

ALASKA LEGISLATURE SPECIAL COMMITTEE/SUBJECT FILE 8672
1997 SCOMM 77: SENATE SPEC. COMM. EXXON VALDEZ OIL SPILL...1991

274

bringing in 21.9 million fish worth an estimated \$33.3 million. Statewide, commercial fishery production totaled \$1.3 billion, the second largest ever.

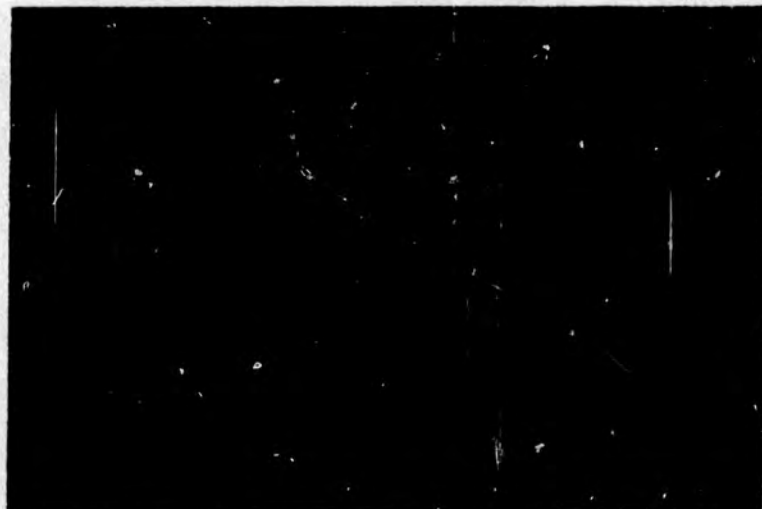
The area's commercial fishermen received financial compensation based on losses resulting from the various 1989 fishery closures. As of year-end 1990, Exxon had paid \$169 million to local fishermen in response to 1989 claims, and another \$133 million had been committed to seafood processors and related industries.

Many of the local fishermen assisted with the oil spill cleanup during the two summers following the accident. Because of their knowledge of the remote area, the fishermen proved invaluable to Exxon's cleanup operations and wildlife-rescue programs. Exxon paid more than \$105 million in wages and chartering fees to 1,440 individuals and firms that also received compensation for damages. This group includes 1,160 local commercial fishermen.

The potential long-term impact of the oil spill on fish is under careful study, but it is unlikely that any significant adverse effects on finfish populations will be discovered. Throughout 1989 and 1990, there were no confirmed reports of large fish mortalities, oil tainting, or contamination of commercial seafood products from the spill. In addition, long-term damage to finfish has not been documented in the hundreds of studies of earlier oil spills — many of which were larger than the *Exxon Valdez* spill.



*Oil from the spill
reached less than 20%
of the Prince William
Sound shoreline.*



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IMPACT OF THE SPILL

Prince William Sound and the Gulf of Alaska constitute an enormous area, nearly 9,000 miles of coastline. Surveys showed that oil from the 1989 spill reached less than 20% of the Prince William Sound shoreline, and a small percentage of the Kenai peninsula, Kodiak Island, and Alaska peninsula shorelines. It spread into the western portions of the Sound and about 500 miles west to the Alaska peninsula and Kodiak Island (Maki, 1991).

Impact of the Spill on Water Quality

About one-third of North Slope crude oil consists of volatile hydrocarbons, which are relatively toxic, but almost all of them evaporate into the atmosphere within a few days (Galt, 1990). Three days elapsed before any oil reached the shoreline, and by that time a significant portion of the volatile hydrocarbons had evaporated. The remaining two-thirds of the North Slope crude oil is predominately composed of less toxic materials — the object of the massive cleanup operations Exxon mobilized during the summers of 1989 and 1990.

Exxon engaged five independent research organizations to study the quality of water in Prince William Sound immediately following the spill. More than 2,300 samples were taken from 61 locations from March to October of 1989, including the most heavily oiled areas. The findings were published in 1990

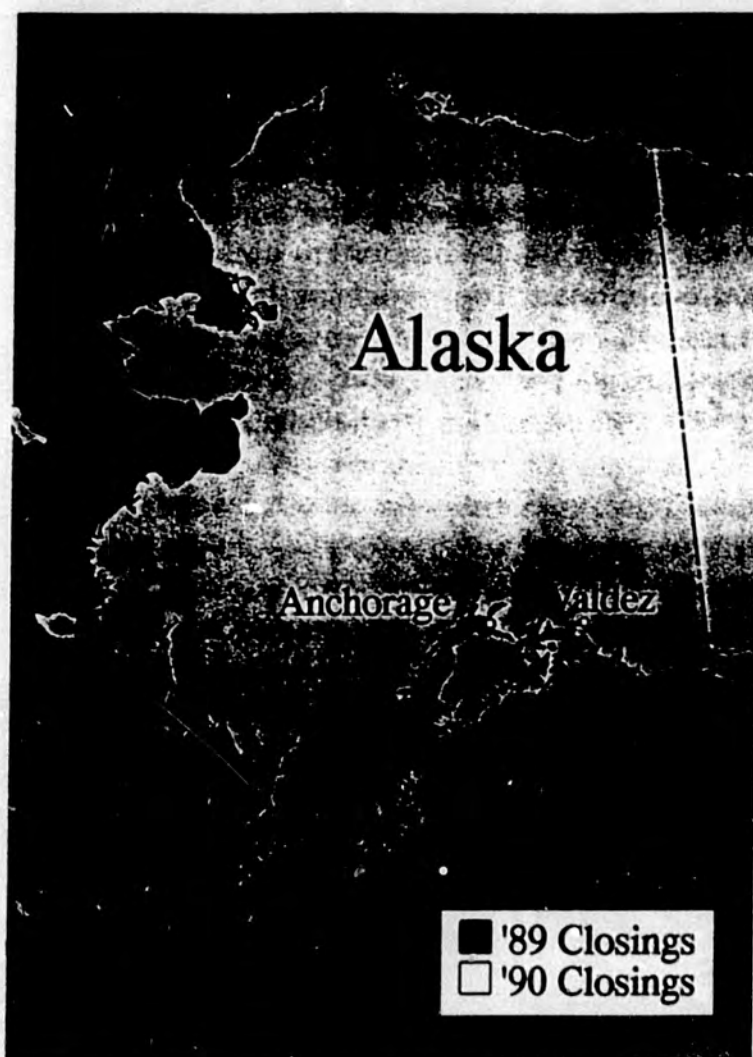


Today, the waters and shorelines of Prince William Sound and the Gulf of Alaska have been essentially cleansed of oil from the 1989 spill.

by Dr. Jerry M. Neff, senior research leader of Battelle Ocean Sciences, Duxbury, Massachusetts. His summation:

Fish kills have been reported after some oil spills, though it is important to note that there have been no verified reports of fish kills in Prince William Sound attributable to the oil spill...

Based on these observations from other spills, it is unlikely that there were effects of the oil spill on fishery species in Prince William Sound. Any effects would have



Portions of five (marked in red) of the state's 15 fishery management areas were closed at some point during 1989. By 1990, only two small areas (marked in yellow) in Prince William Sound had closings.

occurred in the few weeks immediately after the spill and would have been very localized and minor relative to fishery stock sizes and future catches. It is unlikely that any long-term effects directly attributable to the spill will be observed in terms of reduction in reproduction and early survival of fisheries species or in decreased fishery catch of any commercial species...

In most cases, the [hydrocarbon] concentrations measured in the Sound were at least 1000-fold lower than concentrations that are harmful to fish. Thus, the margin of safety for fish in Prince William Sound is very large and has grown larger as the concentrations of petroleum hydrocarbons in the water column have decreased over the summer and fall of 1989.

After two summers of cleanup and two winters of harsh storms and powerful waves, the waters and beaches of Prince William Sound were essentially clean at the end of 1990. Except for a few scattered sections with weathered residue, shoreline survey teams with representatives from the U.S. Coast Guard, Alaska's Department of Environmental Conservation, and Exxon did not find oil in August 1990.

Impact of the Spill on the 1989 Fisheries

In 1989, the Alaska Department of Fish and Game closed several commercial fisheries in order to prevent fish contaminated by oiled gear from reaching the consumer. The department



Prince William Sound's purse seiners netted 8,300 tons of herring — more than the entire year's harvest quota — in just twenty minutes, though the season typically lasts several hours. The State of Alaska's pre-season projected harvest was 6,300 tons of fish.

closed portions of five of the state's 15 fishery management areas (Savikko, 1990).

But, even with some areas closed to fishing in 1989, the statewide seafood harvest reached 5.2 billion pounds, with a value of \$1.3 billion — the second highest value at that time (Savikko, 1990). The 1989 Alaska harvest represented 38% of the total revenues from all United States commercial fisheries (USNMFS, 1990).

Immediately after the spill, Exxon and local fishermen gave the highest priority to protecting the salmon hatcheries, four of which are located in the spill area. Protective booms were placed around the hatcheries, and all of them remained totally free of oil. In Prince William Sound, protection of the hatcheries was considered especially vital to survival of the salmon fishery, which depends on hatchery-reared pink salmon fry for over 80% of the catch (ADF&G, 1990).

Impact of the Spill on the 1990 Fisheries

In 1990, as cleanup operations continued on isolated beaches, the fisheries operated normally in Prince William Sound and the Gulf of Alaska. Only two small areas were placed off-limits for the season; these were not prime commercial or recreational fishing areas, and there were no reports of fouled gear or contaminated fish attributable to the 1989 spill (ADF&G, 1990).

Although final figures are not yet available, preliminary Department of Fish and Game reports indicate that the statewide 1990 salmon catch may surpass the 1989 totals, partly because of extraordinary returns in Prince William Sound (Savikko, 1990).



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SALMON AND HERRING: THE LITMUS TESTS

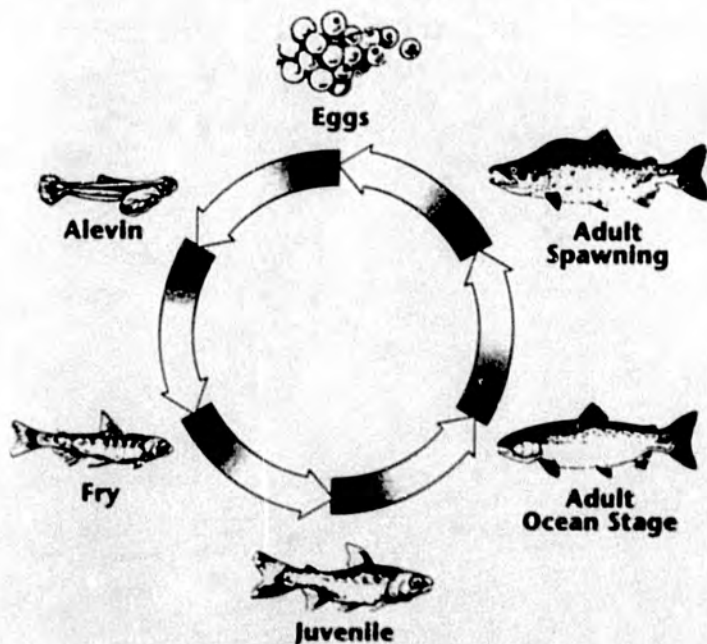
Two major Alaskan fisheries — pink salmon and herring “sac-roë” — warrant special attention because those species have traditionally been harvested in large numbers within Prince William Sound and because the spawning herring and the young of both pink salmon and herring were especially vulnerable to the oil spill.

Pink Salmon

Salmon species constitute a vital element of Alaska's economy and lifestyle. Salmon harvests provide the main source of revenue for the state's commercial fishing industry, the prime target of sport fishermen, and a basic component in the subsistence diet of many villagers.

Pink salmon, the most abundant Pacific salmon species, have a relatively simple two-year life cycle (see illustration), distinct from other salmon species. These fish are spawned in freshwater intertidal areas or streams. As fry, young salmon move into marine intertidal areas to feed before they head for open seas to mature as adults. After approximately two years at sea they return to their native streams to spawn and die.

Two-Year Life Cycle of Pink Salmon

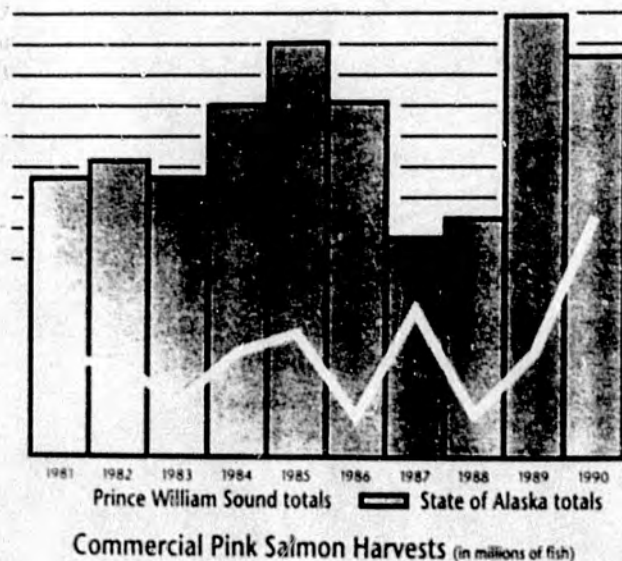


Pink salmon caught during the 1990-1991 season in Prince William Sound have been found to be especially vulnerable after the oil spill.

The adult pink salmon harvested in August 1990 had emerged as fry into the intertidal areas of the Sound and Gulf of Alaska in April and May of 1989. They were heading to sea within a few weeks of the oil spill at a particularly vulnerable time in their life cycle when they would grow from about one-and-a-half inches to about three inches in length. Young pink salmon tend to remain close to shore during their first summer and move into deeper coastal waters in September (Hart, 1973). This migration pattern near the path of the spilled oil raised questions about the oil's possible effect on them.

Even under normal conditions, many unpredictable factors impact the survival rate of young fish, including weather conditions, predators, and the availability of food. The harvest of pink salmon is also subject to annual fluctuations.

In 1989, many commercial fishermen seeking pink salmon had to abandon their traditional grounds and seek waters that had not been closed by Alaska's Department of Fish and Game. As pink salmon swam out of the oiled areas, fishermen were able to catch them as they moved from closed to open areas. Despite the closings, 1989's total harvest in the Sound was 21.9 million pink salmon, with a value of \$33.3 million (Brady, 1990). It is the fourth largest pink salmon harvest on record and compares to 11.8 million fish in 1988 and 29.2 million fish in 1987 (Brady, 1990).



Fluctuations mark pink salmon catch totals in Prince William Sound and Alaska over the last ten years.

The statewide catch in 1989 totaled 96.5 million pink salmon, a record (see chart p. 10). Fishermen in 1989 received prices within the normal range for the decade (Savikko, 1990).

In establishing the catch limits for all salmon stocks, the state Department of Fish and Game attempts to allow an optimum number of fish to escape for spawning purposes. In 1989, because of the fishing limitations, state biologists estimated that in some streams more than the usual number of pink salmon escaped the fishing nets and went on to spawn. These larger "escapements" may be beneficial to those streams that have been depleted of breeding stock, many of which are in Prince William Sound, but a surplus could be wasteful in other streams. The impact of the 1989 escapement will not be known, however, until the pink salmon harvest of 1991 is completed.

By the time the 1990 salmon arrived, the state had removed restrictions on fishing in the spill-affected region, with two minor exceptions. Statewide, 87 million pink salmon with an average value of about \$1 each were caught (Engstrom, 1990). Prince William Sound accounted for 51% of the total with a catch of 44.2 million fish, breaking the 1987 record of 29.2 million fish (Brady, 1990). The average fish size was somewhat smaller than normal, 3.0 pounds versus a ten-year average of 3.5 pounds, which may be due to competition for food or to other marine habitat changes at sea.

In 1990, catches in the Lower Cook Inlet were about half the long-term historical average (Bucher, 1990). In the Kodiak management area, catches were below expectations (ADF&G, 1990). One possible factor influencing these results was a lower-than-expected return from the Tutka and Kitoi Bay hatcheries, neither of which was affected by the oil spill. Both of these low returns are not inconsistent with past harvests from these hatcheries. For example, the total Kitoi catch ranged from 301,000 fish in 1982 to 6,771,000 fish in 1989. Another factor was the closing of one district to salmon fishing for sockeye stock-management purposes, thus allowing a large number of pink salmon to escape the fishermen's nets.

State biologist James Brady called the 1990 pink salmon catch in Prince William Sound "a pleasant surprise." He credited

the catch to exceptional 1989 weather coupled with a plentiful plankton bloom to feed the young salmon (Villeneuve, 1990). Most significantly, the 1990 pink salmon catch should alleviate fears that the Alaska salmon fishery has been harmed by the spill.

Implications for Other Salmon

In addition to the pink (humpback) salmon, four other species of salmon are harvested commercially in Prince William Sound and the Gulf of Alaska — chinook (king), sockeye (red), coho (silver), and chum (dog). Because the harvest for pink salmon — the most vulnerable species — was bountiful, we are optimistic that the other salmon fisheries were likewise unharmed.

Oil did not threaten the spawning and rearing areas of the sockeye, chinook and coho salmon because they are located in freshwater lakes and streams far from the spill area. Unlike pinks, these species mature for one, two and sometimes three years in these areas before heading for the ocean. For example, the commercially important sockeye or red salmon is four or five inches long when it heads to sea as a one- or two-year old — much larger, older and stronger than the tiny pinks that head for salt water. If the spill did not harm the pink salmon fry of 1989, the larger sockeye juveniles were even more likely to survive. King and coho juveniles are even larger when they head to sea, averaging between five and seven inches in length (Hart, 1973).

In spite of the oil spill, the state of Alaska experienced a record salmon harvest in 1989, a catch of more than 153.3 million fish (Savikko, 1990). The 1990 statewide salmon catch was not affected by the oil spill and is expected to top 1989's total harvest after all the statistics are compiled. The preliminary 1990 catch figures include about 650,000 chinook, more than 52 million sockeye, 5.2 million coho, and more than 7.5 million chum salmon (ADF&G, 1990).

The statewide salmon harvest has increased significantly during the past decade because of improved management techniques, development of hatcheries, and favorable weather.

The catches of 1989 and 1990 — especially the 1990 pink salmon run in Prince William Sound — suggest that this favorable trend has not been affected by the oil spill.

Pacific Herring

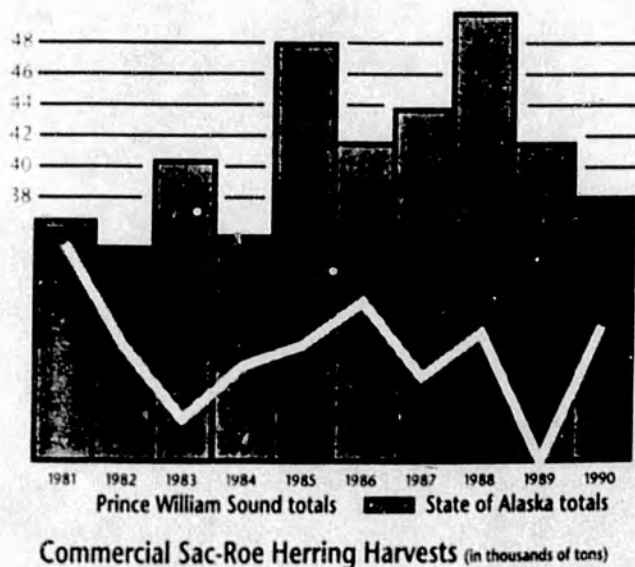
The Pacific herring is important to the Alaska fishing industry because its eggs or roe are sold in large quantities to the Japanese market and because, as part of the food chain, it is consumed by larger commercial species of fish such as salmon and halibut.

Herring are mass spawners and congregate in shallow areas (depths less than 35 feet) where eelgrass, kelp and other seaweeds can be found. From April to June, females deposit eggs. The eggs, which are sticky, adhere to underwater plants, rocks and other surfaces where they are fertilized by the males (Hart, 1973). Since herring spawn in such places, there was potential in 1989 for spawning fish or their eggs to become exposed to spilled oil.

The annual harvest draws from herring within a five-year age span. Thus, each year's catch is not dependent on a single year's successful survival, as with pink salmon.

In Alaska, there are four commercial herring fisheries. First, a small number of fish are caught for food and bait. Second, divers gather herring eggs or roe on kelp in shallow, open waters.

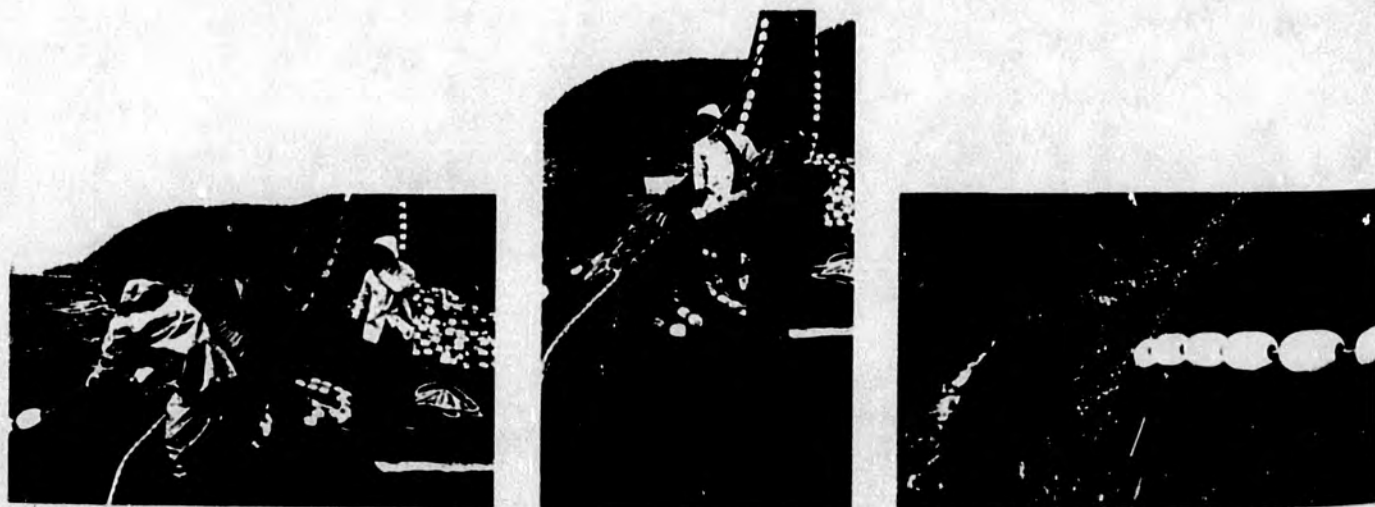
*Herring sac-ro
harvests fluctuate
from year to year.*



Third, roe is gathered on kelp in man-made enclosures (this is known as the pound-kelp fishery). The fourth and most important commercial harvest is the "sac-ro" fishery, in which herring are netted to collect the mature female's egg-filled membrane or sac. Each year the state limits the sac-ro harvest to 20% of the estimated herring stocks.

In 1989, the state closed Prince William Sound to the sac-ro herring harvest, which usually takes place in April. Nevertheless, the statewide sac-ro harvest was 41,387 tons with a market value of \$16.3 million — compared to 49,766 tons in 1988 (Savikko, 1990).

Most of the herring that spawned in Prince William Sound in 1989 were available to fishermen in 1990, since herring, unlike salmon, do not die after they reproduce. They continue to reproduce until they are nine years old or older. The bulk of herring harvested in Prince William Sound are three to seven years old. The 1989 crop of eggs will start returning as harvestable three-year-olds in 1992. Based on current population estimates by the Alaska Department of Fish and Game, prospects are encouraging for future herring harvests.



Prince William Sound was reopened to sac-roë fishing in April 1990, and the herring were so plentiful that fishermen netted 8,300 tons in 20 minutes, a harvest 32% higher than the pre-season projection of 6,300 tons (Brady, 1990; Savikko, 1990). That catch represented 22% of the statewide total harvest of 37,866 tons.

The successful Prince William Sound 1990 sac-roë harvest indicates that the herring population is thriving. Many of the fish caught in 1990 were spawning in Prince William Sound at the time of the oil spill.

Alaska's Department of Fish and Game has also recently measured a huge mass of herring in the Sound and is projecting a large harvest in 1991 (Brady, *et al.*, 1990). The healthy state of the herring fishery is not only significant from the standpoint of the oil spill, but it also shows that there will be a plentiful supply of herring as food for salmon, other large species of finfish, marine mammals, and waterfowl.

Prince William Sound's pink salmon harvest was a record in 1990, even though most of these two-year old adults had traveled through the Sound's waters as vulnerable fry in the months following the spill.





*This youngster and other
Alaskan villagers subsist
on the area's fish stocks.*



4

OTHER FISHERIES IN ALASKA

In addition to commercial harvests, there are two other important fisheries in Alaska — subsistence/personal-use harvesting and sport fishing. In contrast to the numerous 1989 commercial fishery closings, only one area had restricted subsistence fishing, and there were no restrictions on sport fishing. Government officials announced that the salmon and other finfish throughout the area were safe to eat.

Subsistence/Personal-Use Fishing

When the oil spill occurred, some 2,500 rural Alaskans feared that two of their food resources, fish and shellfish, were endangered (Fall, 1990). To assess the healthfulness of the subsistence seafood resources, joint scientific studies were undertaken by the National Oceanic and Atmospheric Administration (NOAA), the Alaska Department of Fish and Game (ADF&G), and Exxon. Fish and shellfish specimens for these studies were gathered from the most important subsistence resource areas, which were selected by representatives from the rural villages. These village leaders often accompanied the scientists collecting the samples. The State of Alaska and NOAA conducted all chemical or taste and smell tests on more than 900 halibut, 5,000 other finfish, and 300 shellfish samples collected for both subsistence and commercial food safety studies (ADHSS, 1989).

The tests showed that all finfish were safe to eat. Additional tests showed that the hydrocarbon content of smoked fish was substantially higher than the hydrocarbon content of seafood tested in Alaska following the 1989 spill. Some clams and mussels from a few areas with especially heavy concentrations of oil had elevated hydrocarbon levels, although several had been contaminated by refined petroleum products (e.g., diesel fuel) from other sources, not by the 1989 spilled crude oil (Oil Spill Health Task Force, 1990).

Clams and mussels do not constitute a major part of the subsistence diet. Most Alaskans were already cautious about eating these seafoods because of the threat of paralytic shellfish poisoning caused by microorganisms known as "red tide."

Dr. Tom Nighswander, Director of the Alaska Native Health Service, founded the Oil Spill Health Task Force with members including the following organizations:

Alaska Department of Environmental Conservation
ADF&G
Alaska Department of Health and Social Services
Alaska Governor's Office
Exxon
Indian Health Service
Kodiak Area Native Association
NOAA
North Pacific Rim

On the task force's behalf, Dr. Nighswander asked the U.S. Food and Drug Administration (FDA) to conduct a complete food safety assessment based on the results of the NOAA/ADF&G tests. The FDA concluded that all the fish and shellfish, including those taken from the most heavily impacted areas studied, were safe for a lifetime of subsistence consumption (Quantitative Risk Assessment Committee, 1990).

Task force representatives traveled to the subsistence villages and advised residents: "The best tests to determine the safety of subsistence foods are performed by those who gather the food. If the resources smell or taste of petroleum, they should not be eaten. If they appear clean by these methods, they are almost certainly safe to eat."

Shellfish/Bottomfish

The findings for subsistence fisheries hold positive implications for the area's shellfish and bottomfish fisheries. Unfortunately, the commercial harvest of shrimp and crab in the Prince William Sound area had already ground to a near-halt because the stocks had been depleted by overfishing and consumption by sea otters (Savikko, 1990). Most of Alaska's crab are taken in the Bering Sea, far away from the spill area.

Likewise, the state's prime bottomfish areas are located far outside the reach of the spill, most of them beyond the three-mile limit of the state's jurisdiction. Alaska bottomfish,

which feed on the ocean floor, include halibut, pollock, cod and flounder.

Shortly after the spill, the state closed the waters of Prince William Sound and the outer Kenai peninsula to the harvesting of bottomfish. The areas were reopened to bottomfishing in July 1989. By this time, however, boats normally seeking these fish were either working on the cleanup operation or had shifted to other fisheries. There were no restrictions on halibut fishing in 1989, and the Alaska harvest was greater than it had been the previous year.

Sport Fisheries

Sport fishing for halibut, several varieties of salmon, char (Dolly Varden), cutthroat and lake trout, crab and shrimp provides Alaska with a significant share of its tourist and recreation income from May through September. It is a significant source of recreational enjoyment both for Alaska residents and for visitors from throughout the world. Salmon is the main lure, and the latest attraction is fly-fishing for sockeyes. The state is undertaking special programs to increase fish runs attractive to sportsmen, and it advertises that the Kenai River has the world's largest king salmon and that 450-pound halibut can only be caught off the Alaska coast.

The cold-climate wilderness mystique is attracting tourists to Alaska in ever-increasing numbers from all corners of the world. There has been significant improvement in access to



Sport fishermen continued catching and eating fish in the wake of the spill.

Alaska's fishing centers, and charter-boat touring is a thriving business in such ports as Cordova, Valdez and Whittier in Prince William Sound, and in Homer and Seward on the Kenai peninsula.

Statewide sport fishing rules apply to catch and possession limits, and waters are not normally opened or closed by regional officials on short notice. In the wake of the spill, the state's policies toward commercial and sport fishing were markedly different. While most of Prince William Sound was closed to commercial fishing boats in 1989, there was no prohibition on sport fishing in the same waters. In fact, according to the ADF&G, sport fishing activity in Prince William Sound set a new record in 1989. Activity was 71% higher than the average for the previous ten years (Whitmore, 1991).



State officials kept Prince William Sound open to recreational fishing in 1989 and 1990.

5

SCIENTIFIC INFORMATION FROM EARLIER OIL SPILLS

Based on extensive scientific studies of previous oil spills, such as those reported by the National Research Council of the U.S. National Academy of Sciences in *Oil in the Sea: Inputs, Fates and Effects*, no one should have been surprised by the successful 1989 and 1990 fish harvests in Prince William Sound and the rest of Alaska.

Other scientific literature that has been developed on the effect of oil in the oceans of the world also supports the National Research Council conclusions. The literature includes a 1990 review of scientific knowledge by the Congressional Research Service of the Library of Congress, a 1982 publication by the Royal Society, and a 1990 compilation of literature on the subject by four United Kingdom oil-spill specialists, *Natural Recovery of Cold Water Marine Environments After an Oil Spill*.

1989

Oil continues to plague fisheries
Anchorage Times July 2, 1989

Oil Spill Leads to Partial Salmon Fishing Closure
United Press International May 20, 1989

First Catch of Salmon Free of Oil but Fishermen Remain Wary as Vessels Move Westward
Anchorage Times May 24, 1989

Upper Inlet season delayed
Anchorage Daily News June 24, 1989

Outlook: Salmon Alaskans Face Uncertainties
August 1989
National Fishermen's West Coast Focus

Salmon Fishermen see Alaska Spill Dash Record Harvest Dreams
REUTERS
September 13, 1989

1990

Pink returns unexpectedly strong
Anchorage Daily News August 10, 1990

PWS harvest could top 40 million pinks
Kodiak Daily Mirror
August 22, 1990

Sockeye haul hits 3 million
The Associated Press
July 31, 1990

Record pace for returning Sound pinks
Anchorage Daily News
July 13, 1990

Record Pink Salmon Harvest Tallied in Prince William Sound
Sitka Sentinel August 20, 1990

Record catch of pinks expected in sound
Juneau Empire August 13, 1990

1989's dismal expectations contrast with 1990's headlines.

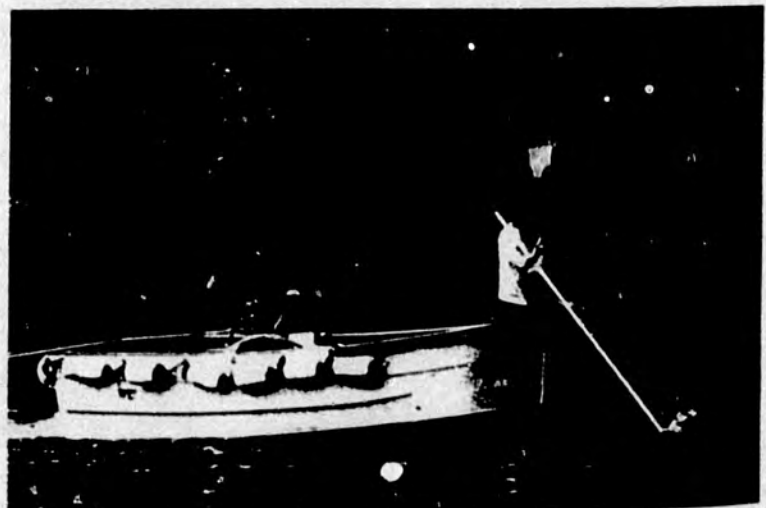
These publications identify more than 2,000 scientific papers that have been written on the subject. The conclusions:

For species of shellfish, finfish and waterfowl that are harvested, the mortality from an oil spill, so far as is known, has never come close to approaching the magnitude of the annual harvests (Mielke, 1990).

The most significant commercial impact of oil pollution is tainting of the catch, or fear that the catch may be tainted, but natural population fluctuations, or the effects of commercial fishing practices, or the insensitivity of the estimates of recruitment and stock size, mask any impact that losses from oil pollution may have (Clark, 1982).

Massive fish kills during oil spills probably have not occurred. Some mortalities have been observed at a number of spills, but generally only in limited areas, and then not in large amounts. Fish have the ability to move away from an impacted area, either laterally or by moving to a greater depth (National Research Council, 1985).

Annual recruitment of fish stocks fluctuates naturally, and the size of the catchable stocks is determined more by the activities of the fishing industry (e.g. overfishing) and by climatic changes than by any other factor (Baker, et al., 1990).



Finfish appear to have the capacity to detect chemical substances and avoid those that might be harmful. Scientists also believe that natural losses of eggs and larvae are normal and that losses, if any, caused by an oil spill would not be measurable.

In previous spills, kills of mobile adult fish have rarely been recorded. In 1978, the *Amoco Cadiz* spilled more than 70 million gallons of crude oil — six times the amount spilled by the *Exxon Valdez* — off France's Brittany Coast, and the only significant mortality was of fish that were trapped in the rocky, intertidal waters. Following the 1969 offshore oil rig blowout in California's Santa Barbara Channel, professional spotters observed the fish habitat from the air and recorded no heavy mortality of fish. Studies of numerous spills show that shellfish in shallow-water or intertidal sediments can be the most significant casualties of an oil spill (Baker, *et al.*, 1990).

Oil is not an unusual element in the fishery environment. In Alaska, there are 29 documented natural oil seeps that put an unknown quantity of crude oil into the water (Becker, 1988). Worldwide, the National Research Council estimates that naturally occurring seepage totals average 185 million gallons of oil a year. According to their 1985 report, the best estimate is that an average of more than one billion gallons of petroleum enter the world's oceans each year, but only about 10% of it comes from tanker accidents. This compares with 37% from municipal and industrial wastes, plus runoff from the land.

The existing body of research from previous spills and observations of the Alaska fisheries provide encouragement that the 1989 oil spill should have had no measurable effect on the size or quality of the harvest in 1989 or 1990, nor should it in the future.

THE EXXON CLAIMS PROGRAM

Within weeks after the *Exxon Valdez* spill, Exxon established claims offices in locations throughout the spill-impacted area so that any adverse economic impact on the fishing industry could be ameliorated. Claims adjusters gave advance payments to fishermen and others suffering hardship due to lack of income.

Through year-end 1990, Exxon reported that it had committed more than \$302 million in damage compensation on 12,300 claims. This includes \$169 million in payments to more than 7,300 commercial fishermen and individuals employed by fishing permit holders. An additional \$133 million was committed to about 5,000 claims to seafood processors, cannery workers, tender-boat owners, and other individuals and businesses affected by the spill.

A major portion of Exxon's payments was based on a set of "Salmon Permit Holders Claims Guidelines" that described the basis under which the company would pay holders of commercial salmon fishing licenses. The key guidelines:

"Individual permit holders will be compensated for their share of the pre-season ADF&G projected salmon harvest based on their two-year historical average share of the catch...prices used in final payments will be average market prices for the season."

The adjusters computed a catch value for each fisherman based on the size of the projected harvest and market price. As it turned out, the state's projections were high in Prince William Sound. Exxon made larger payments than were warranted by the size of the actual run. In Upper Cook Inlet, Kodiak and Chignik, however, payments were increased because runs were stronger than projected.

ROLE OF FISHERMEN IN THE CLEANUP

Fishermen who work in Prince William Sound and the Gulf of Alaska proved to be a major resource to Exxon and government officials in their cleanup and wildlife-rescue operations. These fishermen had vessels and equipment that were needed for the operations, and they had expert knowledge of tides and geographical features in the affected areas. The vessel owners and their crews towed booms to contain oil, transported technicians and workers to remote beaches, served as pilots on research boats, helped clean beaches, and rescued sea otters and seabirds.

Exxon paid significant amounts for these services. For example, Exxon hired 1,440 individuals and firms in 1989, including about 1,160 commercial fishermen-claimants, and paid them cleanup wages and vessel-chartering fees in excess of \$105 million in addition to the damage compensation they received.

Figures provided by Exxon Company, U.S.A.

6

QUESTIONS AND ANSWERS

The following are answers to questions the authors have been asked about the Alaskan fishery in the wake of the oil spill.

What might explain 1990's extraordinary Prince William Sound pink salmon and herring catches?

There was an unusually abundant plankton bloom in 1989, the largest on record, and this provided an extraordinary amount of food for the pink salmon that were harvested in 1990. The pink salmon harvest reflects the long-term trend of larger catches brought about by increased hatchery releases and a history of good management under the direction of the Alaska Department of Fish and Game. The herring harvest of 1990 included fish that would have been caught in 1989 when the Prince William Sound herring fishery was closed.

Your report concentrates on pink salmon and herring. What about other species of fish?

These two species were chosen because they are important commercially and because they have implications for other species. The record catches of pink salmon and herring are significant because their primary spawning areas are located in shallow intertidal areas that were in close proximity to the spilled oil, and because herring and pink salmon fry swam in the waters of the Sound soon after the spill.

Will the pink salmon and herring harvest levels in 1991 be related to the spill?

In view of the outstanding harvests of pink salmon and herring in 1990, there is no basis to expect any spill-related impacts in future harvests. Fish-harvest predictions are about as reliable as long-range weather forecasts; nature is very unpredictable.

Weren't there reports of significant fish kills immediately after the spill?

There were no verifiable ones. However, the state reported receiving a few dead rockfish at the time of the spill. These deaths are not known to be associated with the spill.

Why were there low pink salmon returns in the Lower Cook Inlet and Kodiak areas in 1990?

One explanation was a low return from the Tutka hatchery in Lower Cook Inlet and Kitoi Bay hatchery in Kodiak. These were not unusual since there has been an erratic pattern of returns from these hatcheries over the years. The poor 1990 returns were probably not associated with the 1989 oil spill since all hatcheries were protected from oil. Also, part of the Kodiak area was closed for sockeye management reasons, allowing a large number of pink salmon to elude the fishermen's nets.

Won't the 1989 "overescapement" — a surplus of spawners — hurt the salmon populations?

The potential impact of large escapements must literally be analyzed stream by stream, almost inch by inch. In some instances, too many fish entering spawning grounds may reduce the output of a stream. On the other hand, a heavy escapement would be beneficial to streams that are producing below historic levels.



Do hydrocarbons accumulate in fish?

No. Hydrocarbons are not like DDT or other toxins that accumulate through the food chain. Fish have the capacity to metabolize, or naturally break down, hydrocarbons and expel them from their systems.

Are some Alaska fish normally exposed to hydrocarbons?

Yes. There are known naturally occurring oil seeps along the Alaska coast. There has never been any indication that this constant petroleum has harmed a fishery.

What are the major threats to our nation's marine fish stocks?

The biggest problems by far are poor fishery management policies, which result in overfishing, and the incidental catch of protected species by those fishing for other species. With proper management strategies, the severity of these problems could be reduced significantly.



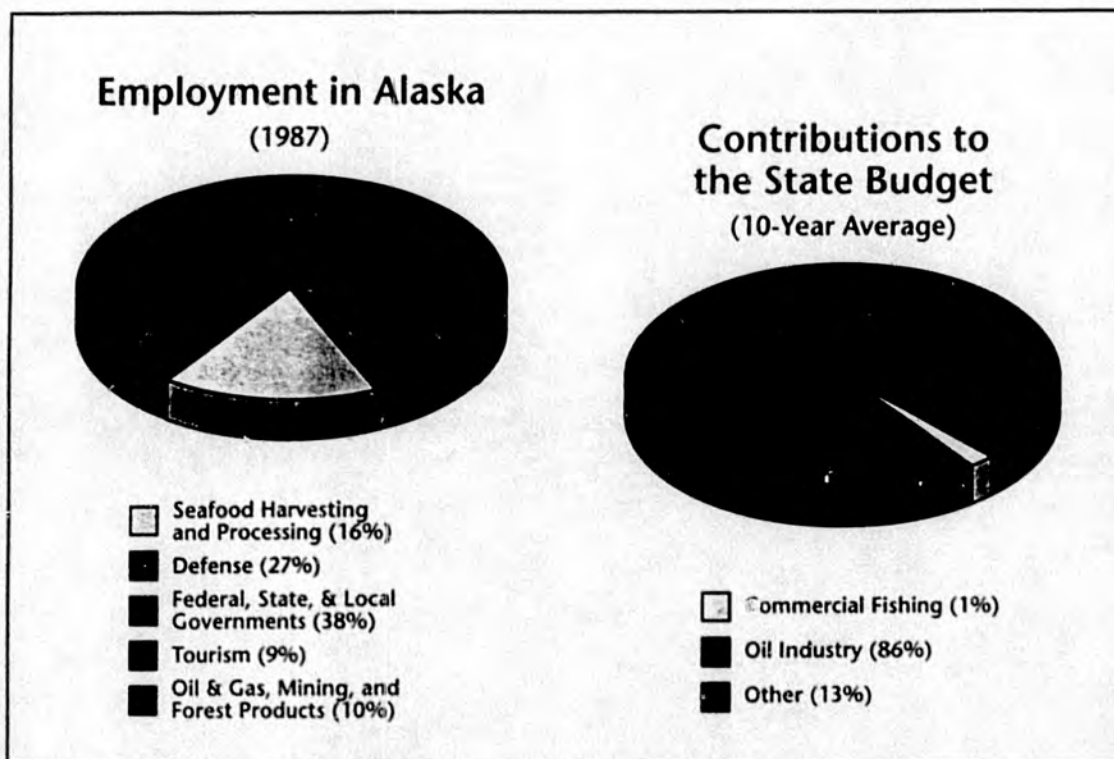
APPENDIX

Commercial Fisheries in Alaska

Alaska is by far the most important fishing state in the United States, accounting in 1989 for almost half the nation's catch in pounds and 38% in value. No other state comes close to Alaska in either category, according to statistics compiled by the U.S. Department of Commerce. The Alaska harvest includes salmon, herring, shellfish, pollock and halibut, with salmon and shellfish producing a majority of the value.

Alaska is a major exporter of fishery products. Seafood valued at \$561 million was shipped overseas in 1987, with all but 5% going to Japan. That represented one-third of the U.S. seafood exports.

The seafood industry is the largest non-governmental employer in Alaska, providing 16.4% of the state's jobs. A 1989 study prepared for the Alaska Seafood Industry Study Commission concluded that the seafood industry provides "nearly 70,000 seasonal jobs, which translates to 33,000 direct, indirect and induced year-round jobs." The report, written by the McDowell Group of Juneau, estimated total seafood industry payroll for 1987 at \$596 million.



Although the fishing industry is Alaska's largest private employer, the oil industry provides an average of 86% of state and local government tax revenue.

Although the seafood industry is the second largest source of state and local government tax revenue, it trails the oil and gas industry by a wide margin. According to media reports and a fiscal policy paper issued by the Institute of Social and Economic Research at the University of Alaska at Anchorage, oil production provides more than \$2.5 billion a year in support for state and local government, compared to about \$50 million in taxes on marine motor fuels and the harvesting of fish. The oil industry provides an average of 86% of total state government revenue.

Alaska's income from the oil industry is so great that the state pays each citizen an annual dividend known as a permanent-fund payment, which in 1990 amounted to \$952 per person. Anyone 65 or over who has lived in Alaska for one year is also entitled to a "longevity bonus" of \$250 a month. The Alaska revenue structure is highly unusual, with no personal income tax or state sales tax levied. In addition, local property taxes are approximately 20% below the national average.

Alaska's Management of Commercial Fisheries

Three decades ago, Alaska's commercial fisheries were described as the victim of a "pathetic history of ruinous exploitation." Until 1961, Alaska's fishery management was in the hands of the federal government, which allowed the industry to catch salmon and other fish "almost unrestrained," according to Dr. William F. Royce, one of the authors of this report, writing in the March/April 1989 issue of *Fisheries* magazine.

After the Alaska Department of Fish and Game took over management of the resource, conservationist steps were taken to limit commercial fishing licenses and to prevent depletion of the species. Today, Alaska has the best managed commercial fisheries in the nation because the state has "separated much of the politics of conservation from the politics of economics and equity," Royce wrote. The per-fish cost to Alaska for salmon management is only about 3% as much as the cost per fish in other Pacific coast states.

Aside from the restricted number of fishing licenses, the key to Alaska's management program is the unique emergency-order authority held by the chief management biologist in each fishery area to preserve the resource as well as the quality of Alaska's seafood products. Based on their unique knowledge of water conditions and fish population levels, biologists have the extraordinary power to open and close fishing areas minute by minute and stream by stream.

The state, which encompasses an area as large as one-third of the lower 48 states, is divided into 15 management areas, each with numerous districts and sub-districts. Fishing regulations vary from area to area, depending upon the conditions each biologist encounters. Close communication and cooperation between the state officials and working fishermen are a key to success of the program.

In the three decades of decentralized control, the state has essentially doubled the salmon run. Despite these controls, however, the size of each salmon run remains unpredictable since biologists never know how fish are going to survive in the ocean and return to their spawning grounds as adults.

Forecasting the annual catch of herring for the sac-roë puts fishery biologists to the supreme test. Where else do you find a fishery with perhaps a 20-minute open season? In Prince William Sound, the sac-roë season can range from less than half an hour to more than several hours, and a successful fisherman may have 300 tons of herring in his net — or may miss the season entirely. The sac-roë season must be short because herring gather in huge schools and a lengthy opening would result in severe over-harvest of the resource.

Following the spill, local biologists retained their autonomy over the opening and closing of the fisheries, but they were placed under a "Zero-Tolerance Policy" designed to guarantee that the quality of Alaskan seafood would not be questioned. The policy was stated in a memorandum of understanding between the two state agencies responsible for protecting the fishery, the Department of Fish and Game and the Department of Environmental Conservation. The key section:

A fishing area will remain closed if there is an indication of oil in any quantity in the area or proximity of the area (including beaches), such that there is an appreciable likelihood that gear will be fouled, fish harvest adulterated, or such that the conduct of an orderly fishery could not take place.

This stringent policy, which resulted in the closing of most of Prince William Sound, Lower Cook Inlet and Kodiak and portions of two other fishing areas in 1989, was designed to prevent adverse impacts on the perception of high quality that consumers associate with Alaskan seafoods. Although scientists indicated that finfish throughout the area would be safe to eat so long as fishing gear remained free of oil, the state elected a conservative policy that kept all commercial fishing vessels out of oiled areas.

In addition to closing fishing areas, the Alaska Department of Environmental Conservation and the U.S. Food and Drug Administration beefed up inspection activities on fishing vessels to guarantee that no fish were contaminated by crude oil. Inspectors were also deployed on fish-transport or tender vessels and in processing plants. Throughout the 1989 and 1990 seasons, there were no reports of fish contamination from *Exxon Valdez* oil on fishing boats, on tenders or in processing plants.

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BIOGRAPHICAL SKETCHES OF THE AUTHORS



William F. Royce, Ph.D.

A consulting fisheries scientist, Dr. Royce is a Professor Emeritus of Fisheries in the College of Ocean and Fishery Sciences of the University of Washington in Seattle and a retired executive of the United States National Marine Fisheries Service. After receiving his doctorate in zoology from Cornell University in 1943, he held a number of research and administrative positions for the Fish and Wildlife Service, including directorship of the Woods Hole (Massachusetts) Laboratory and assistant regional director in charge of research in Juneau, Alaska. In 1958, he became a fisheries professor and director of the Fisheries Research Institute at the University of Washington. During periods of leave, he was employed as a consultant on a variety of fisheries problems around the world. In 1972, he was appointed Associate Director in Charge of Resource Research for the National Marine Fisheries Service in Washington, D.C. Dr. Royce is the author of more than 100 scientific publications, including books entitled *Introduction to the Fishery Sciences*, *Introduction to the Practice of Fishery Science*, and *Fishery Development*. A fellow of the American Association for the Advancement of Science and of the American Institute of Fishery Research Biologists, he has been a member of the American Fisheries Society since 1935 and was elected to honorary membership in 1983.



Thomas R. Schroeder

Schroeder has worked almost his entire adult life managing fisheries in Alaska. He received his bachelor's degree in fisheries science from Colorado State University in 1967, and wrote a thesis on toxicity of pesticides and herbicides to salmon and trout while working on a master's degree. He joined the Alaska Department of Fish and Game's Division of Commercial Fisheries in 1969 as an assistant area biologist in Bristol Bay. In 1974, he was promoted to area management biologist for Lower Cook Inlet, one of the areas affected by the *Exxon Valdez* spill, and managed salmon, herring, bottomfish and shellfish fisheries until retiring in April 1990. Following the spill, he walked the beaches of Prince William Sound and the Gulf of Alaska with other state officials to examine the extent of oiling. A member of the American Fisheries Society since 1965, he is now a private fisheries consultant based in Homer, Alaska.



A.A. "Ole" Olsen

Olsen, a fisheries consultant in Anchorage, is a native Alaskan born in the small coastal village of Afognak, which was destroyed by a tidal wave in 1964. He worked on his family's fishing boats before launching an eight-year career as a bush pilot and salmon spotter flying throughout the state. In 1977, he entered the seafood processing industry as the manager of a salmon cannery and spent 10 years as an executive for firms packing fresh, frozen and canned salmon, crab and other fish for sale throughout the world. Following the spill, he was retained by Exxon as a consultant on commercial fisheries programs and as a liaison to villages of Alaskans whose diet consists largely of the fish and game they catch. He studied engineering and business for two years at the University of Portland, Oregon, and business for three years at the University of Alaska at Fairbanks.



William J. Allender

Over the past 15 years, Allender has worked in Alaskan canneries, on a hatchery construction crew and in several commercial fishing operations. For almost 10 years, he earned his living diving for herring roe in kelp beds and fishing for salmon, herring and bottomfish, with much of his experience in the area affected by the oil spill. Since 1988, he has operated Marcor Charters, a sports fishing business out of Cordova. A native of Big Fork, Minnesota, he is a Coast Guard-licensed captain for carrying passengers and cargo. Following the 1989 oil spill, he worked for 160 days on animal-rescue and eagle-capture teams. In 1990, as a consultant to Exxon, he traversed the beaches and waters of Prince William Sound and the Gulf of Alaska to help state officials ensure the safe operation of fisheries in the region.



Alaskan Fisheries — Two Years After the Spill



*A summary of findings
from the report of
William F. Royce, Ph.D.
Thomas R. Schroeder
A.A. "Ole" Olsen
William J. Allender*

February 1991

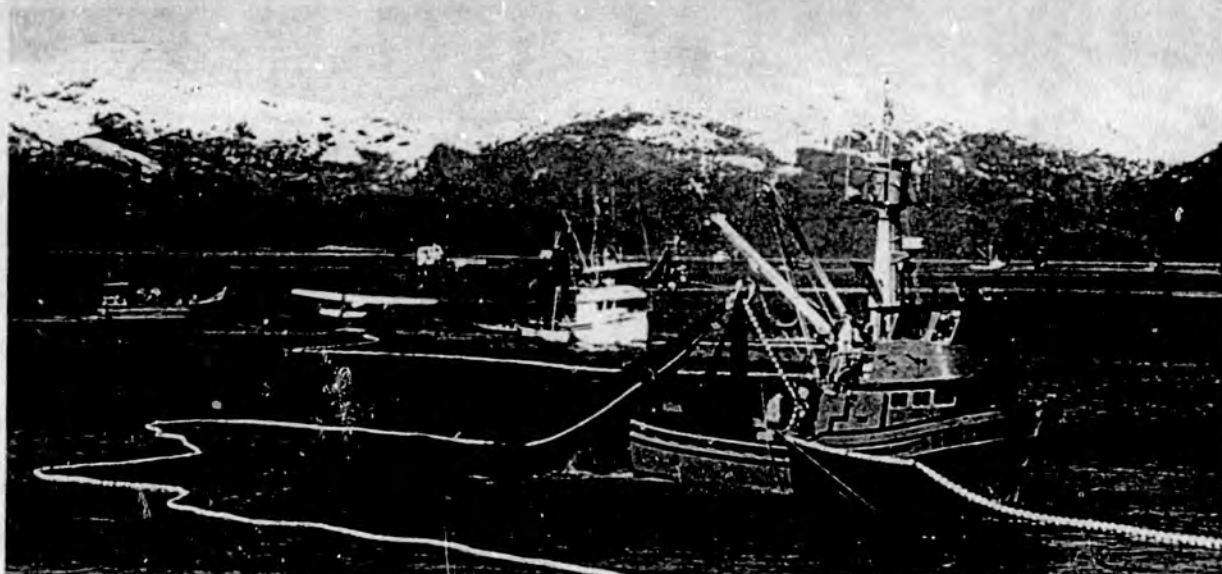
The Robust Fisheries of Prince William Sound, Alaska

Following the Exxon Valdez spill in March 1989, the authors were asked to address concerns about the potential effects of the spill on Alaska's fisheries.

Record 1990 harvests. Fishermen in Prince William Sound enjoyed record-breaking commercial catches during 1990. In April, purse seiners netted 8,300 tons of herring — more than the entire year's harvest quota — in only 20 minutes, though the season typically lasts several hours. Then, over the summer, fishermen caught 44.2 million pink salmon in the Sound, far eclipsing the previous record of 29.2 million fish.

Significant salmon harvest. The enormous pink salmon catch was especially significant because these two-year-old adults had traveled through Prince William Sound's waters as vulnerable fry in the months following the spill. Because the pink salmon proved so resilient, the other, less vulnerable salmon species should have prospered as well.

Abundant herring. Since herring spawn in shallow waters, there was potential in 1989 for these spawning fish to become exposed to oil. The 1990 harvest of 8,300 tons, 32% higher than the pre-season harvest quota, points to an abundance of these fish.



Fishermen netted 8,300 tons of herring — more than the entire year's harvest quota — in just 20 minutes last year.

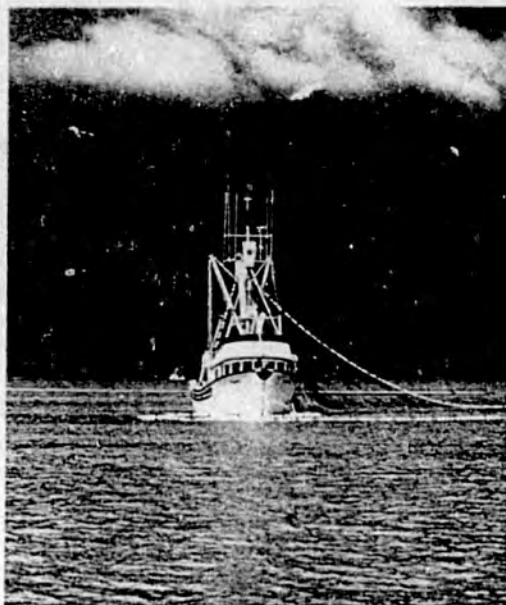
Statewide trend continues upward.

Despite the localized fishery closings in 1989, Alaska's statewide commercial fisheries production totaled \$1.3 billion, second highest ever. Although final figures are not available, preliminary reports indicate that the 1990 statewide salmon catch may surpass the 1989 totals, largely because of extraordinary returns in Prince William Sound. In addition, throughout 1989 and 1990 there were no confirmed reports of tainting or contamination from the spill.

Fishermen compensated for losses, hired for cleanup.

The area's commercial fishermen received financial compensation based on losses resulting from the various fishery closures in 1989. As of year-end 1990, Exxon had paid \$169 million to local fishermen in response to 1989 claims, and another \$133 million had been committed to fish processors and other related industries.

Exxon hired more than 10,000 people for the cleanup. Local fishermen proved invaluable to cleanup operations and wildlife-rescue programs with their knowledge of this remote area. 1,440 individuals and firms who had received compensation for



1990's pink salmon harvest of 44.2 million fish eclipsed the previous record of 29.2 million.

damages, including 1,160 local fishermen, were also paid more than \$105 million in wages and vessel-chartering fees.

Favorable long-term outlook. The potential long-term impact of the spill on fish is under careful study, but it is highly unlikely that any adverse effects on finfish populations will be discovered. In studies of earlier oil spills throughout the world—many of which were larger than the 1989 spill—no long-term damage has been documented. Based on recent fish catches in previously oiled areas, the outlook for commercial fishing is a positive one.

Some Important Questions and Answers

What might explain 1990's extraordinary Prince William Sound pink salmon and herring catches?

There was an unusually abundant plankton bloom in 1989, the largest on record, and this provided an extraordinary amount of food for the pink salmon that were harvested in 1990. The pink salmon harvest reflects the long-term trend of larger catches brought about by increased hatchery releases and a history of good management under the direction of the Alaska Department of Fish and Game.

The herring harvest of 1990 included fish that would have been caught in 1989 when the Prince William Sound herring fishery was closed.

Your report concentrates on pink salmon and herring. What about other species of fish?

These two species were chosen because they are important commercially and because they have implications for other species. The record catches of pink salmon and herring are significant because their primary spawning areas are located in

shallow intertidal areas that were in close proximity to the spilled oil, and because herring and pink salmon fry swam in the waters of the Sound soon after the spill.

Will the pink salmon and herring harvest levels in 1991 be related to the spill?

In view of the outstanding harvests of pink salmon and herring in 1990, there is no basis to expect any spill-related impacts in future harvests. Fish-harvest predictions are about as reliable as long-range weather forecasts; nature is very unpredictable.

Do hydrocarbons accumulate in fish?

No. Hydrocarbons are not like DDT or other toxins which accumulate through the food chain. Fish have the capacity to metabolize, or naturally break down, hydrocarbons and expel them from their systems.

Are some Alaska fish normally exposed to hydrocarbons?

Yes. There are 29 known naturally occurring oil seeps along the Alaska coast, and there has never been any indication that this constant source of petroleum has harmed a fishery.



The Authors



William F. Royce, Ph.D.

Professor Emeritus of Fisheries in the College of Ocean and Fishery Sciences of the University of Washington in Seattle and retired executive of the U.S. National Marine Fisheries Service. For many years, Dr. Royce has studied fisheries management and the fish species of Alaska.



Thomas R. Schroeder

A fisheries consultant based in Homer, Alaska. He recently retired from the Alaska Department of Fish and Game, where he served as commercial fisheries management biologist for part of the area affected by the oil spill.



A.A. "Ole" Olsen

An Anchorage fisheries consultant and former fisherman, bush pilot and manager of seafood processing plants throughout Alaska. In 1989 and 1990, he reviewed results of scientific tests of the area's fish stocks with Alaskan villagers who rely on seafood for subsistence. He also participated in 1990 fishery related spill cleanup activities.

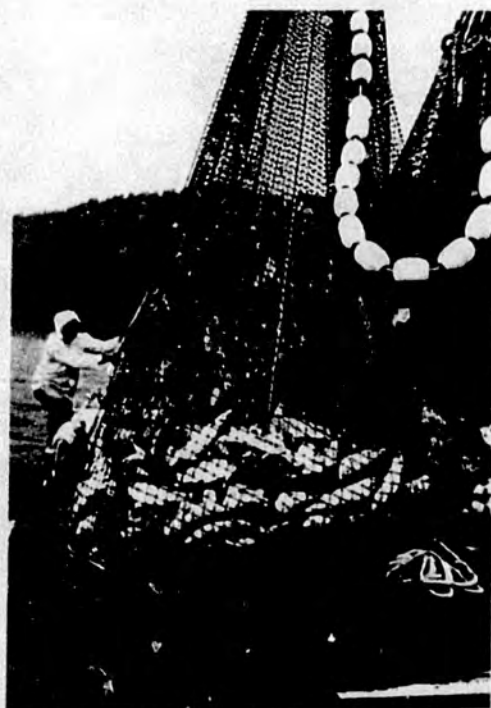


William J. Allender

A former commercial fisherman and owner/operator of a sport fishing business based in Cordova Harbor in Prince William Sound. In 1990, as a consultant to Exxon, he worked with the Alaska Department of Fish and Game to help ensure the safe operation of Prince William Sound fisheries.

If you are interested in more details about the Prince William Sound fisheries or wish to receive a copy of the full report, "Alaskan Fisheries — Two Years After the Oil Spill," please write to:

Cook Inlet Fisheries Consultants
P.O. Box 636
Homer, Alaska 99603



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DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Food and Drug Administration
Washington DC 20204

AUG 21 1990

Thomas S. Nighswander, M.D., MPH
Chairman, Alaska Oil Spill Task Force
Alaska Native Medical Center
255 Gambell Street
Anchorage, Alaska 99501

Dear Dr. Nighswander:

I am pleased to send you the enclosed FDA advisory opinion on the safety of aromatic hydrocarbon residues found in subsistence foods that were affected by the Exxon Valdez Oil Spill.

We hope that this advisory and its accompanying report by the Center for Food Safety and Applied Nutrition's (CFSAN) Quantitative Risk Assessment Committee (QRAC) will provide the necessary safety guidelines for timely interpretation of the data. I wish to emphasize that these are guidelines only. The advisory is not an official FDA action level. It is not a national advisory and it pertains only to the very special conditions having to do with the Exxon Valdez Oil Spill.

Sincerely yours,

Fred R. Shank, Ph.D.
Director
Center for Food Safety
and Applied Nutrition

Enclosure:

August 9, 1990

REPORT OF THE QUANTITATIVE RISK ASSESSMENT COMMITTEE

Subject: Estimation of Risk Associated with Consumption of Oil-contaminated Fish and Shellfish by Alaskan Subsistence Fishermen Using a Benzo[a]pyrene Equivalency Approach

INTRODUCTION

In this report, QRAC is responding to a request to the FDA Commissioner by the Alaska Oil Spill Health Task Force. This Task Force is an inter-agency advisory group on the effects of the oil spill on health and human resources. The members of the task force include the following organizations or agencies: The North Pacific Rim; the Kodiak Area Native Association; the Alaska Area Native Health Service; Exxon Company, U.S.A.; the State of Alaska Department of Health and Social Services; the State of Alaska Department of Fish and Game, Subsistence Division; the State of Alaska Department of Environmental Conservation, Division of Environmental Health. The Task Force has been charged with providing guidance for the sampling studies of subsistence foods that were affected by the Exxon Valdez Oil Spill and in interpreting the results of these studies to the public. Lack of safety guidelines for aromatic hydrocarbon contamination in foods, particularly seafood, has hampered the Task Force's work; hence the request to the FDA.

Two surveys of fish consumption were submitted to the agency. One report surveyed the fish consumption patterns of the village of Chenega Bay (population 60) on Evans Island in Prince William Sound and was conducted by the Alaska Department of Fish and Game, Division of Subsistence in 1984 and 1986. This survey is particularly appropriate for QRAC's purposes since this is an area where fish and shellfish were recently exposed to oil after the EXXON VALDEZ incident. In a second report, food consumption on Kodiak Island, Alaska, was surveyed by the Kodiak Area Native Association and the State of Alaska in 1983.

USE OF THE EQUIVALENCY APPROACH IN ESTIMATING RISK ASSOCIATED WITH POLYCYCLIC AROMATIC HYDROCARBON (PAH) CONTENT

The equivalency approach for PAH has been discussed in a memorandum to the QRAC (Memorandum, C. Carrington, Ph.D., Standards and Monitoring Branch (HFF-156) to S. Henry, Ph.D., (QRAC) dated June 26, 1990). The equivalency approach is a technique for assessing the risk from a number of different

compounds that are present in a single exposure source. Instead of calculating individual risks for each component, one component of known potency is used as a standard and the concentration of each of the other components is adjusted on the basis of its estimated, comparative potency to calculate a concentration equivalent to the standard. Summation of the equivalent concentrations produces a single number from which the risk may be estimated.

Two rationales for using the equivalency approach in the case of a risk assessment for PAH are applicable. First, there may not be fully adequate data for assessing risk for all of the individual components of the mixture, nor is it feasible to obtain such data. However, there may be data from in vitro systems or short term in vivo exposures that measure a parameter thought to be relevant to the carcinogenic mechanism of the compounds that allows the potency of a data-deficient component to be quantitatively related to a compound for which a long-term study is available. Second, the data available for estimating risk may be much better for some of the components than others. In such cases the potencies of the components for which there are relatively little data are highly subject to revision, whereas the potency number for a well studied compound may be expected to be stable. Calculation of an acceptable intake based on the concentration of the component with the best available data will be the least likely to require revision.

The risk calculated by this procedure is only an estimate. It is invariably more reasonable than the estimates obtained either by ignoring all but a few well described contaminants or than by assuming that all the congeners have equivalent potencies. The available toxicology data for benzo[a]pyrene (B[a]P) are much better than those data available for any of the other compounds detected in the fish. Short-term studies for most of the compounds are available that allow potencies relative to B[a]P to be approximated. These studies include (a) comparison of the initiating potency of individual PAHs after a single dermal application, followed by promotion; (b) comparison of the carcinogenic potency of individual PAHs after intraperitoneal injection in dimethyl sulfoxide in new born CD-1 and Swiss Webster mice; (c) comparison of the carcinogenic effects after implantation in the lungs of female Osborne-Mendel rats; (d) comparison of the carcinogenic potency of individual PAHs after long-term dermal application (National Institute of Public Health and Environmental Protection of the Netherlands, 1989; ICF-Clements Associates, 1990). Therefore, the equivalency approach is desirable in that it will emphasize the

data considered to be the most sound and facilitate the incorporation of anticipated future revisions in the relative potencies of the PAHs other than B[a]P.

ESTIMATION OF THE BENZO[a]PYRENE EQUIVALENTS (B[a]PE)
OF OTHER PAHS

Two recent documents have dealt with the relative potency of polycyclic aromatic hydrocarbons (PAHs), one produced by the National Institute of Public Health and Environmental Protection of the Netherlands (1989) and the other produced by Clement Associates (1990) under a contract with the EPA. Both reports review a total of 19 studies with 5 common to both documents. The Netherlands report used a linear model for calculating potency, while the EPA report used either a two-stage (Moolgavkar and Knudson, 1981) or a linear multi-stage model. The potencies from neither report are entirely suitable for QRAC's purposes. However, because the Clements report provided estimates for more of the compounds in question and because it systematically selected the best study for each compound, the analysis below used the equivalencies derived with the multistage model. This model more closely resembles the risk estimate procedure typically used by the QRAC than does the two-stage model.

The Clements report did not provide multistage estimates for either pyrene or fluoranthene. However, the best available study was selected for pyrene (Wislocki et al., 1986). Fluoranthene was not considered in the Clements report. The one study listed in the Dutch report in which a clear tumorigenic response was observed was therefore used to calculate a potency number for fluoranthene (Busby et al., 1984).

Table 1 lists the potency numbers relative to B[a]P judged to be the best available for the nine polycyclic aromatic hydrocarbons measured in the Alaskan marine samples. The B[a]PE values are positively correlated with carcinogenic potency. For the purposes of B[a]P equivalency, all the compounds in the Table are assumed to be probable human carcinogens, despite the conservatism in this approach implied by the IARC Classification.

Table 1. B[A]P EQUIVALENCIES FOR NINE PAHS

PAH	B[a]P equivalency	IARC Class *
Fluoranthene ^b	0.02	3
Pyrene ^b	0.13	3
Benz[a]anthracene	0.014	2A
Chrysene	0.013	3
Benzo[b]fluoranthene	0.11	2B
Benzo[k]fluoranthene	0.07	2B
Benzo[a]pyrene	1.00	2A
Indeno[1,2,3-cd]pyrene	0.25	2B
Dibenz[a,h]anthracene	1.05	2A
Benzo[g,h,i]perylene	0.03	3

* IARC classification: 2A - probable human carcinogen; 2B - possible human carcinogen; 3 - unclassifiable.

^b All values are from Clements Associates except for pyrene and fluoranthene which were calculated by Janet Springer (Memorandum, J. Springer, Division of Mathematics (HFF-110) to C. Carrington, Ph.D., (HFF-156), dated June 19, 1990).

For the alkylated PAHs, the addition of the side chains was assumed to have no effect on carcinogenic potency. Since the alkylated compounds were reported as either mixtures of fluoranthenes and pyrenes or chrysenes and benz[a]anthracenes, the assumption was made that the relative proportions of the alkylated mixtures was the same as the unsubstituted compounds which were measured separately. The alkylated PAHs were not placed in any IARC category since there are no data.

LEVELS OF BENZO[a]PYRENE EQUIVALENTS IN ALASKAN FISH AND SHELLFISH SAMPLES

The spreading of oil spilled from the EXXON VALDEZ (March 24, 1989) led to concern among native Alaskans that their seafood could be contaminated by petroleum hydrocarbons. In response, the National Oceanic and Atmospheric Administration (NOAA) entered into a memorandum of understanding with Exxon to analyze several hundred subsistence fish and shellfish from 13 subsistence fishing grounds used by native Alaskans in or near Prince William Sound for aromatic contaminants which included aromatic hydrocarbons and dibenzothiophenes. Uncontaminated fish and shellfish samples were collected near the village of Angoon in southeast Alaska to serve as a reference. Results of analyses of samples collected from July through September 1989 are reflected in this QRAC report as taken from a NOAA report (Varanasi, 1990).

The NOAA study indicated that the pattern of aromatic contaminants in the fish samples is consistent with the known extensive metabolism of aromatic hydrocarbons by fish. In molluscs, which have little ability to metabolize aromatic contaminants, both alkylated and unsubstituted aromatic contaminants were present.

Using the equivalency values in Table 1., the B[a]P equivalencies in the Alaskan fish and shellfish samples are shown in Table 2.

6

Table 2. B[a]P EQUIVALENCIES (ppb) IN THE ALASKAN FISH AND SHELLFISH SAMPLES

Source	Number of Samples Analyzed					
	ppb	<0.5	1	2-5	8-17	>49
Fish (incl. salmon)	>100	0	0	0	0	0
Molluscan bivalves (except WB)	139	11	4	1	0	
Windy Bay molluscan bivalves	1	0	2	2	2	
Smoked salmon	0	0	0	0	0	4

Individual values (ppb) for Windy Bay molluscan bivalves and smoked salmon:

Windy Bay molluscan bivalves: 0, 3, 4, 11, 17, 71, 107 Mean = 30

Smoked salmon: 49, 52, 133, 215, Mean = 112

In Table 2, it may be seen that levels of B[a]PE are higher in the smoked salmon. PAHs in smoked foods are known to be generated by pyrolysis of the smoke constituents during preparation; searing or smoking food commonly results in a considerable increase in PAH levels (Fazio and Howard, 1983).

FISH CONSUMPTION ESTIMATE FOR ALASKAN SUBSISTENCE FISHERMEN

The Food and Color Additives Review Section (FCARS) (memorandum M.A. Adams, Ph.D., HFF-415 to Mike Bolger, Ph.D., Contaminants Team, HFF-156) has evaluated for QRAC the two Alaskan subsistence fish consumption surveys previously mentioned.

Fish consumption patterns were surveyed for the village of Chenega Bay on Evans Island, Prince William Sound by the Alaska Department of Fish and Game, Division of Subsistence between 1984 and 1986 (Alaska Dept. of Fish and Game). Chenega Bay is

accessible only by air or water. The residents, 77% of whom are Alaska Native, use traditional hunting and fishing practices to obtain a major portion of their food.

Food consumption on Kodiak Island, Alaska, was surveyed by the Kodiak Area Native Association and the State of Alaska in 1983 (Kodiak Island Native Association, 1983).

FCARS also recently estimated freshwater fish consumption among subsistence fishermen in the contiguous United States. (Memorandum G. Cramer, Ph.D. (HFF-415) to S. Henry, Ph.D. (HFF-156), dated Nov. 13, 1989.) Consumption estimates from these three sources are tabulated for comparison in Table 3.

The residents of Chenega Bay are more dependent on food obtained directly from nature than are subsistence fishermen of the contiguous United States who have access to alternate food sources such as supermarkets or farms. In addition, the rigors of living in a cold climate may increase the caloric demand of the body, requiring a higher food intake to maintain normal body function. Thus, it is not surprising that total per capita fish consumption is higher among the Alaskans than subsistence fishermen in the contiguous United States. Fish/shellfish consumption in the isolated Alaskan communities depends on resources available, prevailing customs and tradition, and access to alternate food sources from outside the community. Average fish/shellfish consumption values may vary somewhat from community to community, but all are of the same order of magnitude, as is illustrated by the Kodiak Island study when compared to the Chenega Bay study. Isolated Kodiak Islanders apparently make much greater use of the naturally occurring food resources.

8

Tabel 3. FISH AND SHELLFISH CONSUMPTION FOR SUBSISTENCE FISHERMEN
ALASKA AND CONTIGUOUS UNITED STATES

Resource	g/person/day
Chenega Bay survey (per capita data)	
Salmon ^a	89
All other fish ^b	52
Subtotal	141
Bivalve mollusks ^c	2
Crabs ^d	.8
Shrimp	11
Subtotal	21
Kodiak Island Alaska (per capita data)	
Most isolated population	
Fish (excl. shellfish)	369
Butter clams	27
Less isolated population	
Fish (excl. shellfish) ^e	124
Butter clams	10
Contiguous United States (Estimate for subsistence fisherman & family - FDA)	
Freshwater fish	69 (mean) 116 (90th percentile)

^a Includes king, red, pink chum, and silver salmon.

^b Includes halibut, herring and herring roe, gray and black cod, red and black rockfish, smelt/eulachon, shark, eel, Dolly Varden, and trout.

^c Includes razor and other clam species, cockles, and mussels.

^d Includes dungeness, king and tanner crabs.

^e Mostly red and pink salmon.

RISK ASSESSMENT FOR CANCER

An approach to estimating the carcinogenic risk from contamination of food with many polycyclic aromatic hydrocarbons (PAHs) is to design a scheme whereby the total PAH contamination is expressed as benzo[a]pyrene potency equivalents. This approach has been taken above with the levels of PAHs found in the Alaskan fish/shellfish samples.

After evaluating the available data, the Cancer Assessment Committee of the Center for Food Safety and Applied Nutrition (CFSAN) concluded that the most suitable chronic cancer bioassay for B[a]P, although less than ideal, is the one reported by Brune et al. in 1981. In this study, there was one dose group of rats which were administered benzo(a)pyrene alone for their lifetime, a feature which was not available in the small number of other studies that might even be considered for this purpose. The fact that there is only one dosage level administered makes a dose-response evaluation somewhat limited. However, the existence of a low incidence of treatment-related tumors which were mostly benign, indicates that the response is at the lower end of the observable dose-response curve. The response, therefore, is where QRAC would initiate a linear extrapolation to a zero dose, even if there were more data points.

The administered dose in this study was 0.15 mg/kg bw/day, 5 days per week to Sprague-Dawley rats for 131 weeks. The males were more sensitive with 8/32 having either a benign forestomach tumor or esophageal tumor. The control group had an incidence of rats with benign forestomach tumors of 2/32 after 129 weeks. The time-averaged daily dose was:

$$0.15 \text{ mg/kg bw/day} \times 5/7 = 0.107 \text{ mg/kg/bw/day}$$

UNIT RISK (potency)

$$\frac{8/32 - 2/32}{0.107 \text{ mg/kg bw/day}} = 1.75 \text{ (mg/kgbw/day)}^{-1}$$

QRAC has chosen to use the Chenega Bay fish/shellfish data as presented in Table 3 for the estimation of upper bound lifetime risks presented in Table 4. It is believed that the Chenega Bay residents are among the most likely consumers of fish/shellfish that might have come in contact with spilled oil, making the Chenega Bay data most useful and relevant for risk assessment.

Table 4. RISK FOR ALASKAN SUBSISTENCE FISHERMEN CONSUMING PAH-CONTAMINATED FISH AND SHELLFISH

Source	Intake ^c (g/p/day)	B[a]PE ^a (mg/p/d)	Upper Bound Lifetime Risk ^b
Salmon ^d	89	ND ^e	NQ ^e
All other fish ^d	52	ND ^e	NQ ^e
Smoked Salmon ^f	45	5.0×10^{-3}	1.5×10^{-4}
Bivalve mollusks ^g	2	6.0×10^{-5}	1.8×10^{-6} ^h

^a From Table 2, the mean concentration of B[a]PE for smoked salmon is 112 ppb B[a]PE $\times$ 44.5 g = 5.0×10^{-3} mg/p/d.

^b For Smoked Salmon:

$$\frac{5.0 \times 10^{-3}}{60 \text{ kg person}} \text{ B[a]PE} \times \text{unit risk of } 1.75 = 1.5 \times 10^{-4}$$

^c Taken from Table 3

^d Includes halibut, herring and herring roe, gray and black cod, red and black rockfish, smelt/eulachon, shark, eel, Dolly Varden, and trout. Salmon is mostly red and pink salmon.

^e ND - not detectable; NQ - not quantifiable.

^f Alaskan subsistence fishermen are estimated to consume about 50% of their salmon catch smoked. (Personal communication, Dr. Robert Wolfe, Director, Div. of Subsistence, Alaskan Dept. of Fish and Game, Juneau, Alaska.)

^g Using the mean Windy Bay value of 30 ppb for molluscan bivalves from Table 3.

^h This assumes that persons are exposed to B[a]PE for their entire lifetime from this oil spill. It can be assumed that exposure would be at most no more than 10 years at this level. Therefore, at a minimum, the upper bound lifetime risk can be adjusted by a factor of 1/7 of a lifetime (i.e., $1/7 \times 70$ years = 10 years) to provide an adjusted upper bound risk of 2.5×10^{-7} .

The dose corresponding to a 10^{-6} lifetime upper bound risk would be:

$$10^{-6} / 1.75 \text{ (mg/kg bw/d)}^{-1} = \underline{0.57 \text{ ng/kg bw/d}}$$

For a 60 kg person, the dose corresponding to a 10^{-6} lifetime upper bound risk would be:

$$0.57 \text{ ng/kg bw/d} \times 60 \text{ kg person} = \underline{34 \text{ ng B[a]PE/person/day}}$$

For the purpose of estimating levels of concern for B[a]PE from the Exxon Valdez oil spill in subsistence fishery resources it will be assumed that the impact of the spill will occur for no more than 10 years. This assumption is based on data accumulated from prior spills where the environmental status of an impacted area generally returns to that which existed prior to the spill within several years. The evidence from these spills indicates that oiled environments do cleanse themselves and that there are environmental mechanisms of oil degradation and biological recovery (National Research Council, 1985). Therefore, the duration of exposure would not be for a 70 year life-time, but rather for 10 years or less. The following table presents advisory levels for various subsistence fishery resources.

TABLE 5. FDA ADVISORY LEVELS FOR ALASKAN SUBSISTENCE FISHERY RESOURCES

Resource	Intake g/person/day	B[a]PE Levels for 10^{-6} Risk (ppb)	
		<u>Lifetime</u>	<u>10 year</u> ^a
Salmon	89	0.4	3
Other finfish	52	0.7	5
Bivalve mollusks	2	17.0	120
Crustaceans	21	1.6	11

^a Advisory level corresponding to a 10^{-6} risk and a period of exposure of 10 years (1/7 of a lifetime of 70 years):

$$\text{Advisory Level} = \frac{34 \text{ ng B[a]PE/person/day}}{\text{g of fishery resource/person/day}} \times 7$$

(ppb or ng/g)

where: 34 ng B[a]PE = dose corresponding to a 10^{-6} lifetime upper bound risk

7 = correction factor for less than lifetime exposure of ten years

If a 10^{-5} upper bound risk standard were used rather than a 10^{-6} upper bound standard, then the corresponding advisory levels would be 10-fold greater than those presented in Table 5. In the case of the dioxin advisory opinion a 10^{-6} upper bound risk standard was used. Other governmental institutions (e.g. Environmental Protection Agency and various states) have often based their risk assessment decisions on a 10^{-5} risk standard. The issue of an acceptable risk standard for a consideration like subsistence fishing is one that resides with the state.

These advisory levels can be interpreted as concentrations which if not exceeded for the given conditions of exposure (lifetime or 10 years consumption at 7-fold higher levels) will conservatively limit any carcinogenic risk from ingested B(a)PE to less than 10^{-6} . The actual risk may be lower than these figures suggest. Although PAHs produced by smoking fish are unrelated to the oil spill, an advisory level of 0.8 ppb could be established for smoked salmon (0.8 ppb = 34 ng B(a)PE/45 g salmon). Since the mean concentration of B(a)PE in smoked salmon was reported to be 112 ppb (see Table 2), this illustrates the importance of this method of food preparation as a source of PAHs.

Generally the procedures used to estimate low levels of carcinogenic risk provide exposure levels which are well below those which elicit other toxicological end-points. Therefore, any advisory level based on carcinogenic activity of a toxicant is an conservative estimate of risk which would virtually always subsume the risk from other potential toxicological endpoints.

CONCLUSIONS

The PAHs reported in the subsistence survey account for the majority of the aromatic residues that are measurable by current available analytical methodology. The risk assessment is therefore confined to these measurable PAHs.

In interpreting the risk estimates and advisory levels presented in Tables 4 and 5, several points should be emphasized. First, the equivalency approach to estimating the potencies of various PAHs taken in this report is based on several assumptions pointed out earlier. This approach cannot be assumed to produce exact potencies for the PAHs. Second, there are limitations in the laboratory animal data used to estimate the potency of B(a)P and other PAHs. Third, as with all QRA quantitative risk assessments, an upper bound risk estimate has been produced with the knowledge that the true risk is somewhere between the upper bound number presented and zero.

With regard to fresh salmon, the dose level corresponding to the lifetime 10^{-6} upper bound risk level is at or below the detection limit of the PAHs. The risk associated with the consumption of salmon which is not smoked is insignificant relative to that associated with consuming smoked salmon because smoking significantly increases the PAH level.

Analyses of molluscan bivalves from areas unaffected by the oil spill have indicated that PAH levels are negligible (Varanasi et al., 1990). The risk estimate presented for molluscan bivalves in Table 4 is predicated on the conservative assumption that persons at risk would consume molluscan bivalves contaminated at the level of PAH produced by the Exxon Valdez oil spill for a lifetime; molluscan bivalves would not be expected to be contaminated with PAHs at this level for such a long time period.

Therefore, QRAC concludes that the lifetime upper bound risk of consumption is low for unsmoked salmon, other finfish, crustaceans, and oil-contaminated molluscan bivalves.

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**Advances in Rehabilitating
Oiled Sea Otters:
The Valdez Experience**

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International Wildlife Rehabilitation Council"*

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Summary

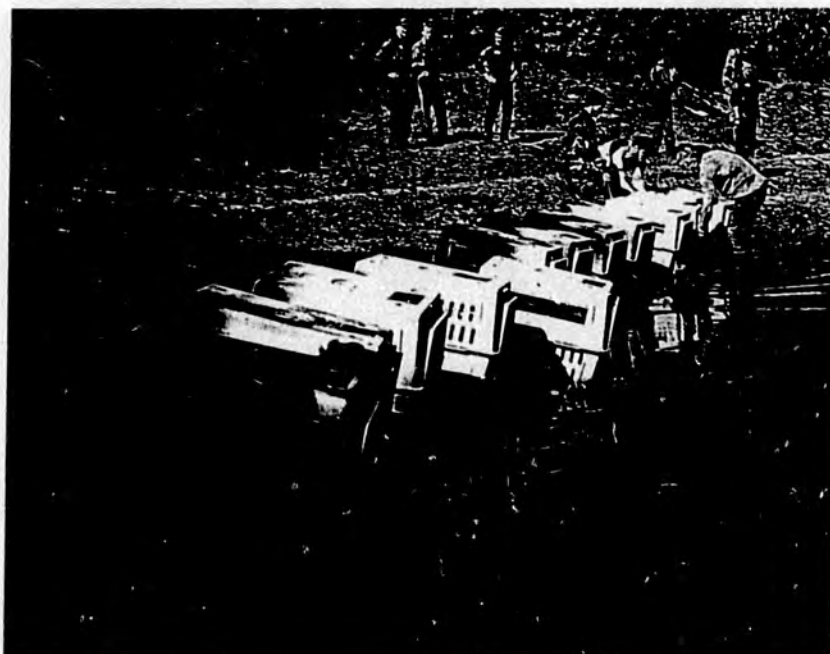
The March 1989 Valdez accident was the first oil spill to involve large numbers of sea otters. Similarly, the response to the Valdez spill involved the largest effort ever to rescue and rehabilitate oiled sea otters. Volunteers and employees captured and delivered 357 otters to the Sea Otter Rehabilitation Centers following the spill. While many of these animals regrettably died, the majority (197) were eventually returned to the wild. Another 37 were placed with seaquariums.

The Sea Otter Rehabilitation Program demonstrated that large numbers of oiled sea otters could be successfully rehabilitated following an oil spill. The experience was often painful and always trying, but it nonetheless contributed enormously to the wildlife rehabilitation community's understanding of what is needed to successfully rescue and treat sea otters after an oil spill. This paper describes some of the ground-breaking developments concerning sea otter rehabilitation. It focuses on rehabilitation facilities, staffing, and the collection of scientifically valuable data.

Background

Although at least 28 oil spills have been larger than Valdez, the March 1989 accident represents the first oil spill to affect a large number of sea otters. More than 16,000 sea otters inhabited the portions of Prince William Sound and the Gulf of Alaska that were impacted by oil (Degange, 1990). This would mean that many of the area's estimated 45,000 sea otters (Townsend, 1989) might have been involved.

At the request of the U.S. Department of the Interior and the U.S. Fish and Wildlife Service (USFWS), Exxon Company USA initiated an unprecedented effort to rescue and treat sea otters that became oiled. They built rehabilitation and pre-release facilities in Valdez, Seward, and Homer—each with a capacity of about 100 otters. All the facilities remained in operation until September, 1989. At its peak, the sea otter rehabilitation program had over 350 paid and volunteer staff, 11 capture vessels, and a dedicated helicopter to transport otters from the capture boats to the rehabilitation centers.



Following the largest effort ever to rescue and rehabilitate marine mammals, 197 sea otters were returned to the wild.

McCloskey, J. Stewart, T.D. Williams, and G. Van Blaricom.

Primary Rehabilitation Facility

The primary rehabilitation facilities in Alaska quickly evolved into a flow-through system with several specialized areas. Sea otters could be moved in assembly-line fashion through areas for triage and sedation, cleaning and rinsing, drying, recovery from sedation, critical care, and pens with seawater pools for short-term holding. Sea otter pups require constant attention and should receive care in a separate nursery area. A kitchen is also needed to prepare the large amounts of seafood that sea otters require to maintain their normally high metabolic rate.

In Appendix 1, the space needs and possible configuration for a flow-through primary facility are described. This sample design would allow simultaneous treatment of 200 otters, with holding pens for 120 otters and space in large pools for another 80. This size was selected because it matches the total capacity of Exxon's two sea otter rehabilitation centers and should be adequate for most moderate-to-large oil spills when combined with a pre-release (i.e., post-treatment) facility (details below). The total number of animals that could be moved through this primary facility to the pre-release facility depends on the rate of rehabilitation. The indoor space measures about 80 ft x 275 ft while the outdoor holding area measures 60 ft x 250 ft.

Because large pools and a filtered seawater system are needed for holding sea otters, the primary rehabilitation facility needs to be a permanent structure. Even with detailed plans and the identification of sites with essential amenities, it may take several weeks to build an otter rehabilitation center. To enable a rapid response that would minimize the exposure of otters to crude oil and reduce mortality, policy-makers would need to consider the development of pre-existing facilities. The more

rapid the response, the more effective future rehabilitation efforts can be.

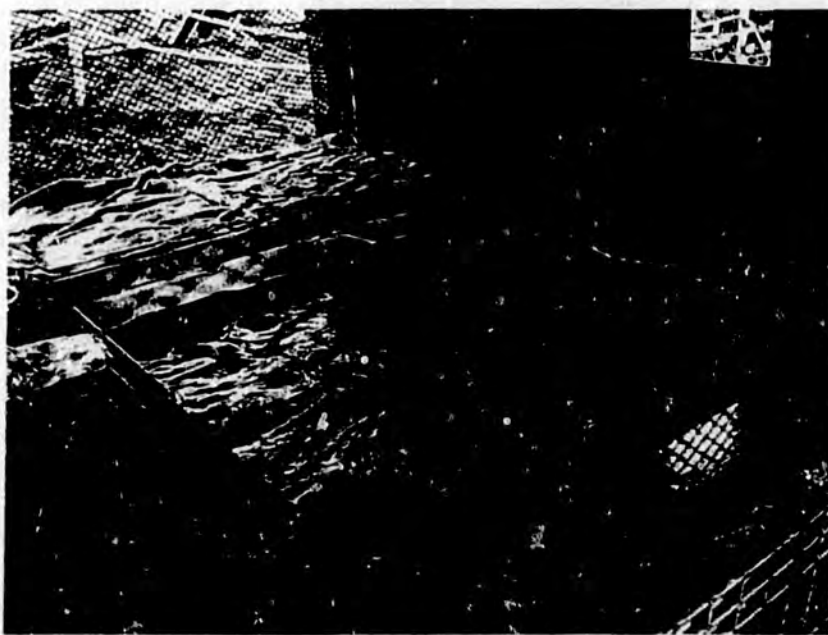
Triage and Sedation

The area for triage and sedation should be designed and stocked to meet the medical and hygienic needs of the in-coming otters. When oiled sea otters first arrive at the rehabilitation center, they are brought to the triage room for initial examination, medical stabilization, weighing, and sedation prior to cleaning. The veterinary staff treats any immediate problems such as dehydration, hypothermia, hyperthermia and shock. The room should have a sink and cabinets that can be locked for storing drugs and other medical supplies. The floors should be covered with a non-porous surface that can be easily cleaned. The temperature should be controlled at 18° C (65°F).

When large numbers of otters might be captured more than 300 miles (a four hour helicopter flight) from the primary facility, a remote mobile triage unit would be beneficial. Such a facility is described in detail in Appendix 2.

Cleaning

Unlike pinnipeds and cetaceans—which have a subcutaneous layer of blubber—sea otters rely on their fur for thermal insulation in water. If otter fur



Specially designed pens allowed otters to groom naturally.

Portable/Transport Pens

After drying, the animal is placed in a portable cage in the recovery room while the effects of sedation wear off. Because otters that have been oiled and cleaned may have difficulty thermoregulating at ambient air temperatures (especially during the winter in northern latitudes), they should be kept in the recovery room until they are alert and begin grooming.

The specially designed cages (figure 2) used in the critical care facility has a slatted bottom to allow the passage of feces and urine, which helps keep the otter's fur clean. The walls are made of pliable netting that prevents injury to teeth and gums. The

sliding, plywood door on top allows easy access to the animal for physical examination and medical treatment. The cages are placed over a shallow trough in the floor that is coated with fiberglass. Feces and urine which fall into the trough are washed into drains that are connected to the sewer. This makes sanitation easier.

Holding Pens

After recovery from sedation, the otter should be taken to an outdoor holding pen with a small seawater pool where it can groom and feed (figure 3). To protect the animals from injury, cage frames should be made of polyvinylchloride pipe or other plastic material with rounded edges. Because otters

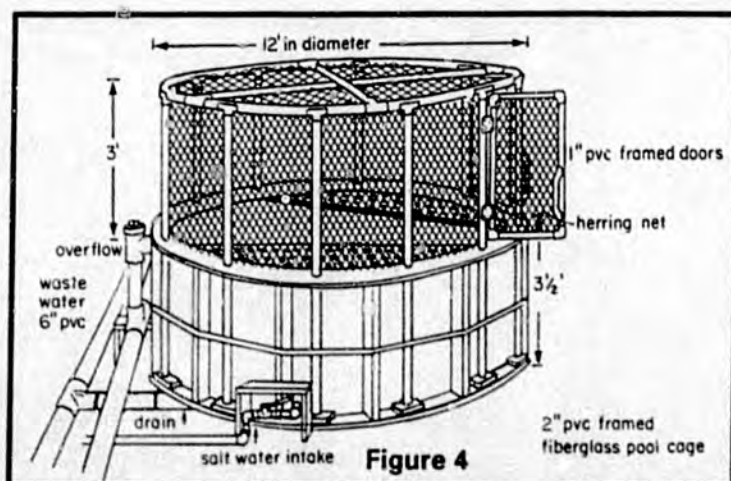
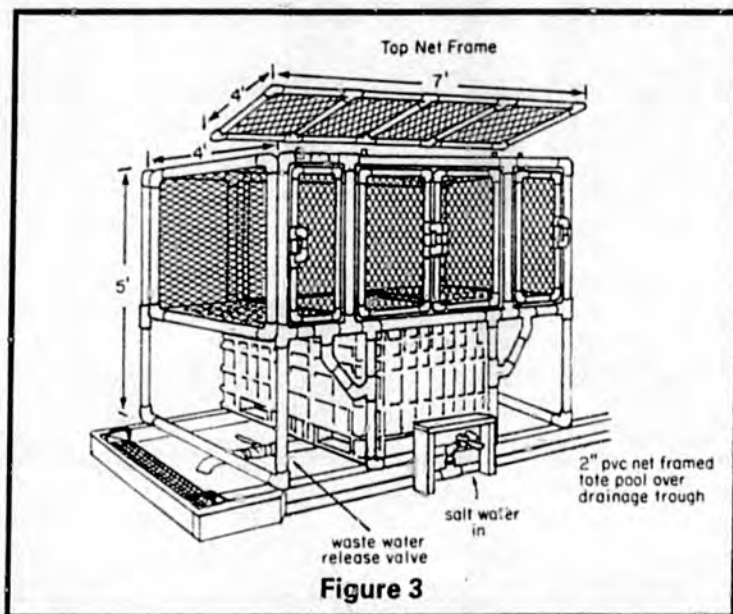
will attempt to chew away the cage lining, the framework of the pens should be covered with two-inch stretch-mesh herring net to prevent any injury to the otters' teeth and gums.

To encourage the grooming that is crucial for restoration of the fur, the pens should have pools that are at least three feet square and two feet deep. In addition, haul-out platforms (two feet by three feet) should be placed on either side of the pool. The surface of the haul-out platforms should be smooth but perforated with small holes to allow water to drain.

The pools should be plumbed with a continuous supply of filtered seawater to maintain good water quality and low bacterial concentrations. We found it advantageous to place the pens in a shallow spillway that collected overflowing seawater and returned it to the ocean. In areas where there might be a heavy snow fall, the outdoor pen area should be covered by a translucent, plastic roof.

Holding Pools

Once the recuperating otters have restored the water repellency of their fur and are in good health, they should be moved to larger pools that enable greater movement (figure 4). These pools can be any shape that allows the animals to socialize in larger groups and maintain muscle strength. We



with cleaning. As a result, mortality decreased dramatically, and more than 70% of the otters arriving at the rehabilitation centers after the third week survived.

Recognition of the the two distinct phases of a crude oil spill should enable veterinarians and animal care specialists to anticipate the medical problems and prepare for them in future spills. In addition, new, more effective treatment protocols can be devised now that we better understand the clinical effects of crude oil on sea otters.

Pup Nursery

Successful techniques to raise sea otter pups have been perfected by the Monterey Bay Aquarium and Sea World. The nursery should occupy a separate room to create a quiet, low stress environment. The basic requirements include a small kitchen (sink and refrigerator) for preparing and storing formula, a second sink and counter top for washing and grooming the pups, and a waterbed on which the pups can rest and play. The unheated waterbed has been shown by animal care specialists at the Monterey Bay Aquarium to be beneficial for the successful rearing of young otter pups, possibly because it is pliable and simulates the surface of the ocean. Because sea otter pups require 24 hour care, we found it useful to place a cot in the room for the caretakers to use at night.

Husbandry Facilities

Throughout the rehabilitation process, the primary responsibility of the husbandry staff is to feed and monitor the otters in their pens. If a rehabilitation facility has 200 adult otters each weighing 20 kg and eating 25% of their body weight in food each day, then the kitchen staff must thaw 1000 kg of sea food daily. The food preparation kitchen should have at least 1000 cubic feet of freezer space for frozen seafood. This is enough space to store three to four days of frozen sea food for 200 sea otters. Ten stainless steel sinks (3 feet x 3 feet x 2 feet deep) are used to thaw the frozen food which is placed into plastic bags, weighed (one kilogram portions), placed in buckets with ice and distributed by the husbandry staff. Pre-weighing the food in plastic bags makes it easier for the husbandry staff to estimate the food consumption of each otter, at least while it is in one

of the holding pens. The waterproof floor and stainless steel counter tops should be sanitized at least once per day. For convenience, a commercial ice maker should be in or adjacent to the kitchen.

Other Facility Considerations

When choosing the site for a primary rehabilitation facility, additional requirements include all-weather access by road and aircraft, telephone communications, and easy access to fresh seawater and a commercial seafood supplier.

Although the primary function of the facility is to clean and rehabilitate oiled animals, the Valdez spill proved the wisdom of allocating space for administration, staff training, and public relations.

To ensure the health of the otters and the staff, coveralls should be issued to all persons to wear over their street clothing. A dressing room with small lockers to store personal belongings should be provided. Staff members should eat only in a designated lounge, which can also be used for training programs and staff meetings.

To prevent the introduction of domestic animal diseases into the wild population, quarantine procedures are essential in the rehabilitation centers. Transport cages should be cleaned and sanitized after use. All pets and unnecessary visitors should be excluded from the site. Ideally, visitors and press corps should be confined to an interpretative center or allowed to view the otters from behind a glass partition.

Pre-release Facilities

Normally about two weeks are required to rehabilitate an oiled sea otter, although the duration may be longer in cases of severe petroleum hydrocarbon toxicosis. Rehabilitated otters should be moved to seawater pens in a pre-release facility as soon as they satisfy the following criteria:

1. Fur is water repellent; otter is able to thermoregulate (does not become chilled) in water;
2. Otter exhibits regular grooming behavior; fur appears healthy and retains loft;
3. Otter is eating well; body weight is either stable or increasing;
4. Otter appears alert and socializes with pen mates;

easily obtained near developed areas. If a large preemptive capture effort is planned immediately after a spill, quick access to seawater pre-release pens would be vital. A modular system like the one above would allow rehabilitators to store and quickly assemble the pens when needed. A modular design also enables the addition of new pens as needed, thereby allowing unlimited capacity.

Staffing and Management Issues

To avoid misunderstandings and inefficiency, the management at a sea otter rehabilitation center requires well defined authority from the USFWS (the federal trustee for sea otters). The organization needs to be interactive and encourage the free exchange of information in order to improve operations, but staff members also need a clear understanding of the chain-of-command. A sample breakdown of job responsibilities is included as Appendix 3.

Otters require continuous care, so a core professional staff of administrators, veterinarians, veterinary technicians and animal care specialists is required. Volunteers can be a valuable supplement to the core professional staff if they are properly trained and supervised. Jobs that can be filled by volunteers include animal monitors, kitchen staff, and logistical support for the rehabilitation center (i.e., transportation of personnel and otters, radio and telephone communications, administrative support).

The total staff should be large enough to accommodate 12 hour shifts while providing 24 hour care for the animals. Some overlap in shifts will allow the exchange of information among staff members, especially among the husbandry staff. We learned that appropriate staff size is a function of the number and health status of otters in the facility. A ratio of one to three staff per otter (1/2 to 1 1/2 people per 12 hour shift) is usually adequate.

A training program for volunteers with yearly refresher courses needs to be an integral part of a pre-existing facility if one were built. This ensures that a group of knowledgeable and highly motivated volunteers could be immediately available if an emergency arises. Training programs for volunteers should include instruction on sea otter behavior, health effects of exposure to crude oil, common

veterinary procedures and their purposes, sanitation and hygiene in animal facilities, record keeping, and quarantine procedures for disease control. Following the Valdez oil spill, training videos were produced on some of these topics to accompany lectures for new staff members.

Data Collection and Analysis

Much valuable information was collected during the 1989 Sea Otter Rehabilitation Program in Alaska that will be used to develop new medical and husbandry protocols. The most useful information fell into five categories:

1. Sea otter biographical data
 - a. Date, location of capture, tag number
 - b. Body weight at time of capture
 - c. Degree of oiling and medical condition
 - d. Pregnancy and birth data
 - e. Final disposition
2. Medical treatments
 - a. Anesthetics
 - b. Antibiotics
 - c. Other drug therapies
3. Clinical laboratory results
 - a. Blood chemistry
 - b. Urinalysis
4. Food consumption
5. Necropsy results

For a detailed list of variables for each category of data, see appendix 4.

Preliminary analysis of the data have been published in a report entitled "Sea Otter Rehabilitation Program: 1989 Exxon Valdez Oil Spill" (Williams and Davis, 1990). Further analysis of the data is planned and should provide additional recommendations for the husbandry and veterinary care of oiled sea otters.

Science and wildlife rehabilitation will continue to benefit for some time from the quality of the Valdez data acquisition and analysis. This documentation process has proved worthwhile to help evaluate treatment protocols. In addition, this facilitates the sharing of information with other rehabilitation programs.

sue samples from most major organ systems were taken for histopathology and toxicology (petroleum hydrocarbon analysis). The analysis of polycyclic aromatic hydrocarbons and aliphatic hydrocarbons was directed by Dr. Terrie Williams and conducted at Battelle Ocean Sciences (Duxbury, MA). When evaluation of the results is completed, it may indicate which organ systems were most susceptible to damage from systemic exposure to oil. These data will be correlated with the types and concentrations of petroleum hydrocarbons in the tissues. In some sea otters, blood petroleum hydrocarbon levels were also measured (Williams, 1990). In acquiring a better understanding of the basis of petroleum hydrocarbons' effects on sea otters, we hope to improve veterinary protocols for oiled sea otters and thereby increase survivorship.

The third research project examined new techniques to restore the water repellency of sea otter fur after cleaning.

While the method for cleaning the fur of oiled otters worked well, the sea otters' fur did not fully regain its water repellency until several days after cleaning. As a result, cleaned otters could not be placed immediately into water because their fur wetted and they became chilled. Although the reasons for the delayed recovery of the water repellency of the fur are not known with certainty, possible explanations include: 1) the alignment of the dense underfur had been disrupted during washing so that it no longer trapped an air layer next to the skin; 2) the normally hydrophobic surface of the hairs retained a monolayer of detergent molecules which made their surface hydrophilic; and 3) washing had removed natural oils which normally contributed to the hydrophobic properties of the fur.

To discover if the time needed for fur restoration could be abbreviated, the rehabilitation centers invited Dr. Lee Hunter of Redkin Laboratories (Canoga Park, CA) to investigate the beneficial effects of applying squalene (an oil similar to the natural oils produced by the otter's sebaceous glands) to the fur of sea otters after they had been cleaned with Dawn™ dish washing detergent. Our hypothesis was that the application of squalene would replace the natural oils that are removed with crude oil during washing, thus returning the fur to its hydrophobic state. Squalene in ethanol was sprayed

on the fur of several otters after their fur had been washed and thoroughly dried. The water repellency of their fur was compared to otters in a control group which were not sprayed. The fur of the treated group appeared to dry quicker when the animals were out of the water. Although the results are preliminary, this research may result in a modified cleaning method, which will not only remove crude oil but will also restore the water repellency of fur immediately. Such a method could shorten the rehabilitation process by one to two weeks.

One problem that we had not anticipated in 1989 was how to decide when to stop capture operations. During the first few weeks of the spill, oil was visible on the fur of otters that were brought to the rehabilitation center in Valdez. However, as the oil dispersed and weathered, it became more difficult to decide when an otter was lightly oiled or unoiled. The situation was further complicated by the absence of information on safe levels of exposure to oil. As a result, the USFWS continued to capture sea otters in the oil affected area, probably longer than necessary.

In an attempt to provide more objective criteria for determining when otters should be brought to the rehabilitation centers, Dr. Ken Hill (staff veterinarian) developed a field test for detecting the presence of petroleum hydrocarbons on the fur of lightly oiled otters. This simple test involved placing a small hair sample from an otter in a 3 ml glass vial with dichloromethane (an organic solvent), which solubilized the oil and visually changed the color (clear to dark brown) of the solvent. The color was compared to a series of standards to provide a semi-quantitative estimate of the amount of oil on the fur. This test could be made more sensitive and quantitative by measuring the spectrophotometric absorbance of the sample at 240 nm, but this required bringing the otter to the rehabilitation center. Further research and testing are needed to verify this method of detecting oil on sea otters in the field. Animals that are unoiled should be immediately transferred to a pre-release facility or translocated outside of the oil affected area.

Acknowledgments

In addition to those previously mentioned in the text, I would like to acknowledge the many people who worked at the rehabilitation centers. Also, I gratefully acknowledge the support of Exxon Company, USA who sponsored this report and the 1989 Sea Otter Rehabilitation Program.

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Appendix 2

Remote/Mobile Triage Facilities

Transporting sea otters over long distances is stressful. For otters that have been exposed to oil, this stress can cause death or seriously complicate medical conditions. Mobile triage units would be beneficial in certain cases because they would allow staff to stabilize some animals medically before they were flown long distances to the primary rehabilitation centers. In our judgment, mortality can be reduced significantly if mobile units are employed when large numbers of otters must be captured more than 300 miles (three hour helicopter flight) from the center.

These mobile units, by necessity, should be self-contained (including electrical generators and hot water) and transportable by truck, boat, large helicopters, or fixed-wing aircraft (C-130 cargo plane); the latter may be necessary for areas inaccessible by road such as the Aleutian Islands or the North Slope of Alaska. One type of mobile facility (see illustration 2) consists of a trailer (12 ft wide and 60 ft long) that is divided into three functional sections. The largest, central section (420 ft²) is for triage and can hold up to eight otters in portable cages until they can be flown to the primary facility. Otters arriving from the capture boats are examined by a veterinarian or animal care specialist and treated for hypothermia, dehydration, malnourishment, capture stress or other medical problems. After they are medically stabilized, the otters are placed in cages and monitored. The cages are placed in a shallow, fiberglass spillway that collects waste water and drains into the sewer. A hose can be used to rinse the cages and spillway. Because heavily oiled otters have lost their ability to thermoregulate at cold temperatures, the room should be maintained at about 18° C (65° F). However, the otters should also be checked regularly to ensure that they are not overheating.

The triage area is connected by a door to one end of the trailer that provides space (180 ft²) for a veterinary clinic, communications center, and an administrative office. Blood samples from newly arrived otters are analyzed for metabolites, electrolytes and hematological variables. This information is vital for the veterinarians to diagnose and treat immediate medical problems. This area is also used

to store clinical supplies and drugs. Hot water is provided by a wall mounted, propane instantaneous water heater. The communications center consists of a VHF radio and telephone to keep in contact with the capture boats, helicopter and the primary rehabilitation facility. Administrative and animal health records are also kept in this area.

The other end of the trailer is used for sea otter food preparation (120 ft²). This kitchen is a smaller version of the one at the primary facility and consists of a stainless steel counter top for preparing the food, three sinks with fresh water for thawing frozen seafood, and two chest freezers (100 ft³ each). This is enough freezer space to store one to two weeks of food for ten adult sea otters. After the food is thawed, it is placed in plastic trays and passed through a window into the sea otter holding area. The otters are then hand fed by the husbandry staff. The trailer must be designed with external connections for water, electricity, propane, and sewage. If these amenities are not available at the site, then backup systems are required. These would consist of 250 gallon portable storage tanks for fresh water and a 5kW diesel electric generator with a 250 gallon fuel tank. The generator should be housed separately in a noise-insulated, weather-proof container. In wilderness areas, waste water from the kitchen and sea otter holding area can be drained onto the ground by running a hose several hundred feet from the trailer. Portable propane tanks can be used for the instantaneous hot water heaters and space heaters. Additional outdoor space for holding sea otters in cages, storing equipment, and for conducting other activities that require overhead shelter can be provided by portable, vinyl enclosures similar to those made by Weatherport Company (Anchorage, AK).

The staff at the mobile triage unit should include a supervisor with management and sea otter rehabilitation experience, a veterinarian, a veterinary technician for analyzing blood samples, and two animal care specialists to perform husbandry tasks including sea otter food preparation. If the mobile unit is placed in a remote area without access to hotels and restaurants, then a second trailer will be required to provide living accommodations for the staff and a kitchen for food preparation.

Appendix 3

Staff and Job Responsibilities for a Primary Rehabilitation Facility

1. Staff positions
 - a. Director
 - b. Operations Supervisor
 - (1) Husbandry Shift Coordinators (two shifts)
 - (a) Animal monitors/handlers cage cleaners
 - (b) Nursery staff
 - (c) Sea otter cleaning crews
 - (2) Animal Food Coordinator
 - (a) Kitchen staff
 - (3) Veterinary Coordinator
 - (a) Clinical veterinarians
 - (b) Veterinary pathologists
 - (c) Veterinary technicians
 - (d) Toxicologist
 - c. Logistics Supervisor
 - (1) Secretarial staff
 - (2) Personnel Housing and Meals Coordinator
 - (3) Supplies and Equipment Procurer
 - (4) Facilities Maintenance
 - (5) Security
 - (6) Transportation Coordinator
 - (a) Aircraft and ship transportation
 - (b) Ground transportation
 - (7) Communications Coordinator
 - d. Personnel Supervisor
 - (1) Accounting/payroll
 - (2) Training
 - e. Documentation Supervisor
 - (1) Archives
 - (2) Computer data entry
 - f. Public Relations Coordinator
2. Responsibilities of the Director and Staff Supervisors.
 - a. Director
 - (1) Organize and direct response operations associated with the cleaning and rehabilitation of oiled sea otters.
 - (2) Maintain contact with designated representatives of the USFWS, members of the Regional Response Team and others directly involved with the capture, cleaning and rehabilitation of oiled sea otters.
 - (3) Obtain USFWS authorization to capture and rehabilitate oiled sea otters.
 - (4) Designate and meet regularly with supervisors; establish priorities to ensure efficient and effective operations.
 - b. Operations Supervisor
 - (5) Meet with Press Relations Coordinator in order to organize press briefings and respond to press inquiries.
 - (6) Approve all requests for personnel, equipment, supplies and construction.
 - (7) Approve the discharge of personnel.
 - c. Logistics Supervisor
 - (1) Coordinate the cleaning, husbandry, food preparation and veterinary care of sea otters in the center.
 - (2) Work with the Logistics Supervisor to identify and maintain required equipment and supplies.
 - (3) Work with the Personnel Supervisor to recommend the hiring or discharge of personnel for sea otter cleaning, husbandry, food preparation and veterinary care.
 - (4) Ensure that all husbandry staff are properly trained and adequately clothed.
 - (5) Establish safety protocols to protect animal monitors and handlers from injury.
 - (6) Supervise the cleaning and care of oiled otters.
 - (7) Work with the Documentation Supervisor to ensure that proper records are maintained and that each otter is identified with a flipper tag.
 - (8) Work with the Logistics Supervisor to arrange for the purchase and delivery of seafood for the otters.
 - (9) Institute quality control procedures for the preparation and distribution of otter food to the husbandry staff.
 - (10) Coordinate with the veterinary staff to ensure proper care and treatment for otters in the center. Ensure that all otters that die in the center are necropsied by a veterinary pathologist and that tissue samples are taken for toxicological and histopathological analysis.
 - (11) Establish security procedures for personnel entering the facility. Ensure that no domestic animals enter the facility.

B. Medical diagnosis

1. Otter identification number
2. Date and time of examination
3. Overall condition and symptoms
 - a. alertness
 - b. body weight (food consumption, see below)
 - c. core body temperature
 - d. heart rate
 - e. respiratory rate (evidence of respiratory distress)
 - f. occurrence of seizures
 - g. pelt condition (includes degree of oiling)
 - h. skin disorders
 - i. appearance of teeth and gums
 - j. appearance and consistency of feces
 - k. additional symptoms and veterinary comments
 - l. comments from husbandry records
4. Blood analysis (see below)
5. Urinalysis (see below)
6. Diagnosis (veterinarian's diagnosis and recommended therapy)
7. Chemical restraint if required (type and dose)
8. Drug therapy (drug types, doses, and frequency)
9. Fluid therapy (type, quantity, and frequency)
10. Surgical intervention (full description)
11. Daily progress reports

C. Blood analysis

1. Otter identification number
2. Date and time of blood sample
3. Reason for blood sample (admission, routine, toxicology, monitoring medical treatment, etc.)
4. Laboratory performing the analysis
5. Hematology
 - a. hematocrit (%)
 - b. buffy coat
 - c. serum color (clear, hemolyzed, etc.)
 - d. erythrocyte sedimentation rate (min)
 - e. hemoglobin concentration (g/dl)
 - f. red blood cell count
 - g. mean corpuscular volume (cubic microns)
 - h. mean corpuscular hemoglobin concentration
 - i. platelets (adequate, increased, decreased, clumped)
 - j. white blood cell count
 - k. neutrophils (%)
 - l. bands (%)
 - m. lymphocytes (%)
 - n. monocytes (%)
 - o. eosinophils (%)
 - p. basophils (%)
 - q. unidentified leukocytes
 - r. Heinz bodies
 - s. other cell types and quantities
 - t. comments

6. Serology

- a. glucose (mg/dl)
- b. blood urea nitrogen (BUN, mg/dl)
- c. creatinine (mg/dl)
- d. BUN to creatinine ratio
- e. uric acid (mg/dl)
- f. cholesterol (mmol/l)
- g. triglycerides (mmol/l)
- h. alkaline phosphatase (U/l)
- i. GGTP (U/l)
- j. SGOT (U/l)
- k. SGPT (U/l)
- l. lactate dehydrogenase (U/l)
- m. total bilirubin (mg/dl)
- n. direct bilirubin (mg/dl)
- o. total protein (g/dl)
- p. albumin (g/dl)
- q. globulin (g/dl)
- r. albumin to globulin ratio
- s. iron (ug/dl)
- t. triiodothyronine (T3) uptake (%)
- u. thyroxine (ug/dl)
- v. amylase (U/l)
- w. lipase (U/l)
- x. ammonia (umol/l)
- y. comments

7. Electrolytes

- a. sodium (mEq/dl)
- b. potassium (mEq/dl)
- c. calcium (mg/dl)
- d. phosphorous (mg/dl)
- e. magnesium (mmol/dl)
- f. chloride (mg/dl)
- g. polychromasia
- h. poikilocytosis
- i. macrocytosis
- j. microcytosis
- k. nucleated RBC to WBC ratio
- l. hyperchromasia
- m. hypochromasia
- n. degree of sample hemolysis (slight, moderate, severe)
- o. comments

D. Urinalysis

- a. pH
- b. total protein
- c. glucose
- d. ketones
- e. bilirubin
- f. hemoglobin
- g. specific gravity
- h. sediment (bacteria, blood, crystals, epithelial cells, casts)



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**Results of the
Eagle Capture, Health Assessment,
and Short-term Rehabilitation Program
Following the Valdez Oil Spill**

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"The Effects of Oil on Wildlife"

held in conjunction with

*"The 13th Annual Conference of the
International Wildlife Rehabilitation Council"*

*Herndon, Virginia
October 17-18, 1990*

Summary

Initial concerns about the impact of the Valdez oil spill on bald eagles in Prince William Sound are being set aside, as accumulating evidence indicates the area's eagle population is generally healthy and thriving. This paper presents and discusses some of that evidence. It reviews the 1989 data collected during the Prince William Sound and Kodiak Island Eagle Capture and Short-term Rehabilitation Programs, as well as 1990 data from the U.S. Fish and Wildlife Service's (USFWS) operational field surveys.

The authors participated in an unprecedented effort to capture bald eagles and assess their health following the Valdez spill. Three teams captured 113 eagles, or about 2% of the area's estimated 5,000 eagles. Although the teams focused their efforts on capturing eagles within the most heavily oiled areas, they noted evidence of oiling on only 35% of the captured eagles.

After conducting a physical exam and rudimentary bloodwork, the teams concluded that 98 (87%) of the captured eagles met release criteria. Those birds were immediately returned to their territories. Fifteen (13%) of the captured eagles required medical treatment or cleaning, and most of these birds were transported to the International Bird Rescue Research Center (IBRRC) in Seward for short term rehabilitation. In addition, IBRRC processed 24 birds that had been delivered by the general public and, in one case, by USFWS.

The positive findings in 1989 have been corroborated by 1990 USFWS operations-related active eagle nest surveys. In May the USFWS pinpointed 1,031 active eagle nests in the general area that had been oiled in 1989. The authors' own August 1990 field observations confirmed sightings of hundreds of eaglets and recent fledglings in the previously oiled areas.



More than 5,000 bald eagles inhabit the Prince William Sound area.

Results of the Eagle Capture, Health Assessment, and
Short-term Rehabilitation Program Following the Valdez Oil Spill



Teams captured 113 bald eagles in the most heavily oiled areas during the summer of 1989 to assess their health. We released 98 of the birds immediately because they met USFWS health criteria.



Teams photographed the birds to document evidence of oiling. Records indicate that only 39 birds had even the slightest oiling. Among the oiled birds, we would typically find a portion of their tail fringe stained.

The 1989 Bald Eagle Program

Background

Shortly after midnight on March 24, 1989 the Exxon Valdez collided with Bligh Reef in Alaska's Prince William Sound, spilling nearly 11 million gallons of North Slope crude. The oil eventually fouled 10% to 15% of the area's shoreline (USFS, 1990). According to the U.S. Fish and Wildlife Service, more than 5,000 bald eagles are associated with the area's intertidal habitats (USFWS, 1989).

USFWS began to develop a program addressing concerns about the area's bald eagles shortly after the spill. Very little, if any, study had been conducted on the effects of oil exposure on bald eagles, but the raptor biologists had various concerns. There was, for example, the possibility that oil ingestion might cause harmful reactions or affect future reproduction and that external oiling would inhibit flight.

Based on such initial concerns, the USFWS developed a capture and treatment protocol for bald eagles in late May, 1989. This original protocol called for capturing and holding many of the area's bald eagles in captivity for one year. It reflected fears that all the eagles in Prince William Sound faced immediate danger, that many were heavily oiled, and that few were nesting.

USFWS directed Exxon to hire specific qualified personnel to implement the capture and long term treatment programs. As soon as weather conditions allowed capture teams to work safely in the Sound and around Kodiak in late May, two groups of three people systematically surveyed the area to identify specific eagles that might have been exposed to oil. Although the surveys focused on the heavily oiled areas, most eagles in these areas evidently were not oiled, and none appeared moderately or heavily oiled. Also, in spite of the large-scale clean-up activities, many of the birds were maintaining territorial boundaries and hunting as usual. Many pairs were even breeding, an unexpected event because of the disruptive human

activity and suspicions that food sources might have been contaminated.

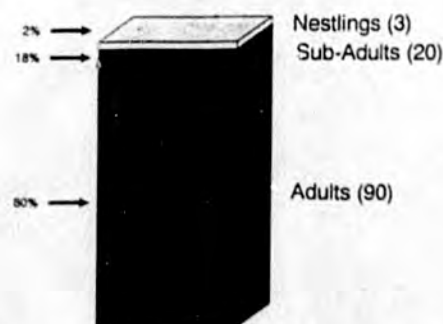
Using the information from the May 1989 surveys, the capture teams began working with USFWS to amend the initial protocol. Although most of the eagles observed during the surveys appeared to be in good health, the teams wanted to feel secure that the eagles could survive in their natural habitat. For those birds in the nesting cycle, they also wanted to be certain the adults were strong enough to feed and raise young.

The revised protocol reflected these concerns, the realities of conditions in Prince William Sound and around Kodiak, and the preference for keeping nesting pairs together in their natural habitat. The revised protocol called upon the capture teams to assess the health of as many eagles in the spill area as possible. Teams were to capture eagles, visually inspect them for signs of oil ingestion, and conduct rudimentary bloodwork. If the birds were not injured and showed no evidence of distress from oiling, teams were to release the trapped eagles as soon as possible (In practice, the entire exam required from 20 to 30 minutes). All the captured birds were to be banded with USFWS bands before release.

Capture Data

The capture teams trapped 113 eagles between June 3 and August 14, 1989. Adults represented 80% (90) of the total, with sub-adults and immatures comprising 18% (20), and nestlings, 2% (3) (figure 1.). The preponderance of adults is probably a

Figure 1
Age Distribution of Captured Eagles



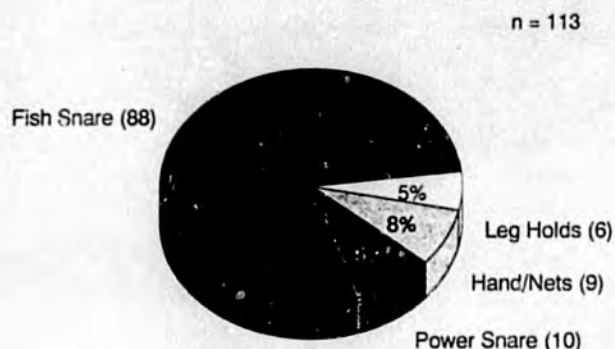
function of the season and that we targeted prime nesting locations. During the nesting season, breeding adults claim the prime areas, forcing non-breeders and younger birds to less desirable areas with more dispersed feeding sites and carrion sources (Brown, J.L., 1969).

The most successful capture technique proved to be a modified floating fish snare (see Appendix A for a description of this technique). The teams employed the floating fish technique to trap more than three-fourths (88) of the total sample. Nine eagles that had been weakened by injuries could be captured by hand or with nets. One team used power snares early in the program to trap ten birds, six of which were immature eagles. Another team used padded leg holds to successfully and safely trap four immature birds and two adults (figure 2).

Results On-Site Health Assessment

The vast majority of the captured birds met USFWS release criteria; teams immediately returned 98 (87%) of the eagles to the wild. Fourteen of the non-released eagles were transferred to IBRRC in Seward for short term rehabilitation and, in nine cases, cleaning (A fifteenth eagle from the capture teams — a severely injured eagle — was transferred

Figure 2
Capture Techniques Employed



to Anchorage, where it was later euthanized). Of the 14 birds sent to IBRRC by capture teams, 12 were returned to the wild eventually, most after about two weeks. Of the remaining eagles, one is non-releaseable, and the other which had broken its wing, is on loan from the USFWS to one of the authors for educational purposes.

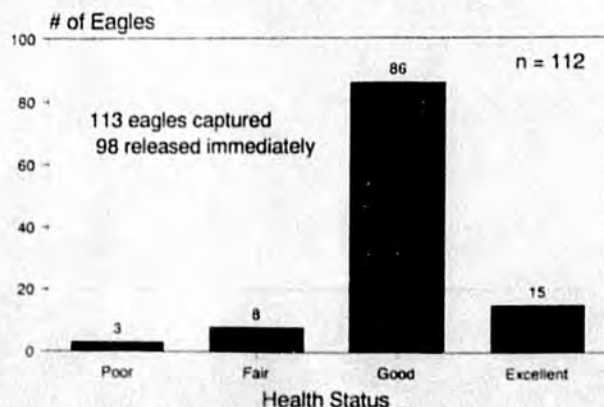
Physical Examinations

Of the 113 captured eagles, 101 (89%) were rated as being in excellent or good condition (15 and 86 eagles respectively), eight were considered in fair condition, three were in poor condition, and body condition was not recorded for one bird (figure 3). Records are incomplete for a few eagles, particularly from early in the program.

Teams marked 108 of the captured birds as alert, while three were rated as lethargic. All three of the lethargic eagles had been injured, two definitely had not been oiled, and there is no record of oiling for the third. After short term treatment by IBRRC, the three were sent to a facility in Anchorage, where they were held in captivity for one year and then released.

Physical examinations of eyes, nares, oral cavities and respiratory systems were equally positive. Except for one non-oiled bird with

Figure 3
General Health Status upon Capture



bloody nares and corneal opacities, all records noted bright eyes and clear nares. One bird's oral cavity appeared cyanotic, seven appeared pale, and 98, pink. As a result, capture teams determined that five of the birds with pale oral cavities were healthy enough for release. This determination was based on the totality of physical examination information including clinical pathology data. The average packed cell volume (PCV) of the five birds was 49%.

Capture teams also rated body condition of the eagles on a scale from one to five. A "one" would have indicated the bird was emaciated, and none of the birds received the "one" rating. A "five" indicated superior pectoral muscle development — a relatively rare condition for wild birds, particularly during breeding season (Gibson and Bloom unpublished). Only three eagles received a rating of "five." The vast majority (60) of the birds rated as a "three"; 37, as a "four"; and eight, as a "two" (figure 4).

External Oiling

The capture program documented evidence of oiling on the captured birds. Teams members took field notes and photographs for documentation (see photos attached for examples). They were particularly concerned about signs of oil around the beak, neck or vent because this would denote possible ingestion.

Records indicate that 39 eagles (35%) exhibited no evidence of oiling. In addition, degree of oiling was not specifically noted for 35 birds (31%). A blank on the form was understood to represent no oiling. Since oiling was the focus of the capture program, it is likely, but not certain, that birds without oiling notations were also non-oiled. Of the 39 eagles (35%) for which oiling was noted, one was classified as heavily oiled, three as

moderately, and 35 as lightly (i.e., spots, stains or sheens along the tail fringe or on the feet; figure 5). Most of the 39 oiled birds appeared in good condition overall. Their health ratings were as follows: five, excellent; 29, good; four, fair; and one, the heavily oiled bird, poor.

Because oiling was typically limited, often to a spot the size of a dime, capture teams would occasionally "spot clean" eagles on the capture vessel. Teams were able to wash thirty of the oiled birds and release them immediately. They forwarded the other nine birds to the IBRRC for processing and washing.

Bloodwork

Because of earlier studies of oiled seabirds, it

Figure 4
Body Condition upon Capture

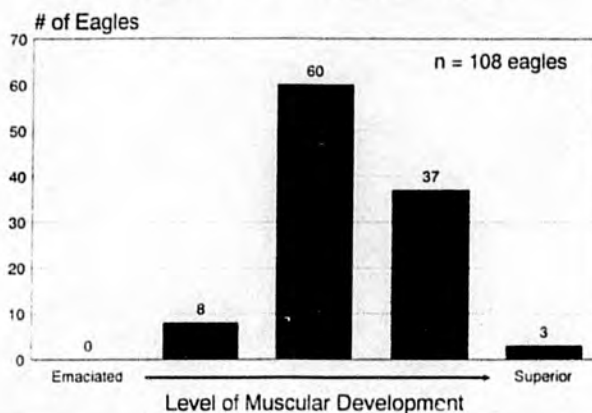
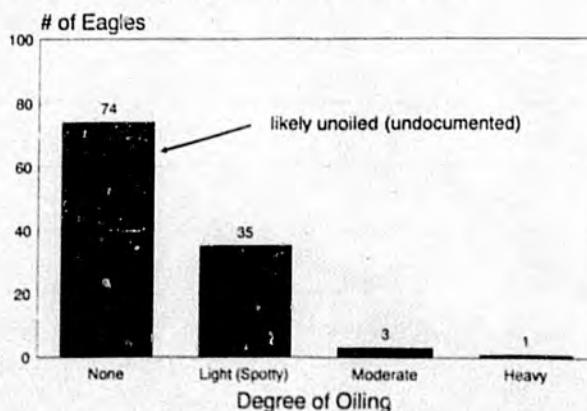


Figure 5
Oiling on Captured Eagles



was feared that eagles in the spill area might suffer from hemolytic anemia and kidney and/or liver insult (Williams, 1985; Fry, 1987). In addition, PCV is a good clinical indicator of health stamina and is an important criteria for release. To determine the PCV of the blood, each capture boat was equipped with a microhematocrit centrifuge. To obtain a sense of a bird's nutritional status, as well as get an indication of liver or kidney problems, teams measured total solids using a refractometer. Total solids are the amount of plasma substances found in healthy birds (glucose, uric acid, plasma proteins, etc). In debilitated birds, this value is often depressed.

The capture teams drew blood (approximately 10 cc's) from the brachial vein using a heparinized 20-25 gauge needle. With the same needle, the team

leader immediately made four blood smears on alcohol cleaned slides. The slides were then air dried, fixed in absolute methanol, and stored in microscope slide boxes.

In general, the results indicated that the hematopoietic (i.e., blood manufacturing) systems were in good shape. We collected 77 acceptable samples for PCV counts—10 from treated birds and 67 from immediately released birds. Among the 67 samples from immediately released birds, the minimum was 35%; the maximum, 68%; the mean, 46.6%; and the standard deviation, 5.8%. For the 10 treated birds hematocrit levels ranged from 20% to 68%, with a mean of 46.0% (standard deviation is 5.8%). Using a total of 85 samples, including 10 treated birds, total solids ranged from 2.5 g/dl to 7.3 g/dl, with a

mean of 4.1 g/dl (standard deviation is 0.7 g/dl); (figures 6 and 7). Among the 75 samples from immediately released birds, the statistical results are identical to those for the total sample of 85.

Based upon data from rehabilitated birds in captivity, the USFWS determined that rehabilitation care might be justified for birds with total solids below 4.0 g/dl or PCV below 40%. However, standards were not based on data from a wild population and were viewed as guidelines, not as firm criteria. USFWS directed capture teams to consider blood levels in the context of the birds' overall conditions. Low total solid values only compelled rehabilitation when combined with other signs of distress. With this in mind, the capture teams considered and released 17 birds with total solids below the 4.0 guideline. Release in each case was justified by the evident health of the bird.

The two on-board blood tests were micro-techniques, requiring less than 0.5 cc's of blood. The microscopic slides and the remaining blood (six to nine cc's)

Figure 6
Distribution of Hematocrit Measurements

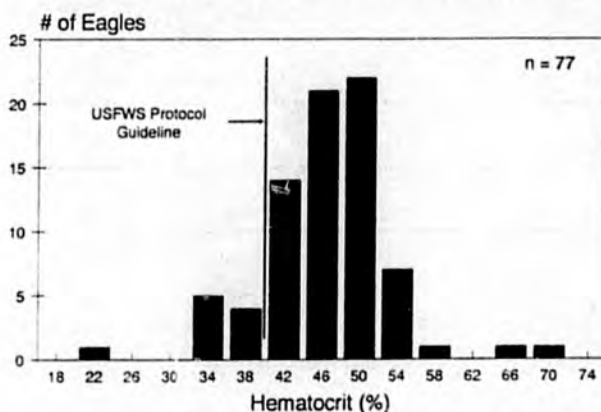
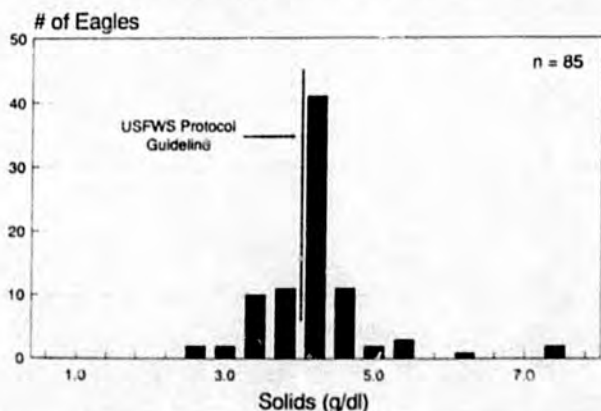
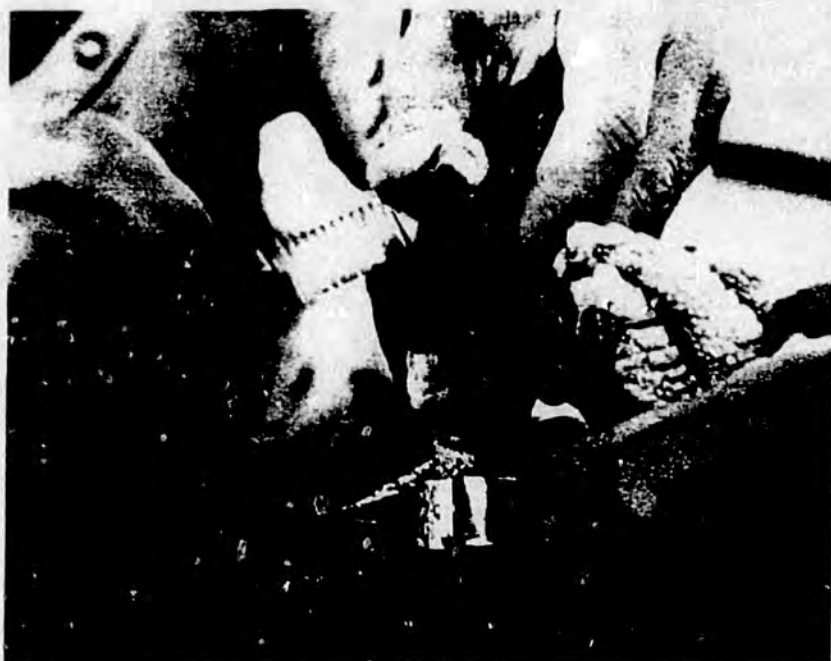


Figure 7
Distribution of Protein Measurements





In the few cases where eagles were oiled, we could usually spot clean the birds and release them immediately. Nine eagles were cleaned by the IBRRC in Seward and later released.

were put in heparinized tubes, separated, and frozen for shipment to Dr. Pat Redig at the Raptor Center of the University of Minnesota. Dr. Redig subsequently conducted comprehensive blood chemistry and hematological examinations, which have confirmed the positive findings of the field examinations (Redig, 1990).

Short-Term Rehabilitation Center

Background

The non-profit International Bird Rescue Research Center served as the short-term eagle rehabilitator following the Valdez spill. IBRRC has a long history of developing and directing rehabilitation efforts for wildlife affected by oil spills. Since 1971, IBRRC staff has consistently provided professional advice about rehabilitating oiled wildlife and, on more than 25 major spill responses, established and directed emergency oil spill rescue and rehabilitation programs.

The Alyeska Pipeline Company, which manages spill response for the Trans-Alaskan Pipeline and the Valdez area, had contracted IBRRC to serve as wildlife rehabilitators in the event an oil spill

impacted wildlife in Prince William Sound since 1979. When the Valdez accident occurred on March 24, 1989, Alyeska contacted IBRRC and requested immediate action. By early the next morning, March 25, IBRRC staff had begun to set up and operate a response.

During the next month, bird rehabilitation centers or initial care sites were instituted in Valdez, Seward, Kodiak and Homer. The IBRRC bird rescue program operated through mid-September. While the centers focused their efforts on the area's seabirds, it was also prepared to handle eagles.

In total, rehabilitation centers handled 39 eagles between April 11, 1989 and August 20, 1989. As noted above, eagle capture teams supplied 15 of those birds. Mem-

bers of the public and, in one case, USFWS personnel delivered the other 24.

Medical Evaluations and Treatments

Upon arrival at the IBRRC facility, each of the 39 eagles was given a physical examination and checked visually for oil on feathers. The veterinary staff weighed each bird and, when warranted, performed tracheal cultures to check for candidiasis and aspergillosis, common respiratory ailments. Fecal samples were examined by direct microscopy, as well as floated for parasites. We also drew blood to assess red blood cell status and to conduct serum chemistries. We used two off-site labs for bloodwork, as well as in-house lab equipped with an Abbott[™] Visions machine.

While at IBRRC facilities, eagles were monitored routinely with serial serum chemistries (approximately weekly) and hematology (PCV, total proteins, total solids, white cell counts). Beginning in mid-June, staff performed routine tracheal cultures on most of the birds. Routine parasitology proved unrewarding, but was performed on in-house birds. Eagles were photographed to document their condition while in the program.



Blood work reassured that the released eagles did not have internal problems.

Only nine of the eagles had enough oil on them to warrant cleaning (see appendix B for cleaning techniques). No parasites were found in fecal flotation or direct examinations. Staff performed tracheal cultures in-house on 14 birds for fungal/yeast growth. Only two cultures showed any growth; neither showed fungus.

On the whole, blood work performed on these birds was within normal ranges. Birds presented with old infected injuries exhibited elevated white cell counts and slightly depressed PCV, as would be expected with chronic anemia of disease. Many eagles had slightly elevated enzyme CPK, a natural occurrence given that they would have exerted significant muscle activity during trapping.

Birds from the capture teams typically had some oil to be evaluated for removal (usually spots on tail feathers) and slightly depressed total solids. After a week to ten days of rest and good food, these birds usually responded well and the total protein

levels would climb to about the 4.0 g/dl, allowing release according to the USFWS protocol.

Two of the birds from capture teams had medical problems thought to be unrelated to the oil spill. One immature bird had avian pox and was sent to the Raptor Center in Minnesota for surgical treatment of lesions. It was returned before the end of the summer and flown back into the exact territory in which it had been caught. Another was missing the tip of its wing, making it non-releasable.

In contrast, most of the birds delivered by the public had the types of serious medical injuries that are seen regularly in wildlife care centers. At least five bald eagles had fractured limbs. Various other cases included one bird that had been hit by a car, two that had lead poisoning, and others that had problems ranging from old facial wounds, leg lacerations, wing droop, swollen legs. Most of these injuries were old and were likely to be non-spill related.

The records indicate that 11 of the public-captured birds had some evidence of oiling; ten were not oiled, and there were no notations for three of the birds. Although it is not likely that many of the public-captured birds had spill-related problems, IBRRC admitted them for humanitarian reasons. Many of these birds would have died if a program to save oiled bald eagles had not been in place.

The serious medical problems of public-captured birds were reflected in hematological tests and total solid readings. The incoming PCV on this group of birds ranged from 17% to 50% with an average value of 36% — about 10 percentage points less than field captured eagles. Total solid readings ranged from 1.0 g/dl to 4.4 g/dl, with an average of 3.4 g/dl. While not dramatically depressed, this figure is significantly lower than the capture team birds.

Release Criteria

To determine whether bald eagles met release criteria, the staff conducted physical exams and pre-release blood work. Additionally, we tested eagles for flight ability in large flight aviaries or on flight lines (creance lines). We completed serum chemistries and blood counts in-house, or at Seward General Hospital. In this way, timely results could be obtained and the period of captivity could be kept as

short as possible.

Using the established protocol, IBRRC released eagles when the bird's hematocrit exceeded 40%, total solid readings exceeded 4.0 g/dl, and when relevant, medical problems had been resolved. At release, the birds were measured, weighed, and banded.

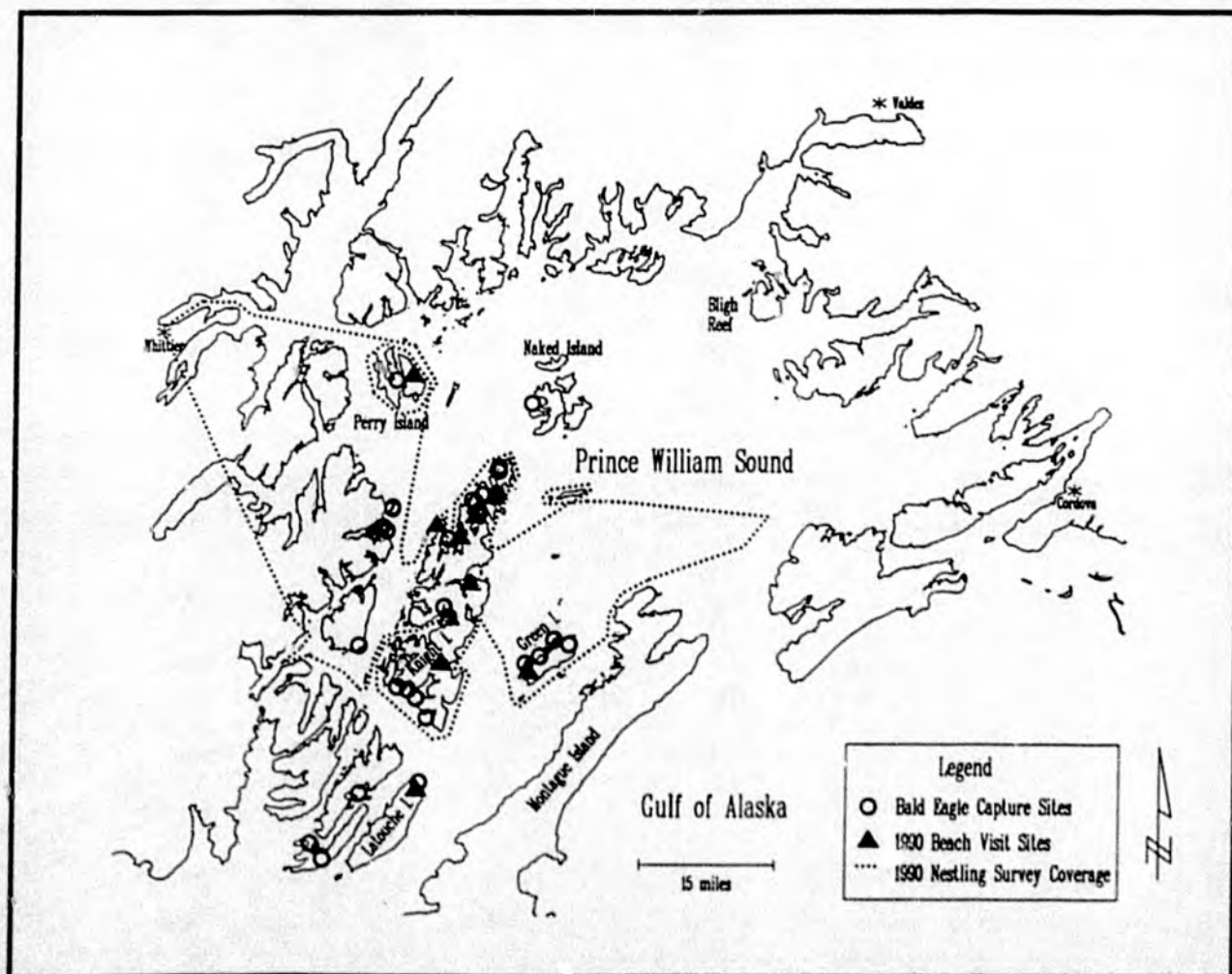
Of the 15 capture team birds, nine were released in 1989, three others were released in June 1990, one was euthanized, one is on loan from the USFWS to one of the authors for educational purposes and one is held. Of the 24 public-capture birds, eight were released in 1989 and another four were returned to the Sound in 1990. That is, 24 of the 39 birds (62%) were eventually released. Six eagles are non-releasable and remain in captivity, including four at the Bird Treatment and Learning Center in Anchorage, and one at a facility in New Mexico.

Conditions in 1990

USFWS Survey of Active Nests

In preparation for the summer 1990 Exxon beach clean-up operations, USFWS surveyed eagle nests in the oil spill area to assess whether clean-up operations might disturb nesting pairs. Their appraisals covered segments of Prince William Sound, the Kenai Peninsula, Kodiak Island, and the Alaskan Peninsula (see maps).

Wherever active nests were observed, access to the immediate area was restricted jointly by Exxon and USFWS in order to prevent the possibility of nesting loss. Initially clean-up crews and boats were prohibited from approaching closer than 1/4 mile of the nest; aircraft were not to approach closer than 1/2 mile. These restrictions were all reduced to 1/4 mile due to the program's success, and ultimately



USFWS dropped these restrictions altogether.

Geographically, the breakdown of active nests in previously oiled areas is as follows:

Region	Number of Active Nests
Prince William Sound	268
Kenai Peninsula	105
Kodiak Island	407
Alaskan Peninsula	251
TOTAL	1,031

Field Observations

The authors visited the Prince William Sound area in 1990 to gauge qualitatively the reproductive success of eagles in previously oiled areas. The trip was made in August when the nestlings were nearing fledgling age.

We observed numerous eaglets and recent

fledglings throughout the area (see photographs). In 1990, many pairs were not only occupying previously oiled territories, but they had also nested, laid eggs, incubated, and hatched chicks that had developed normally. These sightings, along with the 1,031 active nest count, are a positive contrast to 1989, when, according to USFWS, only about 200 young were produced in the Prince William Sound portion of the spill area (USFWS, 1989). If oil was still a problem, it could have most likely prevented the completion of the nesting cycle.

During our habitat observation trip, we also revisited many of the islands and bays that had been most heavily oiled in 1989. Again, the contrast between 1989 and 1990 was significant. We returned to beaches that last year had several inches of bulk oil covering everything. This year those same beaches appeared restored, not only by continuing



clean-up operations but also the natural cleansing forces of Alaska's harsh winter storms.

Our visit also coincided with the return of pink salmon to the area's spawning streams. Their presence underscored the ample food supplies available to eagles in Prince William Sound. Because these fish had been juveniles during the spill, there had been concern about the size of this year's catch. Such concern was put aside, however, as local fisherman celebrated the largest commercial catch of pink salmon in Prince William Sound ever recorded (Wall Street Journal, 1990).

Because so many birds were fledging during our visit, and because there were two chicks in many of the nests, we conclude that food sources were more than adequate. We also conclude that oil did not pose a threat to the area's bald eagles in 1990.

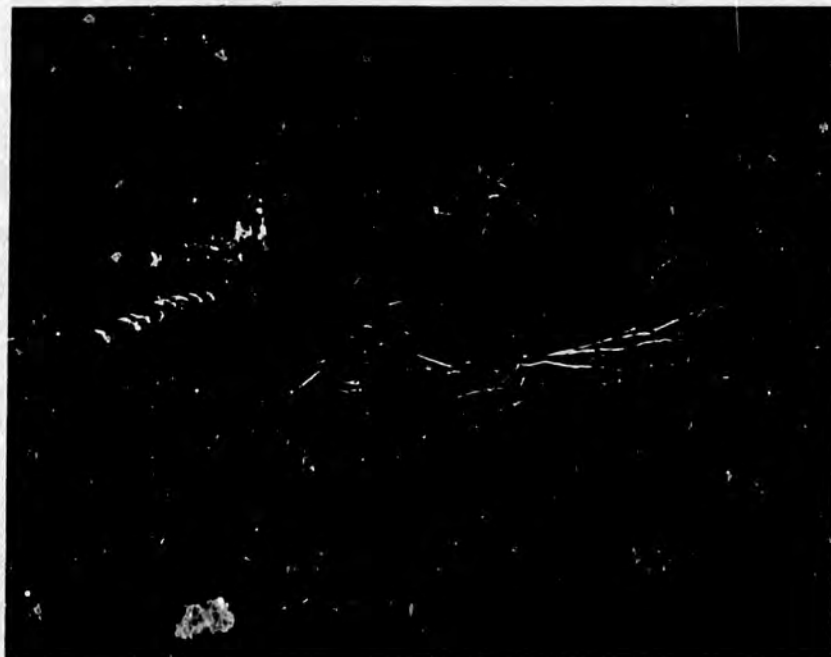
Discussion and Conclusion

The evidence from the 1989 Eagle Capture and Assessment Program, as well as the qualitative observations in 1990, indicate that the Valdez oil spill was not the catastrophe for bald eagles that we had originally feared. There was indeed eagle mortality in 1989. USFWS recovered 153 carcasses during the summer of 1989, and many of those were likely victims of the oil spill. But preliminary fears that most of the area's estimated 5,000 eagles would die have not been supported by the facts. A year after the spill, the bald eagle population in the area seems healthy.

Most theories about why the eagles tolerated the oil spill so well are related to the bird's physiology (Duke, 1986). Like other birds of prey, bald eagles have the ability to collect in their crop undigestible products such as the large bones, fur, and feathers of their prey. The eagle egests this material daily. It may be that the eagles can egest tar balls in this manner without an effect to the bird (Duke, pers. comm.).

There is, of course, significant doubt about whether most eagles even ingested oil. It seems that eagles could have easily found non-oiled areas in which to hunt and eat. First, large portions of Prince William Sound and the Gulf of Alaska were never oiled in 1989. The tanker spill impacted only about 10% to 15% of the area's linear shoreline. Second, because the pattern of oil dispersal was dictated by the ocean currents, the oil was not evenly distributed in 1989. Where one beach might be loaded with crude, another only a mile away might be totally clean. Finally, within a couple of months, there was little oil left on the waters in Prince William Sound (Neff, 1990). This is important because the primary prey for eagles in the area is fish.

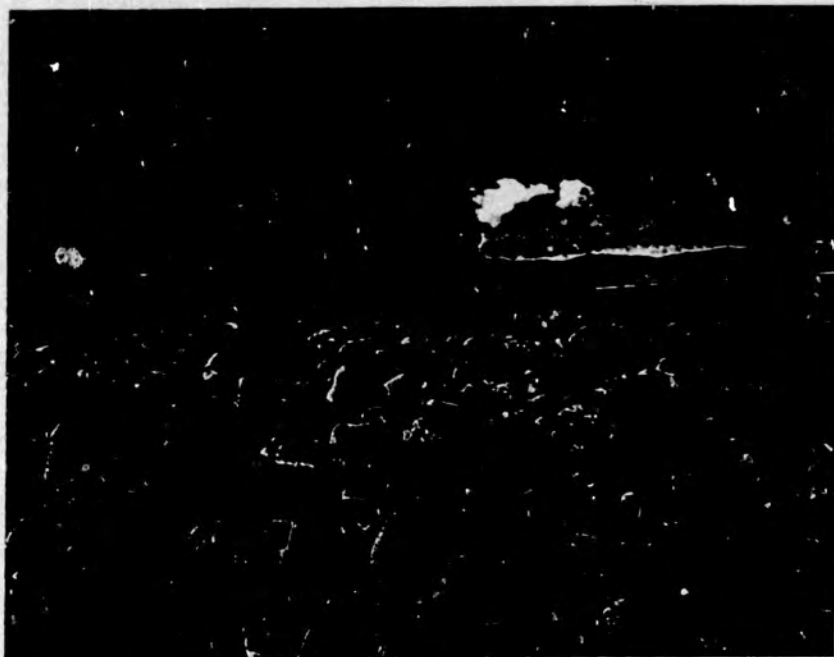
While initially there were reports that the eagles were attracted to oiled carrion, the capture teams did not notice the bald eagles hunting in oiled areas. We trapped eagles in some very heavily oiled areas in 1989, but the captured birds were usually not only healthy but also clean (see attached photos). We also found that eagles would ignore our floating fish snares if they were set near an oiled shoreline (within 30 meters) or other contaminated areas. Only after teams reset in a clean area within the same territory would a bird respond.



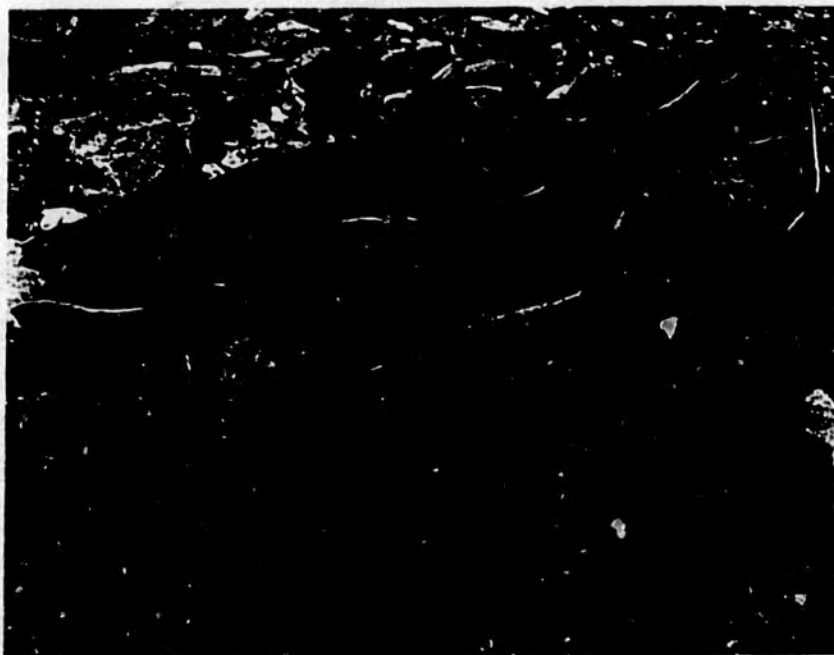
USFWS pinpointed more than 1,000 active eagle nests in 1990. Many held more than one chick.

The nature of crude oil also might have mitigated the impact of the oil spill. Within a few days after the spill, most of the volatile components of crude had already evaporated (Neff, 1990). Within a few weeks, the crude had altered chemically enough that it posed a reduced threat to wildlife. By the time it reached Kodiak Island, the oil had formed into a biologically inert oil-water emulsion commonly called mousse. Therefore, few birds were oiled.

Whatever the reason, the bald eagle population in Prince William Sound is evidently thriving. In spite of the Valdez oil spill, we can be generally optimistic about the future of the Prince William Sound bald eagles.



The Prince William Sound eagle habitat has essentially been cleansed of oil, thanks to natural processes and clean-up efforts. What little oil remains has weathered to the point that it would not present a problem for eagles.



Salmon returned to Prince William Sound in record numbers this year. These ample fish stocks are good news for eagles, who prey primarily on fish for food.



Acknowledgements

A paper of this nature would not have been possible without the commitment and efforts of many.

We express special appreciation to Valdez team members Teryl Grubb and Glenn Stewart and Kodiak I team members Dick Anderson, Linda Spiegel and Robert Haussler, to Harry Dodge, who served as bear guide for both Kodiak teams. A special note of thanks to the crews of the Myra Jean and the Maricor, as well as many fine pilots, with whom we weathered many storms. Also thanks to Greta Angason of IBRRC for developing the database that made much of this paper possible.

We specifically thank Phil Schempf of USFWS for introducing us to the "Robards" trapping technique, and to Dave Harlow and staff at the Anchorage USFWS for working with us to develop protocols under crisis conditions. Thanks to Ed Henckel, Judy Henckel and Peter Harrity of the Kodiak II capture team, who helped refine the capture techniques and gave helpful advice on this paper.

We are grateful as well for the advice and encouragement given by Pat Redig and Peter Bloom. Also to Pat Redig's staff (Jean Dunnette, Paula Lind, and Barbra Talbut) at the University of Minnesota Raptor Center for their roles in the medical assessment.

In addition, we thank Exxon for supporting the 1989 Eagle Capture, Assessment and Short-term Rehabilitation Program, as well as for their review of this paper.

Finally, we want to underscore our appreciation of families, friends and colleagues who understand our extended absences from home and offer unflagging moral support.

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Appendix A

Eagle Capture Techniques

While capturing bald eagles is always a challenge, conditions in Prince William Sound and Kodiak Island made trapping even more difficult than usual. Such conditions inspired the capture teams to refine trapping techniques. This appendix describes the development of the technique that proved superior.

The teams considered four general capture techniques: 1) net gun; 2) power snares; 3) padded leg-holds; and 4) floating fish snares. Because of the Sound's harsh weather, occasionally violent seas, and near freezing water temperatures, the net gun techniques were considered too dangerous to employ. The risk of injuries or fatalities for the birds and the capture teams was simply too great.

Land sets were used on a limited basis with some success. In June, the first team based in Kodiak employed power snares to capture eight birds, six of which were immature eagles (immature birds appeared to be more susceptible to carrion-baited traps). The Valdez team caught six eagles, including two adults, using leg holds. Trap safety did not present any problems with either technique, but conditions such as the following did preclude more extensive use:

- Tide shifts of 20 feet and more prevented teams from using shoreline sets for extended periods.
- Extended daylight made unobserved placement difficult.
- Other native wildlife, most notably bears, would often abscond with the bait.
- Because all animal carcasses in the spill area were picked up for necropsy studies, bait for the traps could not be found in the area easily (The most successful bait came from a single seal carcass, which was hauled around for several weeks).
- Purchasing fish stocks from local fishing villages also proved futile. The local bear population would often devour the cache before it could be used.

The capture method of choice became the floating fish snare. Used historically by the USFWS in the area with great success, the general technique is based on the "Robards method" (unpublished citing and Cain and Hodges, 1989 *Journal of Raptor Research*). We refined the technique to meet the peculiar conditions of Prince William Sound, as well as seasonal conditions and feeding habits.

The floating fish snare is an eagle-triggered multi-noose system. For bait, we preferred either trout or black cod ranging from 20 cm to 30 cm in length. Eagles seemed disinterested in herring, perhaps because the oily sheen it creates either seemed distasteful or because the sheen made the snare more visible. An attempt was also made to bait with seal blubber, but it was so soft that nooses would slip from it.

To enable floatation, two methods were used. If the fish had been gutted, we sewed a styrofoam plug into the abdominal cavity

with cotton thread. If not, we carved a styrofoam plug for each fish and inserted it behind the gill. A single, high density styrofoam plug is recommended. If the eagle escaped with and ate the styrofoam, it would be best able to cast the single piece.

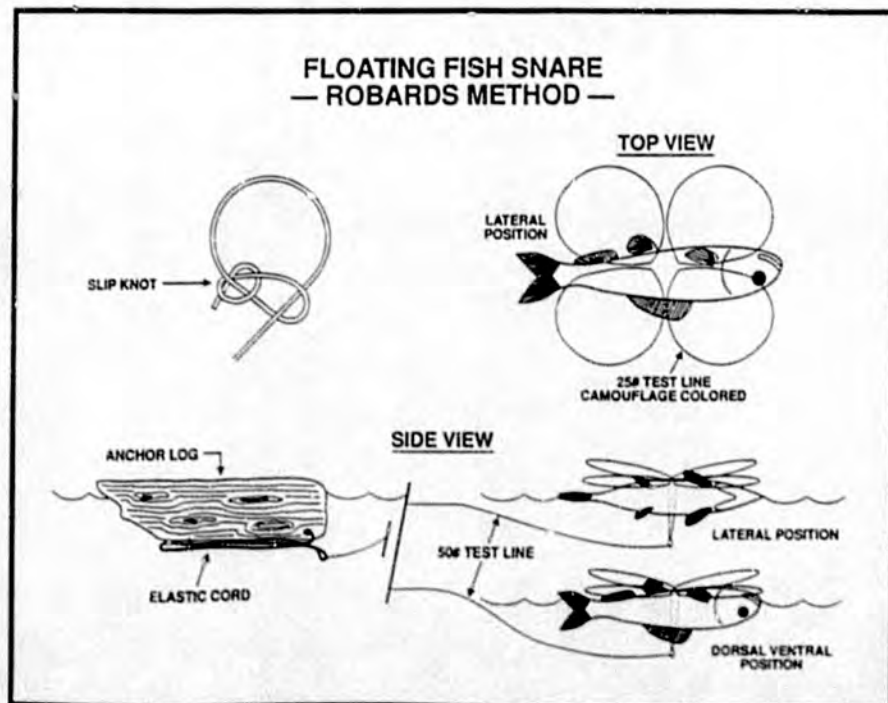
We configured a clover-leaf shaped noose (see illustration) using 25 pound test clear monofilament line. Four 18 inch segments were tied into four slip-knot nooses, each about four inches in diameter. A hole was punched through the dorsal, the styrofoam plug (if necessary) and the ventral at the center of the fish. We tied the four nooses to a separate 25 pound monofilament line that ran through the fish and connected to a bungie cord, which was in turn attached to a log. The nooses protruded from the dorsal side of the fish, clustered above the fish and stood clearly out of the water (The bait floats ventral-side up). Knots were tied at the ventral and dorsal openings to provide stability to the snare. If the punch holes were so large as to inhibit stability, they were reduced in size with a few stitches of cotton thread. A second variation of the floating fish mounted the nooses on the fish's lateral side with all other specifications remaining the same as the dorsal ventral version.

The size and shape of the anchor log was crucial to capture success. If the log offered too much resistance, the eagle would drop the bait before the noose tightened firmly. We found a cylindrical log approximately two feet in length and four inches in diameter was ideal.

Before setting the trap, an eagle was located on a hunting perch overlooking the water. A team using a skiff would place the fish in direct view of the eagle. The distance between the snare and the eagle was usually between 100 and 200 meters, depending upon tide and wave activity. The skiff moved away from the snare but kept both the bird and the trap constantly in sight. The skiff had to be prepared to seize the eagle within 45 to 60 seconds of ensnarement.

Once caught in the noose, the eagle would lift the fish and the anchor log from the water with little difficulty. However, the pendulum motion of the log would inhibit the bird's flight, and the weight would bring the eagle quickly and gently to the water's surface. The team on the skiff motored into place to seize the eagle, restrain its wings, and place a hood. The bird was transported immediately to the main vessel for processing.

As improvements were made in snare setting techniques, the capture success rate rose. Teams initially used 50 pound monofilament line for the noose configuration, a large block-shaped log as the anchor, and water surface noose placement. Capture success improved about 75% when teams began employing the more difficult to see 25 pound monofilament, the less resistant log, and the above water noose placement.



Appendix B

Short-term Rehabilitation Techniques

Nine of the bald eagles delivered to IBRRC during the Valdez oil spill required cleaning. As far as we know, our care and treatment of these birds comprise the wildlife rehabilitation community's entire experience with oiled bald eagles.

Cleaning and rehabilitation methods for bald eagles are similar to those used for other oiled birds, but there are important differences. Eagle feathers, for example, absorb rather than repel water. In addition, eagles are capable of inflicting serious injury to unwary staff.

Because cleaning can be stressful, we stabilized all eagles for at least 24 hours before initiating treatment. Un-hooded eagles were housed in individual wooden mews (8' x 8' x 6' H) with netted tops covered with sheets. Natural perching was provided.

Before cleaning, staff placed hoods on the eagles to block visual stimuli and to calm the birds. Three or more people held the eagle as washing proceeded. We wrapped the talons in sturdy tape, and one person was responsible for holding the head at all times.

We used a solution of fresh water and 1% Dawn dishsoap for cleaning. A large circular metal bucket (about 30 gallons) served as the cleaning tub. Depending on degree of oiling, cleaning required from 30 to 60 minutes. Rinsing, which took place in the same stalls as were used for seabirds, required about an hour.

Because eagle feathers had become saturated with water during cleaning and rinsing, staff returned the birds to the wooden mews for drying. Pet dryers were placed in windows and heated the mews to 95 degrees F. The birds would perch until completely dry, usually about six hours.

One of the cleaned birds had broken its wing, and it was transferred to Anchorage. Staff placed the other eight birds in one of two outdoor flight pens (32' L x 24' W x 16' H) until they could be released. We also equipped these pens with natural perches.



The Abundant Bald Eagles of Prince William Sound, Alaska



Alaska's Prince William Sound encompasses what may be the world's largest concentration of bald eagles. Experts like Miguel Colón have been studying the area's eagles since the World War II occupation there. In March 1980, the results offer good news.

February 1991

More Than 5,000 Eagles and Eaglets

Prince William Sound is a near perfect habitat for the bald eagle. Thanks to ample food sources and shoreline forests for perching and nesting, more than 5,000 bald eagles make the area their home.

Biologists believe the population is a "saturated" one. That is, the environment could not support a larger stable eagle population.

In 1990, the U.S. Fish & Wildlife Service pinpointed more than 1,000 active eagle nests in the area.



More than 1,000 active eagle nests were pinpointed in the area during 1990 by the U.S. Fish & Wildlife Service.



Eagles and humans alike feasted on the 1990 record-breaking pink salmon catch.

1990's Record Fish Harvests

Many of Prince William Sound's eagle nests support more than one chick. That is unusual, since eagles in

most places find it too difficult to secure enough food for more than one youngster.

But food is not a problem in Prince William Sound. The eagles can rely on the area's renowned fish stocks for prey.

1990's record-breaking commercial salmon and herring harvests reflect the abundance of fish stocks in the area.



Less than 20% of the Prince William Sound area coastline was oiled in 1989. Today, the shorelines are essentially clean.

Clean, Nearly Recovered Habitat

Following harsh winter storms and two summers of clean-up operations, Prince William Sound is essentially cleansed of oil from the Valdez spill. By the end of 1989, there were no oil slicks on the water's surface and the small amount of oil that remained had "weathered" (i.e., changed chemical composition) and presented no threat to eagles.

Immediately after the accident, eagles were able to find non-oiled areas in which to hunt fish. The tanker spill impacted less than 20% of the area's shoreline. Also, because the pattern of oil dispersal was dictated by the ocean currents, the oil was not evenly distributed in 1989. Where one beach might have been covered with crude, an adjacent beach might have been totally clean.

Healthy, Thriving Eagle Population

Immediately after the 1989 oil spill, many people feared the worst and worried whether eagles would be able to recover from the spill. Now, nearly two years after the spill, the evidence shows that eagles and eaglets are thriving in the area.

The Valdez spill was an unfortunate accident and everything reasonable should be done to prevent another spill. Nature's restorative powers should not be taken for granted.

Yet, now that the evidence shows that the eagles are doing well, we can be grateful for nature's resilience.

Now that the evidence shows that eagles are doing well, we can be grateful for nature's resilience.



Marge Gibson has focused her life on caring for birds of prey through research, education and rehabilitation. In 1989, she led a team of eagle experts who captured Prince William Sound bald eagles to evaluate their health following the Valdez oil spill.

If you are interested in more details about the Prince William Sound bald eagles, please write to: Exxon Company, U.S.A., Eagles, P.O. Box 2180, Houston, Texas, 77252-2180 for a technical report entitled "Results of the Eagle Capture, Health Assessment and Short-term Rehabilitation Program Following the Valdez Oil Spill" by Marge Gibson and Jan White, D.V.M.



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