Exxon Valdez Oil Spill Trustee Council

2000 Status Report

SEA

NVP

APEX

GEM

Ecosystem Research

Molly McCammon
Executive Director

Letter from the Executive Director

During 1999, the Trustee Council took big strides toward the future of restoration in the spill region.

A research and monitoring effort, expected to be decades in duration, is being established in the Gulf of Alaska with at least $120 million in seed money. The Gulf Ecosystem Monitoring (GEM) program is being planned as a sentinel system, keeping watch over the ecosystem and acting as an early warning mechanism for human-influenced and natural changes occurring in the northern gulf. GEM research will concentrate on providing needed tools and information for fisheries, wildlife, and land managers to improve forecasts and decision-making.

In addition to GEM, the Council decided to place $55 million into an account for continued habitat protection in the spill region. How this fund will be used has not yet been determined, although some of it will hopefully be used for long-term protection of the Karluk River on Kodiak Island. Planning efforts will continue through the year and the public will be asked to provide input into the process.

After a two-year lobbying effort, Congress made it possible in December for the Trustee Council to substantially increase the interest income from its investments. The change in law will allow the Council to establish investment strategies similar to government employee retirement accounts, and could double the funds available each year for programs like GEM.

The Council's efforts in 1999 have added substantially to a legacy of restoration that will pay dividends in the form of a healthier ecosystem for generations to come.

Molly McCammon

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Cover photo: Measuring blue mussels, by Roy Corral; Inside cover: Kodiak Island sea lion haulout, by Roy Corral.

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Looking at the big picture

Ecosystem studies anchor Trustee Council's research program

Since 1993, the Trustee Council has invested tens of millions of dollars in an organized effort to better understand the marine ecosystem that both supports and enchants the people of Southcentral Alaska.

To be good stewards of the resources, we must understand the intricacies of this marine ecosystem to the best of our abilities. What are the changes taking place? What factors limit the productivity of key species? How can we best react to inevitable changes in the sea, caused by both natural fluctuations and human activities?

In the Trustee Council's view, long-term restoration of the spill region will depend on knowledge of natural resources and a better understanding of how populations rise and fall as changes — both natural and human-caused — occur in the sea.

It was in the spring of 1993 that the herring crashed in Prince William Sound, its population plummeting from an all-time high the previous year to an all-time low. A few short months later, the return of pink salmon to the sound turned dismal. Something had drastically changed in the ecosystem and commercial fishers demanded action and answers. They took their frustrations to the Valdez Narrows and formed a blockade that for three days kept oil tankers at bay.

The result was an agreement that the Trustee Council would support ecosystem studies focused on herring and pink salmon in Prince William Sound. The six-year, $22 million Sound Ecosystem Assessment (SEA) project was born later that year after months of discussion between commercial fishers, fishery managers, scientists, and others.

This was the genesis of the Trustee Council's emphasis on ecosystem-based studies. The settlement with Exxon was not yet two years old. The previous year, the Trustee Council made the transition from reactive damage assessment studies to a more proactive plan for restoration. A draft of the Restoration Plan (which was adopted in 1994) was already being prepared and in it, the Trustee Council clearly stated its intentions concerning research. "Restoration will take an ecosystem approach to better understand what factors control the populations of injured resources."

In addition to the SEA project, the Trustee Council made a long-term commitment to understanding how seabirds are affected by the availability of forage fish. The Alaska Predator Ecosystem Experiment (APEX) received $10.8 million over an eight-year period.

Another ecosystem-based research effort, the Nearshore Vertebrate Predator (NVP) project, began in 1995. That six-year, $6.5 million study used four species injured by the spill — river otters, pigeon guillemots, sea otters, and harlequin ducks — to determine what factors in the nearshore area were limiting recovery.

What have we learned from these major ecosystem projects and dozens of other studies that focused on individual species? This 2000 Annual Report will take a look at some of the major research efforts and the lessons learned.

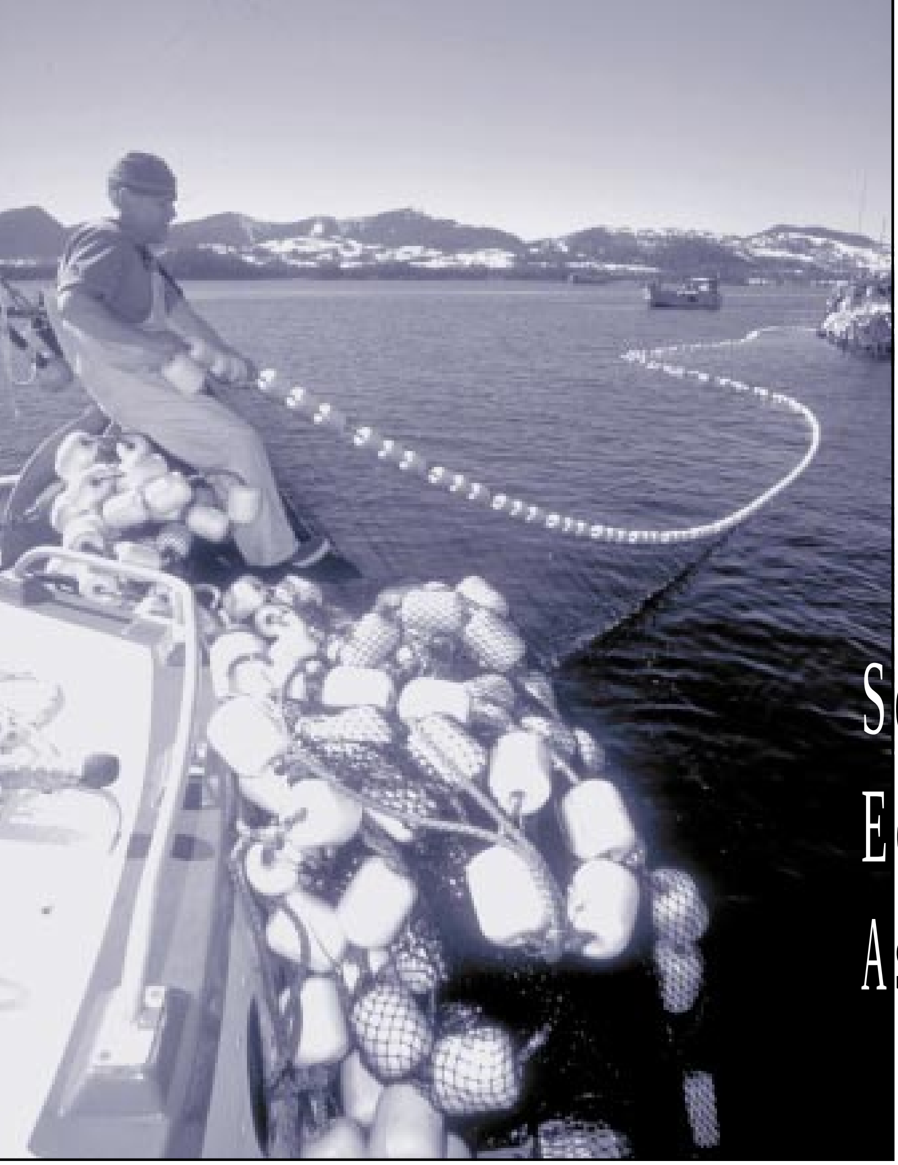


Photo by Al Grillo

Herring fishing in Prince William Sound (1990)

Sound Ecosystem Assessment

Pink salmon and Pacific herring in Prince William Sound

The 1993 collapse of the herring population in Prince William Sound, followed that summer by a poor return of pink salmon, served as a clarion call for a better understanding of the sound ecosystem.

Prince William Sound endured a major ecosystem change after the 1964 earthquake when subtidal areas were lifted above the tide line and community oil tanks were laid open by tsunamis. Twenty-five years later, the northern Gulf of Alaska absorbed the largest oil spill in U.S. history. Along the coast of the northern gulf is where more than half of Alaska's population lives, works, and plays and it is a destination point for many of the one million tourists who vacation in Alaska each summer.

Understanding both the natural changes and the human impacts on the region is vital to maintaining this rich ecosystem on which Alaskans depend.

The Sound Ecosystem Assessment (SEA) project is the largest of the ecosystem-scale research projects funded by the Trustee Council. SEA was initiated by commercial fishers and implemented by a team of research scientists coordinated out of Cordova. It included more than a dozen integrated components organized to obtain a clear understanding of the factors that influence productivity of Pacific herring and pink salmon in Prince William Sound.

This project has produced new information about the survival needs of juvenile herring and unraveled mysteries showing the effects of wind and ocean currents on plankton, the very base of the food chain. Researchers have developed a clear new picture of how pink salmon fry, no more than three inches in length, dodge predators and fatten up on plankton during their first few months in saltwater when their survival is most in doubt.

Pink Salmon

Pink salmon hatch in the streams of Prince William Sound or in the incubators of five hatcheries in the area. During the spring, they emerge from the streams or are released from the hatcheries to begin their migration out of the sound and into the northern Pacific. Research scientists chose to focus their studies at the point where pink salmon appear to be most vulnerable: as fry trying to survive the migration to the open ocean.

Pink salmon fry, in salt water for the first time, must quickly fatten up on animal plankton and at the same time avoid predators that must fatten up on them. Why is it that some years they do this with great success and return as adults in large numbers the following year, while in other years the survival of fry is poor and the adult return dismal?

SEA researchers began their focus on plant and animal plankton. They knew that plankton come from two main sources. Winds and currents can sweep plankton into the sound from the Gulf of Alaska. Or plankton can emerge from the deep recesses of Prince William Sound, including an area reaching 700 meters in depth known locally as the "black hole." But it was not known whether the black hole could produce enough plankton to support the needs of the sound or whether the sound was dependent on production in the Gulf of Alaska.

To determine this, SEA researchers developed a computer-based circulation model that predicts the movement of currents in the sound. A powerful computer was used to simulate circulation using information about the underwater landscape, inflow of saltwater from the Gulf of Alaska, inflow of freshwater from streams, tides, and winds.

Basketball-sized buoys were released at different locations in the sound to help validate the predictions of the model. The buoys, tracked by satellite, measured currents at the surface and at 15 meters depth.

The circulation model provided a wealth of information about how water movement impacts biological processes. For instance, the model simulated what would happen as plankton eggs, deep in the black hole, floated to the surface. In this way, scientists were able to determine that zooplankton from the black hole were retained in the sound for several months, meaning that the region was not wholly dependent on the gulf for food. The circulation model, using 1996 data, showed that plankton in the southeast portion of the sound were from the gulf while the majority of plankton in the western corridor were from the nearby black hole.

Another SEA model involved the groundbreaking work of predicting when the plankton blooms (the peak of plankton abundance) will occur. The timing and duration of the blooms have enormous implications for survival of salmon fry. Depending on conditions, the onset of the blooms can vary year to year by several weeks. Drs. David Eslinger and Peter McRoy developed a highly accurate model that is based on easily monitored ocean and weather conditions (Figure 1). In general, they found that during stormy, windy years, the onset

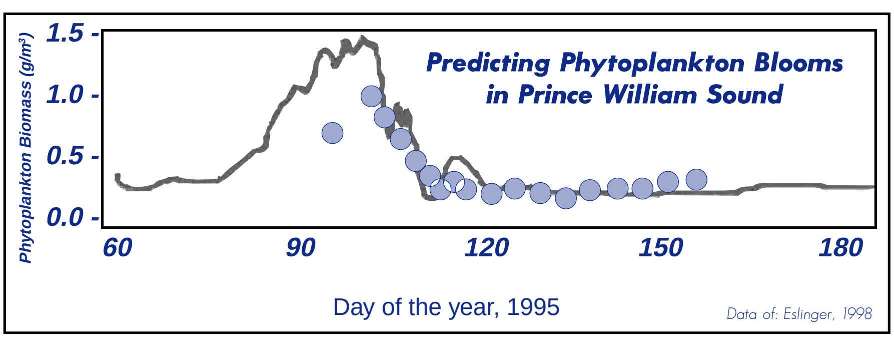


Figure 1. Models generated through the Sound Ecosystem Assessment (SEA) project estimated the timing and size of the animal and plant plankton blooms. The grey lines show the models' predictions compared to the actual measurements, represented by blue dots.

> *"The oceans are changing dramatically. We are ignorant about many of these changes, in denial about some and generally complacent about the likely consequences.*
>
> Dr. Jane Lubchenco, Keynote Speaker
> *Exxon Valdez:* Legacy of an Oil Spill, Report to the Nation


Photo courtesy ADF&G

Pink salmon eggs

of plankton blooms are late but prolonged, while those in calm years are early, intense, and short-lived.

Other SEA researchers were simultaneously working on another key question: Which is more limiting to salmon fry, food or predation?

SEA's salmon researchers mounted an intensive sampling campaign. Salmon fry and predator fish were caught, counted, weighed, their distributions mapped, and their stomach contents examined to find out their eating habits. Although it was generally known which fish preyed on salmon fry, it was not clearly known how much of an impact different predators had on the salmon population.

Researchers were able to show that pollock are the dominant predator on pink salmon fry, and that knowledge helped confirm an ecological theory. The plankton blooms not only feed the salmon fry, they also help shield them from predators. Scientists determined that, depending on the size and timing of the plankton bloom, pollock may prefer to feed on plankton instead of fry. The opportunistic pollock will feed on whatever prey provides the most energy for the least effort, and this often means they prefer floating plankton over the swimming salmon. When plankton is plentiful, salmon fry are less likely to be preyed upon.

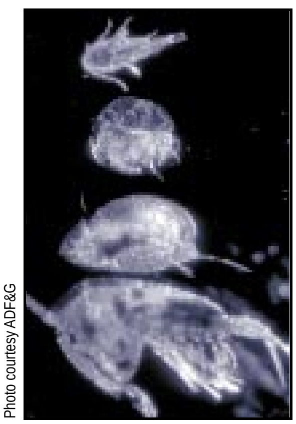


Photo courtesy ADF&G

Zooplankton

To gauge the impact of this discovery, SEA developed another computer-based model. This model was designed to simulate the migration path of the fry. As the fry disperse and move toward the ocean, the computer model predicts where they will go, what food they will encounter, and what predators will encounter them.

The model is more than a fascinating look at predator-prey relationships. It has some very practical applications. In some circumstances, for example, it's better for the survival of fry when hatchery managers release them *en masse*. But other marine conditions call for a different strategy. When the zooplankton bloom is weak, it can make better sense to release the fry in batches.

Although there are many factors involved in fry survival, SEA has narrowed the field to a subset that can be monitored: light, temperature, fry size at release, fry density and group clustering, plankton bloom timing and abundance, and predator composition and size. These data can be used in a computer model to predict the survival of salmon fry, thereby providing a new tool to more accurately predict the return of adult pink salmon the following year.

So what have we learned from SEA?

The basic scientific knowledge gained is almost incalculable and new discoveries will continue as data are analyzed for many years to come. But of more immediate importance are the practical applications for users of the gulf ecosystem.

SEA has developed models that can now tell us where the plankton is coming from, where the currents will take it, when the bloom will occur and how strong it will be. Predator-prey models predict the survival rate of salmon fry.

This information is important not only when it comes to planning the release of fry from hatcheries and in forecasting the return of those salmon the following year, but also in understanding how salmon survive and grow.

Pacific Herring

Herring spawn in early April and the hatched larvae spend months drifting around Prince William Sound. Like the plankton, herring larvae are at the mercy of the currents until they metamorphose into juvenile fish in August.

Just as they did with pink salmon, SEA researchers focused primarily on the early stages of life as the most critical for herring survival. What were they feeding on? How did they survive the winter when plankton were practically non-existent? Unlike pink salmon, very little was known about the first year of life for Pacific herring. Researchers were pretty much starting from scratch.

The SEA herring team conducted a painstaking series of surveys to map the distribution of the juvenile herring and document their habitat needs. The groundbreaking information they gathered depended on a highly coordinated series of aerial surveys, hydroacoustic surveys, and intensive net sampling efforts.

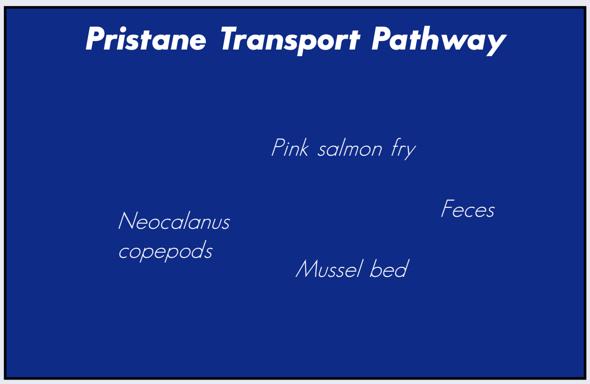
SEA learned that young herring begin appearing in small bays in late July and August each year and were feeding on plankton into the fall. However, by late fall their food supply nearly disappears.

It turned out that juvenile herring must survive three or four months with very little food. They fast and preserve their energy, or "cut power and float," as some scientists refer to it. If they fail to store up enough energy for the winter, they may die. The energy reserves of the herring, the severity of the winter, and the bay in which they overwinter all play significant roles in their survival.

Dr. A.J. Paul went to eight different Prince William Sound bays in March and measured the energy reserves of juvenile herring found there. He found that the herring in Simpson, Sheep, and Boulder bays had plenty of reserves to survive the winter. Juvenile herring in Jack and Whale bays were low on reserves and those in Eaglek, Paddy, and Drier bays were near the point of starvation. This information confirmed that a particularly cold or stormy winter could cause starvation in many areas and lead to a poor return as adults.

Once again the SEA modelers took this information and built it into a model for herring overwintering survival. The model inputs body protein and energy content measured from a sample of young herring in late fall and, based on expected winter temperatures, estimates the proportion of herring that will survive until spring. This provides another tool for better predicting the survival of a herring year class.

Development of the various SEA models is continuing. More fine tuning and testing must be done before they can be used routinely for management purposes.



Potential predictive tool for pink salmon being put to the test this summer

Jeff Short, a research chemist at the National Marine Fisheries Service Auke Bay Laboratory, is cautiously stepping out on a limb this summer. He is testing a potential new tool, known as a pristane production index for forecasting the return of hatchery-raised pink salmon to Prince William Sound. Pristane is a naturally occurring hydrocarbon, produced by Neocalanus copepods, the dominant food of pink salmon fry. The pristane passes through the salmon and settles as fecal material on mussel beds. By monitoring the pristane level in blue mussels, Short can determine whether hatchery salmon, released en masse, had good or poor feeding success. A low level of pristane could mean a low survival rate for fry and a poor return of adult pinks the following summer. The pristane index is still in its infancy, but compared to previous years, the 1999 index was low at two hatcheries and high at a third. Based on this, Short predicts that the return of hatchery salmon will be down at the two hatcheries and up at the third in 2000.

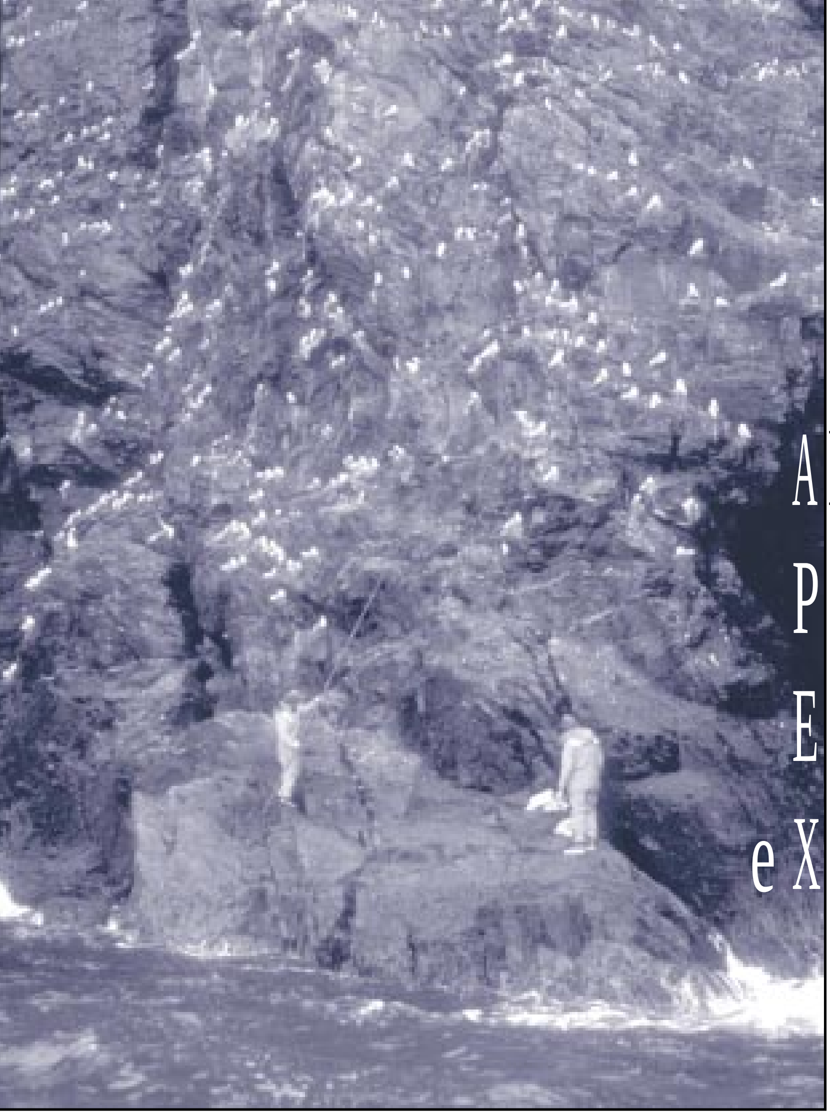


Photo by L.J. Evans

Alaska Predator Ecosystem eXperiment

Forage fish and seabirds in the Gulf of Alaska

Common murres, black-legged kittiwakes, harbor seals, and Steller sea lions are examples of apex predators, fish eaters at or near the top of the food chain. Declines in these and other apex populations have occurred in the Gulf of Alaska since the 1970s. At the same time, the gulf has undergone a drastic change in the type and abundance of forage species, such as herring, capelin, sand lance, shrimp, young pollock and juvenile cod.

The Alaska Predator Ecosystem Experiment (APEX) began in 1994 in an effort to determine why some seabird species injured by the oil spill showed no sign of recovery. Such knowledge was seen as essential to undertaking biologically realistic recovery. APEX asked the basic question: How does food availability — the type and abundance of forage fish — limit the ability of seabirds to recover from oil spill injuries?

A shift in the dominant forage fish populations occurred in the last half of the 1970s, likely triggered by a decadal shift in climate. Warming waters resulted in a shift from an ecosystem dominated by shrimp to one dominated by pollock and cod. Small-mesh trawl surveys, conducted annually since 1953, resulted in a strong database with nearly 10,000 individual sampling tows, collected over widely dispersed regions of the Gulf of Alaska. These data illustrate a massive change in the marine ecosystem, beginning in 1978. Shrimp and forage fish gave way to pollock and cod, and within two years there was a complete reversal in dominance (Figure 2).

Recent analysis of the 1996-1998 survey data has shown that the groundfish-dominant trophic structure still exists, but there are signs that the ecosystem may be shifting again. Water temperatures have fallen for two successive years and the amount of cod and pollock taken in the trawl surveys has declined. Long-term monitoring is needed to determine what drives and maintains these marine-ecosystem changes and how they impact apex predators.

Photo by Rob Suryan

If the sea is sick, we'll feel it. If it dies, we die. Our future and the state of the oceans are one.

Dr. Sylvia Earle
Sea Change: A Message of the Oceans

Energetics

If the ecosystem shift forced a change of diet on seabirds, how does that affect egg production and survival of chicks?

APEX researchers measured lipid or fat content of forage fishes because it is the primary factor determining energy available to apex predators. Lipid content of seabird prey ranged from 5 percent of dry mass (Pacific tomcod) to 48 percent of dry mass (eulachon, also known as hooligan). Most of this variation was from species to species, but there were also variations within species related to age, sex, location, and the reproductive status of the fish.

Of the main fishes consumed by seabirds, juvenile herring, pre-spawning capelin, and sand lance had the highest energy content (Figure 4). Kittiwake diets were dominated by these high-lipid forage fishes at all study sites and this correlated with good nestling growth and survival. The trend in the 1990s of higher kittiwake productivity associated with increasing availability of sand lance, capelin, and herring was broken in 1997, a poor year at most kittiwake study colonies. The poor productivity of 1997 appears to be associated with fewer herring in their diet.

Controlled laboratory studies were conducted to better understand the nutritional difference between high-lipid and low-lipid fishes in the diets of kittiwakes. Kittiwakes fed a high proportion of sand lance and herring also had high growth rates and productivity (Figure 4). This compared to much lower growth rates and productivity in birds that consumed mostly demersal fishes (pollock) or gadids (cod). Juvenile kittiwakes required roughly twice the amount of pollock and cod to obtain the same growth rates as juveniles fed herring and sand lance.

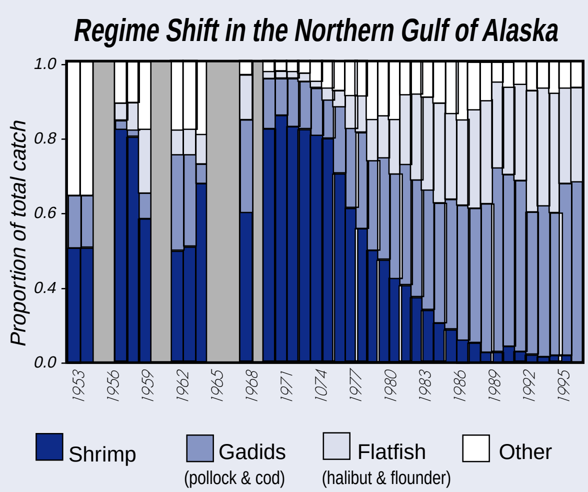
These results support the hypothesis that productivity of kittiwakes and guillemots in the gulf region is strongly linked to the availability of three species of forage fishes: Pacific sand lance, Pacific herring, and capelin. These three species form schools near shore and have high energy densities compared with most other forage fishes. Recovery of seabird populations injured by the oil spill will likely depend, at least in part, on increases in these key fish stocks.

Feeding behavior

By observing individual seabirds and schools of fishes the APEX study has found several factors that influence how seabirds forage. In summer, the waters

A return to shrimp in the northern gulf?

Figure 2. *In 30 years of conducting trawl surveys around the Kodiak Island region, Paul Anderson has seen the shrimp disappear from the nets, and cod and pollock rise to dominate the northern Gulf of Alaska ecosystem. The continuity of these surveys has allowed researchers to document a complete shift in the ecosystem in the late 1970s, probably due to a change in water temperature from around 2-degrees Centigrade to around 5-degrees Centigrade. Two decades later, Anderson is witnessing another potential shift. For two successive years, trawl surveys have shown that waters are again cooling and the population of cod and pollock has started to dwindle. Will shrimp again return to dominance in the Gulf of Alaska? Time will tell.*



of Prince William Sound are stratified with little mixing and the near-surface fish schools (herring, sand lance, and capelin) are small, occur in low density, and are located close to shore. Seabirds in the sound respond by foraging singly or in small flocks close to shore.

This is in contrast to lower Cook Inlet where there is strong tidal mixing of the water column, the fish are in larger and more dense schools than in the sound, and the fish occur offshore (capelin and pollock) as well as nearshore (capelin and sand lance).

When prey are predictable, seabirds learn and remember where prey can be found and individual birds return to the same area repeatedly. They do not always forage on fish that are closest to the colony. Instead, they pass by fish schools to return to the area where they have successfully foraged in the past. This may increase the birds' foraging efficiency.

Seabirds change their foraging strategy in respect to prey abundance: when prey are scarce seabirds generally forage in flocks, but when prey are abundant they often forage alone. This behavior increases their efficiency when food is scarce by using other birds to locate schools.

Halibut provide clues to forage fish availability

The availability of forage fish is both difficult to assess and expensive to measure. In an effort to find a cost-effective means of monitoring forage fish availability, the Trustee Council funded an experiment using halibut stomachs. Halibut sport-fishing guides were trained to collect stomachs from their daily catch and record when and where the halibut were caught. Preliminary results show that the stomach contents appear to correlate with the known schools of forage fish. Halibut caught in areas where seabirds are struggling had been eating mostly crab and shellfish. Halibut from areas with healthy seabird populations were feeding on forage fish. It is too early to know whether this will prove to be a good monitoring method, but researchers say the results are promising.

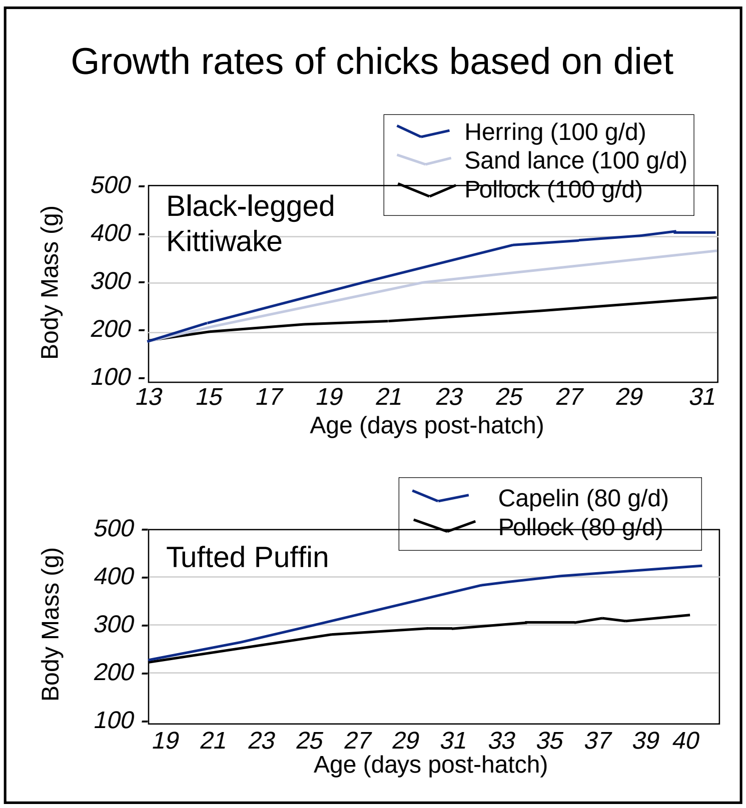


Figure 3. *The energetics of forage fish play an important role in the growth rate and survival of chicks. In a controlled experiment, black-legged kittiwake chicks fed herring and sand lance grew more than twice as fast (measured by body weight) as chicks fed the same amount of pollock. At the same time, tufted puffins fed fat-rich capelin doubled the growth rate of those fed pollock, a lean fish. A similar experiment conducted separately found that pigeon guillemots (not graphed here) had similar rates of growth, responding strongly to herring compared to pollock.*

Photo by Roy Corral

> *Nature to be commanded, must be obeyed.*
>
> Sir Francis Bacon
> *Novum organum*

Modeling

The population dynamics of kittiwakes and other seabirds in Prince William Sound are usually in a state of flux. At any given time, some seabird colonies are growing and some are declining. Although there is strong evidence that variation in food supply underlies much of the fluctuation in colony size, the mechanism by which food supply influences colony dynamics needs to be more clearly defined.

Using detailed data on the movement patterns and foraging behavior of radio-tagged kittiwakes, coupled with extensive concurrent aerial surveys of fish schools, APEX researchers have constructed a computer model designed to mimic the behavior of a foraging kittiwake. This model can be used to simulate the response of a foraging kittiwake to various patterns of food distribution and abundance. These simulated foraging behaviors can then be used to predict the distance that adults must travel in order to forage, and the rate and nature of food deliveries to the chicks. Since chick survivorship is known to be strongly influenced by these factors, it may be possible to make predictions about the performance of individual colonies based on hypothetical fluctuations in the distribution and abundance of the forage fish.

APEX data are also being considered for a model that would help predict the recruitment of juvenile herring to the adult population. Little is known about the survival rate of juvenile herring, so it is difficult to predict how large a group will grow up to join the population of spawning adults each spring. One possible prediction method would use observations of diets in seabirds. By quantifying the amount of juvenile herring in the diets of kittiwakes, for example, a model could extrapolate the strength of the juvenile year classes.

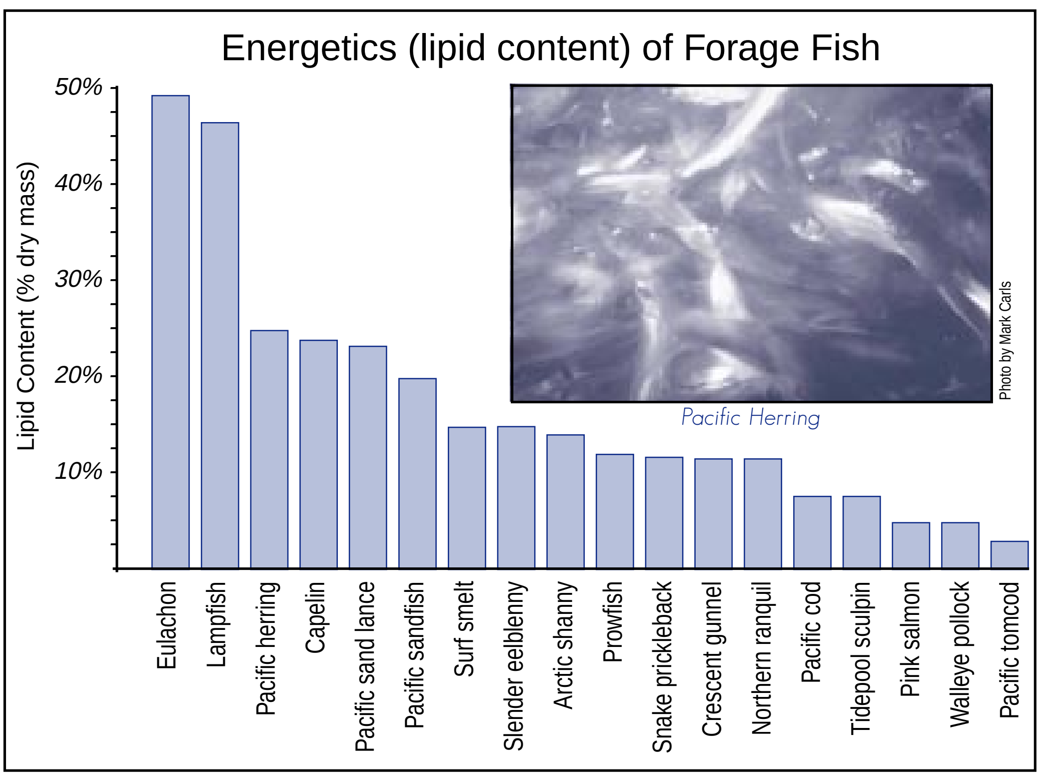


Figure 4. *The kinds of forage fish available to seabirds can have a big impact on survival of the chicks. Herring, capelin and sand lance are rich in fats when compared with pollock, cod and pink salmon. Seabird colonies with fatty forage fish in the area do better than those feeding on the lean cuisine of pollock and cod.*

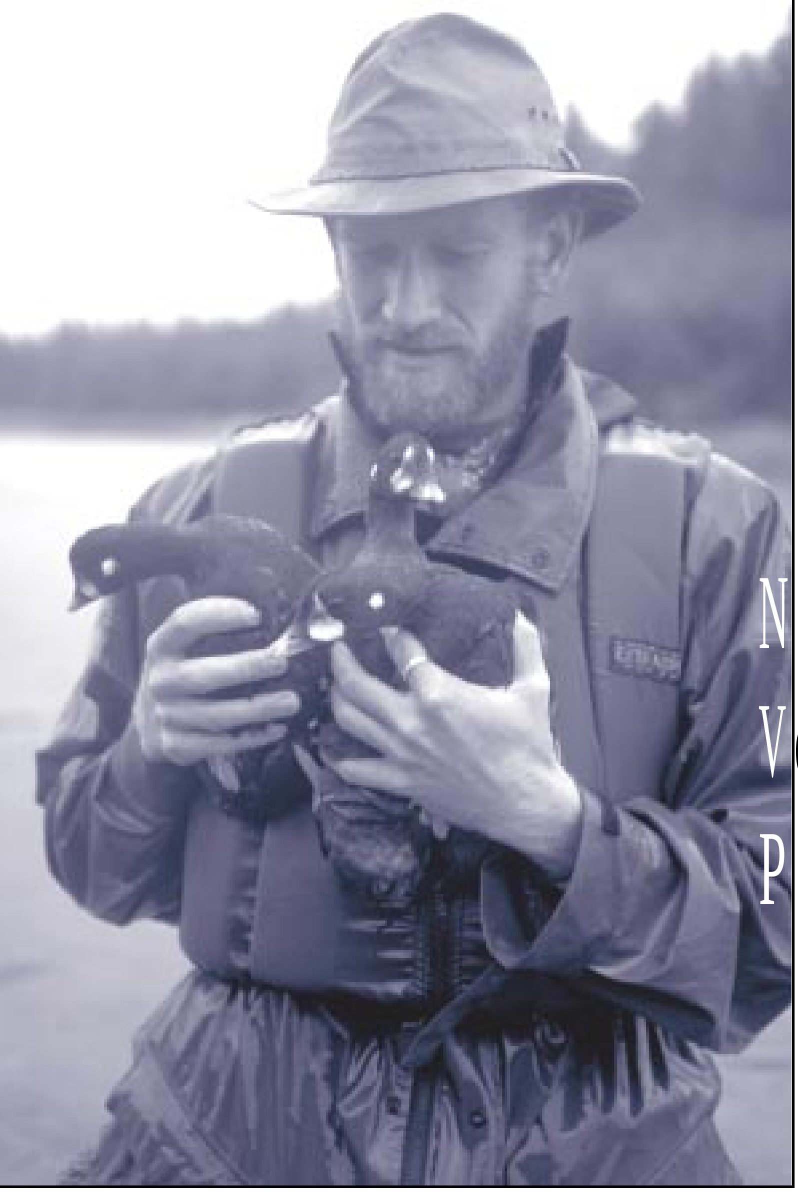


Photo by Roy Corral

Nearshore Vertebrate Predator Project

Long-term impacts of oil in the nearshore environment

The plants and animals living along the coast took the brunt of the spilled oil as millions of gallons washed up along hundreds of miles of shoreline. Ten years later, some of the more heavily oiled areas remain polluted with tar, asphalt, and unweathered oil either at or just below the surface.

But what about the animals that live there? Of the eight species that remain listed as "not recovering" ten years after the spill, seven use the nearshore environment for nesting, feeding, and resting. Is it oil that is preventing their recovery or are other factors involved, such as food availability, reproductive ability, weather, or predation? How long does it take for populations to rebuild to pre-spill levels?

This central question became the basis of the Nearshore Vertebrate Predator project, a six-year $6.5 million effort conducted by the Alaska Biological Science Center of the U.S. Geological Survey in cooperation with scientists from NOAA and the University of Alaska Fairbanks. This team of scientists sought answers to the fundamental question about oil spills: how long does oil persist in the environment and does it continue to impact wildlife?

Researchers narrowed their study to four species injured by the spill: two fish eaters (river otters and pigeon guillemots) and two species that feed on shellfish (sea otters and harlequin ducks). All four species are long-lived and spend most of their time in the nearshore environment.

All four species could face oil contamination in the nearshore waters whenever oil in sediments is released. Other potential avenues of oil exposure, through diet or direct contact, differ for each species. Sea otters, which feed on shellfish and dig through large volumes of sediments where residual oil persists, are likely to contact oil while foraging or through their diet. River otters, which catch fish for

Photo by Roy Corral

> *EVOS damage is not the most egregious change; it is one of many, the vast majority of which are invisible, incremental, sometimes irreversible and, taken together, quite insidious.*
>
> Dr. Jane Lubchenco, Keynote Speaker
> *Exxon Valdez:* Legacy of an Oil Spill, Report to the Nation

food, are more likely to be exposed on shore. Pigeon guillemots would have minimal direct exposure to oil, although they do supplement their diets with invertebrates. Harlequin ducks, on the other hand, live on shore and feed on shellfish and could be exposed to oil through preening and diet.

The risk of oil exposure is greater for animals that eat invertebrates, such as clams and mussels, because they concentrate hydrocarbons. Fish, on the other hand, metabolize hydrocarbons quickly and, thus, don't concentrate them.

The NVP research team split up into groups studying each of the four species. They maintained two research sites, one in an area that was heavily oiled in 1989 and the other in an area that saw very little or no oil. In this way they could compare results from oiled areas to non-oiled areas.

Animals were captured, weighed, measured, aged, and had blood samples taken. Before being released some harlequin ducks and river otters had transmitters attached to allow researchers to follow their movements and to indicate death (should that occur).

The results differed between regions and among species. Harlequin ducks showed signs of continued stress, and populations in the oiled areas had zero growth. Sea otters in the most heavily oiled areas of northern Knight Island have not increased in abundance, despite food supplies capable of supporting population growth. There has, however, been an increase in numbers of sea otters in the comparison group.

Female harlequin ducks in the oiled areas were less likely to survive the winter than those from non-oiled areas (Figure 5). Although the difference was not great (78 percent survival versus 84 percent survival), it is enough to have a significant impact on the population. Researchers calculated that the winter survival rate in oiled areas was enough to cause a 5 percent population decline versus approximately stable populations in the unoiled areas. Survey data are consistent with these data on survival.

Researchers used a biomarker of hydrocarbon exposure to determine whether animals in the oiled area were still being exposed to oil. Based on analysis of blood and tissue samples, both species showed evidence of recent exposure to oil. Researchers say, however, that the exposure appears to be variable, and there is some indication that it is diminishing each year.

For the harlequins, ducks with the highest levels of the biomarker tended to have the lowest body weights, suggesting that oil exposure was negatively affecting their health. In contrast, sea otters from

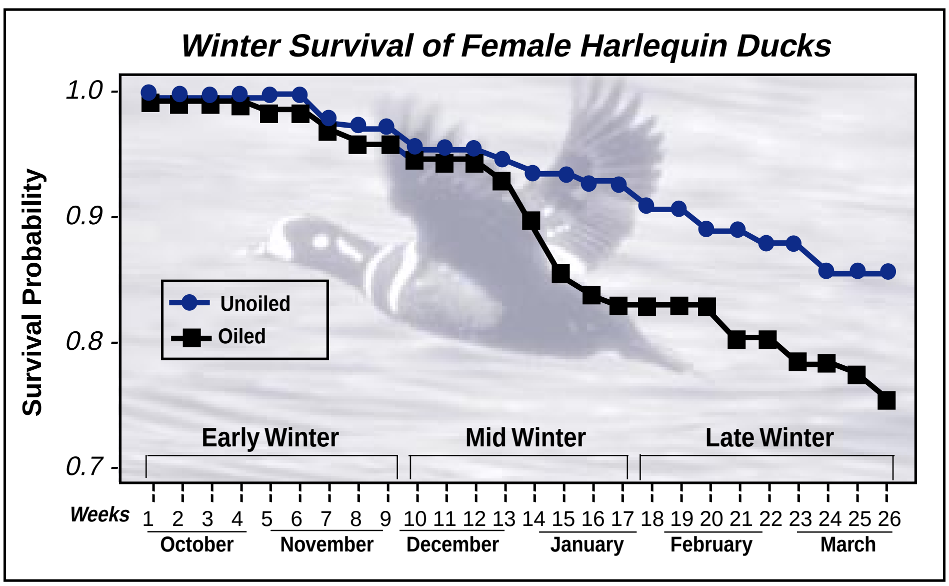


Figure 5. *Winter survival of female harequins was significantly lower in oiled areas versus unoiled areas during the winters of 95-96, 96-97 and 97-98. The difference in survival is enough to cause a 5 percent decline in population in the oiled areas compared to stable populations in unoiled areas.*

the oiled study area tended to be in better condition than their counterparts in the nonoiled area, perhaps because of greater availability of food, given the low numbers of otters there. However, over the last decade, blood work on sea otters has indicated liver damage in animals residing in the oiled areas, which could be a result of exposure to the oil.

By the end of the NVP study, researchers determined that only a small proportion of the sea otters still exhibited abnormal blood values, which is consistent with declining amounts of residual oil in the environment. It is also important to note that both sea otters and harlequin duck populations appear to be healthy or stable when considering the entire Prince William Sound. Effects of continued exposure to oil are seen primarily in more heavily oiled regions in the western part of the sound.

A colony of pigeon guillemots at Naked Island is not rebounding from the impacts of the oil spill, and apparently, both oil and food availability may be affecting recovery. The Jackpot Bay colony is growing dramatically, whereas the Naked Island colony remains depressed. Based on biomarker results, pigeon guillemots at Naked Island continue to be exposed to oil, although perhaps at relatively low levels. However, blood work on birds from the Naked Island colony suggests that oil may be affecting the function of liver and other organs. Recovery of the guillemots may also be complicated by diet differences: birds at the healthy Jackpot colony eat twice as much herring and other high-energy fish as do those at the Naked Island colony. A major shift in forage fish (see APEX) has impacted many species and colonies throughout the Gulf of Alaska region. The food available to Naked Island guillemots consisted mostly of pollock and cod, which has about half the amount of fat as herring.

In following the trail of river otters, NVP researchers were able to determine that the river otter had recovered from the effects of the spill. Biomarker levels were higher in river otters from the oiled area in

Status: *Recovering*

Diet: *Mussels, clams, invertebrates*

Sources of continued exposure to oil:
- *Through diet: high*
- *By grooming: low*

Population trend:
- *Up in unoiled areas*
- *Stagnant in oiled areas*

Evidence of oil exposure:
- *Elevated P450 and serum enzymes*

Sea Otter

Status: *Recovered*

Diet: *Fish*

Sources of continued exposure to oil:
- *Through diet: low*
- *By grooming: high*

Population trend:
- *Stable*

Evidence of oil exposure:
- *No significant impacts since 1996*

River Otter

Status: *Not Recovering*

Diet: *Invertebrates*

Sources of continued exposure to oil:
- *Through diet: high*
- *By preening: medium*

Population trend:
- *Stable in unoiled areas*
- *Declining in oiled areas*

Impacts of continued oil exposure:
- *Elevated P450, reduced body weight, reduced survival*

Harlequin Duck

Status: *Not Recovering*

Diet: *Forage Fish*

Sources of continued exposure to oil:
- *Through diet: low*
- *By preening: low*

Population trend:
- *Declining throughout region*

Impacts of continued oil exposure:
- *Elevated P450/serum enzymes in adults*

Pigeon Guillemot

1996, the initial year of the study, but by 1998, no differences were seen between animals in oiled and nonoiled areas. Other measures of health, which indicated that river otters suffered from oil effects in the early 1990's, had also returned to normal by the time of the NVP study. In 1999, the Trustee Council officially declared the river otter "recovered."

The NVP research team concluded in 1999 that continued oil exposure appears to be through a diet of invertebrates and, possibly, by grooming or preening. This can come from mussels left untreated after the oil spill or other intertidal and subtidal invertebrates from the sound's floor. Oil on shorelines or in the nearshore water column may also be a source of contamination, getting onto an animal's fur or feathers.

"The collective evidence supports the hypothesis that patchy, persistent oil in the sound is still being sufficiently mobilized some 10 years post-spill to constrain recovery within the nearshore ecosystem," the NVP final report concludes.

"It is apparent that we are no longer studying populations under acute stress, but rather that components of the invertebrate-based nearshore community are still under chronic, but decreasing levels of stress. This stress is observed not at a regional level where both sea otters and harlequin duck populations are stable or growing, but in those areas of the sound most heavily oiled by the 1989 *Exxon Valdez* oil spill and examined under the NVP study."

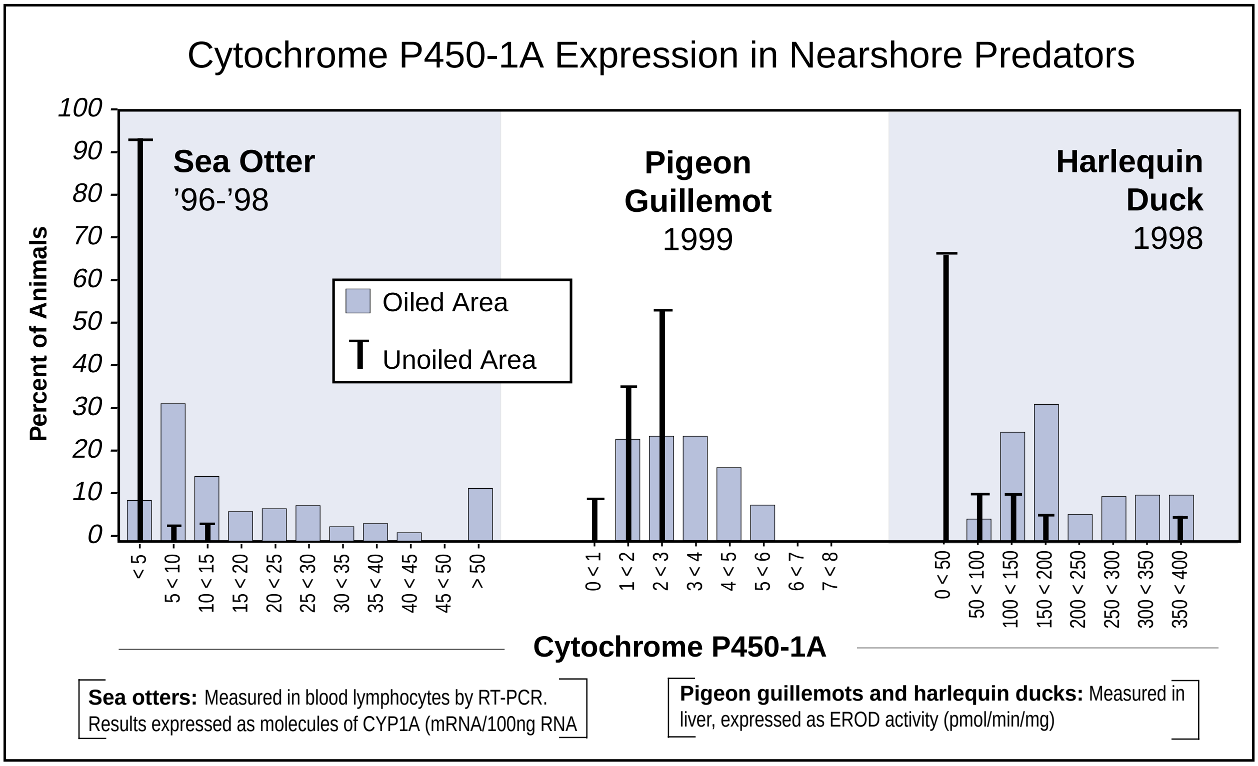


Figure 6. *In an effort to determine whether residual oil was affecting the four key NVP predators, researchers looked at a biomarker of hydrocarbon exposure, cytochrome P450-1A (CYP1A). Biochemical analysis showed higher expression of CYP1A in animals from oiled areas, compared to those from unoiled areas. River otters in oiled areas also showed higher expression of CYP1A after the spill, but by 1998, no differences were found between oiled and unoiled areas.*

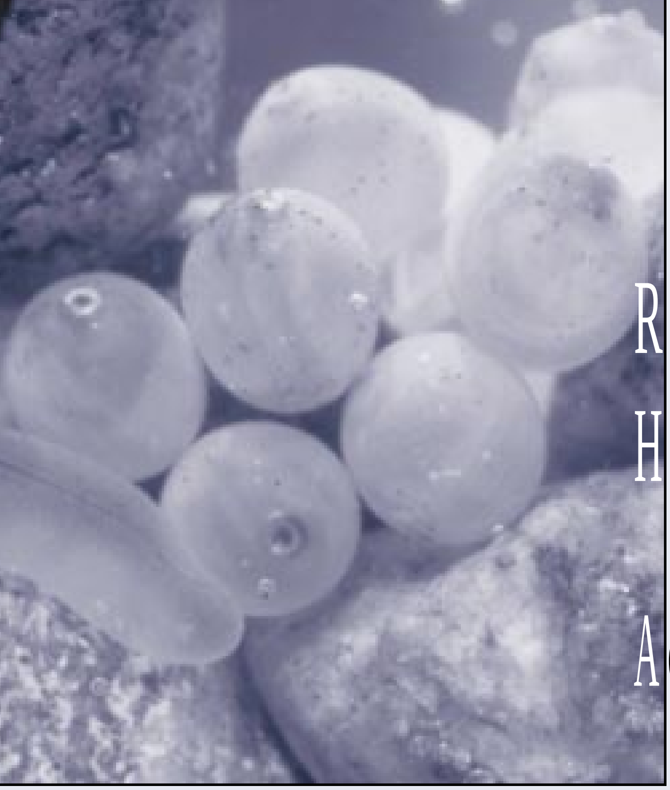


Photo courtesy ADF&G

Research Highlights and Accomplishments

Pink Salmon

Excavation of Port Dick Creek on the Kenai Peninsula opened new spawning habitat for pink and chum salmon.

Improvements to a bypass at Little Waterfall Creek on Kodiak Island increased the number of pinks reaching spawning habitat.

Development of remote video technology may prove a technological breakthrough to economically monitor spawning.

A plankton model is being developed to forecast optimum release times of hatchery salmon smolt.

Genetic work of pink salmon will identify genetic traits such as disease resistance, growth, and timing of the run.

New studies on the sensitivity of pink salmon eggs, larvae and fry to fresh and weathered oil can aid in establishing water quality standards and in contingency planning for future spills.

The study of pristane (Page 6) in mussels could lead to better forecasting of pink salmon runs in PWS.

Pacific Herring

Improved assessment methods have helped fisheries managers better determine herring biomass and set harvest quotas.

Intensive research indicated disease played a major role in the 1993 collapse of the PWS herring population.

A herring model is being developed to help forecast harvest levels by estimating overwinter survival of juveniles.

Changes in the pound fishery were made as a result of questions raised about pounding methods and the possible link to disease.

Genetic research revealed significant differences between the Bering Sea and Gulf of Alaska herring populations.

Studies on the sensitivity of young herring to oil can aid in establishing water quality standards and in spill contingency planning.

Sockeye Salmon

Genetic identification of Kenai River stocks helps protect sockeye salmon by ensuring escapement to vital tributaries.

Cook Inlet sonar provides a better measure of the run strength and better management decisions.

Rearing and survival in nursery lakes are better understood and aid in predicting/managing sockeye runs.

Coghill Lake in PWS was fertilized to promote sockeye production.

Disease could be vital part of future herring forecasts

Photo by Heather Rand

Researcher Gary Marty looks for disease in herring with lesions.

The collapse of Pacific herring in Prince William Sound in 1999 might be related to the same disease that decimated the population in 1993. This time, however, researchers have data from the previous year that could provide clues on how to use disease indicators in making forecasts. Gary Marty, research pathologist at the University of California at Davis, noted that the prevalance of ulcers and virus was high during the 1998 spawning season. Marty now believes that the herring suffered a high mortality rate shortly after undergoing the stress of spawning. In the future, he said, disease indicators will likely become part of the formula for determining forecasts for the following year. Sampling for disease is easy and relatively inexpensive. "This year ('99), fish are relatively healthy and they should provide the basis for population recovery," Marty said.

Marine Mammals

Can something be done to arrest the on-going population decline of harbor seals? Researchers are studying whether the carrying capacity has diminished due to changes in forage fish availability.

Data from wild, healthy seals and sick/injured seals help veterinarians evaluate the health status of individuals and populations.

Genetic data on killer whales will help in interpreting population changes and responding to conservation problems.

Some killer whale populations were found to have high concentrations of contaminants in their blubber.

New information on reproduction is crucial for understanding the effects of harvests on sea otters.

Data on life expectancy of sea otters has led to improved estimates of survival and recovery.

Improved aerial survey techniques are now being used throughout the sea otter's range.

Improved technique allows aging of sea otters using teeth.

Habitat Improvement

Hands-on restoration projects are stabilizing and restoring stream banks which protect rearing sockeye salmon.

A PWS human use model will help predict how increased human uses will impact fish and wildlife habitats and resources. This should help managers reduce or mitigate such impacts.

Fatty acid analysis proves popular

As part of her research to understand why harbor seals in Prince William Sound were declining, Alaska Department of Fish and Game Biologist Kathy Frost needed to find out what seals were eating, and whether diets differed before and after the decline. When her study began, the only way to get that information was by examining stomach contents or scat. Both were hard to get. To overcome this problem, Frost teamed up with Sara Iverson at Dalhousie University. Iverson had pioneered a new process to analyze the fat in seal blubber. Working together, Frost & Iverson found that harbor seals "are what they eat." The fatty acid signatures of the blubber can be matched with the fatty acids in prey species to reveal an accurate picture of the seals' diets. Frost and Iverson learned that seal diets were quite different 20 years ago than they are today. Dietary changes may have affected the growth and survival of young seals, and caused the decline. "In the beginning, we weren't sure this technique would work," Frost said. "Now it is being used around the world for research on everything from seals to belugas."

Photo by Roy Corral

Frost (L) and Iverson radio-tag seals in the sound

Capturing pigeon guillemot chicks in Resurrection Bay

Seabird/Forage Fish

The availability and quality of forage fish was linked directly to seabird productivity. As a result, the North Pacific Fishery Management Council strictly limited forage fish bycatch and prohibited new commercial fisheries on forage fish species.

Blood samples may provide a simple means of predicting reproductive success of seabirds and serve as a broad indicator of overall environmental stress.

Forage fish schools can be monitored by examination of stomach contents of halibut caught on charter boats.

Non-native foxes that were introduced to some seabird-nesting islands were removed to help increase bird populations.

Surveys of marine bird populations in PWS now provide powerful data on population change, vital for long-term evaluation of the ecosystem.

Researchers identified species-specific indicators for health of seabird populations, such as productivity for kittiwakes and foraging time for murres.

A new method to monitor marbled murrelets on the water was developed.

The first full-scale study of the Kittlitz's murrelet, one of the least known seabird species in the world, was conducted. This seabird is found near tidewater glaciers and may be a victim of global climate change.

Harlequin Duck

New data on populations resulted in curtailment of the sport hunting season in PWS.

New techniques were developed to age and sex ducks, improving population assessments.

First large-scale use of surgically-implanted radios was conducted to study movements and survival .

Information on genetics, site fidelity, and movements will support decisions such as harvest levels and siting of facilities.

Remote cameras could supplement field research, salmon counts

The use of remote video camera technology could prove a cost-effective way to monitor fish and wildlife in the field as well as a strong tool for public education. The Trustee Council sponsored two pilot programs using remote video cameras, one to count salmon in streams and one to monitor seabirds in the Barren Islands. The seabird project included live video feeds to the Pratt Museum in Homer where specialists monitored common murres and helped educate visitors about seabird and forage fish ecology. The camera used to count salmon used time-lapse photography, allowing technicians to review 1,100 hours of escapement information in about 42 hours. The camera count documented 85-87 percent of the salmon counted at a weir.

Photo by Carol Harding

Remote camera pioneer Daniel Zatz

Cutthroat Trout and Other Fish

Habitat inventories and in-stream improvements enhanced spawning and survival of cutthroat trout and coho salmon.

Research on cutthroat trout supported changes in regulation of the sport fishery to conserve the resource.

Studies will help determine if PWS pollock should be managed as part of the Gulf of Alaska population.

River Otter

Researchers pioneered a new method for trapping otters for mark-and-recapture population estimates.

Ground-breaking work on oil ingestion will aid in understanding exposure from oil and other contaminants.

Reduction of Marine Pollution

Waste management plans help reduce marine pollution, such as waste oil and hazardous household waste, by providing proper disposal facilities and equipment in PWS, Kodiak Island, and lower Cook Inlet.

Otolith marking aids fishery management

The otolith (earbone) of a pink salmon is about the size of a grain of rice, yet it carries information that is solving several mysteries of pink salmon. Hatchery-raised pink salmon from Prince William Sound are now easily identified by the markings placed on the otoliths. This helps protect wild stocks by allowing fishery managers to accurately determine whether a school of salmon is wild or not. It has resulted in additional commercial fishing in some bays when wild stock were not present. Otolith marking also provides accurate information about straying of hatchery-raised salmon into streams. And it helps identify salmon taken on the high seas as bycatch, explaining something about the migration patterns of salmon.

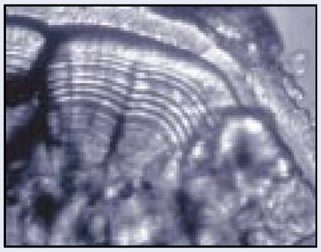


Photo by Heather Rand

Pink salmon otolith (earbone)

Subsistence

Broke new ground by including traditional knowledge of some species as part of the overall research into populations, trends, and health.

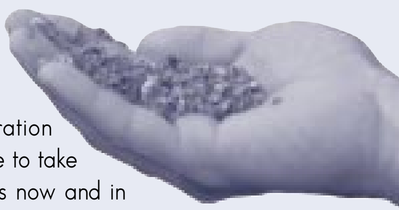
Subsistence hunters have been trained to take biosamples from harbor seals for scientific analysis.

Smolt have been released in Boulder Bay near Tatitlek annually since 1994 to create a subsistence fishery.

Sockeye salmon have been stocked in Solf Lake to provide more subsistence resources in the Chenega Bay area.

King salmon fry released near Chenega Bay provide additional subsistence resources.

A clam restoration project is expected to stock littleneck clam populations on subsistence beaches. New techniques to spawn clams could help the shellfish industry as well.



Hundreds of tiny clams fit in the palm of a hand.

Students take part in ongoing restoration projects, learning the skills and knowledge to take part in restoration activities now and in the future.

Elders/Youth Conferences in 1995 and 1998 brought subsistence users, youth and researchers together to learn and exchange ideas.

Two videos document subsistence uses and traditions involving harbor seals and herring.

A coho salmon project on the Kametolook River near Perryville will strengthen the return to the river and improve subsistence resources.

Ecosystem Synthesis

A dynamic computer model for PWS will help predict effects of changes in the system as variables such as increasing fisheries harvests change.

Maps are being produced bringing together all the new knowledge about species location and seasonal use in PWS.

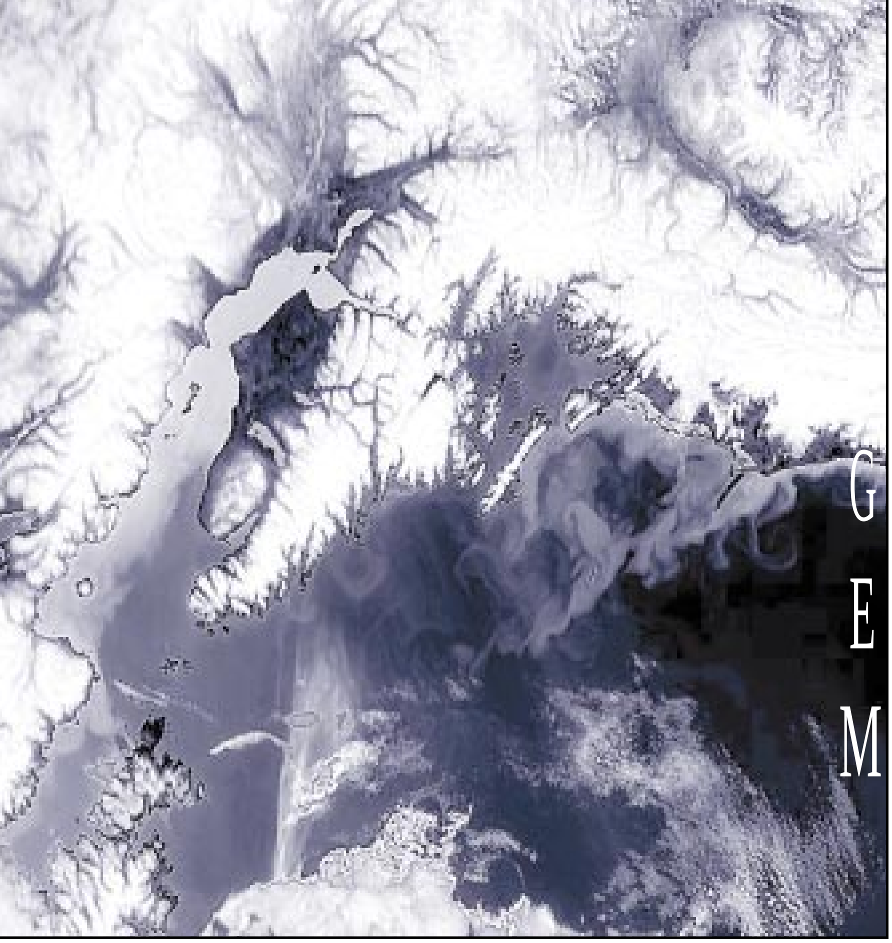


Photo courtesy the SeaWIFS Project, NASA/Goddard Space Flight Center and ORBIMAGE Corporation

Gulf Ecosystem Monitoring

A sentinel program for the northern Gulf of Alaska

A health watch for the Gulf of Alaska, in which researchers continually take the pulse of the marine environment and its watershed, is being planned as part of the long-term legacy of oil spill restoration. In March 1999, the Trustee Council established a $120 million fund for a research and monitoring effort now known as GEM - Gulf Ecosystem Monitoring - that could span the entire century or more.

In return, the people who live, work and play in the spill region are expected to gain unprecedented knowledge about the ecosystem they depend on as well as new tools and strategies for management of fish and wildlife. Such knowledge will provide an early warning system for changes, both natural and human-caused, that occur in the Gulf of Alaska ecosystem, from mountain headwaters to the depths of the open ocean beyond the outer continental shelf.

At the start of the third millennium A.D., the northern Gulf of Alaska remains as pristine an environment as can be found almost anywhere on earth. Environmental signals, especially climate, continue to be the determining factors in the overall health of the ecosystem.

But history in other parts of the world has taught us that eventually the human signals will overtake and overwhelm the natural signals. If anyone doubts this, simply look at the tripling of Alaska's population over the last 40 years, the increased fishing pressure in Southcentral Alaska, the doubling of tourism in the last 10 years, and, soon, the opening of the Whittier Road. And then, consider what the next 40 years might bring. Developed properly, GEM will serve as a sentinel over the gulf, providing an early warning system that will help resource managers, policy makers, and the public to minimize the impacts and better prepare for the inevitable increase in human use.

GEM will cover an area similar to the spill region, including Prince William Sound, lower Cook Inlet, Kodiak Island, and the Alaska Peninsula. Its mission is "to sustain a healthy and biologically diverse marine ecosystem in the northern Gulf of Alaska and the human use of those resources through greater understanding of how productivity is influenced by *human activities* and *natural changes*."

The gulf ecosystem is extremely complex, consisting of thousands of interacting species. It will not be possible for GEM to answer all, or even most, *"Far and away the greatest threat to the sea and to the future of mankind is ignorance.*

Dr. Sylvia Earle
Sea Change: A Message of the Oceans

of the questions that could be posed about the gulf. Instead, GEM will focus on 1) key species in the system, picked on the basis of perceived ecological importance and human relevance, and 2) on the most telling physical and biological processes responsible for healthy production.

The GEM program will continue to work with resource managers, stakeholders, the scientific community and the public to refine a common set of priorities for research, monitoring and protection in the northern gulf. GEM will coordinate its efforts with other government agencies, universities, and private groups that are already studying individual components of the gulf ecosystem. This will allow GEM to fill in vital gaps without duplicating studies.

The $120 million GEM fund will act as an endowment, providing annual funding of $5 million to $10 million depending on investment earnings.

Independent peer review is essential for a high caliber scientific program. Participation in research and monitoring is expected to be completely open to competition. Periodic "State of the Gulf" workshops, public reports, and a GEM website would serve to keep the public, and especially stakeholders, up to date with research.

The draft GEM program will be submitted to the National Research Council in Washington, D.C. for a thorough scientific review before being implemented.

Goals of GEM

Detect: Serve as an early warning system by detecting annual and long-term changes in the marine ecosystem, from coastal watersheds to the central gulf.

Understand: Identify causes of change in the marine ecosystem, including natural variation, human influences, and their interaction.

Predict: Develop the capacity to predict the status and trends of natural resources for use by resource managers and consumers.

Inform: Provide integrated and synthesized information to the public, resource managers, industry and policy makers in order for them to respond to changes in natural resources.

Solve: Develop tools, technologies, and information that can help resource managers and regulators improve management of marine resources and address problems that may arise from human activities.

GEM
Gulf Ecosystem Monitoring

GEM Implementation Schedule

April 2000
- Submit Draft to the National Research Council for review
- FY 2001 Invitation to seek transition proposals

October 2000
- Initiate FY 2001 transition projects

January 2001
- Receive preliminary NRC feedback
- Begin revisions to GEM plan to address NRC recommendations and use results from transition projects

February 2001
- Invite additional transition projects for FY 2002

October 2001
- Begin FY 2002 transition projects

January 2002
- Trustee Council finalizes GEM Program

February 2002
- Issue GEM invitation for proposals (FY 2003)

October 2002
- Begin GEM monitoring and research program

Photo by Daniel Zatz

Habitat Protection

The long-term protection of threatened habitat, considered essential for the well-being of species injured by the oil spill, was one of the earliest goals of the Trustee Council. Even before the Restoration Plan was finalized in 1994, the Trustee Council, in cooperation with the Alaska State Legislature, funded the protection of two key parcels, along Kachemak Bay and on Afognak Island, each under imminent threat of logging.

Six years later, one of the largest habitat protection efforts in the United States is nearly complete. The Council's goal of protecting key habitats throughout the spill region was largely achieved in February of 1999 when a package was finalized with Eyak Corporation protecting 75,452 acres in eastern Prince William Sound.

Through a creative series of conservation easements, timber easements, and fee simple acquisitions, the Trustee Council expanded the portfolio of its Large Parcel program to a total of 635,770 acres protected, including at least 1,400 miles of shoreline and more than 300 salmon streams.

This includes 55,402 acres surrounding the popular Karluk and Sturgeon rivers on Kodiak Island, which is protected by a conservation easement, but only through 2001. The permanent protection of these rivers is the only unfinished business remaining in the Trustee Council's $360 million Large Parcel program. Negotiations with the landowner, Koniag, Inc., are continuing.

An additional $24.4 million has been spent or earmarked to protect at least 11,179 acres through the Small Parcel program, which deals with smaller, more strategically located habitats, usually along rivers, coastal areas, and lagoons. To date, 47 parcels totaling 7,240 acres have been acquired and protected. The Council has set aside funds for another 3,939 acres under consideration for protection.

In March of 1999, the Trustee Council decided that it would use $55 million from its Restoration Reserve account to continue habitat protection efforts into the future. The fund will be used to finance protection of the Karluk and Sturgeon rivers, if negotiations are successful, and to create an account for future parcel acquisitions. How the account will be structured and the types of habitat that will qualify for protection have not yet been determined.

Altogether, the Trustees have dedicated about 60 percent of available settlement funds or $431.4 million for habitat protection in the spill region.

Many species injured by the oil spill nest, feed, molt, winter, and seek shelter in the habitat protected through these programs. Several other species live primarily in the nearshore environment and benefit from the protection of the nearby uplands.

Habitat protection also supports the restoration of tourism, recreation, commercial fishing and subsistence, all of which are dependent upon healthy productive ecosystems.

Habitat Protection Large Parcel Program

Parcel Description	Acreage	Coastal Miles[3]	Salmon Rivers[4]	Total Price	Trustee Council's Share
Acquisitions Complete					
Afognak Joint Venture	41,750	99	18	$74,133,824	$74,133,824
Akhiok-Kaguyak	115,973	202	39	$46,000,000	$36,000,000
Chenega	59,520	190	45	$34,000,000	$24,000,000
English Bay	32,537	123	31	$15,371,420	$14,128,074
Eyak	75,425	189	80	$45,126,704	$45,126,704
Kachemak Bay State Park inholdings	23,800	37	3	$22,000,000	$7,500,000
Koniag (fee title)	59,674	41	11	$26,500,000	$19,500,000
Koniag (limited easement)	55,402			$2,000,000	$2,000,000
Old Harbor [1]	31,609	183	13	$14,500,000	$11,250,000
Orca Narrows (timber rights)	2,052		2	$3,450,000	$3,450,000
Seal Bay/Tonki Cape	41,549	112	5	$39,549,333	$39,549,333
Shuyak Island	26,665	31	8	$42,000,000	$42,000,000
Tatitlek	69,814	212	50	$34,550,000	$24,719,461
TOTAL:	**635,770**	**1,419**	**305**	**$399,353,038**	**$343,357,396**

Negotiations Continuing

Koniag (fee title)[2]

1. As part of the protection package, the Old Harbor Native Corporation agreed to protect an additional 65,000 acres on Sitkalidak Island as a private refuge.
2. Negotiations with Koniag concern fee title to the 55,402 acres that are currently protected under a temporary conservation easement due to expire in December 2001.
3. Approximate miles of coastline.
4. Approximate number of anadromous rivers, streams and spawning areas.

Photo by Susan Harding

Public Participation

While public involvement continues to be at the forefront in the restoration process, it's fair to say that public information efforts peaked in 1999 with the 10th anniversary of the oil spill.

"Legacy of an Oil Spill: 10 Years after *Exxon Valdez*" was the theme for a flurry of activities marking a decade since the spill. An all-day public "Report to the Nation" was held in Anchorage on March 23, followed by a three-day scientific symposium to report what has been learned since the spill.

A documentary about restoration activities was released in February, 1999 and provided to biology teachers and every school library in Alaska. It also aired over Alaska's public television stations. In addition, independent documentaries were produced by KTOO-TV in Juneau, KTUU-TV in Anchorage, and by National Geographic Television.

The world's media again focused on the *Exxon Valdez* in large numbers. Executive Director Molly McCammon conducted a standing-room-only press conference and luncheon presentation at the National Press Club in Washington, D.C. in February 1999. In addition, hundreds of newspaper, magazine, television, and radio reporters from 13 countries contacted the Restoration Office as part of their 10th anniversary coverage. Media groups included: CNN, ABC, NBC, 60 Minutes, Discovery, National Geographic, Newsweek, People, Life, TIME, Christian Science Monitor, Wall Street Journal, USA Today, and several newspapers from around the country.

A 10-year anniversary exhibit at the Alaska SeaLife Center has been seen by about 400,000 visitors over a two-year period. That exhibit was reproduced as a traveling display, exhibited at the public symposium in March and then shown at the Juneau, Anchorage, and Fairbanks libraries.

The 1999 Annual Report was a special edition answering basic questions about the spill with straightforward answers. That annual report has been widely requested and used by teachers throughout the country who are making the *Exxon Valdez* spill part of their curriculum. The 10-year report has been reproduced on the Trustee Council's web site and can be found at: www.oilspill.state.ak.us.

Alaska Coastal Currents, a series of weekly radio reports and newspaper columns that described the restoration process one piece at a time, provided nearly three years of detailed information to the public leading up to the 10-year event.

New titles were added to the popular Restoration Notebook series, a look at the natural history of injured species and associated restoration activities, written by the scientists in the field. Notebooks on

> “EVOS has . . . consistently innovated in developing diverse opportunities for involvement in EVOS programs and decision making.
>
> Dr. Sally Fairfax
> *Conservation Trusts*

Photo by Susan Harding

Public Advisory Group

Rupert Andrews (chair)	Brenda Schwantes
Torie Baker	Stacy Studebaker
Chris Beck	Charles Totemoff
Pamela Brodie	Howard Valley
Sheri Buretta	Ed Zeine
Dave Cobb	
Chip Dennerlein	**Ex-Officio Members**
Dan Hull	Sen. Loren Leman
James King	Rep. John Harris
Charles Meacham	

the bald eagle and subsistence were added in 1999 to a series that already included harbor seals, killer whales, marbled murrelets, pigeon guillemots, sea otters, black oystercatchers, and herring. The entire series is available on the web.

The Restoration Update, the newsletter of the Trustee Council and the Restoration Office, continues to be published four times yearly. Newsletters for the last three years are available on the web.

In a scholarly evaluation of public trusts in the United States[1], the Trustee Council’s public involvement process was singled out for its unique and innovative programs. Sally Fairfax, professor of Natural Resources at the University of California Berkeley, noted that the memorandum of understanding that established the Trustee Council specifically required “meaningful public participation in the injury assessment and restoration process.”

Fairfax pointed to open meetings, the opportunity for all spill area communities to be included by teleconference at each meeting, public comment periods at each meeting, and the Public Advisory Group as exemplary of a public trust. But it was in regard to the various public involvement projects funded through the Council that she said the Trustees were “charting new territory.”

Establishing community facilitators in 10 spill area communities, coordinated through the Chugach Regional Resources Commission, has been an effective way to disseminate information to the villages, get feedback from residents, and help communities apply for funds for local projects, she said. Fairfax also pointed to efforts such as establishment of the Alaska Native Harbor Seal Commission, local stewardship of archaeological resources, and recognition of Traditional Ecological Knowledge (TEK) as a tool for restoration. “In the field of TEK, EVOS is truly a pioneer, developing both programs and protocols for addressing the practical problems of sensitive and effective cross-cultural inquiry, and working on the cutting edge of a new field of social science to understand theoretical and social implications of such research,” she wrote.

1. *Conservation Trusts*, by Darla Gunzler and Sally Fairfax, forthcoming from University Press of Kansas.

Evolution of Funding for Subsistence Projects

Fiscal Years 1992-2000

Fiscal Year	*Projects Funded*	*Funding Provided (In thousands)*	*Percentage of Work Plan Budget*
92	0	0.0	
93	2	241.7	
94	4	430.3	3.0
95	9	895.0	5.2
96	12	1,250.3	6.9
97	15	1,319.5	8.4
98	14	1,453.4	10.3
99	12	1,271.6	11.1
00	13	1,092.6	13.2

Several other projects impacting subsistence culture and communities have also been funded, either outside of the Work Plan or as part of the “archaeology” category.

Project	**Funding** *(in thousands)*
Archaeology	$2,026.8
Alutiiq Museum	1,500.0
Community Exhibits	2,800.0
Port Graham Hatchery	781.3

Figure 7: *A 1994 planning effort involving subsistence communities resulted in the funding of a Community Involvement program. This program helped keep communities informed of restoration activities and provided assistance for communities that wanted to submit project proposals. The number of projects and amount of funding increased as a result of this effort.*

Appendix A

The Settlement: United States and State of Alaska vs. Exxon Corporation

The settlement among the State of Alaska, the United States government and Exxon was approved by the U.S. District Court on October 9, 1991. It resolved various criminal charges against Exxon as well as civil claims brought by the federal and state governments for recovery of natural resource damages resulting from the oil spill. The settlement had three distinct parts:

Criminal Plea Agreement. Exxon was fined $150 million, the largest fine ever imposed for an environmental crime. The court forgave $125 million of that fine in recognition of Exxon's cooperation in cleaning up the spill and paying certain private claims. Of the remaining $25 million, $12 million went to the North American Wetlands Conservation Fund and $13 million went to the national Victims of Crime Fund.

Criminal Restitution. As restitution for the injuries caused to the fish, wildlife, and lands of the spill region, Exxon agreed to pay $100 million. This money was divided evenly between the federal and state governments.

Civil Settlement. Exxon agreed to pay $900 million with annual payments stretched over a 10-year period. The settlement has a provision allowing the governments to make a claim for up to an additional $100 million to restore resources that suffered a substantial loss, the nature of which could not have been anticipated from data available at the time of the settlement.

Exxon Valdez Oil Spill Trustee Council

The *Exxon Valdez* Oil Spill Trustee Council was formed to oversee restoration of the injured ecosystem through the use of the $900 million civil settlement. The Council consists of three state and three federal trustees (or their designees):

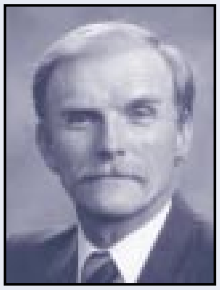
Commissioner, Alaska Department of Fish and Game; Commissioner, Alaska Department of Environmental Conservation; Attorney General, Alaska Department of Law; Secretary, U.S. Department of the Interior; Director, National Oceanic & Atmospheric Administration; Secretary, U.S. Department of Agriculture.

Bruce Botelho
Attorney General
State of Alaska

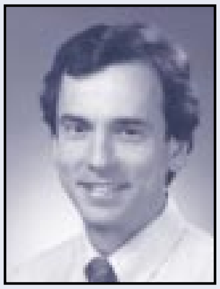
Michele Brown
Commissioner
Alaska Dept. of Environmental Conservation

Dave Gibbons
Supervisor, Chugach National Forest
US Dept. of Agriculture

Marilyn Heiman
Assistant to the Secretary for Alaska
US Dept. of the Interior



Steve Pennoyer
Director, Alaska Region
National Marine Fisheries Service



Frank Rue
Commissioner
Alaska Dept. of Fish & Game

Appendix B

The Restoration Plan and Budget

The Trustee Council adopted a Restoration Plan in 1994 after an extensive public process that included meetings in 22 spill-area communities as well as in Anchorage, Fairbanks and Juneau. More than 2,000 people participated in the meetings or sent in written comments.

Reimbursements. As part of the settlement agreement, $173.2 million went to reimburse the federal and state governments for costs incurred conducting spill response, damage assessment, and litigation. Another $39.9 million went to reimburse Exxon for cleanup work that took place after the civil settlement was reached.

The remaining funds were dedicated to implementation of the Restoration Plan, which consists of five parts:

Research and Monitoring. Surveys and other monitoring of fish and wildlife in the spill region provide basic information to determine population trends, productivity, and health. Research increases our knowledge about the biological needs of individual species and how each contributes to the Gulf of Alaska ecosystem. Research also provides new information and better tools for effective management of fish and wildlife populations.

General Restoration. This category includes projects to protect archaeological resources, improve subsistence resources, enhance salmon streams, reduce marine pollution, and restore damaged habitats.

Habitat Protection. Protection of habitat helps prevent additional injury to species due to intrusive development or loss of habitat. The Trustee Council accomplishes this by providing funds to government agencies to acquire title or conservation easements on land important for its restoration value.

Restoration Reserve. This savings account was established in recognition that full recovery from the oil spill would not occur for decades. The reserve fund will support long-term restoration activities after the final payment is received from Exxon in September 2001. The reserve, including unallocated funds and interest, is expected to be worth approximately $170 million by that time.

Science Management, Public Information & Administration. This component of the budget includes management of the annual work plan and habitat programs, scientific oversight of research, monitoring and restoration projects, agency coordination, and overall administrative costs. It also includes the cost of public meetings, newsletters and other means of disseminating information to the public.

Photo by Joe Hunt

Uses of Civil Settlement:

(in millions)

REIMBURSEMENTS FOR DAMAGE ASSESSMENT AND RESPONSE	**213.1**
Governments (includes litigation and cleanup) (a)	173.2
Exxon (for cleanup after 1/1/92)	39.9
RESEARCH, MONITORING AND GENERAL RESTORATION	**166.4**
FY 1992 - FY 2000 Work Plans	117.3
FY 2001 - FY 2002 Work Plans (estimate)	12.0
Alutiiq Museum (Kodiak)	1.5
Archaeological Repository/Exhibits (PWS & Kenai Pen)	2.9
Alaska SeaLife Center	26.2
Port Graham Hatchery	.8
Reduction of Marine Pollution/Waste Oil	5.7
HABITAT PROTECTION	**376.4**
Large Parcel and Small Parcel habitat protection programs (past expenditures, outstanding offers, estimated future commitments and parcel evaluation costs)	
RESTORATION RESERVE (Principal, projected interest, unobligated funds)	**173.8**
Habitat Protection (including Koniag Phase II)	55.0
Gulf Ecosystem Monitoring (GEM)	118.8
SCIENCE MANAGEMENT, PUBLIC INFORMATION & ADMINISTRATION	**29.9**
FY 1992 - FY 2000	26.9
FY 2000 - FY 2002 (estimate)	3.0
TOTAL	**959.6**
Exxon Payments	900.0
Accrued interest (minus fees)	42.5
Projected interest (through 9/30/02)	17.1

(a) Reimbursement to governments reduced by $2.7 million included in the FY 1992 Work Plan.

As of February 15, 2000

Appendix C

Status of Natural Resources and Human Services

Eleven years after the *Exxon Valdez* oil spill, it is clear that many fish and wildlife species injured by the spill have not fully recovered. It is less clear, however, what role oil plays in the inability of some populations to bounce back.

An ecosystem is ever changing and continues its natural cycles and fluctuations at the same time that it struggles with the impacts of spilled oil. As time passes, separating natural change from oil-spill impacts becomes more difficult.

Not Recovering

There are eight species that continue to be listed as not recovering: **common loons, cormorants (pelagic, double-crested** and **red-faced), harbor seals, harlequin ducks, killer whales (AB pod),** and **pigeon guillemots.** The reasons behind their continuing problems, however, vary.

Common loon

Loons are long-lived, slow-reproducing, and have small populations. Common loons in the spill area may number only a few thousand, including only hundreds in Prince William Sound, yet carcasses of 395 loons were recovered following the spill, including at least 216 common loons. Boat surveys in the sound show no recovery through 1998.

Cormorant

Cormorants are large fish-eating birds that spend much of their time on the water or perched on nearby rocks. Three species typically are found within the oil-spill area: pelagic, double-crested, and red-faced. Post-spill counts showed significant declines in the estimated numbers of cormorants (all three species combined) in Prince William Sound when compared to pre-spill populations. Boat surveys in the sound show no recovery through 1998.

Harbor seal

Harbor seals in Prince William Sound and the Gulf of Alaska have lost 80 percent of their population over the last 20 years. Originally, the declines may have been related to environmental changes occurring in the late 1970s, but reasons for the continued decline are unknown. The oil spill killed an estimated 300 seals, resulting in a one-year drop of 43 percent in oiled areas. The decline has continued at an average rate of about 2.5 percent from 1990-1998.

Photo by Robert Angell

Harbor seal

Harlequin duck

Harlequin ducks feed in intertidal and shallow subtidal habitats where most of the spilled oil was initially stranded. Three years of data on overwintering adult female harlequins indicate significantly lower survival rates in oiled versus unoiled parts of the sound. Researchers continue to look at weathered oil remaining on some beaches as a possible reason behind their lack of recovery.

Killer whale

A pod of killer whales, which lost 13 of 36 members in the two years following the oil spill, has yet to regain its former size, even though the overall Gulf of Alaska population is higher than pre-spill numbers. The AB pod lost several adult females and juveniles and it is expected to take many years for natural reproduction to make up for those losses. The pod has increased by two members since 1996.

Pigeon guillemot

There is evidence that the pigeon guillemot population in Prince William Sound had declined before the spill and it is estimated that 10-15 percent of the spill-area population may have died following the spill. Surveys in the sound show no recovery through 1998.

Recovered

At the other end of the recovery scale are **bald eagles** and **river otters**. These species have been declared "recovered" because their populations now appear healthy.

Photo courtesy USF&WS

Bald eagle

Bald eagle

An estimated 6,000 bald eagles live year-round or seasonally in Prince William Sound. Although an estimated 250 eagles died during the spill, the population rebounded quickly and the bald eagle was formally designated as recovered in 1996.

River otter

River otters feed in intertidal areas making them vulnerable to spilled oil. Studies from 1989-91 identified differences between river otters in oiled and unoiled areas, including evidence of exposure to hydrocarbons or other sources of stress, reduced body size, and increased territory size. River otters were listed as recovered in February 1999 after two years in which differences were no longer measurable.

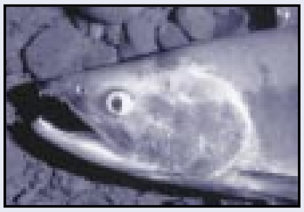


Photo courtesy ADF&G

Sockeye salmon

Recovering

Several resources appear to be making clear progress toward recovery, but have not yet met specific recovery objectives. These include **black oystercatchers, common murres, marbled murrelets, mussels, Pacific herring, pink salmon, sea otters, sockeye salmon, clams,** and **intertidal** and **subtidal communities**.

Black oystercatcher

It's estimated that there are only about 15,000 black oystercatchers worldwide, about 10 percent of which summer in the sound. They spend their entire lives in the intertidal area and are highly vulnerable to spilled oil. Oystercatchers appear to be reoccupying and nesting at once-oiled sites.

Common murre

About three-quarters of all the bird carcasses found after the spill were murres, resulting in declines of as much as 40 percent in local common murre populations. By 1997, common murre colonies had bounced back to near normal conditions. Though recovery was clearly underway, the year of *El Niño* brought a setback for the murres as carcasses washed up on shorelines and reproduction was disrupted.

Marbled murrelet

The marbled murrelet is listed as a threatened species throughout the Pacific Northwest, but is relatively abundant in Alaska waters. It is estimated that as much as 7 percent of the marbled murrelet population in the spill area was killed by the spill. Marbled murrelets declined before the spill, losing 67 percent of their population in Prince William Sound since 1972. Murrelet numbers in winter increased after the spill and productivity appears to be within normal bounds.

Mussel bed

To protect mussel beds and the many species they harbor from additional injury, the beds were not cleaned after the spill. Ten years later, oil persists in several mussel beds in Prince William Sound, providing potential pathways of oil contamination for sea otters, river otters, black oystercatchers and harlequin ducks.

Pacific herring

Some Pacific herring spawning areas were contaminated by oil, resulting in increased egg mortalities and larval deformities. Although the significance of these initial injuries to long-term population levels has not been established, sharp declines in herring numbers after the spill are cause for concern. Pacific herring in Prince William Sound suffered a complete collapse in 1993 due to a fungus and a latent virus that flared into an epidemic. The $12 million commercial herring fishery in the sound was closed for four successive years, opening again in 1997 and 1998. In April 1999, the herring population suffered another setback, probably due to disease seen in 1998, and the commercial season was again closed.

Pink salmon

Overall, pink salmon are recovering well from the effects of the oil spill. There is still concern about egg mortality in streams that were oiled in the western part of Prince William Sound. Patches of weathered oil still persist in or near intertidal spawning habitats in some of the streams used by pink salmon. These patches of oil may be exposed by winter storms and result in new local episodes of egg mortality that are expected to diminish in the long-term.

Sea otter

It is clear that recovery is underway for sea otters, with the exception of local populations in the most heavily oiled bays on Knight Island. An estimated 13,000 sea otters populate the sound. The lack of recovery at Knight Island may reflect the extended time required for population growth for a long-lived mammal with a low reproductive rate, but it also could reflect the effects of continuing exposure to hydrocarbons or a combination of both factors.

Sockeye salmon

Commercial salmon fishing was closed throughout the spill region in 1989, allowing too many sockeye to enter some rivers. This produced an overabundance of juvenile sockeye that overgrazed the nursery lakes. The result was a decline in growth of juveniles and reduced returns of adults. These effects seem to be over, but returns from some of the affected brood years are not all in yet.

Intertidal & subtidal communities

Intertidal and subtidal communities are well on their way to recovery, but recovery is generally incomplete and lagging. Subtidal communities include such species as eelgrass, starfish and helmet crabs that remain nearshore but underwater at all times. Intertidal communities include the flora and fauna that live between the low- and high-tide lines, such as clams, ***Fucus***, barnacles, and chitons.

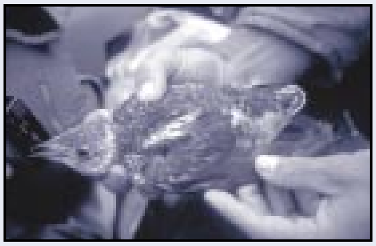


Photo by Robert Day

Kittlitz's murrelet

Recovery Unknown

For some species, not enough is known about their original injury, their current populations, reproductive success, and overall health to make a judgment on their recovery. Studies are underway or in planning to learn more about **cutthroat trout, Dolly Varden, Kittlitz's murrelets,** and **rockfish**.

Cutthroat trout

Prince William Sound cutthroat trout populations are small and geographically isolated. Cutthroat trout, therefore, are highly vulnerable to exploitation, habitat alteration, or pollution. Following the oil spill, cutthroat trout in a number of oiled streams grew more slowly than in unoiled streams. This persisted through 1991.

Dolly Varden

Dolly Varden winter in rivers and lakes, but spend their summers feeding in nearshore marine waters. Dolly Varden had some of the highest hydrocarbon concentrations of any fish studied in 1989. There is evidence that Dolly Varden in a number of oiled streams grew more slowly than in unoiled streams. However, this effect did not persist in 1991.

Photo by Roy Corral

Commercial fishing in Prince William Sound

Kittlitz's murrelet

Kittlitz's murrelets are found only in Alaska and portions of the Russian Far East. It's estimated that 1,000-2,000 individuals died from the oil spill, which would represent a substantial fraction of the world population. Very little is known about this species. Small population, low reproductive success, and affinity to tidewater glaciers (some of which are receding rapidly) are reasons for concern about the long-term conservation of Kittlitz's murrelet.

Rockfish

Relatively little is known about the complex of rockfish populations in the northern Gulf of Alaska. Some dead adult rockfish were recovered following the oil spill and autopsies indicated oil ingestion as the cause of death. In addition, closures of salmon fisheries apparently increased fishing pressure on rockfish. However, the original extent of injury could not be determined so the current recovery status of these species are unknown. Strategies for studying rockfish are expected to be part of the long-term ecosystem-based programs (GEM) now being planned.

Photo courtesy ADF&G

Rockfish

Human Services

The lives of the people who live, work, and play in the areas affected by the spill were completely disrupted in the spring and summer of 1989. Commercial fishing families did not fish. Those people who traditionally subsist on the fish, wildlife and plants of the region could no longer trust what they were eating and turned instead to high-priced groceries. Recreational opportunities were mostly shut down and the world-wide image of an attractive and pristine Prince William Sound was tarnished with oil.

Eleven years later, a sense of normalcy is returning to the spill region, but residents, fishermen, and the tourism/ recreation industry have not fully recovered.

The Trustee Council determined that the "human services" of **commercial fishing, subsistence, recreation/ tourism,** and **passive use** will have recovered when the injured resources on which they depend are once again healthy and productive. Since that level of recovery has not been achieved, each of these services is considered to be recovering.

Resources and Services Injured by the Spill

Not Recovering

Species are showing little or no clear improvement since spill injuries occurred.

Common loon
Cormorants (3 spp.)
Harbor seal
Harlequin duck
Killer whale (AB pod)
Pigeon guillemot

Recovering

Substantive progress is being made toward recovery objective. The amount of progress and time needed to achieve recovery vary depending on the resource.

Archaeological resources
Black oystercatcher
Clams
Common murres
Intertidal communities
Marbled murrelets
Mussels
Pacific herring
Pink salmon
Sea otter
Sediments
Sockeye salmon
Subtidal communities

Recovered

Recovery objectives have been met.

Bald eagle
River otter

Recovery Unknown

Limited data on life history or extent of injury; current research inconclusive or not complete.

Cutthroat trout
Designated Wilderness Areas
Dolly Varden
Kittlitz's murrelet
Rockfish

Human Services

*Human services that depend on natural resources were also injured by the oil spill. These services are each considered to be **recovering** until the resources on which they depend are fully recovered.*

Recreation & tourism
Commercial fishing
Passive uses
Subsistence

Resources in boldface have each moved on this Recovery Line during the most recent update (February 9, 1999)

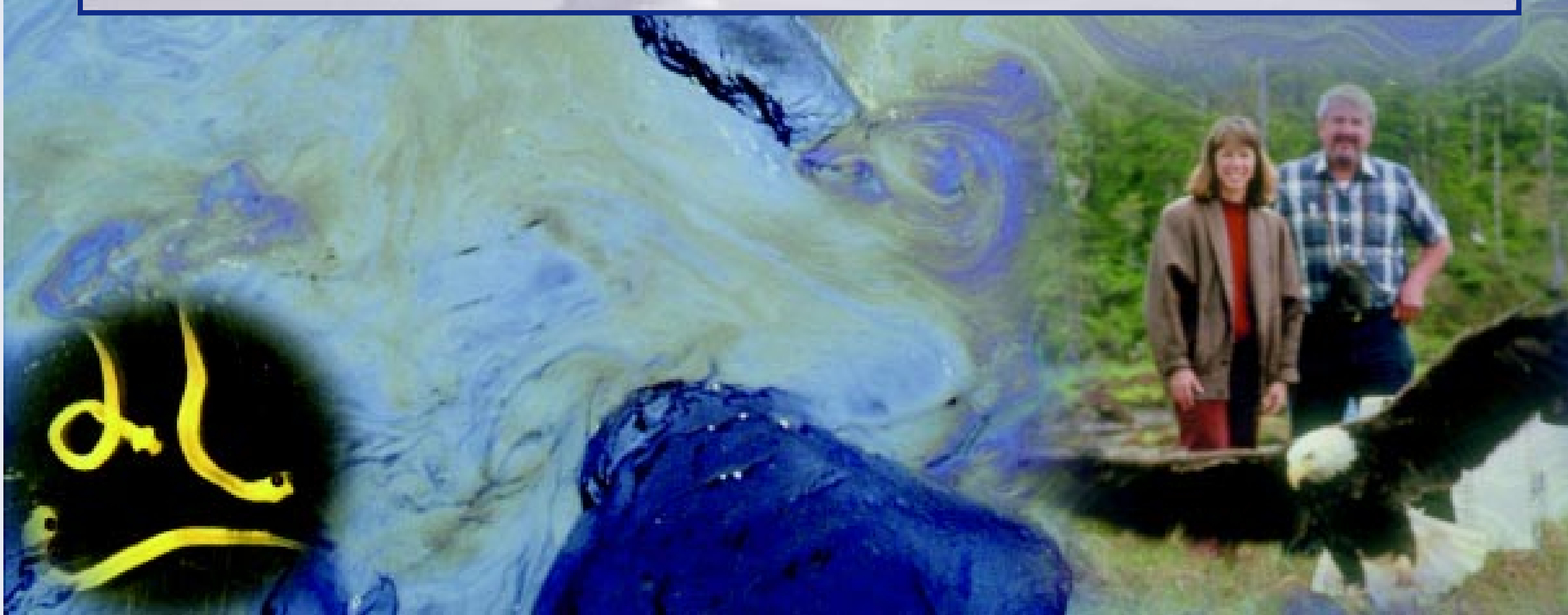


Photo by Stan Senner

www.oilspill.state.ak.us

Project Abstracts & Reports

Research Assistance and Tips

Links to Research Websites (SEA, NVP, APEX, Others)

Update on Injured Resources and Services

Habitat Protection Information and Maps

10-Year Report to the Nation

Updates on GEM

Newsletters and other Publications