# SENSITIVITY OF COASTAL ENVIRONMENTS AND WILDLIFE TO SPILLED OIL: LOUISIANA

## INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for marine and coastal areas of Louisiana. The maps extend inland to Interstate 10. ESI maps are a compilation of information for three main categories: shoreline habitats, sensitive biological resources, and human-use resources.

The maps are plotted at two scales. The outer coast maps (map numbers 1-73) are divided according to the 1:24,000 U.S. Geological Survey (USGS) topographic quadrangle index and plotted at a size of 11 x 17 inches and a scale of 1:50,000. Grey-scale Digital Orthophoto Quarter Quadrangles (DOQQ) are used as backdrops for the outer coast maps. Maps for the interior area (map numbers 74-144) are divided according to a group of 1:24,000 USGS topographic quadrangles that are plotted at a size of 11x17 inches and a scale of 1:100,000. The Landsat thematic mapper satellite imagery was used as a backdrop for these inland maps.

## SHORELINE HABITAT MAPPING

The shoreline was primarily digitized from the 1998 DOQQs and represents the high-tide line as visible in the photography. In the case of wetlands, this line was digitized as the seaward extent of vegetation. Areas digitized included the shoreline of all barrier islands from the Chandeleur Islands west, as well as the outer coast of the Mississippi River Delta, the Wax Lake and Main Atchafalaya River Deltas, a portion of the coast of Vermilion Bay, and the Chenier Plain coast from Marsh Island west to Sabine Pass. This shoreline was initially classified by a geomorphologist (Dr. Miles O. Hayes) performing on-screen photointerpretation of the DOQQs using the standard ESI classification scheme. The coastal geomorphological classification data of Ramsey and Penland (1999), interpreted from geo-referenced oblique aerial videography flown in 1999, were used during this process to help differentiate among shoreline types that were visually similar and difficult to photo-interpret. Hardcopy maps of this attributed shoreline were plotted at 1:24,000 scale for field verification of the ESI attributes.

The shoreline ESI classifications were field checked during helicopter overflights conducted in May 2001. The surveys were conducted at elevations of 100-500 feet and slow air speed. All shoreline attributed by photointerpretation was surveyed. A coastal geologist edited the ESI classifications on 1:24,000 scale maps during the overflights. Where appropriate, multiple habitats were assigned for each shoreline segment. In some areas, drastic change in shoreline position occurred between the dates of the 1998 DOQQs and the 2001 field surveys due to erosion or active delta building. These areas included, but were not limited to: 1) The Chandaleur Islands; 2) Several marsh restoration sites in the Isles Derniers and Timbalier Islands; and 3) both the Wax Lake and Main Atchafalaya Deltas. In areas of major shoreline change, the new shoreline position was sketched in and assigned a shoreline type(s) based on field sketches and oblique aerial photography acquired during the field surveys. The field maps were then scanned and registered and edits were made using on-screen digitizing. The variety of wetland plant communities in coastal Louisiana made it difficult to classify marsh shorelines by ESI marsh type during the field surveys. As such, the 1997 Louisiana Department of Wildlife and Fisheries Marsh Type data were used to update all shoreline segments with the appropriate ESI code, via a GIS overlay operation.

To determine the sensitivity of a particular intertidal shoreline habitat, the following factors are integrated:

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

Prediction of the behavior and persistence of oil in intertidal habitats is based on an understanding of the dynamics of the coastal environments, not just the substrate type and grain size. The intensity of energy expended upon a shoreline by wave action, tidal currents, and river currents directly affects the persistence of stranded oil. The need for shoreline cleanup activities is determined, in part, by the slowness of natural processes in removal of oil stranded on the shoreline. The potential for biological injury and ease of cleanup of spilled oil are also important factors in the ESI ranking. Generally speaking, areas exposed to high levels of physical energy, such as wave action and tidal currents, and low biological activity rank low on the scale, whereas sheltered areas with associated high biological activity have the highest ranking. The list below includes the shoreline habitats delineated for Louisiana ordered by increasing sensitivity to spilled oil.

1B) Exposed, Solid Man-made Structures
2A) Exposed Wave-cut Platforms in Clay
2B) Exposed Scarps and Steep Slopes in Clay
3A) Fine- to Medium-grained Sand Beaches
3B) Scarps and Steep Slopes in Sand
4) Coarse-grained Sand Beaches
5) Mixed Sand and Gravel Beaches
6A) Gravel Beaches
6B) Riprap
7) Exposed Tidal Flats
8A) Sheltered Rocky Shores and Sheltered Scarps in Mud or Clay
8B) Sheltered, Man-made Structures
8C) Sheltered Riprap
9A) Sheltered Tidal Flats
9B) Sheltered, Vegetated Low Banks
10A) Salt- and Brackish-water Marshes
10B) Freshwater Marshes
10C) Freshwater Swamps
10D) Scrub-Shrub Wetlands, including Black Mangroves

Each of the shoreline habitats is described on pages 9-15, in terms of their physical description, predicted oil behavior, and response considerations.

## SENSITIVE BIOLOGICAL RESOURCES

Biological information presented in this atlas was collected, compiled, and reviewed with the assistance of biologists and resource managers from the U.S. Fish and Wildlife Service (USFWS), Louisiana Department of Wildlife and Fisheries (LDWF), U.S. Geological Survey (USGS), National Marine Fisheries Service (NMFS), National Park Service (NPS), and the Louisiana Natural Heritage Program (LNHP). Information collected and depicted on the maps denotes the key biological resources that are most likely at risk in the event of an oil spill. Six major categories of biological resources are included in this atlas: terrestrial mammals, reptiles, birds, fish, invertebrates, and benthic and wetland habitats.

Certain portions of the Louisiana Natural Heritage Program Element Occurrence Record (EOR) database were included as part of the biological resources mapped. The data were processed to filter records of concern. In general, records were preserved for species with a Global or State Conservation Status Rank of 1-3 or that are federally threatened or endangered species. Historical records and records for extirpated species and occurrences were removed from the database. Records describing the location of animal specimens or marine mammal strandings were also removed from the database. Rather than use actual common and scientific species names, species for all records, except ecological communities, were converted to generic sub-element descriptor (e.g., Rare wading bird). The prefix "Rare" was attached to all generic sub-element descriptors, except federally threatened or endangered species. For these species, the prefix "Threatened" or "Endangered" was used. The LNHP EOR database contained point locations collected over time from a variety of sources with varying degrees of spatial precision, ranging from seconds to "general". Point locations that were obviously incorrect (e.g., located far offshore or far outside the boundary of the state) were removed from the data. The remaining point locations were buffered by 800 meters (m) to create circular polygons. Overlapping polygons were dissolved such that the resulting polygons contain information describing all species found in the original overlapping polygons. The LNHP EOR database contains information describing the spatial precision of each record, but this information was not included in the attribute data associated with this layer. Also, note that the EOR database is continually updated and maintained by the LNHP. For the most up to date, specific, and complete version of this dataset, please contact the Louisiana Natural Heritage Program at 225/765-2823.

Polygons, points, and arcs represent the spatial distribution of biological resources on the maps. Associated with each of these representations is an icon depicting the types of species that are present. Species have been divided into groups and subgroups, based on their behavior, morphology, taxonomic classification, and spill vulnerability and sensitivity. The icons below reflect this grouping scheme. Please note that benthic marine habitats are displayed on the maps using “simplified-wetland” patterns rather than the hatched patterns used for the other species groups, and no icons are used (see legend). For all other species, the groups are color coded, and different icons represent the subgroups:

**TERRESTRIAL MAMMALS**

- Bats
- Bears
- Small Mammals

**BIRDS**

- Diving Birds
- Gulls and Terns
- Passerine Birds
- Raptors
- Shorebirds
- Wading Birds
- Waterfowl

**FISH**

- Fish

**REPTILES**

- Alligators
- Turtles
- Other Reptiles / Amphibians

**INVERTEBRATES**

- Bivalves
- Cephalopods
- Crabs
- Crayfish
- Insects
- Shrimp

**HABITATS**

- Plants
- Seagrasses

The polygon color and pattern are generally the same for all species in each major group (e.g., birds are green), and match the icon colors. Also associated with each biological polygon or point feature on the map is a Resources at Risk identification number (RAR#), located under each icon or group of icons. The RAR# references a table on the reverse side of the map with a complete list of species associated with the polygon, point, or line feature, and the state and federal protected status as threatened, endangered (T&E), or species of special concern (C), concentration, seasonality, and life-history information for each species.

There are some species that are found throughout specific geographical areas or habitat types on certain maps. Displaying the polygons for these species would cover large areas or would obscure the shoreline, ESI classification, or other biological features, making the maps very difficult to read. Thus, species that occur over the majority of certain geographic areas or habitats are often identified in a small box on the maps which states that they are “Present in ...” (e.g., “Present in Terrebonne Bay” or “Present in Salt Marsh”). The use of this strategy is implemented on a map per map basis, depending on the location, size, and number of polygons present on each map.

### TERRESTRIAL MAMMALS

Louisiana black bear concentration areas are depicted in the Louisiana atlas. LDWF wildlife biologists provided the names of the 1:24,000 USGS topographic maps representing the distribution of Louisiana black bear in the state. Based upon these data, expert habitat information from LDWF biologists, and additional habitat and distribution information from the 1995 USFWS Louisiana Black Bear Recovery Plan, polygons representing occupied habitat for the Louisiana black bear were developed. The primary sources used to create polygons depicting Louisiana black bear habitat areas were: 1) the 1988 USGS Coastal Louisiana Habitat data; and 2) the 1997 LDWF Louisiana Coastal Marsh Vegetative Type data. The 1988 USGS Coastal Habitat data represent the actual habitat polygons used to create bear polygons. Habitats used in the development of this layer included forested wetlands, agricultural fields (mainly sugarcane), and certain marsh types adjacent to forested wetlands. Integration of the 1988 USGS and 1997 LDWF Marsh Type data was performed using a GIS overlay operation to reattribute the more spatially explicit USGS marsh polygons with marsh type values from the more recent 1997 LDWF marsh type data.

Small semi-aquatic, fur-bearing mammal areas with harvest density values by habitat zone are also shown on the maps. These species include nutria, muskrat, raccoon, mink, and river otter. The primary sources used to create polygons depicting small semi-aquatic, fur-bearing mammal areas were: 1) the 1988 USGS Coastal Louisiana Habitat data; 2) the 1997 LDWF Louisiana Coastal Marsh Vegetative Type data; and 3) the 2000 LOSCO Louisiana Parish Boundaries data. Polygons representing semi-aquatic fur-bearing mammal distributions and densities are based on habitat type "zones" comprised of land and adjacent water. Major habitat zones include fresh marsh, intermediate marsh, brackish marsh, salt marsh, and forested wetlands. The 1988 USGS Coastal Habitat data represent the actual wetland polygons used for this atlas. Integration of the 1988 USGS and 1997 LDWF Marsh Type data was performed using a GIS overlay operation to reattribute the more spatially explicit USGS marsh polygons with marsh type values from the more recent 1997 LDWF marsh type data. Wetland polygons adjacent to water features were buffered to create polygons that included small waterbodies and extended out into coastal lakes and bays by either 100 or 500 m depending on the location and the complexity of the shoreline. In addition, larger coastal lakes were either included or excluded from the semi-aquatic fur-bearing mammal polygons based on the expert opinion of LDWF wildlife biologists. Small (area <3 $km^2$) polygons of a particular marsh or other habitat type that were isolated in an upland area were excluded from the coverage. Similarly, small "inclusion" polygons of one wetland type occurring within another wetland type were dissolved into the surrounding "matrix" habitat type. Finally, physiographic province boundaries were used to further divide semi-aquatic fur-bearing mammal habitat polygons. LDWF fur harvest distribution data for coastal Louisiana from 1972-1985 were used to develop density values for semi-aquatic fur-bearing mammals in each combination of habitat zone (four marsh types, forested wetland areas) and physiographic province. Mean densities were recorded and were rounded to the nearest whole acre per individual. In addition to quantitative density, a categorical description of population status has been assigned to these species. This categorical description (HIGH/MED/LOW) was developed by LDWF biologists and indicates the relative population status by region and habitat of each species described. The LDWF survey effort did not include salt marsh. However, because semi-aquatic fur-bearing mammal are present in salt marsh, concentrations are listed as either 'TRANSIENT' or 'RESIDENT' for polygons representing this habitat type, depending on the behavior of each particular species.

Additional terrestrial mammal species (including rare bats) are included in this atlas as part of the LNHP Element Occurrence Record (EOR) database. See the above description of these data and their preparation for details. Note that the EOR database is continually updated and maintained by the LNHP. For the most up to date, specific, and complete version of this data set, please contact the Louisiana Natural Heritage Program at 225/765-2823.

Terrestrial mammal areas are shown on the maps as polygons with a brown-hatched pattern. A brown icon with a bear silhouette is used to indicate the presence of black bears and is associated with all polygons containing this species. A brown icon with a small mammal silhouette is used to indicate the presence of furbearing mammal species and is associated with all polygons containing these species.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column gives the species name. The next column provides an estimate of the concentration of the species at the site. The seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species is present at a location in a particular month, an “X” is placed in the month column.

Expert contacts are: Gary Lester (LNHP), 225/765-2823, and Greg Linscombe (LDWF), 337/373-0032, and Noel Kinler (LDWF), 337/373-0032.

### MARINE MAMMALS

No marine mammals are included in this atlas. Note that West Indian manatees may be found infrequently throughout the coastal waters of Louisiana.

### REPTILES

Reptiles depicted in this atlas primarily include the American alligator. Polygons represent American alligator habitats with nest density values by habitat zone and management unit. The primary sources used to create polygons depicting alligator habitat areas were: 1) the 1988 USGS Coastal Louisiana Habitat data; 2) the 1997 LDWF Louisiana Coastal Marsh Vegetative Type data; and 3) the 2000 USGS stewardship areas. Polygons representing alligator distributions and densities are based on a combination of habitat type "zones," comprised of land and adjacent water, and management unit boundaries. Major habitat zones include fresh marsh, intermediate marsh, brackish marsh, salt marsh, and forested wetlands. The 1988 USGS Coastal Habitat data represent the actual wetland polygons used for this atlas. Integration of the 1988 USGS and 1997 LDWF Marsh Type data was performed using a GIS overlay operation to reattribute the more spatially explicit USGS marsh polygons with marsh type values from the more recent 1997 LDWF marsh type data. Wetland polygons adjacent to water features were buffered to create polygons that included small waterbodies and extended out into coastal lakes and bays by either 100 or 500 m depending on the location and the complexity of the shoreline. In addition, larger coastal lakes were either included or excluded from the alligator polygons based on the expert opinion of LDWF wildlife biologists. Small (area <3 $km^2$) polygons of a particular marsh or other habitat type that were isolated in an upland area were excluded from the coverage. Similarly, small "inclusion" polygons of one wetland type occurring within another wetland type were dissolved into the surrounding "matrix" habitat

type. Management unit boundaries were used to further divide alligator habitat polygons. In addition, marsh impoundment areas inside some management units were digitized, creating an additional habitat type.

LDWF Alligator Nest Survey data from 1996-2000 were used to develop density values for alligators in each combination of habitat zone (four marsh types, forested wetland areas) and management unit. Nest density values for management units were given higher priority because sampling effort is greater in these areas and/or because theses areas are managed for wildlife, typically resulting in different nest densities than marsh areas in the surrounding parishes. Maximum mean nest densities were recorded as concentrations and rounded to the nearest whole acre per nest. In addition to quantitative density, a categorical description of population status has been assigned to these species. This categorical description was developed by LDWF biologists as follows: HIGH - less than 125 acres per nest; MEDIUM - between 125 and 250 acres per nest; and LOW - greater that 250 acres per nest. American alligators do not typically nest in salt marsh, and the LDWF survey effort did not include this habitat. However, because alligators are sometimes present in salt marsh, concentrations are listed as either 'TRANSIENT' or 'RESIDENT' for polygons representing this habitat type.

Additional reptile species (including sea turtles, aquatic turtles, and terrestrial turtles) are included in this atlas as part of the LNHP Element Occurrence Record (EOR) database. Although sea turtle nesting is a rare event in Louisiana, multiple species of sea turtles may be present in nearshore and onshore waters. See the above description of these data and their preparation for details. Note that the EOR database is continually updated and maintained by the LNHP. For the most up to date, specific, and complete version of this data set, please contact the Louisiana Natural Heritage Program at 225/765-2823.

Reptile areas are displayed on the maps as polygons with a red-hatched pattern. A red icon with an alligator silhouette is used to indicate the presence of alligators. This icon is associated with all polygons containing this species.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column gives the species name. The next column provides an estimate of the concentration of the species at the site. The seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species is present at a location in a particular month, an “X” is placed in the month column.

Expert contact for alligators is: Noel Kinler (LDWF), 337/373-0032.

### BIRDS

Birds included in this atlas are divided into subgroups based on taxonomy, morphology, behavior, and oil spill vulnerability and sensitivity. The species table lists all birds included on the maps, sorted by subgroup. These species are included either because of their likelihood of direct or indirect impact by an oil spill or similar incident, their general rarity or imperilment, or their special protection status as threatened or endangered.

The atlas includes colonial waterbird nesting colonies, waterfowl concentration areas, and shorebird critical habitat. Nesting sites are of particular concern due to high concentrations of birds in adjacent waters, contamination of eggs and young by oiled adults and prey, and the potential for disturbance from response activities.

*Colonial waterbird nesting sites* – Three sources of data were used to depict waterbird nesting colonies for this atlas: 1) the 1990-1999 LDWF Colonial Waterbird data set; 2) the 1997 LSU CCEER Seabird Colonies data set; and 3) selected waterbird colony records from the 2001 LNHP Element Occurrence Record (EOR) Database. The 1990-1999 LDWF data set was used as the primary source. These data included records for active seabird and wading bird nesting colonies for the eastern two-thirds (approximate) of coastal Louisiana. The western portion of the study area not covered by this source corresponded approximately to the following four USGS 1:100,000 topographic maps: Crowley, LA; Lake Charles, LA; Port Arthur, LA; and White Lake, LA. Records in the LDWF data set included the mean number of individuals for each species recorded at each colony during LDWF surveys between 1990 and 1999. These mean abundance values are included in this atlas. The 1997 LSU seabird colony data set covered the entire study area and was used to obtain seabird colony information for the western portion of the coastal zone that was not included in the LDWF data set (note that the LSU data covered seabirds only, not wading bird colonies). All seabird colonies from the LSU data set that were active for at least one year during 1990-1997 were included for the western portion of the study area. In addition, all colonies documented during LSU's 1997 field surveys that were not also recorded in the LDWF data set (colonies not identified or tracked by LDWF) were retained for the entire study area. All records from the LSU data set corresponding to colonies that were present in the LDWF data set were omitted from the layer described here. Records from the LSU data set included 1997 counts of individuals for each species occurring at each colony. These values were retained for the attribute tables associated with the layer described here. For the LSU data set, colonies active during 1990 or later that had no nests recorded during the 1997 field surveys were entered as "0" counts. Since colonies may be active in some years but not others, this does not imply that a colony site is no longer active or no longer present, or that the colony is small or unimportant. Finally, the 2001 LNHP data set was used to obtain wading bird colony locations for the western portion of the study area not covered by the LDWF data set. Only colonies that were active during or since 1990 were considered. For the LNHP data, counts of individuals or nests from the latest survey period were included.

*Migratory waterfowl concentration areas* – Polygons in this atlas represent waterfowl habitats with density values by marsh habitat zone and watershed, or by nearshore survey zone. Waterfowl in these data include several species of ducks and American coot. Geese were not part of the survey data available when this atlas was created, although migratory geese occur in the study area. Waterfowl represented in this dataset fall into two major groups: 1) marsh waterfowl distributions and peak monthly densities for multiple species (including lesser scaup); and 2) separate lesser scaup distributions and peak densities in nearshore Gulf of Mexico waters and coastal lakes and bays. The geographic area, habitat type, species, type of survey, and volume of survey data (number surveys, months surveyed, and years surveyed) differ substantially between these two groups.

The primary sources used to create polygons depicting marsh waterfowl habitat areas were: 1) the USGS 1988 Coastal Louisiana Habitat data; and 2) the 1997 LDWF Louisiana Coastal Marsh Vegetative Type Map data. For the marsh waterfowl polygons, LDWF Marsh Waterfowl Transect Survey data from 1988-1998 were used to develop density values for each species in each combination of habitat zone (four marsh types, selected agriculture areas), for each surveyed month. For all species, density values were rounded to the nearest whole individual per square mile. Mean monthly densities less than 0.5 were rounded to zero. For areas where the peak mean monthly density for a species was not sampled, concentrations were listed as 'PRESENT'. In cases where the peak mean monthly density was zero, concentrations were listed as 'PRESENT'. Because waterfowl are present in coastal Louisiana outside the months when surveys were conducted, seasonalities reflect when migratory concentrations (for most species) and major resident populations (mottled duck) are present in the study area.

Lesser scaup distributions and densities in nearshore Gulf of Mexico waters and coastal lakes and bays were developed from hardcopy maps depicting lesser scaup survey zones and transect lines which were distinct and separate from the more extensive marsh waterfowl transect surveys. Lesser scaup is the major diving duck species using nearshore Gulf waters and coastal lakes and bays, hence the separate survey effort and polygons depicting this species, in addition to the marsh waterfowl areas.

*Shorebird concentration areas* – Polygons in this atlas represent concentration areas and "hotspots" for migratory shorebird species. Nesting locations for certain resident species are also depicted. LDWF wildlife biologists identified areas considered important for migratory shorebirds based upon expert knowledge. The primary sources used to create polygons depicting migratory shorebird habitat areas were: 1) the USGS 1988 Coastal Louisiana Habitat data; 2) the 2001 Outer Coast Environmental Sensitivity Index (ESI) data; 3) the 2000 USGS managed lands boundaries; and 4) the 2001 mini-refuge boundaries. Both the 1988 USGS Coastal Habitat data and the 2001 ESI shoreline classification were used to delineate shorebird concentration areas. In some cases, polygons represent a 100 m buffer of the shoreline. Some coastal management areas were identified as concentration areas for migratory shorebirds. Mini-refuge boundaries, describing boundaries of private properties managed for shorebirds and waterfowl, were also used to delineate shorebird concentration areas. In addition, digitized marsh impoundment areas inside some management units were used to delineate shorebird concentration areas.

Additional bird species, including raptor-nesting sites, are included in this atlas as part of the LNHP Element Occurrence Record (EOR) database. See the above description of these data and their preparation for details. Because historical and inactive waterbird colony locations can become active, all records describing waterbird colonies were retained, regardless of the age of the record. The waterbird colony records from the LNHP EOR database and mapped as buffer polygons that were duplicated in the LDWF Colonial waterbird nesting colonies were deleted. Note that the EOR database is continually updated and maintained by the LNHP. For the most up to date, specific, and complete version of this data set,

please contact the Louisiana Natural Heritage Program at 225/765-2823.

Expert contacts are: Gary Lester (LNHP), 225/765-2823, Robert Helm (LDWF), and William Vermillion (LDWF).

Birds are shown on the maps as polygons with a green-hatched pattern. Waterbird nesting colonies are shown as green points. Users should be aware that waterfowl may be feeding and rafting in nearshore and offshore areas in the vicinity and up to several kilometers (km) away from their nests.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column contains the species common name. The second column indicates whether the species is listed as threatened (T), endangered (E), or special concern (C) on either the state (S) and/or federal (F) lists. The next column provides an estimate of the concentration of the species at the site. See the descriptions of the species groups mapped and the sources of data used (above) for information on how numeric concentration values and descriptive terms were generated. In some cases, concentration values have not been used if the information was not available. Note that concentration should not be interpreted as the "level of concern" or "importance" associated with a certain site or particular resource.

The seasonality for each species or resource is shown in the next twelve columns, corresponding to months of the year. If a species or resource is present at a location in a particular month, an "X" is placed in the month column. The last three columns denote the migratory, nesting, and molting time-periods for each species.

### Fish

Finfish depicted in this atlas include selected marine, estuarine, and freshwater species. Species of commercial, subsistence, recreational, ecological, and/or conservation interest are emphasized.

*Freshwater fish* – Polygons in this atlas represent waterbodies and other fish habitats with similar species composition and relative abundance summarized from groups of sampling stations and grouped by waterbody. LDWF fisheries biologists delineated representative waterbodies for each major group of sampling stations. In some cases, such as the Atchafalaya and Pearl River Basins, polygons represent both waterbodies and areas of regularly flooded wetlands. When these areas are flooded, fish species identified as present in waterbodies may be present in adjacent flooded habitats. The Mississippi and Atchafalaya Rivers were delineated as the boundary of the river itself as well as any connecting waterbody that fell within a 1 km buffer of the approximate centerline of the river. The primary source of data used to map inland fisheries for this atlas was the 1965-1997 LDWF inland fisheries sampling data set. In many locations, only electro-fishing was used to sample largemouth bass, a species of significant recreational importance. In some larger waterbodies, other gear, such as gillnets and rotenone sampling, was used, resulting in data for a larger variety of fish species. Gillnetting typically targets catfish, carp, drum, crappie, buffalo, gar, and bowfin. Rotenone typically results in data for the largest variety of species, including many smaller forage species. Data for each major waterbody were applied to the waterbody polygon delineated by LDWF fisheries biologists. A categorical description of the abundance values calculated by LDWF fisheries biologists was recorded as concentration. For largemouth bass, data from 1987 to 1997 were combined to derive average catch rates. For species sampled with rotenone or other gear, all data from 1965 to 1997 were combined to derive average catch rates. Categorical descriptors of relative abundance values for each species are based on percentile breaks in catch rates for that species, across waterbodies sampled in Louisiana, including waterbodies outside this atlas. In some cases, species were identified as present in certain waterbodies without a relative concentration. These species were assigned a concentration of 'PRESENT'. Note that all species identified as present in the Mississippi and Atchafalaya Rivers were not sampled and are based on expert knowledge. These species were assigned a concentration of 'PRESENT'. Many inland freshwater areas in coastal Louisiana are not sampled by the LDWF. Though not documented in this atlas, species such as catfish, carp, minnow and silverside are typically present in these areas.

*Marine/estuarine fish* – Polygons for marine/estuarine fish were obtained from NOAA Estuarine Living Marine Resources (ELMR) fish data. The ELMR data contained polygons of identified groups of fish based on the seasonality and salinity regime. The ELMR data were generalized to combine all regions that had the same species composition, regardless of lifestage and concentration, into one region. The variability was usually +/- 2 months on the seasonality information. The maximum relative abundance and sum of the seasonal range were used in creating the generalized distributions. Relative abundances are listed by month in the BREED data table. For each month where an ELMR species is present, a number code indicates the species abundance (1 = no information, 2 = rare, 3 = common, 4 = abundant, 5 = highly abundant). The maximum abundance during the year is shown. The ELMR abundance codes usually refer to juvenile life stages, even though other life stages may be present. If juveniles are not present, the abundances refer to adults, or to larvae if adults and juveniles are not present. Various life-history stages or activities associated with the ELMR fish data include: spawning (parturition for sharks); eggs; larvae; juveniles; and adults.

To prevent conflict with the LDWF Inland fisheries data, duplicate species in the ELMR dataset were removed.

Additional freshwater and marine/estuarine fish species are included in this atlas as part of the LNHP Element Occurrence Record (EOR) database. See the above description of these data and their preparation for details. Note that the EOR database is continually updated and maintained by the LNHP. For the most up to date, specific, and complete version of this data set, please contact the Louisiana Natural Heritage Program at 225/765-2823.

The resource experts listed below should be contacted for additional information on any of these or other finfish species that may occur in the area. Expert contacts are: Inland Fisheries Department (LDWF), 225/765-2330 and for ELMR Mark Monaco (NOAA), 301/713-3000.

Fish are shown on the maps as polygons with a blue-hatched pattern. In cases where multiple resource types occupy the same polygon (such as fish and invertebrates), a black-hatched, multi-group pattern is used rather than a blue-hatched polygon. A blue icon with a fish silhouette is used to indicate the presence of fish. This icon is associated with all polygons containing fish.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column contains the species common name. The second column indicates whether the species is listed as threatened (T), endangered (E), or special concern (C) on either the state (S) and/or federal (F) lists. The next column provides an estimate of the concentration of the species at the site. Concentration values were not used for fish because concentration is often quite variable from year to year or not well known.

Seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species or resource is present at a location in a particular month, an "X" is placed in the month column. If the species is from ELMR data then a value of 1-5 is placed in the month column to indicate relative abundance. The last columns denote different life-history time-periods for fish including spawning, eggs, larvae, juveniles, and adults.

### Invertebrates

Invertebrates depicted in this atlas include crawfish and freshwater shrimp, which are species of commercial interest. Distribution and density information were derived from the 1965-1997 LDWF inland fisheries sampling data set used to map freshwater fish.

Polygons for marine/estuarine invertebrates were obtained from NOAA ELMR invertebrate data. The ELMR data contained polygons of identified groups of invertebrates based on the seasonality and salinity regime. The ELMR data were generalized to combine all regions that had the same species composition, regardless of life-history stage and concentration, into one region. The variability was usually +/- 2 months on the seasonality information. The maximum relative abundance and sum of the seasonal range were used in creating the generalized distributions. Relative abundances are listed by month in the BREED data table. For each month where an ELMR species is present, a number code indicates the species abundance (1 = no information, 2 = rare, 3 = common, 4 = abundant, 5 = highly abundant). The maximum abundance during the year is shown. The ELMR abundance codes usually refer to juvenile life stages, even though other life stages may be present. If juveniles are not present, the abundances refer to adults, or to larvae if adults and juveniles are not present. Various life-history stages or activities associated with the ELMR invertebrate data include: spawning; eggs; larvae; juveniles; and adults. Expert contacts are: Inland Fisheries Department (LDWF), 225/765-2330 and for ELMR Mark Monaco (NOAA), 301/713-3000.

Additional invertebrate species may be included in this atlas as part of the LNHP Element Occurrence Record (EOR) database. See the above description of these data and their preparation for details. Note that the EOR database is continually updated and maintained by the LNHP. For the most up to date, specific, and complete version of this data set, please contact the Louisiana Natural Heritage Program at 225/765-2823.

Invertebrates are shown on the maps as polygons with an orange-hatched pattern. An orange icon with a crab or bivalve silhouette is used to indicate the presence of these species. This icon

is associated with all polygons or point features containing invertebrates.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column contains the species common name. The second column indicates whether the species is listed as threatened (T), endangered (E), or special concern (C) on either the state (S) and/or federal (F) lists. The next column provides an estimate of the concentration of the species at the site. Concentration values were not used for invertebrates because concentration is often quite variable from year to year or not well known.

The seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species or resource is present at a location in a particular month, an "X" is placed in the month column. If the species is from ELMR data then a value of 1-5 is placed in the month column to indicate relative abundance. The last columns denote different life-history time-periods for invertebrates including spawning, eggs, larvae, juveniles, and adults.

### BENTHIC AND WETLAND MARINE HABITATS

Three primary sources of data were used to map benthic and wetland habitats for this atlas: 1) 1988 USGS Coastal Louisiana Habitat data; 2) 1997 LDWF Louisiana Coastal Marsh Vegetative Type data; and 3) 1992 USGS Submerged Aquatic Vegetation data. Data for habitat types, particularly marsh types (saline, brackish, intermediate, and fresh), are critical to the entire Louisiana ESI atlas, in that most of the other biological data sets are based fully or in part on wetland habitats. The 1988 USGS Coastal Habitat data represent the actual wetland polygons used for this atlas. Integration of the 1988 USGS Coastal Habitat and 1997 LDWF Marsh Type data was performed using a GIS overlay operation to reattribute the more spatially explicit USGS marsh polygons with marsh type values from the more recent 1997 LDWF Marsh Type data.

In addition to the four marsh types, other habitats from the USGS data used in this atlas include forested wetlands, scrub-shrub wetlands, mangroves, and seagrasses. The 1992 USGS Submerged Aquatic Vegetation data were used to delineate seagrass beds in the Chandeleur Islands. Polygons representing seagrass beds from both the 1992 USGS data set and the 1988 USGS data set were merged to develop polygons representing seagrass in this data layer.

In summary, the wetland habitats added to the maps from the integration of USGS and LDWF data are listed below with their corresponding ESI shoreline code. (Also see legend for patterns shown on the maps).

| | |
|---|---|
| 10A) Salt Marsh | 10B) Freshwater Marsh |
| 10A) Brackish Marsh | 10C) Forested Wetland |
| 10A) Intermediate Marsh | 10D) Scrub-Shrub Wetland (including black mangroves) |
| | Seagrass (no ESI code) |

Additional habitats and community occurrences may be included in this atlas as part of the LNHP Element Occurrence Record (EOR) database. See the above description of these data and their preparation for details. Note that all occurrences of seagrass and mangrove habitat occurrences were removed from the EOR database. The EOR database is continually updated and maintained by the LNHP. For the most up to date, specific, and complete version of this data set, please contact the Louisiana Natural Heritage Program at 225/765-2823.

Rare plants are shown on the maps as polygons with a purple-hatched pattern. A purple icon with a plant silhouette is used to indicate the presence of these species. This icon is associated with all polygons or point features containing rare plants.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column contains the species common name. The second column indicates whether the species is listed as threatened (T), endangered (E), or special concern (C) on either the state (S) and/or federal (F) lists. The next column provides an estimate of the concentration of the species at the site. Concentration values were not used for plants because concentration is not available.

## HUMAN-USE RESOURCES

Most human-use resources in this atlas are mapped as point features, indicated by a black and white icon (see legend). Management areas such as wildlife refuges, national parks, and scenic rivers, are mapped as polygons, with the boundaries indicated as a black dot-dash line with the corresponding icon placed near the center of the polygon. Where the feature is a known point location (e.g., airport), the exact location is shown as a small black dot and a leader line is drawn from it to the icon. The types of human-use features included in the atlas are described below:

| | |
|---|---|
| Airport / Heliport | National Park / Nature Conservancy |
| Boat Ramp | Scenic River |
| Indian Reservation | State Park |
| Marina | Wildlife Refuge |

**Airports/Heliport:** Locations of airports, airfields, landing strips, helipads etc., whether they are manned or unmanned, are shown as point features.

**Boat Ramps:** Locations of boat ramps, improved and unimproved, are shown as point features.

**Indian Reservations:** Tribal lands are depicted using dashed lines to indicate site boundaries. Site names are provided on the data tables for each map.

**Marinas:** Locations of marinas are shown as point features.

**National Parks:** Areas managed by the National Park Service are depicted using dashed lines to indicate site boundaries. Site names are provided on the data tables for each map.

**Nature Conservancy Preserves:** Areas managed by the Nature Conservancy are depicted using dashed lines to indicate site boundaries. Site names are provided on the data tables for each map.

**Scenic Rivers:** National Wild and Scenic Rivers are depicted using dashed lines to indicate designation boundaries.

**State Parks:** Areas managed by state and local authorities are depicted using dashed lines to indicate site boundaries. Site names are provided on the data tables for each map.

**Wildlife Refuges:** Areas managed by the USFWS as National Wildlife Refuges and Wilderness Areas are depicted using dashed lines to indicate site boundaries. Site names are provided on the data tables for each map.

## GEOGRAPHIC INFORMATION SYSTEM

The entire atlas product is stored in digital form in a Geographic Information System (GIS) as spatial data layers and associated databases. Format for the data varies depending on the type of information or features for which the data are being stored.

Under separate cover is a metadata document that details the data dictionary, processing techniques, data lineage, and other descriptive information for the digital data sets and maps that were used to create this atlas. Below is a brief synopsis of the information contained in the digital version. Refer to the metadata file for a full explanation of the data and its structure.

### SHORELINE CLASSIFICATIONS

The ESI shoreline habitat classification is stored as lines and polygons with associated attributes. In many cases, a shoreline may have two or three different classifications. These multiple classifications are represented on the maps by double and triple line patterns and in the database by ESI#1/ESI#2, where ESI#1 is the landward-most classification and ESI#2 is the seaward-most classification. In addition to the line features, exposed wave-cut platforms (ESI = 2A) and tidal flats (ESI = 7, ESI = 9A) are also stored as polygons.

### SENSITIVE BIOLOGICAL RESOURCES

Biological resources are stored as polygons, points, or arcs. Associated with each feature is a unique identification number that is linked to a series of data tables that further identify the resources. The main biological resource table consists of a list of species identification numbers for each site, the concentration of each species at each site, and identification codes for seasonality and source information. This data table is linked to other tables that describe the seasonality and life-history time-periods for each species (at month resolution) for the specified map feature. Other data tables linked to the first table include: the species identification table, that includes common and scientific names; the species status table, that gives information for state and/or federal threatened or endangered listings; and the source database, that provides source metadata at the feature-species level (specific sources are listed for each species occurring at each mapped feature in the biology coverages).

### HUMAN-USE FEATURES

Human-use features are represented as lines, points, or polygons. The resource name, the owner/manager, a contact person, and phone number are included in the database for management areas when available. All metadata sources are documented at the feature level.

## REFERENCES

The major hardcopy reference materials used in this project are listed below. In some instances, reference materials were not directly used as source materials, but were instead used or interpreted by scientists or resource managers who provided expert knowledge or personal communication for the resources depicted in the atlas.


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At Research Planning, Inc., Scott Zengel was the LA G-WIS Project Manager. Colin Plank and Miles Hayes performed the shoreline classification. William Holton was responsible for atlas production. Zach Nixon was the GIS Coordinator. Jeff Dahlin, Jon Whitlock, Chris Locke, and Jennifer Rainman performed data processing under the direction of Mark White, GIS Manager. Vermell Simon prepared the final metadata. Joe Holmes provided cartographic design, text, and graphics production.


## APPROPRIATE USE OF ATLAS AND DATA

This atlas and the associated database were developed to provide summary information on sensitive natural and human-use resources for the purposes of oil and chemical spill planning and response. Although the atlas and database should be very useful for other environmental and natural resource planning purposes, it should not be used in place of data held by the USFWS, NPS, USGS, LDWF, NMFS, or other agencies. Likewise, information contained in the atlas and database cannot be used in place of consultations with natural and cultural resource agencies, or in place of field surveys. Also, this atlas should not be used for navigation.

# SPECIES LIST

| Common Name | * Species Name |
|---|---|
| **BIRDS** | |
| **DIVING BIRDS** | |
| Anhinga | *Anhinga anhinga* |
| Brown pelican | *Pelecanus occidentalis* |
| Neotropic cormorant | *Phalacrocorax brasilianus* |
| **GULLS AND TERNS** | |
| Black skimmer | *Rynchops niger* |
| Caspian tern | *Sterna caspia* |
| Colonial waterbirds | - |
| Endangered seabird | - |
| Forster's tern | *Sterna forsteri* |
| Gull-billed tern | *Sterna nilotica* |
| Laughing gull | *Larus atricilla* |
| Least tern | *Sterna antillarum* |
| Rare seabird | - |
| Royal tern | *Sterna maxima* |
| Sandwich tern | *Sterna sandvicensis* |
| **PASSERINE BIRDS** | |
| Endangered passerine-like bird | - |
| Rare passerine-like bird | - |
| Raptors | - |
| Rare raptor | - |
| Threatened raptor | - |
| **SHOREBIRDS** | |
| Piping plover | *Charadrius melodus* |
| Rare shorebird | - |
| Shorebirds | - |
| Snowy plover | *Charadrius alexandrinus* |
| Threatened shorebird | - |
| Wilson's plover | *Charadrius wilsonia* |
| **WADING BIRDS** | |
| Black-crowned night-heron | *Nycticorax nycticorax* |
| Cattle egret | *Bubulcus ibis* |
| Great blue heron | *Ardea herodias* |
| Great egret | *Ardea alba* |
| Little blue heron | *Egretta caerulea* |
| Rare wading bird | - |
| Reddish egret | *Egretta rufescens* |
| Roseate spoonbill | *Ajaia ajaja* |
| Snowy egret | *Egretta thula* |
| Tricolored heron | *Egretta tricolor* |
| White ibis | *Eudocimus albus* |
| White-faced or Glossy ibis | *Plegadis spp.* |
| Yellow-crowned night-heron | *Nyctanassa violacea* |
| **WATERFOWL** | |
| American coot | *Fulica americana* |
| American wigeon | *Anas americana* |
| Blue-winged teal | *Anas discors* |
| Canvasback | *Aythya valisineria* |
| Gadwall | *Anas strepera* |
| Green-winged teal | *Anas crecca* |
| Hooded merganser | *Lophodytes cucullatus* |
| Lesser scaup | *Aythya affinis* |
| Mallard | *Anas platyrhynchos* |
| Mottled duck | *Anas fulvigula* |
| Northern pintail | *Anas acuta* |
| Northern shoveler | *Anas clypeata* |
| Ring-necked duck | *Aythya collaris* |
| **FISH** | |
| **FISH** | |
| Endangered fish | - |
| Rare fish | - |
| Threatened fish | - |
| Diadromous fish | - |
| American eel | *Anguilla rostrata* |
| Gizzard shad | *Dorosoma cepedianum* |
| Gulf sturgeon | *Acipenser oxyrinchus desotoi* |
| Hybrid striped bass | *Morone sp.* |
| Skipjack herring | *Alosa chrysochloris* |
| Striped bass | *Morone saxatilis* |
| Estuarine nursery fish | - |
| Atlantic croaker | *Micropogonias undulatus* |
| Bay anchovy | *Anchoa mitchilli* |
| Black drum | *Pogonias cromis* |
| Gray snapper | *Lutjanus griseus* |
| Gulf menhaden | *Brevoortia patronus* |
| Hogchoker | *Trinectes maculatus* |
| Ladyfish | *Elops saurus* |
| Red drum | *Sciaenops ocellatus* |
| Sand seatrout | *Cynoscion arenarius* |
| Sheepshead | *Archosargus probatocephalus* |
| Southern flounder | *Paralichthys lethostigma* |
| Spot | *Leiostomus xanthurus* |
| Spotted seatrout | *Cynoscion nebulosus* |
| Striped mullet | *Mugil cephalus* |
| Tarpon | *Megalops atlanticus* |

| Common Name | * Species Name |
|---|---|
| **FISH cont.** | |
| Estuarine resident fish | - |
| Gulf pipefish | *Syngnathus scovelli* |
| Inland silverside | *Menidia beryllina* |
| Lined sole | *Achirus lineatus* |
| Roughtail stingray | *Dasyatis centroura* |
| Silver perch | *Bairdiella chrysoura* |
| Violet goby | *Gobioides broussoneti* |
| Freshwater fish | - |
| Alligator gar | *Lepisosteus spatula* |
| Bantam sunfish | *Lepomis symmetricus* |
| Bighead carp | *Hypopthalmichthys nobilis* |
| Bigmouth buffalo | *Ictiobus cyprinellus* |
| Black buffalo | *Ictiobus niger* |
| Black bullhead | *Ameiurus melas* |
| Black crappie | *Pomoxis nigromaculatus* |
| Blue catfish | *Ictalurus furcatus* |
| Blue sucker | *Cycleptus elongatus* |
| Bluegill | *Lepomis macrochirus* |
| Bowfin | *Amia calva* |
| Catfish | - |
| Channel catfish | *Ictalurus punctatus* |
| Chubsucker | *Erimyzon sp.* |
| Common carp | *Cyprinus carpio* |
| Darters | - |
| Flathead catfish | *Pylodictis olivaris* |
| Flier | *Centrarchus macropterus* |
| Freshwater drum | *Aplodinotus grunnieus* |
| Golden shiner | *Notemigonus crysoleucas* |
| Goldfish | *Carassius auratus* |
| Grass carp | *Ctenopharyngodon idella* |
| Green sunfish | *Lepomis cyanellus* |
| Hybrid sunfish | *Lepomis spp.* |
| Largemouth bass | *Micropterus salmoides* |
| Logperch | *Percina caprodes* |
| Longear sunfish | *Lepomis megalotis* |
| Longnose gar | *Lepisosteus osseus* |
| Madtoms | *Noturus spp.* |
| Minnows | - |
| Orangespotted sunfish | *Lepomis humilis* |
| Paddlefish | *Polyodon spathula* |
| Pirate perch | *Aphredoderus sayanus* |
| Quillback | *Carpiodes cyprinus* |
| Redear sunfish | *Lepomis microlophus* |
| River carpsucker | *Carpiodes carpio* |
| Shiners | *Notropis spp.* |
| Shortnose gar | *Lepisosteus platostomus* |
| Shovelnose sturgeon | *Scaphirhynchus platorynchus* |
| Silver carp | *Hypopthalmichthys molitrix* |
| Smallmouth buffalo | *Ictiobus bubalus* |
| Spotted bass | *Micropterus punctulatus* |
| Spotted gar | *Lepisosteus oculatus* |
| Spotted sucker | *Minytrema melanops* |
| Spotted sunfish | *Lepomis punctatus* |
| Threadfin shad | *Dorosoma petenense* |
| Warmouth | *Lepomis gulosus* |
| White bass | *Morone chrysops* |
| White crappie | *Pomoxis annularis* |
| Yellow bass | *Morone mississippiensis* |
| Yellow bullhead | *Ameiurus natalis* |
| Marine Benthic | - |
| Bay whiff | *Citharichthys spilopterus* |
| Florida pompano | *Trachinotus carolinus* |
| Fringed flounder | *Etropus crossotus* |
| Gobies | - |
| Speckled worm eel | *Myrophis punctatus* |
| Marine pelagic fish | - |
| Atlantic needlefish | *Strongylura marina* |
| Crevalle jack | *Caranx hippos* |
| Spanish mackerel | *Scomberomorus maculatus* |
| **HABITAT** | |
| **PLANTS** | |
| Endangered plant | - |
| Rare plant | - |
| Seagrass | - |
| Submersed aquatic vegetation | - |
| Upland | - |
| Coastal dune grassland | - |
| Coastal dune scrub thicket | - |
| Coastal live oak-hackberry forest | - |
| Coastal prairie | - |
| Hardwood slope forest | - |
| Live oak forest | - |
| Longleaf pine savannah | - |
| Pine flatwoods | - |
| Pine savannah | - |

*** Threatened and endangered species are designated by underlining.**

| Common Name | * Species Name |
|---|---|

## HABITAT cont.

| | |
|---|---|
| **PLANTS cont.** | |
| Prairie terrace loess forest | - |
| Salt dome | - |
| Slash pine/post oak forest | - |
| Spruce pine-hardwood mesic flatwood | - |
| Wetland | - |
| Brackish marsh | - |
| Forested wetland | - |
| Freshwater marsh | - |
| Intermediate marsh | - |
| Salt marsh | - |
| Scrub-shrub wetland, including black mangroves | - |
| Slash pine-cypress/hardwood forest | - |

## INVERTEBRATES

| | |
|---|---|
| **BIVALVES** | |
| Rare freshwater mussel | - |
| Threatened freshwater mussel | - |
| **CEPHALOPOD** | |
| Bay squid | *Lolliguncula brevis* |
| **CRABS** | |
| Blue crab | *Callinectes sapidus* |
| Gulf stone crab | *Menippe adina* |
| **CRAYFISH** | |
| Rare crayfish | - |
| Red swamp crawfish | *Procambarus clarkii* |
| White river crawfish | *Procambarus acutus* |
| **INSECTS** | |
| Rare insect | - |
| **SHRIMP** | |
| Brown shrimp | *Penaeus aztecus* |
| Florida stone crab | *Menippe mercenaria* |
| Pink shrimp | *Penaeus duorarum* |
| River shrimp | *Macrobrachium sp.* |
| White shrimp | *Penaeus setiferus* |

## REPTILES

| | |
|---|---|
| **ALLIGATORS** | |
| American alligator | *Alligator mississippiensis* |
| **OTHER REPTILES/AMPHIBIANS** | |
| Rare amphibian | - |
| Rare lizard | - |
| Rare snake | - |
| **TURTLES** | |
| Rare terrestrial/aquatic turtle | - |
| Threatened aquatic turtle | - |
| Threatened sea turtle | - |

## TERRESTRIAL MAMMALS

| | |
|---|---|
| **BATS** | |
| Rare bat | - |
| **BEARS** | |
| Louisiana black bear | *Ursus americanus luteolus* |
| Threatened bear | - |
| **SMALL MAMMALS** | |
| Common raccoon | *Procyon lotor* |
| Mink | *Mustela vison* |
| Muskrat | *Ondatra zibethicus* |
| Northern river otter | *Lutra canadensis* |
| Nutria | *Myocastor coypus* |
| Rare small mammal | - |

*** Threatened and endangered species are designated by underlining.**

# SHORELINE DESCRIPTIONS

**EXPOSED, SOLID MAN-MADE STRUCTURES** **ESI = 1B**

DESCRIPTION

- Typically composed of concrete or metal bulkheads
- Organisms, such as barnacles and algae, may be common on the lower levels, whereas biota along the upper intertidal zone are sparse
- Attached organisms are hardy and accustomed to strong hydraulic impacts and pressures
- Found only in small areas usually on the barrier islands to provide protection to residential and industrial developments where these structures are threatened by beach erosion

PREDICTED OIL BEHAVIOR

- Much of the oil will be held offshore by wave reflection
- Oil could percolate between the joints of the structures
- Under heavy accumulations, oil may coat the intertidal area and biota present would be impacted

RESPONSE CONSIDERATIONS

- High-pressure spraying may be required in order to:
  - remove oil
  - prepare substrate for re-colonization of epifaunal communities
  - minimize aesthetic damage
  - prevent the chronic leaching of oil from the structure

**EXPOSED WAVE-CUT PLATFORMS IN CLAY** **ESI = 2A**
**EXPOSED SCARPS AND STEEP SLOPES IN CLAY** **ESI = 2B**

DESCRIPTION

- Regular exposure to high wave energy, with strong wave reflection patterns
- Intertidal zone is a flat muddy bench of variable width
- The mud may incorporate a high percentage of organic material and root masses from older salt marsh vegetation
- May be backed by a shell berm (considered a gravel beach)
- Substrate is relatively impermeable though potential for deep subsurface penetration exists where burrowed by organisms or where root cavities are exposed
- Surface is irregular and tidal pools may be present
- Small accumulations of gravel or shells can be found in the tidal pools and crevices in the platform
- May support large populations of encrusting animals and plants, with rich tidal pool communities
- Common throughout the more exposed shorelines of the delta

PREDICTED OIL BEHAVIOR

- Oil will not adhere to the muddy substrate, but rather be transported across the platform and accumulate along the high-tide line, where it can penetrate in beach sediments, if present. Oil may also adhere to any relict plant material (root masses, etc.)
- Persistence of oiled sediments is usually short-term, except in burrows or larger sediment accumulations at the landward edge of the platform, where oil can persist for up to several weeks to months
- Biological impacts can be immediate and severe, particularly if fresh oil slicks cover tidal pool communities or penetrate burrows
- Where oil penetrates burrows it can be expected to persist in relatively unweathered condition for long periods of time

RESPONSE CONSIDERATIONS

- Cleanup is usually not required, because oil is quickly removed by wave action
- Access may be difficult and dangerous; minimize trampling to avoid increased penetration
- Where the high-tide area is accessible, it may be feasible to remove heavy oil accumulations and oiled debris in areas of high recreational use or in order to protect a nearshore marine resource, such as marine birds

**FINE- TO MEDIUM-GRAINED SAND BEACHES** **ESI = 3A**
**SCARPS AND STEEP SLOPES IN SAND** **ESI = 3B**

DESCRIPTION

- Generally flat, wide, and hard-packed
- Rate of sediment mobility is relatively low, thus rapid, dramatic changes in the beach profile are not common
- Surface sediments subject to regular reworking by waves
- Beach fauna can vary in type and density; mobile surface, burrowing, and interstitial forms are typical
- Shorebird nests, eggs, and hatchlings can be expected on nearly all outer coast sand beaches
- Extensive fine- to medium-grained sand beaches are found on the barrier islands of the outer coast

PREDICTED OIL BEHAVIOR

- Light oil accumulations are deposited as oily swashes or bands along the upper intertidal zone
- Heavy oil accumulations, can cover entire beach surface; the oil will be lifted off the lower beach with the rising tide

- Maximum penetration of oil is about 10 cm into fine-grained sand and 15 cm into medium-grained sand
- Burial of oiled layers by clean sand can occur within hours on these microtidal beaches, but the maximum burial will typically occur along the upper beach face to depths less than 30 cm
- Organisms living in the beach may be killed by smothering or lethal oil concentrations in interstitial water
- There can be direct and indirect impacts to bird nests, eggs, and hatchlings

RESPONSE CONSIDERATIONS

- The easiest beach type to clean, because hard substrate can support vehicular and foot traffic and depths of oil burial and penetration are minimal
- After all oil has come ashore, cleanup activities should concentrate on the removal of oil from the upper swash zone
- Vehicular traffic and walking through oiled areas and dunes should be limited to prevent contamination of clean areas and disturbance of dune vegetation
- Vehicular and foot traffic, and mechanical or manual beach cleanup, should be carefully planned and monitored in shorebird nesting areas to avoid disturbance and destruction of nests, eggs, and young
- Manual cleanup, rather than road graders and front-end loaders, is advised where feasible to minimize the volume of sand removed from the shore
- Prevent the mixture of oil deeper into the sediments by vehicular and foot traffic

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**COARSE-GRAINED SAND BEACHES** **ESI = 4**

DESCRIPTION

- Moderate to steep beachface slopes. Sediments are soft and permeable with low trafficability
- The rate of sediment mobility is relatively high, with the vertical accumulation of up to 20 cm of sediments possible within a single tidal cycle
- Beach fauna can vary in type and density; mobile surface, burrowing, and interstitial forms are typical
- Not quite as common as fine-to-medium grained sand beaches, they are found on transgressive portions of the barrier islands, usually grading into mixed sand and gravel beaches
- In places, they occur at the upper intertidal zone on wave-cut platforms

PREDICTED OIL BEHAVIOR

- During small spills, oil may be deposited primarily as a band along the high-tide line
- Under very heavy accumulations, oil may spread across the entire intertidal zone, though it will be lifted off the lower part of the beach during the rising tide
- Penetration up to 25 cm possible
- Burial of oiled layers by clean sand can be rapid, to depths of 1 m or more if the oil comes ashore at the start of a depositional period
- Organisms living in the beach may be killed by smothering or lethal oil concentrations in interstitial water
- There can be direct and indirect impacts to bird nests, eggs, and hatchlings

RESPONSE CONSIDERATIONS

- Cleanup is more difficult than for finer-grained beaches because equipment tends to grind oil into the substrate due to the loosely packed and permeable nature of these coarser-grained sediments; therefore, special care must be exercised at all times while using heavy equipment in order to prevent mixing oil deeper into the beach sediment

- Use of heavy equipment for oil/sand removal may also result in the removal of excessive amounts of sand; therefore, where feasible and for smaller amounts of oil, manual cleanup may be desirable
- Vehicular traffic and walking through oiled areas and dunes should be limited, to prevent contamination of clean areas and disturbance of dune vegetation
- Vehicular and foot traffic, and mechanical or manual beach cleanup, should be carefully planned and monitored in shorebird nesting areas to avoid disturbance and destruction of nests, eggs, and young
- Removal of sediment should be limited as much as possible to avoid erosion problems on the beach in the future; however, the common occurrence of multiple buried oil layers in these types of beaches increases the amount of sediment to be handled and disposed of
- Mechanical reworking of the sand into the surf zone (surf washing) may be used under optimal conditions as a polishing step for lightly oiled sediments without sediment removal

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**MIXED SAND AND GRAVEL BEACHES** **ESI = 5**

DESCRIPTION

- Moderately sloping beach composed of a mixture of sand and at least 20 percent gravel
- Soft sediments with low trafficability
- Sediment mobility is very high during storms, but considerably less than sand beaches during normal conditions
- Spatial variations in the distribution of grain sizes may be significant, with separate zones of pure sand, pebbles, or cobbles, in addition to the mixed zones
- Gravel can be composed of a variety of materials, including shells and other calcium carbonate materials
- Substrate has medium-to-high permeability
- Beach fauna can vary in type and density; mobile surface, burrowing, and interstitial forms are typical
- Though relatively uncommon they are found where the barrier islands are undergoing long-term erosion and as berms perched at the landward edge of mud platforms

PREDICTED OIL BEHAVIOR

- During small spills, oil may be deposited along the high-tide swash line
- During large spills, oil may be spread across the entire intertidal area
- Oil penetration into the beach sediments may be up to 50 cm; however, the sand fraction can be quite mobile, and if the sand fraction exceeds about 40 percent, oil behavior is similar to that described for sand beaches
- Significant amounts of oil can be eroded away during storms
- Burial of oil may be deep (up to 1 m) if oil comes ashore while the beach is recovering from storm conditions
- Organisms living in the beach may be killed by smothering or lethal oil concentrations in interstitial water

RESPONSE CONSIDERATIONS

- Remove heavy accumulations of pooled oil as quickly as possible
- All oiled debris should be removed
- Vehicular traffic and walking through oiled areas should be limited, to prevent contamination of clean areas
- Vehicular and foot traffic, and mechanical or manual beach cleanup, should be carefully planned and monitored in shorebird nesting areas to avoid disturbance and destruction of nests, eggs, and young
- Mechanical reworking of oiled sediments from the high-tide zone to the upper intertidal zone for wave reworking (berm relocation) can be effective in areas subject to significant wave action
- In-place tilling may be used to expose deeply buried oil layers to wave reworking in areas subject to significant wave action
- In-place Mechanical reworking of the sediments into the surf zone (surf washing) may be used under optimal conditions as a polishing step for lightly oiled sediments without sediment removal

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**GRAVEL BEACHES** **ESI = 6A**

DESCRIPTION

- Composed of sediments larger than 2 mm (granules, pebbles, cobbles and boulders) made up of shell fragments
- Most permeable of all beach sediments
- Lowest trafficability of all beach types
- Slope is intermediate to steep with multiple, wave-built berms and washovers usually forming the upper beach (see arrow)
- Sediment replenishment rates are lowest of all beach types
- Attached animals and plants are usually restricted to lowest parts of the beach, where the sediments are less mobile
- Common throughout the delta as perched berms and washovers atop wave-cut mud scarps

PREDICTED OIL BEHAVIOR

- Deep penetration and rapid burial of stranded oil is likely; penetration of tens of cm (over 1 m possible) can extend oil to depths below where it cannot be reworked by any natural process except extreme storms
- Therefore, long-term persistence will be controlled by the depth of penetration versus the depth of routine reworking by storm waves
- Oil may be carried over the normal high-tide line and storm berms during high-water events, where it can pool and persist above the normal zone of wave wash
- In more sheltered areas, formation of asphalt pavements is likely if oil accumulations are heavy

RESPONSE CONSIDERATIONS

- Because of the low trafficability, the rapid rates of burial, and deep penetration of the oil, this is the most difficult of all the beach types to clean

- Sediment removal should be limited as much as possible, because of potential beach erosion problems in the future
- Low-pressure flushing can be used to remove heavy oil where collection of the flushed oil is feasible, but high-pressure flushing should be avoided since the shell fragments are likely to be blown away by the water pressure

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**RIPRAP** **ESI = 6B**

DESCRIPTION

- Composed of cobble- to boulder-sized rock fragments
- Used for shoreline protection and inlet stabilization
- Attached low-intertidal zone biota may be plentiful and varied
- Relatively common in all the developed areas of the barrier islands and in small amounts associated with industrial sites

PREDICTED OIL BEHAVIOR

- Oil can penetrate deeply into the highly permeable riprap
- Oil adheres readily to the rough rock surfaces
- If left uncleaned, oil may cause chronic leaching (weeks to months) until it hardens
- Resident fauna and flora may be killed by the oil

RESPONSE CONSIDERATIONS

- Flushing can be effective for removing mobile oil, but large amounts of residue can remain after flushing, particularly for heavy oil

**EXPOSED TIDAL FLATS** **ESI = 7**

DESCRIPTION

- Flat intertidal areas, composed primarily of sand and mud, that vary in width from a few to hundreds of meters
- The presence of sand indicates that tidal or wind-driven currents and waves are strong enough to mobilize the sediments
- Usually associated with another shoreline type on the landward side of the flat
- Sediments usually remain water-saturated, with only the topographically higher ridges drying out during low tide
- Sediments are generally too soft for vehicular traffic
- Biological utilization can be very high, with large numbers of infauna and heavy use by birds for roosting and foraging
- Common in the study area, associated with inlets and washovers of barrier islands and the chenier west of the deltas

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of exposed tidal flats, but rather moves across the flat and accumulates at the high-tide line
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy
- Oil does not typically penetrate these water-saturated sediments, except on the top of sand bars and into animal burrows if they dry out at low tide; thus, oil penetration is limited to a maximum of a few cm
- Because of the high biological use, impacts can be significant to benthic invertebrates that are smothered or exposed to the water-accommodated fraction of the oil

RESPONSE CONSIDERATIONS

- In most cases, the best response is to let the oil, which is primarily on the surface of the flat, be removed naturally
- Natural removal tends to happen rather quickly in this habitat, because of its exposure to waves and tidal currents
- Cleanup is very difficult, because of the potential for mixing the oil deeper into the sediments
- If cleanup is attempted, the use of heavy machinery should be restricted in order to prevent contamination of the subsurface sediments, with manual removal being preferred; however, heavy foot traffic can also result in mixing the oil deeper

**SHELTERED ROCKY SHORES AND SHELTERED SCARPS IN MUD OR CLAY** **ESI = 8A**

DESCRIPTION

- Mud and clay shores of variable slope (from vertical cliffs to wide, rocky ledges) that are sheltered from exposure to most wave and tidal energy
- Attached biota may be plentiful and varied, especially in lower and mid-intertidal zones
- Sheltered muddy scarps are relatively rare on the outer coast and are usually associated with man-made cuts through salt marsh, occurring naturally in only a few bays and coves

PREDICTED OIL BEHAVIOR

- Oil will be found along the high-tide line, forming a distinct oil band
- Oil can persist because of the low energy setting
- Where burrowing is present, oil can penetrate deeply, causing long-term contamination of the subsurface
- Impacts to attached organisms can be severe

RESPONSE CONSIDERATIONS

- Cleanup is often required because natural removal rates are slow
- Water flushing at ambient water temperatures is most effective when the oil is fresh

- All pooled oil and oiled debris should be removed as soon as possible
- Pockets of liquid oil can be removed manually or with sorbents

**SHELTERED, MAN-MADE STRUCTURES** **ESI = 8B**

DESCRIPTION

- Include revetments, seawalls, piers, and docks typically constructed of impermeable materials such as concrete and wood
- Commonly found inside harbors and bays in highly developed areas sheltered from direct exposure to waves
- Attached biota may be plentiful and varied, especially in lower tidal zones

PREDICTED OIL BEHAVIOR

- On impermeable surfaces, the oil will form a band at the high-tide line
- If the oil is not removed, it may cause chronic leaching until the oil hardens
- Impacts to attached organisms can be severe

RESPONSE CONSIDERATIONS

- Cleanup is frequently required, because natural removal rates are slow and these features are located in populated areas
- High-pressure spraying may be required to remove oil for aesthetic reasons and to prevent oil leaching from the structure
- Cleanup crews should make sure to recover all released oil
- All pooled oil and oiled debris should be removed as soon as possible

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**SHELTERED RIPRAP** **ESI = 8C**

DESCRIPTION

- Composed of cobble- to boulder-sized rock fragments, similar to exposed riprap but sheltered from wave energy
- Commonly found inside harbors and bays in highly developed areas sheltered from direct exposure to waves
- Attached biota may be plentiful and varied, especially in lower tidal zones

PREDICTED OIL BEHAVIOR

- On impermeable surfaces, the oil will form a band at the high-tide line; oil will adhere readily to the rough rock surfaces
- Deep penetration of oil possible because of the high permeability of the riprap
- If the oil is not removed, it may cause chronic leaching (weeks to months) until the oil hardens
- Impacts to attached organisms can be severe

RESPONSE CONSIDERATIONS

- Cleanup is frequently required, because natural removal rates are slow and these features are located in populated areas
- Flushing can be effective for removing mobile oil, but large amounts of residue can remain after flushing, particularly for heavy oil. Clean up is often difficult and intrusive

- High-pressure spraying and/or scraping may be required to remove oil for aesthetic reasons and to prevent leaching of oil from the structure
- Cleanup crews should make sure to recover all released oil
- All pooled oil and oiled debris should be removed quickly

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**SHELTERED TIDAL FLATS** **ESI = 9A**

DESCRIPTION

- Sheltered tidal flats are composed primarily of mud with minor amounts of sand and shell
- They are present in calm-water habitats, sheltered from major wave activity, frequently in unvegetated areas within back-barrier portions of the islands and inner regions of the delta
- The sediments are very soft and cannot support even light foot traffic in many areas
- They can have heavy wrack deposits along the upper fringe
- There can be large concentrations of invertebrates on and in the sediments

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of sheltered tidal flats, but rather moves across the flat and accumulates at the high-tide line
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy
- Oil will not penetrate the water-saturated sediments, but could penetrate burrows and desiccation cracks or other crevices in muddy sediments

RESPONSE CONSIDERATIONS

- These are high-priority areas necessitating the use of spill protection devices to limit oil-spill impact; deflection or

sorbent booms and open water skimmers should be used

- Cleanup of the flat surface is very difficult because of the soft substrate; many methods may be restricted
- Care should be taken to limit foot traffic during any cleanup operations, to avoid mixing oil into the sediments
- Low-pressure flushing and deployment of sorbents from shallow-draft boats may be helpful
- Oiled wrack should be removed without sediment disturbance

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**SHELTERED, VEGETATED LOW BANKS** **ESI = 9B**

DESCRIPTION

- Sheltered banks of stream channels, canals, and other waterways
- Calm-water habitats that are typically muddy, soft, and highly vegetated
- Wave energy is very low, although there may be some tidal and/or riverine currents along the banks
- Present but not abundant throughout the delta, usually along man-made cuts or areas flooded during surveys

PREDICTED OIL BEHAVIOR

- Oil adheres readily to vegetation
- Natural removal rates very slow because of low energy and dense vegetation

- The band of oil coating on the vegetation will vary widely, depending upon the tidal stage at the time of oiling; there may be multiple bands
- If the vegetation is thick, heavy oil coating will be restricted to the outer fringe, with penetration and lighter oiling to the limit of tidal influence
- In areas of high suspended sediments, sorption of oil can result in deposition of contaminated sediments on the channel banks and bottoms

RESPONSE CONSIDERATIONS

- These are high-priority areas necessitating the use of spill protection devices to limit oil-spill impact; most are along channels that have a opening to the open ocean close by; therefore, deflection booming should be used to prevent the oil from entering the channel mouth
- Cleanup of the banks is very difficult because of the soft substrate
- Manual operations and deployment of sorbents from shallow-draft boats may be helpful
- Under light oiling, the best practice is to let the area recover naturally
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing
- Any cleanup activity must not mix the oil deeper into the sediments; trampling of the plant roots must be minimized
- Cutting of oiled vegetation should only be considered when other resources present (such as birds) are at great risk from leaving the oiled vegetation in place

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**SALT- AND BRACKISH-WATER MARSHES** **ESI = 10A**

DESCRIPTION

- Intertidal wetlands consisting of emergent, herbaceous vegetation
- Marshes vary in extent from extensive areas to narrow fringes
- Sediments in the substrate range from fine sands to silts and organically rich muds

PREDICTED OIL BEHAVIOR

- Oil adheres readily to intertidal vegetation
- Oil coating typically takes the form of a band of varying width; multiple bands are possible
- Large slicks will persist through multiple tidal cycles and coat vegetation from high tide line to the base of the stem
- If the vegetation is thick, the heaviest oil coating will be restricted to the outer fringe of the marsh. However, the lighter the oil, the further into the marsh it may penetrate
- Heavy and weathered oils do not readily adhere to or penetrate the fine sediments, but can pool in surface depressions or collect in burrows
- Light oils can penetrate the top few centimeters of sediment and deeply into burrows and cracks (up to one meter)

RESPONSE CONSIDERATIONS

- Extent of oiling and natural removal processes and rates should be evaluated prior to conducting cleanup
- Under light oiling, allow the area time to recover naturally

- Sorbents should be deployed to contain oil as it is naturally removed
- Cleanup crews and activities must be carefully monitored to avoid unnecessary vegetation damage
- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized
- Cutting of oiled vegetation should only be considered when other resources present (such as birds) are at great risk from leaving the oiled vegetation in place
- In-situ burning may be considered for removal of free oil pooled in the marsh

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**FRESHWATER MARSHES** **ESI = 10B**

DESCRIPTION

- Consist of emergent, herbaceous freshwater vegetation
- Marshes vary in extent from extensive areas to narrow fringes
- Sediments are composed of fine sand, silt, organic-rich mud, and potentially thick accumulations of peat

PREDICTED OIL BEHAVIOR

- Oil adheres readily to vegetation
- Oil coating typically takes the form of a band of varying width; multiple bands are possible
- If the vegetation is thick, the heaviest oil coating will be restricted to the outer fringe of the marsh. However, the lighter the oil, the further into the marsh it may penetrate
- Medium to heavy oils do not readily adhere to or penetrate the fine sediments, but can pool in surface depressions or collect in burrows
- Light oils can penetrate the top few centimeters of sediment and deeply into burrows and cracks (up to one meter)

RESPONSE CONSIDERATIONS

- Extent of oiling and natural removal processes and rates should be evaluated prior to conducting cleanup
- Under light oiling, allow the area time to recover naturally
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing taking care to prevent oiling of sensitive areas down slope or along shore
- Sorbents should be deployed to contain oil as it is naturally removed

- Cleanup crews and activities must be carefully monitored to avoid unnecessary vegetation damage
- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized
- Cutting of oiled vegetation should only be considered when other resources present (such as birds) are at great risk from leaving the oiled vegetation in place
- In-situ burning may be considered for removal of free oil pooled in the marsh

**FRESHWATER SWAMPS** **ESI = 10C**

DESCRIPTION

- Freshwater swamps consist of shrubs and forested wetlands
- The sediment tends to be silty clay with large amounts of organic debris
- They may be seasonally flooded, though there are many low, permanently flooded areas
- Resident flora and fauna are abundant with numerous species
- They occur along freshwater drainages, often adjacent to freshwater marshes

PREDICTED OIL BEHAVIOR

- Oiled woody vegetation is less sensitive than marshes to oil coating
- Some oil can be trapped and pooled on the swamp flood plain as water levels drop
- Penetration into the floodplain soils is usually limited because of high water levels, muddy composition, surface organic debris, and vegetation cover
- Large amounts of oily debris can be sources of chronic sheening
- During dry periods, terrestrial spills flow downhill and accumulate in depressions or reach waterbodies

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is to let the area recover naturally
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. During flushing, care must be taken to prevent transporting oil to sensitive areas down slope or along shore

- Cleanup crews and activities must be carefully monitored to avoid unnecessary vegetation damage
- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized
- Cutting of oiled herbaceous vegetation should only be considered when other resources present (such as birds) are at great risk from leaving the oiled vegetation in place; trees should not be cut
- Under stagnant water conditions, herding of oil with water spray may be needed to push oil to collection areas
- Oily debris can be removed where there is access

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**SCRUB-SHRUB WETLANDS, INCLUDING BLACK MANGROVES** **ESI = 10D**

DESCRIPTION

- Roots and trunks are submerged in water, with only the lowest leaves inundated at high water levels
- Includes black mangroves along the outer coast, which increase in occurrence during years of mild winters; black mangroves tend to occur along the outer fringe of salt marshes
- Relatively sheltered from waves and strong tidal currents
- The width of the forest can range from one tree to a many kilometers
- The substrate generally consists of muds and/or hydric soils
- Important feeding and nesting areas for wildlife (such as birds)
- Occur along sheltered shorelines and estuarine areas throughout the delta

PREDICTED OIL BEHAVIOR

- Oil can wash through vegetation if it comes ashore at high tide
- Heavy and emulsified oil can be trapped in and adhere to thickets of roots or pneumatophores
- Re-oiling from resuspended or released oil residues may cause additional injury over time
- Oiled trees may start to show evidence of effects (leaf yellowing) days to weeks after oiling; tree mortality may take months, especially for heavy oils
- Oil that penetrates the substrate or gets mixed into the sediments can cause long-term contamination of sediments and severe plant injury and mortality

RESPONSE CONSIDERATIONS

- Wrack may protect the trees from oiling, so wait until the threat of oiling has passed before removing it

- Sorbent boom can be placed in front of oiled forests to recover oil released naturally
- In most cases, no other cleanup activities are recommended
- Where thick oil accumulations are not being naturally removed, low-pressure flushing or vacuum may be attempted at the outer fringe
- It is extremely important to prevent disturbance of soft substrates by foot traffic, which can mix oil into the sediments