VENUS Salish Sea Workshop Report

15-17 July 2025, Victoria and online

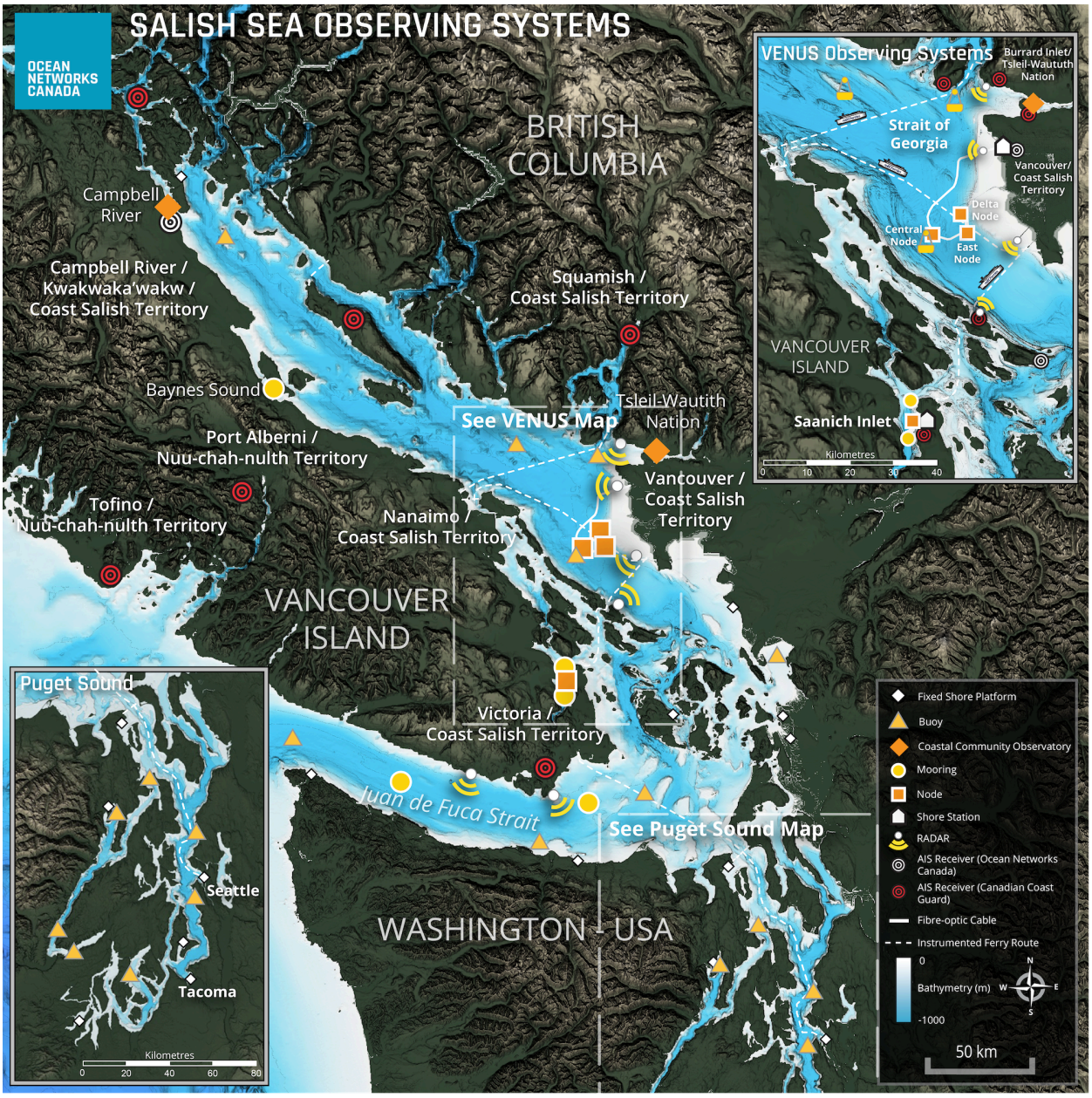

Figure 1: Map of the Salish Sea observing systems including ONC's assets like the VENUS observing system, as well as CIOOS, DFO and NANOOS-hosted stations.

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Published 26 November 2025

Executive Summary

The VENUS/Salish Sea Workshop was held at Ocean Networks Canada (ONC), University of Victoria, from 15 to 17 July, 2025. The purpose of the workshop was to celebrate nearly two decades of monitoring with the VENUS observatories in the Salish Sea and envision the next-generation ocean observing system for the region. The hybrid workshop was attended by 63 in-person and 37 remote attendees from a wide range of sectors, including academia/research, industry, Indigenous communities, government, and (29) ONC staff. The outcomes of the workshop will help inform ONC's plans for future observing systems, data management, science, partnerships and knowledge mobilization for the Salish Sea region.

The workshop sessions were organized around six themes: (1) Salish Sea Digital Twin, (2) Large-Scale System and Changes, (3) Biological Systems and Ecosystem Health, (4) Biogeochemistry in the Salish Sea, (5) Coastal Management, Soundscapes & Traffic, and (6) Physical & Digital Infrastructure and Innovation. Speakers presented their perspectives, research, and ideas under each theme; then the ideas were discussed and further developed with the attendees during breakout sessions. The final day was centred around a visioning exercise to help shape the future observing system.

The high-level outcomes of the workshop can be grouped in the following four themes:

1. **Towards a Salish Sea Digital Twin:** A system to enable responsible science-based management of the urban-ocean environment for a sustainable future.
2. **Next generation 4D observing system:** A paradigm shift in ocean observing to monitor the entire Salish Sea at an unprecedented spatial and temporal resolution.
3. **Vibrant partnerships across sectors and disciplines:** Co-designing the system and ensuring impact for science, society, and industry will require enhanced and sustained collaboration with partners throughout the region.
4. **Leading edge science with meaningful impact:** The multi-use system will support resilience to climate change, responsible shipping, tourism, and security, and meet the priorities of Indigenous communities.

With this report, the summary and outcomes will be shared with a broader audience, including workshop invitees unable to participate and members of the ONC community, in order to gather further input. The resulting short-term and long-term recommendations and the emerging vision will be incorporated into ONC's strategic planning for the future of observing systems in the Salish Sea.

Introduction

Why now?

The idea for seafloor cabled observatories was conceived in the 1990s and became a Canadian reality in February 2006, when data began streaming from the Victoria Experimental Network Under the Sea (VENUS) Saanich Inlet platform. Nearly two decades later, we gathered to celebrate the discoveries and progress made as well as revisit the observatory's initial scientific questions and requirements in light of today's community needs and technological capabilities. Fortuitous in timing, the Canada Foundation of Innovation requested ONC to develop a forward-looking 15-year strategic plan to inform ONC's future as a Major Research Facility. The time was, therefore, apt to rethink VENUS and coastal observatories around the Salish Sea, with a focus on establishing a vision for the next generation of Salish Sea monitoring that ONC can help conduct.

Inviting Participation

This workshop aimed to bring together researchers, First Nation communities, governments and industry to review past successes and help define future needs and opportunities for continuing to monitor this important inner sea. ONC contacted everyone in their user database with a connection to the Salish Sea, asking for this invitation to be shared broadly. Workshop registration was open to everyone, with the option to attend remotely or in person. First Nation engagement was prioritized as invitations were extended specifically to all Salish Sea First Nations. Tribal engagement on the U.S.-side was also invited.

Workshop Planning

The workshop registration form gathered information on topics and regions of interest, potential presentation titles, and asked for volunteers to help with the event. This information supported the workshop planning committee in outlining main workshop themes and determining the detailed agenda including breakouts. The committee identified workshop theme leaders who completed detailed planning for sessions with inspiring presentations and discussions feeding into theme-based breakouts.

External organizing committee members:

- Ian Black, Ph.D. Candidate, Ocean, Earth, and Atmospheric Sciences, Oregon State University
- John Delaney, Professor Emeritus, School of Oceanography, University of Washington
- Richard Dewey, Former ONC Associate Director, Science Services
- Jeffrey Harris, Research Associate, Saint-Venant Hydraulics Laboratory Associate Professor, École nationale des ponts et chaussées
- Phil Hill, Emeritus Research Scientist, Geological Survey of Canada, Natural Resources Canada
- Rich Pawlowicz, Professor, Earth Ocean and Atmospheric Sciences, University of British Columbia
- Meghan Tomlin, Program Lead, Malahat Nation
- Di Wan, Section Head, Ocean Sciences Division, Fisheries and Oceans Canada

Workshop Themes and Agenda

The six workshop themes were: (1) Salish Sea Digital Twin, (2) Large-Scale System and Changes, (3) Biological Systems and Ecosystem Health, (4) Biogeochemistry in the Salish Sea, (5) Coastal Management Soundscapes & Traffic, and (6) Physical & Digital Infrastructure and Innovation. The first theme, Digital Twin, was the broadest and had identical breakout sessions for subgroups, and all other themes were more specialized and had parallel breakout sessions dividing the group by specialized interest.

Figure 2: Layout of the six workshop themes that were the focus for the first two workshop days. Each theme had all-in inspirational presentations and discussions, but some breakout sessions were held in parallel, with overlap represented by row/colour.

The first two days were focused on capturing experiences and ideas for the six workshop themes; the last day was reserved to develop a future vision, with breakout sessions followed by “capturing the gold” (or “rare earth minerals”).

Attendance

Registration for in-person attendance closed three months prior to the workshop to allow time for venue planning, but registration remained open for remote participation. In total, the workshop attracted 63 in-person and 37 remote attendees (though not everyone attended all three days), spread over 35 affiliations, with ONC as the largest group (29 participants). The following image summarizes the various organizations represented.

Figure 3: Word cloud of workshop registrant affiliations.

Photo 1: Fiftyfour in-person workshop participants of the VENUS Salish Sea workshop at the ONC headquarters on the Queenswood ocean and climate campus of the University of Victoria. Not pictured are another nine people who attended in-person and all 37 virtual participants.

Outcomes

Over the course of the workshop, attendees reflected on the presentations and discussions and were challenged to “capture the gold” at the end of each workshop day. On the final day, a survey was circulated to attendees which asked the question ***“Articulate the vision which emerged by finishing the sentence: The next generation Salish Sea ocean observing system will.....”.*** The following four major outcomes emerged, integrating the reflections of the attendees and the summaries of all the thematic sessions and discussions.

1 Towards a Salish Sea Digital Twin

A system to enable responsible science-based management of the urban-ocean environment for a sustainable future.

The idea of a Digital Twin of the Salish Sea urban sea system was introduced, and it resonated well among participants, inspiring many to think of the Salish Sea as an interconnected system of systems. Participants encouraged ONC to serve a leadership role in coordinating efforts towards a Digital Twin, or at the very least, expanding and providing observations that can enable predictions on how the Salish Sea reacts to change, while supporting future decision-making.

Building a Digital Twin needs to start somewhere. Concrete initial steps could be to focus on a couple of important component systems like the regional economy, energy flows, or environmental impacts. Such steps can help demonstrate the usefulness of a Salish Sea Digital Twin, which would serve as an excellent example for implementation. Ultimately, twins could be developed for as many as 200 Urban Sea Systems globally (Greene and Delaney, 2025). An operational Digital Twin would enable real-time and responsive data-driven decision-making for cities, communities, policy-makers, infrastructure operators, utilities, and environmental management organizations. The input must be high-quality data and model results, delivered in real time. The implementation of a Digital Twin will require spatial and temporal information at varying scales and resolutions (Outcome 2), partnerships and collaborations across sectors (Outcome 3), and an impact-driven design (Outcome 4).

Figure 4: Graphical summary of first major workshop outcome theme “Towards a Salish Sea Digital Twin.”

2 Next generation 4D observing system

A paradigm shift in ocean observing to monitor the entire Salish Sea at an unprecedented spatial and temporal resolution.

The second major potential that ONC can help enable is to expand observations, from the currently existing fixed bottom nodes in Strait of Georgia and Saanich Inlet, to add Juan de Fuca Strait and potentially other inlet-based real-time nodes. New sensors and instrument platforms to expand temporal and spatial coverage could include:

- Profiling and active acoustics (ADCP) moorings
- Fibre-optic distributed sensing
- Additional ferry systems
- Additional high-frequency radar systems
- Expanded Community Fishers and citizen science observations
- More coastal community observatories
- Enhanced water column measurements with autonomous mobile monitoring using surface or diving platforms

The ultimate vision is to create a comprehensive high-resolution 4D (3-dimensional over time) observing system of the entire Salish Sea. The Juan de Fuca Strait, with its key role in water exchange between the Salish Sea and the Pacific Ocean, came up as an important area of focus, with opportunities to fill existing knowledge and data gaps. Continuing to monitor sediment transport from the Fraser River and throughout the whole system was noted as important. This system should integrate related data sets such as satellite imagery and data collected by First Nations in the region.

Figure 5: Graphical summary of second major workshop outcome theme “Next generation 4D observing system.”

3 Vibrant partnerships across sectors and disciplines

Co-designing the system and ensuring impact for science, society, and industry will require an enhanced level of collaboration.

Collaboration is key, and the community welcomes a more collaborative future. Moreover, ONC is inspired to play a role in being a convening “space” to enable this collaboration. There was a call for additional focused workshops, particularly addressing First Nation community needs more strongly, as well as efforts to foster more urban and industry partnerships. Again, ONC's convening power can provide leadership, and regular community exchanges will help keep this work relevant. In particular, a vision of a coordinated and collaborative Salish Sea Digital Twin will help optimize observations and their applications across provider organizations. Cross-border collaboration is also critical to understanding and supporting comprehensive stewardship for the entire Salish Sea system.

Figure 6: Graphical summary of third major workshop outcome theme “Vibrant partnerships across sectors and disciplines.”

4 Leading edge science with meaningful impact

The system will enable resilience to climate change, responsible shipping, tourism, and security, and meet priorities of Indigenous communities.

The Salish Sea, as an inland sea encompassing the Strait of Georgia, Juan de Fuca Strait, and Puget Sound, connects mountain watersheds to the Pacific Ocean. It is rich in biodiversity, including the iconic Southern Resident Killer Whales and Pacific salmon. It is also home to nearly 9 million people and is an important region for shipping, tourism, and other industries. Coast Salish Indigenous communities have stewarded the lands and waters of the region since time immemorial and maintain close cultural, economic, and geographic connection to the Salish Sea. Ensuring that the outcomes of the next generation Salish Sea observing system have maximum impact means designing the system, its applications, and its scientific outputs with knowledge mobilization across these different sectors as primary considerations. The system should help communities monitor conditions, promote resilience to climate change impacts, and make decisions that matter to them. It should support policy-makers and community managers with accurate knowledge of current ocean and coastal conditions and predicted changes. It should be a world-leading, innovative, comprehensive system which delivers trusted information while supporting cutting-edge research.

Figure 7: Graphical summary of the fourth major workshop outcome theme "Leading edge science with meaningful impact."

Advice for ONC

Workshop participants provided some advice for ONC throughout the workshop. These recommendations were provided either as part of the inspirational presentations, or during the breakout sessions, breakout summary presentation and discussions, or as part of the Day 3 visioning survey. These recommendations were divided into short- (1-5 years) and long-term (5+ years) categories dependent on when such plans could potentially begin, not necessarily completed:

Short-term recommendations

Suggested recommendations to begin within 5 years:

- More collaboration:
    - Keep engaging Indigenous communities
    - Initiate focused workshops for specific themes and Indigenous community partners with the intent to identify specific goals and objectives
    - Convene working groups that can advise and support ONC's efforts
    - Expand cross-border collaboration and share knowledge, including infrastructure expertise
- Towards a Digital Twin - early steps
    - Help design and develop small proof-of-concept mini Digital Twin components for predicting Salish Sea conditions
    - Integrate Machine Learning, Artificial Intelligence (AI), and modelling
    - Develop AI-ready data protocols

- Fill data gaps, improve data:
    - Add more Juan de Fuca Strait High-Frequency (HF) radar
    - More ferry systems and add hyperspectral data
    - Fill contaminant monitoring gaps
    - More profiling moorings
    - More surface buoys with instrumented tethers
    - More Acoustic Doppler Currant Profiler (ADCP) moorings
    - More Bottom Boundary Layer (BBL) observing platform deployments
    - More weather stations on buoys
    - Support sediment management by sediment transport, coastal change and erosion observations
    - Leverage autonomous observation options
    - Consider Open Ocean Robotics Uncrewed Surface Vehicle (USV) profiling winch as an option for Community Fishers, Distributed Biological Observatory and other programs
    - Utilizing robust and standardized underway (e.g. ferry) pCO2 measurements to help observe carbonate system
- Collaborate on data:
    - Help Pacific Salmon Foundation (PSF) and Natural Resources Canada (NRCan) to combine their near-shore and deeper Salish Sea mapping data
    - Help with Fisheries and Oceans Canada (DFO) plankton imaging data archiving
    - Help archive Rockland Scientific microstructure and turbulence data
    - Standardize methods, metadata, and best practices
    - Work with Northwest Association of Networked Ocean Observing Systems (NANOOS) to fix broken links and add more ONC assists to NANOOS portal
- General:
    - Continue core monitoring for climate signals

Long-term recommendations

Suggested recommendations to begin in more than 5 years:

- Towards a Digital Twin - longer term:
    - Establish a Salish Sea Digital Twin Implementation Centre, like the Community Surface Dynamics Modeling System (CSDMS at the University of Colorado in Boulder); it could combine existing models (e.g. Salish Sea oceanography, weather) and observations (from ONC, NANOOS, Automatic Identification System (AIS) vessel traffic) and grow from there.
- Expand infrastructure and monitoring:
    - Plan and implement high priority monitoring expansions such as Juan de Fuca, Haro and Rosario Straits and Sabine Channel
    - Add a real-time bottom pressure station to the mouth of Juan de Fuca Strait
    - Expand to more Salish Sea inlets and fjords
    - Add river moorings
    - Add a drifter program
    - Add aerial drone monitoring

- Enhance data and information services
    - Synthesize observing data from various agencies, including satellite data
    - Develop enhanced data products, including satellite data
    - Add more information services to the existing data services

Themes - Theme-based reports (Days 1 & 2)

Theme 1: Salish Sea Urban Sea System - Digital Twin

The Salish Sea Urban Sea System Digital Twin theme emerged during the workshop planning as potentially the ultimate goal for combining all Salish Sea monitoring, modelling and prediction efforts for a safe and sustainable coexistence of all living beings in the Salish Sea, and therefore it was chosen as a workshop opening theme with the following inspirational presentations:

- The very first presentation was by Tammy Sam and Robbie Davis from the Tseycum First Nation, entitled "*Tseycum First Nation Marine History, Culture, Education and Networking*," providing a perfect background on the long history of human existence and knowledge gathering in the Salish Sea, their recent challenges, and concrete examples of collaboration and data sharing.
- John Delaney (University of Washington, Seattle) answered the question "*Digital Twins: Key to Sustainable Stewardship of Urban Sea Systems?"* with a yes since we already have many necessary components with the exception of a leader and time, as it will take a generational plan to implement.
- Gary Greene (Moss Landing Marine Labs, Tombolo Mapping Lab, San Jose State University) rounded up the session with "*The Salish Sea: A Potent Natural Laboratory for Designing the First Urban Sea Digital Twin*," by stressing that the Salish Sea is an ideal starting point for this idea, but cautioned that we may need to start small.

This was the perfect segway to the breakout question: What do you think are the early steps towards a Digital Twin?

Theme 1 breakout summary

Vision & Purpose

- Clarify the motivation and purpose of preserving the Salish Sea—who benefits and why.
- Ensure the approach treats the Salish Sea as an interconnected whole system, not focused narrowly (e.g., beyond the Port of Vancouver).
- Define intended users and beneficiaries of the Digital Twin (e.g., policy, research, Indigenous communities, public).
- Aim for early, visible successes that demonstrate value and build momentum.

Governance & Inclusivity

- Ensure Indigenous Nations are acknowledged as rights-holders, co-develop research priorities, and are active partners and decision-makers in all discussions.

- Foster high-level coordination among groups (ONC could play a convening role).
- Clarify data ownership and governance (e.g., DND, institutions, First Nations).
- Define spatial boundaries, feedbacks, and relationships among modules (e.g., Fraser Delta, Juan de Fuca Strait).

Data & Infrastructure

- Identify existing real-time data streams and acknowledge key data gaps.
- Build on existing physical models and link them with real-time observations (e.g., tidal and tsunami models, watershed processes).
- Develop data standards and protocols to make data AI-ready, while ensuring observational validation.
- Address data collection, processing, and storage strategies, including the structure of “clouds” or shared repositories (e.g., ClOOS as a potential “mother cloud”).

AI, Modelling & Caution

- Proceed carefully with AI integration—recognize both its potential and its risks.
- Ensure AI supports, rather than replaces, human and observational validation.
- Explore how exponential technologies and digital twins can guide sustainable decisions and influence societal systems (economy, energy, education).

Theme 2: Large Scale System and Changes

The second workshop theme was focusing on physical oceanography, looking at the larger patterns that determine environmental conditions in the Salish Sea, looking at individual regions of the Salish Sea, observatory and campaign data, how everything is connected, and what knowledge gaps need to be filled in order to better understand the Salish Sea. The following four presentations set the stage for discussing this theme:

- Richard Dewey, ONC former Associate Director, Science and UVic Adjunct Professor, presented on “*Two decades of second-by-second State of the Ocean monitoring with VENUS”* where he gave a brief history of VENUS and showed the value of continuous long-term time series and pointed out that 20 years is not quite long enough for seeing climate signals.
- Rich Pawlowicz (Professor, University of British Columbia), in “*Circulation processes in the Salish Sea,*” summarized scientific process, existing data and missing data for each region and depth zone in the Salish Sea and advocated for operational nowcast models as a first step for a Digital Twin.
- Jennifer Jackson (Research Scientist at the Institute of Ocean Sciences, Fisheries and Oceans Canada) presented “*An overview of DFO's Salish Sea Biophysical and Shore station data programs from 1914 to present*” with the research station time series of their biophysical and shore station programs that documented gradual changes since 1930.
- Jody Klymak (Professor, University of Victoria) showed “*Water column observations to better constrain overturning circulations*” and emphasized again the data gap in Juan de Fuca and Haro Straits which can be filled with $4.8M worth of profiling and acoustic moorings.

Theme 2 breakout summary: Topics

Physical and Biogeochemical Processes

- **Water and Mass Exchange:** Deep-water renewal and large-scale fluxes between the Salish Sea and the Northeast Pacific are critical for ecosystem health; better sampling in key gateways (e.g., Johnstone Strait, Juan de Fuca Strait) is needed.
- **Sediment and Salinity Dynamics:** Improved understanding of sediment transport and riverine inputs (Fraser, Skagit, Squamish, Puget) is essential to link terrestrial and marine systems and to track related salinity changes.
- **Surface and Atmospheric Interactions:** Winds, waves, tidal rips, and atmospheric processes play key roles in shaping surface conditions and should be better monitored and modeled.
- **Tsunami and Tidal Interactions:** Enhanced modeling of tsunami–tide interactions is important for hazard assessment and response.

Climate Change and Ecosystem Stressors

- Monitor and model climate-driven changes and extreme events—warming, acidification, deoxygenation, harmful algal blooms, landslides, and heat domes—as emerging stressors to the marine ecosystem.

Societal Connections

- Recognize links between ocean conditions and **food security**, emphasizing how physical and biogeochemical processes directly affect human communities, culture and ecosystem resilience.

Theme 2 breakout summary: Monitoring Systems

Monitoring Strategy

- **Autonomous and Collaborative Approach:** Prioritize autonomous observing systems and cross-border coordination, engaging First Nations partners to fill data and coverage gaps.
- **Integrated Observing Network:** Combine distributed and point-based measurements to capture variability across the Salish Sea.
- **Community Involvement:** Support community-based monitoring (e.g., Community Fishers) to collect CTD, oxygen, turbidity, nutrient, and carbon data.

Technologies and Platforms

- Employ autonomous profilers, vehicles powered by platforms, and lithium-battery ships to expand temporal and spatial coverage.
- Use numerical simulations and machine learning to extrapolate difficult-to-measure variables.
- Integrate DAS and GNSS for seismic and atmospheric river monitoring, with GNSS also serving as a tide gauge.

Measurement Priorities

- Focus on sediment transport and multi-frequency echosounders.
- Prioritize sensors for current-dependent profilers and monopile systems.
- Monitor key marine stressors affecting ecosystem health.

Modeling and Real-Time Systems

- Develop a physical model of the Salish Sea—akin to a Digital Twin—integrating real-time data from ADCPs, BPRs, WERA, and CODAR for improved tsunami and circulation modeling.

Theme 3: Biological Systems and Ecosystem Health

The Salish Sea is a habitat for many living species, and this theme acted as a journey from small plankton to large fish (stopping short of whales which were part of the coastal management theme that included traffic). Four presenters gave inspiration ahead of discussing optimal monitoring in the breakout.

- Akash Sastri (Research Scientist at the Institute of Ocean Sciences, Fisheries and Oceans Canada, and Adjunct Professor at the Department of Biology, UVic) provided an overview over "*Monitoring plankton productivity and diversity in the Salish Sea*" by introducing the DFO Pacific Plankton Time Series for tracking biomass and productivity as well as Harmful Algal Blooms (HABs), and highlighted opportunities for ONC to help with image data archiving.
- Vera Pospelova (Professor at the University of Minnesota Twin Cities) advocated for the need of running sediment traps in her talk "*What we have learned from our studies of dinoflagellates, their cysts, and biogenic silica content in sediment traps*," which also gave background on reconstruction of past environmental conditions, and emphasized the usefulness of cabled sediment traps where we can then also track environmental conditions directly.
- Meghan Tomlin and Steven Henry Jr. from Malahat Nation, one of the W̱SÁNEĆ Nations, also known as the "Saltwater people," shared a presentation on "*Tides and Teachings - Continuous care and renewal at the Salish Sea clam garden*" where they talked about the usefulness of both clams and clam gardens from ocean health to social interactions, and how they collaborate with others.
- Stephane Gauthier (Research Scientist with Fisheries and Oceans Canada) concluded the theme talks with "*Active acoustics monitoring in the Salish Sea: Pacific have, Pacific herring, euphausiids, and everything in between*" where he showed the acoustic survey data that allow mapping of species including their ages, and stressed the importance of permanent cabled echosounders to help interpolate between surveys.

Theme 3 breakout Summary: Topics

- Measure **phytoplankton** and **zooplankton** biomass, rates, and interactions to understand food web dynamics.
- Track **fish population fluxe**s and the mechanistic drivers of biological change across spatial and temporal scales.
- Link ecosystem monitoring to **food security** through rapid detection of **harmful algal blooms** and ongoing **ocean acidification** assessment.

Theme 3 breakout Summary: Monitoring

- Consultation with local **fishermen** and **First Nations partners.**
- **Sediment traps**, with sensors for primary production monitoring, in key locations.
- **Acoustic profiling** (e.g., with multi-frequency echosounders).
- Phytoplankton biomass and rates measurements (e.g., on **ferries**) and **imaging** (FlowCytobot); potential early warning for Harmful Algal Blooms (HABs).
- Developing **new technologies**, incl. eDNA, using the Buoy Profiling System or other easily accessible observatory systems.
- Leveraging the VENUS network for short-term process-based studies.

Theme 4: Biogeochemistry in the Salish Sea

This theme closely links the physical oceanography and the biology and ecosystem health themes but was scheduled for Day 2 to allow workshop attendees to attend both thematic breakouts. Knowing the biochemical conditions is important for ensuring to stay within life-supporting boundaries, and the following four presentations provide an overview of the boundary conditions and currently biogeochemical monitored:

- Kohen Bauer (Science Director, ONC) kicked off the theme with "*Integrating Planetary Boundaries thinking into the future of Salish Sea observing systems*" by highlighting a need for tools to analyze the integrated Earth system reliably to stay within livable boundaries, with a particular emphasis on the ocean and ocean observing for a sustainable future.
- Roberta Hamme (Professor, SEOS Department, University of Victoria) zoomed in with "*Drivers of biogeochemical changes in deep Saanich Inlet*" a fjord with seasonally anoxic bottom water conditions. The presentation focused on interdisciplinary observing approaches to understand processes ongoing in this area.
- Wiley Evans (Lead Oceanographer, Hakai Institute) introduced "*Hakai Institute's Marine CO2 Studies in the Northern Salish Sea*" that consist of continuous and survey-based marine carbonate system and biogeochemical monitoring and research. He showed how the Salish Sea carbonate system responds to biogeochemical and physical drivers. He also described how the program is growing with additional buoys, tethers and data platforms.
- Maycira Costa (Professor, Geography Department, University of Victoria) continued the plankton story with "*Phytoplankton bloom time and groups: interannual variability from Sentinel 3 satellite and ferry-based reflectance data*", emphasizing the importance of ferry data and recommending hyperspectral data plus enhanced data products for better understanding things like blooms, salmon health, or kelp loss in the Salish Sea. A focus was placed on integrating different ways to observe the oceans to create more robust interpretations.

Theme 4 breakout summary: Topics

- Address **multiple stressors** and **extreme events** in the context of natural variability.
- Improve understanding of **exchange flows** through Juan de Fuca Strait and their role in regional biogeochemistry.
- Establish **data standards** and expand observations using **BGC Argo** floats, **satellite**, and **model** integration.

Theme 4 breakout summary: Monitoring

- Expand vertical profiling, moorings, and **water column** sampling.
- Utilize **ferry and vessel-based** platforms (e.g., Comox ferry, Clipper, Black Ball) for continuous biogeochemical monitoring.
- Expand **reflectance** measurements and incorporate **hyperspectral** sensors to align in situ and satellite observations (e.g. on underway systems).
- Strengthen **community-based monitoring** and establish **new coastal observatories** (e.g., Sabine Channel) to fill geographic gaps.
- Advance **phytoplankton** composition and **HAB monitoring** through tools like Imaging FlowCytobot and remote sensing.
- Develop trusted, standardized methods for **underway *p*CO_2** measurements to help observe the carbonate system.

Theme 4 breakout summary: Implementation

- Fostering **collaboration** is key
- Profiling system maybe difficult to implement in **Haro Strait** due to fast currents, tethered or moored system might be better
- Address challenges when estimating **uncertainty** (*p*CO_2 and pH)

Theme 5: Coastal Management, Soundscapes & Traffic

Ocean observations are important for coastal management, and coastal management includes marine traffic, and traffic includes noise and marine mammals, and so this theme included all these aspects. This time a panel discussion with representatives from First Nations, municipalities and academia was providing insights to the different aspects, existing and missing observations. The discussion was guided by Gwyn Lintern (National Resources Canada).

- Lorne Underwood (W̱SÁNEĆ Nation Elder, Tsawout Village) opened with a personal story, past fruitful exchanges where traditional knowledge supported Western science discoveries, and proposed to help each other more to put research into action.
- Shahin Dashtgard (Earth Science Professor, Simon Fraser University) shared his research on the dynamics of the Fraser River Delta growth and erosion, impacted by coastal development, and highlighting the importance of sediment management which ONC monitoring can support.
- Harvy Takhar (Manager of Drainage and Natural Hazards, City of Delta) took us on land (where he grew up) and talked about the City of Delta's vulnerability to inundation, what is being done and what needs to be done to manage the risks.
- Kees Lokman (Associate Professor, UBC Coastal Adaptation Lab) introduced the shared First Nations, municipalities and government initiative Living with Water initiative and SSEDS (Sustainable Ecosystem Enhancement with Dredged Sediments) project that tests sediment enhancement that results in new or improved habitat, and again promoted that ONC monitoring can help.

Theme 5 breakout Summary

- Address **coastal erosion, delta stability**, and **geohazards** linked to both natural events and human activities.
- Enhance **noise monitoring and modeling**, integrating AIS and non-AIS vessel data.

- Support the **Quiet Vessel Initiative** and other mitigation initiatives through improved regulation and real-time acoustic monitoring.
- Track and manage the **changing soundscape** from shipping, ports, and recreation.
- Incorporate offset and **restoration** measures (e.g., eelgrass, biofilms) in coastal development and port expansion plans.

Theme 6: Physical and digital infrastructure and innovation

The final theme brought together data, information and hardware providers and opportunities from modern computing to revolutionize Salish Sea observations and predictions, closing the loop to the opening Digital Twin theme. Severn lightning presentations from academia, NGOs and industry brought to light many opportunities:

Theme 6 presentations for inspiration

Ben Skinner (GIS Specialist, Pacific Salmon Foundation) on "*Marine Data Centre*" summarized PSF's main focus as salmon survival and the data input and output they produce, with opportunities to combine efforts with others.

- Brad De Young (Exec Director of CIOOS Pacific) provided an overview over "*CIOOS Pacific - Expanding west coast ocean data and information*" which has been active since 2019, primarily to point to many ocean observing data, many partners, and expanding to information services.
- Jan Newton (NANOOS and UW) followed with "*NANOOS Observing System and science observations from it*" as part of NOAA's IOOS program, active since 2003, linking to and showing ocean data and models, established information services and more, and also showed the gaps that Canada-US collaboration can fill.
- Jean-Philippe Juteau (Rockland Scientific) presented "*Turbulence measurements in British Columbia*" with their commercial microstructure sensor products that are used on gliders and floats, and wondered if ONC can help with data rescue.
- Randy LeVeque (Prof. Emeritus in Applied Maths at University of Washington) showed how "*Tsunami forecasting in the Salish Sea using Machine Learning*" could profit from a realtime bottom pressure recorder at the entrance of the Juan de Fuca Strait for more precise warnings.
- Jeffrey Harris (Researcher and Associate Professor, Institute Polytechnique de Paris, France), in "*Towards a Digital Twin of the Salish Sea*," showed several examples how to predict ocean conditions with a subset of data through Machine Learning, essentially mini Digital Twins.
- Oliver Kirsebom (Senior Data Scientist at Open Ocean Robotics) finished the workshop presentations with "*New opportunities for data collection and environmental monitoring in the Salish Sea*" with how their commercial Uncrewed Surface Vehicle (USV) enables autonomous data acquisition, including CTD profiling.

Theme 6 breakout Summary

- Topics
    - Data processing
    - Data types (HDF)
    - Contribution of observation data to predictive models

    - "People-ready" data sets (low latency data — compute close by)
- Monitoring systems
    - Profilers/water column observation
    - Bottom Pressure
    - Distributed Temperature Sensing (DTS)
- Advice
    - Not everything needs to be real-time; not everything needs to be cabled
    - Don’t miss out on AI
    - Facilitate coordination amongst engineers in different organizations

Summary and Next Steps

The VENUS Salish Sea Workshop was intended to bring the Salish Sea researchers, First Nations, governments and industry communities together to develop a vision for the next generation Salish Sea ocean observing system. This workshop was motivated by the opportunity to celebrate almost two decades of VENUS data, the need to review aging existing observing systems, and Ocean Networks Canada's main funder, the Canadian Foundation for Innovation (CFI), asking for a 15-year plan to continue operating as one of six Major Research Facilities in Canada. Everyone was invited to join this hybrid in-person and online event hosted by ONC, and 100 attendees across 35 affiliations, mostly from Canada and the US, came together in Victoria and online for three days in July 2025.

Pre-workshop surveys identified volunteers for a workshop organizing committee that then created a 6-theme approach to discuss ideas about a Salish Sea Digital Twin, new frontiers in physical, biological, biogeochemical, coastal management, and physical and digital systems. A total of 25 speakers shared inspirational insights, after which focused breakout sessions identified potential early steps for a Digital Twin as well as high-impact research topics and favourite Salish Sea observing infrastructure and monitoring programs to support these topics. The third and final day of the workshop was then used for a visioning exercise, crystallizing the major future themes for a new vision. The four guiding themes to create a future Salish Sea observing system were: (1) Towards a Salish Sea Digital Twin, (2) Next generation 4D observing system, (3) Vibrant partnerships across sectors and disciplines, and (4) Leading edge science with meaningful impact. Furthermore, the workshop participants provided concrete short- and long-term recommendations for ONC and many ideas and considerations for shaping the future. In addition, a graphical recorder crafted visual summaries for each of the three workshop days, a colourful and inspiring documentation of all presentations and discussions.

At the time of writing, CFI has received ONC's (confidential) high-level 15-year plan which contains ideas for the Salish Sea discussed during this workshop that, if turned into a proposal exercise, will be a chance to be worked on in more detail with community help. In the meantime, ONC is revisiting all the ideas that can already be implemented with current operating and maintenance funding and is reaching out to the community for additional advice, starting with simple, low-cost high-impact ideas. For every fiscal year (April-March) ONC is developing an annual program plan with actionable tasks that are connected to priority focus items, for all its observatories. The workshop outcomes serve as an ideal source for the Salish Sea observing systems.

To achieve the workshop outcome goal 4, leading-edge science with meaningful impact, it is essential to follow goal 3, vibrant partnerships, and ONC is welcoming continuous engagement, input, feedback, and is grateful for any help for ONC to be able to help the community best. Together, the community and ONC will then aim for goal 2, the full 4D observing system, that ultimately gets us to goal 1, the Salish Urban Sea Digital Twin.

Photo 2: Graphical recorder Erica Bota created three images capturing the discussions from each day of the workshop. These images with summaries are included in the Appendix to this report.

Acknowledgements

We acknowledge and respect the Lək̓ʷəŋən (Songhees and Xʷsepsəm/Esquimalt) Peoples on whose territory this workshop was hosted at Ocean Networks Canada (ONC) headquarters at the University of Victoria, and the Lək̓ʷəŋən and W̱SÁNEĆ Peoples whose historical relationships with the land and sea continue to this day. We also acknowledge the Indigenous communities with whom ONC has the honour to partner on coastal monitoring and data management solutions. In this workshop, the land and sea of the Coast Salish Peoples have inspired us to work together toward a future where the Salish Sea is understood, respected, and cared for by all.

We are thankful to Danica Paul, a young Indigenous leader from the Songhees, Tsartlip, Ahousaht, for both opening and closing the workshop for us, and who shared her connection to the Lək̓ʷəŋən history. Həysxʷq̓ə siém!

Thank you also to the many helpers in front and behind the scene, in particular Dwight Owens, Grace Bartozzi and especially Tricy Aquino who sent around hundreds of emails, for organizing the finest details of this workshop. Thank you to Pieter Romer and Maia Hoeberechts for reaching out to all Salish Sea First Nations and inviting them to the workshop and pre-workshop information sessions. And thank you to the Reception and other ONC staff who arranged things, not least the refreshments, and helped with note-taking, summarizing, and sharing insights throughout, and cleaning up after.

We are grateful to those who in the workshop registration survey or otherwise offered to help organize the workshop and then found themselves enrolled in the VENUS Salish Sea Workshop Organizing Committee (VSSWOC): Meghan Tomlin, Di Wan, John Delany, Phil Hill, Ian Black, Jeff Harris, Rich Pawlowicz, and Richard Dewey externally to ONC, and Maia Hoeberechts, Luci Marshall, Manman Wang, Kohen Bauer and again Grace, Tricy and Dwight internally.

Much appreciation to Erika Bota from ThinkLink Graphics for the stunning graphical artistic work.

And last but not least thank-you to everyone who had made the commitment to join this workshop (even if it changed their summer plans), especially the speakers squeezing in inspiring presentations into a busy schedule, and for the lively discussions we had in the breakouts and the breaks, that we hope to continue towards the next-generation of seeing the Salish Sea System of Systems.

References

H. Gary Greene, H.G., and Delaney, J.R. (2025). Urban Sea Systems and why they are important: A preliminary characterization. Estuarine, Coastal and Shelf Science, 322 (109274). https://doi.org/10.1016/j.ecss.2025.109274.

Appendix

Introductory Presentations

Kate Moran, ONC's CEO, gave a background presentation on Ocean Networks Canada and our current 15-year planning process.

Adrian Round, ONC's former Director of Operations, presented a *Victoria Experimental Network Under the Sea VENUS: Inspiration to Installation—a very brief history*. (Recording)

Theme Presentations and Breakout Session Summaries

Theme 1: Salish Sea Digital Twin

Theme 1 Presentations

Tammy Sam and Robbie Davis (Tseycum First Nation): *Tseycum First Nation Marine History, Culture, Education and Networking*

- Shared the history and connection of their people with the sea, emphasizing its importance.
- Highlighted challenges working with Canadian government agencies and preparing for events like oil spills.
- Stressed that every living being counts, beyond what authorities list.
- Collaborating with 29 Nations, their work has 18 months of funding left.
- Utilize a portal with historic data from Terra Remote:

John Delaney (University of Washington, Seattle): *Digital Twins: Key to Sustainable Stewardship of Urban Sea Systems?*
Recording | *Slides*

- Defined sustainable stewardship as long-term, encompassing an entire system of systems for urban sea areas.
- Stated that Digital Twins, enabled by AI, can replicate real-world systems and answer "what ifs" using real-time data.
- Identified the Salish Sea as a globally important natural lab for testing solutions.
- Noted that ONC's Oceans 3.0 cloud can handle real-time data, but knowing "what to measure, where, when, and how often" is key.
- Proposed a 20-40 year Salish Generational Plan for a Digital Twin of the entire Urban Sea System, which he believes is achievable given rapid growth of AI capability and humanity's other accomplishments.

Gary Greene (Moss Landing Marine Labs, Tombolo Mapping Lab, San Jose State University): *The Salish Sea: A Potent Natural Laboratory for Designing the First Urban Sea Digital Twin*
Recording | *Slides*

- Believes the Salish Sea is an ideal starting point for designing the first Urban Sea Digital Twin.
- Suggested considering the six "e"s: Economy, energy, environment, ecology, education, and empathy, with economy and energy as initial drivers.
- Emphasized thinking big but starting small, focusing on areas like port operations and supply chain, including tracking ships and whales.
- Stated that the Salish Sea can provide predictable energy through safe tidal generation technology, using historical data to find optimal locations. One suggested location is Rosaria Strait in the San Juan Islands.
- Advocated for breaking out of silos and combining historical with real-time data for social and environmental justice.

Theme 1 Breakout Slides

Question: What do you think are the **early steps** towards a Digital Twin?

Team QW 101 - Reporter: Kohen/Lynn

- Identify the motivation/purpose (who benefits and why) for the preservation of the Salish Sea
- Ensure inclusivity and the Salish Sea as a whole system (e.g. not primarily focused on the Port of Vancouver)
- Identify real-time data already being collected and in place
- Acknowledge the data gaps that exist
- Needs high-level coordination between groups (ONC may have convening power)
- Develop protocols for data to be AI-ready to be usable in the Digital Twin system
- Data also needs to have observational validation (AI and data cannot run the entire show)
- Really think about how AI will impact the system. Proceed with caution!
- Who owns the data? Will DND have ultimate authority?

Team 109 - Reporter: Martin/Nicolai

- Definition of feedbacks and spatial boundaries
- Data collection to train the models - what data is available? Build around what exists or what is possible to collect?
- Process and Storage of Data
- Start simple and attempt to show early success - addressed or targeted towards the larger feedbacks (Economy / Energy / Education)
- Will we be empowered by the exponential change of technology? How can a digital twin influence the direction?
- Fraser Delta could be a good starting point - but it is also a complex system. How do we connect the modules? Juan de Fuca Strait also an area of interest - focal point of various modules

Team 135 - Reporter: Maia/Daniela

- Appreciated the perspective of what a digital twin is - system of systems - it is more than just modelling and recognition of the large potential the real-time aspect brings to decision-making
- Identify issues we need to address/imagine who the users/customers are
- Ensure that Indigenous Nations are at the table in all discussions
- Collection of clouds, should there be a mother cloud, should that be ClOOS?
- Build on existing physical models with real-time tidal flow, these could be synced with real-time events and inform for example tsunami models better
- Watersheds are really important and new ways to model them should be incorporated

Additions from Breakout Whiteboards

- Governance agreement (use Wikipedia model)
- Scale, how granular? Start big
- Cross border working group
- Visualization
- Cost estimate, then funding
- Focus on the most mature (and open) models

Theme 2: Large Scale System and Changes

Theme 2 Presentations

Richard Dewey (Former ONC Associate Director, Science; UVic Adjunct Prof.): *Two decades of second-by-second State of the Ocean monitoring with VENUS*
Recording | *Slides*

- Shared the history of VENUS from proposal stage to observing Salish Sea changes at all time scales: minutes, hours, days, months, years
- Data clearly track El Nino warming, La Nina cooling, extreme events like the 2014-2015 "warm blob", seasonal salinity and oxygen changes, diurnal zooplankton migration, Fraser River fresh water inputs with ferry data, fine structure surface currents from radar data
- Showed Community Fishers program example, with some locations having up to 100 CTD profiles gathered through community efforts
- Concluded that 19 Years may still be too short to detect climate signals

Rich Pawlowicz (Professor, UBC): *Circulation processes in the Salish Sea*
Recording | *Slides*

- Addressed current science questions and what monitoring is needed, both now and over the next 15 years possibilities
    - Despite many research questions being addressed and monitored by ONC, many more questions and processes are not captured
- Suggestions for expansion:
    - HF radar, ferry systems (in the Northern Salish Sea), weather stations, profiling moorings, ADCP moorings, BBL node deployments
- Suggested new monitoring systems:
    - Aerial drones, river moorings, acoustic tomography, Iona node, northern Strait of Georgia nodes, Juan de Fuca bottom node, Juan de Fuca bottom pressure array, Distributed Temperature Sensing cable, short vertical density moorings, flow-through system at Race Rocks, Drifter program
- Identified the biggest monitoring gaps in Juan de Fuca Strait, Haro and Rosario Straits, and most Inlets
- Concluded that towards the Digital Twin idea we need “Operational Nowcast models” everywhere

Jennifer Jackson (Research Scientist at IOS/DFO): *An overview of DFO's Salish Sea Biophysical and Shore station data programs from 1914 to present*

- Introduced DFO’s Salish Sea Biophysical Program, active since 1999 in its current form (using data from since 1930), conducting 3-4 cruises per year, collecting physical, chemical, biological, and more (participation welcome)
    - Two stations added as suggested by ONC: Saanich Inlet and Baynes Sound
- Long-term station data show climate change warming and freshening signals
- Introduced DFO's Shore Station Program with hand-held instrument measurements by lighthouse keepers and helpers (incl. prisoners for Race Rocks sampling), with 4 Salish Sea stations, the oldest since 1910 of near-daily measurements
- Again clear warming trend as well as apparent freshening, winters not cooling down much anymore

Jody Klymak (Professor, UVic): *Water column observations to better constrain overturning circulations* *Recording* | *Slides*

- Using existing data and models, showed how dense Pacific water enters into Juan de Fuca Strait but does not progress much past Victoria sill. Transport is driven by ocean, river, wind and mixing processes.
- Concluded that Haro Strait mixing processes are the least understood, and more data and better modelling are required.
- Suggested more profiling moorings through Juan de Fuca, Haro and Strait of Georgia that can provide residence time budgets, upper ocean dynamics in each basin and better contain the models
    - Good: At least 4 profiling moorings (~$3.6M)
    - Better: Additional 2 High Frequency ADCP moorings (Victoria and Boundary Pass) on sills (~$1.2M)

Theme 2 Breakout Slides

Question1: What are some high impact research **topics** within this theme?

Team 101 - Reporter: Richard/Maia

- **Deep water renewal** is a fundamental process that keeps the Salish Sea healthy. The massive exchange happens not only at depth but throughout intermediate depths. Additional measurements may be useful.
- **Sediment transport** is an important process in numerous parts of SoG (Fraser River, Puget Sound, Skagit, Squamish, etc.). Understanding the connections between the terrestrial and marine via rivers is essential.
- Climate-related effects and **extreme events** (warming, acidification, deoxygenation, heat domes, landslides) are essential to be able to monitor and report on.
- **Fluxes in and out of SoG** can be better constrained by using Johnstone Strait and JDF as our laboratories.
- It is imperative that these be better sampled.
- **Salinity changes** (related to sediment transport via the river connections) need to be better measured and understood.

Team BOR114 - Reporter: MartinS/Jesse

- Large scale mass exchange between NEP and Salish Sea, including reflux
- Tsunami modeling: interactions with tidal currents
- Climate Change
    - Emerging marine stressors: Ocean Acidification, warming, HABs and O2 Dynamics
- Food Security
- (Brought up during discussion:)
    - Surface processes (winds, waves, tidal rips) most relevant for society
    - Atmospheric processes

Question 2: What do the ideal Salish Sea observing infrastructure and **monitoring** programs look like to support these topics?

Team 101 - Reporter: Richard/Maia

- **Measurement** suggestions: sediment transport, 3 frequency echosounders
- **Technology** suggestions: vehicles powered by platforms, autonomous profiling first, lithium battery-powered ships, numerical simulations / ML to extrapolate hard-to-measure variables
- **Strategy** suggestions: go autonomous first, importance of cross-border collaboration, fill gaps by handing off to our First Nations partners

Team BOR114 - Reporter: MartinS/Jesse

- Profilers: Current dependant, using monopiles; need to prioritise sensors
- Create a physical model of the Salish Sea to allow more accurate tsunami modeling (similar to Digital Twin) using real-time instruments (ADCPs, BPRs, WERA, CODAR etc.)
- DAS
- GNNS for Atmospheric River monitoring, and usable as tide gauge
- Marine stressor detection
    - Distributed measurements vs point measurements
    - Community Fishers with CTD casts, O2, turbidity, nutrients, more stable carbon sensors

Additions from Breakout Whiteboards

- Autonomous surface moorings with weather stations and profiling water column measurements

Theme 3: Biological Systems and Ecosystem Health

Theme 3 Presentations

Akash Sastri (IOS, DFO, and Adjust Professor at the Department of Biology, UVic): *Monitoring plankton productivity and diversity in the Salish Sea*
Slides

- Introduced the DFO Pacific Plankton Time Series for monitoring the base of the food web with ship-based water sampling at specific locations (stations) measuring phytoplankton pigments, nutrients, salinity dissolved oxygen, and phytoplankton and zooplankton taxonomy
    - Strait of Georgia's time series data are statistically robust since 1995
- Showed the data converted to biomass annual anomalies, tracking productivity
- Mentioned modelling of early marine survival of juvenile salmon, and phytoplankton indicators of productivity and occurrence of Harmful Algal Blooms
- Also mentioned Zooplankton and Phytoplankton imagery (since 2022), though archiving and working with imagery s a challenge for DFO (perhaps ONC can help)
- Highlighted the support from ONC-BC Ferries monitoring in the SoG East and Central platforms
- Sees huge potential to combine ONC echo sounder data with imaging profiles (more to come from Stephane Gauthier later this session)

Vera Pospelova (University of Minnesota Twin Cities): *What we have learned from our studies of dinoflagellates, their cysts, and biogenic silica content in sediment traps*
Slides

- Studies long-term and high-resolution time series data of phytoplankton from sediment traps, with a specific focus on dinoflagellates (including species responsible for harmful algal blooms), and provides valuable insights into their complex life cycles and ecology
- This information is essential for reconstructing past biodiversity and environmental conditions, such as primary productivity, sea surface temperature, and salinity. It aids in predicting future changes in primary producers as a result of climate change
- Studies them with microscopy and DNA analyses
- Mentioned that sediment traps are ideal for sampling them, ideally with physical parameters
- Highlighted that on cabled networks, rotating bottles can be controlled, reacting to events
- Concluded that the abundance is controlled by changing environmental conditions, but also needs to consider the source of trapped material, it could come through nearby rivers

Meghan Tomlin and Steven Henry Jr. (Malahat Nation): *Tides and Teachings - Continuous care and renewal at the Salish Sea clam garden*
Recording | *Slides*

- Opened with introducing W̱SÁNEĆ Nations, also known as "Saltwater people", who have been stewarding clam gardens in this region for thousands of years
- Stressed that clams are important for ocean health
- Introduced their thriving legacy clam garden, behind 2-4 m wide boulder wall, which they keep working on during community events, and they are trying to bring back lost species from other areas
- Applying two-eyed seeing approach, combining Traditional Knowledge and Western Science
- Conducting drone imagery and intertidal surveys using DFO's intertidal biodiversity protocol
- Showed how beach closures from contamination often prevent harvesting
- Working with many government agencies (DFO, CFIA, ECCC) to better understand sources of chemical and biological contamination, perhaps to predict closures
- Concluded that First Nations need adequate data to harvest safe traditional foods from the Salish Sea

Stephane Gauthier (DFO): *Active acoustics monitoring in the Salish Sea: Pacific have, Pacific herring, euphausiids, and everything in between*
Slides

- Introduced acoustic surveys with focus on Strait of Georgia and surrounding inlets, going every year just before spring bloom
- Seeing Pacific hake spawning, layers of young hake, Walleye pollock spawning, Pacific herring, mesopelagic species, mapping different species and their ages
- Concluded that they only have snapshot in time (once a year), but echo sounder data from ONC can help fill the gaps

Theme 3 Breakout Slides

Question1: What are some high impact research **topics** within this theme?

Team - ROOMs 109+201+virtual135 - Reporter: Kohen/Vera/Fabio/Daniela/Herminio/Lynn

- Phytoplankton + zooplankton biomass and rates measurements
- Coupling phyto-zooplankton
- Food security and resource access - fast response for toxic algal species, ocean acidification monitoring
- Fish population fluxes
- Mechanistic drivers of biological change across different spatio temporal scales

Question 2: What do the ideal Salish Sea observing infrastructure and **monitoring** programs look like to support these topics?

Team - ROOMs 109+201+virtual135 - Reporter: Kohen/Vera/Fabio/Daniela/Herminio/Lynn

- Sediment traps in key location
- Phytoplankton biomass and rates measurements with new sensors - e.g. on ferry flow through
- eDNA
- Consultation with local fisherman and First Nations partners
- Developing new technologies using the BPS, or other nearby easy to access observatory systems
- FlowCytobot (top end) - imaging of phytoplankton - link to red tides
    - Machine learning approach for a classification could be used as an early warning threshold
- AZFP
- Leveraging the VENUS network for short-term process-based studies

Additions from Breakout Whiteboard

- Sediment traps with sensors for primary productivity

Theme 4: Biogeochemistry in the Salish Sea

Theme 4 Presentations

Kohen Bauer (Science Director, ONC): *Integrating Planetary Boundaries thinking into the future of Salish Sea observing systems*
Recording | *Slides*

- Humanity is exceeding six of nine planetary boundaries, highlighting a need for tools to analyze the integrated Earth system reliably.
- The planetary boundaries framework defines a safe operating space for humanity by identifying nine critical Earth system processes and setting quantitative limits.
- The ocean is central to many planetary boundaries, and ocean observing systems are vital tools for tracking planetary health and informing policy.
- Applying the planetary boundaries framework to ocean observing helps manage Earth's systems sustainably for future generations.

Roberta Hamme (Professor, SEOS Department, University of Victoria): *Drivers of biogeochemical changes in deep Saanich Inlet*
Recording | *Slides*

- Deep Saanich Inlet is largely anoxic due to a shallow sill separating it from the Salish Sea, restricting new oxygen-rich water from entering.
- Continuous data from moorings provides important context for ship-based data and helps explain biogeochemical changes, such as step-like density increases indicating new water entering.
- High-frequency data (e.g. profiling mooring + benthic moorings) is crucial for understanding complex dynamics, providing context for observations, and revealing evidence of driving processes in the Saanich Inlet's water column.

Wiley Evans (Lead Oceanographer, Hakai Institute): *Hakai Institute's Marine CO2 Studies in the Northern Salish Sea*
Recording | *Slides*

- Hakai Institute's Marine CO2 Studies in the Northern Salish Sea aim to understand how the marine CO2 system varies from event to inter-annual timescales and what drives these variations.
- Current observing sites include continuous CO2 observing at the Quadra Island Field Station and in Johnstone Strait, and bi-weekly observing at oceanographic station QU39 (North SoG).
- New CO2 observing in Bute Inlet (monthly surveys and surface mooring) is focused on interplay between marine stressors and how habitat quality is impacted.
- Opportunities for impactful biogeochemical research include cross-strait surface variability resolved by the Comox/Powell River ferry, surface buoys with instrumented tethers in Haro Strait and Sabine Channel, and a data platform to synthesize observing data from various agencies in the Strait of Georgia.

Maycira Costa (Professor, Geography Department, University of Victoria): *Phytoplankton bloom time and groups: interannual variability from Sentinel 3 satellite and ferry-based reflectance data*
Recording | *Slides*

- Key uses of the ONC ferry data include developing the Sentinel 3 algaeexplorer.ca for chlorophyll-a (Chla) and total suspended matter (TSM), identifying Phytoplankton Functional Types (PFTs) including Harmful Algal Blooms (HABs), and understanding bloom development.
- The research is also focused on applying data for bioregionalization and quantifying dynamics of the BC coast, linking phytoplankton phenology to zooplankton abundance and salmon health, and studying kelp loss in the Salish Sea.
- ONC's research support could include ferry-based to in-situ hyperspectral data for upcoming satellite missions (PACE, SBG, CHIME) and a data portal beyond algae explorer, providing satellite-derived information on phytoplankton groups, blooms, HABs, turbidity, CDOM, and sea surface temperature. Additional coupled in-situ and satellite informed data products?

Theme 4 Breakout Slides

Question1: What are some high impact research **topics** within this theme?

Team Rm 109 - Reporter: Kohen, Daniela, Steve

- Multi-stressors have to be considered together
- Exchange flows in Juan de Fuca Strait (how, what, when)
- Understanding extreme events and their emergence, natural variability
- Determining standards for data streams for BGC measurements
- BGC Argo
- (During discussion:)
    - Integration with satellite observations, other spatial observations, and modelling

Team Virtual - Reporter: Jesse, Polina, Herminio

- Phytoplankton composition, harmful algae bloom identification, Imaging FlowCytoBot, remote sensing)
- ~~Development a trustful method for underway PCO2 (think about how to do that) - carbonate system~~ [Note from post-workshop feedback: such trusted methods actually exist, so the emphasis is on ONC to use them. Revised statement:] Utilizing robust and standardized underway pCO2 measurements to help observe carbonate system

Additions from Breakout Whiteboards

- Hypoxia, O2 variability
- Marine Carbon Dioxide Removal (mCDR)

Question 2: What do the ideal Salish Sea observing infrastructure and **monitoring** programs look like to support these topics?

Team Rm 109 - Reporter: Kohen, Daniela, Steve

- Integrating community observations
- Vertical profiling and water column measurements,
- Consider ferry data for BGC to increase spatial coverage
    - (During discussion:)
        - Add hyperspectral sensors for correlation with satellite data
- Collection of physical water samples

Team Virtual - Reporter: Jesse, Polina, Herminio

- Increase coverage of reflectance measurements (Comox vessel could be a start point), other vessels opportunities (e.g. the clipper and blackball)
- Moorings
- It would be good to have an observatory in Sabine Channel

Question 3: What specific **infrastructure** (physical and/or digital) and time-series (existing and/or future) are valuable for supporting this research?

Team Rm 109 - Reporter: Kohen, Daniela, Steve

- Offer of collaboration from various participants to implement some of the monitoring solutions

Team Virtual - Reporter: Jesse, Polina, Herminio

- Profiling system maybe difficult to implement in Haro Strait due to fast currents, tethered system with multiple instruments might be better
- Challenges when estimating uncertainty (PCO2 and pH)

Theme 5: Coastal Management, Soundscapes & Traffic

Theme 5 Presentations

Lorne Underwood (W̱SÁNEĆ Nation Elder, Tsawout Village)

- Gave a personal introduction to his upbringing and the immense challenges that Indigenous people were forced to face
- Turned the focus on capacity building within First Nations, for example with the Salish Sea Initiative Funding 5 years ago, which is running out but should not
- Mentioned fruitful exchanges with John Harper and Brian Bornhold, e.g. how First Nations' centuries old knowledge on flooding events were only recently "newly" discovered by western sciences
- Asked how we can learn from each other, help each other, beyond collaborations, and offered to help putting research into action, establish opportunities

Shahin Dashtgard (Earth Science Professor, SFU)

- Looked at the Fraser River Delta over timescales of thousands and tens to thousands of years, with the delta growing through river sediment input being larger that the power in waves and tides to erode the system
- Presented lidar profiles showing Boundary Bay erosion larger than elsewhere over last 4000 years due to closure of tidal channel between Point Roberts and the delta; accompanied by marsh back-step of ~1500 m
- Explained how future sediment management planning includes building living dykes and doing sediment enhancements with sediment being dredged from shipping lanes
- Concluded that natural defence against erosion is hampered, a sediment management plan needed, and that ONC can help monitoring

Harvy Takhar (Manager of Drainage and Natural Hazards, City of Delta)

- Mentioned how he grew up around Delta, a city surrounded by three seas: Salish Sea east, Boundary Bay west, and Fraser River north
- Mentioned that over half of Delta is vulnerable to inundation, primarily from storm surges during King Tides, spring freshet and atmospheric river events
- Explained that a series of dykes are threatened by sea level rise and coastal squeeze, and that simply raising dykes is challenging
- Have pumping system but risk of being overwhelmed
- Flood protection infrastructure complex, more diligent with development now than before

- Needs $2B for just following guidelines

Kees Lokman (Associate Professor, UBC Coastal Adaptation Lab)

- Explained his work on Living with Water initiative and SSEDS (Sustainable Ecosystem Enhancement with Dredged Sediments), with several First Nations, municipalities and government; bringing experts together
- Centers community knowledge and global precedents to guide beneficial reuse, coordinating sediments, and works on how to communicate different concepts
- Showed examples of Living Foreshore (Living Dykes) test at Boundary Bay, Sturgeon Banks sediment enhancements through sediment pipeline outfalls and barges, creating barrier islands, and Dyke Setback that forms new habitat between dykes, new aquaculture systems, and Indigenous ways like clam gardens
- Explained that ONC can do long term monitoring of coastal change, sediment dynamics, ecosystem response; high-res realtime data to inform adaptive management of these nature-based solutions; tools to evaluate performance of sediment-based hybrid interventions over time; platform for collaboration that integrates Indigenous knowledge and scientific data

Theme 5 Breakout Slides

Question1: What are some high impact research **topics** within this theme?

Team Rm 101 - Reporter: Phil, Martin S, Lanfranco

- Coastal erosion and subsiding (geohazards)
- Shipping:
    - Wakes contribute to erosion
    - Noise
    - (From discussion:)
        - Integration of AIS data
        - Quiet vessel initiative (Ocean Protection Plan))
- Increase monitoring of ambient noise and its environmental impact (mammals, crustaceans, fish, even plants) - need regulations and laws
- Improve modelling of sound propagation

Team Virtual - Reporter: Gwyn, Reza, Lynn (also rm 135)

- SRKW/non-AIS vessel acoustic presence
- Changing soundscape (recreational and other noise sources)
- Delta stability
- New port, monitoring needs
- Offset areas (eel grass, biofilms)
- Natural hazards (tsunamis, storm surge)

Additions from Breakout Whiteboard

- Sea level rise
- Coastal hardening
- Contaminants, non-point source pollution
- Nature-based solutions (Nbs) on stabilizing shorelines

- Fraser sediment study, sediment transport distances, impacts, dredge re-use

Question 2: What do the ideal Salish Sea observing infrastructure and **monitoring** programs look like to support these topics?

Team Rm 101 - Reporter: Phil, Martin S, Lanfranco

- Hydrophones to monitor shipping noise and mammals. Digital twin can extend to sound propagation and help traffic decision making
- Sound speed profiles over water column
- Coastal erosion -
    - Fraser delta - Monitoring sediment transport (esp. from the river to the sea) - package of instruments along delta front
    - Communities - Monitoring shoreline erosion (LIDAR, photography) for planning and post solution

Team Virtual - Reporter: Gwyn, Reza, Lynn (also rm 135)

- Identifying geographical data gaps for hydrophones to monitor killer whale presence and alerts, and also to create accurate changing noisescape maps
- Need a better understanding of noise thresholds (especially the impact of non-AIS vessels) and how we can manage the increased noise contributions moving forward. Small vessels and whale behaviour.
- Develop increased monitoring for long term temperature/salinity data to better understand sound propagation and improve ambient noise models
- Design a sensor network around the new terminal being built at RBT2
- Salish SeaCast, can ocean networks improve that model product
- Instrumentalize some of the sediment enhancement and living dyke projects already in progress
- Early warning tsunami systems - Bottom-pressure sensors should be installed to monitor tsunami and tidal impacts

Additions from Breakout Whiteboard

- Sediment transport data and modelling to help sediment management (primarily Fraser River; collaboration with SFU, Delta, UFRPA)
- Community support and Indigenous-led programs
- Monitoring protocols and digestible data management
- Coastal stations to inform erosion risk; whether areas are accreting → community makes decisions of whether restoration occurs & how

Theme 6: Physical and digital infrastructure and innovation

Theme 6 Presentations

Ben Skinner (GIS Specialist, Pacific Salmon Foundation): *Marine Data Centre*
Recording | *Slides*

- Introduced PSF as a centre for understanding salmon survival in the Salish Sea, looking at ecological, oceanographic and human factors

- Offering open access data (hosted at UBC), accessible in map form, including Oceanographic Conditions Atlas, with 1500+ datasets from 200+ organizations, 1.4+ million data rows since 2015
- Currently have 7 patrols (vessels), 55 stations, 11 long-standing Citizen Scientists (volunteers)
- Showed marine ecosystem map example with salmon spawning streams and eel grass, used to predict salmon locations
- Q&A suggestion to combine PSF near-shore shallow data with NRCan's deeper mapping data

Brad De Young (Exec Director of CIOOS Pacific): *CIOOS Pacific - Expanding west coast ocean data and information*
Recording | *Slides*

- Introduced CIOOS as the Canadian national program initiative with regional associations at Pacific, Atlantic and Gulf of St Lawrence, with many partners, primarily funded by DFO and MEOPAR
    - Pacific office operating since 2019, initially with Hakai, now working to reorganize
- Primary function is hosting metadata to point to existing data archives, but also plan to directly support data, e.g. west coast ocean acidification data
- Announced new partnerships, in addition to ocean acidification also with Bamfield Marine Science Centre (BMSC) and PSF
- Mentioned that in addition to data services, they are also starting information services, e.g. Ocean Connect App for ocean/boat users with the Salish Sea model data, which is now maintained by Hakai
- Welcomed feedback on extending to other information services

Jan Newton (NANOOS and UW): *NANOOS Observing System and science observations from it*
Recording | *Slides*

- Introduced NANOOS as one of 11 U.S. regional associations under the NOAA-funded Integrated Ocean Observing System (IOOS) national-regional partnership program for new tools and forecasts to improve safety, enhance the economy and protect health, providing an integrated information system in near real time
    - Built since 2003 from identifying user/societal needs, determining system requirements, operating long-term observation and forecast systems, co-designing data tools and information products; focused on leveraging and linking, and also partners with/links to OOI and ONC (though ONC links currently broken!) and many more
    - NANOOS portal allows to compare models with data
    - Buoys one focus area (currently funded to enhance buoys, and also running Backyard Buoys program, similar to ONC's Community Fishers but for wave data)
- Showed science highlights (documenting recent warming, increased salinity, anoxic conditions)
- Suggested that future observing infrastructure and ocean monitoring in the Salish Sea should fill existing gaps (e.g. HF Radar)
- Q&A: Only 2 years of data? Yes, NANOOS mostly meant for near real-time, but links to ERDDAP for full raw data
- Need to fix broken links to ONC (and maybe add more ONC assets)

Jean-Philippe Juteau (Rockland Scientific): *Turbulence measurements in British Columbia* Recording | Slides

- Introduced Rockland Scientific as an instrument manufacturer headquartered in Victoria, offices in Halifax, Seattle and Marseille, about 30 people, specialized in microstructure and turbulence instrumentation for oceanography and limnology since 2005
- Explained turbulence as the dominant mechanism for ocean mixing, and Salish Sea turbulence data go back to 1950s
- Mentioned that ONC has profiling floats with Rockland sensors; they are doing glider measurements in Saanich Inlet with UVic, and also did measurements in Haro Strait
- Suggested that, as data Rockland are often lost/deleted after collection and initial analysis, maybe ONC could help archive

Randy LeVeque (Prof. Emeritus in Applied Maths at University of Washington): *Tsunami forecasting in the Salish Sea using Machine Learning*
Recording | Slides

- Promoted that an ocean bottom sensor in the Strait of Juan de Fuca or other direct tsunami observation entering the Salish Sea through the Strait could be very useful for creating accurate tsunami warnings in the Salish Sea
- Showed that tsunami waves through the Strait travelling as perfect plane wave, easy and with plenty of time to model/forecast, and only 30 min, better 60 min of measured data allows for accurate Salish Sea tsunami forecasting

Jeffrey Harris (Researcher and Associate Professor, Institute Polytechnique de Paris, France): *Towards a Digital Twin of the Salish Sea*
Recording | Slides

- Explained the idea to combine existing data with Machine Learning and modelling (data simulation), and interest to inverse the problem, to get spatial distribution of parameters
- Showed use case example for a Salish Sea Digital Twin
    - Storm surge prediction in Victoria, combing surge, tide, pressure, wind; after machine training, approximate solutions can be run simply on a laptop or web page
    - Temperature and salinity predictions for SoG Central and East from using just currents after training with existing data
        - Might be a simpler, smaller way of getting NOAA forecasting data (which are 0.5 Gb per time stamp in the Salish Sea)
    - Actual sea level prediction for Victoria Harbour using HF radar data from Juan de Fuca Strait
- Mentioned that they are preparing a Digital Twin session at the WCCM 2026 conference in Germany in 2026, and that there are interesting Horizon Europe proposal calls that fit this theme

Oliver Kirsebom (Senior Data Scientist at Open Ocean Robotics): *New opportunities for data collection and environmental monitoring in the Salish Sea*
Recording | Slides

- Introduced Open Ocean Robotics, founded in 2018, has 25 people working there, headquartered in Victoria, and featuring Uncrewed Surface Vehicles (USVs) supporting data acquisition

- Described USVs, size of standup paddle board, solar powered (300 W in a sunny day), self-uprighting, very shallow water capabilities, easily deployed, uses cameras and AIS for situational awareness, currently cell phone but soon satellite communication
- Showed how mission planning works with simple portal that also allows single person to operate the vessel from shore
- Showed examples on eDNA survey for eel grass restoration, marine mammal monitoring with realtime hydrophone detection, and ocean carbon dioxide removal support
- Highlighted that USV capable of running autonomous profiling casts using a 100-m winch

Theme 6 Breakout Slides

Question1: What are some high impact research **topics** within this theme?

Team Rm 201 - Reporter: Maia, Ian, Drew, Benoît

- Water column observation
- Data processing
- Coordination amongst engineers in different organizations

Question 2: What do the ideal Salish Sea observing infrastructure and **monitoring** programs look like to support these topics?

Team Rm 201 - Reporter: Maia, Ian, Drew, Benoît

- Profilers, DTS (but maybe not), Bottom Pressure
- Not everything needs to be real-time
    - (During discussion:)
        - Or not everything needs to be cabled (real-time helps, but could be done remotely)
- Setting priorities (how?) / Anything we can remove?

Question 3: What specific **infrastructure** (physical and/or digital) and time-series (existing and/or future) are valuable for supporting this research?

Team Rm 201 - Reporter: Maia, Ian, Drew, Benoît

- Data types (HDF)
- Contribution of observation data to predictive models

Question 4: Do you have any other **advice** for ONC related to this theme? Or where do you see the needs/gaps, something that wasn't brought up so far?

Team Rm 201 - Reporter: Maia, Ian, Drew, Benoît

- Make "people-ready" data sets (low latency data — compute close by)
- (During discussion:)
    - Don't miss out on AI

Day 3 Visioning Survey Response

Here's a **condensed synthesis** of the main ideas people found most exciting in the workshop, grouped by theme.

1. Digital Twin & Integrated Modelling

- Broad enthusiasm for developing a **Salish Sea Digital Twin** that integrates physical, biogeochemical, and ecological data for real-time prediction, scenario testing, and decision support.
- Use of **machine learning, modelling, and satellite integration** to enhance predictive capability and connect data streams across scales.
- Interest in **modular, "siloed" starts**—beginning with focused components that can grow into a comprehensive system.

2. Expanded and Innovative Observations

- Excitement about **autonomous and relocatable platforms**, vertical profilers, and new moorings (especially in **Juan de Fuca Strait** and deep-water renewal zones).
- Calls to maintain and expand **time-series and cross-border observations**, with increased spatial coverage through **ferries, Argo floats, and community observing programs**.
- Support for **standardized methods, metadata, and best practices** to ensure interoperability of diverse data streams.

3. ONC's Leadership and Collaboration Role

- Recognition of ONC's potential to **convene a transboundary community**—including **First Nations, U.S. partners, researchers, and agencies**—to coordinate observing, modelling, and stewardship efforts.
- Interest in **shared infrastructure** such as an instrument bank or sensor test bed, and in ONC's role in **data management leadership** (e.g., CIOOS improvements, open data tools).

4. Focus on Key Processes and Regional Challenges

- Strong interest in studying **sediment transport**, **Fraser River inputs**, **coastal erosion**, and **deep-water renewal** as foundational system processes.
- Emphasis on **climate change impacts** (warming, deoxygenation, acidification) and on **food security**, particularly for Indigenous and coastal communities.
- Attention to **marine traffic, soundscapes, and wake effects** as emerging management priorities.

5. Collaboration, Community & Societal Relevance

- Widespread excitement about **collaborative, community-based science** linking research, technology, and local knowledge.
- Recognition that the Salish Sea is a **living laboratory** for global coastal issues—an ideal testbed for innovation, monitoring, and climate resilience strategies.

Q: What are the 3 ideas you heard in the workshop that you are most excited about?
ONC start operating a Salish Sea model assimilating ONC data, alongside other data; Oceans 3.0 extensions to include a data explorer with layers to show satellite data and model output along with observational data; ONC assuming a leadership role in convening the broader trans-border Salish Sea observing/prediction/stewardship community, including First Nations from all around the Salish Sea.
Juan de Fuca Node Salish Sea ARGO modelling Coastline monitoring
New modes of observations, additional measurements of wider Salish Sea areas, replacing infrastructure for continued time-series observations showing climate-changes in system.
Short term: potential new moorings near deep water renewal areas. Long term: development of an unprecedented observing system
1) Starting a Digital Twin with focused silos: The idea of beginning with clearly defined silos that have a specific purpose, knowing who the end user is and who holds responsibility for each silo. From there, allowing the silos to grow organically as the system matures makes a lot of sense. 2) Expanding autonomous monitoring and cross-border observation: The idea of autonomous moorings in several locations, especially in cross-border areas—such as in the Juan de Fuca Strait—is valuable in understanding the budgets 3) Integrating BGC and physical data with user needs in mind. In particular, the recognition that BGC measurements need to be complemented by physical data—such as currents—and that physical understanding requires a spatial array of stations, is crucial to create usable datasets.
1. Standardized formats, metadata, and best practices when discussing digital twins and relating/aggregating various datasets from various disciplines. 2. Emphasis/push for more profiling instrumentation. ONC has developed/developing much better support for cast/profile data and would be great to expand to more moorings. 3. Reorganization and improvements to CIOOS, increase variety of dataset support as well as increase data support services and tools
ONC responding to increases in marine shipping monitoring, increased emphasis on First Nations collaborations, help with data management best practices.
1. I like the idea of continuing to collaborate in the future 2. Planetary boundaries 3. Fraser River sediment and impact on the Salish Sea
That more direct observations of flow in the Strait of Juan de Fuca could be useful for many purposes, and may be possible. The MEOPAR model, which I wasn't familiar with. The Backyard Buoys project.
Digital twin development for the regional ocean Additional sensor placement to get data throughout the water column Renewable energy development in the Salish Sea
phytoplankton growth rate monitoring (especially helping to support food security for Indigenous communities and traditional harvests); sediment movement monitoring and coastal currents in the Salish Sea (and how this can help identify areas of erosion/accretion; and, ultimately, restoration potential); possibility to study wakes from shipping/cruises and speed of sound profiles related to impacts on various coastal species.
ONC as a facilitator of community models leading to digital twins; focus on sediment transport from Fraser River to offshore depocentres; coastal observatory to serve community needs.
1) Enhancing and expanding water column time series measurements throughout the SS, from JdF to JS. 2) work towards components and systems (physical and digital) that will be strong elements of a SS Digital Twin.

3) strengthen and integrate the distributed community observing programs into the whole coastal system. At the moment they seem to be a collection of new silos, not integrated.
Extension and Continuation of continuous monitoring in the Salish Sea; Continuity of measurement methods and equipment to allow comparison between sites; Extension to Juan de Fuca (particularly on the Eastern Edge) with real time monitoring
collaboration. ocean circulation/biodiversity/biogeochemical change. digital twins
In the workshop, I was particularly excited about the development of a Digital Twin for the Salish Sea, which offers a powerful real-time virtual model to simulate scenarios and support decision-making. The use of machine learning to analyze complex oceanographic data and enhance predictive modeling also stood out as a cutting-edge approach. Additionally, the focus on sediment transport and coastal erosion research highlights the importance of understanding these processes for effective coastal management. Throughout, it was clear that continuous monitoring is considered a fundamental part of the project, providing essential data to inform both models and management strategies. I was also reminded that collaboration is key to the success of all these efforts.
1) sediment transport study in the Fraser, understanding DAS practices and their impacts on the Fraser Estuary and Salish Sea, the need to study NbS projects with real time data collection 2) big data collection on the Fraser and coastal regions including repeat surveys of LiDAR, bathymetry to understand erosion and deposition taking place 3) understanding the data that is missing such as AIS vessel tracking - push for regulatory change so that certain information becomes mandatory for vessels to display. ONC could get more involved in lobbying activities to push for these important changes.
ONC sensor test bed, digital twin, fast response sensors
More water column measurements; better integration and feedback to inform ocean prediction systems; more flexible and lighter weight nodes that may be relocatable - cables have use for some applications, but have a large cost.
1) Digital Twin idea (or at least some approximation) is good. 2) The idea of an 'instrument bank' for researchers (or at least the possibility of requesting to use on-the-shelf equipment) in some way that doesn't feel 'under-the-table'. 3) The idea of monitoring the JdF inflows.
1. Expand physical and biogeochemical observing in the Salish Sea with vertical profiling in key regions (water column) and underway ferry work (surface and air-sea flux). 2. A comprehensive observing system does and should involve more than just ONC (for example remote sensing and numerical modelling and ship-based sampling to some extent naturally lie with others). ONC is needed to not just provide autonomous observations, data products, and asset sharing but to also convene scientists, communities, and organizations to collaborate and to pitch the vision at higher levels. 3. The Salish Sea is an important regional natural laboratory for global impact, a place where hot, low oxygen, high acidity events are happening, where long-term climate monitoring is needed, where numerical prediction on many spatial and temporal scales is needed. Techniques and science questions addressed in this region demonstrate best practices for other urban sea systems.
General acceptance of the Digital Twins concept, development of working groups, initiation of a simple digital twin system
Finally instrumenting JdF, paradigm shift to using autonomous platforms, establishing a coherent view of studying the Salish Sea among the res. bodies, i.e. DFO, Univ., Hakai, NOAA, Nanoos and ONC by using ONC convening ability and influence.
full water column and near surface air column sampling with multi sensors - community engagement and societal communication for both remote communities and "urban sea" population - improving vessel time for data and AI model validation through "in situ" observation
BELOW: From breakout notes (not from survey)
Long-term monitoring and data handling of coastal protection, restoration, sediment enhancement, + living dykes projects

Safe, reliable tidal power at Salish Sea border and Northern passages. Assessment & Monitoring. Test bed for tidal energy technologies.

Next Generation Salish Sea Observing System

We asked participants to complete the sentence, “The next-generation Salish Sea observing system will…” Here is a synthesis of their responses.

The next-generation Salish Sea observing system will be a **comprehensive, collaborative, and transformative platform** that unites real-time observation, advanced modeling, and community engagement to protect and understand the Salish Sea as a living, interconnected system.

It will:

- **Integrate real-time 3D measurements** across the full water column (physical, biogeochemical, and biological variables) at unprecedented resolution and frequency.
- **Power a Salish Sea Digital Twin**—a dynamic, data-assimilative model linking observations, forecasts, and decision tools for communities, researchers, and policymakers.
- **Leverage AI, automation, and autonomous platforms** (moorings, profilers, sensors, ferries, and buoys) to extend spatial and temporal coverage.
- **Serve communities and Indigenous Nations**, supporting stewardship, resilience to sea level rise, and responses to marine shipping, pollution, and climate change.
- **Foster transboundary collaboration** among ONC, DFO, NOAA, Hakai, universities, ECCC, and First Nations, sharing standards, data, and infrastructure.
- **Act as a testbed and exemplar** for next-generation coastal observing and Digital Twin systems globally—an “urban sea” model for innovation, sustainability, and equity.

Q2: The next generation Salish Sea ocean observing system will....
help communities monitor conditions, answer questions and make decisions that really matter to them.
...enable to feed a Digital Twin of the Urban Sea System for a safe, sustainable and fair future for all life.
be more encompassing of areas impacting people and climate.
measure the entire 3D Salish Sea (T,S,U,V,O2,N2,CO2,Chl,turbidity,.....) at an unprecedented resolution (100m? 10m?) and at an unprecedented repeat cycle (one week? one day?). The point is to make the next generation system a paradigm shift in observing in comparison to the existing systems. This is in contrast to incremental growth of the observing network, which amounts to "more of the same". Examples of prior paradigm shifts in global observing include the ARGO program, and the satellite era (which continues to deliver paradigm shifts -- SWOT is a major leap over previous satellites -- we can now see the submesoscale). While a global paradigm shift is out of reach here, the Salish Sea is a much more manageable size and developing the unprecedented observing system here would amount to a test bed to export to other regions in Canada or internationally. This is a broad, grand vision! More of the same is not a grand vision, it's an extrapolation of the existing Strategic Plan. Perhaps the 15-year vision should be structured as a "continuing excellence" part that handles the incremental buildout, and a visionary part that aims to realize the next generation paradigm shift in ocean observing. The potential of such a system would be vast; it would yield tremendous situational awareness in ocean conditions, supercharge data-assimilative forecast models and feed into a potential digital twin system, and dozens of more things I don't have time to enumerate here..
.. consist of autonomous stations equipped with biogeochemical and physical sensors spanning the full water column, strategically placed in cross-border regions to enable the study of key oceanic budgets.
require even more collaboration than what we currently have

provide information that is helpful to First Nations in stewardship of their marine territories.
be innovative and collaborative. It will include the most useful data for the science community and its stakeholders.
allow monitoring real-time water levels and currents due to tidal changes and river discharge, and be coupled to a digital twin numerical model.
provide real-time 3D knowledge throughout the region accessible for all
1) help us advocate for stronger regulations related to marine shipping, tourism (cruises) related to sound and contaminant pollution. 2) inform decision-making around sustainable development along the coastline keeping in mind human safety and preserving coastal habitat.
1.Include a digital infrastructure to support community access to numerical ocean models as a pathway to regional digital twin 2. Facilitate the assimilation of real time ocean data into numerical models. 3. Support a network of customized observatory for coastal communities.
1) be part of a SSDT. 2) continue to enable cutting edge research. 3) leverage AI and emerging technologies. 4) have active and strong partnerships. 5) be part of a national program for marine stewardship and security.
Provide live data but also summarized data consistently measured, collected and directly comparable across a variety of sites coupled with a digital twin
collaboratively integrate diverse observing platforms for tracking biodiversity and biogeochemical changes in support of developing ocean-based solutions for climate change.
The next generation Salish Sea ocean observing system will be an integrated, collaborative platform that combines real-time monitoring, advanced modeling including a Digital Twin, and community engagement to enhance understanding, support decision-making, and promote resilience in the region.
support communities with not just research but improving their resilience in the face of sea level rise. The most densely populated area of BC is surrounding the Lower Fraser so understanding the processes taking place within this area are crucial.
realize increased engagement outside of academia.
be a world leading, comprehensive ocean observing system that leads to accurate knowledge and prediction of ocean state for scientists and stakeholders.
Approach "everything, everywhere, all the time" by combining observational data streams with data assimilating numerical models. Obviously it won't be EVERYTHING (but perhaps T/S/currents could be available hourly over some grid), and we want the raw data streams as well.
be a comprehensive effort that uses the Salish Sea as a natural laboratory to address observing ocean state / events, climate monitoring, and prediction on many time scales; and which integrates ONC's role with other partners including universities, DFO, Hakai, Indigenous communities, municipalities, ECCC, etc.
be the engine of innovation and the driver for the generation of an overall digital twin system from which it’s construction and methodologies will have national and global implications. ONC is well positioned to be an urban sea digital twin exemplar with the potential of developing a template useful to more than the other 200 recognizable urban sea systems of the world. A very constructive and critical future lies before ONC based on its excellence in past sensing, monitoring, and open-source data distribution along with its present foresight in moving ahead with the latest technologies including cables, autonomous platforms, and buoys for obtaining oceanographic sensory data. Also, ONC is well positioned to support the monitoring of next generation clean, sustainable, and secure electrical power generation devices and structures that can harvest tidal and wave energy.
effectively coordinated to enhance our understanding of the entire inland sea, including the inlets.
become a sandbox providing an holistic understanding opportunity of a complex ecosystem uniting all lifeforms. From phytoplankton to whales, from a lonely rare specimen to multi-million people cities all living in ever more complex bubble.

Who/what was missed at this workshop?

We asked participants for their closing thoughts on who and what may have been missing from this workshop. Here is a summary of their responses.

Missing Voices and Representation

- **First Nations participation** was limited, especially from Lower Fraser and Coast Salish Nations; calls for a dedicated Indigenous-led tier-1 workshop and inclusion of organizations such as the Emergency Planning Secretariat.
- **Government and regulatory agencies**, particularly **DFO**, were largely absent, as were **industry partners**, **early-career scientists**, and **students**.
- **Modeling experts** (e.g., Susan Allen, Parker MacCready) and **cross-border U.S. collaborators** were noted as underrepresented.

Undiscussed or Underdeveloped Areas

- **Data management and interoperability**: how to handle and standardize the growing data volume, make it AI/ML/Digital Twin-ready, and integrate watershed, river, and urban data.
- **Biological and contaminant monitoring gaps**: limited attention to microplastics, "forever chemicals," effluent, and under-studied habitats such as the **Lower Fraser marshes** and **Jervis Inlet**.
- **Data sovereignty and ethics**: concerns about equitable sharing, Indigenous data governance, and the energy and ethical implications of large Digital Twin systems.
- **Community engagement**: need for improved transparency, outreach to the public and policymakers, and alignment with ONC's mission.

Implementation and Collaboration Needs

- **Broader, ongoing collaboration mechanisms**: suggested regular Salish Sea seminars, annual science meetings, and a clear roadmap toward the Digital Twin.
- **Technological innovation**: explore **autonomous fleets**, **drones**, and **new profiling systems**; learn from existing models like **CSDMS**.
- **Strengthen research community support**: funding and coordination for shared science priorities, inclusion of industry in co-designing sensors and systems.
- **Ethical and scientific oversight**: proposal to establish an **AI ethics or peer-review committee** to ensure transparency and scientific integrity in AI-driven analyses.

(Optional) Do you have any last thoughts to share? **- What/who was missed at this workshop?** **- Are there locations or priorities that weren't discussed?** **- Any implementation suggestions?** **- Anything else?**
Many First Nations were not represented. Industry representation was minimal. We were lacking people from the modelling community such as Susan Allen and Parker MacReady.
Missing modellers, advice for keeping or re-considering existing infrastructure, and clarity on the pathway to a Digital Twin.
I believe those attending widely represented the various communities and stakeholders with the possible exception of government agencies (didn't see/hear anyone from DFO, etc.). I also believe the spatial coverage of different (non-ONC) data shared by participants makes the case for expanding this network in some ways to capture some more societally

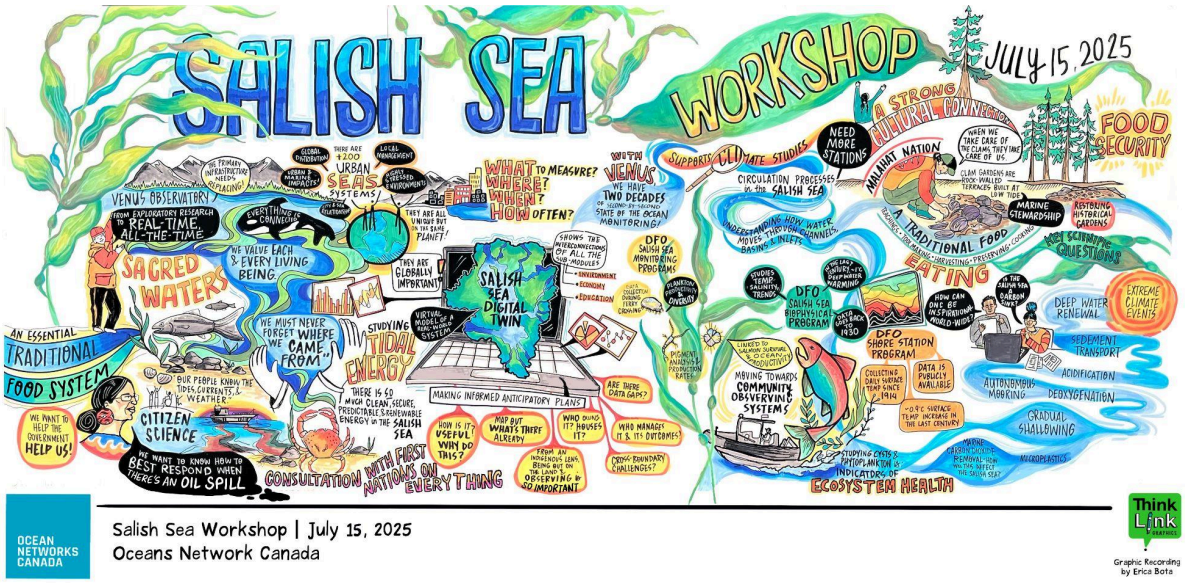
relevant areas and processes. For implementation, being sure to articulate the alignment of final decisions to the overall ONC vision/mission shared this morning will be very useful as transparency is so key to community acceptance and support.
Implementation ideas: * the 3D repeat project could include autonomous drone fleets / gliders / nearshore ARGOs etc --- some of which are emerging technology and others that are at a more mature level of maturity. On a 15 year time scale these will surely mature further. * Instead of adding a couple more hyperspectral cameras on more ferries (incremental) we put them on a drone fleet and measure the entire Salish Sea with them (paradigm shift) This would not be entirely on ONC's plate; it would require the involvement of other agencies as partners and funders for the continuing part and the new developments part.
1. Not too much about data management. We discussed increasing platforms, areas, datatypes, new instruments, etc. Not many talked about how that data will/should be managed. Particularly if we are talking about cross-disciple works like digital twins or models. Can we relate ocean variables with river variables, do they use standard formats? Relates to making data AI/ML/Digital Twin ready. Also speaking of Digital Twin and covering not just ocean, but should we be inviting watershed experts, city experts, etc. or find a way to get invited to their workshops 2. See 1. 3. More collaboration, run this workshop more often 4. The virtual/tech was clunky at times. Breakout rooms weren't clear at times
I would like to see more Indigenous involvement in these conversations. I think planning a specific Indigenous multi-Nation tier 1 meeting would be best, to discuss long term monitoring and research goals.
I realize the workshop was already quite large and naturally focused on the Canadian side of the border, so thanks for including me and some others from the US. But I know many others here who are very interested in the topics discussed, and I feel like there is often not enough cross-border collaboration or even information exchange, at least in the areas I am most familiar with. So this workshop was very useful for me, and I think a similar workshop focused on cross-border collaboration might be very useful in the future.
Potentially useful to loop in with more modelers in terms of what locations/sensors or length/time scales which pose difficulties or which are well described even if there might not be many sensors today
- Some gaps: contaminants (effluent, black water, 6PPDq, microplastics); data sovereignty (idea of digital twin could be challenging to capture all the monitoring efforts happening around the Salish Sea - some groups may not want to share, which could lead to a lack of information about the biological elements of the coast). I would be keen to know what ONC could do regarding microplastics and monitoring of forever chemicals. - I feel apprehensive about the idea of a digital twin, and the energy demands of a system like that. I support more R&D into clean energy tech such as the tidal energy generator devices (VIV, PNNL, OPALCO) rather than putting more pressure on energy and water demands.
Suggest looking into the Community Surface Dynamics Modelling System (CSDMS) hosted at U of Colorado Boulder as a model for community support of models towards a digital twin
DFO interests were minimal. DFO scientists continue to struggle to access (easily) core data. ONC might identify participants with common ideas (water column measurements) and form a sub-committee to flush out details of these ideas.
Great workshop, thank you for the opportunity to contribute. I look forward to our continued and developing collaborations.
Missing: Lower Fraser First Nation representatives from communities such as Musqueam, Tsawwassen, Squamish, Tsleil-Waututh. Could even invite an org such as EPS (Emergency Planning Secretariat) who work with dozens of coast Salish Nations. One area EPS is beginning to focus on is the study and push for additional NbS, including coastal flood protection projects. Locations: The upper Fraser was mentioned but I think this is an area that should be studied in much more detail. This is the largest river in the Salish Sea and drains 25% of BC. Implementation: Increase coastal observations such as repeat LiDAR and bathymetry. Other: The biology group was very focused on various plankton species but there are so many other biological processes and species in the Salish Sea that are understudied or deserve to be more represented, which ONC could support. For example, no one realized over 160Ha of low elevation marsh vegetation had died off over a 30 year period (1980s - 2010s) along the western foreshore of Richmond (Sturgeon Bank). This mass loss of marsh vegetation means a loss of habitat for hundreds of fish and wildlife species including all 5 Pacific salmon that rely on this space to acclimatize to the changing salinities as they migrate both downstream as juveniles and

upstream as adults. Given their proximity to densely populated communities and their role as critical habitat, the Lower Fraser and Delta front should be a key focus for ONC over the next 15 years.
Thank you to Martin for inviting me to this event, otherwise I would not have known about it. I think without Martin's invitation the company I work for (ASL Environmental Sciences) would also have been unaware of this workshop. There may be other companies, local or not, who would be interested to attend if they knew of the workshop. On the topic of engagement between ONC/industry, I know small companies like ASL are often looking for ways to collaborate. I think engagement with industry could be fruitful, as we are always looking for researchers to basically tell us what they want. For instance, if someone says 'we want a new type of sensor' or 'we want a sensor that is similar to this, but with increased X and decreased Y' then we usually try to accommodate. As we envision next-gen observing systems, this is a good time to tell people from industry what sort of sensors would be useful.
In terms of implementation, it would be nice to see a stronger research community around the Salish sea, and ONC could take a lead in that. People need funding to work on the data with their groups, and it is easier to attract that if there are cohesive widely agreed upon plans on what the next research steps are, and buy-in from potential in-kind organizations. This meeting was a great first step, and as some folks mentioned, the Salish Sea is such an awesome natural laboratory for so many processes, it could become even more of an international research hub than it already is.
An easy thing that could be done SOON is to engage with CFMETR people to get CHl and O2 added to the Nanoose time series CTDs. The last time I pushed this ONC really didn't do CTDs and so this got pushed down in priority, but since then the Community Fishers program has really taken off so it can't be such a stretch. The Nanoose time series is an incredibly valuable resource for climate monitoring, and getting some BGC parameters for the full water column, at weekly intervals, for the next 20 years would be SO SO useful - without the "gappy" nature of that are the best you can get with profiling moorings.
1. Look carefully at solutions that have already been developed elsewhere, e.g. different engineering for profiling moorings. Consider un-cabled solutions. 2. Increase collaboration (convening) with a monthly (two-month?) Zoom seminar series on Salish Sea science and contribute to organizing an annual short meeting focused on Salish Sea science, questions, and needs. 3. Create delayed-mode digital products that are directly downloadable (not as a database query) in a standard format (for example all variables at a single site with each year in a separate file), which would be more readily accessible to AI and other numerical methods.
Outreach to the general public, regulators, and policy makers should be included in a focus on the application of the science.
There were very few early career scientists and students. We need to somehow engage these groups in the discussions. Jervis Inlet with the deepest inshore basin (700m) needs to be prioritized if we are to develop an understanding of the sea.
create an AI ethical committee as coming reasoning AI models will be by definition subjective. To process data fetched outside of the human cognitive ability will require thorough pier reviews, challenging AI output to provide objective scientific results.
BELOW: From breakout notes (not from survey)
Delta processes and geohazards, DDL, for both short-term experiment and long-term monitoring at important mouth of river (fish, whales, traffic). Experiment (5 years) to make use of known turbidity currents to test impacts and design mitigation measures to cables and pipelines (impacts, abrasion, vibrations, stromming). This would also include DAS for testing and comparison with traditional instruments. European and industry collaboration.
Select DT submodules to experiment with to see how a DT of Salish Sea can be developed.
Consider instruments and data needed to evaluate water energy for electrical power
Investigate ways to extend capability of ONC into the southern part of the Salish Sea.

Graphical Records

A graphical recorder summarized key messages and presented three murals to attendees.

Day 1



Summary

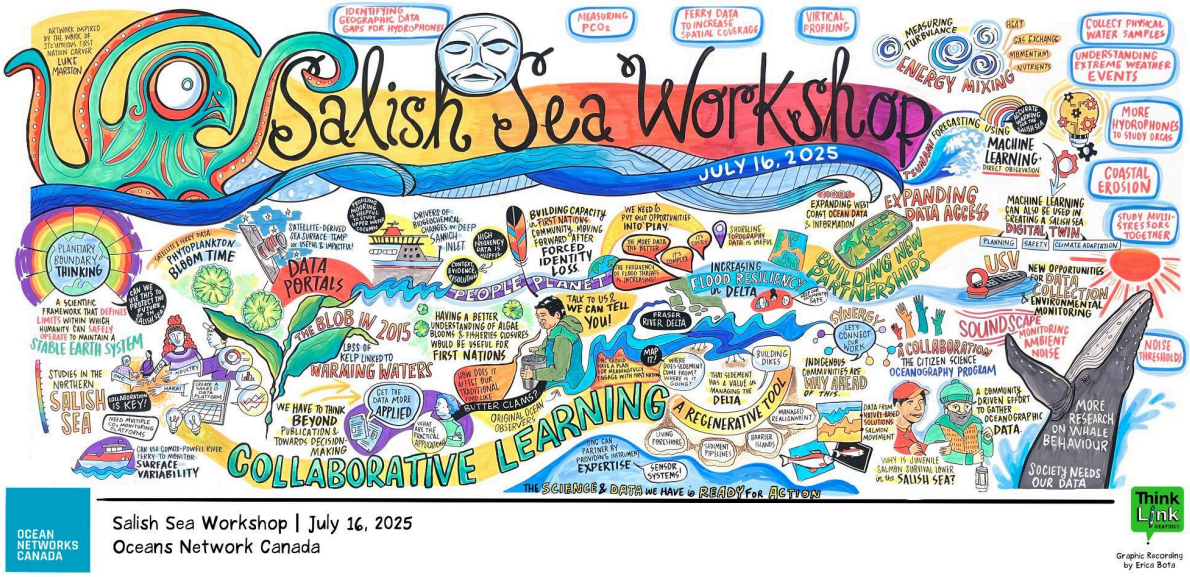
VENUS started as an exploratory research project but quickly became a “real-time-all-the-time” platform. We have now compiled decades of second-by-second state of the ocean observations. However, the primary infrastructure needs replacing.

We heard from the University of Washington’s John Delaney about Urban Sea systems— there are over 200 globally—and how representing these with Digital Twins could be beneficial. Such systems represent the vast complexity of interconnections among the environment, economy, education, and many other sub-systems. Digital Twins can help societies make informed anticipatory plans. How to move toward a Digital Twin? We begin by mapping out what’s already there, considering who owns/operates/manages what, looking for data gaps, considering cross-jurisdictional and cross-boundary challenges.

It is essential never to lose sight of Indigenous perspectives on our sacred waters (which are essential traditional food systems): everything is connected, each and every living being is valued. Indigenous elders advise that we must never forget where we came from, and recognize that so much knowledge is already incorporated within Traditional Knowledge systems. There are strong cultural connections, for example relating to clam gardens: taking care of the clams so they can take care of us. Consultation with First Nations on everything is key. We also talked about citizen science and community observing systems, as well as existing DFO programs.

Key scientific topics: Deep water renewal, extreme climate events, sediment transport, acidification, autonomous moorings, deoxygenation, mCDR, microplastics, ecosystem health.

Day 2



Summary

On Day 2, we delved into numerous science topics. We considered planetary boundaries, the framework that defines limits within which humanity can safely operate to maintain a stable earth system. Can we use this framework to consider how to protect the future of the Salish Sea?

For studies in the Salish Sea, collaboration is key. Expanding data access can be supported by building new partnerships. CIOOS is expanding access to West Coast ocean data and information. Groups such as ONC, DFO, Hakai, Industry and others can work together to contribute to a shared data platform. For example, we need to combine CO2 monitoring from multiple organizations and systems. Collaboration can also enable community science oceanography to help us improve juvenile salmon survival and monitoring/protection of marine mammals. Data portals should incorporate satellite-derived Sea Surface Temperatures. We can use satellite and ferry data to monitor phytoplankton blooms; in the northern Salish Sea, we can use the Comox-Powell River ferry to monitor surface variability. Profiling moorings are helpful to study the upper water column. We want to understand turbulence, energy mixing, heat, gas exchange, momentum, nutrients. We would like to improve forecasting and warnings through direct observation combined with machine learning. High frequency data are helpful to understand drivers of biogeochemical change. In the Fraser River Delta, we can support increasing flood resiliency. The frequency of flood threats is increasing, it's complex and costly, so having more data can help improve planning and decision making. Uncrewed Surface Vessels provide new opportunities for data collection and environmental monitoring.

Above all, we need to engage in collaborative learning, thinking beyond publications and towards decision making, to address practical applications. We want our science and data to be ready for action.

Day 3

Summary

On Day 3 we envisioned the next generation Salish Sea Ocean Observing System—a system that will be more spatially distributed, integrating diverse observing platforms for tracking biodiversity (including marine mammals) and biogeochemical changes. This observing system should incorporate more profiling systems, more autonomous monitoring systems and improved rate measurements. We returned again to the idea of the Digital Twin, working to make our data ready through standardized formats & metadata as well as best practices, including the use of AI to analyze big data. This system, which could become a shared data portal, should take full advantage of data that already exists and embody stronger internal coherence. It will incorporate a planetary thresholds lens for monitoring climate change and supporting societal decision making.

The grander the vision, the greater the need to build community — collaboration is key for all projects ONC should take a leadership role in building this community, both regionally and internationally. We emphasized the importance of Indigenous and community inclusion, supporting local stewardship programs and Indigenous focused workshops. ONC can convene short-term working groups and focused workshops considering next steps. ONC can support efforts to access funding, but ONC also needs to set realistic priorities, while also providing a clear and comprehensive guideline for how best to engage with ONC.

John Delaney ended with a quote from TS Eliot: “We shall not cease from exploration. And the end of all our exploring. Will be to arrive where we started. And know the place for the first time. Through the unknown, remembered gate. When the last of earth left to discover is that which was the beginning; At the source of the longest river. The voice of the hidden waterfall. And the children in the apple-tree. Not known, because not looked for. But heard, half heard, in the stillness Between two waves of the Sea.”

List of Attendees

Name	Affiliation	Attendance
Adrian Round	Ex-VENUS Team member	In Person
Akash Sastri	Fisheries and Oceans Canada	In Person
Alice Bui	Ocean Networks Canada	In Person
Andy Lin	Fisheries and Oceans Canada	Remote
Anneke ten Doeschate	Rockland Scientific	In Person
Ben Biffard	Ocean Networks Canada	Remote
Ben Skinner	Pacific Salmon Foundation	Remote
Benoît Pirenne	Ocean Networks Canada	In Person
Bernie Yang	Fisheries and Oceans Canada	Remote
Brad deYoung	CIOOS Pacific	In Person
Carly Ringer	Oregon State University	Remote
Christophe Sandoz	R&O Scientific Support Inc.	In Person
Dandan Huang	Open Ocean Robotics	Remote
Danica Paul	Songhees, Tsartlip, Ahousaht First Nation	Remote
Daniela Loock	Ocean Networks Canada	In Person
Deniz Coskuner	University of British Columbia	Remote
Derek White	Vancouver Fraser Port Authority	Remote
Di Wan	Fisheries and Oceans Canada	Remote
Diana Varela	University of Victoria	In Person
Dirk Brussow	Ocean Networks Canada	In Person
Drew Snauffer	Ocean Networks Canada	In Person
Dwight Owens	Ocean Networks Canada	In Person
Erica Bota	ThinkLink Graphics	In Person
Fabio De Leo	Ocean Networks Canada	Remote
Fritz Stahr	Open Ocean Robotics	In Person
Giuliana Berden	University of Victoria	In Person
Grace Bertozzi	Ocean Networks Canada	In Person

Gwyn Lintern	Natural Resources Canada	In Person
H. Gary Greene	Moss Landing Marine Labs, Tombolo Mapping Lab, San Jose State University	In Person
Harvy S. Takhar	City of Delta	Remote
Hector Alvarez-Vazquez	RBR	In Person
Herminio Foloni Neto	Ocean Networks Canada	In Person
Ian Black	Oregon State University	In Person
Jamie Gauk	Ducks Unlimited Canada	In Person
Jan Newton	University of Washington - NANOOS	In Person
Jean-Philippe Juteau	Rockland Scientific	In person
Jeffrey Harris	École nationale des ponts et chaussées	In Person
Jennifer Jackson	Fisheries and Oceans Canada	In Person
Jesse Hutchinson	Ocean Networks Canada	In Person
Jody Klymak	University of Victoria	In Person
John Delaney	University of Washington	In Person
Kate Moran	Ocean Networks Canada	In Person
Kate Mussett	Malahat First Nation	Remote
Kees Lokman	University of British Columbia	Remote
Kohen Bauer	Ocean Networks Canada	In Person
Kyla Sheehan	Pacific Salmon Foundation	In Person
Lanfranco Muzi	Ocean Networks Canada	In Person
Lorne Underwood	WSÁNEĆ Nation Elder, Tsawout Village	In Person
Lu Guan	Fisheries and Oceans Canada	Remote
Lucianne Marshall	Ocean Networks Canada	In Person
Lynn Pinnell	Stz'uminus First Nation	Remote
Lynn Rannankari	Ocean Networks Canada	In Person
Maddy Langston	Pacific Salmon Foundation	Remote
Maia Hoeberechts	Ocean Networks Canada	In Person
Manman Wang	Ocean Networks Canada	In Person
Martin Heesemann	Ocean Networks Canada	In Person

Martin Scherwath	Ocean Networks Canada	In Person
Martin Williamson	University of Victoria	In Person
Maycira Costa	University of Victoria	In Person
Megan Kot	Ocean Networks Canada	In Person
Meghan Tomlin	Malahat First Nation	In Person
Michael Dunphy	Fisheries and Oceans Canada	In Person
Mitchell Wolf	Ocean Networks Canada	Remote
Natalia Sannikova	CIMAR, National Oceanic and Atmospheric Administration	Remote
Natasha Melo Buckiewicz	University of British Columbia	Remote
Nicholas A Rome	University of Washington - NANOOS	In Person
Nick Hammar	Ocean Networks Canada	In Person
Nicolai Bailly	Ocean Networks Canada	In Person
Nicole McEwan	Ocean Networks Canada	Remote
Oliver Kirsebom	Open Ocean Robotics & Simon Fraser University	In Person
Paulina Salinas Ruiz	Pacific Salmon Foundation	Remote
Phil Hill	Natural Resources Canada	In Person
Pieter Romer	Ocean Networks Canada	Remote
Polina Erofeeva	University of Victoria	Remote
Pramod Thupaki	Fisheries and Oceans Canada	In person
Randy LeVeque	University of Washington	Remote
Reza Amouzgar	Ocean Networks Canada	Remote
Rich Pawlowicz	University of British Columbia	In Person
Richard Dewey	Formerly Ocean Networks Canada	In Person
Robbie Davis	Tseycum First Nation	In person
Roberta Hamme	University of Victoria	In Person
Rosario di Carlo	NATO Centre for Maritime Research and Experimentation	Remote
Sarina Clay-Smith	Pacific Salmon Foundation	Remote
Sean Rogers	Bamfield Marine Sciences Centre	In Person
Shaheli Masoom	Metro Vancouver	Remote
Shahin Dashtgard	Simon Fraser University	Remote

Shauna Johnson	W̱SÁNEĆ Leadership Council	Remote
Shumin Li	University of British Columbia & Rockland Scientific Inc.	In Person
Soroush Kouhi	Ocean Networks Canada	Remote
Stephane Gauthier	Fisheries and Oceans Canada	In Person
Steve Mihaly	Ocean Networks Canada	In Person
Steve Pearce	ASL Environmental Sciences	Remote
Steven Henry Jr.	Malahat First Nation	In person
Tammy Sam	Tseycum First Nation	In Person
Tricy Aquino	Ocean Networks Canada	In Person
Vasily Titov	National Oceanic and Atmospheric Administration	Remote
Vera Pospelova	University of Minnesota	In Person
Wiley Evans	Tula Foundation / Hakai Institute	Remote
Yong Wei	University of Washington	Remote
Zoë Crookshank	University of Toronto	Remote

Detailed Agenda

https://indico.oceannetworks.ca/event/7/timetable/#20250715.detailed