

NEW DIRECTIONS IN MARINE POLLUTION CONTROL

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INTRODUCTION

From the earliest times of man's attempts to traverse the world's oceans ships have been interacting with the marine environment. Shipping casualties provide the most obvious manifestation of this interaction, especially if they result in the death of crew or passengers, or in the release of hazardous substances. Whilst by no means the most damaging to the marine environment, the shipping casualties that invariably attract the attention of politicians, the world's media and the public at large are those that result in the spillage of highly visible crude oil or heavy fuel oil.

This paper begins by examining the incidence of major marine oil spills from tankers and other types of ships before describing the potential for controlling the resulting pollution. Particular attention is given to the technical and organisational problems associated with combating major marine oil spills and to some of the 'new directions' that have become evident in recent years, not all of which are helpful. Whilst our ability to deal with oil spills has improved greatly over the past thirty years, there have been no dramatic developments in spill response technology and it is probably unrealistic to expect any in the near future. This statement will be justified during the presentation by illustrations drawn from ITOPF's first-hand experience of having attended on-site at some 400 incidents in more than 75 countries world-wide, on behalf of ship owners, P&I Clubs and the International Oil Pollution Compensation Funds. Such spills include the EXXON VALDEZ in Alaska, USA; the BRAER and the SEA EMPRESS in the UK; the NAKHODKA in Japan, and the IRON BARON in Australia.

INCIDENCE OF TANKER SPILLS

The only real solution to minimising the environmental and economic damage that can result from major tanker spills lies in preventing such events happening in the first place. The graph over the page demonstrates that much has been achieved in this regard over the past two decades. Whilst the relatively small number of spills over 700 tonnes precludes detailed statistical analysis and there are considerable annual variations, the overall trend is clear. Thus, the average number of spills of this size each year in the 1980s and continuing through to 1998 was about one-third of that experienced in the 1970s. The average annual amount of oil lost as a result of tanker accidents has also been reduced since the beginning of the 1980s and now represents less than 0.01% of the total quantity transported by sea each year.

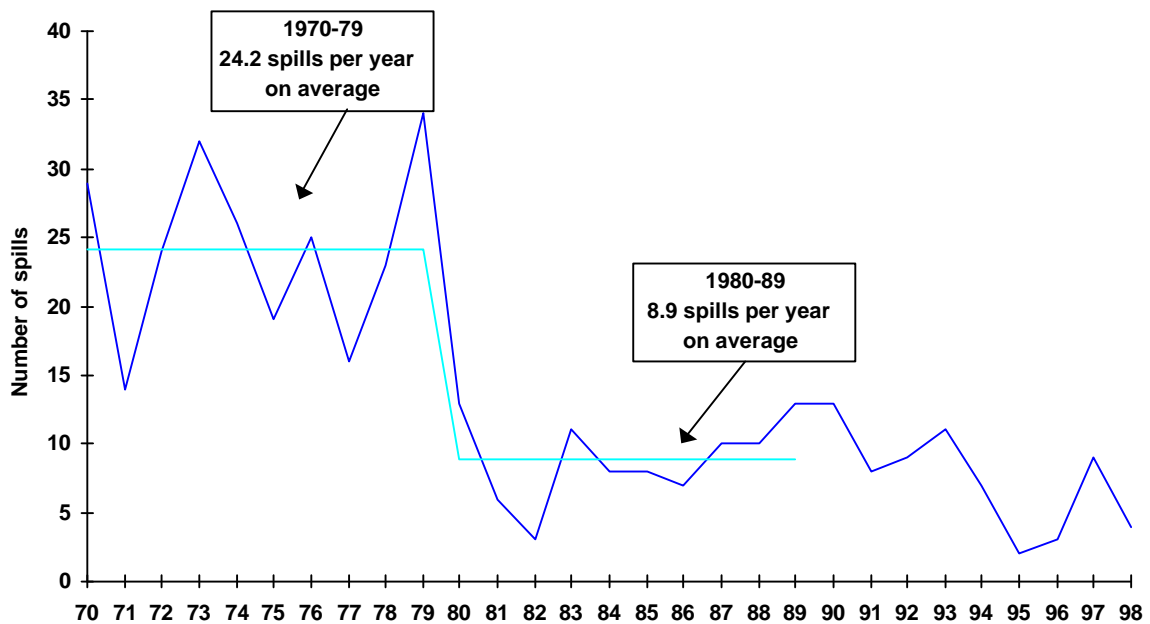


Figure 1. Tanker Spills over 5000 barrels (700 tonnes)

Certain other types of ship, such as container liners and bulk carriers, can carry more bunker fuel than many tankers carry as cargo. While bunker spills tend, on average, to be relatively small they can still cause great problems, as described later. Unfortunately, comprehensive statistics are not available on bunker spills although it would appear that they are relatively frequent on a world-wide basis. This has certainly been shown to be the case in a number of countries where national

statistics are available, including the USA and Australia. It is also illustrated by the fact that about 25% of all the oil spills attended on site by ITOPF staff over the past ten years involved bunker fuel spilled from non-tankers. This gave rise to the decision to allow the owners of non-tankers to become Associates of ITOPF (see Annex 1).

Whilst the reduced incidence of major marine oil spills from tankers is encouraging, world-wide statistics are of little consolation to those whose coastlines and livelihoods are affected by such events. Attention is then understandably focused on the inability to deal effectively with spilled oil on the surface of the sea and thereby prevent it from fouling beaches and damaging wildlife and coastal resources. The truth is that, although the world is now much better prepared and equipped to deal with such problems than it was thirty years ago when the TORREY CANYON ran aground in the South-Western approaches to the English Channel, there are fundamental problems associated with combating major marine oil spills that defy a simple technological solution. To understand these fundamental problems it is necessary to examine some of the main factors that determine the seriousness of a spill, before examining the limitations of the cleanup techniques that are currently available.

TYPE OF OIL

In considering the fate of spilled oil at sea, the need for cleanup, and the nature and seriousness of probable impacts, a distinction is frequently made between non-persistent and persistent oils. Non-persistent oils include light refined products (e.g. gasoline) and even some light crude oils which are highly volatile materials with low viscosities. As they do not normally persist on the sea surface for any significant time due to rapid evaporation and the ease with which they disperse and dissipate naturally there is usually only a limited requirement for cleanup. Such oils may, however, pose a significant fire and explosion hazard as well as cause public health concerns if they occur close to centres of population. They may also cause significant environmental impacts due to their high concentration of toxic components but, as these same components evaporate rapidly, any such effects will be highly localised.

At the other end of the spectrum of oil types are heavy crudes, heavy fuel oils and oils which form stable water-in-oil emulsions ("chocolate mousse") as the oil absorbs up to four times its own volume of water. These oils and "mousses" tend to be highly persistent when spilled due to their

greater proportion of non-volatile components and high viscosity. Such oils have the potential, therefore, to travel great distances from the original spill location, causing widespread contamination of coastlines and damage to amenity areas, fishing gear and wildlife, mainly through physical smothering. As a consequence, the cleanup of heavy oil spills can be difficult, extend over large areas and be very costly. This is well illustrated by the recent NAKHODKA spill in Japan and, longer ago, by the TANIO, which broke up off the north coast of Brittany, France in 1980. In this latter case the cleanup of the resulting spill of some 14,500 tonnes of the heavy fuel oil cargo was in many ways just as difficult as for the 223,000 tonnes of crude oil from the AMOCO CADIZ which had contaminated the same coastline almost exactly two years earlier.

The problem of dealing with heavy oils is also well illustrated by many bunker spills from non-tankers. Such spills can often cause problems that are out of proportion to the amount of oil spilled, as illustrated by the IRON BARON, which grounded on Hebe Reef in northern Tasmania in July 1995. An even more dramatic example is the KURE. This general cargo vessel lost some 17 tonnes of intermediate fuel oil after striking a dock in California, USA in November 1997. The resulting cleanup cost a staggering US\$10 million, excessive even by US standards.

MOVEMENT AND FATE OF SPILLED OIL

When oil is spilled onto the surface of the sea it spreads very rapidly. After a few hours the slick will usually also begin to break up and form narrow bands or "windrows" parallel to the wind direction. Within a very short time, therefore, the oil will often be scattered within an area of many square miles with large variations in oil thickness being evident. This is one of the main factors which limits the effectiveness of any response to a major oil spill in offshore waters, even when responders are at the scene very quickly.

At the same time as the oil spreads, moves and fragments it also undergoes a number of physical and chemical changes, collectively termed weathering. Most of these weathering processes, such as evaporation, dispersion, dissolution and sedimentation, lead to the disappearance of oil from the sea surface, whereas others, particularly the formation of water-in-oil emulsions ("chocolate mousse") and the accompanying increase in viscosity, promote its persistence. Ultimately, the marine environment assimilates spilt oil through the long-term process of biodegradation. The speed and relative importance of the processes depends on factors such as the quantity and type

of oil, the prevailing weather and sea conditions, and whether or not the oil remains at sea or is washed ashore.

RESPONSE OPTIONS

Knowledge of the type of oil and predictions of its probable movement, behaviour and fate are vital in order to evaluate the risk to coastlines and the likely impact of the spill on environmental and economic resources. If the evaluation indicates that the oil will remain offshore where it will dissipate and eventually degrade naturally, it may only be necessary, and indeed feasible, to monitor the movement and fate of the floating slicks to confirm the predictions. On this basis, many of the largest tanker spills of the last 20 years, including the ATLANTIC EMPRESS, ABT SUMMER, CASTILLO DE BELLVER and ODYSSEY did not require a major cleanup response. In other cases a combination of light crude oil and severe weather conditions can also dramatically reduce the need for and feasibility of a cleanup response, even when very large quantities of oil are spilled close to the coastline. The BRAER in the Shetland Isles in January 1993 is an excellent example of this since the entire cargo of 85,000 tonnes of crude oil dispersed naturally in the hurricane force winds and seas prevailing at the time.

If the evaluation of the spill suggests that the oil does pose a serious threat to coastal resources, the next stage is to consider the most appropriate cleanup techniques and the best sources of the required equipment, trained operators and all the other components of a major response operation.

RESPONSE OPERATIONS AT SEA

Two main options are available for combating oil on the surface of the sea: containment and recovery, and chemical dispersion.

Containment and Recovery

The use of floating booms to contain and concentrate floating oil prior to its recovery by specialised skimmers is often seen as the ideal solution since, if effective, it would remove the pollutant from the marine environment. Unfortunately, this approach suffers from a number of fundamental problems, not least of which is the fact that it is in direct opposition to the natural

tendency of the oil to spread, fragment and disperse. Thus, even if ship-borne containment and recovery systems are operating within a few hours of an initial release (which is rare) they will tend to encounter floating oil at an extremely low rate.

Wind, waves and currents, even quite moderate ones, also limit the effectiveness of recovery systems on the open sea by making correct deployment difficult and causing oil to splash over the top of booms or be swept underneath. Even when oil has been concentrated within a boom the problems are not over since many skimmers are only effective with a limited range of oil types, with severe limitations on the pumping of viscous oils and "chocolate mousse".

Because of all these limiting factors it is rare, even in ideal conditions, for more than a relatively small proportion (10-15%) of the spilled oil to be recovered from open water situations. In the case of the EXXON VALDEZ, for example, where enormous resources were dedicated to offshore oil recovery, the percentage was at most 9%.

While at-sea recovery rates may be low when viewed as a percentage of the total volume spilled, the benefit of such operations can be maximised by targeting the heaviest oil concentrations and areas where collection will reduce the likelihood of oil impacting sensitive resources or contaminating shorelines that will be particularly difficult to clean. A higher degree of success can also be achieved by containment and recovery operations in sheltered coastal areas and where floating slicks are concentrated within port areas or by natural features. Equally, improved rates of recovery may be achieved in the event of an on-going release from a tanker, offshore platform or other static source since more time will be available to mount an effective response operation close to the spill source where the oil is fresh and more concentrated. Even in such circumstances, however, adverse weather and sea conditions, logistical problems, equipment malfunction, the difficulty of conducting cleanup operations during the hours of darkness and a variety of other factors will usually result in a significant quantity of oil escaping.

In-situ Burning

Because of the difficulties of picking up oil from the surface of the sea, as well as the problems associated with storing it and the associated water, an alternative technique involves concentrating the spilled oil in fire-resistant booms and setting it alight. Such *in-situ* burning is not new in concept but has recently received renewed attention, particularly in the USA. However, in practice it is

difficult to collect and maintain sufficient thickness of oil to burn and because the most flammable components of the spilled oil evaporate quickly, ignition can also be difficult. Residues from burning may sink, with potential long-term effects on sea bed ecology and fisheries. Closer to shore or the source of the spill, there may be health and safety concerns as a result of the risk of the fire spreading out of control or atmospheric fall-out from the smoke plume.

Dispersants

The main alternative to containment and recovery of floating oil is to try to enhance natural dispersion through the use of chemical dispersants. As with containment and collection, the rapid spreading and fragmentation of oil spilt on the open sea tends to work counter to the effective application of dispersants. However, the likelihood of success can be increased by using aircraft which are able to deliver the chemical more rapidly than ships and with greater precision on to the thickest concentrations of oil or those slicks posing the most significant threat to sensitive resources. The success of such a strategy was well illustrated in the SEA EMPRESS incident in 1996 when the use of about 450 tonnes of dispersant was judged to have removed at least 18,000 tonnes of crude oil from the sea surface, thereby greatly reducing the quantity of oil available to impact sea birds and the coastline of South-West Wales.

However, aircraft of the appropriate type equipped with specialised spraying equipment, as well as the required stocks of suitable dispersant chemical, may well not be immediately available unless they are an integral part of the relevant contingency plan. Delays whilst these problems are overcome can be crucial in the event of a large instantaneous release since the natural weathering of spilt oil and the formation of "chocolate mousse" will rapidly render slicks increasingly resistant to dispersant treatment. It should also be appreciated that some types of oil such as heavy fuel oil and viscous crude are less amenable to chemical dispersion from the outset, although there are new products on the market which have shown promise in laboratory and sea trials in extending the viscosity limit.

In a number of countries the use of dispersants is severely restricted on environmental grounds, although the rapid dilution of the small dispersed oil droplets to below concentrations likely to cause biological damage has been shown to be very rapid in open sea conditions. In these circumstances the decision on dispersant usage should be based on a comparison of the probabilities of significant damage being caused by untreated floating oil slicks (e.g. to birds,

amenity beaches and mangroves) as against dispersed oil droplets (e.g. to plankton, fisheries and coral reefs). In this way it can be established whether or not the controlled use of dispersants will reduce the overall impact of an oil spill on environmental and economic resources to achieve a "Net Environmental Benefit".

Whilst far greater attention has been given in recent years to the concept of "Net Environmental Benefit Analysis" in spill response, it remains the case in many countries that these considerations have not been adequately addressed at the contingency planning stage in relation to the use of dispersants. In such countries it is virtually certain that it will be difficult to resolve any major differences of opinion in the highly charged atmosphere following a major oil spill, thereby reducing the possibility of mounting an effective dispersant spraying operation within the limited time-scale available.

PROTECTING SENSITIVE RESOURCES

The protective booming of sensitive coastal resources, such as mariculture facilities, power stations and ecological and wildlife sites of particular importance, is a response option which can be highly successful. Whilst this 'defensive' approach to oil spill combat can be regarded as a 'new direction' it is unfortunate that it is not always employed to full advantage, often due to the fact that all effort and equipment is tied up chasing widely-spread and fragmented slicks at sea. Furthermore, if such a defensive strategy is to be employed with success, there must be agreement at the contingency planning stage as to which resources are to be given priority for protection. It must also be ascertained in advance that their protection is feasible since otherwise it may be discovered during an actual incident that, for example, the currents are too strong for booms to be anchored in the desired configuration.

SHORELINE CLEANUP

It is impossible to protect an entire coastline and every sensitive resource with equal success and so in a major oil spill some contamination of coastal areas is virtually inevitable, unless winds and currents carry the oil offshore where it breaks down naturally. Effort should first be directed to areas which have the heaviest concentrations of mobile oil, which could otherwise migrate to nearby uncontaminated areas. The removal of floating oil from harbours and elsewhere where it

becomes concentrated is relatively straightforward, using a combination of specialised booms and skimmers and locally-available resources such as vacuum trucks and similar suction devices, so long as there is good access.

Once the oil has stranded on shorelines a combination of cleanup techniques is normally used. In order that the clean-up does not cause more damage than the oil alone it is vital that techniques are selected that are appropriate for the particular shoreline types, the level of oil contamination and the priority concerns (e.g. environmental recovery or amenity).

Shoreline cleanup is usually highly labour intensive and not a 'high-tech' business. Reliance is therefore once again usually placed on locally-available equipment and manpower, rather than specialised equipment. Thus, bulk oil can usually be removed without difficulty from hard-packed sand beaches using a combination of well-organised teams of manual labourers assisted by front-end loaders and road-graders, so long as care is taken not to remove excessive quantities of uncontaminated sand or to mix the oil deeply into the beach substrate.

Greater problems are caused where oil penetrates deeply into shorelines consisting of boulders, cobbles or gravel since it is rarely practical to do more than remove surface accumulations which would otherwise provide a reservoir for the re-contamination of other previously-cleaned areas. If amenity or wildlife concerns dictate a more thorough cleanup, the most effective technique is likely to be sea water flushing, with the containment and collection of any oil that is released using booms and skimmers. It may also be feasible to bulldoze contaminated cobbles and coarse gravel into the surf zone to enhance natural cleaning.

On many occasions with rocky and cobble shores experience has shown that environmental recovery is fastest when natural processes are relied upon to deal with any residual oil. A similar approach of leaving the oil alone is also usually recommended for sensitive shoreline types such as salt marshes and mangroves, which again have been shown to be more easily damaged by the physical disturbance caused by cleanup teams and vehicles than by the oil itself.

The environmental sensitivity of a particular stretch of coastline and the use to which it is put (e.g. as an amenity beach) will always need to be balanced in order to determine the most appropriate approach, as well as the degree of cleaning and its termination. This last aspect can be a highly

contentious issue with considerable implications for the overall cost of an oil spill. Particular problems in this regard can arise if political considerations over-ride technically justified solutions. This is an unfortunate 'new direction' in many parts of the world.

DISPOSAL OF OILY WASTE

At-sea recovery and shoreline cleanup generate substantial amounts of oil and oily waste which need to be transported, temporarily stored and ultimately disposed of in an environmentally-acceptable manner. This may result in liquid oil and oily water being reprocessed at a refinery or being used as low-grade feedstock in some industrial processes. Other disposal final routes include landfill, land farming, incineration or use of the stabilised material in construction projects.

The disposal of oily waste often continues long after the cleanup phase is over, especially if the material falls under regulations designed to deal with highly toxic or hazardous waste. In such circumstances it is even more regrettable when the relevant government agencies have been reluctant to address the issue at the contingency planning stage, with the result that when a spill occurs cleanup operations have to be suspended until at least a temporary storage solution is worked out. This is an area where a 'new direction' is desperately required in many areas of the world.

MANAGEMENT OF SPILL RESPONSE

Whilst the technical aspects of dealing with an oil spill, including the availability of good equipment and operators, are clearly important, the overall effectiveness of the response will ultimately depend upon the quality of the contingency plan, and of the organisation and control of the various aspects of the cleanup operation. Numerous difficult decisions as well as compromises will be required throughout the response operation, and the widely differing requirements of a multitude of governmental and private organisations, as well as public and political pressures will need to be reconciled.

In some countries there is an increasing tendency to manage spills by committee, with all interested parties being allowed access to the decision-making process, whether or not they are technically qualified to participate. Whilst this 'new direction' may be democratic, it is not

conducive to the rapid decision making required in any emergency response situation since it leads to very large, unwieldy spill management teams and high associated costs. It is therefore preferable that the legitimate concerns of all interested parties in relation to response strategies and priorities are addressed during contingency planning, leaving a single On-scene Commander or, at most, a small team to direct operations during an actual incident.

The effectiveness of spill management can also have major implications for the overall cost of an oil spill cleanup operation. One of the crucial factors will be whether decisions are made primarily on technical grounds or whether other factors are paramount. Thus, on many occasions the ineffectiveness of offshore oil-combating techniques and the inappropriateness of cleaning certain types of shorelines will be ignored and as many resources as possible will be deployed in an attempt to persuade politicians, the media and public that everything possible is being done to deal with the problem. The fact that the operations themselves may be more damaging to the environment than the oil is often not a persuasive argument. Equally, the requirement that every trace of oil must be removed to assuage public anger and to meet the demands of politicians is neither possible nor environmentally sound. The fact that it is also likely to result in exorbitant cleanup costs is unlikely to be a major concern for those making the demands unless, of course, they will have to directly bear the costs, in which case a greater degree of realism may prevail. In this regard it is important to note in passing that the technical justification of response measures ("reasonableness") is fundamental to the effective operation of the international compensation Conventions, including the 1992 Civil Liability and Fund Conventions, both of which have been ratified by Australia and New Zealand. (For further information on Claims Admissibility issues under the 1992 Civil Liability and Fund Conventions reference should be made to the 1992 IOPC Fund's Claims Manual).

CONTINGENCY PLANNING

It will be clear from the above that a major oil spill will present those in charge with numerous, complex problems, some of which will be non-technical in nature. There is a greater likelihood that prompt and effective response decisions will be made if considerable effort has been devoted in advance of any spill to the preparation of comprehensive, realistic contingency plans for different levels of risk. Issues which are difficult to resolve in 'peace time' are likely to become major conflicts in the highly charged atmosphere following a major spill when everyone should be

working together in a common desire to cleanup the oil as effectively as possible with the minimum of damage to the environment and economic resources.

The preparation of contingency plans and enhanced cooperation between various interested parties (including between governments and the oil and shipping industries) is a key element of the International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990 (OPRC). One facet of this Convention, which was developed by the IMO in the wake of the EXXON VALDEZ incident, is the enhanced potential availability of cleanup resources from neighbouring governments, possibly through bi-lateral, multi-lateral, regional or other agreements, or from international cooperatives or oil industry stockpiles.

Whilst this 'new direction' can be helpful in the event of a major incident, total reliance should never be placed on the availability of international resources, especially if arrangements have not been put in place to ensure their rapid mobilisation and transport, to facilitate their entry into a country and to agree the financial basis. In addition it must be recognised that the effective deployment of equipment brought into a country from further afield will always be dependent upon the receiving country's own contingency plan. Without the foundation of an organisational structure, adequate logistic support (e.g. transport within the country, suitable boats, oil storage facilities) and a clearly defined response policy and strategy in the country requiring assistance, international resources will, at best, be of limited value and may, at worst, be unusable.

CONCLUSIONS

Major tanker spills are now, thankfully, exceptionally rare events. However, smaller spills, including bunker spills from non-tankers, continue to cause problems and are increasingly being viewed by governments and the public as serious events. Positive 'new directions' in controlling marine oil spills tend to be manifest as improvements in oil spill contingency planning, response strategies, equipment, and in the routine application of our greater understanding of the environmental effects of oil spills and cleanup techniques. All such initiatives enable oil spills to be dealt with more effectively than was the case thirty years ago but a dramatic technological breakthrough that will overcome the fundamental problems associated with combating oil on the surface of the sea remains elusive and improbable. The best that we can strive for in the event of a major spill is that everyone involved will co-operate in mounting the most effective response that existing technology

and the circumstances of the incident will allow. In this context it is important that full attention is given to the experience and technical knowledge accumulated world-wide over the past three decades so that past mistakes are not repeated, and that adequate attention is given to the organisational aspects of spill response.

ANNEX 1

The International Tanker Owners Pollution Federation (ITOPF) was established as a non-profit making organisation in 1968 for the principal purpose of administering TOVALOP, the tanker industry's voluntary oil spill compensation agreement. Since the termination of this agreement on 20th February 1997, ITOPF's sole function has been the provision of a broad range of technical services to and on behalf of shipowners (most particularly the organisation's 4,000 tanker owner Members), their P&I (oil pollution) insurers and others prominently involved in oil spills, most especially the International Oil Pollution Compensation Funds.

Given ITOPF's high level of involvement in bunker spills from non-tankers, it has been decided with effect from 20th February 1999 to offer Associate status to the owners of such ships so that they can benefit from ITOPF's technical services on a similar basis to tanker-owner Members. In return, they will be required to contribute to ITOPF's running costs through the payment of Associate dues at a rate that is about one third of that paid by tanker owner Members. As is the case with ITOPF's tanker owner Members, the P&I Clubs and other third party liability insurers will look after the administrative procedures involved with Associate status, including the payment of dues, on behalf of their shipowner members.

This is an exciting 'new direction' that will reinforce ITOPF's position as the maritime industry's primary source of objective technical advice, expertise, assistance and information world-wide on effective response to ship-source pollution.

ITOPF's technical services fall under the headings of:

- Response to Marine Oil Spills - This is ITOPF's priority technical service and is normally performed, without charge, at the request of its Members, Associates and their P&I insurers. The

International Oil Pollution Compensation Funds also usually call on ITOPF's technical services for incidents with which they are involved. Since 1977 ITOPF technical staff have attended some 400 spills in about 75 countries.

- Damage Assessment and Claims Analysis - Assessment of the technical merits of claims for compensation - both in relation to cleanup and damage to economic resources such as fisheries and mariculture - is a natural extension of ITOPF's on-site attendance at the time of a spill. Requests for such assistance are received not only from shipowners and their oil pollution insurers but also from the IOPC Funds. It is important to emphasise that ITOPF's role is one of providing advice on the technical merit of claims. It is not for ITOPF but for those who will pay the compensation to decide whether or not a particular claim should be settled.
- Contingency Planning and Advisory Work - Because of the experience gained through active involvement in spills around the world, ITOPF is often asked to advise on the preparation of contingency plans and to undertake other advisory assignments.
- Training and Education - ITOPF runs and participates in numerous training courses and seminars for government and industry personnel around the world, as well as oil spill drills and exercises conducted by tanker-owner Members and other groups.
- Information - The widespread dissemination of ITOPF publications is designed to keep Members and others around the world in touch with developments in relation to oil spill preparedness, response and compensation. Various databases are also maintained, including on the world-wide incidence of tanker spills and on the availability of stocks of cleanup resources. Since mid-1996 ITOPF has also maintained an extensive Web site on the Internet, which can be found at:

<http://www.itopf.com>

In addition to the above specific areas of technical activity, ITOPF regularly contributes on behalf of its Membership to national and international discussion on matters related to oil pollution. Since 1980 ITOPF has had observer status at both the IMO and the IOPC Funds.

ITOPF PUBLICATIONS:

1. Technical Information Papers 1-12 (1981-1986).

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| 1 "Aerial Observation of Oil at Sea" | 2. "Use of Booms in Combating Oil Pollution" |
| 3 "Aerial Application of Oil Spill Dispersants" | 4 "Use of Oil Spill Dispersants" |
| 5 "Use of Skimmers in Combating Oil Pollution" | 6 "Recognition of Oil on Shorelines" |
| 7 "Shoreline Cleanup" | 8 "Disposal of Oil and Debris" |
| 9 "Contingency Planning for Oil Spills" | 10 "The Effects of Marine Oil Spills" |
| 11 "Fate of Marine Oil Spills" | 12 "Action: Oil Spill" |

2. "Response to Marine Oil Spills", pub. Witherby & Co. Ltd., London (1987), ISBN O 948691 51

4. Available in English, French and Spanish.

3. "Ocean Orbit" - ITOPF's Annual Newsletter.

4. "The Real Story - the Environmental Impact of the BRAER", a video produced by The Marine Laboratory, Aberdeen and available from ITOPF.