Best Practices at Ocean Networks Canada

Fifteenth Observations Coordination Group (OCG-15) Meeting | 14 May 2024

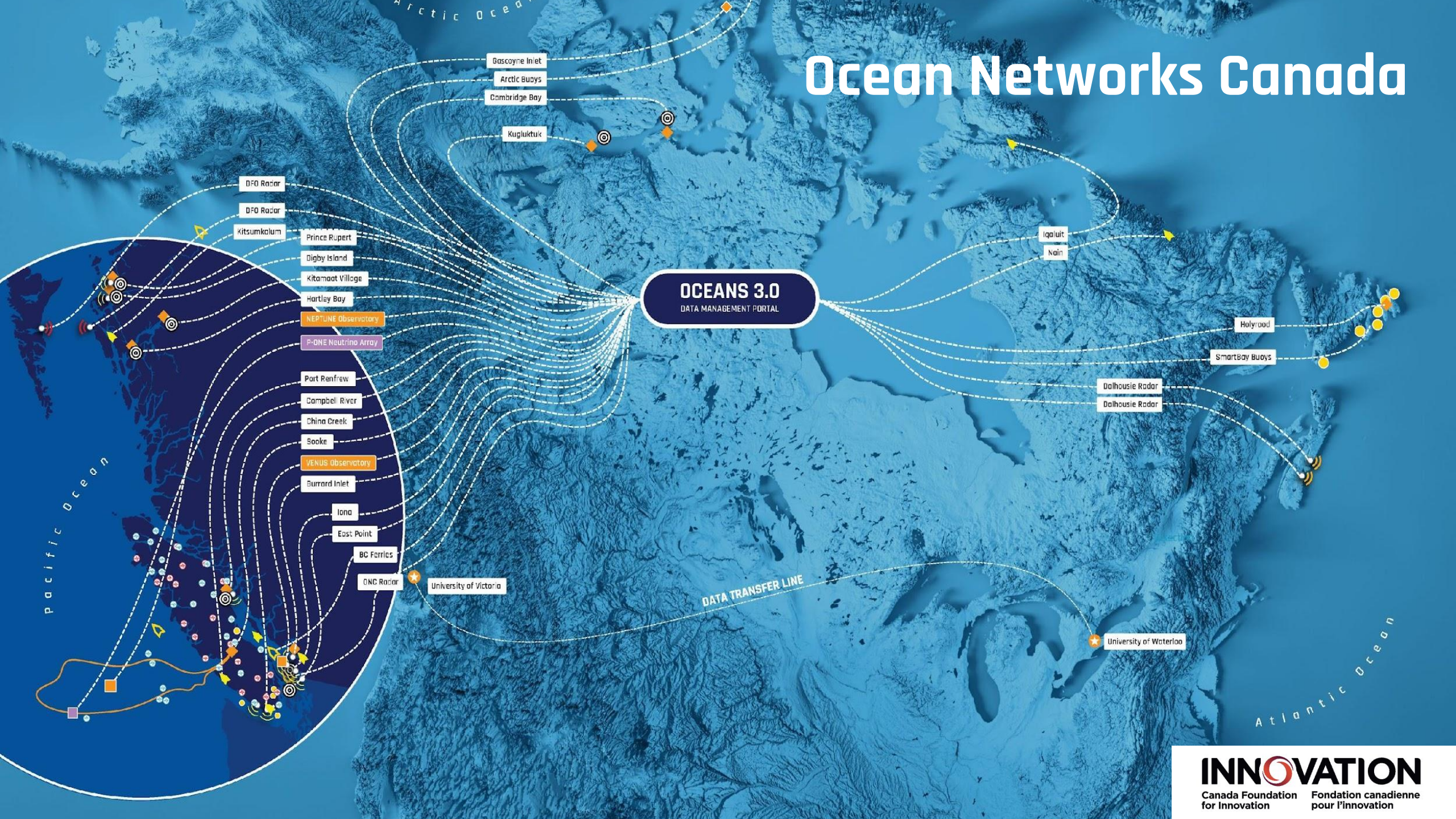
A UNIVERSITY OF VICTORIA INITIATIVE

Land & Sea Acknowledgement

We acknowledge and respect the Lək̓ʷəŋən (Songhees and Esquimalt) Peoples on whose territory Ocean Networks Canada's offices are located, and the Lək̓ʷəŋən and W̱SÁNEĆ Peoples whose historical relationships with the land continue to this day.

Workshop agenda

9:00 - 9:05	Welcome and overview
9:05 - 10:30	Indigenous Ocean Observing
10:30 - 11:00	**Coffee break**
11:00-11:45	CIOOS
11:45-12:45	Ocean Carbon Solutions
12:45	**Adjourn**


Ocean Networks Canada
Gascoyne Inlet
Arctic Buoys
Cambridge Bay
Kugluktuk
DFO Radar
DFO Radar
Kitsumkalum
Prince Rupert
Digby Island
Kitamaat Village
Hartley Bay
NEPTUNE Observatory
P-ONE Neutrino Array
Port Renfrew
Campbell River
China Creek
Sooke
VENUS Observatory
Burrard Inlet
Iona
East Point
BC Ferries
ONC Radar
University of Victoria
OCEANS 3.0
DATA MANAGEMENT PORTAL
Iqaluit
Nain
Holyrood
SmartBay Buoys
Dalhousie Radar
Dalhousie Radar
DATA TRANSFER LINE
University of Waterloo
Pacific Ocean
Atlantic Ocean
INNOVATION
Canada Foundation for Innovation
Fondation canadienne pour l'innovation

About Us

~ 180 staff members

12,400+ sensors

1.5PB archived open data

305+ data products formats

30,000+ data users

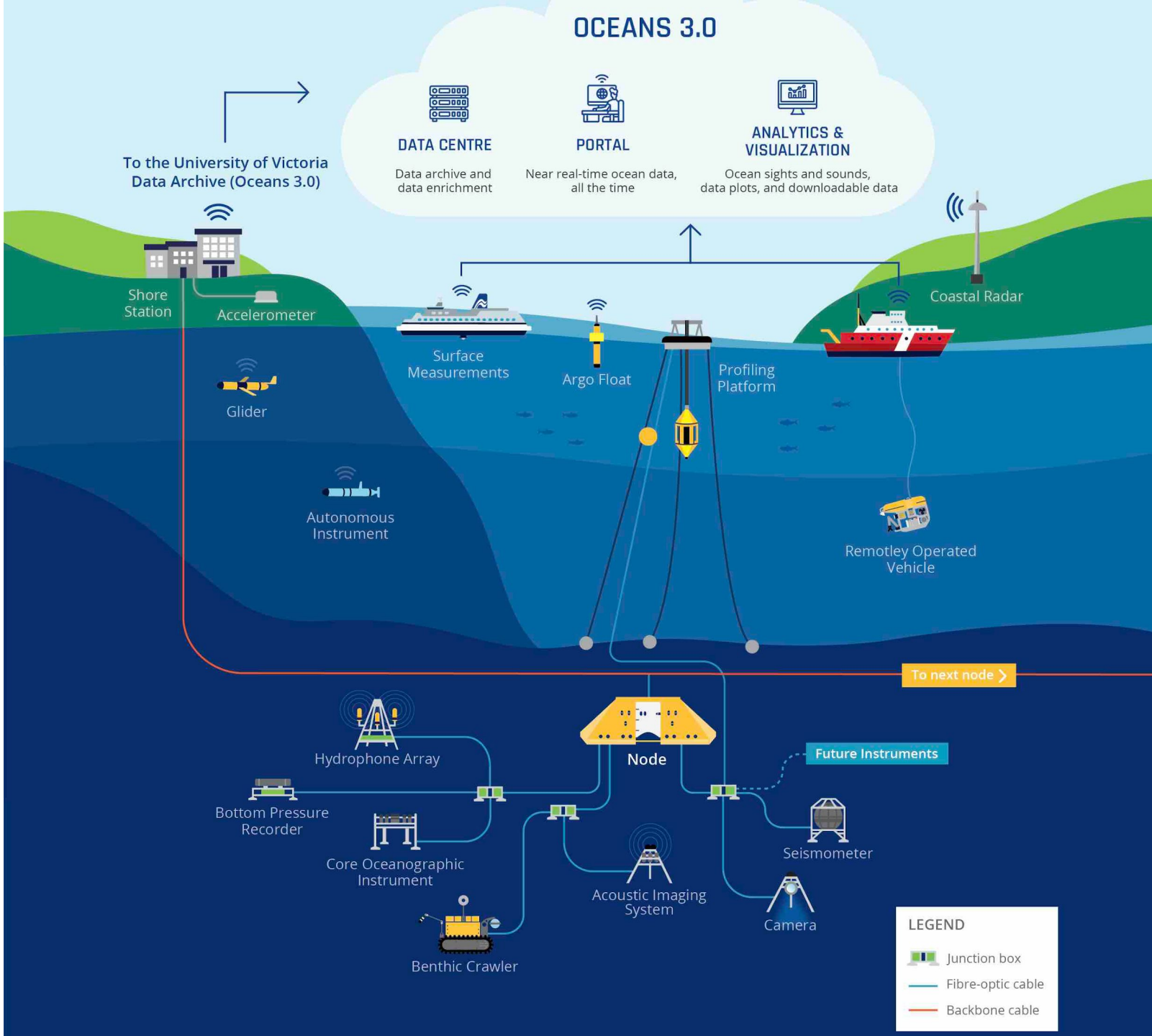
1 large observatory (NEPTUNE)

1 medium-sized (VENUS)

10 coastal observatories

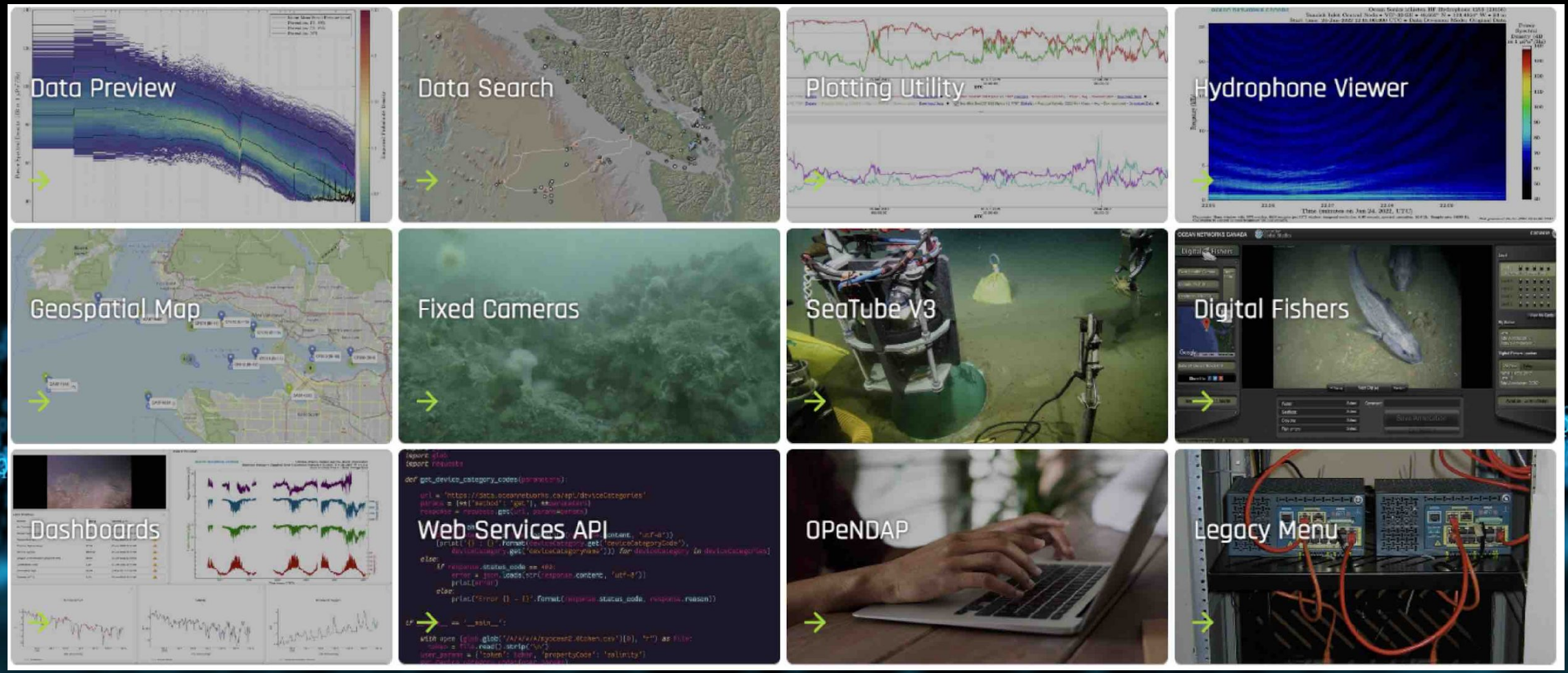
2 ferries

12 citizen science communities



Oceans 3.0 - Open Data Management System

https://data.oceannetworks.ca/home



Goal #1: Advance Ocean Observing

Goal #2: Develop & Deliver Data and Ocean Intelligence Products and Services

Goal #3: Enable Ocean-based Solutions for Climate Change Mitigation & Coastal Resilience

Ocean Intelligence for Science, Socie and Industry


OCEAN NETWORKS CANADA
Arctic Ocean
Pacific Ocean
Atlantic Ocean
OCEANS 3.0
DATA MANAGEMENT PORTAL
Scientific Discovery
Ocean Health Monitoring
Tsunami Inundation Modelling
Earthquake Early Warning
Climate Mitigation Solutions
Neutrino Detection
Forensics
Marine Transport Safety
Marine Mammal Avoidance
Ocean Soundscapes
Climate Impact Tracking
Blue Economy
Underwater Imagery
Inform Incident Response
Arctic Observing
Ocean Science Education
Hazardous Spill Response
Partnerships
Coastal Resilience

Indigenous Ocean Observing:
Partnerships and Programs at Ocean Networks Canada

Dr. Maia Hoeberechts | Associate Director, Learning & Community Engagement

Fifteenth Observations Coordination Group (OCG-15) Meeting

Global Ocean Observing System (GOOS) | 14 May 2024

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Overview

- Break out introductions
- Indigenous Engagement at ONC
- Coastal Community Observatories
- Community Fishers
- Youth Science Ambassador
- Successful Practices
- Q & A and Break out discussion

Indigenous Engagement at ONC

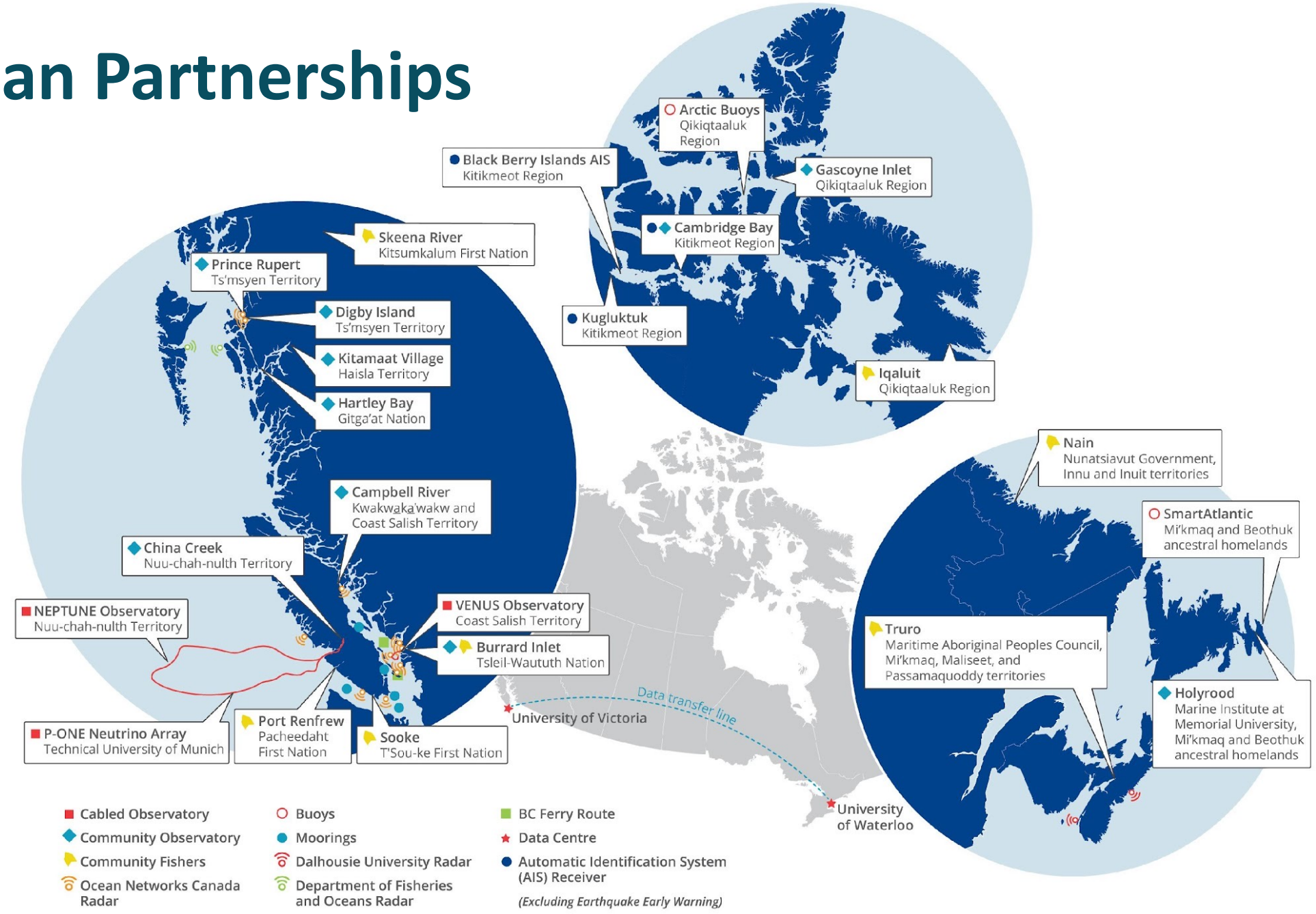
“The most comprehensive and profound understanding of our ocean stems from a diversity of perspectives.”

- ONC 2030 Strategic Plan

Aspects of Indigenous Community Engagement

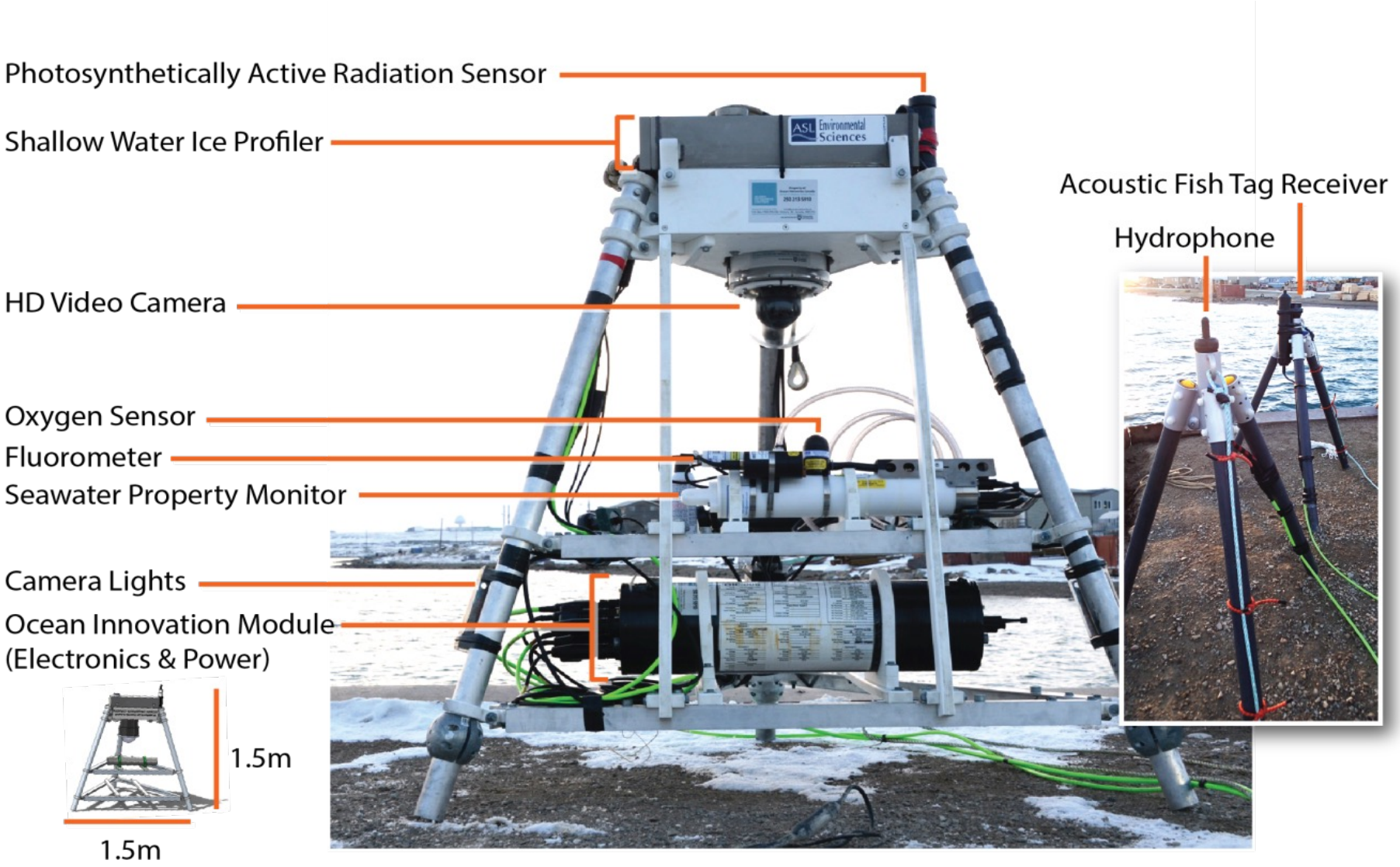
- Foster ocean equity and knowledge
- Support community-led projects
- Enhance capacity for stewards and guardians
- Inspire youth
- Strengthen connections between Indigenous knowledge systems and science

Canadian Partnerships



Coastal Community Observatories

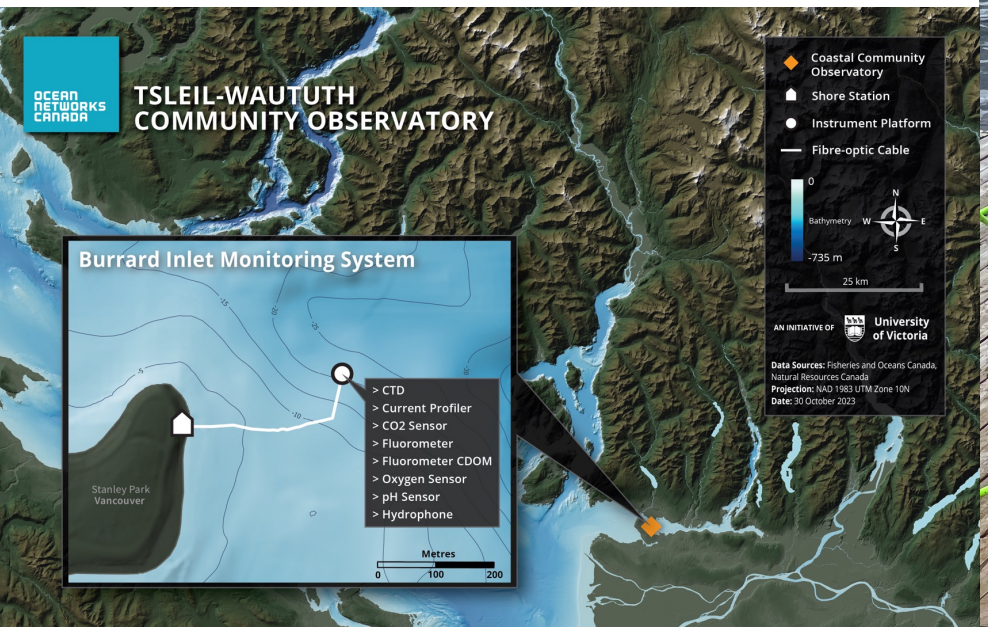
Coastal Community Observatories – Underwater Platform



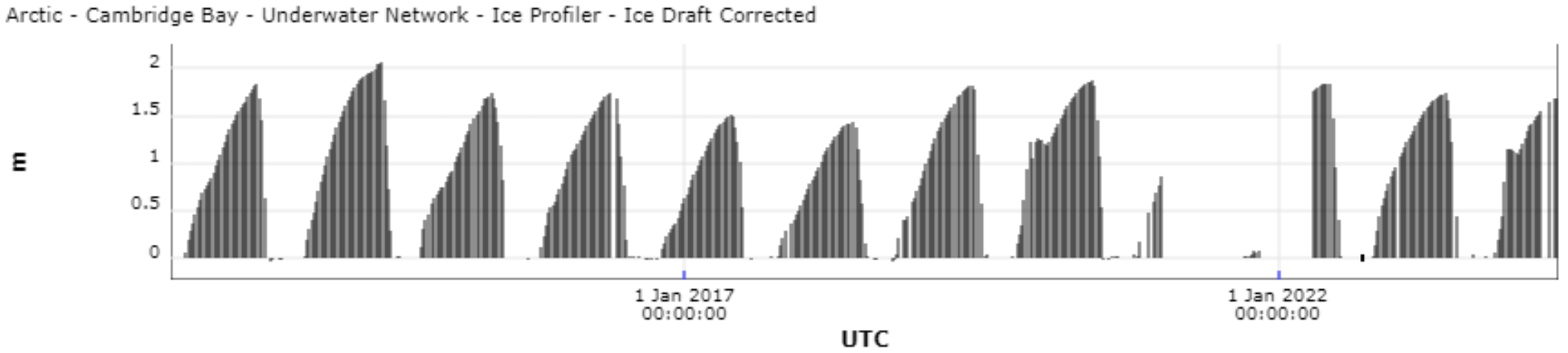
Burrard Inlet Coastal Community Observatory

Partnership with Tsleil-Waututh Nation

- Data collected:
  - Currents, oxygen, chlorophyll, sound
  - Temperature, salinity, pressure (depth)
  - pH, CO_2 (ocean acidification)



Data example: Ice thickness (draft)



Arctic - Cambridge Bay - Underwater Network - Ice Profiler - Ice Draft Corrected

- Arctic - Cambridge Bay - Underwater Network - Ice Profiler - Ice Draft Corrected (21593) - Clean - Data Values - Not Downsampled
- Arctic - Cambridge Bay - Underwater Network - Ice Profiler - Ice Draft Corrected (3937) - Clean - Avg - Downsampled
- Arctic - Cambridge Bay - Underwater Network - Ice Profiler - Ice Draft Corrected (14590) - Clean - Avg - Downsampled

Coastal Community Observatories – Data Applications

Long-term, continuous data:

- Assess changes in oceanic conditions over time (e.g., climate change)
- Compare oceanic conditions before and after the addition of a stressor (e.g., industrial development)

Camera data:

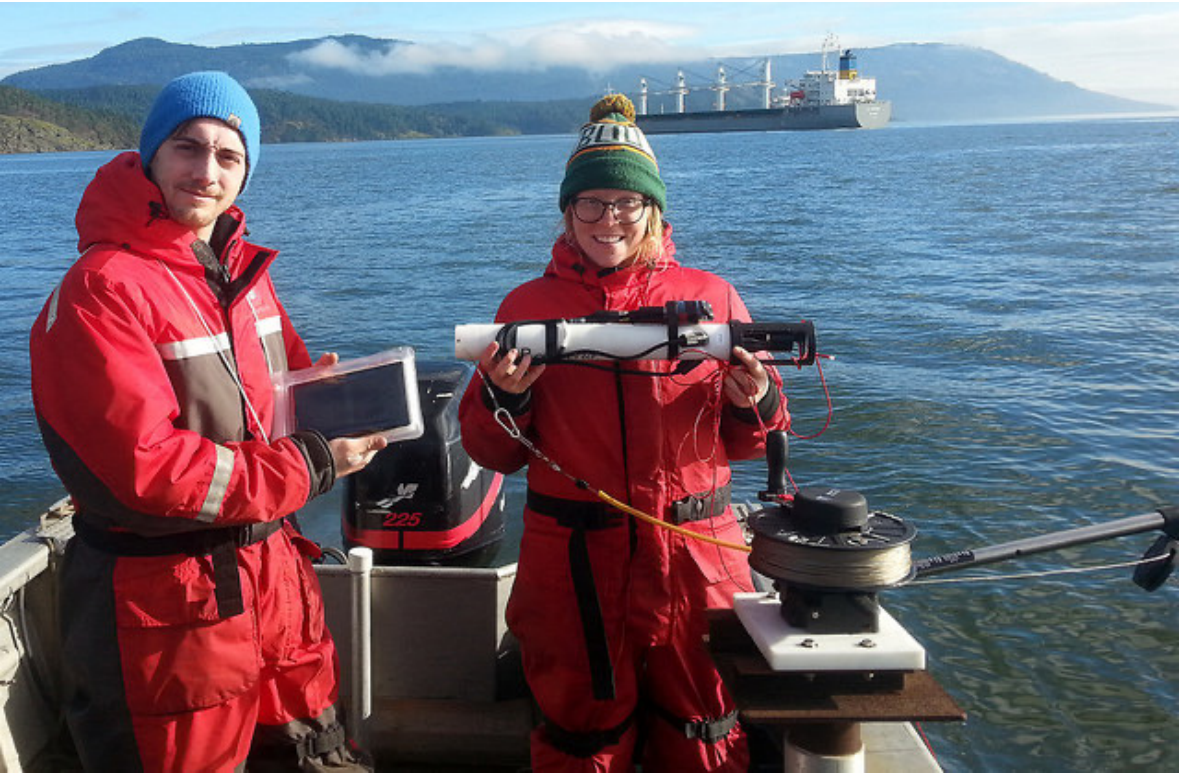
- Ecological surveys; biological diversity

Hydrophone data:

- Marine mammal, fish, and anthropogenic noise monitoring

Community Fishers

Overview: Data are collected with a conductivity-temperature-depth (CTD) instrument, transmitted to an archive with a tablet, and made available online.

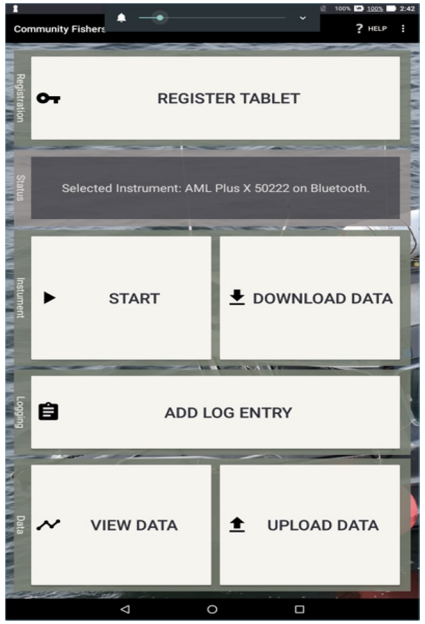


Data collected: Temperature, salinity, turbidity, chlorophyll, and dissolved oxygen.

Community Fishers Pipeline, Portal, Data Products

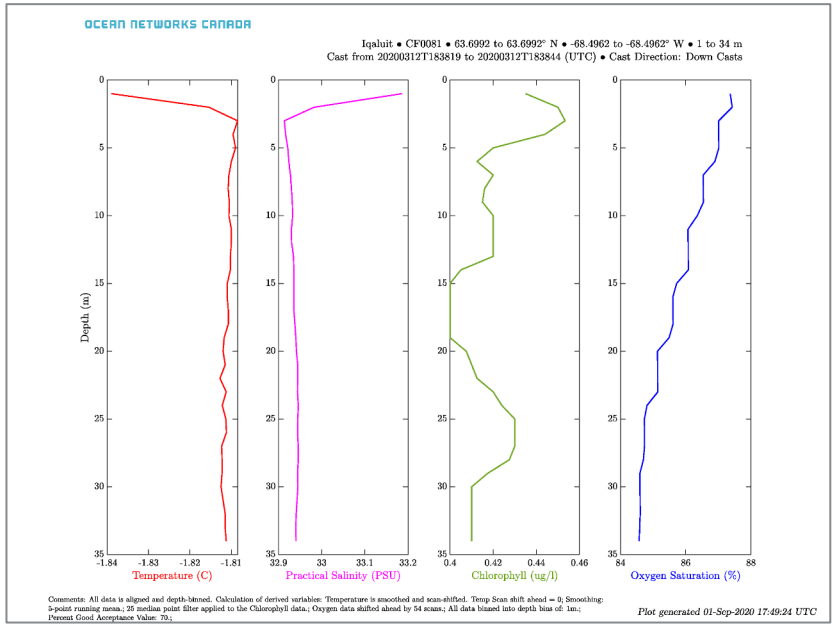
Motivation:

- Make data acquisition and access for the program more community-friendly, automated and scalable



Tablet App

Data Portal



Community-friendly Data products

Community Fishers Training Program

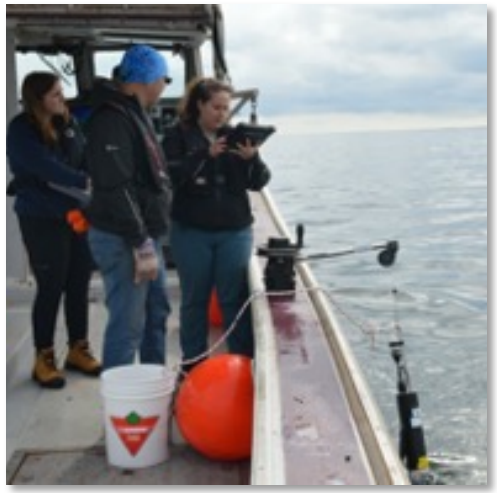
Microcredit course offered through University of Victoria Continuing Studies and the UN Institute for Training and Research (UNITAR)

Community Fishers Partners

Snuyneymuxw First Nation

T'Sou-ke First Nation

Tsleil-Waututh Nation



Maritime Aboriginal People's Council

Iqaluit Community

Kitsumkalum First Nation

Pacheedaht First Nation

Pacific Salmon Foundation

Gov't of Nunatsiavut

Prince Rupert Port Authority

Community Fishers – Example Data Applications

- **Establishing baselines for water properties –** evaluate ocean conditions over seasons and years
- **Tracking climate change impacts –** monitor key variables such as temperature and oxygen
- **Characterizing local habitats –** understand physical ecosystem parameters
- **Understanding regional water properties** – conduct transects and repeat stations to understand regional water column properties

Youth Science Ambassadors

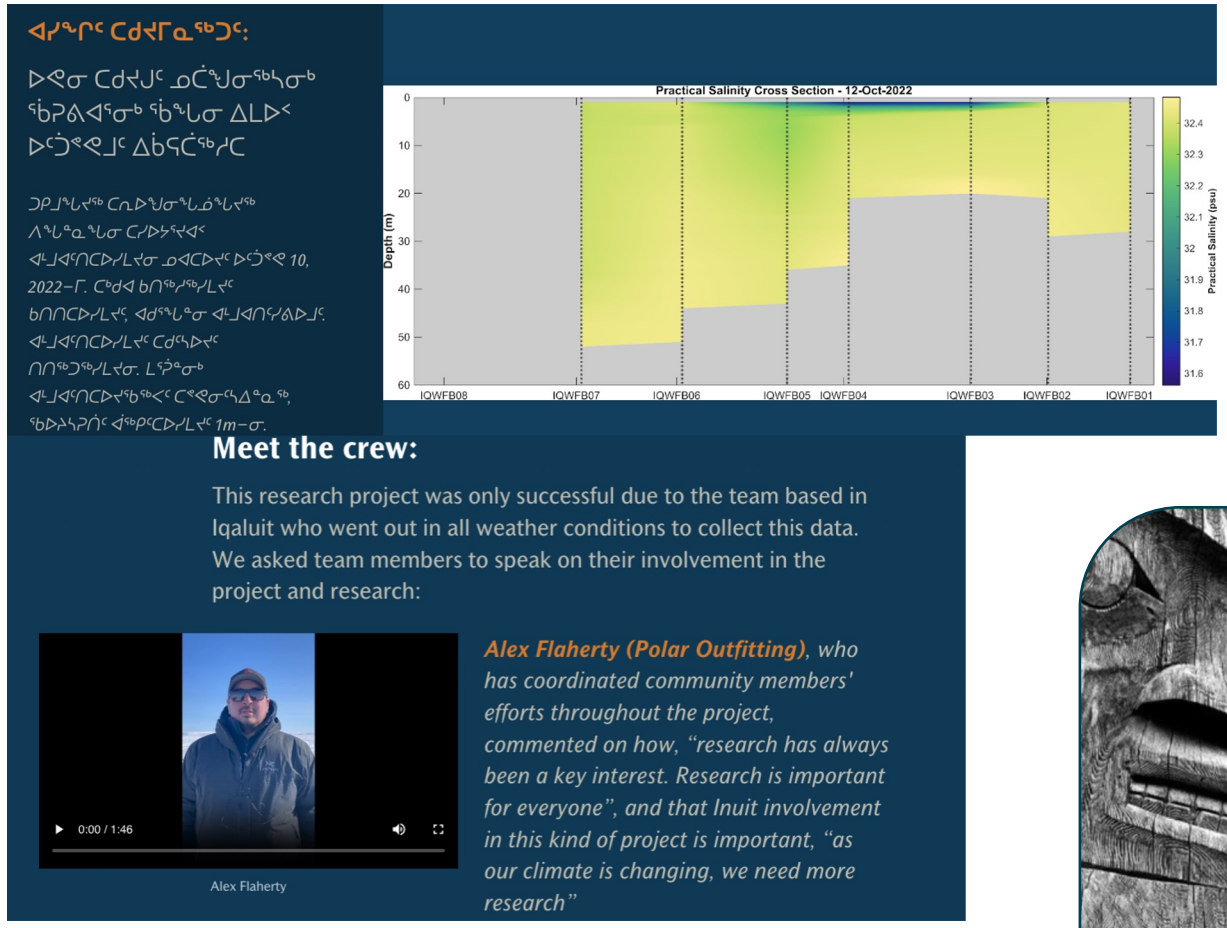
Local Observations – Global Connections

2016 – Cambridge Bay, NU

2022 – UN Ocean Conference, Lisbon

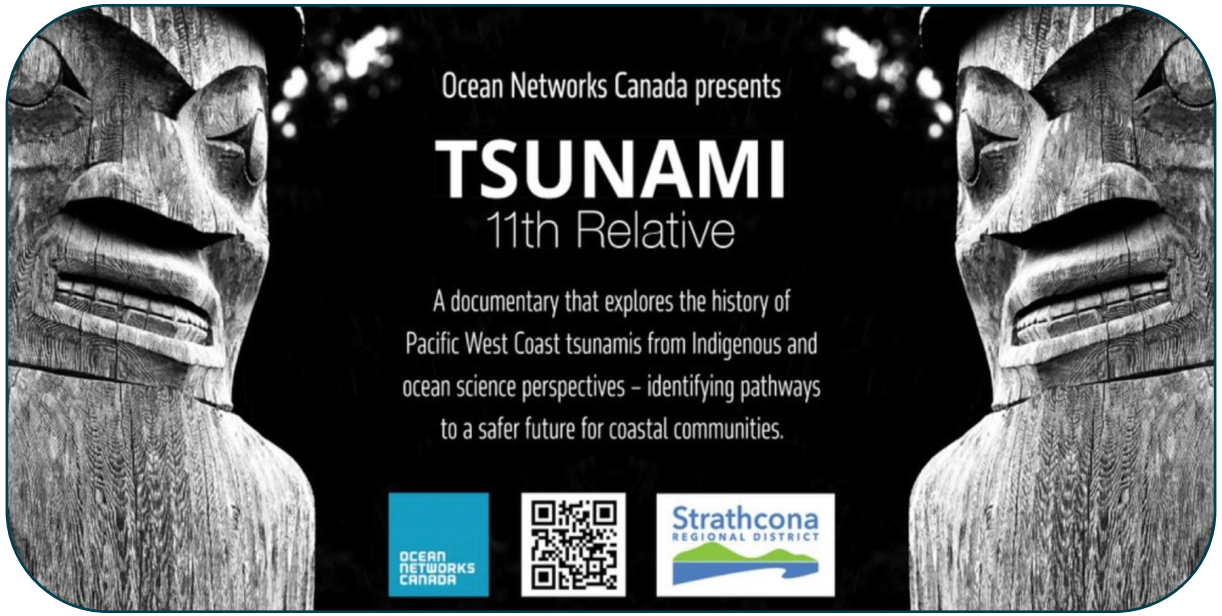
NSERC CRSNG
PromoScience

Co-creating and sharing knowledge



Story Maps (Iqaluit Community Fishers)

Documentary capturing Indigenous knowledge of tsunamis



Learning & Community Engagement Team

Leadership



Community-Based Monitoring

Formal & Informal Education

Indigenous Engagement

Ocean Networks Canada - Successful Practices

- Engage early and often
- Embrace priorities identified by communities and their leaders
- Support Indigenous-led projects
- Share funding equitably
- Hire staff dedicated to engagement
- Co-create and share knowledge
- Respect Indigenous knowledge systems
- Co-design programs, installations, data tools and services
- Design data services supporting Indigenous data sovereignty
- Secure organizational commitment and leadership support

Q & A

Break Out Discussion

- Give an example of a successful program or practice at your organization for building partnerships with Indigenous communities.
- Where could Indigenous partnerships enhance the work that you are doing?
- What areas would your organization need to develop its practices in order to build meaningful partnerships with Indigenous communities?

Discover the Ocean.
Understand the Planet.

Observations Coordination Group:
ONC's FAIR and CARE Principles in Action and Indigenous Data Sovereignty

Sean Tippett (https://orcid.org/0000-0002-9307-3596) | 2024-05-14

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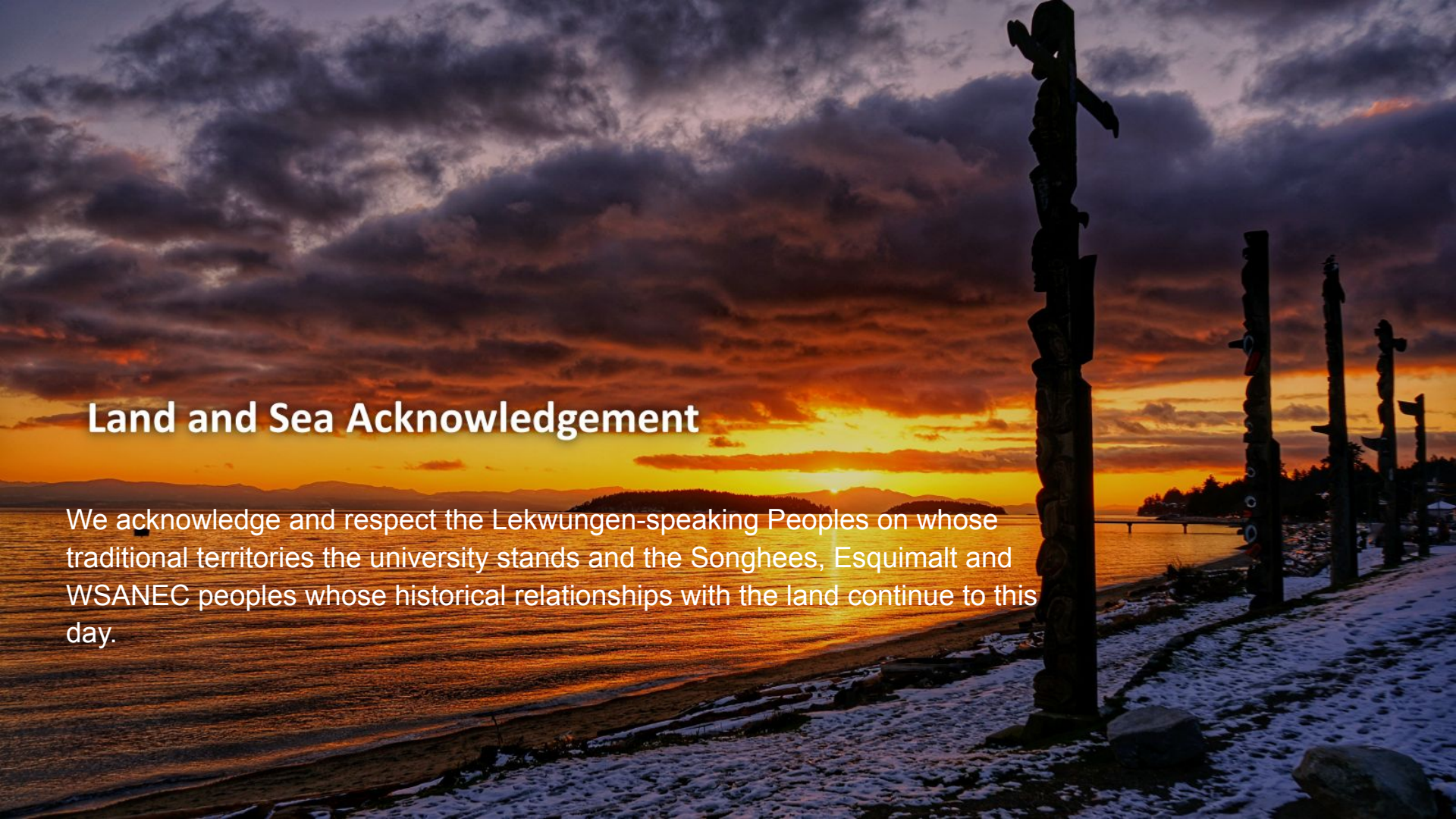

Land and Sea Acknowledgement

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Table of Contents


OCEAN NETWORKS CANADA
COMMUNITY OBSERVATORIES & INDIGENOUS PARTNERSHIPS
Gascoyne Inlet / Qikiqtaaluk Region
Kugluktuk / Kitikmeot Region
Cambridge Bay / Kitikmeot Region
Iqaluit / Qikiqtaaluk Region
Prince Rupert / Ts'msyen Territory
Skeena River / Kitsumkalum Territory*
Kitamaat Village / Haisla Territory
Hartley Bay / Gitga'at Territory*
China Creek / Nuu-chah-nulth Territory
Campbell River / Ligwiłda'xw Territory
NEPTUNE / Nuu-chah-nulth Territory
Snuneymuxw First Nation*
Burrard Inlet / Tsleil-Waututh First Nation*
University of Victoria
VENUS / Coast Salish Territory
T'Sou-ke First Nation*
Nunatsiavut Government*
Hudson Bay
Holyrood Marine Institute*
Atlantic Ocean
Pacific Ocean
Community Fishers Mobile Asset
Community Partnership
Major Observatory
Community Observatory
Data Centre
Fibre-optic Cable
Community-led Project
0
Bathymetry (50 m contour lines)
-3500 m
N
W
E
S
AN INITIATIVE OF
University of Victoria
Ocean Networks Canada, an initiative of the University of Victoria, is actively seeking community input for this map. This is a living document and is supported by the Office of Indigenous Affairs.
Data Sources: Smith and Sandwell Terrain, USGS Cascadia DEM, National Geophysical Data Centre and NOAA (1999) Great Lakes Bathymetry
Datum: WGS84
Projection: Lambert Conformal Conic
Last Updated: 14 September 2023

FAIR and CARE Principles

FAIR (Guiding Principles)
https://www.go-fair.org/fair-principles/

- Ensuring (meta)data are Findable, Accessible, Interoperable, and Reusable

CARE (Principles for Indigenous Data Governance)
https://www.gida-global.org/care

- Promoting and partaking in Collective Benefit, Authority to Control, Responsibility, and Ethics

OCAP Principles

https://fnigc.ca/ocap-training/

- Striving for Indigenous Ownership, Control, Access, and Possession of their own information
- The training course helps researchers, stewards of indigenous data better understand historical injustices to communities due to power imbalance
- ONC staff are trained under this program and are OCAP Certified

- **Note** this does not include Inuit perspectives
  - Refer to National Inuit Strategy on Research (NISR) to inform partnership development

FAIR, CARE, and OCAP applied at ONC

1. Exploring methods for communities to use their own data that works for their needs
   a. Customizable Community Dashboards, SeaTube, Geospatial Map Depth Profiles

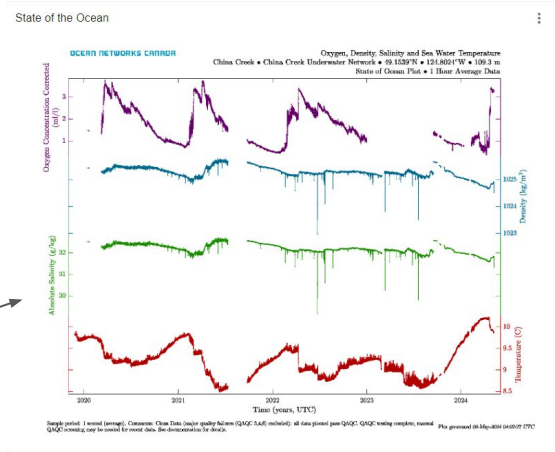
2. Ownership of (meta)data and the rights included are discussions to have
   a. Examples becoming more common of ONC as distributor and custodian only
   b. Open vs Open and Restricted Data Agreements

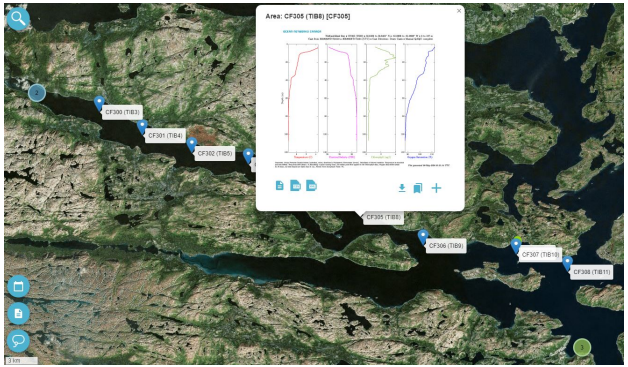
3. Building capacity in “community-led” research opportunities with the Community Fishers Program

4. Expanding the horizons of how one can find indigenous data
   a. Oceans 3.0, ERDDAP, CIOOS
   b. Licenses and policies, restrictions, interoperable controlled vocabularies

Managing Indigenous Data

- Oceans 3.0 Data Portal
  - Data Search
  - Plotting Utility
  - SeaTube (V3 and Pro)
- Dashboards
  - Widget based community views of data at your fingertips
- Geospatial Maps
  - Depth-series CTD casts available for ally participating community fishers





Citation

DOI Citation

Gitga'at First Nation, Ocean Networks Canada Society. 2023. Douglas Channel Conductivity Temperature Depth Deployed 2023-09-15. Ocean Networks Canada Society. https://doi.org/10.34943/42b13719-559e-475a-9848-fcd517bc91ae.

Data Links

Download data using Data Search
View device details for AML CTD Metrec X 50149
Download latest ISO 19115 XML metadata

Version History

DOI	Reason	DOI Generation Date
10.34943/42b13719-559e-475a-9848-fcd517bc91ae		2023-10-12 09:07:02.832

Publisher
Ocean Networks Canada Society

Publication Year
2023

Resource Type
One Deployment

Rights
Please refer to our data policy page https://www.oceannetworks.ca/data/data-policy/

Formats
mat txt pdf qaqc csv png json

Geolocations

geoLocationPoint	(53.421978, -129.246883)

Contributors

DataManager	Ocean Networks Canada Society
Distributor	Ocean Networks Canada Society

Related Identifiers

+ ADD RELATED IDENTIFIER

Related Identifier Type	Relation Type	Resource Type	Related Identifier	Status	Actions
No data					

lentifier>

ISO 19115 RoleCode

	Concept name (English)	Code	Definition
	CI_RoleCode		**function performed by the responsible party**
1.	resourceProvider	resourceProvider	party that supplies the resource
17.	rightsHolder	rightsHolder	party owning or managing rights over the resource
18.	contributor	contributor	party contributing to the resource
19.	funder	funder	party providing monetary support for the resource
20.	stakeholder	stakeholder	party who has an interest in the resource or the use of the resource

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DataCite

Fabrica

Ocean Networks Canada's ERDDAP

Easier access to Ocean Network Canada's data

CIOOS

CANADIAN INTEGRATED
OCEAN OBSERVING SYSTEM

Policies and Licences

- ONC as a non profit organization applies an open data policy by default

https://www.oceannetworks.ca/data/data-policy/

- Current Licence agreements in-use at ONC with our partners:
  - Creative Commons Attribution International 4.0
  - Creative Commons Attribution International Non Commercial 4.0

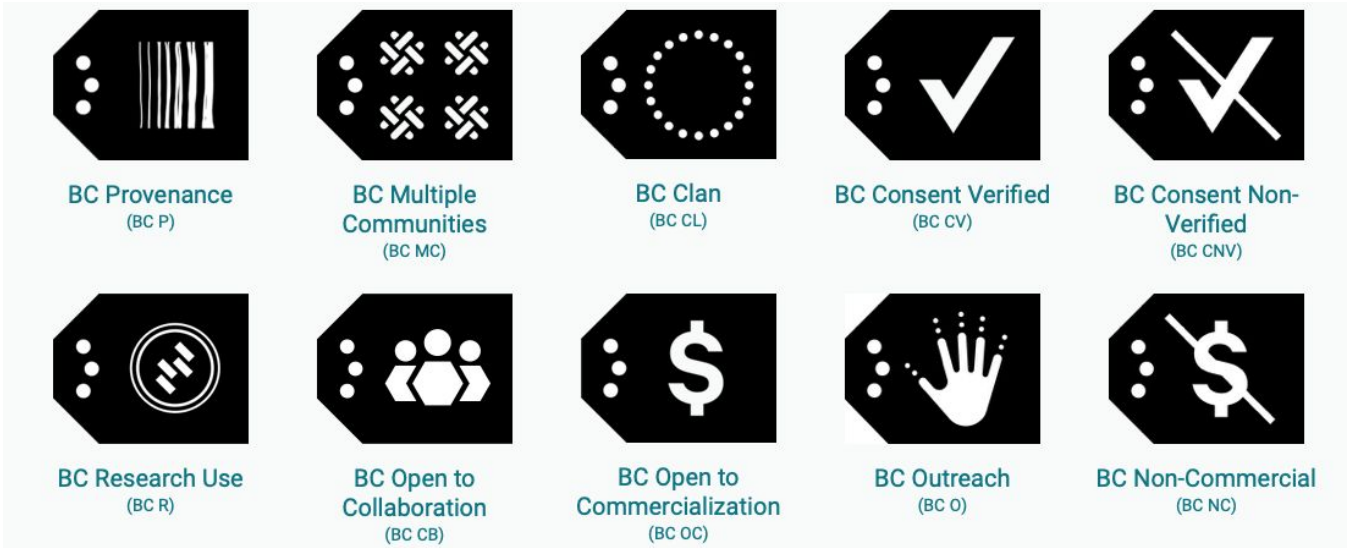
- Restrictions may apply with respect to datasets considered sensitive to communities

- Licences are informed by the international standard SPDX License List
  - It's an open discussion to have if a partner approaches with Intentions to use another license policy found here

https://spdx.org/licenses/

Beyond Licenses - Interoperable Indigenous Data Sovereignty

- Local Contexts - Biocultural (BC) Labels and Traditional Knowledge (TK) Labels
  - Putting the power into communities' hands through ability to create, edit, maintain, and dictate what can be done with their data
  - Machine-readable API makes interoperability a possibility for embedding into metadata
  - ONC will be exploring implementing labels into our metadata profile as a way to support indigenous ownership and control over their resources

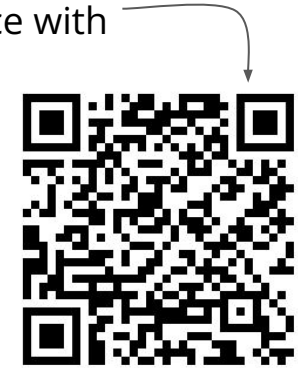


Advancing Indigenous Data Governance

1. **Local Contexts - further improvements and growing pains**
   a. Basically the only option for interoperability in indigenous data governance with instruction from DataCite on how to implement into their standards

   b. Will look into working together with Local Contexts to see what works well and what needs improvement

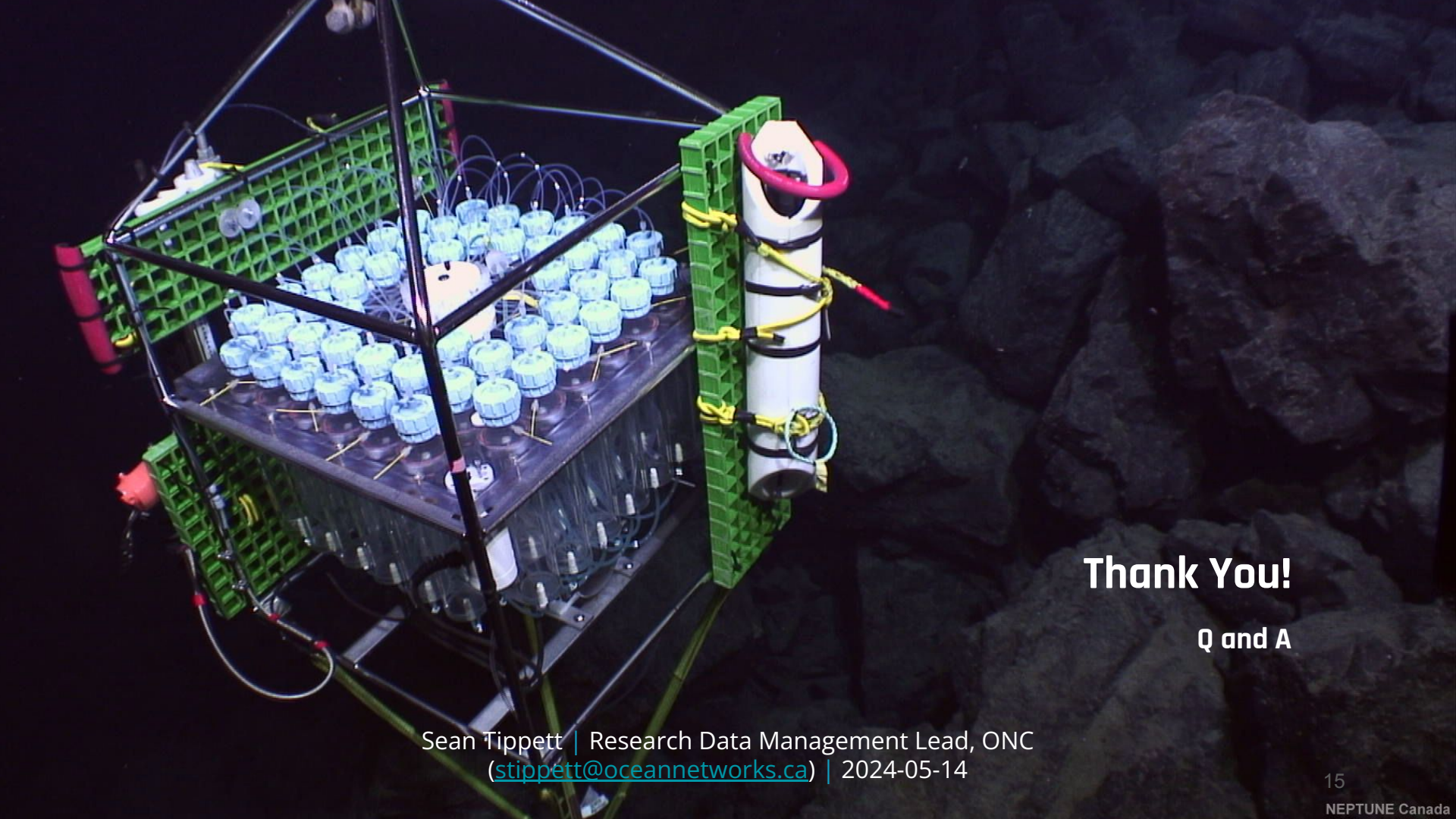
   c. One idea is to request Digital Keyboards be supported in Labels so Communities can list their name using their local language



2. **Making Licensing interoperable at ONC**
   a. Our ONC Data Policy is currently hardcoded into our datasets

   b. As our partnerships expand there may be datasets that do not fall under this generalization

   c. Work will be done to be able to assign licences directly to the dataset within the metadata



Thank You!

Q and A

Sean Tippett | Research Data Management Lead, ONC
(stippett@oceannetworks.ca) | 2024-05-14

Breakout Questions:

- What are some ways to represent indigenous rights and/or interests in data? What do you look for in terms of legal tools? Extralegal assertions or expressions?

- What are the hurdles preventing institutions from relinquishing power over to their indigenous data partners? What are some solutions we can explore to make partnerships community-driven and equitable?

CIOOS
CANADIAN INTEGRATED OCEAN OBSERVING SYSTEM

SIOOC
SYSTÈME INTÉGRÉ D'OBSERVATION DES OCÉANS DU CANADA

Canada's home for ocean observing data

Brad deYoung, Maxence St-Onge and Shayla Fitzsimmons

May 2024

Funded by : MEOPAR · Fisheries and Oceans Canada · Pêches et Océans Canada · OCEAN NETWORKS CANADA

Questions and considerations

CIOOS
CANADIAN INTEGRATED OCEAN OBSERVING SYSTEM

SIOOC
SYSTÈME INTÉGRÉ D'OBSERVATION DES OCÉANS DU CANADA

- How should CIOOS better support access to ocean data?
- What are the critical real-time needs and opportunities to provide information services?
- How might CIOOS support Arctic observing?
- Are there opportunities for connection and support between CIOOS and OCG?
- How could GOOS and CIOOS collaborate better? Are there particular projects, for example under the Ocean Decade, for connection?
- How best can/should CIOOS support GTS/WIS2?

Founded Through Collaboration

CIOOS ATLANTIC

OCEAN FRONTIER INSTITUTE

MEMORIAL UNIVERSITY

DALHOUSIE UNIVERSITY

MARINE INSTITUTE

CIOOS PACIFIC

COINAtlantic
COASTAL AND OCEAN INFORMATION NETWORK

OCEAN TRACKING NETWORK

University of Victoria

Hakai
Science on the Coastal Margin

OCEAN NETWORKS CANADA

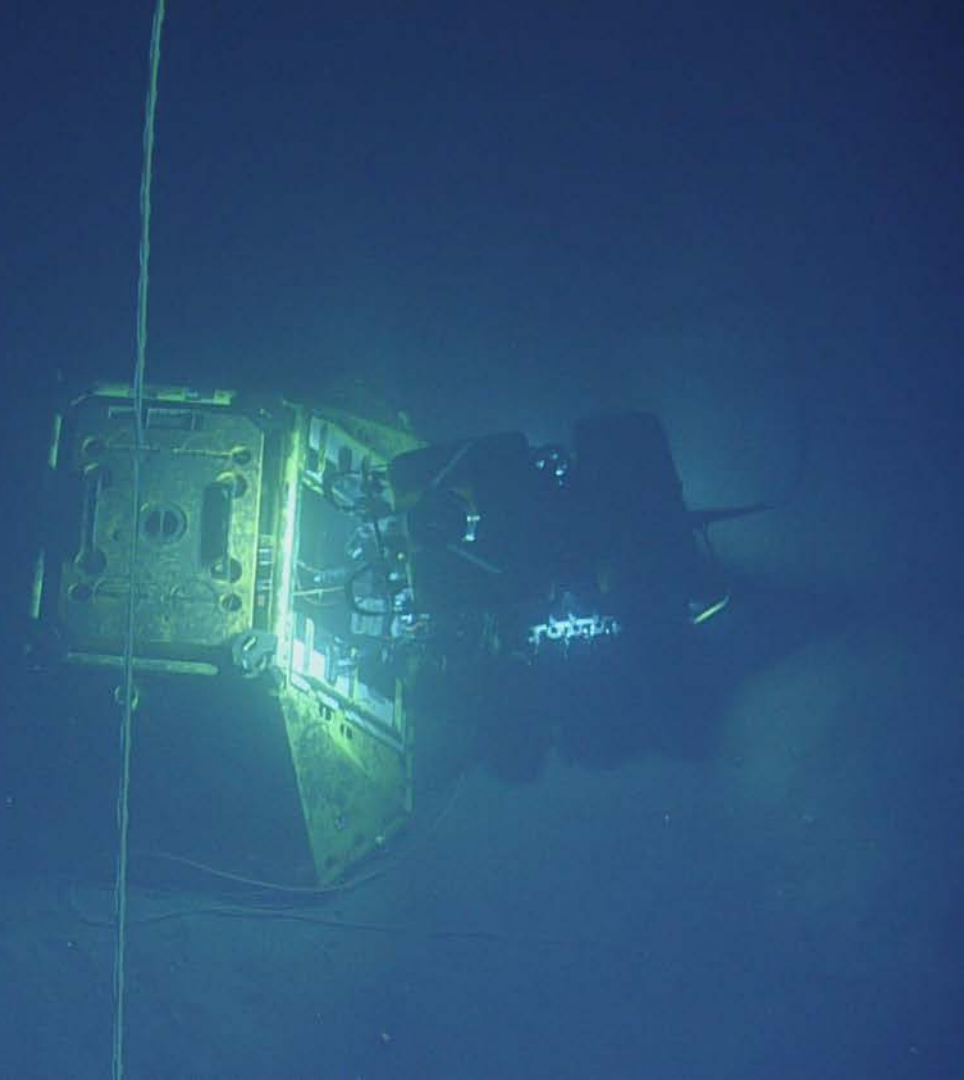
SLGO.ca
St. Lawrence Global Observatory

North American Collaboration

Ocean Observing Systems Around The World

How are we doing?

- 1775+ datasets
- 100+ partner organizations
- 23 data applications
- EOVs in alignment with GOOS
    - Integrating biological + model data

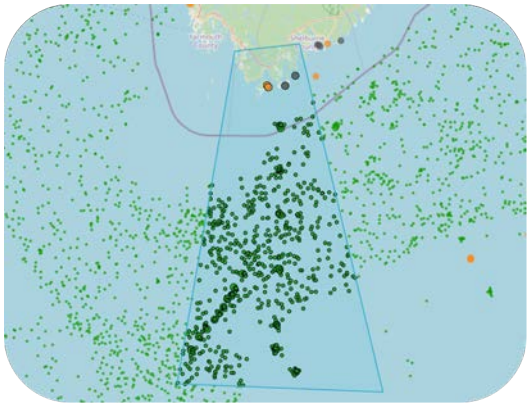


What are we accepting?

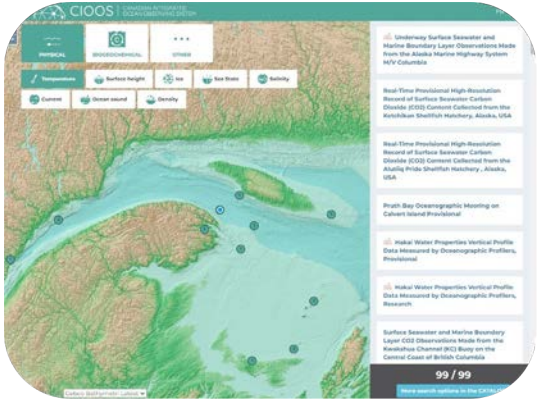
Metadata Entry Tool

- Ensures required fields are completed and does automatic translations
- Added features for region selection, bilingual translations

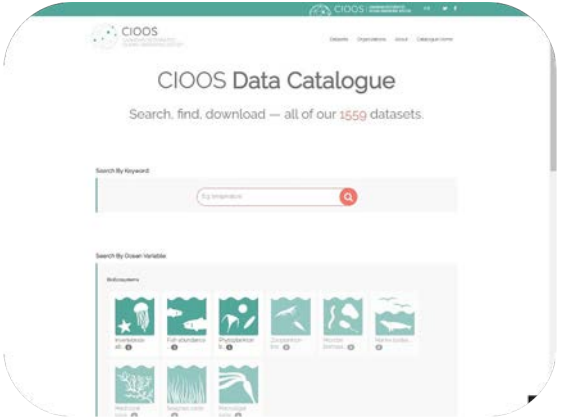
Data Exploration Tools



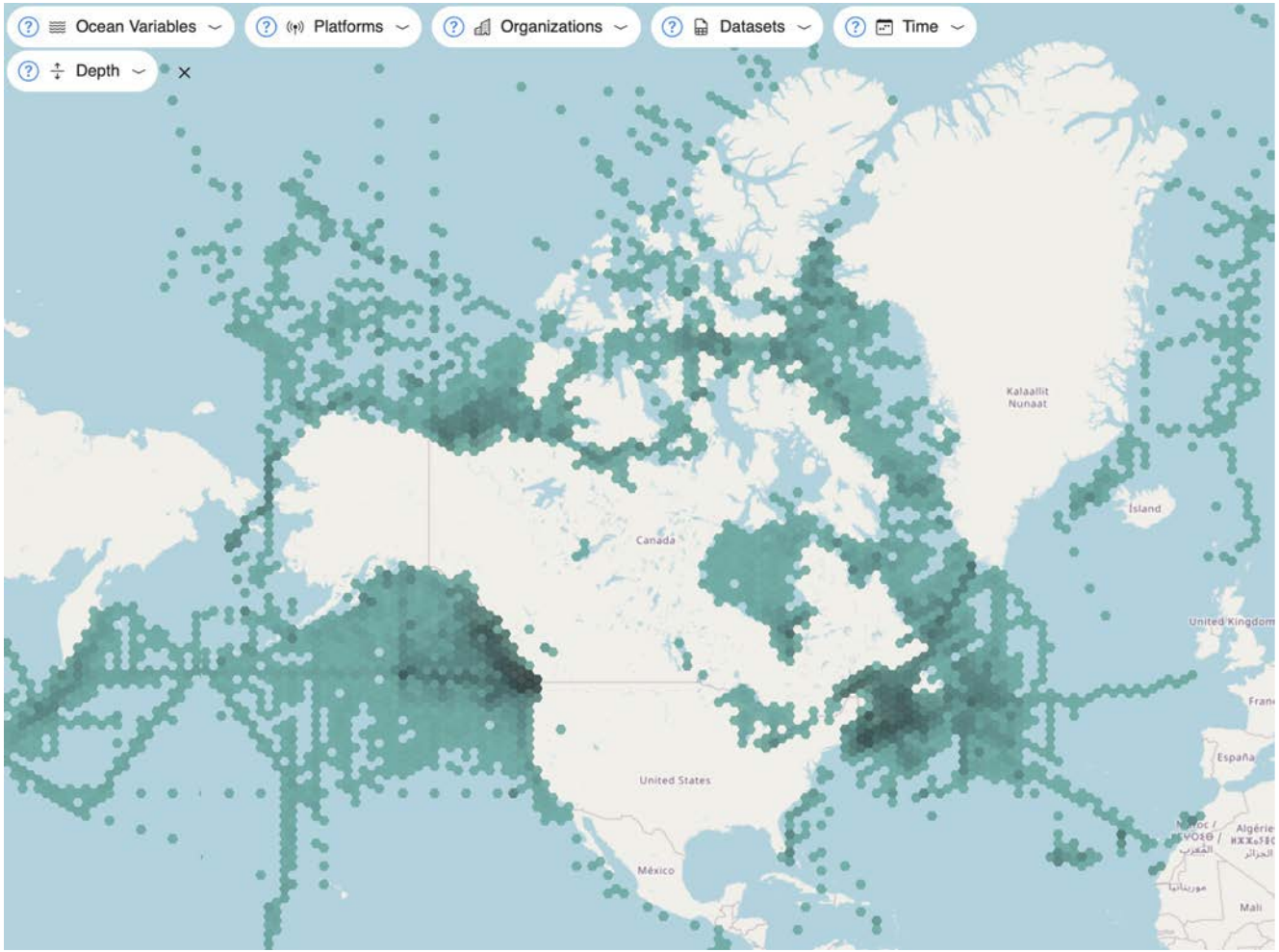
Data Explorer



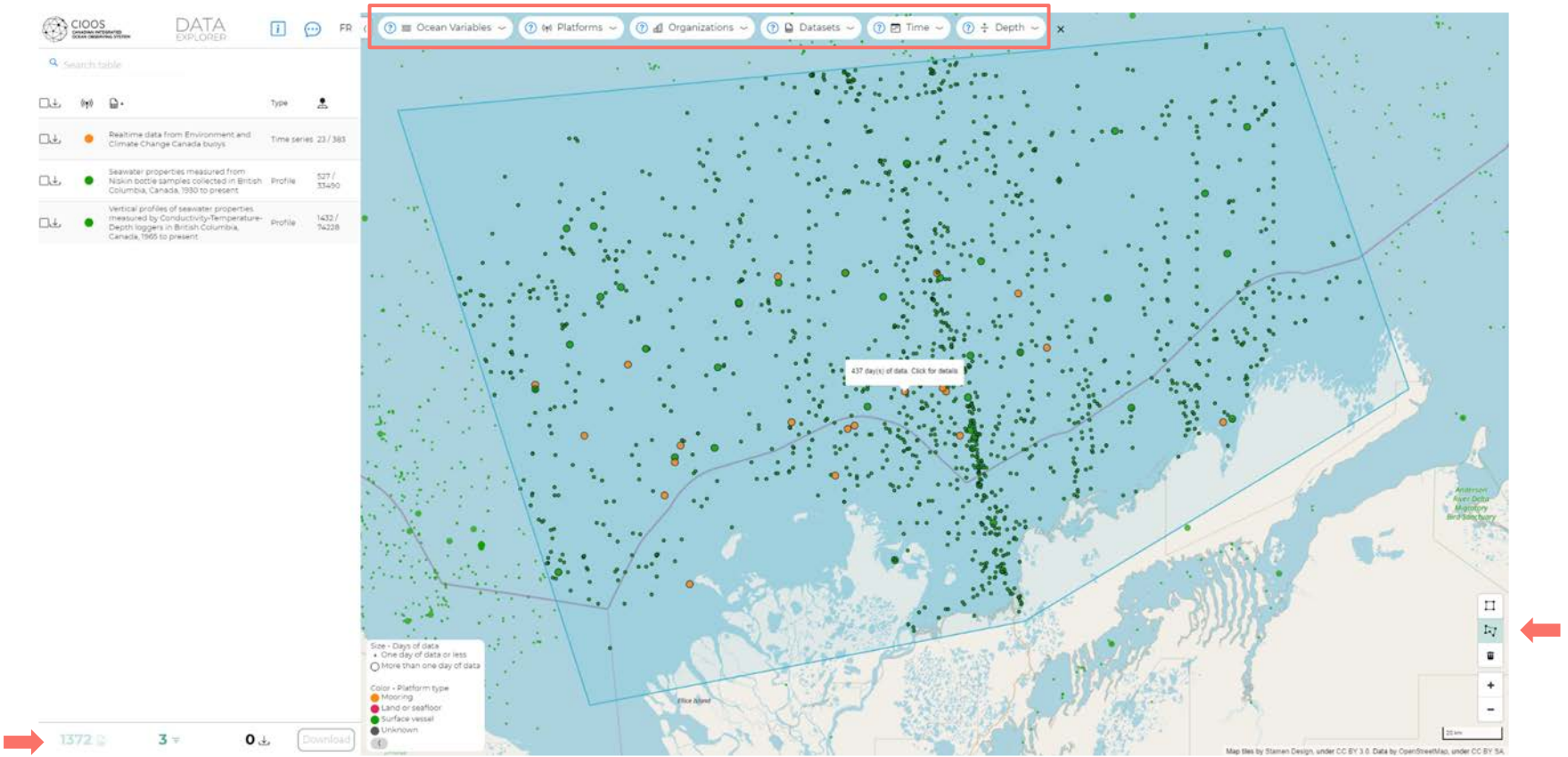
Catalogue Map



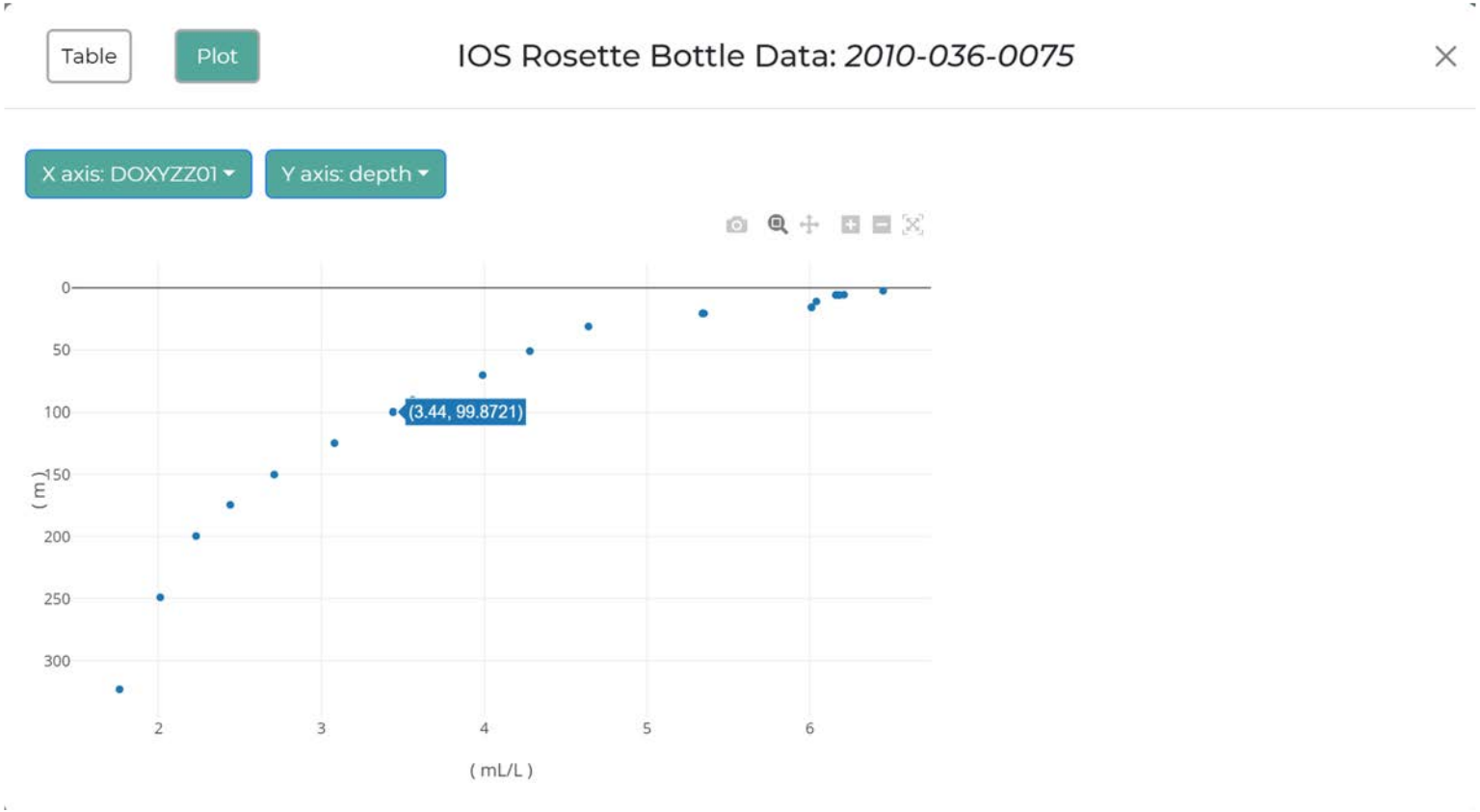
Data Catalogue


Ocean Variables
Platforms
Organizations
Datasets
Time
Depth
Kalaallit Nunaat
Ísland
Canada
United Kingdom
España
United States
México
Mali

Data Explorer - Discovery



Data Explorer - Data Preview



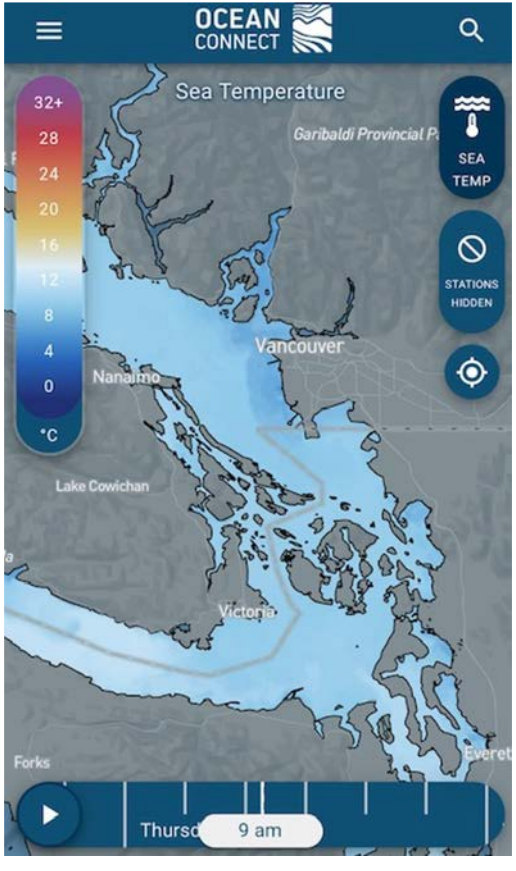
Data Explorer Improvements

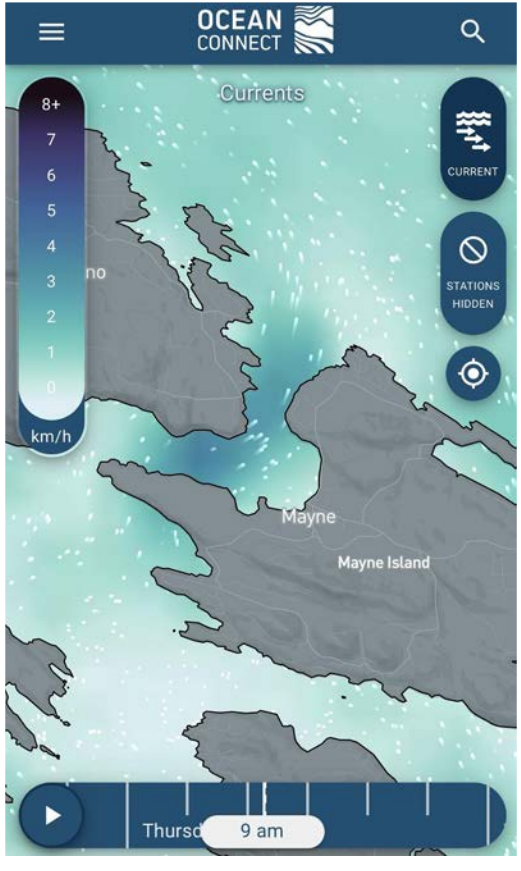
- New ways to search
- Increased download limits
  - Email download link: 100 MB ⇨ 1 GB
  - If > 1 GB, download direct from ERDDAP
- Search parameters creates URL
- Dataset highlight on hover
- Quick filters for common searches
- Search and sort tables
- MORE DATA!

CIOOS PACIFIC
REGIONAL ASSOCIATION OF THE
CANADIAN INTEGRATED OCEAN OBSERVING SYSTEM

Ocean Connect

A *New Information Service*



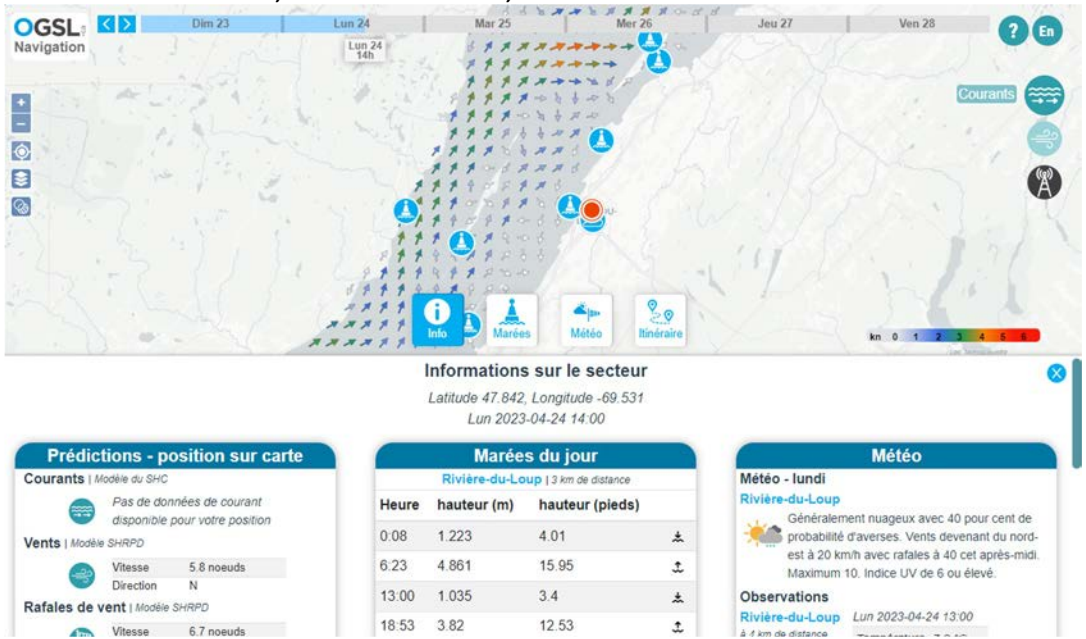


- Provide information, not just data, to non expert users e.g. boaters, fishers, coastal communities, …
- Information provided through a graphical interface, focus on phone users - simple and easy
- Offer layers of data - model, historical and station data
- Focus on ocean and atmosphere, new access to model data
- Initial focus on the Salish Sea

SLGO - Navigation app

Deployed in 2022, the **Navigation** web application is a boating aid tool on the St. Lawrence and displays current data, wind data, weather forecasts and tide data. Makes substantial use of ECCC model results

Web traffic in 2022: 16,500 visits for 4,500 users



- Users:
  - boaters, divers, kayakers and cruisers
- Ergonomics adapted to smart phones
- 1-5 day forecasts
- Route function

CIOOS ATLANTIC
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CANADIAN INTEGRATED OCEAN OBSERVING SYSTEM

Atlantic Hurricane Dashboard

Hurricane Fiona (September 2022)

- Strongest (central pressure)
- Large-scale power outages
- Extensive damage

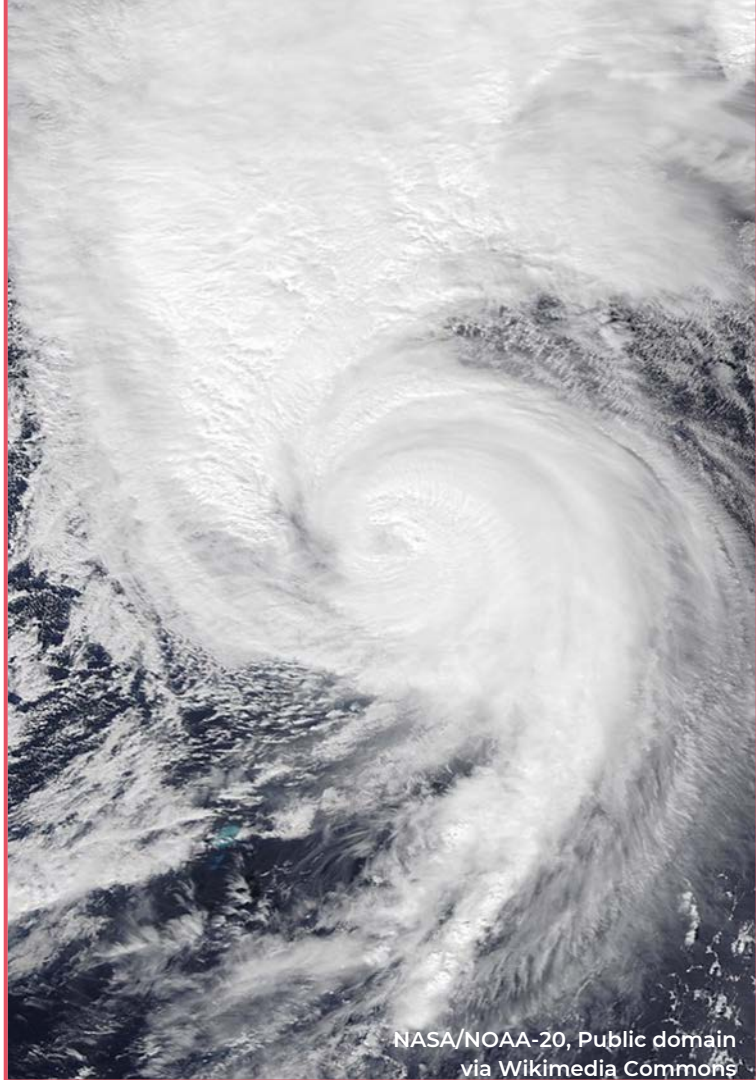
↓

Hurricane Dashboard

↓

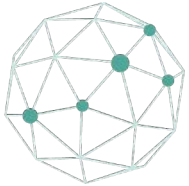
User Resource

- Background and history
- Historical storm details
- (Near) real-time data



NASA/NOAA-20, Public domain
via Wikimedia Commons

CIOOS
CANADIAN INTEGRATED OCEAN OBSERVING SYSTEM



SIOOC
SYSTÈME INTÉGRÉ D'OBSERVATION DES OCÉANS DU CANADA

Looking forward to Cycle 4 of CIOOS

- Strengthened National Office and presence
- Further development of societally directed information services
- Expansion of data holdings, making it easier to bring data to CIOOS
- Expanded regional, national and international partnerships
- Improve eases of access to and tracking use of data
- Engagement with GOOS and Ocean Decade related data activities

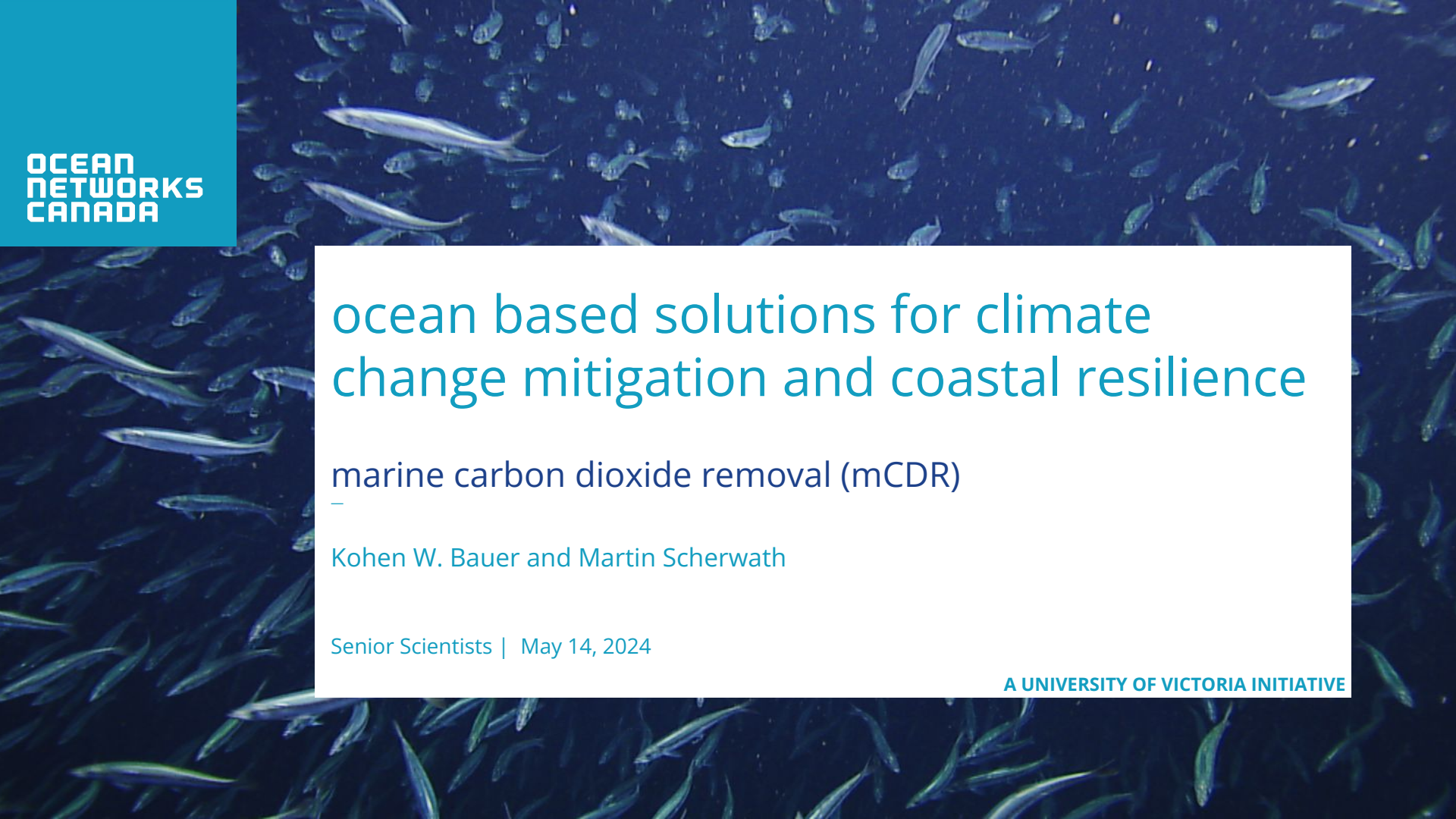

CIOOS
CANADIAN INTEGRATED OCEAN OBSERVING SYSTEM
SIOOC
SYSTÈME INTÉGRÉ D'OBSERVATION DES OCÉANS DU CANADA

Questions and considerations

CIOOS
CANADIAN INTEGRATED OCEAN OBSERVING SYSTEM

SIOOC
SYSTÈME INTÉGRÉ D'OBSERVATION DES OCÉANS DU CANADA

- How should CIOOS better support access to ocean data?
- What are the critical real-time needs and opportunities to provide information services?
- How might CIOOS support Arctic observing?
- Are there opportunities for connection and support between CIOOS and OCG?
- How could GOOS and CIOOS collaborate better? Are there particular projects, for example under the Ocean Decade, for connection?
- How best can/should CIOOS support GTS/WIS2?



OCEAN NETWORKS CANADA

ocean based solutions for climate change mitigation and coastal resilience

marine carbon dioxide removal (mCDR)

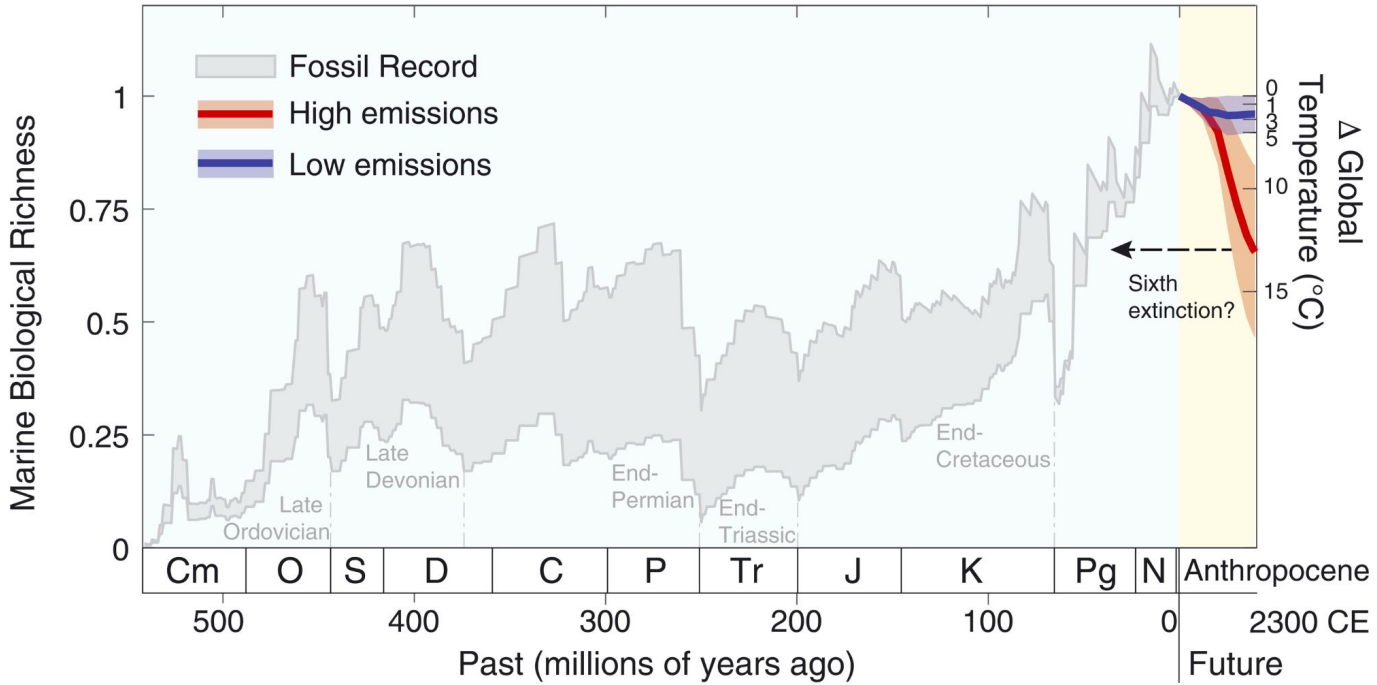
Kohen W. Bauer and Martin Scherwath

Senior Scientists | May 14, 2024

A UNIVERSITY OF VICTORIA INITIATIVE

adverse impacts from human caused climate change

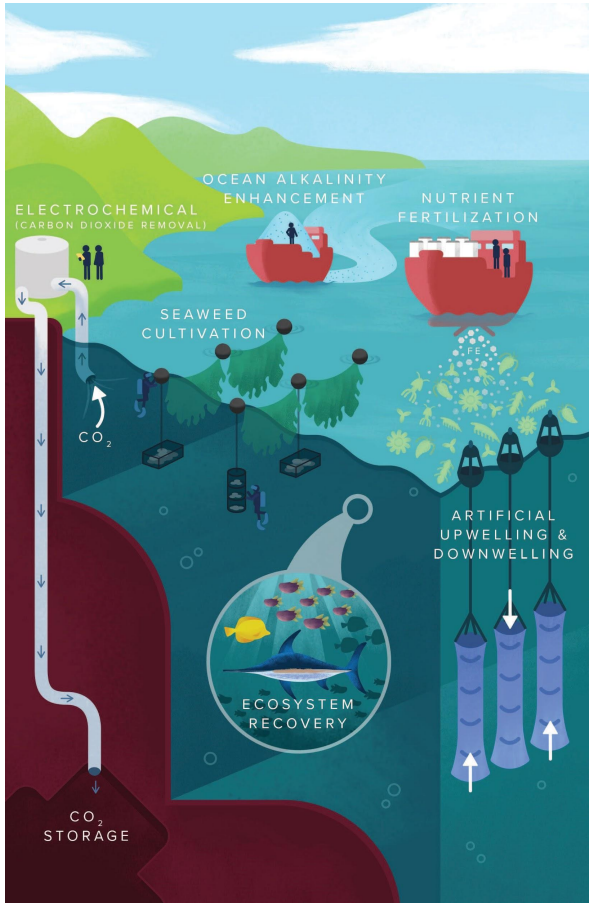
"Avoiding ocean mass extinction from climate warming"



A typical emissions scenario consistent with a **50% chance of limiting global mean surface warming to 1.5°C** envisions extremely rapid reductions in emissions ***as well*** *as* gigaton scale CDR.

SOURCE: Penn and Deutsch (2022), Science

the NASEM report - ocean based CO_2 removal



The NASEM 2022 report outlined 6 mCDR approaches with high potential to contribute to climate stabilization

1) Electrochemical CO_2 removal

2) Ocean Alkalinity enhancement (OAE)

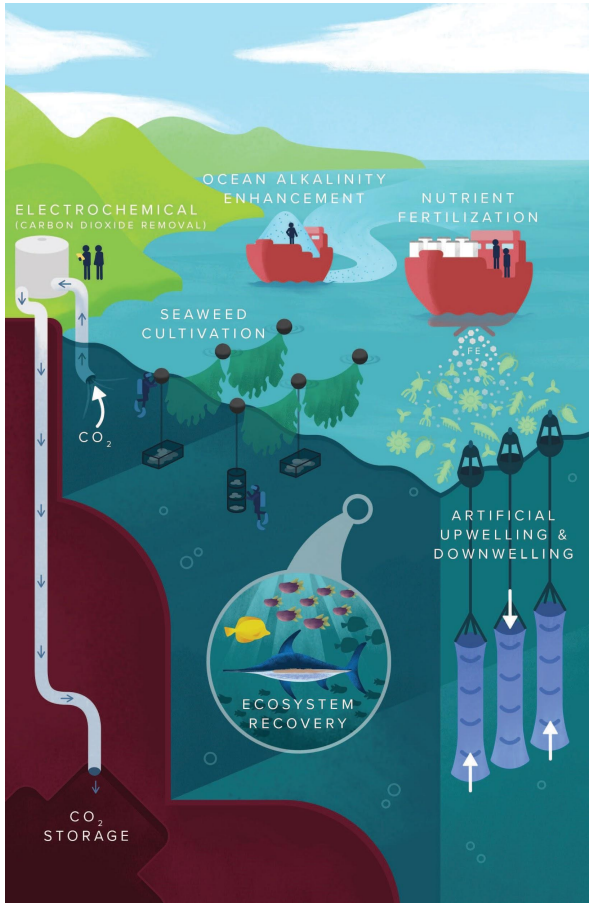
3) Nutrient fertilization and augmentation of the biological carbon pump

4) Seaweed cultivation and biomass sinking

5) Artificial upwelling and downwelling

6) Ecosystem recovery

the NASEM report - ocean based CO_2 removal



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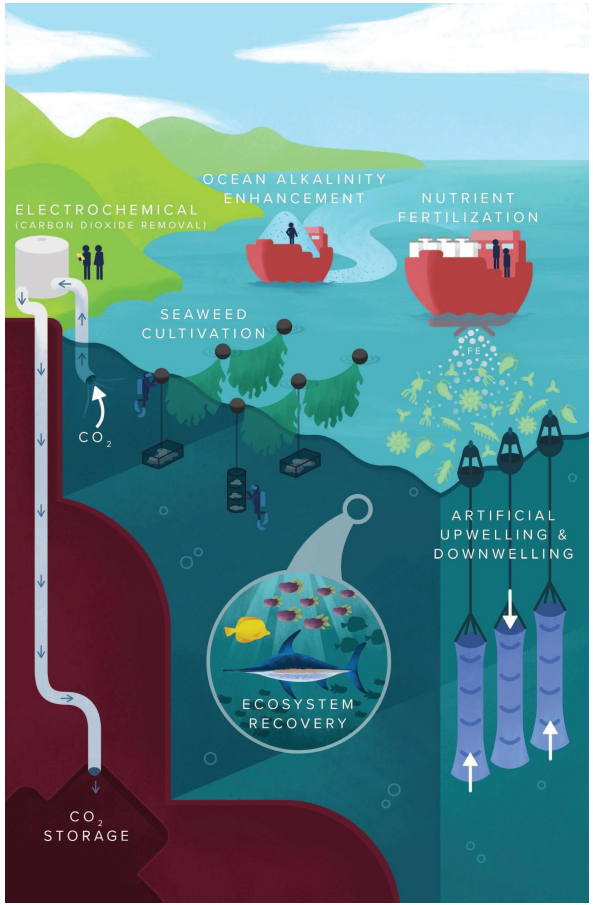
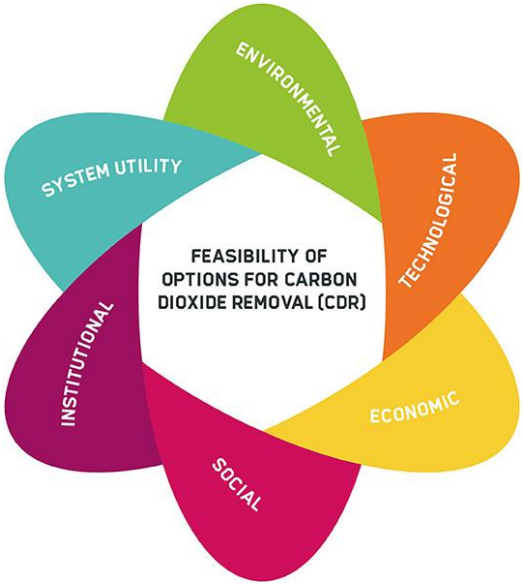
6) Ecosystem recovery

Monitoring, Reporting, and Verification (MRV)

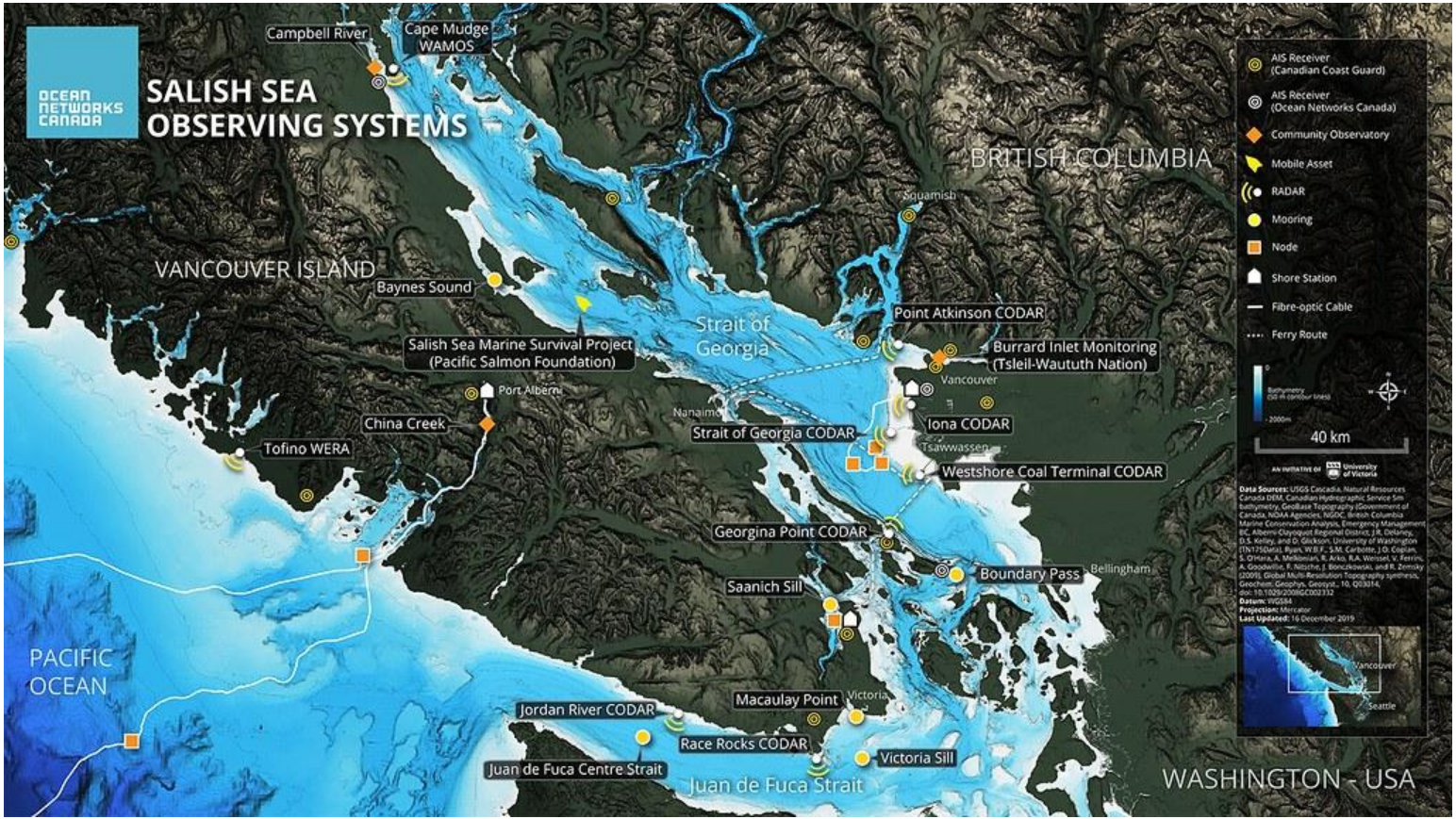




Quantifying the effectiveness and durability of marine carbon dioxide removal (mCDR) processes requires robust science for monitoring, reporting, and verification (MRV).

SOURCE: Förster et al., (2022), Palter et al., (2023)

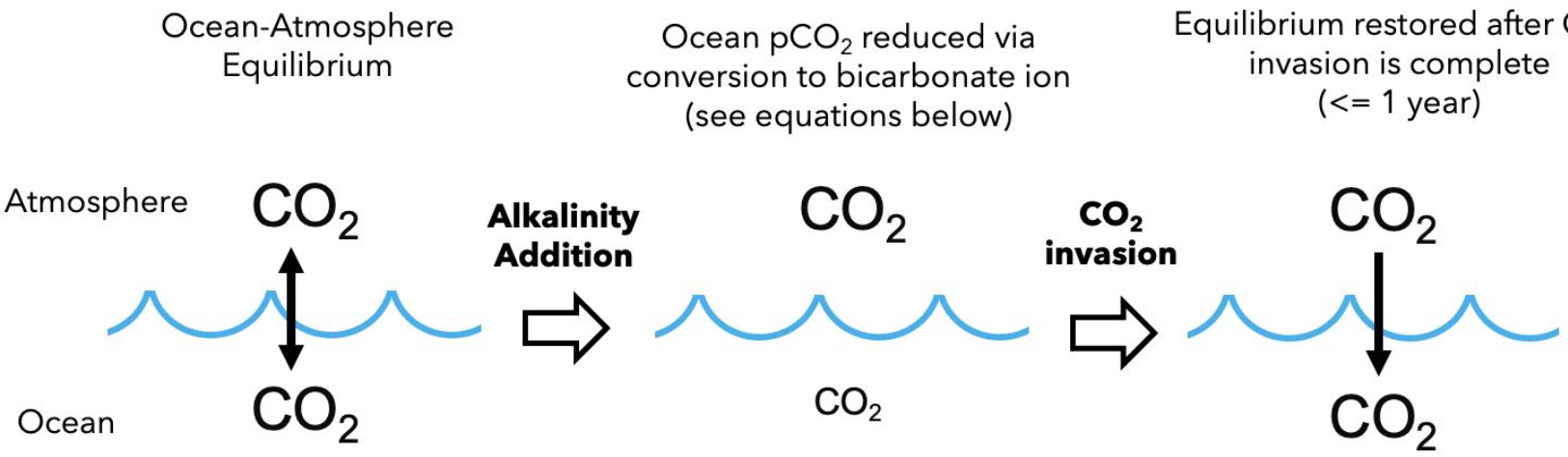
ONC observing assets key to mCDR - VENUS



ONC observing assets key to mCDR - coastal

- ocean alkalinity enhancement (OAE)
- ecosystem restoration
- seaweed cultivation

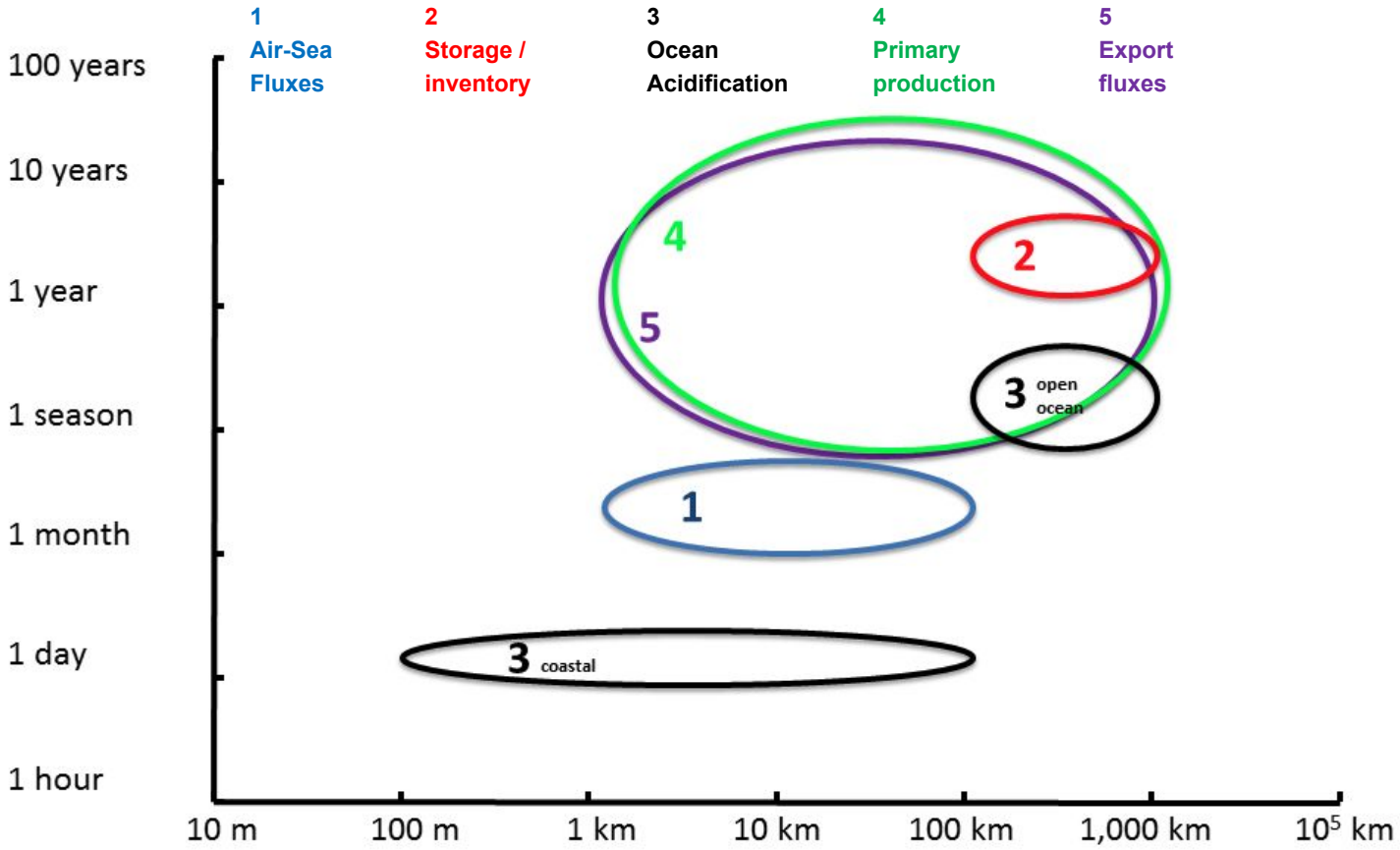
ocean alkalinity enhancement - point source addition



Simplified Equation: $OH^- + CO_2 \rightarrow HCO_3^-$

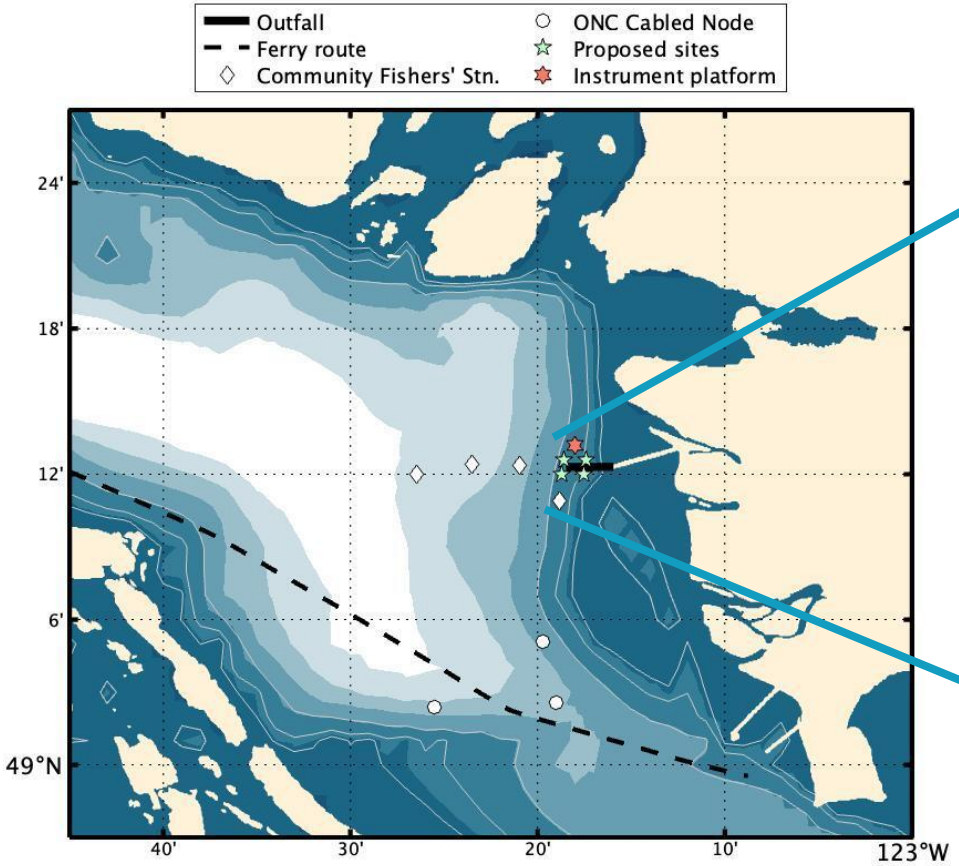
SOURCE: Planetary's MRV protocol → Basic chemistry of OAE by MH addition

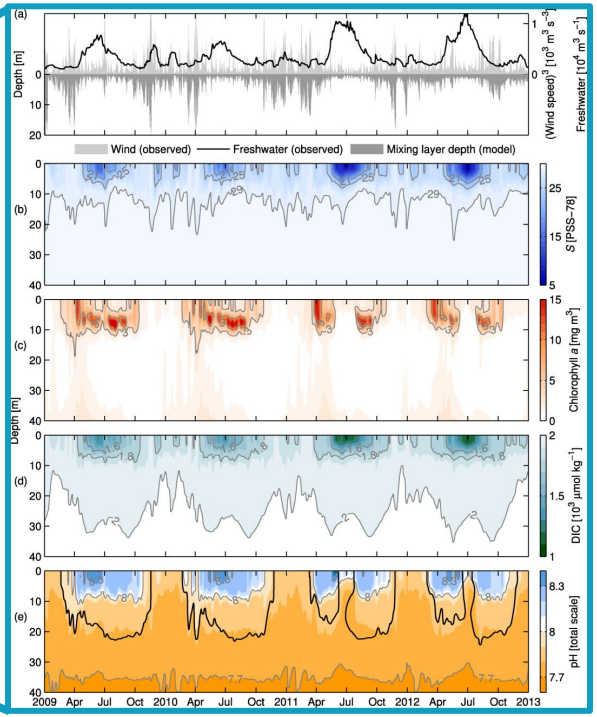
inorganic carbon (EOV) - spatiotemporal dynamics



SOURCE: GOOS Essential Ocean Variable (EOV): Inorganic Carbon

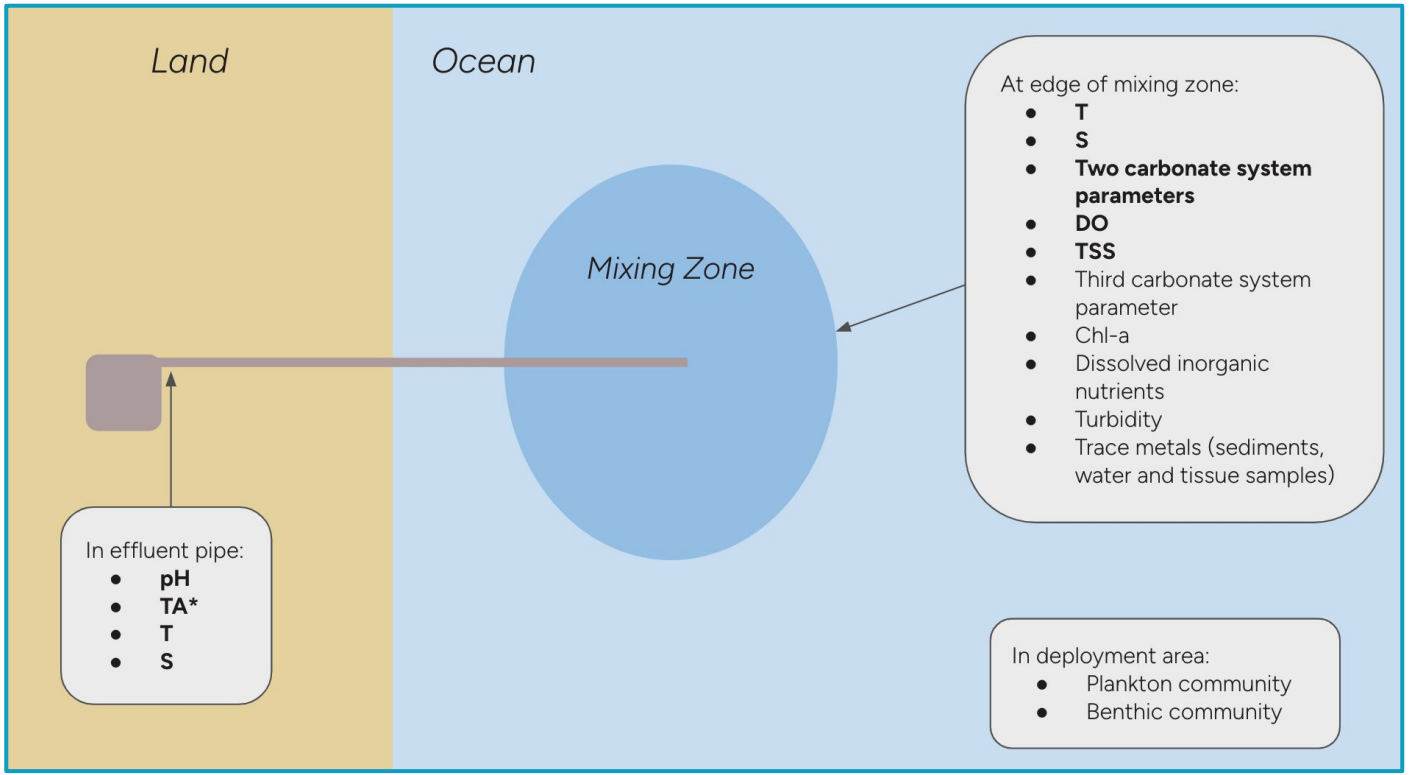
ocean alkalinity enhancement - ONC example





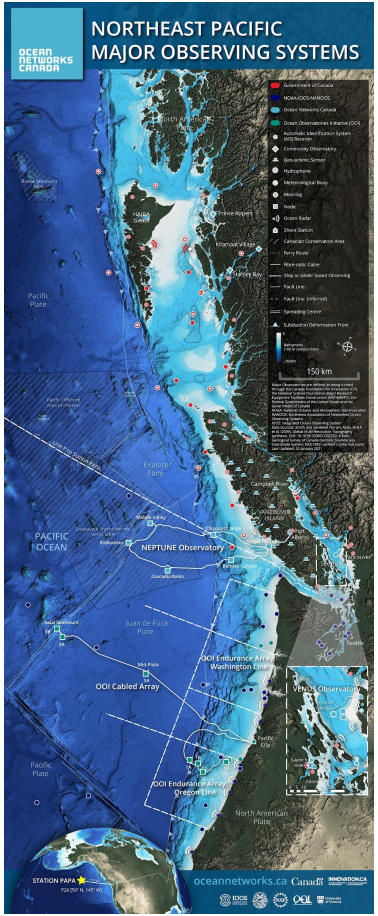
SOURCE: Moore-Maley et al., (2016)

Isometric OAE protocol - carbon removal registry



SOURCE: Ocean Alkalinity Enhancement from Coastal Outfalls v1.0 — Isometric (2024)

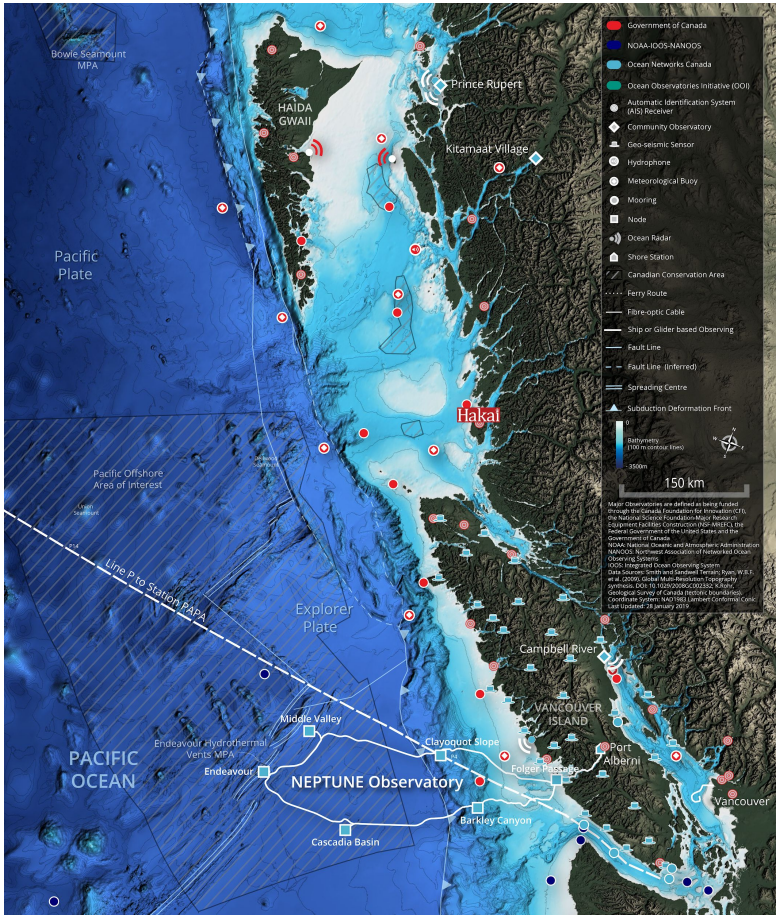
ONC observing assets key to mCDR - NEPTUNE

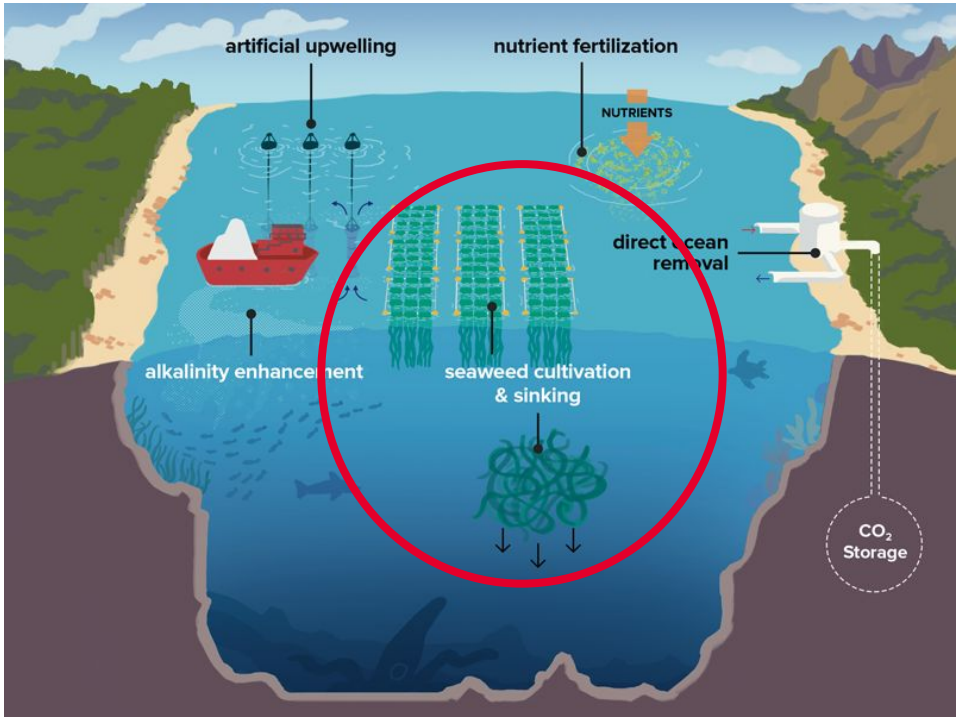


ONC observing assets key to mCDR - offshore

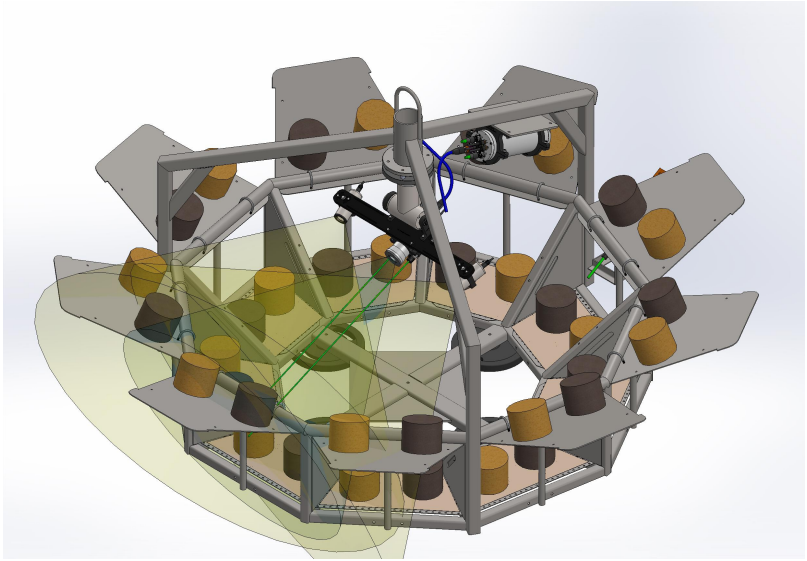
- artificial upwelling / downwelling
- nutrient fertilization
- seaweed cultivation and biomass sinking
- OAE

biomass sinking experiment - NEPTUNE



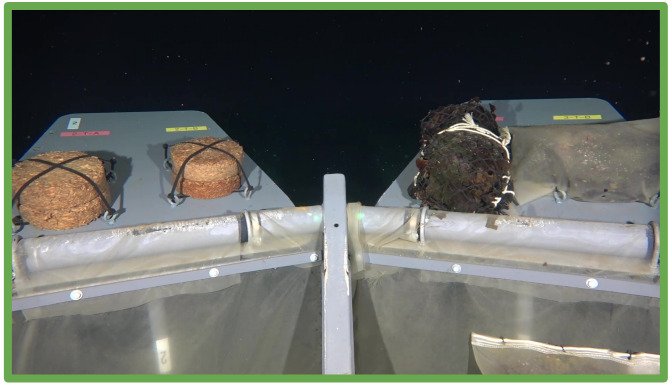


biomass sinking experiment - benthic ecosystem MRV

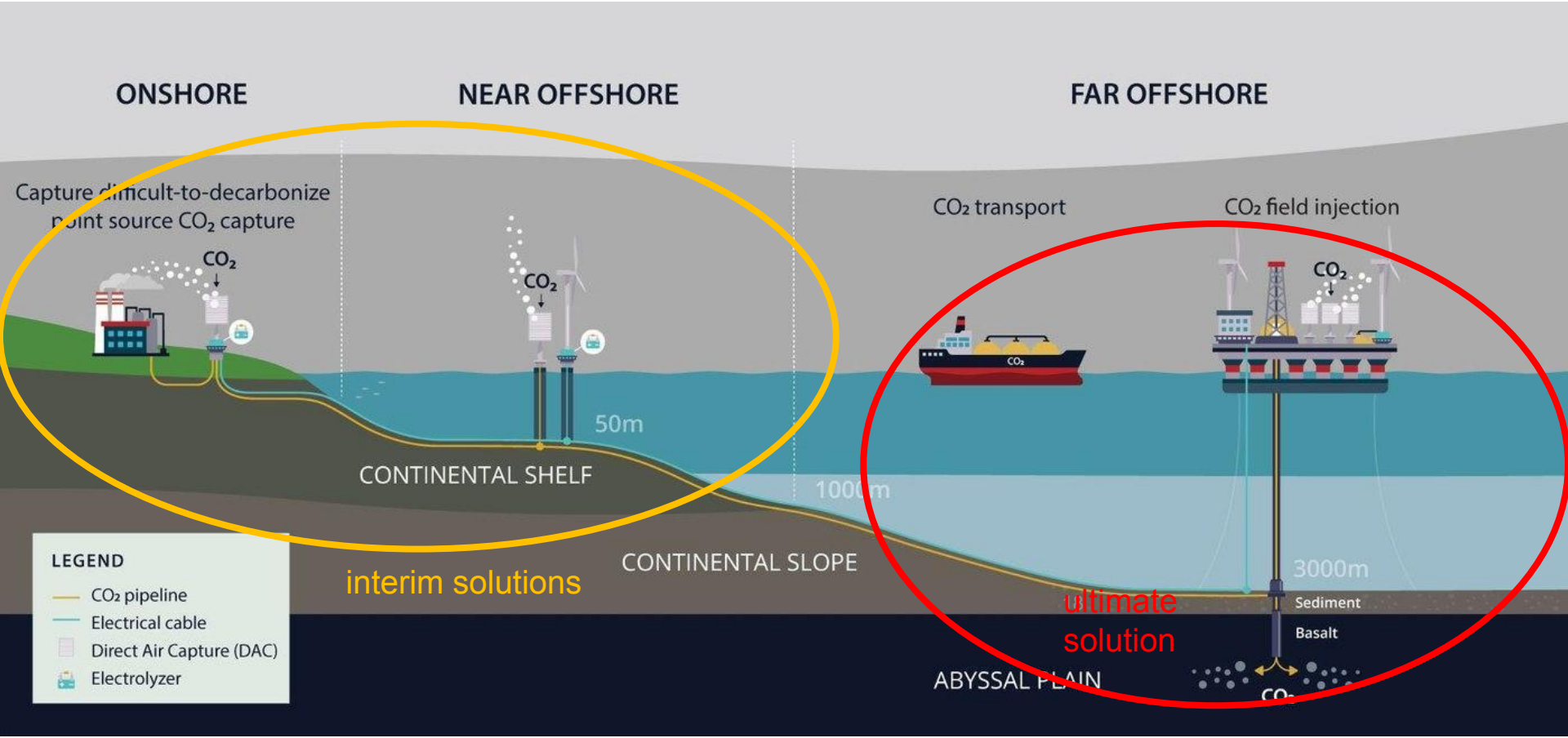


- Image the fate of sunken biomass during the experiment using camera systems
- Water and sediment samples for biogeochemical analyses
- Mass balance of biomass degradation over time
- Long-term changes in water properties

biomass sinking experiment - benthic ecosystem MRV



ocean-based CDR - below the seafloor



CO2 in ocean crust turns into solid carbonate rock

Global scalability

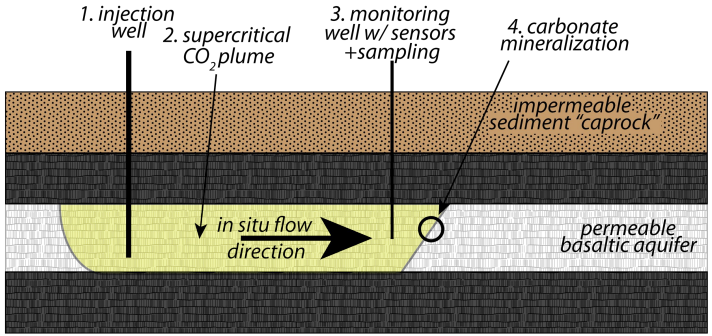
We are here

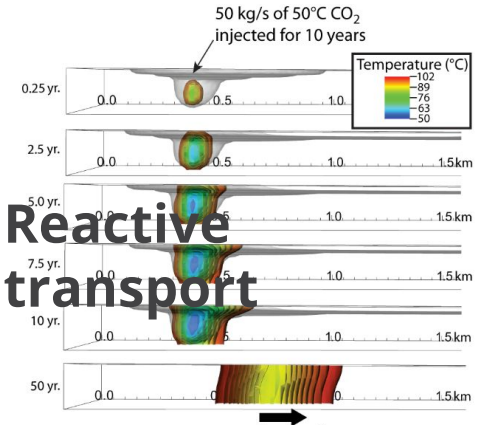
Cascadia Basin
Sequestration
Potential:
750 Gt CO_2

Global Sequestration
Potential:
>100,000 Gt CO_2

SOLID
CARBON

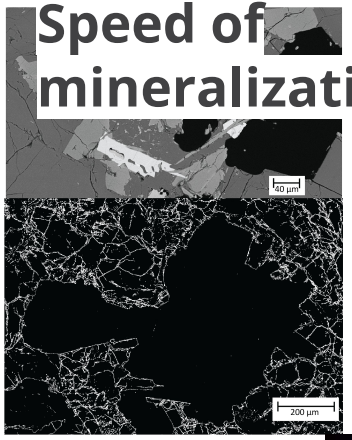
Solid Carbon Monitoring

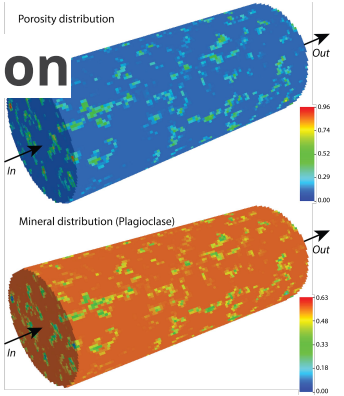




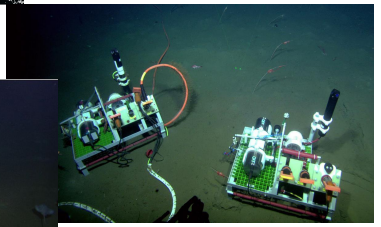
Reactive transport

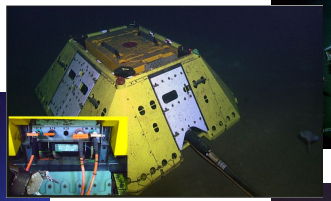
Speed of mineralization

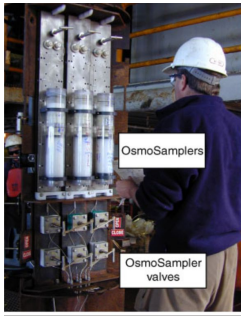


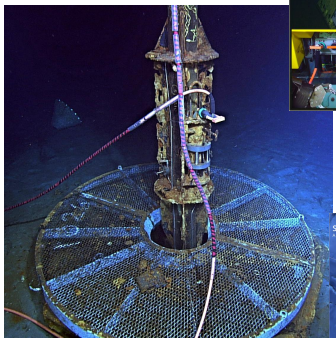


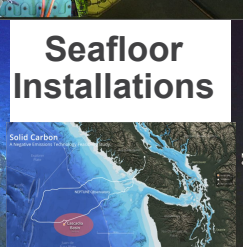
Conservative and reactive tracers



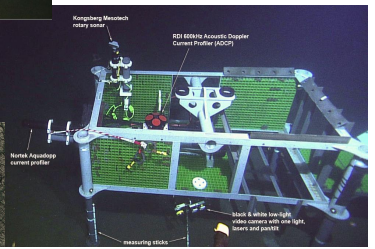




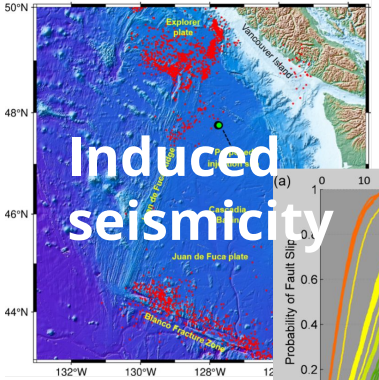


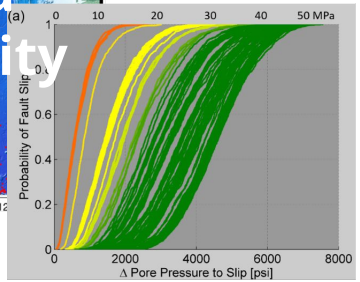


Seafloor Installations



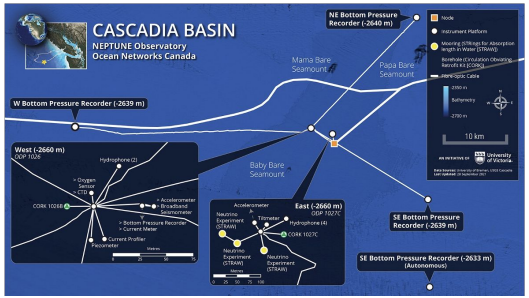
Induced seismicity





OCEAN NETWORKS CANADA

Monitoring Parameters



- **Existing**
  - Conductivity
  - Temperature
  - Pressure
  - O_2
  - Currents (incl. profiler)
  - Acoustics
  - Seismicity
  - CORK Borehole Properties
- **Proposed**
  - Bubble Sonars
  - Camera
  - Seismic Arrays
    - Autonomous Ocean Bottom Seismometers from NFSI
    - Fibre-optic Distributed Acoustic Sensing
  - Electromagnetics
  - Carbon Sensor (pCO_2)
- **Additional Options**

  Direct Tracer Detector (e.g. Fluorometer, Conductivity)

  Temperature Array

  Active Seismic Source (e.g. Sparker or Vibrator)

  Non-stationary Underwater Sensing (e.g. AUV plus Docking Station)

discussion topics

1. What is the **baseline** against which ocean carbon efforts are evaluated - how to approach this problem?

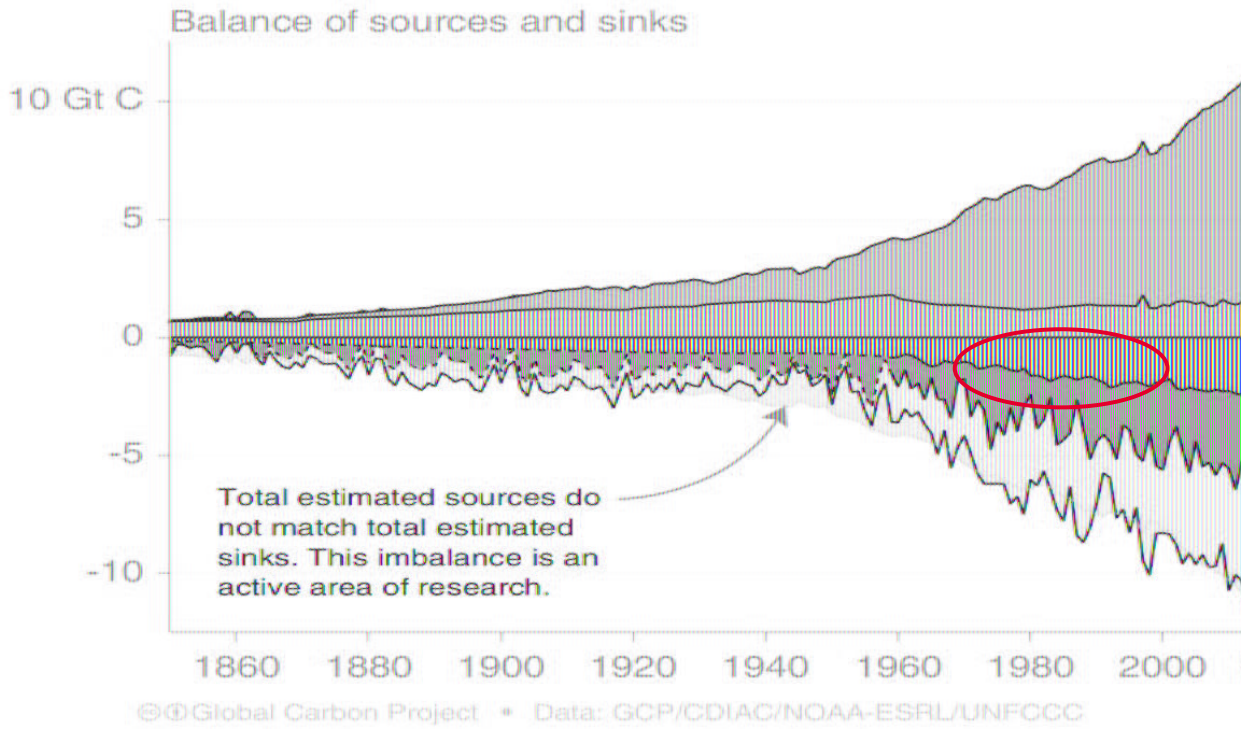
2. How is the principle of **EOVs** included in emerging carbon removal protocols?

3. What are key priorities in terms of **new sensor technology**?

- Mechanism to verify, collaboration, etc. Involvement of GOOS, private sectors, other groups?

- How, where, and in what form should mCDR data be made available?

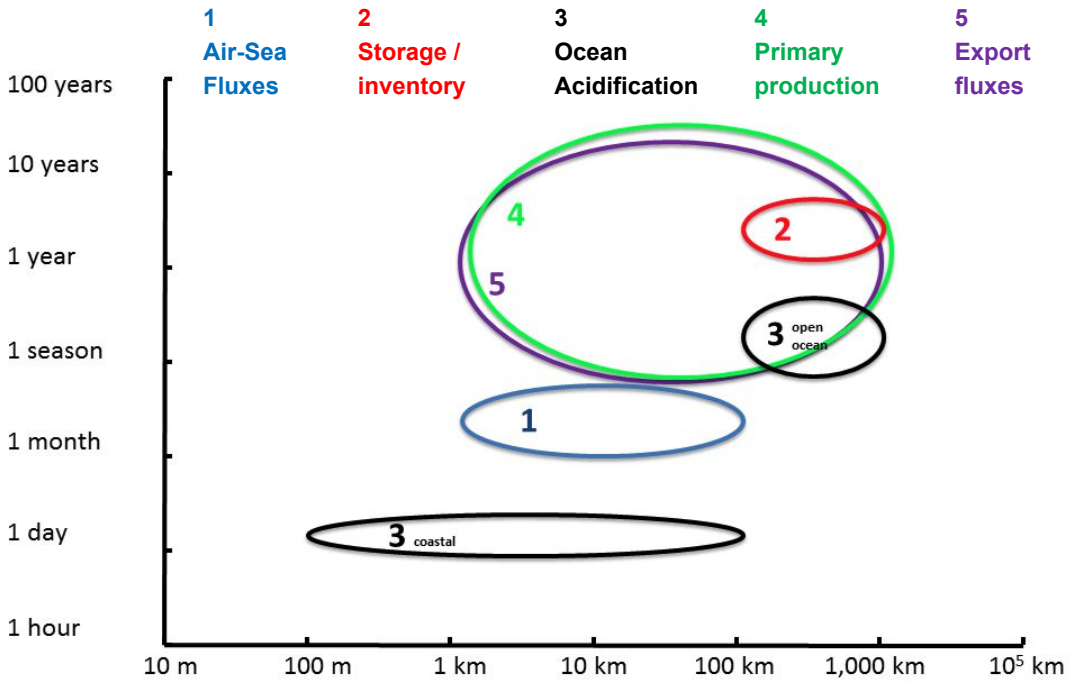
What is the baseline against which ocean carbon efforts are evaluated - how to approach this problem?

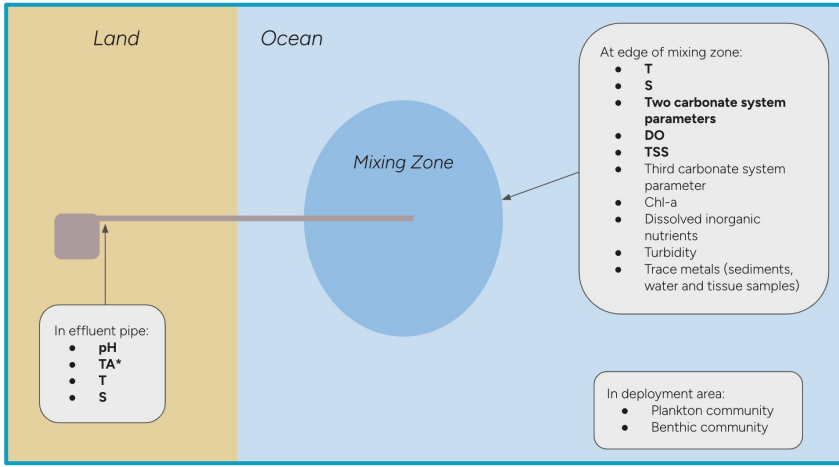


Reconstruction over time of the industrial period of human carbon emissions to the atmosphere from fossil fuel use and land-use change (positive fluxes), ocean and land sinks (negative fluxes), and atmospheric accumulation.

SOURCES: Friedlingstein et al., (2020) and Global Carbon Project, (2020)

How is the principle of EOVs included in emerging carbon removal protocols?





What are key priorities in terms of new sensor technology?