ENVIRONMENTAL SENSITIVITY INDEX: NORTHWEST ARCTIC, ALASKA

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for marine and coastal areas of the Northwest Arctic, Alaska. 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. The name and date on the bottom right of each map page refer to the corresponding USGS quadrangle and its publication or latest photorevision date.

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 Norton Sound was originally mapped during overflights in June and July 1980. North of Cape of Prince of Wales the shoreline types were classified during overflights in July 2001 using fixed-wing aircraft operated by the U.S. Civil Air Patrol, flying at altitudes of 400-600 feet and slow air speeds. During this work, the shoreline depicted on current 1:63,360-scale USGS topographic maps was annotated with the ESI ranking of observed intertidal shoreline habitats. Where appropriate, revisions to the existing shoreline depictions were made and where necessary, multiple habitats were described for each shoreline segment. Coastal wetlands, while extensive in the region, were not mapped as polygonal features. The shoreline of St. Lawrence Island was not 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 the Northwest Arctic ordered by increasing sensitivity to spilled oil.

1A) Exposed Rocky Shores
1B) Exposed, Solid Man-made Structures
2A) Exposed Wave-cut Platforms in Bedrock, Mud, or Clay
2B) Exposed Scarps and Steep Slopes in Clay
3A) Fine- to Medium-grained Sand Beaches
3B) Scarps and Steep Slopes in Sand
3C) Tundra Cliffs
4) Coarse-grained Sand Beaches
5) Mixed Sand and Gravel Beaches
6A) Gravel Beaches
6B) Riprap
7) Exposed Tidal Flats
8A) Sheltered Rocky Shores and Sheltered Scarps in Mud and Clay
8B) Sheltered, Solid Man-made Structures
8C) Sheltered Riprap
8E) Peat Shorelines
9A) Sheltered Tidal Flats
9B) Sheltered, Vegetated Low Banks
10A) Salt- and Brackish-water Marsh
10D) Scrub-Shrub Wetlands
10E) Inundated Low-Lying Tundra

Each of the shoreline habitats are described on pages 9-17, 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), National Park Service (NPS), Northwest Arctic Borough, Alaska Department of Fish and Game (ADF&G), Bering Straits Coastal Resource Service Area, Sitnasuak Native Corporation, U.S. Geological Survey (USGS), Norton Sound Economic Development Corporation, Maniilaq Association, local residents, and other agencies, organizations, and groups (see the acknowledgments). 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 or habitats 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. The groups are color coded, and different icons represent the subgroups:

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

TERRESTRIAL MAMMALS
- Muskox

MARINE MAMMALS
- Pinnipeds
- Polar Bears
- 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 or 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 Norton Sound" or "Present in Selawik Lake"). 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

Muskox concentration areas were mapped for the Northwest Arctic, Alaska atlas. Muskox occur on the western Seward Peninsula, near Cape Thompson along the Chukchi Sea coast, and in the Mulgrave Hills area southeast of Kivalina. Riparian vegetation serves as major feeding habitat. Snow-free habitats are preferred during the winter, such as ridges, bluffs, and slopes. The calving period is late April to mid June. Locations of muskox were based on expert opinion.

Expert contacts for muskox are LeeAnne Arges (USFWS, Kotzebue), 907/442-3799; and Jim Dau (ADF&G, Kotzebue), 907/442-3420.

Terrestrial mammal areas are displayed on the maps as polygons with a brown-hatched pattern. A brown icon with a terrestrial mammal silhouette is used to indicate the presence of

terrestrial mammals and is associated with all polygons containing these resources.

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 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 have not been used for terrestrial mammals.

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 Northwest Arctic, Alaska atlas include: beluga, blue (state and federally endangered), bowhead (federally endangered), fin (federally endangered), gray, killer, minke, and northern right (state and federally endangered) whales; spotted, ringed, and bearded seals; stellar sea lions (federally endangered); walruses; and polar bears. Nearshore concentration areas, most environmentally sensitive areas (MESAs), haul-out sites (seals, sea lions, walruses), denning areas (polar bears), and migration routes were specifically indicated on the maps. Stellar sealion haul-out sites are depicted on the maps as points and polygons. Polar bear denning sites were depicted as points. All other 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, USFWS, and Northwest Arctic Native Association (NANA); and published reports and books. We did not attempt to show the complete distribution of any of these species, as they occur throughout a much larger range than the areas depicted. Also, ribbon seals and harbor porpoises were not mapped, but may be present in the area. Ribbon seals may be near the Bering Sea ice front in the spring and early summer, and offshore in ice-free waters in late summer and fall. A few may summer in the Chukchi Sea. Harbor porpoises may be present throughout the area in coastal waters during the summer.

The species that were mapped are described below.

Stellar sea lion (federally endangered) – Stellar sea lions use secluded rocky islands for haulouts and rookeries and may be present in the Northwest Arctic on St. Lawrence Island, the Punuk Islands, Fairway Rock, and the Diomede Islands from June to November. Females give birth to one pup per year in June or July, and molting takes place from July to November.

Ringed seal – Nonbreeding ringed seals are associated with moving pack ice, while breeders use the stable shorefast ice for pupping and breeding, and are therefore concentrated nearshore from October to June. Pups are born from March to May, 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 March to July. Most ringed seals occur along the edge of the permanent ice pack during the summer.

Spotted seal – This species is present in the Chukchi and Bering seas between July and December, and around St. Lawrence Island from April to December. Major population segments migrate through outer Norton Sound from April to June and from November to early January. Spotted seals haul out on ice floes in late fall and early winter, and on sandy beaches, spits, rocky points, and capes during the summer and early fall. There are no documented pupping activities in the study area.

Bearded seal – This species is typically associated with the moving pack ice-edge, as well as in association with leads, flaws, and polynyas. Many bearded seals migrate through the Bering Strait in the spring and are found along the Chukchi Sea ice edge in the summer. Bearded seals occur in Kotzebue and Norton Sounds between October and July, and immediately north of St. Lawrence Island during the winter months. Pupping occurs between March and May.

Beluga whale – Beluga whales bound for the Beaufort Sea migrate past St. Lawrence through leads in the Bering Strait during the spring, and may return to their wintering grounds in the Bering Sea, southeastern Chukchi Sea, and occasionally Norton Sound during the fall. In late spring, summer, and fall, belugas are often found nearshore along the Seward Peninsula and Chukchi Seas coasts, and in Kotzebue and Norton Sounds where coastal feeding and calving concentrations occur.

Bowhead whale – Bowhead whales have a similar migration pattern to beluga whales, migrating north through the Bering Strait and along the Chukchi Sea coast in the spring, and south during the fall. This species winters along the Bering Sea pack ice edge.

Other whales – Gray whales may be feeding near St. Lawrence Island and in the Bering Strait, Norton Sound, and Chukchi Sea during the ice-free spring, summer, and fall months. Killer, fin, minke, northern right, and blue whales may be present around St. Lawrence Island during the spring through fall open water period. Killer and fin whales are also occasionally seen along the Chukchi Sea coast from June to October.

Polar bears – Polar bears are faithful to a den habitat type, but not to a specific location. Den locations shown on the maps indicate historic locations of polar bear dens. The exact location of the dens cannot be predicted, since the dens are built in areas where sufficient snow accumulates. This varies by season, but usually occurs along coastal or river bluffs, or pressure ridges on ice. Only pregnant females den, starting in the late fall (October-November) and emerging in the spring (March-May). Polar bear feeding areas occur along the shoreline, barrier islands, and in areas of open water such as leads and polynyas.

Walruses – Walruses haul out on secluded shores and islands during the ice-free months, which is when they may be present in Norton Sound. They are present in the St. Lawrence Island polynya during winter and spring months. They use moving pack ice for resting, pupping, and molting, but are not likely to pup in the study area.

Expert contacts for marine mammals are Lloyd Lowry and Kathy Frost (retired ADF&G, Fairbanks), 907/455-6885, and Lori Quakenbush (ADF&G, Fairbanks), 907/459-7214; for sea lions is John Sease (NMFS, Seattle), 206/526-4024; for walruses is Joel Garlich-Miller (USFWS, Anchorage), 907/786-3820; and for polar bears is Susi Kalxdorff (USFWS, Anchorage), 907/786-3828. Expert contacts for subsistence resources (marine mammals, birds, fish, and invertebrates) are Susan Georgette (ADF&G, Kotzebue), 907/442-3420; Noah Naylor (Northwest Arctic Borough, Kotzebue), 907/442-2500; and Chuck Degan (Bering Straits Coastal Resources and Service Area, Unalakleet), 907/624-3062.

Marine mammal areas are displayed on the maps as polygons with a brown-hatched pattern, or as points for some Stellar sea lion haul-out sites. A brown icon with a whale, pinniped, or polar bear silhouette is used to indicate the presence of marine mammals and is associated with all polygons and points containing these resources.

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 usually represented using a descriptive term, such as "very high" or "high". Descriptive concentrations are based on the opinion of local resource managers or from published reports concerning relative concentrations within the study area. 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, peregrine falcon nesting sites, waterfowl, wading bird, and loon nesting areas and migration routes, waterfowl spring and fall staging, wintering, 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 may be rafting and feeding in large concentrations in offshore waters. Information on nesting colony size is included in tables on the reverse side of the maps. This information was derived from a frequently updated USFWS database.

Peregrine falcon nesting sites – Locations are shown where peregrine falcons have been documented as nesting in coastal areas. The nesting information is from 1991 ADF&G surveys and USFWS endangered/threatened species data that were compiled from various surveys. The nesting season is from April through September.

Waterbird nesting areas and migration routes – Locations of documented nesting areas for loons, waterfowl, and cranes in coastal areas. This information is based on various breeding population surveys and published observations. The nesting season varies by species, but is generally from June through September. Large numbers of sea ducks and loons migrate through the Bering Strait during the spring and fall, and therefore they may be present along the Seward Peninsula, Chukchi Sea, Norton Sound, and St. Lawrence Island coasts. This migration route is mapped as a large general polygon throughout most of the study area.

Migratory waterfowl spring-fall concentration areas – Coastal areas where migratory waterfowl (e.g. dabbling ducks, diving ducks, geese, sea ducks, etc.) concentrate. Information on waterfowl concentrations in coastal waters along the Selawik National Wildlife Refuge are based on 2001 USFWS survey data. Waterfowl may be rafting in these areas between June and October. Other spring-fall waterfowl concentration areas were based on information provided by resource experts and published sources.

Sea duck molting and wintering areas – Wintering and molting concentration areas are shown for spectacled eider (federally threatened), king eider, and long-tailed duck. Geographic and concentration information were based on 1993-1997 USGS and USFWS aerial survey data. Wintering occurs between October and April, and molting occurs between August and October. Waterfowl are particularly vulnerable to the effects of spilled oil during the molting period. The world's largest concentration of wintering spectacled eiders (~ 363,000 birds) occurs along the southern shore of St. Lawrence Island. King eider and long-tailed duck concentration areas also occur around St. Lawrence Island. An important spectacled eider molting area (~ 4,000 birds) occurs in Norton Sound.

Migratory shorebird stopover points and nesting areas – Areas where large concentrations of shorebirds occur annually during the spring, summer, and/or autumn months were mapped. A shorebird species is often listed twice under the same RAR# in the same polygon due to the fact that large concentration differences may occur during different months in the same geographic area. Information on the locations of these areas and concentrations of particular species were based on information provided by USGS personnel who compiled survey data from various sources over many years.

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, Chris Dau (USFWS, Anchorage), 907/786-3908, and Tina Moran (USFWS, Kotzebue), 907/442-3799 ext. 24; for loons, Joel Schmutz (USGS, Anchorage), 907/786-3518; for endangered/threatened species, Charla Sterne (USFWS, Anchorage), 907/271-2781; for peregrine falcons, John Wright (ADF&G, Fairbanks), 907/459-7292, and Ted Swem (USFWS, Fairbanks), 907/456-0441. Expert contacts for subsistence resources (birds, marine mammals, fish, and invertebrates) are Susan Georgette (ADF&G, Kotzebue), 907/442-3420; Noah Naylor (Northwest Arctic Borough, Kotzebue), 907/442-2500; and Chuck Degan (Bering Straits Coastal Resources and Service Area, Unalakleet), 907/624-3062.

In some cases, general terms referring to species assemblages, such as "waterfowl", "diving ducks", or "dabbling ducks" were included along with common names of individual species or in place of individual species names because the exact composition of the assemblages varies or is not known. Table 2 provides a list of species that may be included in the assemblages that were mapped.

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.

In cases where multiple resource types occupy the same polygon (such as birds and fish), a black-hatched, multi-group pattern is used rather than a green-hatched polygon. A green icon

TABLE 2. Bird species potentially present in coastal areas in the Northwest Arctic.

Assemblage	Species Examples
Diving ducks	Canvasback, scaup, long-tailed duck, scoters, bufflehead, goldeneyes, mergansers, etc.
Dabbling ducks	Green-winged teal, mallard, northern pintail, American wigeon, northern shoveler, etc.
Seabirds	Cormorants, gulls, terns, kittiwakes, dovekies, murres, guillemots, auklets, puffins, etc.
Shorebirds	Plovers, curlews, godwits, sandpipers, tattlers, phalaropes, turnstones, yellowlegs, whimbrels, dowitchers, snipe, etc.
Geese	Greater white-fronted goose, Canada goose, snow goose, emperor goose.
Waterfowl	Wigeons, shovelers, scaup, mergansers, teals, buffleheads, etc.
Loons	Red-throated loon, arctic/Pacific loon, common loon, yellow-billed loon.

pattern is used rather than a green-hatched polygon. A green icon (or icons) with the appropriate subgroup silhouette(s) is used to indicate the presence of different bird types (seabirds, waterfowl, raptors, etc.). The appropriate icons are associated with all polygons containing birds.

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 may be represented as the number of birds or nests, or as a descriptive term, such as "high", "very high", or "unknown". 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 pre-nesting, nesting, and post-nesting 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 and wintering area – Intertidal and subtidal areas used by herring and capelin for spawning, and sheltered inlets used by herring for wintering were mapped. Geographic information was provided by NPS and ADF&G resource experts and published ADF&G coastal habitat maps. Adult herring are present in spawning areas from April to September, and spawning occurs in May and June. Wintering occurs from November through April. Adult herring form large spawning groups and deposit their eggs onto eelgrass, kelp, and other suitable substrate in nearshore areas. Capelin are present in spawning areas during the summer months, and spawning occurs during June full moons on gravel beaches. 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 provide an important item in the diet of marine fishes, mammals, and birds, and 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, arctic char, Dolly Varden, sheefish, and whitefish are present in Northwest Arctic, 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 June 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.

Whitefish, sheefish, and northern pike – Estuarine concentration areas (e.g. lagoons, river deltas) were mapped for these species. Geographic information was gathered from NPS and ADF&G resource experts and published coastal resource atlases.

Marine/estuarine fish – Some fishing grounds for Pacific halibut in coastal areas were mapped. Information on Pacific halibut was provided by the Norton Sound Economic Development Corporation and by ADF&G maps of groundfish distribution. General distributions of saffron cod, rainbow smelt, and starry flounder were mapped in nearshore waters. Cod and smelt were also mapped in coastal lagoons where they tend to concentrate as the lagoons are freezing up in the fall. Starry flounder may be quite numerous and caught along the beaches. All of these species are important subsistence species. Representatives from several native corporations and resource experts from NPS provided information on the geographic distribution and seasonal presences of these species.

Expert contacts for finfish are: Charlie Lean (NPS, Nome), 907/443-6119; Wes Jones (ADF&G, Nome), 907/443-5167; Ed Weiss (ADF&G, Anchorage), 907/267-2305; Fred DeCicco (ADF&G, Fairbanks), 907/459-7270; and Jack Winters (ADF&G, Fairbanks), 907/459-7285. Expert contacts for subsistence resources (fish, marine mammals, birds, and invertebrates) are Susan Georgette (ADF&G, Kotzebue), 907/442-3420; Noah Naylor (Northwest Arctic Borough, Kotzebue), 907/442-2500; and Chuck Degan (Bering Straits Coastal Resources and Service Area, Unalakleet), 907/624-3062.

Fish are shown on the maps as polygons with a blue-hatched pattern. Anadromous streams are shown as blue arcs and polygons. 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 is usually represented as a descriptive term, such as "high". Descriptive concentrations are based on the opinion of local resource managers or experts concerning relative concentrations within the study area. In many cases, concentration values have not been used if information is not available. Note that concentration should not be interpreted as the "level of concern" or "importance" associated with a certain site or particular resource.

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, which are marine species of commercial interest, and several species of molluscs and crabs that are harvested for subsistence use. Crab distributions are based on expert opinion and information gathered from NMFS Essential Fish Habitat data. Concentration areas for multiple life history stages (spawning, eggs, larvae, juveniles, and adults) were mapped. Distributions of molluscs and other crab species were based on subsistence harvest information from native villagers and opinions of resource experts. Because little information is available on the exact geographic distribution of these species, they were mapped in a general "nearshore areas" polygon. Subsistence harvest of most invertebrate species generally occurs along the shoreline during ice-free periods. During a spill, subsistence users may need to be contacted regarding current species locations and abundances.

Expert contacts for invertebrates are: Charlie Lean (NPS, Nome), 907/443-6119; Wes Jones (ADF&G, Nome), 907/443-5167; and Matt Eagleton (NMFS, Anchorage), 907/271-6354. Expert contacts for subsistence resources (invertebrates, marine mammals, birds, and fish) are Susan Georgette (ADF&G, Kotzebue), 907/442-3420; Noah Naylor (Northwest Arctic Borough, Kotzebue), 907/442-2500; and Chuck Degan (Bering Straits Coastal Resources and Service Area, Unalakleet), 907/624-3062.

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 crabs.

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 is represented as a descriptive term, such as "high". Descriptive concentrations are based on the opinion of local resource managers, local subsistence users, and NMFS Essential Fish Habitat data concerning relative concentrations within the study area. 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 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

Two types of benthic marine habitats were mapped for the Northwest Arctic, Alaska atlas, eelgrass and kelp. Locations of these resources were based largely on expert opinion. Both eelgrass and kelp are important habitats for Pacific herring and capelin spawning.

Expert contacts for eelgrass and kelp are Charlie Lean (NPS, Nome), 907/443-6119; Wes Jones (ADF&G, Nome), 907/443-5167; and Mac McLean (ADF&G, Fairbanks), 907/459-7281.

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 Chukchi Sea, Seward Peninsula, and Norton Sound coasts in October and 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 near Wales and along the northern shoreline of Norton Sound, to over 30 nautical miles offshore along the northern Seward Peninsula and southern Norton Sound shorelines. On average, pack ice (any area of sea ice other than fast ice) begins to form in the Bering Sea in November, and in the Chukchi Sea between October and early December. Average ice breakup in the area is in May and June.

Figure 1 (page 5) displays the average "five-tenths ice concentration" boundaries for November, December, 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 November boundary lines, (i.e. Kotzebue and Norton Sounds and Chukchi Sea on November 15) 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 November boundary lines (i.e. the Bering Strait on November 15), 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 south, indicating that the entire area likely has ice coverage of 50% or greater between December and June (excluding leads and polynyas which are described below). On average, by June 1, southern Norton Sound ice is breaking up (the unhatched side of the June 1 boundary line), and by June 15, Kotzebue Sound and waters below the Arctic Circle typically have less than five-tenths ice coverage. Between July and October (the "ice-free

season"), the average five-tenths ice concentration boundary line is well 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 areas during the winter (e.g. ringed seal, polar bear) are utilizing the shorefast 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. Millions of spring and fall migrants pass through the Bering Strait

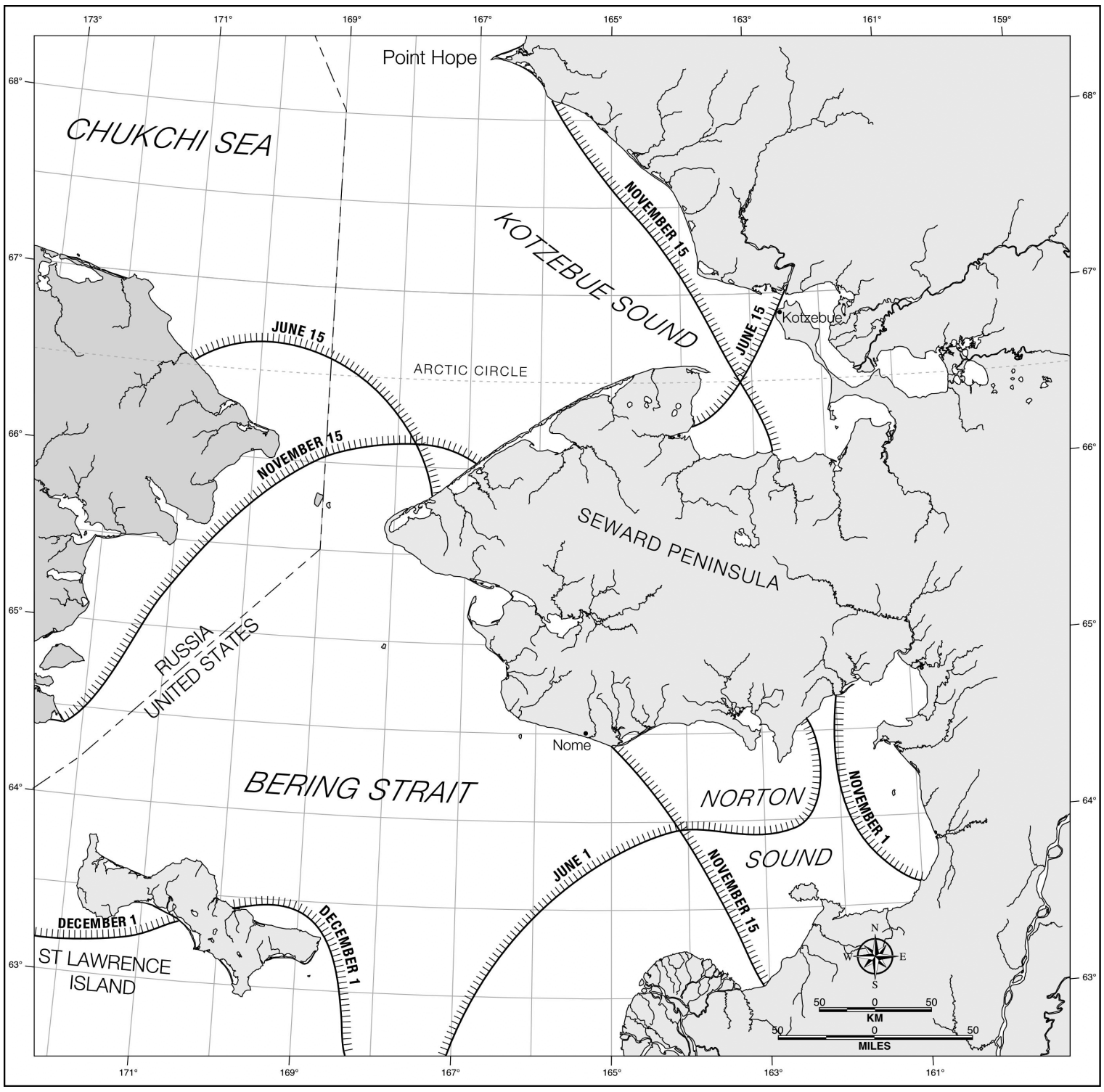
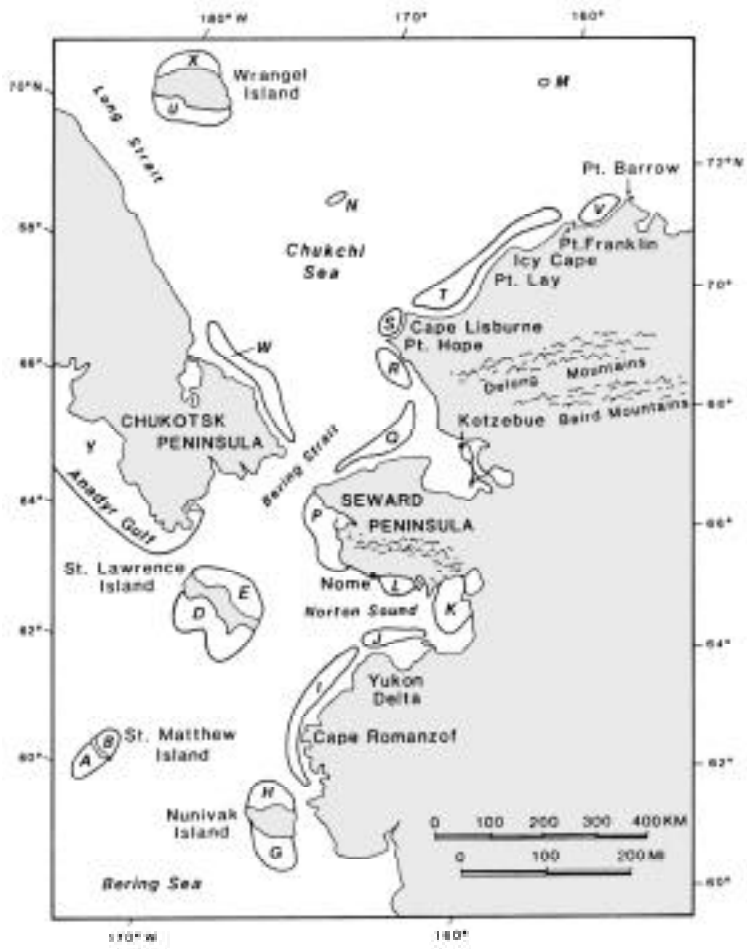


FIGURE 1. Five-tenths ice concentration boundaries for November, December, and June. Lines represent median position of five-tenths ice concentration boundaries. On average, sea water on the hatched side of a line has five-tenths ice coverage or greater on the date shown, and sea water on the unhatched 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.

using leads and polynyas. Hundreds of thousands of spectacled eiders (federally threatened), as well as walruses and other marine mammal species, winter in a recurring polynya along the southern shore of St. Lawrence each year. A recurring polynya is one that occurs in relatively the same position most years. Figure 2 (page 5) shows several recurring polynyas in the Chukchi and Bering seas. 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.

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, 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. marina/port, airport), the exact location is shown as a small black dot and a leader line is drawn from it to the icon.

Airports
Critical Habitats
Management Areas
Marinas/Ports
Mining Sites
National Parks
Wildlife Refuges

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 USGS 7.5" topographic quadrangles, the DeLorme Alaska Atlas and Gazetteer, and local knowledge.

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 the spectacled eider (federally threatened, state species of special concern) is depicted in this atlas (Figure 3). Designated Critical Habitat for the spectacled eider occurs in Norton Bay (molting habitat) and off of the southern coast of St. Lawrence Island (wintering habitat). The USFWS Ecological Services Field Office, Anchorage (907/271-2778 or 2781) provided this information in digital format.

Management Areas: These are locations of resource management areas administered by state or federal agencies. The Unalakleet Wild and Scenic River is in this management category. Property names are provided in the data tables for each map. The 2000 ADNR "Administrative Large Parcel Boundaries" digital coverage was used as the source for management area locations.

Marinas/Ports: Locations of marinas and shipping ports are depicted as point features. This information was gathered from overflight observations.

Mining Sites: Points are used to depict general locations where active beach mining occurs. Sitnasuak Native Corporation provided this information.

National Parks: Areas managed by the National Park Service, including national parks, national historic sites, and national monuments, are depicted using dashed lines to indicate park/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 management area locations.

Wildlife Refuges: Areas managed by the USFWS as National Wildlife Refuges are depicted using dashed lines to indicate park/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 management area locations.

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;

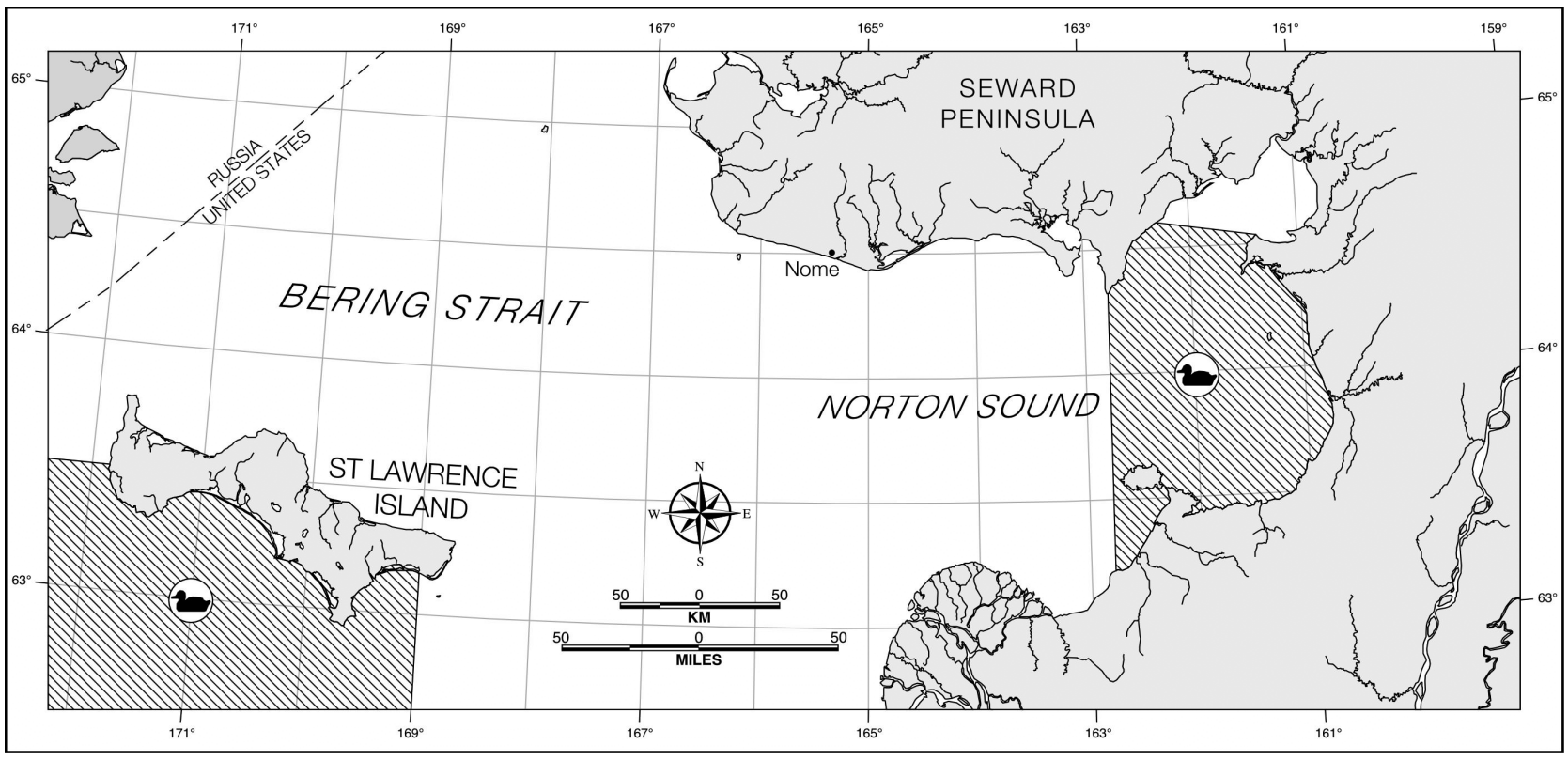


FIGURE 3. Spectacled eider Designated Critical Habitat for molting (Norton Sound) and wintering (south of St. Lawrence Island) is shown by a hatched pattern and waterfowl icon.

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), National Park Service (NPS), Alaska Department of Fish and Game (ADF&G), NOAA National Marine Fisheries Service (NMFS), and U.S. Geological Survey (USGS) 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: Norton Sound Economic Development Corporation, Alaska Department of Natural Resources (ADNR), Northwest Arctic Borough, Sitnasuak Native Corporation, Maniilaq Association, Bering Straits Coastal Resource Service Area, Kotzebue IRA, and Kawerak, Inc. 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. Jacqueline Michel was Project Manager. Colin Plank conducted the 2001 shoreline habitat mapping for Kotzebue Sound. The biological and human-use data were collected, compiled onto basemaps, and edited by Christine Lord. Chris Locke (GIS Project Coordinator), Jon Whitlock, Vermell Simon Pyatt, and Jessica Diimmler entered, processed, and produced the GIS data and hardcopy atlas under the supervision of Mark White, GIS Director. Jeff Dahlin assisted with the biological data collection and compilation phase of the project, as well as with processing of GIS data. Joe Holmes conducted the graphic art production. Erin Rieber, Becky Cox, Kristi Suggs prepared the final text documents and metadata.

APPROPRIATE USE OF ATLAS AND DATA

This atlas and the associated database were developed to provide summary information on sensitive natural and human-use resources for the purposes of oil and chemical spill planning and response. Although the atlas and database should be very useful for other environmental and natural resource planning purposes, it should not be used in place of data held by 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

TERRESTRIAL MAMMALS

MUSKOX

Muskox	*Ovibos moschatus*

MARINE MAMMALS

PINNIPEDS

Bearded seal	*Erignathus barbatus*
Ringed seal	*Pusa hispida*
Spotted seal	*Phoca largha*
Steller (Northern) sea lion	*Eumetopias jubatus*
Walrus	*Odobenus rosmarus*

WHALES

Beluga whale	*Delphinapterus leucas*
Blue whale	*Balaenoptera musculus*
Bowhead whale	*Balaena mysticetus*
Fin whale	*Balaenoptera physalus*
Gray whale	*Eschrichtius robustus*
Killer whale	*Orcinus orca*
Minke whale	*Balaenoptera acutorostrata*
Northern right whale	*Eubalaena glacialis*

POLAR BEARS

Polar bear	*Ursus maritimus*

BIRDS

DIVING BIRDS

Cormorant	*Phalacrocorax sp.*
Loons	*Gavia spp.*
Pacific loon	*Gavia pacifica*
Pelagic cormorant	*Phalacrocorax pelagicus*
Red-necked grebe	*Podiceps grisegena*
Red-throated loon	*Gavia stellata*
Yellow-billed loon	*Gavia adamsii*

GULLS/TERNS

Aleutian tern	*Sterna aleutica*
Arctic tern	*Sterna paradisaea*
Glaucous gull	*Larus hyperboreus*
Herring gull	*Larus argentatus*
Mew gull	*Larus canus*

RAPTORS

American peregrine falcon	*Falco peregrinus anatum*
Arctic peregrine falcon	*Falco peregrinus tundrius*

SEABIRDS

Black guillemot	*Cepphus grylle*
Common murre	*Uria aalge*
Crested auklet	*Aethia cristatella*
Dovekie	*Alle alle*
Horned puffin	*Fratercula corniculata*
Least auklet	*Aethia pusilla*
Murre	*Uria sp.*
Parakeet auklet	*Aethia psittacula*
Pigeon guillemot	*Cepphus columba*
Thick-billed murre	*Uria lomvia*
Tufted puffin	*Fratercula cirrhata*
Black-legged kittiwake	*Rissa tridactyla*
Pomarine jaeger	*Stercorarius pomarinus*
Seabirds	-

SHOREBIRDS

American golden-plover	*Pluvialis dominica*
Bar-tailed godwit	*Limosa lapponica*
Black-bellied plover	*Pluvialis squatarola*
Dunlin	*Calidris alpina*
Hudsonian godwit	*Limosa haemastica*
Long-billed dowitcher	*Limnodromus scolopaceus*
Pacific golden-plover	*Pluvialis fulva*
Pectoral sandpiper	*Calidris melanotos*
Red phalarope	*Phalaropus fulicaria*
Red-necked phalarope	*Phalaropus lobatus*
Rock sandpiper	*Calidris ptilocnemis*
Ruddy turnstone	*Arenaria interpres*
Semipalmated sandpiper	*Calidris pusilla*
Sharp-tailed sandpiper	*Calidris acuminata*

Common Name	Species Name

BIRDS cont.

SHOREBIRDS cont.

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*
Dabbling ducks	-
Diving ducks	-
Emperor goose	*Chen canagica*
Geese	-
Greater scaup	*Aythya marila*
Greater white-fronted goose	*Anser albifrons*
Green-winged teal	*Anas crecca*
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.*
Snow goose	*Chen caerulescens*
Spectacled eider	*Somateria fischeri*
Steller's eider	*Polysticta stelleri*
Surf scoter	*Melanitta perspicillata*
Tundra swan	*Cygnus columbianus*
Waterfowl	-
White-winged scoter	*Melanitta fusca*

FISH

FISH

Sheefish	*Stendous leucichthys nelma*
Whitefish	-
Arctic char	*Salvelinus alpinus*
Chinook salmon	*Oncorhynchus tshawytscha*
Chum salmon (dog)	*Oncorhynchus keta*
Coho salmon (silver)	*Oncorhynchus kisutch*
Dolly varden	*Salvelinus malma*
Pink salmon (humpy)	*Oncorhynchus gorbuscha*
Sockeye salmon (red)	*Oncorhynchus nerka*
Pacific herring	*Clupea pallasi*
Starry flounder	*Platichthys stellatus*
Burbot	*Lota lota*
Northern pike	*Esox lucius*
Rainbow smelt	*Osmerus mordax*
Pacific halibut	*Hippoglossus stenolepis*
Saffron cod	*Eleqinus gracilis*
Capelin	*Mallotus villosus*

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*

HABITATS

SUBMERSED AQUATIC VEGETATION

Eelgrass	*Zostera marina*

*Threatened and endangered species are designated by underlining.

SHORELINE DESCRIPTIONS

EXPOSED ROCKY SHORES **ESI = 1A**

DESCRIPTION

- Steep intertidal zone (usually greater than 30 degree slope), 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
- Much of the Norton Sound coastline is of this type; not nearly as common in Kotzebue Sound

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, SOLID MAN-MADE STRUCTURES **ESI = 1B**

DESCRIPTION

- Typically composed of concrete or metal bulkheads
- Regularly exposed to high wave energy, with strong wave reflection patterns
- Organisms, such as barnacles and algae, may be common on the lower levels, whereas biota along the upper intertidal zone are sparse
- As a result of the high-energy setting, attached organisms are hardy and accustomed to strong hydraulic impacts and pressures
- Provide protection to residential and industrial developments where these structures are threatened by beach erosion
- Not common in study area; small portions of the northern shore of the Baldwin Peninsula, associated with the town of Kotzebue, consist of solid man-made structures

PREDICTED OIL BEHAVIOR

- Much of the oil will be held offshore by wave reflection
- Oil could percolate between the joints of the structures.
- Under heavy accumulations, oil may coat the intertidal area and biota present would be impacted

RESPONSE CONSIDERATIONS

- High-pressure spraying may be required in order to:
  - remove oil
  - prepare substrate for re-colonization of epifaunal communities
  - minimize aesthetic damage
  - prevent the chronic leaching of oil from the structure

EXPOSED WAVE-CUT PLATFORMS IN BEDROCK, MUD OR CLAY **ESI = 2A**

DESCRIPTION

- Intertidal zone with a flat rock bench of highly variable width
- Platform may consist of flat lying bedrock or eroding muddy marsh substrate
- 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 sand- to 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
- Much of the Norton Sound coastline is of this type; present only along limited portions of the southern coast of Kotzebue Sound

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

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

DESCRIPTION

- Regular exposure to high wave energy, with moderate to weak wave reflection patterns
- Scarp heights vary from about 1 to 3 feet and usually consist of a heavily rooted, loamy soil with a highly irregular, moderately permeable surface
- May be accompanied by a narrow beach of fine to medium-grained sand
- Relatively uncommon, generally found along the shores of larger lagoons, such as Lopp Lagoon, and the Kobuk delta

PREDICTED OIL BEHAVIOR

- Oil may adhere to roots or become entrapped in depressions or irregularities on the scarp surface near the high tide line. Oil in such irregularities could persist in small amounts, despite high wave energy
- Biological impacts can be immediate and severe, particularly if oil is left to pool on the landward side of scarp

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 order to protect a nearshore marine resource, such as marine birds

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

DESCRIPTION

- Generally flat (less than 5 degree slopes), wide, and hard-packed
- Rate of sediment mobility is relatively low, thus rapid, dramatic changes in the beach profile are not common
- Surface sediments subject to regular reworking by waves
- Beach fauna can vary in type and density; mobile surface, burrowing, and interstitial forms are typical
- Extensive beaches of this type are found on the barrier islands from Cape Espenberg south to Cape of Prince of Wales

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 microtidal beaches, 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

SCARPS AND STEEP SLOPES IN SAND — ESI = 3B

DESCRIPTION

- Not common in the study area, generally associated with inlets separating barrier islands and the landward side of the recurved spit at Cape Espenberg
- Bluffs and scarps of fine- to medium-grained sand typically associated with undeveloped, seasonally open inlets and the cut banks of meandering rivers and tidal creeks
- Tops of scarps and slopes may be vegetated with grasses, scrub-shrub vegetation, or trees all of which are eventually undercut by the retreating shoreline, resulting in a collection of woody debris at the high-tide line
- These shoreline types are also found in association with beaches where erosion is episodic or is occurring at a moderate rate. When this is the case the position of these features is likely to have changed from their location at the time of mapping, due to their somewhat ephemeral nature
- Uncommon in study area at the time of overflights, these shoreline types may develop on any erosional coastline

PREDICTED OIL BEHAVIOR

- Stranded oil may accumulate at the high tide line, possibly penetrating sandy sediments
- Potential for burial exists due to instability of the slope or scarp
- Oil may adhere to dry surfaces of the woody debris at the base of the slope or scarp

RESPONSE CONSIDERATIONS

- Cleanup is usually not required, because oil is quickly removed by wave action
- Access may be difficult and dangerous. Crews must be mindful of slope instability
- The need for the removal of oiled sediments and debris should be carefully evaluated because of the potential for increased erosion

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TUNDRA CLIFFS — ESI = 3C

DESCRIPTION

- These are erosional features with tundra vegetation overlying peat and exposed ground ice or permafrost
- Cliff heights range from less than 1 meter to as much as 10 meters
- There is commonly a narrow beach of fine sand at the base of the cliff
- Fragmented and irregular blocks of peat and tundra vegetation accumulate at the base of the cliff as it erodes. The clumps of peat and vegetation range in size from less than a foot to a yard in length
- The vegetation on the tundra is a living plant community that is sensitive to disturbances
- Large numbers of migratory birds can use these shorelines during the summer months
- Commonly found along the interior shorelines of lagoons north of Cape of Prince of Wales

PREDICTED OIL BEHAVIOR

- Oil could be stranded onshore only during the ice-free summer season
- Oil is not likely to adhere to exposed ground ice, unless air temperatures are below freezing
- Oil persistence on the *in situ* vegetation and peat substrates would be short in most cases, due to the natural cliff erosion, provided that oil is not stranded at the onset of freeze up
- If the oil mixes with accumulations of peat blocks at the base of the cliff, sheens may persist until the peat is reworked by wave energy

- Biological risks would be the greatest to birds feeding along the oiled cliffs in summer months

RESPONSE CONSIDERATIONS

- Natural peat can be used as a sorbent as long as it is taken from the beach peat deposits and not the living tundra
- Manual or mechanical removal of oil or oiled tundra/peat may be the most practical method if oil removal is required. Caution should be exercised, however, as the peat substrate is soft and readily trampled
- Hot-water washing or even low pressure flushing are not appropriate because they may accelerate thermal and mechanical erosion of the ice in the cliff, triggering unexpected blockfalls, slumping, or mud flows
- The cliffs are commonly undercut and naturally unstable, so worker safety is a primary concern

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COARSE-GRAINED SAND BEACHES — ESI = 4

DESCRIPTION

- Moderate to steep beachface slopes, typically between 5 and 15 degrees
- 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
- Relatively uncommon, these are found on the northern shores of Norton Sound

- In places, they occur at the upper intertidal zone on wave-cut platforms

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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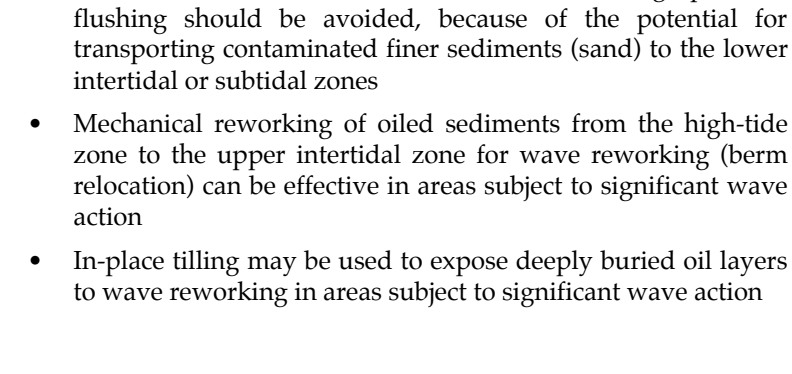
MIXED SAND AND GRAVEL BEACHES — ESI = 5

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; mobile surface, burrowing, and interstitial forms are typical
- Common throughout the study area both as broad beaches and narrow intertidal tracts in association with other shoreline types

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

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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
- Relatively uncommon in the study area, the largest segments of this coastal type are found on the northern shore of the Baldwin Peninsula and on the southeastern shoreline of Norton Sound

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

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RIPRAP **ESI = 6B**

DESCRIPTION

- Composed of cobble- to boulder-sized rock fragments
- Used for shoreline protection and inlet stabilization
- Attached mid- and low-intertidal zone biota may be plentiful and varied
- Uncommon in the study area, associated only with the villages of Shismaref and Kivalina

PREDICTED OIL BEHAVIOR

- Deep penetration of oil because of the high permeability of the riprap
- Oil adheres readily to the rough rock surfaces
- If left uncleaned, oil may cause chronic leaching (weeks to months) until it turns to asphalt
- Resident fauna and flora may be killed by the oil

RESPONSE CONSIDERATIONS

- Flushing can be effective for removing mobile oil, but large amounts of residue can remain after flushing, particularly for heavy oil

- Scrapping and/or hot-water spraying of residual heavy oils may be required in areas of high recreational value

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EXPOSED TIDAL FLATS **ESI = 7**

DESCRIPTION

- Flat (less than three degrees) intertidal areas, composed primarily of sand and mud (sand dominant), that vary in width from a few 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
- 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
- Relatively common throughout the study area. Large tidal flats are associated with washover sites on barrier islands and the Noatak delta

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 AND SHELTERED SCARPS IN MUD AND CLAY — ESI = 8A

DESCRIPTION

- In some areas, such as Tursuk Channel on the north side of Norton Sound, the shoreline consists of bedrock shores of variable slope (from vertical cliffs to wide, rocky ledges) that are sheltered from exposure to most wave and tidal energy
- In other areas, such as the lagoons backing the barrier islands north of Cape Prince of Wales, this shoreline type consists of sheltered scarps in densely rooted and organic muds
- Attached biota may be plentiful and varied, especially in lower and mid-intertidal zones

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

SHELTERED, SOLID MAN-MADE STRUCTURES — ESI = 8B

DESCRIPTION

- Include revetments, seawalls, piers, and docks constructed of impermeable materials such as concrete and wood
- Found inside harbors and bays sheltered from direct exposure to waves
- Attached biota may be plentiful and varied, especially in lower and mid-intertidal zones
- Uncommon in the study area; limited amounts mapped in Kotzebue

PREDICTED OIL BEHAVIOR

- On impermeable surfaces, the oil will form a band at the high-tide line
- If the oil is not removed, it may cause chronic leaching until the oil hardens into an asphalt deposit
- Impacts to attached organisms can be severe

RESPONSE CONSIDERATIONS

- Cleanup is frequently required, because natural removal rates are slow and these features are located in populated areas

- High-pressure spraying may be required to remove oil for aesthetic reasons and to prevent leaching of oil from the structure
- Cleanup crews should make sure to recover all released oil
- All pooled oil and oiled debris should be removed as soon as possible

SHELTERED RIPRAP — ESI = 8C

DESCRIPTION

- Composed of cobble- to boulder-sized rock fragments, similar to exposed rip rap but sheltered from wave energy
- Found inside harbors and bays in highly developed areas sheltered from direct exposure to waves
- Attached biota may be plentiful and varied, especially in lower and mid-intertidal zones
- Uncommon in the study area; limited amounts mapped in Kotzebue

PREDICTED OIL BEHAVIOR

- On impermeable surfaces, the oil will form a band at the high-tide line, oil will adhere readily to the rough rock surfaces
- Deep penetration of oil possible because of the high permeability of the riprap
- If the oil is not removed, it may cause chronic leaching (weeks to months) until the oil hardens into an asphalt deposit
- Impacts to attached organisms can be severe

RESPONSE CONSIDERATIONS

- Cleanup is frequently required, because natural removal rates are slow and these features are located in populated areas

- Flushing can be effective for removing mobile oil, but large amounts of residue can remain after flushing, particularly for heavy oil. Clean up if often difficult and intrusive
- High-pressure spraying and/or scraping may be required to remove oil for aesthetic reasons and to prevent leaching of oil from the structure
- Cleanup crews should make sure to recover all released oil
- All pooled oil and oiled debris should be removed as soon as possible

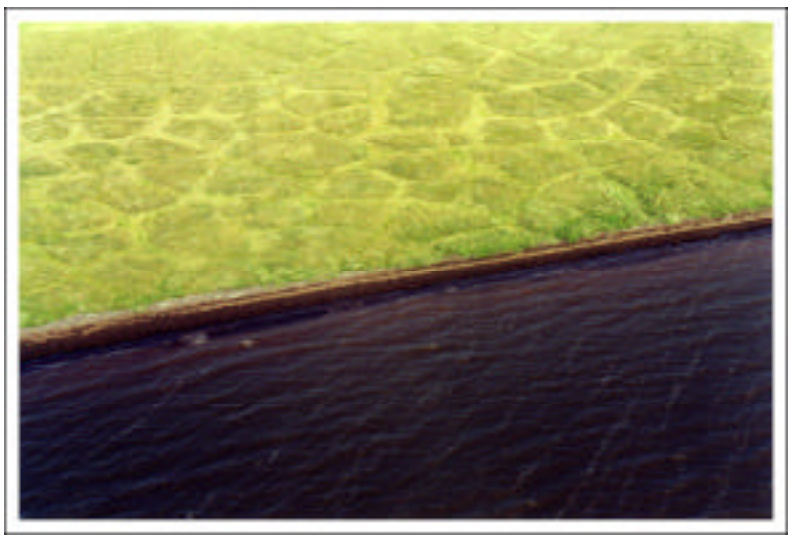
PEAT SHORELINES **ESI = 8E**

DESCRIPTION

- This shoreline type includes exposed peat scarps, eroded peat, and slurries of rafted peats
- Exposed scarps occur only where the peat is frozen and are therefore rare in the Kotzebue area during the summer months
- These are typically erosional coastlines, resulting from wave action, ice scour, and melting of the frozen peat
- The intertidal zone is often very complex, with slumped peat blocks, fine- to medium-grained sands, and peat slurries intermixed.
- Peat slurries (which have the appearance of coffee grounds) are up to 50 cm thick and 10 meters wide
- Peat slurries are found at the base of eroding peat scarps and in depositional areas; they are relatively permanent features but may move slightly and vary in thickness due to shore parallel transport
- The intertidal zone of the this shoreline type is not particularly important as a biological habitat

PREDICTED OIL BEHAVIOR

- Oil could be stranded onshore only during the ice-free summer season
- Oil penetration and persistence are expected to be very low in frozen peat scarps
- Light oil can penetrate peat slurries, especially when dry, resulting in persistent sheens
- Heavy oil does not penetrate peats, 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
- If shoreline is an eroding peat scarp, 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 and tundra 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
- 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

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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SHELTERED, VEGETATED LOW BANKS **ESI = 9B**

DESCRIPTION

- Sheltered banks of stream channels, canals, and other waterways
- Calm-water habitats that are typically muddy, soft and highly vegetated
- Wave energy is very low, although there may be some tidal and/or riverine currents along the banks
- Relatively uncommon in the study area, usually found on the shores of lagoons and coastal ponds, sometimes in association with peat shorelines

PREDICTED OIL BEHAVIOR

- Natural removal rates very slow because of low energy and dense vegetation
- Oil adheres readily to vegetation

- The band of oil coating on the vegetation will vary widely, depending upon the tidal stage at the time of oiling; there may be multiple bands
- If the vegetation is thick, heavy oil coating will be restricted to the outer fringe, with penetration and lighter oiling to the limit of tidal influence
- In areas of high suspended sediments, sorption of oil can result in deposition of contaminated sediments on the channel banks and bottoms

RESPONSE CONSIDERATIONS

- These are high-priority areas necessitating the use of spill protection devices to limit oil-spill impact; most are along lagoonal shores that are exposed to the open ocean only when near an inlet; therefore, deflection booming should be used to prevent the oil from entering the channel mouth
- Cleanup of the banks is very difficult because of the soft substrate
- Manual operations and deployment of sorbents from shallow-draft boats may be helpful
- Under light oiling, the best practice is to let the area recover naturally.
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing
- Any cleanup activity must not mix the oil deeper into the sediments; trampling of the plant 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

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

DESCRIPTION

- Intertidal wetlands consisting of emergent, herbaceous vegetation
- Marshes as mapped in this atlas vary in extent from extensive areas to narrow fringes
- Sediments in the substrate range from fine sands to silts and organically rich muds
- Typically sheltered from heavy wave energy

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

- Extent of oiling, natural removal processes and rates should be evaluated prior to conducting cleanup

- 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
- 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

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SCRUB-SHRUB WETLANDS **ESI = 10D**

DESCRIPTION

- Roots and trunks of woody vegetation may be supratidal, but are inundated occasionally during storm surge, spring tides, and freshwater flooding
- Width of vegetation stand may vary from a single tree to kilometers
- The substrate may be sand, mud, or peat
- Wrack accumulations tend to be heavy
- Uncommon in the study area; mapped only along distributary channels of the Kobuk delta

PREDICTED OIL BEHAVIOR

- Oil may be stranded in pools among the tree roots
- Oil readily adheres to roots, trunks and woody debris
- Reoiling from resuspended or released oil residues may cause additional injury over time
- Oiled trees start to show evidence of effects (leaf yellowing) weeks after oiling; tree mortality may take months, especially for heavy oils

RESPONSE CONSIDERATIONS

- Oiled wrack can be removed once the threat of oiling has passed. Wrack can actually protect the trees from oiling

- Sorbent boom can be placed in front of oiled forests to recover oil released naturally
- In most cases, no other cleanup activities are recommended
- Where thick oil accumulations are not being naturally removed, low pressure flushing or vacuum may be attempted at the outer fringe
- It is extremely important to prevent disturbance of the substrate by foot traffic; thus most activities should be conducted from boats

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INUNDATED LOW-LYING TUNDRA **ESI = 10E**

DESCRIPTION

- This shoreline type occurs where very low-lying sections of the arctic shoreline have been recently flooded by the sea due to subsidence
- Also includes areas that are not normally in the intertidal zone but can be frequently inundated by salt water during springtides or wind-induced surges
- They have complex and convoluted shorelines comprised of tundra, vegetated flats, peat mats, brackish lagoons, and small streams.
- These shorelines may have a high ice content; the surface material is mostly peat with little in the way of mineral or clastic sediments
- The tundra is a living plant community and provides important feeding areas for migrating birds in the summer

PREDICTED OIL BEHAVIOR

- Oil could be stranded onshore only during the ice-free summer months
- During storm surges, spilled oil could become stranded hundreds of meters inland
- During the summer months, the surface sediments/peat deposits are usually water saturated, so stranded oil is likely to remain on the surface
- Physical removal rates of medium to heavy oils will be slow

RESPONSE CONSIDERATIONS

- In summer, the substrate will be too soft to support foot or vehicular traffic; any work will require construction of walkways or roads
- In winter, the load-bearing capacity of these low-lying areas is increased and damage due to response traffic is less likely

- Excessive physical disruption can completely alter the substrate, hydrology, and vegetation patterns for many years
- Avoid raking and trampling oil into living plants
- Peat may be used as a natural sorbent; sorption will be more effective with liquid and fresh oils
- Low-pressure, ambient-water flood and/or flushing could raise the local water table to float and direct oil towards a boomed area for collection
- If salt-tolerant species are present, seawater may be used; use only freshwater if plants are not salt-tolerant
- Consider burning only where there is an insulating water layer to protect roots and prevent deeper penetration into the substrate. Peat with a high water content may make burning ineffective, leaving a persistent surface residue that is more difficult to remove than the spilled oil