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 1992 on 7 May and 7 June. The shorelines were delineated by polygons, lines, and points, as appropriate. Associated with each of these representations is an icon depicting the types 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, are more sensitive to biological activity than areas protected by sheltered areas with associated high biological activity. The highest ranking. These ranks are used to determine the relative sensitivity of shorelines. Key to the sensitivity ranking is an understanding of the relationships between: physical processes, substrate type, product type, sediment transport, and predict the event of an oil spill. Thus, the intensity of energy and effect. 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 Scarpas 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. Rippard Revetments, Groins, and Jetties
7. Exposed Flats (not present in study area)
8A. Sheltered Scarpas 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. The number under the icon references the table on the back of the map. The polygon color and pattern are the same for all the animals that are present in the polygon or at the point location. The number under the icon indicates the number of animals present in the polygon.

Fish

The fish areas depicted on the maps are either the spawning areas for many species of fish or areas with particularly high fish concentration. The number under the icon references the table on the back of the map. The polygon color and pattern are the same for all the animals that are present in the polygon or at the point location. The number under the icon indicates the number of animals present in the polygon.

BIRDS

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. 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 response to this problem, species are found in over 25 percent of the water area are identified in a box stating that they are “COMMON IN SHORELINE AREA”. 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.

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. The concentration column indicates the number of animals present in the polygon. The T/E column indicates if the species is threatened (T) or endangered (E). The S/F column indicates if the species is 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 in the polygon. The T/E column indicates if the species is threatened (T) or endangered (E). The S/F column indicates if the species is protected status is State (S) or Federal (F). The T/E column indicates if the species is threatened (T) or endangered (E). The S/F column indicates if the species is protected status is State (S) or Federal (F).
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 purple circle 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 specific distribution is shown by a polygon with a black hatch pattern.

MAMMALS

Although mammals were considered for inclusion in the atlas, none are included 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 there are several native resource mammals, 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 the 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 USGS topographic maps and other sources.
- State park—This symbol identifies the location of state parks. The park locations were obtained from USGS topographic maps and 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 management 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 outmiguration 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

Indiana Department of Natural Resources, 1993, Indiana's Rare Plants and Animals: A Checklist of Endangered and Threatened Species.

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SHOREBIRDS

WADING BIRDS

DIVING BIRDS

BELTED KINGFISHER

COMMON LOON

DOUBLE-CRESTED CORMORANT

HORNEGREBE

PIED-BILLED GREBE

RED-NECKED GREBE

WESTERN GREBE

GULLS AND Terns

BLACK TERN

BONAPARTE’S GULL

CASPIAN TERN

COMMON TERN

FORKER’S TERN

FRANKLIN’S GULL

GLAUCOUS GULL

GREY-BACKED GULL

HERRING GULL

LAUGHING GULL

RING-BILLED GULL

THAYER’S (HERRING) GULL

PELAGIC

BLACK-LEGGED KITTIWAKE

RAPTORS

AMERICAN KESTREL

BALD EAGLE

OSPREY

PETRIGINE FALCON

SHOREBIRDS

BAIRD’S SANDPIPER

BLACK-BELLIED PLOVER

DUNLIN

GREATER YELLOWLEGS

KILLDEER

LEAST SANDPIPER

LESHER YELLOWLEGS

PECTORAL SANDPIPER

PINGING POVER

PURPLE SANDPIPER

RED KNOT

Ruddy turnstone

SANDERLING

SPELUMINATED PLOVER

SEMIPALMATED SANDPIPER

SHORT-BILLED DOWITCHER

SOLITARY SANDPIPER

UPLAND SANDPIPER

WHITE-RUMPED SANDPIPER

WILLET

WADING BIRDS

AMERICAN BITTERN

AMERICAN COODOCK

BLACK-CROWNED NIGHT HERON

CATTLE EGRET

GREAT BLUE HERON

GREAT EGRET

LEAST BITTERN

SANDHILL CRANE

SORA RAIL

VIRGINIA RAIL

\* Threatened and endangered species are designated by underlining.

FISH

PLANTS

SPECIES LIST

SPECIES LIST
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 uncleared, 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  
Not present in study area

SHELTERED SCARPS IN BEDROCK  
Not present in study area

SHELTERED, SOLID MAN-MADE STRUCTURES  
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 uncleared, 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  
DESCRIPTION  
• Sheltered vegetated low banks are colonized by terrestrial plants that grow in aerated soils.  
• They occur along the upper reaches of streams and embayments.  
• 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  
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
SHORELINE HABITAT RANKINGS

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)

HUMAN-USE FEATURES

AIRPORT
BOAT RAMP
COAST GUARD
MARINA
NATIONAL PARK
STATE PARK
WATER INTAKE
WILDLIFE AREA

INTERNATIONAL STATE BOUNDARY
PARK BOUNDARY

SENSITIVE BIOLOGICAL RESOURCES

BIRDS
DIVING BIRDS
GULLS & TERNS
PELAGIC BIRDS
RAPTORS
SHOREBIRDS
WADING BIRDS
WATERFOWL
NESTING SITES

FISH

PLANTS
TERRESTRIAL PLANTS
MULTI-GROUP
THREATENED OR ENDANGERED

ID NUMBER

ID NUMBER

ID NUMBER