

ShoreZone Summary Report

Burrard Inlet

April 2018



Prepared for:
Tsleil-Waututh Nation



On the cover:

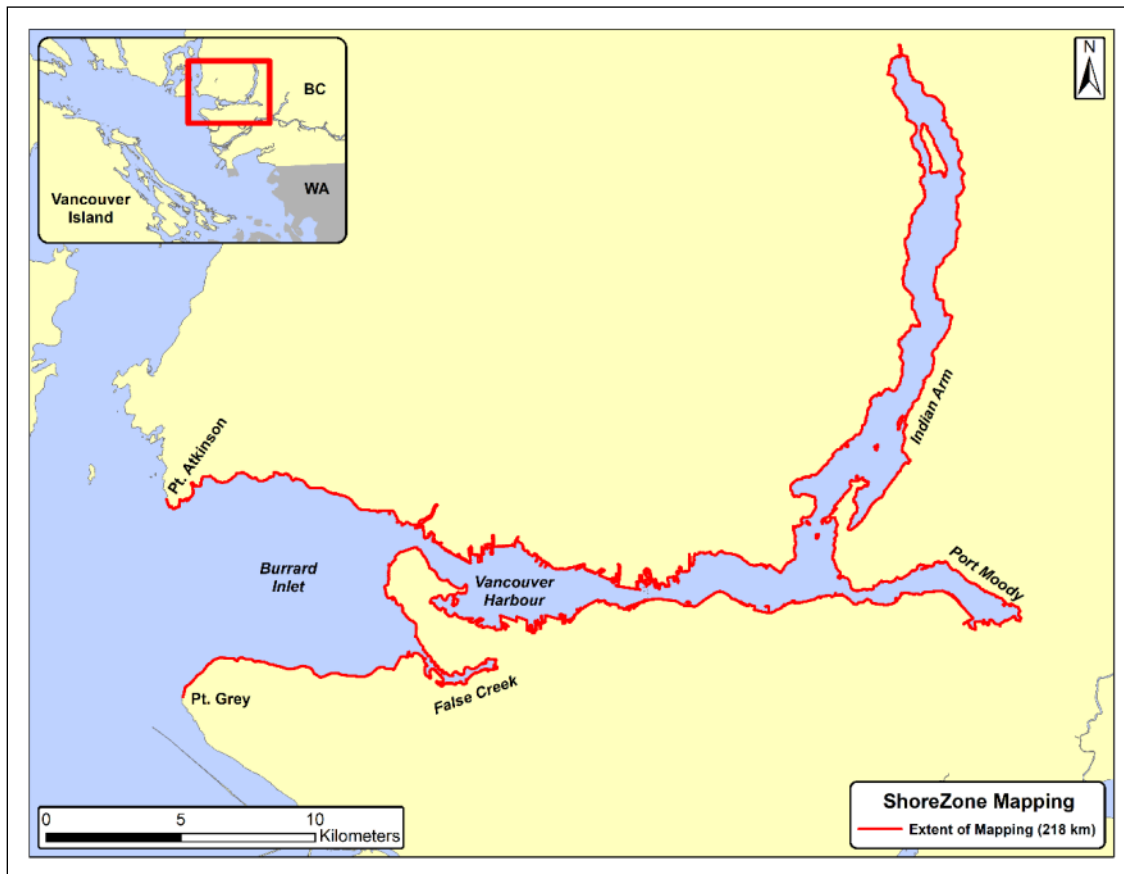
Maplewood Flats, Vancouver Harbour

Point Atkinson, Burrard Inlet

Vancouver Harbour

ShoreZone Habitat Mapping Summary Report

Burrard Inlet Survey Area



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Burrard Inlet Area Summary

218 km of shoreline mapped

850 shoreline units created

Average unit length is **256 m**

42% of the intertidal is classified as **Sediment-dominated** and **31%** is classed as **Anthropogenic (modified)**

76% of the shoreline has a high Oil Residence Index value (residence of months to years)

69% of the shoreline has a **Shoreline Modification** of some type

11 intertidal biobands were classified, with **Green Algae** and **Barnacle** being the most common (84% of units each)

8 supratidal biobands were classified, with **Black Lichen** being the most common (56% of units)

4 subtidal biobands were classified, with **Bladed Brown Algae** being the most common (20% of units)



Point Atkinson Lighthouse



Second Narrows



Port Moody



Indian River Estuary

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1 INTRODUCTION

ShoreZone is an imaging and habitat classification system for the coastal nearshore margin including the shallow subtidal, intertidal shoreline and supratidal fringe. One objective of ShoreZone is to produce a georeferenced, searchable inventory of the physical and biological attributes of coastal habitats. ShoreZone imagery and habitat 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 and managers. The ShoreZone mapping system provides a decision support tool with many potential uses including: community planning, facilities citing, conservation planning, research and fisheries management, emergency planning and response, search and rescue, education and habitat modeling.

The ShoreZone system was developed in the 1980s and 1990s to map coastal habitats in British Columbia and Washington State (Howes 2001; Berry *et al.* 2004). In 2001 ShoreZone was implemented in Alaska, beginning with Cook Inlet, Outer Kenai, Katmai, and portions of the Kodiak Archipelago (Harper and Morris 2004). ShoreZone has since expanded to a spatially continuous database of over 75,000 km of coastal Alaska and 45,000 km of British Columbia, Washington and Oregon (see Figure 1). Figure 2 shows the extent of the shoreline mapped in Burrard Inlet and is the section of shoreline covered by this summary report.

The ShoreZone imaging survey conducted in Burrard Inlet in July 2017 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 according the most recent ShoreZone coastal habitat mapping protocol (Cook *et al.* 2017). The purpose of this report is to provide a summary of the physical (Section 2) and biological (Section 3) data imaged and classified in the Burrard Inlet survey area.

The length of shoreline mapped is 218 kilometers in 850 along-shore segments (units), averaging 256 m in length. The digital shoreline used for the ShoreZone habitat mapping was compiled from multiple sources to create the best available representation of the current shoreline. The primary source for this project was the CHS Pacific High-Water Coastline 2014 BC Albers.

It should be noted this is third time Burrard Inlet has been imaged and mapped with the ShoreZone protocol (1982, 1997 and 2017 for the imaging surveys). The first mapping was completed before biobands were added to the protocol, although it would provide an interesting historical perspective to analyze and compare the three sets of data.



Figure 1. Extent of ShoreZone imagery in Alaska, British Columbia, Washington State and Oregon as of April 2018. Some sections of the coastline in BC have been imaged more than once.

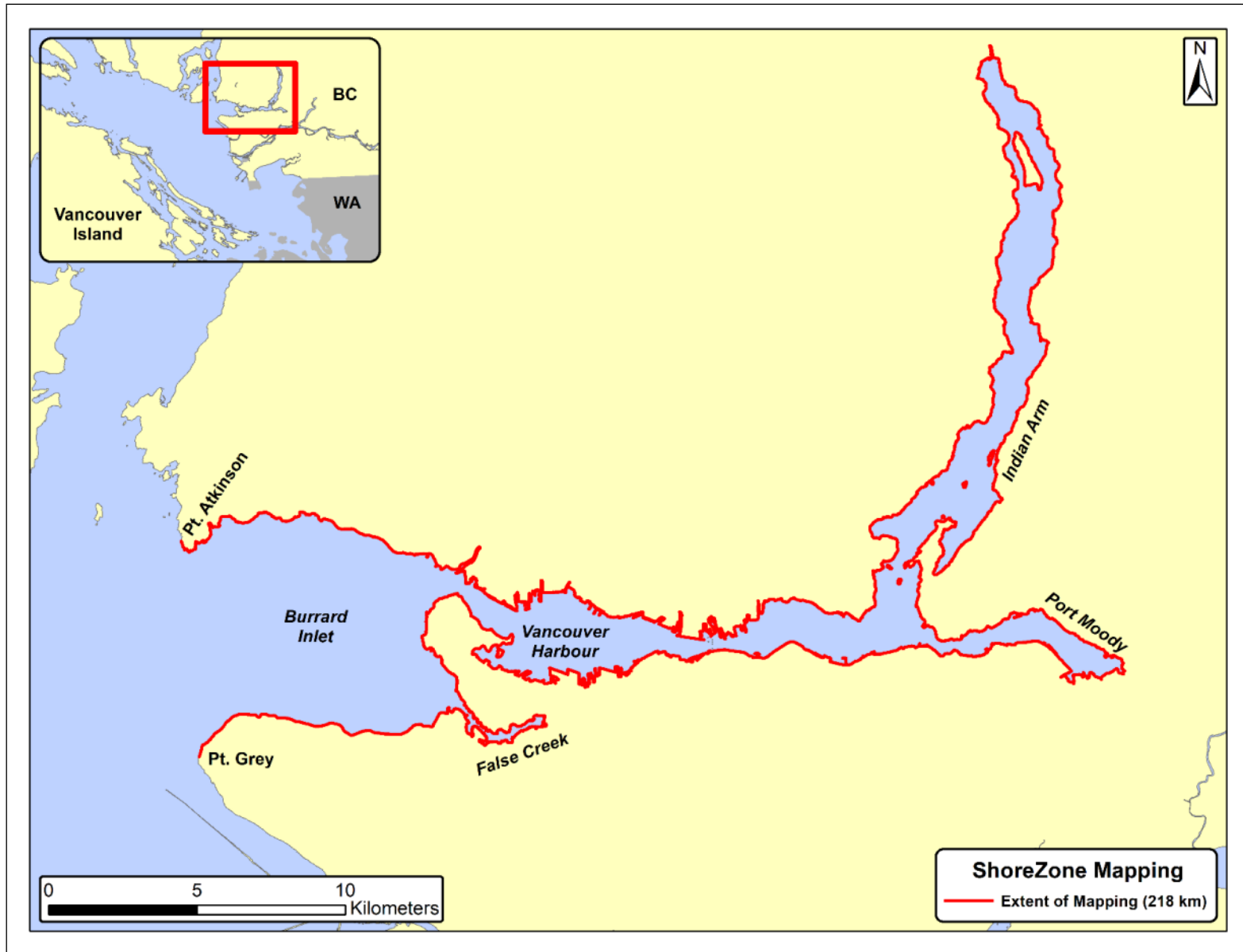


Figure 2. Extent of mapping in the Burrard Inlet survey area.

2 PHYSICAL ATTRIBUTE DATA SUMMARY

2.1 Coastal Class

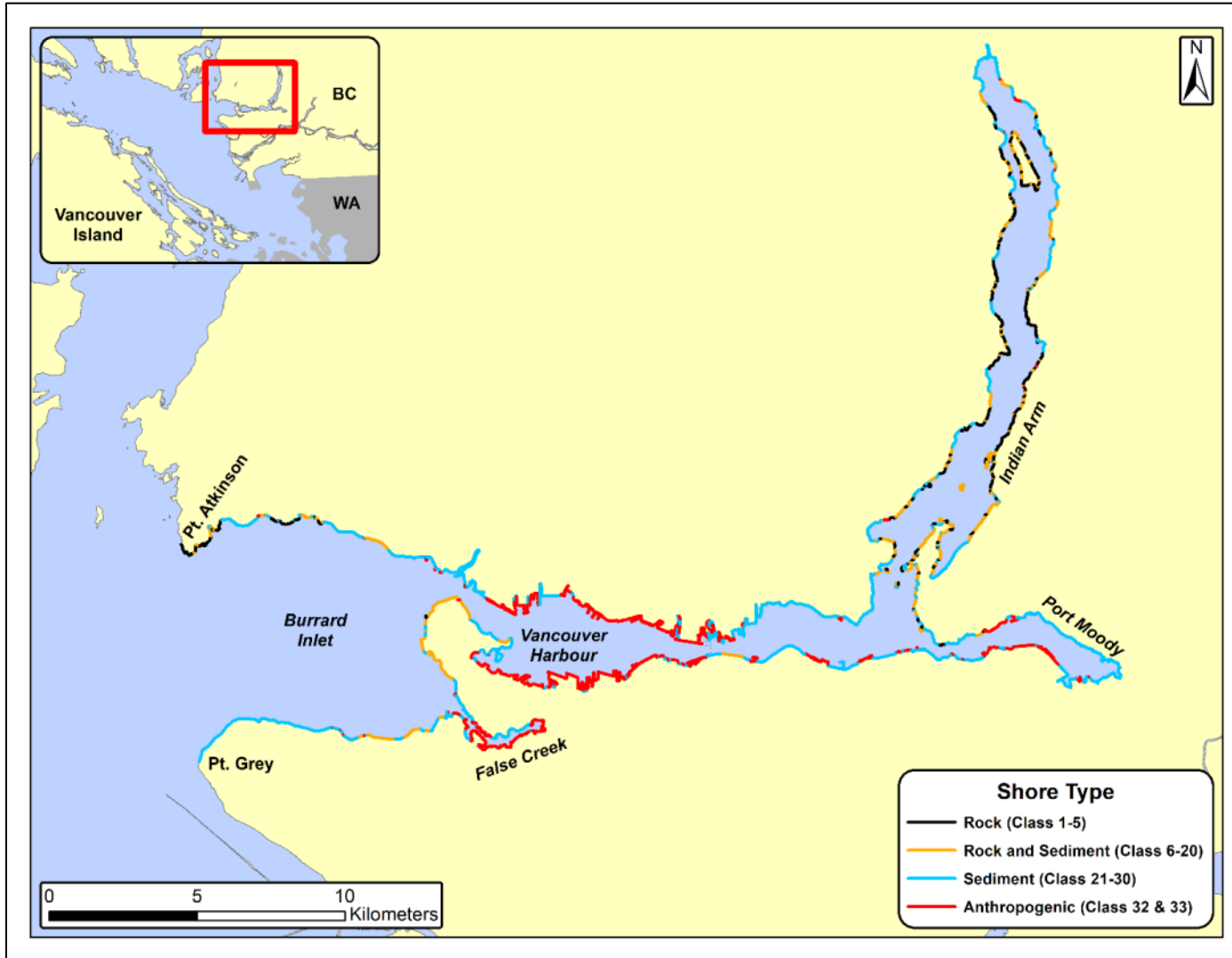


Figure 3. Map of the Coastal Class categories (also known as Shore Type) in Burrard Inlet, grouped by type.

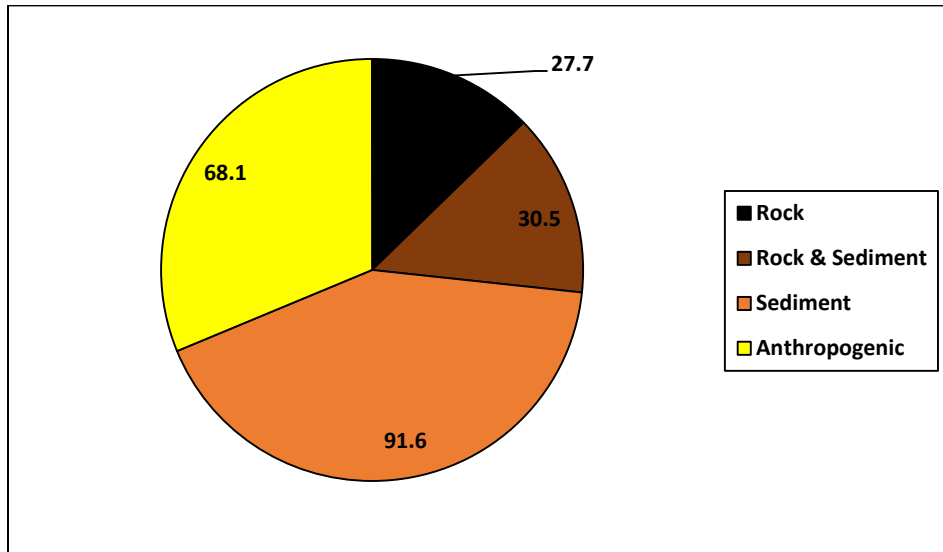


Figure 4. Grouped Coastal Class categories by shoreline length (km).

The Coastal Class is used to define along-shore coastal units based on the dominant process, geomorphic features and other attributes such as substrate size, 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. Sediment shorelines (42.0%) and Anthropogenic shorelines (31.3%) dominated the Burrard Inlet area. Rock and Sediment shorelines followed with 14.0% and Rock shorelines were found along 12.7% of the coast (see Figures 3 and 4 for distribution and summary statistics). The description for each Coastal Class category in the survey area is given in Table 1. Photographic examples of the major Coastal Classes mapped in Burrard Inlet are found in Appendix A, Table A-1.

Table 1. Summary of the Coastal Class attribute for the Burrard Inlet survey area.

Substrate Type	Shore Type		Sum of Unit Length (km)	# of Units	% Occurrence (by length)	Cumulative Occurrence (% , km)
	No.	Description				
Rock	3	Rock Cliff	25	115	11.5	27.7% 12.7 km
	4	Rock Ramp, narrow	2.8	15	1.3	
Rock & Sediment	8	Cliff with gravel beach	10	66	5	14% 30.5 km
	9	Ramp with gravel beach	5	32	3	
	11	Ramp w gravel & sand beach, wide	1	8	<1	
	12	Platform with G&S beach, wide	6	20	3	
	13	Cliff with gravel/sand beach	1	8	<1	
	14	Ramp with gravel/sand beach	5	34	3	
	15	Platform with gravel/sand beach	<1	3	<1	
	17	Platform w sand beach, wide	1	5	1	
	18	Cliff with sand beach	<1	1	<1	
19	Ramp w sand beach, narrow	<1	1	<1		
Sediment	22	Gravel beach, narrow	1	7	<1	42% 91.6 km
	24	Sand & gravel flat or fan	38	135	18	
	25	Sand & gravel beach, narrow	35	158	16	
	27	Sand beach	<1	1	<1	
	28	Sand flat	17	32	8	
	29	Mudflat	<1	1	<1	
	30	Sand beach	<1	1	<1	
Man-made	32	Man-made, permeable	52	173	24	31.3% 68.1 km
	33	Man-made, impermeable	16	34	7	
Totals:			218	850	100	100%

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

2.2 Environmental Sensitivity Index (ESI)

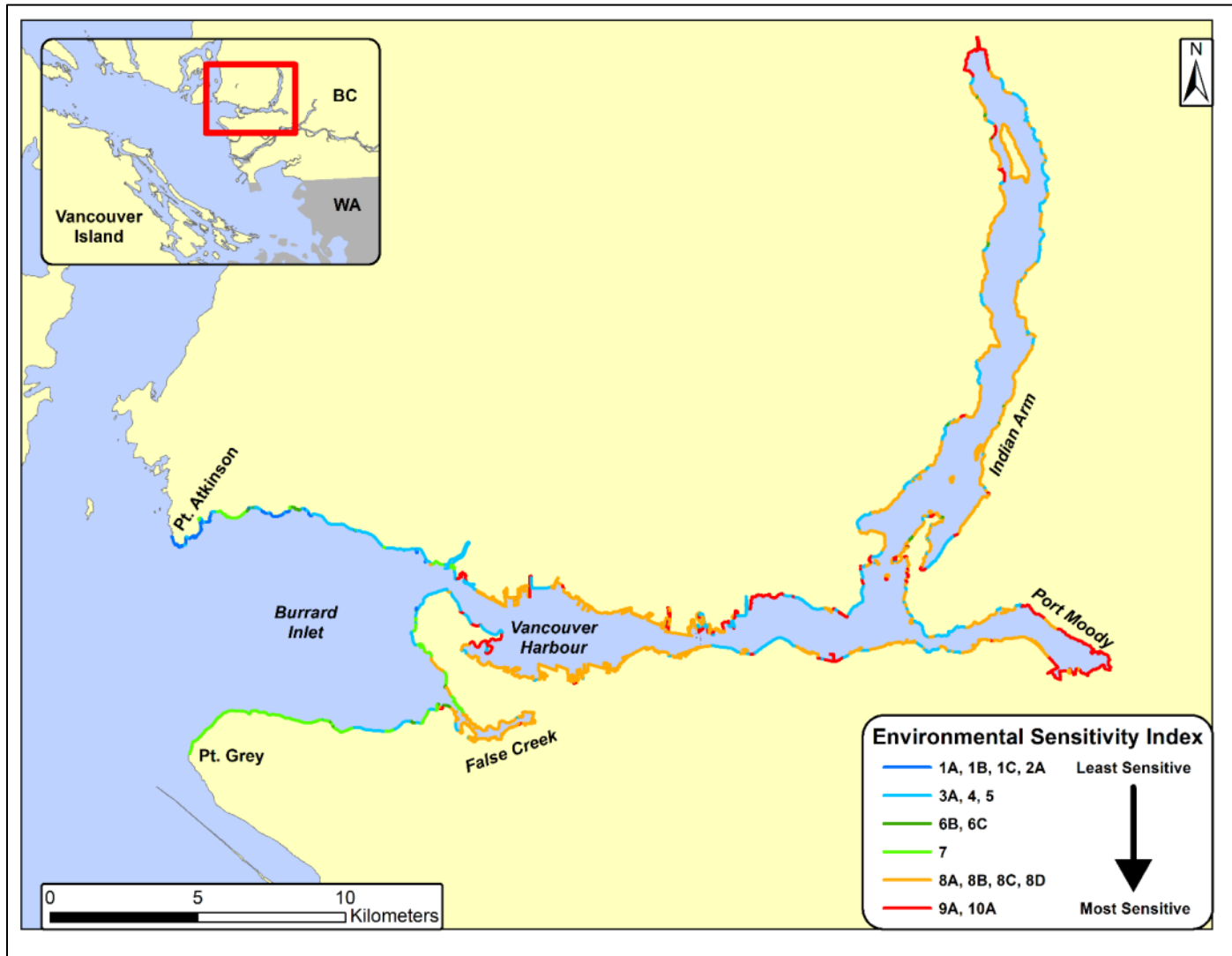


Figure 5. Distribution of the grouped ESI categories from least to most sensitive to oiling.

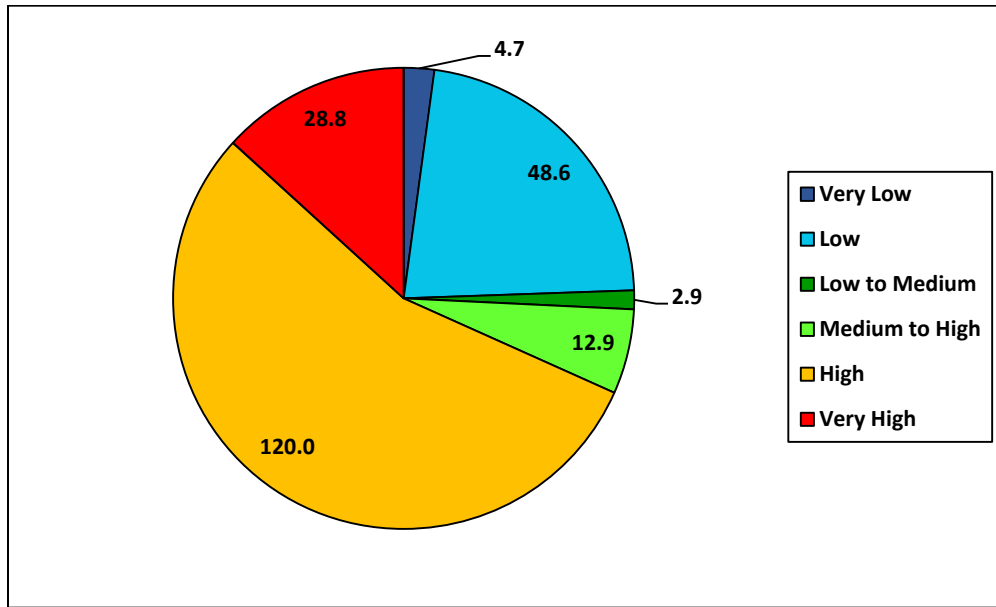


Figure 6. Grouped most sensitive ESI categories by shoreline length (km).

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.

Burrard Inlet is dominated by the grouped High and Very High categories (68.3% of shoreline length). These sections of the shoreline have a potentially high sensitivity to oil. At the other end of the spectrum, only 24.4% of the shoreline was mapped with a potentially low sensitivity to oil (Figures 5 and 6). The summary of Shore Type by ESI class can be seen in Table 2.

Table 2. Summary of Shore Types by ESI Class for the Burrard Inlet survey area.

Environmental Sensitivity Index (ESI)		Sum of Unit Length (km)	# of Units	% of Total Shoreline Length
No.	Description			
1A	Exposed rocky shores; Exposed rocky banks	2	2	1
1B	Exposed, solid man-made structures	1	4	<1
1C	Exposed rocky cliffs with boulder talus base	<1	1	<1
2A	Exposed wave-cut platforms in bedrock, mud, or clay	2	10	1
3A	Fine- to medium-grained sand beaches	<1	3	<1
4	Coarse-grained sand beaches	<1	1	<1
5	Mixed sand and gravel beaches	48	196	22
6B	Gravel beaches (cobbles and boulders)	2	18	1
6C	Rip rap	1	8	<1
7	Exposed tidal flats	13	29	6
8A	Sheltered scarps in bedrock, mud, or clay; sheltered rocky shores (impermeable)	26	139	12
8B	Sheltered, solid, man-made structures; sheltered rocky shores (permeable)	44	117	20
8C	Sheltered Rip Rap	34	123	16
8D	Sheltered rocky rubble shores	17	104	8
9A	Sheltered tidal flats	21	81	10
10A	Salt- and brackish-water marshes	8	14	4
Totals:		218	850	100

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

2.3 Oil Residence Index (ORI)

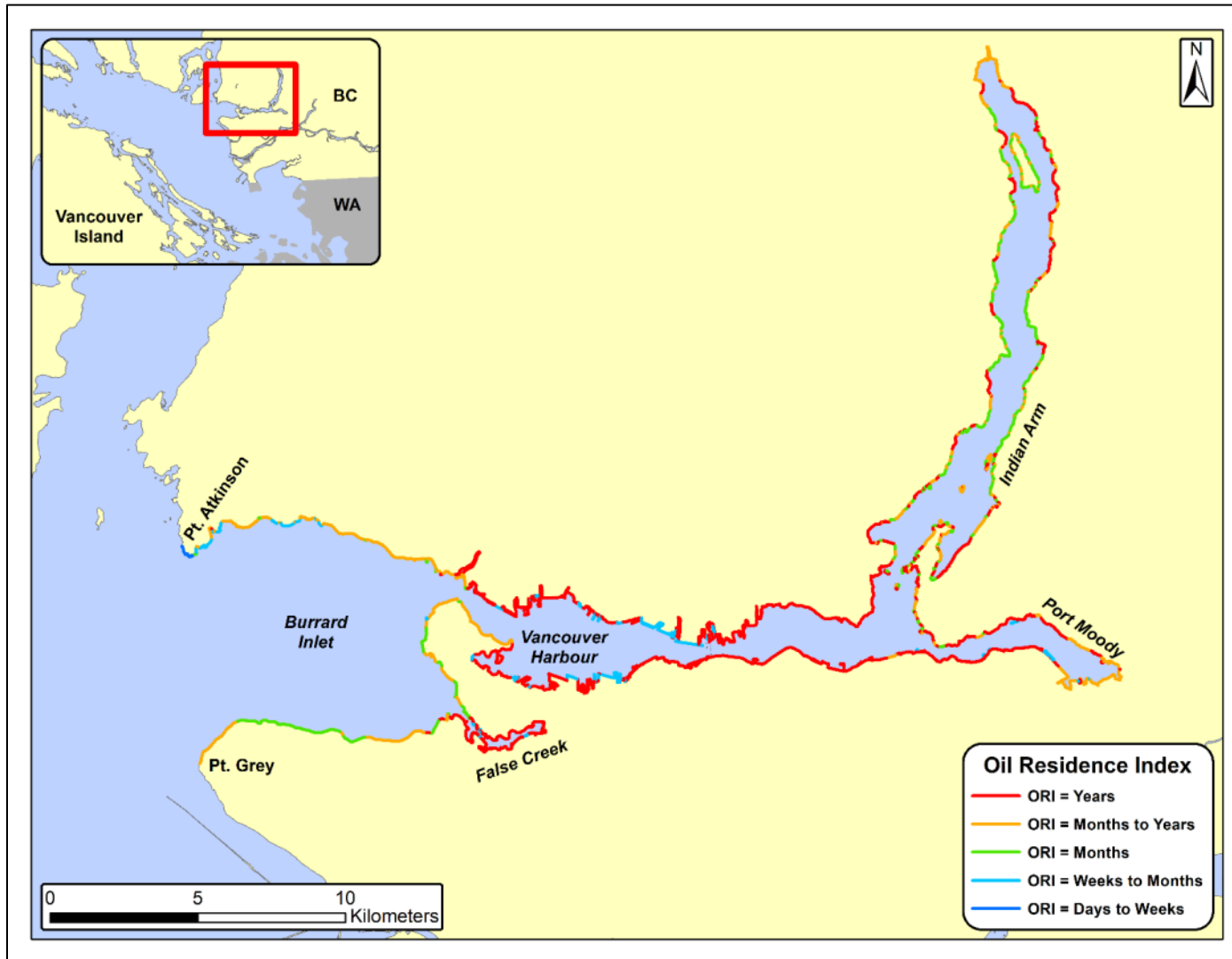


Figure 7. Distribution of the Oil Residence Index (ORI) categories.

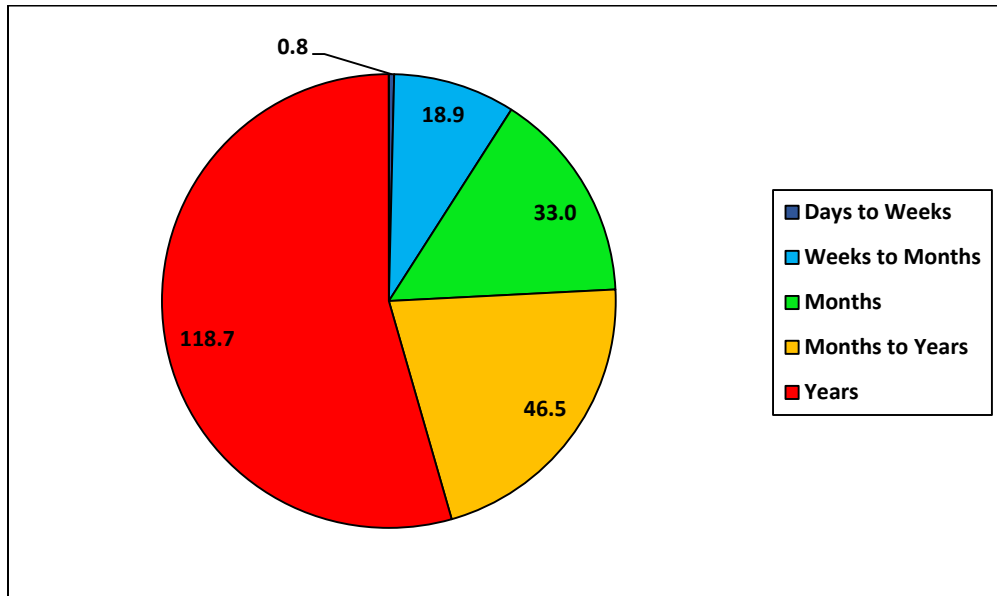


Figure 8. Oil Residence Index (ORI) categories by shoreline length (km).

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 unconsolidated sand and gravel sediments lead to high ORI values for 75.8% of the shore segments in Burrard Inlet, indicating oil residence times are on the order of months to years (see Figures 7 and 8 for distribution and summary statistics).

2.4 ShoreZone Coastal Vulnerability

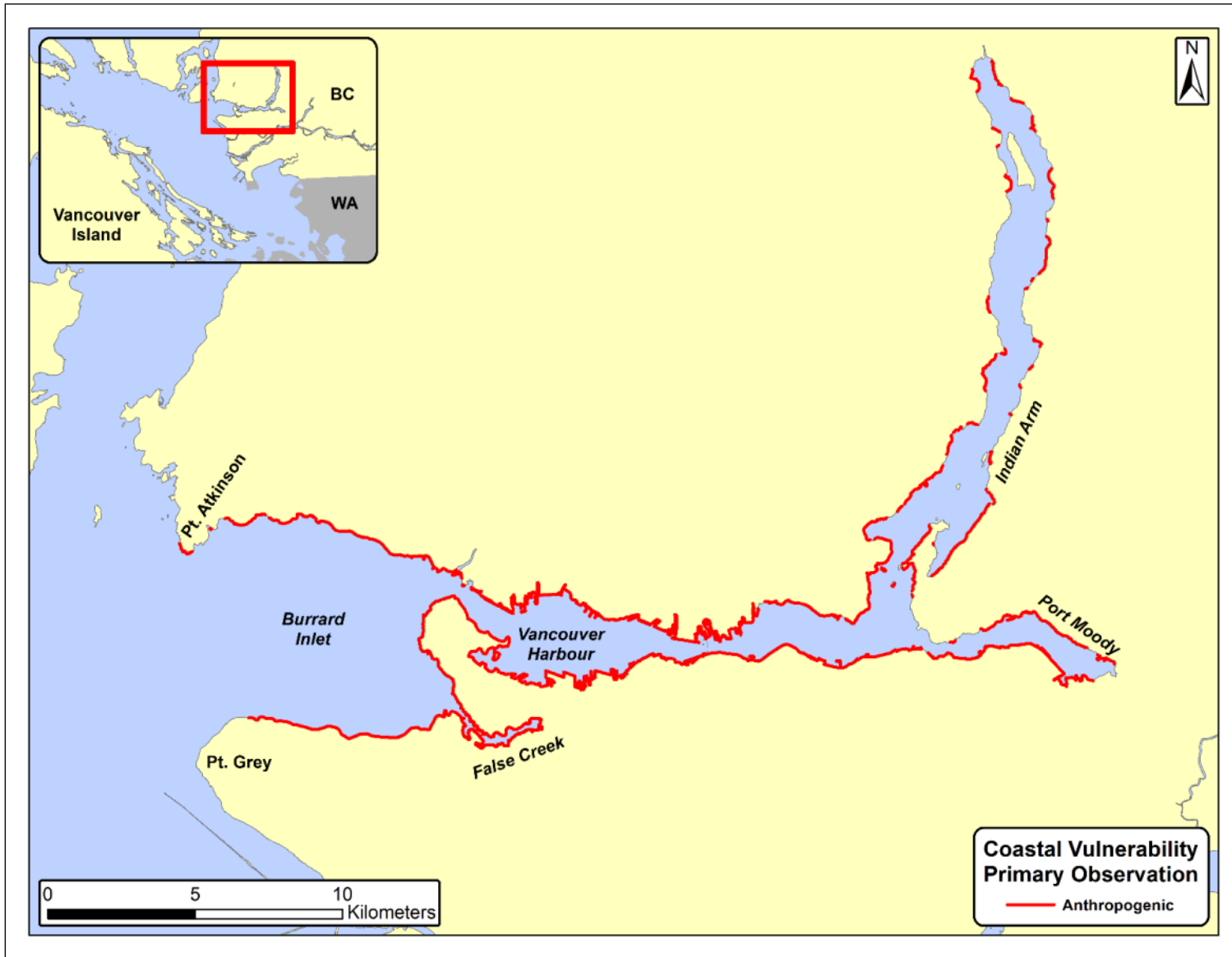


Figure 9. Distribution of the Coastal Vulnerability Observations categories.

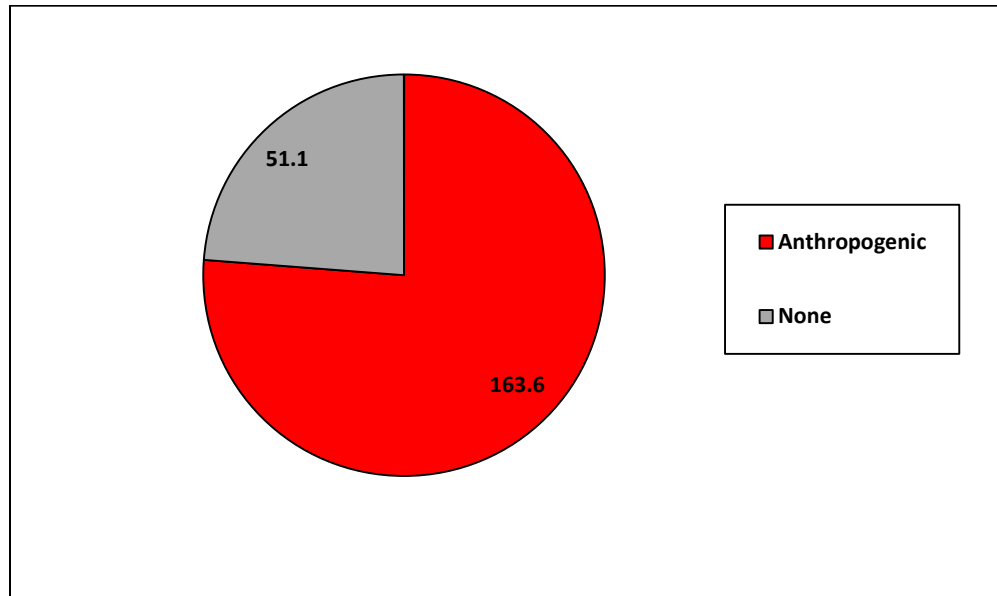


Figure 10. Coastal Vulnerability Observation categories by shoreline length (km).

The Coastal Vulnerability Module of ShoreZone includes several attributes to provide qualitative estimates of the vulnerability of a unit to impact from sea level rise, whether that is due to anthropogenic causes or natural phenomena such as storm surge (Cook *et al.* 2017). One of these attributes are observations of features important for estimating the potential impact of coastal inundation based on the condition of the shoreline in the supratidal. Natural shorelines are, generally, considered to be more resilient to inundation due to features such as marshes or dunes while shoreline hardening or modification can cause the shore to lose resiliency. These observations are meant to complement the ‘Anthropogenic’ Coastal Class (Page 7) which indicates significant modification of the intertidal and the Shoreline Modifications attribute (Page 14) which catalogues the type of modifications observed (supratidal or intertidal). In the Burrard Inlet survey area 75% of the shoreline has some form of Anthropogenic modification in the supratidal or backshore (see Figures 9 and 10 for distribution and summary statistics). It is important to point out that these areas are not necessarily areas of vulnerability, but areas that could have reduced resilience.

Another attribute of the Coastal Vulnerability Module is the Coastal Vulnerability Index (CVI). The methods of Thieler and Hammer-Klose (2000) were adapted to develop the CVI using five ShoreZone attributes: Coastal Class, Max Tide Range, Shoreline Erosion Index, Flood Zone Width, and Wave Height (Cook *et al.* 2017). This Index has so far only been calculated for ShoreZone in Alaska and was developed using datasets available in Alaska. The equivalent datasets are not readily available for British Columbia and we have not had the opportunity to determine if those that are can fit the CVI algorithm we developed. The data from the current project will need to be analyzed and compared to existing analyses of vulnerability to sea level rise to determine if the ShoreZone data can be applied appropriately. As more ShoreZone mapping is completed, we will continue to work with the CVI to apply it to BC coasts and will update the geodatabase and deploy to our clients as appropriate.

2.5 Anthropogenic Shore Modifications

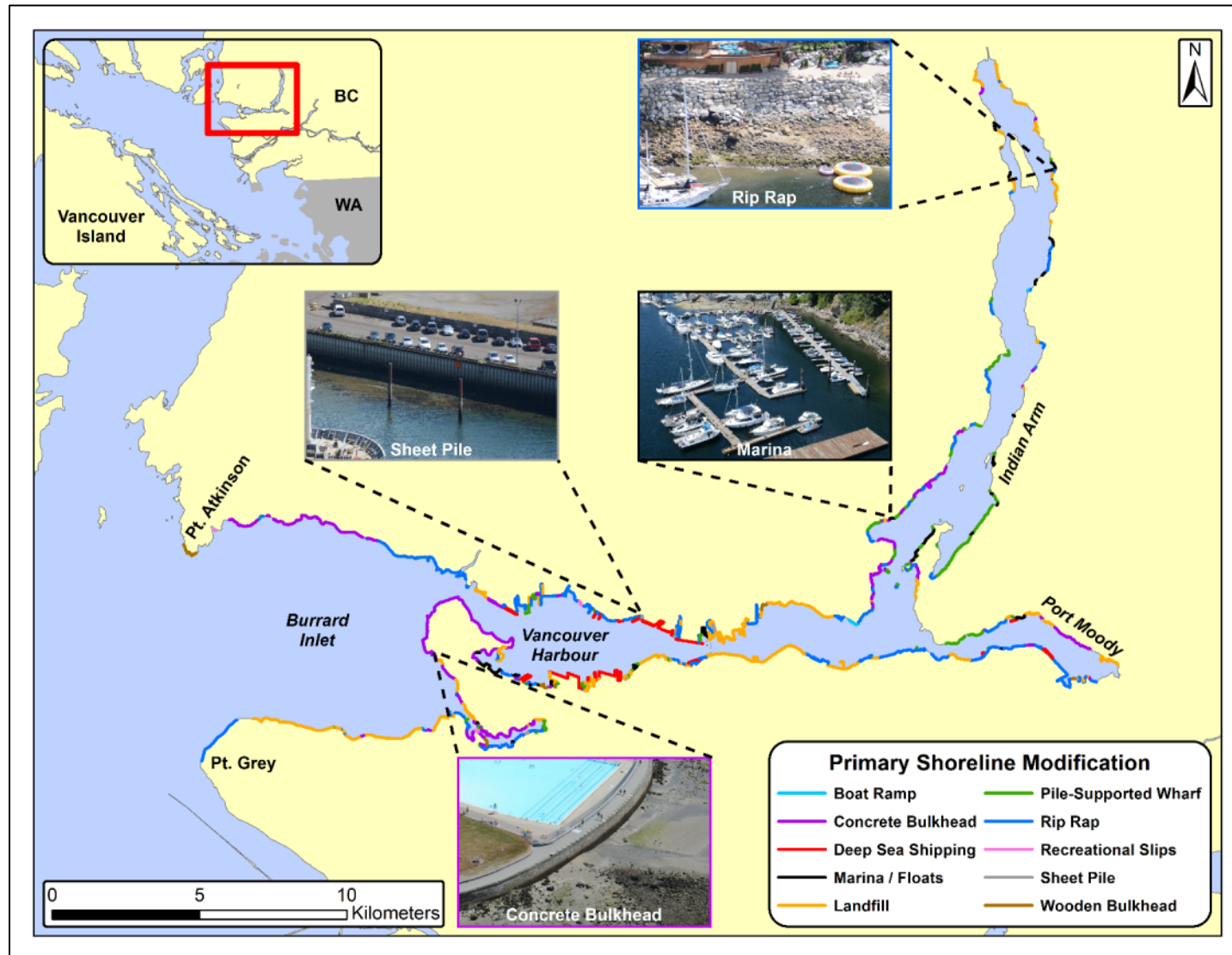


Figure 11. Distribution of types of the primary Shore Modifications. There may be other shore modifications in any given unit. That data would be found in the Shore Modifications table in the geodatabase.

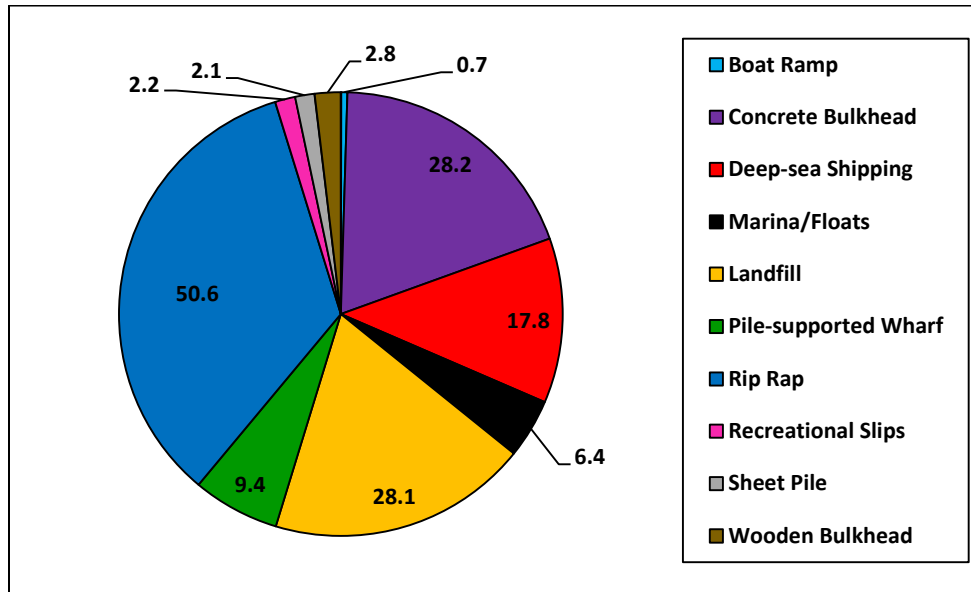


Figure 12. Shore Modifications by estimated shoreline length (km) of each modification type.

The Shoreline Modification attribute provides a thorough catalogue of the specific types of anthropogenic modification in each unit (Cook *et al.*, 2017). This includes many modifications 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 68.9% of the shoreline (taking the estimated length of that modification within the unit into account) exhibits shore modifications in the Burrard Inlet study area (Figure 12). Rip Rap was the most commonly recorded observation (34.1%) with Concrete Bulkheads along 19.0% of the shore and Landfill along 18.9%. The associated map (Figure 11) shows the distribution of primary shore modifications though it should be noted that any given modification is necessarily 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.

2.6 Riparian Overhang

This attribute was classified at the request of the client for this project. The Riparian Overhang records the percent alongshore length category of the unit that has trees overhanging the intertidal zone. It does not include areas where trees are only overhanging the supratidal. Riparian overhang of the intertidal provides shade to the beach and can influence the suitability of the habitat for beach spawning forage fish. Many units recorded with riparian overhang in this survey area are in the rocky, fjord area up Indian Arm and therefore not likely to be suitable for forage fish so this attribute may need to be combined with Coastal Class or the across shore materials to determine the impact of shade on forage fish habitat. Photos of two examples of riparian overhang are found in Figure 13 and a map of the distribution of this attribute is found in Figure 14.



Figure 13. Examples of the Riparian Overhang attribute on a narrow rocky shore in Indian Arm (bc17_br_02175) (top) and on a sediment beach in outer Burrard Inlet (bc17_br_00106) (bottom).

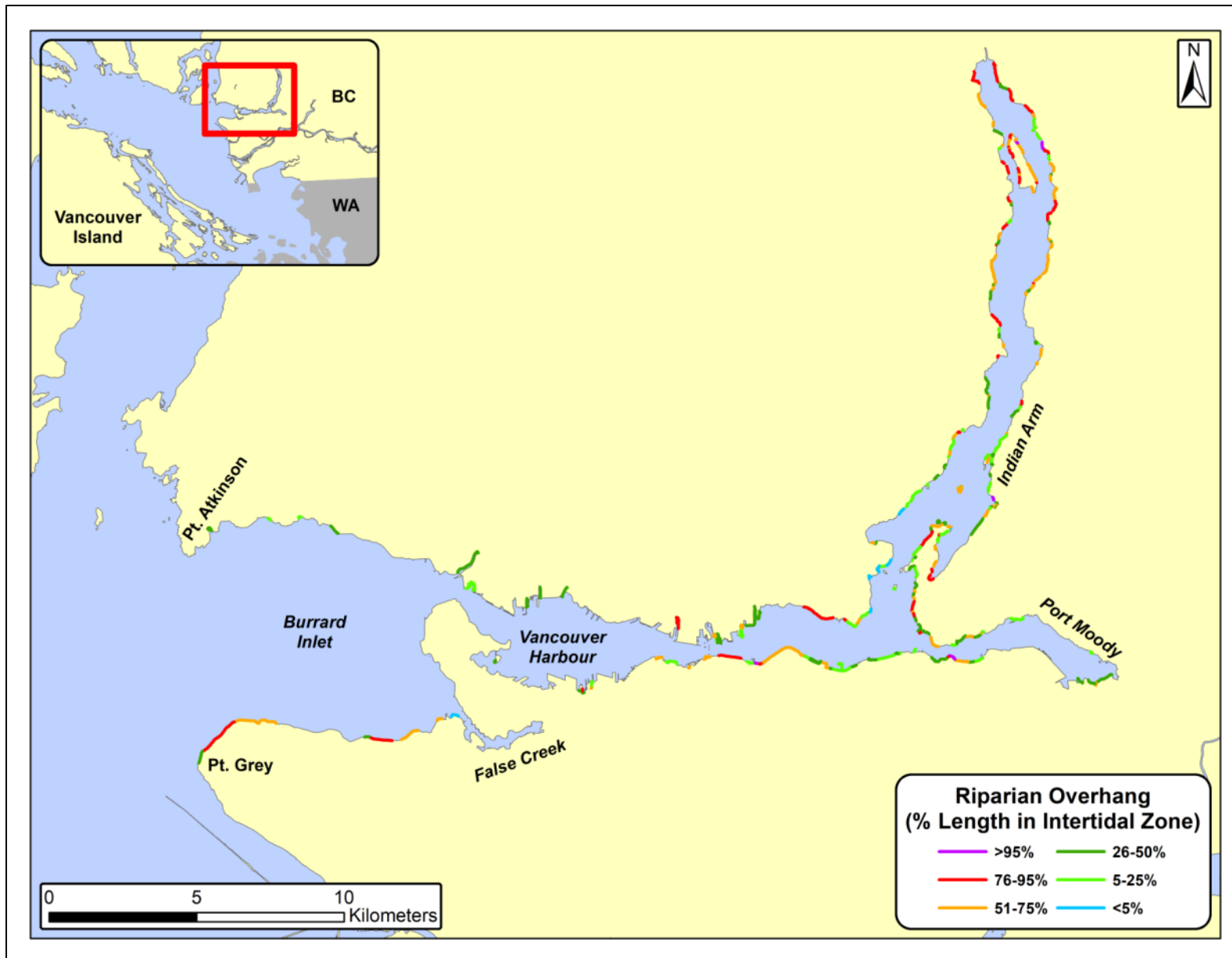


Figure 14. Distribution of the Riparian Overhang attribute in the Burrard Inlet survey area.

3 BIOLOGICAL ATTRIBUTE DATA SUMMARY

3.1 Biobands

Biobands represent assemblages of coastal biota found on the shoreline at typical wave exposures, substrate conditions and across-shore elevations. Biobands are spatially distinct, with alongshore and across-shore patterns of color and texture that are visible in aerial imagery (see Appendix A, Table A-2 for examples from the Burrard Inlet survey area). Full descriptions of all biobands, including indicator and associated species can be found in the ShoreZone protocol (Cook *et al.* 2017). The metrics for measuring the biobands are also detailed in the protocol document. The specific elevation (or zone) of the bioband on the shoreline determines the metrics applied. 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.

The 20 individual biobands mapped in the Burrard Inlet survey area are summarized in Tables 3 and 4. The survey area was dominated by anthropogenic structures and this influenced the biota, with those that attach to hard substrates, including pilings and seawalls, dominating. That explains why the most commonly occurring intertidal biobands were Green Algae (84.2%) and Barnacle (83.9%) and the most common Splash Zone bioband was Black Lichen, occurring in 55.8% of the units. Dune Grass and Salt Marsh were less common than might be expected in an estuarine system such as Burrard Inlet, at 10.2% and 4.9% of units, respectively. This is likely due to the extremely high percent of units with shore hardening and modifications in the supratidal zone. The most common subtidal biobands were Brown Bladed Algae and Bull Kelp at 20.4% and 10.7%, respectively. See Figure 15 for a map of the distribution of Bull Kelp. This is one of the few areas where ShoreZone has been completed where Sargassum, an introduced kelp, could clearly be seen forming a bioband in the subtidal. Sargassum was only noted in 3.4% of units, mostly up Indian Arm. It was challenging to see into the nearshore, due to a significant amount of sediment just off the beaches, so it is possible some subtidal vegetation was underestimated.

The Intertidal/Subtidal Vegetation bioband recorded in 7 units was used to indicate the presence of a flat, matte green ‘crust’ on the mud flats at the head of Port Moody. It is possible this is some kind of diatom or biofilm or possibly even a low turf of Salt Marsh but it was not clear from the imagery. We hope to determine the identity of this bioband during the ground survey scheduled for summer 2018 and will update the database according to what we learn.

Table 3. Percent cover category for the intertidal biobands in the Burrard Inlet survey area.

Bioband		Zone	Number of Units							Total Number of Units With Bioband Present*	% of Total Units with Bioband Present
Name	Code		Percent Cover Category (Intertidal Zone)								
			<5%	5-25%	26-50%	51-75%	76-95%	>95%	Bioband Present, Percent Cover Not Assessed		
Salt Marsh (BC)	SAMB	Upper to Mid-Intertidal (B)	1	13	0	0	0	0	0	14	1.6
Barnacle	BARN		26	651	16	1	0	0	19	713	83.9
Rockweed	ROCK		31	492	26	1	0	0	4	554	65.2
Biofilm	BIOF		0	1	0	0	0	0	0	1	<1
Intertidal/Subtidal Vegetation	INSV		4	3	0	0	0	0	0	7	<1
Blue Mussel	BLMU		29	323	22	5	0	0	9	388	45.6
Green Algae	GRAL		23	611	57	18	1	0	6	716	84.2
Filamentous and Foliose Red Algae	FFRA	Mid- to Lower Intertidal (B)	51	326	3	0	0	0	0	380	44.7
Surfgrass	SURF		0	1	0	0	0	0	0	1	<1
Eelgrass	EELG		11	12	0	0	0	0	0	23	2.7
Brown Bladed Algae	BRBA		56	105	5	0	0	0	3	169	19.9

*Please note that Total Number of Units is used to describe the distribution of biobands rather than length (in kilometers) because biobands are usually not continuous along the entire length of a unit. A calculation could be performed to estimate length of a bioband over a region using the percent length metric in the dataset.

Table 4. Width category of supratidal and subtidal biobands in the Burrard Inlet survey area.

Bioband		Zone	Width Category (m)				Total Number of Units With Bioband Present*	% of Total Units with Bioband Present
Name	Code		<1 m	1-5 m	>5 m	Bioband Present, Width Category Not Assessed		
Splash Zone	SPZO	Splash Zone (A)	206	76	0	0	282	33.2
Lichen	LICH		19	58	2	0	79	9.3
Black Lichen	BLLI		251	221	2	0	474	55.8
Yellow Lichen	YELI		0	1	0	0	1	<1
			<10 m	10-30 m	>30 m	Bioband Present, Width Category Not Assessed		
Trees and Shrubs	TRSH	Supratidal (A)	1	0	0	0	1	<1
Grasses	GRAS		2	0	0	0	2	<1
Dune Grass	DUGR		85	1	1	0	87	10.2
Salt Marsh	SAMB		35	3	4	0	42	4.9
Eelgrass	EELG	Subtidal (C)	16	6	2	0	24	2.8
Sargassum	SARG		8	0	0	21	29	3.4
Brown Bladed Algae	BRBA		84	8	3	78	173	20.4
Bull Kelp	BUKE		76	8	7	0	91	10.7

*Please note that Total Number of Units is used to describe the distribution of biobands rather than length (in kilometers) because biobands are usually not continuous along the entire length of a unit. A calculation could be performed to estimate length of a bioband over a region using the percent length metric in the dataset.

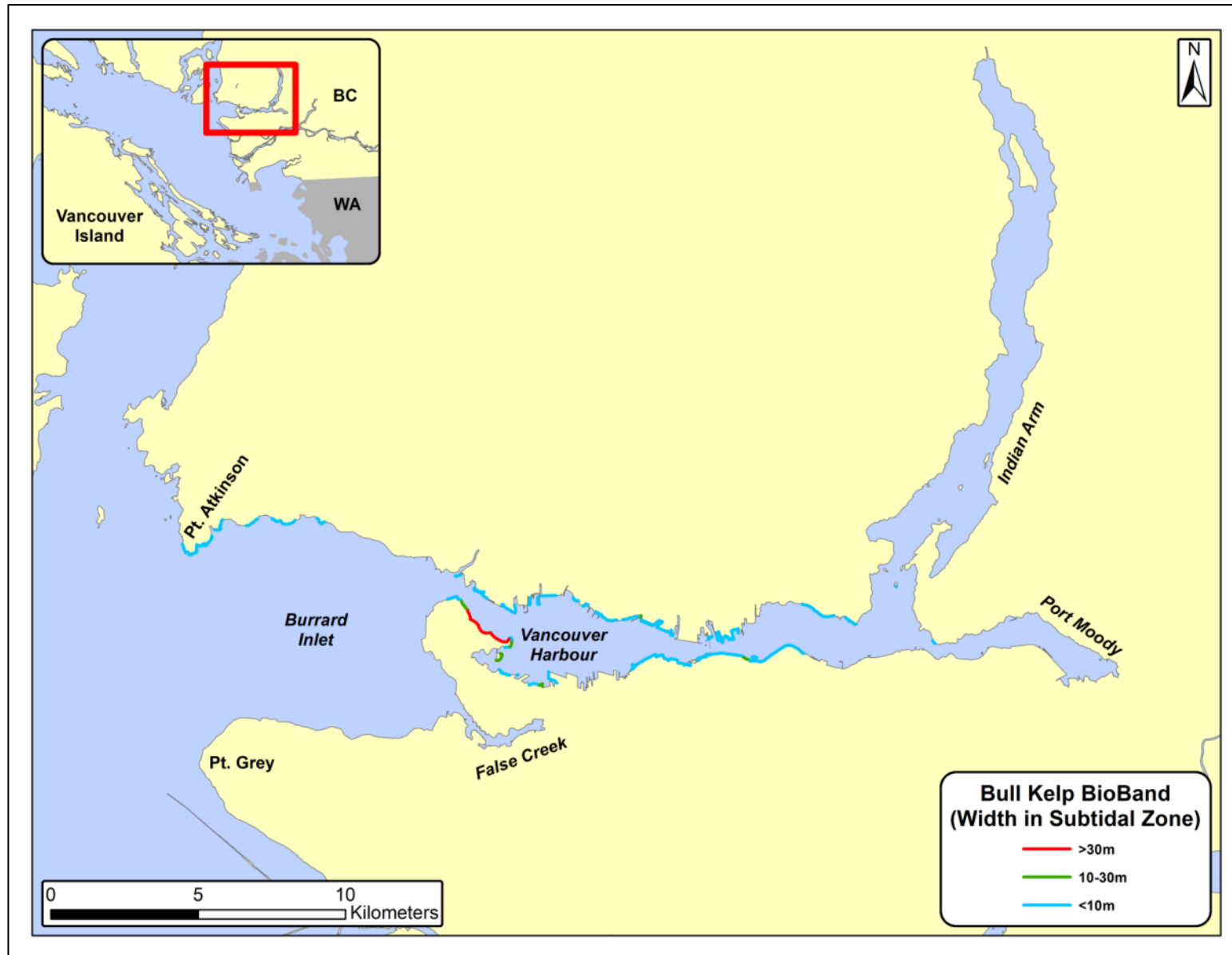


Figure 15. Distribution of the Bull Kelp bioband by Width Category in the subtidal zone of the Burrard Inlet survey area.

Eelgrass was recorded in the intertidal in 2.7% of units and in the subtidal in 2.8% of units so it was not common in the survey area. Eelgrass was noted at Spanish Banks, mixed with foliose green algae, although it had not previously been recorded as an area with eelgrass habitat. It is possible that area has been colonized by *Zostera japonica*, an introduced eelgrass that occurs higher in the intertidal than the native *Z. marina*. We cannot distinguish between the species in an aerial survey. We intend to check this observation as part of the ground survey planned for the area in summer 2018. If needed, the database will be updated to record what is discovered. We also compared the distribution of Eelgrass as mapped with ShoreZone with the 2015 Burrard Inlet-Indian Arm Eelgrass Mapping report (Rao 2015). ShoreZone captured the larger beds but missed some of the small, patchy subtidal beds in Indian Arm. Upon review of the imagery it was determined those beds were not visible on the day the imagery was taken due to the murky conditions immediately off the beach (see Figure 16 for an example). See Figure 17 for a map of the distribution of Eelgrass in the survey area from the ShoreZone observations.



Figure 16. Example of murky subtidal conditions during the ShoreZone imaging survey in July 2017. The 2015 Burrard Inlet-Indian Arm Eelgrass Mapping report indicated there was a patchy subtidal eelgrass bed off the tombolo between the mainland and this island. The shallow subtidal is not visible in this image so we were not able to capture that bed in the ShoreZone mapping.

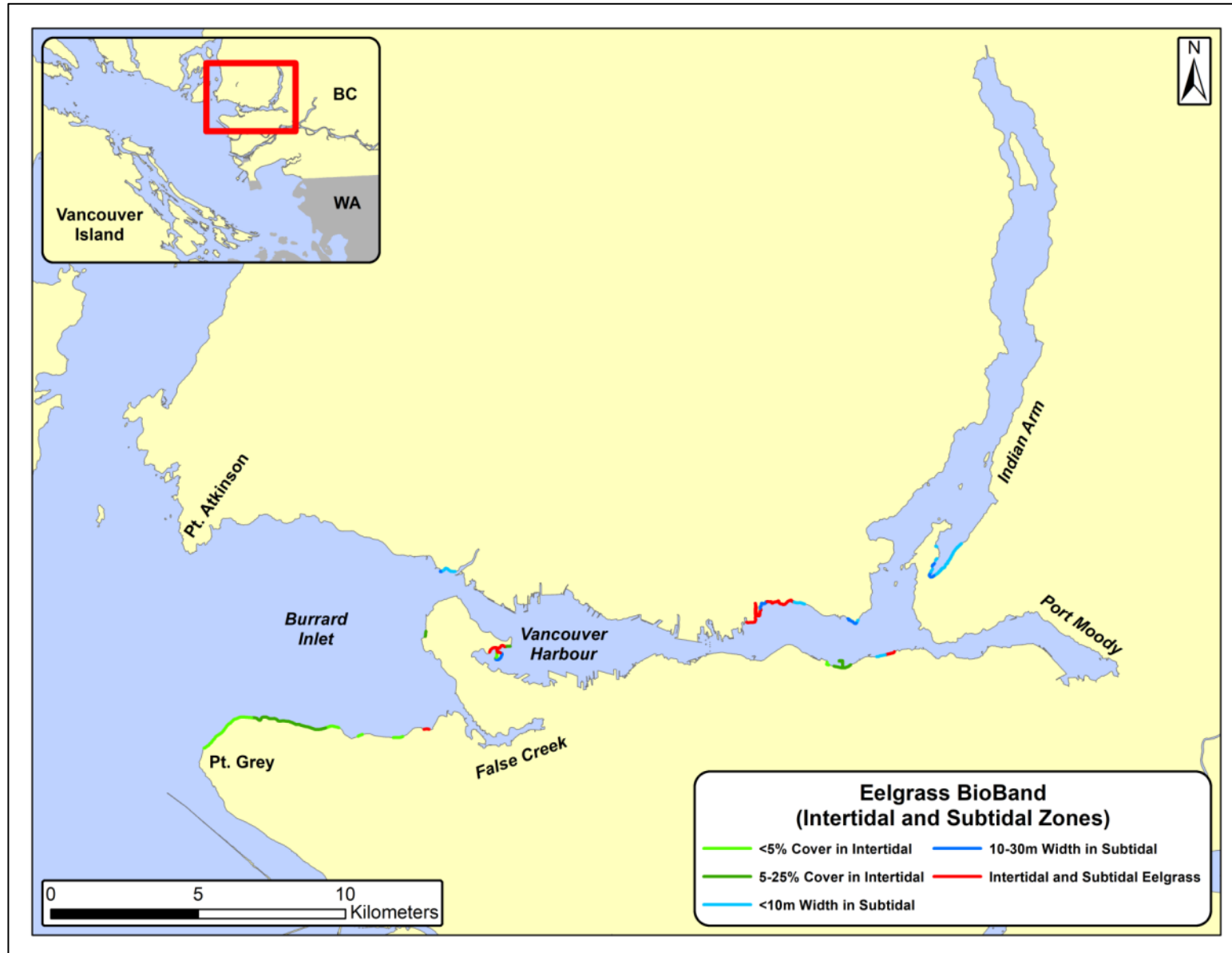


Figure 17. Distribution of the Eelgrass bioband by Percent Cover in the intertidal zone and Width Category in the subtidal zone in the Burrard Inlet survey area. The units where both intertidal and subtidal Eelgrass was recorded are in red.



The Blue Mussel bioband was noted in roughly half the units (45.6% overall) and formed extensive beds on the rock substrate around Point Atkinson and on the beaches on the north shore of Burrard Inlet, to the west of the Lions Gate Bridge. It was also common on the cliffs in the Indian Arm fjord area. See Figure 18 for a map of the distribution of Blue Mussels in the survey area. It was interesting to note that the mussel beds in Burrard Inlet were more sprawling and did not appear to have a clearly defined lower limit in the intertidal, although some of the mussel beds noted further up the inlet appeared to be more well-defined. The lower limit of mussels is usually defined by predation by sea stars, which have recently been decimated by sea star wasting disease. It should be noted that Ochre Sea Stars (*Pisaster ochraceous*) could clearly be seen at the waterline in a few of the units in the more protected part of the survey area (Indian Arm) where the lower limit of the blue mussel bed appeared to be higher in the intertidal and have a more distinct lower limit. See Figure 19 for two photos showing examples of the diversity in the Blue Mussel band. We hope to explore these observations in the ground survey planned for summer 2018.

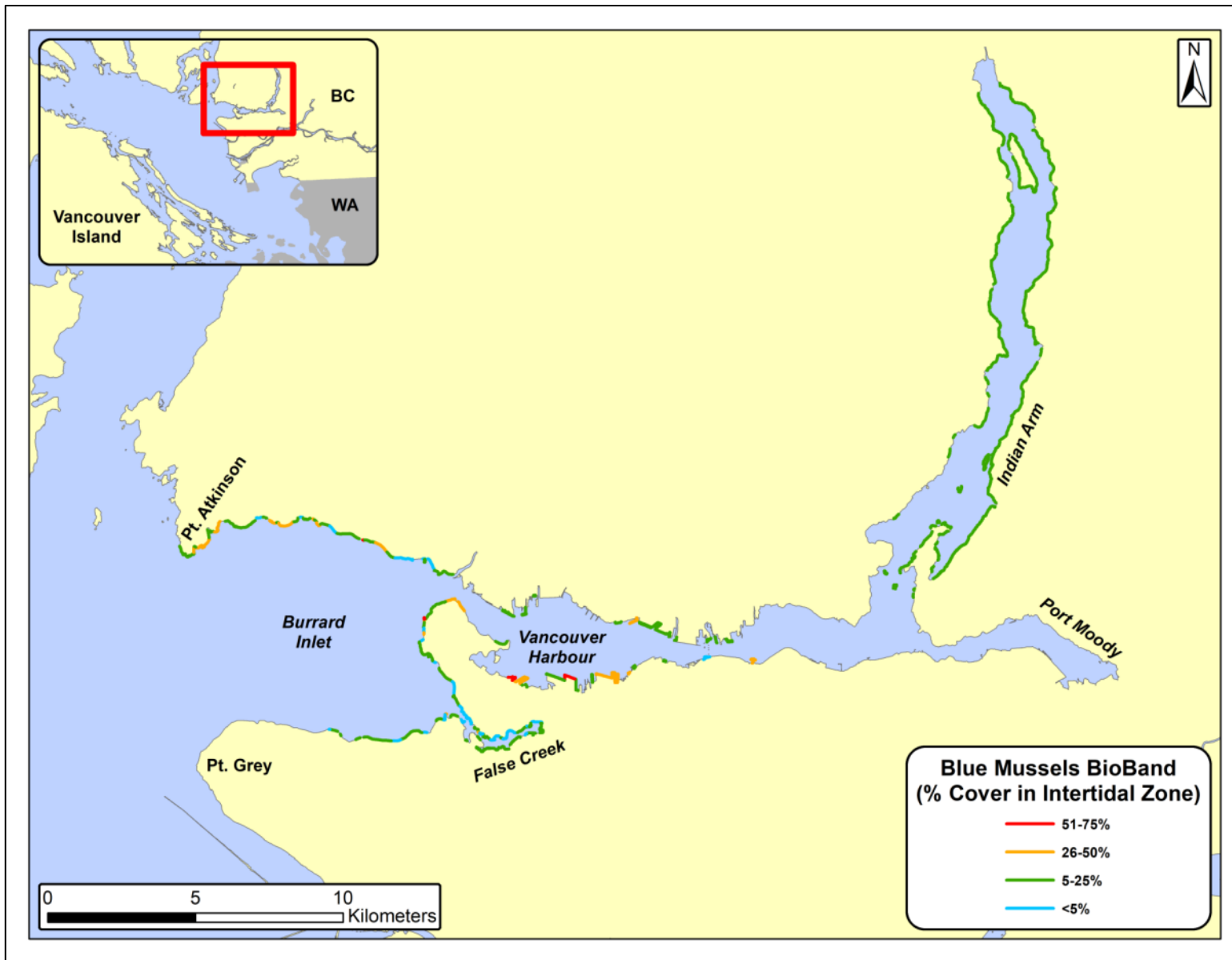


Figure 18. Distribution of the Blue Mussel bioband by Percent Cover in the intertidal zone in the Burrard Inlet survey area.



Figure 19. Examples of the Blue Mussel bioband at Point Atkinson (bc17_br_00007) (top) and at the entrance to Indian Arm, near Deep Cove (bc17_br_01945) (bottom). Purple Ochre Stars are visible at the waterline in the lower photo. Both photos have been cropped for better illustrative purposes.

3.2 Biological Wave Exposure

Biological wave exposure categories range from Very Protected (VP) to Very Exposed (VE) and are defined in ShoreZone on the basis of a typical set of biobands. When present, the observation and relative abundance of biota in each alongshore unit is used to determine the classification for the biological wave exposure. The assemblages of biota observed are then used as a proxy for 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 in the Burrard Inlet survey area are summarized in Figure 20 and a distribution map of the categories is shown in Figure 21. 99% of the coastline was in the lower exposure categories of Semi-Protected, Protected or Very Protected so this area is characterized by limited wave fetch.

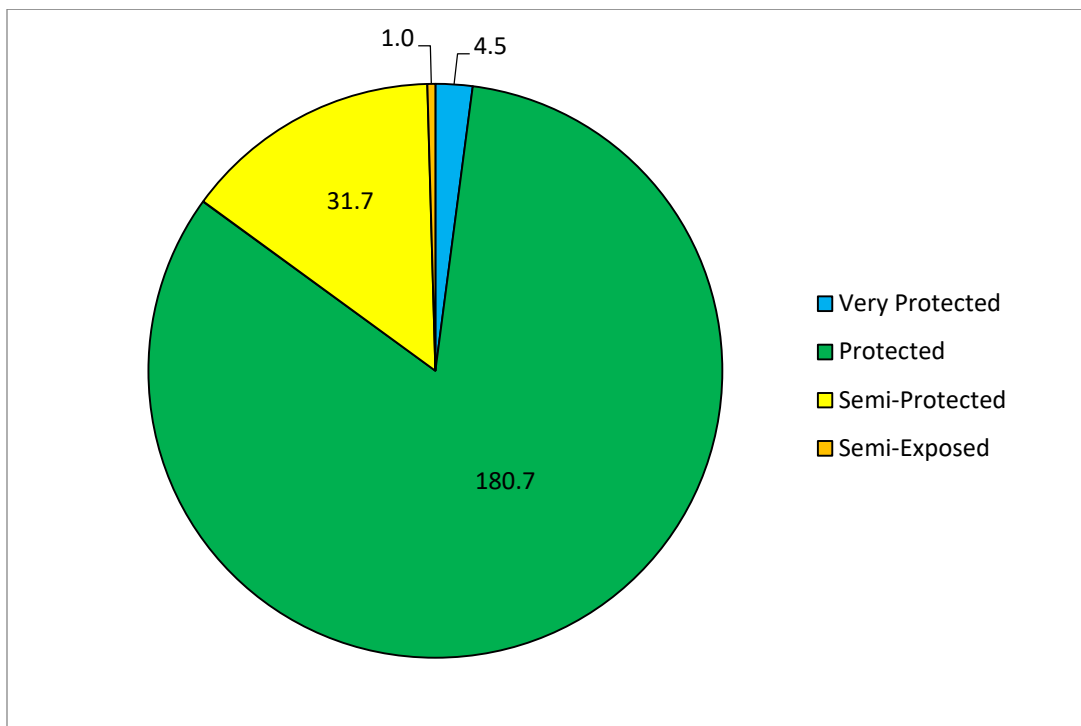


Figure 20. Distribution of biological wave exposures mapped in the Burrard Inlet survey area by shoreline length (km).

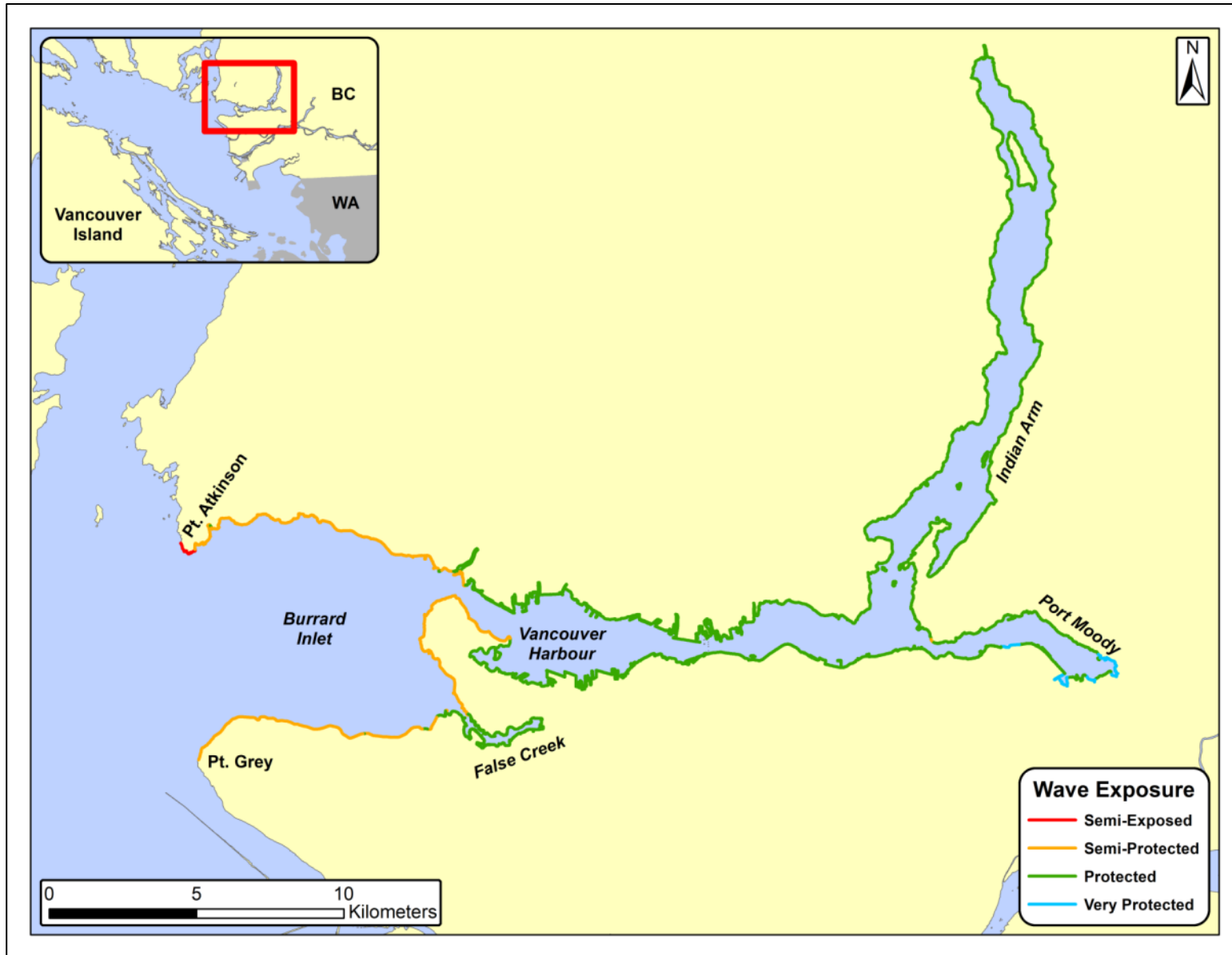


Figure 21. Distribution of the Biological Wave Exposure in the Burrard Inlet survey area.

3.3 Habitat Class

The **Habitat Class** attribute is based on wave exposure and geomorphic characteristics observed on 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 exposure is the most common structuring process, with less commonly observed habitats are those structured by current, estuarine/fluvial processes, and anthropogenic structures. For habitat classes structured by wave exposure, 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 habitat class categories mapped for the Burrard Inlet survey area are summarized in Figures 22 and 23. Partially Mobile and Immobile substrate classes are the dominant shoreline types (51.7%) with Anthropogenic habitat classes only somewhat less common (37.7%). These anthropogenic habitat classes included both areas with anthropogenic structures and areas where the natural sediment in the supratidal or intertidal had been significantly moved or altered, thereby affecting the biota present or the distribution of the biota in the unit. The Riparian, or Estuary, Habitat Class was quite rare (4.3% of the shoreline length) and is characterized by a significant source of fresh water flowing into the unit, the presence of a delta fan and the presence of marsh habitat (the Salt Marsh bioband).

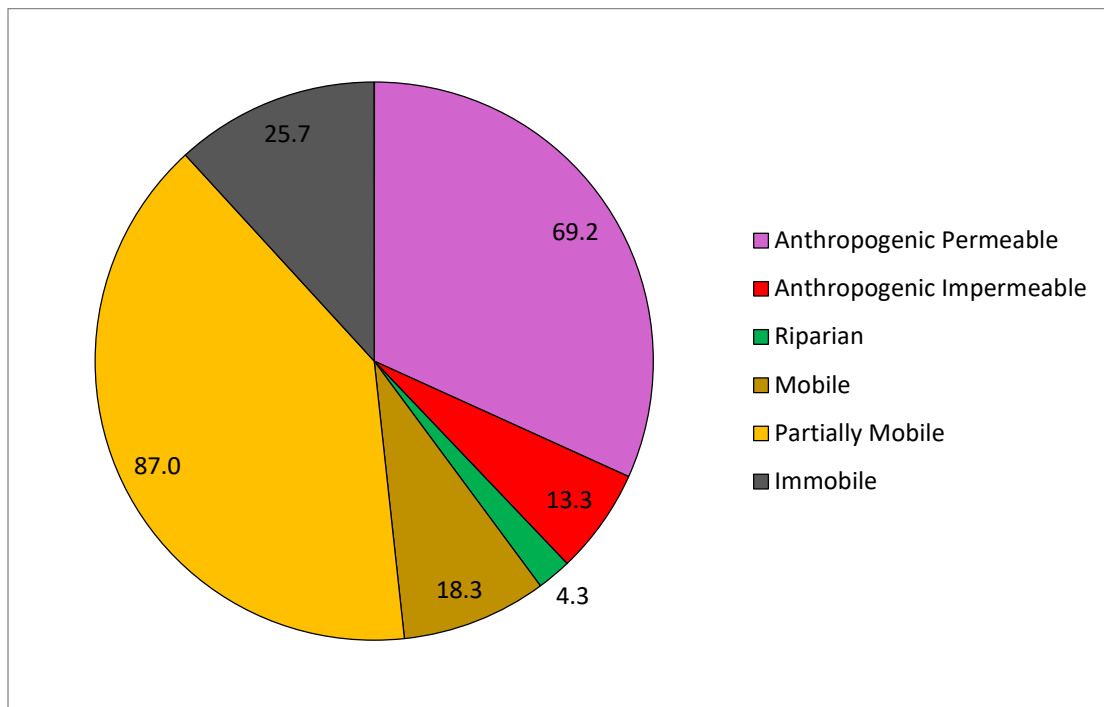


Figure 22. Distribution of Habitat Class categories in the Burrard Inlet survey area by shoreline length (km).

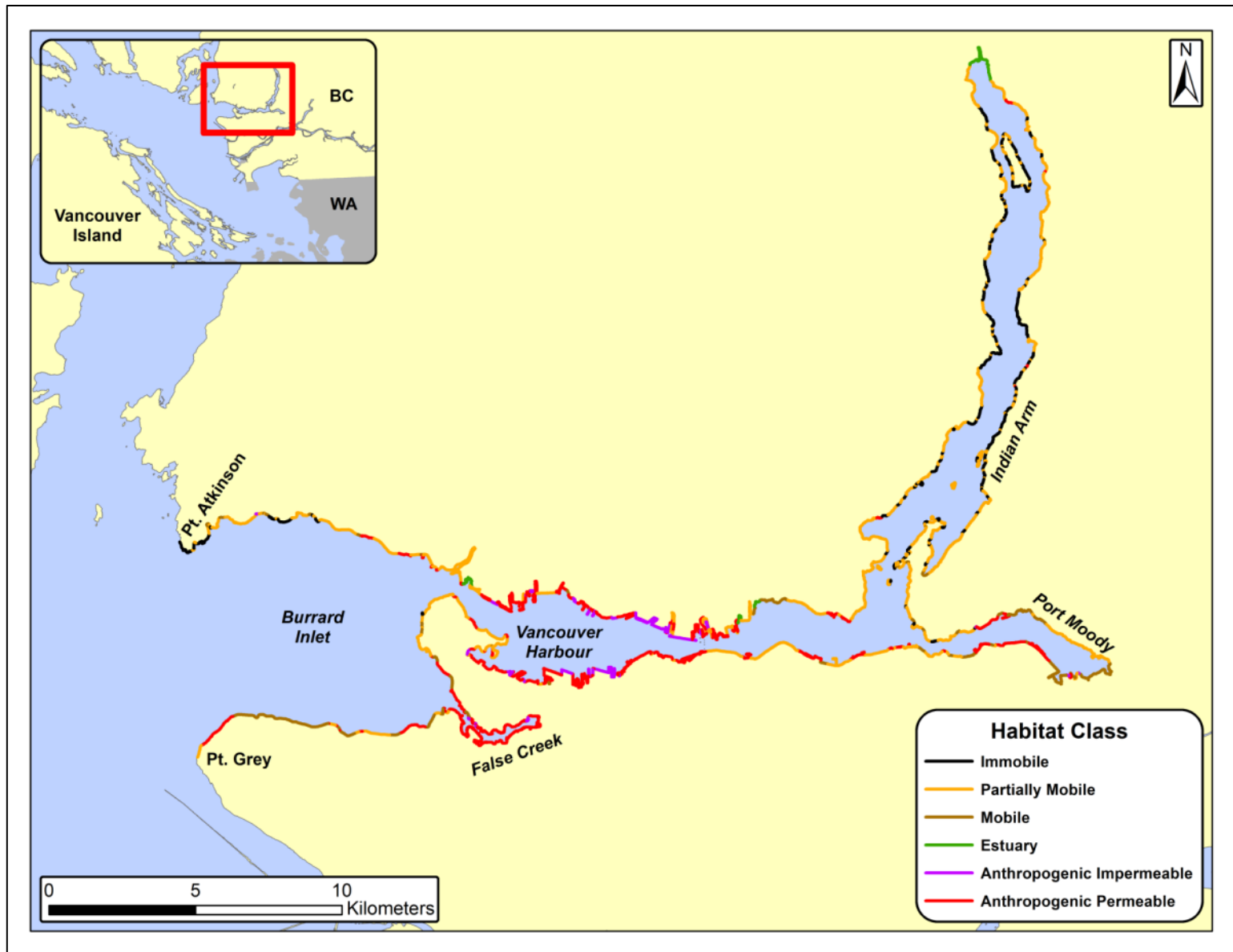


Figure 23. Distribution of Habitat Class categories in the Burrard Inlet survey area.

- Berry, H.D., J.R. Harper, T.F. Mumford, Jr., B.E. Bookheim, A.T. Sewell and L.J. Tamayo, 2004. Washington State ShoreZone Inventory User's Manual, Summary of Findings, and Data Dictionary. Reports prepared for the Washington State Dept. of Natural Resources Nearshore Habitat Program.
- Cook, S., S. Daley, K. Morrow and S. Ward. 2017. ShoreZone Coastal Imaging and Habitat Mapping Protocol. Coastal and Ocean Resources, Victoria, BC. 78p.
- Harper, J.R., and M.C. Morris, 2004. ShoreZone Mapping Protocol for the Gulf of Alaska. Report prepared for the Exxon Valdez Oil Spill Trustee Council (Anchorage, AK). 61 p.
- Howes, D.E., 2001. British Columbia biophysical ShoreZone mapping system – a systematic approach to characterize coastal habitats in the Pacific Northwest. Puget Sound Research Conference, Seattle, Washington, Paper 3a, 11p.
- Petersen, J., J. Michel, S. Zengel, M. White, C. Lord, C. Plank, 2002. Environmental Sensitivity Index Guidelines. Version 3.0. NOAA Technical Memorandum NOS OR&R 11. Hazardous Materials Response Division, Office of Response and Restoration, NOAA Ocean Service, Seattle, Washington 98115 89p + App.
- Rao, A. 2015. 2015 Summary Report Burrard Inlet-Indian Arm Eelgrass Mapping. Prepared by SeaChange Marine Conservation Society and Tsleil-Waututh Nation. 26p. Accessed at <http://seagrassconservation.org/wp-content/uploads/2016/05/Burrard-Inlet-Indian-Arm-site-report.pdf> on April 03, 2018.
- Thieler, E.R. and E.S. Hammar-Klose, 2000. National Assessment of Coastal Vulnerability to Sea-Level Rise: Preliminary Results for the U.S. Pacific Coast. U.S. Geological Survey. Accessed at <http://pubs.usgs.gov/dds/dds68/reports/westrep.pdf> on September 19th, 2016.

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Protocols for data access and distribution are established by the program partner agencies. Please see www.ShoreZone.org for a list of partner agencies and related web sites. Video imagery can be viewed and digital stills downloaded online at www.ShoreZone.org. 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 Sarah Cook, General manager of Coastal and Ocean Resources at Sarah@coastalandoceans.com (Tel: 250-658-4050). For data requests or analytical support contact Kalen Morrow at Kalen@coastalandoceans.com.

APPENDIX A

Photographic Examples of Coastal Classes and Biobands

Table A-1. Examples of the Coastal Classes in Burrard Inlet (Page 37).

Table A-2. Examples of the most common Biobands in Burrard Inlet (Page 41).

Table A-1. Examples of the Coastal Classes in Burrard Inlet.



Photo bc17_br_02783: Example of Coastal Class 3; Rock Cliff.
Indian Arm.



Photo bc17_br_02287: Example of Coastal Class 8; Cliff with gravel beach.
Croker Island, Indian Arm.



Photo bc17_br_00998: Example of Coastal Class 14; Ramp with gravel and sand beach. Vancouver Harbour.



Photo bc17_br_00113: Example of Coastal Class 24; Sand & gravel flat or fan. West Bay, Burrard Inlet.



Photo bc17_br_01770: Example of Coastal Class 28; Sand flat. Spanish Banks, Burrard Inlet.



Photo bc17_br_00272: Example of Coastal Class 32; Permeable man-made structures. Vancouver Harbour.

Table A-2. Examples of the most common biobands in the Burrard Inlet survey area.



Photo bc17_br_00075: Good example of the Black Lichen (BLLI) bioband which is a black band in the supratidal zone, usually caused by the lichen *Verrucaria* sp. Near Point Atkinson.



Photo bc17_br_00015: Good example of the Lichen (LICH) bioband which in this case is a pinkish-orange band that occurs with the Black Lichen band. Near Point Atkinson



Photo bc17_br_00166: Good example of the Dune Grass (DUGR) bioband as a narrow blue-green strip at the top of the beach.



Photo bc17_br_03195: Good example of the Salt Marsh (SAMB) bioband which appears as a light green strip at the top of the beach and extending onto the flats by the delta. This photo also shows Dune Grass above the Salt Marsh. Port Moody.



Photo bc17_br_02153: Good example of the Barnacle (BARN) bioband in the high intertidal. It appears white and beige in the survey area Indian Arm.



Photo bc17_br_01946: Good example of the Rockweed (ROCK) bioband in the upper intertidal. Indian Arm near Deep Cove.



Photo bc17_br_00068: Good example of the black, velvety Blue Mussel (BLMU) bioband in the mid- to lower intertidal. Burrard Inlet.



Photo bc17_br_00113: Good example of the Green Algae (GRAL) bioband in the mid- to lower intertidal. Burrard Inlet.



Photo bc17_br_01978: Example of the Filamentous and Foliose Red Algae (FFRA) bioband in the lower intertidal, mixed with Green Algae and Bladed Brown Algae. Indian Arm.



Photo bc17_br_01899: Good example of the Brown Bladed Algae (BRBA) bioband in the lower intertidal, right at the waterline. Entrance to Indian Arm.



Photo bc17_br_01773: Good example of the Eelgrass (EELG) bioband, mixed with foliose Green Algae, in the lower intertidal. Possibly *Zostera japonica*. Spanish Banks.



Photo bc17_br_00900: Good example of the Sargassum (SARG) bioband as a narrow strip of brown in the shallow subtidal. This bioband is characterized by a 'fluffy' crown floating on the surface. Entrance to Indian Arm.



Photo bc17_br_01007: Example of the Bull Kelp (BUKE) bioband in shallow subtidal. Near Iron Workers Memorial Bridge.