SHORELINE MODIFICATION & CLIMATE CHANGE ON LEKWUNGEN TERRITORY OAK BAY, BRITISH COLUMBIA

Implications for communities, natural systems and salmon

Photo Credit: Maria Catanzaro

Prepared by Resilient Coasts for Salmon

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

In 2022, the Resilient Coasts for Salmon project collected imagery of the shorelines of Oak Bay, ləkʷəŋən (Lekwungen) Territory, from a small vessel. The resultant dataset has been used to characterize the extent of shoreline modification, overwater structures and log accumulation on beaches in the region. In this report, we present these findings with respect to coastal habitat health for species such as Pacific salmon and forage fish. We also examine the prevalence of these features in areas with high sensitivity to sea level rise, high relative wave exposure, among other factors. It was found that approximately 51.7% of the shoreline in Oak Bay was modified with structures like concrete seawalls, riprap and marina infrastructure. There are six residential docks and two marinas, with the latter found within 100m of predicted Pacific sand lance habitat. Nearly 17% of the shoreline experienced high or extreme accumulation of logs during the time of digitization. The following report will offer recommendations for addressing coastal adaptation with nature-based approaches where possible.

INTENDED PURPOSE

This report is intended for educational purposes only and aims to share basic information and context regarding shoreline modifications and how they overlap with basic climate models and other ecological data. While it may highlight areas of concern, it is not a comprehensive assessment or risk inventory. The content should not be used for detailed analysis or decision-making without formal, in-depth assessments from qualified environmental professionals including coastal geomorphologists, who can provide expert guidance tailored at local scales. Visit Appendix A for a list of acknowledged limitations of the data, and considerations for interpreting the results presented in the report.

ACKNOWLEDGEMENTS

We acknowledge and deeply respect the enduring relationships that First Nations have with these unceded lands and waters - a connection rooted in care, responsibility, and stewardship since time immemorial. Despite the ongoing impacts of colonization and the suppression of spiritual and cultural practices, Indigenous communities continue to manage and steward their lands in a way that honours the balance of the ecosystem and ensures a sustainable and thriving world for all - now and for generations to come. We strongly advocate that all initiatives stemming from this dataset be guided and prioritized by local Indigenous governments and Nation members from inception, with financial compensation for their time as noted in each Nation's protocols for engagement.

We would like to acknowledge the dedication of the individuals who have made this mapping initiative possible. Thank you to Mitch Miller, videographer and vessel captain - we greatly appreciate your commitment to capturing quality imagery to help build this dataset, to Ben Skinner, GIS Expert, Pacific Salmon Foundation, for your guidance and creating the foundation for the analyses and entire dataset, and to Isobel Pearsall, thank you for dreaming up and making the Resilient Coasts for Salmon project possible.

A big thank you to all the individuals who provided their expertise that helped us develop the mapping methodologies. A special shout out to ShoreZone, Friends of the San Juans, and SeaChange Marine Conservation Society for laying the foundations and groundwork that guided the development of this initiative. A full list of individuals and references can be found here (pg. 15).

This project is funded in part by the Government of Canada (Environment and Climate Change Canada, Climate Action and Awareness Fund) (2021 – 2026), and we are grateful for this funding to reach our goals of raising awareness of the impacts of coastal modification, climate change, and how to adapt to sea level rise using nature-based solutions.

KEY TERMS

For a full list of terms, see our Data Dictionary within the Digitization Protocol

coastal squeeze: the loss of habitat due to sea level rise where hard structures, like seawalls, prevent habitats from naturally migrating landward.

digitization: the process of converting imagery (boat-based and satellite aerial imagery) or ground-truthed visual inspections, into data in QGIS, consisting of line and point feature data. Classify is often used synonymously.

hard armour(ing): a human-made feature that was built with the intention of shielding a property or structure from incoming waves. This includes walls that have been built to protect land along the coast from the sea (e.g. bulkhead/seawall/riprap). These structures can be made of a variety of materials including concrete, rocks, masonry, wood, etc.

nature-based solutions/approaches: the protection and/or enhancement of natural ecosystem features to improve or restore ecosystem services that natural (or semi-natural) ecosystems can provide. Often employed to address impacts of climate change including sea level rise, erosion and biodiversity loss (International Union for Conservation of Nature and Natural Resources, 2024).

For the purposes of this report, we refer to the following when this term is used: any restorative activity or action that aims to utilize the most natural methods possible, based on the specific site conditions in question, which may require a hybrid approach. Specifically, actions that support natural processes and the ability for habitats to adapt to change, as opposed to hard engineered designs that disregard natural processes and function.

shoreline modification: any human-made feature constructed along the coastline that has the ability to impact natural coastal processes (see Data Dictionary within Digitization Protocol for more details).

shore type: defined by ShoreZone, shore types - also referred to as coastal class - are the dominant structuring process, slope, morphology, substrate, and width character for a shore unit (segment of shoreline) of the intertidal zone (Cook et al., 2017).

managed retreat: the approach to property management in response to sea level rise where infrastructure is physical moved (relocated or reconstructed) further inland in order to prevent risk of damage to those structures by waves, flooding and storms, and/or to reduce the impacts of coastal squeeze on shoreline habitat.

BACKGROUND

Project Overview & Objectives

Communities on the east coast of Vancouver Island are experiencing sea level rise and more frequent, intense storms because of climate change, exposing coastal communities and habitats at risk. The **Resilient Coasts for Salmon** project, initiated by the Pacific Salmon Foundation, implemented a multi-faceted approach to educate communities, government decision makers, and coastal professionals in British Columbia about current and future climate impacts and the long-term adaptive benefits of nature-based approaches to address coastal climate change. Funded by the BC Climate Action and Awareness Fund, the Resilient Coasts project initiated the following objectives:

- producing educational resources, presentations, and workshops to raise awareness about the impacts of hard armouring, such as seawalls, along the coast and provide nature-based alternatives when the circumstances allow,
- building capacity for implementing nature-based approaches on shorelines impacted by climate change by providing Green Shores® training free of charge. Led by the Stewardship Centre for British Columbia, the Green Shores® program offers a credit-based framework for the implementation of nature-based solutions for shoreline development,
- initiating three Green Shores for Shoreline Development demonstration sites on Vancouver Island to showcase nature-based approaches to restoration,
- and finally, creating a dataset of the extent of shoreline modifications, which this report pertains to. These data are for local planners, researchers, and decision makers, to help facilitate informed decisions for adapting to coastal climate change and encourage the uptake of more natural shoreline solutions for the protection and restoration of important habitat.

This report is a follow-up to the shoreline mapping workshop that took place in Oak Bay on October 7, 2022, where the Resilient Coasts team invited community members and interested individuals to learn about coastal climate change, how shorelines function, and ways we can adapt with nature in mind (Figure 1). Detailed data were collected using our Field Guide to Shoreline Mapping, as a means to initiate discussion and learning. After the workshop, the Resilient Coasts team digitized shoreline modifications, log accumulation, and overwater structures within Oak Bay, ləkʷəŋən (Lekwungen) Territory, which you will find in this report. For the full scope of these and additional data, please check out the Resilient Coasts for Salmon Atlas.

Figure 1 - A group photo from the Resilient Coasts for Salmon shoreline mapping workshop in Oak Bay, October 7, 2022.

LOCATION

The Resilient Coasts for Salmon project activities take place on the unceded Traditional Territories of many First Nations, including the Kwakwa̲ka̲'wakw People, Coast Salish People, W̱SÁNEĆ People, and ləkʷəŋən People. These Territories belong to: T'Sou-ke, Scia'new, Songhees, Xwsepsum (Kosapsum), Semiahmoo, S'Klallam, W̱JOȽEȽP (Tsartlip), SⱦÁU,TW̱ (Tsawout), BOḰEĆEN (Pauquachin), WSÍ,KEM (Tseycum), MÁLEXEȽ (Malahat), Quw'utsun, Tsawwassen, Penelakut, Halalt, Lyackson, Stz'uminus, Snuneymuxw, Snaw'naw'as, Qualicum, K'ómoks, Ma'amtagila, Tlowitsis, Homalco, Ligʷiłdaxʷ Nations (We Wai Kai, Wei Wai Kum, Kwiakah), ɬaʔamɩn gɩǰɛ (Tla'amin), and 'Namgis First Nations.

The area of focus for this report is on the Traditional Territory of the ləkʷəŋən (Lekwungen) speaking peoples – the Songhees and Xwsepsum (Kosapsum) First Nations, colonially known as Oak Bay, Victoria, on Southern Vancouver Island. This area is called Matoolia by the Xwsepsum First Nation, with two of Matoolia's five territories being the shorelines of Cheko'nein (around Cadboro Bay) and Chikowetch (around Oak Bay) in which this report covers. SN̲AḴE, which refers to a story, is the name given for this area by *SENĆOŦEN* speaking people, translates to "of snow" (Elliott, 1983). These place names illustrate the nuanced ways Indigenous communities live and move through life within their Traditional Territories and beyond, and between and amongst time and space with built relationships and agreements - which greatly deviates from colonially set boundaries.* In 2015, a Welcome Pole, designed by Butch Dick (Yuxwelupten) and carved by his son Clarence Dick (Wa'shk), was erected at

Oak Bay High School. The *Sno'uyutth* pole honours the spirit and resilience of the ləkʷəŋən People, and, sets the intentions of shared understanding and respect between communities; the name *Sno'uyutth* translating to "spreading good energy" (District of Oak Bay, n.d.).

* "*We did not know strict boundaries between our brothers and our friends*" wrote Dave Elliott Sr. in Saltwater People, referring to people who lived close by like the Lummis, Songhees, and Klallams. Additional resource used: Phillip Kevin Paul. 1995. The Care-Takers. The Re-Emergence of the Saanich Indian Map.

For the purposes of this report, the extent of shoreline covered is approximately 14.7 km known as the municipal boundaries of the District of Oak Bay (Figure 2), and encompasses a range of shoreline types (Figure 3), including:

- human-made,
- rock with gravel beach,
- sand and gravel beach,
- rock sand and gravel beach,
- rocky outcrops/platforms,
- sand and gravel flat,
- sand flat, and
- rock with sand beach

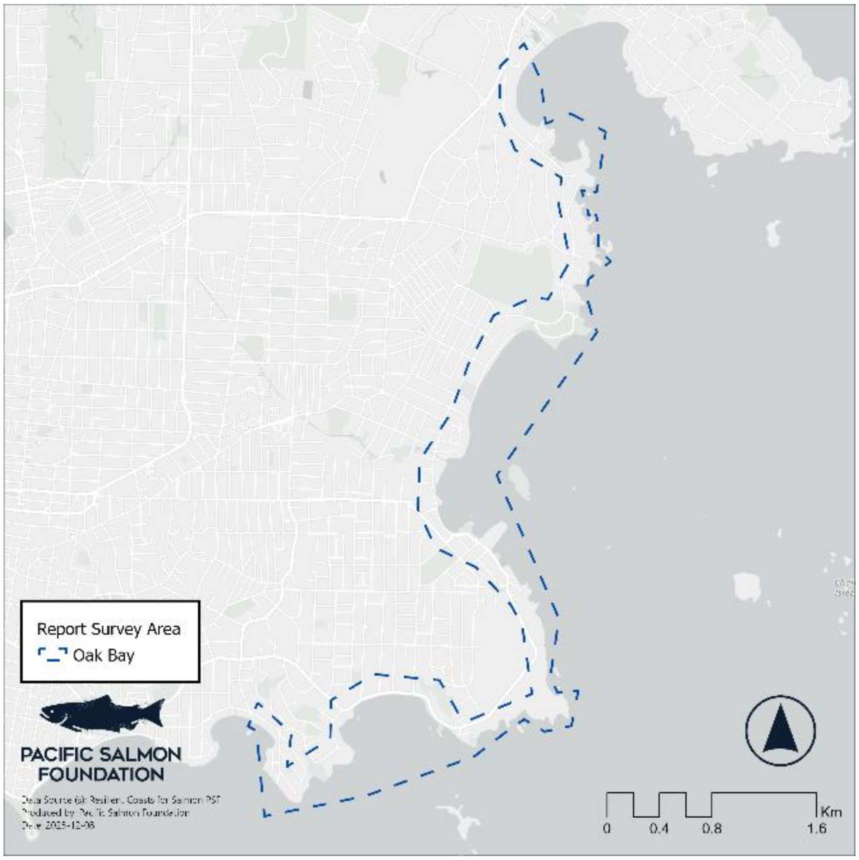

Figure 2 - The extent of shoreline covered in this report encircled in the blue dashed line.

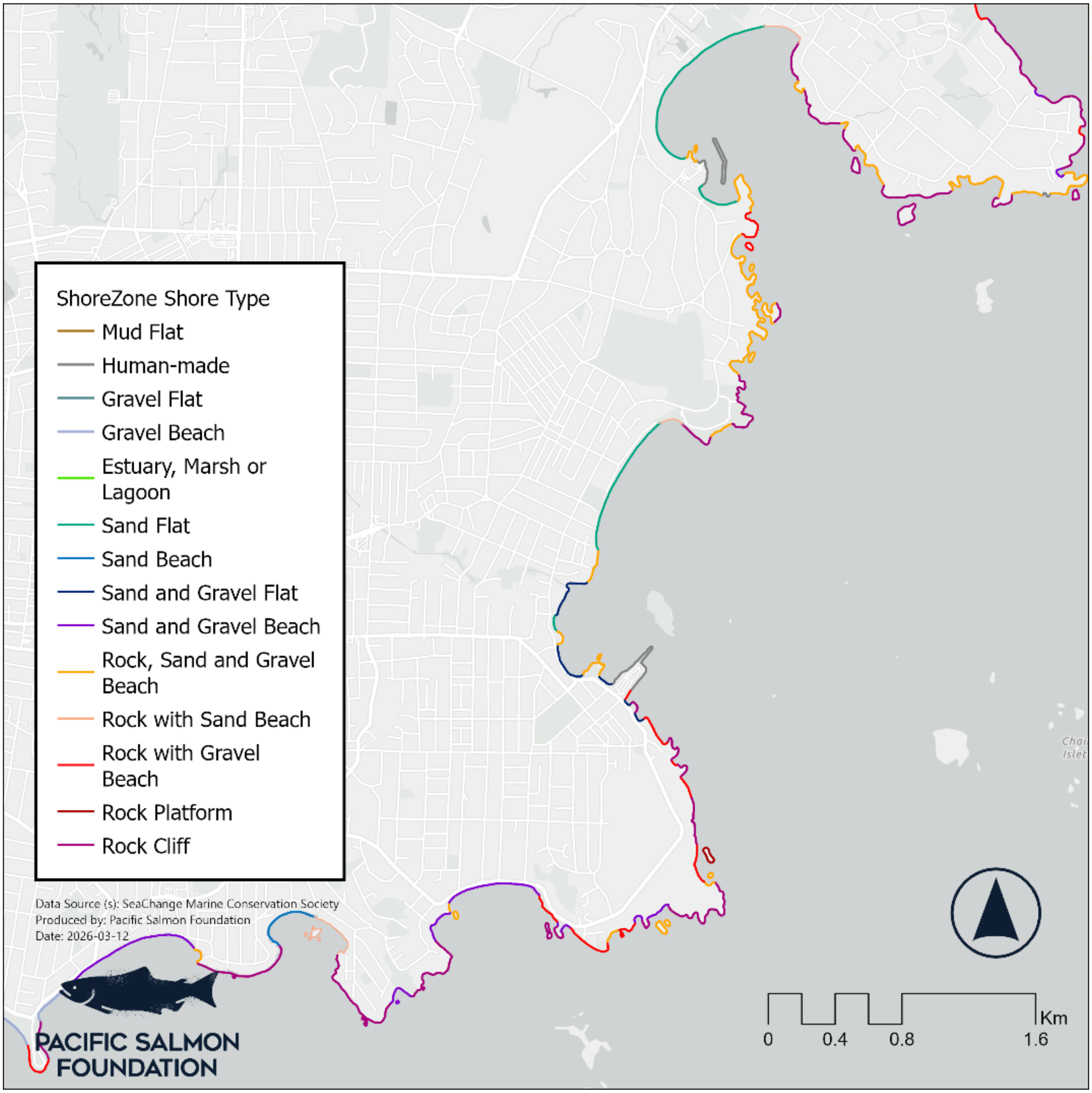

Figure 3 - The distribution of shore types within Oak Bay. Data from ShoreZone (Coastal and Ocean Resources, 2017).

INTRODUCTION

Sea Level Rise and Flooding

Sea levels rise as ocean waters warm and expand in volume, combined with increasing freshwater draining into oceans from increasing precipitation falling in the form of rain, and from melting glaciers and polar ice caps.

Sea level rise, in combination with larger and more intense winter storms, increases the risk of flooding and erosion that communities face (IPCC, 2019). Culturally important areas and shoreline infrastructure are at risk. Impacts extend from saltwater intrusion to destruction of property. The financial, ecological and social implications are huge and already being felt by a growing number of communities. Sea level rise varies across Vancouver Island, with low-lying areas being most vulnerable. Sea level rise is projected to be greatest on the north coast, the Fraser Lowland and around southern Vancouver Island (Vadebonceour, 2016). In Victoria, the sea level has risen at a rate of 6.6 cm per century, and this rate is accelerating (MOE BC, 2016). Low-lying regions are becoming more vulnerable to frequent flooding. By 2050, historical extreme sea level events that occurred once a century are projected to increase in frequency and occur on average at least once a year in many low-lying regions (Oppenheimer et al., 2019). This places homes, beaches, wetlands, and sites of cultural importance at risk (MOE BC, 2016).

Natural Coastal Processes

Natural coastal processes, like erosion and deposition of sediment, occur simultaneously to maintain and create our beaches, and they are needed to sustain our shorelines and their integrity into the future. The landscape, as well as wind, waves, and currents that continuously move water and beach materials like logs and various sizes of sediment such as sand, gravel and cobbles. Recognizing that healthy shorelines have natural variations in the movement of water and sediment is fundamental to understanding how shorelines work. While Figure 4 illustrates sediment transport and deposition by longshore current, it is important to recognize that transport mechanisms can vary significantly across shoreline morphologies. The orientation of the shoreline will also influence the exposure of that shoreline to wave energy and other factors. Human-made structures like seawalls, jetties and groynes can artificially influence erosion and deposition patterns, which we will explore below.

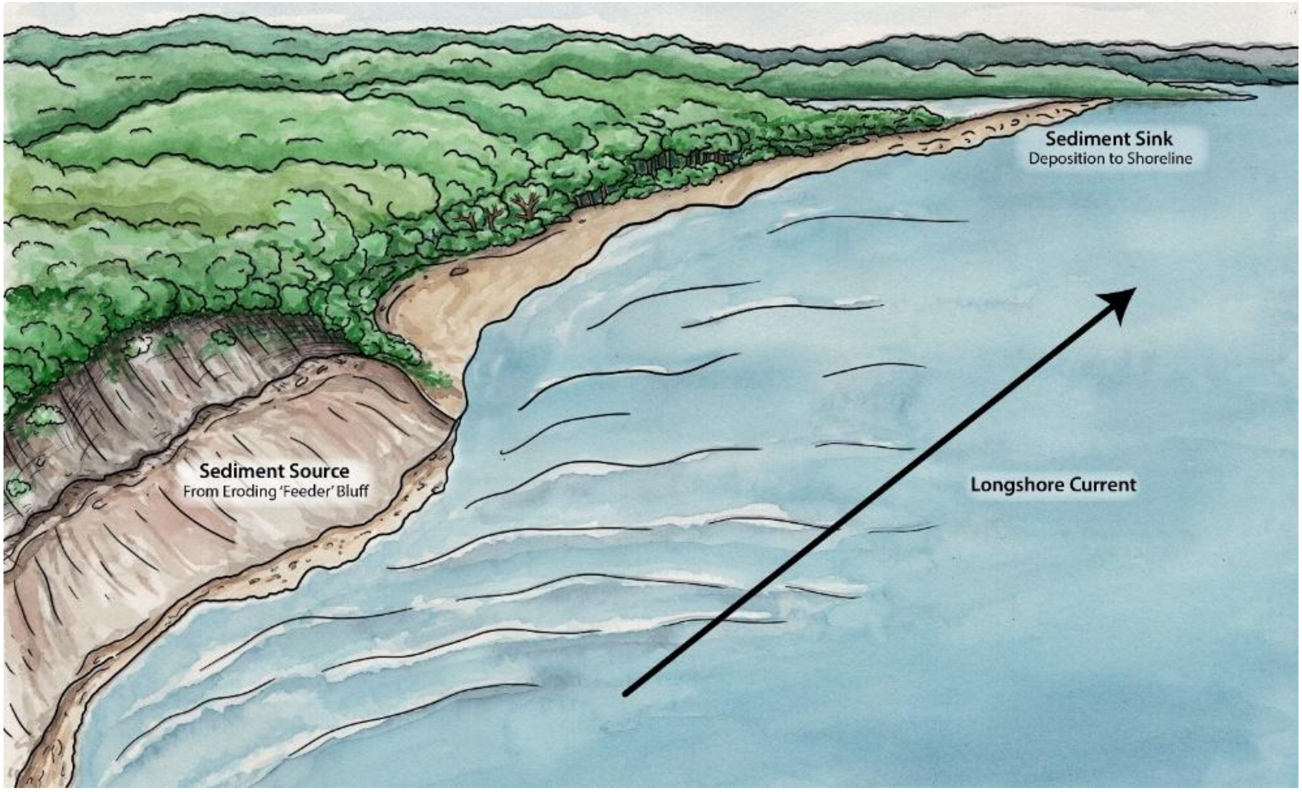

Figure 4 - Longshore current, which is one example of a coastal process, moves sediment from a source like a feeder bluff to a sink area where the sediment is deposited (e.g., a growing sand spit). Illustration by Holly Sullivan.

Shoreline Modification

Figure 5 - An example of a seawall (one type of shoreline modification). Photo by Maria Catanzaro.

Hard armour refers to structures like **concrete seawalls or rock riprap that are installed to armour shores and the infrastructure behind them from incoming waves** (Figure 5). The construction of shoreline armour has led to a false sense of security and an associated rise in populations in flood-prone areas (Rumson et al., 2017). In British Columbia, there are no provincial regulations preventing landowners from constructing shoreline armouring up to the mean high-tide line, which can have negative implications for forage fish and other coastal species (Buchanan et al., 2019). Seawalls also support 23% lower biodiversity and 45% fewer organisms than natural shorelines (Gittman et al., 2016). Local governments have some power here to impose community policies and bylaws to prevent further armouring from being constructed and to protect shoreline habitat. We are hopeful that the new B.C. Coastal Marine Strategy will lead to provincial legislative protection of B.C. shorelines. Hard armouring on shorelines can exacerbate erosion by waves scouring the base of the structure over time, causing structures to crack over time. Natural sediment transfer (replenishment), a natural process along coastlines, is disrupted when modifications exist. Combined with sea level rise, the shoreline's ability to adapt to sea level rise over time will be disrupted where structures exist. While hard armour is very common on shorelines, there are other types of coastal modifications, including overwater structures, which have impacts on the coastal environment.

Overwater Structures

Overwater structures include personal docks, municipal piers, wharfs, marinas, and even ferry terminals. **Overwater structures can shade the environment below, which has cascading impacts on the coastal food web.** There is often reduced prey availability underneath piers and docks because the lack of light below them changes the habitat for algae, seagrasses (reducing critical rearing habitat for coastal species) and the epibenthic invertebrates that are a critical food source for Pacific salmon (Cordell et al., 2017). Salmon also tend to avoid piers and docks (Munsch et al., 2014) as the lack of light makes it more difficult to see their predators, properly orient themselves, or school together. Particularly for juvenile salmon, the presence of overwater structures in estuaries could impact the success of their outmigration (Toft et al., 2007). Loss of marine vegetation can also impact another important forage species, Pacific herring, which spawn on nearshore surfaces like eelgrass and kelp.

Log Accumulation

Log accumulations on beaches are a concern due to their potential to **impact coastal habitat for forage fish**. The logs that are predominantly found washed up on beaches are from the logging industry. This means that they have been processed in some way: most have had their ends cut with branches and bark removed, and some have been further treated with preservative agents.

While **natural logs with root wads can be remarkable shoreline restoration tools to help accumulate and secure sediment, their processed counterparts can have very negative impacts on shoreline habitats**. Without branches or root wads, they can easily roll over beaches, crushing any creatures that might be living there, including forage fish eggs. Logs can also impact the biotic communities of rocky shorelines. A recent study showed that populations of key foundational intertidal species such as the thatched barnacle were 20-80% lower on rocky intertidal areas where there was abrasion from logs, compared to adjacent areas that were protected from the abrasion (Pérez Andresen et al., 2025).
An accumulation of logs can also smother vegetation on the shoreline (Figure 6). When this is combined with coastal modification, those logs may continue to be mobile since they cannot settle higher in the backshore, exacerbating the impacts of erosion on those beaches, and potentially degrading the structures themselves. These impacts can be exacerbated by increasingly frequent and intense storms.

Often, logs treated with creosote (a preservative made from tar) can end up on beaches or are present in the nearshore environment as pilings, which can have negative consequences for forage fish. Persistent chemicals such as PAH's found in creosote have negative impacts on marine organisms (Sibley et al., 2001). For forage fish species like Pacific herring whose eggs attach to surfaces like pilings and eelgrass in the nearshore environment, the presence of creosote pilings can sabotage a spawn event, decreasing the success of hatching in some and causing physical abnormalities in others (Vines et al., 2000).

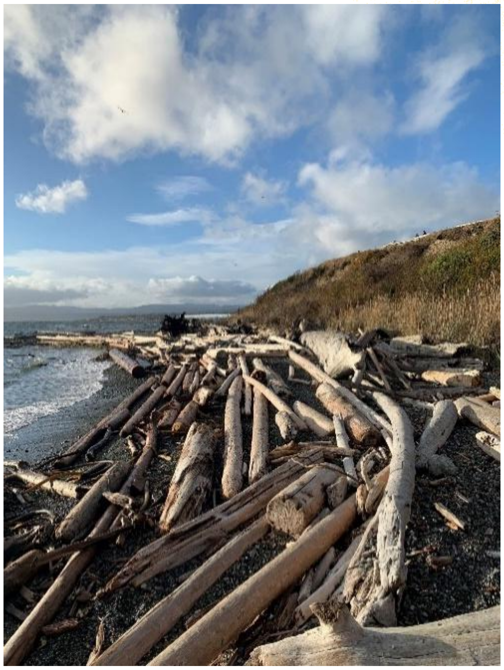

Figure 6 - An extreme accumulation of logs on a shoreline in Victoria, BC, where the majority of the accumulated logs are processed logs from the forestry industry.

Natural woody debris is considered beneficial for many reasons including stabilizing shoreline sediments, adding nutrients to the shoreline, and providing a substrate for riparian and shoreline plants to grow. Since naturally woody debris can have root wads and branches, they can settle on shorelines, whereby sediment can accumulate, and vegetation may grow. Because natural logs tend to settle and become embedded in shoreline sediments, they will not cause scour like processed mobile logs do. As the trees decompose, they provide nutrients back into the water column that zooplankton feeds on, adding to the productivity of that area. As natural logs are untreated with preservatives, shoreline plants often can grow on those logs, which adds habitat value to the shoreline.

Impacts of Sea Level Rise and Shoreline Modifications on Salmon and the Coastal Food Web

Juvenile Pacific salmon rely on healthy coastal habitats, including estuaries, marshes, and pocket beaches, to rear and grow in preparation for their open ocean migration. Though modifications along the shoreline alter how natural shorelines function and impact Pacific salmon. For example:

- The impacts of sea level rise are exacerbated by coastal modifications. For example, **coastal squeeze occurs, which prevents habitats from naturally migrating landward as sea levels rise**. When structures like seawalls are present, intertidal habitats are 'squeezed', which can eventually cause a complete loss of intertidal areas, including the associated species, habitat values, and ecosystem services they provide. Eelgrass beds, for instance, provide critical habitat for herring spawn to attach to, and for juvenile and small fish to hide from predators and feed on invertebrates. Because eelgrass occupies a specific range within the intertidal, it can be squeezed out when seawalls prevent that habitat from shifting landward as sea level rises (Figure 7).

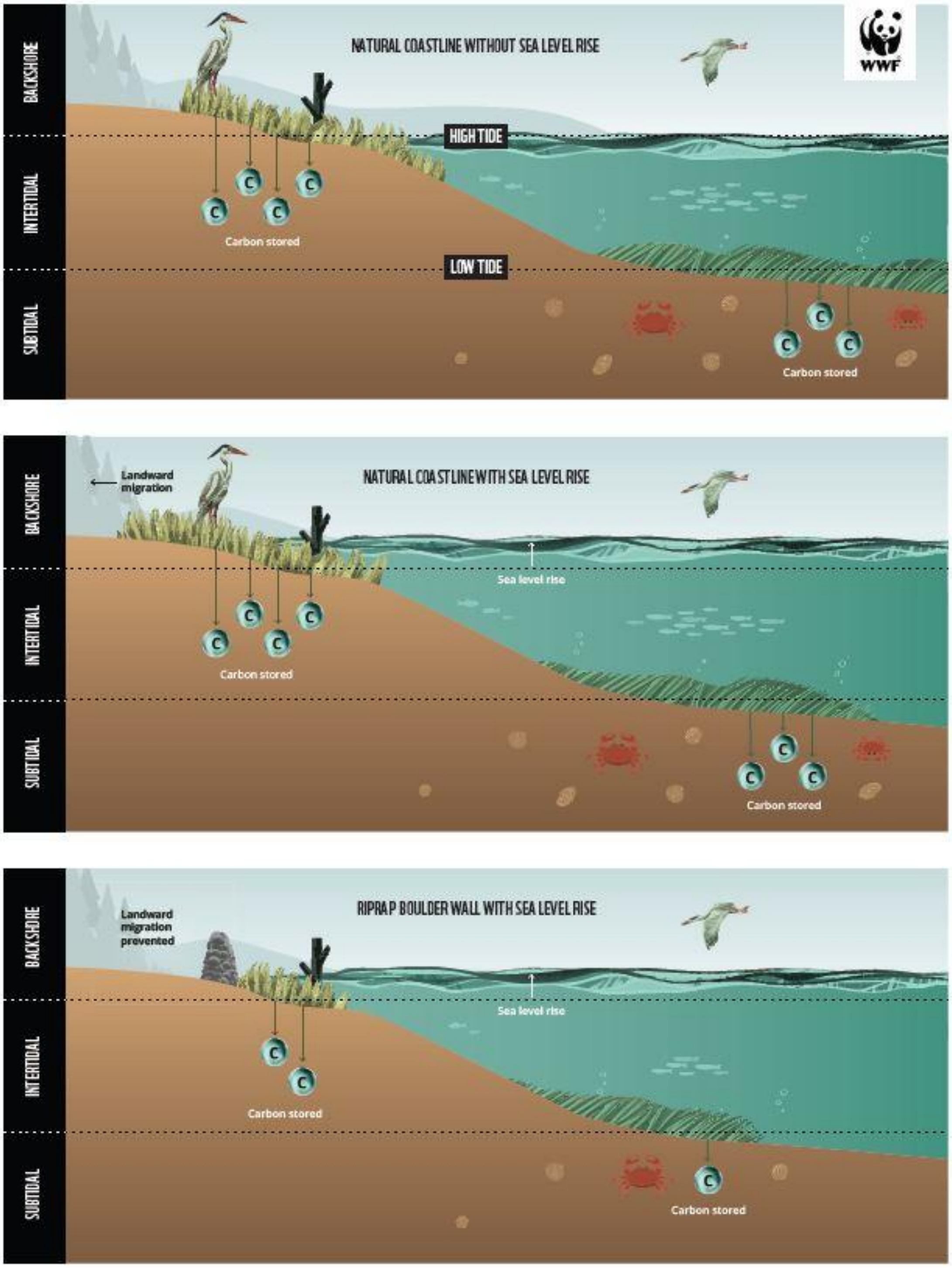

Figure 7 - Depiction of coastal squeeze, where the combination of coastal modification and sea level rise results in a loss of eelgrass habitat and shoreline vegetation. Illustration by World Wildlife Fund Canada.

- **On armoured shorelines, salmon are unable to access their preferred prey items.** Studies have found that shoreline armouring reduced the number and diversity of epibenthic invertebrates (that reside on or above the rock, sand, and mud of the seafloor) and the availability of terrestrial insects compared to unarmoured areas (Cordell et al., 2017). As a result, when young salmon are next to a seawall and other anthropogenic structures, they end up feeding on alternative prey types such as planktonic prey that might be harder to catch and less nutritious.

- **Structures like seawalls that extend into the intertidal zone take away important shallow habitat and expose juvenile salmon to greater predation risk.** With deep water right up to the shoreline, rather than a natural slope where the water gets gradually shallower, these structures allow for larger predators to get close to the shore and hunt smaller fish.

- Surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes personatus*) are forage fish that play a critical role in the coastal food web, transferring energy to higher trophic levels (Figure 8). These species spawn in the intertidal zone by burying their eggs in pebbly and sandy beach sediment. **Erosion caused by incoming waves crashing into seawalls can take away these key spawning habitats**, by rendering the substrate unsuitable.

Figure 8 - A school of forage fish. Photo by Jake Dingwall.

- Another way that hard armouring can impact forage fish is by altering sediment supply and deposition. Areas of armouring can cause erosion on adjacent beaches (Krueger et al., 2009), **cut off sediment sources that would replenish beaches through natural shoreline processes**, and contribute to cumulative impacts. In the San Juan Islands of Washington State, it was found that a large portion (28%) of the modified shoreline cut off feeder bluffs that would have otherwise contributed sediment that could create and maintain nearby spawning beaches (Friends of the San Juans, 2014).
- Coastal modification also **disrupts overall land and sea connectivity**. Coastal riparian vegetation is lost on modified shores along with the insects that would fall into the water – an important food source for salmon. Surf smelt, a prized prey item for salmon as they grow in coastal areas, also suffer without overhanging coastal vegetation. The shade of the vegetation regulates the temperature of the upper shoreline, and this is important for surf smelt beach spawning. A recent study in Puget Sound, WA, found that beaches with a seawall or other structures **had more extreme substrate temperatures** (mean 18.8°C compared to 14.1°C

on natural shorelines) and air temperatures due to the lack of riparian vegetation that would otherwise shade the beach from the sun (Rice, 2006). Beaches with seawalls also had lower relative humidity. Together, these **hotter, drier conditions could impact egg survival, making modified beaches far less suitable for spawning compared to natural beaches** (Rice, 2006).

Nature Based Approaches to Shoreline Restoration

As mentioned, **human-made seawalls are static** (Figure 9, left side of the image) and offer little habitat value, can cause overtopping (waves splashing onto the property), and deflects wave energy, which causes erosion and impacts to adjacent areas. However, **an alternative** to hard armouring are nature-based approaches to restoring shorelines. Restoring shorelines with soft shore (nature-based) approaches (Figure 9, right side of the image) encourages a more **diverse habitat** on the shore and intertidal zones. The **natural gradient tempers wave energy and can adjust dynamically as sea levels rise**. Overhanging tree branches and shrubs also benefit salmon by **providing shade and prey species**.

Figure 9 - A comparison of an armoured shoreline (left) with a natural shoreline (right). Illustration by Holly Sullivan.

Working with nature encourages resilient ecosystems by allowing natural processes to occur. These actions can be taken at the residential and community planning level to reduce the impacts of climate change, whilst maintaining or enhancing critical habitat for species like Pacific salmon. Depending on the approach you take, restoring elements of natural functions and processes could allow room for habitats to shift as sea levels rise, and provide numerous climate change mitigation benefits like buffering wave energy. For example, one method used by Guardians of our Salish Estuaries (GooSE) is eco-cultural fencing, whereby natural materials are used to weave a fence around areas of salt marsh, allowing the re-establishment of vegetation and preventing further degradation by goose herbivory. Salt marshes are incredibly important to protect, as they are critical habitat for Pacific salmon. These habits are also carbon sinks, contributing to climate change resilience, and they accumulate sediments which can raise the elevation of marsh platforms over time and protect coastal from erosion by attenuating wave energy.

There are a variety of restoration approaches depending on your site-specific ecological needs, and can include methods like:

- **managed retreat** - moving infrastructure back to allow and plan for sea level rise
- improving drainage on your property to reduce erosion
- protecting the upland by retaining or planting native trees and shrubs to help stabilize the shoreline bank and provide valuable habitat benefits,
- sediment addition (also referred to as nourishment) when the conditions are appropriate, whilst recontouring the gradient of the beach to a natural angle,
- terracing steep slopes while using live staking of native vegetation to stabilize the slope, helping it to erode at a more natural pace,
- preventing herbivory on marsh sites with eco-cultural fencing that deters geese from entering,
- eco-cultural fencing prevents geese from consuming and degrading marsh habitat that species rely on, like Pacific salmon,
- planning for sea level rise by preventing new hard structures from being built in unsuitable areas
- removing existing seawalls, where conditions are suitable, and bringing natural elements back, like planting riparian vegetation to help stabilize the bank

To explore more on how nature-based solutions can be used to help protect coastal properties and provide habitat for coastal ecosystems, check out the educational primer (short version), tool kit, and articles on resilientcoasts.ca.

METHODS

Data Collection

Between 2022 and 2024, the Resilient Coasts for Salmon team collected imagery of the shorelines of east coast Vancouver Island by boat using a high-resolution and 360-degree camera. Still shots of the shoreline were captured from 25-metres to 400-metres distance, at set intervals. The track lines and associated images were uploaded to a web platform, Mapillary. Additional means of capturing data were utilized including OpenStreetMap, QGIS, Google Earth Pro, ArcGIS (ESRI), drone imagery and ground surveys. Boat-based shoreline imagery for Oak Bay was captured in 2022.

Data Digitization

With these data, the team created a digitized dataset of shoreline modifications, log accumulation on beaches, and overwater structures. The digitization process involved reviewing the boat-based imagery to identify features along the shoreline that were anthropogenically constructed, followed by recording them as line or point features in QGIS. To digitize features, the geo-referenced image files were reviewed in OpenStreetMap, along with the aforementioned sources, then the observer either traced the corresponding curvature of the shoreline while creating line features, or added point features, in QGIS. Features within estuarine areas were removed from the analyses, as these data are qualitative. Shorelines within First Nation reserve lands were also excluded from the analyses as they were not digitized out of respect for privacy.

The following provides a glimpse into the digitization process, while the thorough protocols for each dataset can be found here.

Coastal Modification Line Feature Dataset

Features were included if they had the ability to interact with natural shoreline processes at the time imagery was taken. The following attributes were captured when modifications were found - whether the modification (feature) was on rocky outcrop/platform or not (i.e., loose sediment beaches), the type of modification (form) (e.g., seawall), the material of the modification (e.g., concrete), a confidence rating from the observer for the presence of the modification, and whether the modification was ground-truthed (i.e., visited in person). Modifications were digitized if they were greater or equal to 2 metres in length.

All modifications of the same type and material were mapped in a continuous line regardless of property lines or time of construction. Landscaping features or modifications that are currently situated on the backshore (above the reach of the highest high tide), and any structures built on rocky outcrop/platforms that were deemed to not have any influence on coastal processes due to their elevation, were not included. Additional imagery sources, including Google Earth Pro and OpenStreetMap, ArcGIS (ESRI) and QGIS were often used to confirm the presence or absence of a feature if there was any uncertainty. In some cases, beaches were visited on foot.

Log Accumulation Line Feature Dataset

The level of log accumulation along the coast was digitized as linear segments and included both natural logs (i.e., fell and deposited naturally on the shoreline, typical to contain roots and branches attached) and logs originating from the forestry industry (i.e., logs with cut ends). Categories described how much the beach was covered by logs between the high tide line and the backshore at the time the imagery was taken and included: low (19% or less), medium (between 20% and 49%), high (between 50% and 89%), and extreme (90% and above). It was noted whether the logs on the beach were mobile (i.e., able to be moved by the tide and waves), and/or embedded in the sediment, and whether any logs appeared to be treated with creosote. It should be noted that approximately 10% of Oak Bay's total shoreline was not categorized for log accumulation due to issues with visibility. These gaps include areas behind large marinas and in bays where the entire shoreline was not visible.

Natural-source wood like dead and fallen trees, that are no longer attached to the soil (i.e., resting on the shoreline), were included and digitized within log accumulations. Structures on the beach made from driftwood, such as forts and sculptures, were included in the dataset. It is assumed that the logs used to build the structure were logs that had accumulated nearby on the shoreline.

Ground truthing was not performed for log accumulation data and thus, represents a snapshot in time. However, log accumulations are subject to change throughout the seasons, and often day to day. These data likely represent 'best conditions' of the shoreline, as the imagery was captured during the summer months when the impacts of storms are not as prominent. The boat-based Resilient Coasts shoreline imagery was solely used for this dataset and was captured in July 2022. Gaps exist in this dataset where imagery was not available.

Overwater Structures Point Feature Dataset

Overwater structures, including personal docks, abandoned docks, marinas, and pilings, were recorded using point features, and corresponding data was included for the types of material used to construct the structure, and whether it was permanent or floating.

Ground truthing was not performed for overwater structure data and thus, represent a snapshot in time. The boat-based Resilient Coasts shoreline imagery was primarily used for this dataset, with some occurrences where satellite imagery was used. Gaps exist in this dataset where imagery was not available.

Analyses

This report will provide a glimpse into the analyses performed and associated maps to describe the Resilient Coasts' data layers described above, along with external layers, and what this means for Oak Bay as they overlap (e.g., sensitivity to sea level rise with shoreline modifications).

Feature Manipulation Engine (FME) software was employed to calculate reporting metrics, whereby numerous workflows were developed. It should be noted that none of these workflows, nor the raw data, provide a level of precision that would be needed for activities requiring real world alignment, such as engineering. Details for analyses related to each external data layer are included in the sections below. For additional information on the methodologies undertaken to produce these results, please contact marinedatacentre@psf.ca.

Additional testing was performed for the Resilient Coasts results (i.e., analyses for coastal modification features, log accumulation and overwater structures) to check relative accuracy against the FME workflow process, whereby QGIS vector geometry and vector analysis tools were used to summarize the Resilient Coasts data within each community polygon. Additional quality analysis/quality control were performed on geospatial statistics related to all layers.

Natural, Modified, and Total Shoreline Length Values

In order to create boundaries for conducting analyses within communities, polygons were created to reflect the extent of a specific community. To calculate the relative length and proportion of shoreline containing modified features and total on natural segments of shoreline, the total shoreline length value was required. Because the shorelines that were deemed natural were not digitized (i.e., no line features were drawn), the total length for natural stretches of shoreline was determined by taking the total length of shoreline from the Freshwater Atlas Coastlines (FAC) dataset (Government of Canada, 2020). Due to disparate methods used to create the FAC layer and the methods used by the Resilient Coasts project, the values are not precise. The FAC layer typically followed the curvature of the shoreline that yielded greater values compared to those recorded by the Resilient Coasts team (Figure 10). In some regions, small islets close to the shoreline were included in community polygon layers (i.e., were not removed and therefore included in the total shoreline length values) which resulted in greater values in comparison, as nearshore islands were only digitized by Resilient Coasts recorders when the islands were connected to Vancouver Island (e.g., by a constructed road). For these reasons, any comparisons between modified areas (digitized by Resilient Coasts staff) and natural areas (extracted from the FAC) are approximate. The 'comments' attribute for the coastal modification dataset was also extracted to support discussion of nuances in the data.

Figure 10 - The FAC (green line) often diverts from where coastal modifications were digitized, which could result in an over or underestimation of shoreline length (Government of Canada, 2020).

Log accumulation data were analyzed by determining the length of each log accumulation segment, and totaling the length per category of log accumulation (i.e. all segments of low accumulation of logs were summed together). The proportions of the shore with each category of log accumulation was then generated by comparing the sum of each category with the total shoreline length for a given community. These results, as well as results such as number of shore segments where creosote logs were found, were generated in FME.

The results related to overwater features were generated using FME, where the overwater structures were totaled by type within the boundaries of a given community.

Wave Exposure

ShoreZone conducted surveys between the 1980's and 2007 to describe wave exposure along the coastline (Cook et al., 2017). This dataset was used to interpret relative exposure along the coastline in Sidney. The wave exposure attribute estimates the amount of wave energy that could potentially impact the intertidal zones of specific Shore Units. Fetch, the maximum distance/length that wind-driven waves can travel unobstructed, can help explain how exposed an area is to wave energy. The level of exposure for a specific area may impact the amount of erosion, flooding, and ultimately damage due to the amount of distance that waves can generate energy.

To calculate the amount of modified shoreline parallel to varying levels of wave exposure, transformation involved the following process: 1) the data input which includes information on wave exposure (e.g., very exposed coastline) was separated based on the varying degrees of exposure, 2) a buffer of 50 metres was created on the left and right sides of each wave exposure sublayer, 3) it was determined which modified shoreline features fell within this buffer, 4) the summative length of these features was calculated, 5) the length of total coastline in the survey area was calculated, 6) the lengths of shoreline modifications that overlap with each wave exposure, respectively, were divided by the length of total shoreline. This gives, for example, the percent of modified shoreline which is very exposed to wave action. Due to the spatial misalignment between the shoreline modifications layer and the comparative layer (i.e., ShoreZone's wave exposure represented within distinct Shore Units), the results in this report add up to slightly more than 100%.

Sensitivity to Sea Level Rise

To analyze shoreline sensitivity to sea level rise, the BC Parks Shoreline Sensitivity to Sea Level Rise Model was utilized, which ranks units of shoreline in one of five categories of sensitivity to sea level rise from very low sensitivity to very high sensitivity. This dataset is derived from existing datasets including the Broad Ecosystem Inventory (biogeographic land classification) and the shoreline sensitivity ratings by ShoreZone, along with effects of exposure, slope, and sediment mobility to provide relative sensitivity ratings of BC shorelines (Biffard, Stevens and Rao, n.d.). This BC Parks Shoreline Sensitivity to Sea Level Rise dataset is a simple polyline layer indicating shore units that have physical characteristics that are potentially more or less vulnerable to sea level rise. This analysis was used for the entire BC coast; however, it is quite coarse due to their results showing the overall sensitivity to sea level rise per Shore Unit, rather than showing exactly where the shores vary in sensitivity. Similar to the wave exposure results, spatial misalignment between the shoreline modifications layer and the Sensitivity to Sea Level Rise layer resulted in values slightly more than 100%. This was also true for results that compared shoreline modifications, wave exposure and sensitivity to sea level rise (i.e., combinations).

Forage Fish

Two datasets were used to look at the presence or potential presence of forage fish habitat. The first dataset is from the BC Coastal Forage Fish Network (CFFN, 2019), a collaborative group who monitor beaches for forage fish presence. These data represent beach sampling efforts, as well as any positive detections of forage fish eggs. These values were extrapolated from overlaying the community boundary layer and positive detections of forage fish data.

The second dataset explores potential suitable habitat for Pacific sand lance (PSL). Huard et al. (2022) developed a habitat suitability model for intertidal PSL spawning habitat in the Canadian Salish Sea. This model categorizes coastal habitat based on the likelihood of its ability to support PSL, based on variables such as proximity to estuaries, shoreline slope, substrate, and the distance to predicted subtidal sand lance habitat. The study determined that approximately 5.4% of all intertidal zones within the Salish Sea are predicted as likely or highly likely to support PSL, with only 1.4% of the intertidal predicted to be highly likely to support PSL. Uncertainty in the model outputs are identified as a mask layer, whereby areas are deemed more uncertain when environmental conditions are more dissimilar from the areas where model data were collected. In other words, the model was not able to predict into these areas with high confidence due to the differences in the underlying environmental prediction data. Each area of the modelled region has a numeric value of uncertainty associated with it, where the areas with the lowest uncertainty values corresponded to areas with the highest habitat suitability values. The model does not cover the entire Resilient Coasts project region, and there are some areas that are outside of the model's scope (Huard et al., 2022).

Notes for unanalyzed data

Coastal Flood Hazards

Coastal floodplain data are an important piece of the coastal adaptation puzzle. Although coastal flooding data were not analyzed for this community, we encourage the Town of Oak Bay to consider using the local coastal floodplain model that was completed for the Capital Regional District to take a closer look at the overlap of coastal modification data and areas that are predicted to flood in the future.

Sediment Stability

To describe a shoreline's sediment stability, the Stability Index was used to report qualitatively. The Stability Index is one component of ShoreZone's Coastal Vulnerability Module. The Stability Index, referred to in this document as sediment stability, relates to the relative rate of erosion on a given segment of shoreline. This index categorizes Shore Units into accretional (gaining sediment over time), erosion (losing sediment over time) or stable (no significant change over time) (Cooke et al., 2017). These data were not analyzed (i.e. quantitative results were not generated) for the community of Oak Bay, however the data are shown in static maps and discussed qualitatively in the results section of this report.

RESULTS

Visit Appendix A for a list of acknowledged limitations of the data, and considerations for interpreting the results presented in the report.

Shoreline Modification

The total length of shoreline that was digitized is approximately 14.7 km, as retrieved by the Freshwater Atlas Coastlines. As of 2022, the approximate length of shoreline that was modified in Oak Bay was 7,610 m, with the remaining 7,121 m being either unmodified (i.e., 'natural') or modified but not yet interacting with natural coastal processes. Thus, approximately **51.7% of the shoreline was modified** at the time the data was collected (Figure 11). See Figure B1 for the extent of coastal modification without the community boundary line.

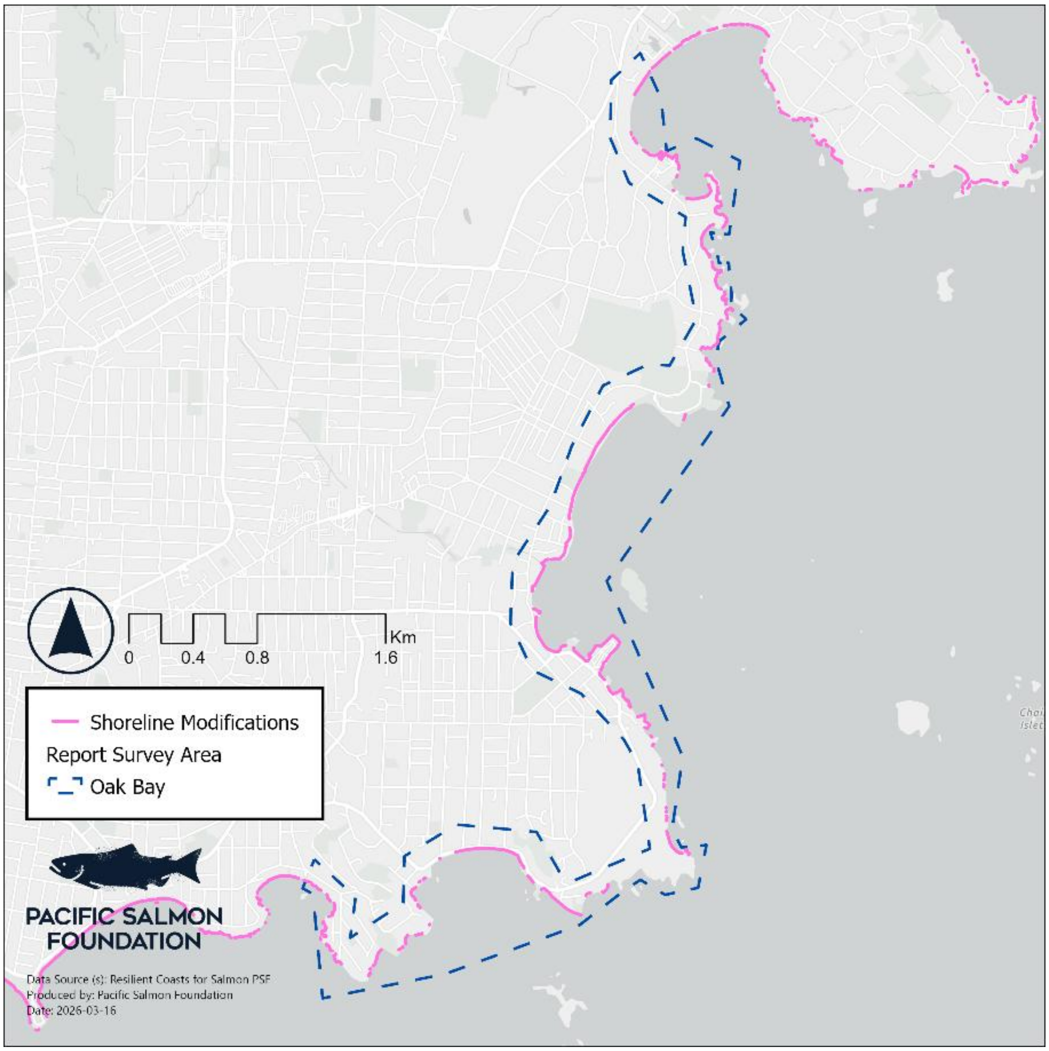

Figure 11 - The extent of coastal modification (shown in pink) within the study region (outlined in blue dashes).

Approximately 35% of the modifications were built on consolidated rock (e.g., hard shoreline substrate like rocky outcrop, rock platform, rock cliff), and approximately 65% were built on unconsolidated sediment (e.g., soft shoreline sediment like sand, pebble, cobble).

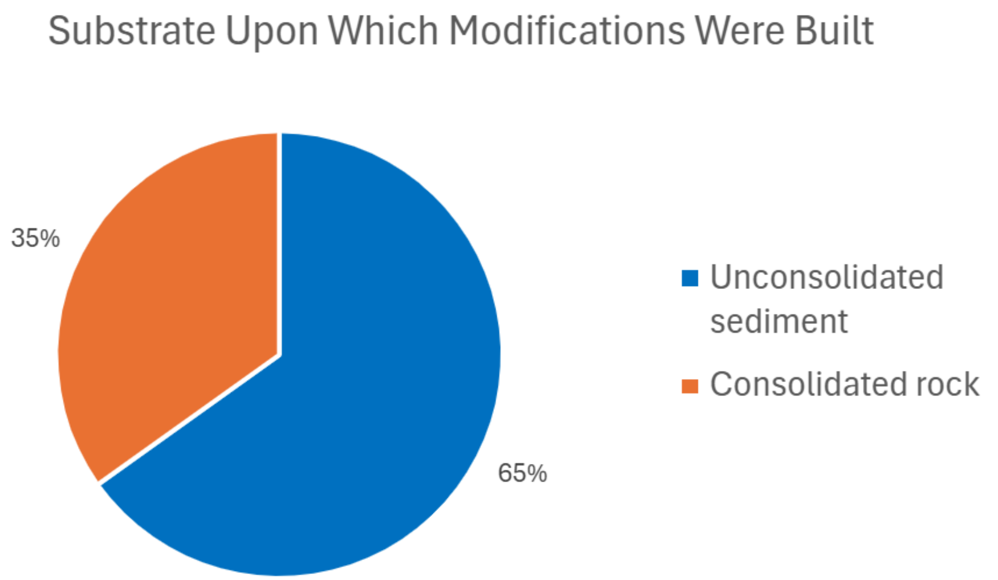

Figure 12 - The proportion of modifications built on consolidated rock (i.e., rock substrate like rocky outcrop, rock platform, rock cliff) compared to modifications built along shorelines with unconsolidated sediment (e.g., sand, pebble, cobble).

The modifications along the shoreline in Oak Bay are constructed along residential and commercial properties, schools, marinas, municipal parks, and recreational beaches. The majority of modified shoreline was composed of seawalls/bulkheads (69.3%), riprap (17.1%), and modifications associated with marinas (6.9%) (see Figure 13 and Table 1 for all modification types). Other noted features include beach access (path/stairs), boat ramps and sheds, docks, groynes, stormwater outfalls, patios, beach cabins, and overwater structures.

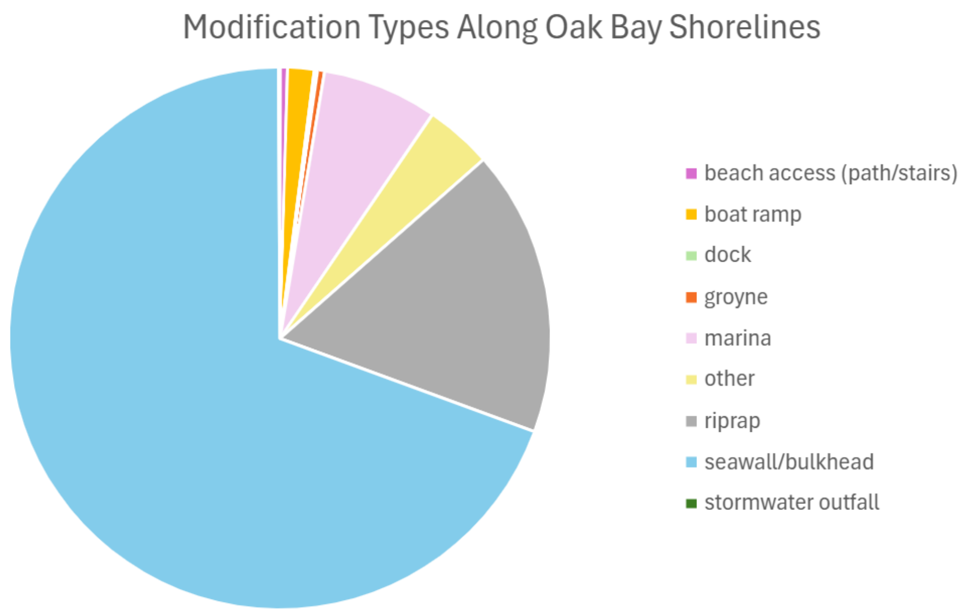

Figure 13 – The proportion of each type of modification found on modified shorelines of Oak Bay, with seawalls/bulkheads being the most common.

Table 1 – The length and proportion of shoreline by modification type (Form_1 only).

Type of modification (Form_1)	Total extent/ length (m)	Percent of total modified shoreline by modification type (%)	Percent of overall shoreline with these modifications (%)
Seawall/bulkhead	5275	69.3	35.8
Riprap	1298	17.1	8.8
Marina	523	6.9	3.6
Other*	306	4.0	2.1
Boat ramp	120	1.6	0.8
Beach access (path/stairs)	34	0.5	0.2
Groyne	32	0.4	0.2
Dock	15	0.2	0.1
Stormwater outfall	7	0.1	0.05

*Including but not limited to the following modification types: patio, shed/storage area, beach house, tennis court, overwater structure, structure that cuts off beach from rest of ocean, tiny house.

The type of building materials most utilized to construct the structures on the shoreline were concrete (43.8%), unknown material (33.1%), rock (12.0%), and masonry (11.0%) (see Table 2). The unknown/undefined category indicates that the recorder could not determine the material that was used, due to issues with image clarity or obstruction, or in cases when a mix of materials were used.

Table 2 - The percentage of modifications, based on the type of material used in the modifications.

Material of Modification (Form_1)	Percentage of Modifications
Concrete	43.8
Unknown/Undefined	33.1
Rock	12.0
Masonry	11.0
Wood	0.1

Sensitivity to Sea Level Rise

The BC Parks Shoreline Sensitivity Model, although coarse and high level, helps raise awareness on sea level rise but in-depth modelling should be conducted at site specific scales. Bearing these limitations in mind, most of the shoreline in Oak Bay can be classified as highly sensitive (69.8%) and very highly sensitive to sea level rise (31.9%), with small sections of shoreline being moderately sensitive to sea level rise (1%) and none predicted as low or very low sensitivity (Figure 14). In fact, nearly all of the modifications were built along areas of high and very high sensitivity to sea level rise (98% or 7457 m) (Figure B2 in Appendix B).

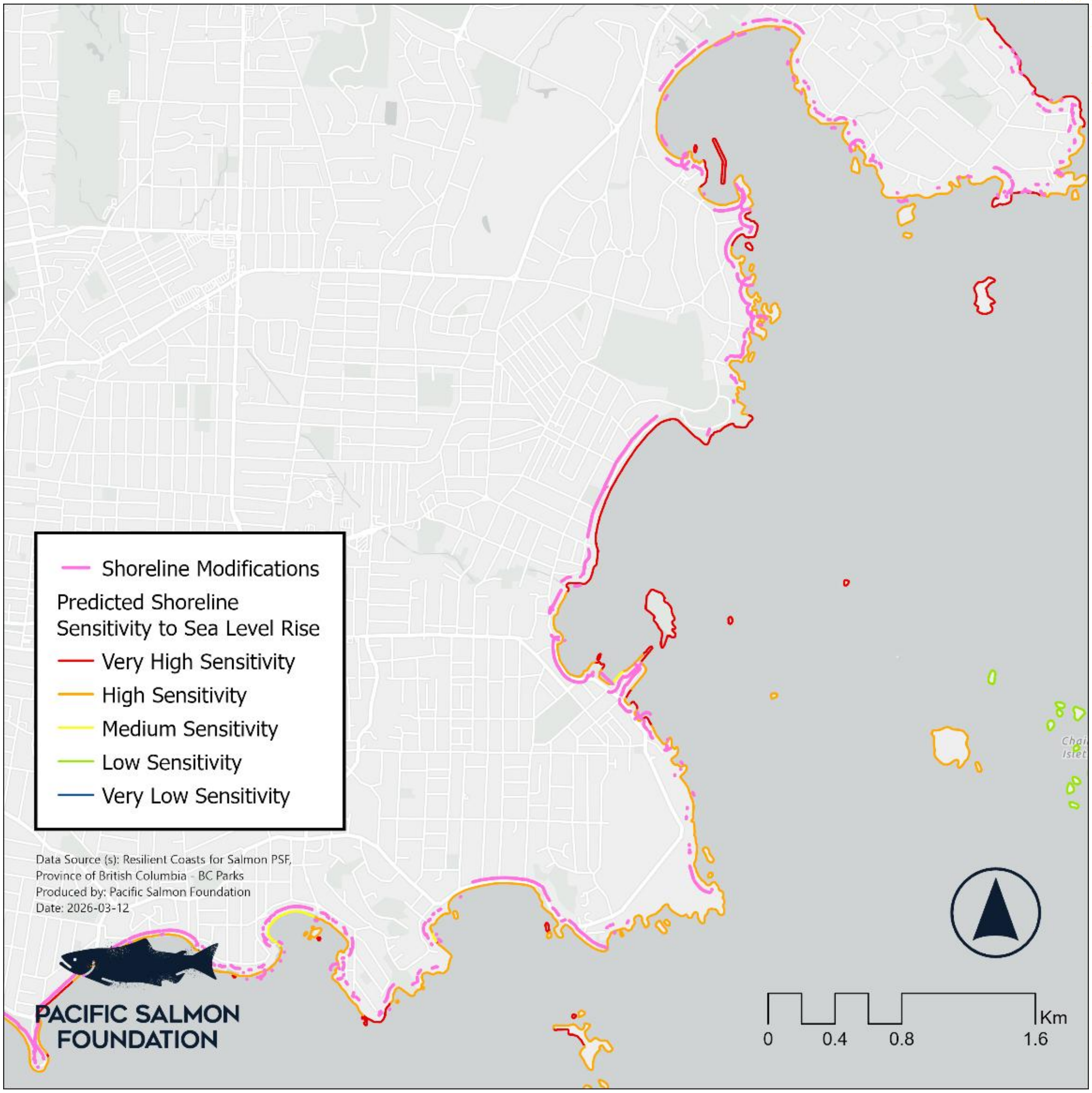

Figure 14 - The Oak Bay shoreline colour-coded into varying degrees of shoreline sensitivity to sea level rise (MOE BC, 2014) overlaid with the Resilient Coasts coastal modification features (shown in pink).

Wave Exposure

The Wave Exposure attribute (Cook et al., 2017) provides an estimate of the amount of wave energy that could impact intertidal zones of specific shore units (designated stretch of shoreline). The shoreline of Oak Bay consists of semi-protected coastline, semi-exposed coastline, and two protected bays (Figure 15). Based on the definitions from Cook et al. (2017)'s values for wave exposure, the semi-protected regions in Oak Bay have maximum wave fetch distances in the range of 10 to 50 km and waves are low most of the time except during high winds. In semi-exposed regions, the maximum wave fetch distances are between 50 and 500 km with swell, creating relatively high wave conditions.

These semi-exposed shorelines, including those around McNeill Bay and southern Oak Bay, will receive the largest relative waves within Oak Bay. Extremely large waves may occur during storms. In protected regions, like Cadboro Bay and Oak Bay (between Bowker Creek south to Currie Rd), the maximum wave fetch is less than 10 km; these areas are usually where you would find provisional anchorages and low wave exposure except in extreme winds. When wave exposure classifications are overlaid with shoreline modification data, we found that the proportion of modified shoreline that is protected from wave exposure is 57.1% and 27.4% is semi-protected, while 19.4% is semi-exposed (Figure 15).

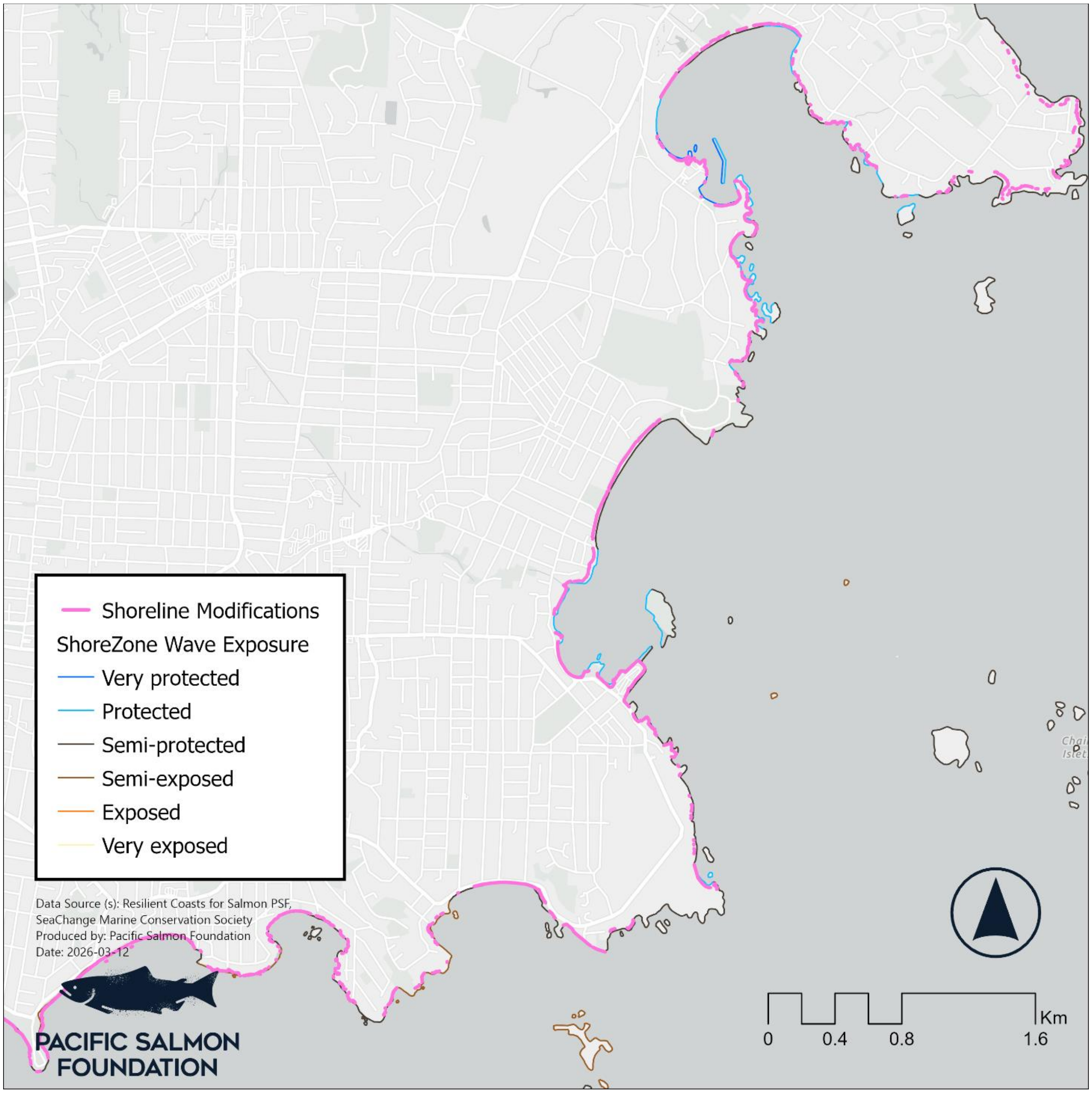

Figure 15 - The shorelines of Oak Bay, showing their relative wave exposure category (Cook et al., 2017) overlaid with the extent of coastal modification.

The majority (96.5%) of the semi-exposed segment of modified shoreline can also be described as highly or very highly sensitive to sea level rise, which is 18.8% (1.4 km) of the total 19.4% (1.5 km) of the modified shoreline that is semi-exposed. Similar results were found for the proportion of modified shoreline with protected wave exposure classifications parallel to high/very high sensitivity ratings (56.1% of the total 57.1%), and semi-protected along high/very high sensitivity ratings (25.1% of the total 27.4%).

Coastal Floodplain

Although the Capital Regional District's coastal flooding data were not analyzed for this community, a static map of the modelled coastal floodplain can be viewed in Appendix B (Figure B3).

Coastal Sediment Stability

Due to the high proportion of rocky shores within the District of Oak Bay, most of the shoreline is considered stable in terms of sediment stability (Figure 16). These categories described by ShoreZone, indicate whether shoreline segments are eroding and providing (transporting) material to other areas of shoreline, and where areas are accreting sediment (receiving that sediment) (Coastal and Ocean Resources, 2017). Some sand beaches, sand flats, and rock, sand and gravel beaches exist within Oak Bay, and are described as stable (not eroding, nor accreting) (Figure 16). In fact, no areas were considered to be accreting nor eroding. Additionally, since the sediment stability class description delineates the flow of sediment, a natural coastal process, it does not identify locations of localized erosion due to sea level rise.

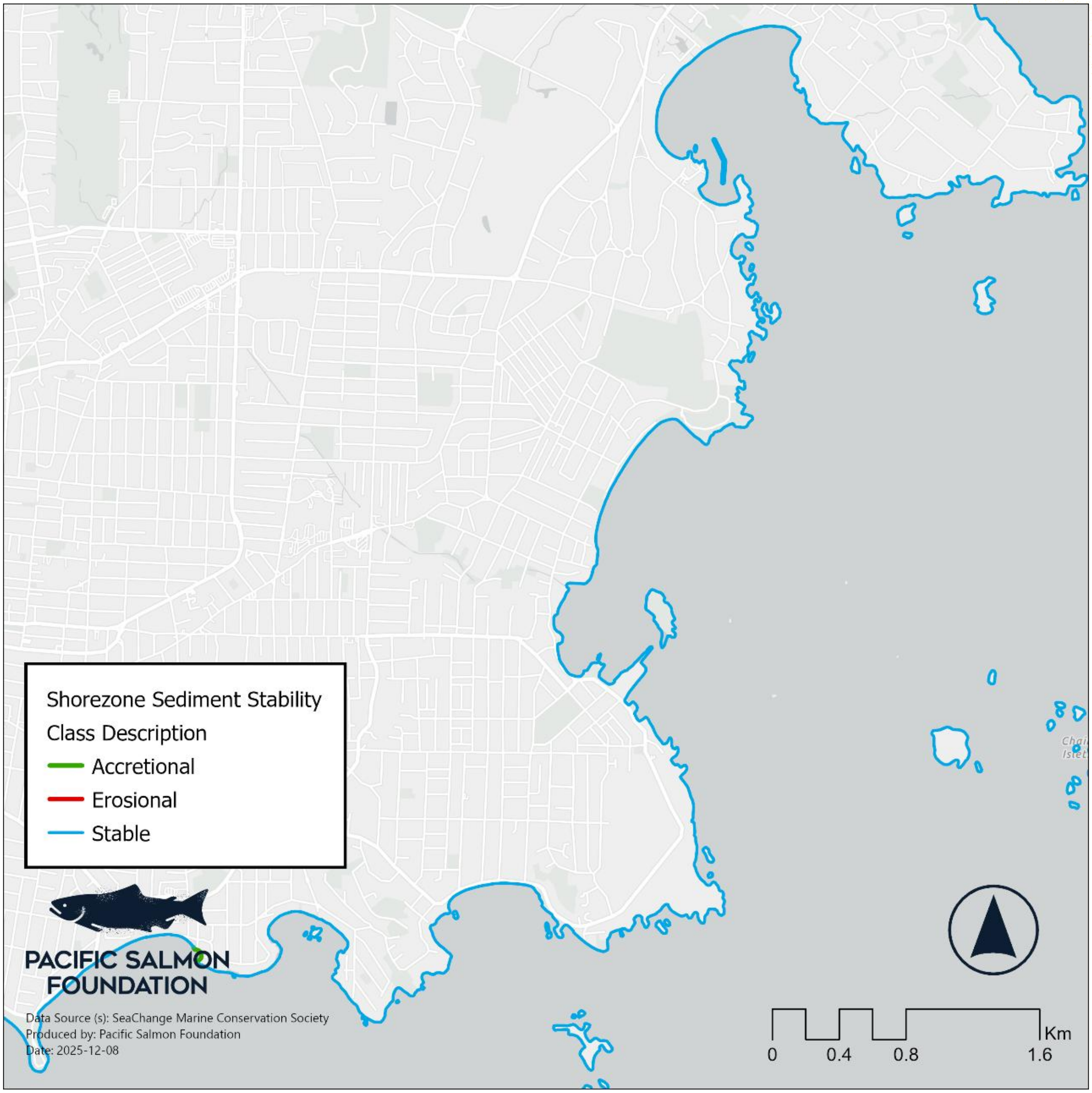

Figure 16 - ShoreZone sediment stability class descriptions for Oak Bay, showing that most of the shoreline is considered stable (Coastal and Ocean Resources, 2017.

Forage Fish Habitat

The model (Huard et al., 2022) does not cover the entire Oak Bay shoreline (54.9% of the shoreline was outside of the model's scope). Approximately 29% (4.3 km) of the shoreline has modelled results for PSL habitat suitability with higher certainty values, whereas the remaining 16.1% (2.4km) of shoreline has modeled results, but with less certainty (i.e. within model uncertainty). The results presented below include values that are all modelled results (i.e., both outside and within model uncertainty).

Oak Bay has a significant amount of predicted suitable spawning habitat for Pacific sand lance, with 31.6% (4.7 km) of the shoreline estimated to be likely and 6.6% (1 km) highly likely to support the species. Unfortunately, about 73% (4,100 m) of that likely and highly likely habitat also contained shoreline modifications (e.g., seawalls, rip rap and marinas), with the majority of those beaches having a high likelihood of being suitable (63%, 3,541 m). That is over 4.1 km of potential forage fish habitat that could be lost if those sediments are eroded or will erode (Figure 17, Table 4).

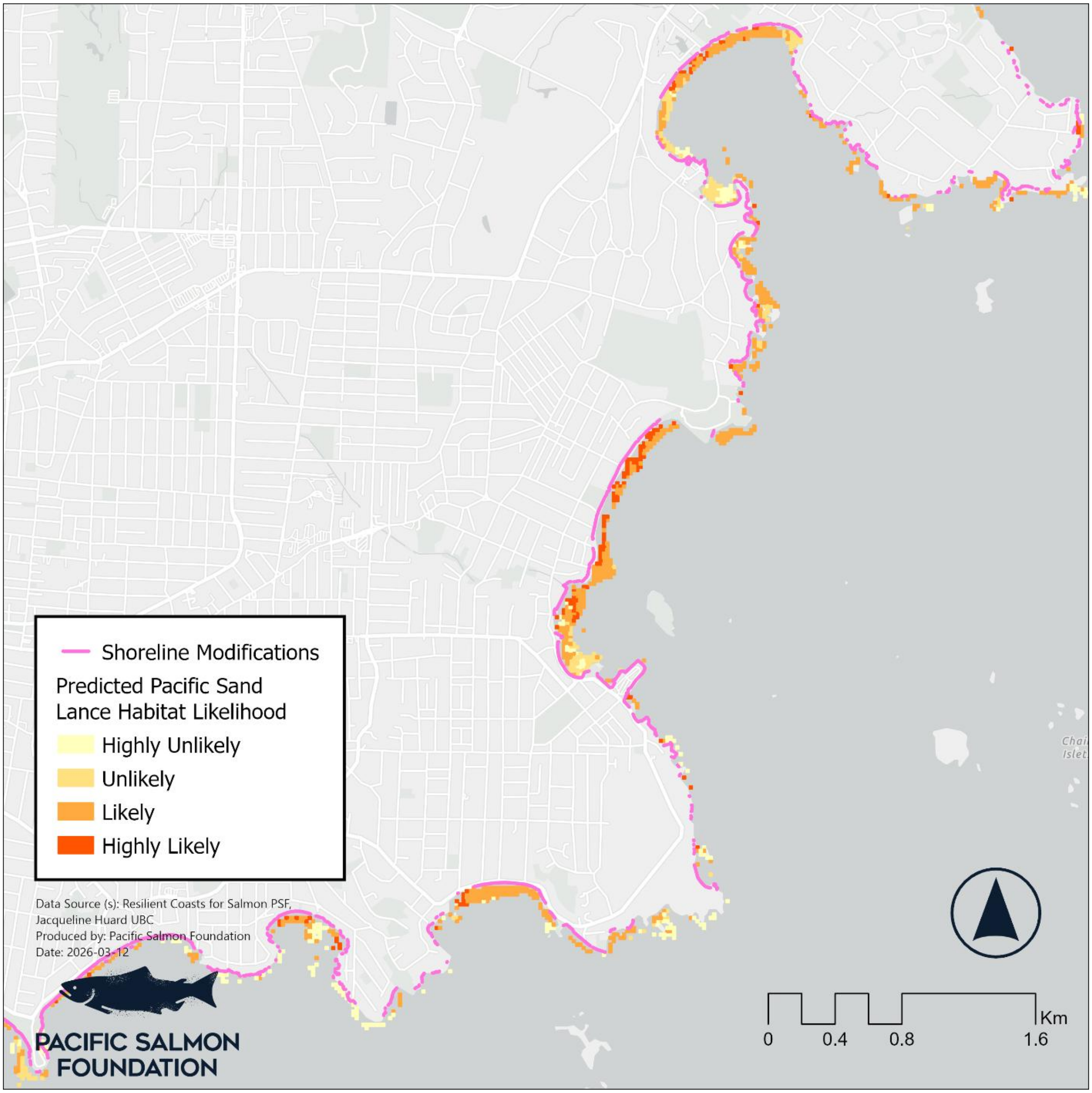

Figure 17 - The results of a predictive model (Huard et al., 2022) showing the likelihood of Pacific sand lance habitat, overlaid with the extent of coastal modification within Oak Bay.

Table 3 - Values of shoreline proportion and length by likelihood of Pacific sand lance habitat (Huard et al., 2022).

Likelihood	Proportion of total shoreline (%)	Length of total shoreline (natural and modified combined) (m)	Length of modified shoreline (m)	Length of natural shoreline (m)
Very highly likely modelled Pacific sand lance habitat (>93%)	0	0	0	0
Highly likely = high likelihood modelled Pacific sand lance habitat (89 – 93%)	31.37	4620.81	3541.24	1079.57
Likely = moderate likelihood modelled Pacific sand lance habitat (71 – 89%)	6.65	979.70	559.70	420.01
Unlikely = low likelihood modelled Pacific sand lance habitat (42.1 – 70%)	5.11	752.93	601.98	150.96
Highly unlikely = very low likelihood modelled Pacific sand lance habitat (0 – 42%)	4.55	670.71	231.62	439.10

Groups like Peninsula Streams and their dedicated volunteers have been monitoring Oak Bay beaches for forage fish eggs since 2014. While there were surf smelt eggs found in Oak Bay in the 2022-2023 sampling season, they were found on unmodified (natural) beaches (Peninsula Streams and Shorelines, 2023). In fact, there are no structures within 25 m of any location where forage fish eggs have been detected in Oak Bay.

Overwater Structures

Overall, the extent of overwater structures in Oak Bay is minimal, with seven residential docks and two large marinas. However, these marinas have the capacity to serve approximately 600 boats at any given time. A variety of modification forms serve the marinas, including boat ramp/launch, parking lots/fill, rip rap, groynes, and nearshore breakwaters. Both of these marinas are located within 100 m of predicted Pacific sand lance habitat, and therefore could have impacts on the quality of those habitats (Figure 18).

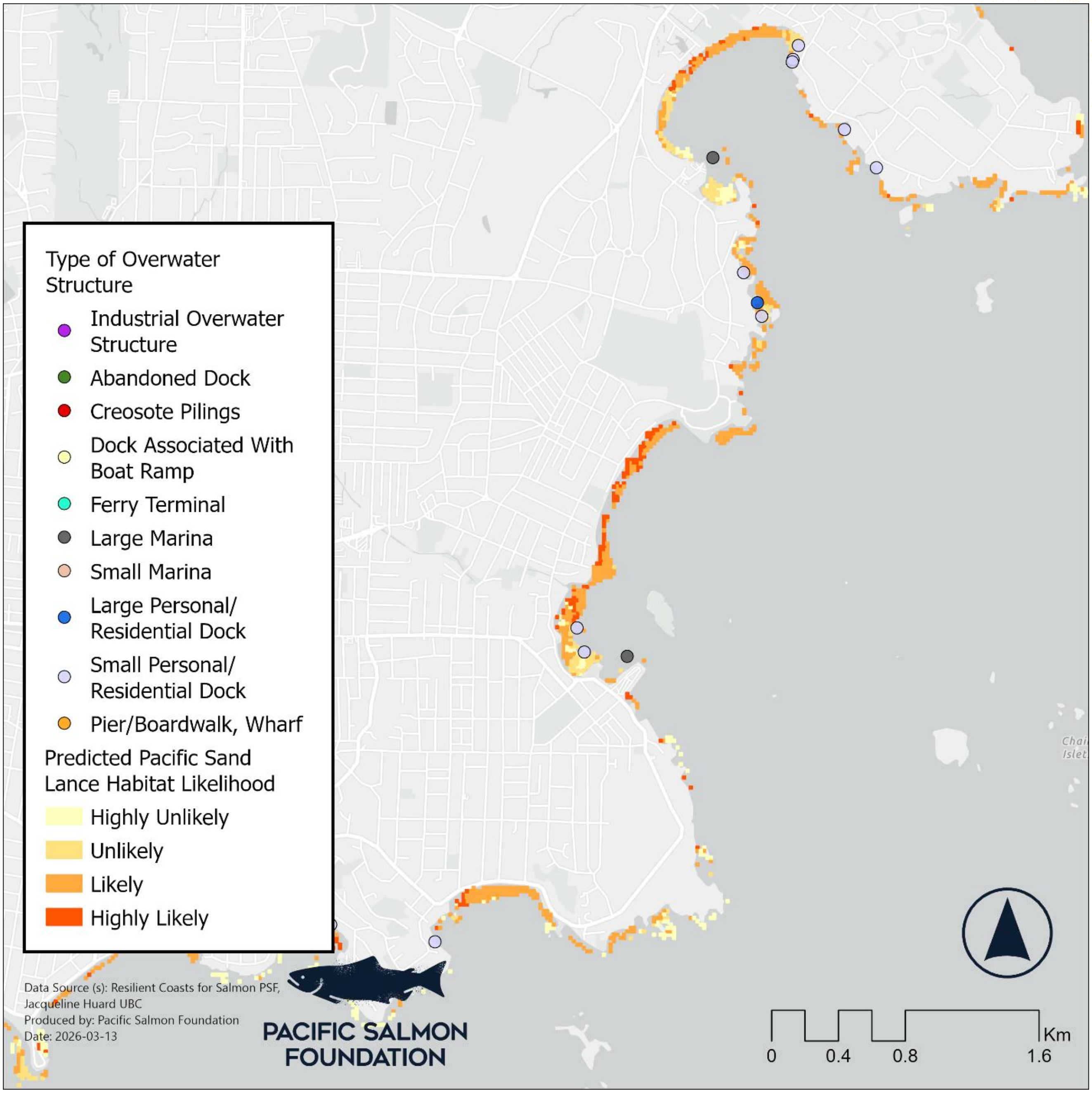

Figure 18 - The extent of overwater structures within Oak Bay, overlaid with the predicted habitat for Pacific sand lance (Huard et al., 2022).

Materials

The dominant materials noted for overwater structures in Oak Bay was wood (89%), while the remaining (11%) was noted as mixed material. It should be noted that overwater structures often are made of multiple materials including synthetic materials used as pilings, railings, or to help the structures float, although the recorders noted the dominant material.

The dominant kind of pilings were also noted, although often there are multiple types (materials) of pilings used in one structure. For most of the structures (five out of nine, or 56%) the material of the pilings was unknown. For the remaining overwater structures, three had creosote/treated wood pilings, and one had concrete pilings.

Abandoned Docks and Other Marine Debris

There were no abandoned docks found in Oak Bay, though anecdotal evidence suggests numerous sunken or derelict vessels in the region.

Creosote-treated Pilings

No creosote pilings were detected within 25 m of modelled PSL habitat.

Log Accumulation

Of the total shoreline, 6.6% (977 m) was found to have an extreme (>89%) accumulation of logs, with another 10% (1472 m) with high accumulations (50 to 89% coverage), and 10.8% (1584 m) having moderate levels (20% to 49%) of the beach covered by logs (Table 4, Figure 19). It should be noted that the moderate log accumulation category also represents a significant coverage of logs – whereby 20-49% log coverage on a given beach could negatively impact shoreline habitat.

Table 4 - The length of shoreline (in percentage and metres) by category of log accumulation.

Log Accumulation	Percentage of Shoreline	Metres
Extreme (>89%)	6.6	977
High (50 to 89%)	10	1472
Moderate (20 to 49%)	10.8	1584
Low/None (<20%)	62.2	9157
Unknown	10.4	1541

Figure 19 - The extent of log accumulation on the beaches of Oak Bay.

Log Mobility

The logs accumulated on beaches were often mobile, defined as being susceptible to shifting on top of the sand with the tide and waves. In fact, approximately 52.8% of the shoreline segments contained only mobile logs, and 24.6% had both mobile and anchored wood. Only a small portion (0.1%) of the shoreline contained only anchored logs, while the remaining 22.5% of the shoreline is unknown where the log accumulation could not be digitized due to a lack of available boat-based imagery (Figure 20). To see the overlap of log accumulation and overwater structures in Oak Bay, see Figure B4 in Appendix B.

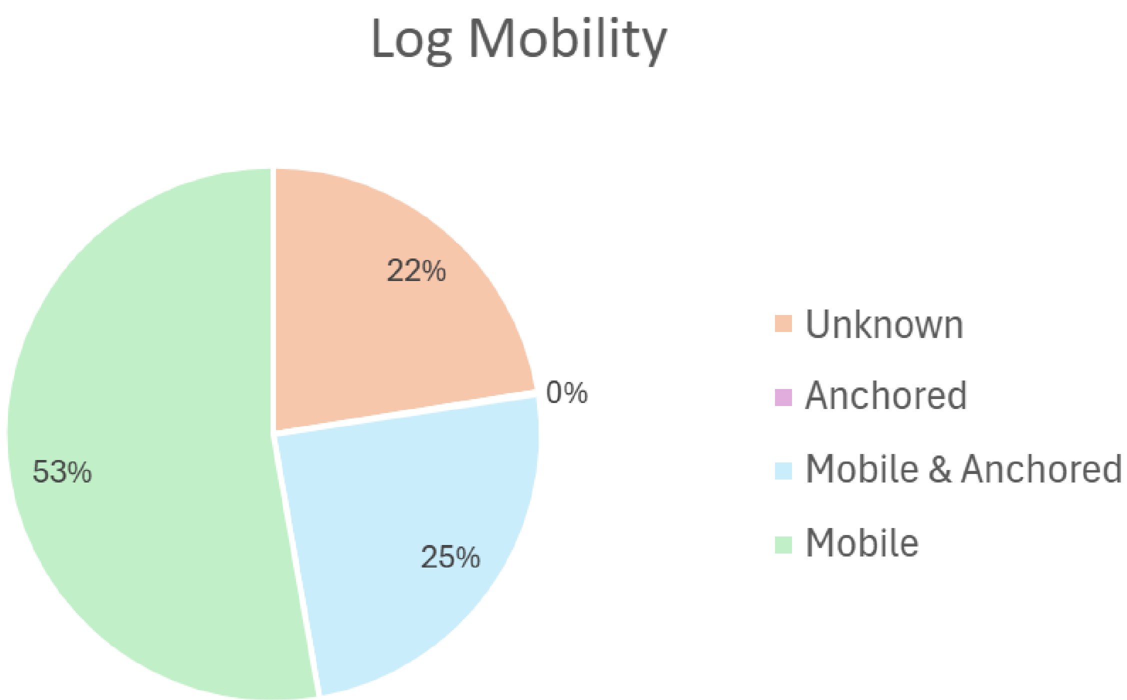

Figure 20 - The proportion of logs on beaches by their level of mobility (from mobile to anchored).

Creosote-treated Logs

Creosote logs were observed within 48 shoreline segments, which means there were at least 48 individual creosote logs noted on the beaches of Oak Bay.

Log Accumulation and Forage Fish Habitat

Of particular concern is the overlap of log accumulations with forage fish spawning habitat. This occurred on 18.6% (2,740 m) of Oak Bay's shoreline, where a moderate to extreme accumulation of logs coincides with a high likelihood of PSL spawning habitat. If we include both likely PSL habitat, this number grows to 20.4% (3,012 m). Of this, 61.8% (1,860 m) is also modified with structures including sea walls (Table 5). This was most pronounced on the north end of Willow's Beach, where there were significant sections of high and extreme log accumulation (Figures 21). Much of this area of shoreline was also modified with seawalls (Figure 17). By referencing Figure 3, you can see that the Willow's Beach area is made up of sand flat, sand beach, rock with sand beach, rock, sand and gravel beach, and rock cliffs.

Table 5 - Length of shoreline characterized by moderate to extreme log accumulation and likelihood of Pacific sand lance habitat (Huard et al., 2022).

Log Accumulation	Length which is likely to be PSL habitat (m)	Length which is highly likely to be PSL habitat (m)	Length which is likely or highly likely to be PSL habitat AND is modified (m)
Moderate (20 to 49%)	222	1,076	893
High (50 to 89%)	50	978	614
Extreme (>89%)	0	686	353
Total (Moderate to Extreme Log Accumulation)	272	2,740	1,860

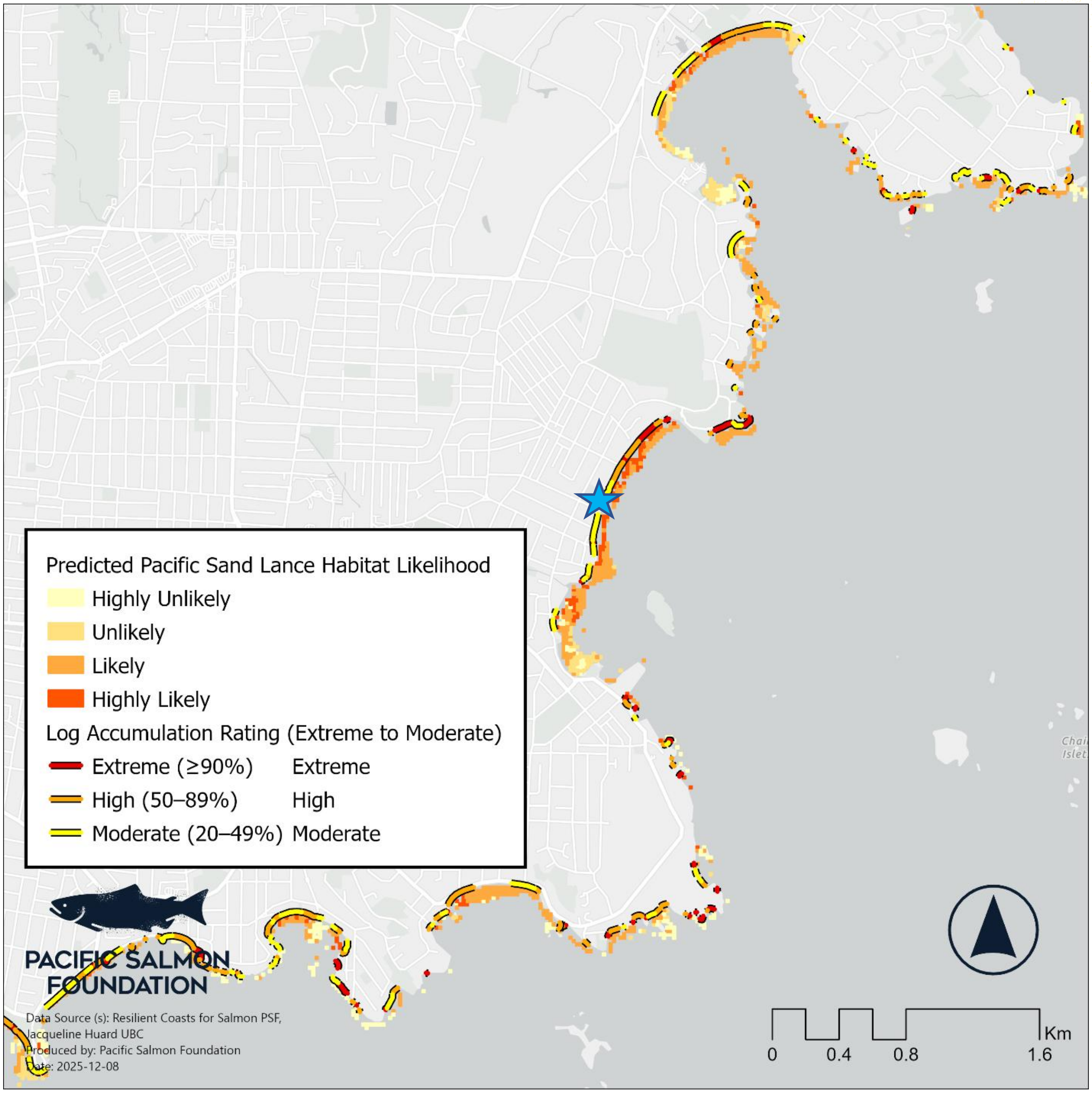

Figure 18 - The extent of log accumulation on the beaches of Oak Bay, overlaid with the modeled likelihood of Pacific sand lance habitat (Huard et al., 2022). The blue start indicates Willows Beach.

See Figure B5 in Appendix B to see the full log accumulation dataset (including low accumulation) overlaid with the modelled habitat for PSL, and Figure B6 to see just the modeled likelihood of PSL spawning habitat.

Luckily, there were no occurrences where extreme log accumulation was within 25 m of surveyed areas where forage fish embryos had been detected by the Coastal Forage Fish Network. Cadboro Bay is one area which was largely modelled to be likely and highly likely PSL spawning habitat (Figure 21). In this area, there were positive detections of surf smelt in recent years (Figure 22). Unfortunately, Cadboro Bay is largely made up of moderate and high accumulations of logs (Figure 22).

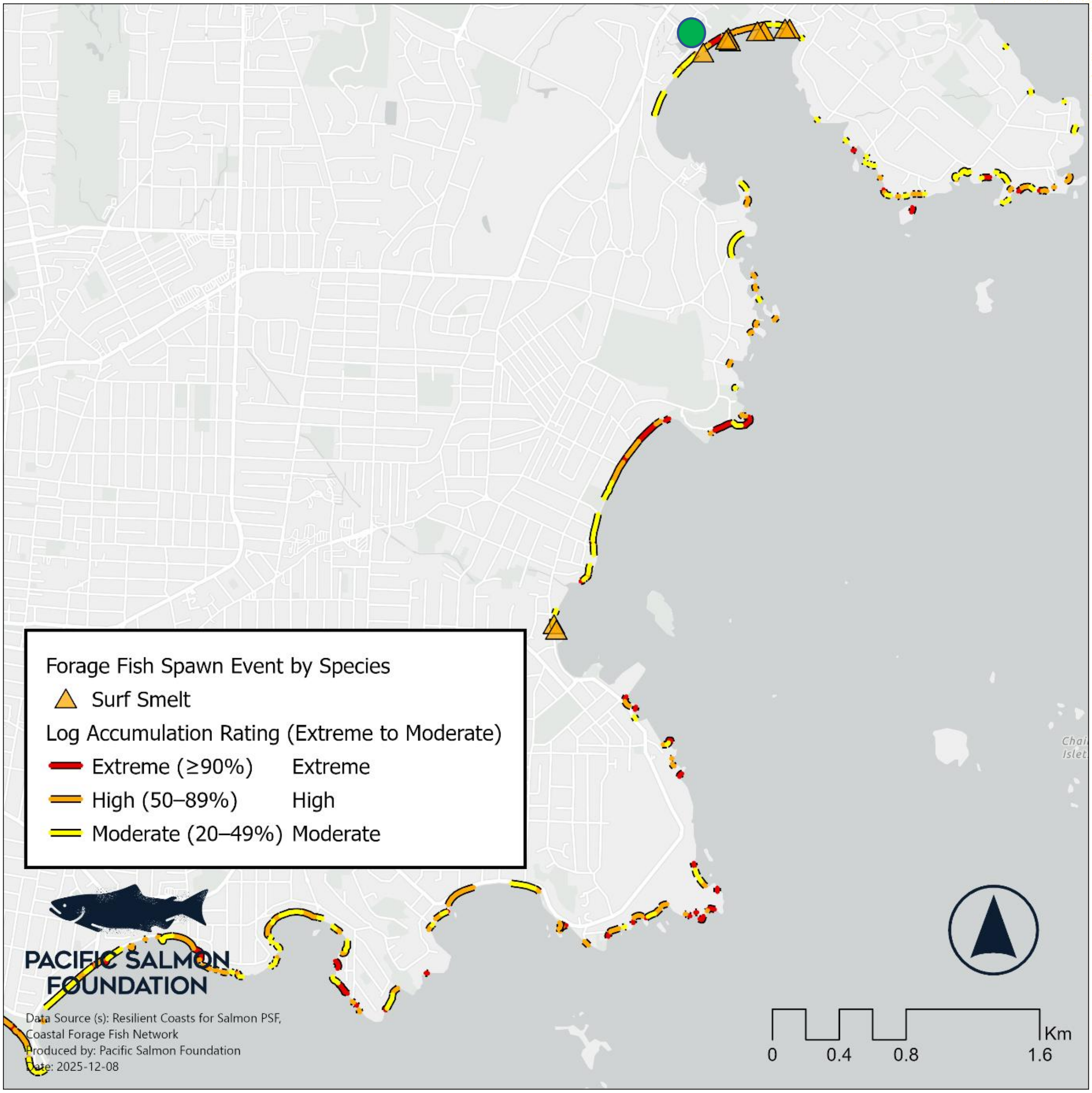

Figure 19 - The extent of moderate, high and extreme log accumulation within Oak Bay, overlaid with CFFN (2019) survey results, showing multiple positive detections of surf smelt spawn. The green circle indicates Cadboro Bay.

Log Accumulation and Wave Exposure

Areas with high wave exposure and an accumulation of logs could be at risk of further erosion – particularly on sediment shorelines. For the areas of high and extreme log accumulation, 577.7 m of shoreline was also semi-exposed to wave action, which could indicate susceptibility to erosion with incoming waves potentially battering logs against the shoreline (Table 5).

Table 6 - Length and percent of shoreline by wave exposure rating where there was also a high or extreme amount of accumulated logs.

Wave Exposure Rating	Length of Shoreline with High or Extreme Log Accumulation (m)	Percent of Shoreline with High or Extreme Log Accumulation (%)
Very Protected	0	0
Protected	30.7	0.2
Semi Protected	1594.2	10.8
Semi Exposed	577.7	3.9
Exposed	0	0
Very Exposed	0	0

Figure 20 - A screenshot of the shoreline imagery from Mapillary.com, showing an area of extreme log accumulation in Oak Bay (Willow's Beach).

See Figure B7 in Appendix B for a look at the extent of log accumulation overlaid with the ShoreZone shore types of Oak Bay.

DISCUSSION/KEY TAKEAWAYS

Coastal Modification

This survey represents a snapshot in time, as the imagery for this area was collected in 2022, with some ground truthing in 2022 and early 2023. During this time, it was found that just over 50% of Oak Bay's shorelines were modified with structures, with the majority being seawalls. Our estimates of the extent of shoreline modifications are conservative, as our methodology captures modifications that currently have the ability to impact natural coastal processes and not modifications that will in the near future. For example, roads situated along the ocean, will at some point be impacted by storm surges and sea level rise, and can be identified by a lack of or minimal vegetation at the higher high-water mark, and how far up drift logs and beach wrack get during intense storms, especially when they coincide with king tides. Additionally, this value will inevitably change over time: new developments could increase the number of structures present on the shoreline, existing structures may be removed and replaced with nature-based solutions, and some may remain in place, but their interaction with the sea will change. And, unfortunately, nearly all the modifications found in Oak Bay were built along areas of high and very high sensitivity to sea level rise.

Semi-exposed shorelines, including those around McNeill Bay and southern Oak Bay, can likely expect to receive the largest relative waves within Oak Bay. Extremely large waves may occur during storms in these areas. In protected regions, like Cadboro Bay and Oak Bay (between Bowker Creek south to Currie Rd), the maximum wave fetch is less than 10 km; these areas are usually where you would find provisional anchorages and low wave exposure except in extreme winds. Since about 19% of the modified shorelines were also semi-exposed to waves and had high or very high sensitivity to sea level rise, nature-based approaches to shoreline management may be more challenging in these areas. However, there may be options for hybrid approaches (i.e., a design that includes elements of nature-based approaches, as well as some hard features), similar to the Songhees Walkway Pocket Beach which contain both soft and hard features due to site conditions. For the majority (80%) of the modified shorelines, however, conditions may be more suitable (e.g., lower wave exposure) for soft approaches that still protect coastal infrastructure. These are coarse findings however, and the best approaches for specific sites should be determined by professional assessment. Along those lines, it's important to note that protected and semi-protected areas are not immune to the impacts of climate change - particularly when sensitivity to sea level rise is rated as high or very high, in low-lying areas, and where the toe elevation of hard structures are low in the intertidal. Once more robust models of sensitivity to sea level rise become available, it would be beneficial to examine areas of overlap with the following: moderate, high, and very high sensitivity to sea level rise, areas that are subject to wave exposure with classifications of semi- exposed, exposed, and very exposed. This can provide a glimpse of what areas are or will likely experience the greatest coastal climate change impacts, helping to identify areas to prioritize adaptation strategies. These areas are likely the most susceptible to impacts of intense storm energy, erosion, and coastal squeeze, especially when sediment type and coastal processes data is included. It would also be beneficial to examine areas that are very protected from waves and very low sensitivity to sea level rise, which may or may not be areas that are less at risk of impacts. However, local knowledge offers the most accurate insights into current conditions, often supplemented by historical data on changes in the area over time. Combined with professional assessments, this information can help inform projections of future site conditions and guide the development of the most effective strategies to lessen these impacts.

With the majority of the modifications being found on shores made up of unconsolidated sediment, rather than consolidated rock, like rocky outcrops/platforms, there is more potential for erosion and changes to the shoreline, due to greater ease of material being carried away by waves. Therefore, erosion that causes a change to the shoreline will occur much more slowly on a rocky shoreline compared to one with loose sediment. However, regardless of sediment type, hard structures built on top of intertidal areas will impact habitat. For example, rocky outcrops provide nesting habitat for bird species, and bio-banding seen on rocky shorelines indicate the presence of living organisms, whereby the availability of habitat and species present depend on factors like duration of being covered by the tide – but this can be altered when structures are built on top of them. Unfortunately, structures and added fill were identified in some areas that extend beyond the natural boundary, including overwater structures and boat houses low in the intertidal zone, with some interrupting natural coastal processes.

It would be beneficial to overlay the CRD's detailed coastal floodplain modelled data with the Resilient Coasts data layers to more clearly identify which stretches of shoreline are expected to become coastal floodplain areas in the near and distant future. This would support thoughtful adaptation in those areas and help identify where future development should be avoided. Although the sea level rise risk data presented here is coarse, it indicates that the vast majority of the modified shorelines in Oak Bay were rated as highly and very highly sensitive to sea level rise. These shorelines are at risk of losing intertidal and shoreline habitat due to the projected higher sea levels squeezing them out.

It is important to note that, in some cases, seawalls may be necessary, such as in situations where managed retreat is not feasible and the modeled risk to climate change impacts are high. However, regardless of the predicted risk at a site, it is important that we plan for sea level rise when building new structures, building further from the shoreline boundary to allow space for sea levels to rise and the shoreline, and habitat, to adapt. If a wall cannot be removed, consulting professionals is recommended to identify ways to minimize its impact on both the site and adjacent shoreline. The intent of this report is not to shame or denigrate property owners who have built shoreline armouring, but to raise awareness of the impacts that these structures can have on coastal habitats, and how we can use nature-based and hybrid designs to protect coastal infrastructure as well as provide habitat for coastal species.

Log Accumulation & Forage Fish

The coincidence of coastal modification and log accumulation on beaches could result in even greater erosional stress, with the incoming waves pushing mobile logs up against structures like seawalls. All of Oak Bay's shorelines are considered to be naturally stable (not eroding or accreting), however, over time, coastal modification features and log accumulation can contribute to the erosional forces acting upon those soft sediment shores. In areas where there are modifications that sit low on the shoreline, mobile logs may be less likely to become embedded in the sediment, and they could bounce off the seawalls during storm events, leading to increased erosion of the sediment.

McNeill Bay and Oak Bay (Willow's Beach) are two areas within the community predicted to provide the most suitable habitat for Pacific sand lance. For the most part, log accumulation in Oak Bay is not a prevalent issue. However, the areas of high and extreme log accumulation do overlap with those two bays that are likely to be suitable habitat for Pacific sand lance.

Willow's Beach is an area of concern because of the potential of the mobile logs to impact the suitability of the habitat for forage fish. Although the areas of Willow's Beach are considered to be stable in terms of sediment stability (not eroding nor accreting), and semi-protected in terms of wave exposure, this beach could be at risk of sediment loss due to log-driven erosion and increasing intensity of storms. This means that over 2.7 km of Oak Bay's shoreline provides incredible habitat for Pacific sand lance, but if sand lance are using these beaches as spawning grounds, the eggs are at risk of being crushed by mobile logs at each high tide, and during storms. These areas should be prioritized for log removal/salvage.

Cadboro Bay is another area worth closer investigation due to the convergence of log accumulation, positive detections of forage fish, and likely modelled PSL habitat. Although this area is semi-protected and protected from incoming waves, log salvage could be helpful in reducing the risk of smothering the habitat.

Fortunately, Oak Bay was found to have a high proportion (38%) of shoreline that is likely or highly likely to support Pacific sand lance, but factors like coastal modification and log accumulation can threaten that habitat. This figure is significant, considering that only 5.4% of all intertidal zones in the Salish Sea are estimated to be likely or highly likely to support these species (Huard et al., 2022). These shorelines could be considered for nature-based approaches to shoreline restoration to protect these beaches where forage fish are likely to spawn.

Overwater Structures

Although the overwater structures in Oak Bay were minimal, they can impact Pacific salmon, forage fish, and other marine life, and the habitats they rely on. Eelgrass habitat, a critical nursery area for juvenile salmon and crab species, requires light to grow, while overwater structures threaten their ability to survive if they are shaded out. Additionally, boat anchoring can scour and damage eelgrass, resulting in a reduction in density and extent of this important habitat, leaving it fragmented. Anchoring also suspends sediment in the water column that can smother eelgrass by reducing its ability to grow and thrive. Effluent, gas, and oil from marine traffic and vessel storage associated with marinas are yet another threat to marine life.

On several occasions after storms, boats were displaced or had sunk in Cadboro Bay and near the Oak Bay Marina, as reported by local news, and observed in person by Resilient Coasts data recorders. Abandoned and derelict vessels can negatively impact the marine environment when they leak fluids like oil and gasoline, and when washed up on shore, they can cause erosion and smothering of habitat

– not to mention, they can be navigational hazards. See our recommendations section to learn about how we can reduce the impacts of the marinas and residential docks in Oak Bay.

RECOMMENDATIONS

As noted earlier, this report is intended for educational purposes only and aims to share basic information and context regarding shoreline modifications and how they overlap with basic climate models and other ecological data. While it may highlight areas of concern, it is not a comprehensive assessment or risk inventory. The content should not be used for detailed analysis or decision-making without formal, in-depth assessments from qualified environmental professionals and coastal geomorphologists, who can provide expert guidance tailored at a localized scale. With this in mind, the following are some recommendations.

Suggested Management Actions

We strongly advocate that the District of Oak Bay (DOB) prioritize what is desired by local First Nations' government and communities and allow these requests to guide next steps, including amendments to already established plans made by the DOB. Ask local First Nations' government what their capacity to engage is, what they require, and create space and time for this process. Follow engagement protocols chosen by each Nation, establish cultural safety, provide financial compensation for engagement as set by each Nation, set up agreements and/or memorandums of understanding if requested, and begin the process of educating oneself about historical and present day colonialism on Southern Vancouver Island and beyond. The following recommended management strategies are not meant to negate the positive work that the local government has done or is currently working towards. We appreciate that many local governments have taken significant steps in working respectfully with First Nations towards effective coastal adaptation, and it should be noted that we did not conduct a detailed review of the actions that the DOB already has in place. Please consider this list of recommendations a starting point in working to build coastal resilience for people and habitat.

1. Collect and model comprehensive datasets for flood inundation and sea level rise modeling that include site investigations, coastal engineering analysis, alongside coastal geomorphologists and geologists. It is recommended to overlay these high resolution, in-depth localized modelling with the shoreline length, to visualize how much of the shoreline, and where, are most susceptible to coastal flood hazards. Furthermore, it would be beneficial to overlay these modeled results with the shoreline modification layer to ascertain the length of modified shoreline that runs parallel to these areas that are projected floodplain areas. This information can help inform which areas are at greatest risk of losing intertidal and shoreline habitat due to the projected higher sea levels squeezing them out.

2. Collect additional data and submit to the Vital Signs data portal, including drift cells in functional condition, extent of forest cover in nearshore marine riparian areas, feeder bluffs in functional condition, areas of sediment accretion and erosion, and miles of intertidal beach in functional condition.

3. Official Community Plans (OCP) can help guide decision making at a local level by addressing the following:
   - Introduce stricter coastal development policies for Oak Bay with the Shoreline Development Permit Area (DPA), to protect the integrity of the shoreline, further manage or limit coastal development, and protect existing development from the impacts of coastal climate change. This includes strengthening what constitutes an exemption and ensures compliance.
   - Expand the Shoreline Management plans in the OCP, with financially compensated consultation with local First Nations, to strengthen erosion monitoring (which can include indicators chosen by the Nations), to move towards a non-contingency fund to support the longevity of shoreline health, and towards planning for continued, foreseeable changes on shorelines.
   - Incorporate strong sensitivity to sea level rise models into community adaptation plans; consulting models before any development permits are accepted. Since the vast majority of the modified shorelines in Oak Bay were rated as highly and very highly sensitive to sea level rise, it is highly recommended that any work to remove modifications such as sea walls be guided by qualified coastal professionals.
   - Hire coastal geomorphologists, coastal engineers, and biologists to provide expert consultation to review and provide expert guidance for approvals for shoreline development permits and design plans. Ensure that individuals responsible for issuing permit approvals have readily available access to these experts. Ensure that all Qualified Environmental Professionals (QEP) and Registered Landscape Architects hired under the DPA to supervise or provide recommendations for development plans, are: highly knowledgeable about natural coastal processes and hydrology, and include the following in their process: site specific coastal processes modelling, historical change assessments including historical knowledge, observed and future erosion potential, recommending setbacks to accommodate erosion when possible, assessments to drastically reduce project footprint and potential habitat degradation, requiring landowners to monitor the project into the future (designed by experts), and following up with monitoring requirements.

   - Strengthen the OCP to minimize further hard armouring and shoreline development
     - Create bylaws and policies whereby seawalls/bulkheads are a last resort. Some communities have done so by requiring that it be proven that hard armouring is the only viable option before proceeding with building a new structure or replacing/repairing an existing structure.
     - Require strict ecological assessments to prevent loss of habitat, including shellfish habitat that can become buried.
     - Recommend stricter conditions for development permits that address bank instability and the identification of areas that cannot be developed except what is permitted in the conditions (Hewson et al., 2023).

  - Introduce laws for larger setbacks. Prohibit new builds along the coastline within a specific setback so that parks and natural areas have the ability to adjust with rising sea levels. Require adequate consultation with professionals like coastal geomorphologists.
  - Remove unnecessary armouring on public lands, such as parks, with proper assessment by coastal professionals.
  - Taking a precautionary approach to potential habitat degradation and habitat disruptions.
  - Refer to other jurisdictions that have included Green Shores measures in their Official Community Plans (e.g., District of Central Saanich).
- In addition to protecting environmentally sensitive areas with high ecological value, prioritize the protection of:
  - places that First Nations' communities express interest in protecting,
  - existing natural shorelines,
  - stretches of shoreline with intact marine riparian vegetation,
  - beaches with favorable forage fish spawning sediment beaches (identify with expert guidance**),
  - beaches where forage fish spawning has or is occurring,
  - and areas that have maintained their natural hydrological functions.

**We encourage that marine and terrestrial conservation planning be guided and informed by the model developed by Huard et al. (2022) and other relevant research and forage fish monitoring data.

- Focus on bio-cultural indicators of well-being as expressed by First Nations' community members, First Nations' governments, and general community members. This may include physical, mental and spiritual health, ability to access safe foods, ability to practice traditions and ways of life that support holistic well-being, and much more. This can help guide restoration priorities and areas that require protection from future degradation and development.
- Protect and restore connectivity between the upland and shoreline where possible; and support soft shore approaches (nature-based approaches) for climate change impacts such as erosion, as well as critical habitat. If redevelopment in coastal areas occurs, include restoration requirements on the foreshore that protect natural coastal processes and habitat.
- Reduce runoff into the marine environment by replacing stormwater pipes that cross sewage pipes and incorporating rain gardens in areas that have high levels of impervious surfaces.
- Introduce stricter policies to greatly restrict or prohibit tree removal and other riparian vegetation within a specific setback distance along the shoreline.

4. Incorporate coastal natural assets into the Oak Bay Asset Management Program

- Encourage sustainability efforts and investment into natural resources and environments by incorporating them into a management program.

- Create an inventory of existing natural assets.
    - Initiate condition assessments and ratings of natural assets that can inform the municipality on the ecological health of natural resources and influence decision-making for coastal development, restoration, and more. Include human well-being as indicated above (#3).

5. Develop a strategy to reduce habitat fragmentation by boat moorings. Traditional moorings, which consist of heavy chains and anchors, drag and scour the seafloor as the tide ebbs and flows. Anchoring can scour and damage eelgrass, resulting in a reduction in the density and extent of eelgrass and creating fragmented habitat. It also suspends sediment in the water column that can smother eelgrass, reducing its ability to thrive and receive light.
   - Damage to eelgrass can be avoided by anchoring in depths beyond 7m.
   - Environmentally- friendly moorings contain a mid-line float that holds a rope above the seafloor – it will not scour or damage eelgrass. See here for more information.
   - Explore opportunities to install Voluntary No Anchor Buoys in your community.

6. Reduce impacts of overwater structures:
   - Pursue and/support marinas that want to pursue eco-certification through the Strait of Georgia Alliance's Clean Marine BC program.
   - Encourage the building of salmon-friendly docks when docks are necessary, and the sharing of docks amongst neighbours when possible.

7. Create and/or promote climate action incentives for community members to:
   - reduce erosion on properties by incentivizing the installation of proper drainage by professionals
   - plant marine riparian vegetation with emphasis on native species
   - utilize nature-based soft shore restoration instead of hard armouring
   - restore riparian vegetation in locations where seawalls are necessary
   - consider managed retreat where possible
   - remove seawalls when the site and conditions are appropriate as deemed by qualified professionals
   - apply nature-based solutions around the home, including reducing impermeable paving (there are incentives through the City of Victoria), discouraging the use of pesticides and fertilizers, encouraging the use of less harmful cleaning supplies or by making them, manage stormwater runoff and incorporate raingardens to help filter pollutants before it can enter waterways, and encouraging rainwater harvesting and not watering lawns during the summer months.

8. Provide ongoing environmental training by professionals (local climate change specialists, biologists, coastal geomorphologists, coastal engineers) for Oak Bay and CRD staff

- Provide training opportunities for local planners and other staff to understand current climate change risks and impacts, and restoration strategies that utilize a nature-based approach. The Green Shores® training program is a great place to start.

9. Reduce log accumulation on beaches through log salvage. Log salvaging can be a great way to remove unwanted logs from a beach and protect forage fish habitat. Anyone looking to salvage logs from the shore must obtain a valid provincial permit. Western Log Sort and Salvage (wlssc.ca) is a licensed buyer of marine salvage logs in the Vancouver/Vancouver Island region – helping drift logs return to the market, helping to reduce the impacts to marine vessels and the environment. Learn more at Marine Log Salvage - Province of British Columbia (gov.bc.ca).

10. Address, control and rectify contaminants and pollution within Oak Bay and surrounding areas, including sanitary waste control, akin to the Comprehensive Harbour Strategy, to work towards safe access to traditional foods and a healthy ecosystem.

Climate Change Adaptation and Nature-Based Solutions in the Capital Regional District was created to showcase what steps the CRD is taking for coastal adaptation, and what practical tips local governments can take to address climate change now.

RESOURCES

Funding Opportunities for Nature-based Approaches

Looking for funding to support a restoration or adaptation project? There are federal, provincial, private and non-profit organization funds available. Here are some examples.

For First Nations

Funding from the Federal and Provincial Government

- The Government of Canada:
  Federal funding opportunities change every few years, but you can start at this landing page for environmental funding to see what is currently available.

  https://www.canada.ca/en/environment-climate-change/services/climate-change/indigenous-partnership/funding.html

  - In March of 2026, the Government of Canada announced $3.8 billion of new funding through the strategy: A Force of Nature, where there will be three streams of funding available. Watch this space for more information from the Federal Government about eligibility and how to apply for the funds. Click here to read the statement regarding this funding announcement from PSF President & CEO, Mike Meneer.
  - As of April 2026, funding applications have closed for the Indigenous Habitat Participation Program, however futures opportunities to apply for funding and capacity support will be updated on the linked page.
  - Additional funding may be available through Indigenous Services Canada – there are often many streams of funding available, with climate adaptation funding usually being listed under the Health and Infrastructure headings. The ISC's Capital Facilities and Maintenance Program, for example, offers funding to support infrastructure for First Nations on reserve properties. In terms of climate-related updates, this funding can be applied for things like roads and bridges, community energy systems, water and waste-water, and more.
  - The Indigenous Partnerships for Species at Risk (IPSAR) may also be an opportunity for funding related to species at risk and their habitats. For general questions, enquiries, and news about the IPSAR, including funding opportunities, please email PAEP-IPSAR@ec.gc.ca
  - For grant funding through Fisheries and Oceans Canada (DFO), visit their funding page for current offerings. Indigenous groups seeking funding between 2019 and 2025 can contact DFO.AHRF-FRHA.MPO@dfo-mpo.gc.ca.
  - Environment and Natural Resources funding includes current funding like the Coastal Restoration Fund and the Indigenous Habitat Participation Program. Check back often to determine which funding is currently active and best suits your needs.
  - Natural Resources Canada offers various funding programs for Indigenous communities and individuals – these funding opportunities may include support for local Indigenous-

led community development and natural resources projects that support the transition to clean energy.

Funding from the Non-Profit Sector

- First Nations Emergency Services Society (FNESS)
  - FNESS is a nonprofit society that supports BC First Nations in climate adaptation. FNESS connects communities with resources, research and funding to support their specific needs related to climate adaptation and emergency preparedness and response.
- Community Salmon Program (Pacific Salmon Foundation)
  - Provides grants to streamkeepers, First Nations, schools, and conservation organizations — People for Salmon across the province — to save and restore Pacific salmon and their habitats. This includes emergency funding.
- Climate Emergency Fund (Pacific Salmon Foundation)
  - This fund is intended to support entities with qualified personnel and experience in salmonid habitat requirements, hydrology, and in-water construction techniques to undertake emergency actions which directly benefit salmon that are threatened by drought or other climate emergencies. For enquiries about the funding or to submit a proposal, please contact emergencyresponse@psf.ca.
- North American Partnership for Environmental Community Action (NAPECA): cec.org
  - The NAPECA grant program, a program of the Commission for Environmental Cooperation (CEC), is aimed at empowering Indigenous Peoples in climate adaptation.
  - Future grant programs may become available through the CEC; you can check back at any time through the Grants tab (http://www.cec.org/grant-programs/), or email napeca@cec.org.
- Habitat Conservation Trust Foundation (HCTF)
  - HCTF regularly offers grant funding for projects that benefit habitat and biodiversity in B.C. Visit https://hctf.ca/grants/ to learn about current offerings.
- SeaDoc Society
  - Funding through the SeaDoc Society is intended to support scientific research and conservation concerning environmental issues facing the Salish Sea. There was a round of funding offered in 2024, but it is unclear whether another call for proposals will occur in the future. (seadocsociety.org)
- Coast Funds
  - Coast Funds is a partnership of two organizations managing and delivering funds from private donors, the British Columbia Provincial Government and the Government of Canada. Each year, Coast Funds compiles a list of available funds for First Nations in the Great Bear Rainforest area and Haida Gwaii.

Funding from Industry

- BC Hydro Fish and Wildlife Compensation Program (FWCP)

    - The FWCP is a partnership between BC Hydro, the Province of B.C., Fisheries and Oceans Canada, First Nations, and public stakeholder to conserve and enhance fish and wildlife in watersheds impacted by existing BC Hydro dams. Projects are funded to compensate for impacts to fish, wildlife, and their supporting habitat resulting from the construction of existing BC Hydro dams. For more information contact FWCP's Environmental Project coordinator Melissa.FieldeSousa@bchydro.com or fwcp@bchydro.com.
- TD Friends of the Environment Foundation (FEF)
    - The TD FEF supports a wide range of environmental initiatives, with a primary funding focus on revitalization, animating, and stewarding public green spaces. Questions can be directed to the TD FEF Pacific and Prairies Regional Manager: Mandip.Kharod@td.com
- Wawanesa Climate Champions: Local Grants
    - New granting initiative to support organizations working on the front lines to improve climate resiliency in local communities across Canada. Questions can be directed to communityimpact@wawanesa.com

For Municipal Governments

- The Government of Canada –
    - Federal funding opportunities change every few years, but start at this landing page for environmental funding to see what is currently available.
    - In March of 2026, the Government of Canada announced $3.8 billion of new funding through the strategy: A Force of Nature, where there will be three streams of funding available. Watch this space for more information from the Federal Government about eligibility and how to apply for the funds. Click here to read the statement regarding this funding announcement from PSF President & CEO, Mike Meneer.
- The Union of BC Municipalities (UBCM)'s Local Government Program Services offers administration for Provincially-funded grant programs. Check out this link for active funding programs to take on large scale climate adaptation projects with nature-based solutions.
- Visit the Natural Resources Canada Green building programs landing page to find funding that supports green infrastructure. This can be applied to energy efficiency, reducing pollution, and getting infrastructure up to environmental and safety coding.
- You can browse the latest and upcoming funding programs from Environment and Climate Change Canada at this link. These funding programs are specifically targeted to support climate adaptation in communities, supporting species at risk, and addressing pollution.
- To apply for support related to infrastructure projects, Infrastructure Canada offers funding to help communities address natural disasters related to climate change and invest in green buildings.
- The Clean Coast Clean Waters (CCCW) was a provincial fund to help communities remove sunken or abandoned vessels. CCCW initiative funds are available for both local governments

and organizations – local governments and organizations who hope to clean up marine debris that might be impacting coastal ecosystems. While this funding opportunity is closed as of 2024, it may return in future years and is worth checking on.

For Homeowners

- Many nature-based solutions are low cost and may even help your household save money on monthly water and heating bills. The Resilient Coasts for Salmon Tool Kit provides advice that you can incorporate today.
- Incentives/Rebate Programs:
    - Check out Oak Bay's Grants Policy: Grant Policy Report.pdf (oakbay.ca). Funds could be used for shoreline cleanup projects, small-scale restoration and more.
    - The District of Oak Bay's Home Energy Navigator Program offers free guidance for homeowners throughout the process of retrofitting their home to be more energy efficient.
    - You can also apply for a Canada Greener Homes Loan through Natural Resources Canada to make energy-efficient updates to your home.

Links to Relevant Resources

- Visit resilientcoasts.ca to browse our educational resources and learn about all things related to coastal stewardship. Our website hosts videos about restoring a coastal slope and choosing native plants for your garden or restoration project, as well as a plethora of 'how to' articles in our Tool Kit.
- The Marine Ecosystem Map, from the Marine Data Centre, is a visualization platform of geospatial data with hundreds of layers from ecological to human use. You can also submit data to the portal for others to use – contact them here.
- Browse ShoreZone data to help inform community planning.
- The Climate Ready Infrastructure Service is a new free service offered by the Government of Canada to connect communities with climate experts to help inform and support projects related to addressing challenges associated with climate change.
- Work with local stewardship groups and environmental non-profits across the Island, such as Peninsula Streams and Shorelines, and Friends of Bowker Creek Society, to identify potential sites for restoration or bring awareness to these issues.
- Read the document: Rising Seas and Shifting Sands: Combining Natural and Grey Infrastructure to Protect Canada's Eastern and Western Coastal Communities – Intact Centre on Climate Adaptation (intactcentreclimateadaptation.ca) to learn more about how communities can use hybrid designs.
- To learn more about the Resilient Coasts for Salmon Green Shores for Shoreline Development demonstration sites, click here or visit them at Songhees Walkway and Esquimalt Gorge Park, just a few minutes' drive from Oak Bay.

- Check out the Stewardship Centre for British Columbia's Green Shores programs. The Green Shores for Shoreline Development Credits and Ratings Guide can be used as a framework for implementing nature-based solutions in commercial, multi-family residential, subdivision, park, and institutional waterfront development areas.
- Sign up for Green Shores training to learn about the program's guidelines and how nature-based solutions can provide shoreline benefits.
- Check out Northwest Straits Foundation's Shore Friendly program website for helpful articles and videos about shoreline restoration and coastal processes in the Salish Sea.

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RESILIENT COASTS FOR SALMON
GREEN SHORES
STEWARDSHIP CENTRE FOR BRITISH COLUMBIA

PACIFIC SALMON FOUNDATION

APPENDIX A – DATA LIMITATIONS & CONSIDERATIONS

This section highlights factors to keep in mind when interpreting the results produced by the Resilient Coasts for Salmon project.

General

- The length of a line feature, for shoreline modifications, does not correspond to the level of impact it may have on natural coastal processes.
- It is likely that a greater number of coastal modifications exist than what was digitized due to several reasons including:
  - many elements in the landscape can obscure views, including dense vegetation;
  - aerial imagery was less clear in some regions – digitization in some regions relied heavily on aerial imagery as its source;
  - many features were observed that will imminently interact with natural coastal processes as sea levels rise but are not included in the dataset as they do not currently interact with coastal processes;
  - the imagery sources used to digitize features vary, including the dates they were captured (dates are included for each feature within each dataset).
- The exact measurement and location of features that were digitized reflect the best of the recorders visual estimations and are not precise due to the complexity of using imagery to visualize real-world positions- the accuracy may vary by up to 3 metres for all data.
- All wall structures, whether built as shore protection or to delineate property lines or deter trespassers, are included as shoreline modifications when they meet the protocol criteria (i.e., if they could interact with natural coastal processes). All walls are classified under the attribute "seawalls/bulkheads," although the intention behind building them may differ.
- Shoreline Type options are limited - There are segments of shoreline that have been modified by restoration or restoration using a "hybrid" approach (i.e., using both "hard" and "soft" elements in their design). However, these features are not separated from "hard" shoreline protection in this protocol. For example, riprap can be a part of a hybrid approach to shoreline protection but is considered a coastal modification feature in this protocol. Recorders made notes in the Comments section when they were aware of such projects; however not all are known, nor would all hybrid restoration projects be visibly obvious.

Data Gaps

- Gaps exist in all three datasets where boat-based or aerial imagery was not available, image quality was poor, the area was excluded for privacy reasons, or for other reasons.

Shoreline length values

- To report on the level of modified shoreline in a specific region, the Freshwater Atlas Coastlines (FAC) line was used as a proxy for total shoreline length. While the FAC provides a line from which analyses can be run, it is imperfect, and often resulted in overestimations of total shoreline length, producing discrepancies toward more conservative estimates. Some ways this occurs include:
    - The polygons around each community analysed were created intentionally so that major nearby islets and islands not connected to Vancouver Island by road or bridge were excluded from the total shoreline length (FAC) to increase accuracy of analyses.
    - The FAC line diverges from the locations of digitized features, which skews some results, often producing a higher total length of shoreline (Figure A1).
    - Shorelines on First Nation reserve lands were not digitized out of respect for privacy, so those shorelines were excluded from the analyses. In some cases, the Federal Government reserve land polygon boundaries were slightly waterward of the FAC (Figure A2). Unfortunately, for the communities of **Oak Bay, Sidney and Cowichan Valley**, these shorelines were not excluded from the calculations, resulting in an overestimation of 'non-modified' or 'natural' shoreline.

Figure A1 – The FAC dataset (green line) does not align with the digitized feature locations (orange line), which skews results, resulting in an over or underestimation or shoreline length.

Figure A2 – In some cases, the Federal government First Nation reserve land boundary (shaded blue) was inland of the FAC (purple line).

Conservative Values due to Timing of Mapping

- Because the imagery was captured during the summer months when storms are less frequent, there is a high likelihood that the log accumulation data layer represents a lower threshold of accumulation than what a specific area may hold during winter months.

Shorezone Shore Type Analyses

- The Shore Type data layer used (ShoreZone) contains a category for 'human-made' shore type. This prevented visualization of original shore type before the modified structure was installed.

Additional Imagery Capture

- For estuaries and certain bays where access was difficult by a larger vessel, shoreline imagery was collected by alternative means. This includes imagery capture my tender (small vessel), drone, or on foot. In most cases for estuaries, shoreline imagery capture was not possible, so digitization was completed through available aerial imagery.

APPENDIX B -SUPPLEMENTARY FIGURES

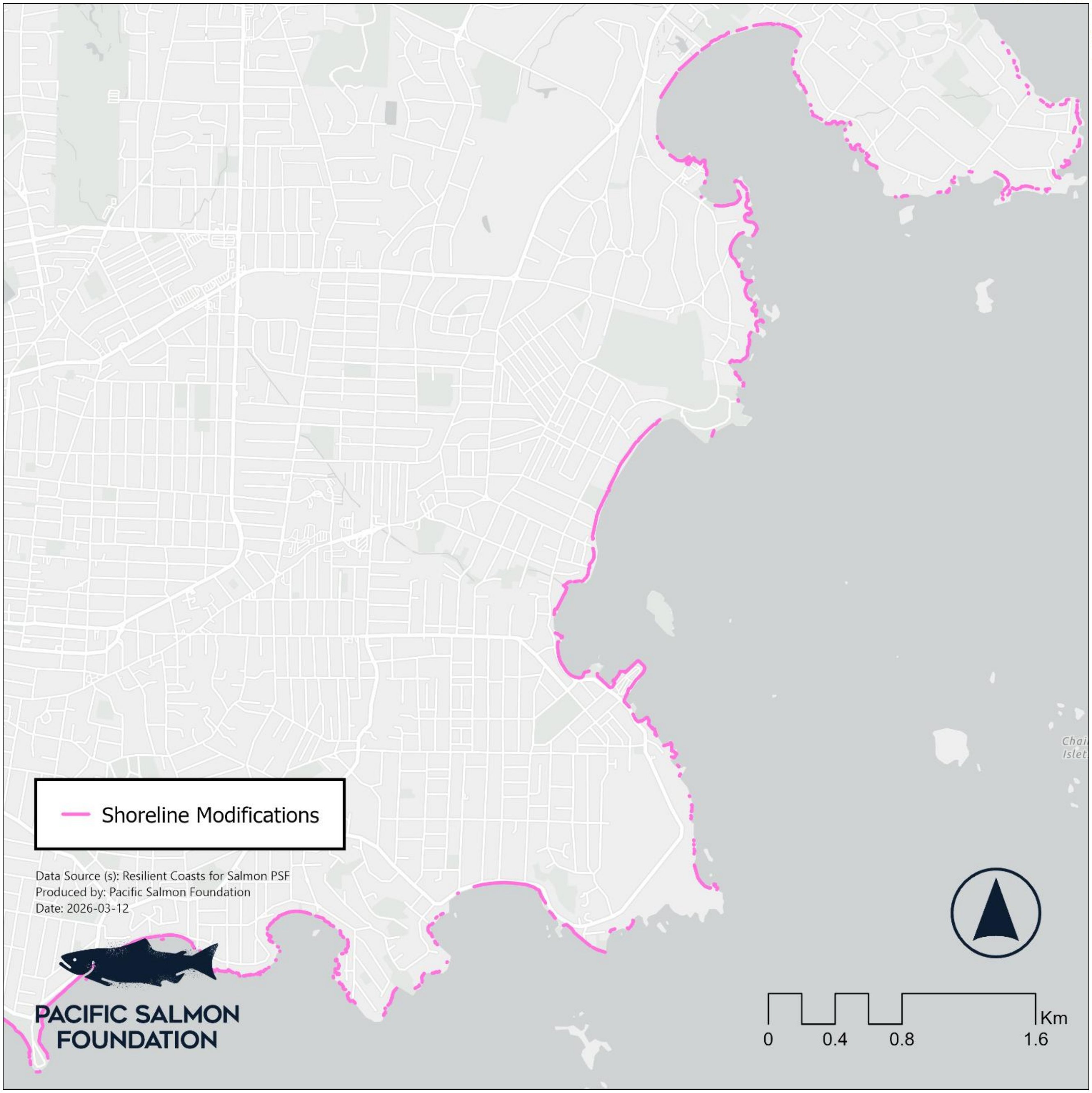

Figure B1 – The extent of coastal modification features in Oak Bay.

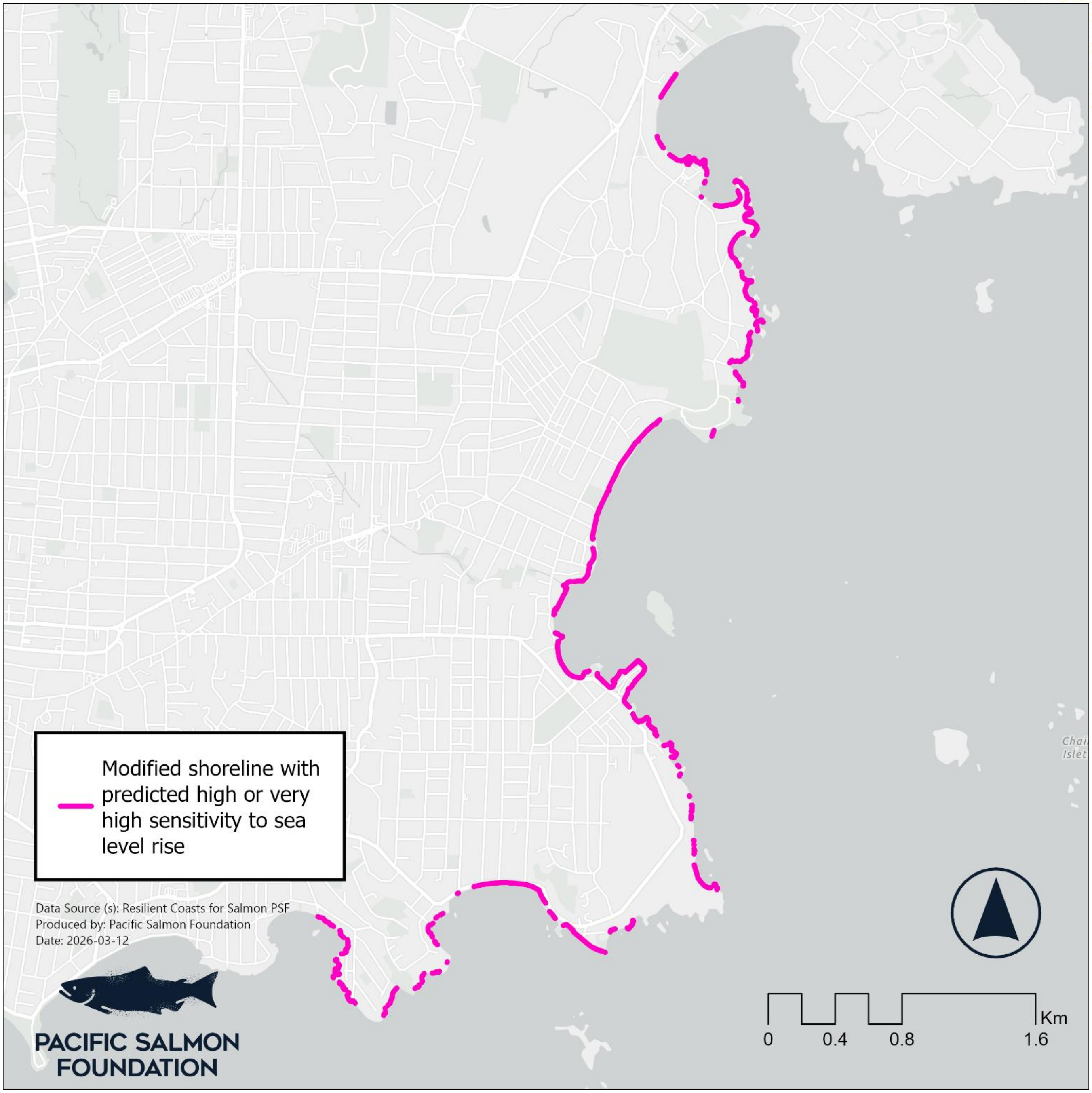

Figure B2 – The extent of shorelines covered in this report, showing where the shoreline is modified and classified as high or very high sensitivity to sea level rise (MOE BC 2014).

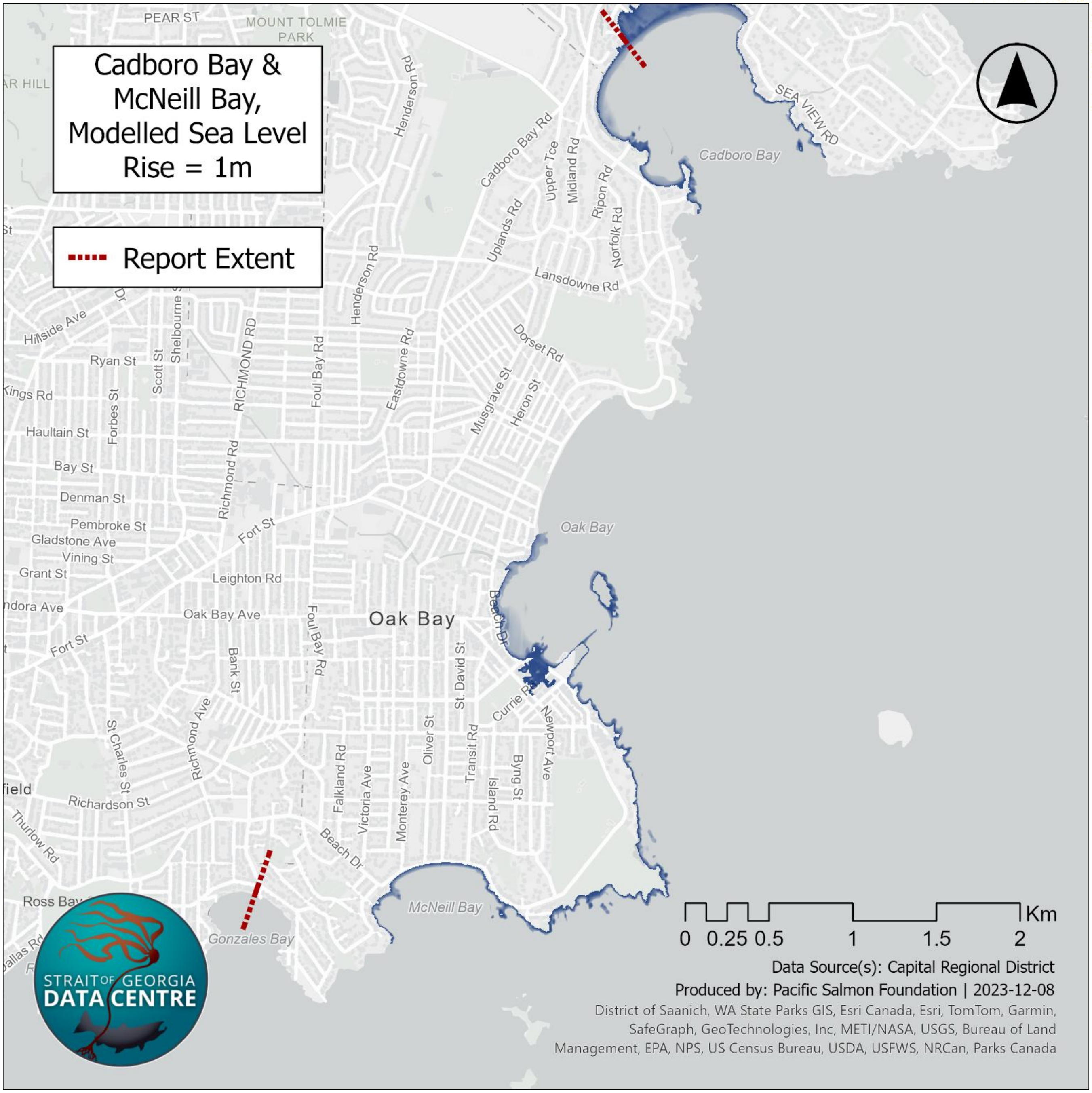

Figure B3 - The Capital Regional District's modeled floodplain area within Oak Bay for a 1m sea level rise scenario (Capital Regional District, 2021).

Figure B4 – The extent of log accumulation, overlaid with overwater structures along the shorelines and in the nearshore environment of Oak Bay.

Figure B5 – The extent of log accumulation along the shores of Oak Bay, overlaid with modelled results for Pacific sand lance habitat (Huard et al., 2022).

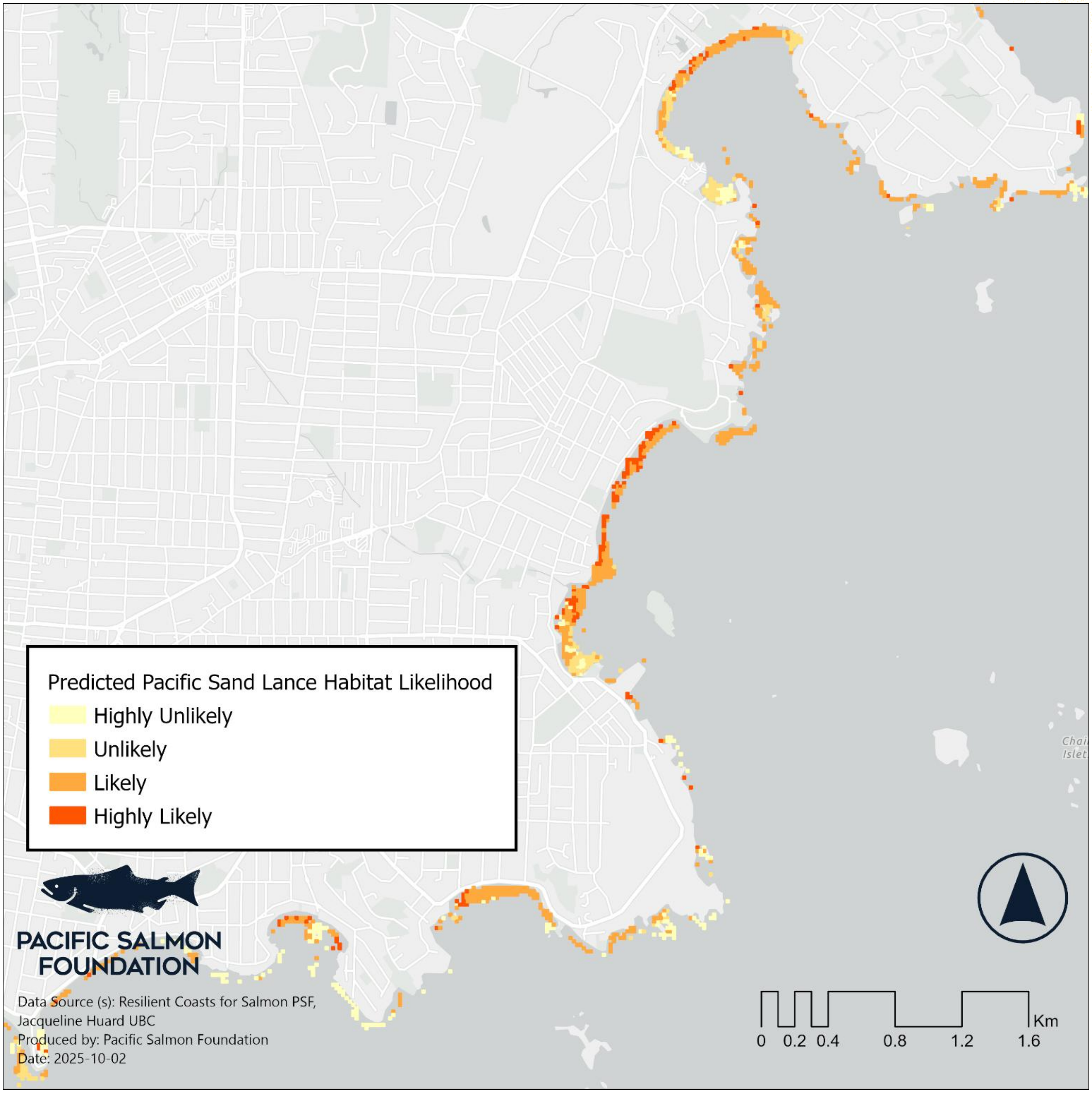

Figure B6 – Modelled results for the likelihood of Pacific sand lance habitat along the shores of Oak Bay (Huard et al., 2022).

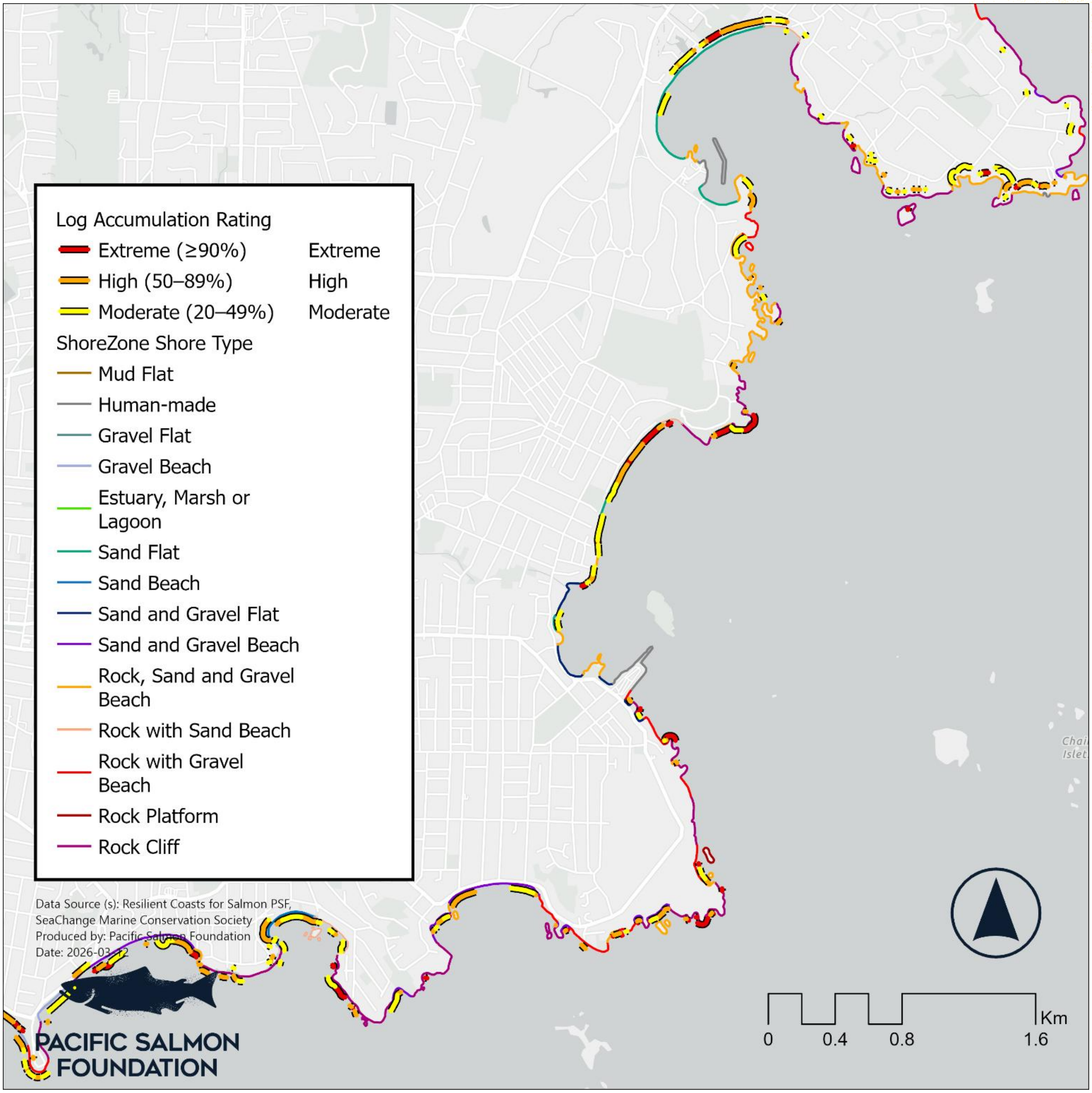

Figure B7 – The extent of extreme, high and moderate log accumulation along the shoreline of Oak Bay, overlaid with the ShoreZone shore types (Coastal and Ocean Resources, 2017).