


COASTAL OCEAN RESEARCH INSTITUTE

OCEANWATCH

Howe Sound Edition | Executive Summary



A group of people, likely from the Squamish Nation, are shown in traditional regalia on a boat. The man in the foreground wears a large feathered headdress and a beaded necklace, holding a drum. Other people in similar regalia are visible behind him. The background shows a body of water and a clear blue sky.

“For the Squamish Nation, geography is at the heart of everything. We are not exaggerating when we say that the mountains, rivers, lakes and ocean have shaped our histories, customs, arts and artisanship. Indeed, the landscape of southwest British Columbia has shaped who we are and the way we live.”

REPRODUCED WITH PERMISSION FROM
“WHERE RIVERS, MOUNTAINS AND PEOPLE MEET”,
SQUAMISH LÍL’WAT CULTURAL CENTRE

Acknowledgements

Many authors, reviewers, and contributors generously shared their special knowledge and photos. Special mention and big thanks go to Bob Turner, who assisted with soliciting, writing, editing, compiling and shaping this report and to photographer Gary Fiegehen, for sharing his spectacular work with us. The Squamish Nation and the David Suzuki Foundation have been dedicated partners in bringing attention to Howe Sound and seeking better information and planning.

PHOTO: GARY FIEGEHEN

Howe Sound

Howe Sound, an inlet of the Salish Sea cut deep into the mountains, is the seaward part of famed Sea to Sky country. The Sound, home and traditional territory of the Skwxwú7mesh Úxwumixw (Squamish Nation), is a place of wild beauty sitting just next door to the busy Vancouver world of two and a half million people.

In the last century, the Sound witnessed rapid industrial development, pollution and significant environmental degradation. Most of the damaging activities have been curtailed and the effects of pollution mitigated.

Now, Howe Sound is showing signs of ecological recovery and rapid growth and development. Recent observations of herring and anchovies, dolphins, whales, and some salmon species are promising. In parallel with this environmental recovery has been the rise of citizen science and community-led habitat restoration in an era of declining government capacity. Nature is proving resilient, but as we go forward, we need to foster a stewardship of Howe Sound that shows we have learned from our past mistakes.

The Coastal Ocean Research Institute and Ocean Watch

Keeping our coasts and oceans healthy starts with understanding what is happening. The Coastal Ocean Research Institute (CORI) was established by Ocean Wise® to do just that. Ocean Watch, our new reporting series, delves into what’s happening in our coastal ecosystems through articles organized into seven themes. This Howe Sound Edition is our pilot report.

In the full report, we present a collection of Howe Sound articles contributed by many guest authors and reviewers. We invited scientists behind the global Ocean Health Index to contribute as well. We hope you find this mix of perspectives informative.

In order to provide a visual snapshot summary of all the status information we compiled, we developed and applied a rating scheme to help people understand what is happening at a quick glance. From there you can dive in deeper.

Browse and download the full report at
oceanwatch.ca/howesound

Snapshot Assessment

HEALTHY 1) The status is healthy according to available data, 2) the trend is positive if known, 3) some data are available, and/or 4) actions to address or mitigate are well underway and are known to be effective. Actions should be taken to maintain positive status and/or trend.

CAUTION Status, trend, data, and/or actions provide contradictory or inconclusive information. Actions are needed to move into positive status and trend and avoid negative status and trend.

CRITICAL 1) Impacts or issues are high risk or have resulted in a low or vulnerable status, 2) improvements are uncertain, minor, or slow, and/or 3) actions to address or mitigate are non-existent, vague, or have low effectiveness. Actions are needed to move into positive status and trend.

LIMITED DATA/ NOT RATED Not rated due to the nature of the article, or there are not enough data to produce an assessment.

Species and Habitats		
PLANKTON Limited Data: Plankton levels have not been systematically surveyed since the 1970s.		
FORAGE FISH Limited Data: Despite great efforts to observe and record observations, we lack robust data to assess status and trends.		
SEA STARS Wasting syndrome has affected 20 species with no robust signs of recovery.		
SALMON Populations are low, trends are uncertain, we have little data.		
LINGCOD Lingcod stocks have failed to rebound and threats remain.		
ROCKFISH Rockfish populations do not appear to have rebounded.		
EAGLES Eagle populations fluctuate; recent counts are quite low.		
MARINE BIRDS Several species are far less common than they once were. Count efforts are significant but do not cover the whole Sound.		
CETACEANS Dolphins, whales and porpoise counts are increasing, but compared to historical abundance, numbers are low.		
EELGRASS Vulnerable eelgrass beds face many threats from human activity.		
GLASS SPONGES Efforts to study and protect these vulnerable species are high, but protection is minimal and threats remain.		
SQUAMISH ESTUARY Some vital wildlife habitat has been restored, yet the impact of industry and human intervention will be felt for a long time.		
ANNAPOLIS A healthy diversity of marine species is populating the Annapolis artificial reef.		

Clean Water		
BRITANNIA MINE CONTAMINATION Ongoing remediation efforts have returned aquatic life to the waters around the site, but contamination lingers.		
PULP MILL EFFLUENT Regulations have eliminated new input of pulp mill pollutants, but these toxins are persistent.		
PROBLEM VESSELS The federal Ocean Protection Plan signals welcome movement on this issue, but existing vessels remain unaddressed.		

Sense of Place and Wellbeing		
CULTURAL CONTINUITY Not Rated: Assessment is not appropriate due to the nature of the subject.		
CITIZEN SCIENCE Citizen science effort is increasing and contributes to a positive sense of place.		
OUTDOOR LEARNING Opportunities for environmental education abound and outdoor learning provides health benefits with no known negative impacts.		

Coastal Development and Livelihoods		
COASTAL DEVELOPMENT Population growth and increasing development put pressure on coastal areas and highlight the need to track and manage growth.		
LARGE VESSEL TRAFFIC Expected increases in shipping traffic may lead to conflict with other boats and marine life. Monitoring will inform solutions.		
TOURISM AND RECREATION An influx of tourist activity presents the need to balance economic benefits with environmental risks.		

Stewardship and Governance		
SQUAMISH NATION STEWARDSHIP Not Rated: Assessment is not appropriate due to the nature of the subject.		
MARINE PROTECTED AREAS Less than one percent is protected under provincial legislation. Interest is high and efforts are ongoing.		
COMPREHENSIVE PLANNING Efforts continue to be hampered on several fronts. The Sound remains vulnerable without coordinated action.		

Oceanography and Climate Change



OCEAN WARMING

Warming waters can mean major ecological change and lack of local data causes some uncertainty.



SHORELINES

Armouring of shorelines puts homes, businesses and ecosystems at risk. The Green Shores approach can be useful.



STREAM FLOWS

Changes in seasonal stream flow patterns are evident (in limited data) and signal risks to aquatic species and human settlements.



SQUAMISH FLOOD PLANNING

Rising sea levels are expected to increase the threat of flooding. The risks are significant despite much planning and mitigation.



Seafood



SPORT FISHING

Growing interest in angling generates great economic benefit and adds to the pressure on vulnerable fish stocks.



PRAWN AND SHRIMP FISHERIES

Celebrated as sustainable and economically valuable, this industry is not without environmental impact.



Ocean Health Index Scores for Howe Sound

BIODIVERSITY

68 out of 100; a score that combines an 80 for species and a 56 for habitats.

68

SENSE OF PLACE

58 out of 100; a score that combines a 70 for iconic species and a 45 for lasting special places.

58

COASTAL PROTECTION

73 out of 100, measured by the condition of salt marshes and coastal forests that provide protection to natural and human environments.

73

CARBON STORAGE

70 out of 100, measured by the condition of carbon storing habitats including salt marshes and coastal forests.

70



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LIMITED DATA/NOT RATED Not rated due to the nature of the article, or there are not enough data to produce an assessment.

Catch of the Day

Strait of Georgia, 1930s

3

two-hour drags
for fish in sandy
bottom habitat

1

half-hour drag
for crab in
shallow water



2,500

pounds
of sole



1,800

prime crabs



800

pounds of
flounder



500

pounds of
skate wings



150

pounds of
lingcod



120

pounds of
halibut



100

pounds of
rock cod



100

pounds of
silver perch



50

pounds of
red snapper



40

pounds of
red squid



3

large springs
(~20 pounds ea.)

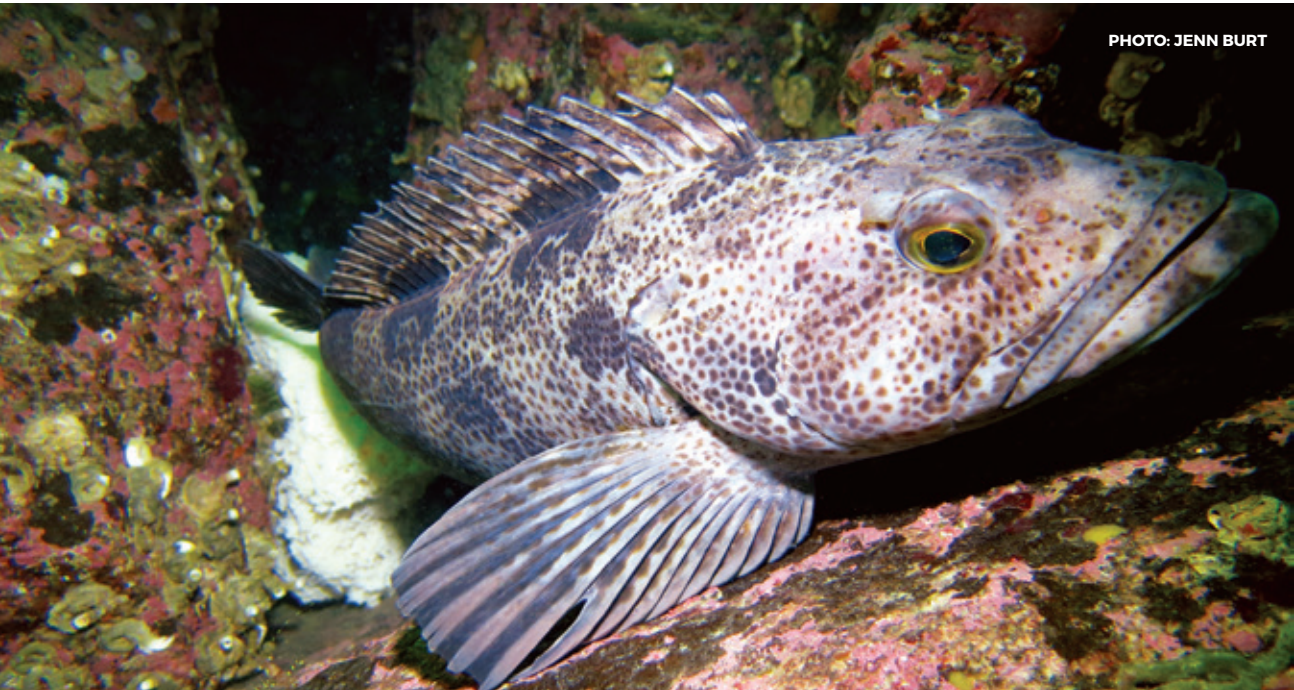


3

octopi
(~20 pounds ea.)

As related by Norman Safarik in his book, "Bluebacks and Silver Brights: A Lifetime in the B.C. Fisheries from Bounty to Plunder," ECW Press

Risks of Coastal Development



Key Issues and Action Plan

Through the broad range of topics explored in the report you will find evidence that Howe Sound is recovering from past industrial impacts, experiencing rapid growth and development, and facing emerging global ocean issues, such as climate change. You will also find many specific issues that need to be addressed. Here, we highlight some common issues across all themes that are influencing the state of Howe Sound coastal ecosystems and propose an action plan in response.

Key Issues

- Valuable habitat has been lost in areas affected by industrialization, some contamination introduced in past decades still lingers, and many sensitive habitats remain unprotected.
- Growth in population, commercial and residential development, and even tourism are outpacing the capacity to manage the growth.
- Popular outdoor learning, tourism, recreation, and cultural continuity, which contribute to human wellbeing, depend upon a healthy environment. All are at risk due to increasing activity and development.
- There are limited baseline data to properly assess the status of many ecosystem components, pressures, and drivers. Data from past and existing research and monitoring are often not readily accessible. Baseline data are needed to further assess impacts and changes, including cumulative effects.
- Science and monitoring activities (including citizen science) are not connected to each other or to a larger set of research priorities, and significant research gaps exist.
- Limited monitoring and enforcement means that regulations are often ineffective at achieving objectives such as conservation, safety, and security.
- Many risks (flooding, drought, coastal squeeze), threats to sensitive habitats, and best stewardship practices are not widely acknowledged and understood.
- Marine activities in Howe Sound are currently managed by more than ten different government bodies. Yet no one is looking at the overall picture of what is happening, including the combined (cumulative) effects of all the activities and stressors in the area. Coordinated, comprehensive information and planning does not exist.
- Further reconciliation is needed with First Nations in order for communities, governments, and businesses to move forward with greater clarity and wellbeing.
- A variety of groups are engaged in different issues, agendas, and locations, but there is no uniting initiative that focuses people on working together to solve current and emerging challenges.

Action Plan

The full Report includes many actions needed on specific issues. The following Action Plan includes items that were common across many of the themes and articles in the Report. If implemented, these actions can boost the assessment ratings for Howe Sound.

This Action Plan will need to be accompanied by an Implementation Plan that outlines specific activities, partners, resources, and timelines in the next two years to accelerate recovery and continued abundance in Howe Sound.

Action 1

Create a Marine Guide that brings together information about the area.

1. Identify areas of significant ecological and/or human value, and create recommendations related to their use.

2. Serve as a unified information source for planning and decisions by all levels of government (e.g., marine use planning, new tenure placement, foreshore development, protected area planning, oil-spill response planning, hazard planning and management, cultural sites, etc.) while respecting their jurisdictions.
3. Provide a platform for sharing monitoring and model results (e.g., contamination levels, models of potential climate change impacts, etc.).

4. Provide best practices and resources for businesses, residents and managers in protecting significant values (e.g., protecting marine mammals, eagle nests, functioning shoreline habitat, etc.).

Action 2

Protect and restore priority marine species, habitats, and functions.ⁱ

1. Increase the proportion of area protected,^{i,ii} with an immediate focus on protecting glass sponge reefs, beach spawning habitat, water flow, important bird areas, and wildlife management areas.ⁱⁱⁱ

2. Establish a restoration strategy and fund^d with an immediate focus on salmon, forage fish, estuary habitat, and eelgrass.
3. Remove existing wrecked and abandoned vessels and prevent problem vessels.^l

4. Reduce entry of pollutants into marine environment (e.g., harmful chemicals and minerals, plastics and microplastics, wastewater, and hydrocarbons).ⁱⁱ

Action 3

Track the status and trends of key indicators using science, traditional knowledge, and citizen engagement.

1. Identify priority values and indicators.

2. Where possible identify targets.

3. Identify methods and partners to collect data, including a citizen science portal.

4. Gather new or existing data on the state of key indicators (e.g., volume, location and timing of marine vessel traffic and marine traffic incidents).

5. Analyze results and, where possible, correlate ecosystem changes with changes in pressures on the values and indicators.
6. Inform a cumulative effects analysis.^{l, iii, iv}

7. Inform management and recovery strategies for predators with improved information on the status of prey species.

8. Inform actions, policies and regulations on key subjects, such as better response to local marine traffic issues.^l

9. Ensure data are available and easy to access via the internet.

10. Link data and results to the 'Marine Guide' outlined above so that they can be georeferenced and quickly found on a single map platform.

Action 4

Develop a Howe Sound marine use plan.^{iii,v}

1. Build on the Squamish Nation's land use plan for the upper watersheds, Xay Temixw – Sacred Land, by incorporating plans for the marine environment and stream catchments to the mouth of Howe Sound.^v

2. Protect Wild Spirit Places and heritage, traditional use, sacred, and cultural sites.ⁱⁱ
3. Working through existing authorities, set targets and boundaries that balance and protect different values.

4. Address the cumulative impacts of activities and pressures in Howe Sound.^{i,iii,iv}

Action 5

Increase awareness, education, and the practice of stewardship.ⁱⁱ

1. Increase appreciation for and connection to nature and First Nations spiritual and cultural heritage.ⁱⁱ

2. Work with outdoor educators, youth camps, and tourism businesses to introduce and connect people to the area and its values, including getting Squamish Nation members into their traditional territory for health, education, recreation, spiritual, and cultural purposes.ⁱⁱ
3. Enable people to understand and share information about proper wildlife viewing ethics, proper angling techniques, effective poaching reporting, and relevant regulations.

4. Enable people to understand and share information about emerging climate related threats (e.g., coastal flooding, landslide, drought, coastal squeeze) and marine safety.

Action 6

Improve monitoring and enforcement of regulated activities in order to decrease illegal activity.

1. Explore the use of technology to improve monitoring and enforcement.
2. Explore opportunities for citizens and businesses to work with government agencies with legislative authority (e.g., ranger program).

Action 7

Negotiate co-management arrangements related to marine resources to provide greater understanding and certainty for residents, businesses and managers.^{i,iii}

1. First Nations, governments and businesses continue to develop agreements related to aboriginal rights and title.^{ii,iii}
2. Get Squamish members more involved in resource management.ⁱⁱ

Action Plan Leadership

This Action Plan complements government and other planning processes by identifying a unified set of priorities and opportunities. Federal, provincial, local, First Nations, private, charitable and other entities can use this Plan to highlight commitments and coordinate activities.

The Action Plan should be considered a collective effort to be implemented by diverse partners. To lead the collective effort, it is recommended that Federal, Provincial, First Nations, and local governments:

a) Convene an intergovernmental task force to coordinate government efforts and funding.

b) Accept nominations and appoint a Leadership Team of individuals from government, business, communities, and other sectors that will act cohesively to advance the Action Plan. Team members should have a track record of personal achievement related to the Action Items. The mission of the Leadership Team is to engage citizens, businesses, and governments in developing an implementation plan and achieving measurable results over the next two years.

c) Fund a secretariat to assist the intergovernmental task force and Leadership Team to complete their work.

ⁱ Reflects commitments in the Federal DFO Mandate Letter and Ocean Protection Plan.

ⁱⁱ Reflects commitments in the Squamish Nation's land use plan for the upper watersheds: Xay Temixw – Sacred Land.

ⁱⁱⁱ Reflects Squamish Nations' conditions on the Woodfibre LNG proposal.

^{iv} Reflects commitments in Province of BC's Cumulative Effects Assessment Framework.

^v Reflects Squamish Nation's direction related to a Marine Use Plan.

“In our world, where we come from there is the great circle that we call a medicine wheel. We walk into the future backwards because we are looking to our ancestors. If you are listening to your elders you are learning our traditions and culture. What was given to you is now in your arms. So that sometime in the future you can turn around and give it to your grandchildren. What took place you can give to your children. That is the value of our circle.”

**T'ÉCHUXANM-T SIYÁM (LATE CHIEF JOE MATHIAS),
SQUAMISH NATION**

**Please visit
oceanwatch.ca
to learn more.**

You can browse and download the full report online.

As this is our first report in the Ocean Watch series, we look forward to your questions and suggestions on content and presentation. Our aim is to produce independent, credible, and well-presented information so that you are inspired to make better decisions for nature and people. Creatures large and small face great odds, and need our help. Together we will make a difference to their lives, and in doing so, to ours.

Peter Ross, Ph. D.

VP Research And Executive Director Of Coastal Ocean Research Institute



COASTAL OCEAN
RESEARCH INSTITUTE

OCEANWATCH

Howe Sound Edition

Credits

This Ocean Watch report was prepared by the Coastal Ocean Research Institute. Established by the Vancouver Aquarium Marine Science Centre to measure and monitor the health of coastal ecosystems, the Coastal Ocean Research Institute produces and communicates scientific knowledge and understanding about Canada's West Coast. Please visit oceanwatch.ca for additional content, including an executive summary with key issues and recommended actions.

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Acknowledgements

We would like to thank all of the many authors, reviewers, and contributors who have each generously shared their special knowledge and photos. Special mention and big thanks go to Bob Turner, who assisted with soliciting, writing, editing, compiling and shaping this report and to photographer Gary Fiegehen for sharing his spectacular work with us. We are grateful to the Squamish Nation and the David Suzuki Foundation, who have been dedicated partners in bringing attention to Howe Sound and seeking better information and planning. Our gratitude also goes to the Squamish Líl'wat Cultural Centre, who permitted us to reproduce content from the book "Where Rivers, Mountains, and People Meet."

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Dear Reader,

Do you enjoy going to the beach or being out on the water? Do you love whales, dolphins, and other mammals? Do you enjoy fishing or eating seafood? If so, you probably want to make sure that you can continue to enjoy those opportunities in the future.

Keeping our coasts and oceans healthy starts with understanding what is happening. Unfortunately that isn't as simple as it sounds. There are not any easy measures like blood pressure that doctors use to monitor our health. Further, research and data are often divided by subject, researcher, or institution. No one is responsible for looking at all of the issues, species, and habitats in areas like Howe Sound.

This same problem occurs when it comes to mobilizing action. Dozens of government agencies, businesses, organizations and individuals have responsibility for different decisions and actions, yet no one is responsible for looking after the whole. It would be like having different doctors doing research on different parts of you to answer questions they have, but no one actually looking after your health or coming up with a plan to get better.

The Coastal Ocean Research Institute was established by the Vancouver Aquarium Marine Science Centre to address this problem. CORI was set up to gather and analyze information from diverse sources to produce a picture of what is happening in British Columbia's coastal ocean regions.

Howe Sound is our first reporting region. With past industrial impacts, new development happening quickly, and emerging global ocean issues such as plastic pollution and climate change, many are wondering how it can restore and maintain its ecological values and way of life in the face of big challenges.

But while the obstacles are big, so are the passion, experience, and exceptional ability of people to make a difference. Places like Monterey Bay, California have experienced dramatic recoveries because people became informed, engaged, and connected.

We are very grateful to the many people who are already involved, many of whom have contributed to this report. We are especially grateful to this report's authors and reviewers, and to the Squamish Nation and David Suzuki Foundation, who have been dedicated partners in bringing attention to Howe Sound and seeking better information and planning.

As this is our first report, we look forward to your questions and suggestions on content and presentation. Our aim is to produce independent, credible, and well-presented information so that you are inspired to make better decisions for nature and people. Creatures large and small face great odds, and need our help. Together we will make a difference to their lives, and in doing so, to ours.



ANDREW DAY

Executive Director, Coastal Ocean Research Institute

About Howe Sound

“For the Squamish Nation, geography is at the heart of everything. We are not exaggerating when we say that the mountains, rivers, lakes and ocean have shaped our histories, customs, arts and artisanship. Indeed, the landscape of southwest British Columbia has shaped who we are and the way we live.”

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“WHERE RIVERS, MOUNTAINS AND PEOPLE MEET”,
SQUAMISH LÍL’WAT CULTURAL CENTRE**



Photo: Gary Fiegehen

AUTHOR

Bob Turner, Geoscientist and Citizen
Scientist, Bowen Island, Howe Sound

Howe Sound, an inlet of the Salish Sea cut deep into the mountains, is the seaward part of famed Sea to Sky country. Currently the home and traditional territory of the Squamish Nation, the Sound has been inhabited by indigenous peoples since long before recorded time – for at least 9800 years according to archeological evidence. It is a great gift of natural circumstance that Howe Sound, a place of such wild beauty, survives just next door to the hectic Vancouver world of two and a half million people.

The entire B.C. coast, from Vancouver to Alaska, is an ice-carved fiordland. Howe Sound, like other fiords, is narrow and steep-walled north of Porteau Cove; but to the south it is a broad, island-strewn sound that makes it both more accessible and habitable. The waters of Howe Sound are strongly influenced by the rivers and streams that flow into it; smaller streams to the east and west, but extensive to the north where tributaries of the Squamish River draw from high mountains and glaciers.

Given its proximity to Vancouver, Howe Sound is amazingly wild, with visible and charismatic species including harbour seals, whales, porpoise and dolphins, seabirds and shorebirds, eagles in record setting concentrations, black and grizzly bears, abundant deer, and with the less visible but world famous underwater cloud sponge reefs. Howe Sound is also Vancouver's playground. Squamish fairly considers itself Canada's Outdoor Recreation Capital given its unique combination of climbing, biking, wind sports, hiking, and paddling opportunities. Distributed around its shores are nine marinas and four yacht stations, one of the highest concentrations of summer cottages in coastal B.C., and the largest cluster of summer camps and outdoor education facilities in the Province.

In the last century, the Sound witnessed rapid industrial development, pollution and significant environmental degradation. Most of the damaging activities have been curtailed, effects of pollution mitigated, and natural habitats have been somewhat restored. The industry that remains provides socio-economic benefits and operates with an environmental awareness not present in the past.

Howe Sound is showing signs of recovery. Recent observations of herring, dolphins, whales, and salmon tell us so. In parallel with this environmental recovery has been the rise of community groups to take on the responsibility of citizen science, restoration, and repair in this era of declining government capacity. Nature is proving resilient, but as we go forward, we need to foster a stewardship of Howe Sound that shows we have learned from our past mistakes.



“Howe Sound watersheds provide an estimated annual value of \$800 million to \$4.7 billion in ecosystem services. The natural systems provide residents with food, clean water, a stable climate, protection from natural disasters and a place to relax, recreate and reconnect with nature.”

In addition to watersheds, the marine ecosystem provides an estimated service value between \$100 million and \$2.8 billion (2014 \$Can).

**FROM SOUND INVESTMENT:
MEASURING THE RETURN ON
HOWE SOUND'S ECOSYSTEM ASSETS**

(MICHELLE MOLNAR, 2015, DAVID SUZUKI FOUNDATION)

About this Report

AUTHORS

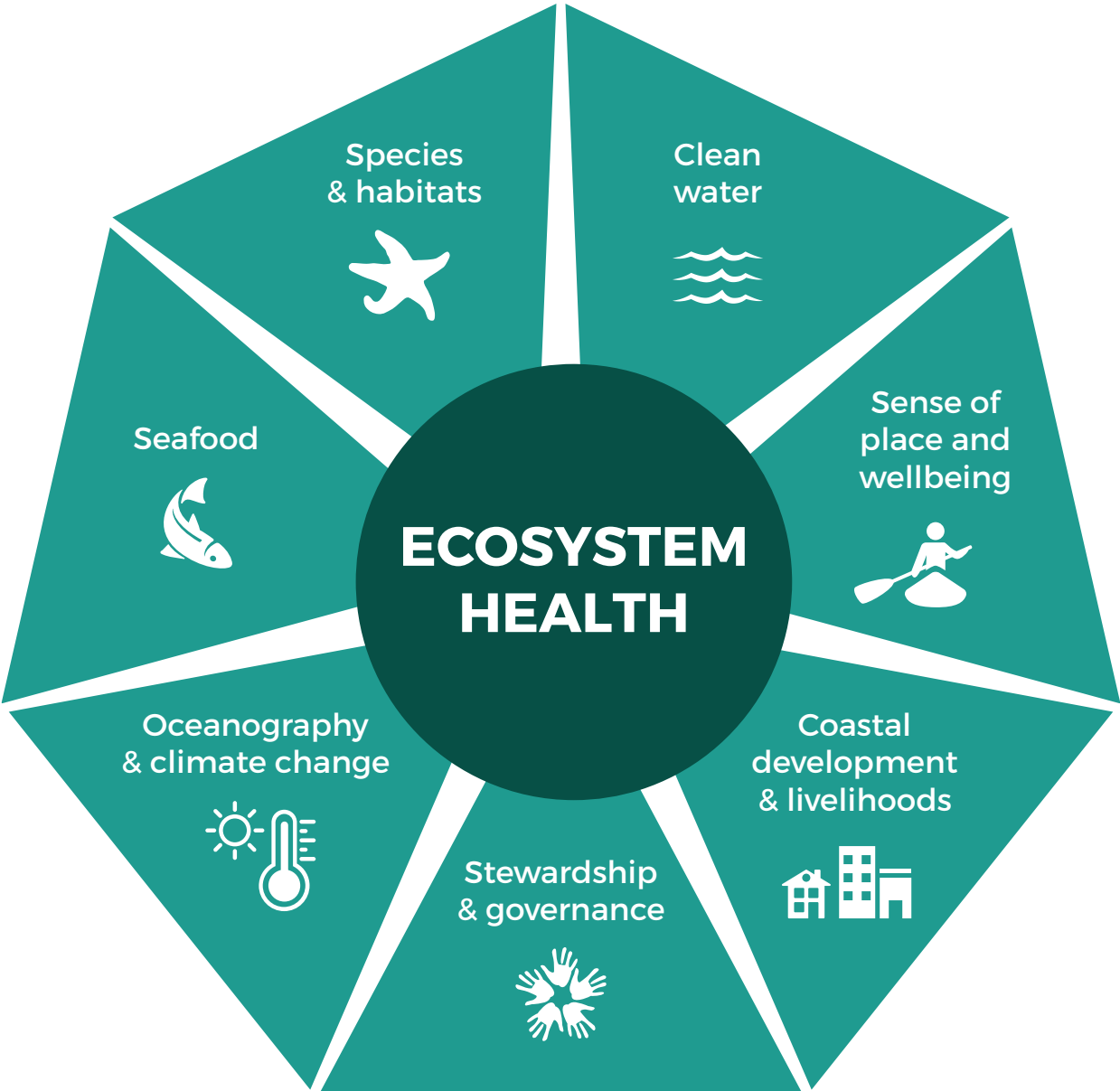
Karin Bodtker, MRM, Manager, Coastal Ocean Health Initiative, Coastal Ocean Research Institute

Based on several years of research focusing on marine ecosystem indicators, CORI identified seven reporting themes for its Ocean Watch series. These themes taken together touch on ecological, socioeconomic, cultural, and governance aspects of ecological health and provide a window to the whole picture of what is happening in an area.

CORI set out to report on the status of coastal ocean health in Howe Sound, having listened and heard the need for such a compilation at Howe Sound Aquatic Forums in 2014 and 2015. These forums brought together First Nations, governments, businesses, community members, and people from many walks of life from around the Sound to share knowledge and discuss opportunities to work together.

The set of articles in each theme represents a collection of topics that were unearthed at the Forums with some additions made when we started soliciting data and information. There are gaps from a technical standpoint, but the topics presented rose to the top in larger community and scientific discussions about issues in the area.




Each article underwent review by an expert in the appropriate field; reviewers are listed by name, with a few exceptions. Due to the limited number of experts related to Howe Sound, we asked reviewers to identify any inaccuracies and unsupported statements rather than undertake a lengthy formal blind peer review process. We welcome comments on the accuracy of the information presented.



In order to provide a snapshot assessment of all the status information we compiled, a rating scheme was developed. The ratings say as much about the need for action related to any topic as they say about the health status overall. Ratings were assigned by CORI staff

based on the authored papers. Authors were asked to review and comment. Due to limited data and expert capacity, it was not possible to undertake a solely quantitative assessment based on defined benchmarks, targets, and reference points.

Ocean Watch Rating Legend

<p>Healthy</p> <p>1) The status is healthy according to available data, 2) the trend is positive if known, 3) some data are available, and/or 4) actions to address or mitigate are well underway and are known to be effective. Actions should be taken to maintain positive status and/or trend.</p>	
<p>Caution</p> <p>Status, trend, data, and/or actions provide contradictory or inconclusive information. Actions are needed to move into positive status and trend and avoid negative status and trend.</p>	
<p>Critical</p> <p>1) Impacts or issues are high risk or have resulted in a low or vulnerable status, 2) improvements are uncertain, minor, or slow, and/or 3) actions to address or mitigate are non-existent, vague, or have low effectiveness. Actions are needed to move into positive status and trend.</p>	
<p>Limited Data/Not Rated</p> <p>Not rated due to the nature of the article, or there are not enough data to produce an assessment.</p>	

Over the past year, as editor of this report, I have had the pleasure of working with a remarkable collection of authors, reviewers, and contributors who have each generously shared their special knowledge. I want to especially thank Bob Turner who assisted me in soliciting, writing, editing, compiling and shaping this report.

To supplement our assessment, we invited the scientists behind the Ocean Health Index to contribute quantitative assessments to parts of this report. You will find three articles that present OHI scores and explanations. We hope you find this additional perspective informative.

What is the Ocean Health Index?

AUTHOR

Courtney Scarborough, Project Scientist, Ocean Health Index

The Ocean Health Index (OHI) is working with B.C. partners over the next year to measure and track ocean health not just within Howe Sound, but across all of British Columbia. Overall, the project aims to address three core questions that inform management of healthy oceans in British Columbia:

1. How do different communities view and value aspects of ocean health, and how does this influence people's understanding of how healthy the ocean is?
2. How can the Ocean Health Index be used to inform and support ongoing comprehensive ocean planning efforts across British Columbia?
3. Have past management actions affected overall ocean health, and if so, in what ways?



Regions within British Columbia included in the full Ocean Health Index assessment to be completed in 2017, plus smaller Howe Sound sub-region designation included in this report.

What aspects of ocean health did the Index measure in Howe Sound?

The Ocean Health Index team worked with members of the Coastal Ocean Research Institute (CORI) to identify aspects of ocean ecosystem health that could be further informed by quantitative information provided by the Ocean Health Index.

We have added three articles that provide quantitative information about the following Themes to help tell the full story of ocean health in Howe Sound:

CORI THEME	OHI GOAL
Sense of Place and Wellbeing	Sense of Place
Oceanography and Climate Change	Coastal Protection and Carbon Storage
Species and Habitats	Biodiversity

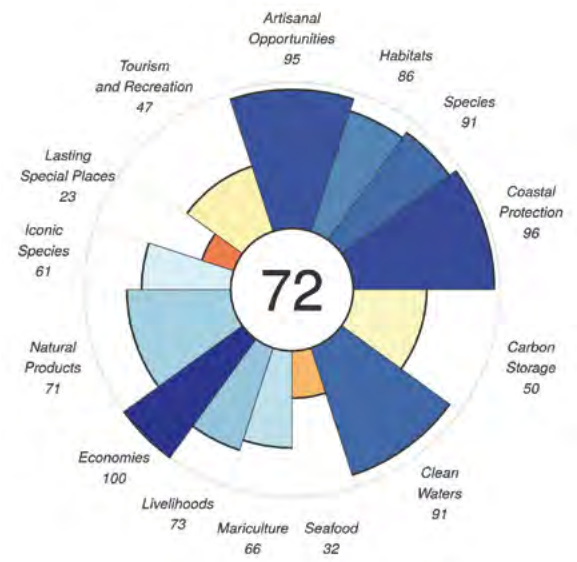
How is the Ocean Health Index calculated?

Ocean Health Index scores are calculated separately for each goal people have for healthy oceans and then combined to get an overall score on a scale of 0–100. Goal scores are represented by the length of the petals in a flower plot, and the overall score is in the center.

To learn more about calculating the Index and other regional assessments that have been conducted please visit:

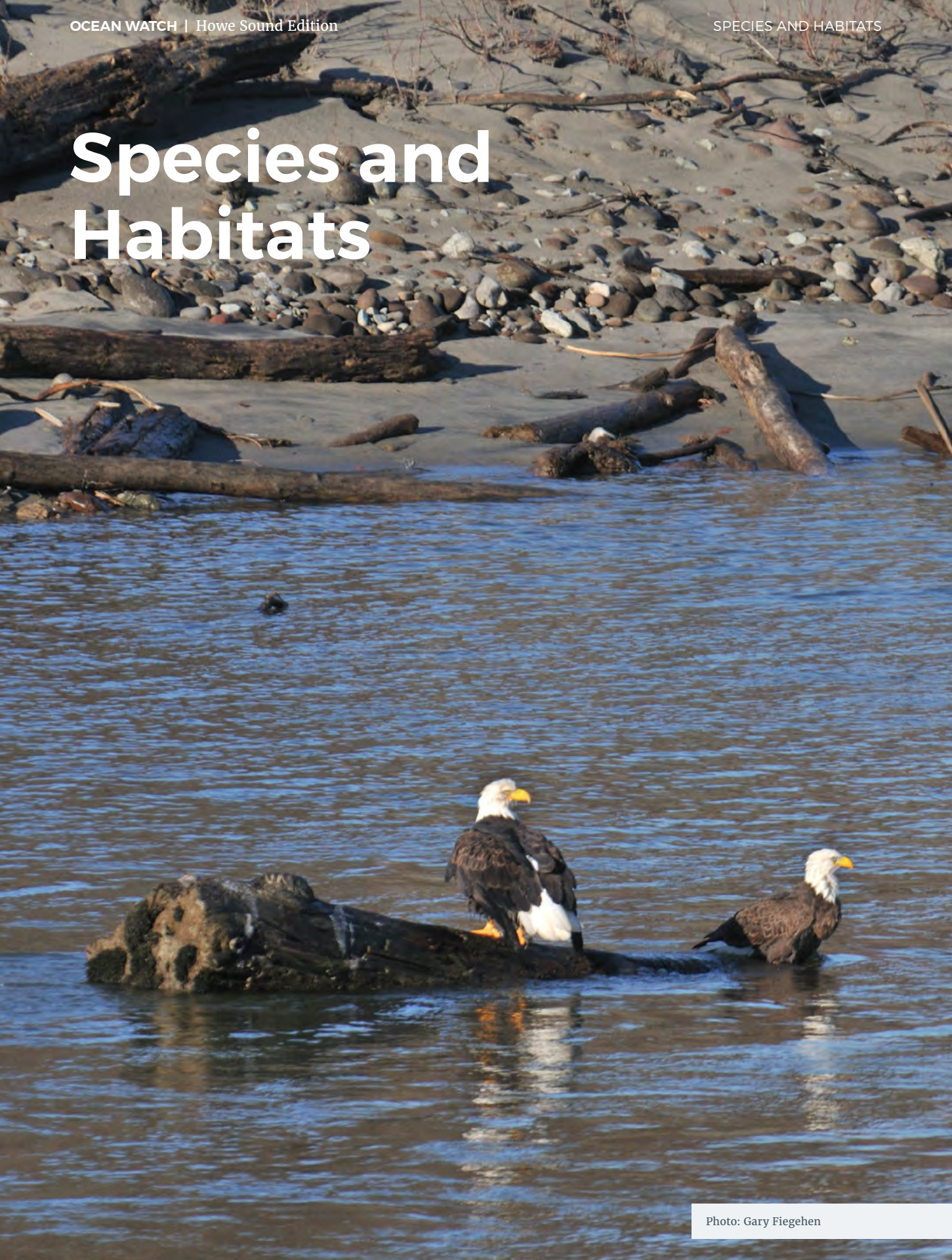
OceanHealthIndex.org

OHI-Science.org



This flower plot shows scores from the 2016 global assessment, where all of Canada's oceans were assessed together. By incorporating local information, our work will evaluate ocean health at a finer resolution with goals tailored to the region, providing scores for all of the sub-provincial regions in B.C. For the Howe Sound report a sub-set of these goals were used to assess ocean health.

Species and Habitats



Summary

The return of whales, dolphins and porpoises to the waters of Howe Sound after a near 100-year absence is a huge victory for conservation efforts. Once devastated by commercial whaling, hunting, and the effects of industrial activities such as mining, logging and pulp and paper production, Howe Sound has seen a resurgence of cetaceans, including orcas, humpback whales and porpoises. Increasing sightings of these and other iconic animals, such as herring and other forage fish, suggest remediation efforts in the Sound have had some success in restoring the health of coastal habitat.

Yet the status of other species is more uncertain.

While pink salmon have had record runs in recent years, other salmonids are showing signs of struggle recovering to previous abundance. Nearly two decades after the lingcod fishery was closed, numbers of spawning females have failed to rebound significantly. And a mysterious wasting disease afflicting sea stars throughout the Pacific Northwest, including Howe Sound, has caused ripples through the ecosystem.

The variation in the health of different species that call Howe Sound home shows the picture we have of our complex coastal ecosystems is far from complete. As the region faces unprecedented change from a shifting climate, increased human activity, and even conservation efforts, more needs to be done to track the health of the area's wild inhabitants, from the cetaceans at the top of the food chain to the tiniest organisms that form the basis for all aquatic life.

Species and Habitats Snapshot Assessment

Plankton

Plankton are the tiniest and most important organisms in the Sound since they form the basis of the food chain and are crucial for all life in Howe Sound. Unfortunately, their levels have not been surveyed since the 1970s. Although the recovery of whales in the Sound suggests that plankton populations have improved, regular monitoring is needed to track the abundance and productivity of these organisms.



LIMITED DATA

Forage fish

Despite recent efforts to observe and report observations of herring, anchovy, and even species like dolphins that prey on these fish, we lack robust data that would allow us to assess the status of forage fish.



LIMITED DATA

Sea stars

A mysterious condition leading to the death of large numbers of sea stars of various species throughout the Pacific Northwest continues to confound the scientific community and could potentially have huge impacts on the marine food web in Howe Sound. The sunflower star, a keystone species, shows no robust signs of recovery.



CRITICAL

Salmon

While one species of salmon thrived in recent years, others remain in reduced abundance as we see variations in ocean conditions, changing patterns in stream flows, rising water temperatures and other effects of human activity and climate change. Populations are low, trends are uncertain, we have few data, but some positive actions are being taken.



CRITICAL

Lingcod

Despite the closure of commercial fisheries in the 1990s, lingcod stocks have failed to rebound significantly in Howe Sound. Researchers and citizen scientists continue to monitor populations carefully through annual egg mass surveys, but threats remain.



Rockfish

Rockfish populations in Howe Sound do not appear to have rebounded since fishing restrictions and conservation areas were introduced. More research and longer-term data are needed to determine whether protected areas have been correctly placed and will have a lasting impact.



Eagles

Eagle counts in Squamish and Lower Howe Sound show numbers have rebounded since a low point in the 1970s and 1980s, but eagle populations continue to fluctuate based on available food sources and recent counts are quite low. The local trend is concerning, but elsewhere eagles are abundant and counting efforts are robust.



Marine Birds

One of the most common sights along Howe Sound, several species of marine birds are far less common in coastal areas than they once were. Bird count efforts are significant but do not cover the whole Sound.



Cetaceans

Dolphins, whales and porpoises have made a triumphant return to Howe Sound after a near 100-year absence, suggesting remediation efforts have been successful in combating the polluting effects of industrial activity. Citizen reporting continues to be a crucial tool in monitoring cetacean populations in the Sound. Still, compared to our impressions of historical abundance, cetacean numbers are low.



Eelgrass

A crucial part of our underwater ecosystems, eelgrass beds face threats from human activity such as docks, boat moorings, log booms and coastal erosion. Efforts need to be stepped up to map, track, and re-colonize these underwater meadows.



CRITICAL

Glass Sponges

Once thought extinct, the discovery of glass sponge reefs in Howe Sound has spurred a flurry of interest in these ancient organisms. Efforts from citizen scientists, divers and researchers have been instrumental in expanding protected marine areas to safeguard this critical fish habitat. Threats remain and research and advocacy efforts are high.



CAUTION

Squamish Estuary

Two decades of revitalization efforts have returned large areas of the Squamish Estuary to a vital wildlife habitat and reversed the effects of human activity and industry. Yet the impact of industry and human intervention will be felt for a long time in this valuable aquatic area.



CRITICAL



CAUTION

Annapolis

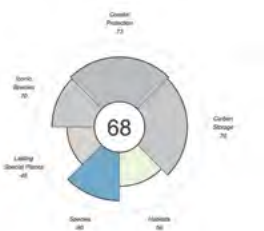
In April 2015, a decommissioned naval ship sunk off of Gambier Island became B.C.'s newest artificial reef. More than a year later, marine species are populating the Annapolis, bringing new life to an area of Howe Sound once devastated by the logging industry.



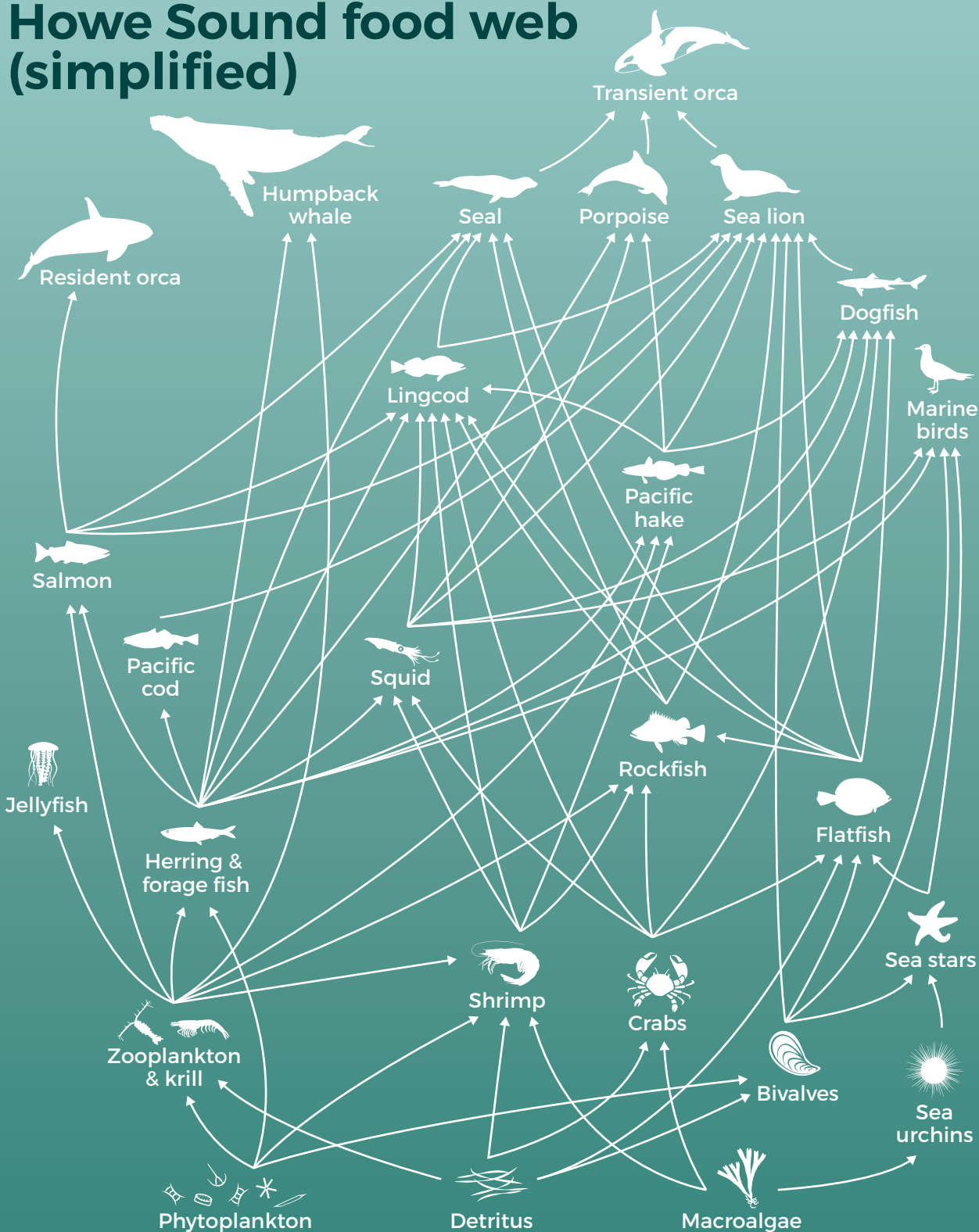
HEALTHY

Ocean Health Index score for Biodiversity

Howe Sound scores 68 out of 100 for biodiversity; a score that combines an 80 for species and a 56 for habitats. A healthy ocean provides a diversity of healthy marine species, habitats, and landscapes.



Howe Sound food web (simplified)



Plankton – What do we know about the bottom of the aquatic food chain?

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REVIEWER

Stephanie King, Sea This Consulting,
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What's happening with plankton?

Chances are with other changes occurring in Howe Sound, plankton, the tiny organisms at the base of the food chain, may be changing too. The problem is we don't know what's happening because no one is currently doing any research in this area. The last time any extensive plankton surveys were undertaken in Howe Sound was in the 1970s, so we currently have no data to tell us if there have been any changes in plankton biomass and the timing of their cycles. We can observe phytoplankton blooms remotely by sensing water colour using a satellite sensor such as MERIS (Figure 1), with its 300 meter spatial resolution, but this sensor is no longer in operation. Early in 2016, the European Space Agency launched the OLCI sensor onboard the Sentinel-3 satellite, which has the same resolution and data will be available soon.¹

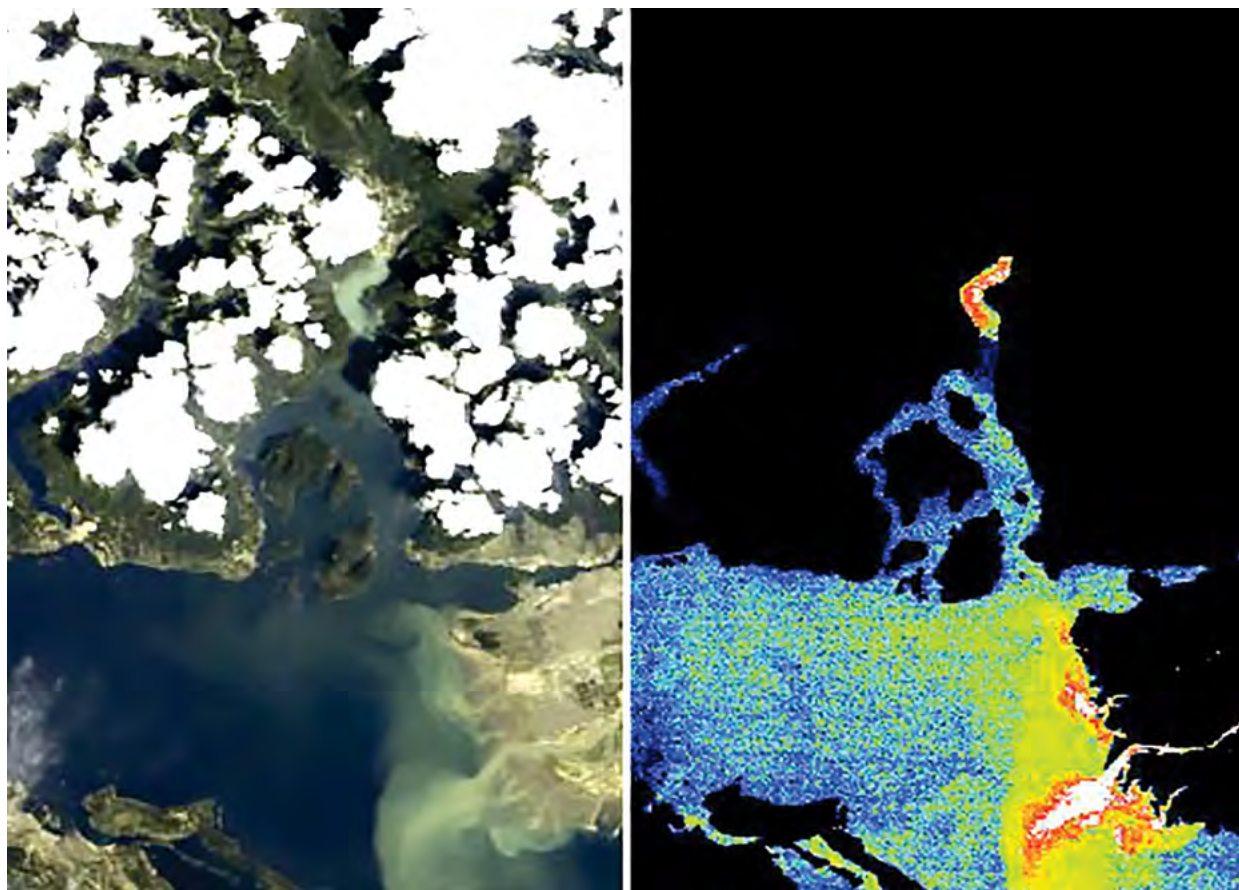


Figure 1. Full resolution (300 m) MERIS images of Howe Sound. The true colour image (left) shows high sediment levels at the head of the Sound and at the mouth of the Fraser River, while the fluorescence signal (right) gives an indication of different levels of chlorophyll (Chl) in Howe Sound. Red indicates high Chl, blue indicates very low Chl, while orange and green indicate intermediate values. The apparent high levels of Chl at the head of the Sound and near the mouth of the Fraser River are a false signal caused by high suspended sediment. (Image data provided by the European Space Agency and processed by S. King, Sea This Consulting.)

What are plankton and why are they important?

Phytoplankton (i.e., plant plankton) are microalgae and they are the main primary producers of food in the sea (the 'grass of the sea'). They combine carbon dioxide, nutrients, and sunlight via the process of photosynthesis to produce organic carbon and provide food for the animals in the food chain. They can 'bloom' and increase their biomass by 1,000-fold during spring, when conditions are just right (high nutrients, good light and little wind). Zooplankton (i.e.,

animal plankton) range in size from microscopic to a few millimetres. They are the 'insects of the sea' and are the main grazers of phytoplankton, and then small fish and invertebrates feed on the zooplankton and so on up the food chain. Without plankton, the food web of Howe Sound would collapse. Forage fish such as herring, sandlance and smelt would disappear, as would the salmon, dolphins and humpback whales that eat the great schools of these small fish.

Are there any known cultural connections by First Nations to plankton?

Phytoplankton are very small and cannot be seen with the naked eye unless they are in a colonial stage, form surface blooms (e.g., red tides) or produce bioluminescence. Therefore, it is less likely that cultural connections were made to these organisms, unlike with several larger iconic animals. However there is no

doubt about First Nations' very strong connections to eelgrass, *Enteromorpha* (seaweed, sea lettuce), *Rhizoclonium* (green alga – a cladophora), kelp and other macrophytes located within the shallower waters of the Squamish River estuary.²

What is the current state of plankton health?

The current state of the health of plankton is unknown. In the 1970s, John Stockner, Colin Levings, and others from Department of Fisheries and Oceans (DFO) West Vancouver Laboratory began a three-year extensive bio-oceanographic survey to provide a better understanding of plankton and their distribution and production at multiple stations throughout Howe Sound (Figure 2). Their studies revealed information on the dominant species of phytoplankton, timing and production levels of the spring phytoplankton bloom, and some data on zooplankton. Changes in the timing of this spring phytoplankton bloom due to warmer surface waters (earlier bloom) or too much wind (later bloom) could produce a timing mismatch and may impact the growth and survival of zooplankton if they arrive before the phytoplankton bloom (too early) or well after the bloom (too late).

A bloom of phytoplankton in Howe Sound can be seen in satellite images, provided the area is not cloud covered and the bloom is near the surface. The timing of the spring bloom in the mid- to outer sectors of the Sound varies from year to year, usually between April and early May and is mainly dependent upon sunlight and very light winds to produce a calm surface layer that provides sufficient light for phytoplankton growth. The inner sector (Zone 1) blooms later due to turbidity from the river. This is similar to the Strait of Georgia where the onset of the spring bloom is dependent on sunny calm weather for several days and not dependent on surface water temperature nor the Fraser River discharge.^{4,5,6}

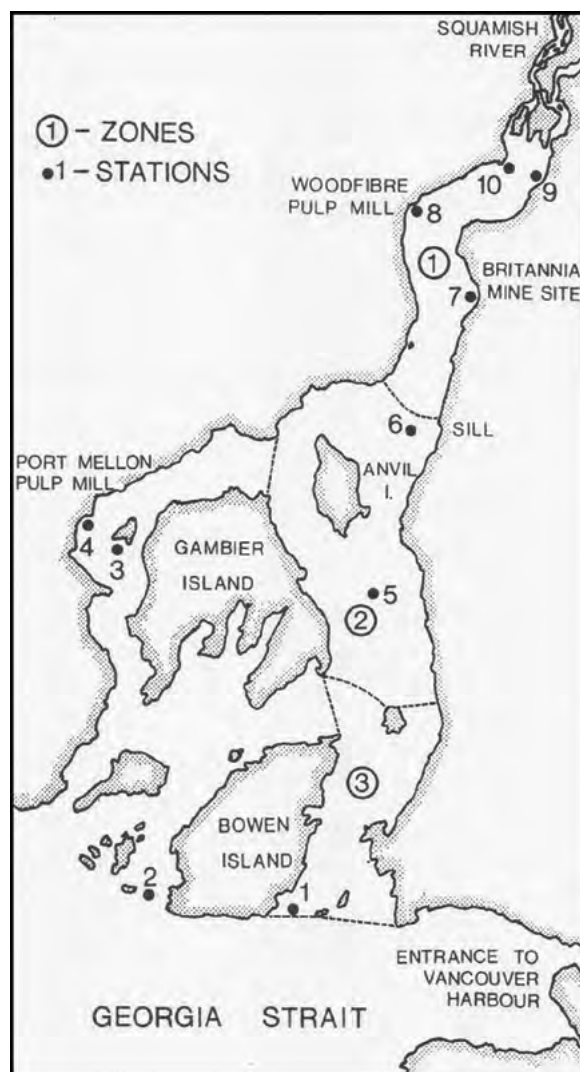


Figure 2. Map of Howe Sound with 1970s plankton sampling stations 1-10, and three major zones (circled numbers): Zone 1 — inner true fjord portion — inner sill to river; Zone 2 — mid-section; Zone 3 — seaward boundary with Strait of Georgia.³

At the head of the inlet (Zone 1), because of snowmelt in the mountains, the high flows of the Squamish River from April to June strongly affects both the production and distribution of phytoplankton owing to fine sediment in the outflow, which limits sunlight penetration, and increases flow and mixing within the surface layer. Once phytoplankton “bloom,” they move with the currents, so understanding the dynamics of currents and tides is particularly important. In the upper portion of the Sound, a prominent “sill” or shallow topographic barrier/boundary prevents complete mixing of deeper waters of this zone with the lower Howe Sound waters and hence is likely of paramount importance to the biological activities (Figure 3).⁷

Based on surveys in the 1970s, peak primary production occurred in June with values of 3,000–5,000 milligrams of carbon per square metre per day adjacent to the Strait of Georgia (Zone 3, boundary waters). Peak primary production levels at the head of the inlet adjacent to the Squamish River estuary (Zone 1) were almost 100 times less productive, at 40–50 milligrams of carbon per square metres per day, and they occurred in July.³ Turbid waters and low light penetration during spring with high river flows are responsible for the large difference in primary production between Zones 1 and 3.⁸

DEPTH PROFILE OF HOWE SOUND FROM SQUAMISH TO STRAIT OF GEORGIA

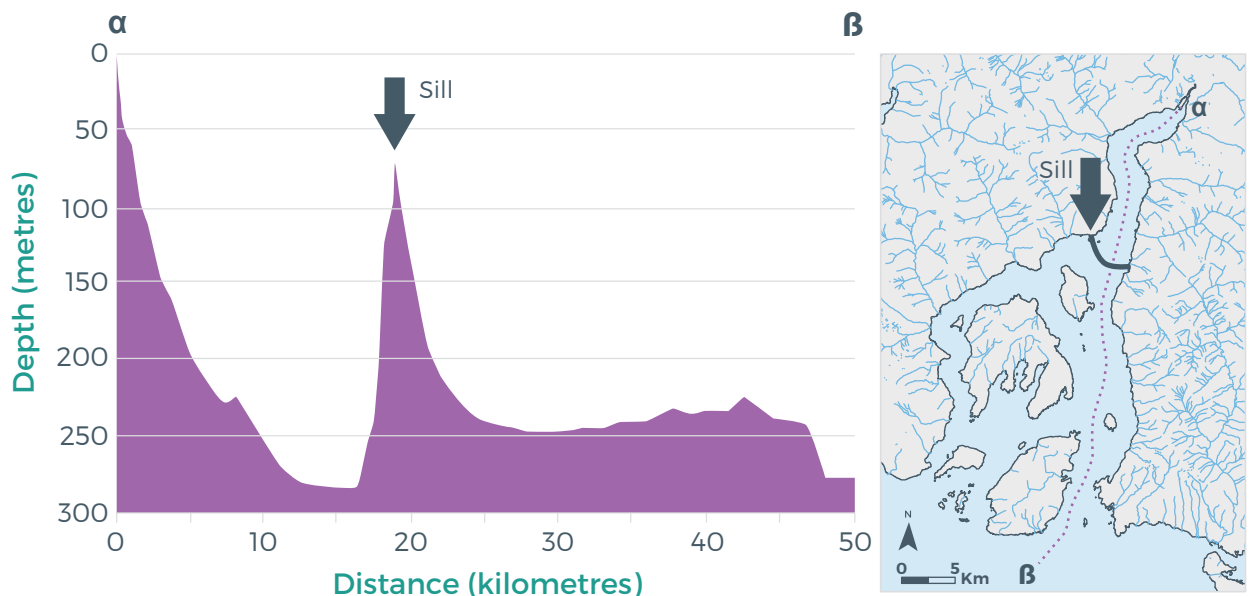


Figure 3. Vertical section along the main channel of Howe Sound showing the depth profile with the prominence and the shallowness of the “sill” at 50 metres depth. (The main channel was cut by glaciers during the Ice Ages, and the sill is a moraine that was left at the toe of a glacier during a short-lived advance at the end of the last Ice Age.) The head of the inlet is on the left. The sill is also marked near Station 6 in Figure 2.⁹

What did we learn in the 1970s?

The studies in the 1970s found five major classes of phytoplankton within Howe Sound:

1. Bacillariophyceae
(diatoms)
2. Dinophyceae
(dinoflagellates)
3. Chrysophyceae
(coccolithophores, silico-flagellates)
4. Cryptophyceae
(cryptomonad flagellates)
5. Chlorophyceae
(green flagellates, euglenophytes)

The dominant species were the diatoms *Thalassiosira aestivalis*, *T. nordenskioldii*, *T. pacifica*, *Skeletonema costatum*, and *Chaetoceros* spp. (Figure 4). *S. costatum* and *T. pacifica* are the dominant species during the spring bloom and are common through much of the summer in most regions of Howe Sound.¹⁰ These three diatoms are also dominant in the Strait of Georgia.¹¹ In addition, large inflows of freshwater from the Squamish River to surface layers in the

fjord portion (Zone 1) contain mainly freshwater diatoms of lake or river origin: *Asterionella*, *Hannaea*, *Meridion*, *Eunotia* and *Tabellaria*.¹²

The focus of the initial studies of Howe Sound in the 70s was on phytoplankton and hence zooplankton populations were sampled infrequently and only at a few key stations. Identified zooplankton included both crustacean (shrimp-like mysids, euphausiids, calanoid and cyclopoid copepods) and jellyfish (*Cyanea* or stinging jelly fish and, *Aurelia* or moon jellies). Some common examples appear in Figure 5. Usually there was a distinct annual lag of approximately two to three weeks between the peak phytoplankton bloom and peak zooplankton numbers. More recent work has shown that there is a higher proportion of crustaceans (the preferred food source of salmon and herring, especially the smaller cyclopoid copepods that are preferred food for both juvenile salmon and herring) and fewer jellyfish in Howe Sound compared to Indian Arm.¹³



Figure 4. Photomicrographs of three common chain-forming diatoms *Thalassiosira* sp. (left), *Chaetoceros* sp. (center), and *Skeletonema costatum* (right). These three diatoms are the main food source for the copepods, the dominant group of zooplankton. (Photos courtesy of David Cassis)

Current and emerging threats to healthy phytoplankton

Some current threats to healthy phytoplankton production include climate change with the dual impacts of increasing CO₂ (ocean acidification), and the warming of surface waters (global warming). Organisms that produce calcium carbonate structures, including many plankton species and bivalves, are impacted by the lower pH levels. Over time there will likely be a shift towards species that are more tolerant of warmer waters as average temperatures begin to rise. Some may be new invasive species that move up from the south and could possibly be toxic to shellfish or carry new viruses that might affect starfish, mussels, crab, shrimp and crustacean zooplankton.

In addition, proposals for new developments, such as gravel extraction and transport of sediment from McNabb Creek, could threaten plankton production if proposed activities reduce light penetration.

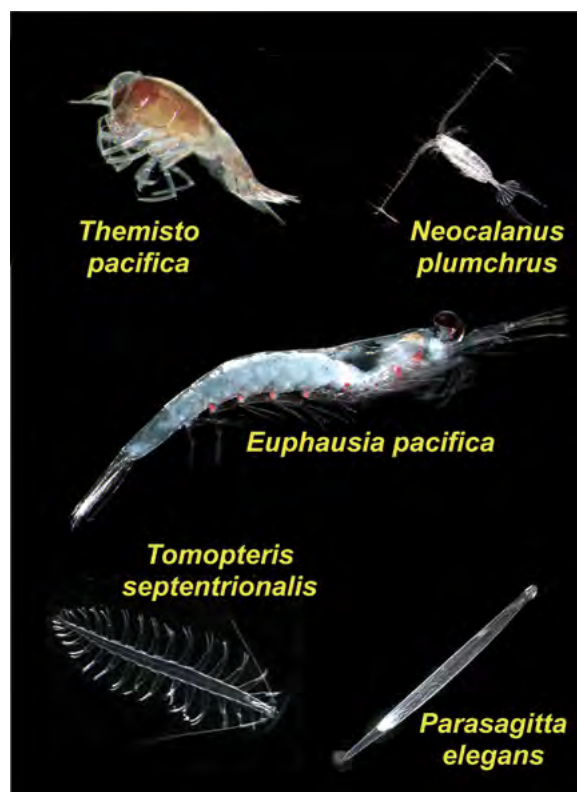


Figure 5. Some dominant zooplankton in lower Howe Sound, scaled to relative body size. Top row is the hyperiid amphipod (*Themisto pacifica*), and large copepod (*Neocalanus plumchrus*). Middle: the euphausiid (*Euphausia pacifica*). Bottom: the planktonic polychaete (*Tomopteris septentrionalis*) and the chaetognath (*Parasagitta elegans*).¹⁴ (Photos are copyright Dr. Russell Hopcroft, University of Alaska, and reproduced with permission).

What is being done?

Currently, there is little or no research on plankton in Howe Sound. In the 1970s, an important component of the research by DFO was to understand connections between disturbance in the Sound, including pulp mills, foreshore log booms, gravel washing operations and dissolved metal inputs from Britannia mine

and Squamish terminals, and primary production of phytoplankton. These disturbances and industrial activities were thought to be responsible for a marked decline in fisheries production, notably herring, salmon and ground fish stocks.¹⁵

Among the anthropogenic stressors in the 1970s, discharge from two pulp mills (Woodfibre, Port Mellon; Figure 2, Station 4) with associated toxicity to plankton were the most significant pollutants.^{16,17,18} Copper and other metals from mine tailing effluent from Britannia Mine (Figure 2, Station 7) delivered to the Sound via Britannia Creek destroyed all shoreline vegetation, both macrophytes and epiphytes, for several kilometers from the river discharge point during the 1970s and 1980s.^{19,20} Gravel washing discharge from tributaries on the west side of the Sound and extensive log-boom storage along the shorelines of Gambier and Anvil Islands impacted and shaded the intertidal zone and affected algal and marine plant production. Collectively these point-source anthropogenic industrial activities strongly influenced populations of marine resources, such as oysters, clams, crabs, shrimp and prawns and seaweeds. The identification of these stressors and their effects on food webs within the Sound, e.g. populations of plankton, herring, salmon, ground fish, and shellfish fisheries, eventually led to new strict regulations that over several decades have restored many fisheries and seem to have improved the health of the Sound.

Assessing potential trends in plankton health is difficult because little or no scientific studies were conducted before 1970 and very few after the 1980s. There have been only a few brief surveys for identification of the presence or absence of major species. There have also been several identifications requested by curious residents of possible deleterious or toxic phytoplankton blooms, or red tides, that still occur in summer in Howe Sound and are most common in the southern sectors (Zones 2 and 3).



Unusual plankton bloom, August 2016. (Photo: Ric Careless)

For example, there was an unusual coccolithophore bloom in the Sound and Strait in mid-August 2016 that turned the surface waters a green/turquoise color²¹ due to the calcium carbonate scales on the surface of the cell (a similar optical effect to glacial flour in lakes) (Figure 6). Coccolithophore blooms often occur on the west coast of Vancouver Island, but this is the first large-scale occurrence of such a visible bloom in the Strait and the Sound. They are not toxic and the reason for their sudden appearance in these inland waters is not known, but unlikely to be related to global warming.

However, we can surmise that current plankton production is relatively healthy, when we consider anecdotal indications of recovery from the 1970s and 1980s stressors. We have seen the return of significant numbers of herring and along with them the return of marine mammals; dolphins and whales now occur in the inner waters of the Sound along with increasing numbers of harbor seals.



Figure 6. The Landsat-8 true colour image of Howe Sound on Aug. 19, 2016 at 30 m spatial resolution. The bright water covering most of the Sound is from the unusual coccolithophore bloom observed in the Sound and the Strait of Georgia in August 2016. The very bright water at the head of the Sound is from high-suspended sediment. The image was downloaded from USGS Earth Explorer using The Development Seed's Libra Browser for Landsat-8 and processed by S. King, Sea This Consulting.

What can you do?

SOME ACTIONS CONTRIBUTED BY CORI



Individual and Organization Actions:

- Keep an eye out for unusual blooms and continue to ask what they are and why are they occurring in the Sound.
- True colour satellite imagery, useful for monitoring coccolithophore blooms and turbidity, can be viewed in near real time on NASA's Worldview (worldview.earthdata.nasa.gov). The satellite images will be the “web-cam” for active citizen science groups that are interested in on-going plankton events in the Sound.



Government Actions and Policy:

- Conduct a survey, preferably utilizing the same DFO stations in the 1970s (Figure 2), so valid comparisons of decadal changes can be made. This survey should include standard physical, chemical (nutrients, oxygen) and biological (dominant species, phytoplankton and zooplankton biomass, and primary productivity) parameters. What species are being lost or gained (i.e., changes in biodiversity) due to climate change and what are the changes in plankton/ecosystem productivity?
- Information on zooplankton, an important food source for many small fish, is lacking and should be conducted similar to an on-going study on zooplankton seasonal succession in another fjord, Rivers Inlet, up the B.C. coast.²²
- Continue the practice of testing water quality in front of the Port Mellon pulp mill (Station 4, Figure 2) to determine if the present mill is meeting provincial and federal marine foreshore water standards.
- Similarly, if an LNG terminal at the old Woodfibre site (Station 8, Figure 2) is approved, then an extensive survey will be needed to determine the “before” or baseline inventory and continued monitoring if it begins operations.
- Make baseline inventory and regular monitoring of plankton (the key food resource for all higher trophic levels) a requirement for coastal development projects, so that any changes in production, diversity, or timing can be assessed.
- Collect important historical data on the Sound (before scientists and other groups retire) and archive the data in a government data centre.

Footnotes

¹J. Gower and S. King, personal communication with the authors, June 2, 2016.

²Pomeroy, W.M., and J.G. Stockner. 1976. Effects of environmental disturbance on the distribution and primary production of benthic algae on a British Columbia estuary. *J. Fish. Res. Board Can.* 33: 1175-1187.

³Stockner, J.G., D.D. Cliff, and D.B. Buchanan. 1977. Phytoplankton production and distribution in Howe Sound, British Columbia: a coastal marine embayment fjord under stress. *J. Fish. Res. Board Can.* 34: 907-917.

⁴Collins, A.K., S.E. Allen, R. Pawlowicz. 2009. The role of wind in determining the timing of the spring bloom in the Strait of Georgia. *Can. J. Fish. Aquat. Sci.* 66: 1597-1616.

⁵Allen, S.E., and M.A. Wolfe. 2013. Hindcast of timing of the spring phytoplankton bloom in the Strait of Georgia, 1968-2010. *Prog. Oceanogr.* 115: 6-13

⁶Harrison, P.J. and D.L. Mackas. 2014. The biological oceanography. pp 41-65. In: *The Sea Among Us: The Amazing Strait of Georgia*. R. Beamish and G McFarlane (eds). Harbour Publ. Madiera Park, BC, Canada.

⁷For more information on the hydrography of Howe Sound see: Pickard, G.L. 1961. Oceanographic features of inlets in the British Columbia mainland coast. *J. Fish. Res. Board Canada.* 18: 907-999, and LeBlond, P.H. 1983. The Strait of Georgia: functional anatomy of a coastal sea. *Can J. Fish Aquat. Sci.* 40: 1033-1066.

⁸Buchanan, D.B., and J.G. Stockner. 1976. A mathematical model of oceanographic mechanisms governing phytoplankton production in Howe Sound, British Columbia. *Fish Mar. Serv. Tech. Rep. No. 654*, 116 p.

⁹Bell, W.H. 1975. The Howe Sound current metering program. Vol. 1, 2, 3 *Pac. Mar. Sci. Rep.* p.75-77.

¹⁰Stockner et al. 1977.

¹¹Harrison, P.J. J.D. Fulton, F.J.R. Taylor and T.R. Parsons. 1983. Review of the biological oceanography of the Strait of Georgia: pelagic environment. *Can. J. Fish. Aquat. Sci* 40: 1064-1094.

¹²Pomeroy, and Stockner. 1976.

¹³MacKinlay. D.D. 2014. Differential survival of chinook salmon released into two adjacent but dissimilar fjords. DFO internal communication, Salmonid Enhancement Program, 6 p.

¹⁴Harrison and Mackas. 2014.

¹⁵For references to this early research see:

Harrison, P.J., J.D. Fulton, G. Miller, C.D. Levings, F.J.R. Taylor, T.R. Parsons, P.A. Thompson, D.W. Mitchell. 1984. A bibliography of the biological oceanography of the Strait of Georgia and adjacent inlets, with emphasis on ecological aspects. *Can. Tech. Report Fish. Aquat. Sci No.* 1293.

¹⁶Stockner, J.G., and I.H. Rogers. 1973. Assessment of environmental impact of pulp mills discharging to B.C. coastal waters: effect of phytoplankton productivity. *Pub. Pollution Abate. Research (CPAR)*, Ottawa, Ont. 102

¹⁷Stockner, J.G., D.D. Cliff, and K. Munro. 1975. The effects of pulp mill effluent on phytoplankton production in coastal waters of British Columbia. *Fish. Mar. Serv. Tech. Rep. No.* 578.

¹⁸Stockner, J.G., and A.C. Costella. 1976. Marine phytoplankton growth in high concentrations of pulp mill effluent. *J. Fish. Res. Board Can.* 33: 2758-2765, and Stockner, J.G., and A.C. Costella. 1976. Field and laboratory studies on effects of pulp mill effluent on growth of marine phytoplankton in coastal waters of British Columbia. *Environ. Can. Survey. Rep. (EPS)* 5 PR 76 9. 60 p.

¹⁹Varela, D.E., K.L. Barry, M. Guo, G.E. Piercy, N.M. Mehlenbacher, P.J. Harrison and C.D. Levings. 2000. Water quality and oceanographic data near a deep water outfall discharging acid mine drainage from Britannia Mine Into Howe Sound, British Columbia. *Can. Data Rept Fish Aquat. Sci. No.* 1063, 43 p.

²⁰Levings, C.D. D.E. Varela, N.M. Mehlenbacher, K.L. Barry, G.E. Piercy, M. Guo, P.J. Harrison. 2005. Effect of an acid mine drainage effluent on phytoplankton biomass and primary productivity at Britannia Beach, Howe Sound, British Columbia. *Mar. Poll. Bull.* 50: 1585-1594.

²¹For example, From August 22, 2016 see cbc.ca/beta/news/canada/british-columbia/why-is-the-water-so-green-around-southern-b-c-1.3731466. Accessed Sept 26, 2016.

²²Tominasi, D., B.V.P. Hunt, E.A. Pakhomov, D.L. Mackas. 2013. Mesozooplankton community seasonal succession and its drivers: insights from a British Columbia, Canada, fjord. *J. Mar. Syst.* 115-116: 20-32.

Forage fish: a critical link in the food web

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Ramona de Graaf, Forage Fish Biologist, Sea Watch Society

What is happening?

This past summer there was much excitement in Howe Sound over anchovy sightings. Large schools of adult anchovy were occasionally observed from May through July, and larvae or very small young fish (also called YOY, young of year) were observed into November, so much so that it made the news.¹ Sport fishers, biologists, and citizen scientists all reported seeing more anchovy in 2016 than in 2015, when reports precipitated action to identify the fish, as anchovy hadn't been seen for 10 years prior. In 2016 anchovy were observed in locations all across the outer part of the Sound from Horseshoe Bay to Gibsons, and around Bowen Island and the Paisley Group. They were also reported in the Caulfield area of West Vancouver, in False Creek (Figure 1), and in Indian Arm.



Figure 1. Northern anchovy larvae collected in August 2016 in Burrard Inlet. (Photo: Doug Swanston)

Other species of forage fish in Howe Sound include herring, Pacific sand lance and surf smelt. Herring and their eggs, called spawn, have been witnessed in recent years in upper Howe Sound by many and diligently recorded over the past six years by John Buchanan, citizen scientist. Beach spawning habitat for Pacific sand lance and surf smelt was assessed and mapped around Gambier, Keats, and Bowen Islands in 2014.



Schooling northern anchovy (Photo: Sarama)



Herring eggs on rockweed algae. (Photo: John Buchanan)

Why is it important?

The excitement is warranted because the status of forage fish populations can be an indicator of the health and productivity of nearshore systems in our marine environment. Forage fish are small schooling fishes, aptly named because, as a vital link in the food web, they provide abundant forage for upper trophic feeders, such as salmon, birds, and seals, for their entire life. They are also known as bait fish to anglers. While northern anchovy are occasional visitors to Howe Sound, Pacific herring, surf smelt and Pacific sand lance all contribute to a staple diet for many Howe Sound species. Eulachon and sardines are also examples of forage fish. Other species do provide significant forage in different habitats including salmonids when they are small, Pacific lamprey, and even prawn and shrimp larvae. Young-of-year hake and pollack provide forage further from the shore and are arguably the most abundant small fish, although they are low-fat and provide less energy to predators. The number of eulachon (also known as oolachan) returning to spawn in the Squamish river was once in the millions (Figure 2) and today they are thought to be extinct.



Herring "bait ball" attracting seagull predators. (Photo: Lance Barrett-Lennard)

Most forage fish species depend on nearshore and intertidal habitat for their survival, especially when it comes to reproduction. Herring spawn (lay eggs) in intertidal and subtidal areas on vegetation such as eelgrass and seaweed and even manmade structures like piers. Pacific sand lance and surf smelt spawn on pebble and sand beaches just below the high-tide line. Small fish also depend on subtidal areas such as kelp forests and eelgrass beds for rearing. Howe Sound is lacking the bull kelp beds that are typical elsewhere in the Pacific Northwest and its steeply-sloped banks mean that eelgrass beds have always been limited in their distribution. In some places, subtidal eelgrass has suffered significantly due to log handling and booming practices that starved these habitats of both light and oxygen. All the species that depend on healthy nearshore and beach habitat are vulnerable to impacts from shoreline development.²

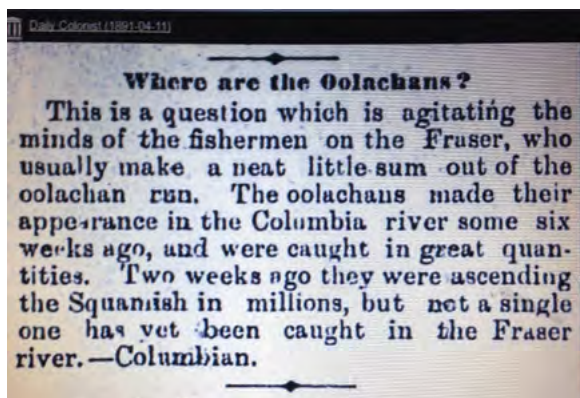


Figure 2. Clipping from the Daily Colonist newspaper, April 11, 1891. (Courtesy of J. Buchanan)

Notes on forage fish from the British Columbia Language Project 1976³

“Smelt (surf smelt – **schá7kwem**) was an important species of food for the Squamish Indian people. In the summer months, the people travelled to Point Grey to collect smelts which spawned on the sandy beaches around Jericho Beach and English Bay.”

Different words in the Squamish language to refer to Squamish River eulachon (**s7áynixw**) and Fraser River eulachon (**swí7ew**). A word meaning “time of eulachon” (**tem-s7áynixw**) refers roughly to a time period corresponding with April.

“The Squamish people recognize two sub-species of the species that is recognized scientifically as *Thaleichthys*.⁴ The first sub-species, **s7áynixw**, the Squamish River eulachon, is apparently found only at the head of Howe Sound and in the Squamish River. This species is ‘four to five inches long,’ is ‘more silver-blue in colour’ than the Fraser River eulachon and has a ‘higher oil content’ than the Fraser River eulachon. Apparently both sub-species spawn during the month of April. ... Until not too long ago, certain Squamish people had the ‘power’ to make eulachons appear in the Squamish River. ... Two such men were Chief George, **Chepxím**, who died around 1905, and Doctor Jim, **Lhek’lhák’elk**, who died around 1910. They were the last Squamish men to have this ‘power.’ They each had a small wooden box, in which was kept a ‘powdery’ mixture of eulachon bones, seal bones, duck bones, salmon bones, and sometimes also rotted red cedar wood ‘powder.’ A small handful of this total mixture was placed in a bundle of moss and then placed gently in the water. Four times the water would ‘ripple,’ and then small fish would appear. By the following day, these small fish were full-sized eulachons.”

“There are several versions recorded of the ‘true event’ that explains the origin of eulachons in the Squamish River.”

What is the current state?

In the middle of July 2015, John Buchanan, citizen scientist, witnessed a fish mass that seemed about half a kilometre long and 100 metres wide at Porteau Cove and “counted 20 seals that were working very well together in a line that basically cut off a section of the school and penned it in a small cove right in front of the beach where the campsites start.”⁵ These fish were northern anchovy. Their presence in Howe Sound has been recorded in seven different years since 1971, including 2015 and 2016 (Figure 3).⁶ With identification confirmed by a taxonomist, observations of anchovy submitted by scientists, divers, and citizen scientists are recorded in a database of marine

life held by the Vancouver Aquarium Marine Science Centre. This unique database holds the only records of anchovy observations that we are aware of for Howe Sound. Northern anchovy are known to be responsive to shifts in ocean condition⁷ and are much more commonly found in the waters off California. There is a weak link between El Niño years⁸ (warm waters in the North Pacific) and years that anchovy were observed in Howe Sound (Figure 3). Adult anchovy tend to be spotted in years following the warm years when larval recruitment is likely more successful. However, absence of recorded observation of adult anchovy in Howe Sound does not mean they were not present.

COMPARING EL NIÑO YEARS AND NORTHERN ANCHOVY OBSERVATIONS IN HOWE SOUND

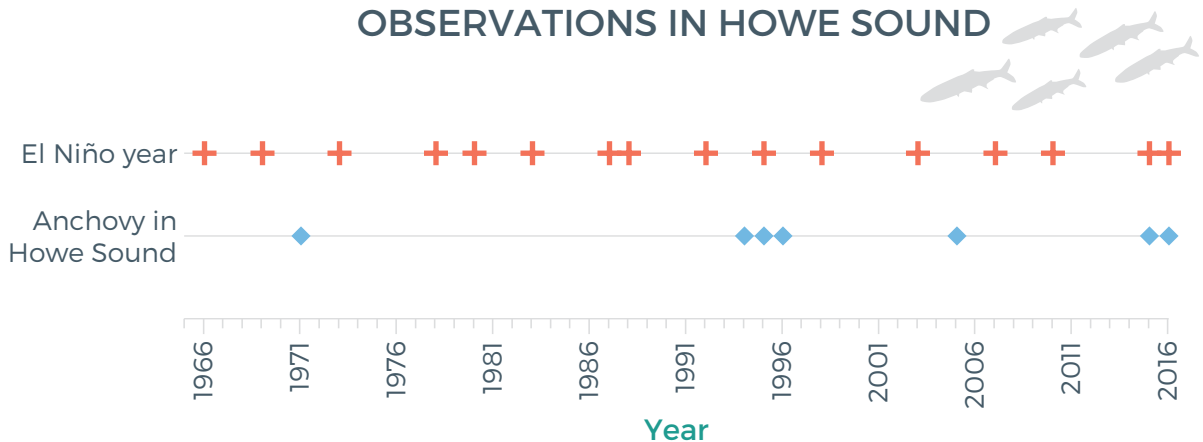


Figure 3. El Niño years compared to years when northern anchovy were observed in Howe Sound.

Herring were more abundant in Howe Sound in the early 1960s than any time since 1940, according to Fisheries and Oceans Canada (DFO) data (Figure 4).

Even then, the maximum estimated 2,000 tonnes of spawners hardly compares to other locations in the Strait of Georgia like Baynes Sound, for example, that supported up to 70,000 tonnes of herring spawners in the early 1990s.⁹ The locations of herring spawn aggregations also shift from year to year. (See an animation on the DFO website.¹⁰) DFO calculates a cumulative herring spawn index which ranks and classifies each kilometre of herring spawning habitat according to the long-term frequency and magnitude of spawns over time.¹¹ Spawn locations in Howe Sound are clas-

sified as medium, minor, and low, because they rank below the 70th percentile compared to coast wide records of spawn (Figure 5, left panel). Citizen scientist, John Buchanan, has been surveying the north end of Howe Sound and recording herring spawn observations each spring since 2010. His findings since 2011 are mapped (Figure 5, right panel).

While there is some spatial overlap between observations made by DFO and J. Buchanan at the head of the inlet, there is an obvious gap in DFO data along the northwest stretch of coastline in upper Howe Sound where there is now evidence of consistent herring spawn. DFO surveys have been undertaken for stock assessment purposes and this remains the priority

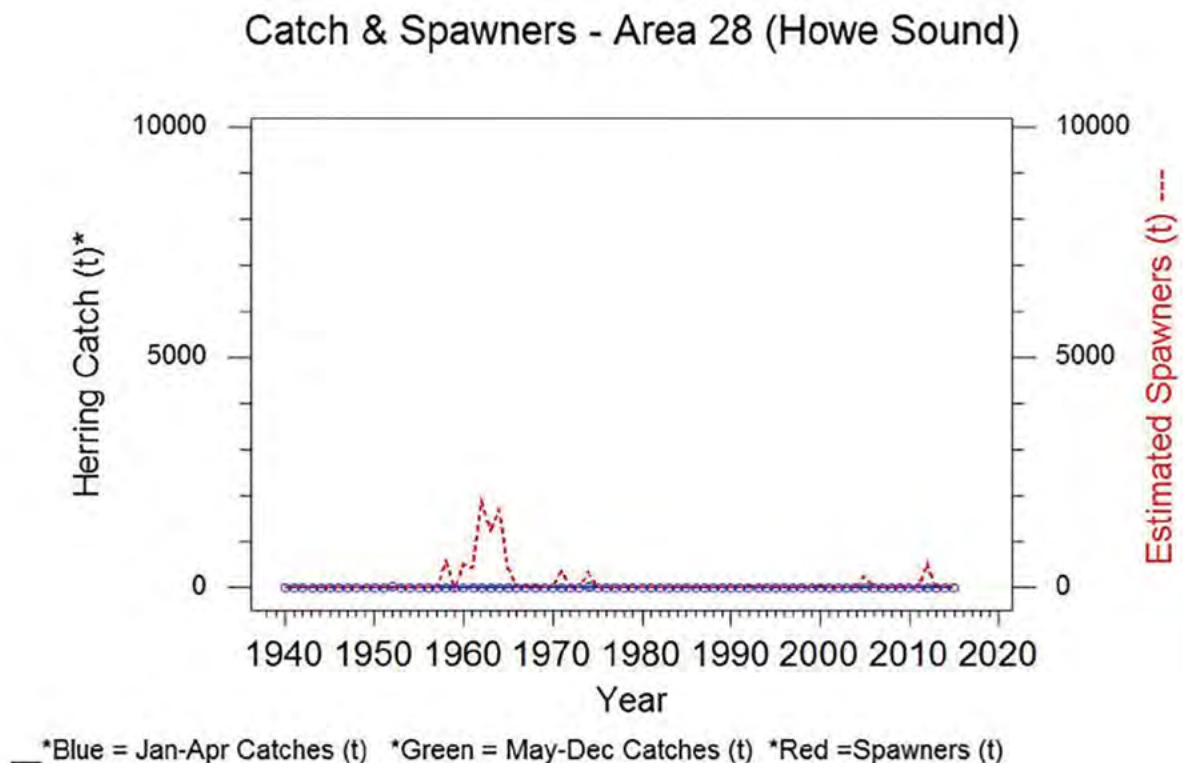


Figure 4. Estimated herring spawners in Howe Sound. Data: Fisheries and Oceans Canada.

today, so small but visible spawn may not have been recorded.¹² Spawn sites are often located by flying over the coast (e.g., Figure 6) with on-the-water surveys to follow. The spawn locations and events recorded by J. Buchanan over the last six years provide valuable insight into the extent of herring spawn habitat in upper Howe Sound.

Herring spawn early in the year and multiple spawn events can extend the period of spawn activity. John Buchanan observed herring spawn in upper Howe Sound as early as January 9th in 2014. DFO data illustrate the variability in the timing of herring spawn. The data also suggest that spawning may be occurring earlier in recent years, but this could be an artifact of limited DFO survey effort in Howe Sound, as data provided by J. Buchanan suggest that the range of spawn

dates is still quite broad (Figure 7). Although forage fish are little studied in Howe Sound and the Strait of Georgia, existing research suggests that there may be three spawning stocks of surf smelt in the Strait of Georgia; summer, winter and year round spawners. Sand lance tend to spawn from November to January.¹³ Limited records suggest that in years when northern anchovies arrive, they spawn in July and August, but evidence of larvae late into the fall in 2016 suggest that several spawning events occurred and extended later than August.

No annual abundance surveys of forage fish other than herring are undertaken. In an effort to identify sensitive beach spawn habitat for surf smelt and Pacific sand lance, Ramona de Graaf, of the Sea Watch Society, surveyed and recorded suitable and not suit-

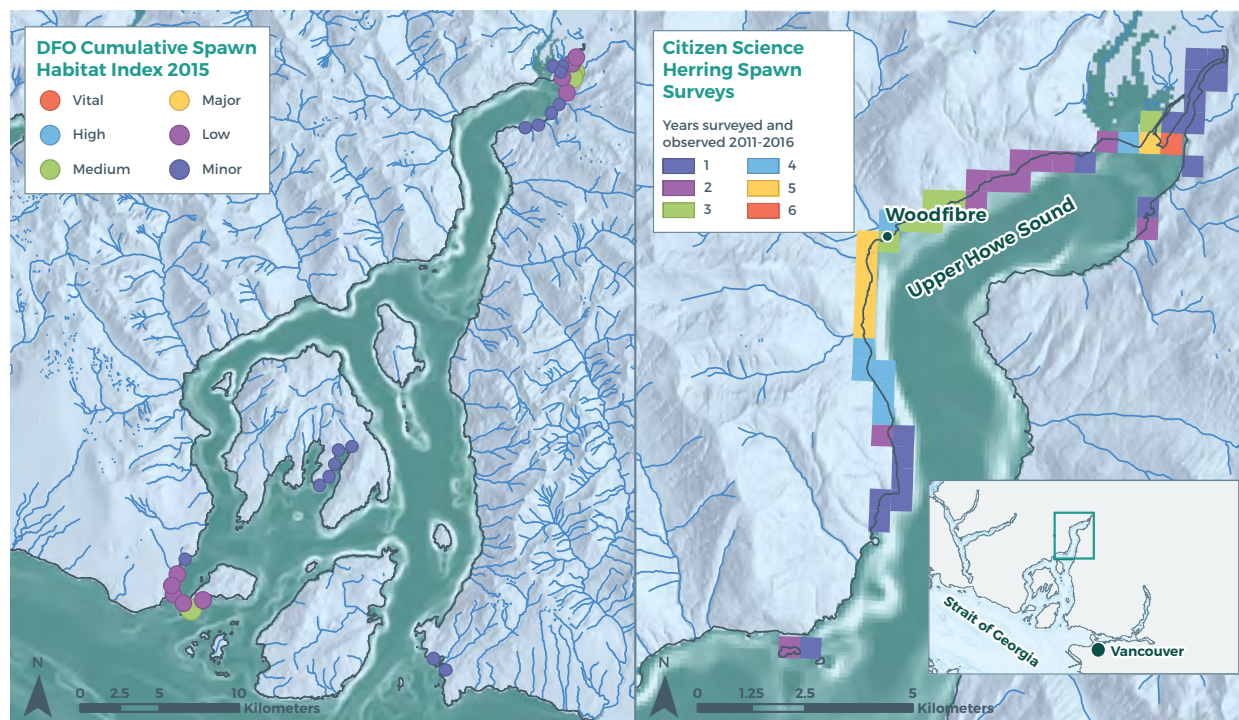


Figure 5. Herring spawn data from two sources. Fisheries and Oceans Canada cumulative spawn habitat index for 2015 (left panel) and survey locations where herring spawn was observed and recorded by citizen scientist, John Buchanan (right panel).



Figure 6. Milky white herring spawn around Hornby Island in the mid-1960s. (Photo: DFO)

able habitat on Gambier, Keats, and Bowen Islands in Howe Sound in 2014 (Figure 8).¹⁴ Suitable habitat was determined using a habitat assessment protocol, the Forage Fish Habitat Assessment, which was developed collaboratively by forage fish biologists from British Columbia and Washington State.¹⁵ Bowen Island was found to have more suitable habitat (almost 3.4 kilometres) than Gambier and Keats Islands, which have about two kilometres each.

Commercial fisheries for forage fish are not common in Howe Sound. Commercial catch of herring in Howe Sound occurred in only seven years between 1950 and 1980 and has not occurred since then. Catches ranged from one to 51 tonnes.¹⁶ Surf smelt are currently managed by DFO for both commercial and recreational

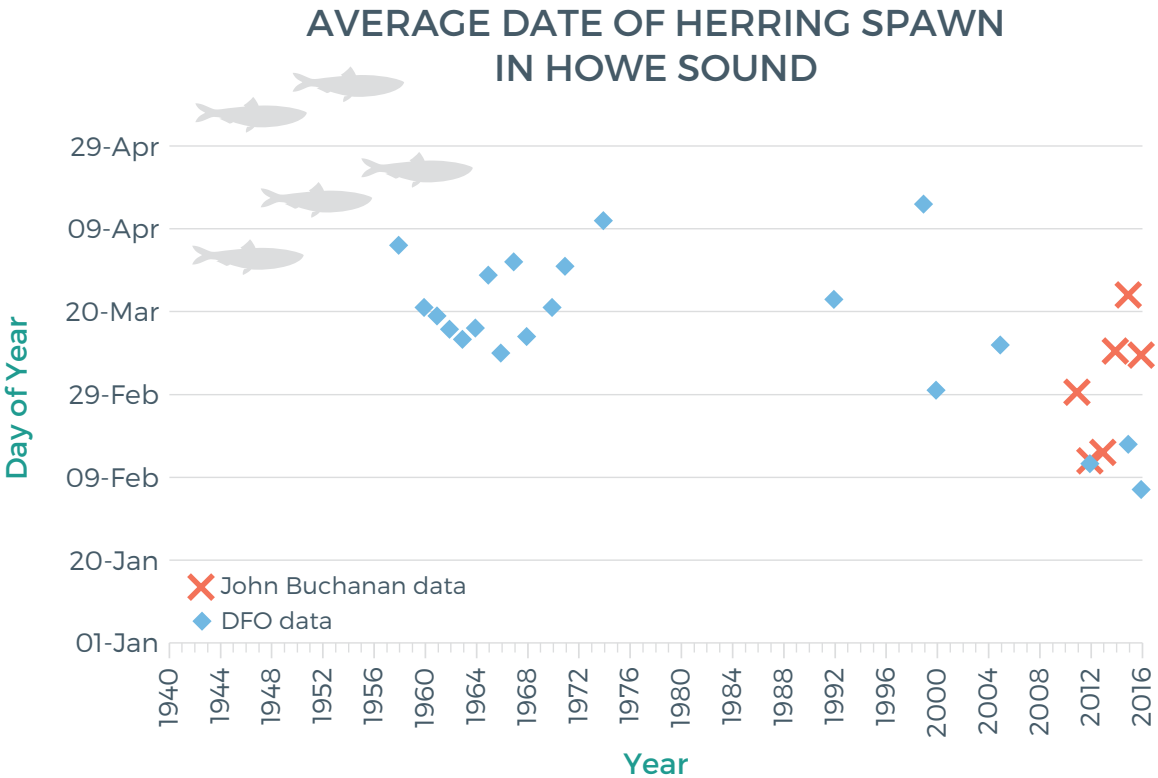


Figure 7. Average date of spawn for herring in Howe Sound.

fisheries and commercial fisheries for surf smelt have existed since the mid-1800s. Much of the historical catch in B.C. came from Vancouver beaches. Recreational fishing for surf smelt has increased significantly since the early 1990s, especially on beaches of the Lower Mainland, rivers of Alberni Inlet, and docks in the Prince Rupert area.¹⁷ The most recent stock status report is dated 2002¹⁸ and the most recent Integrated Fisheries Management Plan is for April 1, 2012 to March 31, 2014.

Threats to beach spawning fishes are numerous, but the number one threat is hard armoring of the beaches; seawalls, riprap, and boat ramps. As sea level rises these fish may lose their place to lay eggs due to a phenomenon known as coastal squeeze ([see illustration in Shorelines article](#)).¹⁹ Activities including improper shoreline development, marine shellfish aquaculture in the foreshore, and diversion of sediment-bearing streams through culverts can render beaches unusable for spawning. These shoreline modifications can also limit sediment exchange in the shallow subtidal where sand lance is known to burrow. Acute oil spill events and chronic oiling are deadly as oiling suffocates embryos. Climate change will further affect the survival of forage fish because increasing ocean acidity and increasing sea surface temperatures will likely affect larval survival. Changes in the timing of spring bloom have already been linked to the success of herring larval recruitment in the Strait of Georgia.²⁰ In particular, the mismatch between spawn timing and the start of the spring plankton bloom was found to have a substantial impact on survival and production of herring.

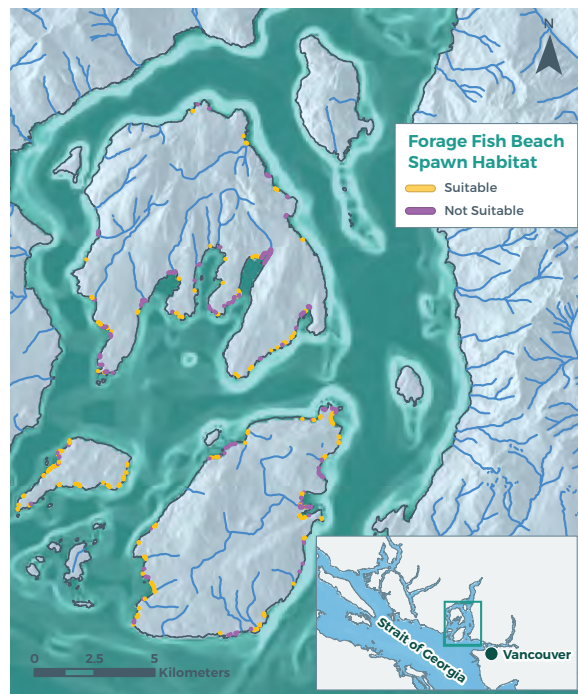


Figure 8. Beach spawn habitat on Gambier, Keats, and Bowen Islands in Howe Sound. Gambier and Keats Islands have about two kilometres of suitable spawn habitat each, while Bowen Island has almost 3.4 kilometres of suitable beach spawn habitat.

What is being done?

There are no consistent or comprehensive monitoring efforts in Howe Sound directed at schooling or spawning foraging fish, except herring spawn monitoring by DFO and self-funded efforts by citizen scientist, John Buchanan. Regular small fish surveys are undertaken by DFO in the Strait of Georgia and sometimes, but not consistently, sampling is done in Howe Sound. These surveys are known as the Strait of Georgia juvenile herring and nearshore pelagic ecosystem survey²¹ and juvenile salmon trawl surveys and they target juvenile herring and salmon. Catches do include other small fish such as Pacific sand lance and surf smelt, however information on the abundance and distribution of these forage fish species is not regularly reported on. Some additional research has resulted from a growing recognition of the importance of forage fish. A model developed to identify subtidal burying habitat for Pacific sand lance in the Strait of Georgia suggests that suitable burying habitat is quite rare (six percent) in the study domain.²² Unfortunately Howe Sound was not included in the study area.

The Sea Watch Society undertakes spawning surveys and continues to expand the forage fish habitat suitability assessments. Sightings of forage fish species recorded in a database of marine life, which is housed at the Vancouver Aquarium Marine Science Centre, are opportunistic, meaning that they are not the product of systematic surveys, but they do provide evidence of species presence going back in time.

In an effort to increase the survival of herring spawn in upper Howe Sound local stream keepers have wrapped toxic creosote pilings in the Squamish area

with weed control fabric.²³ Prior to these efforts, herring eggs would die on the pilings and never hatch. One mission of the Squamish Streamkeepers Society is to enhance then maintain herring spawning habitat in the upper Howe Sound.

A pre-feasibility restoration project studying habitat potential for eulachon and Pacific lamprey in and around the Squamish river estuary is underway, as a partnership between Squamish First Nation and Didier Wesley from the University of British Columbia.²⁴

The BC Shore Spawners Alliance (BCSSA) is an alliance of community groups working to document and protect the intertidal spawning habitat of forage fish (surf smelt and Pacific sand lance). The BCSSA provides presentations, educational resources, protocols, training and equipment to allow for the collection of scientifically credible data. The goal of the BCSSA is to increase efforts to manage and protect shoreline forage fish spawning habitats through science, education, community stewardship, and habitat restoration. Ramona de Graaf, a marine biologist, forage fish specialist, marine educator, and researcher who has been studying and surveying forage fish habitats since 2000, is the BC Shore Spawners Alliance coordinator.

The B.C. Government's Ministry of Environment Ecosystems Branch prepared a coastal forage fish fact sheet that contains background information and environmental guidelines for urban and rural land development.²⁵

What can you do?



Individual and Organization Actions:

- Prevent sediment, chemical or oil run-off from your property. Oiling from vessel operations near beaches can potentially cause mortality of incubating forage fish eggs. Siltation of beaches can smother tiny eggs.
- Avoid building breakwaters, riprap, seawalls, docks or pilings near beach habitat that may support forage fish.
- Retain natural shoreline vegetation because shade from overhanging vegetation keeps fish eggs moist in the summer and insects from overhanging vegetation are a source of food for forage fish. The roots of natural vegetation on the foreshore and coastal bluffs also help to bind the soil and minimize erosion. Removing shoreline vegetation increases temperatures within the spawning gravel and removes a food source for young fish. On hot summer days, without shade, eggs can't survive.
- Re-establish native shoreline vegetation if absent.
- Trim trees to improve your view instead of removing them. This helps to retain the stability of the bank and slope soils and to maintain shade on the beach.
- Set back any new development from the bluff or foreshore, to minimize the future need for foreshore protection.
- Manage storm water and maintain vegetation above bluffs to avoid soil saturation and slumping.
- Retain natural drainage patterns and design storm water systems so that water is cleaned before it enters the foreshore.
- Use soft shore or Green Shores approaches rather than hardening the shoreline.
- Volunteer with the BC Shore Spawners Alliance: facebook.com/foragefish



Government Actions and Policy:

- Increase efforts to educate land owners on foreshore regulations.
- Monitor and enforce the legislation (B.C. Land Act) that prohibits changes below the high tide line without lease or license of occupation.
- Prioritize and fund research, monitoring, and protection of forage fish habitats.

Resources

Islands Trust Forage fish Habitat Assessments

[islandstrustfund.bc.ca/initiatives/
marineconservation/foragefish.aspx](http://islandstrustfund.bc.ca/initiatives/marineconservation/foragefish.aspx)

BC Shore Spawners Alliance, a project of Sea Watch Society

facebook.com/foragefish

Friends of Forage Fish

friendsofforagefish.com

Bowen Island surf smelt and Pacific sand lance Spawning Habitat Suitability Assessment Report

[islandstrustfund.bc.ca/media/77286/final-report-
bowen_oct302014_v6_rcdg-with-maps-for-web2.
pdf](http://islandstrustfund.bc.ca/media/77286/final-report-bowen_oct302014_v6_rcdg-with-maps-for-web2.pdf)

Detailed guidelines for protecting fish and wildlife habitats along the foreshore are provided in Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia
env.gov.bc.ca/wld/documents/bmp/devwithcare/

Fisheries and Oceans Northern Anchovy fishery – Pacific Region

[pac.dfo-mpo.gc.ca/fm-gp/commercial/pelagic-
pelagique/anchovy-anchois/index-eng.html](http://pac.dfo-mpo.gc.ca/fm-gp/commercial/pelagic-pelagique/anchovy-anchois/index-eng.html)

Footnotes

- ¹ Vancouver Sun. 2016. "Anchovy schools are back in session, with 'phenomenal numbers' spawning in Howe Sound." August 20, 2016. Accessed Oct 30, 2016. <http://vancouversun.com/news/local-news/anchovy-schools-are-back-in-session-with-phenomenal-numbers-spawning-in-howe-sound>
- ² de Graaf, R. 2014. Gambier and Keats Islands surf smelt and Pacific sand lance spawning habitat suitability assessments. Report prepared for the Islands Trust and Islands Trust Fund. 68 pp.
- ³ Utilization of fish, beach foods, and marine mammals by the Squamish Indian people of British Columbia, Bouchard.003, Survey of California and Other Indian Languages, University of California, Berkeley, <http://cla.berkeley.edu/item/2498>
- ⁴ The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) refers to all pacific stocks of eulachon as *Thaleichthys pacificus*.
- ⁵ Buchanan, J. 2016. Email communication copied to the author.
- ⁶ Anchovy sighting data from Gibbs, D.M., C. Gibbs, and A. Lamb. Pacific Marine Life Surveys. Data accessed Sept 16, 2016. Opportunistic sightings are recorded, so the information is not from systematic surveys and anchovy may have been present in years not recorded.
- ⁷ Horn, M., L.A. Allen and R.N. Lea. 2006. Biogeography. In: Allen, L.G., D.J. Pondella II and M.C. Horn (Eds) The Ecology of Marine Fishes California and Adjacent Waters. University of California Press. 660pp.
- ⁸ National Oceanic and Atmospheric Administration. 2016. Climate Prediction Center. Cold and Warm Episodes by Season. Accessed Nov 12, 2016. http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml
- ⁹ <http://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagique-pelagique/herring-hareng/herspawn/142fig-eng.html>
- ¹⁰ http://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagique-pelagique/herring-hareng/herspawn/BCS_spa-eng.html
- ¹¹ Hay, D.E. and P.B. McCarter. 2013. Herring Spawning Areas of British Columbia; A review, geographic analysis and classification. Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, British Columbia V9T 6N7
- ¹² Ibid.
- ¹³ de Graaf 2014.
- ¹⁴ Data provided by Islands Trust, 2016.
- ¹⁵ de Graaf 2014.
- ¹⁶ <http://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagique-pelagique/herring-hareng/herspawn/tabcbkm2-eng.html>
- ¹⁷ Fisheries and Oceans Canada. 2012. Pacific Region Integrated Fisheries Management Plan, Surf Smelt, April 1, 2012 to December 31, 2014. Accessed Nov 20, 2016. <http://www.dfo-mpo.gc.ca/Library/343255.pdf>
- ¹⁸ DFO. 2002. Surf Smelt. DFO Can. Sci. Advis. Sec. Stock Status Rep. B6-09 (2002) Accessed Nov 20, 2016. http://www.dfo-mpo.gc.ca/csas/Csas/status/2002/SSR2002_B6-09_e.pdf
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- ²⁰ Schweigert, J.F., M. Thompson, C. Fort, D.E. Hay, T.W. Therriault, and L.N. Brown. 2013. Factors linking Pacific herring (*Clupea pallasii*) productivity and the spring plankton bloom in the Strait of Georgia, British Columbia, Canada. Progress in Oceanography 115: 103-110.
- ²¹ Reports on this survey at the DFO State of the Ocean workshop suggest that an index of juvenile herring (age-0) may be the best indicator of the amount of prey available to predators in the Strait of Georgia and the number of herring that survive to spawn 2.5 years later. From: Boldt, J., M. Thompson, C. Fort, C. Rooper, J. Schweigert, T.J. Quinn II, D. Hay and T. Therriault. 2016. Strait of Georgia Juvenile Herring Survey. In Chandler, P.C., King, S.A., and Perry, R.I. (Eds.). 2016. State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2015. Can. Tech. Rep. Fish. Aquat. Sci. 3179: viii + 230 p.
- ²² Robinson, C.L.K., D. Hrynyk, J.V. Barrie, and J. Schweigert. 2013. Identifying subtidal burying habitat of Pacific sand lance (*Ammodytes hexapterus*) in the Strait of Georgia, British Columbia, Canada. Progress in Oceanography 115: 119-128.
- ²³ <http://www.squamishstreamkeepers.net/streamkeepers/Welcome.html>
- ²⁴ Didier, W. 2016. Email communication with the author, Feb 26, 2016.
- ²⁵ <http://www.env.gov.bc.ca/wld/documents/bmp/devwithcare/Fact-Sheet-21-Forage-Fish.pdf>

Sea Stars: wasting disease taking its toll

AUTHOR

Jessica Schultz, Manager, Howe Sound Research Program, Coastal Ocean Research Institute

REVIEWER

Neil McDaniel, Marine Naturalist

What's happening with sea stars?

Starting in the late summer of 2013, Howe Sound began experiencing a mass mortality of sea stars. The die off is part of a larger outbreak of sea star wasting syndrome happening up and down the west coast of North America from Alaska to southern California, and possibly into Mexico.¹ The event, which is affecting at least 20 different species of sea stars along the coast, might be the largest wildlife mortality event in recent history.² Although a virus has been associated with sea star wasting,³ the causes and consequences of the outbreak remain largely unknown. In Howe Sound, the sunflower star, *Pycnopodia helianthoides*, (Figure 1) was the hardest hit species, with dense aggregations disappearing from many sites in a matter of weeks. More recently, there have been sporadic influxes in tiny young sea stars at some sites. However, the fate of these juveniles is not clear, as they seem to vanish as quickly as they appear. In 2015 and 2016 there has been a low but consistent number of small (quarter- to saucer-sized), mostly healthy-looking sunflower stars. Wasting is also still present at low levels in purple stars (*Pisaster ochraceus*) and mottled stars (*Evasterias troschelii*), but other species such as leather stars (*Dermasterias imbricata*), vermillion stars (*Mediaster aequalis*) and blood stars (*Henricia* spp.) appear to be abundant and healthy in Howe Sound.



Figure 1. A healthy sunflower star moves across sea colander kelp (left). A diseased sea star begins to lose its grip near Pam Rocks, Sept 2013 (right). (Photos: Donna Gibbs)

Why are sea stars important?

Sea stars are important predators in the marine environment. Many sea stars are keystone predators, meaning that they have a disproportionately large influence on their surrounding marine communities.⁴ In subtidal habitats, sunflower stars are voracious predators of bottom-dwelling invertebrates and are the main predator of green sea urchins (*Strongylocentrotus droebachiensis*) in Howe Sound. The sudden decline in sunflower stars may be responsible for the widespread explosion in the green sea urchin population currently underway (Figure 2), which in turn may be leading to a decline in kelp cover (primarily the sea colander kelp, *Agarum fimbriatum*).⁵ Because kelp provides

critical habitat for a variety of fish and invertebrates, a decline in sea stars could have large-scale ecological impacts at multiple levels of the food web. Other species of sea stars function as more specialized predators, scavengers and/or detritivores (animals that feed on dead organic material), and also play an important role in the ecosystem.⁶ In addition, sea stars have an intrinsic, cultural value to the public. In the absence of sea star wasting, sea stars have been a familiar sight on the beaches, shorelines and underwater habitats of Howe Sound. There is considerable public concern regarding the wellbeing of sea stars.

ABUNDANCE OF GREEN SEA URCHINS AND SUNFLOWER STARS

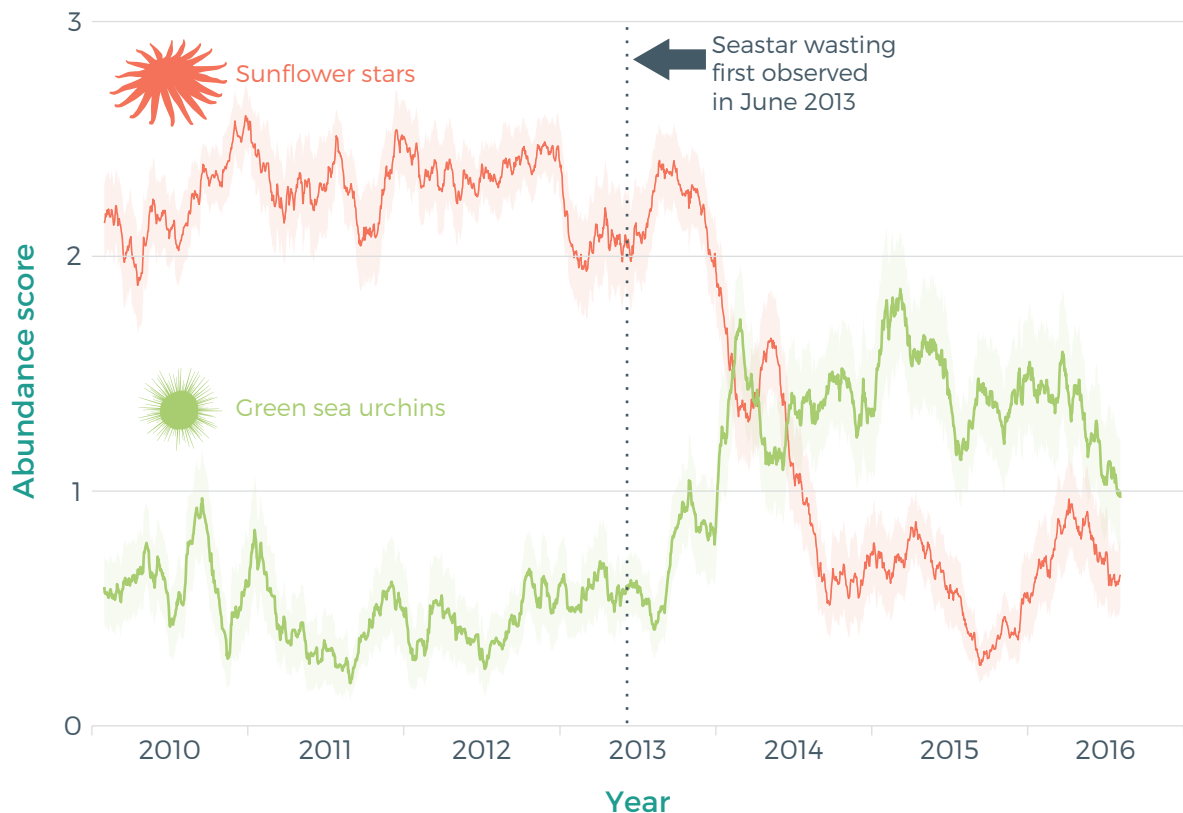
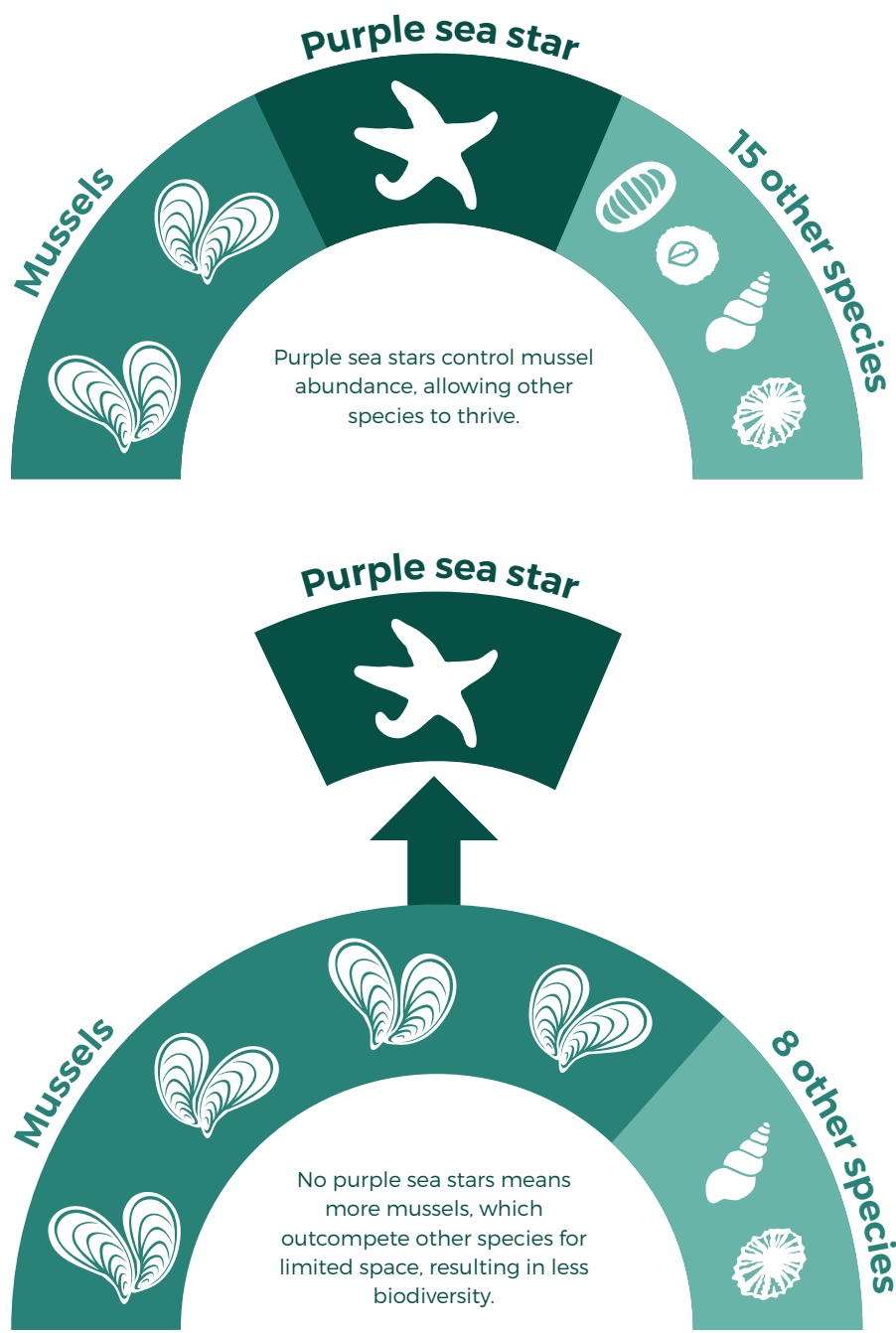


Figure 2. Sixty-day running average abundance scores for green sea urchins (*Strongylocentrotus droebachiensis*; green solid line) and sunflower stars (*Pycnopodia helianthoides*; orange solid line) recorded in surveys from Jan 2010 to Sept. 4, 2016 in British Columbia. Data are from the Reef Environmental Education Foundation (www.reef.org) database, which collects qualitative observations from recreational SCUBA divers trained in basic marine life identification. Shadows around trend lines indicate 95 percent confidence intervals of the running average. (updated from Schultz et al. 2016).

Purple sea star is a keystone predator



What is the current state?

Based on data collected from 20 sites in Howe Sound, the abundance of sunflower stars declined by 89 percent on average following sea star wasting, from an average of roughly one sea star every two square meters in 2009–2010 to one sea star every 17 square meters in 2014 (Figure 2).⁴ At least 15 other species in Howe Sound have been observed with signs of wasting; six species were considered to have high or very high mortality rates, and nine species were considered to have some mortality based on qualitative observations by citizen scientist Neil McDaniel⁷ (Figure 3). For this article, the sighting frequency (the percent of dives during which a particular species was observed based on presence/absence data⁸) was qualitatively compared for groups of sea stars with high mortality versus lower mortality (Figure 3). It is no surprise that sighting frequency varies greatly, but rather unexpected that it increased for some species following sea star wasting syndrome. It is clear that neither relative abundance nor level of mortality can be inferred from these sighting frequency data. On a positive note, all species that were observed before the wasting event were still observed after the event, with the exception of the northern sea star (*Solaster endeca*).

Although some species were seen less frequently following the die-off event compared to before, for many species the opposite was true: sighting frequency actually increased after the sea star wasting disease outbreak. One reason for this may be a heightened sense of awareness about sea stars (leading to more recording of sea star sightings) following the onset of wasting syndrome. It is also important to note that sighting frequency does not account for sea star health and many of the observed individuals may have been exhibiting signs of wasting.

Disease continues to be a major threat to sea stars in Howe Sound, especially for the sunflower star. Wasting disease is ongoing. Some researchers have suggested the possibility of listing sea stars as imperiled under the Species at Risk Act.⁹ However, many observers have reported high densities of newly settled “baby” sea stars in many areas.^{10,11} The long term resilience of affected species is unknown and will depend largely on juvenile survival and the existence of healthy, adult sea star populations able to repopulate heavily impacted areas.

SIGHTING FREQUENCY OF COMMON SEA STARS IN HOWE SOUND



Figure 3. The sighting frequency of common sea stars in Howe Sound before sea star wasting syndrome (SSWS) (2009-2010; green bars) and after sea star wasting (2014-2015; orange bars). Top Panel includes species categorized as having experienced high or very high mortality, and Bottom Panel includes species categorized as having experienced some mortality.⁷ Almost all species were observed both before and after the onset of SSWS. Sighting frequency data are from the Pacific Marine Life Surveys database.⁸

What is being done?

Researchers from institutions across the continent continue to work to understand sea star wasting syndrome. In Howe Sound, a number of groups monitor echinoderm populations and/or health status, including:

- Howe Sound Research, Coastal Ocean Research Institute: researching cascade effects and monitoring populations
- Neil McDaniel, Naturalist and Videographer: monitoring and documenting sea stars (www.seastar-softhepacificnorthwest.info)
- MARINe Network, University of California, Santa Cruz: collecting and mapping sea star observations from anywhere on the west coast of North America (www.seastarwasting.org)
- Reef Environmental Education Foundation (REEF; www.reef.org), which trains scuba divers to identify and record common species during recreational dives, tracks the qualitative abundance score of fish and invertebrates, including sunflower stars (*Pycnopodia helianthoides*), pink stars (*Pisaster brevispinus*), leather stars (*Dermasterias imbricata*) in the Northeast Pacific.
- Pacific Marine Life Surveys: taxonomists and citizen science divers Donna Gibbs, Charlie Gibbs and Andy Lamb have been recording biodiversity observations, including the presence of sea stars, in Howe Sound and elsewhere for several decades.

What can you do?



Individual and Organization Actions:

- If you see a sick or dying sea star, please submit your observations to the UC Santa Cruz monitoring site, www.seastarwasting.org. Your observations can help researchers track disease spread and understand the potential causes and consequences of sea star wasting. If applicable to your organization, encourage company-wide participation in this citizen science project.
- Ecosystems that are already stressed due to overfishing, pollution, habitat damage or other stressors are more prone to disease outbreaks and are less resilient to disturbance. Anything we can do to mitigate pressures on marine ecosystems may help prevent future disease outbreaks and promote ecosystem recovery.



Government Actions and Policy:

- Increase public education about sea star wasting disease to encourage participation in citizen science projects, and personal actions to help decrease overfishing, pollution, habitat damage and stressors.
- Financially support ongoing research projects, and assess the need for additional research. Support further studies specifically on the cause(s) of sea star wasting disease.
- If studies reflect the need, classify sea stars as an Imperiled Species by the Species At Risk Act.

Resources

Summary of sea star wasting and current map of observations

seastarwasting.org

Vancouver Aquarium sea star wasting webpage

vanaqua.org/act/research/sea-stars

Sea star health category guide

env.gov.bc.ca/bcparks/partnerships/Item/docs/protocols/intertidal/SeastarDiseaseCategoryGuide_2.0.pdf?v=1468460904481

Footnotes

¹ Stockstad, E. 2014. Death of the stars. *Science* (New York) 344:464–467; DOI: 10.1126/science.344.6183.464.

² Johnson, L. 2016. “Sea star wasting disease among worst wildlife die-offs say scientists.” CBC News, Jan 21, 2016. Accessed Sept 19, 2016. <http://www.cbc.ca/news/canada/british-columbia/sea-star-wasting-die-off-1.3414607>.

³ Hewson, I., J.B. Button, B.M. Gudenkauf, B.G. Miner, A.L. Newton, J.K. Gaydos, J. Wynne, C.L. Groves, G. Hendler, M. Murray, S. Fradkin, M. Breitbart, E. Fahsbender, K.D. Lafferty, A.M. Kilpatrick, C.M. Miner, P. Raimondi, L. Lahner, C.S. Friedman, S. Daniels, M. Haulena, J. Marliave, C.A. Burge, M.E. Eisenlord, and C.D. Harvell. 2014. Densovirus associated with sea-star wasting disease and mass mortality. *PNAS*, 111(48): 17278–17283.

⁴ Paine, R.T. 1966. Food web complexity and species diversity. *The American Naturalist* 100:65–75; DOI: 10.1086/282400

⁵ Schultz, J.A., R.N. Cloutier, and I.M. Côté. 2016. Evidence for a trophic cascade on rocky reefs following sea star mass mortality in British Columbia. *PeerJ* 4:e1980; DOI 10.7717/peerj.1980

⁶ Lambert, P. 2000. *Sea stars of British Columbia, Southeast Alaska, and Puget Sound*. Vancouver: Royal British Columbia Museum, UBC Press.

⁷ McDaniel, N. 2013. The sea star wasting in syndrome in the Pacific Northwest. Unpublished report. 9p. For additional sea star information see www.seastarsofthepacificnorthwest.info

⁸ Data from Gibbs, D.M., C. Gibbs, and A. Lamb. Pacific Marine Life Surveys. Data accessed March, 2016.

⁹ Harvell, C.D. 2016. Sea Star Wasting Summit, Seattle, Washington, January 17, 2016.

¹⁰ Eisenlord, M.E., M.L. Groner, R.M. Yoshioka, J. Elliott, J. Maynard, S. Fradkin, M. Turner, K. Pyne, N. Rivlin, R. van Hooideonk, and C.D. Harvell. 2016. Ochre sea star mortality during the 2014 wasting disease epizootic: Role of population size structure and temperature. *Philosophical Transactions of the Royal Society B*, 371: 20150212.

¹¹ Menge, B.A., E.B. Cerny-Chipman, A. Johnson, J. Sullivan, S. Gravem, and F. Chan. 2016. Sea star wasting disease in the keystone predator *Pisaster ochraceus* in Oregon: Insights into differential population impacts, recovery, predation rate, and temperature effects from long-term research. *PLoS ONE*, 11(5): e0153994.

Salmon

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What is happening with salmon?

For many Howe Sound streams, accurate counts of spawning salmon are not available but some trends are apparent from fisheries records and a few detailed studies. Following a number of years of low abundance, the dramatic return of Squamish River pink salmon in 2013 and 2015 is a major story for Howe Sound salmonids. Pink salmon returns were so strong in 2013 that Howe Sound had its first commercial opening for salmon in recent memory.¹ Meanwhile chum salmon returns in the Cheakamus Rivers in recent years have varied three fold. Chinook and coho salmon stocks have been depressed since the 1970s and 1980s, both in Howe Sound streams and in other systems throughout the Salish Sea.

Why are salmon important?

Salmon, by virtue of their abundance and provision of nitrogen from the sea, provide critical food supplies to the Howe Sound ecosystem at various stages of their life cycle. For example, resident orcas may feed on adult Chinook salmon as they return to Howe Sound through the Salish Sea. Spawning salmon and their carcasses provide food sources for eagles, gulls, bear and other predators.² Nutrients from carcasses may fertilize stream-side vegetation.

Cutthroat trout, along with dippers and mergansers may feed on the salmon eggs during spawning, while marine fish and seals can feed on juvenile salmon the following spring.

Salmon supply ecosystem services such as provision of seafood for Howe Sound communities and beyond. For example Squamish River Chinook salmon are caught

in commercial fisheries on the North Coast of B.C. as well as sports fisheries in the Strait of Georgia.³ Recreational fishers in streams draining into Howe Sound are usually restricted to catch and release for other salmonids (i.e., steelhead, cutthroat trout and bull trout). Regulations for other species vary from year to year and are usually set to protect wild stocks (e.g., currently only hatchery-reared coho may be retained).



Spawning salmon. (Photo: Gary Fiegehen)

How and where do salmon live in Howe Sound?

Salmon are anadromous fish, which means they spawn in fresh water and grow in the ocean. There are at least 33 streams draining into Howe Sound that salmon are known to use (Figure 1). Their eggs are laid in gravel in lakes, rivers, and streams. As an example of a salmon pattern life history, after they emerge from

eggs, Squamish Chinook salmon fry rear in rivers to the parr stage and move to the estuary, assuming the smolt stage, when they are ready to tolerate salt water. They rear in coastal waters, spend their adult life in the ocean, and return to the river to spawn.

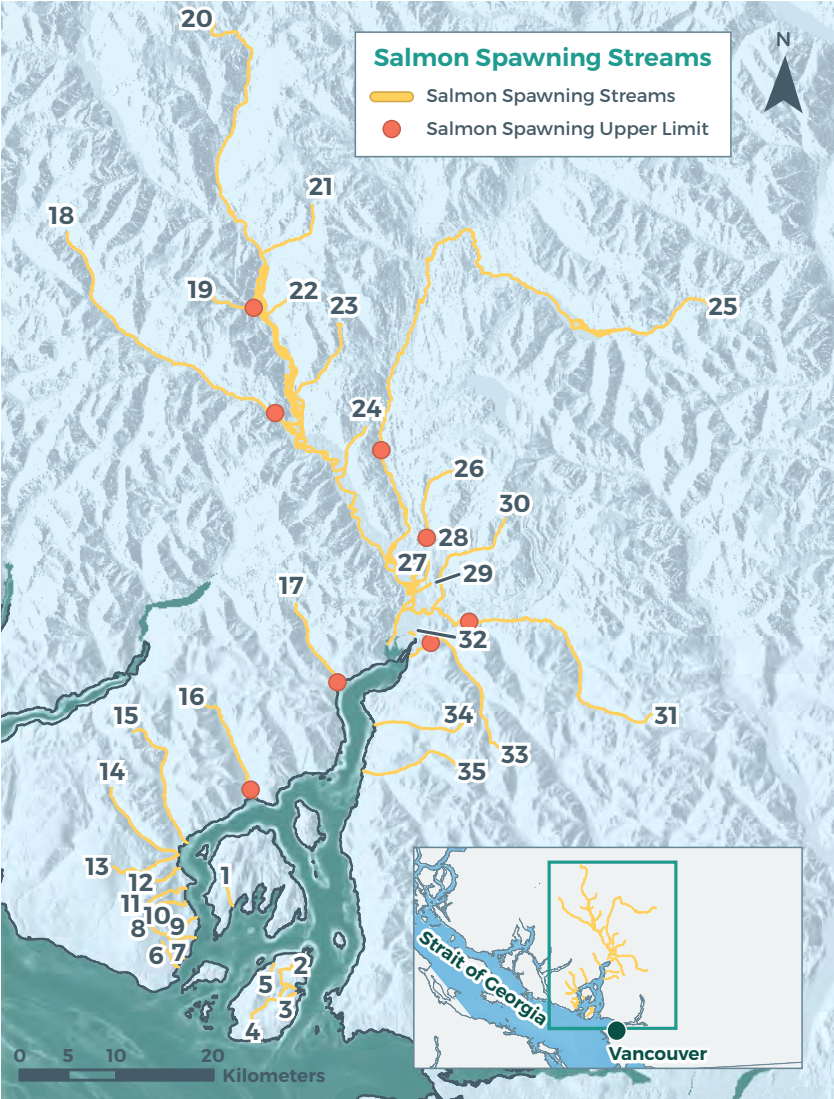


Figure 1. Major salmon streams draining into Howe Sound. Table on the following page shows stream names and salmon species present.⁴ (This is not an exhaustive list of streams that are ‘potential’ salmon habitat, and not all ‘known’ upper limits are marked.)

NUMBER	STREAM NAME	CHUM	COHO	PINK	CHINOOK	STEELHEAD
1	Whispering Creek					
2	Killarney Creek					
3	Davies Creek					
4	Terminal Creek					
5	Grafton Creek					
6	Gibsons Creek					
7	Soames Creek					
8	Langdale Creek					
9	Hutchinson Creek					
10	Ouillet Creek					
11	Twin Creek					
12	Bear Creek					
13	Dakota Creek					
14	McNair Creek					
15	Rainy River					
16	McNab Creek					
17	Mill Creek					
18	Ashlu Creek					
19	Spring Creek					
20	Squamish River					
21	Shovelnose Creek					
22	Twenty Eight Mile Creek					
23	High Falls Creek					
24	Pillchuck Creek					
25	Cheakamus River					
26	Brohm River					
27	Dryden Creek					
28	Hop Ranch Creek					
29	Meighan Creek					
30	Mashiter Creek					
31	Mamquam River					
32	Loggers Lane Creek					
33	Stawamus River					
34	Britannia Creek					
35	Furry Creek					

Chinook, coho, pink, chum and sockeye salmon die after spawning. Steelhead, cutthroat trout, and bull trout spawn more than once and may migrate to the ocean several times as kelts.

CHUM SALMON – Chum salmon are often the most abundant salmon species in the Squamish River system, and spawn in many small rivers and creeks along Howe Sound. Migration from the river to the estuary occurs fairly quickly after fry emerge from the gravel. Extensive studies of chum salmon ecology have been carried out in the Cheakamus River to monitor the BC Hydro Cheakamus Project Water Use Plan.⁵ Studies have shown that egg to fry survival is much higher in side channels as compared to the main stem of the Cheakamus River. The Squamish River estuary and its tidal channels are important habitat for chum fry⁶ and they are found in shallow water along all shorelines in Howe Sound.⁷ Chum fry near the mouth of Howe Sound (e.g., Bowen Island) are likely migrants from the Fraser River and other systems mixed with fish of Squamish River origin. Chum fry food sources along beaches include riparian vegetation.⁸

PINK SALMON – Pink salmon spawn every second year (odd years) in Howe Sound and complete their life cycle in two years. Pink salmon fry migrate to the estuary and ocean within a few days or even hours after they hatch and move along shoreline habitats in Howe Sound. When returning adults of this species are very abundant, as was the case in 2013 and 2015, they move into almost all the streams in Howe Sound to seek spawning gravel.

Within the Howe Sound watershed, **CHINOOK SALMON** only use the Squamish River system. Chinook salmon are a mixture of Vancouver Island stocks

introduced at the Tenderfoot Hatchery (Cheakamus River) starting in 1989 and wild native stocks. Some fish spend a year in the river before moving to the estuary and ocean⁹ while others may move seaward in less than a year.¹⁰ Hatchery-reared fish are now released into the river as smolts, sometimes after rearing in sea pens in Howe Sound at Porteau Cove. Abundance of juvenile Chinook salmon rearing on beach habitat in Howe Sound is highly variable; catches were highest in the head of the Sound and in the southeast sector of the fjord.¹¹

COHO SALMON are adapted to live in small streams. They typically spend one year in freshwater before migrating in spring to the estuary and ocean.¹² This species is found in the Squamish River system, streams on the west side of Howe Sound, and in several creeks on Bowen Island. Coho smolts migrate through Howe Sound in deep water channels.¹³ They feed on herring and large zooplankton at the head of the Sound.¹⁴

SOCKEYE SALMON were recorded from the Squamish River system in early surveys¹⁵ and must have been river rearing populations as there are no nursery lakes in the system. Sockeye smolts from the Fraser River have been captured in surface trawl surveys in Howe Sound.¹⁶

RESIDENT AND SEA RUN CUTTHROAT trout are sometimes recognized as indicators of the health of urban streams. If cutthroat trout are present, the stream likely provides potential salmon habitat.

Salmon in Squamish Nation cultural and spiritual heritage¹⁷



Xwelápetwx (Ned Lewis), Squamish Nation, with chum salmon caught in the Squamish River in 2008. (Photo: Gary Fiegehen)

“In the long ago, the Squamish people believed that salmon are supernatural, as reflected in an oft-told story that teaches listeners to treat the salmon with special respect because they are gifts from the Salmon People.

According to the story, the Xays (transformers), who traveled the world changing people into animals and mountains, were invited to a feast hosted by the Chief of the Salmon People. The Chief sent two young people into the water, where they were transformed into Salmon for the gathering, on the condition that every single salmon bone be returned to the water.

But, as the story goes, one of the Xays deliberately kept a bone, causing one young person to come back from the river deformed. The Chief took revenge by killing Xay and the seagulls plucked out his eyes. Brought back to life by his brother, Xay had to try out different salmon eyes as substitutes and the eyes that worked the best were from the Pink Salmon.

The story ends with the humbled Xays trying to convince the Chief to be at peace with them. The Chief agrees to send his people in cycles, the Pink Salmon only every other year, on the condition that all the bones of the first salmon caught during each harvest be returned to the water.”

What is the current state?

The number of salmon returning to spawn (escapement) in Howe Sound streams depends on their survival in river, estuary, and ocean. With the possible exception of pink salmon, the abundance of all salmonids in Howe Sound is lower now compared to the mid-1940s, which is the “baseline” time period for the Squamish River Watershed Salmon Recovery Plan.¹⁸ In general, spawning data for Howe Sound streams are not comprehensive¹⁹ and are of mixed quality. Visual counts are unreliable in the many rivers and streams in the Squamish River system, due to turbidity from

glacial silt. Visual counts are not comparable to tagging methods such as Peterson mark-recapture estimates. Chum salmon on the Cheakamus River probably have the best record (Figure 2).²⁰ Coho salmon hide in small streams and spawners are notoriously difficult to assess.

There are a variety of pressures on Howe Sound’s salmon populations. Salmon grow and mature in the Salish Sea as well as the coastal and mid-Pacific Ocean and are affected by factors such as sport and

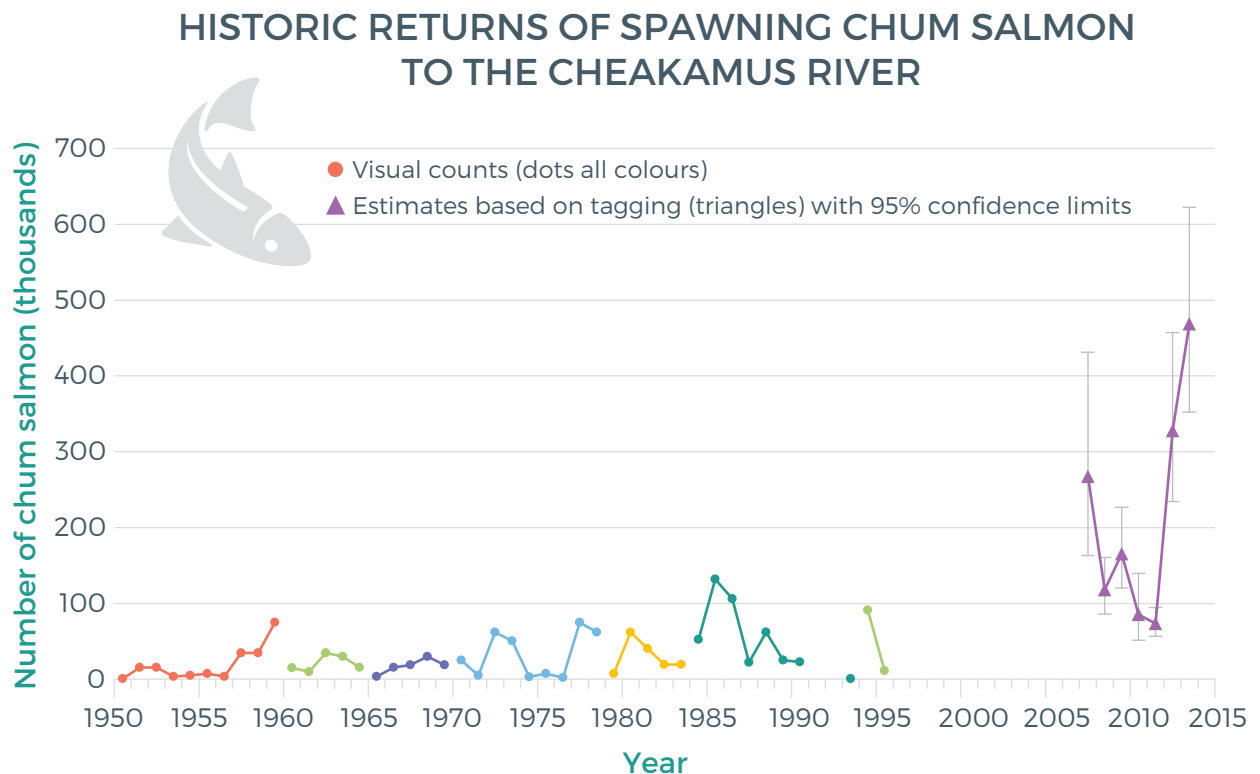


Figure 2: Historic returns of spawning chum salmon (escapement) to the Cheakamus River. Each series (lines of different colours) is not necessarily comparable to the others due to different methods used or different observers providing the visual counts. Data sources: Visual counts, 1950–1995, different colours indicate different personnel collecting data, (Adapted from Golder 2005). Estimates based on Peterson estimates (2007–2013) (Fell et al. 2015), confidence limits (vertical grey lines) illustrate the uncertainty surrounding the tagging estimates.

commercial harvesting, as well as ocean warming and acidification that can negatively affect food supply. Within Howe Sound, salmon have been adversely affected by loss of stream and estuary habitat, degraded water quality, and changes in freshwater flow. Increased winter flood events can scour salmon eggs from river gravels, while low flows in late summer can block returning salmon from access to their spawning grounds. Many of the problems are associated with land development in the past few decades, especially in the lower Squamish River system and urbanized creeks on Howe Sound. The continuing development of watersheds and estuaries, proposed industrial activity, and the cumulative effects on ecosystem processes and salmonid food supply are key emerging issues for Howe Sound.

The resilience of salmon may vary because of their differing life histories but this is an area of uncertainty. Pink salmon, with a short life span and brief residency as juveniles in the river and estuary, may be more resilient than Chinook salmon that live longer and use multiple habitats. Pink salmon have rapidly colonized newly constructed spawning and rearing areas along the Ashlu River, and this may link to increased survival. On the other hand, the substantial recovery of Chinook juvenile rearing habitat in the Squamish River and estuary has not led to increases in the wild populations, although it has helped support their conservation and persistence.

What is being done?

The Tenderfoot Creek hatchery on the Cheakamus River is run by the Department of Fisheries and Oceans and began releasing juvenile salmon in 1989. In 2015 the hatchery released about 200,000 chinook smolts, 550,000 coho smolts, and 1 million chum fry. In 2012, the hatchery released 1.3 million pink fry.

Community groups and others have also assisted in the recovery of salmonids in Howe Sound. For example, the community hatchery on Bowen Island²¹ has incubated chum and coho eggs from Tenderfoot Hatchery and released fry into island creeks. Community groups such as the Squamish Streamkeepers are involved in monitoring spawner abundance in the watershed. In addition, Squamish Nation biologists have assisted by providing information and synthesizing data on Chinook spawning areas which can help prioritize habitat restoration efforts.²²

Local community groups and agencies have done extensive salmonid habitat restoration in the Squamish River watershed and estuary: development of coho and chum salmon spawning channels in the Mamquam River, construction or restoration of extensive rearing channels in lower Squamish and Cheakamus Rivers, and reconnection of estuary side channels by putting culverts through dikes.²³ Other salmonid habitat restoration or recovery programs in Howe Sound include construction of a treatment plant for Britannia Mine waste water,²⁴ continuing remediation efforts at Britannia Mine (see Britannia Mine article), and installation of weirs to stabilize spawning ground gravel on Ouillet Creek near Port Mellon.²⁵

What can you do?

ACTIONS CONTRIBUTED BY CORI



Individual and Organization Actions:

- As an individual or organization, join local restoration efforts (e.g, Squamish Streamkeepers) to help monitor and maintain freshwater salmon habitat.
- Monitor fishery status and limits. Ensure you are fishing within current regulations.
- Eat sustainable seafood.



Government Actions and Policy:

- Increase focus on data collection in order to get accurate, high quality counts of spawners. Use tagging methods over visual counts where feasible.
- Increase support for community habitat restoration efforts including spawning channels, rearing channels, reconnection of side channels, and weirs.
- Promote and fund the rehabilitation of modified rivers and streams such that salmon habitat is enhanced. This includes promoting shaded riparian areas to help lower stream temperatures.
- Continue to monitor water quality and treatment, and support on-going remediation at Britannia Mine.
- Increase public education on the status of salmon, and how people can help salmon stocks recover.
- Recognise the importance of estuary habitat for spawning and rearing salmon.
- Protect all estuary habitats from residential, commercial, or industrial development.
- Reclaim and rehabilitate estuary habitat that has been modified by past development.
- Increase monitoring and enforcement of fishery limits, openings and closures.

Acknowledgements

Thanks are owing to the following for providing information or advice on Howe Sound salmon: Edith Tobe, Squamish River Watershed Society; DFO staff- community advisors Rob Bell-Irving and Grant McBain; assessment biologists Joe Tadey and Bruce Baxter;

Tenderfoot hatchery enhancement technician Jordan Uittenbogaard; Caroline Melville, Instream Consultants; retired Fishery Officer and salmon manager Bert Ionson; Squamish First Nation biologist Randall Lewis.

Resources

Tenderfoot Creek Hatchery

pac.dfo-mpo.gc.ca/sep-pmvs/projects-projets/tenderfoot/tenderfoot-eng.html

Squamish Streamkeepers Society

squamishstreamkeepers.net/streamkeepers/Welcome.html

Sunshine Coast Conservation Association (nominating Fisheries Sensitive Watersheds)

thescca.ca/index.php?option=com_content&view=article&id=293&Itemid=236

Footnotes

¹ According to Golder Associates (2005, Squamish River Watershed Salmon Recovery Plan. Submitted to Pacific Salmon Foundation. p.74) commercial gillnetting and trolling for salmon in Howe Sound were active until 1956 and 1968, respectively. According to Keller and Leslie (Keller, B.C. and R.M. Leslie. 1991. Bright Seas, Pioneer Spirits. The Sunshine Coast. Horsdal and Schubart. Victoria. p.180) gillnetters fished out of Gibsons “until the 1940s when the Howe Sound dog (chum) salmon petered out.” DFO catch statistics (<http://www.pac.dfo-mpo.gc.ca/stats/comm/index-eng.html>) show that for Area 28 (mainly Howe Sound) there were gillnet landings up to 1967 and troll landings to 1968. The last seine landings were from 1951 but it should be noted the catch records in the above file begin that year and there may have been seine fisheries in previous years. The author acknowledges the assistance of retired DFO Fisheries Officer Bert Ionson in locating historical catch data sources.

² E.g., Elliott, K.H., J.E. Elliott, L.K. Wilson, I. Jones, and K. Stenerson. 2011. Density-dependence in the survival and reproduction of Bald Eagles: Linkages to Chum Salmon. The Journal of Wildlife Management 75(8): 1688-1699.

³ Levings, C.D. and B.E. Riddell. 1992. Salmonids and their habitats in Howe Sound: status of knowledge, p. 65-81 in Levings, C.D., R.B. Turner and B. Ricketts (Ed) Proc. Howe Sound Environmental Science Workshop Can. Tech. Rep. Fish. Aquat. Science 1879. 262p.

⁴ Information on which streams are supporting salmon and which species have been recently observed in each stream was provided to the author by B. Ionson, retired DFO Fisheries Officer, R. Bell-Irving and G. McBain, DFO Community Advisors, by personal communication in 2016. Concerning Grafton Creek, coho fry were released there but no adults have been observed so far (R. Bell-Irving). Concerning Soames Creek, salmon have not been observed in recent years, but the creek was clearly identified as a cutthroat stream in 2005. (Slaney, P. and J. Roberts. 2005. Coastal Cutthroat Trout as Sentinels of Lower Mainland Watershed Health. Ministry of Environment. Accessed Sept 12, 2016. <http://www.shim.bc.ca/cutthroat/ct.pdf>).

⁵ Fell, C., D.J.F. McCubbing, L.J. Wilson, and C.C. Melville. 2015. Evaluations of the Cheakamus River Chum Salmon Escapement

Monitoring and Mainstem Groundwater Survey from 2007–2014, and Chum Fry Production from 2001–2015. Cheakamus River Monitoring Program #1B. Technical report for BC Hydro – Coastal Generation. 80 p. + Appendices

⁶ E.g., Levy, D.A. and C.D. Levings. 1978. A description of the fish community of the Squamish River estuary, British Columbia: Relative abundance, seasonal changes, and feeding habits of salmonids. Fisheries and Marine Service Manuscript Report No. 1475.

⁷ Tobe, E. and K. Morgan. 2012. Howe Sound Chinook Smolt Outmigration Pilot Study. Final Report. Prepared for Pacific Salmon Foundation. January 28, 2012.

⁸ Romanuk, T.N. and C.D. Levings. 2005. Stable isotope analysis of trophic position and terrestrial vs. marine carbon sources for juvenile Pacific salmonids in nearshore marine habitats. Fisheries Management and Ecology 12(2): 113–121.

⁹ Schubert, N.D. 1993. Enumeration of the 1988–1992 Squamish River Chinook salmon escapement. Canadian Manuscript Report Fisheries and Aquatic Sciences No. 2187.

¹⁰ Levings and Levy 1978; Tobe and Morgan 2012.

¹¹ Tobe and Morgan 2012.

¹² Ryall, R. and C.D. Levings. 1987. Juvenile salmon utilization of rejuvenated tidal channels in the Squamish estuary, British Columbia. Canadian Manuscript Report of Fisheries and Aquatic Sciences 1904, 23 pp.

¹³ Melnychuk, M.C., V. Christensen and C.J. Walters. 2013. Meso-scale movement and mortality patterns of juvenile coho salmon and steelhead trout migrating through a coastal fjord. Environmental Biology of Fishes 96(2–3): 325–339.

¹⁴ Parker, R.A. and B.A. Kask. 1972. Third progress report on studies of the ecology of the outer Squamish estuary, June 7 1972. Fisheries Research Board of Canada Manuscript Report Series 1994. 13 p.

¹⁵ Golder Associates Ltd. 2005. Squamish River Watershed Salmon Recovery Plan: Final Report. Prepared for the Pacific Salmon Foundation. 187p.

¹⁶ Beamish, R., C. Neville and R. Sweeting. 2012. An early marine life history strategy for Fraser River sockeye salmon. NPAFC Doc. 1423. 23 pp. Fisheries and Oceans Canada, Pacific Biological Station. (Available at www.npafc.org).

¹⁷ Reproduced with permission from “Where Rivers, Mountains and People Meet,” Squamish Líl’wat Cultural Centre

¹⁸ Golder Associates Ltd. 2005.

¹⁹ For example, the available data record for chum salmon spawning in McNab Creek only extends from 1950 to 1989 (Sunshine Coast Conservation Association. 2016. Accessed Aug 10, 2016. http://www.thescca.ca/index.php?option=com_content&view=article&id=294&Itemid=237).

²⁰ See references in Fell et al 2015.

²¹ <http://www.bowenhatchery.org>

²² Randall Lewis, Squamish Nation, kindly made the following report available to the author during the preparation of this article: Golder Associates. 2008b. Synthesis of 10 years of Chinook spawner enumeration data for selected systems in the Squamish River watershed: 1997–2006. pp. 85. Burnaby, BC: Golder Associates Ltd. Prepared for the Squamish Nation.

²³ Squamish Streamkeepers. Ashlu Channels Pink Counts (2003–2011). Accessed August 10 2016. http://www.squamishstreamkeepers.net/streamkeepers/Ashlu_Pink_Counts.html

²⁴ O’Hara, G. 2007. Water Management Aspects of the Britannia Mine Remediation Project, British Columbia, Canada. Mine Water and the Environment 26(1): 46–54.

²⁵ McBain, G. 2016. Data from Community Advisor Files, Department of Fisheries and Oceans, Madeira Park, B.C.

Lingcod

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What's happening with lingcod?

Lingcod stocks in Howe Sound remain low despite commercial and recreational fishing closures for the last decade or more. During the last century, lingcod biomass was drastically reduced due to commercial fishing. By the late 1980s, lingcod stocks in Howe Sound hit a low of 1% of original biomass.¹ Commercial fishing closures were introduced in 1990, but lingcod abundance did not improve and in 1993 Porteau Cove and Whytecliff Park were designated as no-take closure areas under the Fisheries Act of Canada. An increase in the abundance of spawning lingcod was evident at the turn of the millennium, but levels were still far below those outside of Howe Sound. No discernible increase in large female spawners — typically the most successful spawners — has been evident since 1994 (Figure 1). Today, recreational fishing presents the greatest threat to Howe Sound lingcod populations despite fishing closures, and poaching is a likely contributor to the lack of recovery of spawner abundance. Research has shown that larger lingcod populations occur along island shorelines that are accessible only by boat.²



Adult lingcod with two plumose anemones.
(Photo: Vancouver Aquarium)

Why are lingcod important?

Lingcod range from Northern California to the Aleutian Islands in Alaska and can be found throughout Howe Sound. They are typically found on rocky reefs between 10–100 metres deep, where crevices and large boulders provide ideal habitat for spawning during the winter. Lingcod are an important component of reef

communities in Howe Sound. They act as a top-down control on mid-level predators such as rockfish and smaller greenlings, maintaining a balanced community structure.³ Lingcod consume a variety of smaller fish including herring and bottom-dwelling fish, while marine mammals are their main predator.⁴

Do lingcod play a role in First Nations cultural and spiritual heritage?

Lingcod have been relied upon as a food source by First Nations during times of famine when salmon returns were low.

What is the current state?

Extensive commercial and recreational fishing pressures from the mid 1800s until the 1980s depleted lingcod stocks to a historic low. An annual lingcod spawning population survey — conducted in Howe Sound since 1994 — indicates a slow recovery may be taking place since the late 1990s based on diver surveys, with a notable increase in egg mass sightings in 2000 but no sustained increase since then (Figure 1). Abundance peaked in 2006 following a Fisheries and Oceans Canada (DFO) enforcement campaign along the Sea-To-Sky corridor in 2005, which targeted illegal recreational fishing. Prior to 2014, DFO assessments of lingcod stocks have excluded management areas 28 and 29 (Howe Sound, Indian Arm and the ad-

jacent nearshore waters of the Strait of Georgia) due to confusion with historical catch data. In scenarios where these areas were included in the 2014 assessment,⁵ increase of lingcod stock biomass compared to historical levels was lowest. However, in all scenarios of inclusion or exclusion of this region, spawning lingcod biomass was predicted with 100 percent certainty to be greater in 2014 than in 2006, when stocks were last assessed.

An annual lingcod egg mass survey runs each February–March and is organized by the Vancouver Aquarium Marine Science Centre’s Howe Sound Research Program with help from divers up and down the coast

of British Columbia. During the spawning survey, information about egg mass size is collected to provide clues about the age structure of the female population, as older lingcod produce larger egg masses. At five years of age females begin to produce watermelon-sized egg masses. The percentage of large egg

masses has fluctuated over the years of the survey, and 2015 represents an average year with 47 percent of females aged five or older (Figure 1). In contrast, areas of Northeast Vancouver Island consistently record greater than 90 percent of egg masses as watermelon-sized.

ANNUAL LINGCOD EGG MASS SURVEY IN HOWE SOUND

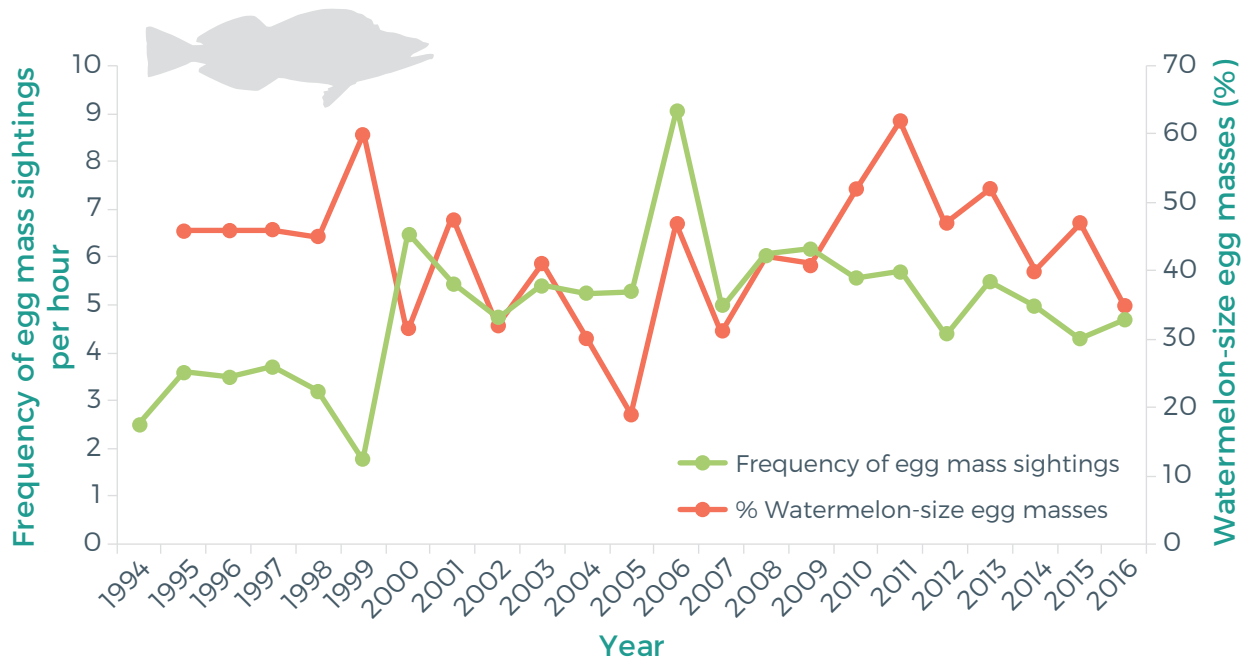


Figure 1. Frequency of egg mass sightings per hour and percentage of watermelon size egg masses (females at least five years old) in Howe Sound 1994-2015.

What is being done?

Commercial fishing for lingcod in Howe Sound has been closed since 1990. Recreational fishing for lingcod is prohibited throughout the Sound and has been since 2002. As a further measure, and due to the ex-

tremely low abundance of lingcod in Howe Sound and Burrard Inlet, all hook-and-line fishing for groundfish (lingcod and rockfish) was banned beginning in the summer of 2007.

What can you do?



Individual and Organization Actions:

- Follow fishing closures for the recreational fishery and report any illegal fishing to 604-666-3500 (1-800-465-4336). Even if not involved in fishing, educate yourself on fishing practices so you are able to report poaching.
- Support the annual Lingcod Egg Mass Survey in February and March by spreading awareness and contributing dive surveys to the Vancouver Aquarium (www.vanaqua.org/lingcod-survey).



Government Actions and Policy:

- Increase public education and awareness surrounding the closures of commercial and recreational fisheries, and the status of Lingcod populations.
- Work with the Vancouver Aquarium to help encourage awareness of and participation in the annual Lingcod Egg Mass Survey.
- Designate more resources to effective monitoring and enforcement of fishing closures.
- Continue to include area 28 and 29 in ongoing assessments of lingcod stocks.



Lingcod with egg mass. (Photo: Jenn Burt)

Resources

2015 Lingcod egg mass survey report including more information on lingcod biology and comparative survey results for other areas in British Columbia.

www.vanaqua.org/files/7514/4857/6020/2015_LEMS_report.pdf

DFO. 2015. Stock assessment for Lingcod (*Ophiodon elongatus*) for the Strait of Georgia, British Columbia in 2014.

www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2015/2015_014-eng.pdf

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Footnotes

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Rockfish: the search for hints of recovery

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What's happening?

Inshore rockfish populations remain low in Howe Sound following severe depletion through the last century. Species such as black, Bocaccio and yelloweye (red snapper) rockfishes saw declines in their populations due to bycatch in salmon sport fishing during the 1960s, a significant issue in the Strait of Georgia and Howe Sound. In fact, many of these rockfish species were considered “trash fish” in sport fishing and were promptly discarded.¹ However, black rockfish were successfully re-introduced in Howe Sound, via transplant in 2005 to one site, and can now be found at two additional sites (Figure 1). Bocaccio rockfish are rarely sighted in Howe Sound, whereas yelloweye rockfish occupy southwestern Howe Sound at low levels. Yelloweye rockfish were previously abundant in the shallow waters of the Strait of Georgia.²

Further depletion of rockfishes occurred during the 1980s when live market fisheries caused the serial depletion of rockfishes on a reef-by-reef basis — particularly for copper and quillback rockfish.³ Due to rapidly declining populations, Fisheries and Oceans Canada introduced a Rockfish Conservation Strategy⁴ that included the introduction of 164 rockfish conservation areas (RCAs) along the B.C. coast in 2007, 11 of which were designated in Howe Sound (Figure 2).

Why is it important?

There are 65 species of rockfishes ranging from Alaska to Baja California, and 37 species found in British Columbia. A total of 14 species have been recorded in Howe Sound during scuba-depth surveys, though sightings of some species (blue (deacon), China, split-nose and canary rockfish) have been rare (Figure 1). An additional two species are known to occur in the sound — redstripe rockfish and greenstripe rockfish – but often at depths beyond scuba surveys. Inshore rockfish species such as those found in Howe Sound, occur in highest densities on rocky reefs and com-

plex boulder piles between one and 838 metres deep. The most common species are quillback and copper rockfishes, which can be found in all parts of Howe Sound (Figure 1). Many species of rockfishes are long-lived — some over 100 years — and occupy small home ranges, making them particularly susceptible to over-fishing.⁵ Rockfishes fulfill a mid-level predator role in the reef community in the Northeast Pacific. In reef communities, rockfishes eat crustaceans and small fishes and are in turn eaten by lingcod and seals, making them an important link in the food chain.⁶

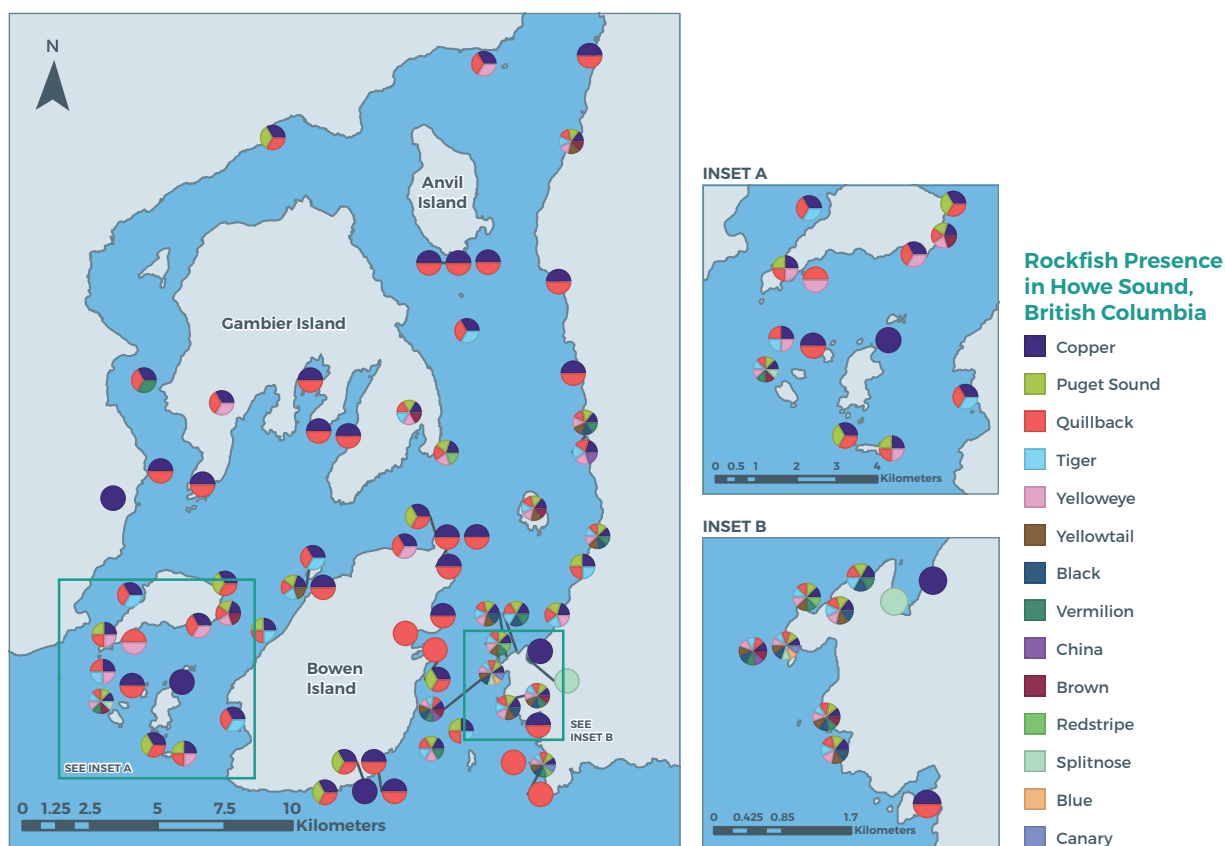


Figure 1. Distribution of rockfish species sightings in Howe Sound since 1967 based on scuba surveys.

Do rockfish play a role in First Nations cultural heritage?

Inshore rockfishes have been harvested on the coast of British Columbia for millennia by coastal First Nations peoples. In the Salish Sea, rockfishes were harvested and consumed likely as a staple food available at any time of year when seasonally abundant species like salmon were not available.⁷

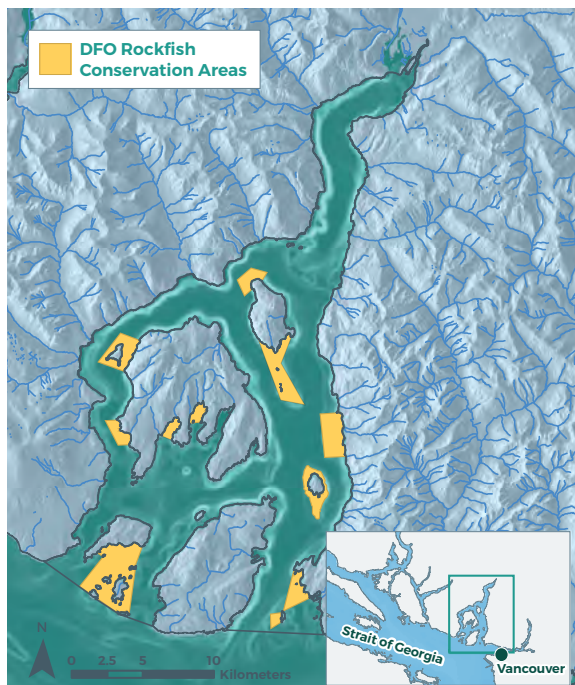


Figure 2. Rockfish Conservation Areas in Howe Sound.



Adult copper rockfish, one of the most common species of rockfishes found in Howe Sound. (Photo: Lee Newman)

What is the current state?

Rockfishes are long-lived species and do not reach sexual maturity for decades in some cases. Therefore it will take many years of monitoring to provide conclusive evidence of any trend if there is one. One positive indication of change comes from comparing the size distributions of copper rockfish populations at Whytecliff Park⁸ prior to its designation as a no-take protected area in 1993 with more recent data (Figure 3). Unpublished data, from detailed dive surveys in the 1980s with the main focus on Whytecliff Park,⁸ provided to the Vancouver Aquarium Marine Science Centre's Howe Sound Research Group (HSRG), compared to data collected by the HSRG in 2010–2011 show that the fish were smaller in the 1980s (Figure 3). The average size of fish prior to fishing closures was approximately 20 centimetres, still considered a juvenile and thus not sexually mature.⁹ By comparison, the size distribution of copper rockfish at Whytecliff Park 25 years later, and after 17 years without legal fishing pressure, shows larger fish on average, indicative of more sexually mature adults. This size difference is a positive indication of change, as larger rockfish produce more numerous larvae that also exhibit greater survival.¹⁰ Additional data for this comparison (not shown) indicated that overall abundance of copper rockfish was greater in 2010–2011. It is on this length of time scale that we can reasonably assess changes in rockfish abundance and demography.

Several studies have examined the effectiveness of RCAs in recovery of rockfish populations in Howe Sound,^{11,12} and the Strait of Georgia¹³ since 2006. Placement of RCAs was initially determined by a habitat model followed by public consultation. During the

establishment of these RCAs, a study examined how rockfish density varied based on habitat at sites inside and outside RCAs in Howe Sound, and found that only the percentage of boulders (high complexity habitat) predicted rockfish abundance.¹⁴ Another study examining effectiveness of RCAs in Howe Sound and other Strait of Georgia regions in 2009–2010 showed similarly that habitat was a key predictor of rockfish abundance and density and also found lower rockfish density in Howe Sound than in Sechart and the Southern Gulf Islands.¹⁵ Surveys using Remotely Operated Vehicles (ROVs), from 2009 to 2011, of deeper water in 13 RCAs in the Strait of Georgia, including two in Howe Sound, again found that there was no detectable effect of RCAs on rockfish abundance.¹⁶ Each of these studies found that habitat quality was strongly linked to rockfish abundance, more so than the presence of an RCA. This begs the question of whether the RCAs were effectively placed and reinforces the idea that longer time scales are required when studying change in rockfish populations. The Vancouver Aquarium's annual citizen science rockfish abundance survey conducted along the South Coast of B.C., including Howe Sound, will help to create a long-term dataset that can identify trends in rockfish abundance in Howe Sound.

What is being done?

Howe Sound continues to be closed to all hook-and-line jigging for groundfish (rockfishes and lingcod) and has been since 2007. Eleven RCAs in Howe Sound remain in effect, however there is some evidence that lack of compliance with fishing closures and regulations maybe compromising the effectiveness of RCAs.¹⁷ The Vancouver Aquarium conducts an annual

Rockfish Abundance Survey from August to October each year in Howe Sound, collecting information on species abundance and age class (adult, juvenile and young-of-the-year). Data from these surveys are summarized in a report made available online through the Vancouver Aquarium webpage.¹⁸

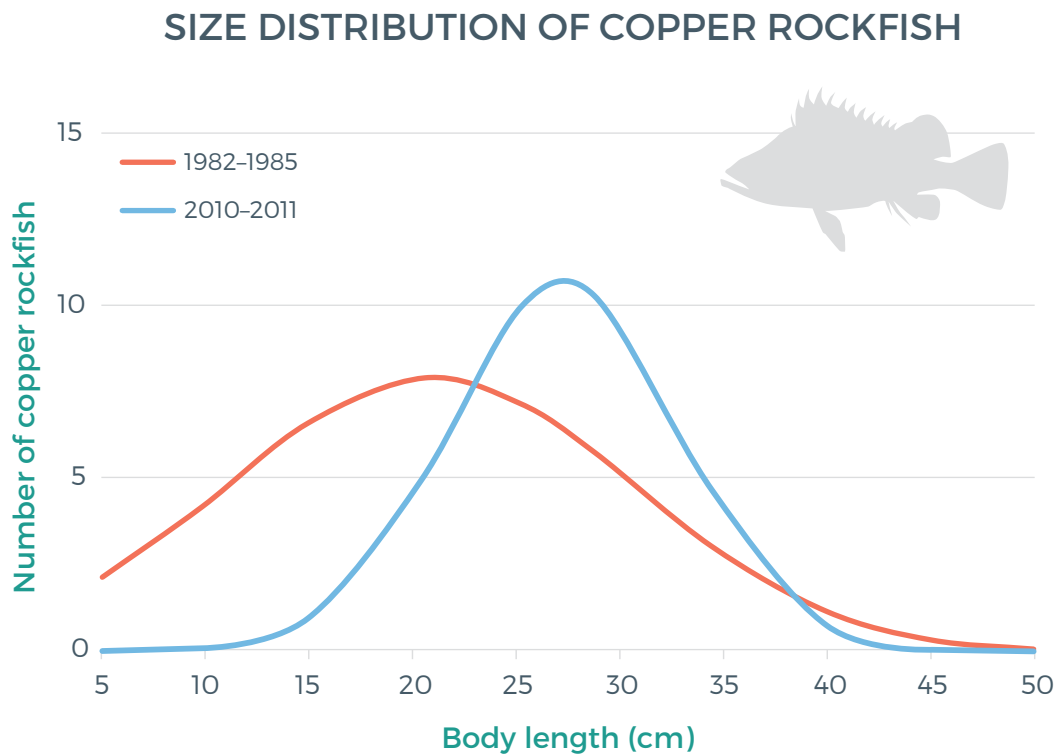


Figure 3. Size distribution of copper rockfish at Whytecliff Park, Howe Sound in 1982-1985 and 2010-2011.

What can you do?



Individual and Organization Actions:

- Abide by fishing regulation which has all of Area 28, which includes Howe Sound, closed to hook-and-line jigging for groundfish
- Report illegal fishing activities to DFO 604-666-3500 (1-800-465-4336)
- Support the annual rockfish abundance survey by spreading awareness and contributing dive surveys to the Vancouver Aquarium (www.vanaqua.org/rockfish-survey)



Government Actions and Policy:

- Commit more resources to monitoring rockfish populations in RCAs with suitable habitat
- Commit more resources to monitoring and enforcing compliance with fishing regulations in RCAs
- Simplify regulations in the RCAs
- Increase public education and awareness of closures to commercial and recreational fisheries, and the status of rockfish populations.

Resources

David Suzuki Foundation Rockfish Conservation Areas in B.C.: Our current state of knowledge. 2013 www.davidsuzuki.org/publications/RockfishConservationAreas-OurCurrentStateofKnowledge-Mar2014.pdf

Vancouver Aquarium Annual Rockfish Abundance Survey Report www.vanaqua.org/rockfish-survey

Fisheries and Oceans Canada Rockfish Conservation Areas (RCAs) – Pacific Region www.pac.dfo-mpo.gc.ca/fm-gp/maps-cartes/rca-acs/index-eng.html

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Bald Eagles

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What is happening with bald eagles in Howe Sound?

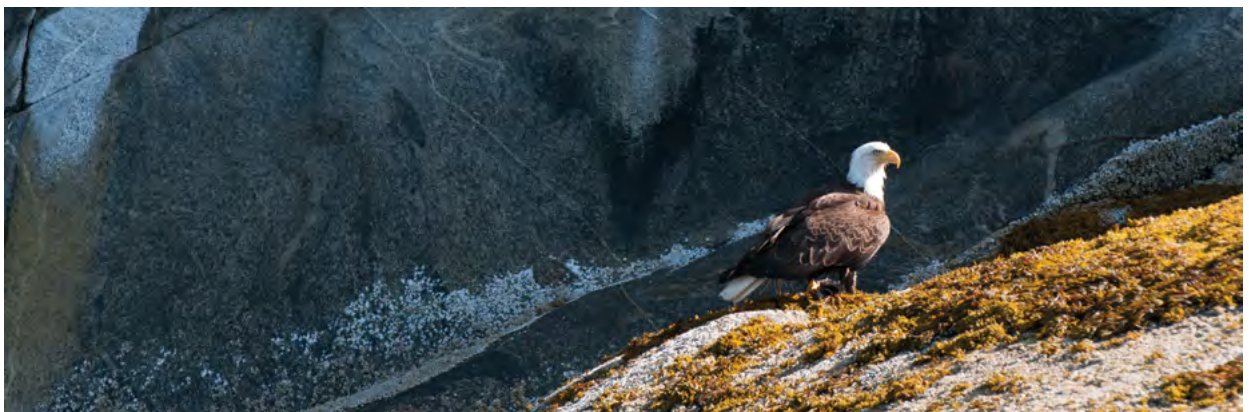
Large numbers of bald eagles are drawn each year during the late autumn and winter to the Squamish Valley to feed on spawning salmon. Thousands of visitors flock to the Brackendale area to see this spectacle of nature. Each weekend from November to January, Eagle Watch volunteers provide visitors with telescopes or binoculars for eagle viewing along the Squamish River at Brackendale.¹ In 2015, the Eagle Watch program of the Squamish Environment Society celebrated its 20th year. January 2016 was also the 30th anniversary of the Brackendale Winter Festival and Eagle count, sponsored by the Brackendale Art Gallery. Dozens of volunteers led by Thor Froslev count eagles each January. In 1994, 3,769 eagles were counted, a world record at the time. In January 2016, the count was only 411 eagles, the lowest count on record. This low number was likely due to late autumn and early winter floods that swept salmon carcasses to the sea, and forced eagles to move elsewhere for food, such as the Fraser River delta, which saw high numbers.²

Why are bald eagles in Howe Sound important?

Bald eagles are versatile and opportunistic feeders, exploiting a wide range of foods. In coastal British Columbia, they prey predominantly on fish, seabirds, waterfowl, intertidal invertebrates, small mammals and even gull eggs³ and carrion of all sorts. On occasion, they do take small domestic animals. In spring most eagles migrate north along the coast or inland to nest. Some eagles nest along the coast, choosing large old trees close to shoreline areas where they can forage for food. Eagles move back to the coast after salmon spawning begins in late August and September and spent salmon carcasses become available.⁴ Eagles gorge on food when it is available and then can digest it over several days. They can survive days and even weeks of fasting which allows them to take full advantage of seasonally abundant food sources.

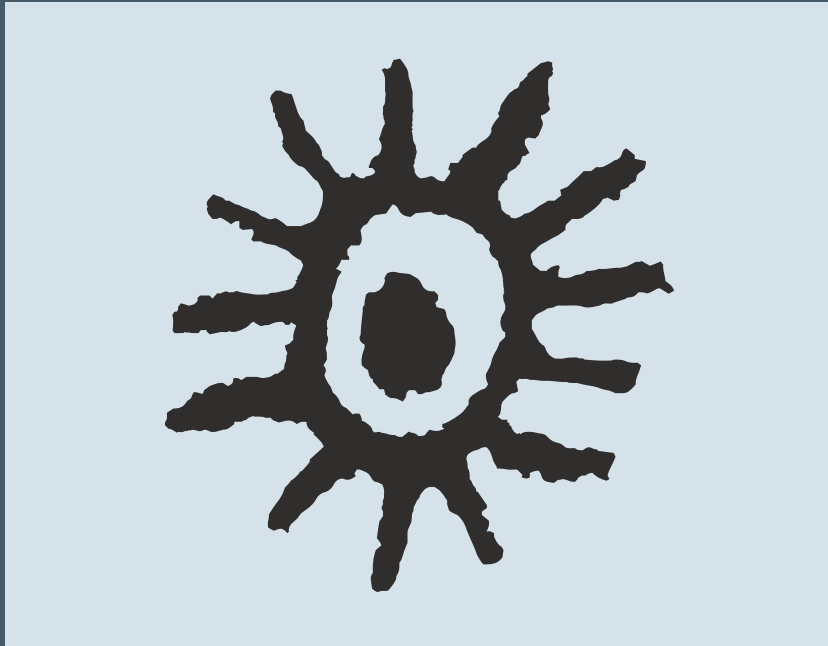
Bald Eagle numbers in the Pacific Northwest have rebounded tremendously over the past decades following restrictions on hunting, lead shot, and contamin-

ants such as DDT and PCBs.⁵ There are, however, still concerns of their being exposed to persistent dioxins and furans (pulp mill pollutants). Historically the lower Squamish River Valley has been a major winter feeding ground for bald eagles along the south coast, arriving during the annual chum salmon runs from mid November to mid February.⁶ Because of the eagles, Brackendale is identified as one of Canada's Important Bird Areas (IBA).⁷ The IBA Program is an international conservation initiative coordinated by BirdLife International with Canadian co-partners Bird Studies Canada and Nature Canada. In 1999, Brackendale Eagles Provincial Park was established to protect 755 hectares of prime habitat for winter roosting and foraging by eagles.⁸ Because of our admiration for these great birds, eagle watching has become an important part of the Squamish lifestyle and tourist economy and celebrated through the Eagle Watch program and Eagle Festival.^{1,6,9}



Bald eagle in near shore habitat. (Photo: Gary Fiegehen)

Do bald eagles have a particular connection to First Nations?



“Cultures all over the world have similar ways of depicting the sun. In Squamish mythology, the sun comes to the earth in the form of an eagle.”¹⁰

What is the current state of bald eagles?

Bald eagles flock to the lower reaches of the Squamish River during the mid winter chum salmon runs. Most of what we know about bald eagles comes from winter counts during this period. Scientific counts of the transitory eagle population likely began with the advent of the awakening of the coastal estuary crisis

in the early 1970s¹¹ but this task was soon overtaken by citizen initiative counts beginning with the annual Christmas Bird Count in Squamish in 1980 and the Brackendale Eagle Festival, sponsored by enigmatic and irrepressible Thor Froslev of Brackendale, in the winter of 1985/86. The Christmas Bird Count

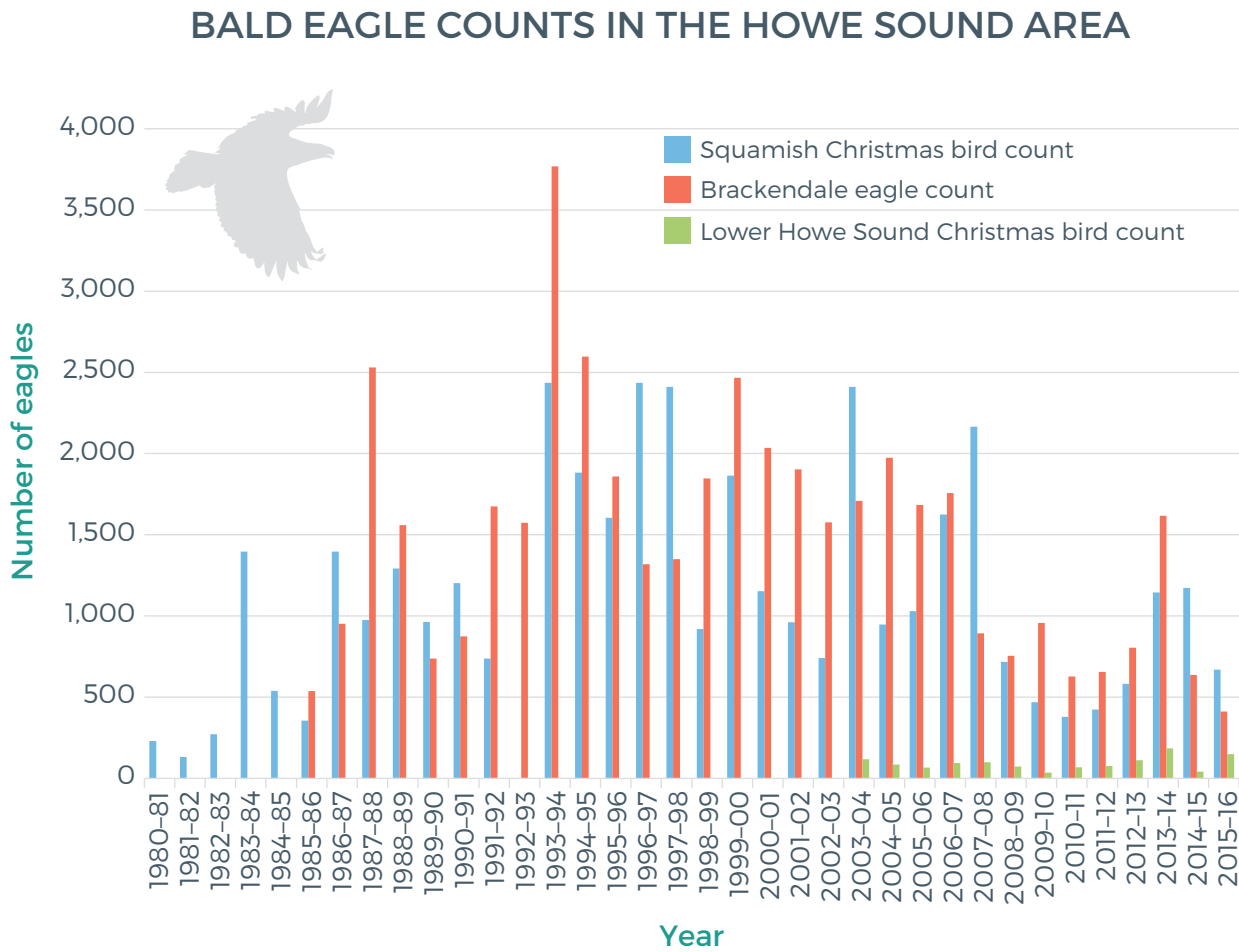


Figure 1. Counts of bald eagles in the Howe Sound basin from three regular bird counts.¹² Note the variability and the lower numbers in recent years.

at Squamish usually takes place in mid December, whereas the Brackendale Festival Count is usually in early January. The early January count encompasses all parts of the Squamish River watershed where salmon carcasses are found including the lower reaches of the Ashlu and Elaho rivers, the Cheakamus River up to the end of the road in Paradise Valley, and the Mamquam River upstream to the powerhouse. On the other hand, the area surveyed in mid-December extends only 15 kilometres upstream into the Squamish River basin. Fortunately, it covers the lower reaches of the Mamquam, Cheakamus and Squamish Rivers where eagles are most abundant.

Weather and human factors can affect the reliability of eagle counts. On one count, a heavy snowfall blanketed the trees and likely caused white-headed eagles to be overlooked, especially in distant viewing areas. In another year, rafts failed to launch, thus 15 kilometers of an otherwise unreachable section of the Squamish River remained uncounted. In yet another year, the count occurred during a deep freeze and a biting north wind. The eagles retreated from exposed sites, deep into the shelter of dense forest and out of view of many counters. Wind or other disturbance can cause birds to leave their tree perches too early in the day for the count. Once airborne, eagles fly in huge circular “kettles” which move erratically from one count sector to another, confusing the counters below. Despite these shortcomings, the manager of the early January count, Thor Froslev, maintains that the overall accuracy is out by no more than five percent.

Winter resident eagles frequent the islands and mainland shorelines at the entrance to Howe Sound. However, eagles counted during the Lower Howe Sound Christmas bird count surveys, begun in 2003, are less

than 10 percent of winter counts in the Squamish area. Year-round residents within the Sound are also low in numbers and their nests are far apart and few. For example, there are only two nests at the Squamish Estuary and one in Lighthouse Park near the entrance to the Sound.

Are there hot spots in the counts? Contrary to popular thought, the site of the 20-year old Eagle Watch Program¹ on the river dike at Brackendale is not, but it is a handy spot to see some, and volunteers provide spotting scopes to watch them. The 36 years of winter counts invariably shows the greatest concentration of eagles on the lower reach of the Cheakamus River and its confluence with the Squamish River, where the primary author usually does his observations for each count. Upstream, areas near the Cheakamus Center and Tenderfoot Hatchery typically host large numbers. More rarely the artificial spawning channels on the lower Mamquam River, and the Ashlu and Elaho tributaries provide counts that number in a few hundred eagles. There are also anomalous years with unusual hotspot locations. In the 2015/16 count season, the Squamish municipal landfill provided the highest number of the paltry 411 eagles counted for the early January survey. In that year there were virtually no fish carcasses in or beside the rivers; they had been swept away by late autumn and early winter storm events, forcing eagles to other food sources, including the tasty fare of thousands of gulls at the landfill.

Comparing the two winter eagle surveys in Figure 1, there are 19 years of higher counts for the more extensive early January count, as would be expected, but, surprisingly, nine other years where the earlier but less extensive Squamish survey had the higher numbers. That is, the higher count was in mid-December as op-

posed to early January. Why? Furthermore, over the three decades that both surveys have been conducted, only three years have produced very high counts in both surveys (i.e. 1993/94, 1994/95 and 1999/2000). Both of these observations indicate a large variation in eagle populations over the course of any given winter season. The “finger” points to the following to account for the discrepancies: (1) high runoff storms are removing spent fish carcasses (usually chum and perhaps coho salmon); (2) the spawning runs of either species were low or arrived early; and (3) both possibilities together.

The data for the 35 years of eagle counting allows some summary observations: eagle counts were low in the period of 1980 to 1985, generally high for 1993 to 2000, and low again in the last eight years (2008 to 2015/16), with one year above-average in 2013/14. While the numbers are low in the last few years, it does not mean that eagles are disappearing. Eagles are very opportunistic and move elsewhere for their winter food,² Harrison River counts have been high in recent years, and in 2016 there was such an unusual abundance at Burns Bog and nearby Fraser River delta that it attracted news media attention.¹³ The Brackendale Festival, however, suffered an all-time low of 411 eagles in 2015/16. This has prompted the organizers to re-schedule next year’s count to early December in the hope that eagle numbers will be higher then.

Bald eagles are very dependent on chum salmon runs for food during the early and mid winter when adult eagle mortality is high.⁵ When salmon are not available, eagles turn to less favourable prey such as gulls, marine birds, and landfill waste. Climate models for coastal B.C. suggest that flood events in late autumn and early winter due to storms and rain-on-snow



Bald eagle. (Photo: Thor Halvorson)

events will increase in magnitude and frequency with future climate change.¹⁴ Such increased future floods will pose the risk of larger and more frequent flushing of salmon carcasses to the sea, depriving eagles of important winter food supplies, causing eagles to move from the lower Squamish valley to places with alternative food supplies such as the Fraser delta. Overall, while continental populations of bald eagles may be increasing, their geographic range is gradually shrinking due to habitat loss.

What is being done?

The Eagle Watch Volunteer Interpretive program of the Squamish Environmental Society educates visitors about eagle biology and viewing ethics during winter weekends and the Christmas week at the Eagle Run dike in Brackendale, one of the easiest access sites

in the Squamish Valley.^{6,15} Each year the Brackendale Winter Eagle Festival and Count promotes education and awareness of eagles with lectures and events.¹⁶ The annual Christmas Bird Counts in Squamish and lower Howe Sound also observe and count eagles.



Bald eagle. (Photo: Thor Halvorson)

What can you do?



Individual and Organization Actions:

- Learn more about eagles by watching live streaming web cams of eagle nests (see “Resources”) or by attending Eagle Watch at Brackendale during the winter.
- Use proper viewing ethics when watching eagles. Do not disturb eagles feeding or roosting.
- Know the rules that protect eagles. It is an offense to possess, take, injure, molest, or destroy a bird or its eggs. Eagle nests are protected year round, whether or not the nest is in use, by the B.C. Wildlife Act.¹⁷
- Adopt the best practices guidelines for protecting eagle nests during development that include identification of eagle nests before development and the establishment of a vegetated no-disturbance buffer zone around the nest tree.¹⁸



Government Actions and Policy:

- Empower local stewardship by increasing public bald eagle education efforts and education of regulations of the B.C. Wildlife Act, and locations of eagle nests and Important Bird Areas. Increase enforcement of activities restricted in the B.C. Wildlife Act.
- Closely monitor and manage prey species populations, specifically to ensure adequate chum runs are available to support eagle populations.
- Legally recognize and strictly regulate Important Bird Areas as Protected Areas, especially in IBAs that do not have established legal protection (e.g. National and Provincial Parks). Where this is not feasible, consider conservation easements and agreements, private land stewardship, and land acquisition to ensure protection.
- Legislate against the production and use of harmful chemicals (e.g. POPs).

Resources

Eagle Watch, Squamish Environmental Society
squamishenvironment.ca/programs/eaglewatch/

Brackendale Winter Eagle Festival
brackendaleartgallery.com/Festival.html

Squamish as an Important Bird Area of Canada
ibacanada.ca/site.jsp?siteID=BC023

Eagle nest cams in Vancouver region
hancockwildlife.org/index.php?topic=cam-sites

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Marine Birds

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REVIEWER

Rob Butler, Pacific Wildlife Foundation

What is happening with marine birds?

If you are out on the waters of Howe Sound, you are more likely to see and hear marine birds than any other wildlife. Marine birds animate Howe Sound with sounds of gulls, roosting cormorants at Horseshoe Bay, and great rafts of scoters and goldeneye that provide a magnificent shoreline spectacle during the winter months. Because marine birds are highly visible, changes in their populations are easier to observe than other species and they've become important indicators of environmental stress.² But recent reviews of marine birds throughout the Strait of Georgia and Salish Sea have identified long term declines in a number of species that raise serious concerns.^{3,4} A recent assessment compares changes in marine bird counts in Howe Sound to changes noted in the Strait of Georgia and finds that changes in Howe Sound winter bird counts tend to parallel, with a few exceptions, the trends in nearby coastal marine birds as documented for the Strait of Georgia.⁵

Most of what we know about marine birds in Howe Sound comes from the observations of volunteers over many years. Volunteers conduct annual Christmas bird counts and monthly counts at several locations within Howe Sound. For example, in December 2015 and January 2016, groups in Lower Howe Sound (including parts of Bowen, Keats and Gambier Islands), Squamish (including the estuary and called Upper Howe Sound) and the Sunshine Coast (including the western shores of Howe Sound between Gibsons and Port Mellon) conducted counts as part of the Audubon Society's Christ-

mas Bird Count.⁶ The count in Lower Howe Sound involved 68 people and observed 78 species, among others, 1,071 surf scoters, 1,012 Barrow's goldeneye, 104 double-crested cormorants, 30 marbled murrelets, and 14 horned grebes. Twenty-one observers with the Squamish Environment Society counted 72 species including 117 bufflehead, 4,217 glaucous-winged gulls, 36 great blue herons, 25 pelagic cormorants and 27 double-crested cormorants.



Lighthouse Park Preservation Society members conducting a monthly bird count in 2016. (Photo: Suann Hosie)

Why are marine birds important to Howe Sound?

Marine birds include shorebirds, seabirds, and sea-ducks.⁷ Seabirds, such as cormorants, gulls, guillemots, murres, and murrelets, spend most of their lives at sea but come ashore to breed, typically in colonies on islands. Sea ducks, such as goldeneyes, scoters, mergansers, harlequin ducks, and buffleheads are marine birds but typically breed inland. Shorebirds, such as sandpipers and plovers live along shorelines and forage on intertidal invertebrates.

Marine birds play a variety of roles in the Howe Sound ecosystem as carnivore hunters of fish and invertebrates, herbivore grazers, scavengers of carrion, and as prey. The overall number of marine bird species in Howe Sound is about 130, and Christmas bird surveys typically observe about 11,000 individual marine birds representing 73 different species. About 23 species breed or are suspected to breed in Howe Sound.⁸ Several sites in Howe Sound are especially important

for marine birds. Christie Islet is a federally listed Migratory Bird Sanctuary, the only site in the Vancouver area where substantial numbers of seabirds nest, including pelagic cormorants, double-crested cormorants, and glaucous-winged gulls.⁹ The lower reaches of the Squamish River, its tributaries, and estuary are designated an Important Bird Area by BirdLife International.¹⁰ This area is deemed globally significant for Bald Eagles that congregate in winter, nationally significant for Great Blue Heron, and breeding grounds for several species of ducks and geese. Old growth forests are critical nesting habitat for marbled murrelets, and the murrelet populations on Howe Sound likely reflect access to such nearby forests on the Sunshine Coast,¹¹ and perhaps Gambier Island and the North Shore Mountains.

Is there a particular importance or connection to First Nations?¹²



Great Blue Heron. (Photo: Gary Fiegehen)

Long ago, within Squamish Nation society, there was strict division of labour. Men hunted, fished and made tools; women cooked, gathered berries and roots, weaved baskets, mats and clothing, as well as looked after the children. Among the Squamish people, the power to hunt was considered a special gift reserved only for the guardian spirits. Grouse and waterfowl were an important source of food, while other birds provided feathers for ceremonial purposes. Ducks were hunted at night in special narrow canoes, which were very fast. The hunters attracted the ducks to the canoes with small fires, lit on top of mud and kept going under a small peaked hut made out of three cedar slabs tied together.

What is the current state of marine birds in Howe Sound?

A more comprehensive report on marine birds in Howe Sound has been produced by the senior author.⁴ Seasonal abundance checklists provide information on the abundance of individual species throughout the year, whether breeding occurs locally, and the habitats where each species is found. Seasonal abundance checklists are qualitative and different observers over time can gain different impressions of abundance. Such local checklists have been produced for the Squamish Estuary,¹³ the upper Howe Sound Region and Squamish River Watershed,¹⁴ and the Sunshine Coast, including the shorelines of West Howe Sound between Gibsons and Port Mellon.¹⁵ The seasonal abundance of marine birds is well established in Upper Howe Sound based on monthly bird counts since the early 1990s in the Squamish estuary (Table 1). Seasonal abundance of marine birds in Lower Howe Sound (south of Brunswick Point) is not well documented; as an approximation, we have included data from the Sunshine Coast checklist (Table 1). The checklist for this adjacent area

includes surveys of the western shores of Howe Sound between Gibsons and Port Mellon.

Bertram's report on the Strait of Georgia (SoG) showed statistically significant changes for a number of marine bird species in Christmas Bird Counts between 1978 and 2008.² The double-crested cormorant (up 171 percent in SoG) breeds in Howe Sound and is commonly observed. The Canada goose (up 114 percent) also breeds in Howe Sound and is listed as common in Upper Howe Sound. Species that experienced the most precipitous declines in the SoG study include the western grebe (down 86 percent), the common murre (down 84 percent), marbled murrelet (down 69 percent), canvasback (down 63 percent), the greater scaup and lesser scaup (analyzed together and down 51 percent), the black scoter (down 47 percent) and the glaucous-winged gull (down 37 percent). The direction and significance of trends in the SoG² are corroborated for the Canada goose, the western grebe,



Gull with bait fish. (Photo: Lance Barrett-Lennard)

TABLE 1

Seasonal abundance of select marine bird species in Upper Howe Sound and Sunshine Coast based on checklists from 2011 to 2014.^{12, 13, 14} (Upper Howe Sound means north of Porteau Cove; Sunshine Coast – West Howe Sound includes the west shore of Howe Sound from Gibsons to Port Mellon.) **C**: Common (more than 20 birds/day); **FC**: Fairly common (6–20 birds/day); **U**: Uncommon (1–5 birds/day); **R**: Rare (1–10 birds/year, every year); **Ca**: Casual (not seen every year in season indicated); **Ac**: Accidental (one record only for season indicated); **Ir**: Irruptive (significant fluctuation in numbers); **c/w**: Count week observation only (no numerical record); *: Breeds or suspected to breed in Howe Sound.

	SEASONAL ABUNDANCE OF SELECT MARINE BIRDS BY CHECKLIST DISTRICT							
	MAR – MAY		JUN – AUG		SEPT – NOV		DEC – FEB	
	SUNSHINE COAST – WEST HOWE SOUND	UPPER HOWE SOUND	SUNSHINE COAST – WEST HOWE SOUND	UPPER HOWE SOUND	SUNSHINE COAST – WEST HOWE SOUND	UPPER HOWE SOUND	SUNSHINE COAST – WEST HOWE SOUND	UPPER HOWE SOUND
GEESE & SWANS								
Canada Goose*	C	C	C	C	C	C	C	C
Trumpeter Swan	FC	FC	–	U	FC	Ir	U	FC
DUCKS								
American Wigeon	C	C	R	FC	C	C	C	FC
Mallard*	C	C	FC	C	C	C	C	C
Northern Pintail*	U	C	U	FC	C	Ir	R	FC
Green-winged Teal	FC	C	U	C	C	C	U	FC
Ring-necked Duck*	U	FC	U	U	U	Ir	U	FC
Greater Scaup	U	FC	–	U	U	U	U	U
Lesser Scaup	U	FC	–	U	U	U	U	U
Harlequin Duck*	C	FC	FC	FC	C	U	C	FC
Surf Scoter	C	FC	U	U	C	Ir	C	Ir
Black Scoter	FC	Ca	–	Ac	FC	–	FC	Ca
Bufflehead*	C	C	–	U	C	C	C	C
Common Goldeneye*	FC	C	–	U	FC	C	FC	C
Barrow's Goldeneye*	C	C	U	U	C	C	C	C
Hooded Merganser*	FC	U	FC	U	FC	FC	FC	FC
Common Merganser*	C	C	C	C	C	C	C	C
Red-breasted Merganser	FC	U	–	–	FC	U	FC	Ir
LOONS								
Pacific Loon	FC	Ca	–	–	FC	Ca	FC	Ca
Common Loon*	C	U	U	U	FC	U	FC	U

GREBES								
Horned Grebe	FC	FC	–	U	FC	U	FC	FC
Red-necked Grebe	FC	R	–	R	FC	R	FC	R
Western Grebe	U	U	R	U	U	Ir	U	Ir
CORMORANTS								
Brandt's Cormorant	FC	Ac	U	Ca	FC	Ca	FC	Ca
Double-crested Cormorant*	C	C	U	FC	C	C	C	C
Pelagic Cormorant*	C	U	U	U	C	FC	C	FC
WADERS								
Great Blue Heron*	FC	FC	FC	C	FC	C	FC	FC
PLOVERS								
Killdeer*	C	FC	C	FC	C	FC	C	FC
OYSTERCATCHERS								
Black Oystercatcher*	C	FC	U	FC	C	U	C	FC
SANDPIPERS								
Surfbird	C	Ca	U	Ca	C	Ca	C	Ca
Western Sandpiper	U	Ir	FC	Ir	U	C	–	Ca
Least Sandpiper	U	Ir	FC	R	U	R	–	–
Long-billed Dowitcher	U	U	FC	U	FC	FC	–	–
Wilson's Snipe	U	U	–	U	U	U	U	Ir
GULLS, TERNS, JAEGERES								
Bonaparte's Gull	FC	Ca	FC	Ca	C	Ca	U	Ca
Mew Gull*	C	C	U	U	C	C	C	C
California Gull	C	Ac	C	Ca	C	Ca	U	Ca
Herring Gull	U	R	R	R	U	R	U	R
Thayer's Gull	U	U	–	Ac	U	U	U	Ir
Glaucous-winged Gull*	C	C	C	C	C	C	C	C
ALCIDS								
Common Murre	U	U	U	Ac	U	Ca	U	Ca
Pigeon Guillemot*	U	U	U	U	U	–	U	Ca
Marbled Murrelet*	FC	U	FC	U	FC	Ca	FC	Ir
Ancient Murrelet	R	–	–	–	R	–	U	–
Rhinoceros auklet	R	Ca	U	–	U	–	U	R
RAPTORS								
Osprey*	R	U	U	U	R	U	R	Ca
Bald Eagle*	C	FC	FC	U	C	C	C	C
DIPPER & KINGFISHER								
Belted Kingfisher*	FC	U	FC	U	FC	FC	FC	FC
American Dipper*	U	U	U	U	U	U	FC	C

canvasback, great and lesser scaups, the black scoter and the glaucous-winged gull by Crewe et al.'s analysis of Coastal Waterbird Surveys.³ The western grebe and common murre are uncommon at best in Howe Sound, while the marbled murrelet is fairly common along the Sunshine Coast and West Howe Sound and likely breeds in the limited old-growth forest in the region. Scaups are 'fairly common' in Upper Howe Sound in the spring, but uncommon at other times and elsewhere in the Sound. The Glaucous-winged gull likely breeds in Howe Sound and is commonly observed year round in both Upper Howe Sound and Sunshine Coast. The black scoter, a diving duck/sea duck that feeds on herring spawn among other things, generally uncommon in the Strait of Georgia, is considered fairly common along the Sunshine Coast and West Howe Sound, except in summer when it is not observed.

Locally, the decline in the Pacific herring is identified

as a reason for declines in many fish-eating marine bird species, and Bertram² supports this view in his discussion on the Strait of Georgia, although he also highlights competition with seals, gulls, and other species for herring. The seal population in Howe Sound is very robust, especially near the mouth of the Squamish River when fish are present. Other factors discussed are human threats including the herring fishery, habitat alienation by a variety of man-made expansions, toxic compounds including creosoted pilings, bilge discharge and spills, bird harvesting (which is still legal), impacts from climate change,² and the overbearing presence of dogs in many shoreline habitats.



Surf scoters enjoying the calm waters around Mickey Island in Lower Howe Sound. (Photo: Bob Turner)

Who is working on this issue in Howe Sound?

Most of what we know about marine birds in Howe Sound is based on volunteer annual and monthly bird counts at several locations within Howe Sound. There are three Christmas Bird Counts in Howe Sound. The Sunshine Coast count includes the western shores of Howe Sound between Gibsons and Port Mellon within a much larger count area. Hence data specific to the Howe Sound portion of that count have not been obtained for this report. The Lower Howe Sound count, now under the direction of Marja de Jong with local leaders on Bowen, Keats and Gambier Islands, only began in 2003 so is limited when assessing long-term trends. The Squamish (Upper Howe Sound) count is now under the direction of Marcia Danielson, while historic count data were compiled by Wisnia¹⁶ (1980 – 2001) and Ricker¹⁷ (2002 – 2015).

Monthly bird counts in the Squamish River estuary by the Squamish Environment Society, in Lighthouse Park by the Lighthouse Park Preservation Society, and in Lower Howe Sound by the Pacific Wildlife Foundation provide data to the ongoing British Columbia Coastal Waterbird Survey, a long term citizen science monitoring program run by Bird Studies Canada to assess population trends and ecological needs of marine birds, and involves more than 200 different monthly counts throughout the Strait of Georgia.¹⁸

Monthly boat surveys during 2015 in among the outer islands of Howe Sound by the Pacific Wildlife Foundation (PWF) observed a surprising abundance of marbled murrelets,¹⁹ a federally listed Species at Risk.²⁰ Publication of PWF's survey results is pending. There is a clear need for the collection of monthly marine bird survey data in Lower Howe Sound that would support the development of a seasonal bird checklist for that area.

Legal protections to stymie bird declines include various regulations, creation of land reserves, quotas on bag limits and commercial fish catch, and various restoration and monitoring efforts. In this vein the Squamish Estuary has been at the forefront of habitat improvement and protective changes. A forceful Squamish Environment Society, Squamish River Watershed Society, and local Stream Keepers group have been instrumental in improving the protection and restoration of the Squamish Estuary and in the monthly monitoring of its bird populations.²¹ A portion of the estuary is now a Nature Trust Conservation Area²² and a larger part is the designated Squamish (Skwelwil'em) Wildlife Management Area.²³

What can you do?

SOME ACTIONS CONTRIBUTED BY CORI



Individual and Organization Actions:

- Bird watching is one of the fastest growing hobbies in North America.²⁴ Whether you are a beginner or advanced, you can join one of the annual Christmas Bird Counts that occur in West Vancouver, Bowen Island, Squamish, and the Sunshine Coast, or the more frequent monthly bird counts with the Squamish Environment Society or Lighthouse Park Preservation Society. It is a great way to learn from people who know more than you.
- If you are a knowledgeable birder, you can submit your observations directly through eBird, the online repository for worldwide bird observations managed by the Cornell Lab of Ornithology.²⁵ Any unusual sightings require an accompanying photograph to be accepted by eBird.
- Keep your practices friendly to marine birds. During the spring and summer, stay away from offshore rocks that are nesting sites for oystercatchers, gulls, and cormorants. Never take your dog to these islands.
- During the winter, don't disturb flocks of winter birds along the coastline. You may disrupt their feeding or resting and cause them to waste valuable energy.
- Collect lost nets and traps and plastics on beaches that might trap or kill birds.



Government Actions and Policy:

- Continue to support and facilitate the education, monitoring, and restoration activities of local groups in Howe Sound. Provide funding assistance and partnership opportunities where feasible.
- Increase monitoring and enforcement of illegal bird harvesting.
- Legally recognize and strictly regulate Important Bird Areas as Protected Areas, especially in IBAs that do not have established legal protection (e.g., National and Provincial Parks). Where this is not feasible, consider conservation easements and agreements, private land stewardship, and land acquisition to ensure protection.
- Explore the possibility of increasing the size of the Skwelwil'em Wildlife Management Area or Nature Trust Conservation Area, or create more Wildlife Management Areas to increase protection.

Resources

Audubon Christmas Bird Count

audubon.org/conservation/science/christmas-bird-count

Results of local Christmas bird counts (Lower Howe Sound, Squamish, Sunshine Coast)

netapp.audubon.org/CBCObservation/CurrentYear/ResultsByCount.aspx

BC Waterbirds Abundance Maps

bsc-eoc.org/volunteer/bccws/index.jsp?targetpg=bccwsmaps

Bird Studies Canada, Citizen Science

bsc-eoc.org/volunteer.jsp?lang=EN

BC Coastal Waterbirds Survey 1995-2010, population trends, Strait of Georgia

birdscanada.org/volunteer/bccws/index.jsp?targetpg=index
and bsc-eoc.org/birdmon/default/popindices.jsp

Monthly abundance of bird species through the seasons in the Squamish River Area IBA

ibacanada.ca/barchart.jsp?siteID=BC023

Lighthouse Park Preservation Society, monthly bird counts

lpps.ca/volunteering

Pacific Wildlife Foundation

pwlf.org

Squamish Environment Society, monthly Estuary Bird Count

squamishenvironment.ca/programs/squamish-birders/

Footnotes

¹ Although Karl Ricker is the lead author and compiled much of the information presented in this article, he did not see the final version due to a logistics issue.

² Morton, B. 2009. Let's hear it for the birdwatchers! *Marine Pollution Bulletin*, 58(1):1-2.

³ Bertram, D. 2014. The coastal birds, Chapter 7, pp 211-257; in Beamish, R. and G. McFarlane (eds.). *The Sea Among Us – the amazing Strait of Georgia*. Harbour Publishing Co., Madeira Park, B.C. 385 pp.

⁴ Crewe, T., K. Barry, P. Davidson and D. Lepage. 2012. Coastal waterbird population trends in the Strait of Georgia 1999–2011: results from the first 12 years of the British Columbia Coastal Waterbird Survey. *British Columbia Birds* 22: 8-35.

⁵ Ricker, K. 2016. Marine birds of Howe Sound – their present and change in populations. 13p. Accessed October 20, 2016. <http://www.squamishenvironment.ca/wp-content/uploads/2016/10/Ricker-Marine-Birds-of-Howe-Sound-Population-Trends-.pdf> and <http://www.squamishenvironment.ca/wp-content/uploads/2016/10/Table-1-Seasonal-Abundance-of-Marine-Birds-in-Howe-Sound.pdf>

⁶ Christmas Bird Count. Audubon Science Center and Bird Studies (Etudes d'Oiseaux) Canada. Accessed July 2016. www.christmasbirdcount.org.

⁷ Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, and M.C.E. McNall. 1990. *The birds of British Columbia*. Vol. 1 and 2. Royal British Columbia Museum, Victoria.

⁸ Ricker, K. 2016. Squamish Christmas Bird Count – 2002 to 2015 and comparison to data compilation of 1980 to 2001. Prepared for Squamish Environmental Society, 7p.

⁹ Environment and Climate Change Canada. Christie Islet Migratory Bird Sanctuary, 1990. Accessed July 2016. <http://www.ec.gc.ca/ap-pa/default.asp?lang=En&n=F2703322-1>.

¹⁰ IBA Site Summary BC023, Squamish River Area, Squamish, British Columbia. Accessed July 2016. <http://www.ibacanada.ca/site.jsp?siteID=BC023>.

¹¹ Hamer, T. E., and S. K. Nelson. 1995. "Characteristics of marbled murrelet nest trees and nesting stands" in *Ecology and conservation of the marbled murrelet* edited by C. J. Ralph, G. L. Hunt, Jr., M. G. Raphael, and J. F. Platt, 69-82. U.S. Forest Service General Technical Report PSW- GTR-152.

¹² Reproduced with permission from "Where rivers, mountains and people meet", Squamish Lil'wat Cultural Centre.

¹³ Dale, C. and K. Ricker. 2012. Checklist of Birds Squamish Estuary, Squamish Environmental Conservation Society, 3rd edition. Accessed Sept 2016. https://www.dropbox.com/s/3dff53i95df5e51/Squamish_Estuary_Birding_Checklist_2012.pdf?dl=0

¹⁴ Ricker, K. and C. Dale. 2014. Checklist of Birds Upper Howe Sound Region and Squamish River Watershed, Squamish Environmental Conservation Society, 2nd edition.

¹⁵ Greenfield, T. 2011. Birds of the Sunshine Coast – a checklist. Sunshine Coast Natural History Society and British Columbia Wildlife Watch, B.C. Ministry of Environment, Lands and Parks.

¹⁶ Wisnia, J. 2002. Squamish Christmas Bird Count 1980 – 2001 – a year by data compilation. Squamish Estuary Conservation Society.

¹⁷ Ricker, K. 2016. Squamish Christmas Bird Count – 2002 to 2015 and comparison to data compilation of 1980 to 2001. Squamish Environmental Society.

¹⁸ Crewe et al. 2012

¹⁹ Rob Butler, in discussion with the author, Jan 8 2016.

²⁰ Species at Risk Public Registry, Marbled Murrelet. Accessed July 21, 2016. http://www.registrelep-sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=39.

²¹ Squamish Environment Society, Squamish Estuary Monthly Bird Count Records. Accessed August 10, 2016. <http://squamishbirds.webs.com/countrecords.htm>.

²² The Nature Trust of British Columbia, 147 – Squamish Estuary. Accessed August 9, 2016. <http://www.naturetrustbcmaps.ca/index.cfm/nature-trust-sites/?siteID=E847CE18-CE90-4886-CC46D3CB4DEFAF10>.

²³ Ministry of Forests, Lands and Natural Resource Operations. Skwelwil'em Squamish Estuary Wildlife Management Area. Accessed August 9, 2016. http://www.env.gov.bc.ca/fw/habitat/conservation-lands/wma/skwelwil_em/.

²⁴ Biodivcanada.ca. The 2012 Canadian Nature Survey: Awareness, participation and expenditures in nature-based recreation, conservation, and subsistence activities. Accessed August 11, 2016. <http://biodivcanada.ca/default.asp?lang=En&n=2A0569A9-1>.

²⁵ eBird. Accessed at August 10, 2016. <http://ebird.org/content/ebird/>.

Once Common, then Rare: Today Cetaceans are Back

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What's happening?

Hearing the familiar “whoooooosh” of a whale’s blow is becoming a normal occurrence – again – when paddling through, walking along or wading in the waters of Howe Sound. Cetaceans (whales, dolphins and porpoises) have been making a welcome comeback to the area, after a several-decades-long virtual absence, likely due to human activities. 2015 was a record year with regards to data received from the Howe Sound area, with 141 reports received from 100 volunteer observers (Figure 1). Harbour porpoises were the most commonly reported small cetacean last year, with killer whales being the most frequently reported large cetacean (Figure 2).



Photo: Vancouver Aquarium

B.C. CETACEAN SIGHTINGS NETWORK DATA FOR HOWE SOUND

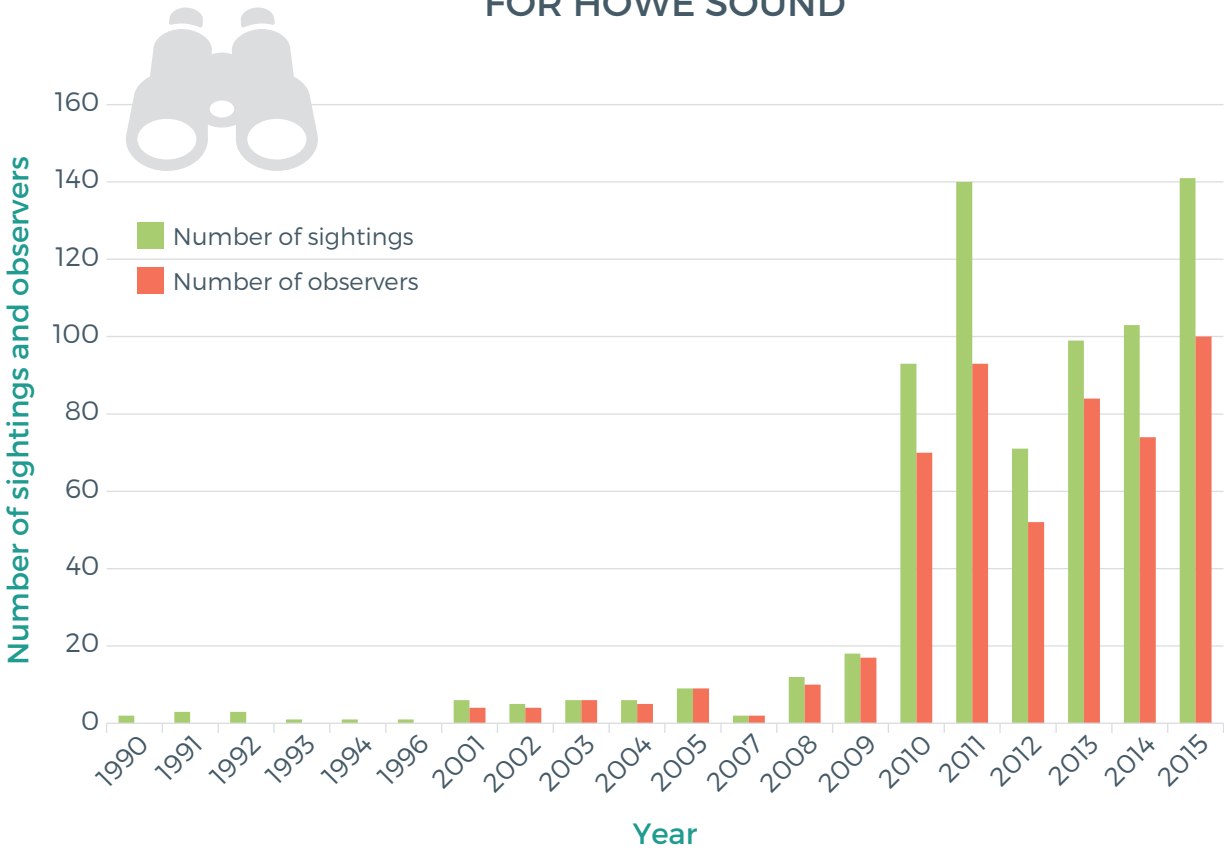


Figure 1. Annual numbers of observers reporting and sightings reported to the B.C. Cetacean Sightings Network in Howe Sound from 1990 to 2015.

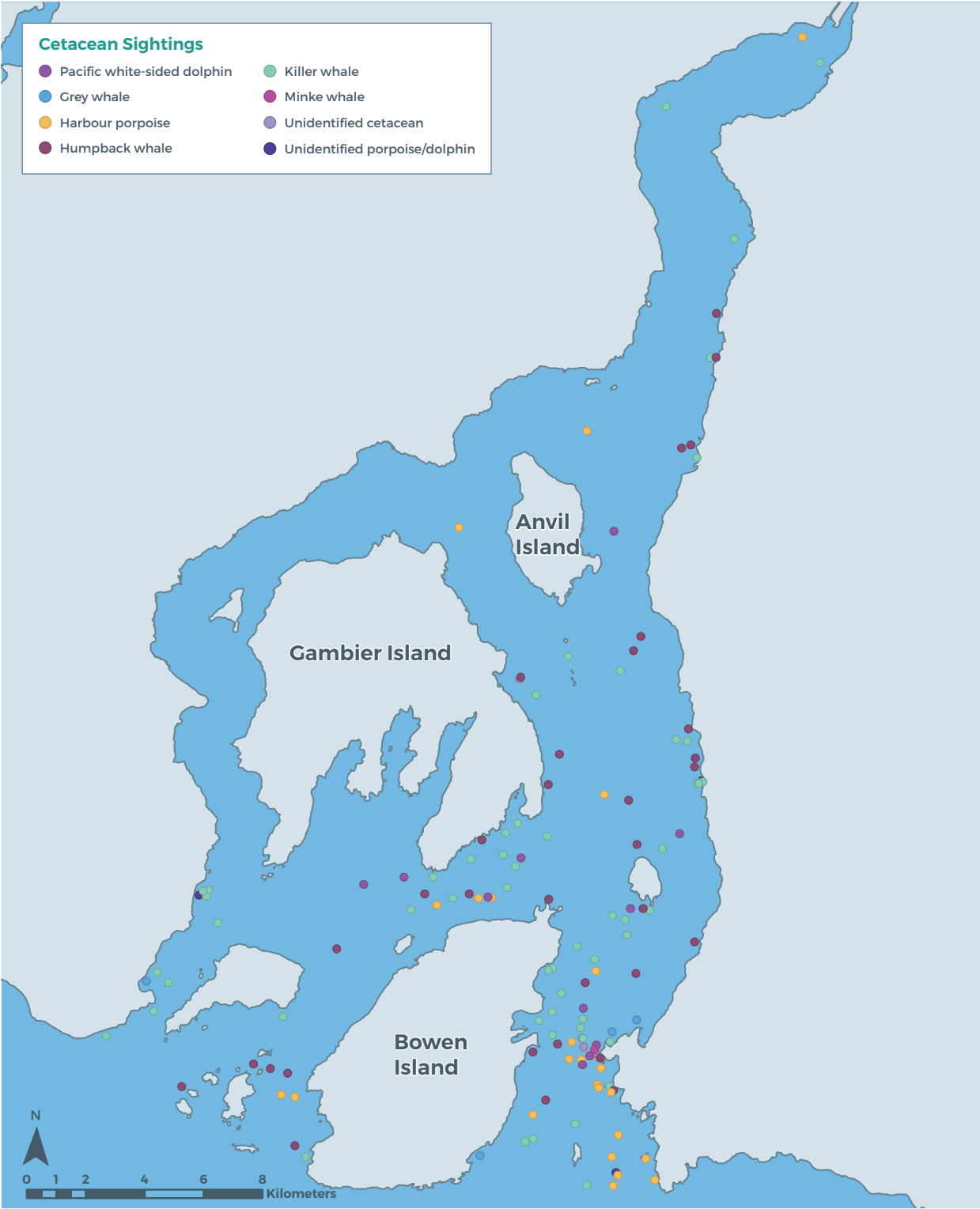


Figure 2. Cetacean sightings reported to the B.C. Cetacean Sightings Network in Howe Sound in 2015.

Why is this important?

Many long-term residents of the Sound and the Lower Mainland are surprised to learn that more than 100 years ago, the Strait of Georgia was the seasonal home for 100–150 humpback whales, many of which fed around Bowen Island. The Cates family ran whale-watching trips regularly between Vancouver and Howe Sound to see these magnificent whales. Sadly, in 1907, the Pacific Whaling Company began operating out of Nanaimo and within a few short years over 140 humpbacks were killed in the Strait of Georgia, abruptly ending the first whale-watching business to Howe Sound.¹ Low population sizes, pollution from industrial activity and depletion of prey are likely responsible for keeping cetaceans away from the area for most of the 20th Century.²

Systematic surveys are a slow and expensive way to assess changes in the abundance of cetaceans, and

our understanding of the reoccupation of Howe Sound by cetaceans is largely based on sightings provided by members of the B.C. Cetacean Sightings Network, a research initiative of the Vancouver Aquarium's Coastal Ocean Research Institute in collaboration with Fisheries and Oceans Canada. The citizen science program solicits sightings from coastal citizens and mariners along the entire coast of B.C. and uses the data for conservation-based projects.

Residents of the Howe Sound area have been keenly reporting their sightings of these species to the B.C. Cetacean Sightings Network since 2003 (although the Sightings Network collects historic data, which for Howe Sound dates back to 1990), and the data they've contributed allows the Sightings Network to get a clear picture of where and when cetaceans spend time in the Sound.



Pacific white-sided dolphins visit Howe Sound. (Photo: Vancouver Aquarium)



Whalebone club carved by Xálek/Seḱyú Siyám (Chief Ian Campbell), Squamish Nation.
(Photo: Gary Fiegehen)

“I carved this whalebone club to honour our warriors who protected our homelands. It represents a wolf, symbolizing swiftness, and family values. The wolf has a human figure at its center representing the spirit and essence of our connections, transformation. The frog in the foot of the wolf honours the supernatural, shamanism, and power. The handle is a thunderbird wearing an eagle headdress, which honours the sky realm and the power and forces of nature.”

XÁLEK/SEḶYÚ SIYÁM (CHIEF IAN CAMPBELL)

What is the current state?

The number of cetacean sightings in Howe Sound increased significantly in 2010 and has remained high since, as has the number of observers (Figure 1). It is likely that cetaceans visiting Howe Sound have increased in numbers, and this has prompted more observers to report their sightings, but these data alone cannot rule out the possibility that more observers means more sightings despite a similar number of cetacean visitors, however unlikely that may be.

The temporal distribution of cetacean sightings in Howe Sound for 2015 showed some deviation from the typical annual pattern (Figure 3), with August seeing

a spike in the number of sightings reported (35), followed by June and May which saw 23 and 20 sightings reported, respectively. A slight temporal shift in humpback sightings occurred in 2015, with the majority occurring in August. In past years humpback whales were most frequently observed in September and October. While it's difficult to determine what caused this change with certainty, it's possible that they were attracted by one of their prey species, northern anchovy, which was observed and reported in Howe Sound several times in the summer of 2015, for the first time since 2005.³

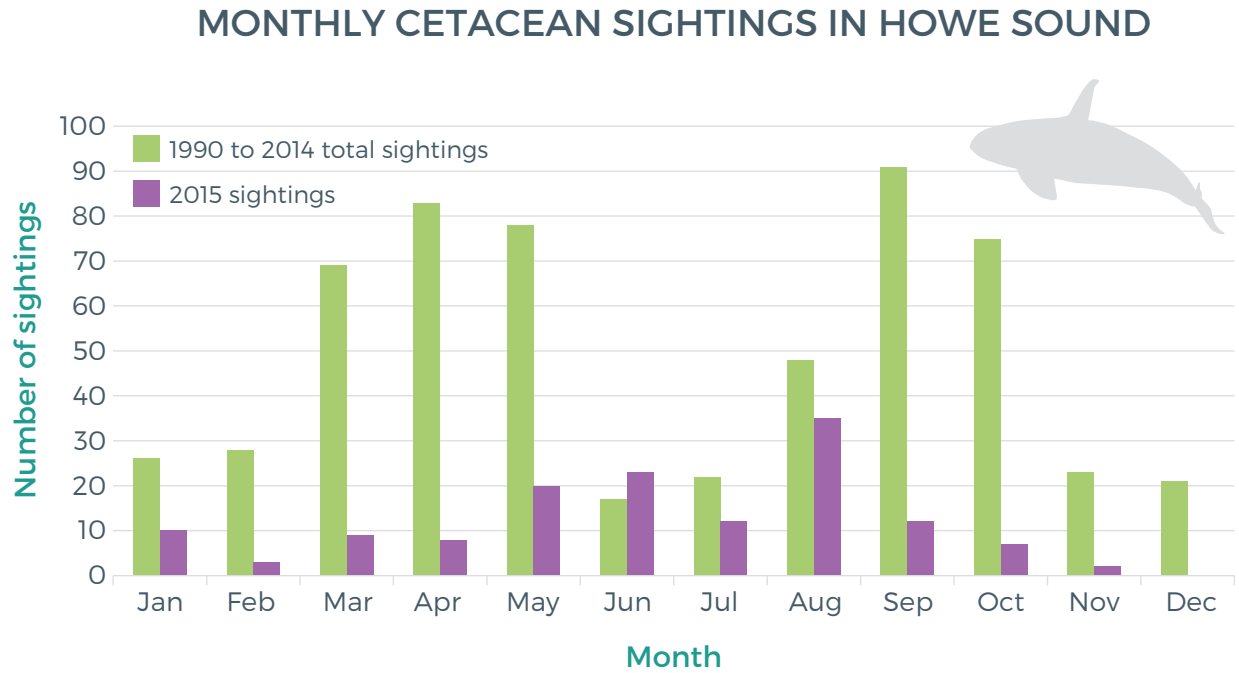


Figure 3: The historical monthly pattern of cetacean sightings reported to the B.C. Cetacean Sightings Network in Howe Sound (1990 – 2014) compared to the pattern in 2015.



Kwilák̓m (Bowen Island) is the southernmost of Howe Sound's large islands. It is known by the Squamish people for its excellent clam harvesting. It was also an important sea-lion and whale-hunting site. Photo: Gary Fiegehen. (Photo and caption reproduced with permission from "Where Rivers, Mountains and People Meet," Squamish Líl'wat Cultural Centre.)

Spatially, southeast Howe Sound is where the majority of cetaceans were seen in 2015, with clusters appearing along the ferry routes, near Lions Bay and at the southeast entrance to the Sound (Figure 2). Unsurprisingly, it is in these areas where we also find more eyes out on the water due to a significant level of vessel traffic, waterfront homes and human activities occurring in these places.

To better understand abundances of cetacean species and their spatial use of Howe Sound (and elsewhere in B.C.) and to remove the bias of uneven observer ef-

fort, the Sightings Network team, along with marine mammal researcher Erin Rechsteiner, created a GIS model to adjust or correct Sightings Network data to reflect the distribution of observer effort. According to the model we would expect high abundances off Whytecliff Park in Horseshoe Bay, near Lions Bay, and off the east side of Gambier Island, as well as at the very north end of the Sound near Squamish. These are all areas where sightings were reported over the past year.

What is being done to help cetaceans recover?

It is important to give extra consideration to important areas where cetaceans are spending time to feed, socialize and rest. Worth noting is that 12 of B.C.'s 25 species and populations of cetaceans are listed in one of the "at-risk" categories under Canada's Species at Risk Act. These vulnerable populations are threatened by vessel disturbance, reduction in prey availability, entanglement, ingestion of marine debris and toxins. Federal and other protections or status for species listed under SARA can be found in individual species reports at the Public Registry website.⁴ The level of legal protection afforded depends upon the SARA classification. For example, Fisheries and Oceans Canada recently announced that the SARA status of the North Pacific humpback whale population — listed as "threatened" under SARA at the time of writing — will soon be downgraded to "special concern." In terms of protection, this means that once the status

change occurs the population will lose its legal protection from physical harm and any designated critical habitat within Canadian waters loses special protection status. These measures only apply to species listed as "extirpated," "endangered" or "threatened" under the Act.

Reporting sightings is also a way to take direct action to conserve B.C.'s cetaceans. The need for more information on use of Howe Sound by cetaceans has never been more pressing. With further development proposed for the area, it's important to understand where and when cetaceans spend time in the Sound. Reporting sightings of cetaceans and sea turtles to the B.C. Cetacean Sightings Network will help researchers learn more about the occurrence, distribution and abundance of these species in B.C. waters.

What can you do?



Individual and Organization Actions:

- Report what you see with WhaleReport, the Sightings Network's new smartphone app, available for iOS and Android devices in the iTunes and Google Play stores, respectively. Alternatively, sightings can be reported via an online webform at www.wildwhales.org, by calling 1.866.I.SAW.ONE, emailing sightings@vanaqua.org or by hardcopy logbooks, available by request.
- When viewing cetaceans from a boat, follow the Be Whale Wise Guidelines: (<http://www.bewhalewise.org/>) to avoid disturbing or displacing them.
- Purchase sustainable seafood: <http://www.oceanwisecanada.org/>. In your business, ensure food sold or supplied is sustainable (if applicable).
- Purchase products that do not contain harmful toxins such as Persistent Organic Pollutants (POPs).
- Participate in a shoreline cleanup <http://www.shorelinecleanup.ca/>. Organize a community or company-wide cleanup.
- Recycle and properly dispose of garbage to prevent marine debris that can be harmful if ingested, or cause entanglement. Ensure workplaces are equipped with proper disposal options.
- Minimize the use of plastics, especially single-use plastics.



Government Actions and Policy:

- Monitor pollutant levels, enforce and where necessary amend pollution regulations.
- Monitor and when warranted restrict fishing to protect the prey resources of cetaceans in Howe Sound.
- Continue to update Species at Risk Act (SARA) reports on a regular basis to reflect current status of species.
- Continue to aid and support population studies of Species At Risk, or potential Species At Risk.
- Continue to support and facilitate growth of the Marine Mammal Response Network to ensure timely and safe incident responses coast-wide.
- Increase public education regarding species of cetaceans, the risks they face, and how the public can help. Continue to support children and youth educational programs.
- Support citizen science and grassroots initiatives related to cetacean conservation.
- Empower local communities by ensuring they are educated on the proper actions to take in the event of an oil spill. Provide the required resources for communities to safely respond and assist in the event of a spill.
- Provide large vessel captains and pilots with cetacean resources that include distribution of species, and how to safely transit when whales are in the area (e.g., The Mariner's Guide to Whales, Dolphins and Porpoises of B.C.)
- Legislate against the production and use of harmful chemicals (e.g., POPs).
- Legislate against the production and use of single-use plastics (e.g., plastic grocery bags).
- Legislate mandatory safe-distance for vessels from cetaceans (e.g., using Be Whale Wise Guidelines).
- Facilitate the creation of ecosystem-based species management plans in order to help ensure a sustainable predator-prey balance.

Footnotes

¹ Trites, A. 2014. The Marine Mammals, Chapter 6, pp 183-210; in Beamish, R. and G. McFarlane (eds.). The Sea Among Us – the Amazing Strait of Georgia. Harbour Publishing Co., Madeira Park, B.C. 385 pp.

² David Suzuki Foundation 2015 Sound Investment: Measuring the Return on Howe Sound's Ecosystem Assets. Vancouver, BC: Molnar, M.

³ Anchovy sighting data from Gibbs, D.M., C. Gibbs, and A. Lamb. Pacific Marine Life Surveys. Data accessed Sept 16, 2016. Opportunistic sightings are recorded, so the information is not from systematic surveys and anchovy in intervening years could have been missed.

⁴ Government of Canada. 2016. Species at Risk Public Registry. Accessed Oct 3, 2016. https://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm

Eelgrass

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What's happening with eelgrass?

Native eelgrass (*Zostera marina*) in Howe Sound serves as critical habitat for marine wildlife, including waterfowl, shellfish, fish and invertebrates (Figure 1). Up to 80 percent of important fish species and marine invertebrates use eelgrass during some part of their life cycle.¹ These important and richly diverse habitats are most vulnerable to loss and degradation because they grow in shallow marine waters close to human activity.

Eelgrass subtidal habitats in Howe Sound are presently at risk. Specific shoreline development practices, log storage locations (past and present), and boat moorage in eelgrass beds are the major impediments to the plants flourishing in the Sound.

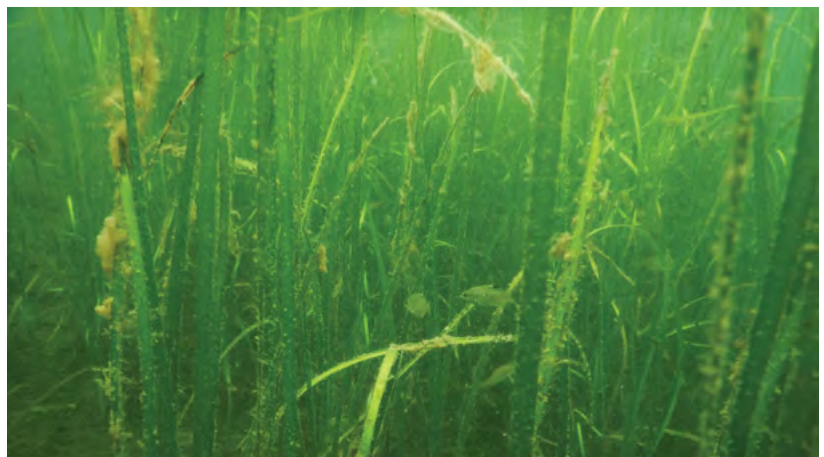


Figure 1. Native eelgrass (*Zostera marina*) with juvenile fish.
(Photo taken in Sechelt Inlet by Jamie Smith)

Eelgrass provides up to
\$87,000
 in ecosystem services
 per hectare per year

Resting & feeding
 habitat for migratory
 birds (e.g., eagles)

Stabilizes
 adjacent marsh

Habitat & food source
 for resident waterfowl

Up to 80% of fish species and marine invertebrates
 use eelgrass during some part of their life cycle.

CO₂

Traps carbon
 and stores it
 in sediment

Reduces wave energy

Habitat refugia
 for adult salmon

Nursery habitat for
 juvenile salmon, herring,
 & other species

Sediment deposition
 improves water clarity

Roots & rhizomes
 stabilize sediment
 and prevent erosion

Eelgrass habitat is vulnerable to loss and degradation from nearby human activities



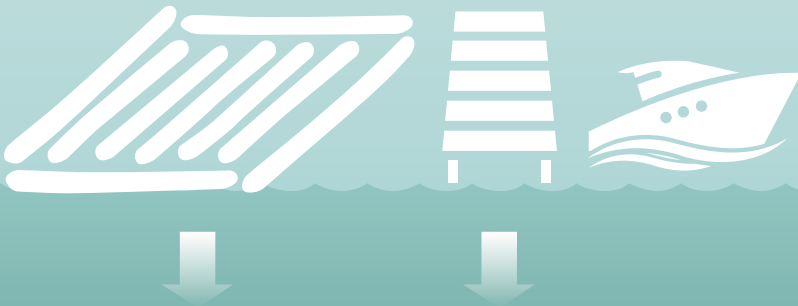
Sunlight

Log booms & jetties shade essential sunlight needed for eelgrass growth

Sunlight

Hard shorelines reflect wave energy & increase erosion of sediment

Removal of vegetation increases sediment runoff which smothers eelgrass



Boat anchors & propellers damage delicate eelgrass roots and leaves.



Excess nutrient pollution creates algal blooms that reduce sunlight and overgrow eelgrass

Bark waste from log booms smothers eelgrass and changes chemical, physical, and biological health of sediments



Why is eelgrass important?

Eelgrass beds provide highly valued ecosystem services to wildlife and humans alike. Within the lower reaches of the Salish Sea, the estimated value of carbon sequestration and storage, habitat refugia, nursery and nutrient cycling provided by eelgrass is about \$80,000 per hectare per year.² Factoring these economic benefits into decision-making would reinforce the economic, cultural and ecological values of near-shore habitats within the Sound.

The meadows assist with coastal protection by providing a physical baffle (leaves) and reducing erosion (roots & rhizomes). Eelgrass also has important influences on ecological processes such as the cycle in which chemical elements and simple substances are transferred between living systems and the environment (biogeochemical cycling), sediment stability and the food web.^{3,4}

Does eelgrass play a role in First Nations cultural and spiritual heritage?

First Nations in British Columbia harvest eelgrass for food, ceremony, cooking, and for other purposes. T'anuu 'Il'nagaay (Eelgrass Town) is located in Haida Gwaii and its name conveys the importance of the

plant to coastal indigenous communities. *Tending the Meadows of the Sea* provides a wealth of information about historical uses and harvesting of eelgrass by local First Nations.⁵

TABLE 1. PERCENT OF SHORELINE COVERED BY PATCHY EELGRASS HABITAT AROUND THE ISLANDS OF HOWE SOUND.

ISLAND	% OF SHORELINE	SURVEY YEAR	POTENTIAL RESTORATION SITES	OBSERVED THREATS TO EELGRASS HABITATS
Bowen	11.6	2013	yes	Docks, moored boats, boat anchoring, boat wakes
Bowyer	11.4	2013	no	Docks, chain debris
Gambier	8.3	2012	yes	Historical log storage practices, docks, wharves
Passage	15.7	2013	no	Ropes, floating docks, moorings
Islands west of Bowen including Keats and *	13	2013	yes	Docks, log booming, moored boats, water park play structures

* Shelter, Home, Preston, Ragged Islets, Pasley, Mickey, Worlcombe, Hermit, Little Popham, Popham, Grace, Woolridge, Anvil.

What is the current state?

A recent survey by the Islands Trust of all the islands of Howe Sound identified eelgrass beds along eight to 16 percent of shorelines⁶ (Table 1). Eelgrass is most likely present where the bottom is sandy or mixed with small pebbles, and most beds surveyed are described as patchy and sparse. Eelgrass does not flourish where there are large boulders or shallow sand. The survey did note areas with suitable sediment but a lack of eelgrass. This may suggest damage to native eelgrass beds and opportunities for re-colonization.

Several sites within the bays of southeast Gambier Island were identified during the surveys as potential restoration areas (Figure 2). These bays have been severely impacted by historical log boom activities. Potential restoration sites around other islands were also identified. For all maps and reports on native eelgrass in Howe Sound and related subjects, please refer to: www.seagrassconservation.org

Fish species and other marine wildlife observed in eelgrass during mapping in Howe Sound indicate that these habitats are functioning, but few eelgrass beds were classified as dense and robust. Most are continuous fringing,⁷ or patchy and sparse. Specific shoreline development practices, log storage locations both past and present, and boat moorage that block light needed for growth, create excess sediment, or physically disturb the plants are the major impediments to eelgrass flourishing in the Sound. For example, boat anchor chains that sweep across the bottom with changing tides and winds can destroy plants. Eelgrass is dependent on good water quality and thus healthy eelgrass beds serve as an indicator of good water quality near coastal communities.

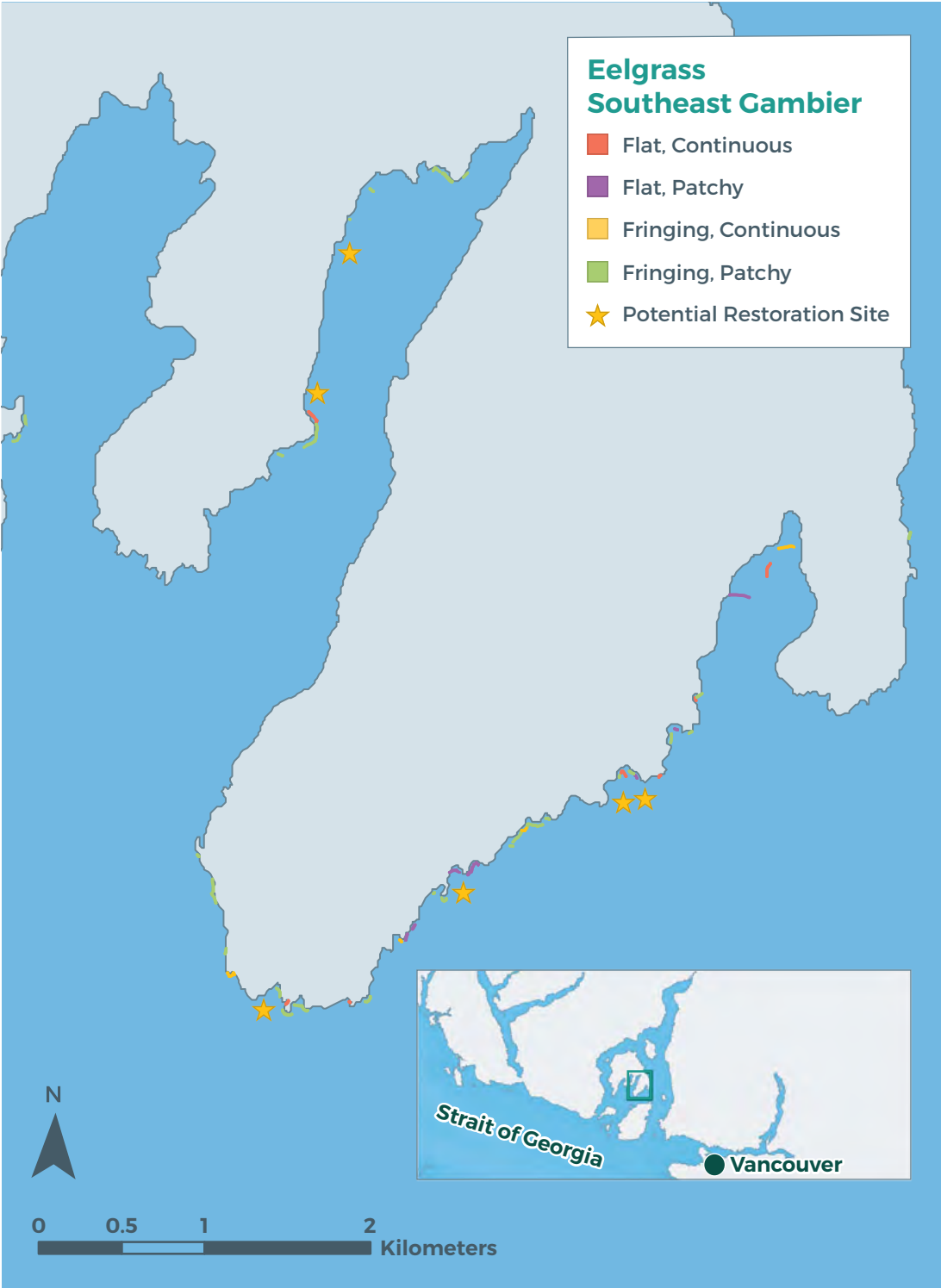


Figure 2. Existing eelgrass and sites identified for potential restoration, Southeast Gambier Island. (Data provided by Islands Trust. For complete maps and reports on native eelgrass in Howe Sound see www.seagrassconservation.org)

More on threats...

There are a variety of shoreline structures and activities that are detrimental to eelgrass meadows. Docks that shade the bottom can inhibit plant growth. The removal of backshore native plant vegetation can increase the amount fine sands and soil entering shoreline waters and smother the plants. Hardening the shore with built walls reflects wave energy back to shallow eelgrass beds and, over time, erodes the fine sediment in which eelgrass grows. Chemical contaminants, such as fertilizers, pesticides and household hazardous wastes, runoff from roads, and industrial activities add to the toxic composition of muddy bottoms of eelgrass meadows.⁸

Anchoring of recreational boats along the nearshore disturbs eelgrass rhizomes, the plant's underground root system. Boat propellers can cut eelgrass beds in very shallow waters. Creating protected zones for eelgrass, and promoting the use of mooring buoys for recreational boats outside of large eelgrass beds may help the entire eelgrass ecosystem in Howe Sound.

Log booms along shorelines in Howe Sound are often located in areas suitable for eelgrass growth. Log booms are detrimental to eelgrass as they shadow the seafloor and produce large volumes of bark waste that settle on the bottom sediments and change their chemical, physical and biological health. Eelgrass beds and the organisms within them are not adapted to this debris. Storage of these logs in deeper waters or on land can mitigate these problems in some instances.

What is being done?

Eelgrass habitat can be replanted and restored. The Squamish River Watershed Society has replanted eelgrass in the Squamish estuary. Community volunteers are an essential part of these restoration efforts. Other

potential restoration sites in Howe Sound were identified during the Islands Trust mapping surveys, and the work of planting and monitoring small test plots of 800-1000 eelgrass shoots has been undertaken.

What can you do?

SOME ACTIONS CONTRIBUTED BY CORI



Individual and Organization Actions:

- Protect eelgrass by learning where eelgrass beds are in Howe Sound.
 - Howe Sound islands: www.islandstrustfund.bc.ca/initiatives/marineconservation/eelgrass-mapping
 - Bowen, Passage, and Bowyer Islands: <http://seagrassconservation.org/wp-content/uploads/2016/02/2013-Metro-Vancouver-Eelgrass-Mapping-Report-Bowen-Passage-Bowyer-Islands.pdf>
 - Sechelt: <http://seagrassconservation.org/wp-content/uploads/2015/01/get.pdf>
- Shoreline landowners can minimize the impact of docks by using light-penetrating materials, and using shared community docks rather than private docks.
- Shoreline owners can maintain trees, shrubs and ground cover plants close to the shore to reduce erosion and detrimental sedimentation.
- Join or contribute to funding eelgrass restoration efforts. Eelgrass habitat needs to be monitored and mapped every three to five years to evaluate changes over time.
- Avoid boating or anchoring in eelgrass beds.
- Participate in eelgrass restoration activities, and encourage your organization to participate.



Government Actions and Policy:

- Continue to financially support community eelgrass restoration and monitoring practices within Howe Sound. Ensure monitoring and mapping is occurring every three to five years, and updated data is made widely available.
- Support and facilitate community education and stewardship involving the importance of eelgrass, the threats eelgrass faces, and how coastal citizens can help.
- Consider relocating log boom tenures, or reducing size and restoring eelgrass beds.
- Prohibit shoreline armouring near eelgrass.
- Create protected zones for eelgrass areas identified as important. Within these areas; restrict removal of backshore native plants, encourage a “no anchor zone,” restrict the installation of non-light-penetrating docks, and restrict the implementation of new logging operations.
- Allow no new tenures in eelgrass habitat or habitat suitable for eelgrass restoration.
- Ban harmful chemical fertilizers and pesticides.

Resources

Learn about eelgrass and related conservation efforts in the Salish Sea.

seagrassconservation.org

Learn about best practices for protecting shorelines from both erosion and environmental deterioration.

greenshores.ca

Footnotes

¹ Durance, C. 2002. Methods for mapping and monitoring eelgrass habitats in British Columbia. Funded by the Canadian Wildlife Service, Environment Canada.

² Molnar, M., M. Kocian and D. Batker. 2012. Nearshore natural capital valuation. David Suzuki Foundation. p. 12. A more recent report focused on Howe Sound updated this value to upto \$87,000 in ecosystem services per hectare per year. Please see Sound Investment: Measuring the Return on Howe Sound's Ecosystem Assets, M. Molnar, 2015, David Suzuki Foundation.

³ McGlathery, K.J., J. Sundback, and I.C. Anderson. 2007. Eutrophication in shallow marine bays and lagoons; the role of plants in the coastal filter. Marine Ecology Progress Series 348:1–18.

⁴ Orth, R. J., T. J.B. Carruthers, W. C. Dennison, C. M. Duarte, J. W. Fourqurean, K. L. Heck, Jr., A. R. Hughes, G. A. Kendrick, W. J. Kenworthy, S. Olyarnik, F. T. Short, M. Waycott, and S. L. Williams. 2006. A Global Crisis for Seagrass Ecosystems. Bioscience 56:987–996.

⁵ Cullis-Suzuki, S. 2002. Tending the meadows of the sea: Traditional Kwakwaka'wakw harvesting of Ts'áts'ayem (*Zostera marina* L.; Zosteraceae). Master of Science Thesis, University of Victoria. 202pp.

⁶ Islands Trust Fund. 2016. Nearshore Eelgrass Habitat Mapping. Accessed Sept 8, 2016. <http://www.islandstrustfund.bc.ca/initiatives/marineconservation/eelgrass-mapping.aspx>

⁷ Continuous fringing beds provide a continuous, connected habitat for salmon and other marine wildlife, although they may contain less biomass than continuous flat beds of eelgrass.

⁸ Josselyn, M., T. Zedler, and T. Griswold. 1990. Wetland mitigation along the Pacific coast of the U.S. In: Wetland Creation & Restoration: the Status of the Science, Kusher and Kentula (eds). Island Press. p. 16.

Glass Sponge Reefs: a new opportunity for conservation research

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What's happening with glass sponge reefs?

In 2015, Fisheries and Oceans Canada (DFO) closed bottom contact fishing (i.e., all commercial and recreational bottom contact fishing activities for prawn, shrimp, crab and groundfish, including halibut, were prohibited) at nine glass sponge reefs in the Strait of Georgia, including reefs surrounding Passage Island at the entrance to Howe Sound, and at Defence Islands northeast of Anvil Island.¹ During the process leading to those closures, citizen scientists Glen Dennison and Lena Clayton were actively using a new method of drop-camera drift transects to identify locations of glass sponge reefs in Howe Sound (Figure 1). These newly identified Howe Sound sponge reefs were not considered during that earlier federal process, so they remain unprotected, with the exception of the Passage Island sponge reefs.



Photo: Adam Taylor

Therefore, citizen scientist divers, dive industry representatives (guides, instructors) and the Vancouver Aquarium's Howe Sound divers met in May 2015 to discuss approaches to protecting these Howe Sound sponge reefs. In an about-face on previous secrecy about reef locations in order to protect sponges from accidental anchor damage, it was decided to go public and invite citizen science divers on the reefs to gain public awareness. With a grant from Mountain Equipment Co-op (MEC), the Vancouver Aquarium Marine Science Centre developed a web page² showing citizen science divers how to locate and photograph or video-tape various bar-coded stakes around the periphery of the inshore Defence Island bioherm, then submit im-

ages of the sponges together with these location identifier stakes, in order to allow monitoring of sponge growth and health over time at this site.

In late May, the annual prawn fishing season took place, with many observations of fishing on Howe Sound glass sponge reefs noted by conservationists. The fishery closed earlier than planned in 2016 owing to low catch rates. The greatest human conflict with glass sponge reefs relates to fishing gear damage to the reefs,³ whether from downrigger contact, bottom trawling or prawn trap contact, and has been the basis for almost all the negotiated closures with fishing sectors for the sake of sponge reef protection.



Photomural of offshore Defence bioherm at 100 feet depth. Eight photos taken by Jeff Marliave in August of 2004 and merged using Photoshop.

Is there a particular importance or connection to First Nations?

The Defence Islands are sacred to the Squamish Nation, and the Squamish Nation has indicated interest

in seeing conservation of the glass sponge reefs off the eastern Defence Island.

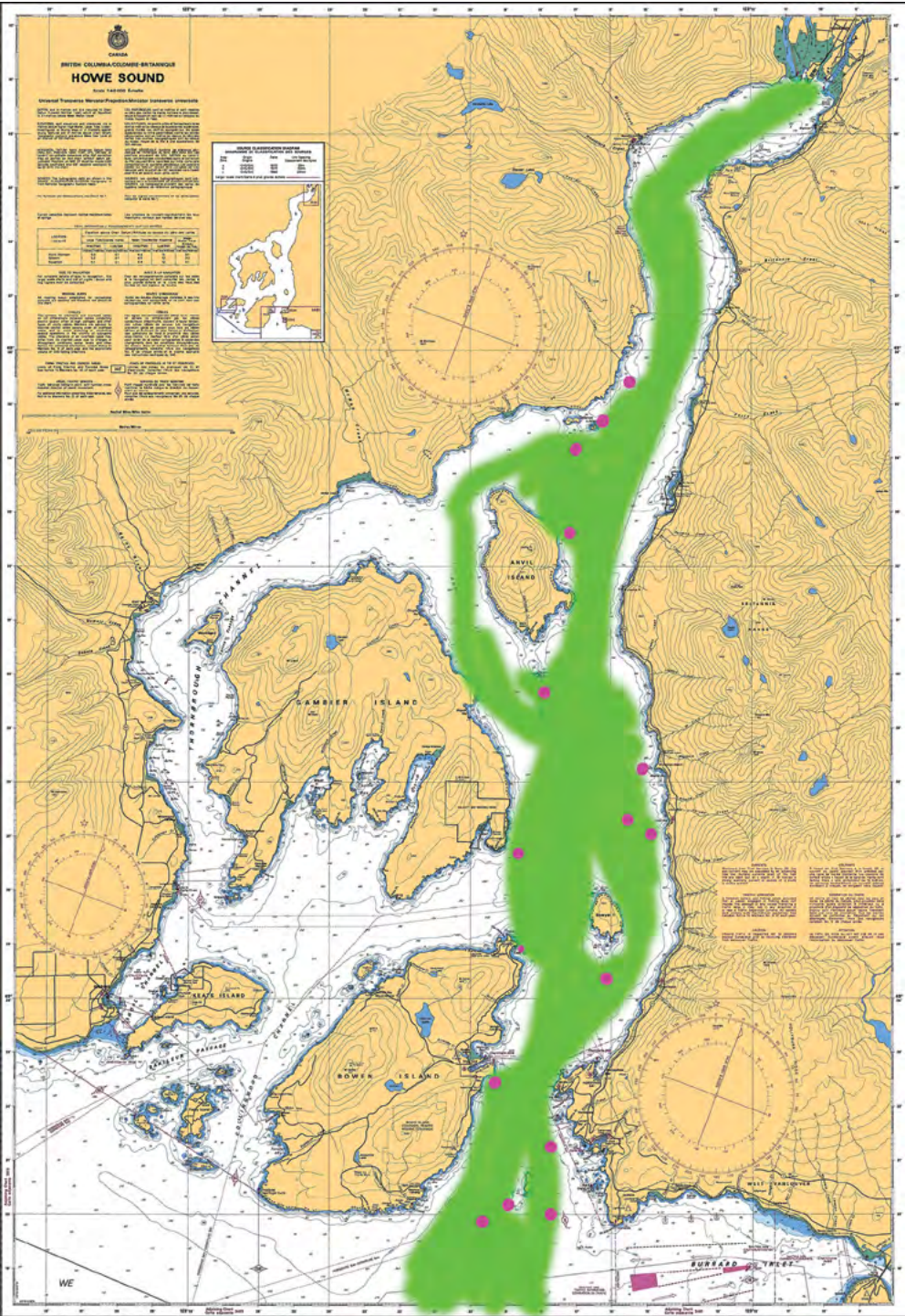


Figure 1. Pink dots indicate glass sponge reef locations in Howe Sound determined by drifting drop-camera method of Glen Dennison and Lena Clayton (personal communication). The four southern-most reefs are located inside a DFO closure implemented in 2015. The green shading represents the approximate area of Squamish River and Fraser River outflows in Howe Sound.

Why is it important?

Glass sponge reefs (also called bioherms) were thought to have gone extinct thousands of years ago⁴ when they were discovered off the Canadian continental shelf in the mid-1980s.⁵ Howe Sound is the only known location where these glass sponge reefs are shallow enough to be studied by scuba divers using compressed air, making them uniquely accessible to the diving community. Cloud sponge is a common name for *Aphrocallistes vastus*, the main reef-forming

glass sponge species in Howe Sound. The cloud name comes from its appearance.

These glass sponge reefs provide refuge for rockfish broodstock,^{6,7} and in Howe Sound the redstripe rockfish is a species almost exclusively associated with these reefs. Spot prawns aggregate around the sponge reefs, and for that reason the conflict with prawn trapping activity arises.

What is the current state?

“Local knowledge” about cloud sponges differs depending on who you talk to. Fishermen have long said of cloud sponges, “oh, yeah, that’s sea cabbage, and it grows back the next winter.” In contrast, divers had the lore that cloud sponges are hundreds of years old and never grow back if damaged. The truth is that there appears to be a tendency for individual sponges to grow at varying rates during different climate cycles. Deterioration has been observed during the buildup of El Niños (warm coastal winters) and rapid episodic growth was observed in some sponges during La Niña cycles (cooler winters). In 2015, the first proof of fragment healing and reattachment in cloud sponges was published;⁸ notably, healing took place during La Niña weather.

Mechanical damage to sponge reefs in Howe Sound has been documented in the video transects of Glen Denison.⁹ The prawn fishery has focused on fishing near these reefs because of the high densities of prawns

that accumulate around the periphery of the reefs. Whereas the Pacific cod trawl fishery in the Strait of Georgia eliminated large areas of glass sponge reef on Halibut and McCall Banks, the prawn trap fishery has caused more localized damage, which may experience healing and recovery during favourable climate cycles.

Monitoring is needed to determine the extent to which sponge reefs can heal damage caused by climate cycles or mechanical damage by humans. The dive volunteers posting on the Aquarium website for the bar code marked areas at the inshore Defence Island location have already documented that necrosis of a head of cloud sponge can occur within several months.¹⁰

What's being done?

In October 2016, seven organizations¹¹ submitted a proposal to Fisheries and Oceans Canada asking for protection of the glass sponge reefs in Howe Sound. The Regional Director General for the Pacific Region responded suggesting that the detailed information provided on the Howe Sound Sponge Reefs would feed directly into the marine conservation target strategy of establishing new effective area-based conservation measures, such as closing fisheries in waters that are home to sensitive sponges and corals.

Diving representatives approached BC Parks to discuss possible expansion of Halkett Bay Marine Provincial Park on Gambier Island, to include the Halkett pinnacle sponge reef. On May 26, 2016, the B.C. Minister of Environment, Mary Polak, announced the expansion of Halkett Bay Marine Park to include the sponge reef. Future plans are for funding a safe, permanent boat moorage for divers' access to that sponge reef. Citizen science will be enhanced owing to the accessibility of this reef at Halkett Point to commercial dive charters out of Horseshoe Bay.

On March 23, 2016, Canadian Parks and Wilderness Society (CPAWS) hosted an evening at Science World on glass sponge reefs, which included discussion of the Strait of Georgia and Howe Sound reefs. At the

Salish Sea Ecosystem Conference in Vancouver in April 2016, there were four presentations on the glass sponge reefs of Howe Sound, covering various aspects of the biology, ecology and conservation of these reefs. Between these March and April meetings and the May announcement of inclusion of the sponge reef near Halkett Point inside the new boundaries of Halkett Marine Park, there has been favourable publicity of these reefs. On May 31, the David Suzuki Foundation and Vancouver Aquarium hosted a public meeting at Kay Meek Centre featuring Howe Sound videos, including a sponge reef video by Roy Mulder.

A new federal process for protection of Howe Sound glass sponge reefs under the federal Pacific Region Cold-Water Coral and Sponge Conservation Strategy,¹² which was released in 2011, is being urged for Howe Sound. Requests are now being promulgated.

Divers need to exercise caution to avoid breaking sponges by contact with fins or hands, so a new Professional Association of Diving Instructors (PADI) course has been developed to teach safe diving practice around sponge reefs.



Glass sponge reef home to juvenile rockfish. (Photo: Adam Taylor)

What can you do?



Individual and Organization Actions:

- Contribute to citizen science projects in order to monitor glass sponge growth at the inshore Defence Island sponge reef.
- Report illegal fishing and trapping to DFO within sponge closure areas.
- Take the PADI course developed to teach safe diving practice around sponge reefs before diving around sponge reefs.
- Familiarize yourself and others with locations of sponge reefs throughout Howe Sound, specifically if bottom contact fishing or mooring your vessel.



Government Actions and Policy:

- Encourage local education and awareness of the importance of sponge reefs, and the risks they face.
- Advertise the uniqueness of the opportunity to dive a sponge reef using compressed air in Howe Sound.
- Support local citizen science projects, and formal studies aimed at understanding and monitoring glass sponge reefs.
- Install a safe and permanent moorage for dive boats at glass sponge reef sites.
- Implement full protection of glass sponge reefs throughout all of Howe Sound.
- Restrict bottom contact fishing throughout all glass sponge reefs in Howe Sound.

Resources

Drop camera and other videos of sponge reefs in Howe Sound

mlssbc.com/2013/04/27/mlss-collaborates-with-experts-from-vancouver-aquarium/

Footnotes

¹ http://www.pac.dfo-mpo.gc.ca/oceans/protection/sponge_reef-recif_eponge-eng.html

² <http://www.vanaqua.org/act/research/howe-sound-group/sponges>

³ Kahn, A.S., L.J. Vehring, R.R. Brown, and S.P. Leys. 2016. Dynamic change, recruitment and resilience in reef-forming glass sponges. *Journal of the Marine Biological Association of the United Kingdom*. 96 (2): 429–436.

⁴ Krautter, M., K.W. Conway, J.V. Barrie and M. Neuweiler. 2001. Discovery of a “living dinosaur”: globally unique modern hexactinellid sponge reefs off British Columbia, Canada. *Facies*. 44: 265–282.

⁵ Conway, K.W., J.V. Barrie, W.C. Austin, and J.L. Luternauer. 1991. Holocene sponge bioherms on the western Canadian continental shelf. *Continental shelf research*. 11: 771–790

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⁷ Cook, S.E. 2005. Ecology of the hexactinellid sponge reefs on the western Canadian continental shelf. MSc thesis, University of Victoria, Canada.

⁸ Marliave, J. 2015. Cloud Sponge, *Aphrocallistes vastus* (Porifera: Hexactinellida), fragment healing and reattachment. *Canadian Field-Naturalist*. 129(4):399–402.

⁹ For examples, see Mulder, R. “Sponge Damage.” Video, June 1, 2015. Accessed Sept 19, 2016. <https://mlssbc.com/2015/06/08/defence-island-bioherm-dive-may-31-2015/> and “MLSS Discovers Massive Sponge Bioherm in Howe Sound.” Oct 7, 2014. Accessed Sept 19, 2016. <https://mlssbc.com/2014/10/07/mlss-discovers-massive-sponge-bioherm-in-howe-sound/>

¹⁰ Vancouver Aquarium. “Diving Sponge Reefs and Gardens. Accessed Sept 19, 2016. <http://www.vanaqua.org/act/research/howe-sound-group/sponges>

¹¹ Canadian Parks and Wilderness Society, Marine Life Sanctuaries Society, Canadian Marine Environment Protection Society, David Suzuki Foundation, Future of Howe Sound Society, Sunshine Coast Conservation Association, and the Vancouver Aquarium Marine Science Centre.

¹² <http://www.pac.dfo-mpo.gc.ca/oceans/protection/docs/cscs-pcce-eng.pdf>

Squamish Estuary

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What is happening in the Squamish Estuary?

The Squamish Estuary is situated at the head of Howe Sound, one of the southernmost fjords in British Columbia, where the Squamish River drains over 3,650 square kilometers of coastal rainforest into the ocean. An estuary is formed when fresh water mixes with marine waters to create a brackish tidally influenced zone. Estuaries are one of the most productive ecosystems on the planet, providing habitat for fisheries, waterfowl, and wildlife.

There have been many anthropomorphic impacts to the Squamish Estuary since it was settled first by First Nations and later by Europeans and other cultures. The impacts have included urbanization, diking and logging and resulted in loss of habitat, changes to hydrology, and introduction of contamination.



Figure 1. The brownfield site, a former log sort in the central Estuary, is the location of current restoration efforts. (Photo: Colin Bates, June 2015)

Organizations such as the Squamish River Watershed Society (SRWS) have been working for close to 20 years on re-establishing the estuary to its original function by reconnecting tidal channels, installing culverts, planting aquatic and terrestrial vegetation, and creating wildlife habitat for aquatic and terrestrial species. From 1999 – 2013 an area of over 15 hectares of brownfield (the former dredge spoils at the south end of the Training Dyke) were restored to functional estuary as well as the placement of 10 culverts along a three-kilometre section of the Training Dyke road. More recently, restoration of a major brownfield site in the central Squamish estuary got underway in 2015 (Figure 1). The site was used as a log sort for many years and is located within the Skwelwil'em Wildlife Management Area (Figure 2). The goal is to re-establish

tidal channels, mud flats and sedge marshes on the site. In 2015, efforts included removal of a large amount of wood waste, grading the site, and transplanting Lyngbye's sedge (*Carex lyngbyei*), the dominant grassy plant in the estuary and in many Pacific coastal marshes. From 2001 to 2016 the SRWS has also planted over 10,000 eelgrass shoots in the Mamquam Blind Channel and Cattermole Slough in an effort to restore eelgrass beds in the sub-tidal zones. The Squamish Streamkeepers have been monitoring herring returns to the estuary and are undertaking efforts to reduce mortality to larval spawn by removing or replacing toxic creosote pilings. Most of the environmental based organizations conduct monitoring, including the monthly bird counts and annual bald eagle count by the Squamish Environment Society.

Why is the Squamish Estuary important to Howe Sound?

The Squamish Estuary provides valuable habitat to fisheries including salmonids (Chinook, chum, pink, coho, steelhead salmon and rainbow trout) as well as herring and eulachon.¹ The Squamish Estuary is recognized as a Canadian Important Bird Area (IBA)² and provides a home to numerous resident avian species including waterfowl and songbirds, as well as providing an important resting and feeding spot for migratory birds, such as the bald eagle and mountain blue bird. The monthly bird counts by organizations such



Figure 2. Skwelwil'em Wildlife Management Area protects much of the western side of the Squamish Estuary. Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRIS, IGN, and the Gis User Community

as the Squamish Environment Society help to monitor and determine the overall health of the avian populations.

Estuaries provide numerous ecological functions that include critical flood control, filtering of contaminants, and providing a diverse natural buffer that adapts to sea level changes and helps to moderate against climate change. The Squamish River and its numerous tributaries originate in glacial mountain peaks and transport large volumes of sediment downstream that accumulate to create the flat delta of the estuary. Year by year, decade by decade, century by century the Squamish Estuary delta has advanced

southwards into Howe Sound created by consecutive layers of silt, sediment and woody debris that forms the land base that we see today. These rich sediments and soils provide the basis for the vegetation growth in the estuary, in particular Lyngbye's sedge, which stabilizes the ground and allows other plants to colonize and provide cover, habitat, and food that attracts diverse and rich wildlife. Furthermore, the Squamish River has a significant influence on Howe Sound, especially in the summer months when the freshet of glacial meltwaters containing fine talc-like sediments spills out into the Sound and creates the milky-green coloured water well south of Anvil Island and Porteau Cove.



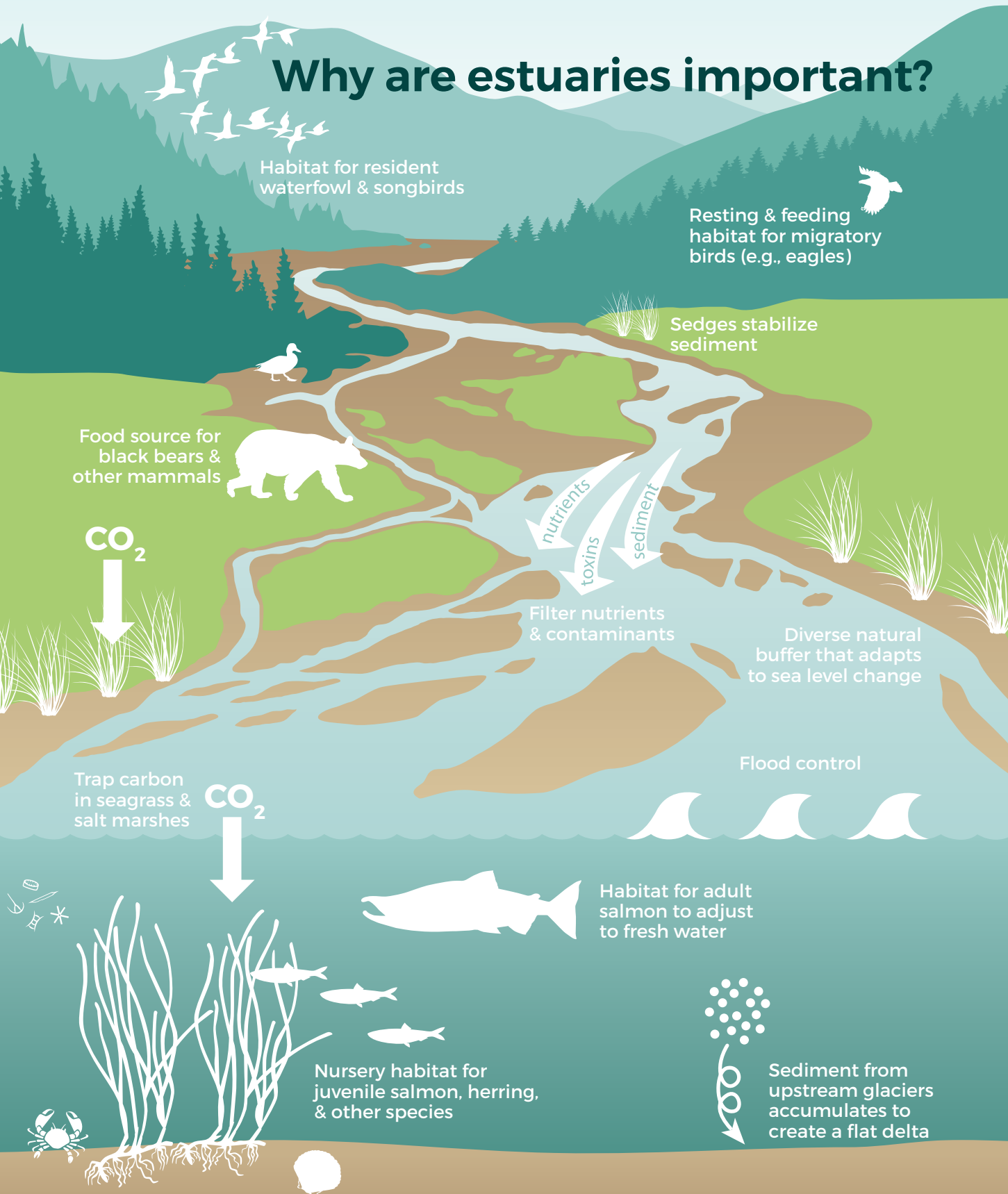
Photo: Coastal Photography, March 2016

What is the role of the Estuary in the life of First Nations?

Due to the rich abundance of life in estuaries, relative accessibility and flat topography, humans have migrated to these sensitive habitats since time immemorial. Estuaries provide easy access to water for transportation, a ready source of food, and an abun-

dance of materials to build and construct homes and shelter. The Squamish Estuary is no different, first being inhabited thousands of years ago by the Squamish Nation peoples, who remain a rich part of the community today.

Why are estuaries important?



Evaluation and ranking of B.C. estuaries

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Karin Bodtke, MRM, Manager, Coastal Ocean Health Initiative, Coastal Ocean Research Institute



Photo: Edith Tobe

More than a decade ago, the Pacific Estuary Conservation Program (PECP) evaluated the importance of 442 estuaries along the Pacific Coast to water birds. Evaluation was based on size, habitat type and rarity, herring spawn occurrence, water bird use, and intertidal biodiversity. The Squamish River estuary was assigned a rank of medium biological importance.^a Ideally estuary health can be measured by the amount of functioning habitat such as tidal marshes, swamps, mudflats, tidal channels, and eelgrass beds. Such quantitative analysis was not undertaken in the PECP study. However, recent work to assess the impact of human activities to estuaries along the entire B.C. coast ranked the Squamish estuary as “highly threatened.”^b

^a Ryder, J.L., J.K. Kenyon, D. Buffett, K. Moore, M. Ceh and K. Stipec. 2007. An integrated biophysical assessment of estuarine habitats in British Columbia to assist regional conservation planning. Delta BC: Canadian Wildlife Service Technical Report #476.

^b Robb C.K. 2014. Assessing the Impact of Human Activities on British Columbia's Estuaries. PLoS ONE 9(6): e99578. doi:10.1371/journal.pone.0099578

What is the current state of the Squamish Estuary?

The landscape of the Squamish Estuary today is quite different from what it was historically with over 50 percent of the estuary now developed for part of the town site, roads, dykes, and industrial deep sea terminals (Figure 3). In the early 1900s much of the estuary was logged for the Sitka spruce, red cedar and other softwood lumber that was used in the ship building trade. Later, in the mid-1950s the remaining forests were logged for the pulp and paper industry, which was active in upper Howe Sound until the early 2000s. In the early 1950s, the first large deep sea port was constructed at the Squamish Terminals to ship pulp to the Asian markets. In the early 1970s, B.C. Rail intended to fill the western portion of the Squamish Estuary to create a coal port and constructed a large dike down the west side of the estuary to “train” the Squamish River to the western edge (Figure 3).³

In the 1970s, the government of the day shut down coal port development, but the training dike remains in place to this day. From 2001 to 2010, organizations

such as the SRWS have installed culverts through the training dike to once more allow the fresh water of the Squamish River to mix with the marine waters of the central estuary. As well as installing culverts, the SRWS has spent the past 15 years re-establishing tidal channels and estuary habitat (Figure 4). To date, the SRWS has helped to restore over 20 hectares of brownfield back into functional estuary and has built over 25,000 square metres of tidal channels in partnership with Fisheries and Oceans Canada staff.

In 2008 the Province of B.C. established the Skwel-wil'em Wildlife Management Area (Figure 2), which protects 673 hectares of the estuary.⁴ However, the remaining estuary outside of the Wildlife Management Area lacks the same level of protection and is under threat from new roads, loss of the habitat to marinas, logging, log booms, industry and urban expansion that have all but destroyed life in the subtidal zones (visual observations by Edith Tobe).



Figure 3. Squamish estuary circa 1954 to left and circa 2010 to right. (Photos: Al Bird, Google Earth)

The Future of the Squamish Estuary

The Squamish region has become an attractive location for young families or those nearing retirement to settle and call home in a community that provides much in the way of natural features. Pacific white-sided dolphins, Orcas, and even humpback whales are now making their way all the way up Howe Sound to the waters of the Squamish Estuary. Restoration of the tidal channels and transplanted eelgrass and marsh plants have all contributed to improved habitat and migratory routes for waterfowl, fisheries, and other wildlife including a rich annual herring run each

spring and salmon runs each fall.⁵ However, education and outreach programs and stewardship activities may not be enough to protect the sensitive lands of the Squamish Estuary. Awareness and understanding of how the estuary acts like our lungs, sustains our inner spirit, and helps to protect the life around it is a message that needs to be conveyed to our present and future planners and decision makers to keep the Squamish Estuary as healthy and vibrant as it was over 100 years ago!



Figure 4. Reclaimed former dredge spoil site in the Squamish Estuary facing north towards Mount Garibaldi. (Photo: Edith Tobe)

What can you do?

SOME ACTIONS CONTRIBUTED BY CORI



Individual and Organization Actions:

- Volunteer individually or as an organization with one of the local environment groups (i.e., Squamish Streamkeepers, Squamish Environment Society, Squamish River Watershed Society, or Squamish Climate Action Network) and learn about the estuary on a walk with any of these organizations.
- Report ecological information to local citizen science programs (see citizen science article).



Government Actions and Policy:

- Increase educational and awareness campaigns that support widespread understanding of the importance of estuary health to all life in Howe Sound. Ensure accurate and comprehensive information is available and reviewed by area planners and decision makers.
- Continue to support and facilitate education, monitoring, and restoration activities of local groups in Howe Sound. Provide funding assistance and partnership opportunities where feasible.
- Explore the possibility of increasing the size of the Skwelwil'em Wildlife Management Area, or create more Wildlife Management Areas to increase protection throughout the estuary.
- Recognise the importance of estuary habitat for spawning and rearing salmon.
- Protect all estuary habitats from residential, commercial, or industrial development.
- Reclaim and rehabilitate estuary habitat that has been modified by past development.

Resources

A number of energetic and effective local groups are helping to protect the health of the Squamish Estuary through education, monitoring and restoration works.

Squamish Climate Action Network
squamishcan.net

Squamish Environment Society
squamishenvironment.ca

Squamish River Watershed Society
squamishwatershed.com

Squamish Streamkeepers
squamishstreamkeepers.net

District of Squamish, trails map
squamish.ca/discover-squamish/maps-and-data/mobile-web-maps/parks-and-trails/

Footnotes

¹ Hoos, L.M. and C.L. Vold. 1975. The Squamish River estuary: status of environmental knowledge to 1974: report of the Estuary Working Group, Department of the Environment, Regional Board Pacific Region. Environment Canada, Special Estuary Series, no. 2.

² IBA Canada. Squamish River Area Site Summary. Accessed Sept 8, 2016. <http://www.ibacanada.ca/site.jsp?lang=EN&siteID=BC023>

³ Squamish Estuary Management Plan. 1999. Accessed Sept 8, 2016. <http://squamish.ca/assets/PDF/3.14.4-Squamish-Estuary-Management-Plan-1999.pdf>

⁴ Ministry of Forests, Lands and Natural Resource Operations. 2016. Skwelwil'em Squamish Estuary Wildlife Management Area. Accessed Sept 8, 2016. http://www.env.gov.bc.ca/fw/habitat/conservation-lands/wma/skwelwil_em/

⁵ Golder Associates. 2005. Squamish River Watershed Salmon Recovery Plan. Submitted to Pacific Salmon Foundation. 187 pp.

Former HMCS Annapolis as reef habitat: Regaining lost ground

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REVIEWER

Neil McDaniel, Marine Naturalist

What's new in the world of reef habitat?

The newest artificial reef in British Columbia is the 370-metre long Annapolis, formerly the HMCS Annapolis, a Canadian naval destroyer escort. The ship was sunk in April 2015 at Halkett Bay on Gambier Island in Howe Sound. Over the past 27 years the Artificial Reef Society of B.C. (ARSBC) has created eight artificial reefs along the coast of B.C. and all provide habitat opportunities for underwater life in areas assessed as having low marine life potential primarily due to flat and featureless topography of the seafloor. The Halkett Bay site was also previously impacted by pollution and lacking biodiversity as a result. These artificial reefs provide unique recreational SCUBA diving opportunities.

Concerns over any risks posed to the marine environment were addressed to the satisfaction of Environment Canada, who, after thorough inspections, issued a Disposal at Sea permit stating that all waste from the ship had been removed, including all petroleum-based products. In addition, a park use permit was issued by BC Parks, which allows for the long term use of Halkett Bay as the home for the Annapolis.



The Annapolis in Halkett Bay prior to sinking. (Photo: Doug Pemberton)

Why are artificial reefs important?

For several decades, Halkett Bay on Gambier Island was used extensively for log boom storage. The wood debris from these log booms eventually smothered the bottom, creating a detrimental environment and severely reducing the potential for marine life growth. Howe Sound has also suffered a severe depletion of rockfish and lingcod over the past few decades. Some species of rockfish have disappeared and lingcod

numbers have been reduced by about 90 percent.¹ Rockfish and lingcod naturally favour irregular rocky reef environments. The Annapolis provides similar new reef habitat with complex structure and vertical profile for these fishes. The sport diving opportunities offered by the Annapolis artificial reef also provide an economic benefit to dive charter businesses, local restaurants and hotels.

Is there a particular importance or connection to First Nations?

Consultation was very important in the process of getting approvals to sink this ship in Howe Sound and particularly in Halkett Bay as the Squamish Nation has an historical presence in the area. They supported the

project from the outset and the Artificial Reef Society continues to work closely with them through an on-going study of the increasing biodiversity found at the reef (Project Annapolis Biodiversity Index Study).

What's the current state of habitat in and around the reef?

In the 1970s research on environmental quality undertaken by an Interdepartmental Task Force on National Marine Parks showed that bottom-dwelling marine life potential had been severely impacted by wood debris from the nearly constant presence of log booms moored in Halkett Bay and many other locations in Howe Sound.² More recently, this damage was confirmed by a biological study to the depth limit of rec-

reational diving (130 feet). The study found evidence of little to no marine life, which was documented in detail as part of the mandatory permit application process for the sinking of the Annapolis.³ Regular use of Halkett Bay for log boom storage has ceased, though booms in transit are occasionally stored in the bay temporarily during periods of bad weather.

What is being done?

Protection and study of sensitive and vulnerable habitats is one way to conserve biodiversity. Howe Sound is the only place in the world where glass sponge reefs can be safely studied by SCUBA divers, because some have been discovered here at accessible depths. A new extension of Halkett Bay Marine Park protects and preserves one of these reefs and allows citizen science divers to document observations of the glass sponge reef and its inhabitants over time. Such observations may help us better understand the impacts of climate change on these unique habitats.

In order to better understand the progression and abundance of species that populate the new Annapolis reef, the ARSBC has instituted the Annapolis Biodiversity Index Study (Project A.B.I.S.), a citizen scientist based study. The Project A.B.I.S. team includes members of BC Parks, Fisheries and Oceans Canada, the Vancouver Aquarium Marine Science Centre,



Spot prawn using the new artificial reef as habitat.

Squamish Nation, the Marine Life Sanctuaries Society and the ARSBC. Underwater photographers, videographers and knowledgeable divers have been encouraged to contribute observations since the ship's sinking on April 4, 2015. To date nearly 50 species of marine flora and fauna have been documented using

the Annapolis reef including two species of rockfish and 12 species unique to this new reef (Figure 1). Comparison of species counts at two natural sites with different habitats, Halkett and Pinnacle, illustrates natural differences among habitat types (Figure 1). Sponges are the only group that had not been seen on the Annapolis, as of March 2016. As time progresses, counts at the Annapolis site would not be expected to match either of the others, but should be more similar to the Halkett site, just across the Bay from the sunken ship. The biodiversity information is being shared between all involved parties and is made available on

the Vancouver Aquarium website as well as the ARSBC website.

Encouraged by the volunteer response to this study and by the biodiversity results that were recorded in the first year, the ARSBC applied for a Parks Enhancement Funding grant in May 2016. The application was accepted and the funds will be used to help offset the cost of getting a dedicated core of citizen scientist divers out on the ship on a regular basis to continue documenting observations.

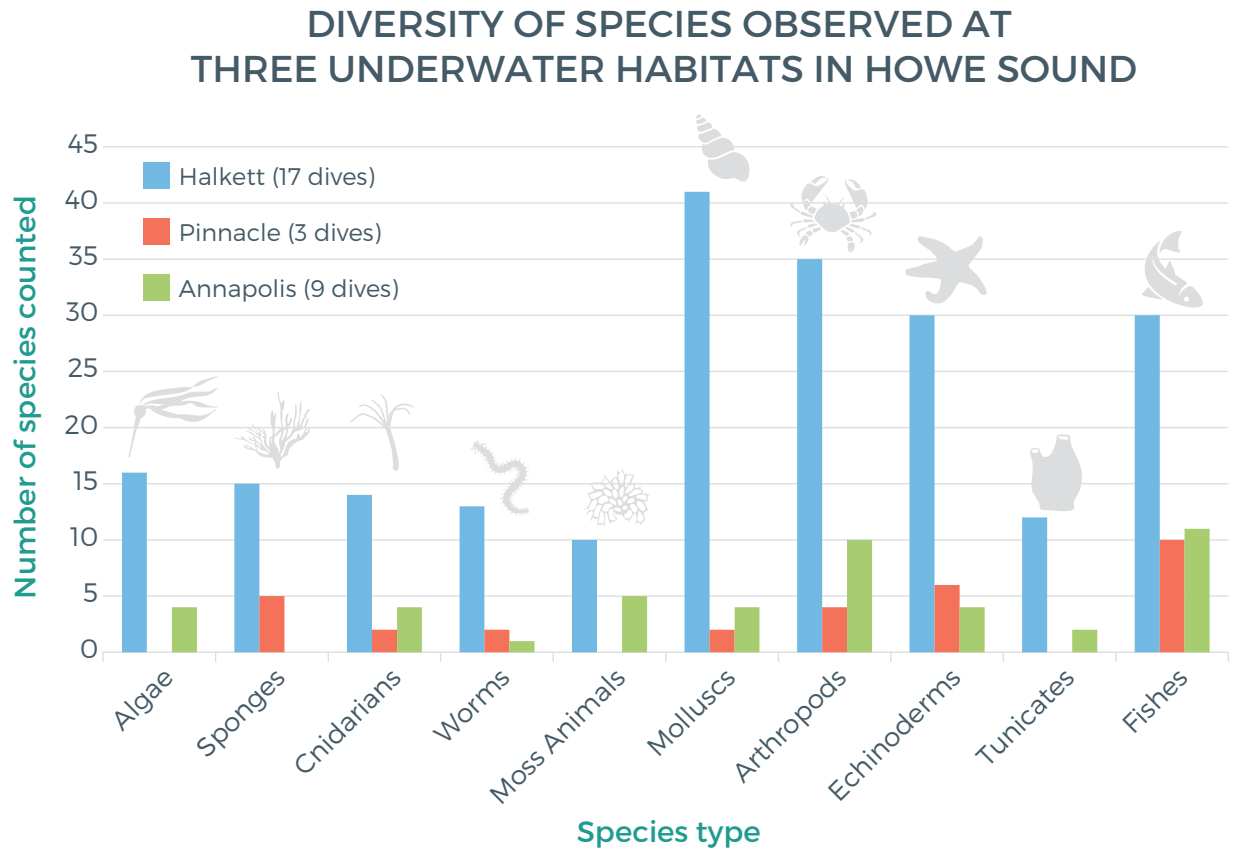


Figure 1. Number of species in different categories observed at three underwater sites in the area. Halkett (blue bars) refers to East Halkett Bay, a natural underwater wall habitat. Pinnacle (red bars) refers to the sponge bioherm east of Halkett Bay, and within the Halkett Bay Marine Park expansion. Annapolis (green bars) refers to the new Annapolis artificial reef. The three sites represent different types of habitat so the number of species in different categories is not expected to match among sites. (Analysis done March 2016)

What can you do?



Individual and Organization Actions:

- Learn about the monitoring project through the ARSBC website: artificialreefsocietybc.ca
- If you are a diver, please contribute your observations. Pictures, videos and information can be uploaded to the Vancouver Aquarium here: vanaqua.org/act/research/annapolis



Government Actions and Policy:

- Support citizen science efforts.
- Monitor and assess the effectiveness of artificial reef habitat.

Acknowledgements

The authors wish to thank the divers and photographers who have contributed to data summarized in this article: Anton North, Heather McAlpine, Chris Straub, Neil McDaniel, Doug Swanston, Gary Friesen, Jessica Schultz and anyone else we may have missed.

Resources

<http://www.aquablog.ca/2016/01/all-aboard-the-annapolis/>

Footnotes

¹ Martell, S.J.D. and S. S. Wallace. 1998. Estimating historical lingcod abundance in the Strait of Georgia. Pages 45–47 in D. Pauly and D. Preikshot, eds. Back to the future: reconstructing the Strait of Georgia ecosystem. Fisheries Centre, Univ. British Columbia, Vancouver. 211 p.

² McDaniel, N.G. 1973. A Survey of the Benthic Macroinvertebrate Fauna and Solid Pollutants in Howe Sound. Fisheries Research Board of Canada, Technical Report No. 385, 64pp. Retrieved from <http://www.dfo-mpo.gc.ca/Library/20924.pdf> 26 July 2016.

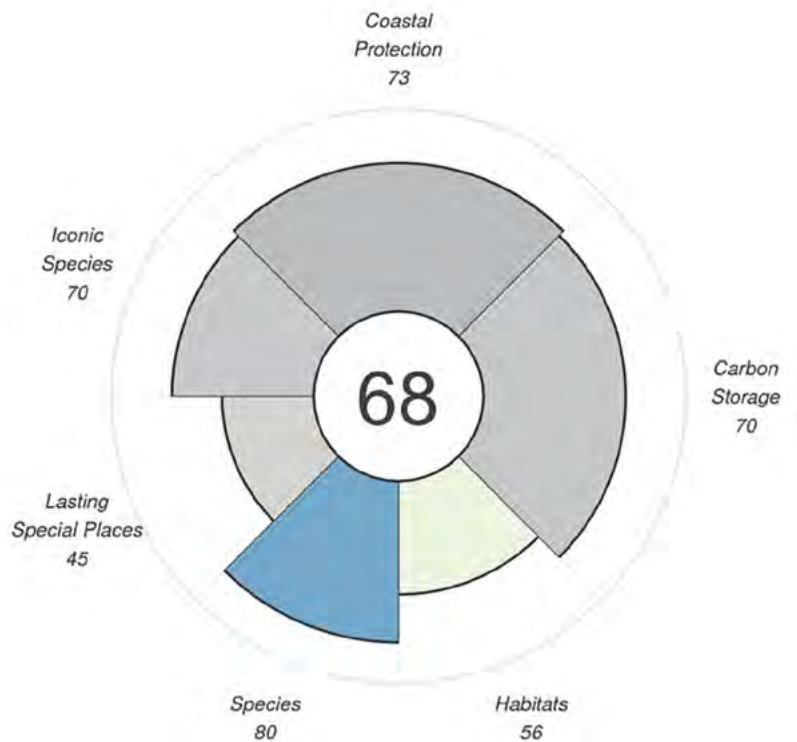
³ Artificial Reef Society of BC (ARSBC). 2009. HMCS Annapolis – Benthic Survey Report for Halkett Bay Site, Prepared for BC Ministry of Environment & Federal Department of Fisheries & Oceans, 19pp.

What can the Ocean Health Index tell us about Species and Habitats?

AUTHORS

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The overall Biodiversity score (68) is an average of a Species score (80) and a Habitats score (56).

How did the Ocean Health Index define Biodiversity?

Biodiversity: A healthy ocean provides a diversity of healthy marine species, habitats, and landscapes.

How did the Ocean Health Index measure Biodiversity?

The Ocean Health Index measured how well the ocean and coasts are providing biodiversity benefits in Howe

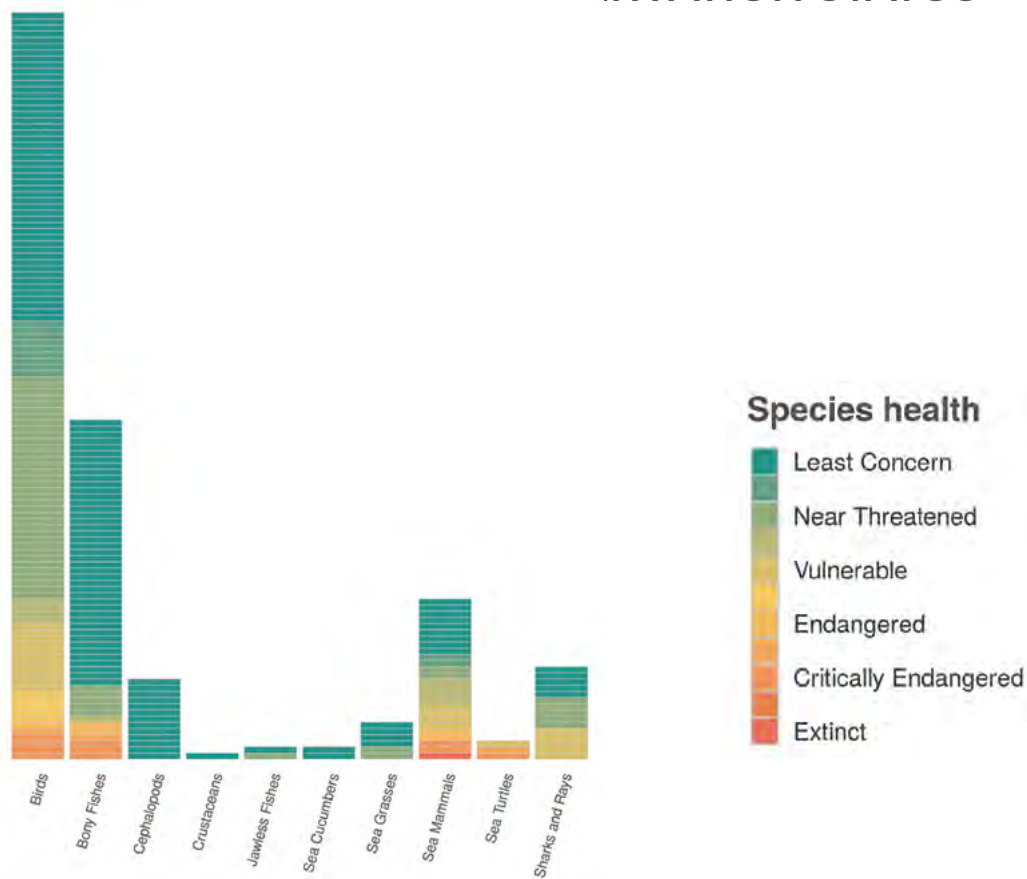
Sound by measuring the condition of **marine related species** and **marine related habitats** around the Sound.

TO MEASURE THE STATUS OF MARINE RELATED SPECIES WE ASSESS THE THREAT STATUS OF MARINE RELATED SPECIES IN HOWE SOUND.

The Ocean Health Index team used local, regional, and global datasets to determine the conservation status of as many species as possible throughout the Howe Sound region. By using data across different groups of species, from tiny sea cucumbers to huge whales, we sought to get a clearer picture of how well all species

are being conserved in the region and tell the whole story of the status of marine species Biodiversity. To achieve a perfect score, all species in Howe Sound should be listed as of “least concern,” meaning there is little risk of extinction.

SPECIES GROUPS INCLUDED IN THIS ASSESSMENT AND THEIR CURRENT CONSERVATION STATUS



TO MEASURE THE STATUS OF MARINE RELATED HABITATS WE ASSESS THE THREAT STATUS OF MARINE RELATED HABITATS IN HOWE SOUND.

To dig deeper into the status of Biodiversity in the region, we looked at the status of marine and coastal related habitats. We specifically focused on marine habitats that are known to have high biodiversity associated with them including salt marshes, sponge reefs, and soft-bottom habitats. Due to data and information limitations we were not able to include seagrasses in this calculation. By assessing how well these biodiverse habitats are being conserved we hope to capture more of the biodiversity status story in the region. We use these habitats as an estimate of not only the status of the habitats themselves, but also the status of all of the species that are associated with these habitats and use them for food, shelter, and other resources. If the habitats themselves are being well conserved, this is a good indication that the species that need these habitats for their own well-being are also being conserved.

Salt Marshes: To assess the conservation status of salt marshes we used land-cover change data to look at how much saltmarsh has been lost in Howe Sound through time. Howe Sound is known to have lost ~30% of its salt marsh area before 1990¹ and we were able to use land-use change data to look in detail at how much has been lost since 1990. We used land-cover data for 2010 (last available year) and then included

restoration efforts conducted since 2010 for our final calculations. This allowed us to look at net change in salt marsh coverage and we based our final calculations on these values. The target we used that would achieve a perfect score was zero net loss of salt marsh in Howe Sound.

Sponge Reefs: To calculate the status of sponge reefs we used maps of where sponge reefs are known to be located throughout Howe Sound and then looked at how many of these reefs are protected from fishing pressure by closures. Because sponges are extremely long-lived species that grow quite slowly and are extremely sensitive to physical disturbances like trawling, we set a target of 100% of all known sponge reefs protected by fishing closures to achieve a perfect score.

Soft-bottom Habitats: Soft-bottom habitats make up a large portion of the Sound. These habitats and the species that call them home are also quite sensitive to physical disturbances such as trawling. To calculate the status of this habitat we used maps of where soft bottom habitats occur throughout the Sound and then looked at where fishing pressures have occurred across this area. For this habitat, a perfect score could be achieved by no trawling occurring over any soft-bottom habitat areas.

¹ Levings, C.D. and R.M. Thom. 1994. Habitat Changes in Georgia Basin: Implications for resource management and restoration. In Review of the Marine Environmental and Biota of Strait of Georgia, Puget Sound and Juan de Fuca Strait: Proceedings of the BC/Washington Symposium of the Marine Environment, January 13 and 14 1994. Pp. 330–351. Canadian Technical Report Fish. Aquat. Sci. no 1948.

Clean Water

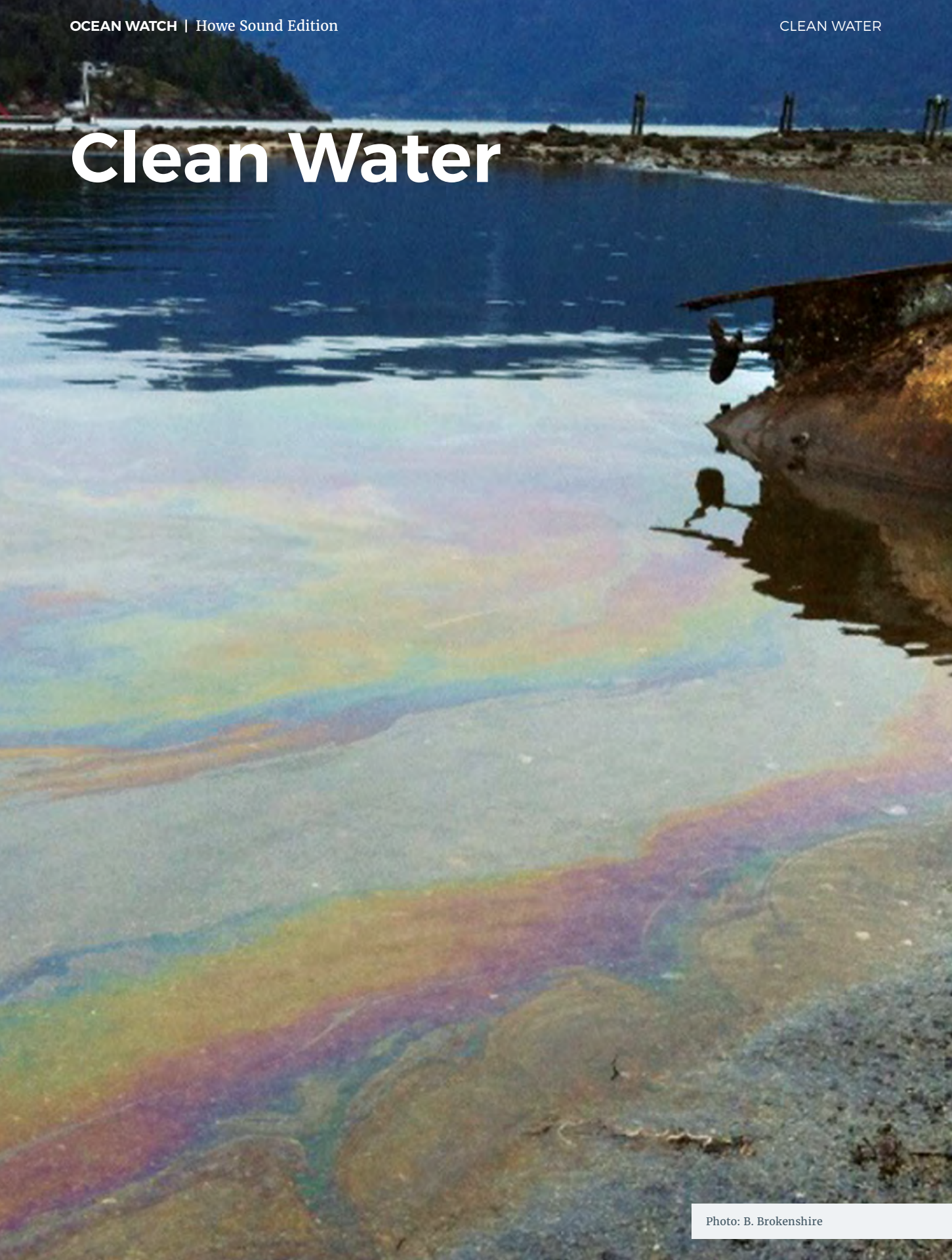


Photo: B. Brokenshire

Summary

The story of Howe Sound's recovery from nearly a century of heavy industrial use is one of wins and losses. For much of the 20th Century, effluent and toxic chemicals from pulp and paper mills and heavy metals from the Britannia Mine site poured into the Sound, contaminating sea life, soaking up oxygen and smothering the sea floor. The result was near devastation of many aquatic ecosystems, leading to widespread fisheries closures and health warnings — some of which are still in place today.

But environmental regulations and remediation efforts introduced beginning in the late 1980s have had a remarkable effect. Today, the Sound is once again home to many viable fisheries, and has seen a return of cetaceans and other large species to the area, suggesting a proliferation of food sources farther down the food chain. Concentrations of pollutants such as dioxins and furans in fish tissue and sediment have declined dramatically, while the closure of the Britannia Mine and the introduction of remediation efforts at its site in 2001 have also had a substantial positive impact.

Howe Sound will not soon return to its pre-industrial state, however. Nearly two decades after the closure of the mine, heavy metals are still leaching into the water from unknown sources, while some Dungeness crab in the Sound still show dangerously high levels of pollutants previously used in pulp and paper production. At the same time, derelict vessels abandoned or wrecked in the Sound increase the risk of contamination and fuel spills. Howe Sound's recent history shows us that, while much can be done to improve the health of ecosystems affected by contamination, human-caused damage is very difficult to undo.

Clean Water Snapshot Assessment

Britannia Mine Contamination

After being deemed one of the most polluted areas of Howe Sound, aquatic life has started to return to the waters around the old Britannia Mine site. But despite ongoing remediation efforts at the site, metals continue to leach from unknown sources.



CAUTION

Pulp Mill Effluent

Regulations introduced to pulp mills along Howe Sound have eliminated new input of marine pollutants associated with the industry. Yet lingering concentrations in marine sediment and Dungeness crab underscore the persistent impact of these toxins, so concerns remain.



CAUTION

Problem Vessels

Abandoned, wrecked and derelict vessels continue to populate Howe Sound calling attention to the need for a coordinated effort to track owners and enforce marine laws. While there is some effort and movement on the problem, including commitments in the new federal Ocean Protection Plan, the costs and removal strategies associated with existing problem vessels remain largely unaddressed.

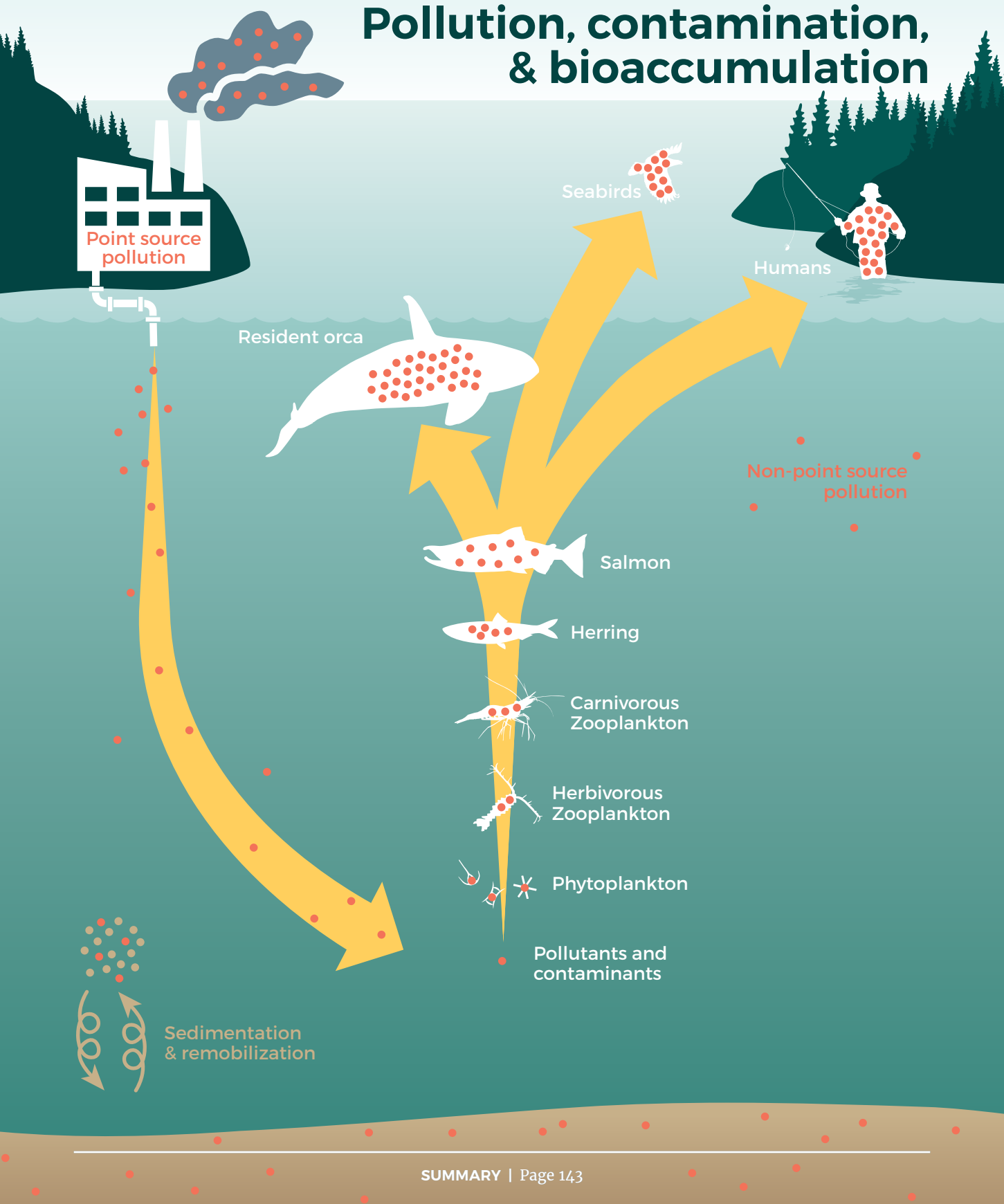


CAUTION

“The ecosystem service of clean water refers to the benefits associated with the filtering, retention and storage of water that occurs primarily in forests, streams, lakes and aquifers of watersheds. ... The total value for water supply services in Howe Sound ranges from approximately \$300 million to \$770 million per year.”

**FROM SOUND INVESTMENT: MEASURING THE RETURN ON HOWE SOUND’S ECOSYSTEM ASSETS
(MICHELLE MOLNAR, 2015, DAVID SUZUKI FOUNDATION)**

Pollution, contamination, & bioaccumulation



Metal contamination from the Britannia Mine site: lingering problems, ongoing remediation

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CONTRIBUTORS/REVIEWERS

Two reviewers improved the article and prefer to remain anonymous.

What's happening with metal contamination from the old Britannia Mine site?

Despite considerable and ongoing remediation efforts, metal contamination from the Britannia Mine workings of the past lingers. The flow of contaminated water directly into Howe Sound has decreased, however sampling of the aquatic environment, including freshwater, groundwater, and marine water as recently as spring 2013 reveals metal contamination well above water quality guidelines.¹ The Britannia Mine Museum (Figure 1) now occupies part of the mine site, but the mine itself has been closed for approximately 40 years. The mine covered an area of 28 to 36.5 square kilometres consisting of a series of tunnels and some open-cast mining.^{2,3} Between 1898 until 1974, over 40 million tonnes of tailings were generated and deposited onto the marine subtidal slope near Britannia Beach and four to 40 million litres of metal-laden waters (acid mine drainage) were discharged into Howe Sound every day, depending on the time of year.^{4,5} Metals from rock are mobilized when large quantities of rock containing sulphide minerals are exposed to

air and water, in mine tunnels for example, and sulphuric acid is created. The resulting acid rock drainage can carry high levels of heavy metals and sulphate. Acid mine drainage from the Britannia site included contaminants such as copper, aluminum, iron, zinc and manganese. Remediation efforts underway since 2001 have resulted in significant improvements in the creeks draining the area and in the nearshore environment, and ongoing efforts plan to address the remaining potential sources of metals.

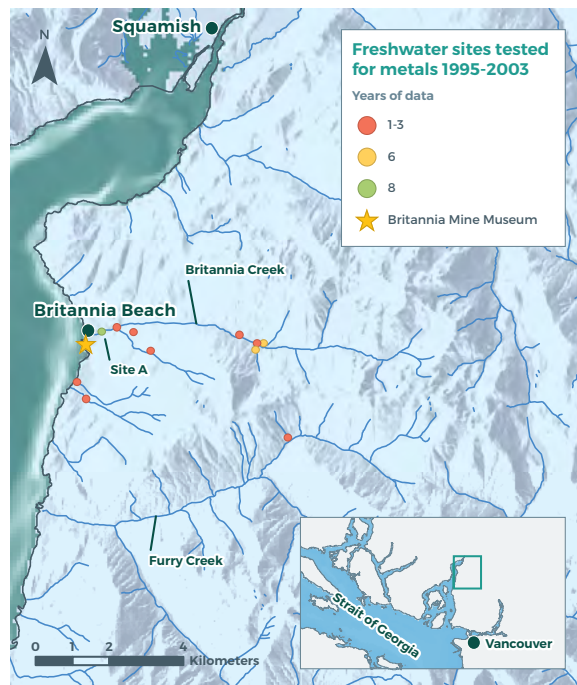


Figure 1. Britannia Beach community, Britannia Mine Museum, and freshwater sampling sites tested for metal contaminants between 1995 and 2003.

Why is it important?

Heavy metals can be toxic to many organisms, including humans. For instance, cadmium can affect humans, while copper has toxic effects on the behaviour and olfaction systems of salmonids.^{6,7,8} Some metals bioaccumulate in organisms, when intake of the metal occurs at a greater rate than excretion, and these contaminated organisms are consumed by other organisms which become contaminated in turn. Water quality guidelines (WQGs) for both marine and freshwater are put in place by governments for the protection of

aquatic life.⁹ It is important to recognize, however, that the area geology is naturally mineral-enriched (hence the historic mining activity) which can result in naturally occurring concentrations of metals exceeding WQGs.

In the late 1990s, it became clear that contamination from the old Britannia mine was an issue that needed attention, when reports documented copper concentrations in mine drainage that were thousands of times

greater than provincial water quality guidelines of the time^{10,11,12} and there were clear indicators of the effects in the shoreline community. In 1999, concentrations of dissolved copper in seawater detected in near shore waters close to the mouth of Britannia Creek¹³ exceeded British Columbia WQG¹⁴ by approximately 20 times and was lethal to caged salmon and local mussels. Research on the effects of metal contamination at Britannia prior to remediation has shown impacts on salmon fry,¹⁵ mussels, algae, and invertebrates of Howe Sound. Primary production in Howe Sound was reduced,¹⁶ contaminated sediments in Britannia Creek were toxic to important food sources such as midge

larve and amphipods, sand dollar reproduction was impaired,¹⁷ and blue mussel growth was impaired.¹⁸

Historically, the site was referred to as being one of the worst sources of water pollution involving metal contamination in North America^{19,20} and the worst point source of heavy metal pollution in British Columbia.²¹ Remediation began in 2001.

While the construction of a water treatment plant was underway, freshwater and acid mine drainage from a point source at the mine were diverted into an outfall off Britannia Creek. This led to an immediate re-



Britannia Creek drainage (centre left) with the mine museum (white stepped building) close to the shoreline. (Photo: Gary Fiegehen)

duction in acid mine drainage to Britannia Creek and nearshore areas, and allowed the beach ecosystem to start recovering.²² Additional remediation efforts have included:

- several surface water diversions of clean water away from the mine,
- use of the mine workings as a storage reservoir to balance seasonal flows,
- a water treatment plant, operational since 2005,
- a deep-water outfall for the outflow of the treatment plant, which discharges to Howe Sound,

- a ground water management system to intercept metal-contaminated fresh ground water and direct it to the treatment plant,
- relocation of metal contaminated soils,
- surface water drainage diversions to keep metal-contaminated surface water away from intertidal areas,
- and maintenance of these operations (e.g., Figure 2).^{23,24}

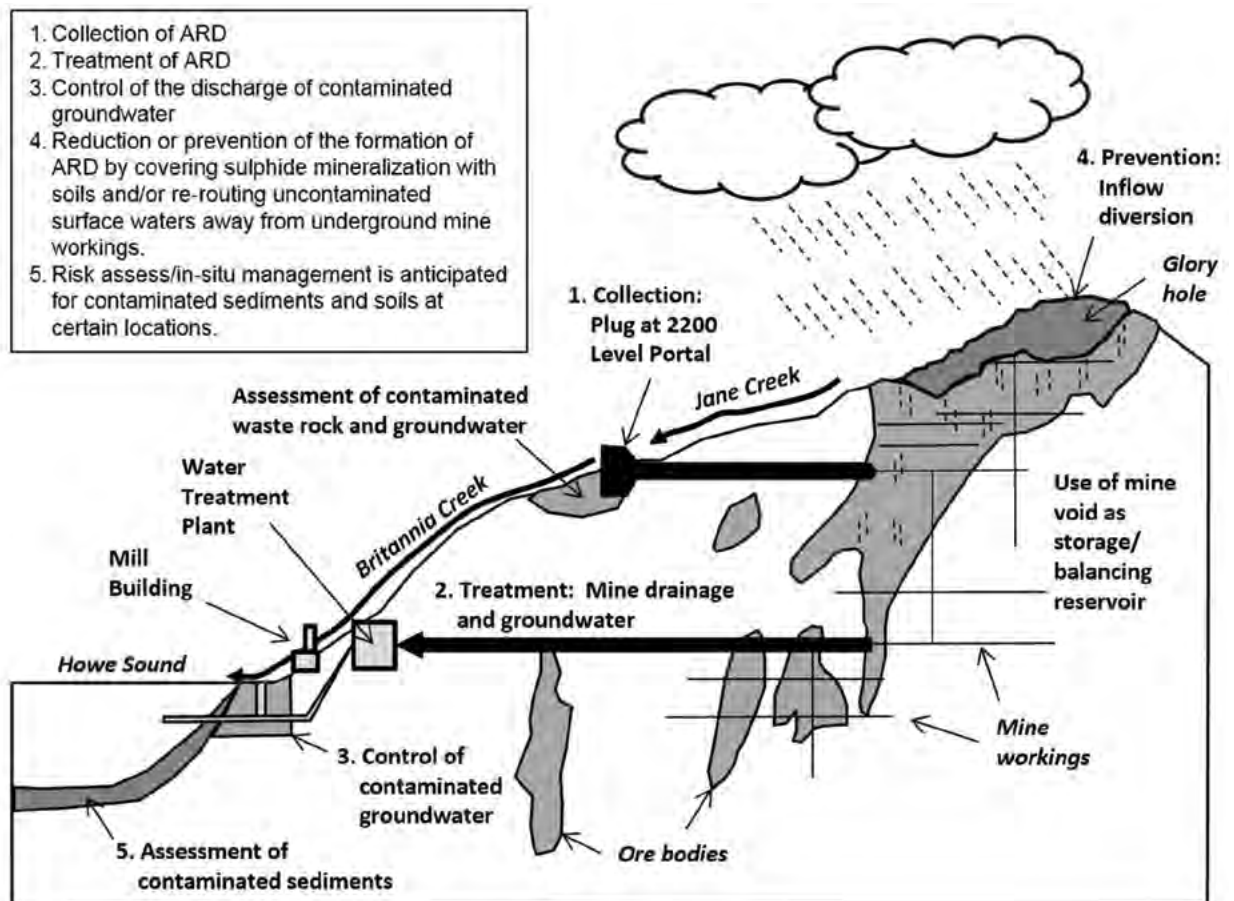


Figure 2. Some of the pollution prevention measures and remediation systems required to address and mitigate metal contamination in the coastal marine environment from Britannia Mine. ARD is Acid Rock Drainage. (drawing courtesy of Golder Associates)

What is the connection to First Nations cultural and spiritual heritage?

Contamination by acid mine drainage in Howe Sound can have and has had important implications for First Nation communities that rely on salmon and seafood from Howe Sound and the Squamish River Estuary. Salmon is not only a traditional food but holds strong spiritual and cultural significance. First Nations communities on the B.C. coast eat 15 times more seafood than the general B.C. population.²⁵ This fact alone puts the First Nation population at greater risk of toxic effects of contaminated seafood.

Nearshore areas all along the coast of Howe Sound are used by juvenile chum salmon, Chinook salmon, and

other salmonids as they migrate from the Squamish River to the open ocean. Chum salmon fry abundance was found to be significantly lower near Britannia Creek mouth (up to 1.2 per 100 square metres) than in reference areas (between 11.5 and 31.4 per 100 square metres) in 1997 and 1998.²⁶ Prior to any mitigation, water quality near Britannia Creek was poor enough (e.g., dissolved copper concentrations of ~2.67 mg/L) that 100 percent of caged Chinook salmon smolts died within two days of being placed there.²⁷ The contamination can not only affect abundance of fish in the area, but the balance of the marine food web, upon which First Nation communities rely.

What is the current state of metal contaminants around Britannia Mine?

There is an overall closure plan in place, and remediation and risk assessment are ongoing to address residual contamination in the Britannia Fan Area.²⁸ Currently, most of the mine water and some of the contaminated ground water is captured, treated, and discharged to Howe Sound at a depth of 50 metres. The ecological recovery of Britannia Creek became news in 2011, when citizen scientist John Buchanan discovered pink salmon inhabiting the lower reaches of the Creek for the first time in about 80 years. Fisheries and Oceans Canada (DFO) confirmed his observation.²⁹ Mussels, common to Howe Sound, are now natural-

ly colonizing the shoreline except in a few localized areas, and rockweed — a common Howe Sound seaweed which was long absent along the shoreline in the proximity of Britannia Creek — is now also present except at a few sites.³⁰

However, recent monitoring, by Golder Associates and the Province of B.C., of creek water, groundwater, intertidal water and intertidal ecology show evidence of lingering metal contamination and suggest that the area will never be returned to its pre-industrial state.

In 2013, sampling efforts found that metal concentrations in some porewater (i.e., groundwater seeping from the Britannia Creek alluvial fan into the marine intertidal area) and intertidal surface and bottom water samples continued to exceed B.C. marine WQG³¹ at levels comparable to years since 2004.³² The highest copper concentration observed in porewater in March 2013 was over 4,000 times greater than the acute WQG.³³ Furthermore, copper concentrations in porewater exceeded WQGs at all locations except one reference location at the Magnesia Creek outlet,³⁴ about 20 kilometres to the south. At a test site in the Furry Creek intertidal area, located several kilometres south of the mine site, porewater copper concentrations increased approximately 10-fold between 2003 and 2012.³⁵ It is not clear why concentrations at Furry Creek were higher during parts of 2011 and 2012, as the Britannia Mine does not have an influence on intertidal porewater there. Substantial spikes in other metals in porewater were also observed in 2013 at sites in the Britannia fan area (i.e., iron concentration up 100-fold at one site and zinc concentration up approximately 10-fold at another) compared to 2005 levels.³⁶

Marine intertidal water at reference locations (Magnesia and Furry Creeks) showed copper concentrations at or below WQG for the most part, which is expected, but samples from two sites in the Britannia Beach fan area showed numerous copper concentrations higher than WQG between 2003 and 2013 (Figure 3).³⁷

While intertidal invertebrate community shows increasing healthy diversity at some sites in the Britannia Beach foreshore, some continue to exhibit lower diversity than comparable sites near Furry Creek and Magnesia Creek.³⁸ Not surprisingly, the sample site

with the highest porewater metal concentrations showed the lowest intertidal species diversity.³⁹

Older data (from 1995 to 2003) from the Environmental Monitoring System (EMS) at the British Columbia Ministry of Environment⁴⁰ showed variation in freshwater concentrations of most metals associated with acid mine drainage (i.e. copper, aluminum, iron and zinc) at sites around Britannia Mine. Metal concentrations at one sampling location furthest downstream on Britannia Creek (Figure 1, site A) did show a sharp decline in 2002, likely related to the diversion of a point source of acid mine drainage away from the Creek in 2001 when mitigation efforts began, but 2003 concentrations for copper and zinc were still above the Federal WQGs⁴¹ (Figure 4).

In 2006, concentrations of copper, zinc and other metals in Britannia Creek were still at levels exceeding water quality guidelines.⁴² In Jane Creek and surrounding Britannia Creek stations, water concentrations of several metals, especially copper, zinc and cadmium, exceeded WQGs by two to 149 times.⁴³ Since 2006, sampling in the freshwater areas of the mine site has been linked to specific studies to support remediation planning and risk assessment.

Reoccurring high metal concentrations in porewater, marine water, and in rockweed at the mine site require further investigation to elucidate the source. Groundwater could be flowing in from areas outside of the groundwater management system and becoming contaminated or metals could be leaching from mine tailings buried under beach sediments.⁴⁴ Work on these issues is continuing.

COPPER CONCENTRATIONS IN INTERTIDAL WATERS NEAR BRITANNIA CREEK AND FURRY CREEK

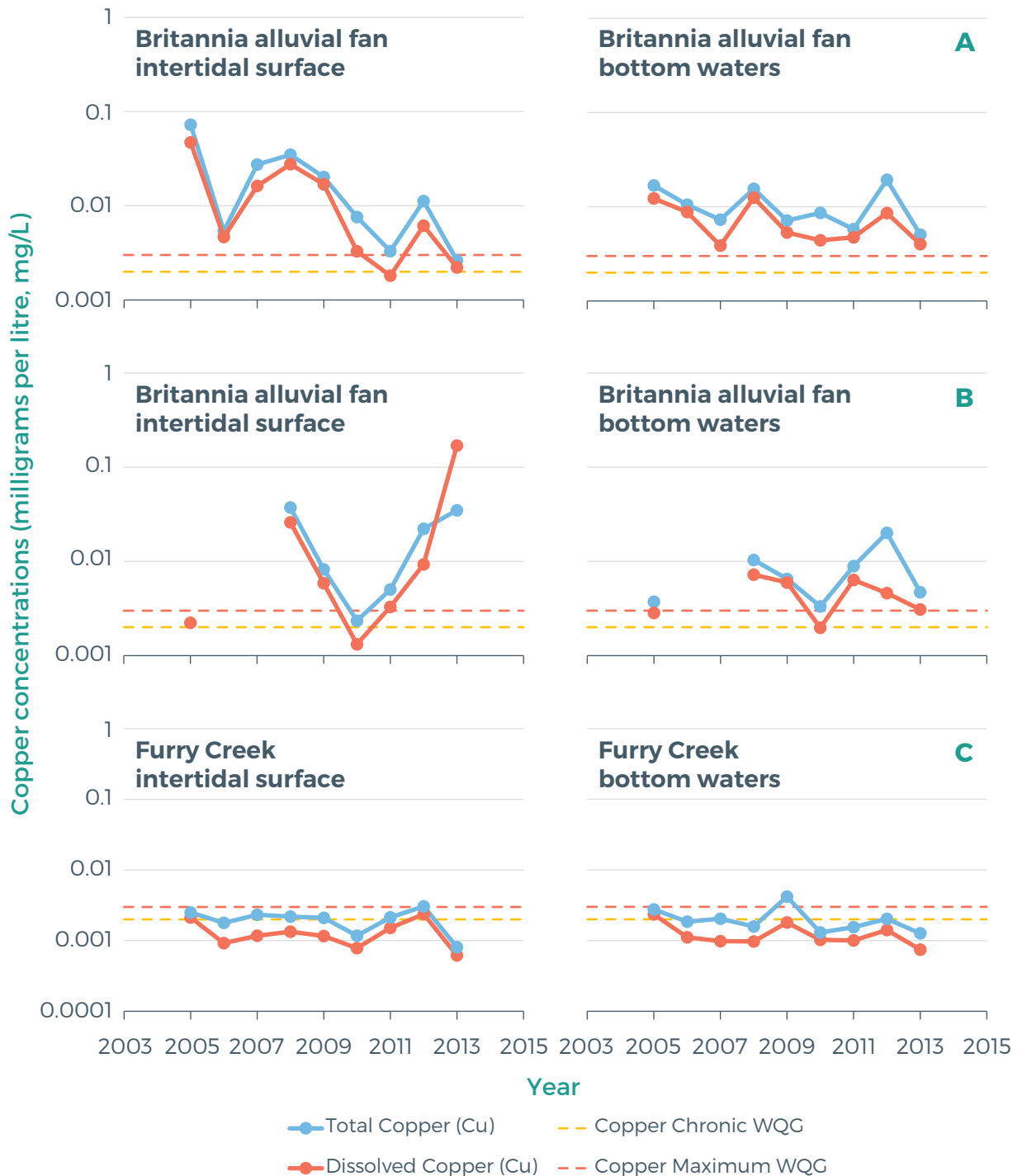


Figure 3. Annual averages of total and dissolved copper concentrations (mg/L) in marine intertidal surface and bottom waters measured at two sampling sites, from 2005 to 2013, of the Britannia Fan Area Reach, south of the Customs Wharf, Britannia Mine (rows A and B), and the Furry Creek reference site (row C). Concentration data for 2006 and 2007 were not available or measured for the second site (row B). The chronic and maximum water quality guidelines (WQGs) (dashed lines) are set for the protection of marine aquatic life in British Columbia.⁴⁵ Note the log scale on the y-axis. (Data courtesy of Golder Associates)

What is being done?

Both federal and provincial regulations have played a role in the remediation and clean-up of the former Britannia mine site. Several remediation orders were issued between the 1970s and late 1990s under the former provincial Waste Management Act,⁴⁷ replaced by the Environmental Management Act in 2004. Since 2004, an environmental monitoring program and ecological risk assessment have been underway and remediation is on-going.

Significant improvements to Britannia Creek and nearshore ecology have been achieved. For example, the waters are no longer lethal to fish. The source(s) of reoccurring high metal concentrations in porewater and intertidal water at some shore locations near the mine is under investigation, as is the feasibility of further remediation options. It is unlikely that the area around Britannia Mine will ever be returned to its pre-mine state, copper levels may never consistently meet WQG, and risk assessment will be used as a tool to determine what an acceptable end state will be. Even when closure is achieved for the Britannia Remedi-

ation Project through a closure plan, there will be on-going risk management obligations, for example the continued operation of the Water Treatment Plant.⁴⁸

Meanwhile, development of the community at Britannia Beach has renewed interest. Residential and mixed purpose development is being planned for both North and South Britannia Beach in uncontaminated lands. An application for a mixed residential development of 1,000 dwelling units at Britannia Beach South (south of Britannia Beach proper where the mining infrastructure is), to be phased over 15 to 20 years, was presented to the Squamish-Lillooet Regional District Board in June 2016 (see Coastal Development article in this report). Replacement and upgrade of dilapidated infrastructure for the existing community, in Britannia Beach proper, has proceeded over recent years; private home ownership was implemented, new development lots were identified and the town is enjoying a general rejuvenation.⁴⁹

CONCENTRATIONS OF FOUR METALS IN FRESH WATER SAMPLES FROM BRITANNIA CREEK

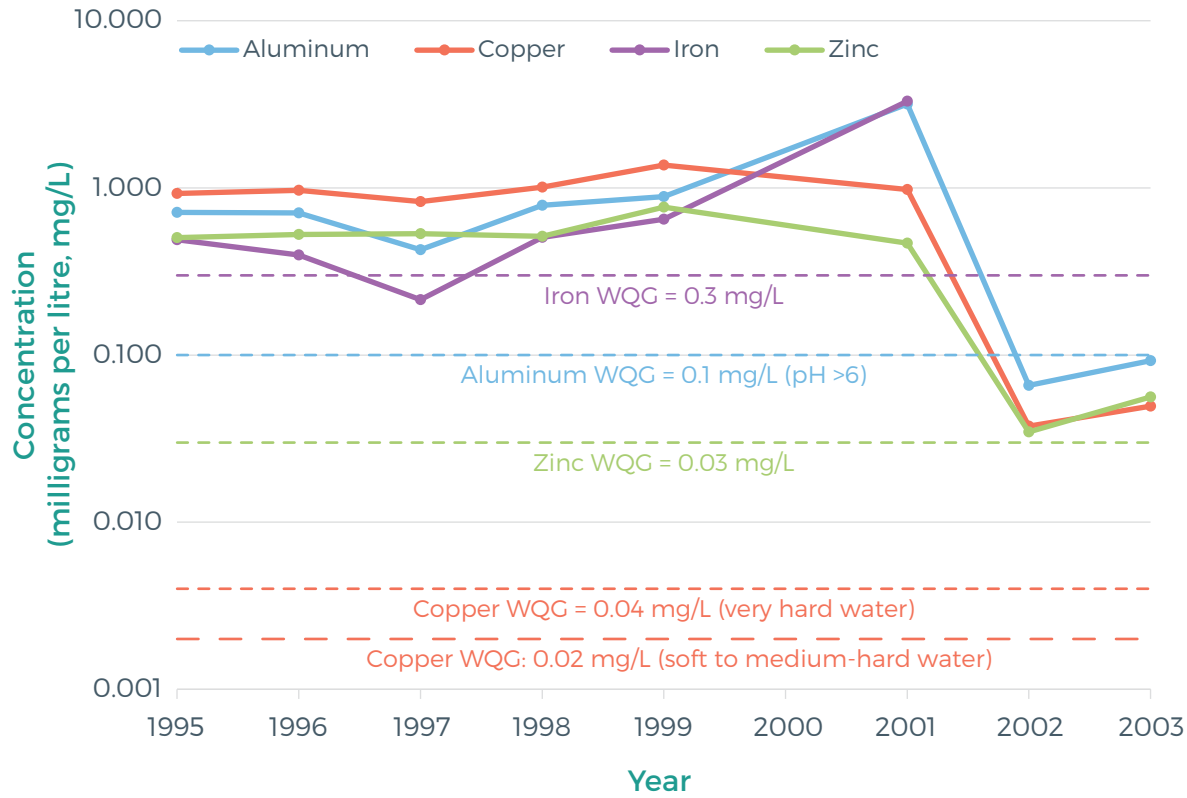


Figure 4. Concentrations of aluminum, copper, iron and zinc in fresh water samples collected from 1995 to 2003 around Britannia Mine in Britannia Creek (Site A, Figure 1). Data were retrieved from the database of the Environmental Monitoring System (EMS), British Columbia Ministry of Environment.⁴⁶ Note the log scale on the y-axis.

What can you do?



Individual and Organization Actions:

- Sources of metals in waste-water are not all industrial. Be aware that what goes down your household drain or into the street gutter almost always ends up the ocean. Water treatment facilities can remove many contaminants, but plenty of dangerous chemicals that go down your drain will still end up in rivers, lakes, and oceans. Phosphates from detergents, chlorine from bleach, and the toxins in pesticides will all wreak havoc on fragile ecosystems once they leave your local sewage treatment plant.
- Do not put paint, solvents, pesticides or other chemicals down your drain.
- Recycle all batteries.
- Help reduce the environmental impacts of mining by:
 - Reducing your consumption of minerals; reducing consumption of consumer goods in general.
 - Taking transit rather than buying a new car.
 - Using recycled materials instead of mined materials and recycling all your metals (e.g., tin cans).



Government Actions and Policy:

- Track the state of the ecosystem health using a consistent ocean pollution indicator. Identify and use a resident and an abundant biological indicator or bioindicator (i.e., an organism that can be used to monitor the state of pollution levels in the long term) to track metal contamination.
- Reach out to the community with updates on remediation in the Britannia Mine area. The community needs information about observed metal concentrations and any risk of harm they pose to human and marine life.
- Increase public education campaigns designed to educate citizens about the impact of phosphates, chlorine, and pesticides, and how to minimize their impact.
- Increase support of research focuses to assess levels of metal contamination in waterways.
- Support local recycling and zero waste initiatives.
- Protect salmon stocks against the negative health effects of copper to the salmon's olfactory system similar to that established in Washington State (<http://www.seadocsociety.org/scientists-who-showed-how-copper-damages-salmons-sense-of-smell-receive-prestigious-award/>), which will benefit salmon recovery by reducing the amount of toxic metals entering the Salish Sea by hundreds of thousands of pounds each year.
- Legislate against the use of phosphates in household products.

Resources

A Fact Sheet on Acid Mine Drainage

focs.ca/wp-content/uploads/2012/07/Acid-Mine-Drainage-FNEHIN.pdf

Footnotes

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Dioxin and furan contamination from pulp mills: A successful history of source control and regulations

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What's happening with dioxin and furan contamination in Howe Sound?

Historically, two pulp mills have long operated in Howe Sound, the Port Mellon and the Woodfibre mills. The Howe Sound Pulp and Paper (HSPP) mill at Port Mellon began operation in 1908 and is the only mill in operation today in Howe Sound. For decades, effluent from HSPP and the Woodfibre mill, which closed in 2006, created a variety of impacts on receiving waters in Howe Sound. These impacts included high biological oxygen demand causing oxygen depletion, smothering of local seafloors with fine fibre beds, reduced light penetration leading to lower phytoplankton production, and impacts from a variety of chemical contaminants, including dioxins and furans. The chemical contamination resulted in the closure of fisheries in most of Howe Sound in the 1980s.¹ However, effluent regulations introduced in the late 1980s and early 1990s and mill process changes since the mid-1980s have dramatically reduced contamination and related impacts in Howe Sound.

In 1995, harvest restrictions due to dioxin/furan contamination were removed for 40 percent (486 square kilometres) of the previously closed area in Howe Sound,¹ and today permanent fisheries closures remain in effect for crab but not for prawn, shrimp and finfish. Recent sampling reveals that dioxins and furans remain in the sediment in the proximity of HSPP, but levels in sediments are in general decreasing.

Contamination in fish and shellfish has generally declined near HSPP to levels below the Health Canada consumption criteria,^{2,3} but advisories to limit consumption of crab (i.e., specifically the hepatopancreas where dioxins are concentrated) are posted and remain in effect in Howe Sound.⁴ Environment Canada oversees an Environmental Effects Monitoring (EEM) program that continues today at the HSPP mill.



Howe Sound Pulp and Paper mill at Port Mellon. (Photo: Bob Turner)



Crab is a popular food item for fishers in Howe Sound but some areas remain closed to crab fishing due to contamination. (Photo: Gary Fiegehen)

Why is dioxin and furan contamination an important issue?

For many years, the Port Mellon (i.e. HSPP) and Woodfibre pulp mills used liquid chlorine for the bleaching process and, consequently, produced and discharged effluent containing byproducts known as polychlorinated dibenzo-p-dioxins (i.e. dioxins) and dibenzofurans (i.e. furans).⁵ Human intake of dioxins and furans poses potential health risks because these organic pollutants are among the most persistent, toxic, bioaccumulative and carcinogenic hazards to

humans.^{6,7} Because of dioxin and furan contamination in the marine environment and high tissue concentrations in seafood, fisheries (including harvesting of prawn, shrimps and crab) were closed in Howe Sound and other parts of the B.C. coast near pulp mills in 1988.^{5,8,9}

What is the current state?

Monitoring has shown a marked decrease in dioxin and furan contamination in Howe Sound over time (Figure 1). Since initial testing in 1987, concentrations measured in the digestive organs (hepatopancreas) of Dungeness crab at Port Mellon and Woodfibre have decreased by 97 percent and 99 percent, respectively (Figure 1 top panel).^{2,10} However, in 2012, dioxin and furan concentrations in the hepatopancreas of Dungeness crab collected from three of eight sampling sites at the HSPP mill exceeded the Health Canada consumption criteria,² indicating that crabs from these sites are not safe or suitable for human consumption.

Contamination in sediments decreased by 19 percent at Port Mellon and 99 percent at Woodfibre between 1987 and 1995 (Figure 1 bottom panel). The more rapid decrease of dioxins and furans at the Woodfibre mill site relative to Port Mellon likely relates to higher rates of fresh sediment deposition at the Woodfibre site due to its proximity to the mouth of the Squamish River. In 2012, concentrations of dioxins and furans in sediments near the Port Mellon mill were still within the lower end of the historical range, suggesting that the sediments here may act as both sink and source of dioxin and furans.

In B.C., the monitoring of effluents from pulp and paper mills, as well as nearby sediments, water and benthic invertebrates, has routinely been conducted since the 1970s.¹³ In October 1976, the Environmental Protection Service (EPS) initiated a program to assess the environmental impact at the Port Mellon pulp and paper mill.¹⁰ The EPS collated relevant data and

environmental monitoring information, which led to additional monitoring studies and environmental impacts assessments and the installation of treatment plant facilities at the Port Mellon mill.¹⁰ To meet effluent quality standards/guidelines, treatment facilities at pulp mills were required to reduce the amount of suspended solids and toxic substances released to the receiving marine environment.¹⁴ Primary and secondary effluent treatments plants were installed in September 1990.¹⁴

At the Woodfibre pulp mill, effluents were treated with an oxygen-activated sludge system starting in December 1992, resulting in a 95 percent reduction in biochemical oxygen demand, meaning that the effluent no longer used up oxygen that plants and animals need to survive in the receiving marine water. Monitoring of fish tissue at Woodfibre up until the time of mill closure in 2006 indicates decreasing concentrations of dioxins and furans.¹⁵ However, dioxin and furan concentrations in 2006 in crab hepatopancreas and dogfish liver near Woodfibre remained above the Health Canada consumption advisory threshold.¹⁵

While the level of dioxin and furan contamination has decreased in the region, ongoing monitoring is still required as the most recent data showed that Dungeness crabs still have elevated levels of dioxins in some locations at the HSPP mill.² Seafloor sediments can function as a contaminant source or sink because exposure pathways for crabs may have changed since the mills ceased producing dioxins and furans; sediment contamination may have improved faster at some sites than others.¹¹

DIOXIN AND FURAN CONCENTRATIONS MEASURED
IN DUNGENESS CRAB AND MARINE SEDIMENTS

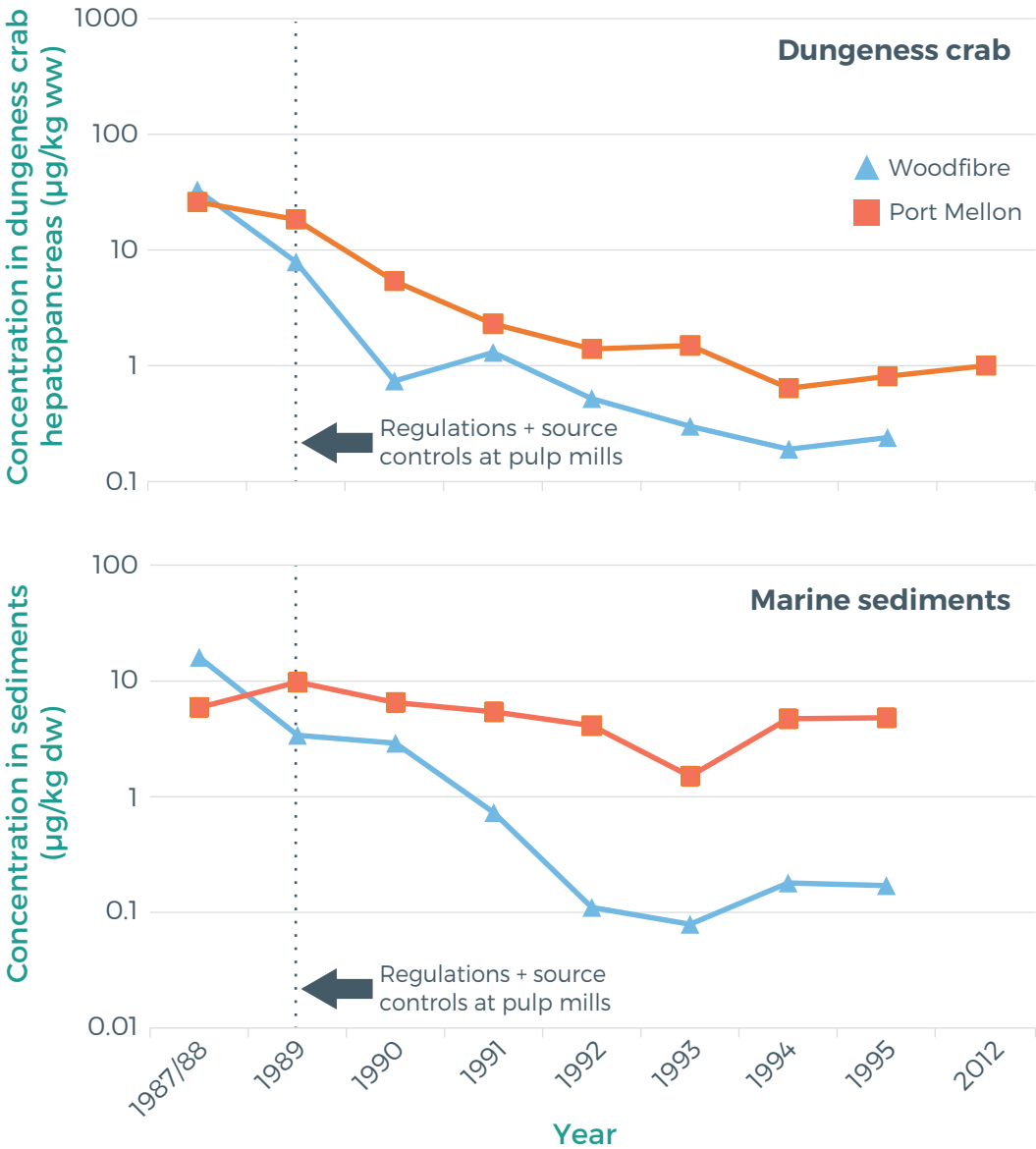


Figure 1. Trends of total dioxin and furan concentrations measured in (top) Dungeness crab hepatopancreas (µg/kg wet weight) and (bottom) marine sediments (µg/kg dry weight) collected at Woodfibre and Port Mellon (i.e. HSPP) from 1987 to 1995.¹¹ The dashed line represents the timing of implementation of regulations and source control in pulp and paper mills to address and reduce dioxin and furan emissions. The concentration in 2012 for Port Mellon (top) is the average of total concentrations of dioxin and furans measured (≈1.0 µg/kg wet weight) in Dungeness crab hepatopancreas at eight sample sites.¹²

What is being done?

Federal regulations passed in 1992 improved pulp and paper mill effluents. The amended Pulp and Paper Effluent Regulations (PPER) under the Fisheries Act significantly reduced load limits and two new Canadian Environmental Protection Act (CEPA) regulations curtailed dioxins and furans releases.¹⁶ To meet these stricter regulations, pulp mills upgraded their processes and installed secondary treatment so significant improvements occurred over the past 20 years. HSPP conducts biological monitoring as part of their Environmental Effects Monitoring (EEM) program under the PPER. The mill had a coordinated program with the Western Pulp Mill until the latter closed permanently in 2006.¹⁶ Thus, EEM studies are on-going and directly assess the effects of mill effluent on fish, fish habitat, and use of fisheries resources in the vicinity of the effluent discharge as commanded by Environment Canada.¹⁶ For example, the EEM Cycle Six program for HSPP at Port Mellon ran between April 2010 and April 2013 to conduct studies of the potential negative and lethal effects of mill effluents on bottom dwelling organisms to support sediment quality assessment, as well as dioxin/furan monitoring survey of sediment, crab and fin fish in support of the EEM fish tissue survey.²

Health Canada monitors the concentrations of dioxins and furans in foods in its ongoing Total Diet Study surveys. As part of its risk assessment activities, Health Canada continues to assess the concentrations of these compounds in foods as well as monitoring any new research about the health effects of dioxins and furans.¹⁷

In terms of policy and legislation, dioxins and furans are scheduled for virtual elimination under the Canadian Environmental Protection Act (CEPA), the federal Toxic Substances Management Policy (TSMP) and the Canadian Council of the Ministers of Environment (CCME) Policy for the Management of Toxic Substances. Under the federal PPER (SOR/92-269), pulp mills are required to monitor the chemistry and toxicity of mill effluent and its potential effects on the receiving environment.¹⁸ Environment and Climate Change Canada and the Department of Fisheries & Oceans developed the first EEM program for inclusion in the 1992 amendment of the Regulations. The EEM portion of the Regulations were subsequently amended in 2004 and in 2008 as a result of experience with implementation of the program, stakeholder consultations, and feedback from the Smart Regulation Initiative¹⁹ on Improving the Effectiveness and Efficiency of Pulp and Paper Environmental Effects Monitoring.

What can you do?



Individual and Organization Actions:

- Avoid the incineration of organic matter and plastics to prevent the release of dioxins into the air and coastal environment.
- Use and apply “green” or homemade pesticides and organic fertilizers in gardens and agricultural fields to avoid toxic run off (e.g., salmon friendly lawn and/or orca friendly lawn: non-toxic pesticides, non-toxic herbicides, non-toxic fertilizers).



Government Actions and Policy:

- Help to guide and design creative solution-oriented practices to reduce the levels of dioxins and furans in Dungeness crabs which still exhibit concentrations of dioxin/furans of concern for public health.
- Promote and sponsor national programs and solutions for marine pollution to protect ocean life from human made chemicals with research, continued education and engagement, and advocacy to succeed with actions.
- Continue with the implementation of source controls and regulations to hamper dioxin and furan pollution from pulp mills in the coastal marine environment of Howe Sound.
- Regulate and control the usage of pesticides containing potential traces of dioxins and furans as impurities to avoid the accidental release of these byproducts into the coastal marine environment.
- Address the appropriate disposal of old tanks and bins and any material containing dioxin-contaminated fluids and/or oil from former military facilities, old refineries, junk yards and harbours.

Footnotes

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¹⁸ <http://laws-lois.justice.gc.ca/eng/regulations/SOR-92-269/?showtoc=&instrumentnumber=SOR-92-269>

¹⁹ <https://www.ec.gc.ca/esee-eem/default.asp?lang=En&n=96B3035D-1>

Wrecked, abandoned and problem vessels

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What is happening with problem vessels?

On February 11, 2015 another abandoned vessel capsized causing diesel to seep from her inboard engine into Mannion Bay, Bowen Island. As tides ebbed and flowed the diesel sheen dissipated but hydrocarbon residue may have infiltrated prime forage fish spawning habitat.¹ Removal of the wreck was authorized by Transport Canada's Receiver of Wrecks, an officer that acts as a custodian of a wreck in the absence of the rightful owner. Demolition and disposal of this boat cost Bowen Island Municipality approximately \$3000. This amount does not include the social and environmental costs associated with this abandoned, wrecked vessel.

During the last decade, there has been an increase in the number of boats abandoned in Howe Sound.^{2,3} It is not lawful under the Canada Shipping Act to abandon a vessel, but due to a lack of identification such as boat name or hull identification number, tracking down the owner is difficult. As a result, often the cost of removal and disposal of wrecked and abandoned vessels falls upon concerned citizens and local government.

What are problem vessels and why are they an issue?

While the term derelict is often used to describe an unmaintained boat, wrecked, abandoned and problematic are terms that have more distinct legal meaning:

- **WRECKED VESSELS** are those boats that are no longer intact. They may reside on the sea floor or clutter the shoreline. Vessels in imminent danger of sinking may also be classified as wrecks. Without restoration they are no longer seaworthy. Transport Canada's (TC) Receiver of Wrecks can authorize the removal of a wrecked vessel under provisions in the Canada Shipping Act (CSA) and the Navigation Protection Act (NPA).
- **ABANDONED VESSELS** are legislated in the NPA and the CSA. The NPA, Section 20, deems a vessel abandoned after 30 days when no owner can be located. Authorized removal of abandoned vessels in Howe Sound waters may be obtained through TC's Receiver of Wrecks. Funding for the removal is limited. Often the person or agency performing the work is held financially accountable.
- **PROBLEM VESSELS** include boats that are causing social unrest or ecological degradation as a result of, for example, raw sewage or grey water discharge, garbage disposal, or intentional beaching by live-aboard occupants or known owners. Problem vessels may be abandoned and become wrecks. Problem vessel owners may be found in contravention of local bylaws, e.g. land use or zoning bylaw provisions; provincial legislation, e.g. Land Act, Trespass Act Environmental Management Act, Public Health Act; or federal statutes, e.g. Fisheries Act.

The problems with problem vessels include environmental contamination, compromised safety and visual impacts. Bays, harbors and channels near amenities and with accessible beaches are particularly susceptible to harmful ecological, social and economic impacts arising from these boats. Unmaintained, abandoned, and problem vessels such as floating storage units may sink and release toxins and debris into the marine environment. Marine life and habitat are impacted and degraded from these polluting vessels and mariner and beachgoer safety is jeopardized.



Diesel spill at Sandy Beach, Bowen Island, February 11, 2015.
(Photo: B. Brokenshire)

Who is working on the issue?

Multi-jurisdictional authority exists in Howe Sound's waters making navigation through the sea of legislated authorities and responsibilities challenging. Collaborative enforcement involving local bylaw officers, RCMP, Coast Guard, federal Fishery officers, federal

Environmental Enforcement officers and provincial Natural Resource officers is often required to effectively manage legal breaches associated with problem vessels. Pursuant to provisions in Part 2 of the CSA, all boat owners must ensure their license or registration



Wrecked, abandoned and problem vessel accumulation sites and other sites where wrecked or abandoned vessels were found in Howe Sound from 2013 to 2015. Imagery: ESRI World Imagery

information is up-to-date. Federal enforcement of this section could reduce the community's burden associated with wrecked, abandoned and problem vessel as anonymous vessel owners may be more likely to pollute or abandon their boats.

The Federal Government is now working on the issue. From Pamela Goldsmith Jones, Member of Parliament for West Vancouver–Sunshine Coast–Sea to Sky Country, comes this message: “On, June 6, [2016] MP Bernadette Jordan from Nova Scotia introduced her private member’s Motion 40 on derelict and aban-

doned vessels. On behalf of the government of Canada I introduced amendments to strengthen the motion. I will be working closely with Transport Canada to broaden the definition that reflects challenges on the west coast. Based on the work of many in our community, we refer to the matter as abandoned and derelict vessels, barges and docks. Transport Minister Garneau is taking the lead on this, which is very good news.”⁴ Federal commitment to the addressing the issue was confirmed in the new federal Ocean Protection Plan released November 7, 2016.⁵



Figure 1. GIS vessel inventory layer (blue dots) from Bowen Island Municipality database 2015. Imagery: Islands Trust

What can you do?

SOME ACTIONS CONTRIBUTED BY CORI



Individual and Organization Actions:

- Keep your boat license and registration information up-to-date, and maintain your boat!
- Share information with local governments. For example, Bowen Island Municipality conducts vessel inventories in Mannion Bay every six months (Figure 1).
- Establish a Howe Sound action group. A group of citizens and government representatives could assemble to collectively share data and develop integrated solutions to reduce ecological, social and economic impacts associated with wrecked, abandoned and problem vessels in Howe Sound.
- Explore opportunities at the local community level to support the Federal and Provincial agencies (with legislative authority) to increase enforcement and compliance of marine regulations. This could include a marine committee consisting of local concerned stakeholders and local government representation to provide a watchful eye on activities on the water to report problem situations before they create larger environmental problems.



Government Actions and Policy:

- Keep vessel inventories.
- Enforce local and municipal bylaws with respect to live-aboards.
- Develop educational material to increase awareness of environmental risks associated with problem vessels.
- Develop policies to close the gaps in jurisdiction over problem vessels.
- Implement owner pay policies.

Resources

Island Trust Derelict Vessel Advocacy

<http://www.islandstrust.bc.ca/trust-council/advocacy/marine-environment/abandoned-and-derelict-vessels-advocacy/>

Transport Canada publication related to wrecks and abandoned boats

<http://www.tc.gc.ca/eng/marinesafety/abandoned-boats-wrecks-4454.html>

BC Ministry of Forests, Lands and Natural Resource Operations; Dealing with Problem Vessels and Structures in BC Waters

http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/dealing_with_problem_vessels_and_structures.pdf

BC Ministry of Forests, Lands and Natural Resource Operations; Technical Staff Guide on Problem Vessels and Structures

https://georgiastrait.org/wp-content/uploads/2015/04/14.09-technical_guide_to_dealing_with_problem_vessels_and_structures.pdf

Future of Howe Sound Derelict Ships – Finding Solutions

<http://futureofhowesound.org/campaigns/shipbreaking/derelict-ships/>

Footnotes

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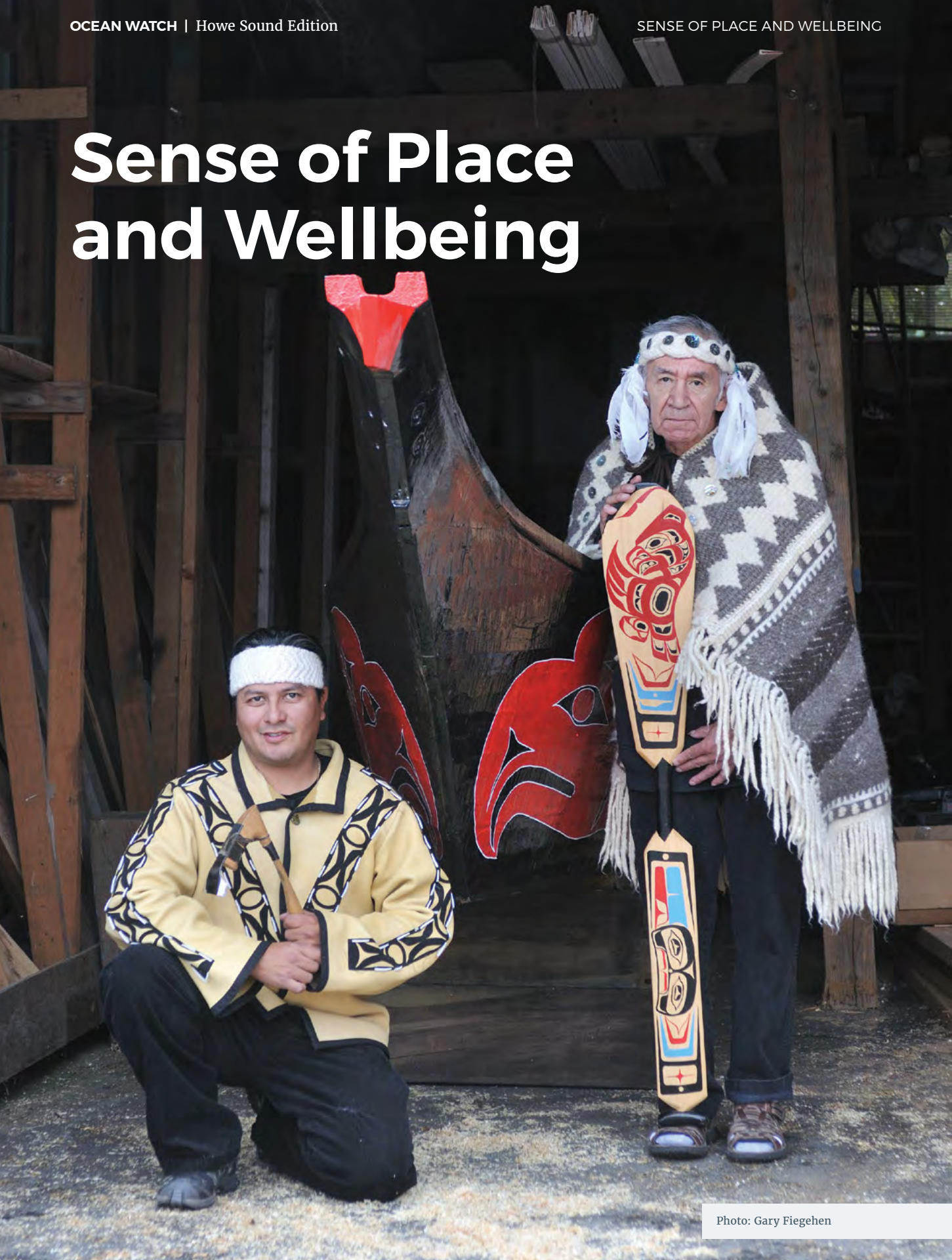
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³ Bowen Island Municipality Vessel Inventory 2005 – 2015. Retrieved from: Bowen Island Municipality GIS database and records May 2016 by the author.

⁴ <http://pgoldsmithjones.ca/>

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Sense of Place and Wellbeing



Summary

Connection to nature is a powerful force uniting all those who call Howe Sound home. Many of the people who live, work and play in the region view themselves as stewards, contributing to a local identity that hinges on respect for the environment and a desire to protect sensitive ecosystems, now and into the future.

After surviving the effects of residential schools, colonialization and industrialization, Howe Sound's first peoples — the Squamish Nation — are in a period of cultural renewal and continuity. Efforts to revive the Squamish language and traditions are beginning to take effect, reaffirming cultural ties to nature and positioning Indigenous people as leaders in the area. The Squamish are an important voice in determining policies and practices to manage growth in the region and mitigate environmental impacts.

Meanwhile, citizen scientists play an increasingly crucial role in monitoring the health of aquatic and terrestrial ecosystems in Howe Sound by acting as the scientific community's eyes and ears. From participation in wildlife surveys, to running advocacy campaigns, to participating in public consultations, the work of citizen scientists fills gaps in the regulatory framework governing Howe Sound. This has contributed to some major wins for conservation efforts, such as the expansion of Halkett Bay Marine Park. At the same time, Howe Sound's proximity to Metro Vancouver has positioned it as an "outdoor classroom" — a valuable resource for environmental education. More than 22,000 students visit the area each year to participate in education programs while many more people receive conservation education through ecotourism, summer camps and events aimed toward ensuring all who visit the area are armed with the knowledge necessary to reduce their impact on this ecological jewel.

Sense of Place and Wellbeing

Snapshot Assessment

Cultural Continuity

Efforts to bolster the Squamish Nation’s language and traditions have ignited a period of cultural renewal and continuity for Howe Sound’s Indigenous people. (Assessment is not appropriate due to the nature of the subject).



Citizen Science: Eyes on the Sound

Many community members play an important role in monitoring the health of Howe Sound. Citizen science effort is increasing and contributes to a positive sense of place.



Outdoor Learning

From outdoor schools to summer camps to ecotourism, opportunities for environmental education abound in Howe Sound’s “outdoor classrooms.” The increase in outdoor learning provides health benefits with no known negative impacts.



Ocean Health Index score for Sense of Place

Howe Sound scores 58 out of 100 for Sense of Place; a score that combines a 70 for iconic species and a 45 for lasting special places. A healthy ocean provides a deep sense of identity and belonging through connections with our marine communities.



Cultural Continuity

“Our Squamish Ancestors and leaders protected and preserved our knowledge systems through practice, rather than the written word. It is by our people’s tenacity, grace and collective memory, passed from generation to generation, that we maintain an intimate connection to our lands and traditions.”

SXWELHCHÁLIYA (COUNCILLOR JULIE BAKER), SQUAMISH NATION¹

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What’s happening?²

The people of the Squamish Nation are in a time of powerful cultural renewal and revitalization. Interest in and adherence to cultural traditions and practices, including learning **Sk̓wx̓wú7mesh snichim** (the Squamish language), is growing strongly. This follows a period when cultural continuity was somewhat interrupted by external forces. Thus, while **Sk̓wx̓wú7mesh snichim** is critically endangered, the language is still a vital part of the Squamish culture.

The **Sk̓wx̓wú7mesh snichim** word for Squamish people, also the word for villages and community, is **Sk̓wx̓wú7mesh Úxwumixw**.³ The Squamish Nation consists of 23 villages from the Greater Vancouver area and Gibson’s landing to the Squamish River watershed, though only 0.423 percent of the traditional territory was allotted to the Nation under the Indian Act, in scattered parcels of land. **Sk̓wx̓wú7mesh snichim** traces ancient connections to the territory through place names.

Ceremonial events of the Squamish people are customarily conducted in the Longhouse. The Longhouse is a sacred place that plays a significant role in the culture of the Coast Salish people. At one point in history, the Squamish

Nation proudly possessed more than twenty Longhouses from the Upper Squamish Valley to False Creek and Burrard Inlet.⁴ Longhouse-like buildings, such as Totem Hall in the Squamish valley, are still used for ceremonies of celebration, witnessing and healing.

Art and sport are integral to the rich cultural tradition of the Squamish people. Canoe pulling, including ra-

cing, reflects the strong connection to the marine part of the territory, and paddling is a crucial part of the Nation's history and culture. However, over the past 30 years, the popularity of canoe racing has dropped. At the same time ocean journey canoeing has been revived internationally. Several tribal journeys have been undertaken by canoe over the last few years.

Why is it important?

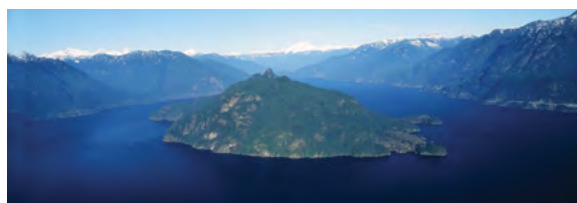
The wealth of the Squamish people lies in their culture, in the stories connected with their lands. As Chief Ian Campbell stated during discussions leading up to **Xay Temíxw** (Sacred Land land use plan):⁵ "This is what keeps us together as a people. We're not going to be packing up and moving. This land is where we come from. This is where our songs come from. This is where our power is. It's on the land. When you go on the land, that's when your dreams get strong, your feelings get strong." These deep values apply as strongly to the waters of Howe Sound as to the watersheds. Every little creek in the Sound has a **Skwxwú7mesh snichim** name.

General values and uses of the Squamish traditional territory that community members care deeply about include:⁶

- secluded places for traditional cultural practices (e.g., storing regalia, vision quests);
- wildlife and wildlife habitat;
- fish for fishing, and healthy rivers and streams;
- clean air, and clean water for drinking, for the ecosystem and for ritual bathing;
- resources from which Squamish members can earn a living; and,

- places to heal, recover and re-connect with the land.

The Howe Sound ecosystem is critical to the well-being of the **Skwxwú7mesh Úxwumixw**. Integral to Squamish culture is the consumption of food harvested from Howe Sound, and in modern times seafood has been essential to supplementing store-bought food, especially for the elders. In the past, Squamish fishers harvested herring, rockfish, salmon, crab and many other species. Cod could be speared as they would get stuck in pond traps as the tide receded. Elders recall that killer whales used to go up the west side of Howe Sound to calve and rub on the rocks. Canoe travel, village to village, from areas around Vancouver to the Squamish River and between, was commonplace.



"The island commonly referred to as Anvil Island is the northernmost of the four major islands in Howe Sound. Its name is derived from the anvil-like appearance created by its narrow angular profile. The original Squamish name is **Lhaxwm** and it has been an important place of spiritual training."¹
(Photo: Gary Fiegehen)

“Songs are a way of keeping history — who owns the songs and how they “received” the songs, it all has a history.”

CHARLENE WILLIAMS, SQUAMISH NATION



Photo: Gary Fiegehen

The ceremonies of the Squamish people are integral to community life, involving young and old, men and women, people from all walks of life. Songs, stories, dancing and regalia are still featured in most ceremonies even today, despite the fact that the design and materials of the regalia might have changed somewhat. The spirit of the regalia remains the same, to connect to Ancestors by paying respect to earthly things such as animals and birds, as well as the supernatural.¹

What's the current state?

The **Skwxwú7mesh Úxwumixw** have a profound connection to Howe Sound. Squamish people learned everything about their surroundings from their parents and extended family prior to contact. This provided a continuity of traditional knowledge and uses of the resources within their homelands and waters. However, intensive use of Howe Sound by Squamish members has skipped a couple of generations due to a number of tragic circumstances, primarily residential schools and industrial pollution:

- In a meeting in early 2016, Squamish Nation elders commented that “We have a long history of not being home.” Children were taken away to residential schools for eight years or so, some starting as early as age 5. They never had an opportunity to learn cultural ways such as canoeing. “Grandma and Great Grandmother would take me to the river to bathe and harvest and would show me what and how to gather. Once residential schools came along, we could not go to the land and gather.” Communities were broken up as some of those taken away moved and settled elsewhere, and those returning from school didn’t know each other.
- Squamish members were advised by their elders to stop fishing when pollution from Britannia Mine became a threat. That pollution, as well as pollution from the Woodfibre pulp mill, lasted for decades. A comment in the input to **Xay Temíxw** was “My father used to say ‘No longer can we go up and even fish for the oolichans.’” More recently, an elder related that “Before [the pollution] you could put branches in the water and get herring eggs to eat.”
- The tradition of ritual bathing in streams has been compromised by privacy issues. As a Squamish member put it during input to **Xay Temíxw**: “We’ll be seen if we don’t go really early to bathe.”
- Canoeing has become more difficult and hazardous as larger boats and ships have become more numerous in the Sound. This is due to the wakes of the vessels and the sheer volume of traffic.
- First Nations were pushed out of the prawn fishing industry in the 1960s. First Nations youth now re-entering the fishery have a learning curve due to this period of lack of access to the resource.

Despite the interruption of **Skwxwú7mesh Úxwumixw** intensive use of Howe Sound, harvest of resources from Squamish territories is still an important part of the contemporary and ongoing activities of the Nation, providing resources for food, medicine, ceremonial and spiritual uses as well as other benefits.

What's being done?

Squamish hereditary chief Ian Campbell said recently that his people are in a chapter of building up the language and culture again. A rhythm of flourishing, crashing, and building up again is echoed in all natural processes.⁷

Much is being done to encourage learning **Sk̓wx̓wú7mesh snichim**, including a certificate program at Capilano University. The program is designed to give Squamish Language teachers training in the Squamish Language and to provide a range of courses relevant to Squamish culture (told from a Squamish perspective).⁸ The arts and education organization, Kwi Awt Stelmexw, focuses on restoring **Sk̓wx̓wú7mesh snichim** as the primary language of communication, and is co-hosting with Simon Fraser University an adult immersion program called **Temstl'í7 ta Sníchim**.⁹ In 2015, a new Language Immersion House was opened where learning through “living the language” is encouraged.¹⁰

Many organized events support growth in the awareness and practice of thriving Squamish culture. These include annual canoe races (the most recent of which was held at Ambleside Beach in July 2016), the annual Squamish Nation Youth Powwow (the 28th one was also held in July 2016), and the Annual Squamish Nation Amalgamation Gathering, which includes storytelling, drumming, singing and dancing. Other events celebrate Squamish culture on a “one-off” basis, such as a Squamish Nation Arts and Culture Exhibition at the Gibsons Public Art Gallery in the summer of 2016.

The Squamish Lil'wat Cultural Center in Whistler was specifically built to preserve and grow the cultures of the two nations and share them with others.¹¹

First Nations culture and spirituality have a deep-rooted connection to the land and water. Amongst the Squamish Nation's goals for Howe Sound, conserva-



Two generations of master carvers at the canoe shed — **Sxayilkin Siyám** (Chief Cedric Billy) and **Kaapul / Sesiyám** (Ray Natraoro) of the Squamish Nation in front of a 14-metre ocean-going canoe which **Kaapul / Sesiyám** carved from a single red-cedar log, featuring a Thunderbird design on the prow. (Photo: Gary Fiegehen) Reproduced with permission from “Where Rivers, Mountains and People Meet”, Squamish Lil'wat Cultural Centre.

tion of natural and cultural resources is the highest priority: Critical habitat for species has to be protected, and heritage, traditional use and sacred and cultural sites also have to be protected.

Working with the other communities of Howe Sound is important to the Squamish Nation, but members of those communities must be aware of cultural and spiritual values within the planning process, rather than being focused only on recreational, economic and scientific perspectives. Inclusion of scientists in the planning process is based on their knowledge of specific areas and they don't typically have an integrated perspective on the values of Howe Sound. As one person described the problem (in their input to *Xay Temíxw*), "The Spaniards and the British didn't get along very well ... so they said 'we're up here doing scientific work on this coast.' But look at what that

science and technology has done to our land ... That's why our traditional knowledge, our elders' wisdom, is so important to us, to help bring Mother Nature back to health. We have to look at developing our traditional knowledge again to heal our land – that's critical."

Restoring and maintaining Squamish Nation access to the marine area of the territory is also critical to reestablishing the essential cultural connection with it. The rights and opportunities of Squamish members to harvest or otherwise use sea resources for cultural, spiritual, sustenance, economic and trade uses must be assured and take precedence over all other uses, within the limits of the ecosystem. Development and use cannot substantially deprive future generations of the benefits of Squamish territories. It is often said that the priority is to sustain the traditional territory for "our children's children for seven generations."



Squamish Mount Chaki Canoe Club practicing in Howe Sound. (Photo Gary Fiegehen)

What can you do?

- Study the Nation's stories and cultural history — see below for some resources.
- Visit the Squamish Lil'wat Cultural Centre at slcc.ca. The Centre manages cherished collections of the Squamish Nation, and has many ambassadors from the Nation who work there and provide a daily tour of the facilities.
- Keep an eye open for events you can attend, like art shows or Powwows – try the Squamish Nation Facebook page — facebook.com/SquamishNation
- Engage with the Squamish Nation on planning for Howe Sound.

The Squamish Nation will conduct its Howe Sound planning process and consult with other governments as appropriate. Cooperation with non-government interests is also appropriate in some aspects of planning, recognizing that concerns of Howe Sound communities beyond the Squamish Nation overlap with those of Squamish Nation members. Relationship-building between the Squamish Nation, governments and non-government organizations in connection with Howe Sound is well underway, thanks in part to the Howe Sound Community Forum (HSCF). Established in 2002, eleven parties including regional districts,

municipalities and the Squamish First Nation signed a document called “Howe Sound Community Forum Principles for Cooperation.” The Forum meets regularly to share information and discuss current issues.

People from outside the Squamish Nation can support cultural continuity for the Squamish Nation by continuing to cultivate the cooperative approach described above while appreciating the fundamental importance of spiritual and cultural values, and by preventing these priorities from being overwhelmed by scientific and economic worldviews.

Resources

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Footnotes

¹ Reproduced with permission from "Where Rivers, Mountains, and People Meet", Squamish Lil'wat Cultural Centre.

² Much of the information in this section comes from <http://www.squamish.net/about-us/our-culture/>

³ Sk̓w̓w̓m̓esh is pronounced Squ-HO-o-meech.

⁴ In June Baker's description of the Legacy of the Longhouse. Source: <http://www.squamish.net/about-us/our-culture/>

⁵ <http://www.squamish.net/about-us/our-land/xay-temixw-sacred-land-land-use-plan/>

⁶ Ibid.

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⁸ <https://www.capilano.ca/linguistics/Squamish-Nation-Language-and-Culture-Certificate/>

⁹ <https://www.kwiawtstelmexw.com/>

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¹¹ <http://slcc.ca/visit/about-us/>

¹² https://en.wikipedia.org/wiki/Squamish_culture

Citizen Science: Eyes on the Sound

“There’s always that inquisitive part of me. I always want to know a little bit more. I am always after the story... even when I’m going out to film a creek, I’m a reporter in the water interviewing the fish. I want to know their story, their take on things.”

JOHN BUCHANAN, CITIZEN SCIENTIST, SQUAMISH¹

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Citizen scientists are critical “eyes on the Sound” and keen explorers, advocates and ambassadors for Howe Sound’s nature and health. For example, research work by the Marine Life Sanctuaries Society led to the successful extension of Halkett Bay Provincial Park in 2016 to include offshore glass sponge gardens and bioherms.² Mapping of herring spawn by Squamish-based citizen scientist John Buchanan is used as evidence by advocacy groups to respond to the design and location of the Woodfibre LNG plant.³ In 2016, citizen science groups and individuals alerted the public, researchers, and agencies to the record low number of bald eagles wintering in the Squamish area,⁴ the upsurge of orca visits to Howe Sound,⁵ and the surprising abundance of anchovy in outer Howe Sound⁶ that may be related to the best recreational Chinook fishery in decades.⁷



Volunteers and biologists surveying intertidal life on Bowen Island under the Coastal Scene Investigation program run by Dr. Shannon Bard. (Photo: Bob Turner)

Why is Citizen Science Important?

Citizen science is a global movement through which scientists and non-scientists work in partnership to conduct scientific research.⁸ It engages hundreds, and sometimes thousands, of people of all ages, occupations, and locations, and helps scientists accomplish tasks that could not otherwise be undertaken. Non-scientists also set up research projects that ask questions of local importance that may be too small or isolated to be initiated by scientists alone.⁹ They range from one day ‘bioblitzes’ (an intense period of biological surveying in an attempt to record all the living species within a designated area) to multi-year breeding bird surveys. The most important characteristic is public participation in genuine scientific research.¹⁰

Citizen science projects bring science and scientists into the public eye and increase local appreciation and understanding of science.¹¹ Individuals are motivated to engage in citizen science largely to help the environment or their community, to contribute to scientific knowledge or to learn, develop scientific skills, or be outdoors.¹²

The degree of community member involvement in citizen science projects varies.¹³ “Contributory” projects are designed by scientists while members of the public contribute data. In “collaborative” projects community participants also collect data and some help to refine project design, analyze data, and/or disseminate findings. “Co-created” projects are designed by scientists and members of the public together, and some community participants are involved in most or all steps of the scientific process, as described in Table 1. The highest levels of community engagement are in self-created projects, run by lay people with advanced scientific knowledge and the skills to develop and manage studies on levels equal to those of professional scientists.

TABLE 1: STEPS IN THE SCIENTIFIC PROCESS

Steps in the Scientific Process ¹⁰	
1.	Identify and define questions for study
2.	Gather information and make observations
3.	Develop hypotheses about possible answers to questions
4.	Design experiment and data collection methods
5.	Collect data
6.	Analyze data
7.	Interpret data and draw conclusions
8.	Communicate conclusions, discuss results and ask new questions

What is the connection to First Nations?

First Nations artists have long interpreted and communicated the natural world to others with a sense of place that may be similar to today's citizen scientists.



Squamish pictograph found in Howe Sound near **Ėnwilh Spálh̓xen** (Furry Creek).
(Photo: Gary Fiegehen)

“Artistry has always been widespread in the Squamish culture. Men carve and women weave. Women weave healing and protecting powers into the items they make. Carved tools were adorned with designs depicting the owner's spirit helpers. A beautifully carved halibut hook, for example, honoured and pleased the fish, which brought the fishermen good luck.

The Squamish Nation has more than 250 registered artists working in a range of mediums: jewelers, printmakers, wood carvers, stone and bone carvers, sculptors, potters, glassworkers, fashion designers and textile and beading artisans.

For the Squamish Nation, our art, songs, and stories have spiritual significance because the maker of the art has connections to the land and seas. Consequently, we hold all artists — whose art we believe comes from dreams, visions or other spiritual connections — in high regard.”¹⁴

What is the current state?

A broad range of citizen science activities are currently underway in Howe Sound (Table 2). Some are year round; others follow the seasonal rhythms of nature. The number of citizen science activities and participation seems to be increasing with five new activities started since 2010; however, more than half of the activities listed have been occurring regularly since before the turn of this century (Table 2). Citizen science is not new, but it may be growing

in its sophistication, as well as in recognition and acknowledgement of the benefits. We highlight three differing citizen science enterprises to illustrate the range of community engagement in Howe Sound. Other citizen science activities have contributed elsewhere in this report (e.g., see Bald Eagles article, Marine Birds article, and Annapolis article).

TABLE 2: SELECT CITIZEN SCIENCE ACTIVITIES IN HOWE SOUND

ACTIVITY	ORGANIZATION	LOCATION	MARINE SPECIES	ROLES OF CITIZEN SCIENTISTS AND SCIENTISTS	LEVEL OF INVOLVEMENT	START OF PROGRAM
Christmas Bird Count Outer Howe Sound	Lighthouse Park Preservation Society in collaboration with local birding groups	West Vancouver to Anvil Island to Gibsons	all birds including marine species	Volunteers observe, record, and report. Organizers coordinate count, compile and submit results to Audubon Society. Results available on line.	about 50 persons in 2015	2003
Christmas Bird Count Squamish	Squamish Environment Society	Squamish area	all birds including marine species	Volunteers observe, record, and report. Organizers coordinate count, compile and submit results to Audubon Society.	19 in 2015	1980
Christmas Bird Count Sunshine Coast	Sunshine Coast Natural History Society	includes west shore of Howe Sound from Port Mellon to Gibsons	all birds including marine species	Volunteers observe, record, and report. Organizers coordinate count, compile and submit results to Audubon Society.	N/A	1971
Eagle Count, Brackendale Winter Eagle Festival	Brackendale Art Gallery and Squamish Environment Society	Lower Squamish River and tributaries	Bald Eagles	Volunteers observe, record, and report. Organizers coordinate count and compile results.	N/A	1985
Monthly Bird Count Squamish Estuary	Squamish Environmental Society	Squamish estuary	all birds including marine species	Volunteers observe, record, and report to eBird. Results available on line.	5 to 10	1991
Monthly Bird Count Lighthouse Park	Lighthouse Park Preservation Society	Lighthouse Park, West Vancouver and adjacent marine waters	all birds including marine species	Volunteers observe, record, and report to eBird. Organizers coordinate count.	5 to 8 each count	2004

ACTIVITY	ORGANIZATION	LOCATION	MARINE SPECIES	ROLES OF CITIZEN SCIENTISTS AND SCIENTISTS	LEVEL OF INVOLVEMENT	START OF PROGRAM
Spawning Salmon Counts	Squamish Streamkeepers Society	streams and spawning channels from Furry Creek to upper Squamish River valley	salmon (chum, coho, pink)	Volunteers are responsible for specific streams. This includes stream maintenance and enhancement, counts of spawning salmon. Some enumeration by underwater video recording.	16	2000
Streamkeeping and stewardship, ocean shoreline stewardship and eelgrass and kelp planting	West Vancouver & Squamish Streamkeepers, West Vancouver Shoreline Preservation Society, Future of Howe Sound Society, Cheakamus Center, Squamish River Watershed Society, Bowen Island Fish and Wildlife Club	throughout Howe Sound and Squamish River watershed	salmon (coho, chum, pink, Chinook), herring, forage fish, marine mammals, riparian vegetation, invasive plant species, eelgrass, kelp	Volunteers are involved in habitat protection and restoration, habitat assessments, liaison with local and senior governments and First Nations, salmonid enhancement, projects with primary and secondary schools.	500	most during mid 1990s
Terminal Creek Hatchery, Bowen Island	Bowen Island Fish and Wildlife Club with DFO Salmon Enhancement Program	Bowen Island	salmon (chum, coho, pink)	Volunteers prepare, operate, maintain facilities for incubation, rearing and release of salmon fry. Volunteers assist with taking of brood stock and eggs.	10	1982
Intertidal diversity studies	Coastal Scene Investigation by Dr. Shannon Bard (ecotoxichology.ca)	Tunstall Bay (Bowen Island), Port Mellon and Chaster Beach, Lions Bay, Porteau Cove, Darrel Bay, Britannia Beach	intertidal life	Scientists train volunteers to identify species and conduct surveys. Scientists supervise work.	30	1990-93; 1997; 1998; 2004; 2005; 2012-2016
Whale, dolphin, porpoise sightings	BC Cetacean Sightings Network (Vancouver Aquarium and Fisheries & Oceans Canada)	all marine waters in Howe Sound, as well as elsewhere	whale, dolphin, porpoise	Volunteers observe, record, and report via smartphone app (WhaleReport), web form (www.wildwhales.org), log book, or toll-free number.	100 observers reported 141 sightings in 2015	2000
Lingcod egg mass survey	Vancouver Aquarium Marine Science Centre	Howe Sound and B.C. coast wide	lingcod	Volunteer divers observe, record and report data from personal dives.	88 divers in 2016	1994
Rockfish survey	Vancouver Aquarium Marine Science Centre	Howe Sound and B.C. coast wide	rockfish	Volunteer divers observe, record and report rockfish abundance during personal dives. Supplemented with Aquarium staff surveys.	30-40 divers/year	2006
Fish and invertebrate Surveys	Vancouver Aquarium and Reef Environmental Education Foundation (reef.org)	Howe Sound and worldwide	invertebrates and fish	Volunteer divers take identification course run by Aquarium. Divers observe, record and report data from personal dives. Dive data available at reef.org	40-50 volunteers trained every 2-3 years	2015

ACTIVITY	ORGANIZATION	LOCATION	MARINE SPECIES	ROLES OF CITIZEN SCIENTISTS AND SCIENTISTS	LEVEL OF INVOLVEMENT	START OF PROGRAM
Glass sponge surveys	Vancouver Aquarium Marine Science Centre	Defence Islands	glass sponges	Volunteer divers photograph and video glass sponge reef/gardens and reference markers during personal dives and submit online. This provides repeated observations of one reef.	6 to 10	2013
Annapolis Biodiversity Index Study	Vancouver Aquarium Marine Science Centre	Annapolis wreck dive site, Halkett Bay, Gambier Island	invertebrates and fish	Volunteer divers observe, record and report data from personal dives. Temperature logger has been installed.	N/A	2015
Howe Sound sponge reef studies	Marine Life Sanctuaries Society of BC	throughout Howe Sound from Defence Islands in north to Passage Island in south	glass sponges, rockfishes	Volunteers build deep sea survey equipment, design studies, gather data using bathymetric mapping, drop camera, depth sounders, and seafloor instruments including temperature logging and collaborate with scientists from DFO and Vancouver Aquarium.	15	1998
Exploratory dives and seafloor technical assistance	Underwater Council of BC	Dive sites at Lions Bay, Pam Rocks, Anvil Island, Bowen Island and elsewhere	glass sponges, rockfish	In collaboration with Vancouver Aquarium and Marine Life Sanctuaries Society, volunteer divers explore, record, and install seafloor monitoring instruments such as temperature loggers.	N/A	2013
Herring spawn surveys	Squamish Streamkeepers Society	upper Howe Sound including Squamish estuary and Woodfibre area	herring	Volunteers map extent and character of herring roe along intertidal zone during herring spawn. Principal surveyor John Buchanan posts results on YouTube.	12	2006
Beach sampling for forage fish spawn	Sea Watch Society (Ramona de Graaf) and BC Shore Spawners Alliance	Gibsons to Langdale, Sunshine Coast, Bowen Island	forage fish (surf smelt, Pacific sandlance)	Volunteers collect samples, analyze for presence of forage fish eggs, coordinated by marine scientist Ramona de Graaf.	40	2008
Marine mammal counts	Sewells Marina Sea Safari with Pacific Wildlife Foundation	outer Howe Sound	all marine mammals	Sewells Marina SeaSafari boat tour guides, with help from guests, observe and report wildlife sightings to Pacific Wildlife Foundation	daily boat tours April to October	2014

Table 2 Sources of Information: Christmas bird counts;^{15,16,17} Eagle Count — Brackendale Winter Eagle festival;¹⁸ Monthly bird counts in the Squamish estuary;¹⁹ and Lighthouse Park;¹³ Spawning salmon counts, Squamish Streamkeepers;²⁰ Howe Sound streamkeeping and stewardship, ocean shoreline stewardship and eelgrass and kelp planting;²¹ Terminal Creek Hatchery, Bowen Island;²² Intertidal diversity studies;²³ Whale, dolphin and porpoise sightings;³¹ Ling cod egg mass, rockfish, fish and invertebrate, and glass sponge, surveys;³⁰ and Annapolis Biodiversity Index Study;³⁰ Howe Sound sponge reef studies;³¹ Exploratory dives and seafloor technical assistance;²⁴ Herring spawn surveys;²⁵ Beach sampling for forage fish spawn;²⁶ Marine mammal counts.²⁷

What is being done?

Spotlight #1: Coastal Ocean Research Institute (CORI), Vancouver Aquarium: scientist-directed citizen science



Volunteer diver collecting data. (Photo: Donna Gibbs)

The Vancouver Aquarium supports a number of citizen science activities in Howe Sound.²⁸ The B.C. Cetacean Sightings Network allows the public to provide information on their sightings of whales and dolphins by phone call, online app, or through the website. In 2015, 100 observers reported 141 cetacean sightings in Howe Sound.²⁹ Volunteer divers, many organized through the Underwater Council of B.C., gather data on marine life for CORI researchers. In 2016, 88 divers were involved in the lingcod egg mass survey during February and early March. A second volunteer dive survey from August to October records rockfish abundance and usually involves 30–40 divers. Volunteer divers also survey sponge reefs near the Defence Islands.³⁰ Markers placed on the reef locate photos and videos

provided by divers and allow repeated observations of specific locations. In 2015, the Aquarium launched the Annapolis Biodiversity Index Study that uses photographs and videos by volunteer divers to document the colonization by marine species of the Annapolis artificial reef in Halkett Bay (see Annapolis article).

The Aquarium also runs training courses for fish and invertebrate identification to support REEF volunteer fish and invertebrate surveys.³¹ About 40–50 volunteers are trained every second year to identify species and use consistent survey techniques. As of 2016, the online database records species and abundance at 40 sites in Howe Sound.³²

Spotlight #2: Marine Life Sanctuaries Society: Non-Government Organization (NGO) directed citizen science



Diver installs sea floor monitoring equipment with the MLSS. (Photo: Glen Dennison)

The Marine Life Sanctuaries Society of BC (MLSS) has employed sophisticated deep water technology and survey techniques to locate and map glass sponge reefs (bioherms) in Howe Sound and document their ecology. MLSS members built a deep water drop-camera and lighting system to remotely video and photograph the seafloor, use GPS and depth sounder to create high resolution 3D maps of the seafloor, and conduct SCUBA dive team surveys to gather detailed information on the sponge reefs and to deploy instruments.³³ To date, the Society has identified 12 reefs at eight locations and many more sponge gardens in Howe Sound³⁴ in collaboration with divers from the Underwater Council of B.C., scientists at Fisheries and Oceans Canada (DFO) and the Vancouver Aquarium.

Much of this research is led by Glen Dennison who has been SCUBA diving in Howe Sound for over 40 years³⁵ and in 2015 alone, logged 49 days of boat work on the waters of Howe Sound. MLSS continues to discover and describe new reefs,³⁶ provide educational talks in local communities, educational beach interpretation programs, and advocate against the use of bottom contact fishing gear on sponge reefs.³⁷ Recently MLSS has initiated a project to monitor water temperatures in Howe Sound at depths between 25 and 40 metres depth at five sponge reefs and the Annapolis artificial reef. MLSS leadership led directly to the recent expansion of Halkett Bay Provincial Park into the marine environment to protect an offshore sponge garden and bioherm.³⁸

Spotlight #3: John Buchanan: an individual citizen scientist



Herring spawn on intertidal algae with Woodfibre, a closed pulp and paper mill, in the background. (Photo: John Buchanan)

John Buchanan has contributed greatly to the public understanding of Howe Sound's nature and environmental issues. John has lived most of his life in Howe Sound, and driven by curiosity and care, spends large portions of his free time "keeping an eye" on Howe Sound.²⁴ John surveys streams in late summer and fall for spawning salmon, using an underwater camera to get accurate counts as he moves upstream through various pools.³⁹ In February and March John is on the water in his boat, surveying the distribution of herring spawn along the shores of Howe Sound, recording the spawning activity with underwater cameras, and posting survey results on line.⁴⁰ John is also an opportunistic storyteller; he records what he sees while out on the water or walking streams and has posted over 250 videos of wildlife from orcas and otters to bear and sea jellies.⁴¹ As a passionate advocate for a healthy Howe Sound, John flags environmental issues he encounters such as low stream flows during the drought of 2015,⁴² shoreline debris that needs clean up,⁴³ and

questionable management practices in the Squamish Estuary.⁴⁴

Though much citizen science is being done in Howe Sound, at present there is no central way to share information or coordinate the planning of these projects. A solution could be as simple as an imaginative website that serves as a forum for nature sightings and observations, citizen science conversations about Howe Sound, and networking opportunities. More ambitiously, such a site could store and share collected data, coordinate data gathering and community training, and act as a portal for researchers to Howe Sound. An example of such a hub that could be emulated and serves a subject-specific community – volcanoes – is called the VolcanoCafe.⁴⁵ Such a site could invigorate citizen science in Howe Sound, draw researchers' interest, and increase the accessibility of data for policy decisions by local and regional governments.

What can you do?

SOME ACTIONS CONTRIBUTED BY CORI



Individual and Organization Action:

- Get involved with an ongoing citizen science project in Howe Sound (Table 2).
- Share your photos and videos of Howe Sound nature on your favourite social media platform.
- Join NatureWatch (naturewatch.ca), a partnership of Nature Canada and the David Suzuki Foundation to engage Canadians in four ongoing citizen science projects: FrogWatch, PlantWatch, IceWatch and WormWatch.
- Donate. Almost all the groups engaged in citizen science projects in Howe Sound are non-profit groups and projects depend upon donations to continue.
- Learn more about citizen science and how to do it at Citizen Science Central sponsored by Cornell University's Lab of Ornithology: birds.cornell.edu/citscitoolkit/toolkit/steps
- Encourage citizen science participation within your company or organization (e.g., Use citizen science participation to give back to the community, and serve as a team-building exercise).



Government Actions and Policy:

- Continue to support and raise awareness of the ongoing citizen science projects within Howe Sound (Table 2).
- Provide and maintain a central portal of information including; citizen science project listings, data gathering, community training, and a tool-kit for best practices of designing and maintaining citizen science projects.
- Provide resources needed to enhance and continue local citizen science projects as funding permits.
- Promote closer relationships with stakeholders to citizen science projects in order to facilitate further participation and awareness.
- Increase the use of citizen science data contributing to natural resource and environmental science, natural resource management, and environmental protection and policy making.
- Develop policy to recognize and weigh citizen science, in addition to other scientific evidence and traditional knowledge, submitted for review in the environmental assessment process.
- Invite citizen scientist representation at public engagement events for policies and management to add their voice to input throughout decision-making processes.
- Partner with non-government organizations and other groups to create more citizen science projects on diverse subjects.

Resources

John Buchanan YouTube videos:
youtube.com/user/sqecs2/videos

Audubon Bird Count data:
netapp.audubon.org/CBCObservation

B.C. Cetaceans Sightings Network
wildwhales.org

Bowen Fish and Wildlife Club
bowenhatchery.org

Bowen Island Conservancy
bowenislandconservancy.org

Gambier Island Conservancy
gambierc.ca

Howe Sound dive sites biodiversity
reef.org/db/reports/geo/PAC/136/

Lighthouse Park Preservation Society
lpps.ca/volunteering

Marine Life Sanctuaries Society
mlssbc.com

Squamish Environment Society
squamishenvironment.ca

Squamish Streamkeepers
squamishstreamkeepers.net

Sunshine Coast Natural History Society
sites.google.com/site/scnaturalhistorysoc

Vancouver Aquarium, Howe Sound Group
vanaqua.org/act/research/howe-sound-group

West Vancouver Streamkeepers
westvancouverstreamkeepers.ca

Footnotes

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Outdoor Environmental Learning

“Nature provides opportunities for cognitive development through education and research about organisms and habitats. The estimated value of nature-based education was based on the 2012 Canadian Nature Survey... we arrived at a total value of approximately \$9.5 million per year.”

**FROM SOUND INVESTMENT: MEASURING THE RETURN ON HOWE SOUND'S ECOSYSTEM ASSETS
(MICHELLE MOLNAR, 2015, DAVID SUZUKI FOUNDATION)**

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What's happening?

Each year, over 22,000 students experience environmental education with Howe Sound as the classroom. The Howe Sound area hosts the largest regional cluster of summer camps, outdoor schools, and environmental programs in British Columbia.¹ Many more, young and old, meet and learn about nature through schools and universities, local community groups, and commercial ecotourism in Howe Sound. This outdoor learning relies on proximity to Vancouver and the diverse geography and ecology that Howe Sound offers.



Squamish Nation canoe at Camp Suzuki. (Photo: Carmen Leung)

Howe Sound's role as a classroom continues to grow. Camp Suzuki, a summer environmental program run by the David Suzuki Foundation and Squamish Nation, had its first season at Camp Fircom on Gambier Island in 2015. West Vancouver School District began a new year-round outdoor program in 2013 at its elementary school on Bowen Island. A boom in ecotourism is also playing a role in environmental education. For example, Sea to Sky Gondola drew about 300,000

visitors in 2014,² its first year of operation. Sea to Sky Gondola employs nature guides and interpretive signage to explain Howe Sound geography, marine biology and First Nations culture at the viewpoints and along its trails. In 2014, Sewell's Marina expanded its Sea Safari boat tours to link with land-based tours of Sea to Sky Gondola, Britannia Mine, and the Sea to Sky Highway.

Why is environmental education important?

According to the United States Environmental Protection Agency (EPA), environmental education is a process that allows individuals to explore environmental issues, engage in problem solving, and take action to improve the environment. As a result, individuals develop a deeper understanding of environmental issues and have the skills to make informed and responsible decisions.³ Between 2001 and 2004 the American Camp Association conducted research with over 5,000 families from 80 camps to determine the outcomes of the camp experience as expressed by parents and children. Parents, camp staff, and children reported significant growth in self-esteem, peer relationships, independence, adventure and exploration, leadership, environmental awareness, friendship skills, values and decisions, social comfort, spirituality.⁴ It's not peer-reviewed research but check it out!



Capilano University students discuss the natural history of the Squamish Estuary. (Photo: Roy Jansen)

What is the current state?

Howe Sound's diversity of wild spaces yet proximity to metropolitan Vancouver make it an ideal outdoor classroom. In 2015, five outdoor school programs brought over 15,000 elementary and secondary school students to Howe Sound from the Vancouver region and Sea to Sky Corridor (Table 1). Public secondary

and elementary schools in Squamish, Lions Bay, West Vancouver, North Vancouver, Bowen Island, Langdale, and Gibsons, as well as a private school on Bowen Island used their school sites and nearby Howe Sound forests and shores to teach a variety of natural science subjects. Two universities, Qwest University Can-

TABLE 1: OVER 22,000 STUDENTS OF ALL AGES ARE INVOLVED IN ENVIRONMENTAL EDUCATION PROGRAMS IN HOWE SOUND

ORGANIZATION	PROGRAM	ATTENDEES	ANNUAL ENROLLMENT	LOCATION OF OUTDOOR CLASSROOM
Cheakamus Centre	Elementary Outdoor School, Field School, Coast Salish Bighouse; High school leadership	elementary, secondary, teachers	6,700	420 acre ecological reserve, including farm and salmon hatchery, Brackendale
Evans Lake Forest Education Centre		primarily youth, also adults	4,000	33 acre property and 240 acre demonstration forest, Brackendale
Camp Elphinstone Langdale, Sunshine Coast	Beach study, stream study, forest interpretive hike, wild edibles, fire building	mainly grade 7, some secondary students	7,000	Camp Elphinstone property, Langdale, Sunshine Coast
Sea to Sky Outdoor School for Sustainability Education	Spring and fall, 3-4 day outdoor experiential education programs; sustainability education; place-based learning, indigenous history	elementary, secondary	2,000	Camp Elphinstone, Camp Fircom, Halkett Bay Park, Keats Camps
Camp Fircom Gambier Island	Spring and fall; 3 day programs, farm to school table, renewable energy, aquatic life; host for Sea to Sky Outdoor School and Camp Suzuki	elementary, secondary, adult, families	500	120 acre Camp Fircom property and nearby Halkett Bay, Gambier Island
Camp Suzuki	Summer camps; conservation leadership, climate change, Squamish Nation culture and knowledge, sustainable living	children (7-13), young adults (18-30)	150	Camp Fircom, Gambier Island
Bowen Island Community School , Bowen Island	Year round "outside45" program; natural systems, local community, geology, ecology, environmental issues, outdoor skills	elementary	56	Bowen Island, Halkett Bay Park, Sea to Sky corridor
Island Pacific School , Bowen Island	Incorporated in year round science and outdoor recreation teaching; ecosystems, biodiversity, conservation, stewardship	grade 6-9	65	Bowen Island; Halkett Bay, Gambier Island
Metro Vancouver School & Youth Leadership Programs	Strategies and tools to support engagement, understanding, awareness and action for sustainability.	K-12 teachers, students, youth leaders, teacher candidates	1,500+	Occasional activities on Bowen and Gambier islands, Squamish area
Southlands Heritage Farm , Vancouver	Summer camp educational programs; industry on the water, to intertidal life, to first nations use of coastlines	elementary with secondary school volunteers	300	Bowen Island, Camp Elphinstone and Camp Fircom
Qwest University Canada , Squamish	Undergraduate learning and research in biology, marine biology, intertidal life; conservation and restoration; biodiversity	undergraduate students	~400	Squamish River estuary, Qwest University Campus, Porteau Cove, Woodfibre
Capilano University , Squamish, North Vancouver	Natural history course (Squamish campus); Environmental Stewardship class (North Vancouver campus)	undergraduate students	50	Squamish estuary, Porteau Cove, Lighthouse Park, Horseshoe Bay

ada and Capilano University, have campuses in the Squamish area and conduct field-based courses for undergraduate students, principally at Squamish Estuary, Porteau Cove Provincial Park, and Lighthouse Park.

Local community groups are also important environmental educators. Groups such as the Lighthouse Park Preservation Society, Squamish River Watershed Society, Sunshine Coast Naturalists, Friends of Cypress

Park, and Bowen Nature Club conduct interpretive hikes and other outdoor activities for the public throughout the year. Each winter, the Squamish Environmental Society and the Brackendale Art Gallery run the Eagle Watch program and Bald Eagle Festival to help thousands view and learn about the yearly return of eagles to the Squamish area. Cheakamus Centre in the Paradise Valley hosts a community Open House to share outdoor environmental learning with its 2000+ annual visitors.

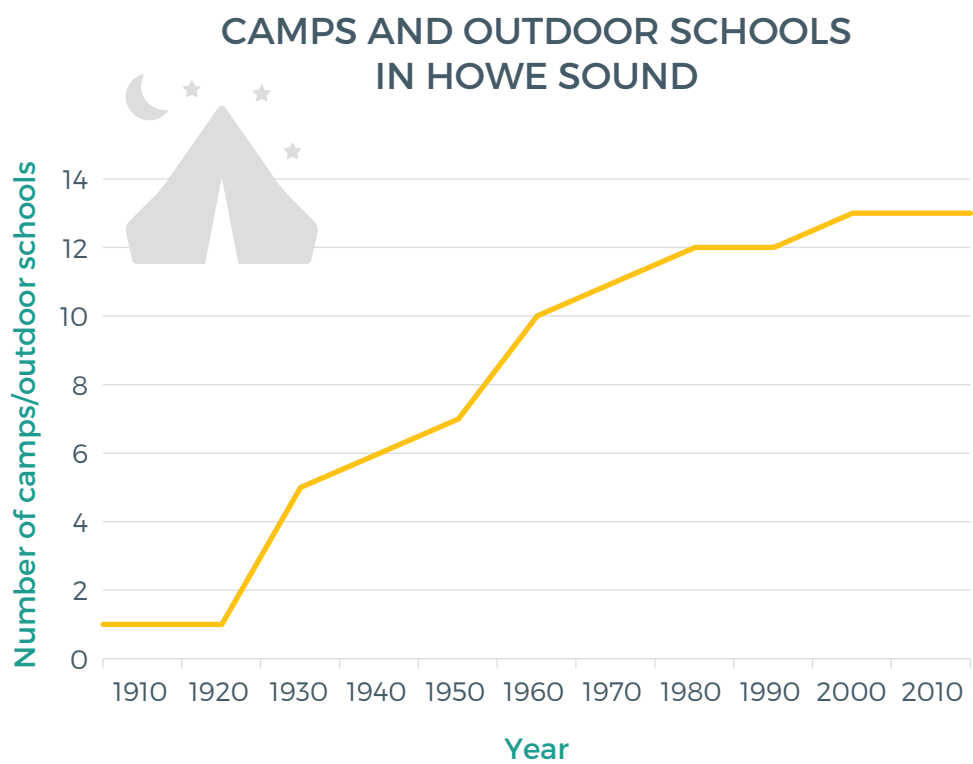


Figure 1. Establishment of camps and outdoor schools in Howe Sound continued steadily through the 20th century.

For over 50 years, Howe Sound has been the site of one of the largest concentrations of summer camps in British Columbia. One camp started operating in 1907! Each decade through the 1990s has seen more camps opening and there are 13 camps and outdoor schools

in the vicinity today (Figure 1). Thousands of youth and adults enroll in outdoor recreational programs at eight camps, primarily during the summer months (Table 2).

“Yet we also recognize that at a time when children are becoming increasingly disconnected from nature, it is of critical importance that as a society, we continue to support and invest in outdoor environmental learning.”

CONOR MCMULLAN, CHEAKAMUS CENTRE



Sea to Sky Outdoor School students studying marine ecology on Gambier Island.
(Photo: Tim Turner)

TABLE 2: CAMPS AND OUTDOOR SCHOOLS IN HOWE SOUND

NAME	OWNER	LOCATION	START OF OPERATION	ANNUAL ENROLLMENT	AGE RANGE	OPERATING SEASON	SIZE OF PROPERTY
Cheakamus Centre	North Vancouver School District 44	Paradise Valley, Brackendale	1969	13,000+	children, youth, adults	year round	420 acre
Evans Lake Forest Education Centre	Evans Lake Forest Education Society	Paradise Valley, Brackendale	1960	4,000	youth	Summer camp, winter camp, year round rentals	33 acres
Easter Seals Camp Squamish	BC Lions Society for Children with Disabilities	Brackendale	1972		youth	Summer camp	
Daybreak Point Bible Camp	In Trust by 11 Greater Vancouver Churches	Anvil Island	1939	1,100	youth	Summer camp; rentals spring and fall	96 acres
Camp Potlach	Boys and Girls Clubs of South Coast BC	Potlach Creek	1940s	1,000+	youth	July-August	133 acres
Camp Elphinstone	YMCA of Greater Vancouver	Langdale, Sunshine Coast	1907	7,000+	youth to adults	year round	
Camp Sunrise	Salvation Army	Gibsons	1925				
Camp Latona	Privately owned; Camp Latona Society leases the site	Gambier Island, north shore	1959		youth	July-August	118 acres
Camp Artaban	Camp Artaban Society	Gambier Island, SE shore	1923		youth and families	Spring, summer, fall	67 acres
Camp Fircom	Camp Fircom Society	Gambier Island, SE shore	1923	500	youth	Summer camp; rentals spring/fall	120 acres
Sea to Sky Outdoor School for Sustainability Education	Tim and Wendy Turner	Camp Elphinstone, Camp Fircom, Keats Camps	1991	2,000	elementary, secondary	Spring, fall	
Keats Camps	Convention of Baptist Churches of BC	Keats Island	1926	1,200	youth	Summer camp; year round rentals	230 acres
Camp Bow-Isle	Christian Science	Bowen Island	1960		youth, families, adults	Summer	

Note: Camp Summit was excluded due to its location 30 kilometres up the Squamish valley.

What role does environmental education play in First Nations cultural and spiritual heritage?

Four out of 12 environmental education organizations surveyed included some First Nation heritage or Indigenous practices content in their curriculum. This is particularly relevant as the Ministry of Education has recognized the importance of integrating First Nations Principles of Learning across the curriculum. On the other hand, First Nations inhabiting or using Howe Sound since time immemorial have been educating their children immersed in the environment without exception. There was no other classroom.

The Skw'une-was program at Cheakamus Centre has shared traditional practices of First Nations people since 1986 through its overnight programs at its Coast Salish Big House. Students engage in traditional long house life, eating traditional foods over open fires, hearing local legends and traditional songs; and learning about ceremonies, medicinal plants, basket-weaving and carving.



Skw'une-was ceremony. (Photo: Cheakamus Centre)



Photo: Gary Fiegehen

“South of Squamish beside Highway 99 is the celebrated granite mountain known to the Squamish people as *Siyám Smánit* (the Chief). In the long ago, the mountain was actually a long-house transformed to stone by *Xáys* (transformer brothers). If you look closely at the mountain you can see the outlines of the animals and people trapped inside when it was transformed. Also visible is a dark vertical line said to have been created by the corrosive skin of a two-headed sea serpent, *Sínulhkaý*, as he slithered to the summit”⁵

What trends relate to environmental education in Howe Sound?

To our knowledge no one has done an analysis to see if the number of youth attending camps and outdoor schools in Howe Sound has increased over the years, or if the numbers per capita for the region might be increasing, but judging by the longevity of the organizations, interest and participation in outdoor education has certainly not diminished. Several new private and public ventures in environmental education have arrived in Howe Sound over the past decade, including Quest University Canada which opened in Squamish in 2007, a West Vancouver School District year-round outdoor program at the Bowen Island Community School, which launched in 2013, and Camp Suzuki, with a strong Squamish Nation involvement, just launched in 2015.

Ecotourism operators engage thousands each year in diverse activities that offer a potential for greater environmental learning: Highway 99 based bus tours with popular stops at Porteau Cove, Shannon Falls, and Britannia; boat tours on Howe Sound, and raft trips on the Squamish and Cheakamus rivers. The Sea to Sky Gondola offers guides and interpretive information at its lookouts and along trails. The Britan-

nia Mine Museum provides guided tours of the water treatment plant that now protects Howe Sound from the harmful discharge of mine waters.

At the same time, outdoor schools in Howe Sound have had a growing student enrollment over the past decade. There is a broad resurgence or interest in outdoor learning, given concerns about the time that children spend indoors, the so-called “nature-deficit disorder” coined by author Richard Louv.⁶ The BC Ministry of Education is releasing a new curriculum that provides greater opportunity for place-based or outdoor “learning” and indigenous First Nations culture. Educators are also showing increased interest in new professional development opportunities in outdoor learning as evidenced by the development of adult programs on offer at educational sites.⁷ There is a growing partnership between schools and educational partners such as Metro Vancouver, Vancouver Aquarium, and the Maritime Museum. In Howe Sound, Quest University Canada collaborates with the Squamish River Watershed Society to connect student learning and research with environmental rehabilitation and monitoring in the Squamish Estuary.

What can you do?



Individual and Organization Action:

- Familiarize yourself with educational opportunities available to all ages in Howe Sound, and get involved!
- Explore opportunities to incorporate outdoor learning and natural sciences into professional development.



Government Action and Policy:

- Increase awareness of and encourage participation in the many educational opportunities offered in Howe Sound for all ages.
- Prioritize protection of Howe Sound's natural beauty so that it remains preserved for educational opportunities to thrive and expand in the future.
- Support research on children and youth development outcomes from natural science educational opportunities, in order to better understand and document the benefits of these programs, and justify further growth.
- Collect and maintain information on educational opportunities and participation in Howe Sound to track trends to understand needs and desires for this type of learning.
- Identify additional local conservation groups, citizen science projects, and restoration efforts for potential collaborations with educational initiatives.
- Capitalize on the uniqueness of Howe Sound's natural beauty and accessible location by expanding outdoor education programs throughout more schools in the Greater Vancouver Area.

Resources

Bowen Island Community School
go45.sd45.bc.ca/schools/bowenisland

Camp Artaban
campartaban.com

Camp Elphinstone
gv.ymca.ca

Camp Fircom
fircom.ca

Camp Sunrise
campsunrise.ca

Camp Suzuki
campsuzuki.org

Camp Potlach
bgcbc.ca

Capilano University
capilanou.ca

Cheakamus Centre
cheakamuscentre.ca

Easter Seals Camp Squamish
eastersealscamps.ca

Evans Lake Forest Education Centre
evanslake.com

Island Pacific School, Bowen Island
islandpacific.org

Quest University Canada
questu.ca

Metro Vancouver School & Youth Leadership Programs
metrovancover.org

Sea to Sky Outdoor School for Sustainability Education
seatosky.bc.ca

Southlands Heritage Farm
southlandsfarms.com

Footnotes

¹ <http://www.bccamping.org>

² T. Dunn, Managing Partner, Sea to Sky Gondola, personal communication, June 17, 2016

³ <https://www.epa.gov/education/what-environmental-education>

⁴ http://www.acacamps.org/sites/default/files/resource_library/report-directions-youth-development-outcomes.pdf

⁵ Reproduced with permission from “Where Rivers, Mountains and People Meet”, Squamish Lil’wat Cultural Centre

⁶ Louv, Richard. 2005. Last Child in the Woods: Saving our Children from Nature Deficit Disorder. Chapel Hill, NC : Algonquin Books of Chapel Hill. 323p.

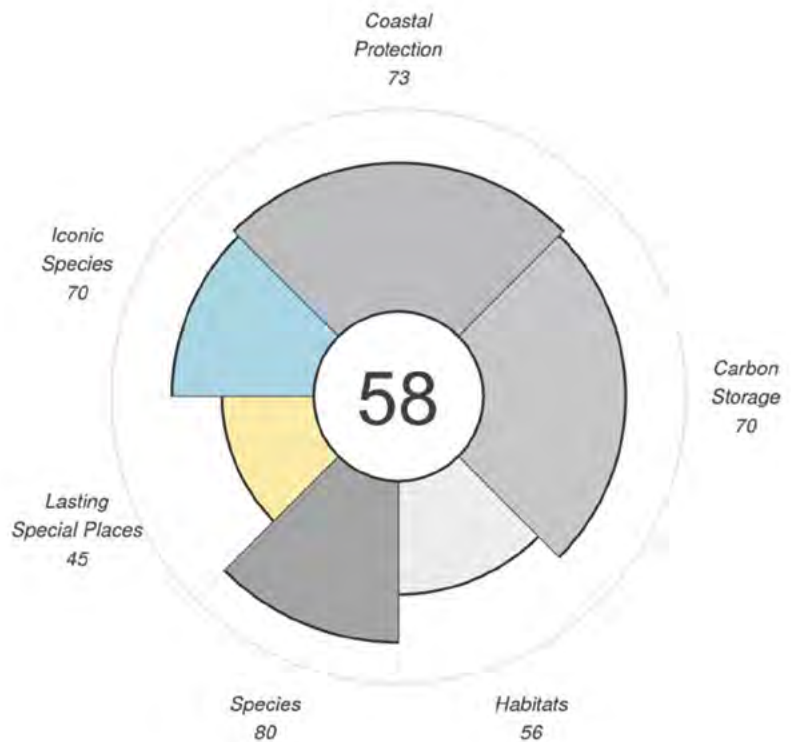
⁷ <http://www.cheakamuscentre.ca/s/programs.asp>

What can the Ocean Health Index tell us about Sense of Place and Wellbeing?

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The overall Sense of Place score (58) is an average of an Iconic Species score (70) and a Lasting Special Places score (45).

How did the Ocean Health Index define Sense of Place?

Sense of Place: A healthy ocean provides a deep sense of identity and belonging through connections with our marine communities.

How did the Ocean Health Index measure Sense of Place?

The Ocean Health Index measured how well the ocean is providing a Sense of Place to the people of Howe Sound by measuring how well **iconic species** populations in the region are faring and how well the spe-

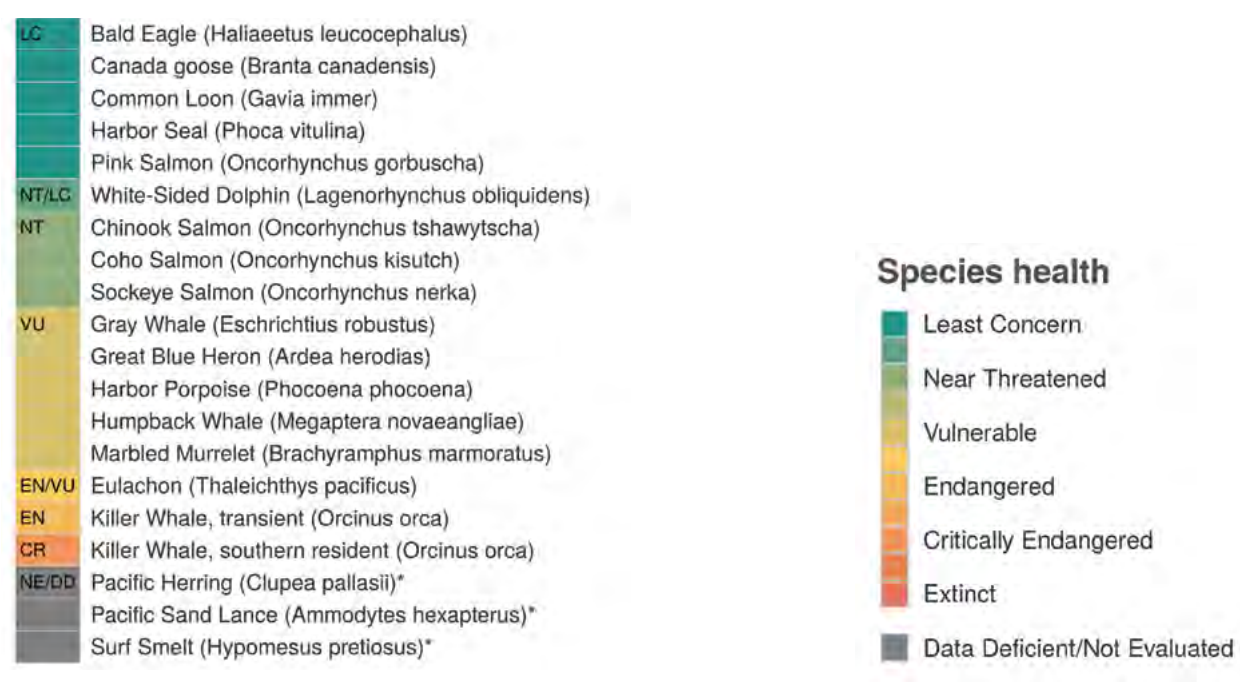
cial places around Howe Sound are being conserved through **marine and coastal protected areas**. Each one of these components contributed equally to the overall score of 58 out of 100.

TO MEASURE THE STATUS OF ICONIC SPECIES WE ASSESS THE THREAT TO SPECIES THAT ARE CULTURALLY OR SOCIALLY IMPORTANT TO HOWE SOUND.

First the Ocean Health Index team worked with CORI and other local community members to define a list of species that are iconic to the people of Howe Sound. Iconic Species are species that are special from a cultural perspective and symbolize the cultural, spiritual, and aesthetic benefits that people hold for a region, often bringing intangible benefits to coastal com-

munities and beyond. Once we had this complete list we used data from local, regional, and global sources to determine the conservation status of each species. To achieve a perfect score, all iconic species in the region should be listed as of “least concern,” meaning there is little risk of extinction.

ICONIC SPECIES INCLUDED IN THIS ASSESSMENT AND THEIR CURRENT CONSERVATION STATUS



TO MEASURE THE STATUS OF MARINE AND COASTAL PROTECTED AREAS WE ASSESS THE CONSERVATION STATUS OF MARINE AND COASTAL AREAS AROUND HOWE SOUND.

Here we looked at how much of the marine and coastal area within the Howe Sound region is designated as protected (Figure 1). In the marine environment 0.7% of Howe Sound is protected. To determine the terrestrial extent of protection we looked at the entire watershed around Howe Sound and the Squamish River. In the terrestrial environment 26.4% of Howe Sound is protected. We used an internationally established target of “30% of marine and coastal areas protected” as the benchmark for a perfect score for this measure.

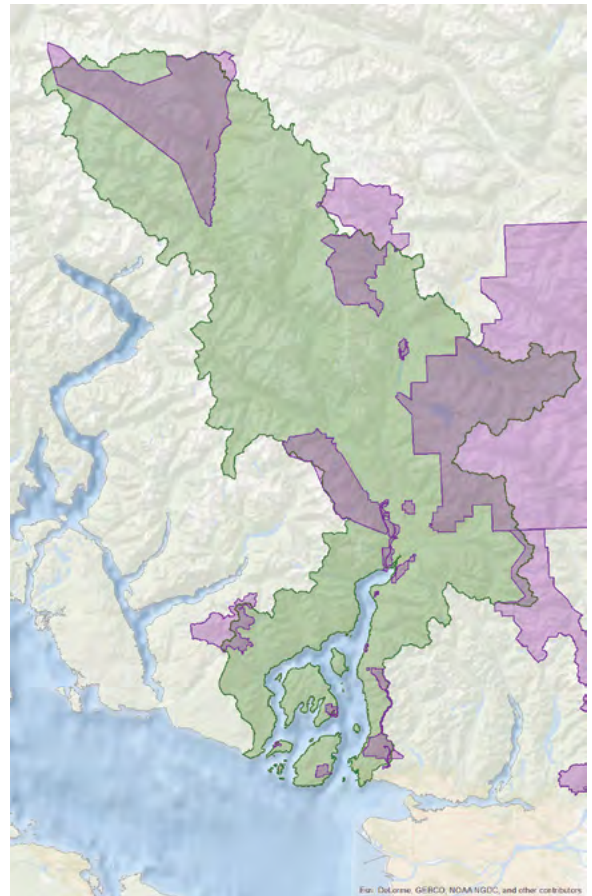


Figure 1. Marine and coastal protected areas (purple) throughout Howe Sound watersheds (green).

Coastal Development and Livelihoods



Photo: Tracy Saxby

Summary

As more people flock to B.C. from across Canada and around the world, Howe Sound is an increasingly sought-after destination. Upgrades to the Sea-to-Sky highway made for the 2010 Olympics have vastly improved access to the region for tourists and locals alike, who are drawn to Howe Sound's spectacular natural settings and recreation opportunities. Meanwhile high housing prices in the Lower Mainland have pushed more residents to settle in the relatively affordable communities in the region.

Population growth in Squamish is currently outpacing both the provincial and Metro Vancouver averages and tourism across the Sound is booming. More than two million people visited B.C. parks in Howe Sound in 2014-2015, a near 50 percent increase since 2010, and tourist attractions, such as Squamish's Sea to Sky Gondola, drew hundreds of thousands more. Meanwhile, BC Ferries vessels packed with residents and visitors account for nearly three-quarters of large vessel marine traffic.

This influx of activity poses tremendous economic opportunity for the area, which is seeing tourism eclipse the resource industry as a primary economic driver — but it is also bringing change that requires careful management to reduce ecological impact. Thousands of units of new housing, an all-season ski resort, and a new highway connection to the Sunshine Coast are just some of the projects currently under consideration for the region. Meanwhile the possible conversion of a former pulp-and-paper plant into a production facility for liquefied natural gas could increase shipping activity in the waters of Howe Sound.

As the region grows, finding a balance between emerging economic drivers, social well-being, and ecological preservation is more important than ever.

Coastal Development & Livelihoods Snapshot Assessment

<h2>Coastal Development</h2> <p>Population growth in Squamish is outpacing the provincial average, and increasing development pressure on coastal areas highlights the need for a coordinated approach to track and manage growth. Potential cumulative impacts to the marine environment are largely unstudied.</p>	 <p>CAUTION</p>
<h2>Large Vessel Traffic</h2> <p>BC Ferries accounts for nearly 75 percent of large vessel marine traffic on Howe Sound. Several proposed and approved industrial activities, such as an LNG plant, could lead to a marked increase in shipping traffic in the Sound in the coming years. With an increase in potential conflict with boats, recreation, and marine life, it will be important to understand the risks and consequences.</p>	 <p>CAUTION</p>
<h2>Tourism and Recreation</h2> <p>An influx of tourist activity in Howe Sound presents economic benefits as well as an opportunity for environmental stewardship and education. There is a need to balance environmental protection and community well-being with this booming economic driver.</p>	 <p>HEALTHY</p>  <p>CAUTION</p>

Coastal Development: balancing growth with ecosystem health

AUTHOR

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CONTRIBUTORS

Members of a discussion table at the Howe Sound Socio-Economic Knowledge Workshop, June 2016¹

What's happening?

The word around the Sound is that there are more coastal development applications and proposals than ever. Does this perception have any basis in reality? As the population increases is the rate of residential development increasing (i.e., the size or number of housing proposals)? Is shoreline modification increasing? Looking at some metrics of coastal development will help to answer these questions.



Photo: Tracy Saxby

What is “coastal development” and why is it important to Howe Sound?

Coastal development is development involving some human-made structure(s) along the coastline. Development can be industrial, commercial, community or residential. There is no worldwide standard that tells us what distance from the coast is considered coastal development, but in this article we focus on development with a shoreline component. At a socio-economic knowledge workshop in June 2016,¹

participants from around Howe Sound agreed that we need to look beyond shoreline modification to see how development is affecting the health of the Sound. A watershed analysis would certainly be more comprehensive, is ecologically sensible and fits better with First Nations' world view. At any scale, coastal development is important to plan for because it comes with benefits and with environmental impacts.

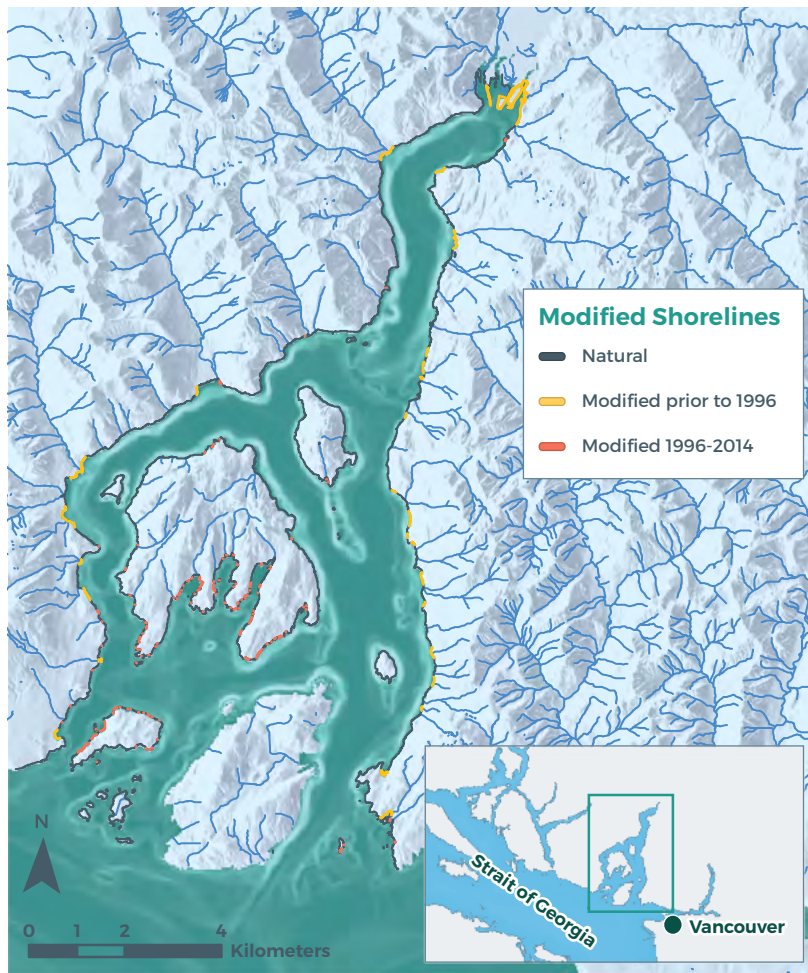


Figure 1. Natural and modified shorelines (2014), modified before and after 1996. No data available for Bowen Island due to cloud cover in satellite imagery.²

Risks of coastal development



What is the current state?

One simple metric, although it won't tell the whole story, is shoreline modification. Twelve percent of Howe Sound's shoreline had been modified by 2014, up from 9.25 percent in 1996 (Figure 1).² By comparison, approximately half of Burrard Inlet's shoreline was classified as altered, or not natural, in 2005, up from 27 percent in the 1930s.³ In general, the greater the coastline alteration and modification, the more the natural processes and ecosystem function are interrupted and the less productive and resilient the ecosystem becomes.⁴

Coastal development can also be quantified by studying foreshore land use according to Land Act Tenures, or Crown land dispositions that are issued for specific purposes and periods of time under an agreement between an individual or company and the provincial government for an interest in Crown land, because the foreshore is owned by the Province. The percent of Howe Sound coastline that is "tenured" is



Recently modified shoreline in a commercial/industrial tenured area near the Defence Islands in Howe Sound. (Photo: Donna Gibbs)

approximately 13.4 percent and a further 2.2 percent was subject to a tenure application as of January 2016.⁵ The permitted purpose of tenures varies and currently about nine percent of the coastline is designated for commercial and industrial use, while less than one percent is residential (Table 1).

TABLE 1. COASTAL TENURES AND APPLICATIONS (JAN 2016); PURPOSE AND PERCENT OF SHORELINE COVERED IN HOWE SOUND.

TENURE PURPOSE	EXISTING TENURES (% SHORELINE COVERED)	TENURE APPLICATIONS (% SHORELINE COVERED)
Commercial and Industrial	8.9	1.6
Protection & Reserves	2.6	0.1
Moorages (public, commercial, & residential)	1.2	0.2
Commercial recreation	0.1	0
Residential	0.1	0
Other	0.5	0.3
Total	13.4	2.2

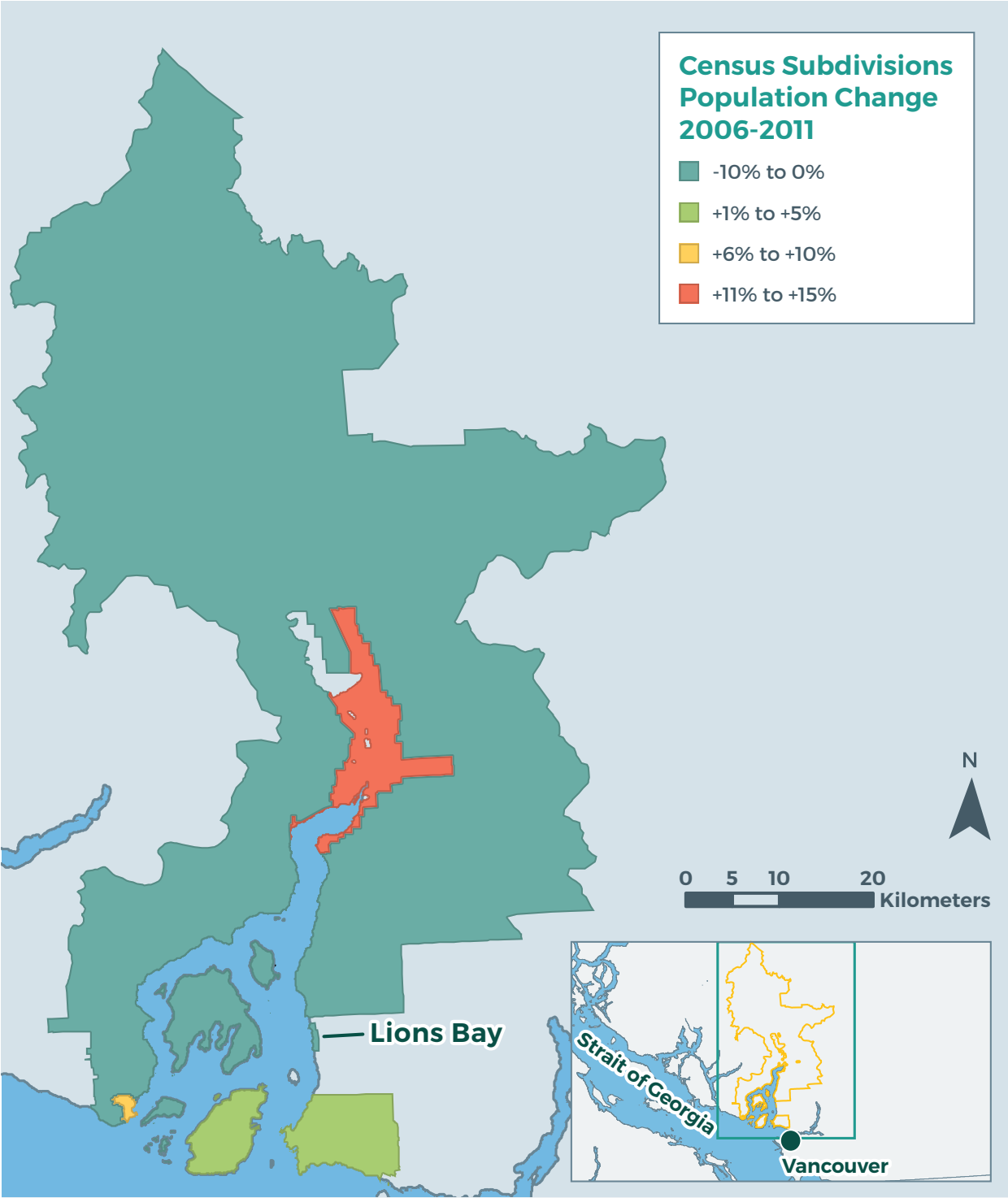
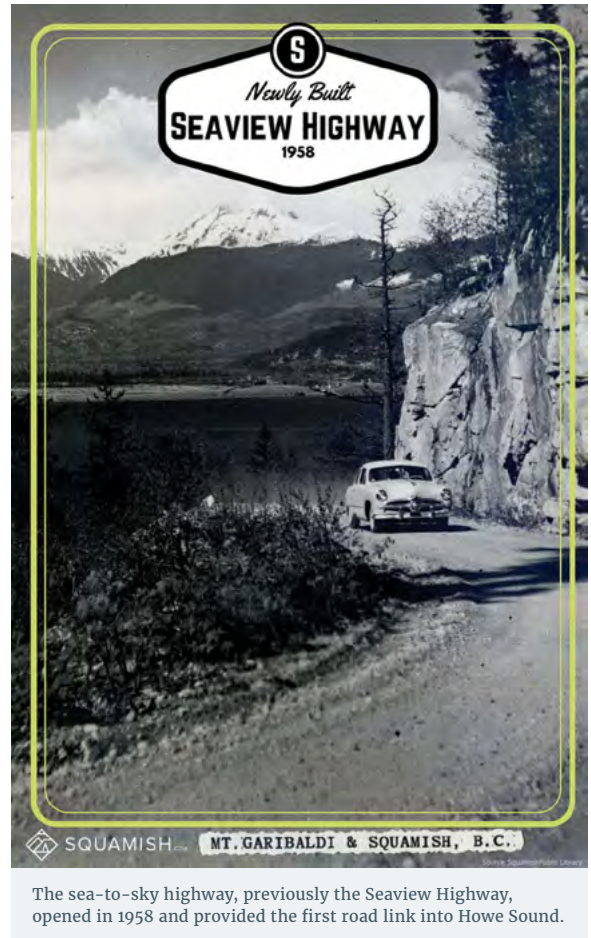


Figure 2. Population change by census subdivision, 2006 – 2011.

Population pressures drive residential development which results in population growth. Populations in the region are increasing with British Columbia growing at seven percent (2006–2011)⁶ and greater Vancouver (the Regional District) growing at eight percent (2006–2011).⁷ Combining all the census subdivisions of Howe Sound, the overall area grew at a rate of four percent between 2006 and 2011, with District of Squamish seeing the highest growth rate of 15 percent and the largely rural districts seeing small declines (Figure 2).⁸ The pace of growth and movement to the area is further documented in traffic data, which show that average daily vehicle counts along the sea-to-sky highway have increased 39 percent between 1999 and 2015 (Figure 3). Traffic volume was relatively stable until the 2010 Olympics and has increased steadily since then. Further, the rate of increase at Brakendale is less than that north of Horseshoe Bay suggesting that most of the increase is south of Brackendale. Traffic at Langdale does not show a similar increase (Figure 3).

Population growth and population density indices are used by governments to determine services and infrastructure needs, while the number or density of dwelling units is often used by realtors and developers. Each describes density from a different perspective.⁹ Currently, three proposals of 1,000 or more dwelling units are under consideration in Howe Sound (Table 2). (Understanding cumulative impacts would require analysis of all development proposals, big and small, as acknowledged at the socio-economic knowledge workshop,¹ but that is beyond the scope of this article.) Significant housing and development was approved for Furry Creek when new zoning by-laws were adopted in 1999. Approximately 800 units are still to be constructed.



Around Howe Sound, there are a number of coastal developments, industrial, commercial and residential, at various stages of consideration (Table 2). Each of these has some kind of shoreline component and has the potential to impact coastal and marine ecosystems at the same time as providing economic and social benefits.

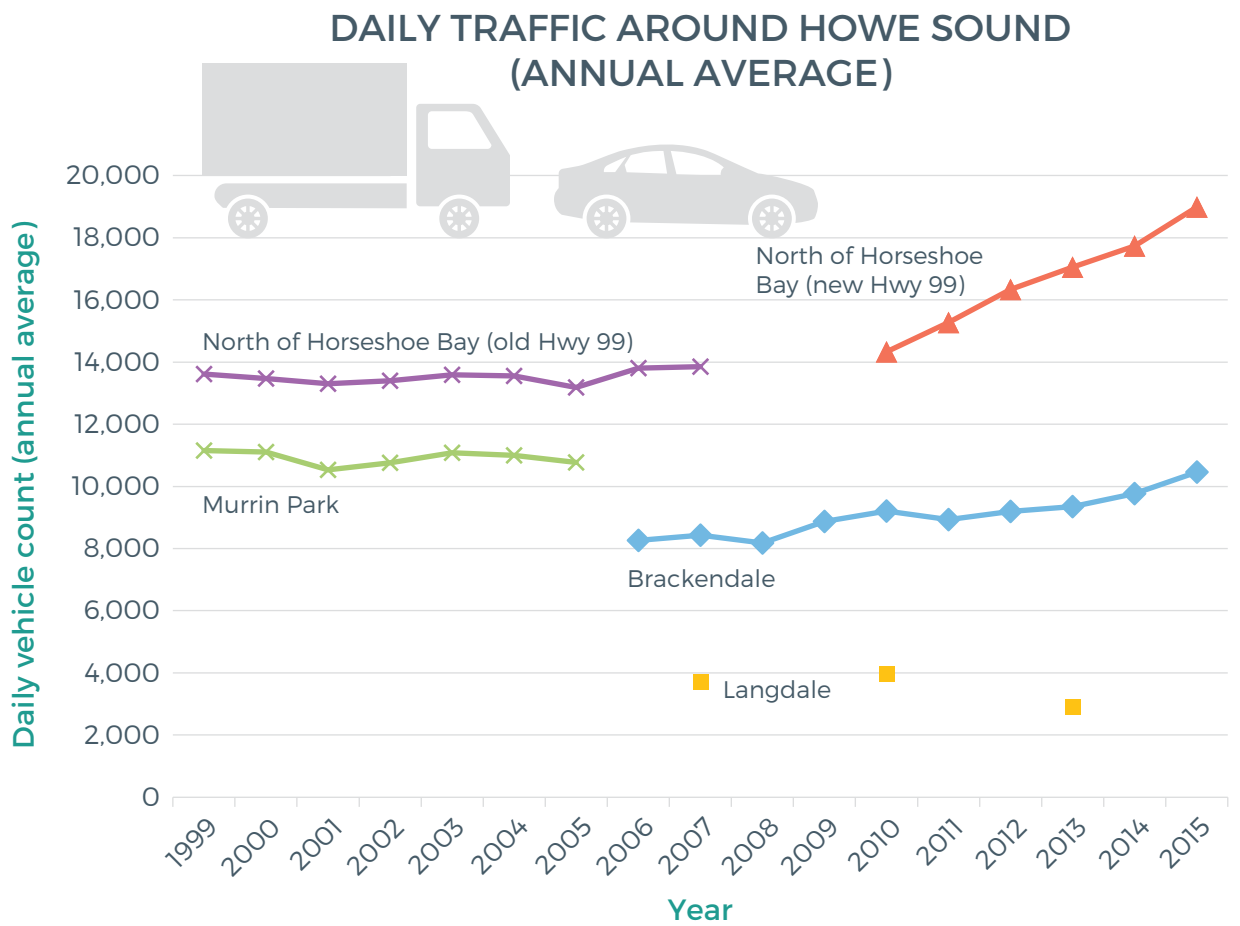


Figure 3. Average annual daily traffic at several locations in Howe Sound, including, from north to south, Brackendale (north of Squamish), Murrin Park (south of Squamish), a point north of Horseshoe Bay (HSB) prior to the highway upgrade (old Hwy 99) and since the highway upgrade (new Hwy 99), and Langdale (on Hwy 101 after the ferry exit). Data Source: Province of B.C. Traffic Data Program¹⁰

How might coastal developments benefit society and/or threaten a healthy marine environment?

The benefits of coastal development range from economic to social and cultural wellbeing stemming from new jobs, greater community wealth, improved access to the waterfront, and, in Howe Sound, housing for young people. New development often funds research, environmental studies, and community improvements such as required sea level rise adaptation and public transit. On the other hand, development along the coast interrupts the natural ecosystems' land-sea connection and can alter marine circulation patterns, shade eelgrass beds, reduce biodiversity, increase erosion, degrade nearshore and intertidal habitat, reduce coastal seafood production, and introduce pollution

and contaminants. Social and economic costs of coastline development include potential loss of property value due to flooding or sea level rise, and loss of wilderness value as more shoreline becomes developed. To complicate the tallying of benefits and impacts, some development is redevelopment where former industrial waterfronts are converted to residential, such as at Squamish Oceanfront, a former chemical plant, and South Britannia, a former gravel pit. In the former case, remediation which was an asset to the marine environment, preceded redevelopment. (This is an example of the net gain concept discussed at the June 2016 workshop.)



Golf course and other development at Furry Creek. (Photo: Gary Fiegehen)

Participants at the Socio-economic knowledge workshop acknowledged the rapid growth in the region, existing development pressures, and the sense of place that has blossomed with what some call an “ecological recovery.” This group of developers and planners shared these thoughts on the challenges related to coastal development in Howe Sound:

- Sharing success stories is important.
- Developers need specific guidelines and access to current best practices. (E.g., GreenShores doesn’t have set guidelines.)
- Guidelines that are consistent across jurisdictions around Howe Sound would be helpful.
- The concept of net-gain is important, especially in Howe Sound as remediation of past industrial development occurs.
- Comprehensive planning is lacking; too many jurisdictions are involved; the cumulative effects of rapid and ongoing development need to be assessed. There is a desire (by some) to have Howe Sound recognized as a single entity.
- Howe Sound needs environmental and social targets or goals (i.e., what “healthy” looks like), informed by carrying capacity and ecological potential.
- Howe Sound needs baseline information on conditions and traditional uses pre-contact.
- It may be valuable to look at similar regions globally — places that are environmentally sensitive and facing similar pressures and stressors.
- There is a desire for overall land use planning transparency.
- Coastal development is booming; things are happening at a fast pace and questions remain about how to best manage the rapid growth for the benefit of all.



Coastal development at Furry Creek. (Photo: Bob Turner)

What is being done?

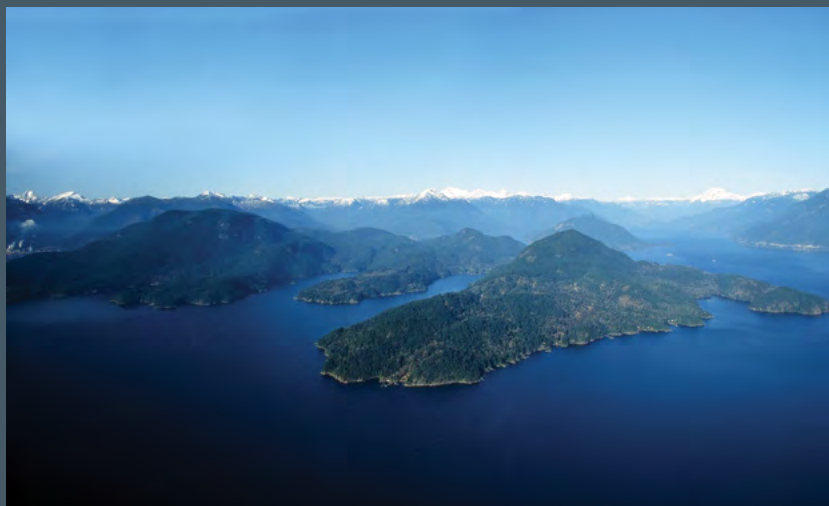
As table 2 illustrates, there is no single level of government that is responsible for overseeing and approving coastal development in Howe Sound. Residential and commercial building permits are issued by local governments which include municipalities, regional districts, Islands Trust, and First Nation governments. Review and approval of industrial development projects is coordinated by the provincial government. First Nations are integral to all of these decision making processes through a comprehensive referral process and often direct consultation with project proponents.

These processes consider the cumulative effects of multiple proposals in a cursory way, but the need for more comprehensive planning and analyses to consider continuing development pressure has been raised by Howe Sound residents and governments have acknowledged the need. B.C. has completed a few assessments of cumulative effects in terrestrial ecosystems and a draft framework for assessing and managing cumulative effects is being revised following a public review period (October 2016).¹¹ Work on a cumulative effects assessment for Howe Sound has begun with a current condition report on seven terrestrial values due out in March 2017.¹²

With respect to collecting and collating data that informs ecological state, potential impacts, social climate, and more, currently each development proponent undertakes research and collates many types of data. Although these data have great value, in most cases they are not shared and made available. This was raised as an issue of concern at the socio-economic knowledge workshop along with the lack of a central data hub for Howe Sound, where data required for tracking cumulative effects could have a home. Collation of data and information from a variety of proposals might allow us to compare how residential units versus accommodation units (hotels, etc.) versus industrial developments contribute to the cumulative impacts.

Housing in the long ago

Squamish people moved about during the year to different fishing and hunting areas, so they needed shelter that could be taken down and reassembled easily somewhere else. Accordingly, they constructed portable **Tl'aktáxen Lá'm** (longhouses), in which everything could be dismantled but for the frames. When moved, pieces of the longhouses were balanced carefully and lashed with rope across the bows of pairs of cedar canoes that plied the waters of Georgia Strait and Howe Sound.¹³



St'ápes is the spiritual name of Gambier Island — a popular destination for canoe travel. **St'ápes**, a celebrated deer-hunting area for the Squamish people, was rich in resources, particularly **Yekwákwlhka** (Avalon Bay), **Humám̓k** (Brigade Bay) and **Ch'á7elsm** (Halkett Bay). Photo: Gary Fiegehen. Reproduced with permission from “Where Rivers, Mountains, and People Meet”, Squamish Líl'wat Cultural Centre. (Photo: Gary Fiegehen)

TABLE 2: CURRENT COASTAL DEVELOPMENT PROJECTS AND PROPOSALS ON THE SHORES OF HOWE SOUND.

Each of these will result in some kind of shoreline modification.

PROJECT NAME, DEVELOPER	LOCATION	TYPE OF DEVELOPMENT	PLANNING AUTHORITY RESPONSIBLE	STATUS (JUNE 2016)	DWELLING UNITS
Sewell's Development	Horseshoe Bay	Comprehensive	District of West Vancouver	Application to be submitted?	171
Furry Creek Community	Furry Creek	Planned community on golf course	Squamish-Lillooet Regional District	Under Development Covenant (permit granted)	800
Porteau Cove Community	Porteau Cove	Comprehensive	Squamish-Lillooet Regional District	Zoned, no development permits issued; application under review?	up to 1400
Britannia Beach South, Taicheng	Britannia Beach	Mixed Residential, 5 phases over 15-20 yrs	Squamish-Lillooet Regional District	Master planning, zoning required; present to SLRD board June 22	~ 1000
Britannia Beach North, Macdonald Development Corporation	Britannia Beach	Commercial, Residential	Squamish-Lillooet Regional District	Application to be submitted?	?
Klahanie Resort	Shannon Falls, District of Squamish	5 Star Resort Hotel, Residential	Squamish-Lillooet Regional District	Application to be submitted?	42 +
Squamish Oceanfront Development, Bethel Lands Corporation	Squamish	Comprehensive, 6 phases over 20 years	District of Squamish	Application approved	1000
The George Hotel and Residences	Gibsons	Hotel, Residential	Town of Gibsons	Application under review?	35
Seaglass	Gibsons	Residential, commercial	Town of Gibsons	Application submitted?; First reading given to zoning and OCP amendments	12
Gibsons Foreshore Redevelopment	Gibsons	Community Development	Town of Gibsons		N/A
Waste to Energy Facility	near Port Mellon, in SCRD	Industrial	Sunshine Coast Regional District	No longer a potential project? Metro Vancouver has discontinued its current waste-to-energy procurement process	N/A
Burnco Gravel Mine	McNab Creek, in SCRD	Industrial	Environmental Assessment - British Columbia. Land use zoning — Sunshine Coast Regional District	Pre-application started 2010; EA underway — latest document is a public consultation and communications plan, Jan 2016	N/A
Woodfibre LNG	West of Squamish, in SLRD	Industrial	Environmental Assessment - British Columbia for Federal and Provincial governments. Other permits?	Provincial EA Certificate Issued Oct 2015; Federal environmental approval rec'd March 2016; Squamish Nation Council issued an Environmental Assessment Certificate with legally binding conditions in Oct 2015	N/A

What can you do?



Individual and Organization Actions:

- Individuals, developers and industry can follow, promote, develop, discuss and share best practices (e.g., Green Marine certification – green-marine.org, GreenShores approaches for shoreline development – islandstrust.bc.ca/islands/island-ecosystems/caring-for-my-shoreline/greenshores-approach).
- Collate and make available pre-proposal data from environmental and social research.



Government Actions and Policy:

- Prioritize studies to further understand the effect of shoreline development on marine circulation patterns, shading, biodiversity, erosion, habitat degradation, seafood production, pollution and contaminants.
- Develop and promote an inventory of best practices for developers and update it regularly.
- Apply new and proven methods to assess development projects. For example, innovative tools to provide decision support for complex planning problems are becoming more available and more accepted. Taking ecosystem service values into account when evaluating the trade-offs of proposed development is one way to proceed.¹⁴ Howe Sound is the study area for a comprehensive assessment that estimates the total annual value of intact ecosystems at between \$793 million and \$4.7 billion.¹⁵
- Add marine values to the B.C. cumulative effects assessment that is underway for Howe Sound.
- Collate and make available pre-proposal data from environmental and social research.
- Support jurisdictions that want to work together to develop comprehensive land and marine use plans cooperatively.
- Implement a trust fund from development proceeds to fund environmental mitigation and remediation.
- Plan for construction of key facilities and infrastructure to occupy previously developed shoreline, if feasible.
- Make sharing of pre-proposal data from environmental and social research mandatory.
- Develop targets for ecosystem health, goals for sustainability indicators, and limits for environmental impacts.

Acknowledgements

This report draws in part on a summary of development proposals compiled by Kate-Louise Stamford and Ruth Simons for the Howe Sound Community Forum meeting in April 2016. In addition, we would like to acknowledge contributions made at a Howe Sound Socio-Economic Knowledge Workshop held June 17, 2016 at the Vancouver Aquarium. Participants at a “Coastal Development” discussion table shared knowledge which has been incorporated

into this article. Participants included Hillary Highland, Tsleil-Waututh Nation, Kate-Louise Stamford, Islands Trust, Patricia Heintzman, Mayor, District of Squamish, Bill Baker, Macdonald Development Corporation, Marian Ngo, Woodfibre LNG, Derek Holmes, BURNCO Rock Products Ltd., Carlos Zavarce, Cornerstone Development, and Andre Boel, Director of Planning for the Town of Gibsons.

Resources

The Density Atlas: a website explaining metrics of population density with case studies; Developed at Massachusetts Institute of Technology
www.densityatlas.org/measuring/index.shtml

The Development of Major Projects within the Natural Resource Sector: An Overview of British Columbia's Regulatory Process
www2.gov.bc.ca/gov/content/industry/natural-resource-use/natural-resource-major-projects

Sound Investment: Measuring the Return on Howe Sound's Ecosystem Assets, 2015
www.davidsuzuki.org/publications/reports/2015/sound-investment-measuring-the-return-on-how-sounds-ecosystem-assets/

Valuing the Aquatic Benefits of British Columbia's Lower Mainland: Nearshore Natural Capital Valuation, 2012
www.davidsuzuki.org/publications/reports/2012/nearshore-natural-capital-valuation/

Footnotes

¹ Please see acknowledgements for a list of participants.

² Analysis done at CORI, Feb. 2016: The shoreline of Howe Sound was digitized using Geographic Information System (GIS) software from the satellite imagery base map provided by ArcGIS (Last modified December 12, 2014). Structures seen on the shoreline including seawalls, jetties, offshore breakwaters, bulkheads, riprap, revetments and/or groins were interpreted as “modified.” Bowen Island could not be digitized because of high cloud cover in the satellite image. Modified shoreline prior to 1996 was calculated from “man-made” classes in the BC shorezone dataset (<http://geobc.gov.bc.ca/base-mapping/coastal/docs/BritishColumbiaShorezoneMappingSystem.pdf>).

³ An analysis done using digital ortho-imageries for the Burrard Inlet Environmental Action Program: Stantec. 2009. Burrard Inlet Shoreline Change – Baseline Assessment Final Report. Prepared for the Burrard Inlet Environmental Action Program. December 2009.

⁴ Kittinger, J.N. and Ayers, A.L. 2010. Shoreline Armoring, Risk Management, and Coastal Resilience under Rising Seas. *Coastal Management* 38(6): 634–653. DOI:10.1080/08920753.2010.529038

⁵ Analysis done at CORI, Feb. 2016: Tenures downloaded from BC Data Catalogue, Jan 2016, were tallied by purpose if they intersected with the coastline buffered by 100 meters. <https://catalogue.data.gov.bc.ca/dataset/tantalus-crown-tenures>

⁶ BC Stats. 2016. Accessed Oct 2016. <http://www.bcstats.gov.bc.ca/StatisticsBySubject/Census/2011Census.aspx>

⁷ BC Stats. 2016. Population estimates. Accessed Oct 20, 2016. <http://www.bcstats.gov.bc.ca/StatisticsBySubject/Demography/PopulationEstimates.aspx>

⁸ BC Stats. 2016. The Census of Canada. Accessed Oct 2016. <http://www.bcstats.gov.bc.ca/StatisticsBySubject/Census/2011Census/PopulationHousing/CensusSubdivisions.aspx> and <http://www.bcstats.gov.bc.ca/StatisticsBySubject/Census/2006Census/PopulationHousing/CensusSubdivisions.aspx>

⁹ Massachusetts Institute of Technology. The Density Atlas. <http://www.densityatlas.org/measuring/metrics.shtml>

¹⁰ Province of British Columbia. 2016. Traffic Data Program GIS Application. Data downloaded Sept 21, 2016. <http://www.th.gov.bc.ca/trafficData/index.html>

¹¹ <http://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/cumulative-effects-framework>

¹² Juthans, J. October 14, 2016. Update on the Howe Sound Cumulative Effects Project presented to the Howe Sound Community Forum at Glen Eagles Golf Club in Horseshoe Bay.

¹³ Reproduced with permission from “Where Rivers, Mountains, and People Meet”, Squamish Lil’wat Cultural Centre.

¹⁴ For example, recent work from the Natural Capital Project at Stanford University suggests that coastal and marine planning that takes specific ecosystem services (i.e., things like seafood production and recreational opportunities that generate tourism) into account can lead to better outcomes for both people and nature. In a national coastal planning initiative in Belize, engaged stakeholders were able to agree on a preferred plan that should lead to greater returns from coastal protection and tourism, reduced habitat impacts, and increased fishing revenues. Arkema, K. et al. 2015. Embedding ecosystem services in coastal planning leads to better outcomes for people and nature. *Proceedings of the National Academy of Sciences* 112 (24) 7390–7395. doi: 10.1073/pnas.1406483112

¹⁵ Molnar, M. 2015. Sound Investment: Measuring the Return on Howe Sound’s Ecosystem Assets. David Suzuki Foundation, 76p. <http://www.davidsuzuki.org/publications/downloads/SoundInvestment-HoweSoundEcosystemAssets.pdf>

Maritime Industry and Large Vessel Traffic

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Members of a discussion table at the Howe Sound Socio-Economic Knowledge Workshop, June 2016¹

What's happening with large vessel traffic in Howe Sound?

Howe Sound is a valued marine transportation corridor, which supports local, regional and global economies. Currently, most of the goods and raw materials moved through Howe Sound are associated with the forest industry. In terms of vessel traffic in and out of Howe Sound, the movement of goods by large vessels is dwarfed by the movement of people (and their vehicles) on BC Ferries.

In 2015, almost 13,000 large vessels (i.e., vessels over 20 metres in length,² including ferries, coastal tugs, cargo vessels, and a few coast guard vessels and fishing boats) entered Howe Sound (Figure 1).³ Ferries alone account for 72 percent of this traffic, while tugs make up 24 percent. The volume of traffic increased slightly (by seven percent overall) between 2011 and 2015 with most of the increase represented by tug traffic (Figure 1). Averaged over a year, the large vessel traffic volume translates to 35 vessels per day entering Howe Sound.

In the next few years, two coastal development projects, in different stages of planning and permitting, would add to the large vessel traffic in and out of Howe Sound, if they proceed. The Woodfibre LNG project would bring LNG carriers in out of Howe Sound and the Burnco Aggregate project would transport gravel by barge out of the Sound. In addition, the volume of timber arriving by log boom to the Mamquam Blind Channel for processing is projected to increase⁴ and several other projects in the conceptual stage may add to marine traffic as well.

High numbers of recreational boats and vessels smaller than 20 metres in length travel in Howe Sound and are supported by over a dozen marinas, public docks and yacht clubs, but this article focuses on large vessels and the ports and terminals that accommodate them.

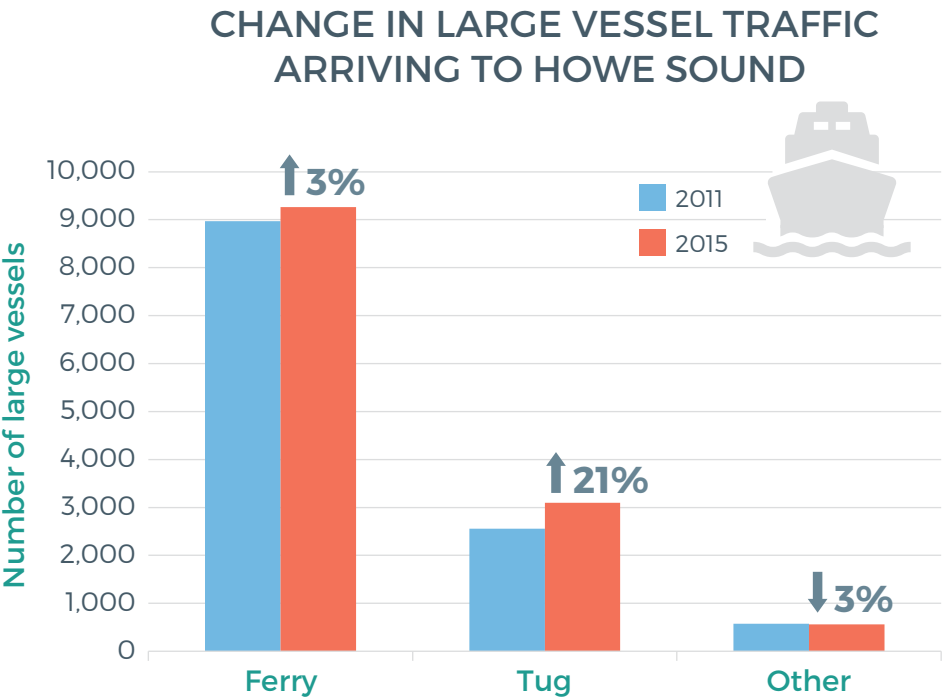


Figure 1. Large vessel traffic arriving to Howe Sound in 2011 compared to 2015, with percent change shown.

Why is the maritime industry and large vessel traffic important to Howe Sound?

The maritime industry refers to the business of trading by sea. Over 90 percent of the world's trade is carried by sea, which is the most cost-effective way to move goods and raw materials around the world, according to the International Maritime Organization. Merchant vessel traffic accounts for only about 25 percent of the large vessel traffic in Howe Sound,⁵ because the volume of BC ferry traffic coming and going from Horseshoe Bay overwhelms all else. However, the maritime industry and marine transport is invaluable to the pulp and paper operation in Howe Sound and to the forestry industry extending well beyond Howe Sound and B.C. The annual value of logs shipped out of Squamish through the Mamquam Blind Channel Port is about \$60 million, while the value of logs arriving from elsewhere on the coast to be handled in Squamish is \$40 million.⁶

The BC Ferries traffic, which makes up 72 percent of the large vessel traffic, is part of the Province's highway system and provides crucial transportation links between Horseshoe Bay, Bowen Island and the Sunshine Coast, with a terminal at each location (Figure 2). The remaining large vessel traffic includes Coast Guard and Department of Defense vessels, fishing vessels, the occasional cruise ship on a scenic loop around Bowen Island, tour boats and a few large yachts.⁵

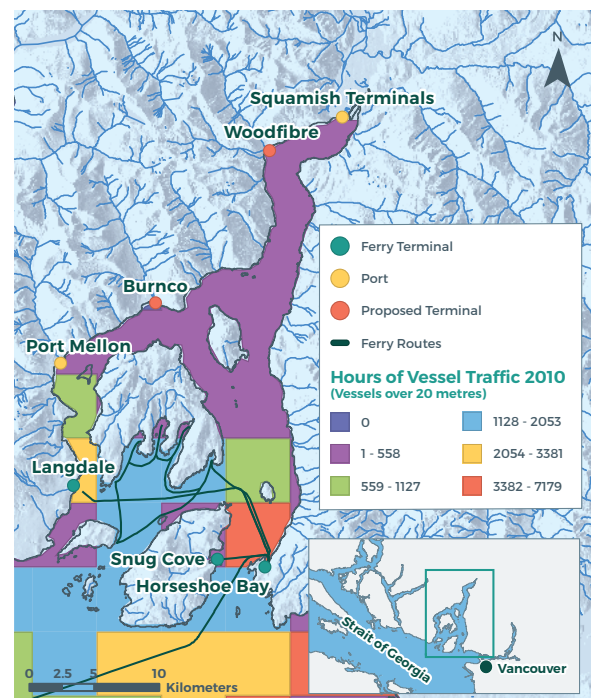


Figure 2. Terminals, ports and density of vessels over 20 metres in length, including government vessels, research vessels, passenger and cruise, fishing vessel traffic, tug and service vessel, shipping and transport vessels, in 2010. Facilities at Mamquam Blind Channel (Squamish) and Watts Point are missing from the map.

What is the current state?

Vessels over 20 metres in length are tracked by Marine Communications and Traffic Services (MCTS). None of the vessel trips that take place within Howe Sound without leaving Howe Sound (e.g., ferries between Horseshoe Bay and Snug Cove) would be included in the tally of vessels arriving to the Sound. Large vessels moving within Howe Sound are required to have an Automatic Identification System (AIS) transceiver that supplements marine radar and allows large vessels to track each other. The tracking systems allow overall vessel traffic densities to be calculated. Densities, mapped by the BCMCA using MCTS data from 2010, are highest in Queen Charlotte Channel between

Horseshoe Bay and Bowen Island as a result of all the ferry traffic in and out of Horseshoe Bay (Figure 2). The large vessel traffic density in this zone is up to 13 times greater than densities in most of northern Howe Sound.

Ports and landing facilities are an important component of maritime and large vessel operations. Land facilities in Howe Sound include ferry terminals at Horseshoe Bay, Snug Cove on Bowen Island and at Langdale on the Sunshine Coast, ports at Squamish Terminals, Port Mellon Pulp and Paper Mill and Mamquam Blind Channel, and log handling facilities



BC Ferry leaving Horseshoe Bay. (Photo: Jenn Burt)

at Watts Point, which is located across the fjord from Woodfibre (Table 1). The facilities at the Port Mellon Pulp and Paper Mill, Squamish's Mamquam Blind Channel (MBC), and Watts Point move largely wood products, while the deep-water break-bulk facility at Squamish Terminals handles pulp, lumber, steel and other cargo. Goods shipped to and from Squamish through the MBC port also include hydro equipment, construction materials and logging equipment. Vessel calls to each facility are tracked individually by facility and anticipated change is hard to estimate with any certainty. The forestry industry makes extensive use of the Mamquam Channel for log handling and in-bound timber volume is projected to increase in the future.

Two proposed industrial developments would require new facilities and would result in additional large vessel traffic. The Woodfibre LNG project proposes six to eight large vessel transits per month through Howe Sound along with associated support tugs (approximately 40 LNG carriers per year, two transits per carrier¹⁰) while the Burnco Aggregate project could contribute up to 34 transits per month (320 movements per year) of tugs and barges,¹¹ based on projected volumes of gravel to be removed. It is uncertain if the vessel routes used by these two projects would necessarily overlap, but if both used Queen Charlotte Channel between Horseshoe Bay and Bowen Island, large vessel transits in this area could increase by nearly 50 percent.¹²

In addition to the LNG tankers that operations at Woodfibre LNG would require, water taxis would be used to ferry workers to the site from Darrell Bay and Squamish. This would likely involve two ferries per day. Currently water taxi services throughout Howe

Sound are provided by Mercury Transport, out of Horseshoe Bay, Cormorant Marine, whose home port is Snug Cove on Bowen Island, and Sunshine Coast Water Taxi, based in Gibsons. Services provided by these three operators vary but overall they include passenger and freight service, crew boats, charters and tours, emergency response, barging and towing. Vessels used for these services are smaller than 20 metres in length and water taxis hold up to 42 passengers, but Cormorant Marine can carry 90 passengers.

Finally, several projects in the conceptual design stage, prior to submission of a formal proposal, may also increase large vessel traffic in Howe Sound. These include the possibility of solid waste export by barge from the Squamish-Lillooet Regional District, export of chips by barge from MBC, export of aggregate by barge from Watts Point, and a ferry from the Squamish Oceanfront Development.¹³ These activities may or may not come to fruition.



Large bulk carrier at Squamish Terminals. (Photo: Bob Turner)



Watts Point (Photo: Bob Turner)

TABLE 1. LAND FACILITIES AROUND HOWE SOUND, NUMBER OF LARGE VESSELS CALLING TO EACH IN 2015, AND ANTICIPATED CHANGE.

LAND FACILITIES	LARGE VESSEL CALLS (2015)	ANTICIPATED CHANGE
Squamish Terminals	78	Unknown; currently at 60% capacity
Port Mellon Pulp and Paper Mill	50	Unknown
Watts Point	Unknown	Unknown
Mamquam Blind Channel	Unknown	Increase in inbound timber is expected
Horseshoe Bay Ferry Terminal	11,003	Unknown
Langdale Ferry Terminal	2,945	Unknown
Snug Cove Ferry Terminal	5,335	Unknown
Proposed Woodfibre LNG	0	+40
Proposed BURNCO	0	+320

Sources: Squamish Terminals⁷, BC Ferry Services Inc 2016⁸, participants at the Howe Sound Socio-Economic Knowledge Workshop, June 17, 2016⁹

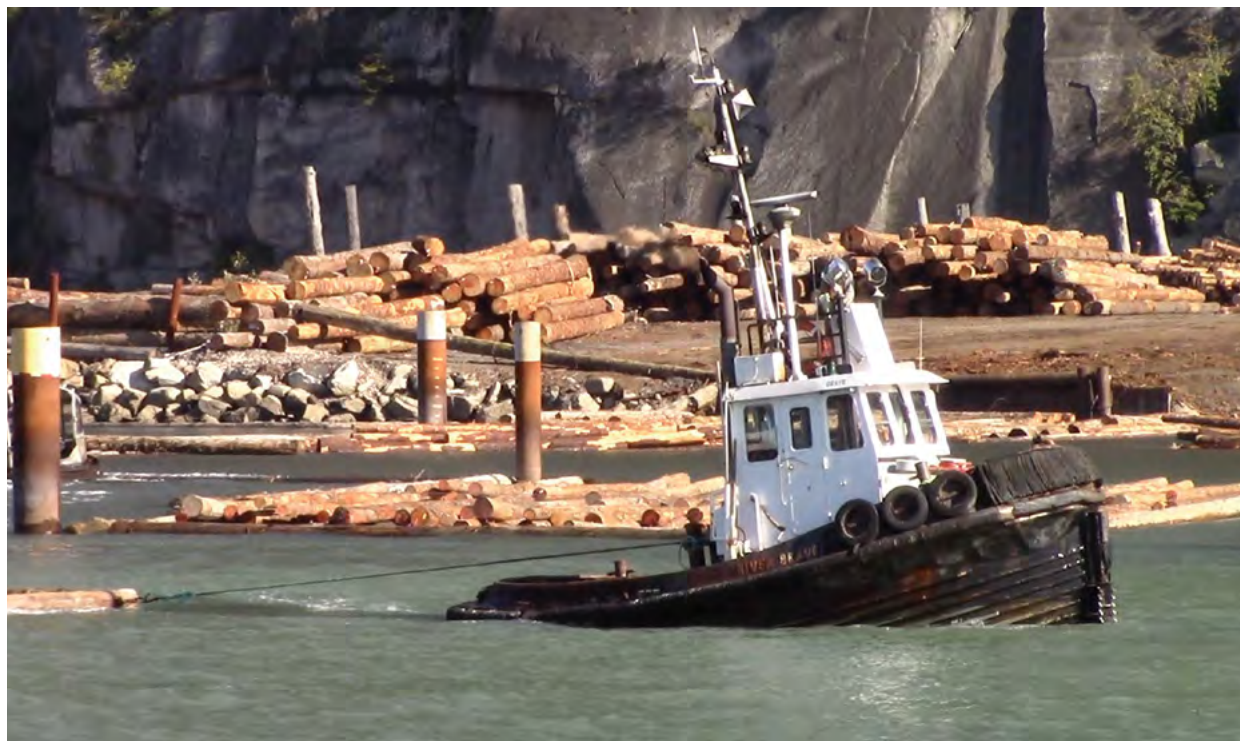
What are the benefits and risks associated with increasing vessel traffic?

The benefits of using the water, rather than roads, to transport goods are significant. One barge is equal to 60–80 tractor trailer loads with benefits ranging from safety of transport, reduced impact on air quality, to reduced fuel consumption and greenhouse gas emissions. Further, trail line towing of logs (i.e., a tug towing a line of boomed logs) can replace up to 200 logging trucks.

With population increases, ferry service increases would be necessary to maintain current standards, but

no increases are currently envisioned.¹⁴ In the same manner, increased economic activity in the Sound, or in the forestry industry that uses Howe Sound for transport, might require increased marine transport of goods.

Vessel traffic can negatively affect marine life in a variety of ways. Large vessels may cause a harmful or fatal strike to whales and other marine mammals^{15,16,17} that are known to frequent the Howe Sound area (see cetaceans article). As large vessel transits increase



Blind channel log sort in Squamish. (Photo: Bob Turner)

and whales frequenting the area increase, the risk of harmful or fatal strikes increases.

Pollution from vessels can be detrimental to marine life and comes in several forms including underwater noise pollution,¹⁸ air pollution, and water pollution. Many of the threats to the marine environment that can be caused by vessels of all sizes are actually illegal in Howe Sound. These include discharges of bilge water, grey water, and sewage release, which can lead to contamination, health hazards to humans and marine life, and introduced species.¹⁹ More vessel traffic means a higher risk of oil spills, which can have severe impacts on marine environments.²⁰ Finally, while vessels do impact nearshore habitats through waves and erosion, propeller contact, increased turbidity, and physical disturbance of marine plants and animals,²¹ this mostly applies to smaller vessels. If a large vessel is traveling faster than it should by regulation, waves and erosion may be an issue.

Many of the impacts can be avoided or mitigated, but an increase in large vessel traffic does pose some additional risk to the health of the marine environment. To accommodate large vessels at new terminals or ports, the infrastructure often requires dredging which causes significant disturbance of habitat in the



Coast Guard vessel. (Photo: Ruth Simons)

area of dredging and at the dump site. In addition, conflict over marine space may become intensified as increasing numbers of small recreational vessels and large commercial vessels occupy the same marine areas. Finally, some feel that large vessel traffic, presumably industrial, takes away from the picturesque quality of the Sound that is increasingly attractive to the film industry.

It should be noted that impacts from increasing vessel traffic are not understood well enough currently to set healthy thresholds or even to predict how impacts from several sources combined might differ. Cumulative effects assessment is a growing field of study.

Risks of increased vessel traffic

35 large vessels enter
Howe Sound every
day, on average



Illegally introduced
pollutants & contaminants
from bilge water, grey
water or sewage release



Conflict between large
vessels & smaller
recreational vessels



Air pollution



Marine emergency
response capacity
is limited within
Howe Sound



Higher risk of
fuel & oil spills



Dredging for ports
disturbs nearshore
habitats and disrupts
ecosystem processes



Cumulative effects of
increasing vessel traffic
not well understood



Underwater noise
impacts fish &
marine mammals



Risk of harmful or
fatal strikes to
marine mammals



Altered marine
circulation patterns
from port infrastructure



Propeller contact
increases turbidity
& damages sensitive
nearshore habitats

Vessel wake causes
shoreline erosion

Ancient and modern Squamish Nation travel by canoe



Photo: Gary Fiegehen. Reproduced with permission from “Where Rivers, Mountains, and People Meet,” Squamish Lil’wat Cultural Centre

Canoeing through *Atl’kítsem Texwnéwets’* (Howe Sound). During modern-day ocean-canoe journeys, Squamish canoe paddlers take their songs — representing the natural rhythms of the land in harmony with all of creation — to other First Nations to share in the richness of West Coast traditions.

What is being done?

The maritime industry is well regulated through international law and by multiple federal laws.²² Several recent initiatives will serve to improve monitoring and reduce risks and impacts of shipping. The Canadian Coast Guard is modernizing its infrastructure to increase effectiveness and reliability. The ECHO program (Enhancing Cetacean Habitat and Observation), a Port Metro Vancouver led initiative, is aimed at better understanding and managing the impact of shipping activities, including underwater noise, on at-risk whales throughout the southern coast of British Columbia. The long-term goal of the program is to develop mitigation measures that will reduce potential threats to whales that result from shipping activities. Not a recent initiative but crucial to safe shipping, the Pacific Pilotage Authority is mandated to provide safe, reliable and efficient marine pilotage and related services in the coastal waters of British Columbia. Howe Sound is within the mandatory pilotage area of the B.C. coast meaning that ships over 350 gross tons are required to have a local pilot on board before they even enter Howe Sound.²³

Other organizations involved in the shipping industry in Canada's Pacific include the B.C. Chamber of Shipping, which represents and advocates for the marine industry on Canada's west coast, and Clear Seas, an independent, not-for-profit organization that provides impartial and evidence-based research about marine shipping in Canada, including risks, mitigation measures and best practices. Clear Seas' vision for safe and sustainable shipping encompasses environmental, social and economic impacts of the shipping industry.²⁴

Within Howe Sound, the District of Squamish is in the process of developing a Marine Action Strategy.²⁵ The process is designed to mobilize shared leadership and the Strategy is intended to guide decision making on local waterfront/marine issue and opportunities.



In the long ago, Squamish people were known to travel by canoe to Alaska, Hawaii, California, and South America. Today canoe racing is a popular sport. (Photo: Gary Fiegehen)

What can you do?



Individual and Organization Actions:

- Reduce your consumption of goods to reduce your footprint and the need for shipping.
- Educate yourself on the pattern, trend and function of large vessel traffic in Howe Sound, and any potential threats.
- If on a large vessel or transiting near large vessels, ensure you are familiar with best practices for transiting by wildlife, response to pollution, and emergency response.
- If you operate a large vessel terminal, keep the area clean and free from oil and other pollutants that can contaminate the nearby marine environment.



Government Actions and Policy:

- Provide large vessel operators/pilots with on-board cetacean resources that include the distribution of species in the area, and how to safely transit when cetaceans are observed (e.g., The Mariner's Guide to Whales, Dolphins and Porpoises of B.C.)
- Continue to support and grow the Marine Mammal Response Network to offer guidance on what to do in the event that a cetacean is struck by a vessel, or observed in distress.
- Create an alert system to notify large vessel operators via AIS when cetaceans are observed in the area (e.g., using real-time verified reports from the B.C. Cetacean Sightings Network, or a similar data source).
- Empower local communities by ensuring they are educated on the proper action in the event of an oil spill. Provide the required resources for these communities to safely respond and assist in the event of a spill.
- Ensure proposed developments have a thorough public consultation period, and ensure Citizen Science data and citizen scientists are consulted extensively for all development decisions.
- Increase monitoring of marine pollution produced from large vessels, and enforce penalties for preventable pollution.
- Monitor and enforce safe condition of vessels transiting the coast in addition to vessels coming from elsewhere.
- Create and enforce a mandatory safe-distance for vessels from marine mammals.
- Explore the possibility of implementing a Traffic Separation Scheme in Howe Sound.
- Incentivize slower transits within Howe Sound and the Vancouver area to aid environmental protection (by decreasing emissions, whale ship strike risk, and noise pollution).
- Explore the need for a policy related to shipping activities in the vicinity of sensitive marine habitats (e.g., productive estuaries).

Acknowledgements

This report draws in part on a 2016 report “Socio-Economic Baseline of the Howe Sound Area” by Lions Gate Consulting, commissioned by the David Suzuki Foundation. We would like to acknowledge contributions made at a Howe Sound Socio-Economic Knowledge Workshop held June 17, 2016 at the Vancouver Aquarium. Participants at a “Large Vessel Traffic” discussion table shared knowledge which has been in-

corporated into this article. Participants included Greg Peterson, BC Ferries, Erik Toren, Mercury Transport, Eric Anderson, Squamish and District Forestry Association, Lara Taylor, Hemmera, representing Woodfibre LNG, Sudhir Lamba, Howe Sound Pulp and Paper, Kim Stegeman-Lowe and Emma Jarrett, Squamish Terminals.

Resources

Squamish Terminals

sqterminals.com/

District of Squamish Marine Action Strategy

squamish.ca/yourgovernment/projects-and-initiatives/marinestrategy/

BC Ferries

bcferries.com/

Burnco Aggregates

burnco.com/aggregate/aggregate-overview/

Port Mellon Pulp and Paper Mill

hspp.ca/

Woodfibre LNG

woodfibrelng.ca/

Woodfibre LNG Application for an Environmental Assessment Certificate

a100.gov.bc.ca/appsdata/epic/html/deploy/epic_document_408_38525.html

Port Metro Vancouver ECHO program summary

portvancouver.com/wp-content/uploads/2015/10/2015-10-22-ECHO-Program-One-Pager-with-Recognition-of-Collaborators-FINAL.pdf

Transport Canada

canada.ca/en/transport-canada.html

Pacific Pilotage Authority

ppa.gc.ca/text/index-e.html

Clear Seas Organisation

clearseas.org/

BC Chamber of Shipping

cosbc.ca/index.php/home

An Advocacy Site by BC Chamber of Shipping

safeshippingbc.ca/

Footnotes

¹ Please see acknowledgements for a list of participants.

² We use this definition because movements of ships this size are tracked by the Canadian Coast Guard often using an Automatic Identification System (AIS).

³ Canadian Coast Guard data presented in: Lions Gate Consulting. 2016. Socio-Economic Baseline of Howe Sound Area. Prepared for David Suzuki Foundation, May 30, 2016. 31p

⁴ Anderson, Eric. Personal Communication at the June 17, 2014 workshop.

⁵ Lions Gate Consulting. 2016. Socio-Economic Baseline of Howe Sound Area. Prepared for David Suzuki Foundation, May 30, 2016. 31p.

⁶ Anderson, Eric. 2016. Mamquam Blind Channel Port/Industrial Waterway, Squamish Marine Services Ltd. Information provided to the Howe Sound Socio-economic Forum, June 17, 2016.

⁷ Yeo, Erin, Manager, Administration & Traffic, Squamish Terminals, personal communication, Feb. 10, 2016

⁸ British Columbia Ferry Services Inc. 2016. 2003 BC Ferries Services Inc/The Province of British Columbia Unofficial Contract (Amended April 2016). http://www.bcferries.com/files/AboutBCF/CFSC_-_Unofficial_Consolidation_Contract.pdf

⁹ See footnote 1.

¹⁰ WoodfibreLNG Limited. 2015. Application for Environmental Assessment Certificate, Section 7.3 Marine Transport. https://a100.gov.bc.ca/appsdata/epic/documents/p408/d38525/1421092736668_KQOVJoPJSg1cH9LDD8L1JoCQhQw7NgD32kZQsVPHsxWNdyq1qCg13783384551421086505978.pdf Accessed June 10, 2016.

¹¹ Confirmed at the June 17 2016 workshop.

¹² WoodfibreLNG Application for EAC reports 843 annual transits currently; and increase of 80 LNG tanker transits plus 320 aggregate barge transits represents an additional 400 transits or an increase of 48 percent of current volume.

¹³ These possibilities were shared at the Howe Sound Socio-Economic Knowledge Workshop, June 17, 2016.

¹⁴ In 2016, the Province announced that work was underway on a feasibility study for a highway connection to the Sunshine Coast, including potential routes through Howe Sound. A highway would reduce the ferry traffic in the Sound.

¹⁵ Ware, K. 2009. Assessment of the impacts of shipping on the marine environment. OSPAR Commission.

¹⁶ Jensen A.S. and G.K. Silber. 2004. Large Whale Ship Strike Database. In: Commerce USDo, Administration NOAA, Service NMF (eds), Silver Springs, Maryland.

¹⁷ Laist D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17: 35-75.

¹⁸ Hildebrand, J. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecological Progress Series 395: 5-20.

¹⁹ Bax, N., A. Williamson, M. Agüero, E. Gonzalez, and W. Geeves. 2003. Marine invasive alien species: a threat to global biodiversity. Marine Policy 27(4): 313-323.

²⁰ Ware 2009.

²¹ Johnson, R.J., C. Boelke, L.A. Chiarella, P.D. Colosi, K. Greene, K. Lellis-Dibble, H. Ludemann, M. Ludwig, S. McDermott, J. Ortiz, D. Rusanowsky, M. Scott, and J. Smith. 2008. NOAA Technical Memorandum NMFS-NE-209 Impacts to Marine Fisheries Habitat from Nonfishing Activities in the Northeastern United States, Chapter 5: Marine Transportation. <http://www.nefsc.noaa.gov/publications/tm/tm209/pdfs/ch5.pdf>

²² For example see the Wheel of Maritime Law at <http://clearseas.org/publications-library/>

²³ BCMCA. 2011. Shipping and Transport – Compulsory Pilotage Areas. Accessed Oct 18, 2016. http://bcmca.ca/datafiles/individualfiles/bcmca_hu_shippingtrans_pilotageareas_atlas.pdf

²⁴ <http://clearseas.org/>

²⁵ District of Squamish. 2016. Marine Action Strategy. Accessed Oct 18, 2016. <http://squamish.ca/yourgovernment/projects-and-initiatives/marinestrategy/>

Tourism and recreation: new attractions and growing participation

“The ecosystem service of recreation and tourism refers to the ability of natural areas to attract people to engage in recreational activities, often leading to increased property values and attractiveness for business. Tourism and recreation are related to, but not totally encompassed by, aesthetic values. ... We calculated the total value of aesthetic and recreational services in the study area to range from approximately \$100 million to \$3 billion per year.”

FROM SOUND INVESTMENT: MEASURING THE RETURN ON HOWE SOUND'S ECOSYSTEM ASSETS
(MICHELLE MOLNAR, 2015, DAVID SUZUKI FOUNDATION)

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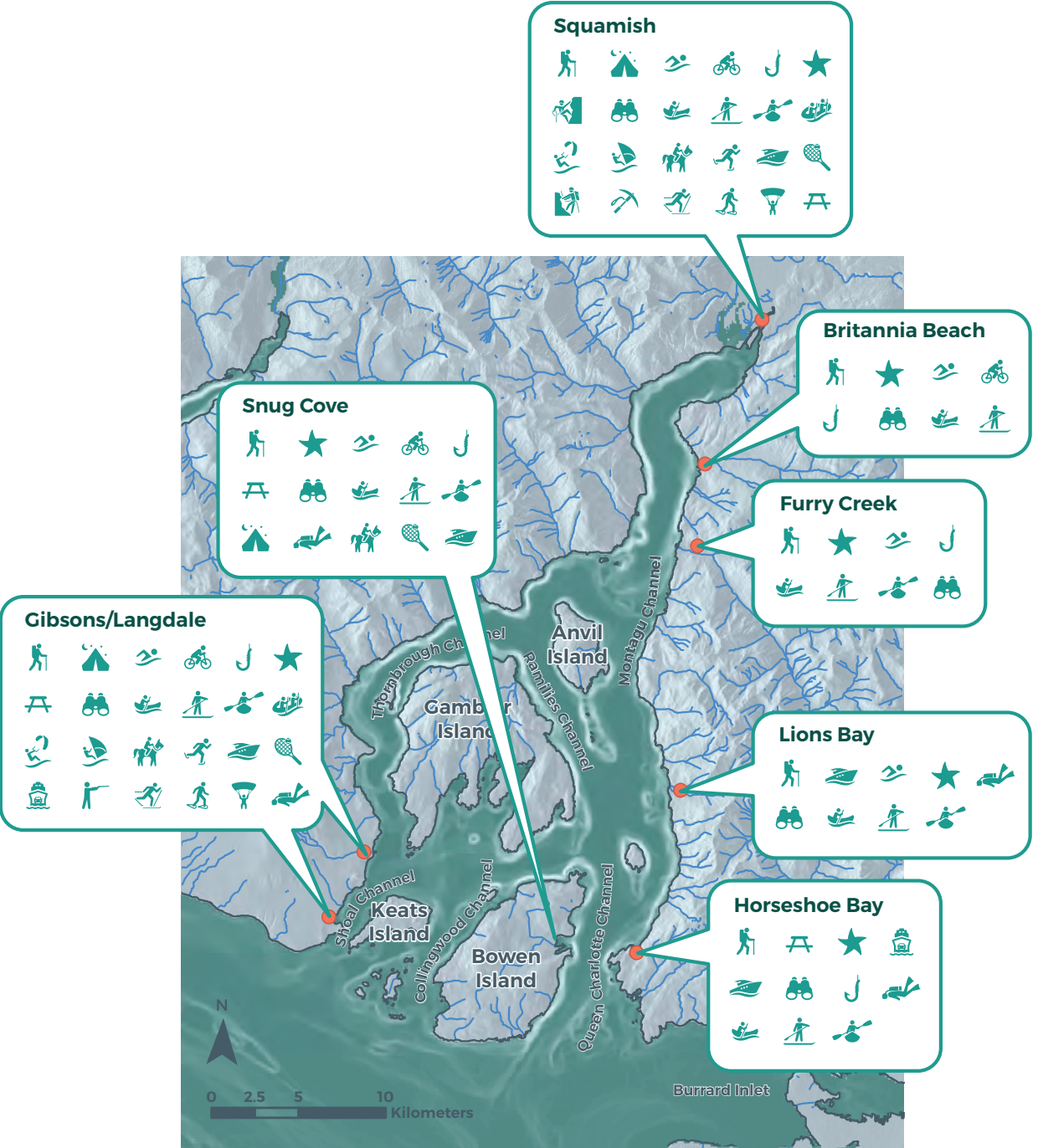
What is happening with tourism and recreation in Howe Sound?

**“An unusual combination of West Coast wilderness
and accessibility”**

NEW YORK TIMES²

Squamish made the New York Times travel section in 2015 as a “place to go.” Tourism has surged recently along the Sea to Sky highway corridor, fueled by an upgrade to Highway 99 and international attention brought by the 2010 Olympics. Marine recreation is growing with a trend toward multiple activities in a single outing (e.g., kayaking and hiking, or rock climbing and wind surfing). For example, visitation to B.C. Parks in Howe Sound grew to over two million in 2014–2015, a 48-percent increase compared to average vis-

Examples of tourism & recreation from community access points



itation prior to 2010 (Figure 1). There are several new attractions that are partly responsible for increased tourism and recreation. The Sea to Sky Gondola near Squamish opened in 2014, and drew about 300,000 people in the first year.³ In 2015, the Sea to Sky Marine Trail for kayakers was officially opened with six new campsites, and a new scuba diving destination in Halkett Bay Marine Park was created. An example of new tourism synergy is the Land and Sea Bus tour from Vancouver that links Sewell's Sea Safari, via rigid hull inflatable boats, from Horseshoe Bay to Britannia with bus connections to tours of Shannon Falls, Sea to Sky Gondola, and Britannia Mine Museum before returning by bus down Highway 99.

Recent announcements suggest this tourism and recreation upswing will continue into the future. In January 2016, the provincial government granted an environmental assessment certificate for the pro-

posed Garibaldi and Squamish all season ski resort on Brohm Ridge, 15 kilometres north of Squamish.⁴ In February 2016, the District of Squamish announced an oceanfront residential and commercial development that will provide Squamish with an enhanced connection to the Howe Sound marine environment with a waterfront park and walks, wind sports beach, boat launches, and sailing center.⁵ In May 2016, a proposal for a 14-hectare waterfront resort with lodge across Highway 99 from Shannon Falls was announced.⁶

In 2016, the Province announced that work was underway on a feasibility study for a highway connection to the Sunshine Coast, including potential routes through Howe Sound.⁸ It is hard to overstate the potential impacts on tourism and recreation activities (and more broadly on future development and the environment) if a new highway transportation corridor were established through Howe Sound.

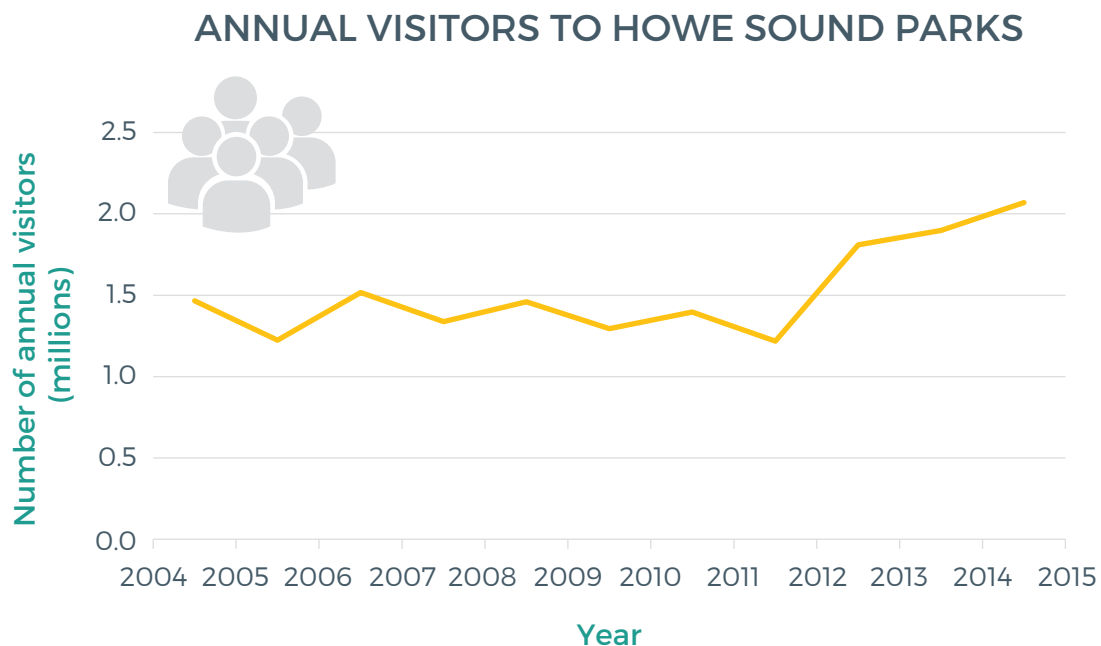


Figure 1: Annual visitation in B.C. Parks in the Howe Sound region, 2004-05 to 2014-15⁷.

Why are tourism and recreation important to Howe Sound?

“Tourism in Howe Sound is intimately tied to the quality of life in Howe Sound. Quality of life is why people want to live here, and why people want to visit. Tourism allows more people to connect to Howe Sound, both tourists and local recreationalists.”

TREVOR DUNN, SEA TO SKY GONDOLA, JUNE 2016⁹

Tourism supports an important and growing component of the Howe Sound economy. Over the past three decades, there has been a marked shift from the forestry and industrial sector to services and tourism.¹⁰ While the economic value of tourism is acknowledged and documented by the Province, the economic value of recreation, which is often self-guided, is not. Quantifying the value of tourism and recreation that takes place in Howe Sound is fraught with challenges. Many small operators are involved, including some located outside of Howe Sound but who use it as a destination (e.g., whale watching tours or fishing charters that originate in Greater Vancouver).

In 2014, tourism to the Province of B.C. contributed more to provincial gross domestic product (GDP) than the forestry and agriculture and fish primary resource industries, but less than the mining, oil and gas extraction industry.¹¹ Provincial tourism revenue was up 38 percent between 2004 and 2014,¹² and tourism sector employment has grown 17.6 percent since 2003. A study on the economic benefits of Provincial Parks showed that every dollar invested in the protected areas system generates \$8.42 in visitor spending on food, entertainment, transportation and other goods and services.¹³ While these statistics illustrate

the growth and value of tourism and recreation, they are not specific to Howe Sound.

Visitation data¹⁴ compiled by Destination BC for 2012 reveals that the Vancouver, Coast and Mountains Region received 8.2 million overnight person-visits which generated \$4.7 billion in related spending. This accounts for 43 percent of provincial overnight visits and 57 percent of related spending province-wide. Interestingly these overnight travellers who came primarily from B.C., Washington and Alberta took part in a number of outdoor activities during their trip, including visiting provincial parks, hiking/backpacking, visiting a beach, and camping. These are some of the many attractions of Howe Sound. Same-day travel-



Sewell's Sea Safari provides visitors access to the rich marine wildlife in Howe Sound. (Photo: Jessica Heydahl)



The Sea to Sky Gondola creates new access to the mountain country above the east side of Howe Sound. (Photo: Bob Turner)

lers accounted for 49 percent of visitor volume, which means that the region had about 8 million visitors that did not stay overnight. These visitors likely did not venture to Whistler, but may have visited Howe Sound.

Tourism and recreation have great social value to Howe Sound. Tourism supports local events, jobs, infrastructure and attractions that enhance the quality of life of residents of the Howe Sound community. This is true of services and events such as restaurants, ecotourism operators, and summer festivals for the arts, as well as built infrastructure such as marinas and the Sea to Sky Gondola.

Similarly, outdoor recreation exposes the grandeur of place. Workshop participants¹⁵ from recreation organizations felt strongly that recreation was more than entertainment; it makes people fall in love with the place and want to care for it. Tourism and recreation opportunities can be used to raise awareness about current issues, conflicts, and sustainability challenges. The benefits range from improved personal wellbeing from being outdoors, and possibly physical activity, to the economic contributions; some of which flow directly to tourism providers and outfitters, while some flow indirectly to hotels, restaurants, and the service industry.

Is there an important tourism connection to First Nations?

Aboriginal cultures are a major draw for tourism in B.C.¹⁶ Aboriginal Tourism BC¹⁷ fosters First Nations tourism and provides access to aboriginal cultural events, services, and accommodations. Capacity building within Aboriginal tourism is provided regionally by the Native Education College in Vancouver.¹⁸ Within Howe Sound, the most accessible link to Indigenous cultures is the Cultural Journey along the Sea to Sky Highway between Horseshoe Bay and Whistler.¹⁹

A series of seven roadside kiosks tell the story of Squamish and Líl'wat First Nations, their traditional land use, place names, and supernatural beings. This Cultural Journey connects with the Squamish Líl'wat Cultural Centre in Whistler where visitors engage with Indigenous culture through demonstrations, exhibits, and film. First Nations seek to generate awareness, interest and activity in aboriginal cultural tourism.²⁰



The Cultural Journey kiosks along the Sea to Sky Highway have distinctive roofs in the shape of traditional woven cedar-bark hats. (Photo: B. Turner).



Photo: Vancouver Aquarium

“I will never forget one day, I asked the late Harry Moody how to shape a racing canoe. He said to me, “What is the fastest fish?” I jokingly said a bullhead. “No,” he said, “A sockeye salmon. You have to shape your canoe like a sockeye.”

SXAYILKIN SIYÁM (CHIEF CEDRIC BILLY), SQUAMISH NATION²¹

What is the current state?

“The Sea to Sky corridor as a marketable concept is something that didn’t exist 20 years ago but which, because the 2010 Winter Olympics especially, and the combined effects of the development and marketing of many different experiences locally, has emerged as a destination in and of itself.”

STEVE NICOL, LIONS GATE CONSULTING

Increasing volumes of visitors and recreationists, increasing demand for access to the marine environment and land-based recreational activities, limited existing access, and limited capacity to deal with the growing demand typify the current state in Howe Sound. Tourist activities are mainly accessible along Highway 99, from population centers around the Sound, and from the Lower Mainland. Highway 99 provides access to five popular provincial parks, Furry Creek golf course, and the Sea to Sky Gondola and Britannia Mine Museum. Major Vancouver-based operators provide a variety of bus tours along Highway 99. Whale watching operators out of Vancouver and Richmond increased their visits to Howe Sound in 2015 and 2016 drawn by an increase in sightings of transient orcas. In addition, some cruise ship passengers get an introduction to Howe Sound through an interpretation program on board, as they pass by or cruise around Bowen Island to take advantage of scenery.

In 2015, over 7 million passengers and 2.7 million vehicles passed through the Horseshoe Bay ferry terminal on their way to or from Vancouver Island, the Sunshine Coast, and Bowen Island.²² Horseshoe Bay,

Sunset Marina and Lion’s Bay marina are the major nodes for water taxi service to the islands of Howe Sound. Sewell’s Marina at Horseshoe Bay provides moorage and boat rentals, and marine ecotourism through its Sea Safari Eco Tours. Over the last two decades these tours have grown an international clientele, drawn by the opportunity to see eagles, seals, sea ducks, dolphins and whales close to Vancouver. Horseshoe Bay is also a center for fishing and sailing charters, and dive boats. Saltwater fishing has had steady growth since 2010. In 2015, more than 9,000 angler days landed over 8,500 fish in Howe Sound, of which over three quarters were salmon.²³

Howe Sound’s Provincial and municipal parks draw both tourists and recreationists. Visits to Howe Sound parks and protected areas in 2014–15 exceeded 2.3 million (Table 1). Boating of all kinds is popular in Howe Sound with no fewer than 17 marinas and yacht club stations in Howe Sound (Table 2).

TABLE 1: MAJOR PARKS AND PROTECTED AREAS IN HOWE SOUND.²⁴

NAME	LOCATION	MARINE COMPONENT?	ACTIVITIES	VISITATION (2014-15)	SIZE (HA)
Lighthouse Park, West Vancouver	Shoreline, West Vancouver	Yes	  	n/a	75
Whytecliffe Park, West Vancouver	Shoreline, West Vancouver	Yes	    	n/a	16
Horseshoe Bay Park	Shoreline, West Vancouver	Yes	  	n/a	1
Porteau Cove Provincial Park	Shoreline, Highway 99	Yes	             	524,863	56
Murrin Lake Provincial Park	Britannia	No	    	228,291	24
Shannon Falls Provincial Park	Squamish	No	   	485,091	87
Stawamus Chief Provincial Park	Squamish	No	    	339,359	530
Brackendale Eagles Provincial Park	Squamish	No	   	n/a	755
Skwelwil'em Squamish Estuary Wildlife Management Area	Squamish	Yes	      	n/a	673
Alice Lake Provincial Park	Squamish	No	       	474,606	411
Brohm Lake Interpretive Forest	Squamish	No	    	n/a	400
Crippen Regional Park	Bowen Island	Yes	     	281,000	
Plumper Cove Marine Provincial Park	Keats Island	Yes	       	16,659	66
Halkett Bay Marine Provincial Park	Gambier Island	Yes	         	45	309
Tantalus Provincial Park	Squamish	No	       	n/a	11,351
Garibaldi Provincial Park	Squamish	No	        	96,880	194,676

ACTIVITIES LEGEND



BACK COUNTRY SKIING



BEACH COMBING



BIKING



BOAT LAUNCHING



CAMPING



CANOEING



FERRY WATCHING



FISHING



HIKING



HORSE RIDING



HUNTING



ICE CLIMBING



ICE SKATING



KITESURFING



MOUNTAINEERING



PARAGLIDING



PICNICKING



RIVER RAFTING



ROCK CLIMBING



SCUBA DIVING



SEA KAYAKING



SNOWSHOEING



STAND-UP PADDLE BOARDING



SWIMMING



TENNIS



WILDLIFE VIEWING



WINDSURFING

Squamish was self-titled the “Outdoor Recreation Capital of Canada” but that tagline was changed in 2014 to “Hard-wired for Adventure” following an extensive branding process.²⁵ Nevertheless, Squamish, surrounded by accessible year-round mountain, valley, river and ocean recreation opportunities, is the northern Howe Sound hub for these activities. Squamish’s eco-tourism is built around mountain biking, rock climbing, wind sports, hiking, fishing and water sports, as well as outdoor festivals and events.

The Sea to Sky Gondola with its high elevation lodge, sweeping views of Howe Sound, interpretive trails, backcountry access and events has quickly become a major attraction in Howe Sound. The Britannia Mine Museum, with a major expansion completed in 2010, showcases mining, the historic mine life, and current environmental remediation. In 2015, attendance was approximately 74,000 and admission revenues were \$1 million, a threefold increase over 2010.²⁶

TABLE 2: MARINAS AND YACHT CLUB STATIONS IN HOWE SOUND

NAME	LOCATION	SERVICES
Sewells Marina	Horseshoe Bay, West Vancouver	moorage, boat rental, fishing charters, Sea Safari tours, fuel
Thunderbird Marina	Fisherman's Cove, West Vancouver	moorage, storage, haulout, repairs
Eagle Harbour Yacht Club	Eagle Harbour, West Vancouver	moorage, sailing program
West Vancouver Yacht Club	Fisherman's Cove, West Vancouver	
Sunset Marina	Sunset Beach, West Vancouver	moorage, boat storage, fuel, boat launch, boat repair
Lions Bay Marina	Lions Bay	dry storage and launch, fuel, supplies, overnight dockage
Union Steamship Marina	Snug Cove, Bowen Island	moorage, accommodations, supplies
Bowen Island Marina	Snug Cove, Bowen Island	moorage
Snug Cove Public Dock	Snug Cove, Bowen Island	moorage
Thunderbird Yacht Club	Ekins Point, Gambier Island	outstation, seasonal moorage
Burrard Yacht Club	Ekins Point, Gambier Island	outstation, seasonal moorage
Royal Vancouver Yacht Club	Centre Bay, Gambier Island	outstation, seasonal moorage
West Vancouver Yacht Club	Centre Bay, Gambier Island	outstation, seasonal moorage
Gibsons Marina	Gibsons	moorage, fuel
Gibsons Landing Harbour Authority	Gibsons	moorage
Harbour Authority of Squamish	Squamish	moorage
Squamish Yacht Club	Squamish	moorage, sailing program

Away from the Highway 99 corridor, recreation and tourism in Howe Sound is more dispersed. Ferries connect to the Sunshine Coast and Bowen Island, and water taxis to the various islands. Gibsons and Bowen Island have sizeable clusters of tourist accommodations, services, and events. Eleven summer and youth camps on the islands of Howe Sound and Sunshine Coast host thousands of children annually ([see Outdoor Learning article](#)). Additional activities that take place in Howe Sound include scuba diving by shore and boat access, stand-up paddle boarding, road cycling and mountain biking, golfing, and even stargazing away from the light pollution of Vancouver.

Tourism operators and recreation association representatives discussed a number of challenges related to the increased demand for and participation in these activities in Howe Sound:

- Access to the ocean in Howe Sound is limited by insufficient access points. Further, limited shore facilities, marinas and boating amenities and overcrowding of available sites constrains tourism and recreation growth. The rugged shores of Howe Sound, limited public shoreline, and a shortage of marina berth space all contribute to the problem. The limited number and types of access points also leads to conflict and competition among users and to conflict between users and private land owners.
- Increasing private ownership of recreational property along the shorelines can discourage public recreational use of the foreshore and/or lead to conflicts.
- The very activities that bring visitors closer to the environment and introduce a stewardship ethic to many can also have negative impacts on the marine and terrestrial ecosystems, especially when participation exceeds carrying capacity.²⁷ Problems and impacts noted include misuse/overuse of Ministry of Forests recreation sites, unlicensed use of boats and ignorance of best practices, unlicensed fishing and poaching, lack of enforcement of existing regulations, untenured docks and foreshore structures, damage to sensitive intertidal zones by dragging surf boards, kayaks and other boats, oil and fuel spills and unregulated sewage discharge around marinas, disturbance of marine wildlife, and the introduction of invasive species.
- People working in the tourism and recreation industries increasingly struggle to find affordable housing in the area.
- Marine emergency response capacity is limited within the Sound.
- There is no cohesion in terms of policy that is comprehensive to the Sound. Each jurisdiction makes its own rules that may differ from the neighbouring jurisdiction.

Marine mammals are particularly vulnerable to tourism pressures. A number of Bowen Islanders have expressed concerns that boats observing orcas along its shores in 2015 and 2016 have not observed the 100 meter distance guidelines for whale watching (e.g., Figure 2). Given the early stages and rapid growth of marine-based tourism and recreation in Howe Sound, there is an opportunity for tourism operators to be leaders and educators regarding best practices, instilling a culture of stewardship among visitors and recreationists.



Figure 2: Commercial whale watching boats and orcas along the shores of Bowen Island. (Photo: Anonymous, April 9, 2015)

What is being done?

Tourism operators have noted that there is no business improvement association specifically for Howe Sound.²⁸ This may in part relate to the weak identification of Howe Sound as a marketing area, and the lack of an individual brand for Howe Sound. Instead, the North Shore (North and West Vancouver), Squamish, Bowen Island and the Sunshine Coast each have tourist organizations that promote local operators and events. And of course, tourism operators throughout Howe Sound promote tourism in Howe Sound through their individual entrepreneurship.

Greater recreational access to the marine environment is a challenging problem to solve, however proposed developments in both Horseshoe Bay and Squamish

promise greater access to marine recreation as a major selling point (e.g., Sewell's Landing and Oceanfront at Squamish). Access to high elevation areas including subalpine and alpine hiking southeast of Squamish was recently improved when the Sea to Sky Gondola began operation in 2014.

As far as getting a better sense of the growth of demand and participation, several organizations said they were hoping to put user count systems in place. Without better information on patterns of use and capacities it is hard to develop solutions.

Risks of increased numbers of visitors

48% increase in visitors to B.C. Parks in Howe Sound in 2014–2015 compared to before 2010



Loss of wilderness value



Increasing volume of visitors may exceed carrying capacity



Conflict between large vessels & smaller recreational vessels



Introduction of invasive species



Unlicensed use of boats & ignorance of best management practices



Increased traffic

Unlicensed fishing & poaching



Oil/fuel spills & sewage discharge pollutes water



Damage to sensitive intertidal areas by dragging boats



Hard for workers to find affordable housing in the area



Increased use of foreshore for recreation can lead to conflict with private property owners



Limited shore facilities & sites results in overcrowding

Increased demand for access for marine recreational activities



Untenured docks & foreshore structures damage sensitive habitats



Not observing minimum distance guidelines when viewing marine mammals

What can you do?



Individual and Organization Actions:

- Encourage your local marina to achieve a Blue Flag designation. In May 2016, Gibsons Marina received a Blue Flag environmental designation for its marina operations,²⁹ the first in Howe Sound. Blue Flag is a certification by the Foundation for Environmental Education that sets standards for marinas using criteria for water quality, safety, environmental education, and general environmental management.^{30,31}
- Encourage your marina to provide sanitary waste pump-out facilities. If you operate a marina, make these facilities available.
- Boaters can also fly the Blue Flag on their vessels by taking the Blue Flag Pledge of Conduct, available at the Gibsons Marina.
- Encourage your local municipality, regional district, or B.C. Park to achieve a Blue Flag designation for its beaches.³² A Blue Flag beach meets criteria for water quality, environmental management, environmental education, and safety and services. At present, no Howe Sound beaches have been designated.
- Protect marine mammals by adhering to guidelines.³³ Report violations of the Be Whale Wise Guidelines in Canada to Fisheries and Oceans Canada, 1-800-465-4336.
- Report whale and dolphin sightings to Wild Whales.³⁴ You can report by phone, your Wild Whales app on your smartphone, or at the online website. This database of sightings assists researchers in understanding whale and dolphin habitat in Howe Sound and the Salish Sea, and can provide advice to management of vessel traffic or other human activities.
- If you fish, obtain a fishing license. Be informed of fishing regulations and the location of no-fish Rockfish Conservation Areas. Report poaching at: Department of Fisheries and Oceans: Observe, Record, Report (ORR) Line, 1-800-465-4336; Province of B.C.: Report All Poachers and Polluters (RAPP), 1-877-952-7277
- Organizations and societies can keep track of club membership and use of recreational infrastructure or resources to ensure the growth in demand is documented.
- Educate yourself on safe boating practices. If you operate a boat, be sure you obtain your B.C. Boat License.



Government Actions and Policy:

- Survey existing docks and foreshore structures and enforce related tenure restrictions.
- Develop and publish a map of sensitive habitat where boat anchoring is prohibited.
- Identify and develop additional marine recreation sites and controlled/managed access points to help address increasing demand.
- Develop thresholds or limits for certain activities or areas, along with associated management and regulatory tools.
- Develop and promote regulations and guidelines for safe distances between boaters and other recreationists, wildlife, and sensitive habitats such as the small islets in Howe Sound.
- Maintain recreation infrastructure.
- Require sanitary waste pump-out facilities at more marinas and outstations.
- Rename “Crown land” to “public land” to acknowledge ownership and invite stewardship.
- Ministry of Forests, when planning forested areas to cut, account for the views of boaters on the water in the Sound, and hikers on mountain trails or at the gondola, in addition to viewpoints along Highway 99.
- Increase monitoring and enforcement on the water in Howe Sound.
- Support and encourage volunteer enforcement options including marine and river steward programs.
- Develop coastal management policy, legislation and regulations to manage recreational use of Crown lands and the foreshore and keep the benefits of recreation and tourism sustainable.

“Are there carrying capacity issues for tourism? Yes. However, if we don’t introduce people to these places, people won’t know about the land and sea and, collectively as a society, we won’t make balanced decisions.”

KIRBY BROWN, SEA TO SKY GONDOLA, JUNE 2016

Acknowledgements

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Gondola & Tourism Squamish, Greg Suidy, Sunshine Kayaking Ltd., Oydis Nickle, Bowen Island Tourism & Union Steamship Marina, Dennis Thomas, Takaya Tours and Willard Sparrow, Musqueam Nation. Participants in Marine Recreation included Joshua Viner, Squamish Windsports Society, Allen Wong, Director, Artificial Reefs Society of B.C., Alistair McCrone, Sea to Sky Regional District, Lisa Geddes, Executive Director, Boating BC Association, Mick Allen, Director, BC Marine Trails Network Association, Steve MacDonald, Council of BC Yacht Clubs, and Michael George, Tsleil-Waututh Nation.

Resources

Aboriginal Tourism BC
aboriginalbc.com

BC Parks
env.gov.bc.ca/bcparks

Britannia Mine Museum
britanniainemuseum.ca

Cultural Journey Map and Audio Tape
slcc.ca/experience/cultural-journey

Gibsons Tourism
gibsonsvisitorinfo.com

Native Education College
necvancouver.org

Sea to Sky Gondola
seatoskygondola.com

Squamish Tourism
exploresquamish.com

Sewell’s Marina
sewellsmarina.com

Sunshine Coast Tourism
sunshinecoastcanada.com

Vancouver’s North Shore Tourism Association
vancouvernorthshore.com/

Be Whale Wise Guidelines, Wild Whales B.C. Cetacean Sightings Network
wildwhales.org/watching-whales/whale-watching-guidelines/

Footnotes

¹ Please see acknowledgments for a list of workshop participants.

² New York Times. 2015. http://www.nytimes.com/interactive/2015/01/11/travel/52-places-to-go-in-2015.html?_r=0

³ T. Dunn, Managing Partner, Sea to Sky Gondola, personal communication, June 17, 2016.

⁴ BC Environmental Assessment Office. 2016. *In the matter of the Environmental Assessment Act S.B.C. 2002, c. 43 (Act) and In the matter of an Application for an Environmental Assessment Certificate (Application) by Garibaldi at Squamish Inc. (Proponent) for the Garibaldi at Squamish Resort Project (Project) Reasons for Ministers' Decision*. Accessed: May 28, 2016. https://a100.gov.bc.ca/appsdata/epic/documents/p404/1454111131687_v2DTWr5ZmpK1NhMGhFdJPN5gQDHS46qTj9bYsDwqf7sSxqdV-n2Yl-1856054728!1454111065584.pdf

⁵ Squamish Oceanfront. 2016. "Squamish Oceanfront lands deal is signed, sealed and set to deliver on a community dream." Accessed: May 28, 2016. <http://www.newportbeachsquashish.ca/uncategorized/squamish-oceanfront-lands-deal-is-signed-sealed-and-set-to-deliver-on-a-community-dream/>

⁶ Squamish Chief. 2016. "Klahanie Resort could break ground across from Shannon Falls in 2018." Accessed: May 28, 2016. <http://www.squamishchief.com/news/local-news/400-million-all-season-resort-in-works-1.2220168>

⁷ Parks included are Alice Lake Park, Halkett Bay Park, Murrin Park, Plumper Cove Marine Park, Porteau Cove Park, Shannon Falls Park, Stawamus Chief Park. Data from modified from Lions Gate Consulting, Steve Nicols, 2016 Table 3-6, with 2014-15 data from BC Parks, 2014/15 Statistics Report.

⁸ Ministry of Transportation and Infrastructure. 2016. "Sunshine Coast highway link study underway." Accessed May 28, 2016. https://archive.news.gov.bc.ca/releases/news_releases_2013-2017/2016TRAN0014-000138.htm

⁹ See acknowledgements.

¹⁰ Lions Gate Consulting. 2016. Socio-economic baseline of the Howe Sound area. For David Suzuki Foundation, 32 p.

¹¹ Destination British Columbia. 2016. "Value of Tourism 2014." Accessed Sept 21, 2016. http://www.destinationbc.ca/getattachment/Research/about-research-planning-and-evaluation/Future-Releases/Value-of-Tourism-2014-Snapshot_FINAL.pdf.aspx

¹² BC Government News. 2016. "Study shows strong tourism growth in last decade." Accessed Sept 21, 2016. <https://news.gov.bc.ca/releases/2016/TST0024-000209>

¹³ Province of B.C. 2016. BC Parks reports and surveys. Accessed Oct 16, 2016. <http://www.env.gov.bc.ca/bcparks/research/research.html> Data from: Canadian Parks Council. 2011. "Economic Impact of Canada's National, Provincial and Territorial Parks in 2009, Report Part 1." Accessed Oct 16, 2016. <http://www.parks-parcs.ca/english/cpc/economic.php>

¹⁴ Destination British Columbia. 2015. Vancouver, Coast and Mountains, Regional Tourism Profile. Accessed Sept 21, 2016. http://www.destinationbc.ca/getattachment/Research/Research-by-Region/vancouver-coast-and-mountains/RegionalProfiles_Vancouver-Coast-and-Mountains_2014.pdf.aspx

¹⁵ See acknowledgements

¹⁶ Mair, A. BC Business. July 3, 2012. The Rise of Aboriginal Tourism in BC. Accessed August 8, 2016. <http://www.bcbusiness.ca/tourism-culture/the-rise-of-aboriginal-tourism-in-bc>

¹⁷ Aboriginal Tourism BC. Accessed August 6, 2016. <https://www.aboriginalbc.com>

¹⁸ Native Education College. Accessed August 6, 2016. <http://www.necvancouver.org>

¹⁹ Squamish Lil'wat Cultural Centre. 2016. The Self-Guided Cultural Journey Route through the Squamish and Lil'wat First Nations. Accessed May 29, 2016. <http://slcc.ca/experience/cultural-journey/culturaljourney/>

²⁰ Squamish Lil'wat Cultural Centre. 2016.

²¹ Reproduced with permission from "Where Rivers, Mountains, and People Meet," Squamish Lil'wat Cultural Centre

²² BC Ferries. 2016. BC Ferries Traffic Statistics for April 2016. Accessed May 29, 2016. <http://www.bcferries.com/about/traffic.html>

²³ DFO data reported in Lions Gate Consulting, 2016.

²⁴ Source: BC Parks (2015). MetroVancouver (2016); www.env.gov.bc.ca/bcparks/; <http://www.metrovancouver.org/services/parks/parks-greenways-reserves/crippen-regional-park>

²⁵ District of Squamish. 2016. Accessed Oct 28, 2016. <http://squamish.ca/yourgovernment/projects-and-initiatives/squamish-brand-enhancement-project/>

²⁶ K. Flett, Marketing Director, Britannia Mining Museum, Personal communication, June 17, 2016.

²⁷ Worldwide, research confirms that coastal tourism results in significant impacts on coastal and marine ecosystems, and while early ecotourism catered to the hardy and small footprint visitor, increasing popularity has expanded the market to include more invasive activities and higher impact structures. From: Davenport, J. and J. Davenport. 2006. The impact of tourism and personal leisure on coastal environments: a review. *Estuarine, Coastal and Shelf Science*. 67:280–292. Accessed August 8, 2016. <http://www.sccf.org/files/content/docs/Davenport,%20J.,%20Davenport,%20J.%20L.%202006.pdf>

²⁸ Lions Gate Consulting 2016.

²⁹ BC's First Blue Flag Marina, Gibsons Marina. Available at <http://gibsonsmarina.ca/environmental-stewardship/>. Accessed August 8, 2016.

³⁰ Blue Flag Beach, Wikipedia. Accessed August 8, 2016. https://en.wikipedia.org/wiki/Blue_Flag_beach

³¹ Criteria for Marinas. Blue Flag Canada. Environmental Defense. Accessed August 8, 2106. <http://environmentaldefence.ca/report/guide-blue-flag-criteria-for-marinas/>

³² Ibid.

³³ Be Whale Wise Marine Wildlife Guidelines for Boaters, Paddlers and Viewers (Revised 2006). Accessed on August 8, 2016. <http://wildwhales.org/watching-whales/whale-watching-guidelines/>

³⁴ Wild Whales B.C. Cetacean Sightings Network. Accessed August 8, 2106. <http://wildwhales.org/sightings/>

Stewardship and Governance



Summary

After decades of environmental degradation due to industrial use, overfishing and development, the ecological value of Howe Sound is gaining recognition among regulators and policy-makers — as is the need to protect it.

A growing effort to establish and expand marine protected areas within Howe Sound has had some success, most notably in the 2016 expansion of the Halkett Bay Marine Park, which includes critical habitat for fragile glass sponge reefs. Recent court decisions have also defined the rights and title of Indigenous communities, which gives added legal weight to the Squamish Nation's traditional role as stewards of the land as well as its plans — currently in development — for marine use planning throughout their traditional territories.

Yet Howe Sound lacks a clear leader in developing a comprehensive, region-wide plan to manage growth and protect its ecology. Despite understanding that such a strategy is needed, jurisdiction over the region continues to be fragmented, with various municipalities, First Nations, government bodies and special interest groups bringing competing interests to the table and, in some cases, opposing points of view. Resulting gaps in the framework have left large swaths of the marine environment unprotected and unmonitored and the region without a clear set of objectives to ensure responsible development, track environmental health, and mitigate increased pressure from population growth, climate change and recreational and industrial use.

Stewardship and Governance

Snapshot Assessment

<h3>Squamish Nation Stewardship</h3> <p>As courts continue to define the rights and title of Indigenous people, the Squamish Nation has emerged as a powerful voice in determining land-use planning and development in Howe Sound. (Assessment is not appropriate due to the nature of the subject).</p>	 <p>NOT RATED</p>
<h3>Marine Protected Areas</h3> <p>A recent expansion of Halkett Bay Marine Park is an example of a growing effort to protect marine areas, yet less than one percent of Howe Sound is protected under provincial legislation. Interest in improving protection status is high and efforts are ongoing.</p>	 <p>CRITICAL</p>
<h3>Comprehensive Planning</h3> <p>Despite consensus that Howe Sound needs a comprehensive plan to direct stewardship and growth, efforts to establish such a strategy continue to be hampered by competing jurisdictions, a fragmented regulatory framework and the absence of agreement on the process and leadership. Howe Sound remains vulnerable without coordinated action.</p>	 <p>CAUTION</p>

Squamish Nation Stewardship

“The Squamish Nation has a vital, long-standing and future-looking interest in the environment of their traditional territory, which includes all of the islands in Howe Sound and the entire Squamish Valley and Howe Sound drainages.”

AUTHOR

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What's happening?

The Squamish Nation has started work to develop their own plan for Howe Sound, which is the next step in painting a holistic vision for Squamish Nation territory. It will build on the land use plan for the upper watersheds, **Xay Temíxw** – Sacred Land, by incorporating plans for the marine environment and stream catchments to the mouth of Howe Sound.

The Squamish Nation has a vital, long-standing and future-looking interest in the environment of their traditional territory, which includes all of the islands in Howe Sound and the entire Squamish Valley and Howe Sound drainages. The Nation has used and occupied the various islands located in Howe Sound for all time and maintains rights and title over its entire territory.

A top priority of the Squamish Nation is to protect its rights and title. A priority for all Howe Sound communities is the practice of stewardship, which calls on current generations to care for the environment and manage resources sustainably on behalf of generations to come. This concept has always been integral to First Nations culture and way of life, and protecting rights and title is a modern manifestation of this stewardship ethic.

How does Squamish Nation governance work?¹

Under the mandate of the Squamish Nation membership, the Squamish Nation Chiefs and Council work to protect and enhance the quality of life of the **Sk̓w̓w̓ú7mesh** **Úxwumixw** (Squamish people and communities).

The Squamish Nation governance model is unique. Sixteen **Síyám** (Chiefs) remain from a long line of leaders, and current **Sk̓w̓w̓ú7mesh** generations can trace their connections to one or more of the strong leaders and speakers who signed the Almagamation on July 23, 1923. The Almagamation established the Squamish Nation Council of Hereditary Chiefs to conduct the affairs of the Squamish Nation and to guarantee good government and equality to all Squamish people. This model modified the traditional custom of consensus-based decision making through the long house.

The governance structure was further modified in 1981, shifting it from a hereditary system to a democratically elected system. Sixteen councillors are elected for four-year terms (plus an elected Band Manager). The sixteen councillors elect Co-Chairs of the Council instead of a Chief, and two political spokespersons.

The Department of the Squamish Government most relevant to Howe Sound stewardship is the Intergovernmental Relations, Natural Resources and Revenue (IRNR&R) department. The department's mission is "focused on building our nation and protecting

our land and resources. We support the needs of our people by creating opportunities for our membership and generating revenue. We improve the lives of our people through economic development, and by protecting and asserting Aboriginal Rights and Title."



Photo: Gary Fiegehen

“The Squamish word for gathering fish for food is **scháyilhen**. In the old days, the Squamish people used nearly everything in the water as a source of food, including kelp and seaweed, which supplemented their diet. Sea urchins and abalone were especially prized. Mussels, clams and oysters were smoked for winter consumption or eaten fresh. Trout and all five species of salmon were caught throughout the year. In March, Squamish fishers collected herring, the first fresh food source after a long winter of dried foods, followed by oolichan and smelt. They rendered oil from the oolichan as an important trade item. Specially trained hunters harvested seals and sea lions from **S̓wespéps ta Kwenís**, a rocky outcrop off Gibsons Landing on the Sunshine Coast.”

Reproduced with permission from “Where Rivers, Mountains and People Meet”, Squamish Líl’wat Cultural Centre.

Why is it important?

The Squamish Nation's responsibility for the stewardship of Howe Sound includes protecting and restoring the environment while realizing benefits to the **Sk̓wx̓wú7mesh Úxwumixw** and defending their rights. To do this, they rely upon their cultural teachings and traditions. Their approach to their responsibilities is based upon the principles of respect, equality and harmony for all.

The Nation has its own established customs, laws and governance systems that apply in Howe Sound. Court decisions have increasingly recognized the authority that First Nations hold in their territories, and recent court settlements place the Squamish Nation in a position of power, with the ability to continue asserting title. The Tsilhqot'in Supreme Court decision² stated:

(p.8) The nature of Aboriginal title is that it confers on the group that holds it the exclusive right to decide how the land is used and the right to benefit from those uses, subject to the restriction that the uses must be consistent with the group nature of the interest and the enjoyment of the land by future generations.

D. [94] ... this is not merely a right of first refusal with respect to Crown land management or usage plans. Rather, it is the right to proactively use and manage the land.

First Nations may soon be able to directly apply plans, laws and policies for their territories, especially as the implications of the Tsilhqot'in decision come into play. Continuing affirmation of Aboriginal rights and title through treaty, litigation and other means will

further strengthen the Squamish Nations' ability to implement and enforce provisions resulting from its plans. Enforcement officers could include guardians and/or watchmen appointed by First Nations.



There are two categories of stories in Squamish tradition: accounts of events that happen in the physical world; and mythology or legend, stories that take place in the spiritual world. Physical-world accounts include stories of the Great Ice Ages or the Great Flood, for example, and Ancestors' accomplishments. Mythological stories feature animals, mountains and supernatural beings journeying through different realms. (Photo: Gary Fiegehen) Reproduced with permission from "Where Rivers, Mountains and People Meet", Squamish Lil'wat Cultural Centre.

What's the current state?

As court cases have been decided in favour of First Nations, there has been an evolving establishment of First Nations rights and title along with the duty to consult and accommodate. For example, the provincial and federal governments have a duty to consult with First Nations on any shoreline tenure applications to ensure that they do not significantly affect aboriginal or treaty rights. Accommodation of First Nations interests is not optional.

In the words of Councillor Chris Lewis: “All good things start at the top of a mountain, and flow their way into the sea — that is a teaching of our elders.” Squamish Nation interests and concerns for Howe Sound range from loss of access to resources to hopes for increased benefits, concerns about pressures on Howe Sound ecosystems, and opportunities and issues related to ecosystem recovery.

Management priorities from **Xay Temíxw**³ that can apply to water as well as the forest and wilderness of the Squamish traditional territory include:

- protecting the rights and interests of the Squamish people;
- sustaining the traditional territory for our children's children, looking ahead seven generations;
- planning ahead instead of always reacting to problems and conflicts;
- protecting heritage, traditional use, sacred and cultural sites;
- providing opportunities for hunting, fishing and gathering;
- repairing damage to the land and water, and reducing soil, water and air pollution;

- getting Squamish Nation members into the traditional territory for health, education, recreation, spiritual and cultural purposes, including camps for children and youth;
- regulating tourism, and minimizing impacts of tourism and recreation, while increasing benefits to Squamish members (e.g., as guides in ecotourism); and,
- getting Squamish members more involved in resource management.

While the Squamish Nation accepts its role as a steward of the environment, it has a right to economic viability — to realize economic benefit and well-being for the **Skwxwú7mesh Úxwumixw** from Howe Sound resources. This could include employment and entrepreneurial opportunities, impact-benefit agreements between the Squamish Nation and businesses, and revenue sharing agreements with Federal and Provincial Governments.

But economic development has to be sustainable. Chief Gibby Jacob has pointed out that the Squamish Nation fought the fight against polluters virtually alone for decades, “so in the end we have a lot invested in ensuring our environment stays as clean as can be.” In the words of Chief Ian Campbell,⁴ “We make it an article of faith to protect the valuable marine resources of the Squamish estuary and Howe Sound, both within our traditional territory. ... If our lands and waters are not protected LNG plants or other industrial operations simply won't get built. Period.”

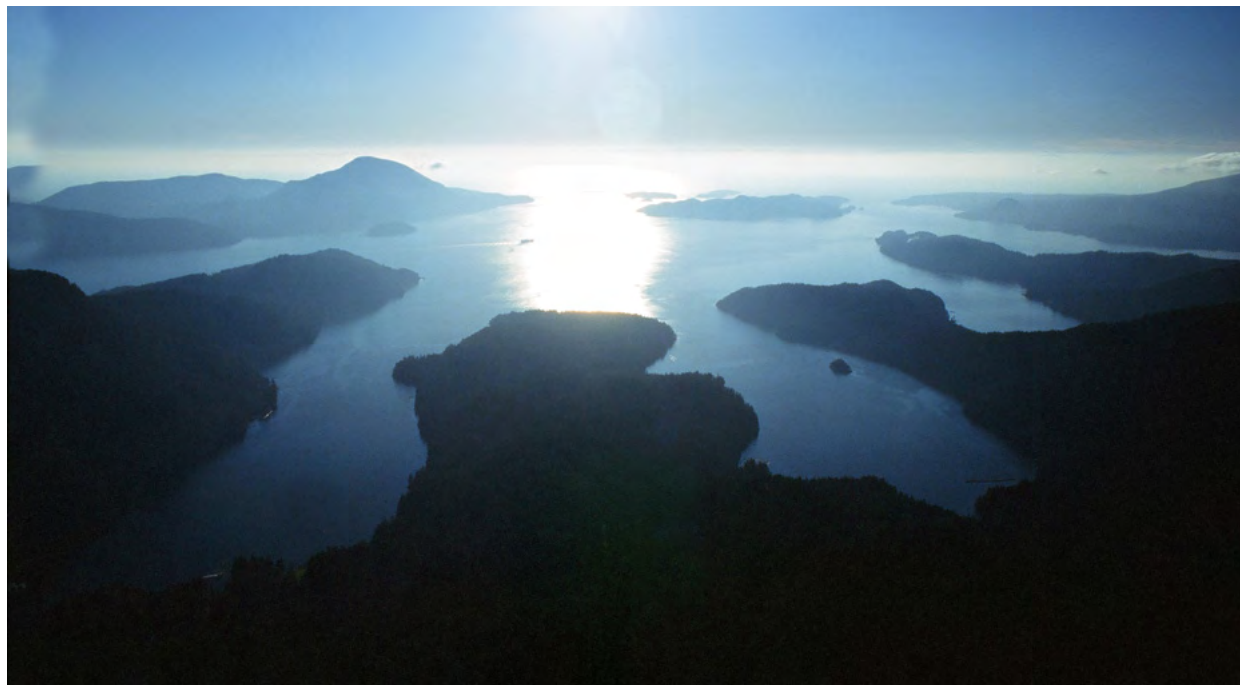
What's being done?

Squamish Nation is taking leadership in Howe Sound planning. The Squamish perspective is holistic — from height of land, across the Sound, to height of land. The plethora of non-First Nations jurisdictional divisions in Howe Sound is inconsistent with this. As a Squamish member commented,⁵ “All the different ministries have their own ways of protection and techniques. The municipalities also have their own land ethic. All these entities cut up the pie and then set out to looking after different pieces in different ways.”

Planning is a means for improving decision-making about the use of resources and space, and the Squamish Nation has an effective land use plan for the upper

forests and wilderness of their territory: **Xay Temíxw** — Sacred Land. A Howe Sound plan will take the next step in painting a holistic vision for Squamish Nation territory, building on **Xay Temíxw**. While Squamish territories extend beyond Howe Sound into the Salish Sea, Howe Sound is a good starting-point for marine planning. A goal of the Howe Sound Marine Use Plan is to identify areas in the marine environment to protect, as the Wild Spirit Places do, stemming from **Xay Temíxw**.

The Howe Sound Plan will be the Squamish Nation's foundational document for guiding Howe Sound management in a new, post-Tsilhqot'in era.



As stewards of the land, we are, in a way, the original environmentalists. And the gravity of that responsibility has been handed down from generation to generation. (Photo: Gary Fiegehen) Reproduced with permission from “Where Rivers, Mountains and People Meet”, Squamish Lil'wat Cultural Centre.

What can you do?

- Support a collective approach

The concerns and interests of Howe Sound communities beyond the Squamish Nation significantly overlap with those of Squamish Nation members and leadership. Local and regional governments, several organizations, and some federal and provincial government agencies are taking an increasing interest in a sustainable future for Howe Sound.

At the Howe Sound Aquatic Forum in April 2014, Chief Ian Campbell emphasized that the best approach to planning for Howe Sound involves good governance: “We must work collectively and ensure strong community and connectivity to reach our goals. It is important to recognize that many key issues are multidimensional. ... Open approaches are important. Continuity is important.” Chief Gibby Jacob noted that the Squamish Nation has a duty to engage in the issues that concern their territory and Nation. The

Squamish people will be here forever; they are not going anywhere. At the same time, finding a commonality of purpose and objectives with others is important. Councillor Chris Lewis summarized the challenge as being how to sustain **Sk̓w̓wú7mesh Úxwumixw** livelihoods as well as the livelihoods of neighbouring communities and still protect the ecosystem. He also pointed out that rights and title can be integral to the planning process without precluding cooperation with other governments. The Squamish Nation can drive the process at the same time as it works collaboratively with NGOs and local governments, being clear the plan is a Squamish Nation plan.

At a pragmatic level, Squamish Nation laws, federal laws and provincial laws are all relevant to plan implementation, and the limited capacity of any government makes a collective approach necessary.

Footnotes

¹ Much of the information in this section comes from <http://www.squamish.net/about-us/governance/>

² On June 26, 2014, the Supreme Court of Canada granted declaration of aboriginal title to lands outside of a reserve for the first time in Canadian history. Decision accessed Nov 7, 2016. <http://scc-csc.lexum.com/scc-csc/scc-csc/en/item/14246/index.do?r=AAAAAQAFMzQ5ODYB#>

³ See <http://www.squamish.net/about-us/our-land/xay-temixw-sacred-land-land-use-plan/>

⁴ <http://www.squamish.net/wp-content/uploads/2015/07/SN-WoodfibreUpdate-Summary-03.pdf>

⁵ During consultations for Xay Temíxw.

Marine Protected Areas: lacking coverage to meet commitments

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What is happening with Marine Protected Areas in Howe Sound?

The latest addition to a protected area in Howe Sound was the expansion of Halkett Bay Marine Park. An addition of 136 hectares or 1.36 square kilometres of marine foreshore was announced in May 2016. This addition protects a recently discovered rare glass sponge reef southeast of Gambier Island (Figure 1). The glass sponge reef is especially unique because it is adjacent to sponge garden habitat and the reef is only 30 metres deep, making it accessible to both scientists and recreational scuba divers. A mooring buoy to facilitate safe access for citizen science work is being considered. An update to the Park Management Plan will include limiting anchoring and bottom disturbance near areas of glass sponge reef and garden.

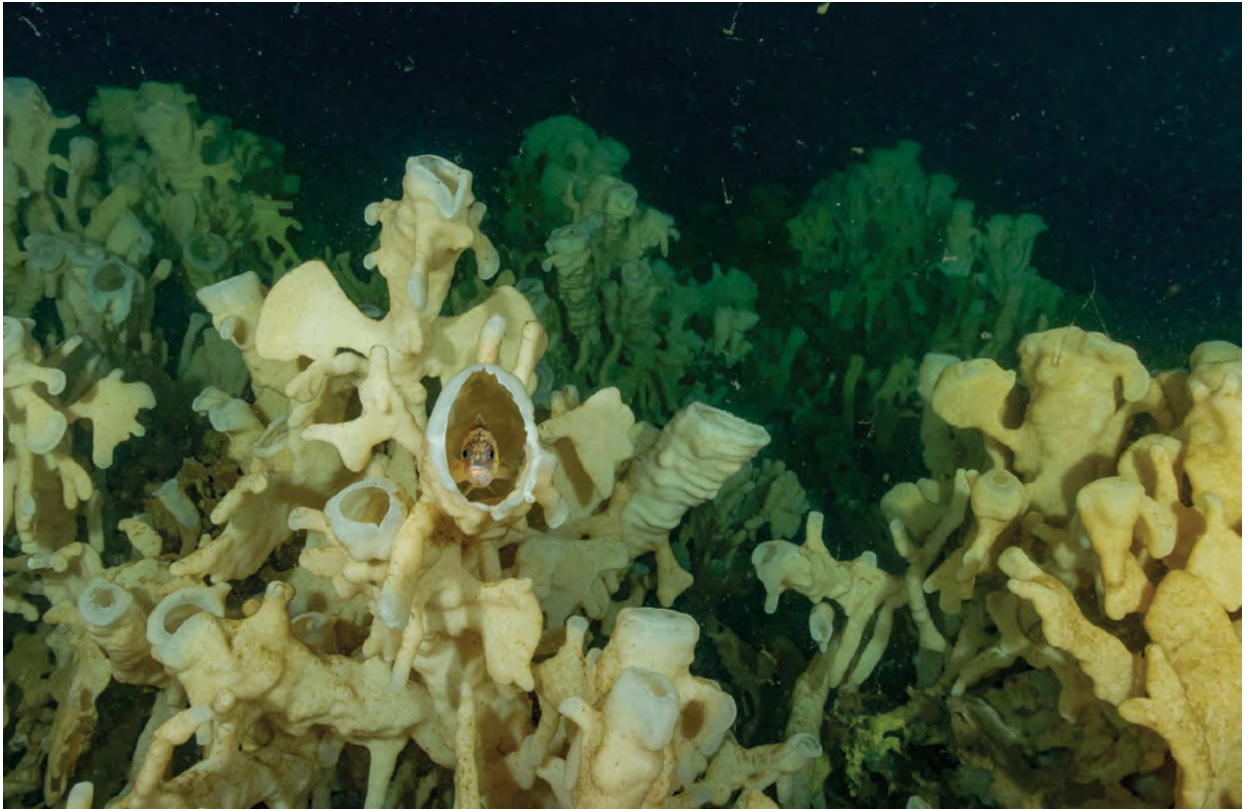


Figure 1. Newly protected glass sponge reef in Howe Sound. (Photo: Adam Taylor)

Including this new addition, just less than one percent of the marine area of Howe Sound is in a designated Provincial or Municipal Protected Area. There are no Federal Marine Protected Areas in Howe Sound. Howe Sound is lacking protection compared to Canada's international commitment to set aside 10 percent of our oceans as marine protected areas by 2020 (known as the Aichi Target under the United Nations Convention on Biological Diversity) or even the recent Liberal Government's promise to protect five percent by 2017.

A recent initiative led by B.C. Spaces for Nature and the Future of Howe Sound Society is exploring the possibility of achieving UNESCO Biosphere Reserve status for Howe Sound.¹ A biosphere reserve would include core areas where the ecosystems are strictly protected.

Why is it important?

Protection of habitats and species can be achieved through marine protected areas, fisheries closures, marine parks, wildlife refuges, or even a “critical habitat”² designation. Protection of this kind is just as important in the marine environment as it is on land. In B.C., 37 percent of the land base is under some kind of conservation designation.³ Marine protected areas (MPAs) and other designations can provide industry-free areas for recreation, impact-free areas for species, habitats, and natural processes to thrive, preserve eelgrass and estuaries, which are critical for storing carbon, and even enhance vegetation that shelters coastal communities from storm damage and rising sea levels. Protecting areas of the seascape provides some insurance against the unknown, resilience in the face of climate change, and can help to sustain the extractive activities that feed our communities and economies. Glass sponge reefs even represent a substantial silicon sink, based on estimates made for the three Strait of Georgia reefs.⁴ Silicon in the ocean is important for primary productivity as some plankton need silicon to build their tiny skeletons.

A marine protected area is a general term referring to an area of ocean in which human activity is restricted to conserve the marine environment and the wildlife that lives there. Under this umbrella term there are many different types of protected areas, including marine parks, marine reserves and special areas of conservation, each with its own level of protection. Other types of designations also provide some protection to species and habitats. Rockfish Conservation Areas (RCAs) are not MPAs but have been closed to a suite of fisheries since 2007 to facilitate the recovery of rockfish populations in B.C., although rockfish can still be caught as accidental bycatch in these areas by gear that is permitted, such as prawn traps. In 2015, Fisheries and Oceans Canada (DFO) implemented another type of fishing closure, Glass Sponge Reef Fishing Closures, to protect sponge reef habitat.⁵ The main differences between fishing closures and MPAs are that fishing closures are not permanently designated through legislation and can be lifted at any time by DFO, and the closures do not have individual management plans.⁶

What is the connection to First Nations?



Photo: Bob Turner

Squamish Nation partners with the Province to manage the Skwelwil'em Squamish Estuary Wildlife Management Area. "Porteau Cove Provincial Camp-ground [and Park] is an area known by the Squamish Nation as Xwaxw'chayay, referring to the sturgeon traditionally fished there. Historically, it was a place rich in marine and other wildlife and one of the oldest archaeological sites on the Northwest Coast is located here, dating back 9,800 years."⁷

What is the current state of protection in Howe Sound?

Currently Howe Sound has six marine protected areas covering just one percent of the ocean area (some of which are more accurately recreation areas), 11 RCAs covering 12 percent, and two Glass Sponge Reef Closures covering one percent (Figures 2, 3). Eighty-six percent of Howe Sound is without any special designation which protects the marine environment. Five areas designated by the provincial government include Apodaca Park, Halkett Bay Marine Park, Plumper Cove Marine Park, Porteau Cove Park, and Skwel-wil'em Squamish Estuary Wildlife Management Area.

These are considered to be marine protected areas by the province, even though the first three have no fishing closures in place.⁸ Fishing regulation is federal jurisdiction, so in order for provincial or municipal protected areas to implement fishing closures they must work with DFO. Whytecliff Park and Porteau Cove have annually renewable fishing closures implemented federally. Whytecliff Park, designated by the Municipality of West Vancouver, has the distinction of being the only marine protected area in British Columbia that prohibits commercial fishing in 100

TYPES OF MARINE PROTECTION IN HOWE SOUND

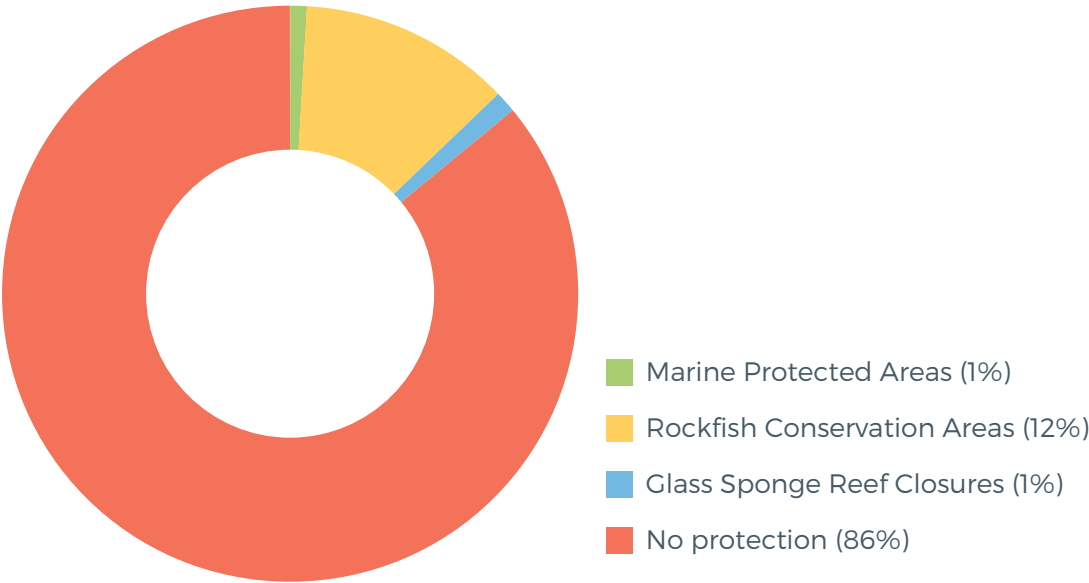


Figure 2. Types of marine protection in the Howe Sound marine area which totals 32,640 hectares.

percent of its marine area,^{9,10} but that area is just 22 hectares, and the closures must be renewed annually by DFO. Enforcement of fishing regulations, whether it is in a protected area or a closed area is also a federal responsibility and capacity is limited.

Only the Skwelwil'em Squamish Estuary Wildlife Management Area was originally designated with conservation or protection (i.e., restoration and maintenance of habitat) as the sole and primary purpose (Table 1). The Halkett expansion was created to protect glass sponge reefs and fishing closures to implement this protection remain a topic of discussion.

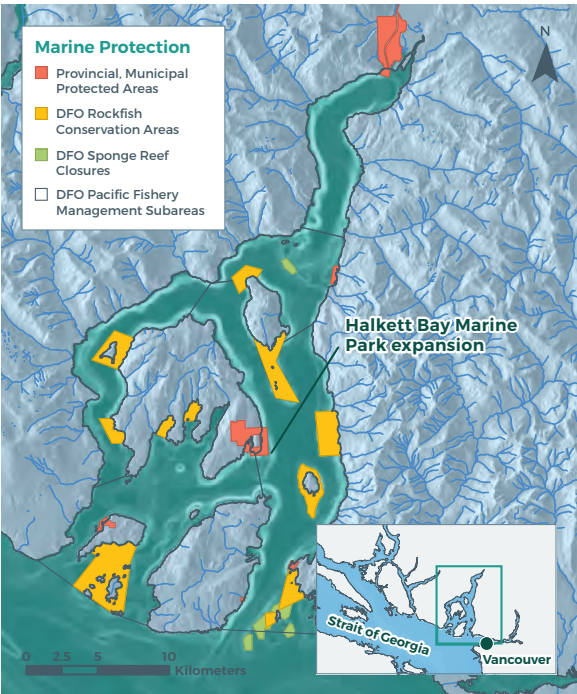


Figure 3. Types of marine protection in Howe Sound.

TABLE 1. PROVINCIAL AND MUNICIPAL MARINE PROTECTED AREAS IN HOWE SOUND

MARINE PROTECTED AREA	ESTABLISHED	PRIMARY PURPOSE ¹¹	MARINE AREA (HECTARES)
Apodaca Park	1954	Preservation, recreation	4
Halkett Bay Marine Park	1988	Recreation; Park expansion to protect glass sponge reef	154
Plumper Cove Marine Park	1960	Recreation	33
Porteau Cove Park	1981	Conservation, recreation	52
Skwelwil'em Squamish Estuary Wildlife Management Area	2007	Maintenance, restoration of habitat	40
Whytecliff park	1909	Recreation	22

What is being done?

In Howe Sound, Marine Life Sanctuaries Society (MLSS) has long been pursuing various approaches to securing marine conservation. The Society was instrumental in the Halkett Bay Provincial Park Expansion and reports that multiparty discussions with user groups, conservation groups, BC Parks and Fisheries and Oceans Canada (DFO) regarding fishing closures to protect the glass sponge reef will be held.¹² On another front, at the request of MLSS, Bowen Island Municipal Council (BIMC) passed three resolutions in October 2015¹³ related to the Dorman Point sponge reef, located within Bowen Island Municipality boundaries, resulting in these actions:

- A letter from BIMC was sent to DFO requesting that stakeholder consultation be re-opened and that recently announced fishing closures on glass sponge reefs be expanded to all known reefs in Howe Sound including Dorman Point.
- BIMC has acknowledged the boundaries of Dorman Point sponge reef and municipal staff is considering the reef when any development permit application overlaps the area. The plan is to amend Bylaws to make this mandatory.
- BC Hydro has been made aware of Dorman Point reef with a detailed site map provided by MLSS so that they can avoid it when laying cable to Bowen Island.

The current federal government has renewed the commitment to protect five percent of the coastal and marine environment by 2017, and 10 percent by 2020.¹⁴ Individual advocacy organizations are working to encourage the government to meet this commitment. The Government of Canada, Province of B.C. and 17 First Nations are working together to develop a marine protected area network in the Northern Shelf Bio-region (NSB), which extends from the top of Vancouver Island to the Canada — Alaska border,¹⁵ but that leaves out the South Coast including Howe Sound.

What can you do?



Individual and Organization Actions:

- Participate in Marine Life Sanctuaries Society of B.C.'s "Voluntary No-Take initiative"; <https://mlssbc.com/programs/voluntary-no-take-initiative/> and pledge to not harvest marine life from these areas regardless of current fishing regulations.
- Become a steward of Howe Sound and report illegal fishing activities in MPAs and RCAs to DFO.
- Educate yourself and others on where the marine protected area boundaries are, and ensure you are adhering to all regulations within them.



Government Actions and Policy:

- Increase public education and awareness of marine protected areas, their boundaries, and regulations.
- Increase capacity to ensure better monitoring and enforcement in RCAs and MPAs.
- Add conservation objectives to the management plans for B.C. Parks that were designated for recreation, or do not count them as "marine protected areas."
- Meet commitment to protect five percent of the coastal and marine environment by 2017, and 10 percent by 2020. Increase the area of MPAs in Howe Sound.
- Clearly distinguish between conservation objectives and recreation objectives when designating new enhanced management areas. Acknowledge that designation of areas primarily for recreation is not equivalent to designation of areas for conservation.

Resources

Protect Plant Ocean

protectplanetocean.org/introduction

B.C. Parks

env.gov.bc.ca/bcparks/

Canadian Commission for UNESCO

unesco.ca/home-accueil/ccu

Footnotes

¹ <http://futureofhowesound.org/campaigns/exploring-unesco-biosphere-reserve-status/>

² <http://www.dfo-mpo.gc.ca/species-especes/act-loi/habitat-eng.htm>

³ <https://news.gov.bc.ca/releases/2016ENV0031-000859>

⁴ Chu, J.W.F., M. Maldonado, G. Yahel, and S.P. Leys. 2011. Glass sponge reefs as a silicon sink. *Marine Ecology Progress Series* 441: 1–14. doi: 10.3354/meps09381

⁵ http://www.pac.dfo-mpo.gc.ca/oceans/protection/sponge_reef-recif_eponge-eng.html

⁶ Robb, C.K., K.M. Bodtker, and K. Wright. 2015. Marine Protected Areas in the Canadian Pacific: Do They Fulfill Network Criteria? *Coastal Management* 43(3): 253–269. doi: 10.1080/08920753.2015.1030306

⁷ Reproduced with permission from “Where Rivers, Mountains and People Meet”, Squamish Lilwat Cultural Centre

⁸ Some non-government and marine conservation organizations do not consider these to be marine protected areas, but call them “recreation areas” for this reason.

⁹ Robb, C.K., K.M. Bodtker, K. Wright, and J. Lash. 2010. Commercial fisheries closures in marine protected areas on Canada’s Pacific coast: The exception not the rule. *Marine Policy* 35(2011): 309–316. doi:10.1016/j.marpol.2010.10.010

¹⁰ Robb et al. 2015.

¹¹ From management plans; see www.env.gov.bc.ca/bcparks, www.env.gov.bc.ca/fw/habitat/conservation-lands/wma/skwelwil_em

¹² Taylor, A. Email communication with the author, Sep 29, 2016.

¹³ [https://bowenland.civicweb.net/document/78827/151026%20RC%20FINAL%20\(E\).pdf?handle=89B91ABB08B24E6E9185CA06408FF9BA](https://bowenland.civicweb.net/document/78827/151026%20RC%20FINAL%20(E).pdf?handle=89B91ABB08B24E6E9185CA06408FF9BA)

¹⁴ <http://pm.gc.ca/eng/minister-fisheries-oceans-and-canadian-coast-guard-mandate-letter>

¹⁵ <http://mpanetwork.ca/bcnorthernshelf/whats-happening/>

Towards Comprehensive Planning for Howe Sound

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REVIEWER

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What is happening with comprehensive planning for Howe Sound?

A comprehensive planning process for Howe Sound is needed to take a holistic view of the region, including the marine environment, and bring all governments and stakeholders together to work towards a common vision. While no one body is taking the lead to develop a comprehensive plan for Howe Sound, there has been some progress on coordinating actions to address priority topics as well as jurisdictional and planning gaps and overlaps such as derelict vessels.

In the past, the Provincial Government took the lead in conducting multi-stakeholder sub-regional Land and Resource Management Plans (LRMPs) across much of B.C. However, it is no longer developing plans for areas not covered by LRMPs, such as most of Howe Sound. In 2015, in response to a request from the Howe Sound Community Forum (see below) for a “comprehensive marine and land use plan for Howe Sound” and to an expressed concern over cumulative impacts from proposed new industrial and residential developments, the province agreed to conduct a Cumulative Effects Assessment (CEA) for the Sound.

A CEA identifies key environmental values (social and economic values can also be included), collects data and establishes objectives, indicators and benchmarks for environmental health. The resulting Cumulative Effects Assessment and Management Report can be used as an information and decision-support tool to manage development, and could be part of any future planning initiative. The B.C. Ministry of Forests, Lands and Natural Resource Operations (FLNRO) started the CEA in 2016 by identifying terrestrial values to be included. Spring 2017 is the target for Current Condition Reporting, which can also address trends. This is to be followed by cumulative effects assessment and the development of management recommendations. FLNRO hopes to add marine values to the Howe Sound's CEA in future, but there is as yet no firm commitment.

Additional activities that can contribute to the information base needed for a comprehensive plan include:

- Squamish Nation commenced background work for a Marine Plan for Howe Sound in 2015. A consultant has been hired and the process is ongoing.
- In March 2015, the Coastal Ocean Research Institute at the Vancouver Aquarium, Squamish Nation, and the David Suzuki Foundation (DSF) co-hosted a Howe Sound Science and Knowledge Holders Forum. Participants shared data and agreed on the need for a report on the state of the Howe Sound marine environment, which led to this new Ocean Watch report. In May 2016, these same parties co-hosted the Howe Sound Socio-Economic Knowledge Workshop, a first-of-its-kind gathering of businesses and other stakeholders from the tourism, recreation, development, transport and sport fishing sectors.

- In 2015, DSF published Sound Investment — Howe Sound Ecosystem Assets¹, a report on the economic value of natural capital and ecosystem services in Howe Sound, followed by the Socio-Economic Baseline Study of the Howe Sound Area in 2016.² DSF is also engaging the public through its Great Howe Sound Recovery initiative. This includes evening events with videos of First Nation elders and their stories, videos profiling scientists and citizen scientists who do remarkable work in the region, panel discussions, and the gathering of participant responses on a vision for a sustainable future for Howe Sound.
- Several local governments and Regional Districts around Howe Sound are updating their Official Community Plans (OCPs) or Regional Plans. An OCP is a local government bylaw that provides objectives and policies to guide decisions on planning and land use management within the area covered by the plan.³

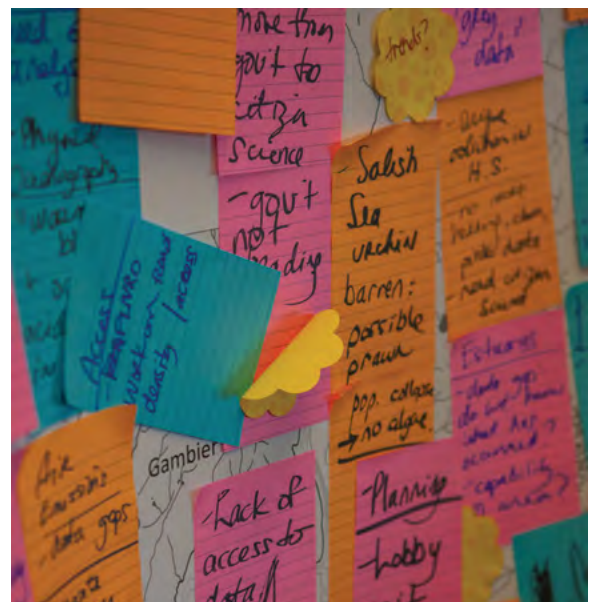
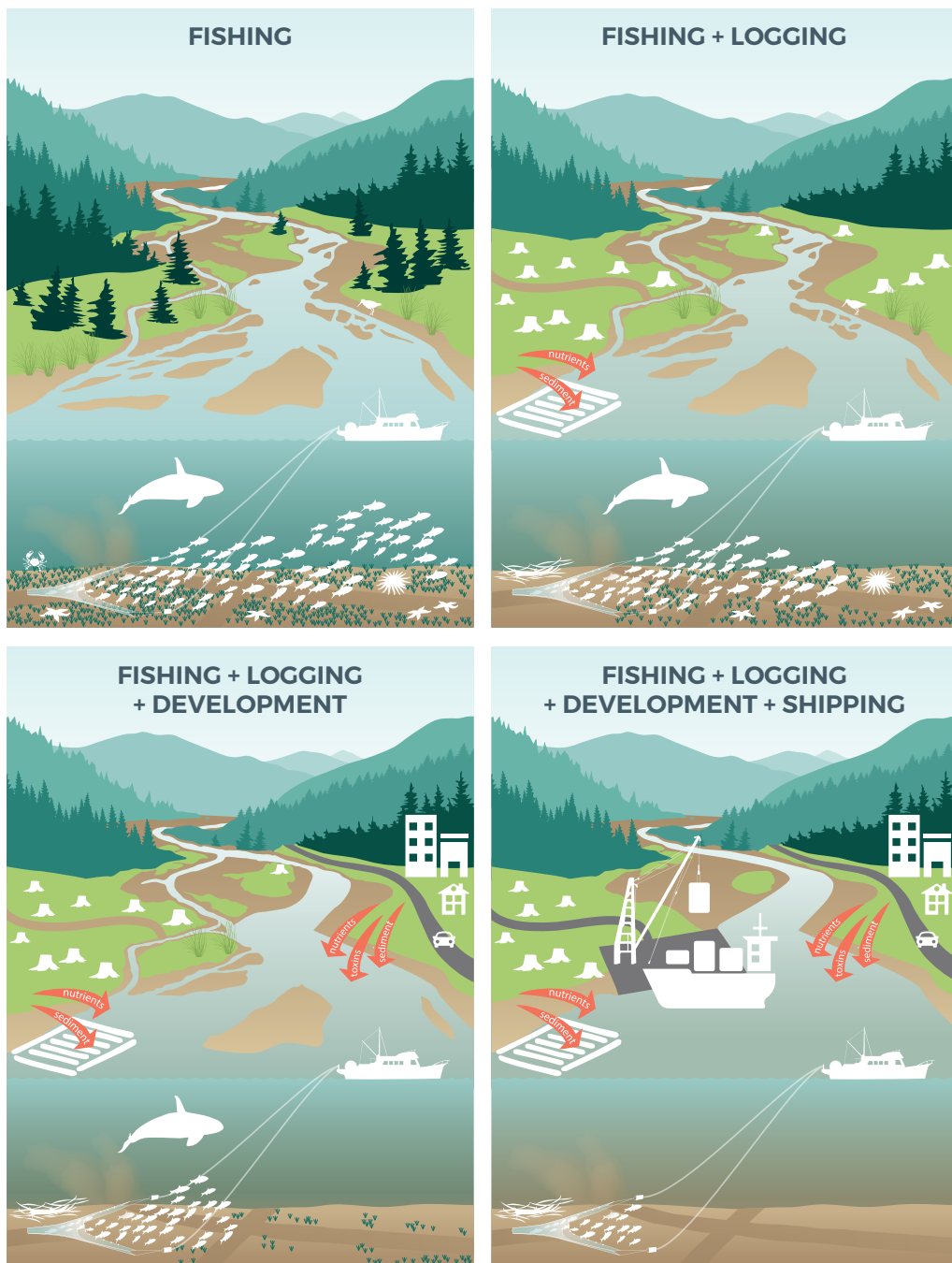


Photo: Lisa Wilson

Cumulative effects



Comprehensive planning, low-impact development, and smart growth practices can address cumulative impacts by preserving forests, reducing impervious surfaces, and fostering more livable coastal communities.

Why is comprehensive planning important for Howe Sound?

A comprehensive land and marine plan would establish a clear set of objectives — based on a common vision — that would aim to protect long term social, economic, environmental and heritage values for the Howe Sound region. Such a plan could provide guidance to decision-makers for planning and management within their specific jurisdictions and reduce the chance of harm caused by the cumulative impacts of uncoordinated changes.

Effective management of Howe Sound suffers from complex and fragmented governance arrangements. The watershed falls within multiple jurisdictions and administrative areas, including three regional districts, the Islands Trust, five municipalities, two provincial ridings, three provincial forest districts and is subject to several areas of federal jurisdiction related to fisheries, environmental protection and transportation in marine waters. While Howe Sound is in the traditional territory of Squamish Nation, the Tsleil-Waututh and Musqueam Nations also have claims in the area. A Sea to Sky Land and Resource Management Plan completed by the Province in 2008 and **Xay Temíxw**, Squamish Nation's land use plan, cover the northern Howe Sound watersheds, leaving the southern portion of the Sound without overall planning guidance, open to competing interests by municipalities, the regions, the Provincial Crown and First Nations.

Howe Sound's fragmented jurisdiction makes it difficult to ensure effective planning and management of development pressures in the region as a whole. The Sea to Sky corridor along the east side of the sound was significantly transformed in preparation for the 2010 Winter Olympics. The expansion of Highway 99 has resulted in a surge of residential and commercial development along the corridor and greatly increased the number of visitors to the area. As well, there have been a spate of major new industrial proposals, including woodlot logging on Gambier Island, the McNab Creek gravel mine proposal, and the Woodfibre LNG plant, which, if it proceeds, will introduce very large LNG carriers into the busy waters of the sound. To further complicate Howe Sound's future scenarios, the B.C. government initiated a feasibility study in 2015 for a possible road or bridge link across Howe Sound to connect the Sunshine Coast and Highway 99. This would have significant impacts on development patterns in the Sound. These proposals are being evaluated by different levels of government, with different priorities and jurisdictions. Among the levels, the Squamish Nation is the one government mandated to consider the whole region and the potential impacts of all the pressures taken together.

How does comprehensive planning relate to First Nations?

Squamish Nation completed their land use plan, called **Xay Temíxw**, a decade ago. **Xay Temíxw** covers the northern part of Howe Sound and the entire area of the Squamish River drainage basin. The Nation was successful in building community consensus, defining newly protected Wild Spirit Places, and establishing tenured forest areas for logging that provide their

community with jobs and benefits. The land use plan provides a solid foundation for the next step, a Marine Plan for Howe Sound. A consultant has been retained, preliminary studies have been undertaken, and marine planning is expected to commence once a budget is in place.

What is the current state of comprehensive planning in Howe Sound?

Since the late 1990s, there have been public demands for comprehensive planning for Howe Sound. In 1996 the Howe Sound Round Table on environment, economic and social sustainability produced a report entitled *Howe Sound 2020* (futureofhowesound.org/wp-content/uploads/2013/02/Howe-Sound-2020.pdf). The report was a call to action, and the result of two years of public forums and community consultations. The Round Table heard consistently that there was a need to establish a watershed-wide perspective for Howe Sound and coordinate activities at

the government and community levels. The Howe Sound Community Forum (HSCF), consisting of all local and regional governments and Squamish Nation, was formed in 2000, and in 2002 its Principles for Cooperation were signed.⁴ Elected officials from local, regional, provincial, federal and Squamish Nation governments meet twice annually and share information about activities in the sound, based on a common set of values (Figure 1). In recent years, the HSCF has accomplished important foundational work in support of a vision and planning for Howe Sound.



Figure 1. Howe Sound Community Forum participants. Left: Bowen Island, Spring 2015. Right: Camp Fircom, Gambier Island, Spring 2016

In 2012, every municipality and regional district in the Sound passed a motion calling for a “comprehensive land and marine use planning for the region.” This call received province-wide support when a supporting resolution was passed by the Union of BC Municipalities (UBCM) in 2013. To date, the B.C. government has declined to enter into such planning, even though up to 90 percent of the province has some form of land use plans in place and the B.C. government has been a partner in marine spatial planning in the Central and North Coast⁵ and on the West Coast of Vancouver Island.⁶

Since 2013, participation in the HSCF has continued to grow and the meetings provide a critical venue for discussions about key issues, from large-scale industrial and residential projects to environmental best practices and initiatives (Figure 2).

In addition, several workshops and forums during this time, including the Howe Sound Aquatic Forum in 2014 (Figure 3), have brought together elected officials, First Nations, NGOs, business leaders, members of the public and stakeholders to discuss Howe Sound issues. Common values and themes contin-



Figure 2. Visual notes, Howe Sound Community Forum, Fall 2015. Notes by Erin Stewart.



Figure 3. Howe Sound Aquatic Forum, 2014

ue to emerge from these meetings. A major advance in planning for Howe Sound was the announcement that Squamish Nation would initiate a marine plan for Howe Sound, beginning in 2016.

Many of the organizers of these initiatives aim to move the mindset of governing bodies towards more consultative and collective care for Howe Sound, with decision-making considering the whole ecosystem, from mountain-top to sea bottom. A recurring theme emerging from workshop and meetings is that local

governments and non-profits are ready to cooperate as a “community of communities” to develop plans and agreements to guide conservation and development in the region as a whole. These collaborations have also helped the often physically separated communities across the Sound better know their neighbours, including First Nations communities.

What challenges exist?

Given its proximity to Vancouver and its recreation values, Howe Sound will attract increasing numbers of residents and visitors. As Metro Vancouver continues to grow, the Howe Sound fjord is becoming an ever more important “blue belt” and “green belt” for the region. Howe Sound is a special place for the people that live there, from West Vancouver to Squamish to Gibsons, and on the islands such as Bowen, Gambier and Keats. It is hard to overstate the profound commitment to place that is repeatedly expressed by people living in and visiting the Sound. Their deep connection to the land and waters breeds a strong desire by those who live there, and many who visit, to do right by the area. And for many, doing right at this moment in history means creating a comprehensive

land and marine plan that will envision and implement a sustainable future for this stunning place.

A major challenge for collective planning concerns possible governance arrangements for comprehensive planning: who will lead, how will decisions be made and how will it be funded? The current provincial government has declined to take a lead in comprehensive planning for Howe Sound. This poses a challenge when Crown land is being used for activities that do not consider the region as a whole or local and regional community plans. Competing interests generate conflict over land use. The challenge for local communities and First Nations is having enough resources to take the lead.

What is being done?

In response to proposed industrial, residential and logging projects for the Sound, conservation groups have expressed their concern and new citizen groups have formed to “Save Howe Sound” and to protect the environmental recovery that is underway (e.g., Save our Sound flotilla, Figure 4). This renewal is “the talk of the Sound,” and everyone has a story of recently observed sea life, be it herring, salmon, dolphins, orcas or humpbacks. Long-term residents don’t need to wait for scientific evidence to conclude that a recovery is underway.

As noted above, the Howe Sound Community Forum (HSCF) plays a key role in bringing together members

of all levels of government (Figure 2). One member organization hosts each meeting and the agenda focuses on Howe Sound initiatives. Squamish Nation plays an important role and used the HSCF to announce the launch of marine planning for the Sound. One limitation of the HSCF is that, while all elected officials in the area have the opportunity to share and consult, the Forum has no decision-making authority. Non-profit organizations are allowed to attend as observers only, but are not formally involved.

The Future of Howe Sound Society (FHSS) was formed in 2011 with a mission to engage stakeholders and First Nations in the need for a comprehensive plan.

A FHSS workshop in 2013, attended by 140 people representing 65 organizations, identified a series of common values for Howe Sound. This was the first gathering of stakeholder groups since the 1996 Howe Sound Roundtable initiative. FHSS, through social media and ongoing events, continues to collaborate with many Howe Sound organizations and acts as a key information provider for the public.

BC Spaces for Nature (BCSN) initiated a strategic campaign to protect Howe Sound's values in 2013. BCSN

framed a campaign vision, catalyzed a coordinated strategy and has since provided ongoing strategic guidance to a range of organizations in Howe Sound. BCSN and FHSS are currently exploring the potential for Howe Sound to be recognized as a UNESCO World Biosphere Reserve.

The Town of Gibsons has adopted a practice to integrate nature into their decision-making, using key principles of asset management, financial planning and ecology. In 2014, the town deemed nature to be its most valuable asset and it has redefined infrastructure to include inheritance of natural capital.

The David Suzuki Foundation's (DSF) Howe Sound campaign has been convening an ever-widening circle of partners, with the goal of creating strong working relationships and bonds among community groups, governments, First Nations, researchers, businesses and citizens across the sound (Figure 5). For example, working closely with Squamish Nation, DSF created Camp Suzuki — Howe Sound, which focuses on learning First Nations culture, building community, activism and leadership, and on fostering a deeper appreciation and understanding of our lands, oceans and amazing biodiversity. The camp furthers the goal of relationship-building by aligning new partnerships, in this case Squamish Nation and the Camp Fircom owners, the United Church. DSF has also begun the process of creating a new, near-urban national park in Howe Sound.



Figure 4. Save Our Sound flotilla, June 30, 2013. (Photo: Ruth Simons)



Figure 5. David Suzuki being adopted by Squamish Nation at Porteau Cove, 2014. (Photo: Lisa Wilcox)

As noted above, the B.C. Ministry of Forests, Lands and Natural Resource Operations is proceeding with the first stage of a Cumulative Effects Assessment (CEA) for Howe Sound. The CEA will provide data, indicators, and benchmarks and current conditions information related to selected key values, including watershed condition, old growth forests, forest biodiversity, forest visual quality and several species at

risk that can be used in the planning and development approvals processes. Setting thresholds is most important when considering the cumulative impacts of development. Without thresholds that are accepted by those in governance, measuring and monitoring the indicators will not achieve the objectives of a comprehensive land and marine plan.

What can you do?



Individual and Organization Actions:

- Engage and contribute to your Regional Plans and Official Community Plans; they always include public input!
- Encourage your OCP to consider how impacts of growth, development and zoning relate to the whole of Howe Sound. (Transportation is a perfect example. Moving from Squamish to Vancouver on transit means passing between BC Transit authority and Translink's authority. Efficient services suffer because neither authority is focused on the Squamish to Vancouver commuter.)
- Work to make Howe Sound live up to your own vision for the area. You can, for example, join and follow one of the many non-profit organizations focused on Howe Sound conservation and protection. Volunteer for restoration programs, such as the wetland work on the Squamish foreshore, or work with local conservancies to improve trails. Give your time to marine groups who are looking to citizen vigilance to monitor illegal fishing or trapping. Attend events and learn about the diverse communities around the sound, starting with First Nations and their history and culture (see other articles in this report).
- Experience the awesomeness that is Howe Sound! Get on a boat and experience the sound from the water. Hike a ridge or kayak the new Sea to Sky Marine Trail.



Government Actions and Policy:

- Undertake/collaborate on comprehensive marine and land use planning for Howe Sound.
- Participate in the Howe Sound Community Forum meetings.
- Recognize the value of ecosystem services in Howe Sound when considering the best allocation, use and regulation of Crown Land, foreshore and marine areas.

Resources

Future of Howe Sound Society
futureofhowesound.org

The David Suzuki Foundation
sustainablehowesound.ca

Cumulative Effects Assessment
gov.bc.ca/gov/content/environment/natural-resource-stewardship/cumulative-effects-framework/get-involved

Squamish Nation Land Use Plan (Xay Temíxw)
squamish.net/about-us/our-land/xay-temixw-sacred-land-land-use-plan/

Sea to Sky Land and Resource Management Plan
for.gov.bc.ca/tasb/slrp/plan79.html

Howe Sound Community Forum
futureofhowesound.org/category/campaigns/howe-sound-community-forum/

Footnotes

¹ Molnar, M. (2015). Sound Investment — Measuring the Return On Howe Sound's Ecosystem Assets. Vancouver, BC: David Suzuki Foundation.

² Lions Gate Consulting, 2016, Socio-economic baseline of the Howe Sound area, For David Suzuki Foundation, 32 p

³ <http://www.toolkit.bc.ca/tool/official-community-plan-ocp>

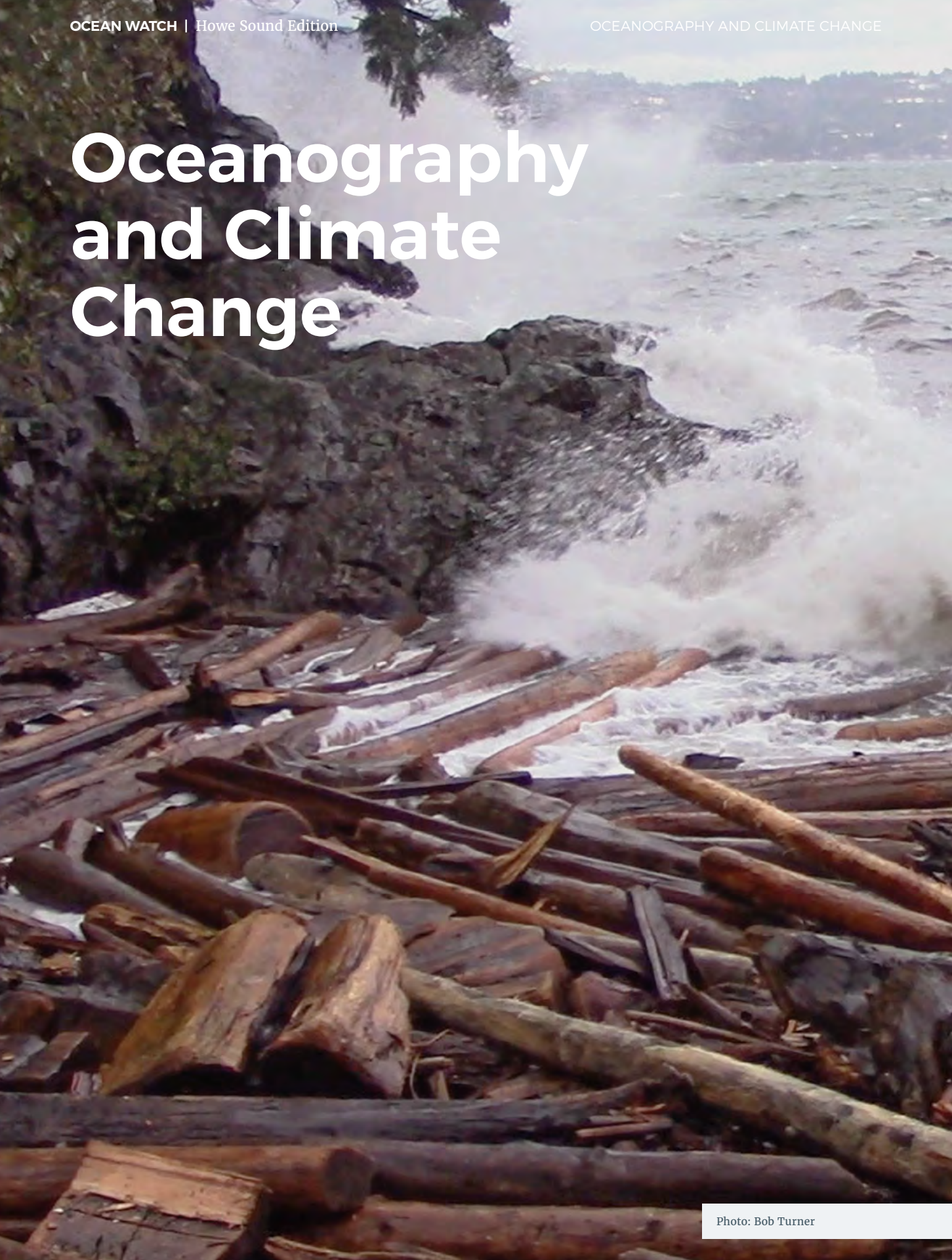
⁴ Howe Sound Community Forum Principles for Cooperation — <http://futureofhowesound.org/campaigns/howe-sound-community-forum-feb-26th/attachment/hscf-principles-for-cooperation-original/>

⁵ Marine Plan Partnership for the North Pacific Coast. Accessed Sept 7,

2016. <http://mappocean.org/>

⁶ West Coast Aquatic. "Marine Spatial Planning." Accessed Sept 7, 2016. <http://westcoastaquatic.ca/marine-spatial-planning>

Oceanography and Climate Change



Summary

As the effects of climate change become more pronounced, coastal communities need to adapt to rising sea levels, increasing temperatures and the resulting threats from floods, storm surges, summer drought and unusual weather events. Howe Sound is no exception.

Rising water temperatures are already being recorded in the area, while a new annual pattern in stream flow is increasing the risk to human settlements and sensitive ecological habitat alike. Shorelines have been altered by human activity over decades of development and industrialization. Berms, dikes and seawalls amplify wave energy causing further erosion along the Sound, making them a poor defense against a shifting climate and increasingly volatile weather patterns.

A promising alternative to these wall-like barriers has emerged in the Green Shores approach, which works with nature to fortify coastlines using native vegetation. Restoring coastal areas to a more natural state is seen as a valuable tool to protect homes and businesses from rising waters, and may increase the ability of local species to adapt to the realities of a changing climate.

The District of Squamish is also bracing for the increased threat of flooding and storm surge by developing a new Integrated Flood Hazard Management Plan that considers the Green Shores approach and establishes flood levels for new developments.

Oceanography and Climate Change Snapshot Assessment

Ocean Warming

Following record years for increasing ocean temperatures worldwide, Howe Sound is showing signs its waters are also warming. Warming can mean major change and lack of data specific to Howe Sound causes local uncertainty.



Shorelines

Armoring of Howe Sound’s shoreline puts homes, businesses and ecosystems at risk from ocean levels rising due to climate change. Research and education in Howe Sound has started but change is slow. The Green Shores approach can be useful, restoring coastal areas to a more natural state, using vegetation to reinforce coastal areas to preserve aquatic ecosystems, preventing erosion and protecting communities.



Stream Flows

The last few years have seen a change in historic stream flow patterns, with increasing rainfall causing high flow in winters and summers affected by record lows. This change can impact migration patterns of aquatic species such as salmon and poses increased flood risk for human settlements and facilities in Howe Sound. We lack data for most of the streams in Howe Sound and lack information on specific impacts.



Squamish Flood Planning

Rising sea levels due to climate change are expected to increase the flood threat for the District of Squamish and Howe Sound. The community is responding by developing an updated flood response plan that works with nature to protect communities and economic activity. Risks due to sea level rise are significant and the fundamental problem of human settlement on the flood plain remains despite much planning and mitigation.



CRITICAL



CAUTION

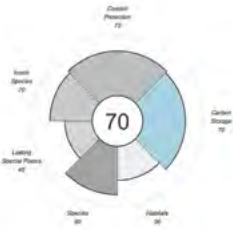
Ocean Health Index score for Coastal Protection

Howe Sound scores 73 out of 100 for coastal protection. A healthy ocean provides protection of our coasts from storm damage by living natural habitats, such as salt marshes and coastal forests.



Ocean Health Index score for Carbon Storage

Howe Sound scores 70 out of 100 for carbon storage. A healthy ocean provides long-term storage of carbon in natural marine and coastal habitats, such as salt marshes and coastal forests.



“During the sequestration of carbon dioxide, trees, marine algae and seaweeds use photosynthesis to convert carbon dioxide into biomass, organic matter used to fuel the plant. ... The total value of carbon sequestration is approximately \$6 million per year.”

FROM SOUND INVESTMENT: MEASURING THE RETURN ON HOWE SOUND’S ECOSYSTEM ASSETS
(MICHELLE MOLNAR, 2015, DAVID SUZUKI FOUNDATION)

Temperatures rise in the ocean

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What is happening?

Lately, we are setting new global temperature records each year. 2015 was the hottest year on record based on land and ocean temperatures (Figure 1), and 2014 had the same notoriety until records were compiled for 2015. Judging by land and ocean temperature or by ocean temperature alone, 2016 is shaping up to set another record.¹ Looking back 135 years, the 16 warmest years have all occurred since 1998, and that's only 18 years ago.²

In the region closer to home (i.e., a 5 degree latitude by 5 degree longitude area that includes Howe Sound, Vancouver, Victoria, and Seattle), a study of recent temperatures compared to a 30-year average for 1981 to 2010 still highlights 2014 as well above average and 2015 as extreme, more than 1.4 degrees Celsius above the 30-year average (Figure 2).³

In coastal B.C., sea surface conditions measured at 12 shore stations (mostly at light stations, part of the Fisheries and Oceans Canada Shore Station Oceanographic program) and 12 Environment Canada weather buoys show that average daily sea surface temperature (SST) at all locations was warmer by about 0.8 degrees Celsius in 2015 compared to 2014.⁴ In particular, SST at shore stations was warmer by 1.1 degrees Celsius in 2015 than the 30-year average (1980–2010) and buoy locations were warmer by 1.2 degrees Celsius in 2015 than a 22-year average for 1989–2010.⁵ None of these stations is in Howe Sound; the closest being a buoy at Halibut Bank in the Strait of Georgia.

Land & Ocean Temperature Percentiles Jan–Dec 2015

NOAA's National Centers for Environmental Information

Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0

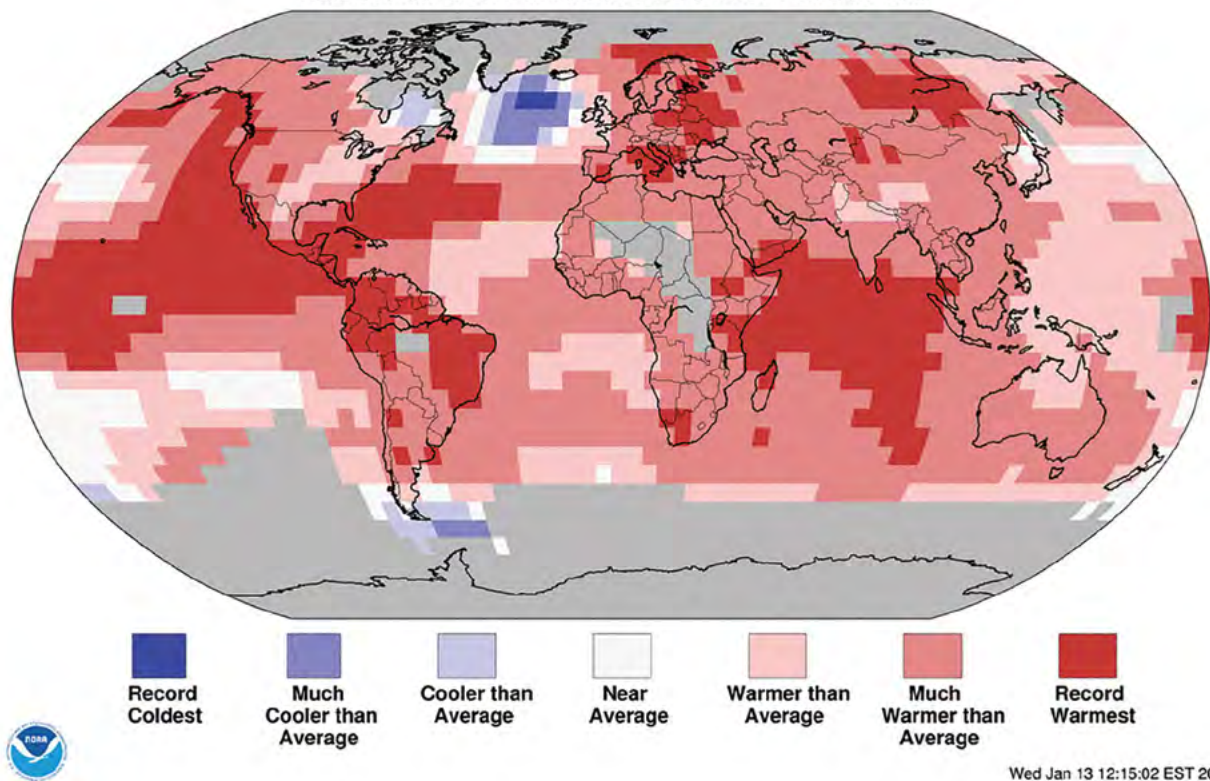


Figure 1. Land and ocean temperature percentiles for January to December 2015, compared to averages for the 20th century. Source: NOAA National Centers for Environmental Information.

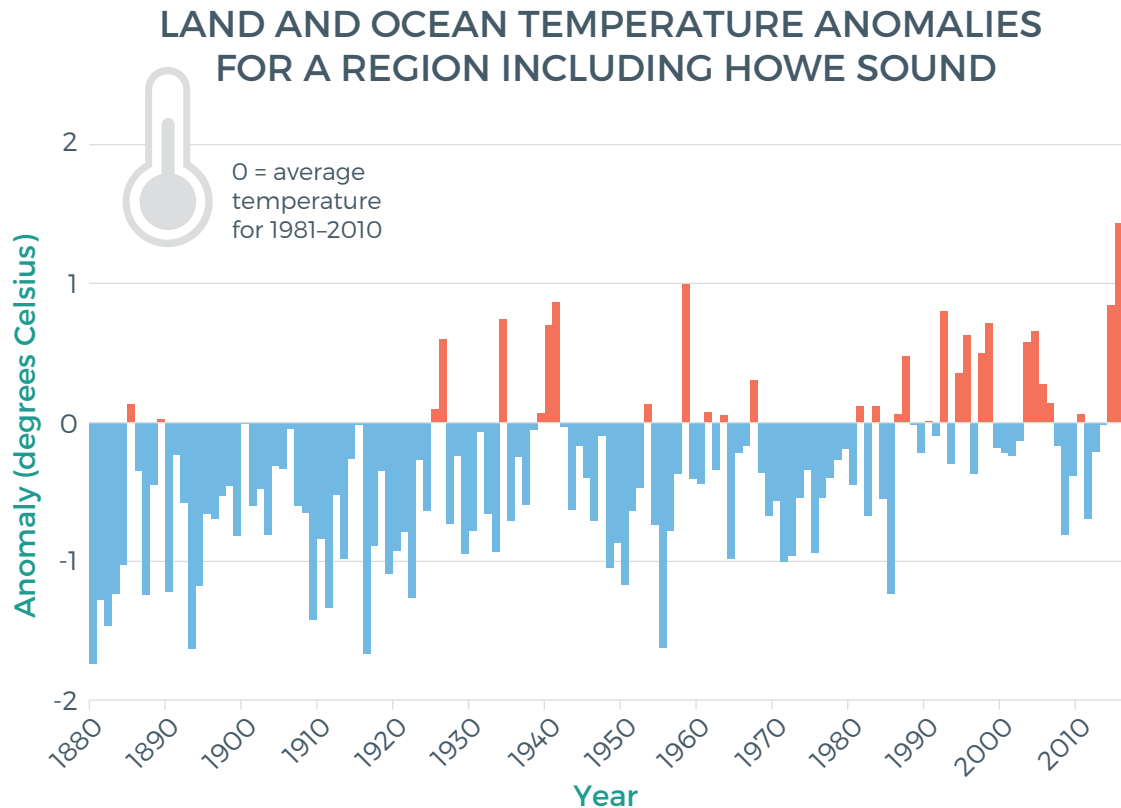


Figure 2. Annual land and ocean temperature anomalies (deviation of average annual temperature compared to the 1981–2010 average) for a 5 degree by 5 degree area that includes Howe Sound, Vancouver, Victoria, and Seattle. Source: NOAA National Centers for Environmental Information.

Why is it important?

Ocean temperature, salinity, and chemical properties like pH, a measure of acidity, tell us about the climate of the ocean. Species have long adapted to ocean climates that are typical for the region where they live. Changes to ocean climate that are outside of the historical range of variability can affect species and predator-prey relationships in various ways. Species ranges may migrate with temperature changes, generally moving north to stay within a preferred thermal zone, or species may suffer or adapt to warmer temperatures. Range shifts and adaptation will vary among species and other factors such as coastal de-

velopment, management patterns, or even population specific adaptation may play a role. Salmon, for example, in fresh water temperatures above 18 degrees Celsius show signs of decreased swimming performance while temperatures above 20 degrees Celsius can result in disease, poor egg quality, and even mortality, but different populations may be able to adapt to changing conditions better than others.⁶ Predator-prey relationships are vulnerable to changes in ocean climate from both a timing and abundance perspective. Preferred prey species may be less abundant due to warming conditions or may become un-

available at the time they are sought. For example, as a consequence of shifts in timing of the spring bloom and the cascade of productivity that results, plankton and zooplankton may not be present when salmon fry emerge and migrate to nearshore habitats.

Warmer ocean temperatures have a direct effect on sea level because as water warms the volume increases. This means sea level is rising in relation to temperature, no matter how much sea ice is melting and adding volume. Increases in sea level⁷ will amplify the risk of coastal flooding (see flood hazard management article).

The timing of biological events can be altered by warming and other effects of climate change like changing freshwater flow patterns and the risk is that critical biological interactions become out of synch. A prime example here is the timing of salmon spawning runs.⁸ If, for example, juvenile salmon migrated to saltwater at a time when the plankton they feed on was unavailable, they would need to adapt to another food source or suffer. At the same time, changes in temperature and salinity patterns will affect ocean currents and, in turn, upwelling processes and cycles of productivity may be altered. Although some study is occurring, projections of changes to circulation patterns and upwelling are not conclusive.⁹

What is the current state?

Sea surface temperature in 2015 was the warmest on record globally and in the Strait of Georgia, but we have no direct observations for Howe Sound. Some of the projected effects of a warmer ocean are being wit-

nessed locally, regionally, and in the Northeast Pacific. The context of Howe Sound's location is important to consider. The oceanography of the Strait of Georgia, the hydrodynamic connections to the Pacific, and the

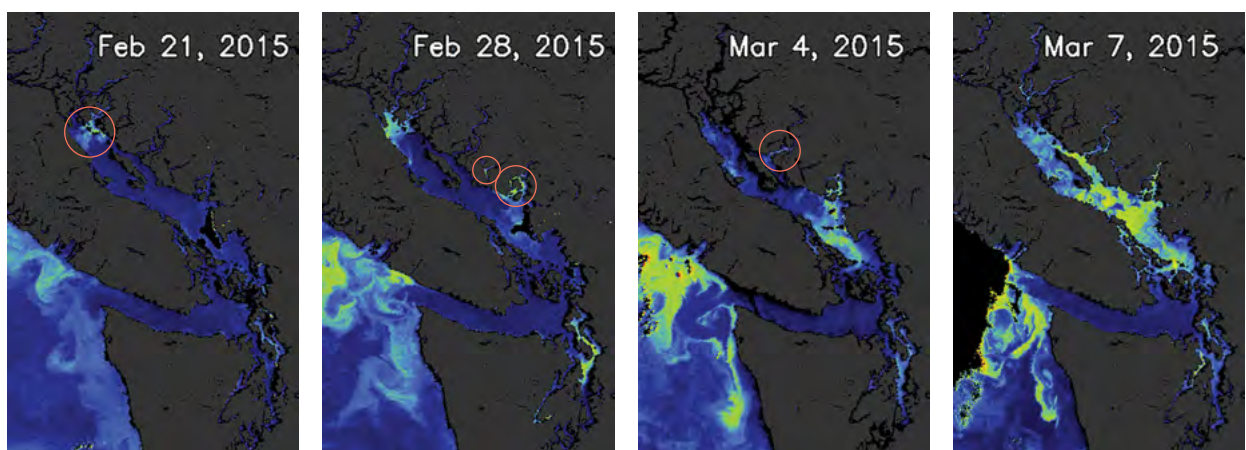


Figure 3. NASA MODIS Aqua fluorescence images for three days leading up to the main spring bloom in the Strait of Georgia (left three panels). Red circles indicate areas where blooms in inlets occur before high chlorophyll values are observed in adjacent areas of the Strait of Georgia. The MODIS image on March 7 (right panel) shows the bloom covering almost the entire Strait. (Figure provided by S. King, Sea This Consulting)

proximity of the Fraser River and the city of Vancouver, will all play a role in local changes observed in Howe Sound.

In Howe Sound, for example, northern anchovy, a species known to be highly responsive to shifts in ocean condition,¹⁰ were observed in Howe Sound in both 2015 and 2016.¹¹ While anchovies have been fished on the West Coast of Vancouver Island and infrequently in the Strait of Georgia,¹² they are much more commonly found along the coast of California in warmer waters.

The timing of a spring phytoplankton bloom is not directly related to sea surface temperature, but the spring bloom in 2015 was earlier than usual off the west coast of Vancouver Island (February 23, as seen in satellite images) and in the Strait of Georgia, where it started in late February in Desolation Sound and Howe Sound (Figure 3).^{13,14} This was the earliest spring bloom in the Strait of Georgia since 2005.¹⁵

Warmer water temperatures and increased stratification (i.e., when water masses with different properties form layers creating a barrier to mixing), both in the North Pacific Ocean and closer to home, have been projected to result in more frequent phytoplankton blooms, including more frequent and severe harmful algae blooms, and a longer season of blooms.¹⁶ In mid November 2016, large schools of juvenile anchovy were observed again in Horseshoe Bay, suggesting that a late fall bloom supported another successful spawn event.¹⁷

In addition, ocean acidification, another effect of climate change, may increase the toxicity of some harmful algal blooms.¹⁸ Exact cause and effect is hard to determine, but 2015 saw an unusually large bloom along

the North American Coast, from California to Alaska, which was prolonged (May to August), and with a toxic (domoic acid) component, a type of harmful algal bloom (HAB).¹⁹ Concentrations of domoic acid in seawater, some forage fish, and crab samples were among the highest ever reported for the region, including levels 10 to 30 times greater than normal in Monterey Bay California.²⁰ NOAA announced an Unusual Mortality Event for large whales in the western Gulf of Alaska, following the death of nearly 30 large whales since May 2015, and numerous fisheries were closed along the U.S. West Coast.²¹ In early July 2015, the Canadian Food Inspection Agency (CFIA) detected toxin levels in shellfish above the Canadian safe allowable standards in three areas along northwest Vancouver Island during routine monitoring and these areas were closed to shellfish harvest as a result.²² Canada does not have a HAB monitoring program in the Pacific region.

Finally, changes in productivity patterns due to reduced upwelling with warming waters are expected. Evidence of this was seen well offshore in 2015 in the northeast Pacific in the form of nutrient (nitrate) depletion and lower than usual chlorophyll concentrations.²³ (I.e., Nitrate is normally upwelled from deeper waters to feed chlorophyll, but a warmer surface layer prevented this from occurring in summer 2015.) Nutrient levels are also monitored in the Salish Sea by Fisheries and Oceans to continue to develop an understanding about nutrient supply conditions, changes in the Salish Sea and possible impacts on Howe Sound.

These reported unusual events and conditions in the region and beyond are linked to a warming ocean. We cannot report local events and conditions due to lack of data locally in Howe Sound.

What is being done?

Fisheries and Oceans Canada (DFO) has numerous scientists monitoring and reporting on ocean conditions, including physical and biological, and select fishery resources for the Canadian Pacific, with some focus on the Strait of Georgia or the Northern Shelf Bioregion, through the “State of the Pacific Ocean” workshop and report series.²⁴ DFO has carried out a Salish Sea monitoring survey over the past 15 years. A science research vessel is used to collect physical, chemical and biological data at about 80 stations over a one week period three to four times per year. Howe Sound and other unique inlets and fjords do not receive individual attention or regular monitoring and reporting with respect to sea surface temperature, chemical properties or plankton surveys.

The Pacific Salmon Foundation is involved in at least two citizen science supported projects in the Strait of Georgia. One uses a “mosquito fleet” of fishing vessels to do oceanographic surveys in nine overlapping areas to collect oceanographic data²⁵ and the other, in collaboration with University of Victoria, involves passengers on BC Ferries in the testing of a Hydro-Colour App that may help turn photos of the sky and sea into useful measurements of ocean productivity.²⁶

Two major groups in Oregon and Washington — the Oregon Climate Change Research Institute at Oregon State University and the Climate Impacts Group at University of Washington — are actively researching climate change in the Pacific Northwest. Among other things, they are looking at impacts on the oceans and coastal communities.

The Pacific Climate Impacts Consortium (PCIC) provides practical information on climate variability and impacts of climate change in our region. They released a “science brief” on simulated oceanic conditions along the B.C. continental shelf, which explains modeled projections in non-scientific language.²⁷

The National Oceanic and Atmospheric Administration (NOAA) of the U.S. provides many online resources and tools. NOAA’s National Centers for Environmental Information monitors and assesses the state of the Earth’s climate in near real time and provides data and information on climate trends and variability including comparisons to the climate of the past.

What can you do?

SOME ACTIONS CONTRIBUTED BY CORI



Individual and Organization Actions:

- Help prevent climate change by producing fewer greenhouse gasses. Adopt policies and practices within your organization.
- Eat sustainable seafood to foster healthy and resilient fish populations.



Government Actions and Policy:

- Incorporate latest climate change hazard assessments into emergency response planning.
- Protect any cold water “refugia” within rivers. Strengthen regulations that protect riparian areas along streams to keep warming to a minimum.
- Acknowledge that diversity among salmon populations will be critical in helping salmon populations adapt to future climate conditions and develop policy to maintain the diversity.

Resources

NANOOS

The Northwest Association of Networked Ocean Observing Systems. NANOOS (nanoos.org) is part of IOOS (ioos.noaa.gov) and provides information and products related to weather and ocean data.

Pacific Climate Impacts Consortium

The Pacific Climate Impacts Consortium (PCIC – pacificclimate.org) is a regional climate service center at the University of Victoria that provides practical information on the physical impacts of climate variability and change in the Pacific and Yukon Region of Canada.

Climate Central

climatecentral.org

An independent organization (U.S.) of leading scientists and journalists researching and reporting facts about the changing climate and its impacts including on the ocean.

Preparing for Climate Change

wcel.org/sites/default/files/WCEL_climate_change_FINAL.pdf

An implementation guide for local governments in British Columbia.

NOAA: National Centers for Environmental Information

www.ncdc.noaa.gov/climate-monitoring/

Map of Shellfish Harvesting Status for B.C. showing biotoxin status and sanitary status

maps.bccdc.org/shellfish/

Footnotes

¹ NOAA National Centers for Environmental information, Climate at a Glance: Global Time Series, published September 2016, retrieved on October 5, 2016 from <http://www.ncdc.noaa.gov/cag/>

² See 135 years of global warming in less than 30 seconds; watch the video. <https://www.theweathernetwork.com/news/articles/see-the-graphics-that-lock-2015-in-as-hottest-year-on-record/62607/>

³ NOAA National Centers for Environmental information, Climate at a Glance: Global Mapping, published September 2016, retrieved on October 5, 2016 from <http://www.ncdc.noaa.gov/cag/>

⁴ Chandler, P. 2016. Sea surface temperature and salinity trends observed at lighthouses and weather buoys in British Columbia, 2015. In: Chandler, P.C., King, S.A., and Perry, R.I. (Eds.). 2016. State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2015. Can. Tech. Rep. Fish. Aquat. Sci. 3179: viii + 230 p. Available online: <http://waves-vagues.dfo-mpo.gc.ca/Library/365564.pdf>

⁵ SSTs along the outer coast of B.C. were significantly influenced in 2014 and 2015 by the warm water anomaly known as “the Blob”. These years are considered anomalous. See 2015 State of Pacific Ocean Report referenced above in footnote 4.

⁶ Eliason, E.J., T.D. Clark, M.J. Hague, L.M. Hanson, Z.S. Gallagher, K.M. Jeffries, M.K. Gale, D.A. Patterson, S.G. Hinch and A.P. Farrell. 2011. Differences in thermal tolerance among sockeye salmon populations. Science 332(6025): 109–112

⁷ Sea level will also be influenced by other changes associated with climate change, notably more intense storm events causing large storm surges.

⁸ Mauger, G.S., J.H. Casola, H.A. Morgan, R.L. Strauch, B. Jones, B. Curry, T.M. Busch Isaksen, L. Whitely Binder, M.B. Krosby, and A.K. Snover, 2015. State of Knowledge: Climate Change in Puget Sound. Report prepared for the Puget Sound Partnership and the National Oceanic and Atmospheric Administration. Climate Impacts Group, University of Washington, Seattle. doi:10.7915/CIG93777D

⁹ Ibid.

¹⁰ Horn, M., L.A. Allen and R.N. Lea. 2006. Biogeography. In: Allen, L.G., D.J. Pondella II and M.C. Horn (Eds) *The Ecology of Marine Fishes California and Adjacent Waters*. University of California Press. 660pp.

¹¹ Anchovy sighting data from Gibbs, D.M., C. Gibbs, and A. Lamb. Pacific Marine Life Surveys. Data accessed Sept 16, 2016. Opportunistic sightings are recorded, so the information is not from systematic surveys and anchovy may have present in years not recorded.

¹² Fisheries and Oceans Canada. 2002. Pacific Region 2002 Management Plan Anchovy. It is not clear in the management plan if any commercial fishery openings for anchovy did occur in 2002, but no management plan for Anchovy has been published since then.

¹³ Gower, J. and S. King. 2016. Satellite and Buoy Observations of B.C. Waters. In: Chandler, P.C., King, S.A., and Perry, R.I. (Eds.). 2016. State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2015. Can. Tech. Rep. Fish. Aquat. Sci. 3179: viii + 230 p. Available online: <http://waves-vagues.dfo-mpo.gc.ca/Library/365564.pdf>

¹⁴ Carswell, T., M. Costa, A. Hilborn and R. Sweeting. 2016. Chlorophyll Phenology in the Salish Sea: Spatial and Temporal Data from Ocean Colour Satellites Imagery. In: Chandler, P.C., King, S.A., and Perry, R.I. (Eds.). 2016. State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2015. Can. Tech. Rep. Fish. Aquat. Sci. 3179: viii + 230 p. Available online: <http://waves-vagues.dfo-mpo.gc.ca/Library/365564.pdf>

¹⁵ Allen, S.E., D.J. Latonell, E. Olson and R. Pawlowicz. 2016. Timing of the spring phytoplankton bloom in the Strait of Georgia, 2015 AND 2016. In: Chandler, P.C., King, S.A., and Perry, R.I. (Eds.). 2016. State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2015. Can. Tech. Rep. Fish. Aquat. Sci. 3179: viii + 230 p. Available online: <http://waves-vagues.dfo-mpo.gc.ca/Library/365564.pdf>

¹⁶ Integrated Ocean Observing System. 2016. Climate. Accessed Oct 6, 2016. <http://www.nanoos.org/education/themes/climate.php>

¹⁷ Jeff Marliave (Senior Researcher, Vancouver Aquarium Marine Science Centre), discussion with K. Bodtker, Coastal Ocean Research Institute, Nov 15, 2016.

¹⁸ Mauger et al. 2015.

¹⁹ Trainer, V.L., McCabe, R. Hickey, B. and Kudela, R. 2015. The impacts of a massive harmful algal bloom along the US west coast in 2015. PICES 2015 Annual Meeting, Book of Abstracts, p. 130. Accessed Oct 7, 2016. http://www.pices.int/publications/book_of_abstracts/2015-PICES-Book-of-Abstracts.pdf

²⁰ Ibid.

²¹ Ibid.

²² Pena, A. and N. Nemcek. 2016. Phytoplankton in the Surface Waters along Line P and Off the West Coast of Vancouver Island. In: Chandler, P.C., King, S.A., and Perry, R.I. (Eds.). 2016. State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2015. Can. Tech. Rep. Fish. Aquat. Sci. 3179: viii + 230 p. Available online: <http://waves-vagues.dfo-mpo.gc.ca/Library/365564.pdf>

²³ Ibid.

²⁴ Fisheries and Oceans Canada. 2016. State of the Pacific Ocean, Technical Reports, Research Documents, Advisory Reports (Summary), and Reports. Accessed Oct 7, 2016. <http://dfo-mpo.gc.ca/oceans/publications/index-eng.html#state-ocean>

²⁵ <https://www.psf.ca/blog/citizen-science-boats-are-coming-communities-near-you>

²⁶ <https://www.psf.ca/blog/citizen-science-bc-ferries>

²⁷ <https://www.pacificclimate.org/news-and-events/news/2014/new-pcic-science-brief-model-simulation-future-oceanic-conditions-along-british-columbia-continental>

Shorelines and Sea Level Rise

“Estuaries and bays, coastal wetlands, headlands, seagrass beds, rock reefs and kelp forests provide protection from storms, storm surges, tsunamis and other disturbances. ... The total value of disturbance regulation services in Howe Sound ranges from approximately \$98 million to \$250 million per year. We found beaches to be the highest per hectare value land class for disturbance regulation.”

FROM SOUND INVESTMENT: MEASURING THE RETURN ON HOWE SOUND'S ECOSYSTEM ASSETS (MICHELLE MOLNAR, 2015, DAVID SUZUKI FOUNDATION)

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REVIEWER

DG Blair, Executive Director, Stewardship Centre for BC

What is happening with our shorelines?

“In the next century, the majority of America’s tidal shorelines could be replaced by a wall, not because anyone decided that this should happen but because no one decided that it should not.”¹

As the climate changes, winter storm surges consisting of big waves and high winds, and anomalously high “king tides,” will increasingly work in concert with sea level rise to threaten coastal communities and shoreline ecosystems (Figure 1). Public discussion can easily focus on fortifying soft shorelines with riprap and seawalls, or building bigger, better sea dikes. But such conventional engineering solutions can have unintended consequences: cause beaches to erode, eliminate habitat for birds, mammals and fish, and disconnect shorelines from upland habitats. However, there are more environmentally friendly alternatives, such as Green Shores, a pro-



Figure 1. Beached logs along outer Howe Sound shorelines were mobilized during a major winter storm coincident with high tides in October 2016. Heaving masses of log debris collected on windward beaches, eroding shorelines, as here at September Morn Beach, Bowen Island. (Photo: Bob Turner)

gram of the Stewardship Centre for British Columbia.² In 2014, Green Shores won the Best Environmental Idea award at Simon Fraser University's RISE event.³ Teams were asked to answer the challenge: "How can we design Metro Vancouver communities to adapt and thrive in the context of a one metre rise in sea level?"

Howe Sound can look to its neighbours for inspiration. The District of West Vancouver in collaboration with the West Vancouver Shoreline Preservation Society pioneered shoreline enhancement projects in

2006 that continue today and include construction of offshore reefs to dissipate storm wave energy and enhance beaches.⁴ The Green Shores Gold-rated project for the restoration at Jericho Beach in English Bay won the City of Vancouver's 2014 Urban Design Awards in Landscape, Public Space and Infrastructure (Figure 2).⁵ The District of Squamish Integrated Flood Hazard Management Plan includes some long term sea diking options that follow the Green Shores approach (see Squamish Flood Planning article).



Figure 2. Jericho Beach restoration in English Bay, Vancouver, a Green Shores Gold-rated project. (Photo: Nick Page)

Why is sea level rise important to Howe Sound?

Shorelines in Howe Sound are critical habitat for diverse species and include the immediate upland, intertidal zone and shallow marine waters of rock shores, gravel and sand beaches, and marsh and fine sediment of estuaries. Like other shorelines around the Salish Sea, they have been greatly modified since the arrival of European settlers in the early 1800s. Shoreline forests were cut and cleared, estuaries diked and drained, stream flow changed by land clearing, and intertidal zones modified and sometimes polluted by settlements and industry.^{6,7} More recently private homes, docks, and shoreline alteration have proliferated and, looking forward, major shoreline residential and industrial developments are proposed.

Against this backdrop of historic shoreline modification, sea level is rising as our changing climate causes oceans to warm and expand, and glaciers to melt, adding water to the oceans. Climate change-driven sea level rise results in a steady and irreversible movement of the natural shoreline landward, punc-

tuated by storm surges that produce coastal flooding and erosion.⁸ The B.C. Government has advised local governments to plan for a rise in sea level of one metre by 2100 and two metres by 2200,⁹ though some climate scientists have recently suggested a “several metre rise in the next 50 to 150 years” is possible.¹⁰

The potential impacts of sea level rise are large: increased risk to coastal infrastructure, including increased maintenance and repair costs, loss of property due to erosion, loss of cultural and historical sites, saltwater intrusion into coastal aquifers, and loss of habitat and reduced biodiversity.¹¹ Costs of adaptation are high; an estimate for Vancouver and surrounding communities is \$9.5 billion over the century.¹² Possible responses to sea level rise in developed areas include shoreline armouring, allowing water in and adapting to its impacts through landscape design and building modifications, and abandoning the land and retreating inland.¹³

What is the status of shoreline protection and enhancement?

“Waterfront property owners sometimes decide to build a wall along the shoreline to protect their property from erosion, but they can do a lot of damage if they do it the wrong way. Poorly designed seawalls not only damage fish habitat and archaeological sites, they interrupt natural shoreline processes. Waterfront owners can actually increase erosion on their own and neighbouring properties.”¹⁴

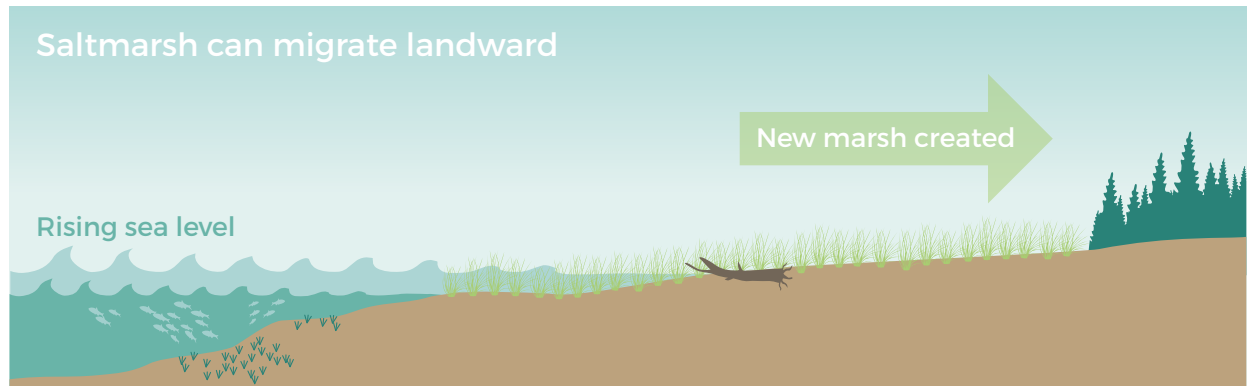
Not all shorelines are equally vulnerable to sea level rise in Howe Sound.¹⁵ Most of Howe Sound’s shorelines are rocky shores that are naturally-armoured. Shorelines with beaches backed by bluffs of sand and gravel, though widespread along the nearby Sunshine Coast and Point Grey, are less common in Howe Sound. Most occur along its west shores between Port Mellon and Gibsons, and scattered elsewhere on the mainland and islands such as Plumper Cove on Keats Island and Mannion Bay on Bowen Island.¹⁶ Bluff tops along these shores have been prime sites for residential developments, and these bluffs are more vulnerable to erosion as seas rise. Flat beaches, and estuary wetlands such as at the mouths of the Squamish River and McNab Creek, are especially vulnerable to erosion and inundation due to their low elevation depending on the relative rates of natural addition of sediment versus sea level rise (Figure 3). Where backstopped by hard barriers such as cliffs or sea dikes, beaches and wetlands cannot migrate landwards with rising seas, leading to loss of their area, a phenomenon known as “coastal squeeze.”¹⁷

As part of a shoreline mapping project,¹⁸ the Islands Trust published a series of shoreline maps for Keats (2013) and Gambier Islands (2011)^{19,20} showing shoreline type, dominant direction of wave energy hitting each island, the locations of streams that supply sediment to the shores, estimated direction of local sediment movement, and vulnerable and valuable areas. The maps illustrate the sediment supply that is critical to maintaining beaches and estuaries in the face of rising sea levels. Mapping project results show that Keats Island has a slightly larger percentage of soft shorelines (Figure 4) which are vulnerable to erosion and most of which are also associated with high recreational value and high ecological value (e.g., pocket



Figure 3. Eroding and retreating shoreline edge of estuary meadow at McNab Creek estuary, Howe Sound. (Photo: Bob Turner.)

Coastal squeeze



AMOUNT OF SOFT (VULNERABLE) AND HARD SHORELINE TYPES

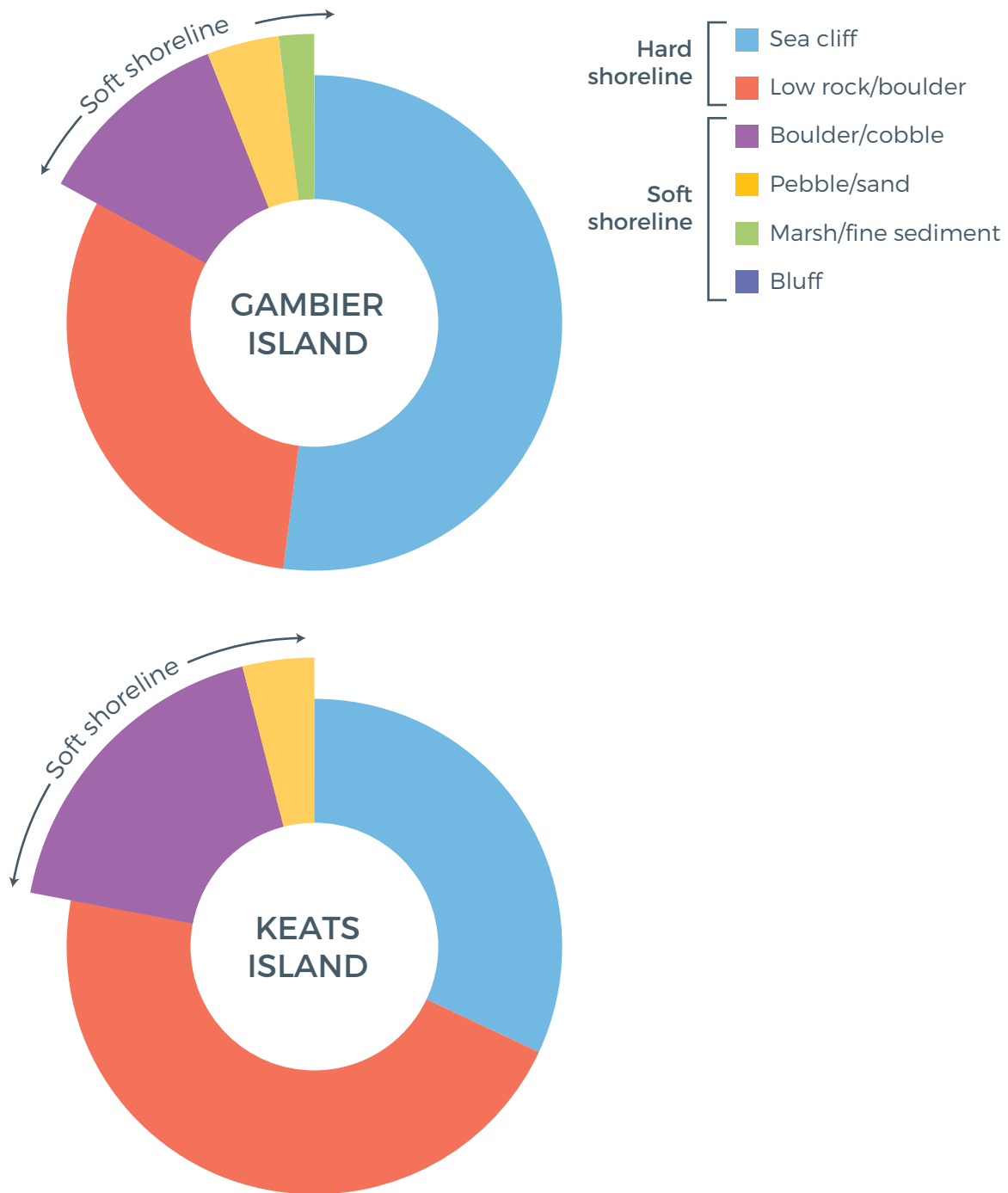


Figure 4. Shoreline types for Gambier and Keats Islands in Howe Sound.

beaches and estuaries). Gambier has some “low lying areas”²¹ mapped as particularly vulnerable to sea level rise.

Traditional “hard” engineering solutions to armouring shorelines with seawalls or riprap can produce unintended consequences such as increased erosion or damage to shoreline environmental habitat.¹⁴ “Soft” shore armouring includes addition of imported sand and gravel (i.e., adding like material to the beach such as sand and gravel to reverse the chan-

ges that often occur with hard armouring), dune and wetland construction, shore vegetation preservation or restoration, and construction of near shore reefs. Beach shorelines prone to erosion and inundation by sea level rise are very amenable to Green Shores soft alternative armouring. Fortunately, this “soft” approach promoted by Green Shores has been found to be more cost effective than traditional “hard” engineering solutions, reducing costs by 30 to 70 percent, while also producing much better environmental outcomes for shorelines.²²

What is being done?

The Islands Trust has embraced Green Shores for shoreline homes²³ and their website hosts a broad range of information on shoreline types and geology, shoreline ecosystems, and best practices for homeowners and residents.²⁴ Following on the shoreline mapping, Islands Trust engaged the Gambier and Keats Island communities in 2013 in a “Greening our Shores” workshop on Green Shores for Homes, and eelgrass and forage fish mapping.²⁵

In 2005 and just around the corner from Howe Sound, concerned citizens, the District of West Vancouver (DWV) and the West Vancouver Shoreline Preservation Society (WVSPS) established the Shoreline Protection Program (SPP) and the first Department of Fisheries and Oceans (DFO) authorized shoreline protection pilot projects along Burrard Inlet.^{26,27,28} Since then, the DWV, its community groups, corporations and private

citizens have worked together with funding from federal, provincial and private sources to develop a SPP that protects and enhances the value of their waterfront community.

The SPP pilot projects developed shoreline techniques to address shoreline erosion and loss of habitat. The techniques retain fine sediments, build habitat features that buffer wave energy and support beach growth, and result in increased biodiversity and habitat productivity. Since 2005, the SPP has completed over 30 projects ranging in size from several 100 square metres to over 10,000 square metres. One SPP project resulted in the beach retention of over 200 truckloads of creek sediments that previously would have been ejected into deep water; another saw the establishment of a barnacle community that produces over 3.5 trillion barnacle larvae annually, a principal

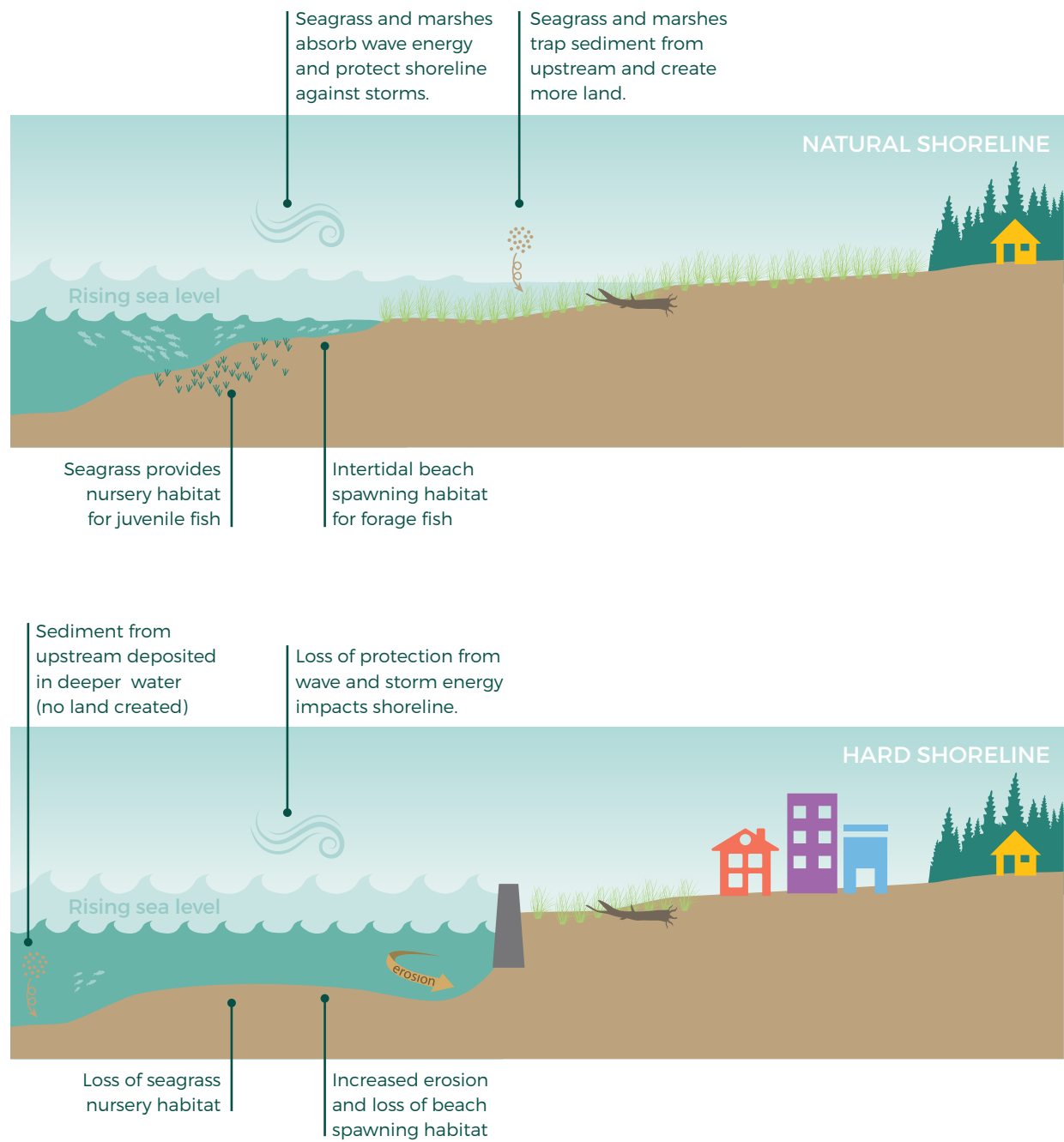


Figure 5. Construction of an artificial offshore reef, West Vancouver. (Photo: Balanced Environmental)

food source for juvenile salmon. DWV SPP techniques have enhanced the estuaries of Lawson, MacDonald and Rodgers Creeks resulting in improved fish access to spawning grounds at lower tides. Salmon can now enter the creeks at low to medium tides rather than needing to wait offshore for higher-high water where they are vulnerable to seal predation.^{29,30}

Key construction materials in the SPP are clean rock and coarse sediments excavated from local development sites that would otherwise be hauled away to landfills (Figure 5). These materials are repurposed for intertidal rock mounds and subtidal reefs that trap beach sediments, are colonized by kelp, other algae, barnacles and mussels, and support a diverse community of marine invertebrates, water fowl and mammals (Figure 6).

Impacts of hard shorelines



What can you do?



Individual and Organization Actions:

- Learn how to care for your shoreline. The Islands Trust has a rich suite of resources on their website: <http://www.islandstrust.bc.ca/islands/island-ecosystems/caring-for-my-shoreline/>
- Check out www.greenshoresforhomes.org for further tips and to enroll your project with Green Shores.
- As a waterfront homeowner, trees are your best defense against erosion. They stabilize slopes with their roots. Trim or limb, rather than remove, to maintain your views. Think twice about sea walls; work with nature instead.



Government Actions and Policy:

- Use Green Shore approaches for protecting and enhancing public shorelines in communities.
- Join the Green Shores Local Government Working Group for Green Shores support and resources http://stewardshipcentrebc.ca/Green_shores/green-shores-local-government-group
- Adopt Green Shores approach as a policy



Figure 6. Marine life colonizing an artificial reef at Ambleside, West Vancouver. (Photo: Balanced Environmental)

Resources

Stewardship Centre of BC

stewardshipcentrebc.ca/Green_shores/

Green Shores Publications

stewardshipcentrebc.ca/Green_shores/resources/

- Green Shores for Coastal Development Guide
- Green Shores for Homes Guide
- Green Shores Policy and Regulatory Tools for Local Government Report 2016

West Vancouver Shoreline Preservation Society

westvanshoreline.ca

Shoreline and Watershed Mapping for Gambier and Keats Islands

islandstrust.bc.ca/media/205766/11.10.17%20IT%20Gambier%20shoreline%20mapping.pdf

islandstrust.bc.ca/media/168406/gambiershorelinemappingkeats.pdf

Sharing our Shorelines Brochure

islandstrust.bc.ca/media/232136/FINAL%20Sharing%20Our%20shorelines.pdf

Footnotes

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Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Guidelines for Management of Coastal Flood Hazard Land Use. 27 January 2011. 15 pages plus appendices. http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/coastal_flooded_land_guidelines.pdf

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¹² Province of B.C. 2012. Cost of Adaptation – Sea Dikes & Alternative Strategies. Prepared by Delcan for Ministry of Forests, Lands and Natural Resource Operations. Accessed Oct 26, 2016. http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/cost_of_adaptation-final_report_oct2012.pdf

¹³ Green Shores Policy and Regulatory Tools for Local Government Report 2016. Prepared by West Coast Environmental Law for the Stewardship Centre for BC. http://stewardshipcentrebc.ca/Green_shores/resources/

¹⁴ L. Adams, Islands Trust News Release, June 11, 2012. <http://www.islandstrust.bc.ca/media/100876/newsjun112012.pdf>

¹⁵ Shoreline types. Islands Trust. <http://www.islandstrust.bc.ca/islands/island-ecosystems/caring-for-my-shoreline/>

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¹⁹ Islands Trust. Keats Island Maps: Distribution of shoreline types; Energy and sediment movement; Shoreline values and vulnerability. <http://www.islandstrust.bc.ca/media/168406/gambiershorelinemappingkeats.pdf> (Note that while the pdf map illustration is accurate, the tally of length by shoreline type at the bottom has errors. The correct data was obtained by email from K. Emmings and M. Van Bakel of Islands Trust.)

²⁰ Islands Trust. Gambier Island. Maps: Distribution of shoreline types; Energy and sediment movement; Shoreline values and vulnerability. <http://www.islandstrust.bc.ca/media/205766/11.10.17%20IT%20Gambier%20shoreline%20mapping.pdf>

²¹ Low lying vulnerable areas were defined as areas 0–4 metres in elevation above existing Mean Sea Level and greater than 50 metres of width from the shore.

²² Lamont, G., J. Readshaw, C. Robinson, P. St-Germain. 2014.

Greening Shorelines to Enhance Resilience, An Evaluation of Approaches for Adaptation to Sea Level Rise; guide prepared by SNC-Lavalin Inc. for the Stewardship Centre for B.C. and submitted to Climate Change Impacts and Adaptation Division, Natural Resources Canada (AP040), 46p. http://stewardshipcentrebc.ca/Green_shores/resources/

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²⁴ Caring for My Shoreline, Islands Trust. <http://www.islandstrust.bc.ca/islands/island-ecosystems/caring-for-my-shoreline/>

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²⁸ Scott Christie, Balanced Environmental, email communication, October, 14, 2016.

²⁹ Department of Fisheries and Oceans. Success Stories, British Columbia, <http://www.dfo-mpo.gc.ca/pnw-ppe/rfcpp-ppcpr/success-succes-eng.html>

³⁰ West Vancouver Streamkeeper Society. <http://www.westvancouverstreamkeepers.ca/activities/major.html>

Changes in streamflow: recent observations match climate change projections

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What is happening?

We hear more and more about “extreme” weather events and their impacts in recent years. For example, on Sept. 20 2015, high rainfall and flooding in the Squamish valley washed out sections of the Forest Service Road accessing the Upper Squamish Valley. Squamish Search and Rescue lifted five adults and two children out of the area by helicopter and reported that at least five vehicles were swept into the river on that day.¹ It turns out that new maximum streamflows were observed, for that calendar day and the next, into the Daisy Lake Reservoir on the Cheakamus River north of Squamish. Streamflows on those days were not extreme compared to historical records, but were higher than recorded since 1960 for those calendar dates.

For this article, naturalized daily freshwater flow into the Daisy Lake Reservoir was examined.² Compared to long-term averages for 1960 to 2014, daily flows in 2015 showed highest volumes early in the year rather than in the fall, and summer flows that were consistently below average from early June almost to the end of August (Figure 1). New minimums for a few calendar days were recorded in June and July. Data for 2016 is following a similar pattern and this new seasonal pattern matches climate projections for the region.³

Impacts of changing climate and weather patterns

Increased
high-intensity
precipitation



Decreased
snowpack

Disruption of tourism
& recreation attractions



Stream water
shortages



Increased water
temperature due
to hotter and drier
summers



Increased
river flooding



Changes in
freshwater
supply



Need for water
conservation &
storage

Increased ocean
storm surge



Thermal
stress
on fish



Shifts in
food web
productivity

Why is it important?

Many species are adapted to the historical patterns of seasonal flow in freshwater streams and creeks. In Howe Sound this would include, among others, salmonid and eulachon species that migrate between the sea and freshwater to spawn and back to mature. Phytoplankton, plant like organisms at the base of marine food webs, blooms in the spring depending on a number of factors including freshwater input and cloudiness of the water, especially at the head of a fjord like Howe Sound. Changes in the timing of a spring phytoplankton bloom due to a different freshwater flow regime could produce a timing mismatch that would impact the growth and survival of zooplankton, and have impacts further up the food web ([see Plankton article](#)).

Streamflow is a traditional metric for hydrology; one that is used to describe the hydrologic regime, or seasonal pattern of flow in a stream or river.⁴ This pattern is obviously a reflection of the climate and weather patterns, as flow varies with rainfall and snow and glacier melt related to temperature.

Howe Sound sits within the South Coast Region, where trends show climate warming and increased precipitation with large variability in the winter season.⁵ Projections for the region include warming in all seasons and modest precipitation changes compared to historical variability. Precipitation is projected to increase in all seasons except summer. These changes are already reflected in the new pattern of flows reported in the Cheakamus watershed.

Potential direct impacts include decreased snowpack, increased high-intensity precipitation, possible water shortages, and increased thermal stress on fish and aquatic habitats (due to hotter and drier summers).³ In addition, both river flooding and ocean storm surge events may increase in frequency and magnitude and a transition to rainfall-dominant watersheds would create the need for water conservation and storage.³ Some of the potential indirect impacts of these projected changes include disruption of tourist and recreation attractions with economic consequences, shifts in food web productivity with ecological consequences, and changes in fresh water supply with consequences for wellbeing and governance.



Flooded road in the Squamish valley, September 20, 2015. (Photo: Barb Lang)

Rivers, waterways were the paths of Our Ancestors⁶

Historically, the rivers, lakes and oceans of our territories teemed with salmon, herring and trout, all valuable food sources. These waterways were also the roads and highways of our Ancestors, an efficient way of getting from one Nation to another for trade and social gatherings. Water features large in our oral histories, reflecting the fact that water was, and in many ways still is, the lifeblood of the Squamish Nation.



Photo: Gary Fiegehen

“We would travel by canoe from Stá7mes (Stawamus) to the town of Newport (Squamish) to go shopping. My sister Ch’atatult-t (Florence) and I would take the canoe. We would buck the tide but we made it. I was strong for a small woman.” – Kwítelut-t Sintl’ (Late Elder Lena Jacobs), Squamish Nation

What is the current state?

Streamflow in 2015 and 2016 compared to the historical pattern shows higher than average winter flows, especially late January through late February when we would typically be experiencing snowfall, earlier spring freshet, and lower than average flows in summer from June through August (Figure 1.) These changes are mirrored to some extent across watersheds that impact B.C. coastal waters.⁷ 2015 was an extreme climate year according to more than one indicator.

Global records set in 2015 include the warmest year, the largest increase in carbon dioxide, the highest sea surface temperatures and heat contained in the upper portion of the ocean (meaning highest sea surface heights), and the lowest sea ice levels.⁸

Historically, the seasonal pattern in the Cheakamus River watershed has included high flows during snow and glacial melt starting in April and peaking in June

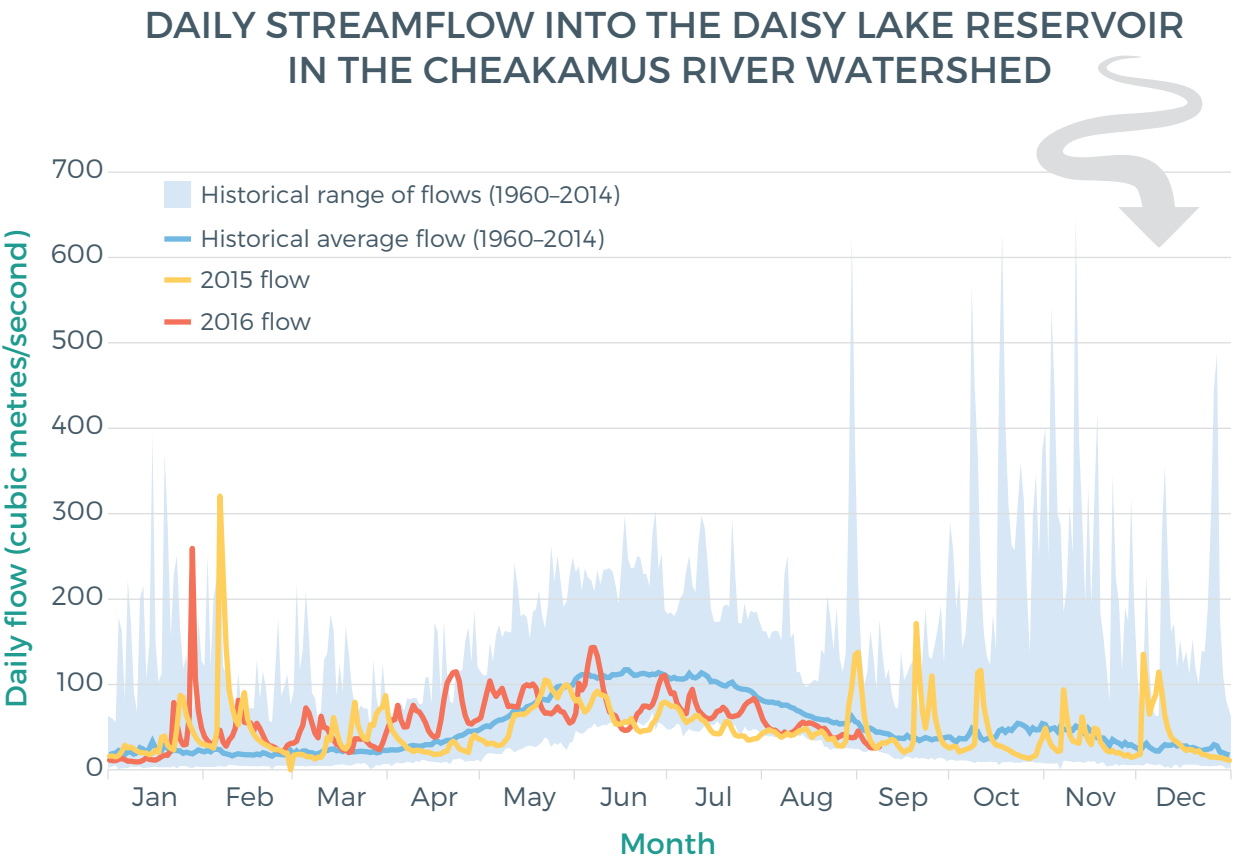


Figure 1. Daily streamflow into the Daisy Lake Reservoir in the Cheakamus River watershed.

or July, and decreasing through late summer and early fall. Flow is highly variable starting in October through December due to significant rainfall events and this is typically where the highest daily flows occur (Figure 1,

average, maximum and minimum flows). Lower flows are also typical of the colder winter months, but large variability in the maximums recorded reminds us that winter snowfalls are interspersed with rainfall events.

What is being done?

Monitoring stream flows and noting the changes in seasonal patterns and extremes allows us to prepare for ongoing changes. For example, the District of Squamish is completing an Integrated Flood Hazard Management Plan ([see Squamish Flood Planning article](#)) in response to increased risk of flooding due to increased rainfall, sea level rise and risk of storm surge. BC Hydro is monitoring and studying hydrological changes to determine how climate change affects water supply and the seasonal timing of reservoir inflows in order to develop a climate change adaptation strategy.⁹

More broadly, local and regional governments around Howe Sound, individuals, and the Squamish Global Innovation Hub responded to the B.C. Government's Climate Action Leadership Plan, showing that people and governments are engaged. In August 2016, the Province released its Climate Leadership Plan.¹⁰ Locally, Squamish has its own Climate Action Network to bring volunteers together on a number of projects looking at energy, food, and waste.¹¹



Photo: Gary Fiegehen

What can you do?

SOME ACTIONS CONTRIBUTED BY CORI



Individual and Organization Actions:

- Record stream levels when enumerating salmon spawning.
- Withdraw, relocate or abandon private assets in high risk areas of flooding.
- Become familiar with the current Integrated Flood Hazard Management Plan. Be aware of flood hazards in your area and be prepared for an emergency at your home and workplace.
- Help prevent climate change by producing fewer greenhouse gasses. Adopt policies and practices within your organization.
- Implement and practice water conservation measures in your home and within your organization.
- Eat sustainable seafood to foster healthy and resilient fish populations.



Government Actions and Policy:

- Continue to closely monitor streamflow data and trends.
- Take action to minimize rainfall related flooding and associated consequences.
- Increase capacity to respond to extreme weather events, including droughts.
- Increase public education on what to do in the event of extreme weather, flooding and drought.
- Develop an education plan for the Integrated Flood Hazard Management Plan to educate locals, especially those in high-risk areas.
- Identify and develop plans for slopes at high risk of landslide.
- Protect the coastline from storm surge and flooding using Green Shores techniques ([see Shorelines article](#)).
- Withdraw, relocate or abandon public assets in high risk areas of flooding.
- Incorporate latest climate change hazard assessments into emergency response planning.
- Continue to renew the Integrated Flood Hazard Management Plan every five to 10 years.
- Develop policies for back-up power in all eventualities.
- Increase flood construction levels, add covenants to reduce liability and retrofit existing buildings.
- Identify future no-build zones or use land acquisition or restriction tools such as land trusts.
- Begin planning for opportunistic retreat of key facilities and infrastructure from high flood hazard areas at the end of their service life.
- Work with BC Hydro to ensure sufficient water flow in “managed” rivers supports salmon spawning and migration.

Resources

Pacific Climate Impacts Consortium

pacificclimate.org

The Pacific Climate Impacts Consortium (PCIC) is a regional climate service center at the University of Victoria that provides practical information on the physical impacts of climate variability and change in the Pacific and Yukon Region of Canada.

Climate Central

climatecentral.org

An independent organization (U.S.) of leading scientists and journalists researching and reporting facts about the changing climate and its impact.

City of Vancouver Climate Change Adaptation Strategy

vancouver.ca/files/cov/Vancouver-Climate-Change-Adaptation-Strategy-2012-11-07.pdf

Preparing for Climate Change

wcel.org/sites/default/files/WCEL_climate_change_FINAL.pdf

An implementation guide for local governments in British Columbia.

Footnotes

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⁵ Pacific Climate Impacts Consortium. 2013.

⁶ Reproduced with permission from "Where Rivers, Mountains and People Meet", Squamish Lilwat Cultural Centre.

⁷ Morrison, J., W. Callendar, M.G.G. Foreman, D. Masson, and I. Fine. 2014. A model simulation of future oceanic conditions along the British Columbia continental shelf. Part I: Forcing fields and initial conditions. Atmosphere– Ocean, 52, 1, 1–19, doi:10.1080/07055900.2013.868340.

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¹¹ Squamish Climate Action Network. Accessed Sept 16, 2016. <http://squamishcan.net/about-us/>

Managing increasing flood hazards due to climate change in Squamish

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REVIEWER

David Roche, Senior Water Resources
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What is happening to manage the risk of flooding in Squamish?

Squamish is located at the north end of Howe Sound in a floodplain with five major river systems and is therefore exposed to both coastal and river flood hazards. Climate change is expected to increase the risk of flooding due to impacts on weather systems (e.g., rainfall) and sea level rise. The Provincial Government issued guidance for communities to begin planning for one metre of sea level rise by year 2100 and two metres by year 2200 (Figure 1).¹ Sea level rise of this magnitude would have significant impacts on Squamish, since the existing downtown core and surrounding area sits at an elevation just above present-day sea level and significant coastal development is anticipated over the next 10 to 20 years.

To appropriately manage community flood risk, the District of Squamish is completing an Integrated Flood Hazard Management Plan (IFHMP) that will improve community flood protection while accommodating anticipated community growth. The project includes a comprehensive analysis of flood hazards, provides river and coastal flood mitigation strategies (e.g., Figure 2) and produces a final plan that summarizes recommendations on land use, flood policy and structural (dike) improvements.

Work on the plan began in February 2014 and is anticipated to be complete by fall 2016. The project, which is funded by the provincial Community Works Fund, a sub-component of the gas tax, is being led by District staff and Council. Technical guidance is provided by a multi-disciplinary consulting team led by Kerr Wood Leidal Associates that includes planning and community engagement, river and coastal engineering, geotechnical engineering and environmental specialists. The IFHMP has four main phases: Background Analysis, Coastal Flood Risk Mitigation Strategy, River Flood Risk Mitigation Strategy, and the final Integrated Flood Hazard Management Plan. The plan’s robust community engagement process included a technical

working group comprised of Provincial agencies and local representatives, a series of public open houses, stakeholder workshops, online surveys, bi-lateral meetings with Squamish Nation and a project website (squamish.ca/floodhazard).

The final plan will develop flood management policy related to appropriate land use, establishing flood levels for new development, identifying and preserving floodways and determining a prioritized plan for ongoing dike improvements. The final IFHMP will be utilized for capital planning, development review, and community planning until the next planned update in five to 10 years.

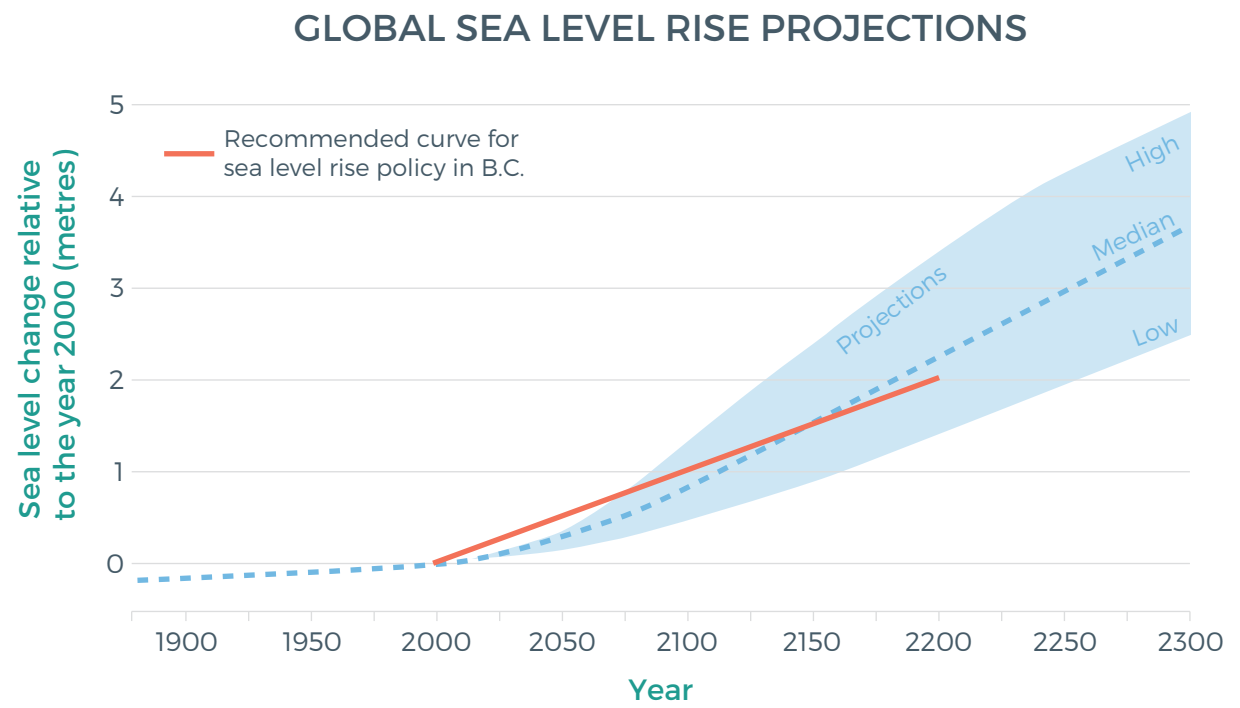


Figure 1. Range of global sea level rise projections and curve adopted for coastal development planning by B.C. government.¹

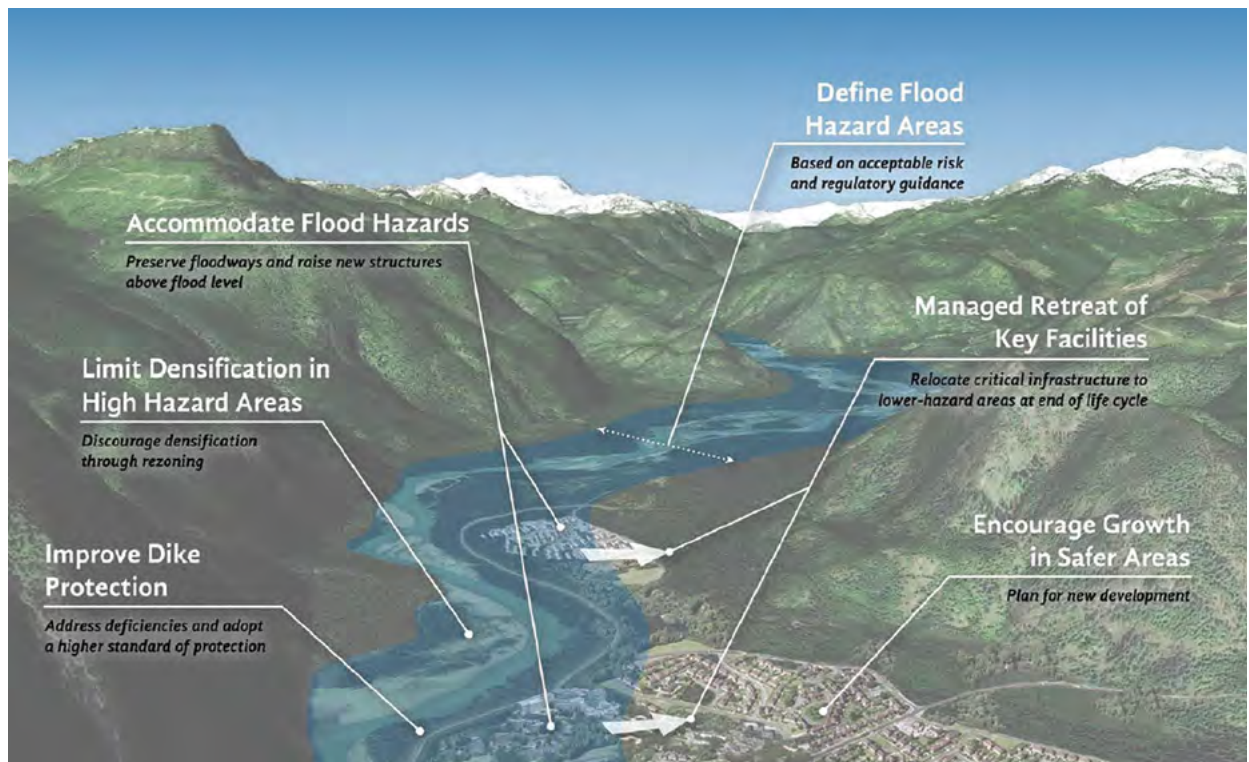


Figure 2: Main mitigation strategies for both river and coastal flood hazards.²

Why is flood management important for Squamish?

One of the most important climate change impacts is sea level rise due to warmer ocean temperatures and melting of polar ice.

The District is protected by a system of dikes and floodgates constructed over the past century with the majority built in the 1970s and 1980s. Downtown Squamish is partially protected by a sea dike, however, some sections remain incomplete and must be

upgraded as soon possible to protect both existing and planned new development (Figure 3). Without mitigation, the area of Squamish that could be impacted by coastal flood hazards based on one metre of sea level rise is significant (Figure 4), and includes several large coastal properties near downtown Squamish that are expecting significant redevelopment. Over the next 20 years, development proposals like the Squamish Oceanfront Development lands at the south

end of downtown are expected to accommodate up to 6500 new residents and direct employment of more than 2300 jobs within the coastal floodplain.

New coastal development provides both opportunities and challenges for Squamish. The development will enhance the community's connection to the coast,

creating both economic and social opportunities. However, new development must overcome many technical challenges to mitigate both environmental impacts and long-term community risk. The analysis and recommendations of the IFHMP provide the necessary foundation that will allow new development to proceed in a safe and sustainable manner.

Is there importance or connection to First Nations communities or issues?

The District of Squamish lies within traditional Squamish Nation territory. Several Squamish Nation Reserves are located throughout the floodplain and

the District and Squamish Nation share an inseparable interest in both community flood protection and environmental preservation.



Figure 3. Coastal water encroaching into the downtown on the Mamquam Blind Channel near the Squamish Yacht Club. (Photo: David Roulston, December 10, 2014)

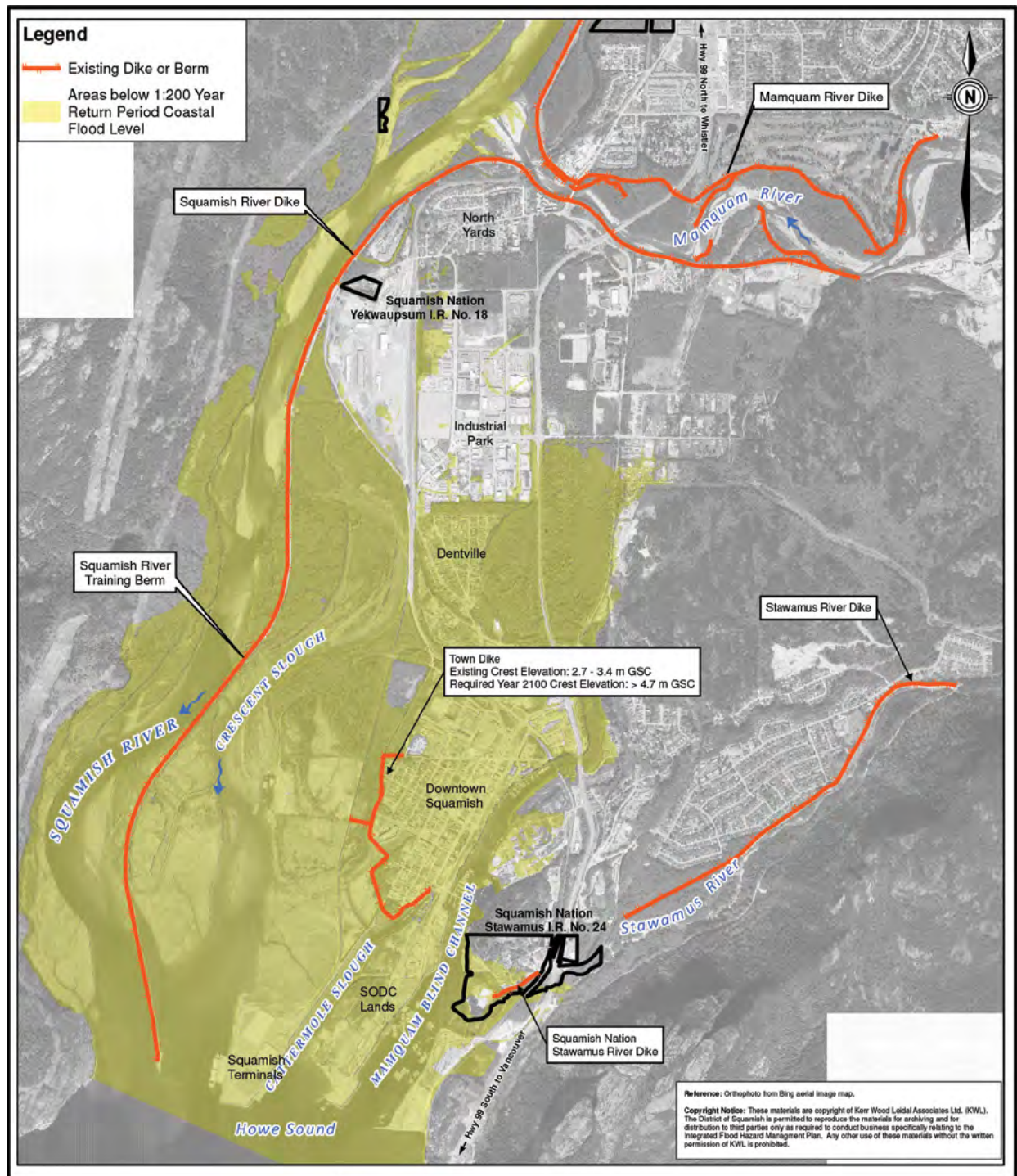


Figure 4. Areas that are impacted by coastal flood hazards without mitigation when taking one metre of sea level rise into consideration.³ The yellow shaded area is the extent of flooding during a one in 200 year flood event with one metre of sea level rise. (Figure provided by Kerr Wood Leidal)

Skwetsás – Squamish Great Flood Story

“In the long ago, in the time of our Ancestors, the waters rose up. The Squamish River got higher and higher. It rained and rained, big drops, bigger than two hands together. And the drops kept falling and falling. And the water rose up and up until it covered Mumtem (Grouse Mountain) and all the little mountains. It covered all the mountains except three peaks: Xwsa7k (Mount Baker), Nch’kaý (Mount Garibaldi) and Sxe’ltskwu (mount Sakus) way up the Squamish River. The people in their canoes rose up and up and as they steered through the cedar trees, one of them broke off the branches and another twisted them and made a big cedar rope about four inches thick. They tied the rope around the top of Mount Garibaldi to make the canoe fast. The remnants of this rope are still present at the very top of that peak today.”

AS TOLD BY XÁTSLÁNEXW-T (AUGUST JACK), SQUAMISH NATION,
1867-1967.³

What is the current state of flood management?

The District of Squamish completed its first Flood Hazard Management Plan (FHMP) in 1994. The 1994 FHMP included updates to Provincial floodplain mapping as well as recommendations on land use management, flood related policy and dike improvements. Since the original FHMP, the community has experienced significant growth and new information and technology have become available. These are being incorporated into an updated plan to ensure that the District is using the best information to inform its decisions. The updated IFHMP utilizes new technical data (river flows, wind speeds, tide levels, and bathymetric/topographic information) as well as state of the art technology and software to produce the river and coastal flood mapping that informs the resulting mitigation strategies.

Ongoing coastal processes can result in a natural loss of habitat. In addition, construction of sea dikes to protect new and existing development can impact environmentally sensitive coastal areas by disturbing, altering or encroaching into natural habitat. The IFHMP seeks to recognize and preserve the environmental value of the estuary and other sensitive areas while providing important community flood protection. A significant example of this is included in the community's long-term sea diking options that envision a Green Shores approach along environmentally sensitive areas such as the Squamish estuary (Figure 5). A sea dike that incorporates this treatment would utilize shallower slopes and "bio-engineering" (reinforced vegetation) to provide the required erosion

protection. In addition, the District seeks to preserve the sensitive and valuable habitat and manage flood risk by concentrating growth in the existing downtown and to avoid development within the estuary's Wildlife Management Area.

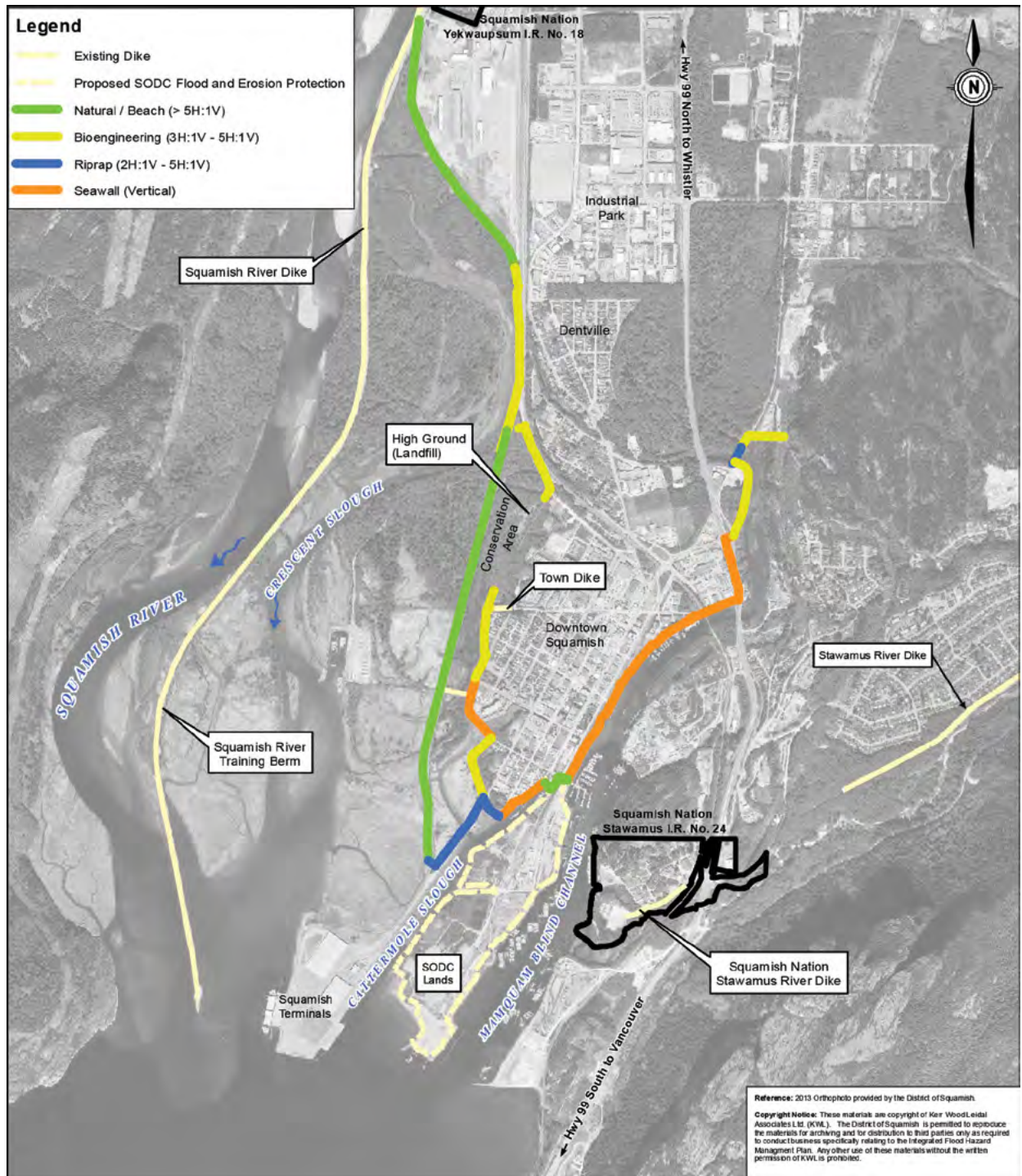


Figure 5. District of Squamish's sea dike and shoreline treatment options showing type of dike, including natural or beach slopes and bioengineered sections in environmentally sensitive areas. (Figure provided by Kerr Wood Leidal)

What can you do?

SOME ACTIONS CONTRIBUTED BY CORI



Individual and Organization Actions:

- Become familiar with the current IFHMP. Be aware of flood hazards in your area and be prepared for an emergency at your home and workplace.
- Help prevent climate change by producing fewer greenhouse gasses. Adopt green policies and practices within your organization.



Government Actions and Policy:

- Conduct further studies on impacts of flood control on environmental processes and continued alternatives that work with nature.
- Improve strategic dike protection for the community.
- Continue to raise awareness of flood risks and responsible watershed stewardship.
- Incorporate latest climate change hazard assessments into emergency response planning.
- Complete complementary flood studies for unique hazards beyond the scope of the IFHMP as funding permits.
- Maintain a toolkit (e.g., models, guidelines, and best practices) to support staff analysis and recommendations to Council.
- Promote closer relationships with stakeholders from the river headwaters to Howe Sound to facilitate working together.
- Continue to renew the IFHMP every five to 10 years.
- Manage development in flood hazard areas through updated OCP, DP guidelines, bylaws, etc.
- Limit continued densification in the highest hazard areas.
- Begin planning for opportunistic retreat of key facilities and infrastructure from high flood hazard areas at the end of their service life.
- Action and policy to reduce greenhouse gas emissions and meet or exceed current targets.

Resources

www.squamish.ca/floodhazard

Footnotes

¹ Ausenco Sandwell. 2011. Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Guidelines for Management of Coastal Flood Hazard Land Use, prepared for B.C. Ministry of Environment. 15pp plus appendices. Accessed at http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/coastal_flooded_land_guidelines.pdf

² Kerr Wood Leidal. 2015. Coastal Flood Hazard Mitigation Strategy and Flood Protection Options. Revised Final Draft Report Prepared for the District of Squamish, 130pp. Accessed August 24, 2016 at <http://squamish.ca/assets/IFHMP/20151020-REV-FINAL-DRAFT-Coastal-Flood-Hazard-Mitigation-Options.pdf>

³ Reproduced with permission from “Where Rivers, Mountains and People Meet”, Squamish Líl’wat Cultural Centre

What can the Ocean Health Index tell us about Oceanography and Climate Change?

AUTHORS

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Two goals identified by OHI - Coastal Protection and Carbon Storage - fit into the Oceanography and Climate Change theme.

How did the Ocean Health Index define Coastal Protection and Carbon Storage?

Coastal Protection: A healthy ocean provides protection of our coasts from storm damage by living natural habitats, such as salt marshes and coastal forests.

Carbon Storage: A healthy ocean provides long-term storage of carbon in natural marine and coastal habitats, such as salt marshes and coastal forests.



How did the Ocean Health Index measure Coastal Protection and Carbon Storage?

Coastal Protection: We measured how well the ocean and coasts are providing coastal protection in Howe Sound by measuring the condition of living habitats around the region that are known to provide coastal protection to natural and human environments. For this goal we were able to include the status of salt marshes and coastal forests. We then weighted the condition of each of the habitats by how much coastal protection they provide relative to one another; in this case coastal forests provide relatively more protection than salt marsh. This allowed us to put more value on habitats that provide more coastal protection benefit. Due to local data and information limitations we were not able to include seagrasses in this calculation.

Carbon Storage: We measured how well the ocean and coasts are providing carbon storage in Howe Sound by measuring the condition of carbon storing habitats around the Sound. For this goal we were able to include the status of salt marshes and coastal forests. We then weighted the condition of each of the habitats by how much carbon they are able to store relative to one another. This allowed us to put more value on habitats that provide more carbon storage benefit. Due to data and information limitations we were not able to include seagrasses in this calculation, but hope to be able to include them in future reports because they are an important contributor to Carbon Storage in the marine environment.

Salt Marshes: To assess the conservation status of salt marshes we used land-cover change data to look at how much saltmarsh has been lost in Howe Sound through time. Howe Sound is known to have lost ~30% of its salt marsh area before 1990¹ and we were able to use land-use change data to look in detail at how much has been lost since 1990. We used land-cover data for 2010 (last available year) and then included restoration efforts conducted since 2000 for our final calculations. This allowed us to look at net change in salt marsh coverage and we based our final calculations on these values. The target we used that would achieve a perfect score was zero loss of salt marsh in Howe Sound.

Coastal Forests: To measure how well coastal forests are being conserved in the region we used land-use change data spanning from 1990 to 2010. By using these data we were able to look at how much of the coastal forest was lost to development across Howe Sound since 1990. To achieve a perfect score for the conservation of this habitat our target was no loss in coastal forest habitat since 1990.

¹ Levings, C.D. and R.M. Thom. 1994. Habitat Changes in Georgia Basin: Implications for resource management and restoration. In Review of the Marine Environmental and Biota of Strait of Georgia, Puget Sound and Juan de Fuca Strait: Proceedings of the BC/Washington Symposium of the Marine Environment, January 13 and 14 1994. Pp. 330–351. Canadian Technical Report Fish. Aquat. Sci. no 1948.

Seafood



Photo: Gary Fiegehen

Summary

Overfishing is one of the biggest threats to the health of our oceans. As awareness of the need for sustainable fishing practices grows, Howe Sound has emerged as home to one of the “darlings” of the sustainable seafood movement. Spot prawns have risen in popularity over the last five years, with commercial catches reaching a peak in 2011, indicating healthy populations and bringing huge economic benefits from the area.

Yet while trap-caught spot prawns are certified sustainable seafood by the Vancouver Aquarium Marine Science Centre’s Ocean Wise program, there is room to improve. Concerns have arisen that some boats’ traps are damaging fragile sponge reefs. A bottom-trawl prawn and shrimp fishery is also active in the Sound, creating impacts on the sea floor, while risk of bycatch and entanglement of other marine life persists in fishing activities.

Sport fishing is another industry on the rise in Howe Sound. Recreational fishing has always been common among residents of the area, but recent years have seen a huge spike in sport fishing tourism. Managed well, sport fishing can be an important way to foster sense of place and connection with nature and bring economic activity to the Sound. However, it also places additional pressure on vulnerable fish stocks and increases risk of overfishing due to unsustainable practices from inexperienced anglers and guides.

Seafood Snapshot Assessment

Sport Fishing

Sport fishing is a huge economic generator for Howe Sound, with interest peaking in the wake of recent record salmon runs. But the growing interest in angling is adding to the pressure on vulnerable fish stocks and underscoring the need for more effective management, monitoring, training and education of visitors to Howe Sound.



Prawn and Shrimp Fisheries

Celebrated as sustainable seafood, Howe Sound’s spot prawns and shrimp fisheries continue to be one of the most economically valuable fisheries in the region. Steps are being taken to further reduce the industry’s impact on the ecosystem by reducing bycatch and limiting fishing in sensitive areas, such as glass sponge reefs.



A glimpse into the bounty of the early 1930s

As related by Norman Safarik in his book “Bluebacks and Silver Brights: A Lifetime in the B.C. Fisheries from Bounty to Plunder”, one day’s catch of a 40 to 48 foot trawler in the early 1930s near Vancouver in the “Gulf of Georgia” (southwest of Point Grey) was significant. According to this memoir, the day’s fishing included three drags, two hours each, of a bottom trawl net in sandy bottom habitat, and one half-hour drag in shallower water targeting crabs.

“Our total catch for the day included one hundred fifty dozen prime crabs, three large red springs (about twenty pounds each), twenty-five hundred pounds of sole, eight hundred pounds of flounders, five hundred pounds of skate wings, one hundred pounds of rock cod, fifty pounds of red snapper, one hundred pounds of silver perch, forty pounds of red squid, one hundred fifty pounds of ling cod, three octopi (each weighing about twenty pounds) and one hundred and twenty pounds of halibut.”

“When we unloaded at Campbell Avenue and the fish was weighed, the *Curlew M*’s catch was worth four hundred and fifty dollars gross. ... Jimmy Martin and the *Curlew M* were making eight thousand dollars per year when school-teachers were taking home less than two thousand.”

Catch of the day

Strait of Georgia, 1930s

3 two-hour drags
for fish in sandy
bottom habitat

1 half-hour drag
for crab in
shallow water



2,500

pounds
of sole



1,800

prime crabs



800

pounds of
flounder



500

pounds of
skate wings



150

pounds of
lingcod



120

pounds of
halibut



100

pounds of
rock cod



100

pounds of
silver perch



50

pounds of
red snapper



40

pounds of
red squid



3

large springs
(~20 pounds ea.)



3

octopi
(~20 pounds ea.)

Squamish Nation seafood notes

Fishing methods were inventive. Sturgeon was an important supplement between salmon runs for the Squamish people. To catch these large fish, Squamish fishers used long poles with detachable harpoon heads attached by cedar rope. After spearing the sturgeon, fishers pulled on the rope to land the fish.

A stinging-nettle fishing line, so called for its adornment of carved lures and hooks, was used to catch deep-sea fish such as rock cod and halibut. Squamish women used hemlock or alder to smoke salmon, which would keep for two years if stored in a dry enough place. Before eating it they would soak it in water to soften it. They also broiled salmon in the open air before a wood fire. They would weave the cleaned fish between split horizontal sticks attached to a short pole, which they would stick in the earth in front of the fire, a process called *skw'elem*, which means loosely “ripening the whole.” Today fishing continues to be a vital part of life in the Squamish Nation, although salmon stocks have been depleted and the economy of the Nation has been adversely affected.²



Photo: Gary Fiegehen

Footnotes

¹ Passage from Bluebacks and Silver Brights: A Lifetime in the B.C. Fisheries from Bounty to Plunder, by Norman Safarik with Allan Safarik, published by ECW press in 2012. Passage from p 16-17 reprinted with permission.

² Content reproduced with permission from “Where rivers, mountains and people meet,” Squamish Lil’wat Cultural Centre.

Sport Fishing: increased participation requires increased vigilance

“While commercial fisheries and aquaculture have a well-established market value, the value of recreational and First Nations subsistence fisheries have no market value.... [Howe Sound provides] a total value of approximately \$95,073 per year in non-market food provisioning. This value is likely an underestimate as the data represent only what has been reported and recorded from 2001 to 2010.”

**FROM SOUND INVESTMENT: MEASURING THE RETURN ON HOWE SOUND'S ECOSYSTEM ASSETS
(MICHELLE MOLNAR, 2015, DAVID SUZUKI FOUNDATION)**

AUTHORS

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Stephanie Linguard, Instream Fisheries Research

CONTRIBUTORS

Members of a discussion table at the Howe Sound Aquatic Forum, June 17, 2016 workshop¹

REVIEWER

Dave Brown, Squamish-Lillooet Sportfish Advisory Committee Vice-Chair, and Sea-to-Sky Fisheries Roundtable Member

What's happening with sport fishing in Howe Sound and its tributaries?

In recent years, an increase in visitors to Howe Sound, as well as large returns of pink salmon in 2013 and 2015, has attracted unprecedented numbers of anglers to the northern end of Howe Sound and the Squamish River watershed. Fishing has long been a popular pastime in Howe Sound (see Salmon Derby inset). Currently, recreational or sport fishing activities include salmon and trout fishing and prawn and crab trapping. In the past lingcod and rockfish were also targeted in Howe Sound, but fishing for these species has been closed since 2002.

While there are many salmon bearing tributaries in Howe Sound ([see Salmon article](#)), the Squamish River watershed is by far the largest and most important. Historically, the Squamish system provided ample angling opportunities for Chinook salmon up to 45 kg as well as retention of up to two wild steelhead per day.² Prior to the late 1980s, retention of all salmon species was permitted in the Squamish River.³ Declines in the salmon populations of Howe Sound in the last few decades are likely due to a combination of factors including habitat loss, fish farm and hatch-

ery production, climate change, and overfishing,^{4,5} although, in the last decade, hatchery production has also been instrumental in restoring some populations to the Squamish River. Anglers in the Squamish River and tributaries are now limited to catch and release only for steelhead, Chinook, wild coho, chum, rainbow trout, cutthroat trout and char. The only species sports anglers are currently able to retain in the Squamish River watershed are pink salmon, and hatchery coho salmon.

Why is sport fishing important to Howe Sound?

Sport fishing is important both economically as well as socially to communities around Howe Sound, providing an essential link to place for communities and a connection to the natural environment. In 2012 the sport fishery contributed \$325.7 million to the provincial economy and employed 8,400 people.⁶ The last economic valuation of the sport fishery in Howe Sound,

in 1980, estimated a total of 151,875 angler days with a value of between \$7.9 million and \$15 million.⁷ Participants at the 2016 workshop¹ also highlighted the important economic contribution of the businesses that support recreational fishing in the Howe Sound region – outfitters, guiding operations and bait and tackle shops.



Photo: Jenn Burt

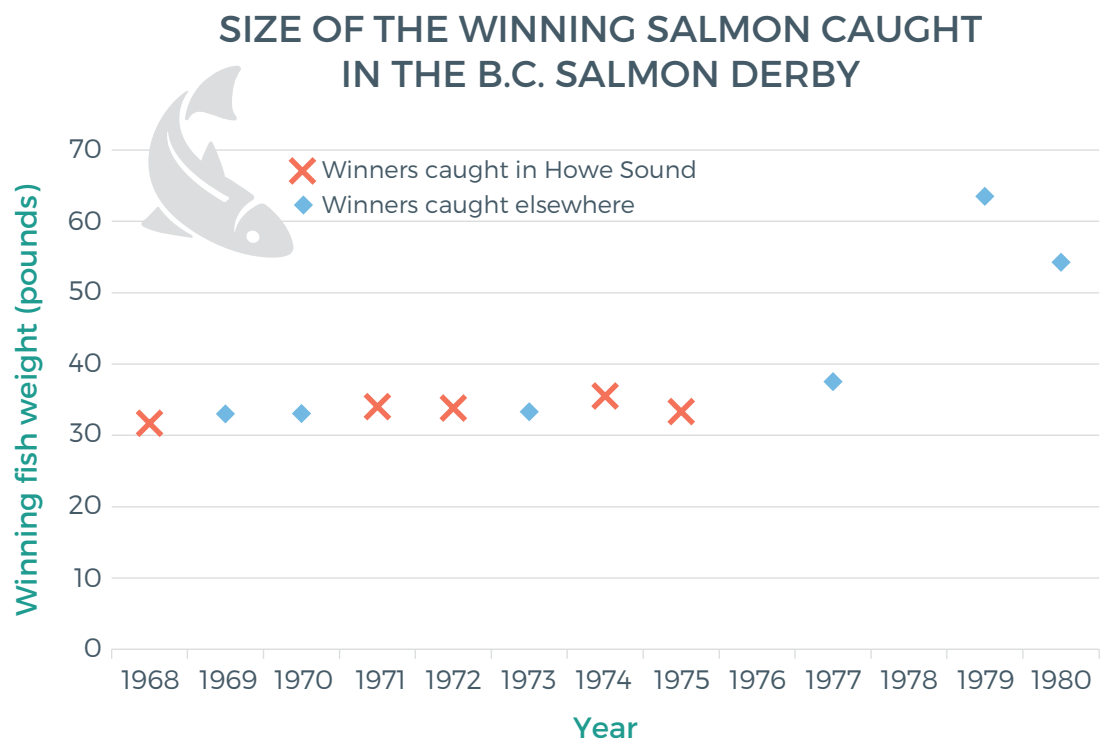


Figure 1. Size of the winning salmon (pounds) caught in the B.C. Salmon Derby (1968 – 1980).

The B.C. Salmon Derby 1968-1980

The "World's Largest Sport Fishing Competition"



The B.C. Salmon Derby,⁸ also called the Sun Derby or the Export 'A' Kings Derby in different years, was billed as the world's largest sport fishing competition. The Derby started on Labour Day weekend 1968, was initially limited to 200 square miles of Howe Sound, and ran for 13 years. Each year the event took place over a weekend in August or early September. 11,000 participants were reported in the first year alone. Newspaper reports from several years documented 10,000 fishermen including 200 from Japan and 13 other countries. The winning salmon, ranging between 31 and 38 pounds (14 to 17 kilograms) until the last years when even larger fish were caught off the eastern shores of Vancouver Island (Figure 1), garnered \$25,000 (reportedly in silver) for the lucky fisherman. In the second year of the Derby, a 15 year old won the prize with a 33 pound (15 kilogram) 'red spring' off Hutt Island in Central Howe Sound. Over 4,200 boats⁹ were involved that year, all fishing within Howe Sound over one weekend! The boundaries of the Derby were expanded several times over the years, but the winning fish often came from Howe Sound. The Derby was finally cancelled in 1981 due to federal restrictions on salmon harvest. In February of 1981, all Fraser River salmon fishing was closed until June 21, downriggers were banned, and the Chinook bag limit was reduced to one fish per day, due to concerns about salmon stocks.

Is there a connection between sport fishing and First Nations?

The Squamish First Nation has harvested salmon, crab, eulachon, herring and other species in the Howe Sound and tributaries for centuries. The culture of the First Nations in the Howe Sound area is closely entwined with the health and runs of salmon and steelhead and many First Nations participate in sport fishing as well as harvesting for food.

Today fishing continues to be a vital part of life in the Squamish Nation, although salmon stocks have been depleted and the economy of the Nation has been adversely affected.¹¹

“When the tide goes out, the table is set.”

SQUAMISH ELDER, AUTHOR UNKNOWN¹⁰



Squamish fishers Shawn Baker and Xwelápeltxw (Ned Lewis) gillnetting salmon on the Squamish River. (Photo: Gary Fiegehen)

What is the current state of sport fishing in Howe Sound?

Since 2009, local guide outfits have reported an increase in fishing pressure in the Howe Sound tributaries. These increases are especially evident during the pink salmon and steelhead runs. The Squamish River Watershed and Furry Creek, in particular, are becoming hotspots for young families and youth looking to forage, re-connect with nature and participate in outdoor recreation. Local stakeholders in the fishing community are seeing significant surges in pressure on the salmon fishery as well as increases in poor angling techniques. The recent large pink salmon returns have attracted many new and uneducated fishers. It is common to see hundreds of people lining the shores of Furry Creek and the banks of the Squamish River during the pink salmon run.¹²

In total there are up to 25 species (or groupings) of finfish open to retention by saltwater anglers the recreational fishery in Howe Sound,¹⁶ however many of these will never be fished in Howe Sound as they don't occur there (e.g., albacore tuna). The main species of finfish targeted and retained in Howe Sound are five salmon species (Chinook, coho, pink, chum, steelhead) and Pacific cod.¹⁷ Currently fishing for lingcod and rockfish is not permitted year round in Howe Sound for conservation reasons. In addition to fin fish, there are 13 invertebrate species or groupings

of invertebrate species (e.g. squid, clam, other) open to retention in Howe Sound. Bivalve fisheries (clams, mussels, oysters) are closed in Howe Sound due to sanitary contamination. The main invertebrate species harvested in the Howe Sound recreational fishery are: crab, shrimp, prawns, octopus, sea cucumber and squid.

In a search of DFO publications, stock assessments were found for less than 25 percent of the species open to retention in Howe Sound. The lack of stock assessment data is a major concern to the sport fish community as there is no knowledge of trends in populations and what effect increased participation, harvesting and industry may have on the resource. For example, the Sportfish Advisory Committee expressed concern over the opening of a 2015 seine fishery for pink salmon due to inadequate scientific justification to open a commercial fishery.¹⁸ Further, a commercial chum fishery in Johnstone Strait continues an annual harvest of fish which include Howe Sound chum, while numbers of spawners returning have been fluctuating three-fold in recent years ([see Salmon article](#)) and the most recent chum salmon stock status report is dated 1999.¹⁹ Overall, there is simply not enough data available to evaluate the health of fish and invertebrate populations in the Howe Sound region.

Main Observations reported at a June 2016 workshop¹³

1. Returning coho, both wild and hatchery, are more abundant and notably larger. **“The coho are as big as I have ever seen for this time of year...”** – J. Tonelli, email prior to workshop
2. Chinook are more abundant.¹⁴ **“2015 was easily the best summer of Chinook fishing that I have seen in more than 30 years of guiding in these local waters... best sustained winter action [Chinook] in at least 20 years. Many over 20 pounds.”** – Dave Korsch
3. Pacific cod catches are increasing and cod is being observed in the bellies of harvested Chinook.
4. Unprecedented amounts of anchovy have been observed in the last two years, with much greater abundance in 2016 compared to 2015.
5. More herring is being observed. Fishers follow the bait fish (or forage fish) and fish in the areas where they are observed.
6. Surf smelt has been observed in the Squamish Estuary.
7. Fishers observe that Howe Sound is increasingly being used as a nursery area (e.g., seeing more juvenile Chinook and coho, while juvenile Harrison sockeye are caught in DFO small mesh surveys¹⁵).
8. Increasing recreational fishing effort in Howe Sound including people and boats harvesting shellfish (i.e., trapping spots are full), more saltwater and freshwater anglers, and more non-licensed “guides” on the saltwater. **“[I counted] 40 boats fishing off Cape Roger Curtis on the weekend, catching coho and Chinook like crazy.”** – Jason Tonelli, email prior to workshop

Key Issues and Concerns reported at a June 2016 workshop²⁰

1. DFO has a lack of capacity to enforce fishery regulations and guidelines. Two officers only, at the Squamish office, patrol a vast area that includes watersheds from Burrard Inlet to Lillooet and little time allocated to actual patrol versus administration.
2. There are a lack of data and information available on the recreational fishery and the fish stocks that support the fishery, specific to Howe Sound watersheds. (E.g., The last economic valuation of the sport fishery in Howe Sound is from 1980.)
3. An increase in unlicensed and inexperienced saltwater guides is detrimental to the fishery; these guides are “bad ambassadors.”
4. Low angler awareness is resulting in poaching and poor practices.
5. Commercial fisheries for pink and chum salmon, although very minimal recently, have a large and negative impact on a fishery resource that is vital to the watershed ecosystems. (E.g., In the cold glacial systems there is a lack of insect life, and abundant pink and chum salmon provide nutrients for the system, and are vital to the health of game fish (Chinook, coho, steelhead and trout) as well as provide flesh and eggs to trout and char through the winter.)
6. Managing agencies don’t consult or engage enough with the sport fish industry and participants when species retention, commercial openings and industrial projects are being considered. (Further, DFO is attempting to replace biannual in-person advisory meetings with webinar-style meetings.²¹)

How does sport fishing benefit society and impact stream and ocean ecosystems?

The guide companies are important economic generators in communities surrounding Howe Sound, such as Squamish, Vancouver and the Sunshine Coast. Sport fishing not only benefits local businesses near docks and river access points but the purchase of fishing licenses and conservation tags generates revenue for conservation.

Currently there are nine freshwater guide outfits operating year round on the Howe Sound tributaries and in local lakes. Ministry of Forests, Lands and Natural Resource Operations reported 10 licensed freshwater guides who reported guiding in the area between 2011 and 2015.²² It is estimated that roughly 20 to 25 assistant guide licenses were issued. Between the years 2011 and 2015 there was a total of 1,268 reported angling days,²³ which roughly translates to \$507,200 in revenue for guide service alone.²⁴ The most commonly caught species were pink salmon and rainbow trout with total estimated catches of 1,192 and 1,315 respectively.²⁵

Approximately 20 to 30 saltwater guide operators out of Vancouver, Horseshoe Bay, Richmond and Gibsons fish Howe Sound year round. Outfits target Chinook, pink, coho and chum salmon and sometimes trap Dungeness crab. The number of two- to four-year-old Chinook using Howe Sound has increased dramatic-

ally in the last few years, and often sub-legal Chinook, less than 62 centimetres in length, are caught and released.²⁶ In addition, coho caught in 2016 have been twice the normal size. Fishers speculate that efforts to restore the herring in the Squamish harbour have likely added significant food sources for salmon and observe that anchovies have exploded in numbers in the outer reaches of Howe Sound as well.²⁷

While sport fishing is an important economic generator in the Howe Sound region, the fishery also has negative impacts on ecosystems in both Howe Sound and tributaries. Lack of DFO enforcement capacity, minimal conservation officer presence, and lack of education in the fishery have all resulted in a number of bad habits by people entering the recreational fishery. Littering, overfishing, retention of prohibited species and increased pressure are a few of the problems associated with the recreational fishery in Howe Sound and tributaries. Allowing only catch and release as well as prohibiting removal of fish from the water when landing would be good solutions to curb poor behaviours and protect dwindling fish stocks.

What is being done?

Sport fisheries in Howe Sound are managed by the Department of Fisheries and Oceans. Fisheries for trout in the tributaries of Howe Sound fall under the jurisdiction of the Government of British Columbia under the ministry of Forests, Lands and Natural Resources. Changes to the Federal Fisheries Act introduced in 2012 and significant cuts to DFO habitat staff resulting in reduced assessment and monitoring of development projects have led to fish habitat degradation and loss.

Perhaps an unintended consequence of on-line purchase of fishing licenses is the lack of interaction between vendors and purchasers which often included angler education in the past. However, many grass-roots interest groups have stepped up their education efforts on proper angling techniques, fish identification and rules and regulations. Some have organized river steward programs for years with pink salmon returns to show community support of proper angling and trash clean up.

What can you do?

SOME ACTIONS CONTRIBUTED BY CORI



Individual and Organization Actions:

- Ensure you are familiar with the current regulations before you fish.
- Take fishing lessons to learn proper fish handling techniques.
- Take your garbage and used fishing line with you when you leave your fishing spot.
- Avoid unwanted and illegal rockfish by fishing away from rocky reef areas, key habitat for these fish.
- Sport fishing organisations and guides/outfitters can collect data on participants and catch and share the data to aid in quantifying the value of the activity to Howe Sound.
- Fish and purchase sustainable seafood.
- Participate in shoreline cleanup.
- Report any poaching and poor angling techniques you witness:
DFO Observe Record Report Line: 1-800-465-4336
Report All Poachers and Polluters (RAPP): 1-877-952-7277



Government Actions and Policy:

- Require angler education through the licensing process.
- Make angler awareness programs available in multiple languages.
- Undertake baseline data studies to better determine fish populations, behaviours, and returns so that conservation projects can be implemented and retention, commercial harvests and industrial projects allowed only when supported by sufficient data.
- Allocate more resources toward monitoring and enforcement of recreational fishing regulations. Ensure salt-water “guides” are licensed.
- Increase levels of protection for forage fish species such as herring, eulachon and anchovy as they are main food sources for Pacific salmon and some marine mammals in Howe Sound.
- Support grassroots stewardship programs.
- Require saltwater guides to be licensed and test their knowledge regularly.
- Require baseline information on species populations that are targeted by sport fisheries prior to approving development projects that may impact these populations.
- Unlink the allocation of DFO Conservation Officer enforcement funds with volume of reported infractions and increase enforcement capacity especially in heavily fished areas.

Acknowledgements

We would like to acknowledge contributions made at a Howe Sound Socio-Economic Knowledge Workshop held June 17, 2016 at the Vancouver Aquarium. Participants at a “Recreational Fisheries” discussion table shared knowledge which has been incorporated into this article. Participants included the author Cortney

Brown, Trout Country Fishing Guides, Scott Sutherland, Mongoose Striker Charters, Dave Loop, Fisheries and Oceans Canada, Jason Assonites, Bonchovy Fishing Charters, Randall Lewis, Squamish Nation, and David Fiero with Squamish Nation.

Resources

DFO Observe Record Report Line

1-800-465-4336

Report All Poachers and Polluters (RAPP)

1-877-952-7277

Learn about fishing in British Columbia at Go Fish BC

gofishbc.ca

Footnotes

¹ Please see acknowledgements for list of participants.

² Mehan, Ken, long-time angler. Personal communication with author C. Brown, October 2016.

³ We can not be certain about the date but this estimate was provided to K. Bodtker by John Wright, retired DFO stock assessment biologist, on the phone, Nov 15, 2016.

⁴ Miller K.M., A. Teffer, S. Tucker, S. Li, A.D. Schulze, M. Trudel, F. Juanes, A. Tabata, K.H. Kaukinen, N.G. Ginther, T.J. Ming, S.J. Cook, M. Hipfner, D.A. Patterson, S.G. Hinch. 2014. Infection disease, shifting climates, and opportunistic predators: cumulative factors potentially impacting wild salmon declines. *Evolutionary Applications*. 7(7): 812–855.

⁵ Noakes D.J., R.J. Beamish, M.L. Kent. 2000. On the decline of Pacific salmon and speculative links to salmon farming in British Columbia. *Aquaculture*. 183(3–4): 363–386.

⁶ Stroomer C, and M. Wilson. 2013. British Columbia Fisheries and Aquaculture Sector, 2012 edition. Prepared for the Department of Fisheries and Oceans Canada by BC Stats. 104 p.

⁷ Province of British Columbia. 1980. Howe Sound an Overview Study. Environment and Land Use Secretariat Committee. 50 p.

⁸ Information compiled by Karin Bodtker, Sept 2016, from newspaper clippings (Vancouver Sun and Province newspapers) held at the Vancouver Public Library.

⁹ This number is corroborated in Hoos, L.M., and C.L. Vold. 1975. The Squamish River Estuary: Status of Environmental Knowledge to 1974: Report of the Estuary Working Group, Department of the Environment, Regional Board, Pacific Region. No. 2. Environment Canada. The report says, “over 40% of British Columbian sport vessels concentrate in the southern Gulf Islands, Saanich Inlet, and Howe Sound. Howe Sound and Vancouver averaged about 350 vessels on most summer weekends, with peak numbers of 4,300 and 3,500 for the British Columbia Derby and the Sun Derby, respectively.”

¹⁰ Reproduced with permission from “Where Rivers, Mountains and People Meet,” Squamish Líl’wat Cultural Centre.

¹¹ Ibid.

¹² The author is a fishing guide; this is a personal observation.

¹³ See footnote 1

¹⁴ Reviewer Dave Brown adds that 2016 was not as good as 2015 for Chinook.

¹⁵ Neville, C. 2016. Strait of Georgia Juvenile Salmon. In: Chandler, P.C., S.A. King, and R.I. Perry. (Eds.). 2016. State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2015. *Can. Tech. Rep. Fish. Aquat. Sci.* 3179: viii + 230 p.

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¹⁷ <http://www.pac.dfo-mpo.gc.ca/stats/rec/gs/index-eng.html>

¹⁸ Brown, D. Personal communication with K. Bodtker, Editor, Oct 21, 2016.

¹⁹ Fisheries and Oceans Canada. 1999. Inner South Coast Chum Salmon. DFO Science Stock Status Report D6–09 (1999). Accessed Oct 21, 2016. <http://www.dfo-mpo.gc.ca/csas/Csas/status/1999/D6-09e.pdf>

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²¹ Brown, D. Personal communication with K. Bodtker, Editor, Oct 21, 2016.

²² Lunn, I. Fish Biologist, Ministry of Forests Lands and Natural Resource Operations, South Coast Region. Email communication to the author. May 10, 2016.

²³ Lunn, I. Personal communication with author C. Brown, May 10, 2016.

²⁴ 1,268 angler days x \$400/day in guide services equals \$507,200 revenue.

²⁵ Lunn, I. Email communication to author C. Brown, May 24, 2016. Corroborated by D. Brown, reviewer, Oct 21, 2016 in conversation with K. Bodtker, editor.

²⁶ Assonitis, J. Email communication to author C. Brown. October 2016. From November through May, Chinook are primarily feeding in Howe Sound (i.e., they are fish from other systems and are not returning to spawn), while in July and early August there is a small fishery for returning Squamish river system fish.

²⁷ Assonitis, J. Email communication to author C. Brown. October 2016.

Prawn and Shrimp Fisheries: no trend evident in spot prawn catch

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What's happening?

2015 was a good year for the commercial spot prawn (*Pandalus platyceros*) fishery in Howe Sound, with a total catch of 64 metric tonnes, certainly better than the last couple of years (Figure 1). In 2011 prawn catch by trap peaked for the decade with a catch of 118 metric tonnes. The pattern of annual catch is similar B.C. coast wide, with a high catch in 2011 followed by a declining trend to a fifteen-year-low in 2014 and an increase in 2015.¹ (Data were not yet available for the 2016 season, as of the writing of this article.) Spot prawns caught by trap in B.C. are ranked a “Best Choice” by the Seafood Watch program,² and are recommended by the Vancouver Aquarium’s Ocean Wise program.³

A fishery for shrimp and prawn by bottom trawl gear also operates in Howe Sound, harvesting between 11 and 30 metric tonnes of pink and sidestripe shrimp each year (Figure 1). (For 2016, the pre-season pink shrimp biomass forecast for areas off the West Coast of Vancouver Island was only about 20 percent of estimates for the 2015 season. Further, 2016 in-season survey results suggested even lower biomass and catch ceilings were reduced ac-

cordingly.⁴) These shrimp are also recommended by Ocean Wise, but ranked slightly lower, as “Good Alternatives,” by the Seafood Watch program because of the additional impact of bottom trawl gear.

Recreational shellfish trapping is popular in Howe Sound. In fact, the area including Howe Sound, Indian Arm, and Burrard Inlet (i.e., Pacific Fishery Management Area 28) sees the highest recreational effort for shellfish trapping by boat on the B.C. coast.⁵ July, August, and September see the highest effort.



Recreational fishing for spot prawns in Howe Sound is popular. (Photo: Steph Hughes)

COMMERCIAL LANDINGS OF PRAWN AND SHRIMP BY TRAP AND TRAWL FROM HOWE SOUND

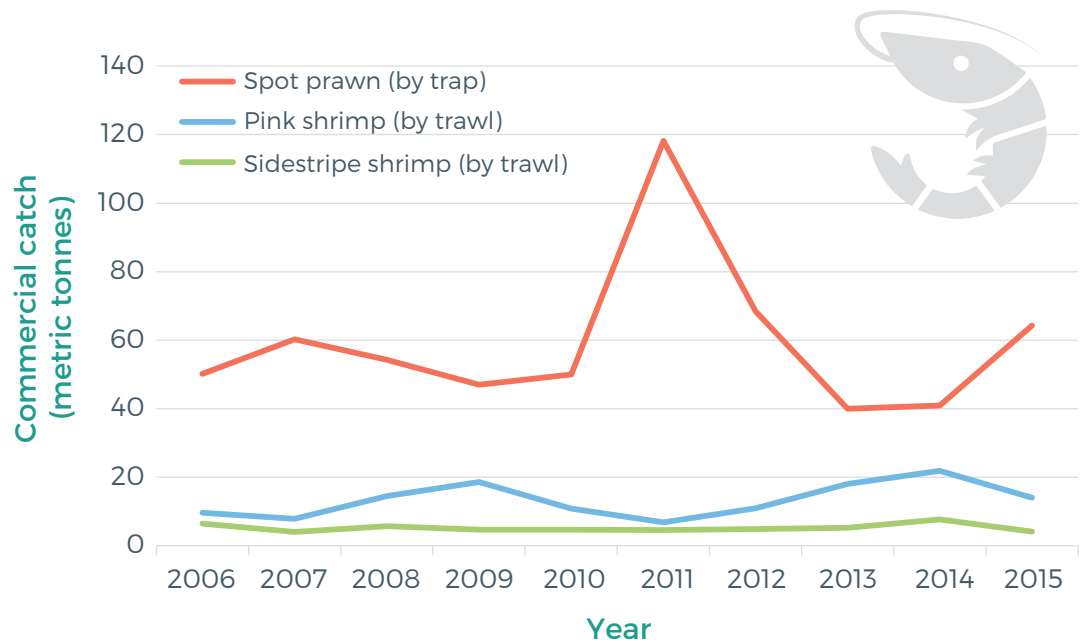


Figure 1. Commercial landings of prawn and shrimp by trap and trawl from Howe Sound.⁶

Why is it important?

The commercial prawn and shrimp by trap fishery is one of the most economically valuable fisheries in the Pacific Region. Coast wide value in 2014 was \$32.6 million, which made it the fourth most valuable commercial fishery after halibut, geoduck, and crab fisheries,⁷ of which only the crab fishery was active recently in Howe Sound. The catch, and presumably value, of the commercial prawn trap fishery in Howe Sound hovers at between two percent and four percent of the B.C. coast-wide total.⁸ The relative importance

of the recreational fishery is even greater. Two thirds of B.C. prawn and shrimp sport fishing effort in 2010 was focused on the Strait of Georgia.⁹ As noted above, Area 28, which includes Howe Sound, has the highest recreational effort in B.C. for shellfish trapping by boat. Recreational fishing activity not only provides food for personal use, it connects people to the natural world. Roughly 75 percent of recreational fishing licenses in B.C. are held by B.C. residents.

History

Howe Sound is the birthplace of the commercial prawn and shrimp by trap fishery in B.C. going back to about 1914. The fishery expanded up the coast and by the mid-1970s, Knight and Kingcome Inlets led production.¹⁰ It wasn't until 1990 that the number of commercial licenses available to fish prawn and shrimp by trap was limited in order to make the fishery more sustainable. The trawl fishery for shrimp dates back to 1930s in B.C., but wasn't significant until the 1960s when salmon and halibut were both in short supply.¹¹ Management first implemented trawl net catch limits for most of the coast as recently as 1997, and precautionary management has resulted in increased regulation and monitoring since then.

Due to industrial contamination of the marine environment, specifically dioxins and furans from pulp mills, parts of Howe Sound were first closed to the harvest of prawn, shrimp, and crab in 1988 and the commercial closure was expanded to all of Howe Sound in June 1989.¹² Some of these contamination closures were removed in 1995, after pulp mills cleaned up processing and discharge.¹³ Currently, there are no permanent closures for contamination in Howe Sound, but Canadian Food Inspection Agency guidelines recommend avoiding fishing near sewage outfalls, discharge pipes, or other contamination sources.

How does this relate to First Nations heritage?

At a 2015 Howe Sound Science and Knowledge Workshop held at the Vancouver Aquarium, Chief Bill Williams of the Squamish Nation reported that First Nations were pushed out of the prawn fishing industry in the 1960s but that their youth were now re-entering the fishery. He said they have a steep learning curve without role models because of the lack of participation in the fishery for such a long time. At the same workshop we heard anecdotally that Musqueam Na-

tion Elders prefer shellfish from Howe Sound over anywhere else in the region because they taste better.¹⁴

In terms of fishery management, First Nations' fishing for food, social and ceremonial (FSC) purposes is the first priority after conservation and FSC fishing for prawn and shrimp by trap is currently open coast-wide throughout the year.

What is the current state?

Spot prawns have become the darling of a local sustainable seafood movement after they became a recommended sustainable seafood choice by the Vancouver Aquarium's Ocean Wise program in 2014, following an assessment done by the Monterey Bay Aquarium's (MBA) Seafood Watch program.¹⁵ Sustainability rankings mean that the fisheries are generally well managed and sustainable, though with potential

for improvement. Concerns about potential adverse effects of trap and trawl gear types on sensitive bottom habitat, especially sponge reefs and bioherms have been repeatedly raised in Howe Sound and elsewhere. This applies to recreational prawn traps as well.

Additional concerns about potential impacts of commercial and recreational fishing gear include bycatch and entanglement. Entanglement of marine mammals, sea turtles and basking sharks is possible, but has not been noted as an issue in Howe Sound. Juvenile rockfish are sometimes unwanted catch, or bycatch, in prawn trap gear and even if released at the surface are presumed not to survive due to their unique physiology. Quillback rockfish, a species quite common in Howe Sound and listed as threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), are the most frequently encoun-



Commercial prawn boat in Howe Sound. (Photo: Bob Turner)

tered in the prawn fishery.¹⁶ However, research from 2002 to 2008 showed that estimated rockfish bycatch is lower in Howe Sound than many other Fishery Management Areas.¹⁷ Bycatch in the trawl fishery can include eulachon, an energy rich forage fish with significant First Nations cultural importance, and listed as endangered by COSEWIC. Eulachon are being considered for listing as Endangered under the Species at Risk Act (SARA)¹⁸ and the viability of eulachon in the Squamish river watershed is currently being studied.¹⁹

According to the MBA Seafood Watch assessment, B.C.'s trawl fishery is at risk because it is primarily a small boat fleet harvesting modest volumes during day trips and the fleet can no longer compete with lower priced coldwater shrimp from the U.S. West Coast and Eastern Canada, let alone a huge surge in aquaculture production of warm water shrimp in tropical coun-

tries.²⁰ However, large trawl vessels were active in the B.C. shrimp fishery starting March 2015,²¹ when high pink shrimp biomass off West Coast Vancouver Island made larger vessels viable.

Data quantifying recreational catch and effort has been lacking in the past. As of April 2013, Tidal Waters Sport Fishing license holders are required to provide information on their recreational fishing activity when requested.²² Survey participants are randomly selected and are asked to participate in the Internet Recreational Effort and Catch (iREC) Survey. A DFO report on recreational buoy surveys (daytime counts of buoys connected to traps) that have been conducted coast-wide to provide baseline information on relative levels of prawn fishing effort is in preparation. DFO conducted such a survey in Howe Sound in 2015.²³

What is being done?

The annual B.C. spot prawn festival, started in 2007 by a Vancouver chef, increases awareness and local access to a product that had previously been mostly exported.

Management of the prawn and shrimp fisheries is undertaken by DFO in consultation with advisory boards that include representatives from First Nations, commercial and recreational industry representatives, and the Province of B.C. DFO also engages in bilateral processes with First Nations.

Biologically based management measures are used to maintain the viability of the stocks and the fisheries.

The commercial prawn fishery is monitored in-season where trained fisheries observers board commercial vessels and sample the catch. DFO then uses this information to ensure conservation targets are met. Other management measures include restrictions on the number of licences, seasonal and area closures, gear limits, minimum size limits, daily fishing time restrictions, and single haul limits all apply. Separate management plans exist for trap versus trawl fishing and different catch limits are imposed. In the Pacific Region, there are 249 prawn and shrimp by trap licences in total, of which 57 are communal commercial for First Nations participation in the commercial fishery. Eighty percent of the prawn and shrimp by trap

fleet was checked for general compliance on board during the 2015 season, including inspections specifically for trap mesh size, trap tags and product size.²⁴

Closures are one way to limit gear impact on sensitive bottom habitat, such as sponge reefs. As of June 2015, all commercial and recreational bottom contact fishing (both trap and trawl) for prawn, shrimp, crab and groundfish is prohibited in nine glass sponge reef areas in the Strait of Georgia including reefs at Passage Island and Defence Islands in Howe Sound. Closures to bottom contact fishing for FSC purposes applied starting April 2016. That leaves at least 11 areas unprotected where glass sponge reefs or bioherms have been identified and documented in Howe Sound ([see Sponge Reefs article](#)).

Rockfish Conservation Areas (RCAs), of which there are 11 in Howe Sound, are closed to bottom trawl gear, but commercial and recreational prawn trap fishing is permitted within RCAs. Third-party observers in the commercial prawn trap fishery have collected additional information on rockfish bycatch as a condition, coast-wide, since 2002.

Additional measures implemented in the trawl fishery include mandatory gear modifications since 2000 to reduce bycatch, and a bycatch monitoring program supported by industry since 1999. However, the observer program that monitors bycatch has been limited in the past (50 days per year) which means that estimating total annual bycatch by the fishery is impossible.

The recreational fishery has a daily catch and possession limit for prawns and shrimp combined. Gear limits and seasonal area closures also apply. To date, DFO has not specified gear or catch limits in communal licences for First Nations' FSC harvest.

DFO continued its semi-annual survey of Howe Sound prawn stocks in February and November 2015. These surveys began in 1985 and the data represent a unique and invaluable time series data set for understanding prawn recruitment and productivity parameters.²⁵

What can you do?



Individual and Organization Actions:

- Make sure your licence is up to date and comply with catch limits when you are sport fishing. (The daily catch limit is 200 pieces of prawn and shrimp, combined, and the possession limit is 400 pieces.)
- Keep your traps away from sensitive areas including sponge reefs, bioherms, and RCAs.
- Release live catch (i.e., bycatch) in waters where caught.
- Use 'rot cords' (a biodegradable escape mechanism) on your traps to allow bycatch to escape in the event traps are lost.
- Make sure your buoys are clearly identified with your name.
- Report any gear theft and the theft of catch from traps to the police.
- Report accurate fishing activity and catch to DFO when requested to do so.
- Release prawns and shrimp that are carrying eggs under their tails (known as berried prawn and shrimp), as soon as possible and at the fishing location.



Government Actions and Policy:

- Expand sponge reef closures to include all sponge reefs and bioherms identified in Howe Sound, in accordance with the Sensitive Benthic Areas Policy.
- Allocate more resources to enforcement of fishing regulations including protected area closures.

Resources

Ocean Wise®

oceanwise.ca is a Vancouver Aquarium conservation program created to educate and empower consumers about the issues surrounding sustainable seafood.

Prawn Fishery – Pacific Region

pac.dfo-mpo.gc.ca/fm-gp/commercial/shellfish-mollusques/prawn-gcrevette/index-eng.html

Shrimp Fishery – Pacific Region

pac.dfo-mpo.gc.ca/fm-gp/commercial/shellfish-mollusques/shrimp-pcrevette/index-eng.html

DFO Research Document, 2009, Rockfish Bycatch in the British Columbia Commercial Prawn Trap Fishery
dfo-mpo.gc.ca/csas-sccs/publications/resdocs-docrech/2009/2009_109-eng.htm

Footnotes

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³ Vancouver Aquarium Ocean Wise. Seafood Items Listing. Accessed Aug 30, 2016. <http://www.oceanwise.ca/seafood>

⁴ Department of Fisheries and Oceans. 2016. Shrimp Survey Bulletin 16-01. Provided to the author by Ken Fong, Sept 29, 2016. No update on Howe Sound was available at this time.

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²¹ DFO 2016d.

²² <http://www.pac.dfo-mpo.gc.ca/fm-gp/rec/irec/index-eng.html>

²³ DFO 2016a.

²⁴ DFO 2016a.

²⁵ DFO 2016a, see references in this management plan for several published papers on prawns that have benefitted from semi-annual survey data.



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