ASOCIACION REGIONAL DE EMPRESAS DE PETROLEO Y GAS NATURAL EN LATINOAMERICA Y EL CARIBE

GUIDELINES FOR THE DEVELOPMENT OF ENVIRONMENTAL SENSITIVITY MAPS FOR OIL SPILL PLANNING AND RESPONSE

Canadian International Development Agency

Environmental Services Association of Alberta

ARPEL GUIDELINE

DEVELOPMENT OF ENVIRONMENTAL SENSITIVITY MAPS FOR OIL SPILL PLANNING AND RESPONSE

Authors

Paul Wotherspoon – Wotherspoon Environmental Inc.
Dave Marks – Wotherspoon Environmental Inc
Laurie Solsberg – Counterspil Research Inc.
Mark West – Counterspil Research Inc.

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ARPEL, Javier de Viana 2345, CP 11200 Montevideo - URUGUAY
Tel.: (598-2) 400 69 93
Fax: (598-2) 400 92 07
E-mail: arpel@arpel.com.uy
www.arpel.org

Authors This Report has been prepared upon request of ARPEL and its Environment, Health and Safety Committee by:

Wotherspoon Environmental Inc.
#750, 521 – 3rd Ave. S.W.
Calgary, Alberta - Canada T2P 3T3
Phone: 1 (403) 269 4351
Fax: 1 (403) 263 6999
E-mail: weinc@cadvision.com

Counterspil Research Inc.
#135 – 1305 Welch St.
North Vancouver, B.C. - Canada V7P 1B3
Phone: 1 (604) 990 6944
Fax: 1 (604) 990 6945
E-mail: crinvan@istar.ca

The ARPEL Contingency Planning Working Group assisted consultants in detailed drafting and revision.

Reviewers

Carlos Benavídes	ECOPETROL
Osmel Manzano	PDVSA
Silvano Torres Xolio	PEMEX
Luiz A. Arroio	PETROBRAS
Patricia Fidel	BRIDAS S.A.P.I.C
Eddy Hernández Marrero	CUPET
Miguel Moyano	ARPEL General Secretariat
Oscar González	Environmental Services Association of Alberta

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Abstract

A guide was developed to assist ARPEL member companies in the development of sensitivity maps for oil spill planning and response. The guide uses a needs-based approach which includes a six step process, from determining the end-use for the maps, through data gathering, and ultimately to map production. A discussion of the Environmental Sensitivity Index (ESI) system, which is commonly used in sensitivity mapping systems worldwide is also included. Detailed sections on information requirements and computer database should assist readers in understanding the specific requirements of sensitivity maps. Finally, the strengths and weaknesses of four computer-based systems are discussed.

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1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

This guideline has been prepared for the Asistencia Re ciproca Petrolera Empresarial Latinoamericana (ARPEL) member companies to provide assistance in developing their sensitivity mapping systems. Much of the information has been based on the methods currently used by ARPEL member companies. Additional information reflects the latest methods and techniques in use throughout the world.

1.2 PURPOSE AND SCOPE

The primary purpose of this guideline is to provide guidance on how to collect the necessary environmental data and how to display that data on maps.

This guideline also addresses:

- map formats, sizes and scales
- use of symbols, legends, colour codes and patterns
- plotting
- associated database requirements

Historically, sensitivity mapping for oil spills has focused on coastal environments. This is mainly due to concern arising from several catastrophic spill incidents, e.g., Valdez, Braer, Amoco Cadiz, and the Torrey Canyon. However, since many in-land environments are subject to similar risks and consequences, the mapping of aquatic (estuarine, lacustrine and riverine) or nearshore (shoreline, intertidal and riparian) areas are also covered.

As a guideline, this document is not intended to provide a single *best* approach which must be followed exactly. Rather, most of the issues are identified which must be considered when developing a sensitivity mapping system. All such systems are unique and should be designed to best suit the needs of the user.

1.3 THE SENSITIVITY MAPPING PROCESS

STEP 1	Identify • Who will use the maps • How the maps will be used • What information is required/available
STEP 2	Determine the Best Method to Satisfy Needs • Paper maps only? • Paper maps and computer database? • Computer maps and database?
STEP 3	Gather Data • Base maps • Shoreline types • Sensitive resources • Spill response information • Other support data, i.e., contact numbers
STEP 4	Build Maps • Add symbols/shoreline types to base maps • Compile support data
STEP 5	Plot Maps • Print maps on paper (computer systems only)
STEP 6	Revise/Update Maps and Data • Update information as required

1.4 THE ROLE OF SENSITIVITY MAPPING IN CONTINGENCY PLANNING

Sensitivity mapping plays an important role in the overall contingency planning process as depicted in Figure 1.1.

The three primary goals of contingency planning are to:

1 Identify areas that require priority protection based on their vulnerability and risk to oil spills

2 Develop protection strategies (proactive)

3 Identify applicable response and/or cleanup methods for both aquatic and shoreline environments

[From USEPA and NOAA - (U.S. National Oceanic and Atmospheric Administration) 1994]

Well designed sensitivity maps provide an easily understood, graphical representation of:

- information critical to spill planners and responders (e.g., sensitive locations, response/cleanup strategies, spill equipment locations)

- support information on biological, geomorphological and human-use resources, as well as spill response and cleanup methods

As such, the development of sensitivity maps facilitates the risk assessment and response planning processes.

Figure 1.2 is an example map produced by Environment Canada for the Great Lakes Region (lake Ontario). As this region is located on the Canada/US border, both countries have jurisdiction in the event of a spill, and therefore a standard was adopted by both countries to facilitate communications and response efforts.

Figure 1.1
The Role of Sensitivity Mapping in the Contingency Planning Process

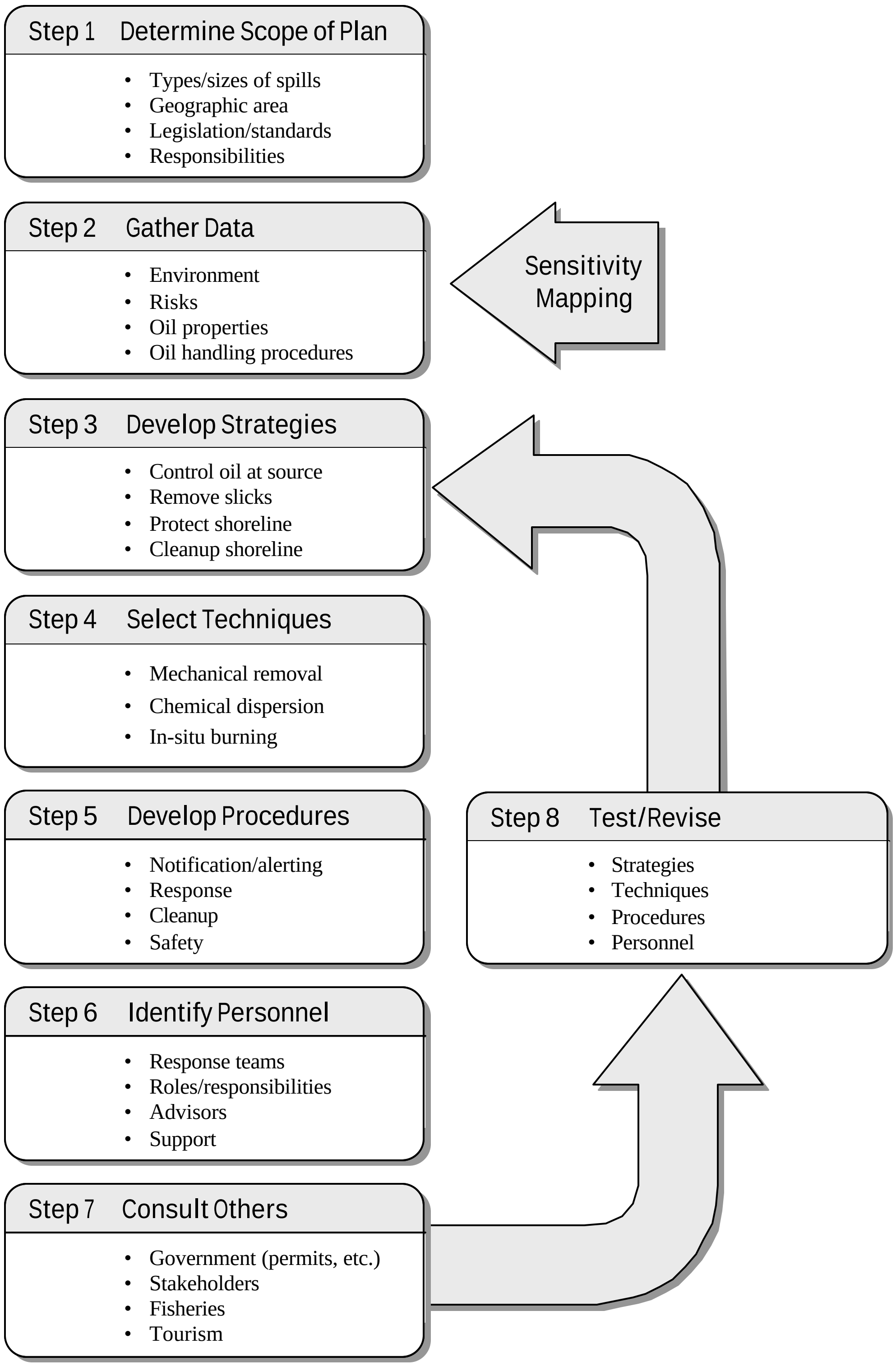
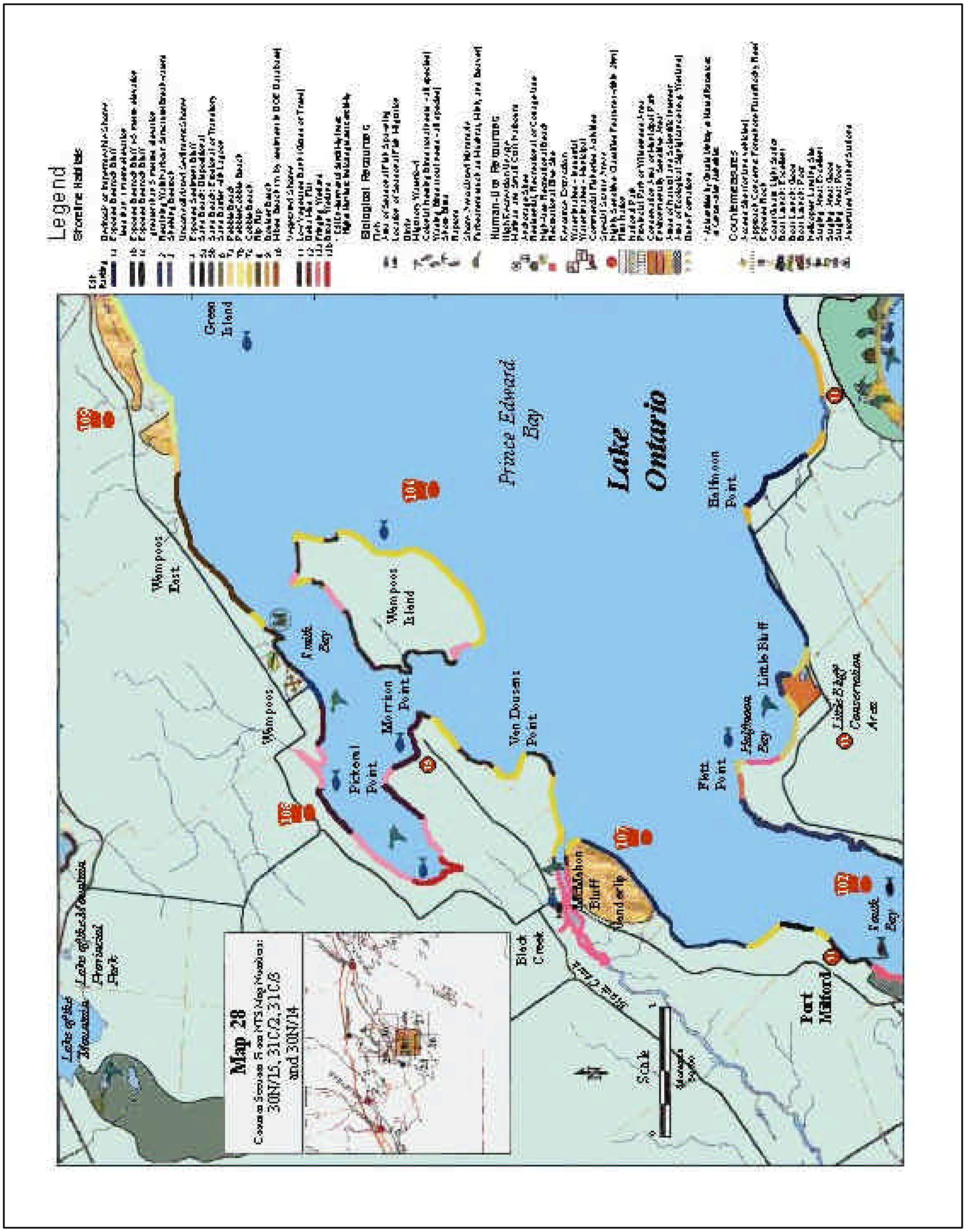


Figure 1.2 - Example Sensitivity Map



1.5 TYPES OF SENSITIVITY MAPS

There is a wide range of possible approaches to the incorporation and display of response (cleanup) strategies. For example, maps may include only sensitivity data with no indication of priority areas requiring protection and/or cleanup, leaving these decisions entirely to the interpretation of the map reader.

Alternatively, systems might include the display of areas where pre-approval for dispersant application or in situ burning has been granted by authorities.

Still-more-sophisticated systems display coloured zones indicating ***low***, ***medium*** and ***highly*** sensitive areas.

Ultimately, some mapping systems include a complex method for developing priority response areas using a matrix calculation based on:

- environmental sensitivity
- cultural impacts
- economic impacts
- archaeological impacts
- shoreline type
- applicability of response countermeasures due to currents and other conditions

These more sophisticated systems provide the map user with valuable information but require considerably more time and expertise of the map developer.

1.6 HOW TO USE THIS GUIDELINE

It is recommended that Section 2 be read first in order to understand the 6-step mapping process in detail. Next, read Section 3 to understand how Environmental Sensitivity Indexes (ESIs) can be used to describe shoreline types. Section 3 also includes a discussion on the inherent weaknesses in the traditional ESI system.

Section 4 provides details on mapping data requirements and Section 5 provides specific guidance for developing computer-based databases.

Finally, Section 6 provides a summary of available computer-based mapping systems and how to select an appropriate system for your needs.

2.0 MAP DEVELOPMENT

2.1 STEP 1 IDENTIFY THE USER(S) AND THEIR NEEDS

Knowing who the user will be and how sensitivity maps are to be used are fundamental to the successful application of the mapping system.

Sensitivity maps serve many different purposes. For example, they may be used as a response tool, providing spill responders and decision makers with the information needed to make quick and sound decisions during a spill.

Maps may also be used by risk assessment personnel to determine what resources might be at risk and where spill response equipment might best be stationed.

Technical specialists such as biologists or countermeasures experts may also use sensitivity maps to graphically display important wildlife and habitat areas, or to indicate possible cleanup strategies/techniques. Maps used by technical specialists normally contain more interest-specific information and often require the use of the additional databases.

Sensitivity maps may be required to provide detailed shoreline and resource information (e.g., the area surrounding a refinery or terminal site) or general area information available on regional maps covering larger areas.

In all cases, sensitivity maps must provide the necessary information in an easy-to-read, understandable format.

Most sensitivity maps include:

- land/waterbody locations (e.g., coastlines, lakes, rivers)
- coastal/shoreline geomorphology
- biological resources potentially at risk
- human-use resources potentially at risk

Depending on the needs of the user, maps may also include other information such as spill response equipment locations and deployment sites.

Note It is important to consider *Step 1* throughout the development process in order to ensure that the needs of the user are met. The sensitivity mapping process may take a long time and it is possible to lose track of the initial requirements of the system. For this reason, the end-user should play a key role in the development process.

2.2 STEP 2 DETERMINE THE BEST METHOD TO SATISFY NEEDS

Sensitivity maps do not need to be produced by a computer to be useful. In many cases, hand-drawn or -drafted maps may suffice. However, because of the complexity of some mapping systems, including symbols and support data, computer-based systems may provide the best possible method for many mapping system developers. It must be remembered that whatever system is used, hard copy maps will need to be printed, either in atlas format or on single pages, for field work.

Also, limited access to funding for computer hardware and/or software may dictate the use of a paper-based system.

Sensitivity maps may be produced in a number of formats and incorporate a number of different media including:

- paper maps or atlases
- computer-based systems
- aerial photographs
- videos

Depending on the needs of the user, several or all of the above systems may be used. Because paper and computer systems are most often used to create maps, this guideline focuses on their development and use. Videos are sometimes used to provide additional resource information.

Computer mapping systems offer the user wide flexibility and extensive data storage capability. Computerized maps are far easier to update and can be linked to other applications such as database or trajectory modelling programs.

The printed format of sensitivity maps will vary depending on user needs. For example, large maps suitable for strategic planning or for display on a wall may be required. Usually, atlases are compiled that provide numerous smaller maps on standard pages in a single document. The small size allows the maps to be easily reproduced or faxed. Atlases may also include detailed support information on facing pages that would otherwise clutter the maps.

2.3 STEP 3 GATHER DATA

Most sensitivity mapping systems have two main components:

1. ***Map or series of maps*** (spatial data)

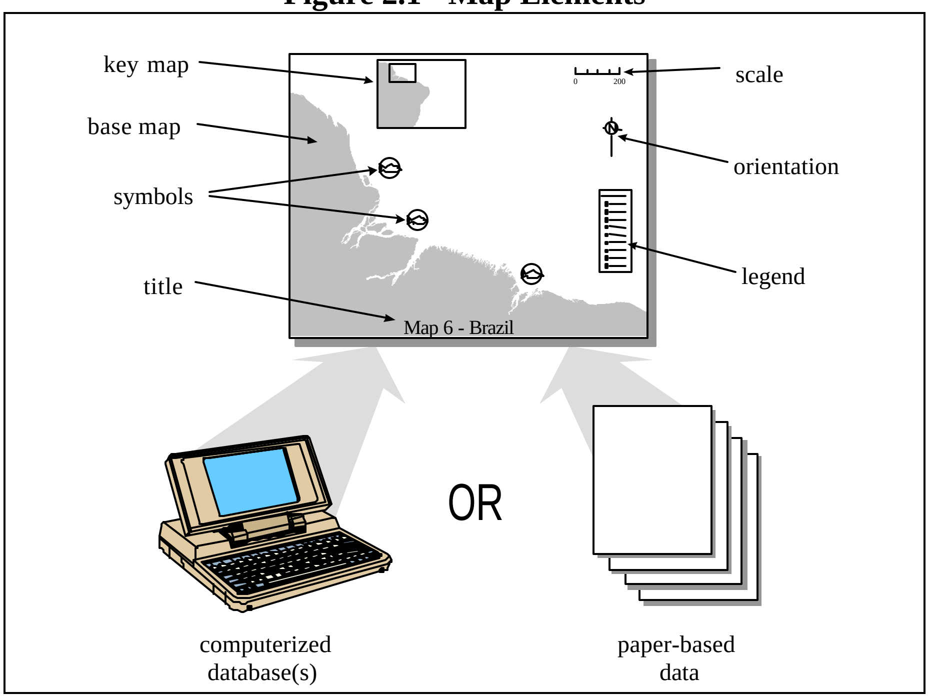
    - base map showing land and waterbodies
    - shoreline types, normally shown as coloured segments
    - biological, human-use and spill response information identified using polygons, lines and symbols
    - map support information, i.e., legend, orientation, scale, production date, etc.

2. ***Supporting data***

    Detailed information supporting the map(s). This may be computer- or paper-based.

    - shoreline, inter-tidal and subtidal habitat data
    - biological data
    - human-use data
    - spill response data

Figure 2.1 - Map Elements



2.3.1 INFORMATION SOURCES

Many sources of information exist that can provide assistance when developing a sensitivity mapping system.

Table 2.1 lists various data components required for sensitivity maps. It does not list all possible information sources, but instead provides several suggested references.

Section 4.0 (Information Needs) details the data from each category which must be gathered.

Additional sources are listed in Section 7.0 "References and Contacts". See also Appendix A (Cartographic Agencies of Mexico, Central America, South America and the Caribbean) for base map information.

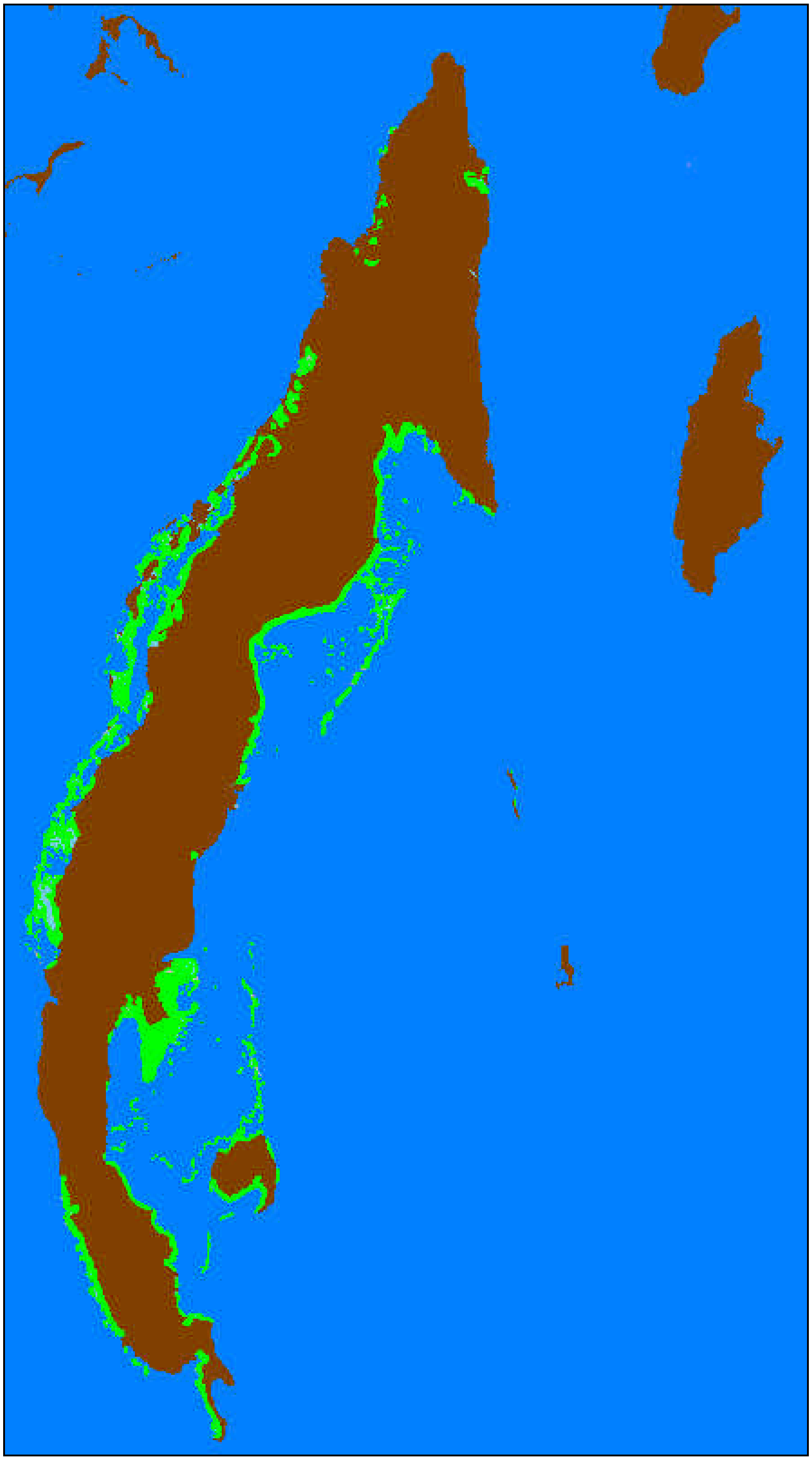
Table 2.1 - Sensitivity Mapping Information Sources

Source	Type of Information	Contact (if applicable)
Base Map		
National Geological/ Geographical Departments	• topographic maps • shoreline maps • cultural feature maps	• specific to individual country
National Oceanographic Departments	• oceanic/coastal maps (may include larger subtidal habitats)	• specific to individual country
National Military	• oceanic/coastal maps (may include larger subtidal habitats) • topographic maps	• specific to individual country
NOAA (National Oceanic and Atmospheric Administration - U.S.)	• oceanic/coastal maps (may include larger subtidal habitats)	• telephone: 1 (301) 436-6990
British Admiralty	• oceanic/coastal maps (may include larger subtidal habitats)	• telephone: 44 (823) 337900
Geomorphology		
"The World's Coastline" E. Bird and M. Schwartz (1985)	• coastal landform types	• see Section 7.0 for details.
National Oceanographic Departments	• coastal maps	• specific to individual country
NOAA	• oceanic/coastal maps (may include larger subtidal habitats)	• telephone: 1 (301) 436-6990
Satellite Imagery Services/Consutants	• coastal/inland area maps	• specific to individual country
British Admiralty	• oceanic/coastal maps (may include larger subtidal habitats)	• telephone: 44 (823) 337900

Table 2.1 - Sensitivity Mapping Information Sources (continued)		
Source	**Type of Information**	**Contact (if applicable)**
	Biology	
National Environmental Departments	• varies	• specific to individual country
Universities	• varies	• specific to individual country
Biologists	• varies	• specific to individual country
WCMC (World Conservation Monitoring Centre - U.K.)	• Digitized biological and ecological information in spatial format (terrestrial and marine) • Biodiversity Map Library (See example - Figure 2.2)	• Dr. Richard Luxmoore telephone: 44 (1223) 277314 Email: luxmoore@wcmc.org.uk
TNC (The Nature Conservancy - U.S.)	• Digitized biological and ecological information in spatial format (terrestrial and marine)	• Roger Sayre telephone: 1 (703) 841-4211 Email: rsayre.tnc.org
The World Bank (Washington D.C.)	• marine species/habitats	• telephone: 1 (202) 458-2715
Local individuals (residents, fishermen, hunters, naturalists, etc.)	• varies - familiar with local conditions	• specific to individual country
	Human-Use	
National Geological/ Geographical Departments	• cultural feature maps	• specific to individual country
Local individuals (residents, fishermen, hunters, naturalists, etc.)	• varies - familiar with local conditions	• specific to individual country
	Spill Response	
Oil companies	• equipment inventory and locations • deployment/staging areas	• specific to individual country
National Military	• equipment inventory and locations	• specific to individual country
Tanker Operators	• equipment inventory	• specific to individual country
Equipment suppliers	• equipment inventory	• specific to individual country
Private Individuals	• equipment inventory	• specific to individual country

If a computer-based system is used, it may be possible to import these data directly from digital files, saving considerable time and cost of manual data entry. Figure 2.2 is an example map showing mangrove locations in Cuba produced using digital data provided by the World Conservation Monitoring Centre.

Figure 2.2 - WCMC Example Data - Mangroves in Cuba



2.4 STEP 4 BUILD MAPS

2.4.1 GENERAL CONSIDERATIONS

The production phase of the mapping process involves overlaying resource and other information over a base map. This is normally done using:

- colours
- patterns
- lines and polylines
- polygons
- symbols
- text

There are a number of important characteristics which all sensitivity maps should have, regardless of their format. Sensitivity maps should:

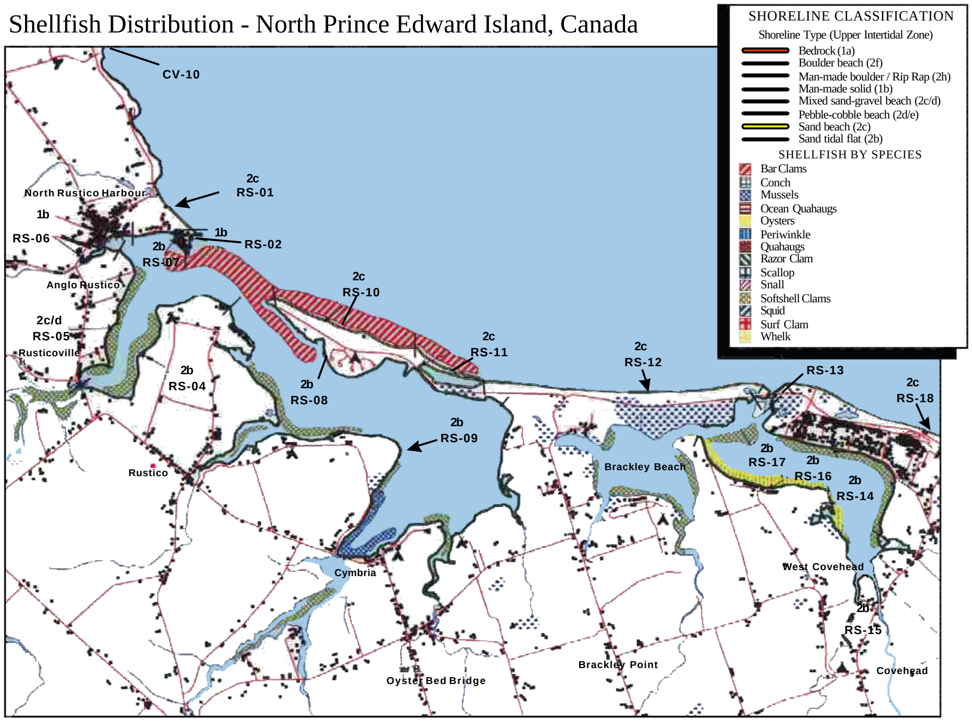
- contain sufficient information to be useful, but should not be cluttered
- clearly display sensitive areas with symbols
- be easy to interpret
- contain natural features which are not bisected
- have scales based on the limits of data being presented
- have scales based on the potential size and potential impact locations of various types of spills
- be clearly labelled with title, scale, direction, legend/key, and date of production/revision
- include a location map to indicate the relation of the mapping unit to other units or a larger scale map
- be reproducible and legible in hard copy black and white (compatible with fax and black and white photocopiers)
- be reproducible in hard-copy on demand
- be reproducible on field-portable computers (if applicable)

The detail required for a given area will depend on user needs. For example, initial spill response personnel may need only the information that will help them to make sound and quick decisions for the containment and cleanup of a spill (see Figure 1.2).

Alternatively, a technical specialist, such as a biologist, may require more detailed information (see Figure 2.3) on biological communities or habitat sizes and locations.

Figure 2.3 - Example Map

Shellfish Distribution - North Prince Edward Island, Canada



2.4.2 MAP SCALE

Map scales will vary with the amount of information required or available, or with the size of the area to be mapped. Extremely detailed, site-specific maps (e.g., a river system with numerous potential spill sources within a heavily populated area) may be produced in a large scale such as 1:10,000, whereas a map covering a large portion of coastline that includes few sensitive resources may be produced in a smaller scale such as 1:1,000,000.

If available, maps of different scales can be used for different purposes or sizes of spills. For example, an overall strategic map at a scale of approximately 1:1,000,000 could be used during a large spill to locate general areas of population, vessel traffic lanes, and significant resources.

Alternatively, more detailed area-specific maps at scales of approximately 1:10,000 are useful in developing response strategies for smaller spills, or where a large spill is nearing shore.

Ultimately, the scale used will depend on:

- the need for details in certain areas
- how the information will be used
- availability of data
- hardware and software limits

The scale should be marked using the bar scale method versus the 1 cm = x m or km method (in case the original copy is reproduced at another size).

2.4.3 COLOUR CODES AND PATTERNS

The use of colour in sensitivity maps is important to differentiate and highlight areas of the map of interest to spill responders. Colours can be used to depict various landforms and waterbodies, and to identify various types of shorelines, critical biological areas/habitats, and other important areas. Table 2.2 summarizes colours used for the NOAA ESI system (see Section 3.0).

It may be necessary, however, that the maps be reproducible and legible in hard-copy black and white.

Shorelines

Table 2.2 - Shoreline Types

ESI	Shoreline Description	Colour
1	• exposed rocky cliffs • exposed vertical seawalls (concrete/wood/metal)	dark purple
2	• exposed wave-cut platforms in bedrock • scarps in unconsolidated sediments	light purple
3	• fine- to medium-grained sand beaches	dark blue
4	• coarse-grained sand beaches	light cyan
5	• mixed sand and gravel beaches	cyan
6	• gravel beaches • rip rap	forest green green
7	• exposed tidal flats	olive
8	• sheltered impermeable rocky shores • sheltered semi-permeable rocky slopes • sheltered solid man-made structures	yellow yellow - orange
9	• sheltered tidal flats • sheltered sand/mud flats	orange
10	• salt water marshes • mangroves • fresh water marshes • fresh water swamps	red light magenta dark red brown

Where black and white reproduction (or faxing) is necessary, it is recommended that in addition to colours, patterns also be used to indicate shoreline geomorphology and habitat types.

Figure 2.4 (developed by the U.S. Geologic Survey for the Valdez area of Alaska, USA) shows the effective use of black and white patterns.

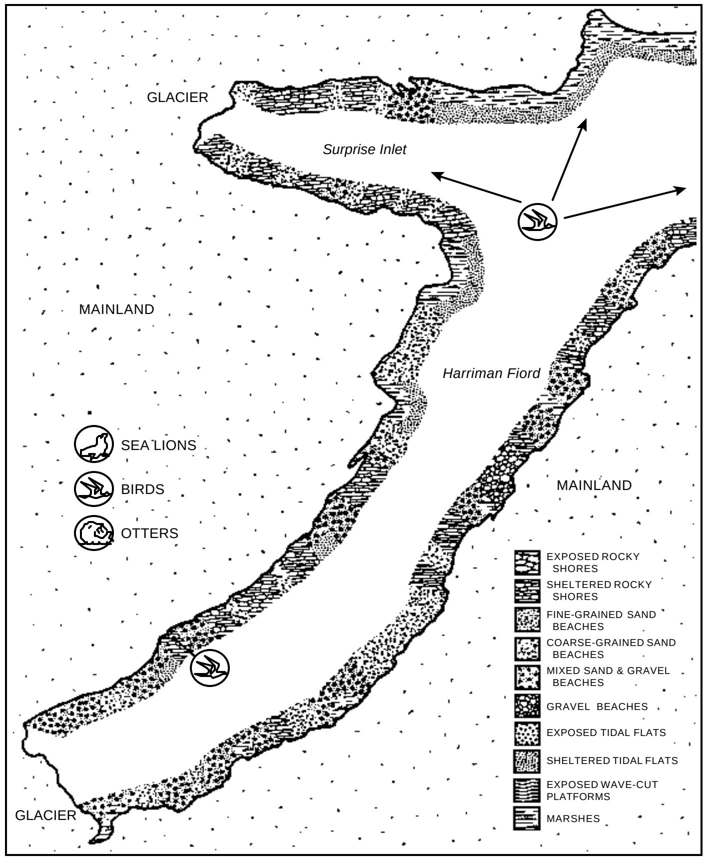


Figure 2.4 - Using Patterns

2.4.4 SEGMENTATION

When dividing any coastline into unique segments, it is important to consider:

- users needs (how the map will be used)
- the amount and availability of detailed coastline data

For example, if the maps will be used to develop shoreline protection and cleanup strategies for specific areas of sensitive coastline, then the maps will require a high degree of segmentation. Such a map might include every unique shoreline type (possibly including a further definition of ***upper*** and ***lower*** inter-tidal zones), including concrete piers and wharves.

Alternatively, maps used to develop overall response strategies or to conduct risk assessment might have shoreline segments 10's or 100's of kilometres long, or might only include only those segments of high sensitivity or vulnerability.

2.4.5 REPRESENTING SENSITIVITIES

Sensitivities can be identified on the map using lines (polylines), polygons, or symbols.

Lines

Lines can also be used in conjunction with symbols to show zones, such as river areas where spawning occurs or shoreline areas where turtles nest.

Resources found throughout a map can be represented using a symbol in a box with the words *common throughout*.

Note If lines are used, they should be of sufficient distance from the coastline to avoid confusion with it, particularly in areas where ESI colours are used to depict shoreline types.

Polygons

It is often difficult to locate a single *point* to identify the location of fish or birds, which can often be found in relatively large areas. For this reason, symbols are usually placed in critical areas such as spawning, rearing, or foraging areas, or where there are known to be large concentrations. Where symbols are used to locate these general resources, shaded or coloured *polygons* should be used to depict the overall coverage area for that resource. Polygon and line colours should be:

Fish	blue
Shellfish	orange
Birds	green
Mammals	brown
Reptiles	red

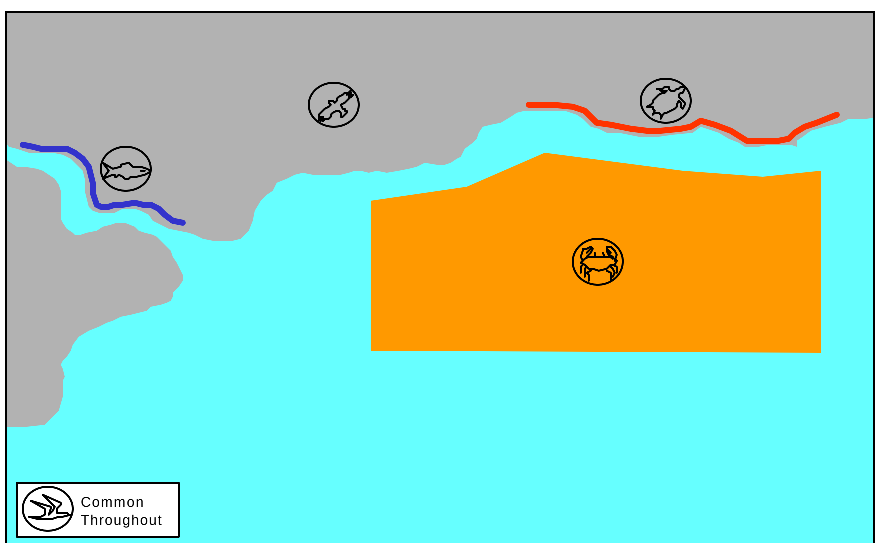


Figure 2.5 - Use of Symbols, Lines and Polygons

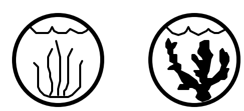
Symbols

The symbols included in this section are used extensively in sensitivity mapping systems throughout the world (Tables 2.3 through 2.6), and are based, in part, on symbols developed by NOAA. It is recommended that readers adopt these standard symbols to facilitate the use and understanding of the maps by outside agencies or when sharing the information with other ARPEL members. It is recognized that there will likely be a requirement to create additional symbols reflecting the specific needs of some regions.

The symbols used are divided into four main groups:

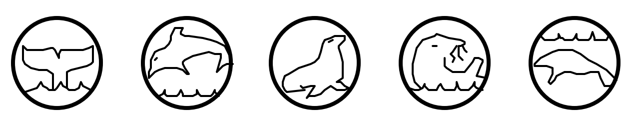
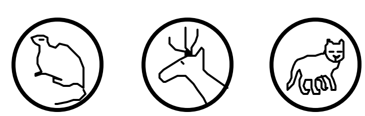
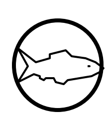
- sub-tidal habitats
- biological
- human-use
- spill-related

Table 2.3 - Subtidal Habitat Symbols

Habitat	Symbol
• eelgrass bed • submerged aquatic vegetation • worm reefs • large beds of kelp • coral reefs	

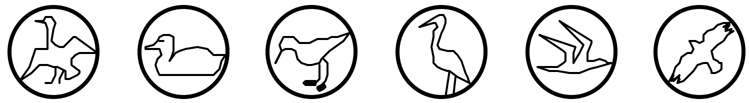
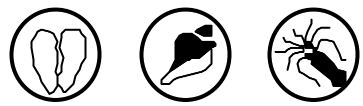
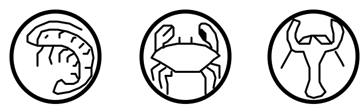
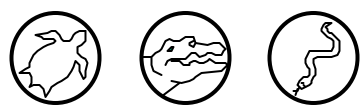
(Michel et al., 1995)

Table 2.4 - Biological Resource Symbols

Group	Symbol
Marine Mammals • whales • dolphins • seals/sea lions • sea otters • manatees	
Terrestrial Mammals • rodents • deer • cat family	
Fish • anadromous fish • beach spawners • kelp spawners • nursery areas • reef fish	

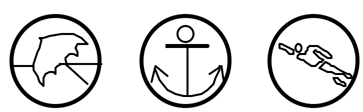
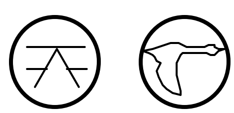
(Michel et al., 1995)

Table 2.4 - Biological Resource Symbols (continued)

Group	Symbol
Birds • diving coastal birds • waterfowl • shorebirds • waders • gulls/terns • raptors	
Molluscs • oysters • mussels • clams • scallops • abalone • conch/whelk • squid/octopus	
Crustaceans • shrimp • crabs • lobsters	
Reptiles • sea turtles • alligators • snakes	

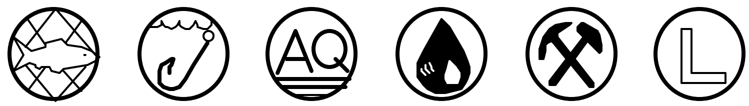
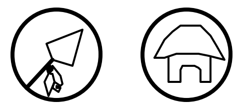
(Michel et al., 1995)

Table 2.5 - Human-Use Resource Symbols

Group	Symbol
Recreation • beaches • marinas • recreation areas	
Management Areas • park • wildlife management area (refuge)	

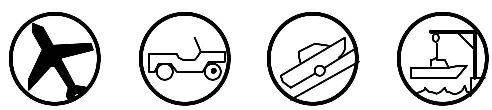
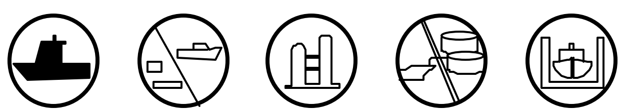
(Michel et al., 1995)

Table 2.5 - Human-Use Resource Symbols (continued)

Group	Symbol
Resources • subsistence fishery • recreational fishery • aquaculture • water intake • mining • log storage	
Cultural • archaeological site • village	

(Michel et al., 1995)

Table 2.6 - Spill Response Symbols

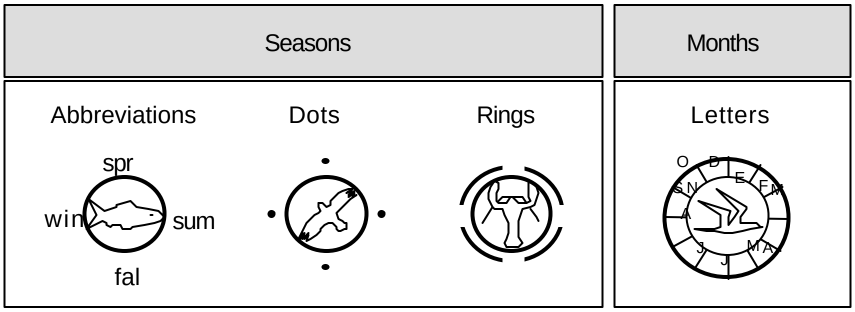
Group	Symbol
Transportation • airport • road access to shore • boat ramp • boat launch	
Response • equipment depot • equipment staging area • oil refinery • oil terminal • drydock	

(Michel et al., 1995)

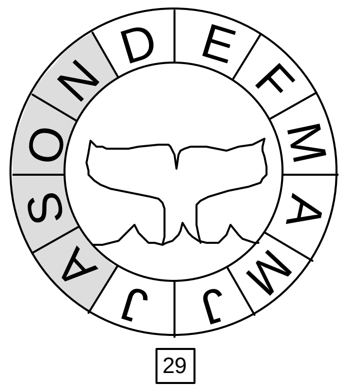
2.4.6 REPRESENTING SEASONALITY

Depending on how the maps will be used, they may also need to indicate seasonality (the period during the year when an item is present or most vulnerable), such as the spawning period of fish. This can be accomplished in a number of different ways. For example, the seasons of concern can be shown using letters, dots, rings or months of the year (see Figure 2.6). In equatorial regions where essentially no seasons exist, the “months of the year” method may be most appropriate.

Figure 2.6 - Showing Seasonality



A number can be used in conjunction with a symbol to represent a specific species or a specific location. The number accompanying the symbol on the map would correspond to specific information within the database (e.g., #29 may specifically represent humpback whales).



It is recommended that ARPEL members adopt a standard system of symbol numbers for individual species for all Latin American and Caribbean countries. This would ensure all map symbols and numbers would be uniform among participating countries.

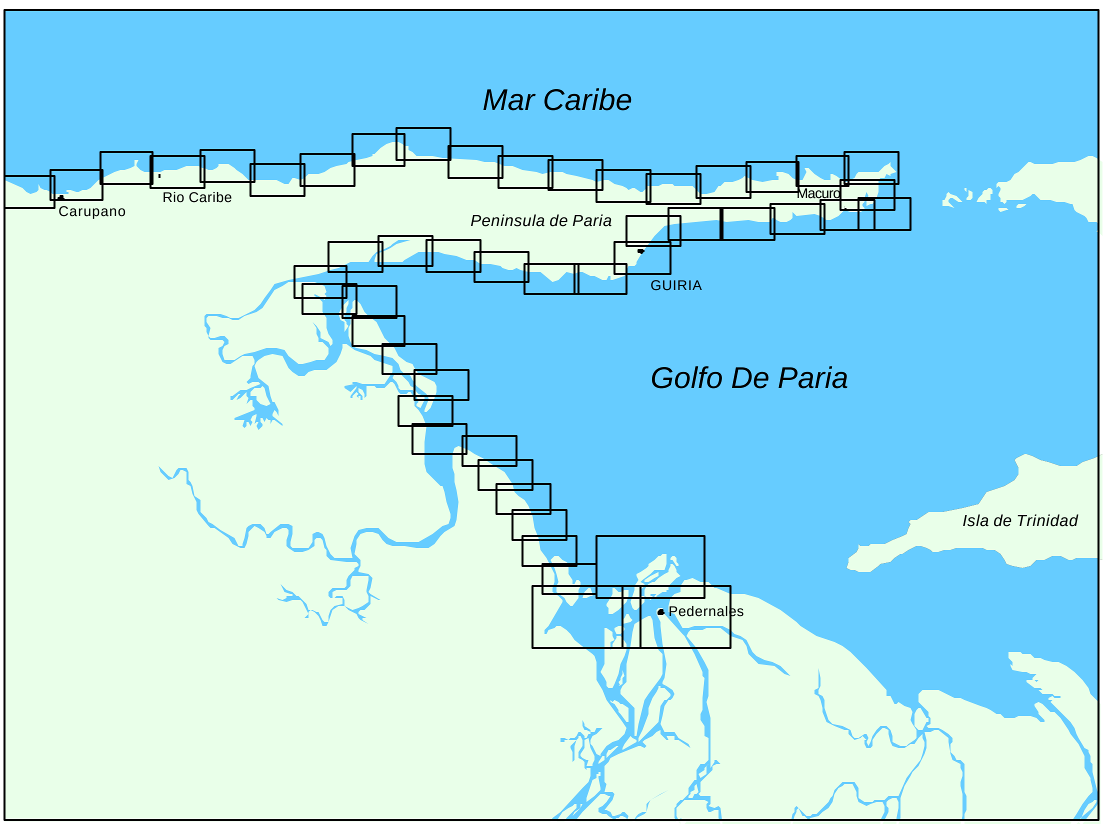
2.5 Step 5 Plot Maps

Once the base map and sensitivity data have been assembled, a set of paper maps is normally produced. If the maps are already on paper (paper-based systems), then these maps can be copied for individual use or compiled into an atlas.

If a computer-based system is used, then maps can either be printed (or plotted) as required, or be compiled in an atlas format. The computer system has an advantage in that a map of any size, depicting any region in the coverage area, can be quickly plotted.

In either case, if an atlas is produced, it will be necessary to create a location map in order to find the individual maps within the atlas. As shown on the map below from Venezuela (Figure 2.7), location maps also indicate the geographic scope of the mapping system.

Figure 2.7 - Example Location Map



(PDVSA / Intevep, 1996)

2.6 STEP 6 REVISE/UPDATE MAPS AND DATA

There are a number of reasons why sensitivity maps might require updating:

- The information needs of the map user change.
- The sensitivity data changes (phone numbers, personnel, etc.).
- More data are available (from ongoing studies, etc.).
- More detail is required in high risk areas.
- The geographic area (scope) of interest is increased.

In any case, it may be necessary to update maps every six months or less. For this reason, the above factors should be carefully considered when choosing a mapping system (Step 2).

3.0 ENVIRONMENTAL SENSITIVITY INDEX (ESI)

3.1 BACKGROUND

ESIs were first proposed as a tool for oil spill response by E.R. Gundlach and M.O. Hayes in 1978 (Michel et al., 1995). Since then, several approaches have been used to assign numerical values to the sensitivity of a shoreline to oil. Most of these use a scale of from 1 to 10, and cover the majority of shoreline types that would likely be encountered anywhere in the world.

Other systems involve the use of either less (e.g., Owens and LeBlanc, 1996), or more (e.g., Harper et al., 1991) numerical values depending on how detailed the shoreline characteristics are defined. Another, more-simplified method, divides the coastline into three simple types:

Red areas	indicating highly sensitive areas
Green areas	indicating medium sensitive areas
Blue areas	indicating low sensitive areas

This method results in more easily understood (and possibly more useful) maps. However, more effort is required to develop them, taking into account such factors as environmental sensitivity, the viability of response methods, socio-economic concerns, and other factors.

Where there are risks from spills to inland areas such as river and stream systems, a watershed rating system can be used. Because the terrain of streams may vary greatly over small areas, it is not practical to map all segments of shoreline. The watershed rating approach segregates individual watersheds which may include several sizes and natures of streams and rivers. This approach is further explained by Michel et al., 1994.

It is important to note that while identifying shoreline types (based solely on geomorphology) can provide useful information to map users, ESIs should not be interpreted as a true sensitivity indicator. Instead, ESIs should be used to identify the **relative vulnerability** of different shoreline types. ESIs do not take into account other potentially significant factors including biological, economic and social issues (see Section 3.3).

In this guideline, the ESI system developed by the U.S. National Oceanic and Atmospheric Administration (NOAA) is described. This system is used and widely accepted throughout the world.

Table 3.1 lists the ten NOAA coastal shoreline ESIs and their lake and river equivalents.

Table 3.1 - Comparable Shoreline/Bank Types			
ESI	**Coastal** (Estuarine)	**Lake** (Lacustrine)	**River** (Riverine)
1	exposed vertical cliffs/walls	exposed vertical cliffs/walls	exposed vertical banks/walls
2	exposed wave-cut platforms	shelving bedrock shores	bedrock ledges
3	fine/medium-grained sand beaches	unconsolidated sediment bluffs	unconsolidated sediment banks
4	coarse-grained sand beaches	sand beaches	sand bars and low-slope banks
5	mixed sand and gravel beaches	mixed sand and gravel beaches	mixed sand and gravel bars and low banks
6	gravel beaches and riprap	gravel beaches and riprap	gravel bars and riprap
7	exposed tidal flats	exposed flats	*no riverine equivalent*
8	sheltered rocky shores and seawalls	sheltered rocky shores and seawalls	sheltered steeply sloping bluffs
9	sheltered tidal flats	sheltered vegetated low banks and mud/sand flats	vegetated low banks
10	marshes, swamps and mangroves	marshes, swamps, bogs, fens	marshes, swamps, oxbow lakes

(From USEPA and NOAA, 1994)

3.2 Factors Affecting Shoreline Vulnerability (ESIs)

Shoreline vulnerability to oil spills is affected by:

1. wave and tidal energy exposure (amount of shelter)
2. type of substrate (permeability, sediment mobility)
3. slope of the intertidal (or flood-exposed) segment of shoreline

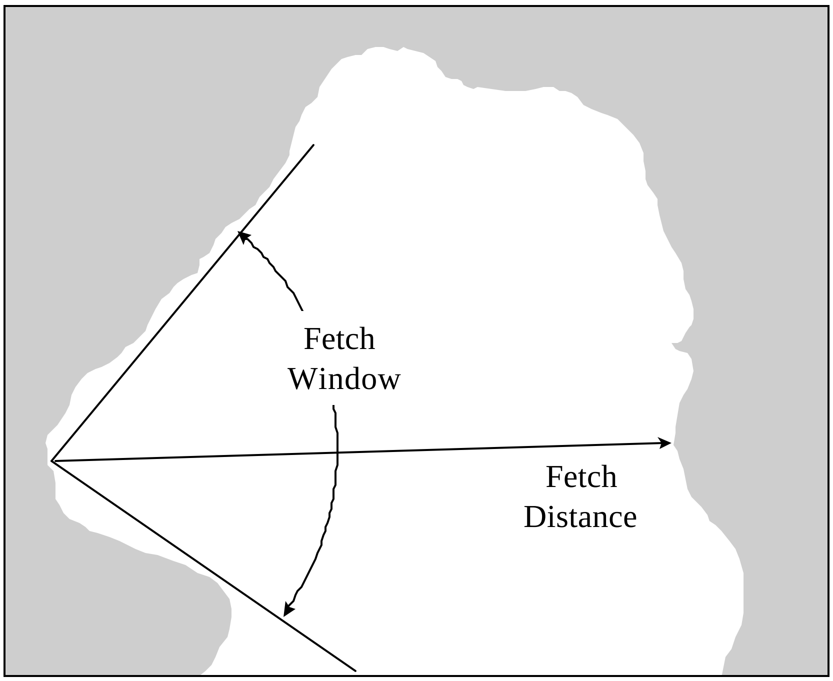
3.2.1 Wave and Tidal Energy Exposure

Shorelines exposed to higher levels of wave and tidal energy usually are assigned lower ESIs because the force of the breaking waves promotes the natural cleaning and reworking of the intertidal shoreline and therefore tends to limit oil residence time.

Offshore currents created from wave refraction/reflection may also push any spilled oil away from the shore and minimize its effects. For these reasons, biological organisms are not usually abundant in high wave energy environments.

Tidal variations (along with shoreline slope) determine the size and extent of the intertidal zone, (i.e., the maximum surface area that may be exposed to oiling in the event of a spill). For lacustrine and riverine environments, the intertidal zone corresponds to the seiche zone or the wave swash zone [between the lowest and highest annual water levels (Environment Canada, 1994a)]. Tidal variations are usually well known and data are relatively easy to obtain. Wave exposure can be estimated using a simple calculation of the *wave fetch*. Wave fetch refers to the distance over which waves may be generated by wind.

Figure 3.1 - Wave Fetch



(From Owens et al., 1992)

Fetch Window is the maximum angle of wind fetches that affect a shoreline.

Fetch Distance is the distance from the shoreline to the nearest landfall occupying a substantial part of the fetch window.

Using Table 3.2, the wave exposure can be estimated.

Table 3.2 - Estimating Wave Fetch

Fetch Distance	Fetch Window			
	< 45°	45° - 120°	120° - 180°	> 180°
< 5 km	low	low	low	low
5 - 10 km	low	medium	medium	medium
10 - 50 km	medium	medium	high	high
> 50 km	high	high	high	high

(From Harper and Williams, 1993)

3.2.2 TYPE OF SUBSTRATE

Substrate type, i.e., texture, is perhaps the most important factor in assigning appropriate ESIs. The type of shoreline substrate will determine or affect several other parameters including permeability, sediment mobility, oil residence, and the types of biological communities.

Substrate permeability correlates directly with the potential infiltration, and thus residency of, oil. The larger the substrate grain size the deeper the oil infiltration. Examples range from an exposed bedrock cliff, which is likely impermeable (unless through fractures), to a coarse, well-sorted gravel beach where oil penetration may exceed 100 cm (Michel et al. 1995).

Unconsolidated substrates are prone to sediment mobility through normal wave action which may be greatly accelerated during storm events. The movement of sediments may increase oil residence time through burial of the oil.

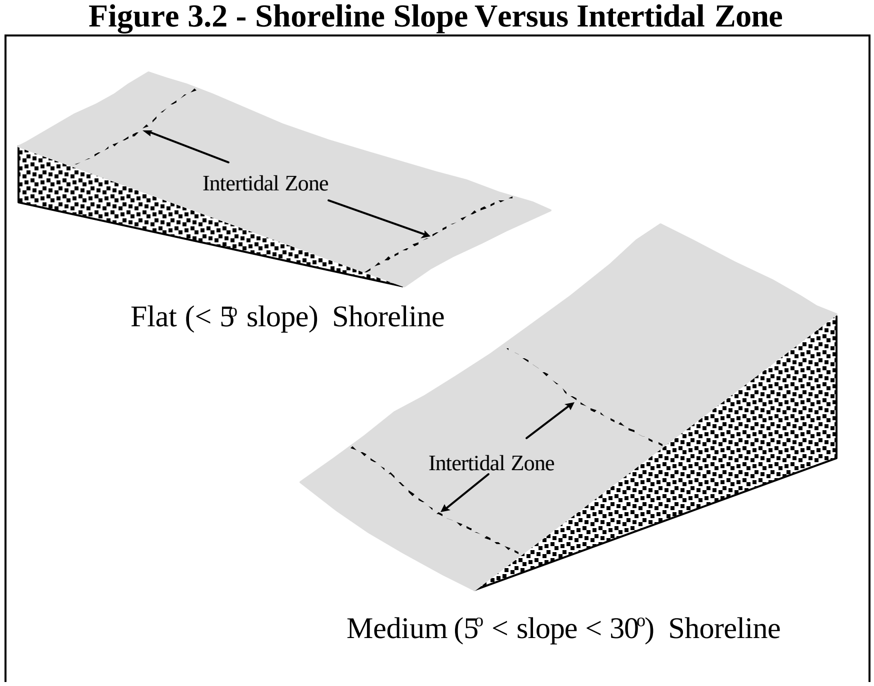
Substrates form the basic foundations which dictate the types of biotic communities which may exist at a given location.

3.2.3 SLOPE OF THE INTERTIDAL ZONE

The degree of slope of a given shoreline segment determines the relative size of the intertidal surface area. Slope is generally described as steep [> 30^{O}], moderate [< 30^{O} and > 5^{O}], or flat [< 5^{O}] (Michel et al. 1995).

The slope of a shoreline dictates the amount of wave breaking and wave reflection energy. Steeper slopes are most often subject to intense wave breaking and reflection energy. Oil residence time is likely minimal and the shoreline is quickly and naturally cleaned of any oil.

Figure 3.2 - Shoreline Slope Versus Intertidal Zone



Flat shorelines are not only subject to less wave energy (longer oil residence time and less natural cleaning actions) but also have larger intertidal surface areas which allow for the establishment of extensively developed biological communities, e.g., clam beds, mussel beds, algae/plant communities (Michel et al., 1995).

3.3 FACTORS NOT INCLUDED IN ESI'S

3.3.1 BIOLOGICAL PRODUCTIVITY AND SENSITIVITY

Biological species present in the area of an oil spill are the end-receptors of any unrecovered oil. The density and diversity of biological communities correlates partly with the previous three factors pertaining to ESI classifications, i.e., exposure, substrate type and shoreline slope. Species density and diversity are generally greatest in low wave and tidal energy environments with flat unconsolidated substrates (e.g., salt marsh or mangrove forest).

Generally, the greater the density of the biological community, the greater the ESI rating.

Although not always included in an ESI analysis, biologically-related variables such as species rarity (threatened or endangered) or seasonal species should be considered.

3.3.2 HUMAN-USE AND SENSITIVITY

Human-use factors are not specifically included within the NOAA ESI ranking system; however, factors such as human population densities, recreational and/or industrial uses and sensitive receptors should be considered when ranking shoreline or bank environments.

3.4 EXAMPLES OF ESIS AND THEIR SPILL CHARACTERISTICS

ESI 1 Exposed Impermeable Vertical Substrates

Exposed vertical cliffs at Cape St. Marys, Newfoundland, Canada

Examples	• rocky cliffs/banks • man-made sea walls
General	• high wave energy or tidal currents • strong wave reflection • impermeable substrates • steep to vertical slope (narrow intertidal zone) • low density or hardy biotic communities
Impact	• no oil penetration • oil persistence is low
Cleanup	• cleanup of shoreline is generally not required

ESI 2 Exposed Impermeable Non-vertical Substrates

Rocky headland at Peggy's Cove, Nova Scotia, Canada

Examples	• exposed wave-cut platforms and ledges
General	• high wave energy or tidal currents • strong wave reflection • impermeable substrates • slope < 30^{o} (wider intertidal zone) • mobile sediments at base of cliffs • hardy biotic communities
Impact	• no oil penetration • oil persistence is higher (particularly in sheltered tidal pools) • impacts to tidal pool biota may be severe
Cleanup	• cleanup of shoreline is generally not required

ESI 3 Semi-Permeable Substrate, Low Oil Penetration/Burial

Fine-grain sand beach at Montevideo, Uruguay

Examples	• fine to medium-grained sand beaches • unconsolidated eroding scarps and banks
General	• medium wave energy or tidal currents • medium wave reflection • semi-permeable substrates (fine to medium sand) • slope usually < 5^{o} (wide intertidal zone) • medium sediment mobility • sediments regularly mobilized (slow process unless storm events) • relatively low densities of biotic organisms
Impact	• oil penetration usually < 10 cm • oil persistence is higher • likelihood of oil burial is minimal due to slow mass-mobility of sediments (except during storm events) • impacts to intertidal biotic communities may be severe (may affect economically important shellfish species)
Cleanup	• cleanup of shoreline may be required through mechanical removal/washing) • vehicular traffic is possible with access

ESI 4 Medium-Permeability, Moderate Oil Penetration/ Burial

Coarse-grained sand beach near Laguna Negra, Uruguay

Examples	• coarse-grained sand beaches or bars
General	• medium wave energy or tidal currents • medium wave reflection • moderately permeable substrates • slope usually between 5° and 15° (wider intertidal zone) • high sediment mobility • relatively low densities of biotic organisms
Impact	• oil penetration usually < 25 cm • oil persistence may be higher • rapid burial of oil is possible • impacts to intertidal biotic communities may be severe (may affect economically important shellfish species)
Cleanup	• cleanup of shoreline may be required through mechanical removal/washing) • vehicular traffic may not be possible (depending on stability of substrate)

ESI 5 Medium-High Permeability, High Oil Penetration/Burial

Mixed sand and gravel beach near Tofino, British Columbia, Canada

Examples	• mixed sand and gravel beaches or bars
General	• various wave energies and tidal currents • medium wave reflection • medium to high permeable substrates • grain sizes vary with the finest near the high-tide line and the largest towards the toe of the beach • gravel comprises at least 20% of the sediment • slope usually between 8^o and 15^o (wider intertidal zone) • high sediment mobility during storm events • density of biotic organisms increases near the lowest intertidal levels • higher intertidal levels dry too rapidly for most intertidal organisms • sediment mobility also restricts biotic settlement
Impact	• oil penetration usually < 50 cm • oil persistence may be high if burial takes place • periodic storm events may aid in the removal and/or burial of oil
Cleanup	• cleanup of shoreline may be difficult due to substantial oil penetration depth and the potentially low trafficability of this shoreline type

ESI 6 High Permeability, High Oil Penetration/Burial

Gravel/cobble beach, Southeast Yemen

Examples	• coarse gravel, pebble, cobble or shell beaches or rip-rap areas
General	• intermittent wave energies and tidal currents • variable wave reflection • highly permeable substrates • grain sizes vary with the finest gravel near the high-tide line and coarser materials towards the toe of the beach • slope usually between 10^o and 20^o (moderate intertidal zone) • greatest sediment mobility during storm events • density of biotic organisms is very low except near the lowest intertidal levels due to sediment mobility
Impact	• oil penetration < 100 cm • oil persistence may be high if burial takes place or storm events after burial are infrequent • rapid burial (possibly below annual scour depths) may occur
Cleanup	• cleanup of shoreline may be difficult due to substantial oil penetration depth and the low trafficability of this shoreline type

ESI 7 Exposed, Flat, Permeable Substrate

Exposed tidal flat, Bay of Fundy, Nova Scotia, Canada

Examples	• exposed tidal flats
General	• lower wave energies and tidal currents • low wave reflection • highly permeable substrates • sediment type is dominated by sand (silt and gravel may also be present) • slope is very shallow usually < 3^{o} (potentially extensive intertidal zone - up to 1 km) • density of biotic organisms is usually very high
Impact	• oil penetration is limited due to water saturated sediments • penetration may occur near the high-tide line • oil is usually transported to the high-tide line from tidal movements • oil impact on the abundant biotic populations may be high through toxic exposure (light oils or disbursed fraction) or smothering (heavy oils)
Cleanup	• cleanup of shoreline may be difficult due to the sensitivity of many of these areas

ESI 8 Sheltered, Impermeable, Hard Substrate

Sheltered rocky shore, Punta del Este, Uruguay

Examples	• sheltered rocky shores • sheltered rubble slopes • sheltered scarps • sheltered man-made structures (e.g., bulkheads) • sheltered steeply sloping bluffs
General	• low wave energies and tidal currents • relatively impermeable to moderate permeable substrates (bedrock or rubble) • slope is generally quite steep > 15^o (narrow intertidal zone) • dense coverage of attached algae and organisms
Impact	• oil penetration varies depending on permeability of substrate • oil persistence may be longer in sheltered, low energy areas • oil impact on the abundant biotic populations may be high through toxic exposure (light oils or disbursed fraction) or smothering (heavy oils)
Cleanup	• cleanup of shoreline may be difficult due to limited access to some sheltered areas and the potentially high biotic mortality from mechanical disturbance

ESI 9 Sheltered, Flat, Semi-Permeable, Soft Substrate

Sheltered tidal flat, Hopewell Rocks, New Brunswick, Canada

Examples	• sheltered sand/mud flats • sheltered tidal flats • sheltered vegetated low banks
General	• low wave energies and tidal currents • tidal variations may be infrequent. • semi-permeable substrates (silt muds) • slope is very shallow usually < 3^{o} (potentially extensive intertidal zone - up to 1 km) • density of biotic organisms is usually very high
Impact	• oil penetration is limited due to water-saturated sediments • penetration may occur near the high-tide line • oil is usually transported to the high-tide line from tidal movements • oil impact on the abundant biotic populations may be severe through toxic exposure (light oils or disbursed fraction) or smothering (heavy oils)
Cleanup	• cleanup potential is very low due to the sensitivity of the environment and the likelihood of extensive mechanical damage • natural recovery rates are very slow

ESI 10 Vegetated, Emergent Wetlands

Mangrove forest, Cartagena, Colombia

Examples	• marshes • mangroves • swamps • oxbow lakes
General	• low energy environments • semi-permeable substrates (silt muds) • slope is very shallow usually < 3^o (potentially extensive intertidal zone) • very high density and diversity of biotic community
Impact	• oil penetration is limited due to water saturated sediments • direct oiling of vegetation occurs in the intertidal zone • direct oiling with viscous oils may suffocate benthic organisms and root systems • lighter oils may kill vegetation (and dependent fauna) through toxic effects • oil impact on the abundant biotic populations may be severe through toxic exposure (light oils or disbursed fraction) or smothering (heavy oils)
Cleanup	• cleanup is difficult due to extensive vegetative coverage • natural recovery rates are very slow due to the low energy levels of these environments and the absence or reduced rates of biodegradation due to anaerobic substrate conditions

4.0 INFORMATION NEEDS

This section outlines the specific data that might be required to support the maps. As previously noted, all mapping systems will differ based on specific user needs, and therefore many systems will not require all of the detail provided here. Similarly, there may be cases where, due to the needs of the user, more detail in some areas may be required.

The information needs are divided into four groups:

- shoreline types
- biology
- human-use
- spill response

4.1 SHORELINE TYPES

The shoreline or river/stream bank geomorphology should be displayed on sensitivity maps because it is critical to determining its sensitivity to an oil spill.

Variables such as substrate type, granule size, slope, exposure and sediment mobility all have effects on the potential residency and impacts of oil exposure. Geomorphology is also a key factor in the type and density of biological communities.

Any survey program of coastal or shoreline geomorphology should address the following parameters:

- exposure/energy conditions
- substrate type (solid or unconsolidated)
- grain or fragment size (if unconsolidated)
- permeability
- sediment mobility
- vehicle/vessel access
- trafficability of tidal area
- applicable oil spill cleanup methods

For information on specific shoreline types, see Section 3.4.

4.2 BIOLOGY

Oil spills can affect a wide range of plant and animal species, depending on their distribution and life stage. In general, oil affects wildlife and plant species in three ways:

Direct Impacts	
Smothering	Animals with sensitive coatings, fur or feathers may be coated with oil thus inhibiting normal bodily functions and movement. Plants may also be affected through diminished oxygen supplies and the inhibition of normal transpiration (e.g., coating of pneumatophores on black mangrove trees). Direct smothering is usually associated with spills of highly viscous, weathered oils.
Toxic Exposure	Direct toxic effects may occur to animals through direct ingestion, absorption and inhalation of hydrocarbon. Plant mortality may occur through direct contact and exposure to oil or through root uptake from contaminated sediments.
Indirect Impacts	
Loss of Habitat or Food Source	Mortality of plants or animals low on the food chain (prey species) from oil spills will indirectly affect animals or plants that depend on them (directly or indirectly), as a food source, or for habitat.

Note *The IPIECA Report Series "Biological Impacts of Oil Pollution", are an excellent source of information on oil spills and their effects on natural life forms.*

In order to avoid clutter and possible confusion, sensitivity maps should only display locations of the most sensitive species, life stages and areas, and not the entire region where a given species may occur (USEPA and NOAA 1994). This will allow the user to focus attention on critical areas.

Biological resources at risk from oil spills can generally be divided into the following categories:

- mammals (marine and terrestrial)
- birds
- fish
- molluscs
- crustaceans
- reptiles/amphibians
- plants
- benthic/intertidal/riparian habitats

Mammal and bird information should include life stage, concentrations and breeding periods.

For fish species, periods of time spent in shallow water, including spawning and rearing, or life stages when they are particularly sensitive to oil, are to be included. Spawning or nursery areas should also be included for anadromous, beach and kelp spawners.

Molluscs and crustacean information is somewhat similar in nature. Key information includes seed beds, harvest areas or other areas of high concentrations.

For reptiles, particularly rare species such as many sea turtles, dates of egg laying and hatching are critical. Other reptile and amphibian information is usually restricted to areas of high population concentrations.

Information on critical plant and benthic habitat communities, including coral reefs, seagrass beds and kelp beds, should include geographical locations and data on other species that depend on the habitat or plant community for survival.

Information should also include expert contacts regarding the biology of individual species should questions arise during critical stages in an oil spill response.

Table 4.1 details the biology data requirements typically used in North American sensitivity mapping systems.

Table 4.1 - Biology Data Requirements

Species	Map/Data Requirements
Marine Mammals	
• sea lions • seals • manatees • sea otters • whales • dolphins	• haulouts, concentration areas • haulouts, concentration areas • concentration areas, endangered species • concentration areas • concentrations, seasonal presence, endangered species • concentration areas, seasonal presence
Terrestrial Mammals	
• rodents • deer • cat family • endangered species	• concentration areas and important habitats (for all) • locations may be confidential
Birds	
• diving birds • waterfowl • shorebirds • wading birds • sea birds/gulls/terns • raptors • penguins • endangered species	• rookeries, forage areas • concentration and nesting areas, migratory corridors • nesting and migration areas • rookeries, important forage areas • nesting sites • nest sites, important forage areas • nest/colony sites • important habitats (locations may be confidential)
Fish	
• anadromous fish • beach spawners • kelp spawners • all fish species • endangered fish species	• spawning streams • spawning beaches • spawning locations • nursery areas, concentration areas • important habitats (locations may be confidential)
Molluscs	
• clams • oysters • mussels	• abundant bed locations • seed beds, abundant bed locations • abundant bed locations
Crustaceans	
• crabs • shrimp • lobsters	• nursery/concentration areas • nursery areas • nursery/concentration areas

(Modified from USEPA and NOAA 1994 and Environment Canada 1993)

Table 4.1 - Biology Data Requirements (continued)	
Species	**Map/Data Requirements**
Reptiles and Amphibians	
• sea turtles • alligators/crocodiles • endangered species	• nesting beaches, feeding areas • concentration areas • important areas (locations may be confidential)
Plants	
• endangered species	• important areas (locations may be confidential)
Benthic Habitats	
• seagrass beds • coral reefs • kelp beds	• locations • locations • locations

(Modified from USEPA and NOAA 1994 and Environment Canada 1993)

In addition, specific species information should also be maintained and included on the maps (from USEPA and NOAA, 1994):

- lifestages present for each month of the year
- concentrations
- regional, national or international status (e.g., rare, threatened, endangered, etc.)
- breeding periods
- expert contacts (local, regional, national or international)

This information, if set up carefully, will provide emergency response decision makers with all of the necessary tools to minimize potential impacts to wildlife.

4.3 HUMAN-USE RESOURCES

Oil spills may also affect human resources. Numerous types of developments and activities occur on or near coastal or shoreline areas and are often extremely sensitive to impacts from spilled oil.

Human-use resources at risk from oil spills can generally be divided into the following categories:

- developments
- recreational
- resource extraction
- cultural/archaeological
- management areas

Developments

Developments refers to man-made structures and "improvements" that may be directly or indirectly affected by oil spills. This category also includes developments which are not necessarily "sensitive receptors", but may assist spill responders, e.g., access routes. Locations, facility-specific information and contact name and telephone numbers are needed for the notification and collection of additional information.

Recreational

Recreational facilities shown on maps should include all high-use areas, indicating their specific activities. Locations, site-specific information and contact name and telephone numbers (if applicable) are needed for notification and collection of additional information.

Resource Extraction

Resource extraction information should include all locations where an oil spill may have an impact. Notification through contact names and telephone numbers is particularly important for any extraction sources involving food sources such as fisheries, aquaculture and subsistence-related operations.

Cultural/Archaeological

Cultural/Archaeological sites should be included. Site locations and any contact names and telephone numbers of private or government agencies that manage the sites should be retained. It is important to recognize the confidentiality of these site locations. In some cases, the general area rather than a specific location should be used in order to protect these important resources. This is a good example supporting the ability of a GIS program to turn “on” or “off” particular data layers.

Management Areas

Sensitivity maps should also include all government-managed special areas such as national or international parks and wildlife or wilderness refuges. Offshore marine-protected areas are also critical to include on maps. Contact names and telephone numbers should also be retained for all identified areas. Government contacts should be consulted regularly with respect to any changes or additions to protected area boundaries or locations.

Table 4.2 - Human-Use Data Requirements

Feature	Map/Data Requirements
Developments	
urban areas/developments	• oil retention properties • oil transmission properties
access routes	• road systems/highways • truck trails
airports	• locations
boat ramps/marinas	• locations • vessels that can be accommodated • number of craft • crafts used as residences
industrial facilities	• locations • local contact name, telephone and fax number
water intakes	• water use (volume and type of use) • local contact name, telephone and fax number
dams/weirs /locks	• locations • local contact name, telephone and fax number

Table 4.2 - Human-Use Data Requirements (continued)	
Feature	**Map/Database Requirements**
Developments	
Spill Source Locations - refineries - production facilities - fuel storage facilities - chemical facilities - offshore production/drilling - pipelines (liquids) - terminals	• locations • nature and volume of stored materials • local contact name, telephone and fax number
pipelines	• locations • nature and volume of stored materials • local contact name, telephone and fax number
Recreational	
beaches	• locations
campgrounds	• locations • local contact name, telephone and fax number
diving	• locations
marinas	• locations • local contact name, telephone and fax number
sport fishing	• locations
Resource Extraction	
aquaculture sites	• locations • owner/operator name and telephone number
commercial fisheries	• locations
mining sites	• locations • local contact name, telephone and fax number
logging sites	• locations • local contact name, telephone and fax number
subsistence fishing/hunting/gathering	• locations • local contacts or resident locations
Cultural/Archaeological	
archaeological sites	• locations (specific locations may be confidential)
historical sites	• locations (specific locations may be confidential)
Management Areas	
international/state/provincial borders	• locations
national/international parks	• locations • responsible agency • local contact name, telephone and fax number

Table 4.2 - Human Use Data Requirements (continued)	
Feature	**Map/Data Requirements**
Management Areas	
marine protected areas	• locations • responsible agency • local contact name, telephone and fax number
terrestrial protected areas	• locations • responsible agency • local contact name, telephone and fax number
wildlife refuges	• locations • responsible agency • local contact name, telephone and fax number

4.4 SPILL RESPONSE INFORMATION

Sensitivity maps should incorporate data that can either be used to formulate response strategies, or if possible, include pre-determined control and cleanup actions. In hard copy format, it is common practice to depict geomorphology and biological and human-use resources on an operational map that is accompanied by text which describes access to critical shoreline segments. An overview is also sometimes given of the spill response resources, including equipment (booms, skimmers, pumps, etc.) and personnel that would be needed to mount protection and cleanup activities. The practicality of both mechanical cleanup and manual methods is addressed in terms of assembly, deployment and operation. Storage and disposal of collected materials can also be included.

Maps should include points of access from both the land and water, especially if there are concerns to vessels due to narrow channels, reefs, rocks or shallow water. Secondary roads that do not appear on commercial maps should be shown since they can be critical to response operations. Access is often linked to small embayments, pocket beaches, tourist attractions and other areas where cleanup would proceed on a priority basis because of localized accumulations of oil and/or a concern for impacts.

Sensitivity maps should also include initial spill response information, e.g., boom deployment areas, equipment cache locations, boat launch sites.

Additional spill response information that cannot be visually displayed on a map, e.g., lists of equipment or site-specific cleanup techniques, are usually shown on an accompanying page or within an associated database.

Operational maps should not identify more than 4 or 5 unique protection areas. This information requires a clear understanding of the shoreline types, the resources at risk, and the response options. Field work by specialists in these areas is highly recommended so that the maps are of practical value during a spill. For extensive coastlines with many repetitive features, there is a temptation to not survey all shoreline segments. If budgets allow, this should be avoided since subtle differences can be missed and critical approaches to cleanup overlooked.

Table 4.3 - Spill Response Data Requirements

Transportation	
• airport • road access to shoreline • boat ramp • boat launch	• local contact name, telephone and fax number • runway length (airport) • maximum boat size (boat ramp/launch)
Response	
• oil refinery • oil terminal • drydock • equipment staging areas	• local contact name, telephone and fax number • oily water reception (oil refinery/terminal) • maximum vessel size (drydock) • area size/terrain/access (staging areas)
Response Equipment	
skimmers	• type (weir/disc/drum/rope mop/brush) • manufacturer • capacity • dimensions • weight • pump (on-board/external) • pump type • pump capacity
booms	• type (internal flotation/pressure inflatable/self-inflating/external tension/permanent) • manufacturer • height (float/skirt) • length • connectors • buoyancy:weight ratio • weight
pumps	• type (centrifugal/diaphragm/peristaltic/other) • manufacturer • capacity • suction head • discharge head

Table 4.3 - Spill Response Data Requirements (continued)	
Response Equipment	
vessels	• hull type (flat bottom or v) • manufacturer • length • beam • draft • maximum persons • power • maximum speed • towing capacity • davit/crane capacity
dispersant	• type (Corexit/Shell/BP/other) • volume • vessel-based equipment • aircraft-based equipment • areas restricted to use
storage	• towable storage (type/volume) • stationary storage (type/volume) • barges (volume) • oily water separation (volume/throughput)
burning	• type of equipment • fire-resistant boom • igniters • monitoring equipment • aircraft

4.5 SITE VERIFICATION

Once all possible information sources have been examined to determine the physical, biological and human-use characteristics of a given area, site-specific assessments should be conducted to verify and add to existing data. This step in the development of sensitivity maps is crucial to ensure that information is accurate and up-to-date.

The production of detailed, large-scale maps is not usually possible without the on-site assessment of resource information. Spill response and other area specific information is not usually available in published or printed form and can only be obtained through on-site assessments.

The assessment of shoreline and nearshore characteristics is most often accomplished through on-site assessments of areas by personnel knowledgeable of shoreline resources and the fate and effects of spilled oil. In Canada and elsewhere, assessment teams formed by the government (Owens and Nelson 1995) are referred to as SCAT or Shoreline Cleanup Assessment Teams. SCATs are usually comprised of:

- a coastal geologist who assesses geomorphology and the exposure to impacts from oil, i.e., oil residency and permeability
- an ecologist who assesses the presence, condition and density of localized flora and fauna
- an archaeologist who assesses historical and archaeological resources

It is important to note that assessment teams do not necessarily need to be comprised of the above professional individuals. Other individuals trained in the assessment of these resources may also perform SCAT assessments.

SCAT and other assessment programs utilize standard forms which are completed by individual assessors. The use of forms ensures that all data are consistent and relates to the information requirements of the end-users.

The information gathered during assessments is most often used to compile or augment existing database information. Information which may be included on a *pre-spill* assessment form is summarized in Table 4.4. The SCAT system also includes *post-spill* forms to verify the “actual” behaviour and impacts of oil on the shoreline.

Table 4.4 - Information Included on SCAT Assessment Forms
General Information
• segment location and identification number • environmental sensitivity atlas cross-reference
Physical Shore-Zone Character
• segment width and length • substrate type • potential oil behaviour • nearshore/alongshore oil movement directions • shoreline oil traps
Resource Issues
• primary resources at risk • environmental restraints on response operations
Operational Considerations
• human-use activities • local logistics (e.g., shelter, power sources, restrooms, potable water, etc.) • pre-impact debris pickup
Operational Safety Considerations
• hazards present on land • hazards present nearshore or subtidal
Response Considerations
• response objectives and strategies • protection/diversion • collection cleanup options • operational activities • nearby response equipment (local to segment)
Operational Issues
• segment access • equipment use feasibility
Response Options
• potential protection options • potential treatment/cleanup options

(Modified from Owens and Nelson 1995)

In addition to the Pre-Spill and Post-Spill SCAT survey form, the SCAT program also includes additional survey forms specific to nearshore ecology, marsh/wetland ecology, human-use and cultural resources.

5.0 DATABASE DEVELOPMENT

There is usually a need to provide data additional to that displayed on the map. This underlying, or support data, are usually too complicated to display directly on the map. It is therefore common practice to include such data in text-based pages which accompany the map or in separate files within a computer-based system. These include specific information relating to:

- habitat
- biology
- human-use resources
- spill response information

In most cases, it is likely that some type of computerized database will be required, due to the complexity and amount of data. These databases are relatively inexpensive to set up and once complete, provide the user with considerable power and flexibility in making the data understandable.

Computer databases, like mapping systems, can either be very simple or very complex, depending on the amount of data in the system and how it will be used. For example, if the data will be used as part of a risk assessment, then a simple database including information such as animal species, types of tourism activities, and fisheries may suffice. If however, detailed biological information is required, i.e., migration, seasonality, nesting, breeding, etc., such as that listed in Section 4, then a much more complex set of databases will be required.

In either case, the database(s) must be linked to the maps, regardless of whether paper only or computer-based maps are used. This is done using some unique identifier which might either be visible in the case of printed maps (see example in Figure 2.6), or invisible using an attribute (unique number associated with an entity) if a computer map is used.

This section provides two alternative approaches. The first is a simple database, suitable for use in risk assessment or basic spill response. The second is a much more complex set of databases capable of supporting all of the data described in Section 4. In both cases, the reader is assumed to have a basic understanding of databases and the terminology of database structures.

Note It is important that the database designer understand the nature of the questions which the system will be called upon to answer, and how the emergency response planner will try to access the information. For example, a countermeasures technical advisor will need to know specific details about skimmer design and characteristics in order to assess the suitability of the skimmer for specific uses. It is therefore strongly recommended that technical personnel who will be involved in response efforts help develop the system.

5.1 APPROACH NUMBER 1 - SIMPLE DATABASE

In this first option the user's focus is risk assessment and hence the data needs are relatively simple:

- shoreline types
- vulnerable animals, i.e., fish, birds, mammals etc.
- recreation areas, i.e., tourist beaches
- wildlife management areas
- archaeological sites
- food fisheries and fish farms
- other water users, i.e., cooling water intakes

Note that the seasonality of animals is of secondary importance when conducting risk assessments because spills can occur at any time during the year.

The database requirements are as follows:

Table 5.1 - Database Structure - Approach Number 1

Field Name	Field Type	Field Size
entity type	text	128 characters
location (latitude)	real number	nnn.nnn
location (longitude)	real number	nnn.nnn
description	text	256 characters
link	integer	nnnn

Because a common data structure is used, a single database can be used to describe all of the entity types.

This simple database would allow the user to apply simple queries based on location, entity types or words found in the description field.

A variation of this approach might include a second database for the animals which includes location (latitude), location (longitude), concentration, period present, period of highest vulnerability, and link.

5.2 APPROACH NUMBER 2 - COMPLEX DATABASE

The following discussion outlines a general approach to the development of a comprehensive database, capable of storing all of the data described in Section 4. It is divided into four sections, dealing with the biology, habitat, human-use, and spill response data.

Biology Data

The design of the biological resource databases is complicated somewhat by the need for seasonality data, such as breeding, spawning periods, etc. For example, if a spill occurs in May, the responder might need to know if a given sensitivity is present during May, and the lifestage (vulnerability) of the animal.

The structure of the biological databases (see Figure 5.1) can be thought of as having two levels. The top level includes specific details associated with each symbol on the map. Identical symbols can be linked to different data, e.g., a certain type of bird may be more abundant in one area versus another and also may be present during different months of the year. The latter will depend somewhat on the size of the map and the level of detail available for a given species.

Each specific entry (record) is linked to a symbol, polygon, or line using a unique identifier called *Symbol Identity*. Each occurrence of the symbol on the map will have a corresponding entry in the resource database, which will in turn be linked to a general seasonality database through the *Species Number*. It is possible for many symbols to be linked to one seasonality entry. The resource database may also include a *Note* field where the user can include any other important information, such as endangered or protected species.

At the bottom level the general seasonality database contains all of the seasonality information for the species. For example, the data for the diving, coastal bird might include:

- lifestage (adult)
- lifestage (breeder)
- lifestage (juvenile)
- lifestage (general, i.e., not known)
- nesting
- laying
- hatching
- fledgling

The data in this level are specific to each species and only need to be entered once for each species. Two methods can be used to indicate the months for each of the fields:

- character (jan feb mar apr may jun jul aug sep oct nov dec)
- numeric (1 2 3 4 5 6 7 8 9 10 11 12)

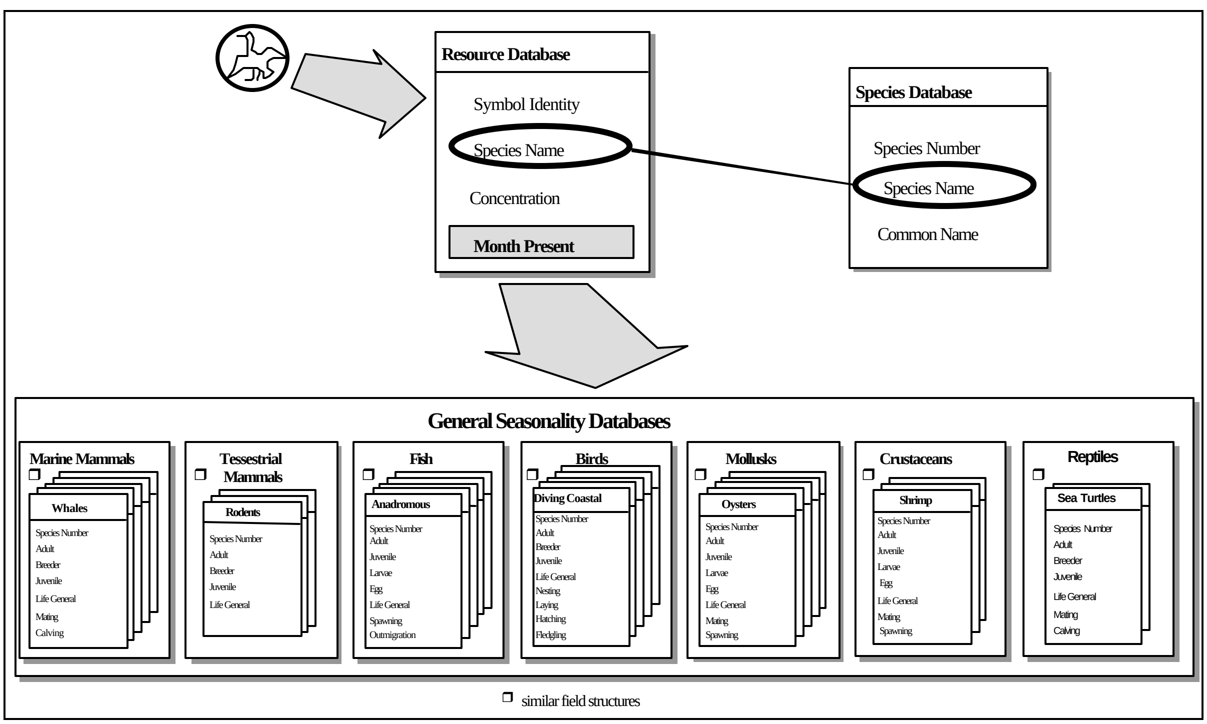
The databases should be linked to allow comparison of the *Month Present* field in the resource database with the general seasonality data to determine if the entity is present during a spill and its current lifestage.

Some, more-complicated systems used in North America, also include extra fields for start and end dates for events such as nesting and hatching; however, this is probably not necessary due to the difficulty in collecting such detailed data and the variance of these activities from year to year.

Another database, which includes fields for a common *Species Name*, and a *Species Number* (which is common to all tables), provides a look-up mechanism for various species data.

The system may also include a link between the species database and an expert database, which could include the expert's name, agency, contact telephone number and dddress. There would be at least one entry per species.

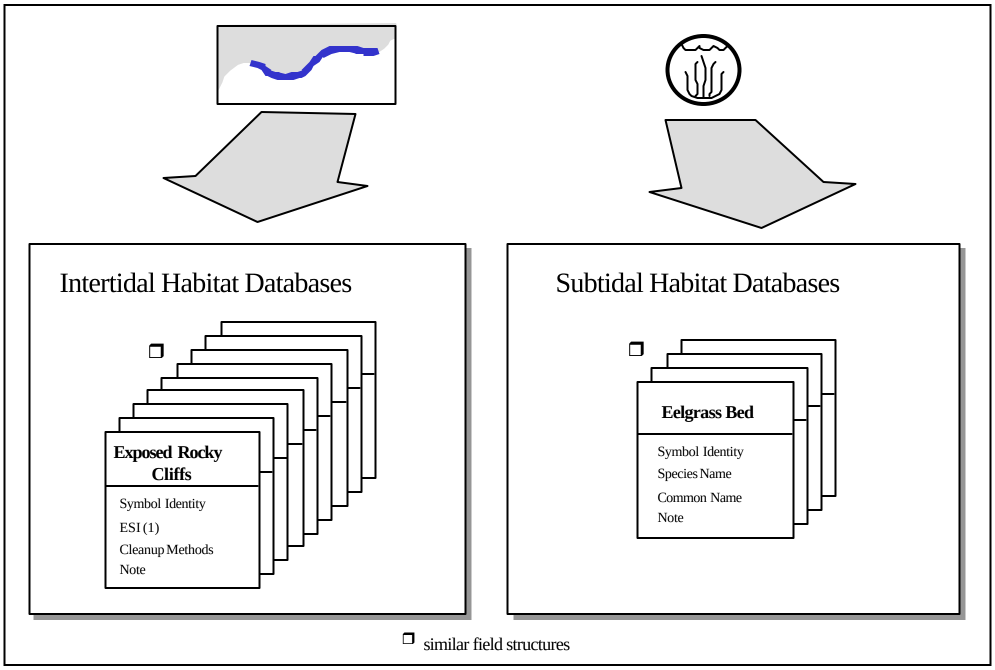
Figure 5.1 - Biology Databases



Habitat Data (including geomorphology)

The habitat databases are comparatively simple (see Figure 5.2), with each habitat-type (intertidal or subtidal) occupying a single record, and each linked to a polyline or symbol on the map.

Figure 5.2 - Habitat Databases

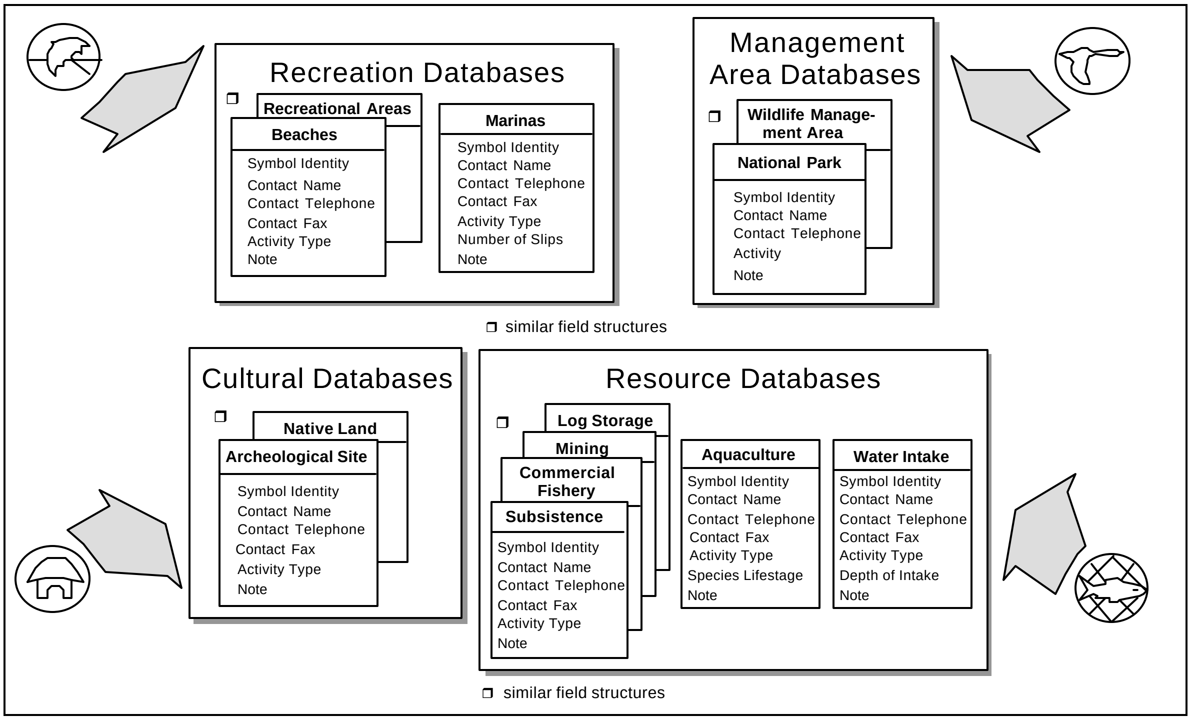


As with the biological databases, the habitat databases can be linked to an expert database, with entries for each type of habitat. Links could also be provided to an additional database which describes possible cleanup techniques/methods.

Human-Use Data

The human-use data requires 12 different database types (see Figure 5.3) due to the differing structures of the data. There are three recreation databases, i.e., for beaches, recreation areas and marinas. There are six resources databases, i.e., for subsistence, commercial fishery, mining, log storage, aquaculture and water intakes. There are two cultural databases, namely, for archaeological sites and native lands.

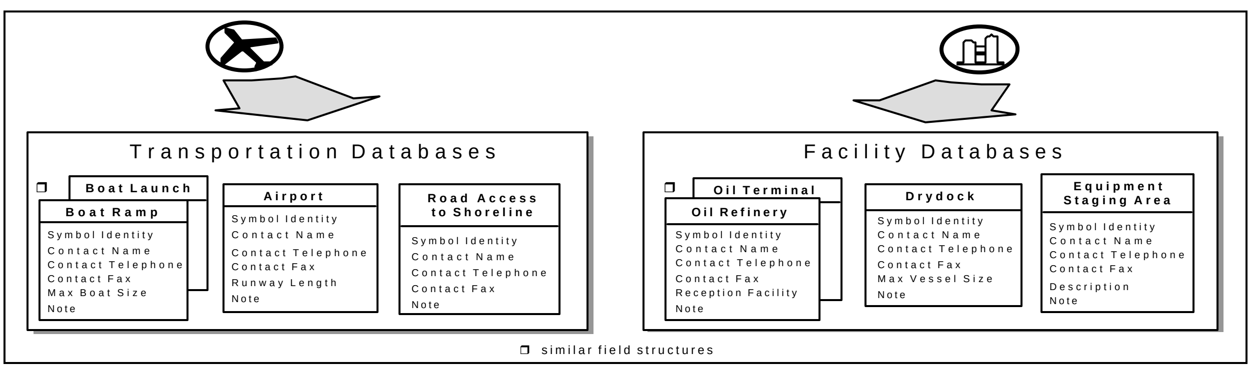
Figure 5.3 - Human-Use Databases



Spill Response Data

There are nine different spill response database types. The transportation and facility databases, which comprise eight of the nine types, are shown in Figure 5.4.

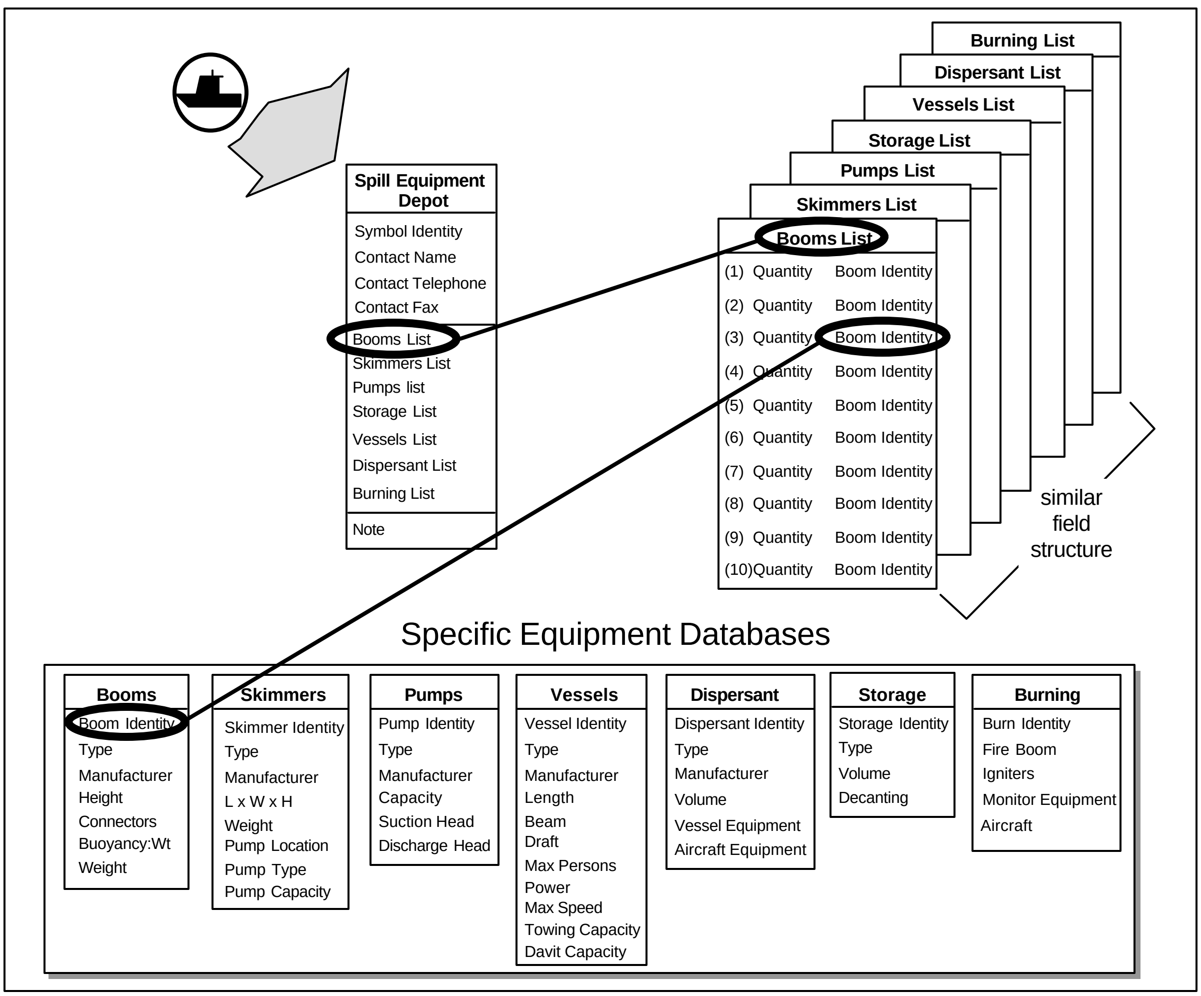
Figure 5.4 - Spill Response Databases



The ninth database is actually a set of databases for response equipment. It is more complicated than the transportation and facilities databases. Not only does each equipment depot have specific information, such as its location and telephone number, but it also includes other information which it might share with other depots, e.g., skimmer and boom types. Further, each equipment depot might have a number of different pieces of equipment in each category. The databases must therefore be capable of accommodating this situation.

The design in Figure 5.5 allows the entry of up to ten specific examples of each equipment type with a character field indicating quantities (or lengths in the case of boom). For example, a spill equipment depot could contain three types of oil spill containment boom which would occupy two fields in the boom list (one for *Quantity* and the second for *Boom Identity*). The *Boom Identity* would be linked to the boom database (see specific equipment databases below) to allow the user to find technical specifications for the specific equipment. The specific boom data would be entered only once, similar to the general seasonality databases in the biology section.

Figure 5.5 - Response Equipment Databases



6.0 COMPUTER SYSTEMS

6.1 ADVANTAGES OF A COMPUTER-BASED APPROACH

Computer-based mapping systems offer a number of advantages over paper-based systems:

1 Maps can be easily updated and printed as required.

2 Maps can be quickly created for any area in the system, thus eliminating arbitrary borders or the display of symbols which are not applicable at the time of a spill.

3 Mapping systems can be used with trajectory modelling programs to display possible/actual spills and the affected sensitivities.

4 Maps can easily be sent digitally via telephone to remote locations.

5 Database support is possible through widely available applications like Microsoft Access, D-Base, etc.

6 Other valuable field information, such as satellite images, airborne photos of the slick, overflight routes, and the positions of response personnel, can be *overlayed*, to create operational maps.

If a computer-based system is used, it should allow transfer of coastline and other data files in standard Geographic Information System (GIS) formats such as ArcInfo. This will allow the direct import of both base maps and resource data, such as the mangrove and coral polygon data for Cuba, provided by the World Conservation Monitoring Centre in a SHP format (see Figure 2.2).

Mapping systems should support a standard data base file structure, i.e., DBF or MDB, to further facilitate the import and export of data.

MS Windows-based systems are recommended to avoid complications with hardware, such as printers and monitors. Windows also offers a familiar environment for most computer users as well as some useful multimedia functionality to allow the use of digital video, etc.

The best possible system would include an integrated system and feature mapping, trajectory modelling, and data-base components. If a modelling program is not desired or available, the system might include only the maps and associated database(s).

6.2 AVAILABLE PROGRAMS

There are four basic system alternatives:

Mapping System	Examples
1 Simple Graphics Program	• Corel Draw • Claris Draw • Powerpoint • Paintbrush
2 CAD-based Program	• AutoCad • VersaCad • InterGraph
3 GIS-based system	• ARCInfo/ARCView • MapInfo • PAMAP
4 Purpose-Built GIS program	• OILMAP • OSIS • OCEANOR • SPILLSIM

Tables 6.1 through 6.4 indicate the strengths and weaknesses of each of the four approaches.

Table 6.1 - Simple Graphics Program			
Strengths		**Weaknesses**	
easy to learn and operate	4	no trajectory model support	8
readily available	4	no database support	8
inexpensive	4	relatively difficult to update	8
operates on PC	4	no geographical referencing	8

Table 6.2 - CAD-Based Systems			
Strengths		**Weaknesses**	
relatively common	4	no trajectory model support	8
geographically referenced	4	limited database support	8
relatively inexpensive	4	relatively difficult to learn/use	8
suited to highly technical drawings	4	may require high-end PC	8

Table 6.3 - GIS-Based Systems			
Strengths		**Weaknesses**	
very powerful	4	limited trajectory model support	8
excellent database support	4	relatively expensive	8
geographically referenced	4	difficult to learn/use	8
some are PC-based	4	may require expensive and powerful hardware	8

Table 6.4 - Purpose Built GIS-Based Systems			
Strengths		**Weaknesses**	
powerful	4	expensive	8
good database support	4	may be difficult to learn/use	8
geographically referenced	4	requires high-end PC	8
excellent trajectory model	4		

Whichever system is used, the following points should be considered:

- Avoid non-mainstream systems requiring special hardware/ software.
- Windows-based systems are preferred.
- Avoid vendors with few users.
- Select vendors with whom good communication is possible.
- Contact existing system users for background on possible software and vendors.

6.3 HARDWARE REQUIREMENTS

Computer hardware requirements, whether IBM- or Mac-based will depend on the type and nature of the software used.

IBM Computers

If a relatively simple paint/draw program is used to develop maps, an IBM 386 based machine can be used, although a 486 or Pentium based machine would be much faster.

If a more complex CAD or GIS program is used to develop the maps, 486 or Pentium machines with at least 16 Mbytes of RAM are essential. In most cases, high resolution colour monitors and colour printers will also be needed.

Macintosh Computers

The same strategy applies to Mac users with a minimum requirement of an 040 based machine to run simple programs and 601 or 604 PowerMacs with at least 16 Mbytes of RAM to run more complex programs. As with the IBM computers, high resolution colour monitors and printers are needed.

7.0 REFERENCES AND ADDITIONAL INFORMATION SOURCES

1. Baker, J.M. 1991. Guidelines on Biological Impact of Oil Pollution - Volume 1. IPIECA (International Petroleum Industry Environmental Conservation Association).

2. Baker, J.M. 1993. Dispersants and their Role in Oil Spill Response - Volume 5. IPIECA (International Petroleum Industry Environmental Conservation Association).

3. Baker, J.M. et al. 1994. Biological Impacts of Oil Pollution - Saltmarshes - Volume 6. IPIECA (International Petroleum Industry Environmental Conservation Association).

4. Baker, J.M. et al. 1995. Sensitivity Mapping Worldwide: Harmonization and the Needs of Different User Groups. Proc. of the 1995 International Oil Spill Conference.

5. Baker, J.M. et al. 1996. Sensitivity Mapping for Oil Spill Response - Volume 1. IMO (International Maritime Organization) and IPIECA (International Petroleum Industry Environmental Conservation Association).

6. Baker, P. 1993. Development of an Environmental Sensitivity Atlas for Lake Superior's Canadian Shoreline Using Electronic Desktop Mapping. Proc of the Sixteenth Arctic and Marine Oil Spill Program (AMOP) Volume 1", Environment Canada, Calgary, Alberta, Canada.

7. Bird, C.F. and M.L. Schwartz. 1985. The Worlds Coastline. Van Nostrand Reinhold Company, New York, USA.

8. Chaw, L.H. et al. 1993. Biological Impacts of Oil Pollution - Mangroves - Volume 4. IPIECA (International Petroleum Industry Environmental Conservation Association).

9. Dahlin, J.A. and J.M. Holmes. 1992. Guidelines for Digitization of ESI Maps and Symbology Standards. Resource Planning Institute. Columbia, South Carolina.

10. Dinerstein, E. et al. 1995. A Conservation Assessment of the Terrestrial Ecoregions of Latin America and the Caribbean. The World Bank, Washington D.C.,U.S.A.

11. Environment Canada. 1994a. Coastal Zone Classification system. The National Sensitivity Mapping Program - Environment Canada.

12. Environment Canada. 1994b “Environmental Sensitivity Atlases for the:
    1. St. Clair River, Lake St. Clair and Detroit River Shorelines,
    2. Lake Ontario’s Canadian Shoreline,
    3. Lake Erie (Including the Welland Canal) and the Niagara River,
    4. St. Marys River Shorelines,
    5. St. Lawrence River Shorelines,
    6. Lake Superior’s Canadian Shoreline,
    7. Lake Huron’s Canadian Shoreline”

    Environment Canada - Ontario Region.

13. Environment Canada. 1994c. Examples and Summaries of Mapping/Data Schemes in Canada to 1993. The National Sensitivity Mapping Program. Environment Canada.

14. Harper, J.R. and G. Williams. 1993. ARPEL Environmental Project (Phase 1) Sensitivity Mapping Module. Unpublished.

15. Harper, J.R. et al. 1991. Shore-Zone mapping Systems for use in Sensitivity Mapping and Shoreline Protection. Proc. of the Fourteenth Arctic and Marine Oil Spill Program (AMOP). Environment Canada, Vancouver, B.C., Canada.

16. Horne, G.J. 1993. Evaluation of Desktop Mapping Software. The National Sensitivity Mapping Program - Environment Canada.

17. IPIECA (International Petroleum Industry Environmental Conservation Association). 1991. A Guide to Contingency Planning for Oil Spills on Water - Volume 2. IPIECA.

18. Kelleher, G. et al. 1995. A Global Representative System of Marine Protected Areas Volume II. - Wider Caribbean, West Africa and South Atlantic. The World Bank, Washington, D.C.

19. Knap, A.H. 1992. Biological Impacts of Oil Pollution - Coral Reefs - Volume 3. IPIECA (International Petroleum Industry Environmental Conservation Association).

20. Michel, J. et al. 1994. Sensitivity Mapping of Inland Areas: Technical Support to the Inland Area Planning Committee Working Group. USEPA Region 5, Seattle, Washington.

21. Michel, J. et al. 1995. Environmental Sensitivity Index Guidelines. National Oceanic and Atmospheric Administration, Seattle, Washington.

22. Moore, J. and L. Guzmán. 1995. Biological Impacts of Oil Pollution - Rocky Shores - Volume 7. IPIECA (International Petroleum Industry Environmental Conservation Association).

23. Owens, E.H. and J.Y. Nelson. 1995. Oil Spill Shoreline Cleanup Assessment Team (SCAT) Manual - For the Ontario Great Lakes and St. Lawrence River Shoreline. Environment Canada.

24. Owens, E.H. and S.R. LeBlanc. 1996. An Integrated Approach to Shoreline Mapping for Spill Response Planning. Proc. of the Nineteenth Arctic and Marine Oil Spill Program (AMOP) Volume 2. Environment Canada, Calgary, Alberta, Canada.

25. Owens, E.H. and W.S. Dewis. 1995. A Pre-Spill Shoreline Protection and Shoreline Treatment Data Base for Atlantic Canada. Proc of the Eighteenth Arctic and Marine Oil Spill Program (AMOP) - Volume 1. Environment Canada, Edmonton, Alberta, Canada.

26. Owens, E.H. et al. 1992. British Columbia Marine Oil Spill Shoreline Protection and Cleanup Manual. British Columbia Ministry of Environment, Lands and Parks. Environmental Emergency Services Branch.

27. Pavia, R. et al. 1995. An Integrated Program for Sensitive Environment Mapping. Proceedings of the 1995 International Oil Spill Conference, Long Beach, California, U.S.A.

28. Percy, R.J. 1993. Canadian National Sensitivity Mapping Program. Proceedings of the 1993 International Oil Spill Conference, Tampa, Florida, U.S.A.

29. Seeliger, U. 1992. Coastal Plant Communities of Latin America. Academic Press Inc. Toronto, Canada.

30. TNC (The Nature Conservancy). 1995. A Regional Analysis of Geographic Priorities for Biodiversity Conservation in Latin America and the Caribbean. The Nature Conservancy, Washington D.C.

31. Torling, G. and J. Fejes. 1995. Geographic Information System (GIS) for Impact Assessment, Ecologically Sound Measures, and Documentation of Oil Spills. Proceedings of the 1995 International Oil Spill Conference, Long Beach, California, U.S.A.

32. Tramier, B. et al. 1981. A Field Guide to Coastal Oil Spill Control and Cleanup Techniques. CONCAWE (the oil companies international group for Conservation of Clean Air and Water - Europe) Report No. 9/81.

33. USEPA (U.S. Environmental Protection Agency) and the NOAA (National Oceanic and Atmospheric Administration). 1994. A Working Paper for the Regional Workshop on Designing a Geographic Information System for Oil Spills. San Francisco, California, U.S.A.

34. Wedeles, C.H.R. et al. 1992. Canadian Sensitivity Mapping System - Results of a Protocols and Standards Consensus Workshop. The National Sensitivity Mapping Program - Environment Canada.

Appendix A

Cartographic Agencies of Mexico, Central America, South America and the Caribbean

Country	Agencies
ARGENTINA	Instituto Geográfico Militar Avenida Cabildo 381 1246 Buenos Aires Telephone 771-3031
BAHAMAS	Director of Lands and Surveys P.O. Box N-592 Nassau
BELIZE	Belize Meteorologist/Hydrologist Ladyville Telephone 501-025-2012 Telex 251 BTL BUREAU DZ
BOLIVIA	Servicio Geológico de Bolivia Federico Zuazo, Esq. Reyes Ortiz Casilla de Correos 2729 La Paz Telephone 326278
BRAZIL	Instituto de Pesquisas Espaciais Caixa Postal 515 12201 Sao Jose dos Campos Sao Paulo, SP Telephone (0123) 22-9509 Telex (123) 3530 INPE BR Directoria do Servico Geografico do Exercito SMU-QG Ex., Bloco F. 20 Pav. 70630 Brasilia, D.F. Telephone (061) 223-8529 Telex (061) 1094 Directoria de Geodesia e Cartografia Instituto Brasileiro de Geografia e Estatistica Av. Franklin Roosevelt, 166 100 Andar 20021 Rio de Janeiro, RJ Telephone (021) 220-6671/6821 Telex (021) 30939

Country	Agencies
BRAZIL (cont.)	Projeto RADAM CRS 509, Bloco A, Loja 1 a 5 70360 Brasilia, D.F. Telephone (061) 244-9432 Telex (061) 2243
COLOMBIA	Instituto Geográfico Militar Subdirección Cartográfica Carrera 30 No. 48-51 Bogota Telephone (571) 3681215 Facsimile (571) 3680991 Email codazzi.igac.gov.com
COSTA RICA	Servicio Geodésico Interamericano Instituto Geográfico Nacional Telephone (506) 222-6413 Comisión Nacional de Emergencias Telephone (506) 220-2020
CUBA	División Comercial TECNOTEX - GEOCUBA Calle No. 303, Miramar, Playa La Havana 11300, Cuba Telephone 22 28 91, 237474, 234101 Facsimile 22 28 91, 332869, 331682 Email: codazzi.igac.gov.com
EL SALVADOR	Ministry of Public Works La. Av. Sur No. 630 San Salvador Telephone 71-6026 Center for Geotechnical Research Avenida Peralta, final. contiguo a Talleres El Coro San Salvador Telephone 22-9011 National Geographic Institute “Ingeniero Pablo Arnoldo Guzman” Avenida Juan Bertis No. 79 San Salvador Telephone 25-5060

Country	Agencies
EL SALVADOR (cont.)	Weather Forecast and Hydrology Service Renewable Natural Resources Center Canton El Matazano, Soyapango San Salvador Telephone 27-0484/27-0622 Ministry of Agriculture Alameda Roosevelt 2823 San Salvador Telephone 23-24434/24-2944 General Directorate of Irrigation and Drainage Canton El Matazano, Soyapango San Salvador Telephone 77-0490
GUATEMALA	Military Geographic Institute Avenida de las Americas 5-76, Zona 13 Guatemala Telephone 363281 to 83
GUYANA	Lands and Surveys Department 22 Upper Hadfield Street D'urban Backlands Greater Georgetown Telephone (02) 72582/60524-9
JAMAICA	Survey Department P. O. Box 493 231/2 Charles Street Kingston Telephone 809-922-6630/5
MEXICO	Departamento Geográfico Militar Servicio Cartográfico Secretaria de la Defensa Nacional Lomas de Sotelo Mexico 10, D.F.

Country	Agencies
PANAMA	Instituto Geográfico Nacional "Tommy Guardia" Apartado Postal 5267, Zona 5 Panama Telephone 64-0444
PARAGUAY	Military Geodetic Service Avenida Artigas y Via Férrea Asuncion Telephone 208858 Ciudad Universitaria Km 10, San Lorenzo Institute of Basic Sciences Telephone 501517
PERU	Geological Mining and Metallurgical Institute Pablo Bermudez 211 Apartado 889 Lima Telephone 316233 National Office for Evaluation of Natural Resources Calle 17 # 355, Urb. El Palomar San Isidro, Lima Telephone 410425 General Bureau of Aerophotography Base Aerea "Las Palmas" Barranco, Lima Telephone 670538 Telex 21501 PE Military Geographic Institute Av. Andres Aramburu 1198 Apartado 2038 Lima Naval Bureau of Hydrography and Navigation Calle Saenz Pena No. 590, La Punta Callao, Lima Telephone 652995

Country	Agencies
SURINAME	Central Bureau Luchtkaartering P. O. Box 971 Dr. Sophie Redmondstraat 131 Paramaribo Telephone 74421
TRINIDAD and TOBAGO	Ministry of Planning and Mobilisation Lands and Surveys Div. Red House, St. Vincent St. Port-of-Spain Seismic Research Unit c/o University of the West Indies St. Augustine Telephone (809) 662-4659
URUGUAY	Dirección de Hidrografía Ministerio de Transporte y Obras Publicas Rincón 561, Piso 2 Montevideo Telephone 95 94 34 Servicio de Oceanografía, Hidrografía y Meteorología de la Armada Capurro 980 Montevideo Telephone 39 92 20
VENEZUELA	Servicio Autónomo de Geografía y Cartografía Nacional Avenida Este 6, Esquina de Camejo Edificio Camejo, Piso 2, Oficina 231 Caracas Telephone 408 1710-4081711

Mission

It is our mission to generate and carry out activities that will lead to the creation of a more favorable environment for the development of the oil and natural gas industry in Latin America and the Caribbean, by promoting:

* The expansion of business opportunities and the improvement of competitive advantages of its members.

* The establishment of a framework to favor competition in the sector.

* The timely and efficient exploitation of hydrocarbon resources and the supply of its products and services; all this in conformity with the principles of sustainable development.

To accomplish this mission, ARPEL works in cooperation with international organizations, governments, regulatory agencies, technical institutions, universities and non-governmental organizations.

Vision

ARPEL aims at becoming an international level organization that through its guidelines activities and principles exert an outstanding leadership in the development of the oil and natural gas industry in Latin America and the Caribbean.

Objectives

* To foster cooperation among members.

* To study and assess actions leading to energy integration.

* To participate pro-actively in the process of development of laws and regulations concerning the industry.

* To support actions that expand the areas of activity and increase business opportunities.

* To serve as an oil and gas activity information center.

* To develop international cooperation programs.

* To promote a responsible behavior for the protection of the environment, thus contributing to sustainable development.

* To take care of the oil and natural gas industry's public image.

* To study and disseminate criteria and opinions on the sector's relevant issues.

Regional Association of Oil and Natural Gas Companies in Latin America and the Caribbean
Javier de Viana 2345 – CP 11200 Montevideo – URUGUAY
Phone: (598 2) 400 6993* Fax (598 2) 400 9207*
E-mail: arpel@arpel.com.uy
Internet web site: http://www.arpel.org