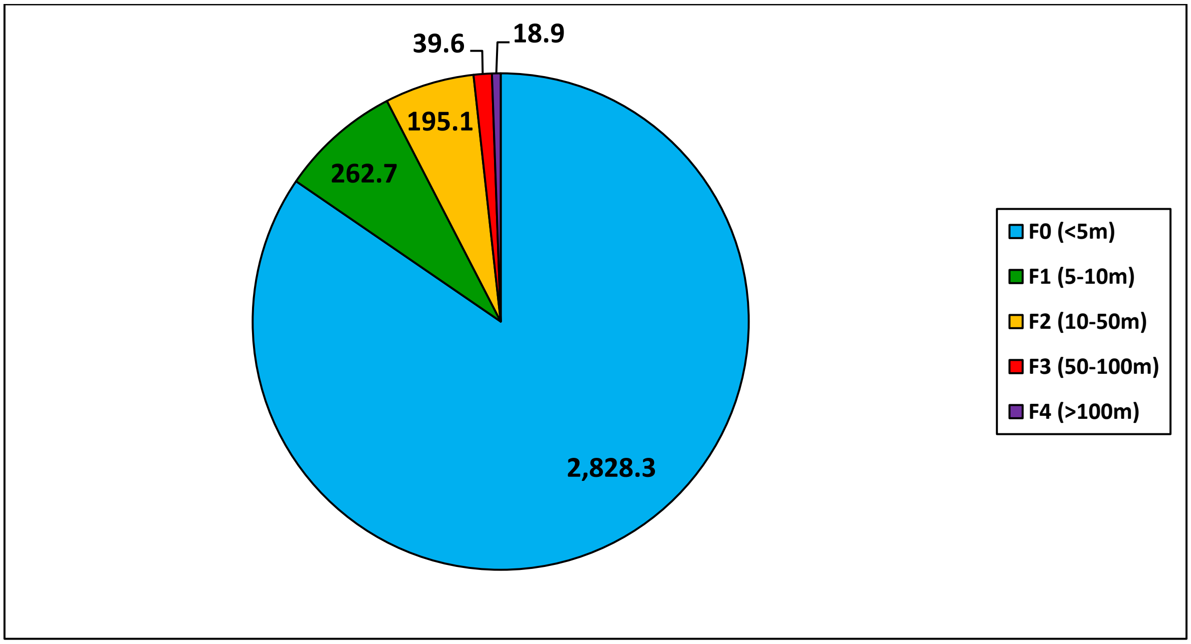

Figure 73. Flooding Class categories by shoreline length (km).

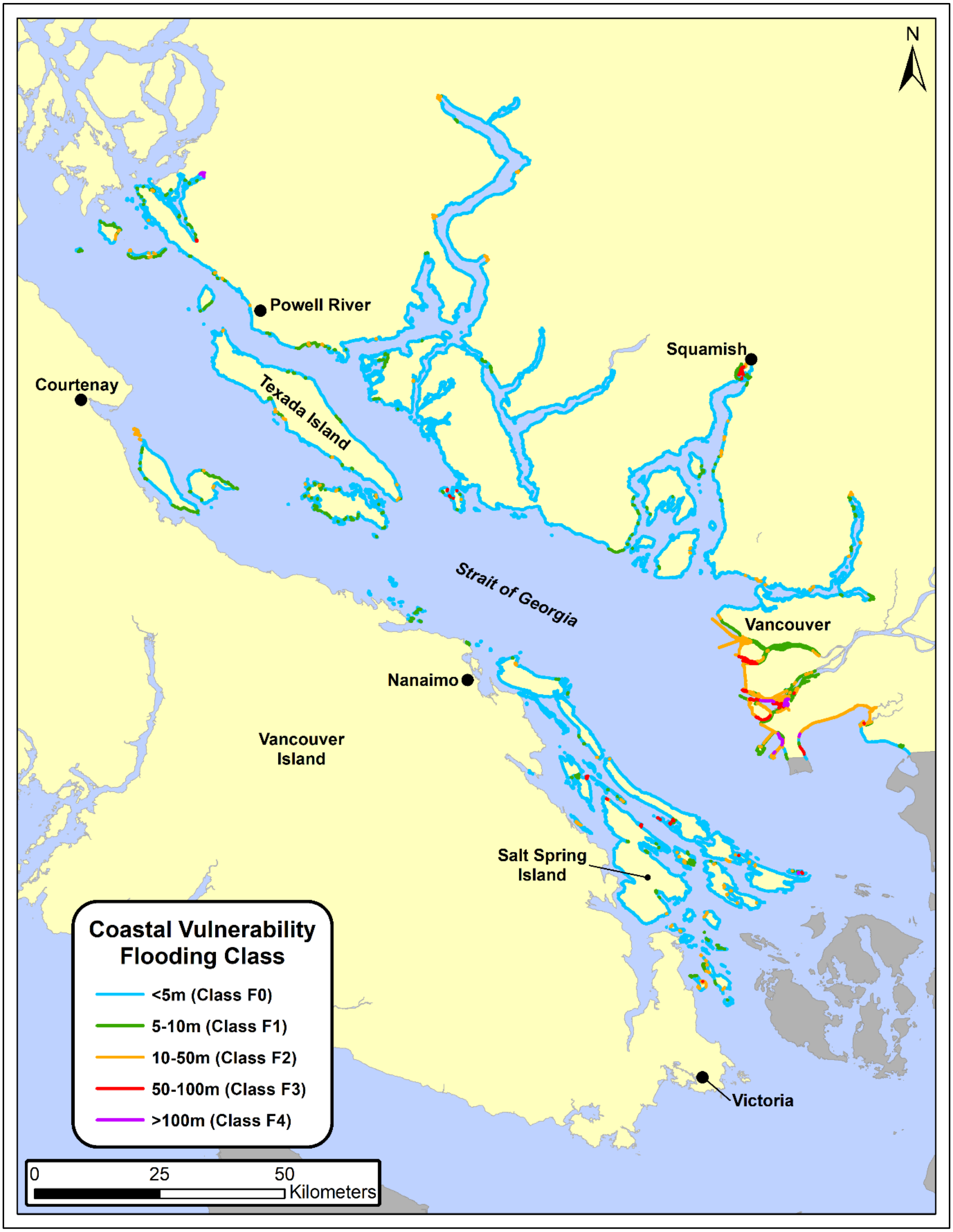

Figure 74. Distribution of the Coastal Vulnerability Flooding Class.

4.6 Anthropogenic Shore Modifications

A total of 3.0% of the shoreline (taking the estimated length of that modification within the unit into account) exhibits shore modifications in the Salish Sea study area (Figure 75). Rip Rap was the most recorded observation (40.8%) with Landfill (30.4%) and Concrete Bulkhead (10.7%) rounding out the top three shoreline modifications along the coast. The associated map (Figure 76) shows the distribution of primary shore modifications, though it should be noted that any given modification is possible along the entire length of the indicated shore unit. The Geodatabase delivered with this report displays each shore modification with a specific length category (meters) along the shoreline pertaining to each unit as well as the specific zone (supratidal or intertidal) the modification occurs in.

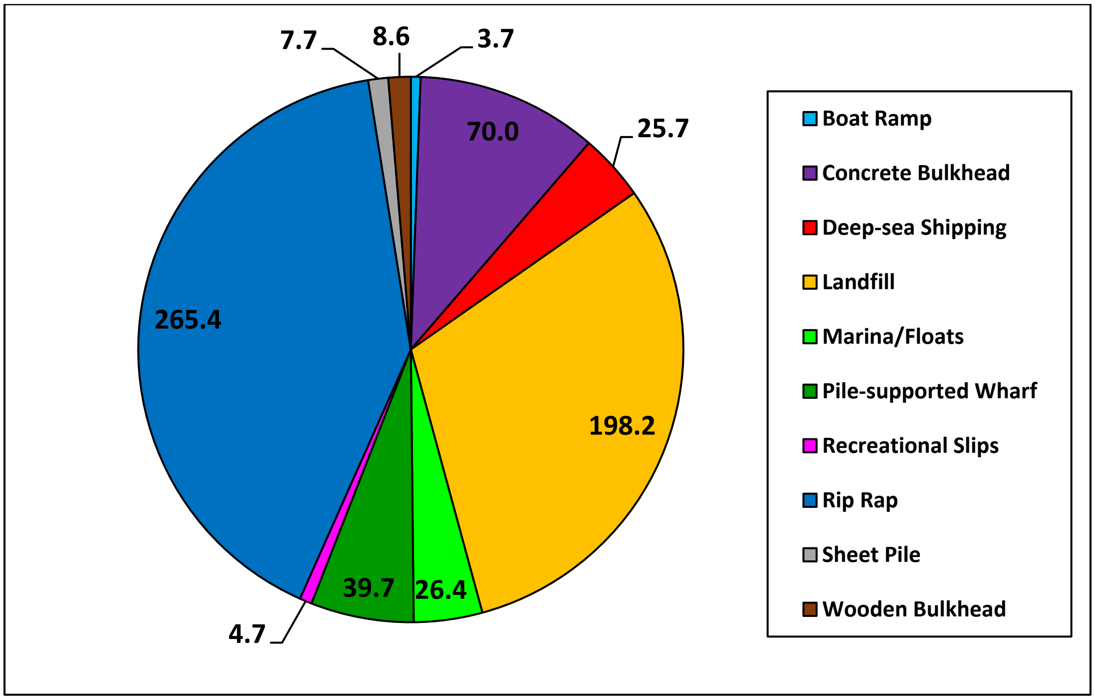

Figure 75. Shore Modifications by estimated shoreline length (km) of each.

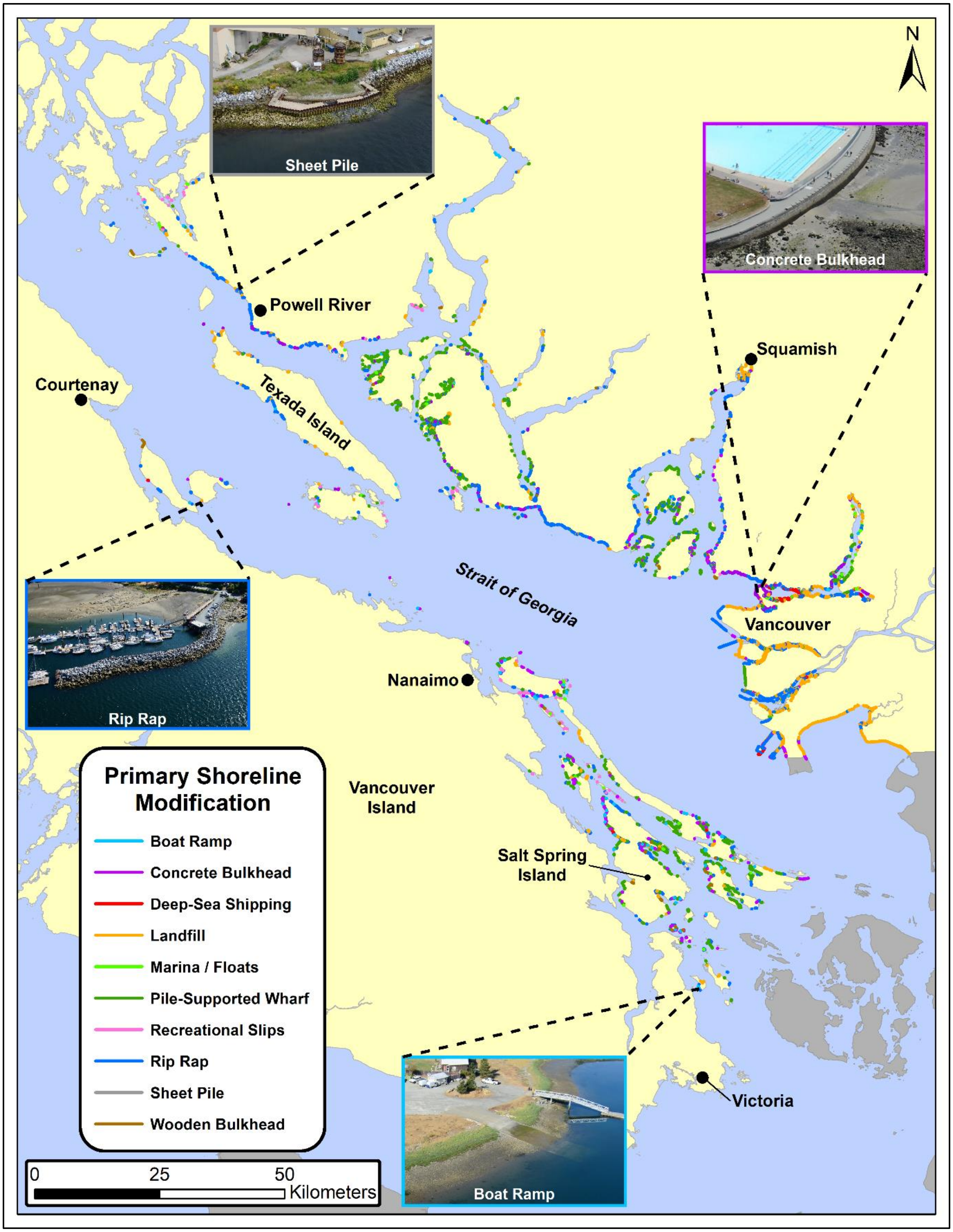

Figure 76. Distribution of types of the primary Shore Modifications.

4.7 Biological Wave Exposure

The distribution of the wave exposure categories mapped in the Salish Sea are summarized in Figure 77 and a distribution map of the categories is shown in Figure 78. Nearly all the Salish Sea (99%) was in the lower to moderate wave exposures (Very Protected to Semi-Protected), with most of that Protected (66%).

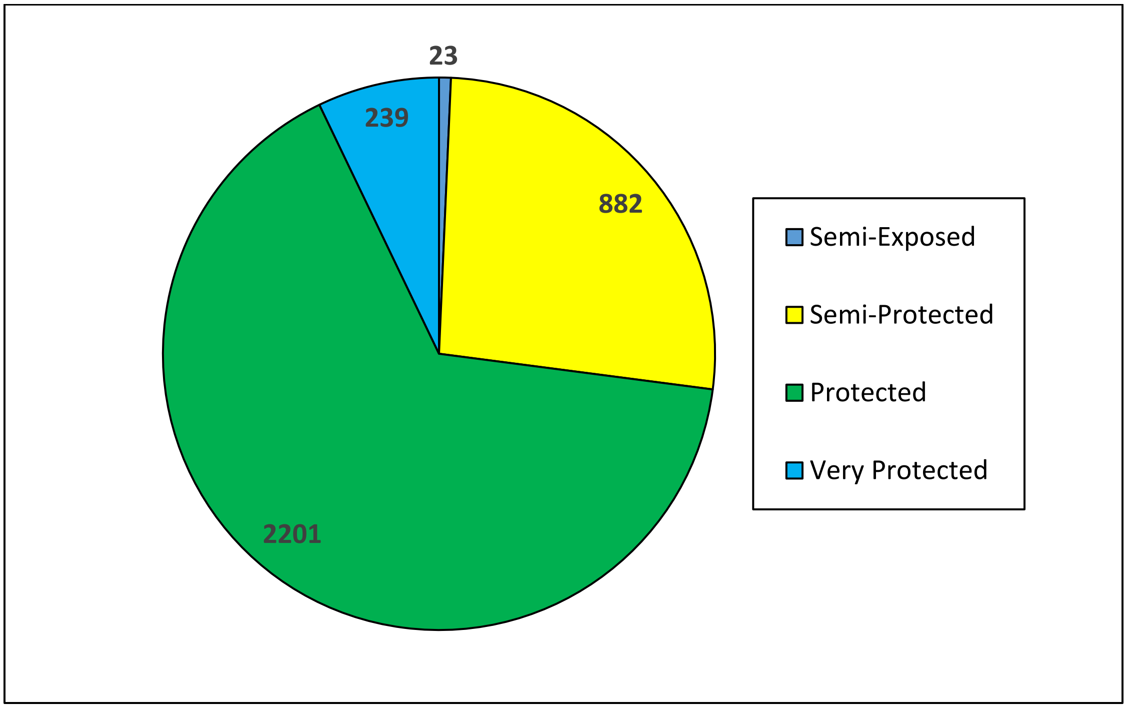

Figure 77. Distribution of Biological Wave Exposures mapped in the Salish Sea by shoreline.

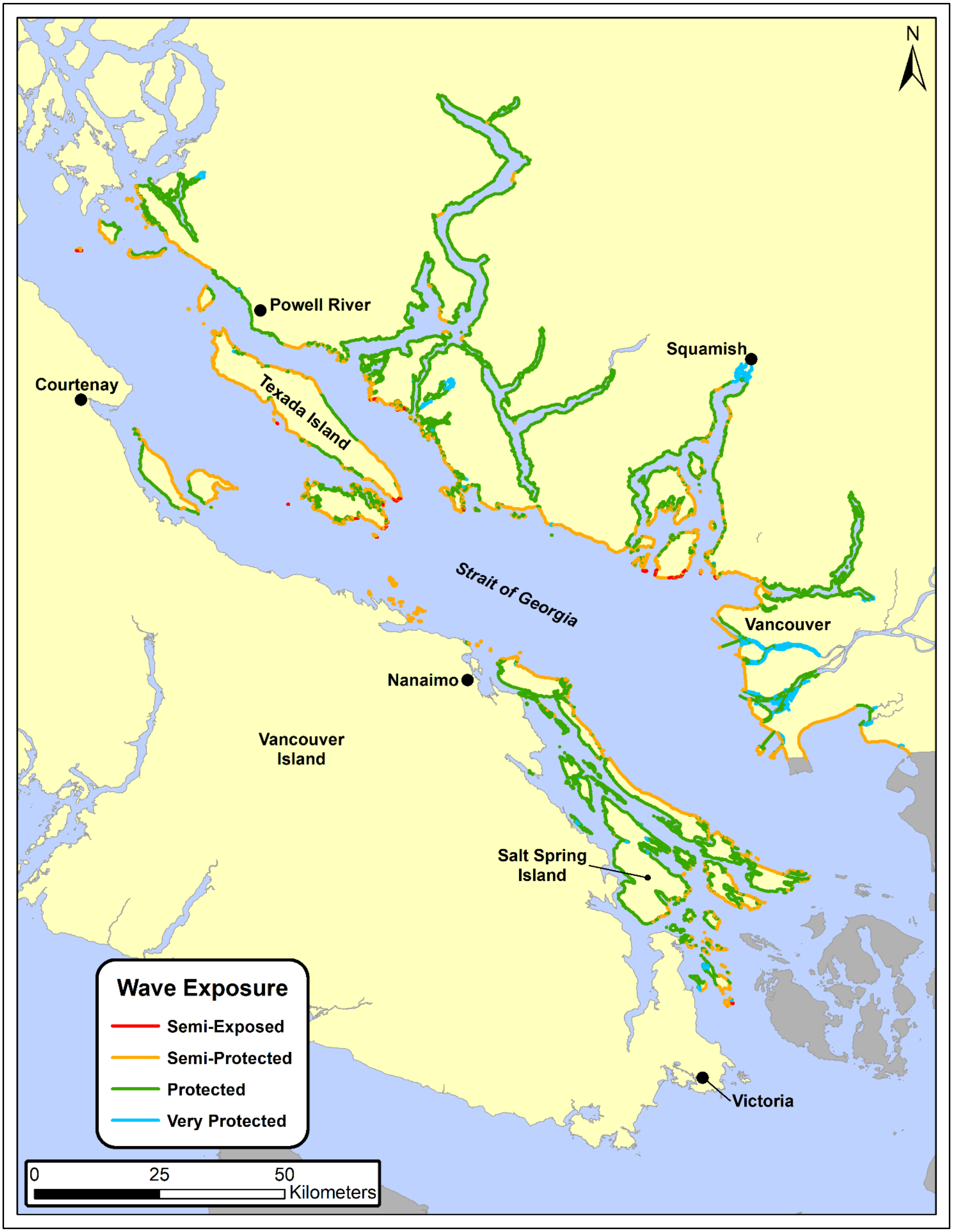

Figure 78. Distribution of the Biological Wave Exposure in British Columbia.

4.8 Habitat Class

The distribution of the Habitat Class categories mapped in the Salish Sea are summarized in Figure 79 and a distribution map of the categories is shown in Figure 80. Partially mobile substrate is the dominant shoreline type (52%), with Immobile accounting for the bulk of the rest (29%).

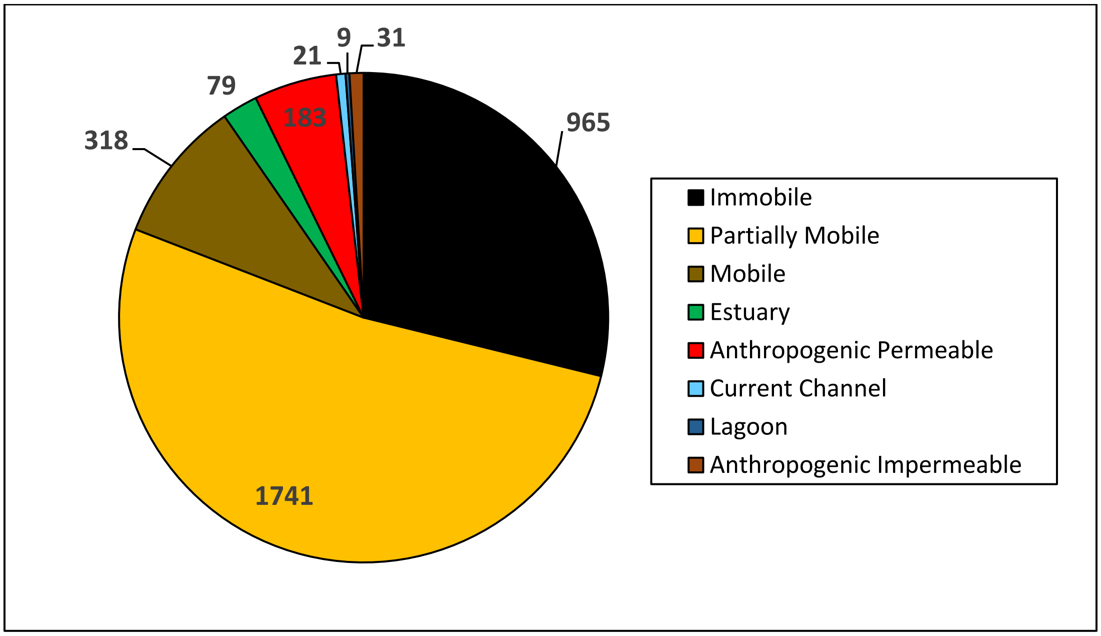

Figure 79. Distribution of Habitat Class categories in the Salish Sea by shoreline length (km).

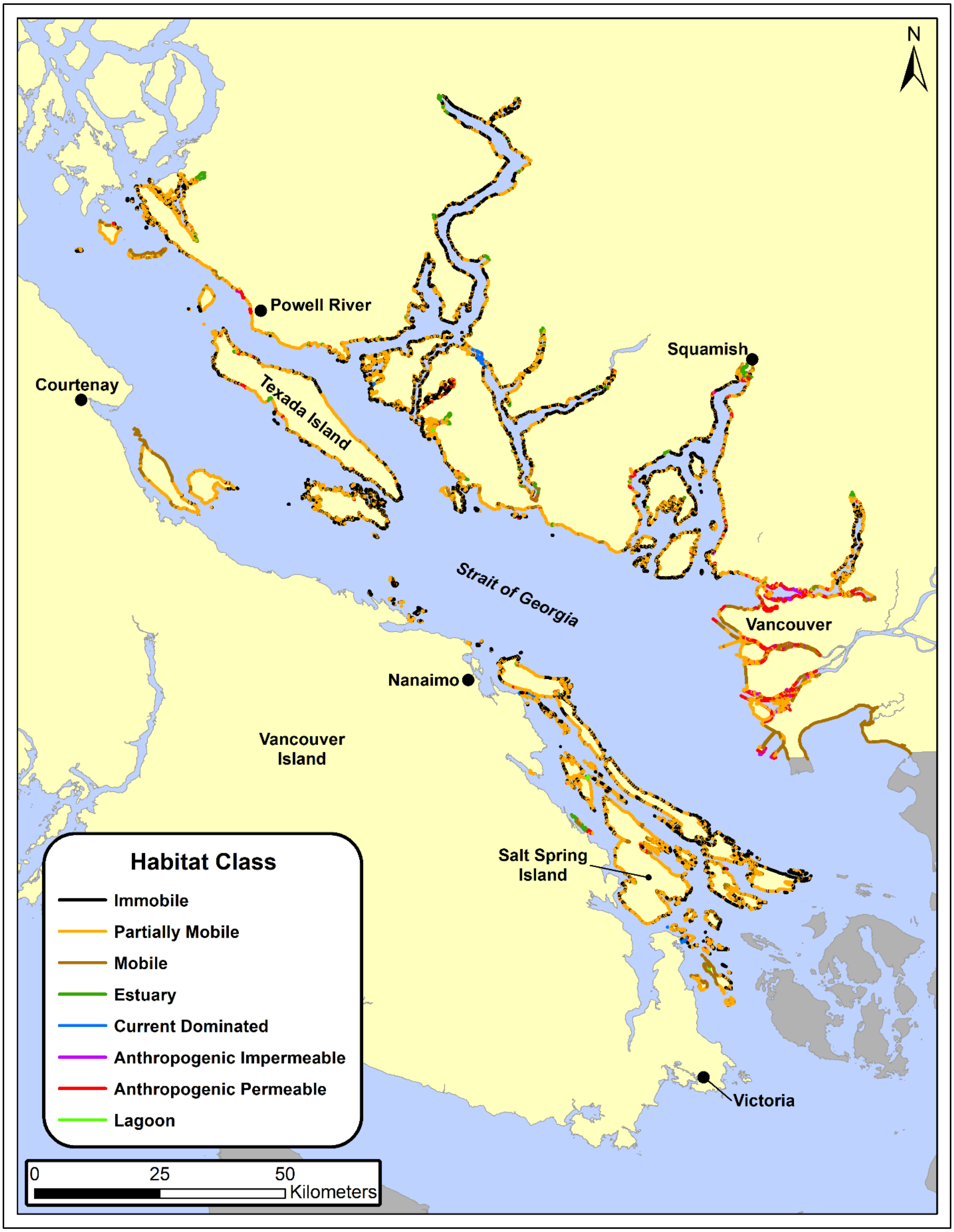

Figure 80. Distribution of Habitat Class categories in the Salish Sea.

4.9 Biobands

Biobands mapped in the Salish Sea survey area are summarized in Tables 7 and 8. Some examples of biobands from the Salish Sea are shown in 81-91. The most commonly occurring intertidal bioband in the survey area was Green Algae in 84% of units. Rockweed and Barnacle were also common and were found in 73% and 78% of units, respectively. The most common supratidal bioband was Black Lichen, occurring in 65% of the units, while the supratidal/high intertidal Salt Marsh bioband was found in only 22% of units. The most common low intertidal/subtidal biobands were Sargassum (25%) and Brown Bladed Kelps (24%). It should be noted that some of the Brown Bladed Kelps may also include Sargassum, which would usually be classified as a Brown Non-Bladed Kelp. Distribution maps, statistics, and observations about some specific biobands are found in the following pages.

Table 7. Bioband abundances for non-splash zone biobands mapped for the Salish Sea.

Bioband		Patchy		Continuous		Total (km)	% of Total Mapped
Name	Code	(km)	%	(km)	%		
Dune Grass	DUGR	290	9	69	2	360	11
Salt Marsh	SAMB	374	11	375	11	749	22
Barnacle	BARN	418	13	2190	65	2608	78
Rockweed	ROCK	832	25	1608	48	2439	73
Green Algae	GRAL	841	25	1975	59	2816	84
Oysters	OYST	264	8	182	5	446	13
Blue Mussel	BLMU	447	13	437	13	884	26
Echinoderms	ECHI	41	1	0	0	41	1
Bleached Red Algae	BRAL	46	1	25	1	70	2
Filamentous and Foliose Red Algae	FFRA	262	8	349	10	611	18
Coralline Red Algae	CORA	2	0	2	0	4	0
Brown Bladed Kelps	BRBA	281	8	508	15	789	24
Dark Brown Kelps	DABK	0	0	0	0	0	0
Soft Browns	SOBK	10	0	4	0	14	0
Sargassum	SARG	298	9	525	16	823	25
Anemone	ANEM	1	0	0	0	1	0
Eelgrass	EELG	214	6	431	13	645	19
Bull Kelp	BUKE	144	4	164	5	308	9
Sand Dollar	SAND	10	0	3	0	13	0
Mixed Canopy Kelps	BRCA	1	0	0	0	1	0
Urchin Barrens	URBA	2	0	1	0	4	0
Biofilm	BIOF	0	0	1	0	1	0
Diatoms	DIAT	1	0	3	0	4	0
Grass	GRAS	7	0	9	0	16	0
Intertidal/Subtidal Vegetation	INSV	23	1	0	0	23	1
Trees and Shrubs	TRSH	41	1	34	1	74	2
Rooted Vegetation	ROVE	4	0	1	0	5	0
Wetland Vegetation	WEVE	2	0	1	0	2	0
Spartina	SPAR	4	0	0	0	4	0

Table 8. Bioband abundances for splash zone biobands mapped for the Salish Sea.

Bioband		Narrow (<1m)		Medium (1-5m)		Wide (>5m)		Total (km)	% of Total Mapped
Name	Code	(km)	%	(km)	%	(km)	%		
Black Lichen	BLLI	1313	39	634	19	212	6	2159	65
Splash Zone	SPZO	534	16	157	5	3	0	694	21
White Lichen	WHLI	455	14	268	8	18	1	741	22
Yellow Lichen	YELI	67	2	27	1	3	0	96	3

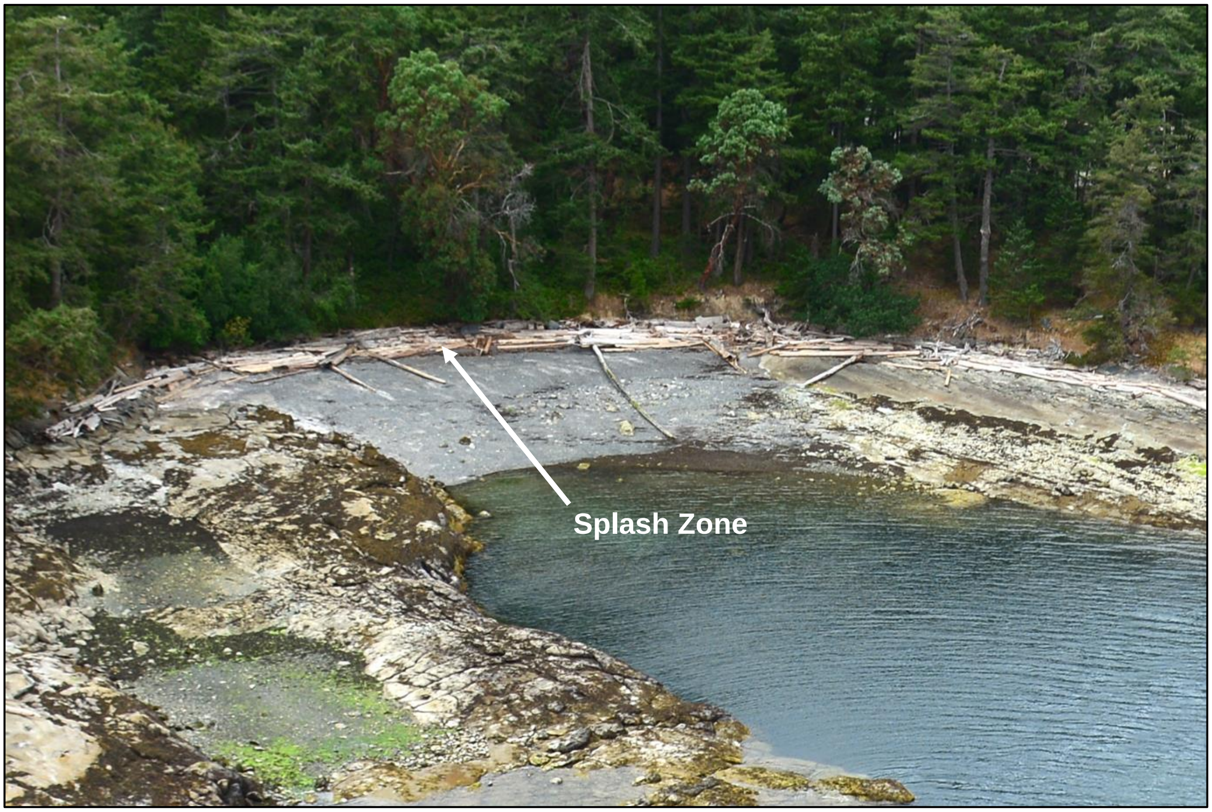

Figure 81. Good example of the Splash Zone (SPZO) bioband which is an erosional or active A zone without attached vegetation. Southeast Vance Island, photo bc21_gi_07612.

Figure 82. Good example of the Yellow Lichen (YELI) bioband which is a yellow-orange band in the supratidal zone. Unnamed island northwest of Sheep Island, photo bc21_gi_11231.

Figure 83. Good example of Salt Marsh (SAMB) bioband in the supratidal/intertidal zone. Walker Hook, Saltspring Island, photo bc21_gi_06362.

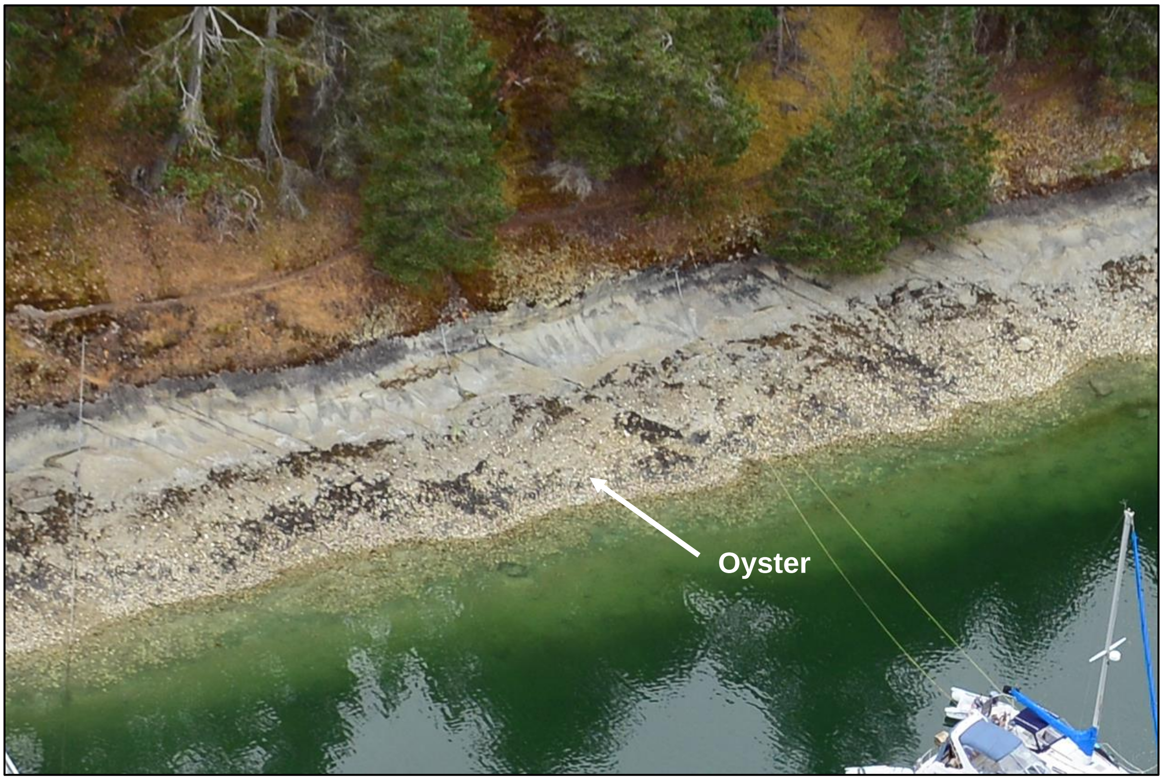

Figure 84. Good example of the white spots of the Oyster (OYST) bioband. Pirate's Cove Marine Provincial Park, De Courcy Island, photo bc21_gi_08245.

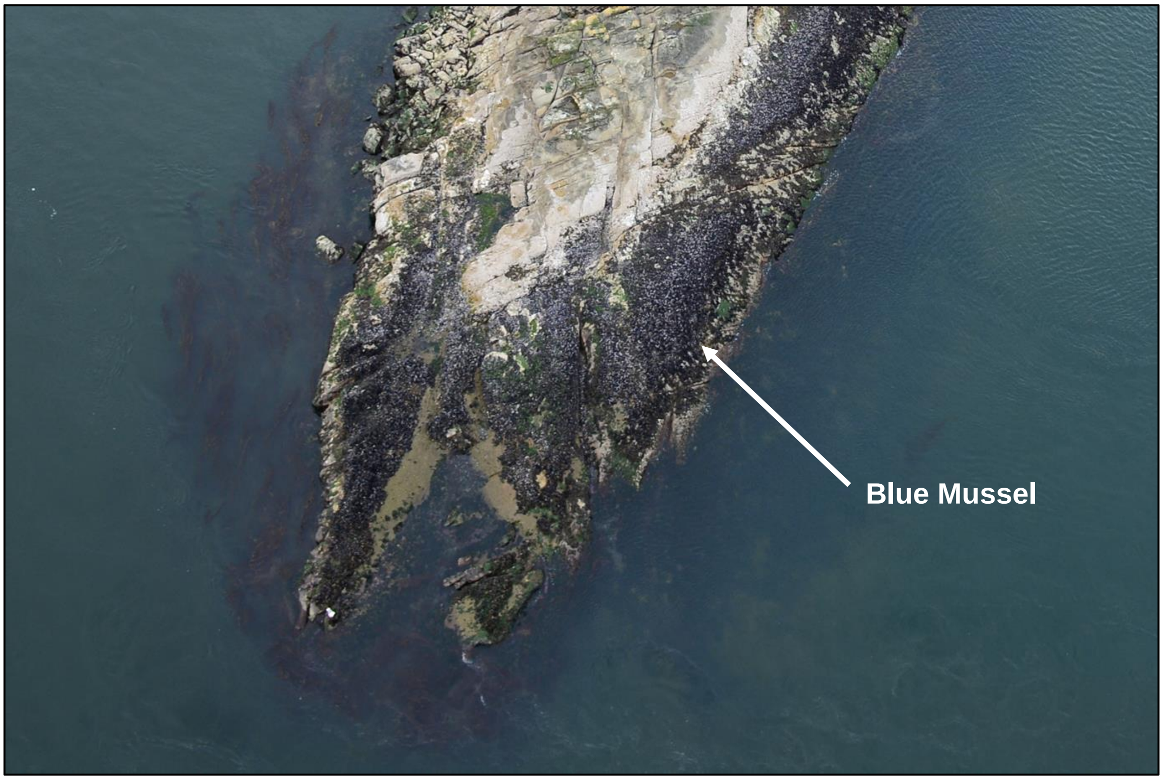

Figure 85. Good example of the black Blue Mussel (BLMU) bioband in the mid-intertidal. South end of Valdes Island, photo bc21_gi_07032.

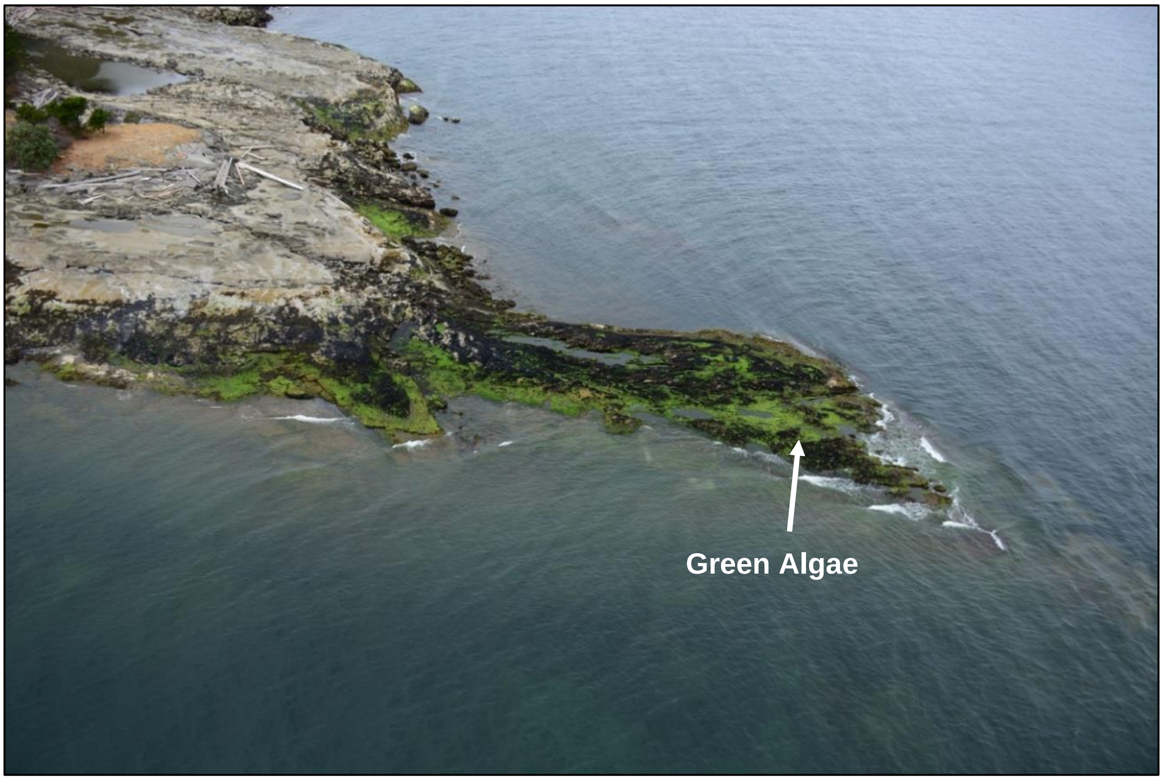

Figure 86. Good example of the Green Algae (GRAL) bioband in the lower intertidal. Gaviola Island, photo bc21_gi_07619.

Figure 87. Good example of the Echinoderm (ECHI) bioband which was all *Pistaster* sp. in this image. Eastern side of Valdes Island, photo bc21_gi_07162.

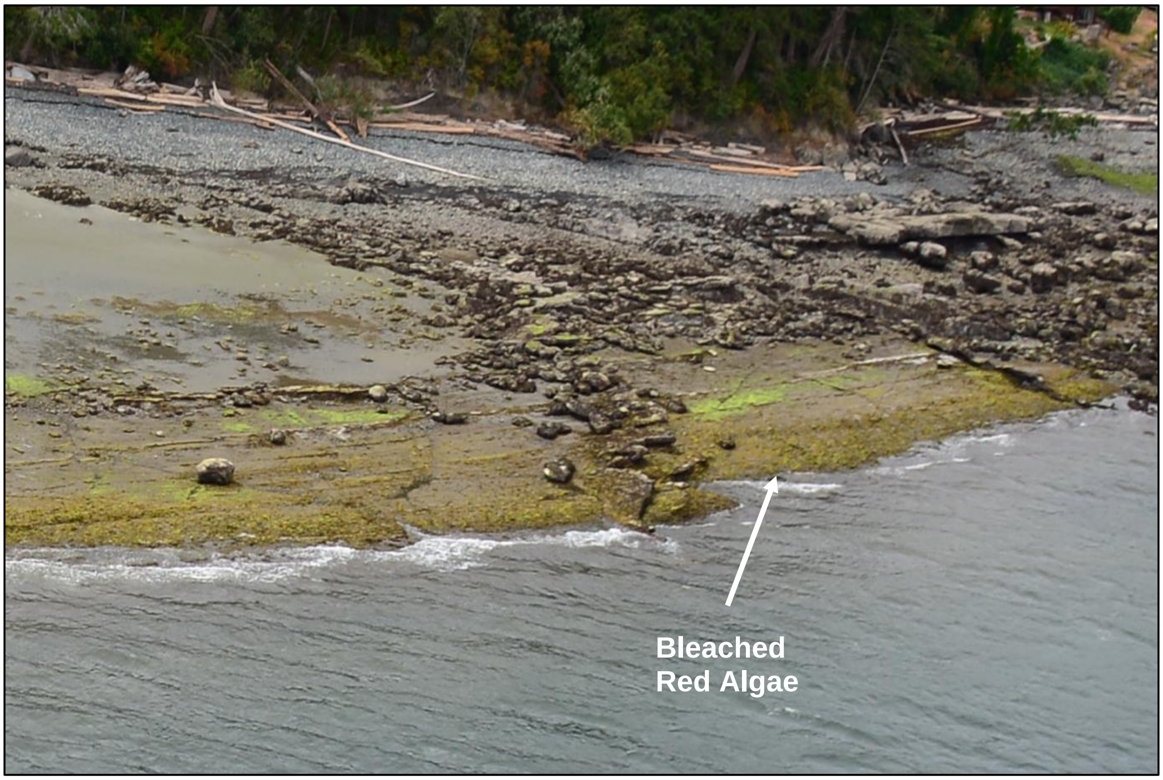

Figure 88. Good example of the golden Bleached Red Algae (BRAL) bioband in the lower intertidal. Gabriola Island, photo bc21_gi_07787.

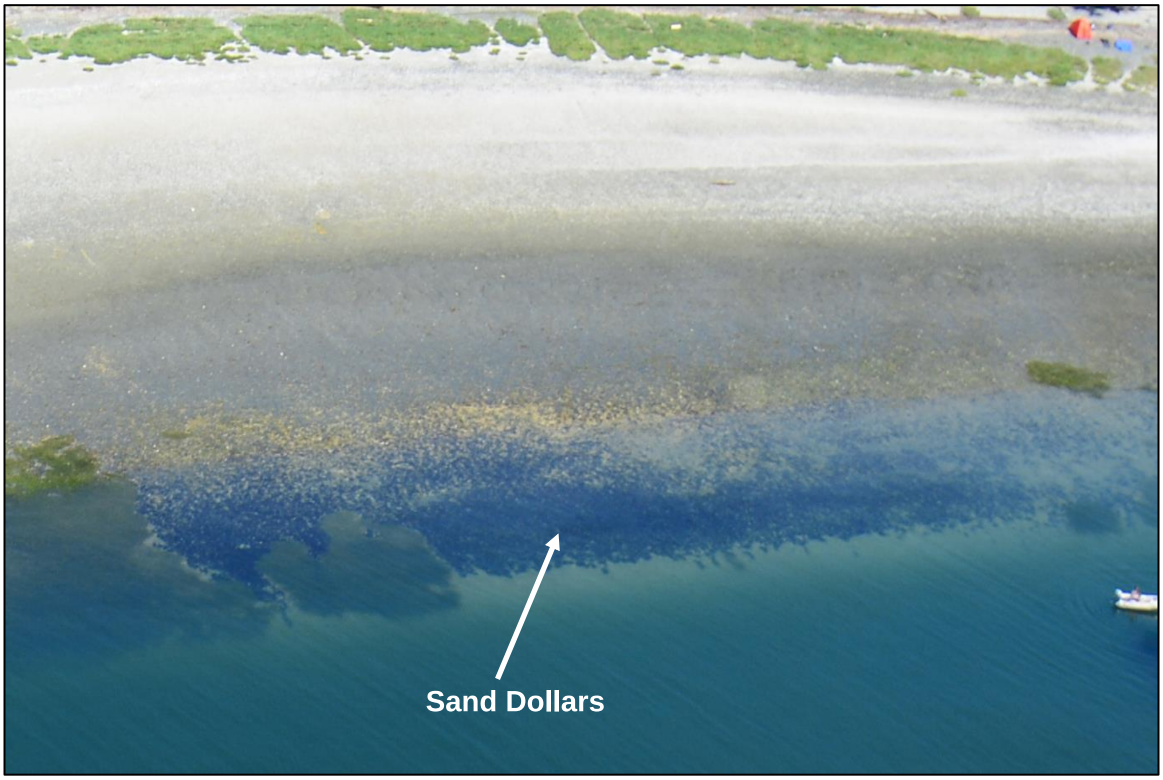

Figure 89. Good example of the Sand dollar (SAND) bioband in the subtidal. Sandy Island Marine Provincial Park, Denman Island, photo bc21_gi_09118.

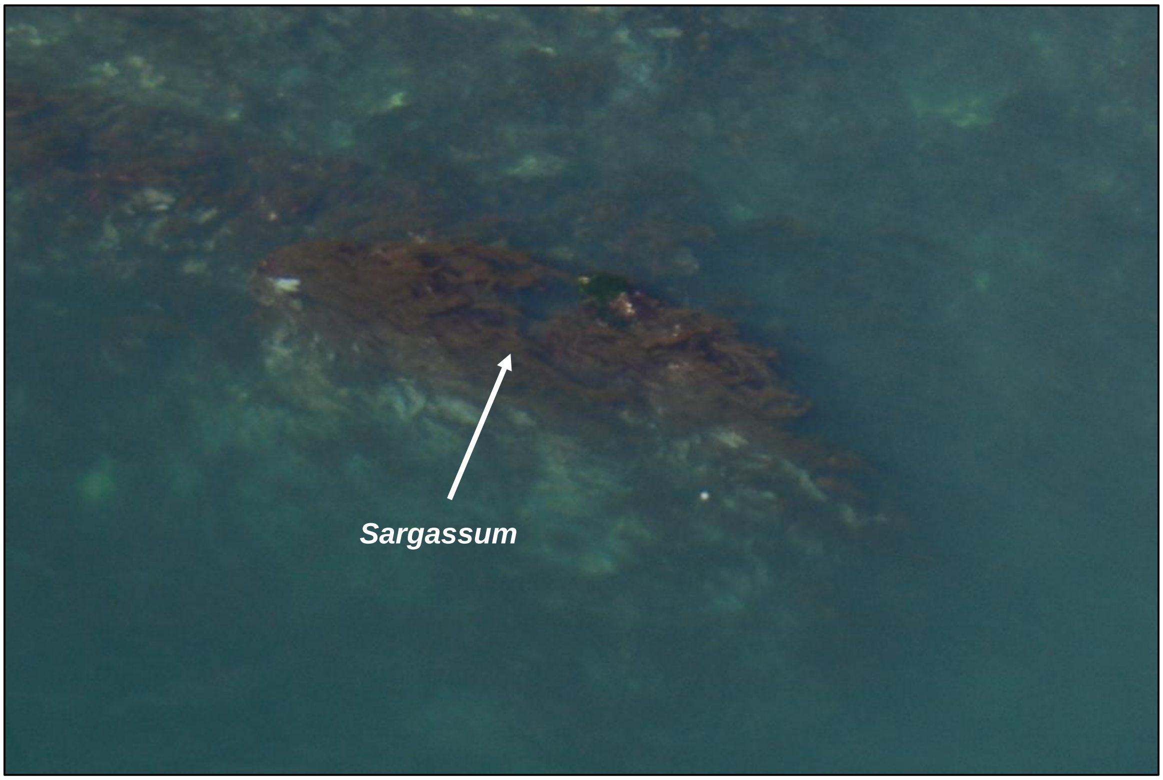

Figure 90. Good example of the fluffy, floating *Sargassum* (SARG) bioband. Brethour Island, photo bc21_gi_11162.

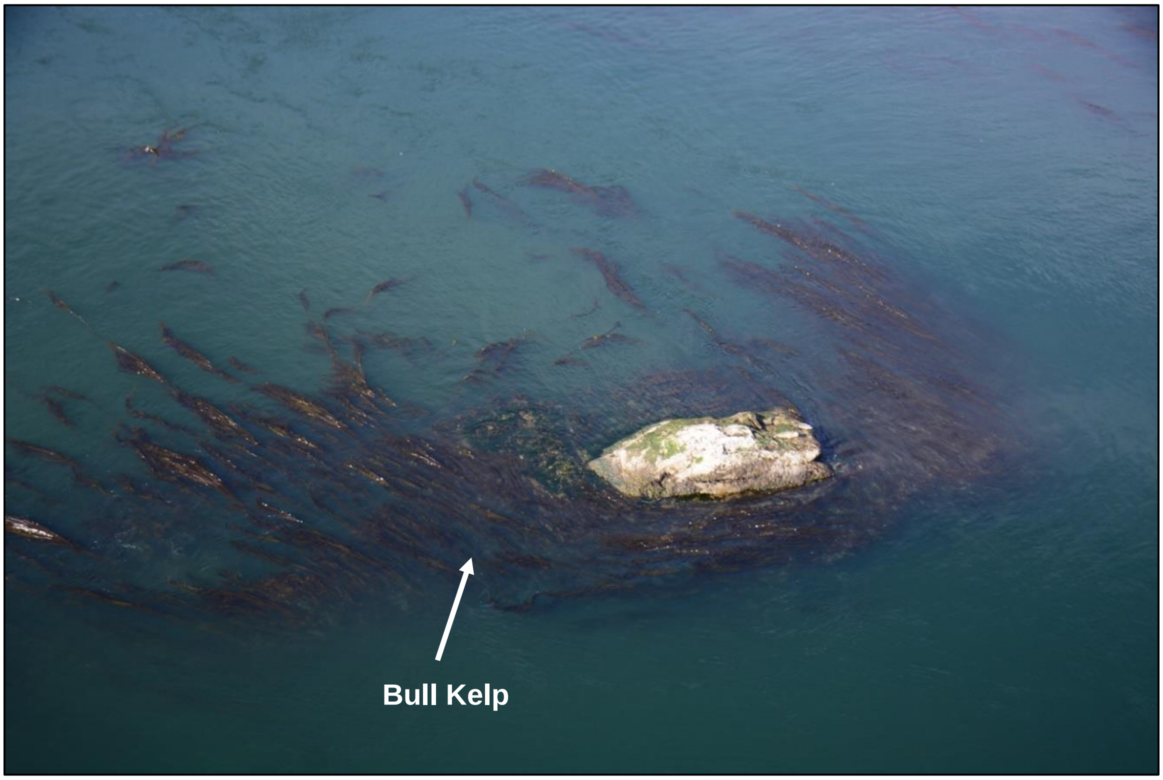

Figure 91. Good example of the Bull Kelp (BUKE) bioband in the nearshore. Forrest Island, photo bc21_gi_11299.

The Oyster bioband tends to be unusual in BC and is generally only seen where concentrations of the introduced Pacific Oyster (*Magallana gigas*) are visible from the aerial imagery. This was generally noted to occur in areas where there is or has been oyster aquaculture, with a concentration of observations around most of the Gulf Islands, most especially Salt Spring Island, as well as in both Jervis Inlet and Okeover Arm adjacent to Desolation Sound. Figures 92 and 93 show a graph of the proportion of the shoreline with the Oyster and Mussel biobands respectively, and a map of the distribution of the two bioband is in Figure 94.

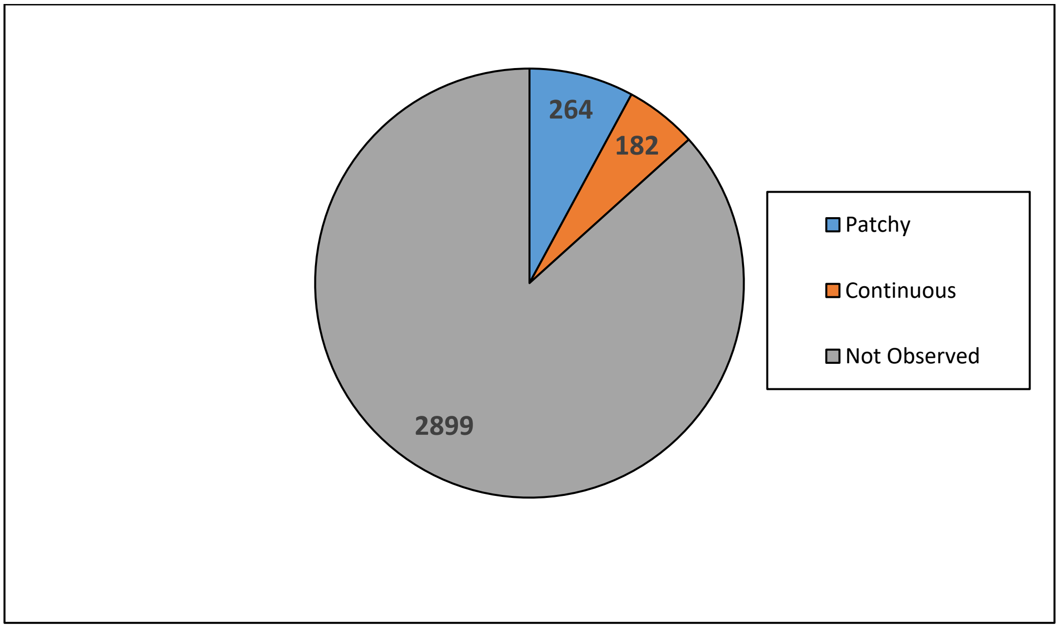

Figure 92. Proportion of shoreline length (km) of the intertidal Oyster (OYST).

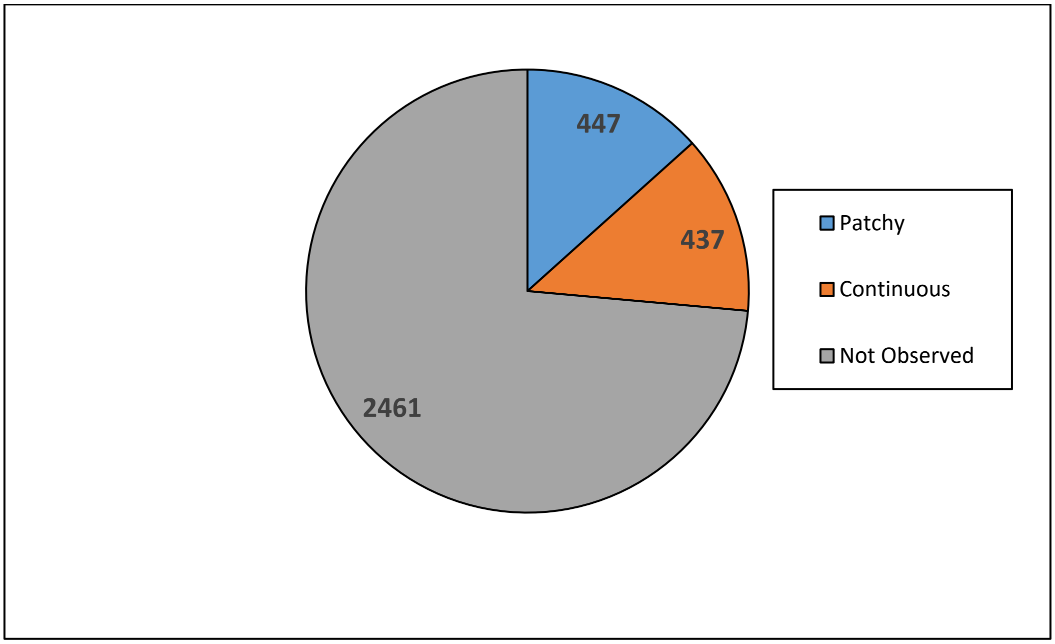

Figure 93. Proportion of shoreline length (km) of the intertidal Blue Mussel (BLMU).

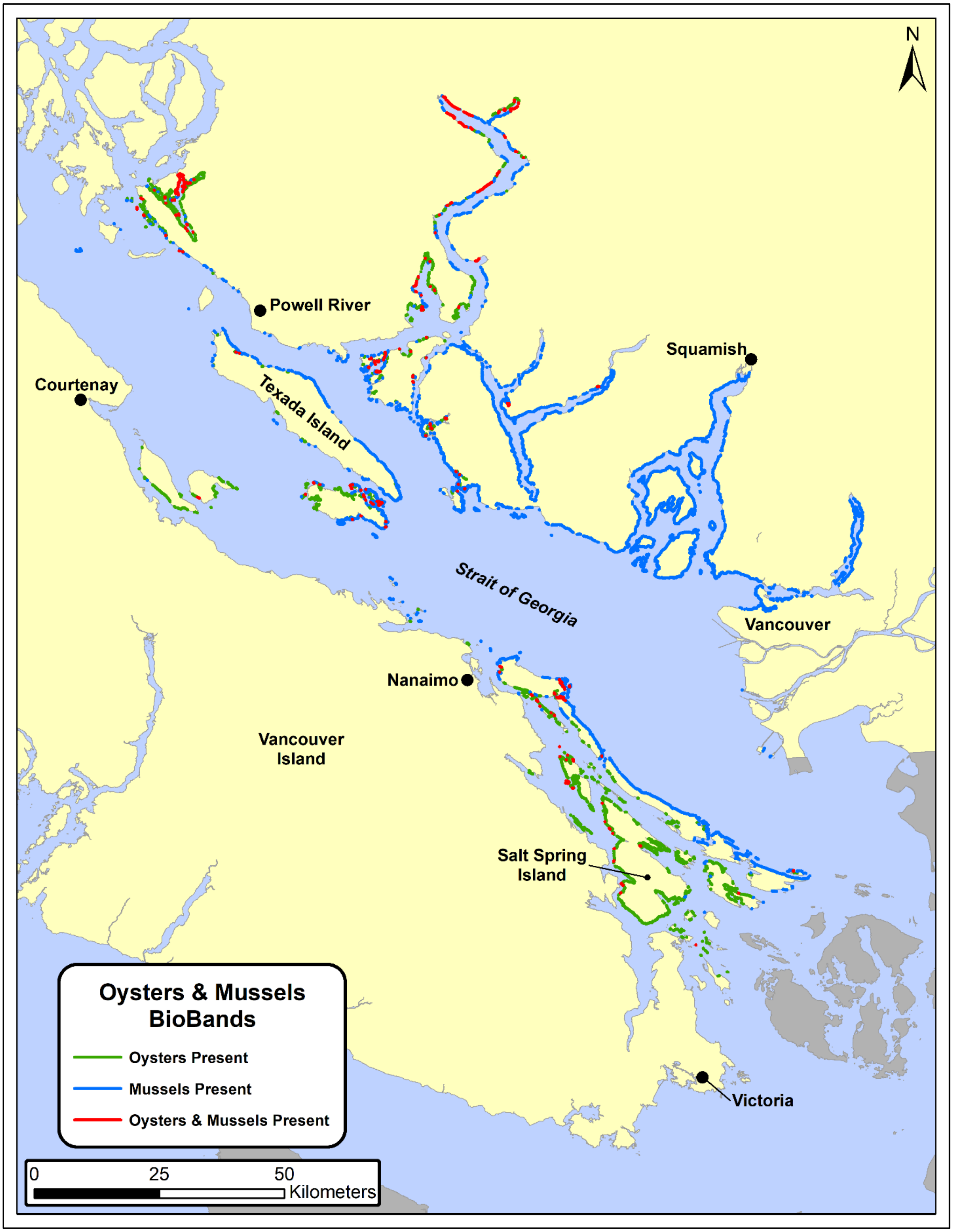

Figure 94. Distribution of the Oyster (OYST) and Blue Mussel (BLMU) biobands in the Salish Sea.

Seagrasses are an important component of coastal ecosystems with Eelgrass beds forming in sandy substrate at Semi-Protected and lower exposures. See Figure 95 for statistics on the distribution of the Eelgrass bioband and a distribution map in Figure 96. It should be noted that Surfgrass was not observed in the Salish Sea due to lower wave exposures.

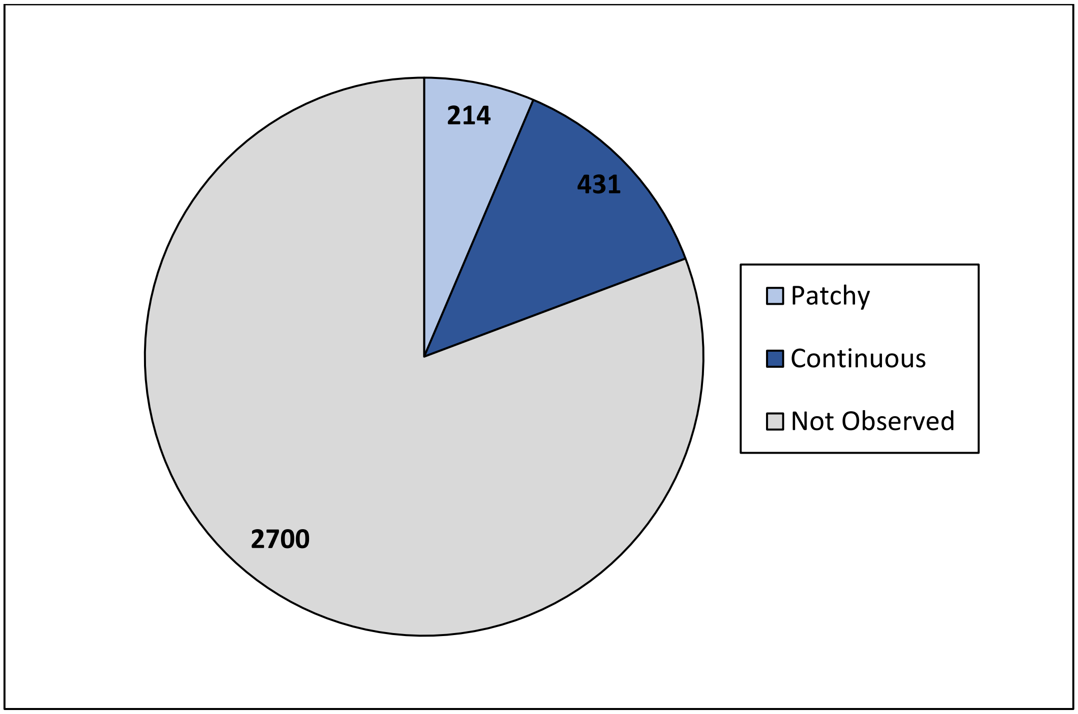

Figure 95. Distribution of the intertidal/subtidal Eelgrass bioband by shoreline length (km).

Figure 96. Distribution of the Eelgrass (EELG) bioband in the Salish Sea.

Canopy kelps form valuable habitat for fish, invertebrates, and other algae and are an important part of a healthy coastline and healthy fisheries. Bull Kelp (*Nereocystis leutkeana*) was the only canopy kelp noted in the survey area, in 10% of the length of surveyed area. It was generally present in the more protected coastline. See Figure 97 for statistics on the distribution of the bull kelp and a distribution map in Figure 98.

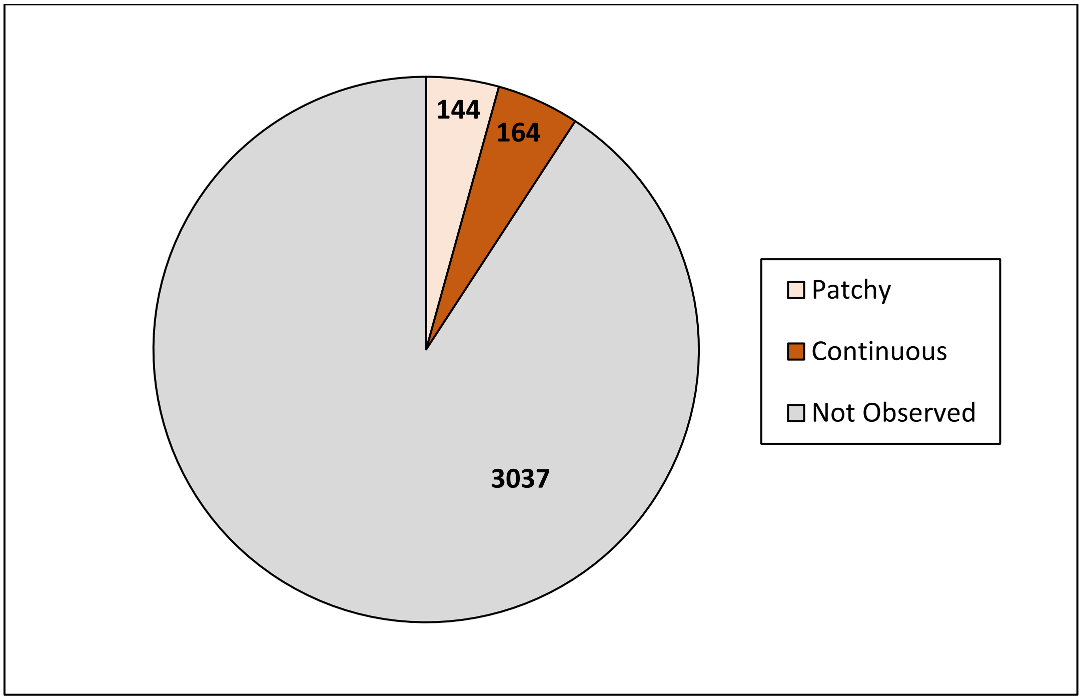

Figure 97. Distribution of the Bull Kelp (BUKE) bioband by shoreline length (km).

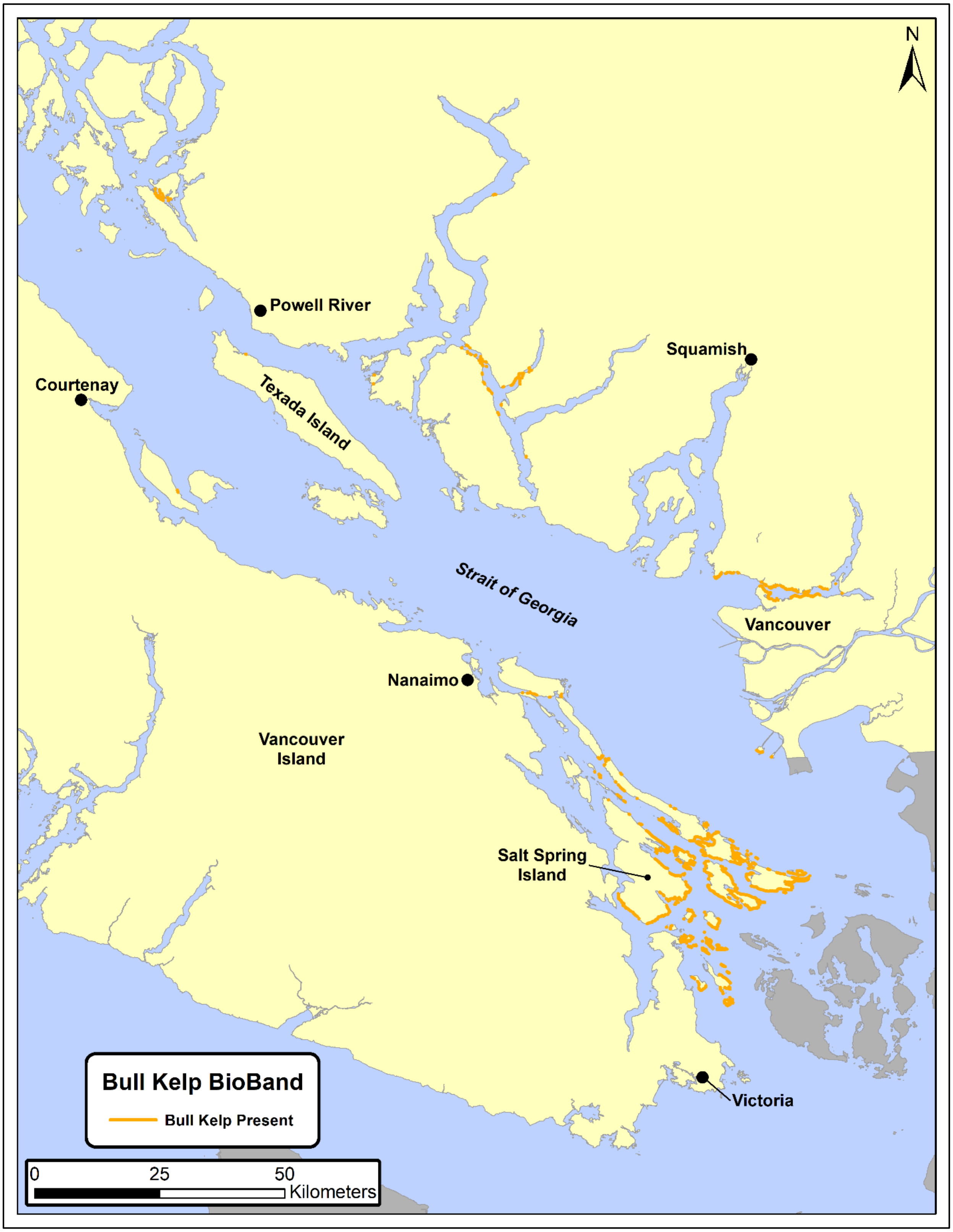

Figure 98. Distribution of the Bull Kelp (BUKE) bioband in the Salish Sea.

Sargassum and Bladed Brown Algae were two of the brown algae biobands observed in the Salish Sea. See Figure 99 for statistics on the distribution of *Sargassum* with a distribution map in Figure 100. The *Sargassum* bioband is defined by the presence of Japanese Wireweed (*Sargassum muticum*). The *Sargassum* band was observed in 33% of the units although it is possible much of the Brown Bladed Kelp that was recorded was *Sargassum* (or other kelps mixed with *Sargassum*) as there were areas where browns could be observed in the subtidal but not enough detail could be seen to determine if *Sargassum* was present. It can therefore be assumed it was more widely distributed than indicated by the ShoreZone mapping. There is significant literature available on the impacts of introduced Japanese Wireweed with somewhat conflicting conclusions, as some studies found negative impacts on native species (DeWreede and Vandermeulen, 1988; Britton-Simmons, 2004) while others have found little to no impacts (Sanchez and Fernandez, 2005; Olabarria et al., 2009). White (2003) studied the effects of *S. muticum* on macroalgal communities and grazing invertebrates in BC and found that the effects of introduction were both density and time dependent and were mediated through competition for light.

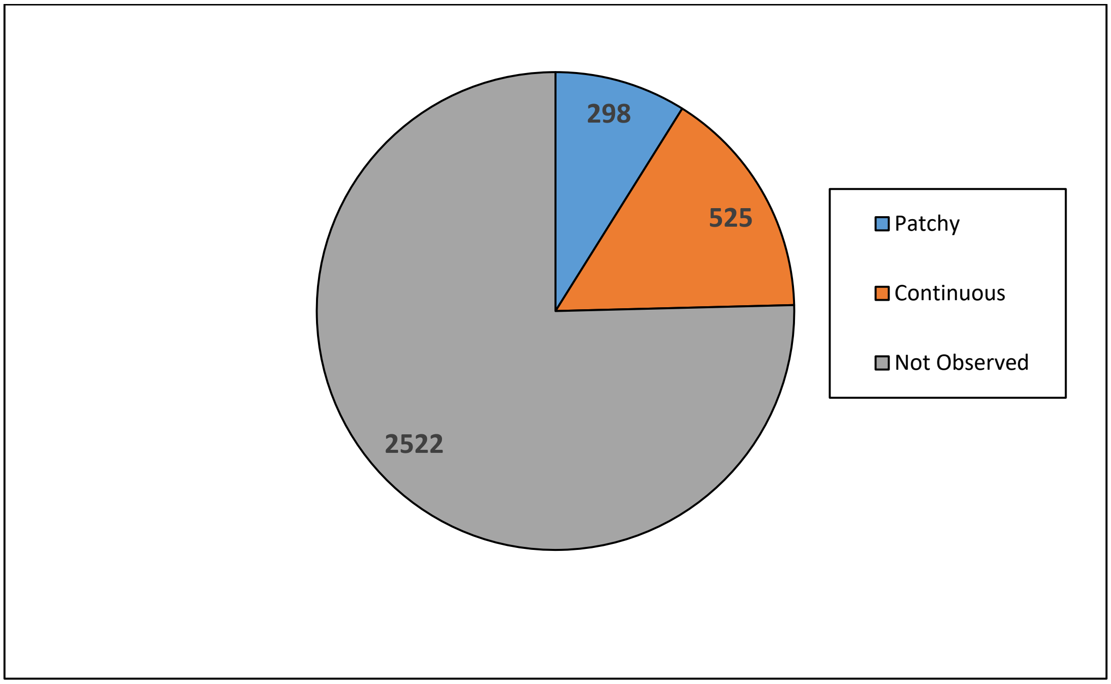

Figure 99. Distribution of the *Sargassum* (SARG) bioband by shoreline length (km).

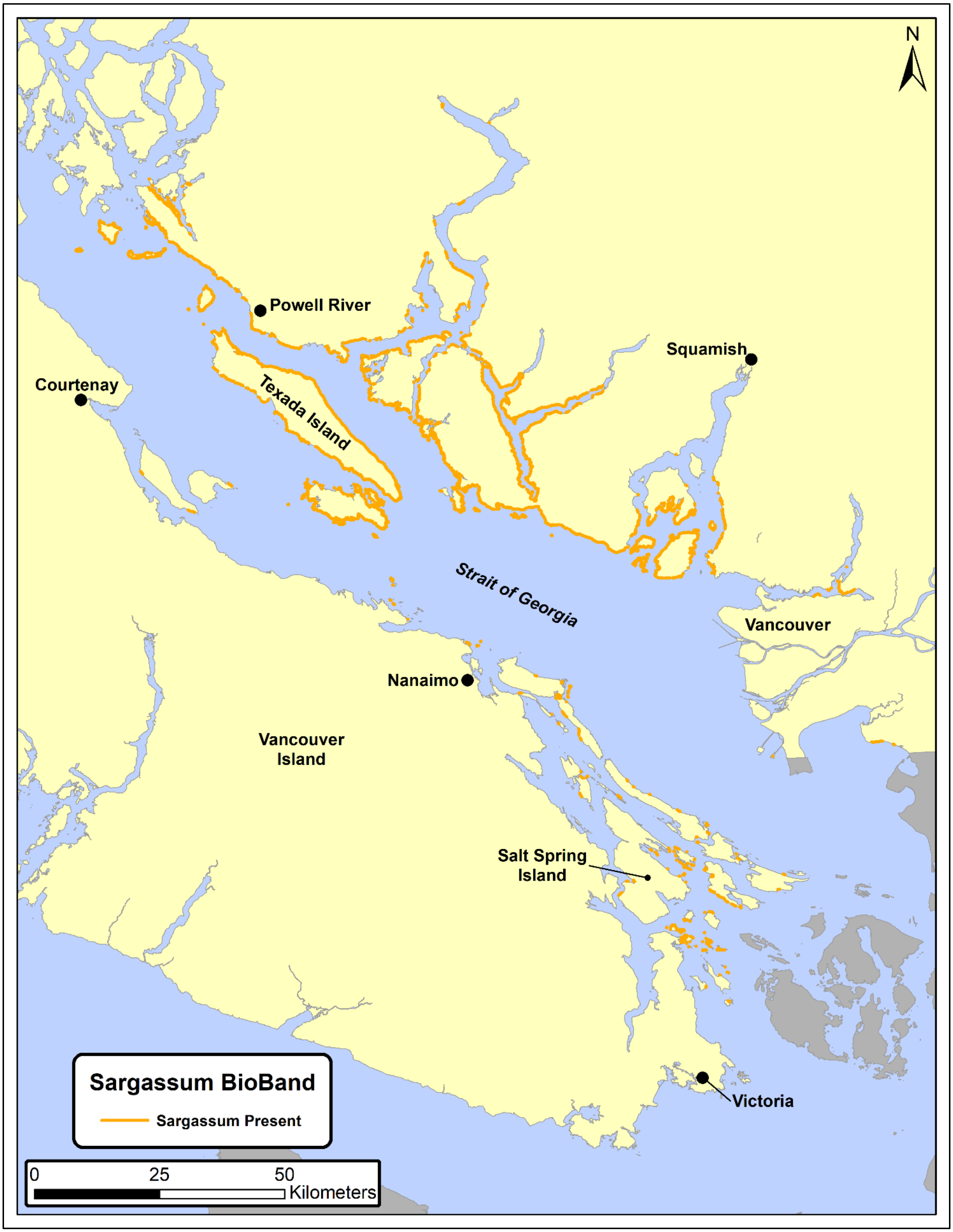

Figure 100. Distribution of the *Sargassum* (SARG) in the Salish Sea.

5 BRITISH COLUMBIA COASTWIDE SUMMARY

5.1 Introduction

The ShoreZone imaging surveys conducted in British Columbia from 1979 to 2000 collected aerial video and digital still images of the coast during minus tides (zero-meter tide levels and lower). The imagery and associated audio commentary were used to map the physical and biological attributes of the shoreline using the old ShoreZone coastal habitat mapping protocol (Howes et al., 1993). From 2014 to 2021, further ShoreZone imaging occurred and approximately 9% of this new mapping was mapped based on the 2014 ShoreZone coastal habitat mapping protocol (Harper et al., 2014) while the rest was mapped according to the most recent ShoreZone coastal habitat mapping protocol (Cook et al., 2017). Although we are summarizing all the data together from the different mapping protocols, it represents a long-time span and not all the data will be representative of current conditions. The purpose of this report is to provide a summary of the physical and biological data imaged and classified throughout the entire coast of British Columbia. Please see the Acknowledgments section included in this report for the imaging and mapping funding partners in British Columbia.

The length of shoreline mapped is **37,083 kilometers** in **89,552 along-shore segments** (units), averaging 415 m in length. The digital shoreline used for the ShoreZone habitat mapping was the CHS_Highwaterline_BCalbers.shp.

5.2 Coastal Class

Throughout all British Columbia, Rock and Sediment shorelines (35.2%) were prominent along with Rock shorelines (34.4%) and Sediment shorelines (23.1%). Riparian, Glacial, Anthropogenic, Current, and Lagoon shorelines all comprised the rest of the coast (Figures 101-104). The description for each Coastal Class category in the survey area is given in Table 9.

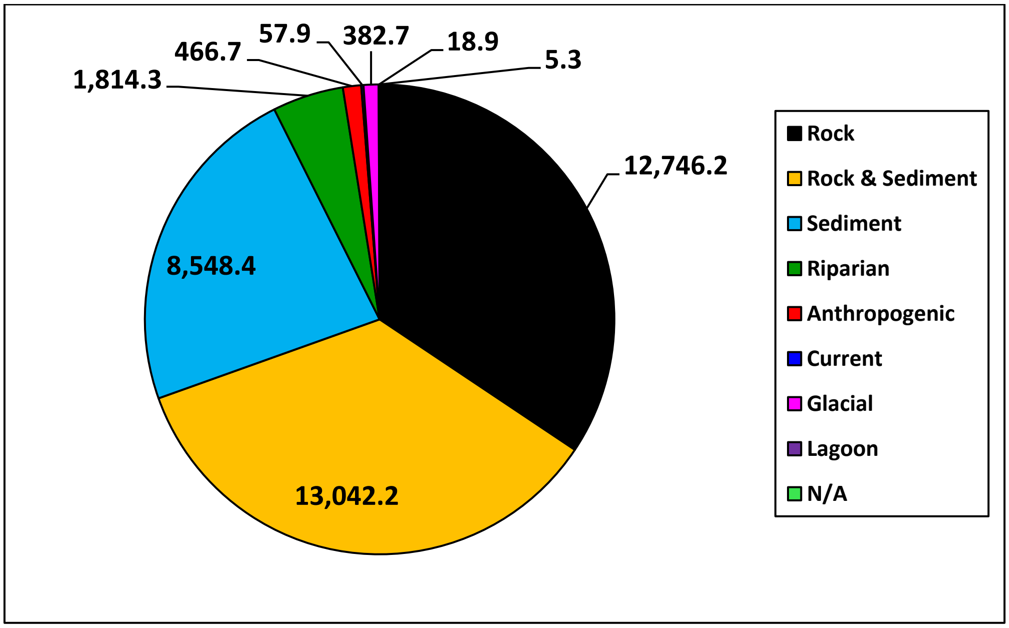

Figure 101. Grouped Coastal Class categories by shoreline length (km).

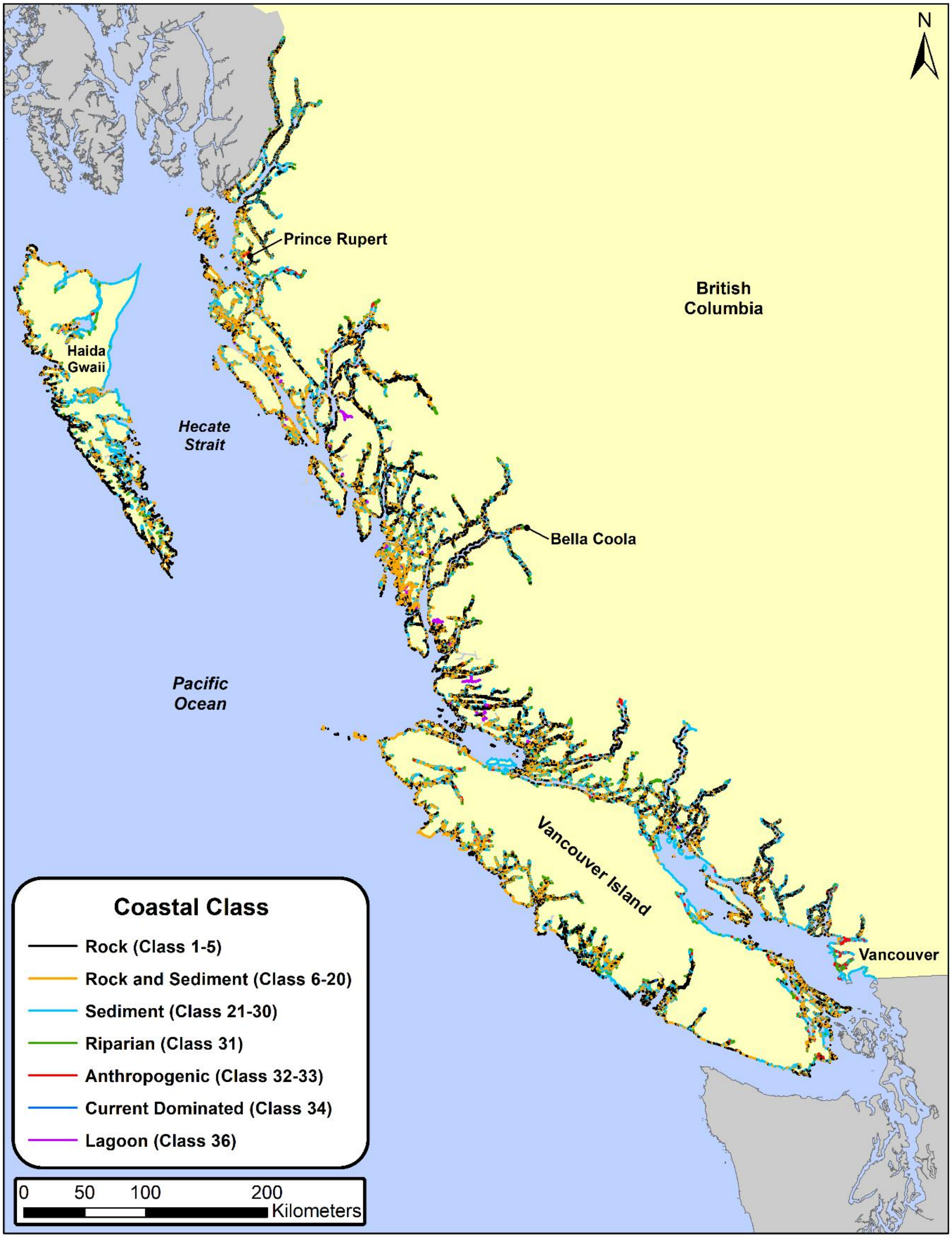

Figure 102. Map of the Coastal Class categories grouped by type (also known as Shore Type).

Figure 103. Example of Coastal Class 24; Sand & gravel flat or fan. King Passage, photo bc21_nk_00268.

Figure 104. Example of Coastal Class 27; Sand beach. Burdwood Point, photo bc21_nk_00563.

Table 9. Summary of Coastal Classes classified in British Columbia.

Substrate Type	Coastal Class		Sum of Unit Length (km)	# of Units	Cumulative Occurrence (km, %)
	No.	Description			
Rock	1	Rock Ramp, wide	733	924	**12,752 km 34%**
	2	Rock Platform, wide	514	834	
	3	Rock Cliff	8,082	19,136	
	4	Rock Ramp, narrow	3,251	7,803	
	5	Rock Platform, narrow	166	293	
Rock & Sediment	6	Ramp w gravel beach, narrow	320	753	**13,042 km 35%**
	7	Platform w gravel beach, wide	607	902	
	8	Cliff with gravel beach	1,262	5,105	
	9	Ramp with gravel beach	4,853	11,386	
	10	Platform with gravel beach	294	663	
	11	Ramp w gravel & sand beach, wide	723	2,748	
	12	Platform with G&S beach, wide	1,621	3,316	
	13	Cliff with gravel/sand beach	253	1,619	
	14	Ramp with gravel/sand beach	2,300	6,886	
	15	Platform with gravel/sand beach	334	649	
	16	Ramp w sand beach, wide	89	215	
	17	Platform w sand beach, wide	198	336	
	18	Cliff with sand beach	41	132	
	19	Ramp with sand beach, narrow	110	227	
	20	Platform w sand beach, narrow	37	58	
Sediment	21	Gravel flat, wide	182	354	**8,548 km 23%**
	22	Gravel beach, narrow	1,282	4,429	
	23	Gravel flat or fan	44	150	
	24	Sand & gravel flat or fan	2,744	6,462	
	25	Sand & gravel beach, narrow	1,892	6,582	
	26	Sand & gravel flat or fan	320	959	
	27	Sand beach	336	386	
	28	Sand flat	1,330	1,941	
	29	Mudflat	237	421	
	30	Sand beach	179	476	
Organics	31	Organics/Estuarine	1,814	1,659	**1,814 km (5%)**
Man-made	32	Man-made, permeable	431	1,288	**467 km (1%)**
	33	Man-made, impermeable	36	137	
Current	34	Channel	58	115	**58 km (<1%)**
Glacial	35	Glacial	383	154	**383 km (1%)**
Lagoon	36	Lagoon	19	41	**19 km (<1%)**
N/A		Coastal class can not be assigned (likely due to poor or a lack of imagery)	5	13	**5 km (<1%)**
		Totals:	***37,083***	***89,552***	***100%***

5.3 Physical Wave Exposure

The Physical wave exposure categories range from Very Protected (VP) to Very Exposed (VE) and are defined in ShoreZone based on fetch length, which is the distance the wind travels over water, unobstructed.

The majority of the British Columbia coastline is represented by the lower to moderate wave exposures (Very Protected to Semi-Protected), which account for 80.4% of shoreline length. At the other end of the spectrum, only 19.6% of the shoreline was mapped with high exposures, Semi-Exposed to Very Exposed (Figures 105 and 106).

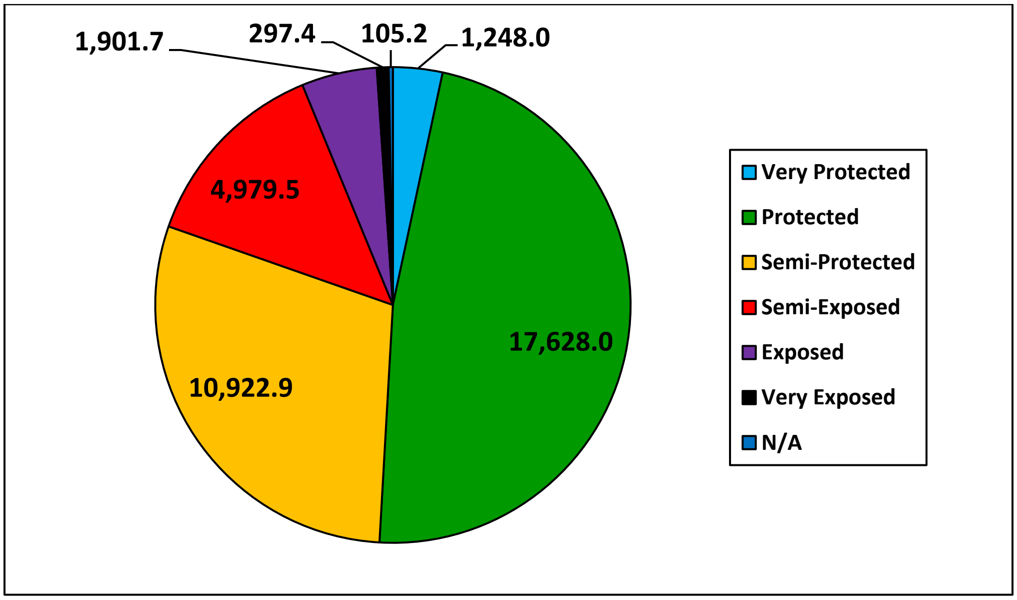

Figure 105. Physical Wave Exposure by shoreline length (km).

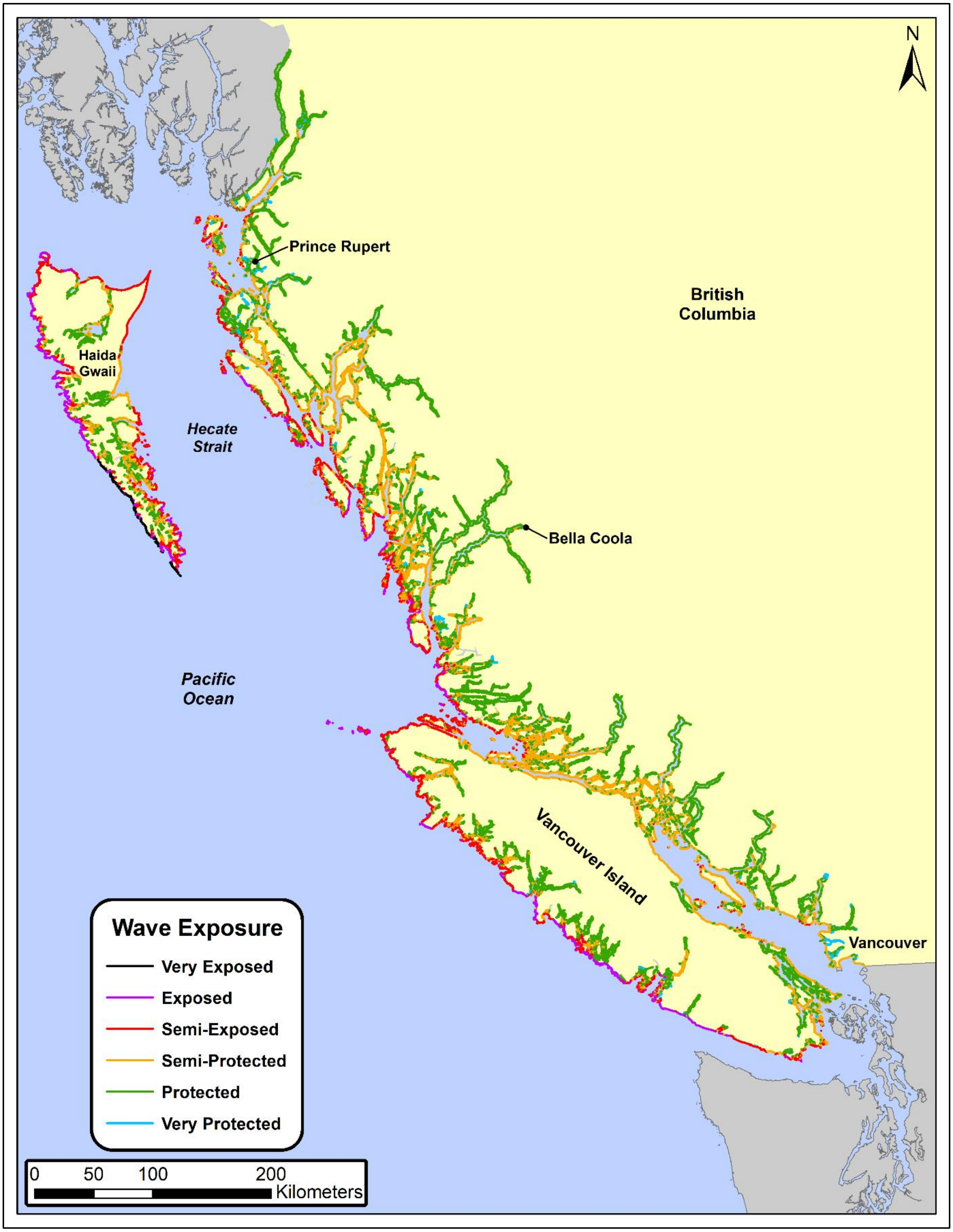

Figure 106. Distribution of the Physical Wave Exposure categories in British Columbia.

5.4 Oil Residence Index

In British Columbia, lower wave exposures and mobile sediments lead to higher ORI values for 57.6% of the shore segments, indicating oil residence times are on the order of months to years (Figures 107 and 108).

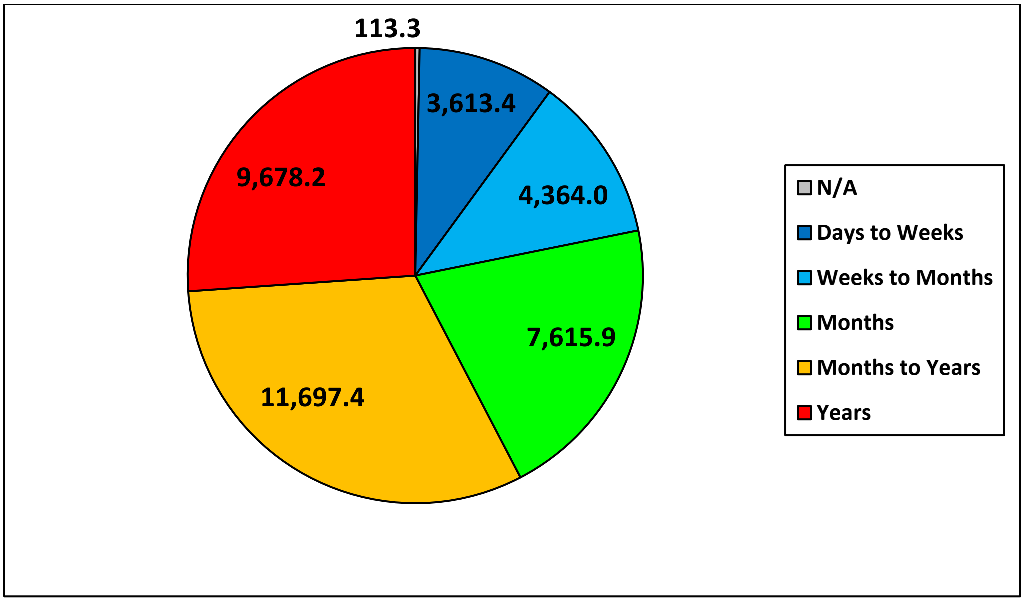

Figure 107. Oil Residence Index (ORI) categories by shoreline length (km).

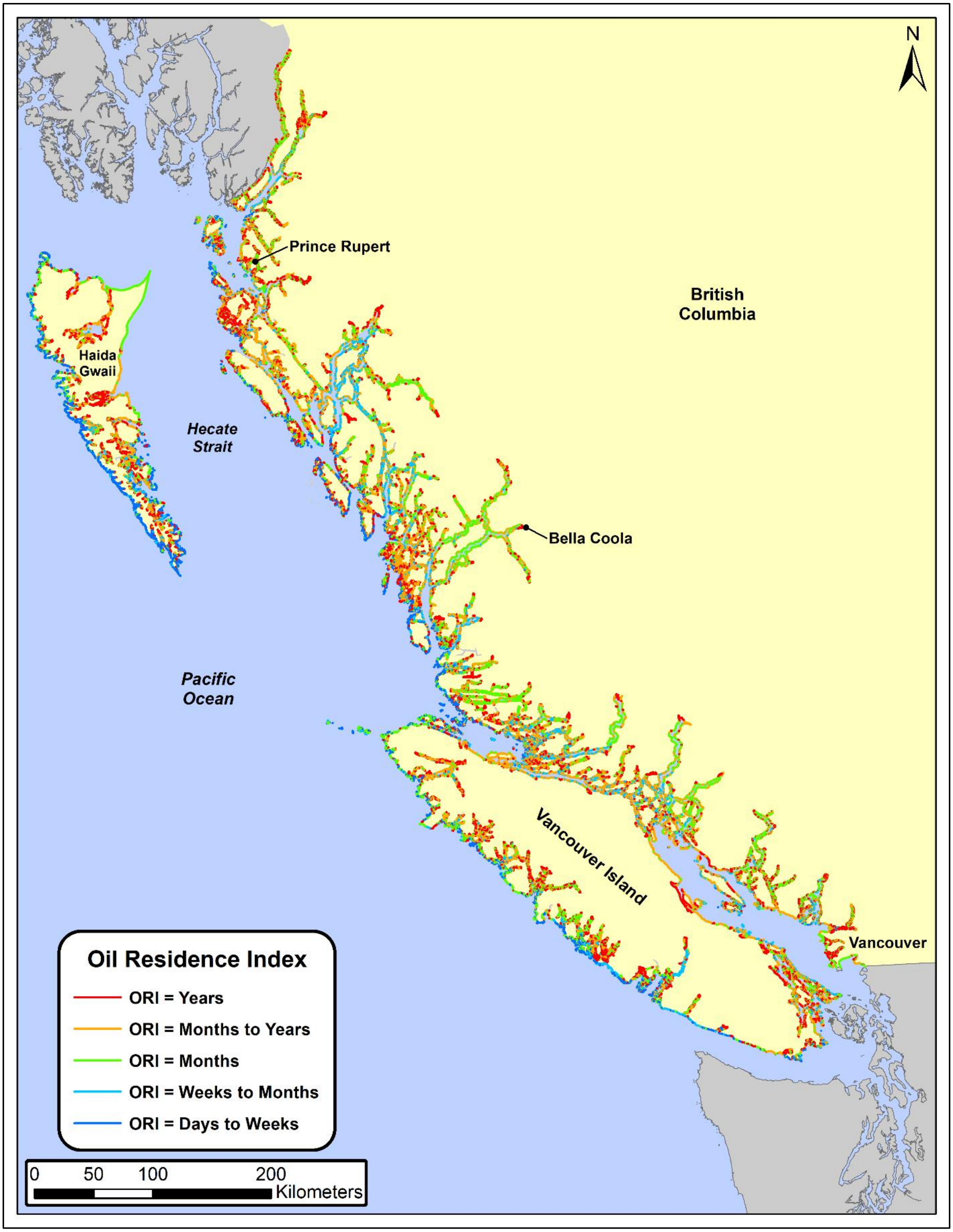

Figure 108. Distribution of the Oil Residence Index (ORI) categories.

5.5 Biological Wave Exposure

The distribution of the wave exposure categories mapped in British Columbia are summarized in Figure 109 and a distribution map of the categories is shown in Figure 110. The majority of British Columbia coastline (81%) was in the lower to moderate wave exposures (Very Protected to Semi-Protected), with most of that Protected (49%).

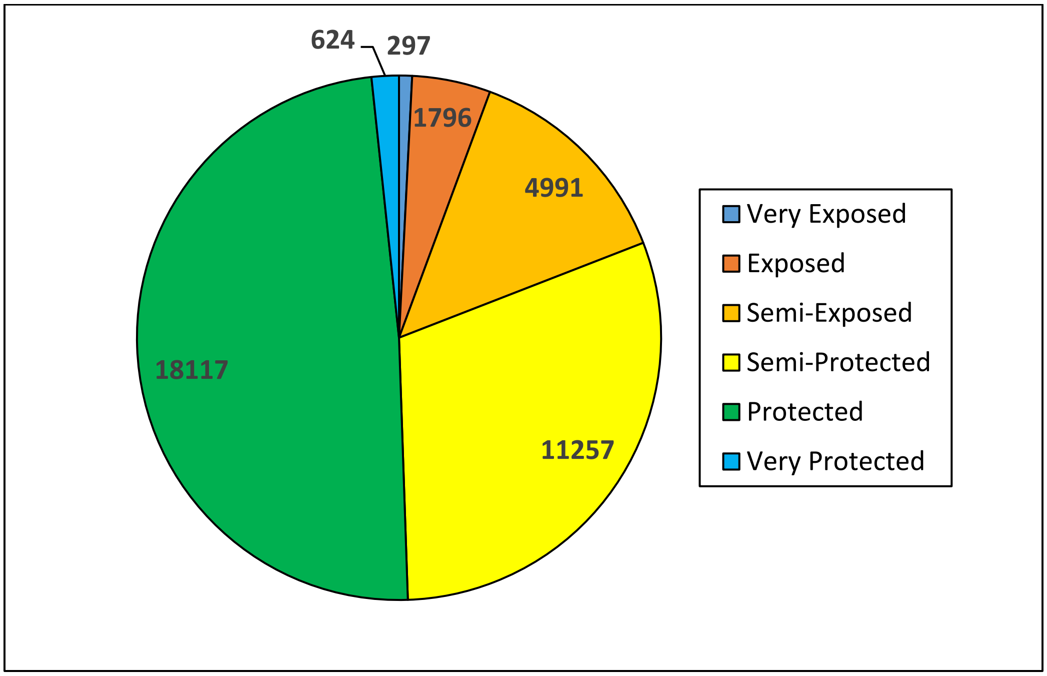

Figure 109. Distribution of Biological Wave Exposures mapped in British Columbia.

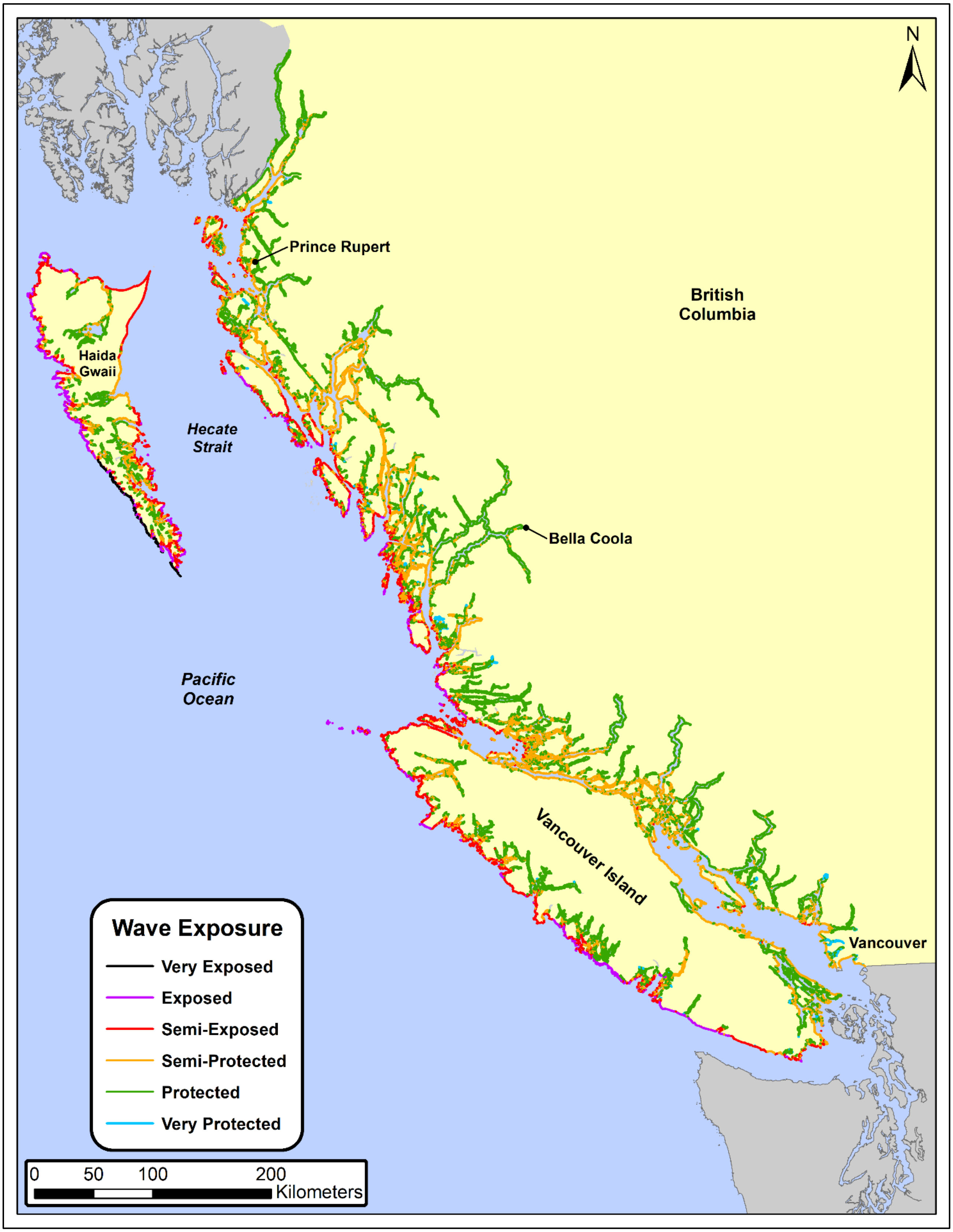

Figure 110. Distribution of the Biological Wave Exposure in British Columbia.

5.6 Biobands

In 2017, interpretation protocols along imaging technology had advanced to the point where some of the old biobands no longer accurately represented what could be seen in the imagery. These biobands were then split into new biobands that are visually distinct. For example, the pre-2017 Red Algae bioband (RED) was split into Filamentous and Foliose Red Algae (FFRA) and Coralline Red Algae (CORA). Figure 111 was taken in 1993 and Figure 112 was taken in 2021. The difference in technology can be easily visualized in a comparison between the two photos. Figure 111 shows that the red color is visible but making a distinction between Coralline Red Algae or Filamentous and Foliose Red Algae would be difficult while Figure 112 exemplifies how the red color and foliose texture are visible in this image at full resolution. The photo quality in Figure 113 is a higher quality and it is easy to make out patches of Coralline Algae just above the Dark Brown Kelp bioband.

To make the bioband data more comparable between the data collected under the older and newer protocols, some rolling up of bioband categories was necessary. A summary of which biobands were combined can be found in Table 10. Some of the new biobands were not visible (such as Echinoderms) or were not recorded (such as White Lichen) in the historical imagery and so do not have a historical equivalent. These biobands are not reported in the coastwide summary (Table 11).

Figure 111. Red Algae (RED) bioband in historical imagery. Photo WCoast93_06_0015: Tzartus Island.

Figure 112. Filamentous and Foliose Red Algae bioband (FFRA). Photo bc_21_bf_00664: Tzartus Island.

Figure 113. Coralline Red Algae (CORA) in the lower intertidal. Photo bc21_bf_02800: East of Darling River.

Table 10. Biobands combined for historical compatibility.

Combined Bioband	Distinct Biobands
Red Algae (REAL)	FFRA & CORA
Brown Bladed Algae (BRBA)	BRBA, DABK & SOBK
Mussels (MUSS)	BLMU & CAMU
Salt Marsh (SAMB)	SAMB & SEDG

Table 11. Biobands excluded for historical compatibility.

Unreported Biobands	
Echinoderms (ECHI)	Terrestrial Vegetation (TEVE)
Sargassum (SARG)	Trees and Shrubs (TRSH)
Alaria (ALAR)	Deciduous Trees (DETR)
Biofilm (BIOF)	Coniferous Trees (COTR)
Cnidarians (CNID)	Anemones (ANEM)
Sand Dollars (SAND)	White Lichen (WHLI)
Sponges (SPON)	Yellow Lichen (YELI)

Biobands mapped in British Columbia are summarized in Tables 12 and 13 and examples of some of the biobands from British Columbia are shown in Figures 114-118. The most commonly occurring intertidal bioband in the survey area was Rockweed identified in 78% of units. Green Algae and Barnacle were also common and were found in 57% and 49% of units, respectively. The most common supratidal bioband was Black Lichen, occurring in 87% of the units, while the supratidal/high intertidal Salt Marsh bioband was found in only 22% of units. The most common low intertidal/subtidal biobands were Brown Bladed Kelps (47%) and Red Algae (36%). Distribution maps, statistics, and observations about some specific biobands are found in the following pages.

Table 12. Bioband abundances for non-splash zone biobands mapped in British Columbia.

Bioband			Patchy		Continuous		Total (km)	% of Total Mapped
Name	**Code**	**Old Code**	**(km)**	**%**	**(km)**	**%**		
Dune Grass	DUGR	GRA	787	2	176	0	963	3
Salt Marsh	SAMB	SAL/SED	4676	13	3443	9	8119	22
Barnacle	BARN	BAR	7270	20	11046	30	18316	49
Rockweed	ROCK	FUC	15463	42	13473	36	28936	78
Green Algae	GRAL	ULV	12918	35	8162	22	21080	57
Mussels	MUSS	MUS/BMU	4444	12	2886	8	7329	20
Brown Bladed Kelps	BRBA	CHB/SBR	8043	22	9337	25	17380	47
Bleached Red Algae	BRAL	HAL	872	2	584	2	1457	4
Surfgrass	SURF	SUR	3114	8	1186	3	4301	12
Eelgrass	EELG	ZOS	3778	10	2230	6	6009	16
Bull Kelp	BUKE	NER	5362	14	3083	8	8445	23
Giant Kelp	GIKE	MAC	1900	5	1500	4	3399	9
Urchin Barrens	URBA	URC	2119	6	2072	6	4190	11
Oysters	OYST	OYS	453	1	270	1	723	2
Diatoms	DIAT	DIA	877	2	1092	3	1969	5
Red Algae	REAL	RED	6016	16	7457	20	13473	36

Table 13. Bioband abundances for splash zone biobands mapped in British Columbia.

Bioband		Narrow (<1m)		Medium (1-5m)		Wide (>5m)		Total (km)	% of Total Mapped
Name	**Code**	**(km)**	**%**	**(km)**	**%**	**(km)**	**%**		
Black Lichen	BLLI	22909	62	6503	18	3035	8	32447	87

Figure 114. Good example of Dark Brown Kelps (DABK) at the waterline. Fleming Island, photo bc21_bf_00988.

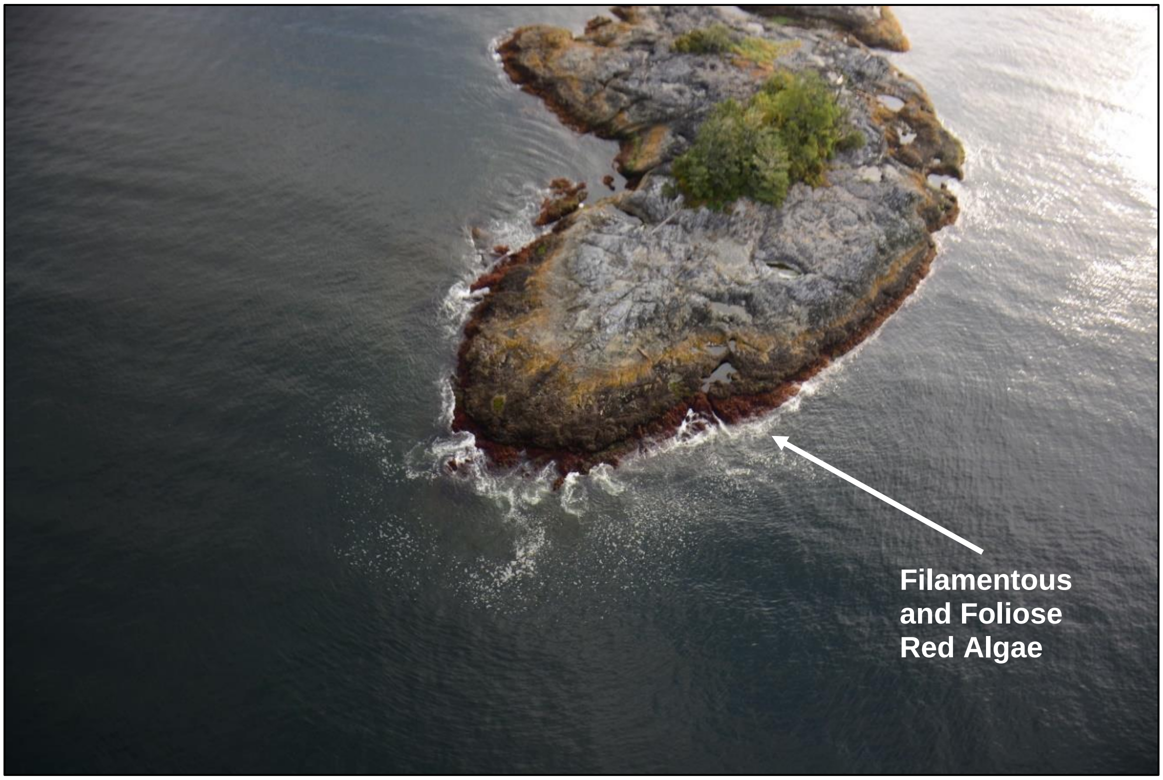

Figure 115. Good example of the Filamentous and Foliose Red Algae (FFRA) bioband in the lower intertidal. Meade Islets, photo bc21_01037.

Figure 116. Good example of the Coralline Red Algae (CORA) in the lower intertidal. East of Darling River, photo bc21_bf_02800.

Figure 117. Good example of the Urchin Barren (URBA) bioband in the nearshore. Clutus Point, photo bc21_bf_02533.

Figure 118. Good example of the Giant Kelp (GIKE) bioband in the nearshore. Helby Island, photo bc21_bf_00349.

The Oyster bioband tends to be unusual in BC and is generally only seen where concentrations of the introduced Pacific Oyster (*Magallana gigas*) are high enough to be visible from the aerial imagery. This was generally noted to occur in areas where there is or has been oyster aquaculture, with a concentration of observations in Tlupana Inlet, which does have an active aquaculture lease within it (Nootka Resource Board, 2001). The oyster bioband has mostly only been seen in the South Coast of BC. While this could be due to where oyster aquaculture has occurred, it is also possible that they could not be viewed in previous lower resolution imagery as it is very cryptic, often blending in with the barnacle bioband. Figures 119 and 120 show the proportion of the shoreline with the Oyster and Mussel bioband respectively. A map of the distribution of the two biobands is in Figure 121. As seen in Figure 121, many inlets on the West Coast of Vancouver Island and the Central Coast appear not to have mussels but this is likely due to the limitations of the historic data. Those areas likely have much lower amounts of mussels that were not visible on the lower resolution imagery.

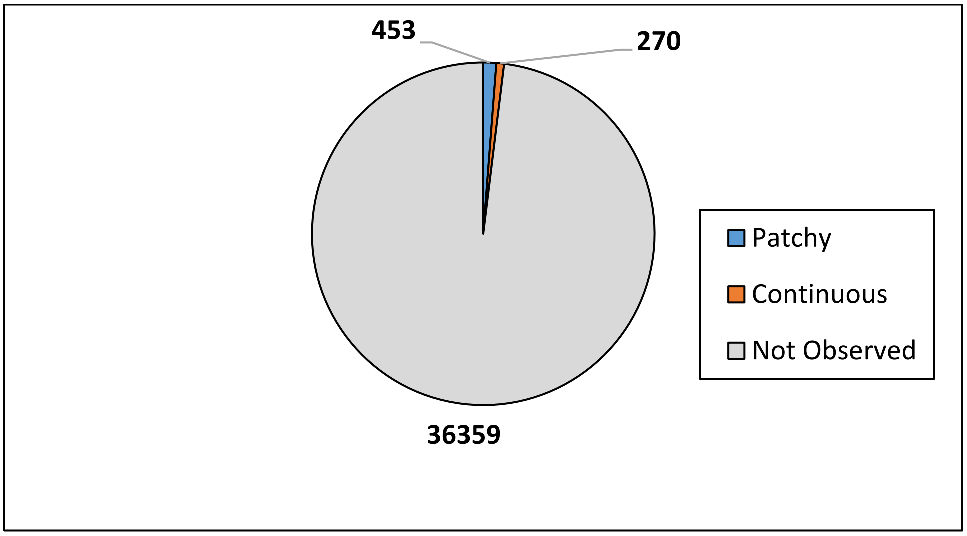

Figure 119. Proportion of shoreline length (km) of the intertidal Oyster (OYST).

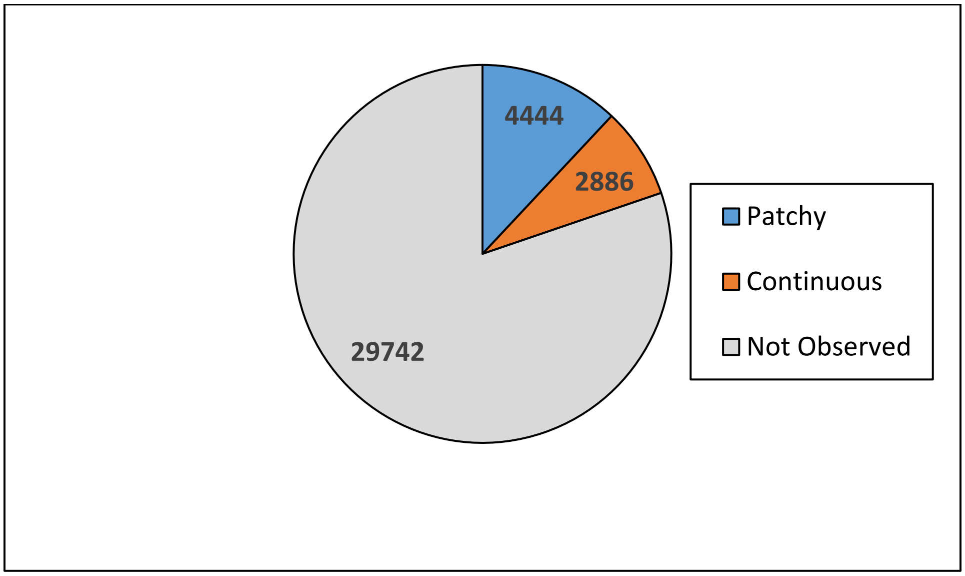

Figure 120. Proportion of shoreline length (km) of the intertidal Blue Mussel (BLMU).

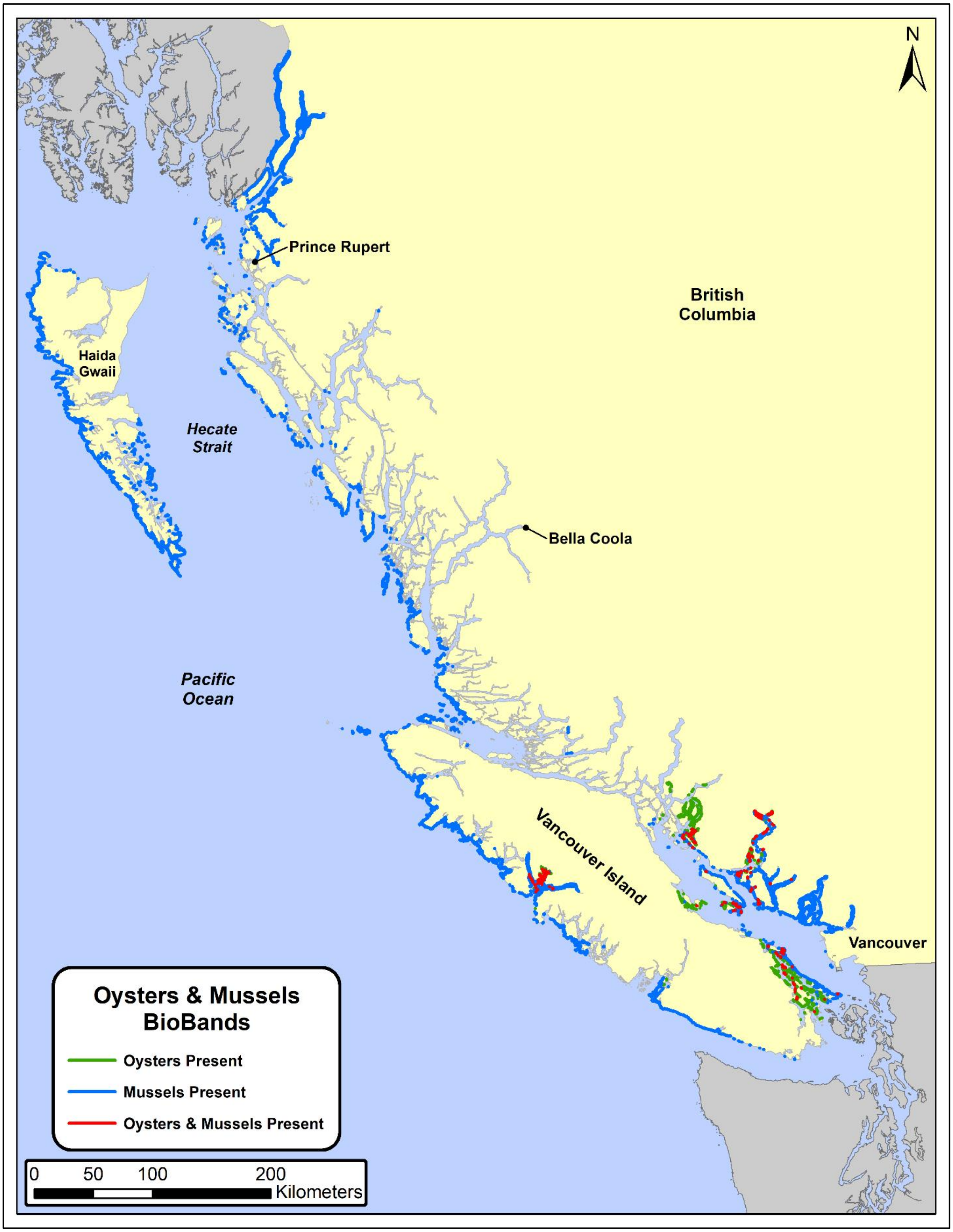

Figure 121. Distribution of the Oyster (OYST) and Mussel (BLMU) biobands in British Columbia.

Seagrasses are an important component of coastal ecosystems with Eelgrass beds forming in sandy substrate at Semi-Protected and lower exposures while Surfgrass generally attaches to hard substrate on Semi-Protected or Semi-Exposed beaches. Eelgrass beds are nursery habitats for juvenile fish and sequester and store atmospheric carbon (called 'Blue Carbon') in addition to other valuable ecosystem services. See Figures 122 and 123 for statistics on the distribution of the individual biobands and a distribution map for both in Figure 124.

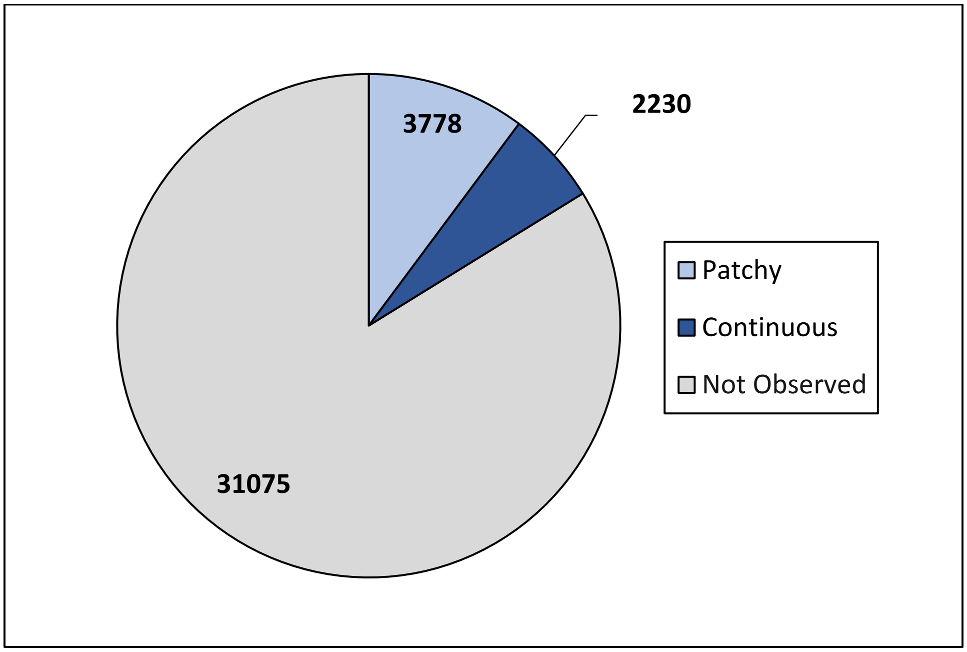

Figure 122. Distribution of the intertidal/subtidal Eelgrass bioband by shoreline.

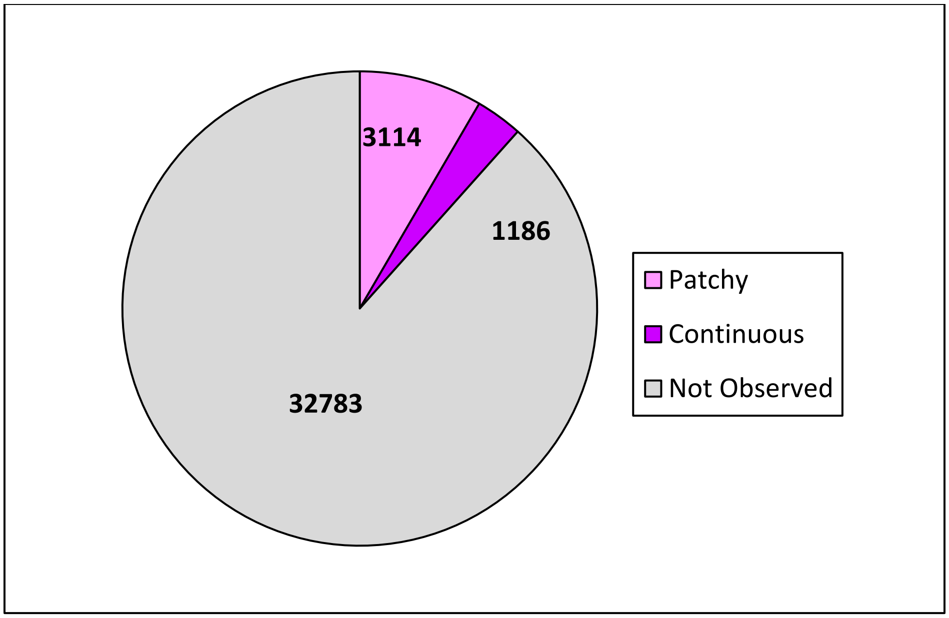

Figure 123. Distribution of the intertidal/subtidal Surfgrass bioband by shoreline.

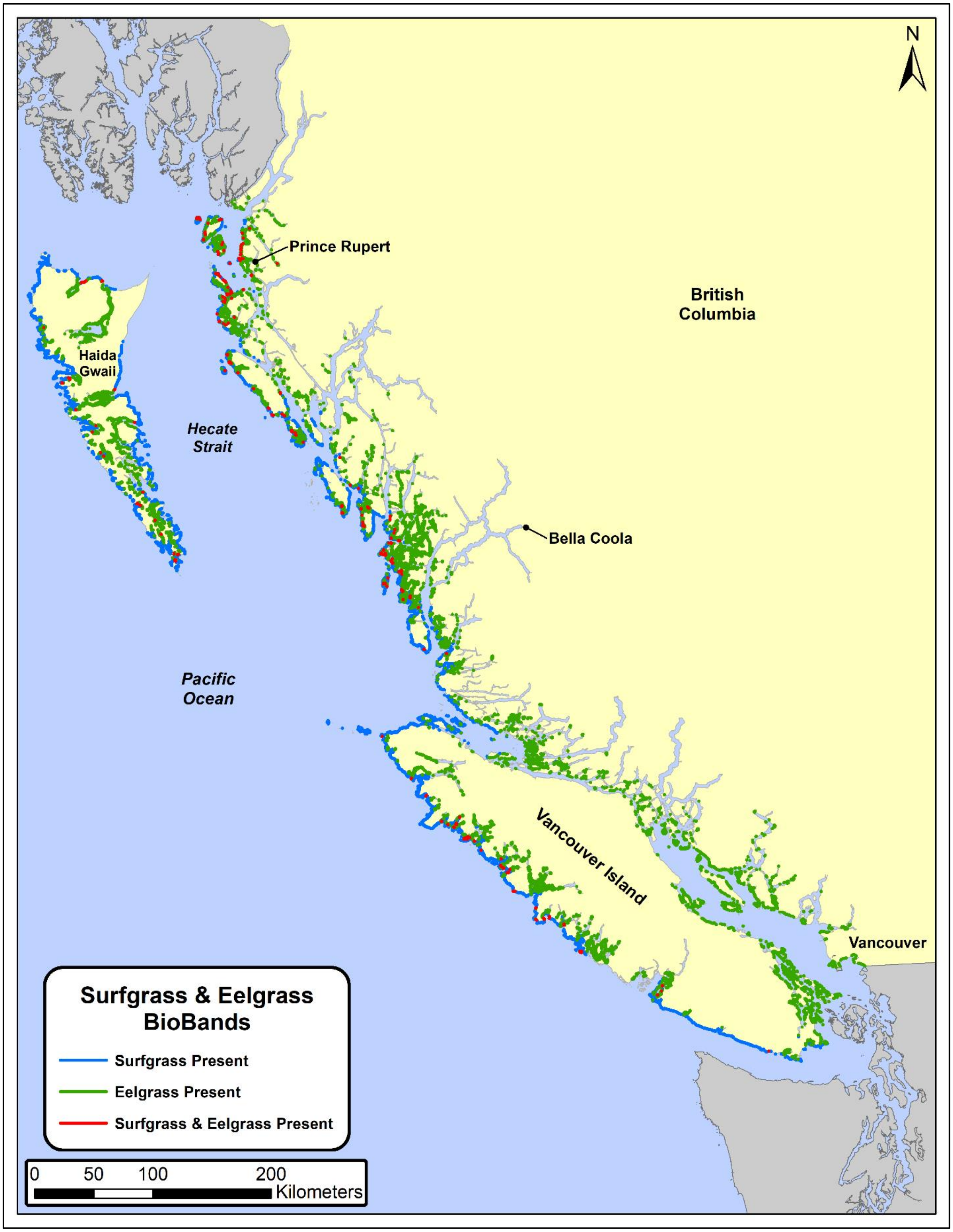

Figure 124. Distribution of the Surfgrass (SURF) and Eelgrass (EELG) biobands in British Columbia.

Canopy kelps form valuable habitat for fish, invertebrates and other algae and are an important part of a healthy coastline and healthy fisheries. Bull Kelp (*Nereocystis leutkeana*) and Giant Kelp (*Macrocystis pyrifera*) were the canopy kelp noted along the BC Coastline. Bull Kelp tended to be seen in higher exposure areas than Giant Kelp, however both tended to be generally absent from the more protected coastline areas. See Figures 125 and 126 for statistics on the distribution of the bull kelp and giant kelp and a distribution map in Figure 127.

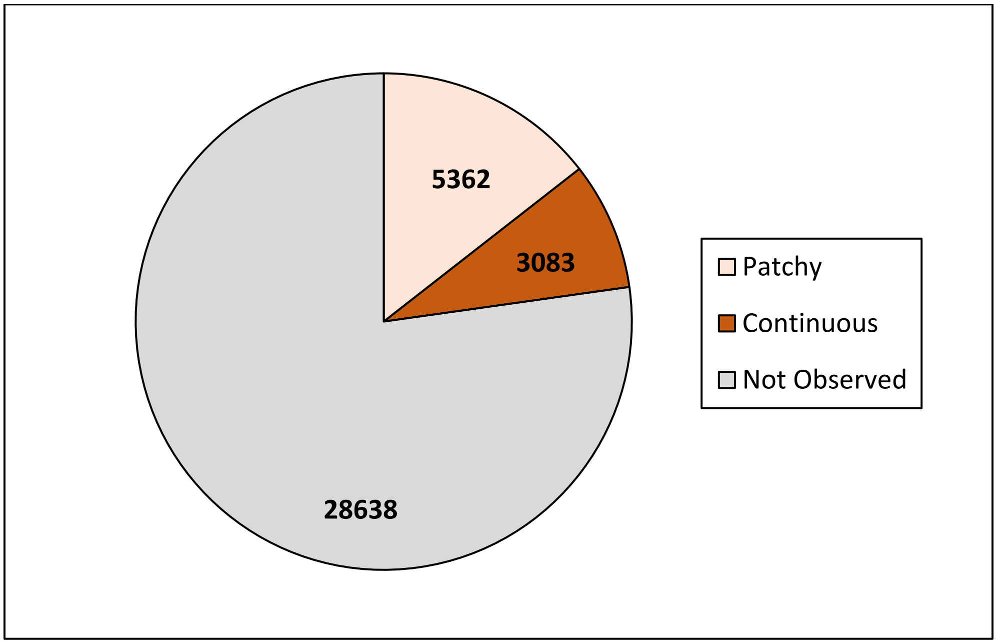

Figure 125. Distribution of the Bull Kelp (BUKE) bioband by shoreline length (km).

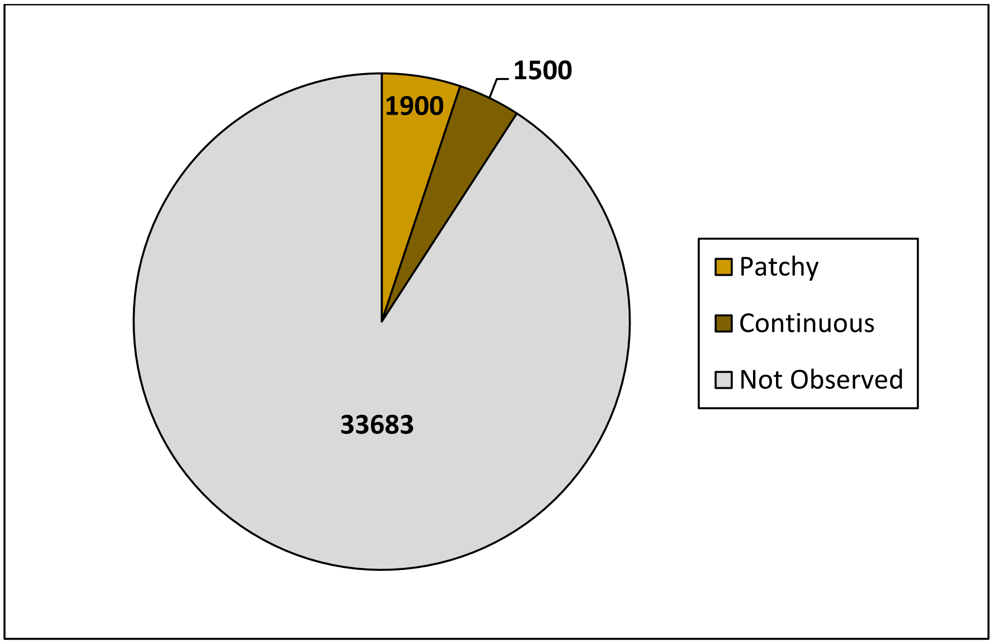

Figure 126. Distribution of the Giant Kelp (GIKE) bioband by shoreline length (km).

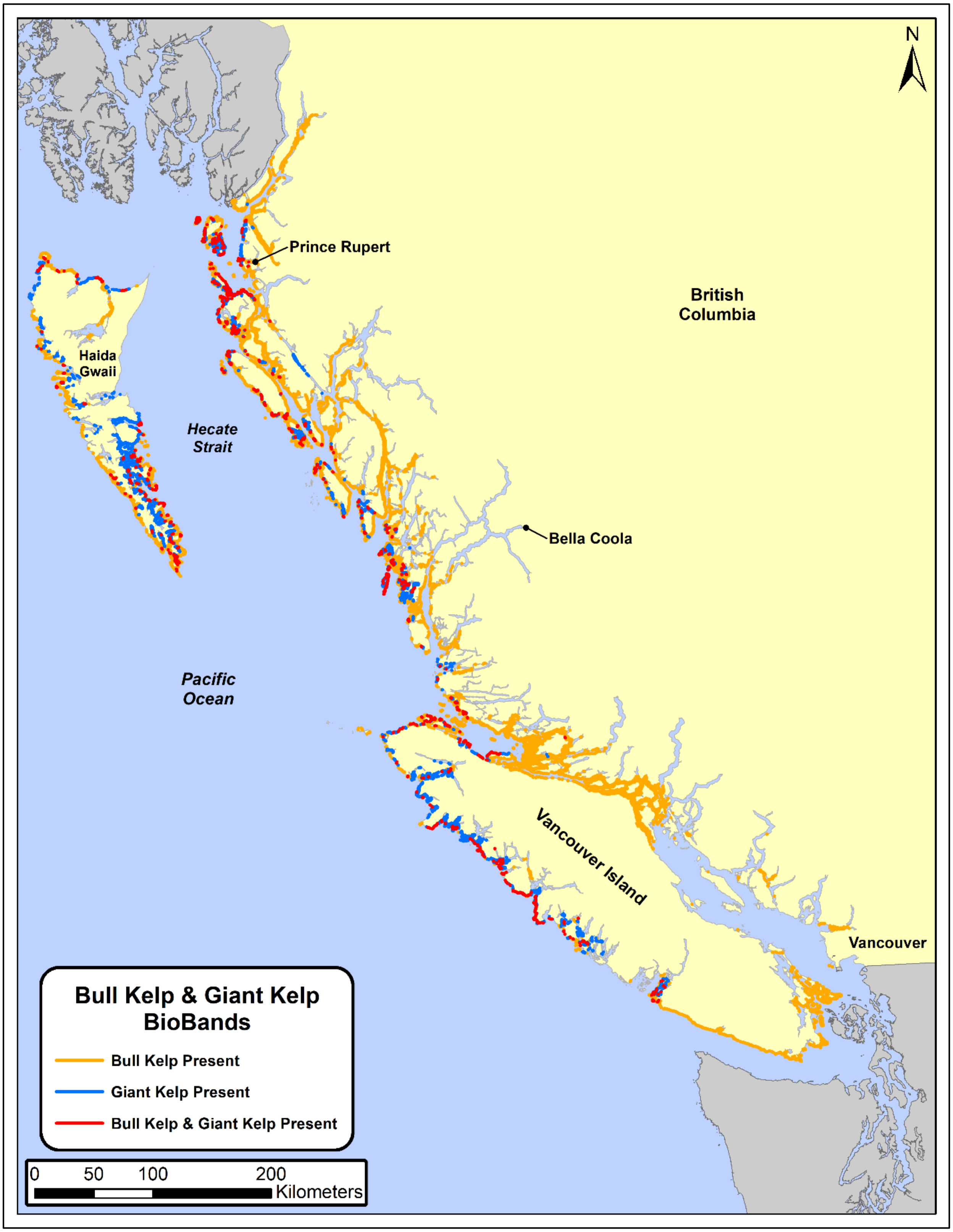

Figure 127. Distribution of the Bull Kelp (BUKE) and Giant Kelp (GIKE) biobands in British Columbia.

Salt Marsh was the most commonly occurring supratidal, non-splash zone bioband but was found in only 22% of units (Figures 128). Salt Marsh can occur either in the lower supratidal or upper intertidal, while this map shows the occurrence of the band at the mean higher high water line (Figure 129). This is an important habitat for many shoreline species and can provide important ecological services, such as filtering land-based nutrients which can help maintain the balance of other habitats such as eelgrass meadows (Valiela et al., 2000).

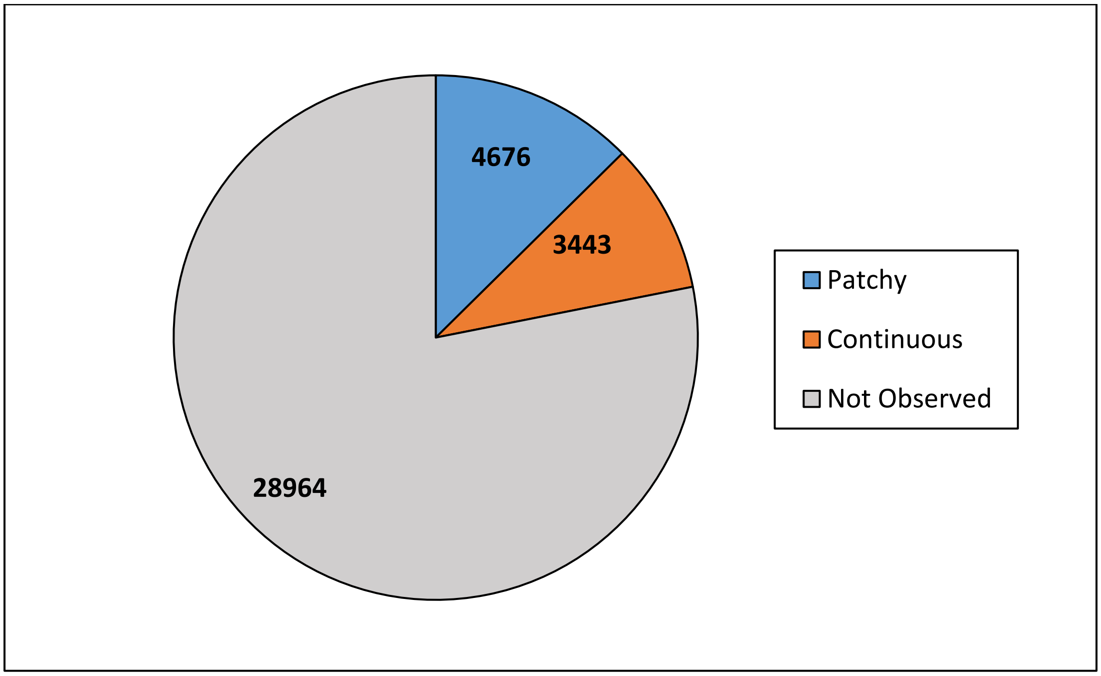

Figure 128. Distribution of the Salt Marsh (SAMB) bioband by shoreline length (km).

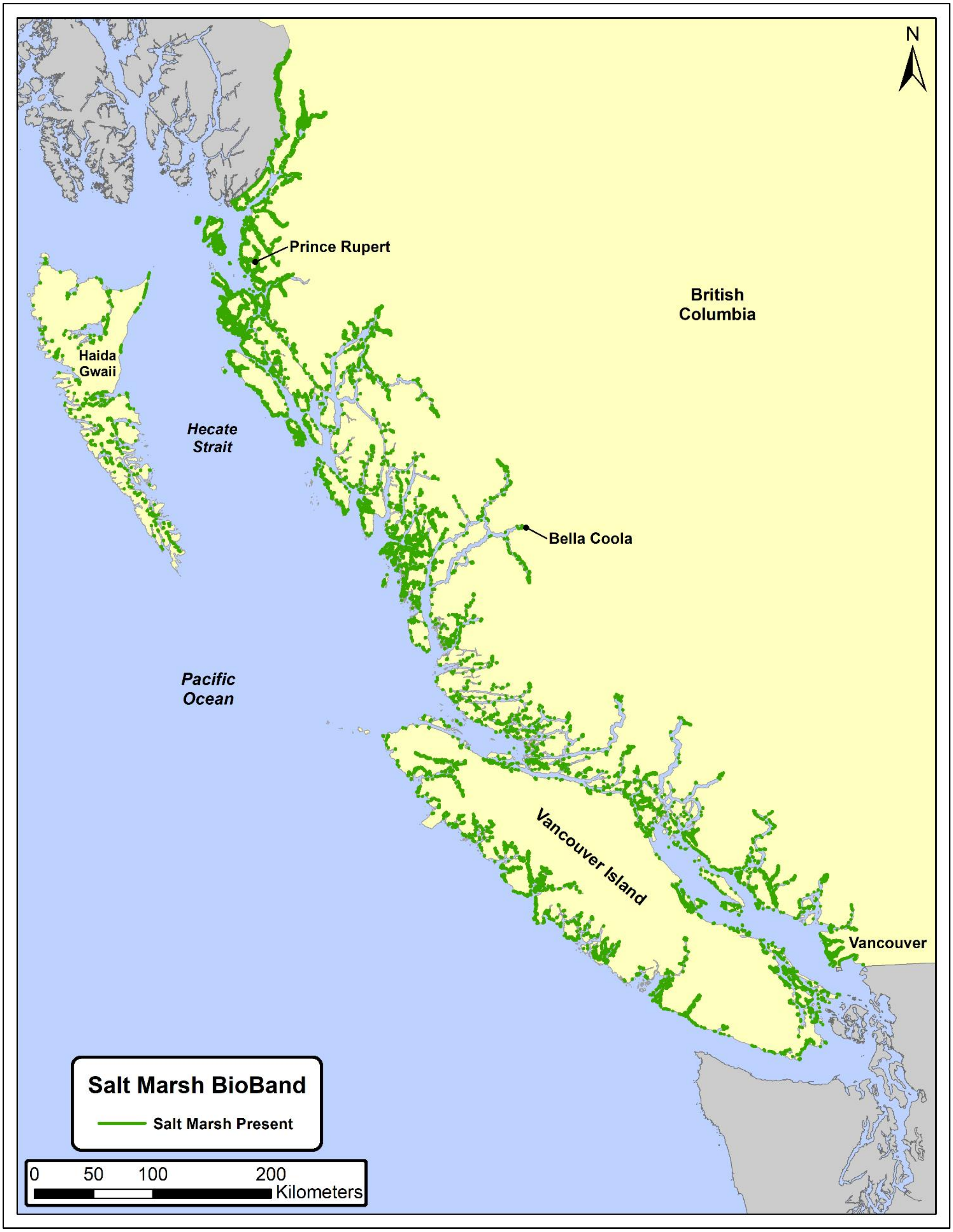

Figure 129. Distribution of the Salt Marsh (SAMB) bioband in British Columbia.

6 COASTWIDE TRENDS IN BRITISH COLUMBIA

6.1 Introduction

The impacts of increasing human pressures, including climate change are having severe consequences for marine ecosystems (Doney et al., 2012). These pressures include pollution, introduction of invasive species, exploitation by humans, and anthropogenic alterations to coastal processes (Kunze et al., 2021). Vitousek et al. (1997) stated that between one-third and one-half of the land surface of the world globally has been transformed by human action and while alterations of marine ecosystems are not as easily quantified, it is suggested that they are substantial.

With ShoreZone's long history of imagery and mapping the coastline of BC, this allows us to view trends across the province's shoreline as well as where imagery and classifications have been repeated to observe changes over time.

In the next section, we highlight examples of change over time that can be seen from ShoreZone imagery for both physical and biological attributes. Although we can see the cause of these alterations in some cases (ex. anthropogenic modifications to the shoreline), in other cases the cause may not be visible in the imagery itself. Using ShoreZone imagery and data with other large-scale datasets (ex. biodiversity monitoring data, surface water temperature data, salinity, turbidity etc.), or even just other observations, may allow for an analysis of underlying causes for the changes observed (Starko et al., in press).

6.2 Anthropogenic Coastal Class

Using imagery taken from 1997 and again in 2017, we were able to compare the length of shoreline impacted by anthropogenic changes found along Burrard Inlet. Over time, cumulative effects of settlement and development have negatively impacted the ecological health and diversity of Burrard Inlet with industrialization leading to it being heavily polluted and with most of the nearshore habitat altered or lost (Macdonald et al. 1990; Precision-Identification 1997; Sobocinski 2021). However, in recent years, work has begun to help restore Burrard Inlet. In 2021, the Burrard Inlet Environmental Science and Stewardship agreement was signed between Canada and the Tsleil-Waututh Nation to support the Nation's stewardship activities in the Inlet including scientific research and analysis, restoration, planning and other science-based activities (Government of Canada, 2021). A four-year collaboration between the Tsleil-Waututh Nation and SeaChange Marine Conservation Society was completed in early 2023 to help restore Burrard Inlet (Kerr-Lazenby, 2023). This project included three components: marine debris removal (including creosote pilings), eelgrass restoration, and restoration of native plants along coastlines (Tsleil-Waututh Nation, n.d.). With the ongoing restoration efforts in the Inlet, more current aerial imaging may be able to show those changes over time.

The Anthropogenic Coastal Classes (Class 32 and 33 in Table 1) are segments of shoreline where anthropogenic features encompass more than 50% of the intertidal zone.

Anthropogenic features are found in the splash zone more often than the intertidal zone; however, if there are less than 50% anthropogenic features in the intertidal zone, it will not be classified as an anthropogenic shore segment. The information for anthropogenic features in the splash zone and in the intertidal zone can be found in the ShoreZone coastwide geodatabase available on ShoreZone.org in the Shore Modifications table and also in the Xshr table. The 2017 Burrard Inlet mapping includes 4.9 kilometers more anthropogenic shoreline (57.5km) than the 1997 Burrard Inlet mapping (52.6km) (Figures 130-134). When comparing percentage of the total shoreline length, anthropogenic shorelines consisted of 54.0% of the Burrard Inlet while in 2017, 51.0% of the shoreline was classified as anthropogenic. Although the total amount of shoreline in the anthropogenic coastal classes has increased, the percentage of shoreline that was considered part of the anthropogenic class has not really changed between 1997 and 2017. It should be noted that the Burrard Inlet mapping in 2017 used a more detailed shoreline than the mapping in 1997, thus the total kilometers added up to slightly more in the 2017 dataset.

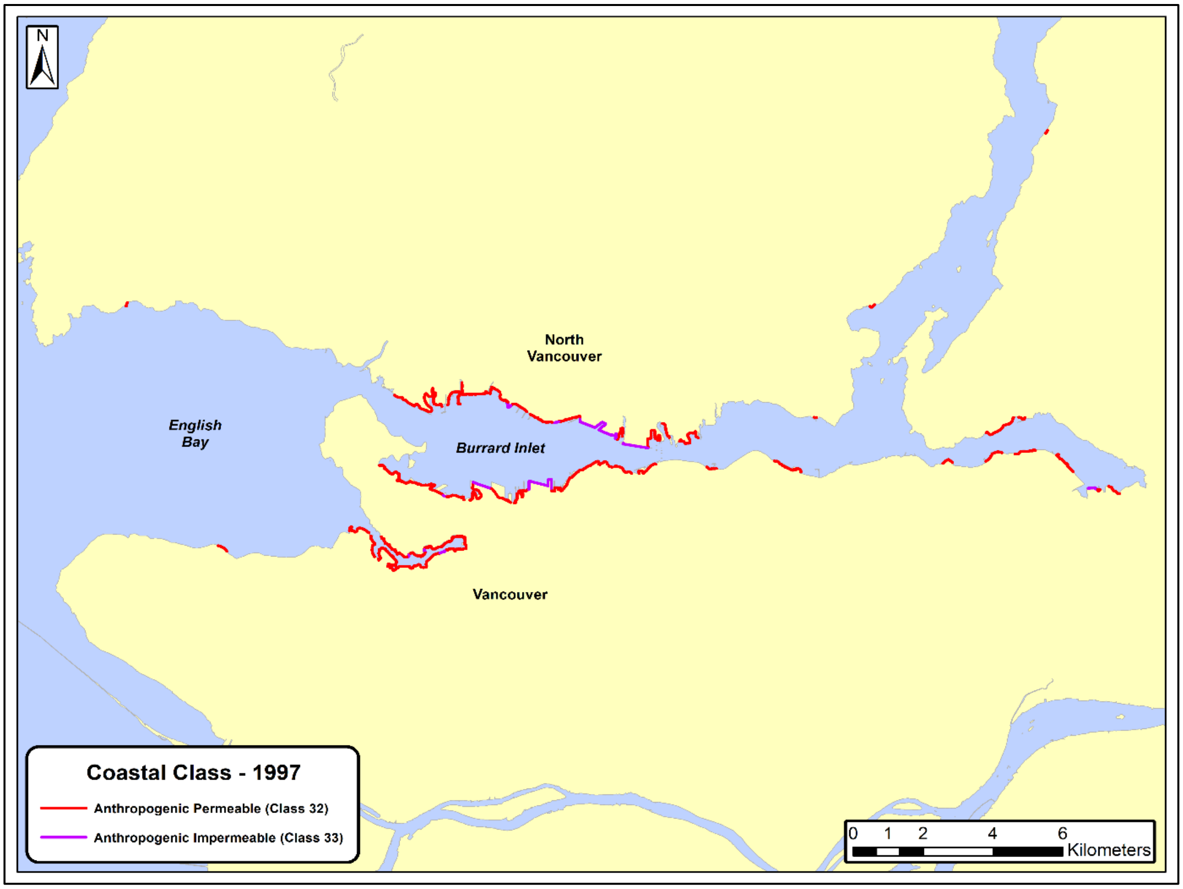

Figure 130. Map of Anthropogenic shoreline in Burrard Inlet in 1997.

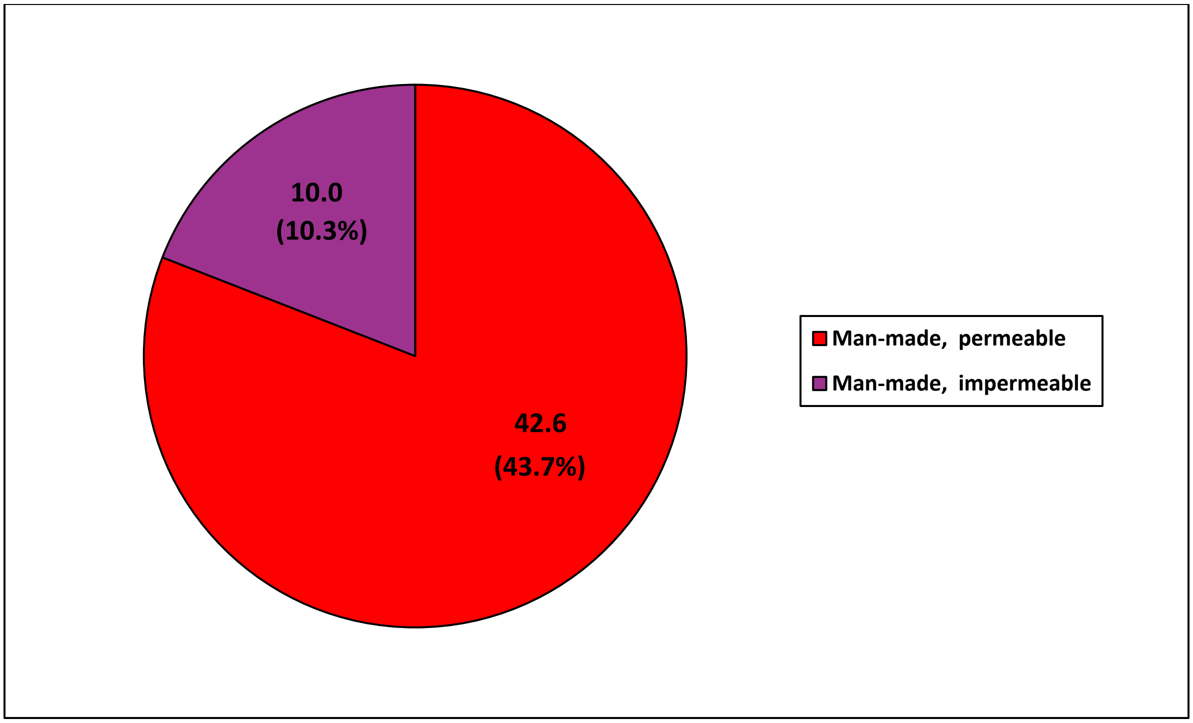

Figure 131. Distribution of Anthropogenic Coastal Classes along the shoreline in Burrard Inlet in 1997 (km).

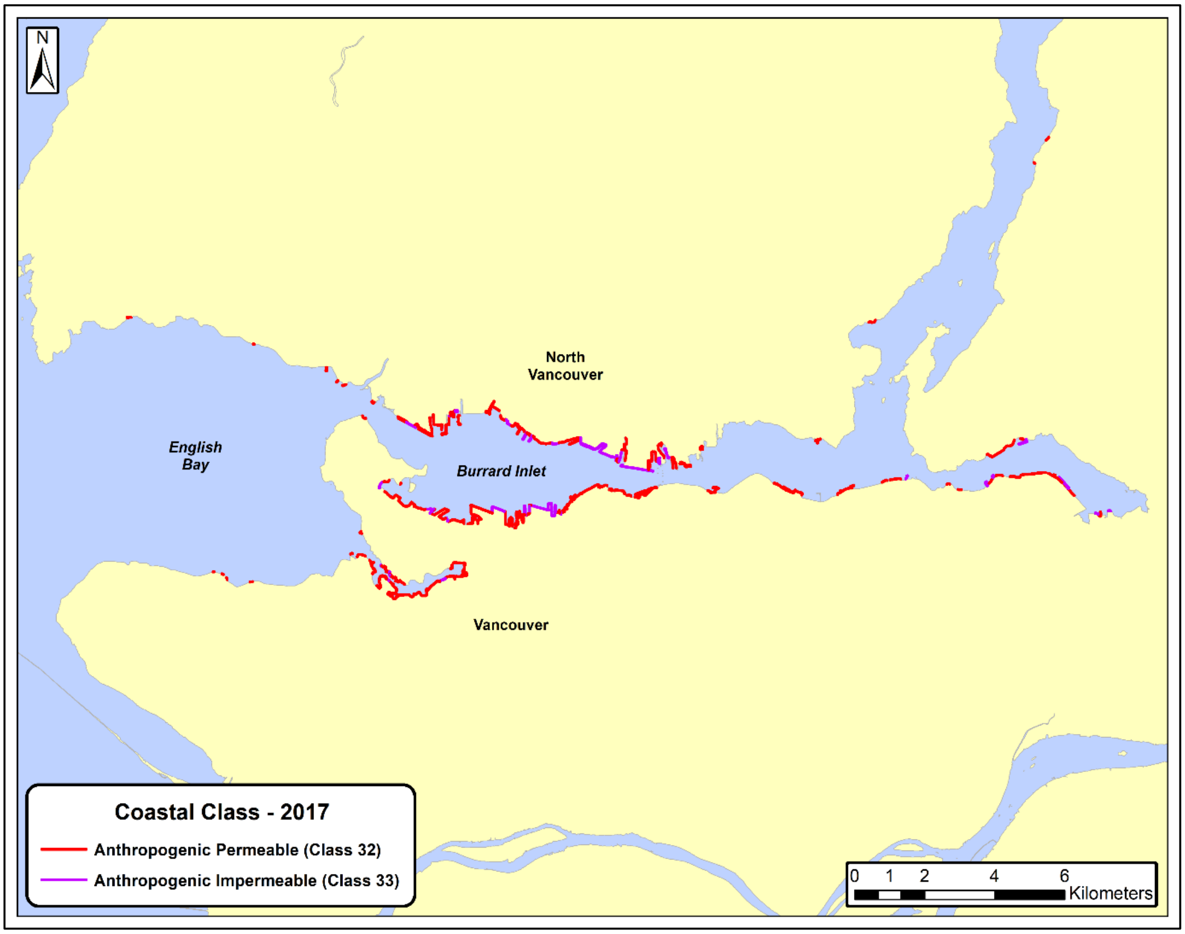

Figure 132. Map of Anthropogenic shoreline in Burrard Inlet in 2017.

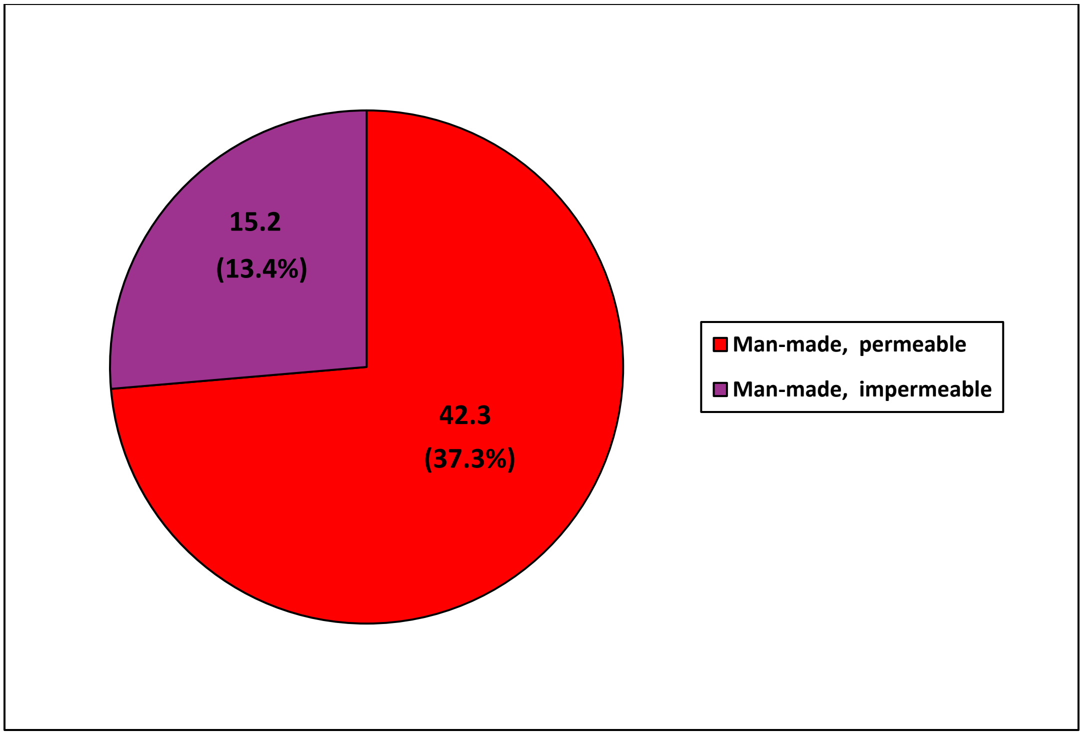

Figure 133. Distribution of Anthropogenic Coastal Classes along the shoreline in Burrard Inlet in 2017 (km).

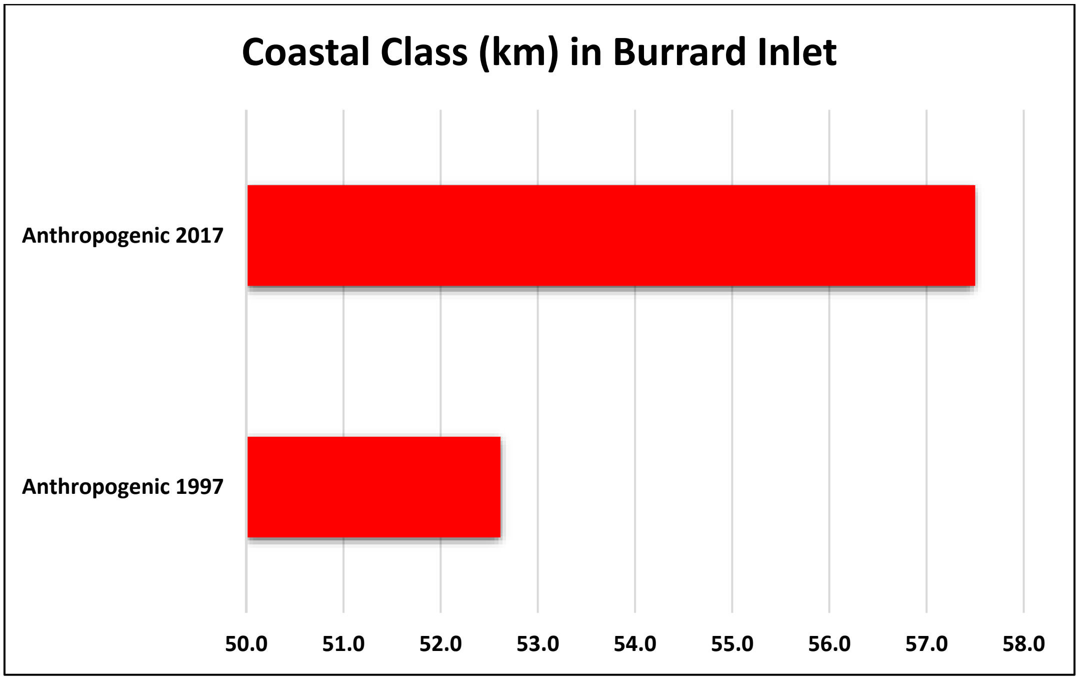

Figure 134. Anthropogenic shoreline comparison by km in Burrard Inlet between 1997 and 2017.

6.3 Biobands

Climate change driven by human actions have directly resulted in global warming and rising sea levels. Hollarsmith et al. (2022) and Starko et al. (2022) found that kelp forests are in decline due to local and global stressors such as climate variability, ocean warming (including marine heatwaves) and human activities. Projections from the Intergovernmental Panel on Climate Change have shown that the coastal waters of the Pacific Northwest will be subjected to altered ocean states that will result in higher primary productivity and increased areas of hypoxia and acidification in inner estuarine waters such as the Salish Sea (Khangaokar et al., 2021). Starko et al. (2022) documented losses up into the intertidal zone of kelp forests providing direct evidence that environmental drivers are responsible for kelp declines in shallow waters when looking at *Macrocystis pyrifera* form *intergrifolia* (Giant Kelp) and *Nereocystis luetkeana* (Bull Kelp) in Barkley Sound, British Columbia. Weigle et al. (2023), in a study of *N. luetkeana*, noted that the kelp is declining in areas with elevated summer water temperatures and low nutrient concentrations in the Salish Sea.

While comparing historical to present data in ShoreZone, we do not see a decline of the Bull Kelp (BUKE) bioband in the Salish Sea, but rather a change in its distribution patterns with losses in some places and gains in others (Figure 135).

In comparing the distribution of brown bladed algae (BRBA) from historical data collected and that seen in the 2021 survey, there appears to be a trend towards a loss of the brown bladed algae bioband over time (Figure 136). It should be noted that the historical imagery has less resolution and therefore, it was more challenging to observe certain species. Also, as the brown bladed algae is a lower intertidal/subtidal alga, it can be difficult to observe due to a number of factors such as: tidal conditions, the sea state, lighting conditions, and time of year imagery was taken.

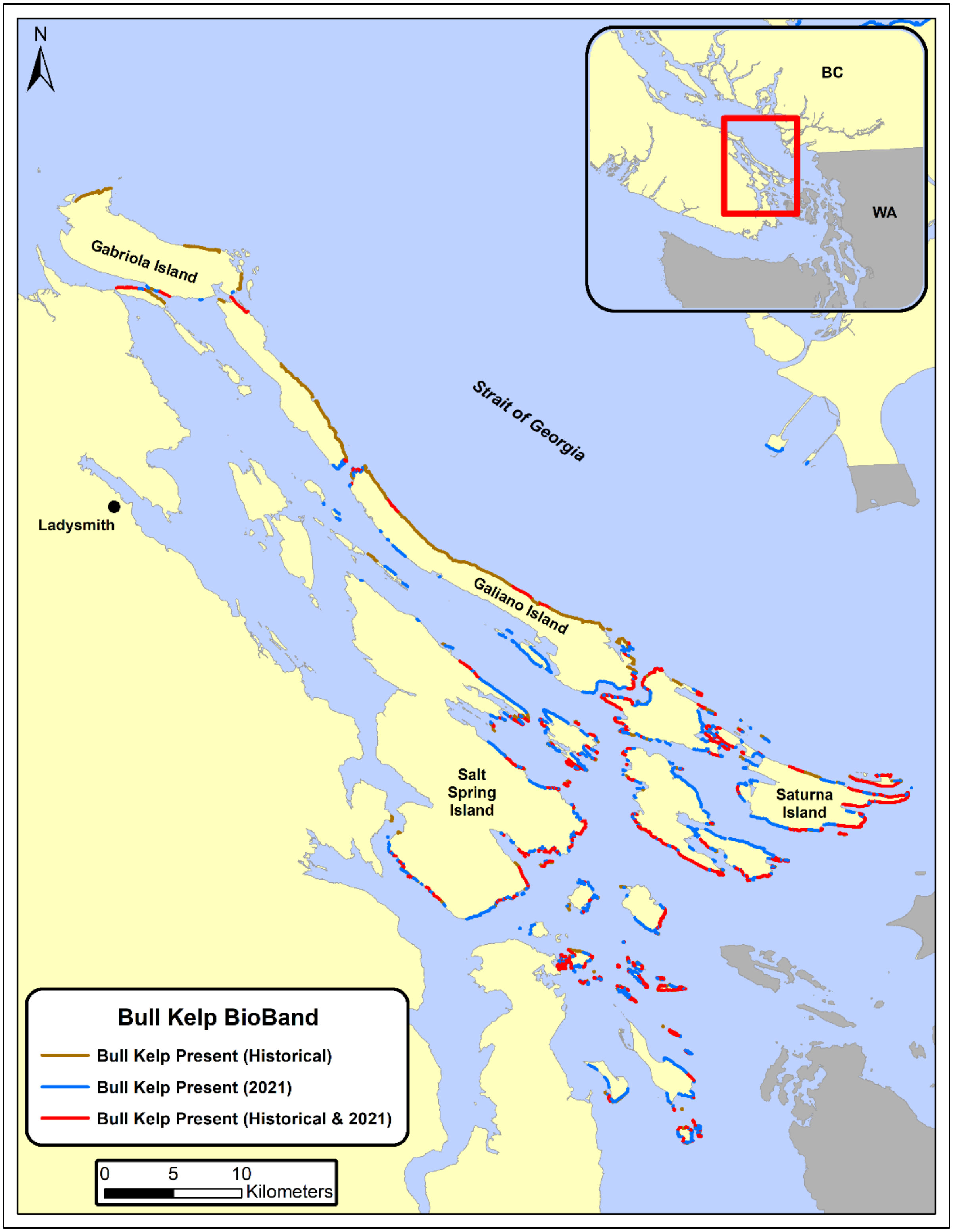

Figure 135. Historical and 2021 presence of the Bull Kelp (BUKE) bioband in the Salish Sea.

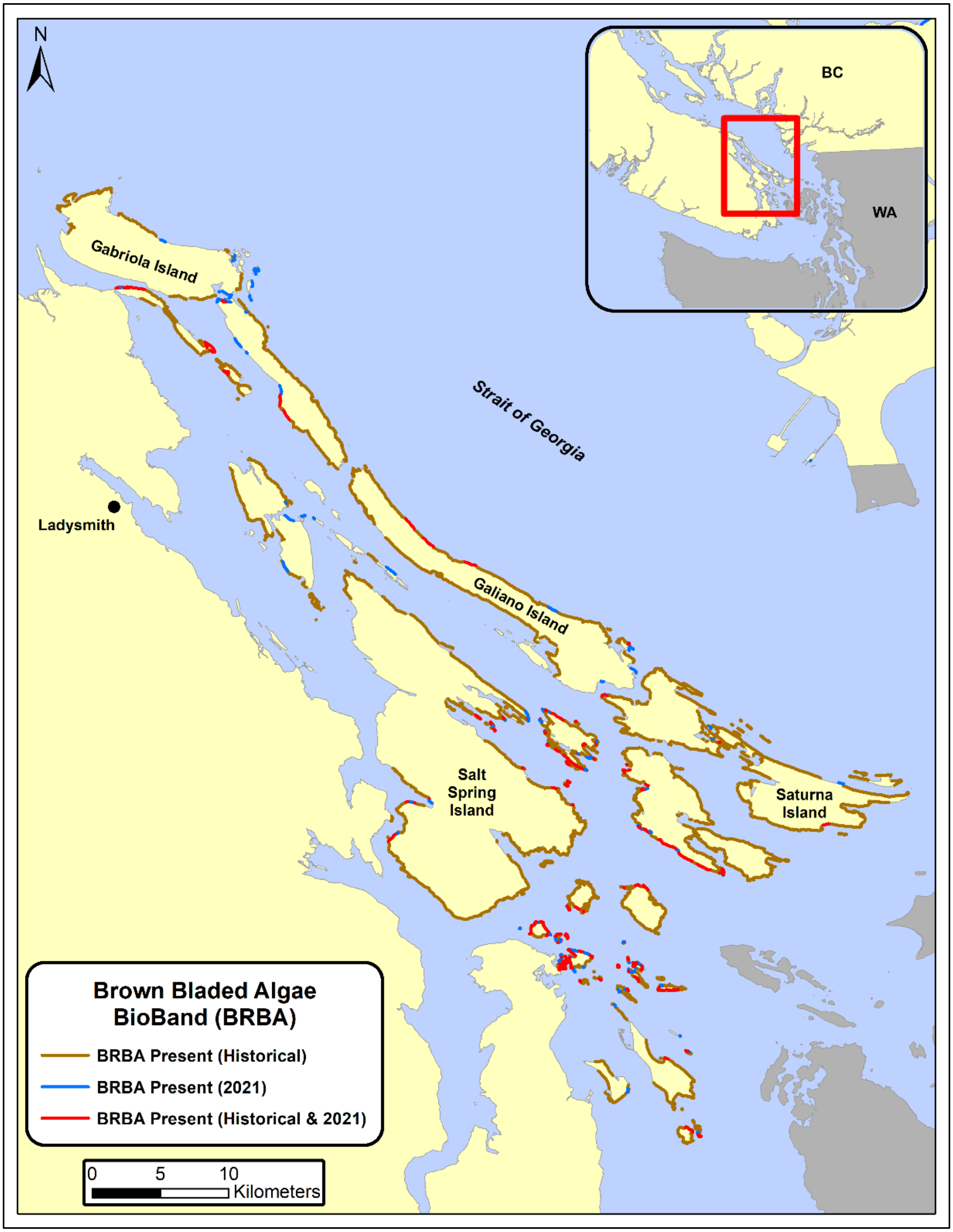

Figure 136. Historical and 2021 presence of the Brown Bladed Algae (BRBA) bioband in the Salish Sea.

7 SHOREZONE POLYGON MAPPING IN BRITISH COLUMBIA

7.1 Introduction

Polygon mapping first began on the North Coast of BC in 2020 using existing imagery to try and provide better spatial depictions of ShoreZone physical data and more specific locations for some biobands that are of more interest to coastal managers.

Full ShoreZone polygon coverage in BC is limited to 4 regions: the North Coast around Prince Rupert, Nootka Sound, Barkley Sound, and the Gulf Islands. There are a few small, localized areas for which we have completed intertidal polygons only or have partial sensitive habitat polygons for (Figure 137). For this report, only areas where there is complete ShoreZone polygon coverage (both intertidal and sensitive habitat polygons) will be discussed.

The ShoreZone imaging surveys conducted around the north coast of British Columbia occurred in June 2014, June 2015, August 2018, and July 2019 (CORI, 2018; CORI, 2020). Nootka Sound was first imaged and mapped in 1994. In July 2021 it was re-imaged and re-mapped) (CORI, 2022a).

Barkley Sound was one of the first parts of BC imaged with the ShoreZone protocol in the early 1990's. A small portion, the mainland of Barkley Sound around Bamfield and down the coast to Victoria was re-imaged and re-mapped in 2007 for BC's Ministry of Environment. In July 2021 the imagery for the Deer Group Islands and the mainland around Bamfield down to Port Renfrew was updated (CORI, 2022b).

The Gulf Islands were first imaged and mapped in the 1990s with the Southern Gulf Islands and the Victoria shoreline being re-imaged and re-mapped in 2004. In August 2021, the Gulf Islands in the Strait of Georgia were re-imaged and the islands on the western side of the Strait were re-mapped (CORI, 2022c).

Those surveys acquired aerial video and digital still images of the coast during minus tides (zero-meter tide levels and lower). The imagery and associated audio commentary were used to map the physical and biological attributes of the shoreline (CORI, 2020; CORI, 2022a; CORI, 2022b; CORI, 2022c). Between 2020 and 2022, the existing ShoreZone imagery and mapping in conjunction with publicly available satellite imagery (ArcGIS Earth, ArcMap, Google Earth), was used to create intertidal and sensitive habitat polygons for the full extent of the North Coast of BC, Nootka Sound, and for the Gulf Islands on the western side of the Strait of Georgia.

The combined length of shoreline now mapped with ShoreZone polygons is **6,079 kilometers** in **26,980 along-shore segments** (units). In total, **39,519 intertidal polygons** (Section 7.2) covering a total of **28,466 ha** and **29,626 sensitive habitat polygons** (Section 7.3) covering **11,981 ha** were created.

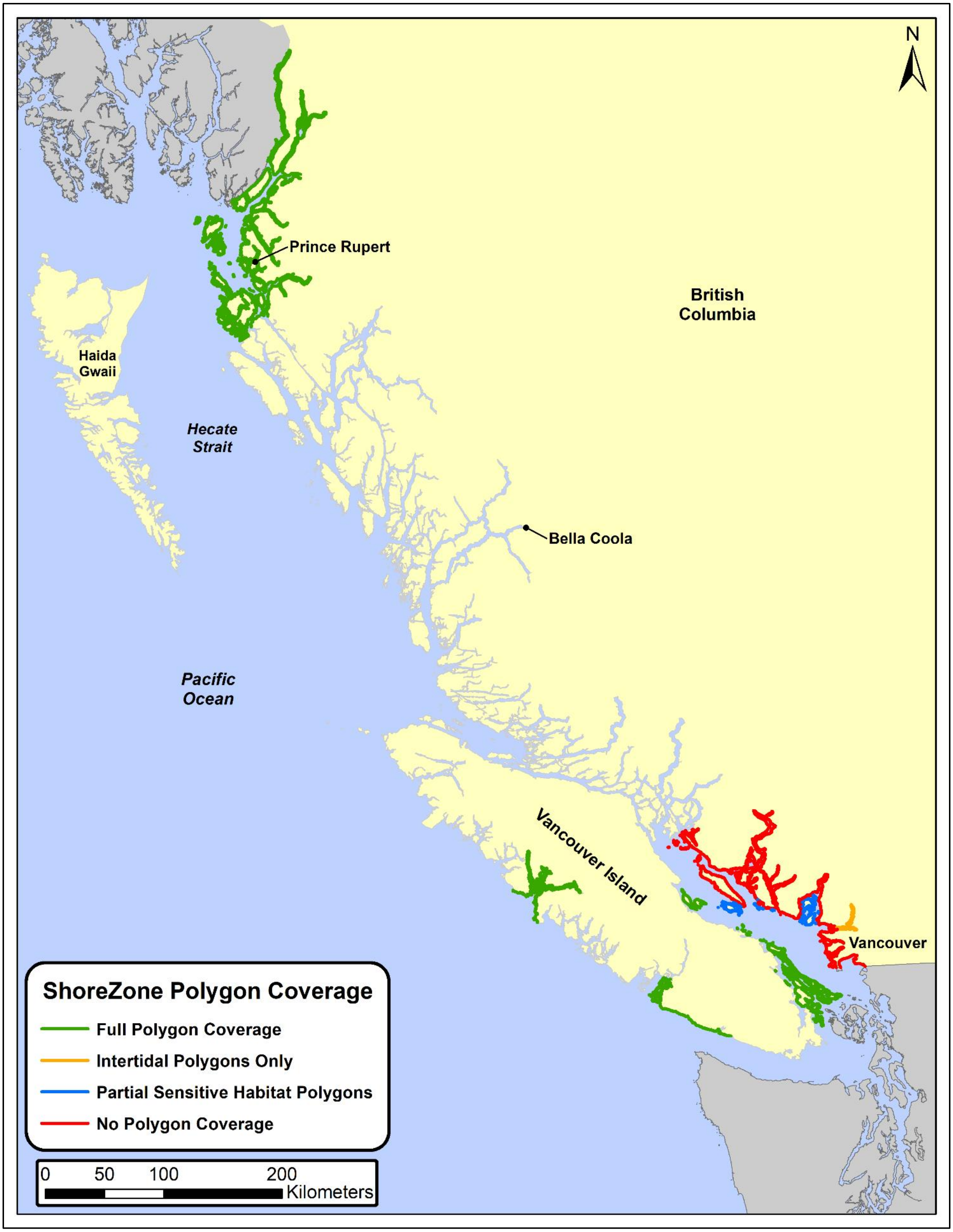

Figure 137. ShoreZone Polygon Coverage in BC.

7.2 Intertidal Polygon Data

ShoreZone habitat mapping uses low-altitude (100 m elevation), high resolution aerial imagery taken from helicopters to define relatively homogenous segments of shoreline, called 'units', based on the physical characteristics of the intertidal and supratidal zones. These units are delineated on the best available digital high water line (HWL) which was the CHS_Highwaterline_BCalbers.shp. Each alongshore unit can also be divided into across-shore components where there is variation in the substrate and geomorphological forms from the top of the beach to the waterline. However, representing ShoreZone data as a one-dimensional line does not accurately display the complexity of the data that is collected. Representing the intertidal as a two-dimensional polygon is possible where there is both a digital HWL as well as a digital low water line (LWL).

Our method for creating polygons of the intertidal portion of each ShoreZone unit was to take the existing digital HWL with the existing unit segments and add the best available digital LWL, which is also from the Canadian Hydrographic Service. We then used the ShoreZone imagery, in conjunction with the best available public satellite imagery, to define the shape of each intertidal polygon. The satellite imagery (which is orthorectified) was used as a guide to provide positional data for all boundaries but the ShoreZone imagery (which is not orthorectified) was used as the final guide as it was taken at low tide while the satellite imagery was often at mid-tide or higher.

We did encounter some challenges in the creation of the intertidal polygons, most of which centered around the accuracy of the high and low water lines. The overall position of each polygon in space sometimes varied when compared to the satellite imagery (Figures 138 and 139); however, we made the decision to not edit the HWL unless we encountered what we considered to be an error which would significantly affect the overall size and shape of the final polygon which we defined as a 100m discrepancy. The LWL did vary significantly from both the satellite imagery and the ShoreZone imagery along most of the coastline so it was edited to better reflect reality.

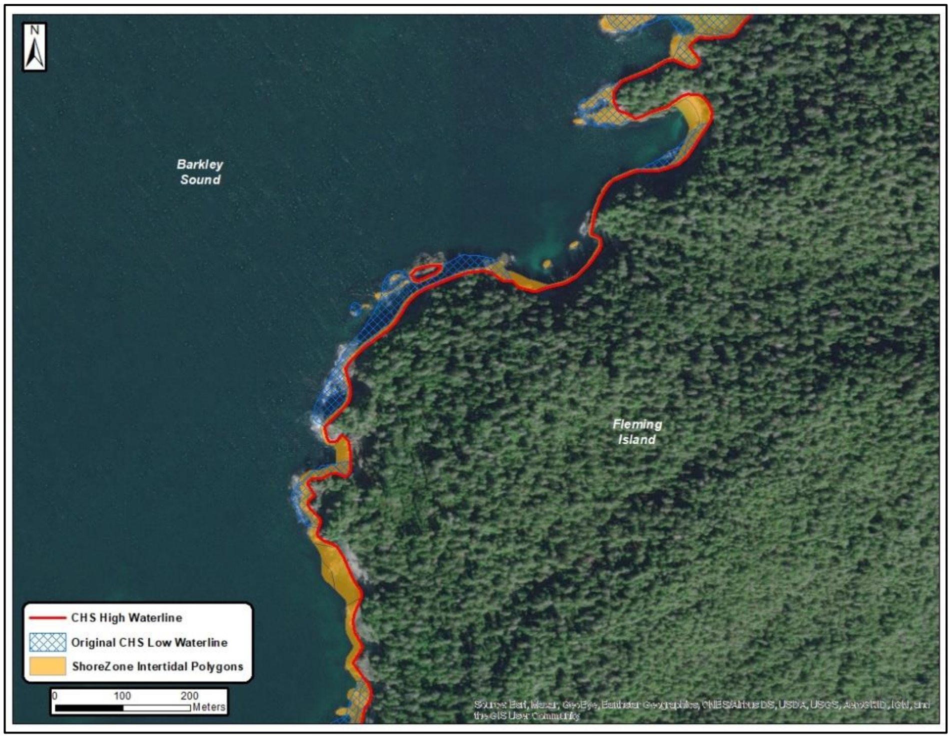

Figure 138. Example of an area where the digital HWL was slightly offset compared to the satellite imagery but did not affect the overall shape and size of the intertidal polygons so was not re-digitized.

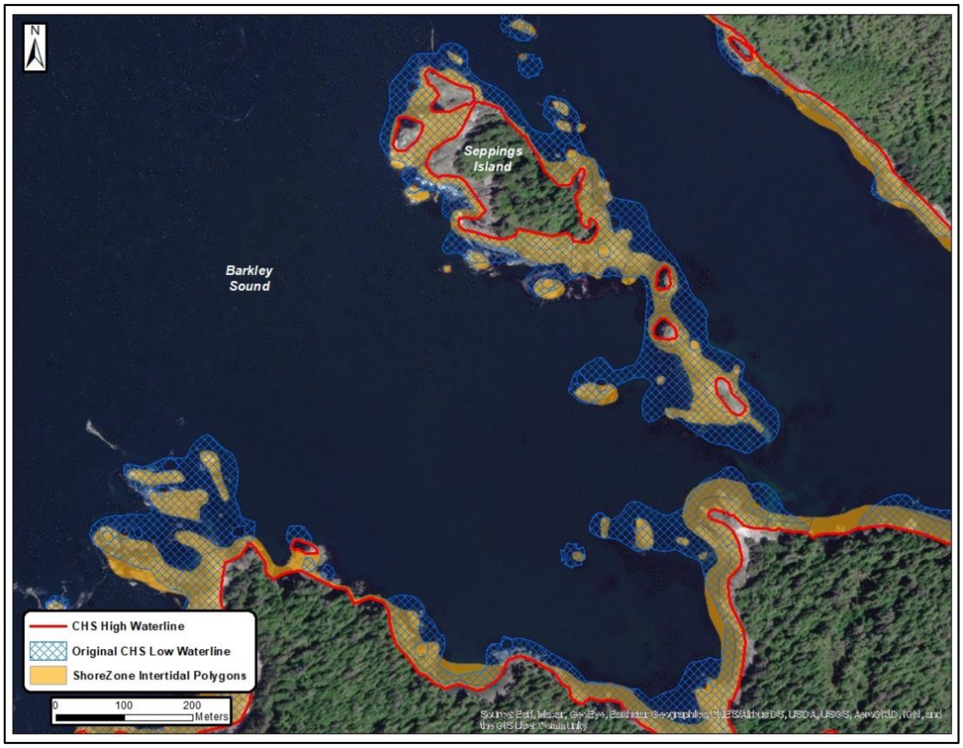

Figure 139. Example of an area where the digital HWL was complex and not necessarily reflective of reality making creation of intertidal polygons more challenging.

Another challenge was that some tidal lagoons did not appear on the digital HWL or LWL (Figure 140). We digitized these lagoons using the satellite imagery and ShoreZone imagery as guides.

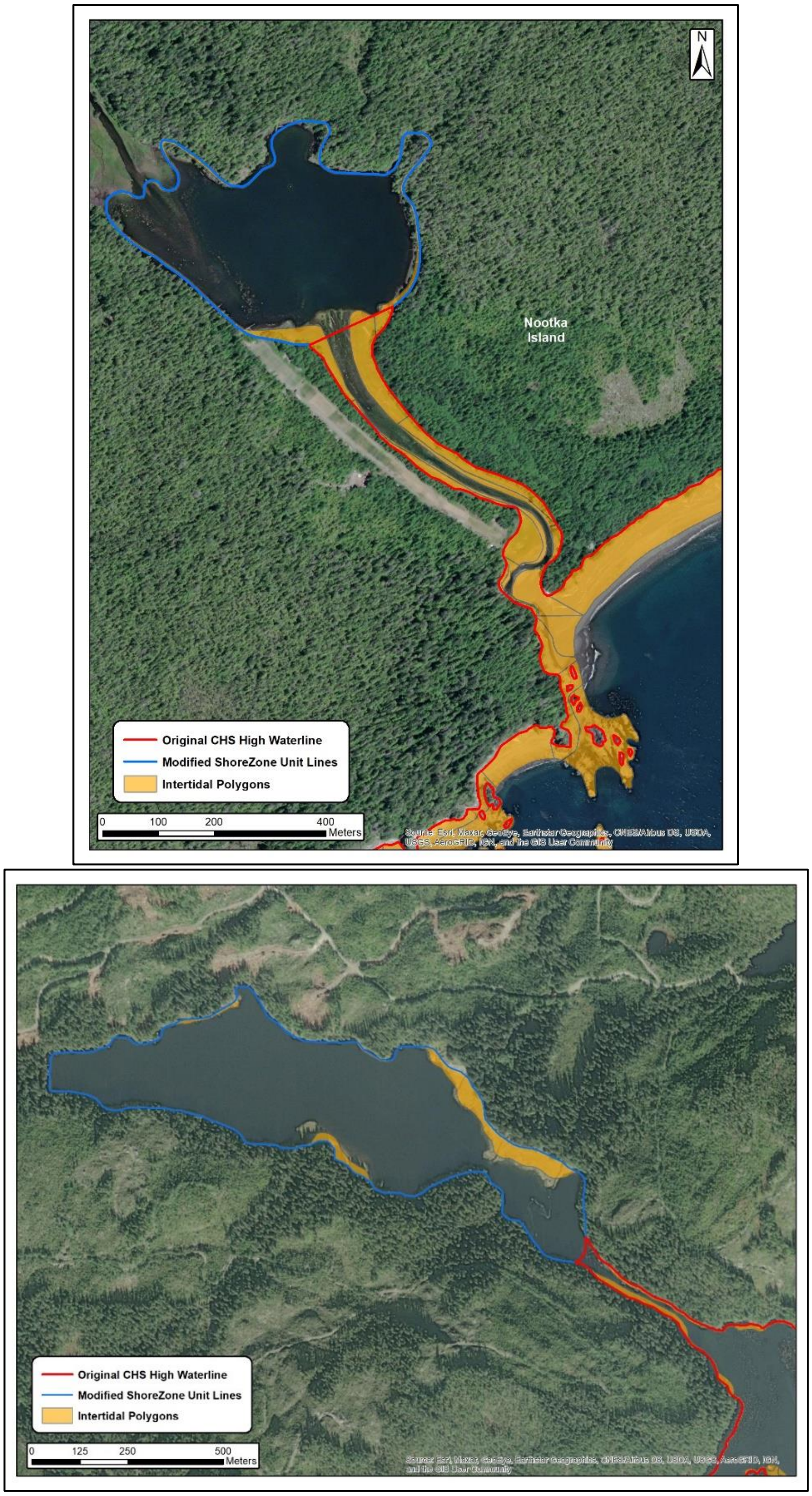

Figure 140. Example of two areas where tidal lagoons were not represented on the digital HWL or LWL so needed to be digitized using the satellite and ShoreZone imagery.

These challenges mean that the quality of the intertidal polygons is variable from unit to unit; however, we feel confident that the general shape and size of the polygons are consistent with reality in the majority of units.

Small corrections were made to the original ShoreZone mapping attributes during the polygon creation process. These changes were noted in a small portion (<1%) of units and were made only where the polygon mapper noted a significant difference between the imagery and the existing ShoreZone mapping.

In total, **39,519** intertidal polygons were created at the component level. These polygons covered **28,466 ha** of the intertidal zone in the 4 regions of completed polygon work in BC: the North Coast, Nootka Sound, Barkley Sound, and the Gulf Islands. The final intertidal polygons add a number of attributes to the ShoreZone dataset and are part of the final geodatabase product for this area. These polygons represent the across-shore components and can therefore represent both unit level and component level attributes such as the Oil Residence Index (Figure 141) and the Primary Intertidal Form (Figure 142). All ShoreZone attributes are detailed in the current protocol (Cook et al., 2017).

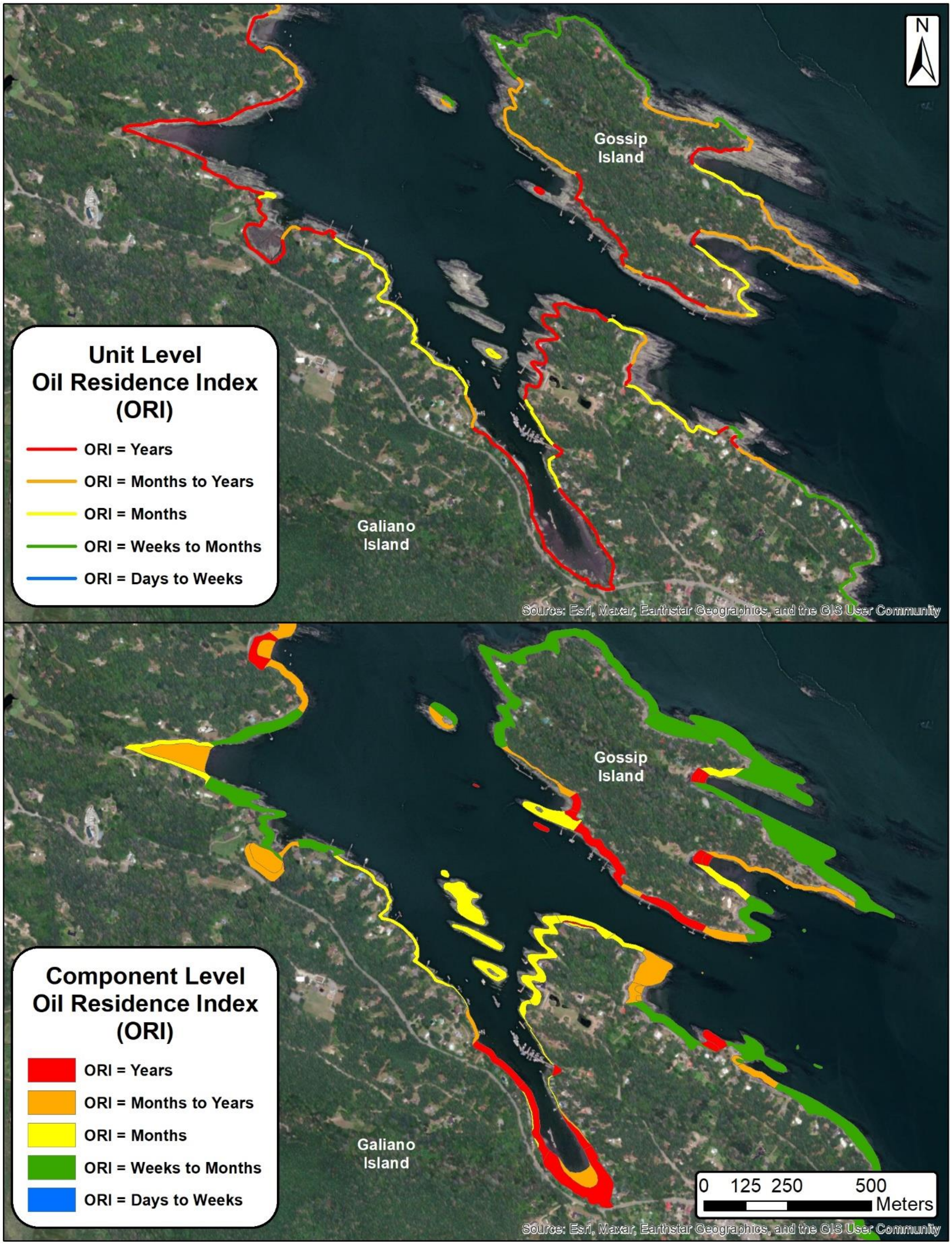

Figure 141. Example of the ShoreZone Oil Residence Index displayed as linear units (top) and intertidal polygons (bottom) on Galiano Island.

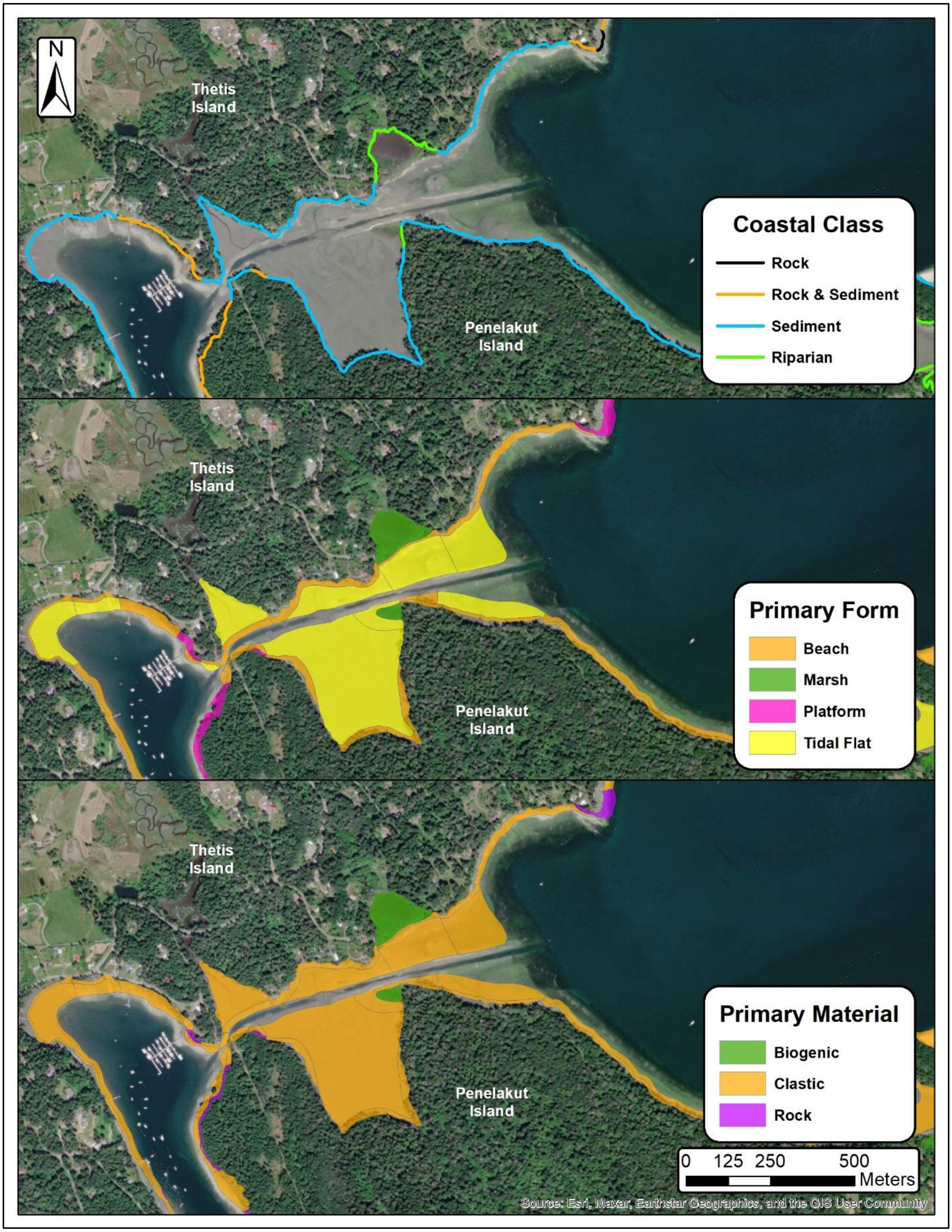

Figure 142. Example of the ShoreZone Coastal Class displayed in linear form (top) and the Primary Intertidal Form (middle), and Material (bottom) displayed as intertidal polygons around Penelakut and Thetis Islands.

7.3 Sensitive Habitat Polygon Data

ShoreZone habitat mapping classifies the biological attributes in each ShoreZone unit as biobands which are defined by a typical tide height, colour, and texture. For ShoreZone polygon mapping of biological data, we focused on the biobands that we defined as 'sensitive habitats', meaning those that are productive ecosystems upon which many other species rely for food or shelter, and which may be adversely affected by pressures arising from human activities (including climate change, fisheries, and development). The 6 biobands that fit these criteria were: **Dune Grass**, **Salt Marsh**, **Eelgrass**, **Bull Kelp**, **Giant Kelp** and **Urchin Barrens**. Please note that Urchin Barrens were included even though they are defined as visible sea urchins in the nearshore that have grazed down all the kelps in a given area. This bioband is thus the absence of kelp forests and therefore represents the loss of sensitive habitat, so it was considered important to include. Only one unit of Nootka Sound had the Urchin Barrens bioband mapped in it, although it is probable there were more in that area. Green urchins are not visible from the ShoreZone imagery so barrens dominated by *Strongylocentrotus droebachiensis* (Green Sea Urchin) would not be identified using this methodology.

Our method for creating polygons of the sensitive habitat biobands identified as part of the ShoreZone mapping (CORI, 2022a; CORI, 2022b; CORI; 2022c) was to take the existing high resolution ShoreZone imagery, in conjunction with the best available public satellite imagery, to define the shape and position of each polygon. The satellite imagery (which is orthorectified) was used as a guide to provide positional data for all boundaries but the ShoreZone imagery (which is not orthorectified) was used as the final guide for shape and extent of the polygon. We attached the unique unit identifier(s) (PHY_IDENT) to each polygon as applicable and also provided an estimate of the Density of the Indicator Species defined for each bioband within each polygon. Our Density categories were Sparse (S), Moderate (M), and Dense (D). These are qualitative assessments based on classifier observations rather than quantitative assessments; however, these categories should still be useful for any calculation of biomass etc. We also added a qualitative measure of Confidence to each polygon to give the users of the data an idea of the overall accuracy of each polygon. Our Confidence categories were Low (L), Medium (M), and High (H).

We did encounter challenges in the creation of the sensitive habitat polygons, most of which centered around the varying resolution and quality of the ShoreZone imagery and the satellite imagery and how those two things interacted. Figure 143 shows an example where the ShoreZone image and the satellite image had a large disparity in the tide level, which made it challenging to see landmarks that allowed for accurate location of any sensitive habitat polygons. Figure 144 shows an example of a ShoreZone image in a complex area where the units in the back portion of the image are difficult to see.

Figure 143. Example of an area where the ShoreZone image (bc21_nk_00393) (top) and the satellite image (bottom) (which show the same inlet off Mooyah Bay) has a large disparity in terms of tide level. The white arrow on each image indicates the same location.

Figure 144. Example of an area where the ShoreZone image (bc21_nk_02246) (top) was taken in a very complex area which meant some units in the background (image on the bottom) were challenging to see. The white arrow on each image indicates the same location.

Another challenge we encountered were areas where biobands were overlapping each other. If it was possible, we created overlapping polygons that indicated where the separate biobands interacted; however, where it was not possible (areas where the imagery made it too time consuming or potentially inaccurate to separate the biobands) we created mixed polygons (Figure 145). These mixed polygons will need to be treated differently in any analyses of the data.

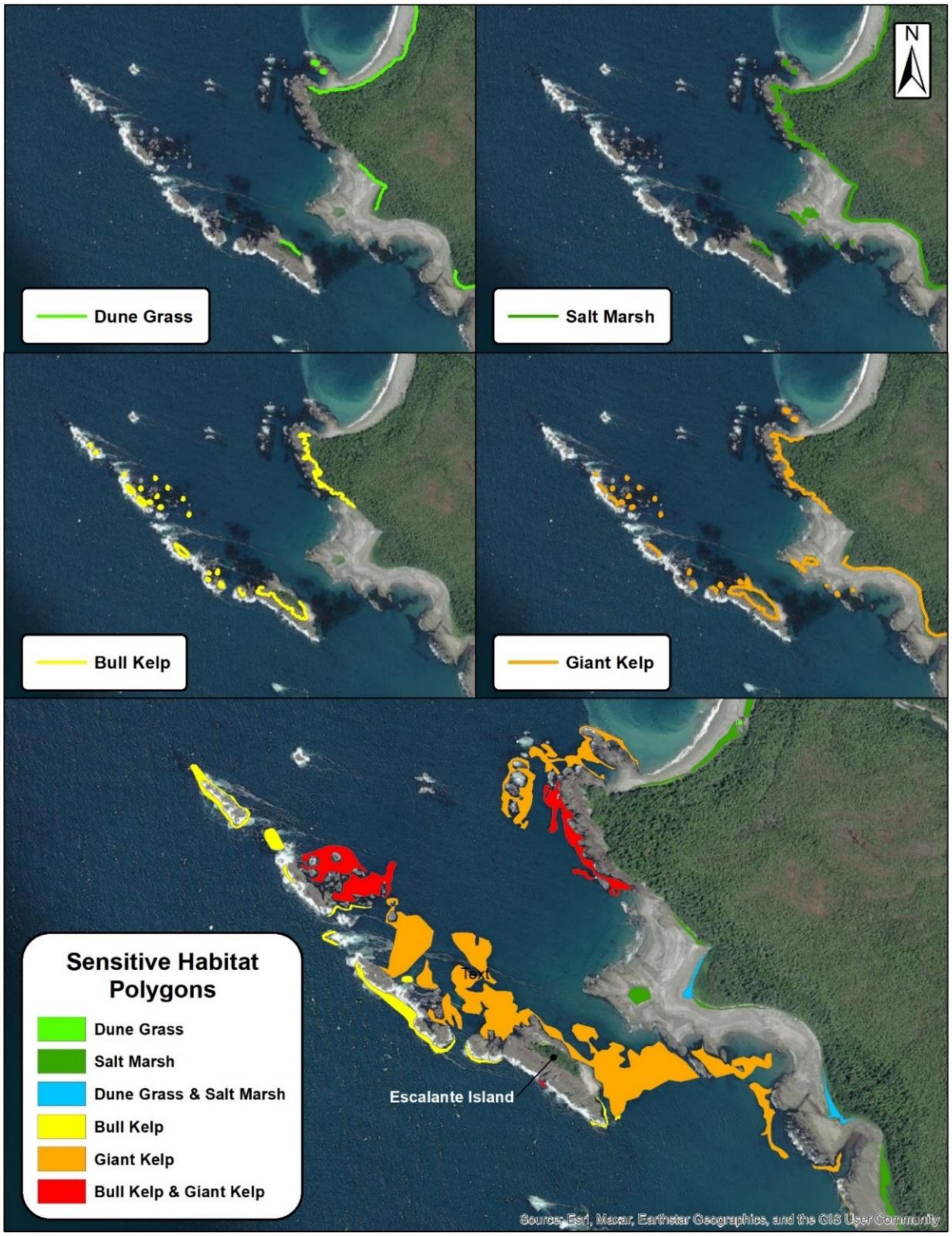

Figure 145. Example of the sensitive habitat biobands mapped around Escalante Pass, just outside of Nootka Sound as both linear features (top 4 boxes) and polygons (bottom).

The challenges encountered in mapping polygons from ShoreZone, and satellite imagery means that the quality of the sensitive habitat polygons is variable; however, we feel confident that the general shape and size of the polygons are consistent with reality in the majority of cases. The more complex the coastline and the more complex the biology of the area, the more variable the polygons might be. The Confidence measure will be useful in allowing users to understand the potential accuracy of each polygon.

Some corrections were made to the original ShoreZone mapping during the polygon creation process which changed the presence and/or abundance of biobands in some units. These changes were only made to a small portion (<1%) of units and were made only where the polygon mapper noticed a significant difference between the imagery and the existing ShoreZone mapping. This means the current coastwide geodatabase posted on ShoreZone.org is now considered the most accurate ShoreZone data for the North Coast of BC and Nootka Sound and should be used to replace any existing geodatabase the user might have from those areas.

In total, **29,626** sensitive habitat polygons were created. These polygons covered **11,981 ha** of the supratidal, intertidal, and subtidal zones on the North Coast of BC, Nootka Sound, Barkley Sound, and the Gulf Islands. Table 14 shows a breakdown of the number and area of polygons of each type over these areas.

Table 14. Totals of sensitive habitat biobands mapped as polygons in BC for locations where there is full polygon coverage (both intertidal and sensitive habitat polygons completed).

Please note that the totals in this table will equal more than the overall total number or overall total area as there are mixed polygons that include multiple biobands.

Sensitive Habitat Bioband	Number of Polygons Created (including mixed polygons with multiple biobands)	Area of Polygons (ha) (including mixed polygons with multiple biobands)
Dune Grass	2579	367
Salt Marsh	13826	2177
Eelgrass	3770	3217
Giant Kelp	3185	3008
Bull Kelp	6386	4368
Urchin Barrens	2642	1301
Wetland Vegetation	93	88

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Prince William Sound Regional Citizens' Advisory Council
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Please see www.ShoreZone.org for a list of partner agencies and related web sites. Video imagery can be viewed and digital stills for the US dataset can be downloaded online at www.ShoreZone.org or the NOAA ShoreZone Page and the BC imagery dataset can be accessed through the Coastal and Ocean Resources' ArcGIS site. The mapping geodatabases and summary reports (as well as ground survey data and reports) can be downloaded through the ShoreZone.org. Further ShoreZone resources, including a newly updated

Illustrated Data Dictionary, can be accessed through ShoreZone.org or the NOAA ShoreZone Page.

Any hardcopies or published data sets utilizing ShoreZone products shall clearly indicate their source. For questions regarding the protocols or information in this report, please contact SeaChange Marine Conservation Society at connect@seachangesociety.com.