HABs in the Northeast Pacific British Columbia prospective

PACIFIC SALMON FOUNDATION

Fisheries and Oceans Canada

Pêches et Océans Canada

Svetlana Esenkulova, Pacific Salmon Foundation

Dr. Andrew Ross, Department of Fisheries and Oceans Canada

History of HABs in Canada

- Coastal waters of British Columbia (BC), Canada have one of the longest documented histories of PSP in the world (Vancouver, 1793)

- A monitoring program for the presence of toxins in shellfish was established in the 1940s (Taylor and Harrison, 2002); since then, PSP closures have been occurring every year

- ASP closures occur on the West Coast (SoG rarely); monitoring since ~80/90th

- The first DSP in BC was confirmed only recently (2011); *Dinophysis* concentrations (Esenkulova and Haigh, 2012, First report on Dinophysis species causing diarretic shellfish poisoning in BC, Canada, Harmful Algae Newsletter 45)

History of HABs in Canada

- DFO led pioneering research on HABs from ~1970 to ~2000
  - Discovery of new toxins and algal species -Max Taylor, Stephen Bates
  - Harmful Algae Monitoring Program - Ian Whyte, Nicky Haigh

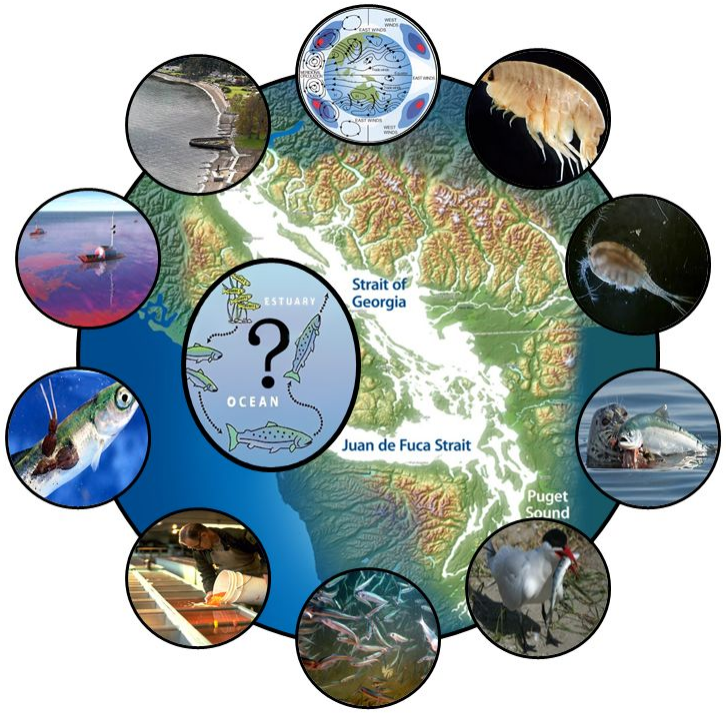
- Delineation of responsibilities between DFO and CFIA ~2000
  - CFIA - testing of shellfish for biotoxins
  - DFO - implements closures of shellfish harvesting areas

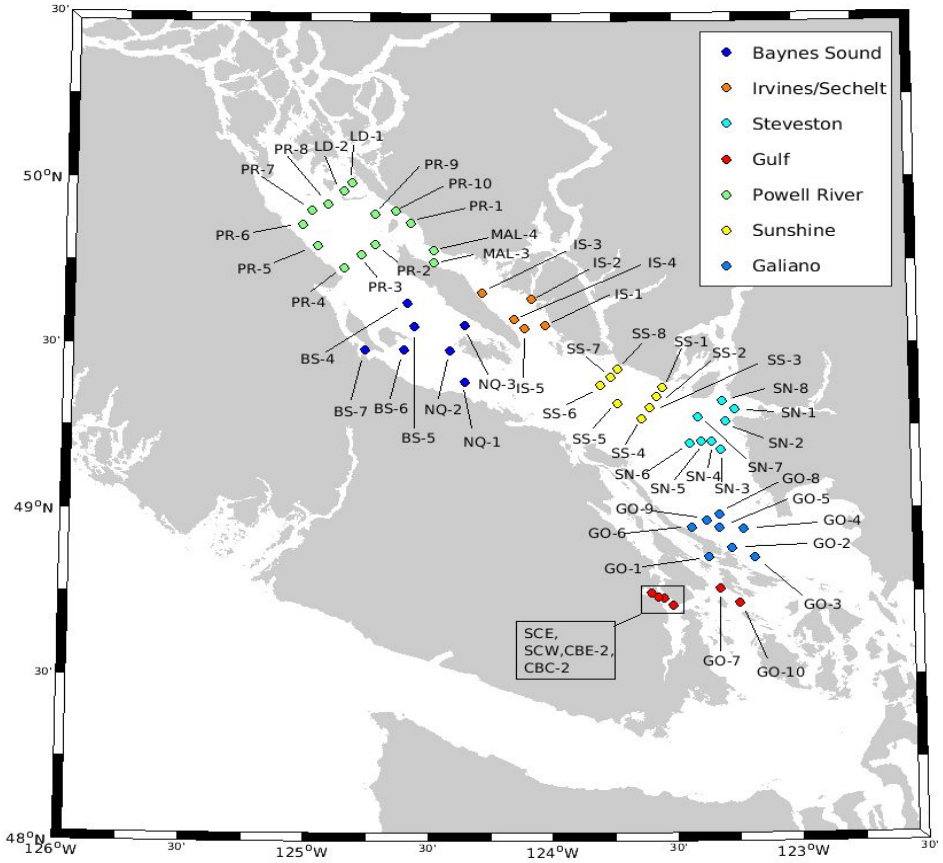
- Current challenges
  - No systematic government monitoring/research due to insufficient funding
  - 2019 CSAS - HABs status, impacts and consequences, and knowledge gaps

PSF Citizen Science Oceanography Program 2015-2024

"scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions"

Our program is endorsed by Intergovernmental Oceanographic Commission UNESCO - section Global HAB



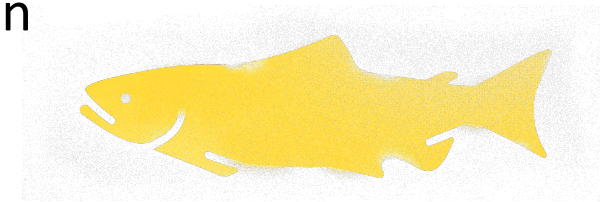


Trained 7 crews collect samples
Analysis – PSF, DFO, UBC

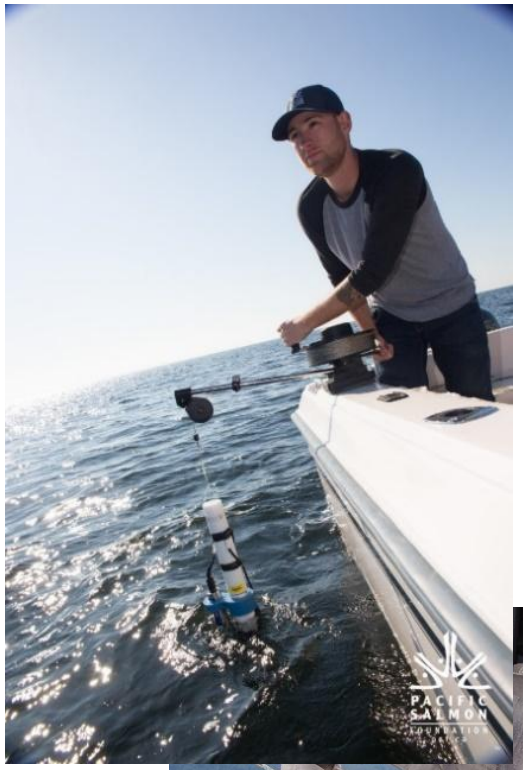
~55 PSF stations

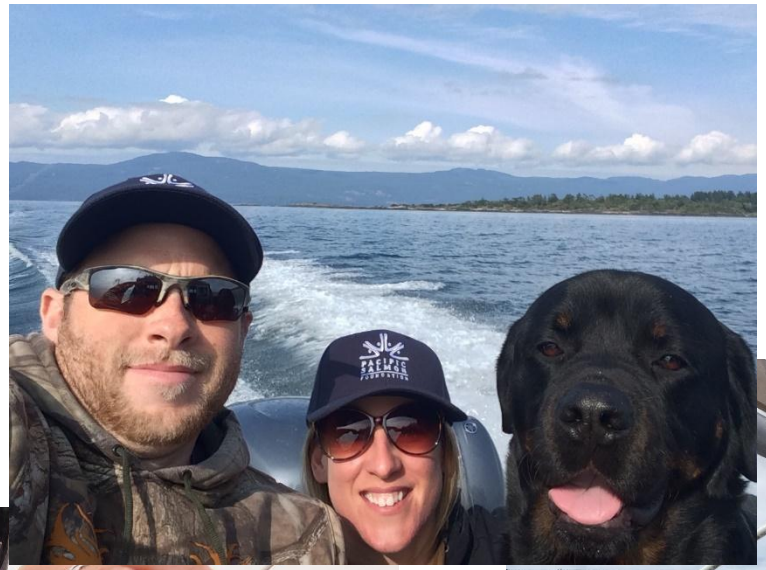
~20 trip/year
February – October: 2/3 times a month
November – January: once a month

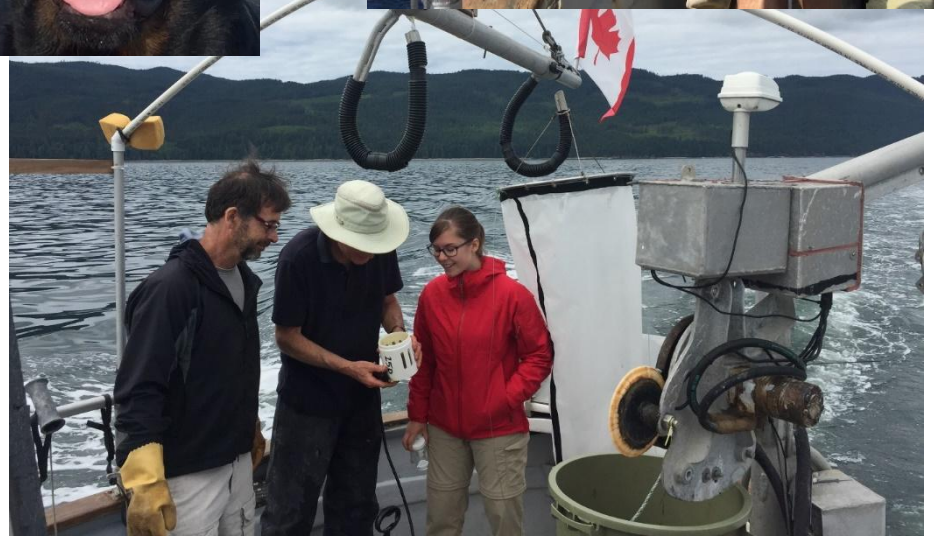
CTD and Phytoplankton – each station
Nutrients ~30 stations
Biotoxins – 4 stations



Citizen Science Oceanography Program people

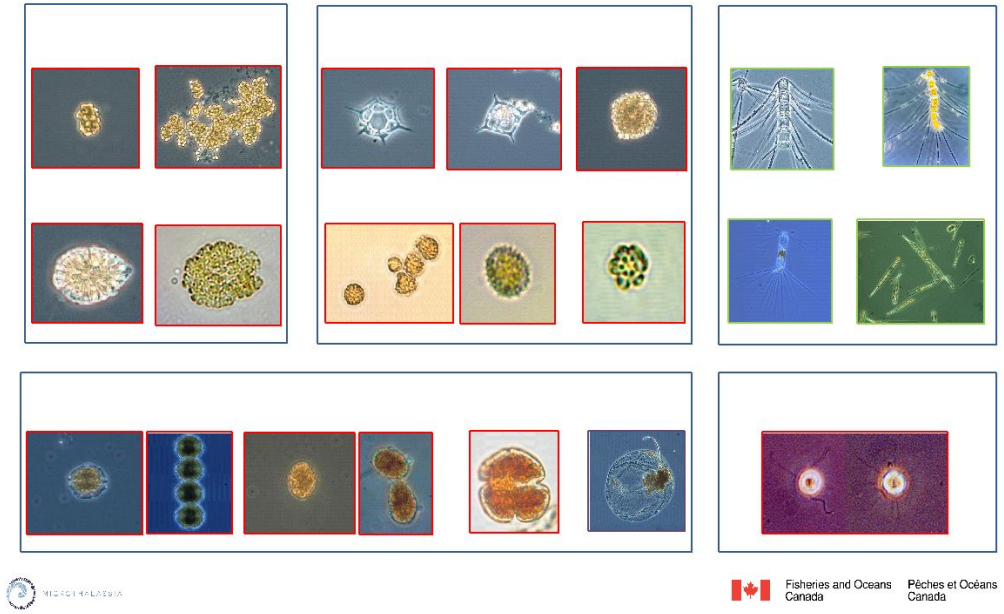






Photos by: PSF Citizen Scientists

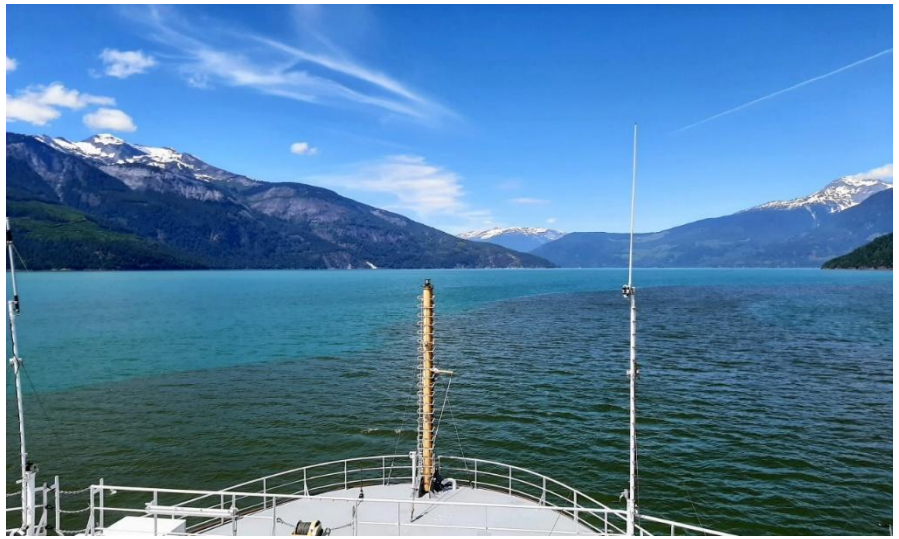
Enumerated (cell mL^{-1}):
Alexandrium spp.
C. convolutus and *C. concavicornis*
Cochlodinium fulvescens
Dictyocha spp.
Dinophysis spp.
Heterosigma akashiwo
Noctiluca scintillans
Rhizosolenia setigera
Pseudo-nitzschia spp.



Heterosigma + *Noctiluca*, 2018, Kuper

Photos by: M. Bahrey and Esenkulova

Gonyaulax spp, June 2018, Mill Bay



Heterocapsa triquetra, June 2021, Bute Inlet

Mixed bloom, July 2021, Howe Sound

Bloom of *Noctiluca,* Strait of Georgia

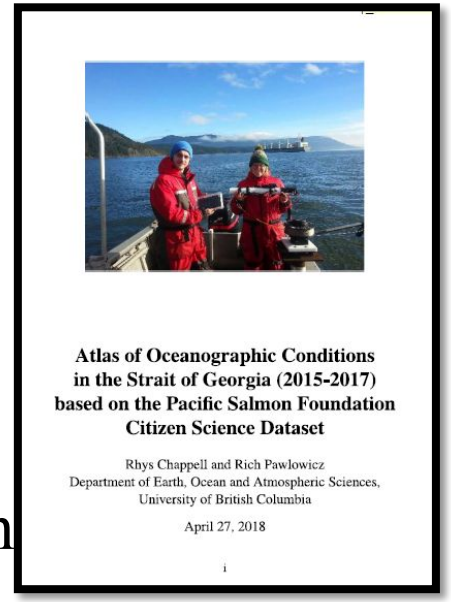
Photos by: Dr. Maycira Costa

Michael Bahrey

Dr. N Christiansen and Esenkulova

DATA - Data Center
http://sogdatacentre.ca/

PLOTS - Digital Atlas, updated annually (Dr. Rich Pawlowicz, UBC)
https://sogdatacentre.ca/atlas/



Annual reports – "Harmful algal blooms and oceanographic conditions in the Strait of Georgia" for the DFO State of the Pacific Ocean

Peer-reviewed publications – S. Esenkulova et al, 2021 Harmful Algae and Oceanographic Conditions in the Strait of Georgia, Canada, Based on Citizen Science Monitoring, Frontiers in Marine Science
https://doi.org/10.3389/fmars.2021.725092

Social Media – HAB updates on facebook page
https://www.facebook.com/CitizenSciencePhytoplankton

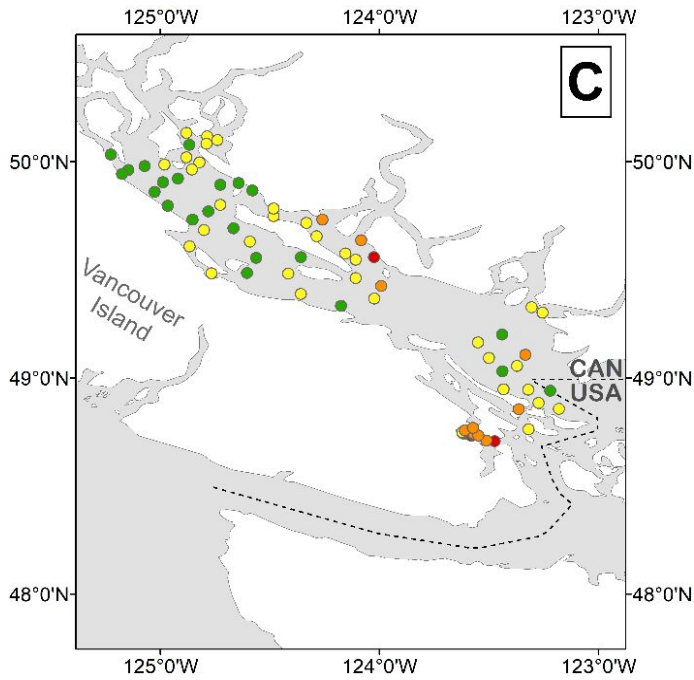
Published results

<u>Inter-annual</u> - Pearson Product-Moment Correlations (r) between mean HABs taxa concentrations and environmental drivers and nutrients during summer (June, July, August) using average values for each station in the Strait of Georgia from 2015 to 2018 (n = 259).

	Environmental Drivers				Nutrients			
	Temperature	**Salinity**	**Stratification**	**Secchi**	**N**	**P**	**N:P**	**Si**
Alexandrium spp.	**-0.143**	**0.169**	**-0.140**	0.106	0.058	0.023	0.058	-0.036

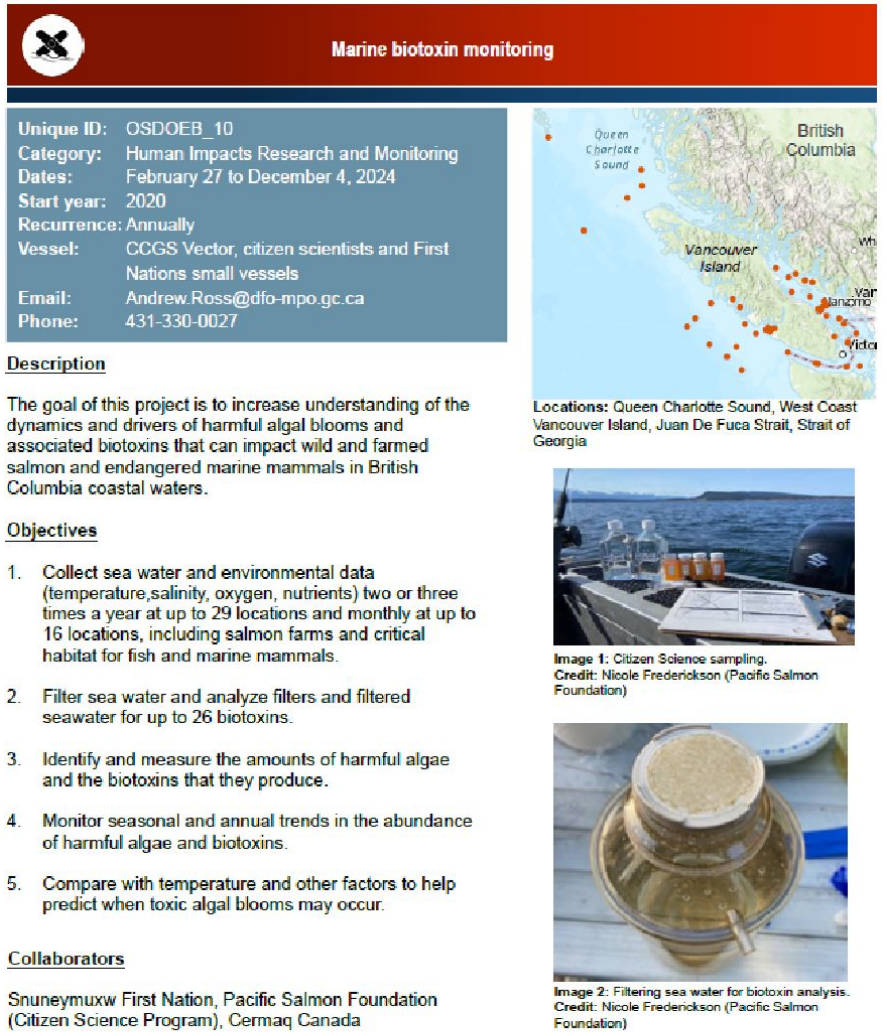
Intra-annual - Pearson Product Moment Correlations (r) between mean monthly concentrations of HABs taxa and various physical and chemical variables from March to September 2015-2018 averaged over the entire SoG (n = 28).

Secchi depth	**-0.497**
Temperature	**0.753**
Salinity	-0.363
Stratification	**0.611**
Nitrate	**-0.651**
Phosphate	**-0.557**
Silicate	-0.205
Wind Speed	-0.174
Rainfall	**-0.505**
Cloud Cover	**-0.653**
Fraser River Flow	0.33



DFO Marine Biotoxin Monitoring Program

- in 2015 an extraordinary phytoplankton bloom took place along the west coast, during a marine heat wave.
- this bloom contained *Pseudo-nitzschia* species that produce domoic acid (Amnesic Shellfish Poisoning).
- in 2016 DFO started monitoring domoic acid in British Columbia coastal waters, using ELISA.
- in 2020 DFO began collaborating with B.C. Salmon Farmers and PSF Citizen Scientists to monitor domoic acid, saxitoxins (Paralytic Shellfish Poisoning) and other (Diarrhetic Shellfish Poisoning) toxins, using LC-MS/MS.
- the Marine Biotoxin Monitoring Program now includes DFO surveys (Salish Sea, La Perouse) and First Nations.



Marine biotoxin monitoring

Unique ID: OSDOEB_10
Category: Human Impacts Research and Monitoring
Dates: February 27 to December 4, 2024
Start year: 2020
Recurrence: Annually
Vessel: CCGS Vector, citizen scientists and First Nations small vessels
Email: Andrew.Ross@dfo-mpo.gc.ca
Phone: 431-330-0027

Description

The goal of this project is to increase understanding of the dynamics and drivers of harmful algal blooms and associated biotoxins that can impact wild and farmed salmon and endangered marine mammals in British Columbia coastal waters.

Objectives

1. Collect sea water and environmental data (temperature,salinity, oxygen, nutrients) two or three times a year at up to 29 locations and monthly at up to 16 locations, including salmon farms and critical habitat for fish and marine mammals.
2. Filter sea water and analyze filters and filtered seawater for up to 26 biotoxins.
3. Identify and measure the amounts of harmful algae and the biotoxins that they produce.
4. Monitor seasonal and annual trends in the abundance of harmful algae and biotoxins.
5. Compare with temperature and other factors to help predict when toxic algal blooms may occur.

Collaborators

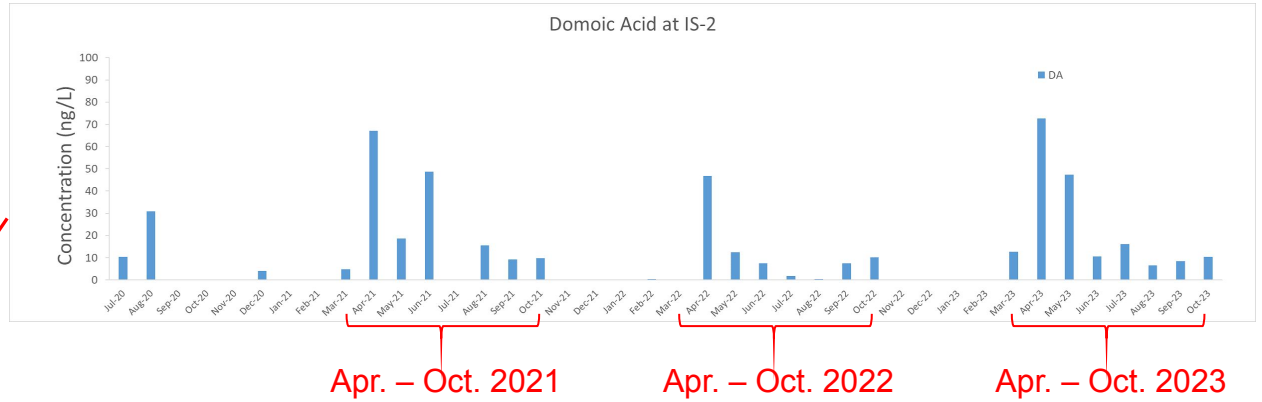
Snuneymuxw First Nation, Pacific Salmon Foundation (Citizen Science Program), Cermaq Canada

Locations: Queen Charlotte Sound, West Coast Vancouver Island, Juan De Fuca Strait, Strait of Georgia

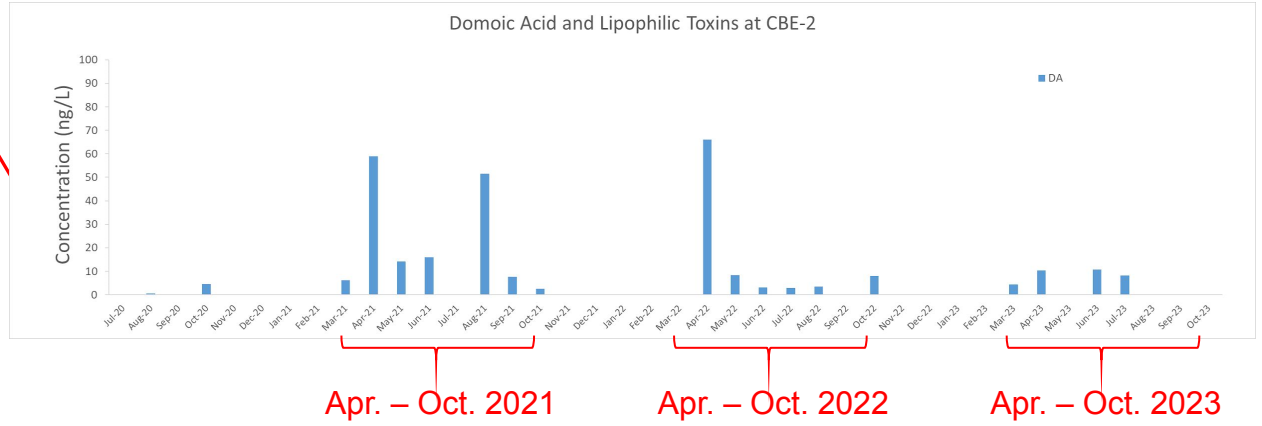
Image 1: Citizen Science sampling.
Credit: Nicole Frederickson (Pacific Salmon Foundation)

Image 2: Filtering sea water for biotoxin analysis.
Credit: Nicole Frederickson (Pacific Salmon Foundation)

Biotoxin Monitoring at PSF Citizen Science Sites



- Domoic acid tends to peak in April in the Salish Sea.
- Domoic acid in Malaspina Strait (IS-2) similar in 2021, 2022 and 2023.
- Domoic acid in Cowichan Bay (CBE-2) lower in 2023 than in 2021 or 2022.

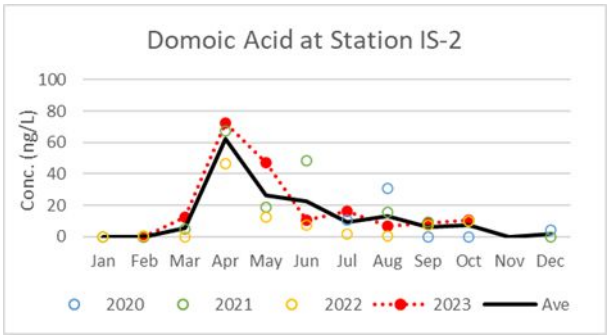


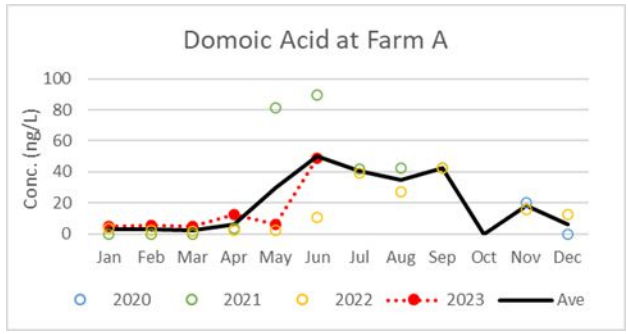
Seasonal Trends in Biotoxin Concentrations

Malaspina Strait

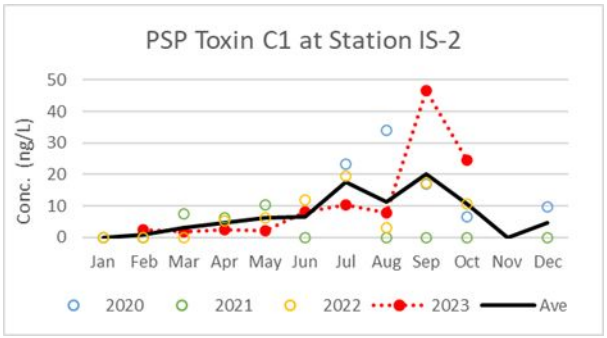
Clayoquot Sound

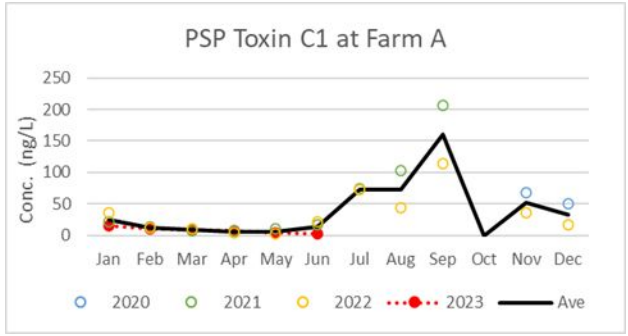
Domoic Acid (DA)





Saxitoxin (C1)

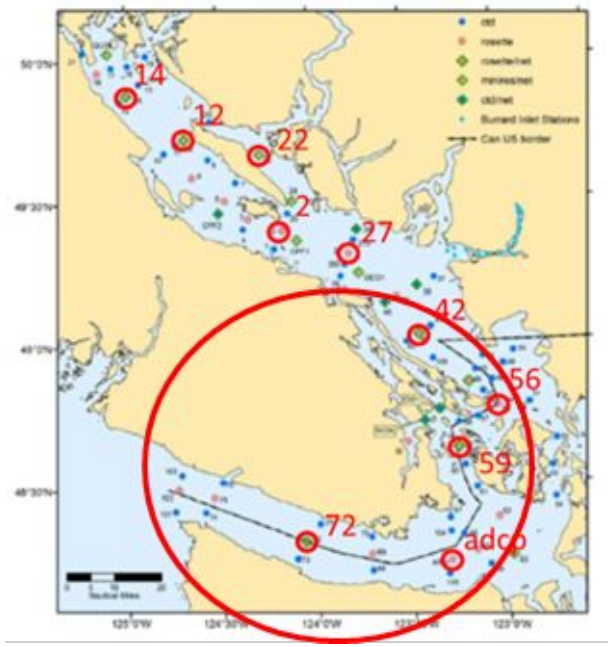




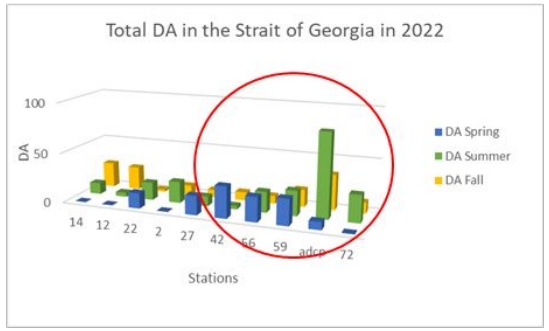
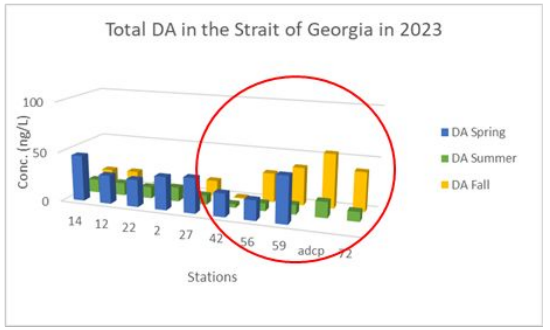
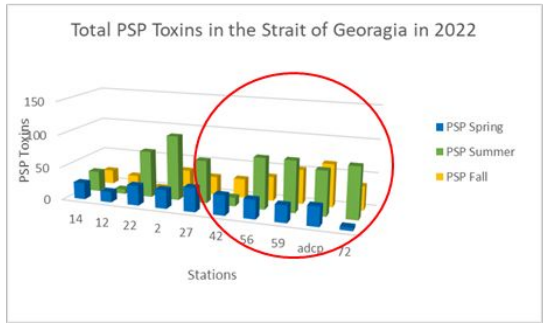
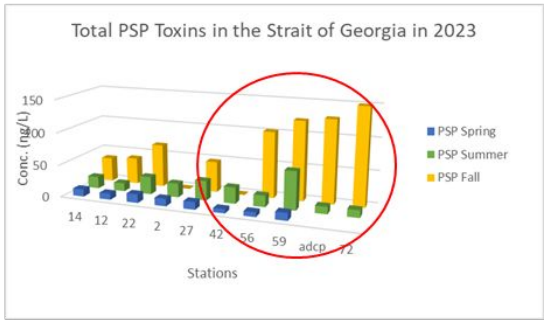
- ASP toxin (DA) peaks in April in Salish Sea and in June on WCVI (*cf.* spring *Pseudo-nitzschia* bloom).
- PSP toxin (C1) peaks in September at both locations (*cf.* fall *Alexandrium* bloom).

Biotoxin Monitoring in SRKW Habitat

- Harmful algal biotoxins previously detected and/or known to cause harm in marine mammals are being monitored in the Salish Sea, including in SRKW Critical Habitat (red circle).



- Domoic Acid and Saxitoxins in the Salish Sea during the Fall tend to be highest in SRKW habitat (particularly in 2023) while in 2022 they were also more abundant during the Summer, indicating seasonal and interannual variability.

	2022	2023
Domoic Acid		
Saxitoxins		

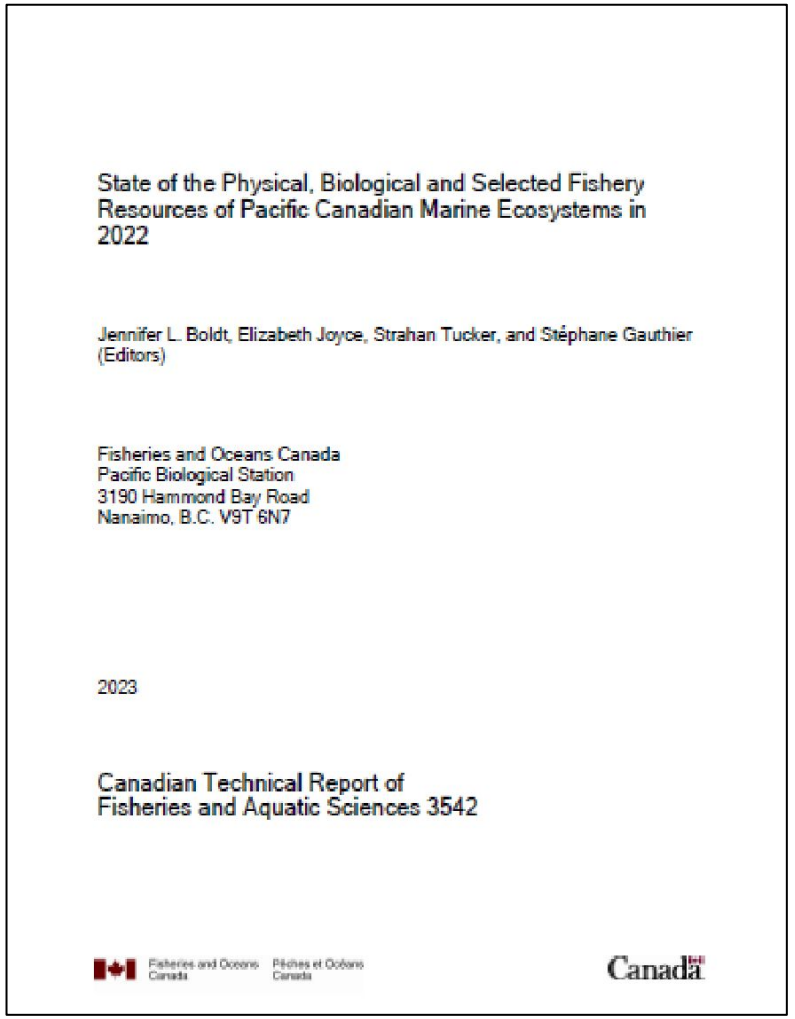
More Information on DFO Biotoxin Monitoring

- Chapter 47: “Marine Biotoxin Monitoring in B.C. Coastal Waters” in the 2023 DFO State Of the Pacific Ocean (SOPO) Report: https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/41199248.pdf

- DFO Pacific Science Field Operations Fact Sheet OSDOEB_10: “Marine biotoxin monitoring” in Fieldnotes 2024-2025: https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/41232719fs.pdf

- Perry, I.A., Nemcek, N., Hennekes, M., Sastri, A., Ross, A.R.S., Shannon, H., Shartau, R.B. (2023) “Domoic acid in Canadian Pacific waters, from 2016 to 2021, and relationships with physical and chemical conditions”. Harmful Algae 24, 102530.

- Shartau, R.B., Turcotte, L., Bradshaw, J.C., Ross, A.R.S., Surridge, B.D., Perry, R.I., Nemcek, N., Johnson, S.C. (2023) “Dissolved algal toxins along the southern coast of Vancouver Island British Columbia”. Environmental Science: Processes and Impacts 24, 1460-1473.



State of the Physical, Biological and Selected Fishery Resources of Pacific Canadian Marine Ecosystems in 2022

Jennifer L. Boldt, Elizabeth Joyce, Strahan Tucker, and Stéphane Gauthier (Editors)

Fisheries and Oceans Canada
Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, B.C. V9T 6N7

2023

Canadian Technical Report of Fisheries and Aquatic Sciences 3542

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada

Summary

- Harmful algae and their blooms are common in BC but government-led monitoring and research are currently limited
- Well managed Citizen Science monitoring can provide valuable and cost effective data
- Based on PSF CitSc Oceanography program we know where, when and a little bit of why harmful algae occur in SoG (e.g. *Alexandrium* is mostly affected by T, stratification, nutrients and appear to be linked with large-scale climate patterns; data on the presence of toxins and associated algae are consistent)
- A lot of potential for research, collaboration, and future studies
- Climate change may lead to increasing frequency and severity of HABs - need to act now

PACIFIC SALMON FOUNDATION

Canada

sesenkulova@psf.ca – Svetlana Esenkulova, PSF
Andrew.Ross@dfo-mpo.gc.ca Dr. Andrew Ross, DFO