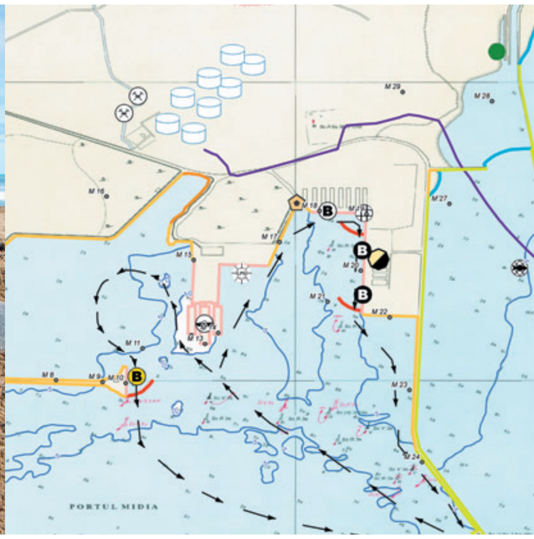
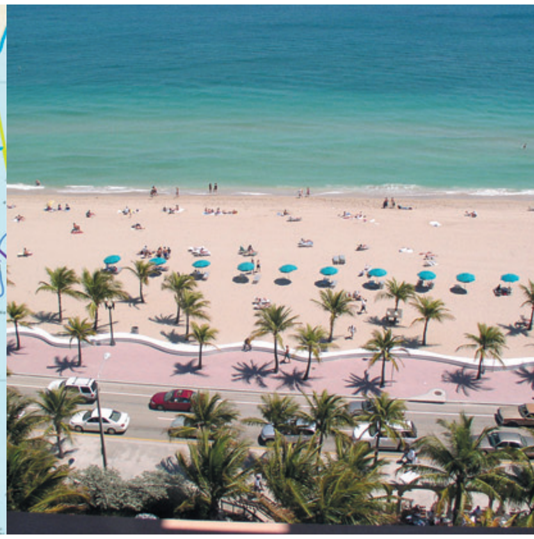
Sensitivity mapping for oil spill response

Good practice guidelines for incident management and emergency response personnel





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Preface

This publication is part of the IPIECA-IOGP Good Practice Guide Series which summarizes current views on good practice for a range of oil spill preparedness and response topics. The series aims to help align industry practices and activities, inform stakeholders, and serve as a communication tool to promote awareness and education.

The series updates and replaces the well-established IPIECA 'Oil Spill Report Series' published between 1990 and 2008. It covers topics that are broadly applicable both to exploration and production, as well as shipping and transportation activities.

The revisions are being undertaken by the IOGP-IPIECA Oil Spill Response Joint Industry Project (JIP). The JIP was established in 2011 to implement learning opportunities in respect of oil spill preparedness and response following the April 2010 well control incident in the Gulf of Mexico.

The original IPIECA Report Series will be progressively withdrawn upon publication of the various titles in this new Good Practice Guide Series during 2014–2015.

Note on good practice

'Good practice' in the context of the JIP is a statement of internationally-recognized guidelines, practices and procedures that will enable the oil and gas industry to deliver acceptable health, safety and environmental performance.

Good practice for a particular subject will change over time in the light of advances in technology, practical experience and scientific understanding, as well as changes in the political and social environment.

Contents

Introduction

The mapping of the sensitivity of the environment to accidental oil pollution is an essential step in oil pollution preparedness, response and cooperation efforts, and maps are a crucial tool to assist responders during an incident.

Protected areas, important areas for biodiversity (not legally protected), sensitive ecosystems, critical habitats, endangered species and key natural resources are considered sensitive to oil spills because they are:

1. of environmental, economic, or cultural importance;
2. at risk of coming in contact with spilled oil; and
3. likely to be affected once oiled or affected by the oil even without direct contact (Michel, Christopherson and Whiple, 1994).

Within this guide, 'sensitivity' always relates to the effects of accidental marine pollution involving hydrocarbons.

Sensitivity mapping is used to support the development of a response strategy for oil spill contingency plans and should be included in these plans.

Sensitivity mapping of the various types of environments and resources potentially exposed to oil spills enables the identification of the most sensitive sites or resources, thus providing a basis for the definition of priorities for protection and clean-up, and information to plan the best-suited response strategy.

During response operations, maps will be used by the decision makers (to define the priorities for protection), by the On-Scene Commanders (for the organization of the response operations) and by the on-site responders (for site-specific operations).

This guidance document aims at providing a structured approach to successfully manage the development of oil spill sensitivity maps, integrated within the oil spill contingency plan, and indicates key elements to be included in each type of map.

Types of sensitivity maps

The tiered preparedness and response approach categorizes spills in terms of severity, complexity and size, and enables responders to plan for the escalation of both regional and global response resources in the unlikely event of a major spill. The tier categories are broadly defined as follows:

- Tier 1: Capability necessary to handle a local spill and/or provide an initial response.
- Tier 2: Regional capability necessary to supplement a Tier 1 response, including general equipment and specialized tools and services.
- Tier 3: Global resources necessary for spills that require a substantial additional response due to incident scale, complexity and/or impact potential.

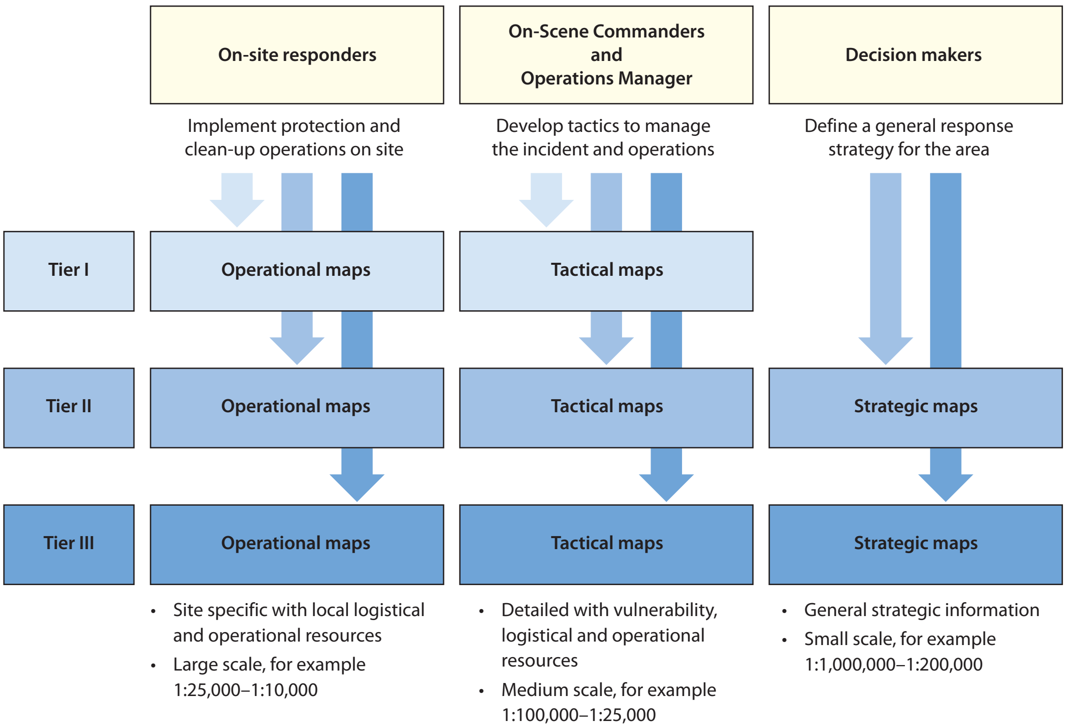
It is important to recognize that while the extent and size of the spill is relevant to the tier classification, other factors such as environmental resources at risk, seasonal accessibility and geographical remoteness also play a part. See the IPIECA-IOGP Good Practice Guide on tiered preparedness and response (IPIECA-IOGP, 2015a) for further information.

Depending on the scale of the incident, specific levels of incident management systems would be mobilized:

- Decision makers (Incident Commander): define general response strategy at national or regional levels (mobilized for Tier 2 and 3 oil spills only).
- On-Scene Commanders and Operations Managers: develop response tactics to respond to spill and manage operations in the field.
- On-site responders: implement operations on site.

The types of maps, scale and level of details are adapted to each user's needs (see Figure 1).

Figure 1 *The types of maps required, depending on the users and the scale of the event*



Different levels of response will be required depending on the scale of the oil spill, and this will dictate the most appropriate types of maps to be used by the various personnel involved in the incident management and response systems.

Strategic sensitivity maps

Establishing priorities for protection and clean-up is a difficult task in the case of a Tier 2 or 3 incident where a large area of the coast can be exposed to an oil spill. Strategic sensitivity maps are developed, at a smaller geographic scale, to provide a broader perspective and to synthesize information, locating and prioritizing the most sensitive sites. The decision makers would use these maps with the objectives of locating and prioritizing the most sensitive sites, and to reinforce the response capabilities for these areas (during the preparedness effort) and resolve the issue of competing priorities in the event of limited protection and clean-up resources during an incident.

Tactical sensitivity maps

Tactical maps are used as a general planning and response tool. During an incident, they are used by the people in charge of the coordination of the operation on-site (the On-Scene Commanders) and in the Incident Command Post (Incident Commander). These maps provide responders with all required environmental, socio-economic, logistical and operational information to plan and implement response and protection operations. They can include additional information to assist the user (clean-up technical guidelines, environment protection and restoration recommendations, etc.).

Operational sensitivity maps

Operational maps are optional. They may be developed only for the most sensitive sites identified, at a much larger scale than strategic or tactical maps, and are designed to be used by the on-site responder.

They include information on the general logistical and operational resources (as on the tactical sensitivity maps) and, more importantly, site-specific information to provide details for on-site oil spill responders.

Sensitivity maps and oil spill contingency planning

Oil spill sensitivity maps should be considered as a support tool to develop the oil spill response strategy, and as an operational tool which complements the oil spill contingency plan. As such, it is preferable if maps are developed during the contingency planning process.

Other considerations

The geographical area (as well as resources and features) covered by the maps must be in line with the scope of the contingency plan. For example:

- For a national oil spill contingency plan, the sensitivity maps should cover the entire coastline of the country, including inlets and islands. Mapping the fluvial and lacustrine environments of the country which may be exposed to spilled oil (e.g. fluvial transport of hydrocarbon products, oil production in lakes, etc.) should be considered. The maps must always stay focused, i.e. they should only include the resources and features that may be affected by a spill, and not list all existing species.

- For local oil spill contingency plans (ports, refineries or offshore facilities), the sensitivity maps should cover the area of coast, river and lakes potentially exposed to a spillage originating from the facilities (to be defined considering the location of the facilities, prevailing winds and currents, and the coastal morphology). Mapping the sensitivity of the terrestrial environment surrounding the installations and pipelines should also be considered.

Tactical maps provide the planner with information about the various types of environment that may be affected by a spill (sand beaches, rocky coast, marshes, etc.) for which the clean-up equipment should be suited. Tactical maps should also take into account the operational constraints (limited access, hazardous areas, etc.) that the planner should consider when developing the response strategy.

The strategic maps, identifying the most sensitive sites, will be used by the planner and decision makers to support the development of the general response strategy, and to define priority actions. The technical feasibility of protection operations for sensitive sites will be assessed: adequate protection techniques, the type and amount of response equipment required and their potential limitations (due to currents or other operational constraints) will be defined. All protection options should be considered, in addition to the deployment of booms (filtration devices at water intakes and channels, building of berms, re-building of sand spits, etc.), shoreline pretreatment agents to limit the adherence of oil, displacement of species (e.g. turtles) or installations (e.g. evacuation of aquaculture installations). When protection or transfer is not possible, priorities for clean-up should be identified.

Risk analysis, combined with an oil spill drift study based on the prevailing winds and currents, identifies the location of high-risk areas, i.e. areas combining higher probability of being impacted by oil pollution and potential major consequences. These High Risk Areas will be highlighted in the oil spill contingency plan. Preventive measures should be reinforced to lower the risk of spillage, and/or specific site protection/a clean-up plan may be implemented, with pre-positioned equipment on site for timely response.

Oil spill sensitivity maps (including the mapping of coastal sub-tidal habitats) can also support the development of a dispersant use policy by providing information on the potential impact of dispersed oil in the water column. Such information can be used in case of spillage of hazardous and noxious substances (HNS), and could serve as the basis to develop HNS incident sensitivity maps.

The sensitivity maps provide a comprehensive overview of the territory, and the sensitive resources at risk in the event of an oil spill.

Developing oil spill sensitivity maps

Baseline maps

Each map must include a minimum set of information to locate the various features mapped (this will vary based on country and scale of maps), referred to as 'baseline map information', e.g.:
- coastline and bathymetric depth contours (5, 10, 20, 50 m), rivers and lakes;
- towns and villages, administrative limits, place names; and
- roads (national, regional, local, track, etc.), railway and main infrastructure.

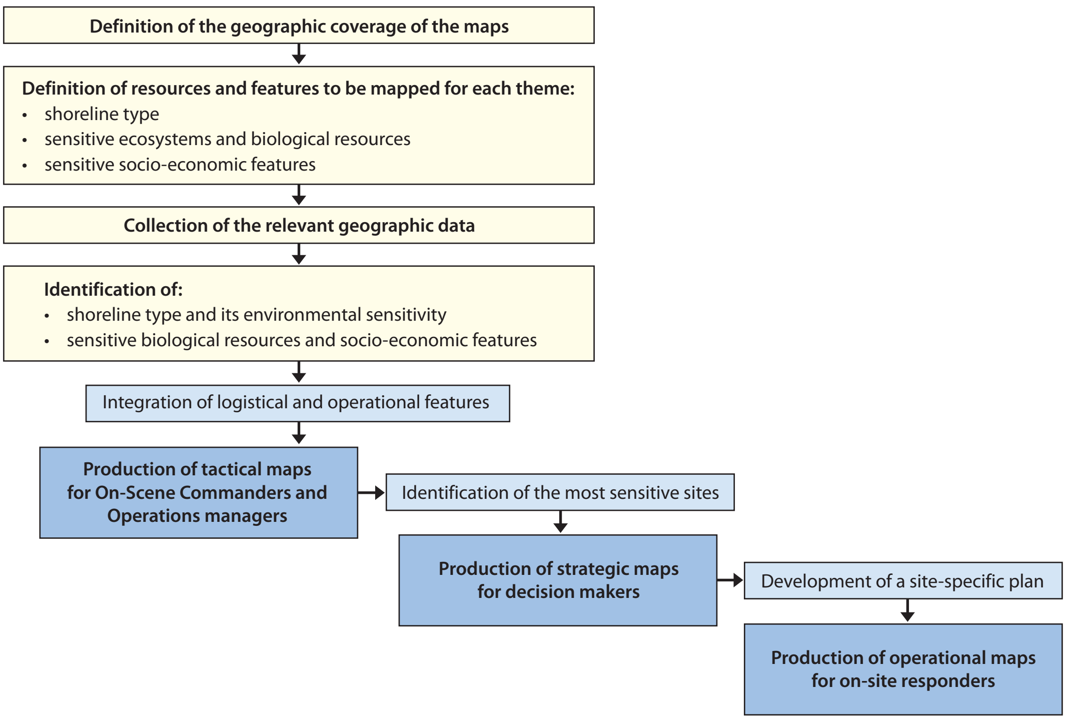
The baseline maps may be developed using existing topographic maps, nautical charts, aerial photos, satellite images or existing Geographic Information System (GIS) data from other projects. Seasonal information should also be added when relevant (e.g. navigational seasons on the rivers, opening and closing of some river mouths by sand bars, strong tidal currents, erosion and accretion of the coast, etc.).

Tactical, strategic and operational sensitivity maps

Mapping is carried out by considering three sensitivity themes, together with the response features:
- the shoreline type and its general environmental sensitivity to oil spill;
- the sensitive ecosystems, habitats, species and key natural resources;
- the sensitive socio-economic features; and
- the logistical and operational oil spill response features.

It is essential that the collection of data remains focused on the needs of the project so that the minimum required information is defined.

Figure 2 *Steps for the development of each type of oil spill sensitivity map*



For each theme, the minimum required information must be defined, and collection of data should focus on the requested information only.

Once the sensitivity data and logistical and operational features are collected, the first set of tactical sensitivity maps may be developed. Simplifying and ranking the information will allow identification of the most sensitive sites, and the strategic sensitivity maps may be produced. For each sensitive site (and possibly sites with a high probability of an oil spill incident), site-specific protection plans can be developed at a larger scale and operational maps may be developed.

Developing tactical sensitivity maps

Mapping the shoreline type and its general environmental sensitivity

For the various types of shoreline (and riverine or lacustrine ecosystems), the widely accepted Environmental Sensitivity Index (ESI) can be adapted for each country. The ESI, ranging from 1 (low sensitivity) to 10 (very high sensitivity), integrates the:

- shoreline type (grain size, slope) which determines the capacity of oil penetration and/or burial on the shore, and movement;
- exposure to wave (and tidal energy) which determines the natural persistence time of oil on the shoreline; and
- general biological productivity and sensitivity.

The 10 levels of the Environmental Sensitivity Index are colour-coded from cool colours to warm colours indicating increased sensitivity. Each colour corresponds to a particular type of coast, allowing identification of the type and relative sensitivity at a glance.

Figure 3 *Colour code of the Environmental Sensitivity Index*

1A	Exposed rocky shore
1B	Exposed, solid man-made structures
1C	Exposed rocky cliffs with boulder talus base
2A	Exposed wave-cut platforms in bedrock, mud or clay
2B	Exposed scarps and steep slopes in clay
3A	Fine- to medium-grained sand beaches
3B	Scarps and steep slopes in sand
4	Coarse-grained sand beaches
5	Mixed sand and gravel beaches
6A	Gravel beaches (granules and pebbles)
6B	Riprap structures and gravel beaches (cobbles and boulders)
7	Exposed tidal flats
8A	Sheltered scarps in bedrock, mud or clay and sheltered rocky shore
8B	Sheltered, solid man-made structures
8C	Sheltered riprap
8D	Sheltered rocky rubble shores
8E	Peat shorelines
9A	Sheltered tidal flats
9B	Vegetated low banks
9C	Hypersaline tidal flats
10A	Salt and brackish water marshes
10B	Freshwater marshes
10C	Swamps
10D	Mangroves

Source: NOAA

The Environmental Sensitivity Index uses a colour-coded system to provide quick and easy visual determination of the type of shore and its general environmental sensitivity to an oil spill.

Examples of the 10 levels of the Environmental Sensitivity Index are shown below.

Index 1

1A *Exposed rocky shore*
1B *Exposed, solid man-made structures*
1C *Exposed rocky cliffs with boulder talus base*

Index 2

2A *Exposed wave-cut platforms in bedrock, mud, or clay*
2B *Exposed scarps and steep slopes in clay*

Index 3

3A *Fine- to medium-grained sand beaches*
3B *Scarps and steep slopes in sand*

Index 4

Coarse grained sand beaches

Index 5

Mixed sand and gravel beaches

Index 6

6A *Gravel beaches (granules and pebbles)*
6B *Riprap structures and gravel beaches (cobbles and boulders)*

Index 7

Exposed tidal flats (large sandy area often covered at high tide)

Index 8

8A *Sheltered scarps and sheltered rocky shores*
8B *Sheltered solid man-made structures (permeable)*
8C *Sheltered riprap*
8D *Sheltered rocky rubble shores*
8E *Peat shorelines*

Index 9

9A *Sheltered tidal flats*
9B *Vegetated low banks*
9C *Hypersaline tidal flats*

Index 10

10A *Salt and brackish water marshes*
10B *Freshwater marshes*
10C *Swamps*
10D *Mangroves*
10E *Inundated low-lying tundra*

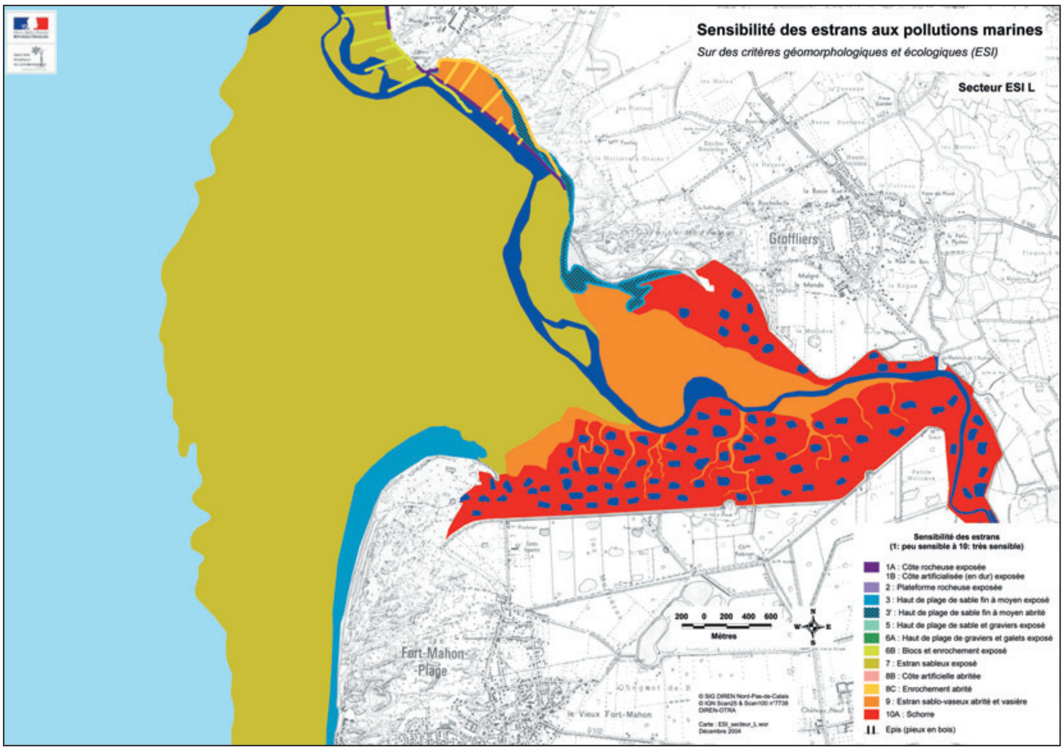
The type of shoreline can be identified through various sources: existing topographic or thematic maps and studies; local knowledge; and remote sensing technologies such as low altitude over-flights, aerial photos, and satellite imagery of (very) high resolution. However, when using remote sensing data, a ground truthing mission is essential to validate the data and to undertake surveys where data are missing.

The ESI used to classify the various shoreline types, as described above, should not be confused with the ESI mapping methodology used to define the overall sensitivity of the coast which takes into account the shoreline ESI, as well as the sensitive biological and human-use resources (see pages 10–15).

To map the general environmental sensitivity of the riverine and lacustrine ecosystems, specific indexes have been developed, derived from the ESI for shoreline, described above. ESI definitions have also been developed for inland terrestrial sensitivity on a case-by-case basis (for example on the path of a pipeline).

Figure 4 *Example of mapping of shoreline type and environmental sensitivity using the ESI*

This example of a shoreline sensitivity map shows the visual effectiveness of the ESI system in practice.



Source: DIREN

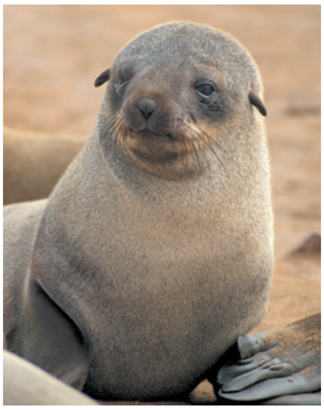
Mapping the biodiversity-sensitive elements of the areas

Mapping both protected areas and areas of biodiversity importance should include the coastal species, habitats and natural resources that could be affected by accidental oil pollution. The ESI (index 1 to 10, see pages 7–9) does not consider the broader context which might be influenced by the oil spill. In particular, this includes:

- protected areas and important areas of biodiversity that can be identified using the UNEP-WCMC Integrated Biodiversity Assessment Tool (IBAT);
- different types of coastal habitats/ecosystems; and
- endangered species that can be identified using the IUCN Red List.

Identification of sensitive areas and species

It is important to understand and map the location of internationally recognized sites and nationally designated sites to identify sensitive ecosystems, critical habitats and endangered species. These data sets can be accessed via the UNEP-WCMC World Database of Protected Areas



Above: examples of sensitive species, left: fur seal; centre: blue-footed boobies; right leatherback turtle

(WDPA). Additional data on important areas of biodiversity are accessible through the IBAT tool. The endangered species (unaccounted for by the ESI) must be identified and localized, as well as the coastal areas of particular interest for the marine flora and fauna.

Endangered sensitive species may include:

- birds (seabird, shorebird, wading bird, migratory species, etc.);
- marine mammals (whale, dolphin, sea lion, seal, walrus, manatee, etc.);
- terrestrial mammals (which may be effected by contact with beached oil or by feeding on contaminated water species, e.g. beaver, mink, bears, wolves);
- fish (nursery areas, coastal species, commercial pelagic species, etc.);
- invertebrates (crustaceans, lobster, shrimp, endangered insects, etc.);
- reptile/amphibians associated to water (turtle, alligators, frogs, etc.).

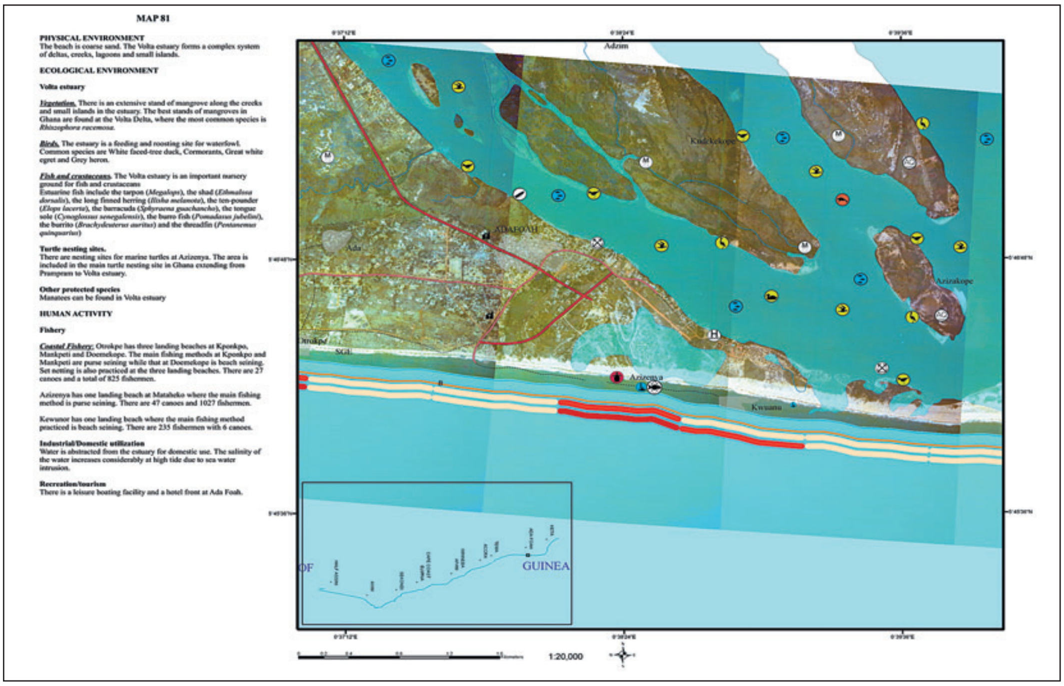
It is necessary to have adequate scientific support to select the specific species to map as these vary both spatially and temporally, and to understand their vulnerability to an oil spill. The species of particular concern (IUCN Red List) which are sensitive to oil must be located precisely where pollution could affect these specific fragile and limited populations.

A standardized set of biological symbols is available and may be added to as needed to meet the needs of the region being mapped. Polygons and lines are used to map the spatial extent of species, and points are often used to show nesting and/or very localized populations. This can also be complemented by the IBAT tool and the WDPA.

Figure 5 (overleaf) shows an example of mapping of sensitive natural resources.

This example shows how sensitive biological resources can be indicated using a range of colour-coded symbols.

Figure 5 *Example of mapping of sensitive biological resources*

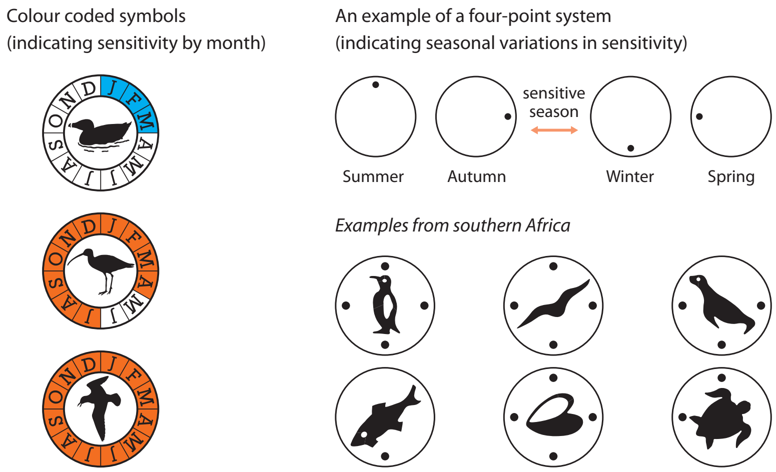


Source: EPA Ghana

A broad range of symbols is used to denote the locations of sensitive biological resources on environmental sensitivity maps.

Figure 6 *Symbols for the mapping of sensitive biological resources*

Figure 7 *Symbols indicating monthly (left) and seasonal (right) periods of greatest sensitivity*



In Figure 7, the bird symbols on the far left show the months when they are most vulnerable to oil spills (blue indicating offshore populations, and red indicating waders, wildfowl and other birds onshore or nearshore. The symbols on the near left use a 'four point' system to indicate seasonal variations in sensitivity.

The mapping of biological resources must also take into account the seasonality and life stages present, i.e. breeding, spawning, hatching, migration, etc. Depending on the detail of information available, the species concentration information can be simple (presence/absence) or more detailed (1: no information, 2: rare, 3: common, 4: abundant and 5: highly abundant). Presenting this information by month is the preference. The use of the four seasons, spring, summer, autumn and winter, should be avoided to prevent confusion between northern and southern hemispheres.

Sub-tidal habitats—an example of a coastal habitat/ecosystem

Some sub-tidal habitats (coral reefs, sea grass beds and kelp beds) are essential for the coastal marine biodiversity. As for the sensitive species, they are not taken into account by the shoreline ESI and must be localized and mapped.

Example of a coral reef subtidal habitat

Mapping the sensitive socio-economic features

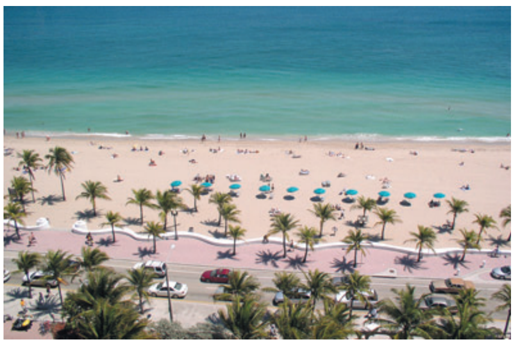
Sensitive socio-economic features to be mapped should include: non-living resources that may be directly injured by oiling; managed areas that may suffer economically, e.g. through interruption of use if oiled; and areas that may be valuable in the event of a spill for access or staging activities. These features can be grouped into various categories:

- subsistence, artisanal and commercial fishing, and fishing villages;
- aquaculture;
- water intakes (salt marsh plant, desalinization plant, aquaculture and salt production, industrial use);
- tourism and recreation areas (hotels, restaurants, marinas, beaches, recreational fishing, diving, etc.);
- port (including the activities and infrastructures);
- industrial activities (relying on maritime transport);
- infrastructures related to oil exploration, production and transport activities; and
- cultural sites (archaeological, historical, religious, etc.).

In mapping socio-economic features, the objective is not to identify all hotels, restaurants or factories comprehensively but to locate the activities and the areas which have the potential to suffer the greatest impact. The mapping project coordinator should define the socio-economic features to consider prior to the development of the maps. The relative importance of these features and the need to protect them in the event of a spill need to be confirmed with local or regional policy makers.

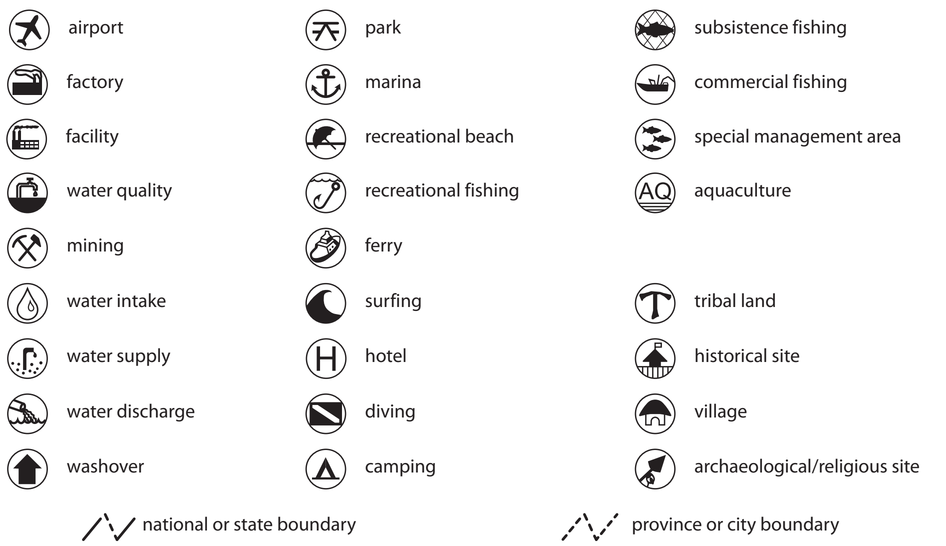
It is important to note that socio-economic features may also be subject to high seasonal variation, e.g. tourist season, fishing season, aquaculture season, etc. and, if possible, seasonal information should be mapped and/or added as additional information accompanying the maps.

Examples of sensitive socio-economic features (clockwise from upper left): aquaculture; fishing operations; tourist beaches and hotels; and port and industrial activities.



A standardized set of socio-economic symbols is available and may be added to as necessary to meet the needs of the region being mapped.

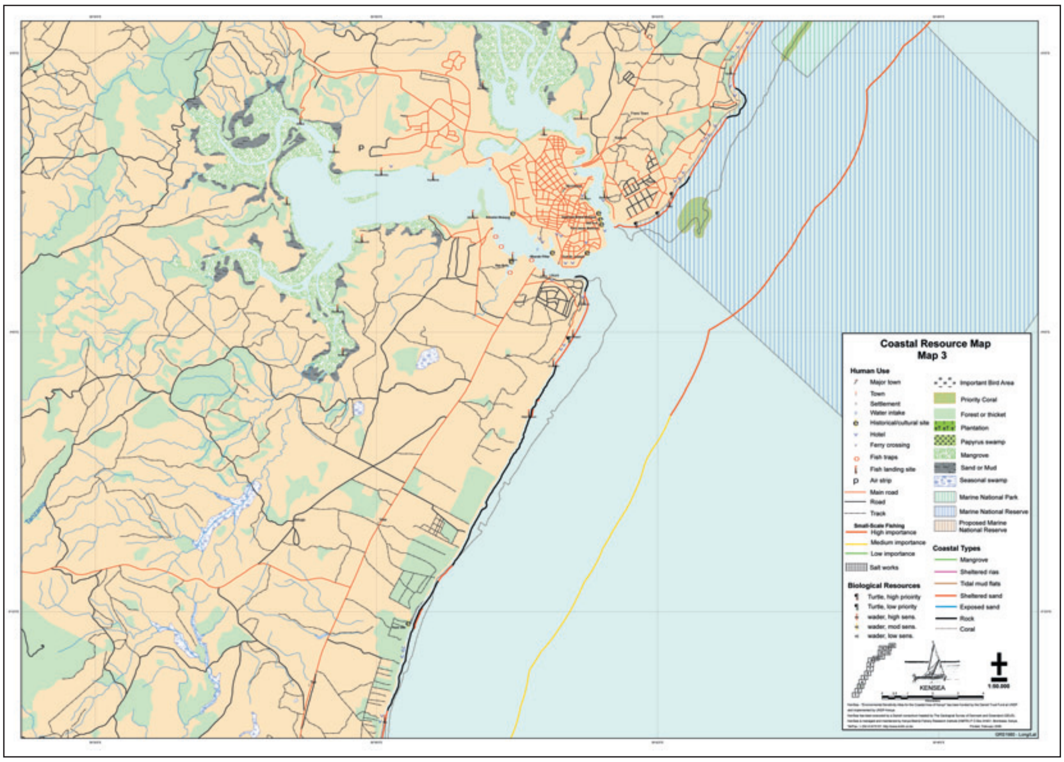
Figure 8 *Symbols for the mapping of sensitive human use and activities*



Source: NOAA

A range of symbols is available to denote the locations of sensitive socio-economic resources and activities. The selection shown here is non-exhaustive and may be added to as required.

Figure 9 *Example of mapping of socio-economic features, Kenya*



Source: Kenya Marine Fishery Research Institute

This coastal resource map provides an example of how the various socio-economic features may be indicated in practice.

Mapping oil spill response logistical and operational features

General logistical and operational resources include:

- detailed information to assist the On-Scene Commanders and operators on-site for the response operations (without overloading the map);
- location of incident command posts and their geographical limits;
- existing stockpiles of equipment;
- pre-approved dispersant areas and their geographic limit(s);
- environmental recommendations (optional) to limit the impact of the pollution and of the cleaning operations, particularly in the sensitive areas.

The logistical and operational resource data must be accurate and well documented to be helpful to the responders. They should be validated during field missions and updated frequently.

Symbols (from the ESI mapping method) can be used for the mapping of the logistics and operational resources. Additional symbols may be appropriate depending on the local resources.

Figure 10 *Symbols for the mapping of logistics and operational resources to be used on the tactical and operational sensitivity maps*

Just as symbols are used for mapping sensitive biological resources and socio-economic resources and activities, a range of symbols is available for mapping logistics and operational resources. The selection shown here is non-exhaustive and may be added to as required.

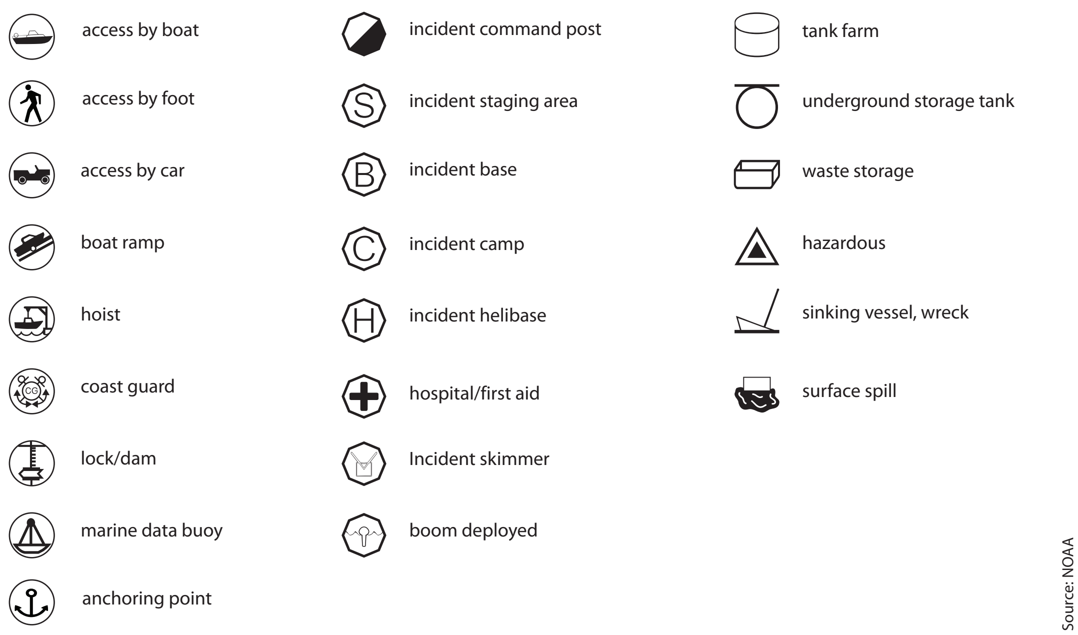
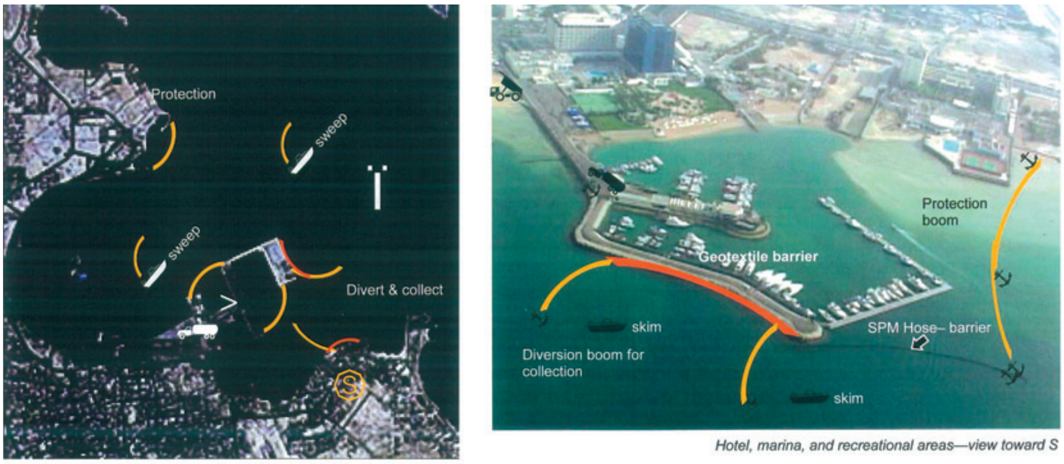


Figure 11 *An example of logistic and operational features*



Source: Qatar Petroleum

Mapping potential sources of accidental pollution

To support the contingency plan, and identify High Risk Areas, the identification of the potential sources of accidental pollution is aided by the mapping of:

- offshore oil activities (oil fields, and exploration and production installations including platforms, pipelines, floating production, storage and offloading vessels (FPSOs), single point mooring buoys (SPMs), etc.);
- onshore oil activities (exploration, production, storage, refining and transport installations, etc.);
- maritime transport activities (traffic lanes, and port infrastructures including loading/offloading, bunkering, passenger traffic, etc.); and
- other potential sources of oil pollution (sunken vessels, etc.).

Developing strategic sensitivity maps

Purpose and principle

The strategic sensitivity maps localize and prioritize the most sensitive sites and resources, for the decision makers, in a simple and usable format (and at a small scale for a synthetic view of the scoped area). In some, rare cases, only a few sensitive sites are present on the coast and the available response equipment may be sufficient. However, in the majority of cases, equipment is limited in comparison to the exposed areas (during Tier 2 incidents or even Tier 1 incidents) and it is necessary to prioritize the sites and resources:
- identified within the geographical area covered by the maps; and
- competing within an area (e.g. mangrove, fishing area, aquaculture versus a luxury hotel with marina and beach).

The principles for the development of strategic maps are presented below (these are not covered by the classic ESI mapping method, which focuses strictly on the mapping of sensitive resources).

Ranking and prioritizing sensitive sites and resources at risk

Because the concept of relative sensitivity and the importance given to each specific resource at risk differs from one area to another (resources that are of high importance in one area may be considered to be of low to medium importance in other areas), there is no single method for locating and prioritizing sensitive sites and resources. Moreover, the sole use of automated computer-aided methods is not advisable as the prioritization should be done through consensus building with the main stakeholders involved in the contingency planning process.

The purpose is to establish a general ranking for each of the three resource types included in the tactical maps, i.e.:
- the shoreline type and its general environmental sensitivity;
- the sensitive ecosystems, habitats, species and key natural resources; and
- the sensitive socio-economic features.

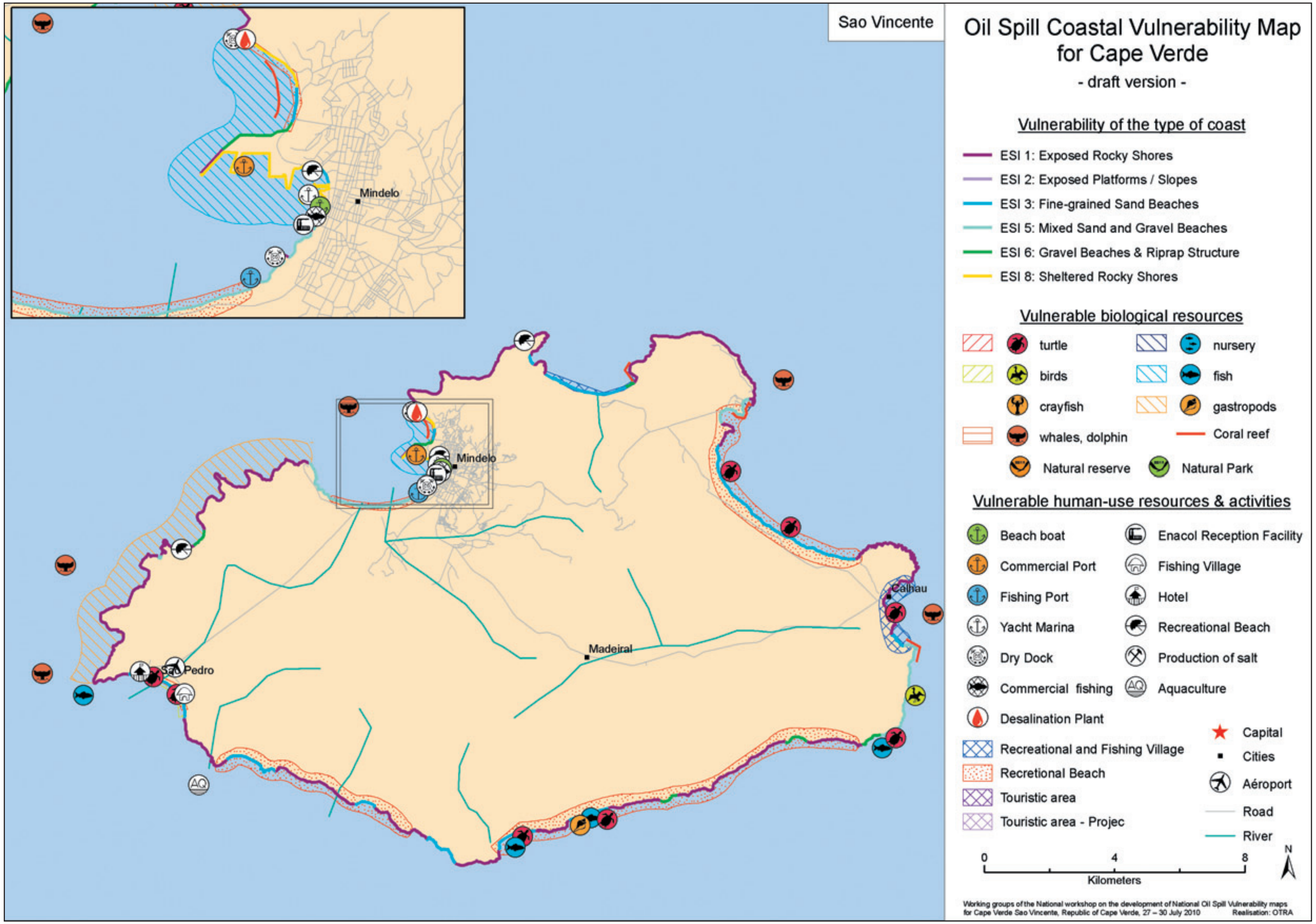
This information can also be utilized when performing a net environmental benefit analysis (NEBA)—see IPIECA-IOGP (2015b).

The sensitivity information on each of these themes is ranked using a methodology that must be defined on a case-by-case basis. Different rankings may be required to account for the variation in sensitivity caused by seasonal effects.

The ranked sensitivity information obtained is then mapped on an integrated map to identify the most sensitive sites.

Various methods are available to rank the sensitivity information, e.g.:
- mathematical modelling of the sensitivity, using multiple indices;
- aggregating the sensitivity information into one index; and
- using a map-based approach to simplify and rank the sensitivity information.

Figure 12 *Tactical oil spill sensitivity map (example from Cape Verde)*



The environmental, socio-economic, logistical and operational information on a tactical oil spill sensitivity map provides the basis for locating sensitive sites and resources along the coastline.

All methods have pros and cons, and if data are limited this will often constrain the choice of methodology. However, since the map-based approach can be implemented widely, and is easily understandable and usable by decision makers, this is the method presented here. It is a three-step process and is introduced briefly below.

The sensitivity information on the tactical map (i.e. type and sensitivity of shoreline, biodiversity-sensitive elements of the area, and socio-economic features) is used as the basis (see example in Figure 12).

- ***Step 1: Ranking the sensitivity of the types of shoreline***

The ESI already ranks the environmental sensitivity of the shoreline into 10 levels. These can be simplified into 3 to 5 classes, keeping only the most sensitive types of shoreline for the strategic map. An example is shown in Table 1:

Table 1: *Simplification of ESI sensitivity rankings*

ESI (from 1 to 10)		Simplified ESI	Mapping of simplified ESI
Index 1 and 2	→	1 (very low)	Not represented
Indexes 3, 4, 5 and 6	→	2 (low)	Not represented
Index 7	→	3 (medium)	Not represented
Index 8	→	4 (high)	**4 (high)**
Index 9 and 10	→	5 (very high)	**5 (very high)**

- ***Step 2: Ranking the sensitive ecosystems and natural resources***

Sensitive natural resources may be ranked depending on their recovery time after a spill. Various existing classifications or lists can also be used to rank them: IUCN red list (conservation status and distribution information on endangered species), lists of rare, endangered and threatened species and habitats, etc. The likelihood of impact must also be considered. The sensitivity ranking may also include managed areas, e.g. low to medium sensitivity for local protection status, medium for national status and high for international status.

If various sensitive species are present in the same area, the highest sensitivity is maintained. To account for this diversity, a simple matrix (see Figure 13) can be used to consider together, and for each area, the sensitivity of the species and the diversity, to assign an overall sensitivity ranking to the area.

Figure 13 *Diversity of sensitive species (in the same area)*

sensitivity of species or protected area (highest)	very low	low	medium	high	very high
very high	very high	very high	very high	very high	very high
high	high	high	high	high	very high
medium	medium	medium	medium	high	high
low	low	low	medium	medium	medium
very low	very low	low	low	low	medium

diversity of sensitive species (on the same area)

This simple matrix can be used to establish a sensitivity ranking for an area where a diverse range of sensitive species is present, by comparing the sensitivity of the species/protected area with the diversity of species in that area.

- ***Step 3: Ranking the socio-economic features***

To rank the sensitive areas of human use and activities which could be affected directly or indirectly by a spill, a similar approach as for the sensitive biological resources can be used. Various parameters are available to rank socio-economic features: the importance of the activity, the number of personnel employed, the revenue, or the duration of interruption for various degrees of pollution (developed by CEDRE).

The number of different activities on the same area of coast can also be considered to develop a similar matrix as for sensitive biological resources above.

Producing the strategic map

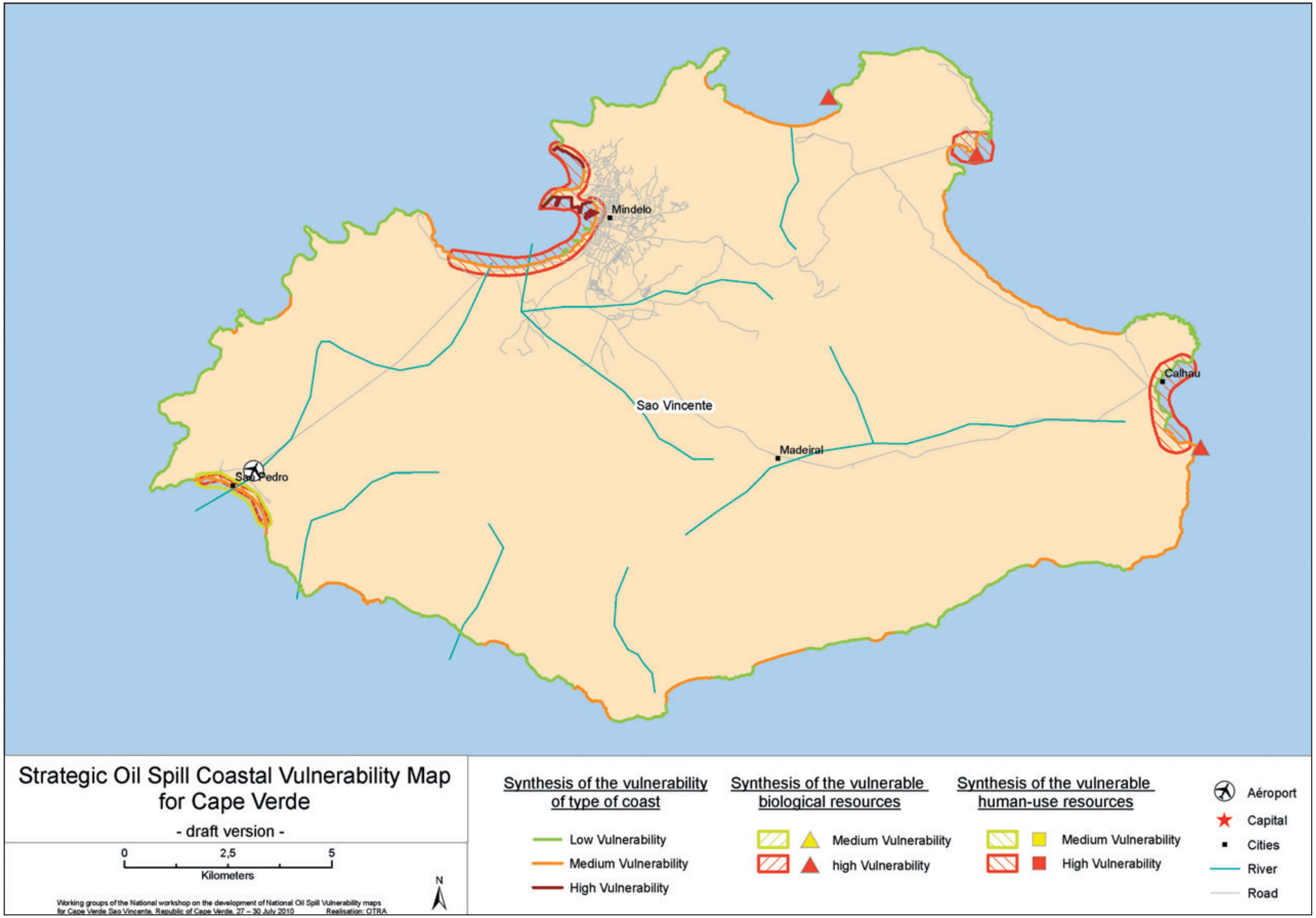
The strategic map can finally be produced with the three types of sensitivities ranked and integrated as described above. The strategic maps will highlight the most sensitive sites and, preferably, will maintain a minimum amount of information to be as clear as possible.

The strategic map facilitates the identification of the most sensitive sites, which may combine several types of sensitivities, through direct visual study of the map or by cross-analysis using a GIS. For example, a visual study of the strategic coastal sensitivity map for Cape Verde (Figure 14, overleaf) shows that various sensitivities are present at the bay of Mindelo, and these should therefore be considered as a high priority for oil spill response operations.

Once the most sensitive sites are identified, it is necessary to prioritize this list of sites to develop a realistic oil spill response strategy. The prioritization process should be conducted with the main stakeholders to openly discuss priorities for protection and clean-up.

When a consensus is reached on the prioritization, the strategic maps should be validated at a high level and, finally, be integrated in the contingency plan as an operational planning and decision support tool to assist with a NEBA.

Figure 14 *Strategic oil spill sensitivity map (example from Cape Verde)*



Strategic oil spill sensitivity maps provide a broad perspective to help locate and prioritize the most sensitive coastal sites.

Developing operational sensitivity maps

Operational maps should be developed for the most sensitive sites and the highest-risk sites (ports, oil handling facilities). They are designed to illustrate the specific site protection and to detail response operations planned for the site. The response operation would depend on local conditions and the local resources to be protected.

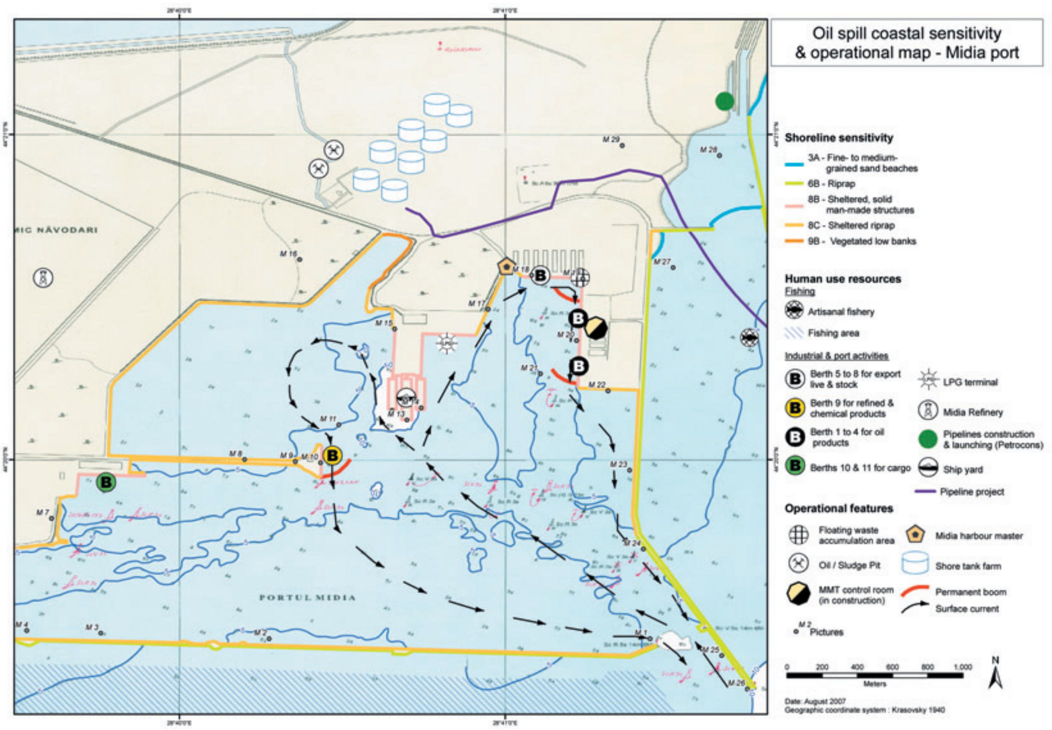
These maps will be used by the operators on site and should display all logistical and operational information available at large scale (e.g. 1:10,000 to 1:25,000) for the area mapped as well as instructions for protection and response operations. The information displayed on operational maps can be listed as below:

- detailed information to assist the operators on-site (access points to the coast, launching and anchoring points for the booms, staging areas close to the shore, temporary waste storage locations, dangerous areas/areas to avoid, tidal range, currents, waves, winds, specific dangers on site, etc.)
- geo-referenced and explicit information for the operators, including global positioning system (GPS) coordinates of the features displayed on the map, and operational instructions for the deployment of the equipment; and
- baseline information to locate the resources easily without prior knowledge of the area, e.g. high resolution satellite images, aerial photos, topographic maps.

The feasibility to protect these sites as well as the sizing of the required booming scheme should be assessed and defined by competent booming experts prior to an actual oil spill.

The maps should be produced in a format suitable for use in the field, such as plasticized A4 sheets, printed on two sides, and special care taken to optimize operational usefulness.

Figure 17 *Example of an operational map, for the port of Midia, Romania*



The operational map is developed at a large scale for the most sensitive site, and indicates all operational and logistical information, including specific site protection and details of the response operations planned. Copies of the map should be reproduced in a sturdy format capable of withstanding practical use in the field.

Managing a sensitivity mapping project

Supervision of the mapping project

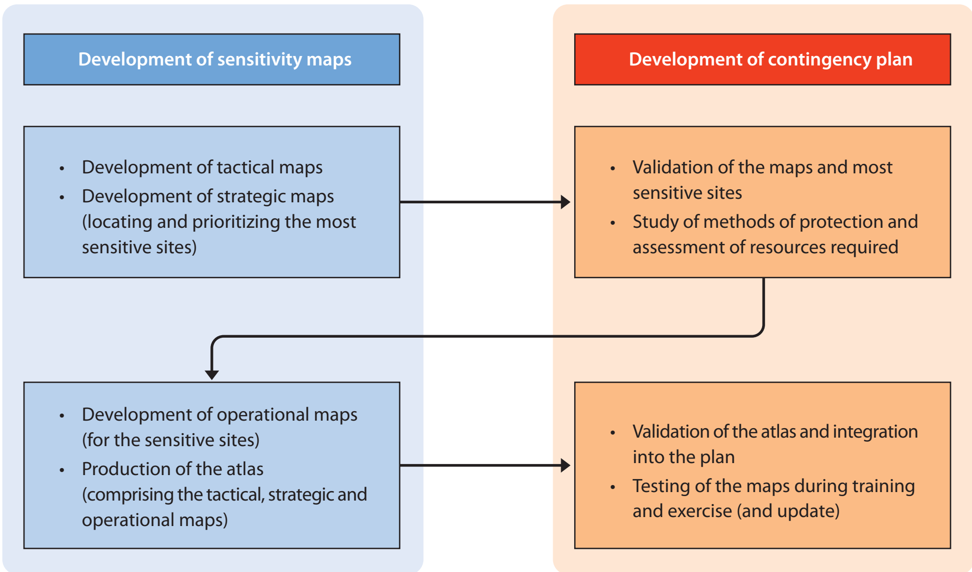
For a national oil spill contingency plan, the national authority in charge of oil spill preparedness and response in the country will be in responsible for the management of the sensitivity mapping project. This includes the dissemination of the final products to the main stakeholders involved in oil spill preparedness and response and those responsible for updates to the atlas.

For the local oil spill contingency plans, the department in charge of oil spill emergency response will supervise the oil spill sensitivity mapping project.

In all cases, the development of the maps and the identification and prioritization of the most sensitive sites should be integrated in the contingency planning process and support the development of the oil spill contingency plan, as outlined in Figure 18.

Development of the maps, and the identification and prioritization of the most sensitive sites, should always be considered as integral to the oil spill contingency planning process.

Figure 18 *Integration in the contingency planning process (see IPIECA-IOGP, 2015c)*



Planning and objectives

It is necessary to set clear objectives to focus the scope, the geographic coverage and the content of the sensitivity maps. The maps to be produced must be clearly defined as a decision support tool; and the maps must be integrated into the preparedness and response system of the country or of the organization. A lack of clear objectives and planning will result in unfocused, lengthy and costly data collection and potential (re-) production of existing data sets.

A decision should be made on the format and what type of Geographic Information Systems would be used (see below).

Resources, roles and responsibilities

Management shall ensure the availability of resources essential to establish, implement, maintain and improve the sensitivity maps. Resources include human resources and specialized skills, organizational infrastructure, and technological and financial resources.

Roles, responsibilities and authorities shall be defined, and communicated to facilitate effective management of the project.

A mapping project coordinator should be appointed for the development of the maps. This individual will be in charge of:
1. identifying the organization that will take the lead in the development of the maps (either internally with in-house expertise and resources or with external assistance); and
2. establishing a team of experts for the development of the maps (comprised of GIS experts, marine geologists, coastal zone environmental experts, coastal and environmental economists etc.).

A steering group consisting of the potential users of the maps may also be set up to ensure the involvement of the key stakeholders during the development phase.

The oil spill sensitivity maps (and GIS) must be envisaged as a participative tool, by:
- maintaining regular contacts (during the project) between data providers (producers or owners), GIS developers, thematic experts and the potential users of the end products at decision making and operations levels; and
- increasing the knowledge of the responders using the maps, to improve the oil spill contingency plan and to support response operations (through training and exercises involving the use of maps).

The use of a Geographic Information System (GIS)

Although sensitivity maps can be developed by drawing directly onto paper maps, or using general graphic/drawing software, specific spatial data and mapping software, i.e. Geographic Information Systems (GIS), are acceptable and widely used in local and national administrations and by the industry.

The use of a GIS to develop the sensitivity maps offers the following advantages:
- easily creating and updating the sensitivity maps;
- sharing and communicating the information;
- storing and managing the information (images, statistics, etc.); and
- producing maps at suitable scales, with the relevant layers of information, and in various formats (paper, PDF, interactive maps using the Internet).

A data management and ownership policy must be implemented at the start of the project, including the definition of the ownership policy of the produced data, particularly the dissemination/sharing of data with other organizations.

Interoperability must be encouraged to facilitate the exchange of data. It is recommended to use, as much as possible, standard GIS software, spatial data format, and geographical referential (data and projection).

Collection and control of geographic information

Two steps are essential before any data is collected.

Firstly, to ensure that the data collection process remains focused on the needs and objectives of the project, the mapping project coordinator should issue a list of the requested data. The information must be homogeneous for the entire area that may be exposed to oil spills (i.e. no areas with absence of data) and focused on the sites and resources that may be affected by an oil spill (and not all environmental features).

Secondly, to avoid recreating existing data, all the potential producers and owners of geographic data should be referenced: from public organizations, international institutions (UNEP WCMC, IUCN, etc.), existing GIS resources and data centres, and the industry. Useful catalogues of geographic information (GIS format) now exist at national, regional and international levels.

Some satellite imagery and aerial photographs are accessible free of charge on the Internet.

Figure 19 *Example of satellite imagery*

Source: Google Earth

Some satellite imagery and aerial photos are accessible free of charge on the Internet. Google Earth also provides worldwide satellite image coverage often of (very) high resolution, representing an accessible and 'free' of charge source of satellite imagery.

The actual collection of data can begin after these steps have been taken. Rather than purchasing the data, conventions/agreements may be signed with the owners of specific information by which they agree that their data may be used for the development of the sensitivity maps. During the collection of data, it is essential to bear in mind the objectives of the sensitivity maps and remain focused only on the collection of the required data.

Each layer of geographic information must be analysed to define its accuracy, interest and limits, and assess the requirements to complete the data or improve its accuracy.

Each layer of spatial data (in GIS format) collected or produced shall be accompanied by 'information on the geographic data' (i.e. metadata), including:

- owner and/or producer, nature of the spatial data (vector/raster);
- year of production, method of creation of the data, scale of digitization, sources;
- frequency of update, dissemination limitation, additional comments, etc.

Note: International Standard ISO 19115 (ISO, 2003) provides a full set of standardized metadata with 409 fields. Some countries have developed Spatial Data Infrastructures (SDI) for GIS, with which the layers of geographic information should comply.

After the collection of data, missions to the field (by land, sea or air) are often required to:

- validate the existing information (particularly for the identification of the type of coastline, e.g. difference between sandy beach and pebble beach, etc.); and
- complete the information for the areas where no data was available.

The use of devices with integrated GPS and GIS allow easy and accurate mapping of the features in the field. A helicopter over-flight (using geo-referencing digital camera and video) is the best compromise between quality, accuracy of data and speed of collection, particularly for large coastal areas or areas which are difficult to access, e.g. mangroves.

Production and distribution of the sensitivity maps

After validation, the maps should be assembled in an atlas with the additional relevant information for response and preparedness, in a suitable and easy to use format. The atlas should then be distributed to all relevant stakeholders, as part of the oil spill contingency plan.

The maps should be produced according to the general mapping recommendations, and accompanied by a clear title, a scale in a graphic format (valid after reduction/increase of size), the orientation (North), the legend (key) using harmonized symbols and colour codes, indication of the source(s) of data, the date and author.

Maps (physically integrated in the oil spill contingency plan as an appendix or distributed in a separate atlas) must be produced in a format suited to the needs of the end users, e.g.:
- decision makers will prefer a large format to use for support during discussions;
- On-Scene Commanders will use a medium-sized format, in a binder; and
- on-site responders will use smaller plasticized documents detached from a folder.

The use of Internet Map Server (IMS) technology enables GIS-based maps to be distributed on the Internet using a friendly and interactive interface, with basic GIS consultation functionalities; open access software is available online. Distributing maps through the Internet is also a cost-effective, updateable and easy way of providing maps to all parties (without the expense of a colour printed atlas). Web maps can also be integrated into electronic Emergency Management Systems and linked to other databases on the system (environmental data, operational information, etc.).

Review and update

Regular updates of the atlas should be carried out every three to five years to take into account any modification of the coast (e.g. erosion or expansion, new installations, etc.).

The use of sensitivity maps should be included during oil spill response exercises to test their usefulness and ease of handling, and to familiarize the responders with their use. Based on the feedback of the exercise, the maps can be updated and improved.

Conclusion

Oil spill sensitivity maps are an important tool to develop the best suited oil spill response strategies. Taking into account the various shoreline types, and more importantly the most sensitive coastal sites, the oil spill sensitivity maps can also guarantee fast and effective oil spill response operations. As such, it is necessary that the development of the oil spill sensitivity maps is considered as an essential step in the development of the oil spill contingency plan. The maps should be integrated into the plan and considered an essential element for preparedness and response operations.

A harmonized approach for oil spill sensitivity mapping is highly recommended. The ESI methodology has been proven to be efficient and is recognized as a worldwide referenced methodology to map the sensitivity of the coast to an oil spill. This methodology is structured around three main themes: shoreline type and its general environmental sensitivity (ranked by the Environmental Sensitivity Index), specific sensitive ecosystems and biological resources, sensitive human-use resources and logistics and operational resources.

However, this mapping methodology must be completed by the ranking of the mapped resources to locate the most sensitive sites (and establish priorities for protection and/or clean-up). There are several ranking methods, but it is recommended that complex methods involving many parameters are avoided.

It is recognized that GIS are of particular interest in the management of a mapping project, but require the implementation of a sound data management policy (including metadata development and encouraging interoperability).

The sensitivity maps should be developed as a project including a wide range of partners (authorities, services, industries, universities, NGOs, etc.). The benefits of such an approach include:
- multiplying and reinforcing the partnerships during 'peace time' (so that players meet before any incident);
- avoiding redundancy in the GIS work and limiting the cost of acquisition of geographic data (increasing sharing of the GIS data collected by other projects); and
- facilitating the distribution and the validation of the maps, and raising awareness among the partners.

An extension of the scope of oil spill sensitivity maps can also be considered, making best use of the potential additional achievements of such tools especially when developed using GIS. Considerations before initiating the technical development of the GIS and atlas include:
- identifying areas suitable for dispersant use considering water depth and specific sensitive resources;
- identifying places of refuge in line with the resolutions of the IMO on places of refuge for ships in need of assistance; and
- consideration of the sensitivity to other types of pollutants, i.e. hazardous and noxious substances (HNS).

Oil spill sensitivity maps must be developed as a tool which is:
- **Simple:** It is not a complete inventory of all living species and resources in the coastal environment or a long-term project. The collection of data must remain 'reasonable' in duration and volume.
- **Focused:** It must remain focused on the needs of the different users and on operational objectives.
- **Operational:** The atlas must be used (and easily usable) during incidents by non-experts.

Finally, it is important to remember that oil spill sensitivity maps are a tactical and strategic decision support tool and a source of information to assist the decision-making process during an incident. However, the final choice will be the responsibility of the responders, who will take all relevant factors into consideration, for maximum effectiveness of oil spill response operations.

Further reading

Documents

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Websites and resources

Data explorer (NOAA): http://nosdataexplorer.noaa.gov/nosdataexplorer

Environment Canada (Environmental Emergencies > Publications): www.ec.gc.ca

Google Earth: http://earth.google.com/intl/fr

International Maritime Organization (IMO): www.imo.org

International Union for Conservation of Nature: www.iucn.org

IOGP-IPIECA Oil Spill Response Joint Industry Project: http://oilspillresponseproject.org

IPIECA: www.ipieca.org

MAGIC web-based interactive map service (DEFRA, U.K.): www.magic.gov.uk/default.htm

Office of Response and Restoration (NOAA): http://response.restoration.noaa.gov

UNEP World Conservation Monitoring Centre: www.unep-wcmc.org

VPS.system / VPS.Sensi, Computer Aided Contingency Planning and Sensitivity Mapping System (Germany): www.vps-web.de

World Database on Protected Areas: www.wdpa.org

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IPIECA

IPIECA is the global oil and gas industry association for environmental and social issues. It develops, shares and promotes good practices and knowledge to help the industry improve its environmental and social performance; and is the industry's principal channel of communication with the United Nations. Through its member led working groups and executive leadership, IPIECA brings together the collective expertise of oil and gas companies and associations. Its unique position within the industry enables its members to respond effectively to key environmental and social issues.

www.ipieca.org

IMO — INTERNATIONAL MARITIME ORGANIZATION

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 the 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.

www.imo.org

IOGP — International Association of Oil & Gas Producers

IOGP represents the upstream oil and gas industry before international organizations including the International Maritime Organization, the United Nations Environment Programme (UNEP) Regional Seas Conventions and other groups under the UN umbrella. At the regional level, IOGP is the industry representative to the European Commission and Parliament and the OSPAR Commission for the North East Atlantic. Equally important is IOGP's role in promulgating best practices, particularly in the areas of health, safety, the environment and social responsibility.

www.iogp.org.uk