ENVIRONMENTAL SENSITIVITY INDEX: SOUTHERN LAKE MICHIGAN

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for the Lake Michigan shorelines of Indiana and Illinois. The ESI maps include information for three main components: shoreline habitats; sensitive biological resources; and human-use resources. The methods of data collection and presentation are summarized in the following sections.

SHORELINE HABITAT MAPPING

The shoreline habitats of southern Lake Michigan were mapped during overflights conducted on 7 May 1993. The surveys were conducted at elevations of 300-500 feet and slow air speed, using a H-65 helicopter provided by the U.S. Coast Guard. An experienced coastal geologist delineated the coastal types directly onto 1:24,000 scale U.S. Geological Survey topographic maps, using a standardized classification scheme. Where appropriate, multiple habitats were delineated for each shoreline segment.

Prediction of the behavior and persistence of oil on shoreline habitats is based on an understanding of the dynamics of coastal environments, not just the substrate type and grain size. The vulnerability of a particular shoreline habitat is an integration of the following factors:

1) Shoreline type (substrate, grain size, tidal elevation, origin)
2) Exposure to wave and tidal energy
3) Biological productivity and sensitivity
4) Ease of cleanup

All of these factors are used to determine the relative sensitivity of shorelines. Key to the sensitivity ranking is an understanding of the relationships between: physical processes, substrate, shoreline type, product type, sediment transport, and product fate and effect. Thus, the intensity of energy expended upon a shoreline by wave action and river currents directly affects the persistence of stranded oil. The need for shoreline cleanup activities is determined, in part, by the lack or slowness of natural processes in removing oil stranded on the shoreline.

These concepts have been used in the development of the Environmental Sensitivity Index (ESI), which ranks shoreline environments as to their relative sensitivity to oil spills, potential biological injury, and ease of cleanup. Generally speaking, areas exposed to high levels of physical energy, such as wave action and river currents, and low biological activity rank low on the scale. Sheltered areas with associated high biological activity have the highest ranking. These rankings follow a shoreline classification system that has been applied nationwide during the preparation of oil spill sensitivity maps. The list below includes the shoreline habitats delineated for southern Lake Michigan, presented in order of increasing sensitivity to spilled oil.

1A. Exposed Rocky Cliffs (not present in study area)
1B. Exposed, Solid Man-made Structures
2. Shelving Bedrock Shores (not present in study area)
3. Eroding Scarps in Unconsolidated Sediments (not present in study area)
4. Sand Beaches
5. Mixed Sand and Gravel Beaches
6A. Gravel Beaches (not present in study area)
6B. Riprap Revetments, Groins, and Jetties
7. Exposed Flats (not present in study area)
8A. Sheltered Scarps in Bedrock (not present in study area)
8B. Sheltered, Solid Man-made Structures
9A. Sheltered, Vegetated Low Banks
9B. Sheltered Sand/Mud Flats (not present in study area)
10A. Fringing Wetlands
10B. Extensive Wetlands (not present in study area)

SENSITIVE BIOLOGICAL RESOURCES

The key biological resources of the area that are most likely at risk in the event of an oil spill are depicted on the maps. Four major categories of biological resources were considered during the production of the maps: birds, fish, plants, and mammals.

Spatial distribution of the species on the maps is represented by polygons, lines, and points, as appropriate. Associated with each of these representations is an icon depicting the types of plants or animals that are present in the polygon. Species have been divided into groups and subgroups, based on their behavior and taxonomic classification. The icons reflect this grouping scheme. The groups are color coded, and the subgroups are represented by different icons as follows:

BIRDS

Diving Birds
Gulls and Terns
Pelagic Birds
Raptors
Shorebirds
Wading Birds

BIRDS (cont.)

Waterfowl

FISH

Fish

PLANTS

Terrestrial Plants

The polygon color and pattern are the same for all the animals in one group. When there is more than one group of animals in one polygon, the polygon is then assigned the multigroup color and pattern. Also associated with each polygon on the map is a number (located under the icon for the polygon). This number references a table on the reverse side of the map with a complete list of species found in the polygon as well as life-history information on each species.

There are some species that are found throughout their preferred habitats on the map. While it is important to note the presence of these species, showing these distributions as polygons would cover large areas. In addition to providing no significant increase in the level of information presented to the user, it would make the maps very difficult to read. In response to this problem, species found in over 25 percent of the water area are identified in a box stating that they are “COMMON IN AREA”. When these species are restricted to within 75 meters of the shoreline zone, they are identified in a box stating that they are “COMMON IN SHORELINE AREA”. This approach informs the user of the presence of these species, while maintaining readability of the map.

BIRDS

The birds are divided into several species groups based on behavior and genealogy. The species list includes all the birds by group included on the maps. These species were included because of the potential for impact by an oil spill, or because they had a special protected status. All bird distributions are shown on the map as green polygons with a diagonal hatch pattern. No bird polygons overlap. Individual nest locations are identified by small green dots. In the event that there are multiple resource categories assigned to a particular area, then the species distribution is shown by a polygon with a black hatch pattern. Icons representing each of the species groups are shown with the polygons and nest sites. The number under the icon references the table on the back of the map, which has a list of the species and seasonalities for the birds in that particular polygon or nest location. To identify the birds in a particular area, find the polygon or nest location number on the map for the birds. Then go to the table and look up the number. Following the number will be a list of species that are present in the polygon or at the point location. The S/F column indicates whether a species protected status is State (S) or Federal (F). The T/E column indicates if the species is threatened (T) or endangered (E). The concentration column indicates the number of animals present—it is either relative (High, Medium, or Low), or specifies absolute numbers (45 nests). For each species, an X is placed in the column corresponding to the month the species is present in the area encompassed by the polygon or point location. The last four columns in the table indicate the months that the species is nesting, laying, hatching, and fledging.

FISH

The fish areas depicted on the maps are either the spawning areas for many species of fish or areas of particularly high fish concentration. Species shown on the maps are important commercial or recreational fish, or species that are an important part of the ecosystem. A blue polygon and hatch pattern were used to represent fish distributions. No fish polygons overlap. In the event that there are multiple resource categories assigned to a particular area, then the species distribution is shown by a polygon with a black hatch pattern. A fish icon is shown for each polygon. The number under the icon references the table on the back of the map, which has a list of the species and seasonalities for the fish in that particular polygon. To identify the fish in a particular area, find the polygon number for the fish of interest on the map. Then go to the table and look up the polygon number. Following the number will be a list of species that are present in the polygon. The S/F column indicates whether a species has State (S) or Federal (F) protection status. The T/E column indicates if the species is threatened (T) or endangered (E). The concentration column indicates the number of animals present—it is either relative (High, Medium, or Low), or specifies absolute numbers (93,000). For each species, an X is placed in the column corresponding to the month the species is present in the area encompassed by the polygon. The last two columns in the table indicate the months that the species spawn and when the juveniles outmigrate.

TERRESTRIAL PLANTS

All of the terrestrial plants included in this atlas are species that are on the State or Federal list of threatened or endangered plants, and found in the areas near the shoreline. These plants may not be impacted directly by a spill of oil since they are found above the normal high water line, but they could be impacted during the cleanup operations. The polygons for the plants, shown as a purple hatch pattern, represent the general location where the plants are found. A plant icon is shown for each polygon. The exact location is not identified in order to protect the plants. In the event that there are multiple resource categories assigned to a particular area, then the species distribution is shown by a polygon with a black hatch pattern.

MAMMALS

Although mammals were considered for inclusion in the atlas, none are depicted on the maps or included in the database. There are several species of mammals which are likely to be impacted by oil spills along the shore of southern Lake Michigan. Even though they are considered very sensitive resources, they were not depicted because they do not occur in appreciable concentrations at any location and are widely scattered throughout their range. The species of mammals in the area that might be impacted are raccoon (Procyon lotor), muskrat (Ondatra zibethicus), river otter (Lutra canadensis), and beaver (Castor canadensis).

HUMAN-USE FEATURES

The features shown on the map are those that would either be impacted by an oil spill or provide access to the cleanup operations. All of the features are represented on the maps by symbols that indicate the type of feature. For most of the features a line is drawn from the symbol to the exact location of the feature. The features shown on the maps include:

- Airport—Location of airfields or airports whether they are manned or unmanned. The locations were obtained from visual observations during the overflights or from U.S. Geological Survey (USGS) topographic maps.
- Boat ramp—The locations of boat ramps were mapped during the overflights and from sites identified on topographic and other maps.
- Coast Guard—Identifies the location of U.S. Coast Guard stations.
- Marina—This symbol shows the location of all the marinas that were identifiable in the area. Marina locations were mapped during the overflights. More detailed information for the marinas can be obtained from the U.S. Coast Guard MSO Area Plan.
- National park—This symbol identifies the location of national parks, lakeshores, and monuments. The park locations were obtained from the USGS topographic maps and National Park Service personnel.
- State park—This symbol identifies the location of state parks. The park locations were obtained from the USGS topographic maps as well as state resource agencies.
- Water intake—This symbol is placed where the actual water intake is located in the lake.
- Wildlife area—These are designated wildlife areas that include wildlife refuges, conservancy areas, wildlife preserves or reserves, and wildlife mangement areas.

GEOGRAPHIC INFORMATION SYSTEM DATA

The entire atlas product is stored in digital form in a Geographic Information System (GIS). The information is stored as maps and associated databases. The format for the data varies depending on the type of information or features for which the data are being stored. The three major formats are shoreline habitat classification, human-use features, and biological resources.

SHORELINE HABITAT CLASSIFICATION

The shoreline habitat classification is stored as lines or polygons with the data identifying the type of habitat associated with the line. In many cases a shoreline segment may have two or three different classifications. These multiple classifications are represented on the maps by double and triple lines, and in the data base by ESI#1/ESI#2 where ESI#1 is the landward-most classification and ESI#2 is the lakeward-most classification.

HUMAN-USE FEATURES

The human-use features are represented on the maps as an icon describing the feature. In the digital file, the icon location is represented by a point. Attached to the point is a data file that contains fields for the name of the owner/manager, a telephone number at which the person can be contacted, an identification of the type of feature, and a brief description of the feature. This information is incomplete and frequently changes, so it is not included in the atlas.

SENSITIVE BIOLOGICAL RESOURCES

Biological resources are shown on the map by colored and shaded polygons, lines, and points. The color of the polygon indicates whether the resource is a bird, fish, or plant. The shading is used to identify the extent of the polygon. In the digital copy the biological resources are also represented by polygons, lines, and points. Associated with each feature is an identification number. This identification number is linked to a series of databases that describe the resource for that particular polygon, line, or point. The first data set is a list of the species present in the polygon (indicated by a species identification number). Next, the concentration of each species (when available), is linked to the database with expert contacts for that species in that area. Temporal distribution information (by month) for that species at that location, and identification of the species complete the data base. The expert contact list contains the name, a telephone number, address, and agency of the person most suited to contact for information on the species of concern in the area of concern. The temporal distribution data base includes the months a species is present, and the months of certain phases of breeding activity. For birds, it indicates the times of nesting, laying, hatching, and fledging. For fish, spawning and outmigration times are identified. The identification database identifies the species by common name, scientific name, species grouping by genealogy and behavior, and state or federal threatened or endangered status.

PRIMARY REFERENCES

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SPECIES LIST*

Common Name	Species Name
BIRDS	
DIVING BIRDS	
Arctic loon	*Gavia arctica*
Belted kingfisher	*Megaceryle alcyon*
Common loon	*Gavia immer*
Double-crested cormorant	*Phalacrocorax auritus*
Horned grebe	*Podiceps auritus*
Pied-billed grebe	*Podilymbus podiceps*
Red-necked grebe	*Podiceps grisegena*
Western grebe	*Aechmophorus occidentalis*
GULLS AND TERNS	
Black tern	*Chilidonias niger*
Bonaparte's gull	*Larus philadelphia*
Caspian tern	*Sternacaspia*
Common tern	*Sterna hirundo*
Forster's tern	*Sterna fosteri*
Franklin's gull	*Laurus pipixcan*
Glaucous gull	*Larus hyperboreus*
Great black-backed gull	*Larus marinus*
Herring gull	*Larus argentatus*
Laughing gull	*Larus atricilla*
Ring-billed gull	*Larus delawarensis*
Thayer's (herring) gull	*Larus argentatus thayeri*
PELAGIC	
Black-legged kittiwake	*Rissa tridactyla*
RAPTORS	
American kestrel	*Falco sparverius*
Bald eagle	*Haliaeetus leucocephalus*
Osprey	*Pandion haliaetus*
Peregrine falcon	*Falco peregrinus*
SHOREBIRDS	
Baird's sandpiper	*Calidris bairdii*
Black-bellied plover	*Pluvialis squatarola*
Dunlin	*Calidris alpina*
Greater yellowlegs	*Tringa melanaleuca*
Killdeer	*Charadrius vociferus*
Least sandpiper	*Calidris minutilla*
Lesser yellowlegs	*Tringa flavipes*
Pectoral sandpiper	*Calidris melanotos*
Piping plover	*Charadrius melodus*
Purple sandpiper	*Calidris maritima*
Red knot	*Calidris canutus*
Ruddy turnstone	*Arenaria interpres*
Sanderling	*Calidris alba*
Semipalmated plover	*Charadrius semipalmatus*
Semipalmated sandpiper	*Calidris pusilla*
Short-billed dowitcher	*Limnodromus griseus*
Solitary sandpiper	*Tringa solitaria*
Spotted sandpiper	*Actitis macularia*
Uplands andpiper	*Bartramia longicauda*
White-rumped sandpiper	*Calidris fusciollis*
Willet	*Catoptrophorus semipalmatus*
WADING BIRDS	
American bittern	*Botaurus lentiginosus*
American woodcock	*Philohela minor*
Black-crowned night heron	*Nycticorax nycticorax*
Cattle egret	*Bubulcus ibis*
Great blue heron	*Ardea herodias*
Great egret	*Casmerodius albus*
Green heron	*Butorides striatus*
King rail	*Rallus elegans*
Least bittern	*Ixobrychus exilis*
Sandhill crane	*Grus canadensis*
Sora rail	*Porzana carolina*
Virginia rail	*Rallus limicola*
WATERFOWL	
American coot	*Fulica americana*
American wigeon	*Anas americana*
Black brant	*Branta bernicla*
Black duck	*Anas rubripes*
Black scoter (common)	*Melanitta nigra*
Blue-winged teal	*Anas discors*
Bufflehead	*Bucephala albeola*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Common goldeneye	*Bucephala clangula*
Common merganser	*Mergus merganser*
Gadwall	*Anas strepera*
Greater scaup	*Aythya marila*
Green-winged teal	*Anas crecca*
Harlequin duck	*Histrionicus histrionicus*

SPECIES LIST*

Common Name	Species Name
BIRDS (continued)	
WATERFOWL (continued)	
Hooded merganser	*Lophodytes cucullatus*
Lesser scaup	*Aythya affinis*
Mallard	*Anas platyrhynchos*
Mute swan	*Lygnus olor*
Northern shoveler	*Anas clypeata*
Oldsquaw	*Clangula hyemalis*
Pintail	*Anas acuta*
Red-breasted merganser	*Mergus serrator*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Ruddy duck	*Oxyura jamaicensis*
Surf scoter	*Melanitta perspicillata*
White-winged scoter	*Melanitta deglandi*
Wood duck	*Aix sponsa*
FISH	
Alewife	*Alosa pseudoharengus*
Black bullhead	*Ictalurus melas*
Black crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis macrochirus*
Brook trout	*Salvelinus fontinalis*
Brown bullhead	*Ictalarus nebulosus*
Brown trout	*Salmo trutta*
Burbot	*Lota lota*
Carp	*Cyprinus carpio*
Channel catfish	*Ictaluruspunctatus*
Chinook salmon (king)	*Oncorhynchus tshawytscha*
Coho salmon (silver)	*Oncorhynchus kisutch*
Emerald shiner	*Notropis atherinoides*
Gizzard shad	*Dorosoma cepedianum*
Green sunfish	*Lepomis cyanellus*
Johnny darter	*Etheostoma nigrum*
Lake trout	*Salvelinus namaycush*
Largemouth bass	*Micropterus salmoides*
Longear sunfish	*Lepomis megalotis*
Ninespine stickleback	*Pungitius pungitius*
Northern pike	*Esox lucius*
Pumpkinseed	*Lepomis gibbosus*
Rainbow smelt	*Osmerus mordax*
Rainbow trout (steelhead)	*Oncorhynchus mykiss*
Rock bass	*Ambolplites rupestris*
Smallmouth bass	*Micropterus dolomieui*
Spottail shiner	*Notropis hudsonius*
Striped bass	*Morone saxatilis*
Tiger musky	*Esox masquinongy + lucius*
Trout perch	*Percopsis omiscomaycus*
Walleye	*Stizostedion vitreum vitreum*
White crappie	*Pomokis annylaris*
White sucker	*Catostomus commersoni*
Yellow bass	*Morone mississippiensis*
Yellow bullhead	*Ictalurus natalis*
Yellow perch	*Perca flavescens*
PLANTS	
Plant (E)	*Endangered plant*
Plant (T)	*Threatened plant*

* Threatened and endangered species are designated by underlining.

Shoreline Habitat Descriptions

EXPOSED ROCKY CLIFFS ESI = 1A

Not present in study area

EXPOSED, SOLID MAN-MADE STRUCTURES ESI = 1B

DESCRIPTION

- These structures are vertical, hard, and impermeable seawalls and piling exposed to direct wave action.
- They are present along developed shorelines where beach erosion has occurred or where harbors have been built, comprising 14.9 percent of the shoreline.

PREDICTED OIL BEHAVIOR

- Any oil that is deposited will be rapidly removed from exposed faces, although oil persistence on any specific shoreline is related to the incoming wave energy.
- The most resistant oil would remain as a patchy band at or above the high-water line.

RESPONSE CONSIDERATIONS

- High-pressure spraying may be required to remove oil for aesthetic reasons and prevent leaching of the oil from the structure.
- Cleanup crews should make sure to recover all released oil.

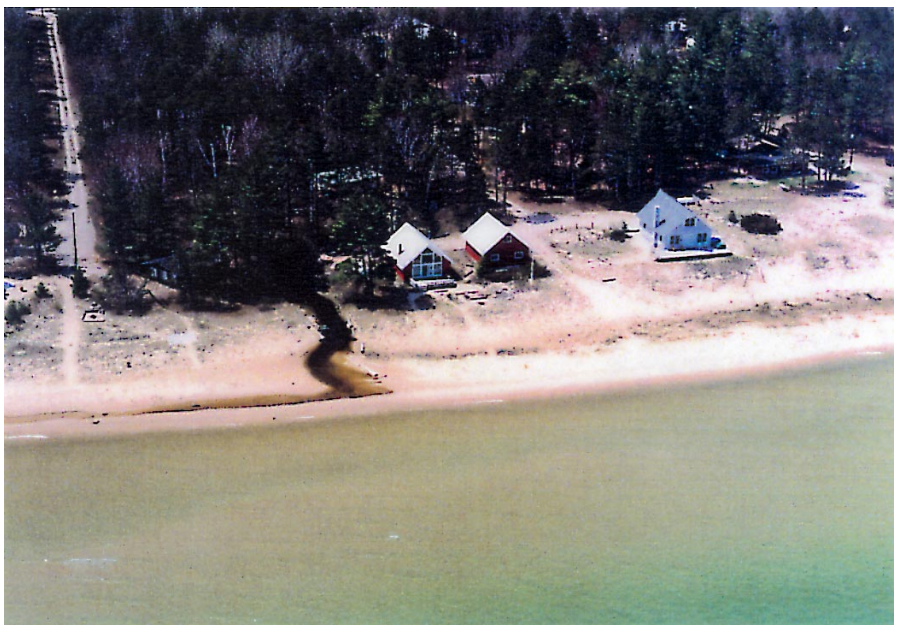
SHELVING BEDROCK SHORES ESI = 2

Not present in study area

ERODING SCARPS IN UNCONSOLIDATED SEDIMENTS ESI = 3

Not present in study area

SAND BEACHES ESI = 4



DESCRIPTION

- Sand beaches are composed of sediments that range in size from fine-grained sand to granules.
- When the sediments are fine-grained sand, beaches may be wide and flat; where the sediments are coarser, they usually are steeper and narrower.
- These beaches may be used by migrating shorebirds.
- They are common along the southern Lake Michigan shore and are heavily used during the summer months for recreation.
- They comprise 12.5 percent of the shoreline.

PREDICTED OIL BEHAVIOR

- During small spills, oil will concentrate in a band along the swash line.
- Maximum penetration of oil into fine-grained sand will be less than 15 cm; penetration into coarse-grained sand can reach 25 cm.
- Burial of oiled layers by clean sand within the first few weeks after the spill will be limited usually to less than 30 cm, whereas burial by up to 60 cm on coarse-grained beaches is possible.
- Deepest burial will occur if the oil is stranded onshore at the beginning of an accretionary period, such as after a storm.
- Much of the oil will be removed during the next storm.
- Heavy accumulations of residual oil can form tar mats.
- Biological impacts are likely to be low, except for when the beaches are being used by shorebirds for resting and foraging.

RESPONSE CONSIDERATIONS

- Because of their heavy recreational use, most beaches will require extensive cleanup efforts to remove as much of the oil as possible.
- Sand removal should be kept to a minimum, to avoid erosional problems.
- Use of heavy equipment for oiled sediment removal may result in the removal of excessive amounts of sand; manual cleanup may be preferable.
- All activity through the oiled sand should be limited to prevent mixing the oil deeper into the sediments and contamination of adjacent clean areas.
- When possible, cleanup crews should wait for all of the oil to come ashore prior to removal of oiled sediment.

MIXED SAND AND GRAVEL BEACHES ESI = 5

DESCRIPTION

- These beaches are composed of a wide range of mixtures of sand and gravel (greater than 10 percent of each).
- Because of the mixed sediment sizes, there may be zones of pure sand, pebbles, or cobbles.
- Where the beach is depositional, there can be multiple berms from the different water levels generated during storms.
- Where the beach is stable or erosional, the sediments are a jumble of grain sizes with the gravel scattered over a relatively wide, flat surface.
- These beaches may be used by migrating shorebirds.
- Mixed sand and gravel beaches are common throughout the study area, comprising 14.7 percent of the shoreline.

PREDICTED OIL BEHAVIOR

- Small oil spills will be deposited at the high-water line.
- Large spills will spread across the entire beachface.
- Oil penetration into the beach sediments may be up to 50 cm; however, the sand fraction can be quite mobile, and oil behavior is much like on a sand beach if the sand fraction exceeds about 40 percent.
- Burial of oil may be deep at and above the swash line, where oil tends to persist, particularly where beaches are only intermittently exposed to waves.
- On more sheltered beaches, extensive pavements of asphalted sediments can form if there is no removal of heavy oil accumulations, because most of the oil remains on the surface.
- Once formed, these pavements are very stable and can persist for many years.
- Biological impacts are likely to be low, except for when the beaches are being used by shorebirds for resting and foraging.

RESPONSE CONSIDERATIONS

- Remove heavy accumulations of pooled oil.
- All oiled debris should be removed.
- Sediment removal should be limited as much as possible.
- Low-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents; high-pressure spraying should be avoided because of potential for transporting oiled sediments to the subtidal zones.
- Tilling may be used to reach deeply buried oil layers on exposed, depositional beaches.

GRAVEL BEACHES ESI = 6A

Not present in study area

RIPRAP REVETMENTS, GROINS, AND JETTIES ESI = 6B

DESCRIPTION

- These structures are composed of cobble- to boulder-sized quarried rocks that have been placed along the shoreline for protection and stabilization.
- Riprap is placed behind beaches, along harbors, and as groins perpendicular to the shoreline.
- Riprap is very common along much of the developed shoreline of southern Lake Michigan, where it comprises 32.7 percent of the shoreline.

PREDICTED OIL BEHAVIOR

- Deep penetration of oil between the boulders is likely where the riprap is placed at the water line.
- Oil adheres readily to the rough rock surfaces.
- If oil is left uncleaned, it may cause chronic leaching until the oil hardens into an asphalt deposit.

RESPONSE CONSIDERATIONS

- When the oil is fresh and liquid, high-pressure spraying and/or water flooding may be effective, making sure to recover all released oil.
- Heavy and weathered oils are more difficult to remove, requiring scraping and/or hot-water spraying.
- It may be necessary to replace heavily oiled riprap.

EXPOSED FLATS ESI = 7

Not present in study area

SHELTERED SCARPS IN BEDROCK ESI = 8A

Not present in study area

SHELTERED, SOLID MAN-MADE STRUCTURES ESI = 8B

DESCRIPTION

- These structures include revetments, seawalls, piers, and docks constructed of concrete or wood.
- They usually extend to the water surface.
- They are found inside harbors in highly developed areas, comprising 22.4 percent of the shoreline.

PREDICTED OIL BEHAVIOR

- On impermeable surfaces, the oil will form a band at the water line.
- If oil is left uncleaned, it may cause chronic leaching until the oil hardens into an asphalt deposit.

RESPONSE CONSIDERATIONS

- High-pressure spraying may be required to remove oil for aesthetic reasons and prevent leaching of the oil from the structure.
- Cleanup crews should make sure to recover all released oil.

SHELTERED, VEGETATED LOW BANKS ESI = 9A

DESCRIPTION

- Sheltered vegetated low banks are colonized by terrestrial plants that grow in aerated soils.
- They occur along the upper reaches of streams and embay-ments.
- They are not common, representing 2.9 percent of the shoreline.

PREDICTED OIL BEHAVIOR

- Oil will adhere to any vegetation along the water line.
- Very heavy accumulations will be trapped along shoreline irregularities and pool in any surface depressions.

RESPONSE CONSIDERATIONS

- All free oil should be removed by vacuum, low-pressure flushing, etc.
- Vegetation removal should be conducted only when deemed necessary and under close supervision.

SHELTERED SAND/MUD FLATS ESI = 9B

Not present in study area

FRINGING WETLANDS **ESI = 10A**

DESCRIPTION

- Fringing wetlands occur as a narrow band of vegetation that requires saturated soils for growth and reproduction.
- Wetland soils are mostly composed of silt and clay, although the vegetation can grow in sandy sediments behind sheltered beaches and rocky shores.
- They are exposed to relatively high wave energy, compared to extensive wetlands.
- Fringing marshes are denoted on the maps as a single band of color along the shoreline. They represent less than one percent of the shoreline.

EXTENSIVE WETLANDS **ESI = 10B**

Not present in study area