ENVIRONMENTAL RECOVERY IN PRINCE WILLIAM SOUND AND THE GULF OF ALASKA

Field Observations of:

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A supplement to the authors' scientific review:
"Natural Recovery of Cold Water Marine Environments After an Oil Spill"

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INTRODUCTION

This report is based on work commissioned by Exxon as part of a programme of analyzing the ecosystem recovery process in Prince William Sound and the Gulf of Alaska following the oil spill of March 1989.

Written by three distinguished scientists, it supplements a comprehensive study they and a fourth researcher prepared on the subject of "Natural Recovery of Cold Water Marine Environments after an Oil Spill." This scientific review was presented at the 13th Arctic and Marine Oilspill Program Technical Seminar sponsored by the Canadian Government in Edmonton, Alberta, on June 6, 1990.

As a followup to this study, the scientists spent two weeks in April 1990 gathering insight into the Prince William Sound and Gulf of Alaska environment as a whole and examining plant and animal life in the area. They compared their Alaska findings to their knowledge gained from studying the recovery process from other oil spills in cold waters of the world.

The scientists, all from the United Kingdom, are:

Dr. Jenifer M. Baker, a biological consultant who works on oil-pollution problems for conservation organizations, corporations and government agencies throughout the world.

Dr. Robert B. Clark, zoology professor emeritus at the University of Newcastle upon Tyne, author of the textbook *Marine Pollution* and editor of the international journal *Marine Pollution Bulletin*.

Dr. Paul F. Kingston, a marine biologist and assistant director of the Institute of Offshore Engineering in Edinburgh, Scotland.

The following pages contain a summary of their conclusions and answers to questions they have encountered since their inspection tour in Alaska. Also, excerpts from their review of previous spills are provided in the back of this report.

Researchers closely examine a worm from a sedimentary shore. From left, Dr. Kingston, Dr. Baker, and Dr. Clark.

OVERVIEW

In April 1990, we toured Prince William Sound and the Gulf of Alaska for two weeks to obtain a perspective on the total area relative to the affected region, and to conduct field observations on the environmental impacts of the Valdez oil spill. Because the Sound and Gulf comprise an immense region with thousands of miles of coastline, most of which was not oiled by the spill, we obtained an overview with extensive low-altitude flights of the area. In addition we conducted shoreline investigations on numerous beaches, including some of the most heavily impacted areas. The map on this page indicates the broad geographical scope of our investigation.

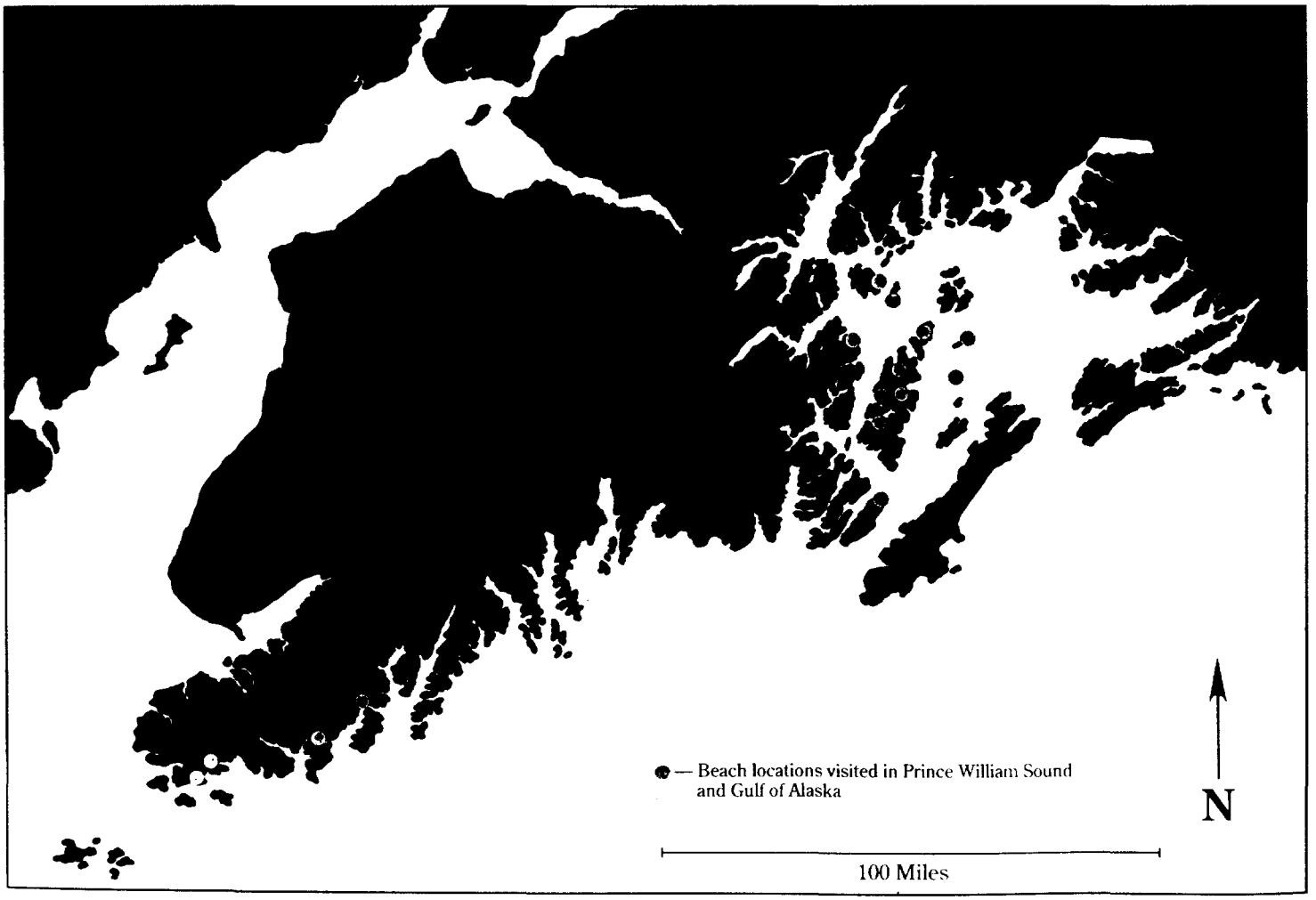
Prior to our field investigation, we were familiar with the considerable body of scientific research focused on the biological implications of previous oil spills. Since the wreck of the tanker Torrey Canyon created a major oil spill off the southwest coast of England in 1967, the scientific community has been investigating how areas affected by an oil spill recover through natural processes. As specialists in this field of study, we were aware of the conclusions reached through this research and therefore what one might expect to find in Alaska.

Our examination of plant and animal life in the many unoiled and previously oiled areas was designed to provide an overall perspective of environmental conditions in Prince William Sound and Gulf of Alaska. From this field analysis, we derived impressions on how the natural recovery was proceeding in Prince William Sound and the Gulf of Alaska. What follows is a brief summary of our field observations and impressions.

General findings

Our experience in Prince William Sound, one year after the oil spill, held few surprises.

Only a portion of the shoreline had been oiled, and, as with most other oil spills, the bulk of the damage had disappeared during the first year. The area has retained its natural beauty; there are abundant signs of



plant and animal life, and recovery is well under way on even the most severely impacted beaches.

Since there are few sheltered areas with extensive mudflats, which elsewhere have sometimes taken a long time to recover, the overall impact of the oil spill on the environment in Prince William Sound and Gulf of Alaska is likely to be short-lived.

The search for oil

Prince William Sound and the Gulf of Alaska are vast, mainly inaccessible areas, and the spilled oil only impacted a small portion of the total shoreline. On our visit one year after the spill, most of the shoreline of the Sound and the Gulf did not have an oily appearance. The main reasons for this generally favourable impression were: most of the shoreline was not oiled or was only slightly oiled by the spill; bulk oil had been removed by the extensive cleanup programme during the summer following the spill; the natural cleaning process has been effective, and this process includes wave action, winter storms and breakdown by bacteria.

Despite the generally favourable appearance from

Rock covered with black lichen, which can look like oil at a distance.

Most of the Prince William Sound had a generally favourable appearance.

the air, dark patches on the rocks and dark zones on the upper shore invited further investigation. On the ground, we found that many of these dark patches were formed by a black lichen, not by oil. Other noticeable dark patches were beds of algae or mussels, although some were caused by oil or oil stains.

The remaining oil

Overall rocky shores generally appeared clean from the air, and this was confirmed by ground observations. However, residues of weathered oil were present and had a varied distribution depending upon exposure to wave action and height on the shore. Most of the residual oil was found in sheltered inner bays or on upper shores.

We dug into several sedimentary shores and found oil that had penetrated below the surface. Even in the sediment bays that were heavily oiled, a variety of plants and animals were present, some of them abundant. This was consistent with recovery processes noted in other oil spills. In some areas, small oil sheens (microscopically thin films) emerged from these disturbed sediments. On some shores, there are recent deposits of fine sediment on top of oil residues, and these could help reduce any remaining surface stickiness.

Beach cleaned by strong wave action, oil stains remaining on sheltered area in the background.

Otter observed in previously oiled waters of Prince William Sound.

Sea otters

Sea otters were affected by the spill and attracted a great deal of media attention. We were therefore particularly interested to see otters in many parts of Prince William Sound and the Gulf of Alaska, including previously oiled waters. The frequency with which we saw the otters suggests that they are reasonably common throughout the Sound and Gulf.

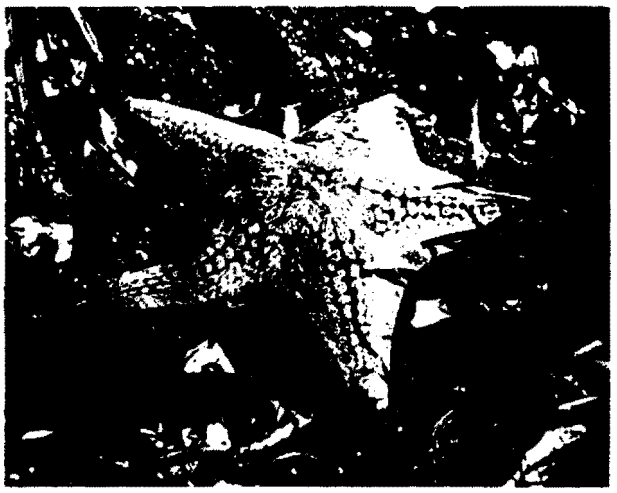
Seals and Sea lions

Large numbers of sea lions, with at least 100 in each group, were basking on the rocks at several locations in the region. In addition, many seals were observed swimming in the open waters. Although we did not undertake a detailed study of the seals and sea lions, large numbers of them appear to exist in areas affected by the spill.

Sea birds

The dominant seabirds in the area were auks (murres) and gulls. These birds, which do not start breeding until late May or June, were primarily distributed in small feeding groups throughout Prince William Sound and the Gulf of Alaska, although large numbers were already congregating around some of the breeding colonies.

Migrant birds were only just beginning to return from their winter quarters. Small groups of mallard and other ducks were seen, in addition to a pair of swans, a group of black-bellied plover and other wading birds. Cormorants were often seen flying around



Starfish found in the tidal region of a previously oiled shore.

Prince William Sound and the Gulf of Alaska.

The most conspicuous casualties of cold-water oil spills are seabirds such as auks, which often congregate in dense flocks on the sea, making it possible for large numbers to be killed by a single oil slick. Despite this, previous research cited in the scientific review on natural recovery has shown that seabird breeding populations rebound rapidly because any losses are replaced from a large reservoir of previously non-breeding adults. Also, we would expect no further casualties since the water now appears clear of oil with only a minor sheen presence.

Fresh grass shoots sprouting from sediment containing residual oil.

Bald eagles

Bald eagles were seen perching at the top of lookout trees at regular intervals along the entire coastal area. It is not a rare bird in the area. Bald eagles obtain much of their food by foraging on the shoreline and may have been affected by oil in this way. As with other large birds of prey, bald eagles do not start breeding until the age of 3 or 4. There is therefore a substantial reserve of young adults ready to fill gaps in the breeding population as nesting territory becomes available.

Shoreline creatures

The creatures we saw most commonly on the rocky shores were barnacles, periwinkles (sea snails), mussels and limpets. They were abundant at widespread

Rock overturned in an oiled area, exposing a variety of shoreline creatures.

locations in Prince William Sound and the Gulf of Alaska, including areas which had been heavily oiled. We found egg clusters of a variety of molluscs at sites which had been oiled. Worms and shellfish were living in the sediments of the more sheltered shores, including areas which had been oiled and some of which still contained oil. Numerous worms and other creatures living in the sediment promote aeration, helping the bacterial breakdown of oil.

polychaets

Sighting of numerous young barnacles on the rocks implies that environmental quality has been good enough to support these animals through the sensitive stages of the life cycle, both at sea and on shore. It is likely that shore oiling killed many barnacles, but we saw many that had survived the spill, some with oil still visible on their shells. Some young barnacles have settled next to oil crusts on the rock, indicating that

Young fucus (rockweed) growth on a previously oiled rock.

Bald eagle atop lookout tree, a common sight.

the residual oil has a very low toxicity. Periwinkles also were active on oiled rocks.

Plant life

In all marshes or upper-shore grass zones, we saw new grass shoots of normal appearance emerging from the sediment. We were particularly interested in the presence of marsh grasses at sites which were reported as heavily oiled. Many of the plants making new growth were rooted in sediments which retained visible oil residues, indicating low toxicity of the residues and the existence of a robust system of underground stems and roots.

Algae were seen throughout Prince William Sound and the Gulf of Alaska, including young rockweed plants which had established themselves after the spill. Filamentous green algae were noticeable on many shores.

We found sea or eel grass on shores which had been oiled and compared it with the grass growing on an unoiled shore. Most of the grass on all these shores looked green and healthy.

We saw numerous kelp beds with plants of normal colour along the more exposed shores of the Kenai Peninsula and the mouth of Prince William Sound.

Fish

While it was not possible to make observations of fish during our field analyses, extensive research referenced in the scientific review has shown that oil spills have little impact on fish, and, indeed, the herring fishery opened successfully while we were in the area.

CONCLUSION

Our examination of the spill area confirmed our expectations, based on knowledge gained from previous accidents, that natural recovery is proceeding in Prince William Sound and the Gulf of Alaska. We expect the recovery to continue and to be relatively rapid.

Although isolated patches of weathered oil may still be found, nearly all of the beaches in Prince William Sound and the Gulf of Alaska are of clean appearance. Some small and isolated portions of the shoreline may retain oil for several years, but our investigations of previous oil spills indicate that the long-term impact on plants and animals should be minimal.

The recovery process is well under way. Once started, if it is allowed to proceed without interruption, it will continue and be robust, as it has been following other spills throughout the world.

What follows are answers to questions perceived to be of general public interest.

COMMONLY ASKED QUESTIONS

The following are responses given by the authors to questions they have been asked following their examination of Prince William Sound and the Gulf of Alaska.

Were you surprised with what you found in Alaska?

What we saw in Prince William Sound, from the point of view of biologists, confirms what the research on previous spills had told us we might expect to find. Over the past 25 years, there has been extensive research on oil spills around the world, at least 30 of them larger than the Valdez spill. That helped prepare us for what we found. What did surprise us was a smaller amount of oil on the beaches than we expected. We were impressed with how extensive the cleanup effort had been, as well as the combined effectiveness of the strong natural cleansing processes and the cleanup operation.

What is the overall impact of the spill on the ecology of Prince William Sound?

For the parts of the Sound that were affected, it was a shock. However, it was more like a rash on a human body that will heal itself, rather than a crippling or terminal disease. After the initial shock, the natural recovery process began. Animals and plants are thriving, and the environment is healing.

What is the scientific evidence on the effects of major oil spills on water quality or on Prince William Sound?

Investigators dig into the sediment to find worms and other creatures.

Indications of the good water quality in Prince William Sound are provided by biological evidence. We saw on the shoreline abundant evidence of life that has survived or has newly settled on shores that were previously heavily oiled. For example, young barnacles and seaweeds are abundant on most shores. These organisms, in their most sensitive stages, float in the water until settling. Furthermore, they are quite fussy about where they settle, and they must find suitable rock surfaces to settle upon.

Will the oil that remains in shoreline sediments pose a danger to plant and animal life?

There are abundant signs of life such as worms, shellfish and grasses thriving on many sedimentary shorelines. This indicates that sediments either do not contain toxic residues or, if they do, the level of toxicity is not high enough to affect the survival or activity of these creatures. Their presence indicates that recovery is in progress. Once started and allowed to proceed without interruption, we believe it will continue and will be robust, as it has been following other oil spills throughout the world.

Is oil a toxic compound that will persist for decades?

No, oil is not a persistent toxic compound like PCBs, mercury and many pesticides. The toxicity in oil diminishes very rapidly as it is exposed to the air and water. Most of the oil released in PWS was afloat for at least four days before it reached the shoreline, and in that time would have lost much of its toxicity. Therefore the damage it did to wildlife was not so much because of its toxicity as because of its smothering effect. It follows it is unlikely that much of the oil that remains is significantly toxic, even that trapped in shoreline pockets. We saw biological evidence for this, such as animals living in sediments with residual oil. In addition, green shoots of upper-shore grasses were sprouting normally from the oily sediment.

Are birds and wildlife threatened by oil sheens?

In our on-site inspection, we looked for sheens from the air and on heavily oiled beaches. From the air, we saw only a few sheens and they were quite small in area and very thin, as indicated by their colour. It is very unlikely, therefore, that they would be harmful to wildlife, including birds and sea otters, the animals most at risk. There is no past evidence to suggest otherwise. Animals exposed to these sheens would, in the normal course of living, groom

themselves.

Small sheens emerged from some sediments we disturbed on the beaches, but they were too small to have any significance for birds and other wildlife.

Has the oil entered the food chain and disrupted it?

Animals may accumulate petroleum hydrocarbons while their environment is oily, but they subsequently purge themselves in a relatively short time and return to normal levels. It is important to understand that oil is not like pesticides, mercury and other substances that cannot be metabolized, cannot be excreted, and thus build up in the flesh.

Have any species been irretrievably lost by this spill?

This is unlikely for a number of reasons. First, only portions of Prince William Sound and the Gulf of Alaska were affected. The sea is continuous and the abundant plant and animal life in the vast unaffected areas provide a reservoir of organisms to move in and replace losses created by the one-time, short-term occurrence of the oil spill. Secondly, the number of bird mortalities caused by the spill was small compared to those caused by naturally occurring phenomena such as extremely cold weather, harsh storms and old age. Finally, sea otters, which were also impacted, have a rapid reproduction rate.

Are the fish after an oil spill safe to eat?

Yes. There is ample evidence that fish avoid floating oil and are unaffected by it. Impounded fish that are exposed to fresh oil may acquire a taste of oil, but this is temporary and quickly dissipates once the fish are returned to clean waters. Even if the fish acquires an oily flavor, there is no evidence that this poses a toxicological hazard.

There are reported although unconfirmed sightings of abnormal fish and other animal life in Prince William Sound since the oil spill. Would you comment on that?

Some fish may have developed in an abnormal way if they were exposed to oil in their early stages.. But it is most unlikely that these abnormalities would be passed on to the next generation. Any grossly abnormal members of the population would not survive long in the struggle for existence. On the other hand, genetic mutations, which also could lead to abnormalities, occur naturally, and there is no evidence from previous spills that link these to oil.

How has the habitat in Prince William Sound been damaged or compromised?

The short-term impact from the spill was serious. From our observations, it is difficult to say anything definite about the long-term impacts, although recovery is well under way. Experience from other oil spills indicates that long-term impacts will be minimal.

Is there any reason to restrict normal human use of Prince William Sound for tourism, hiking, camping, hunting, fishing, kayaking, etc?

No. We were struck by the magnificent beauty of the area. We visited the most heavily oiled areas and found nothing indicating that human use should be or need be restricted because of the spill.

How can you say this "pristine and fragile" area has not been irreparably damaged by the introduction of 11 million gallons of oil?

We saw nothing to indicate the Prince William Sound environment is particularly fragile. The marine environment is a lot tougher and more resilient than most people give it credit for. Life forms in that rather harsh environment have to be hardy to survive. All the evidence suggests Prince William Sound is a robust, resilient environment well on its way to recovery.

Basking group of seals, one of many spotted on rocks throughout the region.

THE NATURAL RECOVERY PROCESS

The following are excerpts from Natural Recovery of Cold Water Marine Environments after an Oil Spill published by the authors and Dr. Rowley H. Jenkins, deputy director of the UK Institute of Offshore Engineering, in March 1990. These findings are based on an extensive review of research into major oil spills into cold water environments throughout the world.

BASIC CONCEPTS

• Current evidence indicates that hydrocarbons are present in all environments. They originate from both natural and human sources and serve to define background levels of petroleum hydrocarbons.

• Recovery of an ecosystem damaged by petroleum hydrocarbons begins as soon as the toxicity or other adverse property of the oil has declined to a level that is tolerable to the most robust colonizing organisms. Recovery processes can begin in the presence of residual oil.

• Recovery of an ecosystem is marked by the re-establishment of a healthy biological community in which the plants and animals of the community are functioning normally. It may not have the same composition or age structure as that which was present before the damage and will continue to show further change and development. It is impossible to say whether an ecosystem that has recovered from an oil spill is the same as, or different from, that which would have developed in the absence of the spill.

• Ecosystems are in a constant state of flux due to natural causes. These fluctuations can be as great as, or even greater than, those caused by the impact of an oil spill.

NATURAL CLEANING

• Most of the toxic components in a fresh oil spill on the surface of the sea rapidly evaporate. After evaporation, these toxic components disperse into the atmosphere and are rapidly diluted to background levels. Most of the remaining toxic components that did not evaporate, dissolve and disperse in the water column to low concentrations.

• Generally, the higher the aromatic content of an oil, the higher the toxicity. Weathered crude is less toxic than fresh crude because most of the toxic components have evaporated. Most of the toxic components are readily degradable.

• Oil concentrations in the water column below oil slicks are very low.

• The persistence of oil slicks on the sea surface is dependent upon the type of oil spilled and sea state conditions. Some slicks can be removed by natural processes within a few days. Other oils can form stable, highly viscous emulsions (mousses), which may persist for weeks or months in the open ocean. Eventually these slicks will form tarballs that are relatively harmless to biological systems.

• High-energy rocky shores usually do not accumulate oil, and if impacted are subjected to rapid cleaning by wave action.

• Oil does not penetrate easily into fine sediments in the intertidal zone, but can sink into shingle, gravel, and coarse sand. In some cases oil may penetrate to the water table, which forms a natural barrier to further penetration.

• On sheltered shores with high biological productivity, oil can penetrate down biological pathways, e.g., worm burrows and plant root systems. Oil may persist for many years in the sediments, especially if oxygenating biological activity (e.g., new burrow formation) is depressed.

• Physical 'removal' of oil by natural processes alone does not eliminate oil from the environment; it redistributes it. This redistribution can be beneficial - e.g., when wave action cleans the shoreline, it facilitates dispersion of the oil in the water column, and increases the surface area of the oil droplets, thereby encouraging other degradation processes. However, such redistribution may also involve sediment-bound oil being transported to the seabed.

NATURAL RECOVERY

• Diving seabirds suffer heavy mortalities from oil. However, the mortalities arising from a single oil spill are not significantly different from natural mass mortalities experienced from time to time and are significantly less than annual mortalities from fishing activities.

THE NATURAL RECOVERY PROCESS

- There is no evidence that seabird populations are declining as a result of oil spills. In fact, North Atlantic populations of most species have been increasing in recent years despite heavy annual losses from oil pollution.

- Kills of adult fish from exposure to oil are rare. The only important casualties from oil spills are rockfish and shellfish in near-shore waters, and fish in mariculture installations.

- Loss of pelagic eggs and fish larvae, when these are present at the time of an oil spill, has had no detectable impact on the fish stocks available to the fishing industry.

- Although the toxic components of petroleum hydrocarbons kill planktonic organisms, there is no evidence that these effects have any ecological significance in open waters. In closed waters, effects may persist for several months.

- Estimates of recovery times vary depending upon the environment. Past experience has shown that exposed, rocky shores usually recover in 2 to 3 years. Other shorelines show substantial recovery in 1 to 5 years with the exception of sheltered, highly productive shores (e.g., salt marshes), which may take 10 years or more to recover.

- Subtidal sand and mud systems recover in recognizable successions. Usually, recovery times are 1 to 5 years, but they can be 10 years or longer in exceptional cases.

- The early colonizers, once the physical and toxic effects of the oil ameliorate, play an active role in the breakdown of the remaining hydrocarbons.

- Removal of oil using drastic cleaning methods, beyond initial bulk oil removal, can actually delay recovery because the cleanup also removes living organisms and damages the habitat.

BIOGRAPHICAL SKETCHES OF THE AUTHORS

Dr. Jenifer M. Baker

Dr. Baker is a biological consultant who conducts research on oil-pollution problems for conservation organizations, corporations, and government and United Nations agencies throughout the world. She is the former research director of the UK Field Studies Council, an independent environmental education and research organization. Her doctoral studies at the University of Wales involved research into the effects of oil and cleaning methods for salt marshes, and she later served as a staff member in the botany department of the University College, Swansea. She recently helped assess potential oil pollution problems on the great lakes of Africa for a conference organized by the International Association of Theoretical and Applied Limnology. A fellow of the British Institute of Biology and the Institute of Petroleum, Dr. Baker has published numerous papers in the scientific literature on the recovery of impacted shoreline ecosystems.

Dr. Robert B. Clark

Dr. Clark, professor emeritus of zoology at the University of Newcastle upon Tyne, received his Ph.D. from the University of Glasgow and a D.Sc. from the University of London. He has served as director of the seabird research unit of the British Advisory Committee on Oil Pollution of the Sea (1969-75) and as director of the Natural Environment Research Council's Unit on Rocky Shore Surveillance (1980-87). He has served as a member of the zoology faculty of the University of California at Berkeley and has worked with numerous national and international scientific bodies, including the United Nations Group of Experts on Scientific Aspects of Marine Pollution and the UK Royal Commission on Environmental Pollution. Dr. Clark is the author of the textbook *Marine Pollution* and is founder and editor of the monthly *Marine Pollution Bulletin*.

Dr. Paul F. Kingston

Dr. Kingston is the assistant director of the UK Institute of Offshore Engineering and a former member of the marine biology faculty at Heriot-Watt University in Edinburgh, Scotland. He obtained his doctorate from the University of London and joined Heriot-Watt University in 1975 following a three-year research fellowship at the University of Newcastle upon Tyne. Dr. Kingston has extensive experience assessing the environmental impact of the offshore oil industry and has worked on most major North Sea petroleum developments. His research centers on the structure and dynamics of seabed communities. He has published extensively and currently serves as news editor of the *Marine Pollution Bulletin*.

Copies of this report or the review
"Natural Recovery of Cold Water Marine Environments After an Oil Spill"
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