IMO/IPIECA REPORT SERIES

VOLUME ONE

SENSITIVITY MAPPING FOR OIL SPILL RESPONSE

IMO
International Maritime Organization

IPIECA
International Petroleum Industry Environmental Conservation Association

IMO

The International Maritime Organization (IMO) is the United Nations' specialized agency responsible for the improvement of maritime safety and the prevention and control of marine pollution. There are currently 153 member states and more than 50 non-governmental organizations (NGOs) participating in its work which has led to the adoption of some 30 conventions and protocols, and numerous codes and recommendations concerning maritime safety and marine pollution. One of the most important goals of IMO's Strategy for the Protection of the Marine Environment is to strengthen the capacity for national and regional action to prevent, control, combat and mitigate marine pollution and to promote technical cooperation to this end.

IPIECA

The International Petroleum Industry Environmental Conservation Association (IPIECA) is comprised of oil and gas companies and associations from around the world. Founded in 1974 following the establishment of the United Nations Environment Programme (UNEP), IPIECA provides one of the industry's principal channels of communication with the United Nations. IPIECA is the single global association representing both the upstream and downstream oil and gas industry on key global environmental and social issues including: oil spill preparedness and response; global climate change; health; fuel quality; biodiversity; social responsibility; and sustainability reporting.

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PREFACE

The International Convention on Oil Pollution Preparedness, Response and Cooperation 1990 (OPRC Convention), which entered into force in May 1995, provides the framework for international cooperation in combating major oil pollution incidents. An underlying premise of the OPRC Convention is the understanding that prompt and effective action is essential in order to minimize the damage which may result from such an incident. The Convention specifically recognizes and emphasizes the important role which the oil and shipping industries have in this regard.

Thus the partnership with IMO and industry is both logical and called for by international convention. In 1993, a working group of the IMO Marine Environment Protection Committee (MEPC) charged with promoting the implementation of the OPRC and its resolutions agreed that it would be useful for IMO and industry organizations to produce joint publications where appropriate, to avoid duplication and to ensure wider acceptance and common use by government and industry of the advice contained therein. As a result, collaboration between IMO and IPIECA has led to the development of a series of joint publications. This report, entitled *Sensitivity Mapping for Oil Spill Response*, is the first in the series and will be shortly followed by the IMO/IPIECA *Guide to Oil Spill Exercise Planning*.

These publications represent a consensus of industry and government viewpoints tested through the parallel review process of IMO's Marine Environment Protection Committee and the IPIECA Oil Spill Working Group. The information provided by these publications should be useful to governments and concerned organizations, particularly those of developing countries, desiring to improve capability to deal with oil spillage. IMO and IPIECA have separately published other manuals and reports on various aspects of oil spill preparedness and response (see *Further Reading* on page 22) and the reader is encouraged to review *Sensitivity Mapping for Oil Spill Response* in conjunction with these publications.

INTRODUCTION

Making and updating sensitivity maps are key activities in the oil spill contingency planning process. These maps convey essential information to spill responders by showing where the different coastal resources are, and by indicating environmentally sensitive areas. The making of a map involves assembling information on resources and deciding on what guidelines for spill response should be included, through consultation with relevant organizations. This can be done regardless of whether or not the benefits of computerized Geographic Information Systems and databases are available.

Uses of sensitivity maps range from planning practical site-specific shore protection and clean-up to strategic planning for large remote areas. This report provides information and guidelines on different map types, categories of information to be included, and symbols, with reference to the different users and their requirements.

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PROSPECTIVE USER GROUPS AND THEIR NEEDS

Prospective user groups of sensitivity maps for oil spill response have a variety of needs related to different categories of oil spill. The tiered response approach (IPIECA 1991) distinguishes the following types of spill.

- *Tier 1*: small localized spills at fixed installations (such as oil terminals). For example, a hose bursts or someone opens the wrong valve during loading or unloading of a tanker, and before the system can be shut down perhaps 10–20 tonnes of oil have been spilled.
- *Tier 2:* medium sized spills, possibly some distance from industry facilities and potentially having a greater impact on the environment. These might be caused by minor collisions, e.g. with a dock or with another vessel, which lead to the spillage of say 300–400 tonnes of oil.

Milford Haven Shoreline Clean-up Guidelines

Name: **Dale Flats** Foreshore No: **5**

Access to shore:

Footpath ☐
Public Road ☒
Public Track ☐
Private Road ☐
Private Track ☐
Boat ☐

Load-bearing capacity of the sediment

Soft (will not support vehicular traffic) ☐
Semi-soft (4-wheel drive vehicles) ☒
Firm (will support vehicles, tractors etc.) ☐

Access description:
Good public road access to top of shore at southwest end of Pickleridge (Grid Ref. SM 808 066) Steep pebble ridge onto beach with no ramp.
Good public road access to top of shore in Dale village (one way system around village) (Grid Ref. SM 812 057), but considerable congestion during summer.

Other information:
Fairly large parking and storage area at Pickleridge access point, but limited parking and considerable congestion during summer in Dale village. Possible storage in disused quarry.

Foreshore type (*CONCAWE* classification):

Sandy beach ☐ Pebbles/Shingle ☒ Rocky/Pools ☒ Other *(see Comments)* ☐
Muddy ☒ Boulders ☒ Industrial ☐ **Slope:**
Salt marshes ☐ Cliffs ☐ Marina ☐ Gradual ☒ Steep ☐

Comments: Predominantly waterlogged muddy shingle with bedrock along uppershore at sides of Flats and boulders in places. Lagoon behind. Abundant shallow sink areas where oil may pool.

Ecological value:

Vulnerability Index (Gundlach and Hayes, 1978): Low 1 2 3 4 5 6 7 8 9 10 High

Waders ☒
Wildfowl ☒
Diving birds ☒
Young fish nursery grounds ☒
Saltmarsh ☐
Seaweed ☒
Important/Rare habitats ☒
Monitoring site ☒
Educational use ☒

Season	Value	Comments
Spring	**High**	High bird interest (Curlew, Turnstone, Grey Plover), Abundant burrowing animals, Many rare species, Moderate surface living animals and algae in rocky areas.
Summer	**High**	Some bird interest (Curlew, Turnstone), Abundant burrowing animals, Many rare species, Moderate surface living animals and algae in rocky areas.
Autumn	**High**	High bird interest (Curlew, Turnstone, Grey Plover), Abundant burrowing animals, Many rare species, Moderate surface living animals and algae in rocky areas.
Winter	**High**	Very high bird interest (Curlew, Turnstone, Grey Plover), Abundant burrowing animals, Many rare species, Moderate surface living animals and algae in rocky areas.

Amenity/Economic value:

Recreational use ☒
Marina/Moorings ☒
Fisheries/Shellfish interest ☐
Fish/Shellfish farm ☐
High scenic value ☒
Water abstraction ☐
Urban area ☒
Industrial use ☐

Season	Value	Comments
Spring	**Mod**	Moderate amenity use of waterway, Small boatyard at Dale, Popular bait digging shore.
Summer	**High**	Moderate amenity use of shore, High amenity use of waterway, Small boatyard at Dale, Popular bait digging shore.
Autumn	**Mod**	Moderate amenity use of waterway, Small boatyard at Dale, Popular bait digging shore.
Winter	**Low**	Small boatyard at Dale, Popular bait digging shore.

Produced for the Milford Haven Standing conference on Anti-Oil Pollution by the Field Studies Council Research Centre, Pembroke, Dyfed, UK.

Oil Clean-up Recommendations:

Dispersant use: PROHIBITED ☒ Possible ☐
Material removal: PROHIBITED ☐ Possible ☒

Preferred: If oil comes ashore leave alone if small or moderate quantites, physical removal (absorbents, skimming and collection) for large quantites. If large quantities strand prevent remobilisation with beach guardians.

Possible: All types of removal method of substratum and cutting of oiled weed are possible on the rocky shores and on the flats below Dale only. Expert advice should be obtained first.

PROHIBITED: **Do not use dispersants. Do not remove shingle or other sediment from Gann Flats below Pickleridge.**

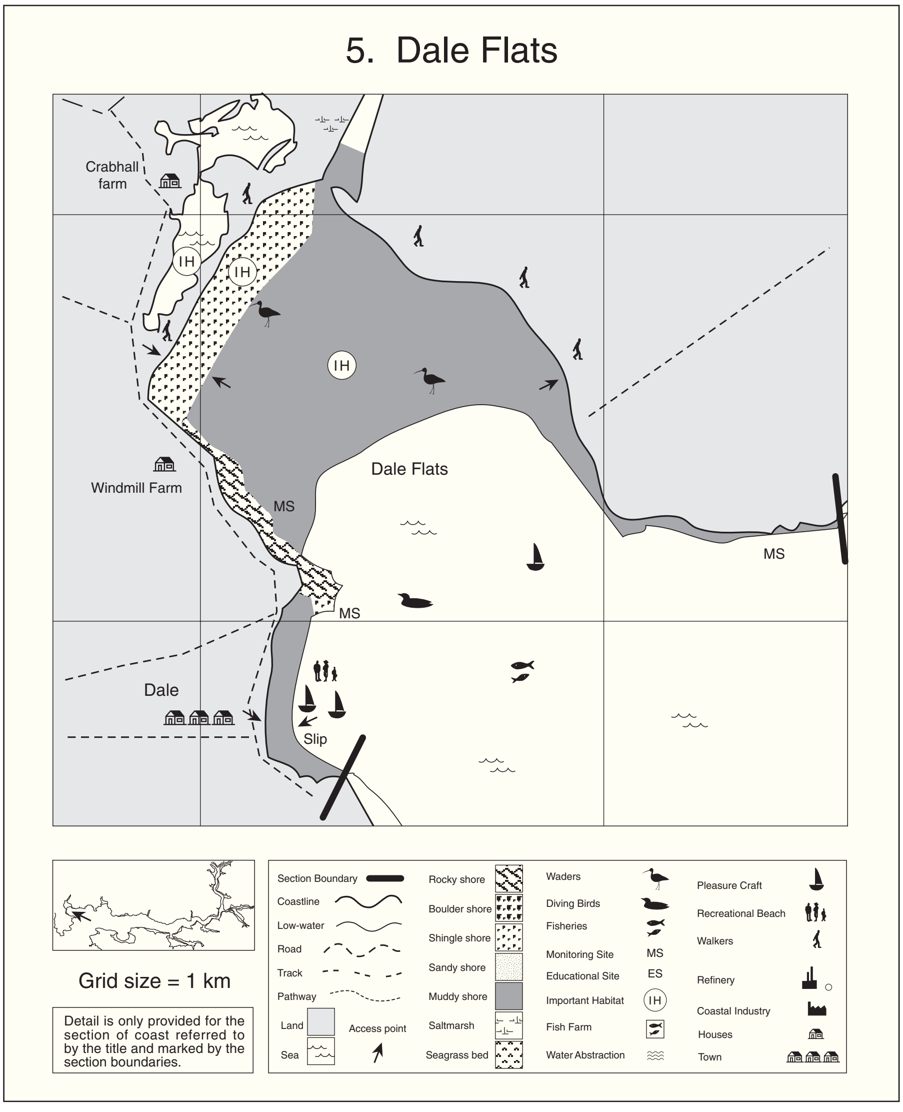
Contact: Warden of Dale Fort Field Centre (Dale 205) and district Inspector of fisheries, Milford Haven 3412 (day), 4308 (eve.)

Comments: Due to the very high ecological value of these flats every effort should be made to prevent oil entering the Dale Roads. Dispersants should not be used since they are likely to lead to increased penetration of oil. The Gann Flats are susceptible to erosion and substratum removal is therefore prohibited from that area.

Typical shoreline clean-up guidelines; this particular example accompanies the map on the following page, and was included in an atlas prepared for the Milford Haven Standing Conference on Anti-Oil Pollution Plan (SW Wales).

- *Tier 3:* major accidents (e.g. collisions, explosions or blowouts) causing spills of thousands of tonnes and having the potential for causing considerable environmental damage over a wide area.

It follows that uses of maps range from planning practical site-specific shore protection and clean-up, to strategic planning on a regional scale for major accidents in remote areas. The latter case is particularly likely to involve more than one country.



A large-scale map relevant for a Tier 1 response, or the later stages of Tier 2 or Tier 3 responses (when the oil has come nearshore or onshore and the protection or clean-up of specific locations is being planned). The map is supplied together with the shoreline clean-up guidelines shown on page 4. This particular example is number 5 in a black and white atlas of 60, prepared for the Milford Haven Standing Conference on Anti-Oil Pollution Plan (SW Wales). Such maps can be hand-drawn though this particular series was produced using a drawing package on a Macintosh computer, which facilitates consistency of style and rapid revision. The maps and guidelines are printed face-to-face in the atlas, but may be printed back-to-back on waterproof paper so single sheets may be used easily on-site.

Especially in the case of a Tier 3 spill, it is likely that different types of map will be used at different stages during the response. For example, when a large spill occurs many miles offshore in a remote area, it may not be clear for some days if or where oil will come ashore. The first requirement is for a strategic map covering a large area, showing the most important resources in all the possible directions that the oil slicks may travel. This alerts the responsible authorities to prepare for potential problems. At a later stage in the spill it may become clear that oil is progressing towards a particular section of coastline, notably an area for priority protection. There will be a need for intermediate-scale tactical maps and information for the spill responder. If oil has actually stranded on a number of shores, there will be a need for detailed operational maps and information for clean-up teams.

For most regions a cost-effective approach is to invest in intermediate scale tactical maps for the whole coastline, and detailed maps for those parts of the coastline which have been identified as ‘high risk’ during the contingency planning process. This recommendation takes into account the existing availability of global strategic information (see page 23).

A clear distinction can be made between the information on sensitive resources needed by contingency planners (e.g. the locations of estuaries, mangroves, fish farms or bird colonies) and practical information for spill response and shore clean-up (e.g. areas where dispersants could or could not be used, booming points, and shore access roads). These two different types of information can be shown on different maps and/or described in different sections of any accompanying text.

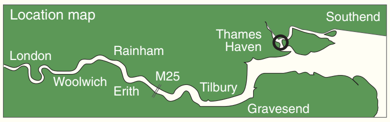
A distinction can also be made between sensitivity maps for spill response, and detailed resource maps used by specialists. The former are based on the latter (that is, if detailed maps are available, which is not always the case), but should only contain information useful for contingency planners. For example, a sensitivity map might show the location of mangrove areas, whereas detailed resource maps might show the individual distributions of several different mangrove species. With sensitivity maps, extra detail can be provided by accompanying text for those that require it. The map of seabird distribution on page 17 is an example of a specialist map at a strategic scale.

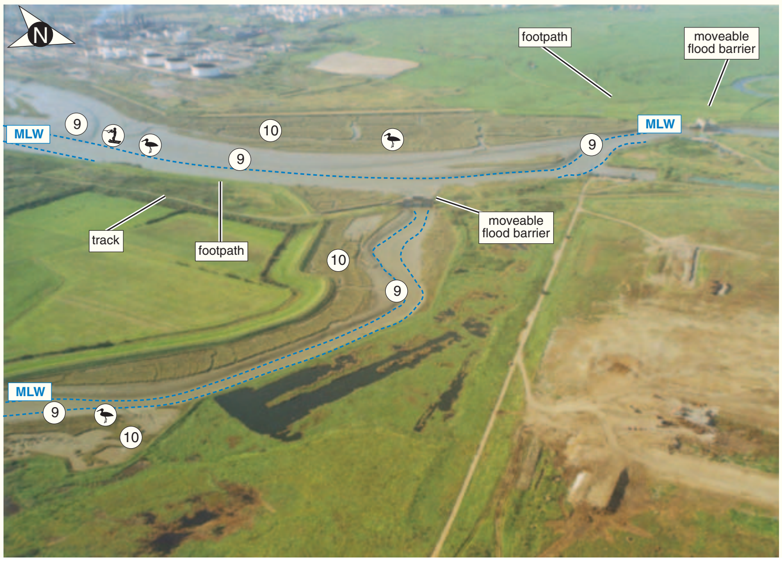
Name: Fobbing Horse **Foreshore No: 32**

Comments: Mudflats and saltmarsh areas of high importance for migratory and wintering waterfowl. Saltmarsh areas are used as high tide roosts.
Clean-up options limited.
Consider use of flood barriers to protect sensitive areas up the creeks.
Water skiers use the creek at high states of tide.

Seasonal Sensitivity:

	Conservation	Amenity	Industrial
Spring	**Mod**	**Mod**	**Low**
Summer	**Low**	**Mod**	**Low**
Autumn	**Mod**	**Mod**	**Low**
Winter	**High**	**Mod**	**Low**





Prepared by the Field Studies Council Research Centre, Pembroke, Dyfed, UK.

Clean-up recommendations:

PROHIBITED: Exercise extreme caution before entering muddy areas; do not enter areas of saltmarsh.
These habitats are fragile and easily damaged.

Recommended: Leave oil to degrade naturally. Strandline oil and debris may be collected.
Avoid unnecessary disturbance of birdlife. However, consider use of bird scaring devices if foreshore becomes polluted.
If bulk oil accumulates along foreshore consider low pressure seawater flushing. Remobilised oil must be collected and recovered using booms and skimmers. Clean-up operations of this nature will require the use of small hovercraft or shallow draft vessels at high water.,
If the flood barriers are lowered there may be opportunities to contain and recover floating oil using booms and skimmers at high states of the tide.

Access: Access limited to boats or foot for majority of foreshore.
Vehicular access to flood barriers.

Map No(s): OS Pathfinder TQ 68/78

Key to symbols

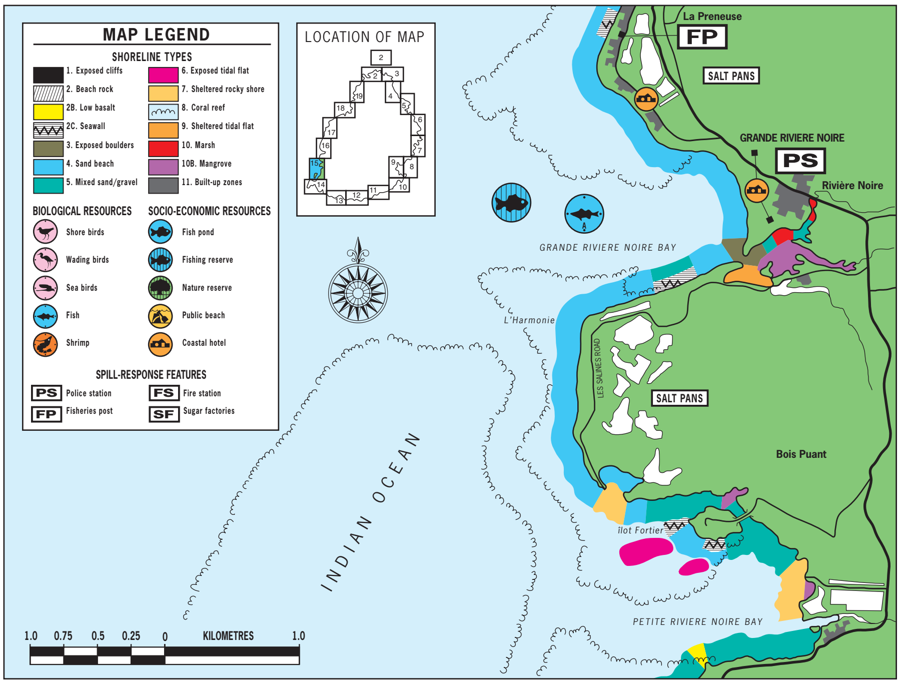
- R Ramsar site
- SPA Special Protection Area
- NNR National Nature Reserve
- SSSI Area of Scientific Interest
- Waders
- Wildfowl
- Seabirds
- Fishing
- Boating/Moorings
- Recreational beach
- Water sports
- Caravans
- 1 (low) — 10 (high) Vulnerability Index

An adaptation of the previous design shown on page 5 uses oblique aerial photographs of shores (taken at low tide). The photographs are scanned into the computer and then annotated with specially designed graphics and text. This provides a 'user-friendly' map which can be prepared quickly. However, updating requires further aerial photography. This is one of 45 maps prepared for the Thames Oil Spill Control Association (TOSCA). There are practical limits to the scale at which photographs can work for this purpose. If the users cannot easily locate their position by looking at features around them, the photograph loses its value as a practical clean-up tool.

MAP REQUIREMENTS

The basic requirements for an understandable and easily useable map are listed below. Fulfilling these requirements involves making potentially difficult decisions about what information to include, and cartographic skills to present the information clearly.

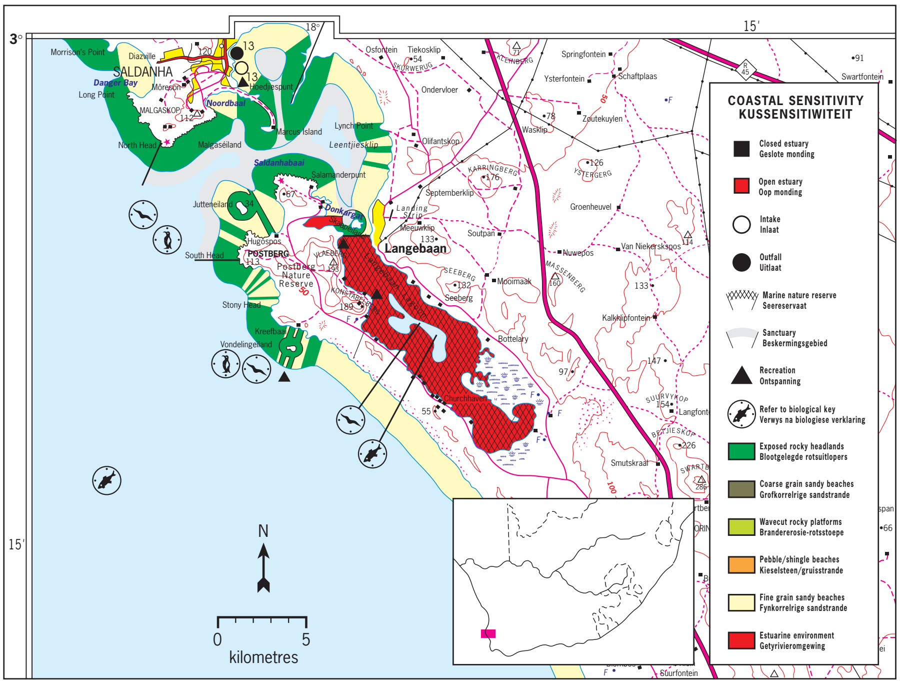
- The maps must convey an instant message and not require too much specialist knowledge to understand that message.
- They should contain enough information to be of value, but be sufficiently uncluttered to prevent confusion.
- They should not unnecessarily bisect natural features. For example, a bay or estuary should, where possible, be shown on one map rather than divided between two maps.
- They should use suitable symbols which do not conflict and do not convey the wrong message.
- They should be set at a suitable scale within the inherent accuracy of the data set.
- They should clearly mark scale, direction, legend/key, date of production and title.
- They should include a location map to show the relationship between any sub-area and the area as a whole.



Extracts of maps from the Coastal Sensitivity Atlas of Mauritius *(near right) and the* Coastal Sensitivity Atlas of Southern Africa *(far right). These are both large-format atlases with a page of descriptive text and information on specific resources opposite each map. These are examples of tactical maps at intermediate scales. Note the inset location maps.*

With respect to the range of scales which may be used, maps suitable for Tier 1 responses, e.g. shore-specific clean-up, may be up to 1:10,000 whereas strategic maps for initial response to Tier 3 spills may be as much as 1:1,000,000. Intermediate scale maps may cover a range below and above 1:100,000. Very approximately, there is a jump in scale of one order of magnitude from one map type to the next. The maps reproduced in this report give a variety of examples. Whatever the scale it should be marked on the map in the form of a scale bar, because this remains accurate even if the map is reproduced on an enlarging or reducing photocopier (statements such as '1 cm = 100 m' obviously become misleading if the map is enlarged or reduced in size).

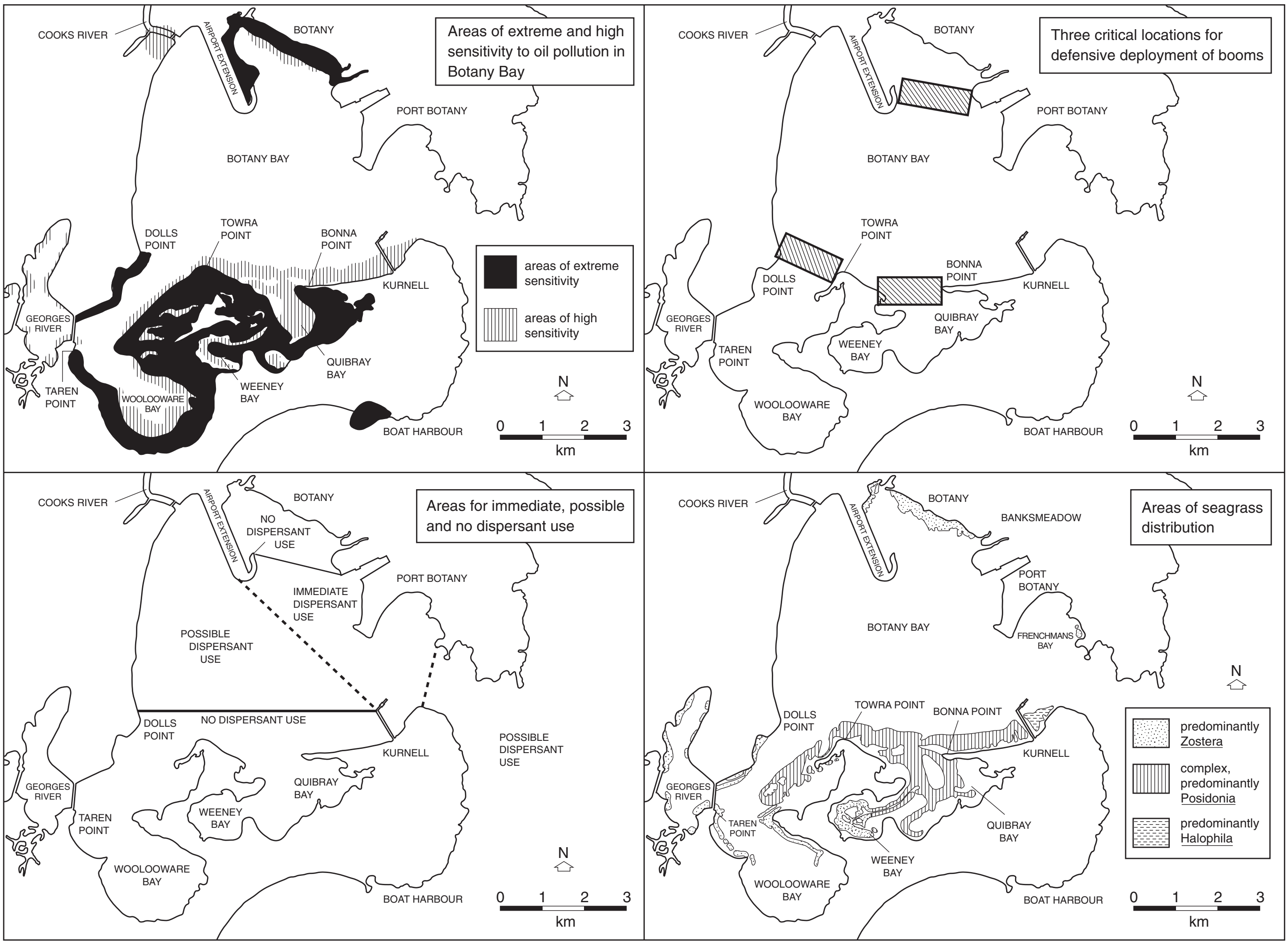
From the format point of view, the examples in this report illustrate both the single map approach (where all the information for an area is on one map) and the series approach. A single map is ideal, but a series of maps may be used to show the distribution of different resources in cases where putting everything onto one map would result in a cluttered and confusing product. In such a case, summary maps with the most important information for spill responders are recommended, along the lines of the examples given from New South Wales, Australia (see page 10). The same approach has been taken with resource maps of the Saudi Arabian coastline. The danger to avoid is to have a



large number of maps (one for each resource) without any interpretative summary map of sensitivities for planners. A series of maps may also be used to show the distribution of resources at different times of year, in cases where this distribution has marked seasonal variations which are well documented. An example is provided by the monthly bird distribution maps for the North Sea (see page 17).

These large scale maps are extracted from the Coastal Resource Atlas for Oil Spills in Botany Bay (State Pollution Control Commission of NSW) *and show part of the coast of New South Wales, Australia. They summarize the areas of greatest sensitivity to oil, show locations for defensive booming, and give indications concerning the use of dispersants. The distribution of seagrasses is an important factor influencing the use of dispersants in this area. As can be seen from the maps, it was decided not to use dispersants in seagrass areas. The seagrass map is one of a series giving details for different resources; this series forms the basis for the summary map showing areas of greatest sensitivity.*

The practical handling of the maps should be considered. Large format atlases can provide excellent source material but are difficult to work with in some field conditions—imagine, for example, cramped helicopter journeys, or exposed shores in strong wind and rain. Maps for field use should be of a suitable size for easy handling and reproduction, and may need to be laminated or printed on waterproof paper. The most cost-effective maps for operational use are black-and-white, and page-sized. Colour and larger format maps have higher production costs and there are great difficulties with rapid reproduction or transmission on standard office equipment such as photocopiers and facsimile machines. Colour maps are more likely to be useful for management levels of responsible organizations, and for strategic or tactical rather than operational use. A standardized colour scheme is available in Michel and Dahlin (1993).



TYPES OF INFORMATION WHICH COULD BE INCLUDED ON MAPS

Shoreline types

Many sensitivity maps (especially intermediate scale tactical maps) classify shorelines using a vulnerability or environmental sensitivity index (ESI), typically based on the original index of Gundlach and Hayes (1978). This arranges shoreline types on a 10-point scale, following the basic principles that sensitivity to oil increases with increasing shelter of the shore from wave action, penetration of oil into the substratum, natural oil retention times on the shore, and biological productivity of shore organisms. However, the numbers on the scales do not represent actual quantified sensitivity—for example ESI 5 is not five times as sensitive as ESI 1. An ESI is a convenient way of summarizing information but gives only part of the picture because it does not take into account uses of the shore by wildlife and people. For example, an exposed rocky shore rated as ESI 1 (low sensitivity) might support a seabird colony which would be of high sensitivity, at least during the breeding season. A sandy shore rated as ESI 3 (relatively low sensitivity) might be important for tourists, or for turtle egg laying, at certain times of year.

There are many regional modifications, for example the six-point sensitivity index used in the Coastal Sensitivity Atlas of Southern Africa (see map on page 9). The UNEP system used in the Eastern African region (see symbols on page 16) classifies shores into ten types, with particular attention being paid to ecological value as well as geomorphology and exposure to wave action.

Subtidal habitats

Some subtidal habitats or particular species using the habitats are sensitive to oil spills, as has been shown by case history and field experimental experience. It is usual to show these habitats on sensitivity maps but it has not been possible to develop an ESI for them because sensitivity is considerably influenced by the specific circumstances of the spill. Maps have commonly included the following:

- *Coral reefs:* reef flat organisms may be seriously affected if oil is stranded on the flat during low tide periods, and chemical or natural dispersion of oil in shallow water may affect some species at greater depths. The effects of oil and clean-up are discussed in greater detail in the IPIECA report *Biological Impacts of Oil Pollution: Coral Reefs* (1992).

- *Seagrass beds*: these may occur both intertidally and in shallow nearshore waters. There is some experimental evidence which suggests that the most likely scenario for damage to seagrass and the organisms utilising this habitat is the presence of high concentrations of dispersed oil.
- *Kelp beds:* the various kelp species (large brown algae) grow on the lower parts of some rocky shores, and in nearshore areas. These algae are quite resistant to oil, but other species using the kelp beds (for example, many different invertebrates, cormorants and sea otters) may be sensitive.

The photographs below show examples of shoreline sensitivity classification, using the environmental sensitivity index (ESI) rankings proposed by Michel and Dahlin (1993).

Recovery times are generally rapid on exposed headlands, such as Hillswick Ness in Shetland (ESI 1) …

… and also on exposed wave-cut platforms like Freshwater West in SW Wales (ESI 2).

A gently sloping fine-grained sand beach (ESI 3) in Galicia, NW Spain. Oil does not penetrate readily, facilitating mechanical removal.

Oil penetration may be deeper, and clean-up more difficult, in more steeply sloping shores of medium to coarse grained sand (ESI 4) such as this one on the Patagonian coast, Chile. The use of this particular shore by penguins during the breeding season would need to be taken into account as well as the shore ESI.

ESI 5 beaches of mixed sand and coarser sediments (gravel, pebbles and boulders), have medium to high permeability to oil, and usually low biological productivity. This one at Islas de las Dos Hermanas off the Caribbean coast of Panama has bags of oily debris awaiting removal following spill clean-up.

Shores of ESI 6 include a range of gravel, pebble and boulder beaches with high permeability. The photograph shows detail of such a beach in Prince William Sound, Alaska (see also photograph at top left of next page).

ESI 6: Rip-rap, as seen here used for coastal protection at Accra, Ghana, is the man-made equivalent of the pebble and boulder beach shown in the photograph at the bottom of the previous page.

ESI 7: Oil does not easily adhere to or penetrate into exposed tidal flats of compacted sediments, but there is often significant biomass—note these mussels on an exposed flat in the eastern Strait of Magellan, Chile. The ranking of ESI 7 takes into account the likely biological damage. Exposed tidal flats with low biomass are ranked ESI 5 in some schemes.

Sheltered rocky shores often have high biological productivity. This oiled example (ESI 8) in Milford Haven, Wales, has abundant large algae among which live many other organisms.

Sheltered tidal flats (ESI 9) such as this oyster-covered area on the west coast of Florida, are also very productive.

The most vulnerable shores (ESI 10) include saltmarshes and mangroves. These examples are from the Gulf coast of Saudi Arabia (far left) and the Niger Delta, Nigeria (near left). The extreme shelter means that such areas act as oil traps, often with severe consequences for the flora and fauna.

Wildlife and protected areas

Maps should show the areas of greatest sensitivity for wildlife species, such as feeding and breeding areas where there are likely to be significant concentrations of individuals, at least at some times of the year. Examples are seabird colonies, estuaries important for migrating shorebirds, seal haulouts, and turtle nesting beaches. Locations which are important for threatened or endangered species should be highlighted, because in these cases there may be the risk that a bad spill could seriously deplete the total population of a species. It is likely that some areas important for wildlife will have protected status (for example, nature reserve or

This exposed rocky shore in SW Wales would, in itself, be rated as ESI 1, but the presence of a gannet colony confers high priority for protection during the breeding season. For some spills a possible option for such protection might be dispersant spraying offshore (see the IPIECA report Dispersants and their Role in Oil Spill Response, *1993).*

national park). It is useful to indicate these on the map, as many have experienced management authorities who will be well-versed with the local region. Furthermore, there may be complex legal and economic considerations in dealing with spills in these areas.

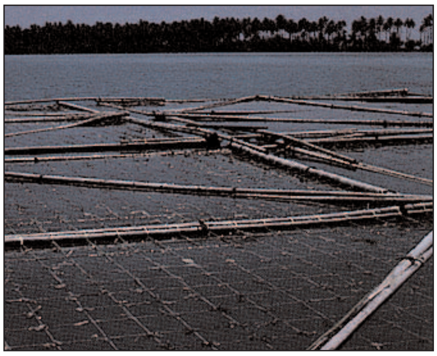
As mentioned in the section on shoreline types, vulnerable wildlife may be present on some shores which, from the narrower viewpoint of the shoreline ESI, have been rated as relatively tolerant of oil. In such cases the wildlife assessment clearly takes precedence for the purpose of spill response.

Fish, fishing activities, shellfish and aquaculture

Both commercial and subsistence fishing need to be considered. The following are examples of features which need to be identified and included on sensitivity maps:

- nearshore shallow water fishing areas, e.g. for finfish, crabs, lobsters, shrimps or other species;
- seaweed gathering;
- shellfish beds in the intertidal zone or nearshore shallow water;
- fish and crustacean nursery areas;
- beaches with fishing activities, e.g. hauling in nets;
- permanent or semi-permanent fish traps and fishing platforms;
- aquaculture facilities for fish, molluscs, crustaceans or seaweeds, e.g. intertidal trestles, floating cages and long-lines, and fish and crustacean ponds; and
- seaward entrances of rivers important for migratory fish such as salmon.






Sensitive areas from the fisheries point of view include beaches from which fishing takes place (top left), fish traps (top right), aquaculture facilities such as these seaweed rafts (bottom left), and the entrances to salmon streams (bottom right). The photographs are from Gabon, United Arab Emirates, Indonesia and Prince William Sound (Alaska) respectively.

Socio-economic features

These include the following:

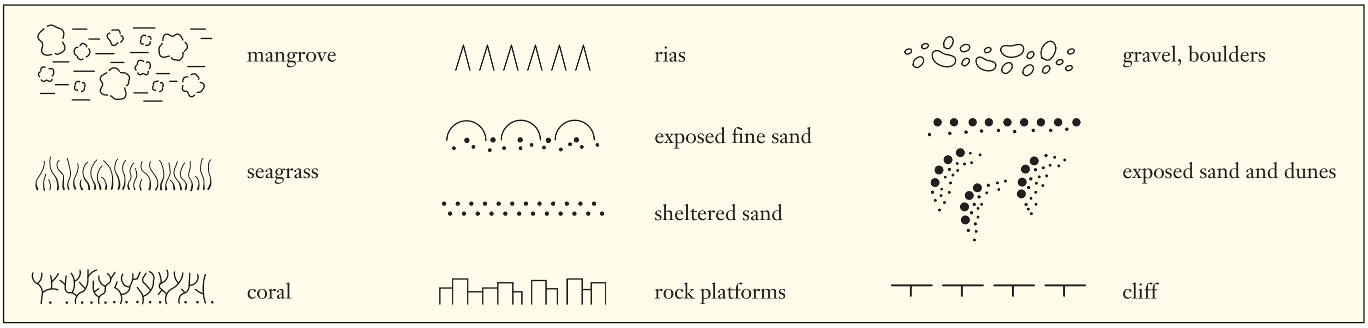
- boat facilities such as harbours, marinas, moorings, slipways and boat ramps;
- industrial facilities, for example water intakes for power stations and desalination plants, coastal mining, and salt evaporation lagoons;
- recreational resources such as amenity beaches, bathing enclosures, water sport and game-fishing areas; and
- sites of cultural, historical or scenic significance, on or close to the shore.

Oil spill response features

For the purposes of practical spill response, it is valuable to know the following: where dispersants could be used and where they should not be used; where booms could be deployed and the locations of any permanent boom moorings; which beaches of low sensitivity could, if necessary, have oil deflected onto them to save sensitive areas; and the locations of access points. This and other response information can be put directly on the map, or included in guidelines which are provided with the map, either printed face-to-face with the map in an atlas or back-to-back with the map on single sheets of paper. An example of a typical set of guidelines and accompanying map is given on pages 4 and 5. Any protection priorities which have been agreed by the relevant organizations should be shown on the map and/or in the accompanying guidelines. For example, some US maps show A, B and C areas where A indicates areas of highest protection priority, B indicates areas which should be protected after A, and C indicates areas which should be protected after B.

Symbols

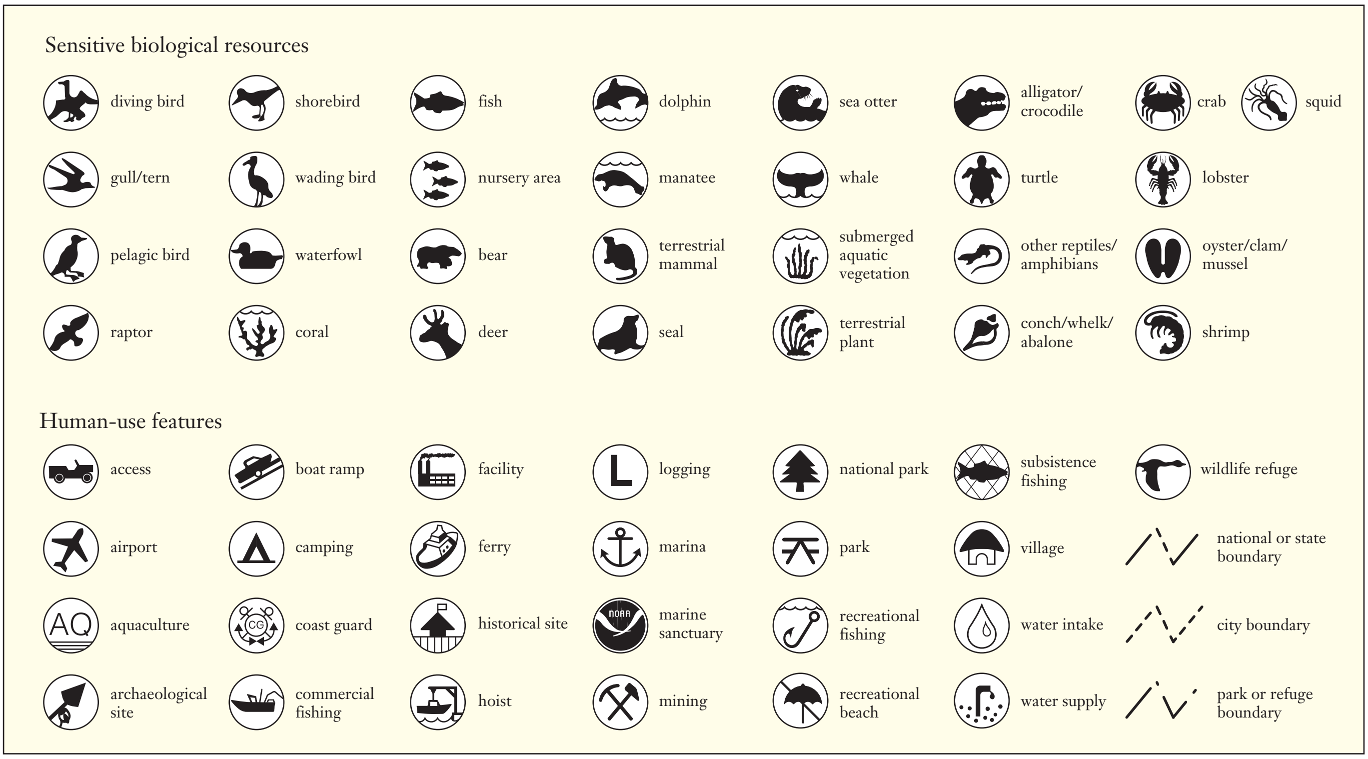
Shoreline ESI ranks have been indicated on some maps primarily using symbols (for example in the *New Zealand Atlas of Coastal Resources*) and on others primarily using colours. Symbols, or a combination of symbols and colour, are recommended for ease of copying and transmission.



Symbols used for sensitivity mapping in East Africa (above). A major advantage is that the coastal types can be clearly distinguished on black and white photocopies. The classification is comparative, based on expert local assessment of value, importance, vulnerability and concern (with mangroves ranking highest and cliffs lowest).

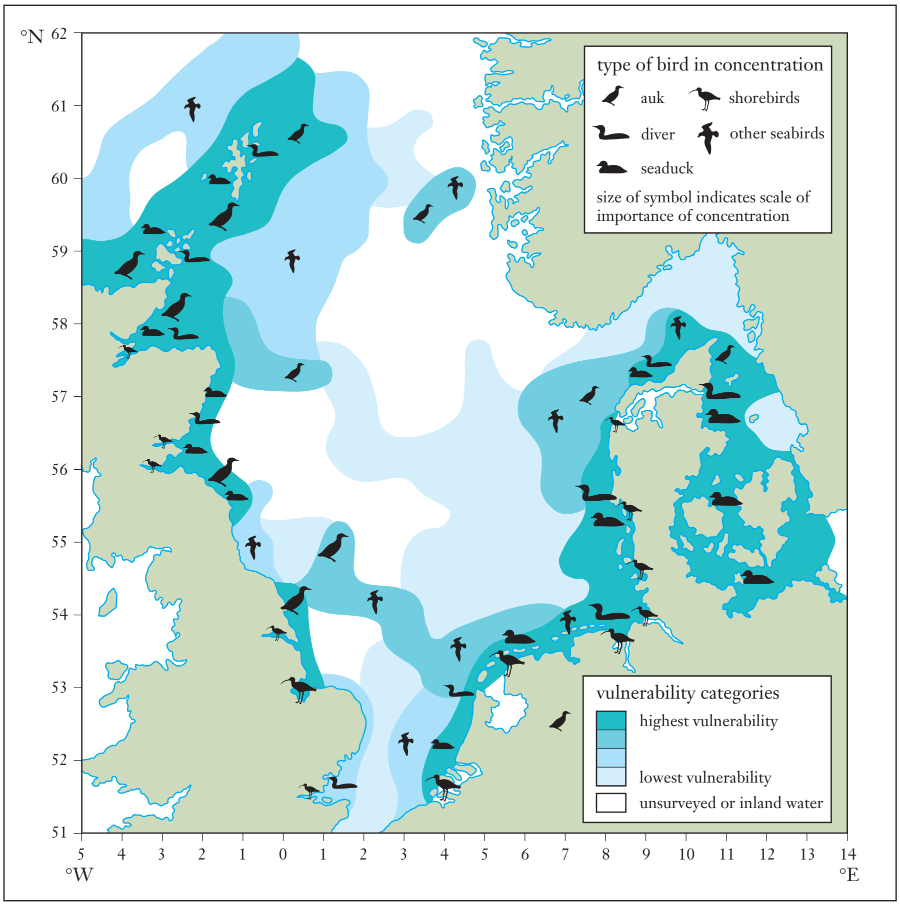
With respect to other resources, examples of generalized symbols are given below. These are suitable for international use. However, according to the diversity of resources, some areas may wish to use a greater range. For example, some Norwegian maps have a lot of detail for fishing activities, including symbols (letters) for different fishing methods and facilities. Given that such details can vary tremendously from one region to another, there seems little point in promoting a standardized universal scheme to cover every possible resource worldwide. In our experience, the users will refer to the key without any problems—this highlights the requirement for a key on each map.

Symbols used to depict a variety of coastal resources (National Oceanic and Atmospheric Administration, USA).



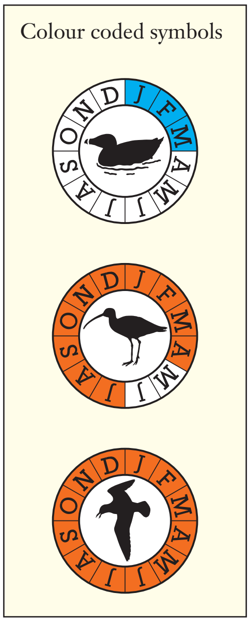
Seasonal aspects

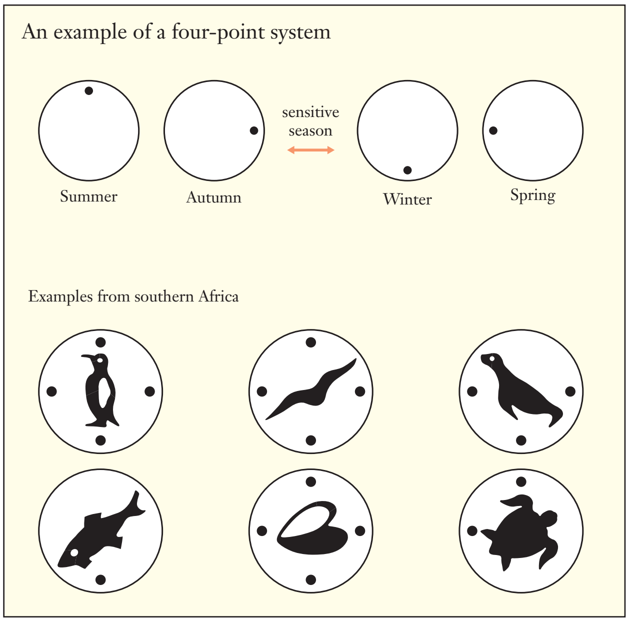
The sensitivity of many of the above resources may vary seasonally, and it is useful to include seasonal information on sensitivity maps. Some methods of doing this are shown below.



Methods of indicating seasonality. In Seabird Concentrations in the North Sea: an Atlas of Vulnerability to Surface Pollutants, *a different map is given for each month of the year. The map for April (left) shows seabird distribution heavily influenced by the breeding season, with birds concentrated around coastal and island breeding areas.*

A similar approach is used in the Gazetteer of Marine Birds in Arctic Canada: an Atlas of Seabird Vulnerability to Oil Pollution, *but in this case the maps are for each quarter of the year rather than each month.*





In the UK map series Coastal Sites Sensitive to Oil Pollution, *bird symbols (far left) show the months vulnerable to oil pollution. They appear in blue for concentrations of birds on the water offshore, and in red for waders, wildfowl and other birds on- and nearshore.*

Many other maps use a four-point system (near left) which is more generally achievable because the level of detail required is not so great as with the month-by-month scheme. However, care should be taken to avoid potential confusion for international users because the winter months in the southern hemisphere are the summer months in the northern hemisphere. It is best to define what is meant by each season using names of months (as has been done, for example, in the case of the German Wadden Sea maps). Many areas in the tropics or in polar regions do not have four distinctive seasons, though they do have times of year when particular species are more sensitive.

OBTAINING AND AGREEING INFORMATION FOR SENSITIVITY MAPS

In most cases, at least some of the information needed for sensitivity maps can be obtained from existing topographic maps, charts, photographs, scientific publications and environmental data held by organizations such as government fisheries departments, universities and conservation groups. Available information may range from detailed shore-specific survey results to data on a global scale suitable for strategic planning maps. A problem is that within any particular area there are likely to be inconsistent levels of information. Lack of information does not necessarily mean there are no sensitive resources.

Inconsistencies can be reduced by simplifying the most detailed specialist information on the one hand, and by filling gaps on the other. Ideally, to fill gaps in information there should be liaison with local people and possibly some additional survey work. In the case of local large scale maps, such work may consist entirely of surveys of ground stations. For larger areas it is often more practical to use aerial photographs or satellite images, with scenes chosen as far as possible for low cloud cover and low tide. Ground station surveys are essential to interpret the remotely sensed data. For example, Landsat scenes have been used in the preparation of sensitivity maps for the United Arab Emirates together with 60 'ground-truth' stations surveyed for features such as beach profile, sediment type, shore processes, flora and fauna.

The information to be included about priorities for protection and clean-up options needs to be decided through consultation with relevant bodies such as fisheries departments, tourist boards and conservation groups. Consensus may well be difficult to achieve, but it is crucial to reach the best possible agreement in advance of a spill occurring—there is never enough time during a response operation. In the event of a spill, the organizations must then accept the priorities presented on the map.

The coastal zone usually represents the most heavily utilized parts of the sea and land areas. As a consequence, features here change frequently and rapidly—whether it be through tourism or industrial development, the designation of national parks and nature reserves, the establishment of fish farms or the destruction of mangrove swamps. It follows that maps need to be updated at intervals, and this may involve re-assessment of priorities.

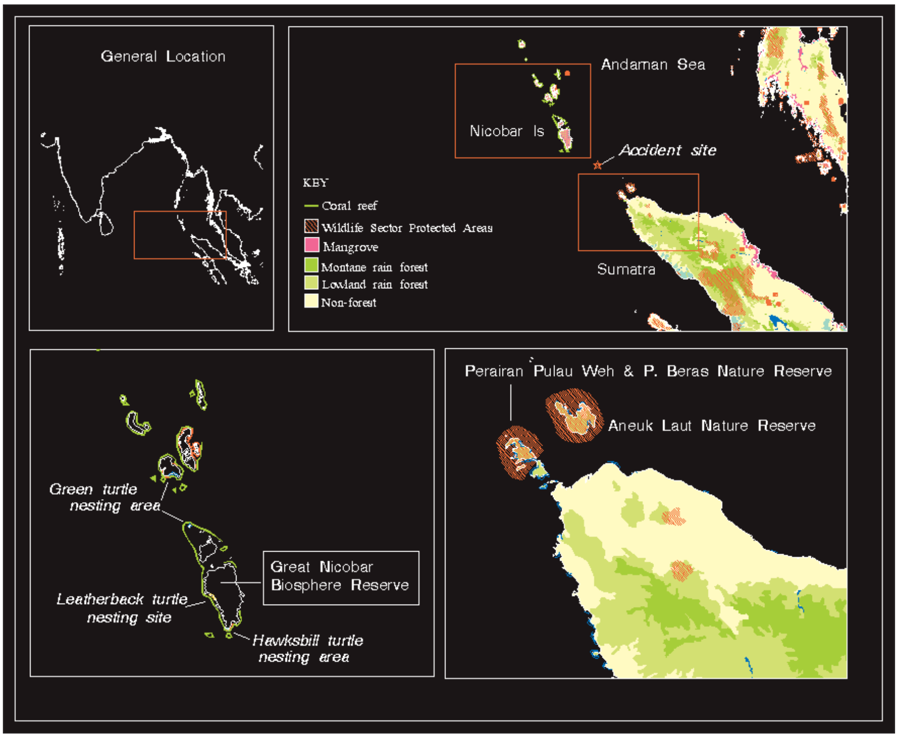
GEOGRAPHIC INFORMATION SYSTEMS

In coastal sensitivity mapping, as in other fields, the use of Geographic Information Systems (GIS) is growing rapidly. Nevertheless, not all organizations or areas worldwide have access to GIS at present, and it should be stressed that first-rate sensitivity maps can be made without them. Knowledge of an area's resources, and agreement on priorities for spill response, are the most basic requirements. It should also be stressed that, at the time of a spill, immediate access to hard copy (paper) maps is usually essential.

A GIS is a software system which specializes in handling spatially referenced data. If GIS is available it offers the following advantages for pre-spill contingency planning. A GIS can hold information at any scale—indeed, provided the data are correctly formatted, data from all sources can reside together, including satellite images, air photos and standard cartographic products. These advantages however can only be exploited with careful use of the data, respecting issues of common data scales and data quality. In the context of coastal sensitivity mapping it is quite legitimate to consider a limited variation in scales allowing for the improvement of resolution in areas of particular interest such as around ports, particularly sensitive areas or areas which are difficult for navigation.

One of the most valuable features of any digitally mapped product is that it can be very easily altered and updated. By assessment of the coastal features it should also be possible to apply ESI classification. Likewise individual features such as shipping routes can be added by different users according to their requirements. As GIS is becoming more widely used the possibilities of linking different GIS systems and data are increasing. In this way it is possible to exchange data between organizations operating different systems. Furthermore it is possible to link such systems to Global Positioning Systems which may be of value for ground-truthing, or for further data addition or amendment. Maps can be imported into oil spill trajectory models.

A fully utilized GIS can be much more than just a map, and indeed the data shown on a map may simply represent the tip of an iceberg. In many cases it is useful to link textual or tabular information to maps, such as contact details of concession holders or administrative and management authorities. This can be done using a GIS simply by pointing at a site and pressing a button for further information. For particular sites on maps it may be relevant to link to legal details of protected areas, lists of key or threatened species, contact details of local experts, scientists or non-governmental organizations. Other data and statistics may also be helpful, such as the number of tourists using particular beaches, the nesting seasons of marine turtles or tide and current information. It is all too easy for maps themselves to become cluttered and confusing, but a well-designed GIS can help to avoid this problem. GIS technology is advancing towards an open approach, making it possible to link to one or more Database Management Systems (DBMS) to facilitate the use of other data already held. The World Conservation Monitoring Centre (WCMC) Biodiversity Map Library is an example of a fully functional GIS operating at a small scale; there are also now a number of systems operating at larger scales such as the Norwegian Marine Resources Database (financed by nine of the major operators on the Norwegian continental shelf), and other national and local systems being developed both for sensitivity mapping and for the modelling of oil spills.



Maps of the environmental resources in the Andaman Sea between Sumatra and the Nicobar Islands—produced by WCMC on 21 January 1993 when a tanker was involved in a collision. These are examples of strategic planning maps for the initial stages of a Tier 3 response. The maps were supplied together with considerable textual information describing protected areas, mangroves, coral reefs, and turtles, as well as contact information for regional experts who would be capable of providing further information.

CONCLUSIONS

A considerable degree of harmonization of approach for sensitivity maps worldwide can be achieved. However, given that resources can vary tremendously from one region to another, it seems better to promote a broad consistency with respect to symbols rather than an exhaustively detailed scheme to cover every possible resource worldwide. The following guidelines are intended to promote harmonization.

- Maps need to convey a clear message to spill responders and to do this quickly. It should not be necessary to have experts on hand to interpret them. In some cases this may require summary maps, showing the main features from sets of more detailed resource maps.
- A distinction should be made between sensitive resource information and spill response and clean-up information. The latter could, for example, be highlighted in a special section of accompanying text.
- Scales should be marked on all maps using scale bars. The direction of north, a legend/key, the date of production and a title to the map should also be included.
- The scale should be appropriate to the type of response (strategic planning, tactical response or operational site-specific clean-up).
- Environmental sensitivity ranking of shorelines is recommended subject to two provisos:
  - this may not be appropriate or practical for the largest and smallest scale maps; and
  - it is essential to include additional sensitivity information, notably on the human and wildlife usage of the shores.
- The most cost-effective maps are black-and-white and page sized, allowing easy copying and fax transmission. Reliance on colour alone is not recommended if it is likely that black and white photocopies of the maps will be used during a spill response operation. Different coastal types should be indicated using symbols.
- General-purpose symbols are recommended for common resources such as fish, birds and amenity areas, but it is to be expected that map-makers in different areas will wish to add further symbols reflecting special features of each area. This does not present any problems provided each map has a key. A multiplicity of symbols (showing, for example, many different species of fish) is not recommended for sensitivity maps though they are appropriate for more detailed resource maps.

- The most widely-used and generally-achievable method for showing seasonality is the four-point scheme showing the sensitive seasons—spring, summer, autumn, and winter. However, the seasons need to be defined in terms of named months to avoid confusion between northern and southern hemispheres.
- Practical information for oil spill response (for example, areas where dispersants may or may not be used) should be agreed between relevant organizations before inclusion on a map.

ACKNOWLEDGMENTS, FURTHER READING AND USEFUL CONTACTS

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The UK maps *Coastal Sites Sensitive to Oil Pollution* (with symbols designed by Robert Irving) were produced by the former Nature Conservancy Council in collaboration with British Petroleum and the Department of Transport's Marine Pollution Control Unit.

Helpful comments at the draft stage were provided by International Tanker Owners Pollution Federation (ITOPF); J. Morales, Fundación Centro de Estudios Marinos, Spain; R. Pavia, National Oceanic and Atmospheric Administration, USA; and R. J. Percy, Environment Canada.

Further reading

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Full references to the sensitivity maps consulted during the presentation of this booklet may be obtained from IPIECA.

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* *The World Conservation Monitoring Centre (WCMC) mapping service is particularly relevant for its production of strategic Tier 3 maps. WCMC is a non-profit organization founded by the three partners of the World Conservation Strategy: the World Conservation Union, the United Nations Environment Programme and the World Wide Fund for Nature. IPIECA is one of the supporters of WCMC.*

The role of WCMC is to gather and disseminate accurate and detailed information relating to biodiversity and nature conservation around the world. In this capacity it has, since 1989, been developing a very large global Geographic Information System (GIS). Most of this information is being placed on a user-friendly ArcInfo system known as the Biodiversity Map Library where it is simple for any user to overlay and produce maps for any region of the world. Marine and coastal data currently available include coverages of coral reefs, mangrove swamps, wetlands including important estuaries, turtle feeding and *nesting sites and protected areas (national parks and nature reserves). This dataset is constantly expanding, both in its global scope and in particular coverages being developed for certain countries and regions. The data, skills and contacts held at WCMC were first put to use in the field of sensitivity mapping during the Gulf War, when WCMC was the first organization to be able to supply a broad range of environmental data on the region.*

These resources have been used regularly in Tier 3 responses since this time, as well as providing more detailed information to aid the preparation of Tier 2 response maps by other organizations. A number of these maps, together with linked information have been made available to a wider audience over the Internet through a server on the World wide Web (http://www.wcmc.org.uk—Response to Environmental Emergencies). The use of the Internet as a medium for the rapid transmission of information is likely to be of increasing value and use in spill response procedures.

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