PACIFIC SALMON FOUNDATION

CITIZEN SCIENCE NEWSLETTER

PSF Citizen Science Oceanography Program Enters Its 11TH and Final Year

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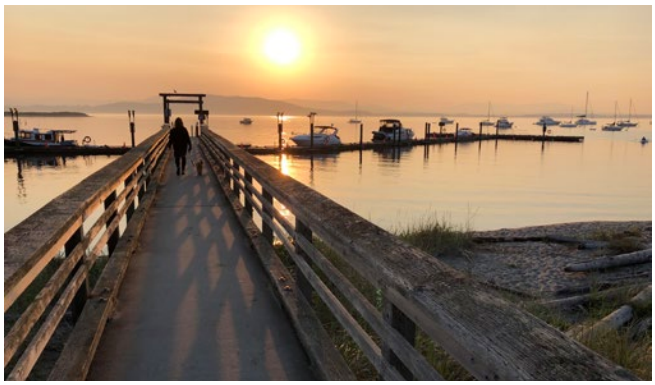
Photos: Mitch Miller

The PSF Citizen Science Oceanography program is halfway through its eleventh and final year, at least at its home as a PSF run and managed project.

Over the past decade, this program has engaged a team of dedicated and passionate citizens who conduct field monitoring and data collections across several set locations in the Salish Sea. This program began during the Salish Sea Marine Survival Project in 2015 and aimed to establish a baseline of data in the marine environment to support research into early marine survival of salmon. Through this comprehensive monitoring program, PSF has amassed a wealth of data on various marine parameters such as sea temperature, salinity, and nutrients.

After careful review, PSF made the decision to conclude the field collection and monitoring of the Citizen Science Oceanography Program at the end of the 2025 field season.

For the final year, the monitoring patrols were reduced from seven to three – Baynes Sound, Irvines/Sechelt, and the Gulf Islands. The last sample date is scheduled for November 27, 2025. This will wrap up the monitoring phase of the work as it has reached its goal of establishing a robust baseline of data on oceanography conditions in the Salish Sea, filling a knowledge gap on environmental conditions and how they relate to early marine survival of juvenile salmon. Originally, the goal of this program was to reach 5 years of consistent data collection. We surpassed that goal two-fold and managed to exceed the decade mark. Now, it is time to take stock of all of the data that has been collected and determine exactly what it all means for salmon in the Strait of Georgia.



Cover photos by Mitch Miller (top, left), Nicole Frederickson (centre) and Rob Newell (right).

PSF would like to thank those who were pivotal in the establishment and long-term success of the program, including: Isobel Pearsall, Brian Riddell, Eddy Carmack, Andrew Ross, Mary Steel, Rich Pawlowicz, all of our partners at IOS, ONC and UBC, and of course, past and present Citizen scientists, including but not limited to Ed Oldfield, John Sinclair, John Field, Andre Alarie, Susan Servos-Sept, Gordon Bishop, Evan Hogarth, Ted and Gail Newell, Ryan and Nicole Frederickson, Brian Dearden, Kevin Swoboda, James Sherrett, the Snuneymuxw Marine Division, Kyle Louis, Bon Chovy Charters, and everyone else who contributed to the project over the past 11 years.

WHAT AN ACCOMPLISHMENT IT HAS BEEN!

A decade of Pacific Salmon Foundation (PSF) Citizen Science Oceanography Monitoring Program

Ten years ago, in 2015, the Pacific Salmon Foundation (PSF) launched the Citizen Science Oceanography Program (CSOP) to address critical data gaps identified by the Salish Sea Marine Survival Project (SSMSP) [1], a multimillion-dollar international research effort involving over 60 organizations working to understand factors limiting salmon and steelhead survival in the Salish Sea. The SSMSP found that bottom-up processes (i.e., environmental conditions and prey availability) were some of the key factors affecting juvenile salmon survival [2], yet the oceanographic data needed to fully assess these factors were lacking. In response, CSOP was created to fill these gaps through systematic, long-term monitoring. The program was inspired by the vision of Dr. Eddy Carmack and developed with input and support from Fisheries and Oceans Canada (DFO) and Ocean Networks Canada. The program engaged volunteers, organized into crews on 7–10 vessels, conducting regular surveys (~20 times a year) across ~55 stations in the Strait of Georgia. With technical support from PSF, ONC, DFO, and the Universities of Victoria (UVic) and British Columbia (UBC), the program leveraged coastal community engagement to advance data collection at an unprecedented scale. In 2016, its work was *endorsed by GlobalHAB [3]*, a collaborative initiative supported by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO.

To ensure high data quality, CSOP separated data collection from analysis, with trained citizen scientists focusing on standardized sample collection (Figures 1-2) while experts handled processing and validation. These volunteers, all locals with a deep connection to the waters they monitored, collected oceanographic samples under regular oversight by a PSF biologist, and professional scientists analyzed the samples to ensure high research standards. While their fuel costs and mileage were covered, volunteers received only a small stipend, reinforcing their role as dedicated contributors rather than paid staff. This model fostered long-term engagement, with volunteers consistently sampling the same locations, ensuring valuable continuity in the dataset. The data are hosted on the PSF Marine Data Center *[4]*, making it widely accessible for research and policy use.

Throughout its ten-year history, CSOP achieved success through volunteer dedication and a commitment to scientific excellence. The team collected over 60,000 samples, including approximately 10,000 CTD casts, collected over 12,000 nutrient samples and 14,000 phytoplankton samples for harmful algae identification and enumeration, along with 2,400 chlorophyll measurements, 20,000 Secchi depth readings, 600 zooplankton samples, and over 300 biotoxin samples. CSOP crews travelled approximately 80,000 kms over 1,400 vessel trips!

Harmful algae monitoring generated the first multi-year, high-resolution dataset on harmful algal distribution and environmental conditions in the Strait of Georgia. The data revealed significant interannual variability in phytoplankton dynamics and bloom patterns, identifying key environmental drivers such as nutrient availability, stratification, and turbulence [5]. These findings enhance our understanding of regional ecological conditions that promote harmful algal blooms and provide valuable insights into their potential impacts on marine food webs and fish populations.

The dataset serves as a critical resource for future research and management efforts, with harmful algae data provided to the Ocean Biogeographic Information System (OBIS) and Canadian Integrated Ocean Observing System (CIOOS) [6] to support broader scientific research and policy development.

Beyond data collection, CSOP made significant contributions to scientific research and public awareness. Findings were published in peer-reviewed journals, annual DFO's State of the Pacific Ocean reports *[7]*, and the Digital Atlas of Oceanographic Conditions in the Strait of Georgia [8]. The program also produced a variety of outreach materials, including interactive story maps, reports, newsletters *[9]*, and social media content *[10]*.

After ten successful years, the CSOP is in its final year of monitoring. PSF is proud to have played a catalytic role in

Fig. 1. PSF Citizen Scientists.

PSF CITIZEN SCIENCE OCEANOGRAPHY PROGRAM WAS FEATURED IN THE HARMFUL ALGAE NEWSLETTER BY UNESCO

The Harmful Algae Newsletter (HAN) by UNESCO has published a report by PSF Biologist, Svetlana Esenkulova, titled *A Decade of the PSF Citizen Science Oceanography Monitoring Program*. The HAN is a bi-annual newsletter that was created in 1992 by the Intergovernmental Oceanographic Commission (IOC) of UNESCO. It serves to disseminate information on toxic and harmful algal blooms (HABs) to the global HAB community, researchers, managers, policy makers and the public.

Read the full report here; pages 24-25.

NEW FOR 2025: ENVIRONMENTAL DNA (eDNA)

While this may be the 11th and final year for the Program at PSF, we are still exploring and implementing additional and novel data collection methods. This year, we have added environmental DNA (eDNA) collection. Samples will be collected across multiple sites in the Strait of Georgia and analyzed by the PSF Salmon Health team and collaborators using a suite of metabarcoding markers. The results will offer comprehensive insights into the presence and distribution of salmonids, other fish species, invertebrates, and broader aquatic biodiversity in the region. This eDNA collection compliments other eDNA sampling work on the Westcoast of Vancouver Island through the Follow the Fish project.

Svetlana Esenkulova and Nicole Frederickson collecting eDNA samples in the Strait of Georgia.

Attendees of the PSF Citizen Science Oceanography Program Symposium, held in Parksville BC on March 20-21st, 2025.

PSF HOLDS THE CITIZEN SCIENCE OCEANOGRAPHY PROGRAM ANNUAL SYMPOSIUM

PSF held the annual Citizen Science Oceanography Program Symposium on March 20-21st, 2025 at Tigh-na-Mara Resort and Conference Centre in Parksville, BC. The symposium kicked off with a recognition dinner to thank staff members and citizen science crews who have been instrumental to the Program over the past decade. The symposium was held the following day, with presentations on the history and key findings of the Program, discussions on oceanographic trends in the Strait of Georgia, and insights from phytoplankton, zooplankton, biotoxin and eDNA research. Sessions covered data accessibility, community partnerships, and the next steps as the program transitions from field data collection to analysis.

After ten years, the Program has conducted over 1400 boat trips, and collected more than 60,000 samples, including:

- **12,949 nutrient samples**
- **14,246 phytoplankton samples**
- **2,422 chlorophyll samples**
- **20,055 Secchi recordings**
- **613 zooplankton samples**
- **373 biotoxin samples**

Citizen Science Samples Collected to Date (December 2024):

Year	Vessel Trips	CTD Casts	Nutrients Collected	Phytoplankton Collected	Chloro-phyll Collected	Secchi Recordings	Zooplankton Collected	Bio-toxins Collected	Total Samples
2015	150	2,264	1,809	1,381	193	2,088	146	0	7,881
2016	199	1,445	1,587	2,064	349	2,825	60	0	8,330
2017	197	1,420	1,529	1,934	340	2,814	54	0	8,091
2018	196	1,125	1,575	1,981	352	2,823	66	0	7,922
2019	133	741	972	1,053	186	1,482	54	0	4,488
2020	119	731	1,257	1,378	231	1,836	54	7	5,494
2021	121	897	1,183	1,264	222	1,746	59	115	5,486
2022	104	782	1,046	1,113	196	1,554	60	108	4,859
2023	104	793	1,133	1,131	197	1,515	10	96	4,599
2024*	91	700	858	947	156	1,372	50	47	4,221
10 years	**1,414**	**10,898**	**12,949**	**14,246**	**2,422**	**20,055**	**613**	**373**	**61,371**

WHAT DID WE LEARN IN 2024?

Information collected by the Program is filling several data gaps, as well as increasing our understanding of changing ocean conditions in the Salish Sea, both seasonally, annually and over the last decade. Below is a summary of key new findings from 2024.

BIOTOXINS:

Biotoxins in B.C. Coastal waters behaved differently in 2024.

- Domoic Acid (DA) peaked later than usual in Malaspina Strait.
- DA was also detected within critical habitat for Southern Resident Killer Whales (SRKW) suggesting that they may be at risk of exposure to DA, which has caused illness and mortality in other marine mammals (See: Did You Know?).
- Paralytic Shellfish Poisoning (PSP) toxins reached unusually high levels in Malaspina Strait during late-summer.
- PSP toxins can harm juvenile fish, but monthly data from the Program can be used by hatcheries to time their releases in order to minimize exposure.
- Diarrhetic Shellfish Poison (DSP) toxin and yessotoxin concentrations in Malaspina Strait were lower than usual.
- **Long-term monitoring made possible by the Program reveals that DA and PSP toxin levels are starting to increase in B.C. coastal waters, driven by climate-related factors such as increasing water temperature and nutrient limitation.**
- These results highlight the importance of continuing to monitor biotoxins, harmful algal blooms (HABs) and environmental conditions in B.C. waters.

DID YOU KNOW?

There was a toxic outbreak of Domoic Acid in California in March this year, causing seizures, neurological issues, and even death in sea lions and dolphins.

Dr. Andrew Ross was interviewed by the Vancouver Sun regarding monitoring for Domoic Acid and other algal biotoxins in B.C. waters, something to which the Citizen Science Oceanography Program has been contributing since 2020.

Read the full article here.

Biotoxin samples collected by PSF Citizen scientists.

Phytoplankton sample, collected in March 2025, preserved with Lugol's iodine.


Photo: Sid Quinn

Noctiluca bloom in Sechelt Inlet, 2024.

PHYTOPLANKTON/ HARMFUL ALGAE:

- The 2024 spring bloom occurred in May and was unique in that there were two separate "peaks".
- There was a high presence of Pseudo-nitzschia species abundance in late spring. Pseudo-nitzachia can cause can cause Amnesic shellfish poisoning (ASP).
- The Spring phytoplankton bloom was larger in the Central Strait of Georgia, compared to other areas of the Strait.
- Heavy Noctiluca blooms were observed in some areas in April, May and June. These can cause low dissolved oxygen levels.

ZOOPLANKTON:

This year, PSF partnered with first year master's student, Deniz Coskuner, from the Pelagic Ecosystems Laboratory, UBC, to conduct novel zooplankton analysis. Nearshore zooplankton assemblages are distinct and provide important habitat for many fish species, particularly for juvenile salmon and herring. Despite the importance of nearshore zooplankton, few surveys are conducted in nearshore habitats, and most of the data that are collected are at coarse temporal resolution. This is where our Program comes in. The Irvine's/Sechelt crew has been collecting zooplankton at three sites, at a minimum bi-monthly basis, consistently since 2015. Now, Deniz has been using Zooscan imaging technology to analyze these samples and explore the seasonal and inter-annual zooplankton dynamics in Malaspina Strait. Zooscan is being used to capture taxon abundance, size

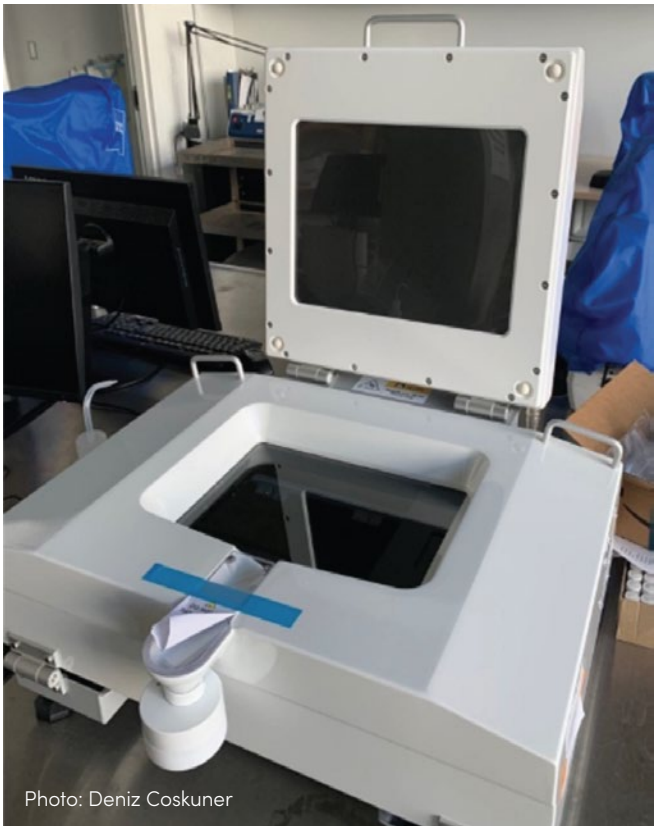


Photo: Deniz Coskuner

Zooscan imaging system.

distribution and biovolume and compare the relationship between these community metrics and oceanic parameters like, temperature and salinity profiles, nutrient concentrations, zooplankton and phytoplankton bloom timing, and chlorophyll a and concentrations of harmful algal species. Preliminary results from 2023-2024 samples show:

The shallowest site had:

- The highest zooplankton density, but the lowest species richness, across all seasons.
- The lowest biovolume in winter and the highest biovolume in summer.
- The highest variability in species composition.

So, what does this tell us? Preliminary results indicate that depth plays a role in structuring nearshore zooplankton assemblage composition, which could be attributed to change in depth, increased predation pressure from forage fish, increased mixing and proximity to terrestrial influences.

To learn more about how zooplankton and phytoplankton may impact coho salmon in the Strait of Georgia, check out this article by Dr. Dick Beamish and Chrys Neville.

HYDROGRAPHY:

- Oceanographic conditions in the Strait of Georgia have a pronounced seasonal cycle.
- 2024 ocean temperatures were above normal in the Strait of Georgia, which is correlated with El Niño and the Southern Oscillation, also known as ENSO.
- Sea surface salinity in the Strait of Georgia is linked to the Fraser River discharge. In years with low Fraser discharge, the Strait is saltier in summer. In recent years, the Fraser River discharge has been historically low, resulting in higher sea surface salinity in summer. For example, in 2024 sea surface salinities were above normal in summer, but below normal in Fall. This is linked to Fraser River discharge and/or the North Pacific Gyre Oscillation (NPGO).

Photo: Rob Newell

Ted Newell, Citizen Scientist, lowering a CTD into the water to measure conductivity, temperature and dissolved oxygen and chlorophyll a.

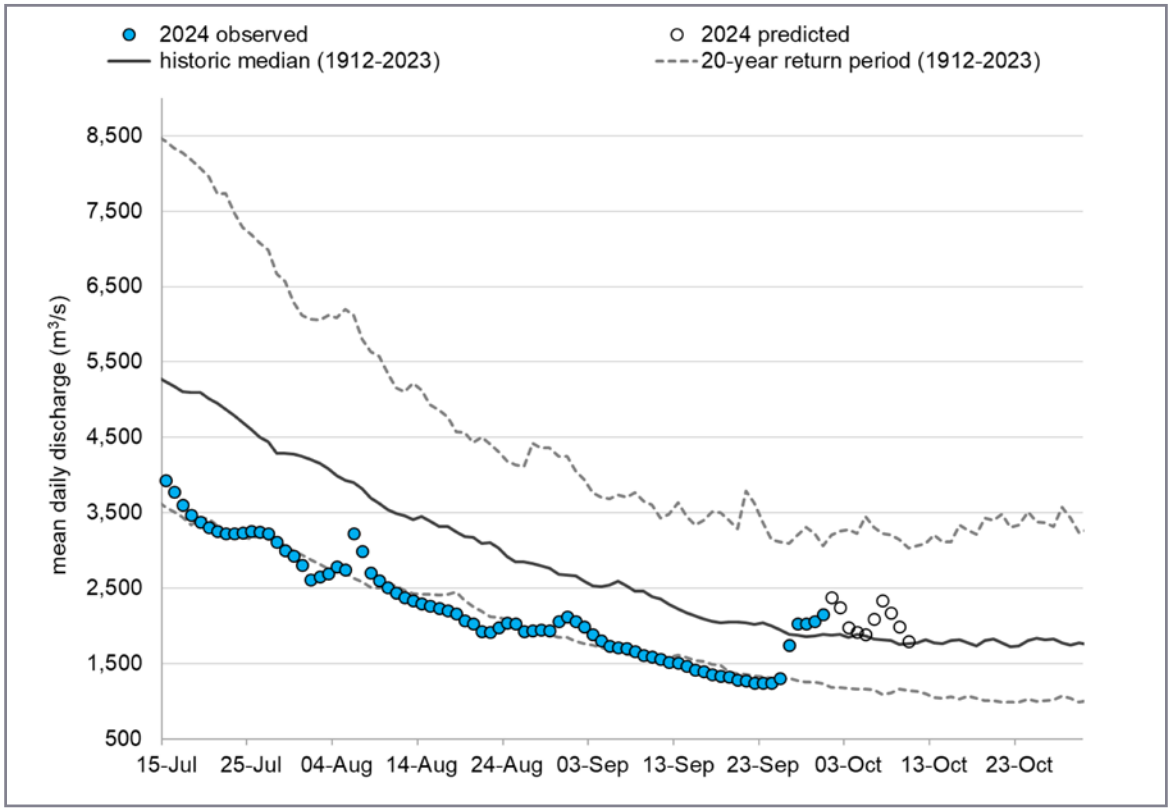


Figure 1. Graph showing the Fraser River mean water discharge at Hope. Graph shows 2024 observed and predicted mean daily discharge, 20 year historic median and 20 year return period (1912 to 2023). Trend lines show a gradual decline from July through September. In 2024, the observed discharge was well below the historic median from July through the end of September, and then a peak in late September/ early October to at or slightly above the historic median. Source: Fraser River Environmental Watch Report. October 01, 2024.

A report prepared by UBC student, Ellie (Jin-Shiang) Hu and Rich Pawlowicz, using PSF Citizen Science Oceanography Program data and other available datasets indicates that:

- The Strait of Georgia has large areas that are problematic in terms of the lack of oxygen for full growth of juvenile fish.
- **There is a long-term decrease in oxygen concentrations in mid-water (i.e., about 1 mg/L since 1968) which could have an effect as large as 10% on salmon growth rates.**
- Interannual conditions are also affected by ENSO (temperature) and NPGO (salinity, possibly oxygen, possibly chlorophyll) but the mechanisms for this are not completely understood, so more work is needed.

These are important findings that require additional research and analysis.

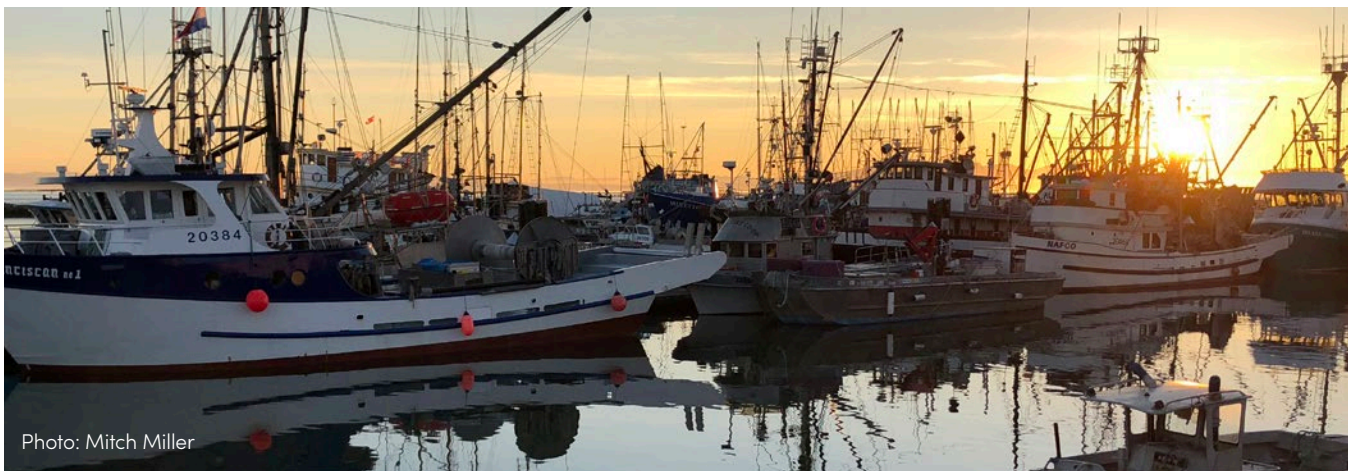


Photo: Mitch Miller

WHERE DO WE GO FROM HERE?

With this being the final year of the program, where do we go from here and what's being done with all the data that has been collected over the past decade? Next steps include:

- Dr. Andrew Ross, at the DFO Institute of Ocean Sciences, plans to prepare and publish a peer-reviewed scientific paper based on biotoxin results from our Program and to secure funding in order to continue the unique, long-term monthly biotoxin time series established in partnership with PSF Citizen Science Oceanography Program.
- Dr. Ross's team has already started analyzing the biotoxin, oceanographic, and taxonomic data collected since the beginning of the program, finding that certain (PSP) toxins appear to be increasing in the Salish Sea and that levels of other toxins in salmon tissues reflect those in the surrounding water.
- Svetlana is working on a paper analyzing long-term ichthyotoxic *Heterosigma akashiwo* bloom dynamics in the Salish Sea to better understand when, where, and why these harmful events occur, which is important for understanding potential risks to salmon and the broader marine ecosystem.
- Svetlana is also working, in collaboration with DFO scientists, on an innovative harmful algae challenge study with juvenile salmon, assessing their physiological and molecular health responses (using histopathology, metabolomics, and the salmon Fit-Chip) after exposure to certain harmful algae commonly present in the Strait of Georgia, whose effects on juvenile salmon health are largely unknown. This is the first study in Canada to integrate these advanced health assessment tools to understand potential impacts of harmful algal blooms on juvenile salmon — a critical step for future ecosystem and fisheries management.
- Prof. Rich Pawlowicz at UBC plans to further investigate the year-to-year changes in oceanographic conditions over the Strait, as measured by this program, to better understand how the Strait is affected by large-scale regional climate variability — so That we might be able to make better predictions for the future.

Photo: Svetlana Esenkulova

Nicole Frederickson, PSF Citizen Science Oceanography Program Manager, collecting nutrient samples.


Photo: Eiko Jones

Svetlana Esenkulova, PSF Biologist and Rich Pawlowicz, UBC Ocean Dynamics Laboratory, presenting findings from the Citizen Science Oceanography Program at the State of the Pacific Ocean meeting, March 2025.

- With PSF's collaboration, a PhD student will lead the sequencing and analysis of our 2025 eDNA samples using advanced metabarcoding techniques to uncover fine-scale biodiversity patterns in the Strait of Georgia. This work will help identify key prey and ecosystem shifts that may influence juvenile salmon survival, supporting broader efforts to understand critical salmon habitats.
- Explore potential other partners and/or collaborators to take on the continuation of the Citizen Science Oceanography Program.
- Continue data collection at three of the existing patrols until the end of 2025; update the Strait of Georgia Atlas and the Marine Data Centre with the collected information.
- Through the Marine Data Centre's Data Portal, create openly available geospatial layers from the Citizen Science Oceanography Program data that allow users to make their own maps.

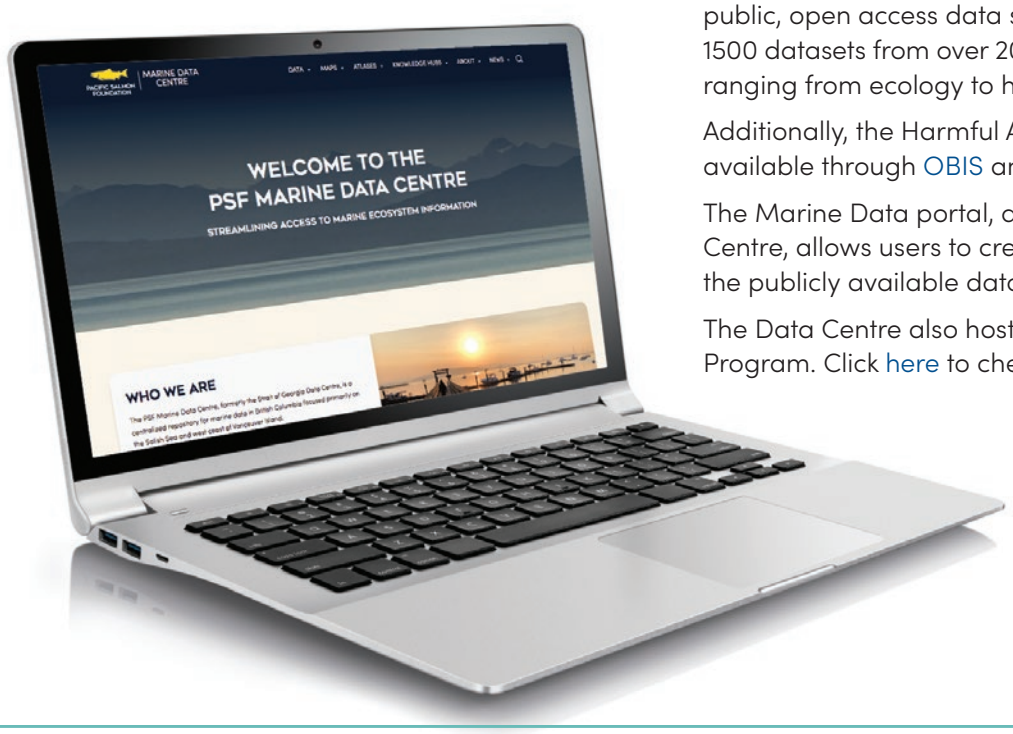
HOW CAN YOU ACCESS THE DATA?

All of the Citizen Science Oceanography Program data is housed on the PSF Marine Data Centre, a public, open access data system that references over 1500 datasets from over 200 organizations, with topics ranging from ecology to human use.

Additionally, the Harmful Algae dataset is publicly available through OBIS and CIOOS.

The Marine Data portal, a component of the Data Centre, allows users to create their own maps using the publicly available data.

The Data Centre also hosts a story map about the Program. Click here to check it out.



Nicole and Ryan Frederickson out on the water collecting samples for the Citizen Science Oceanography Program.

FEATURED CITIZEN SCIENTISTS: RYAN AND NICOLE FREDERICKSON

BAYNES SOUND PATROL

Ryan and Nicole Frederickson have been involved with the Citizen Science Oceanography Program since its inception in 2015. Ryan and Nicole both share a passion for the ocean and marine life in general.

RYAN FREDERICKSON

Ryan was born in Nanaimo and grew up in Nanoose Bay, B.C. When he first got involved with the Citizen Science Oceanography Program he was working for the Mount Arrowsmith Biosphere Region Research Institute (MABRRI) and attending courses at Vancouver Island University (VIU). Through those years, he was able to bring other VIU students and MABRRI staff out on the water to educate them about the Program, the SSMSP and the Salish Sea in general.

Ryan received a $2000 bursary from PSF to help put towards his education because of his involvement with the Program, the DFO based Avid Angler program and MABRRI. He was also successful in helping MABRRI achieve a $90,000 grant to start a bull kelp enhancement project in the Strait of Georgia.

> **"Take the roads less travelled and enjoy life to the fullest. My favorite saying is: all men die and some truly never live."**
> – Life advice from Ryan

When asked what Ryan enjoys about being involved in the program he said, *"I enjoy being part of something that could potentially aid in better managing a resource that brings myself and so many others together and supports coastal communities on Vancouver Island."*

Ryan was paralyzed in an ATV accident in 2007, but he has never let that stand in the way of his passion and love for the outdoors. When Ryan is not volunteering with PSF, he likes to spend his free time hunting, fishing, and exploring as much as possible. He loves to be out on the water and on the land.

Ryan currently works as a Partnership Assistant for Mosaic Forest Management, a long-term funder, partner and supporter of PSF.

When asked what salmon and the ocean mean to him, Ryan indicated that his father was a commercial fisherman and fishing guide, so he has grown up fishing Pacific salmon all around the coast of Vancouver Island. *"Pacific salmon created a way of life for me and my family. To me, salmon also meant flourishing terrestrial and aquatic ecosystems, which are places where I spend a great deal of my free time, hunting and fishing."*

NICOLE FREDERICKSON

Nicole heard rumblings about the Salish Sea Marine Survival Project before it was fully conceptualized, but she knew she wanted to be involved in something that could have the potential to make a difference for local salmon. She reached out to PSF to enquire about any potential volunteer opportunities with the Project and was told about the idea of the Citizen Science Oceanography Program. When she learned about the concept, she immediately ran home to coax her partner, Ryan and his father, Tom Frederickson, into captaining and operating one of the patrols. It was a big commitment and a lot of effort, but Ryan and Tom were up for the challenge.

Ryan and Nicole, with current PSF President and CEO, Michael Meneer and former PSF President and CEO, Dr. Brian Riddell taken at the annual Citizen Science Oceanography Program Symposium March, 2025.

Fast forward four years to 2019, when Nicole became not only a Citizen Scientist, but took over as the manager of the Program. She is looking forward to seeing it through to its completion at the end of this year.

When Nicole is not working with PSF and others, she enjoys being out on the land and the water, hiking, paddleboarding, boating, fishing, and hunting. She is extremely passionate about the conservation of the natural world, specifically salmon, because of their critical role in our local ecosystems. Nicole was born in Nanaimo and grew up in Parksville.

When Nicole reflects on what the ocean and salmon mean to her she says, *"The oceans, and particularly salmon are the fabric of life on the Westcoast, especially wild salmon. They play such a vital role in the functioning of not only the marine ecosystem, but also the terrestrial ecosystem. Salmon are connected directly or indirectly to every piece of the ecosystem. They [salmon] undergo these insane migrations, facing so many threats and obstacles, just to get back to their natal streams to spawn and die. It's the ultimate sacrifice to create new life."*

Ryan and Nicole now reside in Qualicum Beach, on the traditional unceded territory of the K'ómoks and Qualicum First Nations, with their two dogs, Bute and Kona. They are looking forward to completing another year of ocean sampling and feel honored to have been a small part of such an amazing program.

Sign up for our Marine Science quarterly eNews and never miss a newsletter!

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