

Prince William's Oily Mess: A Tale of Recovery

Working With Real Data: Graphing Changes in Marine Life Abundance

Welcome to *Working with Real Data!* In this hands-on activity, students work with real data collected by scientists at NOAA's National Ocean Service, who are studying the ecological **recovery** of Prince William Sound following the *Exxon Valdez* oil spill. From photos of sampling **quadrats** at Mearns Rock, an oiled shoreline **boulder**, students record the **abundance** of marine **intertidal** organisms, graph the data and interpret their results. (All bolded terms are defined in the **Glossary Express** at the end of this document.)

Start with **STEP 1a** below...

STEP 1a: Read the Introduction

Want to try your hand at some marine biology? Then grab your raingear and follow steps 1, 2, 3 & 4 to make a study of the **marine** life occupying a **quadrat** of Mearns Rock. A quadrat is a small sampling plot or area that is designed to represent a larger area that is being studied. Mearns Rock is a boulder in Prince William Sound, Alaska, that was oiled in 1989 by the *Exxon Valdez* oil spill. For your study, you'll use a series of close-up photos of the quadrat, each showing a



different year from 1990 to 2004. Your goal will be to see how the **percent cover** of **mussels**, **barnacles**, and *Fucus gardneri* (a kind of seaweed, also called rockweed) in this study area has changed during those 15 years.

As you complete this project, you'll be using the same method used by real marine biologists. To study how marine life **abundance** changes from one year to the next, marine biologists sometimes section off a small plot of land that's representative of the particular habitat they're studying (for example, a rocky shoreline or a beach). They use a frame (generally a 0.25 or 0.5 square meter of PVC pipe), known as a quadrat, which they place on the ground to mark an area to study in depth. Each year, the biologists return to count the organisms or plants that occupy the area inside the quadrat. In most studies, many quadrat samples are necessary to adequately represent the whole area. In the photo at the left, a NOAA marine biologist is using a quadrat in his studies of the Mearns Rock site. He's trying to find out how the abundance of *Fucus*, barnacles, mussels, and other organisms has changed since the year before.

STEP 1b: Learn the Organisms

Use the field guide on PAGES 3-5 to learn more about the organisms that you will later observe in the Mearns Rock quadrats. The photo on PAGE 3 of the field guide shows representative patches of three common marine, **intertidal** organisms that live on Mearns Rock: *Fucus* (a type of algae), barnacles and mussels.

Then, scroll down to PAGES 4 and 5 to read more about the biology of these three life forms. Later, you'll observe these organisms in the photos of the Mearns Rock **quadrats**, estimate their **percent cover**, and establish the criteria you'll use to make your observations.

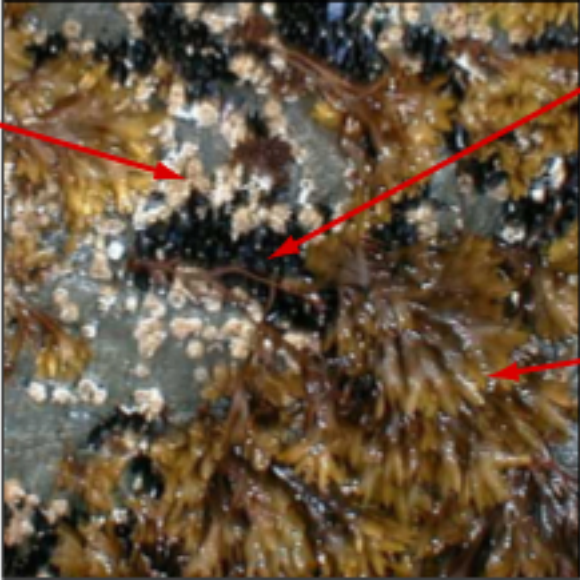
Mearns Rock Field Guide

[Rockweed](#)
(Fucus)

[Mussels](#)

[Barnacles](#)

Barnacles
(whitish regions)



Mussels
(black regions)



Fucus gardneri



Rockweed (*Fucus gardneri*)

Fucus (pronounced like mucus) is a type of brown algae that grows in the middle- to upper-intertidal zone (the higher part of the tidal flat) of cold ocean waters. The body of the alga is composed of flattened "branches," some of which end in swollen receptacles that house reproductive parts (eggs and sperm). (*Fucus* is sometimes called "popweed." Can you guess why?) The holdfast, at the base of the alga, attaches it to the rocks on which it lives. Because *Fucus* is sometimes out of water for hours at a time when the tide is low, it has a thick "skin" that helps it keep its moisture, and it makes a sticky substance to keep from losing water. In late spring and summer, in locations where *Fucus* grows well, it may nearly cover all other intertidal organisms!



Mussels (*Mytilus trossulus*, the Pacific Blue mussel)



Mussels are bivalves (their bodies are enclosed by two shells, or valves) that can be found firmly attached to rocks, floats, and pilings. A mussel stays attached to the substrate by its byssus, a collection of tough, leathery threads of organic material secreted by the mussel. Adult *M. trossulus* range from 3 to 10 cm in length and can vary considerably in color. Generally, the shell is dark blue-black or brownish black, but the shell of young mussels is often brown. Like many other bivalves, mussels are filter feeders, pulling water into their body chambers with their inhalent, or intake, siphon (the larger, frayed-edge gape on the upper edge of the mussel), and then forcing it out the exhalant, or exhaust, siphon (which is smaller and has a smooth edge). Dense masses formed by mussels provide protection and other biological necessities for many organisms, such as small shrimp, amphipods, and polychaete worms. Mussel beds also serve as a substrate to which barnacles may become attached.

Barnacles (*Balanus glandula*)

Barnacles are tiny crustaceans (animals related to crabs, lobsters, and shrimps) that occupy volcano-like shells. They colonize rocks, pilings, and even boats, by attaching masses of their whitish-colored shells to the substrate. The shell of *B. glandula* consists of a number of overlapping plates. The barnacle controls the opening at the top of the shell by moving these plates. A large *B. glandula* is about 1.5 cm across, with its diameter about the same as its height. In large masses, you may notice that the barnacle shell is more cylinder-shaped than volcano-shaped. (Why do you think that is?) The barnacle feeds by using six feather-like appendages, called cirri. As the cirri rapidly extend and retract through the opening at the top of the barnacle, they comb the water for microscopic food.



Reference

Kozloff, Eugene N. 1973. Seashore Life of Puget Sound, the Strait of Georgia, and the San Juan Archipelago. Seattle, WA: University of Washington Press. 282 pp.

STEP 1c: State Your Predictions!

The next step is to state and write down your **prediction(s)** about the results you expect once you collect the data.

Predictions are always stated BEFORE seeing your data. Making predictions is usually the first step in a scientific investigation (perhaps your teacher will explain why this is the case). Before you even look at the photos of the quadrats, you should write down at least one prediction. For example, you could make a prediction about the percent cover for each species. Here is an example:

I predict that as time goes on, mussels will come to dominate the percent cover (it will be >50%) because...

After the "because..." you should state WHY you think this prediction will be true (this is called the rationale for the prediction).

Don't worry whether your predictions are "true" or "false." You are simply making a statement of expectation based on your **hypothesis**, which scientists always assume is true (and so should you).

By the way...What is your hypothesis here?

STEP 2a: Observe Mearns Rock Photos and Quadrats

The goal in this step is to familiarize yourself with the two types of photo data you will see in this exercise.

First, photos of the Mearns Rock quadrat from 1990 to 2004 are located on **PAGES 18-26**. Second, photos of Mearns Rock (in its entirety) from 1990 to 2004 are located on **PAGES 27-44**. Quickly look through some of these photos and learn to navigate on these pages. Don't worry about reading all the accompanying text for now—you will return to this section later to do that.

Later, you will go back to the quadrat photos to estimate the **percent cover** (i.e. abundance) of each organism. You will refer back the Mearns Rock photos at the very end of this activity to help you interpret your data.

But first, you will need to collect a few resources in order to record your data. **Proceed to Step 2b** to gather these resources and begin recording your data.

STEP 2b: Record Your Data

Before you begin collecting data, you need to gather the resources necessary to record your data from the quadrat photos. You should do the following:

▶ **Data Table** - **Print out the Data Table on PAGE 14, if you have not done so already.**

You'll use it to record your estimates of percent cover of *Fucus*, mussels, and barnacles in the Mearns Rock quadrats from 1990 to 2004.

▶ **Charts** - **Print out the Percent Cover and Color Charts on PAGE 15, if you have not done so already.**

You'll use these charts as an aid for estimating the percent cover of a particular form of marine life in the quadrat you are observing.

▶ Tips for Collecting Data

Because the Mearns Rock quadrat photos were taken at different times of day and under different weather and light conditions, they vary in their color and clarity.

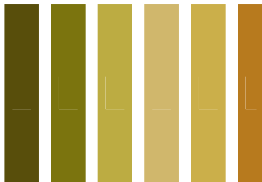
Watch for four color ranges to identify the marine life:



Gray areas tend to be bare rock.



Black areas are often mussels.



Areas that range from green to gold to brown are often *Fucus gardneri* (rockweed or popweed). Young *Fucus* plants are greener in color; mature plants are browner.



White or light gray regions tend to be barnacles.

Establish Observation Criteria

As you look through the photos, you will note that algae or seaweed sometimes covers much of the rock, possibly hiding barnacles and mussels from view. Before making your estimates, first establish the criteria that you'll follow. For example, consider basing your observations on "what's visible" rather than on your best guess of what might be living underneath something else. Also, consider the intense competition for space that exists among marine life forms in the intertidal region. For example, if sea otters clear mussels off a section of the rock, that opens space for barnacles, *Fucus*, or other organisms to "move in" to that space. You'll see several examples in these photos.

Time to Get Started!

You are now ready to open the series of high-resolution photos of the same quadrat of Mearns Rock, taken each year from 1990 to 2004. As you examine each quadrat photo, you will estimate how much of the quadrat *Fucus* occupies (as a percent of the total area), how much of the quadrat mussels occupy, and how much of it barnacles occupy. Record your estimates in the data table you printed out earlier.

Use your printout of the **Percent Cover Chart** and the **Color Chart** as an aid in estimating the percent cover of each organism on the quadrat you are observing. Think of the black areas in the Percent Cover Chart as representing one of three life forms you learned about earlier in the field guide.

Now, go to the quadrat photos located on PAGES 18-26 to start recording your data!

STEP 3a: Plot Your Data

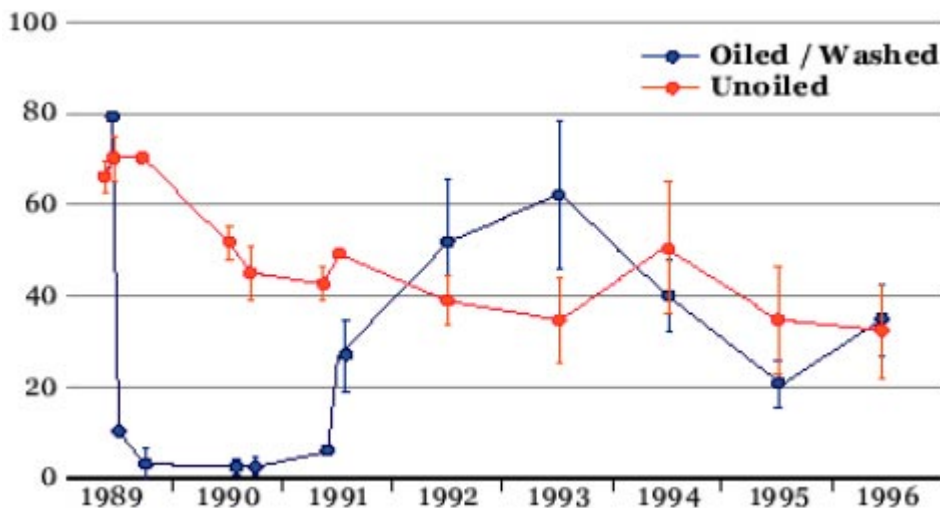
Your next step is to graph your data so that you can see trends over time in the **relative abundance** of the three organisms in the quadrat. **Relative abundance** is the number of individuals of a species compared to the abundance of all the other species. Your graphs will look similar to those that marine **ecologists** make after actually measuring the amount of **cover**.

► **Graphs for Plotting** - [Print out the timeline graphs on PAGES 16-17](#). You'll plot your data from the data table on these graphs.

STEP 3b: View An Example Graph

The graph below was prepared by a marine biologist, and looks much like the graphs you'll prepare as you complete this project. Below is the comparison of rockweed cover at middle elevation unoiled sites and oiled/washed rocky sites, 1989-1996. Washed sites were cleaned by hot-water washing during the months after the spill.

Mean Percent Cover of a 0.25 Square meter Quadrat



Summary of *Fucus gardneri* Abundance

This graph shows mean percent *Fucus gardneri* cover of 0.25 square meter quadrat from 1989 to 1996. Abundance is plotted for these categories: oiled/washed and unooled. The data for oiled/washed sites show a steep decline in cover in 1989 after treatment. Mean abundance of oiled/washed *Fucus* dropped from a high of 80% cover per quadrat in 1989 to a low of less than 5% in 1990. Abundance then steadily increased to a high of over 60% in 1993. Cover again declined, reaching a low of about 20% in 1995, then increasing to about 35% in 1996.

The abundance of unooled *Fucus* fluctuated somewhat during the same period, but gradually decreased from about 70% cover per quadrat in 1989 to just over 30% in 1996. Although the steep decline in *Fucus* cover in 1989 at oiled/washed sites almost certainly reflects the impact of oil and treatment, the other fluctuations are more difficult to explain. This is true for oiled/washed sites, as well as control sites.

Step 4a: Interpret Your Data and Write a Scientific Report

► Interpret Your Data

Now, look at the trends that your graph reveals.

What can you conclude about the relative abundance of different organisms in your study area?

To help you interpret your data, [go to the Mearns Rock photos on PAGES 27-44](#) and read the NOAA biologists' explanations of the year-to-year changes they have observed on Mearns Rock. This will help you in interpreting your data.

► Write a Scientific Report

Your teacher may have you, or your team, write a scientific report. It should have the following sections:

Introduction	<p>What is this report about? Why are you, or your team, writing this report? What should readers expect to learn from this report? What is your hypothesis? What is (are) your prediction(s) and the rationale behind them. Research on Background Information:</p> <ul style="list-style-type: none">• What is the intertidal zone?• Where are intertidal zones located?• What type of plants and animals live there?• What are some interesting facts about these species?• And so on... <p>Purpose/Problem</p> <ul style="list-style-type: none">• What is the question that scientists are asking about Mearns Rock?• Why are scientists conducting a study of Mearns Rock?• How long has this study been occurring?• Why are scientists studying these species?• Why do scientists sample at the same time each year?• And so on...
Procedure	Explain how you or your team recorded data from the

	<p>photographs of quadrats of Mearns Rock (use a step-by-step format).</p>
<p>Data and Results</p>	<p>Keep accurate records using the data table provided. You will want to include your graphs of these data in your report.</p>
<p>Conclusion</p>	<ul style="list-style-type: none"> • Put your table of data, your graphs, and the photos of the quadrats on Mearns Rock side-by-side on the tabletop. Review each and ask yourself: As time passes, what do you observe about the percent cover of each organism living on Mearns Rock • Considering your data and graphs, answer the following questions: Did the prediction(s) you made before you began this study turn out to be true or false? How does this reflect on your hypothesis? Did your data support or refute your hypothesis? • What can the results of the Mearns Rock study tell us about other locations in Prince William Sound? • How can studying Mearns Rock help us to learn about oil spills in other locations in the world? • Explain how Prince William Sound has or has not recovered from the <i>Exxon Valdez</i> oil spill. • What questions do you still have that you would like to explore yourself or discuss with a scientist?

Step 4b: Share What You Have Learned

Scientists share their results with each other at scientific conferences. Your teacher may have you, or your team, share your findings with your classmates at your very own scientific conference. Each team member will present a section of your scientific report at the conference.

For example, Dr. Mearns has shared the results and conclusions of his studies in Prince William Sound at several conferences, including the *Exxon Valdez Oil Spill Symposium*, which was hosted by the [American Fisheries Society](#) in Anchorage, Alaska in 1993. He was an author on three chapters in the proceedings published on the symposium. Here is the citation for one of his chapters:

Mearns, A.J. 1996. *Exxon Valdez Shoreline Treatment and Operations: Implications for Response, Assessment, Monitoring, and Research*. Pages 309-328 in S.D. Rice, R.B. Spies, D.A. Wolfe, and B.A. Wright (editors). Proceedings of the *Exxon Valdez Oil Spill Symposium*. American Fisheries Society Symposium 18. [An abstract for this chapter and all the chapters published in the Proceeding](#)



Mearns Rock as it appeared in 2003—fourteen years after the *Exxon Valdez* oil spill. (Photo credit: OR&R, NOAA)

Glossary Express

(Glossary terms in the text are bolded)

Abundance—the total number of individuals of a species present in an area.

Barnacles—marine crustaceans with feathery appendages for gathering food that are free-swimming as larvae but permanently fixed (to rocks, boat hulls or whales) as adults.

Boulder—a mass of rock greater than 256 millimeters in diameter.

Cover—referring to the amount of plants or other organisms that are occupying the ground, a rock or other surface.

Ecology—the study of the relationship among organisms and between organisms (the biological environment) and their physical environment.

Hypothesis—an idea or explanation that is based on observations and that can be tested; a suggested explanation for an observation often stated in the form of a question that can be answered by the results of an experiment.

Intertidal—on a beach, the area between high tide and low tide.

Marine—relating to the seas and oceans.

Model—an abstraction or simplification of a natural phenomenon developed to predict a new phenomenon or to provide insight into existing ones.

Mussels—a bivalve mollusk usually having a dark elongated shell.

Percent Cover—the proportion (in percent) of a certain species or group of species that is occupying a surface such as the ground, a rock, etc.

Prediction (or “to predict”)— A scientific model to explain what happens, and why it happens; an indication in advance based on observation, experience, or scientific reason.

Quadrat—a small plot or sample of land that is representative of the particular habitat that is being studied. Often the plot of land is demarcated using a frame made of PVC pipe or other material.

Rationale—an underlying reason.

Relative Abundance—the proportion or numbers of a species compared to the total number of individuals of all the species in the community or sample.

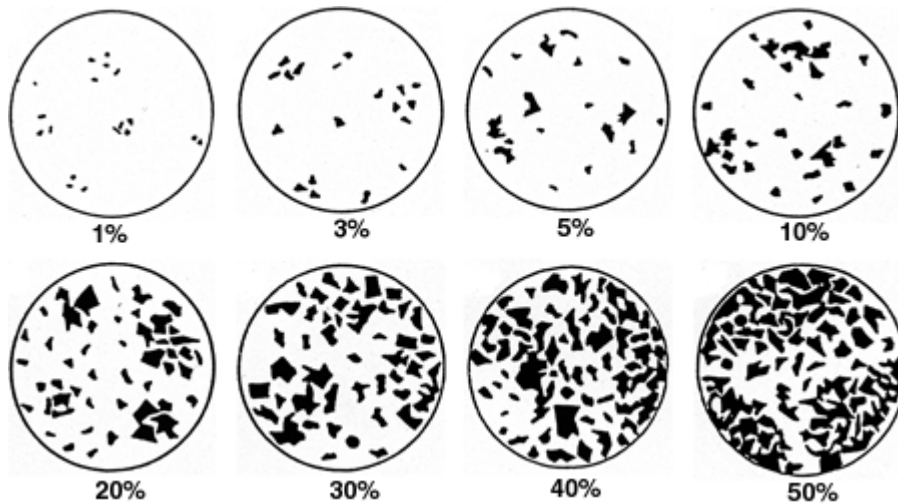
Data Table

Print this table, then use it to record your best estimate of the percent cover of *Fucus gardneri*, mussels, and barnacles from 1990 to 2004. We assume that the percent cover of each species was 0 in 1989. To help you "calibrate" your estimates, we've included our estimates of percent cover in 1990.

Year	<i>Fucus gardneri</i> (percent cover)	Mussels (percent cover)	Barnacles (percent cover)
1989	0	0	0
1990	50	5	5
1991			
1992			
1993			
1994			
1995			
1996			
1997			
1998			
1999			
2000			
2001			
2002			
2003			
2004			

Percent Cover Chart

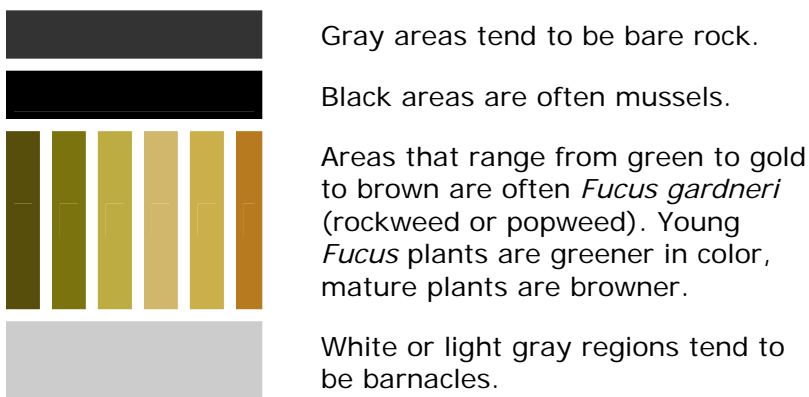
Use this chart as an aid for estimating the percent cover of a particular form of marine life in the quadrat you are observing. Think of the black areas in the chart as representing one of the three marine life forms you're studying.



Color Chart

Because the Mearns Rock quadrat photos were taken at different times of day and under different weather and light conditions, they vary in their color and clarity.

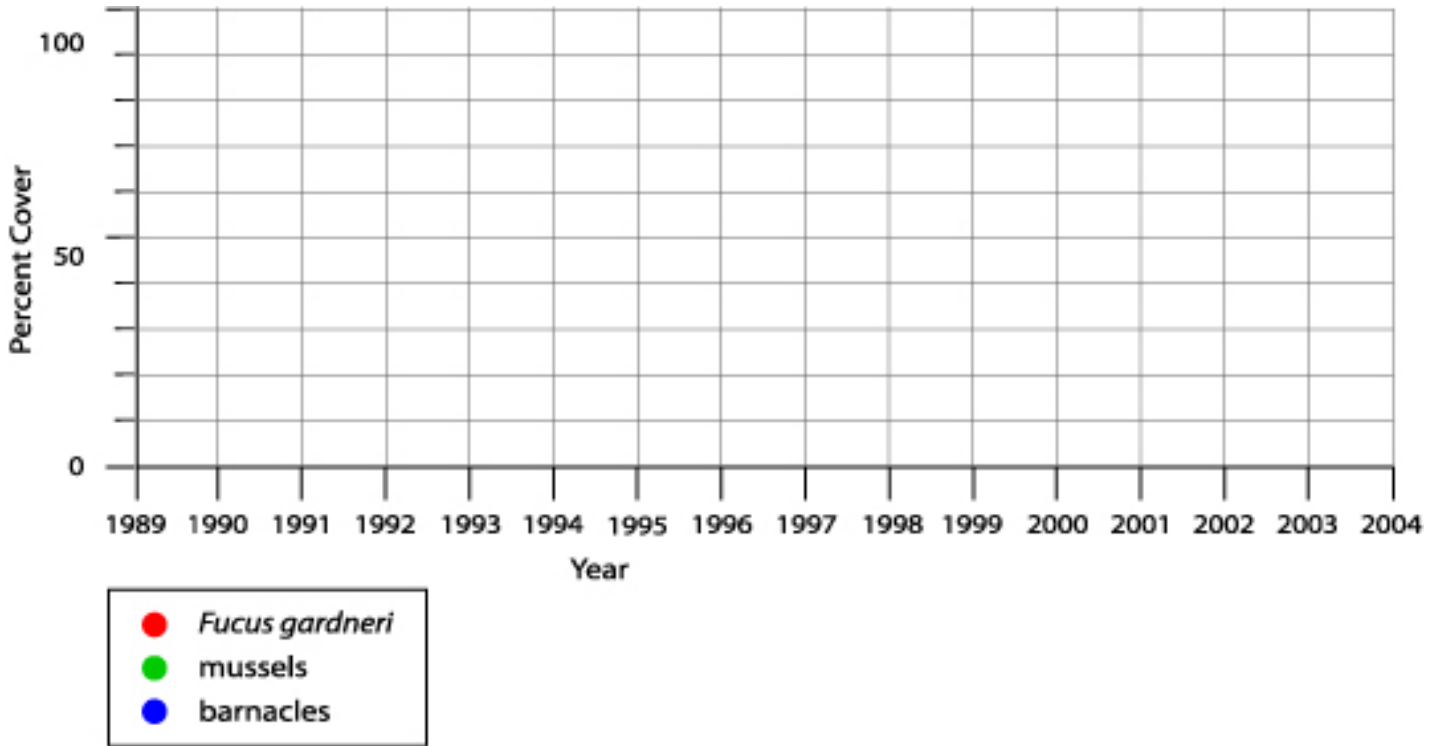
Watch for four color ranges to identify the marine life:



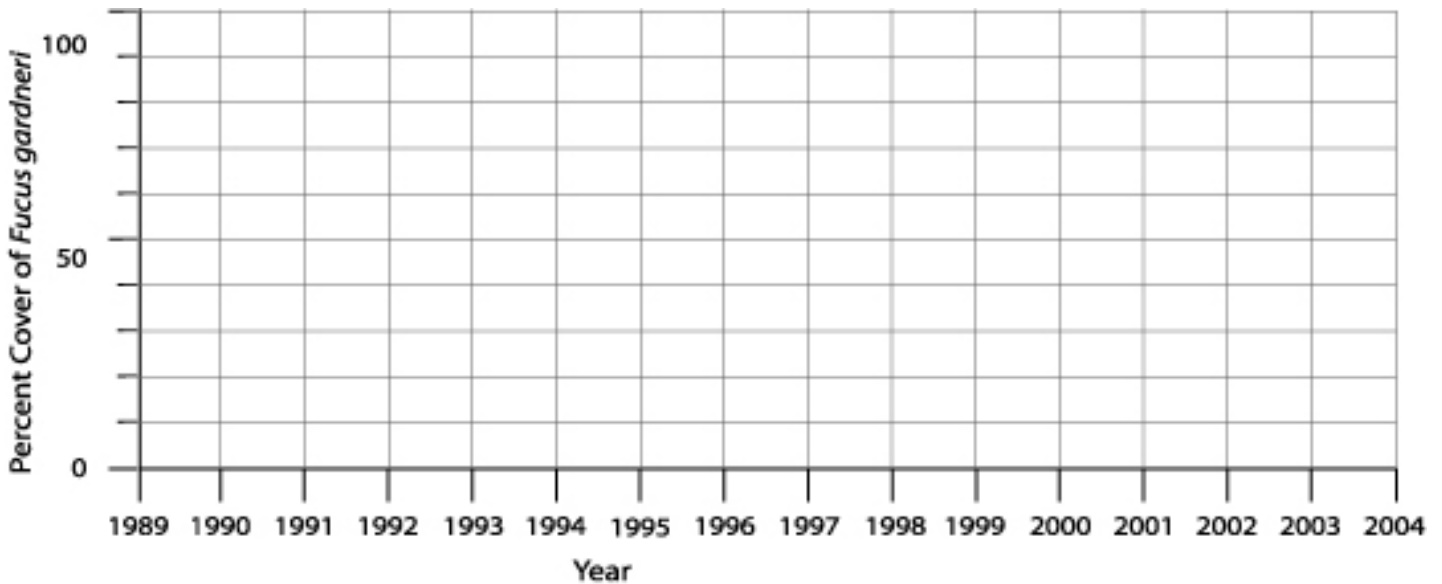
Plotting Your Data

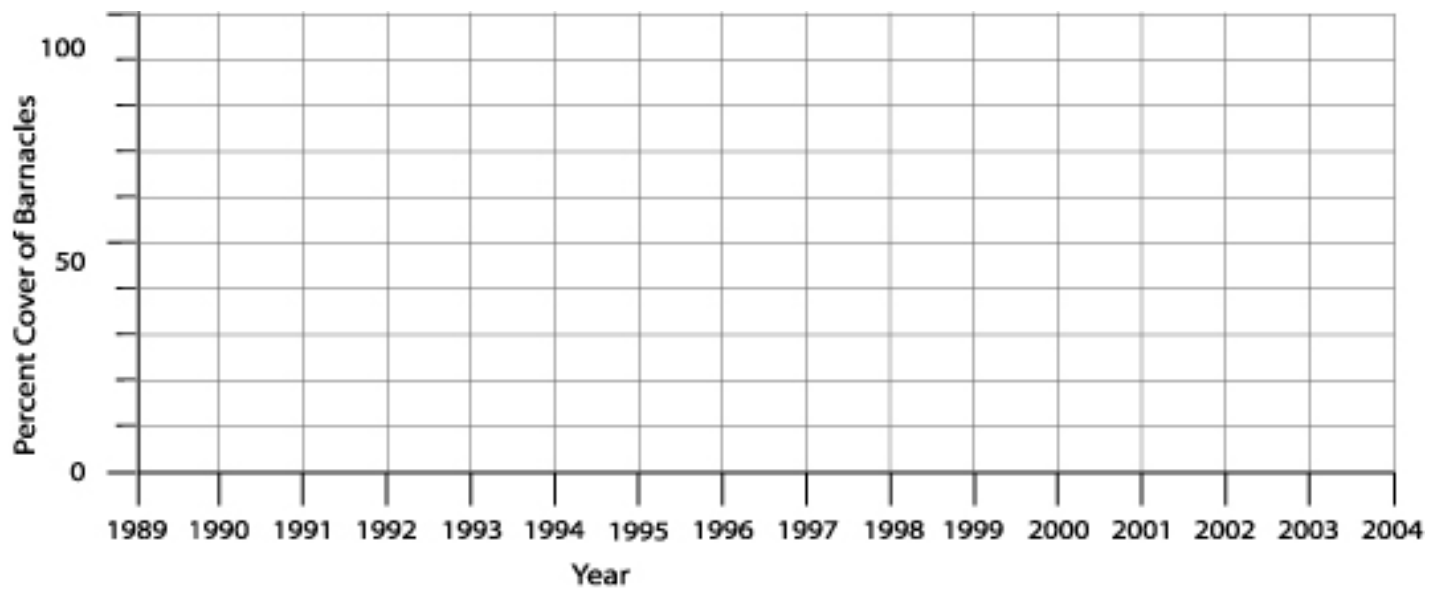
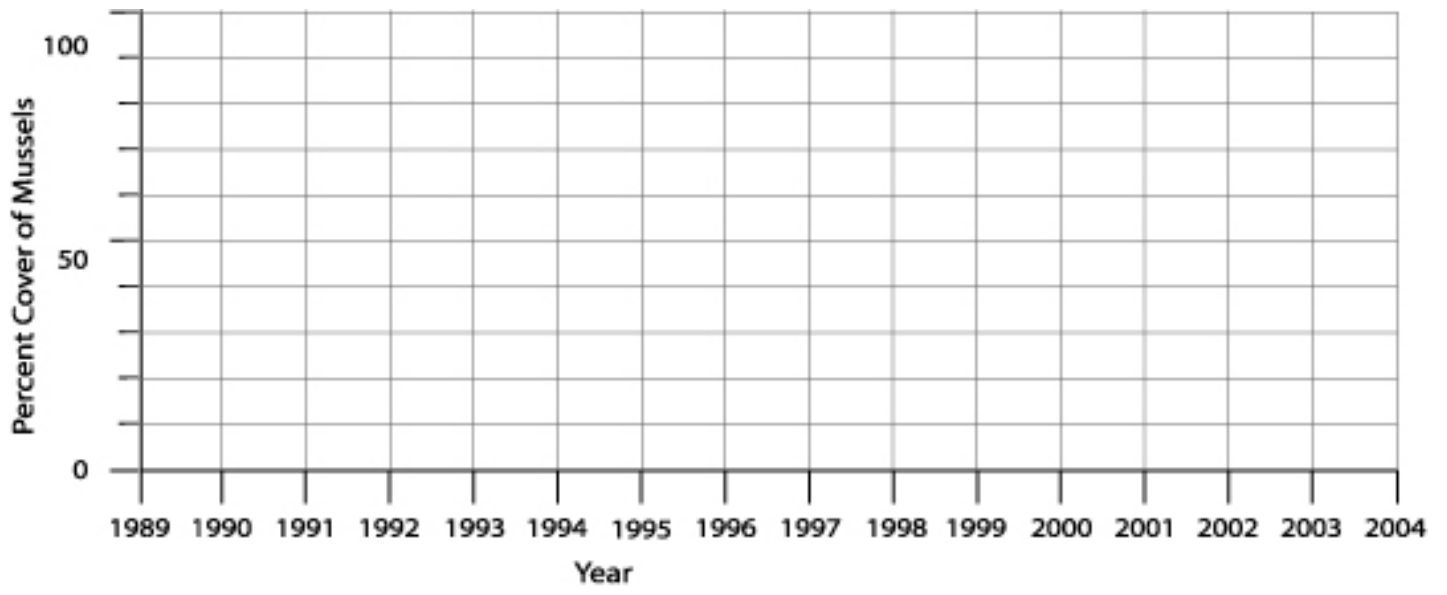
Print this page, then choose either **graph set (a)** to plot the percent cover of *Fucus*, mussels, and barnacles on one graph, or **graph set (b)** to plot the percent covers on separate graphs.

(a)



(b)





Mearns Rock Quadrat Photos

Introduction

We chose a representative section of Mearns Rock to show you at high resolution. Each of the photos in this series is a closeup of the region approximated by the quadrat shown in red below.

[1990](#)

[1991](#)

[1992](#)

[1993](#)

[1994](#)

[1995](#)

[1996](#)



[1997](#)

To view the photos, click the link to any year, at left.

[1998](#)

[1999](#)

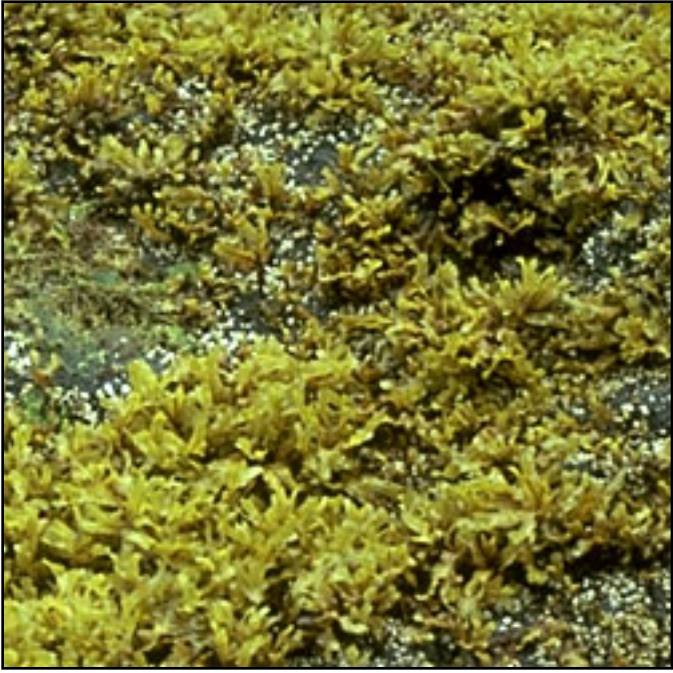
[2000](#)

[2001](#)

[2002](#)

[2003](#)

[2004](#)



1990: In this photograph, you can see the young *Fucus* plants that almost covered the boulder in 1990, as well as young barnacles, which appear as tiny, white spots. We think the dark region in the upper right section of the quadrat may be young mussels.



1991: Although this photo is unclear, we can see more mature, gold-brown *Fucus* and dark-colored juvenile mussels in this photo. Some of the small, very light, circular patches may be barnacles.



1992: Larger, older seaweed (mainly *Fucus*) is dying off. Light-colored barnacles are filling in spaces left by dying seaweed. The mussels appear larger now.



1993: In this photograph, dark patches of mussels have taken hold on the boulder. Also visible are whitish patches of barnacles and, in the upper section of the photo, young, gold-brown *Fucus* plants.



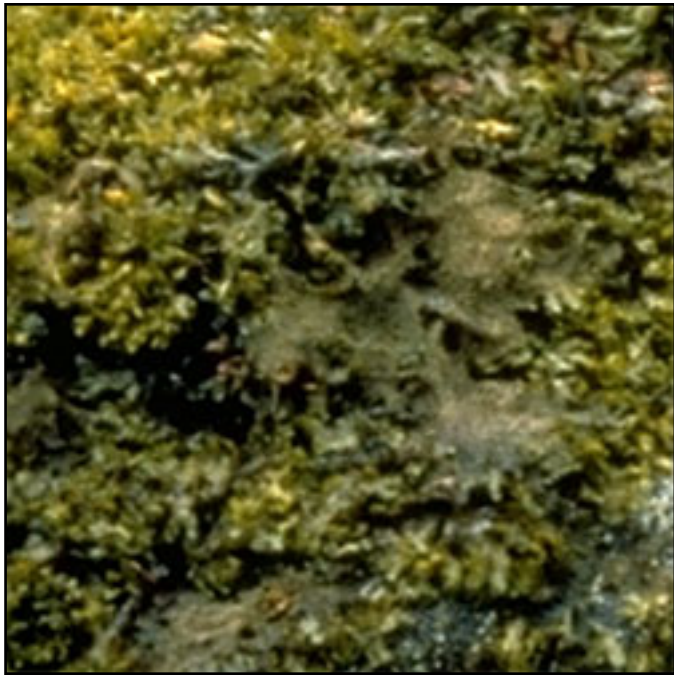
1994: The quadrat is dominated by mature mussels. A few barnacles are visible, but no *Fucus*!



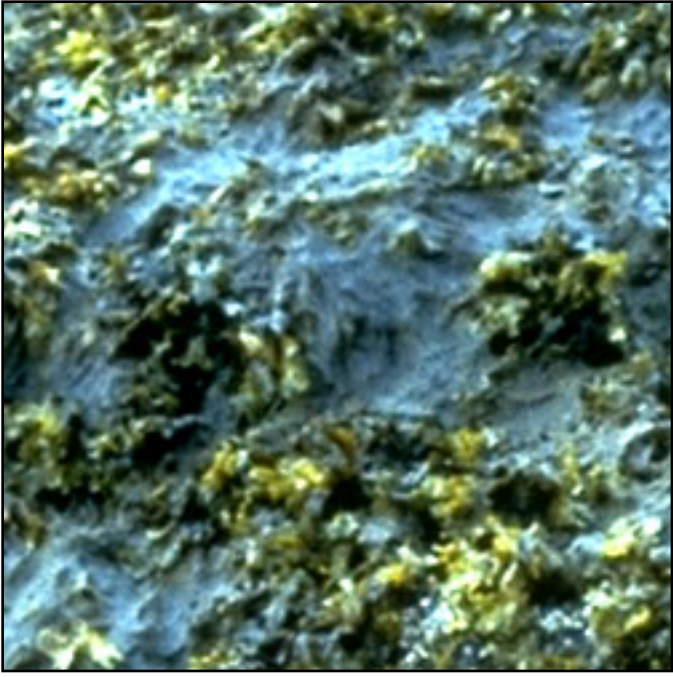
1995: Many of the mussels in the quadrat have disappeared. In contrast to earlier photos, much of the light-colored regions of the boulder is bare rock! Some barnacles are visible (you can distinguish them from the bare rock by their bumpy texture), and in the upper section of the quadrat, you can see some young *Fucus* plants.



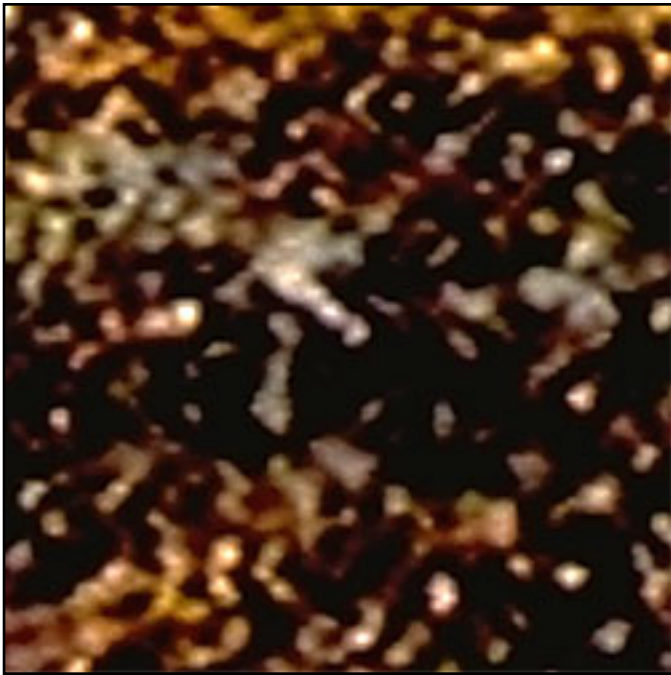
1996: In the quadrat in 1996, the *Fucus* cover has increased. Here, the bare rock appears as darker gray. Most of what was bare rock last year is covered by barnacle spat (young barnacles) this year. It's difficult to tell if young mussels occupy the dark regions of the quadrat.



1997: This year, the quadrat is occupied by *Fucus*, some dark sections of mussels, and a slimy, filamentous algae.



1998: It's difficult to know what quantity of *Fucus* is present under this filamentous algae that has grown on top of it (which we think is *Pilayella littoralis*). We think that the dark areas of mussels have grown larger since the last photo.



1999: Like all scientists, our biologists sometimes experience problems in the field. When this photo was taken in 1999, low tide occurred at sunrise, which didn't provide enough light for conventional photography. Our biologist was able to provide a photograph taken from a videotape; however, this quadrat photo is very unclear.

This is our interpretation of the photo: Mature *Fucus* and possibly mussels are the only marine life forms visible in the quadrat.



2000: Mature *Fucus* and a large filamentous algae are the only marine life forms visible. The mussels seem to have disappeared.



2001: In this photo, the slimy algae appears to be dying back. We can see older (brownish) *Fucus* plants, younger (greenish) *Fucus*, as well as white regions of barnacles. The small dark areas are either mussels or shadows.



2002: Only a few mature *Fucus* plants remain in 2002. More barnacles (white bumps) are visible, but no mussels are present.



2003: In this photograph, we can see a few patches of mature, gold-brown *Fucus*, the largest appearing in the lower left section of the quadrat. Some very young (greenish) *Fucus* plants have also sprouted on the quad. A sprinkling of new barnacles (young of the year, which appear as small whitish bumps) are visible, but much of the boulder is bare rock (dark gray). The barnacles that covered the rock in 2002 have largely disappeared and have been replaced by new baby barnacles in 2003.



2004: Much of the quadrat is covered by young Fucus plants in 2004. No mussels are visible. The tiny barnacles that set in 2003 have grown, creating a white crust under the Fucus. This year, there is little or no bare rock. Note the new species of seaweed (resembling a spider) in the upper right section.

Mearns Rock Time Series

Here is a series of photographs of "Mearns Rock," a large boulder (approximately 4 feet [1.2 meters] high by 7 feet [2.1 meters] long) located in the intertidal zone at Snug Harbor on Knight Island, Prince William Sound, Alaska. The boulder is located on a very protected, south-facing rocky shoreline that was oiled during the Exxon Valdez spill in March, 1989. This section of shoreline was not cleaned after the spill. We presume that the boulder, like the rest of this shoreline, was coated by spilled oil, which was gradually removed from it by natural processes during the first year after the oil spill. (Note that we have not yet provided photos of a "control" site, a boulder on a similar shoreline that was not oiled.)

NOAA biologists have photographed this boulder--and the animals and plants growing on it--once each year (in late June or early July) during the past 15 years. Click on any photo below to see a larger image and our biologist's interpretation of what you're seeing.



1990



1991



1992



1993



1994



1995



1996



1997



1998



1999



2000



2001



2002



2003



2004

Mearns Rock in 1990



What You See

In this photograph, taken 15 months after the spill, you see only the top portion of the boulder because the tide was in at the time that the photo was taken. The boulder's surface is almost entirely covered by young plants of the algae *Fucus gardneri* (commonly called "rockweed" or "popweed"), which is abundant on the shorelines of Prince William Sound. On the right section of the boulder (the area of white color) is a settlement of young barnacles. The dark patch (on the right section) is a colony of small mussels.

What's Happening

No oil appears on the boulder because biological processes have cleared it away. NOAA biologists assume that adult *Fucus* plants that were present at the time of the spill were damaged by the oil and/or the particularly cold temperatures of the previous winter. Young *Fucus* have grown since that time.

Mearns Rock in 1991



What You See

In mid-1991, the entire boulder is covered with gold-brown *Fucus*. You can see darker species of seaweed forming an apron around the base of the boulder; the beach area surrounding the boulder (the "beach face") is also completely covered with other seaweed species. In the water behind the boulder, you can see a healthy eelgrass (*Zostera marina*) bed.

What's Happening

The boulder's condition appears to be improving, shown by the heavier covering of seaweed. One might conclude that this shoreline had recovered from the oil spill.

[1990](#) | [1991](#) | [1992](#) | [1993](#) | [1994](#) | [1995](#) | [1996](#) | [1997](#) | [1998](#) | [1999](#) | [2000](#) | [2001](#) | [2002](#) | [2003](#) | [2004](#)

Mearns Rock in 1992



What You See

The boulder is now about 50% covered with larger, older seaweed (mainly *Fucus*). Barnacles are filling in spaces left by dying seaweed. The beach face is heavily covered with seaweed.

What's Happening

The *Fucus* that was young in the 1990 photo has aged and is now dying off. Why is it dying off?

[1990](#) | [1991](#) | 1992 | [1993](#) | [1994](#) | [1995](#) | [1996](#) | [1997](#) | [1998](#) | [1999](#) | [2000](#) | [2001](#) | [2002](#) |
[2003](#) | [2004](#)

Mearns Rock in 1993



What You See

Fucus now covers about 20% of the boulder's surface. Large, older plants are gone; they seem to have been replaced by young plants. Mussels are growing on the front face of the boulder (black regions). Although the barnacle areas are difficult to see in the photo, the barnacles have died back considerably.

What's Happening

The young seaweed from the 1990 photo has matured, died back, and has almost entirely left the boulder. The patches of mussels probably began as young animals in 1992, but were too small to be seen in the 1992 photo. Now that they are larger, they are more visible. NOAA biologists aren't sure why the barnacles have died back. Have you any ideas why?

[1990](#) | [1991](#) | [1992](#) | [1993](#) | [1994](#) | [1995](#) | [1996](#) | [1997](#) | [1998](#) | [1999](#) | [2000](#) | [2001](#) | [2002](#) | [2003](#) | [2004](#)

Mearns Rock in 1994



What You See

Fucus has completely left the boulder, leaving it dominated by approximately 2-year-old mussels (black areas on the boulder) and scattered barnacles. Very little seaweed is growing on the beach face. Where did the plants go? Why aren't they growing here anymore?

What's Happening

In 1993 and 1994, something happened that caused a great reduction in the abundant marine life on this shoreline. NOAA biologists believe that the loss of seaweed, mussels, and barnacles is part of the growth cycle of the marine life, rather than due to oiling per se.

[1990](#) | [1991](#) | [1992](#) | [1993](#) | 1994 | [1995](#) | [1996](#) | [1997](#) | [1998](#) | [1999](#) | [2000](#) | [2001](#) | [2002](#) | [2003](#) | [2004](#)

Mearns Rock in 1995



What You See

In mid-1995, about half of the mussels have disappeared, leaving smaller dark regions on the right side of the boulder. *Fucus* is making a comeback on the left side and top surface of the boulder. You can also see a resurgence of algal growth on the beach face.

What's Happening

The disappearance of the mussels may be the result of predation (perhaps by sea otters) or natural mortality. Regardless of whatever caused the boulder's plant life to die back in 1993-94, the boulder now seems to be supporting new plant and animal life.

[1990](#) | [1991](#) | [1992](#) | [1993](#) | [1994](#) | 1995 | [1996](#) | [1997](#) | [1998](#) | [1999](#) | [2000](#) | [2001](#) | [2002](#) | [2003](#) | [2004](#)

Mearns Rock in 1996



What You See

This year, the boulder looks somewhat like it did in 1990. Young *Fucus* plants cover much of the boulder, young barnacles appear in the open spaces, and the mussels have disappeared.

What's Happening

A second "wave" of recovery has clearly taken hold.

[1990](#) | [1991](#) | [1992](#) | [1993](#) | [1994](#) | [1995](#) | [1996](#) | [1997](#) | [1998](#) | [1999](#) | [2000](#) | [2001](#) | [2002](#) | [2003](#) | [2004](#)

Mearns Rock in 1997



What You See

The boulder is once again covered (about 80%) with the seaweed *Fucus*. There are several age groups of *Fucus* on the boulder. Young *Fucus* is growing over the top section of the boulder and adult *Fucus* is growing around the mid-portion. The beach face is again rich with seaweed. No mussels are visible and the areas occupied by the barnacles have shrunk. (Which other photo does the boulder resemble now?)

What's Happening

Starfish and sea otters may have been preying on the mussels, and a predatory snail, *Nucella*, has likely been eating the barnacles. (Although you can't tell from the photo, the *Nucella* population has been slowly growing on the boulder.)

[1990](#) | [1991](#) | [1992](#) | [1993](#) | [1994](#) | [1995](#) | [1996](#) | 1997 | [1998](#) | [1999](#) | [2000](#) | [2001](#) | [2002](#) | [2003](#) | [2004](#)

Mearns Rock in 1998



What You See

The boulder is now covered with patches of adult *Fucus* and a filamentous algae, which we think is *Pilayella littoralis*. We can't see what quantity of mussels and barnacles are present because they are covered by the *Pilayella*. What other year does this scene remind you of?

What's Happening

Young plants that took hold in 1995 are now maturing.

[1990](#) | [1991](#) | [1992](#) | [1993](#) | [1994](#) | [1995](#) | [1996](#) | [1997](#) | 1998 | [1999](#) | [2000](#) | [2001](#) | [2002](#) | [2003](#) | [2004](#)

Mearns Rock in 1999



What You See

You can see that a second crop of *Fucus* seaweed, which began to grow in about 1995-96, has matured and now nearly covers the boulder. The larger seaweed that was prominent in 1998 has disappeared.

What's Happening

The mature *Fucus* plants visible in this photo may be starting to die back. Our observations over the years suggest to us that individual *Fucus* plants survive for about 4 to 5 years.

[1990](#) | [1991](#) | [1992](#) | [1993](#) | [1994](#) | [1995](#) | [1996](#) | [1997](#) | [1998](#) | 1999 | [2000](#) | [2001](#) | [2002](#) | [2003](#) | [2004](#)

Mearns Rock in 2000



What You See

Mature *Fucus* now covers about 10% of the boulder's surface. In addition, there is a heavy cover of a grayish, slimy seaweed (this could be any of three or four seaweed species that can look like this). As in other years, these plants may be hiding barnacles, mussels, or young *Fucus* plants from our view. The white areas on the beach face look to be large barnacle sets. Eelgrass is barely visible in the water.

What's Happening

As in the 1993 photo, the mature *Fucus* plants are again dying back. However, at this time, there is no sign of a third new crop of young *Fucus*.

[1990](#) | [1991](#) | [1992](#) | [1993](#) | [1994](#) | [1995](#) | [1996](#) | [1997](#) | [1998](#) | [1999](#) | 2000 | [2001](#) | [2002](#) | [2003](#) | [2004](#)

Mearns Rock in 2001



What You See

This year, the boulder has a 20%-30% cover of *Fucus*. Older (brownish) plants are visible on the left section of the boulder and younger (greenish-brown) plants on the right. A whitish "bald" patch on the upper left is actually a patch of barnacles. Another bare-looking patch on the lower right corner contains barnacles (white) and small mussels (dark spots). A bright green algae, possibly "sea lettuce" (*Ulva*) droops down along the lower third of the rock face. Algae and barnacles also cover most of the cobble on the beach face.

What's Happening

During the early 1990s, marine plants and animals covered most of the boulder. Then, almost everything other than mussels disappeared by 1994. Later, the cycle of new life started up again in 1995 and 1996. We thought this might be part of a four to five year-long cycle of colonization, growth, and death. However, in 2001, six years later, the cover of marine life has not disappeared nearly as completely as it did in 1994.

So what's going on? Perhaps, over the past 12 years, intertidal marine life here has experienced variability that is decreasing with time. We may never see the boulder (and the shoreline) go bare again as it did in 1993-94. On the other hand, other things happened in the late 1990s that had not occurred in the early 1990s, including the pronounced 1997-98 El Niño.

Perhaps the El Niño led to local conditions that prevented plants and animals from dying off in the late 1990s, as they did in 1993-94. How would an El Niño do this?

[1990](#) | [1991](#) | [1992](#) | [1993](#) | [1994](#) | [1995](#) | [1996](#) | [1997](#) | [1998](#) | [1999](#) | [2000](#) | 2001 | [2002](#) |
[2003](#) | [2004](#)

Mearns Rock in 2002



What You See

In 2002, the boulder is dominated by barnacles, creating a 50% cover. A few large, old *Fucus* plants on the upper section of the rock make up a 10%-15% cover. None of the green algae that was present along the mid section of the rock in 2001 is present this year. A small amount of green "sea lettuce" (*Ulva*) (much less than in 2001) is visible in the lower left section of the boulder. In 1993/94, when the rock last appeared quite bare, many mussels covered the boulder; however, none are present now. Overall, the boulder location is a somewhat desolate landscape this year, with more bare rocks exposed than in previous years.

What's Happening

The die off we anticipated in 2001 is now occurring in 2002. Like in 1994/95, there is an absence of juvenile *Fucus* plants, but unlike 1994/95, the mussels are not returning. Perhaps they will in 2003?

Mearns Rock in 2003



What You See

This year, the barnacles have died back somewhat, and no new *Fucus* plants have been established. The *Fucus* plants that remain appear slightly larger this year. Sea lettuce continues to grow in the lower left corner of the boulder.

What's Happening

Conditions are very similar to 2002, with perhaps somewhat less cover of barnacles. We expected both young *Fucus* and mussels to colonize the rock by now, as they had in 1994/95, but they have not. This could be due to a lack of reproduction in both species or heavy grazing by animals such as limpets and snails. Neither are apparent.

[1990](#) | [1991](#) | [1992](#) | [1993](#) | [1994](#) | [1995](#) | [1996](#) | [1997](#) | [1998](#) | [1999](#) | [2000](#) | [2001](#) | [2002](#) |
2003 | [2004](#)

Mearns Rock in 2004



What You See

In 2004, the boulder has a heavy covering of young (greenish-brown) *Fucus* plants. Barnacle density remains high on the right side of the boulder. Again this year, no mussels are visible. In the lower left corner of the boulder, the patch of sea lettuce seems to be dying back. On the beach face, the density of *Fucus* is similar to that on the boulder. In the background, an eelgrass bed (*Zostera marina*) is visible in the water.

What's Happening

Conditions in 2004 are very similar to 1996. At that time, we wrote that it appeared that a second "wave" of recovery was occurring. Now it looks like a third wave of regrowth is occurring. During the first years of recovery, there was a heavy growth of mussels; however, that doesn't appear to be the case for the second and third waves of regrowth.

We had originally thought that there was a 5-6 year period from new growth to die-off. If that was true, we should have seen a new recruitment of *Fucus* by 2001. Obviously, the new growth didn't happen for about 8 years (until 2003/2004). Thus, the time between significant recruitment events is many years, but also variable.

Questions: What do you think this Snug Harbor site will look like in June 2005, and why? Do you think the mussels will ever return?

[1990](#) | [1991](#) | [1992](#) | [1993](#) | [1994](#) | [1995](#) | [1996](#) | [1997](#) | [1998](#) | [1999](#) | [2000](#) | [2001](#) | [2002](#) | [2003](#) | 2004
