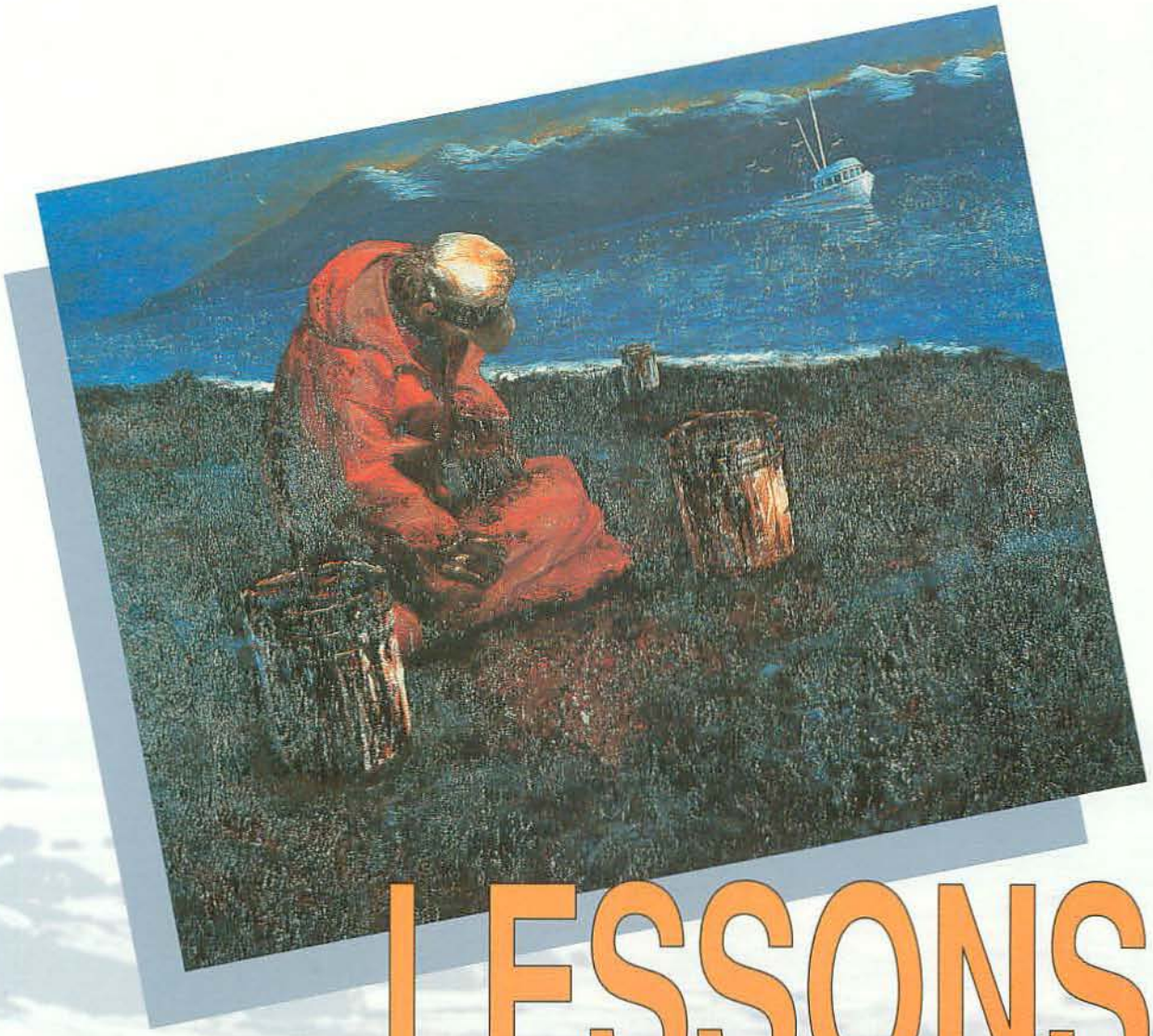

LESSONS
of the Exxon Valdez

Alaska Sea Grant College Program

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Lessons of the Exxon Valdez

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Information and Review

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Production

Lessons of the Exxon Valdez essay was written by Rick Steiner and edited by Kurt Byers. Remaining chapters were compiled and written by Kurt Byers. Sue Keller proofread and edited the booklet. Douglas Schneider provided research assistance on the technology chapter. Kurt Byers designed the publication, Susan Burroughs designed the cover and several pages, and pasted up the booklet; and Karen Lundquist provided design advice. Lisa Sporleder assisted with proofreading and desktop publishing. Typesetting was by Color Art Printing of Anchorage and Automated Business Center of Fairbanks, color separations by Alaska Color Scan of Anchorage, and printing was by University of Alaska Printing and Duplicating Services.

Cover

Cover painting, entitled *Highliner's Blues*, is by Lynn Waldorf, an artist who divides her time between Homer, Alaska, and Oakland, California. Waldorf's painting was part of an art exhibit at the Visual Arts Center of Alaska in Anchorage, entitled *Ground Zero*. The exhibit gave artists and other residents in communities hit by the spill an opportunity to convey through art their feelings and impressions about the oil spill. *Highliner's Blues* has been purchased by the Pratt Museum in Homer, and is on display there. Background cover photo is by Kurt Byers and shows Fossil Cliffs on Kodiak Island along the Gulf of Alaska.

Photographers

Kurt Byers is communications manager with Alaska Sea Grant at the University of Alaska Fairbanks, and his photographs have appeared in *Michigan Natural Resources* magazine, *Michigan Natural Resources Register*, *USDA News*, newspapers throughout Alaska and in Michigan, and university publications. Roy Corral is associate editor of *Alaska* magazine in Anchorage, and his photographs have appeared in *Alaska Fish & Game*, *National Geographic*, *Alaska*, *Outside*, and in newspapers. Alissa Crandall is an Anchorage photographer whose work has appeared in the magazines *National Park*, *Alaska*, *Backpacker*, *Wildlife Conservation*, and in Sierra Club calendars and the *Christian Science Monitor*. John Hyde is a visual information specialist with the Alaska Department of Fish & Game in Juneau, and his photographs have appeared in *National Wildlife*, *Natural History*, *Audubon*, *Outdoor Photographer*, and *Sports Illustrated*. Geoffrey Orth is a Fairbanks photographer and commercial fisherman whose photographs have appeared in *Paris Match*, *Bunte*, *L'Express*, *Le Figaro*, and in *U.S. News and World Report*, *Newsweek*, *Life*, *Outside*, *National Fisherman*, and *Pacific Fishing*. Jeff Schultz is an Anchorage photographer whose photographs have appeared in *Time*, *National Geographic*, *American Photographer*, *Audubon*, *Sports Illustrated*, and *Outside*. Marion Stirrup is a Kodiak, Alaska, photographer and writer whose photographs have appeared in *Alaska*, *Alaska Fish & Game*, *Sierra Club*, *Sea Frontiers*, and *National Geographic* magazines.

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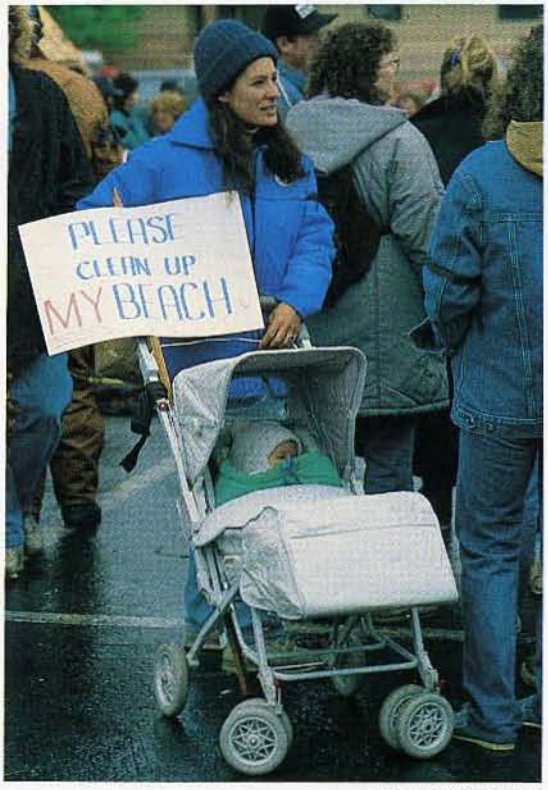
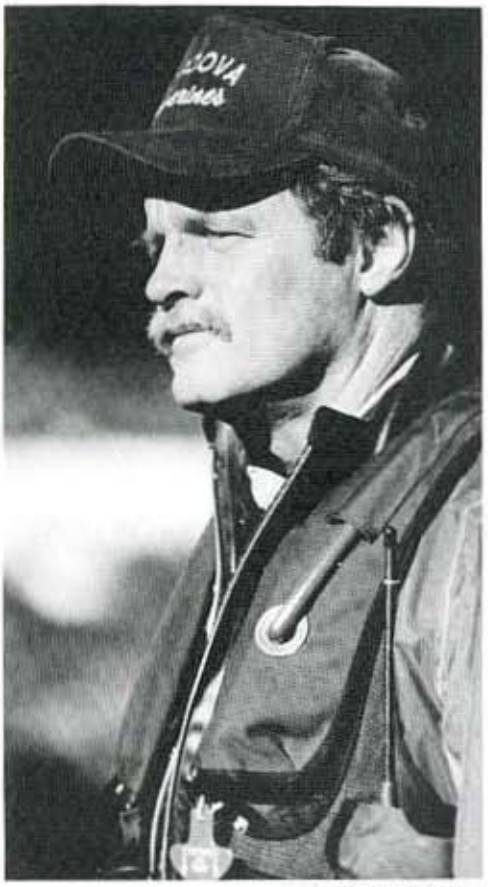


One of 1,000 concerned citizens at a Kodiak Island rally.

Foreword



Governor Steve Cowper on inspection tour of an oiled beach.

The wreck of the *Exxon Valdez* was more than just another oil spill. It was the most significant environmental disaster of the decade and has served as a catalyst for sweeping revisions of how this country deals with oil spills. It has triggered a new sense of environmentalism throughout the world.

Before you now is *Lessons of the Exxon Valdez*, a document with one fundamental and commendable purpose: preventing another *Exxon Valdez* tragedy from ever happening again.

It looks at the oiling of Prince William Sound and other areas of southcentral Alaska as a "teachable moment" in history, beckoning politicians, educators, conservationists, and people in all walks of life to learn from and avoid repeating this catastrophe.

Lessons of the Exxon Valdez provides a look at the many months of scientific and technical research into circumstances that allowed the accident to happen. It proposes preventive solutions that must be part of the public discussion about oil spills. It is instructive, useful, and good reading for those interested in a broad overview of one of America's most unfortunate environmental events.

—Steve Cowper
Governor of the State of Alaska

Introduction

KURT BYERS

Rick Steiner.

This public education booklet features an essay on prevention and control of oil spills. It is intended to provoke thought and action among industry, government, and the public that will lead to safer transport of oil, more effective ways of responding to oil spills, and less dependency on petroleum products.

The essay is followed by a summary of environmental and biological effects of the spill accompanied by information on state and federal research, an overview of oil spill containment and cleanup technology, and a summary of significant state and federal legislative action. Also included is a list of other publications for readers who would like to explore in greater detail different aspects of the spill.

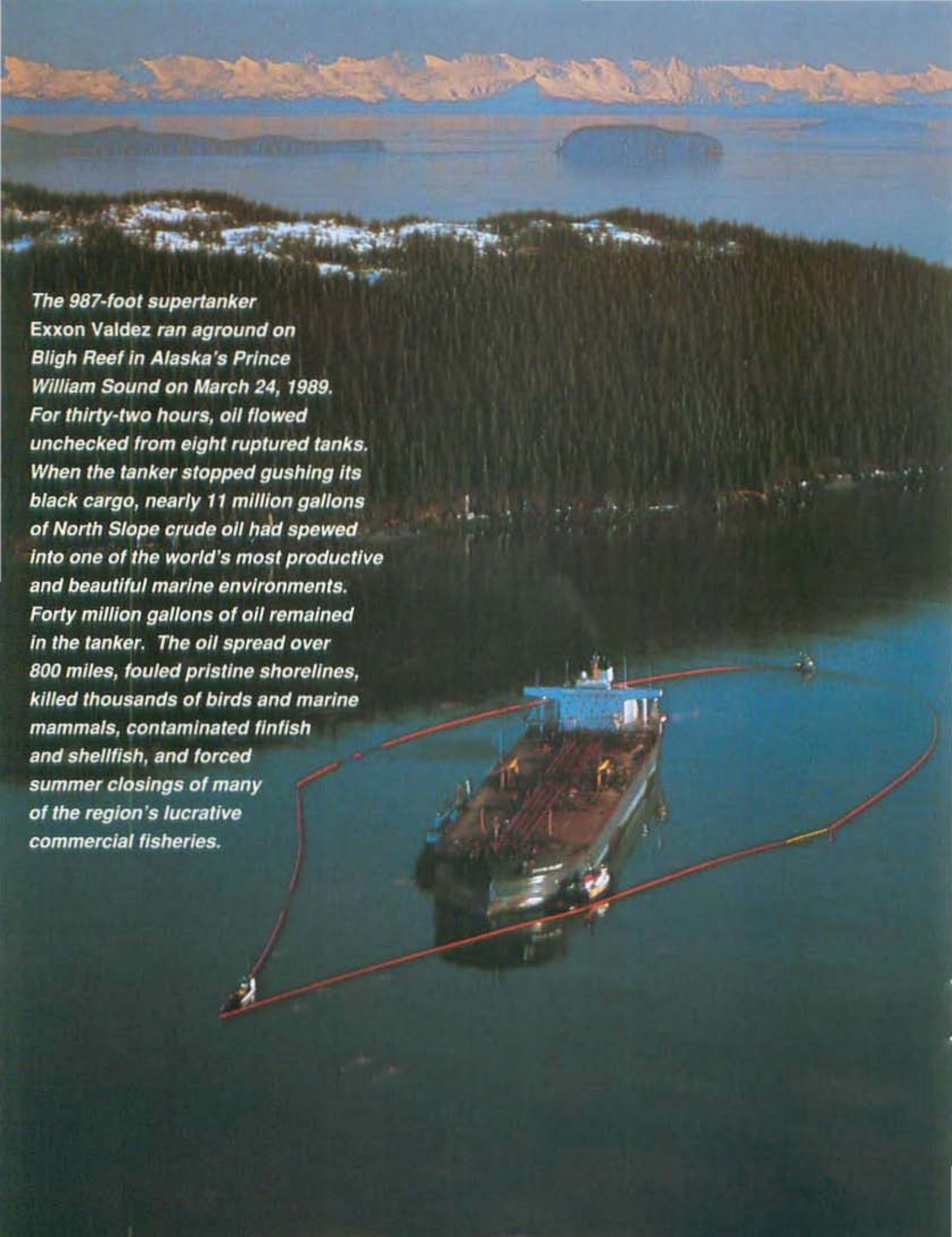
The essay was written by Rick Steiner, associate professor of fisheries with the University of Alaska Fairbanks. Steiner, now on sabbatical leave, is the Sea Grant Marine Advisory agent in Cordova. The essay is part of testimony Steiner presented at the June 3, 1989, meeting of the North Pacific Legislative Task Force in Kodiak, Alaska. His opinions were based partly on a fact-finding trip he took in May 1989, sponsored by Alaska Sea Grant, to Sullom Voe Oil Terminal in the Shetland Islands, Scotland.

Cordova, a town of about 2,000 people forty miles from Bligh Reef, harbors the largest commercial fishing fleet in Prince William Sound. The morning after the spill, Steiner alerted Alaska Sea Grant Director Ron Dearborn of the need for immediate research so that before-and-after comparisons could be made to determine biological effects of the spill. As a result, the University of Alaska was first to dispatch scientists to the sound.

Three days after the spill, Steiner, a commercial fisherman, and three fellow Cordovans met with oil company and Coast Guard officials. They developed a plan to involve Prince William Sound fishermen in a campaign to cordon off with oil containment booms three of the world's largest and most valuable salmon hatcheries, nearby estuaries and escapement streams, and two bays where herring spawn. The effort was a success.

Steiner has since lectured to various groups and presented his ideas to government officials, including U.S. Secretary of Transportation Samuel Skinner. Some of Steiner's ideas have been included in new oil spill contingency plans.

—K.B.



The 987-foot supertanker Exxon Valdez *ran aground on Bligh Reef in Alaska's Prince William Sound on March 24, 1989. For thirty-two hours, oil flowed unchecked from eight ruptured tanks. When the tanker stopped gushing its black cargo, nearly 11 million gallons of North Slope crude oil had spewed into one of the world's most productive and beautiful marine environments. Forty million gallons of oil remained in the tanker. The oil spread over 800 miles, fouled pristine shorelines, killed thousands of birds and marine mammals, contaminated finfish and shellfish, and forced summer closings of many of the region's lucrative commercial fisheries.*

JOHN HYDE—ADF&G

The Exxon Valdez (left) surrounded by 12,000 feet of oil containment boom near Naked Island in Prince William Sound. Tugs moved the ruptured tanker from Bligh Reef to these sheltered waters before towing the vessel to San Diego, California, for repair.

Lessons of the Exxon Valdez

The oil spill in Prince William Sound, as devastating as it was, can also be viewed as a "teachable moment." What we can learn reaches far beyond the immediacy of tanker safety and oil cleanup. Perhaps we are ready to hold a long overdue conversation about the way we do business in the world.

JOHN HYDE—ADF&G

The lessons of the *Exxon Valdez* oil spill are many. Some are obvious, some are not. To understand these lessons, we do not need to know much more about the impact of the spill, other than the simple fact it was serious and unacceptable.

To summarize, effects on the ecosystem center primarily on the intertidal zone, seabird populations, and marine mammal populations. Long-term effects remain speculative, but it appears

KURT BYERS

A 256-pound halibut, a bottom dwelling flatfish, caught in Prince William Sound near Cordova in April 1990. No major commercial fishing seasons were closed in 1990 because of oil contamination, and a record number of pink salmon, many of which were released from hatcheries into the sound during the oil spill, returned to spawn in 1990. The 1990 herring harvest in the sound exceeded predictions. However, in spring 1990 scientists found hydrocarbons in the bile of pollock, a valuable deep water species found in North Pacific and Gulf of Alaska waters. No contamination was detected in edible parts of pollock, but the species will be studied to determine if contamination has long-term, sublethal effects on the fish.

they will be more serious than previously thought.

Effects on commercial species encompass herring spawn mortality, contamination of salmon spawning habitat, and lethal and sublethal effects on outmigrant wild and hatchery salmon fry. Research on salmon is focusing on possible effects such as inhibition of olfactory imprinting, metabolic and behavioral disruptions, mortality, and survival and development of eggs deposited in oiled substrate.

The economic impact of the oil spill has been enormous. The spill forced the 1989 closing of herring fisheries in Prince William Sound, outer and eastern Cook Inlet, and thirty-four of the fifty-six Kodiak districts. Salmon fisheries were closed in most of Prince William Sound, Cook Inlet, Kodiak, and partially at Chignik. Many smaller fisheries also were closed: pot shrimp, blackcod, bottomfish, and crab in Prince William Sound. No one is sure what price tag to place on these closures, but it is certain to run into the hundreds of millions of dollars.*

Most difficult to predict and of great concern to the commercial fishing industry is the damage done to the international market for Alaska seafood. Many local businesses and tourist operations also were hurt by the spill.

The emotional impact on local residents, whose identities are so interwoven with the sound, has been extraordinary. We who live near the sound and draw economic and spiritual sustenance from its waters will long remember what happened on Bligh Reef, March 24, 1989. There has been an overwhelming sense that we have lost another precious corner of wilderness. We know the impacts of such an incident are so profound as to warrant every effort humanly possible to prevent and respond to these catastrophes.

**Most Alaska coastal waters were untouched by the oil spill, and commercial fishing proceeded normally in those areas. For example, despite many commercial fishing season closures, Alaska waters yielded a record 150 million salmon in 1989. But many of the hatcheries that produce salmon for commercial harvest are located in areas affected by the spill. Scientists are concerned that homing ability of young salmon leaving the hatcheries at the time of the spill could have been affected. The result could be fewer salmon returning to spawn one to three years after the spill.*

Solutions

We do not live in a risk-free world, so we must focus on how to best prevent spills, prepare for them, and pay for them. History is clear on one point: Most of our effort should be on prevention. Once oil is in the water, seldom is more than ten percent recovered. While financial compensation can serve as a palliative for some of the human pain, money does not mitigate environmental destruction.

We play a deadly game of Russian roulette wherever hazardous cargo is shipped. The precise set of circumstances that led to the *Exxon Valdez* disaster is only one of myriad scenarios that could produce similar ill effects in other places. If we address only the specific circumstances leading to the Prince William Sound accident, we have likely done little to prevent disaster elsewhere. Now is the time to think as carefully as possible about all the things that could possibly go wrong and to "fix" them before they do.

A caution: In trying to fix something we should remember the March Hare in *Alice in Wonderland*, who tried to fix the Madhatter's watch with butter. When the butter did not work, the surprised March Hare lamented, "And it was such good butter, too, such good butter."

To find solutions to problems like that of the *Exxon Valdez* oil spill, we must carefully sort the watch makers from the butter smearers. We need to involve the experts–master mariners, port directors, naval architects, psychologists, electronics engineers–in fixing the situation that led to this disaster.

Without professing to be a watch maker or butter smearer, I will present a few ideas.

Vessel Traffic Systems

Every vessel traffic control system in the nation should undergo a complete external audit or review. All hazard areas and other critical vessel control points should be identified anywhere tankers transit U.S. ports. An independent team of analysts who have nothing to gain and nothing to lose by speaking their minds should be appointed this task.

This analysis should include such things as adequacy of radar coverage, navigational aids, communication protocols, navigation equipment maintenance, tug escort necessities, transit restrictions, and vessel speed limitations.

A computerized history of every vessel calling at a port should be maintained and routinely updated with Lloyd's of London's registry. This would alert the port to a vessel's previous pollution incidents and its inspection record, and give port controllers adequate basis to refuse passage of a dangerous vessel. This would be a strong incentive for tanker owners to maintain their vessels.

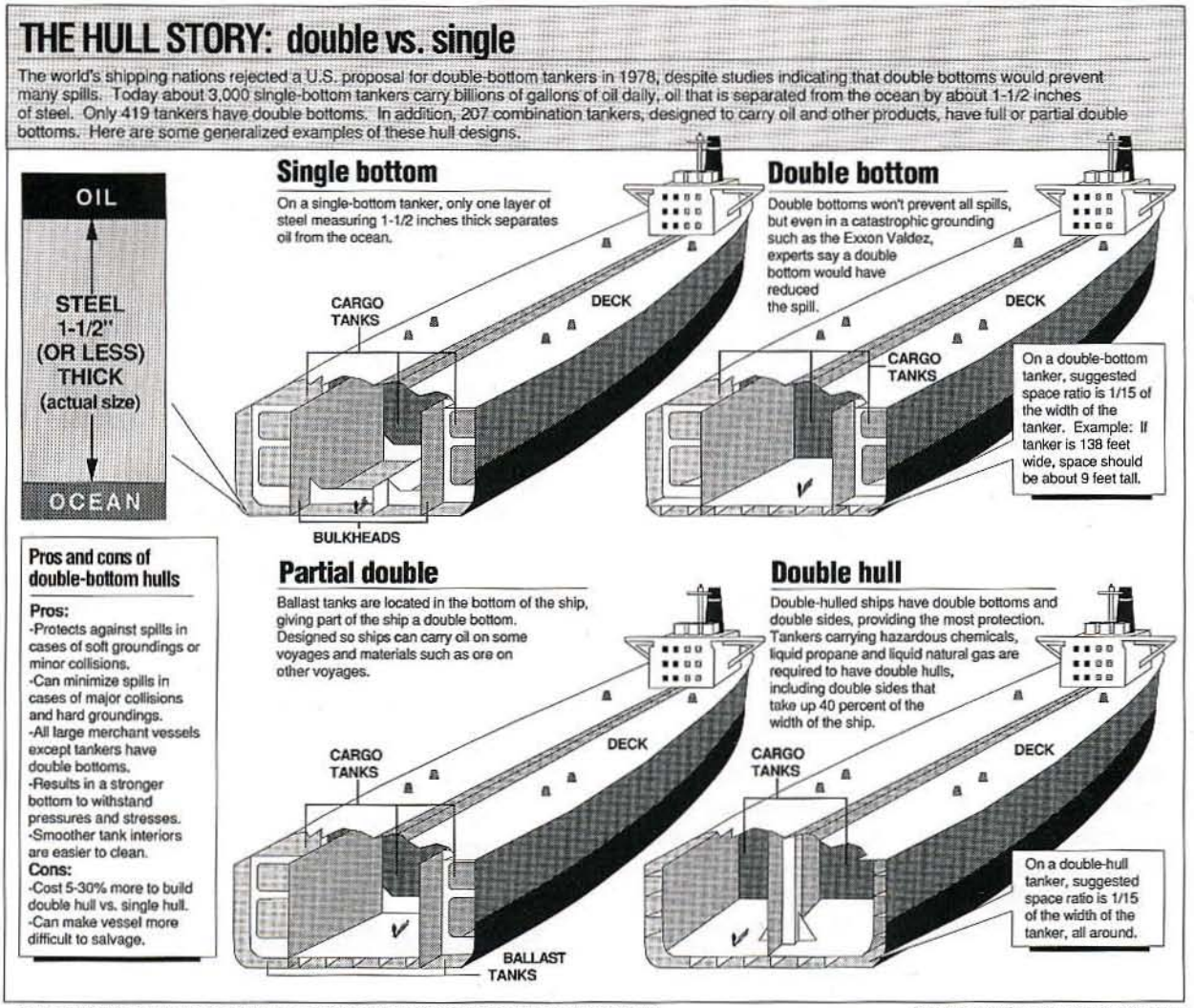
Port control radar systems should incorporate best available technology, such as Automatic Radar Positioning Aid (ARPA). ARPA *sounds* an alarm when a tracked vessel exits an assigned shipping lane. Radar signals should be videotaped and held for a specific time. The system should incorporate equipment redundancy and include rigorous, routine maintenance schedules. Automatic pilots should be fitted with alarms to notify watchstanders whether they are on or off autopilot. Lack of such autopilot alarms is believed to have contributed to the *Exxon Valdez* grounding.

Most important, and often overlooked, is that all vessel traffic control systems should be well-staffed with a surplus of alert, highly trained, highly motivated professionals. All shoreside vessel traffic surveillance should be controlled by certified mariners/pilots.

Shipping Standards

All vessels transporting hazardous substances, including oil, should submit to a rigorous environmental safety audit. Such an inspection would assess structural integrity, piping and pumping systems, deck arrangements, tank cleaning and inerting systems, venting, gauging systems and alarms, electrical safety systems, maintenance logs, and checklists.

Similar inspections must be reinstated for all foreign flag vessels calling at U.S. ports. It is known that there are many vessels in the trans-Alaska pipeline trade that are substandard and should not be allowed to lift oil from the Valdez terminal. The tanker *Stuyvesant*, for example, was recently retired from service only after she developed hull cracks that spilled, in two poorly publicized incidents, over one million gallons of North Slope crude oil into the Gulf of Alaska in 1988. Proper inspection and maintenance could have prevented these discharges. Finally, we need to review inspection standards and protocols.



Tanker Hulls

The issue of double bottoms versus double hulls versus single hulls is a perpetual controversy among naval architects. Each design provides unique protections and risks. The oil industry argues that double hulls add significant cost to vessel construction, make vessels too stiff in heavy weather, and reduce cargo capacity by as much as forty percent when compared to single hull capacity. They estimate fifty percent more vessels would be required to haul the same amount of cargo. The oil industry also raises the point that a rapidly flooding double hull void could render a vessel unstable and result in sinking.

Proponents of double hulls and double bottoms argue that the additional cost of construction, pro-rated on a per barrel basis over a twenty-year life of a vessel, amounts to only three cents per barrel. They believe additional safety wins hands-down over the greater risk of having additional vessels in the trade. The National Academy of Sciences is presently conducting a study on this old issue.

Some industry analysts believe that simply reducing the size of cargo tanks would be the easiest way to minimize spill risk. This can be accomplished only at the expense of a lot of additional steel in construction, and loss of reserve buoyancy. Regardless of how this argument goes, it is clear that more technological innovation can and should be applied to oil transport by sea.

Human Factors

Personnel standards aboard tankers should be thoroughly reviewed. Jean-Michel Cousteau recently reminded me, "A person alone is in bad company." We may need to increase the number of trained crew on the bridge, and require redundant watches in certain circumstances, especially when navigating hazardous waters. Other aspects such as watchstanding protocol, pilot training, and crew certification and recertification need review.

Psychology plays a pivotal role in the chain of events that leads to disasters like the *Exxon Valdez* oil spill. For example, on each tanker carrying thousands of tons of hazardous cargo, there is a helmsman who may be distracted by thoughts of his pension plan, his position in the company, the girl next door, the Super Bowl, how his child is doing in school, and other things. The negative effects of these mental distractions often are exacerbated by fatigue and other disruptive aspects of shipboard social interactions, including ego problems, lack of trust or confidence in shipmates, and other human dynamics.

To mitigate some of these problems, we need systematic studies of human performance under stressful or boring conditions, and further studies on the effects of sleep deprivation and fatigue.

Of course not all of this psychological soup can be distilled to produce information and insights that can be applied to produce more alert, conscientious crew members. Still, enough can be learned that would contribute to practical recommendations for enhancing human performance on the bridge of tankers. Results from such studies also would be applicable to other human endeavors.

A complete reevaluation of shipboard organizational structure is in order. The rigid, authoritarian, tradition-bound master has been the dominant decision-making structure throughout history. Maybe this should be refined to allow specialization and decentralized authority. We should consider realigning responsibilities on board. Teamwork is the obvious answer. NASA uses it. The San Francisco 49ers use it. Airline crews use it. Why not oil tanker crews?

Some sophisticated gadgetry exists that can aid this process. Computers can integrate information from on-board navigational equipment and instantly provide the information to the officer-in-charge. The officer then becomes a more efficient decision maker and spends less time as an information integrator.

Exxon Shipping is pioneering this concept through a system called the Integrated Bridge Concept. The system also incorporates safeguards such as the sounding of alarms if navigational information is presented to a watchstander and he does not respond quickly enough.

Contingency Plans

When precautions fail–it is hoped at a *much* reduced frequency–we must be prepared to effectively respond to a major spill. We should reexamine all contingency plans nationwide, and overhaul those deemed inadequate or impractical. We must anticipate the worst and prepare as if it will happen.

Plans must identify the right players in responding to spills, pre-establish a command structure, empower them, give them immediate unlimited financial capability, and think very carefully about logistics and communications. The command group, composed of containment and recovery experts and local people, should meet periodically to get to know one another and think through response protocols. A complete inventory of state-of-the-art equipment should be quickly available, as should deployment vessels and lightering barges. Local fishing vessels, tugs, and other equipment and personnel should be pre-contracted to respond to spills.

Response personnel should be trained and retrained periodically. Surprise drills should be used, and an international computer inventory of equipment and personnel should be maintained.

In response to the oil spill, the Alyeska Pipeline Service Company, a consortium of seven major oil companies that operates the trans-Alaska pipeline and oil terminal at Valdez, recently implemented a more secure oil transport system. Dubbed the Ship Escort and Response Vessel System (SERVS), it is by far the finest oil spill prevention and response system in the world. This system, which is a tanker escort and backup response vessel system, costs Alyeska approximately $50 million per year to operate.

Each outgoing loaded tanker is escorted by two vessels, at least one of which is a 210-foot ship equipped with oil skimmers, containment boom, oil dispersants, and oil storage tanks.

The escorts provide three primary safeguards. First, they ensure that tankers stay in

KURT BYERS

Portable surface disk skimmers and reels of containment boom aboard one of two 210-foot ship escort and response vessels, part of Alyeska Pipeline Service Company's revamped oil spill prevention and response system. Each ship can store 4,000 barrels of oil-water mixture and carries 4,600 feet of containment boom, two sea skimmers, a 20-foot workboat, and oil dispersants. As of July 1990, since the Exxon Valdez oil spill, these escorts assisted two oil tankers that lost power and drifted near Bligh Reef. Neither tanker was damaged or spilled oil. An empty tanker inbound for Valdez lost power for five hours on June 29, 1990, just outside Prince William Sound. It regained partial power before an Alyeska escort reached the site.

assigned shipping lanes, and shadow tankers 60 miles to the ocean entrance to Prince William Sound, well past the reef that impaled the *Exxon Valdez*. Second, if a tanker should stray into a tight or hazardous maneuvering situation, or lose power or steering capability, the escort vessels can immediately assist or tow the tanker to safety. Third, the escort vessels provide an on-site, first response capability to oil spills.

Liability and Compensation

We need to consider no limit on strict liability for damage and cleanup claims, as Alaska and several other states have enacted. Federal legislation should not preempt state authority. If we decide to keep a liability limit, then it should be raised to at least $1 billion and the limit should be nullified when even simple negligence is proven.

Owners of vessels, including third-party owned or chartered vessels, should be required to prove financial capability, via bonding, letter of credit, insurance, or other recognized means, to cover cost of cleanup of spills from their vessels. The largest tankers could spill up to seven times the amount of oil spilled by the *Exxon Valdez*. The owner of the oil also should be held liable. Finally, a realistic process for filing and settling damage claims should be developed.

Public Oversight

I suppose it is our nature to become complacent about things we get used to. After hauling 8,700 shiploads of oil out of Valdez, who could have predicted the next load would be The Big One? The *Exxon Valdez* incident lays bare the complete failure of the public process. The State of Alaska, the U.S. Coast Guard, the Environmental Protection Agency, the oil industry, and we the people let this happen. All must share the blame.

To solve a problem like this, we have to change the institutions that precipitated it.

For example, because of its size and potential environmental impact, the oil industry must make an extraordinary effort to involve the public in its management. Until now, this has not been done in the United States.

A model for public involvement exists at the Sullom Voe Oil Terminal in the Scottish Shetland Islands north of Great Britain. There a citizen/industry management partnership was formed when the huge state-of-the-art terminal–Europe's largest–was being planned and built in

the early seventies. The Sullom Voe terminal was needed to handle vast reserves of newly discovered North Sea crude oil.

The citizen/industry partnership, which among other duties develops oil spill prevention and response plans, was strengthened soon after the tanker *Esso Bernicia* rammed a jetty in late 1978 and spilled over 1,000 tons of fuel oil, just one month after the terminal opened. Since then, no significant oil spill has occurred at Sullom Voe.

Modeled in part on the Sullom Voe approach, the Alaska commercial fishing industry, the oil industry, and U.S. Congress are developing a citizen involvement arrangement for Prince William Sound.

Central to the new system is the Alyeska Citizens Advisory Committee (ACAC) which will involve local citizens in operation and oversight of the oil transport system in Prince William Sound.

Four subcommittees will report to ACAC. They are:

1. Environmental and Terminal Operations Committee
2. Oil Spill Prevention and Response Committee
3. Port and Vessel Traffic System Committee
4. Scientific Monitoring Committee

For the United States, this is a revolutionary amount of citizen involvement in private industry.

Finally, Alaska legislators must take their share of the blame for not providing environmental regulatory agencies in Alaska with adequate funding to carry out their watchdog responsibilities. The legislature has been too drunk on oil wealth to provide even a minimal amount of money for public scrutiny over its greatest benefactor. In addition, state regulatory agencies deserve more protection from political pressure.

Oil Spill Research

Since research funds are limited, I believe there is not much need to further document precisely how oil affects the marine environment. We know that it does and that the impacts should be avoided at all cost. However, an obligation remains to gather enough scientific evidence to support judicial proceedings, and more research should be directed at spill prevention.

Research also must be conducted on oil spill mitigation. Today's shoreline cleanup technology should be embarrassing to a society as supposedly advanced as ours. It seems a bit ludicrous to label absorbant tissues and hot water spray as "technology." We can do better. Two spill response tools, combustion and dispersants, deserve considerably more attention.

National Energy Policy

After all is said and done with this spill, two nagging facts will remain: We all use a lot of oil, and as long as we use it, we will spill it. No doubt, oil has been a tremendous boon to *Homo sapiens*, but it has had its costs. In production, we lose wilderness. In transportation, we spill it. In burning, we dangerously alter the chemistry of our atmosphere. We need a mammoth, concerted effort to reduce oil consumption and to develop energy alternatives.

The United States has the lowest gasoline tax in the industrialized world. We should consider raising the tax to perhaps $1 per gallon, to be earmarked for alternative energy research and energy conservation. With low cost gasoline, we afford ourselves any and all transportation luxuries.

We must also raise the average fuel economy of new cars from the present 26 mpg to at least 50 mpg; invest in convenient, efficient public transportation; and encourage installation of more efficient lighting, heating, and appliances in homes and offices. We have avoided this issue quite conveniently, but we need to tackle it now, or forever hold our peace. Policy makers who fail to develop an aggressive agenda on energy conservation and alternatives are terribly more negligent than Exxon or Joe Hazelwood.

Some states have asked that future oil exploration and development be held hostage to force the development of a coordinated national energy policy within which we can rationally assess our true needs. In response, President George Bush has asked the Secretary of Energy to develop a national energy strategy, and the Secretary of Transportation to develop a national transportation policy, all in 1990. But if the focus of this energy strategy remains as its subtitle implies, *Success in global markets with cheap energy*, rather than focus on conservation, it will represent yet another irresponsible postponement of our coming to terms with the finiteness of fossil fuel resources.

The disabled Exxon Valdez *being towed to Naked Island in Prince William Sound, April 5, 1989. There divers cut off hanging pieces of steel and patched holes, preparing the tanker for towing 2,370 miles to San Diego, California, where permanent repairs were made. The supertanker has been renamed the* Exxon Mediterranean, *and will operate in the Middle East.*

The most disheartening aspect of the *Exxon Valdez* incident, and arguably the greater disaster, is that a year after the spill, neither our Congress, Administration, individual states, automotive and oil industries, nor the public appear more interested in conserving dwindling supplies of oil. Apparently this is a lesson we do not want to learn.

Corporate Responsibility

A central question is how to motivate large corporations to be as environmentally responsible as humanly possible. To find answers, we should systematically assess how to effectively encourage and improve corporate America's commitment to the health of our environment. Corporate and regulatory restructuring, fines, criminal penalties, tax incentives, internal ombudsmen, and administrative probationary periods should continue to be examined, together with more novel approaches.

The Coalition for Environmentally Responsible Economies, a national alliance of environmental groups, bankers, and investment fund managers, has compiled ten recommendations for businesses to follow, known as the Valdez Principles:

1. *Protection of the Biosphere.* Minimize the environmental impact of our business.
2. *Sustainable Use of Natural Resources.* Protect bio-diversity.
3. *Reduction and Proper Disposal of Waste.*
4. *Wise Use of Energy.* Conservation.
5. *Risk Reduction.* Emergency preparedness for employees and communities.
6. *Marketing of Safe Products and Services.* Inform consumers of environmental impacts of our products.
7. *Damage Compensation.* Take responsibility for any harm we cause the environment.

8. *Disclosure.* Make known to employees and the public any incidents that threaten the environment or human health and safety.
9. *Appoint Environmental Directors and Managers.* At least one member of our board will be a person to represent environmental concerns.
10. *Assessment and Annual Environmental Audit.*

Policy Decisions

Eighteen years ago, a few prophetic congressmen, led by Morris Udall, argued that Alaska North Slope crude oil should be transported via pipeline across Canada rather than through a marine terminal in Alaska. Their fears of a major oil spill in Prince William Sound were deemed reactionary by the oil industry and thus brushed aside by Congress. The oil industry and the federal government assured fishermen, environmentalists, and the Udalls of the world that a major tanker disaster just would not happen. If it did, it could be contained and cleaned up.

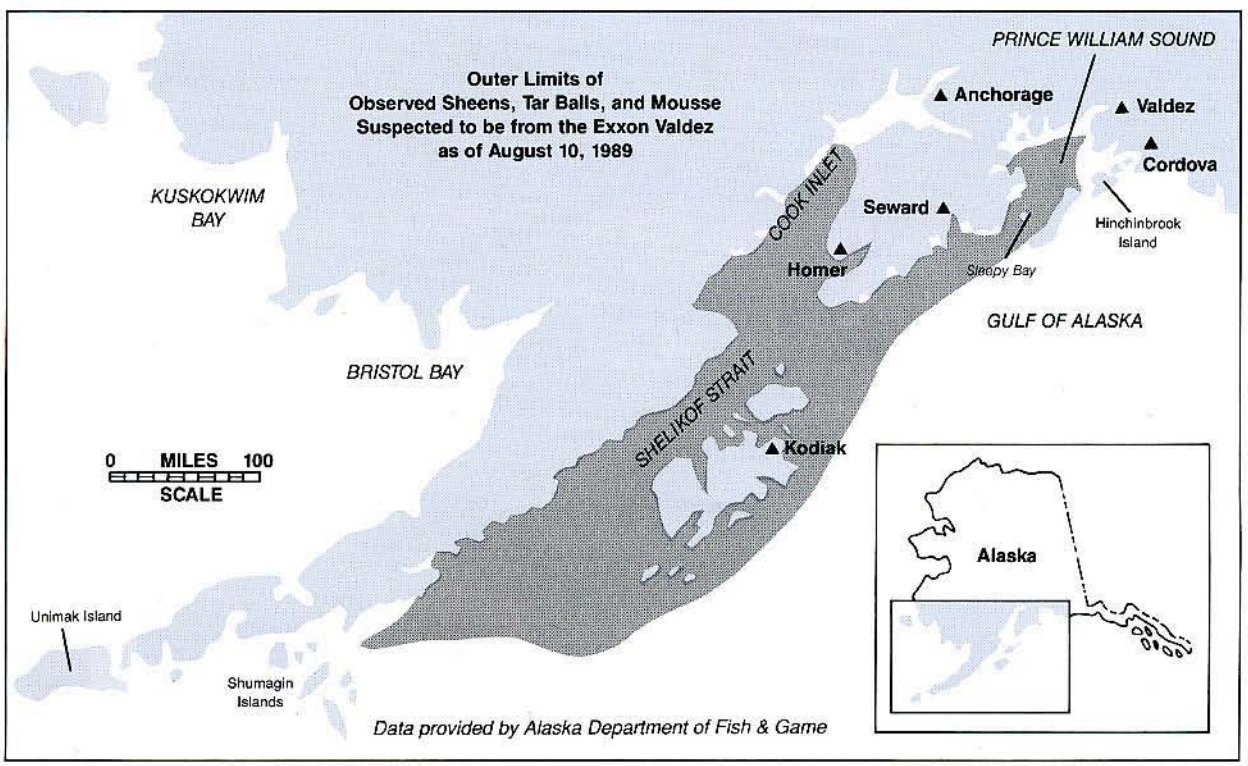
The lesson is that when making policy decisions, we should more carefully assess the consequences of being wrong. In the clamor for short-term wealth, we are evidently not prone to such deliberation. In addition to being thrifty, we have to be careful.

A Kinder and Gentler Global Society

One lesson is beginning to rise above the rest: The disaster is symptomatic of an unsustainable society, and is a stark reminder of our impact on the environment. Species extinction, deforestation, soil erosion, desertification, acid rain, toxic runoff, overflowing landfills, ozone depletion and global warming–all are wrought by a population that will have grown in the twentieth century from 1.5 billion to 6 billion people.

Fortunately, some people are making a quantum deductive leap from "Exxon caused an oil spill" to "We must change the way we think about ourselves and our world, consume less and enjoy more, think more about economic stability than economic growth, and return, indeed, to being kinder and gentler citizens of the biosphere." This is the lesson we must not fail to learn.

—Rick Steiner



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JOHN HYDE—ADP&Q

Effects of the Oil

One of the first questions asked about the *Exxon Valdez* oil spill is "How many animals were killed?" The answer is that no one knows.

The U.S. Fish and Wildlife Service (USFWS) counted birds and sea otters either found dead in spill-contaminated areas, or that died in recovery centers. As of June 1989, USFWS counted 1,016 sea otters and 36,471 dead birds, including 151 bald eagles. In a preliminary study in July 1989, USFWS scientists estimated that from 90,000 to 270,000 birds died from effects of the oil spill. This estimate represents the highest bird mortality rate from any oil spill in history. Researchers say that up to 50 percent of the sea otters that died in captivity died from stress caused by human handling, not from oil toxicity.

The National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADF&G) have watched for dead whales, dolphins, seals, and sea lions. Not many have been found, and scientists have not yet determined how many of these animals died because of the spill. In 1989 in areas affected by the spill, NMFS recorded deaths of up to 20 seals, 20 sea lions, and 25 gray whales. Researchers regularly keep track of killer whales in Prince William Sound, and noted a few of them missing too. However, researchers caution that the deaths and disappearances cannot yet be attributed to effects of oil. Scientists hope laboratory tests will determine cause of death of some of the animals. Unfortunately, many of the carcasses were too decomposed for detailed analysis. In addition, collection of dead seals, sea lions, and dolphins was hindered since many may have sunk to the ocean floor and therefore could not be recovered.

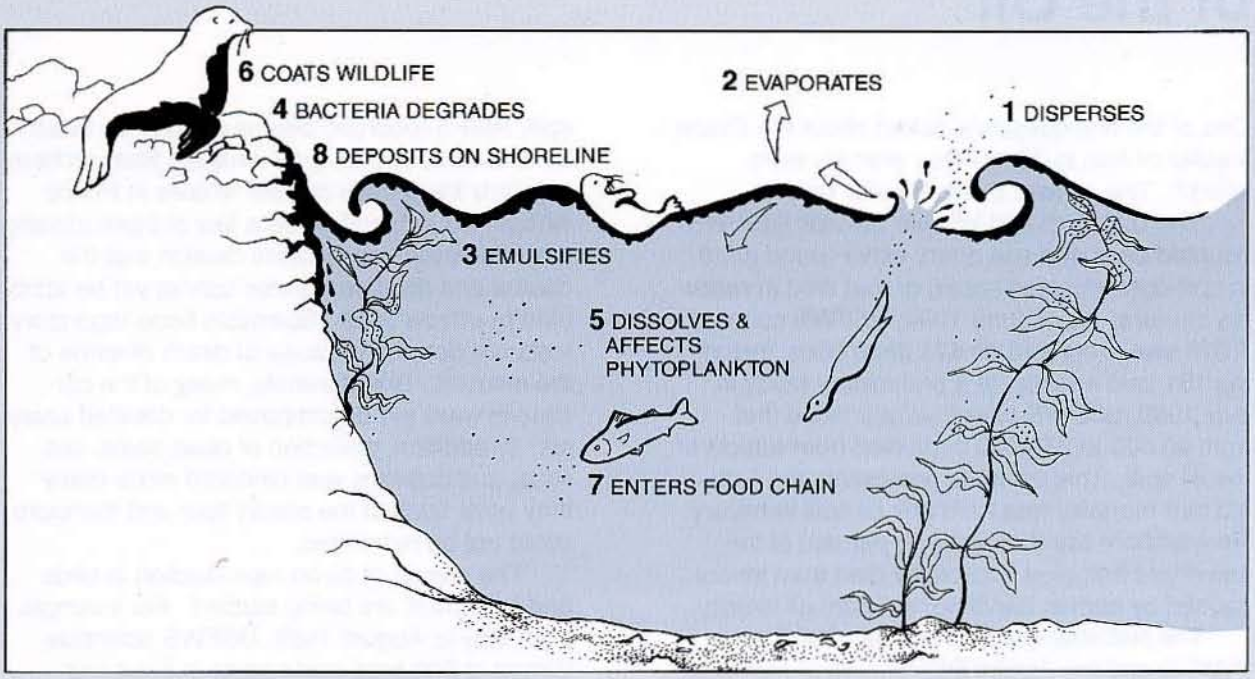
The effects of oil on reproduction in birds and mammals are being studied. For example, from May to August 1989, USFWS scientists looked at 800 bald eagle nests in oiled and unoiled parts of Prince William Sound. Nests in oiled parts of the sound produced one-third as many eaglets as nests in unoiled areas of the sound.

Bald eagle nest failure rates due to abandonment, unhatched eggs, or death of chicks or adults were more than twice as high in oiled areas. Scientists will survey the nesting areas yearly to determine long-term reproduction rates for bald eagles in Prince William Sound.

Two studies on reproduction of seals and sea lions are being conducted by ADF&G on behalf of NMFS. Scientists will assess whether production of harbor seal pups was affected by the oil spill, by looking at the ratios of pups to adults in oiled and unoiled areas. Researchers also will determine if oil toxins that may have been absorbed by adult female Steller sea lions affected reproduction, by collecting and sampling aborted fetuses and pups that die shortly after birth.

Birds and sea otters suffered heavy losses from the oil spill. Seals and sea lions were less affected. Clockwise from upper left–*Dead black scoter, sea otter in recovery pen at Valdez, dead Kittlitz's murrelet, and oiled sea lions on buoy near disabled* Exxon Valdez *at Bligh Reef.*

Effects of Oil in the Marine Environment



1. Depending on weather, surface currents, and suspended sediments, a spill may be dispersed landward, downcurrent, or widely over the ocean surface. Dispersed oil thus may be added to a polluted nearshore environment, weathered on the open ocean, or accumulate in an area far removed from the original spill site.
2. Light oil may evaporate directly into the atmosphere from the spill surface. Wind, sunlight, and warm ocean temperatures accelerate evaporation, but high winds and heavy seas may enhance mixing and dissolving of the oil into the water.
3. Crude oil may be broken into tiny droplets by wave action and forced into the water column, forming an oil-water emulsion. Rain, solar radiation, and warm water enhance mixing. High levels of dissolved oxygen encourage bacterial breakdown. Emulsions are difficult to disperse, slow to degrade, and may remain on the surface, thicken, and drift onto shore. This congealed form of oil is referred to as "chocolate mousse."
4. More than 100 species of bacteria, yeast, and fungi can oxidize hydrocarbons.
5. Light oil dissolves in water and may be absorbed by phytoplankton. Low concentrations of some oils can stimulate photosynthesis. High concentrations may inhibit photosynthesis or kill the tiny drifting plants.
6. Heavy crude oil in contact with mammals and birds can destroy the insulating ability of fur and feathers, reduce buoyancy, and be ingested as the animal attempts to clean itself. These animals can die from exposure, drowning, ingestion of oil, or suffocation. In areas with poor water circulation, such as bays, plant photosynthesis may temporarily decrease due to reduced light.
7. When higher forms of marine life eat oil-tainted organisms, oil residues may be retained in tissues. Sublethal effects include reduced resistance to disease, lower reproductive potential, and changes in schooling and migration behavior. In unpolluted water, fish shed oil contamination over various lengths of time depending on dosage and length of exposure to oil, original physiological state, and ability to metabolically detoxify oil residues. Shellfish have little ability to detoxify or shed oil residues.
8. Crude oil deposited on coastlines may smother coastal plants and animals, and leave a tar-like coating which can persist for years. Intertidal organisms with slimy surfaces resist coating, but others, especially vascular plants and barnacles, can be smothered.

Text adapted and updated (1990) from information compiled for the United States Forest Service by the University of Alaska Arctic Environmental Information and Data Center, Anchorage, 1979. Illustration adapted from *The* Exxon Valdez *Oil Spill: A Report to the President,* by the National Response Team, Washington, D.C., 1989.

Contaminated Seafood and Effects on Humans

A second common question is whether or not the spill contaminated fish and shellfish, and if so, is the contamination a health threat to consumers?

Yes, scientists detected hydrocarbon contamination in some finfish and shellfish collected from oiled areas, but most levels were lower than hydrocarbon levels in commonly eaten foods such as smoked fish and charcoal broiled meats.

Some toxic components of spilled crude oil evaporate or disperse within a few weeks of exposure to the ecosystem. Other toxic parts persist longer in the environment. These can be absorbed into body tissues of marine life.

Researchers can test animals to determine if hydrocarbon toxins are present and at what concentrations they are present. But scientists do not fully know or agree on the level of hydrocarbons in food that is a threat to humans.

Scientists and government officials addressed two major concerns: Hydrocarbon contamination in fish and shellfish harvested by rural Alaskans who subsist on wildlife, and contamination in fish and shellfish harvested by commercial fishers.

Researchers with the National Oceanic and Atmospheric Administration (NOAA) analyzed fish and shellfish collected in twelve areas near subsistence communities threatened by the spill. These areas were always closed to commercial harvest, but open to harvest by Alaska residents who have traditionally depended on wildlife as their main food source.

The tests showed that some samples, mostly clams and mussels, had hydrocarbon contamination high enough to cause concern.

Mollusks, such as clams and mussels, are filter feeders, and readily absorb toxins. Unlike finfish and mammals, mollusks have little ability to break down toxins once toxins enter body tissues. In addition, mollusks are bottom dwellers and stay in the same place. If water or sediments are contaminated, clams and mussels remain exposed to adverse conditions longer than do most finfish.

In a separate study by NOAA, harbor seals and sea lions, harvested and eaten by Alaska Natives, were tested for hydrocarbon contamination. No contamination was found in meat or blubber.

Findings from both studies were relayed to rural residents. Before these results were available, some Prince William Sound subsistence fishing areas that were obviously oiled were closed.

Where subsistence fishing was not closed, ADF&G recommended that fishers take care to avoid any place that showed signs of oil.

NOAA scientists continue to analyze finfish and shellfish from subsistence harvest areas. The samples are being collected by Exxon and ADF&G.

With regard to commercial harvest, the State of Alaska adopted a "no tolerance" harvest policy, prohibiting commercial fishing in areas where any sign of oil was detected.

Where commercial seasons were allowed to open in 1989, the Alaska Department of Environmental Conservation (DEC) and the U.S. Food and Drug Administration (FDA) closely monitored the harvest. The agencies placed inspectors in every on-shore processing plant in spill areas, and conducted random inspections aboard offshore tender vessels. Fish were inspected visually and by smelling for the scent of oil. This method, called the organoleptic method, is considered by scientists a reliable way to detect oil contamination in emergency situations. Laboratory analysis can take up to six months.

Fishermen, processors, and crew members on tender ships were trained in organoleptic inspection, and were required to inspect seafood, keep detailed records, and report all suspected oil contamination.

In addition to on-site inspection by DEC, FDA, and the fishing industry, fish and shellfish samples were regularly sent to DEC, FDA, and NMFS laboratories for detailed analysis. Final results are not ready, but no significant contamination has been reported.

In 1989, every commercial fishery in the path of the oil slick was affected–smelt, herring, crab, shrimp, salmon, and groundfish. Exxon attempted to compensate fishers for lost income, and some fishers recovered some, all, or more than their losses by leasing their boats and services during the cleanup attempt.

In 1990, as of September, two small salmon fishing areas near oiled beaches in Prince William Sound and one small commercial shrimp pot fishery were closed due to oil contamination. No other commercial fishery was closed because of oil contamination. Returns of pink salmon to Prince William Sound were good.

Oil Spill Damage Assessment Program

The *Exxon Valdez* oil spill provides scientists with a unique opportunity to conduct long-term research on fish and wildlife in a near-worst-case, cold climate oil spill.

Alaska's research goals are to (1) understand the extent of the injury to its resources, (2) assess impacts in such a way that recovery of damages from responsible parties can be achieved, and (3) determine how to restore the resources.

Sixty-three research projects, summarized below, comprised the 1989 cooperative state and federal Oil Spill Damage Assessment Program (OSDAP). More than $35.4 million was provided for these studies. A set of new and continuing OSDAP projects for 1990 is awaiting state and federal approval.

State entities conducting OSDAP studies include ADF&G and Alaska Department of Environmental Conservation (DEC). Federal units include the U.S. Department of Agriculture (USDA), U.S. Department of the Interior (USDI), U.S. Department of Commerce (USDC), and U.S. Environmental Protection Agency (EPA).

OSDAP research in 1989 included:

- A joint, comprehensive oil spill damage assessment by ADF&G and the U.S. Forest Service, USDA.
- Five studies on the spill's effects on air and water; four by DEC and the National Oceanic and Atmospheric Administration (NOAA, a division of USDC), and one by DEC.
- Twenty-six projects on finfish and shellfish; twenty by ADF&G, six by ADF&G and NOAA.
- Seven studies on whales, otters, sea lions, and seals, by NOAA.
- Six studies on bear, deer, river otter, mink, and other small mammals, by ADF&G.
- Fifteen projects on birds, including raptors, passerines, seabirds, and waterfowl, by U.S. Fish and Wildlife Service, USDI.
- Three areas of technical service, one each on mapping, histopathology, and chemistry, jointly conducted by state and federal agencies.
- Economic studies and restoration planning by state and federal entities.

In addition to OSDAP projects, many other projects funded by industry, university, state, and federal entities are in progress.

Local Economic and Social Effects

"People are angry and afraid . . . . How will the children learn the values and the ways if the water is dead? Very afraid. If the water is dead, maybe we are dead—our heritage, our tradition, our ways of life and living and relating to nature and to each other."

—Walter Meganack, Sr., Chief of Native Village of Port Graham, Alaska

The *Exxon Valdez* oil spill profoundly affected the social and economic fabric of coastal towns in the path of the oil slick. Communities were disrupted by the closing of many commercial fishing seasons and a few subsistence fishing areas. The sudden influx of bureaucrats, industry personnel, news media, and cleanup workers caused problems. Conflicts arose over uneven distribution of money to residents hired to help with the cleanup, and businesses were crippled by the loss of employees who left for more lucrative cleanup jobs. Native subsistence life styles and economies were severely disrupted because of fears that local seafood was contaminated. In some communities, conflicts ignited between supporters of Exxon and environmentalists. Anger and anxiety about long-term environmental, social, and economic effects took root, as did frustration with government and industry officials.

Socioeconomic studies of the spill have not received as high a priority as environmental and biological research. However, anecdotal information and results of the few studies that have been done point to serious problems.

Personal accounts of social effects of the spill were collected in November 1989 via the Citizens Commission Hearings, sponsored by the National Wildlife Federation. One hundred

twenty citizens, most of them residents of communities hit by the spill, recounted effects such as increased alcohol and drug abuse and mental health problems, business losses, and conflicts among residents caused by large sums of Exxon money entering local economies.

Many of the comments heard during the hearings were confirmed by Dr. Sharon Araji, a University of Alaska researcher who surveyed residents of Homer, Alaska. The survey assessed social, economic, psychological, and health effects of the spill on local residents.

Survey results revealed significant increases in alcohol and drug abuse, domestic violence, and employment problems among both residents and visiting cleanup workers, as reported by police, the alcohol treatment center, and the domestic violence shelter in Homer.

In another local survey, the Valdez Counseling Center found that residents of Valdez and Cordova suffered significant symptoms of post traumatic stress. Valdez residents were more affected by the massive disruptions in day-to-day routine caused by the sudden and prolonged influx of outsiders, while residents of the fishing-dependent community of Cordova were more affected by the environmental damage caused by the oil spill.

Regional Studies

In subsistence communities affected by the spill, fish comprise 50 percent or more of each person's yearly food consumption, and marine mammals up to 25 percent.

Despite state and federal tests that showed most seafood safe to eat, many villagers remained skeptical. Stress was high as normal routines of harvesting, sharing, and eating local harvests were disrupted. Tests of seafood continued, and the ADF&G Subsistence Division maintained communication with subsistence communities about the status of local seafood. The division also interviewed about 400 households to measure how subsistence use among Native families changed as a result of the oil spill. Results are available from the ADF&G Subsistence Division.

The Oil Spill Health Task Force was formed in spring 1989 to coordinate and review research on subsistence food safety, develop a consensus on health issues, and communicate findings to people in coastal villages. The task force represented several Alaska government units, two Alaska Native organizations, NOAA, and Exxon. The group was chaired by the Indian Health Service.

Research that will provide valuable information on the socioeconomic effects of the spill was begun before the spill in 1986 by the U.S. Department of the Interior, Minerals Management Service. The study, called the Social Indicators Project, was designed to detect and describe social, cultural, and economic changes experienced by people facing consequences of oil exploration, production, and transportation.

After the *Exxon Valdez* spill, the study was modified to focus on effects of the real life emergency. The continuing study is run from the Human Relations Area Files of Yale University. Preliminary results are expected in early 1991.

Oiled Mayors Research

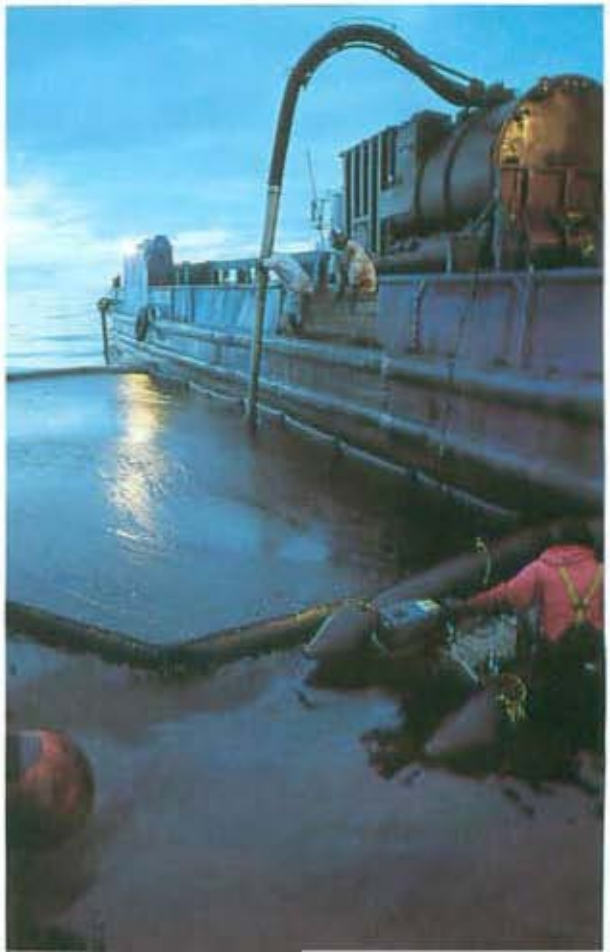
Perhaps the most significant and closely guarded socioeconomic research has been dubbed the "Oiled Mayors Research." Funded by the Alaska Department of Community and Regional Affairs and conducted by Impact Assessment, a social research consulting firm in La Jolla, California, this research documents anxiety, depression, and post-traumatic stress among residents of affected communities. Results will be used in litigation to determine monetary damages to local communities.

Field work ended in June 1990. A final report states that significant numbers of residents in communities affected by the spill exhibit symptoms of psychological problems. According to the report, a household survey of 596 people "clearly showed [the oil spill] affected lives and communities in complex ways . . . and the effects will continue well into the future." The report stated that small towns and villages were "particularly devastated" in the short term, as government and business employees went to work for cleanup contractors.

Similar to findings of the University of Alaska study in Homer, the Oiled Mayors Study documented increases in destructive behavior such as driving while intoxicated, jail bookings, misdemeanors, requests for emergency medical services, visits to mental health clinics, and admittances to women's shelters.

JEFF SCHULTZ-SIPA

Above--*Cleanup workers apply high pressure, hot water spray to oiled beach as landing craft waits in background. Some experts believe such hot water cleanup techniques can do more harm than good, resulting in a "giant clam bake."* Right--*Vacuum trucks mounted on barges sucked oiled water into tanks.* Far right--*A fisherman hauls in containment boom. The deployment of boom by fishermen to cordon off some of the world's largest fish hatcheries was one of the few successful reactions to the oil spill.*



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Oil Spill Containment and Cleanup Technology

The most advanced technology is used to find and refine crude oil. Cleaning up spilled oil is less sophisticated.

America's largest oil spill revealed a lack of cleanup know-how that found state, federal, and industry officials arguing over which techniques to use, scrambling to find necessary equipment, and trying to invent machinery to stop the spread of the oil slick and later clean up oil that landed on hundreds of miles of cobble-strewn shoreline.

At the close of 1989, Exxon had spent well over $1 billion attempting to clean up the spill.

According to the Alaska Department of Environmental Conservation, the combined effort of government and industry recovered 32,500 gallons of the 11 million gallons spilled.

Most of the following information was derived from the federal report, *Coping with an Oiled Sea: An Analysis of Oil Spill Response Technologies,* available free from your U.S. Congressman or woman.

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Chemical Dispersants

How They Work. Dispersants are detergents. They break oil slicks into small particles that disperse in the water or sink into bottom sediments.

Advantages. Dispersants can be spread rapidly over a large area. They help clear oil from the water surface, reducing the amount of oil that can wash ashore.

Disadvantages. Oil remains in the water and can sink into bottom sediments, exposing marine species to oil that can accumulate in tissues. Some dispersants are more toxic than oil.

Burning

How It Works. Floating ignitors, incendiary bombs, or napalm containers lowered from helicopters ignite the oil slick.

Advantages. On a contained, fresh oil slick with volatile components still in the oil, burning can eliminate up to 90 percent of the oil, sparing marine life and beaches.

Disadvantages. Combustion releases black sooty smoke containing toxic gases that may cause nausea, headaches, and breathing problems. Only relatively fresh oil readily ignites, and it must be at least three millimeters thick. Burning can leave hard residue on land surfaces.

Bioremediation

How It Works. Some naturally occurring marine bacteria eat oil. When fertlizer is added, bacteria multiply, increasing consumption and breakdown of oil. Scientists are working on genetically engineered oil-eating bacteria that could be released on oiled sites.

Advantages. The method uses naturally occurring bacteria to reduce oil contamination. Large cleanup crews are not required, cost is reasonable, and fertilizer may not significantly harm the environment. On oiled areas where natural degradation would take five to seven

years, estimates indicate bioremediation would cut the time to two to five years.

Disadvantages. Bacteria have difficulty consuming weathered, hardened oil. Some scientists think fertilizers may dramatically increase plant growth that could reduce water oxygen levels needed by fish and shellfish. Long-term effects of artificial fertilizers are unknown. They are most effective on land, although water tests have been conducted.

Natural Degradation

How It Works. Storms, wind, rain, and snow dislodge oil from beaches and disperse oil particles. Bacteria degrade oil over time.

Advantages. Humans do not further disrupt land surfaces or remaining plants and animals.

Disadvantages. It is a slow process, especially in areas sheltered from the elements. Dislodged oil can reenter the food chain.

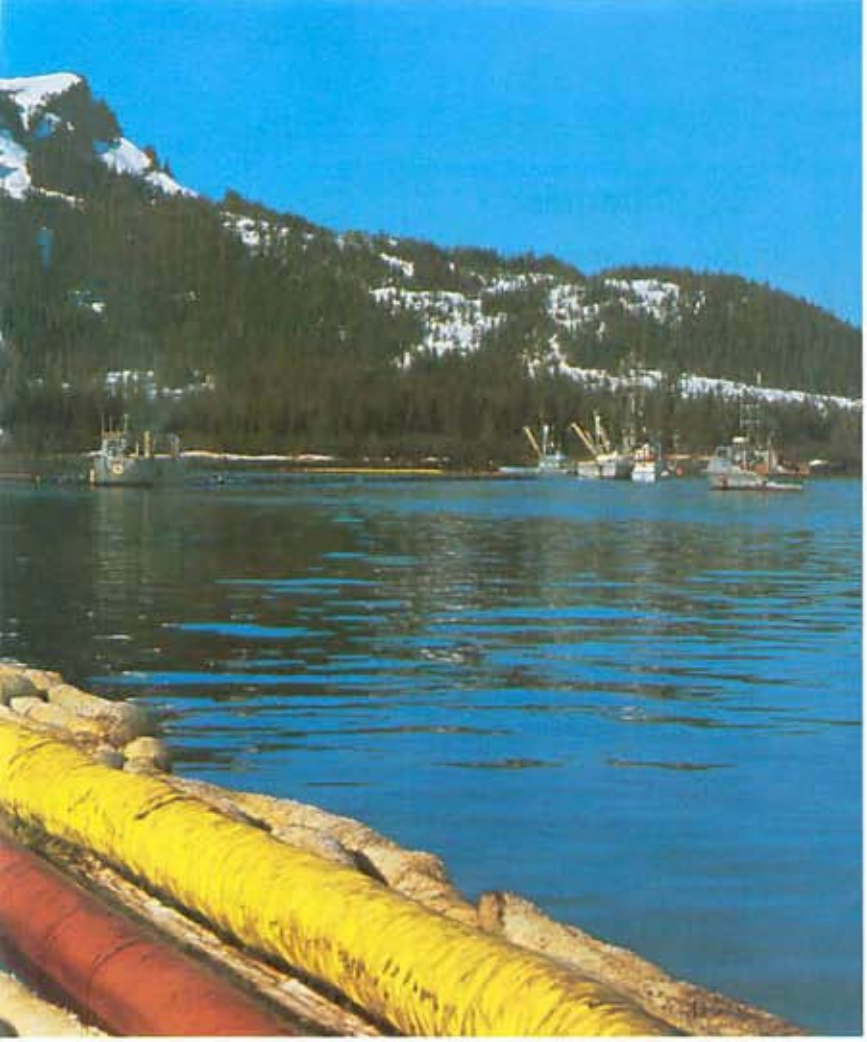
Oil Containment Booms

How They Work. Booms are long, floating, tube-like barriers fitted with rigid or flexible underwater skirts. They are used as floating fences to surround, contain, and deflect spreading oil slicks.

Special use booms include fireproof booms used to contain oil that is burned. Sorbent booms absorb oil and are disposable. Ice or cold weather booms withstand extreme temperatures and work amid ice floes. Some booms have limited skimming capacity. Homemade booms can be a series of tree logs lashed together, sometimes with plywood skirts attached.

Advantages. Booms do not damage the environment. They are effective in containing oil slicks when correct boom is properly deployed in calm to moderate seas.

Disadvantages. They require much time and labor to deploy. Oil can wash over or slip under booms, and different booms must be available for various conditions. Adequate storage space and ways to dispose of sorbent booms pose problems.



Left–*Oil containment booms protecting a Prince William Sound salmon hatchery. Booms work like floating fences. Some block the spread of oil slicks, others also absorb oil. Different booms are used in open ocean, protected waters, and icy conditions.* Below–*Containment boom towed by two fishing vessels funnels oil slick into a weir skimmer.* Lower left–*Residents of Homer, Alaska, built booms by strapping logs together.*

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Above–A vessel-mounted belt skimmer collects oil dislodged from the rocky shore by workers wielding high pressure water sprayers. Containment boom keeps the dislodged oil from spreading seaward. Below–*Workers use water spray to wash oil into the sound where it is sucked up by vacuum equipment.*

Oil Skimmers

How They Work. There are at least 14 categories and sub-categories of skimmers. Often they are used in combination with containment booms and pumps to pick up the surface oil-water mixture, convey the mixture to storage tanks, and separate the oil from the water.

Advantages. Skimmers can work well in calm water on small spills. They are not harmful to the environment.

Disadvantages. Skimmers do not work well in heavy seas, have a relatively low recovery rate, and tend to clog and break down.

Types of Skimmers. *Weir skimmers* are pump-equipped oil collection basins that are towed through oil slicks. Oil flows into collection basins, then is pumped into storage containers. Recovery rate is about 50 percent in a thick oil slick, but they tend to clog unless equipped with a device to grind debris.

Suction skimmers are vacuum heads attached to floating hoses connected to vacuum trucks or portable suction pumps. They have a low oil recovery rate and do not work well in choppy water.

Boom skimmers are oil containment booms equipped with oil collection devices, usually weirs. They have a high recovery rate and work

well on large spills in open seas. Disadvantages are that they are large, contain many working parts, and are susceptible to debris clogging.

Vortex skimmers, sometimes combined with weirs, suck oil and water into a collection chamber where the mixture is spun and separated by centrifugal force. They have a reasonable recovery rate, but low efficiency.

Moving surface skimmers use oil-absorbent materials and metals in a variety of mechanical configurations to collect the surface oil and water mixture. Once collected, oil is separated from water by a mechanical technique of scraping, squeezing, or wringing. Three primary types are: (1) *Disk skimmers*, which contain vertical disks that oil adheres to when the disks are rotated through the oil slick. (2) *Drum skimmers*, which are horizontal drums that are rotating through the oil slick, attracting and holding oil. (3) *Belt skimmers*, which are machines equipped with conveyor belts made of oil-absorbent materials, or that have a series of paddles or brushes attached. The belts lift oil out of the water into ships or on-shore collection devices where the oil is removed. Some handle debris well. Efficiency varies depending on skimmer type, oil concentration, and weather and wave conditions.

Cold Water Low Pressure Wash

How It Works. Sea water pumped through fire hoses onto oiled beaches at low tide dislodges oil. At high tide, skimming vessels and barges with vacuum trucks pick up the oily surface water.

Advantages. The technique is relatively harmless to the environment. It works moderately well on fresh and unweathered oil.

Disadvantages. Cold water is not highly effective for dislodging weathered oil, and high pressure may drive oil deeper into the surface. Cleanup workers disrupt land surfaces.

Hot Water High Pressure Wash

How It Works. High pressure steam cleaners blast weathered oil from rocks and cliffs. Hot water pumped deep into the shoreline dislodges trapped oil. Detergents and solvents sometimes are added to speed the process.

Advantages. Hot water dislodges oil better than cold water, especially on weathered oil.

Disadvantages. Steam and chemicals sterilize beaches, leaving them temporarily void of marine life. Some chemicals are more toxic than the oil. High pressure may drive oil deeper into surface. Cleanup workers disrupt land surfaces. More machinery is needed to heat water.

Large Scale Technology

A 400-foot oil skimming ship operated by the Soviet Union was used near Seward, Alaska, to help clean up the oil slick. The effort failed after the ship collected only 32 barrels of oil. Debris clogging and equipment failure were cited as the reasons the skimmer did not work.

Despite this failure, naval architects and marine engineers have ideas for more exotic large scale cleanup equipment.

For example, naval architects envision a vessel called "Big Gulp," an 810-foot oil tanker modified for use as a super skimmer. Proposed in early 1990 by ARCO, one of the Alyeska consortium members, the skimmer would plow through an oil spill, suck up surface oil-water mixture, separate oil from the water, and discharge water back to the sea. Storage tanks would hold 21 million gallons of oily water. However, it might prove too expensive to build enough of these ships to permit quick response to spills anywhere in the world. Development was suspended in late 1990.

Another idea is "Seaclean," a vessel that resembles a floating oil drilling platform. It would move people and conventional cleanup equipment to a major spill. Though still on the drawing board, the $35 million project would include a helicopter pad, research laboratories, and sleeping quarters. The platform would serve as mothership to several skimmers, and be able to separate oil and debris from water. An on-board incinerator would burn oily wastes, while usable oil would be saved. Non-usable oil would be stored in large vats filled with oil-eating bacteria. Such a platform would not provide quick response to distant spills.

Legal Issues

Editor's note: This chapter was compiled from information provided by Harry Bader, Alaska Sea Grant Legal team member, Suzanne Iudicello of Alaska Governor Steve Cowper's Washington, D.C., office, the Associated Press, and the Anchorage Daily News.

Alaska Sea Grant Legal Research Team

Three months after the *Exxon Valdez* oil spill, Ron Dearborn, director of the Alaska Sea Grant College Program, organized a research team of law faculty from the University of Maine, University of Washington, Boston College, and University of Alaska. Dearborn asked the team to identify legal tools Alaska could use to help prevent oil spills and other environmental problems. The Alaska Sea Grant legal team's research was used by Governor Steve Cowper's Alaska Oil Spill Commission in its comprehensive set of recommendations to the Alaska Legislature.

The Sea Grant researchers focused on three themes - citizen empowerment, strong state sovereignty, and judicial remedies - and recommended four general actions. First, Alaska should establish a citizen oversight council responsible for ensuring vigorous state regulatory enforcement. Second, the state must be less influenced by late 1970s litigation that suggested the federal government dictate oil transport regulation. Third, Alaska should negotiate interstate compacts, legally binding agreements with the force of federal law, with other Pacific Coast states and Canadian provinces to regulate ocean oil transport. Fourth, the Alaska attorney general should seek court injunctions whenever industry procedures for oil transport are deemed unsafe or unwise, and call for injunctions that would force safety measures.

In spring 1990, the Alaska Legislature used the legal team's ideas in enacting new laws. The legal team's efforts also have spurred negotiations on interstate compacts through the Western Legislative Conference.

Most significant of new state laws stemming from the legal team's research was House Bill 578, which established the Citizen Oversight Council on Oil and Other Hazardous Substances. The council will monitor state and federal agencies responsible for environmental protection, request action from the state attorney general, recommend policies to the state legislature, and create local advisory groups throughout Alaska. The council has the power to subpoena witnesses, require production of documents, conduct investigations and technical audits, and appoint special personnel to assist the council.

The Alaska Sea Grant legal team believes the power and vigilance of the citizen oversight council will be the key to establishing long-term, safer oil transport in Alaska.

In addition to the citizen oversight law, state legislators passed three other oil spill laws. The most important, House Bill 567, required industry to stockpile enough equipment in Alaska to clean up a 300,000 barrel spill and to import more equipment within 72 hours. The law improves contingency plans and strengthens insurance requirements for reimbursing victims, and allows the state to monitor vessel traffic and inspect tankers and pipelines.

Another new law makes the reckless operation of an oil tanker or barge a crime punishable by up to five years in jail and a $50,000 fine, and makes it a crime to fail to meet spill response planning standards. A law also was passed increasing fines for corporations and others that cause oil spills.

Federal Laws

President George Bush signed the Oil Pollution Act of 1990 on August 18. The bill establishes new standards for the oil industry that should lower the incidence of catastrophic oil spills. The law requires double hulls on tankers, sets up an oil tax channeled to a cleanup fund, and authorizes money for oil spill research.

After 15 years of debate, the legislation requires that new tankers be built with double hulls, and that old tankers be refitted with double hulls. Double hulls will add about $30 million to the cost of each tanker, according to industry estimates. There are 153 U.S. flagged tankers that must be refitted with double hulls or retired from service. Some older tankers will likely be

phased out of service rather than have double hulls installed. The legislation also affects about 900 foreign flagged tankers that call on U.S. ports.

The two houses agreed to assess a five cent per barrel tax on oil earmarked for a $1 billion spill cleanup and victim compensation fund. The fund is to be used after a spiller's liability limit is reached. If the spiller is guilty of gross negligence, there would be no limit on the spiller's liability, and the fund would not be used.

The law gives the Coast Guard final authority to decide when a beach meets a federal definition of clean. States with cleanup standards higher than federal standards cannot tap the federal pool for additional cleanup expense once the Coast Guard declares a beach clean. If states wish to exceed federal standards, they can only seek reimbursement of extra costs from the oil spiller, or pay the extra costs themselves.

This legislation also authorized $23 million for an oil spill research center in Cordova, Alaska. The appropriation would be spread over 10 years. The bill also calls for a navigation light on Bligh Reef and improved Coast Guard radar stations in Prince William Sound.

Hazelwood and the Law

In a criminal trial in Anchorage, Alaska, former *Exxon Valdez* Captain Joseph Hazelwood was cleared of all but one misdemeanor charge, the reckless discharge of oil. He was required to pay a fine and perform community service in towns affected by the oil spill.

In civil action by the Coast Guard, charges of drunkenness and misconduct were dismissed. Charges of violation of Coast Guard policy prohibiting consumption of alcohol less than four hours before duty aboard a vessel were not contested by Hazelwood. The Coast Guard suspended Hazelwood's ship master license for nine months. The Coast Guard judge concluded the *Exxon Valdez* helmsman and third mate, who were left in charge of the ship by Hazelwood when the tanker hit Bligh Reef, were guilty of human error. No charges were filed against the two men.

In a separate investigation, the National Transportation Safety Board concluded that Exxon failed to provide a fit master and rested crew, trimmed crew levels to save money, and should have had a program to help employees with drug and alcohol abuse.

The board criticized the Coast Guard for poor radar tracking in Prince William Sound, and thought the State of Alaska was too lax with requirements for tanker pilots. Tanker pilots are local pilots who temporarily go aboard and steer tankers until the ships reach open waters, then turn command of the vessels back to the regular captains.

The board decided Hazelwood was legally drunk at the time of the accident, and violated company and Coast Guard policy when he left the third mate in command of the ship. The board concluded the third mate ran the ship aground, and was fatigued after working most of the day aboard ship.

The board's conclusions have no force of law and are not admissible as evidence in court proceedings.

Research as Evidence

State, federal, and Exxon lawyers thought data generated by their respective scientists should be kept confidential so that each party could not use the other's information in preparing lawsuits. Many scientists studying effects of the oil spill were frustrated and angered by these requirements, since information sharing is a normal and important part of effective scientific investigation and helps avoid duplication. Other scientists lost funding or were denied funding because their otherwise important research was deemed unsuitable as evidence in legal proceedings.

It was not until mid-summer, 1990, that state, federal, and Exxon lawyers agreed to share some scientific data. More information sharing is expected.

State and federal governments also could not agree on a legal strategy to use to pursue Exxon. However, the governments agreed not to sue each other.

Annotated Bibliography

These publications, articles, and videos represent a cross section of information on the Exxon Valdez *oil spill and related topics. They reflect various perspectives and are intended to be useful to both lay and technical audiences. Contact your local library for more sources.*

A Report by The Wilderness Society: 100 Spills/1,000 Excuses. Washington, D.C.: The Wilderness Society, 1990. This report lists the 100 worst oil spills, including pipeline and storage tank leaks, that occurred in the year after the *Exxon Valdez* spill. The report outlines four broad approaches the United States might adopt to decrease the likelihood of future spills.

Adler, Jerry. "Alaska After Exxon." In *Newsweek*, September 18, 1989, p. 50. This feature article presents an even-handed recap of the social and environmental effects of the oil spill six months after the event.

Alaska Oil Spill Commission. *Spill: The Wreck of the* Exxon Valdez. *Implications for Safe Transportation of Oil. Final Report, 1989.* Anchorage: Alaska Oil Spill Commission, 1989. 187 pp. Called for by Alaska Governor Steve Cowper, the five volumes and four appendixes present recommendations from a nine-month study by government and policy experts. The commission examined causes of the *Exxon Valdez* disaster and recommended action Alaska should take to prevent and respond to future oil spills. Technical changes in the way oil is transported as well as legal changes are detailed. The Sea Grant Legal Research Report is Appendix M.

Eric Munk, a NOAA National Marine Fisheries Service scientist, conducting a survey of organisms on a Kodiak Island beach before the oil slick arrived. Although some information on ecosystems in Prince William Sound was available before the spill, an overall lack of pre-spill data made assessment of damage difficult.

"Alaska's Big Spill—Can the Wilderness Heal?" In *National Geographic*, January 1990, Vol. 177, No. 1.

Anchorage Daily News, March 25, 1989 to present. In 1989 this newspaper printed 545 stories and many photographs on the *Exxon Valdez* oil spill. All stories are accessible through a nationwide on-line data base called VU/TEXT. Contact your local library for information on availability and use of VU/TEXT.

Bader, Harry, ed. *Legal Tools for Regional Environmental Regulation.* Fairbanks: University of Alaska Sea Grant College Program, 1990. SG-ED-11. Forthcoming. A summary of legal tools for improving state and regional environmental regulation. Derived from recent legal research on oil transport regulation. Intended for policy makers, environmental groups, and other local, state, and regional decision makers. Contact Alaska Sea Grant, 138 Irving II, Fairbanks, AK 99775-5040. (907) 474-7086.

Behar, Richard. "Joe's Bad Trip." In *Time*, July 24, 1989, p. 42. A supposed inside view, well before *Exxon Valdez* Captain Joseph Hazelwood's trial, of the moments leading up to the grounding, and who really bears responsibility for the mistakes.

Briefing: Prince William Sound Tanker Spill Prevention & Response Plan. Anchorage: Alyeska Pipeline Service Company, 1990. 12 pp. Alyeska is responsible to tanker owners, operators, and charterers for oil spill prevention and response. This booklet summarizes Alyeska's oil spill prevention and response plan, designed to be part of the State of Alaska's oil spill contingency plan. Many of the new ideas are already in operation. A video tape also is available that describes Alyeska's plan. It focuses on new tanker escort systems and quick response capabilities to tanker accidents. Contact Alyeska Corporate Affairs, 1835 Bragaw, Anchorage, AK 99512. (907) 265-8197.

Dalby, Ron, ed. *Alaska: The Magazine of Life on the Last Frontier*, June 1989. This controversial issue of a popular monthly magazine about the people and places of Alaska features several articles on the damaging effects of the *Exxon Valdez* oil spill. Well illustrated with color photographs, many tourism officials and advertisers were dissatisfied with graphic, frank coverage. Contact *Alaska*, 808 E Street, Anchorage, AK 99501. (907) 272-6070.

Davidson, Art. *In the Wake of the* Exxon Valdez: *The Devastating Impact of the Alaska Oil Spill.* San Francisco: Sierra Club Books, 1990. 333 pp. According to a Fairbanks, Alaska, book reviewer, this publication is "the first comprehensive, detailed narrative of the oil spill . . . a fair, multifaceted, compelling, and urgent account . . . ." The book describes how the spill occurred, details of citizen and industry response, and what the long-term effects may be. Includes hundreds of quotes from people "in the throes of stress and denial." Useful reading for anyone interested in the environment, Alaska history, or public policy.

Donald, Robert, et al. *The Stress Related Impact of the Valdez Oil Spill on the Residents of Cordova and Valdez, Alaska.* Valdez: Valdez Counseling Center, 1990. Researchers surveyed residents of Valdez and Cordova to compare the psychological effects of the spill on residents of both towns. A greater percentage of Cordova residents were affected by harm caused to the environment, while more Valdez residents seemed adversely affected by the sudden influx of outsiders. Both groups reported symptoms consistent with post traumatic stress disorder.

Frost, Helen, ed. *Season of Dead Water.* Portland, Oregon: Breitenbush Books, 1990. 128 pp. A collection of poems, essays, stories, and sketches on the oil spill from almost fifty contributors, that a reviewer says ". . . express horror, dismay and sadness" and ". . . has little to do with statistics and much to do with feelings." The *Oregonian* says "If the [oil spill] can be explained, it is done so here, in these blunt, beautiful writings."

Harrison, E. Bruce, and Prugh, Thomas. "Assessing the Damage: Practitioner Perspectives on the Valdez." In *Public Relations Journal*, October 1989, p. 40. An interesting article on how big industry should employ "crisis management professionals" to most effectively communicate a company's disaster response to the public. Authors urge companies to avoid creating unrealistic expectations of no-risk operations, and urge a legitimate commitment to environmentally sensitive operating policies. If a disaster occurs, chief executives are urged to get personally involved, including going to the disaster site.

Horton, Tom. "Paradise Lost." In *Rolling Stone*, December 14-28, 1989. Immediately following the oil spill the author spent two months in Prince William Sound documenting the initial shock of the disaster. He returned to the sound in fall 1989 to assess the situation after the summer cleanup stopped. The result is this comprehensive article.

"In Ten Years You'll See Nothing." In *Fortune*, May 8, 1989, p. 50. An interview with Exxon chief executive officer Lawrence Rawl that explores Rawl's response to the spill in terms of public relations.

Leavitt, Margaret, et al. *Alaska's Oil.* Wasilla, Alaska: Quiana Publishing, 1989. 48 pp. A children's activity book with stories, games, and color photos about the discovery of oil in Alaska, building the trans-Alaska pipeline, and the *Exxon Valdez* oil spill. (907) 373-2945.

Lethcoe, Nancy, and Nurnberger, Lisa, eds. *Prince William Sound Environmental Reader: 1989 T/V* Exxon Valdez *Oil Spill.* Valdez: Prince William Sound Conservation Alliance, 1989. 112 pp. This book is semi-technical to technical and includes a description of the physical and biological environments of Prince William Sound, effects of oil in the environment, discussion of oil dispersants and oil cleanup technology, and Exxon's cleanup plan for the Alaska spill. Includes fascinating and informative testimony by a Cordova fisherwoman and biologist, given before the U.S. House Interior Committee, that focuses on the failure of the Alyeska oil consortium to prevent or contain the oil spill.

Holmes, Krys. "The *Exxon Valdez* Spill: One Year Later." In *National Fisherman*, July 1990, Vol. 71, No. 3. This short, illustrated article provides a brief overview of the status of the cleanup and effects of the spill on commercial fish species.

Mickelson, Belle; Trowbridge, Elizabeth; Bauer, P.J.; Jason, Bonnie; and Bain, Claudia. *Alaska Oil Spill Curriculum.* Cordova: Prince William Sound Science Center and Prince William Sound Community College, 1990. This large volume is full of classroom activities and other information to help students learn how dependence on oil affects people and the environment, and how life styles can be changed to move away from oil dependency through saving energy and recycling. It is divided into activity sections for pre-school, kindergarten through third grade, fourth through sixth grade, and seventh through twelfth grade. Included are maps of the spill, newspaper clips, and a bibliography of more than 100 books, magazines, video and audio tapes, newsletters, curricula, catalogs, and other sources of information on oil spills, energy use, and related environmental topics. Contact Prince William Sound Science Center, P.O. Box 705, Cordova, AK 99574. (907) 424-5800.

Milgram, Jerome. *Being Prepared for Future* Argo Merchants. Cambridge: Massachusetts Institute of Technology Sea Grant College Program, 1977. MITSG 77-10. 46 pp. This is a good example of the many useful publications produced before the *Exxon Valdez* disaster that alerted industry to ways to prevent and respond to tanker accidents.

Miller, Stanton S. "In a Faraway State." In *Environmental Science & Technology,* September 1990, Vol. 24, No. 9, pp. 1286-1289. Washington, D.C.: American Chemical Society, 1990. This excellent, easily read article concisely recounts the circumstances leading up to the oil spill, as well as the response, effects, cleanup technology, plans for changing spill response procedures and equipment, and research needs. The journal will print a five-part series on the spill, to begin in January 1991.

National Research Council. *Oil in the Sea—Inputs, Fate, and Effects.* Washington, D.C.: National Academy Press, 1985. The bible of oil impacts. Very technical.

National Research Council. *Using Oil Spill Dispersants on the Sea.* Washington, D.C.: National Academy Press, 1989. 335 pp. Addresses the ecological, aesthetic, and economic elements of dispersant use in open water, and assesses the adequacy of dispersant technologies.

Nickerson, Sheila, ed. *Alaska Fish & Game: Special Oil Spill Issue,* July-August 1989. Juneau, Alaska: Alaska Department of Fish & Game, 1989. This award-winning special issue of the ADF&G bimonthly, color-illustrated magazine focuses exclusively on the *Exxon Valdez* oil spill. Written by ADF&G staff, articles provide the department's perspective of the first two months after the spill. Includes a chronology of events and the spill's immediate effects on people and wildlife. Contact ADF&G, Box 3-2000, Juneau, AK 99802-2000. (907) 465-4112.

No Safe Harbor: Tanker Safety in America's Ports. Washington, D.C.: Natural Resources Defense Council, 1990. 72 pp. Presents an evaluation of oil spill prevention, containment, and cleanup in the United States. Information and historical records are applied to predict how vulnerable San Francisco Bay, New York Harbor, and Los Angeles/ Long Beach Harbor are to major oil spills, and to estimate how serious major oil spills might be in each of these harbors. Contact NRDC, 122 E. 42nd St., New York, NY 10168. (212) 949-0049.

Nulty, Peter. "The Future of Big Oil." In *Fortune*, May 8, 1989, p. 46. Calling the *Exxon Valdez* oil spill a tragedy but not a disaster, and characterizing Alaska citizens as pro-development, this article argues that the "Valdez mess" could be disastrous if it weakens the will of the nation to tap oil reserves in the Arctic National Wildlife Refuge and off the shores of Oregon and California.

O'Donoghue, Brian. *Black Tides: The Alaska Oil Spill.* Anchorage: Alaska Natural History Association, 1989. 40 pp. This glossy, color illustrated booklet presents a Fairbanks, Alaska, newspaper reporter's observations of events covering the first fourteen days of the *Exxon Valdez* oil spill. Contact Alaska Natural History Association, 605 West 4th Ave., Anchorage, AK 99501. (907) 274-8440.

Omohundro, J. *Oil Spills: A Coastal Resident's Handbook.* Ithaca: Cornell University, 1979. 16 pp. Information Bulletin No.164. This bulletin explains protective measures beachfront property owners can use to protect their shorelines from oil slicks.

Omohundro, J. *Oil Spills: A Public Official's Handbook.* Ithaca: Cornell University, 1979. 16 pp. Information Bulletin No.166. This handbook provides information for fire rescue, police, civil defense, Red Cross, chamber of commerce members, resident associations, and other local groups involved in spill cleanup. Emphasizes understanding how and why the public responds as it does to emergencies and suggests how to work with people who arrive from outside the community, such as media, cleanup crews, and emergency teams.

Plater, Zygmunt; Johnson, Ralph; Rieser, Alison; and Bader, Harry. *Legal Research Report to the Alaska Oil Spill Commission.* Fairbanks: University of Alaska Sea Grant College Program, 1990. AK-SG-90-06. Forthcoming. A comprehensive technical report that identifies legal tools state and regional entities can use to strengthen regulation of ocean transport of oil, and more effectively prevent and respond to oil spills. The report explores three themes: citizen empowerment, strong state sovereignty, and judicial remedies. Intended for attorneys, law faculty, and legal departments of industry, government, and environmental groups. The research was integral to new laws enacted by the State of Alaska after the *Exxon Valdez* oil spill. The ideas can be applied to other environmental regulation issues. Contact Alaska Sea Grant, 138 Irving II, Fairbanks, AK 99775-5040. (907) 474-7086.

Restoration Following the Exxon Valdez *Oil Spill.* Anchorage: Restoration Planning Work Group, 1990. 183 pp. This is the proceedings of a public symposium held March 26-27, 1990, in Anchorage. Scientists, Alaska Natives, environmentalists, government officials, tourism industry representatives, and others gathered to share ideas on restoration of Prince William Sound. Topics included: coastal habitat, fisheries, birds, mammals, recreation, cultural resources, and alternative restoration approaches. Contact Oil Spill Restoration Office, 437 E Street, Suite 301, Anchorage, AK 99501. (907) 271-2461.

Restoration Planning Following the Exxon Valdez *Oil Spill.* Anchorage: Restoration Planning Work Group, 1990. 80 pp. Produced by a joint state and federal work group, this document reports progress made restoring areas of Prince William Sound that were affected by the oil spill. Contains an excellent bibliography of scientific publications on oil spill mitigation. Contact the Oil Spill Restoration Office, address above.

Robert J. Meyers & Associates, and Research Planning Institute. *Oil Spill Response Guide.* Park Ridge, New Jersey: Noyes Publications, 1989. 314 pp. A comprehensive guide to planning on-scene response to major oil spills or oil well blowouts. Discusses equipment, techniques, logistics, and personnel. The book will help on-scene response coordinators evaluate spills and identify counter measures that will minimize negative environmental effects. Contact Noyes Publications, Mill Road at Grand Ave., Park Ridge, NJ 07656. (201) 391-8484.

Santa Rosa Press Democrat. "The Lessons of Alaska." May 21-24, 1989. A special series summarizing the Alaska oil spill and applying it to a hypothetical spill off northern California.

Satchell, Michael, and Carpenter, Betty. "A Disaster that Wasn't." In *U.S. News & World Report,* September 18, 1989, p. 60. This interesting article states that Exxon's cleanup effort was not effective, but was necessary to assuage public outrage. The authors cite some scientists' assertions that beach cleanup techniques may be more harmful than helpful, and state that Prince William Sound beaches were no longer "an ecological disaster zone" six months after the spill.

Schneider, Douglas. "Fishermen Fight the Spill of the *Exxon Valdez.*" In *Report from the Alaska Sea Grant College Program, 1985-1988,* AK-ADMIN-18, pp. 4-13. Fairbanks: University of Alaska Sea Grant College Program. This illustrated article highlights how Sea Grant Marine Advisory Agent Rick Steiner, leaders of the Cordova fishing community, and University of Alaska research faculty responded to the oil spill. It includes an interesting first-person account of cleanup activity in Valdez and at an outlying beach. Contact Alaska Sea Grant College Program, 138 Irving II, Fairbanks, AK 99775-5040. (907) 474-7086.

Science, August 18, 1989, p. 704; and March 30, 1990, p. 1537. Contains two articles on bioremediation. The first describes "the biggest test ever conducted of the use of bacteria to clean up an oil spill." The second article is a short, cautiously optimistic report on that test in Prince William Sound.

Seattle Times, March 25, 1989-June 1990. This newspaper won a Pulitzer Prize in 1990 for its coverage of the *Exxon Valdez* oil spill. Over 400 articles on the spill are accessible through two on-line data bases, including a special series on tankers, entitled "Tankers Full of Trouble." Contact your local library for information on availability and use of these data bases, called VU/TEXT and DataTimes.

Sims, Grant. "A Clot in the Heart of the Earth." In *Outside Magazine*, June 1989, p. 39. Describes the remarkable grass roots role played by Prince William Sound commercial fishermen and residents as they struggled to respond to the oil spill, and action that ultimately saved multi-million dollar salmon hatcheries from the spreading oil slick.

Spencer, Page. *White Silk and Black Tar.* A Journal of the Alaska Oil Spill. 181 pp. Minneapolis: Bergamot Press, 1990. A personalized account of the spill.

The Day the Water Died. Anchorage: National Wildlife Federation, Natural Resources Defense Council, Wildlife Federation of Alaska, and Windstar Foundation, 1990. 80 pp. This report is a compilation of often highly emotional citizen comments received by a citizen commission during public hearings in Cordova, Kodiak, Old Harbor, Homer, and Anchorage in November 1989. Sponsored primarily by the National Wildlife Federation, these hearings gave citizens affected by the spill a chance to comment on how the spill and cleanup affected their lives, and to voice their recommendations on how to minimize the threat of future technological disasters. Highly recommended for those interested in social effects of the spill.

The National Response Team. *The* Exxon Valdez *Oil Spill: A Report to the President, 1989.* Washington, D.C.: U.S. Department of Transportation and the U.S. Environmental Protection Agency, 1989. 68 pp. This multifaceted report is a frank discussion of inadequacies of the *Exxon Valdez* oil spill response. It provides a detailed chronology of the first 34 days of the spill, and discusses environmental and social effects. The report focuses heavily on federal response, with emphasis on U.S. Coast Guard activity. Describes oil spill cleanup technology, including skimmers, super suckers, containment and absorbent booms, and a discussion of oil dispersants. Contact your U.S. Environmental Protection Agency regional office.

The Northwest Environmental Journal. Spring/Summer 1990, Vol. 6, No. 1. Seattle: Institute for Environmental Studies, University of Washington, 1990. Includes four articles on oil exploration, transportation, and cleanup, and an interview with the president of ARCO Marine that covers the above topics. The articles focus on potential impacts of oil and gas development off the Washington and Oregon coasts, effects of oil on homing migration of Pacific salmon, the best responses to local oil spills, and pros and cons of cleaning oiled beaches. Also includes book reviews of *In the Wake of the* Exxon Valdez*: The Devastating Impact of Alaska's Oil Spill*, and *Superspill: Could the Valdez Oil Spill Repeat Itself in Puget Sound?*.

U.S. Congress, Office of Technology Assessment. *Coping With an Oiled Sea: An Analysis of Oil Spill Response Technologies.* Washington, D.C.: U.S. Government Printing Office, 1990. 70 pp. Highly recommended. This clearly written, well-illustrated booklet provides excellent descriptions of existing oil spill cleanup technology (described as marginal at best) and cleanup issues. States that improvements can be made through good engineering design and testing, skilled maintenance and training, timely access to and availability of the most appropriate and substantial systems, and the means to make rapid, informed decisions. The report stresses prevention. Available from Superintendent of Documents, GPA, Washington, D.C. 20402-9325.

U.S. Environmental Protection Agency. *Alaskan Oil Spill Bioremediation Project 1990 Update.* Washington, D.C.: Office of Research and Development, 1990. 20 pp. An interesting, non-technical, well-illustrated description of the largest study to date of bioremediation oil spill cleanup techniques, conducted in Prince William Sound in 1989. Also describes field and laboratory activities scheduled for summer 1990.

Editor's note: Exxon provided the following titles shortly before this publication went to press. For more information or to order, contact Exxon Alaska Operations, Media Relations, 3301 C Street, Suite 309, Anchorage, AK 99503. (907) 564-3645.

Natural Recovery of Cold Water Marine Environments After an Oil Spill. Baker, J.M.; Clark, R.B.; and Jenkins, R.H. 111 pp. This technical report commissioned by Exxon reviews scientific literature describing the natural recovery of birds, mammals, and other organisms subjected to oil spills in cold

environments. The report also describes information on natural cleaning of areas polluted by oil spills.

Environmental Recovery in Prince William Sound and the Gulf of Alaska. Baker, J.M.; Clark, Robert B.; and Kingston, Paul F. 12 pp. This color illustrated booklet, written for a lay audience, summarizes the above technical report.

Water Quality in Prince William Sound. Neff, J.M. 36 pp. This technical report describes findings of several research organizations hired by Exxon to monitor the distribution, concentration, and changes over time of petroleum hydrocarbons in Prince William Sound. The report states it is extremely unlikely that hydrocarbons from the *Exxon Valdez* spill in the water column have had or will have adverse effects on organisms living in Prince William Sound. Also available is a four-page, color illustrated brochure written for lay audiences that summarizes this technical report.

The Lamp. Spring 1990. This issue of the Exxon shareholders quarterly newsletter features an article that describes Exxon's cleanup activities. It includes before-and-after color photos of treated beaches.

Prince William Sound, Alaska—One Year After. 30 pp. This booklet contains 31 color photos of beaches on five islands directly hit by the *Exxon Valdez* oil spill, photographed before and after treatment.

Exxon Alaska Update. Published for Exxon employees, this newsletter series covers many aspects of Exxon's response to the oil spill.

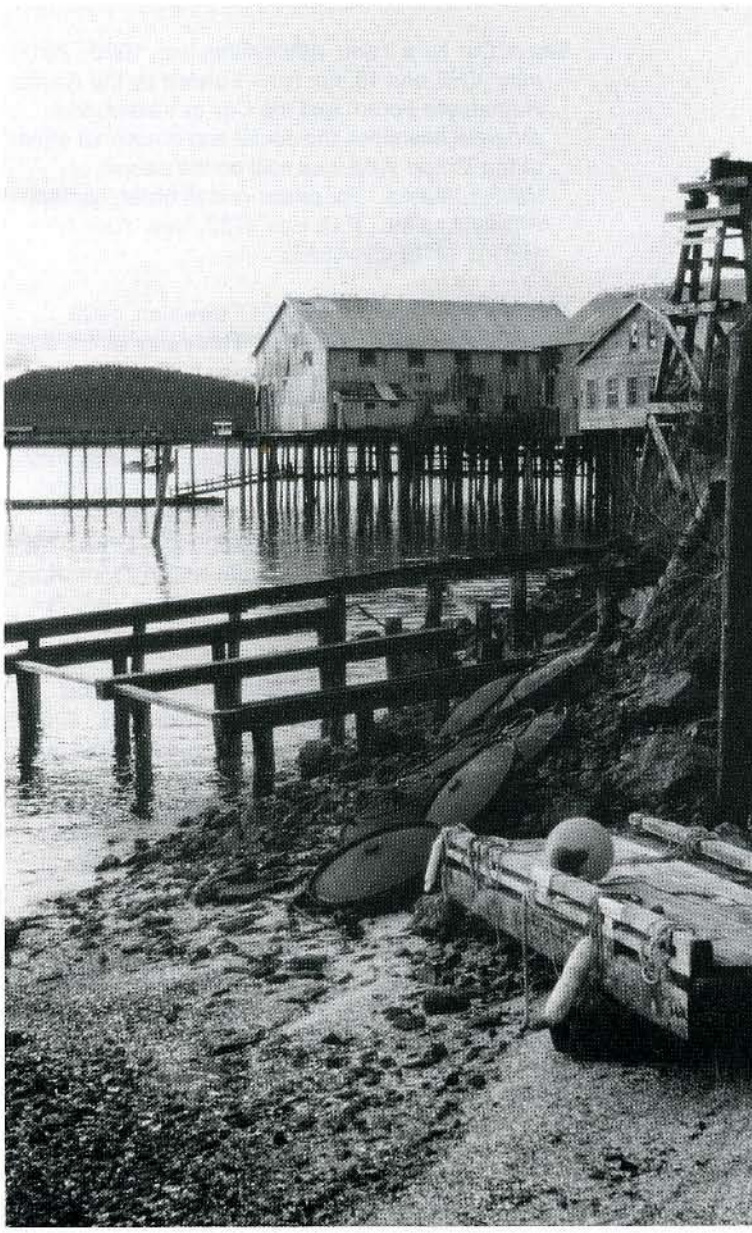
A Sound Response. A brief brochure that describes Exxon's response to the spill, and effectiveness of cleanup.

Videos

Alaska's Big Spill. Anchorage: KTUU, Channel 2, 1989. 50:00 min. VHS or Beta. $19.95. An excellent account of the spill, emphasizing response of fishermen and other local residents. Describes efforts to save wildlife, and the effectiveness of cleanup techniques. Order from Alaska Video Publishing, 3700 Woodland Drive, Suite 800, Anchorage, AK 99517. 1-800-248-WILD. Inside Alaska, 248-9453.

Ocean Ranching. Anchorage: Prince William Sound Aquaculture Corporation and University of Alaska Sea Grant Marine Advisory Program, 1990. 29:00 min. VHS. $15.00. One of the few successful reactions to the oil spill was the effort of fishermen to cordon off sensitive spawning areas and some of the world's largest and most valuable salmon hatcheries. Recorded the summer of the oil spill, this program provides an interesting look at the history of those hatcheries and describes the procedures that produce millions of salmon each year. Order from Sea Grant Marine Advisory Program, 2221 East Northern Lights Blvd., Suite 110, Anchorage, AK 99508-4140. (907) 274-9691.

KURT BYERS



The Chugach Native Corporation seafood processing plant in Cordova, Alaska.

Oil Spill: Threat to Subsistence. Juneau: Alaska Department of Fish & Game, Subsistence Division, 1990. 20:00 min. VHS. Free while supply lasts. This program explains how the oil spill threatened the health and life style of Alaska Natives in subsistence communities affected by the spill, and clearly explains how fish and game were tested for oil spill contamination and the results. Contains graphic footage of oil cleanup and oiled land and animals, augmented by interviews with scientists and residents of subsistence villages. Interesting and educational, this tape is excellent for high school students, lay public, and anyone with an interest in the spill's effects on people and wildlife. Order from: James Fall, ADF&G Subsistence Division, 333 Raspberry Road, Anchorage, AK 99518.

Sea of Oil. New York: Affinityfilms Inc., 1990. 29:00 min. VHS and 16 mm film. Funded by the Alaska Humanities Forum and the City of Valdez, this program examines the social and emotional effects of the *Exxon Valdez* oil spill on the people of Valdez, Alaska. For prices and to order, contact Affinityfilms Inc., P.O. Box 1702, New York, NY 10011. (212) 654-4865.

The Big Spill. Boston: WGBH Television, 1990. 58:00 min. VHS. $250.00. Three-day rental, $125. This is a tape of a NOVA program broadcast on Public Broadcasting Service. It reviews the spill and circumstances that led to the disaster, and examines how advances in research and technology might help prevent future spills. Order from Coronet/MTI Film and Video, 108 Wilmot Road, Deerfield, IL 60015-5196. 1-800-621-2131. Transcripts available for $5.00 from NOVA Transcripts, Journal Graphics, 267 Broadway, New York, NY 10007. (212) 227-READ.

Voices of the Sound. Cordova: Cordova District Fishermen United, 1989. 20:25 min. VHS. $25.00. This program was quickly produced after the spill by residents of affected areas. The program shows the unspoiled majesty of the sound, marine mammals, birds, and other animals. Those elements are contrasted with graphic images of destruction wrought by the oil spill. Personal reactions are presented through interviews with local government officials, Natives, industry representatives, and commercial fishers. Order from Cordova District Fishermen United, P.O. Box 939, Cordova, AK 99574.

Update

Summary of Effects of the *Exxon Valdez* Oil Spill on Natural and Archaeological Resources

Condensed from documents filed by the United States Justice Department in U.S. District Court of Alaska, April 8, 1991

This fact sheet highlights information from a report entitled *Summary of Effects of the Exxon Valdez Oil Spill on Natural Resources and Archaeological Resources, 1989-1990.* The data came from studies conducted by several federal agencies. For the complete report, contact: L.J. Evans, Public Information Office, Alaska Department of Environmental Conservation, Oil Spill Response Center, 4241 B Street, Suite 304, Anchorage, Alaska 99503.

The report reveals damage such as brain damage in harbor seals, altered DNA in sea otters, fish and salmon larvae deformations, reproductive failures in seabird populations, and hydrocarbon contamination in clams and mussels. Effects on subsistence life styles and on archaeological sites are further documented.

Another recent federal report states that high pressure, hot water sprays used to dislodge oil from beaches forced oil deep into shoreline surfaces and sterilized beaches. However, Alaska cleanup officials maintain that hot water treatment was the best way to recover the greatest amount of oil in the shortest possible time.

Timing Was Bad for Biota

The oil spill occurred just prior to the most biologically active season in southcentral Alaska, exposing plants and animals to "the most concentrated, volatile, and potentially damaging forms of the spilled oil." Seaward migrations of salmon fry, major migrations of birds, and the primary reproductive period for most species of birds, mammals, fish, and marine invertebrates took place during the two-month period following the spill.

Coastline Oiled

More than 1,200 miles of coast up to 600 miles from Bligh Reef were oiled, including coastlines of Prince William Sound, the Kenai and Alaska peninsulas, Kodiak Island, and lower Cook Inlet. Also oiled were the coasts of the Chugach National Forest; Alaska Maritime, Kodiak, and Alaska Peninsula/Becharof National Wildlife Refuges; Kenai Fiords and Katmai National Parks; and Aniakchak National Monument and Preserve.

MARINE MAMMALS

Steller Sea Lions

Some tissue samples showed exposure to oil. It is not known if continuing population declines are caused by exposure to oil. Pupping surveys from 1990 are being analyzed.

Killer Whales

There are 182 killer whales in the sound, belonging to nine distinct family groups. Twenty-two killer whales, including several females with calves, are missing from two pods in Prince William Sound. Abandonment of calves by females is unprecedented, but no evidence exists that connects the disappearances to exposure to oil. Killer whale surveys continue in 1991.

Sea Otters

An estimated 3,500 to 5,500 sea otters died in the spill. Of these, 1,011 carcasses were recovered and cataloged. Causes of death were hypothermia, ingestion of oil, and inhalation of toxic aromatic hydrocarbons. Evidence was found of abnormal blood chemistry and DNA, and unusual mortality of prime age sea otters. Pupping rates were not significantly different from before spill, but population continues to decline in Prince William Sound. Higher yearling mortality rates in oiled areas, and adult sea otters released from rehabilitation centers show reproductive failure and high levels of mortality.

Harbor Seals

An estimated 200 harbor seals died in the spill. Unexplained declines in harbor seal populations were occurring prior to the spill. However, population surveys following the spill measured a 35 percent population decline in oiled areas compared to a 13 percent decline in unoiled areas. Brain lesions and high concentrations of hydrocarbons were found in bile long after the spill, indicating continuing exposure to oil. During 1989, observers witnessed abnormal behavior.

Humpback Whales

No mortalities or reproductive failures are directly attributable to the oil spill.

TERRESTRIAL MAMMALS

Brown Bears

Analyses of fecal samples indicate exposure to oil, but no injuries or fatalities have been attributable to hydrocarbons. Radio collared brown bears on the Katmai coast and at a control site on the Alaska Peninsula continue to be studied. Black bears were not studied.

Mink and Other Small Mammals

No deaths from exposure to oil have been documented. Scientists who fed oil-contaminated food to ranch-bred mink in laboratories found that food passed rapidly through the digestive tract, possibly depriving mink of nutrition.

Deer

No injuries or deaths have been attributed to the spill. Some deer taken for human consumption had slightly elevated levels of hydrocarbons in body tissues.

River Otters

A few dead river otters were found, but no cause of death was cited. Hydrocarbons were detected in bile. River otters in oiled areas were found to have larger ranges, their movements were more erratic, and body weights were lower than otters in unoiled areas. Studies continue.

BIRDS

Computer models indicate 260,000 to 580,000 deaths. Models will be run again to refine the estimate. In 1989, 114 species of dead birds were collected from oiled areas.

Bald Eagles

After the spill, 144 dead bald eagles were found. Total mortality is unknown. Productivity surveys in 1989 indicate a failure rate of 85 percent in heavily oiled areas, and 55 percent in unoiled or lightly oiled areas. Effects on eagle population may not be apparent for several years. Additional surveys were taken in 1991.

Common and Thick-billed Murres

Colonies affected by spill lost 60 to 70 percent of their populations, an estimated 300,000 deaths. Complete reproductive

failure is estimated to have caused the deaths of 215,000 chicks in 1989 and 1990.

Sea Ducks
More than 2,000 sea duck carcasses were recovered after the spill, including more than 200 harlequin ducks. These injuries will be further investigated in 1991. Continuing exposure to petroleum hydrocarbons is likely because of sea duck dependence on nearshore invertebrates.

Other Birds
There were reduced numbers of black oystercatchers, pigeon guillemots, and marbled murrelets. Effects on loons, cormorants, and gulls are unknown because pre-spill information is not available. Breeding success of black oystercatchers was reduced, due mostly to death of chicks on oiled beaches. About 1,500 to 3,000 pigeon guillemots were killed. Scoters, marbled murrelets, sandpipers, glaucous-winged gulls, red-breasted mergansers, king eiders, black-legged kittiwakes, and other species were affected. Major wintering areas for many species were contaminated.

FISH AND SHELLFISH

No massive die-offs of adult fish have been documented. Fish are unique in that they metabolize petroleum hydrocarbons so that hydrocarbons are not likely to be found in the edible flesh. Salmon successfully migrated to spawning areas after the spill. Morphological and reproductive problems were detected in salmon and herring.

Hatchery Production
In 1989, returns of adult salmon to hatcheries located in heavily oiled areas were half the percentage of returns to hatcheries in oil-free parts of the sound.

Wild Production
Mortality of pink salmon eggs deposited in oiled intertidal streams was 70 percent greater than mortality of pink salmon eggs deposited in unoiled intertidal streams. Salmon larvae from heavily oiled streams showed gross morphological abnormalities, including club fins and curved spines. Eggs and larvae continue to be exposed to oil in intertidal gravel.

Sockeye Salmon
Closed fishing seasons caused overabundance of adult salmon in spawning areas, which degraded rearing habitat and may have adversely affected larval survival and growth rates.

Pink Salmon
Harm to hatchery salmon released into oiled waters cannot be assessed until they return to spawn in 1991.

Trout
Dolly Varden trout retained the highest concentrations of petroleum hydrocarbons of all fish sampled. Mortality was 32 percent greater in oiled areas than in oil-free areas. Cutthroat trout suffered mortality rates similar to Dolly Varden trout. Growth rates were reduced in some areas. Studies continue on both species.

Pollock, Halibut, Sablefish, Cod, Yellowfin and Flathead Sole, and Rockfish
Hydrocarbons were found in the bile of yellowfin sole, rock sole, rockfish, and pollock. Each species continues to be exposed to bottom sediments that contain petroleum hydrocarbons deposited over a large area. Significant injuries have not been documented, and studies continue.

Pacific Herring
There were large increases in the percentage of abnormal embryos and larvae in oiled areas of Prince William Sound during the 1989 reproductive season. Larvae in oiled areas had a greater incidence of eye tumors. These effects continued at lower rates in 1990. Greater egg mortality occurred in oiled areas as compared with oil-free areas. Herring that return as adults in 1992 and 1993 will be examined for injuries inflicted during the larval stage.

COASTAL HABITAT

Supratidal
Oil contamination and beach cleanup decreased productivity of beach rye grass and other vegetation that help stabilize berms. Increased vegetation was found in Prince William Sound, possibly due to fewer predators or to fertilizers applied to beaches to speed oil breakdown.

Intertidal
Abundance of algae, barnacles, limpets, amphipods, isopods, and marine worms was decreased, and the biomass of mussels and fish was significantly reduced. Uptake of hydrocarbons persists. Gill parasitism and respiration rates were higher in fish from oiled areas. *Fucus*, the dominant kelp and a prominent food in the tidal ecosystem, showed reductions in size, reproductive ability, recruitment, and abundance.

Subtidal Habitat
Hydrocarbons were found in bottom sediments as much as 330 feet under water, and in bottom dwelling fish. Clams and other invertebrates absorbed and retained hydrocarbons and they remain a potential source of hydrocarbon contamination to sea otters and other predators. The oil had significant effects on benthic organisms associated with eelgrass beds.

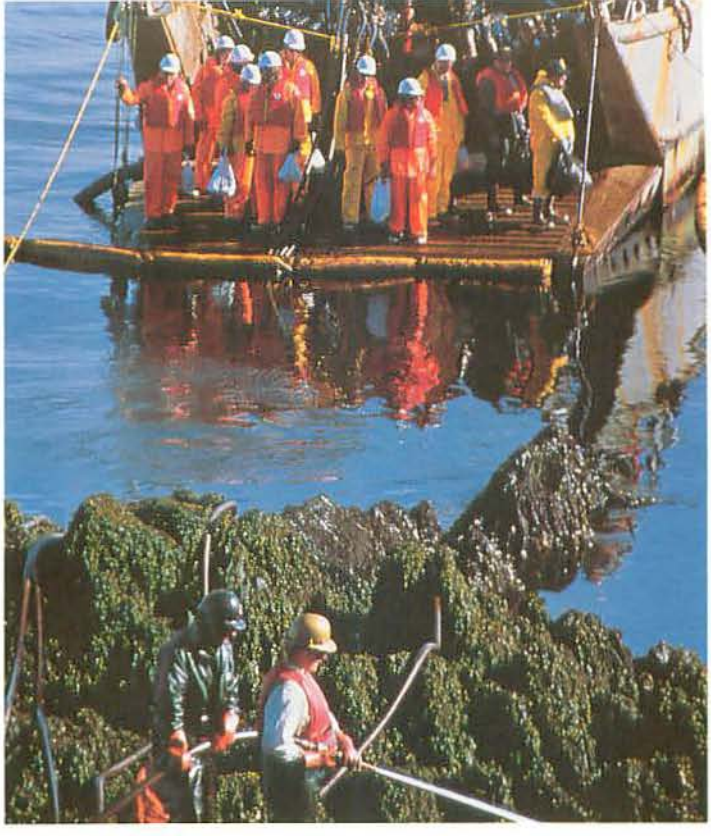
ARCHAEOLOGICAL AND SUBSISTENCE RESOURCES

Archaeological Resources
A minimum of 26 sites were damaged, including home sites and some burial sites that were irreversibly damaged. Assessment is not complete. Some damage makes accurate study and artifact dating impossible. Natives worry that widespread knowledge of the sites may lead to looting.

Subsistence Resources
Subsistence life styles remain disrupted by real or perceived contamination of traditional and historically important subsistence resources. The report *Subsistence Use of Fish and Wildlife in 15 Alutiiq Villages after the Exxon Valdez Oil Spill* details effects on subsistence life styles. With the exception of clams and mussels in certain oiled areas, traditional foods were determined safe for human consumption.

SIGNS OF HOPE

Natural recovery is making headway. Winter storms have helped wash away and break down weathered oil on exposed shores. Fertilizers applied by cleanup workers have accelerated breakdown of petroleum hydrocarbons, although long-term effects of fertilizers on the environment are unknown. Plant and animal communities have begun to reestablish themselves in lightly oiled areas. The U.S. Coast Guard in 1990 installed a marking light on Bligh Reef, and upgraded its Valdez ship radar tracking facility to more effectively monitor tankers traveling in Prince William Sound. Tanker crews undergo tests for alcohol in the bloodstream before sailing.



JEFF SCHULTZ–SIPA

Landing craft preparing to deliver oil spill cleanup workers. According to Exxon, approximately 11,000 workers, 1,400 vessels, and 84 aircraft participated in the oil spill cleanup attempt of 1989.

Fisherman's Foreboding

The pulse that pushes through the vein
Betrays the heart that seeks the gain.

For with the black blood of the earth,
We kill the sea that gives us birth.

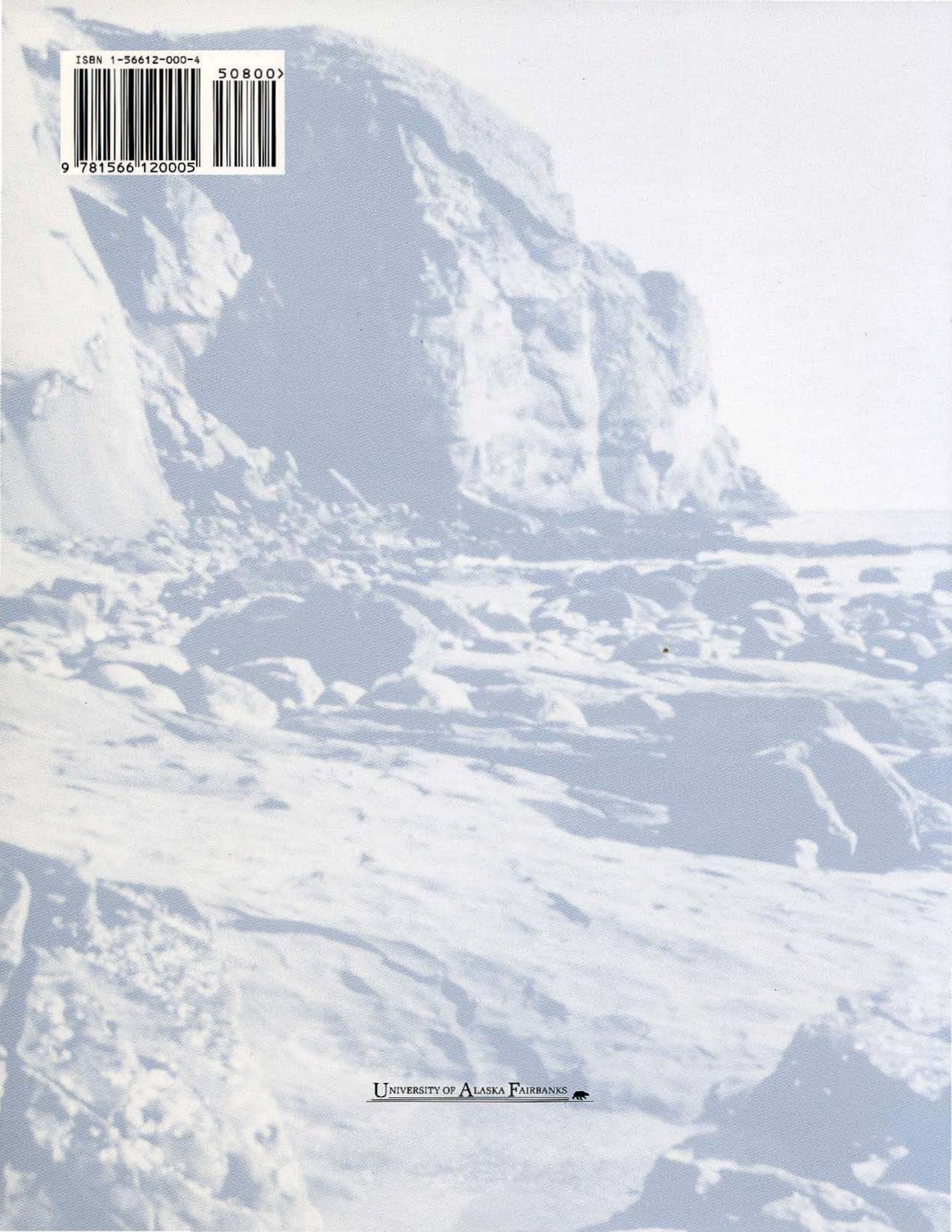
To lubricate the works of man
We pump the crude that stains the hand.

While in bondage to our selfish goals
We burn the oil that blacks our souls.

And as we lust for less than life
Then must we bear the stain,

That marked Macbeth the murderer,
And makes us one with Cain.

–Bill Hall, 1971
Cordova commercial fisherman
and bank marketing director



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