Impacts of Climate Change on Shorelines, People, and Salmon: Nature-Based Approaches for Ecosystem Health

STEWARDSHIP CENTRE
FOR BRITISH COLUMBIA

RESILIENT
COASTS
FOR SALMON

Photo by Eiko Jones

Cover photos by: top, Eiko Jones, left, centre and right: Mitch Miller

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Photo by: Mitch Miller

Chapter 1– Our Home: Living by the Salish Sea

The Salish Sea and its Significance

The Salish Sea is home to diverse ecosystems and has been culturally significant to Indigenous Peoples for millennia. Spanning the Canada/US border, the Salish Sea stretches from the northern end of the Strait of Georgia to the southern end of Puget Sound. It opens to the Pacific Ocean at the Strait of Juan de Fuca. Within the Salish Sea are numerous connecting channels, bays and inlets, such as Haro Strait, Rosario Strait, Bellingham Bay, and the Hood Canal, as well as islands such as the San Juan and Gulf Islands. (Figure 1.1)

Communities around the Salish Sea are deeply rooted to this highly productive inland sea and the ways of life it nurtures. For those of us living around the Salish Sea, it is important to remember that we share this area with the native wildlife and plants and to respect that we are located on the unceded territories of many different Indigenous Peoples.

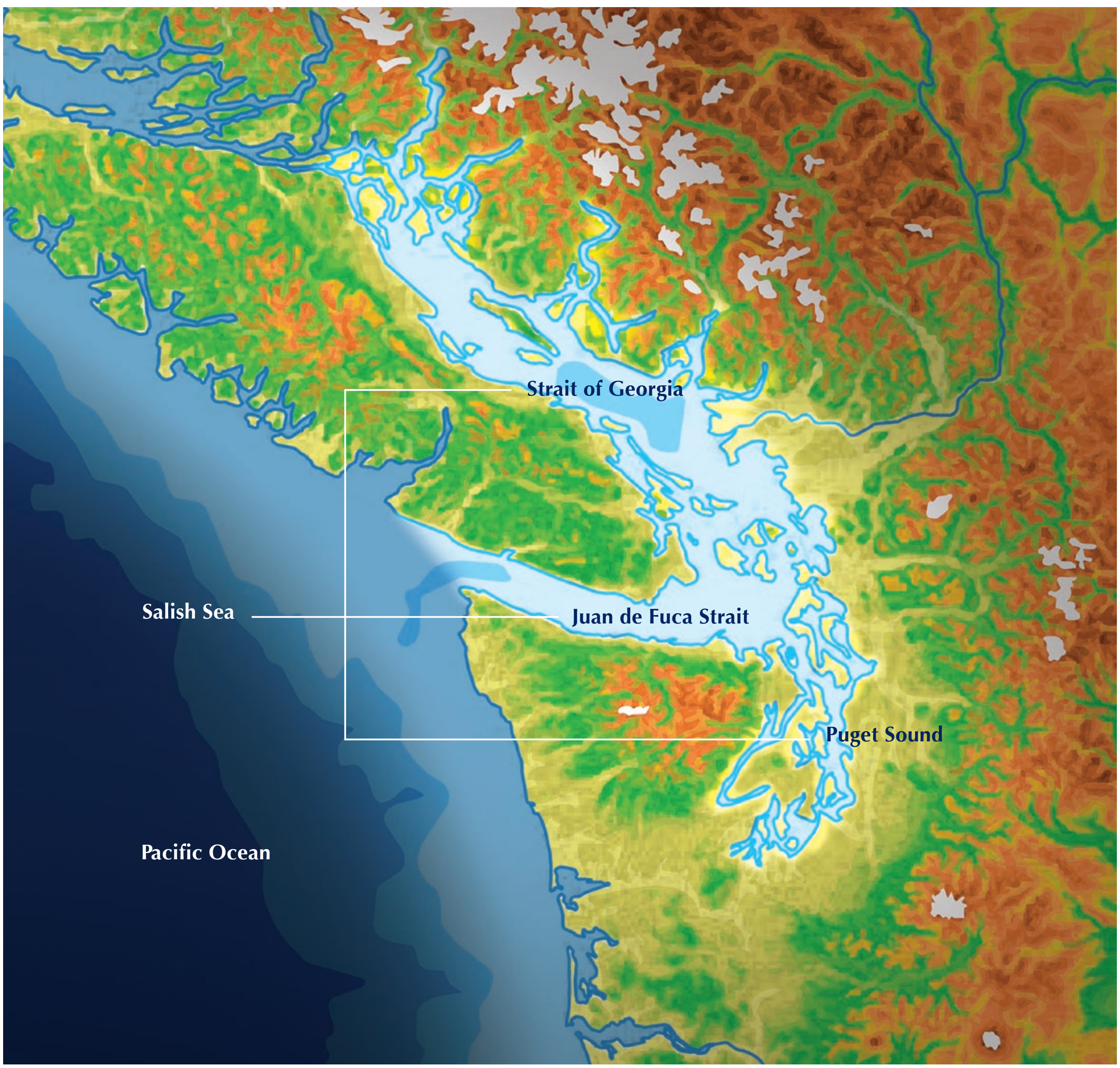


Figure 1.1*– The Salish Sea (Source: The Pacific Salmon Foundation)*

Photo by: Mitch Miller

Shoreline Values: Providing Environmental, Social, Cultural, and Economic Benefits

Indigenous people have relied on food from the ocean since time immemorial, with the familiar saying, "When the tide is out, the table is set." Today, we continue to rely on the shoreline for our food and livelihoods and as places where we love to live, work and play. We all benefit from the ecosystem services that healthy shorelines provide such as clean water and air, carbon sequestration and plentiful food resources. Shorelines provide us with beautiful scenery that can create a sense of spiritual well-being and can bring value to our communities. Significant economic benefits are derived from tourism, and the harvest of organisms such as clams, mussels, and salmon.

An ecosystem service that will become increasingly important in the future is the *resilience and adaptive value* of healthy intact shoreline systems in the face of climate change. Natural shorelines are dynamic and, given the space to move, will adjust to rising sea levels and buffer storm energy. This capacity will help protect our coastal communities from storms surges and higher sea levels. Promoting healthy shorelines will also help ensure we do not lose habitats that support critical links in the food web such as forage fish.

For those who live around the Salish Sea, Pacific salmon are central to their way of life. The annual migrations of adult salmon, sometimes hundreds of kilometers from the open ocean and back to their rearing streams to spawn, are one of the world's greatest natural phenomena. During their life cycle, they feed orca whales and shorebirds on the coast, brown and grizzly bears along riparian forests, and nourish the streams in which they swim, spawn and ultimately, die.

Not only are salmon invaluable as part of the coastal ecosystem, they hold tremendous economic and cultural value as a staple food item for communities around the Salish Sea, and as part of commercial fishing and tourism industries. Salmon depend on healthy freshwater and marine ecosystems, and are highly reliant on functioning estuaries and nearshore areas which serve as important nursery habitats.

Photo by: Macgregor Aubertin-Young

Photo by: Josh Morgan

This document will explore why and how we should value and protect our shorelines so that they can continue to provide their valuable benefits.

Photos by: Sarah Cotter and Mitch Miller

Let's learn more about living by the Salish Sea and what steps we can all take to help salmon, people and the environment.

Chapter 2 – Getting to Know Your Shoreline Neighbours

With the term 'shoreline neighbours', we are referring to all the organisms living at the land/sea interface — both on land and in the ocean! These organisms rely on healthy shorelines just as we do. Many of our shoreline neighbours that live and depend on the Salish Sea are not always visible from shore and require a closer look. Your shoreline neighbours will differ depending on many factors, one being whether you live near a sandy beach or a rocky one.

In sandy environments, you may find clams, crabs and even grass that lives in the sea. This grass is known as eelgrass and it forms underwater meadows in sheltered bays and along shorelines where it is sandy and muddy. Figure 2.1 is a map of eelgrass and kelp distribution around the Southern Gulf Islands within the Strait of Georgia, the Canadian part of the Salish Sea. Eelgrass has two ways that it can reproduce, by their roots or 'rhizomes' and by seed. Yes, they flower and get pollinated under water! Eelgrass needs light to grow and survive, so you will not find it under structures like docks. Eelgrass helps settle sediment, prevents erosion, sequesters carbon, and improves water quality. It is also critical habitat for juvenile salmon: eelgrass meadows serve as nursery areas where salmon can find shelter and refuge. They are also important places for salmon to forage: algae settles on the eelgrass, invertebrates feed on this algae, and in turn become food for juvenile salmon.

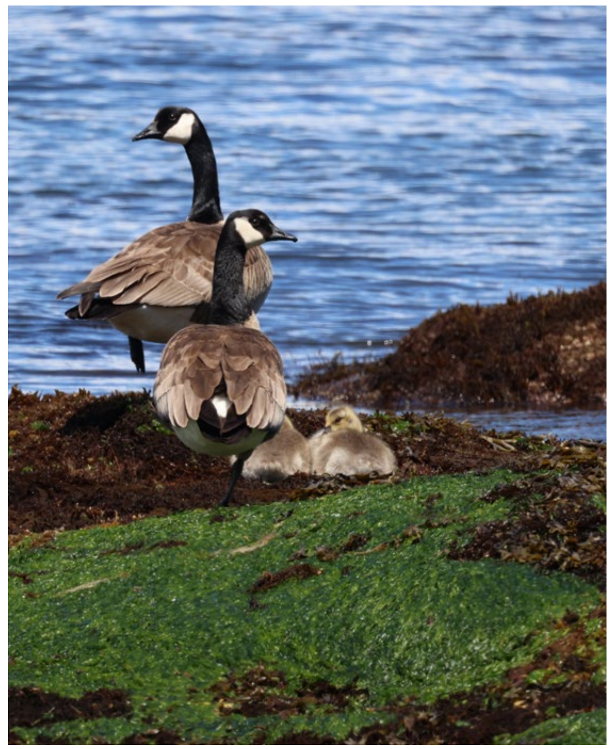


Photo by: Mitch Miller

Photo by: Ryan Miller

Contact Peninsula Streams Society or the Mount Arrowsmith Biosphere Region Research Initiative (MABRRI) at Vancouver Island University if you want to get involved in sampling your local beaches for forage fish!

Photo by: Maria Catanzaro

On natural sandy shorelines, you will find large woody debris (driftwood) that holds sediment in place and provides ideal conditions for saltwater-adapted plants such as dune grass to grow, which further assist in stabilizing the shoreline. Beachgoers and property owners also benefit from enjoying watching the wildlife utilizing these habitats.

Did you know that small fish surf their way up with the tide onto sandy, gravel beaches to spawn? Well, they do! Surf smelt and Pacific sand lance are forage fish that rely on pebble and sandy shorelines for spawning, and require healthy overhanging vegetation along the high tide line to shade their eggs and provide an input of nutrients. These incredible fish support the life cycle of Pacific salmon, shorebirds, and ultimately, even larger iconic species such as killer whales.

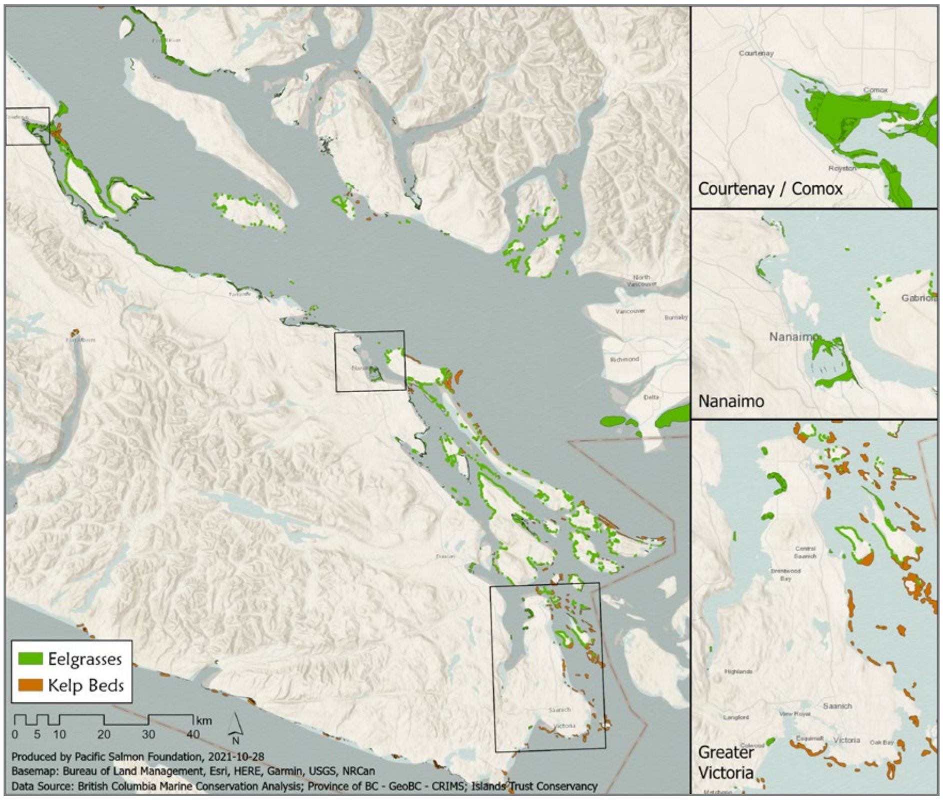


***Figure 2.1** – This map shows the extent of eelgrass and kelp habitat in the Strait of Georgia, British Columbia, including zoomed in regions of Courtenay/Comox, Nanaimo, and Greater Victoria. The map was created with several datasets including, kelp bed layers from GeoBC, an eelgrass layer from Islands Trust Conservancy, and an eelgrass later from the British Columbia Marine Conservation Analysis. For more information, check the Strait of Georgia Data Centre. The overall dataset does not represent extent in its entirety, as data are continually updated from multiple sources. (Source: Strait of Georgia Data Centre, Pacific Salmon Foundation)*


Photo by: Ryan Miller

Photos by: Mitch Miller

In rocky environments you may spot limpets, barnacles and sea anemones living amongst the rocky outcrops and tide pools. If you're snorkeling, you may find sea urchins and kelp crabs in cobble-gravel areas where macroalgae such as floating bull kelp form underwater forests. Often, you can spot a Great Blue Heron riding the stipes of the kelp where they can spot fish and forage.

In both sandy and rocky environments, you'll find marine riparian vegetation, such as shrubs and trees like Arbutus, Douglas fir, and ocean spray, growing along the shore above the high tide line (Figure 2.2). This vegetation has many important functions, including stabilizing the shoreline as well as filtering out contaminants, thus preventing them from entering your favourite swimming spot. Insects also fall from the overhanging vegetation, providing important food sources for juvenile salmon as they prepare for their open ocean journey. Juvenile salmon can be found hugging shallow, coastal areas for this reason, as well as for shelter and evading predators.

***Figure 2.2** - The branches of arbutus trees overhang the shore, shading the nearshore environment from the sun.*

Photo by: Nicole Christiansen

And maybe you have salt marsh habitat nearby — marshes not only provide incredible habitat for salmon, but also provide a critical role by helping buffer coastal communities from rising sea levels through wave energy dissipation and flood mitigation. Coastal salt marshes are biologically rich and diverse habitats! Marshes support animals like beavers, frogs, and birds, as well as a variety of fish. They can exist along a spectrum of salinity (some marshes are freshwater, others are in estuarine environments, while others are entirely marine). Estuarine marshes are especially important habitat for outmigrating juvenile salmon (Figure 2.3). The emergent vegetation and channelized habitat provide safe places for juvenile salmon to grow before they make their way out into the open ocean for the marine component of their life history.

Pacific herring lay their eggs on all sorts of natural materials along the coast as well — from algae like rockweed to eelgrass (Figure 2.4). Herring spawn is a huge annual event that attracts all kinds of animals, including Great Blue Heron, Bald Eagles, orca whales and seals. People come to witness this event too! During spawning events, thousands of fish approach the shallow subtidal area, and coastal waters turn cloudy with the milt of the male fish. Forage fish like Pacific Herring are critical food sources for Pacific salmon, and the latter, particularly Chinook salmon, are critical food for Southern Resident killer whales. During these spawning events, you are often witnessing the coastal food web in action!

***Figure 2.3** - The brackish marshes of the Fraser River estuary are incredibly rich in biodiversity, and are important rearing habitat for juvenile Pacific salmon*
Photos by: Kyla Sheehan

***Figure 2.4** - Pacific Herring spawn* Photo by: Ryan Miller

BOTTOM LINE:

As you can see, **healthy shorelines support a myriad of marine and terrestrial life.** As their human neighbours, we must do our part to support these vital habitats, as both their and our future depends on it.

Especially for Kids!


Photo by: Nicole Christiansen

See who you can meet at your local beach!

Just remember, make sure to gently place rocks where you found them, so the crabs and other creatures can have their cozy homes back.

Check out the Treasure Hunt on page 66!

Barnacle and shore crab illustration by: Holly Sullivan
Kelp and Great Blue Heron illustration by: Anisha Parekh

Image B-03400 courtesy of the Royal BC Museum

Chapter 3 – The Value of Salmon

As British Columbians, many of us have grown up fishing and eating salmon, appreciating salmon-centric art and witnessing the annual migrations and spawning events as salmon return to our local rivers — salmon are woven into our cultures and our way of life on the coast. In British Columbia there are five well known species of Pacific salmon: Chinook, Coho, Sockeye, Chum and Pink. Each species has unique features, but they all have a similar life cycle starting with hatching from eggs laid in freshwater streams, migrating to sea and returning as adults to their natal streams to spawn and die (Figure 3.1). This journey of the Pacific salmon has shaped the way our freshwater and marine ecosystems function, contributing to their incredible diversity and productivity.

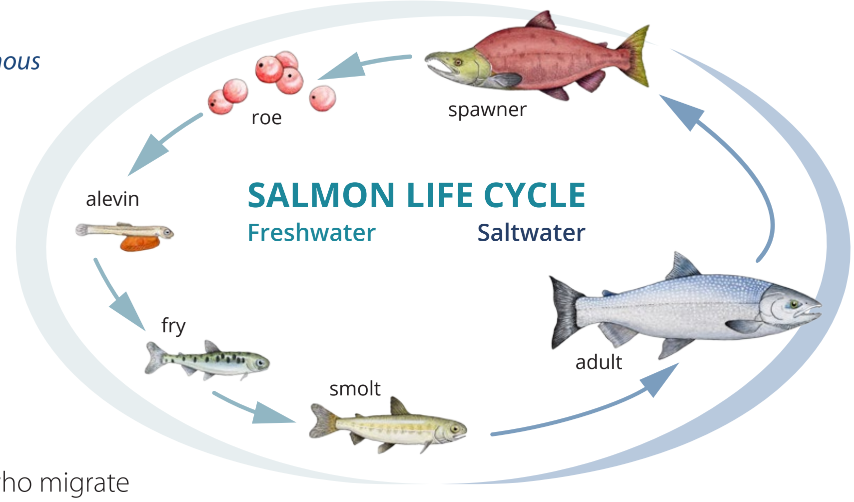


***Figure 3.1** – The life cycle of anadromous Pacific salmon, starting in the fresh water of rivers, streams and creeks, featuring estuaries and the open ocean, and ending back in the waters where they were born.*

Illustrations by: Anisha Parekh

Salmon are incredible creatures who migrate from saltwater to freshwater to carry out their life cycle. We call salmon *anadromous* because they make this long trip from the ocean back up to the freshwater rivers where they were born to spawn. The salmon life cycle starts when salmon alevin emerge from their eggs hidden in patches of gravel called redds in freshwater streams, rivers and creeks. They develop and grow into fry with parr marks to help them camouflage, then into unmarked smolts during their out migration to the marine environment. Fry and smolts often spend some time in estuaries to grow stronger and larger before they enter the open ocean on their migration as adults. Depending on the species, adult salmon spend 1-4 years in the ocean before beginning their migration back up to their natal rivers to spawn.

Photo by: Mitch Miller

***Figure 3.2** – Tom Harry jigging off Malahat Beach by Tozier Creek on a recent fishing trip with Elders of the Malahat Nation. He released the Jack Chinook to let it grow.* Photo provided by: Tom Harry

Indigenous Peoples and Salmon

From traditional diets and daily practices to ceremonies, traditional stories and art, salmon are found throughout Indigenous culture. As one could imagine, salmon are particularly significant to coastal First Nations whose activities throughout the year were centered around harvesting, preserving and eating this crucial food source. Through story-telling and ceremonies Indigenous communities have passed down the importance of salmon. Also shared throughout generations is their rich knowledge of the practices of traditional fishing, cooking and preservation techniques. To First Nations, **salmon are family**. For millennia, First Nations have managed this natural resource, but systemic factors like overfishing, habitat loss and the changing climate threaten to eliminate salmon permanently.

Learn more about how local Indigenous Fisheries like A-Tlegay Fisheries Society, the Central Coast Indigenous Resource Alliance and the First Nations Fisheries Alliance manage these precious marine resources and steward these coastal waters and ecosystems.

Photo by: Eiko Jones

Value in the Ecosystem

From the open ocean to their natal spawning rivers to the forests beyond, salmon play a vital role in these ecosystems. Pacific salmon are a critical food source for resident killer whales, seals, terrestrial animals like bears and wolves, as well as eagles and other birds. In fact, over 137 species depend on Pacific salmon for food (Wild Salmon Centre 2021). Salmon also feed the forests and the streams. When salmon return to the freshwater streams they were born in they bring nutrients from their years of feeding at sea. Some of these nutrients are cycled through the streams themselves as salmon die after spawning and decompose in the water and on the banks. This will be an important resource for the next generation of salmon as the invertebrates and microbes that feed upon the decaying salmon end up as food for the hatchlings. Nutrients from the salmon can also reach deep into the forest as terrestrial animals carry their carcasses away or leave droppings after eating salmon. This pulse of additional nutrients supports our highly productive forests, which, in turn, also support future salmon populations with the shady cool clear water that they need.

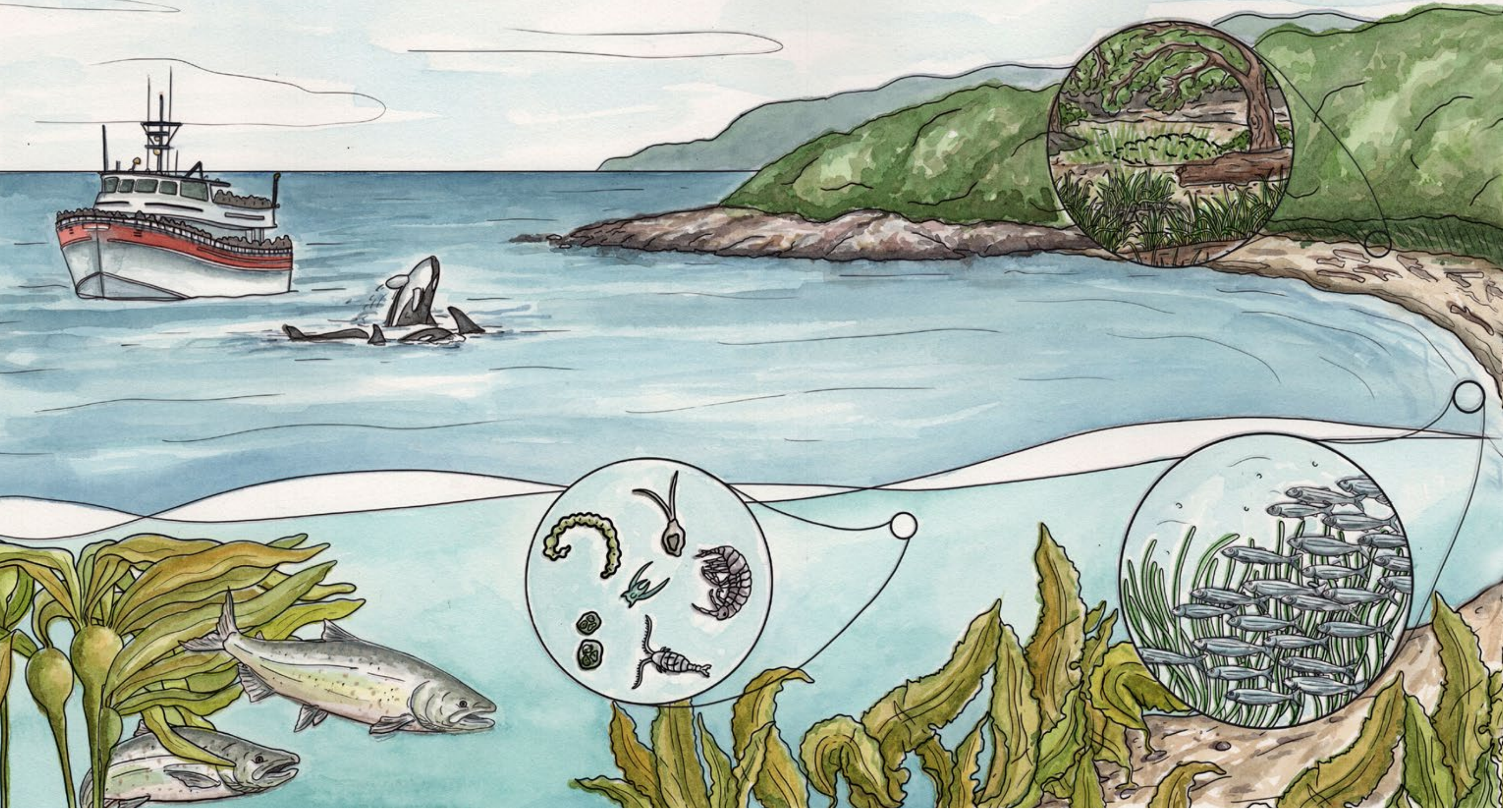


***Figure 3.3** – The Salish Sea ecosystem is complex, supporting countless organisms like Pacific salmon, orca whales, forage fish, kelp, and people!* Illustration by: Holly Sullivan

The Coastal Trophic Cascade

Salmon are incredibly important to freshwater ecosystems and the animals that surround spawning rivers, but did you know that they are also part of a critical trophic web on the coasts? See Figure 3.3 for a depiction of the salmon coastal trophic web.

Our coasts are home to a diverse array of organisms of all sizes. There are tiny zooplankton and phytoplankton that drift in the coastal waters, small schooling fish which rely on our soft shores for spawning, our five species of Pacific salmon, large predators like resident killer whales, and us! We may think of these organisms and their particular habitats as separate entities, but they are intrinsically linked to one another.

Phytoplankton are tiny photosynthetic organisms that drift near the surface of the ocean — they use the energy of the sun to sequester carbon, just like trees, grasses and shrubs do on land. Feeding on these organisms are zooplankton, which in turn are fed on by schools of forage fish such as Pacific sand lance, surf smelt and Pacific herring. Forage fish depend on soft shores since they spawn in the sand and gravel during high tides, and are particularly important because they are a primary food source for predators(also known as secondary consumers) like Pacific salmon, seals, and coastal birds like eagles. At the top of this trophic interaction are predators such as killer whales and humans. Our Southern Resident killer whales depend on the high numbers of forage fish and salmon, but are currently listed as at risk under the Species at Risk Act (SARA) in Canada (Ocean Wise 2019).

Everything that happens on the shorelines has a cascade of impacts on the health of the ecosystem and coastal trophic webs. Whenever we make improvements to the shoreline, like planting native vegetation or creating spawning habitat for forage fish, we are supporting Pacific salmon and Southern Resident killer whales, amongst many other species!

Photo by: Mitch Miller

Diminishing Returns

In recent years, we have seen historically low salmon runs. In 2020, the catch of Pacific salmon was the lowest it has been since 1982 (Government of Canada 2021). While not all species and populations of Pacific salmon are in decline, many populations of southern Chinook, Coho and Fraser River Sockeye are in significant decline (Grant et al. 2018, DFO 2016, DFO 2018). Around the Salish Sea, both Puget Sound Chinook salmon and Steelhead trout are listed as threatened under the United States Endangered Species Act while many populations of Chinook, Coho, and Steelhead in the Strait of Georgia basin are listed as Species at Risk in Canada. The low numbers of salmon in these populations means that they are vulnerable to changes in their environment, such as warmer ocean temperatures caused by climate change. This will have far reaching implications throughout the ecosystem, since it is widely believed that diminishing Chinook salmon populations specifically have contributed to declines in endangered Southern Resident killer whales (Hanson et al. 2021).

In a recent survey from Insights West, the Pacific Salmon Foundation, and Wild First, it was revealed that 86% of BC residents polled are extremely concerned about declining salmon stocks, and rated this as one of the top environmental concerns (Insights West 2021). Some of the main factors impacting Pacific salmon include overharvesting, habitat loss/degradation and climate change. In particular, BC residents seem to be concerned about and perceive the biggest threats to Pacific Salmon populations to be issues related to open-net pen aquaculture (24% of respondents), climate change (18%), and overfishing (18%). The threats to salmon are complex, but we are seeing policies put in place to help alleviate some of these impacts.

For example, to help reduce the impacts of harvest on these vulnerable populations of Pacific salmon, the Government of Canada has imposed new closures for commercial salmon fisheries and First Nations Communal Commercial fisheries for the 2021-2022 season (Government of Canada 2021). In response to research and public push-back against open-net pen aquaculture, the Government of Canada has ordered that all open-net pens transition to closed-containment pens by 2025 (Government of Canada 2020). Similarly, all farms in the Discovery Islands are to be free of fish by June 30th, 2022 (Government of Canada 2020).

BOTTOM LINE:

Our precious Pacific salmon are counting on us to **appreciate the value of shorelines** and to treat them accordingly. We need to take action and recognize the linkages between healthy shorelines, Pacific salmon, and our coastal ways of life.

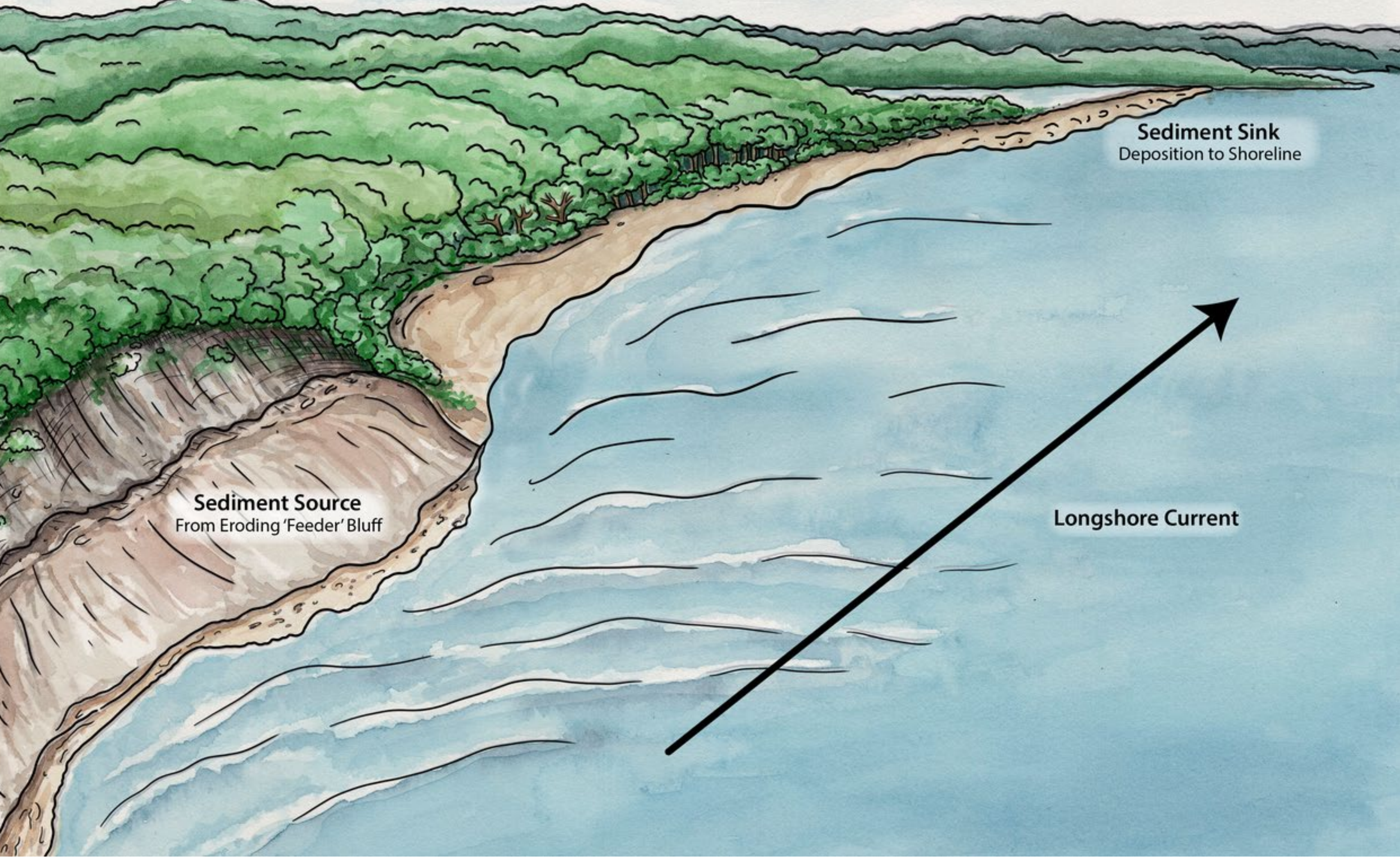
Chapter 4 – Natural Coastal Processes: How Shorelines Work

We often think of our beautiful coast as static, but it is in fact always changing. Tides ebb and flow, and seasons change. Sediments, rocks and debris are constantly moved around by wind, currents and waves through the processes of erosion and deposition. The coastal landscape, including the presence of human-made structures and alterations, influences how these processes play out and has a tremendous influence on the habitats of our rich and diverse coast.

Our Dynamic Coast

The movement of sediment affects the shape and morphology of the beach, and the suitability of the habitat for various species. For example, Pacific sand lance and other forage fish species have very particular requirements for their spawning grounds. They only spawn on parts of the beach where the water reaches at high tide and where the gravel is of a particular size. Sources of sediment such as naturally eroding coastal bluffs as well as rivers and streams provide sediment that creates and maintains beaches. Healthy beaches exist in a balance of erosion and deposition, where both processes occur simultaneously.

Photo by: Sarah Cotter



Natural Processes

Natural coastal processes both maintain and create our beaches, and they are needed to sustain our shorelines and their integrity into the future (Figure 4.1).

Erosion & Deposition

Erosion is the process by which sediment is picked up and moved away by currents, waves and wind. Powerful and persistent waves and currents can scour away beaches until there is nothing but rocky substrate left. Deposition, on the other hand, happens when sediment is "dropped off" (deposited) on the shoreline. Sediment accumulates in certain areas where deposition is favourable - often this occurs around areas of the coastline that stick out. For the same reasons, human-made structures like seawalls, jetties and groynes can artificially influence erosion and deposition patterns.

***Figure 4.1** – All shoreline properties are part of a larger system driven by shoreline features: 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 this graphic illustrates one type of transport, it is important to recognize that transport mechanisms can vary significantly across shoreline morphologies. The shape of the shoreline will be highly dependent upon their interaction with freshwater sources like rivers (e.g. deltaic coastlines), as well as the local marine factors like tidal range, wave energy or currents. The orientation of the shoreline will also the influence the exposure of that shoreline to wave energy and other factors.*

Illustration by: Holly Sullivan

Photo by: Mitch Miller

Photos by: Mitch Miller

Longshore Drift

Have you ever noticed that when you're resting on a floatie or paddling in a kayak, that the water tends to push you in either direction along the shoreline? Well, this is the same force that transports sediment parallel to the beach. This process is called longshore drift, and it is a combination of currents, incoming wave direction, and sometimes wind. Once the sediment is picked up and suspended in the water, it can be moved along the shoreline for many kilometers! The shape of the shoreline, including human-made structures, determines where that sediment is 'dropped off.' Littoral drift is the movement of sediment along the shore by longshore drift. Longshore and littoral drift are critical to creating and maintaining our beaches.

Waves

Waves typically hit the shorelines at an angle (refracted) and that results in energy being directed along the coastline in the direction of the incoming wave. This energy, known as longshore current, is similar to longshore drift and also contributes to erosion, deposition and transport of sediment. Wave energy works in multiple ways to transport and redistribute sediment. As a wave approaches the shore it enters shallow water and the wave base scours the bottom, creating turbulence and picking up sediment. As the wave crests and crashes onto the shore, the sediment is further disrupted and picked up into the water column. The uprush of water that moves onto the beach is called swash — this hits the beach, then the water retreats back over the sand and stones as the next wave approaches the shore.

In high energy shores that experience lots of wave exposure, sands can be deposited and washed away seasonally with storms. Steady supplies of sediments being delivered by longshore drift processes allow accretion into dunes which become stabilized with vegetation and offer protection to the areas above the tidal zone. As sea levels change these buffers naturally migrate and continue to protect our shores.

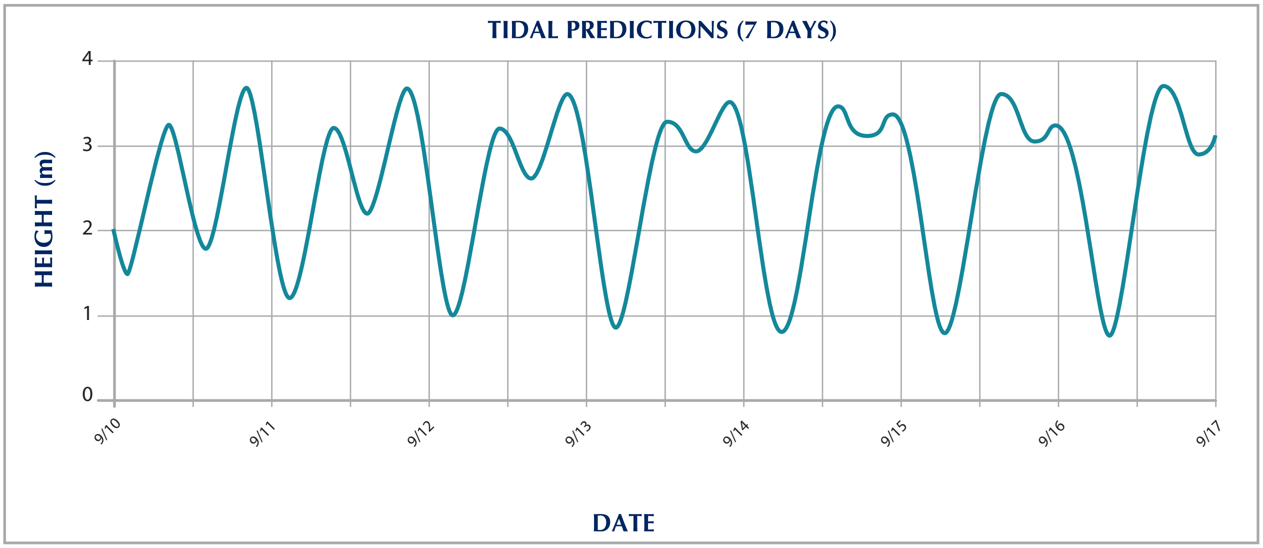


***Figure 4.2** – Example of a mixed semi-diurnal tide chart at Ladysmith for the week of September 10, 2021. Each 24 hours period has two uneven high tides and two uneven low tides.*

Source: [Fisheries and Oceans Canada 2021]

Tidal Cycle

When you visit the beach, the sea level appears to be changing — sometimes by the minute — this is a result of tides. Tides occur because of the gravitational pull from the sun and the moon, as well as the rotation of the earth. In British Columbia, our tidal pattern is called mixed semi-diurnal, meaning there are approximately two high tides and two low tides each day and the height of the two high and low tides are different from each other (Figure 4.2). The area between the highest high tide and lowest low tide is called the intertidal zone. Here, there is a great diversity of life that has adapted to alternating between the extremes of being submerged and exposed. Many significant ecological processes occur in the intertidal zone, such as forage fish spawning and shorebird foraging.

BOTTOM LINE:

If left to play out naturally, the coastal physical and ecological processes described above maintain **dynamic and resilient shorelines** that can adapt to variable conditions. However, human made shoreline armouring structures, including seawalls and rock riprap, interfere with these processes. These are discussed further in the next section, Chapter 5.

Chapter 5 – Coastal Modification: How Hard Armouring Impacts Shorelines

For millennia, hard armouring structures have been used in coastal communities across the globe. The first seawalls date back to 448 A.D. when the Roman Emperor Constantine I ordered their construction as barricades to protect the city from invasion. In more recent history however, seawalls have been used as the go-to solution to shield coastal homes from wave energy and storm surges. The widespread installation of seawalls has allowed us to build right up to the shorelines. However, as our understanding of natural shoreline function improves, there is a growing acceptance that such structural solutions may cause more problems than they solve.

Photos by: Kyla Sheehan & Maria Catanzaro

Coastal Modification

In many urban locations around the world, more than 50% of the shoreline has been "hardened" by coastal armouring structures (Gittman et al. 2016). 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). With approximately 60% of the global population living within 60km of the coast (UN Atlas of the Oceans 2016) and an estimated 72% of British Columbians living in coastal communities (Bodtker and Philibert 2018), we have a lot to lose when it comes to sea level rise and coastal storms.

Photo by: Kyla Sheehan

Breakwaters

Breakwaters are large structures often extending far offshore, and are designed to protect harbours or areas of the coast from incoming waves and erosion by longshore drift. These structures are intended to shield shorelines from the erosive force of incoming wave energy — however this cuts the down-current area off from inputs of sediment normally delivered by longshore drift. Breakwaters and associated harbours are often areas where marine debris like logging debris and styrofoam pieces collect, not to mention harmful gasoline residues and other boat waste — breakwaters trap all of these materials within the area, further reducing the availability of healthy habitat. Harbour structures also directly impact nearshore habitat by shading out areas from the sun — this prevents growth of kelp, seaweeds and eelgrass.

Photo by: Mina Girgis on Unsplash

Groynes & Jetties

Groynes and jetties are rock walls or berms that are positioned perpendicular to the shorelines. They may or may not be attached to the shoreline, and the design and materials used are critical to the function of the shoreline. These structures can be designed to interrupt longshore currents to manipulate where sediment is maintained, preserve beaches and prevent the sand from migrating away from those particular areas. This can be especially helpful in sediment starved beaches. Where there are larger structures like breakwaters blocking sediment input to a particular area, these types of structures can be used to help maintain a beach.

However, while traditional groynes help to maintain sediment beaches in particular areas (depending on the materials used), they do not provide habitat, and can exacerbate the impacts of erosion down the shoreline. In contrast, sills are low rock walls constructed parallel to the shoreline. They are often used to protect beaches from the erosive force of waves by forcing them to crash away from salt marsh, or other sensitive vegetation. Like groynes, sills help to maintain sediment behind them by reducing wave action at the shoreline. All of these structures can be used as part of a beach restoration plan, but they can also cause problems by altering the natural processes of sediment transport if not properly designed.

Seawalls & Bulkheads

Seawalls and bulkheads are hard walls usually made of concrete that limit how far the tide can reach along the shoreline. They are often used along the boundaries of a property in an attempt to protect the home from incoming waves. Seawalls do not dissipate wave energy, instead they reflect it, often resulting in scour at the toe of the structure and increased wave height and runup at the wall. By acting as a hard boundary to the beach, seawalls interrupt the natural process of waves slowing down and crashing onto the beach. Instead, incoming waves are forcibly stopped so that the wave energy is directed vertically - both up the wall, splashing towards coastal homes, and down, eroding away sediment from the beach (Figure 5.1). When waves crash into hardened shorelines, the energy of the water is accentuated resulting in higher wave heights that can overtop the seawall during storm events.

Although seawalls may protect an individual property, there are many drawbacks. These structures cause the wave energy to be deflected to another part of the shoreline, blocking the natural movement of sediment, and exacerbating erosion elsewhere. The unintended diversion of waves could result in flooding on other properties. Seawalls also support 23% lower biodiversity and 45% fewer organisms than natural shorelines (Gittman et al. 2016). Hardened shorelines can even break or flood during storms and other high wave energy events, causing serious damage to the structure and putting those behind it at risk.

These structures also worsen a phenomenon known as *coastal squeeze*. Coastal squeeze is the loss of intertidal habitat as sea levels rise. When the zone above the high-water line is constrained by hard modifications, the shoreline and habitats are not able to move landward and naturally adapt to changing sea levels. This effectively shrinks the intertidal area that is key to many shoreline organisms.

Photo by: Maria Catanzaro

***Figure 5.1** – Impacts of shoreline modification, such as this seawall, include benthic scouring, deflected wave energy, habitat loss, and risks of flooding to the properties they are supposed to protect.*

Illustration by: Holly Sullivan

Coastal Development

Development in coastal areas can also disrupt natural shoreline processes. In developed areas there is typically a net loss of tree canopy and other vegetation. Intact vegetation keeps sediment in place and allows rain to soak in. When vegetation is cleared for building, erosion can be a significant problem. If worksites are not managed properly, additional inputs of sediment can flow to and be deposited along the shoreline. Even after a building has been completed there is still a risk of sediments being washed away until landscape vegetation becomes established. The additional sediments that wash away from developed areas can bury the existing sediment on the beach. This has implications for the critters that live along the shore, including deposited fish roe. Another consequence of coastal development is increased impervious surfaces, such as pavement, roads and roofs, that can accelerate waterflow into streams and coastal areas. During stormwater runoff events currents can be altered and may carry away natural sediments as well as pollutants from these developed areas.

Photos by: Mitch Miller

Beach Starvation

Areas with hard armour will often experience a shift in substrate type — if it's sandy, it may become more gravel-dominant, since sediment may no longer be nourishing the area. The nearshore sediment budget describes whether a shoreline has a surplus or deficit of sediment, and this tells us whether the beach will be eroding or accreting. We would say that a beach is starved if it has been cut off from its source of sediment. Hard armouring structures can leave beaches starved of sediment. Deposition and erosion occur in harmony at the shoreline, but when structures like groynes are installed, beaches are cut off from their supply of sediment and the dominant process becomes erosion. This might look like a beach with large cobbles, but this was once actually a mixed-sediment beach, and now the soft sand has been eroded away.

Throughout British Columbia, residential clearing and shoreline armouring, coupled with the impacts of sea level rise, affect the sustainability of nearshore processes and threaten high value habitat, including areas where forage fish spawn.

Photo by: Isobel Pearsall

Photo by: Isobel Pearsall

BEACH NOURISHMENT:
The addition of sediment to a shoreline to build up the profile of the beach and replace sediment that had been lost due to longshore drift or other erosive processes. Beach nourishment is a technique to maintain or restore a sediment beach in a particular area (often for tourism purposes,) but can be a part of a nature-based approach to shoreline restoration to improve the functioning of the habitat as well. This approach is less costly than hard armour and may require maintenance over time. Sometimes beach nourishment is necessary when natural sediment transport processes have been impeded by armouring structures.

Photo by: Zac Gudakov on Unsplash

How Coastal Modification Impacts Pacific Salmon

Coastal and estuarine areas, which are often extensively developed with shoreline hardening and modifications in urban areas, are vital stop-over habitats where young salmon grow, adjust and prepare for their life at sea. Features such as seawalls, riprap, docks, and piers, not only alter how shorelines function, but they also affect Pacific salmon during their coastal phase of life. How well salmon grow during their time in coastal areas is directly linked to their success out at sea, and ultimately, whether they make it back to spawn the next generation.

When Pacific salmon first migrate down to coastal habitats, they preferentially use shallow areas and shift along the depth gradient and between habitats as they grow (Munsch et al. 2016). Coastal modifications, like seawalls that extend into the lower subtidal zone, eliminate shallow areas and complex habitat gradients. Shallow habitats are particularly important for the smallest salmon as they offer refuge from larger predators that cannot access those areas. Without the shallow areas, young salmon must occupy the same areas as larger fish, leaving them more vulnerable.

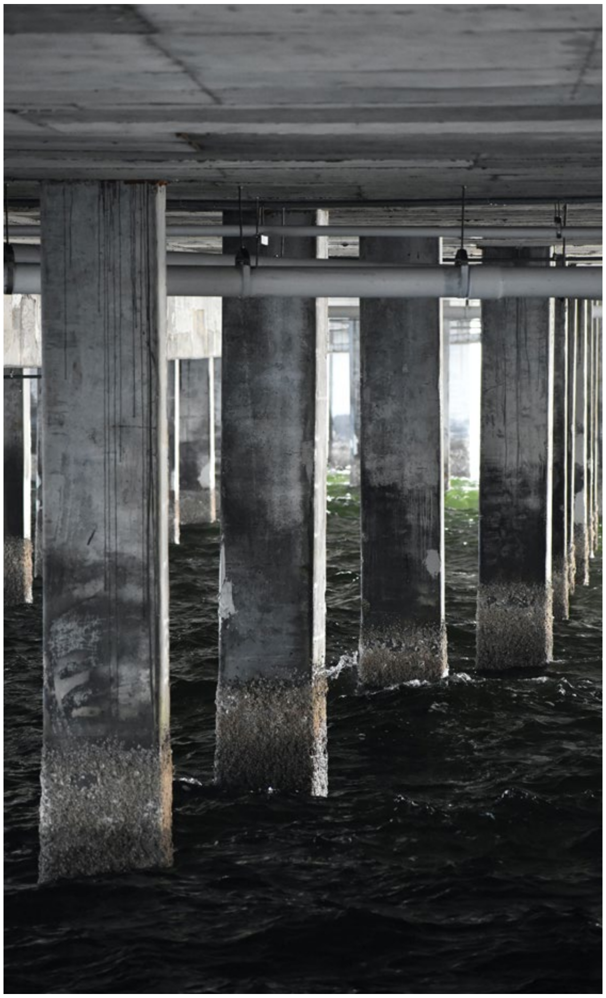


Photo by: Shelter on Unsplash


Photo by: Tavish Campbell on Flickr

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 invertebrate (critters that reside on or above the rock, sand and mud of the seafloor) compared to unarmoured shoreline (Morley et al. 2012). As a result, when young salmon are next to a seawall and other artificial structures, they end up feeding on alternative types of prey that might be harder to catch and less nutritious.

Quality shallow habitat is also lost under traditional overwater structures, such as piers and docks. The areas beneath them are bleak. They cast too much shade and seagrasses and algae cannot thrive (Burdick and Short 1999; Nahirnick et al. 2020). While you may be able to spot crabs and some barnacles or mussels under these structures, overall, there are few fish or other animals. Salmon avoid these areas — it is too dark — the lack of light seems to make salmon nervous, they cannot see predators, find ample prey, properly orient themselves, or school together (Munsch et al. 2017). They end up altering their natural behaviours and avoid the shallow areas that should be their safe havens with plentiful food (Munsch et al. 2014). Instead, salmon are swimming in deeper water, expending more energy, and exposing themselves to predators.

Coastal modification also disrupt overall land and sea connectivity (Heerhartz et al. 2014). Coastal riparian vegetation is lost on modified shores along with the insects that would fall into the water – another important food source for salmon (Toft et al. 2007). 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 successful surf smelt beach spawning (Munsch et al. 2017).

BOTTOM LINE:

Coastal modifications disrupt natural, dynamic coastal processes, ecosystems, as well as Pacific salmon. Change along our coastlines is inevitable because that's what natural coastal processes do! It is in our best interests — and salmons' —

to work with nature, not against it!

Photo by: Isobel Pearsall

Chapter 6 – Climate Change

As a result of increased atmospheric greenhouse gas concentrations, the world is facing unprecedented climatic changes and British Columbia is no exception. In Eastern and Southern Vancouver Island specifically, we are already experiencing warmer air and sea surface temperatures and rising sea levels. Extreme events, such as the record shattering 'heat dome' of summer 2021, and the record flooding of fall 2021, will also be more common.

Predicting the exact changes we will experience into the future is complex due to uncertain future emission scenarios, differences in model outputs, and natural climate variability such as periodic large-scale climate phenomena such as ENSO (El Niño Southern Oscillation). Other unpredictable events, such as the polar ice sheet melting dynamics could greatly alter sea level rise.

Photos by: Mitch Miller

Despite uncertainties, climate scientists have modeled the changes that we can expect so we can anticipate and prepare for the possible consequences. The following is a summary of the projections and impacts for coastal British Columbia.

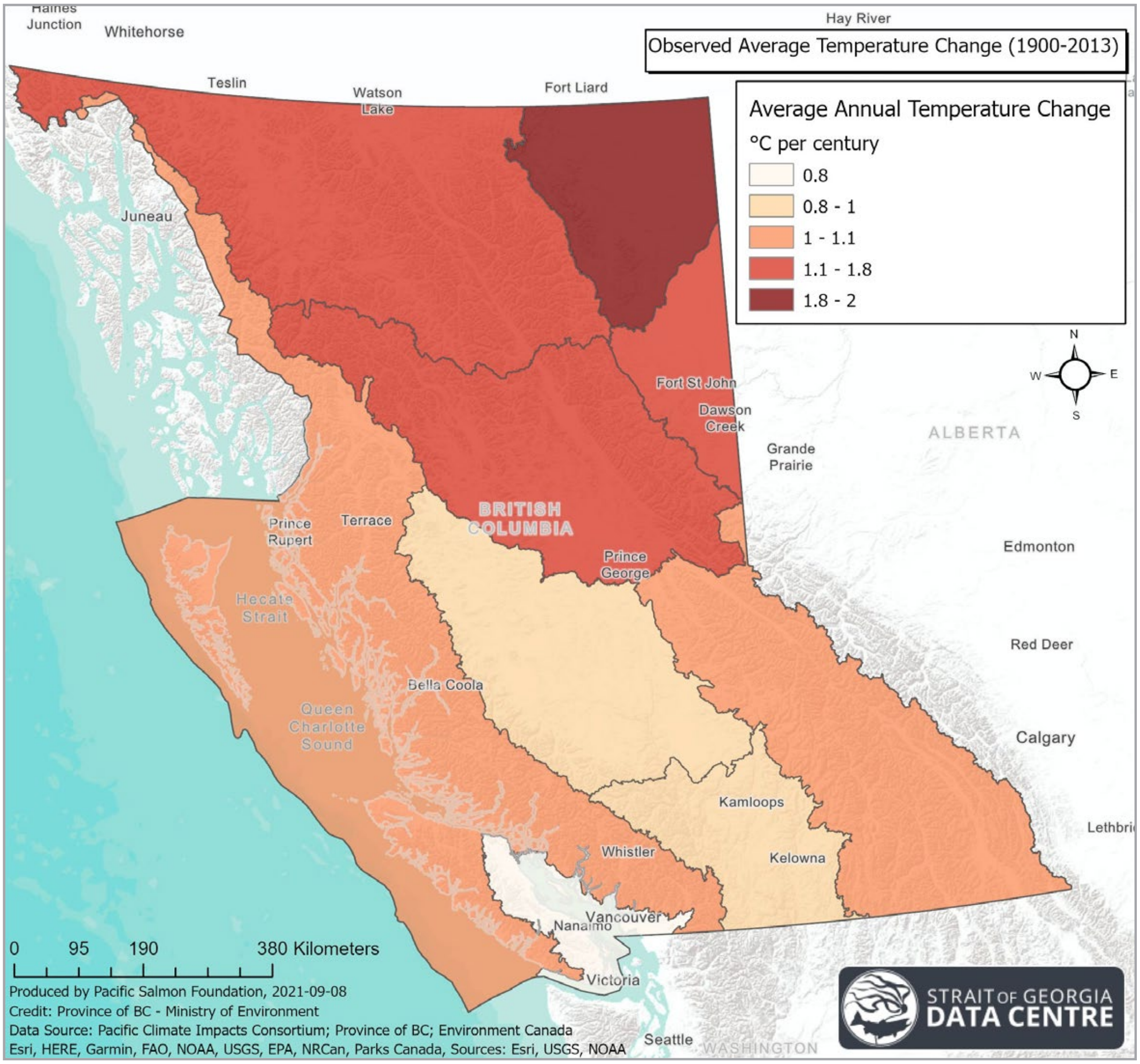


***Figure 6.1** – Map showing the observed rate of warming that has occurred across British Columbia between 1900 and 2013 by bioregion. The greatest increases have been in the Northern Interior whereas the lowest rate of increase to the average annual temperature to date has been in the Strait of Georgia region at a rate of 0.8° C per century.*

Source: Strait of Georgia Data Centre, Pacific Salmon Foundation

Air Temperature

Figure 6.1 depicts the annual average temperature changes in degrees Celsius between 1900 and 2013 throughout different regions of BC. The greatest increases in air temperatures have occurred in the central and northern parts of the Province. Air temperatures in the Eastern and Southern Vancouver Island regions have been relatively stable in the past, but are expected to become warmer and possibly more variable into the future.

The warming experienced to date has been most noticeable for winter night-time minimum temperatures. This trend is expected to continue. Projections for the Capital Regional District indicate that we will rarely have days that dip below freezing except at higher elevations (CRD 2017). This will have implications for our snowpack and river flows as detailed below.

The record shattering 'heat dome' event that blanketed an extensive area of the Pacific Northwest for about a week in June 2021 would have been virtually impossible without human-caused climate change (Phillip et al. 2021). The magnitude and duration of this event has been linked to extensive ecosystem damage. It was estimated that over a billion intertidal creatures were killed by the extreme heat. Summer heat waves like this will become more frequent and intense (IPCC 2021), especially in lower elevations and valleys (CRD 2017).

Sea Surface Temperature

Long-term trends show that the sea surface temperatures have been increasing globally (IPCC 2019) and the same is true along the BC coast (Amos et al. 2015; DFO 2019) and it is projected to continue (Greenan et al. 2019). The Institute of Ocean Sciences in Sidney BC maintains a long-term data set of both daily sea surface temperature and salinity observations taken at a number of shore stations throughout BC: most of these are lighthouses, and the data have been collected since 1914 for some stations! These data show a linear and increasing trend in sea surface temperatures throughout BC ocean waters over the last 85 years (DFO 2019) (Figure 6.2).

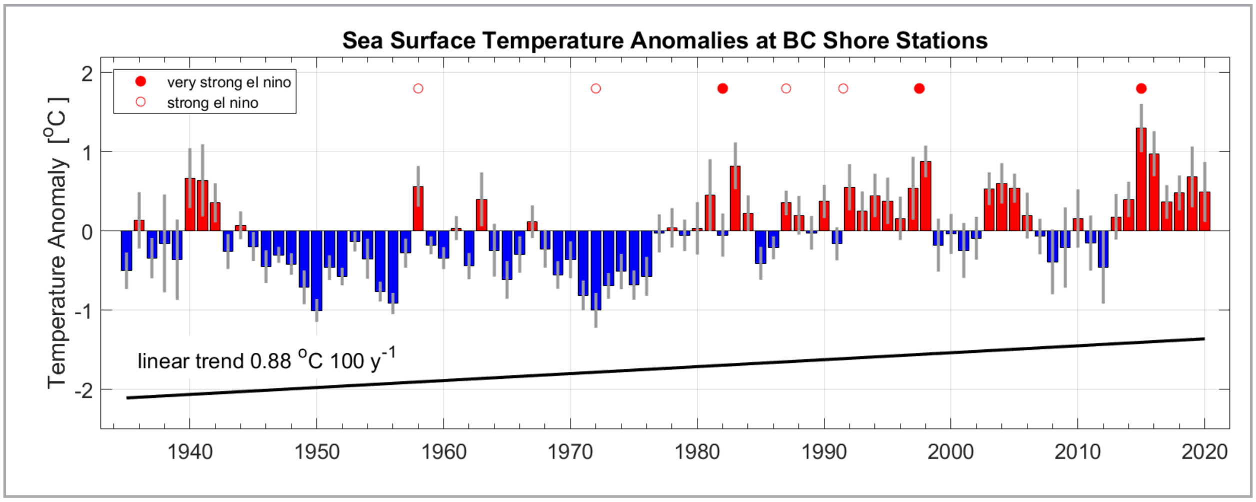


***Figure 6.2** – Trend in annual sea surface temperature based on the observations of all lighthouses from the British Columbia Lightstation Network Dataset. representing inner and outer coast stations. The bars represent anomalies, averaged across all monitoring locations, from the long-term average temperature (1935-2020). Blue bars indicate below average temperatures for that year and red above average. Error bars indicate the variability between lighthouse data for each year. Figure, used with permission, appears in the State of Pacific Ocean Report (DFO).*

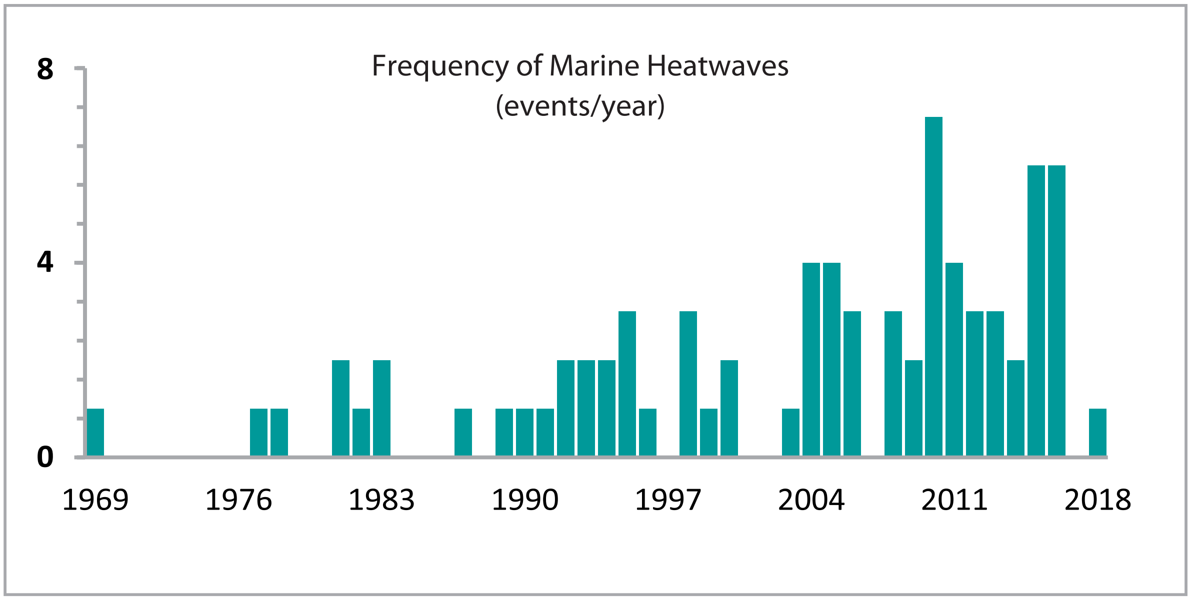


***Figure 6.3** – Number of heatwaves experienced each year in Baynes Sound, east coast of Vancouver Island, based on marine sea surface temperature measurements at the Chrome Island Lightstation from 1969 to 2018. Criteria for a marine heatwave from Hobday et al. 2016, defined as at least five consecutive days that the recorded temperature exceeded the 90th percentile for that calendar day of a baseline dataset of at least 30 years, in this case, the entire available data set of 50 years was used.*

The rate of increasing sea surface temperature varies significantly around British Columbia by region. The increases have been most pronounced for the southern/inner coastal region (Strait of Georgia stations as well as Race Rocks station in the Strait of Juan de Fuca). Based on the BC lightstation dataset, between 1973-2010 the southern/inner coastal region sea surface temperatures have been rising at a rate of 0.40°C per decade (group mean) whereas the temperatures in the northern/outer coastal region have been rising at 0.12°C per decade (Amos et al. 2015). For comparison, the global average rate of sea surface temperature increase has been 0.19°C per decade (IPCC 2013). The dichotomy between the Strait of Georgia and the outer shelf temperatures appears to be increasing with time and is influenced by different factors. Sea surface temperatures for the outer shelf correlate with larger scale oceanographic phenomenon such as the Pacific Decadal Oscillation (PDO) while temperatures in the Strait of Georgia appear to be influenced more locally (Amos et al. 2015). If these trends continue, the sea surface temperatures in the Strait of Georgia may increase by 3°C by 2100 (Amos et al. 2015).

Warmer sea surface temperatures from climate change on top of natural climate fluctuations increase the risk of marine heat waves. Marine heatwaves are extreme temperature events that exceed normal seasonal values. During marine heatwaves, the thermal tolerances of marine species can be exceeded and result in stress or death. Marine heatwaves can range from a relatively brief but intense/high temperature spike to a less intense but longer lasting event. In the future, marine heat waves are projected to increase in frequency, intensity, duration and spatial extent globally (Oliver et al. 2019, IPCC 2019) and El Niño events are projected to occur twice as often (IPCC 2019). Figure Figure 6.3 shows the increasing prevalence of marine heat waves off the east coast of Vancouver Island, at Baynes Sound.

The consequences of warmer ocean temperatures are far reaching. Warmer waters have been implicated in the loss of important habitats such as eelgrass meadows and kelp forests that are crucial to the life cycles of many species including salmon. Pacific salmon fitness, growth and survival can be negatively impacted by warming waters (Vadeboncoeur 2016) while increased incidence of harmful algal blooms, biotoxins and disease outbreaks are also associated with warmer sea surface temperatures. It is also anticipated that there will be cascading impacts to the food web.

Warmer water temperatures can alter the type, abundance, quality and timing of food sources that are available. There are multiple mechanisms by which higher sea surface temperatures can shift how the marine food web will function. First, warmer water tends to stratify, or become a layer, on the surface which reduces its ability to mix with the deeper waters during a process known as upwelling. Upwelling is important because it brings up cooler, more nutrient-rich waters to the surface. Without this mixing there are fewer nutrients available to support the marine food web. This will decrease or change the type of phytoplankton blooms, which in turn will impact the resultant zooplankton biomass and assemblages. Warm water species of zooplankton tend to be less nutritious and their blooms also peak earlier in the season (Johannessen and Macdonald 2009). Another way food web dynamics can be affected is that warmer temperatures can be more favourable to particular species over others. For example, there have been alarming jellyfish blooms in the Strait of Georgia in recent warmer than normal years. The jellyfish form huge clusters — that may weigh as much as 120 tonnes — and compete with other organisms for food. It's been shown that these jellyfish blooms negatively impact salmon and are generally considered a "trophic dead-end" (Ruzicka et al. 2016).

And finally, these impacts can create mismatches in the timing of specific food web interactions — for example, shifting the timing of herring spawn or zooplankton blooms as related to when salmon outmigrate, which can be make or break for salmon that miss important food resources.

Ocean Acidification

Another consequence of the increasing carbon dioxide (CO_2) emissions driving climate change is ocean acidification. Atmospheric carbon has increased tremendously since the Industrial Revolution, with fossil fuel burning being the primary source. As part of the normal carbon cycle, ocean waters absorb about 25% of all CO_2 emissions, which maintains the pH of seawater at a slightly basic level (pH > 7). With higher levels of CO_2 in the atmosphere, seawater is approaching neutral pH, meaning ocean waters are becoming more acidic. More acidic conditions make it more difficult for organisms that rely on calcium carbonate for their shells to form properly. This will challenge shellfish growers and many of our native shellfish species, including clams and crabs. Larval crab and other small crustaceans are vital to the food web and are an important food source for juvenile salmon!

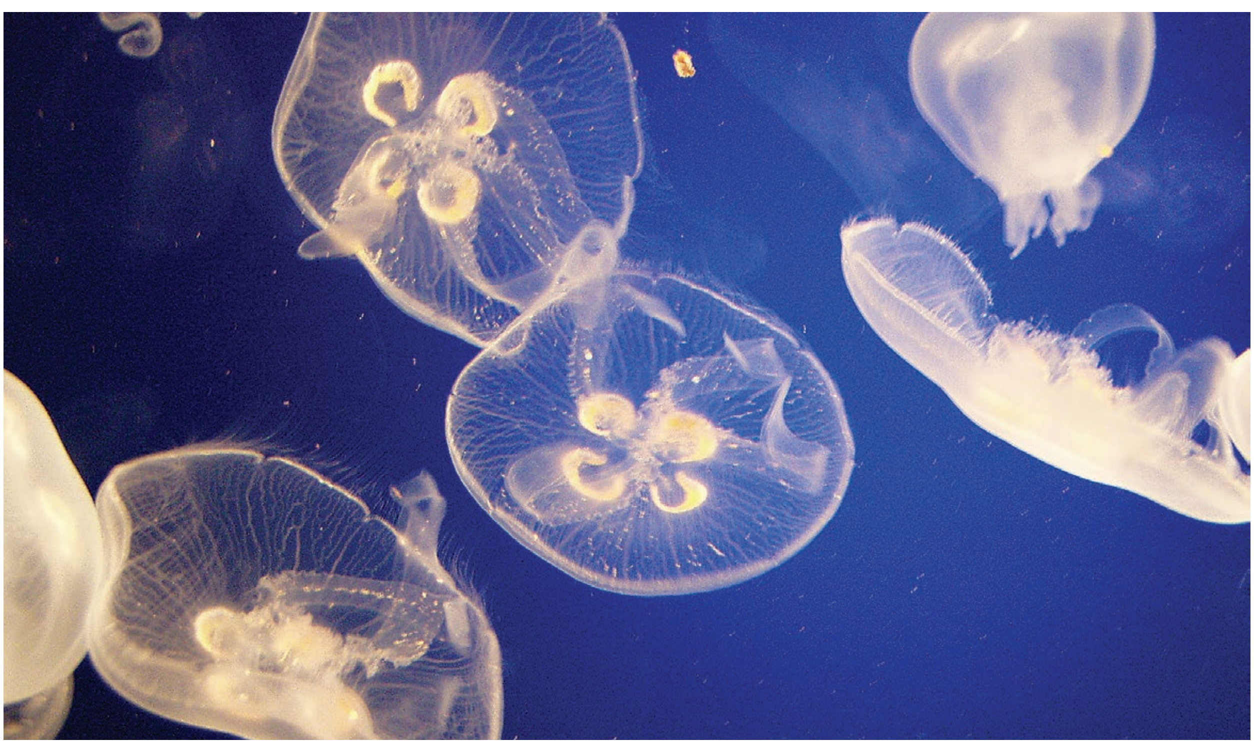


Photo by: Keith Burgin on FreeImages.com

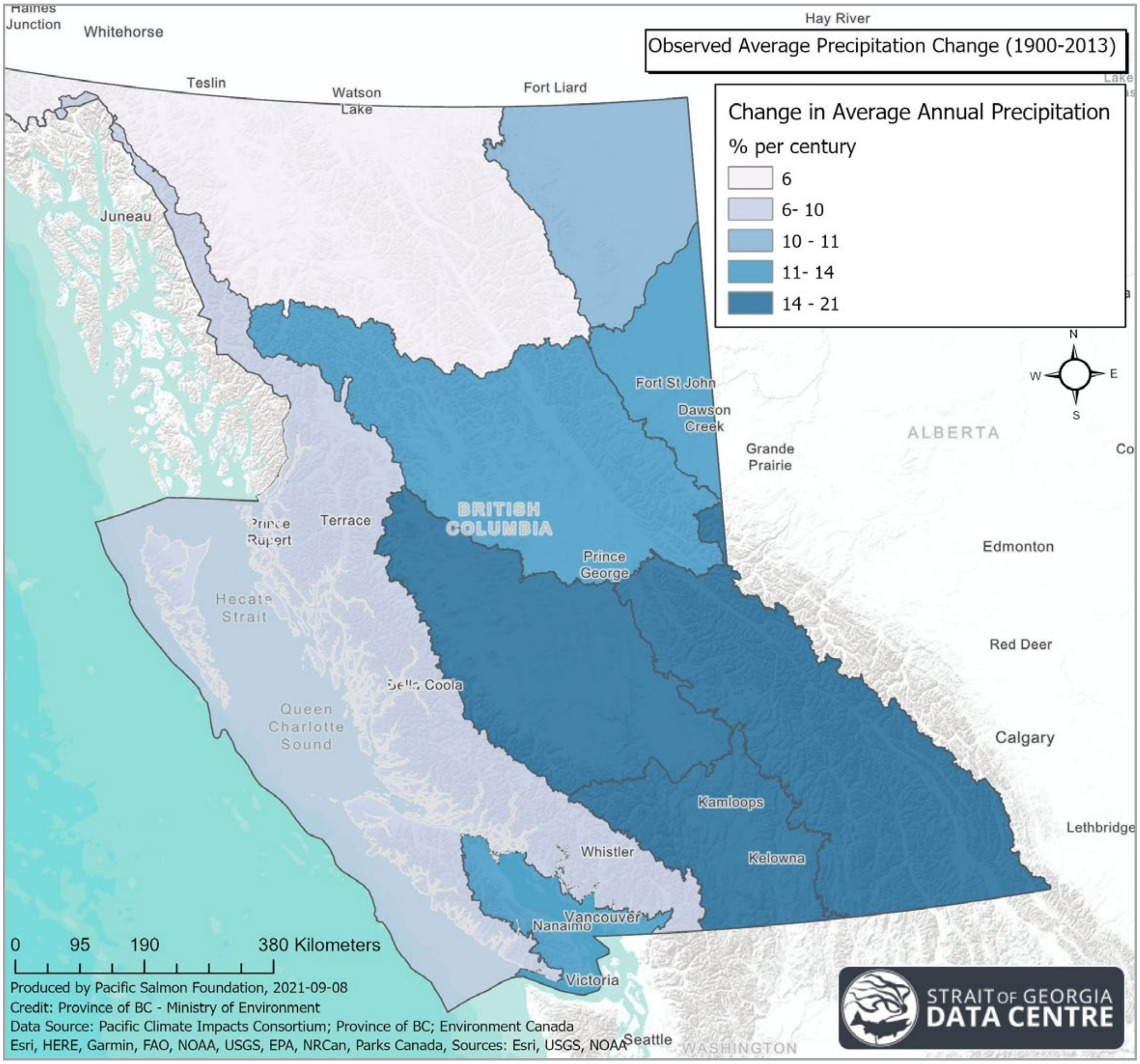


***Figure 6.4** – Map showing the observed change in total precipitation that has occurred across British Columbia between 1900 and 2013 by bioregion. The greatest changes have been in the southern interior. The Strait of Georgia has had a relatively moderate shift at a rate of 10-11% per century.*

Source: Strait of Georgia Data Centre, Pacific Salmon Foundation

Precipitation

Overall, there has been a 14% increase in average annual precipitation per century in BC, with the greatest increases in the BC interior (Figure 6.4). The greatest increase (23%) in seasonal precipitation has been during spring for the Georgia Depression specifically (MOE BC 2016). In the future it is anticipated that the cooler months will see more precipitation, but the summer will become drier (CRD 2017), with a projected decrease in summer precipitation under a high emissions scenario and a small change under a low emission scenario (Zhang et al. 2019).

In winter, less precipitation will fall as snow due to warmer temperatures. This results in reduced snowpack in higher elevations and a loss of consistent melt waters that are so important to sustain streams though the dry season.

River Temperatures and Flow

River temperatures fluctuate naturally with the seasons, but, on average, river waters will warm as our air temperatures increase. During summer hot spells, river temperatures can exceed the threshold of what some aquatic species require to survive.

With snowmelt occurring earlier in spring and early summer, there will be less flow for rivers in later months (CRD 2017). As a result, smaller southern rivers in British Columbia may dry up during summer and early fall — resulting in possible stranding of rearing populations of salmon in ephemeral or side channel habitats. Low fall flows also can impact the critical spawning window for Pacific salmon (MOE BC 2016).

This combination of warmer river waters, and lower river flows and water levels can impede spawning salmon migration, since at times they will need to wait for water to cool and levels to increase. As the fish mill in estuaries and lower river areas waiting for flow levels to increase, they are subject to increased predation and pre-spawning stress. This unfortunate combination is projected to occur more often and will affect the ecosystems and communities that rely on salmon (see Chapter 3).

Meanwhile, increased precipitation in the fall and winter is likely to create more frequent high river flow and runoff events, particularly because less will fall as snow. This can cause overland flooding and erosion along rivers, which could threaten homes and other structures. Heavy rainfall events also have the potential to destabilize slopes, which could trigger mass movement events like landslides, as well as lead to blockages of logs and other debris, causing rivers to overflow their banks. We observed all of these consequences in November 2021, when a series of intense 'atmospheric river' storm events dumped record rainfall across southern British Columbia. This flooding is likely to be the most costly natural disaster in Canadian history due to all the infrastructure and property damage (Judd 2021). It is expected that the event will severely affect several populations of salmon (Nair 2021). Higher flows will impact salmon habitats by lowering water clarity due to increased sediment inputs, scouring spawning gravel and threatening the stability of riparian vegetation that provide salmon shade, cooler waters and insect food sources (MOE BC 2016). Stronger flows could potentially make migration much more difficult for Pacific salmon, and wash away salmon eggs from their redds (nests) in the gravel.

SYNERGISTIC IMPACTS: HIGHER SEA LEVELS AND BIGGER STORMS

Photo by: Marcus Woodbridge on Unsplash

Together, the different impacts associated with climate change can be cumulative, resulting in even greater consequences and challenges for the environment and people alike. This will be true when higher sea levels and larger and more intense winter storms come together. In addition to increasing sea level, low-lying regions will also experience increasing wind, wave height and storm intensity (IPCC 2019). This increase in storm intensity is expected to create even higher storm surges leading to a heightened potential for shoreline erosion, and will cause low lying regions to flood with regularity. By 2050, historical extreme flood events that occurred every century, are projected to increase in frequency, occurring on average at least once a year in many low-lying regions (Oppenheimer et al. 2019). This can result in increased threats of flooding and erosion, placing our homes, our beaches and wetlands, and cultural sites of importance at risk (MOE BC 2016).

Sea Level Rise

Warming temperatures from climate change have a very significant impact on ocean levels globally. Sea levels rise because warmer ocean waters expand in volume and because additional amounts of fresh water are drained into oceans from melting glaciers and polar ice caps. These changing levels along our coastlines, in combination with larger and more intense winter storms with increased wind and wave height (IPCC 2019), will create more occurrences of flooding with resultant erosion and damage to shoreline infrastructure.

In particular, low-lying regions will be particularly vulnerable to more frequent flooding. By 2050, historical extreme sea level events that occurred every century, are projected to increase in frequency, occurring on average at least once a year in many low-lying regions (Oppenheimer et al. 2019). This can result in increased threats of flooding and erosion, placing our homes, our beaches and wetlands, and cultural sites of importance at risk (MOE BC 2016).

See the next chapter for more information on the impacts of sea level rise on our shorelines and coastal ecosystems.

Summary

The table below (Table 1) provides a summary of the predicted changes to climate indicators in British Columbia. Climate change is already occurring, and impacts will only worsen in the future.

Table 1. Projected changes to various climate indicators for Southern Coastal British Columbia.

Parameter	Future Changes
Heat and Cold	
Mean air temperature	**↑**
Extreme heat	**↑**
Cold spell	**↓**
Frost	**↓**
Wet and Dry	
River flood	↑
Heavy precipitation	↑
Hydrological drought	↑
Agricultural and ecological drought	↑
Landslide	↑
Fire weather	**↑**
Wind	
Mean wind speed	**↓**
Severe wind storm	↑
Snow and Ice	
Snow, glacier and ice sheet	**↓**
Lake, river and sea ice	**↓**
Snow avalanche	↓
Coastal	
Relative sea level	**↑**
Coastal flood	**↑**
Coastal erosion	**↑**
Marine heatwave	**↑**
Ocean and lake acidity	**↑**

Projected trends indicated by arrows: ↑ indicating increasing, ↓ indicating decreasing. Bold (**↑↓**) indicates high levels of confidence in the trends for the future. Non-bold (↑↓) indicates medium levels of confidence. Information is based on the model projections and the best available information that is contained in the IPCC Working Group 1: Sixth Assessment Report. Table adapted from the IPCC climate regional summaries for the Western North American and North-Western North America regions accessed from the IPCC Interactive Atlas tool. The trends presented apply on a large regional scale and may vary on a localized scale. Details for the methods behind the IPCC Interactive Atlas are available here.

All of the predicted and currently occurring changes shown in Table 1 will result in an array of impacts to our populations around the Salish Sea and throughout BC. Figure 6.5 depicts many of the possible consequences of changes in climate in BC.

The many different impacts associated with climate change will require significant and creative adaptation measures to manage the increased consequences and risks to our shorelines. These are discussed in Chapter 8.

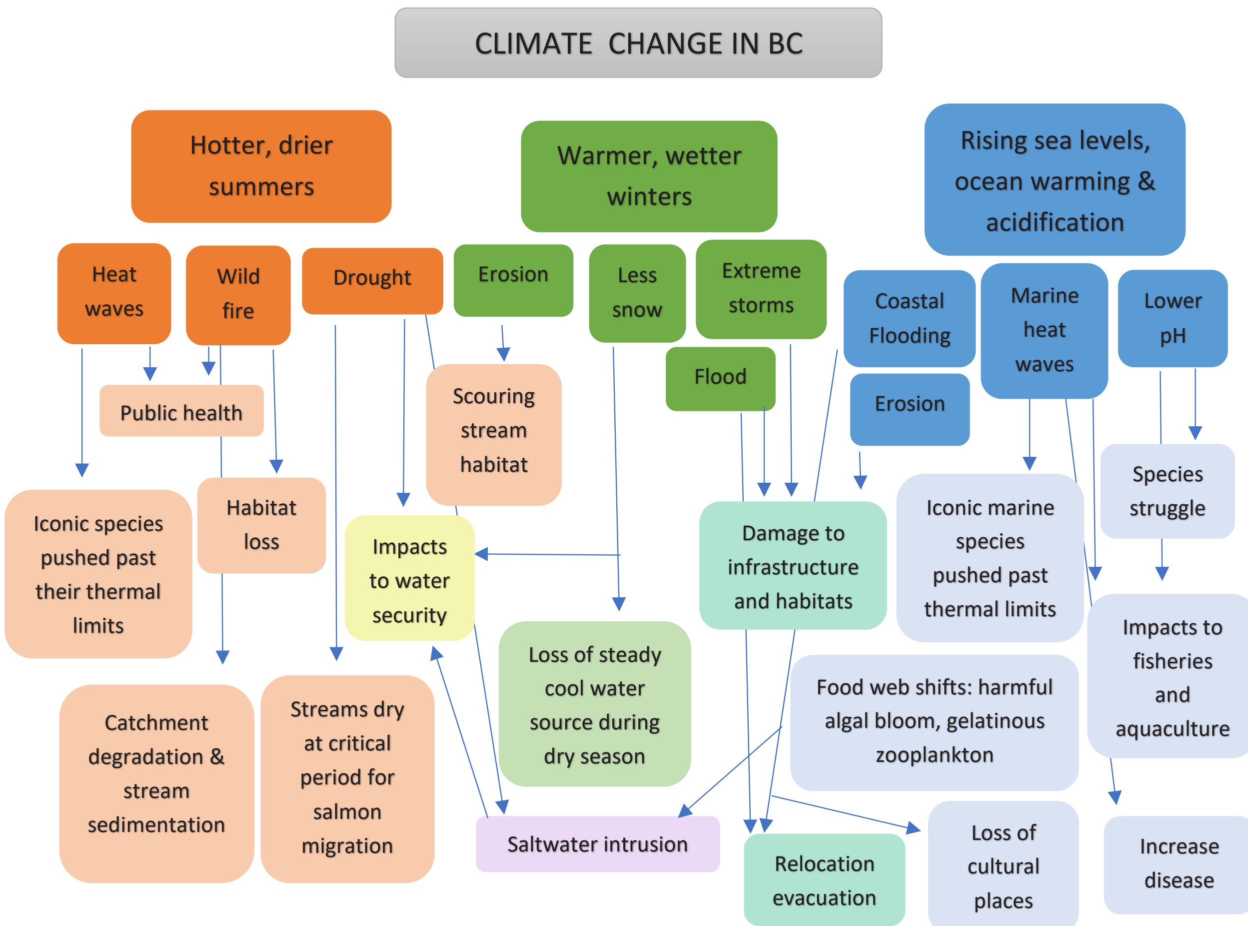


Figure 6.5 – Various impacts of climate change that are or will likely be felt throughout BC.

BOTTOM LINE:

Climate change is happening in BC and we are starting to see impacts to our marine, freshwater and terrestrial ecosystems, our communities and livelihoods. This will include significant impacts to our shoreline, discussed further in the next chapter.

Chapter 7 – How Sea Level Rise is Changing Shorelines

Canada has, by far, the longest coastlines in the world. Yet, our shores are at risk. As sea levels rise, communities are becoming more exposed to flooding, storm surge, erosion and saltwater intrusion. The financial implications of sea level rise in combination with extreme weather events are huge and are already being felt by a growing number of homeowners and communities across British Columbia. Equally significant are the ecological and social implications.

Sea Level Rise

The National Oceanic and Atmospheric Administration (NOAA 2017) projects global sea level rise will be between 30 cm and 2.5 m by 2100. This wide range is mainly due to the uncertainty in the response of the massive Greenland and Antarctic ice sheet disintegration to regional warming across a variety of future emissions scenarios. The impacts of rising sea levels are anticipated to vary markedly among coastlines due to local topography, currents, geological processes such as tectonic activity and post-glacial adjustment. Modelling of the low to intermediate emissions scenarios, suggest that much of the Pacific Northwest will experience less sea level rise than the global average (NOAA 2017).

Changing ocean volume, due to climate change, can be combined with estimates of local uplift along the coastline (due to geologic forces) to yield projections of relative sea level rise. Over the last century, certain portions of the British Columbian coast have had a rise in average sea level, while in some areas the sea level has fallen due to land uplift (tectonics and post-glacial rebound). For example, the west coast of Vancouver Island is being uplifted by tectonic forces faster than sea level rise, with the result that local sea levels are appearing to fall.

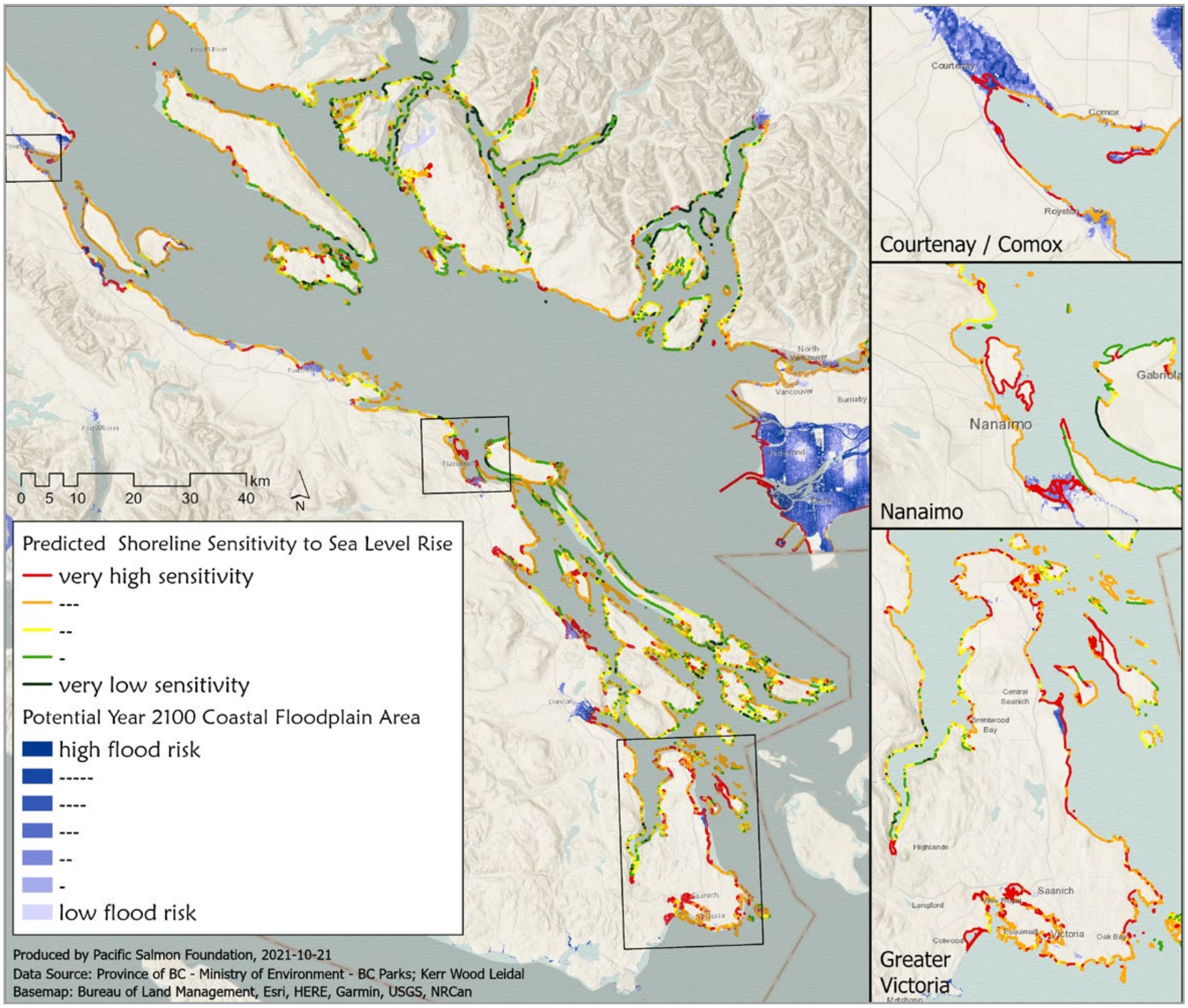


***Figure 7.1** – Maps depicting coastal areas shoreline sensitivity to sea level rise and flood risk in a) Greater Victoria, b) Nanaimo and c) Courtenay/ Comox. Degrees of sensitivity marked by red, amber, yellow, green and black in order from most to least sensitive. Areas that are projected to be vulnerable to coastal flooding by 2100 are shaded in blue. The 2100 coastal floodplain area dataset uses sea level rise and approximate flood construction levels (FCLs). It includes a nominal allowance for wave effects but does not account for river flooding effects nor a combination of these effects with sea level rise, the presence or absence of flood protection structures, and has not been ground truthed. Data are from the Province of BC and Kerr Wood Leidal.*

Source: Strait of Georgia Data Centre, Pacific Salmon Foundation

In Victoria, the sea level has risen at a rate of 6.6 cm per century, and this rate is accelerating (MOE BC 2016). Sea level rise is projected to be greatest on the north coast, the Fraser Lowland and around southern Vancouver Island (Vadeboncoeur 2016). Sea level rise projections for southern Vancouver Island, the region surrounding the City of Vancouver, and northern coastal BC by the year 2100 range from 50-70 cm (median model change under RCP8.5; not accounting for the possibility of Greenland and Antarctic ice sheet disintegration), while the rest of Vancouver Island is projected to experience a much smaller relative rise in sea level (Vadeboncoeur 2016). Even at the modest end of this range, our coastlines as we know them will inevitably change.

Many mapping initiatives are underway in BC to map the predicted sensitivity to sea level rise and vulnerability to flooding of different areas: Figure 7.1 shows the sensitivity of the coastline around many parts of Eastern Vancouver Island. Many of the low-lying areas of southern Vancouver Island could become permanently or periodically flooded in the future.

Photo by: Phillip Flores on Unsplash

Flooding

Many coastal communities have been built on floodplains. Floodplains are low-lying areas that are naturally inundated from time to time. With increasing extreme rainfall events coupled with higher sea levels, flooding will occur more often. Flooding will also occur as a result of storm surges. Storm surge occurs when stormy weather pushes tidal levels higher — resulting in crashing waves hitting above the normal intertidal zone. This will be especially dangerous and damaging when storm surge occurs during high 'king' tides. In developed areas, there are often buildings and other infrastructure built in coastal areas that will be affected.

Erosion

Crashing waves hitting higher on the shoreline will cause increased erosion. Coastal bluffs will crumble at greater frequency than they had previously. Shorelines that have hard armour, like riprap and seawalls, may be undercut causing them to fail. In many locations, accelerated erosion may damage culturally important places, threaten structures and impact intertidal habitats.

Strong winds can create larger waves when there is a large fetch (the distance waves are able to travel across open water without intercepting islands or other land masses). Greater fetch over longer distances increases wave intensity causing a greater threat of coastal flooding.


Photo by: Mitch Miller

***Figure 7.2** – Coastal squeeze occurs where structures like seawalls impede the natural shoreline to adjust to rising sea levels. Natural shorelines leave room for vegetation and tidal zones to move landward.*

Illustration by: Holly Sullivan

Saltwater Intrusion

As seawater moves landward over time and floods low lying areas more often, a phenomenon called saltwater intrusion can occur. Saltwater intrusion is the movement of salty water into freshwater aquifers. Because saline water has a higher mineral content than freshwater, it is denser and has a higher water pressure. As a result, saltwater can push inland beneath the freshwater. This will impact the water quality of groundwater, making it unsuitable for drinking or irrigation. Those in coastal areas that rely on well water will need to secure alternative sources of water if they become affected.

Salmon will experience a reduction in food resources such as vital Pacific sand lance, as a result of loss of critical spawning habitats for forage fish.

Coastal Squeeze

When shorelines are hard armoured with seawalls and riprap, it prevents habitats from naturally migrating landward with sea level rise (Figure 7.2). As sea levels rise, the high-water line is restricted by these structures and coastal processes are impeded. This reduces intertidal habitat and eventually can cause a complete loss of intertidal areas and the associated species. This is known as *coastal squeeze*.

Forage fish, an important food source for salmon, rely on intertidal habitat for spawning. Where coastal armouring structures are in place, their critical spawning areas will be squeezed out. The populations of forage fish will suffer as will the entire food chain if natural coastal processes and habitats are not intact. To learn more about forage fish, see Chapter 2.

Reducing the amount of armoured shoreline and preventing future armouring is critical to the ecological resilience of BC's coasts. The fact remains that sea levels are rising, and protecting our communities is a priority. The good news is that there are sustainable approaches for coastal protection that can protect our homes from climate change related damage in the near term while minimizing our impacts on valuable shoreline ecosystems!

For more information and interactive maps about sea level rise in Southern Vancouver Island follow this link: Surging Seas: Seeing Choices.

FINANCIAL IMPACT

In Canada, damage due to climate change and extreme weather events has cost, on average, $1.8 billion each year between 2009 and 2017 (Moudrak et al. 2018). This is a massive increase compared to previous years where the average was $405 million per year between 1983 and 2008. The primary driver of this jump is coastal and inland flooding which causes expensive water damage. Flooding is not only financially costly, but it also contributes to stress and anxiety, impacting mental health of those affected. Destruction from flooding can be life altering — potentially causing families and individuals to relocate, or to struggle financially as they go through the process of repairing or replacing homes and other infrastructure.

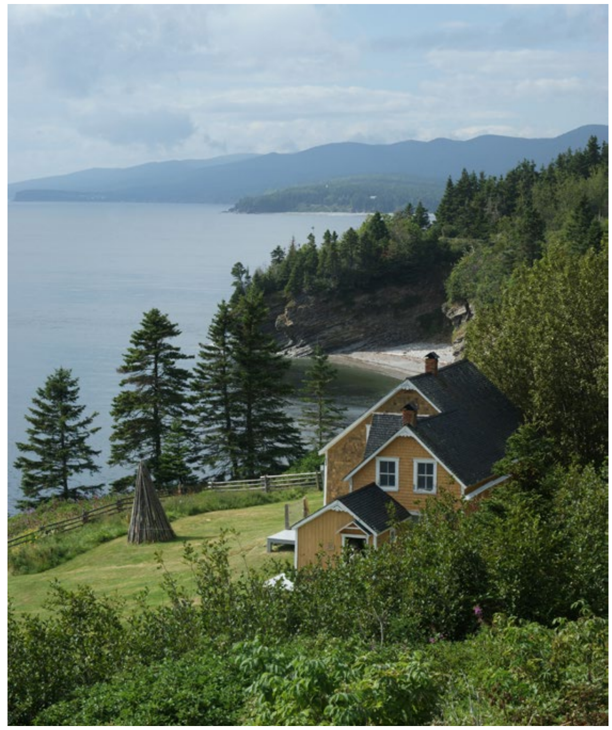


Figure 7.3 *– Moving your home back from the shoreline or planning new builds far away from shorelines is a pre-emptive strategy to plan for sea level rise.*

Photo by: Aude Lozano on Unsplash

Adapting to Sea Level Rise — BC Coastal Adaptation Strategies

Clearly, we need to plan and adapt to a future of higher sea levels. Options for mitigating the threat of sea level rise are to 'Protect', 'Retreat', 'Avoid' and 'Accommodate'.

Protect

One of the strategies to face sea level rise, is to 'protect' coastal properties using hard armouring structures. Although hard armouring structures such as seawalls (bulkheads), riprap and rock revetments, can be rapidly built and protect individual properties, it is a reactive, expensive and short-term strategy. As we have seen, hard armouring structures will not protect properties forever. As sea levels rise and with time, the hard armouring structures will weaken, and higher incoming waves will overtop them, impacting buildings and homes behind them. Hard armouring on shorelines also impedes natural processes, reduce important habitats and exacerbates the effects of rising sea levels (See Chapter 5).

Avoid

Avoiding building along shorelines is another strategy. This should be applied to new developments; whereby low-lying areas are avoided. Construction must be planned far enough from the shoreline to negate the need for hard armouring structures. Consideration must be given to where tidal flooding will reach in the decades to come.

Accommodate

Coastal development may continue so long as we adapt to the rising sea and 'accommodate' for the changes. The accommodate strategy means coastal communities plan for a changing sea level. These plans leave areas along the coastline undeveloped to allow natural processes and the natural migration of habitats to occur. Nature-based solutions such as Green Shores, detailed in Chapter 8, is an excellent example of how we can accommodate sea level rise.

Retreat

Managed retreat refers to relocating structures that are close to the shoreline to protect them from future damage from sea level rise (Figure 7.3). Although this will be costly in the short term, it will be necessary in many low-lying regions.

BOTTOM LINE:

The need to protect communities, properties, culturally important places and resources, and overall ecosystems is urgent. We can choose to **manage our coastlines** to be as adaptive and resilient as possible.


Photo by: Christy Wilson


Photo by: Maria Catanzaro

Chapter 8 – Stewardship of Shorelines

Defined as 'the way in which we take care of something', *stewardship* of our shorelines provides opportunities and challenges to protect all the things that matter in and around these important areas. Shorelines provide work, recreation, living space, and wonderful views. They are also biologically rich, ecologically productive and culturally significant places.

As development pressures increase, many of the natural features that make shorelines so attractive are often casualties. Native trees, shrubs and grasses are cleared to make way for houses, lawns, and more expansive views. Synthetic herbicides, pesticides and fertilizers required to maintain those lawns impact the shoreline through chemical contamination in runoff. Removal of large trees takes away the important functions of overhanging vegetation including shading for temperature control, and provision of food such as leaf litter and insects to the shoreline.

All of these factors lead to the loss of habitat for wildlife and disruption of the food web that connects the land, freshwater systems and the oceans, ultimately affecting iconic aquatic species such as salmon and whales. Additionally, challenges to the shoreline are becoming more prevalent due to the impacts of climate change.

Stewarding our shorelines for the benefit of current and future generations in the context of changing climate can be challenging. And how we approach these challenges will determine if our coastlines can sustain themselves and help us be resilient to climate change. The good news is that people are finding new strategies, such as nature-based approaches, to protect their waterfront properties while also protecting and restoring habitats. As alternatives to hard armouring structures, coastal community members are adding sediment to beaches, planting native vegetation and regrading slopes to improve shoreline habitat and help slow down incoming waves. This will protect the characteristics of a natural shoreline and the properties adjacent to them.

Nature-based solutions such as those noted above are an important tool for successful stewardship of shorelines. Whether you live on the shore or not, here we discuss some of the many possible ways that we can be stewards and make a difference!

***Figure 8.1** – Stewardship on Pender Island - volunteers help prepare eelgrass shoots for restoration in 2019 with SeaChange Marine Conservation Society.*

Photo by: Maria Catanzaro

Definition of a Nature-Based Solution

A nature-based solution (NbS) in its most broad definition, is one that develops and implements approaches that are inspired and supported by nature. They are cost-effective, can vary in size, scale and objectives, and may be created with local materials and expertise. Working *with* nature, NbS provide ways to enhance shoreline resilience to development and climate change, while providing environmental, economic and societal benefits.

Using Nature-Based Solutions to Protect Shorelines

Homeowners are finding that nature-based solutions can be used to protect their waterfront properties while also protecting and restoring habitats. For example, as alternatives to large concrete seawalls, docks with creosote treated pilings, and vegetation that is non-native, these new practices use a combination of structure setback, planting with native species, beach nourishment with sand and gravel, and slope modification to protect the characteristics of a natural shoreline while protecting the properties adjacent to them. Additionally, managing the area above the shoreline, the upland, also benefits shoreline health. Every bit of effort does matter to reduce the cumulative impact of development on shorelines.

WHAT IS STEWARDSHIP?

Stewardship is about taking responsibility to promote, monitor, conserve and restore ecosystems for current and future generations of all species. There are three types of environmental stewards:

1. **Doers** help out by taking action on the ground.
2. **Donors** help by donating money, land or other resources.
3. **Practitioners** work to steer agencies, scientists, property owners or managers, stakeholder groups or other groups toward a stewardship outcome (stewardshipcentrebc.ca).

There are endless ways to become a Doer! Interested in keeping our shorelines free of litter? Join a beach clean up event with local organizations like the Surfrider Foundation, World Wildlife Fund and Peninsula Streams Society. Want to learn about shoreline habitat and help restore degraded areas? Volunteer as a citizen scientist to sample your local beaches for forage fish or help restore eelgrass beds! You can even share your passion and knowledge by being a volunteer with educational centres such as the Shaw Centre for the Salish Sea in Sidney, BC. Learn about all the amazing opportunities where you can be a steward in your community! (For more information, see our site resilientcoasts.ca)

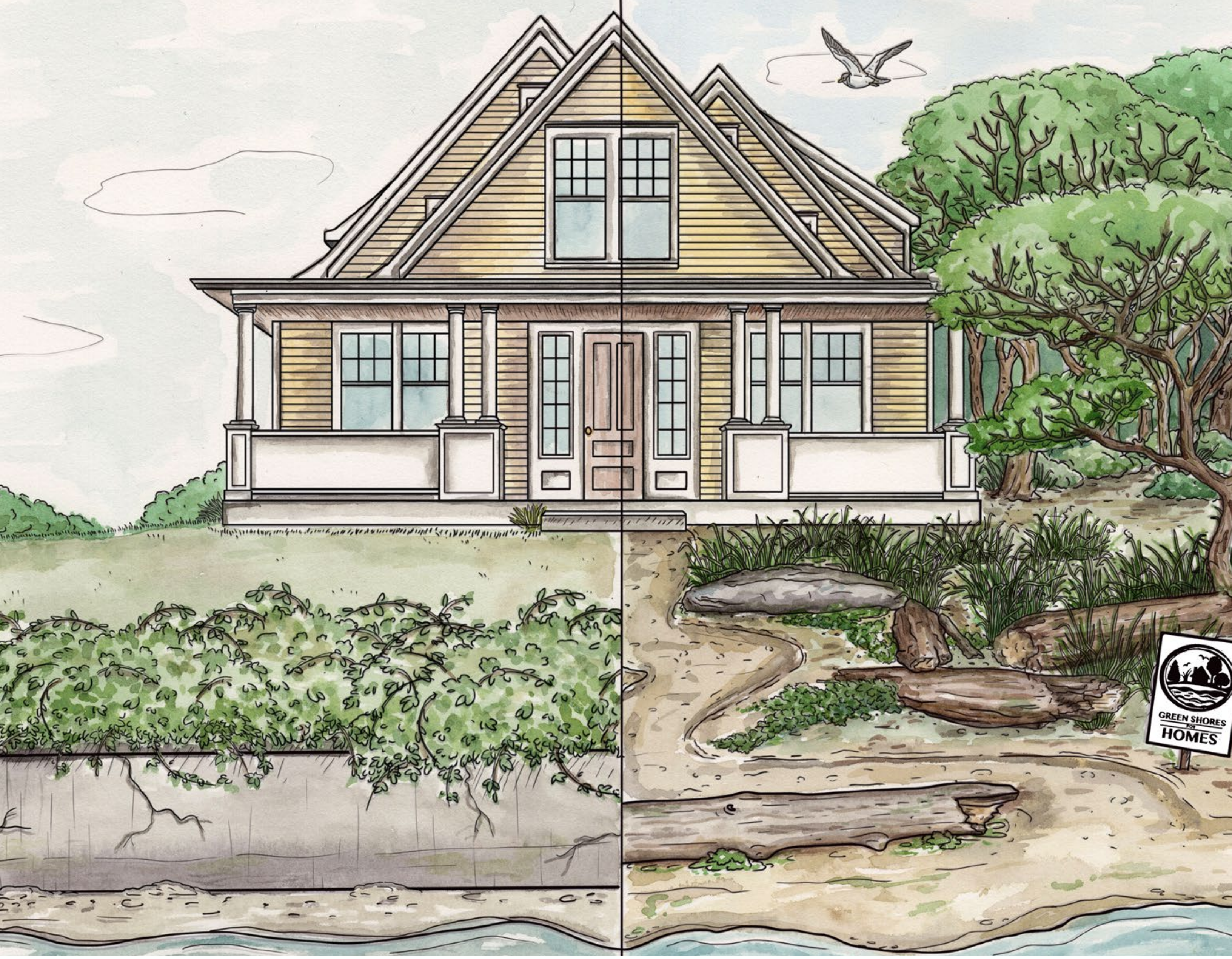


***Figure 8.2** – Using the principles of Green Shores for Homes, you can transform your shoreline from armoured and bare to lush and natural!* - Illustration by: Holly Sullivan

Green Shores® offers a Framework of Nature-based Solutions for Shorelines

Green Shores is an initiative of the Stewardship Centre for British Columbia with the broad objective of increasing capacity to address impacts of shoreline development, including climate change, on shoreline ecology and human well-being. It is a made-in-Canada approach that uses a multi-disciplinary, integrated framework to shoreline management by encouraging adoption of nature-based solutions in the design and construction of projects on marine and lake shores.

Shoreline management increasingly points to the use of nature-based solutions consistent with the Green Shores guiding principles:

1. Preserve the *integrity and connectivity* of shoreline processes
2. Maintain and enhance shoreline *habitat diversity and function*
3. *Minimize and reduce pollutants* to the shoreline environment
4. Reduce and reverse *cumulative impacts* to shoreline systems

There are many nature-based solutions that link to **the four Green Shores principles.**

For example:

Preserving the integrity and connectivity of shoreline processes could include a Green Shores project with removal of a seawall, re-sloping and addition of beach nourishment and large woody materials. This helps to restore and maintain shoreline processes such as sediment movement. Other nature-based options include marsh or estuary restoration of the foreshore, and using features that naturally attenuate wave action and provide habitat.

Maintain and enhance shoreline habitat diversity and function could include a Green Shores design that preserves or restores the riparian area through the use of natural woody materials, stones, and native plants that are well adapted to conditions of the shore environment. This type of vegetation provides food for young aquatic species, helps with wave attenuation, prevents potential erosion from storm activity, and beautifies the shoreline.

Minimizing and reducing pollutants to the shoreline environment can be achieved by reducing the potential for any upland contaminants that drain off a roof, driveway or property as shown in the following diagram, from reaching the shoreline (Figure 8.3). Methods may include use of permeable pavers, water collection systems and development of rain gardens and further details are provided below.

Reduce and reverse cumulative impacts to shoreline systems is accomplished when property owners and communities work together to implement a 'neighborhood scale' Green Shores project that links together adjacent properties. This may be more cost effective for the homeowners and more functionally effective for the ecosystems which operate at a shoreline scale.

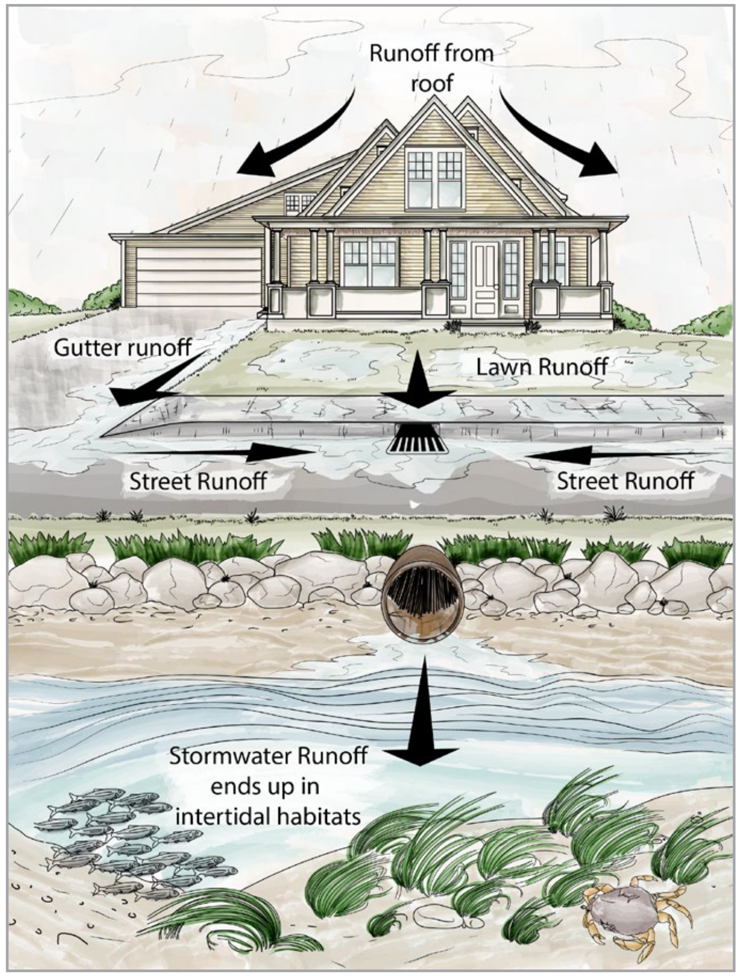


***Figure 8.3** – Typical movement of water runoff to the shoreline via paved surfaces and anthropogenic features.*

Illustration by: Holly Sullivan and Ravi Maharaj

Riparian area is defined as the transitional zone between the upland terrestrial and aquatic environments where riparian vegetation is located.

Other Benefits of Nature-Based Solutions for Shorelines

- Installation of a soft-shore can often be less costly to install and maintain than hard-armouring approaches like seawalls or retaining walls; particularly when long-term maintenance is factored in.
- The shoreline can be designed to protect properties for up to one metre of sea level rise.
- The views to, and the aesthetics of, the shoreline can be improved.
- Access to the beach can be made more user-friendly while also providing privacy for the homeowners.
- In addition to reducing risks of property damage from storm events and rising ocean levels, these designs can enhance land values.

Green Shores encourages shoreline property owners and managers to use it's principles to design and build nature-based projects through two programs: Green Shores for Homes (residential) and Green Shores for Shoreline Development (larger scale such as parks and commercial, multi-family development). It also offers Green Shores Project Certification (similar to Built Green™ or LEEDS™), a Local Government Working Group, Green Shores Training and a registry of Green Shores Approved Professionals to assist property owners.

GREEN SHORES

Altogether, Green Shores focuses on positive steps to empower landowners and managers who live on the shoreline to develop their shorelines in a manner that is *sustainable* and well adapted to changes in coastal conditions such as sea level rise.

How does Green Shores benefit homeowners AND other shoreline users?

There are numerous benefits including increased access to the shoreline with more opportunities to stroll, forage and explore the beach. Viewscapes and opportunities for wildlife viewing can be improved because habitat is maintained or improved. And in light of sea level rise and changing coastal conditions, protection of the shoreline preserves it for everyone to use.

How does Green Shores benefit the environment?

We all depend on a healthy environment. Green Shores helps to preserve or restore the natural shoreline processes that support a biodiversity of native animals and plants.

Stewarding Shorelines with Salmon in Mind

While protecting undeveloped shoreline habitat and restoring eelgrass or coastal riparian areas are important examples of stewardship, there are opportunities for stewardship in places where shoreline infrastructure is unavoidable too.

For example, we know that overwater structures, such as docks and piers, stop juvenile salmon from accessing shallow areas that are normally important refuge and foraging areas for them because they are dark and lack complex habitats (Munsch et al. 2017; and see Chapter 5). The simplest action is to avoid building more docks than necessary, and share with neighbours if possible. When an overwater structure must be built, it can be [designed considering the needs of the ecosystem](). So that it is not so dark underneath, a dock can be made more like to a bridge, that is, above the water and with fewer pilings — especially in the first few metres of the shore. Grating can be used in place of solid decking to allow more light to dapple through to the water below. It is also important to avoid the use of creosoted or chemically treated footings, which are highly toxic.

Since it is unrealistic to fully remove urban waterfronts, scientists, planners, and engineers are coming up with ways that these areas can support more biodiversity once again. Thinking beyond traditional solutions can go a long way in protecting our salmon. Seattle, Washington is leading the way by reconstructing their downtown waterfront with migrating Pacific salmon in mind. Check out the build in action! In areas that are covered with piers and walkways, glass blocks and grating have been installed to allow light to penetrate through to the water (Figure 8.4a). At the same time, on and adjacent to seawalls, they have added surface complexity that mimics a more natural shallow habitat and created depth gradients using textured face panels, constructed marine mattresses, and habitat benches (Figure 8.4b). Seattle has also converted waterfront parks and armoured areas into beaches with backshore vegetation and this has boosted habitat and prey sources for salmon (Toft et al. 2013). These beaches are a win-win as they are also very popular with the human residents. Together, these efforts turn areas of habitat that was lost long ago into places that are usable again for salmon. Learn more about this and similarly spirited projects being trialed around the world.

***Figure 8.4a** – In Seattle, salmon friendly seawalls have been built in the heart of their downtown waterfront. They are made up of glass sidewalks that allow light to dapple through to shallow rocky areas — to support salmon and their prey.* Photo by: Bob Oxborrow

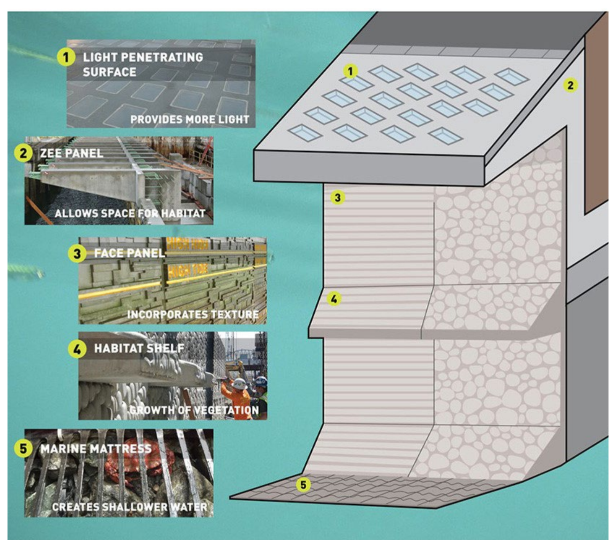


***Figure 8.4b** – The newly restored seawall features structural complexity to help mimic more natural habitat conditions for salmon and their prey.* Credit: Waterfront Seattle

Photo by: Maria Catanzaro

Everyone Can Contribute to Nature-Based Solutions!

Even those that don't live on the shoreline can help protect our beaches and oceans!

For example, there are a number of strategies to reduce polluted runoff from entering the aquatic environment, including:

- ***Using permeable pavers:*** You can replace paved areas with surfaces that allow rainwater to permeate the ground. A Green Shores design seeks to reduce the total area of impervious areas, and can include installation of permeable pavers, gravel or grass grid systems, and specialty concrete mixes, that allow storm water to filter through to the soils below. Use of these alternatives has a number of environmental benefits, including lower pollutant loads entering waterways, reduced erosion and flooding from flashy storm runoff and increased groundwater recharge. If stormwater can filter through the soil, ecosystem processes will naturally improve water quality before it makes it to a stream. It will also recharge local aquifers, which will contribute to more steady stream flows.

  Additionally, less radiant heat is retained by these alternative systems compared to traditional concrete. This will reduce heat pollution that contributes to urban heat island effect. Depending on the type of solution selected, installation methods and costs will vary. Typically, pavers are placed on a level bed that allows infiltration and spaces between are backfilled with fine gravel. Detailed installation guides and summaries of different options can be found online.

Photo by: toinane on Unsplash

- ***Building a rain garden:*** A rain garden is another nature-based solution that a homeowner can create to prevent stormwater from reaching the shoreline. Rain gardens are garden features that are designed to collect, hold and soak in stormwater in depressions planted with native shrubs and flowers. In addition to recharging groundwater, they are highly effective at preventing pollutants from entering our waterways. The plants and soil of a rain garden help to increase infiltration of surface water down into the soil where it can be filtered, and then help to recharge sub-surface aquifers. Helpful guides are available to demonstrate how to design, construct and plant a rain garden.

- ***Building a green roof:*** Green roofs can also reduce rainwater runoff from your home. While constructing a vegetated roof might not be for everyone, a green roof is another example of harnessing nature's ingenuity to reduce runoff as well as insulate your home, increase the longevity of your roof, protect property from fires, create habitat, reduce urban heat affects and store carbon.

Figure 8.5 – Rainwater Capture.
Photo by: Harry Cunningham on Unsplash

- ***Carrying out rainwater harvesting:*** You can prevent runoff from your roof by collecting rain in rainwater harvesting tanks and other rainwater-capture methods to conserve water resources (Figure 8.5). Stored rainwater can later be used for your own needs in the garden or around the home. The Regional District of Nanaimo has a comprehensive guide for doing so, while the Capital Regional District provides a list of suppliers of rainwater tanks and systems.
- ***Changing your car washing habits:*** You can avoid washing your car over paved surfaces, by either going to a carwash that recycles and controls where its water ends up or wash your car over a permeable surface, such as a lawn, to prevent detergents and residues from your car directly entering storm drains. And mind the water restrictions!
- ***Supporting community policies and projects that apply nature-based solutions:*** You can encourage your local government to consider nature-based solutions in their adaptation plans and urban designs and vote for politicians that will.
- ***Remembering that 'messy is beautiful'*** when planning your garden and yard, and planting native plants that are better suited to local conditions, use fewer resources, and are more likely to thrive during adverse conditions such as drought (Figure 8.6).

Photo by: PSF 2012

See how stormwater reducing techniques can be applied to neighbourhoods (SEA Street project, in Seattle) and in urban areas (around Metro Vancouver and Victoria) and the many benefits it can achieve.

***Figure 8.6** – Plant native salmonberry to attract pollinators and provide a food source for wildlife in your yard!* Photo by: Maria Catanzaro

- ***Using green products:*** You can also select garden products that are not harmful to the environment (see Chapter 9 for more information on 'Simple Switches').
- ***Joining a local stewardship group:*** You can also volunteer to be part of a local stewardship or local environmental group (Figure 8.7 & 8.8). There are hundreds of organizations across BC that are devoted to making a difference to our environment, restoring freshwater and estuarine habitats, and conserving salmon.

Information on how to implement the nature based solutions described here, as well as other tips to reduce your environmental impact can be found on our Resilient Coasts for Salmon website Tool Kit.

***Figure 8.7** – Volunteers on Thetis Island participating in marine riparian restoration with live staking 2018 with SeaChange Marine Conservation Society.*

Photo by: Maria Catanzaro

BOTTOM LINE:

Ultimately, we are all stewards of the shoreline and all citizens can contribute to the health and wellness of our environment! Our actions, small and large, make a difference in how our shorelines will function and thrive.

Let's embrace our roles as shoreline stewards!

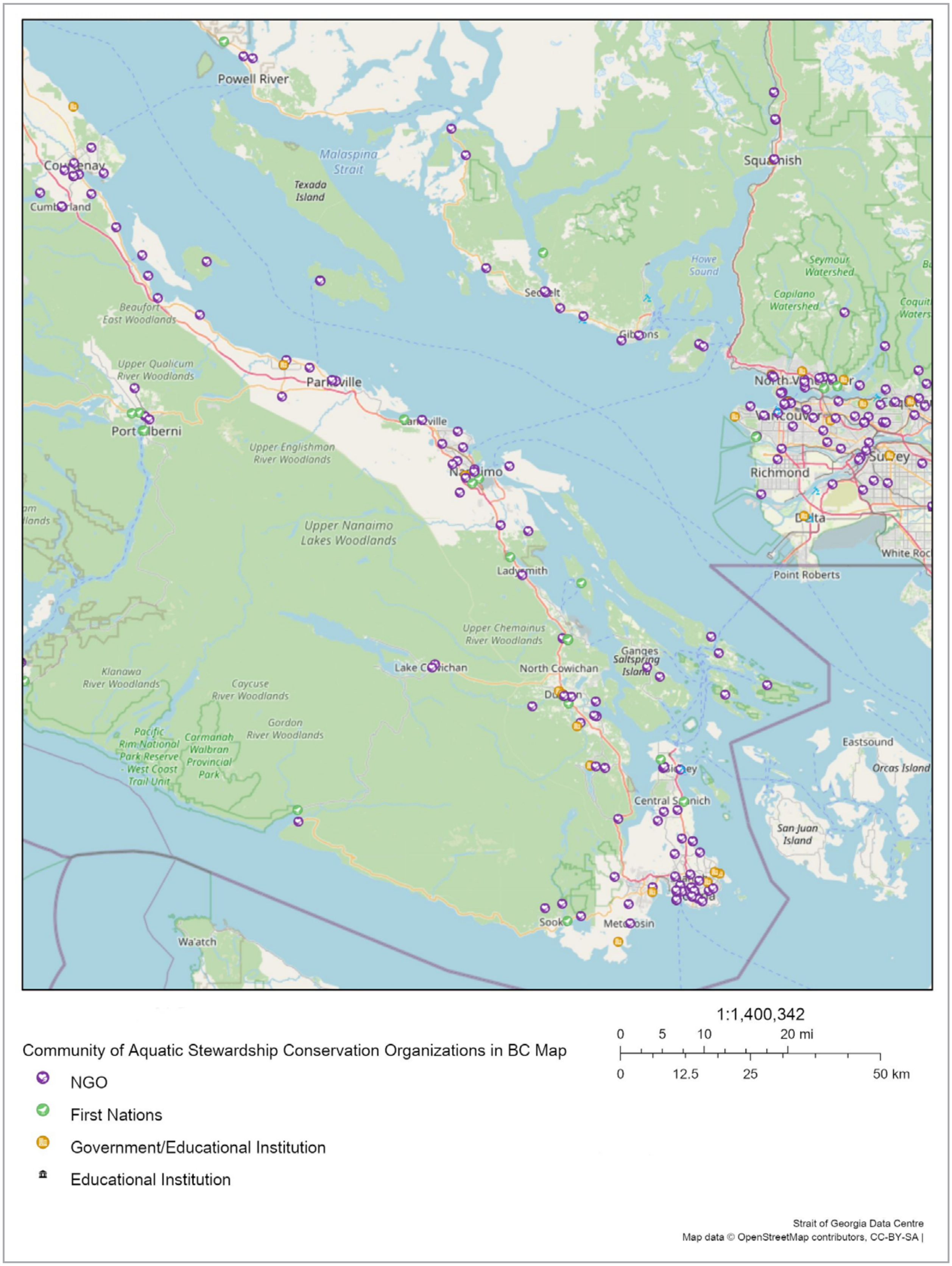


***Figure 8.8** – Map showing location of various stewardship and environmental community groups around the East Coast of Vancouver Island. Access this interactive map from the PSF-UBC Strait of Georgia Data Centre through our Tool Kit.* Source: Strait of Georgia Data Centre sogdatacentre.ca

Chapter 9 – Simple Switches: Changing How We Do Things to Protect Coastal Shorelines

Ensuring healthy shorelines, estuaries and coastal areas is essential for the future of salmon. While this is a complex challenge that requires policies and stewardship on many levels, there are steps we all can take each day to help.

In and Around Your Home: Consider How You Clean

Many cleaners on the market use harsh chemicals that are hazardous to you and the environment. Since salmon and other aquatic species live in water they are particularly sensitive to any pollution that ends up in their home. Unfortunately, there are cleaning products with persistent chemicals (meaning they do not readily break down) that can pass through septic and wastewater treatment and pollute critical habitats. You can do your part to minimize your impact by selecting products with safer ingredients.

Some simple changes you can make are:

- ***Choose products that have been reliably and independently assessed as safer:*** Companies often adorn their products with claims and labels that target eco-conscious consumers and it can be hard to decipher what is 'greenwashing' (weak or vague environmental claims) and what is truly a safe product. Be critical. Trustworthy labels that appear on products in North America include the U.S. EPA 'Safer Choice' and the ECOLOGO certification. The 'Safer Choice' label means the ingredients of the products that carry that seal have been examined by EPA scientists to ensure it is safer yet performs on par with traditional formulas. The ECOLOGO certification label indicates a product has been independently verified to meet high environmental standards based on the product's life cycle.

SAFER CHOICE Meets U.S. EPA Safer Product Standards epa.gov/saferchoice

UL ECOLOGO PRODUCT CERTIFIED FOR REDUCED ENVIRONMENTAL IMPACT. VIEW SPECIFIC ATTRIBUTES EVALUATED: UL.COM/EL UL XXXX

Photo by: Daiga Ellaby on Unsplash

- ***Ditch the anti-microbial/bacterial products:*** These perform no better than normal soap and water and are often harmful (USFDA). Triclosan, a common antibacterial ingredient found in soaps, detergents, cosmetics and toothpastes, is believed to be an 'endocrine (hormone) disrupter' meaning it interferes with proper growth and reproduction. It also hangs around in the environment only to breakdown into other harmful chemicals (dioxins) (Weatherly and Gosse 2017). Even 'natural' anti-microbials such as tea tree and lavender essential oils are suspected endocrine disrupters (Henley et al. 2007). Furthermore, unnecessary use of anti-microbials leads to antibiotic resistance — which poses a significant health risk to everyone.
- ***Opt for non-chlorine bleach if bleach is needed:*** chlorine is a hazardous chemical and very toxic to aquatic life. As chlorine breaks down it can form dioxins and other harmful chemicals, whereas hydrogen peroxide (non-chlorine bleach) breaks down into hydrogen and water.
- ***Use safe cleaning alternatives when possible:*** A vinegar solution makes an effective glass and non-porous surface cleaner, and baking soda works as a non-abrasive scrub. Use chemical free methods such as plungers and drain snakes to clear plumbing clogs.

Photo by: Isobel Pearsall

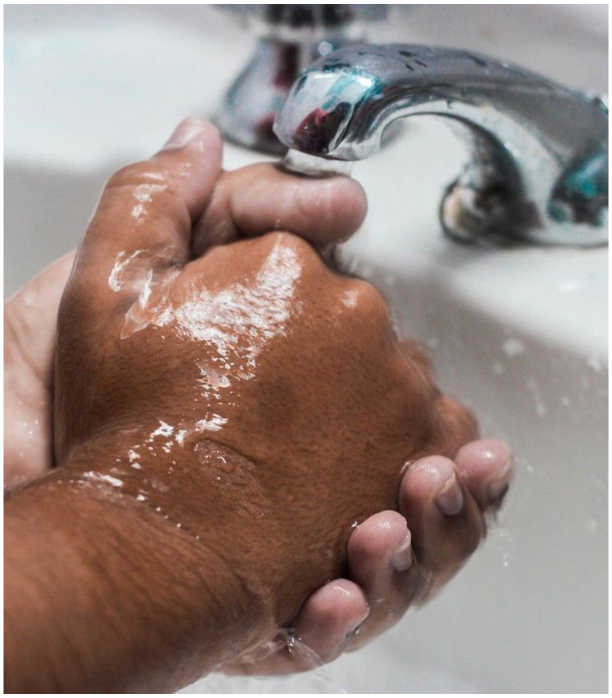


Photo by: Fran Jacquier on Unsplash

ONLINE RESOURCES:

Both the EPA Safer Choice and ECOLOGO have online search databases products that meet their high standards. Another helpful resource is the Environmental Working Group's (EWG) Healthy Cleaning Guide. EWG is non-government organization that independently evaluates products to help consumers choose more environmentally friendly products based on a simple grade scale.

Other tips:

- ***Select reusable and biodegradable sponges and washcloths:*** Most sponges and scourers are made of plastics that fall apart and wash down the drain and into the environment as microplastics. All the consequences of microplastics in the environment are still yet to be determined. What is known is that plastic particles are showing up everywhere and making their way into the food chain — including salmon (Collicutt et al. 2019).
- ***Simplify:*** Clever marketing has made us feel like we need a different product for every cleaning task, this is simply not true. Pare down your household cleaners to the necessities. It is less overwhelming to select environmentally friendly products when you are only choosing a couple.
- ***Consider the packaging and choose less plastic overall:*** Products generally come in single use plastic containers, but plastic waste in waterways has become a significant problem here and around the world. Bar soaps can be purchased free of packaging and some stores offer refill options. Join the global movement to #BePlasticWise. Sign the pledge.

Photo by: Ecologo website, and Artem Makaro and Alecsander Alve on Unsplash

Not all certification and claims on products truly mean they are safer for the environment. The table below includes a handful of claims and certifications you may encounter while shopping. The most reliable are those that are independently assessed for their safety in the environment such as EcoLogo and the US EPA Safer Choice. Information on other certifications can be found here.

Certification Logo	Meaning
EcoLogo	Product has been assessed independently to meet environmental standards for the products lifecycle. Only the top 20% of products available can achieve certification
EPA Safer Choice	Independently assessed by US EPA scientists to meet strict environmental and health standards
Biodegradable	Product will naturally break down, but does not necessarily mean it breaks down into safe components
Certified Organic	Organic products have been made of at least 95% organic ingredients and contain no genetically modified organisms
Leaping bunny	Certifies that a product has not been tested on animals and does not relate to product safety in the environment
Plant based	Products made from plant materials rather than potentially petroleum. Suggests product is more likely to be sustainable but does not necessarily assure safety in the environment
Recycling symbol (Mobius loop)	Indicates a product or packaging can be recycled or is made up of recycled material. Caution as some materials (indicated by the number inside the loop) are less readily recycled. It is generally best to avoid plastic packaging
Fair Trade	Standards for social, economic, and environmental ethics

Photo by: Kyla Sheehan

***Figure 9.1** – Providing habitat for predatory ladybugs can result in natural biological control of aphids.*

Photo by: Sue Thomas on Unsplash

In Your Garden and Around Your Property

- ***Reduce the chemicals you put into the environment:*** Pesticides, herbicides and fertilizers can cause serious environmental damage. When washed into waterways, excess fertilizer transforms healthy, clear, oxygen rich streams into those choked with algae and not enough oxygen for fish to breathe. Pesticides and herbicides are often harsh and persistent chemicals that can kill or seriously harm fish and their prey (Macneale et al. 2010). While the commercial agriculture industry is the greatest source of chemical fertilizers, pesticides and herbicides, the impacts of the landscaping done by individual homeowners along and near shorelines can add up.

Here are some steps you can take to reduce the impact of your landscaping:

- ***Manage garden pests through strategies that don't involve chemicals*** (see integrated pest management – West Coast Seeds and Pestsense – WSU) such as crop rotation and encouraging predatory insects like lady bugs. Manage weeds manually and embrace a few harmless dandelions for the bees.
- ***Select slow-release organic fertilizers to feed your garden*** rather than concentrated chemical fertilizers that wash away into the environment. Composted kitchen scraps, manure and/or commercially available composts will feed your plants and improve your soil at the same time.
- ***Reconsider lawns and landscaping*** that require lots of fertilizer and water. Instead opt for perennial shrubs and trees and take a natural landscaping approach as recommended by Green Shores. Select native species that naturally thrive in our climate and soil conditions, while protecting the shoreline from erosion and providing habitat for insects and organisms. Visit your local native plant nurseries for resources and inspiration (Figure 9.2).
- ***Avoid especially harmful pesticides:*** Salmon Safe has put together guides and certification standards for homeowners, farmers and developers that can be employed to keep salmon safe. They have compiled a list of chemical pesticides to avoid that are especially hazardous. This list, along with a number of helpful resources for reducing your environmental impact, are posted in our online Tool Kit.

Selection of Native Plant Nurseries around Vancouver Island:
Nanaimo & Area Land Trust, Streamside Native Plants, Satinflower Nurseries;
Vancouver area: NATS Nursery, Plan Bee Native Plant Nursery, Coast Salish Plant Nursery;
Elsewhere in BC: Twin Sister Native Plant Nursery, BC's Wild Heritage Plants,
Peel's Nurseries, Violet Creek Nursery, Sagebrush Nursery.
See Figure 9.2 for locations of native plant nurseries around Vancouver Island!

***Figure 9.2** – Visit our Tool Kit to find native plant nurseries in your area! Vancouver Island's key supplier is www.streamsidenativeplants.com*

Source: Strait of Georgia Data Centre sogdatacentre.ca

Photo by: Isobel Pearsall

On Your Boat

When boating you are directly sharing the environment that salmon depend on. It is so important to minimize your impact on the water. Take a look at the Georgia Strait Alliance's Guide to Green Boating for advice on reducing your impact as you boat. This guide has both general and specific local information, such as sewage disposal sites and contact information around the Strait of Georgia. The guide includes important reminders such as the need to take particular care in sensitive areas including kelp and eelgrass beds. The Strait of Georgia Datacentre has mapping tools that show the location of key habitats as well as established moorings sites so that you can plan your trip and avoid any incidental damage. Also check out our guide to protecting eelgrass habitat while boating in our online Toolkit!

Photo by: Josh Thomson

Photo by: : Kyla Sheehan

Clean up your act by avoiding harsh chemicals on your boat and within your home. Try out these alternative cleaning solutions for your daily tasks. Adapted from the Georgia Strait Alliance's Guide to Green Boating and David Suzuki Foundation's Queen of Green cleaning recipes.

Cleaning Task	Alternative Cleaners
Glass and surface	1 part vinegar to 1-2 part water (optional a couple drops of non-petroleum based dish soap)
Floors (tile, hardwood, laminates and boat decks)	1 part vinegar to 8 parts warm water a couple drops of non-petroleum based dish soap
Showers and tubs	Wet and scrub with baking soda
Toilets	Baking soda
Dishes	Hot water with minimal amounts of non-petroleum based dish soap
Scouring	Baking soda and water paste
Bleaching	Hydrogen peroxide bleach
Drain clogs	Plungers and drain snakes
Furniture polishing (interior)	Olive oil
Stainless steel	Rub a rag with a few drops of olive oil and finish with a spray and wipe of glass and surface cleaner above
Laundry	2 parts soap granules to 1 part baking soda and 1 part washing soda (2 Tbs per load)
Dish washer	1 part baking soda to 1 part washing soda (1-2 Tbs per load) and 1 Tbs vinegar in the rise dispenser

BOTTOM LINE:

Whether you are in your home, in your garden or on your boat, there are many **simple decisions** that you can make which can result in elimination or major reduction of harmful chemicals that would otherwise enter into our environment, and ultimately, make their way into our waterways and nearshore areas.

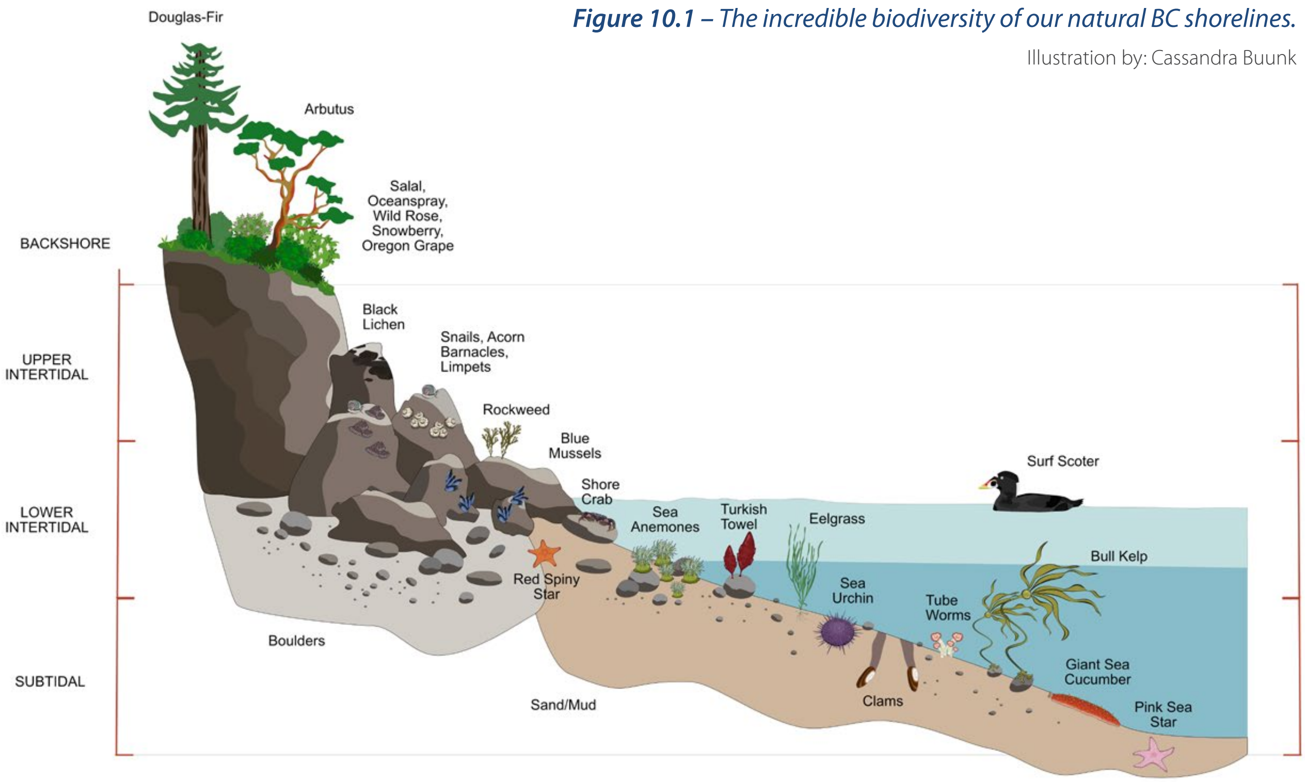


***Figure 10.1** – The incredible biodiversity of our natural BC shorelines.*

Illustration by: Cassandra Buunk

Chapter 10 – It's All Connected

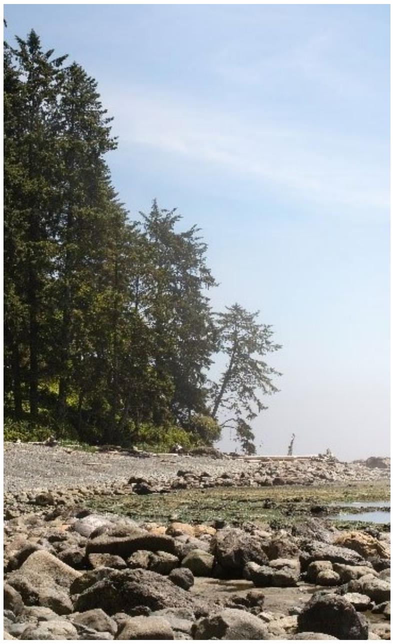
The wellbeing of coastal communities is inextricably linked to the health of our shorelines. Our shorelines nourish us — providing food and offering space for recreational, spiritual and cultural connection. Our shores are more than just sediment beaches — they are abundant with life!

As we have seen in the preceding chapters, healthy habitats are needed for thriving ecosystems. Sediment beaches act as spawning habitat for forage fish like Pacific sand lance. Nearshore kelp forests offer protective habitat for Pacific salmon and sea otters. Eelgrass meadows hold onto herring roe until they are ready to hatch. The rocky intertidal is rich with creatures like barnacles, algae, mussels, crabs, sea stars, and so much more!

The backshore and riparian habitats are also rich with native plant life and terrestrial animals— not to mention, overhanging vegetation near the shore helps to shade these habitats from the hot sun, and the roots help to stabilize riparian soils. When left to function naturally, shorelines house incredible biodiversity (Figure 10.1).

Photo by: Isobel Pearsall


Photo by: Josh Morgan


Photos by: Ryan Miller and Macgregor Aubertin-Young

Shorelines also provide so many ecosystem services that benefit humans and many other organisms, as well as help mitigate climate change impacts. They are dynamic spaces, and it is up to us to allow those natural processes to continue so that our shorelines remain resilient to change. When we take care of shorelines, the shorelines take care of us.

BOTTOM LINE:

What happens on the shorelines **connects us all**.
Let's act consciously and be stewards to help maintain these incredibly important ecosystems!

Want to Learn More?

Take a deep dive into the resources on our Resilient Coasts for Salmon website: resilientcoasts.ca! This includes a tool-kit of information for nature-based solutions.

Use this Tool Kit to find inspiration and actions you can do personally to reduce your environmental impact here: resilientcoasts.ca/building-awareness/tool-kit/

Also check out the Stewardship Centre for BC website (stewardshipcentrebc.ca) and Green Shores site (stewardshipcentrebc.ca/green-shores-home/) for more information on how to access Green Shores project enrollment (stewardshipcentrebc.ca/green-shores-home/gs-programs/project-enrollment/), training sessions (stewardshipcentrebc.ca/green-shores-home/green-shores-training) information and resources.

And learn about all the amazing work happening in the PSF Marine Science Program (www.marinescience.ca) by subscribing to PSF's newsletters and updates.

Your Feedback is Appreciated!

We recognize that many of you are stewards of your community already — please share your feedback with us and keep connected!

- What does living by the Salish Sea mean to you and your family? Let us know! Write to us and submit your photos of how you interact with your shoreline to salmon@psf.ca
- How can we support your community group? Let us know at salmon@psf.ca

PACIFIC SALMON FOUNDATION

RESILIENT COASTS FOR SALMON

STEWARDSHIP CENTRE FOR BRITISH COLUMBIA

References

Amos, C.L., Martino, S., Sutherland, T.F., and Al Rashidi, T. 2015. Sea Surface Temperature Trends in the Coastal Zone of British Columbia, Canada. Journal of Coastal Research 300: 434–446.

Bailey, M., and Sumaila, U.R. 2012. Freshwater Angling and the B.C. Economy. Report prepared for the Freshwater Fisheries Society of B.C.

Bodkter, K., and Philibert, R. 2018. Coastal Development: Patterns of Population Growth, Major Projects, and Coastal Tenures. Ocean Watch – B. C. Coast Edition: 199-210.

British Columbia (BC) Salmon Marketing Council. 2020. Markets & Value.

British Columbia Ministry of Environment (MOE). 2016. Indicators of Climate Change for British Columbia: 2016 Update. Ministry of Environment, British Columbia, Canada.

Burdick, D.M., and Short F.T. 1999. The Effects of Boat Docks on Eelgrass Beds in Coastal Waters of Massachusetts. Environmental Management 23(2): 231–240.

Capital Regional District (CRD). 2017. Climate Projections for the Capital Region.

Collicutt, B., Juanes, F., and Dudas, S.E. 2019. Microplastics in Juvenile Chinook Salmon and Their Nearshore Environments on the East Coast of Vancouver Island. Environmental Pollution 244: 135-142.

COSEWIC. 2016. COSEWIC Assessment and Status Report on the Coho Salmon *Oncorhynchus kisutch*, Interior Fraser Population, in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON.

COSEWIC. 2017. COSEWIC Assessment and Status Report on the Sockeye Salmon *Oncorhynchus nerka*, 24 Designatable Units in the Fraser River Drainage Basin, in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. ON.

DFO. 2016. Integrated Biological Status of Southern British Columbia Chinook Salmon (*Oncorhynchus tshawytscha*) Under the Wild Salmon Policy. Canadian Science Advisory Secretariat. 2016/042.

DFO. 2018. The 2017 Fraser Sockeye Salmon (*Oncorhynchus nerka*) Integrated Biological Status Re-assessments Under the Wild Salmon Policy. Canadian Science Advisory Secretariat 2018/017.

Gittman R., Scyphers S., Smith C., Neylan I., and Grabowski, J. 2016. Ecological Consequences of Shoreline Hardening: a Meta-analysis. BioScience 66(9): 763–73.

Glick, P., Powell, E., Schlesinger, S., Ritter, J., Stein, B.A., and Fuller, A. 2020. The Protective Value of Nature: A Review of the Effectiveness of Natural Infrastructure for Hazard Risk Reduction. Washington, DC: National Wildlife Federation.

Government of Canada. 2020. Government of Canada Moves to Phase Out Salmon Farming Licences in Discovery Islands Following Consultations with First Nations.

Government of Canada. 2021. Minister Jordan Announces Long-term Commercial Closures and Licence Retirement Program in Effort to Save Pacific Salmon.

Grant, S.C.H., MacDonald, B.L., and Winston, M.L. 2019. State of Canadian Pacific Salmon: Responses to Changing Climate and Habitats. Canadian Technical Report of Fisheries and Aquatic Sciences 3332.

Greenan, B.J.W., James, T.S., Loder, J.W., Pepin, P., Azetsu-Scott, K., Ianson, D., Hamme, R.C., Gilbert, D., Tremblay, J-E., Wang, X.L. and Perrie, W. 2019. "Changes in Oceans Surrounding Canada"; Chapter 7 in Canada's Changing Climate Report. (Eds.) Bush and Lemmen. Government of Canada, Ottawa, Ontario. 343–423.

Hanson, M.B., Emmons, C.K., Ford, M.J., Everett, M., Parsons, K., Park, L.K., and Barre, L. 2021. Endangered Predators and Endangered Prey: Seasonal Diet of Southern Resident Killer Whales. Plos One 16(3) e0247031.

Henley, D.V., Lipson, N., Korach, K.S., and Bloch, C.A. 2007. Prepubertal Gynecomastia Linked to Lavender and Tea Tree Oils. The New England Journal of Medicine 356(5): 479-485.

Heerhartz, S.M., Dethier, M.N., Toft, J.D., Cordell, J.R., and Ogston, A.S. 2014. Effects of Shoreline Armoring on Beach Wrack Subsidies to the Nearshore Ecotone in an Estuarine Fjord. Estuaries and Coasts 37: 1256-1268.

Hobday, A. J., Alexander, L. V., Perkins, S. E., Smale, D. A., Straub, S. C., Oliver, E. C. J., Benthuysen, J. A., Burrows, M. T., Donat, M. G., Feng, M., Holbrook, N. J., Moore, P. J., Schannell, H. A., Gupta, A. S., and Wernberg, T. 2016. A Hierarchical Approach to Defining Marine Heatwaves. Progress in Oceanography 141: 227-238.

Insights West. 2021. BC Residents Are Extremely Concerned (86%) About Declining Salmon Stocks As Well As Climate Change (76%) and Single Use Plastics (75%), and Most British Columbians (75%) Believe That Open-Net Salmon Pens Need to Be Transitioned to Land-Based Pens.

IPCC. 2019. IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. eds. Pörtner, H.O., Roberts, D.C., Masson-Delmotte, V., Zhai, P., Tignor, M., Poloczanska, E., Mintenbeck, K., Alegría, A., Nicolai, M., Okem, A. Petzold, J., Rama, B., and Weyer, N.M.

IPCC. 2021. Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. (Eds.) Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S. L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J.B.R, Maycock, T.K., Waterfield, T., Yelekçi, O., Yu, R. and Zhou, B. Cambridge University Press.

Johannessen, S., and Macdonald, R. 2009. Effects of Local and Global Change on an Inland Sea: the Strait of Georgia, British Columbia, Canada. Climate Research 40:1–21.

Judd, A. 2021. Damage and Repairs Could Make B.C. Floods Canada's Most Expensive Natural Disaster. Global News – November 19, 2021.

Macneale, K.H., Kiffney, P.M., and Scholz, N.L. 2010. Pesticides, Aquatic Food Webs, and the Conservation of Pacific Salmon. Frontiers in Ecology and the Environment 8(9): 475-482.

Morley, S.A., Toft, J.D., and Hanson, K.M. 2012. Ecological Effects of Shoreline Armoring on Intertidal Habitats of a Puget Sound Urban Estuary. Estuaries and Coasts 35: 774-784.

Moudrak, N., Feltmate, B., Venema, H., and Osman, H. 2018. Combating Canada's Rising Flood Costs: Natural Infrastructure is an Underutilized Option. Prepared for Insurance Bureau of Canada. Intact Centre on Climate Adaptation, University of Waterloo.

Munsch, S.H., Cordell, J.R., Toft, J.D., and Morgan, E.E. 2014. Effects of Seawalls & Piers on Fish Assemblages and Juvenile Salmon Feeding Behavior. North American Journal of Fisheries Management 34: 814-827.

Munsch S.H., Cordell J.R., and Toft, J.D. 2016. Fine-scale Habitat Use and Behavior of a Nearshore Fish Community: Nursery Functions, Predation Avoidance, and Spatiotemporal Habitat Partitioning. Marine Ecology Progress Series 557: 1-15.

Munsch, S.H., Cordell, J.R., and Toft, J. D. 2017. Effects of Shoreline Armouring and Overwater Structures on Coastal and Estuarine Fish: Opportunities for Habitat Improvement. Journal of Applied Ecology 54: 1373-1384.

Nahirnick, N.K., Costa, M., Schroeder, S., and Sharma, T. 2020. Long-term Eelgrass Habitat Change and Associated Human Impacts on the West Coast of Canada. Journal of Coastal Research, 36:1, 30–40.

Nair, R. 2021. For B.C.'s Salmon, Floods Represent Another Challenge to Survival. CBC News – November 21, 2021.

NOAA. 2017. Global and Regional Sea Level Rise Scenarios for the United States. NOAA Technical report NOS CO-OPS 083.

Ocean Wise. 2019. Wild Killer Whale Adoption Program: Meet the Whales.

Oliver, E.C.J., Burrows, M.T., Donat, M.G., Sen Gupta, A., Alexander, L.V., Perkins-Kirkpatrick, S.E., Benthuysen, J.A., Hobday, A.J., Holbrook, N.J., Moore, P.J., Thomsen, M.S., Wernberg, T., and Smale, D.A. 2019. Projected Marine Heatwaves in the 21st Century and the Potential for Ecological Impact. Frontiers in Marine Science 6:734.

Oppenheimer, M., Glavovic, B.C., Hinkel, J., van de Wal, R., Magnan, A.K., Abd-Elgawad, A., Cai, R., Cifuentes-Jara, M., DeConto, R.M., Ghosh, T., Hay, J., Isla, F., Marzeion, B., Meyssignac, B., and Sebesvari, Z. 2019. Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. (Eds.) Pörtner, H.O., Roberts, D.C., Masson-Delmotte, V., Zhai, P., Tignor, M., Poloczanska, E., Mintenbeck, K., Alegría, A., Nicolai, M., Okem, A. Petzold, J., Rama, B., and Weyer, N.M.

Philip, S.Y., Kew, S.F., van Oldenborgh, G.J., Yang, W., Vecchi, G.A., Anslow, F.S., Li, S., Seneviratne, S.I., Luu, L.N., Arrighi, J., Singh, R., van Aalst, M., Hauser, M., Schumacher, D.L., Marghidan, C.P., Ebi, K.L., Bonnet, R., Vautard, R., Tradowsky, J., Coumou, D., Lehner, F., Wehner, M., Rodell, C., Stull, R., Howard, R., Gillett, N., and Otto, F.E.L. 2021. Rapid Attribution Analysis of the Extraordinary Heatwave on the Pacific Coast of the US and Canada June 2021. World Weather Attribution.

Pew Ocean Commission. 2003. America's Living Oceans. Charting a Course for Sea Change: A Report to the Nation, Recommendations for a New Ocean Policy. Washington, DC.

Rumson, A. G., Hallett, S. H., and Brewer, T. R. 2017. Coastal Risk Adaptation: the Potential Role of Accessible Geospatial Big Data. Marine Policy 83: 100–110.

Ruzicka, J.J., Daly, E.A., and Brodeur, R.D. 2016. Evidence That Summer Jellyfish Blooms Impact Pacific Northwest Salmon Rroduction. Ecosphere 7(4):e01324.

Stewardship Centre for BC. 2015. Green Shores for Homes Credits and Ratings Guide.

Stewardship Centre for BC. 2020. Green Shores for Shoreline Development Credits and Ratings Guide.

Toft, J.D., Cordell, J.R., Simenstad, C.A., and Stamatiou, L.A. 2007. Fish Distribution, Abundance, and Behavior along City Shoreline Types in Puget Sound. North American Journal of Fisheries Management 27(2): 465-480.

Toft, J.D., Ogston, A.S., Heerhartz, S.M., Cordell, J.R., and Flemer, E.E. 2013. Ecological Response and Physical Stability of Habitat Enhancements Along an Urban Armored Shoreline. Ecological Engineering 57: 97-108.

UN Atlas of the Oceans. 2016. Facts: Coasts and Coral Reefs.

U.S. Food and Drug Administration. 2019. Antibacterial Soap? You can Skip it, Use Plain Soap and Water. Consumer Updates.

Vadeboncoeur, N. 2016. Perspectives on Canada's West Coast region; in Canada's Marine Coasts in a Changing Climate. (Eds.) D.S. Lemmen, F.J. Warren, T.S. James and C.S.L. Mercer Clarke; Government of Canada, Ottawa, ON.207-252.

Weatherly, L.M., and Gosse, J.A. 2017. Triclosan Exposure, Transformation, and Human Health Effects. Journal of Toxicology and Environmental Health, Part B 20(8): 447-469.

Wild Salmon Centre. 2021. Why Protect Salmon.

Zhang, X., Flato, G., Kirchmeier-Young, M., Vincent, L., Wan, H., Wang, X., Rong, R., Fyfe, J., Li, G., Kharin, V.V. 2019: Changes in Temperature and Precipitation Across Canada; Chapter 4 in Bush, E. and Lemmen, D.S. (Eds.) Canada's Changing Climate Report. Government of Canada, Ottawa, Ontario, p.112-193.

Bring this treasure hunt on your next visit to your local shoreline!

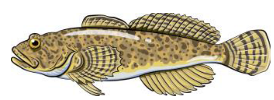
Treasure Hunt

What organisms can you spot on the beach?

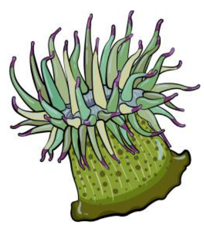
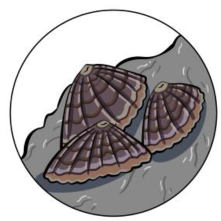
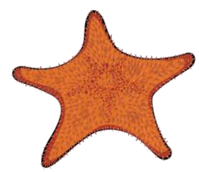



- [ ] Great Blue Heron
- [ ] Snail
- [ ] Bull kelp
- [ ] Eelgrass





- [ ] Mussels
- [ ] Sea lettuce
- [ ] Sculpin

- [ ] Barnacles
- [ ] Sea anemone
- [ ] Limpet
- [ ] Sea star



- [ ] Shore crab
- [ ] Rockweed
- [ ] Seal

Which organism was your favourite and why?

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