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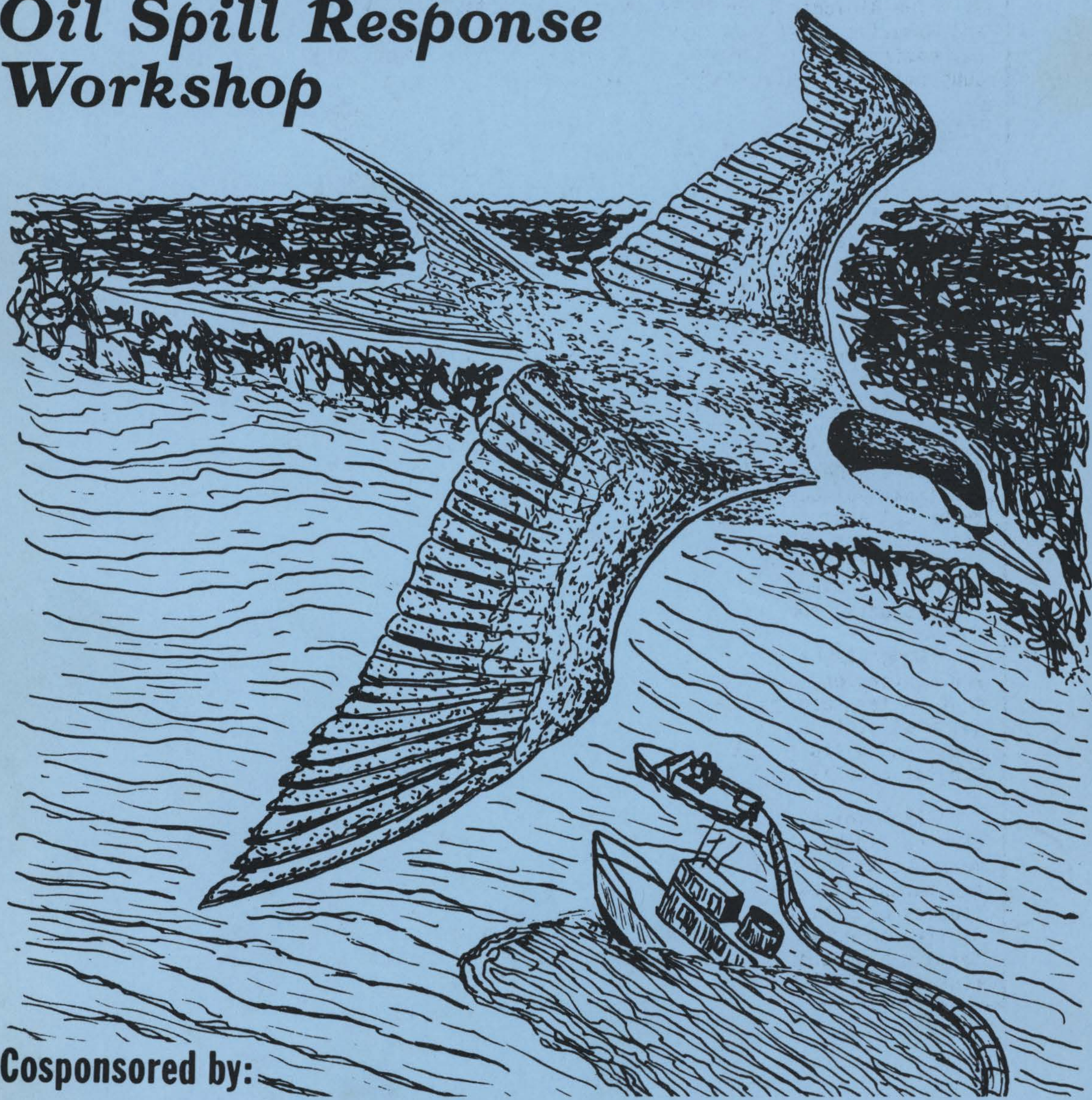
Proceedings of the 1977 Oil Spill Response Workshop



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Office of Migratory Bird Management and
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Fish and Wildlife Service

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PROCEEDINGS OF THE 1977

OIL SPILL RESPONSE WORKSHOP

Paul L. Fore, Editor

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PREFACE

An Oil Spill Response Workshop was held in Metairie (New Orleans), Louisiana, from 15 to 17 February 1977 to improve the Service's capability and effectiveness in responding to oil spills. The workshop was cosponsored by the Office of Migratory Bird Management and the Office of Biological Services, Fish and Wildlife Service, U.S. Department of the Interior.

This workshop was designed for U.S. Fish and Wildlife Service personnel, primarily our regional and field-level oil spill coordinators, who are called upon to make sound decisions on oil spill incidents. The objectives of the workshop were:

- To discuss overall Service responsibilities, capabilities, and procedures in responding to spills;
- To disseminate current information concerning biological impacts of oil on wildlife, techniques for minimizing impacts, and other information essential for developing an effective response by the Service to oil spills;
- To present views of other agencies and organizations on their role in responding to oil spills and their relationship to the U.S. Fish and Wildlife Service; and
- To critique the recently drafted oil spill contingency plan of the Service and assist in preparing a final plan.

The Proceedings are papers presented at the workshop. Most of the papers were prepared from the author's manuscripts, while some were adapted from edited transcripts. In all cases, the content of the papers reflects material presented at the workshop.

Following the technical sessions, the participants were divided into six smaller groups to more effectively review and to make recommendations on various sections of the Service's preliminary draft of the oil spill contingency plan. Later, the group leaders presented their findings and recommendations to the entire audience for discussion. Because of the lengthy discussions and space limitations, their comments were not included in the Proceedings, but the group's recommendations were incorporated in the Service's final plan. The Office of Migratory Bird Management was responsible for developing the updated plan for the Fish and Wildlife Service.

Administrative assistance for the workshop and for preparing the Proceedings was provided by Robert H. Harwood and staff, Gulf South Research Institute, Baton Rouge, Louisiana.

Workshop coordinators were Wilbur N. Ladd, Office of Migratory Bird Management, U.S. Fish and Wildlife Service, Washington, D. C.; and Paul L. Fore, National Coastal Ecosystems Team, Office of Biological Services, U.S. Fish and Wildlife Service, NSTL Station, Mississippi.

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A PHILOSOPHICAL APPROACH TO FISH AND WILDLIFE SERVICE INVOLVEMENT IN OIL SPILL RESPONSE

Harvey K. Nelson[1]

INTRODUCTION

The year 1976 was the worst on record in terms of oil spilled into U.S. waters. Unfortunately, things will likely get worse instead of better. The Service's involvement in spill response will increase proportionately.

Our role and responsibilities during oil and other hazardous substance discharge incidents are not something that someone dreamed up because we did not have enough to keep us busy. Our mandates are clearly defined in the National Oil and Hazardous Substances Pollution Contingency Plan published by the Council on Environmental Quality (CEQ) in 1975. As part of the Interagency Regional and National Response Teams, we do not have a choice as to whether to respond to spills or whether we will get involved in collection and treatment of oil-fouled birds. We do have some choice, however, in just how we go about accomplishing our responsibilities. Looking at those choices is what this meeting is all about.

Oil spills and the response to them are subjects of keen public interest--and, all too often, public outrage. The Service has had its share of scrutiny recently, in the press and elsewhere, and it is clear that we have not demonstrated particularly strong leadership in this field. I hasten to add, however, that we fully recognize the numerous oil spills that have occurred in Region 5 the past 3 months, and the strong efforts the Service mustered to cope with these problems.

As you know, the Director and some others in the Service have been involved for the last 9 months in two Congressional oversight hearings of oil spills. In each case, the Service has been sharply criticized for failure to live up to the public's expectations in regard to oil spill response. The Director has told me that he is less worried about these kinds of hearings themselves--though they do leave the Service and its Director somewhat embarrassed and concerned that we do not come off well as an organization. But he is more concerned about the growing feeling many people have that the Service *does not care* and is not able to muster itself to respond to this kind of emergency. Director Lynn Greenwalt has indicated that he knows this is not true; the Service *can* do these things. His concern is that we probably *are not* doing it properly now, and that concerns me, too.

Recent allegations in print and outlined at the last hearing can lead one to believe that the Service does not care. As I indicated before, this

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is not true. The director has charged me, and all of us, with getting ourselves squared away so that we *can* and *will* perform like the professionals we are, and that our performance will show the country that we *do* care.

The contingency planning effort that many of you have been involved with over the past year or more and the planning that you accomplish at this workshop should provide a solid foundation for developing a smooth, well-planned and coordinated response to any discharge of oil or hazardous substance, especially one for which a Regional or National Response Team is activated. I should add also that communication up and down the line, from the Secretary, the Director, the regional coordinator on down to the field man at the site of a spill, is extremely important and is, in fact, essential. To deal effectively with the media, Congressional interests, the National Response Team, and other groups at the national level, the Washington office must receive timely notification of and be kept abreast of daily activities during the response. This should include the progress of cleanup, potential threats to fish and wildlife, actual wildlife impacts, actions taken to minimize wildlife losses, relationships with other agencies, and a variety of other pertinent activities. The Washington office has been criticized too many times over the past few years because it had not been adequately informed about oil spills in which the Service was involved at the regional or local level.

John Mattoon, Assistant Director for Public Affairs, will touch on some of these things tomorrow when he discusses public affairs aspects of oil spills and our communication with the news media. This situation must be turned around. Proper lines of communication must be established from the very outset of a spill when our people are first notified, and maintained throughout the duration of response and damage assessment.

THE FWS ROLE IN OIL SPILL RESPONSE

The Service's role in oil spill response can be usually divided into three phases: (1) prespill planning and preparedness; (2) actual response, beginning with the first notification of a spill or potential spill and continuing through deactivation of Regional Response Teams (RRT) and termination of wildlife protection and cleanup activities; and (3) postspill evaluation and reporting. I will discuss each of these briefly.

PRESPILL PLANNING AND PREPAREDNESS

The degree to which we plan and prepare for oil spills will, in large measure, determine our success during a spill response--success being measured in terms of effective protection of wildlife and their habitats and in terms of maintaining good working relationships with other agencies and organizations. No longer can we wait until a spill occurs and then react with whatever measures seem appropriate or available at the time. This approach falls far short of fulfilling our responsibilities every time. Neither can we afford to react by sending to the scene the closest warm body that happens to be available at the time.

The *key to success is predesignation of responsibilities* so that specific individuals, again from the Washington office down to the field levels, know their respective geographic area and what they are expected to do. We cannot wait until a spill occurs to assign these responsibilities. Also, practice makes perfect. The more experience a person gains in dealing with oil spills, the more effective his response will be during future incidents. Maintaining continuity, rather than passing around the job during each spill incident, is essential to developing a proper response. The basic assignments are for Washington, regional, and field-level spill response coordinators and their alternates. The responsibilities cannot be on an ad hoc basis--they must be specific, planned and budgeted for, and written in position descriptions.

Once duties have been assigned to specific individuals and their alternates, further planning, inter- and intra-agency coordination, and preparations can be carried out. This means direct contact with chairmen of each Regional Response Team and predesignated Coast Guard and Environmental Protection Agency (EPA) On-Scene Coordinators (OSC). The Coast Guard supplies the OSC for coastal waters, the Great Lakes, and ports and harbors, while EPA supplies the OSC for all other inland waters.

Other prespill actions include direct contact with state agencies, particularly the appropriate fish and wildlife division, to develop a close working relationship and a plan that can be implemented at the time of a spill. It is essential that each agency and person know ahead of time exactly what he is supposed to do during a spill.

Prespill planning must also include contacts with volunteer and professional groups that are interested in collection and treatment of oiled birds. The CEQ National Contingency Plan specifically states our responsibility in this area and directs us to identify such groups ahead of time. These groups include local chapters of the National Audubon Society, Humane Society of the United States, Society for the Prevention of Cruelty to Animals, and others, which are willing and have available manpower and knowledge to carry out an effective bird salvage and treatment operation. One such professional group that has developed relatively successful techniques for rehabilitating oiled birds is the International Bird Rescue Research Center located in Berkeley, Calif. Another is the Wildlife Rehabilitation Center in Massachusetts. Prespill identification and contact with local and national groups interested and knowledgeable in treatment of oiled birds will vastly improve our capability to utilize their knowledge and assistance in a pollution emergency that involves significant numbers of birds so we can carry out our responsibilities under the National Contingency Plan. Another person to contact during prespill planning is the current Department of Interior representative to the Regional Response Team. In some cases, this may be a secretarial field assistant; in others, it could be a member of the U.S. Geological Survey (USGS), since that agency is the Department of Interior's primary representative to the National Response Team. In any case, Fish and Wildlife Service personnel must become closely associated with each RRT, as either a primary or alternate member.

Prespill preparedness also involves insuring that all the necessary equipment is either on hand or readily available upon short notice. Equipment for dispersing birds and for treating oiled birds is the primary need.

A variety of other items may also need to be procured. Equipment and materials should be stockpiled in sufficient quantities to handle several major spills at the same time, and at locations where spills affecting significant numbers of birds or other wildlife are most likely to occur. Procurement of equipment must be planned and budgeted for just like anything else we do in the Service. Some time in the future we may get specific funding to stockpile necessary oil spill response supplies, but for the present, we will have to absorb this cost within our present budget.

Speaking of funding, we have never, to my knowlege, received special funds or manpower for oil spill response. Such funds were included in a fiscal year 1978 budget request that was not approved. This function is addressed specifically in the fiscal year 1979 migratory bird management budget request and will be treated similarly in other program areas. However, until added funding is received, we will have to handle this responsibility through the current and fiscal year 1978 program advice procedure and within the present budget framework. Incidentally, implementation of the Service's Oil and Hazardous Substance Pollution Response Plan is a line item in the fiscal year 1977 migratory bird program advice, but the program advice deals primarily with the plan itself.

A variety of additional steps will have to be taken prior to occurrence of a spill, such as identification and delineation of particularly sensitive habitats for fish, shellfish, and wildlife that must be protected, and the collection of current information on wintering concentrations of migratory birds.

ACTUAL SPILL RESPONSE

The first and foremost step, after receiving notification of a spill, is to make sure the proper contacts are made and people are kept informed. Regardless of who in the Service first hears about a spill, the established communication procedure should be followed up and down the line. That procedure will be discussed and should be fully understood by the time you leave this workshop. The procedure should be made known to all Service personnel shortly after this workshop and should be incorporated into national, regional, and subregional contingency plans. For the present, the Office of Migratory Bird Management will continue to be the primary contact point in the Washington office and should be notified immediately upon receiving official word of a medium-sized or major discharge of oil or other hazardous substance, and any other spill, or potential spill, that may create significant public concern or cause significant damage to fish or wildlife resources. The Office of Migratory Bird Management should be notified immediately by telephone, and a followup should be made with a "concern alert" via Faxform, when a Regional Response Team is activated.

In addition to contacts with the proper people within the Service, other contacts should be made outside the Service, primarily with State wildlife agencies and local, private conservation groups with which we have developed a prespill working relationship. We need to alert them of the situation and make any necessary preliminary arrangements. We sometimes get into trouble in situations where the RRT is activated and our regional coordinator is asked by the OSC to "stand by" until a preliminary assessment of damage is completed and a determination made whether the responsible party is adequately cleaning up the discharge, as called for in CEQ's National Contingency Plan. By the time the Service representative is actually requested to go to the site of the incident, substantial quantities of pollutant may have escaped and significant numbers of birds or other wildlife may already have been contaminated. Should a spill occur in any area previously determined to be particularly valuable to fish or wildlife and sensitive to spills, the Service should dispatch a person to the scene immediately to evaluate the potential impacts on wildlife. That person should make recommendations both to the OSC and the Service field level or regional spill coordinator as to what actions need to be taken. This person may be the manager of a nearby refuge; a biologist with Wildlife or Fisheries Assistance, Ecological Services, or Biological Services; a special agent; or any other qualified employee.

After a preliminary assessment of potential threats to birds or other wildlife is made, and if significant threats exist, preplanned actions can be set into motion to effect a smooth, well-coordinated response. Too often we have waited to be called by the OSC and told what to do. *The Service must take the offensive, be aggressive, and lead the response from the outset,* at least, so far as wildlife aspects are concerned. We should advise the OSC what needs to be done, for example, to protect birds and their most critical habitats, and we should establish the necessary liaison with those interested in salvaging and treating oiled birds. We cannot take a position of "wait and see if someone else will do it." If it appears that significant numbers of birds may be involved, we should take whatever actions are necessary immediately to prevent birds from becoming contaminated. Decisions must be made on the best methods to accomplish this, which might include deployment of audio or visual scaring devices, baiting birds away from the impacted area, or, if feasible, covering the slick with some sort of screening device. Chemical dispersants to emulsify the oil may even be considered in extreme cases, but under normal circumstances, EPA will determine the use of dispersants.

As bird dispersal activities are initiated, bird collection and cleaning stations, and personnel to staff them, should be activated as a precaution in case birds do become contaminated. Again, the Service field coordinator, working directly with state wildlife personnel, is responsible for establishing cleaning stations or for seeing that cleaning stations are established when necessary. Regardless of who may volunteer to assist us, the Service is ultimately responsible and accountable for this function. As I said before, we do not have a choice here. The better we organize a bird cleanup operation in advance of a spill, especially through local conservation groups, the more efficient the operation will be during an actual incident. Having the stations, equipment, and people identified and located prior to a spill is paramount to a smooth operation during a spill response.

All of these steps must be taken within hours, *not days*, after a spill occurs; early warning is the key to minimizing damage to wildlife and their habitats. We need to put this advice into practice during spill incidents and effect our response as rapidly as possible. Our field coordinator must be able to advise the On-Scene Coordinator concerning all matters relating to protection of fish and wildlife and their habitats, as well as to what equipment and personnel are required to provide adequate protection.

We must take prompt and aggressive action in this regard; we must be prepared to do so without waiting to be asked or called upon. We must be ready to tell people that there is a problem and that we want these things to be done to resolve the problem. After all, no one else knows more about the problems of oil spills, birds and their habitats--we are involved because the Service has the knowledge and the responsibility. We must be prepared to assert ourselves and to move ahead promptly to take those actions that will save the resources.

Lynn Greenwalt, FWS director, has asked me to reiterate his very strong feeling about this. We must recognize that the oil spill problem is here to stay and that ours will be a continuing key role in these matters. We simply must do our job: we must work at preplanning, and we must keep those plans current and active. We must respond promptly, skillfully, and aggressively when there is a problem. This is a new kind of activity for us, and, sad to say, is likely to become a routine one. It just will not go away. Neither the Director nor I--nor the public--will settle for anything less than a fully professional, maximum effort in this area.

The Service's coordinator is directly responsible to the Coast Guard or EPA OSC during a spill response and should maintain close contact with him until the RRT is deactivated and field operations are terminated. One other important point in regard to use of the Federal revolving fund to purchase supplies or to make other expenditures during a spill response: prior approval must first be obtained from the OSC, regardless of whether the Service or the State liaison is making the purchase. In the past, purchases have been made without prior approval, and the purchasing agency has been left holding the bag for the bills. Should such problems arise, this should not preclude our involvement if an emergency exists. I suggest FWS personnel take whatever action they, in their judgment, believe is needed.

I have just a few words on the subject of bird cleaning and rehabilitation. This is something foreign to many of us, even disdainful to some, who routinely deal with wildlife on a population level, rather than concerning ourselves with individual birds and the emotional feelings that oil-covered birds evoke in many people. Salvage and treatment of oiled birds will ordinarily have little biological significance, although it may have under certain circumstances, such as when an endangered or other species of precarious status is involved. Certainly, preventing these birds from entering a spill site is much more effective than trying to save them after they are contaminated. However, techniques are available that may result in reasonably high success for bird cleaning--over 30 to 50 percent survival to release into the wild under certain circumstances and when applied by experienced people. Beyond the probability of success or failure, however, oiled birds probably attract as much public attention and consternation as the spill itelf, and equally as much public consternation over the lack of Federal action to try to salvage oiled birds.

Regardless of the biological significance of treating oil-soaked birds, be it great or small, the Service is obliged, and the public and Congress demand, that we take whatever actions are necessary to coordinate bird collection and treatment activities. To be insensitive to this human aspect is to ignore a direct and specifically stated responsibility of the Service under the National Oil and Hazardous Substances Pollution Contingency Plan. Again, our only choice is *how, not if,* we get it done. We can try to develop the expertise and muster the manpower to do it all ourselves, or we can utilize the expertise and talents of other professional and volunteer groups to best advantage. There is no doubt that we must proceed to develop a relatively small central core capability within the Service that can respond when necessary to establish and carry out bird collection, treatment, and rehabilitation activities.

A variety of other actions will be necessary during an actual spill response, but I will not dwell on these here. I am sure many will be brought up and discussed during the workshop.

POSTSPILL EVALUATION AND REPORTING

Our chores do not end after response activities have been terminated and the cleanup is finished. In order to capitalize on our experience from each spill, it is worthwhile to critique our actions and the actions of others during the response to identify weaknesses and strengths in our planning. I am suggesting that after each spill incident involving a significant input from the Fish and Wildlife Service, postspill critiques be held both at the local and Washington office level. The local critique should involve Service and state personnel and representatives from volunteer groups who participated in the response. The Washington critique should involve key Service individuals, such as regional and field-level coordinators, and in some cases, certain State or private individuals particularly involved in the spill.

In any case, a detailed followup report should be prepared by the Service's field coordinator. The report should provide sufficient information, as well as a chronological record of events, to respond fully to the Director, Congress, or the public as to the Service's participation in the response. This analysis should include the potential and actual impacts of the spill on fish and wildlife, working relationships with other agencies, strengths and weaknesses in our response, and recommendations for improvement.

Documentation of the effects of the spill is a vital postspill responsibility. This information is essential to the Service in evaluating the direct impact of an oil spill on the resources for which we are responsible, and in determining effectiveness of response efforts. This information may also be needed to instigate a legal suit against the responsible party, to answer Congressional or public inquiries, or to meet a variety of other purposes. Generally, the EPA will organize and coordinate postspill environmental damage assessments, with input from other agencies. Service coordinators must be tuned into these assessments and provide input whenever possible. Long-term impact studies are often conducted after particularly damaging spills, such as the recent disaster involving the *Argo Merchant* off Nantucket and the disaster involving *Nepco 140* in the St. Lawrence Seaway last summer. We need to play a more prominent role in these studies, both in their design and possibly through financial support.

In addition to the documentation of the biological impacts of the spill, a close tab should also be kept on our dollar expenditures during a response, including both manpower and funds from the Federal revolving fund, as well as from our own program funds. This information is needed if legal action is taken and is also useful in developing budget estimates in our overall planning efforts.

This discussion should give you an idea what we are looking for in post-spill evaluation and reporting.

PROGRAMMATIC RELATIONSHIPS

I would like to say a few words about how these activities relate to the program management system. The impact of oil spills crosses program, category, and divisional interests. There usually is no single program or division responsibility. There must be very close interprogram communication, coordination, and accommodation. Oil spill response must be a coordinated Fish and Wildlife Service effort.

In order to facilitate the administrative aspects of oil spill response, responsibility for coordinating the Service's response capability ideally should be placed in a single program at the Washington level. For the past 3 years, this responsibility has been vested in the Migratory Bird Program because the National Contingency Plan specifies our role in dealing with oiled birds and because oil-soaked birds seem to draw more public attention than almost any other feature during a spill. Unfortunately, we have not previously had the manpower to allocate full-time to this function. However, the Director has now approved the establishment of a position in the Washington office, which will have as its primary responsibility the coordination of the Service's spill response.[2] The person filling the position will develop a close relationship with the Coast Guard, EPA, and other agencies involved with oil spills and will serve as a liaison between research and management in developing research needs relating to oil and its impact on wildlife. This central coordination responsibility will be given to the Program Coordinator for Environmental Contaminants in AER, with key individuals being designated as the principal contact in the Office of Migratory Bird Management, Fisheries Resources and Research. We hope to be able to implement some of these changes by 1 May 1977. This leaves some unanswered questions concerning how to handle regional staffing assignments, which we will have to work out with the individual Regions.

We are also considering the establishment of a central core of technical expertise within the Service that can be rapidly deployed to a spill site to organize an effective bird dispersal and bird treatment effort. This group would not usurp responsibilities of field and regional coordinators, but would supplement our present in-house capabilities.

CONCLUDING REMARKS

I have given you a general idea--a philosophical overview--of how the Service should approach its responsibilities in planning for and responding to oil and other hazardous substance pollution emergencies. *Prespill planning* and *preparedness* cannot be stressed enough--they are the key to an effective response. In the past, we have been too casual and reactive. Responsibilities

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[2]Editor's note: The new position of National Oil and Hazardous Substance Spill Coordinator was filled in the fall of 1977.

have been assigned on an ad hoc, part-time basis, sometimes not until an incident occurs. Our philosophy toward salvaging and treating oil-soaked birds has often been one of avoidance and one based strictly on a practical understanding of the biological significance of such losses.

Ladies and gentlemen, our planning and response to oil spills must be sharpened dramatically so that the Service can fully meet its responsibilities under the National Contingency Plan. This workshop will provide an excellent basis for accomplishing this.

STATUS AND FUTURE TRENDS IN OIL SPILLS AND IMPLICATIONS FOR THE U.S. FISH AND WILDLIFE SERVICE

April E. Fletcher[1]

Somebody once was discussing the population problem and pointed out that in the United States today a woman gives birth to a baby every 7 sec. He offered a solution to the problem: "We've got to find that woman and stop her!"

I'm not going to talk about the population problem today, although that certainly is behind many of the pollution problems we face. But I think this illustrates an important point--that when people are unfamiliar with a subject they try to find easy answers. For example, the easy answer I have heard over the last several years for the problems of oiled waterfowl is: "We've got to stop oil pollution." While I agree this should be our goal, the more I've learned about oil pollution in United States waters the more complicated the picture looks to me.

I don't have any easy answers to offer today. Instead, I will try to give you some perspective on the nature and extent of pollution, particularly oil pollution, in United States waters. Then I will focus on a few points I believe the Fish and Wildlife Service should address in planning for oil spill response now and in the next few years.

Our attention is drawn by big, dramatic accidents, such as the nearly million-gallon oil spill caused by the collision of two tankers at the entrance to San Francisco Bay in 1971. In the shadow of the 7-million-gal *Argo Merchant* oil spill of December 1976, we easily forget that thousands of oil spill incidents occur each year totaling annually an average of twice as much oil as that spilled by the *Argo Merchant*. Most people overlook the chronic sources of pollution, such as street and agricultural runoff which, like dripping faucets, appear deceivingly innocent. These chronic sources may actually contribute substantially larger amounts of pollution and cause far more damage to the environment than the major pollution incidents we hear about in the news.

While recognizing that chronic sources of pollution may cause serious environmental damage, I am going to limit this discussion to recorded pollution incidents. These are the sources with which the National Oil and Hazardous Substances Pollution Contingency Plan and the Fish and Wildlife Service Pollution Response Plan are primarily concerned.

The Water Quality Improvement Act of 1970 required that all pollution discharges be reported to the "appropriate agency." Currently either the Environmental Protection Agency or the Coast Guard receives reports of pollution incidents. The Coast Guard annually compiles data from these reported incidents and I have extracted much of the information for this presentation from these data.

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The number of pollution incidents reported each year since 1970 is indicated in Figure 1a. The Coast Guard believes that the apparent increase in incidents each year actually reflects an improvement in monitoring and surveillance rather than an increase in number of spills. Many smaller spills that were previously overlooked are now being reported, although it is estimated that several thousand more pollution incidents occur that are not being reported.

Between 8 and 24 million gal of pollutants have entered U.S. waters from reported incidents each year since 1970 (Figure 1b). Oil is the predominant pollutant in terms of this volume, contributing an average of 15 million gal annually. (It is important to remember that though hazardous substances constitute a small portion of the total volume, they may be destructive in very small quantities.)

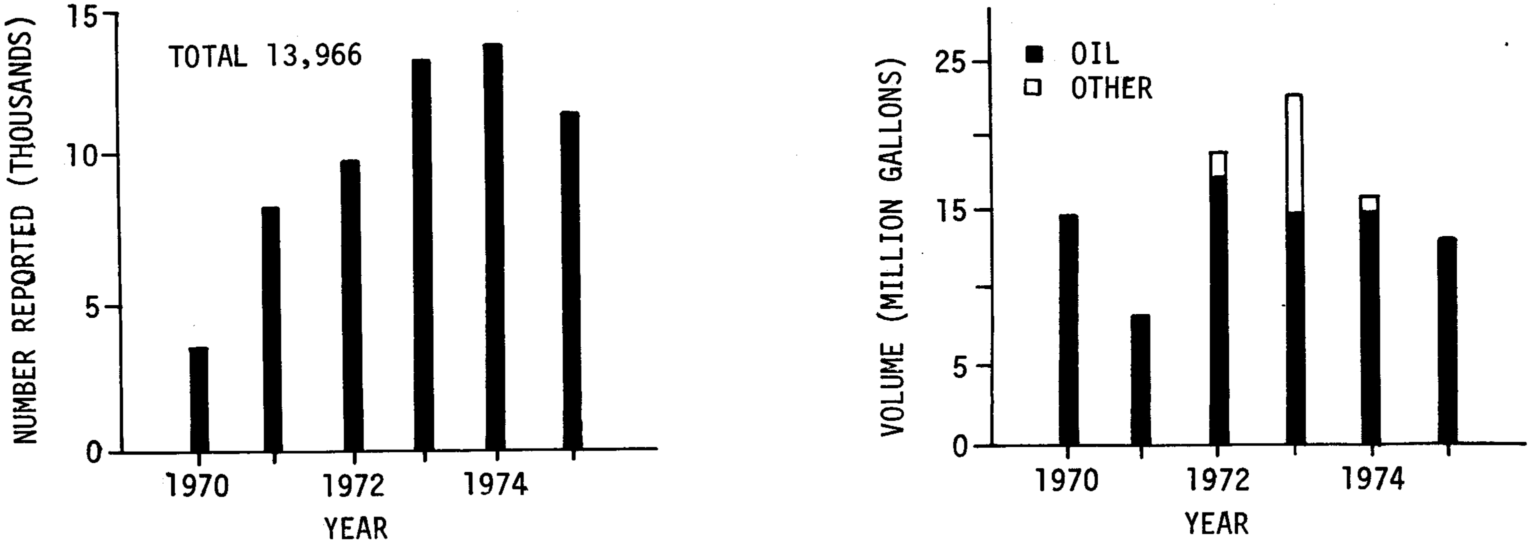
Oil spills have occurred throughout the United States from Florida to Alaska, not only in coastal waters, but also in inland tributaries, rivers, ponds, and lakes. Serious oil spills have occurred in places as remote as Wyoming. Although by far the largest number of spills have occurred in coastal waters (Figure 2a), inland spills accounted for 28 percent of the volume spilled over a 6-year period (Figure 2b).

I have been asked frequently this winter why so many big oil spills have been happening in the United States. I'm not sure yet if oil spills really are worse this winter. They may just be better publicized, perhaps because of the attention drawn by the magnitude of the *Argo Merchant* oil spill.

For the following reasons, however, I do believe that there has been a steady increase in serious oil spills over the last couple of decades. Since 1950 the United States has more than doubled its energy consumption (Council on Environmental Quality 1975). Efforts by industry and government to increase domestic production of oil have been unable to meet this skyrocketing demand; consequently, the amount of oil imported has increased dramatically. The volume of oil imported in 1974 was seven times that in 1950. Importations doubled between 1970 and 1974 (Council on Environmental Quality 1975) and in 1976 accounted for approximately 52 percent of U.S. oil consumption (Siler 1977). Increased consumption led to increased production, transport, processing, and holding of oil and petroleum products. I believe this has increased the probability of spills.

The Santa Barbara oil spill off the coast of California in 1969 angered environmentalists and led to considerable public opposition to offshore oil production. However, analysis of 36 major spill incidents indicates tankers, barges, and other vessels, not offshore production facilities, have been the source of the greatest number of serious oil spills (Figure 3).

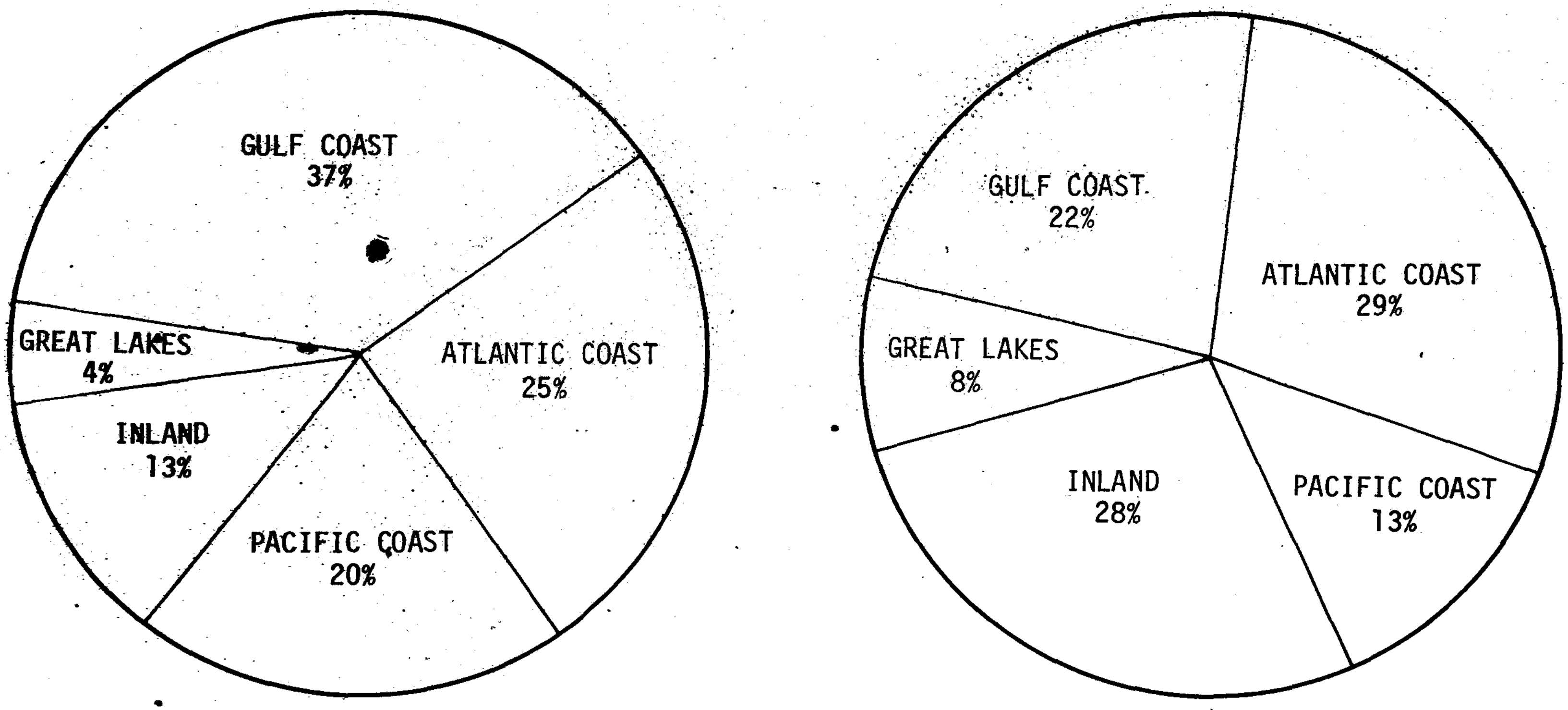
Increased oil importation resulted in increased transportation and traffic congestion in major port areas. This has increased the likelihood of accidents, such as groundings and collisions, involving petroleum carrying barges and tankers. To try to reduce tanker traffic, industry has encouraged an increase in the size of tankers. Shipping companies, with an eye on increasing profits while lowering costs, have been primarily responsible for development of the largest ships. In 1945 the largest tanker in the world oil fleet was only



a. Number of spills

b. Volume of spills

Figure 1. Summary of pollution incidents in and around U.S. waters from 1970 through 1975 (Source: U.S. Coast Guard 1971 to 1977).



a. Number of spills

b. Volume of spills

Figure 2. Regional distribution of pollution incidents in U.S. waters by number from 1970 through 1975 (Source: U.S. Coast Guard 1971 to 1975).

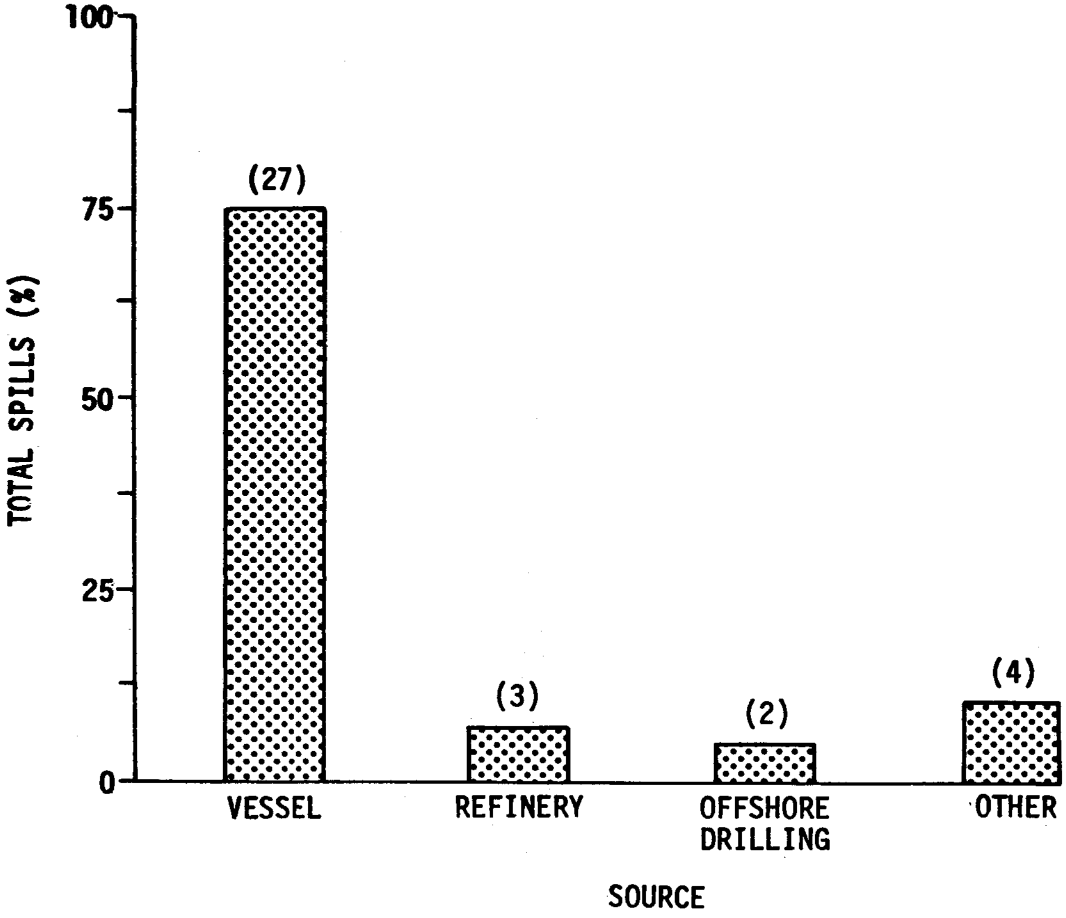


Figure 3. Source of 36 major oil spills. Number of incidents in parentheses (Source: National Petroleum Council 1972).

18,000 deadweight tons (DWT). (One DWT is roughly equivalent to 250 gal. capacity). By 1956 it had increased to 45,000 DWT; by 1968 to 325,000 DWT; and by 1972 to 476,000 DWT (Moestert 1976). By 1975 the world fleet had 540 ships over 200,000 DWT (Department of Transportation 1976); there are undoubtedly more today. The size of these "supertankers" is almost incomprehensible. The largest is almost as long as the Empire State Building is tall and has a draft when loaded of about 90 ft (27.4 m).

Existing American ports cannot accommodate tankers of the 200,000 DWT size and larger. East Coast ports are limited to tankers in the range of 70,000 to 80,000 DWT; although some larger tankers have been admitted when only partially loaded (to reduce draft). Some West Coast ports have received tankers of 125,000 DWT.

The U.S. Government and the oil industry have been examining possibilities of constructing ports to receive "supertankers." Two sites have been approved for construction of offshore receiving facilities for larger tankers and "super-tankers": Seadock off the coast of Texas, and LOOP off the Mississippi Delta (Siler 1977). The receiving facilities will be 20 to 25 miles (32.2 to 40.2 km) off the coast in deep water and are expected to receive oil from tankers as large as 325,000 DWT (Department of Transportation 1976). Tankers will use shipping routes that pass through the Caribbean Islands or around the coast of Florida.

The oil industry has argued that use of larger tankers will reduce traffic, lower the number of accidents, and reduce the amount of oil spilled. Data from 18 major tanker accidents, reported by the Smithsonian Institution Center for Shortlived Phenomena, appear to support industry's contentions. In these 18 major oil spills, the average amount of oil lost per DWT being carried is less for ships over 80,000 DWT than for smaller ships (Table 1). However, it appears from these data that the average size of major oil spills from larger tankers is several times greater than major spills caused by smaller tankers. This may indicate that if average tanker size increases, there will be fewer accidents and a smaller percentage of oil spilled, but if an accident does happen it is more likely to be serious. Remember, however, that small spills in sensitive areas may cause serious damage and that a vessel need not be very large to cause a big oil spill. The *Argo Merchant*, for example, was only 29,000 DWT yet spilled more than 7 million gal.

I would like to turn now to several things which I believe the Service should consider in planning for and responding to oil spills. Since 1970 the largest percentage of oil reported spilled each year, roughly 85 to 98 percent, has been from accidents of over 10,000 gal. Oil spills of 100,000 gal or more accounted for between 55 and 87 percent (Table 2). Although small spills may cause significant damage in critical areas, most spills under 10,000 gal in coastal waters and under 1,000 gal in inland areas probably will not warrant Fish and Wildlife Service involvement in cleanup operations. In general, I believe the Service needs to pay greatest attention to spills over 10,000 gal.

Analysis of data on volume of pollutants spilled by month indicates peak months for volume spilled are October, December, January, March, April, and June. Between 2 and 4 million gal of pollutants (mostly oil) have been

Table 1. Analysis of major oil tanker accidents by ship size (Source: Major Oil Spill Directory, Smithsonian Institution, 1975)

Ship size	Sample size	Loss/DWT[a] carried (Gal)[b]	Average spill size (Gal)[b]
<80,000 DWT	8	45.7	1,638,500
>80,000 DWT	10	32.5	4,797,000

[a]One DWT (deadweight ton) is roughly equivalent to 250 gal capacity.

[b]One gal is equivalent to 3.785 l.

Table 2. Analysis of spills greater than 10,000 gal from waters of the United States (Source: U.S. Coast Guard 1971 to 1977)

Year[a]	Incidents (Number)	Volume discharged (Percent)
	Discharges of 10,000 gal or more	
1970	69	98
1972	82	93
1974	201	83
1975	117	85
	Discharges of 100,000 gal or more	
1970	17	87
1972	19	82
1974	32	55
1975	20	68

[a]Data not available for 1971 and 1973.

reported spilled into U.S. waters in January every year since 1971. During January, of course, waterfowl are concentrated in coastal and inland waters. Unfortunately, the locations where oil spills occur most frequently, i.e., port and harbor areas (U.S. Coast Guard 1977), are generally areas where waterfowl and many sea birds winter in large concentrations. This is indicated by maps illustrating locations of major port areas and areas of wintering waterfowl concentrations (Figures 4 and 5). We need to focus a large part of our attention on these major port and harbor areas in planning for oil spill response. These include in particular: Puget Sound, Los Angeles, and San Francisco in Region 1; Corpus Christi, Galveston Bay, and Beaumont-Port Arthur in Region 2; Lake Charles and the Mississippi Delta in Region 4; and Chesapeake Bay, Boston Harbor, Portland (Maine), Port of New York, and Delaware Bay in Region 5.

It may not be possible for the Service to be completely prepared to respond to oil spills at every site where they might occur in the United States, but it is possible to take steps now in those areas where spills are most likely to occur. Service personnel who are located near key oil pollution areas can be assigned to prepare for and respond to pollution incidents; supplies can be stockpiled within easy transport distance to implement bird dispersal and other field actions; surrounding areas can be examined before pollution incidents to determine what locations are known to be particularly critical and should be protected first if threatened by oil; and good communications should be established with State agencies and private organizations that may respond to pollution incidents in these areas.

Without such preparation, unnecessarily high direct waterfowl mortality may result from inadequate bird dispersal actions and pollution of important habitats may occur that might have been prevented. Significant indirect fisheries and wildlife losses might result from destruction of important wildlife and fisheries food resources and contamination of breeding areas.

The degree of effectiveness of Service actions will be limited considerably by the circumstances of the spill and the species and kinds of habitats involved. We can, however, prepare to respond rapidly and effectively in many of these locations where oil spills happen frequently.

The areas requiring our attention may shift in the next few years as oil shipping patterns change. Those planning for Service response to oil spills should keep this in mind. For example, East Coast ports currently receive the greatest volume of imported crude oil; however, it is anticipated that by 1980 the Gulf Coast will be receiving four times as much crude oil as the East Coast and twice that of the West Coast (even including oil transported from Alaska!) (Department of Transportation 1976).

Unfortunately, though the chances of oil spills occurring are greater in some areas and from some sources, a spill may happen almost anywhere oil is being transported or held. To complicate matters, every oil spill is unique and presents new problems that need new solutions. No matter how you look at it, oil spills offer complex problems. There are no easy answers.

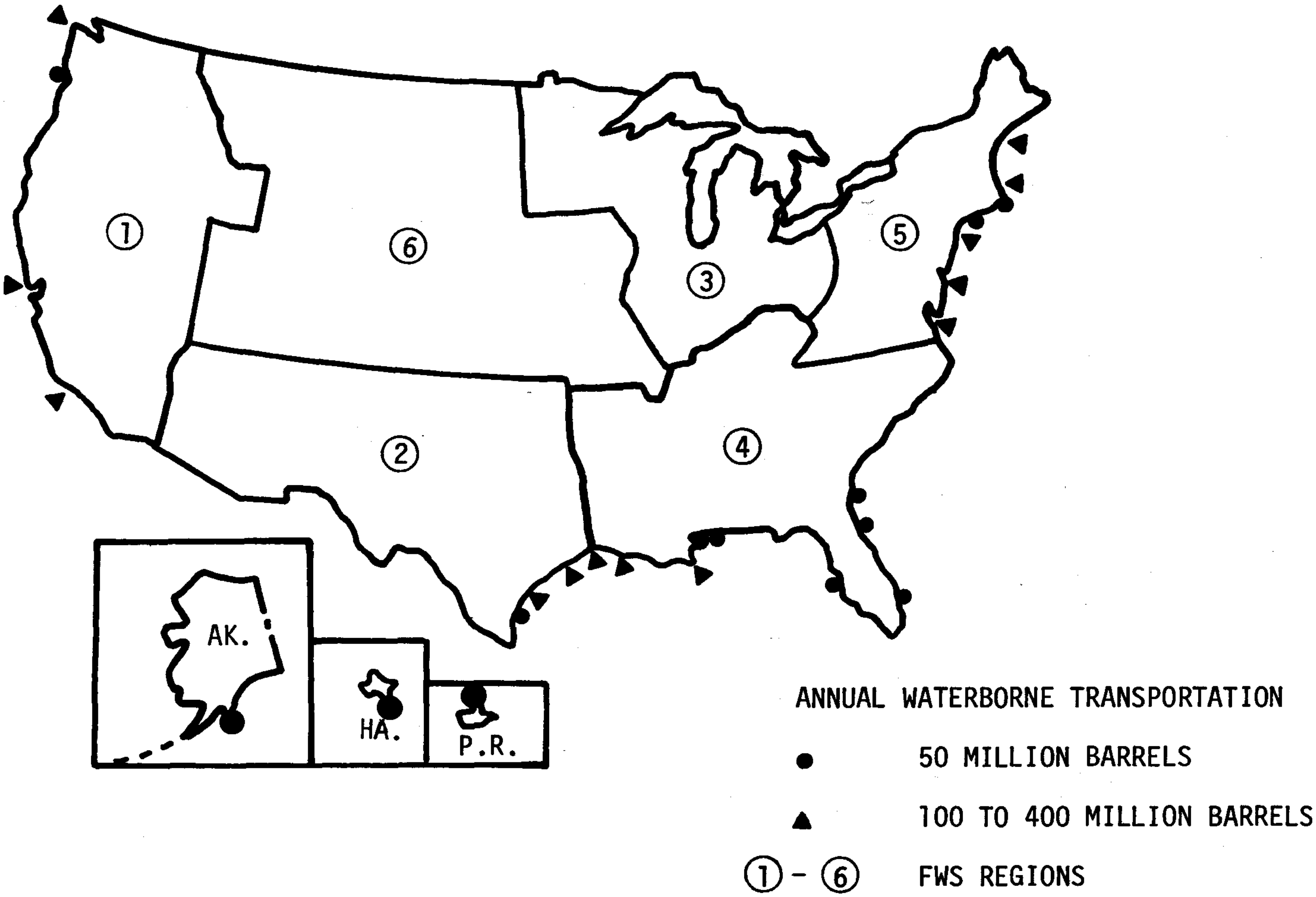


Figure 4. Major petroleum handling ports, 1967 (Source: National Petroleum Council 1972).

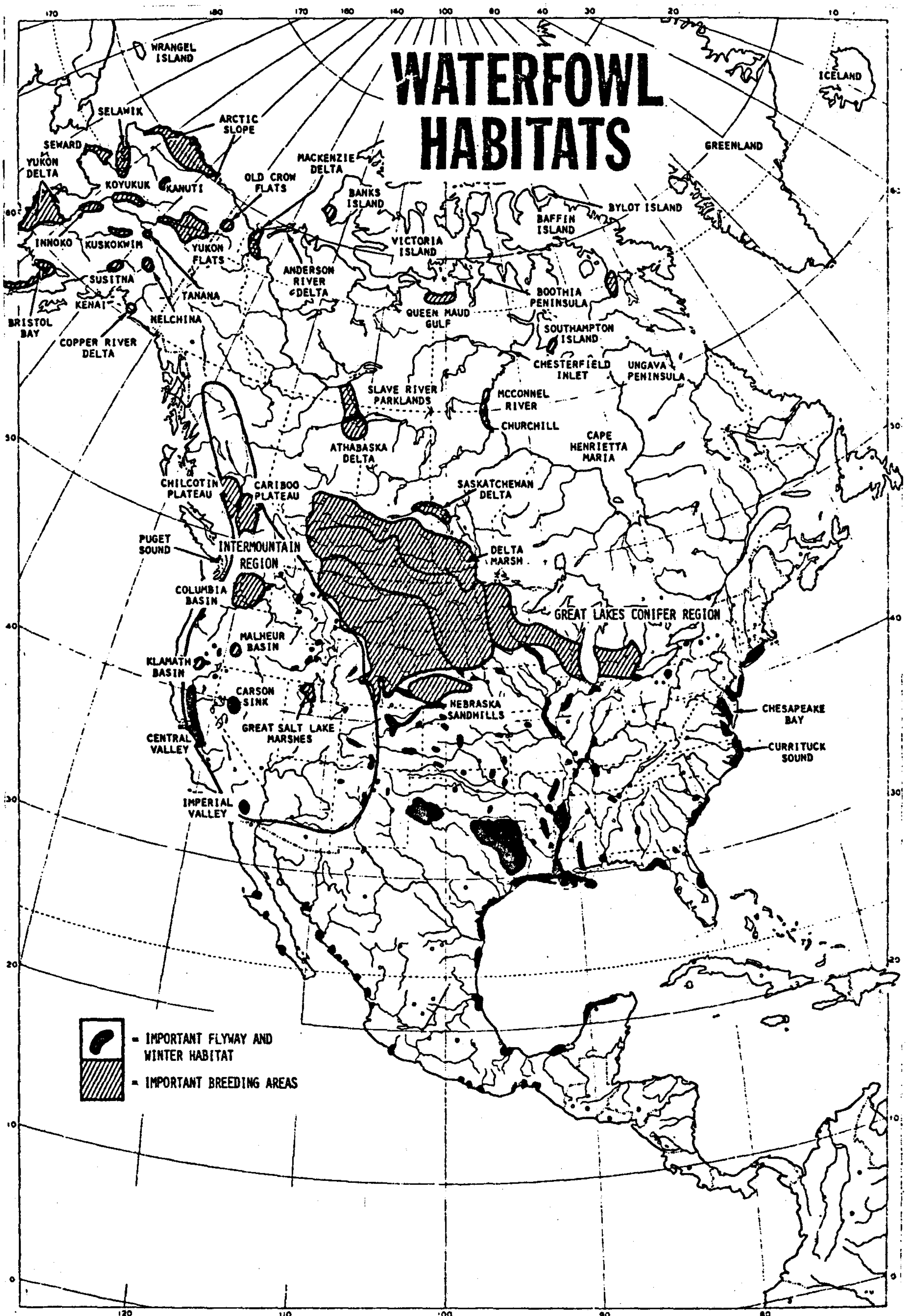


Figure 5. Important waterfowl flyway and winter habitat (Source: Bellrose 1976) (Permission of publisher to reproduce).

As long as our society is dependent on petroleum products, we will be faced with oil spills--many small ones and some very serious ones.

In summary, I think oil spills will be with us for a long time to come. Though we will not be able to prevent all wildlife losses and damage to habitats when oil spills happen, we should prepare as best we can to minimize destruction to the resources for which the Service is responsible.

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NATIONAL OIL AND HAZARDOUS SUBSTANCES POLLUTION CONTINGENCY PLAN AND FEDERAL RESPONSIBILITIES

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The National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 1510), hereafter referred to as the National Contingency Plan, or simply the Plan, fulfills a requirement specified in Section 311 (c)(2) of the Federal Water Pollution Control Act (FWPCA) Amendments of 1972 (Public Law 92-500). The plan is the result of interagency work and cooperation and has as its central theme the concept that is embodied in the Water Pollution Control Act; e.g., it provides for efficient, coordinated, and effective action to minimize damage from oil and hazardous substances discharges. Possibly, its most important aspect is that of specifying that there should be an On-Scene Coordinator (OSC) to serve as the single Federal executive agent on-scene to direct cleanup and removal operations.

The plan was first published as an interagency agreement in November 1968. It became part of the Code of Federal Regulations in June 1970, pursuant to the Water Quality Improvement Act of 1970 (PL 91-224) and assumed its present format in August 1973 to comply with the provision of the FWPCA Amendments of 1972 (PL 92-500). The current version of the plan was published in February 1975, with some minor amendments being incorporated in March 1976.

The FWPCA calls for the plan to include, but not to be limited to: (1) the assignment of duties and responsibilities among Federal departments and agencies; (2) identification, procurement, maintenance, and storage of equipment and supplies; (3) establishment of a National Strike Force to provide necessary specialized services to carry out the plan; (4) establishment of trained and equipped emergency task forces in major ports; (5) development of a system of surveillance and reporting designed to insure the earliest possible notice of discharges of oil and hazardous substances to the appropriate Federal agency; (6) establishment of a national center to provide coordination and direction for operations in carrying out the plan; (7) development of procedures and techniques to be employed in identifying, containing, dispersing, and removing oil and hazardous substances; (8) preparation of a schedule, in cooperation with the states, identifying dispersants and other chemicals, if any, that may be used in carrying out the plan; and (9) development of a system whereby the State or States affected by a discharge can be reimbursed for reasonable costs incurred in the removal of such discharges.

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[2] The views and opinions expressed herein are those of the author and do not reflect the official views or policies of either the Environmental Protection Agency or the U.S. Coast Guard.

The plan accomplishes its purpose by establishing a flexible organization consisting of the OSC and advisory groups capable of providing expertise and assistance as required. The groups consist of Regional Response Teams (RRTs), a National Response Team (NRT), and a National Strike Force (NSF). Generally speaking, Federal On-Scene Coordinators (OSC) are furnished by the Coast Guard for the coastal waters, the Great Lakes, and ports and harbors, and by the Environmental Protection Agency (EPA) for inland waters (Figure 1).

The Coast Guard and the EPA are also responsible for developing and implementing regional contingency plans for their respective areas of responsibility. These plans are used to identify potential problems within the region; the environmental resources that would be jeopardized should a discharge occur; and procedures, equipment, and techniques to protect and/or reduce damage to the water environment in the event of a polluting discharge.

Regional Response Teams (RRTs) draw their membership from the Federal agencies at the regional level. Agencies designated within the plan as primary agencies (Department of Transportation, Department of Defense, Department of Commerce, Environmental Protection Agency and Department of the Interior) are represented in all RRTs. Those designated as advisory agencies (Department of Justice, Department of State, Department of Health, Education and Welfare, Energy Research and Development Administration, and Housing and Urban Development) participate as appropriate. Additionally, appropriate State agencies are actively encouraged to provide liaison to the RRTs.

The RRT acts within each region on an emergency basis to provide advice and assistance to the OSC as required. The RRT can assist the OSC in any number of ways. For example, it could arrange for the use of local law enforcement officials to keep sightseers under control at the scene of a pollution incident, or for State fish and game officials to place bird-scaring devices at appropriate locations to reduce the possibility that waterfowl would become contaminated with oil. The RRT also provides advice and assistance in the development of regional contingency plans. These regional plans are designed to provide detailed information on responsibilities and capabilities of each agency executing the plan; inventories and location of equipment; location and telephone numbers of cleanup contractors and their capabilities; contact numbers for each Federal, State, and local agency having direct or peripheral responsibilities in executing the Plan; and action plans for specific geographical locations within the region. To supplement the regional plans, the EPA and the Coast Guard have directed their OSCs to develop local plans insofar as feasible in high risk areas such as ports, harbors, and commercial waterways.

The RRTs are chaired by the Environmental Protection Agency or the Coast Guard, depending on which of the two agencies has the responsibility to provide the OSC. The plan requires that an RRT be activated automatically whenever a major discharge occurs or the potential for a major discharge (10,000 gal or more in inland regions, 100,000 gal or more for coastal regions) exists. An RRT may also be activated during any other pollution emergency by request from any primary agency representative.

Regional communication center for pollution emergency response activities is known as the Regional Response Center (RRC). The RRC provides facilities for the proper functioning and administration for RRT operations.

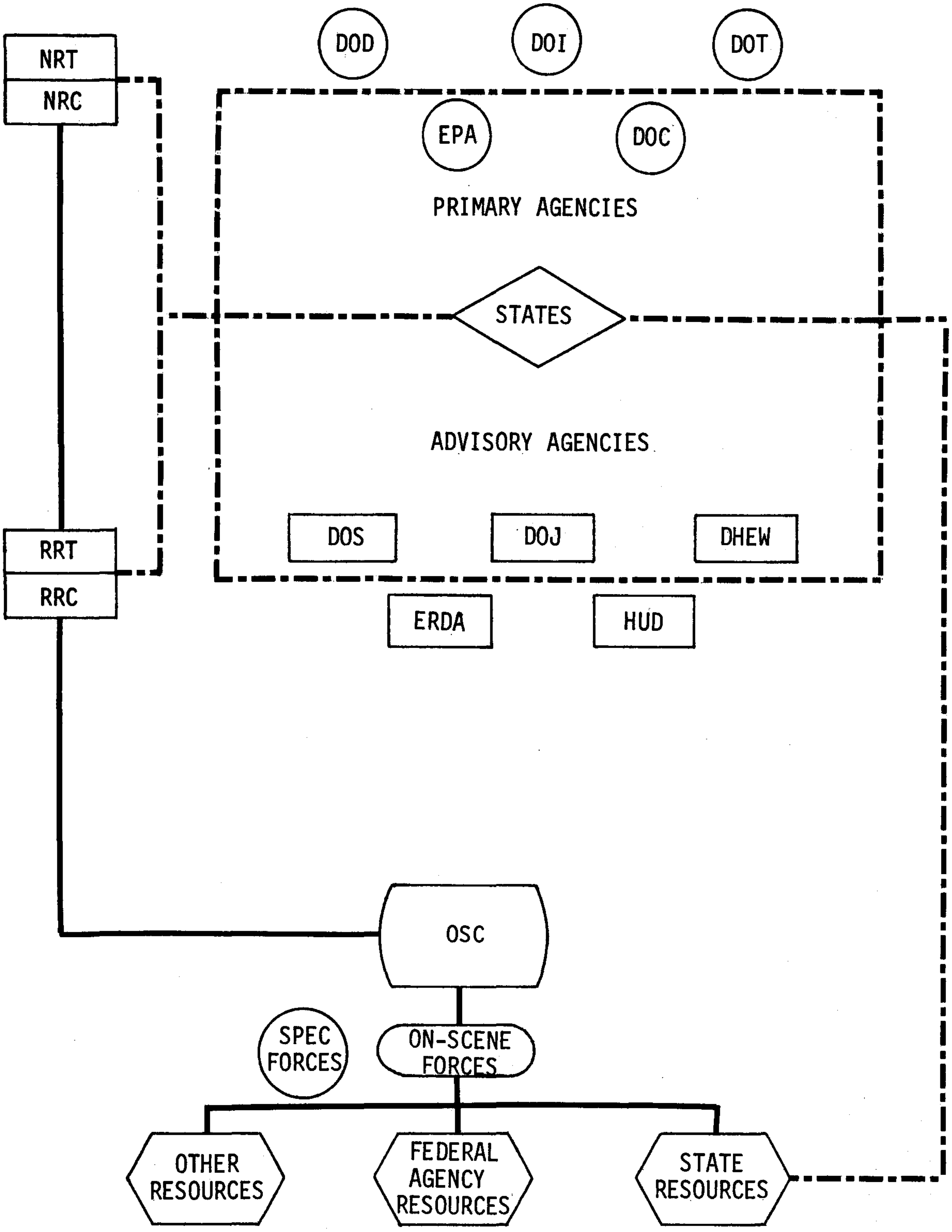

Figure 1. National Contingency Plan concepts. Abbreviations are identified in the text.

The National Response Team (NRT) draws its membership from Federal agencies at the national level. Like the RRT, the NRT consists of representatives from the primary and advisory agencies.

The NRT may be activated as an emergency response team in the event of a discharge involving oil or hazardous substances which: (1) exceeds the response capability of the region in which it occurs; (2) transects regional boundaries; or (3) involves significant numbers of persons or nationally significant amounts of property. The NRT may also be activated upon the request of any primary agency representative. This team is capable of providing such services as the use of Air Force cargo planes, or Navy salvage assistance, or special oil slick trajectory predictions from the Department of the Interior.

Whenever a pollution incident occurs, the Federal OSC for the area is notified. It is the OSC's responsibility to insure that a prompt and accurate assessment of the situation is made. The OSC will continue to monitor the situation if the responsible party is known and is found to be taking all the steps possible to contain and to clean up the pollutant. If the identity of the responsible party is unknown or the party is not considered to be taking adequate steps to contain and clean up the pollutant, the OSC may initiate whatever steps are necessary.

Under the plan, the National Strike Force is to be formed around strike teams established by the Coast Guard and an Environmental Response Team (ERT) established by the EPA. The National Strike Force now consists of three strike teams, any or all of which are available to advise and provide assistance to the OSC. Members of these teams have specialized training in pollution containment and removal, diving, and vessel damage control. Each team is equipped with specialized pollution control equipment.

The FWPCA further calls for the Coast Guard and the EPA to establish, at major ports for which they have OSC responsibility, emergency task forces, consisting of trained personnel with adequate supplies of cleanup equipment to assist OSCs during pollution incidents. Coast Guard Captain of the Port units function as emergency task forces in areas where the Coast Guard has OSC responsibility. The EPA has not established emergency task forces in its areas of responsibility. The Coast Guard, however, has agreed to assume this responsibility in the EPA areas where Coast Guard forces are available for this function.

Up to this point, we have discussed only EPA and USCG responsibilities under the plan. The responsibilities of other agencies are explained in general in Section 1510.22, "Federal Responsibility," of the plan. The following discussion should serve to delineate more clearly how all NRT agencies interact and provide support for Federal discharge removal operations.

Because of the nature and purpose of this workshop, an expansion of the discussion of the Department of the Interior's role and responsibilities is in order.

Within the Department of the Interior, four bureaus or agencies are expected to provide expertise and support to Federal removal operations. These are the U.S. Fish and Wildlife Service (FWS), the U.S. Geological Survey (USGS), the National Park Service (NPS), and the Bureau of Land Management (BLM).

The Fish and Wildlife Service, with its statutory responsibility and its field organization, has primary authority for protecting wildlife resources from damage and for restoring these resources after damage. In this role, FWS personnel are expected to coordinate the activities of State and local forces, including volunteers, and to serve as the OSC's expert on the extent of wildlife damage suffered or anticipated in connection with a spill operation. The FWS has recognized its responsibilities and is moving in the direction of a national program to support the various OSCs. Also, as a result of several spills that severely affected wildlife, the FWS has recommended several amendments to the plan. It is anticipated that these amendments will be published in the near future.

The U.S. Geological Survey, because of its responsibilities and expertise on Outer Continental Shelf operations, provides the OSC for spills occurring on Outer Continental Shelf leases and advises the NRT, RRTs and OSCs with respect to damage control on oil *production* facilities.[3]

The National Park Service and Bureau of Land Management are mentioned because they administer many square miles of Federal-owned land. Many of these Federal lands are traversed by pipelines, rivers, and highways. On many occasions, BLM and NPS personnel and the Federal officials in closest proximity to a spill incident serve as the OSC until the predesignated OSC becomes involved. In addition, these agencies can provide equipment and manpower for spill cleanup operations when appropriate.

Another department with agencies that can provide vital support to the OSC/RRT/NRT operation is the Department of Commerce. Of particular importance are the National Oceanic and Atmospheric Administration (NOAA) and the Maritime Administration. The NOAA provides very useful services directly to the OSC. These include near- and long-term weather forecasting, spill trajectory measurements and projections, and information on commercially valuable fisheries resources. Maritime Administration involvement is primarily with the NRT, to which consultation on ship construction and U.S. merchant fleet characteristics are provided.

Of the primary agencies, the Department of Defense (DOD) is discussed last. This is not because DOD's involvement and support is of less importance than that of other agencies. The DOD, through the armed services, provides equipment and manpower, expertise on ship salvage (through the Navy Supervisor of Salvage) and on the navigable rivers, ports, and channels that constitute the navigable waters of the United States (through the Army Corps of Engineers), and Air Force airlift capability. The Army helicopter fleet, in addition, has provided invaluable transport of specialized equipment.

As previously stated, there are five advisory agencies: the Department of State (DOS); the Department of Justice (DOJ); the Department of Housing and Urban Development (HUD); the Department of Health, Education and Welfare (DHEW); and the Energy Research and Development Administration (ERDA). Each of these agencies brings unique capabilities to the plan organization.

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[3]See August 1971 DOI-DOT MOU concerning respective responsibilities under the National Oil and Hazardous Substances Pollution Contingency Plan.

All of the foregoing information provides a framework or pattern for the Federal response to an oil or chemical spill. That framework can work and work well if preplanning is carried out *prior* to the need for agencies to make their capabilities available to the OSC/RRT. This means that FWS personnel should know their counterparts in EPA, USCG, DOD, NOAA, and the individual States. The converse is also true. The best method for accomplishing this is for the RRT to meet on a relatively routine basis, rather than attempting to sort out responsibilities and authorities during a response action. This has been done in several of the regions with good results; at least names are now connected with telephone voices and faces.

You have been given an overview of the National Contingency Plan, its organization, and the agencies participating in its implementation.

You have an important role and serious responsibilities involved in the Federal response to an oil or chemical spill.

NEEDS OF THE FEDERAL ON-SCENE COORDINATOR AND REGIONAL RESPONSE TEAM FOR WILDLIFE EXPERTISE

Charles R. Corbett[1]

A precise understanding of the organizational relationships and interfaces of agencies responding to oil and hazardous substance spills is essential for all those who are charged with providing timely and meaningful assistance to the Federal On-Scene Coordinator (OSC) and Regional Response Team (RRT). The OSC is the Federal official, predesignated by the Regional Contingency Plan, who coordinates and directs Federal pollution control and cleanup efforts at the scene of a discharge or potential discharge. Usually, the U.S. Coast Guard has the responsibility for assigning OSCs in coastal waters, while the U.S. Environmental Protection Agency (EPA) has that function for inland waters. The Coast Guard and EPA have agreed regionally on the boundary separating the two areas. Information relating to the boundary should be available in the applicable Regional Contingency Plan, but generally one can think of it as being located at the head of commercial navigation. It should be noted that, pending arrival of the predesignated OSC or his representative, the first Federal official to arrive at the scene assumes that role, and this official, of course, could be a member of the U.S. Fish and Wildlife Service.

The Regional Response Team is composed of representatives of the primary and selected advisory agencies named in the National Contingency Plan and is chaired by either the Coast Guard or the EPA, depending on the site of the spill (coastal or inland). The Department of Interior is a primary agency and as such should always be represented on the team. My personal view is that the representative should be from the Fish and Wildlife Service for it is in that field that the OSC, if he is a Coast Guardsman, is more likely to lack expertise that is available in the Department of Interior.

The primary function of the team is to advise and assist the OSC. The team also performs organizational functions such as determining if a shift of OSCs is appropriate, assures the availability of resources that might prove elusive to the OSC, and, of course, is responsible for the development of the Regional Contingency Plan.

In our Coast Guard District, the Ninth, we believe that the RRT should assemble and function near the site of the spill for maximum effectiveness. We make a conscious effort, however, to permit the OSC to do his job while we do ours. Such matters as boom deployment and monitoring of cleanup contractors are a function of the OSC, and for RRT members to become involved with such things only causes confusion. The RRT might and should, however, provide the OSC with *timely information* and *recommendations* upon which *he*, the OSC, can make solid judgments relating to boom deployments and priorities for cleanup.

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The States, by the way, are invited to join the Regional Response Team and, in our district, are asked to participate in all decision-making. The State representative is usually a member of the principal State environmental agency, such as the New York Department of Environmental Conservation, and as such is familiar with the Fish and Wildlife Service organization and personnel.

Another group with which some of you might be familiar is the Joint U.S.-Canadian Response Team, which replaces the RRT when both Canadian and U.S. waters are affected or threatened. Its functions and membership are much like that of the RRT. Membership is, of course, from both sides of the border.

Now, suppose we have a major oil spill in U.S. coastal waters. The OSC is the predesignated Coast Guard official so named in the Regional Contingency Plan. He is assisted by his own resources, such as Coast Guard units under his command; the National Strike Force, a team of highly specialized Coast Guardsmen skilled in pollution prevention, control and recovery; and his parent command, which offers support in such matters as pollution fund monies, logistical support, and availability of other Coast Guard resources. He will also have in the immediate vicinity, as soon as members can arrive, the Regional Response Team to provide advice and assistance. What, then, is the role of the U.S. Fish and Wildlife Service?

Although it is not always the case, participation of the Fish and Wildlife Service is usually limited to those spills of large enough magnitude to warrant activation of the Regional Response Team. It is through the formal activation of the team that assistance is requested. The OSC may also request assistance for small spills with unusual problems, and this would normally be done at the field level. Other serious spills, however, for which a representative is not specifically requested, are brought to the attention of the Department of Interior in Washington, D. C., by formal pollution reports submitted by the OSC. Any Interior representative, Fish and Wildlife Service or otherwise, is welcome to assist with or observe any spill.

On a spill such as the *Nepco 140* incident, the Fish and Wildlife Service role is a dual one. First, a nearby field representative should be made available to the OSC to carry out locally oriented functions. Second, a regional representative should join the Regional Response Team to participate in the deliberations and decisionmaking of that group. The two representatives should maintain close liaison with each other, and the field person usually acts as the wildlife field adviser to both the OSC and RRT, the latter through the wildlife member of the team.

It is likely that the wildlife field representative will have local knowledge of extreme importance to both the OSC and Regional Response Team in developing answers to the following questions: Where are environmentally sensitive areas that deserve a high priority for protection and cleanup, and why? What type of wildlife inhabits these sensitive areas? Is the affected area, or parts of it, subject to migration and if so, when can arrivals be expected? Where are the locations of nesting and spawning areas? When are the eggs laid and how far below the surface is the spawn deposited? What about molting? What other local contacts, government and otherwise, can provide assistance in setting up bird-cleaning stations, and who are the people qualified to do the cleaning? During field trips, the OSC should inventory mortalities for postspill studies and estimate indirect losses based on direct mortalities.

The Fish and Wildlife Service representative to the RRT should be sure that the team is receiving the same information as the OSC representative, and *must* also be authorized to speak for his agency on such matters as the use of dispersants and sinking agents, oil removal by burning, and bird-scaring. He should be capable of addressing long-range impacts of harvesting oil-soaked vegetation and discussing relationships among various species in relationship to feeding habits, how the oil will affect different species, and what the *real* toxicity of the spilled oil is to the various wildlife. He will, of course, coordinate with the EPA and the state environmental agency and may be assigned as liaison to private environmental groups. He should be familiar with, or have knowledge of, highly skilled people on the national level who can assist with complex wildlife problems or make referral to those who can.

If the OSC or RRT is not sensitive to matters affecting fish and wildlife, and believe me, there are many other things that must be attended during the first day or so of a spill, the wildlife representatives should take the very first opportunity to identify themselves and point out their concerns, both informally and in rough write-ups, if time permits. Remember that the OSC and, to a lesser extent, the RRT may not talk your language--*that is why you are there*--so be sure they understand, and do not be timid. Be sure they see the problem as you do.

I have intentionally kept my talk brief since a good bit of my time will be taken up showing the film and slides of the *Nepco 140* spill, and I want to respond to as many questions as possible.[2] I will be here at your conference for as long as I am able to assist you, or you to assist me.

[2]Film and slides were shown on "The St. Lawrence River (*Nepco 140*) Oil Spill of 1976."

CALIFORNIA'S RESPONSE TO POLLUTION INCIDENTS

Walter H. Putman[1]

Now that you have heard about the national oil spill plan, let us see how it affects State and local governments. The national plan, which imposes a planning sequence that flows downward from the Federal Government, causes considerable confusion at local levels because it fails to explain how local governments are to participate.

Since 1950, all 410 incorporated cities and 58 counties in California have been operating under a master mutual aid agreement for disasters. Under this mutual aid system, the city experiencing a disaster relies first on its own resources to combat the problem, then calls for assistance from its neighboring city. As the problem increases in magnitude, the city can call for assistance from the county, the region, the State, and finally the Federal Government--in other words, from the grass roots upward. This planning system has worked well in California for fires, floods, tsunamis, riots, earthquakes, and oil spills.

In the last 8 years, we have had several pollution incidents in California, which caused us to activate oil spill contingency plans of the Coast Guard and the State. During these incidents, the Coast Guard and California's On-Scene Coordinators (OSC) accomplished their goals in an efficient manner. This was because both the Coast Guard's and the State's leading officers, with expertise in the field of water pollution by oil, have established personal rapport in the planning and execution of mission assignments in their respective areas of responsibility. It was during critiques of these incidents that it became apparent that the coastline of California is governed on a day-to-day basis by overlapping local government entities. So why, then, when a pollution incident occurs, should not these local entities be involved in the planning for combating the pollution incident?

The California Oil Spill Contingency Plan reconciles any differences in emergency planning by providing the local governments with all the information developed by the Federal and State OSCs and including them in the decisionmaking process at the operation centers. This is accomplished by the local government's preassigning a representative who will have the authority to speak for his community and to commit personnel, equipment, and facilities to help mitigate the pollution incident. He will also have the responsibility to keep his local levels of government informed of the corrective or contemplated actions agreed upon at the operations center.

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Oil companies and other organizations handling oil and other hazardous materials have been provided with an emergency toll-free telephone number for reporting spills to the California State Office of Emergency Services. When a spill, regardless of magnitude, occurs anywhere in California or in the ocean contiguous to the State, the spill is reported by the responsible party or by any observer to the Office of Emergency Services in Sacramento. This office has a standby procedure for alerting State agencies that may have responsibilities related to the spill.

In all cases, a uniformed officer from the California Department of Fish and Game goes to the scene and estimates the magnitude of the spill and its potential adverse effects. If the spill poses a substantial threat to public health or welfare or to living resources, arouses public concern, or is likely to be beyond the control of personnel or equipment of local organizations, he will recommend to the State Operating Authority that a pollution incident be declared.

The decision as to whether to contact the State Operating Authority rests upon the judgment of the officer, rather than being tied to a factor of the specific number of gallons spilled. If, in the judgment of the officer, the extent and character of the spill do not warrant the declaration of a pollution incident, the officer will investigate the cause and monitor the containment and removal of the oil.

When a pollution incident is declared:

> The State Operating Authority appoints a State agency coordinator. The coordinator is a single State official who delegates mission assignments to State agencies. He is usually a ranking officer of the California Department of Fish and Game, who has command experience and expertise in the containment and removal of spilled oil. He has the added responsibility of coordinating the State's efforts with the Federal agency coordinator, who usually is a ranking Coast Guard officer.
>
> The State agency coordinator activates the designated public information officer; the area Office of Emergency Services, to coordinate local government input; and the Regional Water Quality Control Board, to designate disposal sites and to advise water users of the incident.
>
> Local Department of Fish and Game personnel establish a State operations center near the spill location and the Federal operations center. The State center serves as the State's command and information center for the duration of the pollution incident.
>
> Other members of the 13 agencies represented on the State operating team are activated through the State agency coordinator when their involvement is apparent or a need for their assistance arises.

The California Department of Fish and Game oil spill contingency plan and members of the designated teams are activated. They use patrol boats and aircraft to monitor the oil slick and to determine the number of birds and mammals in the area. Trained Department of Fish and Game personnel bring in bird-cleaning equipment and establish collection and treatment facilities. The Department coordinates and directs public volunteer efforts to assist in the rescue and treatment of oil-contaminated birds and marine mammals. The Department of Fish and Game also utilizes research boats and marine biologist diving teams to document the effect of the spill on the marine environment.

If the spiller can be identified, if he is financially responsible, and if he is taking the necessary steps agreed upon by the State and Federal agency coordinators to contain and remove the spilled oil, both the State and Federal efforts are limited to monitoring and advising. If, on the other hand, the spiller is unknown, or the spill is beyond his financial capacity to handle, or if he refuses to take the necessary steps to contain and remove the spill, the federal agency coordinator assumes the actual contracting for the containment and removal operations. The costs are paid for out of the National Pollution Revolving Fund administered by the Coast Guard.

This, then, is one State's view of oil spill planning. Each of you will find varying degrees of readiness in the States and local governments in your areas of assignments and responsibility. Nonetheless, you should make yourself aware of their plans so you can interface your own plans and thereby obtain the maximum use of personnel and facilities to accomplish the necessary goals.

Now, let us talk about birds.

I mentioned earlier that the California Department of Fish and Game has trained personnel to establish bird collection stations and treatment facilities. We have this capability simply because of necessity. When the oil well blew out in the Santa Barbara Channel in 1969, we were not prepared to treat oil-contaminated migratory or resident birds. We did everything wrong. We tried every conceivable cleanser from kerosene to butter, to cornmeal, to detergents. The treatment facilities were makeshift, and the treatment techniques were administered by untrained personnel. As I recall, we managed to kill about 97 percent of the birds we treated. Secondly, the U.S. Fish and Wildlife Service knew as little about cleaning birds as we did and stayed in the background. As the years rolled by, the Service has continued this hands-off policy.

We are extremely heartened by the knowledge that the Service is actively preparing contingency plans for response to oil spills. How you interface your plans with existing State plans will be a major problem and of keen interest to the States.

As far as bird-cleaning and treatment are concerned, we are in much better shape today, thanks to a lot of research and practical experience. I will not discuss the mechanics of bird-cleaning because other speakers will do that. What I would like to talk about is our experience in California regarding planning and execution.

First of all, when a massive oil spill occurs, it is too late to go shopping for cardboard boxes, rags, rubber gloves, aprons, boots, heaters, blowers, cleansers, cages, and other necessary paraphernalia. It is mandatory to stockpile such equipment and store it so that it is readily available. Perhaps you should consider inventorying existing equipment in your areas of responsibilities, then wrestle with the real problem of funding the needed supplies. I am certain California would welcome any financial assistance you could offer in this regard.

Second, mobile equipment, such as aircraft, trucks, automobiles, boats, and airboats, should be on inventory and readily available. Transects by aircraft to determine the daily number of birds in a given vicinity are essential for planning of treatment facilities and manpower. This information, as well as other communications, should be broadcast to the operations center on a radio frequency available to both the Service and State agencies.

Third, collection stations should be established where oil-soaked birds can be delivered. These stations must not be immobile, but must be able to shift to the area where the greatest number of birds are being captured. From these stations, the birds are whisked away to treatment facilities.

Fourth, the sites selected for treatment facilities should be behind a controlled access route, such as a military installation. The advantages are apparent: it keeps the well-meaning citizen from underfoot and makes it easier to use chemicals for euthanasia of a bird when necessary. A word about these euthanasic chemicals: they may be secondary poisons; if so, the carcasses of the birds must be disposed of by burning.

The treatment facilities must have running water and sufficient electric power and outlets to handle the demand for heaters and blowers.

It is important to keep a daily count, by species, of the birds brought in for treatment, as well as a running tally of their disposition.

The Service and the States have worked together efficiently over the years on botulism outbreaks and have shared the costs and publicity of these incidents. I would hope that this spirit of cooperation will be carried forward in your oil spill contingency planning.

INDUSTRY VIEWS AND RESPONSIBLITIES IN OIL SPILL/WILDLIFE OPERATIONS

Keith G. Hay[1]

The unusually severe winter of 1977 has already had a profound effect on wildlife and man. The unseasonably warm weather in Alaska has stirred bears out of hibernation, and on the Pacific Coast, drought conditions have reduced the supply of surface water, causing ducks and geese to crowd into areas of available water to such an extent that cholera and botulism epidemics are considered likely. The lack of rainfall in the pothole breeding areas of the Midwest will have an adverse effect on next summer's hatch of young birds. On the Atlantic Coast, which is experiencing one of the coldest winters in history, the bitter cold and heavy icing conditions have killed thousands of birds and have resulted in acute shortages of fuel to heat homes and keep businesses and schools operating.

To meet increased energy demands in this country, a steady stream of tankers import about eight million barrels of oil into the United States each day from foreign countries. These tankers supply more than 90 percent of the fuel needs of East Coast residents. As the need for more oil continues to increase, it becomes apparent that petroleum will continue to be this Nation's main source of energy for as long into the future as anyone can see.

Unfortunately, the United States is becoming more and more dependent on foreign sources of oil. At present, this country is importing 41 percent of its petroleum requirements. If this trend continues, the United States will soon be relying on other countries for more than 50 percent of its oil needs. Saudia Arabia is now the number one supplier. The United States is now importing twice as much oil from Arab countries as it was just prior to the oil embargo imposed by the Arab nations just over three years ago. During the last 3 years, the price of Arab oil has more than quadrupled.

Tankers are, and will remain, an indispensable means of moving remote oil supplies to markets around the world. Without the movement of oil by tankers, modern industrial society as we know it would soon cease to exist.

But men and machines are far from perfect. Accidents do occur--on land, on the sea, and in the air. Oil spills at sea are the *sine qua non* of importing vast quantities of petroleum into this country. Unfortunately, accidents of this type are simply not going to disappear. I applaud the efforts of the U.S. Fish and Wildlife Service in developing contingency plans to cope with what will surely be a recurring problem for man and wildlife.

What is the petroleum industry's responsibility concerning this problem? Its primary goal is to keep oil out of the sea. No one is working any harder

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to achieve this goal than the industry itself. It has conscientiously sought to control and clean up spills and is spending millions of dollars each year on new technologies and training programs to improve tanker efficiency and to reduce the potential for accidents.

The American Petroleum Institute (API), for example, has urged the U.S. Coast Guard to take specific measures to identify and prevent substandard tankers from operating in U.S. waters and has urged the adoption of international codes dealing with maritime pollution control and damage liability. The Institute, furthermore, has stressed the need for uniform standards for training and maintenance of navigational aids by all vessels. The broad range of preventive measures voluntarily taken by U.S. oil companies encompass personnel training, operational procedures, and utilization of advanced technology.

Most oil spills--large or small--are directly attributable to human error. The most effective means of preventing spills, therefore, is to employ skilled and attentive crews. To this end, oil companies have developed innovative training programs, including the use of computerized simulators, which use authentic mockups of a ship's bridge and visual devices to duplicate a wide range of real-life situations. One tanker school uses scale-model supertankers on a specially equipped lake to train captains in maneuvering skills, including harbor approaches, moorings at offshore terminals, and ship-to-ship berthing. Regular rotation for all officers reinforces rigorous training regimes for their handling of progressively larger and more complex ships under all sea conditions.

Almost all tankers use the "load on top" procedure instead of discharging oily ballast and tank washings into the sea. These mixtures are put into a special holding tank, where the oil separates from the water. Eventually, only clear sea water from the bottom of the tank is pumped overboard. The new oil cargo is then loaded on top of the oily residues. Some operators discharge their tank washings ashore in special reception facilities now available at many refineries or drydocks.

New waterless tank-washing techniques are now showing promising results. These new methods involve spraying part of the crude oil cargo through high-pressure nozzles to clean the tanks. The resulting solvent action is so effective there is little residue and no oily ballast water to deal with. Henceforth, all new ships over 70,000 deadweight tonnage will be constructed with segregated ballast sections to comply with recent Coast Guard rulings.

The petroleum industry has also made concerted efforts to reduce the risk of accidental oil spills while transferring oil ashore. The industry has compiled a comprehensive, detailed safety guide for all aspects of oil handling at terminals, and all major U.S. oil companies now use this guide.

The most advanced and sophisticated navigational systems are being used on an increasing number of tankers. Long-range radio systems (LORAN) and radar are now standard equipment. The industry has greatly improved accuracy and reaction time by adding computerized collision avoidance systems. These electronic aids are capable of pinpointing the position of a ship and calculating the direction and speed of other vessels in the area within a matter of seconds. Many supertankers today use the latest satellite navigation and communications systems, which can function under any atmospheric conditions and at any distance from shore.

To handle small oil spills that occur at refineries, terminals, and other facilities, major petroleum companies maintain their own equipment and materials. Many companies cooperate with other local and private groups to form "oil spill clean-up cooperatives." Since 1967, some 100 cooperatives have been formed in coastal areas of the United States and on major inland waterways and harbors.

Like volunteer fire departments, these cooperatives purchase and pool equipment and resources, establish a system of communications, and adopt emergency plans to handle various situations. The cooperatives work closely with the Coast Guard, the Environmental Protection Agency, the Corps of Engineers, and local fire and environmental groups. Equipment includes various types of booms and barriers to contain a spill, skimmers and sorbent-handling equipment to remove oil from the water, pumps and portable generators, communications systems, helicopters, motor boats, and skiffs, pollution equipment trailers, and bird rescue and cleaning materials.

Oil spill cooperatives have demonstrated an ability to respond promptly and effectively in sheltered waters or in the open seas under relatively calm conditions. They also provide a good means for providing training and experience, which may help limit potential dangers to property and wildlife in future spills.

Under the National Oil Spill and Hazardous Materials Contingency Plan, the responsibility for the supervision and coordination of emergency efforts to save wildlife fouled by oil is vested in the U.S. Fish and Wildlife Service, working in cooperation with State wildlife agencies. This arrangement is both proper and legal, and it is industry's intention to support the Service in any way possible.

The petroleum industry has long supported legislation for the establishment of a huge "superfund," which could be used immediately to handle expenses involved in the cleanup of spills. The fund would be replenished by the spiller. In the meantime, I know of no spill involving an American oil company in which the company did not immediately cover all expenses for cleanup, including the rehabilitation of wildlife.

Beginning with the Santa Barbara oil spill in January 1969, API initiated various research projects and other efforts to solve the many complex biological problems that occur in achieving high bird survival levels and a rapid return to the wild at reasonable costs.

The API first asked Professor Philip Stanton to begin a research program on cleaning and caring for oiled birds at the Wildlife Rehabilitation Center at Upton, Massachusetts. Since then, Professor Stanton has continued his research efforts in this area and has been at the scene of various spills on both coasts to give constructive advice. He is truly an expert in this field. He has written numerous articles and research papers, including a "how to" guide for the treatment of oil-soaked birds, entitled *Operation Rescue*, which is accompanied with a bibliography. He was very active, incidentally, in the *Argo Merchant* spill near Nantucket in December of last year.

The API has also sponsored a 4-year study in avian physiology at the University of California at Santa Barbara. This study concerned the effects of ingested crude oil on the mucosal transport mechanism and the electrolytic balance in marine birds and the degree of dehydration and resulting pathological changes. A discusssion of replacement therapy, including recommendations for the use of steroids, is incorporated in the final report, which is available from API.

Another API research project, conducted by the Av-Alarm Corp. of Santa Maria, California, concerned the perfection of an acoustical device for repelling aquatic birds. Using this device, the consultant firm was successful in repelling 82 percent of the ducks and 92 percent of the shore birds from a given area. The final report of that study is also available from API.

The International Bird Rescue Research Center in Berkeley, California, just completed an exhaustive compilation of its research for API. This compilation includes a "text book" on rehabilitation techniques for oil-soaked birds, a "how to" pamphlet on bird-cleaning, and an audio/visual presentation. All three materials will soon be available from API.

In May 1974, the API, in cooperation with the U.S. Fish and Wildife Service, sponsored a seminar on oil spill/wildlife response planning at Laurel, Maryland. At that time, efforts were being made to have State wildlife agencies develop their own plans. The Comprehensive California Fish and Game Plan for oiled wildlife was sent to all coastal State wildlife agencies as a prototype model. At the present time, similar workshops on oil/wildlife problems are being planned for the Northeast, for Florida, and for the Northwest. The locations and dates of these workshops will be announced well in advance.

Standard Oil Co. of California provided a grant to Dr. James Naviaux of Pleasant Hill, California, to develop bird-cleaning technology, which includes the testing of various cleaners. His publication, *After Care of Oil Covered Birds*, is available from the National Wildlife Health Foundation at Pleasant Hill, California.

Shell Oil Co. has supplied 50-gal (189.3-l) drums of the cleaning solvent Shell Sol 70 to oil spill control centers throughout the Nation.

In Canada, the Petroleum Association for the Conservation of Canadian Environment (PACE) employed a consulting firm that made a comprehensive review of dispersal and rehabilitation techniques of oil-soaked waterfowl. The report is now available from PACE in Ottawa, Canada.

The BP Co. in Britain has supported considerable research on the problems of oil-soaked birds. Numerous publications dealing with the efficiency of various detergents on oil-soaked waterfowl can be obtained from the Oiled Bird Research Unit, Department of Zoology, University of Newcastle Upon Tyne, England.

I have presented a brief review of the petroleum industry's responsibilities concerning the prevention and cleanup of oil spills and the research efforts and other initiatives taken by the industry during the last decade in solving the difficult problem of treating oil-soaked waterfowl.

The industry pledges its continued interest and cooperation. We will not wait to be invited to be of help. We will be there to assist the efforts of those who have the primary responsibility in wildlife/oil spill matters.

We all have a long way to go in resolving the many and complex problems of saving precious wildlife and in meeting the energy needs of this nation.

FATE OF OIL IN THE SEA

Richard F. Lee[1]

INTRODUCTION

Millions of tons of petroleum enter the sea each year from marine transportation, offshore oil production and coastal oil refineries, sewage outfalls, natural seeps, and atmospheric fallout. Published estimates of the sources and quantities of petroleum in the sea are available from several recent reports (Ocean Affairs Board 1975, American Institute of Biological Sciences 1976). The largest contributor (approximately 2 million tons/year) of petroleum to the sea is marine transportation, which includes losses during normal ship operations, oil spills resulting from accidents at sea, and spills during operations at oil terminals.

Crude oils and oil products can contain many thousands of compounds, most of which are hydrocarbons, both aliphatic and aromatic. Minor components include oxygen-, nitrogen-, and sulfur-containing compounds. After a spill, a "slick" forms on the surface of the sea because of the low water-solubility of most petroleum compounds. The fate of this slick depends on various biological, chemical, and physical processes which act to disperse or modify it (Figure 1). The fate of oil in sediment and in the water phase has been separated in this paper for purposes of discussion.

FATE OF OIL IN WATER

When an oil slick occurs, various processes modify and disperse it. The extent and direction of the slick are affected by winds, waves, and currents. The lighter fractions of the oil begin to evaporate within a short time. The heavier fractions are affected by factors such as emulsification, dissolution, photo-oxidation, biodegradation, uptake by marine life, and adsorption to suspended particles. The relative importance of these processes depends on the composition of the oil, especially as it relates to density and viscosity, and on external factors such as temperature, light, oxygen, and nutrients. Eventually, a tarlike residue is left, which then breaks up into tar lumps or tar balls, which have been observed in waters along tanker routes (Morris 1971, Wong et al. 1974). The following paragraphs contain a discussion of the six major factors affecting the heavier fractions of oil in a spill.

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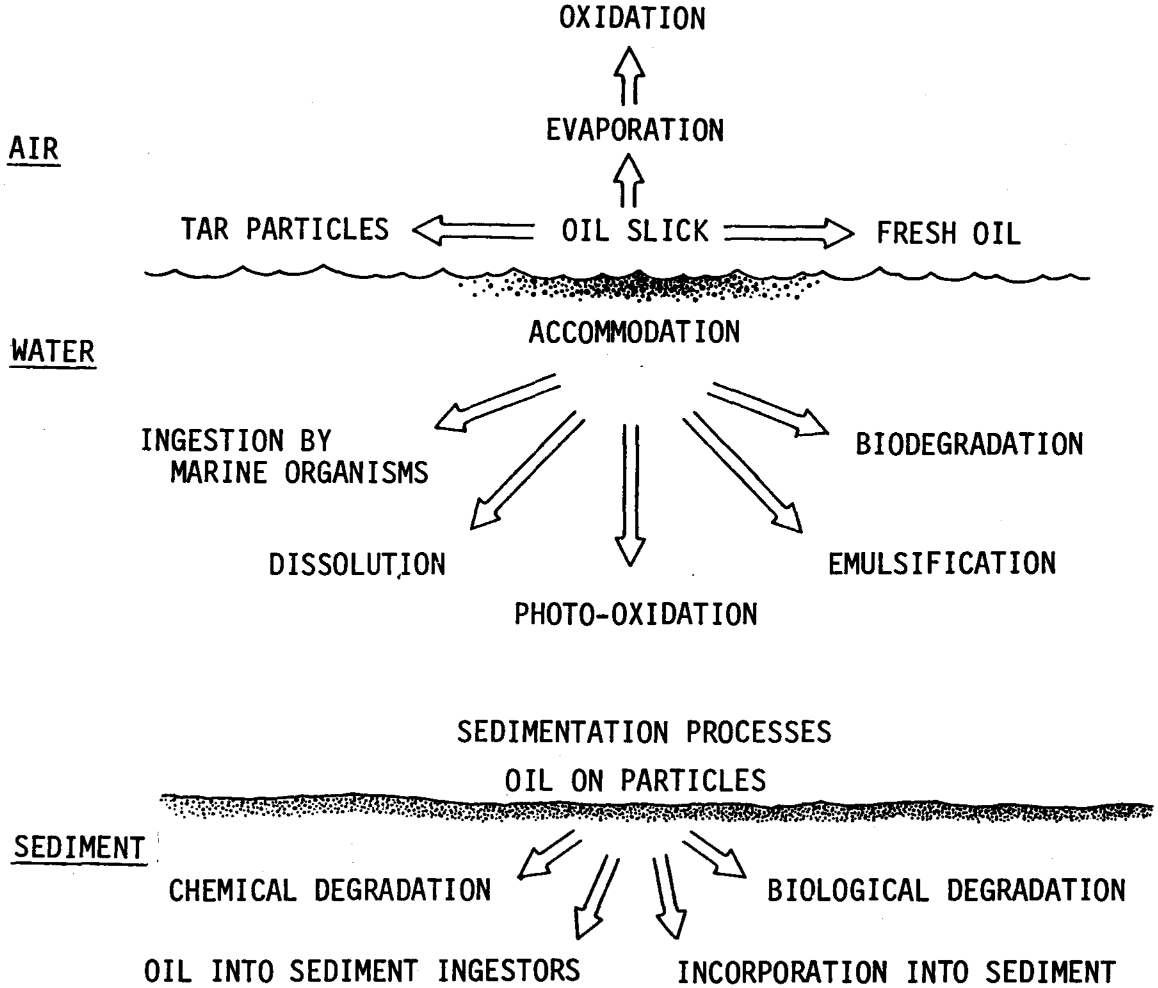


Figure 1. Fate of oil at sea: biological, physical, and chemical processes.

EMULSIFICATION AND DISPERSION

As the lighter fractions of petroleum in a spill are lost as a result of evaporation and dissolution, some of the heavier fractions become viscous as a result of the formation of a water-in-oil emulsion, sometimes referred to as "chocolate mousse" because of its color and consistency. In open water turbulence acts on an oil slick to form oil-in-water and water-in-oil emulsions, as well as fine dispersed oil droplets. The production of surface-active agents (surfactants) by bacteria can help to stabilize the dispersions and oil-in-water emulsions, which can then remain suspended in the water for many days. Some of the emulsions are stable for many months and can eventually be washed ashore, where, after evaporation, a tarlike residue is left on the beach.

DISSOLUTION

The water solubility of most petroleum compounds is very low; hence, the petroleum compounds in the underlying water of an oil slick are often minor components in the whole oil. McAuliffe et al. (1975) found that, in a crude oil spill in the Gulf of Mexico, less than 1 percent of the oil dissolved, while Gordon et al. (1976) found 5 percent of a spilled crude oil in the water. The amount of turbulence and the concentration of dissolved organic matter are important factors affecting the quantity of oil that is dissolved in the underlying water (Boehm and Quinn 1973). Water extracts of crude and fuel oil contain high concentrations of naphthalene-like (two-ringed) and benzene-like (one-ringed) compounds (Anderson et al. 1974, Guard et al. 1975). Polar compounds, such as phenols, quinolines, and toluidines, which are very minor components in the whole oil, are in relatively high concentrations in the water extract of fuel oils because of their solubility in water (Winters et al. 1976). The products of photo-oxidation, such as phenols and ketones, are more soluble than the parent compounds. Thus the greater water solubility of aromatic hydrocarbons, especially those of lower molecular weight, causes the oil slick to lose those compounds and retain aliphatic hydrocarbons of similar molecular size.

PHOTO-OXIDATION

Under the influence of light, many of the hydrocarbons, particularly the aromatics, can react with oxygen to produce polar compounds. Because of their relatively high water solubility, these products of photo-oxidation, including acids, alcohols, ketones, and phenols, are detected in water below a slick (Hansen 1975). Photochemical oxidation of petroleum in oil is particularly important when there is a very thin film of oil on the water and where metal ions are available to act as a catalyst. Some high molecular weight polycyclic aromatics absorb light in the visible region and are readily oxidized by sunlight; thus, benzo(a)pyrene is completely decomposed in seawater within a few days after exposure to sunlight (Andelman and Suess 1970). Ultraviolet light is absent, and many of the short wavelengths present in the visible region attenuate in water a few meters below the surface. One calculation showed that a 100-ton slick, if spread over an area of 8 km^2, would be photo-oxidized at the rate of 1 ton per day (Dodd 1973).

ADSORPTION TO SUSPENDED PARTICLES

Dispersed oil will adsorb to clays and other fine sediments in seawater, and eventually this sediment, with attached oil globules, is carried to the bottom (Poirier and Thiel 1941). In estuarine areas that are characterized by fine sediment salt marshes, the amounts of suspended particles in the water are high and oil in this turbid area is soon carried to the bottom. Adsorption to suspended particles is an important process for high weight aromatic and aliphatic hydrocarbons which have low water solubility. These particles include clays, detritus, living photoplankton, and microbes. Studies off the coast of Georgia have shown that most dissolved hydrocarbons adsorb to detrital particles, which are a mixture of organic matter, living bacteria, and small clay particles (Lee 1977). Scanning electron micrographs reveal rough surfaces on these detrital particles, with bacteria fastened by mucoid-like pads and fibrilla appendages. Lower weight hydrocarbons and more polar petroleum components remain in the water and show little adsorption to particles.

BIODEGRADATION

It is commonly assumed that microbes are the major degraders of oil in the sea. Hydrocarbon-degrading bacteria and fungi have been isolated from both polluted and pristine water (Zobell 1971, Floodgate 1972, Gunkel 1973, Walker and Colwell 1974). Hydrocarbon-degrading microbes are generally more abundant in areas of chronic oil pollution than in petroleum-free areas (Atlas and Bartha 1973). Through the use of radiolabeled hydrocarbons, it has been found that microbes in inshore and offshore waters are important in degrading phenols, lower weight aromatics, and aliphatics, but not higher weight aromatics (Lee and Ryan 1976, Lee 1977).[2] Estuarine waters show higher rates of hydrocarbon degradation than offshore waters, presumably because of the higher bacterial biomass associated with estuaries. Microbial breakdown of higher weight aromatics, such as benz(a)anthracene and benzo(a)pyrene, is probably not so important in ocean waters. Larger organisms, such as zooplankton, can take up and degrade these hydrocarbons (Lee 1975, Corner et al. 1976). After sedimentation of hydrocarbons, sediment microbes metabolize polycyclic aromatic hydrocarbons.

Input of oil into marine waters results in large increases in petroleum-degrading microbes, which will attack the various slicks, emulsions, dispersions, and soluble components that are produced. Most of a fuel oil water extract added to a large controlled ecosystem enclosure (2 m diameter and 15 m deep--60,000 l) in western Canada was biodegraded after 14 days (Lee and Takahashi 1977, Lee et al. 1977a). Three days after fuel oil addition, naphthalene degradation increased from 0.2 to 2.5 μg/l/day (turnover time decreased from 500 days to 10 days). Large clumps of petroleum-degrading microbes were observed, which were absent after the fuel oil components were degraded. Using a continuous growth chamber, Gibbs (1975) found that degradation of a Kuwait crude was 30 mg/l/year in water from the Irish Sea. The temperature and concentration of nutrients (nitrogen and phosphorus) are important in determining the rate of biodegradation. Atlas and Bartha (1973) found that the number of oil-degrading microbes was very low during the winter in Raritan Bay. Other workers have noted slower degradation of crude oils and oil components in the winter (Floodgate 1972, Lee 1977).

[2]This work was supported by NSF/IDOE, Grant No. IDO OCE 74-05283 A01.

UPTAKE BY MARINE LIFE

Petroleum can enter the marine food web by adsorption to particles, followed by ingestion of the particles by filter feeding, by the active uptake of dissolved or dispersed petroleum, and/or passage into the gut of animals that gulp or drink water. The results of analyses of marine organisms exposed to oil spills have demonstrated their ability to take up and store hydrocarbons without necessarily indicating their mode of uptake (Ocean Affairs Board 1975). The data showed highest levels in animals and plants exposed to a large oil spill, with lower levels in areas of chronic pollution. Large amounts of tar were found in the stomach of three sauries collected in the Mediterranean Sea (Horn et al. 1970). Fishes caught in waters near petrochemical industries often have a kerosene-like taint, which is probably due to the presence of volatile aromatic hydrocarbons (Ogata and Miyake 1973). The uptake of dispersed oil droplets by copepods after an oil spill and the elimination of these droplets in fecal matter have been noted by Conover (1971).

The benthic animals and plants from areas of high petroleum input generally have petroleum concentrations in their tissues several orders of magnitude higher than in the surrounding water. Because of their high lipid content, the liver of marine fish and the hepatopancreas of crustaceans are sites of hydrocarbon storage (Lee et al. 1972a, 1972b; Lee et al. 1976; Neff et al. 1976). The gallbladder in fish is also a temporary storage site, although the organ apparently serves mainly as an avenue of discharge. The various groups of petroleum hydrocarbons have different retention times so that oysters from oil-contaminated waters accumulated aromatic hydrocarbons to a greater extent than aliphatic hydrocarbons (Blumer et al. 1970).

All vertebrates and some invertebrate systems that have been examined have a so-called "detoxifying system," which facilitates elimination of lipid, soluble foreign compounds from the organisms by addition of polar groups to the hydrocarbon molecule, thus increasing its water solubility. Involved are a series of enzymes that carry out hydroxylation and conjugation reactions. Degradation of aromatic and aliphatic hydrocarbons occurs in marine fish, crustaceans, and polychaeta worms (Lee et al. 1972a, 1976, 1977b; Corner et al. 1973). Oysters, clams, and mussels remove hydrocarbons from the water while filtering large quantities of water, but these organisms lack the enzyme system for metabolizing these compounds (Lee et al. 1972a). Because of this accumulation of hydrocarbons by bivalves, it has been suggested that bivalves be used to monitor ocean waters for petroleum pollution.

FATE OF OIL IN SEDIMENTS

Various sedimentation processes, such as adsorption to particles, carry petroleum components of an oil slick to the bottom. Blumer and Sass (1972) continued to find petroleum-derived hydrocarbons in sediments from Buzzards Bay, Massachusetts, for many years after a spill of No. 2 fuel oil. Sewage effluents and small oil spills were the sources of the high hydrocarbon concentrations in the sediments of Narragansett Bay, Rhode Island (Farrington and Quinn 1973). The observed biological degradation of hydrocarbons in the sediments of these areas is due to microfauna, meiofauna, and macrofauna.

MICROBES

Hydrocarbon-degrading microbes have been isolated from various types of marine sediments. After introduction of oil into sediments, there is a large increase in the hydrocarbon-degrading microbial population (Zobell and Prokop 1966, Walker et al. 1975). Hughes and McKenzie (1975) added oil to sediment and followed oil degradation by taking sediment cores for 2 years. The surface layer of oil was degraded, but oil below the surface remained unchanged, indicating that microbial degradation takes place at the water-sediment interface. Only slow hydrocarbon oxidation occurred in anaerobic muds, and it was speculated that the sulfate-reducing bacterium *Desulfovibrio* was responsible for the degradation that was observed.

The alkanes are rapidly degraded by sediment microbes, followed by slower attack on isoalkanes, cycloalkanes, and aromatic hydrocarbons (Zobell 1969; Blumer 1973). In oil spill areas, mixed cultures of hydrocarbon-degrading microbes are able to metabolize both aliphatic and aromatic hydrocarbons (Walker et al. 1975). Different crude and refined oils would be expected to show different rates of degradation because of variations in the relative amounts of different petroleum components. In one experiment, hydrocarbon microbes were allowed to act on two crude oils (South Louisiana and Kuwait) and two refined oils (bunker C and No. 2 fuel oil). The South Louisiana crude oil was most susceptible to microbial degradation, and the bunker C oil was the least degraded in the 28-day study (Walker et al. 1976). The high concentration of high molecular weight polycyclic aromatic hydrocarbons in bunker C oil may explain its resistance to degradation. Through the use of radiolabeled hydrocarbon, it has been found that sediment collected off the coast of Georgia rapidly degraded three-ringed aromatics, but only slowly attacked four- and five-ringed compounds.

In addition to bacteria, hydrocarbon-degrading yeast and filamentous fungi have been isolated from marsh sediments along the coasts of Louisiana and North Carolina (Meyers and Ahearn 1972, Perry and Cerniglia 1973). A well-characterized species is the filamentous fungus *Cladosporium resinae*, which occurs in estuarine sediments, and can use alkanes as the sole carbon source (Walker and Conney 1973).

MEIOFAUNA AND MACROFAUNA

In addition to microbes, marine sediments also contain a large interstitial community called the meiofauna, which is composed of harpactoicoid copepods, nematodes, turbellarians, and small polychaetes. Many species from these groups are deposit feeders, which are thus directly exposed to hydrocarbons in the sediments. Polychaete worms, particularly *Capitella capitata*, are associated with areas of high oil input (Reish 1971, Sanders et al. 1972). Detritus associated with sediment is used for nourishment by many benthic polychaetes. Much of this detritus is formed in the water where hydrocarbons can absorb to it. Cell-free extracts of *Capitella capitata* have hydrocarbon-metabolizing enzymes, and living animals will take up polycyclic aromatic hydrocarbons from the sediment with subsequent metabolism to various hydroxylated derivatives (Lee et al. 1977b).

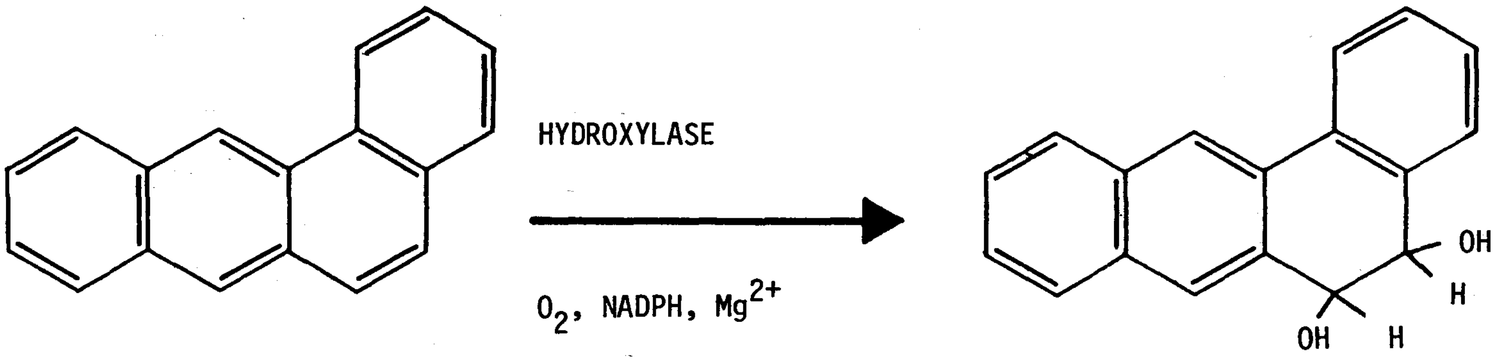
Certain benthic species of molluscs, crustaceans, large polychaete worms, and spinculid worms, referred to as the macrofauna, may play a role in hydrocarbon degradation in the sediments. As noted above, microbes are most effective in hydrocarbon degradation when working at the water-sediment interface. Many of the benthic animals rework the sediment so that hydrocarbons adsorbed to this sediment would be more exposed to microbial action. Tidal flow causes resuspension of fine sediments, with their associated hydrocarbons. These resuspended sediments can be taken in by benthic filter feeders, such as clams, mussels, and oysters. The clam *Macoma* feeds directly on organic matter in the sediment. The work of Farrington and Quinn (1973) has shown the importance of bivalves in the uptake of hydrocarbons from sediments. There is no evidence of hydrocarbon metabolism by these bivalve molluscs, but the discharge of hydrocarbon in the feces and pseudofeces would allow attack by microfauna and meiofauna.

Oil uptake from the sediment has been shown for the brown shrimp *Crangon crangon* (Blackman 1972), and benthic decapods are able to metabolize petroleum hydrocarbons quickly, with subsequent excretion of hydrocarbon metabolites (Corner et al. 1973, Lee et al. 1976).

Many of the large polychaetes ingest sediment during their feeding. Recent work has shown that polychaetes are able to metabolize petroleum hydrocarbons (Rossi and Anderson 1977, Lee et al. 1977b). When benz(a)anthracene was incorporated into sediment containing *Nereis succinea* and *N. virens*, the major metabolite produced by the worms was 5, 6-dihydro-5, 6-dihydroxybenz-(a)anthracene (Figure 2). The hydroxylated and conjugated products of these oxidation reactions are subsequently excreted by the worms.

CONCLUSIONS

As noted earlier, the fate of oil spills at sea depends on the composition of the oil, as well as such external factors as light and temperature. The extent of degradation also depends on the type of coastal area in which the spill occurs. In open, exposed coastline areas, with good circulation of water, most fractions of spilled oil are soon degraded (Rashid 1974). In protected shallow areas with less circulation, spilled oil is incorporated into sediments and much of it remains unaltered for many years (Blumer and Sass 1972). Photo-oxidation, dissolution, emulsification, adsorption to particles, biodegradation, and uptake by marine animals are not processes that act independently, but the interactions of all of these determine the fate of oil in water. The various filter feeders, grazers, and deposit feeders of the meiofauna and macrofauna utilize the organic matter of the sediment. In this process, they may expose deeper sediments to the water sediment interface where there is more microbial activity. The involvement of both microbes and animals in hydrocarbon degradation in marine sediments may be similar to their symbiotic association in recycling organic material in terrestrial sediments.



BENZANTHRACENE

TRANS - 5, 6 - DIHYDRO - 5, 6 - DIHYDROXYBENZANTHRACENE

Figure 2. Metabolism of benz(a)anthracene by tissue extracts from the intestine of the polychaete worm, *Nereis virens*.

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ASSESSING THE BIOLOGICAL IMPACT OF OIL SPILLS: A NEW ROLE FOR EPA BIOLOGISTS

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Whether an oil spill is the result of a catastrophic, highly publicized event like a platform blowout or the sinking of a tanker or a more common-place, but less publicized event, such as a storage tank release, it has a definite effect on the aquatic environment. Storage tank releases, though smaller in terms of the volume of oil spilled, occur more frequently, and, in terms of overall impact, are just as critical as the more catastrophic spills. The effect that an oil spill has on aquatic ecosystems is influenced by a number of factors: type of oil spilled and volume, hydrography of the oil spill area, climatic and seasonal changes, indigenous biota, treatment methods used during the cleanup, and previous exposure of the spill area to oil pollution.

FACTORS AFFECTING BIOLOGICAL IMPACT

TYPE OF OIL SPILLED AND VOLUME

Chemically, oil is not a single compound, but a mixture of compounds, each with its own unique set of physical/chemical characteristics. Some of these compounds are more toxic than others to aquatic organisms. Some are more soluble than others, thus entering the water column and increasing the likelihood of contact with living organisms.

For example, a No. 2 fuel oil, which contains toxic and soluble hydro-carbon compounds, is likely to have a greater impact on living aquatic systems than a No. 6 or a bunker fuel, which has fewer highly toxic or soluble compounds.

Obviously, the amount of oil that is spilled will influence the impact the spill has on aquatic life. The greater the volume of oil, the more likely it is that the oil will contaminate extensive areas of biological importance.

HYDROGRAPHY OF OIL SPILL AREA

Salt marshes and freshwater wetlands are examples of ecologically important and highly productive ecosystems, which are acutely affected by an oil spill. Because of their unique hydrographic characteristics, areas such as these often sustain long-term effects. Oil, for example, is easily entrapped or absorbed onto marsh soil and may remain unchanged there for many years. Because of this, there is the likelihood that the oil will be cycled through existing aquatic life in the marsh ecosystem.

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Climatic and Seasonal Changes

Certain seasons are more critical than others in terms of the biological activity of aquatic life. For most aquatic species, spring and summer are seasons for mating and reproduction. Waterborne embryos and larval stages of many aquatic species, both invertebrate and finfish, are more sensitive to oil than the adult members of the species. Entire year classes of a particular species could potentially be eliminated or severely decimated if a spill were to occur when the young were within the affected area. From a physical standpoint, winter and fall are critical seasons because strong winds usually predominate, which could move spilled oil into areas that might not otherwise become contaminated.

Indigenous Biota

From a biologist's point of view, all aquatic species in or near an oil spill area are of equal importance in terms of the extent and severity of damage sustained. In this respect, species of commercial or recreational importance are no more significant than other, smaller organisms that are part of the complex and delicately balanced ecosystem. These smaller organisms form the base of the aquatic food chain and play a vital role in maintaining the integrity and balance of the entire ecosystem.

TREATMENT METHODS USED TO CLEAN UP

Since the major oil spill involving the *Torrey Canyon* in 1967, the U.S. oil companies have made extensive use of chemicals to disperse an oil spill. Use of these dispersants merely compounds the immediate impact of the spilled oil. Although it is true that the second generation oil dispersants now in use are less toxic as a whole, the fact remains that these dispersants entrain, throughout the water column, oil that would otherwise have remained on the surface. The oil is not changed chemically; it still retains its inherent toxicity, which the chemicals disperse in all directions.

Steam-cleaning of contaminated attached biological communities has an equally devastating impact. The use of steam in previous cleanup efforts has had a serious impact on mucelage-covered algae species, for example, which have some natural protection against the adhesion of oil. Today, high-pressure water is frequently used to clean contaminated rocky shores. This has less of an impact on indigenous species and allows the natural forces of currents, wind, and tidal action to remove adhering oil from contaminated algae and other attached populations.

Previous Exposure of Spill Area to Oil Pollution

Biological populations that are under stress from repeated oil spills within an area, which in terms of volume may be minor, will be affected more than those species that have been exposed to only a single spill. The degree of impact is a function of the timing and intensity of these repeated spills. For instance, oiled hard surfaces will not be colonized so easily by attached populations. Oily, contaminated sediments have residual toxicity to invertebrate larvae. In West Falmouth, for example, the highly contaminated sediments were not colonized by polychaete, molluscs, and other invertebrate larvae so rapidly as the relatively uncontaminated sediments.

SPECIFIC IMPACTS OF OIL ON LIVING SYSTEMS

Now that we have seen how various factors influence the biological impact of an oil spill, it is important to discuss some of the specific effects that oil has on living systems or populations. These effects include, but are not necessarily limited to, the following:

- Death as a result of coating and asphyxiation
- Death through contact poisoning
- Death from exposure to water-soluble toxic compounds
- Destruction of sensitive juvenile forms
- Destruction of food sources or support populations
- Incorporation of sublethal amounts, resulting in the reduced resistance of species to infection or stresses
- Incorporation of sublethal amounts, producing an off-flavor or taint in exploitable species, thereby causing an economic loss to man.

EPA RESPONSIBILITIES TO THE RESPONSE TEAM

When an oil spill occurs, the role of the EPA traditionally has been to serve as an environmental watchdog and as an adviser to the On-Scene Coordinator (OSC). To be effective in these roles, the EPA must assemble, assimilate, and interpret various data for the OSC. In order to gather the most meaningful and accurate information within the shortest period, it is often necessary to disaggregate activities. This means that EPA biologists perform a different role in oil spill response than the biologists from the U.S. Fish and Wildlife Service and other agencies. It is important to stress that this disaggregation of activities is necessary to optimize on available manpower and resources. A typical scenario is outlined in the following paragraphs.

PREFIELD ACTIVITY

- The EPA biologists contact the OSC in order to obtain a briefing on the spill, to collect maps of the affected area, and to obtain a field radio unit that is on the same frequency as the base radio in the command post.

- The biologists become informed about known or suspected damage and any sensitive areas that are threatened (i.e., wetlands, wildlife preserves, bird rookeries, or shellfish beds). Some of the most reliable sources of information concerning affected sensitive areas are State or local conservation officials, naturalists, and biologists. A quick assessment and decision at this point usually pays off by optimizing activities yet to come.

- An immediate decision is made on the types of samples and observations to be taken. This is a most important step since it is at this point that the EPA biologists begin to "do their thing," which is to assess the overt and subtle damages that have already occurred. Moreover, the decision will set the scene for making some professional predictions as to further damages.

- After a plan of action has been formulated, the biological communities/habitats are delineated for sampling: benthos, periphyton, and mudflats/wetlands.

- After all of the preceding steps have been taken, the EPA biologists touch base with the OSC to inform him on their activities; and the purpose, plan, and places they will be working.

FIELD ACTIVITIES

The full-scale sampling program includes the following tasks:

- The affected areas are located and sampled and similar, unaffected areas are located to serve as controls.

- Live specimens are collected in large containers and brought back to shore for some qualitative toxicity tests. These tests are most important for gaining some insight into the possibility of further damage from latent toxicity, etc. For some tests, spilled oil is added to a number of the containers, while other containers are left to serve as controls.

- After the live organisms are collected, additional samples are preserved for positive identification at a later date.

  Environmental substrates (i.e., soils and water) are collected in solvent-rinsed jars for hydrocarbon residue analyses. These samples are stored under ice to avoid deterioration. Water samples should be extracted as soon as possible to capture all of the hydrocarbon compounds.

The EPA assumes that all of the data collected will eventually be used in legal proceedings. This means that:

- Proper sampling methodology, accurate labeling, and preservation techniques must be used.

- Comprehensive photographic documentation, with print labeling after developing, must be accomplished.

- For those samples that change hands from sampler to analyst, a complete chain of custody must be maintained.

The spill scene requires different approaches and a special criterion for assessing environmental damage within a concentrated time frame. Therefore, EPA biologists look for overt responses, such as:

- Abnormal fish or macroinvertebrate behavior, such as sluggishness, disorientation, erratic swimming patterns, benthic infauna leaving their burrows or tubes, etc.

- Appearance of attached fauna or flora; i.e., pigment bleaching or loss of turgor by the soft-bodied animals.

- The movement in the near-shore rushes of waterfowl and/or wildlife that may be distressed from oil.

After the field activities and sampling sorties have been completed, the biologists reassemble to discuss immediate observations and to brief the OSC and the response team on damage assessment. In most cases, this briefing emphasizes:

- The overt damage to the fisheries and other dominant populations

- The results of latent toxicity tests. (In most cases, this information will not be available for 24 to 48 h after the tests are completed.)

- The potential for sensitive habitats to become oiled

After assembling these data and ancillary field observations, EPA biologists then meet with biologists from the U.S. Fish and Wildlife Service and the State to provide the OSC with:

- Recommendations on those biological communities and/or habitats that should receive priority for special consideration during cleanup operations. This treatment may involve boom placement at critical locations to divert floating oil away from the sensitive habitats. It may involve a judgment decision to remove oil from a contaminated but sensitive habitat to lessen the impact.

- Recommendations as to the types of cleanup operations that would be most effective and least damaging to the environment. For example, oiled marsh plants may be left to be washed by currents or tidal action in locations where conditions are optimal for this to occur. In other instances, it may be better to diminish long-term effects by cutting or cropping the oiled grasses. In most cases, the "rule-of-thumb" that EPA advocates is to remove the oiled substrate to diminish the chances of bleed or runoff. More insidious is the prospect for these "loose" hydrocarbons to become active in the food web and be incorporated into the energy pathways, thus eventually contaminating an exploitable or consumable species.

CONCLUDING REMARKS

In the past, the U.S. Fish and Wildlife Service has not always had representatives on the scene, in which cases, EPA biologists have worked with State fish and game personnel to set up and operate oiled bird collection, cleaning, and rehabilitation centers. This has meant that damage assessment activities were not emphasized or did not occur at all.

In the future, I foresee more interest and attention being paid to the total impact concept, especially with the realization that major oil spills will be a problem for some time to come. Moreover, it is particularly pertinent for damage assessment studies to be conducted to "get a handle" on the immediate, as well as the long-term, impact (i.e., biomass contamination via hydrocarbon incorporation and movement through the food web).

I foresee a dichotomy of function among the agencies to allow each agency to serve in its respective capacity as members of the response team. This means that EPA biologists will be doing less with oiled waterfowl and will be concentrating their talents and resources more on assessing the impact to the total ecosystem, using techniques and response criteria that have been developed for just such purposes.

Nevertheless, it is imperative to maintain communication among the representatives of the various agencies to insure that the information and advice being given to the OSC is pertinent and meaningful.

EFFECTS OF OIL ON AQUATIC BIRDS

Peter H. Albers[1]

The lethal effect of spilled oil on seabirds was reported as early as 1910 (Bourne 1968). Large numbers of birds have since been killed or disabled by oil spills (National Academy of Sciences 1975), and the associated pathological conditions have been described (Hartung and Hunt 1966, Snyder et al. 1973). Birds that spend a great deal of time on the water, such as the Alcids and seaducks, are the most vulnerable to surface oil; birds that spend much of their time airborne, such as gulls and terns, are the least vulnerable (Bourne 1968, Vermeer and Anweiler 1975). The vulnerability of a given species to surface oil may vary seasonally according to breeding activities, migration, and feather molt. Although there are some cases where bird populations have apparently been severely reduced as a result of oil spillage, reliable population estimates for the affected species are usually scarce (Bourne 1968, Joensen 1972, and Vermeer 1976).

The plight of birds affected by oil spills attracts much public attention, but not more than 30 to 40 percent of the petroleum in the marine environment comes from accidental spills. Continual discharges from industrial plants, refineries, urban runoff, internal combustion engines, and natural oil seepage account for the remaining 60 to 70 percent (National Academy of Sciences 1975, Grossling 1976). Continual discharges from normal petroleum use are thought to account for an even greater proportion of the oil in inland waters (Grossling 1976). We have some evidence of the impact of direct mortality from oil spills on bird populations, but we know very little about the sublethal and indirect effects of oil on birds.

Research at the Patuxent Wildlife Research Center, Laurel, Maryland, is directed at (1) determining the effects of petroleum on the physiology and reproductive success of birds, and (2) developing the analytical methodology necessary for detection of petroleum in avian tissues.

PHYSIOLOGY

Physiological studies underway at Patuxent are evaluating the effects of petroleum on hepatic, cardiac, and renal functions. The effects of petroleum on hepatic function are under close scrutiny because the liver represents the primary site of detoxification and excretion of toxic compounds. Hartung and Hunt (1966) measured hepatic function of Pekin ducks (*Anas platyrhynchos*) 24 h after dosage with 3 to 24 ml/kg of diesel oil. They found dose-related evidence of liver damage and decreased liver function.

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Liver function is being monitored at Patuxent by the indocyanine green clearance technique. This technique is a sensitive measure of hepatic function in which removal of an injected dye from the blood is carried out entirely by the liver. In addition, tissue-specific enzymes that appear in the circulation because of organ damage are being measured, as well as triglyceride concentrations and cholesterol concentrations. For the past five months, mallard ducks (*Anas platyrhynchos*) have been fed a mixture of 10 aromatic hydrocarbons found in Southern Louisiana crude oil (SLC) at concentrations equivalent to the aromatic content of 2,500 and 25,000 ppm SLC. Preliminary results from this continuing study indicate that the ingestion of large amounts of aromatic hydrocarbons results in increased hepatic function with no biochemical evidence of cellular damage (Patton, unpublished data).

In another study at Patuxent, mallard ducklings were fed 250, 2500, 25,000, and 50,000 ppm of SLC mixed in feed. After 8 weeks, the body weights of ducklings fed 50,000 ppm of crude oil and the liver and spleen weights of ducklings fed 25,000 and 50,000 ppm of crude oil in feed were significantly different from those of the controls (Szaro, unpublished data) (Table 1). The increased liver size and decreased spleen size suggest hyperactivity of the liver and adrenal gland.

Table 1. Body, liver, and spleen weights of mallard ducklings fed Southern Louisiana crude oil from hatching until 8 weeks old

Treatment	Mean body weight after 8 weeks	Liver: Mean liver weight (g)	Liver: Mean percent of body weight	Mean spleen weight (g)
Control	1118.5	34.5	3.2	0.81
250 ppm	1126.5	33.0	3.0	0.74
2500 ppm	1108.8	31.5	2.9	0.64
25,000 ppm	1069.1	51.4[a]	4.8	0.39[a]
50,000 ppm	913.4[a]	69.7[a]	7.4	0.30[a]

[a]Different from the control ($P \leq 0.05$). Sample sizes: body weight, 50; liver and spleen weight, 10.

Waterfowl exposed to salt water increase the water taken in by the small intestine to compensate for osmotic water loss from tissues (Crocker and Holmes 1971). Crocker et al. (1974) used an *in vitro* system of sacs of small intestine and found that ducklings dosed with 0.2 ml of Santa Barbara crude oil prior to exposure to salt water failed to absorb water at a rate equal to undosed ducklings. Using similar techniques, they showed that the increase in intestinal water uptake that developed during prolonged exposure to salt water was abolished after a single dose of crude oil. Dr. Neil Holmes, University of California, Santa Barbara, has contracted with us to extend these studies with mallard ducks. Initially, his group will study electrolyte balance and adrenal hormone responses in mallards adapted to sea water and fed SLC in their food.

In addition to direct ingestion of oil through preening and drinking, petroleum may be transferred to birds in their food. Evidence indicates that petroleum is taken up, and at least partially eliminated, by a variety of invertebrates exposed to oil (Anderson 1975, Burns 1976, Corner et al. 1976, Fossato and Canzonier 1976). Nothing is known about the dynamics of accumulation and elimination of petroleum compounds by birds, however. After preliminary studies at Patuxent with several species of snails, clams, and crayfish, the crayfish (*Procambarus* spp.) was chosen as a food source for mallard ducks (Tarshis, personal communication). The crayfish will be exposed to petroleum-contaminated water before being fed to the ducks. Southern Louisiana crude containing ^{14}C napthalene will be used in an effort to establish the kinetics of oil transfer from water to invertebrate to duck.

REPRODUCTION

Aquatic birds nesting on the shore or in nearshore areas of oceans and lakes may be subject to high concentrations of petroleum from chronic urban and industrial runoff, oil tanker spills, and offshore drilling. Large numbers of birds at colonial nesting sites may be affected by a single oil spill. The low yearly reproductive potential of most marine birds means that recovery from a disastrous nesting season would be slow.

In addition to those birds that are killed by oil spills, many are presumably coated with sublethal amounts of petroleum. Gulls with oil spots on their plumage have been observed for up to 4 weeks after a major oil spill. Some of this oil may be transferred from the feathers and feet of incubating birds to their eggs. The effects of external applications of oil on avian eggs are not well known; however, previous studies and field observations indicate that eggs contaminated by crude or processed oil seldom hatch (Gross 1950, Rittinghaus 1956, Hartung 1965, Kopischke 1972, Birkhead et al. 1973). Egg-oiling experiments performed at Patuxent have shown that external applications of only microliter amounts of SLC, Kuwait crude oil, or No. 2 fuel oil were sufficient to produce very high embryonic mortality in artificially incubated mallard eggs (Albers 1976; Szaro and Albers, in preparation; and Szaro and Coon, unpublished data) (Table 2).

High mortality also occurred in artificially incubated common eider (*Somateria mollissima*) eggs treated with 20 μl of No. 2 fuel oil (Szaro and Albers 1976). Embryonic mortality was thought to be caused by toxic compounds in petroleum, rather than by interruption of normal gaseous exchange because the area covered by the oil was small. Furthermore, eggs treated with propylene glycol exhibited normal hatching success, and eggs treated with a mixture of 9 or 10 aliphatic compounds found in petroleum had normal or near-normal hatching success (Table 2). These results suggest that the toxic components probably are aromatic hydrocarbons or nonhydrocarbons. Mallard eggs have also been treated with external applications of SLC and No. 2 fuel oil at various stages during the incubation period. The petroleum was most toxic during the first 10 days of incubation (Albers, in preparation) (Table 3).

Table 2. Hatching success of 50 mallard eggs treated on the eighth day of incubation with petroleum, propylene glycol, or paraffin mixture

Treatment	No. 2 fuel oil	No. 2 fuel oil	S. La. crude oil	Kuwait crude oil
Control	88	88	92	92
Propylene glycol (50 μl)	80		94	
Paraffin mixture (50 μl)	72[a]		96	
1 μl oil		64[a]	62[a]	72[a]
5 μl oil	45[a]	18[a]	2[a]	24[a]
10 μl oil	12[a]	10[a]	2[a]	16[a]
20 μl oil	2[a]	0[a]	0[a]	6[a]
50 μl oil	0[a]		0[a]	

[a]Different from the control ($P \leq 0.01$).

Table 3. Hatching success of mallard eggs treated with No. 2 fuel oil or Southern Louisiana crude oil at different times during incubation

Treatment	No. 2 fuel oil (5 μl)		S. La. crude oil (5 μl)	
	Number of eggs	Percentage hatching success	Number of eggs	Percentage hatching success
Control	40	80	40	100
2-day	40	13[a]	40	0[a]
Control	38	84	40	100
6-day	40	33[a]	40	3[a]
Control	38	84	40	100
10-day	40	68[b]	40	8[a]
Control	38	84	40	100
14-day	40	83	40	78[a]
Control	38	84	40	100
18-day	40	80	40	88[a]
Control	37	86	40	100
22-day	40	93	40	95

[a]Different from the control ($P \leq 0.01$).

[b]Different from the control ($P \leq 0.05$).

Hatching weights of ducklings from the oiled eggs were not significantly different ($P \leq 0.01$) from the weights of the control ducklings. Ducklings from the oiled eggs did not have an unusual amount of gross external malformations nor did they exhibit unusual behavior.

Female mallard ducks on a diet containing 25,000 ppm SLC have laid significantly fewer eggs ($P \leq 0.05$) than females on clean feed. The number of eggs laid by mallards on a diet containing a mixture of 10 aliphatic compounds or 2,500 ppm of SLC was not significantly different from the controls (Coon, personal communication).

Herring gulls (*Larus argentatus*) from Lake Ontario were examined by Fox, et al. (1975) because they displayed almost totally depressed reproduction and represent a top level consumer in the food chain. One of the factors suspected was poor embryonic survival, which may be caused by embryotoxins. Compounds from lipid extracts identified by gas chromatography/mass spectrometry, or by gas chromatography alone, included 14 polycyclic aromatic hydrocarbons that were not of biogenic origin.

Crude oils contain high concentrations of metals. The National Academy of Sciences (1974) reported that different types of crude oils contain as much as 1,400 ppm vanadium. Scientists at Patuxent Wildlife Research Center have completed the initial phases of a study of the kinetics of vanadium and found that it greatly altered lipid metabolism in laying mallard females (White and Dieter, unpublished data).

CHEMICAL ANALYSIS

The analytical methodology for detecting and quantitating petroleum in avian tissues is in the early developmental stages, and standardization of techniques has not been accomplished. However, petroleum hydrocarbons have been reported in tissues of birds from oil spill areas. Brain and muscle of an immature herring gull from the West Falmouth oil spill site contained around 500 ppm of total hydrocarbons, as compared to 10 ppm in the brain and muscle of an immature gull collected 15 km away in a clean area (Burns and Teal 1971). Snyder et al. (1973) collected tissues from three different aquatic birds at the San Francisco Bay oil spill. Two laboratories in Texas and Massachusetts, which analyzed the samples by gas chromatography, identified petroleum hydrocarbons in a composite sample of liver, kidney, fat, heart and brain of a common murre (*Uria aalge aalge*), in the liver and kidney of a surf scoter (*Melanitta perspicillata*), and in the liver of a western grebe (*Aechmophorous occidentalis*). Comparison with gas chromatograms of Bunker C fuel oil indicated that the tissues of the common murre contained 8,820 ppm of C_{15}+ aliphatic hydrocarbons; the tissues of the surf scoter, 1,250 ppm; and tissues of the western grebe, 9,100 ppm.

Patuxent chemists, and Dr. John Laseter, University of New Orleans (contractual studies), are establishing extraction procedures, checking recoveries, and quantitating petroleum hydrocarbon fractions in avian tissues. Procedures for the detection of petroleum hydrocarbons in liver and muscle tissue have been established; procedures for fat and brain tissue are being developed. Quantitation of specific hydrocarbons in liver and muscle tissue has been achieved (Gay and Belisle, personal communication). Dr. John Laseter (personal communication) has detected petroleum hydrocarbons in the liver, heart, kidney, brain, skin, fat, breast muscle, and uropygial gland of mallard ducks which were dosed with crude oil.

ACKNOWLEDGMENTS

Research on the effects of petroleum on aquatic birds is being performed at the Patuxent Wildlife Research Center by seven people in addition to myself: Dr. Michael Dieter, physiologist and leader of the oil research team; Nancy Coon, biologist; Andre Belisle, chemist; Dr. Martha Gay, chemist; Dr. Jon Patton, physiologist; Dr. Robert Szaro, biologist, and Dr. Barry Tarshis, zoologist. I thank all of them for their assistance in preparing this paper.

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CONTAINMENT AND RECOVERY TECHNIQUES FOR SPILLED OIL IN THE MARINE ENVIRONMENT

Michael J. Donohoe[1]

INTRODUCTION

Since the late 1960s, there has been an increased awareness, worldwide, of the need to prevent spills, to control spills, and to remove discharged oils from coastal and inland waters. With incidents such as those involving the *Torrey Canyon*, *Ocean Eagle*, and the Santa Barbara Channel, the need for more effective equipment and techniques for containment and recovery of such discharges has become clearly obvious. This paper is not concerned with the development of equipment and techniques to accomplish this task, but rather with currently available containment/recovery hardware and appropriate techniques for deployment. The paper also includes a review of design characteristics useful in assessing equipment efficiency in local situations.

CONTAINMENT

The need for prompt and effective containment of spilled oil cannot be overemphasized. The primary goal of a rapid response is a sharp reduction in area contamination and a subsequent lessening of environmental damage. Minimizing the response time involved in effectively containing a spill will normally result in reduced recovery costs.

The wind and the water surface current are two local environmental conditions that must be considered when undertaking steps to contain spilled oil, because separately, or in combination, the two factors have a dramatic effect on spill movement. Failure to assess the movement of the oil slick could result in the placement of containment measures behind the slick or too far away in restricted waters, resulting in more extensive contamination or wasted time in "searching" for the slick in more open areas.

These two response inputs become increasingly important when coupled with the type of water body in which a spill occurs. The difference in slick movement on a shallow, slow-moving stream or creek should be readily obvious when compared to a large river or open bay. Characteristics such as flow rate, depth, accessibility, wave, wind, and tidal action all have an influence and should be considered.

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BARRIERS

The term "barrier" is defined by the American Heritage Dictionary as: "A fence, wall or other structure built to bar passage. . .Anything material or immaterial that acts to obstruct or prevent passage." In terms of oil pollution response, "barriers" satisfy this definition exactly: i.e., the physical placement of some obstruction to retard or stop the flow of spreading oil, and thereby effect containment.

As discussed by previous speakers, many different situations are encountered in oil pollution response activities; thus, different types of containment action are required. The following paragraphs briefly describe the different types of barriers that can be used. These fall, generally, into two classes: booms and earthen dams.

BOOMS

Oil containment booms are undoubtedly the most commonly recognized type of barrier. The term "boom" in the oil pollution industry automatically brings to mind a floatable collar encircling a slick. The following discussion explains why this device is an effective tool in the stockpile of containment equipment available to response personnel. Booms must have five components if they are to be effective:

1. Each boom must have a flotation member, which is necessary to keep the boom afloat until the barrier is established.
2. Each barrier must have a freeboard; that is, a portion of the boom must be above the surface of the water to contain the oil and prevent splashover.
3. A corresponding component or skirt should be below the surface of the water to provide a subsurface restraint for collected oil.
4. In order to keep the skirt in a vertical position to insure effective containment, some form of ballast or weight must be placed on or in the bottom of the skirt.
5. An all-important longitudinal strength member must also be present. This component, which is sometimes referred to as the tension member, is designed to hold the boom together and to provide the strength for towing and anchoring. It is usually placed between the flotation and the bottom of the skirt.

Two views of a typical boom with major components are illustrated in Figure 1.

In addition to the basic components, there are two additional characteristics that should be mentioned since both affect efficiency.

1. Stability: The ability of a boom to contain oil effectively is normally dependent on its ability to remain fairly stable in wind, waves, and surface and subsurface currents.
2. Construction Materials: Materials used in the manufacture of booms should be of a highly durable quality to minimize wear due to abrasion and exposure to sunlight for extended periods.

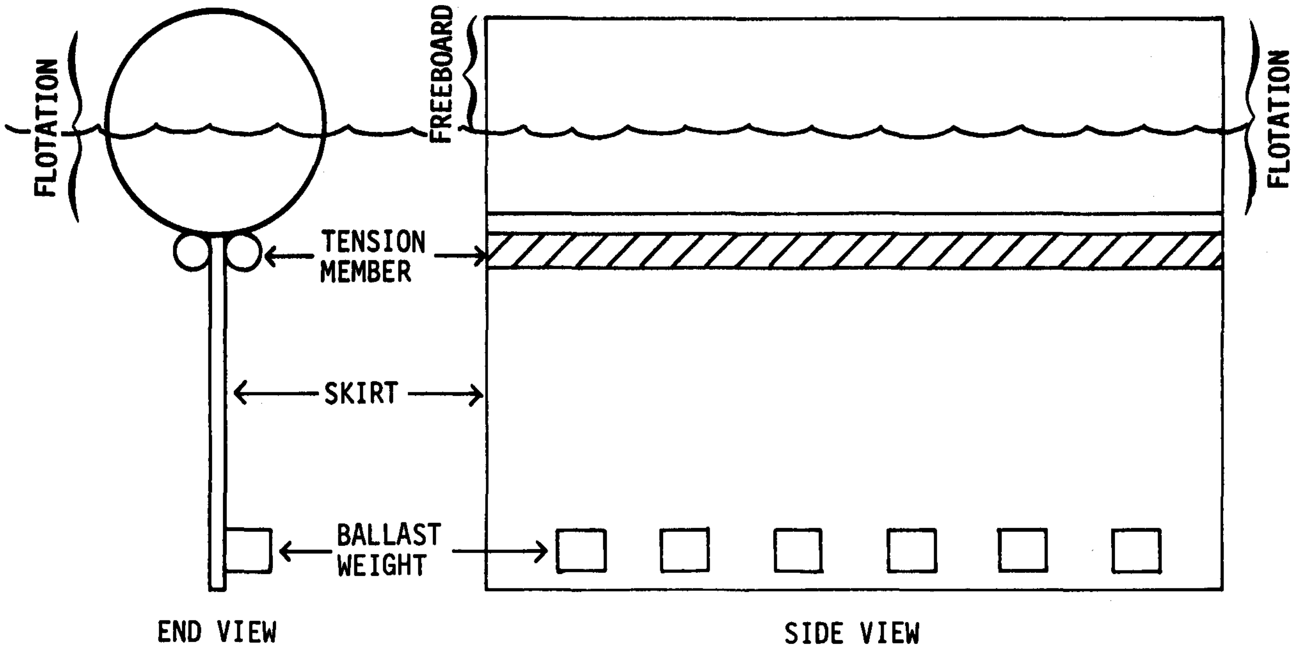

Figure 1. The basic components of an oil containment boom.

Booms are usually susceptible to two kinds of failure while they are deployed: (1) entrainment and (2) splashover.

Entrainment is the loss of oil under the skirt, due normally to a combination of increased headwave thickness and water current. Figure 2 illustrates what happens to cause this undesirable effect.

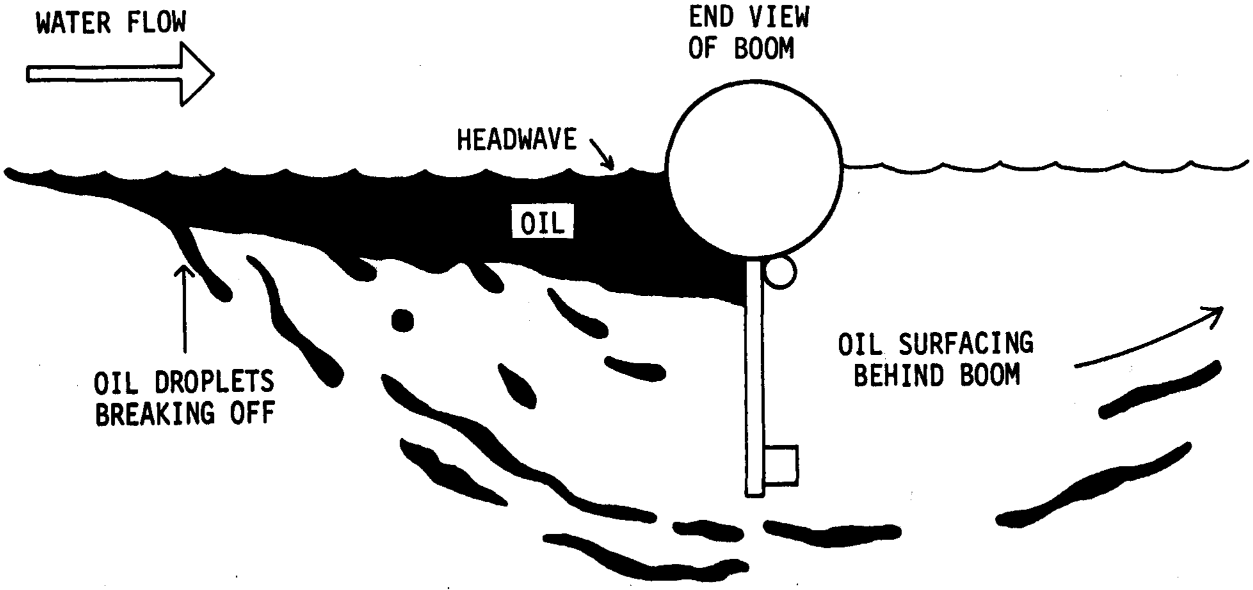

Figure 2. Heavy waves and currents may wash spilled oil under the boom; this type of failure is known as "entrainment."

Entrainment can be accelerated by either of two separate events or a combination of external inputs. One event is the increase of water current velocity. This event has a tendency to push the skirt off the vertical and to decrease the amount of entrained oil (Figure 3). The second event is high winds, which can cause a similar loss of vertical integrity, if sufficient freeboard is present, by pushing the top of the boom toward the water surface. Sometimes, the boom may actually lie flat on the water with a subsequent loss of previously contained oil (Figure 4).

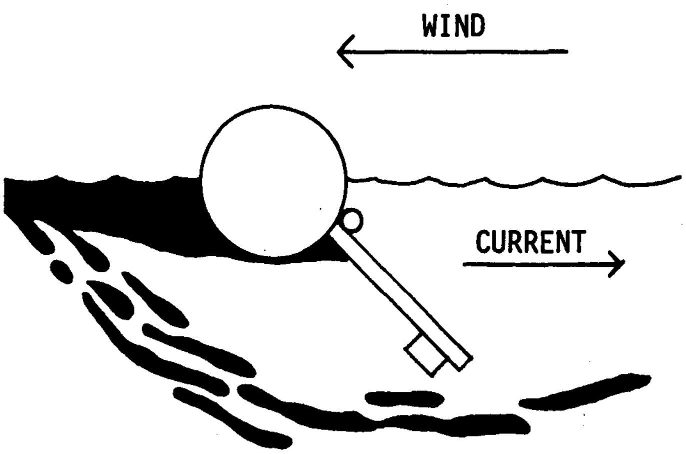

Figure 3. Entrainment increased due to fast current.

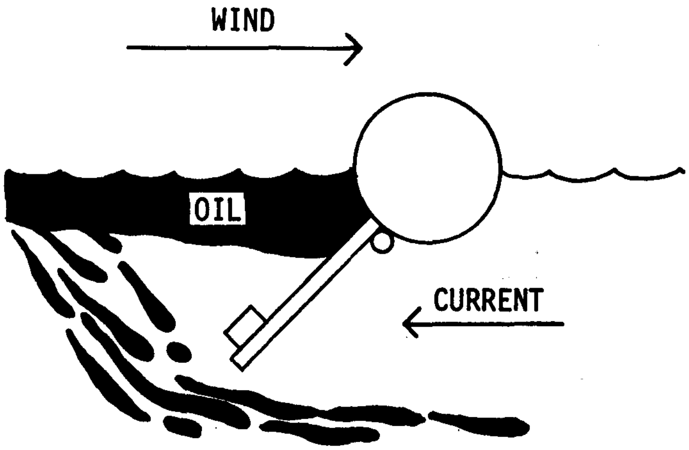

Figure 4. Entrainment increased due to high wind with normal current.

The problems associated with entrainment can be partially countered by decreasing the angle of the boom to the bank. Problems associated with the effect of wind on boom integrity are completely situational and require individual analysis and deployment of "trade-offs" to maximize containment of the spilled product.

The wind and the sea state are primary influences on the second type of failure, which stems from the *splashover* of the boom. Splashover is directly affected by boom design, freeboard height, angle of approach of waves to the boom, and the size and interval of the waves. Any combination of these factors causes the oil to go over the top of the boom. The solution, again, is site-specific, and the amount and direction of movement of the boom to minimize this splashover should be determined on a case-by-case basis. In choppy sea conditions, some oil will probably spill over, but there is no need for alarm unless large quantities are being lost.

Regardless of the type used, booms can be effective only if positioned or deployed in a manner consistent with local conditions.

The most valuable element in boom deployment is a sound working knowledge of local waterways. Knowledge of currents, tides, natural catch areas, water depth, etc., is invaluable in effecting a more rapid response. A second element necessary for timely, effective deployment is the availability of ready support equipment. If the water body is large enough to require a boat for boom deployment, it is important to have available some sort of towing bridle that will place the strain on the tension member.

The following examples demonstrate various techniques that are widely used to contain oil with booms under different stream conditions (Figures 5, 6, and 7). The illustrated solution is not always effective. In the case of most rivers, currents usually subside at or near the banks. Because of reduced flow in these areas, some containment can normally be expected near-shore. As can be seen, all of these deployment techniques require the securing of an anchor on the leading edge of the boom. A recommended method for anchoring the boom is shown in Figure 8.

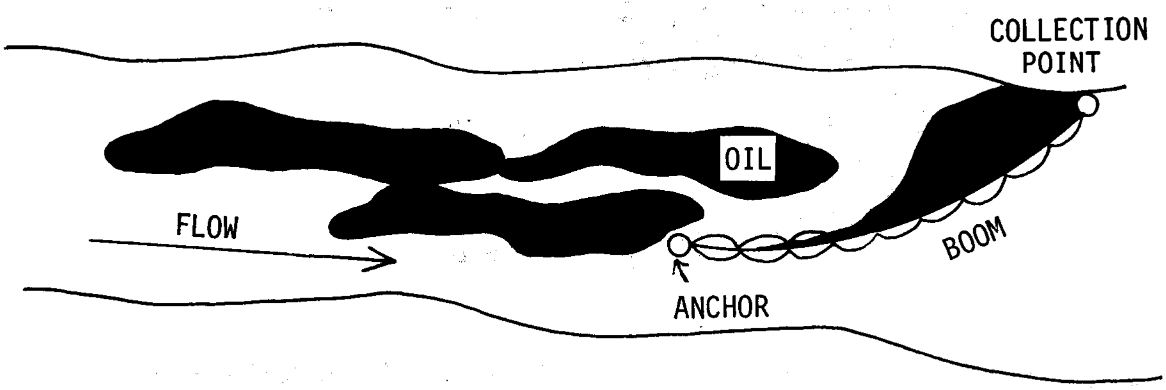

Figure 5. Small river with moderate depth of 15 to 20 ft (4.6 to 6.1 m) and slow current of 1.0 to 1.5 kn (1.8 to 2.8 km/h).

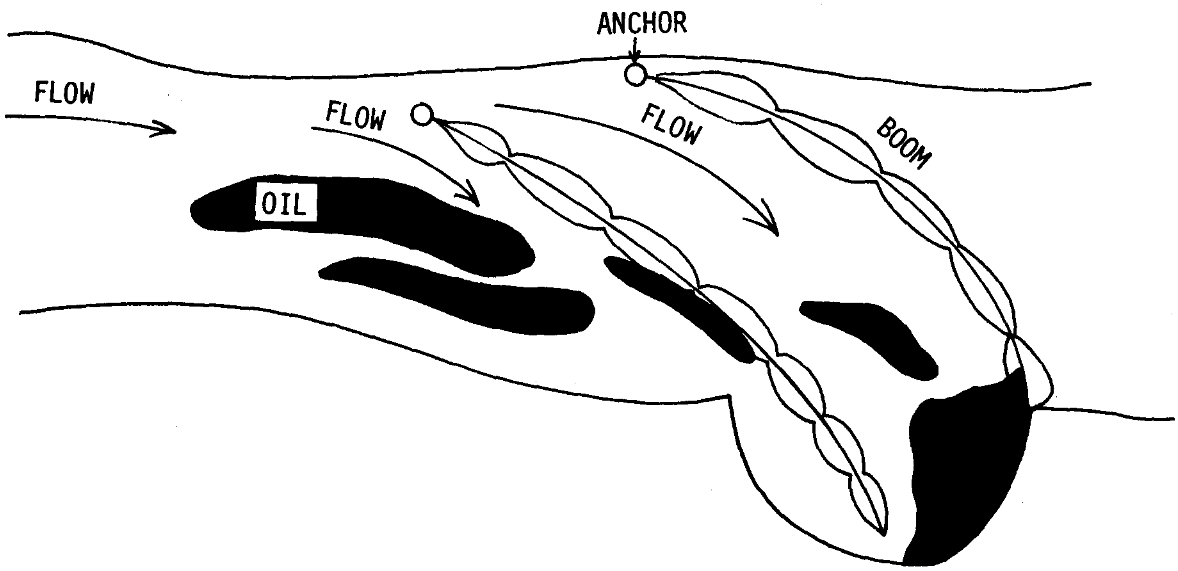

Figure 6. Small river with moderate depth of 15 to 20 ft. (4.6 to 6.1 m) and moderate to fast current of 3 to 4 kn (5.6 to 7.4 km/h).

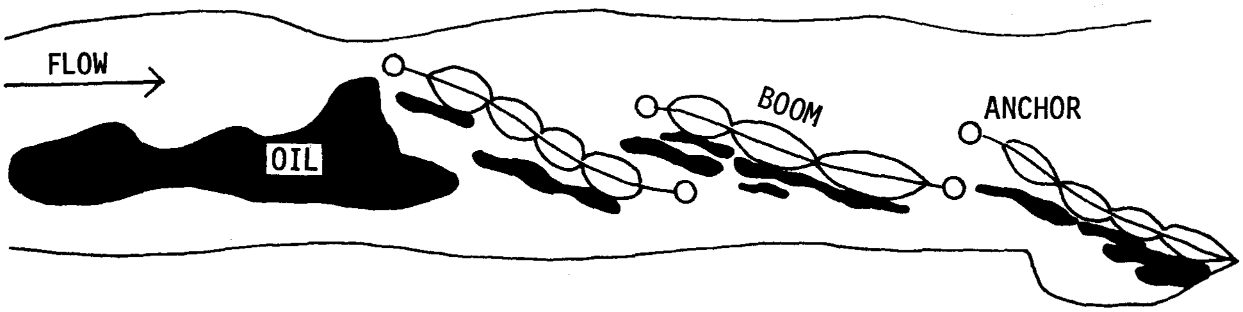

Figure 7. River of moderate to deep depth and fast current of 76 kn (140.8 km/h).

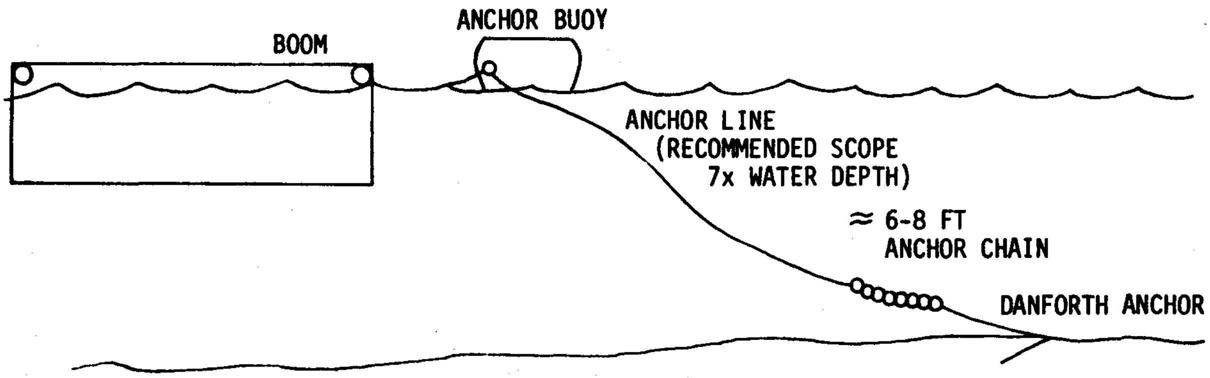

Figure 8. Normal configuration for anchoring booms.

Estuaries and bays are usually affected by tides, which create special problems in containment. The change in direction and flow rate of currents can cause contained oil to move away from the boom and be lost. The best solution is a back-moored boom; that is, oil is allowed to collect in a boom that is deployed in the usual manner and a second boom is then placed on the backside to contain any backflow due to tidal or wind change (Figure 9).

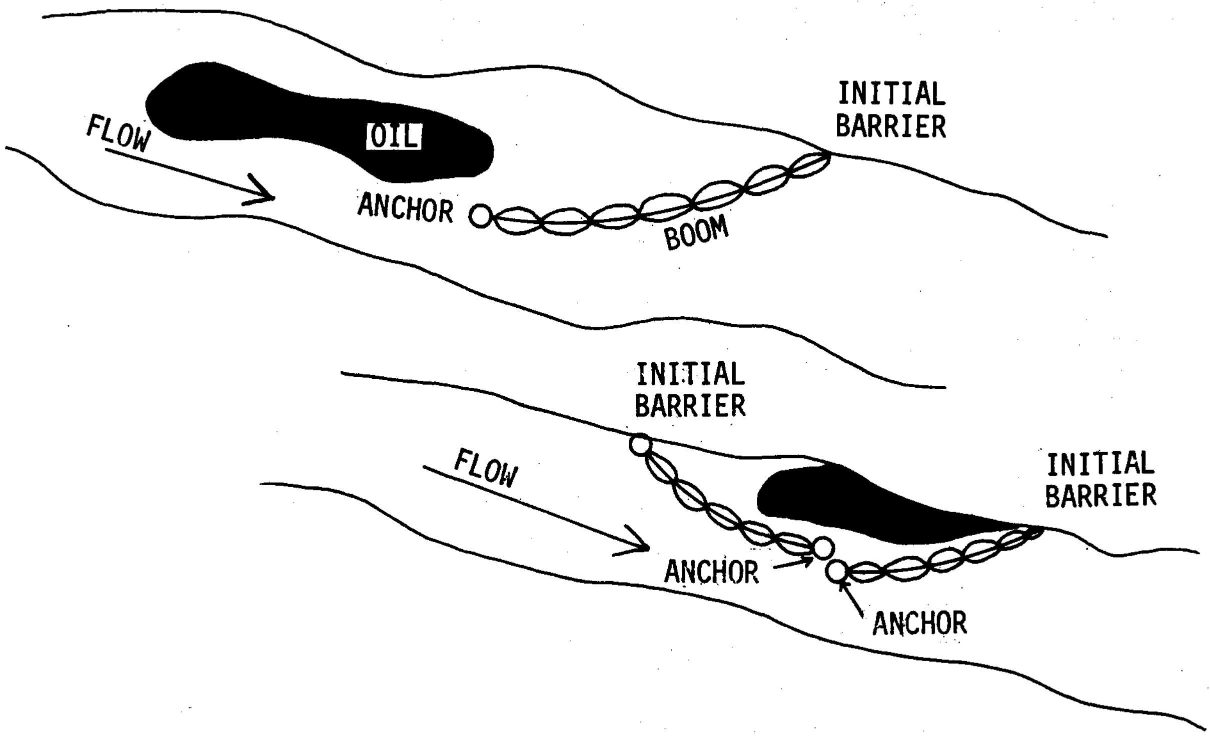

Figure 9. Back-moored boom technique for containing spilled oil in tidal-influenced estuaries and bays.

EARTHEN DAM

Earthen dams are a second type of barrier. This measure is used most frequently on small creeks or tributaries, but could be effectively used on slightly larger water bodies if the flow rate is slow [less than 0.5 knots (kn)]. Earthen dams are very easy to construct, using a bulldozer, dragline, or backhoe. The primary objective is to allow the water to pass downstream while containing the oil. Water passes through an inverted siphon or inclined pipe, which is placed below the water surface (Figure 10).

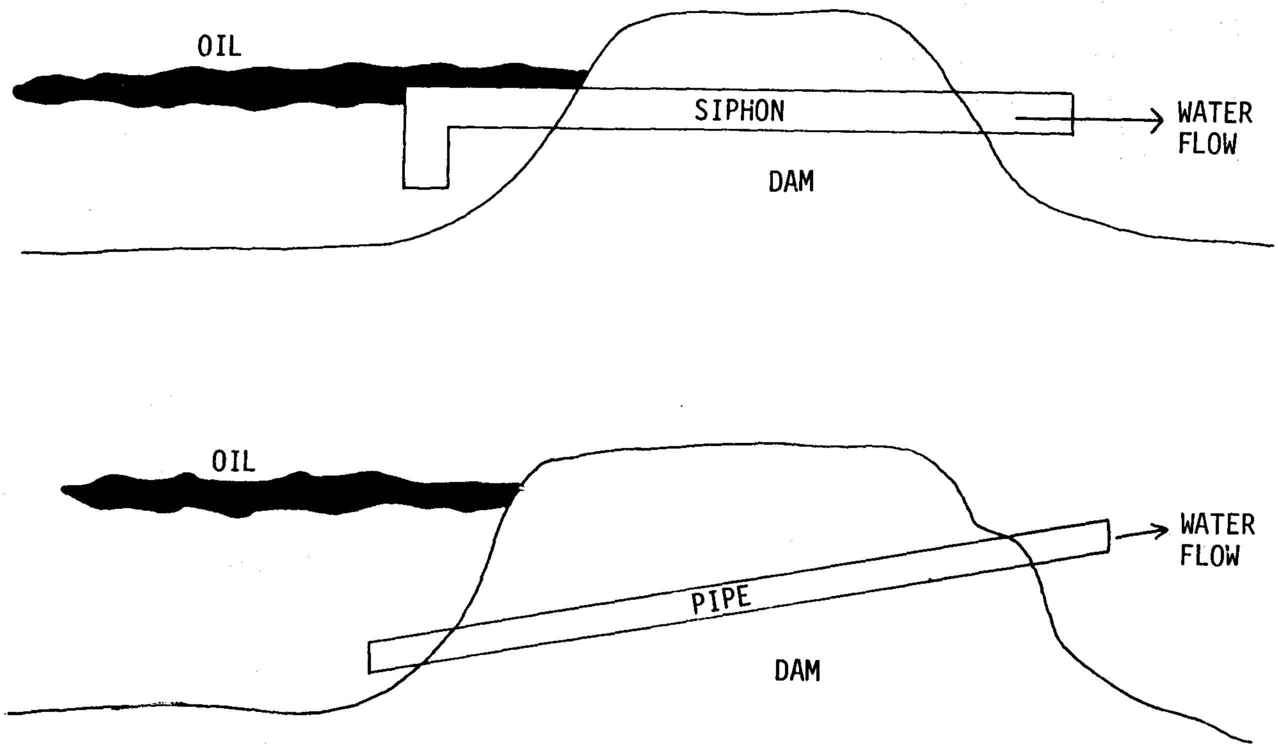

Figure 10. Earthen dam barriers with inverted siphon and inclined pipe for the containment of spilled oil.

In summary, it should be remembered that physical barriers, whether booms or dams, are intended to restrict the spread of oil and decrease contamination. With regard to booms, almost anything that floats can be strung together to assist in the endeavor. Items that have been used in the past with varying degrees of success include bales of hay, telephone poles, and 55-gallon drums. In all oil spill situations, rapid response is the key to an effective operation, and containment must be accomplished as soon as possible, using the best available resources.

SKIMMERS

Assuming that efforts to contain the discharged oil have proved successful, recovery of the spilled oil is then begun. Removal is usually accomplished with the use of mechanical devices called "skimmers."

Skimmers, as the name implies, are designed to collect, or skim, the floating product from the surface of the water. Skimmers can be grouped into four basic categories: (1) vacuum or suction type, (2) weirs, (3) dynamic inclined plane, and (4) oleophilic belts, drums, and disks.

VACUUM OR SUCTION-TYPE SKIMMERS

The suction-type skimmer is a simple device in terms of both design and operation. A suction head and pump are involved, and these devices simply vacuum the oil from the surface of the water. One example of a suction-type skimmer head is called a "duck bill" (Figure 11). The primary advantages of using this device are its adaptability to most environmental situations, its ability to handle almost all types of oils, and the simplicity of operation in most water depths. Its disadvantages include a tendency to become clogged with debris and the need for continual maintenance during recovery operations to prevent clogging and allow efficient skimming.

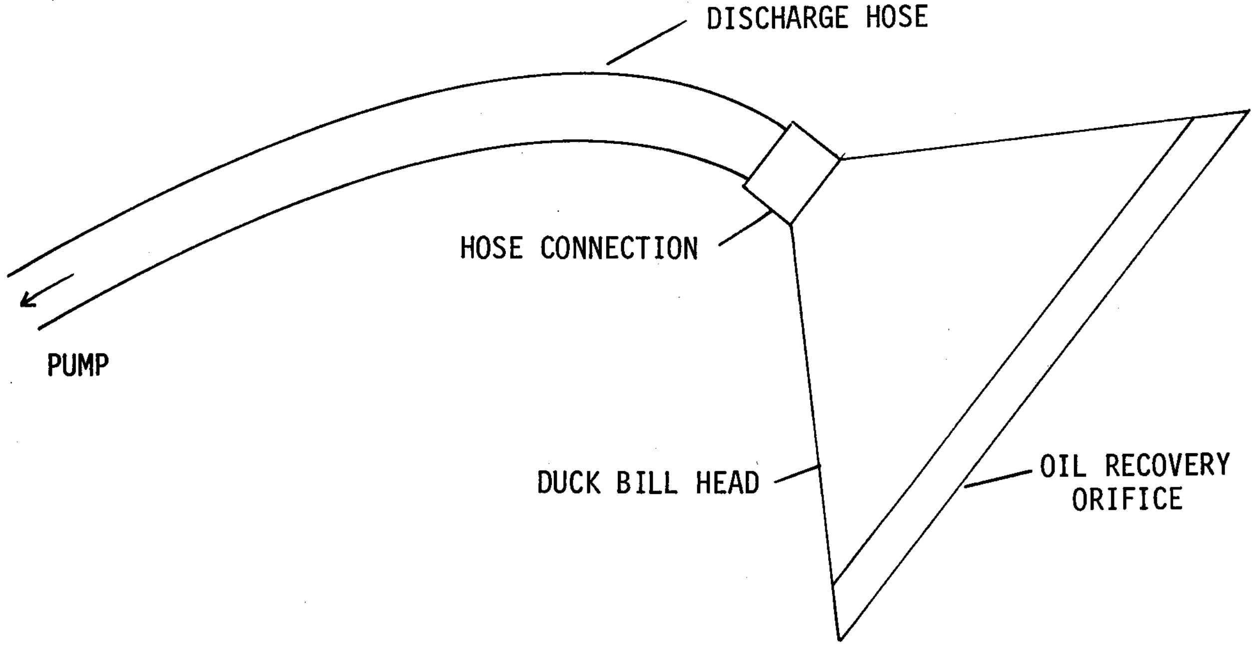

Figure 11. Illustration of a suction-type skimmer head for removing spilled oil.

WEIR SKIMMERS

Weir skimmers are probably the most widely recognized type of recovery device available today. In addition, they are the most widely available type of skimmer for pollution recovery operations.

Weir skimmers consist of four primary components: (1) a flotation device to suspend the skimmer in water, (2) a reservoir to collect the oil, (3) a device to adjust the skimming level to minimize the quantity of oil entering the reservoir, and (4) some method to empty the reservoir, either by positive displacement pumps or suction (Figure 12).

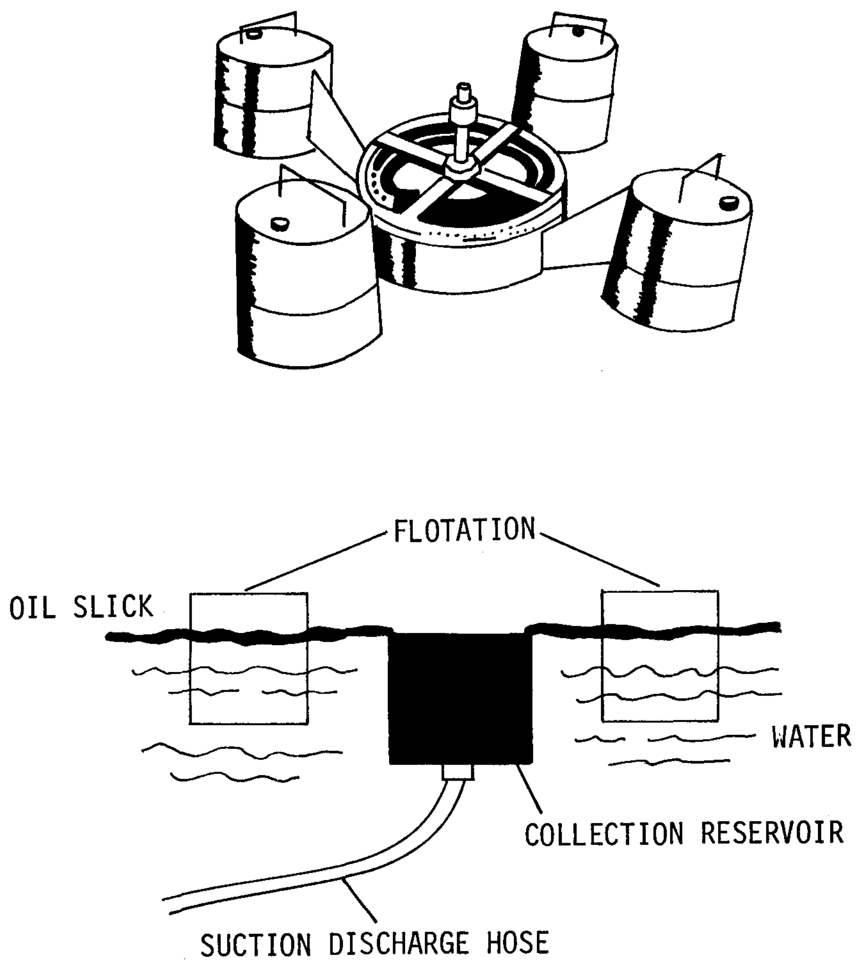

Figure 12. Vertical and lateral views of the components of the weir skimmer.

The idea behind this device is commonly referred to as the "waterfall" principle. The collecting reservoir is submerged to the level of the oil/water interface, at which point, gravity forces the oil into the reservoir, creating a "waterfall" effect. The advantages of this type of skimmer include its high mobility and good recovery efficiency in relatively calm water. The weir is susceptible to being clogged with debris, but a screen can be placed around the unit to minimize this problem.

DYNAMIC INCLINED PLANE SKIMMERS

Dynamic inclined plane skimmers use an inverted, continuous belt; that is, a belt that runs from high to low, as opposed to normal conveyors which run from low to high (Figure 13). The belt takes the oil below the surface of the water. The oil leaves the belt and floats upward to a reservoir, where it is collected and pumped to a storage container. Like oleophilic skimmers, which are discussed later, dynamic inclined plane skimmers have good recovery efficiency and are available in a variety of sizes. Both types have restrictions on maneuverability and loss of efficiency when trash or debris is present.

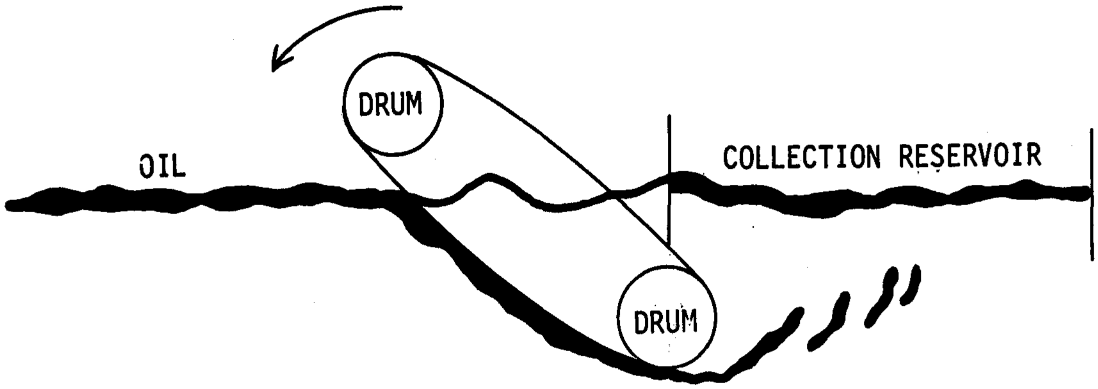

Figure 13. An illustration of the dynamic inclined plane skimmer in operation.

OLEOPHILIC SKIMMERS

Oleophilic skimmers are operated on the principle of oil absorption. The term "oleophilic" means a strong affinity for oil. Almost all of the oleophilic components of this type of skimmer have the characteristic of being hydrophobic, or water-resistant. The common denominator of all oleophilic recovery devices is the passing of the "absorbing" material continuously through the spilled oil. The oil adheres to the surface and is removed from the water. At this point, the oleophilic member is wiped or squeezed by rollers on blades and the oil is deposited in a reservoir. The product in the reservoir is then pumped into some type of holding container.

Oleophilic skimmers are the most sophisticated recovery devices available today, usually employing several different mechanical systems, which require varying levels of preventive maintenance and highly trained operators for use.

The rotating disk, or drum systems, as shown in Figure 14, are noted for very efficient recovery of oil in deeper water where little or no debris is present. Available in various sizes, the large models normally require extensive logistic support.

The most widely used oleophilic skimmers are of the belt and rope type. These devices operate very efficiently in both thick and thin slicks, and are usually capable of recovering sheens. Their ability to remove oil mixed with small amounts of debris remains almost as efficient as debris-free environments.

Because oleophilic belt skimmers require the use of some sort of vessel for staging and employment, they are difficult to operate in close quarters or in shallow water. Figure 15 shows a typical "continuous belt" installation.

The oleophilic rope employs the same basic principle as the "belt"; i.e., a continuous process of "absorption" by the oleophilic component, squeezing by a roller or wiper system, and reentry into or upon the oil in the water.

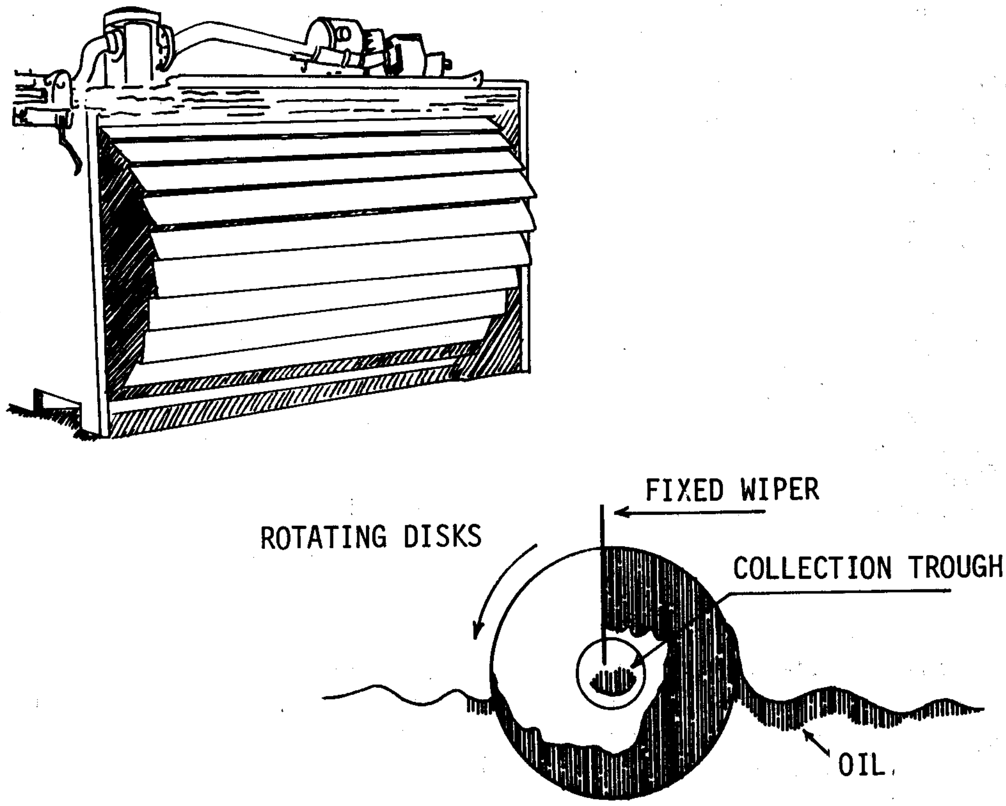

Figure 14. Oleophilic drum skimmer.

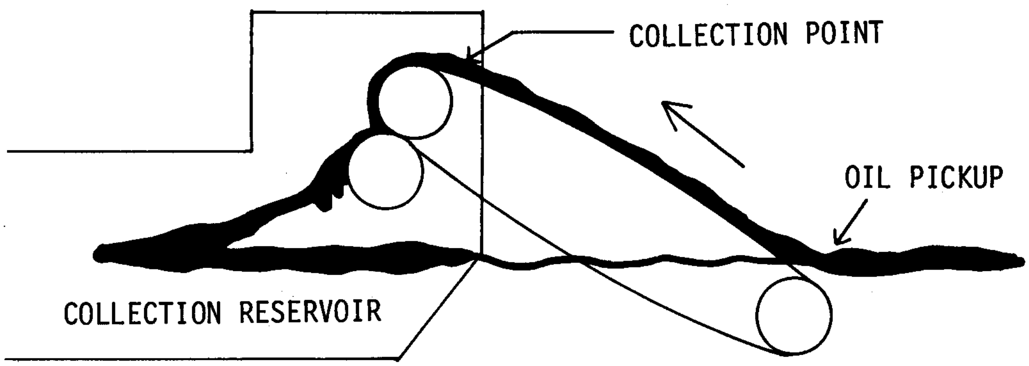

Figure 15. A continuous-belt oleophilic skimmer for recovering spilled oil on the surface of the water.

The "rope" system has greater versatility because it can be deployed from land or from a vessel. Further, the placement of a floating shelf in the water allows the rope to pass through areas that could be inaccessible or areas with high concentrations of oil. Also the "rope" can operate in shallow water and in areas with small amounts of debris with little loss of recovery efficiency. The floating rope will have a tendency to lose efficiency if it is dragged over large debris because the debris acts like a scraper and removes recovered oil.

The techniques normally used in connection with the operation of skimming equipment are specifically limited to skimmer capability and the quantity of oil. The main guideline is positioning of the equipment to maximize rapid recovery. This is accomplished by placing the skimmer in a high concentration of spilled product and by moving the oil to this area. For self-propelled skimmers, the rule remains constant: start in areas of high concentration first, and then move the skimmer to other areas.

SUMMARY

The containment and recovery of oil discharges through the use of commercially available equipment has resulted in a more timely and efficient response to spill incidents. Appropriate materials or devices are available for use in local conditions throughout the United States. Knowledge of specific equipment limitations and appropriate techniques will result in overall minimization of adverse environmental damage as a result of a spill incident. The fact that one must be prepared to act rapidly, evaluating and programming responses prior to real incidents, is without doubt the most important "technique" for the containment and recovery of oil spills in the marine environment.

CHEMICAL OIL DISPERSING AGENTS AND THEIR FEASIBILITY FOR USE

Gerard P. Canevari[1]

INTRODUCTION

Widespread interest in chemical oil dispersing agents first developed after their use during the *Torrey Canyon* disaster in March 1967. Few areas of technology, however, have been more controversial, more misunderstood, or more politically entangled. In order to put the subject in a proper perspective and to assess the feasibility of using dispersants, I am going to discuss the early history and current status of chemical oil dispersing agents.

CONCERNS RELATING TO DISPERSANT USE

Reluctance to consider chemical dispersion as a viable means of minimizing damage from oil spills was due historically to two major concerns:

1. Toxicity of chemical dispersants and dispersed oil, and
2. Effectiveness and practicability of the technique.

The toxicity of chemical dispersants has been a concern from the beginning. In the first widescale use of these dispersants (the *Torrey Canyon* spill), the materials were, in the true sense, detergents. The formulation consisted of a surface-active agent (surfactant) and a solvent, the latter being somewhat aromatic in order to enhance the "cutting of sludge and waxy deposits in oiled tanks." Although the dispersants were effective in dispersing oil with the application of sufficient mixing energy, they would be considered quite toxic by today's standards.

The toxic aspect was emphasized in a study conducted by Smith (1968) after the *Torrey Canyon* incident. The study indicated that, in some areas, particularly in the intertidal zone, the chemicals used were more toxic to marine life than the oil itself. This conclusion is supported by the results of a toxicity test conducted by Oda (1968) (Table 1). Products A, B, C, and D are chemicals that were used during the *Torrey Canyon* incident. The concentrations represent the 96-h TLm.; that is, the chemical concentration required to kill 50 percent of the test species in a 96-h exposure period. Values of 6 to 13 ppm can be considered quite toxic by today's standards. In contrast, the 96-h TLm value for a product developed after the *Torrey Canyon* incident (Product E) can be greater than 10,000 ppm.

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Table 1. Comparison of toxic effects between *Torrey Canyon* era and post-*Torrey Canyon* dispersants

Chemical	96-h TLm (ppm) Fathead minnow (*Pimephales promelas*)
Product A	6.1
Product B	9.5
Product C	5.3
Product D	13.0
Product E	>10,000

Clearly then, the statement that all chemical dispersants are in themselves highly toxic is incorrect. Table 1 does not represent an isolated data point since more than 25 research institutions have conducted studies that have verified the low toxicity of several chemical dispersants developed after the *Torrey Canyon* incident.

In addition to concern about the toxicity of the chemical itself, there are also toxicological factors to be considered with regard to the dispersed oil. Where the surface film of oil is dispersed several feet or more into the water column, it is then available to other forms of marine life, in addition to the hydrocarbon-oxidizing bacteria. Studies at Battelle Pacific Northwest Laboratory (1973) have shown that the oil per se is not made more toxic by the presence of the chemical dispersant. The dispersed oil is merely made more available to the test species in lab bioassays; hence, lab tests with chemically dispersed oil will show increased toxicity, compared to oil that has not been chemically treated.

However, it is important to consider the dilution effect of chemically dispersed oil that is not apparent in the artificial environs of lab bioassays with fixed-volume aquaria. In this regard, one of the most intensively studied oil spills was that accompanying the blowout and fire in March 1972 at Chevron's Main Pass Block 41 Platform C in the Gulf of Mexico. A report by McAuliffe et al. (1975) described in detail the effects of the oil spill on the on the surrounding marine community. A total of 65,000 barrels of oil were spilled from the platform, and the major portion of this spill was dispersed by 2,000 barrels of chemical dispersant. Despite the large amount of oil that was spilled, the maximum level of dispersed oil 1 mile (1.6 km) from the platform was only 1 ppm, and there was no shore contamination. Extensive trawl samples showed no alteration in the annual life cycle of commercially important shrimp. Blue crabs were observed throughout the area, and the number of species of fish collected was comparable to that collected during a prior study.

Of equal significance, because of the extensive activity during the past 2 to 3 years, is the effort to improve effectiveness, principally along the lines of minimizing or eliminating mixing energy. This was probably the key limitation to the large-scale application of chemical dispersants. For example, to provide mixing after chemical application during the *Torrey Canyon* spill, 42 workboats were employed. Despite this fact, a substantial amount of oil still came ashore.

THE MECHANISM OF CHEMICAL DISPERSION AND THE ROLE OF THE SURFACE-ACTIVE AGENT

At this point, it would be in order to consider terminology. The chemicals used in the *Torrey Canyou* incident were basically cleaning agents. They were called *detergents*. Subsequently, formulations were prepared that were meant solely to disperse oil at sea. These are called *dispersants*. The word *emulsifier* is also used in reference to these dispersants.

The mechanism of chemical dispersion is quite simple. Let us first define a surface-active agent (surfactant) as a compound that has an oil-compatible and a water-compatible group. Because of this amphiphatic nature, the surfactant located at an oil-water interface is depicted in Figure 1. By its orientation at the interface, the surfactant reduces the interfacial tension. The generation of interfacial area in the nature of finely dispersed oil droplets is enhanced by the lowering of interfacial tension since:

$$W_K = \gamma_{o/w} A_{o/w}$$

wherein:

W_K is mixing energy, ergs,

$A_{o/w}$ is interfacial area, cm^2,

$\gamma_{o/w}$ is interfacial tension, dynes/cm.

It can now be appreciated that any surfactant (by definition), because of its molecular configuration, lowers interfacial tension. The more subtle requirements for a selected surfactant to perform as an effective dispersant can now be examined. For example, the dispersed oil droplets, once formed, should be prevented from coalescing. This is shown schematically in Figure 2, wherein the hydrophilic portion of the surfactant acts as a "fender" that physically parries droplet collisions. This schematic of the surfactant is somewhat oversimplified since more than one hydrophilic group may exist. This fending characteristic also reduces the tendency of the droplets to stick and thereby wet solid surfaces or to adhere to marine sediments.

From this brief discussion of the dispersing mechanism, it can be seen that the dispersant acts solely as an agent to enhance the formation of oil droplets. It does not "weight" the droplets in order to sink them. It does not solubilize the oil into the water column. It simply promotes an oil-in-water dispersion. Sinking is a misconception of the behavior/mechanisms of chemical dispersion that has persisted for 10 years! It is surprising that even as recent as a large tanker spill in May 1976, there were reports that it took 1,000 tons of dispersant to "sink" 4,000 tons of oil.

THE INCENTIVES OF CHEMICALLY DISPERSING OIL

It is not suggested that chemical dispersion is a panacea to minimize oil spill damage in all instances. Where physical containment and recovery are feasible, this is the preferred route. The limitations of oil skimmers

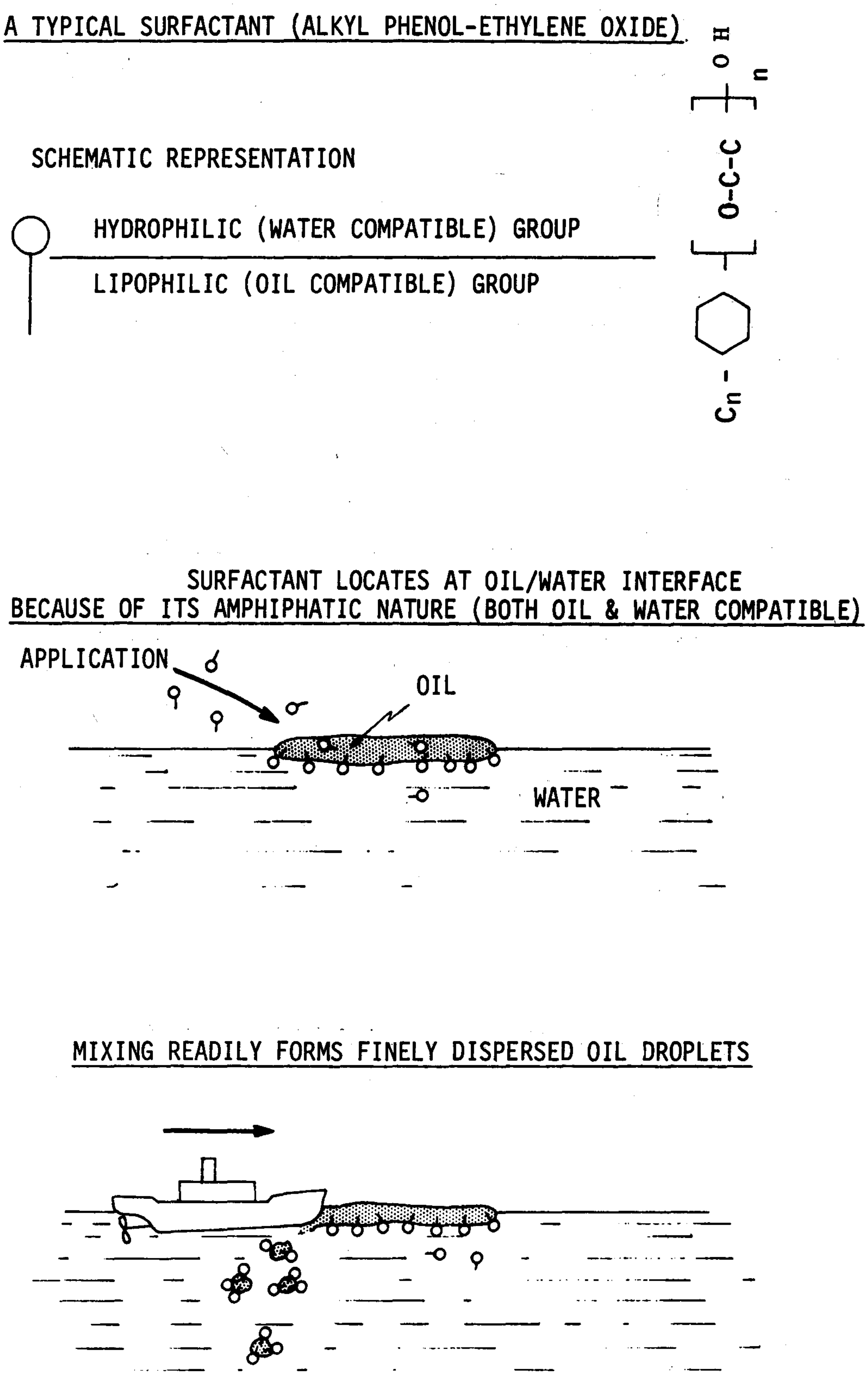

Figure 1. Mechanism of chemical oil dispersion.

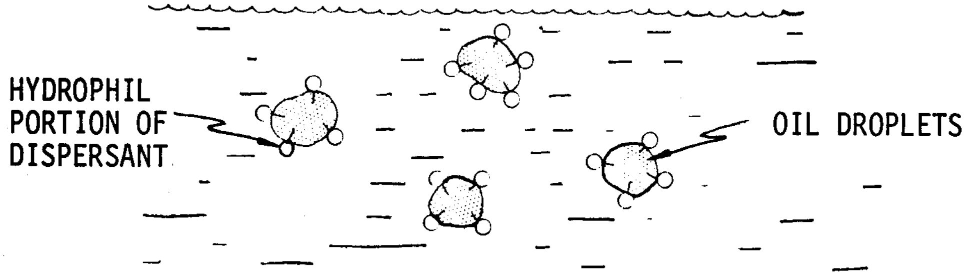

Figure 2. Chemical dispersant prevents droplet coalescence.

and booms are beyond the scope of this paper, but suffice it to indicate that in a sea condition with waves of possibly 3 to 4 ft (0.9 to 1.2 m), oil recovery is limited. In those situations where recovery of the oil is not feasible, the following benefits can be realized as a result of chemically dispersing the oil into the water column as fine droplets:

1. The rate of biodegradation of the oil is increased. This is the historical basis for the dispersion of oil. It is perhaps the most significant contribution of dispersants. The order of magnitude of increase in the interfacial area that are affected by the dispersant greatly increases the rate of biodegradation of the oil. Zobell (1964) has reported biodegradation rates that are one or two orders of magnitude higher in laboratory experiments in which the oil is emulsified. Not only is the physical state of the oil (i.e., small droplets) more conducive to bacterial action, but the oil is also made available to a much larger population of microbial organisms. Because of the importance of this aspect, some pertinent excerpts from Zobell (1964) are presented:

> "The growth of oil-oxidizing bacteria is believed to be beneficial to the food-chain in the sea, because such bacteria are eaten by numerous animal species. In discussing the sequence of events in oil-polluted water, Voroshilova and Dianova (1950) relate that the water becomes progressively enriched with bacteria. The protozoa in turn are devoured by higher animals. Rodina (1949) has reviewed some of the extensive literature on the contribution of bacteria to the nutrition of aquatic animals.
>
> In controlled laboratory experiments, we find that oil-oxidizing bacteria convert an average of 30 to 40 percent of the carbon content of hydrocarbons into bacterial cell substance or protoplasm. Thus for each gram of oil oxidized, from 300 to 400 mg of animal food might be manufactured by bacteria.
>
> The rate at which microorganisms oxidize HCs is influenced largely by the dispersion or solubility of the HCs and by the water temperature. In fact, HCs will not be attacked at all by microorganisms unless there is contact of the HC molecules with water. Since most liquid and solid HCs are only poorly soluble in water, their utilization by microorganisms is dependent upon emulsification, adsorption on solids, or other means of dispersion in water" as reported by Zobell (1964).
>
> "Virtually all kinds of oils are susceptible to microbial oxidation. The rate of such oxidation is influenced by the kinds and abundance of microorganisms present, the availability of oxygen, temperature, and the dispersion of the oil in water. Microbial oxidation is most rapid when the hydrocarbon molecule is in intimate contact with water and at temperatures ranging from 15 to 35 C; some oxidation occurs at temperatures as low as 0 C. An average of one-third of the hydrocarbon may be converted into bacterial cells, which provide food for many animals. The remaining two-thirds of the hydrocarbon are oxidized largely to CO_2 and H_2O. In the marine environment, oil persists only when protected from bacterial action."

2. Damage to marine fowl is avoided since oil is removed from the water surface. The hazard to marine fowl that is presented by the surface oil film is eliminated when the oil is dispersed as fine droplets. The droplets are initially placed several feet below the water surface by the mixing process.

3. The fire hazard from the spilled oil is reduced by dispersion of the oil into the water column. The removal of this combustible material from the water's surface and from contact with the atmosphere prevents possible contamination of the spilled oil. This is perhaps the most widely recognized benefit of using dispersants. It has provided the motivation in the past for many instances of dispersant application, such as the previously cited Gulf of Mexico platform blowout, where 2,000 barrels of dispersant were applied.

4. The spilled oil is prevented from wetting solid surfaces such as beach sand, shore property, etc. As stated previously, the physical fending action of a properly selected surface-active agent prevents the oil droplets from wetting out on a solid surface. This is a particularly important aspect when there is a substantial amount of marine sediment suspended in the water column during turbulent conditions. In these cases, the untreated oil can wet the sand/silt particles and settle into the sediment where it may persist as a contaminant for long periods. As noted, a chemically dispersed droplet would remain as a discrete droplet in the water column.

5. The formation of tarlike residue from an oil spill is prevented. These floating agglomerates range up to 10 cm in diameter. Although the origin of these floating tar balls has been a matter of extensive speculation recently, their formation can be postulated as starting from a larger, intact mass of spilled oil and weathering to a residue of only 10 to 15 percent of the original volume. It is reasonable to assume, however, that if the oil had been chemically dispersed in a stable manner into droplets less than 1 mm in diameter, the formation of these larger agglomerated residues would be prevented.

EFFECT OF MIXING LIMITATIONS ON USE OF DISPERSANTS

As noted previously, 42 workboats were employed during the *Torrey Canyon* spill, yet a substantial amount of oil came ashore. The typical manner in which mixing energy can be applied by a workboat is shown in Figure 3. A craft of this type traveling at 5 knots would cover approximately 35 acres (14.2 ha) of water surface per hour.

A mixing device has been developed by the Warren Spring Laboratory, United Kingdom, wherein a simple structure resembling a "five-bar gate" is towed alongside the workboat. This imparts localized surface agitation and extends the mixing capability of the workboat.

There are also instances where the use of a workboat is not a feasible means of mixing because of shallow water, confined or inaccessible areas, etc. In these instances, as well as in small spill applications, mixing is generally accomplished by use of a fire hose. This more manual and tedious approach would increase the mixing time by several fold over that attained by the use of workboats.

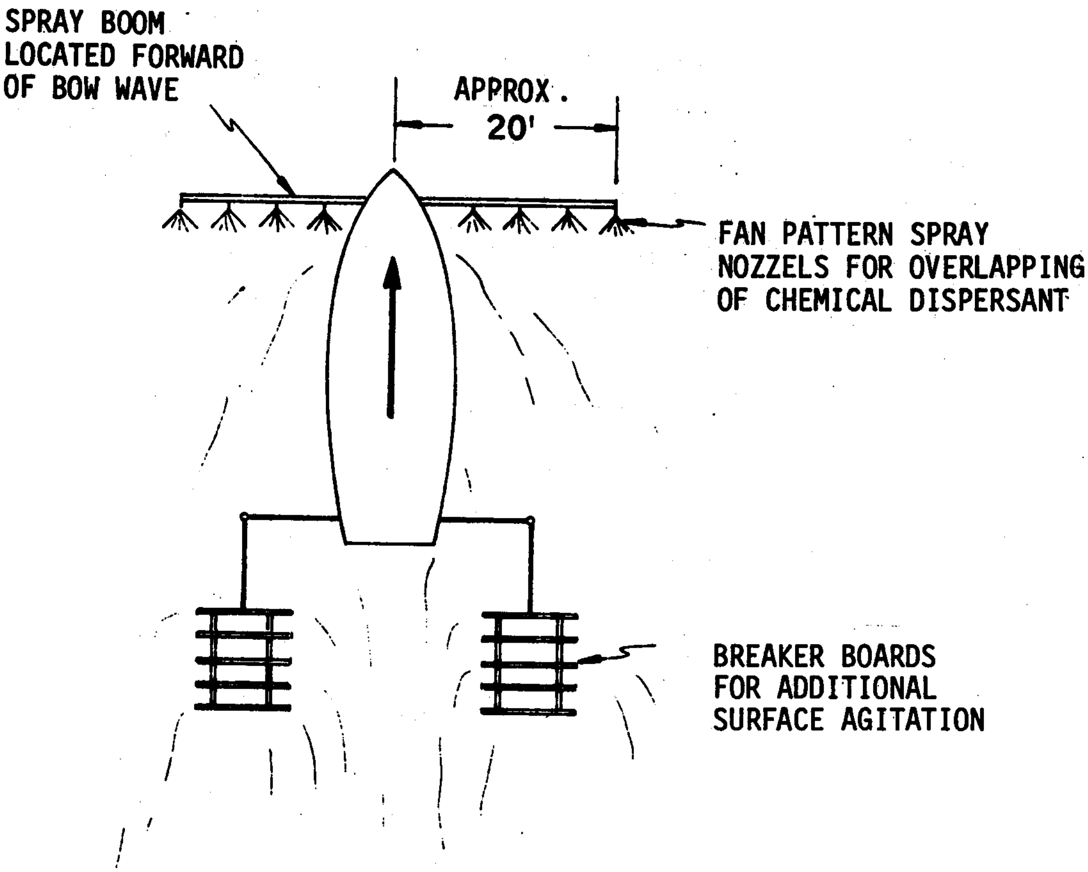

Figure 3. Typical dispersant application and mixing by work boat.

The limitation of mixing, therefore, can be fully appreciated. Furthermore, in some of the more remote locations where spills have occurred, such as Eleuthera Island, Bahamas, and Chedabucto Bay, Nova Scotia, suitable workboats are usually not available readily, if at all.

EFFECT OF RECENT DEVELOPMENTS ON NEED FOR MIXING

Attention has been focused recently on improving dispersing effectiveness by (1) improving the treatment rate (i.e., the amount of chemical needed to disperse a given amount of oil); and (2) by minimizing and/or eliminating the need for mixing. By improving the treatment rate, a workboat could stay on station longer with its supply of chemicals before returning for resupply. Treatment rates have varied from as low as 1 part of dispersant to 1 part of oil to 1 part of dispersant to greater than 30 parts of oil. In 1974, Warren Spring Laboratory, United Kingdom, described the use of such "improved treating rate" chemicals, which are sometimes called concentrates since the surface-active agent concentration is greater than the conventional 15 to 25 percent. The importance of this improvement is cited in the comment by Laboratory personnel that "a spraying vessel carrying concentrate would be capable of remaining at sea up to 10 times longer than one carrying conventional dispersant."

Elimination of the tedious, time-consuming mixing process has greatly enhanced the scope and potential of chemical dispersion, particularly in the case of large spills. Since mixing is no longer required, aerial application alone would be feasible. Some aircraft uniquely adapted for this service and capable of carrying 1,500 gal of dispersant, such as the Canadair CL-215, can cover up to 3,000 acres (1,215 ha) an hour, based on a speed of 150 kn and a treated swath width of 150 ft (45.6 m). Other aircraft, such as the four-engine C-54s and Constellations, are also available for spraying chemicals. These craft have capacities of between 3,000 and 4,000 gal. An entirely new potential for chemical dispersion now exists, therefore.

THE MECHANISM OF SELF-MIX CHEMICAL DISPERSANTS

The mechanisms of self-mix chemical dispersants goes beyond the simple thesis represented by Equation (1). In an ideal no-mixing system, true spontaneous emulsification (or "self-mixing") is postulated to occur in the following manner. The chemical surfactant formulation is made compatible with the bulk oil. However, when the oil phase comes into contact with a water boundary rather than air, part of the surfactant has a strong driving force to diffuse into the water phase. In this transport process, a small amount of oil "associated" with the surfactant is carried into the water phase. A continuation of this process produces a series of fine oil droplets migrating from the oil phase into the water phase, as schematically shown in Figure 4.

As indicated in Figure 4, the surfactant formulation is compatible with the crude oil phase as shown in (a). Because of the nature of the specific compounds, however, there is a driving force for part of the formulation to diffuse into the water phase when it contacts an oil/water interface (b). During this diffusion, some oil associated with the surfactant as fine oil droplets is carried along with the surfactant into the water column, as shown in (c).

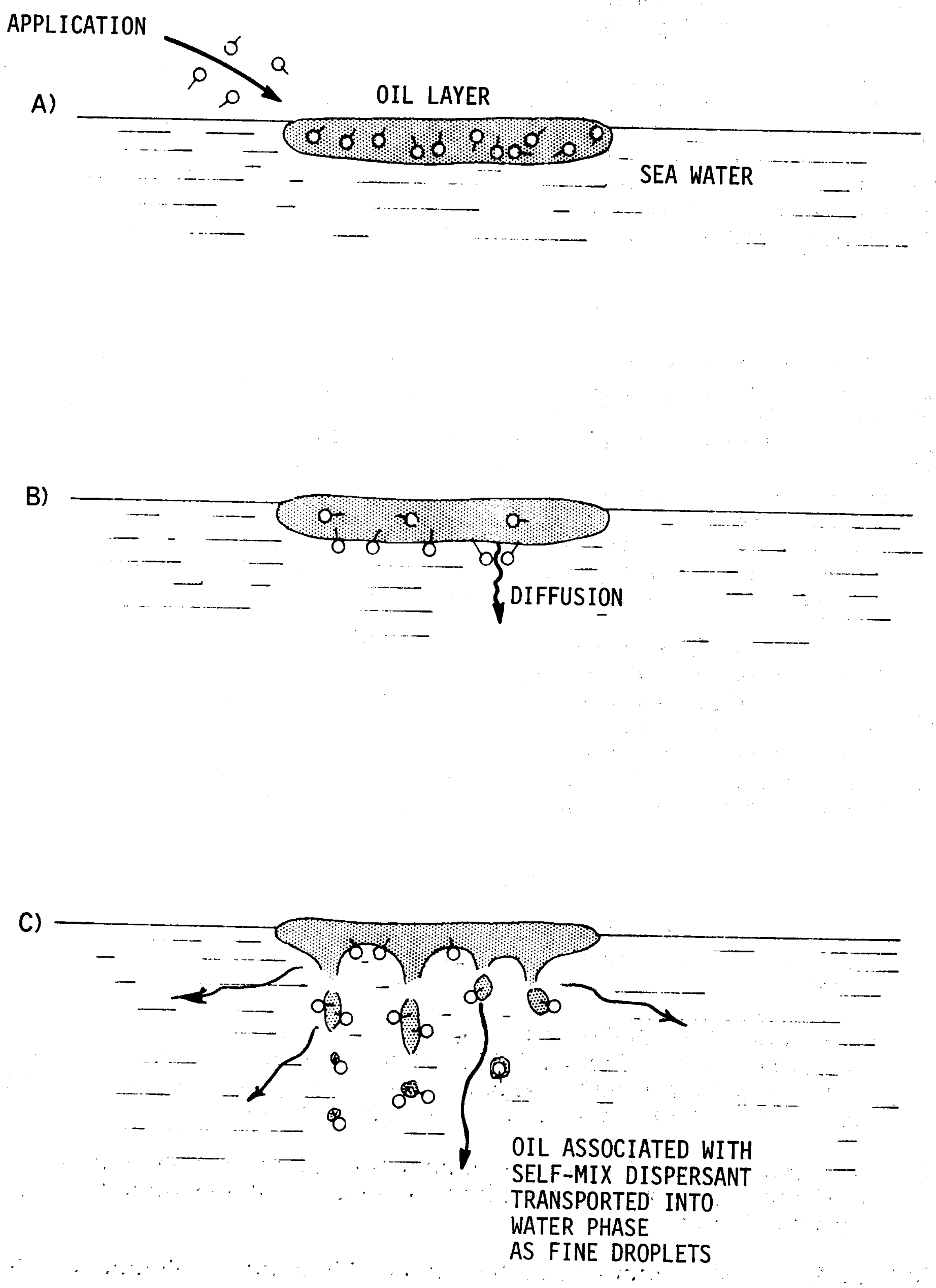

Figure 4. Mechanism of self-mix dispersion.

The migration of the surfactant from the oil into the water phase (in essence, the source of energy for spontaneous emulsification) comes from the redistribution of materials. In order for this system to work in the field as an oil slick dispersant, the surfactant must be brought into contact with the oil phase initially, such as in crop dusting oil slicks.

It is also interesting to note that as the surfactant diffuses through the interface, there is a reduction in interfacial tension. Over the entire oil/water interface, there are dissimilar values of interfacial tension due to the somewhat random diffusion of the surfactant at varying sites along the interface. Any difference in interfacial tension produces a spreading pressure, π, which causes rapid movements of the interface. This interfacial turbulence also aids in the dispersion of the oil into the water phase.

CONCLUSION AND FUTURE OUTLOOK

There is increased recognition that there is a role for chemical dispersants in minimizing damage from oil spills. The improved effectiveness afforded by the self-mix dispersant system has been demonstrated. In addition, several organizations are planning major field demonstrations of this type of dispersant system. In these experiments, the water column will be sampled in the environs of the dispersed oil in order to establish the rate of dilution of oil concentration. The resolution of this important aspect (i.e., the dilution and resultant toxicity of dispersed oil) will help place the various laboratory bioassays, wherein dilution of the dispersed oil concentration is not considered, in a more proper perspective.

Conventional (mixing required) dispersants will continue to be used in the immediate future where mixing energy is conveniently available and the spill size is relatively small. Hardware (sprays, booms, mixing breaker boards, etc.) have been well-developed for boat applications. In this regard, some dispersants are now formulated as concentrates (high surface-active agent content) for greater oil-to-chemical treatment ratios, thereby permitting workboats to remain on station longer before having to replenish supplies.

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FEDERAL VIEWPOINT ON USE AND POTENTIAL OF CHEMICAL OIL DISPERSANTS

J. Steven Dorrler[1]

BACKGROUND

Water-emulsifiable degreasers have been used since the early 1930s to clean oily and greasy surfaces. The degreasers dissolved or dispersed in grease or oil, making the resultant mixture dispersible in water so that it could be flushed away with water.

The early products were composed mostly of soaps and solvents. The early products were of limited effectiveness to the petroleum shipping industry, which needed products that could be used effectively aboard ship with seawater. This need led to the use of materials other than soaps as emulsifying agents because soaps break down in seawater. Sulfonated petroleum oils and, later, more sophisticated synthetic detergents were used in these products.

Emulsifying degreasers were widely used aboard ship for engine room maintenance, as well as for the cleanout of petroleum cargo tanks prior to welding repairs and prior to upgrading of cargo.

Because of their effectiveness in the cleanout of oil residues, degreasers were also used to treat oil spills. In some cases, they were incorporated in oil slops prior to their being dumped overboard to minimize formation.

More than 200 products are commercially available for dispersing oil from the surface of water. These products have been referred to as "soaps," "detergents," "degreasers," "complexing agents," "emulsifiers," and "dispersants." The last term describes best what this type of product is intended to accomplish--the dispersion of oil from the surface into and throughout the body of water. *Dispersant* is therefore the preferred terminology.

COMPOSITION

The primary components of dispersants are surfactants, solvents, and stabilizers.

SURFACTANTS OR SURFACE-ACTING AGENTS (SAA)

These are the major active components in dispersants. Through their affinity for both oil and water, surfactants alter the interaction between oil and water so that the oil tends to spread and can be more easily dispersed into small globules--or what is commonly called an emulsion.

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These agents are often defined according to their behavior in aqueous solutions. These solutions will usually wet surfaces readily, remove dirt, penetrate porous materials, disperse solid particles, emulsify oil and grease, and produce foam when shaken. These properties are interrelated; that is, no surface-active agent possesses only one of them to the exclusion of the rest.

Surfactants can be divided into two broad classes, depending on the character of their colloidal solutions in water: ionic and nonionic. Ionic surfactants form ions in solution, and, like the soaps, are typical colloidal electrolytes. Nonionic surfactants do not ionize, but owe their solubility to the combined effect of a number of weak solubilizing groups such as ether linkages or hydroxy groups in the molecule. A more detailed discussion of SAA is given by Poliakoff (1969).

Commonly used SAA in oil-spill dispersants include soaps, sulfonated organics, phosphated esters, carboxylic acid esters of polyhydroxy compounds, ethoxylated alkyl phenols and alcohols (APE, LAE), block polymers, and alkanolamides.

SOLVENTS

Since many of the surface-active agents applicable to oil-spill dispersant compounding are viscous or solid materials, some form of solvent is often necessary in order to reduce viscosity for ease of handling. In addition, the solvent may act to dilute the compound for economic reasons, to depress the freezing point for low temperature usage, to enable more rapid solubility in oil, and to achieve optimum concentration of surface-active agents for performance reasons. The presence of a suitable solvent also serves to thin the oil to be dispersed, reducing viscosity and making it more easily emulsifiable. The solvent usually comprises the bulk of the dispersant product.

The three general classes of solvents used in oil spill dispersants are petroleum hydrocarbons, alcohols or other hydroxy compounds, and water.

Petroleum Hydrocarbons

Petroleum fractions with boiling points above 149 C (300 F) are usually used, and these may produce finished dispersants with flash points as low as 43 C (110 F). The proportion of aromaticity is of concern, since this affects solubility and emulsification properties, as well as toxicity. Wardley Smith, Warren Spring Lab, UK, in describing the *Torrey Canyon* incident, reported that the aromatic solvents used were 10 times as toxic to marine life as were the surface-active agents. Some typical fractions of applicable petroleum solvents include mineral spirits, kerosene, No. 2 fuel oil, and heavy aromatic naphthas which contain significant quantities of higher alkylated benzenes.

Alcoholic or Hydroxy Group of Solvents

This group includes alcohols, glycols, and glycol ethers. These solvents also lower the viscosity as well as the freezing points of finished dispersants. In addition, they furnish a cosolvent effect, often needed to dissolve the various ingredients in a dispersant for stability of the compound in storage. This group of solvents may be used in conjunction with petroleum hydrocarbons as well as with aqueous solvent systems. Some of the more frequently encountered chemicals in this group include ethyl alcohol, isopropyl alcohol, ethylene glycol, propylene glycol, ethylene glycol monomethyl ether, ethylene glycol monobutyl ether, and diethylene glycol monomethyl ether. The more volatile members of the group are quite flammable.

<u>Water</u>

This solvent is the least toxic, least hazardous, and most economical of the solvents. It lacks solubility or miscibility with oils. When water is used as the solvent, special problems exist in the choice of surface-active agents and other additives in order to provide the necessary miscibility with oils. Glycols and alcohol are used to aid in miscibility. There is also a problem with freezing point depression when water is used.

ADDITIVES--STABILIZERS

Additives are the third major component in dispersants. They are used to adjust pH, inhibit corrosion, increase hard water stability, fix emulsion once it is formed, and adjust color and appearance.

DISPERSANT USE

GENERAL

Dispersants theoretically serve to increase the surface area of an oil slick and to disperse oil globules throughout the larger volume of water, thereby aiding in accelerated degradation of oils by microbiological means. The chemical dispersants do not themselves destroy oil. They vary considerably in toxicity, effectiveness, and ability to stabilize the oil after extended periods of time (Figure 1). Technology for proper application of dispersants over large oil slicks with necessary mixing is currently lacking. Use appears far more critical in harbor and estuarine areas and in proximity to shore. Particular care must be exercised where water supply might be affected. The desirability of employing dispersants in the open sea remains unresolved, although their use in the ocean is potentially more promising, pending additional field data. After widespread dispersant use during major incidents, reports led to the conclusion that dispersant-oil mixture caused more damage to aquatic life than the oil alone. For beaches, they actually compounded the problem by adding the amount of pollutants present, by causing the oil to penetrate more deeply into the sand, and by disturbing the compactness of the sand, so as to increase beach erosion through tidal wave action.

TOXICITY

Current information indicates that dispersants vary considerably in toxicity. The combination of oil and dispersant may increase the toxicity of either the oil, the dispersant chemical, or both. The possibility of this "synergistic" action must be carefully examined before wholesale application of such a product is permitted. Dispersing of the oil, which has toxic components, may also compound the damage. Some examples of the toxicity of 40 older dispersants (Portmann 1970) are shown in Table 1. It is important to point out that the dispersants used during the *Torrey Canyon* incident were mostly solvent-based and highly toxic, killing marine organisms at concentrations of 10 mg/l. Chemicals available today are much less toxic.

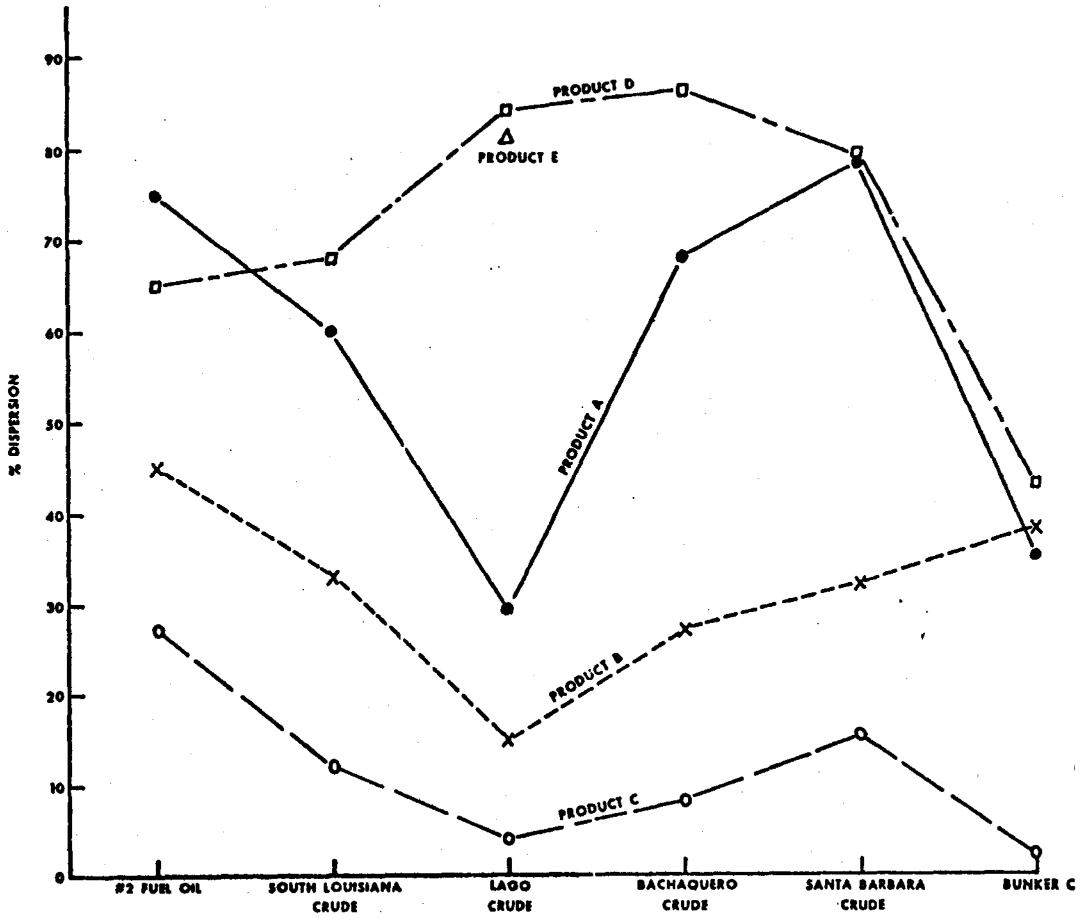

Figure 1. Dispersant effectiveness as a function of oil viscosity.

APPLICATION

The water eductor method is the common means of spreading dispersants. A controlled amount of dispersant is educted into a water stream such as a fire hose. This water jet is an effective vehicle or carrier for the dispersant and provides good coverage in treating the slick.

This application procedure, although compatible with a water-based system, may be incompatible with a petroleum-based system. The incompatibility occurs because a dispersion of the petroleum solvent-in-water emulsion is formed as soon as the surfactant system is educted into the water stream; this accounts for the milky white appearance of the water after such applications (Figure 2). In this state, it is difficult for the surfactant to transfer from its thermodynamically stable location at the petroleum solvent/water interface to the oil spill/sea water interface. For a petroleum-based system, therefore, application of the chemical directly onto the oil slick is a more effective application method.

Table 1. Toxicity to marine organisms of older dispersants in static bioassays TL_{50} for 48 h at 15 C (Source: Portmann 1970)

Solvent emulsifiers	Pink shrimp *Pandalus montagui*	Brown shrimp *Crangon crangon*	Cockle *Cardium edule*	Armed bullhead *Agonus cataphractus*	Flatfish *Pleuronectes limanda*	Star Fish *Asterias rubens*	Shore crab *Carcinus maenas*	Oyster[a] *Ostrea edulis*
				ppm				
Gamlen OSR	12.5	8.8	15.8				20.4	15-50
Polyclens	8.5	15.7	70				23.2	
Six	12.1	114.5	12.7				> 300 (15)	≈100
BP 1002	5.8	5.8	81		10-33		10-25	50-100
Cleanosol	32	44	19.2				102	
Essolvene	8.6	9.6	63				15-20	50-100
Gamlen D	11.5	9.6	38.8					
Gamlen CW	14.6		69.5					
Atlas 1901	87.2	120	48.5				> 150	
Slickgone 1	5.2	6.6	32.4				35.0	
Slickgone 2	4.5	3.5	30.5				21.3	
Shamash R1885	1-3.3	3.3-10						
Crow Solvent M		33-100						
DS 4545		≈1000						
DS 4545 in Pink Paraffin		330-1000						
DS 4545 in IPA		3300-10000	330-1000					
DS 4545 in IBA		330-1000						
Aquaclene		100-330	33-100					

[a]Tests lasted 5 days, not 48 h.

Table 1. (cont'd)

Solvent emulsifiers	Pink shrimp *Pandalus montagui*	Brown shrimp *Crangon crangon*	Cockle *Cardium edule*	Armed bullhead *Agonus cataphractus*	Flatfish *Pleuronectes limanda*	Star Fish *Asterias rubens*	Shore crab *Carcinus maenas*	Oyster[a] *Ostrea edulis*
	ppm							
Esso Solvent FG155		10-33						
Banner DG01		10-15						
Banner DG02		8-12						
Banner DG03		10-15						
Banner DG04		15-20						
Basol AD6		10-15						
Cuprinol 106		4-8						
Penetone X		20-30						
Polycomplex A		100-200	33-100		33-100			
Craine OSR		500-750						
Corexit 7664		7500-10000	3300-10000		1000-3300			
Mobilsol		10-33						
Houghtosolve		10-33						
Raynap Sol B		3.3-10						
Foilzoil		330-1000	33-100					
BP 1100		> 3300	1000-3300	1000-3300				
Ridzlik		330-1000						
Dermol	148	156	148					
Corexit 8666		> 3300						
New Dispersol OS (Dispersol SD)		3300-10000		100-330				

[a]Tests lasted 5 days, not 48 h.

Table 1. (concluded)

Solvent emulsifiers	Pink shrimp *Pandalus montagui*	Brown shrimp *Crangon crangon*	Cockle *Cardium edule*	Armed bullhead *Agonus cataphractus*	Flatfish *Pleuronectes limanda*	Star Fish *Asterias rubens*	Shore crab *Carcinus maenas*	Oyster[a] *Ostrea edulis*
	ppm							
New BP 1100 A		> 3300						
New BP 1100 B		> 3300						
Finasol ESK		100-330						
Finasol SC		33-100						
Hoe SC 1708		330-1000						
Snowdrift SC 98		330-1000						
Neptune Marine Cleaner		33-100						
Finasol OSR		3300						
BP 1100 A		3300-10000						
Sefoil		1000-3300		1000-3300				

[a]Tests lasted 5 days, not 48 h.

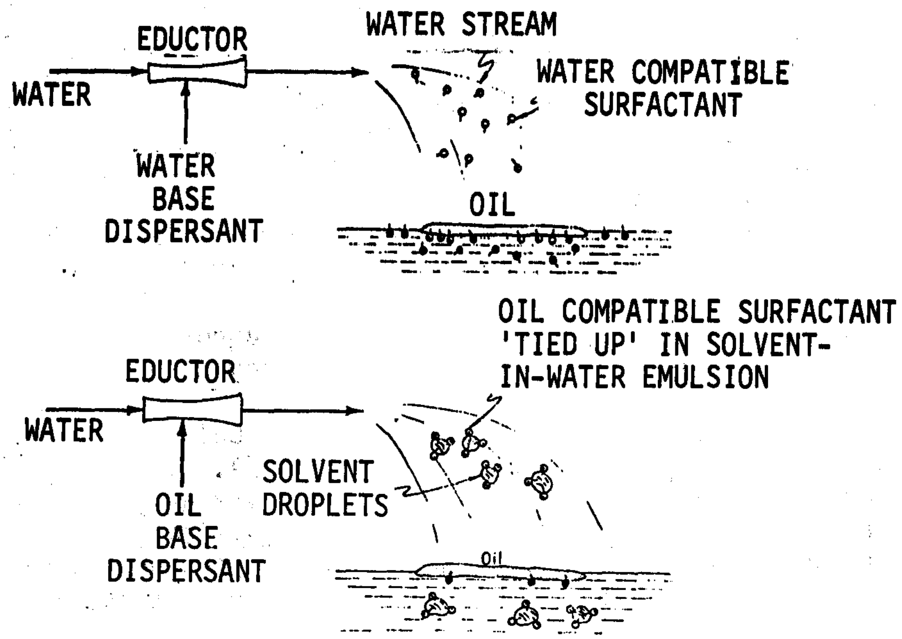

Figure 2. Effect of eduction application with water- and solvent-based dispersants

The prompt application of mixing energy after the dispersant (solvent or water base) has been applied is particularly important. In essence, small oil droplets must be produced while the immediate water environment is surfactant-rich.

FEDERAL POLICY

The National Oil and Hazardous Substances Pollution Contingency Plan published in the 10 February 1975 issue of the *Federal Register* (Council on Environmental Quality 1975), contains the Federal policy on the use of dispersing agents. According to this policy, dispersing agents may be used in any place, at any time, and in quantities designated by the On-Scene Coordinator when their use will:

1. "In the judgement of the On-Scene Coordinator (OSC) prevent or substantially reduce hazard to human life or limb or substantially reduce explosion or fire hazard to property." It is important to note that the authorization for dispersants rests, in this case, with the On-Scene Coordinator, whether an EPA or U.S. Coast Guard official.

2. "In the judgement of the EPA RRT member on a case-by-case basis, in consultation with appropriate state or Federal agencies, prevent or reduce a substantial hazard to a major segment of the population of vulnerable species of waterfowl." In this case, the EPA RRT member is the authorizing official. However, the EPA individual must consult with officials of other Federal or State agencies, such as fish and game or public health organizations; or

3. "In the judgement of the EPA RRT member on a case-by-case basis, in consultation, whenever possible, with appropriate State and Federal agencies, result in the least overall environmental damage, or interference with designated water uses." Again, the authorization for use under this case is from the EPA RRT member. There is a significant difference in the consultation requirement between case 3 and case 2 in that the statement, "whenever possible" appears. In practice, this means that if representatives of other agencies are available, the EPA RRT member should consult them.

These authorizations for use of dispersing agents apply to minor, medium, and major discharges as defined by the contingency plan.

No dispersants can be used on any oil spill unless specific technical product data has been provided and accepted by EPA. This product data is identified in Annex X in the National Contingency Plan and includes dispersant effectiveness and toxicity, as well as several physical testing parameters. To date, no technical product data have been accepted on any dispersant by EPA. The technical product data acceptance requirement applies only to cases 2 and 3 and not to case 1, that is, the hazard to human life or limb case. In the judgment of the On-Scene Coordinator, if the hazards to life or limb are so imminent that the time delay for obtaining an accepted dispersing agent would be excessive, then any dispersant, whether accepted or not, may be used.

After the decision has been made to use a dispersing agent, the On-Scene Coordinator will determine the quantities, location, and time. The intent of the Federal policy on the use of dispersants is to remove or mitigate the effects of oil or hazardous substance discharges. Additionally, in implementing this schedule and in maintaining its relationship with other Federal and State agencies, EPA will recognize that some States may have more stringent laws, regulations, or written policies regulating the use of chemicals in the removal of oil and hazardous substance discharges. In these cases, such laws, regulations, or policies will govern.

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RESTORATION OF OIL-CONTAMINATED SHORELINES

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INTRODUCTION

The development of oil spill control technology has centered around the control and recovery of floating oil. For various reasons, little emphasis has been placed on technological solutions to the complex and environmentally important problems associated with cleanup and restoration of oil-contaminated shorelines. Most restoration efforts attempt to reduce the level of contamination to a point where immediate environmental and social hazards are mitigated and the natural self-healing process proceeds quickly and efficiently. Nature, after all, is the ultimate cleaner and restorer of oil-contaminated shorelines. Unfortunately, scientific knowledge of the fate and effects of oil on coastal ecosystems is only now developing, and is incomplete. This statement is particularly true with regard to long-term and sublethal effects. In addition, little information is available regarding the effects of restoration actions. As a result, well-intended restoration efforts occasionally result in more damage to the environment than would be incurred if no actions were taken at all. Still, oil spills continue to occur and the necessity of preserving shoreline environments persists.

In recent years, URS has actively participated in and conducted long-term monitoring of a number of incidents involving shoreline contamination and restoration. A significant portion of this involvement is ongoing under sponsorship of the Environmental Protection Agency and the American Petroleum Institute. The purpose of this paper is to use this experience as a basis for describing revelant features of shoreline contamination, what appear to be environmentally acceptable and cost-effective restoration techniques, and common misapplications. The paper is based on the assumption that a restoration action is necessary. Techniques considered are primarily physical. Applicability of chemical treating agents is not considered.

SANDY BEACHES

RELEVANT CHARACTERISTICS

For purposes of convenience, this discussion of sandy beaches includes treatment of gravel, cobble, and shingle beaches. The parameters considered are by no means inclusive, but are thought to have a strong influence on the nature and success of a restoration response. Sandy beaches are common along the shores of the United States. These beaches are of widespread public interest because of their recreational potential. In general, these beaches

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are wide and low in slope, and are therefore suitable for mechanized operations. Beaches of coarse-grained sand generally have slopes of 5 to 10 degrees and poor to marginal vehicular-bearing capacity. Beaches of finer-grained sand are usually lower in slope and sufficiently hard-packed to support most types of motorized equipment. Gravel, cobble, and shingle beaches usually have slopes in excess of 10 degrees and, as a rule, cannot support wheeled vehicles. Regardless of type, dry backshore areas almost always have lower bearing capacity and commonly interfere with the access of mechanized equipment. Before attempting to operate mechanized equipment on a beach, one should investigate the degree and variation in bearing capacity and access.

The degree to which oil penetrates a beach is probably the single most important factor governing the type of restoration. Contamination is generally driven onto the beach by waves, wind, and rising tides and is deposited on the foreshore by receding tides. Heavy and weathered oils and emulsions tend to remain on the surface of the foreshore, with minimal vertical penetration. The same material reaching the dry backshore areas may penetrate. Light oils usually penetrate sands quickly and deeply.

RESTORATION TECHNIQUES

Historically, sorbent materials such as straw have been extensively used to clean up heavier oil. Placed on the beach ahead of an approaching slick, the sorbents serve a temporary function. After the oil stands for a while however, it begins to drain into the sorbent material and contaminate the underlying sand. For larger spills, sorbent costs and the difficulties associated with collection, recovery, and disposal of the sorbent materials are additional problems. The use of sorbents may be feasible, however, for small and inaccessible areas.

A study conducted by Sartor (1970) evaluated the use of conventional earth-moving equipment for restoration of oil-contaminated beaches. The adaptations and techniques described have been tested and proved effective on numerous occasions, and remain as probably the most environmentally acceptable procedure. The selection of equipment is particularly important, since the goal of the operation is to remove oil and contaminated sand with as little underlying material as possible. Experience has shown that the combination of motorgraders and motorized elevating scrapers is generally most effective. Operating parallel to the shoreline and following the receding tide seaward, the motorgraders collect layers of surface contamination into windrows. The elevating scraper then recovers the windrows with minimal disruption and contamination of underlying sands. From a cost-effectiveness standpoint, use of bulldozers and front-end loaders is not recommended if graders and scrapers are available. Bulldozers and front-end loaders usually cause more mixing of contamination with underlying sands.

Treatment of sandy beaches contaminated by light oil is more complicated than the cleanup of heavier oil. Because of the increased depth of penetration by light oil, complete removal of the large amount of contaminated sands is usually impracticable. When the oil is concentrated near the surface (in debris and as pools), it can be effectively treated by the aforementioned process. The removal of the remaining material by evaporation and natural flushing can be expedited by turning over the remaining contaminated layer with a beach-cleaner or disking machine.

Methods for treating gravel, cobble, and shingle beaches have not been perfected. Depending on the tendency of the particular oil to adhere to beach materials, water flushing may be partially effective. Care must be exercised, however, since flushing may drive the oil deeper into the beach. When all else fails, complete removal of contaminated materials may be required. Considerable effort is required to accomplish such removal, as exemplified by the extensive dragline operations following the 1972 Casco Bay spill (Foget 1972). It should be remembered that beaches of this type represent high energy environments and should experience the highest rates of natural cleansing. After any operation involving extensive removal of beach material, an assessment should be made of the impact of lost material on the littoral system. Considerable amounts of material can normally be removed without significant disruption of the littoral system. However, if effects are suspected or observed, replacement of materials in kind and quantity is recommended.

ROCKY SHORELINES

RELEVANT CHARACTERISTICS

Natural rocky shorelines are extremely variable in terms of features. Generally, these types of shorelines are associated with the highest energy environments. Operation of all but small portable equipment is usually impossible because of the inaccessibility of the area.

RESTORATION TECHNIQUES

No really effective techniques have been developed to restore rocky shorelines contaminated by oil. Low- and high-pressure flushing with both hot and cold water provides some degree of cleaning of both light and heavy oils, but generally this flushing leaves a residual coating. Pressure and heat will, of course, affect any surviving organisms. Steam-cleaning, although time-consuming and costly, is effective at removing virtually everything except deep stains. All of these methods merely remove oil adhering to rock surfaces. They do not treat under-rock habitats and, in fact, may spread surface contamination to these areas. Collection of removed oil is required. At low tide, a collection trench may be dug at the foot of the rocks, and recovery can be conducted with vacuum equipment, skimmers, or sorbents. If collection trenches cannot be dug, booms and on-water recovery techniques will be required.

Sandblasting is not considered cost-effective or environmentally acceptable. It is not recommended except for localized cosmetic treatment.

WETLANDS

RELEVANT CHARACTERISTICS

Saline and brackish wetlands (or marshes) present particular restoration problems. Isolated usually from human activities and highly inaccessible, these areas contain and support vast and highly productive wildlife resources. Wetlands are particularly sensitive to pollution damage during periods of seed production and spring growth and during waterfowl migration and nesting periods. Substrates are typically muddy or silty and are regularly exposed tidally.

Except for rare cases, oil enters the marshes through the major drainage channels and later spreads into the less accessible interior areas. Contamination is usually restricted to the outer 1 or 2 m of marsh fringe, unless total submergence of an area is involved. In high current drainage channels, the depth of the zone of contamination may be even less. Restriction of contamination to fringe areas appears to be related to the filtering action of the plants and debris and the quelling of the energy of the driving mechanism. Within these fringe areas, contamination is usually limited to the surface of the substrate and plant stalks, although limited amounts may enter the substrate via worm tubes and burrows. Photosynthetic portions of the plants extending above the high-tide level usually are not oil-contaminated. Plants partially contaminated by residual and low toxicity oils can be expected to recover. When coverage is total or more toxic oils are involved, mortality may occur.

RESTORATION TECHNIQUES

Low-pressure flushing provides what is probably the most environmentally acceptable restoration technique. If the flushing is properly conducted, disturbance of the marsh surface is minimal, and the mechanism originally conveying the contamination into the marsh is reversed, floating the bulk of the oil back into the water where it can be recovered. If the flushing is conducted before significant weathering has taken place, even heavy residual oils can be largely removed. Care must be taken not to use excessive pressure, which would cause physical damage to plants, induce erosion, and emulsify the oil.

Granular sorbents applied directly to the marsh fringe may be useful in the treatment of light oil contamination, provided the application is immediate. By temporarily containing the oil, the sorbents slow toxic reactions with the plants and penetration into the soil, thus buying time for more complete recovery efforts. After an extended period, application of sorbents serves little practical purpose. If sorbents are applied, only degradable types should be used, and provision should be made for their recovery. If care is exercised, granular sorbent recovery is not difficult. These materials are surprisingly easy to remove completely with low-pressure flushing. Freed sorbents float and can thus be collected with booms and recovered by vacuum apparatus or seines.

If the type of oil and the situation itself permit, burning may be a useful restoration tool. In many parts of the United States, marshlands are burned routinely as a management technique. In the presence of oil, burning may be more intense and longer in duration, but field experience suggests that damage to buried root systems will be insignificant and that recovery will be rapid. Difficulties in the application of burning techniques include the ignition and sustaining of burning on one hand and control of the resulting fire on the other. Air pollution aspects must also be considered.

Perhaps the most commonly applied marsh restoration technique is the physical removal of contaminated plants (i.e., cutting). In the author's opinion, cutting as it is usually practiced can be extremely damaging to the environment. Cutting is usually done with hand tools or hand-operated machines. Although removal of the upper portions of marsh plants is in itself probably not critical, the physical damage to root systems caused by the presence of the cutting crews can be devastating. Without plants and their soil-binding root systems, bank erosion can be accelerated with resulting land loss, turbidity problems, and sedimentation effects. Cutting does have the beneficial effect of removing the final amount of oil from the marsh environment, eliminating concern of any possible sublethal long-term effects. In many cases, cutting can be done without damage to the substrate. Mechanical weed-harvesting devices are available on the market and can be used for cutting marsh fringes. Channel and fringe areas (which are frequently the location of the largest portion of contamination) normally have sufficient depth to permit the operation of mechanical cutters. The larger cutters are capable of removing vegetation up to several meters from the shoreline and of automatically collecting the cut material.

MANGROVES

RELEVANT CHARACTERISTICS

Mangroves are slow-growing shrubs or trees which grow in the more tropical portions of the United States. Occurring primarily at intertidal and subtidal levels, mangroves can be divided into two anatomically distinct types: (1) red mangroves (*Rhizophora mangle*), which are characterized by red bark and distinctive fork-like aerial prop roots, and which occur in lower intertidal zones with open water exposures; and (2) black mangroves (*Avicennia nitida*), which are characterized by pencil-like aerial "roots" and salt glands at the base of each leaf, and which normally inhabit higher intertidal positions, generally within a fringe of red mangroves. Mangrove forests are complex and virtually inaccessible from directions other than seaward.

Sediments in mangrove areas may be composed of oyster shell, fine coral and organic silts, or almost pure organic debris. The specialized root systems of mangroves have developed in response to continuous water saturation and the anaerobic nature of these sediments. In addition to providing a rich wildlife habitat, mangroves play an important role in landbuilding and stabilization.

Oil contamination of mangrove areas occurs in a fashion similar to that in wetlands. The oil either floats or is blown into the aerial root system. At high tide, the lower portion of the leaf canopy may be soaked with oil.

Several mechanisms having an effect on the plants then begin to occur. Acute toxicity takes place through direct penetration of oils into the plant tissues. This is particularly true in the case of light distillate fuels. Another mechanism involves mechanical clogging of air passages on the aerial roots by heavier oils. A final mechanism includes mixing of oil with debris and the eventual incorporation of these material in the substrate. Because of the anaerobic nature of the sediments, oil incorporated in this way breaks down very slowly and may persist for a considerable period, increasing the opportunity for uptake by the plants. Our observations suggest that if contamination by heavier oils affects only a portion of the aerial root system, plant recovery is probable. Exposure to light fuel oil can be expected to have serious effects, although plants may recover from low levels of contamination.

RESTORATION TECHNIQUES

No proven techniques have been identified. Based on real world observations, however, possible beneficial actions may be suggested. Mangroves routinely collect seagrasses along their fringes among their aerial roots. When sufficiently concentrated, these accumulations have been observed to prevent oiling of the root systems. The concentrations should be particularly effective at minimizing the impacts of light oils. Since oil and seaweed debris will ultimately be incorporated in the substrate, recovery of these materials will be necessary. Recovery should be carefully controlled to prevent mixing with the uncontaminated substrate. The effectiveness of the natural seaweed debris barriers suggests the possible application of straw or other degradable material as a protection/restoration measure.

Once contamination of root systems has occurred, restoration should proceed as rapidly as possible, with particular care being taken to minimize physical damage to the plants. Water flushing using portable, boat-mounted pumps is generally effective in removing the bulk of both light and heavy oils. Water flushing offers the additional advantages of limiting operations in the mangrove forest.

Use of granular-type sorbents may aid in reducing substrate penetration. Generally, however, these materials do not remove the oil, and only cause additional cleanup problems. Pad-type sorbents have been used manually to wipe aerial roots. Such action most likely results in additional pore clogging, and thus extension of damage, and is not recommended.

CONCLUSIONS

With the possible exception of the use of heavy equipment for sandy beach cleaning, a definitive and effective state-of-the-art for restoration of oil-contaminated shorelines is nonexistent. However, common sense applications of the knowledge and resources that are presently available can provide acceptable interim actions. Each restoration situation has its own peculiarities and requirements. If several basic assumptions are adhered to, the best practical restoration decisions should result. These assumptions include:

- Any activity will have some effect on the environment. The restoration procedure and supporting activities (i.e., access, disposal, etc.) must not result in more environmental damage than that caused by the oil itself.

- The restoration procedure should remove (or move to a position where recovery is possible) a maximum amount of contaminant with a minimum amount of disturbance, modification, or removal of the habitat.

- Extensive efforts resulting in low recovery yields are generally antiproductive and should be avoided.
- In some cases, no action at all is a viable alternative.

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TECHNIQUES FOR DISPERSING BIRDS FROM OIL SPILL AREAS

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INTRODUCTION

Bird mortality resulting from the discharge or accidental spillage of oil into water has probably occurred since man first began to transport oil by ship (either as fuel or as cargo), and has been documented as early as 1917 (Wild 1925, *in* Vermeer and Vermeer 1974). In some areas (e.g., Baltic Sea), bird mortality resulting from oil spills has apparently been substantial for many years (Bergman 1961, Lemmetyinen 1966). It was not until 1967, however, when the *Torrey Canyon* disaster occurred and an estimated 40,000 to 100,000 seabirds died (Bourne 1970) that the problem of oil-induced mortality became widely recognized. During the *Torrey Canyon* spill, attempts were made to save oil-soaked birds, but because no information was available on the proper methods of cleaning and rehabilitating these birds, most attempts failed. The "state of the art" for cleaning oil-soaked birds has changed considerably since 1967.

Attention has recently been focused on the concept of deterring birds from oil spill areas, to prevent or reduce encounters with oil by large numbers of birds (Crummet 1973, LGL Limited 1974). The value of this approach is enhanced by the estimate that only a small percentage of the birds that are oil-soaked are ever captured and brought into cleaning centers; many birds that are oil-soaked at sea never reach shore (Tanis and Morzer Bruyns 1968, Hope-Jones et al. 1970).

This paper deals with the subject of bird deterrents and is based on a recent literature study, conducted by LGL Limited for PACE (Petroleum Association for Conservation of the Canadian Environment), on methods for deterring birds from oil spill areas (Koski and Richardson 1976). The report for this study (1) reviews existing knowledge on dispersing and deterring birds from specific areas; (2) gives descriptive, cost, and availability information about commercially available deterrent devices; and (3) contains a discussion of methods and combinations of methods that could be useful as deterrents in various types of areas where oil spills are likely to occur.

One finding of the review is that surprisingly little concrete information is available about the effectiveness of various deterrent methods, despite the widespread use of deterrent methods at airports, in orchards, and in grain fields. Furthermore, of the deterrent tests and observations that have been reported, very few have been in the aquatic, coastal, and marine areas where oil spills are likely to be especially hazardous to birds. As a result, most deterrent devices have not been adequately tested (if at all) against many of the species that are most susceptible to oil during a spill (e.g., loons, grebes, diving ducks, and alcids), and scanty information on the deployment and effectiveness of devices in any situation makes the choice

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of the best devices for trial in aquatic situations difficult. Thus, despite the attention that bird-deterrent methods have received over the years, the answers to the problem of deterring birds from oil spill areas are still largely undefined, and efforts will have to be made to develop and refine the necessary techniques.

This paper, therefore, does not discuss proven methods for deterring birds from oil spill areas. Instead, four aspects that should assist or be considered in the development of deterrent methods are discussed. These are:

1. Approaches that can be taken in developing deterrent techniques.

2. Factors that should be considered when selecting and evaluating devices.

3. Devices or methods that could be useful in deterring birds from oil spill areas.

4. Devices or methods that could be tried in different types of areas.

APPROACHES TO DEVELOPMENT OF METHODS

There are two approaches that can be taken to develop methods for deterring birds from oil spill areas:

1. There is the trial-and-error approach used only during actual spills. A device or method would be tried during a spill and if it did not work, another would be tried, and another, etc., until a successful one was found. The most efficient deployment of this device would also be determined on a trial-and-error basis during spills. The results of such experiments tend to be documented (often poorly) in qualitative rather than quantitative terms, and methods that failed are often not reported. Unless this approach is coordinated or monitored by a central group of people, there will probably be unnecessary trials of techniques already shown to be ineffective. This approach has often been used in the past, but it should not be pursued except perhaps as a desperation attempt to save large numbers of birds threatened by an oil spill.

2. The second approach is systematic and experimental in nature. Rigorous experimental studies would be conducted before a spill in order to determine the deterrent value of several devices that appear to be potentially useful. Adequate controls and statistical analyses of data are required to evaluate the value of each device objectively. Those devices or methods that prove to be useful deterrents could be further refined in actual oil spill situations.

FACTORS TO CONSIDER WHEN SELECTING AND EVALUATING DEVICES

Several factors must be considered when devices are being selected for use, either during experiments or during spills.

1. Oil spills are very dynamic phenomena. The oil moves with the winds and currents; the initial slick spreads out and breaks up into smaller slicks; the oil weathers and the composition of the oil changes. Consequently, in most cases, deterrent methods will have to be mobile in order to stay with the oil. Only when the oil is diverted or drifts into clam water areas (e.g., bays) will stationary deterrent methods become useful.

2. Birds can become oiled either by swimming into the oil before they are aware of it or, in some cases, by landing in it. Therefore, devices will have to be evaluated for effectiveness against both flying birds and swimming birds.

3. Birds appear to be most susceptible to contacting oil during the hours of darkness, and this is also the time when there is the least amount of activity associated with cleanup operations. Effective deterrents must, therefore, be functional during the dark as well as during daylight hours.

4. Oil spills often cover extensive areas; consequently, deterrents must have a large radius of effect in order to be of practical value.

5. Birds will habituate to deterrent devices. This is an important aspect that should be considered during experimental evaluation of deterrents.

6. The difficulty in deterring birds from a given area varies according to the attractiveness of the area to the birds. For example, if oil drifts toward a bird sanctuary, it may be extremely difficult to frighten the birds from the sanctuary (other examples include feeding areas and breeding bird colonies).

7. The responses of different species to a deterrent may not be identical. Diving birds such as loons, grebes, and alcids tend to dive in response to danger rather than fly away, and this behavior may increase the chances that they will encounter oil. The best devices for diving birds, then, will be ones that cause them to take flight. Other birds such as dabbling ducks and gulls generally take flight in response to danger. It must be remembered, therefore, that advice which is useful for one species of bird may not be useful against another species.

DETERRENT DEVICES

Table 1 presents a preliminary evaluation of the usefulness of most of the deterrent devices or methods that have been considered for use in aquatic or marine environments. These devices are described in detail in the report to PACE (Koski and Richardson 1976), but the descriptions are not repeated here. Rather, the devices and methods that may be most useful in oil spill areas or that have been useful in terrestrial areas are briefly discussed below.

DYES

One test has suggested that waterfowl tend to avoid water that contains greenish-yellow dye. If this is true (further tests are required to confirm this observation), then dyeing oil (if economically possible) would be a useful method for reducing numbers of birds that land in or swim into oil. The advantages of this method are that the dye could be applied quickly and over a wide area from an aircraft, and that an oil-soluble dye would remain in the oil as it drifted. Disadvantages are that the dye would not be visible at night; that, as dyes break down, the deterrent effect would wane; and that some species may be attracted to dyed oil.

SEARCHLIGHTS AND FLASHING LIGHTS

Searchlights are at least partially effective in dispersing feeding and flying waterfowl at night; however, some species of birds are attracted to lights at night, especially during conditions of rain, fog, or heavy cloud cover. Flashing lights and strobes may also be useful in dispersing waterfowl at night, and apparently are less likely to attract other birds. Neurophysiological tests of strobes using three species of birds suggest that the optimal color may be red and that the optimal flashing rate may be 6 to 12/sec. However, flash rates of 6 to 12/sec can trigger epileptic seizures in susceptible people. In general, the efficacy of lights as a deterrent has not been proved in any situation for species except ducks and gulls, and even for these birds, effectiveness has not been demonstrated in areas of open water.

HAWKS AND FALCONS

Hawks and falcons have been used successfully to disperse birds from airports. Raptors, however, are useful only by day and during fair weather. They require extensive care and training and are not readily available. Furthermore, efficacy over water is unknown, but is suspected to be less than that over land. In fact, the immediate response of most water birds to the appearance of a falcon nearby is to land on the water and/or dive, and these behaviorial responses would increase the probability that birds would become oil-soaked.

DISTRESS AND ALARM CALLS

Recorded alarm and distress calls of various species, when broadcast in the vicinity of the same species, often cause the birds to disperse. These calls are generally effective longer than most other deterrents, because birds accommodate to them slowly. The most important limitation of this method is that distress calls are usually species-specific and that some species rarely, if ever, utter distress calls. Attempts should be made to identify

Table 1. Potential deterrent methods and a preliminary evaluation of their usefulness

Deterrent method	Preliminary evaluation of usefulness
Microwaves	Impractical
Lasers	Impractical
Dyes[a]	Possible
Searchlights[a]	Possible
Flashing lights and strobes[a]	Possible
Reflectors and balloons	Limited
Flags, kites, smoke	None
Hawks and falcons	Little or none
Models of predators and scarecrows	Little or none
Dead birds in unnatural postures ("crucified")	Little or none
Distress and alarm calls[a]	Possible
Sounds of predators (e.g., killer whales)[a]	Possible
Av-Alarm[a,b]	Possible
Ultrasound (high-frequency sound or ultrasonics)	None
High-intensity sound	Impractical
Shell crackers[a,c]	Possible
Flares, rockets, mortar shells[a,c]	Possible
Gas exploders[a]	Possible
Fixed-wing aircraft and helicopters[a]	Possible
Model aircraft (conventional shape)	None
(falcon-shaped)	Very limited
Lure areas	Little or none
Foam	Untried

[a]Techniques that warrant consideration for use in aquatic and marine areas.

[b]The reference to trade names does not imply endorsement of commercial products.

[c]There may be a fire hazard or hazard to aircraft associated with these devices.

and record distress and alarm calls of the many aquatic and marine bird species for which such calls have not been documented, and thereafter, field trials should be conducted in situations relevant to oil spills to determine their effectiveness as deterrents.

SOUNDS OF PREDATORS

The deterrent value of sounds of predators has not been adequately tested, particularly for marine species of birds. Underwater broadcasting of killer whale vocalizations may be of value in dispersing some marine birds. Above-water broadcasting of calls of hawks or falcons may also be useful in certain situations. However, neither of these methods has been tested in relevant situations.

AV-ALARM

Av-Alarm, a proprietary device that broadcasts loud synthetic sounds, has shown some value as a deterrent in agricultural applications and has been reported to have been partially effective against waterbirds in coastal areas. The frequencies broadcast are chosen on the basis of their similarity to the frequencies of calls produced by the birds of concern. The inference is that their use will interfere with normal communication between members of a flock and thus set up a stress situation that birds will tend to avoid. Additional experimentation in situations related to oil spills is warranted.

PYROTECHNICS

Pyrotechnic devices produce a loud noise and/or flash of light, which frightens the birds. Except in the case of waterfowl, pyrotechnics do not attempt to mimic any hazard regularly experienced by birds. Examples of such devices are shell crackers, Verey flares, rockets, mortar shells, and dynamite.

Shell crackers are very effective deterrent devices because they produce an explosion and a puff of smoke for a distance of 100 m or more from the propelling device (usually a shotgun). Use of shell crackers in conjunction with other approaches is now a standard deterrent technique. Verey flares are fired from hand guns, and produce a flare and trail of smoke, as well as a "bang." Rockets have been recommended as deterrents at airports and in agricultural areas. Mortar shells and fireworks fired from a 127-mm launcher appear promising as deterrents because of the wide area over which they would be conspicuous. However, neither rockets nor mortars have been properly tested for efficacy.

The usefulness of some or all pyrotechnics could be severely limited if there is a danger of igniting the spilled oil or if there are aircraft operating in the area. Moreover, people using any pyrotechnic device must be trained in its use. For example, shell crackers are very simple to use. However, a novice may not be aware of the facts that: (1) they should be fired only from an open-bore shotgun in order to avoid possible jamming or premature ignition of the explosive in the barrel; (2) the use of more than one shell cracker in a pump shotgun could cause premature firing of the second shell during ejection of the spent shell; and (3) some brands of shell crackers appear to be safer than others.

GAS EXPLODERS

Gas exploders periodically produce a loud explosion from the ignition of acetylene or propane gas. They are partially effective as deterrents in agricultural areas, but must be supplemented with other deterrents in order to maintain their effectiveness. An "electronic exploder" that is currently in the prototype stage would probably have similar deterrent value and might require less maintenance. Neither gas nor electronic exploders have been adequately tested in situations related to oil spills.

AIRCRAFT

Fixed-wing aircraft commonly cause some species of water birds to disperse. Ducks and geese can sometimes by "herded" out of large areas rapidly, especially if other deterrent methods are used simultaneously. Helicopters are likely to be more effective because of their maneuverability and noise. The effectiveness of aircraft as deterrents will vary with species, area, and season; many birds dive rather than fly when an aircraft approaches, and waterfowl may be incapable of flight during the molting and brood-rearing periods in summer, or they may be reluctant to leave sanctuaries. Nonetheless, because of their mobility and availability, aircraft will probably be one of the most useful deterrents, especially in the early stages of the cleanup and deterrent operations.

MODEL AIRCRAFT

Standard radio-controlled model aircraft have not proved to be effective in dispersing birds, and long-endurance television-equipped remotely piloted vehicles are too expensive to have any advantage over full-size piloted aircraft. Falcon-shaped model aircraft are more promising, but the reaction of many water birds would probably be to dive into the water. It may be possible to herd birds on the water with this device. A major limitation of this device is that an experienced operator is required to fly it. Birds may also habituate to the device fairly rapidly.

LURE AREAS

Food is the most common attractant used to lure birds from one area to another. In special circumstances, this approach might have some application for waterfowl, gulls, and sea birds. However, the lure area must be established fairly close to the spill so that the birds will find the food. This would probably attract birds into the general area and ultimately increase rather than decrease mortality. Furthermore, waterfowl and gulls are likely to feed at the lure area by day, but the return to their normal roosting sites at night may again place them in a contaminated area. Therefore, lure areas should be established only after a careful assessment by biologists, and deterrent efforts in the contaminated area will probably need to be continued.

DEVICES FOR USE IN DIFFERENT TYPES OF HABITATS

The effectiveness and logistical practicality of individual deterrent methods are known or suspected to vary with habitats, species, age and sex of birds, weather conditions, season, and time of day or night. Because of the limited information on deterrent devices and the enormous variety of circumstances that could arise, it is difficult to identify precisely those devices most likely to be of use in various types of areas. Consequently, the following discussion is general in nature and is intended only to provide suggestions.

PONDS AND SMALL LAKES

It will probably be easier to disperse and deter birds from a small lake or pond than from any of the other types of areas discussed below. It is also probable that oil spilled on small ponds and lakes will seldom be a hazard to large numbers of birds.

The first objective in all situations should be to disperse immediately all birds that are already in the vicinity of the spill. On a pond or small lake (maximum diameter approximately 1 mile or 1.6 km), a combination of shell crackers and mortars could be used to disperse the birds. A motorboat would be required to reach areas not accessible from shore. On a slightly larger water body, an aircraft might be needed to disperse the birds rapidly.

Once the birds have been dispersed from the area of the oil spill, deterrent devices must be set up to prevent birds from returning to the area. Devices that are not species-specific would be most useful. These would include acetylene exploders and revolving or flashing lights. Species-specific methods, such as distress and alarm calls and perhaps "crucified" birds, could be of use if only a small number of different species were of concern in the area.

MARSHES

In general, the methods recommended for ponds and small lakes would also be the most applicable methods in marshes. However, birds would be less conspicuous among the emergent vegetation of marshes than on the open water of ponds and lakes, and would often be less likely to fly. Increased emphasis (relative to ponds and small lakes) on aircraft is recommended for initial dispersal of birds. It should be kept in mind that the marsh vegetation may be sufficiently dense to prevent penetration of the oil, in which case care should be taken not to disturb the birds.

Development of lure areas in suitable marshes near a contaminated marsh might be useful, but only if there are few other marshes nearby and if few transient birds are moving through the area. If there are other marshes in the area, or if many transients are passing through, the lure area would probably attract more birds into the general areas of the spill and increase rather than decrease mortality. Luring should be attempted only if biologists on the scene have carefully evaluated the probable consequences and concluded that alternate methods are ineffective and that the consequences of luring would definitely be beneficial.

It will be difficult to prevent birds from attempting to roost in oil-contaminated marshes during the evening, even if they are lured to alternate feeding areas by day. A greater density of pyrotechnics, exploders, and flashing or revolving lights will therefore be required in a marsh than on a pond or small lake. It is suggested that pyrotechnics, exploders, and lights be supplemented with numerous scarecrows and reflectors.

RIVERS

If oil that had been spilled into a river was contained by booms and/or trapped in a bay, the applicable deterrent techniques would be similar to those useful around ponds and small lakes. However, many devices would be more difficult to deploy. Aircraft would be very useful because of the rapidity with which they could be brought into use. Mortars and rockets would be especially useful because of their long range (relative to shell crackers and flares) and the consequent reduction in the need for boats. Boats would be necessary for proper use of shell crackers and Verey flares.

If the oil is floating downriver, highly mobile techniques would be necessary in order to disperse birds from areas ahead of the advancing oil. The most efficient method would be through use of aircraft and through boat- and/or shore-based crews firing shell crackers, flares, and mortars. It would also be necessary to deter birds from entering the already contaminated area. The difficulty of accomplishing this would be highly dependent on the width of the river, the rate of current flow, and the length of the contaminated section.

COASTAL AREAS

Methods applicable in coastal areas would be similar to those applicable on ponds and small lakes. However, because of the less confined nature of coastlines, aircraft would probably be of most value for the initial dispersal of birds. If the section of coastline that was contaminated or about to become contaminated was long, use of aircraft would probably be the only practical dispersal method, and numerous aircraft might be necessary.

Deterrent methods and devices would need to be deployed along the shore in order to prevent birds from entering the contaminated water. Shell crackers, exploders, lights, reflectors and mortars, together with continued use of aircraft, would be possible approaches. Distress and alarm calls would be useful if calls of the appropriate species exist and are available. The major limiting factor for coastal areas will be the logistical problems of deploying and operating a sufficient number of devices.

OFFSHORE AREAS

No tests have been conducted relating to the effectiveness of deterrent methods in offshore situations. It is clear, however, that many of the devices and methods that are useful on and near shore are impractical in offshore areas, at least until the oil can be surrounded by booms.

The most effective dispersal method offshore would probably be use of aircraft. However, some species of seabirds are more likely to dive than to fly when an aircraft approaches, and some molting species would be unable to fly. Twin-engined aircraft would be necessary for safety, and effective operations would be impossible at night. Searchlights mounted on boats would be useful offshore, but their effectiveness in cases of large spills would be limited. Because of their larger area of coverage, rockets and mortars would probably be more useful than shell crackers and flares, both by day and by night.

There is evidence that penguins (*Spheniscus demersus*) may be repelled by underwater broadcasting of killer whale (*Grampus orca*) sounds (Frost et al. 1975). Killer whales occur off much of the Canadian and U.S. coasts, and so it is possible that species of birds that dive might be dispersed by killer whale sounds. Because underwater sounds attenuate slowly, this method might be effective over a substantial area. Field trials are needed.

LEADS AND ICE

Areas of open water that are surrounded by ice are likely to contain birds, and pools of oil that look like open water are also likely to be attractive to passing birds, particularly if little or no open water is available nearby.

Methods of dispersing or deterring birds from oil spills in leads, in other areas of water surrounded by ice, or on ice have not been tested. However, available evidence indicates that the potential for dispersing and deterring birds from such areas will depend on the size and remoteness of the oil spill and on whether alternate areas of open water are available.

In general, three major classes of problems limit the ability to disperse and deter birds from leads and polynias:

1. Logistics are difficult in remote areas and in open water.
2. Techniques have not been developed or tested in offshore or icebound waters or against the types of birds that would occur in such areas.
3. The deterrent effort would have to continue over a long period because of the extreme difficulty of cleanup operations on icebound waters.

Alleviation of any of these problems could markedly improve the potential for minimizing bird mortality as a result of oil spills near or on ice.

AREAS NEAR A SEA BIRD COLONY

Sea bird colonies that occur in North America range in size from a few pairs of birds to hundreds of thousands of birds. If oil is spilled near a large sea bird colony during the breeding season, it is inevitable that large numbers of birds will be killed.

Sea birds commonly land on the water near their colonies, and are especially likely to do so if the nest sites are disturbed. Research into the efficacy of oil-soluble dyes as bird deterrents is especially desirable for this situation. Standard deterrent methods may also be effective against sea birds in some situations, but no trials have been conducted. Such information is needed before a realistic contingency plan can be prepared to deal with the case of an oil spill near a colony.

The primary goal of any attempt to reduce mortality from an oil spill near a colony should be to minimize the number of adults that are oiled, and thereby to maintain the potential for productivity in future years.

An oil spill near a colony is one situation where it might be advisable to use oil dispersants in an attempt to sink the oil. The advisability of this action would depend on the nature and severity of the spill, the time of year, and the potential for cleanup operations. Use of oil dispersants may reduce immediate mortality to birds, but losses may occur in subsequent years due to secondary poisoning effects that reduce the productivity of marine organisms in the area (National Academy of Sciences 1975).

The immediate needs in relation to the possibility of oil spills near sea bird colonies are for identification of effective deterrent procedures and strategies, and for minimization of the probability of an oil spill near sea bird colonies.

SUMMARY

1. Despite the widespread use of bird deterrents for many years at airports, in orchards, and in grain fields, proven methods of deterring birds from oil spills do not exist.

2. Well-designed and documented experiments on potentially useful devices are required and would be invaluable to all people faced with the task of trying to keep birds out of oil spills. Documentation of failures is as important as documentation of successes.

3. Aspects that need to be considered in selecting deterrent devices for experimentation or actual use include mobility of the device, radius or effect of the device for various species, and rate of habituation to the device by birds.

4. Devices that may be most useful in aquatic and marine areas include dyes, lights, distress and alarm calls, calls of predators, Av-Alarm, shell crackers, mortars, exploders, and aircraft.

5. The use of these devices in various types of areas is discussed. Generally, it appears that methods are available for ponds and small lakes, rivers, marshes, and perhaps coastal areas. This is not the case, however, for offshore areas, areas of leads and ice, and areas near sea bird colonies. Appropriate methods need to be identified for these areas.

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CURRENT METHODS OF OILED BIRD REHABILITATION

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INTRODUCTION

The staff of the International Bird Rescue Research Center believes that although the process of oiled bird rehabilitation is difficult and expensive, the effort is worthwhile. The techniques that we have developed, and the experience that we have gained with each oil spill incident may someday help maintain a threatened local seabird population or an endangered aquatic species. This information will make the job easier for those preparing for or supervising an oiled-bird emergency effort.

We are not yet able to rehabilitate birds in sufficient numbers to have any biological significance. Bird deterrent techniques and rapid oil containment and clean-up methods are of much greater importance at present in protecting aquatic birds from losses resulting from oil pollution. In response to the public mandate that oiled birds be cleaned, techniques are available for rehabilitating significant numbers of those birds affected in a short time, thereby greatly reducing cost and labor requirements.

METHODOLOGY

FACTORS FOR SUCCESSFUL REHABILITATION

Since the inception of the Center following the San Francisco Bay spill of 1971, the staff has treated more than 1,500 birds in local spill incidents, 38 percent of which were released (Table 1).

Table 1. Summary of the number of oiled birds rehabilitated at the International Bird Rescue Research Center, 1973 to 1976

Year	Received (Number)	Released (Number)
1973	523	218
1974	83	26
1975	732	199
1976	235	154
Total	1,573	597

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In some of these incidents, birds were in captivity for only a few days; while in others, birds remained in captivity for as long as 6 weeks. The birds are are not released until they are waterproof, healthy, and capable of fending for themselves in the wild. Little information is available on the ultimate fate of the birds that are released.

The success of a rehabilitation effort depends on a number of factors, which include:

1. The toxicity of the oil involved. Oil is preened and ingested by affected birds and is absorbed through their skin.
2. The weather conditions when the birds are oiled. Since the oil destroys the insulating qualities of the plumage, harsh conditions quickly deplete the energy reserves of the oiled birds.
3. The time elapsing between oiling and treatment. Exposure to cold and oil toxicity progressively debilitate affected birds.
4. The condition of the birds at the time of year they are oiled. When birds have expended their energy reserves in moulting or breeding, they are less able to withstand the stresses associated with oil contamination.
5. The species of bird involved. The larger ducks, geese, grebes, and pelicans are easier to rehabilitate than the smaller individuals.

These factors are largely beyond the control of those preparing for oiled bird cleaning efforts. Additional factors that influence rehabilitation success, however, can and should be controlled by advanced planning. These include:

1. Extensive prior planning, including the training of personnel, the stockpiling of equipment and supplies, and the selection of an adequate facility for cleaning and rehabilitation; and
2. Efficient organization and overall coordination during an incident, and trained supervisory personnel for all phases of rehabilitation, including capture, medical treatment, cleaning, drying, maintenance in captivity, and swimming in preparation for release.

The International Bird Rescue Center offers consulting services in planning for emergencies and in training supervisory personnel, and can also provide some on-scene assistance in distant emergencies.

THE PROCESS OF REHABILITATION

It quickly becomes clear to anyone working with oiled birds that rehabilitation requires more than just effective methods for removing oil from the plumage of birds. The birds must also receive appropriate medical treatment and care during their entire stay in captivity to help them regain or maintain a normal physiological state and to reestablish the water-repelling and insulating qualities of their plumage. Unfortunately, answers have not been found for all of the problems posed by rehabilitation, but more effective methods have been developed, and with continuing investigation and experience, these techniques can be improved further (Table 2).

Table 2. Summary of the recent oiled bird rehabilitation efforts at the International Bird Rescue Research Center

Date	Spill location	Species[a]	Received[b] (Number)	Released (Number)	Average confinement time before release
Sept. 1975	San Mateo Co., Calif.	Common murre Brown pelican	635	159	3 weeks
Jan. 1976	Carquinez Straits, Crockett, Calif.	Canvasback Scaup (two species) Mallard Ruddy duck Goldeneye	140	105	4 days
Mar. 1976	Aquatic Park Lake, Berkeley, Calif.	Ruddy duck Common coot Pied-billed grebe	54	26	2 days

[a]Birds are listed in decreasing order of frequency for each spill. Birds treated include the common murre (*Uria aalgae*), brown pelican (*Pelecanus occidentalis*), canvasback (*Aythya valisineria*), scaup (*Aythya* spp.), mallard (*Anas platyrhychos*), ruddy duck (*Oxyura jamaicensis*), common coot (*Fulica americana*) and pied-billed grebe (*Podilymbus podiceps*).

[b]Total of all oiled birds received, including those that died prior to cleaning and those that were euthanized.

COLLECTION AND ONSITE TREATMENT

The collection of oiled birds is, of course, the first step in their rehabilitation, and can be the most difficult task to accomplish. The Center has had little direct experience in this activity, since the capture, initial treatment, and transport to the Center has been a cooperative effort involving personnel from the California Department of Fish and Game, the U.S. Coast Guard, and local wildlife rehabilitation groups, humane societies, and animal control agencies. For the most part, oiled birds are not accessible for capture until they have become somewhat debilitated by oil toxicity, exposure, or starvation; therefore, they are given some initial treatment at centralized locations near the site of their capture. The location of these "collection stations" may vary, depending on the movement of the oil and the birds and on other factors. The initial treatment includes:

1. The removal of oil from the nostrils and mouths so that no further oil is ingested and breathing is unhampered.
2. Tube-feeding birds with a warm solution of 2 to 5 percent glucose in fresh water to provide hydration and an easily utilized source of energy.
3. Wrapping the birds' bodies in cloth and taping their beaks shut to prevent further preening and ingestion of oil.
4. Placing the birds in a quiet, sheltered area in individual boxes to await transport.

TREATMENT AT THE REHABILITATION CENTER

After the birds arrive at the Center, they are tube-fed additional warm hydrating solution, and the following additional procedures are performed:

1. The birds are weighed and banded, and a short record of treatment is started for each of them, which includes information on prior treatment, location of capture, degree of oiling, species, sex, age, etc.
2. Each bird's temperature is taken with an oral thermometer, and those with temperatures below 38 C (100 F) are placed in a box under a heat lamp for a few hours to produce ambient temperatures of 29 to 32 C (85 to 90 F). When their body temperatures approach the normal range of 39 C (103 F) and above, they are housed with the rest of the birds.
3. Birds that are heavily oiled with fresh oil and are actively preening are wrapped again in clean cloth in such a way as to prevent preening and provide mobility, unless they appear too stressed by the restriction.

When resources are limited, it may be necessary to euthanize some of the birds received, and to concentrate efforts on those that have the best chance of survival. Birds less likely to survive the stress of oiling and rehabilitation include those with obvious signs of distress, such as convulsions, extreme lethargy, or labored breathing accompanied with gasping or gurgling sounds; those with traumatic injury, such as fractured limbs or lacerations;

and those whose body temperature remains low despite supplemental heat and the warm 2- to 5-percent glucose hydrating solution. Abundant bird populations, such as some species of gulls, may be among the first to be euthanized when it becomes apparent that not all birds can be treated. Birds of an endangered species and birds having a limited local population are euthanized only for humane reasons, when it is apparent they will not survive treatment. A high degree of oiling, initial resistance to self-feeding, or bloody droppings are not reliable indicators of a bird's lessened likelihood of survival, and should not be used routinely as criteria for euthanasia.

CARE OF OILED BIRDS IN CAPTIVITY

The care of captive wild birds requires the maintenance of supportive, minimum-stress environment for them. A high level of care is essential to prevent the problems that can develop in debilitated birds, such as inadequate nutrition, dehydration, joint and sternal lesions, cloacal impactions, infectious disease, and a host of other problems.

Because oiled birds have been stressed prior to capture by oil toxicity and exposure to cold and will be further stressed by the cleaning process, it is essential that workers caring for them be aware of, and attempt to reduce, the stresses associated with captivity. Prolonged stress in birds, as in any animal, will have a number of general and specific deleterious effects on the body, causing heavy mortality. The stresses to captive wild birds include:

1. Visual stress. The sight of people is very threatening to wild birds, judging from the alarm calls or the escape behavior the sight produces. Birds should be penned in areas where there is little human activity, and only the workers specifically involved in their care should approach them.
2. Loud, startling noises. Loud conversation and noisy activity should be avoided in the areas where birds are penned.
3. The stress of handling. It is very important that birds be handled only for necessary treatment and care and that otherwise they be left undisturbed.
4. Extremes in temperature. Because the plumage of oiled birds does not provide them with sufficient insulation, the areas in which they are housed must be kept quite warm, at least 21 C (70 F) but not higher than 27 C (80 F), if the birds are particularly chilled or debilitated.
5. Artificial cycles of light and dark. When possible, the birds should be kept on a cycle of day and night that is appropriate for the time of year.
6. Overcrowding. Birds must be given sufficiently roomy pens to allow them to space themselves comfortably (this varies from species to species) and to prevent aggressive interactions.
7. Nutritional inadequacy. The birds must receive sufficient quantities of fresh, appropriate food, and may require tube-feeding to assure adequate intake.

8. <u>Dehydration</u>. Birds should be tube-fed fluids several times a day to keep them sufficiently hydrated, until they are cleaned and swimming frequently, or known to be taking adequate quantities from dishes in their pens.

9. <u>Pathogens</u>. Pens, bedding, and feeding and tubing utensils should be kept clean and disinfected regularly to avoid the transmission of disease. Bedding materials that are likely to mold, such as straw or wet newspaper, should not be used. This will reduce the likelihood of infection by the fungal respiratory disease aspergillosis, a common problem in captive wild birds.

The Center constructs pens for the birds using plywood sheets, measuring 0.6 m x 2.4 m x 0.9 cm (2 ft x 8 ft x 3/8 in). The plywood sheets are usually subdivided with additional sheets of plywood or other barricades, so that the birds can be spaced out within the pen. At first the pens are set up indoors, so that the birds can be kept warm, but in later stages of rehabilitation, many birds can be housed outdoors, depending on the weather. When necessary, covers of plastic or cloth netting are placed over the pens to keep the birds from flying out.

The materials used for bedding in the pens are kept as clean and dry as possible to prevent microbial infection, chilling, and the recontamination of plumage with food and droppings. Two layers of bedding are ordinarily used: a bottom layer of newspaper or thick foam padding, and a top layer of absorbent cloth. It is particularly important that birds that lie continually on their ventral surfaces, such as loons, grebes and sea ducks, be given a resilient bottom layer (of crumpled newspaper or foam). If this resilient layer is not provided, these birds will develop pressure sores along the keel when kept on too hard a surface. Active birds spending most of their time on their feet can be given a bottom layer of flat news sheet only, which is then covered with cloth for absorbency.

During the first few days of captivity, the food and water intake of the birds is supplemented by forced-feeding and tube-feedings of hydrating solution. To avoid the stress of repeated handling, however, every effort is made to have all of the birds feeding themselves within a day or so after their arrival at the Center. They are also encouraged to drink from pans of water in their pens.

Fish-eating birds, such as pelicans, loons, cormorants, alcids, and sea ducks, are fed small saltwater smelt (10 to 15 cm or 4 to 6 in long). Other small fish can be used, but anchovies are not recommended because birds that feed on them produce very oily droppings, which will recontaminate the plumage. Self-feeding is encouraged by tossing a few small live fish into pans of water or on the ground in front of birds. The movement of the live fish will usually produce feeding behavior, as will competition with individual birds that have already begun to feed.

Grain-eating birds, such as swans, geese, dabbling ducks, and ruddy ducks, are fed soft grain feeds at first, such as chick starter mash (nonmedicated) and Trout Chow (Purina), which are presented in low, wide pans of water.

These soft feeds are used at first so as not to irritate further the bird's gastrointestinal tract, which may already be irritated by oil ingestion; within a few days, this diet is supplemented with whole or cracked grain feeds. To encourage self-feeding, the bird's beak is gently placed in the pan with mash and water, or the pan may be swirled in front of the bird. As with fish-eating birds, competition for food will stimulate self-feeding.

The birds should have food available to them continuously, but the food presented to them must be fresh. Uneaten fish or grain feeds in water must be discarded before they begin to decompose or ferment. Multi-vitamin supplements and a thiamine supplement to smelt are given on a regular basis.

Sometimes, birds must be maintained at first by forced feeding. Fish-eaters can be force-fed whole fish or tube-fed a fish mixture that includes vitamins, glucose, and corn oil. Grain-eaters are best force-fed by using a tubing mixture that includes sifted mash, Trout Chow, vitamins, glucose, corn oil, and water. All birds are routinely tube-fed glucose hydrating solution three to four times a day until they are cleaned and swimming, at which point they will need less forced hydration, depending on the amount of time spent in the pools.

CLEANING AND DRYING

A number of factors must be considered in deciding how and when to clean oiled birds. These include:

1. <u>Choice of cleaning agent</u>. The agent must quickly and efficiently remove all of the contaminating oil and must be used at an effective temperature (and at an effective concentration when detergent is used). Strict safety precautions must be taken to protect both birds and workers when flammable and toxic solvents are used.
2. <u>Choice of cleaning method</u>. The techniques used to remove oil from the plumage must not disrupt or damage the alignment of the plumage, but at the same time must be sufficiently forceful to be effective.
3. <u>Condition of the birds</u>. Unless the oil is very toxic, the birds should be maintained in captivity for a short time (12 to 48 h), receiving food, water, and protection from cold so that they will be in better condition for the stressful cleaning process. When possible, the cleaning of birds in poor condition (body temperature less than 39 C (103 F), lethargic) should be delayed until their condition improves.
4. <u>Coordination</u>. Cleaning and back-up activities, such as preparing adequate quantities of cleaning agent, selecting and medicating birds for cleaning, and drying birds after cleaning, must be sufficiently organized so that the shortage of workers, materials, or cleaning agent does not hinder the process.

At the International Bird Rescue Center, the staff has used Shell Solvent 70 in all cleaning efforts involving more than 15 to 20 birds. Solvent is used because it affords the greatest efficiency and speed of cleaning, particularly with viscous or tarry oils. On small numbers of birds oiled with more highly refined oils, the staff has used detergents, specifically Amber Lux (Lever Brothers). Efforts will be made to use this agent more extensively in large-scale efforts in the future, when appropriate. Methods of cleaning that combine two agents should be investigated. One example is an initial cleaning in solvent or mineral oil to remove especially viscous oils, followed by cleaning in a dilute detergent solution to remove the solvent or mineral oil.

Although solvent is an excellent cleaner, it does have the disadvantages of being flammable and toxic to both birds and people through inhalation and skin contact. Workers engaged in cleaning must therefore wear plastic protective gowns and gloves and organic vapor filtering respirators. In addition, fire safety measures, such as fire extinguishers and the removal of spark and flame hazards, are required and careful monitoring of solvent temperature is necessary.

In preparation for cleaning, the solvent is heated to 27 to 32 C (80 to 90 F). (The flash point of Shell Solvent 70 is 40 C or 104 F.) Two or three dishwashing basins are then filled with about 4 inches (10.1 cm) of warm solvent. The bird is dipped in the first basin and the solvent is squeezed into the plumage, working with the lie of the feathers, to loosen the oil. After 30 sec or so, the bird is lifted from the first basin, excess solvent is pressed from its feathers, and it is placed in the next basin. After three or so such baths, most of the oil has been loosened or removed by the solvent, and the bird is then thoroughly rinsed with warm solvent pumped by an explosion-proof pump through small nozzles. Because of solvent toxicity, the cleaning process is limited to only 5 or 6 min, after which the bird is dried with towels and taken to be completely dried with a hot air blower.

The procedure used to clean birds with detergent is somewhat similar to the process involving solvent. Detergents have the advantage of being relatively non-toxic and safe to use. For these reasons, detergents are used to remove more highly refined, toxic oils, and is used for smaller birds, which are more highly affected by toxins absorbed through the skin because of their larger surface/volume ratio.

The most effective brand and the concentration of detergent used depend on the type and "age" of oil encountered. The effectiveness of different detergent solutions should be tested on the plumage of dead, oiled birds. Cleaning with detergent also requires large quantities of hot water--with a temperature of 35 to 46 C (85 to 115 F)--which can be provided by a large tank or coil-type continuous-demand water heater. As in the case of cleaning with solvents, the birds are dipped and then cleaned in several successive basins of hot cleaning solution. After they are cleaned, the birds are rinsed thoroughly with a hot water spray until their feathers begin to resist wetting.

After being cleaned, the birds are dried thoroughly with hot air, in a drier that the Center designed to dry eight birds at at time with a minimum of handling. Pet grooming driers can also be used to dry individual birds. Prior to being dried, the bird is tube-fed hydrating solution, and its feet are protected from excessive heat with A & D Ointment and cloth wraps. It is then dried for 25 to 35 min, until all feathers including the down and those under the wings are completely dry. Thorough drying not only prevents the birds from becoming chilled, but also in the case of solvent cleaning, reduces exposure to the toxic cleaner.

After the drying process, bird handling procedures vary with the type of cleaning agent. Birds cleaned in solvent are quite intoxicated from the effects of the cleaner and require a few hours to recover in safe, well-padded pens. Detergent-cleaned birds, however, do not suffer these effects, but should be left alone in warm pens with plenty of food and water before being handled further.

SWIMMING

After the birds are clean, dry, and rested, they can begin swimming in preparation for release. Some further cleaning of water-soluble stains or detergent residues occurs as the birds swim, but more importantly, they will start to preen their feathers back into the alignment necessary to keep water out and warm insulating air in. This, rather than moult or the replenishment of natural oils, is all that properly cleaned birds need to become waterproof and releasable. As long as the plumage has not been too disrupted by viscous oil, particulate matter, or mishandling, the birds should become waterproof within a very short time of being cleaned.

The best type of pool for a rehabilitation effort is a small--2.4 to 3.6 m (8 to 12 ft)--plastic-lined swimming pool, with a water depth of 30 to 46 cm (12 to 18 in). A filter system and attachments for skimming the surface and vacuuming the bottom are needed to keep the water sufficiently clean. The number of pools needed to provide each bird adequate swimming time varies with the number of birds on hand, their rate of progress in becoming waterproof, and other factors.

At first, birds may be able to stay in the pools for only a few minutes before becoming too wet and cold to swim more. They are then transferred to warm pens, where they usually preen. After they are dry and warm, within approximately 2 to 4 h, they are returned to the pools.

Birds are encouraged to swim as frequently as possible, but must be given time between swims to rest and feed so that they do not become exhausted. Swimming birds require constant observation and frequent handling, and it is often quite difficult to judge how much swimming they can and should be allowed during the course of a day.

RELEASE CRITERIA

Ideally, each bird should become increasingly waterproof with each swim, provided that it has been thoroughly cleaned and is actively preening. After the plumage is waterproof (i.e., the down remains fluffy and the contour feathers resist water despite prolonged swimming), the bird should be considered for release. In addition to having waterproofing status, a bird must be in a physical condition sufficient for its survival in the wild. Feet, legs, and wings must be without injury or damage, and the bird must be active, alert, and of adequate body weight prior to release. Pelagic birds are tested for for salt tolerance before their release since their ability to utilize salt may be depressed by oil ingestion or rehabilitation on fresh water.

SUMMARY

This has been an overview of the methods of rehabilitation that are used at the International Bird Rescue Research Center. In an emergency, the process is more complicated than this presentation may suggest, particularly when large numbers of birds are involved. In the case of a large number of birds, most of the activities of medical treatment, cleaning, drying, feeding, routine hydrating, and other aspects of care must go on simultaneously, requiring a high degree of coordination, a sufficient number of supervisory personnel to direct each activity, and enough workers to carry out each job.

It is beyond the scope of this paper to discuss the kind of preparations that should be made prior to an oiled bird emergency. The plan needed to suit the needs of each area will differ, depending on available personnel, facilities, supplies, and equipment, as well as local species and geography. It has become almost a maxim of rehabilitation, however, that some degree of advanced planning is essential to help make the effort more productive when an emergency does occur.

OPERATIONAL PROCEDURES FOR REDUCING WILDLIFE LOSSES: OVERVIEW AND FUTURE CONSIDERATIONS

Philip B. Stanton[1]

Ecologists have found that bird populations, especially seabird populations, are an integral part of the ecosystem, perhaps to an even greater extent than was formerly realized. Seabird populations are generally quite large and therefore have a tremendous effect on the food chain and overall balance of the oceans of the world. Since mankind looks to the sea for much of its present food as well as for future sources of protein, the importance of seabirds should not be underestimated. Seabird populations are quite vulnerable to oil spills, however, because many species have relatively restricted ranges, nest in colonies along the coast and on islands, or concentrate in large numbers during various seasons.

For many years, efforts have been made to develop effective techniques for saving oil-covered birds. A variety of products and methods have been developed, but only a limited amount of success has been achieved with these developments.

Studies have shown it to be very difficult, and sometimes impossible, to collect oil-covered birds, clean them, and return them to the wild within a few days. For this reason, many birds must be kept in captivity until their waterproofing, body weight, and general health return to normal. Keeping wild birds in captivity presents such problems as providing each species with its proper food and shelter, and preventing injury and disease. The process of keeping birds in captivity is expensive, time-consuming, and often ineffective because many released birds are not able to readjust to the wild after living in a semidomestic environment.

A new approach to the problem of handling oil-covered birds is necessary. Emphasis must be focused on habitat preservation and management, increases in the reproductive potential of affected species, and development of new tanker traffic routes.

Reports of success concerning the rehabilitation of oil-covered birds are often misleading. Each oil spill has its own set of peculiar circumstances. There are differences, for example, in the bird species involved, the type of oil spilled, geographic location, and other physical conditions (water and air temperatures, salinity, etc.). For instance, bird rehabilitation workers on the East Coast may report higher success than those on the West Coast after similar types of oil spills, only because the East Coast workers may be working with scoters and eiders, which are easier to rehabilitate than the guillemots and western grebes present on the West Coast. Individuals and private groups have sometimes reported very high survival rates after rehabilitation work with small groups of birds. However, it would be very difficult to apply their methods on a larger scale where several hundred birds are involved.

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During a large oil spill, it is very difficult to obtain the proper facilities, manpower, and knowledge to cope with the problems of removing oil from birds. To be completely effective, the rehabilitation process must lack any toxic effects and must *immediately* restore the waterproofing and insulating qualities of the plumage, reduce stress, and allow for the immediate release of the birds to the wild. After many years of research on cleaning agents, it has been found that none of those now on the market meet these criteria, and that it will be very difficult to develop a cleaning process that can be applied successfully to all species. A review of rehabilitation efforts of oil-covered birds after large-scale spills indicates a very low level of survival. Whether the surviving birds have become a viable portion of the overall population is not known.

The next logical question is whether to discontinue rehabilitation efforts for oil-covered birds. The answer at this time has to be no. Public sentiment and interest demand that we accept responsibility when man, through his activities, brings harm to any group of living things. There is still a need for rehabilitation centers after an oil spill, where birds can be brought and given the best care possible, with the objective of saving as many as possible. It is also necessary that research be undertaken to study means of improving present cleaning and after-care techniques. In the case of endangered bird species, every effort must be made to save as many individuals as possible to insure that the species will not become extinct.

In the future, a greater effort must be made to divert funds and energies toward gaining a better understanding of the life cycle of various seabirds. More information is needed on breeding, wintering, and feeding of various pelagic species, since present literature on these species is nearly nonexistent. It is equally important to know where various species of seabirds are during different seasons and what their total populations are. Information of this type will enable biologists to pinpoint specific locations of large concentrations of birds and will allow a better understanding of which populations are in jeopardy.

The oil industry can use information of this type to plan and plot present and future tanker traffic routes. In order to avoid a large concentration of birds at sea during certain periods, it may be necessary to reroute ships. The investment of time and money in this sort of effort may seem costly, but this type of program should be considered as an insurance policy against the chance that oil will jeopardize a total population of seabirds. The cost to the environment and the immediate dollar cost to the industry of such a disaster could be phenomenal.

Another consideration for the future is exploration of methods to increase the reproductive potential of various seabirds. Many species, such as auks, petrels, guillemots, and shearwaters, have a very low reproductive potential; they often lay just one egg per year. In many breeding colonies, up to 60 percent of all eggs are lost, mainly because they roll off nesting ledges. It has also been observed that sometimes as many as 40 percent of the young fall off these ledges and die. With such mortality figures in mind, one might ask how these species survive at all in the wild. The answer is that, because of their geographic isolation from man and from most predators, and the relatively long life span of the adult birds, only a low level of annual replacement is necessary to maintain the overall population level. This type of population dynamics is prevalent among many species of seabirds, particularly among those breeding in the northern hemisphere, from New England to the Arctic.

By studying the various populations of breeding birds, we will be able to determine habitat preferences of various species, and possibly the physical conditions conducive to preventing egg and chick losses. Subsequent to gaining such knowledge, we could manage and manipulate areas to produce, hopefully, a substantial increase in numbers of young birds.

There are also numerous uninhabited islands in the world that support many exotic species of plants and animals, which were introduced into the area by man. These foreign plants and animals--the latter sometimes including predators such as feral dogs, feral cats, rats, and foxes--are suppressing or eliminating any existing seabird populations. Efforts must be made to clean up these areas, remove the exotics, and restore the natural habitat. When this is accomplished, native populations could possibly be reintroduced or transplanted from other breeding colonies.

There is a need to establish more sanctuaries and preserves designed to protect remaining breeding areas and to provide for additional habitats. Several islands and important coastal areas are in need of additional protection. A concerted effort must be made by the industry and private organizations to cooperate with international, Federal, and State wildlife agencies in lobbying for the necessary funds to establish such areas. Conservation must definitely become a responsibility of those who plan to manipulate the environment for their own profit. Those individuals must then accept the expense of repairing any damages resulting from their activities.

After these sanctuaries and preserves are established, caretakers could be employed to protect the colonies by managing populations and restricting unwarranted human disturbance. Properly managed seabird colonies can tolerate the presence of humans during nesting seasons without being adversely affected. Additional recreational areas would then be provided, allowing people the opportunity to understand the needs of wildlife and to develop a closer relationship with other living parts of the environment.

Programs such as the ones outlined above should be implemented now in order that losses to populations resulting from oil spills be less than catastrophic.

The time has come for the public to realize that cleaning, rehabilitating, and returning oil-covered birds to the wild is often not the wisest investment of their tax dollar. This idea can be conveyed only through education and implementation of new programs. We must insist on more cooperation among the oil industry and Federal, State, and private wildlife agencies. Biologists in both Federal and State agencies will then have to play a more active role in decisions concerning the treatment of various species of oil-soaked birds. More research and information on nongame species will be required by these agencies. The resulting data will then be used to develop contingency plans to deal with oil spills and affected wildlife species. These agencies may also be called upon to make recommendations on management techniques and policies necessary to repair damage to individual populations.

Not only must government agencies implement these programs but the public must also support wise decisions for the betterment of the environment and mankind.

ROLE OF PUBLIC AFFAIRS DURING AN OIL SPILL

John Mattoon[1]

The telephones in the Public Affairs Office of the U.S. Fish and Wildlife Service in Washington and at the various field offices begin ringing literally the minute news of an oil spill is made public. The public continues to call until the story of the spill fades to the back section of metropolitan newspapers in the vicinity of the incident.

Calls come in from private conservation groups, from news agencies, and from individuals eager to help.

Of greater impact, however, are the television crews and radio and newspaper reporters who descend upon the FWS oil spill coordinator on the scene, who already has his hands full. My remarks today will cover problems encountered at the national and regional level in providing information to the news media. I want to emphasize again that the objective of the Public Affairs Office is not only to provide facts to the public, but also to relieve as much pressure as possible on the personnel conducting the cleanup operation.

The Public Affairs Office is usually not kept up-to-date on developments relating to major oil spills. We are often unable to respond to public inquiries or to requests from the Secretary's Office. This matter requires coordination among all of us since it has become a continuous problem. I hope we can resolve the problem at this workshop.

Until now, we have never taken the time to sit down and work up a Service-wide plan to deal with oil spills. We usually handle each spill as simply another "crisis situation," in which we must scurry about our Washigton office or telephone regional offices to obtain more detailed information.

There has been an increasing number of oil spills in the past few years, and a pattern has emerged concerning public reaction to such events. Oil spills, or possible oil spills, now receive as much media coverage as other controversial issues such as Angola, natural gas shortages, and Gary Gilmore. This situation will not change in the near future.

Before discussing ways in which the media can be more supportive in an oil spill crisis, I shall describe briefly how the Public Affairs Office is organized. The Fish and Wildlife Service is organized into a Washington staff, six regional offices, and an area office in Alaska. Each of the regional offices and the area office in Alaska have a public affairs officer who functions as the regional director's representative and who reports to the Public Affairs Office in Washington. In the event of an oil spill, these men or women are at the service of the regional oil spill coordinator.

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Each of the regional offices has assigned the duties of oil spill coordinator to a specific individual. Part of his or her responsibilities is to keep the Public Affairs Office informed of all developments in the field.

Within the Washington staff, an oil spill coordinator has also been designated. This person is responsible for informing the Washington staff and the Public Affairs staff of all developments relating to an oil spill. These responsibilities remain in force throughout an incident.

Service planning envisages an onsite Fish and Wildlife Service officer, who is responsible for alerting the Service, through the coordinator and Regional Director, of the impact of media and public information requests. If the workload gets too heavy for the on-site team, the Public Affairs staff in Washington and at the field level stand ready to deploy people to the site or to wherever they may be needed.

Out of this pattern comes a few ideas on how to prevent the near panic and anxiety that besets public information officers and others during crises. Some do's and don'ts are suggested.

First, allow me to shock you all just a bit. Oil spills are sometimes good in a very perverse sort of way. Accepting the reality that oil spills are going to occur, I believe that each spill can and will draw intense public attention to wildlife resources. There is no way to change that. In a democracy, an informed public is essential to the functioning of government. In the long run, it will be the public clamor for change that will bring about the actions required to protect wildlife endangered by spills. This help will go the EPA, the Coast Guard, and the Fish and Wildlife Service. Administrators then might view oil spills in two ways--first, as the ecological catastrophe that they are, and secondly, as an opportunity to emphasize the needs of wildlife resources.

This explanation may sound overly simplistic, but it is not intended to be. Regrettably, when oil spills occur, a defensive and "fortress-under-seige" situation seems to occur in the Fish and Wildlife Service. Some bird managers act and react as if they are personally responsible for the spill and the death of birds. Public affairs officers, too, tend to take the defensive because of internal quibbling. Almost immediately, everyone gets bogged down in hairsplitting over "body-count." Whether it is 6 ducks or 6,000 does not diminish public interest in the threat to fish and wildlife resources.

How, then, can we work toward providing a standard approach to public affairs aspects of major oil spills? The public affairs officers at the regional level need to support the overall Federal oil spill effort, regardless of whether they are on the team. Crucial to their efforts is basic biology. For example, a fact sheet could be prepared immediately, giving the most complete biological overview of the area concerned or areas likely to be involved as the spill progresses. Estimates of wildlife populations in the area or areas are essential. The press wants and is entitled to this kind of information.

As the situation unfolds after a spill and actions are taken, the public expects to be kept informed of what is happening. At this point, the agencies involved in the cleanup should provide reasonable figures on confirmed kills.

The news media frequently request information on the long-term effects of a spill. To the extent possible, this information should be provided to the media. This is important since many people believe that if wildlife are not affected immediately after a spill occurs, then the spill will not have any effect. The public seldom considers the long-term aspects.

Another important factor in an oil spill situation is the surge of compassion among the public, particularly young people. Literally hundreds feel compelled to go to the scene and "save the birds." Often these volunteers are quite willing to wade into the murk and mire to gather and help clean oil-soaked birds.

However well-meaning such gestures are, 95 to 100 percent of the birds cleaned by amateurs die in captivity or shortly after release; however, survival rates of 50 percent or higher have been achieved by experienced personnel working with limited numbers of birds of some species under certain circumstances. In addition, it has not yet been clearly demonstrated that a significant number of released birds survive for more than a short period of time. During the next oil spill, it may be useful to develop and disseminate information relating to the complexities of rehabilitating oil-soaked birds, and the factors that limit success.

Choosing the most effective persons for inclusion on an oil spill response team is as important as insuring that the membership of that team is aware of the urgent need to keep the public informed of developments.

One or more team members should devote their time to meeting the information needs of the media and the public. Appropriate officers in charge should be designated to which public statements can be attributed. Periodic statements should be made to the press on behalf of the coordinator, and assistance should be provided to media representatives at the scene with regard to obtaining food and lodging. The team members should also provide any other services that are necessary to assist the coordinator, whether he be from the FWS or some other agency. The most important factor here is access to and support of the operational team leader.

We should not be concerned with who serves as "the lead agency" in an oil spill disaster situation. We should be concerned only that the public demand for accurate and timely information is met. The oil spill contingency plan should clearly state the need for coordination of agency information output; i.e., the Fish and Wildlife Service should not comment on why the spill happened, nor should the Coast Guard comment on estimates of wildlife involved. It may be desirable in major spills to establish a central information source, which reflects all aspects of the spill. In the case of the recent *Argo Merchant* oil spill off Cape Cod, the number of different statements from different sources was staggering. We cannot stop self-styled "experts" from making comments to the press, but we can advise the media, through techniques in the contingency plan, that there will be a coordinated flow of information from the scene.

In this regard, all of the regional public affairs officers of the Fish and Wildlife Service, as well as Washington office staff, are aware that they are to consider themselves available for assignment.

I want to reiterate my belief that we all need to spend some time thinking about and preparing for the next oil spill. Perhaps, the logical starting point is to assemble basic biological data on U.S. coastlines. Then, perhaps we should address the issue of cleaning oil-soaked birds and developing some sort of policy decision on how this facet of future oil spills will be handled. Would a good deal of on-site confusion and emotion be eliminated if it is decided that such humane gestures are truly futile? Or do we, in fact, from the humane standpoint, have to make an effort? In any case, you should discuss this important subject and be prepared, and the public should be informed of the alternatives in advance of the next major spill.

It has been said by prominent observers on the conservation scene that notorious oil spills such as the *Torrey Canyon* incident and the spill at Santa Barbara were instrumental in creating today's environmental awareness. Oil spills, large and small, will continue to be of public concern. The public is entitled to know all that we know about each oil spill. Accurate information can prevent distortions of what actually happened, and may even prevent widespread panic. If the information is well prepared and disseminated in a professional and coordinated manner, it will be of immeasurable benefit to the entire oil spill response effort.

CRITIQUE OF WORKSHOP

Keith G. Hay[1]

INTRODUCTION

I am pleased to participate in the 3-day Oil Spill Response Workshop, cosponsored by the Office of Migratory Bird Management and the Office of Biological Services of the U.S. Fish and Wildlife Service, U.S. Department of the Interior.

The purpose of the workshop is to improve the capability and effectiveness of the Fish and Wildlife Service in responding to oil spills. If the Service will heed the advice presented by the various experts from several agencies during the six sessions of this seminar, I think we will have met that objective. The speakers have disseminated up-to-date information on handling oil/wildlife problems, the responsibilities of the Fish and Wildlife Service, and the biological and technical aspects of oil spill cleanup. They have also presented the views of their respective agencies on oil spill response criteria and their relationship with the Fish and Wildlife Service.

So many important points have been made during these informative addresses that it will be impossible to include them all in this brief critique, but I will try to touch on the highlights as I perceive them. I congratulate all the speakers on a job well done.

The interchange of ideas here has gone a long way toward correcting one of the monumental weaknesses between agencies involved with oil spill cleanups: the problem of inefficient communication. The magnitude of this problem was emphasized in the opening session of the workshop by Harvey K. Nelson, Associate Director for Fish and Wildlife Resources, Fish and Wildlife Service, Washington, D.C.

SESSION I. OPENING REMARKS

A. *Philosophical Approach to Fish and Wildlife Service Involvement in Oil Spill Response:* Harvey K. Nelson

Mr. Nelson reemphasized the purpose of this workshop. To put it bluntly, we are here, he said, to "get the act together." He indicated that although there is room for improvement in the way the Service responds to oil spills, the agency is making every effort to upgrade its activities in this area. He affirmed: "We do care. We can do something...and we are going to settle for nothing less than a very professional job in getting and handling these responses properly." He emphasized the importance of good communications in

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effecting this improvement in services. All agencies, he said, at both the Federal and State levels, must have a clear definition of their responsibilities in the area of response planning and additionally must have adequate funding to carry out these responsibilities. In his words, "everybody within an agency has got to know who carries the ball for that agency" with regard to oil spills. At Fish and Wildlife Service, the ball is being carried by the Office of Migratory Bird Management. According to Mr. Nelson, that office will soon have a full-time coordinator in Washington to handle oil spill problems.[2]

Mr. Nelson stressed how important it is that immediate action be taken to protect wildlife from oil spills. At present, when an oil spill occurs, the Regional Response Team (RRT) meets to determine whether the Fish and Wildlife Service should be called in. It may be too late to save most of the animals affected by the time the team makes that decision. For this reason, he said, the official at the scene must have the authority to initiate appropriate action immediately.

Mr. Nelson stated that, in his opinion, most Congressional legislation has little significance in terms of biology, except in the case of protecting endangered species. Regardless of existing legislation, the Fish and Wildlife Service cannot be insensitive to the fate of birds exposed to the hazards of oil spills. He said the first responsibility is to keep them out of the oil in the first place. In short, it is not *if* but *how* the Service is going to proceed to accomplish this.

B. *Status and Future Trends in Oil Spills and Implications for the U.S. Fish and Wildlife Service:* April E. Fletcher

Ms. Fletcher, of the Office of Migratory Bird Management, indicated that the incidence of oil spills in the coastal waters of the United States has increased tremendously during the last two decades. This increase parallels the twofold increase in the consumption of oil in the United States during the past 25 years. As the demand for oil increased during this period, the smaller tankers of the World War II period were replaced by newer and larger vessels capable of carrying greater cargoes of crude oil. The increasing world ocean-borne trade in oil will continue to provide the impetus for increases in the size of tankers. Giant supertankers are already operating in offshore waters. As the size of tankers continues to increase, there will probably be fewer spills, but when one does occur it will be of much greater magnitude. To emphasize the need for protection of wildlife, particularly birds, Ms. Fletcher showed slides indicating that the major oil ports in the United States are also the locations of major wintering habitat for migratory birds. In her concluding remarks, Ms. Fletcher emphasized that the need for protection of birds from oil spills is going to be with us for a long time.

C. *National Oil and Hazardous Substances Pollution Contingency Plan and Federal Responsibilities:* Richard E. Hess

Mr. Hess of the EPA/Coast Guard Liaison Team stated that the U.S. Department of Interior is represented on the National Response Team (NRT) by the U.S. Geological Survey. (Later, it was recommended that the Department of the Interior representative should be a member of the U.S. Fish and Wildlife Service.) Mr. Hess

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[2]Editor's note: The new position of National Oil and Hazardous Substance Spill Coordinator was filled in the fall of 1977.

discussed the responsibilities of Federal agencies with respect to oil spill response and emphasized the critical need for interagency cooperation in solving oil spill problems. The question of funding came up during his presentation, specifically with regard to the fact that the Fish and Wildlife Service needs to know whether funds are available immediately for use in bird operations.

SESSION II: FEDERAL, STATE AND PRIVATE AGENCY VIEWS ON RESPONSE TO OIL SPILLS AFFECTING WILDLIFE

A. *Needs of the Federal On-Scene Coordinator and Regional Response Team for Wildlife Expertise:* Charles R. Corbett

Commander Corbett, the chief of Marine Environmental Protection for the 9th U.S. Coast Guard District, Cleveland, Ohio, presented a briefing on the cleanup of the St. Lawrence River in 1976, in which 300,000 gal of No. 6 fuel oil were spilled. The cleanup effort, directed by the Coast Guard, involved a joint international response team and required 4 months of work and a cost of $8.5 million. He said the Coast Guard would welcome the assistance of public affairs personnel of the Fish and Wildlife Service in future spills. During his speech, he mentioned a cardinal truism with which anyone who has worked on a spill would agree: that every person (volunteer) involved in the effort is a better expert than you are and one should expect this and act accordingly. He expressed his opinion that the DOI representative on the RRT should be a representative of the Fish and Wildlife Service. He also emphasized the need for field units to have adequate up-to-date information on existing policy and budget allocations with regard to spills and that the units know (as a matter of internal communications) exactly what the policies are, where the funds are coming from, and what funds are available.

B. *California's Response to Pollution Incidents:* Walter H. Putnam

Inspector Putnam, who is patrol inspector for the California Fish and Game Department at Long Beach, affirmed that the States have not taken any initiative in developing wildlife oil spill response plans. According to Inspector Putnam, one has to develop a sustained rapport with the U.S. Coast Guard in order to keep up-to-date on oil spill response capabilities. He emphasized the need for and importance of local government input into State and Federal response teams. He suggested that less emphasis be placed on "the numbers game." As an example, he stated that the RRT is required by law to be activated after a 10,000-barrel spill, but he pointed out that in some cases, depending on the size of spill, its location, and type of product involved, the RRT should be activated after a 5,000-barrel spill, or even a 100 gal spill. In California, State operation centers have been set up to handle spills, and a very definite distinction is made between collection efforts and cleaning efforts. Immediate aerial surveys are made over a spill area and mobile collection stations are set up to aid in the cleanup effort. When cleaning stations are established, they are set up in very restricted areas, such as military reservations, where ingress and egress can be controlled and/or restricted.

In conclusion, he emphasized the need for good public relations representation at the time of the spill and throughout the cleanup effort. Without PR support, the news media is forced to obtain its information from the man on the street. This may lead to inaccuracies and conflicts in reports on the extent of the spill and damages involved.

SESSION III: BIOLOGICAL AND PHYSICAL IMPACTS OF AN OIL SPILL ON THE ENVIRONMENT

A. *Fate of Oil in the Sea:* Richard F. Lee

Dr. Lee of the Skidaway Institute of Oceanography at Savannah, Georgia, discussed processes that determine the fate of oil in the marine environment. His speech included an in-depth presentation on the various physical and biological factors affecting an oil spill. These include: wind, waves, currents, evaporation, emulsion, dissolution, and biodegradation. He also discussed oil uptake by animals and its release or depuration from the animal. Care should be taken with regard to detoxification measures. A lot of people, he said, do not really know what the term "detoxification" means. Dispersing oil may not necessarily mean detoxifying it.

B. *Assessing the Biological Impact of Oil Spills: A New Role for EPA Biologists:* Royal J. Nadeau

Dr. Nadeau of the EPA office at Edison, New Jersey, discussed a variety of subjects including spills from ships, tank farms, and distribution facilities. Oil does not degrade very readily when it becomes imbedded in sand. He said that to a large extent the biological impact of a spill depends on the season of the year. Other important factors include the use of dispersants, steam-cleaning activities, previous exposure of the area to oil, the type and quantity of the oil, and the hydrography of the area affected. He then described the thorough biological documentation process EPA goes through after a spill.

C. *Effect of Oil on Aquatic Birds:* Peter H. Albers

Dr. Albers, from the Patuxent Wildlife Research Center of the Fish and Wildlife Service, Laurel, Maryland, discussed his research. He stated that the most important factor for birds in an oil spill is the amount of time they spend on the water after becoming oiled. Vulnerability of the species depends largely on a variety of seasonal factors. Dr. Albers then discussed more technical aspects of the problem; i.e., the effect of petroleum on avian physiology, hatchability, and hepatic (liver) functions. His research efforts are directed toward an understanding of the full effect of oil on aquatic birds. It will be a long time yet before all the answers are known.

SESSION IV: OVERVIEW OF OIL SPILL RESPONSE TECHNIQUES

A. *Containment and Recovery Techniques for Spilled Oil in the Marine Environment:* M. J. Donohoe

Lt. Donohoe, of the Gulf Strike Team, U.S. Coast Guard, Bay St. Louis, Mississippi, was unable to attend, as he was responding to an oil spill. However, I understand his address will appear in the Proceedings.

B. *Chemical Oil Dispersing Agents and Their Feasibility for Use:* Gerard P. Canevari

Mr. Canevari, representing the Exxon Corporation, Floraham Park, New Jersey, spoke on the feasibility of using chemical oil dispersing agents. He cited several advantages of using dispersants: (1) biodegradation is increased; (2) damage to marine birds is reduced or avoided; (3) the hazard of fire is eliminated; (4) the oil does not wet the surface and adhere to sand particles; and (5) the formation of tar balls is prevented. According to Mr. Canevari, self-mixed dispersants could be sprayed on an area, with only a low level of chemical toxicity resulting.

C. *Federal Viewpoint on Use and Potential of Chemical Oil Dispersants:* J. Stephen Dorrler

Mr. Dorrler of the EPA office at Edison, New Jersey, discussed the use of dispersants in accordance with the authorization under the national contingency plan. He said that dispersants may be used at the discretion of the On-Scene Coordinator (OCS). He indicated he would use dispersants when, in his opinion, their use would involve only a minimal hazard to life and property. The EPA representative on the RRT should be consulted when dispersants are being considered. On the basis of this consultation, the EPA member could recommend that dispersants be used to reduce hazards to waterfowl. The EPA representative could also recommend the use of dispersants when they would reduce overall environmental damage. The question and answer period that followed his speech revealed some aspects of the very difficult process of decision-making in cases; e.g., where it is necessary to trade one environmental factor against the other in deciding whether to use a chemical dispersant.

D. *Restoration of Oil-Contaminated Shorelines:* Robert W. Castle

Mr. Castle of the URS Research Co. at San Mateo, California, spoke on the problem of restoring oil damaged habitats and the monumental task of cleaning up shoreline areas, He discussed how beach cleanup is accomplished. Commander Corbett came back to present an example of some of the latest techniques used in boom deployment and how booms could be specially deployed in waterways to divert oil around sensitive areas.

SESSION V. MINIMIZING IMPACTS OF OIL SPILLS ON AQUATIC BIRDS

A. *Techniques for Dispersing Birds from Oil Spill Areas:* John G. Ward

Dr. Ward with LGL Limited, Edmonton, Alberta, Canada, spoke on various techniques for dispersing birds from oil spill sites. He stated that birds "habituate" to deterrent techniques, and for this reason, no technique can be used for any sustained length of time. In most cases, the birds continue to come back. This, he said, is ample evidence that in general there are no effective, "foolproof" techniques. Also, there are no known techniques for offshore coastal areas and for seabird colonies.

B. *Current Methods of Oiled Bird Rehabilitation:* Anne S. Williams

Ms. Williams is associated with the International Bird Rescue Research Center at Berkeley, California. She discussed the latest techniques for collecting and restoring oil-soaked birds and indicated that the weight of public opinion demands that efforts be made to clean and care for birds affected by oil. She cited the record that the Bird Rescue Center in Berkeley has established in this area. The Center released 125 of 175 birds (a 75 percent return to nature) within 3 days of a spill. The degree of "oiling" of a bird has nothing to do with the decision of whether to employ euthanasia. By far the most important factor in the decision is the amount of stress involved. She then described several forms of stress in oil-soaked birds.

C. *Operational Procedures for Reducing Wildlife Losses: Overview and Future Considerations:* Philip B. Stanton

Dr. Stanton, of the Wildlife Rehabilitation Center at Upton, Massachusetts, stressed the importance of increasing the populations of certain marine avian species. This would be accomplished not by cleaning and returning them to the wild, but by increasing their reproductive potential through management techniques and habitat improvement. He stated that, to his knowledge, no bird species in the continental United States has been jeopardized as a result of oil spills, but that this situation has occurred in other parts of the world. He emphasized the seriousness of oil spills in Arctic waters and their impact on Arctic sea-bird populations.

He questioned the release success of oiled birds that had been cleaned. According to his investigations, about 85 percent of birds that are released from rescue centers die within 6 months. It is not known how many of these would have died from natural causes over the same period of time.

Dr. Stanton then discussed the problems associated with the cleaning of thousands of birds, in the case of major spills. He asked what should be done in situations involving that number of birds.

This point, I think, is a good one: in the case of small spills, every effort should be made to clean and care for all the birds involved and to put these birds through a rehabilitation program. When the spill affects thousands of birds, however, some common sense must be used. To cite an example, I shall describe a situation that occurred in California after the oil spill in 1971. At that time, 7,000 birds were brought in to various rescue centers, each of which was an absolute madhouse. (One cannot comprehend the confusion unless he has experienced the situation.) At some centers, the staff had been working day in and day out for a week. Despite all this effort, nearly 98 percent mortality prevailed. The incident emphasizes the need to look at the total population status of the species involved. It is not practicable to reclaim and clean every bird in a major spill.

Dr. Stanton recommended that the Fish and Wildlife Service take steps to establish bird-cleaning stations, and he also suggested that the public may now be ready to accept the "facts of life" concerning bird-cleaning in general. He said that more information is needed on marine birds, their life history, and their population status, and that an atlas should be compiled indicating sensitive areas containing major bird populations and the seasons at which these populations are highest. Dr. Stanton concluded his speech by stating that it is essential that a uniform national policy be defined on the oiled bird problem not only by the States, but also by the Federal government and industry.

SESSION VI: FWS CONTINGENCY PLANNING AND RESPONSE TO OIL SPILLS

Role of Public Affairs During an Oil Spill: John Mattoon

Mr. Mattoon, the Assistant Director of Public Affairs, Fish and Wildlife Service, Washington, D.C., emphasized that his role was to *support* regional and local staffs involved in oil spill response, rather than dictate the activities of these groups. He said, "We do not intend to publicize tragedies, but we intend to give the facts to the public because they deserve these facts." He said that oil spills have drawn greater attention to wildlife conservation.

CONCLUSION

The 3-day workshop, including the review of the draft contingency plan, has placed the entire problem of wildlife/oil spill response in proper perspective. It is a very difficult and sensitive problem, and this interchange of ideas has been an effective means of bridging the gaps in communication among agencies involved in this effort. The U.S. Fish and Wildlife Service deserves a hearty round of applause for its efforts in sponsoring this conference. May we all continue to work together to solve this most perplexing problem.

APPENDIX

LIST OF WORKSHOP ATTENDEES

Name	Organization
Peter Albers	U.S. Fish and Wildlife Service
James Armstrong	U.S. Fish and Wildlife Service
William Ashe	U.S. Fish and Wildlife Service
James Beers	U.S. Fish and Wildlife Service
Joseph Blum	U.S. Fish and Wildlife Service
Columbus Brown	U.S. Fish and Wildlife Service
Gerard Canevari	Exxon Corporation
Robert Castle	URS Research Company
Ken Chitwood	U.S. Fish and Wildlife Service
Charles Corbett	U.S. Coast Guard
Bill Daugherty	U.S. Fish and Wildlife Service
Donald Dobel	U.S. Fish and Wildlife Service
Steven Dorrler	Environmental Protection Agency
Russell Earnest	U.S. Fish and Wildlife Service
Loren Flagg	Alaskan Fish and Game
April Fletcher	U.S. Fish and Wildlife Service
Paul Fore	U.S. Fish and Wildlife Service
Gordon Frey	Chevron Oil Company USA
Charles Guice	U.S. Geological Survey
Bill Gusey	Shell Oil Company
Don Hankla	U.S. Fish and Wildlife Service
John Hanlon	U.S. Fish and Wildlife Service
Gordon Hansen	U.S. Fish and Wildlife Service

ATTENDEES (cont'd)

Name	Organization
Robert Harwood	Gulf South Research Institute
Keith Hay	American Petroleum Institute
Richard Hess	Environmental Protection Agency
William Hickling	U.S. Fish and Wildlife Service
Joseph Higham	U.S. Fish and Wildlife Service
Bob Hillen	U.S. Fish and Wildlife Service
Guy Hodge	Humane Society
Henry Hosking	U.S. Fish and Wildlife Service
Albert Jackson	U.S. Fish and Wildlife Service
James Johnston	U.S. Fish and Wildlife Service
Arnold Julin	U.S. Fish and Wildlife Service
Nelson Kverno	U.S. Fish and Wildlife Service
Wilbur Ladd	U.S. Fish and Wildlife Service
Richard Lee	Skidaway Institute of Oceanography
David Lenhard	U.S. Fish and Wildlife Service
Calvin Lensink	U.S. Fish and Wildlife Service
Alan Levitt	U.S. Fish and Wildlife Service
Larry Ludke	U.S. Fish and Wildlife Service
John Mattoon	U.S. Fish and Wildlife Service
Royal Nadeau	Environmental Protection Agency
Harvey Nelson	U.S. Fish and Wildlife Service
Mike Nishimoto	U.S. Fish and Wildlife Service
Kathy Osugi	U.S. Fish and Wildlife Service
Bill Palmisano	U.S. Fish and Wildlife Service
Carl Pospichal	U.S. Fish and Wildlife Service

ATTENDEES (Conclusion)

Name	Organization
Walter Putman	California Fish and Game
Gerald Reid	U.S. Fish and Wildlife Service
Wayne Sanders	U.S. Fish and Wildlife Service
Robert Seppala	U.S. Fish and Wildlife Service
Lawrence Smith	U.S. Fish and Wildlife Service
Phil Stanton	Wildlife Rehabilitation Center
Maynard Stephens	Gulf South Research Institute
Howard Tait	U.S. Fish and Wildlife Service
Chuck Walker	U.S. Fish and Wildlife Service
David Walsh	U.S. Fish and Wildlife Service
John Ward	LGL Limited, Canada
Joe Webster	U.S. Fish and Wildlife Service
Don White	U.S. Fish and Wildlife Service
Anne Williams	International Bird Rescue Research Center
Jack Woolstenhume	U.S. Fish and Wildlife Service
Joseph Yovino	U.S. Fish and Wildlife Service

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