Prince William's Oily Mess: A Tale of Recovery

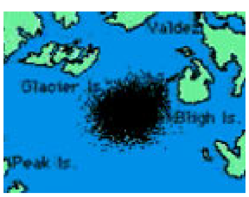
Welcome

How does an ecosystem recover from a major one-time insult such as an oil spill?

Photo credits: OR&R, NOAA; *Exxon Valdez* Oil Spill Trustee Council; Tri-State Bird Rescue & Research

As you will learn from this *Discovery Story*, the answer is not simple. It isn't easy to determine whether a particular area of shoreline has recovered from oiling during a spill, or how to expect it to look when it has.

In March 1989, the tanker *Exxon Valdez* grounded on Bligh Reef in Alaska's Prince William Sound, rupturing its hull and spilling nearly 11 million gallons of crude oil. It remains the largest oil spill ever to occur in U.S. waters.



Watch & Discover: An Oil Spill Trajectory Model - Computer simulation of how oil traveled across Prince William Sound during the first week after the *Exxon Valdez* oil spill.

To learn how Prince William Sound is recovering from this environmental shock, NOAA scientists have conducted a monitoring study there since 1990. Even today, these scientists and others are trying to answer the following questions:

- ***How did the oil impact marine life and their habitats?***
- ***Did the massive cleanup operations actually cause more harm than good?***
- ***How much oil remains in Prince William Sound?***

All the facts aren't yet in, but here you can read about how NOAA biologists have been monitoring the long-term effects of this major spill on marine life, the various cleanup efforts, and the recovery of Prince William Sound ever since that unfortunate day.

- ***What did the Exxon Valdez teach us about oil spill response?***
- ***Has Prince William Sound recovered from the spill?***

You can analyze the Mearns Rock Time Series, which is a sequence of photos of the same oiled rock in Prince William Sound. The photos were taken once each year since the *Exxon Valdez* oil spill occurred there. You can try your hand at working with some real data collected by scientists at Mearns Rock, and answer the question:

- ***How did the Exxon Valdez oil spill affect the abundance of marine life on Mearns Rock?***

(top)

Prince William's Oily Mess: A Tale of Recovery

The Infamous *Exxon Valdez*

A lot can go wrong on the open sea. Heavy seas can drive a ship into dangerous waters. A miscalculation can cause ships to collide or begin a chain of events leading to an explosion or fire. An engine can falter, leaving a heavily loaded tanker to drift toward a rocky shore or reef. Just such an event occurred on March 24, 1989. En route from Valdez, Alaska, to Los Angeles, California, the tanker *Exxon Valdez* grounded on Bligh Reef in Alaska's Prince William Sound, rupturing its hull and spilling nearly 11 million gallons of crude oil into this remote, scenic and biologically productive body of water. The ship was traveling outside normal shipping lanes in an attempt to avoid an iceberg. The oil eventually affected over 1,100 miles of the Alaska coastline, making it the largest oil spill to occur in U.S. waters to date.

Shortly after leaving the Port of Valdez, the *Exxon Valdez* ran aground on Bligh Reef in Prince William Sound, Alaska. This photo was taken three days after the vessel grounded, just before a storm arrived, making the situation even worse. (Photo credit: OR&R, NOAA)

The images that Americans saw on television and descriptions they heard on the radio that spring were of heavily oiled shorelines, dead and dying wildlife, and thousands of workers mobilized to clean beaches. These images reflected what many people felt was a severe environmental insult to a relatively pristine, ecologically important area that was home to many species of wildlife endangered elsewhere. In the weeks and months that followed, the oil spread over a wide area in Prince William Sound and beyond, resulting in an unprecedented response and cleanup—in fact, the largest oil spill cleanup ever mobilized. Many local, state, federal, and private agencies and groups took part in the effort. Even today, scientists continue to study the affected shorelines to understand how an ecosystem like Prince William Sound responds to, and recovers from, an incident like the *Exxon Valdez* oil spill.

Oiled duck on the shore following the *Exxon Valdez* oil spill. (Photo credit: *Exxon Valdez* Oil Spill Trustee Council)

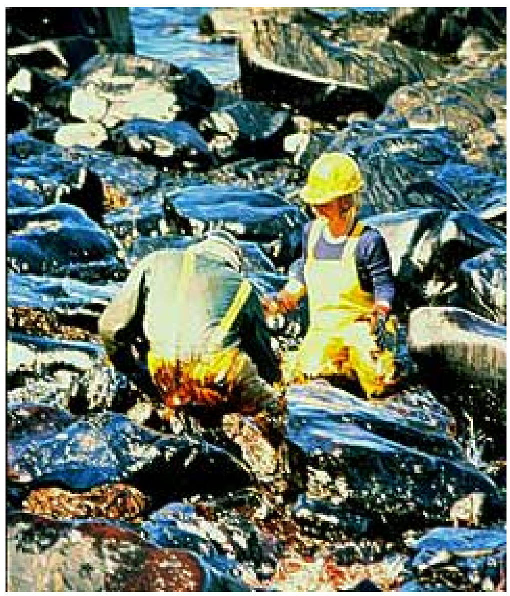
An Oil Spill Primer for Students - Learn the basics about oil spills!

To learn about how Prince William Sound is recovering from the *Exxon Valdez* oil spill, NOAA scientists have been conducting a monitoring study since 1990 (the year after the spill). They chose about 20 study sites around Prince William Sound, including (1) sites that had been oiled by the spill, but not cleaned up, (2) sites that had been oiled and cleaned, and (3) sites that were not oiled, which served as their control.

How Toxic is Oil? - Assessing Oil's Toxicity can be Tricky!

Each year, research crews visit each site to measure the numbers and kinds of species of intertidal plants and animals they find there (see photo, below left). Scientists use these observations to track changes in the biological communities over time.

A NOAA research crew collects data in an intertidal area of Prince William Sound, Alaska. By studying the biological effects of the oil spill, they hope to learn how to respond better to oil spills in the future. (Photo credit: OR&R, NOAA)



Beach cleanup workers in oil-splattered raingear use an oleophilic material called pom-poms to clean a heavily oiled beach on LaTouche Island in Prince William Sound. (Photo credit: *Exxon Valdez* Oil Spill Trustee Council)

(top)

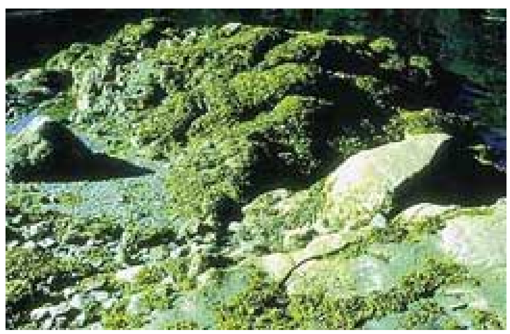
Prince William's Oily Mess: A Tale of Recovery

Remaining Impacts of the Spill

How did the oil spill impact marine life and their habitats?

What scientists have found is that, despite the gloomy outlook in 1989, the intertidal habitats of Prince William Sound have proved to be surprisingly resilient. Many shorelines that were heavily oiled and then intensively cleaned now appear much as they did before the spill. Most gravel beaches where the oiled sediments were excavated and pushed into the surf zone for cleansing have returned to their normal shape and distribution on the shore. Beaches that had been stripped of plants and animals by the toxic effects of oil and by the intense cleanup efforts show extensive recolonization and are similar in appearance to areas that were unoiled.

1989



1998

The photo on the left was taken in June 1989 in Northwest Bay, only months after the oil spill, and very soon after, this area had been cleaned with high-pressure hot water. Extensive areas of dead rockweed (*Fucus gardneri*) are visible in the photo. The photo on the right shows the same location in 1998. **Click on image** for larger view and more information.

Although the Sound has proved to be surprisingly resilient, impacts from the spill remain:

- Deeply penetrated oil continues to visibly leach from a few beaches, as on Smith Island.
- In some areas, intertidal animals, such as mussels, are still contaminated by oil, affecting not only the mussels but any animals (including people) that eat them.

Residual oil on a cobble beach on Smith Island, Prince William Sound, Alaska in 1997. Here, large volumes of oil have penetrated so deeply into this beach that substantial quantities continue to leach out. (Photo credit: OR&R, NOAA)

Learn More:

- Working with Real Data
- Thinking Like a Scientist
- Student Guide
  - Web Resources
  - Glossary
- Take the Quiz!
- For Teachers

Oil Spill Trajectory Model

An Oil Spill Primer for Students

How Toxic is Oil?

Ask an Expert

Report a Spill

- Some rocky sites that were stripped of heavy plant cover by high-pressure, hot-water cleaning remain mostly bare rock.

- Rich clam beds that suffered high mortalities from oil and extensive beach cleaning have not recolonized to their previous levels.

While these are isolated examples, they provide a basis for gaging the overall recovery of oiled areas. Prince William Sound has made a remarkable recovery from a severe injury, but it remains an *ecosystem in transition*.

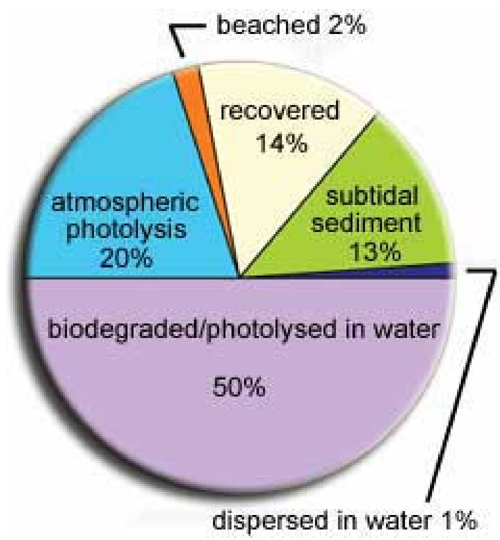
(top)

Prince William's Oily Mess: A Tale of Recovery

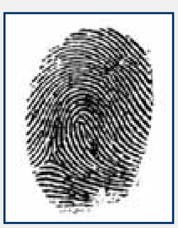
How Much Oil Remains?

What was the ultimate fate of the 10.8 million gallons of oil released from the Exxon Valdez?

Nobody knows for sure, but based on the areas that were studied in the aftermath of the spill, scientists made estimates of the ultimate fate of the oil. A 1992 National Oceanic and Atmospheric Administration (NOAA) study provided some insight, estimating that the great majority of the oil photolysed in the atmosphere, dispersed into the water column or degraded naturally (biodegraded by microorganisms or photolysed in the water). Cleanup crews recovered about 14 percent of the oil, and approximately 13 percent sank to the sea floor. About 2 percent (some 216,000 gallons) remained on the beaches.

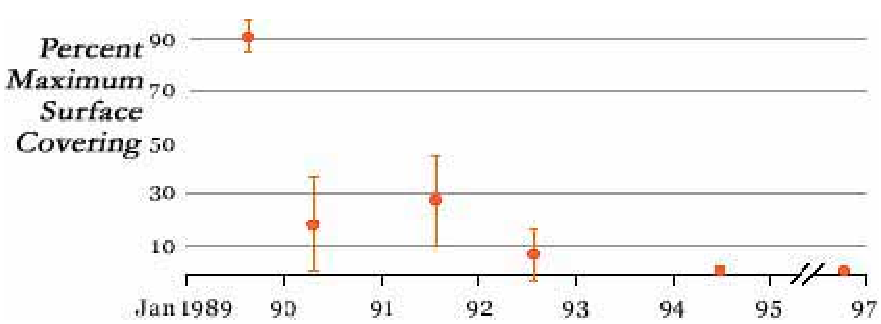


The ultimate fate of the 10.8 billion gallons of oil that leaked from the *Exxon Valdez*. NOAA scientists estimate that 2% of the oil remains on the beaches.



Whodunit?
Fingerprinting Oil

Considering that nearly 11 million gallons escaped from the tanker, and that large quantities eventually fouled shorelines in the sound and elsewhere, very little remains. The graph below shows actual measurements made by NOAA scientists at their study sites in Prince William Sound from 1989 to 1997.



Learn More:

- Working with Real Data
- Thinking Like a Scientist
- Student Guide
  - º Web Resources
  - º Glossary
- Take the Quiz!
- For Teachers

1. Welcome
2. The Infamous *Exxon Valdez*
3. Remaining Impacts of the Spill
4. **How Much Oil Remains?**
5. An Ecosystem in Transition
6. Lessons Learned From the *Exxon Valdez*
7. Has Prince William Sound Recovered?
8. Dr. Mearns' Rock - You Be the Scientist!
9. References

Oil Spill Trajectory Model

An Oil Spill Primer for Students

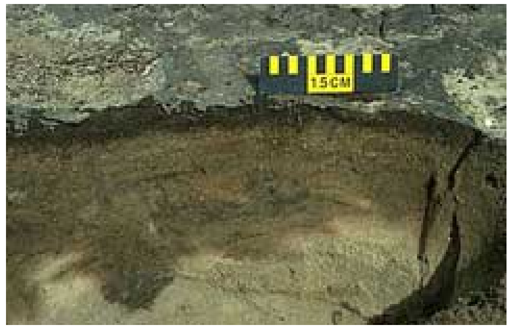
How Toxic is Oil?

Ask an Expert

Report a Spill

The observed maximum percent of the surface covered by oil at eight NOAA study sites in Prince William Sound, 1989-1997. Values are mean percent cover of oil.

Are the data what you expected? What data point on the graph seems out of place?



Residual oil below the surface of a beach. In some places in Prince William Sound the remaining oil is only evident below the surface. (Photo credit: OR&R, NOAA)

At the sites being studied by scientists, surface oil had all but disappeared by 1992, three years after the spill. The apparent increase in surface oiling in 1991 (two years after the spill) was likely to have been caused by heavy equipment digging up buried oil (called "berm relocation"), which was used as a remedial technique that year.

However, oily traces of the spill can still be found on some beaches**.** The remaining oil generally lies below the surface of the beaches in places that are very sheltered from the actions of wind and waves (which help to break down and remove stranded oil), and on beaches where oil initially penetrated very deeply and was not removed**.** At these beaches, there are signs of weathered oil on the surface and deposits of fresher oil buried beneath. Sometimes this oil makes its way to the surface and can be seen as a sheen on the water as the tide comes in. Interestingly, despite the fresh appearance of oil at these sites, chemical analysis and biological observations indicate that the oil is actually of such low toxicity that many intertidal organisms can tolerate its presence, even though it can accumulate in their tissues.

Residual oil on a cobble beach on Smith Island, Prince William Sound, Alaska in 1997. Here, large volumes of oil have penetrated so deeply into this beach that substantial quantities continue to leach out. Oil sheens were observed at this site in undisturbed tide pool water. (Photo credit: OR&R, NOAA)

One of the scientists' goals is to determine whether this residual oil is causing environmental harm to organisms living there, since one of the most difficult questions to answer during any oil spill is, "How clean is clean?" That is, when does cleanup begin to cause more harm than simply leaving the oil in place to degrade naturally?

In addition, reports both in the news and in scientific journals have stated that not all of the oil found in Prince William Sound can be traced back to the *Exxon Valdez***.** This is not surprising. Many potential alternate sources of hydrocarbons exist in the marine environment, even in a region that is relatively unpolluted. As examples:

Some of the hydrocarbons are natural, coming from undersea oil seeps or forest fires.

Others are definitely of human origin, such as the rupturing of oil storage tanks during the Alaskan earthquake of 1964, the pumping of ship ballast tanks, and fuel leakage from commercial ships and recreational boats traveling through the area.

Chemists who "fingerprinted" hydrocarbon residues in both beach sediments and in animal tissues found that not all of the oil came from the *Exxon Valdez***.** More recently, the highest concentrations of oil in mussel tissues have come from small boat harbors and diesel fuel. However, scientists hypothesize that most of the oil contamination found in Prince William Sound does trace back to the *Exxon Valdez*.

Scientists dig for subsurface, residual oil on a beach in Prince William Sound. (Photo credit: OR&R, NOAA)

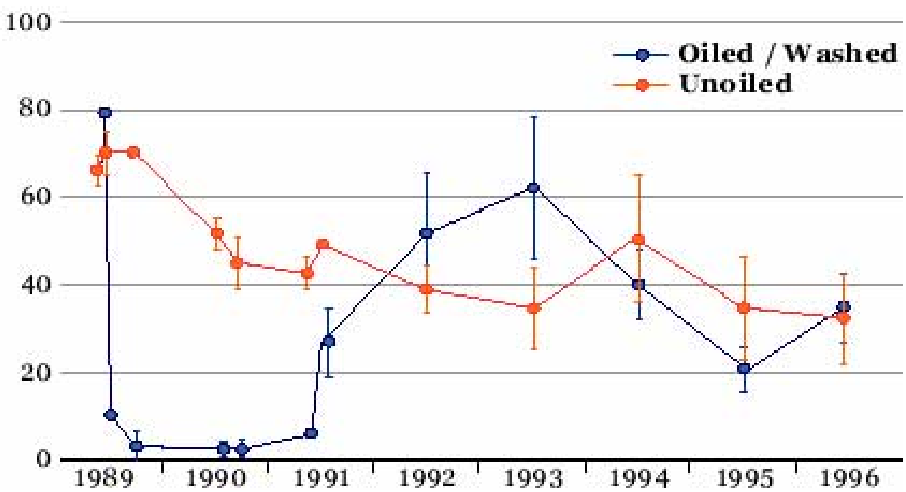
(top)

Prince William's Oily Mess: A Tale of Recovery

An Ecosystem in Transition

The graph below shows changes in the area covered by one of the most abundant alga on the shorelines of Prince William Sound, *Fucus gardneri*, commonly called "rockweed" or "popweed." Because this alga favors the middle part of the intertidal zone where much of the heavy oiling and cleanup occurred, its abundance declined in many areas of the Sound. Beginning in 1990, scientists saw the cover of rockweed increase steadily at oiled sites—until 1994, that is. From 1994 through 1995, there appeared to be a noticeable decline in cover, especially at sites that had been oiled.

A healthy stand of rockweed (*Fucus gardneri*) growing on a boulder in Prince William Sound. This site was oiled during the *Exxon Valdez* spill and has since been recolonized by these plants. (Photo credit: OR&R, NOAA)



Mean Percent Cover per 0.25 Sq Meter Quadrat by Year

Comparison of percent cover of rockweed in unoiled and oiled/washed rocky sites, 1989-1996. Note the steep decrease in percent cover at oiled/washed sites in 1989 after treatment, and the steady decline in percent cover at oiled/washed sites beginning in 1993. The washed sites were cleaned with hot water in the months after the spill.

Learn More:

- Working with Real Data
- Thinking Like a Scientist
- Student Guide
  - Web Resources
  - Glossary
- Take the Quiz!
- For Teachers

1. Welcome
2. The Infamous *Exxon Valdez*
3. Remaining Impacts of the Spill
4. How Much Oil Remains?
5. **An Ecosystem in Transition**
6. Lessons Learned From the *Exxon Valdez*
7. Has Prince William Sound Recovered?
8. Dr. Mearns' Rock - You Be the Scientist!
9. References

Oil Spill Trajectory Model

An Oil Spill Primer for Students

How Toxic is Oil?

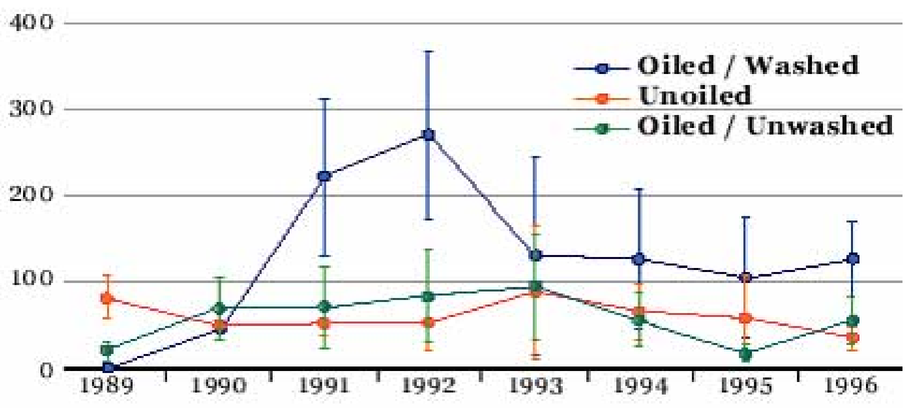
Ask an Expert

Report a Spill

What caused the decline in 1994 and 1995?

Scientists don't know for certain. Here are some possibilities:

- It is possible that the oiling or cleanup (or both) in 1989 killed the original stands of rockweed, so that the normal mix of plants of different ages was not present. Instead, the areas became dominated by plants of all the same age because they were reestablished all at the same time after the spill. In 1994, all these plants would have reached the end of their life cycle at the same time, leading to the decrease evident in the graph. The die-off of plants of all the same age would not be noticeable under normal circumstances because plants of all different ages would be present.
- Alternatively, an explosion in the population of grazers (such as periwinkle snails) that feed on algae two and three years after the spill may have had something to do with the decline in rockweed (see graph below).
- Perhaps it is a subtle, longer-term toxic effect of oiling. Or, it might have nothing at all to do with the spill or cleanup. Data collected in the coming years will help shed light on these conditions.



Mean Abundance per 0.25 Sq Meter Quadrat by Year

Abundance of periwinkle snails (*Littorina scutulata*) at rocky sites, 1989-1996. The large increase in snails at oiled/washed sites in 1991 and 1992 was due to increased numbers of juveniles. Periwinkle snails are grazers that feed on algae, including *Fucus*.

What do these trends over time mean for recovery in Prince William Sound?

Scientists think they suggest that highs and lows in abundance of plants and animals will continue as the system adjusts itself. With time, natural controls will dampen the fluctuations in abundance of marine life. Most of these adjustments will not be noticeable, and to the casual observer, conditions will continue to look much as expected in an area that remains a very beautiful place to visit. However, these subtle changes may have implications for how scientists view the process of recovery from the one-time stress of an oil spill. Eventually, the changes also may affect other parts of the ecosystem that are commercially and aesthetically important, such as the fisheries and tourist destinations. NOAA scientists will continue to study the sound until 2005 in an effort to answer these questions.

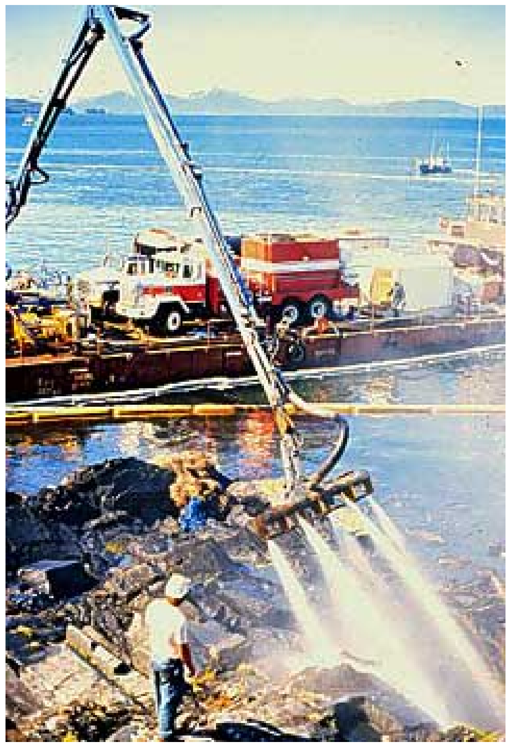
Close-up of periwinkle snails (*Littorina scutulata*), an algal grazer, and a newly-laid egg mass on a boulder in Prince William Sound. (Photo credit: OR&R, NOAA)

(top)

Prince William's Oily Mess: A Tale of Recovery

Lessons Learned From the *Exxon Valdez*

The scientists who monitored the oiled parts of Prince William Sound wanted to study the shoreline's ecological recovery after an environmental disaster like the *Exxon Valdez* spill, and then use those lessons to better respond to future oil spills. Right now, their task is still incomplete. However, some of their findings have changed the way they think about cleaning up oil spills. Following are some examples of what they have learned:



An omni-boom blasts oil-coated rocks in an attempt to clean gross oil contamination from a beach on LaTouche Island. NOAA biologists have concluded that such techniques may do more harm than good. (Photo credit: *Exxon Valdez* Oil Spill Trustee Council)

- More limited and measured use of aggressive cleanup methods, such as hot-water washing, would help to minimize the severe effects scientists have observed in plant and animal communities.

- Using water to flush an oil-contaminated beach may also wash away fine-grained sediments, such as sand and nutrients, which small organisms need to successfully colonize. Sometimes, it takes years for the fine sediment to return.

- Adult animals such as clams may survive in oil-contaminated beaches, but juveniles don't do as well.

- Oil that penetrates

deeply into beaches can remain relatively fresh for years and can later come back to the surface and affect nearby animals.

After the *Exxon Valdez* spill, beaches were reworked by heavy machinery to move heavily oiled upper intertidal sediments into the middle intertidal zone, where they could be washed by the surf and where the oil could be collected in booms. After such large-scale excavations, it can take many years for the beach sediments to recover.

Rocky rubble shores should be of high priority for protection and cleanup because oil tends to penetrate deep and weather very slowly in these habitats, prolonging the harmful effects of the oil when it leaches out.

A NOAA biologist examines freshly excavated live adult clams from heavily oiled beach sediments on Block Island, Prince William Sound, Alaska. Juvenile clams generally do not survive as well as adults on oiled beaches. (Photo credit: OR&R, NOAA)

A brown sediment plume and sheens of refloated oil drift away from this oiled beach as it is cleaned by a team applying high-pressure, hot-water washing. Refloating of oil and the release of sediments are often unavoidable consequences of shoreline cleanup that can cause additional environmental harm. (Photo credit: OR&R, NOAA)

(top)

Prince William's Oily Mess: A Tale of Recovery

Has Prince William Sound Recovered?

We all have some idea of just what "recovery" is—we've all recovered from a cold or the flu—yet to ecologists studying natural systems, it is a very difficult term to define and measure. If you ask a fisherman from Kodiak Island, a villager from the town of Valdez, an Exxon engineer—or, yes, a NOAA biologist—you are likely to receive such different answers that you may wonder if they heard the same question!

Despite the remaining impacts of the largest oil spill in U.S. history, Prince William Sound remains a relatively pristine, productive and biologically rich ecosystem. (Photo credit: OR&R, NOAA)

An ecosystem like Prince William Sound constantly adjusts itself to react to, or compensate for, changes in the environment, such as:

- daily temperature variations;
- changing of the seasons;
- long-term drought;
- rare natural events, like hurricanes and earthquakes; and
- oil spills.

When the *Exxon Valdez* spill occurred in March 1989, the Prince William Sound ecosystem was also responding to at least three notable events in its past:

- an unusually cold winter in 1988-89;
- growing populations of reintroduced sea otters; and
- a 1964 earthquake.

Scientists studying the effects of the spill must evaluate their results against this background of other insults, or stressors, that have affected the sound.

Scientists do not define recovery as a return to the precise conditions that existed before the oil spill. They know that this is unlikely to happen. Nevertheless, they can observe a range of conditions to measure shoreline recovery from the spill.

Learn More:

- Working with Real Data
- Thinking Like a Scientist
- Student Guide
  - º Web Resources
  - º Glossary
- Take the Quiz!
- For Teachers

Oil Spill Trajectory Model

An Oil Spill Primer for Students

How Toxic is Oil?

Ask an Expert

Report a Spill

For example, if they find that unoiled sites are changing in the same ways and at similar rates as the oiled sites, then the changes are probably caused by natural events and cannot be linked to the oil spill. If conditions at oiled sites fall outside the range found at control sites, then scientists would suspect that oil contamination is still affecting these systems.

In summer 2001, roughly 10,000 pits were excavated as part of a shoreline survey of Prince William Sound. Oil was found at 58 percent of the 91 sites surveyed, which is approximately equivalent to 5.8 km of contaminated shoreline (Short et al., 2001). (Photo credit: NMFS, NOAA)

Just as people differ in their ability to recover from injury, so do plants and animals. Some animals and plants are resilient and grow back quickly. In Prince William Sound, green algae and certain types of worms grew back the first summer. Rockweed and barnacles had repopulated many areas within 2 to 3 years. Other animals, such as clams, limpets, and some snails, are taking much longer.

Today, two escort vessels accompany each tanker that passes through Prince William Sound. They not only watch over the tankers, but are capable of assisting them in the event of an emergency, such as a loss of power or loss of rudder control. (Photo credit: Argonne National Laboratory)

In short, biologists consider the intertidal communities in Prince William Sound to be still recovering, but not completely recovered.

Scientists will continue to regularly monitor a range of study sites in Prince William Sound at least through the year 2005. In 2001, they began a smallerscale, experimental phase of their research, focusing on fewer sites. Scientists will use this information to improve oil spill response and cleanup in the future, with an overall goal of minimizing environmental harm. Because of this, the *Exxon Valdez* will leave at least one positive legacy in its unfortunate wake: knowledge that will benefit all of us and the environment the next time disaster strikes.

(top)

Prince William's Oily Mess: A Tale of Recovery

Dr. Mearns Rock—You Be the Scientist!

Now let's turn to a question that you can explore:

How does marine life recover from a major, one-time stress such as an oil spill?

Mearns Rock is located in the intertidal zone on Knight Island in Snug Harbor, Prince William Sound, Alaska. Here is how it appeared in 2003, 14 years after the *Exxon Valdez* oil spill. (Photo credit: OR&R, NOAA)

As you have learned, the answer is not simple. The Mearns Rock Time Series is a series of photographs of "Mearns Rock," a large boulder (approximately 4 feet high by 7 feet long) located in the intertidal zone at Snug Harbor on Knight Island, Prince William Sound, Alaska.

Find the location of Snug Harbor using the trajectory map.

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. Scientists believe that the boulder, like the rest of the shoreline, was coated by spilled oil, which was gradually removed by natural processes during the year following the spill. NOAA biologists have photographed this boulder—and the animals and plants growing on it—once each year, in late June or early July, for the past 14 years. Look at the map on the right to see how the oil spread in Prince William Sound for the first eight days after the spill and answer this question: ***How many days after the spill occurred did oil reach Knight Island, the location of Mearns Rock?***

Here is your chance to work with some real data collected by real scientists.

Learn More:

- Working with Real Data
- Thinking Like a Scientist
- Student Guide
  - Web Resources
  - Glossary
- Take the Quiz!
- For Teachers

Oil Spill Trajectory Model

An Oil Spill Primer for Students

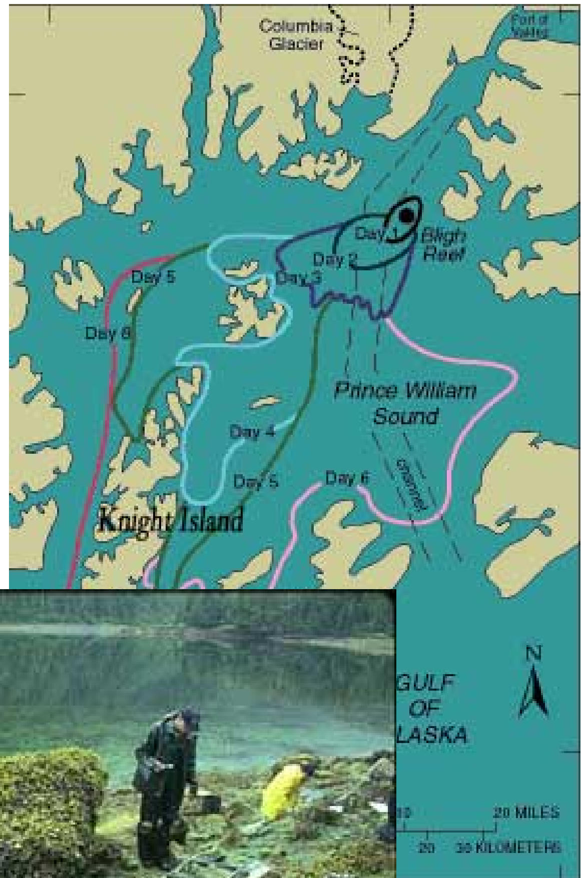
How Toxic is Oil?

Ask an Expert

Report a Spill

Using photos of Mearns Rock, you can graph changes over time in the percent cover of different organisms that have colonized the rock since the *Exxon Valdez* spilled its oil. You will be working like NOAA scientists, including the scientist for whom the rock is named—Dr. Alan Mearns.

Click on Working With Real Data to get started!



ed out of the normal
nce William Sound,
he map shows the oil
the spill. (Map credit:

NOAA scientists establish a transect line and sample quadrats near Mearns Rock during their 1991 survey expedition. (Photo credit: OR&R, NOAA)

(top)

Prince William's Oily Mess: A Tale of Recovery

References

Exxon Valdez Oil Spill Trustee Council. Date unknown. "Oil Spill Facts". Accessed July 30, 2004 at: http://www.evostc.state.ak.us/facts/index.html.

Fukuyama, A.K., G. Shigenaka, and G.R. VanBlaricom. 1998. Oil Spill Impacts and the Biological Basis for Response Guidance: An Applied Synthesis of Research on Three Subarctic Intertidal Communities. NOAA Technical Memorandum NOS ORCA 125 (available online at: http://response.restoration.noaa.gov/oilaids/TM125.pdf).

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. American Fisheries Society, Bethesda, MD. 931 pp.

Peterson, C.H., S.D. Rice, J.W. Short, D. Esler, J.L Bodkin, B.E. Ballachey, and D.B. Irons. 2003. Long-term ecosystem response to the *Exxon Valdez* oil spill. Science 302: 2082-2086 (available online at: http://www.sciencemag.org/cgi/content/full/302/5653/2082).

Shigenaka, G. (editor). 1997. Integrating Physical and Biological Studies of Recovery from the *Exxon Valdez* Oil Spill: Case Studies of Four Sites in Prince William Sound. NOAA Technical Memorandum NOS ORCA 114 (available online at: http://response.restoration.noaa.gov/oilaids/TM114.pdf).

Short, J., S. Rice, and M. Lindeberg. July-September 2001. The *Exxon Valdez* Oil Spill: How Much Remains? Alaskan Fisheries Science Center Quarterly Report. Accessed August 13, 2004 at: http://www.afsc.noaa.gov/Quarterly/jas2001/feature_jas01.htm.

U.S. Environmental Protection Agency. Office of Emergency and Remedial Response. 1998. Understanding Oil Spills and Oil Spill Response. EPA Publication 540-K-99-007 (available online at: http://www.epa.gov/oilspill/pdfbook.htm).

(top)

Learn More:

- Working with Real Data
- Thinking Like a Scientist
- Student Guide
  - Web Resources
  - Glossary
- Take the Quiz!
- For Teachers

1. Welcome
2. The Infamous *Exxon Valdez*
3. Remaining Impacts of the Spill
4. How Much Oil Remains?
5. An Ecosystem in Transition
6. Lessons Learned From the *Exxon Valdez*
7. Has Prince William Sound Recovered?
8. Dr. Mearns' Rock - You Be the Scientist!
9. **References**

Oil Spill Trajectory Model

An Oil Spill Primer for Students

How Toxic is Oil?

Ask an Expert

Report a Spill

Prince William's Oily Mess: A Tale of Recovery

Student Guide

Web Resources
Glossary

In many locations in Prince William Sound, the action of tides and currents distributed oil throughout the entire intertidal zone. Here, a member of NOAA's Office of Response and Restoration oil spill response team stands on Knight Island in Northwest Bay, Alaska. (Photo credit: OR&R, NOAA)

Glossary of Terms

A | B | C | D | E | F | G |

H | I | J | K | L | M | N |

O | P | Q | R | S | T | U |

V | W | X | Y | Z

A

Abundance—the total number of individuals of a species present in an area. Also see, **Relative Abundance**.

Amphipods—a group of small, laterally compressed crustaceans that includes beach hoppers and others.

Aquatic—growing or living in, or frequenting water. The term "aquatic" is sometimes used to refer specifically to freshwater, as opposed to salt or marine water. See Marine.

(back) | (top)

B

Ballast Tanks—special tanks on large ships that are used to provide stability needed when carrying less than a full load of cargo and to keep the ship at the proper depth in the water. When the ship is loaded with cargo, the ballast tanks are emptied and its contents (usually water) are released to surrounding waters; when the ship is empty, the ballast tanks are filled with water (or other substance like soil or sand) to keep it upright.

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.**

Learn More:

- Working with Real Data
- Thinking Like a Scientist
- **Student Guide**
  - Web Resources
  - **Glossary**
- Take the Quiz!
- For Teachers

1. Welcome
2. The Infamous *Exxon Valdez*
3. Remaining Impacts of the Spill
4. How Much Oil Remains?
5. An Ecosystem in Transition
6. Lessons Learned From the *Exxon Valdez*
7. Has Prince William Sound Recovered?
8. Dr. Mearns' Rock - You Be the Scientist!
9. References

Oil Spill Trajectory Model

An Oil Spill Primer for Students

How Toxic is Oil?

Ask an Expert

Report a Spill

Berm—a terrace formed by wave action along the backshore of a beach; a mound or wall of earth, sand or rocks used as a barrier or as insulation.

Biodegradation (or Biodegrade)—the breaking down of substances by microorganisms, like bacteria, which use the substances for food and generally release harmless by-products such as carbon dioxide and water.

Bivalve Mollusk—mollusks with two shells, such as oysters, mussels, and clams. Snails and limpets are gastropod mollusks.

Boom—a temporary floating barrier used to contain an oil spill.

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

(back) | (top)

C

Cobble—a mass of rock greater than 64 millimeters in diameter, but less than 256 millimeters in diameter. Cobblestones are larger than a pebble and smaller than a boulder.

Colonize—to populate or establish a population in an area.

Community—an association of living organisms that have mutual relationships among themselves and with their environment, and thus function, to some degree, as an ecological unit.

Control (or Control Group)—in an experiment, it is the group or subject not exposed to the variable or condition (for example, not exposed to oiling or not exposed to cleanup techniques).

Controlled Experiment—uses an experimental group and a control group to test a hypothesis.

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

Crude Oil—gooey liquid that contains hundreds of different types of hydrocarbons; raw, unprocessed petroleum (i.e. oil in its natural unprocessed state). It is refined or separated into petroleum gas, kerosene, diesel, fuel oil, bunker oil, etc.

(back) | (top)

D

Dispersant—chemical that causes oil to break into small droplets by reducing the surface tension between the water and oil. It is used to cleanup low viscosity oils, yet it impacts the plankton in the upper water layers, because the oil is dispersed within the water.

Diversity (or Biological Diversity)—the variety of species, their genetic makeup, and the natural communities that they compose. All the different kinds of organisms living in an area.

(back) | (top)

E

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

Ecologist—scientist who studies the interactions between species of organisms and their environment (studies the ecosystem).

Ecosystem—a community of living organisms and their interrelated physical and chemical environment.

Environment—the physical and biological conditions that surround an organism or a group of organisms.

Evaporation (or "to evaporate")—the physical change by which any substance is converted from a liquid to a vapor or gas.

Experimental Group—in an experiment, the group exposed to the variable or condition.

(back) | (top)

G

GPS (or Global Positioning System)—satellite-based navigation system that permits a user to pinpoint his or her exact location on Earth.

Grazers—organisms that eat grasses or other herbs or, in the case of fish and aquatic invertebrates, scrape or suck plant material from some surface (for example, rocks).

(back) | (top)

H

Hydrocarbons—a large class of molecules containing only carbon and hydrogen; common in petroleum products and other oils.

Hypothermia—excessive loss of body heat caused by exposure to very cold water or other conditions.

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.

(back) | (top)

I

Indicator Species (or Indicator)— a species whose status (i.e., its presence, absence, or abundance) provides information on the overall condition of an ecosystem and of other species in that ecosystem. They reflect the quality and changes in environmental conditions, as well as aspects of community composition.

Insectivore—a heterotrophic organism that eats insects.

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

Invertebrate—an animal lacking a backbone.

(back) | (top)

L

Leach—to draw out or remove the oil from the soil or sediments, often a result of the action or percolation of water.

Limpet—marine gastropod mollusk that has a low conical shell broadly open beneath and grazes over rocks or timbers in the littoral area and clings very tightly when disturbed.

(back) | (top)

M

Marine—relating to the seas and oceans.

Microorganism—a very small plant, animal or bacterium; some microorganisms, like larger organisms, can be hurt by oil spills; some microorganisms actually break oil down into less harmful substances.

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

Mortality—the proportion of deaths in a population.

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

(back) | (top)

N

NOAA—the National Oceanic and Atmospheric Administration (NOAA), an agency of the U.S. government that conducts research and gathers data about the global oceans, atmosphere, space, and sun, and applies this knowledge to science and service that touch the lives of all Americans. NOAA provides these services through five major organizations: the National Weather Service, the National Ocean Service, the National Marine Fisheries Service, the National Environmental Satellite, Data and Information Service, and the Office of Oceanic and Atmospheric Research; and numerous special program units. In addition, NOAA research and operational activities are supported by the nation's seventh uniformed service, the NOAA Corps, a commissioned officer corps of men and women who operate NOAA ships and aircraft, and serve in scientific and administrative posts.

Non-petroleum Oils—oils that are not derived from petroleum**; this group of oils includes vegetable oils and animal fats.**

(back) | (top)

O

Oil—crude oil **and refined** petroleum **products (motor oils, fuels, lubricants, etc.), as well as vegetable oils, animal fats, and other** non-petroleum oils**.**

Oil Slick—a layer of oil floating on the surface of water.

Oleophilic—having a strong affinity for lipids, including petroleum oils and fats. Oleophilic materials absorb or stick to petroleum oils.

(back) | (top)

P

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.

Petroleum—a mixture of liquid, gaseous, and solid hydrocarbon compounds found naturally underground. The liquid form of petroleum is called crude oil. Crude oil is occasionally found in springs or pools but usually is drilled from wells beneath the Earth's surface. Petroleum can be processed (refined) into a number of useful products including asphalt, diesel fuel, fuel oil, gasoline, jet fuel, lubricating oil, and plastics.

Photolysis (or Photolysed)—chemical decomposition by the action of radiant energy (as light).

Physical Environment (or Abiotic Environment)—nonliving things in the environment, e.g., water and minerals. Also refers to physical processes in the environment such as evaporation, currents, wind, etc.

Polychaetes (class Polychaeta)—segmented worms that have parapodia (i.e. flattened extensions that have stiff and sometimes sharp bristles).

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.

(back) | (top)

Q

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.

R

Rationale—an underlying reason.

Recolonization—to reestablish a colony or population after being removed from a particular location by a disturbance.

Recovery—the act, process or instance of bringing a habitat or ecosystem back to a normal condition; or to save it from loss and restore it to usefulness.

Reef—a chain of rocks or coral or a ridge of sand at or near the surface of the water, forming a hazardous obstruction.

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.

Remedial—intended as a treatment or correction.

Replicate—one of several identical experiments, procedures or samples.

Replication—performance of an experiment or procedure more than once.

Resilience (or Resilient)—the capacity to recover structure and function after disturbance. A highly resilient community or ecosystem may be completely disrupted by disturbance but quickly returns to its former state.

Restoration—bringing back or restoring species and ecosystems after human disturbance.

(back) | (top)

S

Sediments—the matter, such as soils, sand and rocks, that settles or is deposited on the bottom of a water body by the action of water, wind or glaciers.

Seine—a large net with sinkers on one edge and floats on the other that hangs vertically in the water and is used to enclose and catch fish when its ends are drawn together or drawn ashore.

Skimmers—devices used to remove oil from the water's surface.

Sorbents—substances that take up and hold water or oil; sorbents used in oil spill cleanup are made of oleophilic materials.

Stressor—the five external forces (i.e. stressors) identified as affecting coastal and marine ecosystems are pollution, invasive species, climate change, extreme events, and land or resource use.

Subtidal—the coastal life zone that remains underwater (below low tide), but above the continental shelf.

(back) | (top)

T

Tide Pools—small habitats formed when spaces between rocks retain water at low tide.

Tides—very long-period waves that move through the oceans in response to the forces exerted by the moon and sun. Tides originate in the oceans and progress toward the coastlines where they appear as the regular rise and fall of the sea surface. When the highest part, or crest, of the wave reaches a particular location, high tide occurs; low tide corresponds to the lowest part of the wave, or its trough.

Trajectory—the path taken by something.

Trajectory Model—a prediction about the path of something—like an oil slick.

(back) | (top)

V

Viscosity (or Viscous)—amount of resistance to flow by a liquid. Corn syrup is much more *viscous* than water. High molecular weight oils have high viscosity (i.e. do not flow easily).

Volatile—referring to "volatile organic compounds" (VOCs)—a family of chemical compounds found in oils; VOCs evaporate quickly and can cause nerve damage and behavioral abnormalities in mammals when inhaled.

W

Weathering—action of the wind, waves, and water on a substance, such as oil, that leads to disintegration or deterioration of the substance.

(back) | (top)