Cabled ocean observatories as tools for studying biodiversity change
S. Kim Juniper, Ocean Networks Canada
Essential biodiversity variables (EBVs)

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

<table>
<thead>
<tr>
<th>EBV Category</th>
<th>Measurable with cabled observatory technology</th>
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<tbody>
<tr>
<td>Genetic composition</td>
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<td>Species populations</td>
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<td>Species traits</td>
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<td>Community composition</td>
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<td>Ecosystem function</td>
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<tr>
<td>Ecosystem structure</td>
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Biodiversity studies using imagery from cabled observatories - examples from Ocean Networks Canada
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 (e.g. 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
- downloads of all data

Seatube

Plotting utility
Research results – high frequency variability
Shift in relative abundance of dominant megafaunal species follows water mass change coincident with surface storm.
Research results - Seasonal patterns

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

Marjolaine Matabos\textsuperscript{1,2*}, Verena Tunnicliffe\textsuperscript{1,3}, S. Kim Juniper\textsuperscript{1,2}, Courtney Dean\textsuperscript{1}

\textsuperscript{1} School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada, \textsuperscript{2} NEPTUNE Canada, University of Victoria, Victoria, BC, Canada, \textsuperscript{3} VENUS, University of Victoria, Victoria, BC, Canada
Long term observations

8 years continuous data in Saanich Inlet

Graph showing time series data for different variables over a period from July 2007 to July 2014.
A year in Barkley Canyon: A time-series observatory study of mid-slope benthos and habitat dynamics using the NEPTUNE Canada network

S. Kim Juniper*, Marjolaine Matabos, Steven Mihály, R.S. Ajayamohan, Françoise Gervais, Alice O.V. Bui

Research results - bioturbation

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

K. Robert¹,* S. K. Juniper¹,²

Sea Urchin + Flatfish

Number of days required to turnover the 8.8m² study area

doi: 10.3354/meps09623
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 enrichment
- 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:

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

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**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.*
Citizen Science

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

zoourniverse
Real Science Online

Help explore the ocean floor

seafloorexplorer.org
View details
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 focusing 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.*

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Observatory investment > Coordination between programs

EBVs - potential tool for structuring biological observations
Acknowledgements

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