THE ENVIRONMENTAL IMPACT OF MARINE OIL SPILLS -

Effects, Recovery and Compensation

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INTRODUCTION

The short-term effects of oil spills on marine species and communities are well known and predictable. However, concerns are often raised about possible longer-term ("sub-lethal") population effects through, for example, low levels of residual oil affecting the ability of certain species to breed successfully. In fact, extensive research and detailed post-spill studies have shown that many components of the marine environment are highly resilient to short-term adverse changes in the environment in which they live and that, as a consequence, a major oil spill will rarely cause permanent effects.

The marine ecosystem is a highly complex environment and natural fluctuations in species abundance and distribution are a feature of the normal way it functions. These fluctuations can be large and difficult to relate to particular causes, as well as difficult to measure adequately. Against this background it is inevitably difficult to establish the precise extent and likely duration of environmental damage caused by an oil spill and to distinguish such impacts from changes brought about by a variety of other factors, both natural (e.g. climatic or hydrographic changes) and man-made (e.g. commercial fishing or other industrial pollution). Despite the scientific evidence that is available to the contrary, there is frequently a basic presumption that damage must have been caused by an oil spill, and terms such as "injury", "harm", "loss" and "impairment" are used without reference to any defined meaning or reliable evidence of a causal link.

There is also a presumption that everything has a price and that money can always compensate for the damage. In truth, the natural recovery of an affected area is frequently rapid and man is rarely able to do more than help speed up the process through judicious clean-up and restoration. It follows, therefore, that there is a limit to the extent that compensation obtained from the 'polluter' can be used to the direct benefit of a damaged environment.

This paper briefly summarises the impact of oil spills on different components of the marine environment, as well as the potential for natural recovery and man-made restoration/re-instatement measures, as envisaged under the international compensation Conventions.

BIOLOGICAL IMPACTS AND THE RECOVERY PROCESS

Impacts

The environmental impact of oil spills has been extensively researched over the past 30 years and a considerable amount has been learnt about the nature and duration of such effects. As a result, our predictive capability is probably better for oil spills than for many other types of marine pollutant.

The range of biological impacts after an oil spill can encompass:

- Physical and chemical alteration of natural habitats, e.g. resulting from oil incorporation into sediments;
- Physical smothering effects on flora and fauna;
- Lethal or sub-lethal toxic effects on flora and fauna;
- Changes in biological communities resulting from oil effects on key organisms, e.g. increased abundance of intertidal algae following death of limpets which normally graze the algae.

More detailed consideration is given to impacts on a range of habitats and species later in this paper.

Recovery

The seriousness of oil spill impacts is primarily related to the speed of recovery of the damaged habitats and species. However, misunderstandings often arise because of the use of different criteria to determine recovery. Given the difficulties of knowing exactly what pre-spill conditions were, and how to interpret them in the face of natural ecological fluctuations and trends, it is unrealistic to define recovery as a return to pre-spill conditions. The following definition developed by a group of independent scientists takes these problems into account:

> "Recovery is marked by the re-establishment of a healthy biological community in which the plants and animals characteristic of that community are present and functioning normally. It

> may not have the same composition or age structure as that which was present before the damage, and will continue to show further change and development. It is impossible to say whether an ecosystem that has recovered from an oil spill is the same as, or different from, that which would have persisted in the absence of the spill."

Recovery depends upon both removal of oil which is toxic or physically smothering, and biological processes, e.g. settlement of larvae and growth of seedlings. Whilst clean-up is normally the first step in the recovery process, complete removal of all oil is not necessary - there are many examples of recovery progressing in the presence of weathered oil residues.

Whatever the extent of damage, the reproductive success of the survivors, as well as the influx of eggs, juveniles or adults from unaffected areas underpins the recovery process. Many marine species produce vast numbers of eggs and larvae which are widely distributed in the plankton by currents. This is a strategy to overcome high rates of natural mortality (sometimes reaching 99.99%). The number of eggs and larvae which survive and eventually develop into adults is therefore normally very low, but this over-production strategy ensures that there is a considerable reservoir for the colonisation of new areas and the replacement of adults which have been killed as a result of short-term unfavourable conditions.

On the other hand, species which are long-lived, slow to breed and which produce few offspring may take many years to recover from the effects of a short-term adverse change in their environment, even though they too may have in-built compensatory mechanisms (e.g. some species of seabirds have been shown to mature earlier and to have extra broods after a period of population decline). As with short-lived species, migration of adults and juveniles from neighbouring areas which have escaped the unfavourable conditions frequently enhance the recovery process.

Factors that Determine Seriousness of Impact and Speed of Recovery

Factors which have proved to be important in determining oil spill impacts and subsequent recovery rates include oil type; oil loading (the thickness of deposits on the shore); local geography, climate and season; the biological and physical characteristics of the area; relative sensitivity of species and biological communities; and type of clean-up response.

Type of oil

Different crude oils and oil products vary widely in their physical and chemical properties. Severe toxic effects are generally associated with hydrocarbons with low boiling points (particularly aromatics) because these hydrocarbons are most likely to penetrate and disrupt cell membranes. The greatest toxic damage will therefore tend to be caused by spills of light oil (e.g. gasoline) or 'fresh' crude. However, the most toxic components are also those that evaporate and disperse into the atmosphere most rapidly once the oil is released and so any toxic effects on marine life are likely to be highly localised and short lived.

Spills of viscous heavy oils, such as some crudes and heavy fuel oil, may blanket areas of shore and kill organisms primarily through smothering (a physical effect) rather than through acute toxic effects. This is also the case with viscous water-in-oil emulsion ("mousse"). If thick layers of oil or mousse are not cleaned up they may incorporate sand, gravel and stones and harden into relatively persistent asphalt pavements.

Biological characteristics of the area

Open waters of the oceans and the associated pelagic and seabed communities have rarely shown any impact from spills. The high dilution potential that this habitat provides is a major mitigating factor. Even though laboratory research has shown that planktonic organisms which live in surface waters can be variously affected by oil, no long-term effects have been demonstrated due to their huge regenerative potential, as well as immigration from outside the affected area. This regenerative potential is fundamental to the important role the plankton plays in the food chains of the world's seas and oceans.

Concerns are often expressed about the effects of spills on fish and shellfish eggs and larvae which are found in the plankton, especially as their sensitivity to oil pollution has been demonstrated in laboratory toxicity tests. However, there is no definitive evidence that oil induced mortalities of fish and shellfish eggs and larvae in the open sea have resulted in significant effects on future adult populations. This is not surprising because oil-induced mortalities of eggs or young life stages are often of little significance compared with huge natural losses each year (e.g. through predation, temperature changes or storms).

Probably the most vulnerable of the organisms which use open waters are sea birds, which are easily harmed or killed by floating slicks. Although oil ingested during preening may be lethal, the most common cause of death is from drowning, starvation and loss of body heat following damage to plumage by oil. Nevertheless, research has rarely shown any detectable impact from spills on breeding populations, even when mortalities from oil contamination are known to have been high. Shore birds, notably waders, are also at risk though are less likely to become seriously and lethally oiled than seabirds that live and feed on the open sea.

Whales, dolphins and seals in the open sea are not particularly at risk from oil spills. Marine mammals that breed on shorelines are, however, more likely to encounter oil. Species at particular risk are those which rely on fur for conservation of body heat (e.g. otters). If the fur becomes matted with oil, they cannot regulate their body heat and may die from hypothermia or overheating.

Shorelines, more than any other part of the marine environment, are exposed to the effects of oil as this is where it naturally tends to accumulate. The degree of oil retention by a shore considerably affects the short-term impact and duration of damage. Retention depends upon the condition of the oil and beach type e.g. rock, sand, shingle, mud flats. More viscous oils tend to be retained in greater quantities as surface accumulations than less viscous oils. Broken, uneven and gently sloping shorelines with a large tidal range can hold more oil than steep, smooth shores with a small tidal range.

Rocky and sandy shores which are exposed to wave action and the scouring effects of tidal currents are amongst habitats which are most resilient to the effects of a spill, and they tend to self-clean relatively rapidly. These shorelines often have communities of highly adapted species, especially grazers and filter-feeders. If grazers are killed by oil, seaweeds rapidly settle, followed by a slow return of grazers by recolonisation and new recruitment. Recovery to an apparently normal balance is often achieved in 1 - 5 years, but the complete re-establishment of a shore can take many years in extreme situations where very large areas are affected or where species are close to the limits of their geographical range and recolonisation proves to be slow.

If sediments are penetrated by the oil, then considerable quantities may be held and the likelihood of long-term retention and longer-term impacts is greatly increased. However, the more viscous nature of weathered oils may result in reduced penetration compared to fresh, less viscous crudes.

Fine sediments (fine sands and mud) are usually found in more sheltered areas, and tend to be highly productive, particularly in estuaries. They support large populations of migrating birds as well as shell fisheries, and also function as nursery areas for some species. Whilst oil can exert immediate toxic and smothering effects, penetration of the oil to deeper layers is rare, especially if sediments remain waterlogged during low tide. However, there have been cases of oil penetrating into animal burrows, and once oil is incorporated within the sediment it can delay natural recovery.

In fine sediment areas the upper shore fringe is often dominated by saltmarsh which, although generally only temporarily harmed by single oilings, can take more than 10 years to recover if damaged through repeated oilings. However, long-term damage is more usually the result of using inappropriate clean-up techniques than as a direct consequence of oiling. In tropical regions, mangrove swamps become established in preference to saltmarshes, and are an extremely rich and diverse habitat, important in coastal defence and for their high biological productivity. The trees which provide the structure of this community are easily harmed if oil coats their breathing roots or if toxic oils penetrate sediments. Where oiling is heavy and high mortality follows, natural recovery can take several decades. Like saltmarsh, they can be easily damaged by inappropriate attempts at cleaning, and scientific evidence suggests they are usually best left undisturbed.

Time of year/season

The effects of a spill may vary markedly between winter and summer. Winter oiling of a saltmarsh may have little effect on the above-ground parts of plants as many naturally die-back at that time of year. However, oil can affect over-wintering seeds and reduce germination in the spring. In spring or summer oil can damage new growth and may cause a marked reduction of flowering if plants are oiled when the flower buds are developing. Even though there may be good vegetative recovery, there is loss of seed production for that year.

According to season, vulnerable groups of birds or mammals may be congregated (perhaps with young ones) at breeding colonies, and fish and shellfish may be spawning in shallow nearshore waters. Winter months may see large groups of migratory waders and sea ducks feeding in estuaries and coastal areas. At such times the effects of a spill can be considerably increased.

Clean-up

According to circumstances, clean-up efforts can decrease or increase damage. Decisions frequently have to be made between different, conflicting environmental concerns, or between environmental and economic concerns. Weighing up the advantages and disadvantages of any clean-up method is known as net environmental benefit analysis, and this should be considered as part of the contingency planning process. In many cases, the predicted natural cleaning times may be acceptable, either because they are short, or because, even if long, no net environmental benefit can be predicted by human intervention.

COMPENSATION FOR ENVIRONMENTAL DAMAGE

Victims of oil spills from tankers benefit from having access to an international system of compensation that has been in place for some 25 years and is based on the Civil Liability and Fund Conventions. These Conventions are described in another paper by Mr Måns Jacobsson, Director of the International Oil Pollution Compensation Funds. This system remains unique in the field of marine environmental pollution and ensures that those who incur costs or suffer financial loss as a result of an oil spill from a tanker can be promptly compensated.

It is important to note that the principle of compensation is to ensure that claimants are left in the same financial position as they would have been had the oil spill not occurred. This poses a potential problem in the case of damage to natural resources that are not commercially exploited. This has resulted in some groups resorting to abstract calculations using a formulaic approach that attempts to ascribe monetary or market values to those sectors of the marine environment that have allegedly been damaged by a spill.

Whilst it is clear that oil spills can cause environmental damage and that some characteristics of a spill may appear to be relatively easy to measure or quantify (e.g. the type of oil and amount spilled), it is impossible to extrapolate to the nature and extent of damage that will be caused. Because of the interactions of a great number of factors, two spills in the same place will have very different environmental consequences depending, for example, on the time of year, weather conditions and success of the clean-up.

By attempting to oversimplify a very complex and changing situation, the drafters of formulae simply end up with a ‘product’ that may be easy to implement but that is neither scientific nor bears any relation to the true effects of oil spills on the environment, and takes no account of the speed of natural recovery. Attempting to attach a monetary value to this distorted image of reality leads to inconsistencies and injustices and the impression that the main desire is to penalise the 'polluter', with any funds so generated usually being channelled into unrelated activities. Given that the Civil Liability and Fund Conventions require compensation to be paid regardless of fault on the part of the tanker owner, it is inconsistent that attempts should also be made under the system to penalise the same parties for damages that do not affect the financial well-being of individual claimants.

The Civil Liability and Fund Conventions do, however, provide a more direct and rational approach to the problem of compensating for damage to the environment by following the principle of economic loss, in this case resulting from restoration or re-instatement measures. This is a concept that is based on real-world economics and which is designed to benefit the damaged environment. It also provides a realistic alternative to a problem which might otherwise become highly divisive, as well as damaging to the interests of those who have suffered real economic loss.

Restoration of a damaged environment is clearly an extension of clean-up and requires positive steps to encourage natural recovery, especially in some specific instances where such recovery would otherwise be relatively slow. An example of such an approach following an oil spill would be to replant a salt marsh after the bulk oil contamination had been removed. In this way erosion of the area would be prevented and other forms of biological life encouraged to return. A similar approach could be adopted in the case of mangroves. However, it is clear from the earlier summary of natural recovery processes that attempts at restoration will neither be feasible nor appropriate in every case. In many instances natural recovery proceeds sufficiently quickly that attempts at intervention by man, other than by judicious clean-up, would have no benefit.

Whilst it is frequently possible to help restore damaged vegetation and physical structures, animals are generally a more difficult problem. In some cases an artificial breeding programme or enhanced protection of a natural breeding population at a nearby site may be warranted to help overcome pollution related losses. Thus it may be feasible to encourage, for example, a greater natural survival of juvenile turtles or birds in areas unaffected by the oil spill through affording the area special protected status. By minimising early predator impact this protected population could be expected to flourish thereby providing a reservoir from which the recolonisation of the damaged areas would occur. It may in some cases even be justified to carry out an artificial breeding and release programme if the technology exists and the likelihood of a successful enhancement of the wild population is high. The justification for any such approach would, however, have to be the enhancement of natural recovery and there would have to be a high level of certainty that this would occur before the programme could be considered acceptable. Any programme that was purely experimental or merely carried out to satisfy public demand and outrage would clearly have little practical benefit in terms of restoration.

Given the complexity of the marine environment it follows that there are significant limits to the extent to which damage can be repaired by artificial means. It also follows that attempts to meticulously reinstate a damaged site will, in many cases, both be impossible and unreasonable, especially if natural recovery is likely to be rapid. In addition it must be appreciated that excessive intervention by man, for example, by trying to remove every last drop of a pollutant, or by trying to 'engineer' the environment can often itself be destructive and hinder natural recovery. The appropriate clean-up and restorative response will therefore always depend upon the environment in question and the nature and extent of the impact.