

# Cabled ocean observatories as tools for studying biodiversity change

*S. Kim Juniper, Ocean Networks Canada*

## OBSERVATORY AND TIME-SERIES STATIONS: NORTH PACIFIC



PICES 2014 Annual Meeting  
17-26 Oct. 2014 | Yeosu,  
Korea

# *Essential biodiversity variables*

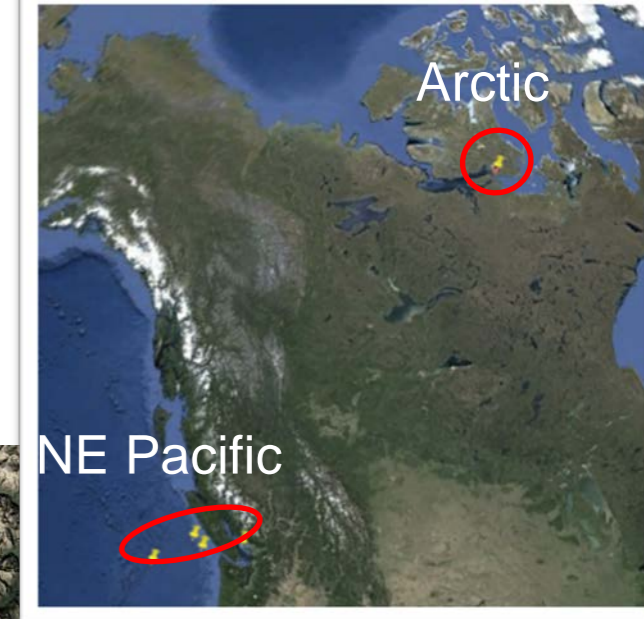
## *(EBVs)*

Standardized, global framework for detecting biodiversity change, based on scientific principles

EBV Category	Measurable with cabled observatory technology
Genetic composition	—
Species populations	**
Species traits	*
Community composition	**
Ecosystem function	*
Ecosystem structure	*

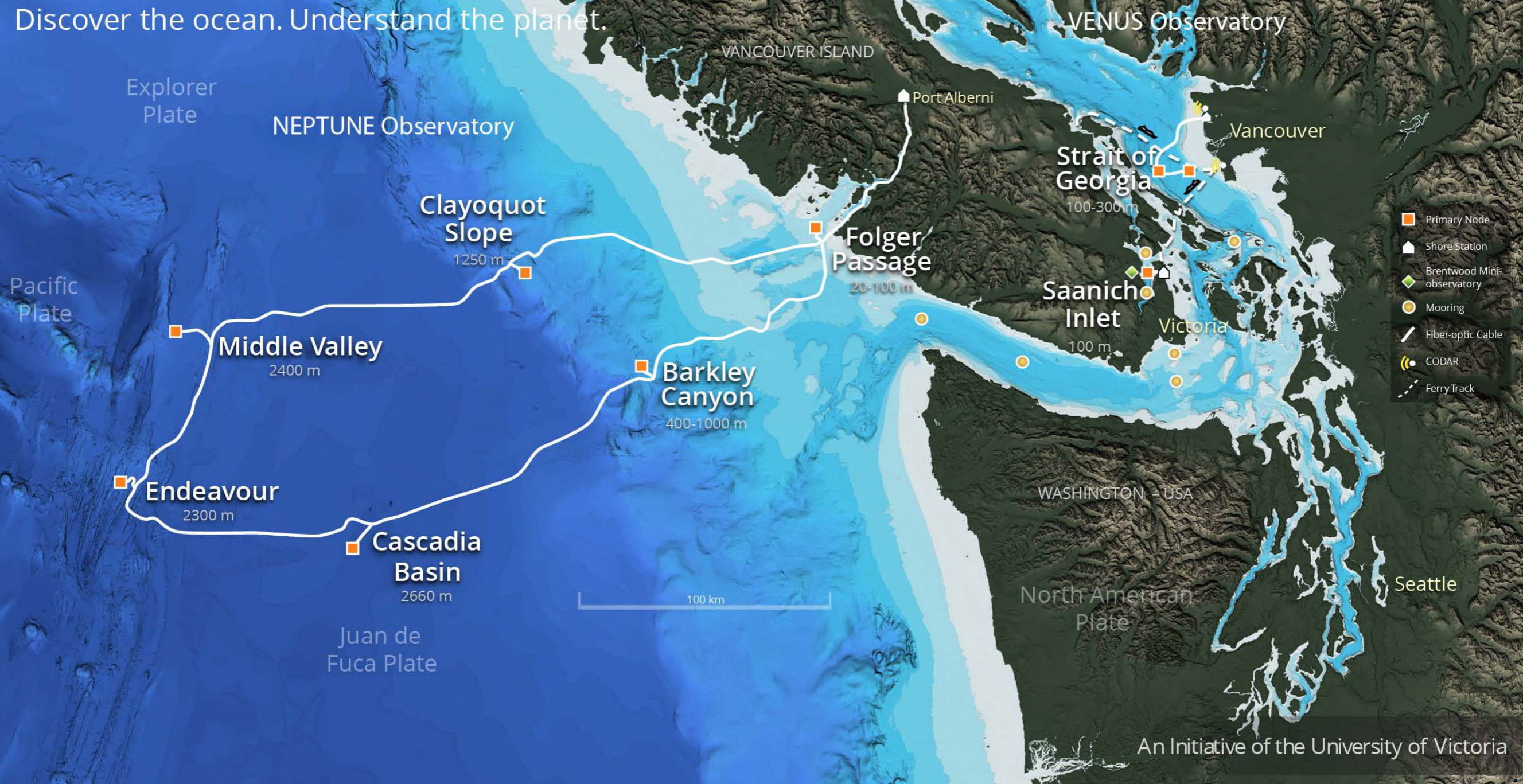
# Biodiversity studies using imagery from cabled observatories

## - examples from Ocean Networks Canada



### OCEAN NETWORKS CANADA

Discover the ocean. Understand the planet.



# EBV studies using time-series video imagery coupled with oceanographic sensors

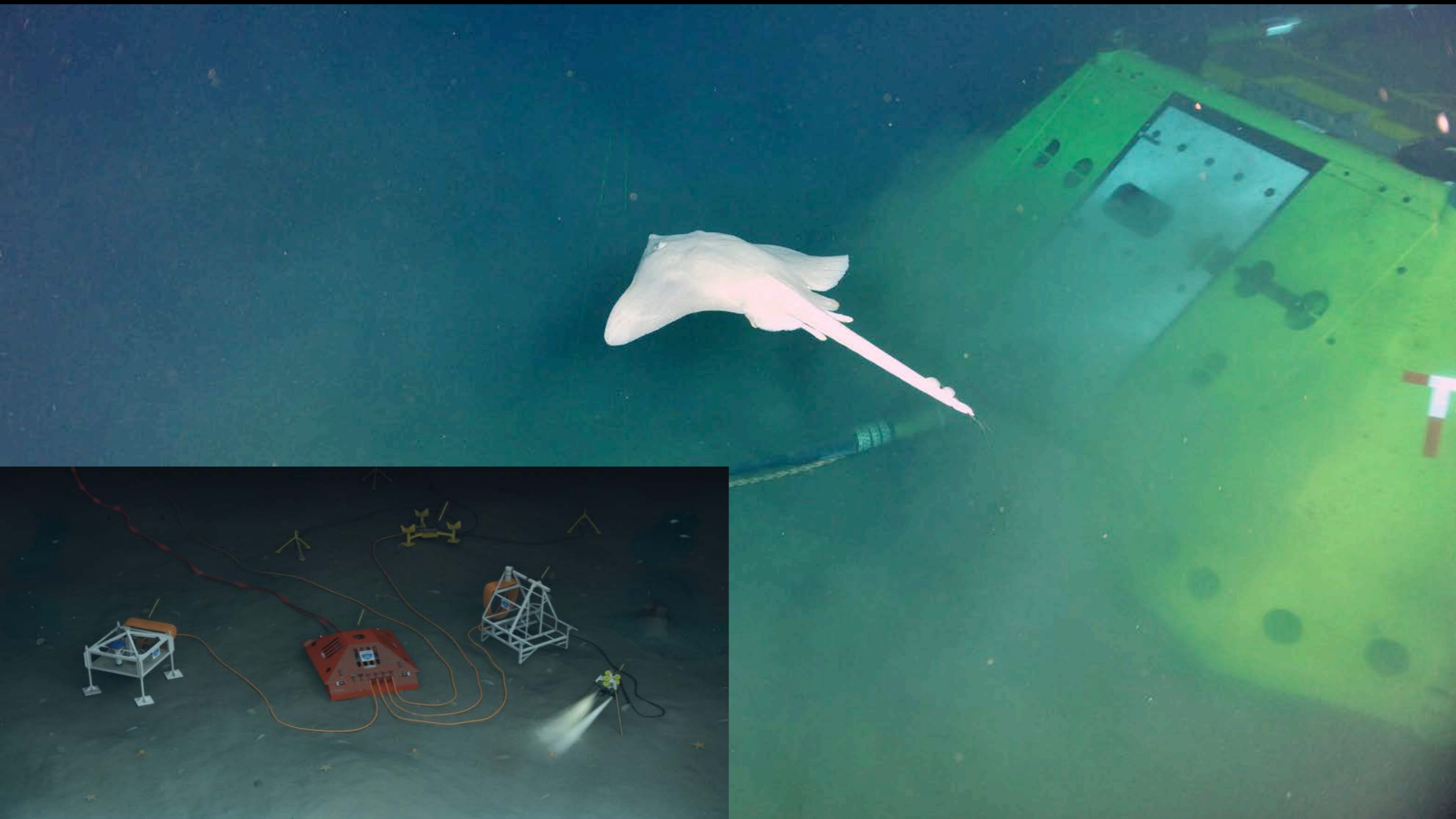
## (Benthic) Community Composition

- Species presence/absence & abundance versus oceanographic variables
- Community responses to perturbations – experimental manipulations

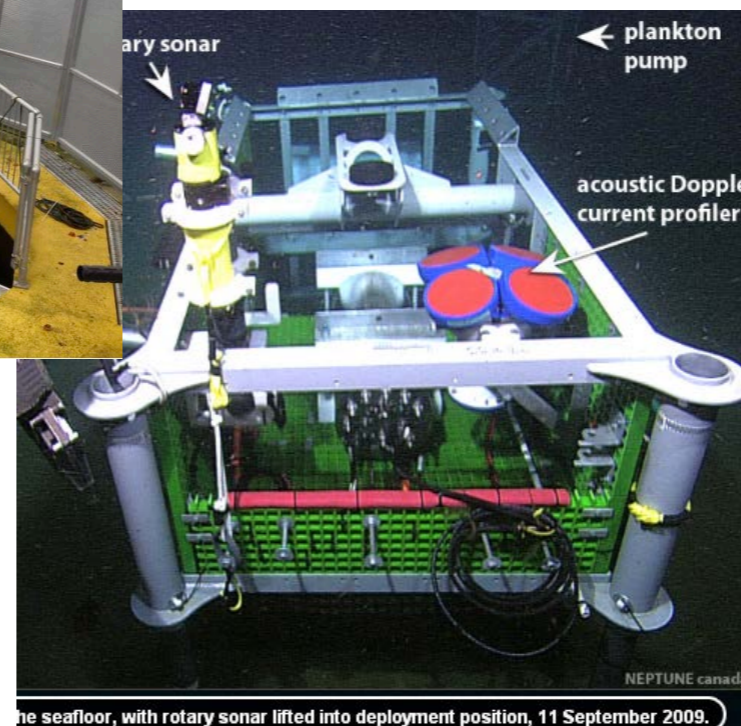
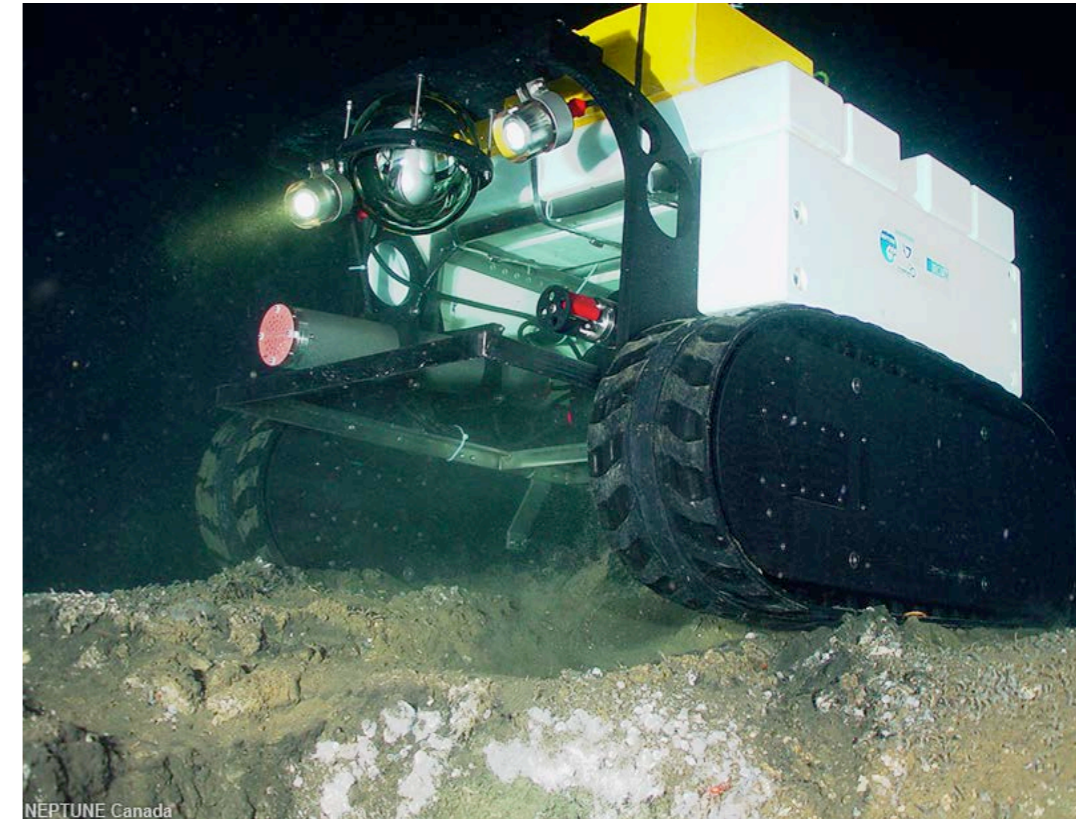
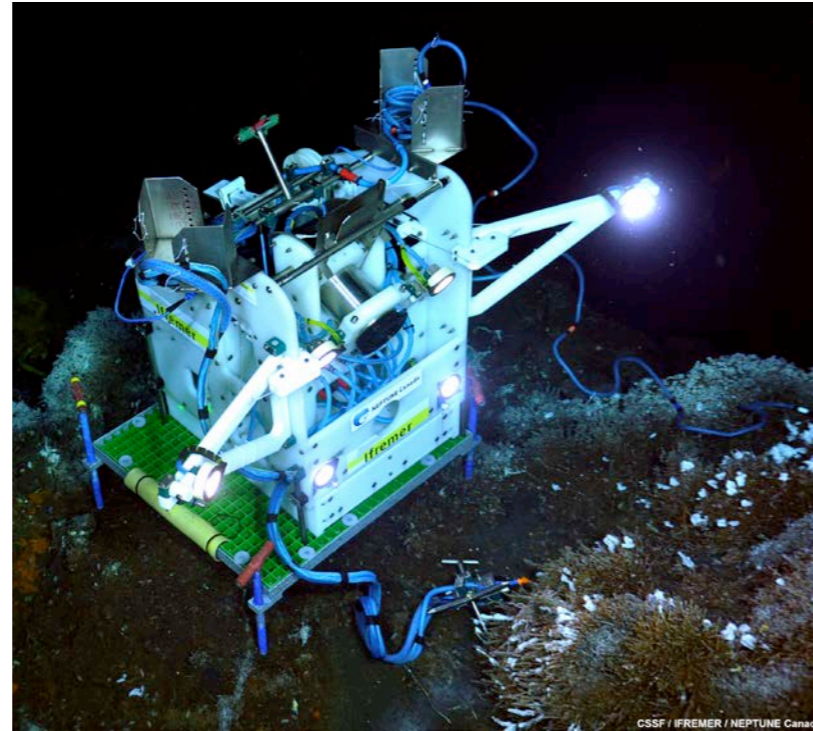
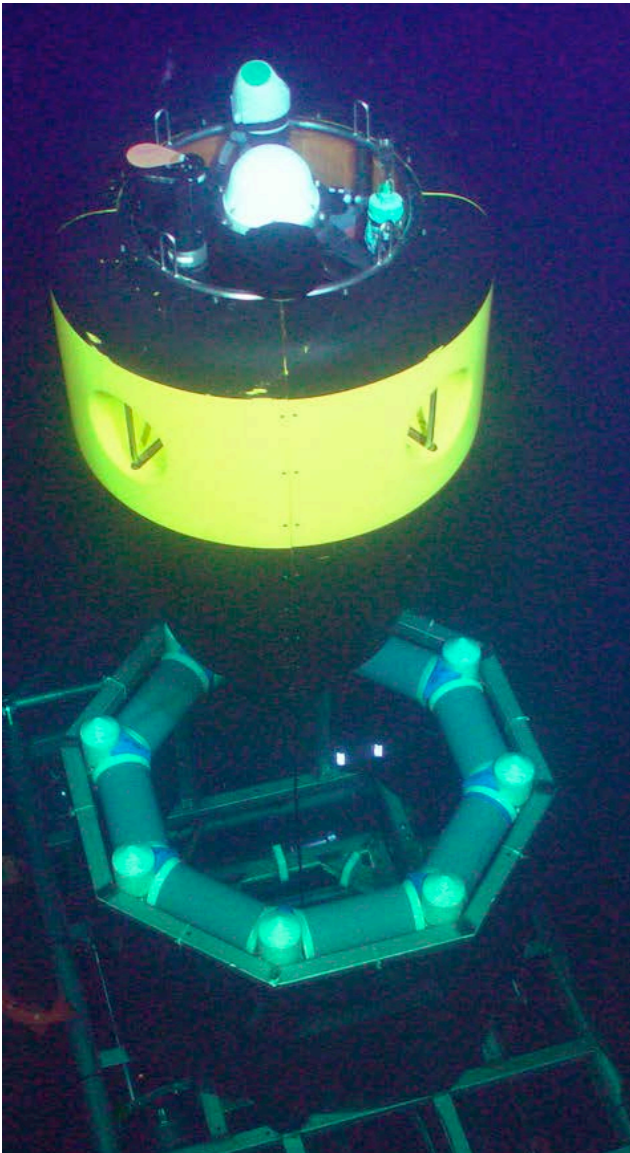
## (Benthic) Ecosystem processes

- Quantifying ecosystem services (eg. surface bioturbation)
- Chronobiology – activity and abundance rhythms

8 seafloor nodes in NE Pacific & Salish Sea provide power and communications to instrument platforms



# and stand-alone instruments



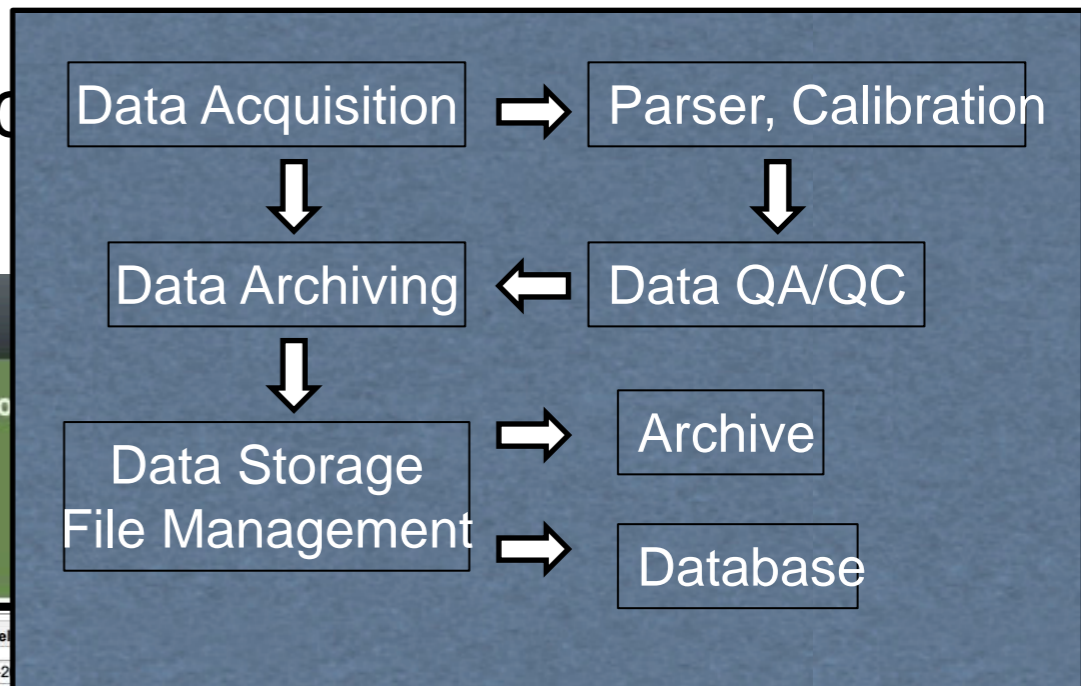
# Data Access and Data Tools

- all sensor data and imagery archived
- online graphical previews of scalar data
- viewers for ADCP and hydrophone data in development
- online viewing of annotated, archived video
- web services delivery of data

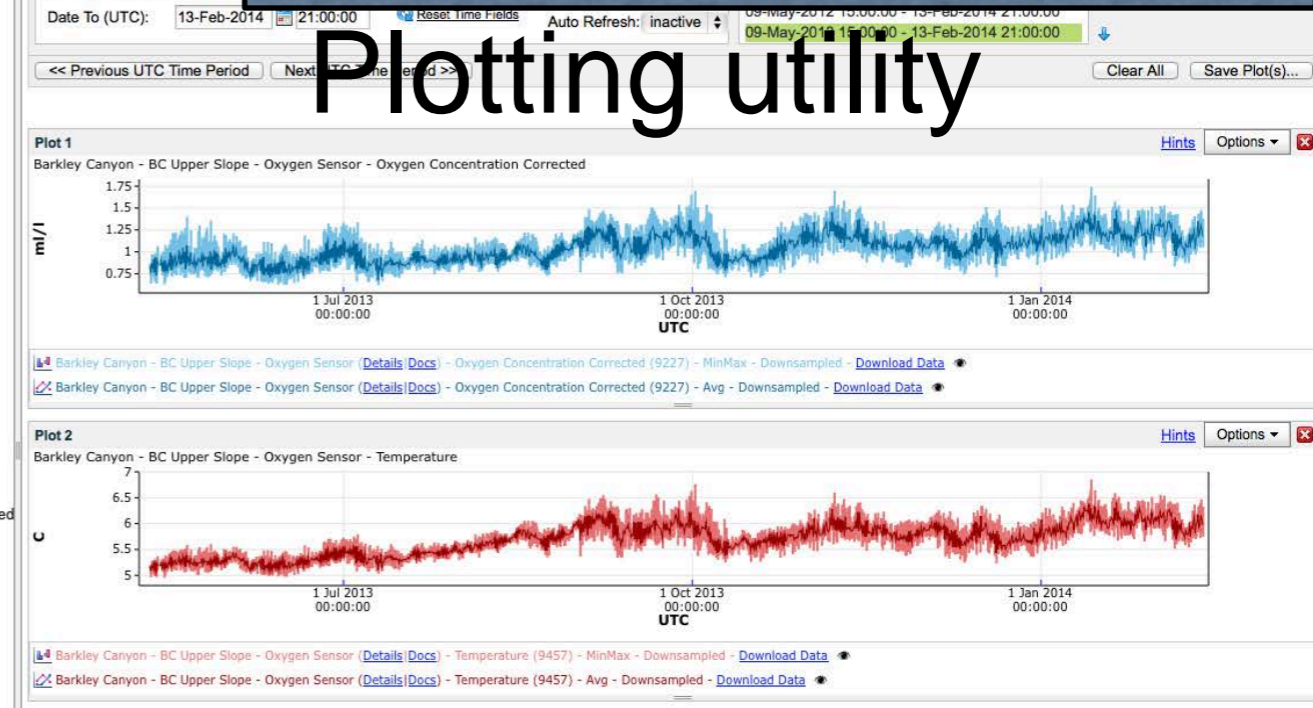
The screenshot shows the 'Seatube' web interface. On the left, there is a list of video entries with columns for video ID, date, and time. On the right, there is a map view showing the location of the data. Below the map, there is a table with columns for 'Start Date (UTC)', 'End Date (UTC)', 'Comment', 'Img', 'Latitude', 'Longitude', 'Depth', and 'Origin'. The table contains several rows of data, including entries for 'NEPTUNE Maintenance Cruise' and 'NEPTUNE Spring 2012'.

The screenshot shows the 'Data & Tools' web interface. It features a navigation menu with options for 'Learning', 'Installations', and 'Data & Tools'. The 'Data & Tools' option is highlighted.

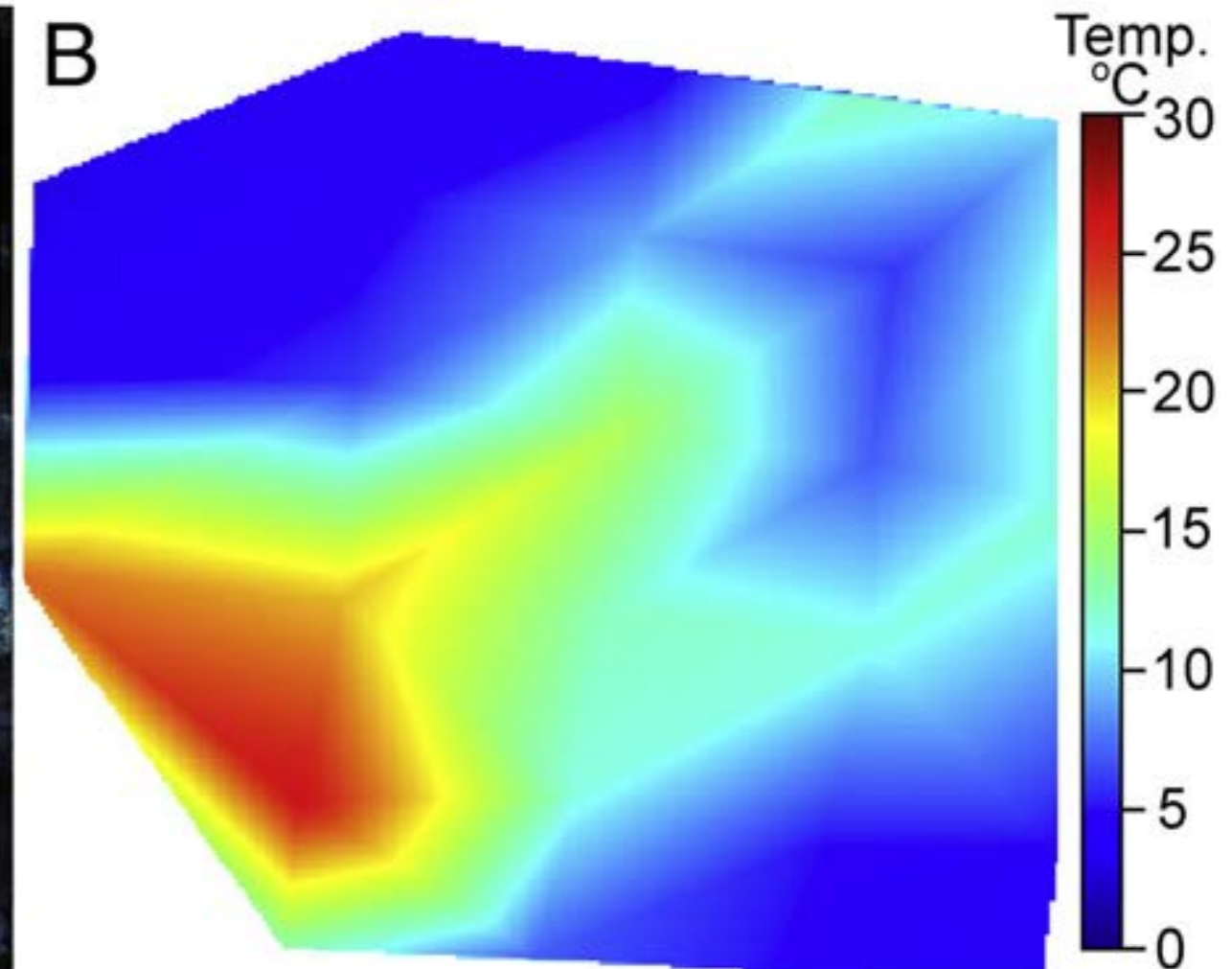
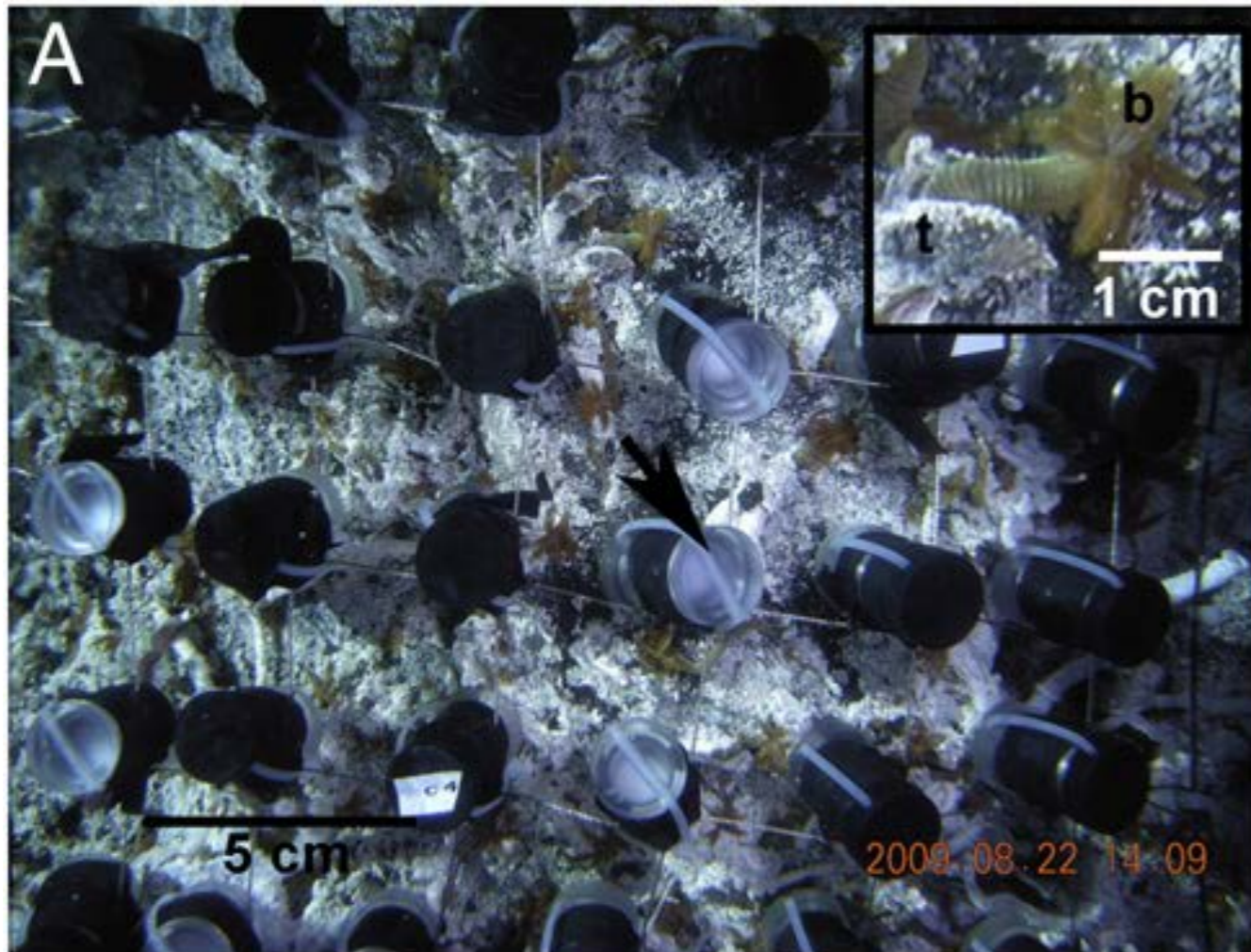
The screenshot shows the 'Plotting utility' web interface. It features a list of instruments and a time period selector. The instruments list includes 'Barkley Canyon', 'BC Axis POD1', 'BC Hydrates', 'BC MidEast POD4', 'BC MidWest POD3', 'BC Upper Slope', 'ADCP 75 kHz', 'BPR', 'CTD', 'Conductivity', 'Density', 'Practical Salinity', 'Pressure', 'SigmaT', 'Temperature', 'Junction Box', 'Oxygen Sensor', 'BC Upper Slope POD2', 'Coral Cliff', 'VPS Upper Slope', 'Wally Hydrates', 'Cascadia Basin', 'Clayoquot Slope', and 'Endeavour'. The time period selector shows 'Date From (UTC): 09-May-2012 21:00:00' and 'Date To (UTC): 13-Feb-2014 21:00:00'.



Plotting utility



# Research results – High frequency variability



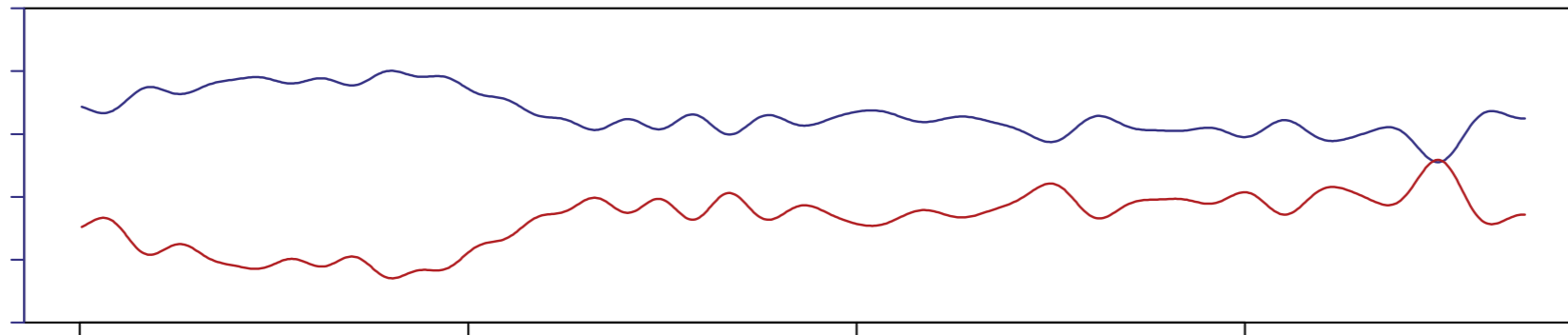


# Research results High frequency variability

High-frequency study of epibenthic megafaunal community dynamics in Barkley Canyon: A multi-disciplinary approach using the NEPTUNE Canada network

Marjolaine Matabos <sup>a,\*</sup>, Alice O.V. Bui <sup>a</sup>, Steven Mihály <sup>a</sup>, Jacopo Aguzzi <sup>b</sup>, S. Kim Juniper <sup>a</sup>, R.S. Ajayamohan <sup>a</sup>

Shift in relative abundance of dominant megafaunal species follows water mass change coincident with surface storm

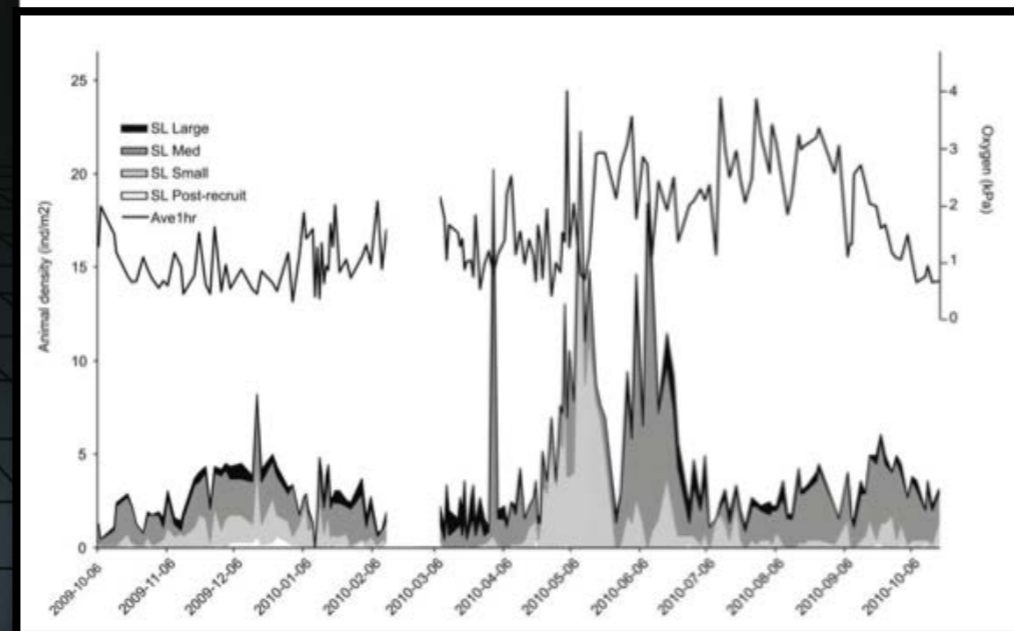
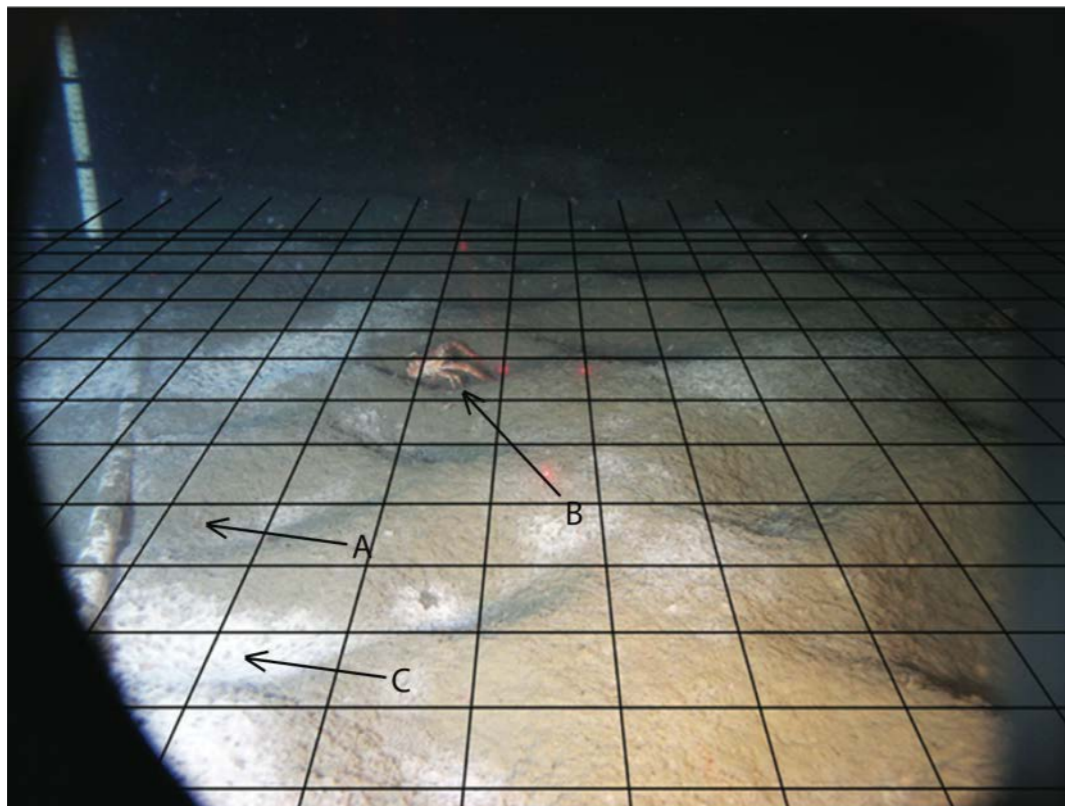


# patterns

## A Year in Hypoxia: Epibenthic Community Responses to Severe Oxygen Deficit at a Subsea Observatory in a Coastal Inlet

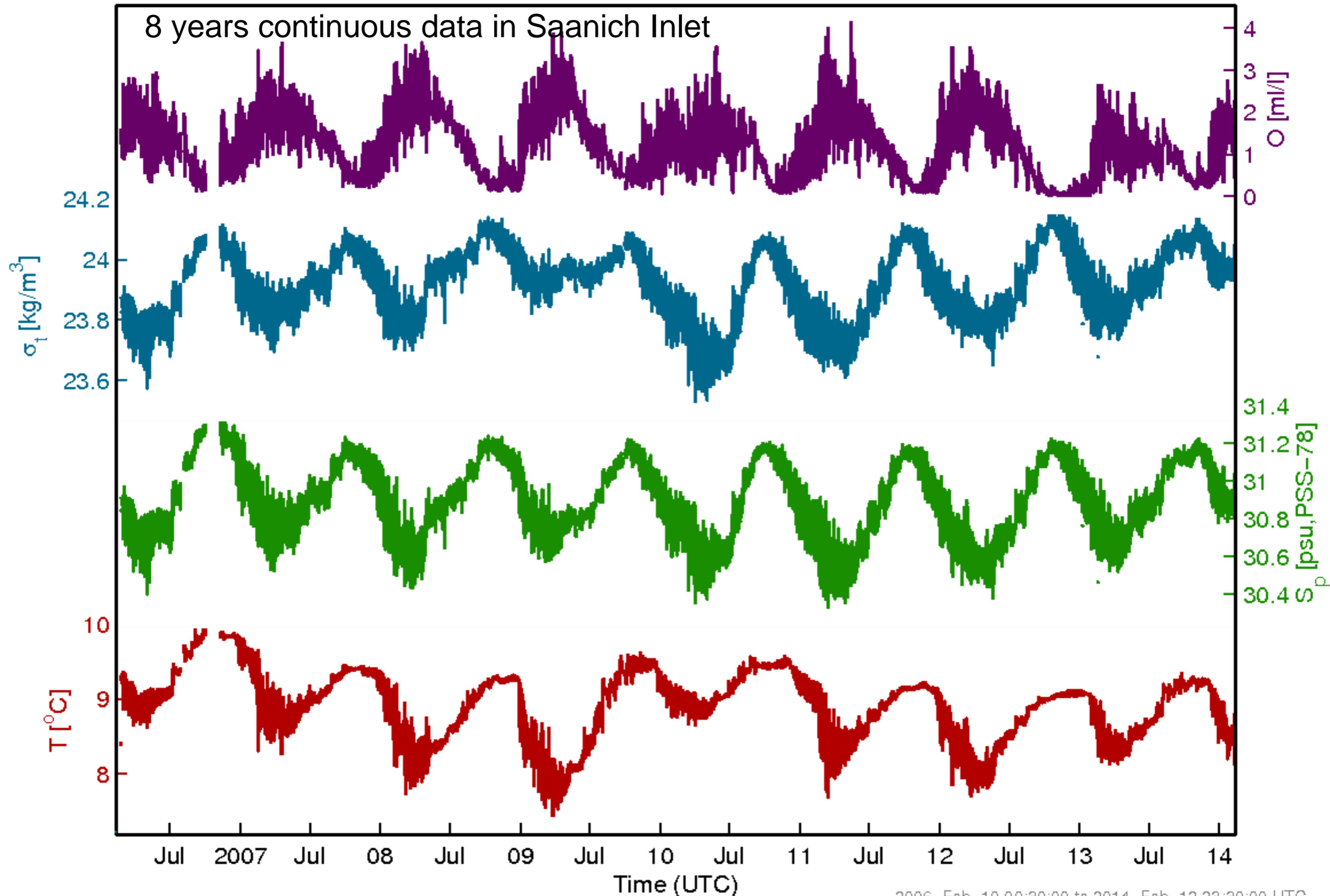
Marjolaine Matabos<sup>1,2\*</sup>, Verena Tunnicliffe<sup>1,3</sup>, S. Kim Juniper<sup>1,2</sup>, Courtney Dean<sup>1</sup>

<sup>1</sup> School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada, <sup>2</sup> NEPTUNE Canada, University of Victoria, Victoria, BC, Canada, <sup>3</sup> VENUS, University of Victoria, Victoria, BC, Canada



# Long term observations

8 years continuous data in Saanich Inlet



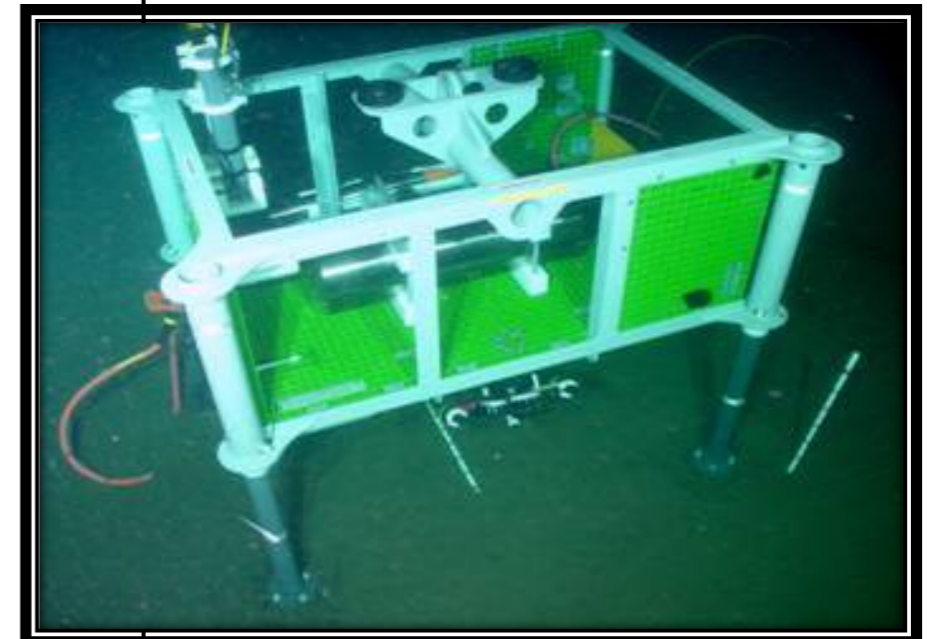
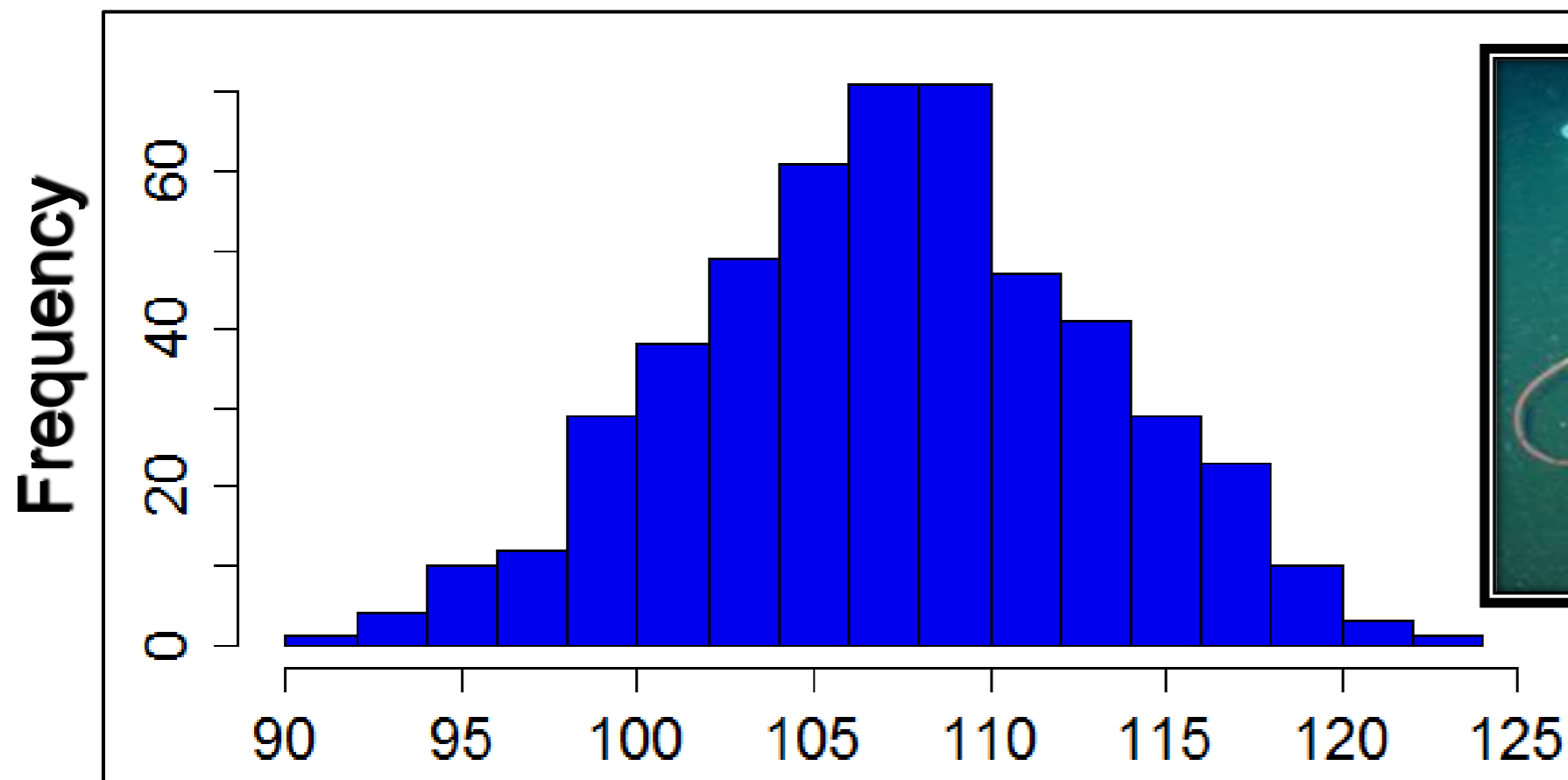


# Research results - bioturbation

## Surface-sediment bioturbation quantified with cameras on the NEPTUNE Canada cabled observatory

K. Robert<sup>1,\*</sup>, S. K. Juniper<sup>1,2</sup>

### Sea Urchin + Flatfish



Number of days required to turnover the 8.8m<sup>2</sup> study area

# Seasonal faunal dynamics in a coastal Arctic setting – Cambridge Bay, Nunavut

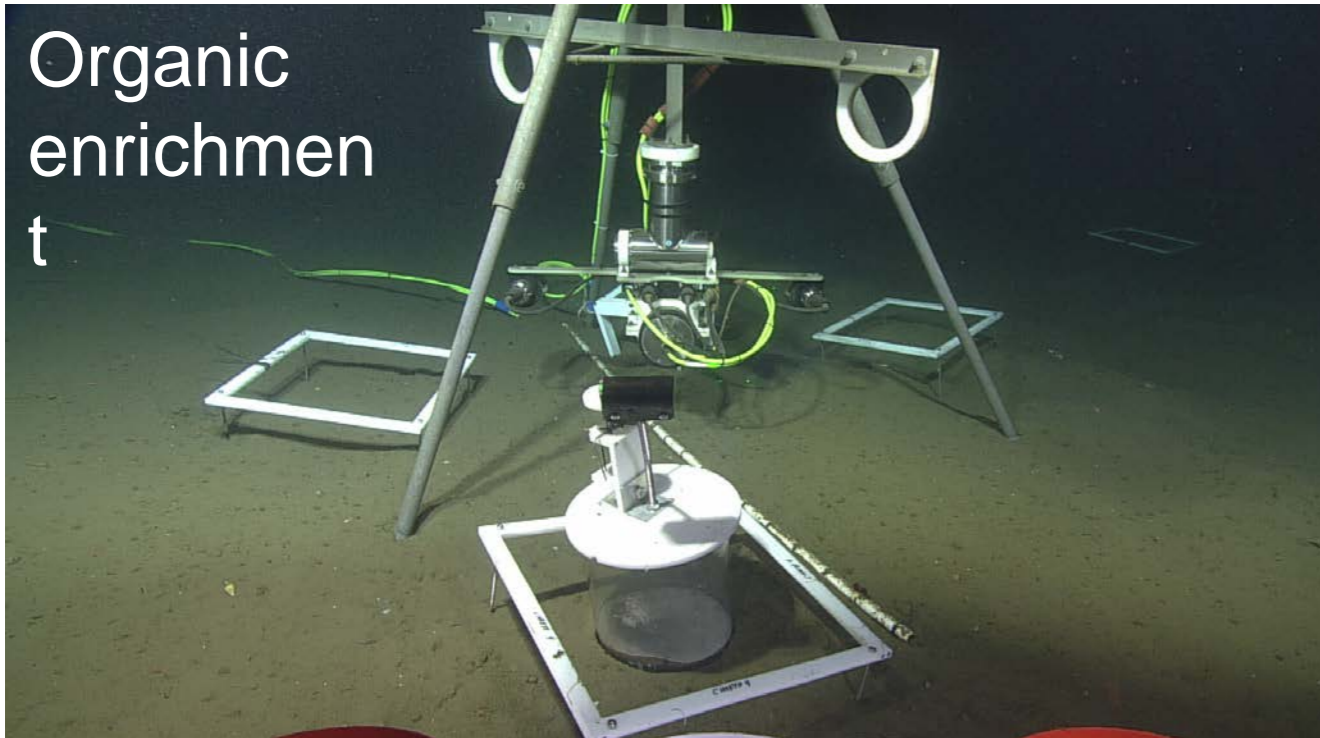
Preliminary Results (J-A Dorval. ISMER-UQAR)

- Faunal abundance increase in summer
  - explained by temperature & dissolved oxygen changes
- No seasonal change in diversity
- Faunal activity higher in winter
  - reduced food supply?



# Experimental use of observatories

Organic  
enrichmen  
t



Deep-water forensics



Deep-sea recruitment  
(INDEEP)



Whale bone  
colonization



# Need for more efficient tools for extracting biological data from imagery

- Growing archive of >10 000 hours of HD video imagery
- Potential for advancing understanding of deep-sea faunal dynamics
- Small community of specialists
- Automated image analysis still very limited



# Computer vision experiments

Develop algorithm to count the number of sablefish  
(*Anoplopoma fimbria*) in one minute video segments

Application: understanding seasonal abundance  
patterns of high value commercial species



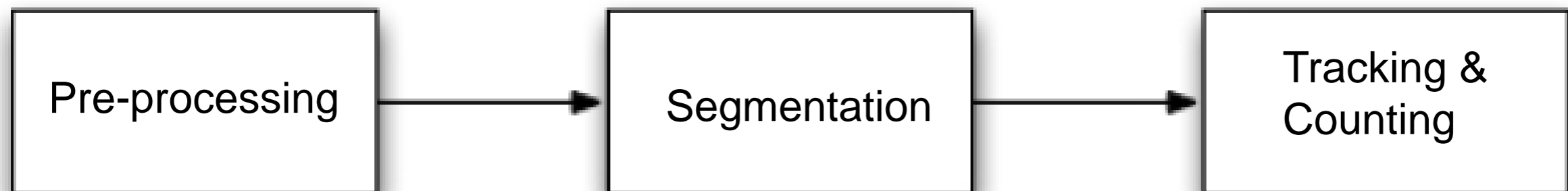
## Method inspiration:

C. Spampinato, et al, "Detecting, tracking and counting fish in low quality unconstrained underwater videos," in Proc. 3rd Int. Conf. on Computer Vision Theory and Applications (VISAPP), Funchal, Portugal, 2008, pp.514-520.

# Approach

3 system major components:

- Preprocessing component to enhance underwater images and reduce noise.
- Fish detection module to segment fish from background.
- Fish tracking system to track and count segmented fish.



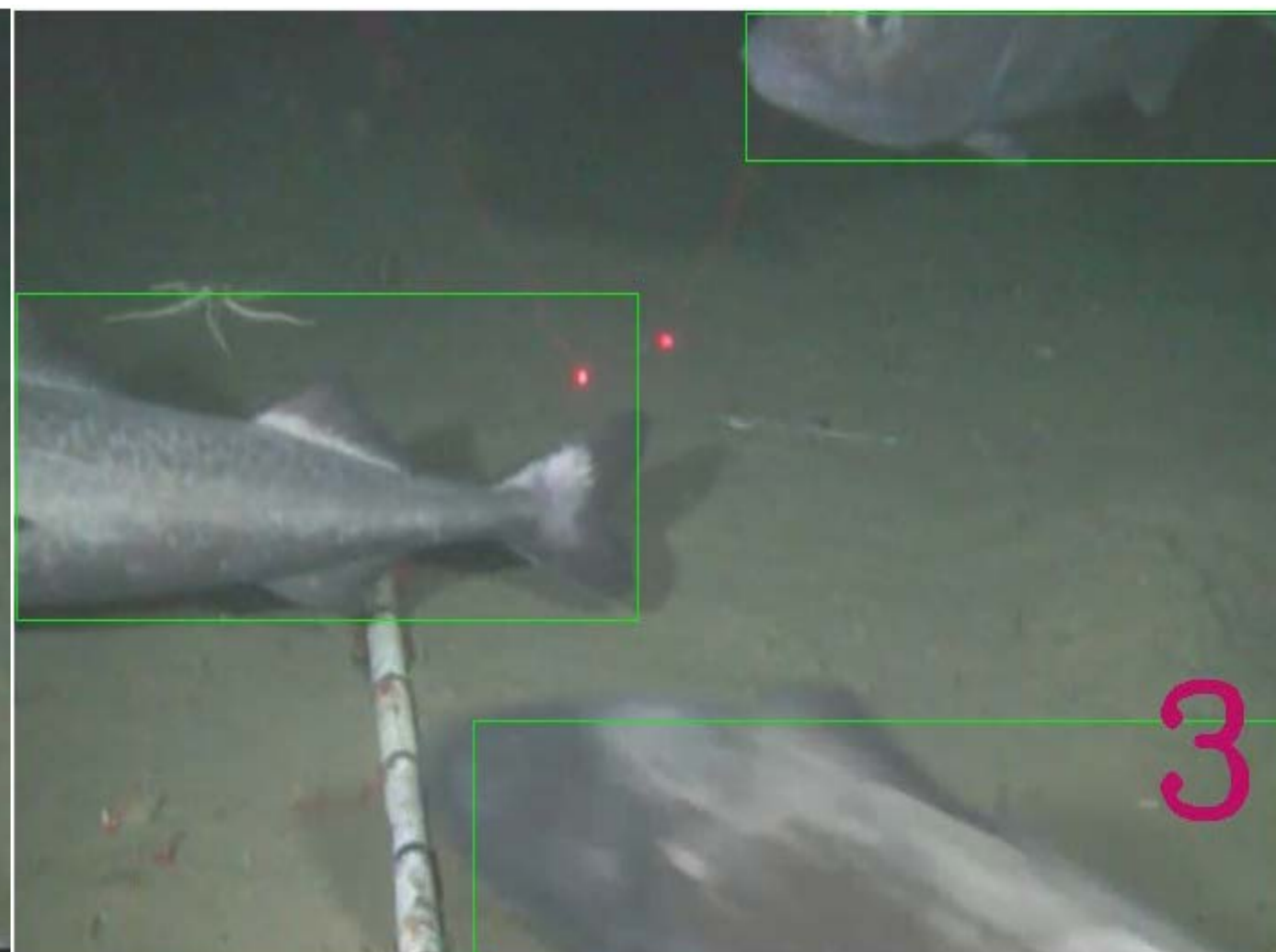
# Tracking and Counting Results

Valid fish tracks are counted

For visual evaluation, bounding boxes are displayed in video.

Original video

Final result



# Automatic Fish Counting System for Noisy Deep-Sea Videos

IEEE Oceans 201

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NETWORKS  
CANADA  
SCIENCE

## Detection module:

- Precision: 65.8%
- Sensitivity: 84.5%

*False negatives - fish "camouflaged" in  
background.*

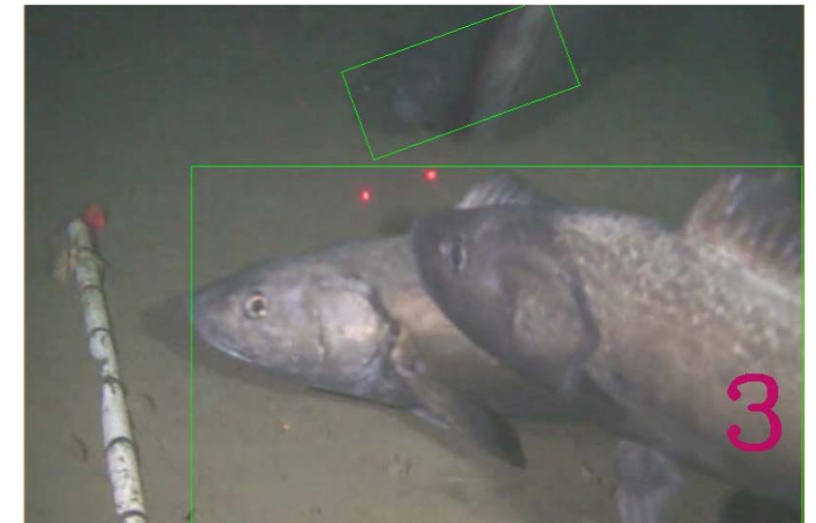
*False positives - background subtraction  
susceptible to noise.*

## Tracking and Counting module:

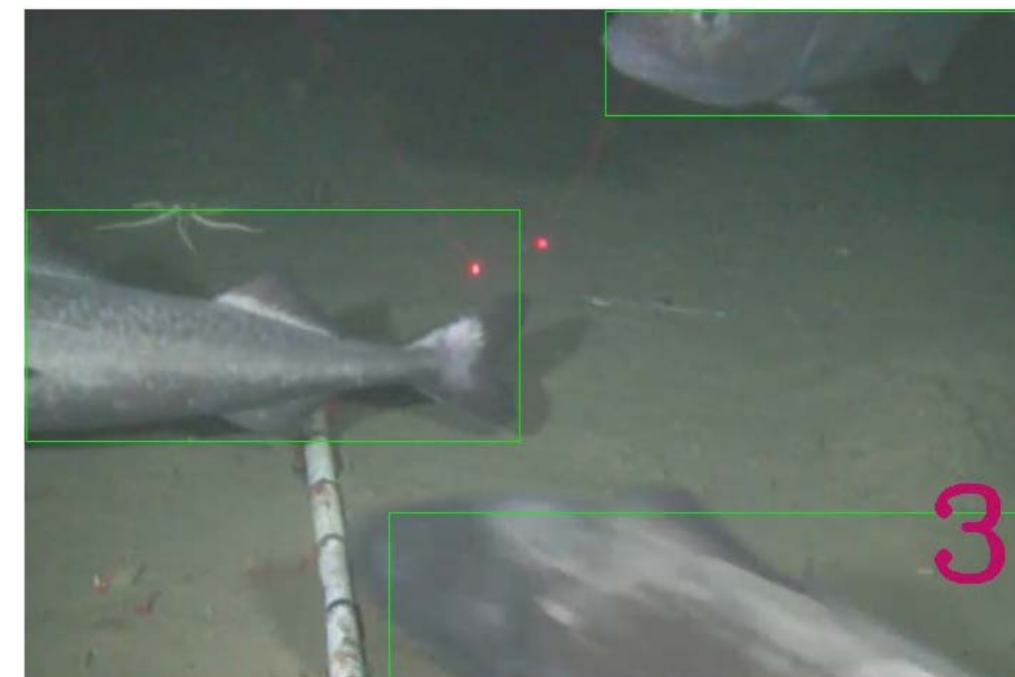
- Precision: 83.8%
- Sensitivity: 77.9%

*False negatives increased due to slow moving  
fish and crowded scenes.*

*Significant decrease in false positives.*



Failed tracking



Successful tracking

# Citizen Science

OCEAN  
NETWORKS  
CANADA  
SCIENCE

- Crowd-sourced science
- Citizens gather or analyze data
- Direct benefits to scientific research
- Can serve outreach and education goals

ZOONIVERSE  
REAL SCIENCE ONLINE

Take part in  
Science Projects

Experiment in  
Laboratory

[seafloorexplorer.org](http://seafloorexplorer.org)

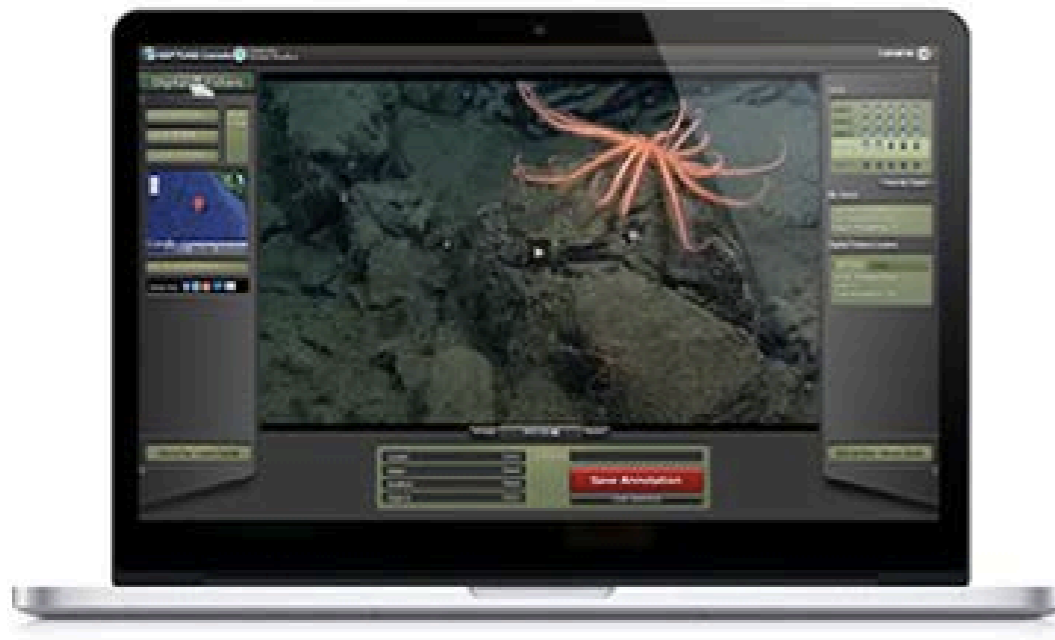
Help explore the ocean floor

[View details](#)





## Digital Fishers



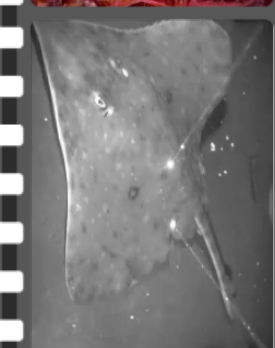
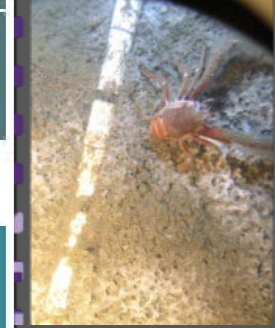
Digital Fishers. A crowd-sourced ocean science observation game.

**Help to contribute to our understanding of:**

- Environmental factors in the deep ocean.
- Biodiversity associated with deep-sea environments.
- How species interact with each other and with their environment.

Get Started Playing Digital Fishers





## New Mission Added: Sablefish (black cod) Countdown Redux!



### Meet the competitors

1. **Scientist (PhD student):** A research group in Spain is investigating the influence of the daily and tidal cycles on the activity of the sablefish. A PhD student from their lab analysed these videos, counting fish and invertebrates, and focussing on the sablefish because of their large numbers.
2. **Experienced users (biology class):** 60 students in a biology class at the [University of Victoria](#) analysed these videos and counted the fish.
3. **Automated detection (computer algorithm):** We have a PhD student who has developed a computer algorithm; this mission can be used as a reliability test.
4. **General public/citizens (Digital Fishers):** YOU



## Current Mission

### Sablefish (black cod) Countdown Redux!

Expert-Student-Computer-Citizen Scientist: How does the crowd compare? What do you do when your experiment returns a variety of results? You run a second trial. Hey that's real science. So, here is the challenge: We need more comparable results from our sablefish competition. We need to compare apples to apples or in this case sablefish to sablefish. So, this time we are asking you to count the sablefish exactly as we are doing in our labs.

We have added the full video clips from Barkley Canyon, where we sampled 1 minute every half hour to study the behaviour/activity rhythms of the animals. Can you be the scientist? Here's the big challenge. For this mission, we'd like you to **count** or in some cases **recount the sablefish (black cod) for the entire segment of the clip – up to 1 minute of your time!** Seems simple enough...

#### Special Instructions

For this mission, in addition to your annotations on the variety of sealife, we ask that you pay particular attention to the sablefish. We need you to **count the number of sablefish** that you see **throughout the entire clip. Every sablefish.** Even if it is only part of a sablefish or if you think the same sablefish came back into the screen. At the end of the clip, your screen will pause. You can then select **Sablefish** and a corresponding number (0-12) from the dropdown menu.

\*NOTE: If you are a returning user, this is a different task than you are used to.\*

#### Meet the competitors

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Sablefish: Black Cod (Anoploma fimbria)

Level

Level 1

Next card in 2 annotations.

Level 2

Level 3

Level 4

Level 5

[View My Cards](#)

#### My Status

Level: 1

Total Annotations: 0

Today's Annotations: 0

#### Digital Fishers Leaders

All Time

Today

Name: Harold Smith

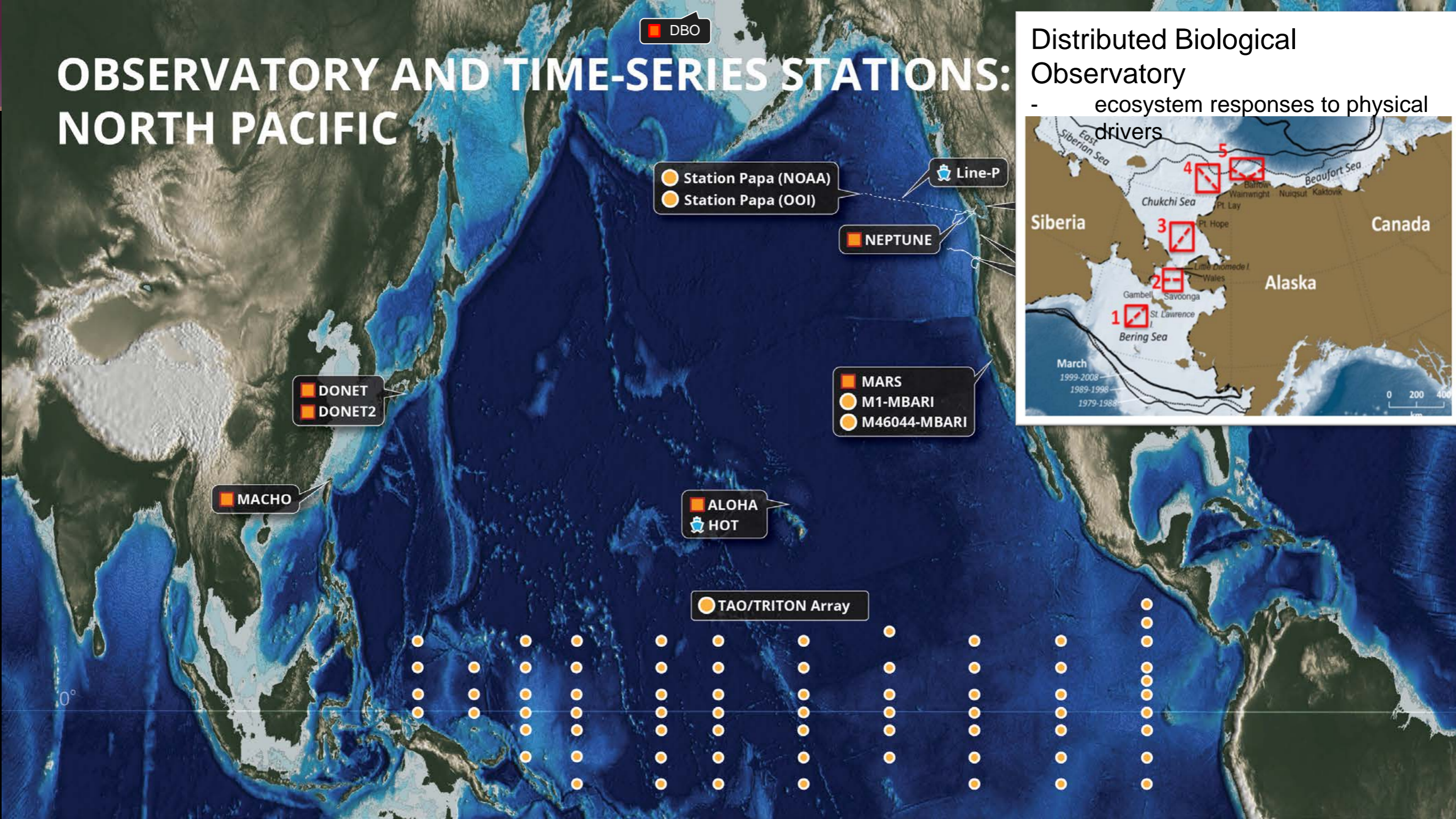
Level: 5

Total Annotations: 20372

[About Us](#) | [Current Mission](#)

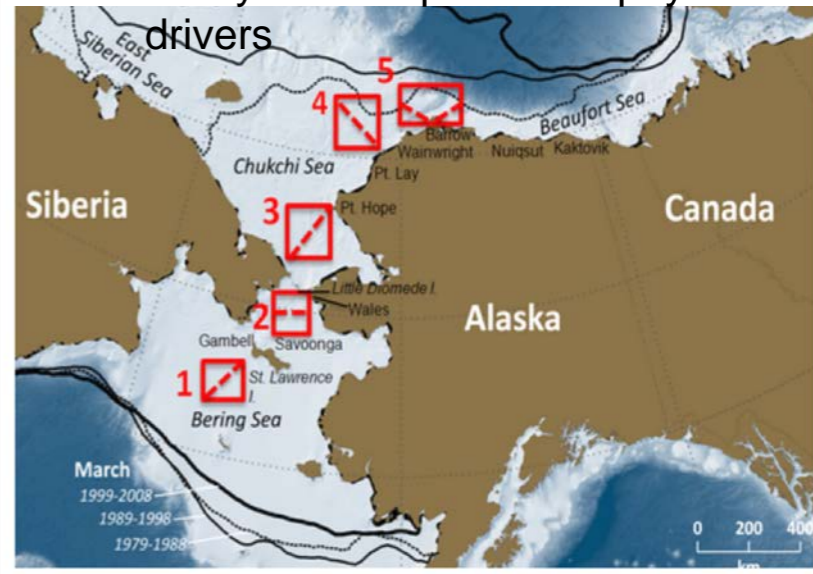


# OBSERVATORY AND TIME-SERIES STATIONS: NORTH PACIFIC



## Distributed Biological Observatory

- ecosystem responses to physical drivers



Observatory investment > Coordination between  
EBVs - potential programs for structuring  
biological observations

# Acknowledgements

- Canada Foundation for Innovation
- British Columbia Knowledge Development Fund
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- University of Victoria



Ministry of Advanced Education

British Columbia Knowledge Development Fund