CONTENTS

Maps 21-30 contained in Volume 2

LEGEND FOLDOUT

ENVIRONMENTAL SENSITIVITY INDEX:
STRAITS OF MACKINAC AND ST. CLAIR-DETROIT RIVER SYSTEM

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for the shorelines of the Great Lakes Straits of Mackinac, which includes portions of Lake Michigan and Lake Huron, and the St. Clair-Detroit River System.

In Lake Michigan, the atlas covers Lake waters and islands from South Fox Island (northwest of Charlevoix on the Lower Peninsula) north to Port Inland (on the Upper Peninsula), southeast to Little Traverse Bay (on the Lower Peninsula), and northeast to the Mackinac Bridge. Major Lake Michigan islands mapped in this atlas include: South Fox Island, North Fox Island, Gull Island, High Island, Trout Island, Whiskey Island, Squaw Island, Garden Island, Little Island, Grape Island, Hog Island, Tims Island, Hat Island, Shore Island, Pismire Island, Beaver Island, Waugoshance Island, Temperance Island, Naubinway Island, Little Hog Island, Epoufette Island, St. Helena Island, and Green Island.

Major Lake Michigan bays mapped along the Upper Peninsula include: Inland Harbor, Epoufette Bay, and St. Martin Bay. Major Lake Michigan bays mapped along the Lower Peninsula include: Trails End Bay, Cecil Bay, Big Stone Bay, Sturgeon Bay, Big Cut, and Little Traverse Bay.

In Lake Huron, the atlas covers Lake waters and islands from the Straits of Mackinac along the Upper Peninsula northeast to Drummond Island and along the Lower Peninsula southeast to Presque Isle. Major Lake Huron islands mapped in this atlas include: Bois Blanc Island, Round Island, Mackinac Island, Presque Isle, Big St. Martin Island, St. Martin Island, Les Cheneaux Islands (Birch Island, Marquette Island, Little La Salle Island, La Salle Island, Government Island, Island No. 8, Hill Island, Boot Island, Coryell Island, Strongs Island), Rover Island, Albany Island, Peters Island, Crow Island, Drummond Island, Arnold Island, Bird Island, Bellevue Island, Garden Island, Bootjack Island, Clark Island, Silver Island, Espanore Island, Long Island, Gravel Island, Meade Island, and Shelter Island.

Major Lake Huron bays mapped along the Upper Peninsula include: Straits of Mackinac, East Moon Bay, Horseshoe Bay, St. Martin, Search Bay, Marquette Bay, Wilderness Bay, Hessel Bay, Mackinac Bay, Muscallonge Bay, Duck Bay, Voight Bay, Islington Bay, Urie Bay, Government Bay, Scammon Cove, McKay Bay, Prentiss Bay, and Beaver Tail Bay. Major Lake Huron Bays mapped along the Lower Peninsula include: Duncan Bay, Grass Bay, Hammond Bay, Thompsons Harbor, North Bay, Preque Isle Harbor, and False Presque Isle Harbor.

In Saint Marys River and Potagannissing Bay, the atlas covers Lake waters and islands south of Lime Island east to and including Drummond Island. Major Saint Marys River and Potagannissing Bay islands mapped in this atlas include: Sweets Islands, Pipe Island Twins, Pipe Island, Little Cass Island, Cass Island, Andrews Island, Butterfield Island, Macomb Island, Maple Island, Big Trout Island, Spence Island, Norris Island, Burnt Island, Claw Island, Wilson Island, Harris Island, Twin Sister Island, Cedar Island, Cherry Island, Long Island, Propellor Island, Bacon Island, Little Trout Island, Bow Island, Surveyors Island, Arrow Island, Adelaide Island, Cove Island, Fairbank Island, Picnic Island, Willoughby Island, Sam Island, Gull Island, Saltonstall Island, Mare Island, Standerson Island, Harbor Island, Boylanger Island, Wreck Island, Rogg Island, Little Rogg Island, Quarry Island, Bald Island, La Pointe Island, Grape Island, Ashman Island, Bay Island, James Island, Rutland Island, Peck Island, James Island, and Drummond Island. Major Saint Marys River and Potagannissing Bay water bodies include Maud Bay, De Tour Passage, Pigeon Cove, Sturgeon Bay, Scott Bay, Walkters Harbor, Colton Bay, and North Channel.

In the Lake St. Clair-Detroit River System and western Lake Erie, the atlas covers the United States sides of Lake St. Clair, Lake Huron from Lakeport to Port Huron, the St. Clair River from Port Huron to St. Clair Flats, the Detroit River from Lake St. Clair to Lake Erie, and western Lake Erie from Pointe Mouille to Maumee Bay/Toledo. Major islands mapped in Lake St. Clair include: Harsens Island, Dickinson Island, Green Island, Strawberry Island, Middle Island, North Island, Sand Island, Gull Island, and Grass Island. Major islands mapped in the Detroit River include: Belle Isle, Mud Island, Grassy Island, Grosse Ile, Stony Island, Elba Island, Sugar Island, Meso Island, Hickory Island, and Round Island, Sturgeon Bar. Major bays mapped in Lake St. Clair include: Bouvier Bay, Anchor Bay, Belvidere Bay, Campau Bay, L'anse Creuse Bay, Scotten Bay, Pollet Bay, Goose Bay, Fisher Bay, Big Muscamoot Bay, and Little Muscamoot Bay. Major bays mapped in Lake Erie include: Brest Bay, La Plaisance Bay, Allens Cove, North Maumee Bay, and Maumee Bay.

The ESI atlas is a compilation of information from three main categories: shoreline habitats, sensitive biological resources, and human-use resources. Though the data will be useful for many natural resource applications, the goal of the ESI data is to present a concise summary of resources that may be particularly vulnerable to spilled oil. The intent of the data should caveat other uses. As an example, the ESI is not intended to present a catalog or comprehensive listing of species present in an area, rather the focus is on species particularly sensitive to oiling and life stages where vulnerability may increase.

SHORELINE HABITAT MAPPING

The shoreline and classifications were fully updated using the following sources and methods. The shorelines for the Straits of Mackinac and St. Clair-Detroit River System were derived from the integration of the National Oceanic and Atmospheric Administration (NOAA) Continually Updated Shoreline Product (CUSP, 2006-2007) and National Shoreline composite (2011); the U.S. Geological Survey (USGS) high-resolution National Hydrography Dataset (NHD, 2011-2016); the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) dataset (1975-2013); the Ontario Ministry of Natural Resources dataset (1998-2018) and manual digitization at 1:4,000 from BING Bird's Eye and Aerial imagery (2012-2019), ESRI Basemap World Imagery (2010-2017), and Google Earth aerial imagery (2014-2018). The most recent shoreline was utilized.

The shoreline habitats were classified based on the USFWS NWI wetland polygons and low-altitude oblique and nadir aerial imagery from the following sources: BING Bird's Eye, BING Aerial, ESRI Basemap, Google Earth, U.S. Army Corps of Engineers (USACE) oblique imagery, Marinas.com imagery, and Agriculture and Agri-Food Canada Land Use data. The ESI shoreline classification and ranking scale has been used to assess sensitivity of shoreline to spilled oil since the mid-1970s. Rankings range from 1 – least vulnerable, to 10 – most sensitive, with a variety of qualifiers unique to the geographic region. The scale incorporates the following considerations:

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

Prediction of the behavior and persistence of oil in shoreline 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 and currents directly affects the persistence of stranded oil. The need for shoreline cleanup activities is determined, in part, by the slowness of natural processes in removal of oil stranded on the shoreline. The potential for biological injury and ease of cleanup of spilled oil are also important factors in the ESI shoreline ranking. Thus, shorelines exposed to high levels of physical energy, such as wave action and currents, and low biological activity rank low on the scale; whereas sheltered shorelines with associated high biological activity have the highest ranking. The shoreline types delineated for the Great Lakes Straits of Mackinac and St. Clair-Detroit River System, presented in order of increasing sensitivity to spilled oil, are listed below.

1A) Exposed, Rocky Shores
1B) Exposed, Solid Man-Made Structures
2A) Shelving Bedrock Shores
3B) Eroding Scarps (Unconsolidated Sediment)
4) Sand Beaches
5) Mixed Sand and Gravel Beaches
6A) Gravel Beaches
6B) Riprap
7) Exposed Flats
8A) Sheltered Scarps (Bedrock/Mud/Clay)
8B) Sheltered, Solid Man-Made Structures
8C) Sheltered Riprap
9A) Sheltered Sand and Mud Flats
9B) Vegetated Low Banks
10B) Freshwater Marshes
10C) Swamps
10D) Scrub and Shrub Wetlands

For each of these shoreline types, a photograph and description of the physical attributes, predicted oil behavior, and response considerations are included at the end of the introductory pages.

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:

- Audubon Great Lakes
- Bay Mills Indian Community
- Chippewa Ottawa Resource Authority (CORA)
- Grand Traverse Band of Ottawa and Chippewa Indians
- Great Lakes Aquatic Habitat Framework (GLAHF)
- Little Traverse Bay Bands of Odawa Indians
- Mackinac Straits Raptor Watch
- Michigan Department of Natural Resources (DNR)
- Michigan Natural Features Inventory (MNFI)
- Michigan State University (MSU)
- Michigan Tech Research Institute (MTRI)
- Sault Ste. Marie Tribe of Chippewa Indians
- University of Minnesota
- U.S. Environmental Protection Agency (EPA)
- United States Fish and Wildlife Service (USFWS)
- United States Geological Survey (USGS)

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

The biological resources shown in this atlas were extracted from the ESI GIS data compiled for this region. The extracted features were mapped at a scale of 1:50,000 and appear on the maps referenced by a combination of number and letter. For example, Map 1B will show the biological features in conjunction with the ESI shoreline. The biology mapped on these maps are "layered" in the PDF maps. This allows the user to turn off the biological features to create thematic maps or more clearly see the underlying shoreline and habitat polygons.

The data published date appearing at the bottom of the maps and on the cover page reflect when the data collection and compilation was completed. This atlas represents those data and was published October 2019.

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, points, and lines.

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.

3) There is a Resources at Risk number (RAR#) associated with each polygonal, point, or line feature. The RAR# references a table in the database that contains species names (common and scientific) associated with the feature.

TERRESTRIAL MAMMAL
- Feline/Small Mammal
- Bat

HERPETOFAUNA
- Amphibian/Reptile/Snake
- Turtle

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

FISH
- Fish/Freshwater/Diadromous

INVERTEBRATE
- Bivalve
- Gastropod
- Insect

BENTHIC
- SAV

HABITATS
- Plant

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

5) The table includes a Mapping Qualifier with each species record (see table of mapping qualifiers and guidelines below). The mapping qualifier should help users understand particular vulnerabilities associated with the map data.

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. Additionally, feature information is included in the GIS database used to create these maps. The GIS data also provide the extent of polygons, points, or lines for all mapped features; it can be queried, filtered, and used with other GIS datasets.

Mapping Qualifiers and Guidelines

Element	Qualifier	Guidelines
All	Concentration Area	Areas where concentrations are considerably higher than other records of the same species in the area of interest.
All	General Distribution	Used for broad, general distributions of species that are often mapped to landscape- or habitat-scale features.
All	Vulnerable Occurrence	Intended for records of rare species with discrete occurrences, where the conservation value of the species should be highlighted for spill response.
Birds, Herps, Fish, Inverts	Migration	Used when an area is a known staging area of high importance to the species for birds; and/or areas are potential or known migration corridors in the marine environment for other elements.
Birds, Herps	Nesting	Applicable to all nesting birds and herps. Should represent known nesting areas rather than all potential nesting habitat.
Birds	Rafting	Similar to 'Concentration Area' qualifier, but specific to large on-water concentrations.
Birds	Wintering	Designates known areas of importance to wintering birds.
Benthic	High Ecological Value	For use in areas where benthic organisms provide high ecological services, high quality habitat, or known areas of high biodiversity.
Fish and Inverts	Harvest Area	May be used as a qualifier for distributions in special cases, where the general distribution was not mapped and/or is widespread, and the distribution of the harvested resources is used to depict important areas.
Fish and Inverts	Nursery Area	Refers to specific areas of known importance to early life history stages (e.g., larvae, juveniles) of a species.
Fish and Inverts	Spawning Area	Areas where animals are spawning. Spawning is loosely defined as the release of gametes or eggs from the adult.

BIRDS

Birds displayed in this atlas include: diving birds, gulls, terns, passerines, 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 correspondence with local resource experts from MNFI, USFWS, Audubon Great Lakes, DNR, MSU, Mackinac Straits Raptor Watch, and the University of Minnesota. Additional hardcopy and digital sources are listed below and included in the metadata.

Shorebirds, diving birds, gulls, terns, raptors, and waterfowl – Survey data on locations of breeding, migrating, and/or wintering shorebirds, diving birds, gulls, terns, raptors, and waterfowl were provided by various agencies via shapefiles, spreadsheets, primary literature, and

expert local knowledge, and was supplemented with information from eBird. In general, data from the various data sources were compiled and either mapped to habitat, park or refuge, or specific locations, per expert recommendations.

Colonial waterbird nesting areas – Numerous resource experts and agencies provided data sets and expert knowledge to facilitate mapping colonial nesting birds. The primary data set used was *The Fourth Decadal U.S. Great Lakes Colonial Waterbird Survey (2007-2010)* generated by Cuthbert and Wires from the University of Minnesota – Twin Cities (2013). In addition, the USFWS Seney National Wildlife Refuge included data from surveys conducted by Central Michigan University (N. Seefelt) on Michigan Islands National Wildlife Refuge (2000-2017). Additional data were provided by USFWS Division of Migratory Birds (2012 survey data), Detroit River International Wildlife Refuge (2012 breeding season), Detroit Zoo, and Audubon (Michigan Important Bird Areas). The majority of nesting colony locations were mapped as nest points. A few nest site polygons were included. Nesting concentrations were reported as ranges (X-XX NESTS or X-XX PAIRS) or maximum nest or nesting pair counts (XX PAIRS). Species mapped using colonial waterbird datasets included: black-crowned night-heron, black tern, Caspian tern, common tern, double-crested cormorant, Forster's tern, great blue heron, herring gull, and ring-billed gull.

Marsh birds – Marsh birds were mapped only in St. Clair Flats where specific marsh bird survey data were available and provided by MNFI. According to expert knowledge, marsh birds, including American bittern, pied-billed grebe, king rail, and sora, are potentially present in all emergent wetlands.

Federally listed birds – Piping plover (FE, SE) were mapped using nest locations provided by the University of Minnesota and critical habitat boundaries provided by USFWS. Additional piping plover areas were mapped from the MNFI Biotics database. Red knot (FT) were mapped everywhere piping plover occurs, per expert knowledge.

Note that locations of nesting, wintering, and/or migratory sites, species composition within polygons, and particularly concentration values, are based on a compilation of observations made over multi-year periods and are not meant to accurately reflect 'current' conditions in the case of an event. Survey limitations and adjustments in protocols over the years, changes in shoreline geomorphology, weather, and other ecological factors contribute to the condition of nesting colonies and migratory or other bird concentrations at any given time. Also, note that bird concentrations vary throughout the multi-month nesting, migratory, and wintering periods 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 planning or response.

Expert contacts for Straits of Mackinac and St. Clair-Detroit River System birds* are:

Name	Agency	City	Phone	Species
Sherry Mackinnon	DNR	Newberry, MI	906-293-5669 x4080	Birds of Michigan
Mike Monfils	MNFI	Lansing, MI	517-284-6205	Birds of Michigan
Vince Cavalieri	USFWS	East Lansing, MI	517-351-5467	Piping plover and red knot
Steve Dushane	USFWS	Grosse Ile, MI	734-692-7604	Birds of Detroit River International Wildlife Refuge
Jessie Fletcher	USFWS	Grosse Ile, MI	734-692-7611	Birds of Detroit River International Wildlife Refuge
Rachael Pierce	USFWS	East Lansing, MI	517-351-5219	Colonial waterbirds
Francie Cuthbert	University of Minnesota	St. Paul, MN	612-624-1756	Colonial waterbirds
Dave Luukkonen	MSU	East Lansing, MI	517-449-2347	Birds of St. Clair-Detroit River System

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

Major Data Sources Used: Birds

Audubon Great Lakes. 2019. Michigan Important Bird Areas, Available at: https://www.audubon.org/important-bird-areas/state/michigan. (Accessed: August 2019).

Bellrose, F.C. 1980. Ducks, geese, and swans of North America, document.

Brewer, R., G.A. McPeek, and R. J. Adams, Jr. 1991. Atlas of breeding birds in Michigan, document.

Chartier, A.T., J.J. Baldy, and J.M. Brenneman. 2011. The Second Michigan Breeding Bird Atlas, 2002-2008, document.

Cuthbert, F., University of Minnesota. 2018. Piping plover nest locations, spreadsheet.

Cuthbert, F.J. and L. Wires, University of Minnesota. 2013. The fourth decadal U.S. Great Lakes colonial waterbird survey (2007-2010): results and recommendations to improve the scientific basis for conservation and management, document.

eBird. 2019. eBird: An online database of bird distribution and abundance [web application]. eBird, Ithaca, New York. Available at: http://www.ebird.org. (Accessed: August 2019).

Mackinac Straits Raptor Watch. 2019. Bird counts, document.

McCormick, D. 2019. Common loon concentrations on Lakes Michigan, Huron, St. Clair, and Erie and the St. Clair and Detroit Rivers during spring and autumn. Common loon concentrations on inland lakes adjacent to the Straits of Mackinac region during the breeding season, hardcopy map.

MNFI. 2007. St. Clair Flats aerial waterfowl summary, spreadsheet.

MNFI. 2007. St. Clair Flats postbreeding survey, spreadsheet.

MNFI. 2007. St. Clair Flats wetland study, spreadsheet.

MNFI. 2017. St. Clair Flats Michigan marsh bird survey, spreadsheet.

MNFI. 2019. Biotics polygons, vector digital data.

Monfils, M. and J. Gehring. 2013. Identifying migrant waterfowl and waterbird stopovers to inform offshore wind energy development in the eastern Upper Peninsula, document.

Russell, R.P., K.E. Koch, and S.J. Lewis. 2016. Upper Mississippi Valley/Great Lakes regional shorebird conservation plan, Version 2.0, document.

Seefelt, N., Central Michigan University, USFWS. 2017. Michigan Islands National Wildlife Refuge waterbird counts, spreadsheet.

Shirkey, B.T. and D.R. Luukkonen. 2015. Phase I final report: Lake St. Clair, western Lake Erie, and lower Detroit River, document.

Singer, H. and D. Luukkonen. 2014. Spring 2014 pelagic bird surveys: Lake St. Clair, western Lake Erie, and the Detroit River, document.

USFWS. 2012. Colonial waterbird survey data, vector digital data.

USFWS. 2013. Gravel Island, Green Bay, Harbor Island, Huron, and Michigan Islands National Wildlife Refuges Comprehensive Conservation Plan, document.

USFWS. 2017. Piping plover critical habitat, vector digital data.

USFWS. 2018. Humbug Marsh Unit Bird Species List, spreadsheet.

USFWS, Ohio Department of Natural Resources, Detroit Zoological Society. 2012. Common tern (*Sterna hirundo L.*) breeding season report for Detroit River – Western Lake Erie, document.

HERPETOFAUNA

Reptiles and amphibians depicted in this atlas include state (S) and federally (F) threatened (T), endangered (E), and state special concern (C) species. Mudpuppies (SC) and eastern foxsnake (ST) were mapped according to expert knowledge. Eastern massasauga (FT, SC) were mapped using species-specific screening data from USFWS. Additional herpetofauna species (turtles, snakes, salamanders) were mapped from survey and inferred-extent data provided by MNFI and DNR. Michigan HerpAtlas data were used to show general distributions of priority species. All T, E, and C species were selected from the HerpAtlas data, and all selected points were buffered by 3 miles and merged into non-overlapping polygons. Species names were generalized to "Sensitive herpetofauna". More specific species information from the HerpAtlas can be obtained by contacting David Mifsud (contact information below).

Expert contacts for Straits of Mackinac and St. Clair-Detroit River System herpetofauna* are:

Name	Agency	City	Phone	Species
Todd Wills	DNR	Harrison Township, MI	586-465-4771 x22	Mudpuppies of St. Clair-Detroit River System
Sherry Mackinnon	DNR	Newberry, MI	906-293-5669 x4080	Michigan turtles
David Mifsud	Herpeto-logical Resource and Manage-ment	Chelsea, MI	517-522-3524	Michigan herps; MI HerpAtlas
Steve Dushane	USFWS	Grosse Ile, MI	734-692-7604	Herps of Detroit River International Wildlife Refuge
Jessie Fletcher	USFWS	Grosse Ile, MI	734-692-7611	Herps of Detroit River International Wildlife Refuge

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

Major Data Sources Used: Herpetofauna

Harding, J.H. and J.A. Holman. 1992. Michigan frogs, toads, and salamanders: A field guide and pocket reference, document.

MIHerpAtlas. 2019. MIHerpAtlas – A statewide herpetological atlas and data hub. Available at: http://www.miherpatlas.com. (Accessed: August 2019).

MNFI. 2019. Biotics polygons, vector digital data.

MNFI and DNR. 2018. GIS layers for MNFI modelled inferred extents for threatened and endangered species, vector digital data.

USFWS. 2016. Detroit River International Wildlife Refuge Habitat Management Plan, document.

USFWS. 2019. Eastern massasauga screening, vector digital data.

FISH

Fish species depicted in this atlas include species of conservation interest, or species of commercial, recreational, or ecological importance. Fish polygons, lines, and spawning points were created based on digital data, publications, and expert opinion provided by resource experts at DNR, USGS, USFWS, and area tribes.

General distributions – Fish general distributions were mapped using expert knowledge collected during workshops. Species included were determined by the experts for each of the basins in the study area. In Lakes Michigan and Huron, fish general distributions were mapped according to bathymetry. Polygons were created for the following depth zones: 0-10 m, 10-40 m, and >40 m, and species assemblages and appropriate life history stages and seasonalities were mapped in each zone. In the St. Clair-Detroit River System study area, fish general distributions were mapped according to geography. Species assemblages and appropriate life history stages and seasonalities were mapped to the following individual areas: St. Clair River, St. Clair Flats, Lake St. Clair, upper Detroit River, lower Detroit River, and western Lake Erie. Expert knowledge for mapping of fish general distributions was supplemented with information from reports and publications (see Major Data Sources Used below).

Concentration areas and tributaries – Concentrations areas of various species were mapped using expert knowledge collected in workshops. Experts were asked to identify concentrations areas for any of the mapped species, and the species were mapped with a concentration of "HIGH" in polygons covering each of these areas. Experts also provided species lists and life history stages present in the tributaries of Lakes Michigan and Huron. Fish in larger tributaries were mapped as polygons, and fish in smaller tributaries and streams were mapped as lines.

Spawning locations – Point locations of spawning sites were provided by GLAHF. Additional spawning point locations were included from documents, publications, and maps provided by DNR, Michigan Sea Grant, and USGS. Information on species that spawn throughout their distributions was provided by resource experts, and these species were mapped with spawning months included in the general distribution polygons.

Expert contacts for Straits of Mackinac and St. Clair-Detroit River System fish* are:

Name	Agency	City	Phone	Species
Jay Wesley	DNR	Plainwell, MI	269-204-7057	Lake Michigan fish
Dave Clapp	DNR	Charlevoix, MI	231-547-2914	Lake Michigan fish
Jory Jonas	DNR	Charlevoix, MI	231-547-2914	Lake Michigan fish
Ben Turschak	DNR	Charlevoix, MI	231-547-2914	Lake Michigan fish
Kevin Donner	Little Traverse Bay Bands of Odawa Indians	Petoskey, MI	231-242-1670	Michigan fish
Nathan Barton	Grand Traverse Band of Ottawa and Chippewa Indians	Peshawbes-town, MI	231-534-7500	Michigan fish
Brad Silet	Sault Ste. Marie Tribe of Chippewa Indians	Sault Ste. Marie, MI	906-635-6050	Michigan fish
Paul Ripple	Bay Mills Indian Commun-ity	Brimley, MI	906-248-8649	Michigan fish
Tom Gorenflo	CORA	Sault Ste. Marie, MI	906-632-0043	Michigan fish
Dave Fielder	DNR	Alpena, MI	989-356-3232 x2572	Lake Huron fish
Randy Claramunt	DNR	Alanson, MI	231-347-4689	Lake Huron fish
Scott Koproski	USFWS	Alpena, MI	989-356-5023	Lake Huron fish
Todd Wills	DNR	Harrison Township, MI	586-465-4771 x22	Lake St. Clair and St. Clair-Detroit River System fish
Ed Roseman	USGS	Ann Arbor, MI	734-214-7237	Fish early life history stages

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

Major Data Sources Used: Fish

GLAHF. 2011. Great Lakes spawning and nursery sites, vector digital data.

GLAHF. 2014. Reef locations, vector digital data.

DNR. 2019. Lake trout spawning locations, hardcopy map.

MNFI. 2019. Biotics polygons, vector digital data.

Riley, S.C., T. R. Binder, N.J. Wattrus, M.D. Faust, J. Janssen, J. Menzies, J.E. Marsden, M.P. Ebener, C.R. Bronte, J.X. He, T.R. Tucker, M.J. Hansen, H.T. Thompson, A.M. Muir, and C.C. Krueger. 2014. Lake trout in northern Lake Huron spawn on submerged drumlins. Journal of Great Lakes Research 40: 415-420.

Michigan Sea Grant. 2019. Summary of St. Clair and Detroit River fish spawning reef projects, document.

Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. Bulletin of the Fisheries Research Board of Canada, 184, 966 pp.

DNR. 2015. Michigan's Wildlife Action Plan, document.

DNR. 2019. Status of the fisheries in Michigan waters of Lake Erie and Lake St. Clair, 2018, document.

Bennion, D.H. and B.A. Manny. 2014. A model to locate potential areas for lake sturgeon spawning habitat construction in the St.

Clair-Detroit River System. Journal of Great Lakes Research, Supplement 40: 43-51.

Tucker, T.R., E.F. Roseman, R.L. DeBruyne, J.J. Pritt, D.H. Bennion, D.W. Hondorp, and J.C. Boase. Long-term assessment of ichthyoplankton in a large North American river system reveals changes in fish community dynamics. Canadian Journal of Fisheries and Aquatic Sciences 75: 2255-2270.

Invertebrates

Invertebrates depicted in this atlas include selected freshwater and terrestrial species of ecological and/or conservation value. Hine's emerald dragonfly distribution was mapped using the USFWS designated critical habitat. State and federally listed insects, gastropods, and bivalves were mapped from the MNFI Biotics database. Names for certain state listed species, as requested by MNFI data providers, were generalized to "Threatened insect", "Endangered snail", "Threatened snail", "Endangered mussel", and "Threatened mussel"; federally listed species names were generalized to "Federally endangered mussel". Additional freshwater mussel streams were mapped using mussel occurrence prediction data from DNR. These data were mapped as lines where the streams occur, and species names from this dataset were not generalized (mapped using genus and species names).

Expert contacts for Straits of Mackinac and St. Clair-Detroit River System invertebrates* are:

Name	Agency	City	Phone	Species/ Program
Vince Cavalieri	USFWS	East Lansing, MI	517-351-5467	Hine's emerald dragonfly
Mike Rubley	DNR	Lansing, MI	517-284-5842	Freshwater mussels digital data provider
Rebecca Rogers	MNFI	Lansing, MI	517-284-6213	T&E species digital data provider

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

Major Data Sources Used: Invertebrates

USFWS. 2019. Hine's emerald dragonfly critical habitat, vector digital data.

MNFI. 2019. Biotics polygons, vector digital data.

DNR. 2019. Mussel occurrence prediction, vector digital data.

Habitats

Data for rare plants were provided by MNFI in the Biotics database. Only state and federally listed plants were mapped in the ESI, and species names were generalized according to their status. State listed species were mapped as "Endangered plant" or "Threatened plant", and federally listed plants were mapped as "Federally endangered plant" or "Federally threatened plant". Occurrences of giant arrowhead in Detroit River International Wildlife Refuge were provided through personal communication with USFWS staff.

Expert contacts for Straits of Mackinac and St. Clair-Detroit River System habitats* are:

Name	Agency	City	Phone	Species/ Program
Steve Dushane	USFWS	Grosse Ile, MI	734-692-7604	Rare plants of Detroit River International Wildlife Refuge
Jessie Fletcher	USFWS	Grosse Ile, MI	734-692-7611	Rare plants of Detroit River International Wildlife Refuge
Rebecca Rogers	MNFI	Lansing, MI	517-284-6213	T&E species digital data provider

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

Major Data Sources Used: Habitats

MNFI. 2019. Biotics polygons, vector digital data.

Benthic Habitats

Benthic habitats mapped in the ESI atlas include submerged aquatic vegetation (SAV) in Lakes Michigan, Huron, and St. Clair. SAV data for Lakes Michigan and Huron were provided by MTRI. In the MTRI datasets, areas that were attributed as "less dense SAV" or "dense SAV" were combined, and these areas were used to map SAV presence. Due to the high resolution of the MTRI data, data were buffered by 20 meters and smoothed by 50 meters to create the final SAV areas. SAV in Lakes Michigan and Huron is predominantly Cladophora, a nuisance, native green alga. Mapped areas also include other SAV, including vascular plants, other filamentous algae, and diatoms. SAV data for Lake St. Clair were provided by GLAHF. All areas with greater than 50 percent cover up to 75 percent cover were selected and mapped with a concentration of ">50 to 75%". All areas with greater than 75 percent cover were mapped with a concentration of ">75 to 100% cover".

Expert contacts for Straits of Mackinac and St. Clair-Detroit River System benthic habitats* are:

Name	Agency	City	Phone	Species/ Program
Colin Brooks	MTRI	Ann Arbor, MI	734-913-6858	Lakes Michigan and Huron SAV
Catherine Riseng	University of Michigan	Ann Arbor, MI	734-763-9422	Lake St. Clair SAV

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

Major Data Sources Used: Benthic Habitats

GLAHF. 2011. Lake St. Clair submerged aquatic vegetation mean percent cover, 2008-2011, vector digital data.

MTRI (R. Shuchman, M. Sayers, C. Brooks, M. Auer, and N. Jessee). 2012. Distribution of optically shallow areas of Lake Huron, vector digital data.

MTRI (R. Shuchman, M. Sayers, C. Brooks, M. Auer, and N. Jessee). 2012. Distribution of optically shallow areas of Lake Michigan, vector digital data.

Terrestrial Mammals

Terrestrial mammals depicted in this atlas include bats, river otter, beaver, muskrat, and Canadian lynx. Species that are federally and state listed, and those that are vulnerable to oiling and response activities, are specifically emphasized. Threatened and endangered mammals include Canadian lynx (FT, SE), little brown bat (SSC), and northern long-eared bat (FT, SSC). Terrestrial mammal occurrence and seasonality information displayed in this atlas were based on data supplied by USFWS and MNFI. Both hardcopy and digital data sources are listed below and included in the metadata. In addition to the species mapped, other terrestrial mammals may occur in the study area, but are not included due to their ubiquity in the area, lack of vulnerability to oiling and response activities, and/or lack of data.

Expert contacts for Straits of Mackinac and St. Clair-Detroit River System terrestrial mammals* are:

Name	Agency	City	Phone	Species
Sara Siekierski	USFWS	Seney, MI	906-586-9851 x11	Harbor Island NWR terrestrial mammals
Steve Dushane	USFWS	Grosse Ile, MI	734-692-7604	Terrestrial mammals of Detroit River International Wildlife Refuge
Jessie Fletcher	USFWS	Grosse Ile, MI	734-692-7611	Terrestrial mammals of Detroit River International Wildlife Refuge

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

Major Data Sources Used: Terrestrial Mammals

MNFI. 2019. Biotics polygons, vector digital data.

USFWS. 2013. Gravel Island, Green Bay, Harbor Island, Huron, and Michigan Islands National Wildlife Refuges Comprehensive Conservation Plan, document.

INVASIVE SPECIES

The spread of invasive or non-native species can degrade habitat, increase the potential for crop damage and diseases in humans, livestock and natural resources, reduce biodiversity through competition and limit recreational opportunities. Invasive species often opportunistically spread after disturbance events alter the natural landscape. Oil spill response and clean up often alters the landscape in a manner conducive to the spread of invasive species as crews often mobilize from all over the U.S. in response to large scale spill events. Boats, trailers, waders and clean up equipment can spread invasive species from waterbody to waterbody unless properly cleaned after use. Invasive species that were mapped are shown on the HUMAN-USE RESOURCE maps.

HUMAN-USE RESOURCES

The human-use resources shown in this atlas were extracted from the ESI GIS data compiled for this region. The extracted features were mapped at scale of 1:100,000 and appear on the maps referenced by a number. For example, Map 1 will show the human-use features in conjunction with the ESI shoreline.

Management areas such as wildlife refuges and state parks are mapped as polygons. Where the feature is a known point location (e.g., marinas, airports, water intakes), the specific location is displayed. Some resources were mapped as linear features.

Human-use numbers (HUNUM) can be found in the accompanying data tables for point, line, and polygon features mapped. The HUNUM 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
- Access
- Airport
- Anchorage
- Archaeological Site
- Army Corps of Engineers
- Artificial Reef
- Beach
- Boat Ramp
- Campground
- Coast Guard
- Critical Habitat
- EPA Facility
- Essential Habitat
- Ferry
- Fishery Area
- Heliport
- Historical Site
- Invasive Species
- Lock and Dam
- Management Area
- Marina
- Marine Sanctuary
- Military Installation
- Mine Site
- National Forest
- National Park
- Nature Conservancy
- Park
- Pipeline
- Port
- Recreational Fishing
- Renewable Energy
- Repeated Measurement Site
- State Protected Area
- Subsistence
- Tribal Land
- Water Intake
- Wildlife Refuge

Abandoned Vessel: Data on locations of abandoned and derelict vessels comes from the NOAA Office of Coast Survey Automated Wrecks and Obstructions Information System (AWOIS).
Access: Various access points including piers and boat launches were provided by Michigan Department of Natural Resources (MIDNR).
Airport: Locations of airports and heliports were downloaded from the United States Department of Transportation (USDOT) Bureau of Transportation Statistics (BTS).
Anchorage: Locations where commercial vessels can be anchored offshore were provided by the NOAA Office of Coastal Survey.
Archaeological Site: Generic archaeological sites were provided by Michigan Department of Natural Resources (MIDNR). More specific, yet non-State Historical Preservation Office (SHPO) certified archaeological sites were provided by Gerard Santoro of Macomb County, Michigan Planning and Economic Development office. These sites depict historical areas with no current protective measures in place. These areas were inundated as river levels rose following channelization.
Army Corps of Engineers: U.S. Army Corps of Engineers (USACE) districts and divisions data were provided from the geospatial platform maintained by USACE.
Artificial Reef: Artificial reef data were provided by the Great Lakes Aquatic Habitat Framework (GLAHF).
Beach: Locations of recreational beaches used for activities such as swimming, sun-bathing, fishing, etc., were provided by Michigan Department of Natural Resources (MIDNR).
Boat Ramp: Designated public boating access sites were provided by Michigan Department of Natural Resources (MIDNR).
Campground: Michigan State Park campgrounds are those situated within Michigan State Parks and were derived from Michigan Department of Natural Resources (MIDNR).
Coast Guard: U.S. Coast Guard (USCG) stations were provided by the USCG via the U.S. Geological Survey (USGS) data portal.
Critical Habitat: Designated Critical Habitat was mapped for the Piping plover (*Charadrius melodus*) and Hine's emerald dragonfly (*Somatochlora hineana*). Data were provided by the United States Fish and Wildlife Service (USFWS).
Environmental Protection Agency (EPA) Facility: This dataset represents facilities required to file a Risk Management Plan (RMP) due to the presence of extremely hazardous substances that may result in a chemical accident. The data are provided by the USEPA.
Essential Habitat: Essential habitat data depicting ecological communities and critical dunes were received from Michigan Natural Features Inventory (MNFI) and Michigan Department of Natural Resources (MIDNR), respectively.
Ferry: Ferry terminal data were derived through digitization using NOAA's Raster Nautical Chart (RNC) as a reference.
Ferry Routes: Ferry routes for the St Clair and Detroit River systems were provided by both the U.S. Department of Transportation (USDOT) Bureau of Transportation Statistics data portal. Routes for the Lake Michigan/Huron area were downloaded from The National Map data repository.
Fishery Area: Fishery Management Units were provided by Michigan Department of Natural Resources (MIDNR).
Heliport: Locations of airports and heliports were downloaded from the USDOT Bureau of Transportation Statistics.
Historical Site: Historical sites were from Michigan Department of Natural Resources (MIDNR) depicting point locations of Michigan's historical markers.
Invasive Species: Invasive plant data were derived from a composite of sources including: USGS Nonindigenous Aquatic Species (NAS) database, NOAA Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS), and the Great Lakes Aquatic Habitat Framework (GLAHF) in a single downloadable format from GLAHF.
Lock and Dam: Data for lock and dam systems were provided by MIDNR on behalf of Michigan Department of Environmental Quality (MIDEQ).
Management Area: Management areas in this ESI atlas include: wildlife management areas, marine sanctuaries, military installations, national forests, state and national parks, nature conservancy lands, state protected areas, and wildlife refuges. These data were provided by several sources including USDA FS, U.S. Census Bureau, TNC, NPS, USFWS, MIDNR, NOAA, and GLAHF. Within the managed lands data, there are also a number of Great Lakes Habitat Restoration sites provided by the USEPA.
Marina: Marinas were located using Google Earth and exported to ArcGIS.
Marine Sanctuary: The location of Thunder Bay National Marine Sanctuary was provided by the NOAA Office of National Marine Sanctuaries.
Military Installation: Military installation data were provided by the U.S. Census Bureau MAF/TIGER (Topologically Integrated Geographic Encoding and Referencing) geographic database.
Mine Site: Active mines and processing plant locations for minerals and metal were provided by the USGS, as these are commodities that are controlled by the National Minerals Information Center of the USGS.
National Forest: Boundaries for the Hiawatha National Forest were provided by the USDA Forest Service.
National Park: Boundaries for the River Raisin National Battlefield Park were provided by the U.S. Department of the Interior (USDOI) National Park Service (NPS).
Nature Conservancy: Boundaries of The Nature Conservancy (TNC) properties were obtained from TNC Lands database.
Park: State park boundaries were provided by MIDNR.
Pipeline: Major crude oil pipelines were provided by the U.S. Energy Information Association (USEIA).
Port: Major port location data were compiled from The National Map of the U.S.
Rail Route: Locations of railways were downloaded from the Michigan Geographic Framework (MGF).
Recreational Fishing: Recreational fishing access sites that depict point locations for public fishing access on DNR lands were provided by MIDNR. The data were derived from their forest inventory process.

Renewable Energy: Wind energy sites were provided by the American Wind Energy Association (AWEA).
Repeated Measurement Site: Repeated measurement sites obtained from the NOAA National Data Buoy Center (NDBC) include national data buoy locations (DB), Mussel Watch monitoring sites (MWS), and Water Quality monitoring stations (WQ).
Road/Bridge: The Mackinac Bridge was digitized by RPI using ESRI Basemap Imagery.
State Protected Area: Areas that receive varied levels of state protection data were provided by MIDNR.
Subsistence: Tribal fish ports were mapped using data from the GLAHF.
Tribal Land: Tribal lands were derived from a variety of sources including the U.S. Department of Commerce, U.S. Census Bureau, USEPA, and GLAHF.
Water Intake: Water intakes were provided by Michigan Department of Environmental Quality (MIDEQ).
Wildlife Refuge: Location of National Wildlife Refuges (NWR) were provided by the U.S. Fish and Wildlife Service.

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 datasets 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 data are 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, 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, lines, 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, a mapping qualifier, 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 feature classes).

HUMAN-USE FEATURES

Human-use features are represented as points, lines, 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 Great Lakes Restoration Initiative (GLRI). NOAA Scientific Support Coordinator LCDR Michael Doig assisted greatly in all aspects of the project's completion. Jill Petersen and Nicolle Rutherford with the NOAA Office of Response and Restoration, Emergency Response Division reviewed and approved the final products.

The biological and human-use data included on the maps were provided by numerous individuals and agencies, including: NOAA, USGS, USFWS, EPA, MI DNR, MNFI, Univ. of MI, MSU, Univ. of MN, GLAHF, MTRI, and others. Staff at these organizations contributed a vast amount of information to this effort, including first-hand expertise, publications, maps, and digital data.

At Research Planning, Inc. in Columbia, South Carolina, numerous scientific, GIS, and graphic staff were involved with different phases of the project. Mark White, GIS Director, and Christine Boring, Biology Dept. Manager, were co-Project Managers. The ESI shoreline was classified by Jennifer Horsman, Katy Beckham, and Lee Diveley. The biological data were collected and compiled onto base maps by Christine Boring and Lauren Szathmary, Lee Diveley, Katy Beckham, Jeff Dahlin, Chris Locke, and Bryan Thom processed and produced the GIS data. Wendy Early and Joe Holmes produced 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 any contributing 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
BENTHIC	
SAV	
Submerged aquatic vegetation	-
BIRDS	
BIRD	
Waterbirds	-
DIVING	
American white pelican	*Pelecanus erythrorhynchos*
Common loon	*Gavia immer*
Double-crested cormorant	*Phalacrocorax auritus*
Horned grebe	*Podiceps auritus*
Loons	*Gavia spp.*
Pied-billed grebe	*Podilymbus podiceps*
Red-necked grebe	*Podiceps grisegena*
GULL_TERN	
Black tern	*Chlidonias niger*
Caspian tern	*Hydroprogne caspia*
Common tern	*Sterna hirundo*
Forster's tern	*Sterna forsteri*
Gulls	-
Herring gull	*Larus argentatus*
Ring-billed gull	*Larus delawarensis*
Terns	-
PASSERINE	
Black-backed woodpecker	*Picoides arcticus*
Cerulean warbler	*Setophaga cerulea*
Dickcissel	*Spiza americana*
Grasshopper sparrow	*Ammodramus savannarum*
Hooded warbler	*Wilsonia citrina*
Marsh wren	*Cistothorus palustris*
Passerine birds	-
Prairie warbler	*Setophaga discolor*
Prothonotary warbler	*Protonotaria citrea*
Warblers	*Parulidae*
RAPTOR	
Bald eagle	*Haliaeetus leucocephalus*
Hawks	-
Long-eared owl	*Asio otus*
Merlin	*Falco columbarius*
Northern goshawk	*Accipiter gentilis*
Northern harrier	*Circus cyaneus*
Osprey	*Pandion haliaetus*
Peregrine falcon	*Falco peregrinus*
Raptors	-
Red-shouldered hawk	*Buteo lineatus*
Red-tailed hawk	*Buteo jamaicensis*
SHOREBIRD	
Black-bellied plover	*Pluvialis squatarola*
Dunlin	*Calidris alpina*
Greater yellowlegs	*Tringa melanoleuca*
Killdeer	*Charadrius vociferus*
Lesser yellowlegs	*Tringa flavipes*
Piping plover	*Charadrius melodus*
Red knot	*Calidris canutus rufa*
Ruddy turnstone	*Arenaria interpres*
Sanderling	*Calidris alba*
Sandpipers	-
Semipalmated plover	*Charadrius semipalmatus*
Shorebirds	-
Yellowlegs	*Tringa spp.*
WADING	
American bittern	*Botaurus lentiginosus*
American woodcock	*Scolopax minor*
Black-crowned night-heron	*Nycticorax nycticorax*
Great blue heron	*Ardea herodias*
Great egret	*Ardea alba*
Green heron	*Butorides virescens*
Herons	-
King rail	*Rallus elegans*
Least bittern	*Ixobrychus exilis*
Marsh birds	-
Sandhill crane	*Grus canadensis*
Sora	*Porzana carolina*
Virginia rail	*Rallus limicola*
Yellow rail	*Coturnicops noveboracensis*

Common Name*	Scientific Name
BIRDS, cont.	
WATERFOWL	
American black duck	*Anas rubripes*
American coot	*Fulica americana*
American wigeon	*Anas americana*
Black scoter	*Melanitta americana*
Blue-winged teal	*Anas discors*
Brant	*Branta bernicla*
Bufflehead	*Bucephala albeola*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Common gallinule	*Gallinula galeata*
Common goldeneye	*Bucephala clangula*
Common merganser	*Mergus merganser*
Dabbling ducks	-
Diving ducks	-
Gadwall	*Anas strepera*
Greater scaup	*Aythya marila*
Green-winged teal	*Anas crecca*
Hooded merganser	*Lophodytes cucullatus*
Lesser scaup	*Aythya affinis*
Long-tailed duck	*Clangula hyemalis*
Mallard	*Anas platyrhynchos*
Mergansers	-
Northern pintail	*Anas acuta*
Red-breasted merganser	*Mergus serrator*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Ruddy duck	*Oxyura jamaicensis*
Scaup	*Aythya spp.*
Sea ducks	-
Surf scoter	*Melanitta perspicillata*
Swans	*Cygnus spp.*
Tundra swan	*Cygnus columbianus columbianus*
Waterfowl	-
White-winged scoter	*Melanitta fusca*
Wood duck	*Aix sponsa*
FISH	
FISH	
Alewife	*Alosa pseudoharengus*
Atlantic salmon	*Salmo salar*
Bloater	*Coregonus hoyi*
Brindled madtom	*Noturus miurus*
Burbot	*Lota lota*
Channel catfish	*Ictalurus punctatus*
Chinook salmon	*Oncorhynchus tshawytscha*
Cisco	*Coregonus spp.*
Coho salmon	*Oncorhynchus kisutch*
Deepwater sculpin	*Myoxocephalus thompsonii*
Eastern sand darter	*Ammocrypta pellucida*
Emerald shiner	*Notropis atherinoides*
Kiyi	*Coregonus kiyi*
Lake chub	*Couesius plumbeus*
Lake sturgeon	*Acipenser fulvescens*
Lake trout	*Salvelinus namaycush*
Lake whitefish	*Coregonus clupeaformis*
Largemouth bass	*Micropterus salmoides*
Longnose sucker	*Catostomus catostomus*
Mooneye	*Hiodon tergisus*
Muskellunge	*Esox masquinongy*
Northern madtom	*Noturus stigmosus*
Northern pike	*Esox lucius*
Pink salmon	*Oncorhynchus gorbuscha*
Pugnose minnow	*Opsopoeodus emiliae*
Rainbow smelt	*Osmerus mordax*
River darter	*Percina shumardi*
Round goby	*Neogobius melanostomus*
Round whitefish (menomonee)	*Prosopium cylindraceum*
Sauger	*Sander canadensis*
Silver chub	*Macrhybopsis storeriana*
Slimy sculpin	*Cottus cognatus*
Smallmouth bass	*Micropterus dolomieu*
Spoonhead sculpin	*Cottus ricei*
Steelhead	*Oncorhynchus mykiss*
Suckers	*Catostomidae spp.*
Trout perch	*Percopsis omiscomaycus*
Walleye	*Stizostedion vitreum vitreum*
White sucker	*Catostomus commersoni*
Yellow perch	*Perca flavescens*

Common Name*	Scientific Name
HABITATS	
PLANT	
Endangered plant	-
Federally endangered plant	-
Federally threatened plant	-
Giant arrowhead	*Sagittaria montevidensis*
Threatened plant	-
HERPETOFAUNA	
AMPHIBIAN	
Mudpuppy	*Necturus maculosus*
Smallmouth salamander	*Ambystoma texanum*
REPTILE	
Sensitive herpetofauna	-
SNAKE	
Eastern foxsnake	*Pantherophis vulpinus*
Eastern massasauga	*Sistrurus catenatus*
Queensnake	*Regina septemvittata*
TURTLE	
Blanding's turtle	*Emydoidea blandingii*
Eastern box turtle	*Terrapene carolina carolina*
Spotted turtle	*Clemmys guttata*
Wood turtle	*Glyptemys insculpta*
INVERTEBRATES	
BIVALVE	
Black sandshell	*Ligumia recta*
Deertoe	*Truncilla truncate*
Eastern pondmussel	*Ligumia nasuta*
Elktoe	*Alasmidonta marginata*
Endangered mussel	-
Fawnsfoot	*Truncilla donaciformis*
Federally endangered mussel	-
Kidneyshell	*Ptychobranchus fasciolaris*
Lilliput	*Toxolasma parvum*
Northern riffleshell	*Epioblasma rangiana*
Paper pondshell	*Utterbackia imbecillis*
Pink papershell	*Potamilus ohiensis*
Purple wartyback	*Cyclonaias tuberculata*
Rainbow	*Cambarunio iris*
Rayed bean	*Paetulunio fabalis*
Round hickorynut	*Obovaria subrotunda*
Round pigtoe	*Pleurobema sintoxia*
Salamander mussel	*Simpsonaias ambigua*
Slippershell	*Alasmidonta viridis*
Snuffbox	*Epioblasma triquetra*
Special concern mussel	-
Threatened mussel	-
Threehorn wartyback	*Obliquaria reflexa*
Wavyrayed lampmussel	*Lampsilis fasciola*
GASTROPOD	
Endangered snail	-
Threatened snail	-
INSECT	
Hines's emerald dragonfly	*Somatochlora hineana*
Hungerford's crawling water beetle	*Brychius hungerfordi*
Threatened insect	-
TERRESTRIAL MAMMALS	
BAT	
Little brown bat	*Myotis lucifugus*
Northern long-eared bat	*Myotis septentrionalis*
FELINE	
Canadian lynx	*Lynx canadensis*
SM_MAMMAL	
Beaver	*Castor canadensis*
Muskrat	*Ondatra zibethicus*
Northern river otter	*Lontra canadensis*

* Threatened and endangered species are designated by underlining

SHORELINE DESCRIPTIONS

EXPOSED, ROCKY SHORES — ESI = 1A

DESCRIPTION

- Exposed bedrock, often forming cliffs with an extended platform offshore
- The rock surface can be highly irregular, with numerous cracks and crevices
- Sediment accumulations are uncommon and usually ephemeral, because waves remove the sediments
- They are very uncommon, comprising less than 0.1% of the shoreline

PREDICTED OIL BEHAVIOR

- Any oil that is deposited is rapidly removed from exposed faces, although oil persistence is related to the incoming wave energy
- The most resistant oil would remain as a patchy band at or above the high-water line

RESPONSE CONSIDERATIONS

- Cleanup is usually not required
- Access can be difficult and dangerous
- Washing techniques with ambient water are most effective while oil is still fresh

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

DESCRIPTION

- These structures are vertical, man-made structures such as impermeable seawalls and pilings exposed to direct wave action
- They are built to protect the shore from erosion by waves, boat wakes, and currents; thus, they are exposed to rapid natural removal processes
- They are present along developed shorelines or where harbors have been built, occurring along approximately 6% of the shoreline

PREDICTED OIL BEHAVIOR

- Any oil that is deposited is rapidly removed from exposed faces, although oil persistence is related to the incoming wave energy
- Oil readily adheres to the dry, rough surfaces, but it does not adhere to wet surfaces
- The most resistant oil would remain as a patchy band at or above the high-water 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

SHELVING BEDROCK SHORES — ESI = 2A

DESCRIPTION

- Shelving bedrock shores occur where flat or gently dipping rock layers are exposed and extend into the shallow nearshore zone
- They generally are exposed to seasonally high wave action that strips most sediment from the rock surface
- The rock surface can be highly irregular with numerous cracks and crevices
- They are uncommon, comprising less than 1% of the shoreline

PREDICTED OIL BEHAVIOR

- Oil will be held offshore by waves reflecting off the most exposed platforms
- Any oil that comes ashore will form a band along the high-water line
- Once deposited, the oil will be rapidly removed from exposed faces, although oil persistence is related to the incoming wave energy

RESPONSE CONSIDERATIONS

- Cleanup is usually not required, because any stranded oil is quickly removed by wave action
- Manual removal of residual surface oil may be needed in wave shadows, both on the platform and along the high-water line

ERODING SCARPS (UNCOSOLIDATED SEDIMENT) ESI = 3B

DESCRIPTION

- This shoreline type occurs where sandy bluffs or dunes 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 1% 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

RESPONSE CONSIDERATIONS

- 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

SAND BEACHES ESI = 4

DESCRIPTION

- These beaches have moderate slopes, variable widths, and soft sediments. These characteristics combine to lower their trafficability
- They occur along about 5% of the shoreline and are used heavily during the summer months for recreation

PREDICTED OIL BEHAVIOR

- During small spills, oil will be deposited primarily as a band along the swash line
- Under very heavy accumulations, oil may spread across the entire beach face
- Penetration of oil into coarse-grained sand can reach 25 cm
- Burial to depths over one meter is possible if the oil comes ashore at the start of a depositional period
- Heavy accumulations of residual oil can form tar mats
- Biological impacts include temporary declines in infaunal populations, which can also affect important shorebird foraging areas

RESPONSE CONSIDERATIONS

- Because of their heavy recreational use, most beaches will require extensive cleanup efforts to remove as much of the oil as possible
- Removal of clean sediment should be limited to avoid erosion problems

- Mechanical reworking of the sediment into the surf zone may be used to release the oil as a final polishing step, to minimize 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

MIXED SAND AND GRAVEL BEACHES ESI = 5

DESCRIPTION

- Moderately sloping beach composed of a wide range of mixtures of sand and gravel (greater than 10% of each)
- Because of the mixed sediment sizes and shapes, there may be zones of pure sand, pebbles, or cobbles
- Where the beach is depositional, there can be multiple berms from the different water levels generated during storms
- They are common, comprising approximately 13% of the shoreline

PREDICTED OIL BEHAVIOR

- During small spills, oil will be deposited along the high-water swash
- Large spills will spread across the entire beach face
- 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%
- Burial of oil may be deep at and above the swash 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
- 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 as a final polishing step, to minimize

sediment removal

- Biological impacts are likely to be low, except for when the beaches are being used by shorebirds for resting and foraging

RESPONSE CONSIDERATIONS

- Remove heavy accumulations of oil primarily from the swash line
- All oiled debris should be removed
- Activity in the oiled sediments should be limited to prevent mixing oil deeper into the beach
- Use of heavy equipment for oiled sediment removal may result in the removal of excessive amounts of sediment; manual cleanup may be more effective

GRAVEL BEACHES — ESI = 6A

DESCRIPTION

- These beaches are composed of a mixture of gravel and less than 10% sand
- On depositional beaches, the gravel is formed into multiple berms from the different water levels generated during storms
- On stable or erosional beaches, the sediments are a jumble of grain sizes with the gravel scattered over a relatively wide, flat surface
- They comprise about 13% of the shoreline

PREDICTED OIL BEHAVIOR

- Deep penetration and rapid burial of stranded oil is likely on exposed beaches
- During storms, oil can be pushed over the berms, pooling and persisting above the normal zone of wave runup
- Long-term persistence will be controlled by the depth of routine reworking by storm waves
- Deeply penetrated oil can be remobilized for long periods
- On relatively sheltered beaches, formation of asphalt pavements is likely where accumulations are heavy

RESPONSE CONSIDERATIONS

- Heavy accumulations of pooled oil should be removed as quickly as possible, to minimize oil penetration into the highly permeable sediments

- 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
- Tilling may be used to reach deeply buried oil layers on exposed beaches

RIPRAP — ESI = 6B

DESCRIPTION

- Riprap structures are composed of cobble- to boulder-sized quarried rocks or concrete
- Riprap is placed as protection behind beaches, along harbors, and as groins perpendicular to the shoreline
- Present along highly developed commercial waterfronts and residential areas, comprising about 4% 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 FLATS — ESI = 7

DESCRIPTION

- Exposed flats are broad, flat areas composed primarily of sand and minor amounts of gravel
- The presence of sand indicates that 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 very uncommon, occurring along less than 1% of the shoreline

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of exposed flats, but rather moves across the flat and accumulates at the high-water line
- 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

- Access and thus cleanup can be very difficult
- The use of machinery should be restricted to prevent mixing of oil into the sediments
- Mechanical reworking of the sediment into the surf zone may be used to release the oil as a final polishing step, to minimize sediment removal

SHELTERED SCARPS (BEDROCK/MUD/CLAY) ESI = 8A

DESCRIPTION

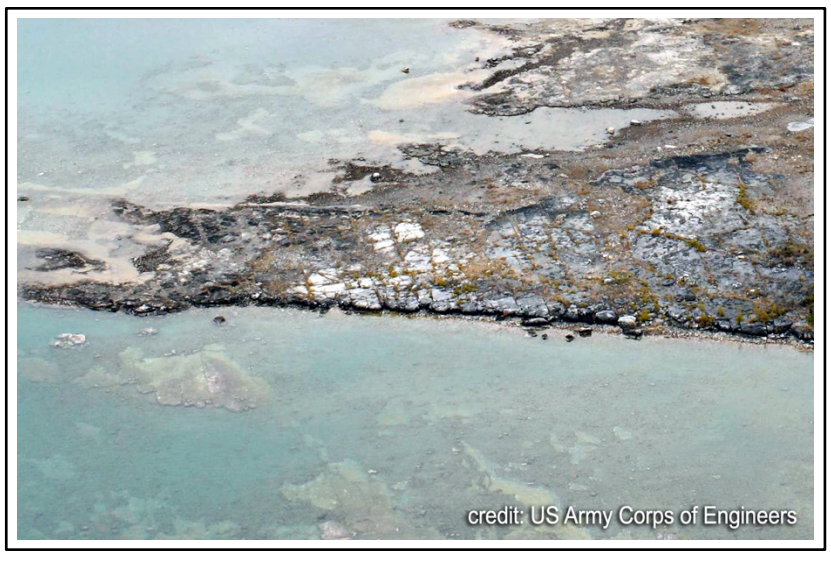
- This shoreline type mostly occurs as vertical rock walls and boulder-strewn rocky ledges inside of bays and coves, sheltered from most wave activity and currents
- In most places, the shore is a very complex arrangement of rubble on a flat rock surface
- They are not common, comprising less than 1% of the shoreline

PREDICTED OIL BEHAVIOR

- On all rocky shores, oil will adhere readily to the rough rocky surface, particularly along the water line, forming a distinct oil band
- Fractures in the bedrock will be sites of oil pooling and persistence
- Even on wide ledges, the lower zone usually stays wet, preventing oil from adhering to the rock surface
- Heavy and weathered oils readily adhere to the dry, rough rock surface and between the surface sediments

RESPONSE CONSIDERATIONS

- Low-pressure flushing at ambient temperatures is most effective when the oil is fresh and still liquid
- Where the high-water 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
- They are common in highly developed areas and harbors, comprising about 12% of the shoreline

PREDICTED OIL BEHAVIOR

- Oil will adhere readily to rough surfaces, particularly along the water line, forming a distinct oil band
- If oil is left uncleaned, it may cause chronic leaching and sheening until the oil hardens

RESPONSE CONSIDERATIONS

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

SHELTERED RIPRAP ESI = 8C

DESCRIPTION

- Riprap structures are composed of cobble- to boulder-sized blocks of quarried rock or concrete
- These structures are found inside harbors and bays in developed areas and in residential waterfront areas, sheltered from direct exposure to waves
- They comprise approximately 3% 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 and sheening until the oil hardens

RESPONSE CONSIDERATIONS

- High-pressure spraying and high-volume deluge 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 SAND AND MUD FLATS — ESI = 9A

DESCRIPTION

- Sheltered flats are flat areas composed sand, silt, and clay that have been exposed by lowered water levels
- The sediments are very soft and cannot support even light foot traffic in many areas
- They can have heavy wrack and debris deposits along the upper fringe
- Large concentrations of fauna can be found on and in the sediments
- They are utilized by birds for feeding
- Sheltered flats are very uncommon, comprising less than 0.1% of the shoreline

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of sheltered flats, but rather moves across the flat and accumulates at the high water line
- Very heavy accumulations of oil will cover the flat at low water levels
- 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 impacts from both oil exposure and damage during response; 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 attempted

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 upper reaches of streams and embayments
- They are common, comprising 12% of the shoreline

PREDICTED OIL BEHAVIOR

- Oil will adhere to any vegetation along the water line
- Very heavy oil accumulations will be trapped along shoreline irregularities and pool in any surface depressions
- 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 liquid 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

FRESHWATER MARSHES — ESI = 10B

DESCRIPTION

- These are grassy wetlands composed of emergent herbaceous vegetation; there can be a mix of species
- Those along major channels are exposed to strong currents and boat wakes; smaller channels tend to be sheltered
- Resident flora and fauna are abundant
- They are the most abundant shoreline type, comprising 39% of the shoreline

PREDICTED OIL BEHAVIOR

- Oil adheres readily to the vegetation
- The band of coating may vary widely, depending upon the water level at the time oil slicks are in the vegetation; there may be multiple bands
- If the vegetation is thick, heavy oil coating will be restricted to the outer fringe, although lighter oils can penetrate deeper
- Medium to heavy oils do not readily adhere to or penetrate the fine sediments, but they can pool on the surface and in burrows
- Light oils can penetrate the top few centimeters of sediment and deeply into burrows and cracks (up to one meter)
- Fluctuating water levels will have great effects on which wetlands are susceptible to oiling
- Rates of natural removal are a function of the site-specific exposure to wave energy. At exposed sites, oil can be removed within months; heavy accumulations of oil can persist in sheltered wetlands for years

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; In-situ burning maybe be considered in remote areas
- 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 20 feet
- 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 and comprises about 6% 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 floodplain 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. Care must be taken to prevent transporting oil to sensitive areas down slope or along shore during flushing operations
- 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; thus, use of walking boards is often necessary
- Live woody vegetation should not be cut

SCRUB AND SHRUB WETLANDS — ESI = 10D

DESCRIPTION

- Scrub-shrub wetlands consist of woody vegetation less than 20 feet tall including true shrubs, small trees, and trees and shrubs
- 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 shoreline type occurs along about 2% of the shoreline

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 floodplain 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; thus, use of walking boards is often necessary
- Live woody vegetation should not be cut