BC Parks Shoreline Sensitivity to Sea Level Rise Model: User Guide

Model prepared by Doug Biffard and Tory Stevens, BC Parks
User Guide prepared by Anuradha S. Rao, M.Sc., R.P.Bio

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Abstract

Traditional management approaches assume that many shoreline features are static and enduring. New information is needed to inform a revised approach that recognizes the importance of adapting to changing conditions, for example rising sea level. Managers, planners and others require knowledge of the relative sensitivity of shorelines to sea level rise to develop an appropriate set of adaptation and mitigation responses. BC Parks developed a model that independently rates marine and terrestrial segments of the British Columbia coastline according to their sensitivity to sea level rise, then spatially combines the ratings to build a map of relative shoreline sensitivity. Ratings were developed using an existing biogeographic land classification dataset (Broad Ecosystem Inventory), and previously rated sensitivity of coastal and marine feature classes (ShoreZone), modified to account for the effects of slope, exposure and sediment mobility. Examples are provided of how the model may be used by both technical and non-technical users.

Acknowledgements

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Purpose of this Guide

This guide provides background information for the shoreline sensitivity to sea level rise model developed by BC Parks for the British Columbia coastline. It is intended to provide information for general users such as geographers, planners and non-governmental organizations, as well as expert users such as GIS analysts and geomorphologists, so that they are able to understand and apply the model according to their needs.

Introduction

Sea level rise is one of the many effects of global climate change, and is particularly relevant to the province of BC, which has a coastline 35,000 km long. Sea level rise is occurring due to expansion of the ocean as it warms and melting of glaciers, ice caps and polar ice sheets (IPCC 2007). Global sea level has risen an average of 1.8 mm per year over the last century and an average of 3.2 mm per year over the last decade (Bornhold 2008). Current projections are on the more extreme end of predictions that were made in 2007 (Allison et al. 2009). Sea level is expected to continue to rise for centuries even after greenhouse gas concentrations are stabilized (IPCC 2007).

The following factors affect how different parts of the BC coastline experience sea level rise (Bornhold 2008):

- Winds and currents affect the vertical height of effects on shore.
- Along the coast, sea level rise is measured relative to vertical land movement. In British Columbia, sea level rise is occurring alongside the rebounding of land masses following the retreat of glaciers, as well as subsidence of areas such as the Fraser delta due to natural conditions and exacerbated by human activities that affect sediment movement.
- Tectonic activity adds an additional layer of complexity to sea level measurements and predictions.

Relative annual mean sea level has been rising in Prince Rupert, Vancouver and Victoria over a period of 93 years (1910-2003; Figure 1). Sea level in Victoria is expected to further rise up to approximately 1 m by 2100 (Bornhold 2008).

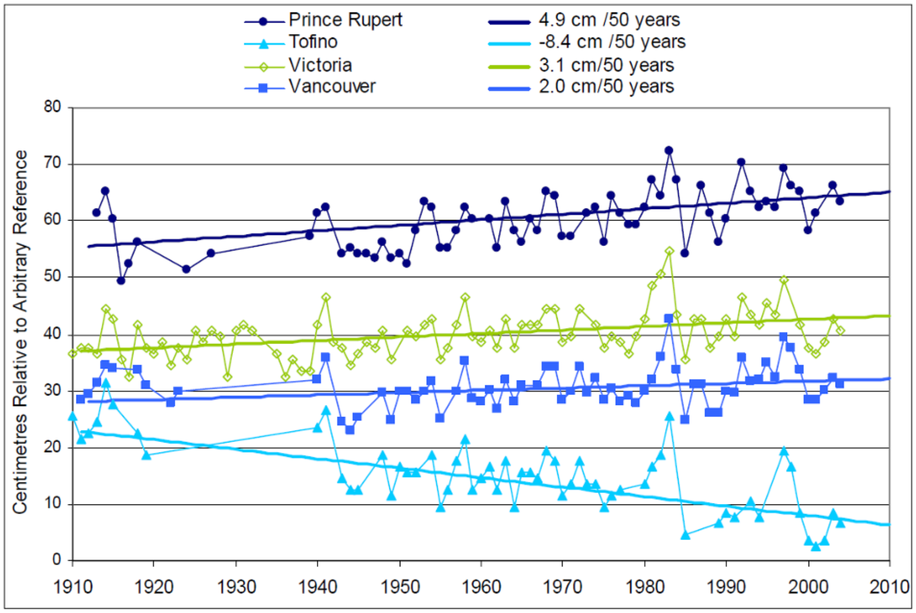

Figure 1. Changes in annual mean sea level at four locations on the BC coast (BC Ministry of Environment 2007)

Effects of sea level rise in coastal areas include the following, particularly in combination with observed changes in frequency of extreme weather events:

- Flooding
- Increased salinization of low-lying areas and groundwater supplies
- Landward and upland shift of intertidal zones and coastal habitats, partially into previously dry, backshore areas
- Reduced efficacy of sea walls and other protective structures due to changes to sediment transport, continued erosion, scouring in adjacent areas and the reflection of waves off the hard structures
- Exacerbation of inundation, storm surges, erosion and other coastal hazards, particularly in combination with human-induced stressors, which can threaten infrastructure, settlements and facilities previously above the high water mark
- Pollution risk from sewer and waste sites

(from BC Ministry of Environment 2007, GreenShores 2012, IPCC 2007, Johannessen and MacLennan 2007, O'Connell 2010)

It is in municipalities', districts' and planners' interest to prepare for effects such as these in coastal communities. Some sections of the coast will undergo greater changes than others due to their inherent characteristics (e.g. substrate, slope) and their degree of wave exposure. Terrestrial habitat type and slope also contribute to shoreline sensitivity; as sea level rises, intertidal areas are expected to migrate landward into terrestrial habitats.

A high-level diagram of the BC coastline's sensitivity to sea level rise and erosion was produced in 2004 (Figure 2; BC Ministry of Environment 2007). While that map was useful to identify broad areas of the coast susceptible to sea level rise, adaptation at provincial and local scales required a finer scale model. As a response, in 2010 BC Parks developed a finer scale, interactive spatial model that predicts sensitivity of individual BC shoreline units to sea level rise through sensitivity ratings of the foreshore (marine) and backshore (terrestrial) areas along the BC coast. The BC Parks model covers nearly the entire coastline of the province and aims to identify sensitive areas along the coast and encourage the development of adaptation strategies. An example output of this model is presented in Figure 3.

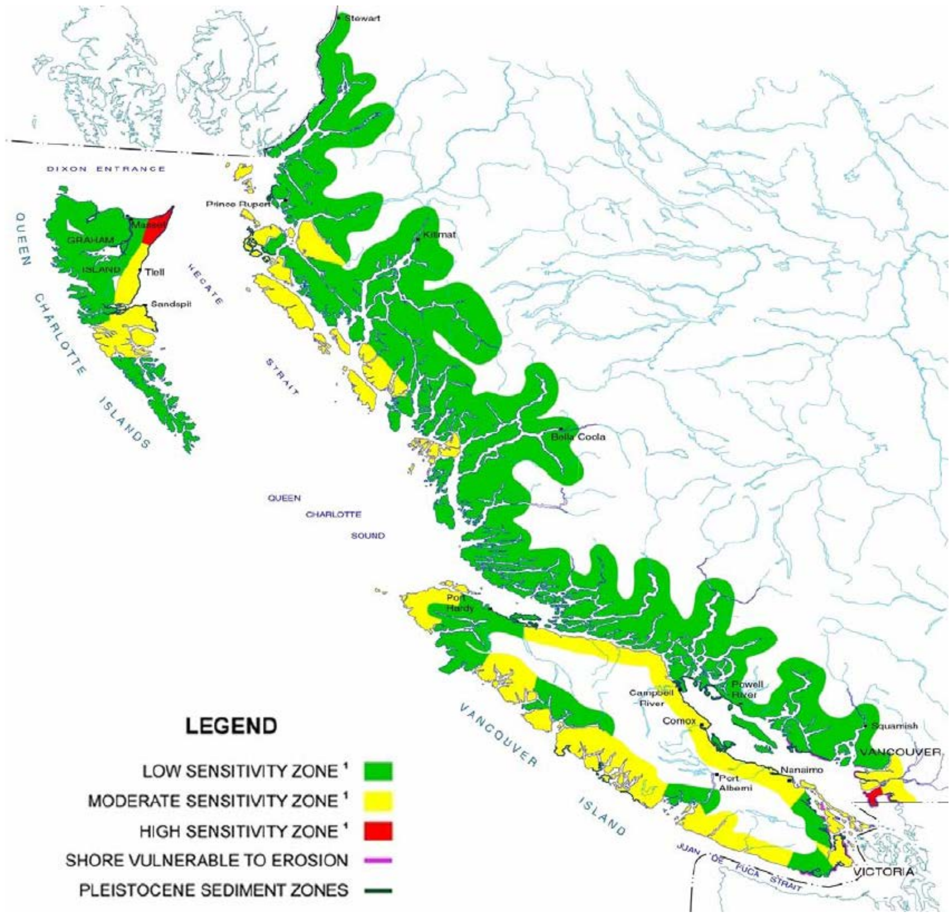

Figure 2. Sensitivity of the BC coastline to sea level rise and erosion (Source: Hay & Co. Consultants 2004, published in BC Ministry of the Environment 2007)

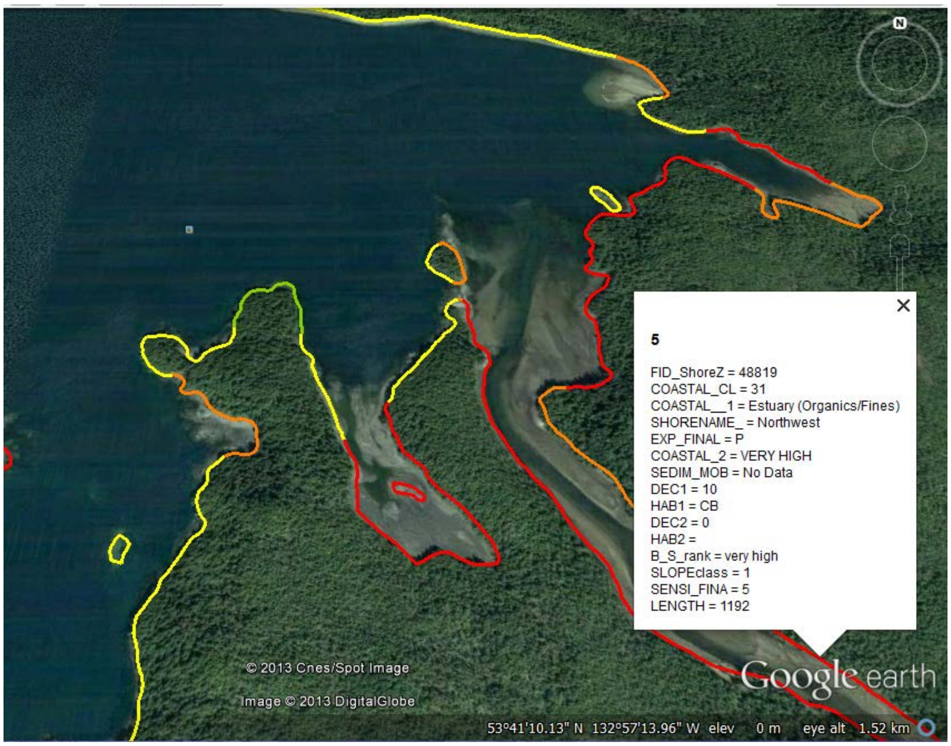

Figure 3. An example of the BC Parks model and data table, viewed in Google Earth as a .kml file. The data are also available as shapefiles for GIS users.

Methods

The BC Parks shoreline sensitivity to sea level rise model uses Geographic Information System (GIS) tools to rank segments or units of the shoreline according to their sensitivity to sea level rise. Sensitivity to sea level rise is defined as one of five colour-coded categories: red is very high sensitivity, orange is high sensitivity, yellow is moderate sensitivity, light green is low sensitivity and dark green is very low sensitivity. The categories from red to yellow are of concern, with red segments being areas of particular concern for adaptation. These final ratings were determined by rating shoreline units according to sensitivity of 1) their foreshore, using ShoreZone data (Howes et al. 1997) and 2) their backshore, using Broad Ecosystem Inventory (BEI; BC Ministry of Environment 2013) and HectaresBC slope class (British Columbia et al. 2013) data, as described below. Pre-existing ShoreZone and Broad Ecosystem Inventory data layers were superimposed, and the shoreline was divided into units based on the smallest length of overlap of those two data layers (lines in the case of ShoreZone and polygons in the case of BEI).

The shoreline sensitivity to sea level rise model assumes that all segments of the BC shoreline will be or are being affected by sea level rise and changes in storm intensity, storm surges and dominant wind and wave patterns. It should also be noted that the model is coarse; the model's sensitivity rating suggests areas that should be studied in finer detail. The spatial scale of the BEI (1:250,000) is much coarser than that of ShoreZone (1:20,000), which results in an overall coarse scale of the model. BEI was chosen for this model because it is currently the only consistent dataset available for the whole BC coast. Finer resolution habitat mapping such as the Terrestrial Ecosystem Mapping (TEM) system could improve the shoreline sensitivity to sea level rise model if those mapping systems become available for the whole coast.

1) Foreshore rating: The initial rating for the foreshore area of each shoreline unit was based on a 5-rank relative sensitivity rating of the 34 BC coastal classes from ShoreZone (Howes et al. 1997, Paterson 2009), as presented in Table 1. ShoreZone data combine physical, oceanographic and biological features. The relative sensitivity of coastal classes was determined using professional judgement based on substrate, width and slope. For the model, this initial rating was modified based on sediment mobility, then based on exposure to determine the overall foreshore rating. Assessments of sediment mobility and exposure for shoreline units were obtained from ShoreZone data (Howes et al. 1997). If sediments in the shoreline unit were accreting (building up) or eroding (retreating), the initial rating was increased by one level (e.g. from high to very high). If sediments were stable, the rating was not modified. Subsequently, the rating was increased by one level if the shoreline unit was exposed or decreased by one level if it was very protected. The rating was not modified if the level of exposure was protected, semi-protected or semi-exposed.

2) Backshore rating: Broad Ecosystem Inventory (BC Ministry of Environment 2013) polygons were clipped to a 5 km band along the coastline; hence, the BEI habitat types used in the model are limited to those which touch the BC coast at least once. There are 88 BEI units and they generally reflect topography, soil and climate. Pre-defined slope classes were obtained from HectaresBC (British Columbia et al. 2013), an internet analysis tool that provides public access to spatial data. Slope class was clipped to a 5 km band along the coastline. Where slope was greater than zero, the raster units that lie along coastline were used to create a polygon of equal slope class. Where slope equalled zero, a polygon of these raster units was created, and another polygon of equal class raster units was created where the slope class increased inland of the zeros. BEI units and slope class were combined into a single layer to create unique polygons, and sensitivity ratings were assigned based on a combination of those two datasets. This rating system is presented in Table 2. To assign these relative sensitivity levels, BC Parks first used professional judgement to rate the sensitivity of each BEI class at medium slope class (3-15°), then rated the BEI classes at high and low slope class relative to the medium slope class rating. A flatter slope generally resulted in a higher sensitivity rating. If a single shoreline unit was composed of two habitat types, the unit was assigned the higher sensitivity rating of the two.

Final rating: The result of the above analyses was a sensitivity rating for the foreshore and one for the backshore for each shoreline unit along the BC coastline. The higher (more sensitive) of the two ratings was used for the final rating of the shoreline unit's sensitivity to sea level rise, which appears as the final, colour-coded result in the model. With respect to the model's presentation of data, the foreshore and backshore ratings are combined as a single line that displays the most sensitive rating of the two. For example, if the foreshore was rated very high and the backshore was rated moderate, the final sensitivity rating for the shoreline unit would be very high and presented as a red line.

Table 1. Rating of ShoreZone coastal classes (Howes et al. 1997) based on relative sensitivity to sea level rise (modified from Paterson 2009). These ratings were used for the initial shoreline sensitivity rating, then modified by sediment mobility and exposure to calculate the final rating in the shoreline sensitivity model.

Coastal Class Code (Howes et al. 1997)	Coastal Class Name (Paterson 2009)	Initial Rating of Sensitivity to Sea Level Rise
1	Rock ramp, wide	Very low
2	Rock platform, wide	High
3	Rock cliff	Not sensitive
4	Rock ramp, narrow	Low
5	Rock platform, narrow	Moderate
6	Ramp with gravel beach, wide	Moderate
7	Platform with gravel beach, wide	High
8	Cliff with gravel beach	Low
9	Ramp with gravel beach	Moderate
10	Platform with gravel beach	High
11	Ramp with gravel and sand beach	Moderate
12	Platform with gravel and sand beach, wide	High
13	Cliff with gravel/sand beach	Low
14	Ramp with gravel/sand beach	Moderate
15	Platform with gravel/sand beach	High
16	Ramp with sand beach, wide	Moderate
17	Platform with sand beach, wide	High
18	Cliff with sand beach	Low
19	Ramp with sand beach, narrow	Moderate
20	Platform with sand beach, narrow	High
21	Gravel flat, wide	High
22	Gravel beach, narrow	Moderate
23	Gravel flat or fan	High
24	Sand and gravel flat or fan	High
25	Sand and gravel beach, narrow	Moderate
26	Sand and gravel flat or fan	High
27	Sand beach	Moderate
28	Sand flat	Very high
29	Mudflat	Very high
30	Sand beach	High
31	Estuaries	Very high
32	Man-made, permeable	High
33	Man-made, impermeable	Low
34	Channel	Low

Table 2. Rating system for relative sensitivity to sea level rise of backshore areas using Broad Ecosystem Inventory habitat types (BC Ministry of Environment 2013) and HectaresBC slope class (British Columbia et al. 2013).

BEI Class (Habitat)*		**Sensitivity by Slope Class**		
		0-3°	**3-15°**	**>15°**
Coastal forest (CD, CG, CH, CP, CR, CW, DA, FR, GO, HB, HL, HS, MF, OA)		High	Low	Very low
Shrub and herb dominated (AV)		Low	Low	Low
Non-forested aquatic and wetland (BG, ES, FE)		Very high	High	Low
Forested wetland and riparian (CB, ME, MR, PB, RS, SC, SH, SR, SW, WL, YB, YM, YS)		Very high	Low	Very low
Urban and agriculture (CF, MI, RM, OV, TR, UR)		Very high	High	Medium
Aquatic (FS, LL, LS, SP)		Very high	Very high	Very high
Sparsely vegetated	CL, RO	Very low	Very low	Very low
	GB	High	Very low	Very low
	GL	Low	Low	Very low
	PO	High	Low	Very low
	UV	High	Medium	Low

** Details of each habitat type are available in Appendix 4 of BC Ministry of Environment (2004).*
***Coastal Forest:** CD – Coastal Douglas-fir, CG – Coastal Western Redcedar – Grand fir, CH – Coastal Western Hemlock – Western Redcedar, CP - Coastal Douglas-fir – Shore Pine, CR – Black Cottonwood Riparian, CW – Coastal Westrn Hemlock – Douglas-fir, DA – Douglas-fir – Arbutus, FR - Amabilis Fir – Western Redcedar, GO – Garry Oak, HB – Western Hemlock – Paper Birch, HL – Coastal Western Hemlock – Lodgepole Pine, HS – Western Hemlock – Sitka Spruce, MF – Mountain Hemlock – Amabilis Fir, OA – Garry Oak – Arbutus; **Shrub and herb dominated:** AV – Avalanche Track; **Non-forested aquatic and wetland:** BG – Sphagnum Bog, ES – Estuary, FE – Sedge Fen; **Forested wetland and riparian:** CB – Cedars – Shore Pine Bog, ME – Meadow, MR – Marsh, PB – Lodgepole/Shore Pine Bog, RS – Western Redcedar Swamp, SC – Shurb - Carr, SH – Shrub Fen, SR – Sitka Spruce – Black Cottonwood Riparian, SW – Shrub Swamp, WL – Wetland, YB – Yellow Cedar Bog Forest, YM – Mountain Hemlock – Yellow Cedar, YS – Yellow Cedar – Mountain Hemlock – Skunk Cabbage; **Urban and agriculture:** CF – Cultivated Field, MI – Mine, OV – Orchard/Vineyard, RM – Reclaimed Mine, TR – Transmission Corridor, UR – Urban; **Aquatic:** LL – Large Lake, LS – Small Lake, FS – Fast Perennial Stream, SP- Slow Perennial Stream; **Sparsely vegetated:** CL – Cliff, RO – Rock, GB – Gravel Bar, GL – Glacier, PO – Lodgepole Pine Outcrop, UV - Unvegetated*

Data Dictionary

The data fields used to develop this model are presented in Table 3, and are visible as a data table/attribute table within the model's spatial files. For those viewing the model using the .kml file, these fields are displayed by clicking a shoreline unit (see "Applications" section below). A number of additional data fields that may be of interest to more technical users are available from ShoreZone and BEI but were not used in this shoreline sensitivity to sea level rise model. To use these additional fields, please refer to the original ShoreZone and BEI datasets.

Table 3. Data fields used to assess and rate each shoreline unit in the shoreline sensitivity to sea level rise model

Field	**Explanation and Range of Values**	**Use in Shoreline Sensitivity Model**
Foreshore sensitivity rating		
COASTAL_CL	BC coastal class or shoreline type (out of 34 unique types; see Washington State DNR 2001, p.9, details on p.47)	Used for initial ranking of foreshore (Howes et al. 1997, Paterson 2009; Table 1)
COASTAL_1	Text description of the coastal class or shoreline type.	Provides information to assist interpretation of model results
SEDIM_MOB	Assessment of the mobility of the sediment in the shore unit, based on geomorphology (Howes *et al.* 1997): Accretional = shoreline unit shows a net accumulation of sediment over time; Erosional = shoreline unit shows net loss of sediment over time (e.g. scarp, cliff); Stable = no net accretion or erosion/retreat of the shoreline within the unit	Used to modify initial ranking of foreshore
EXP_FINAL	Exposure: very protected, protected, semi-protected, semi-exposed or exposed	Used to further modify foreshore ranking
COASTAL_2	Foreshore sensitivity rating developed in the model: not susceptible, very low, low, moderate, high or very high	Overall sensitivity rating of foreshore
Backshore sensitivity rating:		
HAB1	Habitat type 1, according to Broad Ecosystem Inventory (BEI) codes	Used with SLOPECLASS to rate backshore sensitivity (see Table 2)
DEC1	The proportion (percentage) of habitat type 1 in the shoreline unit	Not considered in the model; for information only
HAB2	Habitat type 2, according to Broad Ecosystem Inventory (BEI) codes (if applicable)	Not considered in the model; for information only

Field	Explanation and Range of Values	Use in Shoreline Sensitivity Model
DEC2	The proportion (percentage) of habitat type 2 in the shoreline unit (if applicable)	Not considered in the model; for information only
SLOPEclass	Slope class from Hectares BC: 1 = 0-3°, 2 = 3-15°, 3 = 15+°	Used with HABITAT1 to rate backshore sensitivity (see Table 2)
B_S_rank	Backshore sensitivity rating: combines BEI and slope classes to create unique polygons rated as per Table 2: very low, low, medium, high or very high	Overall rating of backshore
Final sensitivity rating:		
SENSI_FINA	Final sensitivity rating, chosen from the most sensitive of COASTAL_2 and B_S_rank. Rating is out of 5: 1 = very low sensitivity 2 = low sensitivity 3 = moderate sensitivity 4 = high sensitivity 5 = very high sensitivity	Final rating of shoreline unit
LENGTH	Length of the shoreline unit (m)	Descriptive
SHORENAME	Name of the location of the shoreline unit (where available)	Descriptive

Applications

The model can be used by both GIS users and the general public. For the latter, an interactive .kml file has been created that can be viewed on Google Earth, which is freely downloadable software. In that file, clicking on a shoreline unit brings up a callout which shows the data table, with the fields and values as outlined in Table 3, particular to that shoreline unit. Only the fields directly relevant to this model for shoreline sensitivity to sea level rise have been extracted. For additional values associated with the ShoreZone and BEI datasets, please refer to those datasets directly.

In general, sites rated red, orange or yellow are of concern and merit further study, with red being the highest priority.

As an overview of what the model tells us, BC Parks used the shoreline sensitivity to sea level rise model to calculate the amount of shoreline in each sensitivity category in BC as a whole and within BC Parks. As shown in Table 4, 17% of the BC shoreline is highly sensitive and 24% of the shoreline within BC Parks is highly sensitive.

Table 4. Shoreline sensitivity to sea level rise comparison by BC Parks

Final Sensitivity (SENI_FINA)	**Percentage of Final Sensitivity Categories for Total Shoreline in British Columbia**	**Percentage of Final Sensitivity Categories for Shoreline within BC Parks**
1 very low	6%	6%
2 low	19%	19%
3 moderate	28%	23%
4 high	30%	28%
5 very high	17%	24%

Further applications of the model could include the following:

- Calculation of proportions of shoreline within each sensitivity rating in an area of interest, then consultation of the foreshore and backshore ratings of those shoreline units to determine the reason for the sensitivity rating to provide ideas for management and adaptation. An example analysis by BC Parks is provided in the Appendix.
- Ground-truthing of sensitive shoreline units to confirm the rating and develop management or adaptation strategies.
- Consultation of the data table for particular areas of interest to supplement ground observations.
- Prioritization of areas for adaptation and mitigation efforts. Use of the model when planning, zoning and permitting. For example, increasing setbacks from the shoreline when planning new developments.
- Identification of values that will change as sea levels rise; for example, one may examine what is already happening in those areas as a clue to what may happen in the future.
- Identification of resilient sites, i.e. sites with very low sensitivity to sea level rise, and protecting the characteristics of those sites that reduce their sensitivity rating.
- Consideration of this model in conjunction with assessments of slope instability and other expected climate change related phenomena such as increased frequency and intensity of extreme weather events. On the coast, this can include storm surges and wind.

Adaptation and mitigation measures may include:

- Protection or relocation of existing developments.
- Reconfiguration of land use to protect sensitive areas.
- Enhancement and restoration of ecosystems in sensitive areas to increase shoreline resiliency and prevent or minimize damage to areas of human occupation. Specific measures can include the following (from IPCC 2007, Stewardship Centre for British Columbia 2013):
    - reinforcement and protection of natural physical barriers such as dunes, and buffer ecosystems such as wetlands and other vegetated areas
    - preservation of the integrity and connectivity of coastal processes
    - maintenance and enhancement of habitat diversity and function
    - minimization of pollution
    - reduction of cumulative impacts
- Maintenance of sensitive areas that have not been impacted by human activity.

- Reduction of human stressors in sensitive areas, particularly stressors that would exacerbate the characteristics that increase the sensitivity rating in those areas.
- Acquisition of key lands for protection and maintenance of shoreline resiliency.

Three examples from the Saanich Peninsula are provided below where the model has been used for site assessments.

Example 1

Towner Bay, North Saanich (48°40.132'N 123° 28.382'W)

We were interested in exploring sensitivity ratings on a semi-rural shoreline, typical for the Strait of Georgia. One particular area stood out in the satellite imagery, where a clearing was visible close to the shore in an area rated red, indicating very high sensitivity to sea level rise (Figure 4). Upon clicking on the shoreline unit, the data table (Figure 5, Table 5) indicates that the foreshore is rated very high due to the coastal class (sand flat) and the backshore is rated high due to the dominant habitat type (coastal western redcedar/grand fir) and moderate slope. The foreshore rating was higher than the backshore rating, thus it became the final rating. It may be useful to investigate the type of alterations that have been made on this shoreline, and what effects they have had on the sediment.

Table 5. Example data table: Towner Bay, District of North Saanich

Foreshore rating:	
Coastal class	Sand Flat, wide > 30m
Sediment mobility	Stable
Exposure	Protected
Result	VERY HIGH
Backshore rating:	
Habitat type	70% coastal western redcedar / grand fir, 30% urban
Slope class	2 (3-15°)
Result	HIGH
Final rating	VERY HIGH

Figure 4. a) Google Earth image with .kml file of shoreline sensitivity model. Towner Bay, an area in the District of North Saanich, is rated as highly sensitive to sea level rise (indicated by red arrow pointing to red shoreline unit). b) Closer examination of the satellite imagery shows coastal development adjacent to the shore.

Figure 5. Clicking on the shoreline unit representing the area rated as very high sensitivity at Towner Bay provides this data table, indicating that the foreshore is rated as very high sensitivity to sea level rise due to the coastal class, which is a sand flat (also see Table 4).

Example 2

Tsehum Harbour, North Saanich (48°40.422'N 123°25.252'W)

The marinas in this harbour are in areas rated as highly sensitive to sea level rise, but the residential area between them is rated very highly sensitive (Figure 6). Although the area is very protected, the sensitivity rating is due to its foreshore coastal class (mud flat). It is notable that the predominantly urban backshore habitat type with moderate slope results in a high backshore rating (Table 6). This area is worth examining further, but the flat is visible from the satellite images. It would be useful to investigate whether residents have noticed any changes in their shoreline over time, for example whether it is receding, and if they are seeing indications of coastal habitats transitioning onto their properties.

Table 6. Example result: Tsehum Harbour, District of North Saanich

Foreshore rating:	
Coastal class	Mud Flat, wide > 30m (dredged pool)
Sediment mobility	Stable
Exposure	Very protected
Result	VERY HIGH
Backshore rating:	
Habitat type	80% urban, 20% coastal western redcedar / grand fir
Slope class	2 (3-15°)
Result	HIGH
Final rating	VERY HIGH

Figure 6. Google Earth image with .kml file of shoreline sensitivity model. The residential area between the marinas at Tsehum Harbour, an area in the District of North Saanich, is rated as highly sensitive to sea level rise (indicated by red arrow pointing to red shoreline unit).

Example 3

Tod Inlet, eastern portion adjacent to Butchart Gardens (48.55979°N, 123.46576°W)

The model rated this area as having very high sensitivity to sea level rise based on its foreshore rating, which indicated that is an estuary with fine sediment (Figure 7a, Table 7). Low-lying areas such as estuaries are regularly inundated; the extent of inundation will increase due to sea level rise (Borecky and Harney 2007). The backshore is rated low due to its habitat and slope class as Coastal Douglas-fir with moderate slope. Ground-truthing of the area showed that the site was adjacent to the estuary, but itself actively slumping due to infill of fine sediments observed to have toxic effects on biota (Figure 7b). The slope was also undercut at the high water mark. The shoreline was altered and the backshore contained a developed area and additional indicators of slope failure. Further inundation due to sea level rise will certainly remove more of these fine sediments and change the shoreline both physically and biologically.

Resources for restoration of this site would ideally be completed by the party responsible for the toxic infill. Restoration activities could include coastal sediment remediation and decreasing the slope to reduce the erosion rate and enable revegetation. It would be helpful to determine what the shape, slope and sediment content of the shoreline were prior to the alterations, and assess whether those elements could be restored. Replanting salt- and clay-tolerant and slope stabilizing plants could reduce the amount of sediment runoff into the water and reduce the likelihood of slumping and pollution. Red alders were present on the upper slope, suggesting that they may be able to withstand the site conditions.

Figure 7. Estuary at Tod Inlet, Saanich Peninsula. a) Google Earth image with .kml file of shoreline sensitivity model; location of slump indicated with red arrow. b) Slump and scarp at shoreline were observed when the area was ground-truthed.

Table 7. Example result: Estuary at Tod Inlet, Saanich Peninsula

Foreshore rating:	
Coastal class	Estuary (organics/fines)
Sediment mobility	Stable

Exposure	Very protected
Result	VERY HIGH
Backshore rating:	
Habitat type	60% Coastal Douglas-fir / 40% Douglas-fir - Arbutus
Slope class	2 (3-15°)
Result	LOW
Final rating	VERY HIGH

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Appendix: Phillips Estuary Conservancy Shoreline Sensitivity Report (BC Parks)

OVERVIEW			
Total Area: **Shoreline perimeter:**	2,979 m (3 km)		
Total Coastal Shoreline Sensitivity level: (Derived from Foreshore and Backshore Sensitivity)	**Total Sensitivity**	**Total Length (m)**	**Percentage (%)**
	4=High	12	0
	5= Very High	2967	100
Total Foreshore sensitivity	**Foreshore Sensitivity**	**Total Length (m)**	**Percentage (%)**
	High	12	0
	Very High	2967	100
Total Backshore sensitivity	**Backshore Sensitivity**	**Length (m)**	**Percentage (%)**
	Very Low	12	0
	Low	1754	59
	High	585	20
	Very High	628	21
Broad Ecosystem Inventory Units	65% Coastal Western Hemlock-Douglas Fir (CW); 35% mixture of 70% Sitka Spruce-Black Cottonwood Riparian (CR) and 30% CW		

COMPOSITION	
Foreshore Sensitivity:	The foreshore area will see very high level of sensitivity along about 100% of the shoreline within the protected area (a negligible amount is high sensitivity). It is rated with very high foreshore sensitivity because there are estuaries and wide sand flats.
Backshore Sensitivity:	There is high backshore sensitivity along 20% of the shoreline. There is very high backshore sensitivity along 21% of the shoreline. It has high backshore sensitivity due to the low slope and a Coastal Western Hemlock-Douglas Fir Redcedar ecosystem. It has very high backshore sensitivity due to the low slope and the dominant Sitka Spruce-Black Cottonwood Riparian ecosystem.

MANAGEMENT CONCERNS
In this protected area, the foreshore values most at risk are the estuaries and wide sand flats. We can expect substantial re-arrangement of intertidal habitats as high sea levels and storm events coincide. This needs to be confirmed by ground observations. Also at risk are the backshore values of the Coastal Western Hemlock-Douglas Fir Redcedar and Sitka Spruce-Black Cottonwood Riparian ecosystems where low slopes lend to inland incursions during storm events. Loss of trees along the shoreline can be expected. As well, large trees back from the shore are at risk of windthrow as the beach front wind-firm trees lose stability.
MANAGEMENT OPPORTUNITIES
In general, it is recommended that: • Values are identified • Resilient sites are protected • Stressors are reduced (e.g. invasive plant species, development activities) • Land use is reconfigured (e.g. campground locations) • Ecosystem functions are restored **Recommended management options** There are no resistant sites along the shoreline in this protected area. The backshore and farther inland in the estuary however, resistant sites may exist and more analysis is needed to determine the extent of backshore sensitivity inland. Resistant sites are those that offer greater protection of the backshore environment either with higher slopes or features such as rock cliffs. Resistant areas are important areas that are not changing as quickly and can therefore act as refugia for their inhabitants. Based on satellite imagery, no stressors were found in the protected area, so we recommend that managers let nature take its course. Ground work is required to determine local stressors and constraints. If any facilities are anticipated, we recommend that they are kept out of the sensitive areas. . It does look as though development activities (roads, forestry) have occurred adjacent to the conservancy. Based on shoreline sensitivity, management should work to protect resistant sites and ensure park activities do not interfere with adaptation in high sensitive areas.

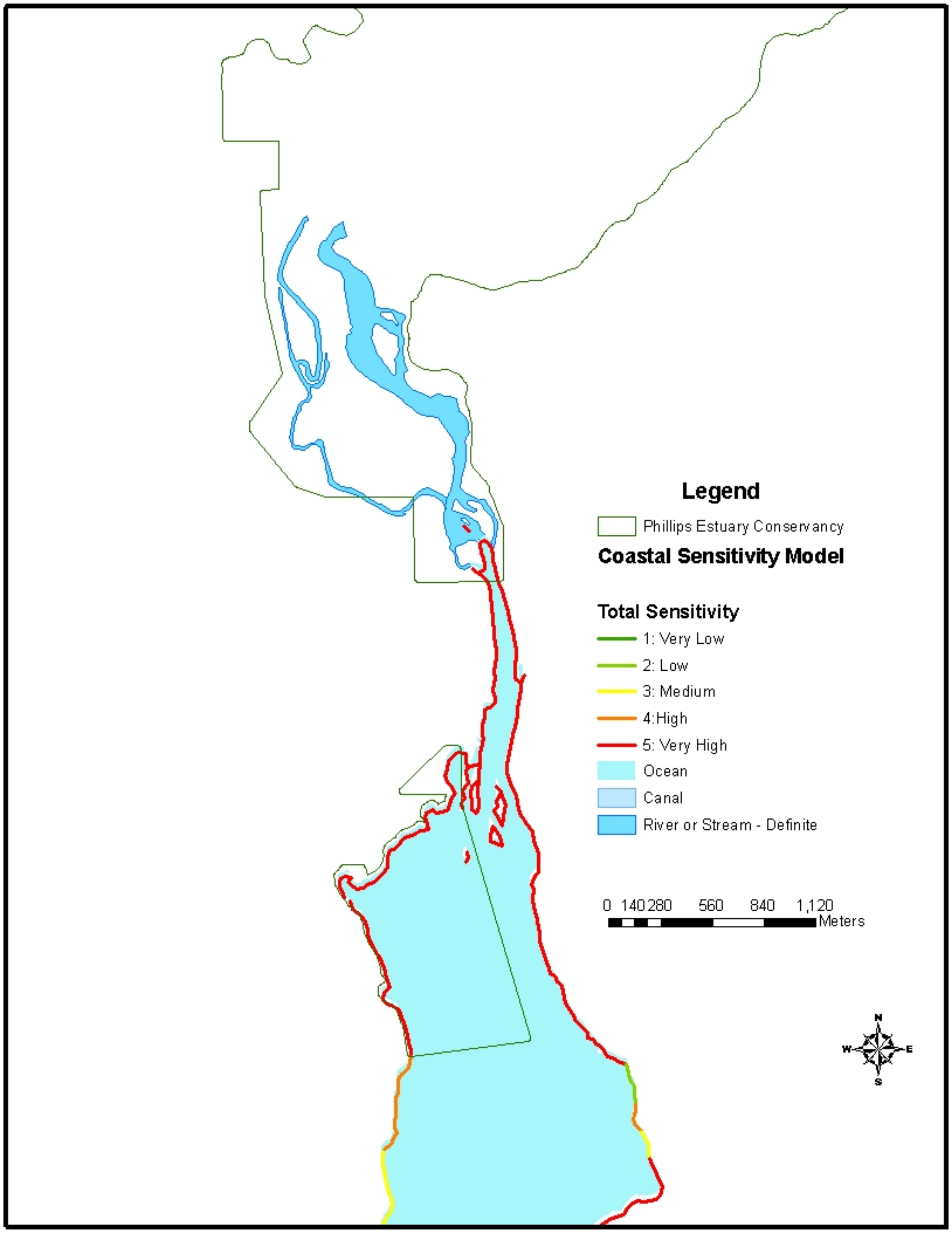

Figure 1: Shoreline Sensitivity in the Phillips Estuary Conservancy. Ministry of Environment.

Figure 2: Satellite Image of Phillips Estuary Conservancy. Google Earth.

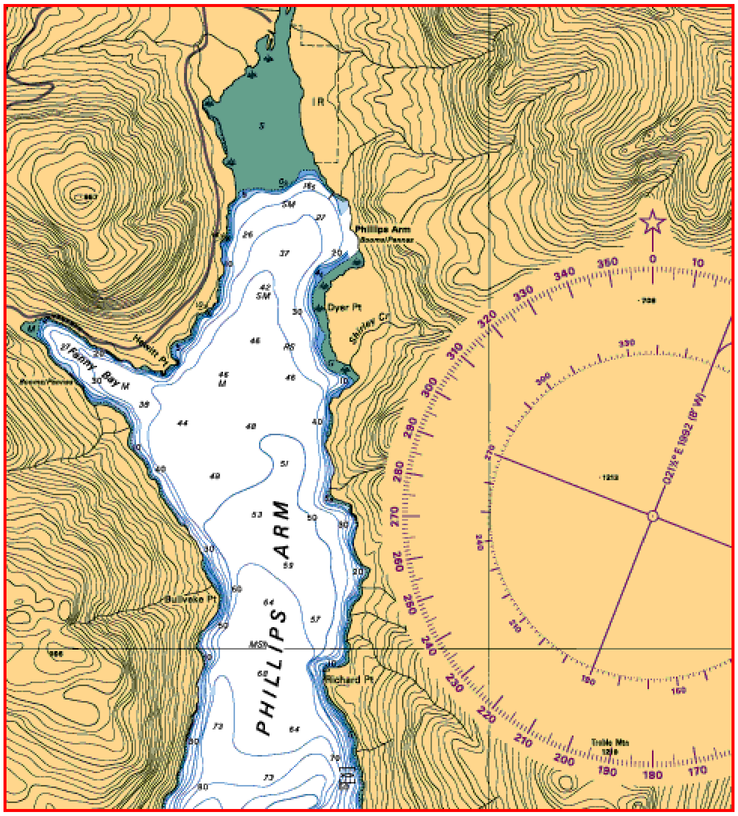

Figure 3: Marine Chart 354301