ENVIRONMENTAL SENSITIVITY INDEX: WESTERN ALASKA

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for marine and coastal areas of Western Alaska. This area extends from St. Michael Island south to Goodnews Bay, including Nunivak Island and St. Matthew Island. ESI maps are a compilation of information from three main categories: shoreline habitats, sensitive biological resources, and human-use resources.

The individual map pages in this atlas are divided according to the U.S. Geological Survey (USGS) topographic quadrangle index. Grey-scale scanned images of these maps are used as a backdrop for each map page in the atlas.

SHORELINE HABITAT MAPPING

ESI maps for the region were created using sources and methods described below. Shoreline habitats were mapped during overflights and ground surveys conducted by experienced coastal geologists. The shoreline of southern Norton Sound (from St. Michael Island to Cape Vancouver) was originally mapped during overflights in June and July 1980, during the fieldwork for the earlier Norton Sound ESI maps. The shoreline of Kuskokwim Bay (from Cape Vancouver to Goodnews Bay) was originally mapped during overflights in July and August 1981, during the fieldwork for the earlier Bristol Bay ESI maps. During these overflights, the shoreline types were recorded on then-current 1:63,360-scale USGS topographic maps. Only large-scale modifications to the shoreline were noted on the maps (and only those observed during the 1980 and 1981 overflights). Because of the complexity of the shoreline, multiple habitats were often described for each shoreline segment. Salt marshes, while extensive in the region, were seldom mapped as polygonal features because of the difficulty determining their landward extent. However, many of the tidal flats were mapped as polygons. The shorelines of St. Matthew Island have never been classified due to its remoteness.

To determine the sensitivity of a particular intertidal shoreline habitat, the following factors are integrated:

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

Prediction of the behavior and persistence of oil in intertidal habitats is based on an understanding of the dynamics of the coastal environments, not just the substrate type and grain size. The intensity of energy expended upon a shoreline by wave action, tidal currents, and river currents directly 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 ranking. Generally speaking, areas exposed to high levels of physical energy, such as wave action and tidal currents, and low biological activity rank low on the scale, whereas sheltered areas with associated high biological activity have the highest ranking. The list below includes the shoreline habitats delineated for Western Alaska ordered by increasing sensitivity to spilled oil.

1A) Exposed Rocky Shores
2A) Exposed Wave-cut Platforms in Bedrock, Mud, or Clay
3A) Fine- to Medium-grained Sand Beaches
4) Coarse-grained Sand Beaches
5) Mixed Sand and Gravel Beaches
6A) Gravel Beaches
7) Exposed Tidal Flats
8A) Sheltered Rocky Shores and Sheltered Scarps in Mud and Clay
8E) Peat Shorelines
9A) Sheltered Tidal Flats
10A) Salt- and Brackish-water Marsh

Each of the shoreline habitats is described on pages 9-13, in terms of their physical description, predicted oil behavior, and response considerations.

SENSITIVE BIOLOGICAL RESOURCES

Biological information presented in this atlas was collected, compiled, and reviewed with the assistance of biologists and resource managers from the U.S. Fish and Wildlife Service (USFWS), Alaska Department of Fish and Game (ADF&G), U.S. Geological Survey (USGS), National Marine Fisheries Service (NMFS), National Park Service (NPS), Alaska Department of Commercial and Economic Development (DCED), and Alaska Division of Governmental Coordination (DGC). 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. Six major categories of biological resources are included in this atlas: terrestrial mammals, marine mammals, birds, fish, invertebrates, and benthic marine habitats.

Polygons, points, and arcs represent the spatial distribution of biological resources on the maps. Associated with each of these representations is an icon depicting the types of species 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 below reflect this grouping scheme. Please note that benthic marine habitats are displayed on the maps using "simplified-wetland" patterns rather than the hatched patterns used for the other species groups, and no icons will be used (see legend). For all other species, the groups are color coded, and different icons represent the subgroups:

BIRDS
- Diving Birds
- Gulls and Terns
- Passerine Birds
- Raptors
- Seabirds
- Shorebirds
- Wading Birds
- Waterfowl

TERRESTRIAL MAMMALS
- Bears

MARINE MAMMALS
- Dolphins
- Pinnipeds
- Whales

FISH
- Fish

INVERTEBRATES
- Bivalves
- Crabs

The polygon color and pattern are generally the same for all species in each major group (e.g., birds are green), and match the icon colors. Also associated with each biological polygon or point feature on the map is a Resources 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 associated with the polygon, point, or line feature, and the state and federal protected status as threatened, endangered (T&E), or species of special concern (C), concentration, seasonality, and life-history information for each species.

There are some species that are found throughout specific geographical areas or habitat types on certain maps. Displaying the polygons for these species would cover large areas or would obscure the shoreline, ESI classification, or other biological features, making the maps very difficult to read. Thus, species that 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 Kuskokwim Bay" or "Present around Nunivak Island"). The use of this strategy is implemented on a map per map basis, depending on the location, size, and number of polygons present on each map.

TERRESTRIAL MAMMALS

Brown bear concentration areas around certain rivers are depicted in the Western Alaska atlas. Locations of brown bears were based on concentration areas depicted on ADF&G habitat maps. Brown bears are likely to occur in and near rivers and streams, particularly when salmon are running. Other mammals potentially occurring in the area that were not mapped include: muskox, moose, caribou, dall sheep, reindeer, bison, wolves, foxes, beaver, mink, marten, river otter, muskrat, and others. These species were not mapped to due to their relatively wide distributions and a lack of information regarding particular concentration areas, and/or the unlikelihood of impact during coastal and marine oil spills due to their use of more upland and inland habitats.

Terrestrial mammal areas are displayed on the maps as polygons with a brown-hatched pattern. A brown icon with a bear silhouette is used to indicate the presence of brown bears and is associated with all polygons containing this species.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column gives the species name. The next column provides an estimate of the concentration of the species at the site. The seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species is present at a location in a particular month, an "X" is placed in the month column.

MARINE MAMMALS

Marine mammals depicted in the Western Alaska atlas include: beluga, gray, and minke whales; harbor porpoises; spotted, ringed, bearded, ribbon, and harbor seals; Steller sea lions (federally endangered and state species of special concern); and walruses. Nearshore concentration areas, most environmentally sensitive areas (MESAs), haul-out sites (seals, sea lions, walruses), and migration routes are specifically indicated on the maps. All marine mammal occurrences are depicted as polygons. Many marine mammal species are important subsistence resources for Alaska Natives.

Information on the geographic distribution of marine mammals was gathered from personal interviews with resource experts, hardcopy maps provided by ADF&G, and published reports and books. We did not attempt to show the complete distribution of any of these species, as they occur throughout a larger range than the areas depicted.

Bowhead whale (federally endangered, state species of special concern), killer whale, and Dall's porpoise were not mapped, but may be present in the area. The northern Bering Sea serves as migratory and wintering habitat for bowhead whales, which are closely associated with sea ice, from September to March. Killer whales are present in ice-free waters of the Bering Sea. Dall's porpoise may be present throughout the area excluding the shallow eastern flats of the Bering Sea.

Several additional species may be present around St. Matthew Island during ice-free months, including: northern right whale, (federally and state endangered), blue whale (federally and state endangered), fin whale (federally endangered), humpback whale (federally and state endangered), and sperm whale (federally endangered). Polar bears may extend as far south as St. Matthew and Nunivak Island during heavy ice years. Rarely they have been observed feeding along the Yukon Delta during the summer.

The species that were mapped are described below.

Steller sea lion (federally endangered) – Steller sea lions use secluded rocky islands for haul-outs and rookeries. Small groups of males may haul-out on St. Matthew Island, Hall Island, Pinnacle Island, and Nunivak Island from May through August.

Ringed seal –Ringed seals are associated with moving pack ice, and stable shorefast ice for pupping and breeding, and they are found in nearshore areas from October to June. Pups are born in March and April, and juveniles may be found in open water. Pups are extremely sensitive to oil contamination for the first 6 to 8 weeks because their primary insulation is from fur and not from a thick layer of blubber. Molting occurs on shorefast ice and on large flat ice floes from May to July. Most ringed seals occur along the edge of the permanent ice pack during the summer.

Spotted seal –This species is associated with the sea ice-front during the winter and while breeding, pupping, and molting. Pupping occurs in April and May, and molting occurs from May until July. Spotted seals occur nearshore and haul-out on land during ice-free months. Several major haul-outs correspond to herring and capelin spawning areas. Spotted seals are abundant on ice around Nunivak Island in the spring and fall.

Harbor seal – Harbor seals are resident in coastal waters of the southeastern Bering Sea. The northernmost extent of this species is typically Kuskokwim Bay and Nunivak Island, where they are observed hauling out on land during ice-free months.

Bearded seal – Bearded seals are typically associated with the moving pack ice-edge, as well as in association with leads, flaws, and polynyas. Some seals migrate north in the summer, while others remain in ice-free Bering Sea waters. Pupping occurs between March and May, and molting occurs in May and June.

Ribbon seal - Ribbon seals may be near the Bering Sea ice front from November through July and offshore in ice-free waters in late summer and fall.

Walrus – Walruses haul out on secluded shores and islands during the ice-free months. Major winter breeding concentration areas occur south and southwest of St. Lawrence Island and in the vicinity of Nunivak Island, Kuskokwim Bay, and Bristol Bay.

Beluga whale – Beluga whales are associated with seasonal ice cover, and they overwinter in offshore waters of the Bering Sea. Some may winter near St. Matthew Island. They migrate to coastal areas in the spring, and concentrate off of the mouth of the Yukon River and in other nearshore areas feeding on salmon, herring, and saffron cod through the summer and into the fall. Calving occurs in June and July.

Other cetaceans – Gray whales are commonly seen along the southern coast of Nunivak Island and around St. Matthew Island in the summer. Minke whales are present in pelagic habitats and in bays and shallow water both in and near ice and during ice-free months. Harbor porpoises are present nearshore throughout the area during ice-free months.

Expert contacts are: for marine mammals are Lloyd Lowry and Kathy Frost (retired ADF&G, Fairbanks), 907/455-6885, Lori Quakenbush (ADF&G, Fairbanks), 907/459-7214, Brian McCaffery (USFWS, Bethel), 907/543-1014, Dave Rugh, (NMFS, Seattle), 206/526-4018, and other staff from the NMFS National Marine Mammal Laboratory (NMML, Seattle), 206/526-4045; for sea lions is John Sease (NMFS, Seattle), 206/526-4024; for seals is Dave Withrow (NMFS, Seattle), 206/526-4019; and for walruses is Joel Garlich-Miller (USFWS, Anchorage), 907/786-3820.

Marine mammal areas are displayed on the maps as polygons with a brown-hatched pattern. A brown icon with a whale, dolphin, or pinniped silhouette is used to indicate the presence of marine mammals and is associated with all polygons and points containing these resources. In cases where multiple resource types occupy the same polygon (such as marine mammals and fish), a black-hatched, multi-group pattern is used rather than a brown-hatched polygon.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column gives the species name. The next column provides an estimate of the concentration of the species at the site. Concentration is represented using descriptive terms or using numeric values estimated in reports or by resource experts. Steller sea lion haul-out concentration estimates (numeric values and the term "few") and gray whale concentration estimates ("common") were derived from the OCSEAP report (see references). Spotted and harbor seal concentration estimates (numeric values and the terms "common" and "high") were derived from OCSEAP, ARRT, and NMML reports and by local resource experts. Walrus haul-out usage estimates and mating area concentrations ("historical", "occasional", "consistent", and "high") were provided by USFWS staff and were based on field studies and peer reviewed journal articles. Beluga whale concentration estimates ("common", "high", and numeric values) were derived from OCSEAP, ARRT, and ADF&G reports and maps and by resource experts. In many cases, concentration values have not been used if the information is not known. Note that concentration should not be interpreted as the "level of concern" or "importance" associated with a site or particular resource.

The seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species is present at a location in a particular month, an "X" is placed in the month column. The final columns list the time periods for sensitive life-history activities, such as pupping for seals and calving for beluga whales.

BIRDS

Birds depicted in this atlas are divided into several subgroups based on taxonomy, morphology, behavior, and oil spill vulnerability and sensitivity. The species table lists all birds included on the maps, sorted by subgroup. These species are included either because of their likelihood of direct or indirect impact by an oil spill or similar incident, their general rarity or imperilment, or their special protection status as threatened or endangered.

The atlas includes seabird nesting colonies; raptor concentration areas; waterfowl, diving bird, and wading bird nesting, migratory staging, and molting areas; and shorebird staging and nesting areas. Nesting sites are of particular concern due to high concentrations of birds in adjacent waters, contamination of eggs and young by oiled adults and prey, and the potential for disturbance from response activities.

Seabird nesting sites – Locations are shown where seabirds have been documented as nesting. Birds are in the vicinity of colonies from April through October, and they may be rafting and feeding in large concentrations in offshore waters. Information on nesting colony size (number of birds present) is included in tables on the reverse side of the maps. This information was derived from a frequently updated USFWS database.

Raptor concentration areas– Locations are shown where raptors have been documented as being present in high numbers nesting and during the fall migration. Information on raptors was gathered during interviews with USFWS staff.

Yukon-Kuskokwim (Y-K) Delta waterbird nesting areas – Locations are shown where waterbirds are nesting in medium to high densities, as determined by annual aerial surveys. **Please note that the term "med-high" which is used to describe nesting densities represents relative densities in the region as determined by USFWS staff. The Y-K Delta is a very important waterfowl breeding area and supports high percentages of the world populations of several species.** The spatial information is based

on breeding population surveys conducted from 1988 to 2001. The nesting season varies by species, but birds are generally present from April through October. The data were provided by USFWS and consisted of separate ArcView coverages for each nesting species. Individual species data were combined and simplified in order to highlight key nesting areas for this atlas.

Sea duck breeding, staging, molting and wintering areas – Concentration areas are shown for spectacled eider (federally threatened), Steller's eider (federally threatened), king eider, common eider, long-tailed duck, and black, white-winged, and surf scoters. Geographic and concentration information was provided by USFWS Migratory Bird Management biologists and was based on published reports, digitally generated maps, 10 years of Spring and Fall aerial survey data, and expert knowledge of the area. Numeric and descriptive concentrations were based on conversations with biologists with extensive experience in conducting bird surveys in Alaska. The terms "high" or "very high" often refer to nearshore or coastal zones of high use for particular species during certain times of year. Numeric concentrations shown for sea ducks typically refer to the total number of birds potentially passing through an area during migration, rather than a single day count. The spatial extent and number of birds using "high-use zones" varies from year to year, and resource experts should be contacted in case of a spill regarding recent counts. Waterfowl are particularly vulnerable to the effects of spilled oil during the molting period, which varies by species, but occurs during the summer and fall months.

Migratory shorebird stopover and nesting areas – Areas where large concentrations of shorebirds occur annually during the spring, summer, and/or autumn months were mapped. Information on the locations of these areas and concentrations of particular species were based on information provided by a USGS report that included a compilation of survey data from various sources over many years and detailed descriptions of major staging and nesting areas. Numeric concentrations shown for shorebirds typically refer to the total number of birds potentially using an area over the entire migratory and nesting season, rather than a single day count.

Other bird nesting, migratory, and molting areas – Coastal areas where birds concentrate during nesting, migration, and molting were mapped. This information was based on various sources provided by USFWS, University of Alaska, and U.S. Bureau of Land Management, including summarized survey and tagging data from the past 5-10 years, published reports, peer reviewed journal articles, and interviews with resource experts. In the concentration field, the term "high" indicates a nearshore or coastal zone of high use for particular species during certain times of year, based on interviews with resource experts. Terms and numeric values used to describe concentrations of birds on Nunivak Island, Carter Bay, and Goodnews Bay were based on reports specific to those areas.

Expert contacts are: for seabirds, Shawn Stephensen (USFWS, Anchorage), 907/786-3691, and David Irons (USFWS, Anchorage), 907/786-3376; for shorebirds, Bob Gill (USGS, Anchorage), 907/786-3514; for waterfowl, Bill Larned (USFWS, Soldotna), 907/262-9863 ext. 224, and Chris Dau (USFWS, Anchorage), 907/786-3908; for loons, Joel Schmutz (USGS, Anchorage), 907/786-3518; for endangered/threatened species, Charla Sterne (USFWS, Anchorage), 907/271-2781, for digital waterfowl nesting data, Bob Platte (USFWS, Anchorage), 907/786-3565; for Yukon Delta National Wildlife Refuge species, Brian McCaffery (USFWS, Bethel), 907/543-1014; for Togiak National Wildlife Refuge species, Pat Walsh and Rob MacDonald (USFWS, Dillingham), 907/842-1063; and for St. Matthew Island species, Kevin Winker (University of Alaska, Fairbanks), 907/474-7505.

Birds are shown on the maps as polygons with a green-hatched pattern. Seabird nesting colonies are shown as green points. Users should be aware that seabirds may be feeding and rafting in nearshore and offshore areas in the vicinity and up to several miles away from their nests. Short-tailed albatross, a state and federally endangered species, may raft in the Bering Sea. During an oil spill, the seabird experts listed above should be contacted for information on current seabird rafting locations.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column contains the species common name. The second column indicates whether the species is listed as threatened (T), endangered (E), or special concern (C) 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. See the descriptions of the species groups mapped and the sources of data used (above) for information on how numeric concentration values and descriptive terms were generated. In some cases, concentration values have not been used if the information was not available. Note that concentration should not be interpreted as the "level of concern" or "importance" associated with a certain site or particular resource.

The seasonality for each species or resource is shown in the next twelve columns, corresponding to months of the year. If a species or resource is present at a location in a particular month, an "X" is placed in the month column. The last three columns denote the migratory, nesting, and molting time-periods for each species.

FISH

Finfish depicted in this atlas include selected marine, estuarine, freshwater, and anadromous species. Species of commercial, subsistence, recreational, ecological, and/or conservation interest are emphasized.

Pacific herring and capelin spawning areas – Documented intertidal and subtidal herring and capelin spawning areas were mapped. Geographic information was provided by ADF&G resource experts and published ADF&G coastal habitat maps. Spawning occurs during the late spring and summer months. Adult herring form large spawning groups and deposit their eggs onto eelgrass, kelp, and other suitable substrate in nearshore areas. Capelin spawn on gravel beaches during June full moons. Because spawning occurs in shallow water, both adults and eggs are susceptible to exposure to both floating slicks and oil remobilized from adjacent intertidal areas. Fish eggs are susceptible to mortality, reduced hatching success, and an overall decrease in the percent of viable hatch during spills. Herring and capelin are important diet items for marine fishes, mammals, and birds. Herring are also an important commercial fishery.

Anadromous fish – Wild stocks of anadromous fish are major components to the marine ecosystem of Alaska. Chinook, chum, coho, pink and sockeye salmon, Dolly Varden, sheefish, arctic lamprey, and four species of whitefish are present in Western Alaska. The streams shown have been classified by ADF&G as anadromous streams, and this listing is frequently updated. When adult fish return to their natal streams to spawn between May and October, they tend to concentrate at the stream mouths prior to moving upstream. Most spawning beds are well upstream, beyond the limit of tidal excursions that could carry oil slicks inland. Juvenile salmon may concentrate in shallow, nearshore habitats, particularly in the spring and summer months and are likely to be impacted during a spill.

Marine/estuarine fish – General distributions of nearshore species, particularly those that are important prey species for marine mammals, were mapped in nearshore waters. Resource experts from ADF&G provided information on the geographic distribution and seasonal presences of these species. Several species of groundfish (e.g., halibut, walleye pollack, yellowfin sole) were mapped using NMFS digital Essential Fish Habitat (EFH) data and information provided by local resource experts.

Several additional species occur in Western Alaska that were not mapped, including anadromous species (e.g. Pacific lamprey), freshwater species (e.g. blackfish, arctic grayling, northern pike, burbot, and lake trout); and marine species (e.g., poachers, greenlings, and wolffish). Please contact the resource experts listed below for additional information on any of these or other species that may occur in the area.

Expert contacts for finfish are: Charlie Lean (NPS, Nome), 907/443-6119; Fred DeCicco (ADF&G, Fairbanks), 907/459-7270; Fred Bue (ADF&G, Fairbanks), 907/459-9217; Tim Ward (ADF&G, Bethel), 907/543-2433; Bob Lafferty (ADF&G, Bethel), 907/543-1677; Matt Eagleton (NMFS, Anchorage), 907/271-5006; Dan Bergstrom (ADF&G, Anchorage), 907/267-2171; Paul Salomone (ADF&G, Anchorage), 907/267-2135; and Tracy Lingnau (ADF&G, Anchorage) 907/267-2121.

Fish are shown on the maps as polygons with a blue-hatched pattern. Anadromous streams are shown as blue arcs. In areas where arcs occur in large water bodies (e.g., wide streams or rivers), it can be assumed that the fish may occur in the entire width of the water body, beyond the width of the arc. In cases where multiple resource types occupy the same polygon (such as fish and invertebrates), a black-hatched, multi-group pattern is used rather than a blue-hatched polygon. A blue icon with a fish silhouette is used to indicate the presence of fish. This icon is associated with all polygons or arcs containing fish.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column contains the species common name. The second column indicates whether the species is listed as threatened (T), endangered (E), or special concern (C) 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 values were not used for fish because concentration is often quite variable from year to year or not well known.

Seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species or resource is present at a location in a particular month, an

"X" is placed in the month column. The last columns denote different life-history time-periods for fish, including spawning, eggs, larvae, juveniles, and adults.

INVERTEBRATES

Invertebrates depicted in this atlas include red and blue king crabs and snow crabs, which are marine species of commercial interest. Crab distributions are based on information gathered from NMFS Essential Fish Habitat data and expert opinion. Concentration areas for multiple life history stages (spawning, eggs, larvae, juveniles, and adults) were mapped. Several species of mollusks and crabs that are harvested for subsistence use were mapped in Norton Sound. Expert contacts for invertebrates are: Charlie Lean (NPS, Nome), 907/443-6119, and Matt Eagleton (NMFS, Anchorage), 907/271-6354.

Invertebrates are shown on the maps as polygons with an orange-hatched pattern. An orange icon with a crab or bivalve silhouette is used to indicate the presence of these species. This icon is associated with all polygons or point features containing invertebrates.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column contains the species common name. The second column indicates whether the species is listed as threatened (T), endangered (E), or special concern (C) 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 values were not used for invertebrates because concentration is often quite variable from year to year or not well known.

The seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species or resource is present at a location in a particular month, an "X" is placed in the month column. The last columns denote different life-history time-periods for invertebrates, including spawning, eggs, larvae, juveniles, and adults.

BENTHIC MARINE HABITATS

The two types of benthic marine habitats mapped for the Western Alaska atlas are eelgrass and kelp. Locations of these resources were based largely on expert opinion. Both eelgrass and kelp are important habitats for Pacific herring spawning.

Expert contacts for eelgrass and kelp are: Charlie Lean (NPS, Nome), 907/443-6119, Brian McCaffery (USFWS, Bethel), 907/543-1014; and Pat Walsh, (USFWS, Dillingham), 907/842-1063.

Eelgrass and kelp are depicted on the maps using two different purple "simplified-wetland" patterns for the different vegetation types. No icons or RAR#s are used for benthic habitats, in order to simplify the maps.

SEA ICE

Shorefast ice (sea ice that forms and remains along the coast where it is attached to the shore) begins to form along the Bering Sea coast in mid-November. The average seasonal fast ice boundary (ice boundary between fast ice and offshore pack ice) ranges from being within a few nautical miles offshore to over 30 nautical miles offshore, depending on the location and time of year. On average, pack ice (any area of sea ice other than fast ice) begins to form in the Bering Sea in November. Average ice breakup in Kuskokwim Bay is early May, in Hooper Bay is late May, and near St. Michael is early June.

Figure 1 (page 5) displays the average "five-tenths ice concentration" boundaries for November, December, January, May, and June. "Five-tenths ice concentration" signifies the ice concentration above which ice breaking vessels are needed for navigation, meaning that approximately 50% of the ocean surface in the area is ice covered. Four- to six-tenths coverage is considered to be "open pack ice". In the figure, the ocean surface on the hatched side of the boundary lines, (i.e., the eastern shores of Nunivak Island and the nearshore areas of the Yukon-Kuskokwim Delta on December 1) has a sea-ice concentration of five-tenths or greater, indicating that ice coverage is greater than 50%, and may be considered to be "close pack ice" (seven- to eight-tenths coverage), or "very close pack ice" (ten-tenths coverage). On the un-hatched sides of the boundary lines (i.e. St. Matthew Island and offshore Bering Sea waters on December 1), the ice concentration is five-tenths or less, indicating less than 50% coverage, and may be considered to be "very open pack ice" (one- to three-tenths coverage). As the winter progresses, the five-tenths ice concentration boundary lines move farther west and south, indicating that the entire area likely has ice coverage of 50% or greater between January and May (excluding leads and polynyas which are described below). On average, by May, Kuskokwim Bay ice is breaking up (the unhatched side of the May 1 boundary line), and by June 1, Norton Sound typically has less than five-tenths ice coverage. Between June and November (the "ice-free season"), the average five-tenths ice concentration boundary line is north of the study area in the Beaufort Sea.

Shorefast ice and pack ice are very important habitats for some marine mammals species. It is important to note that some species present in nearshore waters during the winter (e.g. ringed and bearded seals) are utilizing the shorefast and pack ice habitat, while species present in the same areas during the summer (e.g. salmon, spotted seal) are using open water habitats.

Leads (fractures or passage-ways through sea ice) and polynyas (non-linear shaped openings enclosed in ice) are very important habitats for migratory marine mammals and waterfowl. A recurring polynya is one that occurs in relatively the same position most years. Figure 2 (page 5) shows several recurring polynyas in the Bering Sea. Polynyas typically occur between January and June.

It is important to note that ice conditions can be vary greatly from year to year, and that that information provided in the figures and text are based on multi-year averages and specific studies. For real-time ice conditions, refer to the National Weather Service Alaska region website at www.arh.noaa.gov and select "Ice Desk" under Specialty Items.

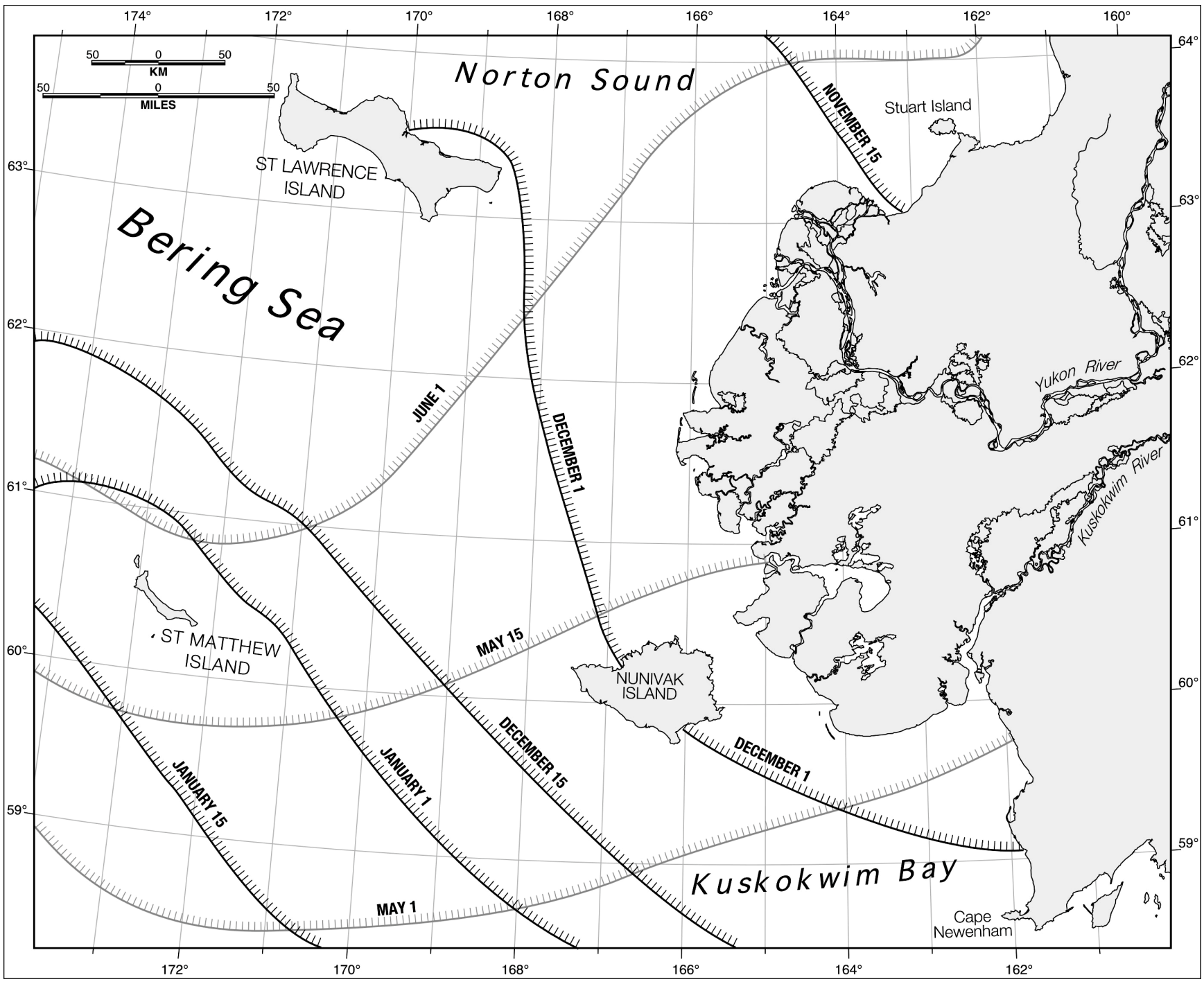
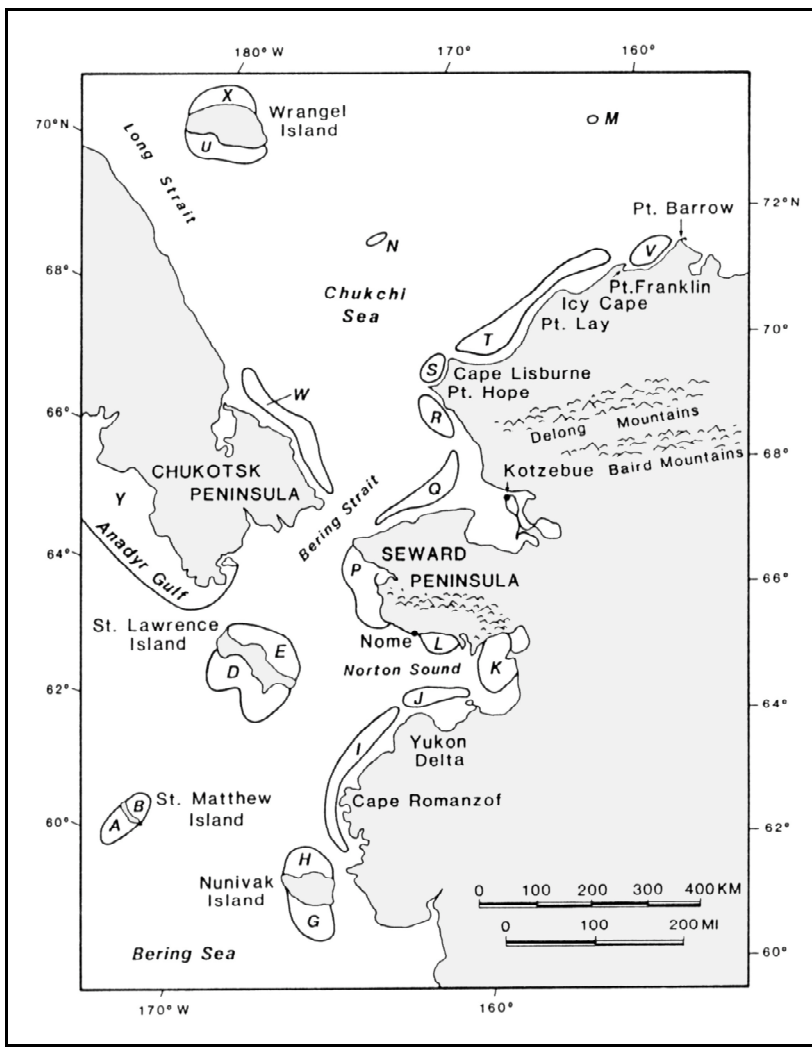


FIGURE 1. Five-tenths ice concentration boundaries for November, December, January, May, and June. Lines represent median position of five-tenths ice concentration boundaries. On average, sea water on the hatched side of a line has five-tenths ice coverage or greater on the date shown, and sea water on the unhatched side of a line has five-tenths ice coverage or less. Figure adapted from LaBelle et al. (1983).



Location of polynyas	Coded designation of Alaska base map
St. Matthew Island Polynya, South	A
St. Matthew Island Polynya, North	B
St. Lawrence Island Polynya, South	D
St. Lawrence Island Polynya, North	E
Nunivak Island Polynya, South	G
Nunivak Island Polynya, North	H
Cape Romanzof Polynya	I
Yukon Delta Polynya	J
Norton Sound Polynya	K
Nome Polynya	L
Hanna's Shoal Polynya	M
Herald Shoal Polynya	N
Seward Peninsula Polynya	P
Kotzebue Sound Polynya	Q
Cape Thompson–Pt. Hope Polynya	R
Cape Lisburne Polynya	S
Chukchi Polynya	T
Peard Bay Polynya	V
Chukotsk Peninsula Polynya	W
Wrangel Island Polynya, South	U
Wrangel Island Polynya, North	X
Sireniki Polynya	Y

FIGURE 2. Polynyas (non-linear shaped openings enclosed in ice) of the Bering and Chukchi Seas. The adjacent table identifies letter codes. Figure adapted from Stringer and Groves (1991). These areas are important migratory and wintering areas for marine mammals and waterfowl.

HUMAN-USE RESOURCES

Most human-use resources in this atlas are mapped as point features, indicated by a black and white icon (see legend). Management areas such as wildlife refuges, national parks, wilderness areas, and designated critical habitats are mapped as polygons, with the boundaries indicated as a black dot-dash line with the corresponding icon placed near the center of the polygon. Where the feature is a known point location (e.g. airport), the exact location is shown as a small black dot and a leader line is drawn from it to the icon.

Airport: Locations of airports, airfields, landing strips, helipads etc., whether they are manned or unmanned, are shown as point features. Information on the locations of these features was gathered from a 1995 ADNR digital database.

Designated Critical Habitat: These are areas managed or regulated by the USFWS as critical habitat for federally listed threatened and endangered species, under authority of the U.S. Endangered Species Act as amended. Designated Critical Habitat for spectacled and Steller's eiders (federally threatened, state species of special concern) are depicted in this atlas. Designated Critical Habitat for spectacled eider occurs in Norton Bay (molting habitat), and in the central and southern portions of the Yukon-Kuskokwim Delta (breeding). Designated Critical Habitat for Steller's eider occurs in the Yukon-Kuskokwim Delta (one of only two known breeding sites), and Kuskokwim Shoals (molting and spring staging). Designated Critical Habitat for Steller sea lion (federally endangered, state species of special concern) is also depicted in this atlas around Hall and St. Matthew Islands. The USFWS Ecological Services Field Office, Anchorage (907/271-2778 or 2781) provided the eider information in digital format. The NOAA NMFS office in Juneau (907/586-7858) provided the Steller sea lion information in digital format.

Mining Sites: Points are used to depict general locations where active beach mining occurs. Information on mining locations was provided by Togiak National Wildlife Refuge staff.

Scenic Rivers: National Wild and Scenic Rivers are depicted using dashed lines to indicate designation boundaries. A 2001 USGS digital coverage was used as the source of Wild and Scenic River designations.

Wildlife Refuges: Areas managed by the USFWS as National Wildlife Refuges and Wilderness Areas are depicted using dashed lines to indicate site boundaries. Site names are provided on the data tables for each map. The 2000 ADNR "Administrative Large Parcel Boundaries" digital coverage was used as the source for wildlife refuge area locations. The USFWS Realty Division provided a digital coverage of the wilderness areas.

Parks: The 2000 ADNR "Administrative Large Parcel Boundaries" digital coverage was used as the source for management area locations. A state park appears in the digital data, but was not located within the geographical boundaries of the hardcopy maps.

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. Format for the data varies depending on the type of information or features for which the data are being stored.

Under separate cover is a metadata document that details the data dictionary, processing techniques, data lineage, and other descriptive information for the digital data sets and maps that were used to create this atlas. Below is a brief synopsis of the information contained in the digital version. Refer to the metadata file for a full explanation of the data and its structure.

SHORELINE CLASSIFICATIONS

The ESI shoreline habitat classification is stored as lines and polygons with associated attributes. In many cases, a shoreline may have two or three different classifications. These multiple classifications are represented on the maps by double and triple line patterns and in the database by ESI#1/ESI#2, where ESI#1 is the landward-most classification and ESI#2 is the seaward-most classification. In addition to the line features, exposed wave-cut platforms (ESI = 2A) and tidal flats (ESI = 7, ESI = 9A) are also stored as polygons.

SENSITIVE BIOLOGICAL RESOURCES

Biological resources are stored as polygons, points, or arcs. Associated with each feature is a unique identification number that is linked to a series of data tables that further identify the resources. The main biological resource table consists of a list of species identification numbers for each site, the concentration of each species at each site, and identification codes for seasonality and source information. This data table is linked to other tables that describe the seasonality and life-history time-periods for each species (at month resolution) for the specified map feature. Other data tables linked to the first table include: the species identification table, that includes common and scientific names; the species status table, that gives information for state and/or federal threatened or endangered listings; and the source database, that provides source metadata at the feature-species level (specific sources are listed for each species occurring at each mapped feature in the biology coverages).

HUMAN-USE FEATURES

Human-use features are represented as lines, points, or polygons. The resource name, the owner/manager, a contact person, and phone number are included in the database for management areas when available. All metadata sources are documented at the feature level.

REFERENCES

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

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The biological and human-use data included on the maps were provided by numerous individuals, agencies, and organizations. U.S. Fish and Wildlife Service (USFWS), Alaska Department of Fish and Game (ADF&G), NOAA National Marine Fisheries Service (NMFS), U.S. Geological Survey (USGS), University of Alaska, and National Park Service (NPS) staff from several divisions and programs contributed a vast amount of information to this effort, including first-hand expertise, publications, reports, maps, and data. Other agencies, organizations, and groups contributing to data development and review included: Alaska Department of Natural Resources (ADNR), Bureau of Land Management (BLM), Alaska Department of Commercial and Economic Development (DCED), Alaska Division of Governmental Coordination (DGC), Alaska Regional Response Team (ARRT), and The Nature Conservancy (TNC). Specific individuals and references used directly as source material for this atlas are detailed in the metadata report that accompanies the digital data set.

At Research Planning, Inc. (RPI) of Columbia, South Carolina , numerous scientific, GIS, and graphics staff were involved with different phases of the project. The biological and human-use data were collected, compiled onto basemaps, and edited by Christine Lord. E. Lee Diveley, Vermell Simon Pyatt, and Katie Born entered, processed, and produced the GIS data and hardcopy atlas under the supervision of Mark White, GIS Director, and Chris Locke. Jeff Dahlin assisted with processing of GIS data. Joe Holmes conducted the graphic art production. Mandie Minton and Wendy Early assisted with final atlas production.

APPROPRIATE USE OF ATLAS AND DATA

This atlas and the associated database were developed to provide summary information on sensitive natural and human-use resources for the purposes of oil and chemical spill planning and response. Although the atlas and database should be very useful for other environmental and natural resource planning purposes, it should not be used in place of data held by the USFWS, NPS, USGS, ADF&G, NMFS, or other agencies. Likewise, information contained in the atlas and database cannot be used in place of consultations with natural and cultural resource agencies, or in place of field surveys. Also, this atlas should not be used for navigation.

SPECIES LIST

Common Name	Species Name
TERRESTIAL MAMMALS	
BEARS	
Brown bear	*Ursus arctos*
MARINE MAMMALS	
DOLPHINS	
Harbor porpoise	*Phocoena phocoena*
PINNIPEDS	
Bearded seal	*Erignathus barbatus*
Harbor seal	*Phoca vitulina*
Ribbon seal	*Histriophoca fasciata*
Ringed seal	*Pusa hispida*
Spotted seal	*Phoca largha*
Steller (Northern) sea lion	*Eumetopias jubatus*
Walrus	*Odobenus rosmarus*
WHALES	
Beluga whale	*Delphinapterus leucas*
Gray whale	*Eschrichtius robustus*
Minke whale	*Balaenoptera acutorostrata*
BIRDS	
DIVING BIRDS	
Cormorant	*Phalacrocorax sp.*
Pacific loon	*Gavia pacifica*
Pelagic cormorant	*Phalacrocorax pelagicus*
Red-faced cormorant	*Phalacrocorax urile*
Red-throated loon	*Gavia stellata*
GULLS/TERNS	
Aleutian tern	*Sterna aleutica*
Arctic tern	*Sterna paradisaea*
Caspian tern	*Sterna caspia*
Glaucous gull	*Larus hyperboreus*
Glaucous-winged gull	*Larus glaucescens*
Ivory gull	*Pagophila eburnea*
Mew gull	*Larus canus*
Sabine's gull	*Xema sabini*
PASSERINE BIRDS	
McKay's bunting	*Plectrophenax hyperboreus*
RAPTORS	
Golden eagle	*Aquila chrysaetos*
Gyrfalcon	*Falco rusticolus*
Merlin	*Falco columbarius*
Northern harrier	*Circus cyaneus*
Peregrine falcon	*Falco peregrinus*
Rough-legged hawk	*Buteo lagopus*
Short-eared owl	*Asio flammeus*
SEABIRDS	
Black guillemot	*Cepphus grille*
Black-legged kittiwake	*Rissa tridactyla*
Common murre	*Uria aalge*
Crested auklet	*Aethia cristatella*
Horned puffin	*Fratercula corniculata*
Least auklet	*Aethia pusilla*
Murre	*Uria sp.*
Northern fulmar	*Fulmarus glacialis*
Parakeet auklet	*Aethia psittacula*
Pigeon guillemot	*Cepphus columba*
Short-tailed shearwater	*Puffinus tenuirostris*
Thick-billed murre	*Uria lomvia*
Tufted puffin	*Fratercula cirrhata*
SHOREBIRDS	
American golden-plover	*Pluvialis dominica*
Bar-tailed godwit	*Limosa lapponica*
Black turnstone	*Arenaria melanocephala*
Black-bellied plover	*Pluvialis squatarola*
Bristle-thighed curlew	*Numenius tahitiensis*
Common snipe	*Gallinago gallinago*
Dunlin	*Calidris alpina*
Hudsonian godwit	*Limosa haemastica*
Least sandpiper	*Calidris minutilla*
Lesser yellowlegs	*Tringa flavipes*
Long-billed dowitcher	*Limnodromus scolopaceus*
Pacific golden-plover	*Pluvialis fulva*
Pectoral sandpiper	*Calidris melanotos*
Red knot	*Calidris canutus*
Red phalarope	*Phalaropus fulicaria*
Red-necked phalarope	*Phalaropus lobatus*
Rock sandpiper	*Calidris ptilocnemis*
Ruddy turnstone	*Arenaria interpres*
Semipalmated sandpiper	*Calidris pusilla*

Common Name	Species Name
BIRDS cont.	
SHOREBIRDS cont.	
Sharp-tailed sandpiper	*Calidris acuminata*
Shorebirds	
Surfbird	*Aphriza virgata*
Western sandpiper	*Calidris mauri*
Whimbrel	*Numenius phaeopus*
WADING BIRDS	
Sandhill crane	*Grus canadensis*
WATERFOWL	
American wigeon	*Anas americana*
Black scoter	*Melanitta nigra*
Brant	*Branta bernicla*
Canada goose	*Branta canadensis*
Common eider	*Somateria mollissima*
Emperor goose	*Chen canagica*
Greater scaup	*Aythya marila*
Greater white-fronted	*Anser albifrons*
Green-winged teal	*Anas crecca*
Harlequin duck	*Histrionicus histrionicus*
King eider	*Somateria spectabilis*
Long-tailed duck	*Clangula hyemalis*
Mallard	*Anas platyrhynchos*
Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Red-breasted merganser	*Mergus serrator*
Scoters	*Melanitta spp.*
Sea ducks	
Spectacled eider	*Somateria fischeri*
Steller's eider	*Polysticta stelleri*
Surf scoter	*Melanitta perspicillata*
Tundra swan	*Cygnus columbianus*
Waterfowl	
White-winged scoter	*Melanitta fusca*
FISH	
Alaska plaice	*Pleuronectes quadrituberculatus*
Arctic char	*Salvelinus alpinus*
Arctic lamprey	*Lampetra camtschatica*
Capelin	*Mallotus villosus*
Chinook salmon	*Oncorhynchus tshawytscha*
Chum salmon (dog)	*Oncorhynchus keta*
Coho salmon (silver)	*Oncorhynchus kisutch*
Dolly varden	*Salvelinus malma*
Pacific cod	*Gadus macrocephalus*
Pacific halibut	*Hippoglossus stenolepis*
Pacific herring	*Clupea pallasi*
Pink salmon (humpy)	*Oncorhynchus gorbuscha*
Rainbow smelt	*Osmerus mordax*
Rainbow trout (steelhead)	*Oncorhynchus mykiss*
Rock sole	*Lepidopsetta bilineata*
Saffron cod	*Eleqinus gracilis*
Sculpin	*Cottidae*
Sheefish	*Stendous leucichthys nelma*
Sockeye salmon (red)	*Oncorhynchus nerka*
Starry flounder	*Platichthys stellatus*
Walleye pollock	*Theragra chalcogramma*
Whitefish	
Yellowfin sole	*Limanda aspera*
INVERTEBRATES	
BIVALVES	
Alaska razor clam	*Siliqua alta*
Butter clam	*Saxidomus giganteus*
Crenulate astarte	*Astarte crenata*
Pinkneck clam	*Spisula polynyma*
Siberia softshell clam	*Mya uzenensis*
Softshell clam	*Mya arenaria*
CRABS	
Blue king crab	*Paralithodes platypus*
Helmet crab	*Telmessus cheiragonus*
Red king crab	*Paralithodes camtschaticus*
Snow crab	*Chionoecetes opilio*
BENTHIC MARINE HABITATS	
Eelgrass	*Zostera marina*
Kelp	

* Threatened and endangered species are designated by underlining.

EXPOSED ROCKY SHORES **ESI = 1A**

DESCRIPTION

- Steep intertidal zone (usually almost vertical), with very little width
- Regularly exposed to high wave energy, with strong wave reflection patterns
- Sediment accumulations are uncommon and usually ephemeral, because waves quickly remove debris slumped from eroding cliffs
- As a result of the high-energy setting, attached organisms are hardy and accustomed to strong hydraulic impacts and pressures
- Impermeable substrate with no potential for subsurface penetration
- Seldom found in combination with another shoreline type, however they are often interspersed along the shore with wave-cut platforms and gravel beaches
- Present mostly on Nunivak Island, rare elsewhere

PREDICTED OIL BEHAVIOR

- Oil is held offshore by waves reflecting off the steep cliffs
- Any oil that is deposited is rapidly removed from exposed faces by wave action
- Most resistant oil remains as a patchy band at or above the high-tide line

- Impacts to intertidal communities are expected to be of a short-term duration, an exception being where heavy concentrations of a light refined product comes ashore very quickly

RESPONSE CONSIDERATIONS

- Cleanup usually not required
- Access can be difficult and dangerous

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

DESCRIPTION

- Intertidal zone with a flat rock bench of highly variable width
- Regular exposure to high wave energy, with strong wave reflection patterns
- Attached organisms are hardy and used to strong hydraulic impacts and pressures
- May be backed by a steep scarp or low bluff
- Perched beach of boulder-sized sediments may be present at base of the scarp
- Substrate is impermeable with no potential for subsurface penetration over much of intertidal zone, except in the ephemeral beach sediments
- Surface is irregular and tidal pools may be present
- Small accumulations of gravel can be found in the tidal pools and crevices in the platform
- May support large populations of encrusting animals and plants, with rich tidal pool communities
- Common on Nunivak Island; also occurs on Nelson Island, Stuart Island, and St. Michael Island

PREDICTED OIL BEHAVIOR

- Oil will not adhere to the rock platform, but rather be transported across the platform and accumulate along the high-tide line, where it can penetrate in beach sediments, if present
- Persistence of oiled sediments is usually short-term, except in wave shadows or larger sediment accumulations at the landward edge of the platform, where oil can persist for up to several weeks to months

- Biological impacts can be immediate and severe, particularly if fresh oil slicks cover tidal pool communities

RESPONSE CONSIDERATIONS

- Cleanup is usually not required, because oil is quickly removed by wave action
- Access may be difficult and dangerous
- Where the high-tide area is accessible, it may be feasible to remove heavy oil accumulations and oiled debris in areas of high recreational use or in order to protect a nearshore marine resource, such as marine birds

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

DESCRIPTION

- Generally flat, wide, and hard-packed
- Surface sediments subject to regular reworking by waves
- Beach fauna vary in type and density but are generally low
- Can be important areas for migrating shorebirds
- Extensive beaches of this type are common from Scammon Bay south to Hooper Bay and on Nunivak Island; Kikegtek and Pingurbek Islands are fronted by extensive sand beaches

PREDICTED OIL BEHAVIOR

- Light oil accumulations deposited as oily swashes or bands along the upper intertidal zone
- Heavy oil accumulations cover entire beach surface; the oil will be lifted off the lower beach with the rising tide
- Maximum penetration of oil is about 10 cm into fine-grained sand and 15 cm into medium-grained sand
- Burial of oiled layers by clean sand can occur within hours on these beaches depending on the beach cycle, but the maximum burial will typically occur along the upper beach face to depths less than 30 cm
- Organisms living in the beach may be killed by smothering or lethal oil concentrations in interstitial water

RESPONSE CONSIDERATIONS

- The easiest beach type to clean, because hard substrate can support vehicular and foot traffic and depths of oil burial and penetration are minimal

- After all oil has come ashore, cleanup activities should concentrate at first on the removal of oil from the upper swash zone
- Vehicular traffic and walking through oiled areas and dunes should be limited, to prevent contamination of clean areas and disturbance of dune vegetation
- Manual cleanup, rather than road graders and front-end loaders, is advised where feasible to minimize the volume of sand removed from the shore
- Prevent the mixture of oil deeper into the sediments by vehicular and foot traffic

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COARSE-GRAINED SAND BEACHES ESI = 4

DESCRIPTION

- Moderate to steep beachface slopes, typically between 5 and 15 degrees in slope
- Sediments are soft, with low trafficability
- Substrate is highly permeable
- The rate of sediment mobility is relatively high, with the vertical accumulation of up to 20 cm of sediments possible within a single tidal cycle
- Beach fauna can vary in type and density; mobile surface, burrowing, and interstitial forms are typical
- Uncommon in Western Alaska; coarse-grained sand beaches occur only on Stuart Island and St Michael Island

PREDICTED OIL BEHAVIOR

- During small spills, oil is deposited primarily as a band along the high-tide line
- Under very heavy accumulations, oil may spread across the entire intertidal zone, though it will be lifted off the lower part of the beach during the rising tide
- Penetration up to 25 cm possible
- Burial of oiled layers by clean sand can be rapid, to depths of 1 m or more if the oil comes ashore at the start of a depositional period
- Organisms living in the beach may be killed by smothering or lethal oil concentrations in interstitial water

RESPONSE CONSIDERATIONS

- Cleanup more difficult than for finer-grained beaches, because equipment tends to grind oil into the substrate due to the loosely packed and permeable nature of these coarser-grained sediments; therefore, special care must be exercised at all times while using heavy equipment in order to prevent mixing oil deeper into the beach sediment

- Use of heavy equipment for oil/sand removal may also result in the export of excessive amounts of sand; therefore, where feasible and for smaller amounts of oil, manual cleanup may be desirable
- Vehicular traffic and walking through oiled areas and dunes should be limited, to prevent contamination of clean areas and disturbance of dune vegetation
- Removal of sediment should be limited as much as possible to avoid erosion problems on the beach in the future; however, the common occurrence of multiple buried oil layers in these types of beaches increases the amount of sediment to be handled and disposed of
- Mechanical reworking of the sand into the surf zone (surf washing) may be used under optimal conditions to release the oil without sediment removal

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MIXED SAND AND GRAVEL BEACHES — ESI = 5

DESCRIPTION

- Moderately sloping beach (8-15 degrees) composed of a mixture of sand and at least 20 percent gravel
- Soft sediments with low trafficability
- Sediment mobility is very high during storms, but considerably less than sand beaches during normal conditions
- Spatial variations in the distribution of grain sizes may be significant, with separate zones of pure sand, pebbles, or cobbles, in addition to the mixed zones
- Substrate has medium-to-high permeability
- Beach fauna can vary in type and density but generally have low densities
- Common in Western Alaska both as extensive beaches, sometimes fronting marshes along the outer Yukon Delta, and shorter pocket beaches between rocky headlands such as on Ninivak Island and Nelson Island

PREDICTED OIL BEHAVIOR

- During small spills, oil will be deposited along the high-tide swash line
- During large spills, oil will be spread across the entire intertidal area
- Oil penetration into the beach sediments may be up to 50 cm; however, the sand fraction can be quite mobile, and if the sand fraction exceeds about 40 percent, oil behavior is similar to that described for sand beaches
- Significant amounts of oil can be eroded away during storms
- Burial of oil may be deep (up to 1 m) if oil comes ashore while the beach is recovering from storm conditions
- In sheltered pockets on the beach, such as in the lee of large boulders, pavements of asphalted sediments can form if there is no removal of heavy oil accumulations, and, once formed, these pavements can persist for many years
- Organisms living in the beach may be killed by smothering or lethal oil concentrations in interstitial water

RESPONSE CONSIDERATIONS

- Remove heavy accumulations of pooled oil as quickly as possible
- All oiled debris should be removed
- Vehicular traffic and walking through oiled areas should be limited, to prevent contamination of clean areas
- Sediment removal should be limited as much as possible, because of potential beach erosion problems in the future
- Low-pressure flushing can be used to remove heavy oil where collection of the flushed oil is feasible, but high-pressure flushing 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 the high-tide zone to the upper intertidal zone for wave reworking (berm relocation) can be effective in areas subject to significant wave action
- In-place tilling may be used to expose deeply buried oil layers to wave reworking in areas subject to significant wave action

GRAVEL BEACHES — ESI = 6A

DESCRIPTION

- Composed of sediments larger than 2 mm (granules, pebbles, cobbles and boulders)
- Most permeable of all beach sediment types
- Lowest trafficability of all beach types
- Rapid erosion and/or burial of shallow oil possible during storms
- Slope is intermediate to steep (between 10-20 degrees), with multiple, wave-built berms usually forming the upper beach
- Sediment replenishment rates are the lowest of all beach types
- Attached animals and plants are usually restricted to the lowest parts of the beach, where the sediments are less mobile
- Common only where rocky headlands provide a source of coarse sediments eroding from the cliffs, such as on Nunivak Island, Nelson Island, Cape Romanzof, Stuart Island, and St. Michael Island

PREDICTED OIL BEHAVIOR

- Deep penetration and rapid burial of stranded oil is likely; penetration of tens of cm (over 1 m possible) can extend oil to depths below where it cannot be reworked by any natural process except extreme storms
- Therefore, long-term persistence will be controlled by the depth of penetration versus the depth of routine reworking by storm waves
- Oil may be carried over the normal high-tide line and storm berms during high-water events, where it can pool and persist above the normal zone of wave wash
- In the more sheltered areas, formation of asphalt pavements is likely if oil accumulations are heavy

RESPONSE CONSIDERATIONS

- Because of the low trafficability, and the rapid rates of burial and deep penetration of the oil, this is the most difficult of all the beach types to clean
- Heavy accumulations of pooled oil should be removed quickly
- All oiled debris should be removed
- Because of the slow sediment replenishment rates of these beaches, sediment removal should be limited as much as possible
- Flushing with ambient water can be used to remove some of the oil from the sediments, provided adequate oil recovery is possible
- Mechanical reworking of oiled sediments from the high-tide line to the upper intertidal zone (berm relocation) can be effective in areas regularly exposed to wave activity (as evidenced by storm berms)
- In-place tilling may be used to expose deeply buried oil layers to wave reworking on beaches with high wave activity

EXPOSED TIDAL FLATS — ESI = 7

DESCRIPTION

- Flat (less than three degrees) intertidal areas, composed of mostly sand but some mud, that vary in width from a few meters to hundreds of meters
- The presence of sand indicates that tidal or wind-driven currents and waves are strong enough to mobilize the sediments
- Usually associated with another shoreline type on the landward side of the flat or as isolated flats in the middle of channels
- Sediments usually remain water-saturated, with only the topographically higher ridges drying out during low tide
- Sediments are generally too soft for vehicular traffic
- Biological utilization can be very high, with large numbers of infauna, and heavy use by birds for roosting and foraging
- Common throughout the outer coast along the Yukon-Kuskokwim Delta and associated with the mouths of streams on the islands

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 typically penetrate these water-saturated sediments, except on the top of sand bars and into animal burrows if they dry out at low tide; thus, oil penetration is limited to a maximum of a few cm
- Because of the high biological use, impacts can be significant to benthic invertebrates that are smothered or exposed to the water-accommodated fraction of the oil

RESPONSE CONSIDERATIONS

- In most cases, the best response is to let the oil, which is primarily on the surface of the flat, be removed naturally
- Natural removal can be fast in this habitat during open-water months, because of its exposure to waves and tidal currents
- Cleanup is very difficult, because of the potential for mixing the oil deeper into the sediments
- Use of heavy machinery should be restricted in order to prevent contamination of the subsurface sediments, with manual removal being preferred; however, heavy foot traffic can also result in oiling of the deeper sediments

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SHELTERED ROCKY SHORES — ESI = 8A

DESCRIPTION

- These shorelines consist of bedrock shores of variable slope (from vertical cliffs to wide, rocky ledges) that are sheltered from exposure to most wave and tidal energy
- The rock surface can be covered with loose sediment and debris
- Attached biota may be plentiful and varied, especially in lower and mid-intertidal zones
- They are uncommon, occurring along bays and estuaries on Nunivak Island

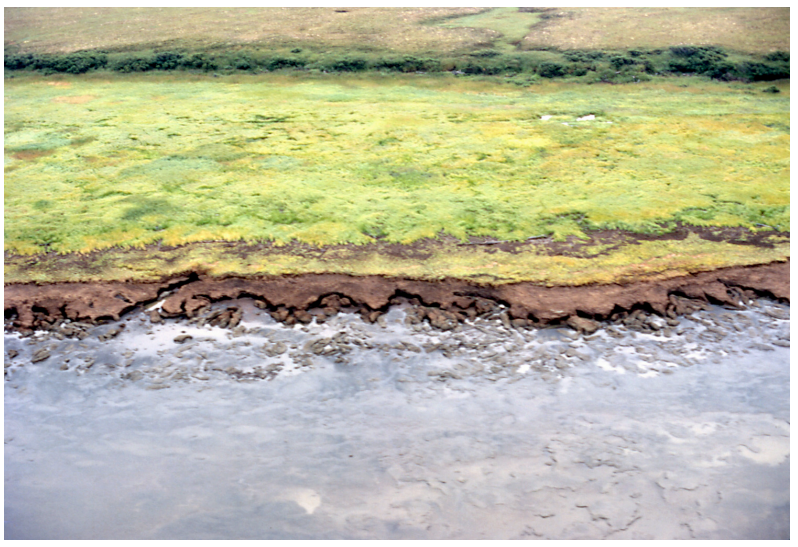
PREDICTED OIL BEHAVIOR

- Oil will adhere readily to the rough rocky surface, particularly along the high-tide line, forming a distinct oil band
- Oil can remain for a long time (months to years) because of the low energy setting
- Where surface sediments are abundant, oil will penetrate into the crevices formed by the surface rubble and pool at the contact of the sediments and the rock surface
- Where the rubble is loosely packed, oil will penetrate deeply, causing long-term contamination of the subsurface sediments
- Impacts to attached organisms can be severe
- Asphalt pavements can form in the cracks and cervices

RESPONSE CONSIDERATIONS

- Cleanup is often required because natural removal rates are slow
- Water flushing at ambient water temperatures is most effective when the oil is fresh
- All pooled oil and oiled debris should be removed as soon as possible
- Weathered asphalt pavements can be removed manually

PEAT SHORELINES — ESI = 8E



DESCRIPTION

- This shoreline type includes exposed peat scarps along the front of the Yukon-Kuskokwim Delta
- They are characterized by a 1-2 meter high wave-cut scarp and blocks of eroded peat of various sizes in front of the scarp
- The intertidal zone is often very complex, with slumped peat blocks, fine- to medium-grained sands, and peat slurries intermixed
- The intertidal zone of the this shoreline type is not particularly important as a biological habitat, although birds do use these areas during migration
- Peat scarps are common along the front of the Yukon-Kuskokwim Delta and away from areas of active sediment deposition

PREDICTED OIL BEHAVIOR

- Oil penetration and persistence are expected to be very low in frozen peat scarps
- Light oil can penetrate the peat surface, especially when dry, resulting in persistent sheens
- Heavy oil does not penetrate peat, even when the peat is dry
- Peat slurries react to oil like loose granular sorbent and will partially contain and prevent the oil from spreading

RESPONSE CONSIDERATIONS

- The peat substrate is soft, thus cleanup will be difficult; trampling is less of concern where peat is frozen or work is conducted from boats
- Peat slurry may be used as a natural sorbent; sorption will be most effective on liquid and fresh oils
- On these eroding peat scarps, stranded oil will have a low residence time due to the natural erosion rates
- Substrate disruption is of limited concern so long as adjacent wetlands are not disturbed
- Hot-water washing or even low pressure flushing are not appropriate because large quantities of peat could be eroded from the treatment area

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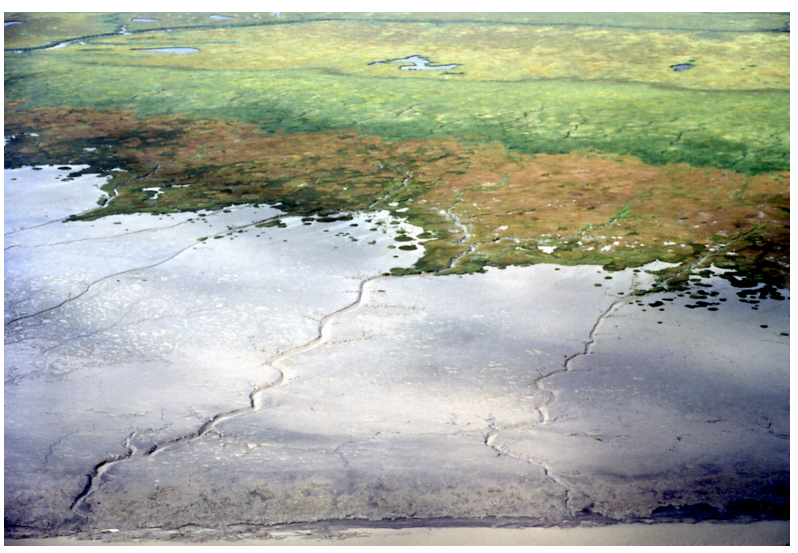
SHELTERED TIDAL FLATS — ESI = 9A



DESCRIPTION

- Sheltered tidal flats are composed primarily of mud with minor amounts of sand and shell
- They are present in calm-water habitats, sheltered from major wave activity
- They are most commonly backed by salt marshes and peat scarps
- The sediments are very soft and cannot support even light foot traffic in many areas
- There can be large concentrations of invertebrates on and in the sediments
- They are common throughout the Yukon-Kuskokwim Delta and tidal channels, as well as with streams entering into sheltered bays, such as on Nunivak Island

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

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
- Care should be taken to limit foot traffic during any cleanup operations, to avoid mixing oil into the sediments
- Low-pressure flushing and deployment of sorbents from shallow-draft boats may be helpful

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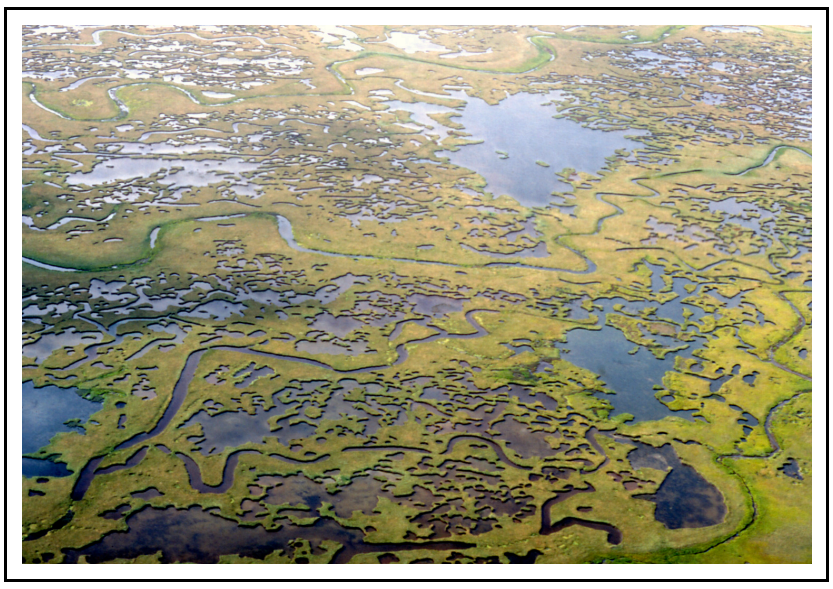
SALT- AND BRACKISH-WATER MARSHES ESI = 10A



DESCRIPTION

- Intertidal wetlands consisting of emergent, herbaceous vegetation
- Marshes as mapped in Western Alaska vary in extent from extensive areas to narrow fringes
- They occur as narrow fringing marshes along tidal creeks and fronting tidal flats; small pocket marshes in embayments; and broad salt-marsh areas in large protected areas.
- Sediments in the substrate range from fine sands to silts and organically rich muds
- Salt marshes along the outer exposed coast along the entire Yukon-Kuskokwim Delta and in embayments on Nunivak Island

PREDICTED OIL BEHAVIOR

- Oil adheres readily to intertidal vegetation
- Oil coating typically takes the form of a band of varying width. The placement of the oil band depends on water level at the time of spilled oil's impact. Multiple bands possible
- Large slicks will persist through multiple tidal cycles and coat vegetation from high tide line to the base of the stem
- If the vegetation is thick, the heaviest oil coating will be restricted to the outer fringe of the marsh. However, the lighter the oil, the further into the marsh it may penetrate
- Medium to heavy oils do not readily adhere to or penetrate the fine sediments, but can pool in surface depressions or collect in burrows
- Light oils can penetrate the top few centimeters of sediment and deeply into burrows and cracks (up to one meter)

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is to allow the area time to recover naturally
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. During flushing care must be taken to prevent transporting oil to sensitive areas down slope or along shore
- Extent of oiling, natural removal processes and rates should be evaluated prior to conducting cleanup
- Cleanup crews and activities must be carefully monitored to avoid unnecessary 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 (such as birds) are at great risk from leaving the oiled vegetation in place