ENVIRONMENTAL SENSITIVITY INDEX: NORTH CAROLINA

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for the shoreline of North Carolina. 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 North Carolina were originally mapped during overflights conducted in July 1981. They were updated onto 1:24,000 U.S. Geological Survey (USGS) topographic maps by an experienced coastal geologist in January 1996 using a set of 1:800 color vertical aerial photographs from late 1989. Portions of the coast were flown in February 1996 to verify the photo-interpretation. The aerial surveys were carried out using a helicopter, flying at elevations of 300-500 feet and slow air speed. 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 sensitivity 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. A comprehensive shoreline habitat ranking system has been developed for the entire U.S. The shoreline habitats present in North Carolina are listed below in order of increasing sensitivity to spilled oil.

1B) Exposed, Solid Man-made Structures
3A) Fine-grained Sand Beaches
3B) Scarps and Steep Slopes in Sand
4) Medium- to Coarse-grained Sand Beaches
6B) Riprap
7) Exposed Tidal Flats
8A) Sheltered Scarps in Mud
8B) Sheltered, Solid Man-made Structures
9A) Sheltered Tidal Flats
9B) Vegetated Low Riverine Banks
10A) Salt- and Brackish-water Marshes
10B) Freshwater Marshes
10C) Freshwater Swamps
10D) Scrub-Shrub Wetlands

Each of the shoreline habitats are described on pages 8-13, in terms of their physical description, predicted oil behavior, and response considerations.

SENSITIVE BIOLOGICAL RESOURCES

Spill response personnel from the NOAA Hazardous Materials Response and Assessment Division, and marine and coastal scientists with Research Planning, Inc., collected and compiled the biological information presented on the maps with the assistance of biologists and resource managers from a variety of state and federal agencies, universities, and other groups. 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 and points, as appropriate. Associated with each of these representations is an icon depicting the types of animals or plants 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 reflect this grouping scheme. The groups are color coded, and the subgroups are represented by different icons:

MARINE MAMMALS


Dolphins

TERRESTRIAL MAMMALS


Small Mammals

BIRDS


Diving Birds


Gulls and Terns


Passerine Birds


Pelagic Birds


Raptors


Shorebirds


Wading Birds


Waterfowl

REPTILES


Alligators


Turtles

FISH


Fish

SHELLFISH


Bivalves


Crabs


Shrimp

HABITATS


Seagrasses


Terrestrial Plants

The polygon or point color and pattern are the same for all the animals in one group (e.g., birds). When there is more than one group of animals in one polygon, the polygon is then assigned the multigroup color and pattern (black hatch). Also associated with each biological polygon or point feature on the map is a Resources at Risk number (RAR#), 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 the state and federal protected status (T/E), concentration or abundance, seasonality, and life-history information on each species.

There are some species that are found throughout specific geographical areas or habitat types. Displaying the polygons for these species would cover large areas, making the maps very difficult to read. Thus, species which occur over the majority of certain geographic areas or habitats are often identified in a small box which states that they are “Common in ...”, (e.g., “Common in Atlantic Ocean” or “Common in Estuarine Waters”). This approach informs the user of the presence of these species, while maintaining readability of the map. In all instances, data for species listed as “Common in ....” exist as polygons in the digital coverages. The use of “Common in ....” is implemented on a map per map basis, depending on the location, size, and number of polygons present on an individual 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.

MARINE MAMMALS

There are no known concentration areas of marine mammals in Volume 1. However, bottlenose dolphins are mapped in Volumes 2 and 3. The endangered West Indian manatee also occurs in the study area, in riverine, estuarine, and nearshore environments, but only in limited numbers during warmer summer months, generally when water temperatures are above 75°F. Bottlenose dolphins are likely to be present throughout the study area, in nearly all estuarine and nearshore waters of the Atlantic. Dolphins are only depicted, however, in specific locations where known calving or nursery concentrations occur. There may be many such areas which are not known, so areas depicted in the atlas should not be considered the only areas where calving and nursery activities occur.

Bottlenose dolphin distributions are displayed on the maps as a brown hatch polygon. A brown icon with a dolphin silhouette is used to indicate the presence of marine mammals. 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 column denotes whether the species has been designated endangered (E) or threatened (T) on either the state (S) or federal (F) list. Bottlenose dolphins are not listed as threatened or endangered, but are protected under the Marine Mammal Protection Act. The next column provides an estimate of the concentration of the species at the site. Concentration is usually indicated as “HIGH”, “MED”, or “LOW”. 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.

TERRESTRIAL MAMMALS

There are no known concentration areas of terrestrial mammals in Volume 1. However, semi-aquatic, fur-bearing species such as river otter, beaver, muskrat, mink, etc., are likely to occur throughout much of the study area. Depending on the species, these mammals are likely to occur where rivers, streams, estuaries, impoundments, and especially wetlands are present. High concentrations of river otters occur at the Swan Quarter National Wildlife Refuge (Volume 2 - maps 55, 56, 57, 58, 62, 63, and 64) and

in the area from the Cape Fear River to Southport (Volume 3 - maps 120, 122, 123, and 124). Semi-aquatic, fur-bearing mammals can be severely impacted by swimming through oil slicks or coming into contact with oiled wetland vegetation. In addition to the semi-aquatic fur bearers, the Dismal Swamp Southeastern shrew also occurs in the study area in damp woodland and brushy habitat types in the lower coastal plain. The species is of concern because it is listed as threatened and may be at risk because of being located in or near wetlands and they use burrows.

Terrestrial mammal distributions are shown as polygons with a brown hatch pattern. If species in addition to terrestrial mammals are included in the polygon, a black hatch (multigroup) pattern is used. A brown icon with a small mammal silhouette is used to indicate the presence of terrestrial mammals. 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 column denotes whether the species has been designated endangered (E) or threatened (T) on either the state (S) or federal (F) list. The next column provides an estimate of the concentration of species at the site. Concentration is usually indicated as "HIGH", "MED", or "LOW". For terrestrial mammals, these estimates are subjective. 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 taxonomy, morphology, behavior, and oil spill vulnerability and sensitivity. 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.

Waterfowl, diving birds (pelicans, cormorants, and loons), and pelagic birds (gannets and shearwaters) are usually at greatest risk during oil spills, because they spend nearly all of their time on the water surface, and/or because they become partially or entirely immersed while feeding. Waterfowl can also be contaminated through contact with oiled wetland vegetation. Wading birds are usually at slightly lesser risk, primarily because they become oiled mainly on the legs and bill while wading for prey. Wading bird feathers and upper body parts can be more extensively contaminated, however, by contact with oiled wetland vegetation. Shorebirds usually avoid oil, but may be impacted by loss of feeding areas or intertidal prey, particularly during important migration periods. Gulls and terns may be at risk because they are often attracted to and will prey on sick or injured prey. This behavior may result in oiling of feathers and the ingestion of oil. Terns are additionally at risk when they dive for prey. Raptors may also prey on oiled or injured species and thus may be contaminated themselves or ingest oil. Osprey may additionally be oiled while diving for fish. Passerine birds are typically not at great risk during spills; however, response activities can disturb nesting or damage coastal habitat for these species. Passerine birds of concern during spills include threatened or endangered species, especially if they nest near the shoreline or in wetland habitats such as mangroves.

Oiling of birds reduces the buoyancy, water repellency, and insulation provided by feathers, and may result in death by drowning or hypothermia. Preening of oiled feathers may also result in ingestion of oil resulting in irritation, sickness, or death. Bird oiling, particularly waterfowl and wading birds, may continue even after floating oil has been removed, depending on the extent of oiled vegetation and debris. Oiling can severely impact breeding and nesting success, especially if oiled adults contaminate the nest, eggs, or young. Disturbance during response activities can also negatively impact nesting success.

Bird distributions are shown on the maps as polygons with a green hatch pattern. If species in addition to birds are included in the polygon, a black hatch (multigroup) pattern is used. Special bird concentration sites, mainly nesting sites and some protected species locations, are displayed as point locations using a green dot. For polygon and point data, a green icon with the appropriate bird silhouette (wading bird, raptor, etc.) is used to indicate the presence of birds. 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 column indicates whether the species is listed as threatened (T) or endangered (E) on state (S) and/or federal (F) lists. The next column provides an estimate of the concentration of each species at the site. For the bird data, concentration is indicated as "HIGH", "MED", or "LOW", or as a numerical value representing the number of nests occurring at a point. The descriptive concentration estimates are subjective, based on local expert opinion on relative concentrations in the area. The numerical concentration values are based on survey data. Numerical concentrations at any particular site may fluctuate seasonally and annually based on local or regional conditions, or other factors. 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 columns denote the nesting seasonality for each species, if nesting occurs in an area or at a site. Nesting refers to the entire nesting period, while laying, hatching, and fledging are discreet subsets of the nesting time period. 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

Reptiles depicted in the North Carolina atlas include marine or sea turtles and the American alligator. Sea turtle areas displayed on the maps are limited to nesting beaches, and several well known in-water concentration areas. Sea turtle nesting beaches include sand beach areas where sea turtles come ashore to nest. In addition to nesting locations and the few in-water areas depicted, loggerhead, green, Kemp's ridley, and leatherback sea turtles can occur throughout the coastal, estuarine, and/or marine waters of North Carolina. All sea turtles are protected as threatened or endangered species.

In addition to direct oiling, sea turtle adults, nests, and young may also be at risk from response activities and equipment. Beach cleanup operations and heavy machinery can disturb both adult and hatchling turtles, as well as their nests. Ruts left on the beach by heavy equipment can entrap hatchlings trying to get to the water, resulting in death from exposure or predation. Hatchlings may also be killed by entrapment behind booms placed to protect the shoreline. Flood lights used for night operations or security could disorient adult turtles or hatchlings, causing them to move towards oiled areas or roads.

American alligators can occur throughout freshwater and estuarine habitats in North Carolina, particularly in wetlands, coastal rivers, ponds, and impoundments. Due to widespread abundance, alligators are only depicted on the maps in areas where Natural Heritage Program data (1996) indicated their presence.

Reptile distributions are depicted as polygons with a red hatch pattern. If species in addition to reptiles are included in a polygon, a black hatch (multigroup) pattern is used. A red icon with a turtle or alligator silhouette is used to indicate the presence of reptiles. 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 column denotes whether the species has been designated as endangered (E) or threatened (T) on state (S) and/or federal (F) lists. The next column provides an estimate of the concentration of the species at a site. Concentration is generally indicated as "HIGH", "MED", or "LOW" for reptiles, although numerical values of the number of individuals have been used when available. 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 sea turtles and alligators, the last two columns indicate nesting and hatching time periods. Nesting refers to the time when adults construct nests and deposit eggs. Hatching refers to the time when young are hatching and emerging from the nests. 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.

FISH AND SHELLFISH

Fish and shellfish included in the North Carolina atlas include estuarine-dependent and anadromous species. Species of commercial, recreational, or conservation interest are emphasized, although other species are included. Fish distributions are based on data compiled by the NOAA Strategic Environmental Assessments Division, under the Estuarine Living Marine Resources (ELMR) Program. Shellfish included in the North Carolina atlas include crustaceans and mollusks. The species table lists all the fish and shellfish shown on the maps, sorted by subgroup. For sessile shellfish (clams and scallops), more detailed concentration areas in estuarine and offshore waters are also indicated in some areas, especially where important commercial or recreational harvests occur. A thorough understanding of the maps would not be possible without a summary description of the ELMR program.

ESTUARINE FISHERIES DATA
Organized into Biologically-based Salinity Zones

NOAA's ELMR program has developed a consistent database describing the distribution, abundance, and life history characteristics of important fish and shellfish in U.S. estuaries (Jury et al., 1994). The spatial and temporal distribution of ELMR's categorical relative abundance data were assigned to North Carolina's estuaries based on regional and local fisheries science experts, survey reports, peer-reviewed literature, and existing quantitative data. The relative abundance categories (highly abundant, abundant, common, rare, and not present) are intended to simulate the categories often used by fisheries biologists. These abundance estimates are then verified through an extensive peer-review process utilizing the knowledge and field experience of fisheries scientists, managers, and biologists. The data summaries represent the best available source of information about the current distribution and abundance of selected species.

A primary factor affecting the distribution of estuarine-dependent fish and shellfish is salinity (Monaco et al., in review). The salinity zones are useful for geographically depicting fish and shellfish. The estuarine salinity zones depicted in this atlas were adapted from the study by Bulger et al. (1993) that quantitatively

defined biologically-based salinity zones. The five salinity zones are: fresh-0.5; 0.5-5.0; 5.0-15.0; 15.0-25.0; and >25.0 ppt.

The seasonal depth-averaged biosalinity zones (isohalines) depicted in the statewide maps were modeled from a subset of field salinity data, mostly from 1970-1994 (Orlando et al., 1994). Salinity analysis for the North Carolina estuarine systems focused on high, transitional, and low salinity time periods. These periods represent the typical high-, transitional-, and low-salinity conditions experienced under average seasonal freshwater inflow conditions. The transitional salinity time period and transitional biosalinity zones were determined, by default, from the spatial and temporal limits of the high and low salinity time periods. The isohalines that define the salinity zones shift seasonally due to environmental factors such as freshwater inflow, evaporation, and wind. The monthly designation of high (H), transition (T), and low (L) salinity time periods are specified on the back of each map.

Fish and shellfish relative abundance and seasonal lifestage data for each quad were condensed to portray the information on the ESI maps. A hierarchical method was used where the relative abundance information for the juvenile lifestage was the default. Using this method, the relative abundance information shown on the back of the ESI maps represents the juvenile lifestage for the vast majority of the months. When juveniles were not present in a given month, information from the adult and larval lifestage was used, in that order. An ELMR supplement to the ESI atlas is available for those seeking a more detailed explanation of fish and shellfish distribution and relative abundance data.

ELMR species salinity range and tolerance data were used to assign 41 North Carolina fish and shellfish relative abundance ranks to the five biologically-based salinity zones (Patillo et al., in press; Christensen et al., in press). The salinity patterns for each North Carolina estuary were analyzed to determine the location of isohalines and seasonal variation. The salinity characteristics for each estuary are described below and illustrated on the following page.

ALBEMARLE SOUND

The Albemarle Sound estuary is a large, shallow, bar-built lagoonal system. Tides, current speeds, and circulation patterns are primarily wind driven. Salinity structure in Albemarle Sound is most influenced by seasonal freshwater discharge. The Roanoke and Chowan rivers are the two major freshwater sources into Albemarle Sound. Salinity is typically no more then 5 ppt and vertically homogeneous, but may exhibit higher salinities and greater variability near Croatan Sound. The high salinity time period is September through November; transitional is May through August and December through January; and low is February through April.

PAMLICO SOUND, PAMLICO AND PUNGO RIVERS, NEUSE RIVER

The Pamlico Sound estuary is a large, shallow, bar-built lagoonal system. The Neuse/Trent, Tar/Pamlico, and Pungo rivers are the principal freshwater sources to Pamlico Sound. Salinity structure in Pamlico Sound is primarily influenced by seasonal freshwater discharge. Salinities in the Pamlico Sound area are highly variable and commonly experience weak-to-moderate vertical stratification. Salinities in the Neuse and Pamlico rivers are variable and often moderately stratified. The high salinity time period is September through November; transitional is May through August and December through January; and low is February through April.

BOGUE SOUND

The Bogue Sound estuary is a narrow, shallow lagoonal system located behind a band of narrow barrier islands. The estuary is comprised of three tidally influenced rivers and two sounds. Though freshwater discharge into the estuary is limited, it is sufficient to produce strong salinity gradients in the three rivers during the late winter and spring. The salinity structure in Bogue Sound is predominantly controlled by rainfall and evaporation patterns. Salinities in the major riverine systems are moderately stratified and experience greater variability during the low-salinity period than do the vertically homogenous and more stable sounds. Salinities become more stable and less stratified in the river systems during the high-salinity period while the conditions in the sounds remain the same. The high salinity time period is June through August; transitional is April through May and September through December; and low is January through March.

NEW RIVER

The New River estuary is a small, coastal plain system which includes three major bays and several smaller bays and coves. The salinity structure is primarily determined by seasonal freshwater discharge from the New River. Moderate stratification conditions persist throughout the middle bay portions of the system, but vertical stratification is infrequent in the lower estuary. Tidal influence is generally restricted to the lower estuary wherein it increases vertical mixing and maintains relatively stable salinities. The high salinity time period is September through November; transitional is May through August and December through January; and low is February through April.

CAPE FEAR RIVER

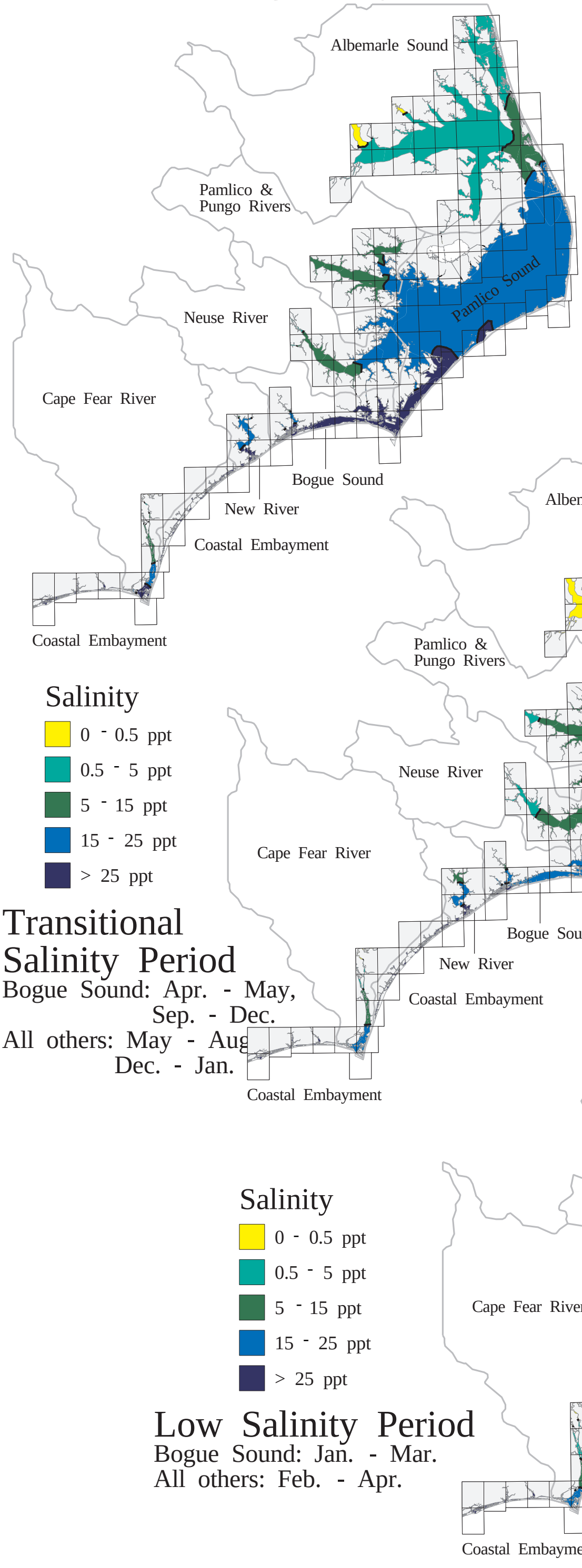
The Cape Fear River estuary is a coastal plain, drowned river valley system. The salinity structure is primarily determined by the seasonal freshwater discharge. Salinities are often moderately-to-highly stratified during high spring discharge conditions. Typically, the shallow periphery of this estuary is vertically homogenous. This estuary experiences significant intra-annual variability. Relatively stable salinities are restricted to the upper tributaries and the estuary mouth. The high salinity time period is September through November; transitional is May through August and December through January; and low is February through April.

COASTAL EMBAYMENTS

There are two regions along the North Carolina coastline which are classified as coastal embayments. These areas are characterized by barrier islands separated from the mainland by narrow, shallow lagoons. The first embayment extends due south from the New River Inlet to Wilmington Beach and encompasses Topsail, Middle, Masonboro, and Myrtle Grove Sounds. The second embayment includes the area just west of Cape Fear River to the South Carolina border. Several small streams contribute fresh-water to these areas, but, in general, the tidal volume far exceeds the freshwater inflow. These conditions generate salinities greater then 25 ppt year-round. Localized stratification may occur in some streams and channels (Baker, 1977). The high salinity time period is September through November; transitional is May through August and December through January; and low is February through April.

The distributions of fish and shellfish are shown as multi-polygons with a black hatch pattern. Blue icons with the silhouette of a fish and orange icons with the silhouette of the shellfish subgroup are associated with the polygons. The more spatially detailed sessile shellfish polygons have an orange hatch pattern. 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 column denotes whether the species has been designated endangered (E) or threatened (T) on either the state (S) or federal (F) list. The concentration column is left blank for the ELMR data because relative abundances are listed by month in the seasonality columns. Under each month where a species is present, a number code (1-5) indicates the species abundance (1 = no information, 2 = rare, 3 = common, 4 = abundant, 5 = highly abundant). The last columns indicate dates for various life-history time periods (fish = spawning, outmigration, larvae, juvenile, adult; shellfish = spawning, larvae, mating, juveniles, and adults). 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.

North Carolina Estuaries
Biologically-Based Salinity Zones



Salinity
- 0 - 0.5 ppt
- 0.5 - 5 ppt
- 5 - 15 ppt
- 15 - 25 ppt
- > 25 ppt

High Salinity Period
Bogue Sound: Jun. - Aug.
All others: Sep. - Nov.

Salinity
- 0 - 0.5 ppt
- 0.5 - 5 ppt
- 5 - 15 ppt
- 15 - 25 ppt
- > 25 ppt

Transitional Salinity Period
Bogue Sound: Apr. - May,
Sep. - Dec.
All others: May - Aug
Dec. - Jan.

Salinity
- 0 - 0.5 ppt
- 0.5 - 5 ppt
- 5 - 15 ppt
- 15 - 25 ppt
- > 25 ppt

Low Salinity Period
Bogue Sound: Jan. - Mar.
All others: Feb. - Apr.

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. State waters classified as outstanding resource waters (ORWs) are identified on the maps by annotations. ORWs may be subject to special point source and non-point source pollution management regulations and strategies, and may be of special consideration during spill events. Most features are represented by icons indicating the type of human-use resource.

ACCESS

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

AIRPORT

Location of airfields or airports, whether manned or unmanned.

AQUACULTURE

Location of aquaculture sites or facilities, such as fish and shellfish hatcheries.

ARCHAEOLOGICAL SITE

Approximate location of known archaeological sites in close proximity to the shoreline or coastal wetlands.

BOAT RAMP

Location of boat ramps.

COAST GUARD

Location of Coast Guard facilities.

COMMERCIAL FISHING

General area where commercial fishing activities take place. Commercial fishing types include river herring pound netting, flounder pound netting, catfish pot harvesting, eel pot harvesting, trotline fishing, and long-haul seining. Other commercial fishing activities such as blue crab and oyster harvesting may occur throughout the study area.

FACTORY

Location of factories which may store, handle, or transport hazardous materials such as oil.

FERRY

Location of ferry landings.

HISTORICAL SITE

Location of historical sites in close proximity to the shoreline.

MARINA

Location of marinas.

MARINE SANCTUARY

Land and water managed by NOAA and the state as National Marine Sanctuaries or National Estuarine Research Reserves.

NATIONAL PARK

Land and water managed by the National Park Service as National Parks, National Seashores, National Monuments, National Memorials, etc.

RECREATIONAL BEACH

Location of beaches used for recreational activities such as swimming, sun-bathing, fishing, etc.

RECREATIONAL FISHING

General area where recreational fishing takes place. Some of these areas may include artificial reefs.

REFUGE OR STATE GAME LAND

Land and water managed by the U.S. Fish and Wildlife Service as National Wildlife Refuges, or by the North Carolina Wildlife Resources Commission as State Game Lands.

SPECIAL MANAGEMENT AREA

Location of Fish Nursery Areas. These estuarine areas support juvenile populations of economically important fish and crustacean shellfish and are protected by state regulations from a variety of activities which could disturb, destroy, or alter nursery habitat quality or function.

STATE PARK

Location of land and water managed as state parks by the North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation.

WATER INTAKE

Location of surface water intakes for industrial processes or cooling, municipal use, aquaculture facilities, etc.

For aquaculture sites and 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. The names of the various managed lands/waters occurring in Volume 1 are listed below.

NAME

NATIONAL MARINE SANCTUARIES (NOAA/NCDEHNR)

Currituck Banks National Estuarine Research Reserve

NATIONAL PARK SERVICE (NPS)

Cape Hatteras National Seashore
Fort Raleigh National Historic Site
Wright Brothers National Memorial

NATIONAL WILDLIFE REFUGES (USFWS)

Alligator River National Wildlife Refuge
Currituck National Wildlife Refuge
Mackay Island National Wildlife Refuge
Pocosin Lakes National Wildlife Refuge
Roanoke River National Wildlife Refuge

STATE GAME LANDS (NCWRC)

Batchelor Bay Game Land
Chowan Game Land
North River Game Land
Northwest River Marsh Game Land

STATE PARKS (NCDEHNR-DRP)

Jockeys Ridge State Park

GEOGRAPHIC INFORMATION SYSTEM DATA

The entire atlas product is stored in digital form in a Geographic Information System (GIS). The information is stored as geographic layers 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 is a metadata document which details the data dictionary, processing techniques, 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. Refer to the metadata file for a full explanation of the data and its structure.

SHORELINE HABITAT CLASSIFICATION

The shoreline habitat classification is stored as lines and polygons with the data identifying the habitat type. In many cases, a shoreline may have two or three different classifications. These multiple classifications are represented on the maps by double or triple color combinations and in the data by ESI#1/ESI#2, where ESI#1 is the landward-most classification and ESI#2 is the seaward-most classification. The wetland habitat polygons were generated from digital NWI data.

SENSITIVE BIOLOGICAL RESOURCES

Biological resources are stored as points or polygons. Associated with each 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/life-history time periods at monthly 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 as lines, points, or polygons. The resource types, names, and the sources for providing information are included in the database. All metadata sources are documented at the feature level.

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.

Amoroso, J.L. and A.S. Weakley, 1995, Natural Heritage Program List of Rare Plant Species of North Carolina. North Carolina Natural Heritage Program, Division of Parks and Recreation, North Carolina Department of Environment, Health, and Natural Resources, Raleigh, North Carolina, 84 pp.

Baker, S., 1977, The citizen's guide to North Carolina's shifting inlets. Sea Grant Publication, UNC-SG-77-08, 32 pp.

Bulger, A.J., B.P. Hayden, M.E. Monaco, D.M. Nelson, and G. McCornmick-Ray, 1993, Biologically-based salinity zones derived from multivariate analysis. Estuaries 16(2):311-322.

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At Research Planning, Inc. (RPI), Joanne Halls was the project manager. Shoreline mapping was conducted by Todd M. Montello. Additional biological and human-use resources data were collected by Scott Zengel, Christopher Locke, and Kara Hastings. The biological and human-use data were compiled onto basemaps and edited by Scott Zengel and Christopher Locke. Kara Hastings was the GIS coordinator. Kara Hastings, Christopher Locke, Mark White, Lee Diveley, and William Holton entered the data and produced the final maps. Systems administration was coordinated by William Holton. Graphics were provided by Joe Holmes and Rebecca Cox. Dot Zaino prepared the final text.

SPECIES LIST*

Common Name	Species Name
BIRDS	
DIVING BIRDS	
Common loon	*Gavia immer*
Red-throated loon	*Gavia stellata*
GULLS AND TERNS	
Black skimmer	*Rynchops niger*
Bonapartes gull	*Larus philadelphia*
Caspian tern	*Sterna caspia*
Common tern	*Sterna hirundo*
Forsters tern	*Sterna fosteri*
Great black-backed gull	*Larus marinus*
Herring gull	*Larus argentatus*
Laughing gull	*Larus atricilla*
Least tern	*Sterna antillarum*
Ring-billed gull	*Larus delawarensis*
Royal tern	*Sterna maxima*
Sandwich tern	*Sterna sandvicensis*
PASSERINE	
Seaside sparrow	*Ammodramus maritimus*
PELAGIC	
Northern gannet	*Morus bassanus*
RAPTORS	
Bald eagle	*Haliaeetus leucocephalus*
Merlin	*Falco columbarius*
Northern harrier	*Circus cyaneus*
Osprey	*Pandion haliaetus*
Peregrine falcon	*Falco peregrinus*
SHOREBIRDS	
American oystercatcher	*Haematopus palliatus*
Black-bellied plover	*Pluvialis squatarola*
Common snipe	*Gallinago gallinago*
Dunlin	*Calidris alpina*
Greater yellowlegs	*Tringa melanaleuca*
Least sandpiper	*Calidris minutilla*
Lesser yellowlegs	*Tringa flavipes*
Long-billed dowitcher	*Limnodromus scolopaceus*
Marbled godwit	*Limosa fedoa*
Pectoral sandpiper	*Calidris melanotos*
Piping plover	*Charadrius melodus*
Red knot	*Calidris canutus*
Ruddy turnstone	*Arenaria interpres*
Sanderling	*Calidris alba*
Semipalmated plover	*Charadrius semipalmatus*
Semipalmated sandpiper	*Calidris pusilla*
Short-billed dowitcher	*Limnodromus griseus*
Stilt sandpiper	*Calidris himantopus*
Western sandpiper	*Calidris mauri*
Whimbrel	*Numenius phaeopus*
Willet	*Catoptrophorus semipalmatus*
WADING BIRDS	
Black rail	*Laterallus jamaicensis*
Black-crowned night heron	*Nycticorax nycticorax*
Cattle egret	*Bubulcus ibis*
Clapper rail	*Rallus longirostris*
Glossy ibis	*Plegadis falcinellus*
Great blue heron	*Ardea herodias*
Great egret	*Casmerodius albus*
Green-backed heron	*Butorides striatus*
King rail	*Rallus elegans*
Least bittern	*Ixobrychus exilis*
Little blue heron	*Egretta caerulea*
Snowy egret	*Egretta thula*
Sora rail	*Porzana carolina*
Tricolored heron	*Egretta tricolor*
Virginia rail	*Rallus limicola*
White ibis	*Eudocimus albus*
Yellow rail	*Coturnicops noveboracensis*
Yellow-crowned night heron	*Nyctanassa violacea*
WATERFOWL	
American coot	*Fulica americana*
American wigeon	*Anas americana*
Black duck	*Anas rubripes*
Brant	*Branta bernicla*
Bufflehead	*Bucephala albeola*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Gadwall	*Anas strepera*
Goldeneye	*Bucephala spp.*
Green-winged teal	*Anas crecca*
Mallard	*Anas platyrhynchos*
Merganser	*Mergus spp.*
Northern pintail	*Anas acuta*

SPECIES LIST*

Common Name	Species Name
BIRDS (continued)	
WATERFOWL (continued)	
Northern shoveler	*Anas clypeata*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Ruddy duck	*Oxyura jamaicensis*
Scaup	*Aythya spp.*
Scoter	*Melanitta spp.*
Snow goose	*Chen caerulescens*
Whistling swan (tundra swan)	*Olor columbianus*
Wood duck	*Aix sponsa*
FISH	
ANADROMOUS	
Alewife	*Alosa pseudoharengus*
American shad	*Alosa sapidissima*
Atlantic sturgeon	*Acipenser oxyrhynchus*
Blueback herring	*Alosa aestivalis*
Shortnose sturgeon	*Acipenser brevirostrum*
Striped bass	*Morone saxatilis*
SPECIAL	
American eel	*Anguilla rostrata*
Atlantic croaker	*Micropogonias undulatus*
Atlantic menhaden	*Brevoortia tyrannus*
Bay anchovy	*Anchoa mitchilli*
Black drum	*Pogonias cromis*
Bluefish	*Pomatomus saltatrix*
Cobia	*Rachycentron canadum*
Gray snapper	*Lutjanus griseus*
Gulf flounder	*Paralichthys albigutta*
Ladyfish	*Elops saurus*
Mummichog	*Fundulus heteroclitus*
Pinfish	*Lagodon rhomboides*
Red drum	*Sciaenops ocellatus*
Seatrout (weakfish)	*Cynoscion regalis*
Sheepshead	*Archosargus probatocephalus*
Sheepshead minnow	*Cyprinodon variegatus*
Silversides	*Menidia spp.*
Southern flounder	*Paralichthys lethostigma*
Southern kingfish (whiting)	*Menticirrhus americanus*
Spanish mackerel	*Scomberomorus maculatus*
Spot	*Leiostomus xanthurus*
Spotted seatrout	*Cynoscion nebulosus*
Striped mullet	*Mugil cephalus*
Summer flounder	*Paralichthys dentatus*
White perch	*Morone americana*
REPTILES	
ALLIGATORS	
American alligator	*Alligator mississippiensis*
SHELLFISH	
BIVALVES	
American oyster (eastern)	*Crassostrea virginica*
Atlantic bay scallop	*Argopecten irradians*
Brackishwater clam	*Rangia cuneata*
Quahog spp. (hard clam)	*Mercenaria spp.*
CRABS	
Blue crab	*Callinectes sapidus*
SHRIMP	
Brown shrimp	*Penaeus aztecus*
Grass shrimp	*Palaemonetes sp.*
Pink shrimp	*Penaeus duorarum*
White shrimp	*Penaeus setiferus*
HABITATS	
SHRUBS	
Carolina grasswort	*Lilaeopsis carolinensis*
Seabeach amaranth	*Amaranthus pumilus*
Yellow fringeless orchid	*Platanthera integra*
SUBMERGED AQUATIC VEGETATION	
Seagrass	

* Threatened and endangered species are designated by underlining.

SHORELINE DESCRIPTIONS

EXPOSED, SOLID MAN-MADE STRUCTURES ESI = 1B

DESCRIPTION

- These structures are solid man-made structures such as seawalls, groins, revetments, piers, and port facilities.
- They are constructed of concrete, wood, or metal.
- Often there is no exposed substrate at low tide, but multiple habitats are indicated if present.
- They are built to protect the shore from erosion by waves, boat wakes, and currents, and thus are exposed to rapid natural removal processes.
- Attached animals and plants are sparse to moderate.

PREDICTED OIL BEHAVIOR

- Oil is held offshore by waves reflecting off the steep, hard surface in exposed settings.
- Oil readily adheres to the dry, rough surfaces, but it does not adhere to wet substrates.
- The most resistant oil would remain as a patchy band at or above the high-tide line.

RESPONSE CONSIDERATIONS

- Cleanup is usually not required.
- High-pressure water spraying may be conducted to:
  - remove persistent oil in crevices;
  - improve aesthetics; or
  - prevent leaching of oil.

FINE-GRAINED SAND BEACHES ESI = 3A

DESCRIPTION

- These beaches are generally flat and hard-packed.
- Though they are predominately fine sand, there is often a small amount of shell or shell hash.
- There can be heavy accumulations of wrack present.
- They are utilized by birds and turtles for nesting and feeding.
- Upper beach fauna include ghost crabs and amphipods; lower beach fauna can be moderate, but highly variable.

PREDICTED OIL BEHAVIOR

- Light oil accumulations will be deposited as oily swashes or bands along the upper intertidal zone.
- Heavy oil accumulations will cover the entire beach surface; oil will be lifted off the lower beach with the rising tide.
- Maximum penetration of oil into fine-grained sand is about 10 cm.
- Burial of oiled layers by clean sand within the first week after a spill typically will be less than 30 cm along the upper beach face.
- Organisms living in the beach sediment may be killed by smothering or lethal oil concentrations in the interstitial water.
- Biological impacts include temporary declines in infauna, which can affect important shorebird foraging areas.

RESPONSE CONSIDERATIONS

- These beaches are among the easiest shoreline types to clean.
- Cleanup should concentrate on removing oil and oily debris from the upper swash zone once oil has come ashore.
- Traffic through both oiled and dune areas should be severely limited, to prevent contamination of clean areas.
- Activity through both oiled and dune areas should be limited, to prevent contamination of clean areas.
- Manual cleanup, rather than road graders and front-end loaders, is advised to minimize the volume of sand removed from the shore and requiring disposal.
- All efforts should focus on preventing the mixture of oil deeper into the sediments by vehicular and foot traffic.
- Mechanical reworking of lightly oiled sediments from the high-tide line to the upper intertidal zone can be effective along outer beaches.

SCARPS AND STEEP SLOPES IN SAND ESI = 3B

DESCRIPTION

- This shoreline type occurs where sandy bluffs are undercut by waves or currents and slump; this shoreline type is common along the lower reaches of the New River (Stones Bay, Morgan Bay, and Stump Sound) in the vicinity of Camp Lejune Military Reservation.
- They normally form along embankments of sandy dredge material and at cutbanks in rivers; they also form where tidal creeks intercept old sandy beach ridge deposits.
- Some scarps are fronted by narrow beaches, if the erosion rates are moderate and episodic.
- Trees growing at the top of these slopes are eventually undercut and the logs can accumulate at the base of the scarp.
- Biological utilization by birds and infauna is low.

PREDICTED OIL BEHAVIOR

- Any stranded oil will concentrate at the high-water line and may penetrate sandy sediments.
- Oil will also adhere to the dry surfaces of any woody debris accumulated at the base of the scarp.
- There is little potential for burial except when a major slumping of the bluff occurs.
- Active erosion of the scarp will remove the oil.

RESPONSE CONSIDERATIONS

- In most cases, cleanup is not necessary because of the short residence time of the oil
- The need for removal of oiled sediments and debris should be carefully evaluated because of the potential for increased erosion.
- Closely supervised manual labor should be used so that the minimal amount of material is removed during cleanup.

MEDIUM- TO COARSE-GRAINED SAND BEACHES ESI = 4

DESCRIPTION

- These beaches have relatively steep beach faces with wide, unvegetated upper beach.
- They are composed of quartz sand and carbonate sediments.
- The amount of wrack varies considerably.
- They are utilized by birds and turtles for nesting and feeding.

PREDICTED OIL BEHAVIOR

- Light oil accumulations will be deposited as oily swashes or bands along the upper intertidal zone.
- Heavy oil accumulations will cover the entire beach surface; oil will be lifted off the lower beach with the rising tide.
- Maximum oil penetration is about 20 cm.
- Burial of oiled layers by clean sand within the first week after a spill typically can be up to 50 cm.
- Organisms living in the beach sediments may be killed by smothering or lethal oil concentrations in the interstitial water.
- Biological impacts include temporary declines in infauna, which can affect important shorebird foraging areas.

RESPONSE CONSIDERATIONS

- Coarse sand sediments are less trafficable, increasing the risk of mixing oil into the substrate by foot and vehicular traffic.
- Cleanup should concentrate on removing oil and oily debris from the upper swash zone once oil has come ashore.
- Traffic through both oiled and dune areas should be severely limited, to prevent contamination of clean areas.
- Manual cleanup, rather than road graders and front-end loaders, is advised to minimize the volume of sand removed from the shore and requiring disposal.
- All efforts should focus on preventing the mixture of oil deeper into the sediments by vehicular and foot traffic.
- Mechanical reworking of lightly oiled sediments from the high-tide zone to the upper intertidal zone can be effective along outer beaches.

RIPRAP **ESI = 6B**

DESCRIPTION

- Riprap structures are composed of cobble- to boulder-sized blocks of granite, limestone, or concrete.
- Riprap structures are used for shoreline protection and tidal-inlet stabilization
- Attached biota are sparse.

PREDICTED OIL BEHAVIOR

- Oil adheres readily to the rough surfaces of the blocks.
- Deep penetration of oil between the blocks is likely.
- Uncleaned oil can cause chronic leaching until the oil solidifies.

RESPONSE CONSIDERATIONS

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

EXPOSED TIDAL FLATS **ESI = 7**

DESCRIPTION

- Exposed tidal flats are broad intertidal areas composed primarily of sand and minor amounts of shell and mud.
- The presence of sand indicates that tidal currents and waves are strong enough to mobilize the sediments.
- They are usually associated with another shoreline type on the landward side of the flat, though they can occur as separate shoals; they are commonly associated with tidal inlets.
- Biological utilization can be very high, with large numbers of infauna, heavy use by birds for roosting and foraging, and use by foraging fish.

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 penetrate water-saturated sediments.
- Biological damage may be severe, primarily to infauna, thereby reducing food sources for birds and other predators.

RESPONSE CONSIDERATIONS

- Currents and waves can be very effective in natural removal of the oil.
- Cleanup is very difficult (and possible only during low tides).
- The use of heavy machinery should be restricted to prevent mixing of oil into the sediments.

SHELTERED SCARPS IN MUD **ESI = 8A**

DESCRIPTION

- Sheltered scarps form by boat-wake erosion of marsh fronts or muddy substrates along navigation channels.
- There may some fringing marsh at the base of the scarp along the edge of the water; it is not significant to map.

PREDICTED OIL BEHAVIOR

- Oil will not adhere to the wet sediment surface but could penetrate burrows if present.
- Stranded oil will persist because of low energy setting.

RESPONSE CONSIDERATIONS

- Where the high-tide area is accessible, it may be feasible to remove heavy oil accumulations and oiled debris.
- The muddy substrate cannot support heavy equipment, and even foot traffic could disrupt the sediments and mix oil deeper.

SHELTERED, SOLID MAN-MADE STRUCTURES ESI = 8B

DESCRIPTION

- These structures are solid man-made structures such as seawalls, groins, revetments, piers, and port facilities.
- Most structures are constructed of concrete, wood, or metal.
- Often there is no exposed beach at low tide, but multiple habitats are indicated if present.
- Most of the structures are designed to protect a single lot, thus their composition, design, and condition are highly variable.
- Attached animal and plant life can be moderate to high.

PREDICTED OIL BEHAVIOR

- Oil will adhere readily to the rough surface, particularly along the high-tide line, forming a distinct oil band.
- The lower intertidal zone usually stays wet (particularly if algae covered), preventing oil from adhering to the surface.

RESPONSE CONSIDERATIONS

- Cleanup of seawalls is usually conducted for aesthetic reasons or to prevent leaching of oil.
- Low- to high-pressure spraying at ambient water temperatures is most effective when the oil is fresh.

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, and are frequently backed by marshes.
- The sediments are very soft and cannot support even light foot traffic in many areas.
- They can be sparsely to heavily covered with algae and/or seagrasses.
- They can have very heavy wrack accumulations along the high-tide line.
- There can be large concentrations of shellfish, worms, and snails on and in the sediments.
- They are heavily utilized by birds and fish for feeding.

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 oyster beds.
- In areas of high suspended sediments, sorption of oil can result in deposition of contaminated sediments on the flats.
- Biological damage may be severe.

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.
- Low-pressure flushing and deployment of sorbents from shallow-draft boats may be helpful.

VEGETATED LOW RIVERINE BANKS ESI = 9B

DESCRIPTION

- Either low banks with grasses or low eroding banks with trees and tree roots exposed to the water.
- The banks are flooded occasionally by high water.
- These shorelines are generally found in fresh or brackish water localities.
- This shoreline type is common along many of the rivers, including the Pungo, Pamlico, and Neuse.

PREDICTED OIL BEHAVIOR

- During low water stages there could be little impact, with the oil coating a narrow band of sediment at the water level.
- During high water, the oil will cover and coat the grasses and base of the trees.
- May cause loss of the grasses, but the trees should survive unless oil penetrates and persists in the substrate.

RESPONSE CONSIDERATIONS

- Low-pressure flushing of oiled areas is effective in removing moderate to heavy accumulations of oil from along the banks.
- Sorbent and containment boom should be placed on the water side of the cleanup operations to contain and collect oil outflow.
- Low- to high-pressure flushing can be used to remove oil from tree roots and trunks, if deemed necessary in high-use areas.

SALT- AND BRACKISH-WATER MARSHES ESI = 10A

DESCRIPTION

- These marshes contain vegetation which tolerates water salinities down to about 5 parts per thousand.
- Width of the marsh can vary widely, from a narrow fringe to extensive areas.
- Sediments are composed of organic-rich muds except on the margins of barrier islands where sand is abundant.
- Exposed areas are located along bays with wide fetches and along heavily trafficked waterways.
- Sheltered areas are not exposed to significant wave or boat wake activity.
- Resident flora and fauna are abundant with numerous species with high utilization by birds, fish, and shellfish.

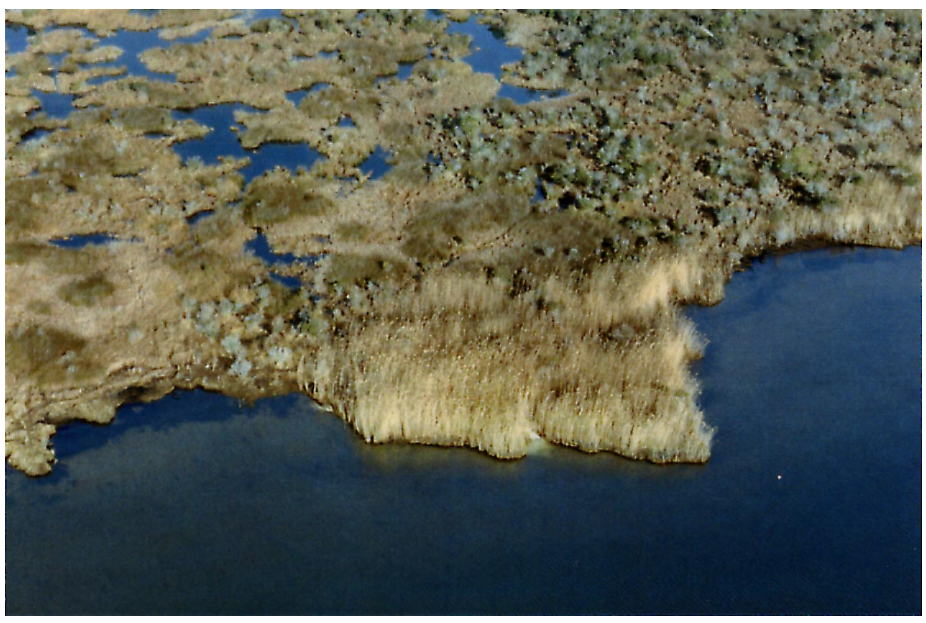
PREDICTED OIL BEHAVIOR

- Oil adheres readily to intertidal vegetation.
- The band of coating will vary widely, depending upon the water level at the time oil slicks are in the vegetation. There may be multiple bands.
- Large slicks will persist through multiple tidal cycles and coat the entire stem from the high-tide line to the base.
- If the vegetation is thick, heavy oil coating will be restricted to the outer fringe, although lighter oils can penetrate deeper, to the limit of tidal influence.
- Medium to heavy oils do not readily adhere to or penetrate the fine sediments, but can pool on the surface or in burrows.
- Light oils can penetrate the top few centimeters of sediment and deeply into burrows and mud cracks (up to one meter).

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is to let the area recover naturally.
- Natural removal processes and rates should be evaluated prior to conducting cleanup.
- 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 activities should be carefully supervised to avoid 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 are at great risk from leaving the oiled vegetation in place.

FRESHWATER MARSHES ESI = 10B



DESCRIPTION

- Freshwater marshes are grassy wetlands composed of freshwater vegetation.
- They occur upstream of brackish vegetation along major rivers such as the Cape Fear River and also dominate the shores of Lake Mattamuskett.
- Those along major channels are exposed to strong currents and boat wakes; inland areas are highly sheltered.
- The substrate is seldom exposed since daily water-level changes are low; greater changes occur during floods.
- Resident flora and fauna are abundant with numerous species and high utilization.

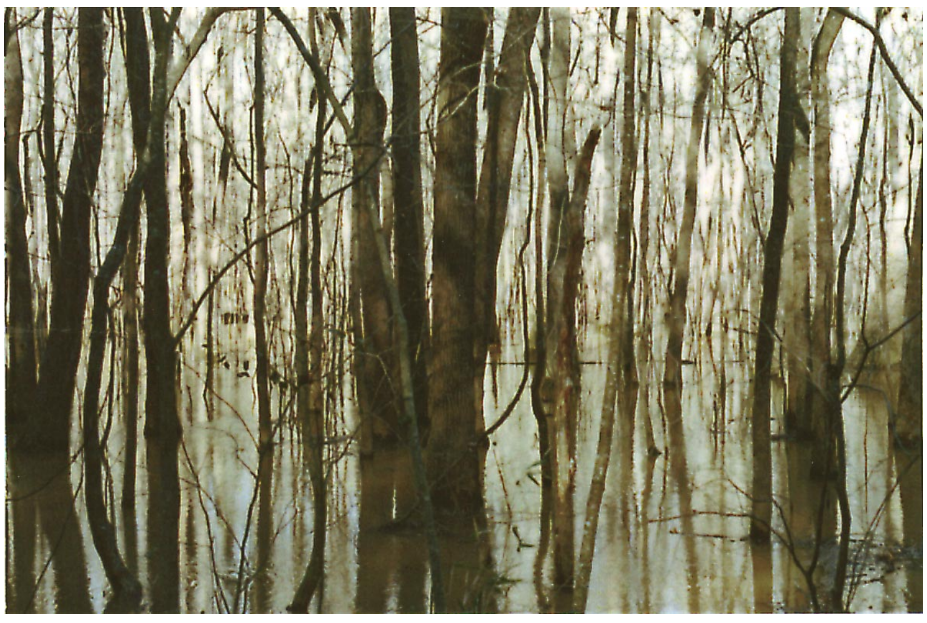
PREDICTED OIL BEHAVIOR

- Oil adheres readily to intertidal vegetation.
- The band of coating will vary widely, depending upon the water level at the time oil slicks are in the vegetation. There may be multiple bands.
- If the vegetation is thick, heavy oil coating will be restricted to the outer fringe, although lighter oils can penetrate deeper, to the limit of tidal influence or elevated water levels associated with a flood event.

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is to let the area recover naturally.
- Natural removal processes and rates should be evaluated prior to conducting cleanup.
- 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 activities should be carefully supervised to avoid 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 are at great risk from leaving the oiled vegetation in place.

FRESHWATER SWAMPS **ESI = 10C**



DESCRIPTION

- Freshwater swamps consist of shrubs and hardwood forested wetlands, which are regularly flooded.
- They are common along major rivers such as the Roanoke and Alligator.
- The sediment tends to be silty clay with large amounts of organic debris.
- They are seasonally flooded, though there are many low, permanently flooded areas.
- Resident flora and fauna are abundant with numerous species.

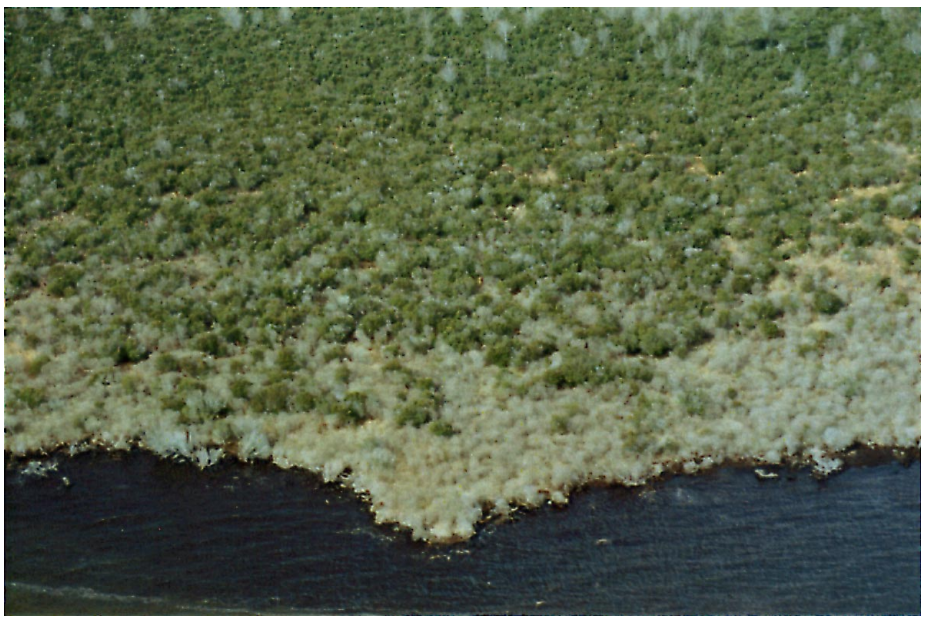
PREDICTED OIL BEHAVIOR

- Oil behavior depends on whether the swamp is flooded or not.
- During floods, most of the oil passes through the forest, coating the vegetation above the waterline, which changes levels throughout the flood event.
- Oiled woody vegetation is less sensitive than marshes to oil impacts.
- 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 content, muddy substrate, surface organic debris, and vegetation cover.
- Large amounts of oily debris can remain once water levels drop.
- 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.
- 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.
- 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 are at great risk from leaving the oiled vegetation in place.

SCRUB-SHRUB WETLANDS **ESI = 10D**



DESCRIPTION

- Scrub-shrub wetlands consists of woody vegetation less than 6m tall including true shrubs, small trees, and trees and shrubs that are stunted because of environmental conditions.
- The shoreline in the vicinity of Stump Point in Pamlico Sound contains an extensive scrub-shrub wetland.
- The sediment tends to be silty clay with large amounts of organic debris.
- They are seasonally flooded, though there are many low, permanently flooded areas.
- Resident flora and fauna are abundant with numerous species.

PREDICTED OIL BEHAVIOR

- Oil behavior depends on whether the wetland is flooded or not.
- During floods, most of the oil passes through the wetland, coating the vegetation above the waterline, which changes levels throughout the flood event.
- Oiled woody vegetation is less sensitive than marshes to oil impact.
- Some oil can be trapped and pooled on the wetland flood plain as water levels drop.
- Penetration into the floodplain soils is usually limited because of high water content, muddy composition, surface organic debris, and vegetation cover.
- Large amounts of oily debris can remain.
- 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.
- 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.
- 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 are at great risk from leaving the oiled vegetation in place.