OUR THREATENED COAST:

Nature and Shared Benefits in the Salish Sea

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RAINCOAST CONSERVATION FOUNDATION

2016

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RAINCOAST CONSERVATION FOUNDATION

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About Raincoast Conservation Foundation:
Raincoast is a team of conservationists and scientists empowered by our research to protect the lands, waters and wildlife of coastal British Columbia. We use rigorous, peer-reviewed science and community engagement to further our conservation objectives. We call this approach 'informed advocacy' and it is unique amongst conservation efforts.

Our mandate: Investigate. Inform. Inspire.
We Investigate to understand coastal species and processes.
We Inform by bringing science to decision makers and communities.
We Inspire action to protect wildlife, their habitats and resources.

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Contents

Preface

The Salish Sea region is an area of outstanding natural beauty. It hosts a diverse archipelago within a unique coastal sea that is surrounded by snow capped mountains.

PHOTO: B. HARVEY

I must go down to the Sea today, for the call of the running tide…

Spanning Canada, the United States, the Province of British Columbia, and the State of Washington, is one of the world's largest coastal seas. From the western entrance of the Juan de Fuca Strait, to the top of Georgia Strait, and bottom of Puget Sound, the Salish Sea mixes the freshwater flow from the Fraser, Skagit and dozens of other large rivers, with saltwater from the Pacific Ocean.

Weaving through an archipelago comprising hundreds of islands, the mixing of these waters in deep basins, shallow bays, and open straits has fostered a diverse abundance of life. The name, Salish Sea, reflects and honours the Coast Salish, the area's first human inhabitants.

Surrounded by the Olympic, Vancouver Island, and Coast Mountain ranges, the Salish Sea is an area of outstanding natural beauty. In some places, these snow-capped peaks still overlook lushly forested river valleys and deltas. The wealth of natural assets that arise from these lands and waters has sustained rich indigenous cultures since the last glaciation, at least 10,000 years ago.

From the smallest plankton to the largest whales, the archipelago supports a fertile food web of feathered, furred, and finned animals. Its popular residents include schools of herring and salmon, marine and shore birds, porpoises and sea lions, and of course killer whales. Connecting the sea and land is the shifting boundary of the intertidal world. It is a unique zone, hosting organisms that have evolved to live between the high and low of Pacific tides.

Over the last two centuries, many plants and animals of the Salish Sea have undergone irrevocable shifts in their range and numbers. Unsustainable human enterprise and population growth have relentlessly depleted numerous species. More than ever, these coastal habitats are now the home of rare, threatened, and endangered species.

The Salish Sea region currently faces a dramatic escalation of threats, many of which stem from the demands of 8 million residents within the urban regions of Victoria, Vancouver, and Seattle. The natural ports and harbours that once supported fishing, forestry, and regional businesses have changed drastically. Linking Canada and the US to international markets, the Salish Sea has become a hub for commercial exports, making it a coveted place for fossil fuel exporters to ship non-renewable, and typically dangerous hydrocarbons to foreign markets. Kinder Morgan's Trans Mountain Expansion is the largest of these proposals.

One hundred years after two very large hydroelectric dams severed the Elwha River from its people and its salmon, their high profile public removal stands as a testimony to the power and awareness of communities determined to restore their connection to place. This historic breaching of two working dams has enabled salmon to reach their historic spawning grounds for the first time in a century and the river to recreate the delta that connects it to the Salish Sea.

PHOTO: J. GUSSMAN

Yet, there is hope. Citizens are organizing in opposition to these proposals in unprecedented numbers. They are saying 'no' to conventional economics that commodify natural habitats and reduce them exclusively to financial chattels. Many are demonstrating visionary and inspiring ways of living less consumptively and destructively. Others are developing and refitting their homes and businesses with renewable energy alternatives. Everywhere, citizens are standing up for the future of this region and its inhabitants—all of them.

Although several of the Salish Sea's species are in decline, others are returning in historic numbers. We are also rapidly gaining an understanding of our expanding 'human footprint' and its impacts on ecological processes at local, regional, and global scales. Empowered by such awareness, a conversation is happening about our future; people are recognizing that our fate is inextricably linked to the natural world.

As conservation biologists with a strong wildlife welfare ethic, we respect (and advocate) for the intrinsic right of wild species to exist. However, we also see that pipeline, supertanker, and fossil fuel development projects are seductively and illusorily, presented by industry and governments as necessities for BC's economic prosperity. For this reason, we address the economic benefits that are naturally provided by the Salish Sea region.

This ecological wealth is the essential link between our environment and well-being. However, the benefits and services generated from the region's natural wealth are generally unaccounted for and undervalued. Tragically, these benefits and ecosystem services are in serious jeopardy if development continues to proceed unrestrained.

Herein, we present a view of the broader socio-cultural, economic, and ecological values, which should contribute to decisions affecting the region's future. These values are not only important to us as humans, but also underscore the provisions of a highly complex natural world that may be approaching an incontrovertible tipping point.

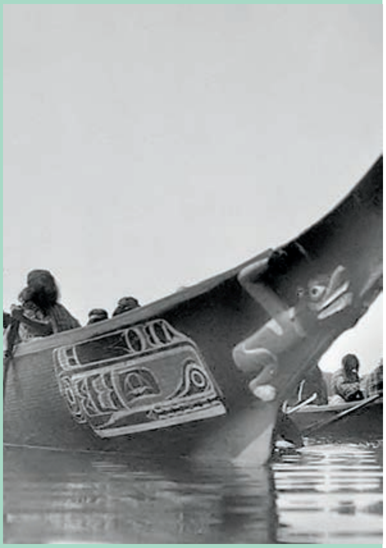
Our report responds to the rising public, business, and indigenous concerns relating to planned increases in the shipping of tar sands oil through the Salish Sea by Kinder Morgan.

First, it provides an overview of the unique labyrinth of coastal geography and diversity we call the Salish Sea. Second, we examine how the Salish Sea's natural features and processes feed our region's economic health and cultural wealth.

Lastly, we examine risk. We believe Kinder Morgan's presentation of oil spill risk is selective in scope, assertions, and probabilities. It is based more on unsupported opinions than on valid, empirical data. Its conclusions about oil spills are unwarranted and unsupported.

Kinder Morgan's risk assessment misleadingly conflates ecological thresholds with socioeconomic and political ones. They omit environmental and social losses, dismiss uncertainty, and exaggerate their ability to manage events they cannot control. It is a false narrative, misleading in both the risks and the costs.

This carefully designed marketing strategy creates fear of lost economic opportunities if fossil fuel exports are not pursued. Government and industry rely on the hope that this fear of economic loss will supersede our concern of ecological harm. Economist Robyn Allan has described this pipeline proposal as



What's in a Name?
In August 2009, the BC Geographical Names Office recommended that the name *Salish Sea* be adopted to refer to the waters of Georgia Strait, Puget Sound, and the Juan de Fuca, contingent on approval by the US Board on Geographic Names. In November 2009, the name *Salish Sea* was approved by the US Board on Geographic Names. The BC Geographical Names Office followed suit with approval in February 2010. The official French name is *Mer de Salish.* The name *Salish Sea* does not replace any existing names for this region, but complements them.

Canada's federal government has been actively promoting the idea that its tar sands decisions are "in the best interest of Canadians." But are they? The burning of fossil fuels is the number one driver of climate change. Oil spills can ruin lives, communities and economies for decades.

PHOTO: C. TATU

a false dichotomy fabricated by the energy industry to give the impression that Canadians must make a difficult choice. Despite millions of dollars spent trying to convince us, this is not a trade-off we face. The 'risk' reality is that we stand to lose both ecologically and economically in pursuit of an oil export economy.

The choice to extract, ship, and burn tar sands oil will likely affect our children for decades to come. Remarkably, the choice whether or not to use our coastal waters to facilitate this objective is within our ability to make. The risks are real and consequential. They are a powerful argument in favour of a radically different course of action. Solutions to our energy and economic problems are everywhere if we make the individual and collective choice to implement them. We cannot afford to lose the foundation of an economy that provides stability, opportunity, and meaningful work. The premise of a sustainable future is not based on shortsighted exploitation, but thoughtful development that fosters a physical and social connection with the ecosystems that sustain us. Our coastal sea is a marvel of features and processes that support a remarkable diversity of life, including our own. It is priceless and irreplaceable; a worth immeasurable in monetary terms.

Growing appreciation and advocacy for free-flowing rivers, mature forests, natural shorelines, and all the parts and processes that connect to make them ecosystems, is driving a powerful defense of the place we call home.

PHOTO: J. TAYLOR

1. A Dirty Energy Superpower?

Alberta's tar sands, the source of oil to be pumped through Kinder Morgan's expanded Trans Mountain pipeline, lie under vast tracts of boreal forest. This 'overburden' (the industry term for soil and vegetation) is the breeding ground for 80–240 million birds of more than 200 species. It is also home to endangered caribou, wolves, and numerous wildlife species that are being severely affected by such development

PHOTO: ST. ALBERT GAZETTE

Fracking, Coal, Tar Sands Oil, and Tankers

Coastal British Columbia, once identified for its vast, majestic landscapes of forested river valleys flowing with salmon, is rapidly being transformed into the gateway for consumption of the world's dirtiest fossil fuels. And Vancouver, with its image of green living and enlightened thinking, is poised to become the nexus for this fossil fuel agenda.

Under the previous Conservative government, the world formed an unfavourable impression of Canada with our distinction as the first country to withdraw from the Kyoto Accord[1] to the radical undoing of environmental laws and regulations. Our thirst to precipitously extract and sell oil, LNG (liquid natural gas), coal, and other non-renewable resources now threatens a broad range of species and habitats from the arctic to the coastal temperate rainforest. This includes habitats of iconic species such as polar bears, woodland caribou, salmon, and killer whales—species that are the fabric of Canada's cultural identity. However with the advent of the new Liberal government, there is renewed hope that Canada can be a leader in climate and environmental policies.

Despite widespread public opposition, objections of First Nations, doubts about economic benefits, and concern about significant environmental impacts, exploitation of the Alberta tar sands has become the world's largest mining initiative. The escalating development of the tar sands is driving plans for greater oil pipeline capacity via projects like the Keystone XL, Enbridge's Northern Gateway, and Kinder Morgan's Trans

1 Part of the UN Framework to address climate change. Canada's withdrawal is despite evidence of the need to surpass required GHG reductions.

Mountain expansion, all of which are occurring without a coherent, sustainable Canadian energy strategy.

PHOTO: ALAMY

The Ghost of Canada's Climate Change Commitments

Under the previous Conservative government, Canada abandoned its greenhouse gas reduction (GHG) commitments. A 2013 Environment Canada report confirmed that Canadian GHG emissions were on the rise. Although a long way from the 2020 reduction goal[2] (about 600 Mt CO_2 e[3] annually), Canada had previously lowered its emissions (by 2009) to below 700 Mt. Yet, rather than try harder to reach the 600 Mt target, the federal government abandoned GHG targets, and put emissions on track to surpass 800 Mt annually by 2020[4] (Fig. 1.1).

At COP 21 in Paris in 2015, Canada's new Liberal government supported the goal of reducing CO_2 emissions to hold global temperature warming to no more than 1.5° C. This goal will require bold climate policies.

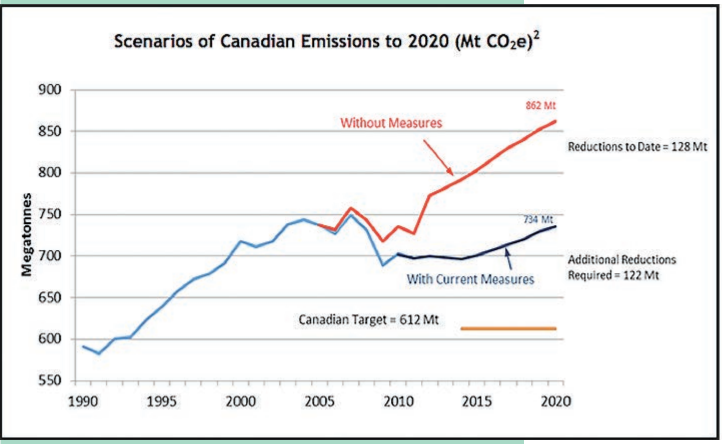


Figure 1.1 Canada's GHG emissions 1990–2020. The red line shows the path of GHG emissions if proposed measures are abandoned. The dark blue line shows the projected emissions if Canada implements its existing commitments. The orange line is Canada's target of 612 Mt annually.

SOURCE: ENVIRONMENT CANADA 2013

Although Canada currently contributes around 2% of global CO_2 emissions (US EPA 2008), it ranks third by CO_2 emissions per capita (UCS 2013). Globally, Australia has the highest per capita emissions of CO_2 (20.82 tons/capita) followed by United States (19.18) and Canada (17.27). Comparatively, Germany is at 10.06 and the UK 9.38 tons/capita, whereas the emerging economies of China (4.91) and India (1.31) are significantly lower but rapidly increasing. This disparity represents a key problem in climate change negotiations and a reason why Canada should not shirk its own responsibilities.

A Lasting Footprint

Due to the nature of extraction processes, the carbon footprint of tar sands development is up to 23% higher than average

2 Copenhagen Accord Target: an unbinding international agreement and successor to the binding GHG emission targets of the Kyoto Protocol that ended in 2012.

3 e is equivalent. Carbon dioxide equivalents account for other GHG and enable standardised reporting.

4 This figure does not include land use, land-use change and forestry. Environment Canada 2013.

Raw Tar Sands
The oil sands yield bitumen, a highly viscous form of petroleum that is produced by surface mining or by injecting steam to mobilize bitumen deep underground. After separation from the host sand and rock, bitumen is diluted with lighter petroleum products for transport (NAS 2015).

PHOTO: GREENPEACE

fuels (Brandt 2011) and requires between 2.5–4 barrels of water for each barrel of bitumen produced (NEB 2012). Production of tailings reached 1.8 billion litres per day in 2008 (Pembina 2008).

Visible from space, the footprint of this development has already created more than 170 sq km of toxic tailings ponds (Swift et al. 2011) and destroyed 65,000 hectares of boreal ecosystems by 2008 (Timoney and Lee 2009). The boreal landscape, including peatland, cannot be restored, and existing plans could release nearly 50 million metric tonnes of stored carbon while reducing potential carbon sequestration by 7-7,000 metric tons per year (Rooney et al. 2012).

Polluted Water, Land, and Air

Despite natural background levels of contaminants and continued failures with industry monitoring (Hall et al. 2012, Ayles et al. 2004) numerous scientific studies are demonstrating a range of environmental impacts from the tar sands (Kurek et al. 2013, Kirk et al. 2014, McLachlan 2014). Studies of

PHOTO: P. ESSICK

snowpack and watersheds in the Athabasca River (Kelly et al. 2010) suggest that the tar sands industry releases numerous pollutants (copper, lead, mercury, nickel, silver and zinc) that exceed Canada's guidelines for aquatic life.

Work by McLachlan (2014) showed elevated levels of metals (cadmium, arsenic, selenium and mercury) in wildlife that form the traditional foods consumed by First Nations including duck, fish, and moose. Other impacts include seepage from tailings ponds, impacts on migratory and resident birds (Schick and Ambrock 1974, Timoney and Lee 2009), risks to aquatic life (Kirk et al. 2014) and various impacts on air quality (Timoney and Lee 2009, Jautzy et al. 2014).

At a regional level, studies of lake sediments in the Athabasca tar sands indicate increased delivery of polycyclic aromatic hydrocarbons (PAHs) and dibenzothiophenes (DBTs), both known contaminants, up to 23 times higher than pre-development levels (Kurek et al. 2013), and with risks to ecosystem health also identified (Timoney and Lee 2009, Kirk et al. 2014, McLachlan 2014).

A Risk to Human Health and Wildlife

Tar sands development presents risks to human health, wildlife, clean water and air.

Human health risks come from air pollution and consumption of contaminated foods. Fish, bird and mammal impacts occur from exposure to contaminants, destruction of forests, rivers and lakes, and caribou recovery efforts that promote wolf kills.

PHOTO: WHITEFISH FROM LAKE ATHABASCA K. RADMANOVICH

A Risk to Human Health

Tar sands development poses chronic and acute risks to human health from air pollution and consumption of contaminated fish and foods (Timoney and Lee 2009, McLachlan 2014). In Fort Chipewyan, a study by the Alberta health board concluded that cancer cases were higher than expected, in particular for biliary tract cancers, cancers of the blood, and cancers of the lymphatic system (Chen 2009). McLachlan found that the occurrence of cancer increased in accordance with employment in the oil sands and consumption of traditional foods including local fish. Although the human health findings from earlier studies have been challenged (RSC 2010), recent and mounting evidence is linking the presence of carcinogens to increased health effects (Timoney 2007, Kurek et al. 2013, Kirk et al. 2014, McLachlan 2014).

In 2008, Kinder Morgan Bulk Terminals pleaded guilty to a violation of the Ocean Dumping Act in a case where a terminal employee bribed a ship's captain to illegally dump potash at sea (USDJ 2008).

The Trans Mountain Pipeline Expansion (TMX)

Operational since 1953, the Trans Mountain pipeline was originally built to serve Canadian domestic needs. Under ownership of Kinder Morgan since 2005, the company has secured increased pipeline capacity through a series of incremental requests designed to avoid environmental assessment and public scrutiny. These have occurred despite written objections to the National Energy Board by concerned conservation groups (Raincoast 2011).

Kinder Morgan is now proposing a new pipeline that will triple capacity from the current 300,000 barrels per day (bpd) to 890,000 bpd. This pipeline would facilitate the export of tar sands oil (as diluted bitumen or dilbit) through the Salish Sea to offshore markets in Asia and the United States. Kinder Morgan is undertaking little more than a desktop review to identify risks from tankers to the marine environment and the species affected.

Kinder Morgan. A Different Kind of Energy Company?

Beginning as Kinder Morgan Energy Partners in 1997 when former Enron executive Richard Kinder and his colleague William Morgan acquired Enron's liquid pipeline assets, Kinder Morgan is now the largest energy transport company in the US (Kinder Morgan 2014). The numbers behind Kinder Morgan's environmental, safety and labour record tell their own story.

In 2007, the company paid 5.2 million $US to resolve liabilities with three oil spills and violations of the Federal Clean Water Act, Oil Pollution Act, Endangered Species Act and California's Water Quality Control and Oil Spill Prevention and Response Acts (EPA 2007a, Sightline Institute 2012).

In the same year, Kinder Morgan subsidiary Transmix Co. paid the US Environmental Protection Agency (EPA) more than 600,000 $US for federal air and waste regulatory violations that included mixing hazardous waste with gasoline (EPA 2007b). In addition, an FBI investigation in 2007 led to Kinder Morgan reaching a 25 million $US civil settlement with the Tennessee Valley Authority for allegedly stealing their own customers coal and selling it themselves (TOIG 2007).

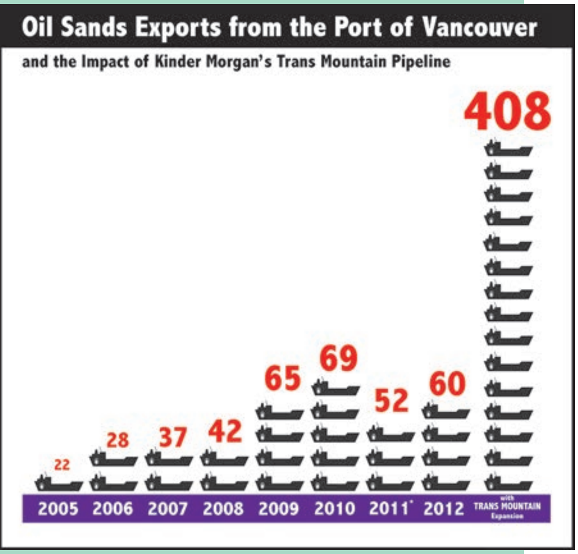


Figure 1.2. Since 2005, the Salish Sea has been host to rising oil tanker traffic. Kinder Morgan's request for expanded pipelines would dramatically increase the number of oil tankers departing Vancouver. Kinder Morgan has already increased tanker traffic three-fold since taking over Trans Mountain in 2005. Their TMX proposal would see an 18-fold increase in tanker traffic above 2005 levels.

IMAGE SOURCE CRED 2013

What Does the New Pipeline Mean for Tanker Traffic through Vancouver and the Salish Sea?

Information provided by Kinder Morgan shows that long-term increases in tanker traffic would be significant compared with historic rates (Figure 1.2, Table 1.1). Although the company anticipates 408 laden tanker departures per year by 2017, this figure could still be an underestimate. Analysis by economist Robyn Allan (2012) indicates that potential increases in pump capacity could bring the pipeline capacity to more than 1 million barrels per day, potentially requiring up to 475 tankers (950 transits) a year.

Expansion of the Westridge Marine Terminal

In addition to refineries in Washington State, the Trans Mountain pipeline delivers crude oil to the Chevron refinery in Burnaby and Kinder Morgan's Westridge Marine terminal for export. With the pipeline upgrade, the Westridge Terminal will increase local storage at Burnaby by 3,900,000 barrels (Kinder Morgan 2013a), and expand its tanker capacity with two additional berths.

In 2011, Kinder Morgan presented plans to increase the size of tankers from the current Aframax (with a capacity of 650,000 bls) to Suezmax tankers with a capacity of 1,000,000 bls (Anderson 2011). Not only does this increase potential spill volume, it also requires dredging of the second narrows bridge. However, Kinder Morgan's project web site (Kinder Morgan 2013b) indicates that these larger tankers are not under consideration.

Kinder Morgan has increased tanker traffic departing Vancouver for the Salish Sea three-fold since taking over Trans Mountain in 2005. The expanded TMX pipeline proposal would see an 18-fold increase in tanker traffic above 2005 levels.

Tanker traffic	2005	2006	2007	2008	2009	2010	2016	2016B	2017
Annual number of crude oil tankers	22	27	38	40	65	71	288	475	408

Table 1.1: Historic and projected crude oil tanker traffic into the Port of Metro Vancouver (Anderson 2011). 2016B[a] figure is based on additional pumping capacity (Allan 2012). Crude petroleum represented 4.5% of total outbound cargo in 2010, dropping to 2.4% in 2011 (due to increased delivery to US refineries), (PMV 2011).[b]

a) As of January 2013, TMX project website indicates up to 34 tanker visits per month by 2017
b) Calculated from data in PMV, Statistics Overview 2011

Traffic Report

US and Canadian oil spill experts recognize that while spill probabilities appear reduced by increased regulatory requirements and enforcement, predicted vessel traffic in the Salish Sea will increase the probability of an oil spill (OSTF 2011). Mitigation measures are no guarantee against the heightened risk of accidents associated with more vessel traffic (Van Dorp and Merrick 2013).

Salish Sea waters are predicted to see an increase in container ship traffic by 300% over the next 15 years. The number of bulk cargo vessels over this time will grow by 25% and cruise ship traffic is expected to increase by at least 20% (Hall 2008). The proposed Roberts Bank Terminal II terminal provides an additional 2.4 million container units.[5]

In Washington State, coal exports are the principal driver for the Gateway Pacific Terminal. This project will have a maximum capacity of 54 million tonnes of coal per year requiring 487 vessels (Booth and Steinberg 2013). It received 124,000 public comments on the scope of the environmental assessment (SVH 2013). A changing US energy supply is also driving US coal exports through Canada.

Expanding exports from Burrard Inlet
Port Metro Vancouver moved 2.5 million container units in 2011, about the same volume as is planned for the Roberts Bank Expansion. In 2013, the City of Vancouver approved Neptune Terminal's (on Vancouver's North Shore) application to expand. This will double coal exports from 8 to 18 million metric tonnes annually.

Port Activity
Port Metro Vancouver is Canada's largest port, handling 122 million tonnes of cargo in 2011. A significant proportion of inbound container goods (47%) are household goods and construction materials with most outbound container cargo consisting of lumber, wood pulp, and speciality crops.

In 2009, more than 80% of crude petroleum exports out of Vancouver went to the US, with just over 10% sent to China (PMV 2011). By 2011, crude petroleum exports to China increased to 28%. Visits of foreign tankers (one inbound, one laden outbound) to Port Metro Vancouver have varied from 206 to 270 between 2009 and 2011 (PMV 2011).

Vancouver, the New Newcastle?

Plans to increase coal exports in the Salish Sea were approved by Port Metro Vancouver in August 2014 (Ball 2014). Fraser Surrey Docks has been approved to ship four million tones of US coal requiring 640 barges a year. The existing Westshore facility is already Canada's largest coal exporter. This exceeds the US coal exports exported in 2011 by 30% (27.3 million tonnes) (Westshore.com Feb 2013). Neptune Terminals, on Vancouver's North Shore, have

5 Containers measured on twenty-foot equivalent unit (TEU)

also submitted plans to increase export by six million metric tonnes and one vessel each week (PMV 2013).

Recent risk assessments of vessel traffic specifically indicate the potential impact of three key proposals, the Pacific Gateway Terminal, Kinder Morgan's Trans Mountain expansion (TMX), and the Delta Port expansion. Draft results indicate that relative to a 2010 base year, these projects increase the potential frequency of vessel traffic collision and grounding by 21% and 17% respectively. Potential loss of oil cargo due to collision is increased by 97% and potential loss of oil cargo because of grounding by 73% (Van Dorp & Merrick 2013).

The Westshore facility at Robert's Bank is Canada's largest coal exporter shipping 30 million tonnes of coal in 2013.

PHOTO: WESTHORE.COM

Sink, Float, or Submerge?

The fate and behaviour of diluted bitumen (dilbit) in the marine environment is poorly understood. Concerns about this were first raised by the Canadian Federal Government in 2011. The Coast Guard highlighted the lack of scientific agreement on how spilled dilbit would behave in the ocean, and the fact that when fine sediments are suspended in saltwater and mixed with diluted bitumen, the mixture either sinks or is dispersed as floating tar balls (GOC 2013).

In late 2015, The US National Academy of Sciences (NAS) released the most comprehensive and rigorous review to date on the potential environmental consequences of diluted bitumen spills. The National Academy found that dilbit differs substantially from other crude oils. Importantly, it behaves like other crude oils when first spilled, but begins reverting back towards the properties of the initial bitumen once evaporation and other weathering processes begin.

Diluted bitumen spilled in the Kalamazoo River floats submerged below the surface.

PHOTO: WDIV -TV

The National Academy also concluded that dilbit is inclined to submerge quite soon after a spill on water, and can sink to the bottom even if the oil is less dense than water (NAS 2015).

Trans Mountain's application to the National Energy Board (NEB) asserts that dilbit (and crudes like it) are quite comparable with respect to fate and weathering, and spill countermeasures (TMEP 2013). Describing the results of its laboratory analysis, Trans Mountain claimed that dilbit proved "no different than what might be expected of other conventional heavy crudes when exposed to similar conditions" (TMEP 2013). These assertions and claims are

Figure 1.3: Accidents happen
On July 22 1991, the Chinese freighter Tuo Hai collided with a Japanese fishing vessel, Tenyo Maru, 40 km (25 mi) northwest of Cape Flattery off the northern coast of Washington close to the US–Canadian border. It sank, releasing 8,500 barrels of fuel oil and 2,300 barrels of diesel (NOAA 2012).

MAP SOURCE: NOAA

In the Navy
The two tugs assisting the fishing trawler American Dynasty did not prevent it from colliding with the naval frigate HMCS Winnipeg at Esquimalt harbour on April 23, 2013 (TSB 2013).

PHOTO: TRANSPORTATION SAFETY BOARD

largely refuted by the findings of the far more authoritative National Academy report.

While the true likelihood of a spill is unknown, the Brander Smith (1990) federal review of tanker safety in Canadian waters predicted, based on 1990 traffic levels, at least one major spill (above 10,000 bls) every year and a catastrophic spill once every 15 years. Similarly, a 1999 report for the Canadian Coast Guard predicted that Canada should expect a major oil spill from a tanker once every seven years (SL Ross 1999).

Based on current traffic levels, the Federal Government's 2013 National Marine Spill Risk Assessment identified two key areas of concern. One, the Pacific region has the highest probability for small spills and two, the southern tip of Vancouver Island has the highest probability for a large spill (GENIVAR 2013).

Accidents Happen

Although there has been a decline in the frequency of tanker oil spills over the last two decades, spills still occur. Once tankers are present, many believe it is a statistical question of when, not if, an accident happens. This point was underscored by the BC Environment Minister, Barry Penner (2008), who informed the Pacific States/British Columbia Oil Spill Task Force that, "given the high marine traffic and topography of our coastline, it simply is not possible to completely prevent spills from happening." Although this does not solely refer to oil tankers, the point is borne out in recorded incidents.

Accidents in the Salish Sea

From the puncturing of the Nestucca oil barge off Grays Harbour to the Westwood Annette oil spill in Howe Sound, accidents involving major marine vessels occur in and affect the Salish Sea in BC and Washington State. There have also been several near misses.

Between 1999 and 2009, more than 1,200 vessel incidents[6] were reported on the BC coast, 12 involving tankers (LOS 2010). From 1995-2008, 14 oil spills from tankers in Washington State released 310 barrels of oil. During the same period, 132 near-miss casualty incidents also occurred for vessels carrying a total of 64 million barrels of oil (ERS 2009).[7]

6 Refers to a vessel in distress, i.e. loss of engine power, which can lead to a casualty. Reid, S. 2008.
7 Within US waters of Washington State.

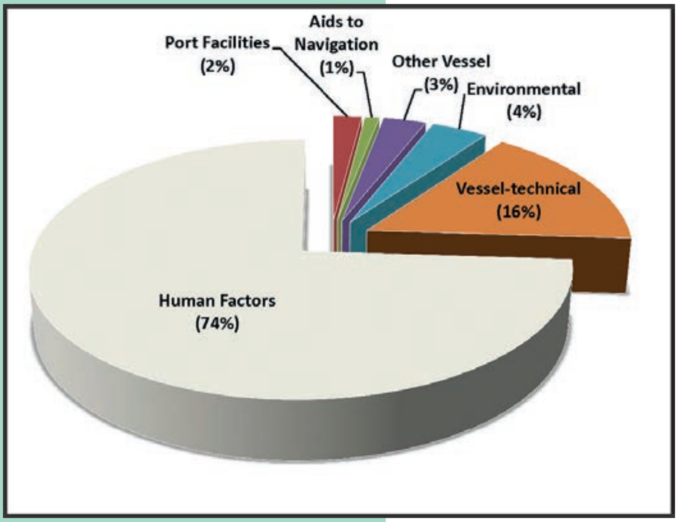


Figure 1.4:
What causes oil spills?
Groundings, collisions, and equipment failures are often cited as the cause of accidents at sea, but these are actually consequences, not root causes. Ultimately, human failures cause up to 80% of the accidents at sea, with miscommunication and cost saving among them (Trucco 2008).

What's the Risk in Canadian Waters?

Causes of Spills: Human Error

Small and medium sized oil spills account for 95% of the reported oil tanker spill incidents globally. Almost 70% of these spills occurred during loading and discharging operations, primarily within ports and oil terminals. Large spills (above 5500 bls) account for the remaining 5% of accidents.

In large oil spills, 58% occurred while vessels were away from port when they hit objects, grounded, or collided with another vessel.[8] Within ports and harbours, collision and groundings account for 95% of the accidents that cause spills (OSTF 2011).

How Safe is the Tanker Route?

High risk places for shipping accidents occur where traffic converges, such as the western entrance of the Juan de Fuca Strait. Risk of groundings and collisions also increase when vessels travel closer to shore (OSTF 2002). In recognition of this, an emergency response tug is stationed at Neah Bay to help prevent incidents. Between 1999 and 2010, the tug was deployed 46 times to assist vessels that were completely disabled or suffering reduced manoeuvrability. In 11 incidents, the tug took vessels in tow to prevent them from drifting onto rocks, ripping holes in the hulls and potentially releasing oil (WSDE 2012). These 11 vessels had a combined spill potential of 120,000 barrels of oil. As tankers travel to and from the Strait of Juan de Fuca, they must navigate sharp turns on entering or exiting Haro Strait and Boundary Pass. In addition to high shipping traffic, there is a high density of pleasure and fishing boats and the shoreline has numerous anchorages. The risk of collision also increases with large vessel speed (OFTF 2011).

Once vessels reach the port of Vancouver, they must pass the first and second narrows of Burrard Inlet (top photo page 16).

8 with other vessels or objects

Currently, second narrows has movement and speed restrictions that require laden oil tankers to pass only in daylight hours within windows for safe tide and wind, and with the use of tugs (VFPA 2010). These measures were largely implemented after a tanker (*Japan Erica*) hit the bridge in 1978, but did not prevent 17 incidents from occurring within the second narrows restricted area (VFPA 2008), including collisions, fire and near contact with the bridge. In addition, a bulk freighter went aground at Stanley Park in 2006.

Ships Safe at Anchor?

Just as ships anchoring in the Gulf Islands represent a spill risk, the same is true of the increasing number of oil tankers in Vancouver Harbour. Some anchorages in English Bay are already known to be susceptible to dragging in certain winds. Although these anchorages are subject to seasonal restrictions, the risk of unseasonably high winds is always present (VFPA 2010) and will be increasing with climate change.

Burrard Inlet and the railway bridge at Second Narrows after the tanker *Erica* hit it in 1978.

BRIDGE PHOTOS: C. PRUTTON

Figure 1.5: Inbound and outbound oil tanker routes to Kinder Morgan's Westridge Terminal.

Close calls should make us wary
In November 2009, the bulk freighter *Hebei Lion*, carrying two million gallons of fuel, dragged anchor in high winds overnight and was blown onto a reef between Pender and Mayne Islands in the southern Gulf Islands (WSDE 2009). Fortunately, the tide was high and the vessel was towed off, but this incident reinforces the fact that heightened regulations and navigational technology cannot override natural forces or human error.

Chronic Oiling

Although our principal concern is large spills, increases in traffic also raise the issue of recurrent oil spills from tanker and other shipping activities. Even if relatively small, these chronic spills have long-term ecological impacts and can contribute more oil to the marine environment than catastrophic spills (Serra-Sogas et al. 2008). The routine nature of these spills at ports and terminals is an important factor in the chronically oiled condition and degraded habitats found near these vicinities.

Are We Fooling Ourselves?

In 1995, a report to the federal government on oil spill risk by Brander Smith found Canada, "wholly unprepared" for a catastrophic spill. Twenty years later, Canada's Commissioner of the Environment and Sustainable Development determined that Canada's plan for oil spill preparedness and response did not establish national preparedness capacity (OAGC 2010). Drastic budget cuts in 2012 to the agencies responsible for dealing with oil spills (Fisheries and Oceans and Environment Canada), further undermined the capacity to respond. Another blow to response capacity was the transfer of BC's oil spill response centre to eastern Canada.

Notably, all of Canada's oil spill response capacity is based on the critical, but false, assumption that oil will float when spilled and that wind and wave conditions will be low.

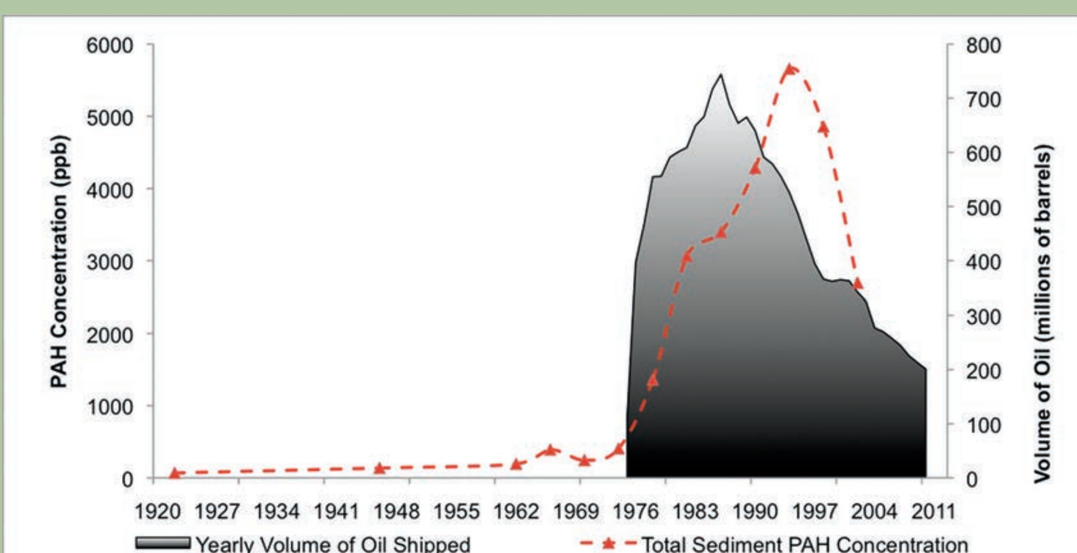


Figure 1.6: Studies from the Port of Valdez show a clear correlation between levels of Poly Aromatic Hydrocarbons in sediment and volume of oil shipped (Savoie et al. 2006).

2. Meet Your Neighbours

Steller Sea Lions: Voracious Salmon Predators?
In the 1900's, the belief that sea lions "competed" with humans for salmon led to the slaughter of entire breeding rookeries. More than 55,000 Steller sea lions in BC were killed. We now know that salmon are a relatively small proportion (around 10%) of the sea lion's diet (Heise et al. 2003).

PHOTO: J. HILDERING

Lying on the continental shelf, the Salish Sea is a labyrinth of remarkable coastal waterways. From shallow embayments to deep fjords, rocky reefs and soft river deltas, these waters provide countless places for marine plants and animals to live. When these geographic features are combined with varying amounts of sunlight, salt and oxygen, the food web for thousands of animal species is created, a food web so rich that it supported the world's smallest and largest creatures for millennia.

Marine Mammals

Twenty-seven species of marine mammals have been observed in the Salish Sea. Thirteen of them can be found regularly. For these animals, the Salish Sea serves a multitude of purposes—feeding, breeding, resting, overwintering, or simply as a migratory corridor. Some species, such as killer whales and Pacific white-sided dolphins, range widely, but others, such as sea otters, are more closely associated with specific areas.

A Troubled Past

Our recent history with marine mammals in the Salish Sea does not summon pride. From the early 1700s to the 1970s, humans have managed to reduce most of the Salish Sea marine mammals to a fraction of their previous numbers.

Starting with the fur trade, sea otters were extirpated[1] from the province in a quest for fur and wealth. The elephant seal, chosen because of its abundant stores of oil, was next to be hunted to near collapse. As the value of oil increased, a new and easier target was identified in grey whales, which were hunted to

1 A local extinction; a species (or other taxon) ceases to exist in a specific geographic area, though it still exists elsewhere.

commercial extinction by the late 1800s. The newfound power of steam and steel then accelerated the killing of larger, faster whales, and with this, the populations of minke and humpbacks disappeared from the Salish Sea and other coastal waters (Nichol et al. 2002).

Even the most ubiquitous of marine mammals, the harbour seal, showed a dramatic population decline by the 1960s as a result of more than 500,000 being killed for bounties, commercial hunting, and predator control measures.

Perhaps the most grievous atrocity committed against the marine mammals of the Salish Sea was the live capture of killer whales prior to 1974 for the aquarium trade. Forty-eight (48) individuals from the Southern Resident population and five transient killer whales were taken from their family units or

PHOTO: BC ARCHIVES

NAME	COMMON NAME	NATIONAL CONSERVATION STATUS
Phoca vitulina	Harbour seal	NOT AT RISK
Mirounga angustirostris	Northern elephant seal	NOT AT RISK
Eumetopias jubatus	Steller sea lion	SPECIAL CONCERN (COSEWIC 2003a, SARA)
Zalophus californianus	California sea lion	NOT AT RISK
Enhydra lutris	Sea otter	SPECIAL CONCERN (COSEWIC 2007, SARA)
Phocoena phocoena	Harbour porpoise	SPECIAL CONCERN (COSEWIC 2003b, SARA)
Lagenorhynchus obliquidens	Pacific white-sided dolphin	NOT AT RISK
Phocoenoides dalli	Dall's porpoise	NOT AT RISK
Orcinus orca	Southern Resident killer whale	ENDANGERED (COSEWIC 1998, SARA 2003)
	Biggs (Transient) killer whale	THREATENED (COSEWIC 2008, SARA)
Eschrichtius robustus	Grey whale	SPECIAL CONCERN (COSEWIC 2004, SARA)
Balaenoptera acutorostrata	Minke whale	NOT AT RISK
Balaenoptera noveangliae	Humpback whale	SPECIAL CONCERN (COSEWIC 2011a); THREATENED (SARA)

Table 2.1: Common marine mammals of the Salish Sea and their corresponding conservation status according to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the Species at Risk Act (SARA)

died in the capture process (Olesiuk et al. 1990). The removal of these animals caused biological and cultural devastation among the remaining pod members and intense suffering to those sentenced to life in captivity.

Because marine mammals reproduce slowly and invest great care in a single offspring, many are vulnerable to over-exploitation and other human related threats. Consequently, recovery from significant population reductions can take many years. The encouraging prospect is that ending destructive human behaviours can stabilize and reverse populations in decline.

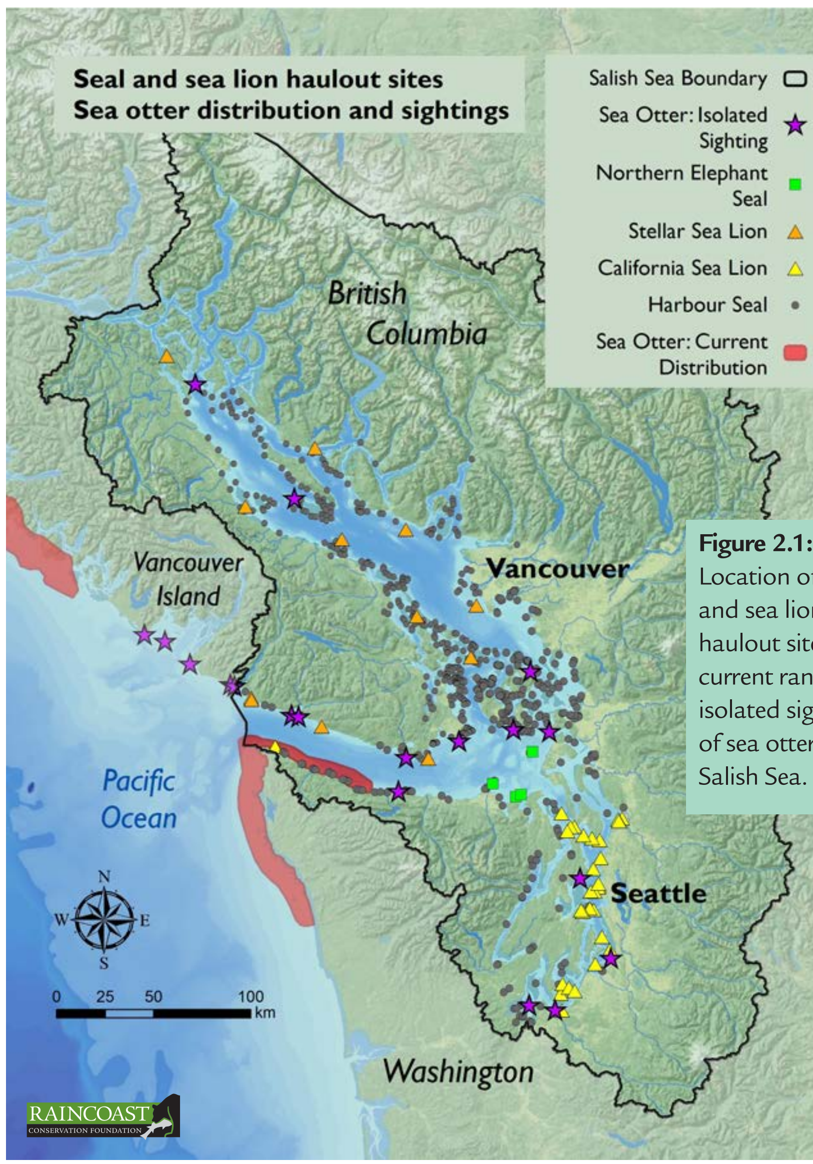


Figure 2.1: Location of seal and sea lion haulout sites with current range and isolated sightings of sea otters in the Salish Sea.

A Remarkable Sighting
Driven to virtual extinction in BC during the height of whaling, the North Pacific right whale has made an astonishing reappearance. Following 60 years without a sighting, two right whales have been spotted off the BC coast, one just outside of the Juan de Fuca Strait. These sightings (shown on map) have brought new hope that this once fated species could return.

PHOTO: J. FORD, FISHERIES AND OCEANS CANADA

Figure 2.2 Location of recent North Pacific Right Whale sightings.

The Road to Recovery

Many marine mammal populations of the Salish Sea are slowly recovering. Areas uninhabited in recent history are gradually being recolonized and large aggregations of marine mammals are now being seen. Some species, however, show little sign of recovery and their future remains uncertain. This is particularly true for the Southern Resident killer whales.

The recent presence of elephant seal pups at Race Rocks in the Strait of Juan de Fuca suggests this to be a new—and most northern—breeding site for elephant seals.

PHOTO CREDIT: E. BOERNER, NOAA

Fur Bearers

Northern Elephant Seal

The northern elephant seal is another species recovering from near extinction. More than 175,000 individuals are now thought to live on North America's west coast (Weber et al. 2000). Elephant seals migrate north from their major breeding rookeries in California and Mexico (Jeffries et al. 2000). Elephant seals are not known to breed in BC, however the presence of pups in the last five years at a (previous) haul-out in the Salish Sea, suggests this is a new—and the most northern—breeding site (Race Rocks 2014).

Steller Sea Lions
Steller sea lions have no breeding rookeries in the Salish Sea but use 11 known haul-out sites, primarily in the winter.

PHOTO: M.MACDUFFEE

Steller Sea Lion

Steller sea lions are one of the most studied marine mammals in the North Pacific. This is because the western population in Alaska (west of 144 ^{0} W) has declined by 80% since the 1970s and is considered endangered in the US. Causes of the decline are the focus of much research and debate. Nutritional stress due to reduced food availability or quality, high predation of pups by transient killer whales (Horning and Mellish 2012), and natural fluctuation have been identified as potential causes.

In Canada, the eastern population of Steller sea lions (east of 1440 W extending down into California) was assessed as Special Concern by SARA in 2003. Hunting and predator culls in the last century killed more than 50,000 sea lions and reduced the population to fewer than 4,000 individuals in three breeding rookeries (Heise et al. 2003, Bigg 1985). Since the culls stopped in 1970, Steller sea lion numbers in BC have increased to between 20,000 and 28,000 (Fisheries 2010a; Fisheries 2008).

California Sea Lion
Often accused of competing for salmon, a sea lion's diet consists more of smaller forage fish, squid, and octopus (Jeffries et al. 2000; Lowry et al. 1991)

PHOTO: T. ORR, NOAA

California Sea Lion

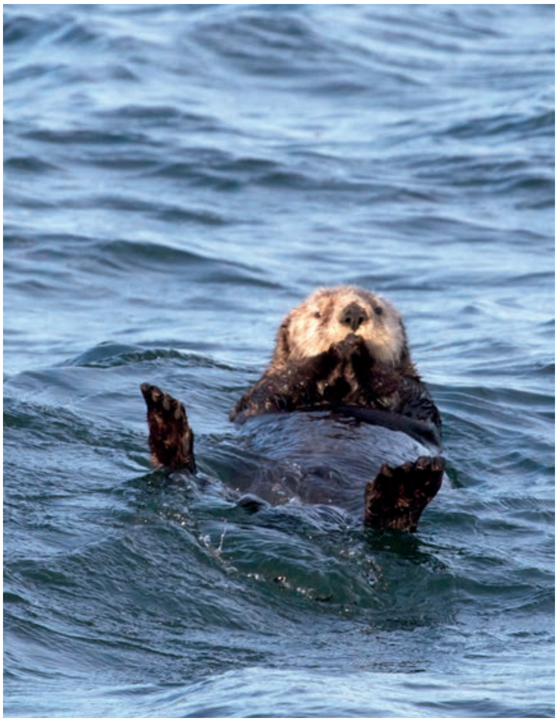
Predominantly a southern species, the California sea lion breeds and lives primarily in California and Mexico. Numbers are estimated at 153,000 individuals (Jeffries et al. 2000; NOAA 2011). Only males seem to migrate northward far enough to reach the Salish Sea and have been observed in spring, summer, and fall (Jeffries et al. 2000; Bigg 1985).

Sea Otter—A Reintroduction Success Story

After being extirpated by commercial hunting, sea otters were reintroduced to British Columbia in an attempt to recolonize historic habitat. Likewise, in the United States, 59 sea otters were reintroduced to the Salish Sea in the 1970s along the coast of Washington. This group now numbers upwards of 1,073 individuals (Jameson and Jeffries 2010) and occupies rocky habitat on the northwest coast of Washington.

Harbour Seals.
Harbour seals that live in harbours and ports are particularly toxic and pose a risk to the whales that eat them (Ross et al. 2004; Ford et al. 2012). Health risks include reproductive impairment, decreased immune function, increased incidence of disease, skeletal abnormalities, and neurological impairment (Fisheries 2007a).

PHOTO; J. FITZ-HIRSCHBOLD



Sea Otter
Healthy kelp beds are one benefit from the reintroduction of sea otters to Washington State, as their consumption of urchins reduces over grazing on kelp (Lance et al. 2004).

PHOTO: M. MACDUFFEE

Toothed Whales

Dolphins and Porpoises

The dolphins and porpoises most commonly sighted in the Salish Sea are the harbour porpoise, Dall's porpoise, and Pacific white-sided dolphin. Recent estimates suggest BC's inside waters host between 5,000–10,000 harbour porpoises and Dall's porpoises (each), and about 25,000 Pacific white-sided dolphins (Best et al. 2015). The density and distribution of these small cetaceans can be linked to the local availability small schooling fish, their primary food (Walker et al. 1998; Heise 1997). Entanglement in fishing gear is one of the biggest threats to their survival.

Super Pods in the Salish Sea
Since the mid 1980s, Pacific white-sided dolphins have become increasingly common in BC's inshore waters (Heise 1997), including recent sightings of dolphin super pods in the Salish Sea. These impressive aggregations can contain more than 1,500 individuals.

PHOTO: C. MOTT

Salish Sea Subpopulations are at Greater Risk
Shy harbour porpoises rarely travel in large gregarious groups like their Dall's or Pacific white-sided cousins. BC's harbour porpoise may be split into genetically and geographically distinct units (Chivers et al. 2002). This puts the subpopulations at greater risk from disturbances that would not typically threaten the entire population (Fisheries 2009).

PHOTO: W. CURTZINGER

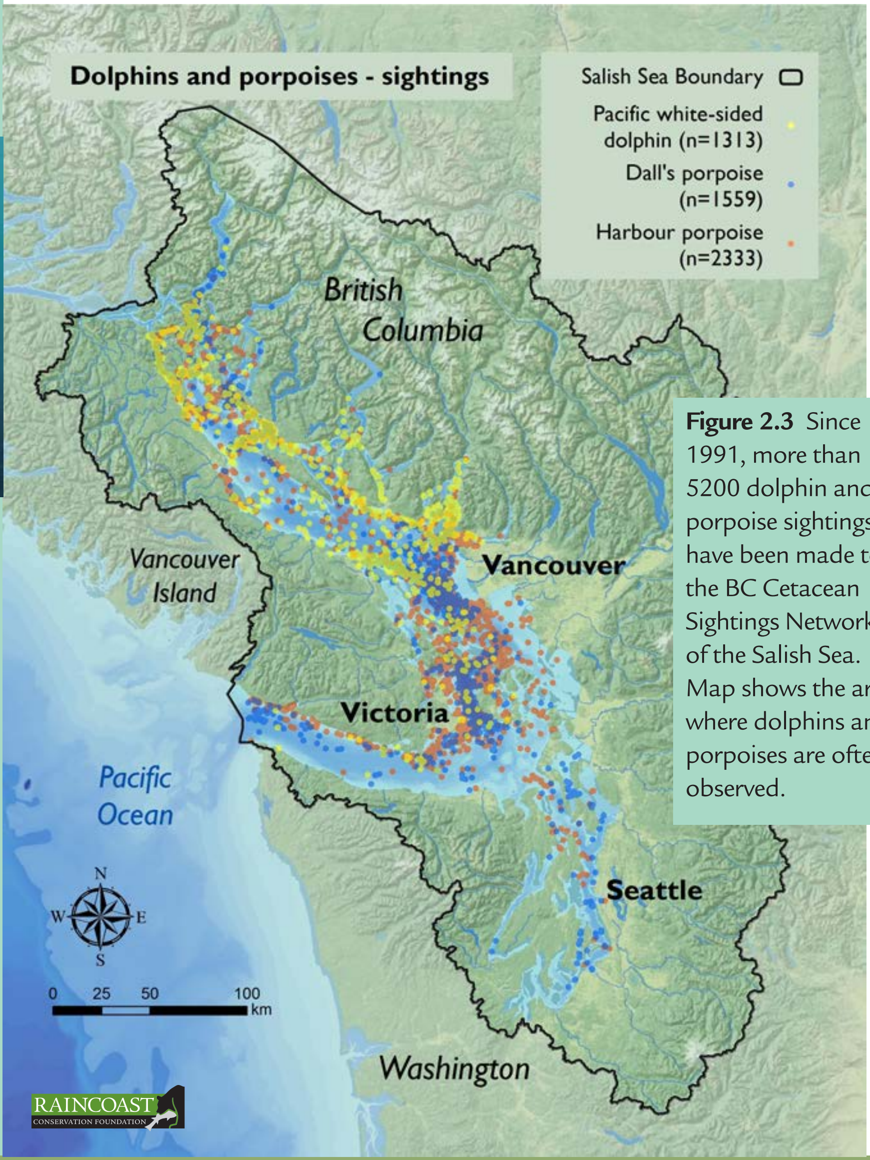


Figure 2.3 Since 1991, more than 5200 dolphin and porpoise sightings have been made to the BC Cetacean Sightings Network of the Salish Sea. Map shows the area where dolphins and porpoises are often observed.

Southern Resident Killer Whales

Perhaps the most revered and iconic species in the Salish Sea, the Southern Resident killer whales, are also the most critically endangered. These salmon-eating whales are genetically distinct from their northern counterparts and have about one-third their numbers. In 2015, the Southern Resident killer whale population comprised less than 85 individuals, separated into three groups of closely related matrilines known as J, K, and L pods.

Thought to be present sporadically throughout the winter and more consistently during the summer, new research is showing that many whales, particularly J Pod, spend considerable time in the Salish Sea throughout the year (NOAA 2014).

Surrounded on All Sides

The Southern Residents travel in relatively large groups that vocalize with each other. This makes them easy for researchers and observers to find, but has led to a near constant flotilla of followers. The sound and disturbance from vessel traffic makes finding food and communication more difficult (Lusseau et al. 2009, Williams et al. 2014). Despite the knowledge that decreased food supply, pollutants, increased noise, and habitat disturbance are affecting whale survival, no adequate actions are being taken to address these threats.

85 Southern Resident killer whales eat between 300,000 and 600,000 Chinook salmon a year, depending the percent of Chinook in their diet, the size and age of the whales and the size and age of the Chinook salmon (Ford et al. 2011a).

PHOTO J. TOWERS

Figure 2.4: Almost half of the Salish Sea has been identified by Canadian and US federal governments as critical to the survival of the Southern Resident killer whales. All three pods use their critical habitat (red) and surrounding areas throughout the year.

The Salmon Eaters

The Southern Resident killer whales have a favourite food—Chinook (spring) salmon. In the summer, these whales target Chinook stocks from the Fraser River and Puget Sound (Hanson et al. 2010). The abundance of Chinook salmon is linked to the survival of the resident whales, with nutritional stress causing increased mortality in years of decreased Chinook salmon availability (Ford et al. 2005). Because of the evidence linking Chinook abundance with killer whale vital rates (like birth and death rates; Ford et al. 2005, 2010, Velez-Espino et al. 2014), measures must be taken to ensure killer whales can catch sufficient numbers of Chinook, particularly in years when Chinook abundance is low.

Transient Killer Whales

Although it is hard visually to distinguish between resident killer whales and transient (increasingly called Biggs) killer whales, they differ widely in their diet, behaviour, and range.

Fire-proof Killer Whales
Transient killer whales that frequent the Salish Sea contain very high levels of toxic pollutants (Ross 2006). Chemicals such as PCBs, flame retardants, and pesticides are introduced from urban and industrial areas to harbours and ports within the Salish Sea.

PHOTO: G. MILLER

More Seals, More Seal Eaters
After receiving protection from commercial hunting and predator control measures that killed more than 500,000 harbour seals by the 1970s, the Salish Sea population has grown from an estimated 4,000 to approximately 40,000 (Olesiuk 1999). The now abundant seal has attracted their primary predator—transient killer whales. In the last 30 years, these mammal-eaters have dramatically increased their numbers and presence in the Salish Sea.

PHOTO: L. JONES, NOAA

Figure 2.5 Proposed critical habitat of transient killer whales in the Salish Sea encompasses the entire BC coastline up to three nautical miles from shore (Ford et al. 2012).

These stealthy, silent predators travel in small quiet groups up and down the coast in search of food. They feed exclusively on marine mammals: particularly harbour seals, porpoises, and sea lions. Transient killer whales observed in the Salish Sea belong to the West Coast Transient population, estimated at 250 individuals. They can appear in the Salish Sea throughout the year, but are seen in greater abundance in the late summer when harbour seals have young pups (Ford et al. 2012).

In the last 30 years, the number of transient killer whales observed in the Salish Sea has increased dramatically, from 10 in 1980 to more than 120 in 2010, with an increase from 60 to 120 between 2000 and 2010 alone. The whales are also arriving in larger groups sizes (Ford et al. 2010). This rapid increase corresponds to recovery of harbour seals and other prey within the Salish Sea (Ford et al. 2011b).

Grey whales are often sighted migrating through BC waters in groups of 1-5. Their route takes them into Salish Sea shipping lanes, an area of known ship strike mortality (Douglas et al. 2008).

PHOTO: C. HYSLOP

Baleen Whales

Grey Whales

Despite a collapse in grey whales to 2,000 individuals after whaling, the eastern population of North Pacific grey whales has recently been estimated at more than 20,000 (Rice et al. 1984; Punt and Wade 2012). Unique among whales, the grey whale is primarily a bottom feeder, which sifts through sediment to obtain amphipods, mysids and other bottom dwelling invertebrates. These whales travel great distances in search of suitable patches of ocean floor on which to feed. The migration between their winter calving grounds in Southern and Baja California to their northern feeding grounds in the Arctic seas is more than 8,000 km (Pike 1962).

Stranded Grey Whale
A successful feeding season is the difference between life and death. In 1999, mass strandings and deaths of grey whales were recorded all along their migration route. The deaths were attributed to starvation and a hypothesized decrease in (krill-like) amphipods in bottom sediments of the northern feeding grounds (LeBouef et al. 2000). An estimated 30,000 whales in 1997 dropped to a startling 16,000 in 2001, showing just how destructive natural or human-caused changes to food availability can be (Rugh et al. 2005)

PHOTO: B. STOTESBURY, TIMES COLONIST

Humpback Whales—A Feeding Mission

Humpback whales are typically present in coastal BC from May to October. Our waters, and those in Alaska, are the northern feeding grounds for whales after leaving their winter calving sites in more tropical waters. Abundance in BC's inside waters has been estimated at around 1,500 animals during these months (Best et al. 2015).

During their stay in northern waters, a humpback's objective is feeding. They must sequester enough energy to maintain themselves through the lean winters in southern seas. Areas where high concentrations of food (typically krill, herring, and sardines) attract humpbacks have been proposed as critical habitat. One of these sites is the entrance to Juan de Fuca Strait (Nichol et al. 2009). Humpbacks appear to be particular about their feeding grounds and as such, may be more susceptible to habitat degradation and energy spent looking for food elsewhere (Calambokidis et al. 2001).

Some Whales don't Want to Leave.
Approximately 200 grey whales remain on the BC coast during the summer months, abandoning the long Arctic migration (Calambokidis et al. 2002). This group has been coined the Pacific Coast Feeding Aggregation and are a distinct subpopulation (Frasier et al. 2011).

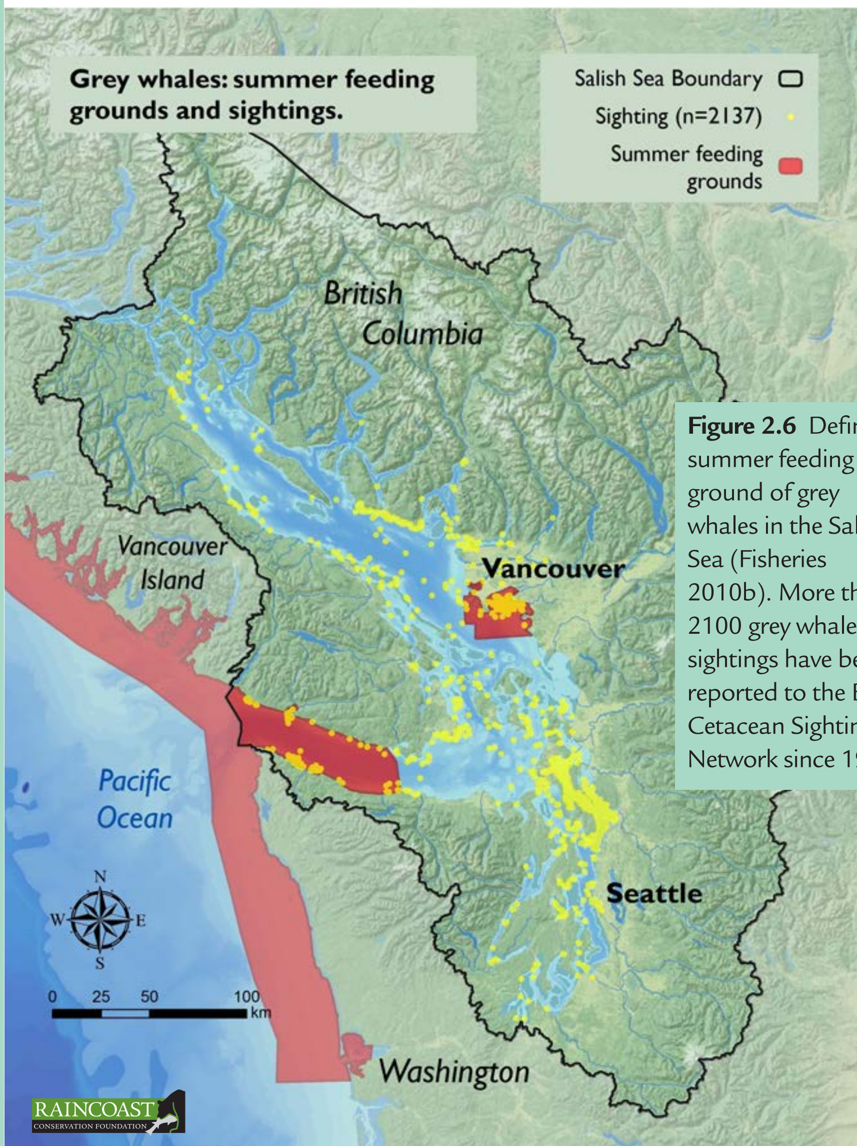


Figure 2.6 Defined summer feeding ground of grey whales in the Salish Sea (Fisheries 2010b). More than 2100 grey whale sightings have been reported to the BC Cetacean Sightings Network since 1988

Minke Whales—The Elusive Loner

Minke whales are most commonly observed in the Salish Sea in the spring, summer, and fall where they feed on small schooling fish. Their coast wide population is estimated at less than 500 individuals (Best et al. 2015). They are primarily seen alone, or in similar areas but acting independently of one another. As with humpbacks, when Minke's find a good feeding area, they tend to linger (Dorsey et al. 1990).

Whales: The Ocean's Gardeners

Commercial whaling devastated whale abundance in the southern ocean over the last two centuries. But it wasn't until recently that the decline of whales was linked to the decline in krill and iron concentrations (Lavery et al. 2010). The discovery provides an explanation for how the southern ocean once supported much more life than it can today. Simply put, whales function like an ocean pump that concentrate and return iron to surface waters where it kick-starts marine food webs. See Chapter 3.

PHOTO: H. HUMCHITT

Whaling in the Strait of Georgia, 1908

Captain Larsen at the harpoon gun on the St. Lawrence in the Strait of Georgia in 1908. A whaling station operated here from October 1907 to February 1908, processing 98 humpback whales before it was closed. In total, more than 24,000 whales were slaughtered as part of BC's commercial whaling efforts.

PHOTO: BC ARCHIVES

Wings over the Salish Sea

The Salish Sea lies along the path of the Pacific Flyway (figure 2.6), a critical migratory route for millions of marine and terrestrial birds that stretches from South America to the high Arctic. The Salish Sea region provides habitat to more than 170 species of marine birds, offering food, shelter, a place to find mates, socialize, moult, and overwinter (Gaydos and Pearson 2011). Some of these birds are year-round residents and others are visitors as they move around the margins of the Pacific Ocean and beyond.

In addition to marine birds, the Salish Sea watersheds are home to land-based bird species. These lands are a mosaic of coastal habitats, including saltwater marshes, estuaries, fields, and forests that interact with marine waters. Although no exact numbers are available, roughly 130 species of land-based birds inhabit the terrestrial areas bounded within the Salish Sea watersheds.

Globally, marine birds face a litany of direct and indirect threats from humans. Humans degrade or destroy their habitat, hunt them, compete for fish and other food, introduce species they cannot cope with, and pollute their waters with plastics, oil, and other contaminants. Unfortunately, the Salish Sea is no exception. Threats to marine birds include lost or degraded habitat, oil spills of all sizes (O'Hara et al. 2009), contaminants (Calambokidis et al. 1985, Elliot et al. 1996), disturbance (Chatwin 2010), introduced mammals on bird colonies, and fishing. Fishing affects food supply (e.g., herring abundance, Therriault et al. 2009) and causes death from by-catch in nets, long lines (Hamel et al. 2009) and derelict fishing gear (Good et al. 2009).

Diving Birds, Diving Numbers

Of the marine and marine-associated birds known to occur in the Salish Sea, at least 23 are listed as Species At Risk or are candidates for provincial/state or federal listings (Gaydos and Brown 2009). Further, long-term monitoring of marine birds in

What is a Marine Bird?

There is no single definition of marine birds. The term marine birds captures true seabirds like puffins, shearwaters, and albatross, but can also include marine-associated birds like waterfowl (ducks, herons, cormorants, gulls), shorebirds (e.g. sandpipers, turnstones) and raptors (e.g. osprey, eagles, and falcons).

Figure 2.6: Pacific Flyway.

CREDIT: U.S. FISH & WILDLIFE SERVICE

the Salish Sea indicates substantial declines in many species, including Western Grebes, Marbled Murrelets, and Common Murres (Anderson et al. 2009 and Bower 2009). Several of these, including Marbled Murrelets, are of urgent conservation concern and declines in the Salish Sea mimic widespread declines elsewhere in their range. For many species, the causes of declining populations remain unresolved.

For the Birds—The Fraser River Delta

At the mouth of the Fraser River lies the largest estuary on Canada's Pacific coast, comprising 754 km^2 near densely populated Vancouver. The Fraser River estuary is of provincial, national, continental and global importance for marine birds.

Marine birds can act as sentinels of ecosystem health (Piatt et al. 2007). Substantial declines are often indicative of trouble for a broader range of plants and animals. Some fish eating birds, such as Western Grebes, have seen dramatic winter declines in the Salish Sea over the last several decades. This disappearance correlates with declining Pacific herring in the Salish Sea and increased sardine abundance off California, where grebe abundance has increased (Wilson et al. 2013).

PHOTO: J.GAYDOS

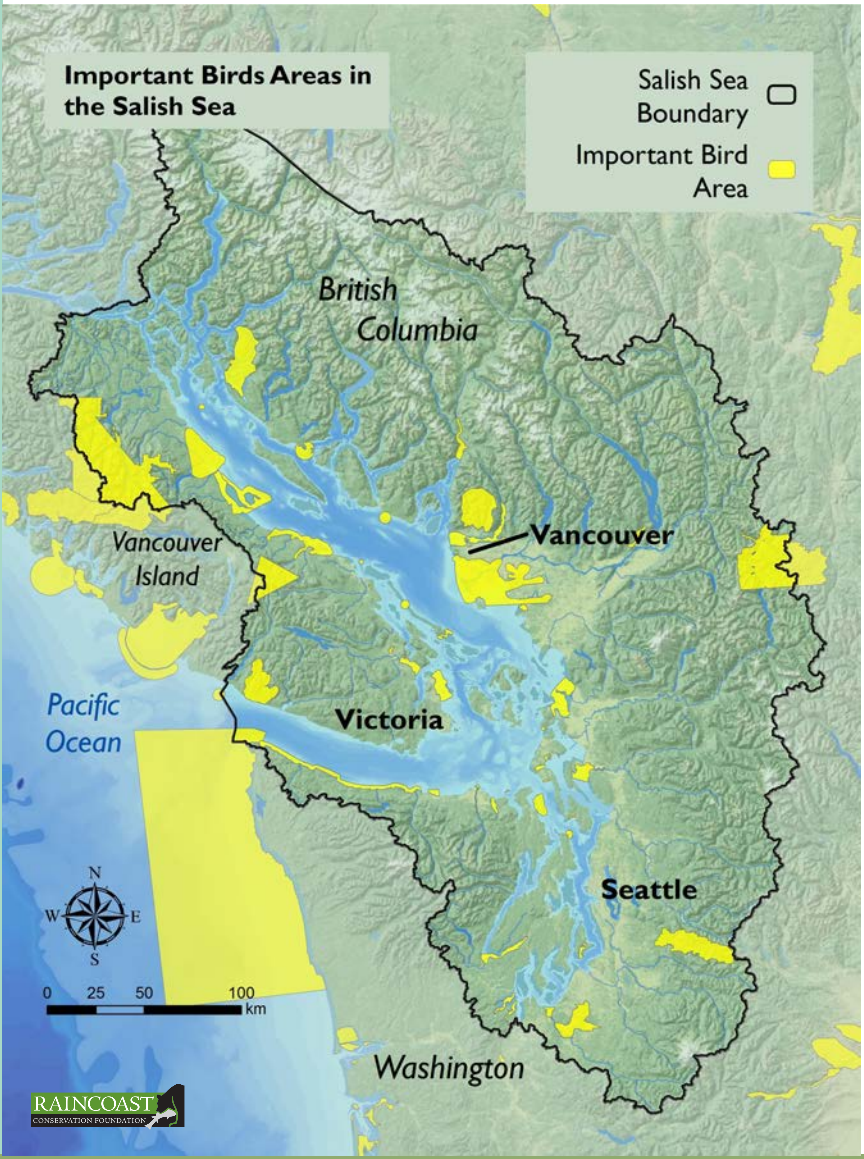


Figure 2.7: Important Bird Areas in Canada (Bird Studies Canada) and in Washington (National Aubudon Society)

Each spring, millions of migratory shorebirds and waterfowl descend onto the Fraser delta to forage, rest, and refuel on their long distance migrations (BC CDC 2006).

In summer, raptors and songbirds are abundant over the fields, hedges, and forests. By late summer, the early trickle of returning migrants from northern breeding grounds increases to a steady flood of millions of birds by fall. During the fall and winter, daily counts of over 100,000 waterfowl are common. Species such as the Western Sandpiper have daily estimates as high as 500,000 (IBA Canada 2015). At times like this, the Fraser delta supports substantial portions of the global populations of some bird species (IBA Canada 2015). While many of these species will continue to move south, for some, such as the Northern Pintails and Brant, the area provides crucial overwintering habitat.

The Fraser River estuary is the largest on Canada's Pacific coast. In addition to its designation as an Important Bird Area, the region contains a Western Hemisphere Shorebird Reserve, a Migratory Bird Sanctuary, the Reifel Bird Sanctuary, and the Alaksen Wildlife Refuge. Supporting millions of birds, the Fraser River delta is of immense importance locally and globally.

PHOTO: E. LESSON

Western Sandpipers in the Fraser River delta have had daily abundance estimates as high as 500,000 during their spring migration. In the last two decades, peak counts have been below 200,000. This still represents a significant percentage of the global Western Sandpiper population (IBA 2015).

PHOTO I. GUTHIE

Fin Fish of the Salish Sea

Five species of commercial salmon (and three species of recreationally fished salmonids) use the rivers, estuaries, and pelagic waters of the Salish Sea. Their habitat extends from the smallest coastal streams to the largest rivers and deltas, the kelp and eel grass beds, the sheltered bays, and the straits leading to and from the North Pacific.

PHOTO: J. KORESKI

PHOTO: A. WRIGHT/COLD-COAST.COM

Salmon

A *foundation species*[2] of the coastal ecosystem, salmon are one of the most important groups of fish in our waters. They play an incomparable ecological role in marine, freshwater and riparian systems and helped build the rich river valleys that once blanketed the Pacific Northwest (Gende et al. 2002, Schindler et al. 2003). These forested rivers in turn provided the shelter, food, and growing conditions needed to nourish future generations of salmon.

Unfortunately, this remarkable conveyor belt of salmon nutrients and energy to the watersheds and wildlife of western North America has been vastly diminished (through multiple ways) or severed (by dams) throughout much of their historic range (Gresh et al. 2000, Lichatowich 2001, Price et al. 2008, 2013).

A salmon's life entails being both predator and prey. Eating insects initially, their diet changes to zooplankton, larger invertebrates, and often other fish species. In turn, young and adult salmon are also food for more than 130 wildlife species including birds, sharks, dolphins, seals, sea lions, toothed whales, and even other salmon (Cederholm 1999).

The strategy of salmon to leave coastal streams for richer (ocean) pastures and then return to spawn, is a remarkable adaptation that serves both salmon and the ecosystem. Upon their return to coastal streams, salmon are a thousand times larger than when they left, with roughly 3% of their body weight composed of nitrogen and phosphorous (Larkin and Slaney 1997).

Salmon have always faced poor odds for survival. From egg to adult, they are eaten, endure habitat limitations, or do not find food at the right place or time. As such, more than 99% of the eggs a female salmon produces do not survive to become spawning salmon. With such poor odds, it is not hard to tip the balance to declining salmon returns once human activities

2 A foundation species is distinct from a *keystone* species. In ecology, the term refers to a species that has a strong role in structuring a community, such as bison or cod. A keystone species has an influence on its surroundings that is disproportionate to its abundance. The influence of salmon is due to their immense abundance and biomass. See Soulé et al. 2003.

Everyone waits for salmon
Even though returning salmon are focussed on spawning, their arrival is awaited by hungry animals from bears to birds. The food contained in their bodies delivers the energy, fat, and protein that wildlife need before hibernating, migrating, giving birth, or simply surviving the winter (Darimont et al. 2010, Hilderbrand et al. 2004).

The nutrients from spawned and eaten carcasses, and from the excreted waste of wildlife that feed on salmon, break down to become the biochemical building blocks for future forests and forest life.

PHOTO: M.CARWARDINE

The Salish Sea is home to roughly 60 ecologically and/or genetically distinct groups of salmon populations, each one of which is unique and irreplaceable. In Canada, these groups are called Conservation Units (CUs); in the US, they are called Evolutionarily Significant Units (ESUs).

are added to the mix. A century of over-fishing, intense urban, agricultural and industrial development in watersheds and on shorelines, the presence of salmon aquaculture net-pens on migration routes, the unintended consequences of hatcheries and the effects of climate change, have pushed many salmon populations that rear in or migrate through the Salish Sea to a fraction of their former numbers (Gresh et al. 2000, Lichatowich 1999, Grant et al. 2011).

Oil tankers, along with the development of other energy and shipping terminals in the Fraser River and Roberts Bank, present a new, added threat to salmon. These threats come from chronic small spills and episodic large spills that degrade and contaminate sensitive shorelines critical to salmon survival. They also come from pavement, roads, shoreline armoring and construction within estuaries, and the extensive loss of vital rearing habitat these activities cause.

Figure 2.8 Salmon conservation units and ecologically significant units of the Salish Sea.

Forage Fish—Linking the Top and Bottom of the Marine Foodweb

Forage fish are the target of the world's largest fisheries, but they play key roles in marine food webs by transferring energy from plankton to upper trophic-level predators, such as large fish, seabirds, and marine mammals (Essington et al. 2015).

A staggering rate of decline (~98% in 10 years) is a major factor in listing the Fraser River eulachon population as Endangered (COSEWIC 2011).

PHOTO: R. MILLER

Situated loosely between zooplankton and bigger fishes, forage fish are a vital link that connects the bottom and the top of the foodweb (Pikitch et al. 2012). From tiny egg to mature fish, they are a food source that fuels much bigger predators, including salmon, marine mammals, and seabirds.

In the Salish Sea, the group we call 'forage fish' is made up of several species, including eulachon (oo-lig-an), surf smelt, Pacific sand lance, and Pacific herring. Each species has different and complex strategies for life; some spawn on beaches, others use shallow bays or freshwater, or spawn offshore. Some are residents of the Salish Sea while others are migratory, visiting for shorter periods.

The forage fish of BC are also woven into the human and natural history of the coast. They carry immense cultural, social, and economic value to First Nations. One of the best examples is eulachon, also known as candlefish for its ability to be lit like a candle once dried and wicked. A highly valued food item, eulachon oil was once traded inland via 'grease trails', named after the rendered fish grease that dripped out as it was transported. With such large population declines, eulachon now represent a tiny fraction of the Salish Sea's forage fish.

Herring Spawning Locations (BC and WA) and Commercial Harvest Areas (BC only)

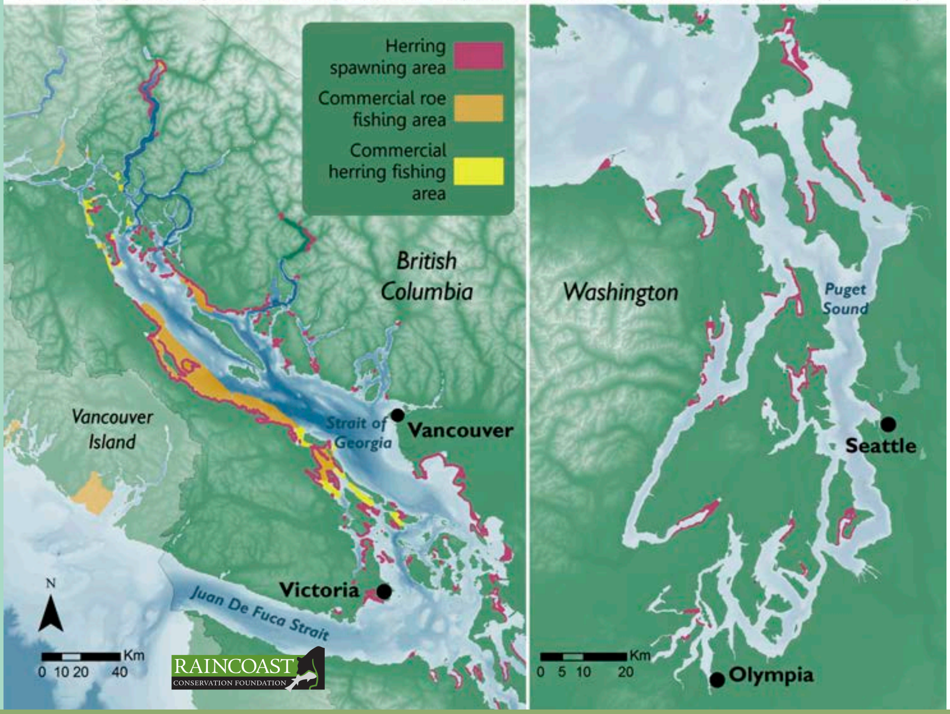


Figure 2.9 Herring spawning locations (Canada and US) and commercial fishery locations (Canada only).

The Silver Wave

Beginning in warmer waters in the southern parts of their range, Pacific herring spawn events proceed north along the Pacific coast in a 'silver wave'. At these spawn events, male herring release milt (sperm), which turns the water milky white, often far out to sea. Each female lays as many as 20,000 eggs (Hay 1985) upon eelgrass, kelp and other substrates. At these spawn events, massive aggregations of marine predators show up to feast, including hundreds of thousands of birds, hundreds of sea lions and, depending on the location of the spawn, whales. Foraging for several weeks, the spawning adults and their eggs provide a pulse of fat-rich food at a time (generally early spring in BC) when other resources are low.

Pacific herring are considered BC's dominant forage fish but they, like eulachon, have experienced sharp declines. For several decades in the last century, Pacific herring were the target of the largest commercial fishery in BC, with landed tonnages and values that exceeded even Pacific salmon.

The Strait of Georgia herring fishery remains open, and currently represents the largest herring fishery in BC. Of the remaining four major herring populations in BC, controversy and objection by multiple First Nations has erupted over the decision to open commercial fisheries on three populations, which are slowly rebuilding following years of low abundance. In Puget Sound, less than half the managed 'stocks' are considered healthy (Stick and Lindquist 2009).

Salish Sea Pacific herring are far more important than simply being the target of a commercial fishery. Like salmon, Pacific herring are a foundation species (Soulé et al. 2003) and the dominant forage fish not just in the Salish Sea, but throughout the BC coast (Schweigert et al. 2010). As such, they make substantial contributions to the diets of bigger fish and other animals (Schweigert et al. 2010).

Of the coast's spectacular natural events, the spawning of Pacific herring ranks among the best. Each spring in the Salish Sea, swarms of herring aggregate and spawn. Eastern Vancouver Island is a favoured area, with many contiguous kilometres of intertidal and nearshore subtidal areas experiencing spawn events.

PHOTO: H. SCHULZ

Roughly half of the Strait of Georgia and west coast Vancouver Island Pacific herring biomass is consumed by fish and marine mammals each year (Schweigert et al. 2010). This is a huge transfer of nutrients and energy to surrounding marine life such as salmon, lingcod, seals, dolphins, humpback whales, and countless marine birds. Without herring, many of the Salish Sea's most popular inhabitants would need to find food elsewhere.

PHOTO: G. MAZILLE

The Ghosts of Past Overfishing

Because herring are a dominant forage fish, fluctuations in their populations ripple throughout marine foodwebs. But concerns

Ancient history of herring presence

A study of 171 coastal archeological sites undertaken by Iain McKechnie and colleagues (2014) found that while modern herring populations can be erratic and exhibit catastrophic declines, the archaeological record indicates a pattern of relatively consistent abundance, providing an example of long-term sustainability and resilience in a species known for its modern variability. The simplest explanation for the discrepancy is industrial harvesting over the last century (McKechnie et al. 2014).

PHOTO: C. FOX

for their conservation extend beyond their numbers. Major questions still surround the genetic diversity of herring populations and how they compare with those of the past.

In the Salish Sea, most herring belong to a large population that migrates between summer foraging grounds off the west coast of Vancouver Island and winter spawning grounds in the Salish Sea. However, some resident herring populations stay year round in the Salish Sea (Therriault et al. 2009). Genetically distinct populations have been identified at spawning grounds in Esquimalt, in BC's mainland inlets (Beacham et al. 2008), and at Cherry Point south of Blaine, Washington (Small et al. 2005).

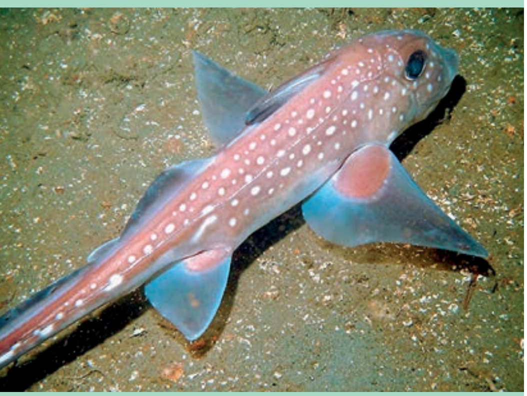
Having previously collapsed and been subject to heavy fishing pressure for more than a century, the health of herring populations both large and small are of conservation concern. Research using archaeological and genetic analyses of ancient herring remains provides promise for evaluating the effects of the commercial fishery on herring diversity and abundance (Speller et al. 2012, McKechnie et al. 2014).

Despite their high ecosystem importance, forage fish are poorly understood. For species with commercial value, such as Pacific herring, we have a basic understanding of their biomass, where they live, feed, and breed. However, other forage fishes such as Pacific sand lance, surf smelt, and longfin smelt, lack even basic information relating to their numbers and where they roam.

This lack of information combines with the history of exploitation and development in the Salish Sea to muddy the waters that would identify causes for their low and declining abundance. In their examination of global forage fisheries, Essington and colleagues (2015) implicate fishing in forage fish stock collapses by showing that high fishing rates are maintained when stock productivity is in rapid decline. In the Salish Sea, many drivers of habitat loss, including damaged intertidal zones, noise, and pollution, act cumulatively to reduce the abundance of forage fish. When Kinder Morgan's expansion project is added to this mix, the concern for forage fish and the species that rely on them is magnified.

Life at the Bottom of the Sea

Groundfish is the collective name given to all bottom-dwelling fish. Included are the flatfish (halibut, flounder, sole), the rockfish (ex quillbacks, bocaccios), and the greenlings, including lingcod.



Sandy bottoms of the Salish Sea host anemone and brittle star gardens, which foster larger bottom fish such as halibut and flounders and in the deep trenches, large rockfish. In the dark depths, beautiful chimeras (called ratfish for their long tails) explore sandy bottoms.

PHOTO: ELASMODIVER.COM

PHOTO: VANCOUVER AQUARIUM

Groundfish

'Groundfish' describe all types of fish that live near the seafloor. Giants like halibut and lingcod are familiar, yet many lesser-known species are essential components of ocean food webs. In the Salish Sea, the seafloor is expansive and variable, with deep trenches, sand-scapes, boulder fields, rocky cliffs and reefs, and silt deposits. Each of these habitats supports a variety of creatures, large and small.

Groundfish are specialized to live near the sea floor, but many specific adaptations exist. Halibut and flounders lie flat along the bottom, exposing only their patterned 'upper side' that blends into the sandy bottom. Sculpins have stiff fins and tend to sit on rocks, hopping more than swimming from rock to rock. Speckled greenlings and lingcod blend into rocky reefs, corals, and sponges. Many of these species are also adapted to live at great depths, with specialized swim bladders that allow them to cope with water pressure.

Groundfish also comprise a major part of the Salish Sea food web—acting as both predators and prey. During juvenile stages when many groundfish live closer to the surface, they become prey for larger creatures including birds, river otters, and other fish. As adults, groundfish will be prey for other fish and marine mammals such as sea lions.

In both Canadian and American waters, groundfish are a commercial and recreational target. In the Salish Sea, they face a variety of threats, but overfishing tops the list (Fisheries 2014c, PFMC 2014). Trawling practices, which drag fishing gear along the sea floor, have also destroyed large areas of habitat throughout their range. In Canada, it was not until several species of groundfish populations began to collapse that an appropriate fisheries management plan was created.

Rockfish

The group of fish we call 'rockfish' comprise many species in the genus *Sebastes*. Around 40 species live in the Salish Sea (Fisheries 2007a, WDFW 2011), some of which congregate in deep trenches (> 40m deep) and others that live closer to shore.

There are three important things to know about rockfish: They are among the longest-lived fish on earth (up to 200 years), they are very vulnerable to over-fishing, and consequently many species are threatened.

PHOTO: T. JACKSON, NOAA

Rockfish transition through several habitats as they slowly mature, typically starting in shallow eelgrass meadows and then moving into kelp forests, then deep rocky reefs or sandy bottoms, sometimes a kilometer below the surface (Palsson et al. 2009). A site on the sea floor can have several rockfish species, with many age classes in each population. The age structure is a key component of a population's resilience.

One of the unique characteristics of rockfish is their extremely slow development. If not caught, many species live to be well above 100. Generation times are slow (quillback, for example is about 30 years COSEWIC 2009) with some species taking 15-25 years to become sexually mature (Meyer, ADF&G). Rockfish give birth to live young. The older they get, the more offspring they produce.

As juveniles, flatfish (e.g. halibut, sole, flounder) are oriented like most fish—vertically. When they are just a few months old, their left eye migrates to the right side of their head. This becomes the topside and the colour on the bottom side fades to white.

PHOTO: NOAA

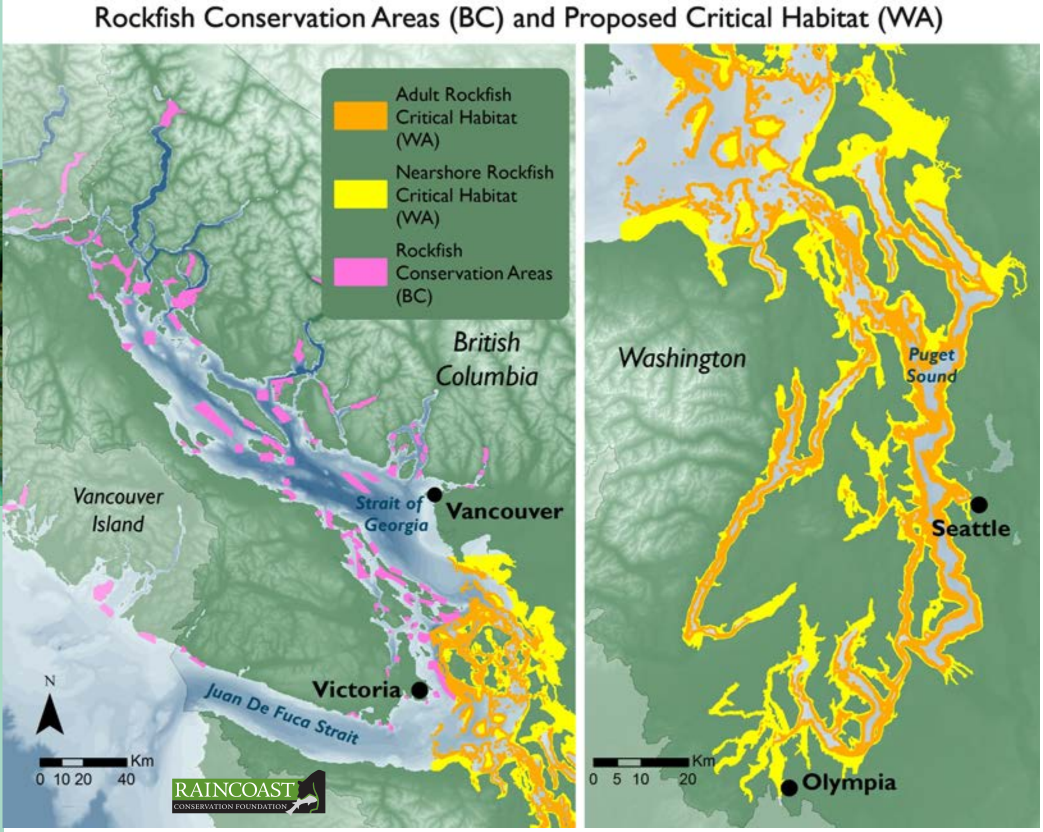


Figure 2.10: Rockfish conservation areas and groundfish distribution and fishing areas in the Salish Sea

A caught rockfish is a dead rockfish.

Rockfish are caught in recreational and commercial fisheries. Their long lives, slow reproduction, and vulnerability to overfishing do not bode well for speedy recovery. Unlike some fish, "catch and release" does not work for rockfish. Their large, gas-filled swim bladder can rupture as they are brought up from depth, which either kills them or prevents them from swimming back down.

A Long Struggle

Given their life history, rockfish do not rebound and recover quickly from population impacts. In Canada and the US, there have been large declines in many rockfish species, largely attributable to fishing practices and harvest rates (Fisheries 2007b, WDFW 2011).

Living at great depths, they are subject to trauma when brought to the surface on fishing lines. Mortality from catch and release is very high, and they are caught as bycatch in nearly all deep-sea fisheries (Yamanaka and Logan 2010). Many species also look similar, leading to potential misidentification and accompanying management difficulties. Other threats include polluted waters near urban areas and derelict fishing gear.

In Washington's Puget Sound, two species are now listed as threatened under the ESA (canary and yelloweye), and one as endangered (bocaccio). In Canada, three species are listed as threatened under SARA (canary, quillback and yellowmouth), with another five species listed as Special Concern (SARA 2014).

Marine protected areas offer some hope for rockfish. In Puget Sound, Edmond's Underwater Park is demonstrating that an enforced no-take zone allows rockfish populations to slowly rebuild (McConnell and Dinnel 2002). More 'no-take' marine reserves are now being proposed near Puget Sound's Skagit County.

In BC, reduced fishing in rockfish conservation areas has been implemented in 86 locations in the Salish Sea (Fisheries 2014). BC's rockfish conservation guidelines, however, are not enforced or legislated by the federal government, and allow mid-water groundfish trawls along with other forms of fishing. Analyses suggest their effectiveness to date has been marginal (Haggarty 2013). Given the long generations of many species and the limited protection they have been afforded so far, recovery will take many decades, assuming that reaching previous levels of abundance is even possible.

Living Dinosaurs: Glass Sponge Reefs of the Salish Sea

Glass sponge reefs were once only known from ancient fossils, believed to have gone extinct sometime in the cretaceous period about 60 million years ago (Leys et al. 2004). But in the 1980s, these 'living fossils' were discovered by researchers studying the depths of BC's Queen Charlotte Sound and Hecate Strait. About a decade later, they were discovered in Georgia Strait and in Howe Sound in 2008.

Formed almost entirely of glass, as the name implies, they are silica-based, stationary animals. Like other sponge reefs, they support an abundance of sea life, and act as refugia and nurseries for threatened rockfish. In fact, young rockfish were found to be five times more abundant on live glass reefs than on nearby dead reefs and off-reef areas (Conway 2005). Glass sponges filter bacteria and debris from the water and return nutrients back into the ocean. To grow, they require extremely stable environments with low sedimentation rates.

Fishing activities, particularly bottom trawling, have seriously harmed these fragile, ancient reefs. In the Salish Sea, more than half of the surveyed reefs have been damaged (Cook et al. 2008). Although some protection has been granted to the northern reefs through trawl closures, the reefs of the Salish Sea have little protection.

Where the Whales Go—Shallow Water Whale Falls. Whale falls may persist for over 100 years in the deep sea and even longer in shallow-water (Glover et al. 2010). Carcasses of whales and dolphins undoubtedly scatter the floor of the Salish Sea. They offer a glimpse of the greater ecological role these animals play, and the linkages between the top and bottom of the sea.

Whale Falls— A Cascade of Food & Nutrients

When a whales dies, rarely does it wash-up on shore. Most whales sink, whole or in pieces, to the bottom of the sea. In doing so, they create islands of food resources on a typically sparse ocean floor. Sunken whale carcasses are known as 'whale falls'. Whales that die and sink in waters shallower than 200 metres, like the Salish Sea, are less studied than those of deep oceans (Dubilier et al. 2008), but research suggest the process is similar. Carcasses contribute a pulse of fat-rich resources to the ocean floor where a host of organisms—from crabs, snails, fish and sharks—move in to scavenge the body (Dahlgren et al. 2006, Glover et al. 2010). The carcass then succumbs to mats of bacteria (Dahlgren et al. 2006) and decades later, bone-devouring 'zombie worms' finish the decomposition process (Glover et al. 2010).

Linking the Land and Sea

The Intertidal Zone

Intertidal zones are the link between the land and the sea. Submerged one hour and dried out the next, an amazing plethora of life has evolved to live between the highs and lows of Pacific tides. With more than 7,000 kilometers of intertidal habitat (Gaydos et al. 2008), the marine shoreline of the Salish Sea is no exception. Whether gently sloping rocky shores, shallow waters or eelgrass beds, a single intertidal site may contain dozens of algae, invertebrate, and fish species, totalling thousands of species throughout the region (Levings et al. 1983, Zacharias and Roff 2001, Lamb and Hanby 2005, Gaydos et al. 2008).

In addition to harbouring a profusion of unique marine life, the intertidal zone is a major, and often vital resource for terrestrial species (Carlton and Hodder 2003, Gaydos and Pearson 2011). Many of the birds and mammals that depend on the Salish Sea derive a large proportion of their diet from the intertidal zone.

Raccoons, mink, otters, and mice are efficient predators that work the low tide into their daily foraging routine. Work by Raincoast scientists shows that raccoons that forage in the intertidal zone can have a strong impact on the abundance of their prey, substantially reducing the numbers of crab and fish around islands where raccoons occur (Suraci et al. 2014).

This highlights the inherent fragility of what seems like plentiful intertidal resources, and the connection that exists among species living at ecosystem boundaries. The diversity and abundance of species on land may depend in a very real way on diversity and abundance of marine communities.

An Intertidal Trophic Cascade
Raccoons are among the many land animals known to obtain a large portion of their diet from seafood in the intertidal zone. This rich resource however is not infinite, and consumption of intertidal resources—such as crabs and fish—by small predators like raccoons can have a large impact on the abundance of their prey. This is particularly true where top predators (cougars, wolves, and black bears) have been removed by humans and no longer keep small predators in check.
PHOTO: J. SURACI.

More species of sea stars occur in and around the Salish Sea than any other place on the planet (Lamb and Hanby 2005).
PHOTO: J. HEATH

Kelp Forests and other Seaweeds of the Salish Sea

Fringing the light-filled waters of the Salish Sea are the marine algae known as seaweeds. They include the red, green, and brown alga. Like land plants and plankton, seaweeds are photosynthetic organisms that take up light and carbon dioxide from the surrounding environment before releasing oxygen.

Compared with land plants, kelps have no roots to take up nutrients (just a holdfast to anchor them), they produce sugars instead of starch, and often form air bladders to help them float
PHOTO: J. HILDERING.

In the Salish Sea, bull kelp are the main species that creates the canopies of kelp forests. These forests offer shelter, protection, and food resources to marine life, in the form of nutrients, detritus, and animals that graze on kelp directly (Steneck et al. 2002).
PHOTO: J. HILDERING

Stuck to rocks in pounding surf, undulating in the current at the sea floor and growing in intertidal zones, seaweeds are major contributors to habitats and processes within the Salish Sea.

Among the most conspicuous seaweeds are the kelps, many of which form forests that host a myriad of species. Kelp forests are one of the most productive, diverse, and dynamic ecosystems on the planet (Mann 1973). They support all forms of animal life including invertebrates, fish, sea otters, corals, sponges, and even marine birds.

The structure, biomass, and diversity of organisms that live in kelp forests combine to have a profound influence on the surrounding ocean. They dampen wave action, alter currents, influence erosion rates, and reduce light (Steneck et al. 2002). They provide a substrate for non-mobile marine life, and shelter, habitat, and nursery grounds for young fishes, including salmon, rockfish, and herring.

Prone to disturbance by storms, changing temperatures and being eaten (namely by urchins), kelp forests can be short lived (Steneck et al. 2002). Entire forests can disappear within days or months but, just as importantly, they and their entourage can return and rapidly regenerate (Tegner et al. 1997; Steneck et al. 2002). In locations like the Salish Sea, grazing by urchins is considered the most common and important agent of kelp deforestation (Steneck et al. 2002).

Eelgrass

Eelgrass is a flowering plant adapted to life in shallow marine waters. It roots in sand or mud where waves and currents are not too severe. Like kelp, eelgrass needs light to grow and reproduce, so it is typically found in less than 10 metres of water (Mumford 2007).

The plants also hosts dozens, if not hundreds of other species of algae and plankton, which also contribute to food webs for young salmon, herring, and groundfish (Wright et al. 2012, Phillips 1984, Olyarnik 2006).

For young salmon, the use of eelgrass can increase survival (Semmens 2008) and the loss of eelgrass has been implicated in local salmon declines (Bravender et al. 1999). Eelgrass beds are equally important to Pacific herring, where they are used as substrate for

The loss of eelgrass beds is a growing concern, both in the Salish Sea and around the world (Orth et al. 2006). Environment Canada states an average global decline of 7% per year since 1990. Although not restricted to eelgrass, an estimated 18% of coastal marine and nearshore wildlife habitat in the Salish Sea had been destroyed by 1994 (Wright et al. 2012).

In the Salish Sea, the Fraser Estuary including Robert's Bank and Boundary Bay, support one of the most extensive and contiguous eelgrass communities on the Pacific coast. Many other areas throughout the Salish Sea also support critical eelgrass habitat.

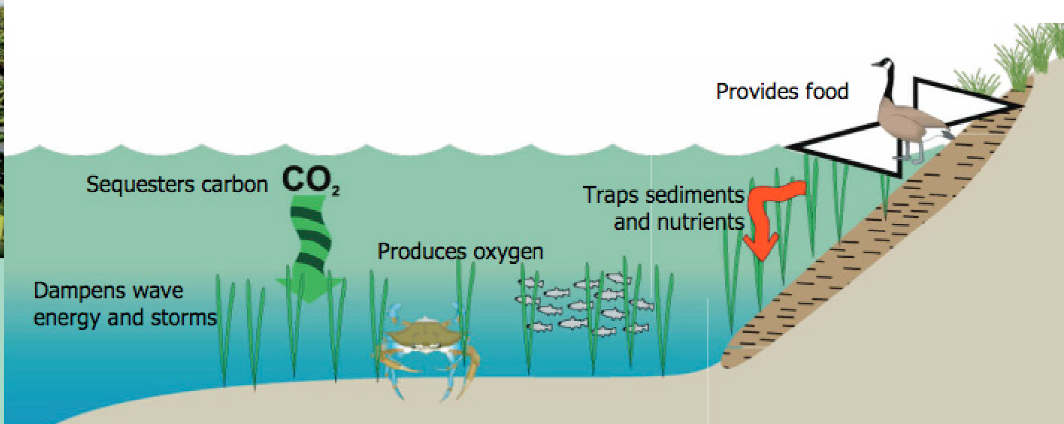
PHOTO: D. AYERS, USGS.

spawning (Penttila 2007) and then rearing grounds for the larvae and juveniles (Olyarnik 2006). Equally, the loss of eelgrass communities can contribute to declines in fish populations, and so on up the food web to reach birds and mammals.

Attempts to determine eelgrass baselines in the Salish Sea are challenging, but the loss of meadows from known locations is documented and driving the need for proper assessments (Dowty et al. 2006, Mumford 2007, Wright et al. 2012). In the last two decades, such assessments have shown more losses than gains in Puget Sound (Mumford et al. 2007), with a significant proportion of shorelines no longer in their natural condition (Pentilla 2007).

In BC, 70% of the Fraser River estuary wetlands (which are not exclusive to eel grass) have been diked, drained, and filled to reclaim land for development. Similarly, on Vancouver Island, about half the Nanaimo and Cowichan estuary wetlands have been lost (BC CDC 2006).

Port and berth construction, dredging, overwater structures likes docks and marinas, and shoreline armouring all degrade and eliminate eelgrass. The beds are also sensitive to contamination from chemicals, oil, fertilizers, and pesticides from gardens and agriculture, decreased light, and sediments.



Eelgrass meadows are highly productive ecosystems. After fixing carbon and developing blades that can grow to more than a metre. Eelgrass beds slow and filter water, stabilize bottom sediments, dampen waves and trap sediment, detritus, and larvae (Mumford 2007). The carbon from the plant also makes its way to food webs that supply nutrients to finfish, shellfish, marine birds, and dozens of insect, bug and small invertebrate species (Wright 2012, Mumford 2007).

Marine Exchanges

The annual return of spawning salmon is the most notable example of marine resources providing important food and nutrients to forest dwellers. Salmon often arrive at a critical time for the mammals, birds, amphibians, and insects that benefit from their arrival (Hocking and Reynolds 2011, Field and Reynolds 2011, Darimont et al. 2009).

Work by Raincoast scientists has shown a similar benefit comes from spawning Pacific herring (Fox 2013, Fox et al. 2014). Black bears may consume substantial quantities of herring eggs in addition to consuming sand hoppers (beach invertebrates) that have eaten herring eggs in the spring, providing them with an important fat-rich food source. Other species, including gray wolves and songbirds, also emerge from the forest in spring to feast on spawned herring eggs.

Some seabirds, including gulls and oystercatchers, derive a huge portion of their diet from the intertidal seafood feast, and even small songbirds, like the song sparrow, can be found foraging on tiny crustaceans along shorelines in the Salish Sea.

While the salmon and herring subsidy can be observed in the rivers and shorelines, less iconic marine species—like crabs, small intertidal fish, clams, and worms—are also critical food sources for many land-dwelling birds and mammals.

PHOTO: A. PAUL, WIKIPEDIA

Trophic Cascades: Ecological Chain Reactions

Top-down trophic cascades occur when predators in a food web suppress the abundance and/or change the behavior of their prey, thereby influencing predation in a lower trophic level. This chain reaction can result in dramatic changes within food webs, including to nutrient cycling. In marine ecosystems, the disappearance of kelp forests is an example of a top down trophic cascade. For more than a century, the absence of sea otters from the Pacific coast allowed urchins to devastate entire kelp forests. When sea otters were present, they preyed on urchins, which controlled the number of urchins and their excessive grazing of kelp. Without sea otters, there were no constraints on urchins, and a series of ecological chain reactions was initiated.

The reintroduction, and subsequent reoccurrence, of the sea otter is bringing this species back to the coast. At present, sea otters have re-occupied small areas of the Salish Sea, primarily along western side of the Strait of Juan de Fuca and the Olympic Peninsula. Isolated sightings have also occurred elsewhere (see Fig. 2.1).

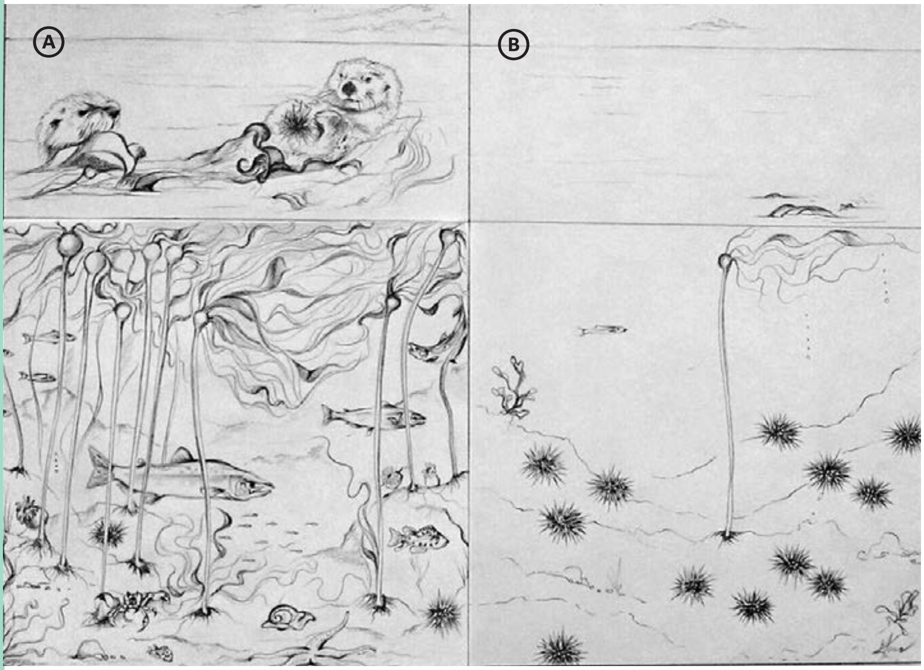


Figure 2.11 A simplified example of trophic cascade interactions. **A)** In the presence of sea otters, kelp forests flourish providing habitat to young fish and other species. **B)** In the absence of sea otters, kelp forests become overgrazed by urchins and no longer support fish and other species that depend on kelp habitats.

GRAPHICS: MAYA KAMO/RAINCOAST

Estuaries and the Fraser River Delta

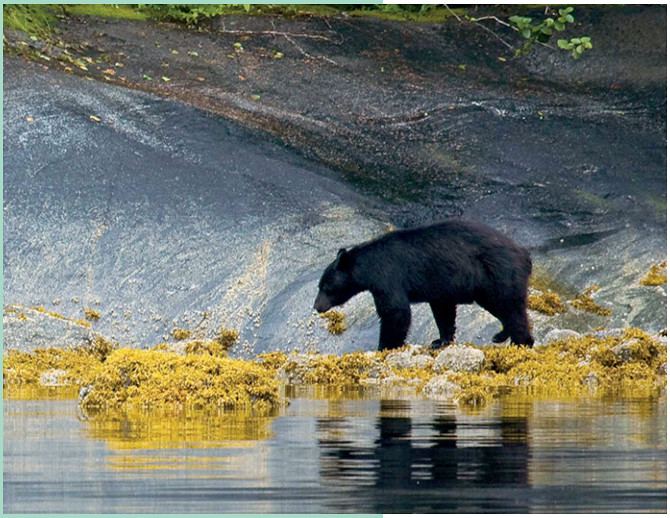
At the mouth of the Fraser River lies one of the most productive and diverse estuaries on the Pacific coast. Its ecological connections extend thousands of kilometres into the Pacific Ocean through the movements of migratory birds, mammals, and fish, especially salmon. The foundations for these remarkable pathways are the river delta's tidal mudflats, marshes, sloughs, flooded fields, eelgrass beds, shorelines, and forests.

The Fraser delta is the rearing ground for some of the world's largest salmon runs. As such, millions of juvenile salmon rely on this estuary for food, shelter, and protection. Fraser River salmon are grouped not just by species, but also into populations that reflect their unique traits and adaptations to local streams and rivers.

Populations such as river-type sockeye, ocean-type Chinook, nomadic coho fry, and chum salmon rely heavily on the sloughs, marshes, and estuary habitats of the delta. These young salmon can spend months feeding, growing and preparing for their ocean journey. Because large tracts of the estuary and shoreline have already been paved and developed (causing extensive loss of salmon and habitat), remaining sections in the delta are irreplaceable.

Juvenile salmon experience the highest growth rates of their lives while in estuaries and nearshore waters. Eelgrass beds are the foraging grounds for dozens of resident and migratory waterfowl.

PHOTO: NOAA.



Land-dwelling mammals that earn their living, or part of it, from the sea are considered maritime mammals. In the Salish Sea, this includes bears, wolves, mink, river otters, cougar, and even black-tailed deer, which rely on intertidal grasses in winter when other foods are scarce (Peterson 2001).

PHOTO: N. DEBRUYN

Estuaries, saltmarsh, eelgrass, and kelp communities are the shallow shoreline habitats that provide food, shelter, and protection to juvenile salmon, herring, lingcod, and flatfish, as well as vital migration corridors for young salmon.

The US federal government has defined these shoreline habitats to be Essential Fish Habitat under the Magnuson–Stevens Act. In coastal marine waters, US definitions mean that every estuary, river mouth, slough, bay, foreshore, and extended shoreline in the Salish Sea is Essential Fish Habitat for salmon.

Although still falling short of adequate protection, the designation underscores the importance of these habitats to wild salmon and other fish species. Eelgrass and kelp beds are further identified as Valued Ecosystem Components by the Puget Sound Nearshore Partnership.

The Human Footprint

Unfortunately, coastal ecosystems have fallen victim to a wide range of human impacts (Foley et al. 2010). Urban development and alteration to the shorelines of the Salish Sea has increased extensively in the past several decades, leading to direct habitat loss (Levings and Thom 1994) and toxic contamination (Gaydos et al. 2008).

In marine waters, habitat can be degraded and fragmented similar to terrestrial landscapes. Acoustic disturbance from vessels and shoreline construction can affect larval fish, adult fish (Slabbekoorn et al. 2010) and marine mammals (Wartzok et al. 2003). Boat propellers can kill copepods, a dominant zooplankton, leaving zones of reduced food abundance (Bickel et al. 2011). Logging activities can release pollutants, raze large sections of shoreline with log-booms and prevent the re-settlement of bottom dwelling organisms (McDaniel 1973). Dock and over-water structures break up mammal access to shorelines. These are a

Other estuaries once existed throughout Vancouver Harbour and Burrard Inlet. The contribution and function of these areas has been significantly reduced due to extensive human modifications that have destroyed foreshore and intertidal habitat, armoured shorelines, and impaired water quality. Unfortunately, these ongoing activities threaten the remaining habitat within the delta.

PHOTO: I. HINKLE

few examples of how human intrusion can create zones of lost or degraded habitat that serves to fragment larger areas.

Another pervasive human impact on Salish Sea intertidal communities is that of introduced species. As many as 90 alien species have been introduced to BC's coastal waters, many of which came as hitchhikers with species introduced for aquaculture (Dudas 2005). The Pacific oyster, the green crab (Dudas 2005), and the seaweed *Sargassum muticum* (Britton-Simmons 2004) have significantly altered intertidal communities by eating or outcompeting native species.

One of the ocean's primary roles is the regulation of the Earth's climate. As carbon dioxide emissions have increased in the last century, the oceans have picked up the slack, absorbing excess CO_2 from the atmosphere and dissolving it into seawater (NOAA 2015).

Although this uptake has mitigated the effects of climate change, the carbon-based molecules formed in this process produce carbonic acid, lowering the ocean's pH and raising its acidity. Plankton, corals, and other invertebrates that have shells or plates made from calcium carbonate, are corroded by carbonic acid. As these animals form the basis of the food web, threats to their populations can reverberate through marine ecosystems and into our economy and food supply.

Independent of the threat that oil tankers pose to the region, the rapidly growing human population has put considerable pressure on coastal waters and habitats. To date, the loss of eelgrass, deltas, foreshores, and natural shorelines is due almost exclusively to human activities. The region's population is forecasted to exceed 9,000,000 people by 2020 (PSGBEIR 2006). From headwaters to deep waters, extensive efforts must be taken now if remaining intertidal, foreshore, and marine habitats of the Salish Sea are to be protected. Critical habitat loss, with a ripple effect through fish, bird, and mammal populations, will accompany this unless countered now.

Restoration of the Salmon Creek mill site in Puget Sound is restoring estuary habitat for steelhead, chum, and Chinook salmon, as well as for shorebirds, shellfish, waterfowl, and even Roosevelt elk.

PHOTO: NOAA

Global climate change and the associated temperature increases have reduced the range of some organisms and expanded that of others. Locally, intertidal organisms like mussels—which provide essential habitat to a variety of other species—have reduced their intertidal range (Harley 2011).

Three Salish Sea invertebrate species are listed as conservation concerns in either Canada, the US or both (Gaydos and Brown 2011). All three (Newcombe's periwinkle snail, the Olympic oyster, and the northern abalone) have fallen victim to habitat loss, competition with invasive species, pollution, and overharvesting.

PHOTO: NORTHERN ABALONE–DFO

3. What is an Ecosystem Worth?

The Value of Nature and the Nature of Value

In the language of economics, the world's ecosystems are capital assets. If properly managed, they yield a flow of vital services, including the production of goods (such as seafood and timber), life support processes (such as pollination and water purification), and life-fulfilling conditions (such as beauty and serenity, Daily et al. 2000).

The Salish Sea is home to a remarkable assemblage of species living in habitats from the headwaters of salmon rivers to the depths of the inland sea. Many of these mammals, fish and birds migrate to places that link the Salish Sea with the entire Pacific region. Their interactions form what we see, hear, and feel when paddling, birding, working in, or simply being grateful for, our marine surroundings.

On a more tangible level, this tapestry between species and their environment provides humans with innumerable benefits, like clean water to drink, flood protection, seafood to eat, whales to watch, and even the air we breathe. Unfortunately, a growing human population has placed stress, sometimes to the breaking point, on the many species and the underlying processes that are integral to the Salish Sea.

As much as humans are an inseparable part of the natural world, human well-being ultimately depends on the connection between non-human creatures and their habitat (Chivian and Bernstein 2008). Much of this connectivity between plants, animals, and human well-being is encapsulated in the concept of ecosystem services, or nature's benefits. However, what do these terms mean, and what does the use of the term imply?

Ecosystem Services

Ecosystem services are the benefits humans derive from the workings of the natural world, such as clean air, pollination, climate regulation, and recreational and tourism opportunities. We take almost all of them for granted, but they are crucial for our survival, and to the social and economic development of societies.

Throughout human history, and certainly before terms like 'ecosystem services' existed, people have understood that their well-being is linked to the functioning of the world around them (Brauman et al. 2007). For some people, this relationship is core to their identity and being, but for others their personal connection is not as strong.

Historically, the commodification of the earth's products—from metals to plants and animals—has been the primary lens through which the planet's amenities have been regarded. The flaw in this standard economic approach is that it overlooks and fails to consider the processes that create the products. In an effort to use established monetary language and accounting procedures, a dollar value has been placed on the uncredited processes that created those products. This 'ecosystem services' approach captures 'services' that the natural world provides, including the wide range of conditions, processes and species, that help sustain and fulfill human life. The concept strives to place value on nature, as seen by humans (Daily 1997). Although monetary valuation is most common, recent efforts are trying to understand ecosystem services through economic valuation techniques that are non-monetary (Shroter et al. 2014).

There is no single accepted definition of ecosystem services or agreed upon methods for classifying the components. All of the definitions in Table 3.1 fall under the widely accepted approach that ecosystems or natural processes serve humanity. Within these broad definitions, ecosystem services are commonly divided into categories, either by functional grouping or otherwise. These typically fall under the following types of descriptions:

- Provisioning (material goods, like food or metals, produced by ecosystems)
- Regulating (climate regulation, flood control, water purification)
- Supporting (nutrient cycling, primary production, and soil formation)
- Cultural (recreation, spiritual, religious, heritage, etc.).

Although food and materials are obvious (provisioning), the vast array of services that provide benefits like clean air and water are crucial to human well-being. Supporting ecosystem services make these benefits possible. Cultural services enrich

What is an ecosystem? There is no single definition.

At its simplest level, an ecosystem is a community of plants and animals—from the largest whales to the smallest microorganisms—and the non-living environment with which they interact (e.g. carbon, oxygen, sand, or sun).

An ecosystem is characterized by its collection of species, the physical environment in which these species live, and the sum total of their interactions—with each other and with their shared environment (Chivian and Bernstein 2008).

An ecosystem is the set of organisms (including humans) living in an area, their physical environment, and the interaction among them (Daily 1997).

lives by creating a sense of place and world for discovery (Figure 3.1). Taken together, the complexity and connectivity between the natural world and humans is astounding—and profoundly essential.

What Contributes to an 'Ecosystem Service'?

The definitions of ecosystem services convey the connections between nature and humans. When adding human inputs, such as labour or capital into the equation, the service ceases to be just ecological (Boyd and Banzhaf 2007). In 2003, the Millennium Ecosystem Assessment provided a framework for people and institutions to value natural systems on a global scale.

"We need them to survive, but they don't need us at all" E.O. Wilson, eminent scientist and father of the modern concept of biodiversity. Although made in reference to ants, the same could be said when referring to any of the vast number of natural inhabitants of the Salish Sea, whether marine mammal, fish, plants, plankton, insects, fungi, or bacteria.

Number	Definition	Reference
1	Ecosystem services are the benefits people obtain from ecosystems	MEA 2005
2	Ecosystem services are the conditions and processes through which natural ecosystems—and the species that live in them—sustain and fulfill human life.	Daily 1997
3	Final ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well being (Boyd and Banzhaf 2007).	Boyd and Banzhaf 2007

Table 3.1 A range of definitions used to describe ecosystem services.

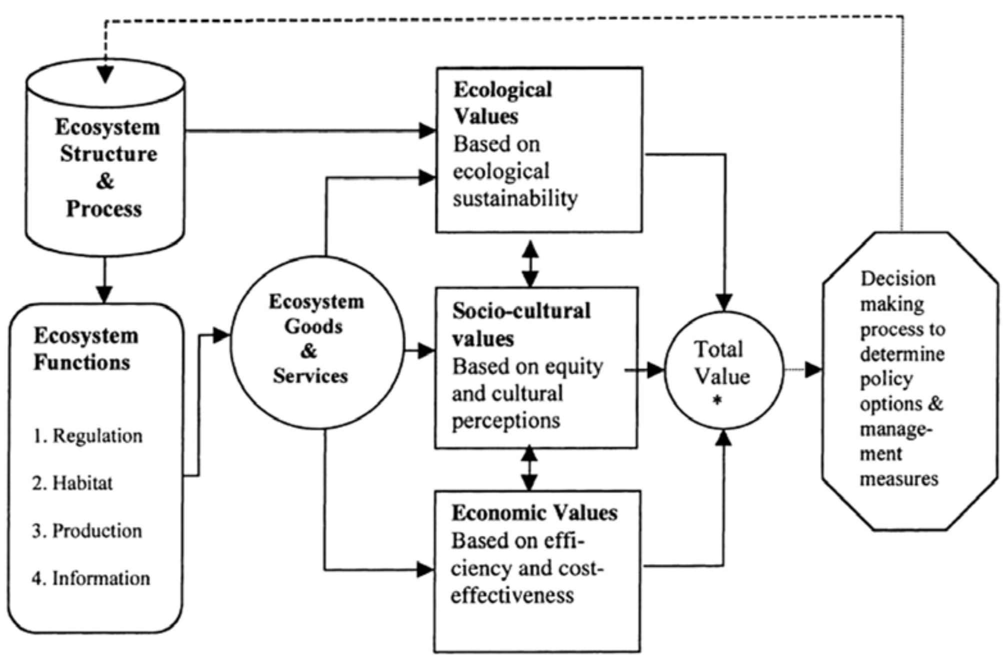


Figure 3.1: A simple framework to assess and value ecosystem functions, goods, and benefits for use in decision-making (de Groot et al. 2002).

Ecosystem Functions	Ecosystem process and components	Ecosystem service
Regulatory functions		
Gas regulation	Role of ecosystems in biogeochemical processes	Ultraviolet-B protection Maintenance of air quality Influence of climate
Climate regulation	Influence of land cover and biologically mediated processes	Maintenance of temperature, precipitation
Disturbance prevention	Influence of system structure on dampening environmental disturbance	Storm protection Flood mitigation
Water regulation	Role of land cover in regulating run-off, river discharge and infiltration	Drainage and natural irrigation Flood mitigation Groundwater recharge
Soil retention	Role of vegetation root matrix and soil biota in soil structure	Maintenance of arable land Prevention of damage from erosion and siltation
Soil formation	Weathering of rock and organic matter accumulation	Maintenance of productivity on arable land
Nutrient regulation	Role of biota in storage and recycling of nutrients	Maintenance of productive ecosystems
Waste treatment	Removal or breakdown of nutrients and compounds	Pollution control and detoxification
Habitat functions		
Niche and refuge	Suitable living space for wild plants and animals	Maintenance of biodiversity Maintenance of beneficial species
Nursery and breeding	Suitable reproductive habitat and nursery grounds	Maintenance of biodiversity Maintenance of beneficial species

Table 3.2 Examples of regulatory and habitat functions, processes, components, and the benefits they create. Source: Barbier 2007, adapted from Heal et al. 2005 and De Groot et al. 2002.

Class of Ecosystem Service	Intermediate Processes	Final Ecosystem Service	Benefit
Provisioning	Water quality, primary and secondary production, availability and quality of rearing habitats	Pacific Salmon	Salmon fishery
Cultural	Chinook salmon abundance	Killer Whales	Whale watching
Recreational	Water quality, air quality, flora and fauna	Water and aesthetics	Sea Kayaking
Cultural	Insects, fish for prey, water quality, forest canopy, nesting sites, etc.	Birds	Bird Watching

Table 3.3 Examples of final ecosystem services and the intermediate processes that lead to common benefits in the Salish Sea.

Resilience

Resilience is the tendency of an ecosystem to retain its functional and organizational structure after a disturbance. The loss of species and genetic diversity decreases the resilience of ecosystems and their ability to maintain particular services, especially as global climate and environmental conditions change (MEA 2005).

In an effort to develop standardized accounting, ecological processes are broken into two broad groups; intermediate and final services. This resulted in a set of guidelines that distinguish services, benefits and intermediate process (Table 3.3). Intermediate processes are defined as the bio-geo-chemical physical steps that result in an ecosystem service, and then the benefits to humans from that service (Mace et al. 2011).

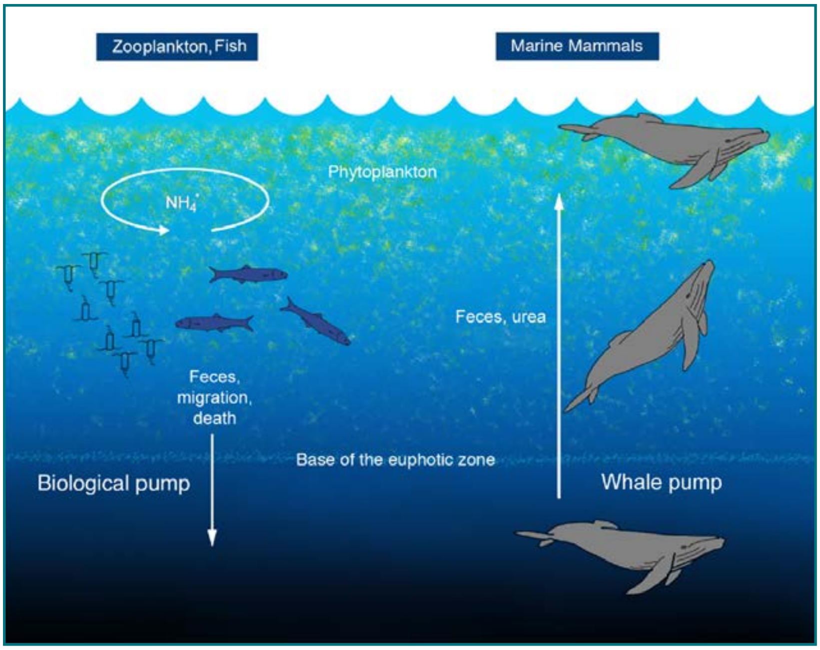
In the case of fish for example, intermediate processes could include primary production of plankton, secondary production of zooplankton, water slowed and filtered by wetlands and sponge reefs, erosion of riverbanks, and foreshores that create spawning grounds. The final ecosystem service (i.e. fish) then provides benefits to humans—a fishery (Table 3.2). Final ecosystem services are components of nature that can be directly enjoyed, consumed, or used to yield human well-being. Benefits are the human values derived from the service, be they economic, social, or cultural.

The Value of Nature

Regardless of the particular definition, cost-benefit analysis is an important premise of ecosystem services. Although valuing nature's worth within an economic framework has its limitations (Gatto and Leo 2000; Ludwig 2000, also see text box), a context is provided within which humans can quantify results of nature's complex processes and functions.

For example, in 1997 global ecosystem services or benefits were estimated to be worth US$16-54 trillion per year—about double the global Gross Domestic Product in 1997—with marine and freshwater values exceeding terrestrial (Costanza et al. 1997). This was considered a gross underestimate because it was based on estimations of aggregated 'total economic value', an approach that is inconsistent with the marginal approach that underpins economic cost-benefit analysis (White et al. 2010). A recent update to this estimation increased the value to approximately $135 trillion annually (Costanza et al. 2014), a figure still considered a minimum estimate, but one that

Figure 3.2: The role of species in ocean nutrient cycling.
In the ocean's biological pump, nutrients are moved from the ocean surface to the bottom, and back up, by different animals. At the bottom of the food chain, zooplankton feed in surface waters but their faecal material sinks to the bottom. Fish typically release nutrients at the same depth at which they feed. In contrast, marine mammals feed at deep depths, but excrete at the surface, thus returning nutrients back to surface waters. Source: Roman and McCarthy 2010.



Whales—The Ocean's Gardeners

Commercial whaling, which continued up until several decades ago, devastated the world's large whales. While tragic in itself, no one anticipated that the loss of whales would have such a ripple effect throughout the world's oceans. It turns out that whales concentrate and redistribute iron. By doing so, they act like giant marine pumps for fertilizing the oceans, kick starting food webs, building fish populations, and even taking huge amounts of CO_2 out of the atmosphere.

How does it work?

Whales eat massive quantities of iron-rich food like krill and squid. They consume food at deep depths, but they digest and carry the waste to waters at the surface. When they excrete waste, the iron concentration in whale faeces is calculated to be up to 10 million times that of Antarctic seawater (Nicol et al. 2010).

Unlocking this mystery explains how the southern oceans were able to support so many whales—numbers that whaling records implied, but scientists thought impossible. When excreting faeces at the surface, the whales fuelled the plankton blooms that resulted in more krill. More krill results in more food for whales, fish and the entire food web (Roman and McCarthy 2010).

The ecosystem services and benefits that the whales provide have only recently become well-known and appreciated. They range from enhancement of primary productivity to rebuilding fisheries, to climate regulation, tourism, and conservation (Roman and McCarthy 2010, Roman et al. 2014). Further, the increased amount of blooming plankton removes tens of thousands of tonnes of carbon from the atmosphere. Scientists now believe the ability of the Southern Ocean to act as a carbon sink was diminished by mass removal of whales during industrial whaling (Lavery et al. 2010).

captured a deeper understanding of ecosystem value. Despite the relative uncertainty in these values, it is unequivocal that nature's benefits carry enormous economic and societal value measurable in dollars.

A more important question might be how much of this value translates to actual market prices, for example, seafood. A review of case studies suggests very little, and underscores the fact that exploitation of ecosystems will come at the expense of the poor and our grandchildren (de Groot et al. 2012). The irony is that economic health in the long term depends on the integrity and resilience of the natural ecosystems within which the economy is embedded (Gomez-Baggethun and de Groot 2010). Standard economic theory neglects this—and the cost is our unfolding ecological crisis.

The tapestry of life

Evidence is compelling that the degradation of the Earth's biodiversity is beginning to threaten the fulfillment of basic needs and potentially the aspirations of humanity as a whole (Diaz et al. 2006).

The Benefits of Biodiversity

Biological diversity is the variety of life on earth. The pressures of a rapidly growing human population, however, mean that biodiversity is now declining 1,000 times faster than at rates in

Already, climate change is being implicated in loss of global and regional biodiversity. For example, in the Salish Sea temperature shifts on intertidal rocks have meant increased predation on mussels by sea stars, a 50% reduction in their vertical distribution, and a complete loss of reproduction at some sites (Harley 2011).

Changing ocean conditions, habitat loss, and fishing, along with other pressures, are likely factors in the decline of Chinook and coho salmon populations in the Salish Sea (PSF 2014). Ongoing urbanization, increased destruction of natural shorelines, and increasing marine pollution, all of which are unfolding around Georgia Strait, will further exacerbate declines in salmon.

the fossil record (MEA 2005). This decline is occurring on land and in the oceans (Worm et al. 2006). Studies linking biodiversity with ecosystem benefits show clear trends that biodiversity underpins ecological goods and benefits (Diaz et al. 2006, Mace et al. 2012). Rates of resource collapse also increase with declining biodiversity (Worm et al. 2006). Conversely, retaining biodiversity has positive effects on the vast majority of ecosystem services and benefits (Balvanera et al. 2006, Harrison et al. 2014).

What is Biodiversity?

Biological diversity is the term used to describe the variety of life on Earth. This variety includes the genes found in all living things, as well as variation in species and the ecosystems these species comprise.

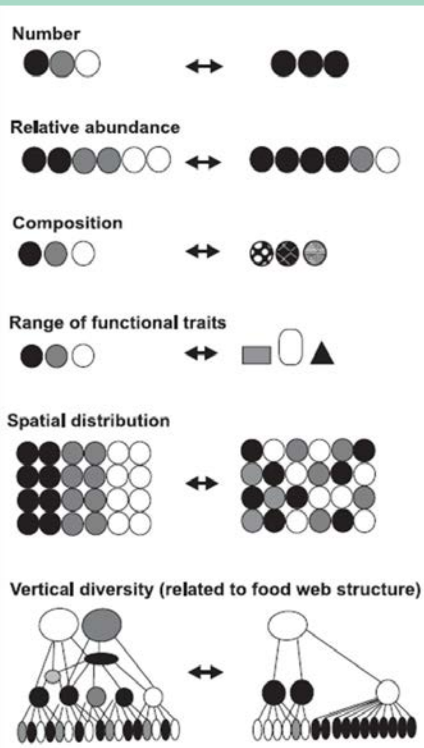


Figure 3.3: The different components of biodiversity (Diaz et al. 2006). Ecosystem components can be affected by human actions (arrows). These in turn have repercussions for ecosystem properties and services. Symbols represent individuals or biomass units. Symbols of different shades represent different genotypes, phenotypes, or species.

Ecosystem Values in the Salish Sea

The physical oceanography of the Salish Sea, including the basins, archipelago of islands, and the estuary circulation of the Fraser River, combine to create highly productive marine waters. The result is an impressive diversity of animal life, and a coast that has attracted more than 7 million residents to its shores. As an exercise in quantifying ecosystem benefits, the value of land (Wilson 2010) and aquatic services in BC's lower mainland (including Georgia Strait) (Molnar et al. 2012), and in Puget Sound (Batker et al. 2010), were assessed through an economic lens.

In BC's lower mainland (Figure 3.4), aquatic near-shore services such as flood protection, water supply, and critical habitat for fish and other animals are estimated to provide between $30 and $60 billion in benefits each year (Molnar et al. 2012). Land-based services such as climate regulation, water filtration, clean air, waste treatment, and water supply are estimated to provide $5.4 billion in benefits each year (Wilson 2010).

In Puget Sound, valuing 14 goods, services and benefits including climate regulation, pollination, water supply and treatment, nutrient cycling, and recreation, amongst others, shows between $10 and $80 billion are provided each year in benefits. Counting these as economic assets results in billions of dollars worth of 'natural capital'. When considering that only some of the known services were valued, uncertainty in the appraisal, issues with methods, and the omission of nature's intrinsic, aesthetic, cultural or irreplaceable merits, these values are undoubtedly underestimates. As context, the GDP of BC and Washington combined was about $630 billion in 2012.

The Coast at Risk: Estuaries and Coastal Habitats

Coastal habitats are some of the most intensively used and threatened natural systems on the planet (Lotze et al. 2006, Worm et al. 2006, Halpern et al. 2008). Estuarine and coastal areas face unprecedented pressures. Driven by increasing numbers of people who want to live near water, the loss of natural shorelines, increasing toxic contamination, and overharvesting of resources are all

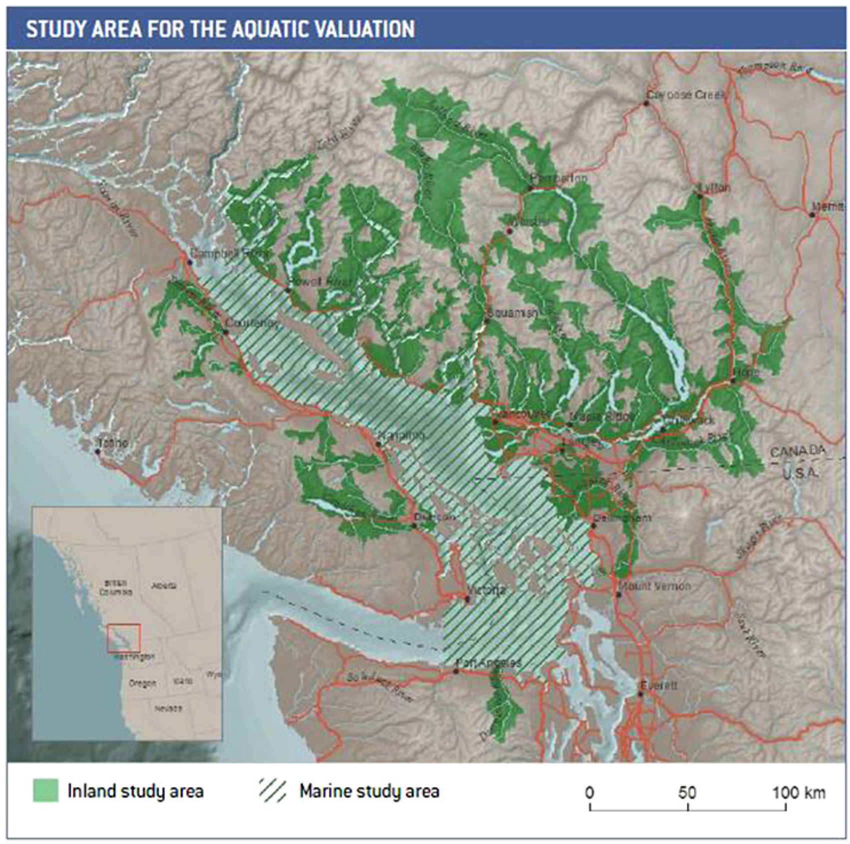


Figure 3.4 Map of the aquatic services study area within BC's lower mainland and Puget Sound. Source Molnar et al. 2012.

The Inside Waters of the Salish Sea

As an coastal sea, the Salish Sea lies on the continental shelf. Continental shelves are places of key ecological importance: although they cover less than 8% of the global ocean by area (Menard and Smith 1966), they contribute 69% of the global fish catch [89% if upwelling zones are included (Pauly and Christensen 1995)]. Continental shelves support high biodiversity including large populations of marine mammals (Keiper et al. 2005) and seabirds (Acha et al. 2004). In the Salish Sea, this translates to more than 200 species of fish, including five species of wild salmon, more than 3,000 invertebrate species, over 170 different seabirds and shorebirds (Gaydos and Pearson 2011) and 500 species of marine plants (Molnar et. al. 2012).

examples of activities fuelling coastal habitat destruction and the loss of species locally and globally (Gaydos et al. 2008).

This declining ecological health is affecting the benefits these areas can provide, such as viable fisheries, nursery habitats of future fish populations, filtering and detoxification processes, coastal protection, and erosion control (Worm et al. 2006, Barbier et al. 2011).

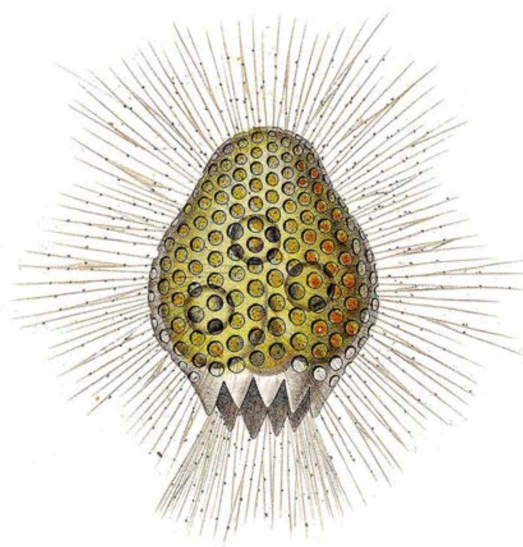
The Fraser River estuary and major rivers draining into Puget Sound are similarly affected. Massive port expansions placed on deltas of critical fish and wildlife habitat, increasing shipments of dangerous goods, marina expansions, urbanization and growing impervious surfaces, acoustic disturbance, alteration to natural water flow patterns, increased sedimentation, and frequent small oil spills are some of the threats facing the Fraser delta.

The true cost of loss. "Often the importance of ecosystem services is widely appreciated only upon their loss" (Daily et al. 2000).

Priceless and Irreplaceable

Ecological goods and services are the benefits arising from the ecological functions and processes of healthy ecosystems. Such benefits accrue to all living organisms, including animals and plants. Increasingly, there is recognition that ecological goods and services provide people with essential health, social, cultural, and economic needs. Many proponents of this perspective endeavour to categorize, measure, and value these benefits, thereby providing people with personal and often financial reasons to protect the planet's ecosystems and support conservation. In addition, assigning monetary value to natural capital such as biodiversity and ecosystem services is often viewed as a key process in influencing economic practices, policy, and decision-making.

Pragmatic and compelling, this human centric approach to conservation shares with traditional economics the assumptions that people are unfailingly rational, and market and life style choices are rooted largely in rational self-interest. In theory, reasonable self-interest maximizes benefits, minimizes costs, and is virtuously self-correcting because the consequences of one's conduct are the ultimate basis for any judgment about the rightness or wrongness of that conduct.



Small in stature, but large in scale.
Microbes provide ecosystem services that are immensely important to society. They carry out most of the biogeochemical processes, regulate climate, water quality, and atmospheric composition, and perform about half of the planet's total primary production (Duckow 2008).

Although ecosystem service based conservation has proven popular, representing 'nature' primarily as a support system for humans is controversial. Critics contend that it fails to address the underlying problems with mainstream economics, growth, market capitalism, and monetary valuation of the environment. Some maintain that the underlying principles are inherently false and ultimately can be harmful to the environment because arguments for the financial value of conservation can unintentionally convince people that conservation should not be pursued when there is no financial value. Accordingly, there is a clear need to create a more meaningful relationship with nature and the non-human world than evident in the instrumentalism of shallow ecology[1].

Although classifying and commodifying 'nature' as a support system for humans does not rectify our current disconnection with the natural world, it might improve our awareness of the cycles, processes, and the interconnectedness of nature's systems. If this leads to full accounting of the costs associated with environmental damage and the benefits associated with ecological protection, ecosystems may benefit in the end. The merits, unfortunately, will only be evident in retrospect.

Raincoast believes that our connection with the natural world is not properly comprehended as a monetary and self-interested relationship. Notably, however, ecosystem service based conservation does not need to replace or conflict with this conviction. Appropriately understood and applied, it can complement the widely held moral perspective that the natural world is priceless, irreplaceable, and inherently valuable.

The Unsung Heroes

For many people, identifying value in animals like whales and bears is understandable. Conveying the value of a coastal marsh or sub-tidal eelgrass bed however, is more difficult, even though these habitats perform functions that animals and humans alike require (Table 3.4).

Sea grasses are a case in point. As with many coastal habitats, eelgrass and other sea grasses are threatened by rapidly expanding

1 The defining feature of shallow ecology is the view that nature has instrumental value. In other words, nature is valuable as a means to an end.

Functions	Ecosystem Processes & Components	Goods and Services (examples)
Regulation Functions	*Maintenance of essential ecological processes and life support systems*	
1 Gas regulation	Role of ecosystems in bio-geochemical cycles (e.g. CO_2/02 balance, ozone layer, etc.)	1.1 UVb-protection by 0_3 (preventing disease) 1.2 Maintenance of (good) air quality 1.3 Influence on climate (see also function 2)
2 Climate regulation	Influence of land cover and biol. mediated processes (e.g. DMS-production) on climate	Maintenance of a favorable climate (temp., precipitation, etc) for example, human habitation, health, cultivation
3 Disturbance prevention	Influence of ecosystem structure on dampening env. disturbances	3.1 Storm protection (e.g. by coral reefs) 3.2 Rood prevention (e.g. by wetlands and forests)
4 Water regulation	Role of land cover in regulating runoff & river discharge	4.1 Drainage and natural irrigation 4.2 Medium for transport
5 Water supply	Filtering, retention and storage of fresh water (e.g. in aquifers)	Provision of water for consumptive use (e.g.drinking, irrigation and industrial use)
6 Soil retention	Role of vegetation root matrix and soil biota in soil retention	6.1 Maintenance of arable land 6.2 Prevention of damage from erosion/siltation
7 Soil formation	Weathering of rock, accumulation of organic matter	7.1 Maintenance of productivity on arable land 7.2 Maintenance of natural productive soils
8 Nutrient regulation	Role of biota in storage and re-cycling of nutrients (eg. N,P&S)	Maintenance of healthy soils and productive ecosystems
9 Waste treatment	Role of vegetation & biota in removal or breakdown of xenic nutrients and compounds	9.1 Pollution control/detoxification 9.2 Filtering of dust particles 9.3 Abatement of noise pollution
10 Pollination	Role of biota in movement of floral gametes	10.1 Pollination of wild plant species 10.2 Pollination of crops
11 Biological control	Population control through trophic-dynamic relations	11.1 Control of pests and diseases 11.2 Reduction of herbivory (crop damage)
Habitat Functions	*Providing habitat (suitable living space) for wild plant and animal species*	Maintenance of biological & genetic diversity (and thus the basis for most other functions)
12 Refugium function	Suitable living space for wild plants and animals	Maintenance of commercially harvested species
13 Nursery function	Suitable reproduction habitat	13.1 Hunting, gathering of fish, game, fruits, etc. 13.2 Small-scale subsistence farming & aquaculture
Production Functions	*Provision of natural resources*	
14 Food	Conversion of solar energy into edible plants and animals	14.1 Building & Manufacturing (e.g. lumber, skins) 14.2 Fuel and energy (e.g. fuel wood, organic matter) 14.3 Fodder and fertilizer (e.g. krill, leaves. litter)
15 Raw materials	Conversion of solar energy into biomass for human construction and other uses	15.1 Improve crop resistance to pathogens & pests 15.2 Other applications (e.g. health care)
16 Genetic resources	Genetic material and evolution in wild plants and animals	16.1 Drugs and pharmaceuticals 16.2 Chemical models & tools 16.3 Test- and essay organisms
17 Medicinal resources	Variety in (bio)chemical substances in, and other medicinal uses of, natural biota	Resources for fashion, handicraft, jewelry, pets, worship, decoration & souvenirs (e.g. furs, feathers, ivory, orchids, butterflies, aquarium fish, shells, etc.)
18 Ornamental resources	Variety of biota in natural ecosystems with (potential) ornamental use	
Information Functions	*Providing opportunities for cognitive development*	
19 Aesthetic information	Attractive landscape features	Enjoyment of scenery (scenic roads, housing, etc.)
20 Recreation	Variety in landscapes with (potential) recreational uses	Travel to natural ecosystems for eco-tourism, outdoor sports, etc.
21 Cultural and artistic information	Variety in natural features with cultural and artistic value	Use of nature as motive in books, film, painting, folklore, national symbols, architecture, advertising, etc.
22 Spiritual and historic information	Variety in natural features with spiritual and historic value	Use of nature for religious or historic purposes (i.e. heritage value of natural ecosystems and features)
23 Science and education	Variety in nature with scientific and educational value	Use of natural systems for school excursions, etc. Use of nature for scientific research

Table 3.4: Some examples of the functions, goods and services of natural and semi-natural ecosystems.

Economic evaluation of ecosystem services strives to place a dollar value on the natural world. Although this approach does not capture the connection many people feel with the world around them, it does recognize nature's contribution to human well-being.

Although the economic value of ecosystem services to human well-being can be quantified and measured (Butler and Oluoch-Kosura 2006, Costanza et al. 1997, Daily 1997, de Groot et al. 2002, Harrison et al. 2010); this does not recognize nature's intrinsic worth or the essence of our personal connection to the natural world.

human populations and associated habitat degradation. Although not restricted to eelgrass, an estimated 18% of coastal marine and nearshore wildlife habitat in the Salish Sea had been destroyed by 1994 (Wright et al. 2012). Yet, eelgrass habitats perform key functions such as nutrient cycling, sediment stabilization, enhancement of biodiversity, and important gas exchanges (Orth et al. 2006). With the rapid declines in global and local eelgrass distribution, the benefits and ecological roles they play will only decline with them. A much greater effort is required for their protection by individuals, provincial/state governments, and federal laws.

PHOTO: B. HARVEY

4. The Tourist Dollar

From the *Super Natural British Columbia* brand to Washington's nickname as *The Evergreen State*, the natural beauty and resources of the Salish Sea region drive a tourism industry of growing importance to the regional economy.

In 2011, tourism in BC generated $13.4 billion in revenue, $1.13 billion in provincial tax, and employed 126,700 people (BC MJTS 2012). Although jobs and total revenue are down from 2008, the general trend since 2001 has been one of growth (Tourism BC 2009). For comparison using GDP[1], tourism contributes more to the economy than BC's three traditional primary industries; agriculture, and fish, forestry, and the mining, oil, and gas extraction sectors (BC MJTS 2012).

Similarly, in Washington State, tourism ranked fourth in contribution to GDP in 2011, supporting 151,000 jobs and $US 16.4 billion in direct visitor spending (DRA 2012). As in BC, the sector has shown slow but steady growth. By 2012, visitor spending reached $US 16.9 billion, employment was 153,300 (WTA 2012) and more than $1 billion was directed to state and local taxes.

One in every three dollars spent on tourism in BC goes to marine and marine related activities (MPA 1998).

PHOTOS: B. HARVEY

Nature-based and Eco-tourism

The natural benefits of the Salish Sea are clearly fundamental to nature-based marine tourism. Importantly, the ability to engage in these activities motivates decisions to visit. Canada's share of the outdoor adventure market, which includes wildlife viewing, is expected to increase by almost 8% for American travellers and 5% for Canadian travellers between 2000 and 2025 (Tourism BC 2009).

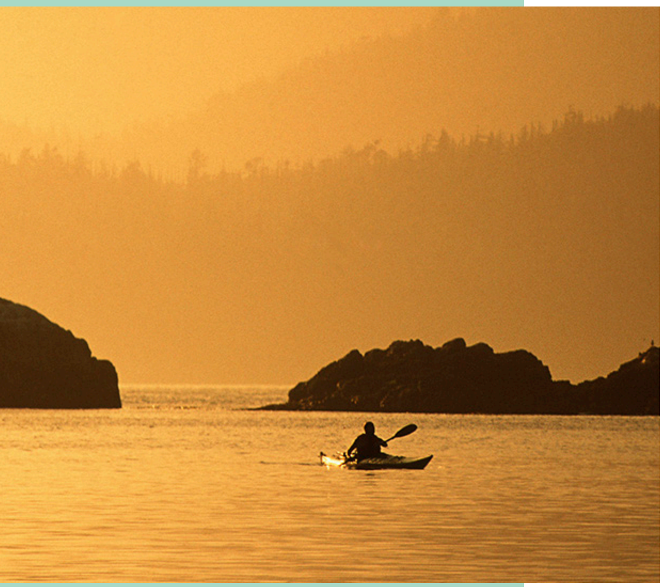
1 Gross Domestic Product (GDP), a common measure of economic performance, is defined as the total value of goods produced and services provided in a country during one year.

Eco-tourism, Nature-based Tourism: Why the Distinction?

The International Union for Conservation of Nature (IUCN) defines ecotourism as:

> environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate nature (and any accompanying cultural features—both past and present) that promotes conservation, has low visitor impact, and provides for beneficially active socio-economic involvement of local populations (Ceballos-Lascuráin 1996).

This definition includes an important distinction from broader nature-based tourism or wildlife tourism in that ecotourism includes a focus on the conservation of the resources on which the business relies (Farrell and Runyan 1999).



To help understand what is at stake from decisions that risk nature and ecotourism sectors, we selected sea kayaking, whale watching, and birding[a] as examples of marine-based nature tourism.[b] These activities rely on wildlife. Because whales and marine birds are highly vulnerable to oil, the sector is vulnerable to oil.

PHOTO: C. CHEADLE

a) Whale watching, bird watching, salt-water fishing and sea kayaking are all considered nature-based tourism activities according to Tourism BC (2005).

b) Nature-based tourism refers to activities that are directly or indirectly dependent on the natural environment; it requires a land or water base according to Tourism BC (2004).

Nature-based Tourism in the Salish Sea

In 2004, nearly one million tourists were already spending more than $900 million through roughly 2,200 businesses that offered nature-based activities in British Columbia (Tourism BC 2004)[2]. In the Salish Sea region, 27% of these businesses operate in Victoria, the Gulf Islands, and Vancouver Island, generating more than 20,000 person years of employment annually (Tourism BC 2005). In Washington State, more than $US 1.7 billion is spent annually on wildlife viewing, supporting 21,000 jobs. The Puget Sound region supports 88,000 tourism related jobs and generates $3 billion in spending (WDE 2008).

Economic Indicators

Economic indicators in this report come from desktop research of existing economic data. In some cases, we have extrapolated available data to provide an estimate across the entire Salish Sea. The examples of whale watching and sea kayaking use

2 This does not include accommodation, food and beverage before and after their nature-based experience. Tourism BC 2004.

direct revenues and employment rather than induced and indirect economic impact. A direct economic effect relates the monetary exchange for goods or services (i.e. the price paid). Conveying a direct economic impact allows comparison with Kinder Morgan's proposed Trans Mountain pipeline project and similar proposals.

We caution that these case studies are only examples of economic value—a full valuation is beyond the scope of this report and broader valuations already show that nearshore natural capital provides 30-60 billion dollars in benefits to BC's lower mainland (not covering the entire study area), annually (DSF 2012).

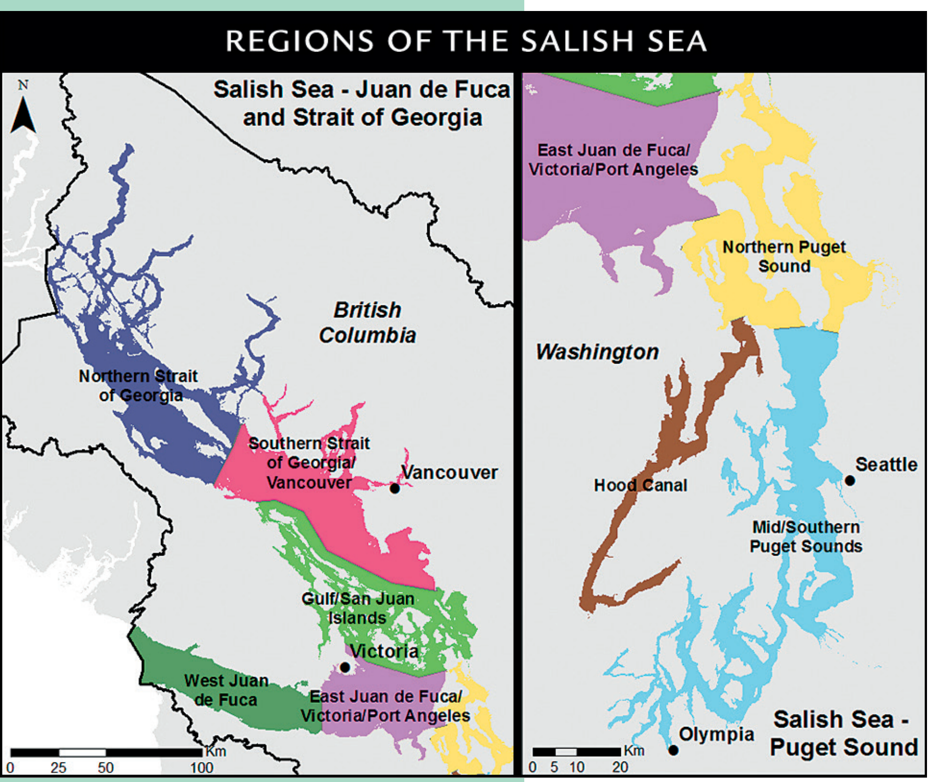
Sea Kayaking

As with many other forms of marine based nature tourism, sea kayaking has expanded rapidly over the last two decades (BC MSRM 2003). For American sea kayakers, BC is the number one Canadian destination (RRC 2007). Within BC in 1997, the sea kayaking sector included 150 guided kayak operations, nine ocean-kayak and kayak accessory manufacturers, 20 "mother ship" operations, 24 retail outlets, and an additional 250 operators providing kayaks and associated goods (BC MSBTC 1997).

Surveys that are more recent identified 114 companies offering sea kayak activities within BC (Tourism BC 2007). These 114 companies serviced almost 70,000 clients in 2005 with gross revenues reaching $14,255,000, averaging more than $120,000 annual revenue per company. Of this amount, $11,277,700 was attributable to tourists (Tourism BC 2007).

Specifically, 72% of these businesses were active within the Salish

Figure 4.1: Sea kayaking and whale watching areas in the Salish Sea.



Animals of interest
Respondents to the Raincoast survey identified species important to sea kayaking clients and company marketing. Seals and sea lions topped the list as the most important, followed by marine birds (71%), killer whales (60%), and porpoises and dolphins (54%).

PHOTOS: (TOP) B. HARVEY; (MIDDLE) K. SMITH, MAPLE LEAF ADVENTURES; (BOTTOM) J. THOMPSON.

Sea. Applying this percentage suggests more than 50,000 annual clients and revenues of $8.2 million in the BC portion of the Salish Sea. This figure is considered conservative given that industry growth projections have not been applied. For the tourists that this industry draws, 70% stayed at least two nights in the community and more than half were specifically visiting for sea kayaking (Tourism BC 2007).

Although similar studies have not been identified for Washington State, there are an estimated 5,000 resident sea kayakers (NPS 2007) and 40 sea kayak outfitting companies with associated businesses (kayak online.com).

Raincoast Survey Says...

A 2013 ecotourism survey conducted by Raincoast[3] provided additional information that supports our research findings. Raincoast survey respondents were largely optimistic about the growth of the sea kayaking sector with half (49%) having grown between 2008-2013. As well, 44% expected further growth over the next five years; only 2% expected decline. In terms of annual revenues, 44% of Raincoast survey respondents had annual revenue under $100,000, 35% between $100,000 and $500,000, and 20% greater than $500,000. The total annual revenue of survey respondents ranged from approximately $4,700,000 to $8,500,000, with a median of $6,600,000. This median provides an average annual revenue of more than $200,000 per company; a figure that compares well with the 2005 average of $120,000, considering industry growth and inflation.

Of 29 companies providing data, full-time employment averaged 86 year round jobs, rising to 129 during the summer months. The average of just below 3 full time employees (FTE) per company and 4.6 peak summer employments again compares well with earlier studies (Tourism BC) that provide averages of 3.2 FTE and 5.7 FTE per company during summer.

3 On-line survey of 49 Salish Sea ecotourism businesses responded to a range of financial and employment questions posed by Raincoast and identified wildlife species important to their operations.

Whale Watching

Images of killer whales breaching and flukes of humpback whales disappearing beneath the ocean adorn web sites, adverts, and post-cards across the Salish Sea, and not without reason. Since 1991, when 4 million people participated in whale watching globally, participation has grown by an average of 12% per year to reach 9 million in 1998 (Hoyt 2001). By 2008, 13 million people were participating in whale watching globally, generating a total expenditure of $2.1 billion (O'Connor et al. 2009).

In Canada, whale watching participation has grown from about 185,000 people spending $9 million in 1991 to 462,000 people spending $22.3 million in 1994. By 1998, more than 1 million whale watchers generated revenues of $50 million (Gill et al. 2006).

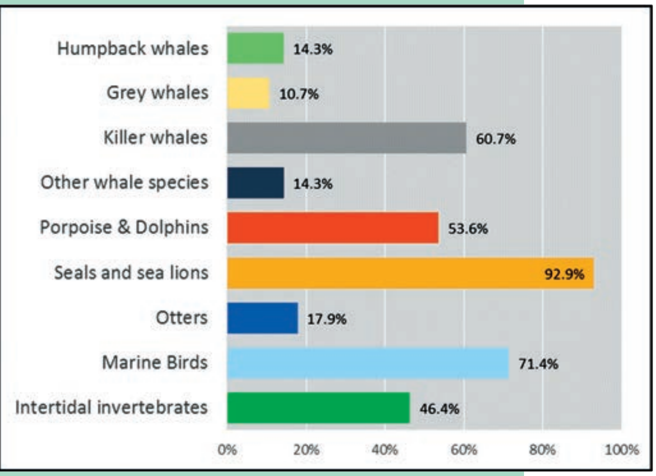


Figure 4.2: 2013 survey results from 28 Salish Sea kayaking companies that ranked wildlife species according to their importance to company marketing and their clients.

In BC, estimated revenue from whale watching reached $69 million in 1998 (Wong et al. 2011). Between 1998 and 2008, the whale watching industry grew more than 4% annually from 285,000 to 430,600 participants. Direct expenditures increased from approximately $9 million to more than $27 million during the same period. Seventy percent (70%) of this business was centered in Victoria (O'Connor et al. 2009). Annually, some 184,000 Canadian and 635,000 US residents are motivated to visit BC because of the opportunity to see whales (Tourism BC 2009b).

PHOTO: B. HARVEY

Whale Watching in the Salish Sea

The number of BC companies that provide whale watching services in the Salish Sea appears to have consolidated since 2000 from 120 companies (Hoyt 2001), to 47 readily identifiable operators in 2013.[4] This includes 28 members of the Pacific Whale Watching Watch Association (pacificwhalewatchassociation.org).

Estimates suggest that half a million people actively watch marine mammals in the Salish Sea (Whale wise 2011). This figure is supported by a 1998 estimate of 215,000 boat based whale

4 Raincoast 2013 Ecotourism survey identified 47 whale watching companies through online listings.

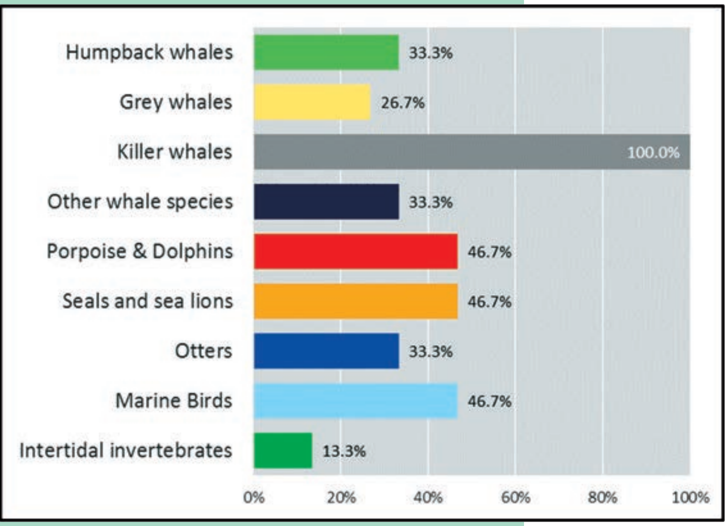


Figure 4.3 2013 survey results from 28 Salish Sea whale watching companies that ranked wildlife species according to their importance to company marketing and their clients (Raincoast 2013).

watching clients in BC (Hoyt 2001) and a 2009 study (Sunderman 2009) that estimated 250,000 clients in the Capital Regional District (CRD). Using this estimate of about 250,000 whale watchers generating $12 million in revenue from the CRD (Sunderman 2009), half a million whale watchers across the Salish Sea would generate annual revenues of $24 million.

Reducing these figures by 10% to reflect local (non-tourist) participation suggests annual direct tourism revenue of $21.6 million from some 450,000 participants (Hoyt 2001). These estimates compare well with 2009 international studies (O'Connor et al. 2009) that suggest roughly 635,000 annual whale watchers in the Salish Sea generating direct expenditure of more than $26 million and providing 412 jobs.[5]

Raincoast Survey Says...

Raincoast's 2013 survey received responses from 14 whale watching companies that indicated total revenue between $5 and $7.3 million. Employment data from 11 responses shows a range between 31–44 year round employees and a summer employment of 76–84.

Since 2008, 46% of respondents indicated a decrease in whale watching numbers, while 38% had an increase. Projections over the next 5 years showed 60% of companies anticipating an increase in numbers and only 6% anticipated a decrease. This is consistent with other studies that show continued growth in this sector.

Whale Watching: The Revenue Splash

Applying averages from the Raincoast survey to a conservative 47 companies in the Salish Sea shows a minimum of $16.8 million in annual revenues to a maximum of $24.5 million. Employment estimates range from 132–188 full-time year round employees to 325–359 in peak summer season.

5 Figures combine 430,600 BC participants and $27,105,800 in direct expenditure with 200 jobs (adjusted by a flat 30% reduction to remove businesses not located in the study area) with 425,000 Washington State participants with expenditure of $10,845,500 and 335 jobs (adjusted to remove the 5% of businesses located outside of the study area). This figure is then reduced by 10% to remove the effect of non-tourist business. Annual growth projections since 2008 have not been added.

Big numbers from tiny boats. Based on a conservative estimate of 122 sea kayaking companies in the Salish Sea region,[a] annual revenue for this sector is $19,900,000[b] supplying more than 375 year round jobs and 630 in the peak summer season.

PHOTO: OCEAN RIVER ADVENTURES

a) Based on the BC Tourism 2005 figure of 114 BC companies, then modified by the 72% operating in the Salish Sea and the web listing of 40 Washington State based companies.

b) Average company revenue estimated at $163,000–$205,734 (Raincoast survey) and the 2005 figure of $120,000.

Birding

In the United States, some 48 million birders spend a staggering $36 billion on trips and equipment annually (USF&W 2009). This in turn generates $82 billion in economic output across the country, and supports 671,000 jobs. Within BC, over 94,000 Canadian birding visitors and 322,000 US visitors come to the province to watch birds (Tourism BC 2009). US studies estimated 315,000 birding visitors annually in Washington State (USF&W 2009). Chapter 5 identifies mean participation rates of more than 1.8 million resident Salish Sea birders.

Animals of interest

Perhaps not surprising, 100% of whale watching companies identified killer whales as the most important species in terms of customer interest and company marketing. Marine birds, seals and sea lions, porpoises and dolphins, followed whales with 46%. Otters (primarily river, as sea otters have a very restricted range in the Salish Sea), humpback whales, and other whale species were identified as important species for their customers by 33% of respondents.

PHOTOS: (TOP) T. KERR, (BOTTOM) J. THOMPSON, OUTER SHORES

Table 4.1
Total expenditure, total economic output, and jobs that relate to birding tourism in the Salish Sea.

Birding participants	Total expenditure (US$)[a] 1000's	Total economic output (US$)[b] 1000's	Jobs supported by birding activities[c]
Salish Sea residents[d]	1,400,205	3,211,033	26,172
Salish Sea visitors[e]	547,519	1,259,513	10,234
Salish Sea total	1,927,724	4,470,546	36,406
Adjusted figure[f]	1,118,079	2,592,916	21,115

Expenditure figures include food, transport, accommodation, and equipment purchases. Total economic impact includes indirect and induced economic impact. Jobs are those associated with food services, transport, accommodation, and equipment.[g]

a) Expenditure relates to trip and equipment purchases. Expenditure calculated as $749 (US) per person based on USFW 2009.
b) Total economic output calculated as $1,723 per person based on USFW 2009.
c) Jobs calculated as 0.014 per birder based on USFW 2009.
d) Total Salish Sea resident birders 1,869,433 (Chapter 5).
e) 731,000 combined of Canadian and American visitors
f) As these figures represent total birders, we have conservatively multiplied them by 58%. This figure represents the percentage of birders were viewing (primarily) shorebirds (USFW, 2009). This adjustment better reflects birding numbers in the Salish Sea. The percentage of birders viewing primarily waterfowl is 77% (USFW, 2009).
g) Figures are based on data from USFW (2009). A per person figure was calculated and applied to birder numbers for BC and Washington. Visitor numbers for BC are from Tourism BC 2007 (Canadian and US visitors only) and USFW 2009 for Washington State.

5. Recreational Behaviour

In BC, 68% of the population chose to live in the province because of the access to nature. In 2011, more than $7.5 billion was spent on nature-based activities (CCRM 2014).

PHOTOS: B. HARVEY

How We Value 'Place' and Other Marine Activities

With almost 7,500 km of shoreline, more than 400 islands, diverse landscapes, fish, and wildlife, the Salish Sea is a mecca for those who love to be on, under, or near the ocean. Each day hundreds of thousands of BC and Washington State residents experience the myriad benefits of the Salish Sea's 'natural capital', from the plethora of recreational opportunities accessible practically at the doorstep, to the inherent quality of life that residing in such a geographically stunning region provides. It is the reason we call this place home and the reason so many visit.

In this chapter, we explore personal use of marine environments throughout the Salish Sea. We focus on rates of participation and the geographic distribution of activities as a proxy for the value placed on the sea around us.

Ultimately, we all determine the importance of walking on a clean beach, kayaking in the presence of killer whales, or watching coastal birds. Although willingness-to-pay and opportunity cost appraisals can be used to assign a commercial worth to these activities, neither captures the cultural and inherent value. Therefore, rather than calculate these activities from commercial perspectives, we present information regarding levels of participation and key locations as indicators of abundance, diversity, and distribution (we're biologists).

In determining the value of outdoor activities within the Salish Sea, we focus on those that are prevalent, involve various demographics, and have a direct link to the marine environment. Specifically, we examine saltwater sport fishing, sea kayaking, bird watching, walking and combing beaches, boating, sailing, and surfing.

Bird Watching

Numerous sanctuaries, parks, and bird watching sites, hosting hundreds of resident and transitory bird species, exist throughout the Salish Sea. We used Important Bird Areas (IBA),[1] marine parks, and other relevant protected areas as proxies for locations where people bird watch, while recognising that the activity could occur in many other locations.[2]

A 2011 US-wide recreation study found a bird watching participation rate of only 5% (TOF 2013), whereas recreation studies from Washington State estimate that 26% of its residents observed or photographed birds and 10% observed or photographed marine life (CR 2007). Other US surveys, which focussed just on birding, found Washington has a participation rate of 36% or 1. 5 million resident birders (USFWS 2009).

In BC, recreational survey results for the Lower Mainland-Coast Mountain region and Vancouver Island indicate very high resident participation in birding at 25% and 32% respectively (Tourism BC 2013). Applying the mean participation rates indicates a Salish Sea birding population of more than 1.8 million with a range of 1.1 million to 2.4 million.[3]

1 Important Bird Areas are discrete sites recognized internationally, which support specific groups of migratory, threatened, large flocks, or birds with restricted ranges or habitat. See http://www.ibacanada.ca/

2 Studies in the US have shown 83% of birders use public land such as parks and wildlife refuges for bird watching (USFWS 2001).

3 For BC, we applied the 25% and 32% rates (BC Tourism 2013) to population statistics for the Mainland and Islands respectively (total 891,383). For Washington, the mean was taken from

Important Bird Areas (*see map, Chapter 4*) of international importance in the study area include Boundary Bay, Washington State's Olympic Peninsula, Port Angeles harbour, Point-no-Point, Skagit Bay, and the Samish/Padilla Bays.

The BC portion of the study area similarly contains numerous sites of high importance to birds and thus bird watchers, including: the Fraser Delta and Boundary Bay, the Cowichan Estuary and Sidney Channel, Little Qualicum Estuary to Nanoose Bay, K'omoks, Carmanah-Walbran Provincial Park, English Bay, and Burrard Inlet in the heart of Vancouver.

PHOTOS: (INSET, ABOVE) J. THOMPSON; K. SMITH /MAPLE LEAF ADVENTURES

Surveys suggest a Salish Sea birding population between 1.1 million and 2.4 million people. Another method—applying a mean participation rate of 22%[a] across the Salish Sea region—finds a comparable 1.8 million residents are interested in birds.

PHOTO: (LEFT) OCEAN RIVER ADVENTURES

a) The average is determined by participation rates quoted in, or relevant to, the study area. Individual rates are not weighted.

Participation rates from Washington and BC suggest over one million Salish Sea [a] residents participate in marine powered boating. Notably this figure does not consider participation from BC or Washington residents not living within the study area boundary.

PHOTO: (ABOVE) R. DIXON

a) Applying the 13% participation rate (CR 2007) to the WA study area population (570,222) and the 15% rate (Tourism BC 2013) in BC (505,695) for a combined 1,075,917.

Power Boats and Sailing

With sheltered anchorages and spectacular scenery, the Salish Sea ranks among the world's best sailing and boating locations. Although somewhat more exclusive (due to boating costs), boating participation[4] is high throughout the Salish Sea.

Studies in Washington show resident participation in saltwater sailing around 7% (CR 2007), a figure much higher than the national average of 1-2% for all freshwater and marine sailing. Boating in general has a participation rate of 15% in Washington with personal boat ownership at 26% (280,000 registered vessels, USCG 2011). Saltwater boating is estimated to have a participation rate of 13% (CR 2007).

Participation is similar in BC with 15% of residents engaging in motorized boating on the ocean (Tourism BC 2013). Lower estimates for boat ownership indicate 610,000 households with boats—one of the highest levels in the country at more than 25% (NMMA 2012).

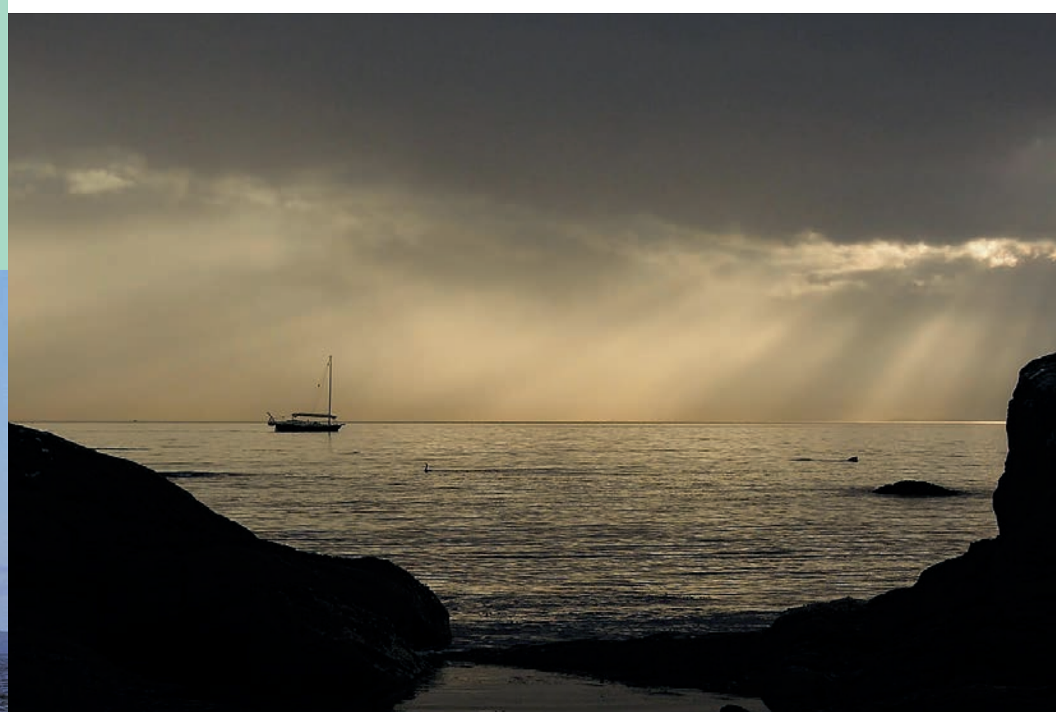
In BC, 45 marine sailing and yachting clubs have 60,000 members (Gill et al. 2006). In Washington State, there are 256 marinas with 39,400 moorage slips (WDE 2008).

the 5% rate (TOF 2013), 26% rate (CR 2007) and 36% (USFWS 2009) and applied to population statistics for the study area (total 978,150).

4 This does not include human powered vessels, e.g. canoes and kayaks.

In an average year, more than one million Salish Sea residents get out on the ocean in a motorized vessel.

PHOTOS: (RIGHT) A. ROSENBERGER; (BELOW) K. SMITH/MAPLE LEAF ADVENTURES



Saltwater Sport Fishing

Saltwater fishing in the Salish Sea is enjoyed by more than half a million annual participants who target crab, prawns, shrimp, groundfish (such as halibut and lingcod) and of course, salmon. Based on BC fishing license sales, the number of resident saltwater anglers has remained largely constant, increasing only slightly from 234,000 in 1999-2000 to 255,000 in 2011-12 (DFO 2012). Similarly, 285,000 residents in Washington State purchased saltwater fishing licenses[5] for the 2008-2009 season (WDF&W 2008).

5 Includes saltwater, combination, and short-term combination licenses.

Lies, damn lies, and statistics

Recreation surveys use various techniques and definitions that make comparisons difficult. Therefore, rather than relying on single references, Raincoast used multiple estimates of participation in each activity and compare these with supporting studies. We apply the average (mean) and range of participation rates to population statistics in the study area to specify the total population participating in each activity. [a]

a) Participation rates are rounded to the nearest whole number. A range of higher and lower estimates is provided where appropriate.

Figure 5.1 Marinas and boat launches in the Salish Sea

The percentage of Washington residents who fish in saltwater from a bank, dock, or jetty (7%) and those who fish from a private boat (10%) suggests that access to a boat does not hinder participation (CR 2007). National US recreation surveys put saltwater fishing participation at only 4% (TOF 2013), whereas surveys that focused more directly on fishing show almost 17% participation in Washington State (RBFA 2013). Peak saltwater fishing in Washington occurs in July with roughly 436,000 participants fishing from a bank, dock, or jetty, and 638,000 individuals fishing from boats (CR 2007).

US-wide industry surveys show participation figures that compare well with license sales (ASFA 2008) and suggest 286,000 people annually participate in saltwater sport fishing in Washington with more than 1,555,000 saltwater fishing days. In the US, the average number of days spent saltwater fishing was roughly 17 (RFBA 2013), versus 13 days in Canada (DFO 2012).

In BC, a provincial survey indicated 12% of residents had been saltwater fishing at least once between December 2008 and November 2009 (Tourism BC 2013). A national survey found the number of active BC saltwater anglers at 146,000 in 2000, 170,000 in 2005, and 167,000 in 2010 (DFO 2012). These survey figures imply a lower participation rate than fishing license sales indicate.

Based on license sales, there are approximately 540,000 resident saltwater anglers in Washington and BC. Based on mean participation rates (applied to population statistics for districts within the study area), more than 865,000 Salish Sea residents actively participate in saltwater fishing. [a] The range is between 580,000 and 1.1 million saltwater anglers in the Salish Sea. [b]

PHOTO: FISHINGWITHROD.COM

a) The 12% rate (Tourism BC 2012) was applied for BC for a total population of 404,556. For Washington a mean of 10.5 was calculated considering the 4 % rate (TOF 2013) and 17% rate (RBFA 2013) for a population of 460,564.

b) No range applies to BC as only the 12% rate (Tourism BC 2012 is applied) for a total population of 404,556. In Washington the lower bound estimate, using the 4% rate (TOF 2013), is 175,453 and the higher bound estimate, using the 17% rate (RBFA 2013), is 745,675.

Sea Kayaking

Sheltered waters, campsites, islands, stunning landscapes, and a range of marine wildlife make the Salish Sea an ideal location for sea kayaking. Popular kayaking areas include the Gulf Islands, Discovery Islands, and Desolation Sound on the east coast of Vancouver Island. In Washington State, the San Juan Islands are one of the most popular regions, but sea kayaking extends throughout Puget Sound and the Strait of Juan de Fuca.

Surveys by the State of Washington show that 4.5% of the population kayak or canoe in saltwater (CR 2007), which is

A participation range of 1–4.5% suggests a resident population of marine kayakers in the Salish Sea between 77,500 and 349,000. The average participation rate of 2.7% would suggest more than 209,000 resident kayakers in the Salish Sea.[a]

PHOTO: OCEAN RIVER SPORTS

a) Figures assume that BC participation rates mirrors Washington State and the US.

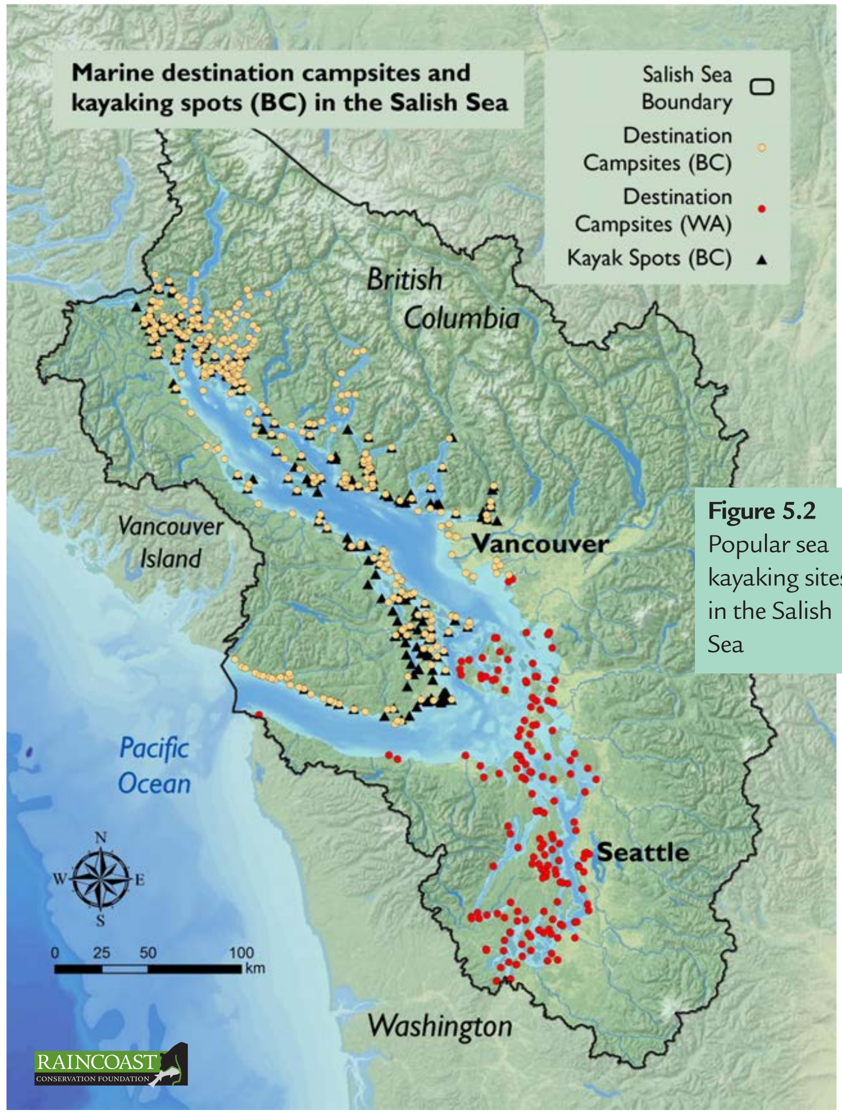


Figure 5.2 Popular sea kayaking sites in the Salish Sea

much higher than the national average of less than 1% (TOF 2013). In BC, estimates suggest sea kayaking is far more popular now than 30 years ago, showing a 20% growth rate since 1995 in resident participation (Gill et al. 2006).

A Club for All Paddlers

The Salish Sea provides recreational opportunities for thousands of enthusiastic paddlers. The region hosts at least 27 sea kayaking clubs representing diverse areas, interests, businesses, and cultures.

Dragon boat racing, not captured in our surveys, is another growing activity for paddle enthusiasts on the Salish Sea.

The mean participation rate [a] indicates 3.3 million residents use beaches in Salish Sea [b] with a range between 2.9 and 3.8 million people [c].

PHOTO: A. ROSENBERGER

a) For Washington the mean is calculated from the 34%, 29%, 37%, and 49% participation rates referenced. The 37% mean indicates a beachcombing population of 1,622,940. In BC, the figures of 60% (Vancouver Island 416,212) and 48% (Mainland 1,285,256) are applied.

b) This range excludes all other residents within BC and Washington, and should be considered conservative.

c) No range applies for BC. In Washington the range represents the 29% rate (1,272,034) and 49% rate (2,149,300) applied across all study area populations.

The Beachcombers

A stroll down the beach, or simply time on the beach, is one of the most common pursuits in the Pacific Northwest. On Vancouver Island, 60% of surveyed residents indicated their participation in "ocean beach activities". This was higher than the 48% of residents from the Lower Mainland-Coast Mountain region who engage in these activities (Tourism BC 2013). Similarly, although 34% of all Washington residents enjoyed beachcombing in the summer, the coastal residents were more active. Average participation in coastal Washington was 49% (Islands) 37% (Coast) and 29% on the Peninsula (CR 2007).

Surfing

Surfers have a direct physical connection to the marine environment. They bond with the activity itself and with specific surf locations; the latter based on the frequency and nature of waves, social, and other environmental factors (Lazarow et al. 2008).

Data on participation rates are sparse for the Salish Sea region, but available studies suggest a resident surfer population

A local surfer catches a nice right-hander at Jordan River, BC. This and nearby areas can host 300+ surfers on a day with good conditions.

PHOTO: C. DARIMONT

of less than 1%[6] (Leeworthy and Wiley 2001, CR 2007, TOF 2013). This translates into more than 59,000 resident surfers around the Salish Sea with experts suggesting a possible 90-120,000 surfers in Washington (C. Nelson, 2013 pers. Comm., May 10).

Revealing actual surf locations is somewhat taboo in surf culture. However, we used a popular surf website, *Wannasurf*, and augmented their sites with input from local Surfrider chapters. Accordingly, we found that the north and south coast of the Strait of Juan de Fuca provide the most consistent waves with more than 40 locations on the southern coast (Figure 5.3 below).

6 The mean of 0.77% is calculated from Rates 0.01% (Leeworthy and Wiley 2001), 1.3% (RC 2007), and 1% (TOF 2013) 2013 59,733.

The Surfrider Foundation[a] has 8 local chapters within the study area: 6 in Washington, 1 in Victoria, and 1 in Vancouver, with a total of 576 members (C. Snyder, 2013 pers. comm., May 10). Although these numbers are low in comparison with other types of recreation, surfers are high frequency participants, typically surfing over 100 times per year (Wanger et al. 2011).

a) An international group whose mission is the protection and enjoyment of oceans, waves, and beaches through a powerful activist network. See: http://www.surfrider.org

Figure 5.3: Popular surfing spots and beach access within the Salish Sea.

6. Time Before Memory

Popular culture often reflects our close connection to the marine world.

PHOTOS: [TOP] B. BAR; [BOTTOM] M. CULVER.

Before European contact, the Salish Sea supported more than 50 distinct Aboriginal societies, each with their own language, government, and dependence on the resources of their territories. Decisions about development projects in the Salish Sea are increasingly made with a focus on the purported economic benefit. Although many economic tools can be used to place a monetary value on social and cultural values, these methods do not adequately reflect the depth and diversity of our social and cultural connections to place. Most people relate to a sense of place that is considerably more than habitation. Often it comprises our historic connections, the plants and animals that live there, our cultural practices, and the natural and man-made features. Ultimately, public tolerance for activities that threaten our connections to place are ethical questions, distinct from those only concerning a matter of price (Sagoff 2004).

Indigenous and Eurasian-Canadian Cultural Heritage

Eurasian-Canadian culture has strong and enduring links to the natural world. Business names, art, architecture, cultural festivals, and the murals on our city walls all reflect a close cultural connection to the ocean and marine environment.

Our strong social and cultural links are well illustrated by the extent to which nature and the marine environment are featured in our recreational pursuits in and on the ocean and its shorelines. The use of killer whales, salmon, and hawks to represent the region's cities and sports teams is a contemporary example of how cultural identity draws from the natural world.

Given the land use, harvesting techniques, and the spiritual connection to the natural world, the entire Salish Sea region could be termed a cultural landscape (UNESCO 2010). The United Nations now recognizes this type of cultural diversity as a distinct component of biodiversity by (UNEP 2007). In this chapter, we focus heavily on the connections of Indigenous communities to the land and sea, as these relationships have been established and sustained for millennia.

Indigenous Socio-cultural Values

With a cultural presence documented at more than 10,000 years and understood to have been in existence for many millennia, the Indigenous communities of the Salish Sea region have unique socio-cultural links and values that continue to inform a way of life in the modern world.

The examples we provide merely help to illustrate a connection to place born of a world-view different from that of most Canadian immigrants, and one that remains at the core of efforts to protect our coastal environment. Contact with Europeans decimated Indigenous populations, yet despite decades of cultural repression, a strong and enduring culture exists. These connections are inextricably linked to place.

The Caretakers is a 1995 report led by Philip Kevin Paul of the WSÁNEĆ (Saanich) people to capture and preserve WSÁNEĆ place names, as well as the concepts and language the place names are built on. "Care-takers of the Earth" was how Philip Sr. described (to his son) the WSÁNEĆ peoples' position with all livings things. The report also captures the paradox of WSÁNEĆ oral tradition being written down in the English language. Cover art is by WSÁNEĆ artist Charles Elliot.

WSÁNEĆ Identity

In reference to the Sannich Nation on Southern Vancouver Island, Earl Claxton Sr. and John Elliott Sr. explain:

> It is the belief of the Saanich tribe that we have occupied this land and have lived according to the Sacred teaching of life given to us by XALS, our Creator, since the beginning. There were no winds, animals, birds, trees, fishes, or islands at that time. All of these beings were changed by XALS from Saanich people to be what they are today. ... To have connection to the land, according to ancient beliefs and teachings, is the Saanich identity (Mason and Ham 1994).

A Connection Since Time Before Memory

Indigenous creation stories, including those from around the Salish Sea, share many common threads. One is that 'personhood' is open to both humans and non-humans. Accordingly, when the Creator added humans to the mix of life on Earth, humans did not see themselves as anything different. Rather, the interdependence with all others was seamless. This connection between people, animals, and the land and waters that sustained them persists.

Swinomish Tribal Community

"The Swinomish live in the Skagit—rooted along the Salish Sea. We are the people of the Salmon and our way of life is sustained by our connection to the waters and to the lands, where we have fished, gathered, and hunted since time immemorial.

We often say to our friends, Swinomish always has been, and always will be, a fishing tribe. Salmon are at the heart of Swinomish cultural and ceremonial life. The ceremonial and subsistence harvests by tribal fishers support a thriving cultural life, sustains the elders and nurtures each new generation of our children".

Brian 'Spee-pots' Cladoosby

Cultural and Personal Identity

The connection of cultural diversity and biodiversity is core to the very identity of Nations, tribes, clans, families, and individuals. Clan systems identify with wolf, bear, eagle, killer whale, and many other species. Similarly, family and individual crests represent names, genealogy, and narratives shared by people and place, where other animals are considered as sisters and brothers.

Spirit in Place

For many Coast Salish peoples, spirit power (s'uylu) is directly embedded and experienced in the land, which includes the living and non-living components. Importantly, this is not restricted to existing sites, and spirit power can be experienced directly, through dream, myth, and narrative (Thom 2006). Dreams and stories are shaped by the land and individual experiences of the land. Preservation of the natural environment permits these experiences to continue.

Cultural Keystones

Just as keystone species exist in an ecological sense, cultural keystone species can also exist. They are based on the significance to cultural identity via roles fundamental to a culture that can include food, medicine, materials, and spiritual practice (Garibaldi and Turner 2004). The salmon of the Pacific Northwest are a pertinent example.

Fossil Fuel Transport Threatens Culturally Important Species

A study on the impact of six fossil fuel proposals* in the Salish Sea (Gaydos 2015) analysed the potential affects on 50 species of recognized cultural importance to indigenous Coast Salish peoples. When considering potential oil spills associated with increased vessel traffic, 72% of the 50 culturally important species (n. 35) were likely to be affected, 18% (n. 9) possibly affected and 10% (n. 5) unlikely to be affected. Importantly, threats associated with these six projects also include noise and ship strikes and likely have an overall additive or synergistic interaction.

*Fraser Surrey Docks, Kinder Morgan Trans Mountain, Gateway Pacific Terminal, increased rail shipment of Bakken Shale crude oil, Tilbury LNG, Woodfibre LNG, Roberts Bank Terminal 2.

Tl'chés—Cultural Keystone Places

Cultural keystone places are now also being proposed (Turner 2013) to represent areas of high cultural importance that can communicate the value of specific places beyond economic potential. These places represent a source of cultural identity, sustenance, spirituality, and associated traditional ecological knowledge. Tl'chés, Chatham Islands, near Victoria, BC, in Lekwungen traditional territory, has been identified as an example (Turner 2013). For generations, the islands have been vital to the cultural expressions and livelihoods of the Straits Salish people, especially the Lekwungen.

Tl'chés is key to the 'Origin of Salmon' story, which tells of how salmon gave themselves to the Straits Salish people. Tl'chés also served as a critical refuge for many Lekwungen families during the smallpox epidemic of 1862-3 (Lutz 2009). The islands helped sustain the Lekwungen with fishing, fruit and vegetables, and sheep rearing until residents moved to the main Lekwungen reserve in Esquimalt in the mid 20th century (Gomes 2012). The site was also used for secret potlatches and winter dances during periods when cultural expression and practices were prohibited (Lutz 2009).

Cultivated by First Nations for centuries, the Garry oak ecosystem is now endangered. In the past, Garry oak meadows were maintained by lightening and fires set by First Nations to promote production of camas, an important food plant. Today, fire suppression, land development, and invasive species have compromised much of this ecosystem.

PHOTO: C. ZITER

Tl'chés is also one of the few remaining remnants of the Garry oak ecosystem, one of the rarest and most endangered ecosystems in Canada (Lea 2006). These forests and woodlands represent culturally maintained landscapes formed from thousands of years intensive Indigenous management, especially low-intensity fire for the benefit of hunting and production of camas and other edible plants (Turner 1999).

The Garry oak meadows include habitat for rare native species including red-listed Macoun's meadow-foam, California buttercup, and the endangered sharp-tailed snake, among many others (COSEWIC 2009).

Tl'chés also encompasses numerous culturally significant sites such as shell middens, culturally modified trees, and sacred areas, all of which are threatened by invasive species and land use conflicts (Gomes 2012). Now elders, the last generation of Tl'chés-born-and-raised Lekwungen, are sharing their memories and local knowledge with younger generations during field outings and traditional pit-cookings at Tl'chés, aiming for cultural renewal and long-term protection of the islands (Gomes 2012, Gomes 2013).

Tsleil Waututh emblem

Tsleil-Waututh Nation—People of the Inlet

The Tsleil-Waututh declaration states "We have lived in and along our Inlet since time out of mind. We have been here since the Creator transformed the Wolf into that first Tsleil-Wautt, and made the Wolf responsible for this land." (Tsleil-Waututh Declaration extract).

The Tsleil-Waututh are stewards of their rivers, streams, forests, and beaches with an over-arching obligation to ancestors and future generations alike. These obligations are the basis for the Nation's Sacred Trust Initiative, a direction sanctioned by Tsleil-Waututh Chief and Council and specifically developed to stop the Kinder Morgan Trans Mountain pipeline project.

Say Nuth Khaw—Two-headed serpent
"A two-headed serpent once lay across the Inlet blocking all that wanted to pass. To paddle up the Inlet, they had to carry their canoes around Say Nuth Khaw. It is said that on the ground over which his frightful body crawled as it traveled to Lake Beautiful [Buntzen Lake], no living thing has ever grown. Not a blade of grass or moss could survive." Adapted from story as told by Annie George, 1966 (SNKY 2010)

Say Nuth Khaw Yum Provincial Park

Say Nuth Khaw Yum (serpent's land) lies within the core of Tsleil-Waututh traditional territory in the area commonly known as Indian Arm. It represents the spirit and connection of the Nation to their territory in future, present, and past.

The southern mouth of Indian Arm was once the location of winter villages, summer villages and spiritual sites that occupied every accessible point of shoreline. At the outlet of the Indian River, the Inlailawatash Estuary supported generations of Tsleil-Waututh in the village proper, and in numerous hunting and fishing camps. The area provides a glimpse at the depth of cultural connection to place beginning with the name itself.

The Nation considers Say Nuth Khaw Yum a place to be cared for and restored, believing that the health of the park and the health of the Nation are intimately

Archaeological sites in Inlailawatash Estuary and Croker Island.
Evidence of sustained use in Say Nuth Khaw Yum includes cliff side pictographs, archaeological sites, settlements, and shell middens

PHOTO: TSLEIL-WAUTUTH NATION

connected. In addition, the Nation sees the park as another means to help establish contemporary connections to the land and waters and that sharing of culture and history will help others develop a sense of respect and care for the air, land, water, and wildlife.

Traditional Use

Traditional Food Sources and Harvesting

Before contact, some Coast Salish communities obtained 90% of their protein from marine sources (Suttles1987) with up to 10% from locally gathered vegetables and fruits (Chisholm et al. 1983). These traditional foods included more than just nourishment. The harvesting experiences, techniques, consumption, and reciprocity were key aspects of cultural expression, identity, and well-being (Donatuto and O'Nel 2010). Sharing of food resources through feasting, trade and social events also provided, and provides, a means to reinforce relations, share knowledge, and maintain kinship ties within

Food Resources

A harvest study (Fediuk and Thom 2003) with the Hul'qumi'num Treaty Group identified 188 culturally relevant species. These include:

- 27 species of fin-fish (including sockeye, Chinook, pink, coho and chum salmon, herring, lingcod, halibut, rock cod and snapper);
- 26 species of shellfish and other marine foods (including Dungeness crab, oysters, little neck clam, butter clam, manila clam, prawns, basket cockle, red urchin, octopus, shrimp);
- 3 species of marine plants;
- 31 species of birds (including black scoter, white scoter, bald eagle, mallard, western grebe, trumpeter swan, murre, ruffed grouse, blue grouse);
- 16 species of mammals (including marine mammals, mule deer, white tailed deer, elk, moose, black bear);
- 22 species of berries (including salmon berry, black cap, soap berry, huckleberry, thimble berry);
- 43 species of food and medicinal plants;
- 16 species of trees; and
- 4 'other' species.

and between Nations (Lepofsky and Caldwell 2013).

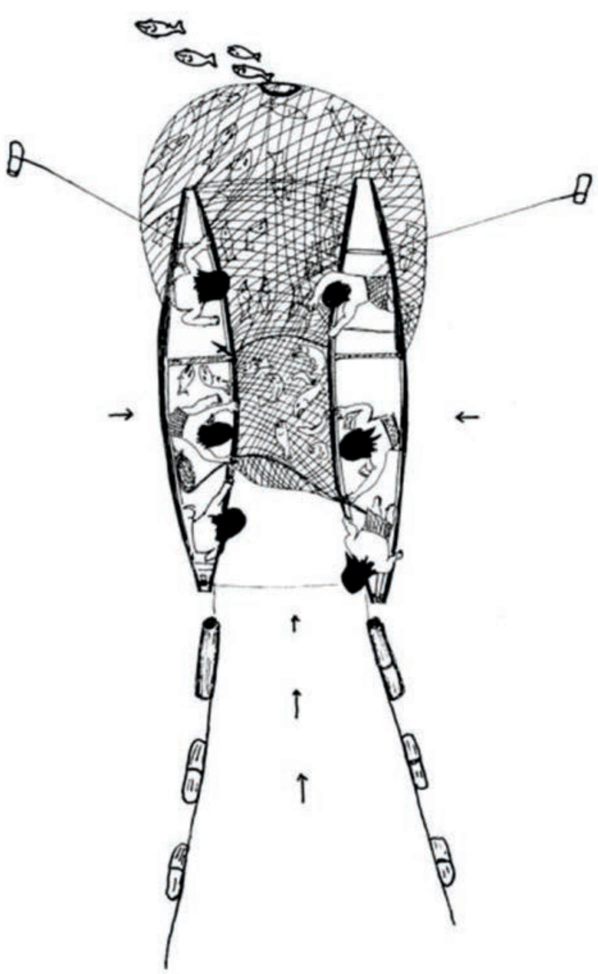
For 10,000 years or more Tsleil-Wautt men, women and children cut trails from the shores to the mountain peaks to enable food harvesting. Lingcod and snapper were caught from shore near Croker Island along with shellfish and shrimp. Twin Islands were used to hunt geese and ducks including goldeneye, mallard, and scoters. Surrounding islands and forests were used to hunt deer, bear, goat, and elk.

Inlailawatash was a fall fishing camp used to catch pink, coho, and chum salmon, which were then smoked or salted. Upstream, huckleberries, blueberries, salmon berries, devil's club, wild parsnip, wild onions, and nettles were gathered in the spring and early summer.

Importantly, food harvesting remains embedded within ceremonial use. For many Indigenous communities food harvesting, preparation, sharing, and eating provide a means to feed ones own spirit and the spirit of passed relatives.

Ceremonial and Religious Use of Sites with the Salish Sea.

For many Saanich people, the Salish Sea region also includes numerous sites for ritual bathing, a practice used to gain power and strength. Many such sites have already been lost to development and water pollution.



Saanich Reefnet Fishery From Turner and Burkes (2006).

DRAWING: J. ELLIOTT

The Saanich Reef Net Fishery—A Way of Life

The SXOLE, or 'reef net' is another example of ways in which cultural practices demonstrate how place, identity, and the natural world are inseparable. WSÁNEĆ (Saanich) history and teachings recognize the reef net fishery as more than just a fishing technique, it was integral to what it means to be 'Saanich' i.e. fish and fishing are the Saanich identity.

Saanich teachings consider this technique a gift from the Salmon People to the Saanich in exchange for a beautiful princess. The key fishing sites, SWÁLET, are passed down through families with community elders holding and passing on knowledge of the fishery. Importantly, families belong to the fishing site (Claxton 2003).

The Reef Net

The Reef Net was constructed from specific local materials including Hooker's willow, cedar logs, and cedar rope.

Canoe Journey

Canoes are a well-recognized identity of coastal Indigenous communities across the Pacific Northwest. As part of a broader movement of cultural revival, the Heiltsuk First Nation of Bella Bella paddled their Glwa (ocean going canoe) to Expo 86 in Vancouver. Paddle to Seattle followed in 1989.

Since then, tribal journeys have emerged as major celebrations of contemporary culture. Canoes and paddlers from Indigenous communities have travelled thousands of kilometers to be hosted by other communities and nations. The events provide an opportunity to share art, culture, history, heritage, song, dance, and food.

PHOTO: TRIBAL JOURNEYS

Senanus Island in Saanich

Grave islands of the Saanich or Malahat Nations exist throughout Saanich Inlet.

PHOTO: WIKIMAP

The technique also relies on an in-depth knowledge of salmon, salmon habitat, and tidal flow. Cedar log buoys and cedar rope formed leads, held in place by anchors, and attached to two anchored canoes. The sides and floor of the net were held with purpose made rock weights and threaded with dune grass to create the illusion that the salmon were safely swimming near the ocean floor. The net was suspended between the two canoes and positioned to open with the tidal flow. Releasing the rear anchors brought the canoes together so the salmon could be collected and brought ashore.

A key feature of the fishery was a small hole at the end of the net, specifically designed to allow some fish to escape. Beyond the principles of conservation and sustainability, the technique comes from a deep respect. Knowing that each salmon run reflected a unique lineage, the technique honoured these lineages so they would continue to persist.

7. The Game of Risk

Probability, Risk and Uncertainty

Gambling is a good example of risk taking. A dice toss has one of six possible outcomes. No one knows what number will surface, but we know what the distribution looks like. Putting your money on a number has a known consequence (good or bad) and you know the odds of that consequence occurring. There is always certainty, even though the process is random and the outcome is unknown.

Uncertainty is different. We don't know what is going to happen next, and we do not know what the possible distribution (the odds) looks like. It's hard or impossible to measure. An estimate might be off by a factor of 10 or by a factor of 1,000; there is no good way to know (Silver 2012). The next earthquake, bird flu outbreak, stock market crash, or oil tanker disaster, are all uncertainties.

From endangered killer whales and highly valued habitats, to a coastal economy and culture that depends on nature's services and benefits, there is much to cherish in the Salish Sea. Yet, increasing tanker traffic places this entire region at risk at a time when climate change and cumulative human impacts already stress coastal wildlife (DFO 2015, Gaydos et al. 2008). This chapter focuses on the risk that Kinder Morgan's proposal poses to our coastal wildlife and a way of life.

Understanding Risk

We subconsciously calculate risk every day. Deciding where to let our children play and when it is safe to cross the road are risk-based considerations. In environmental assessment, risk is the potential for loss resulting from an action, activity or inaction, whether predicted or not.

Quantified risks provide information to evaluate and manage potential hazards. They are the product of the probability of an event occurring multiplied by the expected harm, or consequence, caused by that event. Simply stated, Risk = Probability x Consequence. Accordingly, when the probability of an accident is low but the consequence high, the risk remains high.

Table 7.1 Risk is a combination of probability (likelihood) multiplied by consequence (impact).

Likelihood	IMPACT OR CONSEQUENCE				
	Insignificant	Minor	Moderate	Major	Severe
Almost Certain	Moderate	High	High	Extreme	Extreme
Likely	Moderate	Moderate	High	High	Extreme
Possible	Low	Moderate	Moderate	High	Extreme
Unlikely	Low	Moderate	Moderate	Moderate	High
Rare	Low	Low	Moderate	Moderate	High

Some risks are not worth taking.

Probabilities are Repeatable, Disasters are Not

The nature of disasters is that they are unique, unpredictable events. Catastrophes lie completely outside the set of conditions that contribute to probabilities. As such, we cannot make educated guesses about a future catastrophe from a series of events where catastrophes didn't happen. Yet this is what Kinder Morgan's risk analysis implies.

Knowing the true relationship between the possibility of an oil spill occurring and its potential harm (environmental, social, and economic) is essential for evaluating oil spill risk. Unfortunately, calculating risk on this scale is fraught with problems. Here, we examine the considerations that are not disclosed when Kinder Morgan conveys the risk presented by its project.

Statistics are Not Substitutions for a Lack of Data

We are all familiar with oil industry accidents—from oil rig explosions to grounded tankers, but we are less familiar with the underlying assumptions used to convey the unlikely nature of such events. Despite being portrayed as such, the probability of these events occurring cannot be accurately calculated with likelihoods such as 1 in 5,000 years (0.02%). o empirical data exists that could be used to predict such occurrences. But prior to these events occurring, we are provided with return periods and probabilities for how safe and unlikely these ventures are purported to be.

The Black Swan Event

Kinder Morgan's risk analysis relies on statistical probabilities that attempt to predict rare but potentially catastrophic events. Such events are known as Black Swans. 'Black Swan' occurrences are highly improbable events with three principal characteristics. They are unpredictable, carry a massive impact, and, after the fact, explanations are fabricated to make them appear less random and more predictable than they actually are (Taleb 2007).

In theory, making accurate predictions of future occurrences requires a longer period of observation—perhaps three times longer—than that being forecasted (Taleb 2008). Accordingly, in order for Kinder Morgan to make reliable predictions for a suggested 2,366 year return period (for a large oil spill), 7,098 years of historic shipping data would be required.

What is the Probability of an Oil Spill in the Salish Sea?

The Canadian portion of the Salish Sea ranks in Canada's highest risk category for accidents. Based on current traffic volumes on the Pacific coast, the Canadian Federal Government's 2013 national marine spill risk assessment estimates an 800 year return period for a large spill of crude oil,[1] 272 years for a medium spill of a refined oil,[2] and only 23 years for a medium spill of fuel oil (Transport Canada 2013).

What is a Return Period?

The probability of an oil spill occurring is calculated by oil companies using a 'return period'. A 100-year return period for an oil spill has a **1% chance of occurring each year** or a probability of 0.01 (a probability of 1 being certain). A 100-year return period does not mean one event every 100 years. An event can occur on the inaugural voyage, more than once, or not at all throughout these periods.

The Return Period of a Spill

Kinder Morgan's application to the NEB identifies return periods for various scenarios, which represent "credible worst case" scenarios. True worst case scenarios, like a shipping collision at Turn Point in Boundary Pass, are not considered. Even assuming Kinder Morgan's projections are accurate (which we do not), the Trans Mountain expansion would significantly increase the likelihood of a spill in the Salish Sea (Table 7.2)

More Traffic—More Risk

Many shipping expansions are proposed for the Salish Sea. These include Delta Port and Terminal Two on Roberts Bank, plus coal, jet fuel and at least three LNG terminal proposals. All of these projects increase the potential for accidents through increased vessel traffic and the large volumes of oil they carry as fuel.

Against a 2010 baseline, an assessment of vessel traffic risk (VTRA) undertaken by the Puget Sound Partnership (Van Dorp and Merrick 2014) considered the impact of the Kinder Morgan expansion, Delta Port expansion, and Gateway Pacific expansion at Cherry Point (US) in terms of the volume of oil carried and the frequency and duration of vessel transits. The Kinder Morgan proposal increased predicted accident frequency by 5% and potential oil loss by 18%. When combined, these three pro-

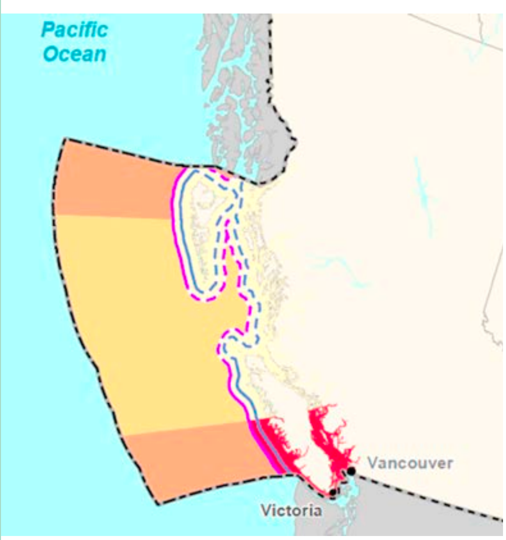


Figure 7.1 Transport Canada's relative environmental risk index for a crude oil spill shows the Salish Sea as a very high-risk area (red) based on the existing level of traffic. Notably, this level of risk does not include significant increases in traffic from proposed expansions at Kinder Morgan, Delta Port, Roberts Bank, Fraser Surrey Docks, and the Discovery, Wood Fibre and WesPac Tilbery LNG developments (map: Transport Canada 2013).

1 > 63,000 barrels

2 6,300–63,000 barrels

posals increase accident frequency and potential oil loss by 36% and 68%, respectively.

Kinder Morgan Fails to Evaluate Risk

Kinder Morgan's application to the NEB lacks a proper risk assessment and is inadequate for conveying the risk from marine oil spills. Although their spill modeling is more advanced than scenarios submitted by Enbridge (for the Northern Gateway proposal), the faults follow a similar pattern.

Critical aspects of the assessment are based on very limited biological information (i.e. they lack species abundance and distribution)—a crucial component of a risk assessment. In addition, many of the assumptions, methods, and analyses lack scientific rigor. Consequently, the results, conclusions, and recommendations are fraught with an unacceptable degree of uncertainty and are not supported by the information presented or the broader scientific literature.

Scenario	Oil Spill Volume (m3 / bbl.)	Return Period
2018 Baseline oil spill risk without TMX or improved safety measures		
Credible worst case	16,500 m3/104,000 bbl.	1 in 3,083 years
Any spill	> 0 m3/0 bbl.	1 in 309 years
Risk of oil spill from TMX traffic[1] without additional safety measures		
Credible worst case	16,500 m3/104,000 bbl.	1 in 456
Any spill	> 0 m3/0 bbl.	1 in 46
Risk of oil spill from TMX oil traffic with additional safety measures		
Credible worst case	16,500 m3/104,000 bbl.	1 in 2,366 years
Any spill	> 0 m3/0 bbl.	1 in 237 years

Table 7. 2 Kinder Morgan's predicted oil spill return periods with and without their Trans Mountain Expansion (TMX) project, and with and without additional safety measures (source: Kinder Morgan 2013).

1 > 63,000 BARRELS

2 6,300–63,000 BARRELS

Freighters in English Bay.

PHOTO: W. LEIDENFROST

"Trust Us" is Not Good Enough

The data and methods that Kinder Morgan used to estimate spill probabilities are considered proprietary and unavailable for independent review. Requests for information by Raincoast and others via the NEB hearing process have been denied (Kinder Morgan 2015),[3] and the hearing process itself omitted cross-examination of evidence. In addition, a key component of the assessment known as TERMPOL[4], a voluntary review of shipping safety, remains incomplete.

3 Raincoast NEB Information Request #2 to Kinder Morgan /TransMountain ULC

4 TERMPOL stand for Technical Review Process of Marine Terminal Systems and Trans-shipment Sites.

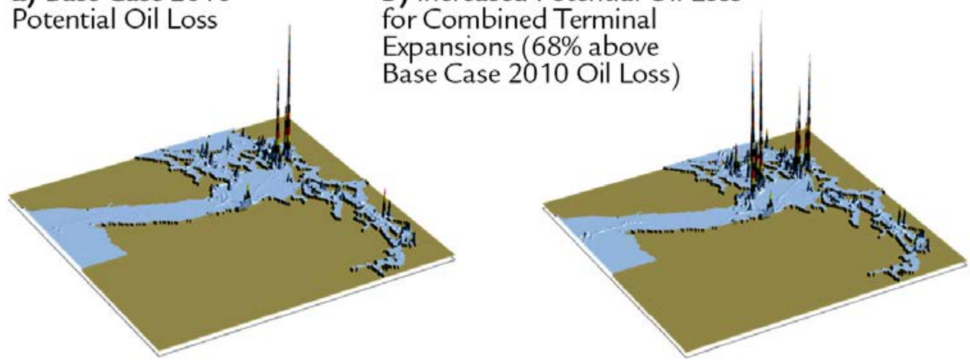
Figure 7.2 a): Potential oil loss in the Salish Sea for base case traffic in 2010; and panel (b): Potential oil loss in the Salish Sea associated with the Kinder Morgan, Pacific Gateway, and Delta Port terminal expansions (Van Dorp and Merrick 2014). b): Does not include risks from increased traffic to Terminal 2 at Roberts Bank, Fraser Surrey docks, Fraser River jet fuel terminal, WesPac-Tilbury, Wood Fibre or Discovery LNG.

Spinning the Roulette Wheel

Each time oil tankers cross through the Salish Sea we spin an imaginary roulette wheel. Kinder Morgan's expansion proposal ups the stakes. An assessment done by analysts at Simon Fraser University indicates this roulette wheel has 90 numbers (Gunton et al. 2015). How many times should we spin the wheel for purported economic benefits, in the hope number 90 never comes in?

A Flawed Assessment of Risk

In assessing Kinder Morgan's proposal[5], internationally renowned oil spill expert Dr. Jeffrey Short concluded that Trans Mountain's Ecological Risk Assessment (ERA) was fundamentally flawed and should not be used to assess the ecosystem risks of the project (Short 2015). His findings include:



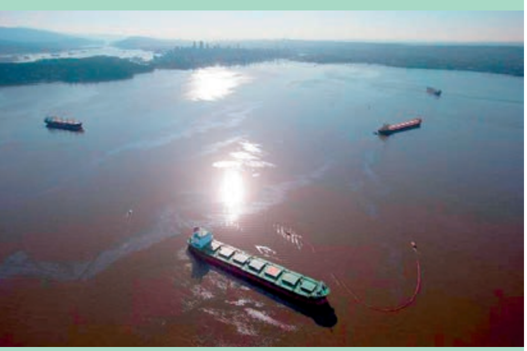
1. The risk assessment only considered spills in a selected number of scenarios. The impact of spills in locations with higher consequences were not considered. This unreasonably eliminated much of the risk.
2. Probability and consequence were confounded. By considering only a select number of oil spill scenarios, Kinder Morgan assumed that species and habitats with a low probability of oil exposure (based on their proximity to a chosen oil spill scenario) had a low sensitivity to the consequences of oil exposure. This flaw alone invalidates Trans Mountain's risk assessment.
3. Kinder Morgan assumes dilbit will not sink or submerge.

Kinder Morgan disregards the impacts of submerged oil on a range of species with commercial and subsistence values such as shellfish, Pacific herring, and salmon. The assumption that dilbit will float is contrary to their own submission, as well as studies and experience that identify the conditions under which dilbit can sink. For example, the presence of freshwater and sediment in both Burrard Inlet and the Fraser River estuary could cause diluted bitumen to sink.

5 On behalf of the City of Vancouver, the Tsleil-Waututh First Nation and Living Oceans Society

For the Birds
Trans Mountain's ecological risk assessment mistakenly claims that shorebirds and birds that wade are not present in large numbers and are widely distributed. In fact, the Fraser River estuary supports some of the highest densities and numbers of these birds within the western hemisphere. Counts of western sandpipers alone—one species of shorebird that uses the Fraser River estuary on its migration—range from 500,000 to one million birds annually (Short 2015).

PHOTO: R. BUTLER



Accidents Happen
Vancouver's Marathassa oil spill occurred on a calm spring day in 2015 on the vessel's maiden voyage. The incident was characterized by major communication and response failings by the Canadian Coast Guard, despite their claims to the contrary.

PHOTO: D. DYCK, CANADIAN PRESS

World-class Spill Response?

A key factor in assessing the consequence of an oil spill is the effectiveness of spill response. The province of British Columbia's latest marine spill response studies (Nuka Research 2013) show that 6 days after a diluted bitumen spill, 56% of the oil would remain on the water, with 13% having dispersed or evaporated and 31% recovered.

The report qualifies the limitations on the oil recovery, including the fact that spill response measures would not be effective in some of the sea states that occur in the Juan de Fuca strait. Perhaps more significantly, the report highlights that diluted bitumen is "poorly understood" and that the model did not account for potential sinking or submergence. Were this to occur, no proven recovery methods exist.

Could Raincoast do a Better Risk Assessment?

Without quantitative data on the distribution and abundance of marine birds and marine mammals in the Salish Sea, a proper and dependable risk assessment cannot be conducted. Although Kinder Morgan has conducted a range of spill scenarios, these are inadequate for decision-making. Simply showing the overlap between a spill scenario and a range of biological or recreational features would better convey the values that are at risk.

An oil spill could occur anywhere along the proposed tanker route as it transits the Salish Sea. This report only considers one spill scenario, Turn Point. Yet, spills could occur in Burrard Inlet, English Bay, the mouth of the Fraser River, or the Strait of Juan de Fuca, one or multiple times.

We have used Kinder Morgan's oil spill modelling from their 2013 application to the NEB to illustrate the probability of a given location being affected by an oil spill. Turn Point is an area with navigational challenges and high vessel traffic.

The Consequence of an Oil Spill—What's at Stake

The Southern Resident Killer Whales

One of region's most valued biological assets are the Southern Resident killer whales. We have overlaid their critical habitat—areas where they hunt, feed and raise their young—with the results of Kinder Morgan's oil spill scenario near Turn Point at the northern end of Haro Strait (Figure 7.3). Kinder Morgan's model is based on fall conditions and only runs for 15 days. Experience from the *Exxon Valdez* oil spill was that oil travelled away from Bligh Reef (accident site) for at least 56 days.

Figure 7.3 shows that a large oil spill near Turn Point has a 95% chance of exposing resident killer whales if they are anywhere near Haro Strait or the eastern end of the Juan de Fuca at the time. There is a 60% chance of surface oiling within a 3,800 km^2 area centered on Haro Strait after a spill at Turn Point. Haro Strait is one of the most routinely travelled areas in the Salish Sea for resident killer whales.

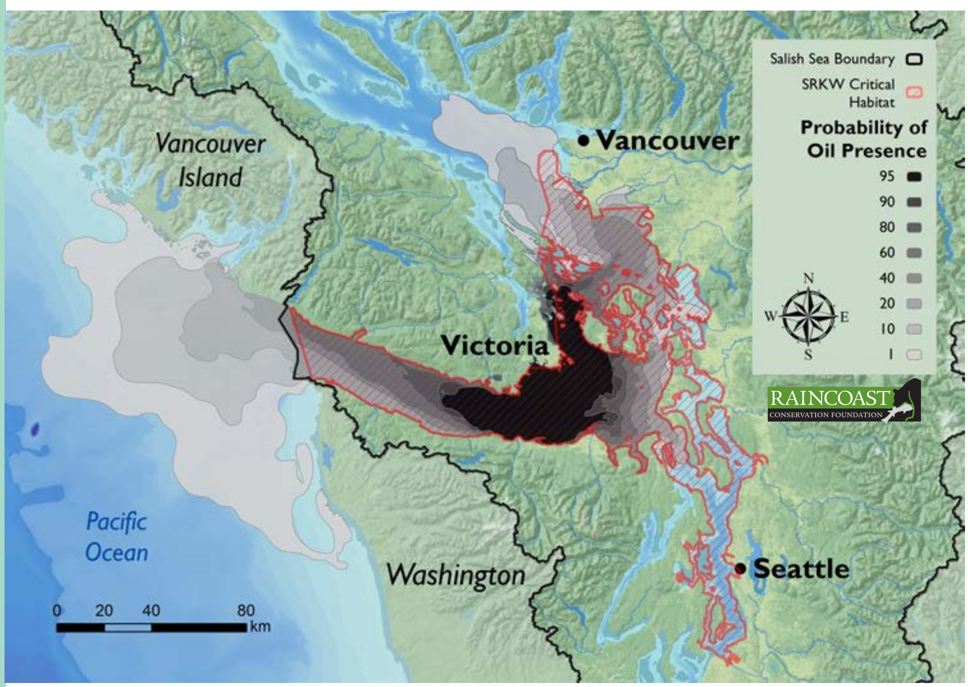


Figure 7.3 Black to grey shading indicates the probability of oil presence within the first 15 days of an oil spill near Turn Point (yellow star) in the fall, according to Kinder Morgan. This scenario is overlaid with the critical habitat for Southern Resident killer whales.

Significant Impact, even without a Spill

Although the threat from oil spills is a large concern, Kinder Morgan's project would have significant adverse affects on Southern Resident killer whales regardless of an oil spill. Even Kinder Morgan acknowledges that the increased underwater noise from its tankers[1] on Southern Resident killer whales "is considered to be high magnitude, high probability and significant" (Kinder Morgan 2013).

PHOTO: S. VEIRS, BEAMREACH

1 And associated vessels; these include escort and assistance tugs, pilot vessels, and potentially tugs and barges.

Table 7.3 Spatial overlap between areas with a probability of oil presence (based on Kinder Morgan's Turn Point oil spill scenario) and the critical habitat of Southern Resident killer whales.

Probability of Oil Presence (%)	Total Overlap Area (km2)	Critical Habitat Impacted (km2)
1	7107	80%
10	6652	75%
20	5985	67%
40	4831	54%
60	3785	43%
80	2687	30%
90	2205	25%
95	1962	22%

Whales Need to Hear and Be Heard

It's not just the direct impacts of an oil spill that can be a problem for the Southern Resident killer whales. Communication space is the area within which a whale can hear and be heard by others. This space decreases with the introduction of human generated sounds, like shipping. Both killer whales and humpback whales have already lost substantial proportions of their communication space in Haro Strait to shipping noise (Williams et al. 2013, Williams et al. 2014). To put this into perspective, a killer whale call that might normally be heard by other whales 8 km away could fill a communication space of 200 km^2. When ships are present, the average area over which this killer whale will be heard shrinks to 75 km^2. At the noisiest times, its call fills only 6 km^2 (AEI 2013, Williams et al. 2013). Reducing a whale's communication space can then require more energy for hunting and communication, or cause a heightened state of alertness (and stress) (AIE 2013).

Oil Spills Leave a Mark on Coastal Tourism

The *Deepwater Horizon* spill provides a recent example of the impact of oil spills on coastal tourism. One-quarter of the people planning to visit Louisiana cancelled or postponed after the spill began (Louisiana Travel 2010). Studies specifically focused on the hospitality industry found that two weeks after the spill began, 35% of regional hotels had cancellations, with 60% four

Turn Down the Volume

The threat to killer whales isn't just from oil spills. Noise from ships reduces the distance at which whales can hear each other. Studies show that killer whales loose more than half of their communication space in the presence of ships, and loose almost all (97%) during heavy traffic (Clark 2015). Singing humpback whales can similarly lose more than half of their communication space under average noise conditions and up to 80% during the noisiest times (Williams et al. 2014).

PHOTO: B. HARVEY

weeks into the spill (Knowland Group 2010). A report by Oxford Economic (2010) estimated the potential economic impact to US coastal economics as $22.7 billion (US) over three years.

After the *Exxon Valdez* spill more than 40% of regional businesses reported significant or complete losses; $19 million in visitor spending was lost in one season (Oxford Economics 2010). Similarly in Spain, Galician tourism was reduced by more than 133 million Euros after the *Prestige* oil spill (Garza-Gil et al. 2005). With regard to Kinder Morgan's Trans Mountain proposal, the City of Vancouver estimated the economic impact of a large oil spill in Vancouver's Burrard Inlet could exceed $2 billion (City of Vancouver, 2015).

Importantly, studies indicate that long-term effects of oil spills on fisheries and related environmental resources can significantly affect associated sectors including tourism. These losses can be greater than direct economic losses, especially for adjacent regions not directly affected by a spill (Sumaila et al. 2012 EVOSTC 2010, Ott 2005).

What Do We Stand to Gain? Economic Myths and Realities

Jobs in the tourism sector employ well over 250,000 BC and Washington State residents and a range of species—including killer whales, other marine mammals and marine birds, are of vital importance to the regional ecotourism economy (see Chapter 4).

The risk presented by Kinder Morgan's oil tanker expansion should be weighed against the purported benefits. Kinder Morgan claims the project will provide 90 permanent jobs upon completion. The project also requires expansion of Alberta's tar sands, an activity heralded as a large boon to the Canadian economy.

The overt support by the Federal Government for the development of the tar sands would suggest that the industry is at the core of the Canadian economy. In reality however, the numbers do not support this—either within BC or at a national level. Based on 2007 data, the tar sands make up only 2% of Canadian

Whale Watching

Our studies indicate a Salish Sea whale watching sector with annual revenues between $17 and $24 million and employing up to 360 people in the summer.

PHOTO: B. HARVEY

Boating

A significant proportion of boat launches (WA) and marinas (BC) fall within the area affected by oil. The extent of a spill would drastically restrict recreational use within the oiled area.

PHOTO: D. STONE, TIMES COLONIST

GDP (CRED 2014) and using 2014 data the entire mining, quarrying, and oil and gas extraction industries employed an estimated 1.7% of the Canadian work force in 2014 (Statistics Canada 2014).

Within BC, over 94,000 Canadian birding visitors and 322,000 US visitors come to the province for the birds (Tourism BC 2009).

Using studies that calculate direct and induced expenditure, the Salish Sea birding sector generates more than $1.3 billion in expenditures and supports more than 24,000 jobs. A single spill scenario indicates that the effects could be devastating.

PHOTO: B. HARVEY

At What Price?

Attaching a dollar value to the damage that spilled oil has on ecosystems is impossible. The monetary cost of the *Exxon Valdez* spill is estimated at US $9.5 billion of which Exxon has paid $3.5 billion; taxpayers paid the remainder. British Petroleum claims to have spent US $14 billion on clean-up and restoration in the first two years following the *Deepwater Horizon* oil spill, but the true costs are unknown. Scientists have speculated that the full environmental consequences will not be understood for decades because the toxic effects from the huge volumes of dispersed oil are presently unknown (Gaskill 2011).

But the question remains: can money truly replace the functional or total loss of a marine species, a productive ecosystem, or the demise of a coastal community's way of life?

From Raincoast's perspective, species and wild places warrant protection, regardless of the utilitarian value that healthy environments provide for people. Nonetheless, values compel us to safeguard species, including humans; all of which depend upon a healthy and ecologically rich environment (Bearzi 2009).

Failure to reconcile ecology and commerce has been a hallmark of domestic and international policy for decades. This is because a fundamental conflict exists between economic growth and conservation (Trauger et al. 2003). As the economy grows, natural capital (such as forests, river banks, soil, and water) is reallocated from wildlife habitat to the human economy. Some believe technological progress may reconcile this conflict, but most technological progress expands the breadth of the human niche and, when primarily in the service of economic growth, only exacerbates the conflict (Czech and Daly 2004).

The concerns we have are not new, nor are the problems that precipitated them. They are, however, a powerful argument in

Surfing

The vast majority of regional surf locations are situated in areas that could be affected by a spill originating at Turn Point.

PHOTO: PACSAFE

Sea Kayaking

The Salish Sea kayaking sector has annual revenues of $20 million, provides 375 year round jobs, and 630 jobs in the summer season.

PHOTO: OCEAN RIVER ADVENTURES

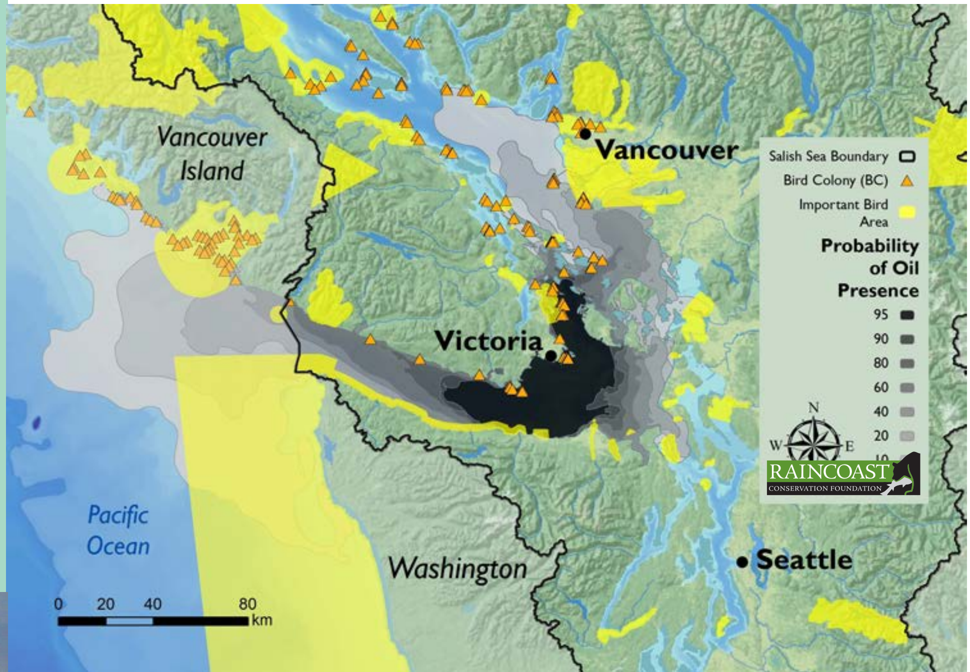


Figure 7.4 Black to grey shading shows the probability of oil presence within the first 15 days of an oil spill accident near Turn Point in the Fall, according to scenarios compiled by Kinder Morgan. This scenario is overlaid with Important Bird Areas and colonies within the Salish Sea.

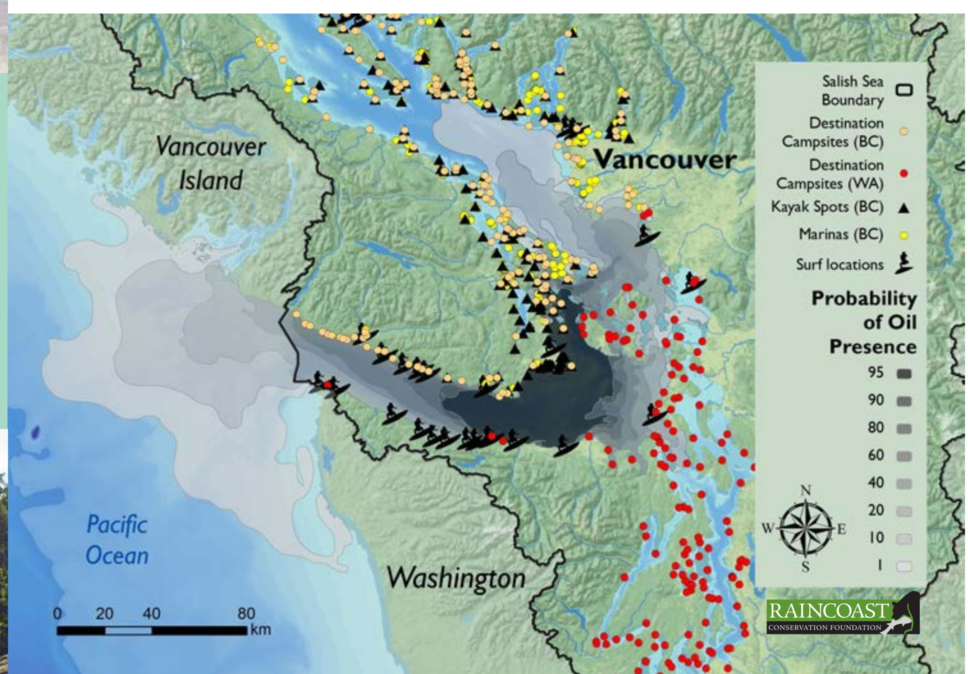


Figure 7.5 Black to grey shading shows the probability of oil presence within the first 15 days of an oil spill near Turn Point in the fall, according to scenarios compiled by Kinder Morgan. This scenario is overlaid with surf locations, kayak landings, coastal camp sites, and marinas.

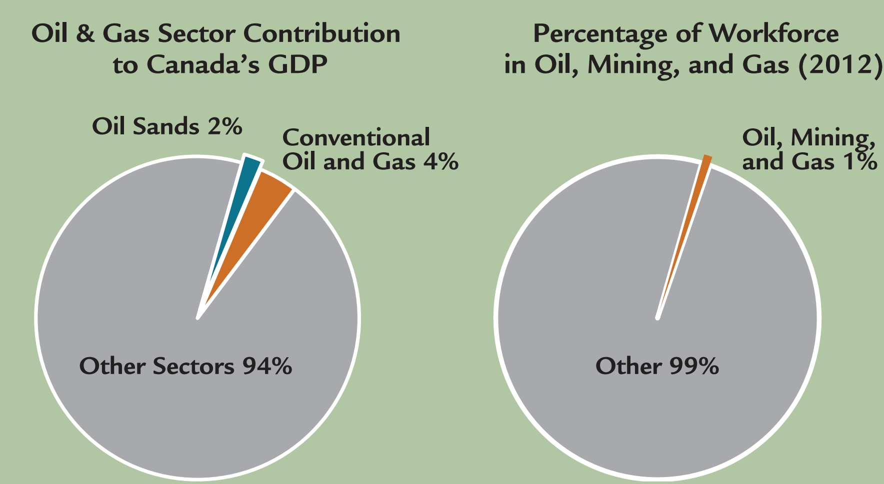


Figure 7.6 a) Using 2007 data, the Canadian oil sands contributed only 2% to national GDP (CRED 2014); **b)** In BC, oil, mining and gas make up 1% of BC's workforce (BC Ministry of Finance 2012).

The Energy Sector and the BC Economy

Contrary to what many believe, the energy sector is not a key driver of the BC economy. Measured in GDP, oil, gas, and support services contributed only 3% of BC's GDP, which is significantly less than financial and real estate (23%), construction, (8%), and manufacturing (7%) (CRED 2014). Measured in jobs, the oil, mining, and gas sector employed only 1% of the BC's workforce in 2012 (BC Ministry of Finance 2012).

favour of a radically different course of action. Solutions to our energy problems are everywhere if we make the collective, individual, and political choices to implement them. In fact, renewable energy alternatives (primarily sun and wind) are coming on line so fast they have grossly outstripped the International Energy Agency's (IEA) predictions for the amount of gigawatt power that would be generated by renewables to date (Boyd 2015). In fact, China alone is now adding more solar-based electricity every six months than the IEA's predicted 2020 total for the entire world (Boyd 2015).

Opening more doors to these solutions begins with saying 'no' to converting our coast to an energy corridor and being the catalyst for the unbridled exploitation of our land, oceans, freshwater, and climate that accompanies tar sands extraction. From here, other protective and restorative actions can be taken, so the priceless and irreplaceable BC coast can continue its unparalleled evolutionary journey.

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