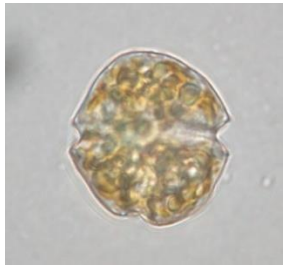
Alexandrium in the Strait of Georgia, a semi-enclosed sea of the eastern North Pacific



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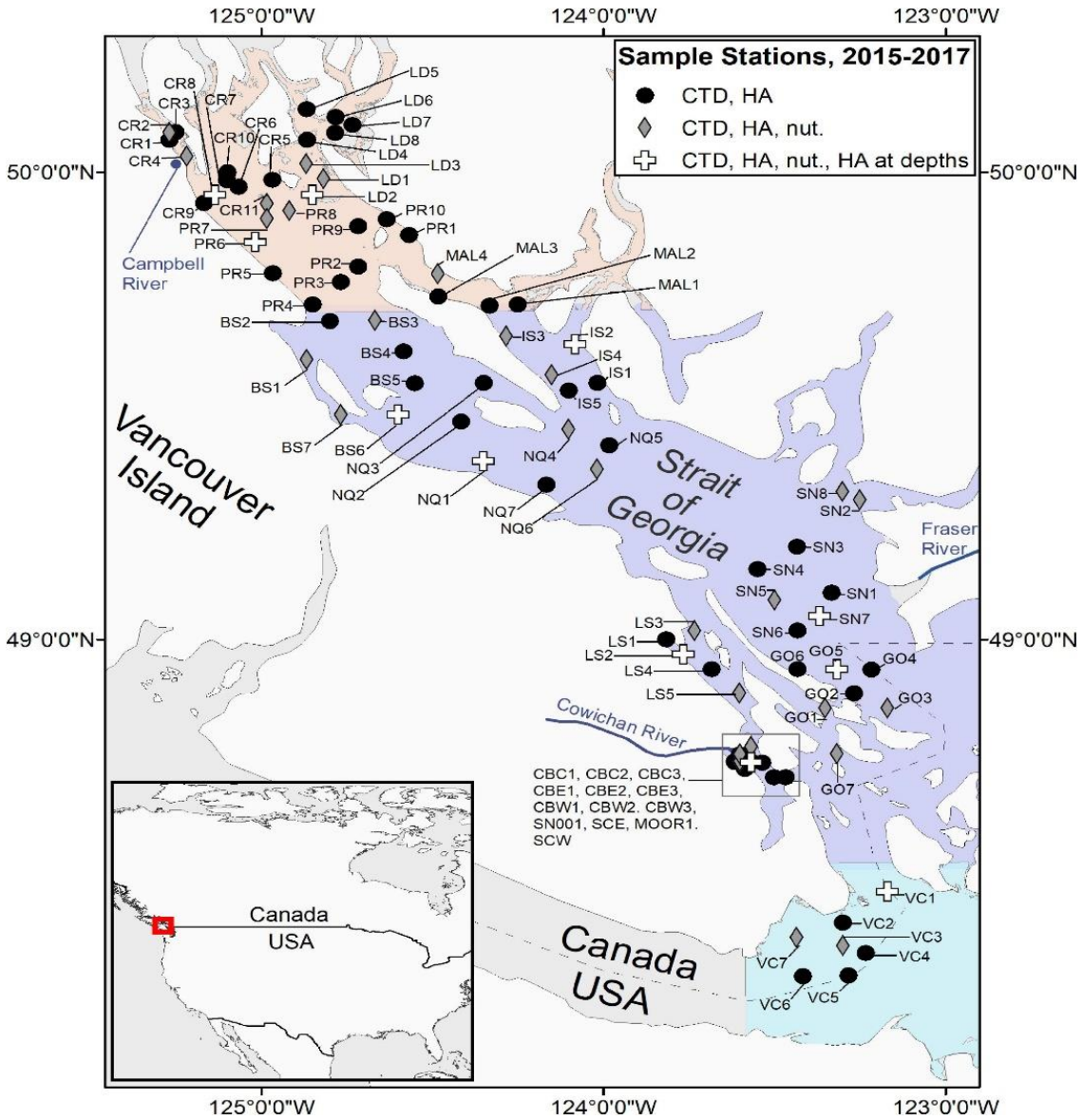
Methods



Strait of Georgia - a semi-enclosed sea on the Pacific coast

It is influenced by freshwater input and tidal exchanges with the Pacific Ocean

It is biologically productive ecosystems, supporting significant commercial and recreational fisheries

2015-2024 – 10 years of data

~55 PSF stations (samples collected by paid citizen scientists, samples processed at PSF, ONC, UBC, DFO)

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

Alexandrium count and CTD – each station
Nutrients (N, P, Si) ~30 stations
Biotoxins (DFO) – 4 stations (last 3 years only)

DATA - PSF

Open access – PSF Marine Data Portal

https://marinedata.psf.ca/atlases/oceanographic-conditions/

Currently 9 years 2015-2023, 2024 will be added

Alexandrium spp. (CSOP-Harmful Algae)

presence/absence and its concentrations (cells per mL), ~14,000 records, with ~70% of the samples collected at the surface and the rest at 5, 10, and 20 meters (~10% each)

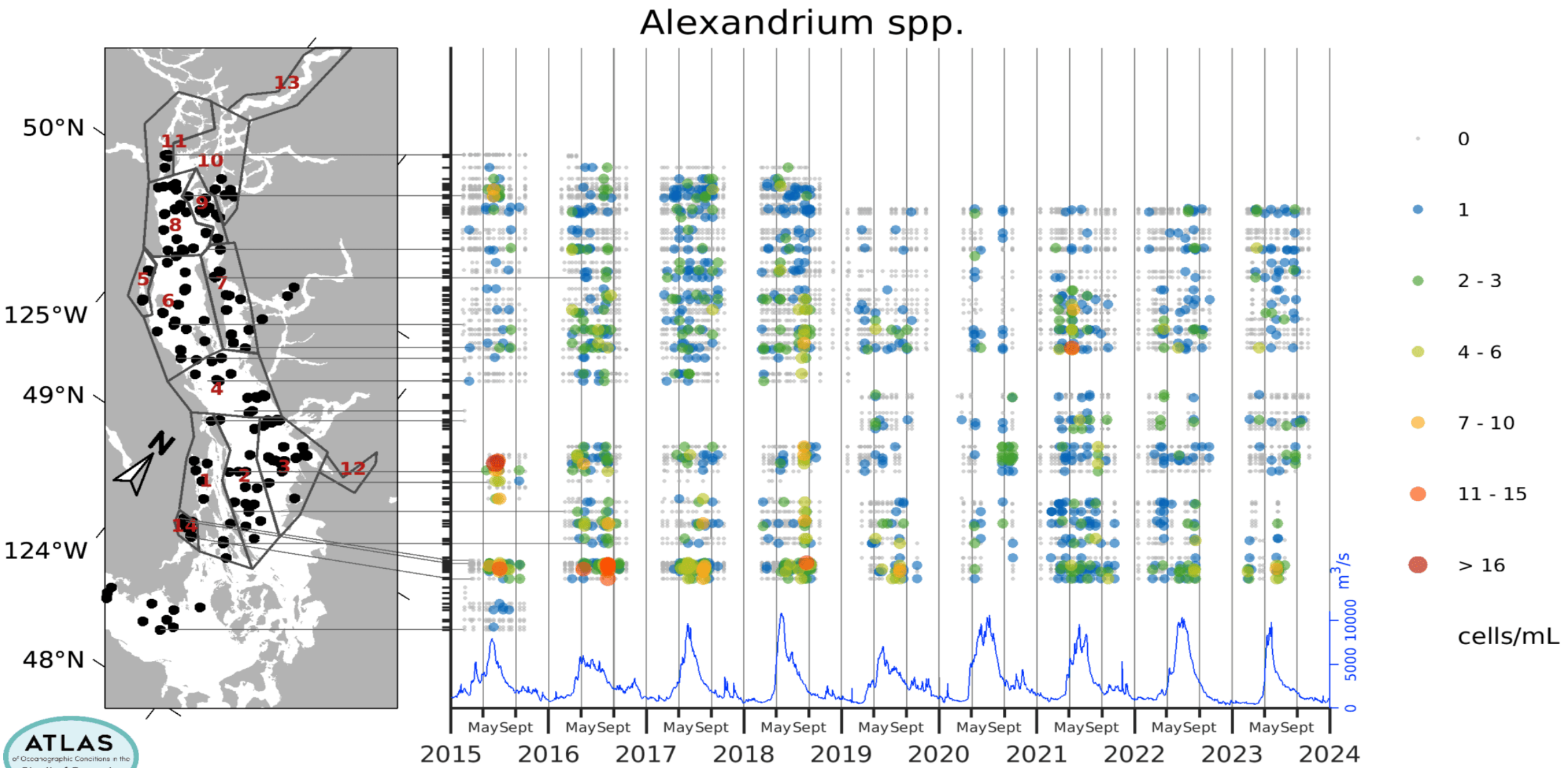
Nutrients

Secchi Depths

Surface Water Temperature

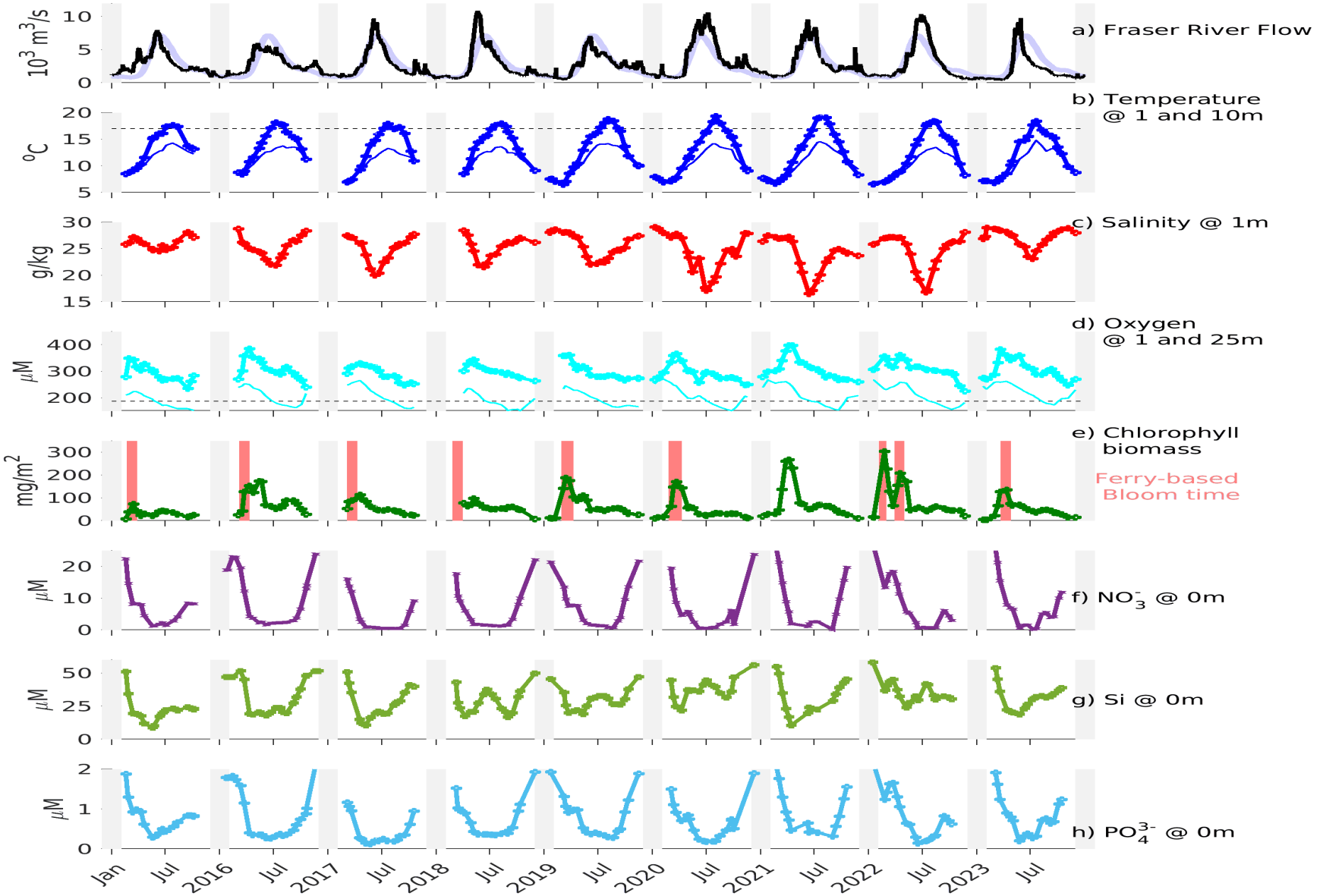
Full CTD casts (~800 a year) are available through UBC

Time Series of Cell Count at 0 m

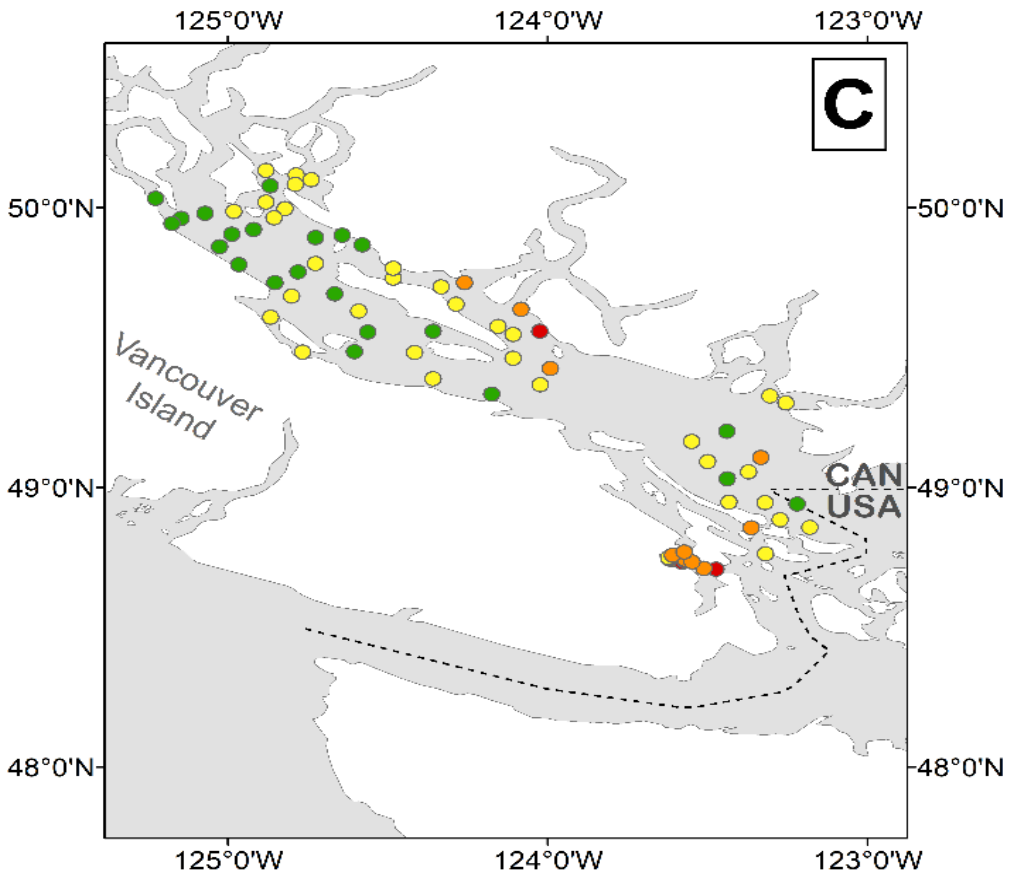


ATLAS of Oceanographic Conditions in the Strait of Georgia

Time Series Hydrography



Published results – based on 4 years of data



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

Alexandrium is one of the most common monitored HA taxa in SoG and occur in ~15% of the samples

It is mostly observed from May through September, max in August

Regionally, it most frequently occurs in shallow, restricted embayments and inlets.

Month	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alexandrium spp.	**0.0**	**5.5**	**8.7**	**17.8**	**21.1**	**22.0**	**25.0**	**15.9**	**0.0**

Published results – based on 4 years of data

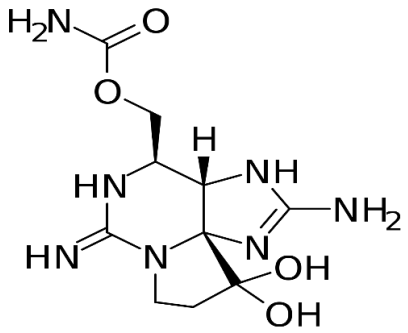
Inter-annual - Pearson Product-Moment Correlations (r) between mean HABs taxa concentrations and environmental drivers and nutrients during summer (June, July, August) using average values for each station in the Strait of Georgia from 2015 to 2018 (n = 259).

	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

Algae – toxins link



Year	Alexandrium %	PSP-total (ug STXdiHCl eq/100g)
2015	10.7	180
2016	16.3	960
2017	18.1	2100
2018	15.7	900

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

Alexandrium frequency of occurrence (%) and maximum toxin concentrations (CFIA) in February – October, Strait of Georgia

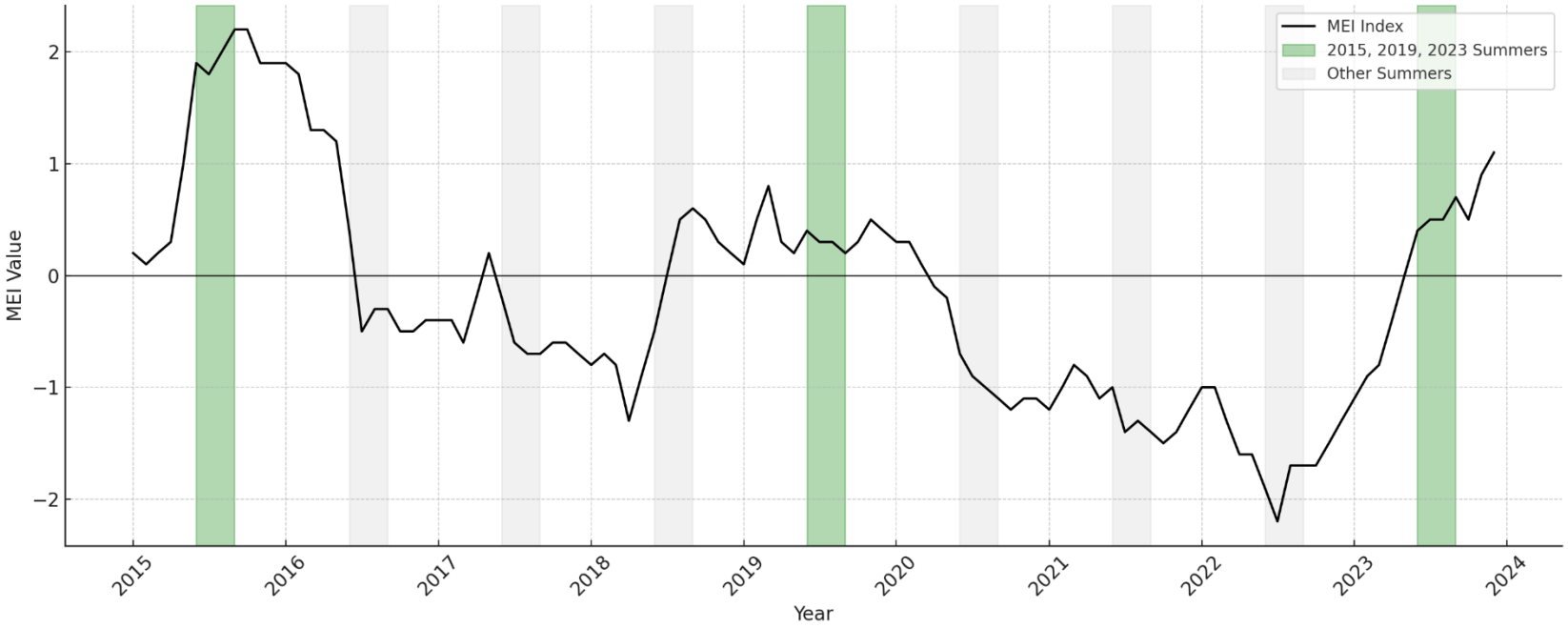
In years *Alexandrium* was more abundant, max PSP concentrations were higher

Annual *Alexandrium* occurrence vs ENSO, unpublished

% of surface samples containing algae, March-September, 4 areas: BS, CB, IS, PR

Year	Alexandrium	ENSO
2015	15.2	very strong El Nino
2016	19.2	very strong El Nino/weak La Nina
2017	21.4	weak La Nina
2018	19.6	weak La Nina
2019	14.6	weak El Nino
2020	21.1	moderate La Nina
2021	20.6	moderate La Nina

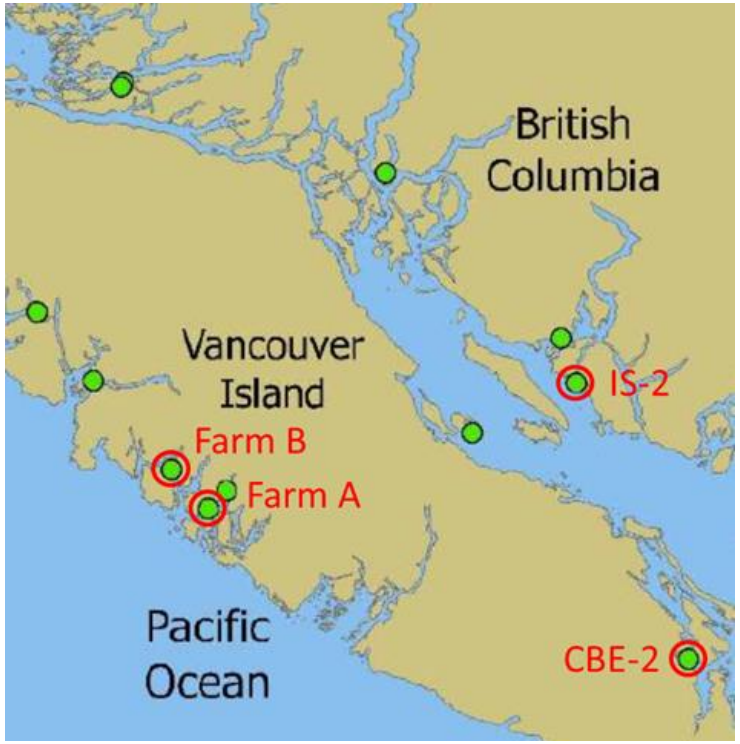
Monthly MEI index, summer month highlighted

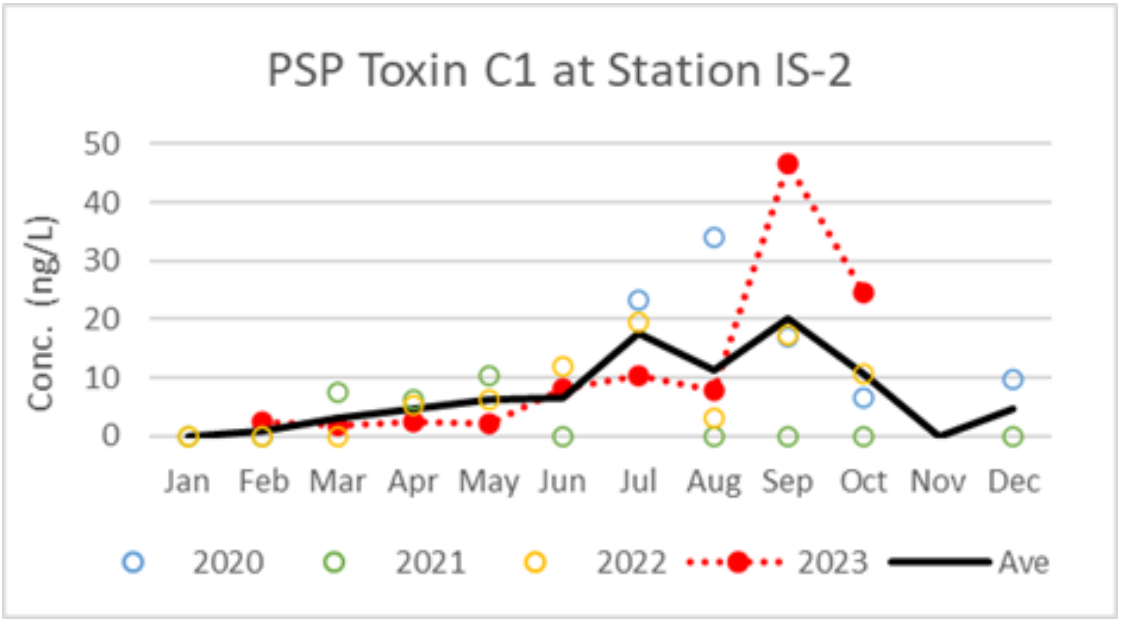


DATA – biotoxins in water, data at DFO

- Dr. Andrew Ross, DFO

Saxitoxin (C1)





PSP toxin (C1) peaks in September

Ross et al., 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

DATA – biotoxins in shellfish, CFIA, BCCDC

Lorraine McIntyre and Esther Tong, Food Safety and Environmental Health Specialists May 23rd , 2024 – presentation for Tula Foundation

Mike Lee found 90% of reports about marine toxins are based on ACUTE events. Biotoxins in marine foods are linked to consequences for the developing fetus and neonates.

Lee et al (2024): The health risks of marine biotoxins associated with high seafood consumption: Looking beyond the single dose, single outcome paradigm with a view towards addressing the needs of coastal Indigenous populations in British Columbia https://www.cell.com/heliyon/pdf/S2405-8440(24)03177-3.pdf

DATA – biotoxins in shellfish, CFIA, BCCDC

- Probable PSP in BC (2021 – 2023)
- Total of 27 individuals exposed
- 7 individuals were asymptomatic but consumed the suspect shellfish
- Total of 20 probable PSP
- 12 were individual/single reports
- Majority of these (60%) were from recreational harvesters
- All reported harvesting areas were on Vancouver Island

DATA – biotoxins in shellfish, CFIA, BCCDC

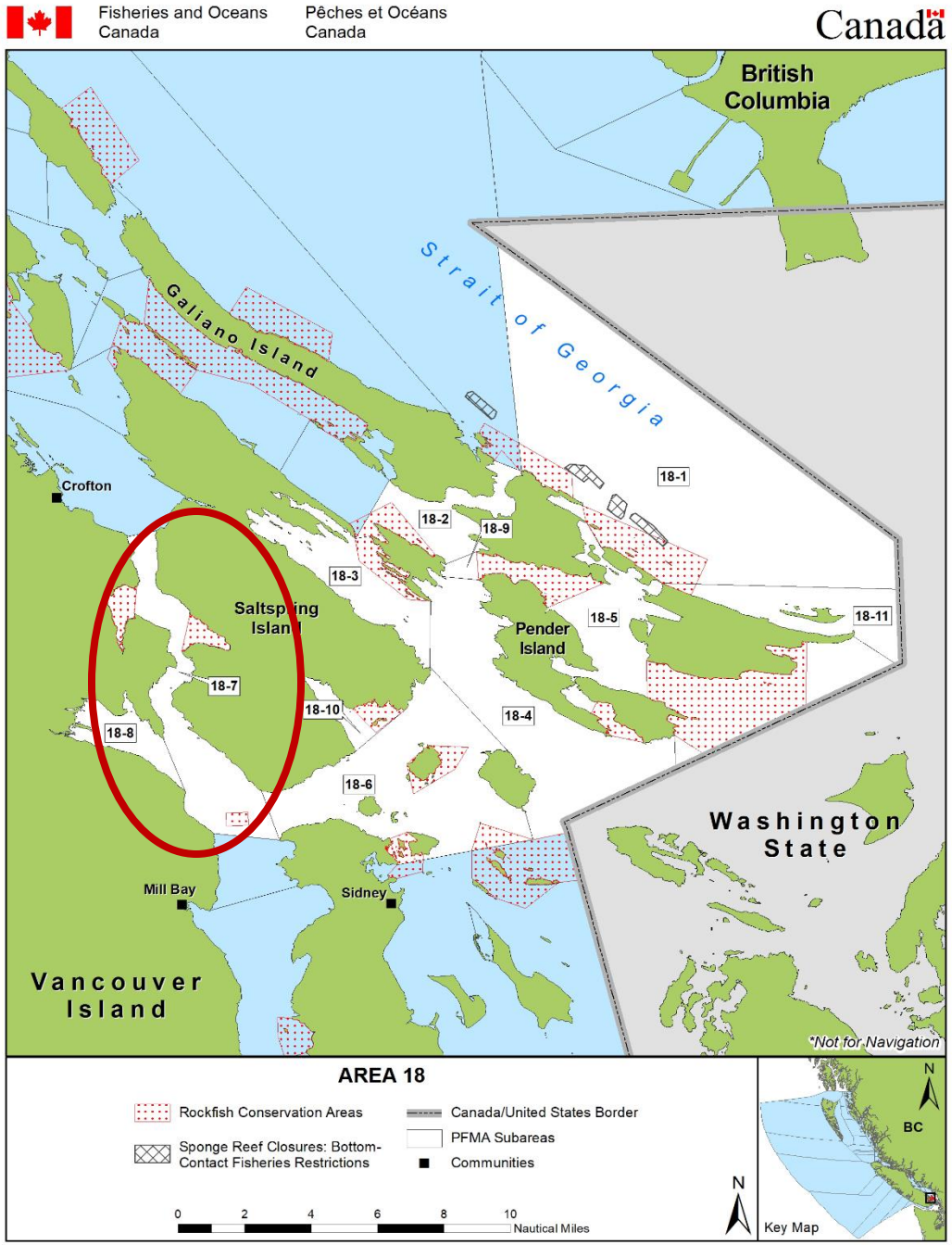
- Toxins in shellfish – Canadian Food Inspection Agency (CFIA)
- CFIA – sampling
- DFO – harvesting closures and enforcement

Shellfish harvesting maps at DFO and BCCDC

https://www.dfo-mpo.gc.ca/shellfish-mollusques/cssp-map-eng.htm

http://www.bccdc.ca/health-professionals/professional-resources/shellfish-harvesting-sites-status-map

- Historic data not freely available, can be obtained through Access to Information Act

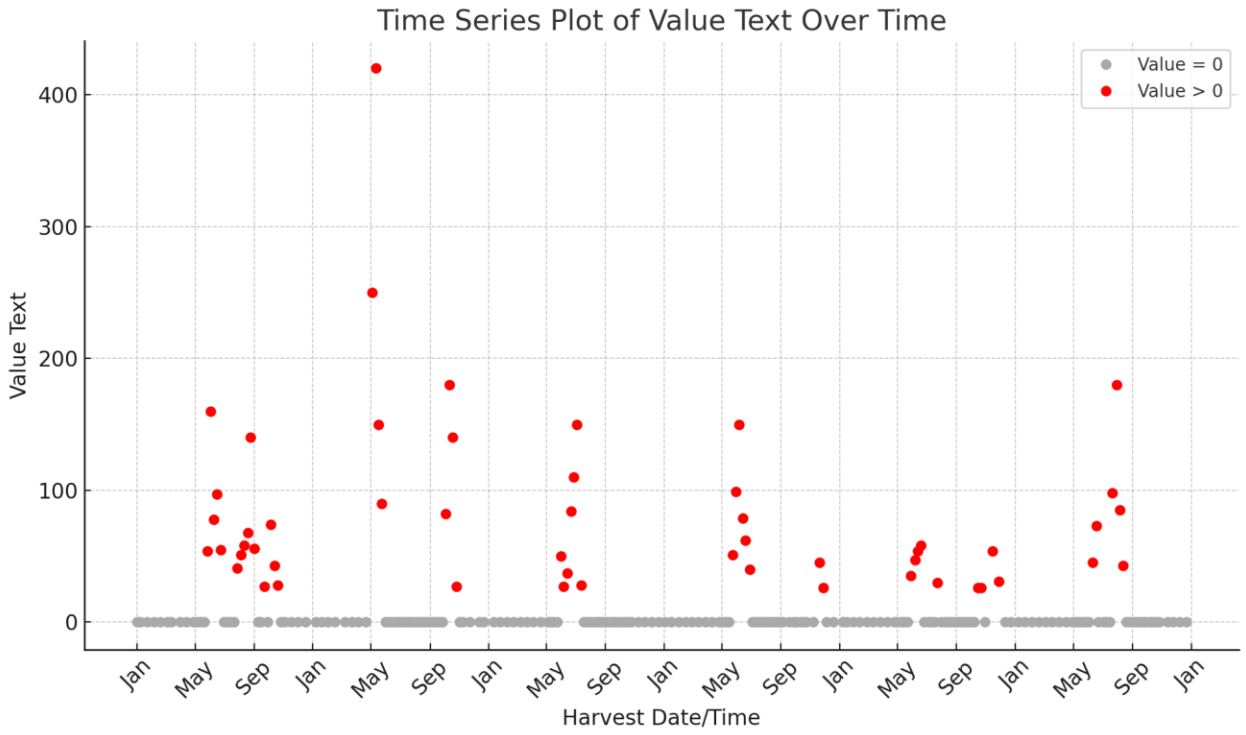


Fisheries management area 18 - Mayne Island

Subarea 18-7 – Maple Bay, Sansum Narrows, Boatswain

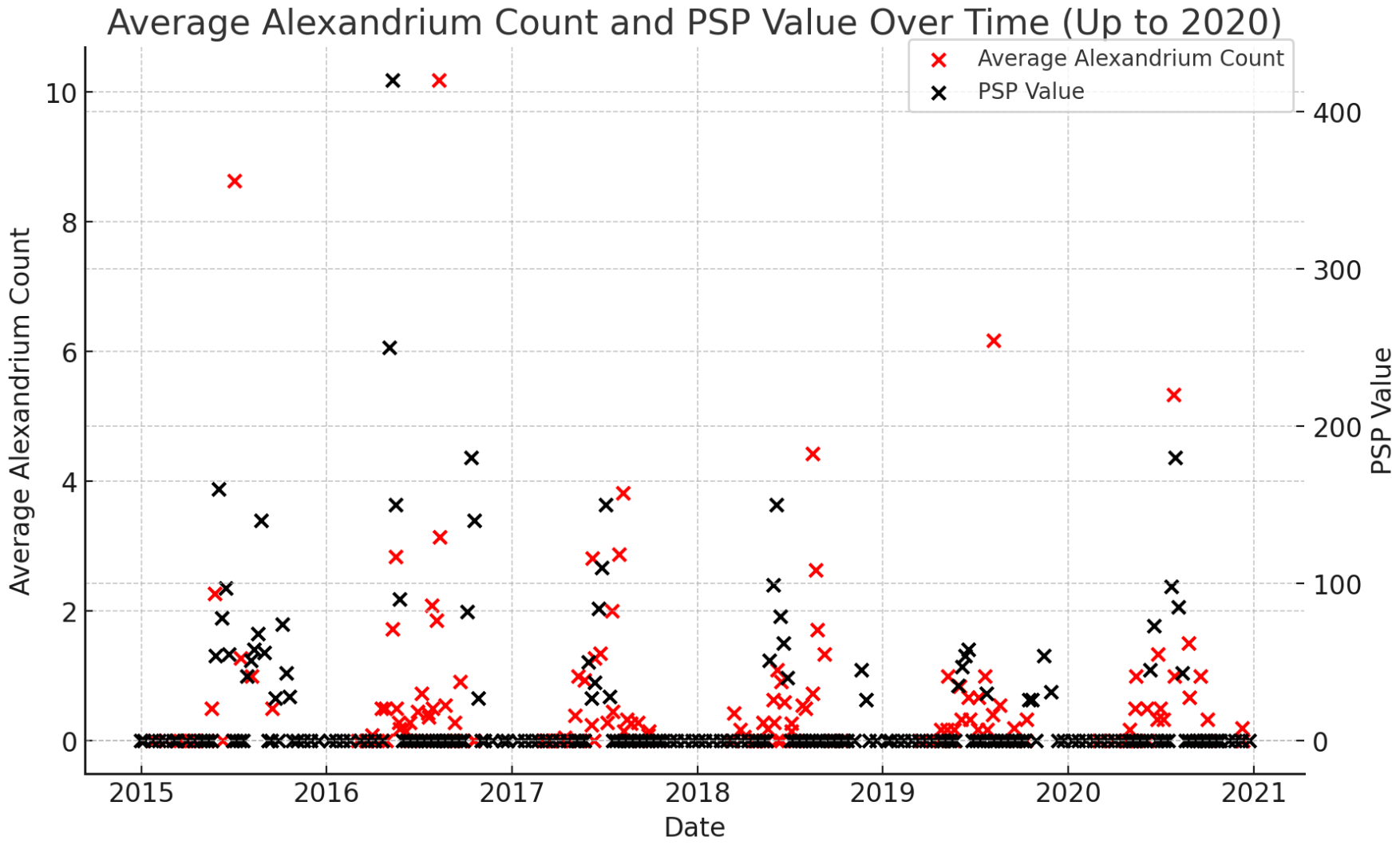
2014 -2020

Total PSP toxin in Blue Mussel (whole and viscera samples)



2015 2016 2017 2018 2019 2020

Alexandrium cells vs PSP total in shellfish



Alexandrium peaks in July and August

PSP peaks in May and June

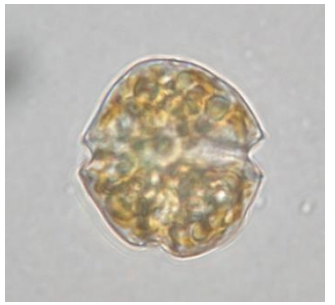
Very strong positive(0.85) annual correlation but very weak monthly

Good potential for analysis and interpretation

Alexandrium culture for a salmon-HAB study

Week 0 (inoculation)

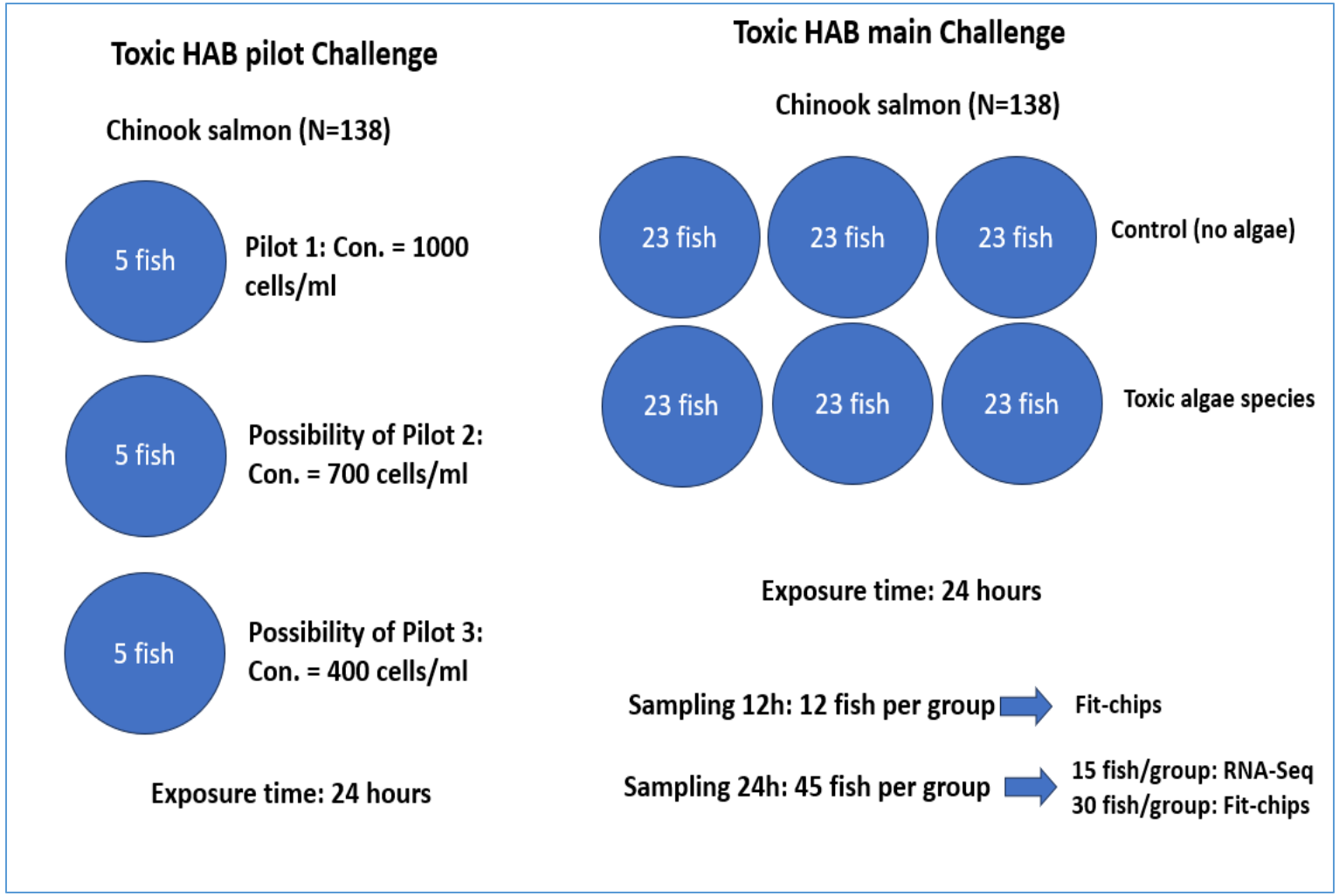
Week 1



Photos by Laurie Keddy, DFO

Alexandrium tamarense grown at PBS, DFO
f/2 medium (enriched natural seawater medium, Harrison et al. 1980)
500L bags at 16 °C, 24 h light
Max concentrations of ~2000 cell mL^{-1} at ~3 week
Preliminary - total saxitoxins 960 ng/L in cultures of ~600 cells/mL (Dr. Ross, DFO)

Salmon-HAB algae challenge study



Will expose juvenile salmon to cultures up to 24 hours, static bath, no feeding

Fish – behavior, histology, some chemicals, genomics

Genomics - q-RT-PCR data will be analyzed to identify the most influential genetic markers. Biomarker panels for classifiers such as hypoxia, osmotic stress, and imminent mortality will be tested alongside the newly designed biomarkers

Summary

- Extensive Dataset: PSF has 10 years of high-resolution data on Alexandrium and environmental variables.
- Environmental Links: Analysis of 4 years shows links to temperature, salinity, stratification, and nutrients.
- Climate Influence: Alexandrium dynamics over 10 years appear tied to large-scale climate patterns.
- Research Gaps: Limited federal research on Alexandrium ecology.
- Untapped Potential.