ENVIRONMENTAL SENSITIVITY INDEX: DELAWARE, NEW JERSEY, AND PENNSYLVANIA

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for the shorelines of Delaware, New Jersey, and Pennsylvania, encompassing the outer coast from the Maryland-Delaware border north to Toms River, in Barnegat Bay, New Jersey and the Delaware Bay and River system to Trenton, New Jersey. The ESI maps include information for three main components: shoreline habitats; sensitive biological resources; and human-use resources. Background information, as well as the methods of data collection and presentation, are summarized in the following sections.

SHORELINE HABITAT MAPPING

The intertidal habitats of Delaware, New Jersey, and Pennsylvania were mapped during overflights conducted from 10-17 April 1995. The aerial surveys were conducted using helicopter, flying at elevations of 300-500 feet and slow air speed. An experienced coastal geologist updated the intertidal habitats originally mapped in 1985 on plots of 1:24,000 U.S. Geological Survey (USGS) topographic maps which had the original shoreline classification plotted on them. Where appropriate, multiple habitats were delineated for each shoreline segment.

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

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

All of these factors are used to determine the relative sensitivity of intertidal habitats. Key to the sensitivity ranking is an understanding of the relationships between: physical processes, substrate, shoreline type, product type, fate and effect, and sediment transport patterns. 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.

These concepts have been used in the development of the 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 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 the shorelines of Delaware, New Jersey, and Pennsylvania, presented in order of increasing sensitivity to spilled oil.

1) Exposed Seawalls and Other Solid Structures Made of Concrete, Wood, or Metal
2A) Eroding Bluffs
2B) Wave-cut Clay Platforms
3) Fine-grained Sand Beaches
4) Medium- to Coarse-grained Sand Beaches
5) Mixed Sand and Gravel Beaches
6A) Gravel Beaches
6B) Riprap Structures
7) Exposed Tidal Flats
8A) Vegetated, Steeply Sloping Riverine Bluffs
8B) Sheltered Seawalls and Other Solid Structures Made of Concrete, Wood, or Metal
9) Sheltered Tidal Flats
10) Salt and Brackish-water Marshes

Each of the shoreline habitats are described on pages 7-12, in terms of their physical description, predicted oil behavior, and response considerations.

SENSITIVE BIOLOGICAL RESOURCES

The biological information presented on the maps was compiled with the assistance of federal, state, and regional biologists and resource managers from the U.S. Fish and Wildlife Service, Delaware Department of Natural Resources and Environmental Control (DNREC), New Jersey Department of Environmental Protection and Energy (DEPE), and Pennsylvania Department of Environmental Resources (DER). 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. Seven major categories of biological resources were considered during production of the maps: marine mammals, terrestrial mammals, birds, reptiles, fish, shellfish, and habitats.

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

MARINE MAMMALS


Dolphins


Seals


Whales

TERRESTRIAL MAMMALS


Small Mammals

BIRDS


Diving Birds


Gulls and Terns


Raptors


Shorebirds


Wading Birds


Waterfowl

REPTILES


Turtles

FISH


Fish

SHELLFISH


Bivalves


Cephalopods


Crabs


Gastropods


Lobsters

HABITATS


Submersed Aquatic Vegetation


Terrestrial Vegetation

The polygon, line, or point color and pattern are the same for all the animals in one group (i.e., birds). When there is more than one group of animals in one polygon, the polygon is then assigned the multigroup color and pattern. Also associated with each biological polygon, line, or point feature on the map is a number (located under the icon). 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 seasonality and life-history information on each species.

There are some species that are found throughout the nearshore zone on the map. While it is important to note the presence of these species, showing these distributions as polygons would cover large areas, making the maps very difficult to read. Thus, species found in over 25 percent of the water area are identified in a box stating that they are "COMMON IN AREA". This approach informs the user of the presence of these species, while maintaining readability of the map.

For many biological resources, information and expert knowledge may not be available for all geographic locations. For this reason, absence of a resource on a map does not necessarily mean it is not present. Under the descriptions of the various biological resource groups, the geographical limits of available knowledge, or the survey boundaries of particular studies, are given when known.

MARINE MAMMALS

Three subgroups of marine mammals, seals, dolphins, and whales, are depicted for Delaware Bay and surrounding areas.

Harbor seals are sighted frequently throughout the area, while gray, harp, and hooded seals are sighted occasionally.

The bottlenose dolphin and harbor porpoise are common throughout the Bay and coastal area. Occasionally, the Atlantic white-sided dolphin, common dolphin, Risso's dolphin, rough-toothed dolphin, and stenellid dolphin are seen in the area. The humpback whale is also a frequent denizen of the Delaware Bay area. These animals have been seen in the Bay during their migrations. Other species of whales are included that are infrequent visitors, so that the full range of mammals that may be present in the Bay is included.

Marine mammal distributions are shown by a brown hatch polygon. However, if species in addition to mammals are included in the polygon, a black hatch (multigroup) polygon is used. The number under the icon references a table on the reverse side of the map. In this table, the first columngives the species name. The second and third columns denote whether the species has either state (S) and / or federal (F) designations as endangered (E) or threatened (T). The next column provides an estimate of the concentration of species at this site. Concentration is indicated as "RARE", "OCCASIONAL", or "COMMON". These estimates are subjective based on local expert opinion on the relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. For many species there is a temporal shift in seasonality with spatial changes in location. Temporal information included in the tables is specific to the one polygon or point that it references.

TERRESTRIAL MAMMALS

Terrestrial mammals included in the Delaware, New Jersey, and Pennsylvania atlas are river otter, raccoon, mink, and muskrat. These animals are found primarily in the wetlands along Delaware Bay. The river otters concentrate in the streams that feed into the Bay.

Terrestrial mammal distributions are shown by a brown hatch polygon. However, if species in addition to mammals are included in the polygon, a black hatch (multigroup) polygon is used. The number under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second and third columns denote whether the species has either state (S) and/or federal (F) designations as endangered (E) or threatened (T). No terrestrial mammals included on the maps have such designations. The next column provides an estimate of the concentration of species at this site. Concentration is indicated as "HIGH", "MED", or "LOW". These estimates are subjective based on local expert opinion on the relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. For many species there is a temporal shift in seasonality with spatial changes in location. Temporal information included in the tables is specific to the one polygon or point that it references.

BIRDS

Birds are divided into several species subgroups based on behavior and taxonomy. The species table lists all the birds included on the maps, sorted by subgroup. These species were included either because of their likelihood of impact by an oil spill or special protection status as threatened or endangered. Of particular importance are the spring migratory shorebird concentrations in Delaware Bay. With 800,000 to 1,500,000 shorebirds present in the spring, Delaware Bay is one of the most significant migratory areas for shorebirds in the Western Hemisphere. Shorebirds are attracted by the spawning horseshoe crab. Delaware Bay area is a significant overwintering place for waterfowl. Pea Patch Island is also a major nesting site for various species of wading birds.

Bird distribution is shown on the maps as green hatch polygons. These areas depict known migratory, overwintering, nesting, or other concentration areas. Green dots on the maps represent the location of nesting colonies. The number under the icon references a table on the reverse side of the map. In this table, the first column gives the species name, followed by the state (S) and/or federal (F) species designation for endangered (E) or threatened (T) status. The species will be identified as threatened or endangered for all occurrences of the species, even if it is only listed as such in one state. The next column provides an estimate of the concentration of each species at the site. For birds, the highest count of individuals recorded at each site is given. Where counts were not available, "Unknown" is listed in the concentration column. Even though concentration may be listed as "Unknown", it should be recognized that the number of individuals or the importance of the site was still significant enough to be included. The species seasonality is shown in the next twelve columns representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. The last column denotes the nesting season for each species, if nesting occurs at the site. For many species there is a temporal shift in seasonality and reproduction along with spatial changes in location. Temporal information included in the tables is specific to the one polygon or point that it references.

REPTILES

The only reptiles included in the Delaware, New Jersey, and Pennsylvania atlas are sea turtles and northern diamondback terrapins. There are no known sea turtle nesting beaches present in the area. The in-water areas represent known foraging, developmental, migratory, or other habitat areas where sea turtles are likely to occur in substantial numbers. Northern diamondback terrapins are a species of special concern and are known to nest in the Delaware and New Jersey area. The maps show known concentration areas rather than nesting sites.

Turtle distributions are shown as polygons with a red hatch pattern. If species in addition to turtles are included in a polygon, a black hatch (multigroup) pattern is used. A red icon with a turtle silhouette is used to indicate the presence of turtles. The number under the icon references a table on the reverse side of the map. In the tables, the first column gives the species name. The second and third columns denote whether the species has either state (S) and/or federal (F) designations as endangered (E) or threatened (T). The next column provides an estimate of the concentration of the species at a site. Concentration is indicated as "RARE", "OCCASIONAL", or "COMMON". Concentration estimates are subjective based on local expert opinion on relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. For many species there is a temporal shift in seasonality along with spatial changes in location. Temporal information included in the tables is specific to the one polygon that it references.

FISH

The fish species included in the Delaware, New Jersey, and Pennsylvania atlas are those of commercial or recreational importance. The species table lists all of the species of fish included on the maps, grouped by anadromous and all other species. There are many more species of fish than those shown on the maps. In addition, most areas depicted reflect only the more significant concentrations. These areas are identified because of higher concentrations, important spawning areas, important juvenile areas, or high use recreational and/or commercial fishing for the named species.

The distributions of fish are shown as polygons with a blue hatch pattern. If species in addition to fish are included in the polygon, a black hatch (multigroup) pattern is used. A blue icon with a fish silhouette is used to indicate the presence of fish. The number under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second and third columns denote whether the species has either state (S) and/or federal (F) designations as endangered (E) or threatened (T). The next column provides an estimate of the concentration of species at the site. Concentration is indicated as "HIGH", "MED", or "LOW". These estimates are subjective based on local expert opinion on the relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at a location in a particular month, an "X" is placed in the month column. The last three columns indicate dates for outmigration, spawning, and the presence of juveniles. For many species there is a temporal shift in seasonality along with spatial changes in location. Temporal information included in the tables is specific to the one polygon that it references.

SHELLFISH

Shellfish included in the Delaware, New Jersey, and Pennsylvania atlas include bivalves (clams and oysters), cephalopods (squid), crabs, gastropods (whelk), and lobsters. The species table lists all the shellfish shown on the maps, sorted by subgroup. Commercially or recreationally important species are included. For clams, only moderate to high concentration areas are depicted. For oysters, the seed beds, lease beds, and general concentration areas have not been differentiated; all of these features are shown as oyster beds. Whelk concentration areas are shown in the lower portion of Delaware Bay, which is an important whelk fishing area.

Horseshoe crab concentration areas are shown for Delaware Bay. This is an important species because tremendous numbers (as many as 1.2 million in a single day) mate every year on the sand beaches of the lower bay. This activity attracts numerous shorebirds during their spring migration.

The distributions of shellfish are shown as polygons with an orange hatch pattern. If species in addition to shellfish are included in the polygon, a black hatch (multigroup) pattern is used. Orange icons are associated with the polygons, and the silhouette of the subgroup is shown. The number under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second and third columns denote whether the species has either state (S) and/or federal (F) designations as endangered (E) or threatened (T). No shellfish included on the maps have such designations. The next column provides an estimate of the concentration of species at the site. Concentration is indicated as "HIGH", "MED", or "LOW". These estimates are subjective based on local expert opinion on the relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at a location in a particular month, an "X" is placed in the month column. The last three columns indicate dates for spawning, mating, and the presence of juveniles. Spawning refers to the release of gametes to the water column during reproductive periods, or the mass release of larvae. Mating applies to shellfish which form temporary reproductive pairs for fertilization of gametes (e.g., blue crabs), with later release of more developed larval young. For many species there is a temporal shift in seasonality and reproduction along with spatial changes in location. Temporal information included in the tables is specific to the one polygon that it references.

HABITATS

Habitats included in the Delaware, New Jersey, and Pennsylvania atlas include seagrasses and terrestrial plants. Seagrasses in Delaware and New Jersey consist of eelgrass. For most oil spills, the many small animals associated with seagrass habitats are often at greater risk than the vegetation. The seagrasses are limited to the northern sections of Barnegat Bay and the eastern edge of the Indian River and Rehoboth Bays.

Habitats are shown as polygons with a purple hatch pattern. If species in addition to plants are present in the polygons, a black hatch (multigroup) pattern is used. Purple icons are associated with the polygons and the silhouette of the subgroup is shown. The number under the icon references a table on the reverse side of the map. The concentration column provides an estimate of the plant abundance at the site. Concentration for seagrasses and terrestrial plants are unknown, since the source information only indicated presence or absence. The last twelve columns provide information on seasonality. All 12 months are marked with an "X" since the plants are present all year. However, it should be recognized that during winter months, above-ground vegetation may be reduced or not present.

HUMAN-USE FEATURES

The human-use features depicted on the maps are those that either could be impacted by an oil spill or could provide access for response operations. All the features are represented by icons indicating the type of human-use resource.

ACCESS POINT

Locations where it is possible to gain vehicle access to the shoreline.

AIRPORT

Location of airfields or airports, whether manned or unmanned. The locations were obtained from USGS 1:24,000 topographic maps.

ARCHAEOLOGICAL SITE

Location of known archaeological sites in close proximity to the shoreline. This information was provided by the Delaware Office of Historic Preservation, the New Jersey Office of Historic Preservation, and the Pennsylvania Bureau for Historic Preservation.

BOAT RAMP

Location of boat ramps. These data were obtained from visual observation during overflights, the Delaware Department of Natural Resources and Environmental Control, the New Jersey Department of Environmental Protection and Energy, and the Pennsylvania Department of Environmental Resources.

COAST GUARD

Location of Coast Guard facilities. This information was obtained from visual observation during overflights and from USGS 1:24,000 topographic maps.

FERRY

Location of ferry docks. This information was obtained from USGS 1:24,000 topographic maps.

HISTORICAL SITE

Location of historical sites in close proximity to the shoreline. This information was provided by the Delaware Office of Historic Preservation, the New Jersey Office of Historic Preservation, and the Pennsylvania Bureau for Historic Preservation.

MARINA

Location of marinas. This information was obtained from visual observation during overflights, the Delaware Department of Natural Resources and Environmental Control, the New Jersey Department of Environmental Protection and Energy, and the Pennsylvania Department of Environmental Resources.

PARK

Location of state parks. The boundaries were obtained from the U.S. Fish and Wildlife Service, the New Jersey Department of Environmental Protection and Energy, and from USGS 1:24,000 topographic maps.

RECREATIONAL FISHING OR BOATING

General areas where there is heavy recreational fishing or boating. These areas were provided by the Delaware Department of Natural Resources and Environmental Control.

RESERVE, PRESERVE, OR REFUGE

All boundaries for the reserves, preserves, refuges, or any other managed and regulated wildlife areas were provided by the U.S. Fish and Wildlife Service and the New Jersey Department of Environmental Protection and Energy. These managed lands include an icon and the name of the property.

WATER INTAKES

Location of surface water intakes whether for cooling water, industrial use, or potable water. All public and private surface water intakes are shown. Information was provided by the Delaware Department of Natural Resources and Environmental Control, the New Jersey Department of Environmental Protection and Energy, and the Pennsylvania Department of Environmental Resources.

For water intakes, the name of the resource, the manager/ owner, an emergency contact person, and a telephone number are provided. The information is listed on the reverse side of the maps, when available.

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, biological resources, and human-use features.

Under separate cover are a complete data dictionary, metadata, and 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. Please refer to the metadata file for full explanations of the data and its structure.

SHORELINE HABITAT CLASSIFICATION

The shoreline habitat classification is stored as lines with the data identifying the type of habitat associated with the line. In many cases, a shoreline may have two classifications. These multiple classifications are represented on the maps by double lines 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.

SENSITIVE BIOLOGICAL RESOURCES

Biological resources are shown on the map as lines, points, or polygons. Associated with each map feature is a unique identification number which is linked to a series of databases that further identify the resources. The first data set consists of a list of the species and the concentration of each species. This dataset is then linked to a dataset that describes the life history of each species (temporal presence and reproductive times at month resolution) for the specified map feature. Other databases linked to the first data set are the species identification database, which includes common and scientific names for all species and their threatened or endangered status, and the sources database, which provides source metadata at the feature level.

HUMAN-USE FEATURES

Human-use features are represented on the maps as an icon describing the feature. In the digital file, the feature location is represented by a point or by polygons. If the feature is either an aquaculture facility or water intake, a data file that contains the fields for the name of the owner/manager, telephone number at which the person can be contacted, identification of the type of feature, and a brief description of the feature is associated with the feature. For all of the other human-use features, only the name, when available, is entered into the database.

REFERENCES

Listed below are the major hardcopy reference materials used during this project. 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 concerning resources depicted in the atlas.

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At Research Planning, Inc. (RPI), Joanne Halls and Mark White were the project managers. Shoreline mapping was conducted by Todd M. Montello. Biological and human-use resources data were collected and compiled by Jeffrey Dahlin. Mark White, Lee Diveley, Kara Hastings, and James Olsen entered the data and produced the final maps, under the supervision of Joanne Halls. Systems administration was coordinated by Bill Holton. Graphics were provided by Joe Holmes and Becky Cox, and Dot Zaino prepared the text.