ENVIRONMENTAL SENSITIVITY INDEX: PRINCE WILLIAM SOUND

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for the coastal zone of Prince William Sound and the Copper River Delta. The ESI maps include information for three main components: shoreline habitats; sensitive biological resources; and human-use resources. Background information, as well as the methods of data collection and presentation, are summarized in the following sections.

SHORELINE HABITAT MAPPING

The intertidal habitats of Prince William Sound and the Copper River Delta were mapped using two sources. For Port Valdez, Knowles Head, Hinchinbrook Island, and Montague Island, ESI classifications were derived from a database provided by SERVS, Ayleska Pipeline Service Company and generated by Owens and Reimer (1999), based on video-tape surveys conducted from 1995 through 1998. For the rest of the study area, ESI classifications were made during overflights conducted by an experienced coastal geologist during 14-19 May 1999. The shoreline classifications were denoted onto 1:63,360 U.S. Geological Survey (USGS) topographic maps. The shoreline classifications were then transferred onto maps on which the shorelines derived from both National Wetlands Inventory (NWI) data and USGS Digital Line Graph (DLG) were plotted. The DLG shoreline was used in most cases; the NWI shoreline and polygons for tidal flats and marshes were used when they best represented the current shoreline conditions, especially in the Copper River Delta and other areas of extensive flats and marshes.

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

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

All of these factors are used to determine the relative sensitivity of intertidal habitats. Key to the sensitivity ranking is an understanding of the relationships between: physical processes; substrate; shoreline type; product type; fate and effect; and sediment transport patterns. The intensity of energy expended upon a shoreline by wave action, tidal currents, and river currents directly affects the persistence of stranded oil. The need for shoreline cleanup activities is determined, in part, by the slowness of natural processes in removal of oil stranded on the shoreline.

These concepts have been used in the development of the ESI, which ranks shoreline environments as to their relative sensitivity to oil spills, potential biological injury, and ease of cleanup. Generally speaking, areas exposed to high levels of physical activity, such as wave action and tidal currents, and low biological activity rank low on the scale, whereas sheltered areas with associated high biological activity have the highest ranking. A comprehensive shoreline habitat ranking system has been developed for the entire United States. The shoreline habitats delineated in Prince William Sound and the Copper River Delta are listed below in order of increasing sensitivity to spilled oil.

1A) Exposed Rocky Shores
2A) Exposed Wave-Cut Platforms in Bedrock
3A) Fine- to Medium-Grained Sand Beaches
4) Coarse-Grained Sand Beaches (not present)
5) Mixed Sand and Gravel Beaches
6A) Gravel Beaches
6B) Riprap
7) Exposed Tidal Flats
8A) Sheltered Rocky Shores
8D) Sheltered Rocky Rubble Slopes
9A) Sheltered Tidal Flats
10A) Salt- and Brackish-Water Marshes

Each of the shoreline habitats are described on pages 5-10, in terms of their physical description, predicted oil behavior, and response considerations.

SENSITIVE BIOLOGICAL RESOURCES

Biological information presented in this atlas was collected and compiled with the assistance of biologists primarily from the U.S. Fish and Wildlife Service, Alaska Department of Fish and Game, and National Marine Fisheries Service as well as many other state and federal agencies and individuals. Information collected and depicted on the maps denotes the key biological resources that are most likely at risk in the event of an oil spill. Four major categories of biological resources are included in this atlas are marine mammals, birds, fish, and invertebrates, with textual reference to submerged aquatic vegetation, and terrestrial mammals.

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

- **BIRDS**
  - Alcid and Pelagic Birds
  - Diving Birds
  - Gulls and Terns
  - Raptors
  - Shorebirds
  - Waterfowl
  - Various Birds

- **MARINE MAMMALS**
  - Pinipeds
  - Sea Otters
  - Whales
  - Fish
  - Invertebrates
  - Crabs

The polygon or point color and pattern are generally the same for all the species in each major group, (e.g., birds are green), and match the icon colors. Species with a red box outlining the icons are listed as threatened or endangered at either the state or federal level. Also associated with each biological polygon or point feature on the map is a resource at risk identification 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 found in the polygon or at the point, as well as the state and federal protected status (T&E), concentration or abundance, seasonality, and life-history information for each species.

There are some species that are found throughout specific geographical areas or habitat types. Displaying the polygons for these species would cover large areas, making the maps very difficult to read. Thus, species which occur over the majority of certain geographic areas or habitats are often identified in a small box on the maps which states that they are "Present in ..." (e.g., "Present in Copper River Delta"). This approach informs the user of the presence of these species, while maintaining readability of the map. In all instances, data for species listed as "Present in ..." exist as polygons in the digital coverages. The use of this strategy is implemented on a case-by-case basis, depending on the location, size, and number of polygons present on each map.

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

**MARINE MAMMALS**

Marine mammals depicted in the Prince William Sound atlas include whales, seals, sea lions, and sea otters. For seals and sea lion, major haul-out sites for harbor seals and Steller sea lions are depicted. Though only haul-out sites are mapped, seals can occur throughout the nearshore waters. High concentration areas for whales are also depicted in the atlas. Though only certain high concentration areas are depicted, whales are highly mobile species, and can occur throughout most of the waters of Prince William Sound. Humpback and killer whales are common residents of the Sound, but other species of whales are also seen in the Sound. Gray whales are most commonly found in the migration corridor along the outer coast, but they may occasionally be found in the Sound. For sea otters, concentrations of up to 50 individuals are shown where surveys has been conducted. Sea otters are present all year throughout the Sound.

Many of the whales included in this atlas are protected as threatened or endangered species, and all marine mammals are protected under the Marine Mammal Protection Act of 1972.

Marine mammal concentration areas are displayed on the maps as polygons with a brown hatch pattern. If multiple resource types (marine mammals and birds) occupy the same polygon, a black-hatched multi-group pattern is used. A brown icon with a dolphin, pinniped, or whale silhouette is used to indicate the presence of marine mammals. The RAR# under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second column denotes whether the species has been designated endangered (E) or threatened (T) on either the state (S) and/or federal (F) lists. The next column provides an estimate of the concentration of the species at the site. Concentration is usually indicated as "High", "Moderate", or "Low", or some combination of these terms, such as "Moderate-High". "Potential" may also be used in a limited number of cases, for seal haul-out sites. The species and/or federal (F) lists. Concentration information was not available and was left blank. Temporal information included in the second column indicates time periods for various life-history stages or activities, such as pupping and molting for seals.

**BIRDS**

Birds are divided into several species subgroups based on taxonomy, morphology, behavior, and oil spill vulnerability and sensitivity. The species tables list all the birds included on the maps, sorted by subgroup. These species were included either because of their likelihood of impact by an oil spill, or their special conservation status, or because of their endemism. A limited number of bird areas depicted in this atlas include: resident and migratory waterfowl concentration areas; migratory shorebird concentration areas; seabad concentration areas; and colonial waterbird nesting sites (for nesting seabirds and wading birds).

Although birds are a major resource shown on the Prince William Sound ESI maps distribution of seabirds are shown only in the areas where surveys have been conducted. Waterfowl concentration areas shown on the map are derived from survey data provided by Alaska Department of Fish and Game. Winter surveys were conducted in March and summer surveys were conducted in July. In addition to the concentrations mapped, waterfowl can be found in most areas that have marshes and tidal flats. The Copper River Delta is the most important concentration area for waterfowl and shorebirds, both migratory and resident birds.

Eagle nest sites are found throughout the continental zone of Prince William Sound. There are approximately 1638 nest in the area covered by this atlas. Because of the density of eagle nests, they are not shown on the maps, though they are included in the digital data. Eagles are present in the Sound all year, but their most critical time is from May to July when they are nesting.

Expert contacts for birds are in the U.S. Fish and Wildlife Service and ADF&G Habitat and Restoration Division.

**BIRDCONCENTRATION AREAS**

Bird concentrations, including nesting areas for some species, are shown on the maps as polygons with a green hatch pattern. If multiple resource types (marine mammals and birds) occupy the same polygon, a black-hatched multi-group pattern is used. Seabird nesting sites from the U.S. Fish and Wildlife Service are shown with a green dot. A green icon with the appropriate bird silhouettes (wading bird, raptor, etc.) is associated with the polygons or points containing birds. The RAR# under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second column indicates whether the species is listed as threatened (T) or endangered (E) on either the state (S) and/or federal (F) lists. The next column in the tables provide an estimate of the concentration of each species at the site. Concentration is indicated as a numerical value representing the number of breeding pairs occurring at a nesting site, or the density of birds per kilometer in the survey areas. "Unknown" is used where the birds have been surveyed but an accurate count was not available. A blank field in concentration indicates no concentration information was provided. Nesting sites at any particular site may fluctuate seasonally and annually based on local or regional conditions, or other factors.

The species seasonality is shown in the next twelve columns representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. The last columns denote the nesting time-period for each species, if nesting occurs in the particular area or site. Nesting refers to the entire nesting period, including laying, hatching, and fledging. For many species, there is a temporal shift in seasonality and reproduction along with spatial changes in location. Temporal information included in the tables is specific to the one polygon or point that it references.

**FISH**

The fish depicted in the Prince William Sound ESI atlas include selected forage fish, herring spawning grounds, and streams important to anadromous fish. Not all species of environmental, recreational, or commercial interest are mapped. The entire coastal area of Prince William Sound can be considered as important waters for anadromous fish. In addition, the National Marine Fisheries Service has classified all waters of Prince William Sound as essential fish habitat for: Walleye pollock, Pacific cod, yellowfin sole, rock sole, flathead sole, arrowtooth flounder, sablefish, sculpin spp., pink, chum, chinook, coho, and sockeye salmon.

The anadromous streams shown on the map are from Alaska Department of Fish and Game database, Waters Important to Anadromous Fish. Species that are included in these streams in these streams are coho, chinook, chum, pink, and sockeye salmon, and dolly varden, and cutthroat trout. The forage fish areas are for capelin, Pacific herring, and Pacific sand lance.

While all of the anadromous streams in the database are shown, some of them are represented as a straight line, connecting the beginning point and endpoint of the stream, because the actual stream was not digitized. It is also cautioned that although this dataset is the best current representation of anadromous streams, it should not be considered definitive in determining the presence or absence of fish runs. Absence of anadromous streams on the maps for any particular location does not necessarily suggest that anadromous runs do not occur there.

Expert contacts for anadromous fish are in the ADF&G Habitat and Restoration Division.

**FISHCONCENTRATION AREAS**

Fish concentrations are shown on the maps as polygons with a blue hatch pattern. If multiple resource types (birds and fish) occupy the same polygon, a black-hatched multi-group pattern is used. A blue icon with a appropriate fish silhouette is associated with the polygons containing fish.

For the anadromous fish streams, a blue line is used to mark the fish runs (in the mouth of the stream). A blue icon with a fish silhouette is associated with the line using a leader line.

The RAR# under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second column denotes whether the species has been designated endangered (E) or threatened (T) on either the state (S) and/or federal (F) lists. Concentration information was not available and was left blank. Seasonality is listed by month with an "X" indicating the species presence in any particular month. The last columns indicate time periods for various life-history stages or activities (spawning, eggs, larvae, juveniles, and adults). For many species there is a temporal shift in seasonality and life-history along with spatial changes in location. Temporal information included in the tables is specific to the one polygon or site that it references.

**INVERTEBRATES**

King crab, Tanner crab and dungeness crab can be found throughout the sound. Depending on the maps are the contours for these species. This data was obtained from the National Marine Fisheries Service Essential Fish Habitat (1999) report.

Crab concentrations are shown on the maps as polygons with an orange hatch pattern. If multiple resource types (crabs and fish) occupy the same polygon, a black-hatched multi-group pattern is used. A orange icon with a crab silhouette is associated with the polygons containing crab.

The RAR# under the crab icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second column denotes whether the species has been designated endangered (E) or threatened (T) on either the state (S) and/or federal (F) lists. Concentration information is given as minor, general, or significant. Seasonality is listed by month with an "X" indicating the species presence in any particular month. The last columns indicate time periods for various life-history stages or activities (spawning, eggs, larvae, juveniles, and adults). For many species there is a temporal shift in seasonality and life-history along with spatial changes in location. Temporal information included in the tables is specific to the one polygon or site that it references.

**TERRITORIAL MAMMALS**

River otter are present throughout the study area, however surveys to determine their location and abundance are still being conducted. Therefore, these species are not mapped in this atlas. The river otter in Prince William Sound feed extensively on marine organisms and salmon, mostly along the shore. (Bowyer et al. 1995, river otters seem to prefer shallow tidal slope and small rock substrates in the intertidal area and old growth forest and less steep vegetated slopes in the adjacent upland environment.

Sitka black-tailed deer are present in the Prince William Sound. They have not been mapped because data on distribution and concentration are not comprehensive, but only from a few selected
sites. However the deer are most abundant on Hawkins, Hintchenbrook, and Montague islands. They are not very common in the northern part of the sound. Deer feed extensively on algae along the shorelines in Prince William Sound, particularly in winter when terrestrial foraging areas are snow covered, and would be at risk of ingesting oil.

Both black bears and brown bears are present in the area. Black bears can be found throughout the Sound. Brown bears are mostly on the larger islands, such as Montague, Hitchenbrook, and Knight Island. Bears feed in the intertidal zone, and on fish in coastal streams thus are at risk of coming in contact with and ingesting oil. They may also present a significant risk to humans engaged in cleanup or survey activities.

HUMAN-USE FEATURES

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

- ![Airport](image)
- ![Hatchery](image)
- ![Aquaculture](image)
- ![Marina/Anchorage](image)

**Airport**—Location of airports, airfields, landing strips, etc., whether they are manned or unmanned. These sites were mapped during the 1999 overflight.

**Aquaculture**—Location of aquaculture sites and facilities. When known, the site name, owner/manager, emergency contact name, and telephone number are provided on the data tables for each map. The locations provided by the SERVS database where validated during the overflight.

**Hatchery**—Location of salmon hatchery. When known, the site name, owner/manager, emergency contact name, and telephone number are provided on the data tables for each map. The location was provided by the SERVS database, and the contact information came from Prince William Sound Aquaculture Corporation.

**Marina/Anchorage**—Location of marinas and anchorages. This information was gathered during the 1999 overflight observations, digital, and expert sources.

REFERENCES

Listed below are the major hardcopy reference materials used during this project. In some instances, reference materials were not directly used as source materials, but were instead used or interpreted by scientists or resource managers who provided expert knowledge or personal communication concerning resources depicted in the atlas.


ACKNOWLEDGMENTS

This project was supported by the National Oceanic and Atmospheric Administration’s Office of Response and Restoration, Hazardous Materials Response Division (HMRD) in Seattle; State of Alaska, Department of Environmental Conservation; Exxon Valdez Oil Spill Trustee Council; U.S. Coast Guard; Prince William Sound Regional Citizens’ Advisory Council; and Oil Spill Recovery Institute in Cordova. John Whitney with NOAA HMRD assisted greatly with project coordination.

The biological and human-use data included on the maps were provided by a great many individuals within the U.S. Fish and Wildlife Service, Alaska Department of Fish and Game, Alaska Department of Natural Resources, National Forest Service, Ayeska Pipeline Company, and BP Exploration, Alaska.

At Research Planning, Inc. (RPI) of Columbia, South Carolina, numerous scientific, GIS, and graphics staff were involved with different phases of the Prince William Sound ESI atlas. Mark White was the project manager. Shoreline habitat mapping was conducted by Jacqueline Michel. The biological and human-use data were collected by Jeffrey Dahlin and John Whitney (NOAA HMRD). Biological and human-use data were compiled onto basemaps and edited by Jeffrey Dahlin. Mark White, Lori Hendricks, and Vermell Simpson entered the data and produced the final maps. Systems administration was conducted by William Holton. Graphics were provided by Joe Holmes.
# SPECIES LIST*

## MARINE MAMMALS

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Species Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harbor seal</td>
<td><em>Phoca vitulina</em></td>
</tr>
<tr>
<td>Northern (Steller) sea lion</td>
<td><em>Eumetopias jubatus</em></td>
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## SEA OTTERS

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Species Name</th>
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<tbody>
<tr>
<td>Sea otter</td>
<td><em>Enhydra lutris</em></td>
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## WHALES

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Species Name</th>
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<tbody>
<tr>
<td>Killer whale</td>
<td><em>Orcinus orca</em></td>
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## BIRDS

### ALCIDS

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<thead>
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<th>Common Name</th>
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<tbody>
<tr>
<td>Alcids</td>
<td><em>Synthliboramphus antiquus</em></td>
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<tr>
<td>Common murre</td>
<td><em>Uria aalge</em></td>
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<tr>
<td>Horned puffin</td>
<td><em>Fratercula corniculata</em></td>
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<tr>
<td>Kittlitz’s murrelet</td>
<td><em>Brachyramphus brevirostris</em></td>
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<tr>
<td>Marbled murrelet</td>
<td><em>Brachyramphus marmoratus</em></td>
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### DIVING BIRDS

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Species Name</th>
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<tbody>
<tr>
<td>Common loon</td>
<td><em>Gavia immer</em></td>
</tr>
<tr>
<td>Common scoter</td>
<td><em>Phalacrocorax auritus</em></td>
</tr>
<tr>
<td>Grebes</td>
<td><em>Podiceps spp.</em></td>
</tr>
<tr>
<td>Horned grebe</td>
<td><em>Podiceps auritus</em></td>
</tr>
<tr>
<td>Loons</td>
<td><em>Gavia spp.</em></td>
</tr>
<tr>
<td>Pacific loon</td>
<td><em>Gavia pacifica</em></td>
</tr>
<tr>
<td>Pelagic coromant</td>
<td><em>Phalacrocorax pelagicus</em></td>
</tr>
<tr>
<td>Red-faced coromant</td>
<td><em>Phalacrocorax urile</em></td>
</tr>
<tr>
<td>Red-necked grebe</td>
<td><em>Podiceps grisegena</em></td>
</tr>
<tr>
<td>Red-throated loon</td>
<td><em>Gavia stellata</em></td>
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### GULLS AND TERNS

<table>
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<tr>
<th>Common Name</th>
<th>Species Name</th>
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<tbody>
<tr>
<td>Aleutian tern</td>
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<tr>
<td>Arctic tern</td>
<td><em>Sterna paradisaea</em></td>
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<tr>
<td>Bonaparte’s gull</td>
<td><em>Larus philadelphia</em></td>
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<tr>
<td>Glaucous-winged gull</td>
<td><em>Larus glaucescens</em></td>
</tr>
<tr>
<td>Gulls</td>
<td><em>Larus spp.</em></td>
</tr>
<tr>
<td>Herring gull</td>
<td><em>Larus argentatus</em></td>
</tr>
<tr>
<td>Mew gull</td>
<td><em>Larus canus</em></td>
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<tr>
<td>Terns</td>
<td><em>Sterna spp.</em></td>
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### PELAGIC

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<th>Species Name</th>
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<tr>
<td>Black-legged kittiwake</td>
<td><em>Rissa tridactyla</em></td>
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<tr>
<td>Fork-tailed storm-petrel</td>
<td><em>Oceanodroma furcata</em></td>
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<tr>
<td>Jaegers</td>
<td><em>Stercorarius spp.</em></td>
</tr>
<tr>
<td>Leach’s storm-petrel</td>
<td><em>Oceanodroma leucorhoa</em></td>
</tr>
<tr>
<td>Northern fulmar</td>
<td><em>Fulmarus glacialis</em></td>
</tr>
<tr>
<td>Pelagic birds</td>
<td><em>Stercorarius pomarinus</em></td>
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<tr>
<td>Pomarine jaeger</td>
<td><em>Stercorarius pomarinus</em></td>
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<tr>
<td>Shearwaters</td>
<td><em>Oceanodroma spp.</em></td>
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### RAPTORS

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<tbody>
<tr>
<td>Bald eagle</td>
<td><em>Haliaeetus leucocephalus</em></td>
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### SHOREBIRDS

<table>
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<tr>
<th>Common Name</th>
<th>Species Name</th>
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<tbody>
<tr>
<td>Black oystercatcher</td>
<td><em>Haematopus bachmani</em></td>
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<tr>
<td>Black turnstone</td>
<td><em>Arnessia melanocephala</em></td>
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<tr>
<td>Greater yellowlegs</td>
<td><em>Tringa melanoleuca</em></td>
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<tr>
<td>Red-necked (Northern) phalarope</td>
<td><em>Phalaropus lobatus</em></td>
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<tr>
<td>Rock sandpiper</td>
<td><em>Calidris ptilocnemis</em></td>
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<tr>
<td>Ruddy turnstone</td>
<td><em>Arenaria interpres</em></td>
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<tr>
<td>Sandpipers</td>
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<tr>
<td>Shorebirds</td>
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<tr>
<td>Surfbird</td>
<td><em>Aphriza virgata</em></td>
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<tr>
<td>Wanderning tattler</td>
<td><em>Heteroscelus inanusc</em></td>
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### FISH

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<tbody>
<tr>
<td>Anadromous fish</td>
<td><em>Atheresthes stomias</em></td>
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<tr>
<td>Arrowtooth flounder</td>
<td><em>Oncorhynchus tsawytscha</em></td>
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<tr>
<td>Chinook salmon</td>
<td><em>Oncorhynchus keta</em></td>
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<tr>
<td>Chum salmon (dog)</td>
<td><em>Salmo clarkii clarkii</em></td>
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<tr>
<td>Cutthroat trout</td>
<td><em>Oncorhynchus kisatch</em></td>
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<tr>
<td>Coho salmon (silver)</td>
<td><em>Salvelinus malma</em></td>
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<tr>
<td>Dolly varden</td>
<td><em>Salvelinus malma</em></td>
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<tr>
<td>Flathead sole</td>
<td><em>Hyphessobrycon elachistos</em></td>
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<td>Pacific cod</td>
<td><em>Gadus macrocephalus</em></td>
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<td>Pink salmon (humpy)</td>
<td><em>Oncorhynchus gorbuscha</em></td>
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<td>Rock sole</td>
<td><em>Leptagonella bilineata</em></td>
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<td>Sablefish (blackcod)</td>
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<td>Sculpin</td>
<td><em>Cottidae</em></td>
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<td>Sockeye salmon (red)</td>
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<td>Walleye pollock</td>
<td><em>Thraena chalcoargi</em></td>
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<td>Yellowfin sole</td>
<td><em>Pleuronectes americanus</em></td>
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### ESTUARINE NURSERY

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<tr>
<td>Pacific herring</td>
<td><em>Clupea pallasi</em></td>
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### MARINE BENTHIC

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</thead>
<tbody>
<tr>
<td>Pacific sand lance</td>
<td><em>Ammodites hexapterus</em></td>
</tr>
</tbody>
</table>

### MARINE PELAGIC

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Species Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capelin</td>
<td><em>Mallotus villus</em></td>
</tr>
</tbody>
</table>

### INVERTEBRATES

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Species Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRABS</td>
<td><em>Paralichthys platypus</em></td>
</tr>
<tr>
<td>Dangerous crab</td>
<td><em>Cancer magister</em></td>
</tr>
<tr>
<td>Golden king crab</td>
<td><em>Lithodes aequispinus</em></td>
</tr>
<tr>
<td>Red king crab</td>
<td><em>Paralichthys camtschaticus</em></td>
</tr>
<tr>
<td>Tanner crab</td>
<td><em>Chionoecetes bairdi</em></td>
</tr>
</tbody>
</table>

* Threatened and endangered species are designated by underlining.
SHORELINE DESCRIPTIONS

EXPOSED ROCKY SHORES  ESI = 1A

DESCRIPTION
• The intertidal zone is composed of bedrock, steep (greater than 30° slope), and thus very narrow
• Sediment accumulations are uncommon because waves remove the debris that has slumped from the eroding cliffs
• They are regularly exposed to wave action and strong currents
• Attached organisms are accustomed to the impacts of the waves and the associated hydraulic pressure
• There is strong vertical zonation of intertidal biological communities; Species density and diversity vary greatly, but barnacles, snails, mussels, and macroalgae dominate
• They are common throughout the area, wherever there is open fetch of greater than a few km facing the direction of storm-generated winds

PREDICTED OIL BEHAVIOR
• Oil is held offshore by waves reflecting off the steep, hard surfaces
• During calm conditions, the oil can form a band at the high-tide line; oil will not adhere to wet, algae-covered surfaces
• Oil that is deposited is rapidly removed from exposed faces
• The most persistent oil would remain as a patchy band at or above the high-tide line
• Impacts to intertidal communities are expected to be short-term in duration.

RESPONSE CONSIDERATIONS
• Cleanup is usually not required
• Access can be difficult and dangerous

EXPOSED WAVE-CUT PLATFORMS IN BEDROCK  ESI = 2A

DESCRIPTION
• These shores consist of a bedrock shelf or platform of variable width and very gentle slope
• The surface of the platform is irregular and the presence of tidal pools is common
• Along headlands, they have only small accumulations of sediments, mostly at the high-tide line
• They most often co-occur with gravel beaches; the gravel beach can be either at the upper or the lower half of the intertidal zone, depending on the nature of the bedrock outcrop
• Species density and diversity varies greatly, but barnacles, snails, mussels, and macroalgae are often very abundant
• Attached organisms are accustomed to the impacts of the waves and the associated hydraulic pressure
• They are common along all exposed sections of the shore

PREDICTED OIL BEHAVIOR
• Oil will not adhere to the wet rock surface, but could penetrate crevices or sediment accumulations if present
• Persistence of oil on the platform itself is usually short-term, except in wave shadows or where the oil was deposited high above normal wave activity

RESPONSE CONSIDERATIONS
• Cleanup is usually not required
• Where the high-tide area is accessible, it may be feasible to manually remove heavy oil accumulations and oiled debris
• Consider potential impacts to rich biological communities on the platforms when cleaning adjacent gravel beaches
FINE- TO MEDIUM-GRAINED SAND BEACHES  

**DESCRIPTION**
- These beaches are flat to moderately sloping and relatively hard packed.
- They are composed of predominantly quartz sand.
- They are utilized by birds for resting and foraging.
- Backshore habitats include dunes and wetlands which are important seasonally as feeding areas for bears.
- They are uncommon, only occurring on the outer islands of the Copper River Delta and in the vicinity of Cape Suckling.

**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 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 at the upper beach face.
- 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 limited, to prevent contamination of clean areas.
- Manual cleanup is advised to minimize the volume of sand removed from the shore and requiring disposal.
- All efforts should focus on preventing the mixture of oil deeper into the sediments by vehicular and foot traffic.
- Mechanical reworking of lightly oiled sediments from the high-tide line to the lower intertidal zone can be effective in speeding natural recovery without having to remove sediment.

MIXED SAND AND GRAVEL BEACHES

**DESCRIPTION**
- Moderately sloping beach composed of a mixture of sand and gravel on the surface.
- Because of the mixed sediment sizes, there may be zones of pure sand, pebbles, or cobbles.
- There can be large-scale changes in the sediment distribution patterns depending upon season, because of the transport of the sand fraction offshore during storms.
- Because of sediment desiccation and mobility on exposed beaches, they have relatively low densities of animals and plants; densities are higher for sheltered beaches.
- They are not common, occurring mostly along the western part of the sound, outer coast, and on the deltas formed by the larger streams and rivers.

**PREDICTED OIL BEHAVIOR**
- Oil penetration into the 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 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, 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.
- Oil can be stranded in the coarse sediments on the lower part of the beach, particularly if the oil is weathered or emulsified.

**RESPONSE CONSIDERATIONS**
- Heavy accumulations of pooled oil should be removed quickly from the upper beachface.
- Sediment removal should be limited as much as possible.
- Even low-pressure flushing should be avoided because of the potential for transporting contaminated sand to the lower intertidal or subtidal zone.
- In-place tilling may be used to reach deeply buried oil layers in the middle zone on exposed beaches.
- Mechanical reworking of oiled sediments from high tide to the upper intertidal zone (not below the mid-tide zone) can be effective in areas regularly exposed to wave activity (as evidenced by storm berms).
GRAVEL BEACHES  ESI = 6A

DESCRIPTION
• Gravel beaches can be very steep, with multiple wave-built berms forming the upper beach
• The grain size of the gravel can vary widely, from small pebbles to large boulders
• They often are associated with rocky shores and tidal flats
• Exposure to wave energy is highly variable. Degree of exposure can be inferred partly by the roundness/angularity of the gravel: well rounded gravel indicates regular re-working of the surface sediments by waves; angular gravel indicates infrequent exposure to waves big enough to re-work the sediments
• Density of animals and plants in the upper intertidal zone is low along exposed beaches, but can be very high on sheltered beaches and on the lower intertidal zone of all beaches
• Gravel beaches are the most common shoreline type in PWS

PREDICTED OIL BEHAVIOR
• Deep penetration of stranded oil is likely on gravel beaches because of their high permeability
• Long-term persistence will be controlled by the depth of routine reworking by the waves; oil can persist for longer than 10 years
• Chronic sheening and the formation of asphalt pavements is likely where accumulations are heavy

RESPONSE CONSIDERATIONS
• Heavy accumulations of pooled oil should be removed quickly from the upper beachface
• Oiled debris should be removed
• Sediment removal should be limited as much as possible
• Low-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents. High-pressure spraying should be avoided because of the potential for transporting contaminated finer sediments (sand) to the lower intertidal or subtidal zones
• Mechanical reworking of oiled sediments from high tide to the upper intertidal zone (not below the mid-tide zone) can be effective in areas regularly exposed to wave activity (as evidenced by storm berms).
• In-place tilling may be used to reach deeply buried oil layers in the middle zone on exposed beaches

RIPRAP  ESI = 6B

DESCRIPTION
• Riprap structures are composed of boulder-sized blocks of bedrock
• Riprap structures are used for shoreline protection and as breakwaters in marinas
• Attached biota are highly variable, depending on the elevation of the riprap
• They are present only in developed areas around Valdez, Tatlitluk, Cordova, Chenega, and Whittier

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 liberated oil
• Heavy and weathered oils are more difficult to remove, requiring scraping and/or hot-water spraying
EXPOSED TIDAL FLATS  

DESCRIPTION

- Exposed tidal flats are broad intertidal areas composed primarily of sand and gravel
- The presence of sand indicates that tidal currents and waves are strong enough to mobilize the sediments
- Biological utilization can be very high, with large numbers of infauna, heavy use by birds for roosting and foraging, and use by foraging fish and sea otters
- They are usually associated with a stream mouth and have another shoreline type on the landward side of the flat, though they can occur as separate shoals in the Copper River Delta region

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of exposed tidal flats, but rather moves across the flat and accumulates at the high-tide line
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy
- Oil does not penetrate water-saturated sediments
- Biological damage may be severe, primarily to infauna, thereby reducing food sources for birds and other predators

RESPONSE CONSIDERATIONS

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

SHELTERED ROCKY SHORES  

DESCRIPTION

- The substrate is solid and composed of bedrock, although cracks and crevices can be common
- This shoreline type is sheltered from significant wave activity and strong currents
- In young, glacial bays, the intertidal zone is steep, composed of a vertical rock face
- Sheltered rocky shores often co-occur with gravel beaches; the gravel beach can be either at the upper or the lower half of the intertidal zone, depending on the nature of the bedrock outcrop
- Intertidal habitats can be rich and diverse, supporting many different users (birds, fish, shellfish, mammals)
- They are common along bays and fjords

PREDICTED OIL BEHAVIOR

- Oil tends to adhere to the upper intertidal zone where the rock surface dries out during low tide, and the algal cover is sparse
- On solid bedrock surfaces, the oil will occur as a surface coating
- Oil will penetrate and persist in crevices and sediment accumulations
- Stranded oil will persist because of low energy setting, particularly on the undersides of rock outcrops and in sediment accumulations

RESPONSE CONSIDERATIONS

- Thick accumulations of pooled oil should be of high priority for removal, to prevent re-mobilization and/or penetration
- Manual removal of heavy oil is likely to leave significant residues, but may be useful for oil in crevices or sediment pockets
- Flushing techniques will be most effective when oil is still fresh and liquid; restrict operations to tidal levels that will prevent oily effluents from impacting lower tidal elevations with rich intertidal communities
- Expect to increase temperature and pressure over time as the oil weathers; Evaluate trade-offs between oil removal and pressure/temperature impacts on intertidal communities
- Consider potential impacts to rich biological communities on the rocky shores when conducting cleanup of associated gravel beaches
SHELTERED, PERMEABLE ROCKY SHORES  
**DESCRIPTION**
- Relatively steep and narrow rocky shore which is covered by a veneer of angular rubble without any evidence of re-working by waves or sediment transport
- The surface rubble is highly variable in size and packing, but there is always some permeability in the surface materials
- Can co-occur with gravel beaches; the gravel beach can be either at the upper or the lower half of the intertidal zone, depending on the nature of the rock outcrop
- This shoreline type is sheltered from significant wave activity and strong currents
- Species density and diversity vary greatly; barnacles, snails, mussels, clams, polychaetes, rockweed, and crabs are abundant
- They are not common, occurring along bays and fjords

**PREDICTED OIL BEHAVIOR**
- Oil tends to adhere to the upper intertidal zone where the rock surface dries out during low tide, and the algal cover is sparse
- On solid bedrock surfaces, the oil will occur as a surface coating
- Oil will pool and penetrate crevices in the surface rubble
- Where the rubble is loosely packed, oil can penetrate deeply, causing long-term contamination of the subsurface

**RESPONSE CONSIDERATIONS**
- Thick accumulations of pooled oil should be of high priority for removal, to prevent re-mobilization and/or penetration
- Manual removal of heavy oil is likely to leave significant residues, but may be useful for oil in crevices or sediment pockets
- Flushing techniques will be most effective when oil is still fresh and liquid; restrict operations to tidal levels that will prevent oily effluents from impacting lower tidal elevations with rich intertidal communities
- Expect to increase temperature and pressure over time as the oil weathers; Evaluate trade-offs between oil removal and pressure/temperature impacts on intertidal communities
- Consider potential impacts to rich biological communities on the rocky shores when conducting cleanup of associated gravel beaches

SHELTERED TIDAL FLATS  
**DESCRIPTION**
- Sheltered tidal flats are composed primarily of mud with minor amounts of sand and gravel; they seldom have any vegetation
- They are present in low-energy habitats, sheltered from waves and currents
- The sediments are very soft and cannot support even light foot traffic in many areas
- There can be large concentrations of shellfish, polychaetes, and snails on and in the sediments
- They are heavily utilized by birds and mammals for feeding and resting
- They are uncommon in PWS, occurring primarily on the landward side of exposed tidal flats in the Orca Inlet and Copper River Delta

**PREDICTED OIL BEHAVIOR**
- Oil does not usually adhere to the surface of sheltered tidal flats, but rather moves across the flat and accumulates at the high-tide line
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy
- Oil will not penetrate the water-saturated sediments, but could penetrate burrows and desiccation cracks 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 attempted
SALT- AND BRACKISH-WATER MARSHES  

DESCRIPTION

- Intertidal wetlands containing emergent, herbaceous vegetation
- Width of the marsh can vary widely, from a narrow fringe to extensive areas at the mouths of large streams, though most marshes are small in area
- Sediments are composed of mixtures of mud, sand, and gravel
- Nearly all salt marshes are associated with stream mouths, and there is nearly always another shoreline type on the seaward side of the marsh (most often a tidal flat)
- Resident flora and fauna are abundant with numerous species and high utilization by birds, fish, and shellfish
- They occur throughout the region, but are generally widely scattered; large marshes are unique and associated with the heads of bay (e.g., Port Gravina) and the Copper River Delta

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

- Natural removal processes and rates should be evaluated prior to conducting cleanup
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. During flushing, care must be taken to prevent transporting oil to sensitive areas down slope or along shore
- Cleanup activities should be carefully supervised to avoid vegetation damage
- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized
- Cutting of oiled vegetation should only be considered when other resources present are at great risk from leaving the oiled vegetation in place