ENVIRONMENTAL SENSITIVITY INDEX: NORTH SLOPE, ALASKA

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for North Slope, Alaska that include marine and coastal areas of the northeastern Chukchi Sea from Point Hope to Barrow and the Beaufort Sea from Barrow to the Canadian border. 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 formatted to fit the 11"x 17" page size at the scale of 1:250,000. Grey-scale images of the U.S. Geological Survey (USGS) 1:250,000 scale topographic maps are used as a backdrop for each map page in the atlas.

SHORELINE HABITAT MAPPING

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

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

Prediction of the behavior and persistence of oil in intertidal habitats is based on an understanding of the dynamics of the coastal environments, not just the substrate type and grain size. The intensity of energy expended upon a shoreline by wave action, tidal currents, and river currents directly affect the persistence of stranded oil. The need for shoreline cleanup activities is determined, in part, by the slowness of natural processes in removal of oil stranded on the shoreline. The potential for biological injury and ease of cleanup 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, have low biological activity and 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 North Slope ordered by increasing sensitivity to spilled oil.

1A) Exposed Rocky Shores
1B) Exposed, Solid Man-made Structures
3A) Fine- to Medium-grained Sand Beaches
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
8E) Peat Shorelines
9A) Sheltered Tidal Flats
9B) Sheltered, Vegetated Low Banks
10A) Salt- and Brackish-water Marsh
10E) Inundated Low-lying Tundra

Each shoreline habitat is described on pages 8-14, in terms of the physical description, predicted oil behavior, and response considerations. Nearly 4,741 kilometers of shoreline were classified. In the shoreline descriptions, the percent of the shoreline mapped for each habitat is provided, though it should be noted that shorelines with multiple habitat types are counted towards the individual habitat percentages, therefore, the total percents of all habitat types exceed 100 percent.

SENSITIVE BIOLOGICAL RESOURCES

Biological information presented in this atlas was collected, compiled, and reviewed with the assistance of biologists and resource managers from:

- U.S. Fish and Wildlife Service (USFWS)
- Alaska Department of Fish and Game (ADF&G)
- U.S. Geological Survey (USGS)
- North Slope Borough (NSB)
- Alaska Department of Natural Resources (ADNR)
- Minerals Management Service (MMS)
- NOAA National Marine Mammal Laboratory (NMML)
- University of Alaska-Fairbanks (UAF)
- Canadian Wildlife Service (CWS)
- ABR, Inc. Environmental Research and Services
- BP Exploration, Alaska

KEY FEATURES ON ESI MAPS

1) Animal and plant species that are at risk during oil spills and/or spill response are represented on the maps by polygons, points, and arcs.

2) Species have been divided into groups and subgroups, based on their behavior, morphology, taxonomic classification, and spill vulnerability and sensitivity. The icons below reflect this grouping scheme.

BIRDS

Diving Birds

Gulls and Terns

Seabirds

Shorebirds

Waterfowl

FISH

Fish

MARINE MAMMALS

Pinnipeds

Polar Bears

Whales

TERRESTRIAL MAMMALS

Bears

Caribou/Muskox

BENTHIC HABITATS

Kelp

3) Polygons, arcs, and points are color-coded based on the species composition of each feature.

ELEMENT	COLOR AND HATCH PATTERN
Birds	Green diagonal hatch
Fish	Blue diagonal hatch
Marine mammals	Brown horizontal hatch
Terrestrial mammals	Brown vertical hatch
Benthic habitats	Purple horizontal hatch pattern
Multi-element group	Black diagonal hatch

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

5) Also associated with each species in the table is the state and federal protected status as threatened (T), endangered (E), or species of special concern (C), concentration, seasonality, and life-history information.

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

TERRESTRIAL MAMMALS

Terrestrial mammal species mapped in this Atlas include:

Brown bears – where they concentrate along the shoreline during certain times of year;

Caribou - from four herds (Central Arctic Herd, Western Arctic Herd, Teshekpuk Herd, and Porcupine Herd) where they are calving and migrating through the area and concentrating along the shoreline post-calving and for insect relief in the summer; and

Muskoxen – where they concentrate coastally in certain areas.

Other mammals potentially occurring in the area that were not mapped include: moose, dall sheep, wolves, and foxes. These species were not mapped 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.

Major Data Sources Used: Terrestrial Mammals

ABR, Inc., 2004. Satellite telemetry data for Caribou: post-calving, summer distribution, insect/mosquito relief for the Teshekpuk Herd (TH): 1990-2002. ABR, Inc., Fairbanks, digital vector data.

Alaska Department of Fish and Game (ADF&G), 2003. Central Arctic Herd (CAH) caribou calving locations: 1990-2002. ADF&G, Fairbanks, digital vector data.

ADF&G, 2003. Teshekpuk Herd (TH) caribou calving areas: 1994-2002. ADF&G, Barrow, 2 maps.

ADF&G, 2003. Western Arctic Herd (WAH) caribou calving grounds: 1988-2003. ADF&G, Nome/Kotzebue, digital vector data.

ADF&G, 2004. Western Arctic Herd (WAH) insect relief areas. ADF&G, Kotzebue, digital vector data.

Schoen, J.W., S.E. Senner, J.Fair, D. Norton, E. Davidian, and J. Nelson. 2002. Alaska's Western Arctic: A Summary and Synthesis of Resources. Distribution of Grizzly Bear map. Audubon Alaska, Anchorage, Alaska, 1 map.

USFWS, 2004. Porcupine Herd (PH) caribou calving area. USFWS, Arctic National Wildlife Refuge (ANWR), Fairbanks, digital vector data.

Expert contacts for North Slope terrestrial mammals are:

Name	**Agency**	**City**	**Phone** (907)	**Species**
Geoff Carroll	ADF&G	Barrow	852-3464	Caribou, Muskoxen
Jim Dau	ADF&G	Kotzebue	442-3420	Caribou, Muskoxen
Beth Lenart	ADF&G	Fairbanks	459-7242	Caribou
Steve Arthur	ADF&G	Fairbanks	459-7213	Caribou
Tara Wertz	USFWS, ANWR	Fairbanks	456-0519	Caribou
Tony Gorn	ADF&G	Nome	443-2271	Caribou

MARINE MAMMALS

Marine mammals depicted in the North Slope Atlas include:

Beluga whale – Beluga whales are present nearshore along the Chukchi Sea coast in the spring and continue migrating northeastward into offshore waters of the Beaufort Sea. A large group of whales concentrates in and around Kasegaluk Lagoon in the summer. The fall westward migration through the Beaufort and Chukchi Seas occurs offshore.

Bowhead whale – Bowhead whales (federally endangered, state species of special concern) migrate through leads in the Chukchi Sea ice in early spring and offshore of Point Barrow in late spring. The westward fall migration occurs along the Beaufort Sea coast in the nearshore environment, while fall migration along the Chukchi Sea coast is farther offshore. The annual spring and fall bowhead whale hunts are extremely important subsistence and cultural events in coastal North Slope communities. Alaska Eskimo whaling community hunting and search areas occur off of several North Slope villages, including: Kivalina, Point Hope, Wainwright, Barrow, Nuiqsut, and Kaktovik.

Ringed seal – Ringed seals are associated with shorefast ice for pupping and weaning in the spring and summer. 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. Adults and juveniles use shorefast ice and large flat ice floes for molting in the summer, and are also present along the edge of the permanent ice pack. Seals return to shorefast ice as it forms in the late fall/early winter.

Spotted seals – Several thousand spotted seals, the largest known concentration in Alaska, hauls out in Kasegaluk Lagoon in the summer and fall. Additional haulout areas occur along the Chukchi and Beaufort Sea coasts.

Bearded seals – Bearded seals occur further offshore than the other seal species along the pack-ice edge, more commonly in Chukchi Sea, but in Beaufort Sea as well.

Walruses – Walruses, primarily females and juveniles, concentrate in the Chukchi Sea ice in the summer and fall. Some have been observed along the Beaufort Sea coast. Haul-outs on land are irregularly used in this area.

Gray whales – Gray whales are present in the area during the ice-free season and concentrate between Icy Cape and Barrow and around the Lisburne Peninsula during the late summer/early fall.

Polar bears – Polar bears are associated with sea ice and are present along the near shore areas of both the Beaufort and Chukchi sea coasts. During the summer and early autumn months (July-October), as the ice melts northward, most bears concentrate along the southern pack ice edge. A small proportion of the population, however, retreats to and remains on the coast during this time. During winter and spring months (November-June), polar bears concentrate along the relatively active pack ice/shorefast ice flaw zone. While polar bears may be present onshore along the coastline throughout the year, most use of terrestrial habitat during winter is by pregnant bears that den next to coastal bluffs, river banks and lake shores. Pregnant females den from October/November to March/April on land and shorefast ice, offshore islands, and on pack ice.

The distribution of polar bears is displayed as large generalized polygons in the hardcopy Atlas, often in "Present Throughout Area" boxes. Please view the digital data that accompanies the Atlas for more location specific details. For the most current information on polar bear den habitat, please refer to the USGS, Alaska Science Center polar bear website:

http://www.absc.usgs.gov/research/programs/mammals.htm#polar

Major Data Sources Used: Marine Mammals

ADF&G, 1986. Alaska Habitat Management Guide, Arctic Region, Map Atlas. State of Alaska, Department of Fish and Game, Habitat Division, Juneau, 19 maps.

ADF&G, 1997. Most Environmentally Sensitive Area (MESA) data. ADF&G Habitat and Restoration Division, 7 maps.

Alaska Regional Response Team (ARRT), 1999. North Slope Subarea Contingency Plan: Sensitive Areas Section. ARRT, pp. D1-D92.

Fay, F.H., 1982. Ecology and biology of the Pacific Walrus, *Odobenus Rosmarus Divergens Illiger*. U.S. DOI, Fish and Wildlife Service, North American Fauna, Number 74, Washington D.C., 280 pp.

Frost, K.J., L.F. Lowry, and G. Carroll, 1993. Beluga whale and spotted seal use of a coastal lagoon system in the Northeastern Chukchi Sea. Arctic 46(1): 8-16.

Huntington, H.P., and the Communities of Buckland, Elim, Koyuk, Point Lay, and Shaktoolik, 1999. Traditional knowledge of the ecology of beluga whales (*Delphinapterus leucas*) in the eastern Chukchi and northern Bering Seas, Alaska. Arctic 52(1): 49-61.

Minerals Management Service (MMS), 2003. Bowhead whale aerial survey project sightings database. MMS, Anchorage, digital vector data.

Suydam, R.S., L.F. Lowry, K.J. Frost, G.M. O'Corry-Crowe, and D. Pikok, Jr. 2001. Satellite tracking of eastern Chukchi Sea beluga whales in the Arctic Ocean. Arctic 54(3): 237-243.

Treacy, S.D., 2002. Aerial Surveys of Endangered Whales in the Beaufort Sea, Fall 2001, 2002. U.S. DOI, Minerals Management Service, Alaska OCS Region, Anchorage, 117 pp.

U.S. Geological Survey (USGS), Alaska Science Center, 2005. Winter and summer polar bear density grids. USGS, Anchorage, digital vector data.

Expert contacts for North Slope terrestrial mammals are:

Name	**Agency**	**City**	**Phone** (907)	**Species**
Lori Quakenbush	ADF&G	Fairbanks	459-7214	Pinnipeds, Cetaceans
Gay Sheffield	ADF&G	Fairbanks	459-7248	Pinnipeds, Cetaceans
Robert Suydam	North Slope Borough	Barrow	852-0350	Pinnipeds, Cetaceans
Steve Treacy	MMS	Anchorage	271-6617	Cetaceans
Steve Armstrup	USGS	Anchorage	786-3424	Polar bears
George Durner	USGS	Anchorage	786-3366	Polar bears
Susanne Miller	USFWS	Anchorage	786-3828	Polar bears
Joel Garlich-Miller	USFWS	Anchorage	786-3820	Walrus

BIRDS

Bird concentration areas depicted in this Atlas include:

Seabird nesting sites – Areas where seabirds have been documented as nesting were mapped. Colony size (number of birds present) is included in tables on the reverse side of the maps.

Waterfowl nesting areas – Areas where waterfowl are nesting were mapped. USFWS staff helped to determine which species are of highest conservation concern in the region based on several factors, including: those species for which a large percentage of the population expected to nest on the North Slope, those species which are rare or imperiled, or those species which nest in high densities nearshore. This subset of species was included on the maps. Descriptive terms such as "med.-high" were used for most species. Common eider, brant, and snow goose survey data were provided with numeric concentrations. Peak values reported over a multi-year survey periods were used.

Waterfowl migratory staging and molting areas – Concentration areas are shown for migratory waterfowl in bays, lagoons, lakes, and coastal areas. Numeric concentrations shown for waterfowl were generalized from count data into categories (100s, 1000s, 10,000s) and typically refer to peak single day counts across segments recorded during aerial surveys. Descriptive terms, such as "high" and "very high" were used in some areas. Waterfowl are particularly vulnerable to the effects of spilled oil during the molting period, typically during July-August.

Migratory shorebird stopover and nesting areas – Areas where large concentrations of shorebirds occur annually during the spring, summer, and/or autumn months were mapped. Numeric concentrations shown for shorebirds vary based on the type of survey conducted. These counts may either refer to the total number of birds potentially using an area over the entire migratory season, or a peak single day count. In either case, large numbers of shorebirds may concentrate for short periods and would be vulnerable during a spill event that spans several days or longer.

Major Data Sources Used: Birds

ABR, Inc., 2004. Snow goose and brant nest sites, colony locations, and brood-rearing areas identified during aerial surveys. ABR, Inc., Environmental Research and Services, Fairbanks, digital tables.

ADF&G, 1997. Most Environmentally Sensitive Area (MESA) data. ADF&G Habitat and Restoration Division, 7 maps.

Dau, C.P., P.D. Anderson, E.J. Taylor, and J.I. Hodges, 2003. Aerial population survey of common eiders and other waterbirds in near shore waters and barrier islands of the Arctic Coastal Plain of Alaska, June-July 1999-2003. USFWS, Migratory Bird Management (MBM), Anchorage, 5 annual reports.

Fischer, J.B. and W.W. Larned, 2003. Summer distribution of marine birds in western Beaufort Sea. USFWS, MBM, Anchorage, 32 pp.

Gill, R.E., Jr., T.L. Tibbitts, and C.M. Handel. 2001. Profiles of Important Shorebird Sites in Alaska. Information and Technology Report USGS/BRD/ITR—2001-000X. Draft. U.S. Government Printing Office, Seattle, Washington, 85 pp.

Johnson, S.R., 1996. Staging and wintering areas of snow geese nesting on Howe Island, Alaska. Arctic 49(1): 86-93.

Johnson, S.R., 1993. An important early-autumn staging area for Pacific Flyway brant: Kasegaluk Lagoon, Chukchi Sea, Alaska. Journal of Field Ornithology 64(4): 539-548.

Johnson, S.R. and D.R. Herter, 1989. The Birds of the Beaufort Sea. BP Exploration (Alaska) Inc., Anchorage, Alaska, 372 pp.

Johnson, S.R., D.A. Wiggins, and P.F. Wainwright, 1993. Late-summer abundance and distribution of marine birds in Kasegaluk Lagoon, Chukchi Sea, Alaska. Arctic 46(3): 212-227.

Larned, W.W., G.R. Balogh, and M.R. Peterson, 1995. Distribution and abundance of spectacled eiders (*Somateria fischeri*) in Ledyard Bay, Alaska, September 1995. USFWS MBM, National Biological Service Alaska Science Center. 11 pp.+ appendix.

Lysne, L.A., E.J. Mallek, C.P. Dau, 2004. Near shore surveys of Alaska's arctic coast 1999-2003. USFWS, MBM, Waterfowl Branch, Fairbanks

National Science Foundation (NSF) and USFWS, 2002. Endangered species consultation for Steller's and Spectacled eiders. NSF Bulletin CB 01-02 March 2002, 9 pp.

Ritchie, R.J., R.M. Burgess, and R.S. Suydam. Status and nesting distribution of lesser snow geese, *Chen caerulescens caerulescens*, and brant, *Branta bernicla nigricans*, on the Western Arctic Coastal Plain, Alaska. Canadian Field Naturalist 114(3): 395-404.

Taylor, A. 2004. Staging shorebirds in the Barrow area. University of Alaska, Fairbanks. 1 map.

USFWS, 2004. Bird nests on barrier islands in the Arctic National Wildlife Refuge, USFWS, Arctic National Wildlife Refuge, digital table.

USFWS, 2004. Snow goose flock distribution, September 7, 2003. UFSWS, Arctic National Wildlife Refuge, 1 map.

USFWS, 2003. 2002 and 2003 sea duck censuses along the north coast of Alaska. USFWS, MBM, Fairbanks, digital vector data.

USFWS, 2003. North Slope eider survey coverages. USFWS, MBM, Anchorage, digital vector data.

USFWS, 2003. Spectacled eider Designated Critical Habitat – Ledyard Bay molting. USFWS, Fairbanks, digital vector data.

USFWS, 2003. Teshekpuk Lake molting geese survey. USFWS, MBM, Anchorage, digital vector data.

USFWS, 2002. Beringian seabird colony catalog. USFWS, MBM, Anchorage, digital vector data.

Expert contacts for North Slope birds are:

Name	**Agency**	**City**	**Phone** (907)	**Species**
Shawn Stephensen	USFWS	Anchorage	786-3691	Seabirds
Bob Gill	USGS	Anchorage	786-3514	Shorebirds
Rick Lanctot	USFWS	Anchorage	786-3609	Shorebirds
Steve Kendall	USFWS	Fairbanks	456-0303	Shorebirds
Bill Larned	USFWS	Soldotna	262-9863	Sea ducks
Chris Dau	USFWS	Anchorage	786-3908	Waterfowl
Julian Fischer	USFWS	Anchorage	786-3644	Sea ducks
Greg Balogh	USFWS	Anchorage	271-2778	Endangered species
Bob Platte	USFWS	Anchorage	786-3565	Waterfowl: digital data
Bob Ritchie	ABR, Inc.	Fairbanks	455-6777	Geese, brant
Margaret Petersen	USGS	Anchorage	786-3530	Sea ducks
Ed Mallek	USFWS	Fairbanks	456-0341	Waterfowl
Larry Lysne	USFWS	Fairbanks	456-0256	Waterfowl
Philip Martin	USFWS	Fairbanks	456-0325	Waterfowl
Lynne Dickson	Canadian Wildlife Service	Edmonton, Alberta	(780) 495-2615	Sea ducks
Audrey Taylor	Univ. of Alaska	Fairbanks	474-6051	Shorebirds
Laura Phillips	Univ. of Alaska	Fairbanks	474-7144	Sea ducks

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.

Anadromous species and populations – Chinook, chum, coho, pink, and sockeye salmon; Dolly Varden; broad, round, and humpback whitefish; and least and arctic cisco are present in the area. The streams shown have been classified by ADF&G as anadromous streams. Migration of juveniles and adults from overwintering areas to estuarine and nearshore brackish habitat occurs from May to June. Reentry into rivers and streams for spawning occurs from June to September and is species dependant.

Freshwater fish – Concentration areas and some general distributions of freshwater species (e.g. arctic grayling, burbot, lake trout, northern pike, etc.) were mapped in rivers and a few coastal lakes.

Marine/estuarine – Concentration areas and some general distributions of coastal species (e.g. arctic cod, fourhorn sculpin, Pacific herring, capelin, arctic flounder, saffron cod, etc.), particularly those that are important prey species for marine mammals and/or are harvested for subsistence, were mapped in nearshore waters.

Major Data Sources Used: Fish

ADF&G, 2003. Anadromous streams catalog. ADF&G, Anchorage, digital vector data.

ARRT, 1999. North Slope Subarea Contingency Plan: Sensitive Areas Section. ARRT, pp. D1-D92.

Craig, P.C. , 1989. An introduction to anadromous fishes of the Alaskan arctic. Biological Papers of the University of Alaska No. 24:27-54.

Craig, P., 1984. Fish use of coastal waters of the Alaskan Beaufort Sea: a review. Transactions of the American Fisheries Society 113(3): 265-282.

Craig, P., 1973. Fall spawning and overwintering area of fish populations along routes of proposed pipeline between Prudhoe Bay and the Mackenzie Delta. Aquatics Environments Ltd.25 pp. + maps.

Jarvela, L.E. and L.K. Thorsteinson, 1999. The epipelagic fish community of Beaufort Sea coastal waters, Alaska. Arctic 52(1): 80-94.

Philo, L.M., J.C. George, and L.L. Moulton, 1993. The occurrence and description of anadromous and freshwater fish in Teshekpuk Lake, Alaska. North Slope Borough, Department of Wildlife Management, Barrow, Table 8.

Expert contacts for North Slope fish are:

Name	Agency	City	Phone (907)	Species
Craig George	North Slope Borough	Barrow	852-0350	Fish
John Burr	ADF&G	Fairbanks	459-7220	Fish
William Morris	ADNR	Fairbanks	459-7282	Anadromous fish
Jeff Adams	USFWS	Fairbanks	456-0218	Fish
David Wiswar	USFWS	Fairbanks	456-0459	Fish

BENTHIC MARINE HABITATS

Boulder fields/kelp beds were mapped in this Atlas. Boulder fields/kelp beds are areas of special concern in the Beaufort Sea because they are the only known areas with a hard substrate. The hard substrate allows the growth of kelp, soft corals, and anemones. As a result, numerous fish and invertebrates are associated with this habitat, prompting the state to classify the boulder fields as a Most Environmentally Sensitive Area.

Major Data Sources Used: Benthic Marine Habitats

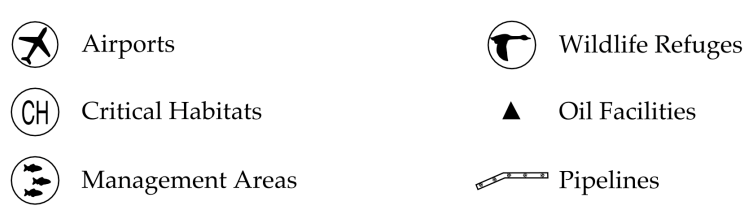
BP Exploration, 1998. Kelp beds and boulder patches. BP Exploration, Anchorage, digital vector data.

Expert contact for North Slope boulder fields/kelp beds is:

Name	Agency	City	Phone (907)	Species
Jack Winters	ADNR	Fairbanks	459-7285	Regional habitats/wildlife and fish species

HUMAN-USE RESOURCES

Management areas such as wildlife refuges, national park lands, and 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, oil facility), the exact location is shown as a small black dot and a leader line is drawn from it to the icon (shown below). Pipelines are mapped using arcs.



Airports: Locations of airports, airfields, landing strips, helipads, etc., whether they are manned or unmanned.

Critical Habitats: Areas managed or regulated by USFWS as designated critical habitat for the protection of fish and wildlife.

Management Areas: Areas managed by the U.S. Bureau of Land Management (BLM).

Wildlife Refuges/Wilderness Areas: Areas managed by the USFWS as National Wildlife Refuges or Wilderness Areas.

North Slope Alaska Oil Field Infrastructure: Oil field production facilities, pipelines, and airstrips.

Subsistence and Personal Use Harvest: Subsistence use of fish and wildlife resources play important economic and cultural roles in North Slope communities. Mapping subsistence use areas was beyond the scope of this project. The Alaska Regional Response Team (ARRT) North Slope Subarea Contingency Plan website provides further details and contact information for federal, state, regional, and local entities with information on subsistence use. http://www.akrrt.org/NSplan/D-Sensitive%20Areas.pdf. Maps regarding traditional whale hunting communities, locations of fishing and hunting cabins, and additional information may be available through the North Slope Borough and other local agencies.

Major Data Sources Used: Human-Use Resources

ADNR, 1995. Airports and runways. ADNR, Land Records Information, Anchorage, digital vector data.

ADNR, 2000. Administrative large parcel boundaries. ADNR, Land Records Information, Anchorage, digital vector data.

BP Exploration, Alaska (BPXA), 2003. North Slope Alaska oil field infrastructure. BPXA, Fairbanks, digital vector data.

USFWS, 2002. Alaska Maritime National Wildlife Refuge (NWR) boundary. USFWS, Division of Realty, Anchorage, digital vector data.

USFWS, 2003. Spectacled eider Critical Habitat – Ledyard Bay molting. USFWS, Fairbanks, digital vector data.

SEA ICE

Figure 1 displays the average "five-tenths ice concentration" boundaries for July, September, and November in Chukchi and Beaufort Seas (LaBelle et al., 1983). "Five-tenths ice concentration" signifies the ice concentration above which ice breaking vessels are needed for navigation, meaning that approximately 50 percent 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/northern side of the boundary lines has a sea-ice concentration of five-tenths or greater, indicating that ice coverage is greater than 50 percent, 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/southern sides of the boundary lines the ice concentration is five-tenths or less, indicating less than 50 percent 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, and as the ice begins to recede in the spring and summer, the lines move north. Ice typically begins forming in October/November in the study area and breakup begins in June/July.

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 seals, polar bears) are utilizing the shorefast and pack ice habitat, while species present in the same areas during the summer (e.g. waterfowl, beluga whales) 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 shows several recurring polynyas in Chukchi Sea. Leads and polynyas typically occur in late winter and early spring.

It is important to note that ice conditions can 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 Areas.

References:

LaBelle, J.C., J.L. Wise, R. P. Voelker, R.H. Schulze, G.M. Wohl. 1983. Alaska Marine Ice Atlas. University of Alaska, Arctic Environmental Information and Data Center, Anchorage, AK, 302 pp.

Stringer, W.J. and J.E. Groves. 1991. Location and areal extent of polynyas in the Bering and Chukchi Seas. Arctic 44(1):164-171

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.

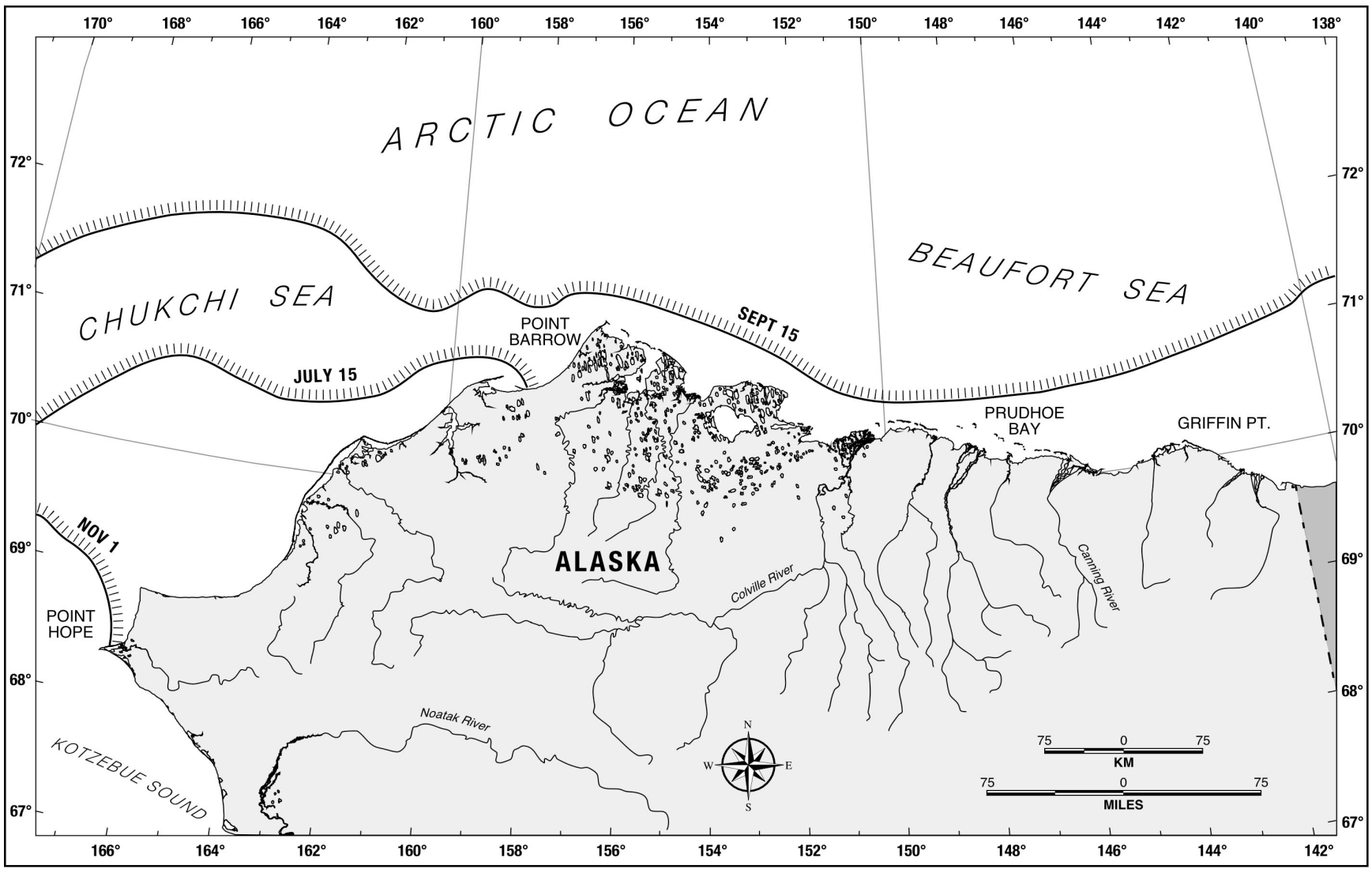
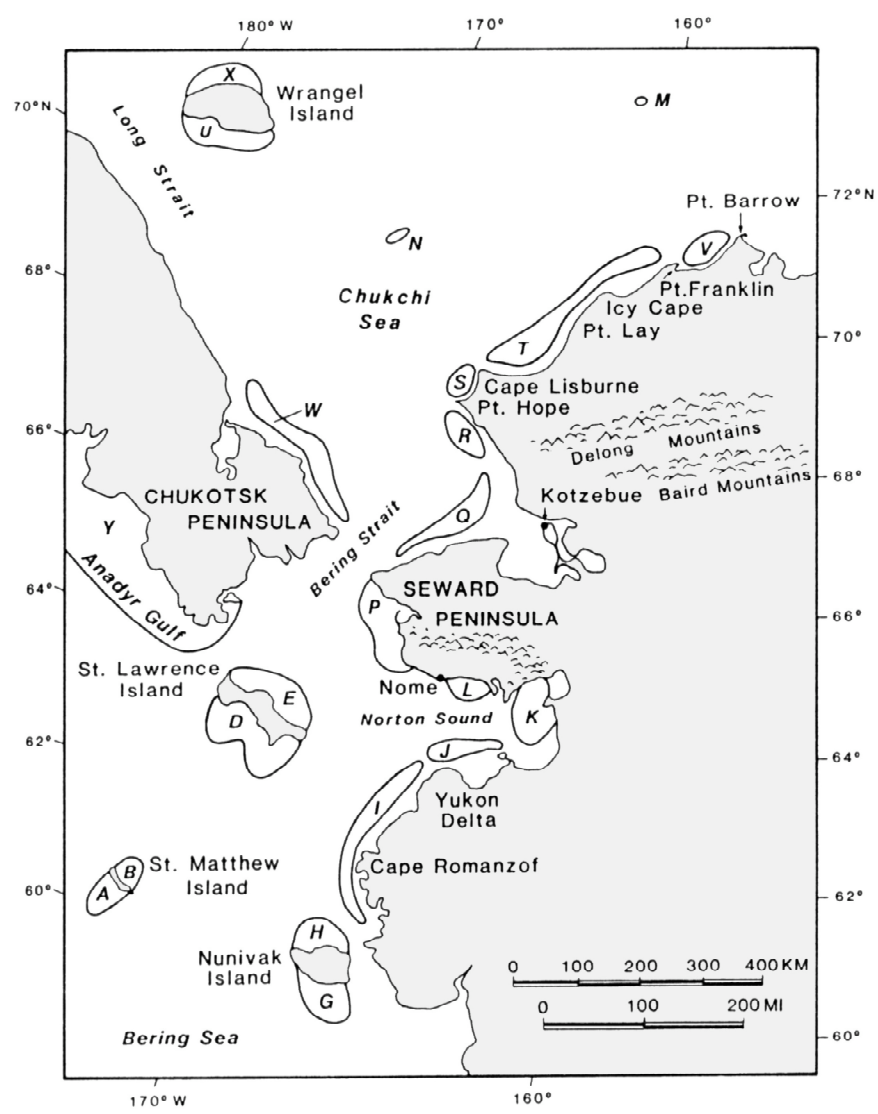


FIGURE 1. Five-tenths ice concentration boundaries for July, September, and November. Lines represent median position of five-tenths ice concentration boundaries. On average, sea water on the hatched side of a line has five-tenths ice coverage or greater on the date shown, and sea water on the unhatched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

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.

ACKNOWLEDGMENTS

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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 Boring. Jeff Dahlin, E. Lee Diveley, Katie Phillips, Jon Whitlock, Greg Whitson, and Mandie Minton entered, processed, and produced the GIS data and hardcopy atlas under the supervision of Mark White, GIS Director. Joe Holmes conducted the graphic art production, and along with 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, USGS, ADF&G, ADNR, North Slope Borough 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*
MARINE MAMMALS	
PINNIPED	
Bearded seal	*Erignathus barbatus*
Ringed seal	*Pusa hispida*
Spotted seal	*Phoca largha*
Walrus	*Odobenus rosmarus*
POLAR BEAR	
Polar bear	*Ursus maritimus*
WHALE	
Beluga whale	*Delphinapterus leucas*
Bowhead whale	*Balaena mysticetus*
Gray whale	*Eschrichtius robustus*
TERRESTRIAL MAMMALS	
BEAR	
Brown bear	*Ursus arctos*
UNGULATE	
Caribou	*Rangifer tarandus*
Muskox	*Ovibos moschatus*
BIRDS	
ALCID	
Black guillemot	*Cepphus grylle*
Common murre	*Uria aalge*
Horned puffin	*Fratercula corniculata*
Murre	*Uria sp.*
Pigeon guillemot	*Cepphus columba*
Thick-billed murre	*Uria lomvia*
Tufted puffin	*Fratercula cirrhata*
DIVING	
Loons	*Gavia spp.*
Pacific loon	*Gavia pacifica*
Pelagic cormorant	*Phalacrocorax pelagicus*
Red-throated loon	*Gavia stellata*
Yellow-billed loon	*Gavia adamsii*
GULL/TERN	
Arctic tern	*Sterna paradisaea*
Gulls	-
Glaucous gull	*Larus hyperboreus*
Pelagic cormorant	*Phalacrocorax pelagicus*
Sabine's gull	*Xema sabini*
Terns	-
PELAGIC	
Black-legged kittiwake	*Rissa tridactyla*
Seabirds	-
SHOREBIRD	
American golden-plover	*Pluvialis dominica*
Baird's sandpiper	*Calidris bairdii*
Bar-tailed godwit	*Limosa lapponica*
Black-bellied plover	*Pluvialis squatarola*
Buff-breasted sandpiper	*Tryngites subruficollis*
Dunlin	*Calidris alpina*
Long-billed dowitcher	*Limnodromus scolopaceus*
Pectoral sandpiper	*Calidris melanotos*
Red knot	*Calidris canutus*
Red phalarope	*Phalaropus fulicaria*
Red-necked phalarope	*Phalaropus lobatus*
Ruddy turnstone	*Arenaria interpres*
Sanderling	*Calidris alba*
Semipalmated plover	*Charadrius semipalmatus*
Semipalmated sandpiper	*Calidris pusilla*
Sharp-tailed sandpiper	*Calidris acuminata*
Stilt sandpiper	*Calidris himantopus*
Western sandpiper	*Calidris mauri*
Whimbrel	*Numenius phaeopus*
White-rumped sandpiper	*Calidris fuscicollis*
WATERFOWL	
Black scoter	*Melanitta nigra*
Brant	*Branta bernicla*
Common eider	*Somateria mollissima*
Geese	-
Greater white-fronted goose	*Anser albifrons*
King eider	*Somateria spectabilis*
Long-tailed duck	*Clangula hyemalis*
Northern pintail	*Anas acuta*
Red-breasted merganser	*Mergus serrator*
Scaup	*Aythya spp.*
Snow goose	*Chen caerulescens*
Spectacled eider	*Somateria fischeri*
Steller's eider	*Polysticta stelleri*
Surf scoter	*Melanitta perspicillata*
Waterfowl	-
White-winged scoter	*Melanitta fusca*

Common Name*	Species Name*
FISH	
Alaska blackfish	*Dallia pectoralis*
Arctic cisco	*Coregonus autumnalis*
Arctic cod	*Boreogadus saida*
Arctic flounder	*Pleuronectes glacialis*
Arctic grayling	*Thymallus arcticus*
Bering cisco	*Coregonus laurettae*
Broad whitefish	*Coregonus nasus*
Burbot	*Lota lota*
Capelin	*Mallotus villosus*
Chinook salmon	*Oncorhynchus tshawytscha*
Chum salmon	*Oncorhynchus keta*
Coho salmon	*Oncorhynchus kisutch*
Dolly varden	*Salvelinus malma*
Fourhorn sculpin	*Myoxocephalus quadricornis*
Humpback whitefish	*Coregonus pidschian*
Lake trout	*Salvelinus namaycush*
Least cisco	*Coregonus sardinella*
Ninespine stickleback	*Pungitius pungitius*
Northern pike	*Esox lucius*
Pacific herring	*Clupea pallasi*
Pacific sand lance	*Ammodytes hexapterus*
Pink salmon	*Oncorhynchus gorbuscha*
Rainbow smelt	*Osmerus mordax*
Round whitefish	*Prosopium cylindraceum*
Saffron cod	*Eleqinus gracilis*
Sockeye salmon	*Oncorhynchus nerka*
Starry flounder	*Platichthys stellatus*
Whitefish	-
HABITATS	
KELP	
Kelp	*Laminaria saludoncula*

* 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
- The substrate is impermeable with no potential for subsurface penetration
- They are seldom found in combination with another shoreline type, however they are often interspersed along the shore with wave-cut platforms and gravel beaches
- They occur along 1.8 % of the shoreline in the study area

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
- They occur along 0.05 % of the shoreline in the study area

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

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
- They occur along 11% of the shoreline in the study area

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 on the removal of oil from the upper swash zone
- Vehicular traffic and walking through back-beach habitats should be limited, to prevent contamination of clean areas and disturbance of back-beach 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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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
- They occur along 21.8 % of the shoreline in the study area

PREDICTED OIL BEHAVIOR

- 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
- They occur along 10 % of the shoreline in the study area

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
- Oil 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 of the loosely packed and permeable nature of these coarser-grained sediments; therefore, special care must be exercised at all times if 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 is preferred
- Vehicular traffic and walking through back-beach habitats should be limited, to prevent contamination of clean areas and disturbance of back-beach vegetation
- Sediment removal should be limited as much as possible; 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

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
- They occur along 21.2 % of the shoreline in the study area

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
- They occur along 0.5 % of the shoreline in the study area

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

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
- They occur along 0.05 % of the shoreline in the study area

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 weathered oil

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

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
- They occur along 13.8 % of the shoreline in the study area

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 limited access and 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

SHELTERED ROCKY SHORES AND SHELTERED SCARPS IN MUD AND CLAY **ESI = 8A**

DESCRIPTION

- These habitats include bedrock shores of variable slope (from vertical cliffs to wide, rocky ledges) that are sheltered from exposure to most wave and tidal energy
- They also consist of sheltered scarps in densely rooted and organic muds
- Attached biota may be plentiful and varied, especially in lower and mid-intertidal zones
- They occur along 0.04 % of the shoreline in the study area

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, eroded peat, and slurries of rafted peats
- 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
- They occur along 21.6 % of the shoreline in the study area

PREDICTED OIL BEHAVIOR

- 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, and are associated with another shoreline type on the landward side of the flat
- 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 occur along 19.6 % of the shoreline in the study area

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

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

DESCRIPTION

- These habitats include heltered banks of stream channels, canals, and other waterways
- They are 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
- They occur along 9.2 % of the shoreline in the study area

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

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 organic-rich muds
- They are typically sheltered from heavy wave energy
- They occur along 0.8 % of the shoreline in the study area

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 are 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 damage to the vegetation
- 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

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

DESCRIPTION

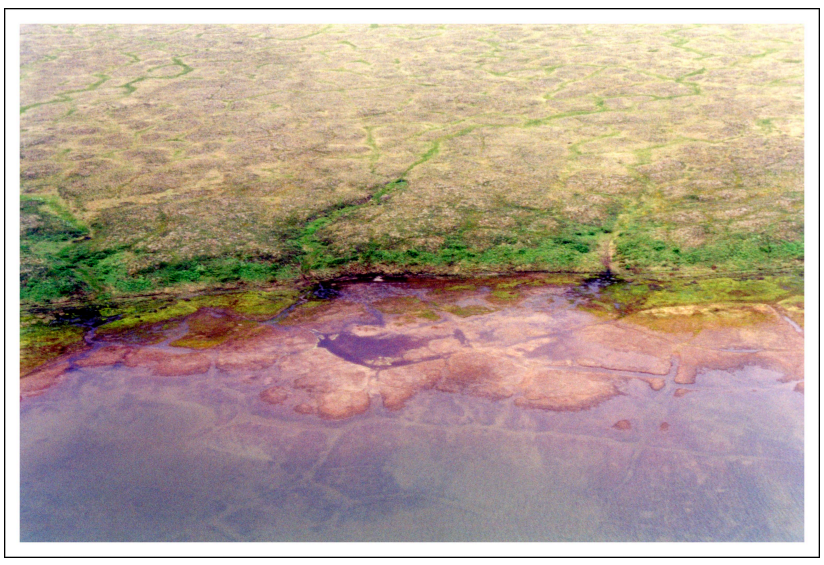
- This shoreline type occurs where very low-lying sections of the arctic shoreline have been recently flooded by the sea due to subsidence
- It also includes areas that are not normally in the intertidal zone but can be frequently inundated by salt water during springtides or wind-induced surges
- They 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
- They occur along 27 % of the shoreline in the study area

PREDICTED OIL BEHAVIOR

- 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