ENVIRONMENTAL SENSITIVITY INDEX: VIRGINIA

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for the marine and coastal areas of Virginia. The ESI maps are a compilation of information from three main categories: shoreline habitats, sensitive biological resources, and human-use resources.

The individual map pages in this atlas are divided according to the U.S. Geological Survey (USGS) topographic quadrangle index. Black and white scanned images of these maps are used as a backdrop for each map page in the atlas. The name on the bottom right of each map page refers to the corresponding USGS quadrangle.

SHORELINE HABITAT MAPPING

Original ESI maps, published in 1983, were re-examined and fully updated using the sources and methods described below. The intertidal shoreline habitats of Virginia were mapped during overflights and ground surveys conducted by experienced coastal geologists in January 2004. The overflights were conducted at elevations of 400-600 feet and slow air speed. During this work, the ESI ranking of observed intertidal shoreline habitats was denoted directly onto the shoreline depicted on 1:24,000-scale USGS topographic maps. Where appropriate, revisions to the existing shoreline were made and, where necessary, multiple habitats 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 ranking. Generally speaking, areas exposed to high levels of physical energy, such as wave action and tidal currents, and low biological activity rank low on the scale, whereas sheltered areas with associated high biological activity have the highest ranking. The list below includes the shoreline habitats delineated for Virginia, presented in order of increasing sensitivity to spilled oil.

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

Each of the shoreline habitats are described on pages 8-14 in terms of their physical description, predicted oil behavior, and response considerations.

In addition to the field mapped ESI shoreline habitats, all of the wetland habitat types derived from the 1974-1988 VIMS and College of William and Mary Tidal Marsh Inventory were plotted on the maps. During overflights, modifications were made to the data if needed. These polygonal wetland types were not checked or edited extensively as a part of this project. Swamps and freshwater marshes occur only in inland areas and, therefore, were not validated as part of the ESI shoreline classification.

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:

- Virginia Institute of Marine Science (VIMS)
- U.S. Fish and Wildlife Service, National Wildlife Refuges (USFWS, NWR)
- Virginia Department of Game and Inland Fisheries (VDGIF)
- Virginia Department of Conservation and Recreation's Division of Natural Heritage (VA DCR DNH)
- Virginia Marine Science Museum (VMSM)
- The Nature Conservancy (TNC)
- College of William and Mary Center for Conservation Biology (CCB)
- University of Maryland, Center for Environmental Science
- Potomac River Fisheries Commission (PRFC)
- U.S. Geological Survey (USGS)

The above agencies provided the majority of information included in the atlas. Other participating agencies will be cited throughout the atlas and 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 on the maps 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.

MARINE MAMMAL
- Dolphin / Porpoise
- Pinniped
- Whale

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

TERRESTRIAL MAMMAL
- Small Mammal

REPTILE
- Turtle

FISH
- Fish

INVERTEBRATE
- Bivalve
- Crab
- Gastropod
- Insect

HABITAT
- Plant

Submerged Aquatic Vegetation
- < 40% Cover
- > 40% Cover

3) Polygons, arcs, and points are color-coded based on the species composition of each feature, as shown below:

ELEMENT	COLOR AND HATCH PATTERN
Birds	Green diagonal hatch
Fish	Blue diagonal hatch
Invertebrates	Orange diagonal hatch
Marine mammals	Brown horizontal hatch
Terrestrial mammals	Brown vertical hatch
Reptiles	Red diagonal hatch
Benthic habitats	"Simplified wetland" patterns
Plants	Purple horizontal hatch
Multi-element group	Black diagonal hatch

4) There is a Resources at Risk number (RAR#) located under each icon or group of icons. The RAR# references a table on the reverse side of the map with a complete list of species associated with the feature.

5) Also associated with each species in the table is the state and federal protected status as threatened (T), endangered

(E), or species of special concern (C), as well as concentration, seasonality, and life-history information.

6) For species that are found throughout general geographical areas or habitat types on certain maps, displaying the polygons for these species would cover large areas or would obscure the shoreline and biological features, making the maps very difficult to read. In these cases, a small box will be shown on the maps which states that they are "Present in ..." (e.g., "Present in Chesapeake Bay" or "Present in marshes").

MARINE MAMMALS

Marine mammals depicted in the Virginia atlas include whales, dolphins, porpoises, and seals. Marine mammal concentration areas were mapped based on interviews with local resource experts from VIMS and Chincoteague NWR, as well as data from the VMSM Stranding Program 2003 Grant Report. Areas where cetaceans are frequently sighted swimming in coastal waters are designated by large polygons.

Expert contacts for Virginia marine mammals are:

Name	Agency	City	Phone	Species
Jack Musick	VIMS	Gloucester Point, VA	804/684 -7317	Marine Mammals
Tom Penn	USFWS	Chincoteague Island, VA	757/336 -6122	Chincoteague NWR Species
Susan Barco	VMSM	Virginia Beach, VA	757/425 -3474	Marine Mammals
W. Mark Swingle	VMSM	Virginia Beach, VA	757/425 -3474	Marine Mammals

Major Data Sources Used: Marine Mammals

Swingle, W.M. and S. Barco. 2004. Virginia Marine Science Museum (VMSM) Stranding Program 2003 grant report. VMSM, Virginia Beach, VA. 37 pp.

Morgan, L.W. , J. A. Musick, and C.W. Potter. 2002. Temporal and geographic occurrences of cetacean strandings and manatee sightings in Virginia, with notes on adverse human-cetacean interactions, from 1983-1989. *Journal of the North Carolina Academy of Science*. 118(1):12-26.

BIRDS

Bird concentration areas depicted in this atlas include:

Waterbird and shorebird nesting and wintering sites – Locations where waterbirds (e.g., herons, egrets, gulls, terns), American oystercatchers, piping plovers (state/federally threatened), and Wilson's plovers (state endangered) have been documented as nesting are mapped. Colony size (number of birds present) is included in tables on the reverse side of the maps. Documented American oystercatcher overwintering sites are also mapped. **Please note:** Point locations of nesting sites and colony size information are typically based on a single year of data. Survey dates varied by data set, but fell between the years of 1998-2004. Exact nest locations and colony counts are ephemeral for some species, and environmental factors, such as weather, play a role in annual variance. The data on the maps can be used as a reasonable prediction of the types of species and potential numbers of birds found in an area. In the case of a spill event, it is critical to contact the local resource experts regarding current conditions.

Raptor nesting sites and concentration areas – Point locations where bald eagles (state/federally threatened), osprey, and peregrine falcons (state threatened) have been documented as nesting. Also included are areas in wetlands, along riverine corridors, and in bays where raptors concentrate for feeding.

National Wildlife Refuge concentration areas – National Wildlife Refuges (NWR) where a large number of birds and a high diversity of species concentrate are highlighted. USFWS staff provided bird distribution information for a large number of refuges. Refuges located in the atlas include: Back Bay NWR, Eastern Shore NWR, Fisherman's Island NWR, Eastern Virginia Rivers NWR Complex (James River, Presquile, and Rappahannock River Valley NWRs), Plum Tree Island NWR, Mackay Island NWR, Nansemond NWR, Wallops Island NWR, Great Dismal Swamp NWR, Potomac River NWR Complex (Mason Neck. Occoquan Bay, and Featherstone NWRs), and Chincoteague NWR.

Waterfowl, diving bird, and pelagic bird migratory staging, wintering, and nesting areas – Concentration areas are shown for migratory and wintering waterfowl and diving birds in bays, rivers, creeks, marshes, and open-water marine/estuarine areas. Descriptive terms, such as "high" and "moderate" are used in some areas and were derived from conversations with resource experts and numeric concentrations reported in mid-winter survey data collected over a multi-year period (2001-2003). Limited waterfowl nesting areas are mapped, most commonly for American black duck (a species of management concern), gadwall, wood duck, mallard, Canada goose, and occasionally for other species in wetlands when information was available.

Migratory shorebird stopover areas – The Barrier Islands Western Hemispheric Shorebird Reserve Network (WHSRN) site (international ranking) occurs along the Eastern Shore of Virginia. Areas where large concentrations of shorebirds occur annually, particularly during the spring and autumn months, are mapped along the barrier islands and in other habitats along the Atlantic Ocean and Chesapeake Bay.

Marsh birds and passerine species – General locations of marsh birds (e.g., rails) and passerine species of concern (e.g., some sparrow species) were mapped.

Expert contacts for Virginia birds are:

Name	Agency	City	Phone	Species
Alexandra Wilke	William & Mary	Williams-burg, VA	757/635 -3133	American oystercatcher
Ruth Boettcher	VDGIF	Painter, VA	757/442 -2429	Eastern Shore species
Tom Penn	USFWS	Chinco-teague Island, VA	757/336 -6122	Chincoteague NWR
John Gallegos	USFWS	Virginia Beach, VA	757/721 -2412	Back Bay NWR
Rachel Cliche	VDGIF	Virginia Beach, VA	757/721 -2412	Back Bay NWR
Gary Costanzo	VDGIF	Williams-burg, VA	757/253 -7072	Waterfowl
Tom Bidrowski	VDGIF	Williams-burg, VA	757/253 -7072	Waterfowl
Pam Denmon	USFWS	Cape Charles, VA	757/331 -2760	Eastern Shore/ Fisherman's Island NWRs
Joe McCauley	USFWS	Warsaw, VA	804/333 -1470	Eastern VA Rivers NWR
Joe Witt	USFWS	Wood-bridge, VA	703/490 -4979	Potomac River NWR Complex
Barry Truitt	TNC	Nassa-waddox, VA	757/442 -3049	Shorebirds and colonial waterbirds
Doug Furcell	USFWS	Annapolis, MD	410/573 -4560	Waterfowl

Major Data Sources Used: Birds

College of William and Mary Center for Conservation Biology (CCB), Virginia Department of Game and Inland Fisheries (VDGIF), The Nature Conservancy (TNC). 2003. Annual American oystercatcher breeding survey. College of William and Mary CCB, Cape Charles, VA, digital table.

Forsell, D.J. 2004. Draft special report of the distribution and abundance of wintering seaducks and waterbirds in mid-Atlantic coastal waters emphasizing the mouth of the Chesapeake Bay. USFWS, Chesapeake Bay Field Office, Annapolis, MD, 10 pp.

Manomet Center for Conservation Sciences. 2004. Barrier Islands Western Hemispheric Shorebird Reserve Network (WHSRN) site description. http://www.manomet.org/WHSRN/.

The Nature Conservancy (TNC). 1998. 1998 seaside lagoon survey results. TNC, Charlottesville, VA, digital vector data.

TNC, College of William and Mary CCB, VDGIF. 2003. American oystercatcher winter roost surveys. TNC, digital table.

Truitt, B., R. Boettcher, A. Wilke. 2004. 2003 winter American oystercatcher roost survey: seaside, Eastern Shore: November 12-18. VDGIF, digital table.

U.S. Fish and Wildlife Service (USFWS). 1991. Chesapeake Bay bald eagle fact sheet. USFWS, Annapolis, MD, 2 pp.

USFWS. 1992. Birds: Eastern Shore of Virginia and Fisherman's Island National Wildlife Refuges. Department of the Interior, USFWS, Cape Charles, VA, brochure.

USFWS. 1999. Chincoteague National Wildlife Refuge Birds. Dept. of the Interior, USFWS, Chincoteague Island, VA, 10 pp.

USFWS. 2003. Birds: Back Bay National Wildlife Refuge. Department of the Interior, USFWS, Virginia Beach, VA, brochure.

USFWS. 2004. Back Bay National Wildlife Refuge osprey nest locations. USFWS, Virginia Beach, VA, 1 map.

USFWS, Eastern Virginia Rivers National Wildlife Refuge (NWR). 2004. Wildlife at Plum Tree Island NWR. USFWS, 2 pp.

USFWS, Migratory Bird Management. 2004. Mid-winter waterfowl survey: 2001-2003. USFWS, digital vector data.

Virginia Department of Conservation and Recreation, Division of Natural Heritage (VA DCR DNH). 2004. Wreck Island bird colonies-2003. VA DCR DNH, 1 map.

VDGIF. 2003. Bald eagle nests active in 2003. VDGIF, 1 map.

VDGIF. 2003. Coastal peregrine falcon coordinates. VDGIF, digital table.

VDGIF. 2003. Virginia Plover Survey: 2001-2003. VDGIF, digital table.

VDGIF, Fish and Wildlife Services. 2000. Eagle concentration zones – James River, Rappahannock River. VDGIF, 2 maps.

Watts, B.D. and B.J. Paxton. 2004. Digital atlas of colonial waterbirds in coastal Virginia: 2003 breeding season. CCBTR-04-05. Center for Conservation Biology, College of William and Mary, Williamsburg, VA, digital vector data.

Wilke, A. 2003. Breeding surveys, banding, and productivity of American oystercatchers on the barrier islands of Virginia. College of William and Mary CCB, Cape Charles, VA, digital map.

REPTILES

Sea turtles depicted in this atlas include Kemp's ridley (*Lepidochelys kempi*, state/federally endangered), loggerhead (*Caretta caretta*, state/federally threatened), green (*Chelonia mydas*, state/federally threatened), and leatherback (*Dermochelys coriacea*, state/federally endangered). The Chesapeake Bay is an essential seasonal foraging ground for juvenile loggerhead, Kemp's ridley, and green sea turtles, as well as adult leatherbacks. Adult loggerhead sea turtles use the state waters and coastal beaches to forage and nest. Nesting seasonality refers to the peak time when adults construct nests and deposit eggs. Locations of nests were based on digital point data provided by VDGIF. Several known in-water concentrations, as well as larger, more general areas where nearshore sea turtle foraging and resting habitat exists are also mapped. These locations were provided by resource experts at VIMS and include the mainstem of the Chesapeake, its tributaries, and coastal waters. Nesting has been recorded on the sand beaches of False Cape State Park, Back Bay National Wildlife Refuge, Assateague Island, and the Dam Neck Naval Base.

Diamondback terrapins are widely distributed in Virginia waters, with significant concentrations located around salt marsh and salt marsh islands, which serve as important nursery habitat for hatchlings and juveniles. Terrapins aggregate in estuarine bays during the winter, migrate up tidal creeks in the spring, and lay eggs on beaches from May-July. Tangier Sound is likely the most fertile terrapin habitat in Chesapeake Bay (G.M. Haramis, USGS, pers. comm.). Distribution information for terrapins was provided by USGS and VDGIF biologists.

Expert contacts for Virginia reptiles are:

Name	Agency	City	Phone	Species
Jack Musick	VIMS	Gloucester Point, VA	804/684-7317	Sea turtles
Kate Mansfield	VIMS	Gloucester Point, VA	804/684-7313	Sea turtles
G. Michael Haramis	USGS	Laurel, MD	301/497-5651	Terrapins
Tom Penn	USFWS	Chincoteague Island, VA	757/336-6122	Sea turtles
Ruth Boettcher	VDGIF	Painter, VA	757/442-2429	Terrapins, Sea turtles

Major Data Sources Used: Reptiles

Mansfield, K. 2003. Surfacing for science. *Virginia Marine Resource Bulletin*. Vol 35(2): 2-8.

Musick, J.A., and C.J. Limpus. 1997. Habitat utilization and migration in juvenile sea turtles. *In* Lutz, P.L. and J.A. Musick (eds.). *The Biology of Sea Turtles*, CRC Press, Boca Raton, pp. 137-164.

TERRESTRIAL MAMMALS

The terrestrial mammals depicted in this atlas are limited to the northern river otter mapped in Mason Neck and Chincoteague National Wildlife Refuges. Other mammals are potentially occurring in the study area, but are not mapped due to their relatively wide distribution, a lack of information regarding particular concentration areas, and/or the unlikelihood of impact during coastal and marine oil spills due to their use of more upland and inland habitats.

Expert contacts for Virginia terrestrial mammals are:

Name	Agency	City	Phone	Species
Joseph Witt	USFWS	Woodbridge, VA	703/490-4979	NWR Species
Tom Penn	USFWS	Chincoteague Island, VA	757/336-6122	NWR Species

FISH

Finfish depicted in this atlas include selected marine, estuarine, anadromous, and brackish water species. Species of commercial, recreational, ecological, and/or conservation interest are emphasized. Fish distributions are based largely on expert opinion and incorporate a combination of hardcopy reports (see references), survey data, field experience, and habitat-based designations provided by resource experts at VIMS and the University of Maryland (UM) Center for Environmental Science.

Estuarine and marine fish species were mapped using broad distributions on most maps. The Chesapeake Bay Multispecies Modeling and Assessment Program (ChesMMAP) divided the Chesapeake Bay into five regions: "Maryland Upper," "Maryland Lower," "Virginia Upper," "Virginia Middle," and "Virginia Lower." For this atlas, the data collected from the "Virginia Middle" and "Virginia Lower" regions were used to depict fish distributions. Based on interviews with local resource experts at VIMS, estuarine and marine fish were placed into three main categories: 1) coastal species (species occurring in waters off the coast of Virginia), 2) Chesapeake Bay species (species occurring from the mouth of the Bay up to the Potomac River), and 3) riverine species (anadromous species and species that inhabit the tributaries of the Bay).

Important spawning areas were noted for anadromous and key commercial species (e.g., striped bass, blueback herring, American shad). Fish species were mapped using polygons to delineate the portions of rivers and streams where spawning occurs, and where juveniles and adults are likely to pass through at some point during their life cycles. Juvenile life stages of marine and estuarine fish were also mapped in the rivers and streams.

Seasonality was based mostly on data presented in Murdy et al. (1997), knowledge from local resource experts, and data collected as part of the National Oceanic and Atmospheric Administration's (NOAA) Estuarine Living Marine Resources (ELMR) Program.

Expert contacts for Virginia fish are:

Name	Agency	City	Phone	Species
Chris Bonzek	VIMS	Gloucester Point, VA	804/684-7291	Marine/ Estuarine
Jack Musick	VIMS	Gloucester Point, VA	804/684-7317	Marine/ Estuarine
Jon Lucy	VIMS	Gloucester Point, VA	804/684-7166	Marine/ Estuarine
Herb Austin	VIMS	Gloucester Point, VA	804/684-7321	Marine/ Estuarine
Mandy Hewitt	VIMS	Gloucester Point, VA	804/684-7351	Marine/ Estuarine/ Brackish
Marcel Montane	VIMS	Gloucester Point, VA	804/684-7328	Marine/ Estuarine/ Brackish
A.C. Carpenter	PRFC	Colonial Beach, VA	804/224-7148	Potomac River species
John Olney	VIMS	Gloucester Point, VA	804/684-7334	Anadromous
Joel Hoffman	VIMS	Gloucester Point, VA	804/684-7814	Anadromous
Ed Houde	Univ. of MD	Solomons, MD	410/326-7224	Anadromous

Major Data Sources Used: Fish

Austin, H.M. 2002. Decadal oscillations and regime shifts, a characterization of the Chesapeake Bay marine climate. *American Fisheries Society Symposium*. 32:155-170.

Austin, H.M., A.D. Estes, and D.M. Seaver. 2002. Annual progress report: estimation of juvenile striped bass relative abundance in the Virginia portion of Chesapeake Bay, January 2001-December 2001. Department of Fisheries Science, Virginia Institute of Marine Science, Gloucester Point, VA, 33 pp.

Austin, H.M., A.D. Estes, and D.M. Seaver. 2002. Annual progress report: estimation of juvenile striped bass relative abundance in the Virginia portion of Chesapeake Bay, January 2002-December 2002. Department of Fisheries Science, Virginia Institute of Marine Science, Gloucester Point, VA, 33 pp.

Bilkovic, D.M., J.E. Olney, and C.H. Hershner. 2002. Spawning of American shad (Alosa sapidissima) and striped bass (Morone saxatilis) in the Mattaponi and Pamunkey Rivers, Virginia. *Fishery Bulletin*. 100:632-640.

ChesMMAP Trawl Program Group. 2004. Chesapeake Bay Multispecies Monitoring and Assessment Program: A preliminary data summary report, 2002 and 2003. Virginia Institute of Marine Science, Gloucester Point, VA, 136 pp.

Chao, L.N. and J.A. Musick. 1977. Life history, feeding habits, and functional morphology of juvenile sciaenid fishes in the York River estuary, Virginia. *Fishery Bulletin*. 75(4):657-702.

Geer, P.J. 1999. Annual data summary report: Bottom trawl survey. Juvenile fish and blue crab stock assessment program. Virginia Institute of Marine Science, Gloucester Point, VA, 322 pp.

Grant, G.C. and J.E. Olney. 1991. Distribution of striped bass *Morone saxatilis* (Walbaum) eggs and larvae in major Virginia rivers. *Fishery Bulletin*. 89:187-193.

Grubbs, R.D. 2001. Nursery delineation, habitat utilization, movements, and migration of juvenile *Carcharhinus plumbeus* in Chesapeake Bay, Virginia, USA. Unpublished dissertation, The Faculty of the School of Marine Science, College of William and Mary, VA, 73 pp.

Lippson, A. J., et al. 1979. Environmental atlas of the Potomac estuary. Martin Marietta Corporation Environmental Center, prepared for Maryland Department of Natural Resources, Annapolis, MD, 279 pp.

Montane, M.M., H.M. Austin, P.J. Geer, and W.A. Lowery. 2003. Estimation of relative abundance of recreationally important juvenile finfish in the Virginia portion of Chesapeake Bay: June 2002 – July 2003. Department of Fisheries Science, Virginia Institute of Marine Science, Gloucester Point, VA, 100 pp.

Murdy, E.O., R.S. Birdsong, and J.A. Musick. 1997. Fishes of Chesapeake Bay. Smithsonian Institution Press, Washington D.C., 324 pp.

Musick, J.A. and J.A. Colvocoresses. 1985. Seasonality and the distribution, availability, and composition of fish assemblages in Chesapeake Bight. Chap. 21, 451-474 pp. *In:* A. Yanez Arancibia (ed.) Fish Community Ecology in Estuaries and Coastal Lagoons: Towards an Ecosystem Integration, UNAM Press, Mexico, 654 pp.

Musick, J.A., B.L. Norcross, and D. Hata. 1999. Fish and fisheries of the seaside of the Eastern Shore of Virginia. Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA, Report #99-5, 26 pp.

Stone, S.L., T.A. Lowery, J.D. Field, C.D. Williams, D.M. Nelson, S.H. Jury, M.E. Monaco, and L. Andreasen. 1994. Distribution and abundance of fishes and invertebrates in Mid-Atlantic estuaries. ELMR Rep. No. 12, NOAA/NOS Strategic Environmental Assessments Division, Silver Spring, MD, 280 pp.

INVERTEBRATES

Invertebrates depicted in this atlas include selected marine and estuarine species and rare/threatened insects. Species of commercial, recreational, ecological, and/or conservation interest are emphasized. Several known invertebrate concentrations, as well as larger, more general areas where invertebrate habitat exists, were mapped. Invertebrate distributions are based largely on expert opinion provided by VIMS and VA DCR DNH. A 2002 digital point dataset for hard clam and Eastern oyster commercial aquaculture sites was also provided by VIMS. Seasonality was based mostly on data collected as part of the NOAA ELMR Program.

Expert contacts for Virginia invertebrates are:

Name	Agency	City	Phone	Species
Mike Oesterling	VIMS	Gloucester Point, VA	804/684-7165	Shellfish
Chris Bonzek	VIMS	Gloucester Point, Va	804/684-7291	Blue crabs
David Rudders	VIMS	Gloucester Point, VA	804/684-7163	Shellfish
Herb Austin	VIMS	Gloucester Point, VA	804/684-7321	Horseshoe crabs
Marcel Montane	VIMS	Gloucester Point, VA	804/684-7328	Blue crabs
G. Michael Haramis	USGS	Laurel, MD	301/497-5651	Horseshoe crabs
Dot Field	VA DCR DNH	Wacha-preague, VA	757/787-5576	Rare insects
Marcia Berman	VIMS	Gloucester Point, VA	804/684-7188	Shellfish
David Hata	VA Tech Univ.	Blacksburg, VA	540/231-7683	Horseshoe crabs

Major Data Sources Used: Invertebrates

Austin, H.M., D. Evans, and D.S. Haven. 1996. A retrospective time series analysis of oyster, *Crassostrea virginica*, recruitment (1946-1993). *Journal of Shellfish Research*. 15(3):565-582.

ChesMMAP Trawl Program Group. 2004. Chesapeake Bay Multispecies Monitoring and Assessment Program: A preliminary data summary report, 2002 and 2003. Virginia Institute of Marine Science, Gloucester Point, VA, 136 pp.

Brindza, L.J. 2002. Monarch butterfly migration project: a summary from 1998-2001. Field Research Report 1995-2002: Coastal Virginia Wildlife Observatory, Eastville, VA, 92-96 pp.

Geer, P.J. 1999. Annual data summary report: bottom trawl survey. Juvenile fish and blue crab stock assessment program, Virginia Institute of Marine Science, Gloucester Point, VA, 322 pp.

Montane, M.M., H.M. Austin, P.J. Geer, and W.A. Lowery. 2003. Estimation of relative abundance of recreationally important juvenile finfish in the Virginia portion of Chesapeake Bay: June 2002 – July 2003. Department of Fisheries Science, Virginia Institute of Marine Science, Gloucester Point, VA, 100 pp.

Stone, S.L., T.A. Lowery, J.D. Field, C.D. Williams, D.M. Nelson, S.H. Jury, M.E. Monaco, and L. Andreasen. 1994. Distribution and abundance of fishes and invertebrates in Mid-Atlantic estuaries. ELMR Rep. No. 12, NOAA/NOS Strategic Environmental Assessments Division, Silver Spring, MD, 280 pp.

HABITATS

Benthic habitats (e.g., submerged aquatic vegetation) and rare/sensitive coastal plants were mapped in this atlas.

Submerged aquatic vegetation (SAV) - SAV distribution included in this atlas is based on 2002 digital data provided by VIMS. Information on SAV distribution in Back Bay NWR was provided by NWR staff. SAV are shown in the atlas as polygons. Two different purple "simplified wetland" patterns were used to display SAV. The "less dense" pattern signifies that the SAV coverage within the polygon ranges from 0-40% cover. The "more dense" pattern signifies that the SAV coverage within the polygon ranges from 41-100%. No icons or RAR#s are used.

Rare/sensitive coastal plants – Plants/vegetative communities deemed as rare or sensitive to coastal oil spills by the VA DCR Division of Natural Heritage and USFWS were included in this atlas. Refer to the species list (p. 7) for documentation of which species/communities were mapped.

Expert contacts for Virginia habitats are:

Name	Agency	City	Phone	Species
Robert Orth	VIMS	Gloucester Point, VA	804/684-7392	SAV
Dot Field	VA DCR DNH	Wachapreague, VA	757/787-5576	Rare plants
Tom Penn	USFWS	Chincoteague Island, VA	757/336-6122	Chinco-teague NWR plants
John Gallegos	USFWS	Virginia Beach, VA	757/721-2412	Back Bay NWR SAV and plants
Kyle Hall	Elizabeth City State Univ.	Elizabeth City, NC	252/335-3595	Back Bay NWR SAV

Major Data Sources Used: Habitats

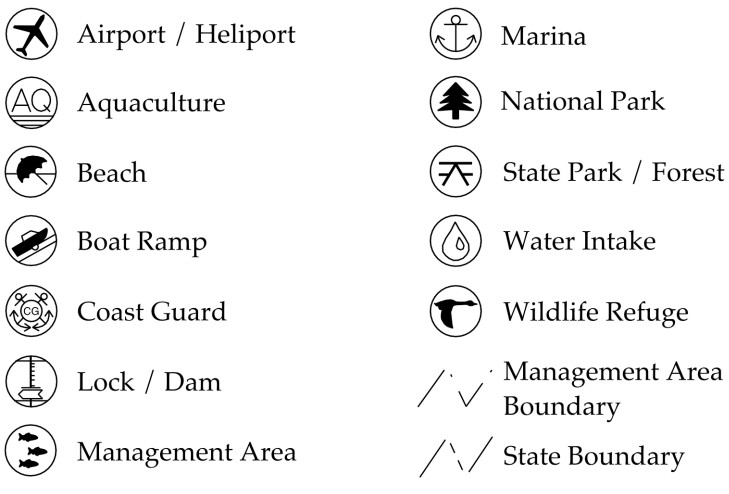
Virginia Institute of Marine Science (VIMS). 2003. Chesapeake Bay Submerged Aquatic Vegetation coverage. VIMS, Gloucester Point, VA, digital vector data.

HUMAN-USE RESOURCES

Management areas such as wildlife refuges, state parks, and state forests are mapped as polygons, with the boundaries

indicated as a black dot-dash line with the corresponding icon placed near the center of the polygon. Where the feature is a known point location (e.g., water intake, marina), the exact location is shown as a small black dot and a leader line is drawn from it to the icon.

A human use number (HU#) can be found below the icon for some resources (such as management areas and aquaculture sites). The HU# references a table on the reverse side of the map and 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.



Airport/Heliport: Locations of airports, airfields, landing strips, helipads, etc., whether they are manned or unmanned. This information was provided by USGS.

Aquaculture: Locations of aquaculture sites. This information was compiled from digital data provided by VIMS. Only those records that were identified as commercial oyster or hard clam aquaculture sites were used for these maps.

Beach: Locations of recreational beaches used for activities such as swimming, sun-bathing, boating, picnicking, etc. Water activities and use of recreational beaches may occur along all shoreline areas where access is possible. This information was gathered from published atlases and local resource managers.

Boat Ramp: Locations of boat ramps. This information was gathered from a digital point coverage provided by VDGIF.

Coast Guard: Location of the U.S. Coast Guard stations. This information was provided by USGS.

Lock and Dam: Locations of lock and dam sites in the coastal zone. This information was collected during the January 2004 overflights while surveying the Chesapeake Bay shoreline.

Management Area: Locations of conservation areas or lands. Property names are provided in the data tables of each map. This information was gathered from a digital polygon coverage provided by VDGIF and VA DCR.

Marina: Locations of marinas. This information was gathered from a digital point coverage provided by the VDGIF.

National Park: Locations of National Park lands. This information was gathered from a digital polygon coverage provided by the VA DCR.

State Park/ Forest: Locations of areas managed by VA DCR as state parks, state forests, and related properties. Property names are provided in the data tables for each map. This information was gathered from a digital polygon coverage provided by VA DCR.

Water Intake: John Gallegos (USFWS, Back Bay NWR) provided the only water intake location for these maps.

Wildlife Refuge/Management Area: Areas managed by USFWS as National Wildlife Refuges and other management area locations were gathered from a digital polygon coverage provided by VDGIF and VA DCR. Site names are provided on the data tables for each map.

GEOGRAPHIC INFORMATION SYSTEM

The entire atlas product is stored in digital form in a Geographic Information System (GIS) as spatial data layers and associated databases. 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 on the maps by double and triple line patterns and in the database by ESI#1/ESI#2, where ESI#1 is the landward-most classification and ESI#2 is the seaward-most classification. In addition to the line features, tidal flats (ESI = 7, ESI = 9A), marshes (ESI=10A, ESI=10B), and scrub-shrub wetlands (ESI = 10D) are also stored as polygons. Therefore, the legend on each map may contain two patterns depicted on a map: a linear feature as well as a polygonal feature.

SENSITIVE BIOLOGICAL RESOURCES

Biological resources are stored as polygons or points. 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, water intakes, and aquaculture sites when available. All metadata sources are documented at the feature level.

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The biological and human-use data included on the maps were provided by numerous individuals and agencies. Staff at the Virginia Institute of Marine Science, College of William and Mary, U.S. Fish and Wildlife Service, Virginia Department of Game and Inland Fisheries, Virginia Department of Conservation and Recreation Division of Natural Heritage, and The Nature Conservancy contributed a vast amount of information to this effort, including first-hand expertise, publications, maps, and digital data. Other agencies and organizations contributing to data development and review included: U.S. Geological Survey, Virginia Polytechnic Institute and State University, University of Maryland, and Virginia Marine Science Museum.

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 Colin Plank and Thomas Freeman. The biological and human-use data were collected and compiled onto base maps by Christine Lord Boring and Heidi Hinkeldey. Lee Diveley, Katie Phillips, Chris Locke, Greg Whitson, and Vermell Pyatt entered, processed, and produced the GIS data and hardcopy atlas. Graphic art production was conducted by Joe Holmes. Christine Lord Boring, Heidi Hinkeldey, Chris Locke, Mark White and Joe Holmes prepared the final text documents and metadata.

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 Virginia Institute of Marine Science, the College of William and Mary, U.S. Geological Survey, Virginia Polytechnic Institute and State University, University of Maryland, Virginia Marine Science Museum, U.S. Fish and Wildlife Service, Virginia Department of Game and Inland Fisheries, Virginia Department of Conservation and Recreation or other agencies. Likewise, information contained in the atlas and database cannot be used in place of consultations with natural and cultural resource agencies, or in place of field surveys. Also, this atlas should not be used for navigation.

SPECIES LIST

Common Name*	Species Name*
BIRDS	
DIVING BIRD	
Brown pelican	*Pelecanus occidentalis*
Common loon	*Gavia immer*
Double-crested cormorant	*Phalacrocorax auritus*
Loons	*Gavia spp.*
Pied-billed grebe	*Podilymbus podiceps*
Red-throated loon	*Gavia stellata*
GULL /TERN	
Black skimmer	*Rynchops niger*
Bonaparte's gull	*Larus philadelphia*
Caspian tern	*Sterna caspia*
Common tern	*Sterna hirundo*
Forster's tern	*Sterna forsteri*
Great black-backed gull	*Larus marinus*
Gull-billed tern	*Sterna nilotica*
Gulls	-
Herring gull	*Larus argentatus*
Laughing gull	*Larus atricilla*
Least tern	*Sterna antillarum*
Lesser black-backed gull	*Larus fuscus*
Ring-billed gull	*Larus delawarensis*
Royal tern	*Sterna maxima*
Sandwich tern	*Sterna sandvicensis*
Terns	-
PASSERINE BIRD	
Brown-headed cowbird	*Molothrus ater*
Henslow's sparrow	*Ammodramus henslowii*
Marsh wren	*Cistothorus palustris*
Saltmarsh sharp-tailed sparrow	*Ammodramus caudacutus*
Sedge wren	*Cistothorus platensis*
Swamp sparrow	*Melospiza georgiana*
PELAGIC BIRD	
Northern gannet	*Morus bassanus*
RAPTOR	
American kestrel	*Falco sparverius*
Bald eagle	*Haliaeetus leucocephalus*
Broad-winged hawk	*Buteo platypterus*
Merlin	*Falco columbarius*
Northern harrier	*Circus cyaneus*
Osprey	*Pandion haliaetus*
Peregrine falcon	*Falco peregrinus*
Red-shouldered hawk	*Buteo lineatus*
Red-tailed hawk	*Buteo jamaicensis*
Sharp-shinned hawk	*Accipiter striatus*
SHOREBIRD	
American oystercatcher	*Haematopus palliatus*
Black-bellied plover	*Pluvialis squatarola*
Black-necked stilt	*Himantopus mexicanus*
Dunlin	*Calidris alpina*
Greater yellowlegs	*Tringa melanoleuca*
Killdeer	*Charadrius vociferus*
Least sandpiper	*Calidris minutilla*
Lesser yellowlegs	*Tringa flavipes*
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*
Spotted sandpiper	*Actitis macularia*
Whimbrel	*Numenius phaeopus*
Willet	*Catoptrophorus semipalmatus*
Wilson's plover	*Charadrius wilsonia*
WADING BIRD	
American bittern	*Botaurus lentiginosus*
American woodcock	*Scolopax minor*
Bitterns	-
Black rail	*Laterallus jamaicensis*
Black-crowned night-heron	*Nycticorax nycticorax*
Cattle egret	*Bubulcus ibis*
Clapper rail	*Rallus longirostris*
Egrets	-
Glossy ibis	*Plegadis falcinellus*
Great blue heron	*Ardea herodias*
Great egret	*Ardea alba*
Green heron	*Butorides virescens*
Heron	-
King rail	*Rallus elegans*
Least bittern	*Ixobrychus exilis*
Little blue heron	*Egretta caerulea*
Rails	-
Snowy egret	*Egretta thula*

Common Name*	Species Name*
BIRDS, cont.	
WADING BIRD, cont.	
Sora	*Porzana carolina*
Striated heron	*Butorides striatus*
Tricolored heron	*Egretta tricolor*
Virginia rail	*Rallus limicola*
Wading birds	-
White ibis	*Eudocimus albus*
Yellow-crowned night-heron	*Nyctanassa violacea*
WATERFOWL	
American black duck	*Anas rubripes*
American coot	*Fulica americana*
American wigeon	*Anas americana*
Blue-winged teal	*Anas discors*
Brant	*Branta bernicla*
Bufflehead	*Bucephala albeola*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Common goldeneye	*Bucephala clangula*
Common merganser	*Mergus merganser*
Common moorhen	*Gallinula chloropus*
Dabbling ducks	-
Gadwall	*Anas strepera*
Green-winged teal	*Anas crecca*
Lesser scaup	*Aythya affinis*
Long-tailed duck	*Clangula hyemalis*
Mallard	*Anas platyrhynchos*
Mergansers	-
Mute swan	*Cygnus olor*
Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Ruddy duck	*Oxyura jamaicensis*
Scaup	*Aythya spp.*
Scoters	*Melanitta spp.*
Sea ducks	-
Snow goose	*Chen caerulescens*
Swans	*Cygnus spp.*
Tundra swan	*Cygnus columbianus*
Wood duck	*Aix sponsa*
FISH	
FISH	
Alewife	*Alosa pseudoharengus*
American eel	*Anguilla rostrata*
American shad	*Alosa sapidissima*
Atlantic croaker	*Micropogonias undulatus*
Atlantic mackerel	*Scomber scombrus*
Atlantic menhaden	*Brevoortia tyrannus*
Atlantic silverside	*Menidia menidia*
Atlantic spadefish	*Chaetodipterus faber*
Atlantic sturgeon	*Acipenser oxyrinchus*
Banded killifish	*Fundulus diaphanus*
Bay anchovy	*Anchoa mitchilli*
Black drum	*Pogonias cromis*
Black sea bass	*Centropristis striata*
Blueback herring	*Alosa aestivalis*
Bluefish	*Pomatomus saltatrix*
Bluegill	*Lepomis macrochirus*
Bowfin	*Amia calva*
Brown bullhead	*Ameiurus nebulosus*
Butterfish	*Peprilus triacanthus*
Chain pickerel	*Esox niger*
Channel catfish	*Ictalurus punctatus*
Clearnose skate	*Raja eglanteria*
Common carp	*Cyprinus carpio*
Gobies	-
Harvestfish	*Peprilus alepidotus*
Hickory shad	*Alosa mediocris*
Hogchoker	*Trinectes maculatus*
Inland silverside	*Menidia beryllina*
Killifish	*Fundulus spp.*
Largemouth bass	*Micropterus salmoides*
Minnows	-
Mummichog	*Fundulus heteroclitus*
Northern kingfish	*Menticirrhus saxatilis*
Northern pipefish	*Syngnathus fuscus*
Northern puffer	*Sphoeroides maculatus*
Northern searobin	*Prionotus carolinus*
Red drum	*Sciaenops ocellatus*
Red hake	*Urophycis chuss*
Sandbar shark	*Carcharhinus plumbeus*
Scup (porgy)	*Stenotomus chrysops*
Silver hake	*Merluccius bilinearis*
Silver perch	*Bairdiella chrysoura*

Common Name*	Species Name*

FISH, cont.

FISH, cont.	
Silversides	-
Spiny dogfish	*Squalus acanthias*
Spot	*Leiostomus xanthurus*
Spotted hake	*Urophycis regia*
Spotted seatrout	*Cynoscion nebulosus*
Striped bass	*Morone saxatilis*
Striped killifish	*Fundulus majalis*
Summer flounder	*Paralichthys dentatus*
Tautog	*Tautoga onitis*
Weakfish	*Cynoscion squamipinnis*
White catfish	*Ameiurus catus*
White perch	*Morone americana*
Winter flounder	*Pleuronectes americanus*
Yellow perch	*Perca flavescens*

HABITATS

PLANT	
Native coastal strand vegetation	
Rare plant	
Southern beach spurge	*Chamaesyce bombensis*
SAV	
Submerged aquatic vegetation	
UPLAND	
Maritime dune scrub	
Sea-beach knotweed	*Polygonum glaucum*
WETLAND	
Sea level fen	
Seabeach amaranth	*Amaranthus pumilus*

INVERTEBRATES

BIVALVE	
Brackishwater clam	*Rangia cuneata*
Carolina marsh clam	*Polymesoda caroliniana*
Eastern oyster	*Crassostrea virginica*
Northern quahog (hard clam)	*Mercenaria mercenaria*
CRAB	
Blue crab	*Callinectes sapidus*
Horseshoe crab	*Limulus polyphemus*
GASTROPOD	
Channeled whelk	*Busycon canaliculatum*
Knobbed whelk	*Busycon carica*
INSECT	
Spectral tiger beetle	*Cicindela lepida*
Monarch butterfly	*Danaus plexippus*
Northeastern beach tiger	*Cicindela dorsalis dorsalis*

MARINE MAMMALS

DOLPHIN/PORPOISE	
Bottlenose dolphin	*Tursiops truncatus*
Common dolphin	*Delphinus delphis*
Harbor porpoise	*Phocoena phocoena*
PINNIPED	
Harbor seal	*Phoca vitulina*
WHALE	
Humpback whale	*Megaptera novaeangliae*

REPTILE

TURTLE	
Diamondback terrapin	*Malaclemys terrapin*
Green sea turtle	*Chelonia mydas*
Kemp's ridley sea turtle	*Lepidochelys kempii*
Leatherback sea turtle	*Dermochelys coriacea*
Loggerhead sea turtle	*Caretta caretta*

TERRESTRIAL MAMMALS

SMALL MAMMAL	
Northern river otter	*Lutra canadensis*

* 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 rapid natural removal processes
- Attached animals and plants are sparse to moderate
- They are common in highly developed industrial and naval ports such as Norfolk and scattered along residential waterfronts, occurring along less than 1% of the shoreline

PREDICTED OIL BEHAVIOR

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

RESPONSE CONSIDERATIONS

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

EXPOSED WAVE-CUT PLATFORMS IN CLAY **ESI = 2A**

DESCRIPTION

- This habitat occurs where the shoreline is eroding across a wetland, leaving behind a wave-cut platform on the old marsh soils; there is often a thin sand/shell washover beach on top of the marsh
- The platform is usually composed of a hard, compact peat-rich clay with numerous holes from old root cavities
- The platform width can vary from a few feet to tens of feet
- Species density and diversity are low because they are highly eroding
- They are uncommon, occurring on less than 1% of the shoreline, mostly along the outer shore and the lower bay in areas of large fetch

PREDICTED OIL BEHAVIOR

- Oil will not adhere to the wet muddy surface, but could penetrate root cavities if present
- Persistence of any stranded oil is usually short-term, except where trapped in slump blocks eroded from the marsh scarp

RESPONSE CONSIDERATIONS

- Cleanup is usually not required except for areas of high biological use
- Where the high-tide area is accessible, it may be feasible to manually remove heavy oil accumulations and oiled debris

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EXPOSED SCARPS AND STEEP SLOPES IN CLAY **ESI = 2B**

DESCRIPTION

- These habitats generally occur along tidal channels and major river tributaries in the marsh where the currents 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
- Very uncommon, comprising about 0.02% of the shoreline

PREDICTED OIL BEHAVIOR

- Oil is not expected to adhere to the wet, impermeable 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
- This shoreline type is common along the outer coast and sporadic in the bay, comprising 6% of the shoreline

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 oiled and dune areas should be severely limited, to prevent contamination of clean areas
- Manual cleanup, rather than road graders and front-end loaders, is advised to minimize the volume of sand removed from the shore and requiring disposal
- All efforts should focus on preventing the 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 the logs can accumulate at the base of the scarp
- Biological utilization by birds and infauna is low
- They are uncommon, comprising less than 0.01% of the shoreline

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 logs that have accumulated at the base of the scarp
- There is little potential for burial except when major slumping of the bluff occurs
- Active erosion of the scarp will remove the oil

RESPONSE CONSIDERATIONS

- In most cases, cleanup is not necessary because of the short residence time of the oil

- The need for removal of oiled sediments and debris should be carefully evaluated because of the potential for increased erosion
- Closely supervised manual labor should be used so that the minimal amount of material is removed during cleanup

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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
- They occur along 3.6% of the shoreline, mostly along banks of major rivers

PREDICTED OIL BEHAVIOR

- During small spills, oil will be deposited primarily as a band along the high-tide line
- Under very 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 to release the oil without sediment removal
- Activity in the oiled sand should be limited to prevent mixing oil deeper into the beach
- Use of heavy equipment for oil/sand removal may result in the removal of excessive amounts of sand; manual cleanup may be more effective

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

DESCRIPTION

- Moderately sloping beach composed of a mixture of sand and shell (shell component should comprise between 20 to 80 percent of total sediments)
- Because of the mixed sediment sizes and shapes, there may be zones of pure sand or shell
- They are uncommon, comprising less than 1% of the shoreline

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

GRAVEL BEACHES **ESI = 6A**

DESCRIPTION

- The gravel fraction is composed of shell fragments; they occur as lag deposits where the finer-grained sediments have been eroded away
- The shells tend to form steep, narrow berms or washover deposits
- Shell beaches occur along areas exposed to high waves or boat wakes, and they comprise only 0.2% of the shoreline

PREDICTED OIL BEHAVIOR

- Deep penetration of stranded oil is likely on shell beaches because of their high permeability
- Long-term persistence will be controlled by the depth of routine reworking by waves or boat wakes
- Deeply penetrated oil can leach out for long periods

RESPONSE CONSIDERATIONS

- Heavy accumulations of pooled oil should be removed quickly from the upper beachface
- All oiled debris should be removed
- Sediment removal should be limited as much as possible

- Low-pressure flushing can be used to float fresh oil away from the sediments for recovery by skimmers or sorbents
- Heavily oiled shells may have to be removed and replaced with clean shells

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RIPRAP **ESI = 6B**

DESCRIPTION

- Riprap structures are composed of cobble- to boulder-sized blocks of bedrock or concrete
- Riprap structures are used for shoreline protection and tidal-inlet stabilization
- Attached biota are sparse on exposed riprap
- Present along highly developed commercial waterfronts and residential areas, comprising about 2% of the shoreline

PREDICTED OIL BEHAVIOR

- Deep penetration of oil between the blocks is likely
- Oil adheres readily to the rough surfaces of the blocks
- 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 heavily oiled blocks and replace them

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 use by foraging fish
- They occur along 1% of the shoreline, most commonly on the eastern shore

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 — 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
- These habitats are not common, occurring along the upper stretches of major rivers and comprising less than 0.2% of the shoreline

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
- Attached animal and plant life can be high
- They are common in highly developed commercial areas such as Norfolk and along residential waterfronts throughout the bay, comprising nearly 4% of the shoreline

PREDICTED OIL BEHAVIOR

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

RESPONSE CONSIDERATIONS

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

SHELTERED RIPRAP — ESI = 8C

DESCRIPTION

- Riprap structures are composed of cobble- to boulder-sized blocks of bedrock or concrete
- These structures are found inside harbors and bays in developed areas, sheltered from direct exposure to waves
- Attached animal and plant life can be present
- They are common in highly developed commercial and residential waterfront areas, comprising 3.5% of the shoreline

PREDICTED OIL BEHAVIOR

- Deep penetration of oil between the boulders is likely
- Oil adheres readily to the rough surfaces
- 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

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
- 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 for feeding
- Sheltered flats are common along most tidal channels, comprising 13% of the shoreline (the second most common habitat type)

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 and deployment of sorbents from shallow-draft boats may be helpful

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SHELTERED, 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
- These shorelines are most common along the major river tributaries and upper sections of tidal creeks to the bay and comprise 9% of the shoreline

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

SALT- AND BRACKISH-WATER MARSHES ESI = 10A

DESCRIPTION

- Intertidal wetlands containing emergent, herbaceous vegetation
- Width of the marsh can vary widely, from a narrow fringe to extensive areas
- 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 with numerous species with high utilization by birds, fish, and shellfish
- They are the most common shoreline type present, comprising 66% of the shoreline

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)

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

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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
- Present along tidal freshwater sections of rivers and large creeks, comprising 8% of the shoreline

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

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

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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
- This shoreline type occurs along low areas adjacent to the major tributaries and comprises about 2% of the shoreline

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 waterbodies

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is to let the area recover naturally
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. During flushing, care must be taken to prevent transporting oil to sensitive areas down slope or along shore
- Under stagnant water conditions, herding of oil with water spray may be needed to push oil to collection areas
- Oily debris can be removed where there is access
- Any cleanup activity must not mix the oil deeper into the sediments

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SCRUB-SHRUB WETLANDS **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
- This habitat type is not common in the study area

PREDICTED OIL BEHAVIOR

- Oil behavior depends on water level
- During high water, most of the oil passes through the forest, coating the vegetation above the waterline
- Woody vegetation is less sensitive than grasses to oil
- Some oil can be trapped and pooled on the swamp flood plain as water levels drop
- Penetration into the floodplain soils is usually limited because of high water levels, muddy composition, surface organic debris, and vegetation cover
- Large amounts of oily debris can remain in the wetland
- During dry periods, terrestrial spills flow downhill and accumulate in depressions or reach waterbodies

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is natural recovery

- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing
- Under stagnant water conditions, herding of oil with water spray may be needed to push oil to collection areas
- Oily debris can be removed where there is access
- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized
- Woody vegetation should not be cut