Harmful algae dynamics in the Strait of Georgia, Canada

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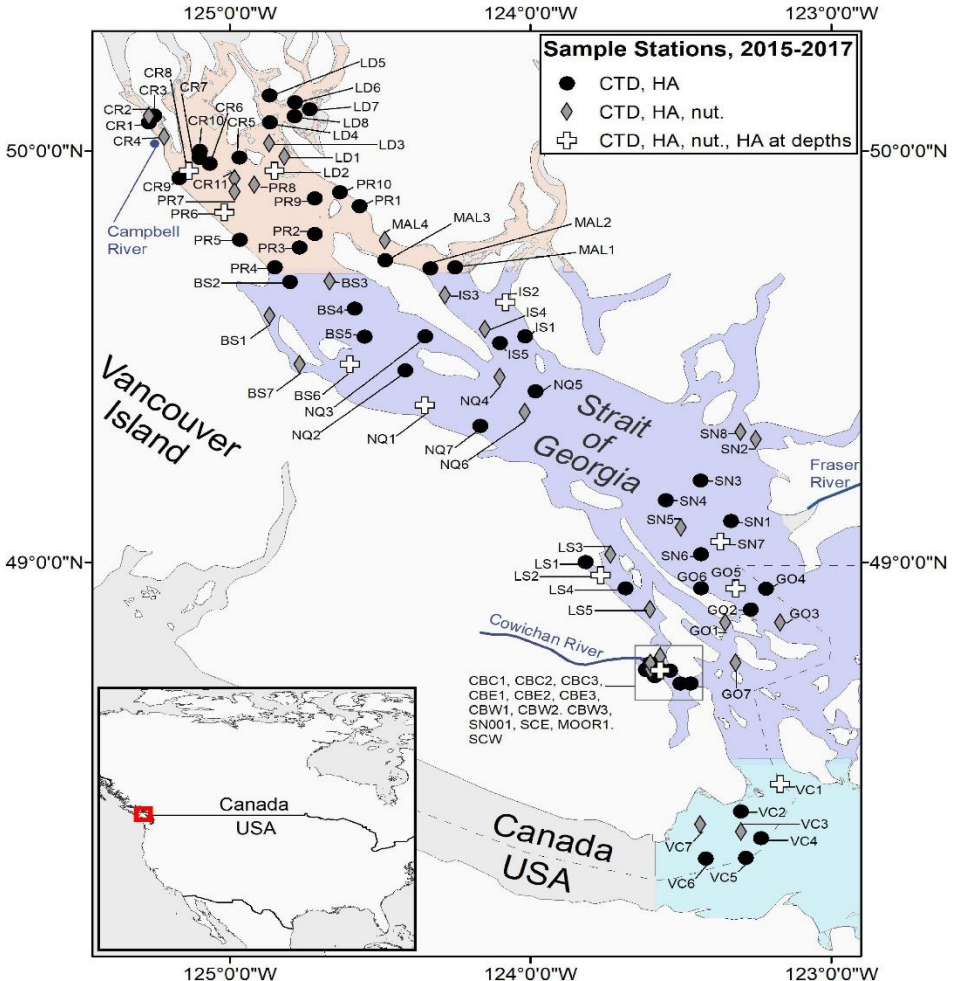
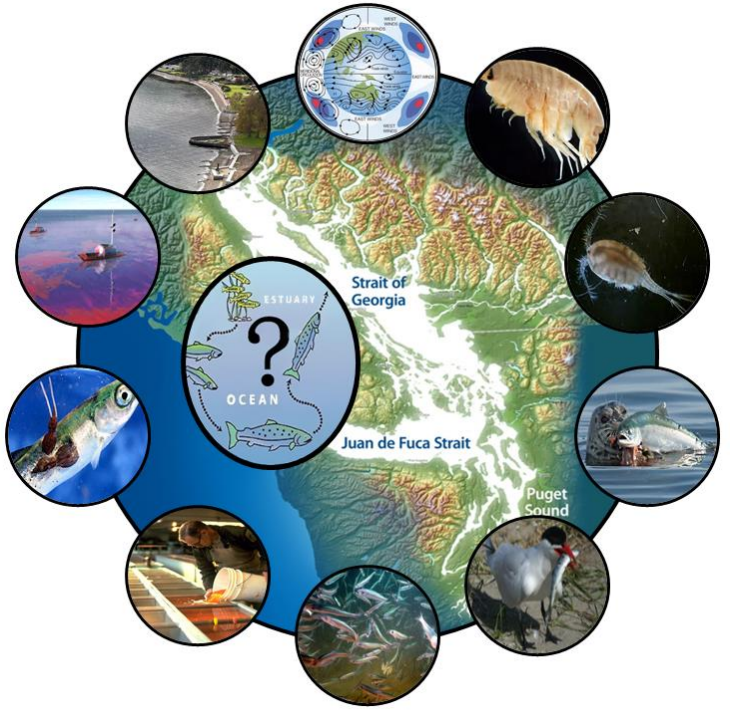
PACIFIC SALMON FOUNDATION

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

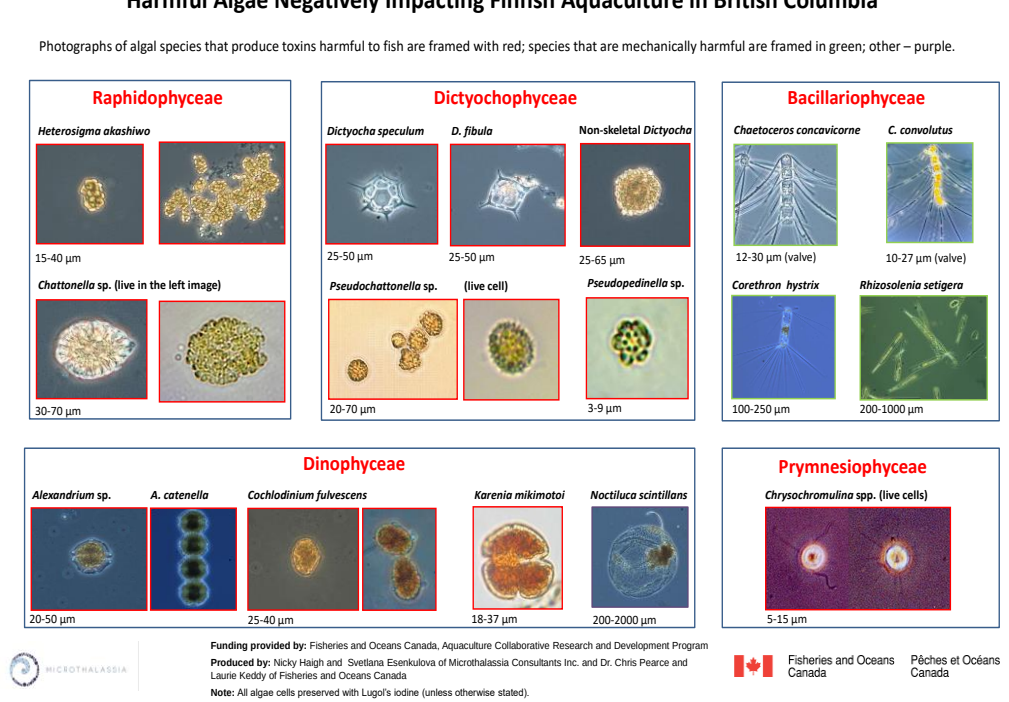
~55 PSF stations

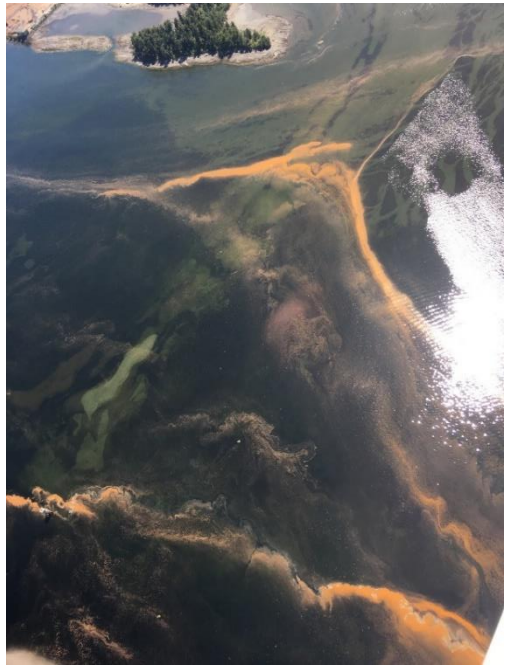
~20 trip/year
February – October: 2/3 times a month
November – January: once a month

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

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.

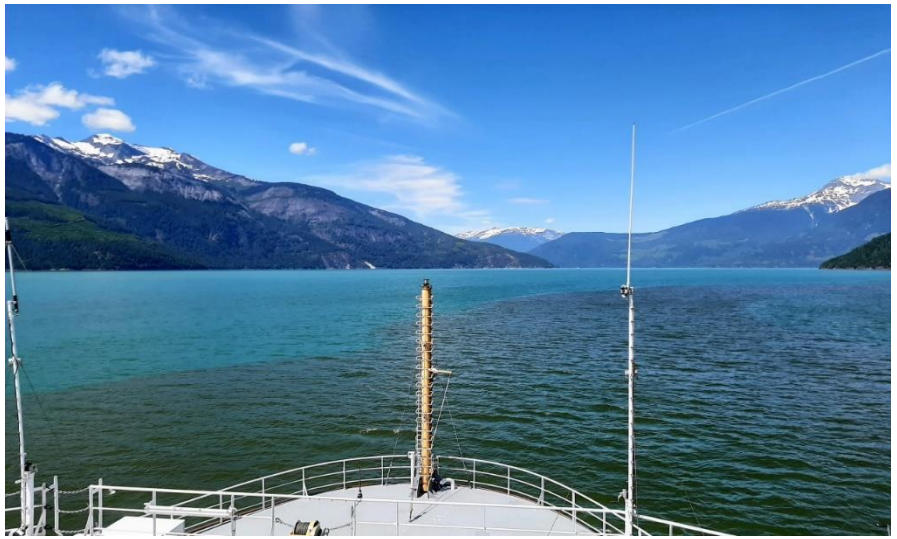




Heterosigma + *Noctiluca*, 2018, Kuper

Photos by: M. Bahrey and Esenkulova

Gonyaulax spp, June 2018, Mill Bay



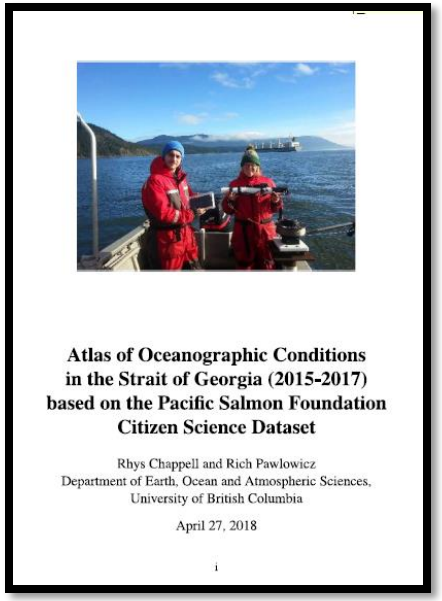
Heterocapsa triquetra, June 2021, Bute Inlet

Mixed bloom, July 2021, Howe Sound

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 based on 4 years data

S. Esenkulova et al, 2021 Harmful Algae and Oceanographic Conditions in the Strait of Georgia, Canada, Based on Citizen Science Monitoring

	Chaetoceros convolutus and C. concavicornis	*Rhizosolenia setigera*	*Alexandrium* spp.	*Heterosigma akashiwo*	*Dictyocha* spp.
Secchi depth	**0.429**	**−0.645**	**−0.497**	**−0.565**	**−0.406**
Temperature	**−0.509**	**0.665**	**0.753**	**0.58**	**0.498**
Salinity	0.368	−0.284	−0.363	−0.361	**−0.441**
Stratification	**−0.537**	**0.619**	**0.611**	**0.709**	**0.443**
Nitrate	**0.609**	**−0.477**	**−0.651**	**−0.541**	**−0.408**
Phosphate	**0.613**	−0.312	**−0.557**	**−0.383**	−0.3
Silicate	0.048	0.003	−0.205	0.04	0.062
Wind speed	0.222	−0.074	−0.174	−0.217	−0.225
Rainfall	0.171	**−0.417**	**−0.505**	**−0.466**	−0.225
Cloud cover	0.352	−0.362	**−0.653**	**−0.379**	−0.155
Fraser river flow	−0.034	0.066	0.33	0.35	−0.01

Bold font indicates statistically significant values.

Intra-annual between mean monthly concentrations of HABs taxa and various physical and chemical variables from March to September

	Environmental drivers				Nutrients			
	Temperature	Salinity	Stratification	Secchi	N	P	N:P	Si
Heterosigma akashiwo	**−0.131**	**−0.178**	**0.237**	−0.110	−0.008	0.035	−0.035	**0.227**
Alexandrium spp.	**−0.143**	**0.169**	**−0.140**	0.106	0.058	0.023	0.058	−0.036
Dictyocha spp.	−0.051	−0.070	−0.022	−0.096	0.013	**−0.165**	0.110	**−0.146**
Rhizosolenia setigera	0.100	**0.226**	−0.027	−0.002	0.066	−0.029	0.095	**−0.287**
Chaetoceros convolutus and *C. concavicornis*	−0.098	0.084	−0.048	0.053	0.050	0.065	0.031	−0.019

Bold font indicates statistically significant values.

Inter-annual relationships between mean HABs taxa concentrations and environmental drivers and nutrients during summer (June - August)

Unusual observations 2015-2024

- atypical phytoplankton dynamics during the **2015** (super El Niño)
- Extremely early spring bloom (Feburary vs April)
- Unusual spring bloom composition (Skeletomena vs. a mix of Thalassiosira, Chaetoceros, and Skeletonema)
- High levels of Chaetoceros convolutes/ concavicorne in spring
- Very low cell counts in summer, no summer HABs

S. Esenkulova et al, 2021 Harmful Algae and Oceanographic Conditions in the Strait of Georgia, Canada, Based on Citizen Science Monitoring

Unusual observations 2015-2024

a rare coccolithophores bloom in late summer of **2016**
uncommon here due to generally lower pH conditions

Will Duguid, PSF, Maple Bay, 2016

https://www.news24.com/news24/pic-strait-of-georgia-turns-green-as-mysterious-phytoplankton-blooms-20160905

Jim Gower, DFO, August 19, 2016

Associated conditions: lower-than-average precipitation and reduced freshwater discharge in 9 years

Unusual observations 2015-2024

Summer **2021** - The first confirmed (BC Centre for Disease Control) infection in a human (man from Denman Island, infected at Baynes Sound) caused by rare Shewanella algae/ bacterium

https://www.pqbnews.com/news/denman-island-mans-infection-from-rare-bacteria-raising-questions-1193860

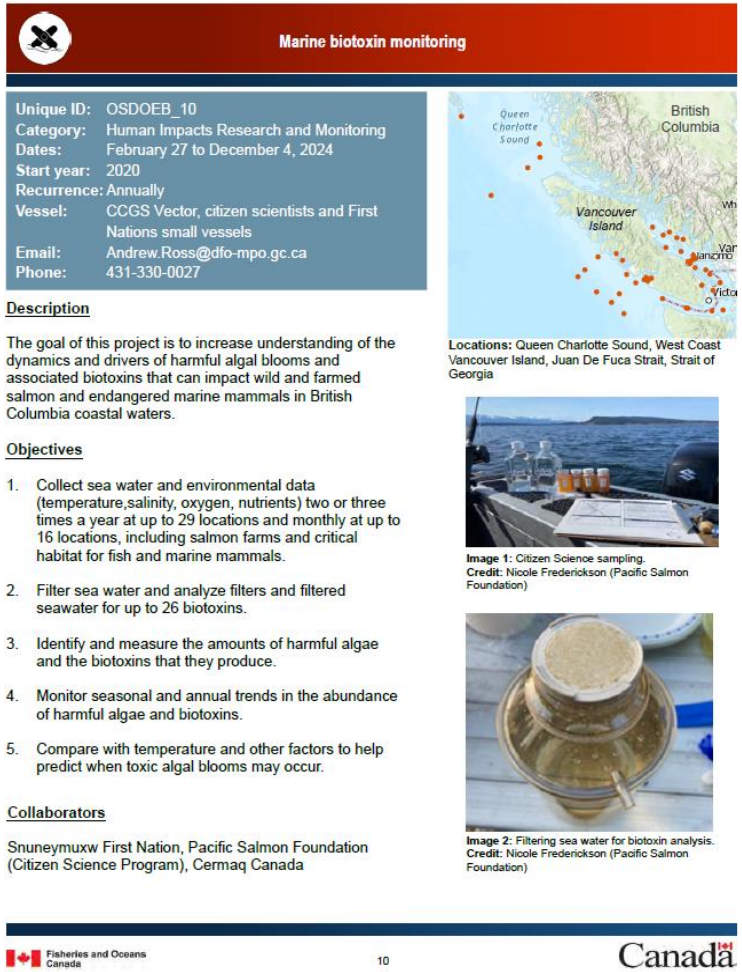
Shewanella is presumably typical for tropical waters

Shewanella species are emerging pathogens (Ng et al., 2022)

Associated conditions: July and August SST were generally warmer than usual, significantly higher PAR

Unusual observations 2015-2024

- Very high abundance of Prorocentratium reticulatum (Yessotoxin producer) in 2022 in July-August (up to 90 cell mL^{-1})
- Yessotoxin in water was abundant (SOPO 2023, Ross et al.)
- Associated conditions: exceptionally high Fraser River discharge in July



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

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

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

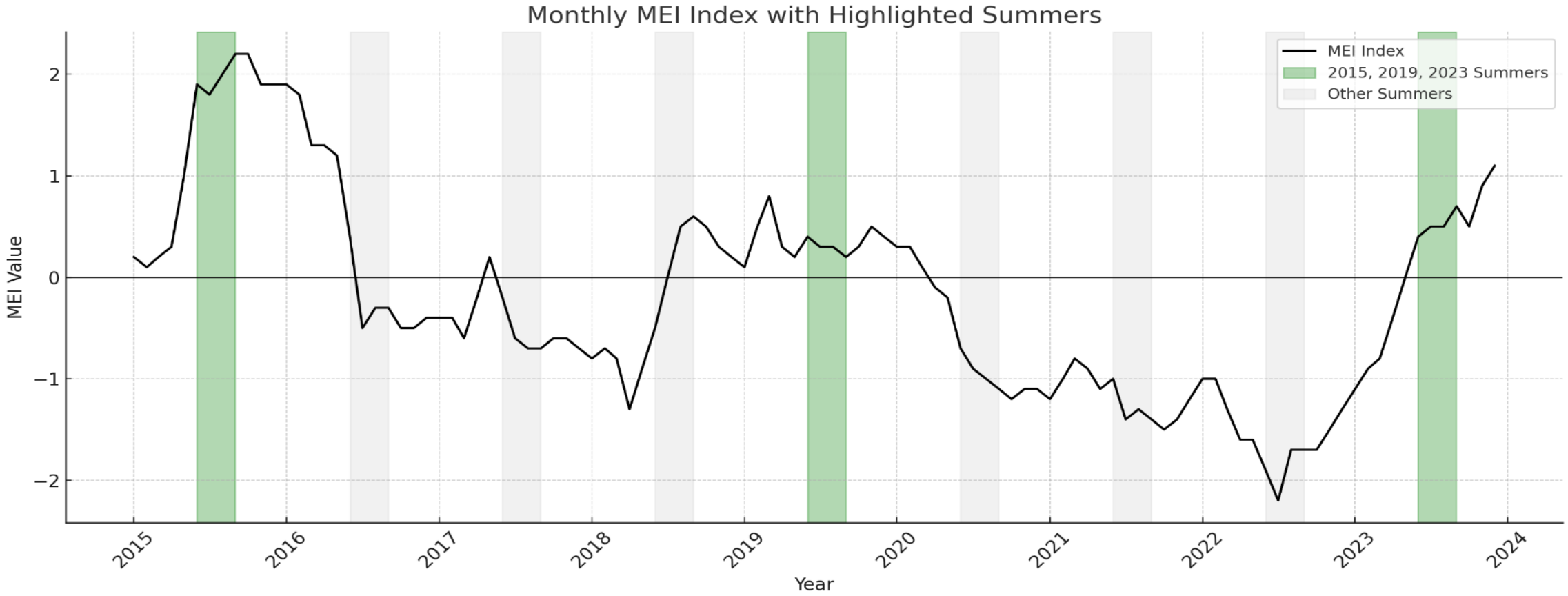
Snuneymuxw First Nation, Pacific Salmon Foundation (Citizen Science Program), Cermaq Canada

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)

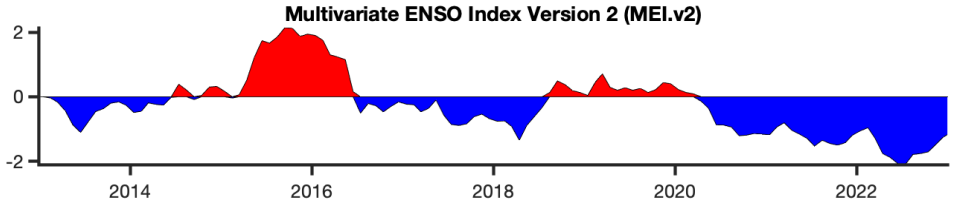
Unusual observations 2015-2024

Alexandrium (PSP) noticeable less common in El Nino summers



Climate Anomalies and CitSc CTD profiles

ENSO



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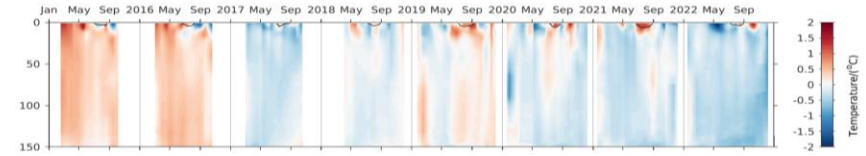
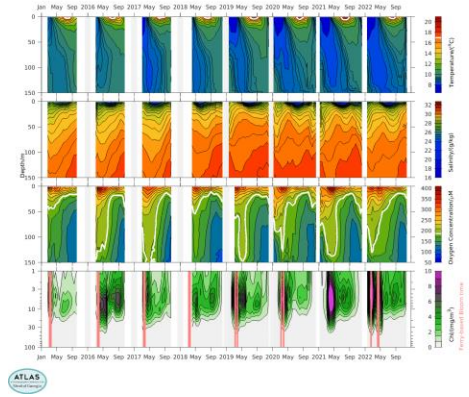
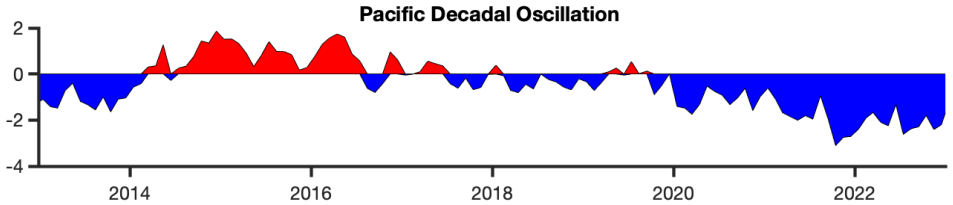


Take this, and subtract the seasonal climatology



Temperature field at depth and ENSO/PDO?

PDO



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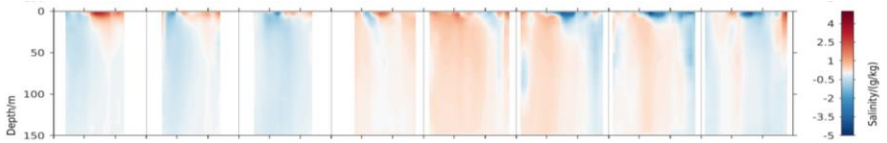
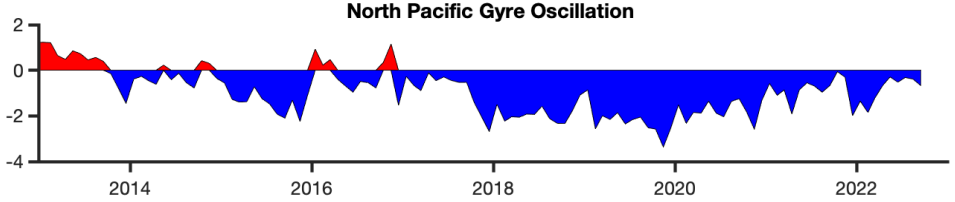


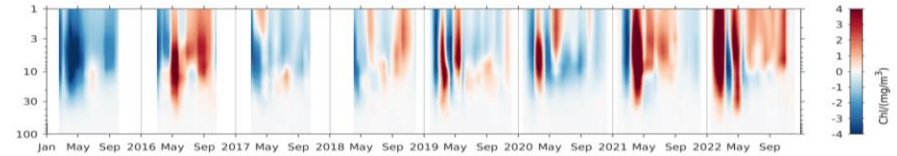
Surface Salinity and PDO?

Deeper Salinity and NPGO?

NPGO



Chl



Summer Chl and NPGO?

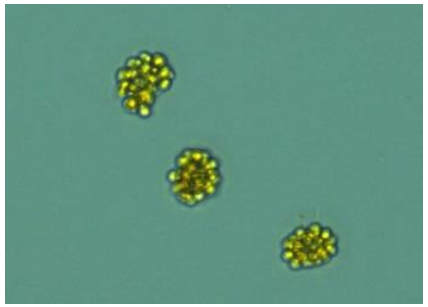
Dr. Rich Pawlowicz, UBC

- DFO juvenile salmon studies
- Pilot phytoplankton sampling add-on
- Opportunistic juvenile salmon histology

Pêches et Océans Canada | Fisheries and Oceans Canada

Esenkulova S, Neville C, DiCicco E, Pearsall I. **Indications that algal blooms may affect wild salmon in a similar way as farmed salmon.** Harmful Algae. 2022 Oct 1;118:102310

Heterosigma akashiwo – HAMP data



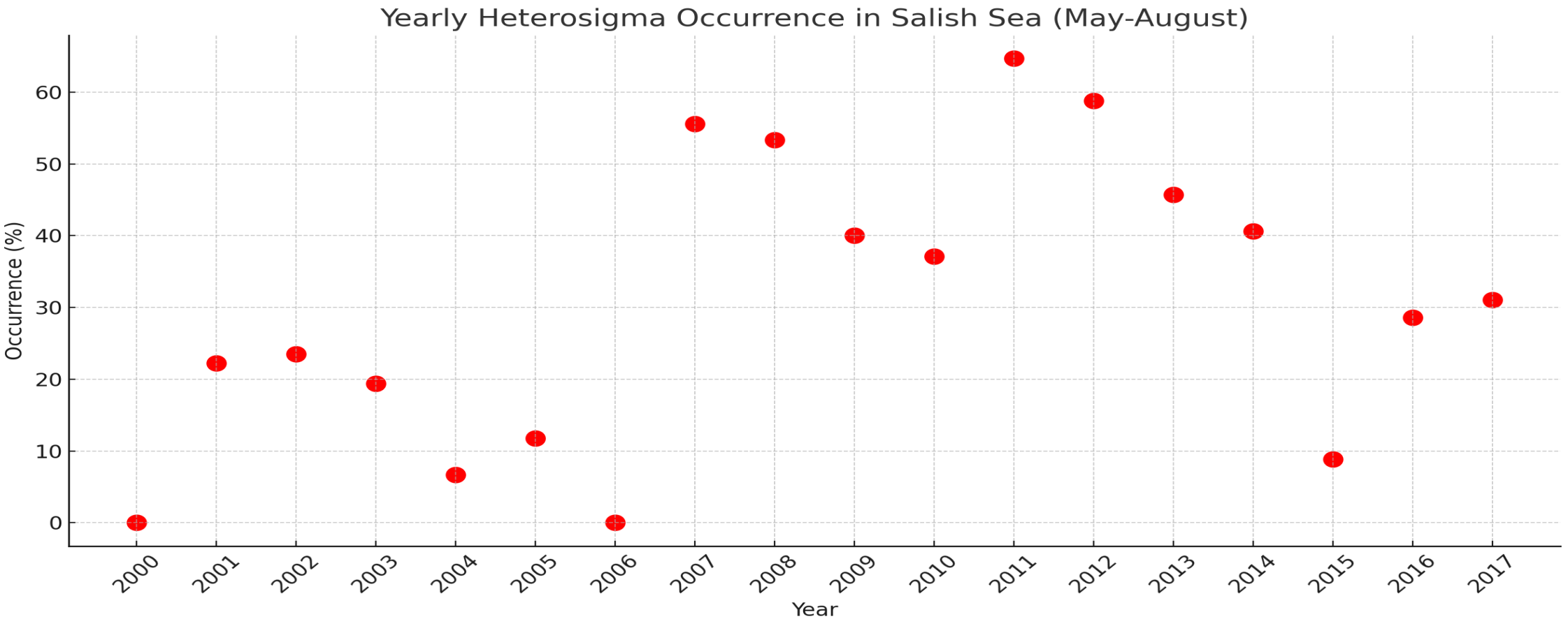
Microthallasia – Nicky Haigh

Samudra – Jay Pudota

Data for the most consistently taken couple of sites

Average for May-August

Heterosigma occurrence in the Salish Sea, HAMP



The trend analysis (linear regression) shows a slight positive slope of approximately **1.65% per year** in Heterosigma occurrence, indicating a **potential increase over time**. However p-value is **0.073**

Summary

- There were several unusual HAB observations in the last 10 years in the Salish Sea

- HABs summary and unusual observations for each year is in annual DFO State of the Pacific Ocean reports, chapter by Esenkulova et al.

https://www.dfo-mpo.gc.ca/oceans/publications/soto-rceo/2021/technical-technique-eng.html

- Based on 17 years of HAMP data, Heterosigma occurrence may be trending upwards

- Understanding shifts in harmful algae distribution and prevalence is important for assessing impacts on trophic level transfer, human health, and the food supply for salmon

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