ENVIRONMENTAL SENSITIVITY INDEX: SOUTH FLORIDA

INTRODUCTION

An Environmental Sensitivity Index (ESI) database has been developed for the marine and coastal areas of South Florida (Dry Tortugas, the Florida Keys, Florida Bay, and Biscayne Bay north to Boca Raton, Florida). The ESI database is a compilation of information from three main categories: shoreline habitats, sensitive biological resources, and human-use resources.

SHORELINE HABITAT MAPPING

The original ESI maps published in 1996 were re-examined and fully updated using the sources and methods described below. The intertidal shoreline habitats of South Florida were mapped and classified via interpretation of a continuous, overlapping set of georeferenced aerial photographs covering the entire study area. These aerial photographs were obtained via a geographic web server from the Marine Resource Geographic Information System and the Florida Fish and Wildlife Commission (FWC). Also used for classification was a continuous, overlapping set of geo-referenced oblique aerial photographs acquired for Monroe and Miami-Dade counties in 2010 during overflights conducted by Research Planning, Inc. (RPI) at elevations of 400-600 feet and slow air speed. All flights were planned to maximize time on site during the 2.5 hours preceding and the 2.5 hours following spring low tide. Where appropriate, revisions to the existing shoreline were made. Where necessary, multiple types were described for each shoreline segment.

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 affect 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 shoreline ranking. Generally speaking, shorelines 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 shorelines with associated high biological activity have the highest ranking. The list below includes the shoreline types delineated for South Florida, presented in order of increasing sensitivity to spilled oil.

1B) Exposed, Solid Man-made Structures
2A) Exposed, Wave Cut Platforms in Bedrock
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 (Shell) Beaches
6B) Riprap
7) Exposed Tidal Flats
8A) Sheltered Scarps in Clay or Bedrock
8B) Sheltered, Solid Man-made Structures
8C) Sheltered Riprap
9A) Sheltered Tidal Flats
9B) Vegetated Low Banks
9C) Hypersaline Tidal Flats
10A) Salt- and Brackish-water Marshes
10B) Freshwater Marshes
10C) Swamps
10D) Scrub-Shrub Wetlands and Mangroves

Each of the shoreline habitats are described on pages 11-18 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 following agencies:

- Florida Fish and Wildlife Conservation Commission – Fish and Wildlife Research Institute (FWC-FWRI)
- U.S. Fish and Wildlife Service (USFWS) – Florida Keys National Wildlife Refuge
- National Park Service (NPS) – Everglades National Park
- National Park Service (NPS) – South Florida/Caribbean Network
- Florida Natural Areas Inventory (FNAI)
- NOAA National Marine Fisheries Service (NMFS), Southeast Regional Office (SERO) and Southeast Fisheries Science Center (SEFSC)
- NOAA Fisheries Office of Sustainable Fisheries
- NOAA's Estuarine Living Marine Resources Program
- Haven Worth Consulting
- Audubon of Florida
- University of Miami Rosenstiel School of Marine and Atmospheric Science
- Texas State University
- U.S. Geological Survey – Southeast Ecological Science Center
- Miami-Dade Department of Environmental Resources Management
- Broward County – Natural Resources Planning and Management Division – Marine Resources Section
- Palm Beach County Department of Environmental Resources Management
- Sea to Shore Alliance

The above agencies provided the majority of the biological information included in the atlas. Other participating agencies will be featured in the sources table and cited in the metadata accompanying the digital product.

KEY FEATURES ON ESI MAPS

1) Animal and plant species that are at risk during oil spills and/or spill response are represented in the database by polygons and points.

2) 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.

TERRESTRIAL MAMMAL
- Small Mammal
- Ungulate

BIRD
- Diving Bird
- Gull/Tern
- Passerine
- Pelagic
- Raptor
- Shorebird
- Wading Bird
- Waterfowl

MARINE MAMMAL
- Dolphin
- Manatee

HABITATS
- Upland/Plant

BENTHIC HABITATS
- Coral/Hardbottom/Reef
- SAV

INVERTEBRATE
- Crab
- Echinoderm
- Gastropod
- Insect
- Crayfish/Lobster
- Shrimp

HERPETOFAUNA
- Crocodile
- Other Reptile
- Turtle

FISH
- Fish

3) Polygons are color-coded in the ArcMap project based on the species composition of each feature, as shown below:

ELEMENT	COLOR
Birds/Nests	Green
Fish	Blue
Invertebrates	Orange
Marine mammals	Brown
Terrestrial mammals	Brown
Reptiles/Amphibians	Red
Benthic habitats	Purple
Plants	Purple

4) There is a Resources at Risk number (RAR#) associated with each polygonal or point feature. The RAR# references

a table in the database that contains species names (common and scientific) associated with the feature.

5) Also associated with each species in the table is the state (S) and federal (F) protected status as threatened (T), endangered (E), species of special concern (C), as well as concentration, seasonality, and life-history information. Federal listings are provided by the USFWS. State listings are provided by FWC.

6) Feature level source information is included for each species within each RAR#, meaning there is a link to a table containing both a Geographic (G Source) and a Seasonality (S Source). Full bibliographic information is included for each source in the Sources Table.

MARINE MAMMALS

Marine mammals depicted in the South Florida atlas are limited to bottlenose dolphin (*Tursiops truncatus*) and West Indian manatee (*Trichechus manatus*, State and Federally endangered). It is possible that other marine mammals are found in the region periodically, but they are not common in the nearshore waters. Identified 'hotspot' areas of oceanic concentrations (i.e. sperm whales west of the Dry Tortugas) do not fall within the area of interest for this project. The Florida Keys National Marine Sanctuary lists the following animals as occurring within the sanctuary waters: Minke whale, Sei whale (FE), Fin whale (FE), Humpback whale (FE), North Atlantic right whale (FE), Sperm whale (FE), Pygmy sperm whale, Dwarf sperm whale, Antillean beaked whale, Cuvier's beaked whale, False killer whale, Short-finned pilot whale, Short-snouted spinner dolphin, Atlantic spotted dolphin, Spinner dolphin, and Risso's dolphin. Strandings of pygmy sperm whales, fin whales, pilot whales, and rough-toothed dolphins have all been reported in the Florida Keys. It is possible that any of these animals could occur in offshore waters, but they are not common.

West Indian manatees were mapped in inland waters, bays, and nearshore waters along the Florida Keys. High concentrations are found from Oct.-March in Biscayne Bay from Key Biscayne north, and in canals and inland waters to the northern end of the study area. Manatee geographic distribution, abundance, and seasonality data was provided via shapefile through a collaboration between Florida Fish and Wildlife Conservation Commission (FWC) – Fish and Wildlife Research Institute (FWRI), Miami-Dade Department of Environmental Resources Management, Broward County – Natural Resources Planning and Management Division – Marine Resources Section, Palm Beach County Department of Environmental Resources Management, and Sea to Shore Alliance.

Bottlenose dolphins are ubiquitous throughout the region. While it is likely that some areas may have higher concentrations than others, these areas have not been definitively identified. Estuarine stocks of bottlenose dolphins were mapped to coastal waters according to the concentrations reported in the NMFS stock assessment reports. Bottlenose dolphins are mapped as present in other shelf waters in the region.

Expert contacts for South Florida marine mammals* are:

Name	Agency	City	Phone	Species
Stacie Koslovsky	FWRI	St. Petersburg	727/896-8626	Manatees
Jenny Litz	NOAA SEFSC	Miami	305/361-4224	Bottlenose dolphins
Lance Garrison	NOAA SEFSC	Miami	305/361-4488	Marine mammals

***Note: this list is not meant to represent all marine mammal experts for the region.**

Major Data Sources Used: Marine Mammals

FWC-FWRI, Miami-Dade Department of Environmental Resources Management, Broward County – Natural Resources Planning and Management Division – Marine Resources Section, Palm Beach County Department of Environmental Resources Management, and Sea to Shore Alliance. 2012. ESI Manatee Relative Abundance in South Florida, vector digital data.

NOAA Fisheries, Office of Protected Resources. 2009. Bottlenose dolphin (*Tursiops truncatus*), Biscayne Bay Stock Assessment Report. Available at: http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2009dobn-bb.pdf

NOAA Fisheries, Office of Protected Resources. 2009. Bottlenose dolphin (*Tursiops truncatus*), Florida Bay Stock Assessment Report. Available at http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2009dobn-fb.pdf

Florida Keys National Marine Sanctuary. 2004. FKNMS Species list. Available at: http://floridakeys.noaa.gov/scipublications/speciesList.pdf

BIRDS

Birds displayed in this atlas include: diving birds, gulls, terns, passerine birds, pelagic birds, raptors, shorebirds, wading birds, and waterfowl. Species that are federally and state listed and coastal nesting, roosting, and migratory staging locations are specifically emphasized.

Bird occurrence information displayed in this atlas is based on information gathered at workshops and via phone/email correspondance with local resource experts from FWC-FWRI, USFWS – Florida Keys National Wildlife Refuges and South Florida Ecological Services Office, NPS – Everglades National Park and South Florida/Caribbean Network, Texas State University, and Audubon of Florida. Additional hardcopy and digital sources are listed below and included in the metadata.

Breeding and Wintering Birds – Survey data on locations of breeding, wintering, and resident birds were provided via shapefiles for the following species and species groups: bald eagle; wading birds; beach nesting birds; reddish egret, roseate spoonbill; piping, snowy, and Wilson's plover; Everglades National Park, Biscayne Bay National Park, and Dry Tortugas National Park breeding colonies; shorebirds; wood stork; Cape Sable seaside sparrow; brown pelican; and magnificent frigatebird. Source information is provided below and in the accompanying data tables and metadata. Point and polygon data were mostly displayed as it was received from the data providers. For species and data sets for which concentration information was available, if the data provided contained a single year of count data, that count was displayed in the concentration field. For data sets with multiple years of data, the maximum value or most recent year recorded at a site over the months or years surveyed is displayed in the concentration field. These data sets were supplemented with information provided in hardcopy documents and by local resource experts. In particular, USFWS, NPS, Audubon of FL, and FWC staff provided additional insight on birds that nest on the Florida Keys and keys within Florida Bay. Bird data collected through Christmas Bird Counts and reported to www.eBird.org were used to depict species utilizing the Dry Tortugas, Florida Bay, and Biscayne Bay.

Please note that locations of nesting, wintering, and/or migratory sites, species composition within a given point or polygon, and particularly concentration values, are based on a compilation of observations made over a multi-year period and are not meant to accurately reflect 'current' conditions in the case of an event. Survey limitations and adjustments in protocols over numerous years, changes in shoreline geomorphology (particularly on small/ephemeral islands), weather, and numerous other ecological factors contribute to the condition of nesting colonies, solitary nest locations, and migratory or other concentrations at any given time. Also, please note that concentrations vary throughout the multi-month nesting, migratory, and wintering period listed in the seasonality table. Please contact local resource experts in the event of a spill or if data are to be used for any reason other than spill preparedness or response.

Expert contacts for South Florida birds* are:

Name	Agency	City	Phone	Species
Janell Brush	FWC	Gainesville	352/955-2081	Eagles, pelicans
Clay Green	Texas State Univ.	San Marcos, TX	512/245-8037	Reddish egrets
Jerry Lorenz	Audubon of FL	Tavernier	305/852-5318	FL Bay birds
Pete Frezza	Audubon of FL	Tavernier	305/852-5318	FL Bay birds
Lori Oberhofer	NPS – ENP	Homestead	305/242-7889	ENP birds
Mario Alvarado	NPS-ENP	Homestead	305/242-7884	ENP birds
Ricardo Zambrano	FFWCC	West Palm Beach	561/882-5719	South FL birds
Tom Wilmers	USFWS – FL Keys NWRs	Big Pine Key	305/879-9352	FL Keys birds
Judd	NPS – So.	Palmetto	786/249-	NPS birds

Name	Agency	City	Phone	Species
Patterson	Florida/ Caribbean Network	Bay	0044	

***Note: this list is not meant to represent all bird experts for the region.**

Major Data Sources Used: Birds

Audubon of Florida. 2012. Roseate spoonbill colony coordinates, tabular digital data.

Florida Fish and Wildlife Conservation Commission (FWC). 2010. Beach Nesting Birds (BNB): 2005-2010, vector digital data.

FWC. 2012. Bald Eagle Nests Florida 2011, vector digital data.

FWC. 2012. Florida Shorebird Database: 2011, vector digital data.

FWC. 1999. Wading Bird Rookeries Florida, vector digital data .

FWC-FWRI. 2003. Midwinter Waterfowl Inventory (MWI) FL Corrected Data, tabular data.

Florida Natural Areas Inventory (FNAI). 2011. Element Occurrence Polygon Data Layer, vector digital data.

Frohring, P.C. and J.A. Kushlan. 1986. Nesting status and colony site variability of laughing gulls in southern Florida. Florida Field Naturalist 14:1-17.

Texas State University. 2007. Reddish egret Florida colonies 2007, tabular digital data.

Maehr, D.S. and H.W. Kale II. 2005. Florida's Birds: 2nd Ed. A Field Guide and Reference. Pineapple Press, Inc., Sarasota, FL, 359 pp.

NPS, Everglades National Park. 2013. Brown pelicans and magnificent frigatebirds, Google Earth kmz file.

NPS, Everglades National Park. 2012. Cape Sable Seaside Sparrow occupancy area, vector digital data.

NPS, Everglades National Park. 2012. ENP colony data, tabular digital data.

NPS, Everglades National Park. 2012. Everglades wood stork foraging data, tabular digital data.

NPS, South Florida/Caribbean Network. 2011. Biscayne bird colonies 2011, vector digital data.

NPS, South Florida/Caribbean Network. 2010. Dry Tortugas bird colony shapes 2010, vector digital data.

Pranty, B. 2010. The Important Bird Areas of Florida. Special Publication No. 8. Florida Ornithological Society. Audubon of Florida, Gainesville, FL, 220 pp.

USFWS. 2009. Lower Florida Keys National Wildlife Refuges Comprehensive Conservation Plan. U.S. Department of the Interior Fish and Wildlife Service, Southeast Region, Atlanta, GA, 334 p.

USFWS. Piping plover critical habitat, vector digital data.

USFWS. 2011. South Florida international winter plover census 2011, vector digital data.

USFWS. 2012. Wood stork colonies, vector digital data.

REPTILES

Reptiles depicted in this atlas include threatened, endangered, and rare species and coastal species of ecological concern.

Sea turtles – Green (FE/SE), hawksbill (FE/SE), Kemp's ridley (FE/SE), leatherback (FE/SE), and loggerhead (FT/ST) sea turtles were included in this atlas. Both nesting and in-water presence polygons are displayed.

Nesting: Beaches are surveyed annually as part of the FWC-coordinated Statewide Nesting Beach Survey Program. The sea turtle nesting data summarized here describe the most recent five years of monitoring (2007-2011). For each of the three more common nesting species (loggerhead, green, and leatherback), the earliest and latest recorded nesting month during the last five years is included in the seasonality table. Species nesting densities were classified as "low", "medium", "high", or "rare" relative to the remainder of surveyed sea turtle nesting beaches in Florida. Hawksbill sea turtles have been observed at two beaches in the study area, and are listed as such.

In-water: The potential presence of sea turtles within south Florida waters was determined based on an examination of all available in-water sea turtle research information (Eaton et al. 2008). FWRI evaluated the in-water presence of loggerheads, greens, leatherbacks, hawksbills and Kemp's ridleys. They also incorporated occurrence information derived from Sea Turtle Stranding and Salvage Network records from 1986 through 2007. Potential presence of sea turtles is described by species and life stage. Species/life-stages likely to be present in the area are noted as present in the concentration field. Rare occurrence refers to species/life-stages that may occur but have not been documented in the area of interest.

- Loggerhead turtles of all life stages may be present in nearshore and offshore waters of south Florida throughout the year. A major foraging area exists within Florida Bay and is comprised of both adult and non-adult animals. Reproductively active loggerheads use continental shelf waters offshore of south Florida during time periods surrounding the nesting season.
- Non-adult green turtles may be present in inshore mangrove and seagrass habitats throughout the year. Non-adult green turtles may also be present, year-round, at nearshore hardbottom habitats off of southeast Florida. Adult green turtles may be present in waters near nesting beaches during time periods surrounding the nesting season. A year-round foraging aggregation of adult green turtles has been documented in Monroe County in the waters surrounding and west of the Marquesas Keys.
- Leatherback turtles may be encountered in offshore waters throughout the year. Adults and hatchlings are the life stages most likely to be encountered nearshore during the nesting season.
- Hawksbill turtles of all life stages are present throughout the year in nearshore reef and hardbottom habitat. Post-hatchling hawksbills occur in offshore waters of this area.
- Non-adult Kemp's ridley sea turtles may be present throughout south Florida waters during all months. Adult Kemp's ridley sea turtles are not often documented in south Florida although they may occur.

Crocodiles – American crocodile (FT/ST) nesting beaches are shown in the atlas as polygonal stretches of land that represent their primary nesting sites. These areas were identified by NPS-Everglades National Park. Nesting points provided by the USFWS were aggregated into polygons representing stretches of beach also. Concentration data on crocodile nesting were compiled from annual monitoring reports (2008 and 2010) and expert opinion from NPS. Nesting concentrations are categorical, ranging from 'Low' to 'Very High', based the number of nests present from the 2008 report and modified by expert opinion. Based on report numbers, the following numbers roughly approximate the number of nests in 2008 (Very High: >25, high: 15-25, Med: 5-15, Low: <5). 2008 nesting data were used instead of 2010 data because it represented a more typical nesting year. In addition to nesting sites, areas of high juvenile and adult abundance were included in the atlas, and adults were mapped to the range of the species, depicted as the critical habitat modified by anecdotal information from FWC.

Other reptiles – FNAI data was used to supplement data provided by State and Federal resource experts for federal and state threatened, endangered, and special concern species, as well as a few rare species (see species list for details) of ecological importance. Mangrove terrapins were mapped in a few locations where they have been observed in the Florida Keys and Florida Bay. American alligators were not mapped in the atlas because they are mostly found inland of the area of interest for this project.

Expert contacts for South Florida reptiles* are:

Name	Agency	City	Phone	Species
Anne Meylan	FWRI	St. Petersburg	727/896-8626	Sea turtles
Robert Hardy	FWRI	St. Petersburg	727/896-8626	Sea turtles
Ricardo Zambrano	FWC	West Palm Beach	561/625-5129	South FL species
Kristen Hart	USGS	Davie	954/236-1067	Sea turtles
Tom Wilmers	USFWS	Big Pine Key	305/872-9352	Mangrove terrapin
Mark Parry	NPS	Homestead	305/242-7893	Crocodiles, terrapins
Judd Patterson	NPS	Palmetto Bay	786/249-0044	South FL species

***Note: this list is not meant to represent all reptile experts for the region.**

Major Data Sources Used: Reptiles

Bresette, M.J., B.E. Witherington, R.M. Herren, D.A. Bagley, J.C. Gorham, S.L. Traxler, C.K. Crady, R. Hardy. 2010. Size-class partitioning and herding in a foraging group of green turtles *Chelonia mydas*. Endangered Species Research 9:105-116.

Cherkiss, M.S. et al. 2011. The American Crocodile in Biscayne Bay, FL. Estuaries and Coasts 43:529-535.

Eaton, C., E. McMichael, B. Witherington, A. Foley, R. Hardy, and A. Meylan. 2008. In-water sea turtle monitoring and research in Florida: review and recommendations. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-OPR-38, 233 p.

FWC-FWRI. 2013. FWC sea turtle nesting density, 2007-2011, vector digital data.

FNAI. 2011. Element Occurrence Polygon Data Layer, vector digital data.

Hart, K.M., I. Fujisaki, A.R. Sartain. 2012. RNA Performance Topic 2. Chapter 5: Use of Dry Tortugas National Park by threatened and endangered marine turtles. *In* Ziegler, T.A. and Hunt, J., editors. 2012. Implementing the Dry Tortugas National Park Research Natural Area Science Plan: The 5-Year Report 2012. South Florida Natural Resources Center, Everglades and Dry Tortugas National Parks, Homestead, FL, and the Florida Fish and Wildlife Conservation Commission, Tallahassee, FL. 63 pp.

Hart, K.M., A.R. Sartain, I. Fujisaki, H.L. Pratt Jr., D. Morley, M.W. Feeley. 2012. Home range, habitat use, and migrations of hawksbill turtles tracked from Dry Tortugas National Park, Florida, USA. Marine Ecology Progress Series 457:193-207.

Hart, K.M., D.G. Zawada, I. Fujisaki, B.H. Lidz. 2010. Inter-nesting habitat-use patterns of loggerhead sea turtles: enhancing satellite tracking with benthic mapping. Aquatic Biology 11:77-90.

Rice, K.G. et al. (Eds). 2009. 2008 Annual Assessment Update: American Alligator Distribution, Size, and Hole Occupancy and American Crocodile Juvenile Growth and Survival. Prepared for the U.S. Army Corps of Engineers, 154 pp.

TERRESTRIAL MAMMALS

The following terrestrial mammals were included in this atlas: Key Largo woodrat (FE/SE), silver rice rat (FE/SE), Key Largo cotton mouse (FE/SE), Florida key deer (FE/SE), and lower keys marsh rabbit (FE/SE). Data were provided by USFWS.

Expert contacts for South Florida terrestrial mammals* are:

Name	Agency	City	Phone	Species
Steve Glass	USFWS	Vero Beach	772/562-3909	T/E species
Phillip Hughes	USFWS	Big Pine Key	305/872-2239	FL Keys NWR species

***Note: this list is not meant to represent all terrestrial mammal experts for the region.**

Major Data Sources Used: Terrestrial Mammals

USFWS. 2011. Cotton mouse focus area, vector digital data.

USFWS. 2011. Key deer focus area, vector digital data.

USFWS. 2011. Marsh rabbit focus area, vector digital data.

USFWS. 2011. Silver rice rat focus area, vector digital data.

USFWS. 2011. Woodrat focus area, vector digital data.

FISH

Fish species depicted in this atlas include selected marine, estuarine, and brackish/fresh water species. Species of commercial, recreational, ecological, and/or conservation interest are emphasized. Commercially important species include species harvested as food or bait and for the aquarium trade. Fish polygons were created based on surveys, digital data, hardcopy reports (see references), and expert opinion provided by resource experts at FWC-FWRI, NOAA and NPS.

Where possible, quantitative data were used to map species densities. If quantitative data were not available, anecdotal or published information was used to assign species to areas based on the benthic (seagrass, reef, hardbottom) or shoreline (mangrove) habitats mapped in the ESI, or to depth zones meant to represent more general species distributions.

Quantitative datasets included in the ESI fish layer include:

Reef visual census (RVC) survey data: Density estimates for commonly encountered reef fish were provided by NOAA SEFSC, based on 2008-2011 RVC sampling data. Densities are included in the concentration field as fish per hectare. Densities were provided for each combination of seven habitat-based strata (Forereef deep low relief, Forereef mid-channel low relief, Forereef shallow low relief, High relief reef [spur and groove], Inshore patch reef, Mid-Channel patch reef, Offshore patch reef), eight geographic regions (Dry Tortugas, Marquesas-Tortugas, Marquesas, Lower Keys, Middle Keys, Mid-Upper Keys, Upper Keys and Key Biscayne), and two protection statuses (protected area or unprotected area). In order to display the data in the ESI products, a crosswalk was developed to match the RVC categories to benthic data displayed in the ESI benthic layer (based on the Unified Florida Reef Tract Map, Level 3; see benthic layer section for details). Densities provided by the RVC were then attributed to polygons representing the appropriate habitat types from the ESI benthic layer, resulting in consistency between the ESI benthic and fish layers (i.e. reef fish are displayed on top of mapped reefs). The RVC data were the best available source for information on reef fish in this region, with a few caveats. Cryptic species are generally considered to be under-represented in this dataset. Reef fish are generally present year round; however some species, such as groupers, will move from deeper to shallower waters, making them more common in the winter. Because sampling for the RVC data set is conducted primarily during the summer, the abundance of groupers, which have higher densities in the winter, may be underestimated.

Reef Environmental Education Foundation (REEF) data: The REEF database, which contains survey data collected by qualified volunteer divers, was used to calculate information on densities for areas north of the RVC survey area (roughly north of Government Cut). Benthic habitats in the region were divided into three categories: hard bottom, inner reef and outer reef. Survey data were aggregated for each of the three types according to the spatial location associated with the REEF survey. Density scores were calculated by multiplying the categorical abundances provided by the REEF dataset (1 – Single, 2 - Few (2-10), 3- Many (11-100), 4- Abundant (>100)) by the occurrence of a species in a strata. Scores were then converted into categorical concentration values, as shown below:

Categorization schema used for REEF data:

Abundance score	Percent occurrence	Average REEF densities (abundance x occurrence)	ESI concentration
> 1.5	> 0.5	> 3	Highly abundant
1.0-1.5		1-3	Abundant
0.1-1.0	0.1-0.5		Common
< 0.1	<0.1	< 1	Uncommon

Nearshore hard-bottom dataset: Nearshore hard-bottom monitoring data from 2002-2007 were obtained from FWRI-Marathon. Areas labeled as shallow (<3.7m) pavement in the ESI benthic layer were divided into geographic regions based on the information provided with the study report. Densities calculated in the report were assigned to the appropriate polygons in the ESI fish layer, and are reported in number of organisms observed per 100 square meters. Information on life stages and seasonalities present in these habitats was obtained from expert knowledge, and by comparing fish lengths in the database to published lengths at maturity in fishbase.

Other major sources of data used in the South Florida ESI atlas are:

Spawning areas: Reef fish spawning aggregation areas were identified based on published literature and expert knowledge from staff at FWRI, NPS and NOAA SEFSC. Areas are depicted as large polygons that include spawning locations. Actual spawning locations are highly localized; therefore spawning aggregations will not be found in the entire polygon. Concentrations are noted as 'spawning area' along with the numbers of fish observed, when available. It is possible that some of these species spawn elsewhere in the study area in addtition to the designated spawning areas.

Estuarine Living Marine Resources (ELMR) data: The ELMR database describes the abundance and seasonality of common estuarine organisms based on salinity zones created for each estuary. ELMR data were used in Biscayne and Florida Bays. Because the area of both of these bodies of water contained mostly one 'high salinity' region, each bay was represented as a single polygon. It should be noted; however, that salinities in both estuaries vary greatly depending on the season and amount of precipitation (wet vs. dry years). Expert opinion from staff at

FWRI was used to adjust the concentrations and fill in data gaps between the two estuaries whenever possible. Additional species were added to the estuarine polygons based on expert opinion and other data sources.

Fisheries Layer: 15-year average commercial fisheries data (FWRI trip ticket data) were used to create a layer representing the relative distribution of fish and invertebrate fisheries in south Florida. Statistical reporting areas were provided by FWC in the form of shapefiles and paper maps. For each statistical reporting area, the ESI fisheries layer displays the annual average landings (fish caught in pounds), annual average catch per unit effort (pounds per trips), annual average value (in dollars), regularly occurring seasonal closures (usually to protect spawning aggregations) and harvest type (either 'marine life' for aquarium species or 'food/bait' for other commercially harvested species). Regulations are current as of January 1, 2013, but could change at any time in the future. Areas where fishing is prohibited were removed from the spatial extent of this layer, and include the Florida Keys National Marine Sanctuary Special Protection Areas (SPAs), Ecological reserves and research only areas for fish, Biscayne Bay Lobster Sanctuary for spiny lobster, and Biscayne Bay National Park for marine life species. The Tortugas shrimp sanctuary was not removed from the fishery layer, but falls in areas 1.9 and 2.8. Parts of these areas are seasonally or permanently closed to shrimp trawling. Please note, that the values reported for each stastical grid are not evenly distributed across the study area. Water bodies for which fisheries data were mapped include the Dry Tortugas, Key West, Marathon, Everglades, Miami and West Palm Beach. Waters are categorized into those under state jurisdiction (3 nm on the Atlantic coast and 9 nm on the Gulf coast) and federal jurisdiction (further divided into Gulf or Atlantic waters for the Tortugas, Key West and Marathon).

Sensitive fish species: Sensitive species mapped in the ESI include smalltooth sawfish (FE/SE), Nassau grouper (NOAA SOC), Goliath grouper (NOAA SOC), bluefin tuna (NOAA SOC), mangrove rivulus (NOAA SOC/FL SSC), and key silverside (NOAA SOC/ST). Smalltooth sawfish records from the National Sawfish Encounter Database (2003-2011) were provided by NOAA and used as a guide for mapping this species. Critical habitat was used to represent nursery areas for smalltooth sawfish. Goliath grouper and Nassau grouper were mapped to appropriate depth ranges, based on literature reported values and observations from the REEF and RVC datasets. Essential fish habitat (EFH) was used as guidance for mapping bluefin tuna. Offshore waters in this area are important passageways for migration of juveniles from spawning grounds in the Gulf of Mexico to secondary nursery areas in the Atlantic Ocean. Key silverside and mangrove rivulus were mapped based on species descriptions found in published literature and expert opinion.

Highly migratory species and sharks: NMFS EFH designations were used as a guide for mapping certain species of highly migratory fish and sharks. Highly migratory species mapped based on EFH information include blue marlin, sailfish, swordfish, white marlin and yellowfin tuna. Shark species mapped based on EFH in South Florida waters include lemon shark, nurse shark, bull shark, bonnethead shark, blacktip shark, scalloped hammerhead shark and dusky shark (NOAA SOC). Shark polygons were refined based on published information and expert opinion from Tonya Wiley-Lescher (Haven Worth Consulting). Life-history stages for sharks, rays and sawfish do not match the standard ESI life-history stages for fish, and should be interpreted as the following: spawning = parturition; larvae = neonate, with the exception of nurse sharks in the Dry Tortugas, which mate in the shallows in June-July and return to pup in November (both seasons are marked as 'spawning').

Expert opinion and published reports or scientific papers were used to map additional species or life history stages. Ed Matheson (FWRI) contributed heavily to the development of the species list, habitat-based mapping, and seasonality information. Pelagic fish seasonality information was provided by FWRI based on commercial encounters. Many species were mapped to depth-based polygons, which were divided into the following bins: 0-3.7 m, 3.7-10 m, 10-30 m, 30-100 m, 100-200 m and greater than 200 m. The benthic layer is mostly within the <30 m range, so all species mapped offshore of the 30 m of water are not mapped to specific habitats.

Expert contacts for South Florida fish* are:

Name	Agency	City	Phone	Species/ Programs
Alejandro Acosta	FWC - FWRI	Marathon	305/289-2330	Fish
Jeremiah Blondeau	NOAA SEFSC	Miami	305/361-4249	Reef fish
Jim Bohnsack	NOAA SEFSC	Miami	305/461-4252	Reef fish
Steve Brown	FWC - FWRI	St. Petersburg	727/896-8626	Marine fisheries
Mike Feeley	NPS	Palmetto Bay	305/252-0347	Marine ecology
John Hunt	FWC - FWRI	Marathon	305/289-2330	Fish
Ed Matheson	FWC-FWRI	St. Petersburg	727/896-8626	Finfish
David Moe Nelson	NOAA	Silver Spring, MD	301/713-3028 x 154	ELMR data
Shelley Norton	NOAA	St. Petersburg	727/551-5781	Smalltooth sawfish
Christy Pattengill-Semmens	REEF	San Diego	n/a	Reef fish
Tonya Wiley – Lescher	Haven-worth Consult-ing	Houston	281/309-6561	Elasmobranchs

***Note: this list is not meant to represent all fish experts for the region.**

Major Data Sources Used: Fish

Acosta, A. et al. 2007. Fish assemblages in seagrass habitats of the Florida Keys, Florida: Spatial and temporal characteristics. Bulletin of Marine Science 81(1):1-19.

Castro, J.I. 2011. The Sharks of North America. Oxford University Press: New York, NY.

FWC-FWRI. 2011. Marine Fisheries Trip Ticket area codes geodatabase, vector digital data.

Froese, R. and D. Pauly. Editors. 2011. FishBase. Online database. Available at www.fishbase.org

Lindeman, K.C. et al. 2000. Developmental patterns within a multispecies reef fishery: Management applications for essential fish habitats and protected areas. Bulletin of Marine Science 66(3): 929-956.

Munro, J.L. et al. 1972. The spawning seasons of Caribbean reef fishes. Journal of Fish Biology 5: 69-84.

Norton, S. (NOAA Fisheries). 2012. National Sawfish Encounter Database, 2003-2012 smalltooth sawfish encounters for the state of Florida, January 2012, digital map.

NOAA Center for Coastal Monitoring and Assessment. 1991. Distribution and Abundance of Fishes and Invertebrates in Southeast Estuaries, vector digital and tabular data.

NOAA Center for Coastal Monitoring and Assessment. 1998. Distribution and Abundance of Fishes and Invertebrates in Gulf of Mexico Estuaries, vector digital and tabular data.

NOAA Fisheries: Office of Sustainable Fisheries. 2009. Highly Migratory Species – Essential Fish Habitat 2009, vector digital data.

NOAA Fisheries: Office of Sustainable Fisheries. 2009. Amendment 1 to the consolidated highly migratory species fisheries management plan: Chapter 5 Essential Fish Habitat, Silver Spring, MD.

NOAA-SEFSC. 2011. Densities of common reef fish by geographic region, habitat, and protection status from the reef visual census database, vector digital data.

Powell, A.B. et al. 2007. Juvenile and small resident fishes of Florida Bay, A Critical Habitat in Everglades National Park, Florida. NOAA Professional Paper NMFS 6, 219 pp.

Serafy, J.E. et al. 2003. Mangrove shoreline fishes of Biscayne Bay, Florida: Spatial and temporal characteristics. Bulletin of Marine Science 72(1):161-180.

Tellier, M. et al. 2008. Monitoring the flora and fauna of the nearshore hardbottom habitats of the Florida Keys. Final report to Florida's State Wildlife Grants Program. FWRI File code: F2196-05-08-F, 84 pp.

INVERTEBRATES

Invertebrates depicted in this atlas include selected marine and estuarine species of commercial, recreational, ecological, and/or conservation interest.

Queen conch spawning areas were provided by FWRI. Delineated areas were buffered to reflect the actual range of areas used by conch; therefore, spawning aggregations may not be

present throughout the mapped area. Categorical densities of low (<200/hectare), medium (200-800/hectare) and high (>800/hectare) were assigned to the aggregation areas for juveniles and adults. Each area has a value for adults and juveniles, noted in the concentration field. Where aggregation areas overlap, the concentration reflects the higher of the abundances present. Densities for aggregation areas were assigned a year-round seasonality but are likely higher in the summer. Records with months noted in the 'Spawn/mate' life-history category refer to months in which queen conch are mating and laying eggs. Gabe Delgado (FWRI) provided anecdotal information on additional low density aggregation areas inside of Hawk's channel. These do not represent spawning areas.

Spiny lobster distribution was mapped based on anecdotal information from staff at FWRI - Marathon. Densities are reported as high or low, along with the corresponding density values taken from Bertelsen et al. (2004).

Pink shrimp and stone crab distributions were mapped based on anecdotal information from Ryan Gandy and Charles Crawford at FWRI. Areas depicted are intended to represent the main centers of abundance for these species, both of which support extremely valuable commercial fisheries.

Invertebrate fisheries were also included in the fisheries layer (see fish section above). Additional species were mapped based on information in the nearshore hard-bottom dataset (see fish section above), expert knowledge and published reports. Please note, for stone crabs and spiny lobsters the life history stages recorded as 'eggs' rfers to the presence of egg bearing females.

Some sensitive species were also mapped based on data provided by FNAI, local resources experts from USFWS and FWC, and the Federal Register.

Expert contacts for South Florida invertebrates* are:

Name	Agency	City	Phone	Species/ Program
Rod Bertelsen	FWC-FWRI	Marathon	305/289-2330	Spiny lobster, other inverts
Gabe Delgado	FWC-FWRI	Marathon	305/289-2330	Queen conch
Ryan Gandy	FWC-FWRI	St. Petersburg	727/896-8626	Invertebrate fisheries
Steve Geiger	FWC-FWRI	St. Petersburg	727/896-8626	Shellfish
Tom Matthews	FWC-FWRI	Marathon	305/289-2330	Spiny lobster

***Note: this list is not meant to represent all invert experts for the region.**

Major Data Sources Used: Invertebrates

Bertelsen et al. 2004. A reexamination of monitoring projects of southern Florida adult spiny lobster. American Fisheries Society Symposium 42:195-210.

Department of the Interior. Fish and Wildlife Service. 2012. 50 CFR Part 17. Endangered and Threatened Wildlife and Plants; Listing of the Miami Blue Butterfly as Endangered Throughout Its Range; Listing of the Cassius Blue, Ceranus Blue, and Nickerbean Blue Butterflies as Threatened Due to Similarity of Appearance to the Miami Blue Butterfly in Coastal South and Central Florida; Final Rule. Federal Register/Vol. 77, No. 67.

FWC-FWRI. 2012. Queen conch aggregation areas, vector digital data and tabular data.

FNAI. 2011. Element Occurrence Polygon Data Layer, vector digital data.

NOAA Center for Coastal Monitoring and Assessment. 2011. Estuarine Living Marine Resources (ELMR) data, vector digital and tabular data.

BENTHIC MARINE HABITATS AND PLANTS

FWRI provided a copy of the Unified Florida Reef Tract Map for use as the primary benthic marine habitat layer in the South FL ESI. The unified reef map integrates benthic mapping efforts along the Florida Keys Reef Tract, Florida Bay and Gulf of Mexico coastal waters along the Florida Keys. This map employs a hierarchically tiered Unified Classification (UC) system which progressively aggregates classes into coarser thematic units until reaching a lowest common denominator classification that provides a common and consistent picture of the entire area. This approach provides common class values for five levels of thematic detail, UC Level 0 – 4, allowing for flexibility in the scope of analysis. To maintain a level of detail commensurate with oil spill response and planning, we chose to display UC Level 3 in the ESI products. The classification schema included attributes describing both the geological formation and biological communities associated with each feature, when available. The following "geoforms" and "biological cover" types from Level 3 were incorporated into the ESI benthic layer:

Coral Reef and Hard-bottom Types:

- Aggregate reef
- Live coral (10-50% cover or discontinuous in the concentration field)
- Coral patch reef
- Pavement
- Reef rubble
- Reef terrace (high profile)
- Remnant (low profile)
- Ridge
- Spur and groove (high relief)
- Wormrock
- Scattered coral/rock

Biological Cover Types:

- Algae (continuous or discontinuous in the concentration field)
- Seagrass (continuous or discontinuous in the concentration field)

Other

- Unconsolidated sediment/sand

Many polygons in the ESI benthic layer, based on the FWRI data, have both a 'geoform' and a 'biological cover', for instance 'pavement' with 'discontinuous seagrass' will be listed as separate species occurring in the same RARNUM.

In addition to the Unified Florida Reef Tract Map, FWRI provided point locations for two federally threatened coral species, elkhorn coral (*Acropora palmata*) and staghorn coral (*Acropora cervicornis*). The data set depicts observations of these two species (presence/absence) from surveys conducted between 1996-2009. For display in the South FL ESI, the points were buffered by 10 m to create small polygons. In cases where the buffers overlapped, the boundaries were dissolved to make slightly larger non-circular polygons. In locations where the number of points were dense within a small polygon, concentrations of 'high' or 'very high' were indicated in the data table.

Benthic data from the Tortugas Ecological Reserves had not been integrated into the Unified Florida Reef Tract Map when we obtained it, and came from two additional sources: (1) the Reef Visual Census sampling grid and (2) NOAA's Center for Coastal Monitoring and Assessment (CCMA). The RVC sampling grid contains information on the habitat found in a cell, and it is updated yearly based on field observations; however, not all grid cells are visited every year. Categories from these datasets were crosswalked to match existing ESI species and the Unified Florida Reef Tract Map, with the exception of some areas mapped as 'Rock reef'.

Locations with Johnson's seagrass are represented in the benthic layer by the critical habitat, because conversations with NMFS indicated that the critical habitat encompasses all known stands of seagrass. These areas were assigned a concentration of 'Potential'.

Plants – Federally and state threatened/endangered plant occurrences that fell within the study area were included. Data were provided by FNAI for most records, USFWS for Keys tree cactus (SE/FE), and NPS for species and communities located in Everglades National Park.

Major Data Sources Used: Habitats

FNAI. 2011. Element Occurrence Polygon Data Layer, vector digital data.

FWRI. 2012. *Acropora cervicornis* present, vector digital data.

FWRI. 2012. *Acropora palmata* present, vector digital data.

FWRI. 2012. Draft Unified Reef Map, vector digital data.

NOAA-SEFSC. 2011. Densities of common reef fish by geographic region, habitat, and protection status from the reef visual census database, vector digital data.

NPS, Everglades National Park. 2013. ENP sensitive coastal habitats, vector digital data.

University of Miami Rosenstiel School of Marine and Atmospheric Science. 2006. Benthic Habitat Map for the Dry Tortugas Region, vector digital data.

HUMAN-USE RESOURCES

Management areas such as wildlife refuges, national parks, and marine sanctuaries are mapped as polygons. Where the

feature is a known point location (e.g., marinas, airports, water intakes), the exact location is displayed.

A human use number (HU#) can be found in the accompanying data tables for each point and polygonal feature mapped. The HU# may provide more information (i.e., name, contact) for that particular resource. The types of human use resources mapped in this atlas are depicted below.

Abandoned Vessel / Shipwreck: Locations of underwater archaeological preserves and shipwrecks and obstructions in coastal waters of the southeast United States. Point data sets were provided by FWRI.

Access Site: Beach access site data were provided by FWRI.

Airport / Heliport:. Information on the locations of airfields or airports was contained in an ESRI digital point coverage provided by FWRI.

Aquaculture Site: Locations of aquaculture sites. The data were provided by FWRI.

Artificial Reef: Locations of artificial reefs. This information was provided by FWRI.

Boat Ramp: Locations of boat ramps. This information was provided as a digital point coverage from FWRI.

Coast Guard: Locations of U.S. Coast Guard Stations. This information was provided as a digital point coverage by FWRI.

Critical Habitat: USFWS Critical Habitats were mapped for *Acropora*, American crocodile, Cape Sable seaside sparrow, Johnson's seagrass, West Indian manatee, piping plover, rice rat, and smalltooth sawfish. The data were downloaded from the USFWS Critical Habitat Portal.

Ferry: Locations of ferry terminals. Data were provided by FWRI.

Historical site: Historical site data were provided by FL State Historic Preservation Office.

Management Area: Locations of Aquatic Preserves, Outstanding Florida Waters, Florida Conservation Lands, Marine Protected Areas and other management area boundaries. This information was provided as multiple digital polygon coverages from FWRI.

Marina: Locations of marinas. This information was provided as a digital point coverage from FWRI.

Marine Sanctuary: Boundaries of Florida Keys National Marine Sanctuary. Data were provided by NOAA Office of Coastal Resource Management.

National Park: Locations of National Parks: Dry Tortugas National Park, Everglades National Park, and Biscayne Bay National Park. This data set was provided by the FL DEP through FWRI.

Nature Conservancy: Boundaries of Nature Conservancy Lands. The data was provided by FNAI.

Park: Locations of State park lands. This data were provided by FWRI.

Port: Locations of commercial ports based on USACOE data. These data were provided by FWRI.

Recreational Beach: Locations of recreational beaches. These data were provided by FWRI.

Recreational Fishing: Locations of fishing piers, jetties, and beaches where recreational fishing occurs. A point data set was provided by FWRI.

Water Intake: Locations of surface water intakes. This information was provided as a digital point coverage from FWRI.

Wildlife Refuge: Locations of National Wildlife Refuges. These data were provided by the FL DEP through FWRI.

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. The 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 or colored lines on the shoreline. These multiple classifications are represented 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, tidal flats (ESI=7, ESI=9A), marshes (ESI=10A, ESI=10B), swamps (ESI=10C), and scrub-shrub wetlands (ESI=10D) are also stored as polygons.

SENSITIVE BIOLOGICAL RESOURCES

Biological resources are stored as points and polygons. 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, which includes common and scientific names; the species status table, which gives information for state and/or federal threatened or endangered listings; and the source database, which 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 points or polygons. The resource name, the owner/manager, a contact person, and phone number are included in the database for management areas, and socio-economic points when available. All metadata sources are documented at the feature level.

ACKNOWLEDGMENTS

This project was funded by the NOAA Office of Response and Restoration, Emergency Response Division and Florida Fish and Wildlife Conservation Commission - Florida Fish and Wildlife Reserch Institute. Richard Knudsen, State SSC, assisted greatly in all aspects of the project's completion. Access to aerial photography was provided by Florida Fish and Wildlife Conservation Commission - Florida Fish and Wildlife Reserch Institute and NOAA.

The biological and human-use data included on the maps were provided by numerous individuals and agencies, including: FWC-FWRI, USFWS, NPS, FNAI, NMFS, NOAA, Audubon of FL, USGS, and University of Miami. Staff at these agencies contributed a vast amount of information to this effort, including first-hand expertise, publications, maps, and digital data.

At Research Planning, Inc. (RPI) of Columbia, South Carolina, numerous scientific, GIS, and graphic staff were involved with different phases of the project. Mark White, GIS Director, was Project Manager. Shoreline habitat mapping was conducted by Lincoln Smith and Katy Beckham. The biological and human-use data were collected and compiled onto base maps by Christine Boring and Jennifer Weaver. Lee Diveley, Katy Beckham, Jeff Dahlin, Bryan Thom, and Chris Locke entered, processed, and produced the GIS data. Joe Holmes created the final documents.

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 FWC-FWRI, USFWS, NPS, FNAI, Audubon FL, USGS, NMFS, University of Miami 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*	Scientific Name*
BIRDS	
DIVING	
American white pelican	*Pelecanus erythrorhynchos*
Anhinga	*Anhinga anhinga*
Brown pelican	*Pelecanus occidentalis*
Common loon	*Gavia immer*
Cormorant	*Phalacrocorax sp.*
Diving birds	-
Double-crested cormorant	*Phalacrocorax auritus*
Horned grebe	*Podiceps auritus*
Pied-billed grebe	*Podilymbus podiceps*
GULL/TERN	
Black noddy	*Anous minutus*
Black skimmer	*Rynchops niger*
Bridled tern	*Onychoprion anaethetus*
Brown noddy	*Anous stolidus*
Caspian tern	*Hydroprogne caspia*
Forster's tern	*Sterna forsteri*
Gulls	-
Herring gull	*Larus argentatus*
Laughing gull	*Larus atricilla*
Least tern	*Sternula antillarum*
Lesser black-backed gull	*Larus fuscus*
Ring-billed gull	*Larus delawarensis*
Roseate tern	*Sterna dougallii*
Royal tern	*Thalasseus maximus*
Sandwich tern	*Thalasseus sandvicensis*
Sooty tern	*Onychoprion fuscatus*
Terns	-
PASSERINE	
Belted kingfisher	*Ceryle alcyon*
Black-and-white warbler	*Mniotilta varia*
Cape Sable seaside sparrow	*Ammodramus maritimus mirabilis*
Common yellowthroat	*Geothlypis trichas*
Mangrove cuckoo	*Coccyzus minor*
Northern waterthrush	*Seiurus noveboracensis*
Palm warbler	*Setophaga palmarum*
Prairie warbler	*Setophaga discolor*
Seaside sparrow	*Ammodramus maritimus*
Thrushes	-
Warblers	*Parulidae*
White-crowned pigeon	*Patagioenas leucocephala*
White-eyed vireo	*Vireo griseus*
Yellow warbler	*Dendroica petechia*
Yellow-billed cuckoo	*Coccyzus americanus*
Yellow-throated warbler	*Setophaga dominica*
PELAGIC	
Brown booby	*Sula leucogaster*
Magnificent frigatebird	*Fregata magnificens*
Masked (blue-faced) booby	*Sula dactylatra*
Northern gannet	*Morus bassanus*
RAPTOR	
American kestrel	*Falco sparverius*
Bald eagle	*Haliaeetus leucocephalus*
Broad-winged hawk	*Buteo platypterus*
Cooper's hawk	*Accipiter cooperii*
Florida burrowing owl	*Athene cunicularia floridana*
Merlin	*Falco columbarius*
Northern harrier	*Circus cyaneus*
Osprey	*Pandion haliaetus*
Peregrine falcon	*Falco peregrinus*
Raptors	-
Red-shouldered hawk	*Buteo lineatus*
Sharp-shinned hawk	*Accipiter striatus*
Short-tailed hawk	*Buteo brachyurus*
Swainson's hawk	*Buteo swainsoni*
Swallow-tailed kite	*Elanoides forficatus*
SHOREBIRD	
Black-bellied plover	*Pluvialis squatarola*
Black-necked stilt	*Himantopus mexicanus*
Dunlin	*Calidris alpina*
Greater yellowlegs	*Tringa melanoleuca*
Killdeer	*Charadrius vociferus*
Least sandpiper	*Calidris minutilla*
Long-billed curlew	*Numenius americanus*
Long-billed dowitcher	*Limnodromus scolopaceus*
Marbled godwit	*Limosa fedoa*
Piping plover	*Charadrius melodus*
Red knot	*Calidris canutus*
Ruddy turnstone	*Arenaria interpres*
Sanderling	*Calidris alba*
Semipalmated plover	*Charadrius semipalmatus*
Semipalmated sandpiper	*Calidris pusilla*
Shorebirds	-
Short-billed dowitcher	*Limnodromus griseus*
Snowy plover	*Charadrius alexandrinus*

Common Name*	Scientific Name*
BIRDS, cont.	
SHOREBIRD, cont.	
Spotted sandpiper	*Actitis macularia*
Stilt sandpiper	*Calidris himantopus*
Western sandpiper	*Calidris mauri*
Whimbrel	*Numenius phaeopus*
Willet	*Catoptrophorus semipalmatus*
Wilson's plover	*Charadrius wilsonia*
WADING	
American flamingo	*Phoenicopterus ruber*
Black-crowned night-heron	*Nycticorax nycticorax*
Cattle egret	*Bubulcus ibis*
Great blue heron	*Ardea herodias*
Great egret	*Ardea alba*
Great white heron	*Ardea herodias*
Green heron	*Butorides virescens*
Little blue heron	*Egretta caerulea*
Reddish egret	*Egretta rufescens*
Roseate spoonbill	*Ajaia ajaja*
Snowy egret	*Egretta thula*
Tricolored heron	*Egretta tricolor*
Wading birds	-
White ibis	*Eudocimus albus*
Wood stork	*Mycteria americana*
Yellow-crowned night-heron	*Nyctanassa violacea*
WATERFOWL	
American coot	*Fulica americana*
Blue-winged teal	*Anas discors*
Red-breasted merganser	*Mergus serrator*
FISH	
FISH	
African pompano	*Alectis ciliaris*
Anchovies	*Anchoa sp.*
Atlantic spadefish	*Chaetodipterus faber*
Atlantic tripletail	*Lobotes surinamensis*
Balao	*Hemiramphus balao*
Ballyhoo	*Hemiramphus spp.*
Banded butterflyfish	*Chaetodon striatus*
Bank butterflyfish	*Prognathodes aya*
Banner goby	*Microgobius microlepis*
Bar jack	*Caranx ruber*
Barred hamlet	*Hypoplectrus puella*
Batfish	*Ogcocephalus spp.*
Bay anchovy	*Anchoa mitchilli*
Bearded goby	*Barbulifer ceuthoecus*
Beaugregory	*Stegastes leucostictus*
Bermuda sea chub	*Kyphosus sectatrix*
Bicolor damselfish	*Stegastes partitus*
Black drum	*Pogonias cromis*
Black grouper	*Mycteroperca bonaci*
Blackear wrasse	*Halichoeres poeyi*
Blackfin snapper	*Lutjanus buccanella*
Blackfin tuna	*Thunnus atlanticus*
Blacktip shark	*Carcharhinus limbatus*
Blennies	-
Blue angelfish	*Holacanthus bermudensis*
Blue chromis	*Chromis cyanea*
Blue marlin	*Makaira nigricans*
Blue parrotfish	*Scarus coeruleus*
Blue runner	*Caranx crysos*
Blue tang	*Acanthurus coeruleus*
Bluefin tuna	*Thunnus thynnus*
Bluefish	*Pomatomus saltatrix*
Bluehead	*Thalassoma bifasciatum*
Bluelip parrotfish	*Cryptotomus roseus*
Bluestriped grunt	*Haemulon sciurus*
Bonefish	*Albula vulpes*
Bonnethead shark	*Sphyrna tiburo*
Bridled goby	*Coryphopterus glaucofraenum*
Brown chromis	*Chromis multilineata*
Bucktooth parrotfish	*Sparisoma radians*
Bull shark	*Carcharhinus leucas*
Burrowing eels	*Ophichthidae*
Cardinalfishes	-
Caribbean reef shark	*Carcharhinus perezii*
Cero	*Scomberomorus regalis*
Chain pipefish	*Syngnathus louisianae*
Cherubfish	*Centropyge argi*
Clown goby	*Microgobius gulosus*
Clown wrasse	*Halichoeres maculipinna*
Cobia	*Rachycentron canadum*
Cocoa damselfish	*Stegastes variabilis*
Code goby	*Gobiosoma robustum*
Common snook	*Centropomus undecimalis*
Coney	*Cephalopholis fulva*

Common Name*	Scientific Name*
FISH, cont.	
FISH, cont.	
Cottonwick grunt	*Haemulon melanurum*
Creole wrasse	*Clepticus parrae*
Crevalle jack	*Caranx hippos*
Cubera snapper	*Lutjanus cyanopterus*
Doctorfish	*Acanthurus chirurgus*
Dog snapper	*Lutjanus jocu*
Dolphin	*Coryphaena hippurus*
Drum	*Equetus spp.*
Dusky damselfish	*Stegastes adustus*
Dusky pipefish	*Syngnathus floridae*
Dusky shark	*Carcharhinus obscurus*
Dwarf seahorse	*Hippocampus zosterae*
False albacore	*Euthynnus alletteratus*
Fantail mullet	*Mugil trichodon*
Fat snook	*Centropomus parallelus*
Filefishes	-
Flying fishes	-
Foureye butterflyfish	*Chaetodon capistratus*
French angelfish	*Pomacanthus paru*
French grunt	*Haemulon flavolineatum*
Fringed pipefish	*Anarchopterus criniger*
Frogfishes	*Antennariidae*
Golden tilefish	*Lopholatilus chamaeleonticeps*
Goldspotted killifish	*Floridichthys carpio*
Goliath grouper	*Epinephelus itajara*
Gray angelfish	*Pomacanthus arcuatus*
Gray snapper	*Lutjanus griseus*
Gray triggerfish	*Balistes capriscus*
Graysby	*Cephalopholis cruentata*
Great barracuda	*Sphyraena barracuda*
Greater amberjack	*Seriola dumerili*
Grunts	*Haemulidae*
Gulf flounder	*Paralichthys albigutta*
Gulf pipefish	*Syngnathus scovelli*
Gulf toadfish	*Opsanus beta*
Hamlets	*Hypoplectrus spp.*
Hardhead catfish	*Arius felis*
Hogchoker	*Trinectes maculatus*
Hogfish	*Lachnolaimus maximus*
Horse-eye jack	*Caranx latus*
Houndfish	*Tylosurus crocodilus crocodilus*
Key anchovy	*Anchoa cayorum*
Key blenny	*Starksia starcki*
Key silverside	*Menidia conchorum*
Key worm eel	*Ahlia egmontis*
King mackerel	*Scomberomorus cavalla*
Ladyfish	*Elops saurus*
Lane snapper	*Lutjanus synagris*
Lemon shark	*Negaprion brevirostris*
Lined seahorse	*Hippocampus erectus*
Lined sole	*Achirus lineatus*
Lizardfishes	-
Longfin damselfish	*Stegastes diencaeus*
Longsnout butterflyfish	*Prognathodes aculeatus*
Lookdown	*Selene vomer*
Mahogany snapper	*Lutjanus mahogoni*
Mangrove rivulus	*Kryptolebias marmoratus*
Masked goby	*Coryphopterus personatus*
Midnight parrotfish	*Scarus coelestinus*
Mojarras	*Eucinostomus spp.*
Moray eels	-
Mutton snapper	*Lutjanus analis*
Nassau grouper	*Epinephelus striatus*
Needlefishes	*Belonidae*
Neon goby	*Elacatinus oceanops*
Nurse shark	*Ginglymostoma cirratum*
Ocean surgeon	*Acanthurus bahianus*
Ocean triggerfish	*Canthidermis sufflamen*
Ornamental serranids	-
Peacock flounder	*Bothus lunatus*
Permit	*Trachinotus falcatus*
Pinfish	*Lagodon rhomboides*
Porgies	-
Porkfish	*Anisotremus virginicus*
Princess parrotfish	*Scarus taeniopterus*
Puddingwife	*Halichoeres radiatus*
Purple reeffish	*Chromis scotti*
Queen angelfish	*Holacanthus ciliaris*
Queen parrotfish	*Scarus vetula*
Rainbow parrotfish	*Scarus guacamaia*
Rainbow runner	*Elagatis bipinnulata*
Rainwater killifish	*Lucania parva*
Red drum	*Sciaenops ocellatus*
Red grouper	*Epinephelus morio*
Redband parrotfish	*Sparisoma aurofrenatum*

Common Name*	Scientific Name*
FISH, cont.	
FISH, cont.	
Redtail parrotfish	*Sparisoma chrysopterum*
Reef butterflyfish	*Chaetodon sedentarius*
Reef croaker	*Odontoscion dentex*
Rock beauty	*Holacanthus tricolor*
Rock hind	*Epinephelus adscensionis*
Round scad	*Decapterus punctatus*
Sailfish	*Istiophorus platypterus*
Sailors choice	*Haemulon parra*
Sand tilefish	*Malacanthus plumieri*
Scalloped hammerhead	*Sphyrna lewini*
Schoolmaster	*Lutjanus apodus*
Scorpionfishes	-
Scrawled cowfish	*Acanthostracion quadricornis*
Sea bream	*Archosargus rhomboidalis*
Sergeant major	*Abudefduf saxatilis*
Sharpnose puffer	*Canthigaster rostrata*
Sheepshead	*Archosargus probatocephalus*
Silver perch	*Bairdiella chrysoura*
Silver seatrout	*Cynoscion nothus*
Silversides	-
Slippery dick	*Halichoeres bivittatus*
Smalltooth sawfish	*Pristis pectinata*
Smooth trunkfish	*Rhinesomus triqueter*
Snowy grouper	*Hyporthodus niveatus*
Southern stingray	*Dasyatis americana*
Spanish hogfish	*Bodianus rufus*
Spanish mackerel	*Scomberomorus maculatus*
Speckled hind	*Epinephelus drummondhayi*
Speckled worm eel	*Myrophis punctatus*
Spotfin butterflyfish	*Chaetodon ocellatus*
Spotted eagle ray	*Aetobatus narinari*
Spotted seatrout	*Cynoscion nebulosus*
Squirrelfish	*Holocentrus adscensionis*
Stoplight parrotfish	*Sparisoma viride*
Striped mullet	*Mugil cephalus*
Striped parrotfish	*Scarus iseri*
Sunshinefish	*Chromis insolata*
Swordfish	*Xiphias gladius*
Swordspine snook	*Centropomus ensiferus*
Tarpon	*Megalops atlanticus*
Tarpon snook	*Centropomus pectinatus*
Threespot damselfish	*Stegastes planifrons*
Tomtate	*Haemulon aurolineatum*
Wahoo	*Acanthocybium solandri*
Warsaw grouper	*Hyporthodus nigritus*
White grunt	*Haemulon plumierii*
White marlin	*Kajikia albida*
Wreckfish	*Polyprion americanus*
Yellow jack	*Caranx bartholomaei*
Yellowcheek wrasse	*Halichoeres cyanocephalus*
Yellowedge grouper	*Hyporthodus flavolimbatus*
Yellowfin tuna	*Thunnus albacares*
Yellowhead jawfish	*Opistognathus aurifrons*
Yellowhead wrasse	*Halichoeres garnoti*
Yellowtail damselfish	*Microspathodon chrysurus*
Yellowtail parrotfish	*Sparisoma rubripinne*
Yellowtail reeffish	*Chromis enchrysura*
Yellowtail snapper	*Ocyurus chrysurus*

HABITATS

ALGAE	
Algae	-
CORAL	
Coral patch reef	-
Elkhorn coral	*Acropora palmata*
Live coral	-
Staghorn coral	*Acropora cervicornis*
HARDBOTTOM	
Pavement	-
Ridge	-
Rock reef	-
Spur and groove	-
Unconsolidated sediments	-
Wormrock	-
PLANT	
Atlantic Coast Florida lantana	*Lantana depressa var. floridana*
Bahama brake	*Pteris bahamensis*
Bahama maidenbush	*Heterosavia bahamensis*
Bahama sachsia	*Sachsia polycephala*
Bahama wild coffee	*Psychotria ligustrifolia*
Beach jacquemontia	*Jacquemontia reclinata*
Big Pine partridge pea	*Chamaecrista lineata var. keyensis*
Blodgett's wild-mercury	*Argythamnia blodgettii*

Common Name*	Scientific Name*
HABITATS, cont.	
PLANT, cont.	
Brittle thatch palm	*Thrinax morrisii*
Burrowing four o'clock	*Okenia hypogaea*
Cape Sable ageratum	*Ageratum maritimum*
Cape Sable thoroughwort	*Chromolaena frustrata*
Caribbean princewood	*Exostema caribaeum*
Christmasberry	*Crossopetalum ilicifolium*
Climbing vine fern	*Microgramma heterophylla*
Creeping maiden fern	*Thelypteris reptans*
Crenulate lead-plant	*Amorpha herbacea var. crenulata*
Cupania	*Cupania glabra*
Deltoid spurge	*Chamaesyce deltoidea ssp. Deltoidea*
Devil's smooth-claw	*Pisonia rotundata*
Few-flower caesalpinia	*Caesalpinia pauciflora*
Florida bitterbush	*Picramnia pentandra*
Florida gamagrass	*Tripsacum floridanum*
Florida prairie clover	*Dalea carthagenensis var. floridana*
Florida royal palm	*Roystonea regia*
Florida silver palm	*Coccothrinax argentata*
Florida thatch palm	*Thrinax radiata*
Garber's spurge	*Euphorbia garberi*
Golden leatherfern	*Acrostichum aureum*
Gulf licaria	*Licaria triandra*
Hand fern	*Cheiroglossa palmata*
Joewood	*Jacquinia keyensis*
Key tree cactus	*Pilosocereus polygonus*
Krug's holly	*Ilex krugiana*
Lamarck's trema	*Trema lamarckiana*
Least halberd fern	*Tectaria fimbriata*
Locustberry	*Byrsonima lucida*
Manchineel	*Hippomane mancinella*
Mangrove berry	*Mosiera longipes*
Marsh's dutchman's pipe	*Aristolochia pentandra*
Meadow jointvetch	*Aeschynomene pratensis*
Milkbark	*Drypetes diversifolia*
Modest spleenwort	*Asplenium verecundum*
Myrtle of the river	*Calyptranthes zuzygium*
Pineland jacquemontia	*Jacquemontia curtissii*
Pineland noseburn	*Tragia saxicola*
Pineland pencil flower	*Stylosanthes calcicola*
Polynesian peperomia	*Peperomia humilis*
Porter's broad-leaved spurge	*Chamaesyce porteriana*
Pride of Big Pine	*Strumpfia maritima*
Red stopper	*Eugenia rhombea*
Rhacoma	*Crossopetalum rhacoma*
Roadside leafbract	*Malachra fasciata*
Rockland painted-leaf	*Euphorbia pinetorum*
Rough strongbark	*Bourreria tomentosa*
Sand flax	*Linum arenicola*
Sea lavender	*Tournefortia gnaphalodes*
Skyblue clustervine	*Jacquemontia pentanthos*
Small-fruited varnishleaf	*Dodonaea viscosa*
Swartz's snoutbean	*Rhynchosia swartzii*
Tearshrub	*Vallesia antillana*
Villose fennel	*Koanophyllon villosum*
Wedge spurge	*Chamaesyce deltoidea ssp. serpyllum*
West Indian cherry	*Prunus myrtifolia*
West Indian mahogany	*Swietenia mahagoni*
White fenrose	*Kosteletzkya depressa*
White ironwood	*Hypelate trifoliata*
White passionflower	*Passiflora multiflora*
Wild cinnamon	*Canella winterana*
Wild cotton	*Gossypium hirsutum*
Wild dilly	*Manilkara jaimiqui*
Yellowwood	*Schaefferia frutescens*
REEF	
Aggregate Reef	-
Linear reef	-
Reef rubble	-
Reef terrace	-
Remnant	-
SAV	
Johnson's seagrass	*Halophila johnsonii*
Seagrass	-
UPLAND	
Buttonwood hammock	-
False boxwood	*Gyminda latifolia*
Hardwood hammock	-

Common Name*	Scientific Name*
INVERTEBRATES	
CRAB	
Blue crab	*Callinectes sapidus*
Hermit crabs	-
ECHINODERM	
Variegated sea urchin	*Lytechinus variegatus*
GASTROPOD	
Queen conch	*Strombus gigas*
Stock Island treesnail	*Orthalicus reses reses*
INSECT	
Bartram's scrub-hairstreak	*Strymon acis bartrami*
Miami blue	*Cyclargus thomasi bethunebakeri*
LOBSTER	
Caribbean spiny lobster	*Panulirus argus*
SHRIMP	
Florida stone crab	*Menippe mercenaria*
Grass shrimp	*Palaemonetes spp.*
Peppermint shrimp	*Lysmata wurdemanni*
Pink shrimp	*Farfantepenaeus duorarum*
MARINE MAMMALS	
DOLPHIN	
Bottlenose dolphin	*Tursiops truncatus*
MANATEE	
West Indian manatee	*Trichechus manatus*
REPTILE	
CROCODILE	
American crocodile	*Crocodylus acutus*
LIZARD	
Florida Keys mole skink	*Plestiodon egregius egregius*
SNAKE	
Key ringneck snake	*Diadophis punctatus acricus*
Lower Keys ribbon snake	*Thamnophis sauritus*
Red rat snake, Fl Lower Keys pop	*Pantherophis guttatus*
Rim rock crowned snake	*Tantilla oolitica*
TURTLE	
Gopher tortoise	*Gopherus polyphemus*
Green sea turtle	*Chelonia mydas*
Hawksbill sea turtle	*Eretmochelys imbricata*
Kemp's ridley sea turtle	*Lepidochelys kempii*
Leatherback sea turtle	*Dermochelys coriacea*
Loggerhead sea turtle	*Caretta caretta*
Mangrove terrapin	*Malaclemys terrapin rhizophorarum*
TERRESTRIAL MAMMALS	
SMALL MAMMAL	
Key Largo cotton mouse	*Peromyscus gossypinus allapaticola*
Key Largo woodrat	*Neotoma floridana smalli*
Lower Keys marsh rabbit	*Sylvilagus palustris hefneri*
Rice rat	*Oryzomys palustris natator*
UNGULATE	
Florida key deer	*Odocoileus virginianus clavium*

* Threatened and endangered species and species of special concern 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
- Many structures 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 relatively high-energy processes
- Attached animals and plants are sparse to dense
- Present in highly developed industrial and port areas and scattered along residential waterfronts

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 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;
  - minimize aesthetic damage; and
  - prevent chronic leaching of oil from the structure

EXPOSED WAVE-CUT PLATFORMS IN BEDROCK ESI = 2A

DESCRIPTION

- The intertidal zone consists of a flat rock bench of highly variable width
- There may be a perched beach of sand- to boulder-sized sediments at the base of the scarp
- The platform surface is irregular and tidal pools are common
- Small accumulations of gravel can be found in the tidal pools and crevices in the platform
- Attached organisms are hardy and used to strong hydraulic impacts and pressures

PREDICTED OIL BEHAVIOR

- Oil will not adhere to the lower rock platform, but rather be transported across the platform and accumulate along the high-tide line
- Oil can penetrate in beach sediments, if present

RESPONSE CONSIDERATIONS

- Cleanup is usually not required, except where the oil is thick
- Where the high-tide area is accessible, it may be feasible to remove thick oil accumulations and oiled debris
- Access can be difficult and dangerous

EXPOSED SCARPS AND STEEP SLOPES IN CLAY ESI = 2B

DESCRIPTION

- These habitats generally occur along tidal channels and major tributaries in the marsh where currents and boat wakes cut a steep bank into the marsh soils
- Scarp heights vary from about 1 to 3 feet and usually consist of a heavily rooted, peaty soil
- May be fronted by a narrow beach of fine- to medium-grained sand and/or shell fragments
- Low biological utilization because of strong currents
- Typically backed by wetland vegetation
- Uncommon, occurring mostly along the outer exposed margins of marsh areas

PREDICTED OIL BEHAVIOR

- Oil is not expected to adhere to the wet, impermeable, and vertical clay surface
- There may be a thin band of oil left at or above the high water line

RESPONSE CONSIDERATIONS

- Cleanup is usually not required, because any stranded oil is quickly removed by wave action
- Access may be difficult

FINE- TO MEDIUM-GRAINED SAND BEACHES ESI = 3A

DESCRIPTION

- These beaches are flat to moderately sloping and relatively hard packed
- They are composed of predominantly quartz sand
- There can be heavy accumulations of wrack present
- They are utilized by birds and turtles
- Upper beach fauna include ghost crabs and amphipods; lower beach fauna can be moderate, but highly variable
- They are generally areas of heavy recreational use

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- to medium-grained sand is about 10-15 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 dune areas should be limited, to prevent contamination of clean areas and disturbance of habitat and birds
- Manual cleanup is advised to minimize the volume of sand removed from the shore and requiring disposal, particularly for non-amenity beaches
- Mechanical sand sifters may be effective on oil in the form of tarballs and patties
- All efforts should focus on preventing the mixing 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

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SCARPS AND STEEP SLOPES IN SAND ESI = 3B

DESCRIPTION

- This shoreline type occurs where sandy bluffs are undercut by waves or currents and slump
- 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 logs can accumulate at the base of the scarp
- Biological utilization by birds and infauna is low
- Prevalent near topographic highs along canals and rivers

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 that has accumulated at the base of the scarp
- Burial risk is low except when 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; sorbents can be deployed to recover oil being mobilized from the shore
- 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

COARSE-GRAINED SAND BEACHES ESI = 4

DESCRIPTION

- These beaches are moderate sloping, of variable width, and have soft sediments. These characteristics combine to lower their trafficability
- Generally species density and diversity is lower than on fine-grained sand beaches

PREDICTED OIL BEHAVIOR

- During small spills, oil will be deposited primarily as a band along the high-tide line
- Under heavy accumulations, oil may spread across the entire beach face, though the oil will be lifted off the lower part of the beach with the rising tide
- Penetration of oil into coarse-grained sand can reach 25 cm
- Burial of oiled layers by clean sand can be as rapid as one tidal cycle and to depths of 60 cm or more
- Burial to depths over one meter is possible if the oil comes ashore at the start of a depositional period
- Biological impacts include temporary declines in infaunal populations, which can also affect important shorebird foraging areas

RESPONSE CONSIDERATIONS

- Remove oil primarily from the upper swash lines

- Removal of sediment should be limited to avoid erosion problems
- Mechanical reworking of the sediment into the surf zone may be used as a final polishing step for stained sand treatment without sediment removal
- Use of heavy equipment for oil/sand removal may result in the removal of excessive amounts of sand; manual cleanup and mechanical sifters may be more effective

MIXED SAND AND GRAVEL (SHELL) BEACHES ESI = 5

DESCRIPTION

- Moderately sloping beach composed of a mixture of sand and gravel (shell or limestone fragments); shell component comprises between 20 to 80 percent of total sediments
- Because of mixed sediment sizes, there may be zones of pure sand or shell
- Uncommon, present in erosional areas and artificial fill

PREDICTED OIL BEHAVIOR

- During small spills, oil will be deposited along and above the high-tide swash
- Large spills will 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 oil behavior is much like on a sand beach if the sand fraction exceeds about 40 percent
- Burial of oil may be deep at and above the high-tide line, where oil tends to persist, particularly where beaches are only intermittently exposed to waves
- In sheltered pockets on the beach, pavements of asphalted sediments can form if there is no removal of heavy oil accumulations because most of the oil remains on the surface
- Once formed, these asphalt pavements can persist for years

RESPONSE CONSIDERATIONS

- Remove heavy accumulations of pooled oil as soon as possible
- All oiled debris should be removed
- Sediment removal should be limited as much as possible

- Low-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents. High-pressure spraying should be avoided because of potential for transporting contaminated finer sediments (sand) to the lower intertidal or subtidal zones
- Mechanical reworking of lightly oiled sediments form the high-tide zone to the upper intertidal zone can be effective in areas regularly exposed to wave activity (as evidenced by storm berms). However, oiled sediments should not be relocated below the mid-tide zone
- In-place tilling/excavation may be used to reach deeply buried oil in layers in the middle zone on exposed beaches

RIPRAP ESI = 6B

DESCRIPTION

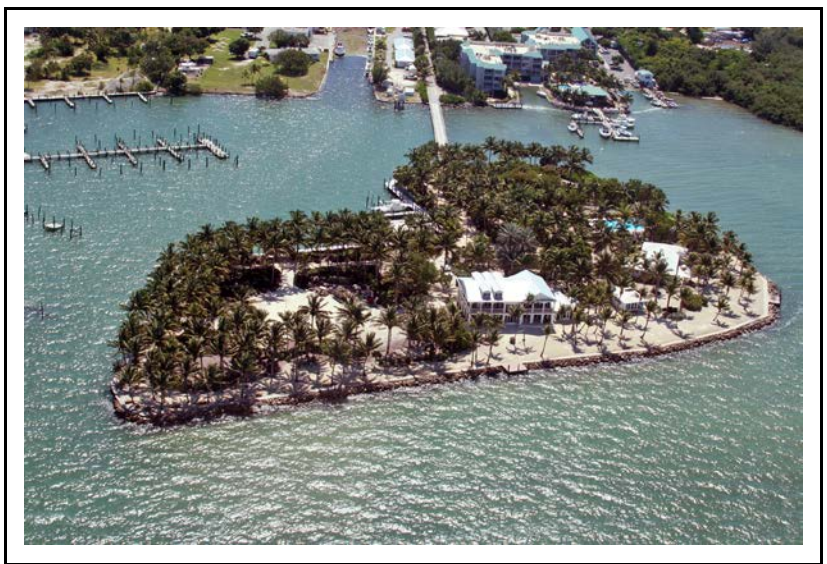
- Riprap structures are composed of cobble- to boulder-sized blocks of rock or concrete
- Riprap structures are used for shoreline protection and tidal-inlet stabilization
- Attached biota are highly variable in cover
- Common along highly developed commercial waterfronts, residential areas, and inlets

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 hardens

RESPONSE CONSIDERATIONS

- When the oil is fresh and liquid, high-pressure spraying and/or water flooding may be effective, making sure to recover all mobilized oil
- Heavy and weathered oils are more difficult to remove, requiring scraping and/or hot-water spraying



- It may be necessary to remove and replace heavily oiled blocks in high-use areas

EXPOSED TIDAL FLATS — ESI = 7

DESCRIPTION

- Exposed tidal flats are broad, flat, intertidal areas composed primarily of sand and minor amounts of shell
- 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 by foraging fish
- Present at tidal inlets, along the outer coast, and exposed areas of bays

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 machinery should be restricted to prevent mixing of oil into the sediments

SHELTERED SCARPS IN CLAY OR BEDROCK — ESI = 8A

DESCRIPTION

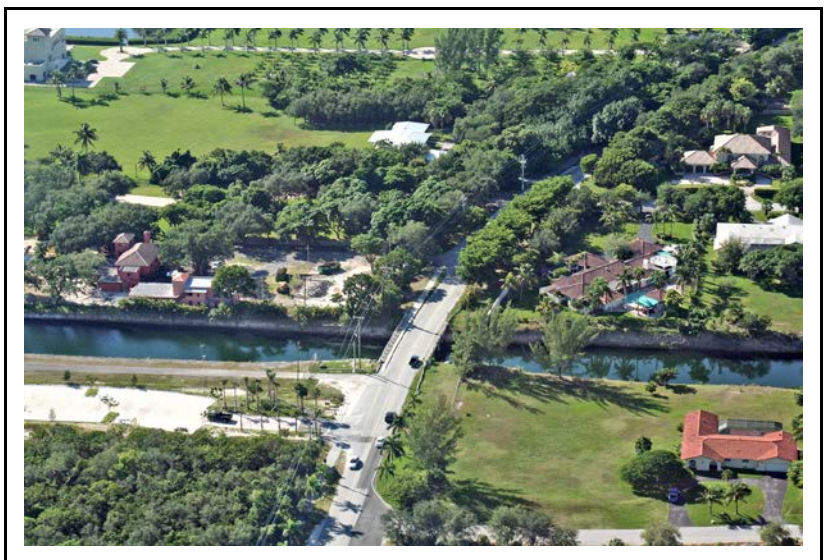
- This shoreline type is sheltered from wave activity and strong currents
- Sediments (rock debris, etc.) may accumulate at the base of this shoreline type
- The slope of the intertidal zone is generally moderate to steep (greater than 15°) with little width
- Uncommon, located along canals or creeks

PREDICTED OIL BEHAVIOR

- Stranded oil will persist because of low energy setting

RESPONSE CONSIDERATIONS

- Low-pressure flushing at ambient temperatures is most effective when the oil is fresh and still liquid
- Where the high-tide area is accessible, it may be feasible to remove heavy oil accumulations and oiled debris



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 of the structures are designed to protect a single lot, thus their composition, design, and condition are highly variable
- 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
- High densities of attached biota may be present at lower tidal elevations
- Common in highly developed commercial and residential waterfront areas

PREDICTED OIL BEHAVIOR

- Oil will adhere readily to rough surfaces, particularly along the high-tide line, forming a distinct oil band
- If the oil is not removed, it may cause chronic leaching until the oil hardens
- 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 RIPRAP — ESI = 8C

DESCRIPTION

- Riprap structures are composed of cobble- to boulder-sized blocks of rock or concrete
- These structures are found inside harbors and bays in developed areas, sheltered from direct exposure to waves
- High densities of attached biota may be present at lower tidal elevations
- Common in highly developed commercial and residential waterfront areas

PREDICTED OIL BEHAVIOR

- Oil adheres readily to the rough surfaces
- Deep penetration of oil between the blocks is likely
- If oil is left uncleaned, it may cause chronic leaching until the oil hardens

RESPONSE CONSIDERATIONS

- High-pressure spraying 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
- It may be necessary to remove and replace heavily oiled riprap in high-use areas

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 usually backed by marshes or mangroves
- The sediments are very soft and cannot support even light foot traffic in many areas
- Sheltered tidal flats can be sparsely to heavily covered with algae and/or seagrasses
- They can have heavy wrack deposits along the upper fringe
- Large concentrations of shellfish, worms, and snails can be found on and in the sediments
- They are heavily utilized by birds and fish for feeding
- Common along marsh channels and sheltered areas of the bays

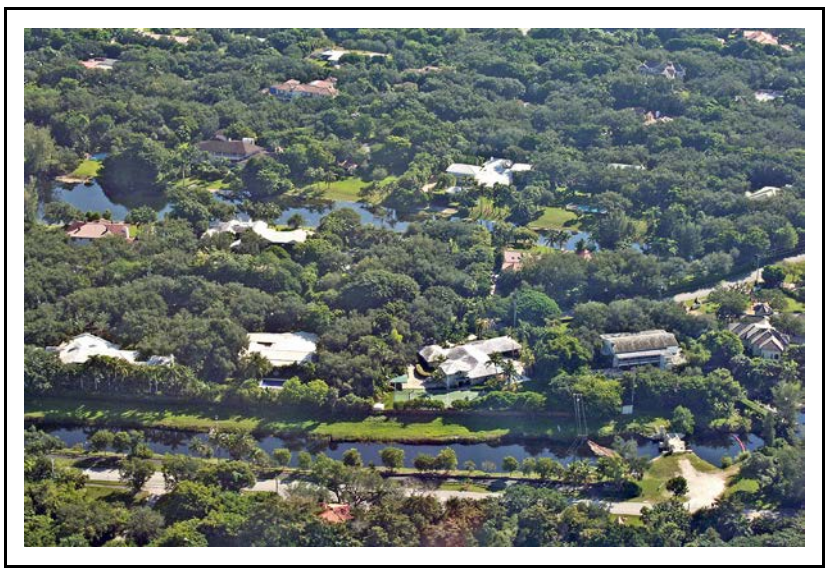
PREDICTED OIL BEHAVIOR

- 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 or other crevices in muddy sediments
- 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, vacuum and deployment of sorbents from shallow-draft boats may be appropriate for use under heavy oiling

VEGETATED LOW BANKS — ESI = 9B



DESCRIPTION

- These habitats are either low banks with grasses or trees and tree roots exposed to the water
- They are flooded occasionally by high water
- Present along upper canals and rivers

PREDICTED OIL BEHAVIOR

- During low water stages there is 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 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 fresh 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 weathered oil from tree roots and trunks, if deemed necessary in high-use areas

HYPERSALINE TIDAL FLATS — ESI = 9C

DESCRIPTION

- These are shallow brine ponds located between intertidal vegetation and upland
- They are artificially inundated and contain waters with high salinity levels

PREDICTED OIL BEHAVIOR

- Sheltered from wave energy and tidal currents
- Oiling could occur if a spill coincides with a high water event or from an upland source
- Oil will permeate into sediments and persist
- Damage to bird communities may be severe

RESPONSE CONSIDERATIONS

- Sorbents booms may be used to prevent oil from entering the flats via adjacent creeks during high water
- Access will be very difficult

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

DESCRIPTION

- These are grassy intertidal wetlands containing emergent, herbaceous vegetation
- Width of the marsh can vary widely, from a narrow fringe to extensive areas; many have been extensively ditched
- Sediments are composed of organic muds except on the margins of 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 and diverse, 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 cracks (up to one meter); heavy oils will thickly cover or pool on the sediment surface

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is natural recovery; 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

- These are grassy wetlands composed of emergent herbaceous vegetation
- They occur upstream of brackish vegetation in the upper estuary and along creeks and rivers
- Those along major channels are exposed to strong currents and boat wakes; smaller channels tend to be sheltered
- Resident flora and fauna are abundant

PREDICTED OIL BEHAVIOR

- Oil adheres readily to the 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
- Most of the time, there will be a narrow band because of the small tidal range; the band can be very large during high-water events
- If the vegetation is thick, heavy oil coating will be restricted to the outer fringe, although lighter oils can penetrate deeper
- Medium to heavy oils do not readily adhere to or penetrate the fine sediments, but can pool on the surface or in burrows

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is natural recovery; 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
- 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

SWAMPS **ESI = 10C**

DESCRIPTION

- Swamps consist of shrubs and hardwood forested wetlands, essentially flooded forests; vegetation is taller, on average, than 6 meters
- 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
- Common along upper sections of rivers

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 at the waterline, which changes levels throughout the flood event
- Oiled woody vegetation is less sensitive than grasses 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, saturated soils, 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 water bodies

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

SCRUB-SHRUB WETLANDS AND MANGROVES ESI = 10D

DESCRIPTION

- Scrub-shrub wetlands consist of woody vegetation less than 6 meters tall including true shrubs, small trees, and trees and shrubs that are stunted due to environmental conditions
- The sediments are silty clay mixed with organic debris
- They are seasonally flooded, though there are many low, permanently flooded areas
- Resident flora and fauna are abundant
- Uncommon, occurring in low areas adjacent to canals and rivers
- Mangroves can grow in substrates that are sand, mud, or peat, often as a veneer over bedrock
- Wrack accumulations can be very heavy
- Mangroves are highly productive, serve as nursery habitat, and support a great diversity and abundance of animals and plants

PREDICTED OIL BEHAVIOR

- Oil can wash through mangroves if oil comes ashore at high tide
- If there is a berm or shoreline present, oil tends to concentrate and penetrate into the berm sediments or accumulated wrack and litter
- Heavy and emulsified oils can be trapped in the thickets of red mangrove prop roots or dense young trees
- Oil readily adheres to prop roots, tree trunks, and pneumatophores
- Re-oiling from re-mobilized oil residues may cause additional injury over time
- Oiled trees start to show evidence of effects (leaf yellowing) weeks after oiling; tree mortality may take months, especially for heavy oils

RESPONSE CONSIDERATIONS

- Oiled wrack can be removed once the threat of oiling has passed. Wrack can actually protect the trees from direct oil contact
- 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, or pose risks to wildlife, low-pressure flushing or vacuum may be attempted from the outer fringe
- No attempt should be made to clean oil from the mangrove interior, except where access to the oil is possible from terrestrial areas
- Woody vegetation should not be cut
- It is important to prevent disturbance of the substrate by foot traffic; thus, most activities should be conducted from boats or the use of walking boards