

Investigating the diversity of benthic animals in the Pacific Ocean using underwater observatories and deep-sea video cameras

Introduction

Understanding the causes of patterns in biological diversity (biodiversity) is a fundamental challenge in biological oceanography and marine ecology. Changes in biodiversity have significant consequences for a variety of food web and biogeochemical processes. Climate change can affect multiple aspects of marine environments, such as temperature and acidity, which may influence animal diversity. Human activities can also degrade the physical habitat of marine communities, changing which species can use that habitat.

Ocean Networks Canada's observatories collect thousands of hours of video of deep-sea benthic (i.e., sea bottom) environments. Our knowledge of these remote ecosystems is hampered by the limited access to them. Ocean Networks Canada's video data provide a significant opportunity to improve our understanding of how biodiversity varies in the benthic region of the ocean, and how physical factors such as substrate type or temperature influence the distribution of animals in these regions.

The goal of this laboratory exercise is to introduce you to ocean observation networks, and then to use the outputs of an Ocean Networks Canada underwater observatory to understand patterns of biodiversity at the bottom of the deep ocean.

Before you begin, please watch these YouTube videos for an introduction to Ocean Networks Canada and the Oceans 2.0 data portal (specifically the *Data Search* and *SeaTube* tools):

1. [Ocean Networks Canada – A Retrospective](#)
2. [Data Search demo](#)
3. [SeaTube demo](#)

For this lab, you will be watching undersea videos collected by a remotely-operated vehicle (ROV-ROPOS) during Ocean Networks Canada's missions to six locations in the northeast Pacific. These are:

1. Folger Pinnacle (coastal zone)
2. Barkley Upper Slope (upper continental slope)
3. Barkley Canyon Axis (axis of the canyon)
4. Clayoquot Slope (continental slope)
5. Cascadia Basin (abyssal plain)
6. Main Endeavour Field (hydrothermal vent)

A map of these locations in relation to the British Columbia coast can be found [here](#). (The map is also displayed at the home page of the *Data Search* tool web interface.)

For each location, you will determine the following environmental parameters using the *Data Search* tool:

- a) Average water temperature
- b) Average bottom depth

Using the ROV videos available on *SeaTube*, you will also determine:

- a) Animal biodiversity (measured as species richness)
- b) Total abundance of animals
- c) Substrate type (muddy, sandy, rocky, or mixed)

Your task will be to describe patterns of biodiversity in each of the locations, and to explore which environmental metric best predicts this diversity: water temperature, bottom depth, or substrate type.

Part 1: Collecting water temperature and bottom depth data

Use the [Data Search](#) tool in Oceans 2.0 to determine the *average* water temperature and bottom depth (using pressure data) at the locations listed in Table 1, on the specified day. You will need to download two .csv files: one containing the temperature data and the other containing the pressure data, for the specified time period. Then, open the files in Excel and calculate the average for the parameters. Enter the values in Table A1: *Environmental Parameters at ONC study sites* (see page 5 of this document).

Table 1. Information required to collect temperature and depth at each location.

Location	Instrument	Timeframe
Folger Pinnacle (at Folger Passage)	ADCP 600kHz	15-16 May 2011*
Barkley Upper Slope (at Barkley Canyon)	CTD	16-17 Jul 2012
Barkley Canyon Axis (at Barkley Canyon)	ADCP 75kHz	2-3 Jun 2012
Clayoquot Slope (at Bullseye)	CTD	3-4 Jun 2012
Cascadia Basin (at ODP 1026)	CTD	7-8 Jun 2012
Main Endeavour Field (at Endeavour)	Averages provided in Table A1 (page 5 of this document)	

*Note: 2012 data are not available at this location, therefore 2011 at same time of year is used for comparison.

Part 2: Calculating biodiversity as species richness

Next, you will use [SeaTube](#) to view video segments from observatory maintenance cruises that have been selected for this exercise.

The video numbers and segments that you will be watching are listed in Table 2. You will start the video at the specified time stamp, but will only watch the first **5 minutes** of each segment. Note that videos from dives R1451 and R1692 at Main Endeavour field are included for demonstration purposes only, and to introduce you to the communities of hydrothermal vents. You don't have to identify species from it, but you should look at them for interest (Video R1692 has the audio-tracks from the ROV pilots and scientists conducting the dive, which is good to give you an idea how the operation is undertaken!)

Table 2. Dive numbers, locations and start times of videos covered in this assignment.

Dive #	Location	Beginning time stamp and date	Duration (mins)
R1320	Folger Pinnacle	15 May 2010 – 23:37:54	5
R1440	Barkley Upper Slope	16 July 2011 – 22:49:56	5
R1552	Barkley Canyon Axis	02 June 2012 – 07:00:11 (see May 2012 cruise)	5
R1555	Clayoquot Slope	03 June 2012 – 12:45:20	5
R1556	Cascadia Basin	07 June 2012 – 09:10:47 (dive R1556 starts at June 04 – it's a long dive!)	5
R1448	Main Endeavour Field	22 July 2011 – 07:16:33	5
R1451	Main Endeavour Field*	23 July 2011 - 23:10:53	* demo only
R1692	Main Endeavour Field*	22 May 2014 - 01:09:44	* demo only

There are several metrics of biodiversity that are commonly used in the literature. For the purposes of this exercise, we will use a simple yet powerful metric: **species richness (S)**. Species richness is defined as the total number of different species observed in each location or video segment.

As an example, here is a hypothetical pair of locations where we observed and enumerated species richness (S) (Table 3). For location A, S=5 because we only observe five different species in that location. For location B, S=3 because we only observe three species in that location. Location B has lower species richness than location A even though B has many more individuals (i.e. a higher total abundance) than A.

Table 3. An example of calculating species richness and total abundance.

Location	Rockfish	Flatfish	Sea star	Sea pen	Shrimp	Species richness (S)	Total abundance
A	5	1	3	6	1	5	21
B	40	20	10	0	0	3	70

For the purposes of this lab, we will simplify our measure of species richness by making a few assumptions. For example, we will not distinguish between different species of rockfish, even though there are many. It is sufficient for the purposes of this exercise to distinguish fish based on broad groups: rockfish, pelagic fish, or flatfish. You can use Ocean Networks Canada’s *Marine Life Field Guide* to help you: a PDF of the 1st Edition and a link to the Apple Books 2nd Edition are available [here](#).

In addition, it may be difficult to accurately enumerate small animals that tend to colonize large patches of space (e.g., corals, anemones, or barnacles) or fishes that swim around in large schools. You may either pause the video and count these taxa, or you can quickly “guesstimate” how many individuals there are per colony, or in patches of space. The latter is what birders use to estimate the number of birds in a large flock. Use your best judgement on how to proceed. Fill out this information in Appendix 1 on pages 6–8 of this document. Calculate species richness and total abundance, and then enter these values in Table A2: *Species richness and total abundance measured at each location* (see page 5 of this document).

Part 3: Substrate type

Observe the type of substrate present in each video: muddy, sandy, rocky, or mixed. Mixed habitats have a mixture of different substrates. Record your observations in Table A1. There is also space in this table to write down any other observations that you think are useful or interesting.

Final Instructions

After you have collected all of your data, proceed to the questions on page 5.

If you are completing this assignment as part of a class or course, please submit your completed assignment—including tables, appendices, and your answers to the questions—to your teacher, instructor, or TA, as appropriate.

If you are completing this assignment at home and would like to submit your work for review, or if you have questions or would like to discuss further any aspect of this assignment, please contact Dr. Dave Riddell, Post-Secondary Education Coordinator at riddelld@uvic.ca.

Thank you!

Table A1: Environmental parameters at ONC study sites.

Location	Depth (km)	T (°C)	Substrate type	Substrate notes
Folger Pinnacle				
Barkley Upper Slope				
Barkley Canyon Axis				
Clayoquot Slope				
Cascadia Basin				
Main Endeavour Field	2.15	1.84		

Table A2: Species richness and total abundance measured at each location.

Location	Species richness	Total abundance
Folger Pinnacle		
Barkley Upper Slope		
Barkley Canyon Axis		
Clayoquot Slope		
Cascadia Basin		
Main Endeavour Field		

Questions

1. Briefly describe the communities you observed at each location (2–3 sentences for each community should be sufficient).
2. Use graphing techniques to help you visualise how species richness and abundance of organisms are influenced by the environmental variables that you observed in this study. Note that your figures should have proper titles, legends, axes, etc. Include up to four, but no less than two figures.
3. Of all the environmental variables you have examined, what variable, if any, most strongly influences species richness? Explain why you think this is so. Does the same variable influence total abundance? Explain.
4. What other factors might influence the diversity and abundance of benthic communities in the ocean?
5. Do you think species richness is a useful measure of biodiversity? Why or why not?

APPENDIX 1. Tables used to enter raw species diversity data, and to compute species richness and total abundance.

Location:

Species	Number of individuals
Species richness	
Total abundance	

Location:

Species	Number of individuals
Species richness	
Total abundance	

Location:

Species	Number of individuals
Species richness	
Total abundance	

Location:

Species	Number of individuals
Species richness	
Total abundance	

