Kelp Forest Complexity

What factors affect biodiversity and community structure in West Coast kelp forests?

Overview

Ecosystems are made up of species interacting with each other and their environments. In this unit, students will learn about how food webs, competition for resources, and environmental factors shape communities, especially in kelp forests. Students will also learn the ways that researchers collect data in underwater habitats.

Essential Questions

- *What drives species distributions?*
- *What factors affect biodiversity?*
- *How do scientists measure biodiversity? Why are these measurements important?*
- *How can we use analyzed data to support explanations about factors affecting biodiversity?*

Learning Goals

Students will learn the following:

- *Kelp forests increase local biodiversity by providing habitat, food, and structure in an ecosystem.*
- *Oregon's kelp forests are influenced by several factors, including ocean temperature and sunlight, currents, predator-prey interactions, food availability, and competition for resources between organisms.*
- *Researchers use quantitative methods to determine if abiotic factors such as water depth and flow rate can influence patterns of algal biodiversity, species richness and evenness.*

Learning Objectives

Students will be able to:

- *define biodiversity and why it is important.*
- *describe the ways that different organisms interact with each other and their environments.*
- *use surveys to collect data and explore patterns of biodiversity in kelp forests.*
- *analyze and interpret data to identify patterns and construct a claim that is supported by evidence and reasoning.*

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Grade Level

9-12

Time

8 hours

Anchoring Phenomenon

Kelp Forest Complexity

Driving Question

What factors affect biodiversity and community structure in West Coast kelp forests?

Standards

Next Generation Science Standards

LS2.A – Interdependent Relationships in Ecosystems
LS2.C – Ecosystem Dynamics, Functioning, and Resilience

Common Core Math Standards

HSF-LE.B.5

Kelp – Photo: K. Tonra

Introduction

Along the west coast of North America, brown algae kelp seaweeds create vast underwater forests that support many different species by providing food and habitat. The species that live in kelp forests are distributed according to their biological needs, resulting in specific and distinct patterns of distribution. For example, seaweeds usually live near the surface where there is lots of light, and invertebrates like anemones live deeper underwater where water flow rates are higher.

In this unit, students will use survey data to make observations about what types of organisms live in different areas of a kelp forest and how environmental and human impacts are affecting biodiversity underwater. Additionally, students will learn how different data collection methods are used to study various underwater habitats. Some of these methods include SCUBA diving, boat surveys, drones, submersibles, and satellites. Finally, students will learn about threats to kelp forest ecosystems like marine diseases, heatwaves, and overfishing, and how research and conservation efforts can help.

Lesson Procedure

ENGAGE

Activity: Surface Splash (15 min)

Play two videos to the class to give students a brief introduction to kelp forest ecosystems. In the Wild Kingdom video *Kelp Forest Ecosystem*, students hear from Dr. Jenn Caselle, a researcher at UC Santa Barbara who studies kelp conservation and human impacts. For an additional and more local perspective, the Oregon Marine Reserves video *A Prickly Problem with Sea Urchins* explains threats that local kelp beds are facing. For additional information, see the accompanying article by the same title.

Ask students:

- *What do you notice?*
- *What do you wonder?*
- *Does this remind you of anything?*

Create a three-column chart to capture students' thoughts. Accept all ideas.

LESSON RESOURCES

Surface Splash

- *Video: Kelp Forest Ecosystem [6:14]*
- *A Prickly Problem with Sea Urchins – video [2:56] & article*

Purple sea urchin – Photo: K. Tonra

EXPLORE

Activity: Virtual Dive (20 minutes)

This activity will allow students to investigate an "ecosystem" by looking at photos taken along the seafloor. Start by using the *Virtual Dive* presentation introduce students to Catalina Island. These 12 slides contain background about why this area is an interesting location, and how kelp forests increase biodiversity.

Near the end of the presentation, pause the presentation and have students use *Transect Photos* to simulate a dive along a transect line. Six photos of the seafloor at four different sites can be printed and arranged around the classroom or used in their digital form. Each photo is annotated with depth and light index. Have students work in groups. Each group will travel along one of the transects of a site, recording observations and looking for patterns in the data. You may want students to pick up the photos as they go.

Guiding questions:

- *What changes as you dive?*
- *What types of organisms are found at each depth?*
- *What patterns can you identify?*
- *What factors might be affecting where you find different species?*

EXPLAIN

This section of the lesson contains lessons about kelp forest ecology through teacher presentations and class activities. These are meant to be taught together but can take place over separate days. Teacher instructions, presenter notes, and any associated materials are embedded in the *Deep Dive presentation*, which is meant to cover all four parts of this section. The links are also provided separately below.

Deep Dive Part 1: Components of a Kelp Forest Ecosystem (15 min)

This mini-lesson will cover the basics of what a kelp forest is, what abiotic and biotic factors shape the ecosystem, and how those factors impact different organisms.

Watch *Take a Virtual Dive in a Kelp Forest* with your class. Ask your students to make a list of components that they saw in the video and classify each as an organism, species interaction, or environmental factor. Discuss biotic and abiotic factors they identified, and with the examples found in the presentation slides.

Virtual Dive

- *Presentation: Virtual Dive (ppt)(pdf)*
- *Transect photos (pdf)*

Transect photos – K. Tonra

Deep Dive

- *Presentation (ppt)(pdf)*

DD Part I: Components of a Kelp Forest Ecosystem

- *Video: Take a Virtual Dive in a Kelp Forest [3:18]*

Biotic: *Organisms interacting in a way that affects the ecosystem. For example: Kelp provides habitat for other species. Algae and invertebrates compete for space on the rocks. Sunflower stars eat urchins (predation).*

Abiotic: *Characteristics of the environment that affect organisms. For example: temperature, salinity, nutrients, oxygen, light, water flow.*

Deep Dive Part 2: Species Profile and Social (60-90 min)
Students will work independently to learn about one species and fill in a species profile, then work in pairs to compare profiles and identify connections between their different organisms. Students will need to use computers with internet access.

Provide each student with a copy of the *Species Profile* and the *Species Social* student worksheets. Assign species to students or allow them to choose one from the provided *Species List*. Using the *Monterey Bay Kelp Forest* or the *Cabrillo Marine Aquarium Kelp Forests* webpages as sources, have students complete the profile for their chosen species.

Next, have students pair up and fill in a row in their species social worksheet with information about their partner's species. Repeat this step until they fill in all rows or run out of time.

Deep Dive Part 3: Construct a Food Web (30 min)
In this activity, students will *Construct a Food Web* as a group. Ask students to volunteer to come up to the board for this portion of the lesson. The goal will be to draw a food web on the board (whiteboard or large paper) that incorporates all of the species from the Species Social.

Begin by calling out the **primary producers**. Students with organisms that fit into that group (algae) should stand up and draw their organism on the board and connect it to any other organisms with which it interacts. They will likely mention things that eat algae, **grazers** such as urchins and snails. Have the student with those organisms go next, and end with **top predators** like the sunflower star and sea otters.

When the food web is complete, spend a few minutes asking questions like "How would this web be affected if [choose a species] disappeared?" or "If urchins increased, what would happen to kelp?" To summarize the activity, go over the "actual" kelp forest food web and example trophic cascade slides in the *Deep Dive presentation*.

See the full *Construct a Food Web* activity description for modifications for younger students, in which students create a food web using a ball of string to connect the organisms.

DD Part 2: Species Profile & Social

- *Species Profile student worksheet (pdf)(doc)*
- *Species Social student worksheet (pdf)(doc)*
- *Species List (pdf)(doc)*
- *Monterey Bay Kelp Forest*
- *Cabrillo Marine Aquarium Kelp Forests*

Where does it live?

Students filling out the Species Social worksheet may be tempted to write "kelp forest" in the section that asks where their animal lives. However, there are different places within a kelp forest that could be described in this space. For example:

- *in the water column*
- *hidden in kelp blades*
- *in crevices on the bottom*
- *on underwater cliffs*
- *in high/low flow areas*
- *on the surface of the water*
- *on rocks or sand, etc*

DD Part 3: Construct a Food Web

- *Construct a Food Web activity description (pdf)*

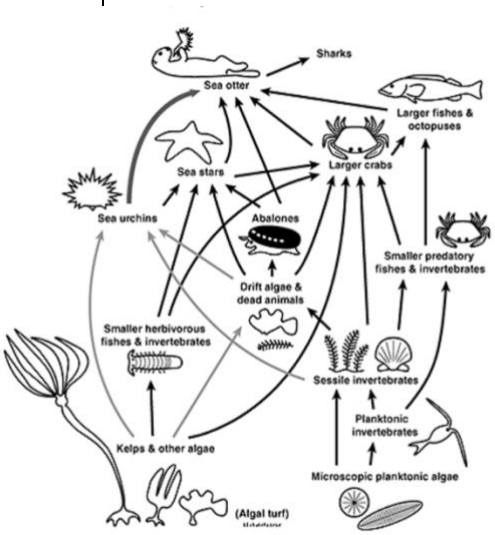


Figure by Daniel R. Brumbaugh (2000)

Deep Dive Part 4a: Career Connection & Research Introduction
This section is the bridge between our general kelp forest ecology background and the data we will use in the rest of the lesson. It begins with introducing Kaitlyn Tonra, a kelp forest researcher from Oregon State University.

Play the *Scientist Spotlight* video in which Kaitlyn explains what scientists do, what research questions she is working on, and how she collects data to answer those questions.

Deep Dive Part 4b: Calculating Biodiversity
Use the *Calculating Biodiversity* presentation to introduce the concepts of species richness, evenness, and biodiversity. Explain that these are different ways that scientists quantify or measure ecological communities based on what species are present. These concepts will be used in the data analysis and graphing activities.

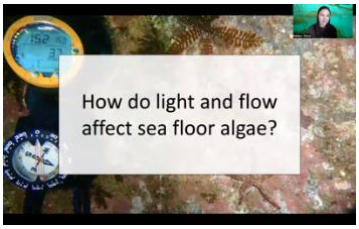
Assign students to small groups to work together on calculating richness, evenness, and biodiversity for one plot (photo) from the *Transect Photos* used in the EXPLORE section. Students will calculate and compare the biodiversity at different sites using the instructions on the *Calculating Biodiversity student worksheet*. Follow up with discussiong and reflections about what the calculations showed.

Guiding questions:

- *How did overall biodiversity differ between Blue Caverns and Big Fisherman Cove?*
- *How did 'evenness' at either end of a transect (0-1m or 19-20m) compare to the middle sections (~8m)? Explain what this means and why.*

Their biodiversity calculations will show the biggest differences between Blue Caverns and Big Fisherman Cove. Overall, evenness should be the highest at the very shallow and very deep ends of the transects and lower in the middle depths, regardless of site.

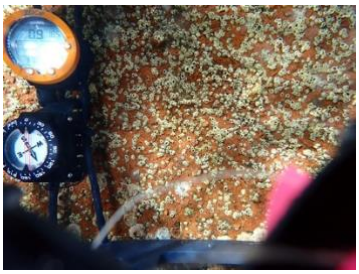
Optional Field Trip
Bring students outside to calculate biodiversity and species richness in other habitats. Students piloting this lesson explored tidepool communities using transects and quadrats.



Scientist Spotlight with Kaitlyn Tonra

DD Part 4a: Career Connection & Research Introduction
- *Video: Scientist Spotlight [22:39]*

DD Part 4b: Calculating Biodiversity
- *Presentation: Calculating Biodiversity (ppt)(pdf)*
- *Calculating Biodiversity student worksheet (pdf)(doc)*


Transect photos – K. Tonra


Exploring biodiversity in other systems
Photo: K. Abraham

ELABORATE

In this section, students apply their new skills to explore biodiversity using real data from Catalina Island kelp forests. There are three options for this depending on time and student level:

Activity A (easier): Interpreting Graphs: Role of currents
What role do currents play in algal community structure? Use the *Activity A student worksheet* to guide students through the process of interpreting graphs and drawing conclusions about a process in nature.

Activity B (harder): Analyze & Interpret: Species Richness & Depth
How does algal species richness change with depth? Students will use the *Activity B student worksheet* to make a prediction then use data to draw conclusions. An *Activity B Teacher Key* with answers is provided.

Activity C (hardest): Open-ended Graphing and Analysis
To provide students with opportunities for an independent exploration of data, use the *Activity C student worksheet*. Given the open-ended questions, this version of the activity will require the most teacher involvement and experience with graphing and doing minor calculations using the *Activity C datasheet* in Google Sheets or Excel.

EVALUATE

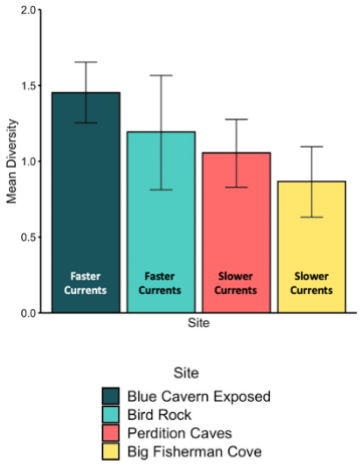
Assess student learning by asking them to develop a claim, back it up with evidence, and use reasoning to answer the following question:

What factors affect biodiversity in kelp forests, and in what ways?

Students can use the *CER Template* which presents sentence frames for them to structure their Claim, Evidence, and Reasoning statements.

Using Real Data

- *Activity A: Interpreting Graphs student worksheet (pdf)(doc)*
- *Activity B: Analyze & Interpret student worksheet (pdf)(doc)*
- *Activity B: Teacher Key (pdf)*
- *Activity C: Open-ended student worksheet (pdf)(doc)*
- *Activity C: Datasheet (xls)*



Using Real Data Assessment

- *CER Template (doc)*

Students explore marine communities
Photo: K. Abraham

Next Generation Science Standards

Performance Expectations:

HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Science & Engineering Practices:

Using Mathematics and Computational Thinking

Disciplinary Core Ideas:

LS2.A – Interdependent Relationships in Ecosystems
LS2.C – Ecosystem Dynamics, Functioning, and Resilience

Crosscutting Concepts:

Scale, Proportion, and Quantity

Common Core Math Standards

Math Standards:

HSF.LE.B.5 – Interpret the parameters in a linear or exponential function in terms of a context.

Math Practices:

MP4 - Model with mathematics.

Transect slide analysis
Photo: K. Abraham

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Unless noted otherwise, all photos in this lesson were taken by Kaitlyn Tonra and not to be used, altered, or shared for any other purpose.

See more lessons on the ORSEA webpage: oregoncoaststem.oregonstate.edu/orsea