Prince William Sound:
Our Changing Perspective on Recovery

A Long-Term Monitoring Program by NOAA Hazardous Materials Response Division

The Exxon Valdez. Those words and their associated images resonate through the American environmental consciousness. The Hazardous Materials Response Division of the National Oceanic and Atmospheric Administration (NOAA/HAZMAT), Office of Response and Restoration has been a part of the *Exxon Valdez* story from the very beginning. Through a long-term monitoring program, NOAA/HAZMAT continues to study the aftermath of the spill in Prince William Sound so that we can improve the way we respond to oil spills.

With several years of results in hand, it is now reasonable to ask some questions about the spill, its effects, and what we have learned. For example: Is the oil gone? Has Prince William Sound recovered? What did the *Exxon Valdez* teach us about spill response? We can now begin to answer those questions — although it is also abundantly clear that we have much to learn.

National Oceanic and Atmospheric Administration • National Ocean Service • Office of Response and Restoration

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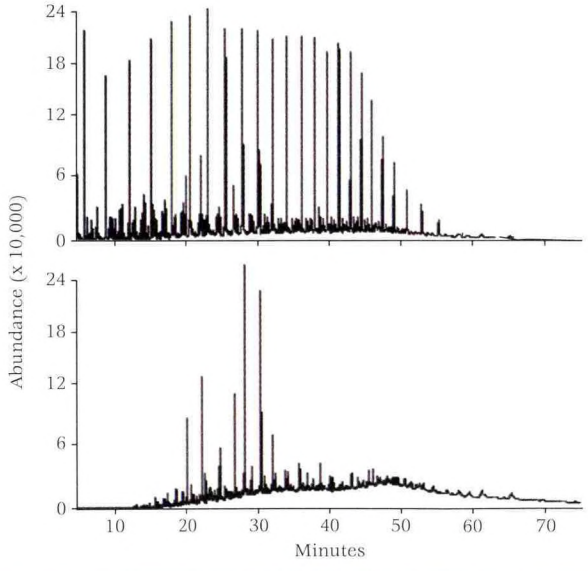
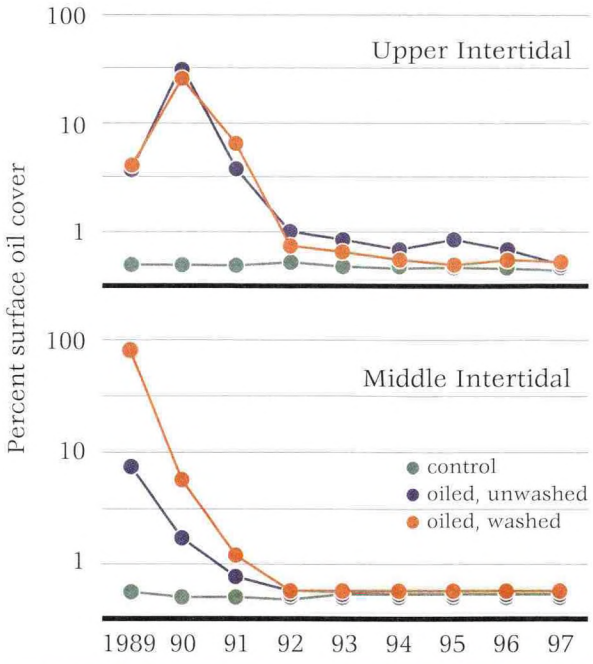
Is the oil gone?

The adjacent graph documents that surface oil at our study sites had all but disappeared by 1992, three years after the spill. However, today there is still residual oil to be found in the impacted areas we study. The remaining oil generally lies below the surface of the beaches in those places that are very sheltered from the actions of wind and wave (which help to break down and remove stranded oil), and those beaches where oil initially penetrated very deeply and was not removed.

Interestingly, despite the fresh appearance of oil at these sites, chemical analysis and biological observations indicate that the oil is actually highly weathered and of such reduced acute toxicity that many intertidal species can tolerate its presence even though it can accumulate in their tissues. Comparing the chemical profiles of fresh *Exxon Valdez* oil and the oil found at the excavations illustrated below reveals substantially less oil and fewer numbers of oil components remaining.

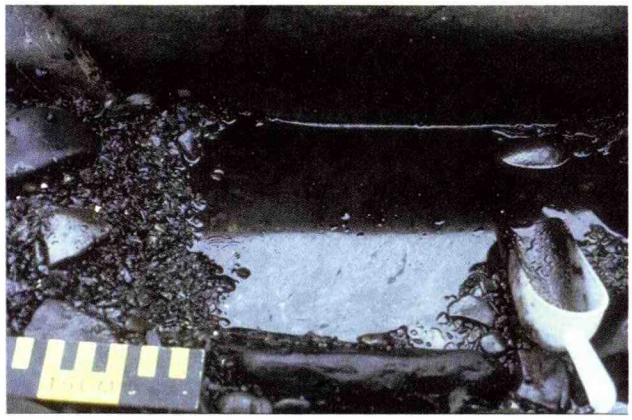


Chemical profiles (chromatograms) of alkane compounds in fresh Exxon Valdez *oil (top) and residual oil collected in the Bay of Isles in 1996 (bottom). Fewer and lower "spikes" reflect fewer compounds and lower concentration levels.*



Decline in surface oiling at middle and upper tidal elevations of study sites, 1989-1997. Three different oiling and shoreline treatment categories used in the monitoring program are shown.

Liquid oil and oil sheen mobilized at the Bay of Isles, Knight Island, while collecting clams in June 1998.



Heavy residual oiling in sediments of Smith Island, June 1998. Oil sheens were observed at this site in undisturbed tide pool water.

Has Prince William Sound recovered from the spill?

Controversial, contentious, and complex, this is the $2 billion question. Depending on the definition of "recovery," based on the perspective we in NOAA/HAZMAT have gained through two decades of spill response experience and from the results of ten years of intertidal monitoring, we consider Prince William Sound to be well along the road to recovery — but not yet recovered.

In Prince William Sound, there are many different and sometimes conflicting definitions of recovery. If you ask a fisherman from Cordova, a villager from Chenega, an Exxon USA corporate attorney from Houston — and, yes, a NOAA biologist — you are likely to receive such different answers that you may wonder if they heard the same question.

The immediate, or short-term, adverse effects of oil and some of the cleanup techniques are probably less arguable than is the longer-term question of recovery. It is well-documented that fresh oil can kill shoreline plants and animals, and it is obvious that aggressive cleanup methods can stress or kill (see the photos at left).

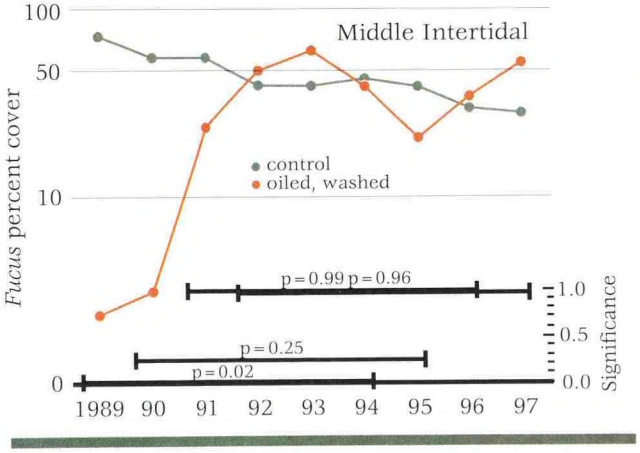
The most commonly held definition of recovery probably is this: return to the way things were before the spill. Simple in concept, it is also intuitive and can be judged anecdotally or experientially by people who live and work in the Sound. Unfortunately, this benchmark is also vague and hard to quantify. In the case of Prince William Sound, it is particularly difficult to apply this standard of recovery because there is little information about the way things were before the spill.

Clean-up operations in the sound (top).

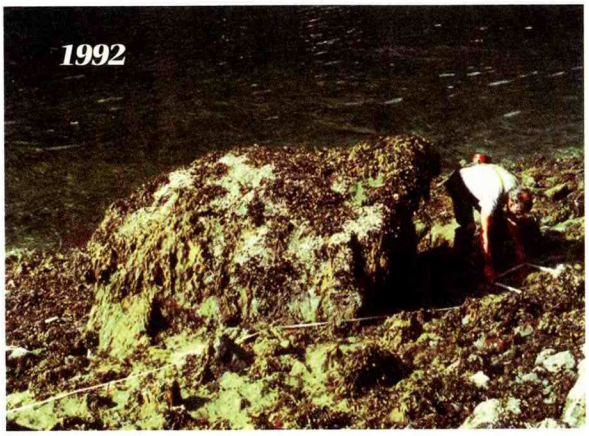
Healthy Fucus gardneri *plants in Prince William Sound (middle), heavily stressed* Fucus *after washing with high-pressure hot water (bottom).*

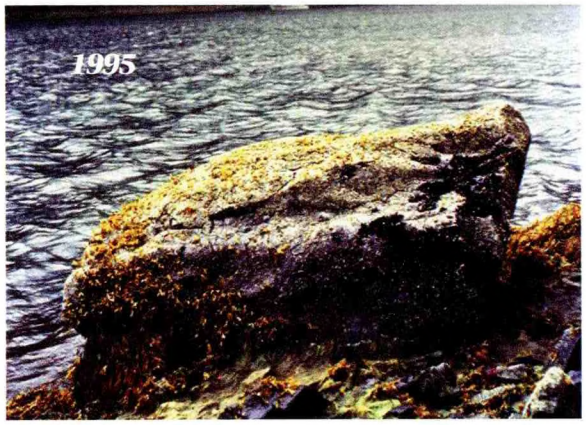
Moreover, things change. Even in the absence of a major disturbance like an oil spill and cleanup, the physical and biological conditions that once characterized any given site, impacted or not, are likely to shift considerably over time. Prince William Sound is a highly dynamic environment, and we note with regularity the substantial changes occurring even from year to year in the same locations.

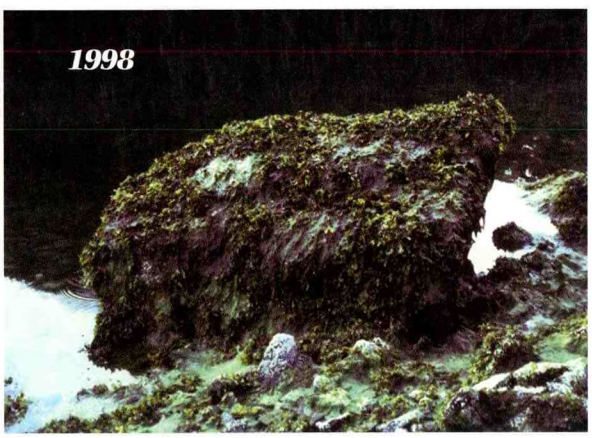
The high degree of variability in the Prince William Sound environment, the special (sometimes frantic) circumstances of site selection during an oil spill, and the fairly rigorous requirements of traditional statistical methods have led us to develop and apply new ways to assess recovery at sites affected by the *Exxon Valdez* spill and cleanup. For example, we compare the shape and direction of plant and animal abundance trendlines to determine if they "parallel" each other, with parallelism representing one measure of recovery. In the graph below, we see a plot of the abundance of a common intertidal algal species, *Fucus gardneri* (also called rockweed). In the first years following the spill, the patterns of abundance (measured as percent cover of the rocky shores) between unoiled sites and those that were



Analysis of parallelism in Fucus gardneri *cover, 1989-1997. Following the rapid increases between 1989 and 1991 at the oiled and washed sites, trendline differences between the two categories of sites were significantly reduced (i.e., the trends became more parallel).*



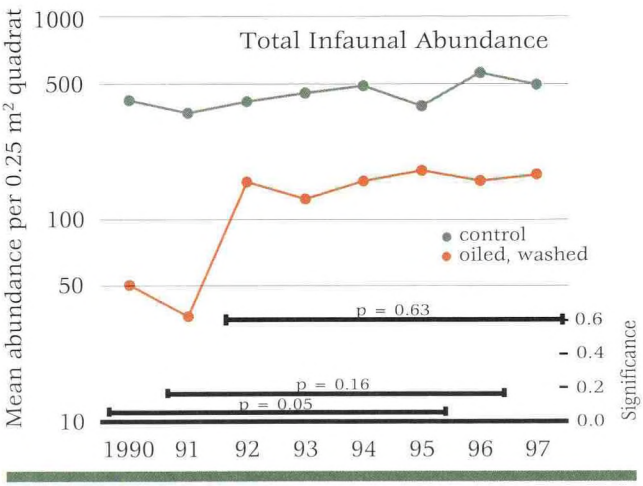




The many faces of "Mearns Rock," a boulder in Snug Harbor, Knight Island, between 1991 and 1998, illustrating how conditions at a site vary widely even from year to year. This area was oiled in 1989 but was a designated "setaside site" that was not subjected to cleanup activities.

oiled and washed with high-pressure hot water bore little resemblance to each other: the washed sites had much less *Fucus* cover immediately following shoreline cleaning. This is not terribly surprising, as we have seen from the previous photos contrasting healthy *Fucus* with plants that had been stressed and killed by the washing treatment. However, the graph shows that, despite the very noticeable short-term impacts to the rockweed, rapid increases in plant cover between 1989 and 1991 at the oiled and washed sites significantly reduced the trendline differences between those sites and the unoiled sites. In fact, from 1991 on, the patterns have been effectively the same.

We see similar trends for infauna, the animals living in gravel beach sediments. The following plot shows abundance over time between unoiled sites and sites that were oiled and washed. Once again, a rapid increase in abundance before 1993 was followed by an ongoing period of "parallelism." However, in this case, parallelism does not also include the same levels of abundance. The graph shows that, despite a return to a trend pattern similar to that at unoiled sites, actual numbers were



Analysis of parallelism for infaunal abundance, 1990-1997. Despite a return to a trend pattern similar to that at unsoiled sites (i.e., parallelism), actual numbers were lower at oiled and washed sites.

lower at oiled and washed sites and the two lines have not intersected. It is, therefore, a mixed message: we see one indication of recovery and one indication of non-recovery.

Keeping all this in mind, then, what can we say about conditions in Prince William Sound? Has it in fact recovered? Strictly speaking, we cannot extrapolate the conditions we observe in the selected areas we monitor to the Sound as a whole. But for our set of sites, we in NOAA/HAZMAT's monitoring program have our own perspective and our own answer to the questions.

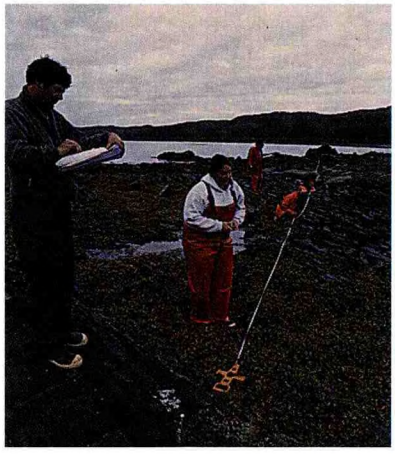
That answer is a definite, "Yes and no." On the one hand...our work in the field, laboratory, and on the frontlines of statistical theory indicate that, yes, by many criteria, a number of the intertidal communities we study can be considered recovered. Does that mean all traces of the largest spill in U.S. history are gone and the Sound is recovered? No, not necessarily.

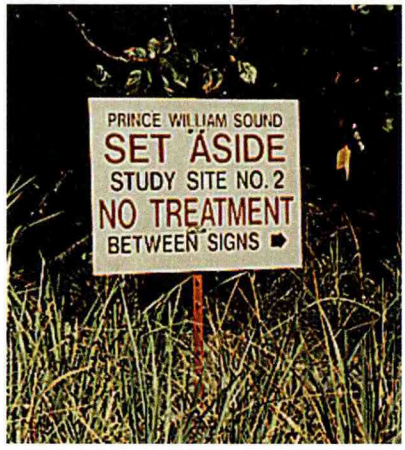
Northwest Bay study site in 1989 (top) and 1998.

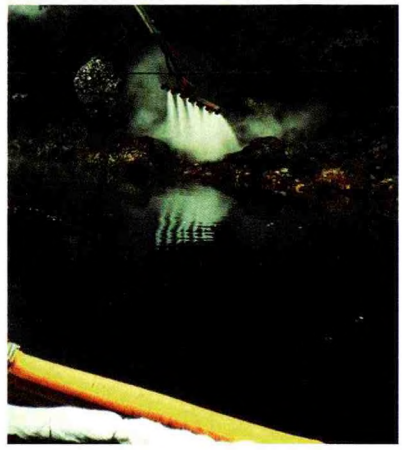
We have seen that oil remains in Prince William Sound. The extent to which it may be having an adverse impact is subject to debate and investigation, but for some people the fact that it remains at all is evidence that recovery has not taken place.

Some of the data and results from the NOAA/HAZMAT monitoring program also show differences between unoiled and cleaned sites: as we discussed above, infauna abundance trends at unoiled and oiled/washed sites are parallel but not absolutely equal. What is the reason for this difference? It might be a fluke of nature or of the way we selected and grouped our study sites, but we are also investigating the possibility that physical changes in the sites caused by the washing process (e.g., removal of the silty material in the beaches) may be preventing convergence in abundance as noted above.

Recovery, therefore, is in the eyes, the context, and the special interests of the beholder. While it is safe to say that nearly all of us are impressed by the degree to which Prince William Sound has rebounded from the spill and its aftermath, it would also be a fairly good bet that there will be disagreement for some time on the nature and details of that rebound and how far it needs to progress for recovery to be considered complete.







What lessons have we learned?

The raison d'etre for the NOAA Prince William Sound Monitoring Program has always been to improve the way we respond to oil spills in a complex environment like the Sound. Our goal is to use science to better understand physical and biological recovery, and then apply the lessons to spill response. The insights we gain relate to both the process of environmental monitoring itself, and impacts caused by the spill and cleanup. With that in mind, what have we learned?

- *First, it is difficult to assess the impacts from a disturbance — even a major one like the* Exxon Valdez *spill — in a dynamic system like Prince William Sound. The inherently high degree of variability found in such systems limits or precludes the use of standard or traditional statistical methods.*
- *So-called "set-aside sites," areas that were oiled but intentionally left uncleaned, have been critical in the NOAA/HAZMAT monitoring program's ability to discern impacts attributable to oiling alone and those due to cleanup. During an oil spill, there are compelling reasons to clean up all oil; however, to monitor the recovery of shorelines, set-aside sites are key considerations. We recommend that the concept be discussed during oil spill contingency planning, and again during the inevitable spill events.*
- *High-pressure, hot water washing of shorelines, while effective at removing stranded oil, can damage plants and animals in the treated zone directly and indirectly, short-term and long-term. This might seem obvious, but before the* Exxon Valdez *spill there was almost no real documentation of these impacts.*
- *Much has been made of the cleanup doing "more harm than good." While to some extent true, this statement is a bit of an oversimplification that does not fully convey the complexities and competing interests associated with evaluating environmental tradeoffs. We now know the detrimental effects of intrusive shoreline cleanup methods like high-pressure, hot-water washing. However, this does not mean we would eliminate its use in the future. Hopefully, with the guidance of monitoring efforts like this one, we can employ the method in a wiser fashion.*
- *Physical characteristics of the environment determine the makeup of biological communities. Therefore, altering the physical features of a beach or shoreline can significantly affect the recovery of impacted plants or animals. Physical recovery and stabilization of a site are necessary for biological recovery. The photo on the following page shows one of our study sites on Eleanor Island being cleaned, with silty sediments being noticeably washed out into the water. We believe that many, if not most, of the animals that normally live in this kind of beach require a certain mix of fine-grained sediments, and so may not return until the beach sediments have stabilized.*

If there is a proverbial silver lining to the *Exxon Valdez* oil spill, it must include the fact that the incident and its aftermath have represented a remarkable opportunity to learn from misfortune. Our research is but one example of the many scientific investigations in Prince William Sound that should help us to understand the environment, how it responds to oil spills and cleanup, and how we can facilitate the process of recovery — however you may choose to define that term.

NOAA provides the nation's science expertise for many facets of oil spill prevention, response, damage assessment, and environmental restoration and recovery efforts, and has been deeply involved in a wide array of *Exxon Valdez* oil spill studies and issues. Information in this report and information about other *Exxon Valdez* oil spill related studies conducted by NOAA's National Marine Fisheries Service, plus news about important work by NOAA and other agencies to improve navigation safety in Prince William Sound can be found on the World Wide Web at the following addresses:

NOAA National Ocean Service *Exxon Valdez* oil spill monitoring program -- **http://response.restoration.noaa.gov**

NOAA National Marine Fisheries Service *Exxon Valdez* oil spill studies -- **http://www.fakr.noaa.gov/oil**

NOAA National Ocean Service navigation safety work in Prince William Sound - **http://www.noaa.gov/public-affairs/pr97/nov97/noaa97-r422.html**

Retrospective

On March 24, 1989, the tanker *Exxon Valdez* struck a reef in Prince William Sound, Alaska. Nearly eleven million gallons of Prudhoe Bay crude oil spilled from a gash in the tanker's starboard side into an area known for its nearly pristine habitat and abundant wildlife. For months, media images of oiled and dying otters and birds were seared into viewers' consciousness. Today, ten years later, many people immediately see these and other graphic images of injured animals simply when they hear the words *"Exxon Valdez."*

Hundreds of scientists from Federal, state, and local agencies, academia, and volunteers converged on the small town of Valdez at the entrance to Prince William Sound, offering assistance. NOAA/HAZMAT's scientific support team of biologists, geologists, oceanographers, oil chemists, and information managers coordinated the flow of this advice to the U.S. Coast Guard Federal On-Scene Coordinator charged with directing the cleanup of the spill. The cleanup continued for over a year, breaking only for Alaska's arctic winter.

After cleanup resumed in 1990, NOAA/HAZMAT initiated its unprecedented study of the recovery of the Sound from the effects of the cleanup and response operations.

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