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Factors that Influence Biodiversity in the Intertidal Zone

Jan Hodder

Oregon Institute of Marine Biology, University of Oregon, P.O. Box 5389, Charleston OR, 97420 USA
(**Jhodder@uoregon.edu**)

This laboratory exercise is designed to be undertaken in the marine rocky intertidal. It tests two hypotheses related to diversity, abundance and physical disturbance by collecting data on the types and numbers of organisms found living under two different size boulders in two areas of the rocky intertidal. Students work in groups to collect the data and then share data with others to analyze the data to test the hypotheses.

Keywords: marine, diversity, abundance, disturbance, intertidal, field exercise

Introduction

This exercise is designed to test two hypotheses related to diversity and disturbance in the rocky intertidal. Hypothesis 1: The diversity of organisms in the intertidal zone does not differ between low and mid intertidal areas. Hypothesis 2: There is no difference in the number and diversity of organisms living under small and large boulders. Prior to the exercise the instructor should introduce the concepts of biodiversity and measures of species diversity and total abundance. There should also be some discussion of biological and physical disturbance in the rocky intertidal, although this exercise only considers physical disturbance by wave action. If specimens or good photos are available students could learn to identify the most common organisms they will encounter in the intertidal. The actual exercise needs to take place in the field and takes about 2 – 2.5 hours to accomplish depending on how much time is given to self-exploration. Once the exercise is completed students need an additional lab period to process the data. The exercise was designed for the introductory majors biology sequence. It could be adapted to other marine habitats, for example one could look at protected and exposed sandy beaches, mudflats with different sediment size fractions, or gradients along an estuary.

Student Outline

Some animals and plants are found in the marine environment in the area between low and high tides - the intertidal zone. At low tide they are exposed to air, sunlight, rainfall, and terrestrial or avian predators and thus have to be adapted to desiccation, heating, freshwater input and predation. Organisms in higher locations in the intertidal zone are exposed to air for longer periods than those lower on the shore. When covered with water at high tide, when organisms will be more active, there are different factors that influence their lives including wave action and marine predators. These physical and biological factors will influence where organisms live in the intertidal and thus will impact the patterns of diversity that we see.

Many organisms in the intertidal zone live on the tops, sides, and underneath boulders. Different organisms will be found living in these three areas as a result of the complex interactions of the physical and biological factors that control distribution. The size of the boulder will also influence the diversity of organisms you find. Larger boulders have more surface area and thus might be predicted to have a higher "species-area" relationship. Waves will play a role in controlling diversity as when they crash onto boulders they can turn or roll them, and this disturbance will have a major impact on the types and number of organisms that live on boulder tops, sides, and undersides. In general, at any given beach location smaller boulders will be moved at a higher rate than larger boulders, and thus will experience higher disturbance. This will impact the number and diversity of organisms living on and under the boulder.

In this exercise you will test two hypotheses related to diversity and disturbance by collecting data on the types and numbers of organisms found under different size boulders in two areas of the intertidal.

Hypothesis 1: The diversity of organisms in the intertidal zone does not differ between low and mid intertidal areas.

Hypothesis 2: There is no difference in the number and diversity of organisms living under small and large boulders.

Each group should discuss these hypotheses and make a prediction for what you expect to see with respect to diversity and location and size of the boulders in the intertidal.

Your exercise today is to collect data to test the two hypotheses. Each group of four students will collect data on kinds and numbers of organisms **under** one small and one large boulder in the low-mid intertidal, and **under** one small and one large boulder in the mid-high intertidal (= four rocks per group). To improve the test of your hypotheses you will share data with two other groups in your lab section. So your group will analyze the data for 12 rocks: 3 small and 3 large from the low-mid intertidal (3 *sl*, 3 *ll*) and 3 small and 3 large from the mid-high intertidal (3 *sh* and 3 *lh*).

Before you begin to collect these data you will spend about 45 minutes in the intertidal with someone from Oregon Institute of Marine Biology (OIMB) or your instructor looking at animals that you are likely to find. You should also consult the Mac's Field Guide Sheet. Learn to identify these animals, as it will make your data collection in the field faster and more accurate and thus provide you with a good data set for testing the hypotheses.

Methods

In your group of four decide on your criteria for small and large rocks.

Assign the roles of rock lifter, organism counters (two people), and data recorder. Rotate these roles for each rock.

Procedure for All Rocks:

1. Measure the height, length, and width of rock to determine surface area and volume of each rock. Record these measurements on the data sheet.
2. One person should carefully lift the rock and hold it while the others collect and record data on the type and number of organisms. Two persons quantify under-rock organisms; use the knowledge you gained from the OIMB helpers and the Mac's Field Guide Sheet. For organisms that are individual **count numbers**. For encrusting organisms, such as sponges, estimate % **cover**. One person records these data.
3. Once finished with the rock carefully replace it in its original position.

Pick your small rock in the low-mid intertidal. Survey.
Pick your large rock in the low-mid intertidal. Survey.
Repeat the survey for a similar size small and large rock in the mid-high intertidal.

An example of the data sheet is attached. You will be given a data sheet on waterproof paper for actual recording in the field.

Biodiversity in the Intertidal Zone – Data Analysis

Extract and compile the data from the field collection sheets of the three other groups in your lab section. This will provide you with 12 data sets – three for each rock size at each of the two intertidal locations.

A. For Each Rock:

a) Calculate an under-rock surface area (= width x length) and a rock volume (= width x length x height)
b) Count the total numbers of different **species** (= diversity)
c) Determine the total number (abundance) of sessile (= attached, non-mobile) organisms
d) Determine the total number (abundance) of mobile organisms
e) Determine the total number (abundance) of organisms

B. Use these Data to Test the Hypotheses.

Hypothesis 1: The diversity of organisms in the intertidal zone does not differ between low and mid intertidal areas.
Hypothesis 2: There is no difference in the abundance (=number) and diversity of organisms living under small and large boulders.

Hypothesis 1: Calculate the mean and standard deviation for diversity measures on each of the rock types.

Small rock low sl _______________

Small rock high sh _______________

Large rock low ll _______________

Large rock high lh _______________

Use these data to test the hypothesis that diversity of organisms in the intertidal zone does not differ between low and mid intertidal areas.

1. Do the data support or refute your hypothesis?

2. Construct an explanation for your answer to whether your hypothesis was supported or not.

Hypothesis 2: To help you analyze your data to test the hypothesis that there is no difference in the abundance and diversity of organisms living under small and large boulders make the following five x-y plots. Use a different symbol for each of the four rock types (sl, ll, sh, lh)

Attach these to the back of this report:
a) Species diversity (y-axis) vs under-rock surface area in cm^2 (x-axis).
b) Species diversity (y axis) vs rock volume in cm^3 (x-axis).
c) Species-area relationships. Total number of all organisms (y-axis) vs under-rock surface area in cm2 (x-axis
d) Total number of sessile organisms (y axis) vs rock volume in cm^3 (x-axis)
e) Total number of mobile organisms (y axis) vs rock volume in cm^3 (x-axis).

3a. What is the relationship between rock surface area and s**pecies diversity** when both high and mid intertidal rocks are included?

3b. What is this relationship for rocks in the mid intertidal only, and how does it compare with rocks in the high intertidal?

3c. Do these data support or refute your hypothesis?

4a. What is the relationship between the **total abundance** of organisms and under rock surface area?

4b. How does this relationship differ between mid and high intertidal rocks?

4c. Do these data support or refute your hypothesis?

5. Consider the idea that wave action disturbs small rocks more frequently than it disturbs large rocks. How do you expect **species diversity** to be affected based upon rock susceptibility to overturning? Explain how your data supports or refutes

this idea.

6a. Would you expect sessile and mobile animals to be influenced differently by wave disturbance? If so, how? If not, why not?

6b. Explain how your data supports or refutes this idea.

7. To measure the effects of area on diversity we used under-rock surface area, and to measure the effects of disturbance on diversity we used rock volume. Why were these different x-axis variables used for these comparisons?

8. How would you set up an **experiment** in the field to determine the relative contributions of surface area and disturbance on species diversity?

Materials

Each group needs a measuring tape, a clip board for the waterproof data sheet, a pencil (mechanical is best) and a plastic coated field guide for identification of the organisms.

Waterproof paper can be purchased from Rite in the Rain: http://www.riteintherain.com/

Notes for the Instructor

Before beginning this exercise the instructor should provide some safety information. I suggest doing this on reaching the field site so the information is fresh in their minds. In the case of the rocky shore the information will depend somewhat on the shore characteristics. If there are waves students should be reminded not to go too far into the low intertidal and to not turn their back on the ocean. The instructor should point out the possibility of slipping on algae, especially if the rocks have a thin film on them, which can be notoriously slick. Advise students to "become crabs" and use both their hands and feet as they move around the intertidal. Remind them not to step on the tops of rocks, which can be very slippery. Impress on them to replace their turned boulders in the same orientation that they were before turning. Finally remind them that the more care they take with their data collection and recording the easier it will be to complete the analysis of the data!

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About the Author

Dr. Jan Hodder is a Senior Lecturer at the University of Oregon's Institute of Marine Biology (OIMB). Her research focuses on faculty professional development and student centered teaching. She is the Director of the National Science Foundation funded Center for Ocean Science Education Excellence - Pacific Partnerships which has provided community college faculty with professional opportunities to work with ocean scientists and learn about current ocean science research. She is also a P.I. of the Supporting and Advancing Geoscience Education in Two-year Colleges project and was a P.I. of OIMB's G K-12 "Learning About Where We Live" project and the Faculty Institutes for Reforming Science Teaching (FIRST) project. She is a University of Oregon Williams Fellow in recognition of her demonstrated commitment to undergraduate education.

Appendix
Sample Data Sheets

Under Rock Diversity **South Cove, Cape Arago**

Group #: **Student Names:**

Mid-High Intertidal Boulders
Rock Size (dimensions):

Rock #1
Height:
Width:
Length:

Rock #2
Height:
Width:
Length:

Organism – Nos. or % cover	**Rock 1**	**Rock 2**
Sponge – red		
Sponge – purple		
Sponge – yellowy green		
Sponge – other color (note)		
Anemone – aggregate		
Anemone – green		
Anemone – other		
Crab – porcelain		
Crab - shore crabs		
Crab – hermit		
Crab – Cancer species		
Crab – decorator		
Crab – other		
Acorn Barnacle		
Worm – spirorbid		
Worm – calcareous tube		
Worm – hairy gilled		
Worm – scale		
Worm – peanut		
Worm – sand		
Worm – Ribbon		
Worm – other		
Flatworm		
Snail - Periwinkle (*Littorina* sp.)		
Snail – Black turban		
Snail – Ringed top snail		
Snail – whelks		
Snail – other		
Mussel		
Sea slug		
Mussel		
Sea slug		

Chiton – black		
Chiton – gum boot		
Limpet		
Key hole limpet		
Purple Star (can also be orange)		
Six-rayed Star		
Blood Star		
Brittle Star		
Purple Sea Urchin		
Fish – Gunnel		
Other:		
Other:		
Other:		

Under Rock Diversity **South Cove, Cape Arago**

Group #: **Student Names:**

Low-Mid Intertidal Boulders
Rock Size (dimensions):

Rock #1
Height:
Width:
Length:

Rock #2
Height:
Width:
Length:

Organism – Nos. or % cover	**Rock 1**	**Rock 2**
Sponge – red		
Sponge – purple		
Sponge – yellowy green		
Sponge – other color (note)		
Anemone – aggregate		
Anemone – green		
Anemone – other		
Crab – porcelain		
Crab - shore crabs		
Crab – hermit		
Crab – Cancer species		
Crab – decorator		
Crab – other		
Acorn Barnacle		
Worm – spirorbid		
Worm – calcareous tube		
Worm – hairy gilled		
Worm – scale		

Worm – peanut		
Worm – sand		
Worm – Ribbon		
Worm – other		
Flatworm		
Snail - Periwinkle (*Littorina* sp.)		
Snail – Black turban		
Snail – Ringed top snail		
Snail – whelks		
Snail – other		
Mussel		
Sea slug		
Chiton – lined		
Chiton – mossy		
Chiton – black		
Chiton – gum boot		
Limpet		
Key hole limpet		
Purple Star (can also be orange)		
Six-rayed Star		
Blood Star		
Brittle Star		
Purple Sea Urchin		
Fish – Gunnel		
Other:		
Other:		
Other:		

Under Rock Diversity **South Cove, Cape Arago**

Group #: **Student Names:**

Low-Mid Intertidal Boulders
Rock Size (dimensions):

Rock #1
Height:
Width:
Length:

Rock #2
Height:
Width:
Length:

Organism – Nos. or % cover	**Rock 1**	**Rock 2**
Sponge – red		
Sponge – purple		
Sponge – yellowy green		
Sponge – other color (note)		
Anemone – aggregate		

Anemone – green		
Anemone – other		
Crab – porcelain		
Crab - shore crabs		
Crab – hermit		
Crab – Cancer species		
Crab – decorator		
Crab – other		
Acorn Barnacle		
Worm – spirorbid		
Worm – calcareous tube		
Worm – hairy gilled		
Worm – scale		
Worm – peanut		
Worm – sand		
Worm – Ribbon		
Worm – other		
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Snail - Periwinkle (*Littorina* sp.)		
Snail – Black turban		
Snail – Ringed top snail		
Snail – whelks		
Snail – other		
Mussel		
Sea slug		
Chiton – lined		
Chiton – mossy		
Chiton – black		
Chiton – gum boot		
Limpet		
Key hole limpet		
Purple Star (can also be orange)		
Six-rayed Star		
Blood Star		
Brittle Star		
Purple Sea Urchin		
Fish – Gunnel		
Other:		
Other:		
Other:		
Other:		

Mission, Review Process & Disclaimer

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