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OIL SPILL SENSITIVITY
OF COASTAL ENVIRONMENTS AND WILDLIFE
NORTON SOUND AND THE PRIBILOF ISLANDS, ALASKA

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EXECUTIVE SUMMARY

Environmental sensitivity maps of coastal Norton Sound and the Pribilof Islands were prepared for two purposes:

- 1) To aid decisions concerning outer continental shelf (OCS) lease sale 57.
- 2) To assist oil spill contingency planning for this region.

Funding was provided by the National Oceanic and Atmospheric Administration/Outer Continental Shelf Environmental Assessment Program (NOAA/OCSEAP), through interagency support by the Department of Interior, Bureau of Land Management. Apart from the text, a total of 65 maps (primarily 1:63,360 original scale) and a duplicate set of 50 percent black-and-white reductions were submitted.

The method used to illustrate oil-sensitive shorelines, wildlife, and socioeconomic features is called the Environmental Sensitivity Index (ESI). All shoreline types are ranked on a scale of 1 to 10, with the higher values being more sensitive to impact by spilled oil. Within the study area, marshes (ESI=10), sheltered tidal flats (ESI=9), sheltered rocky shores (ESI=8), and eroding peat scarps (ESI=8a), are the most sensitive. Location of oil-sensitive wildlife, particularly bird rookeries, salmon and herring spawning sites, sea and walrus haulout and pupping areas, and areas of known beluga whale residence or migration, are marked on the ESI maps by coded circles. Spill response measures are recommended for each shoreline type and major ecological group. Important socioeconomic features including coastal and near-shore mining areas, private lands, archaeological sites, and coastal airstrips are designated by decal symbols. The location for placing spill protection measures (in this case the use of booms and inlet closure) are also symbolized on the maps. Utilized geomorphic, biologic, and socioeconomic data were collected through an extensive literature search and more than one month of field work.

A total of 4,470 kilometers (km) of shoreline, from Cape Prince of Wales to Cape Vancouver, were mapped in Norton Sound. The most prevalent coast types are marshes (26.5%), exposed tidal flats (16.5%), and sheltered tidal flats (15%), because of the Yukon-Kuskokwim delta complex located along the southern edge of Norton Sound. Mixed sand and gravel beaches (12%) are particularly common along the northern and eastern portions of the study area. Eroding peat scarps (8.5%) and sheltered mixed sand and gravel beaches (7%) are less common, but are not restricted in locality.

Sensitive shoreline environments in Norton Sound include the Port Clarence embayment (a string of narrow lagoons be-

tween Cape Douglas and Cape Wooley) and Safety Sound. Sensitive areas in eastern Norton Sound include Golovin Lagoon, parts of Norton Bay (particularly Kwiniuk River and Inlet, Kwik River, a large delta marsh complex associated with Koyuk River, and a sheltered embayment located near Reindeer Cove), and the estuaries near Shaktoolik and Unalakleet. In addition, although ranked lower (ESI=7b), there is a large stretch of basaltic, boulder-dominated shoreline between Klititwik and Stuart Island which contains an extensive algal and epifaunal community.

Of all the areas studied, the Yukon-Kuskokwim delta along the southern edge of Norton Sound is by far the largest, most sensitive area. The extensive marshes and tidal flats along the delta margin support millions of birds which could be damaged in a spill. In addition to the long-term persistence of oil within sheltered areas of the delta front, the continual offshore transport of sediments from the delta provides a pathway to contaminate subtidal areas.

Major shoreline types on the Pribilof Islands are eroding, wave-cut platforms (55%), gravel beaches (15.5%), exposed mixed sand and gravel beaches (13%), and fine-grained sand beaches. Marshes and sheltered tidal flats are restricted to an area less than 1 km in length located near St. Paul. The priority, contingency plan problem involves protection of the enormous nesting bird and fur seal populations located on the islands. In all likelihood, preventing oil from impacting the shore will not be possible; however, hazing of birds and fur seals from heavily oiled areas and setting up of treatment centers may reduce losses. Dispersant application should be considered to prevent oil from impacting these important wildlife areas.

ACKNOWLEDGMENTS

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We would like to thank the many people who helped bring this project to completion. Dr. Paul R. Becker of the NOAA, Office of Marine Pollution Assessment (OMPA), Alaska office, is commended for his liaison activities between the Bureau of Land Management and Research Planning Institute, Inc. George Lapiene, also of the NOAA/OMPA Alaska office, very efficiently handled our logistical requests. NOAA Pilot Gary Van Den Berg and Mechanic Bob Neald kept us flying in spite of two major breakdowns. RPI staff who assisted include George Miles, Sydney Pearce, Joann Trauger, Len Mangum, Gene Speer, Susan West, and Starnell Perez, graphic artists; Scott Dinnel, computer specialist; Burk Scheper, photographer; C. Y. McCants, geologist; and Diana Gaines, Phyllis Carter-Frick, and Joanna Hooker, publication specialists.

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INTRODUCTION

This project was undertaken to aid in the environmental assessment of the Norton Sound area relative to upcoming Norton Sound outer continental shelf (OCS) lease sale 57, and in the preparation of regional oil spill contingency plans. This work represents a continuation of our shoreline studies in Alaska dating back to 1974. We have more recently begun using this mapping technique in the lower 48 states to provide the scientific support coordinator (SSC) with coastal environmental data during an oil spill (Fig. 1).

This investigation involved more than one month of field work during June and July 1980, and an extensive literature survey to collect relevant data on the physical and biological processes of the study area. The final product is an oil spill Environmental Sensitivity Index (ESI) which ranks shoreline environments on a scale of 1 to 10 in terms of potential spill-induced impacts. The locations of major spill-sensitive wildlife and important socioeconomic features are also indicated. Although the latter two components are not ranked, spill protection and response measures are recommended.

The area of study extends from Cape Prince of Wales south to Cape Vancouver, comprising a total of 4,670 km of shoreline represented on 65 (1:63,360 scale) topographic maps (Fig. 2). The Pribilof Islands, located on the outer edge of the Bering Sea shelf, were also mapped during this project (1:250,000 scale). Three copies of each map were made. The original topographic maps and one 50 percent black-and-white reduction were sent to NOAA/OCSEAP. RPI retains an additional reduction on file for reference.

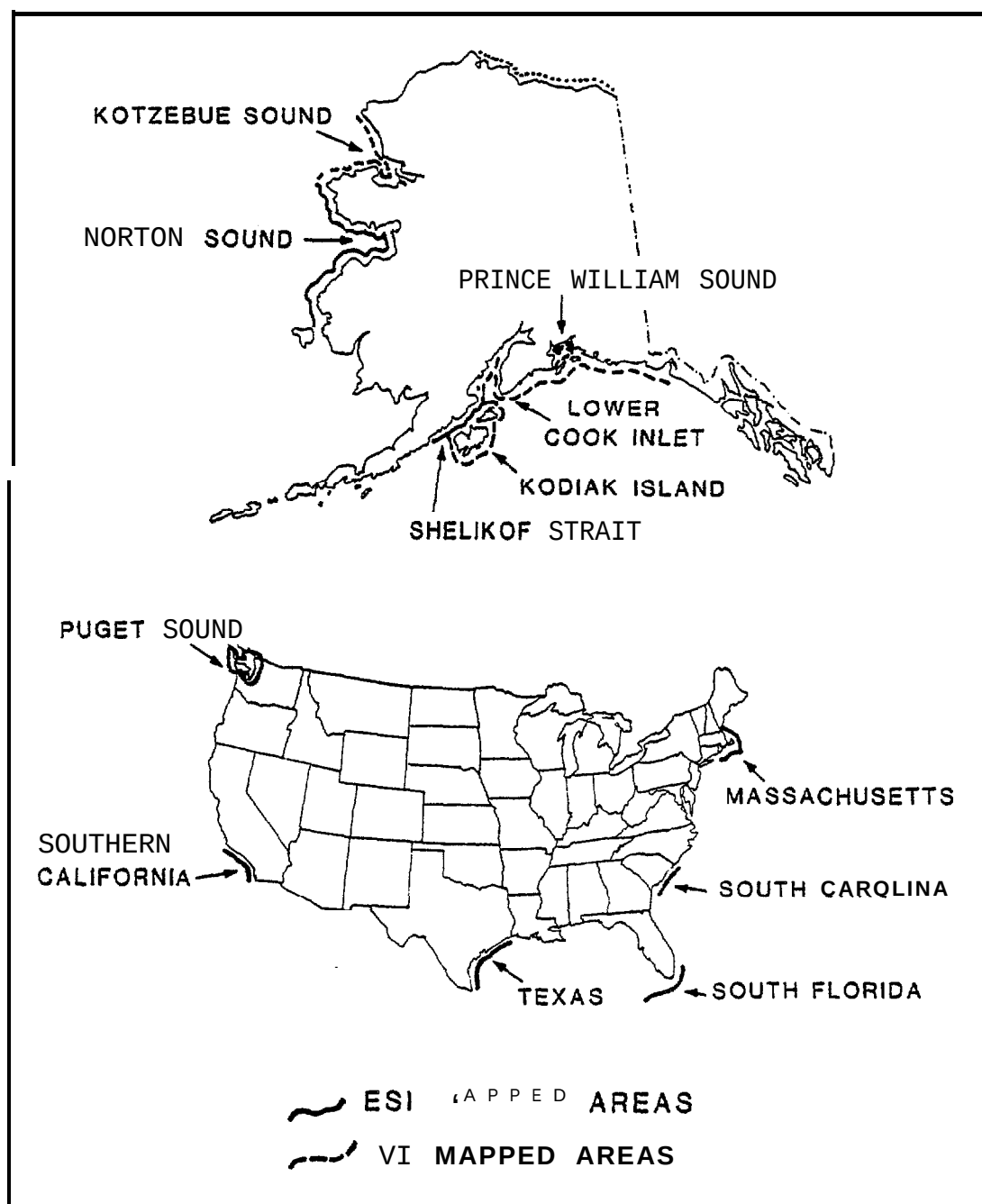


FIGURE 1. Areas in Alaska and the lower 48 states which have been mapped according to either the Vulnerability Index (VI, Gundlach and Hayes, 1978) or the Environmental Sensitivity Index (ESI, Hayes et al., 1980). The ESI includes the addition of critical biological and socioeconomic resources. The Beaufort Sea coastline was mapped by Nummedal and Ruby (1979) using a specially developed retention index.

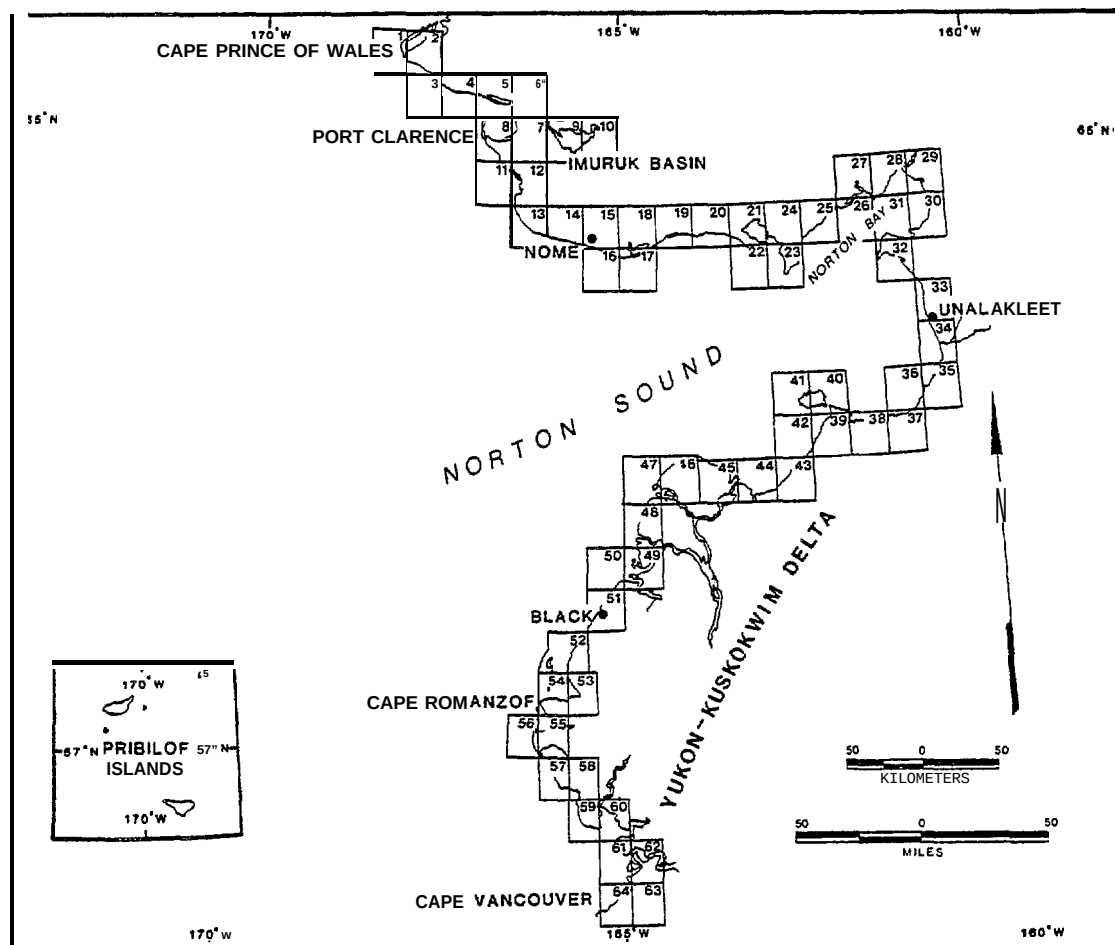


FIGURE 2. Location of ESI maps submitted as part of this project. All but the Pribilof Islands are on a scale of 1:63,360.

REGIONAL SETTING

Physiography

Norton Sound is a shallow (average depth=18 m; maximum depth=30 m), subarctic embayment located on the western coast of Alaska, south of the Seward Peninsula. It is rectangular in shape, measuring approximately 250 km in an east-west direction and 130 km north-south. A prominent feature on its southernmost limb is the active lobe of the Yukon River delta. The older Yukon-Kuskokwim delta complex continues south to the southern terminus of the study area, interrupted by two rocky outliers, Cape Romanzof and Cape Vancouver.

The four Pribilof Islands are small isolated points of land on the Bering Shelf, located approximately 500 km southwest of Cape Vancouver.

Climate

The climate of the study area is subarctic with the Bering Sea exerting a strong tempering influence. During the summer, air rises over the Alaska interior initiating onshore winds and generally a low-pressure system over Norton Sound. In winter, however, the region is influenced by high-pressure cells and the Aleutian Trough, an elongate low situated above the Gulf of Alaska. Interactions between these cells cause cyclones to pass through the Aleutian Trough, where they either stagnate or track northwest if forced by Pacific highs (Herman, 1974; Nummedal and Stephen, 1976) (Fig. 3).

Prevailing winds (summarized in Appendix II) blow from the north-northeast in northern Norton Sound at approximately 22 m/sec (11 kn), and from east-northeast at 19 m/sec (10.5 kn) in southern Norton Sound. Average daily air temperatures for Norton Sound range from about 20°C to -45°C. Annual mean maximum and minimum temperatures are 0.5°C and -7.0° for Norton Sound and 3.6° and -0.8° for the Pribilof Islands (AEIDC, NCC, 1977).

Total annual precipitation increases southward through the study area, from 41.5 cm at Nome to 64.1 cm at Cape Romanzof. Precipitation occurs primarily as snow during February in western Norton Sound and during April in the east. Most rain falls during late summer (August) for the entire region.

Precipitation patterns for the Pribilof Islands closely resemble those of the Norton Sound area, averaging about 62 cm annually (AEIDC, NCC, 1977). Climatic conditions are dictated by the open-ocean weather in the Bering Sea.

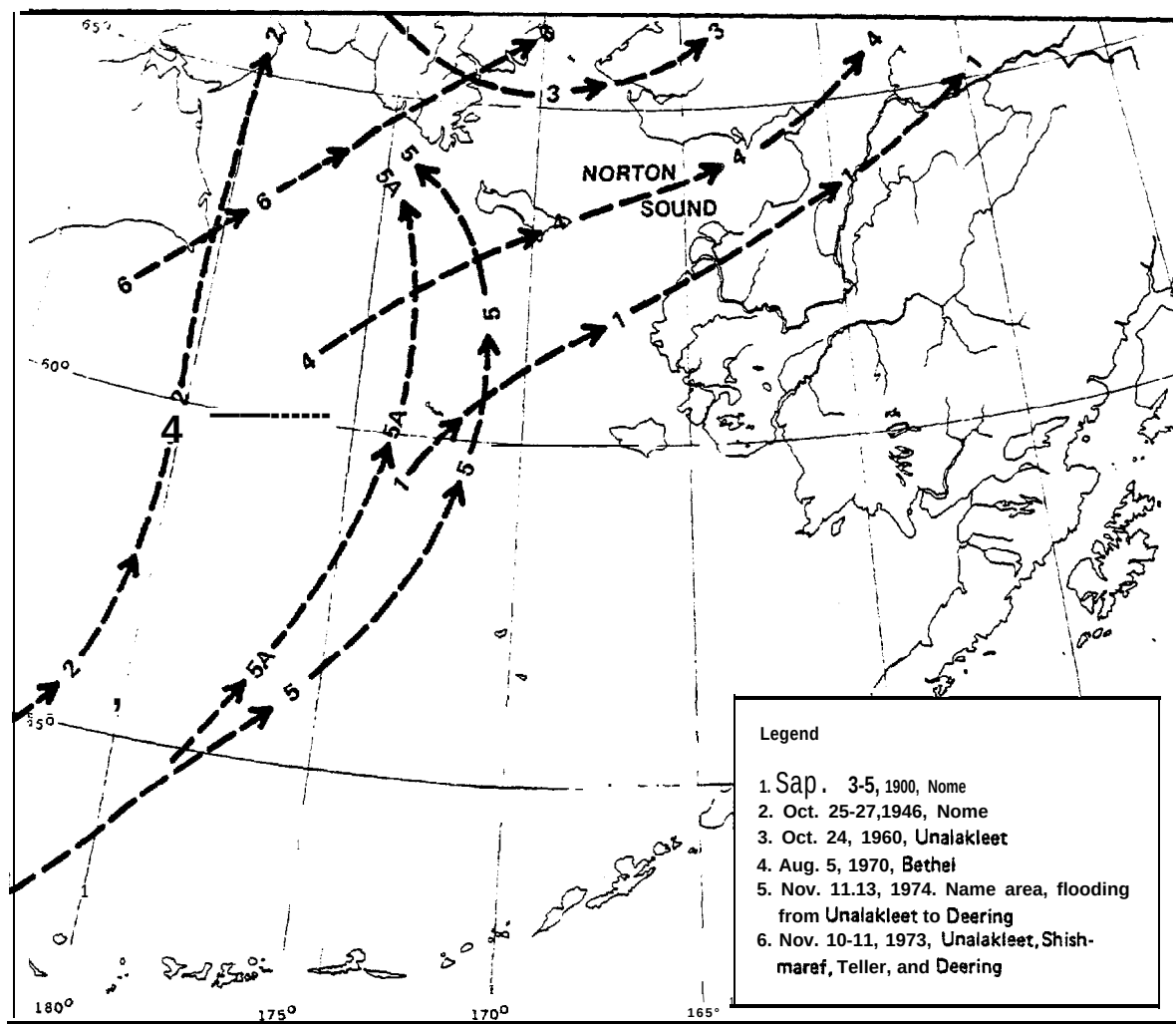


FIGURE 3. Tracks of major storms through Norton Sound which caused major storm surge and extensive flooding (AEIDC, NCC, 1977; also see Appendix I). Note these storms all occurred within the storm-domination period from late August to mid-November.

Bedrock Geology and Geologic History

The region is composed of 2300-2500 m of nonmarine and transitional sedimentary deposits of the Cenozoic Norton Basin, nonconformably overlying an acoustic (igneous or metamorphic) basement (Scholl and Hopkins, 1969). Principal studies of the bedrock geology have been depositional and tectonic interpretations of seismic records (Scholl and Hopkins, 1969; Nelson et al., 1974; Marlow et al., 1976).

Regional stratigraphic patterns suggest the Norton Basin is composed of three depositional packages separated by unconformities. The lowermost unit is a nonmarine sandstone similar to the onshore Koyukuk geosynclinal rocks (Cretaceous) and is topped by an erosional surface. It is covered by a broad, northwest-trending synclinorium of indurated sandstones and shales deposited during Late Miocene submergence. This unit is capped by flat-lying marine and glaciomarine sandstone and shale of probable Late Tertiary and Plio-Pleistocene age.

In the vicinity of Norton Sound, older rocks are covered with a thin veneer of Quaternary sediments. North of Unalakleet, these are mostly outwash/fan delta deposits from the adjacent mountains or fluviodeltaic sediments near the mouths of river systems. From Unalakleet to Pastel Bay, young basalt flows cover much of the coastal area. South of Pastel Bay, Quaternary surface deposits are derived from the Yukon-Kuskokwim delta complex which provides more than 90 percent of the sediment and nutrients to the northern Bering Sea (Dupré, 1978).

Major faults and fold axes in this region trend northwest, parallel to the axis of Norton Basin. This pervasive, structural grain has initiated widespread Quaternary vulcanism and hydrocarbon seeps (Cline and Holmes, 1977). Many of the faults in this region appear active, particularly those in the Port Clarence area and along the Kaltag Fault, a major transcurrent fault in western Alaska. Geologic maps of the study area are included in Appendix III.

Permafrost is extensive (maximum depth=200 m) but discontinuous, and several episodes of thermokarstification (the process of ground settling due to the melting of ground ice) have been noted (Dupré, 1978).

Oceanographic Conditions

Waves

The wave climate of the Norton Sound study area is determined mainly by swell generated in the central and southern Bering Sea. Wave refraction and frictional energy dissipation greatly reduce the magnitude of these waves as they travel over the wide Bering Shelf (Sallenger et al., 1978). The resulting fair-weather surface waves are small (>0.5 m amplitude, period=6 sec). Monthly wave data are summarized in Figure 4.

Around the Pribilof Islands, waves generally range from 1 to 3 m with storm waves commonly exceeding 8-10 m. Waves usually approach from the northwest during summer and early fall. They approach from the east for the remainder of the

FIGURE 4. Wave and height approach direction data for the ice-free season in Norton Sound (from AEIDC, NCC, 1977). During spring and early summer, dominant wave approach for Norton Sound and the Yukon-Kuskokwim Delta region is from the easterly quadrant. Waves only rarely exceed 3 m in height. In late summer, average wave heights increase by 1-3 m and approach from the northerly quadrant, and to a lesser extent from the west during October and November. storms from the north and west generate waves greater than 6 m in height. The wave climate for the Pribilof Islands area shows a slightly dominant, westerly approach which shifts to northerly in the fall. Average wave heights are 1-2 m higher than Norton Sound, and storm waves are more likely to occur at any time during the season.

DIRECTION FREQUENCY TOP SCALE: BARS REPRESENT PERCENT FREQUENCY OF WAVES FROM EACH DIRECTION.
 HEIGHT FREQUENCY BOTTOM SCALE: PRINTED FIGURES REPRESENT PERCENT FREQUENCY
 OF WAVE HEIGHTS OBSERVED FROM EACH DIRECTION.

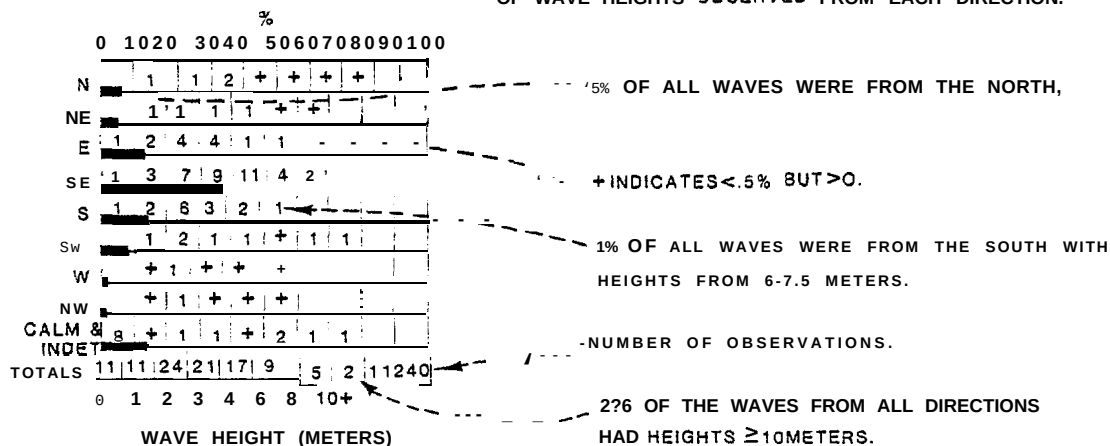
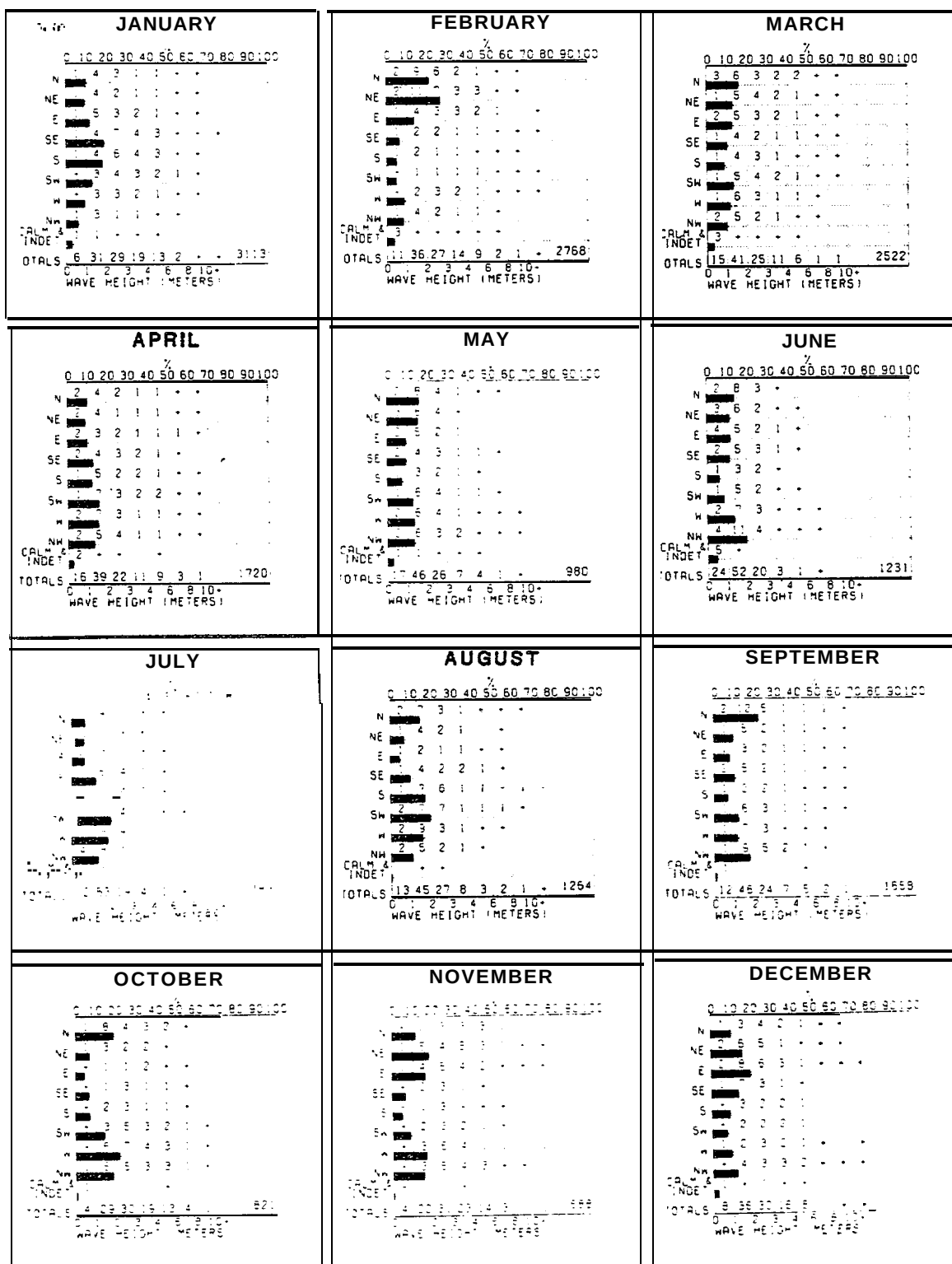


Figure 4



year. During spring, no dominant direction of wave approach is evident. Storm waves generally come from the west or southwest.

Tides

Tides in Norton Sound are extremely variable and complex, and generally show a range of about 1 m (Leendertse and Liu, 1978; Schumacher et al., 1978; NOS, 1979) (Fig. 5). They are primarily semidiurnal-mixed to semidiurnal. In spite of the low amplitude, tidal variation drives the ambient water circulation throughout Norton Sound and the Bering Sea (Drake et al., 1979). On St. Paul Island in the Pribilofs, tides are semidiurnal and range up to 1 m.

Currents

Current patterns in Norton Sound and the adjacent Bering Sea (Fig. 6) illustrate a complex interaction of storms, tidal flux, and wind-driven and thermohaline circulation.

The Norton Sound water body is a 2-layer structure with a pronounced pycnocline, or density gradient. In the eastern and southeastern portion of the sound, convection currents during winter ice formation generate a deep, cold, saline water mass. Circulation within this water body is westward and of negligible velocity. Vertical diffusive flux is very slow such that this water mass persists throughout the summer. Above the pycnocline is a warm, low-salinity water mass derived from adjacent land runoff (Schumacher et al., 1978). The two water masses are not as well defined in the western portion of Norton Sound. In western and central Norton Sound, vertical turbulence has an homogenizing effect, overcoming the density gradients caused by the influx of abundant surface water introduced by the Yukon River.

During fair weather, most warm surface water moves out of the sound and into the Chukchi Sea by the northerly Bering Sea circulation (Coachman et al., 1975). These currents sweep a wide, counterclockwise surface gyre in the western two-thirds of the sound, effectively isolating the eastern portion of the sound from the general circulation pattern (Coachman et al., 1977; Cline and Holmes, 1977; Schumacher et al., 1978). A weak bottom current flows eastward in the northwest area of the sound. These currents do not always bear an Ekman relationship with winds (Coachman et al., 1977) and are probably tidally induced (Drake et al., 1979). In addition, Bering Sea currents demonstrate a northward, venturi-velocity increase from 5 cm/sec at St. Lawrence Island to 15 cm/sec in the Bering Straits as a consequence of the narrowing of the basin cross-sections (Muench, 1977). During prefreezeup, late summer storms and high-velocity (55 cm/sec), wave-generated bottom currents initiate a 2-fold increase in turbidity by re-suspension of bottom muds (Cacchione and Drake, in press).

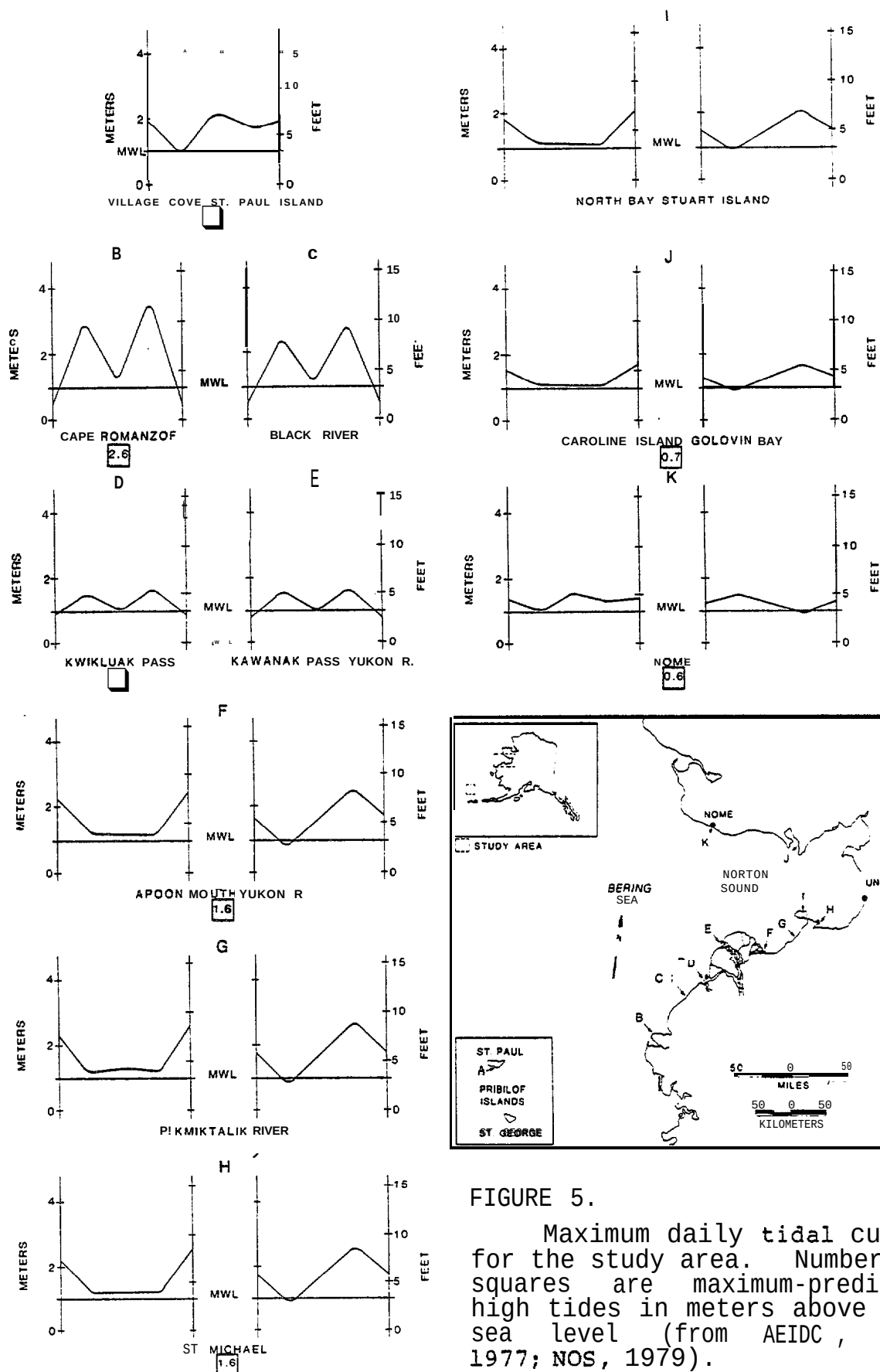


FIGURE 5.

Maximum daily tidal curves for the study area. Numbers in squares are maximum-predicted high tides in meters above mean sea level (from AEIDC, NCC, 1977; NOS, 1979).

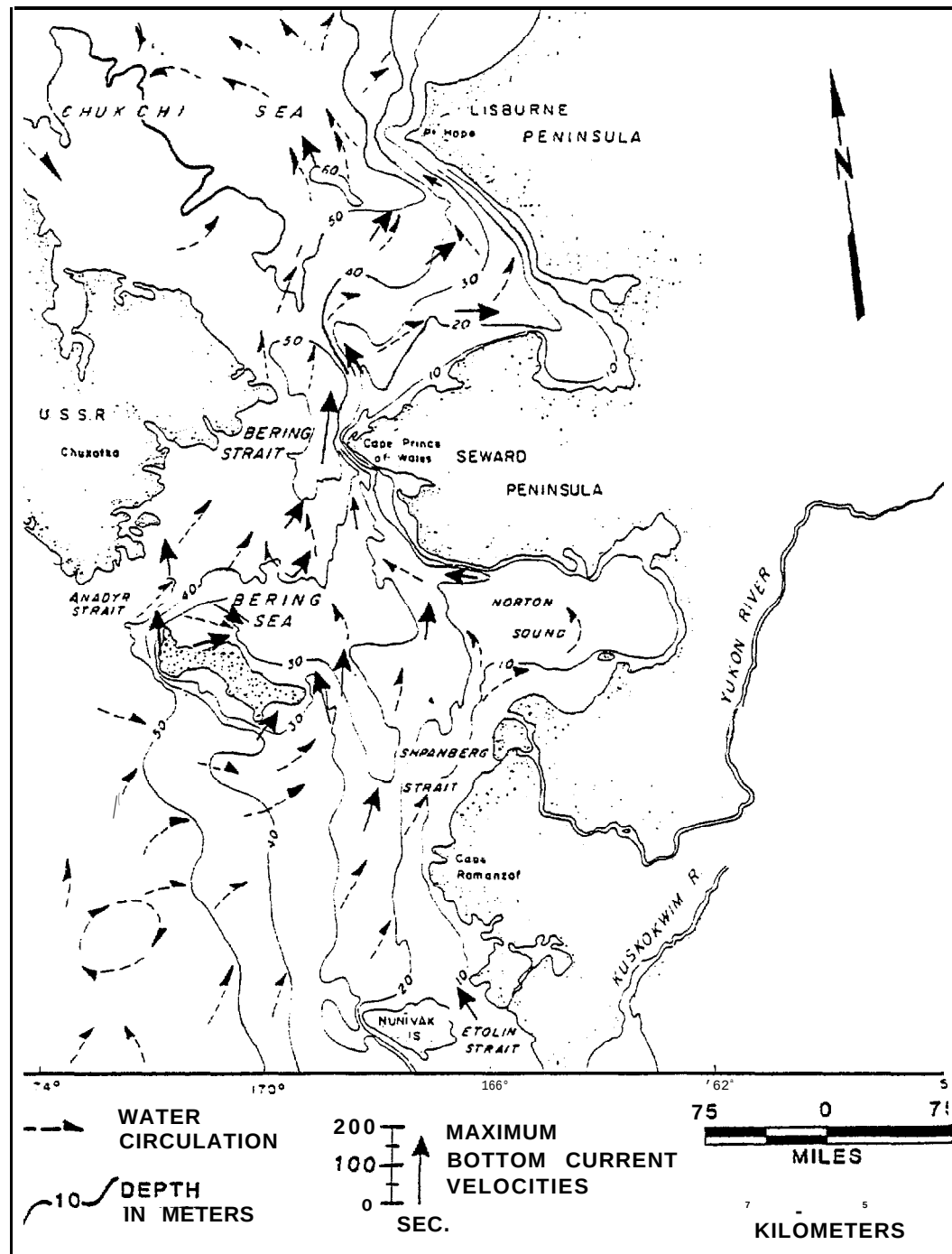


FIGURE 6. Bathymetry and general patterns of water circulation for the Norton Sound region (from Herman, 1974). Note the northerly-trending current gyre in Norton Sound generated by northward water movement on the Bering shelf.

During the icebound season (November through May), gross water circulation patterns beneath shorefast and pack ice are similar to those operative in fair weather, but net current energy is decreased two to five times. This is presumably due to the ice-damping effects on tidal variations as well as shielding of the sea surface from wind. The northerly Bering Sea circulation has been observed west of the Yukon delta and Cape Prince Wales to reverse 180° on four- to six-day intervals during the winter months (Schumacher et al., 1978). General water-circulation patterns during the winter months are not well understood.

Seasonal Variations

Investigators of coastal processes in the study area recognize the control exerted by storms, ice formation and dynamics, and sediment input from the Yukon delta complex on the shoreline geomorphology of Norton Sound (Cacchione and Drake, 1978; Dupré, 1978; Sallenger et al., 1978). Owing to the seasonality of these factors, each dominates for only a portion of the year.

Storm Domination (late August to mid November). - During this period, there is a decrease in river discharge and an increase in the frequency and severity of southwesterly storms and storm surge. Longshore transport is primarily active during storms and is northerly dominant (Sallenger et al., 1977) (Fig. 7). Resuspension of bottom sediments is widespread during storms, and the presence of large-scale, mobile bedforms indicates tractive bottom currents induced by storm waves (Nelson and Thor, 1978). Dupré (1978) reports extreme seasonal rates of shoreline erosion (1-60 m) from storms. Storm-surge flooding can proceed inshore up to 15 km in the Yukon delta region (Dupré, 1978) and, elsewhere in Norton Sound, can deposit storm berms and debris up to 4.75 m above mean water level (Sallenger et al., 1978).

Ice Domination (late November to mid May). - In Norton Sound, ice first forms in shallow nearshore bays and later in the center of the sound (Muench and Ahlnas, 1976) (Fig. 8). All varieties of ice present within the sound form in place, none being transported in from the Bering Sea. Shorefast ice forms a shelf that reaches a maximum width (15-30 km) on the southern shore, insulating the coast from all storm effects except major surges which can transport ice inland. The patterns and movement of pack and shorefast ice vary with wind and water circulation. Bottom sediments are reworked beneath the ice by ice gouging at zones of shear (Nelson and Thor, 1978) and by floating fast ice pumping, while tidal currents running between floating shorefast and bottomfast ice keep sediment in suspension (Reimnitz et al., 1977). Subice channels associated with rivers are active and sediment-laden (Dupré, 1978).

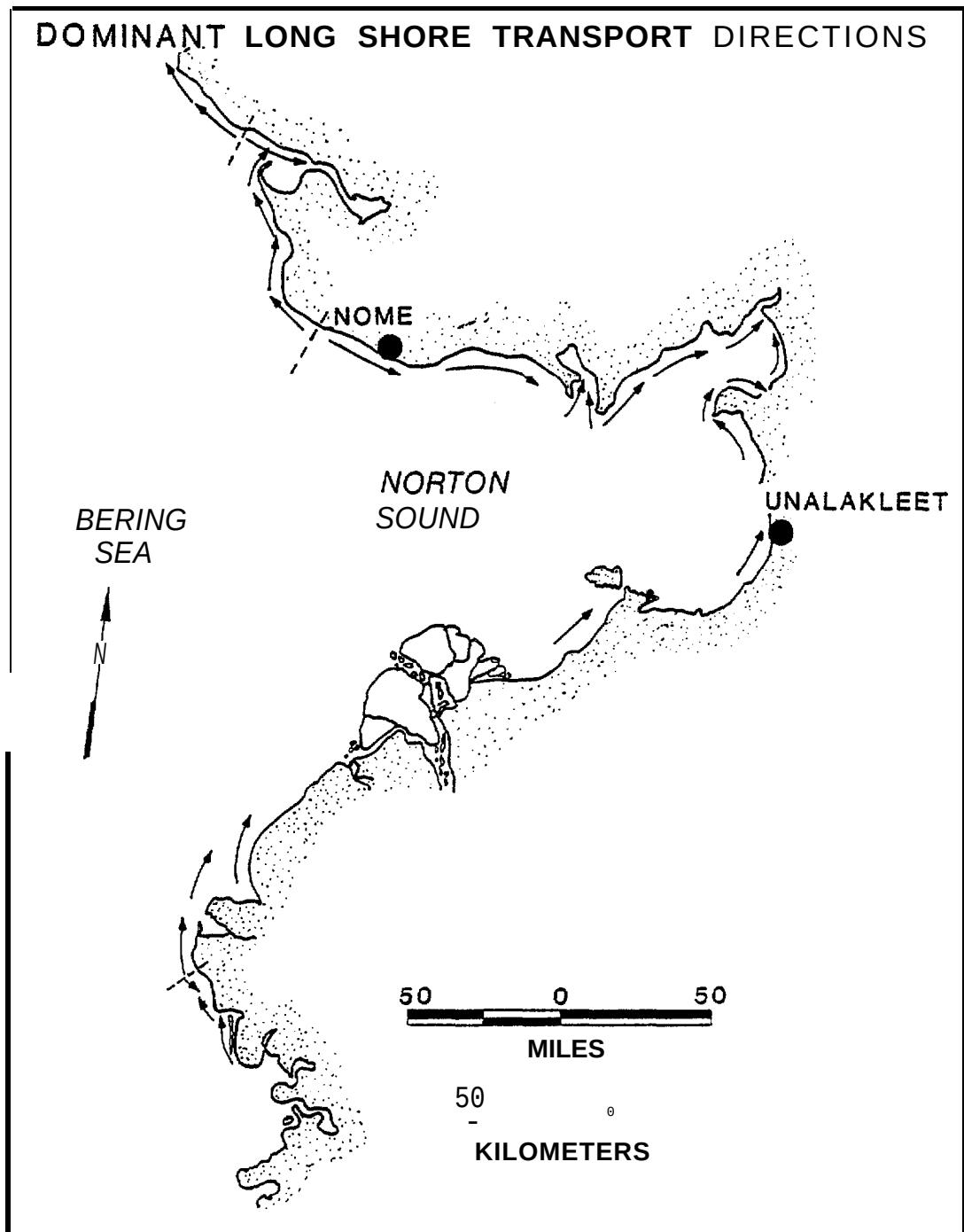
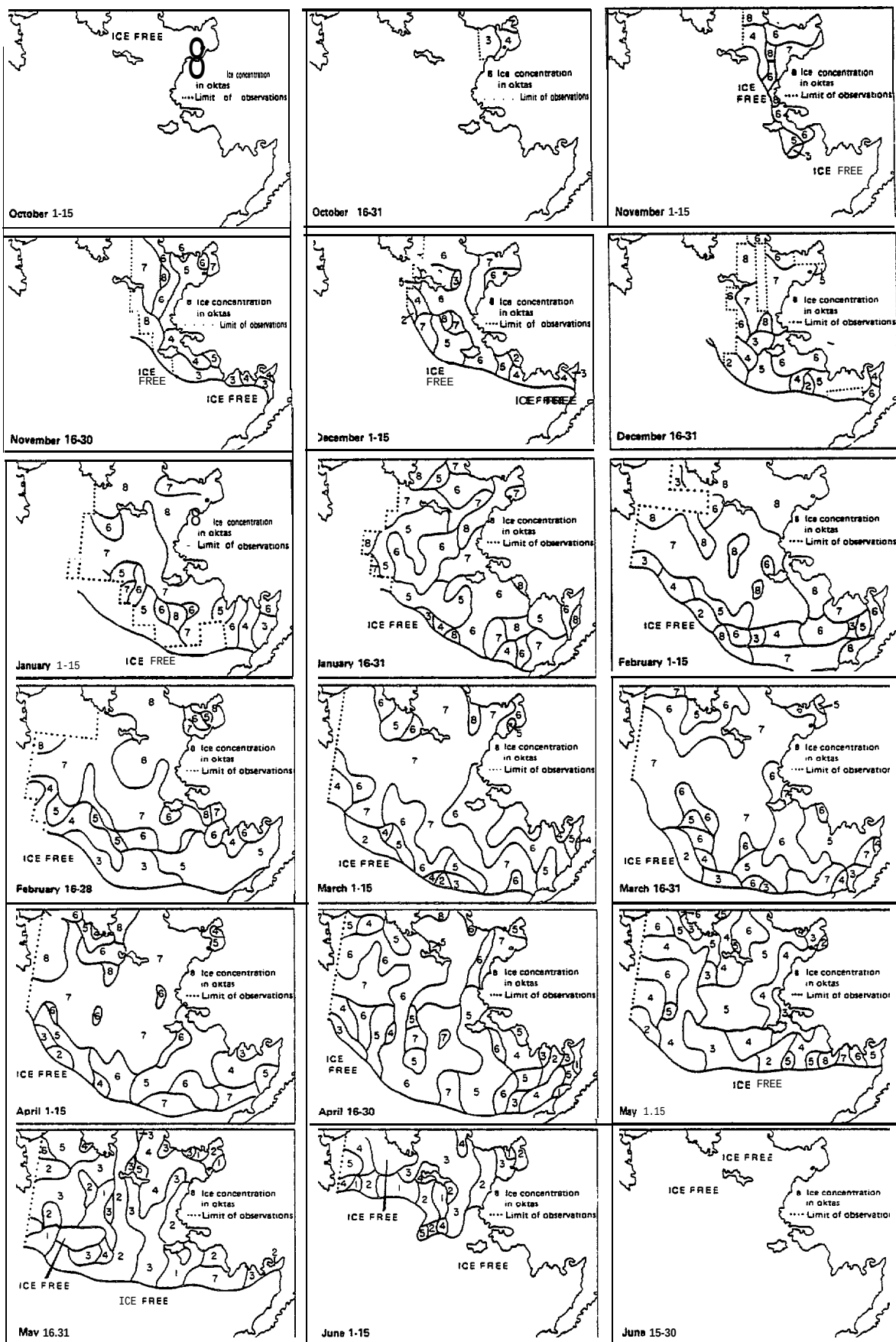


FIGURE 7. Dominant directions of longshore transport as interpreted from the orientation of coastal depositional features. Longshore transport is northerly dominant (from Sallenger et al., 1977).

FIGURE 8. Annual distribution of sea ice in Norton Sound and the northern Bering Sea (from AEIDC, NCC, 1977). Ice concentration is reported in oktas where eight oktas equal 100 percent aerial coverage. Sea ice forms initially in eastern Norton Sound and Norton Bay, where the salinity is lowest and where mixing with open ocean water is minimal (see Fig. 6). The Norton Sound area ices two to six weeks earlier than the rest of the Bering Sea, owing to the proximity of a high-albedo land mass. It averages greater than 50 percent sea ice coverage from November until May. Spring melt begins earlier in the south due to influx of Yukon-Kuskokwim river flow.



River Domination (late May to mid August}. - Following spring breakup, the wave regime of Norton Sound decreases, initiating a period in which coastal processes are dominantly **depositional**. High sediment input from the Yukon River causes accretion of distributary mouth bars and progradation of intertidal mud flats. Much of the Yukon sediment is transported into the sound as bedload via the main Yukon distributary channels or in a plume of suspended sediments that may extend 50 km offshore. Accretion at the mouth of the delta approaches 40 m/yr.

Coastal Geomorphology and Sediment Transport

The coastal geomorphic features of Norton Sound and vicinity indicate the importance of storm events. Shorelines are generally either abrupt, steep cliffs and bluffs eroded into bedrock, tundra mounds, or basalt flows. Narrow, sand and gravel beaches commonly fringe the coast, and spits enclose marsh and lagoonal complexes. Exclusive of the Yukon-Kuskokwim delta region, Norton Sound intertidal sediments tend to be primarily coarse-grained, mixed sand and gravel. Storm berms are common 3.0-4.5 m above mean water level, reflecting major shoreline modification during storms. The coastal geomorphology of the Pribilof Islands is indicative of higher wave energy conditions. The majority of these shorelines is mixed gravel/boulder beaches.

Depositional-type coasts are common only in sheltered areas or near river systems (such as the Yukon-Kuskokwim delta) where broad intertidal mud flats, chenier plains, low unvegetated barrier islands, and a few sand or gravel beaches are present. The relative stability of these environments is controlled by: (1) proximity to the sediment source (mouths of major distributary channels), (2) the sheltering effects of headlands or offshore islands, (3) proximity to laterally migrating tidal inlets, and (4) local tectonics. Along the Yukon-Kuskokwim delta, Dupré (1978) measured rates of erosion and deposition up to 100 m/yr.

Nearly all the recent sediment entering Norton Sound is supplied by the Yukon River. The bulk of this sediment is transported north across the Bering Shelf and into the Chukchi Sea (Drake et al., 1979). However, there is abundant Yukon-derived mud in the eastern portion of the sound. The transport mechanisms responsible for this sedimentation are not well understood, but storms are probably responsible as there is little continuity between the Yukon River sediment plume and areas of recent sediment accumulation in eastern Norton Bay (Schumacher et al., 1978). Storms also generate fairly high velocity, bottom currents in areas southwest of the Yukon

delta, Nome, and Cape Prince of Wales where megaripples and sand waves have been observed (NOAA/ERL, Alaska BLM, 1977).

Biological Setting

The Norton Sound area contains two physiographic provinces: (1) the Seward Peninsula Province which includes Cape Prince of Wales in the north extending south to the northern half of Norton Sound, and (2) the Bering Shelf Province which includes the southern half of Norton Sound just east of Stuart Island extending south to Kuskokwim Bay.

Seward Peninsula Province

The Seward Peninsula Province is a broad interior area of hills and plains (range 150-600 m in altitude) with scattered groups of mountains (Gusey, 1979). Numerous streams flow from the interior through steep valleys into deltas of the coastal lowlands. Coastal lowlands contain many thaw lakes and occasional rock-basin, morainal, and volcanic-crater lakes. Permafrost underlies much of the area. Coastal vegetation includes (1) "wet tundra" vegetated with low sedges and grasses in the northwestern peninsula, and (2) "moist tundra" vegetated with moss, sedges, low shrubs, and lichens in the southern peninsula. Higher slopes of coastal lowlands contain both "dry tundra" vegetated with lichens, heaths, and dwarf shrubs and "high brush" vegetated with willow thickets, balsam poplar groves, and dwarf shrubs.

Coastal shoreline habitats are ice-covered for most of the year. The intertidal fauna and flora which are present have adapted to compensate for the rigors of the environment. Ice scour combined with the low tidal range and unconsolidated beach sediments may eliminate many species of flora and fauna normally found in both intertidal and shallow subtidal habitats not exposed to these stresses (McCroy and Allen, 1974).

Bering Sea Province

The Bering Shelf Province is a submerged level plain which includes the Yukon-Kuskokwim delta region, a large lake-dotted marsh area which rises to an elevation of 100 m in the east. More than one-third of these coastal lowlands are lakes. The Yukon and Kuskokwim Rivers wind through these lowlands, building large delta complexes into the Bering Sea. These deltas contain extensive wet tundra, aquatic, and marsh communities. According to Gusey (1979) who summarized most of the existing biological data for the Norton Sound region, delta uplands support moist tundra and high brush habitats similar to those of the Seward Peninsula. The aquatic portions of the wet tundra are less productive than subaerial interior portions; however, the presence of large numbers of

lakes which are very productive habitats compensate for this deficiency. Most of the delta is treeless, willow and alders being the only large woody plants present. Alpines, willows, sedges, and other tundra vegetation are found closer to the coast.

These coastal tundra areas and tideland fringes of the Kuskokwim and Yukon delta region support perhaps the world's largest waterfowl populations. The tidal habitat of the Clarence Rhodes Wildlife Refuge contains densities of more than 200 black brant and geese per square mile. All the whistling swans and the majority of the emperor and cackling geese are found in the delta area. Additionally, the majority of the black brant population and most of the white-fronted geese of the Pacific Flyway are found here. Over 12 million ducks comprising 19 species nest on the delta. Three species (greater scaup, pintail, and old squaw) make up 75 percent of this total. The delta is one of most important greater scaup nesting areas. Other duck species include American widgeons, green-winged teals, mallards, scoters, and eiders (Gusey, 1979).

By far, the heaviest utilization of the Yukon delta is by shore birds. An estimated 100 million shore birds either nest on or migrate to the Yukon delta (Gusey, 1979). Gill and Handel (USFW memo, undated) indicate that millions of shore birds use the intertidal area of the Yukon River. Dunlins and western sandpipers are the two most common shore birds. Although 136 species of birds are estimated to nest on the Yukon delta, only 13 species are present during the winter (ADF&G, 1977c, 1977d; Gusey, 1979).

Coastal shoreline habitats of the Bering Sea are also affected by ice scour, but to a lesser extent than in the more northerly Seward Province. Along the southern edges, sea scour is confined to the intertidal zone, which allows for partial recolonization by shallow subtidal fauna during the spring and summer. In the more northern areas, sea ice scour extends into shallow subtidal habitats, which may prevent recolonization of the intertidal zone. Our observations indicate increased abundance of fauna and flora in the southern part of Norton Sound as compared to the northern portion.

Previous zoogeographic studies indicate that the Norton Sound region is not well understood in terms of faunal and floral distributions. Forbes (1859) reported an Arctic Province extending from the northern coast of Alaska to a point just south of the Bering Strait. Zenkevitch (1963) also noted that many Arctic Province species are found in subarctic and boreal (northern) environments. Stephenson and Stephenson (1972) have described a distinct faunal Bering Province north of the Alaskan peninsula. Earlier work by Andriashev (1939) delineated an Aleutian Province which included an area extending north from the Aleutians to Cape Romanzof. Valentine

(1966) concluded that the northern boundary for the Aleutian Province was at Nunivak Island (at about 60° N latitude) based upon the distribution of molluscs. This may conform to a mean southern limit of pack ice during January and February. Thus, arctic waters appear to come far enough south to form a temperature barrier at Nunivak Island (Briggs, 1974), although there are some arctic-boreal species which are eurythermal (able to withstand large temperature variations) and have continuous range throughout the Bering Sea.

An additional factor, other than ice scour, affecting the distribution and density of fauna and flora in this region may be the close proximity of boreal (north temperate), range-extended species of the Pacific Ocean which extend into Bristol Bay and portions of Norton Sound (Ekman, 1953). This may partially explain some of the more lush fauna observed in the southern portion of Norton Sound. However, the exact limits of this boreal-Pacific range extension are unknown.

The zoogeographic boundaries of the Arctic and Aleutian Provinces are not exact and may vary depending upon climatic events. Norton Sound appears to lie between the northern boundary of the Aleutian Province and the southern boundary of the Arctic Province. Observations and data from this study indicate a richer faunal community in the southern portion of Norton Sound, which may represent some overlap of Aleutian Province fauna in this region.

METHODOLOGY

The Environmental Sensitivity Index (ESI) Concept

The need for a rapidly applied and easily understandable system of representing shoreline environments in terms of potential oil spill damage became evident after viewing the effects of several large oil spills in South America, Europe, and the United States (see Table 2). In each case, there was no effective contingency plan.

The first application of the sensitivity index concept by our group was made while mapping the coastline of lower Cook Inlet, Alaska, in 1976 (Hayes et al., 1976; Michel et al., 1978). That study defined an Oil Spill Susceptibility Index, which was based primarily on "the physical longevity of oil in each environment in the absence of cleanup efforts." This same principle was used by Nummedal and Ruby (1979) to map the Alaskan portion of the Beaufort Sea. Gundlach and Hayes (1978b) expanded the concept to include biological considerations pertaining only to each shoreline type. This expanded index, called the Oil Spill Vulnerability Index, was used to map several additional areas in Alaska (e.g., Ruby and Hayes, 1978).

The ESI used in this report integrates geomorphic and biological factors which developed out of NOAA-sponsored mapping projects in Prince William Sound, Alaska (Hayes, Ruby, and Maiero, principal investigators), and Puget Sound, Washington (Gundlach et al., 1980). The shoreline is biologically characterized in much greater detail than with the Vulnerability Index, and the locations of coastal wildlife are marked by symbols. Symbols are used specifically to designate areas critical to certain fishes, birds, and marine mammals for reproduction and/or feeding (Getter et al., 1981). These symbols also include the seasons in which these species are usually present.

Important socioeconomic considerations, such as marinas, park lands, and coastal lease areas, were first incorporated into the ESI mapping project in Puget Sound and more recently in Texas (Hayes et al., 1980). This Alaska work further advances this concept by designating offshore-mining lease sites, archaeological sites, private properties, and bush airstrips.

ESI maps were first tested during a major oil spill following the IXTOC I blowout in the Gulf of Mexico. The ESI maps became an integral part of the overall federal response plan to protect the south Texas coast, providing the scientific basis for setting protection priorities and cleanup strategies (Gundlach et al., 1981). Since then, ESI mapping has been carried out in southern Florida, Massachusetts, South Carolina, central and northern Texas, southern California, Shelikof Strait, the Pribilof Islands, and Norton Sound.

TABLE 2. The ESI predicts the potential sensitivity of coastal environments and wildlife to spilled oil. These predictions are based upon observations made at the following oil spills.

OIL SPILLS	DATE	TYPE AND AMOUNT	STUDIES
WW II Tankers U.S. East Coast	Jan.-June 1942	Various; 533,740 tons .	Campbell et al. (1977)
TORREY CANYON Stilly Isles, U.K.	Mar. 1967	Arabian Gulf crude; 117,000 tons total; 18,000 tons onshore	Smith (1968)
Santa Barbara Blowout	Jan. 1969	California crude; 11,290 to 112,900 tons total; 4,509 tons onshore	Foster et al. (1971)
ARROW , Chedabucto Bay, Nova Scotia	Feb. 1970	Bunker C; 18,220 tons total	Owens (1971); Vander- muelen and Gordon (1976)
METULA, Strait of Magellan, Chile	Aug. 1974	Saudi Arabian crude; 53,000 tons total; 40,000 tons onshore	Harm (1974); Blount (1978)
GARVIS Florida Keys	Aug. 1975	Crude; ~210 tons	Chan (1977)
URQUIOLA, La Coruna, Spain	May 1978	Arabian Gulf crude; 110,000 tons total; 25,000-30,000 tons onshore	Gundlach and Hayes (1977) ; Gundlach et al. (1978)
AMOCO CADIZ Brittany, France	Mar. 1978	Arabian Gulf crude; 223,000 tons total	Gundlach and Hayes (1978b); Hayes et al. (1979)
HOWARD STAR Tampa Bay	Oct. 1978	Crude and distil- late; "140 tons	Getter et al. (1980b)
PECK SLIP Eastern Puerto Rico	Dec. 1978	Number 6 Oil; 1,500 tons	Getter et al. (1980a); Gundlach et al. (1979)
IXTOC I Gulf of Mexico	June 1979 to April 1980	Crude oil; several hundred thousand tons	Getter et al. (1980c); Gundlach et al. (1981)
BURMAH AGATE Texas	Nov. 1979	Crude and refined product	Thebeau and Kana (1981)

(Alaska). Further details of the ESI are presented in Hayes and others (1980).

The ESI classifications defined for the Norton Sound/Pribilof Islands area of Alaska are presented under the results section of this report.

Method of Application

In an area as large as the Norton Sound region of Alaska, a technique is required that can be used to assess large sections of shoreline rapidly, and synthesize the findings onto maps of a suitable scale (primarily 1:63,360 in this study). The method employed is called the integrated zonal method, developed by Hayes and others (1973) to classify large sections of Alaskan coast for the Office of Naval Research. The addition of biological components to these geologically oriented field studies provides an integrated approach determining priorities for environmental protection.

During all stages of the project, pertinent literature was consulted for regional and local information pertaining to ecological setting, geology, climate, and socioeconomic. Upon completion of the initial literature survey, an intensive field survey was undertaken by a four-man research team between 10 June and 11 July 1980. The field investigators included geologists, Erich Gundlach and Jim Sadd, and biologists, Geoffrey Scott and David Maiero. During this period, aerial reconnaissance of the entire coastal zone was conducted. Observations and initial shoreline classifications were recorded directly onto U.S. Geological Survey topographic maps using a color code. Oblique aerial photographs were taken with a 35-mm camera, and descriptions were recorded on tape.

Ground study sites were selected to view the largest variety of shoreline types using an approximate spacing of 15 km (Fig. 9). Special attention was given to areas of ecological sensitivity and/or socioeconomic importance. Two types of ground stations were established: (a) rapid-survey sites and (b) detailed profile sites.

At the rapid-survey sites, biological and geomorphic characteristics of the ground station were quickly assessed in less than 30 minutes. A series of photographs were taken at various positions along the beach to document the biota and beach morphology present at the study site. In some cases, specimens and sediment samples were collected and logged. A description of the ground site was recorded on tape and in field notebooks.

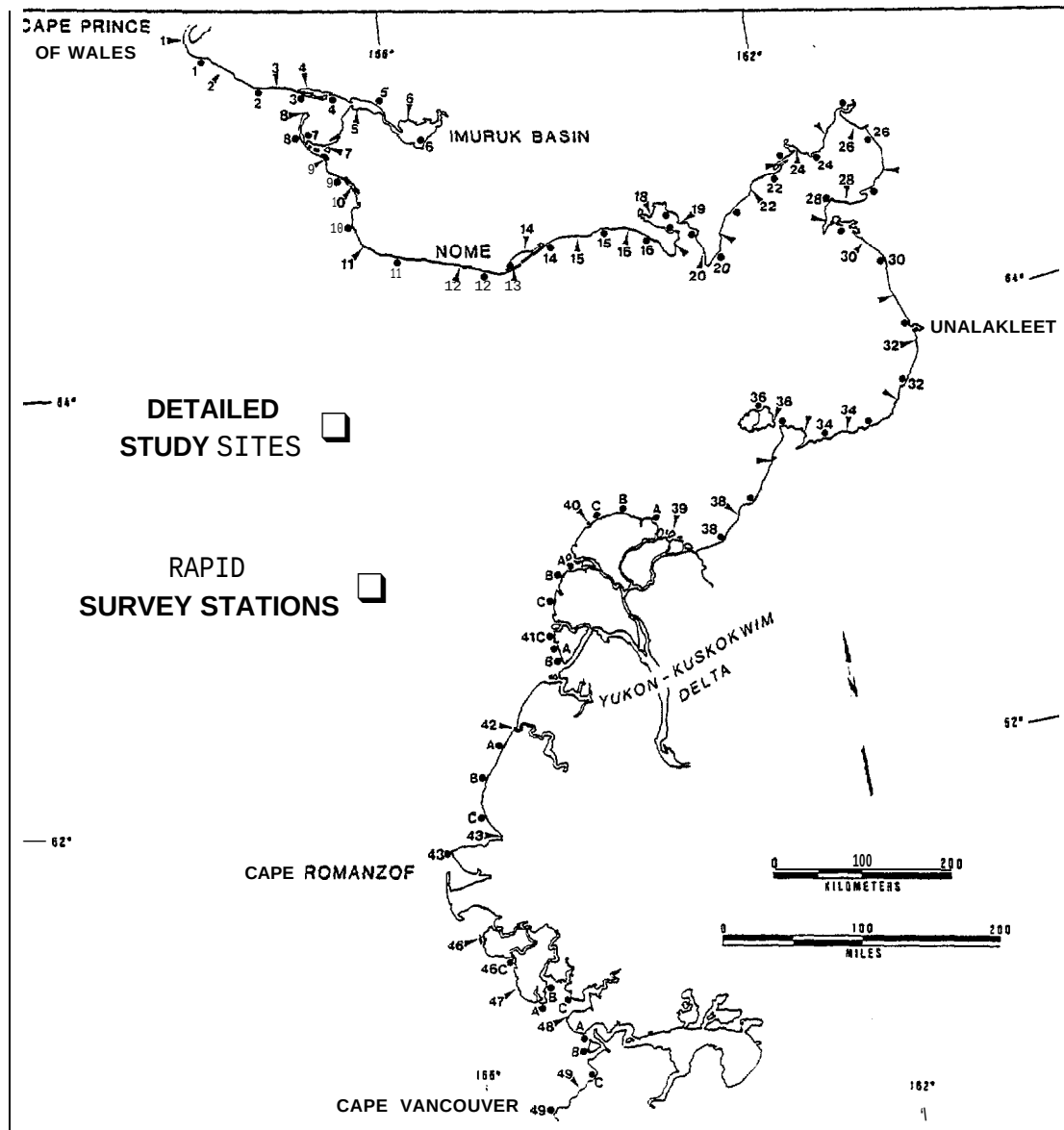


FIGURE 9. Station locations within the Norton Sound study area. Stations on St. Paul, Pribilof Islands, are depicted in Figure 78. Descriptions of all stations are presented in Appendix V.

At the detailed profile sites, the following methods were used:

- a) A topographic profile of the beach was measured using the Emery (1961) method. Descriptions of geomorphic features, sediment types, and biological information (e.g., species density and abundance) were superimposed on the profile. Profile intervals were selected to encompass geomorphic

and biologic changes along the profile line. Computer-plotted profiles are included in Appendix V.

- b) Sediment samples were collected from the mid-beach face along the profile. In addition, samples from the upper and lower beach face were described in the field. The location of each sample was recorded on the profile data sheet. The mid beach face samples were later analyzed for standard Folk (1968) grain-size characteristics by settling tube (sand fraction) and sieving (gravel fraction). Grain-size data are presented in Appendix V.
- c) Macroepifauna present inside of a 0.016 m^2 quadrat placed along the lower, mid, and upper intertidal zone were counted in triplicate.
- d) The abundance of rooted vegetation was recorded as light ($<20\%$ surface coverage), moderate ($20-70\%$) or heavy ($>70\%$) within each profile interval.
- e) Macroalgal abundance was recorded within each profile interval as light, moderate, or heavy (as above), and as estimated percent coverage.
- f) Macroinfauna were censused using triplicate cores (core diameter = 10 cm; 0.008 m^2 surface area) driven to a maximum of 15 cm into the sediment at the lower, mid, and upper beach face and, where possible, in the shallow subtidal zone. Samples were passed through a 1-mm mesh sieve while in the field and identified. Samples for lab identification and voucher specimens were preserved in ten percent formalin, bagged, and labeled.
- g) Standard statistical measures applied to the epifaunal and infaunal counts include calculation of the mean, standard deviation, and standard error. Species richness, the number of infaunal or epifaunal species observed, was also similarly treated. Due to the patchy distribution of most marine organisms and the time/logistical constraints involved in this study, most of the reported population estimates are maximum values rather than absolute random values. Therefore, this approach provides an estimate of maximum population dynamics in each habitat.
- h) Birds utilizing the shore zone were classified; abundance was recorded as light (<10 birds), moderate (10-20), or heavy (>20).

- i) A sketch was made to illustrate all aspects of the study site. Sample locations as well as biological and geomorphic features were indicated on the sketch.
- j) Photographs were taken at several angles to document the morphological and biological aspects of each station.
- k) Detailed verbal descriptions of the site were recorded on tape. A shorter description was written in each investigator's field notebook. A brief description of each station is presented in Appendix V.

These data were used to describe and characterize each environment according to its sensitivity to damage by spilled oil. Each shoreline type is represented on the maps by a number identifying its rank in the ESI; the higher the number, the greater the sensitivity of that environment to spilled oil.

In addition to characterizing the shoreline, areas of special biological importance were identified, primarily from previous studies. Localities of oil-sensitive, protected, or commercial species and communities are noted on each map by colored circles. The information is on circles as illustrated in Figure 10. On the full-scale maps, the color of the circle indicates rapid identification of the type of organism present: yellow = mammals; green = birds; blue = fishes; and orange = shellfish. The silhouette in the center of the marker refers to the ecological groups listed in Table 3. The number refers to a species or species group as listed in Appendix VI. Seasonality data, presented on the outer perimeter of the marker, are shown to indicate the seasons of the year that a particular species or group of species (i.e., mixed bird colonies) are most likely present. Consideration is given to such factors as reproduction, migration, and feeding behavior.

Primary data sources for this baseline information include the principal investigators reports for Alaska OCSEAP (1976-1979), Alaska Department of Fish and Game resource maps (ADF&G, 1977a, 1977b; 1977c, 1977d), SOWLS and others (1978), and Gusey (1979) .

Socioeconomic resource information is presented to provide specialized data relevant to OCS lease sale 57 and to augment the decision-making processes in the event of an oil spill. The socioeconomic information appearing on the base maps does not affect the ESI numerical rating and is designed to be used in the same manner as the biological resource information - to highlight areas of special attention or response.

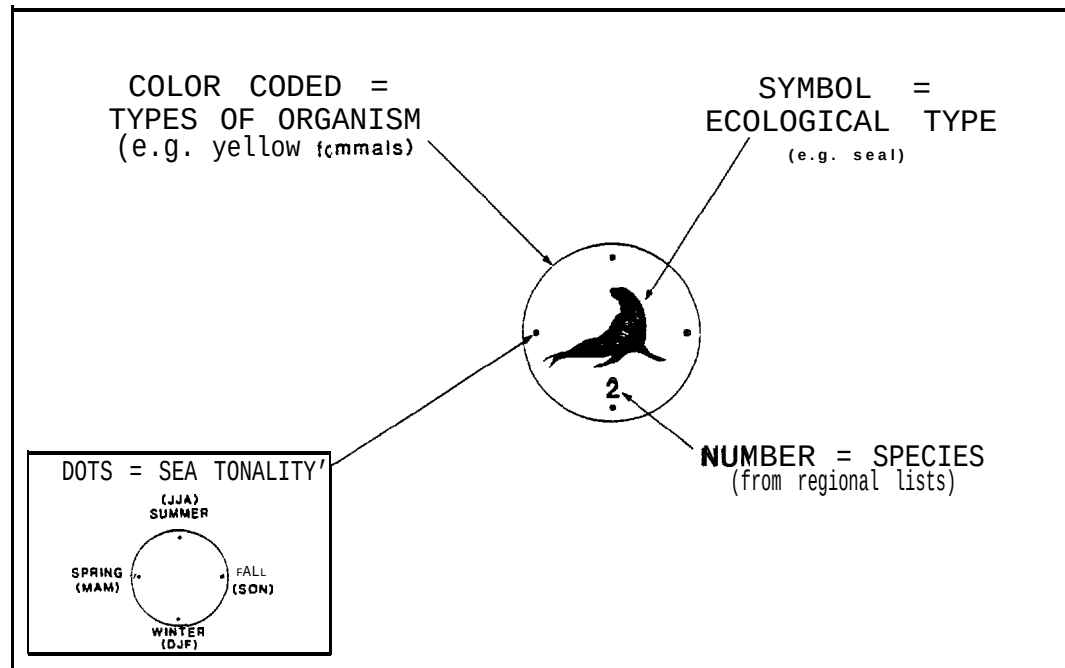


FIGURE 10. Key for biological information contained on the ESI maps.

Socioeconomic data was compiled by David Maiero from four principal sources:

- 1) The 1977 Alaska Coastal Land Status and Land Use Atlas.
- 2) The Bureau of Land Management - Alaska (land status records current through 1980) .
- 3) The Draft Environmental Impact Statement prepared by BLM Alaska Outer Continental Shelf office for oil and gas lease sale 57.
- 4) The map file housed as public record by the Alaska Resource Library, Anchorage.

TABLE 3. Symbols of critical wildlife used on the Norton Sound/Pribilof Islands ESI maps.

RESIDENT MARINE MAMMALS

-  Seals and walruses - Pupping or haulout grounds
 Whales - Migration and summer residence

MARINE BIRDS - Rookeries and critical forage areas

-  Alcids
 * Diving birds
 Gulls and Terns
 Shore birds
 -Waterfowl

FISHES

-  Salmon - Spawning areas or runs
 Herring - Spawning areas

SHELLFISH

-  Clams - Abundant clam areas
-

RESULTS

The Environmental Sensitivity Index (ESI)
for Norton Sound and the Pribilof Islands

- SHORELINE TYPES
- 1) Exposed rocky headlands
 - 2) Wave-cut platforms
 - 3) Fine-grained sand beaches
 - 4) Coarse-grained sand beaches
 - 5) Exposed tidal flats
 - 6) Exposed, mixed sand and gravel beaches
 - 7) Gravel beaches
 - 7a) Sheltered, mixed sand and gravel beaches
 - 7b) Basalt-boulder beaches
 - 8) Sheltered rocky shores
 - 8a) Eroding peat scarps
 - 9) Sheltered tidal flats
 - 10) Marshes

BIOLOGICAL RESOURCE INFORMATION

Mammals

Seals and walruses



Whales

Birds

Alcids



Shore birds



Diving birds



Waterfowl



Gulls and terns

Fishes

Salmon



Herring

Shellfish

Clams



Eelgrass beds

Subtidal Vegetation

SOCIOECONOMIC AND SPILL RESPONSE INFORMATION



Archaeological sites

Mining claims



Private lands



Onshore



Landing strips



Offshore



Boom locations

Washovers



Recommended closures

ESI=1 EXPOSED ROCKY HEADLANDS

General Description

- .Represent 3. 5 percent of the total shoreline
- One station surveyed
- Composed of steeply dipping bedrock
- Exposed to high waves and currents
- .Deep water is located directly offshore
- Generally inaccessible to ground-based cleanup equipment

Biologic Description

- .Contain several species of attached algae (up to 35 percent surface coverage)
- .Lichens are common in the upper intertidal zone
- .Barnacles (dominant) , amphipods, and insects are common epifauna
- No infauna present on hard-rock surface
- .Bird rookeries are located on several headlands

Predicted Oil Impact

- .Most spilled oil held offshore by waves reflecting off the steep cliffs
- .Oil that-impacts the shoreline, possibly during calm seas, would be rapidly removed by wave activity during the following days to weeks

Recommended Response Activity

- .No cleanup necessary; natural processes would remove oil rapidly depending on wave activity
- .Bird areas should be protected by open-water skimmers and deflection booms, weather and seas permitting
- .Diving and wading birds may be hazed

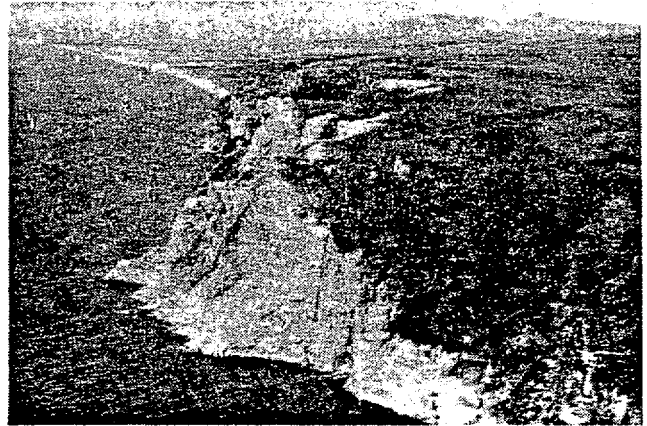
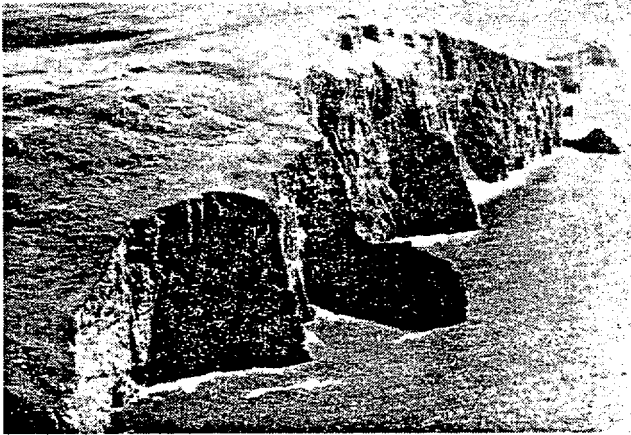


FIGURE 11. Exposed rocky headlands located near Cape Darby (left) and 25 km east of Solomon (right). These steep faces eroded into bedrock are exposed to maximum wave attack. Attached algae are commonly visible during low tide.

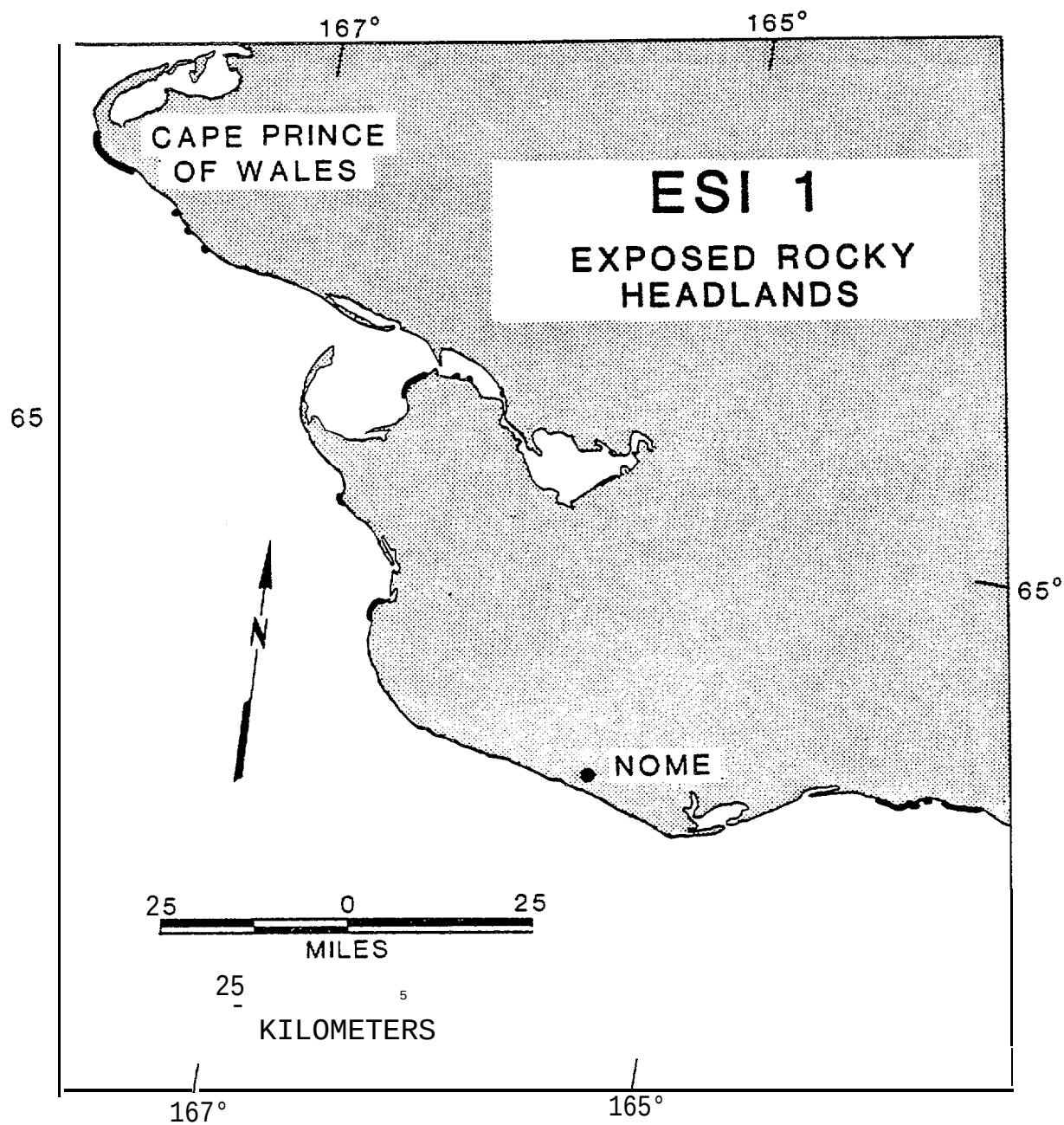


FIGURE 12. Distribution of exposed rocky headlands in northern Norton Sound.

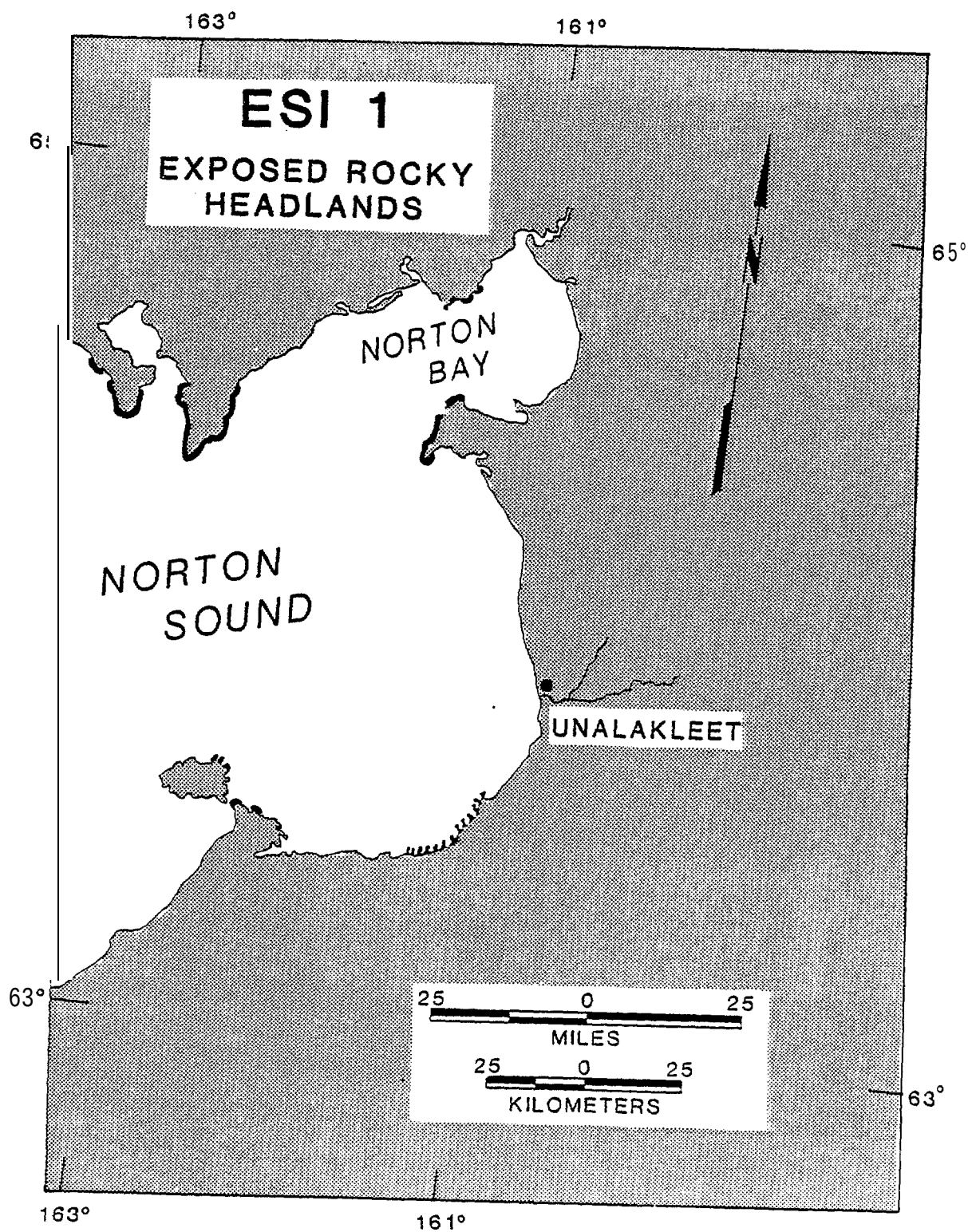


FIGURE 13. Distribution of exposed rocky headlands in eastern Norton Sound.

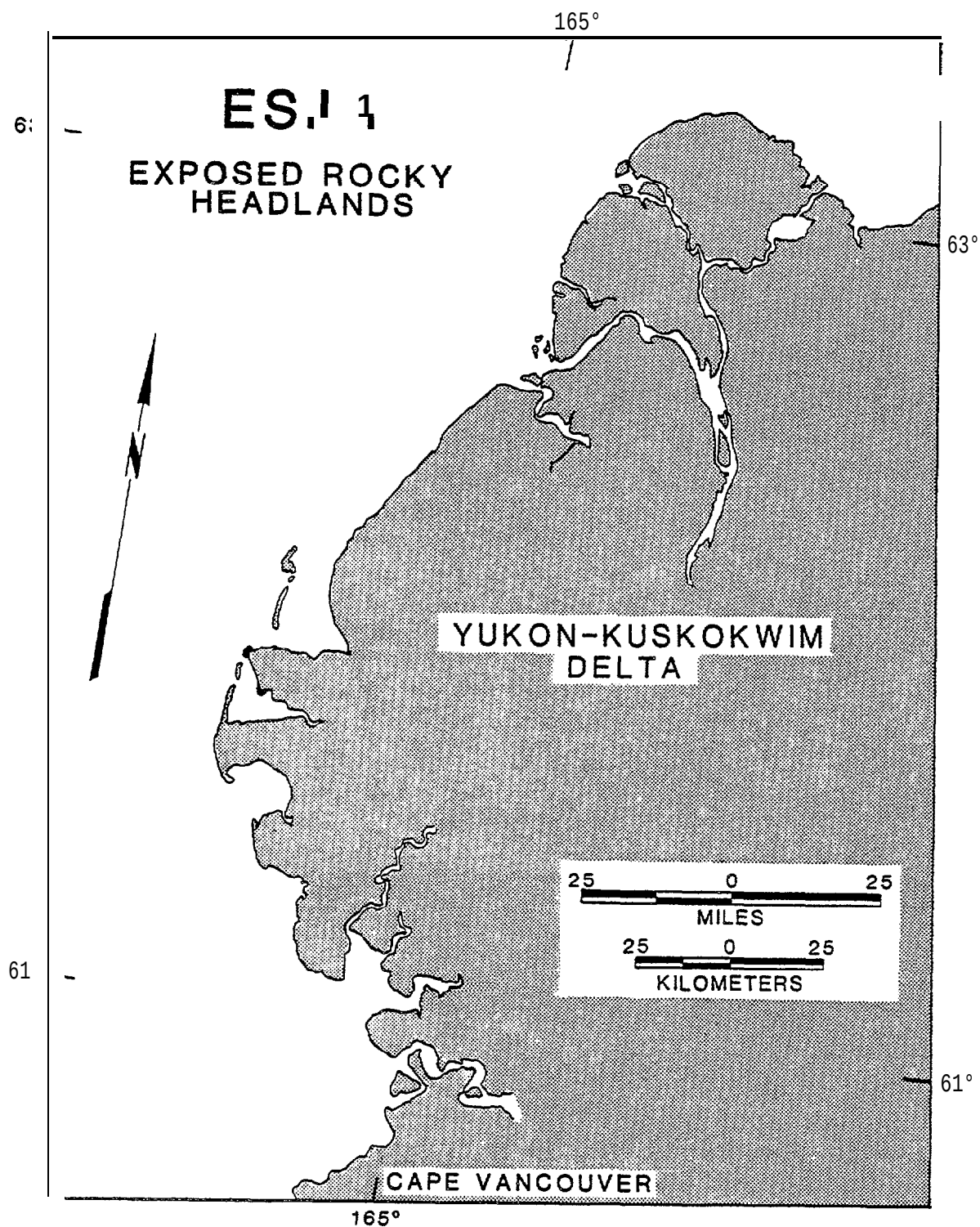


FIGURE 14. Distribution of exposed rocky headlands in southern Norton Sound.

ESI=2 WAVE-CUT PLATFORMS

General Description

- .Represent 2.5 percent of total shoreline
- .Two stations surveyed
- . Composed of low-lying bedrock in north and of steeper bedrock in areas south of Norton Bay
- .Mixed sand and gravel beaches are commonly located adjacent to this shoreline type

Biologic Description

- .Four species of attached vegetation observed
 - Three algae
 - One lichen
- .Algae attached at low- to mid-intertidal zone
- .Five epifaunal species found
 - Four marine
 - One insect
- .Barnacles are the most common epifauna
- . Three species of infauna present
 - Two marine
 - One insect
- .Amphipods found under cobbles and boulders in low populations are dominant infauna
- .Bird use is low

Predicted Oil Impact

- .Spilled oil would be removed rapidly by natural ocean processes

Recommended Response Activity

- .No cleanup necessary
- .Oil residence would be short-lived, depending on storm frequency

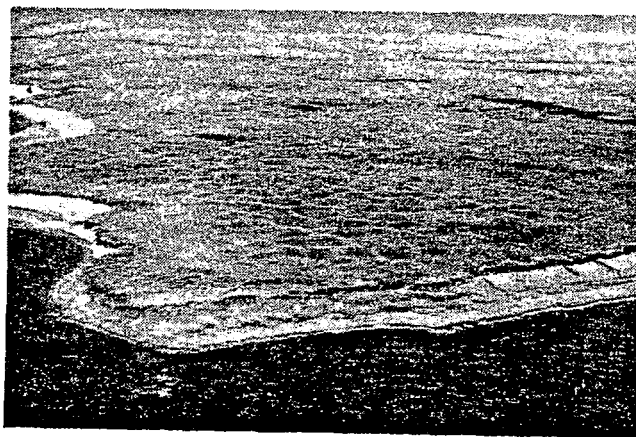


FIGURE 15. Wave-cut platform near Cape Douglas. The platform and its thin veneer of highly mobile sediment would be cleaned rapidly of oil by waves. The polygonal-patterned ground behind the beach is a result of permafrost processes.

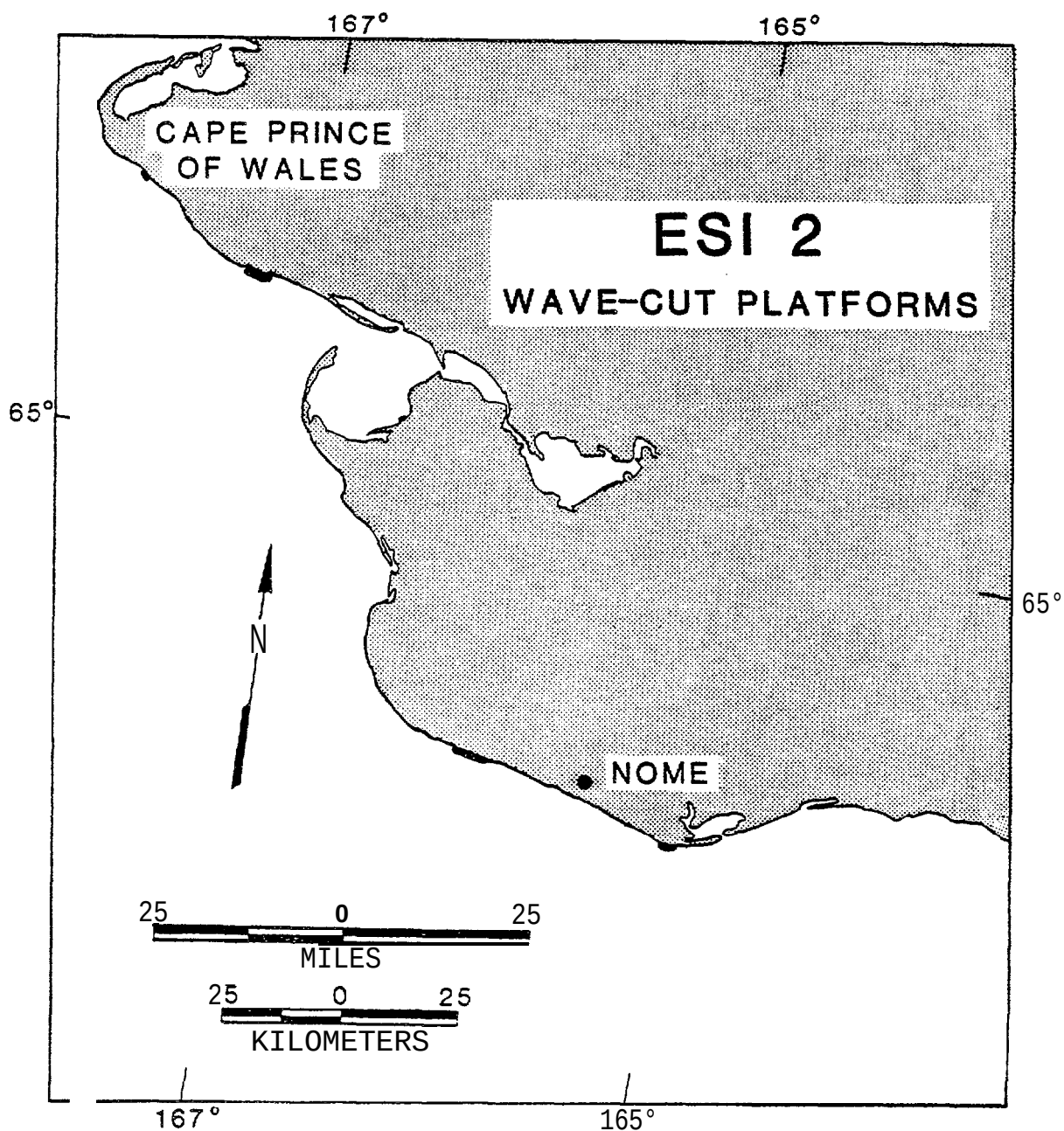


FIGURE 16. Distribution of wave-cut platforms in northern Norton Sound.

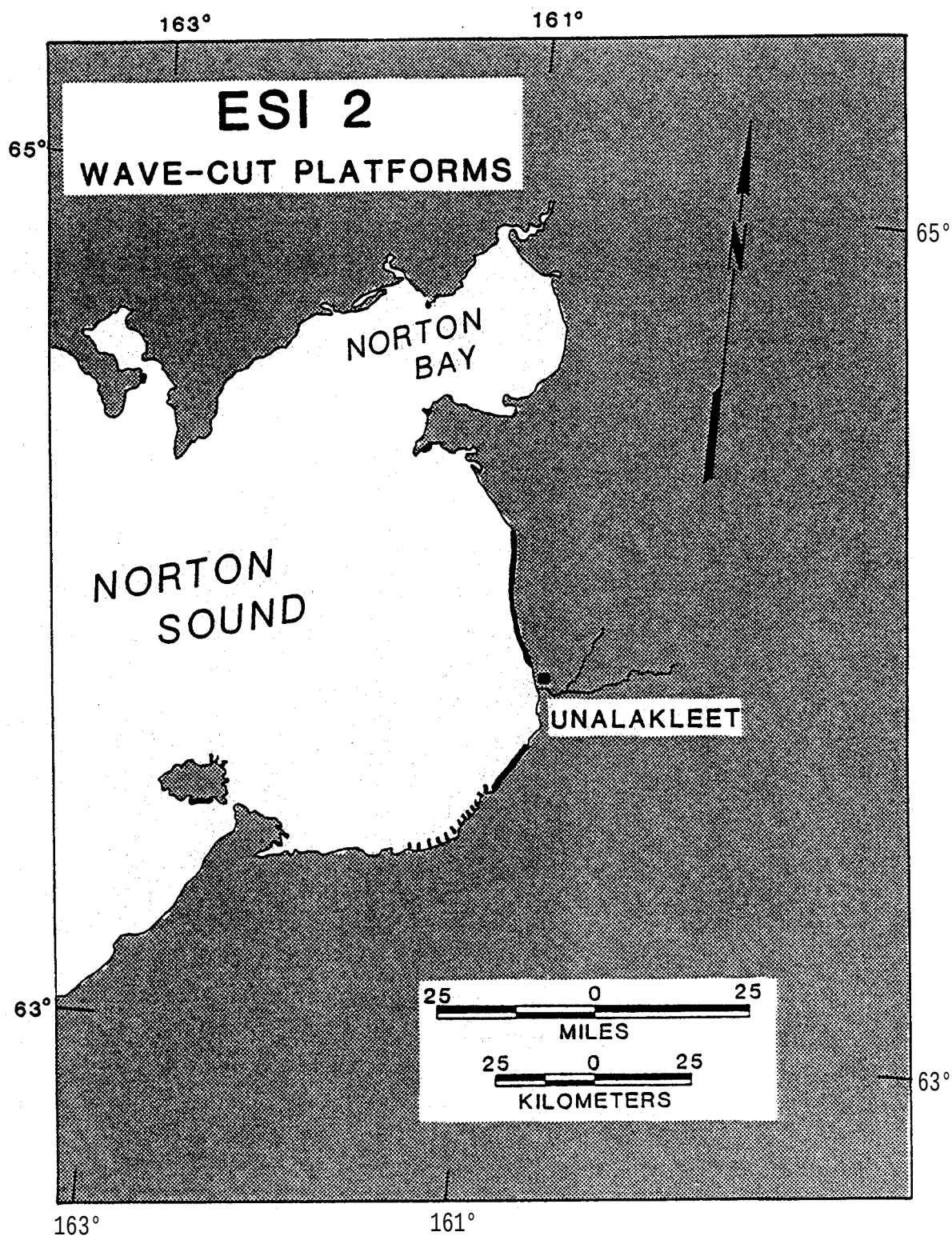


FIGURE 17. Distribution of wave-cut platforms in eastern Norton Sound.

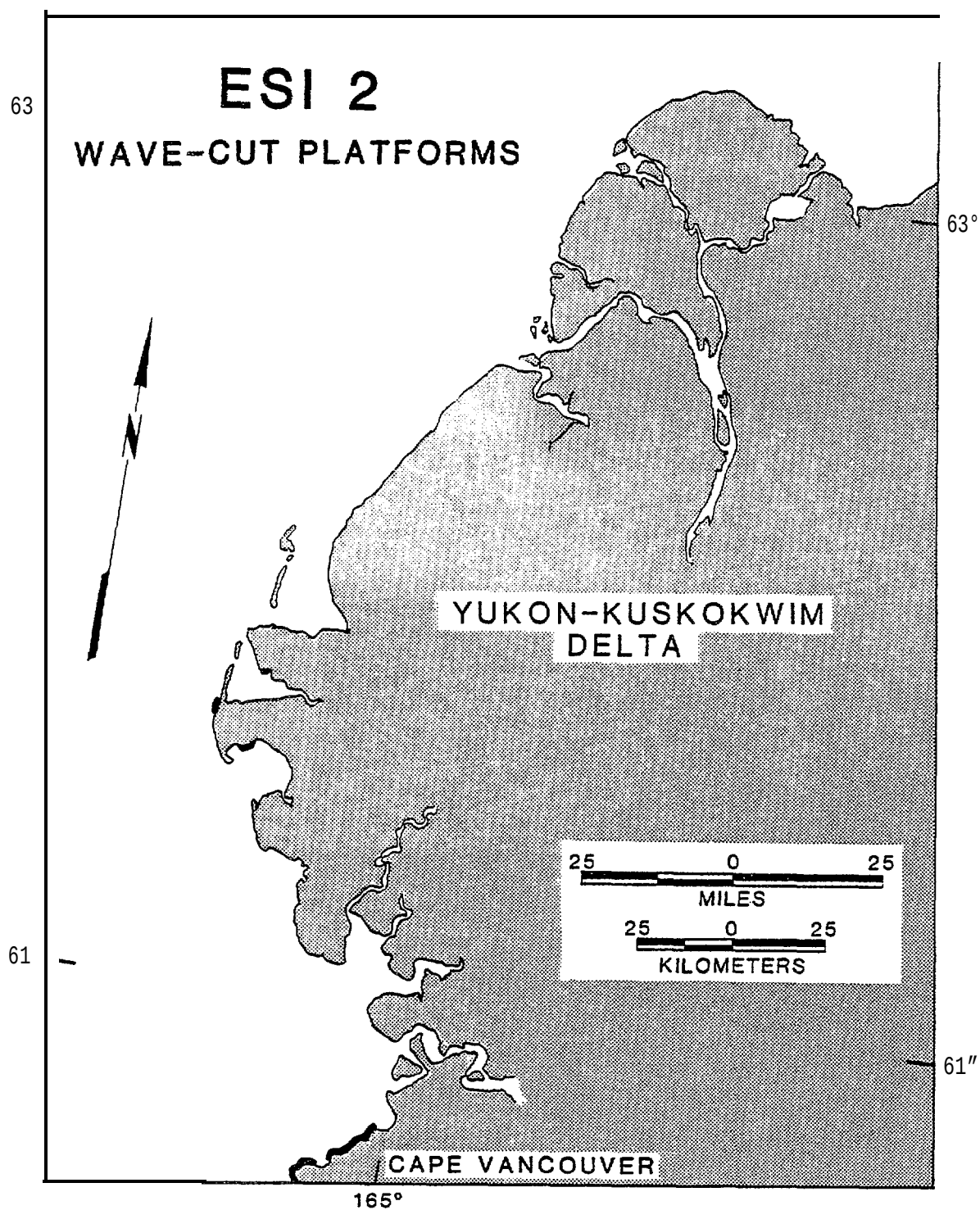


FIGURE 18. Distribution of wave-cut platforms in southern Norton Sound.

ESI=3 FINE -GRAINED SAND BEACHES

General Description

- .Represent three percent of total shoreline
- .Not common in study site
- Four stations surveyed
- .Mostly present near Cape Romanzof (owing to outflow of Yukon-Kuskokwim delta distributaries)
- Gently sloping beach profile

Biologic Description

- No attached vegetation present
- .Back-beach vegetation dominated by sedges, willows, and grasses
- Epifaunal densities are low, averaging 0.25/0.016 m²; maximum species richness = 1/0.016 m²
- Epifauna present include amphipods and two species of insects
- Two infaunal species present
 - Hemichordates (average density = 0.42/0.008 m²)
 - Clams (average density = 0.75/0.008 m²)
- .Average infaunal densities = 0.67/0.008 m²
- .Maximum species richness = two species/0.008 m², averaging 0.50 species/0.008 m²
- Bird use varies from low to high

Predicted Oil Impact

- Spilled oil would be deposited primarily along upper berm area
- Oil penetration and burial would be less than 20 cm
- Oil residence time, depending on storm activity, would vary from several months to one year

Recommended Response Activity

- .Cleanup would be aided by the hard, compacted sediment surface
- .All oil should be deposited onshore before cleanup begins
- .Manual cleanup is usually better than mechanical means when accumulations are not very heavy

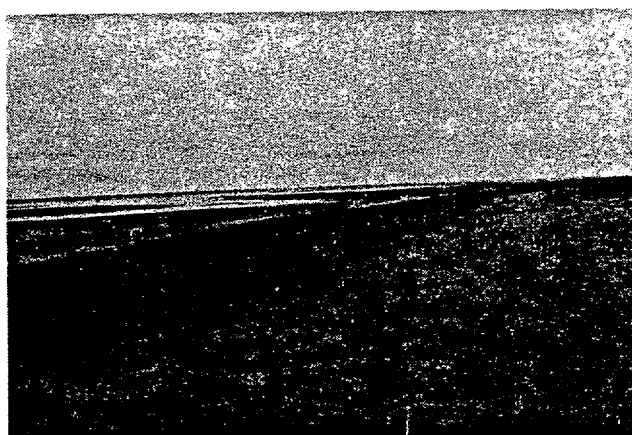


FIGURE 19. Aerial and ground views of a fine-grained sand beach at the south end of Hooper Bay (station NSS-46). Very well-sorted, fine-grained sand creates a flat, hard-packed surface which resists oil penetration.

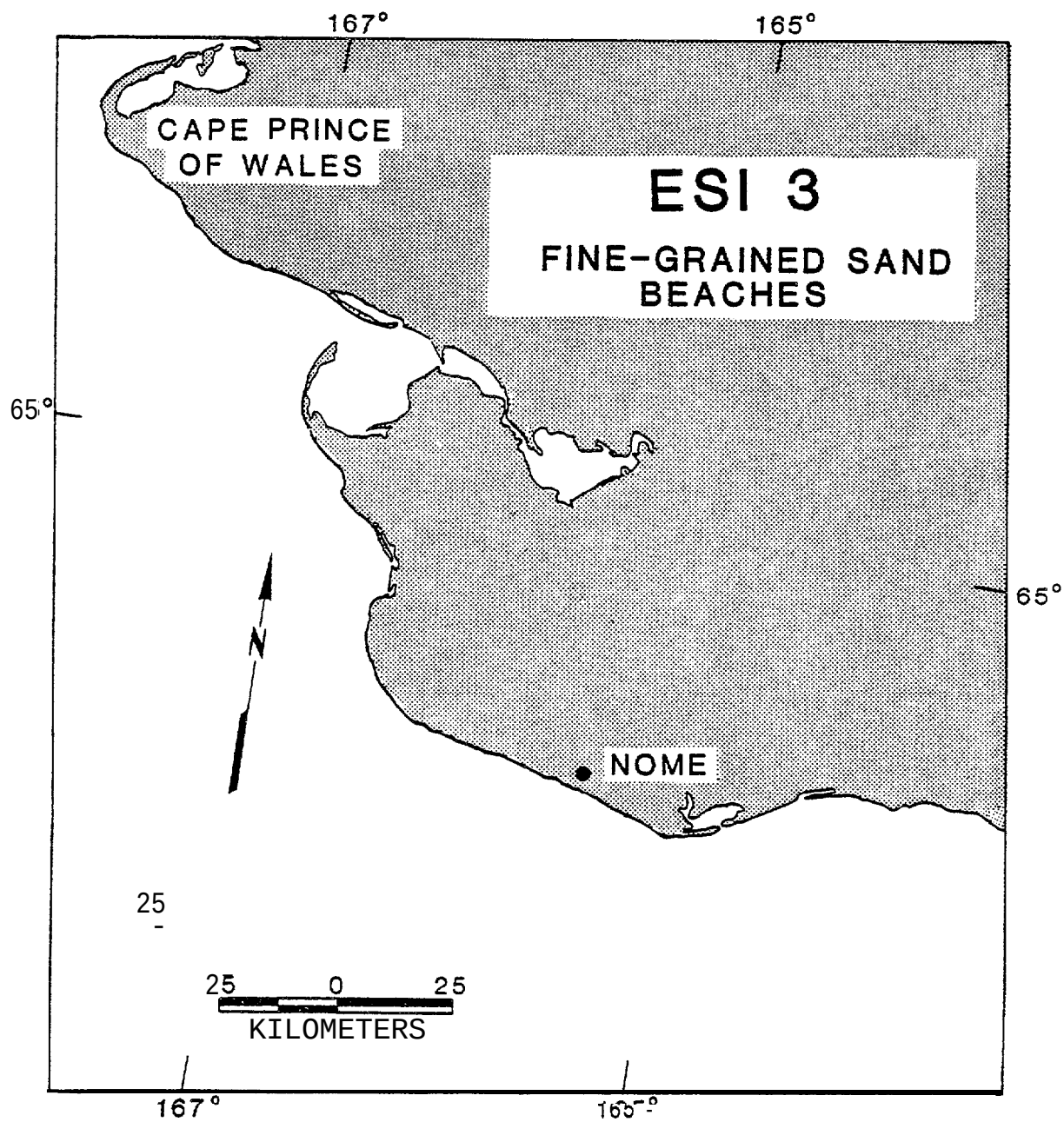


FIGURE 20. Distribution of fine-grained sand beaches in northern Norton Sound.

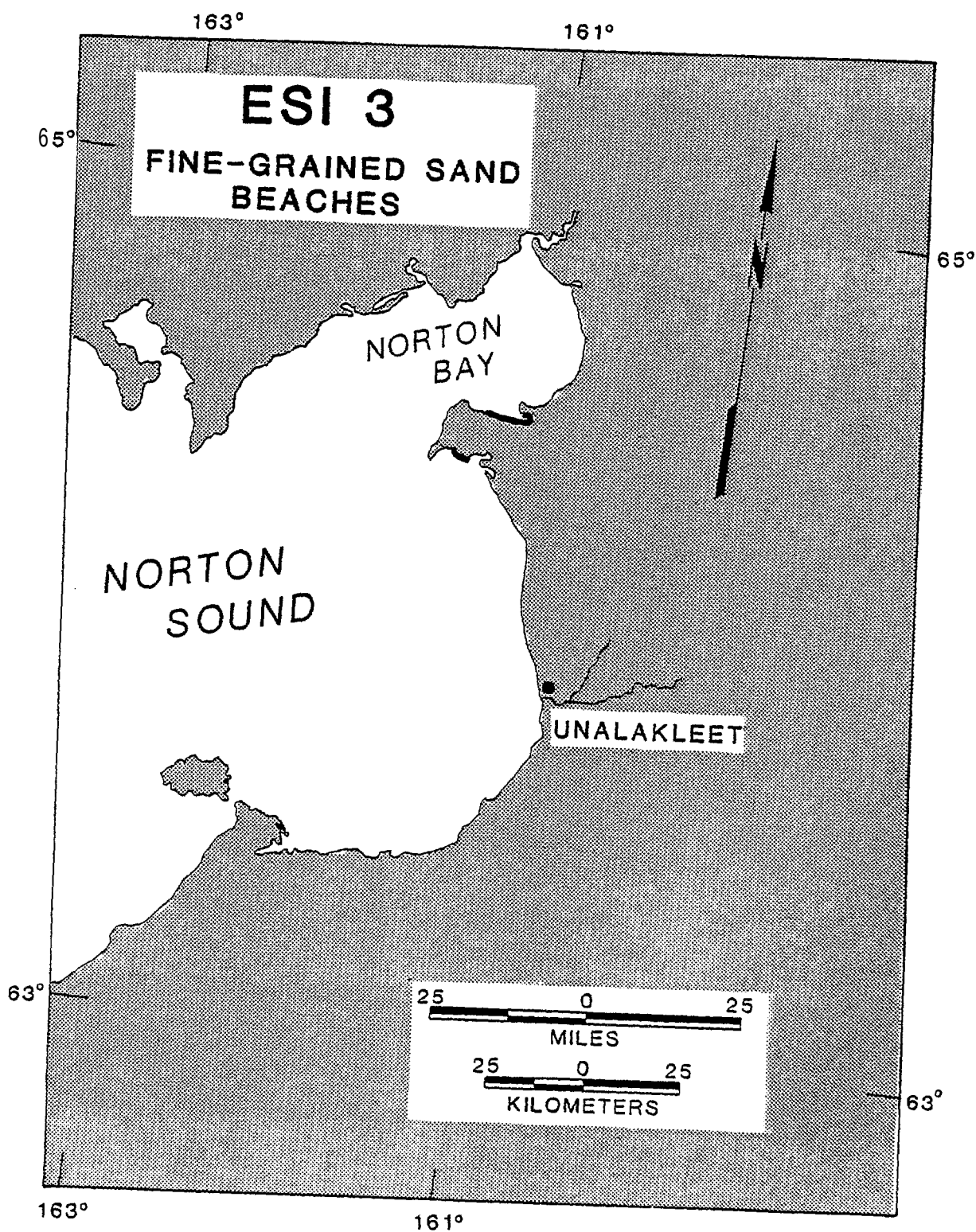


FIGURE 21. Distribution of fine-grained sand beaches in eastern Norton Sound.

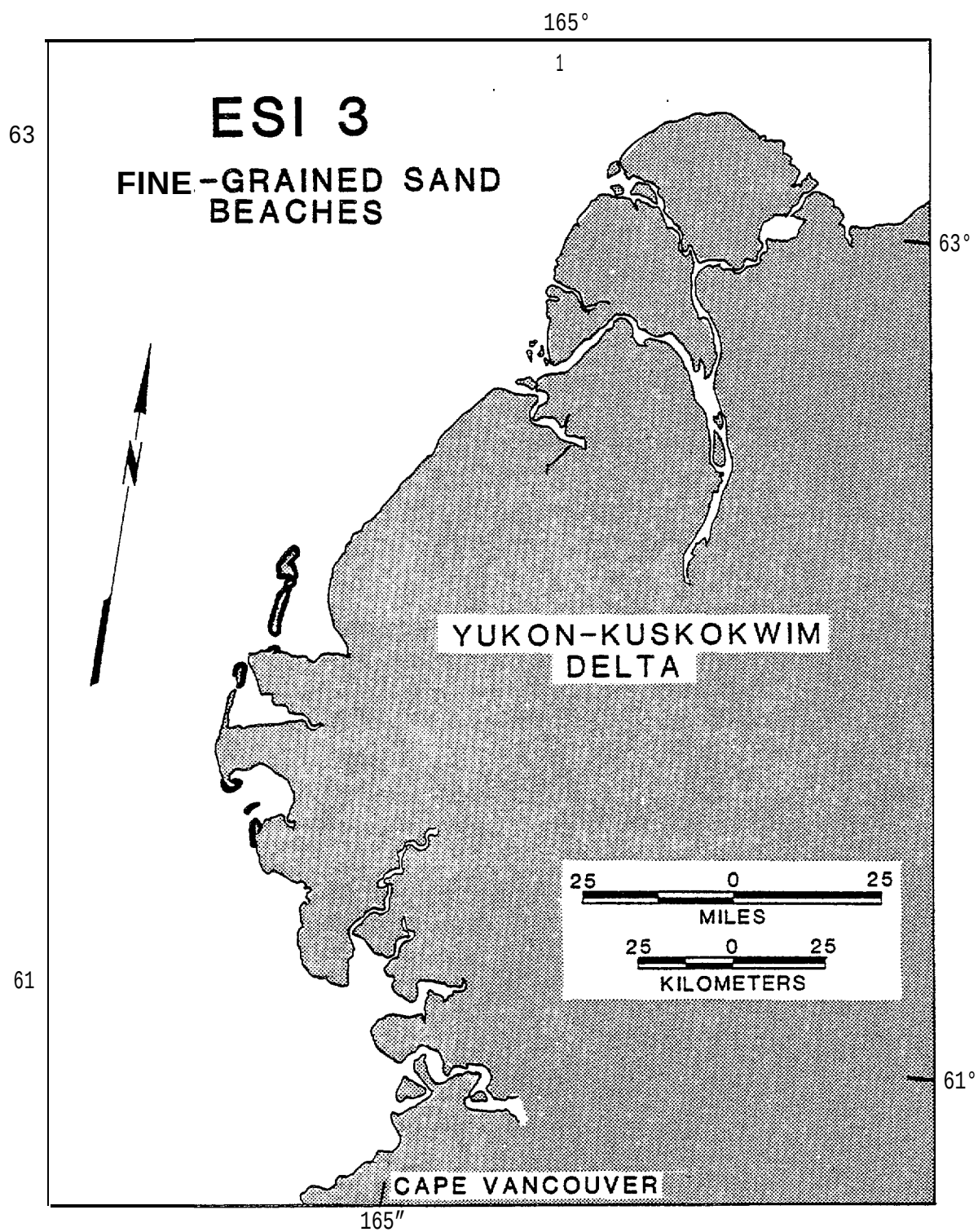


FIGURE 22. Distribution of fine-grained sand beaches in southern Norton Sound.

ESI=4 EXPOSED, COARSE-GRAINED SAND BEACHES

General Description

- .Represent 2.5 percent of the total shoreline
- .Not common in the study area
- Eight stations surveyed
- .Moderately steep beach profile
- .Scattered logs are common along the storm swash on back beach

Biologic Description

- .Insects and spiders common along the storm swash on back beach
- . No infauna observed
- Eight plant species are present behind the beach
- Bird use is low

Predicted Oil Impact

- .Spilled oil. would be deposited primarily along upper swash-line
- .Oil may be buried up to one meter, depending on topographic changes of the beach profile
- .Oil may penetrate 10-20 cm into the sand
- .Oil deposited low on the beach face would be removed within weeks to months
- .Oil may persist on the back beach for a year

Recommended Response Activity

- .Cleanup would be difficult because of deep oil penetration and burial
- .oil should be removed first from the upper beach face

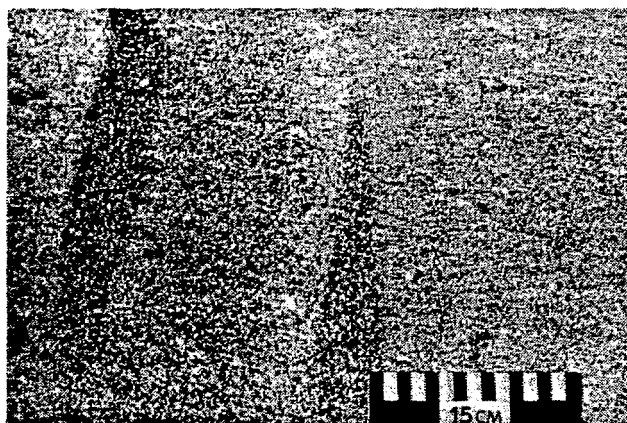


FIGURE 23. Ground-level and close-up views of an exposed, coarse-grained sand beach at Portage Roadhouse (station NSS-21). The beach slope is steeper than that of a fine-grained sand beach, and oil would soak further into the coarser sediment.

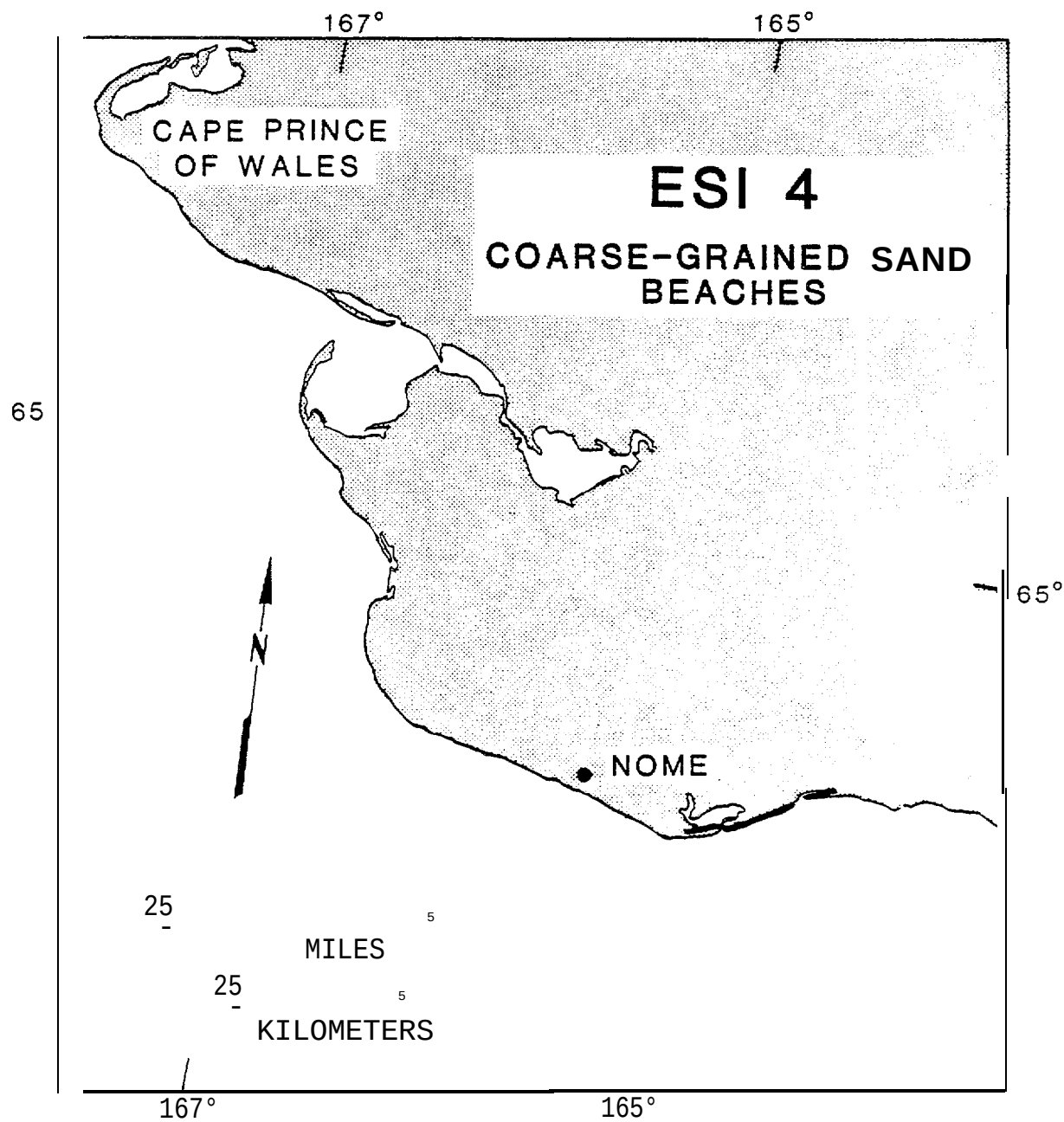


FIGURE 24. Distribution of exposed, coarse-grained sand beaches in northern Norton Sound.

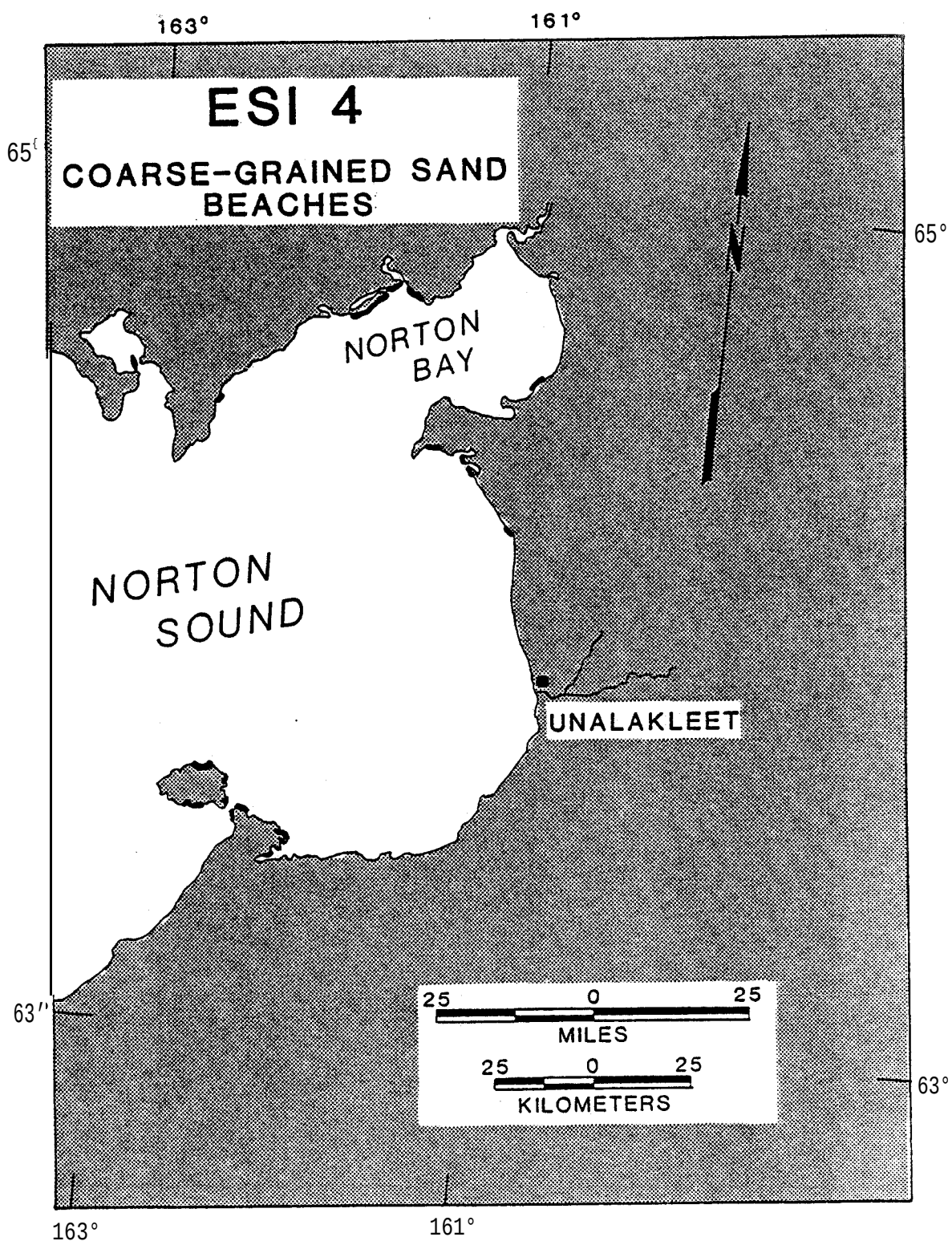


FIGURE 25. Distribution of exposed, coarse-grained sand and beaches in eastern Norton Sound.

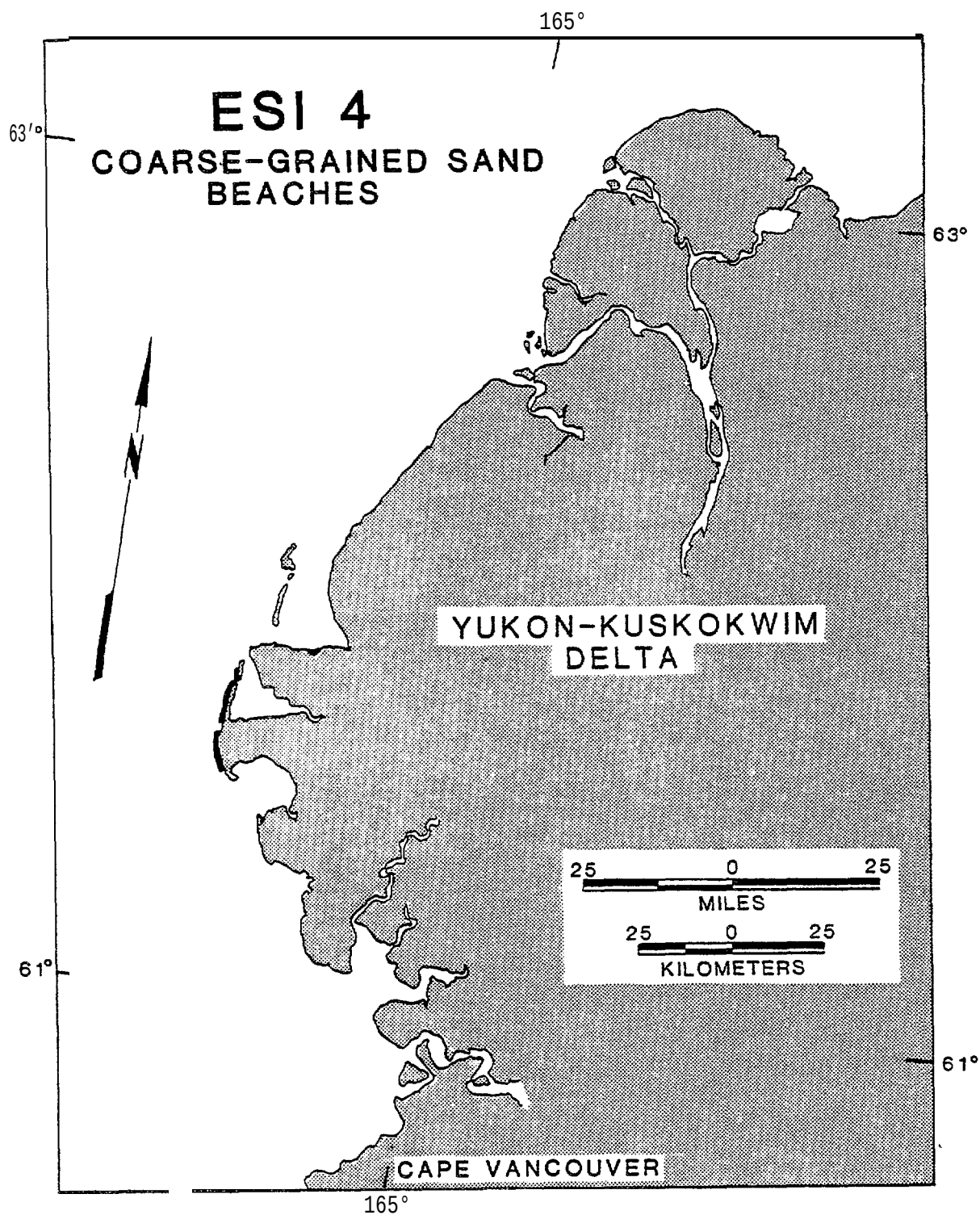


FIGURE 26. Distribution of exposed, coarse-grained sand beaches in southern Norton Sound.

ESI=5 EXPOSED TIDAL FLATS

General Description

- Represent 16.5 percent of the total shoreline
- Seven stations surveyed
- Either a wide, exposed, low-tide terrace fronting a beach or intertidal sand bodies associated with lagoons
- Long, flat topographic profile

Biologic Description

- Biologic activities change from low in the north to moderate along the Yukon-Kuskokwim delta region
- Infauna (one polychaete species with densities up to 534/m²) were observed only at stations in the southern portion of the study area
- Epifauna (particularly isopods) were absent in the north, lightly present in the central portion, and lightly to moderately present in the south
- A green alga was present on cobbles on the flat surface at some stations

Predicted Oil Impact

- Spilled oil would pass over the flat, except under very heavy impact
- Some oiling of the interstitial water may occur
- In moderate biomass areas, particularly along the Yukon-Kuskokwim delta front, biologic damage may occur

Recommended Response Activity

- Mechanical cleanup should be restricted on soft flats owing to probable churning-in of the oil
- Response should wait until all oil is deposited onshore

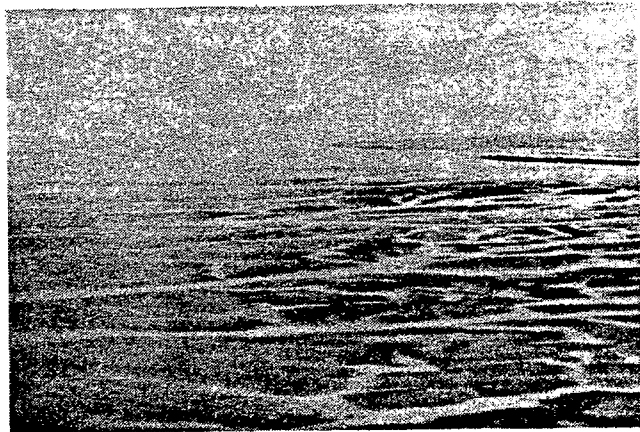


FIGURE 27. Ground-level and aerial photos of tidal flats located at station F-49 (left) and Hazen Bay (right). Exposed tidal flats in the study area are commonly composed of water-saturated, fine-grained silts or sands with relatively low infaunal biomass.

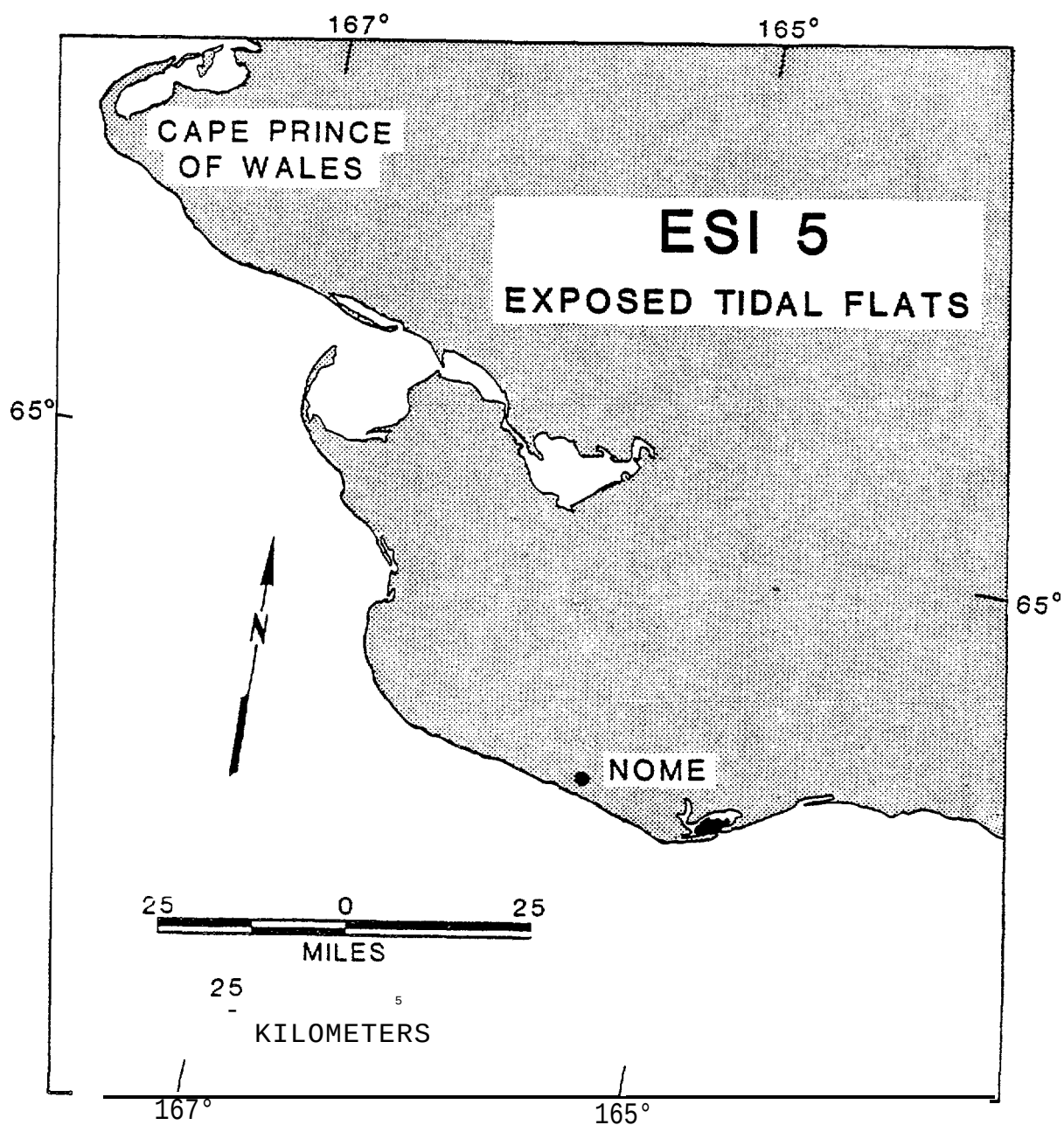


FIGURE 28. Distribution of exposed tidal flats in northern Norton Sound.

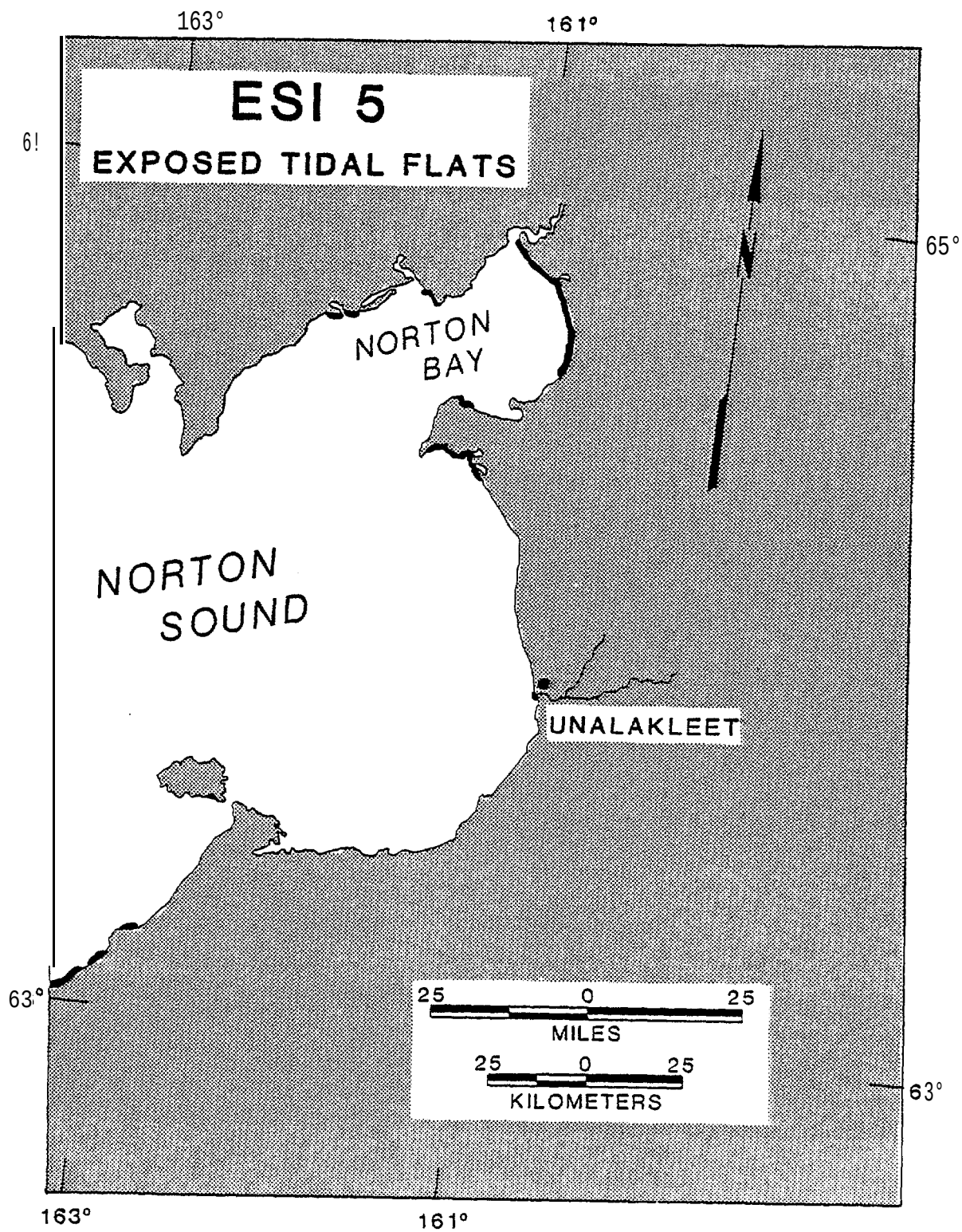


FIGURE 29. Distribution of exposed tidal flats in eastern Norton Sound.

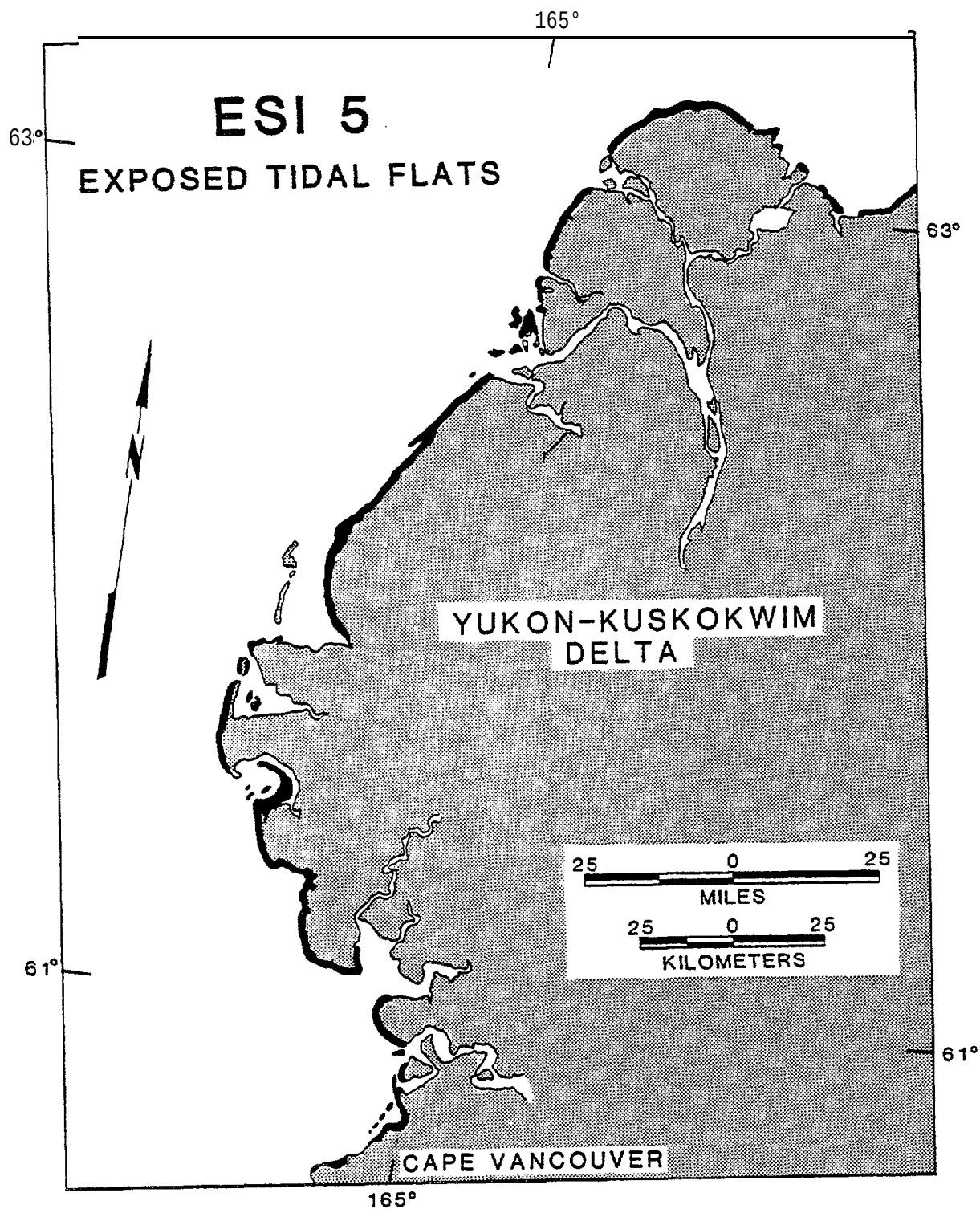


FIGURE 30. Distribution of exposed tidal flats in southern Norton Sound.

ESI=6 EXPOSED, MIXED SAND AND GRAVEL BEACHES

General Description

- Represent 12 percent of the total shoreline
- Third most common beach type in the study area
- 32 stations surveyed
- Common as a depositional feature (e.g., spits) or fronting eroding or vegetated tundra scarps
- Greatly disturbed by shorefast ice and storm waves

Biologic Description

- Attached vegetation (total of 8 algal species and 1 lichen) is present at only 15 percent of these habitat types; algae are found primarily on stable boulders along lower intertidal zones
- 28 species of rooted vegetation, grasses, willows, sedges, mosses, and lichens are present behind the active beach
- Marine epifauna are present on 37 percent of the stations
- Insects are found at 85 percent of the stations
- Nine species of epifauna are present
 - Four crustaceans
 - Three gastropod
 - One echinoderm
 - One bivalve
- Barnacles are common at 15 percent of the stations
- Pooled mean epifaunal density is 3/0.016 m² with species richness ranging from zero to two species/0.016 m²
- Eight infaunal species are present
 - Four polychaete
 - Two crustacean
 - One annelid worm
 - One nematode worm
- Infauna were observed at 22 percent of the stations; no one species occurred at more than one station
- Mean infaunal densities = 1.8/0.008 m²; individual mean densities range from 0.11 to 6.77/0.008 m²
- Mean species richness ranges from zero to two, averaging 1.33/0.008 m²
- Polychaete worms are the most common fauna, comprising 83 percent of the total
- Bird activity is generally low

Predicted Oil Impact

- Oil would be deposited primarily along upper swash lines
- Winter ice and storm waves would probably remove oil within one year

Recommended Response Activity

- . Cleanup should concentrate on oil removal from upper swash lines in high-use areas
- . Sediment removal, except in populated areas, is not a problem; high-pressure flushing may be more effective



FIGURE 31. Aerial (near Cape Prince of Wales) and ground-level (12 km west of Cape Nome, station F-12) views of exposed, mixed sand and gravel beaches. These types of shorelines are common throughout the study area north of the Yukon delta. Common features include back-beach washover terraces, numerous small gravel berms, swash lines of logs and cobbles, and gravelly low intertidal zones.

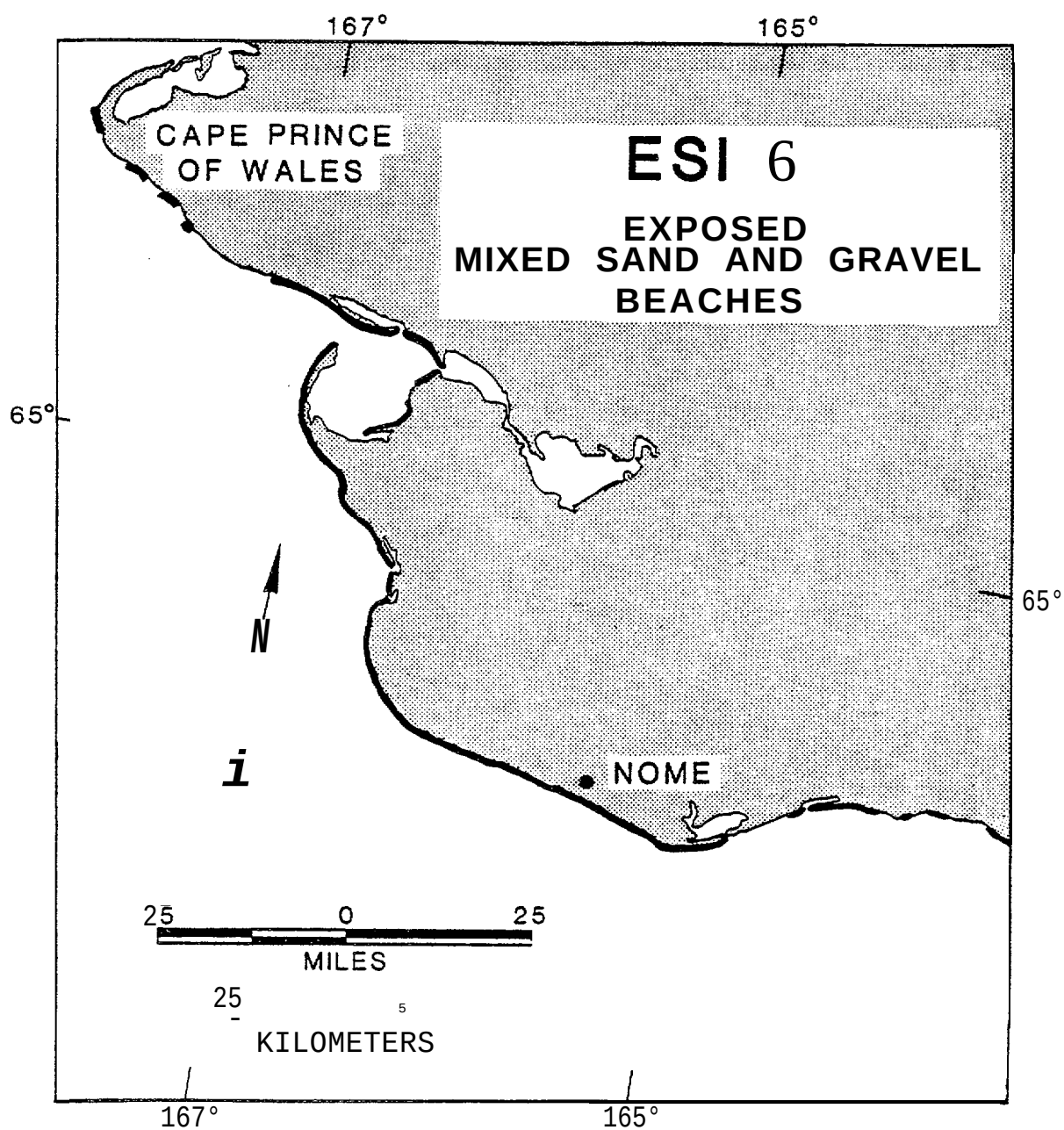


FIGURE 32. Distribution of exposed, mixed sand and gravel beaches in northern Norton Sound.

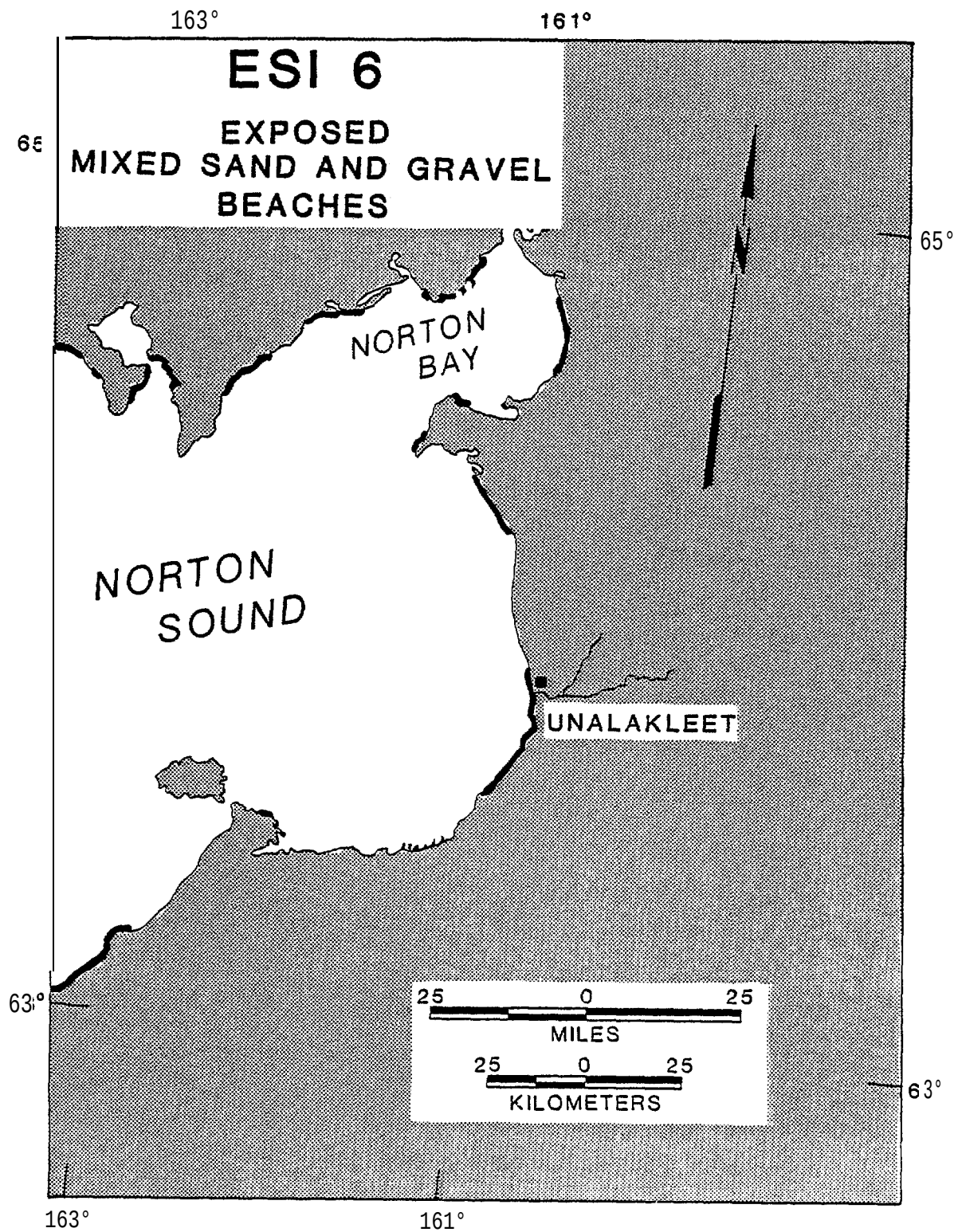


FIGURE 33. Distribution of exposed, mixed sand and gravel beaches in eastern Norton Sound.

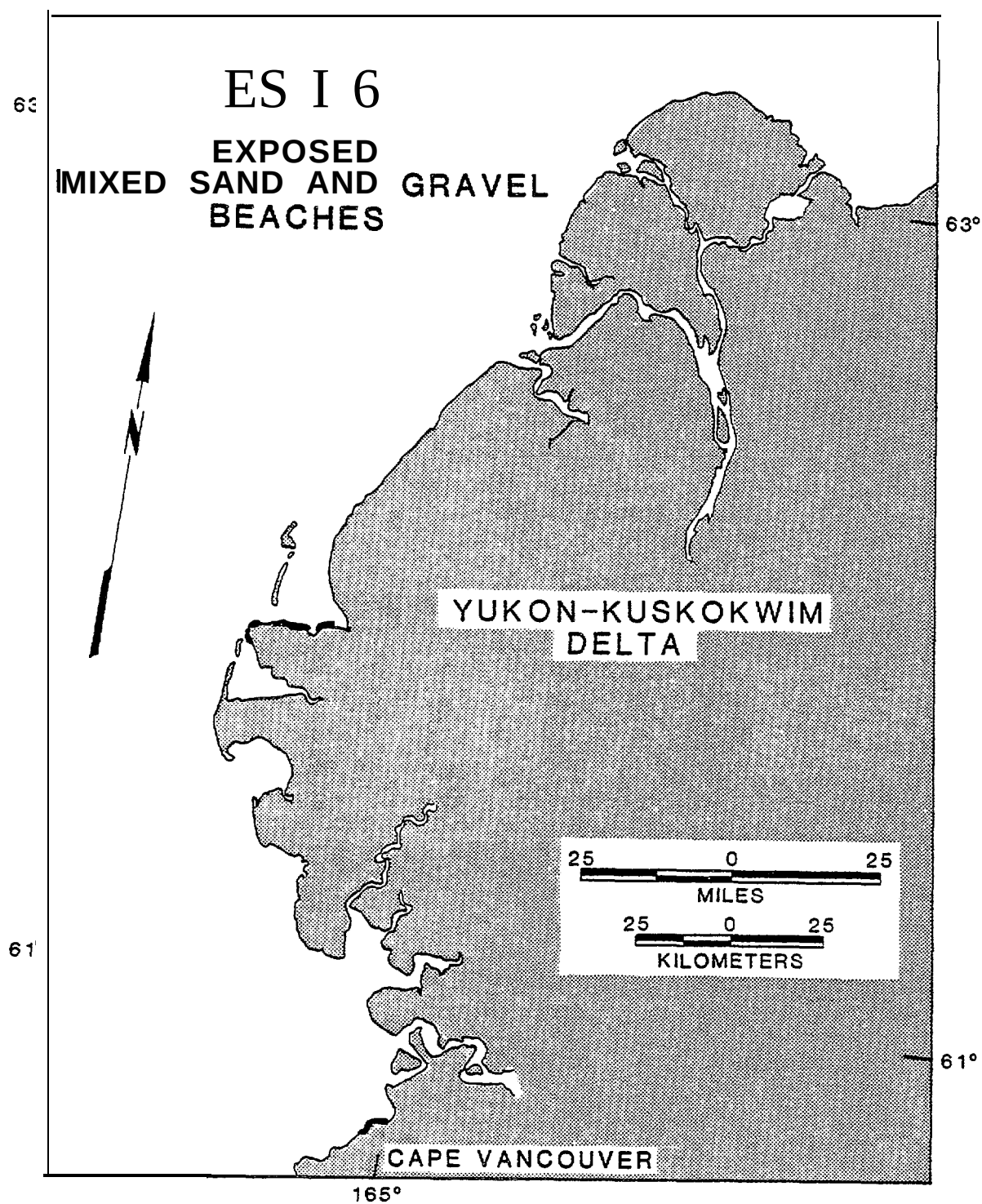


FIGURE 34. Distribution of exposed, mixed sand and gravel beaches in southern Norton Sound.

ESI=7 GRAVEL BEACHES

General Description

- Represent 0.5 percent of the total shoreline
- Not common in the study area
- Composed of gravel or cobbles (less than 10% sand)
- Exposed to high waves

Biologic Description

- High wave conditions and the mobile substrate inhibit colonization by intertidal organisms and plants
- Adjacent upland scarps vegetated with several species of rooted vegetation, dominated by willows, grasses, and sedges
- No attached vegetation was observed in the upper intertidal zone, although the lichen, Verrucaria sp., was occasionally observed in adjacent supratidal areas
- Enteromorpha and Fucus sp. occasionally found attached to large boulders in the lower intertidal zone
- No infauna or epifauna present, although remains of barnacle disks are found on some cobbles and boulders
- Insects are lightly abundant
- Bird activity is low

Predicted Oil Impact

- Spilled oil would penetrate rapidly and deeply into the beach, particularly along upper swash lines
- Burial of oil may be rapid and deep
- Oil persistence may be longer than one year, depending on ice and storm activity

Recommended Response Activity

- Cleanup generally not needed; however, if necessary high-pressure spraying and mechanical reworking recommended

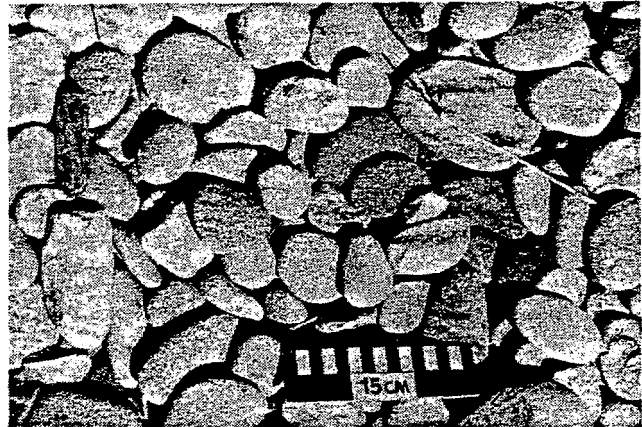


FIGURE 35. Overview and close-up of a gravel beach located 10 km north of Cape Darby (station NSS-20). This shoreline type is uncommon within the study area, primarily found as small, isolated pocket beaches between headlands. The flat, well-sorted and rounded cobbles make a very highly permeable substrate which results in deep oil penetration.

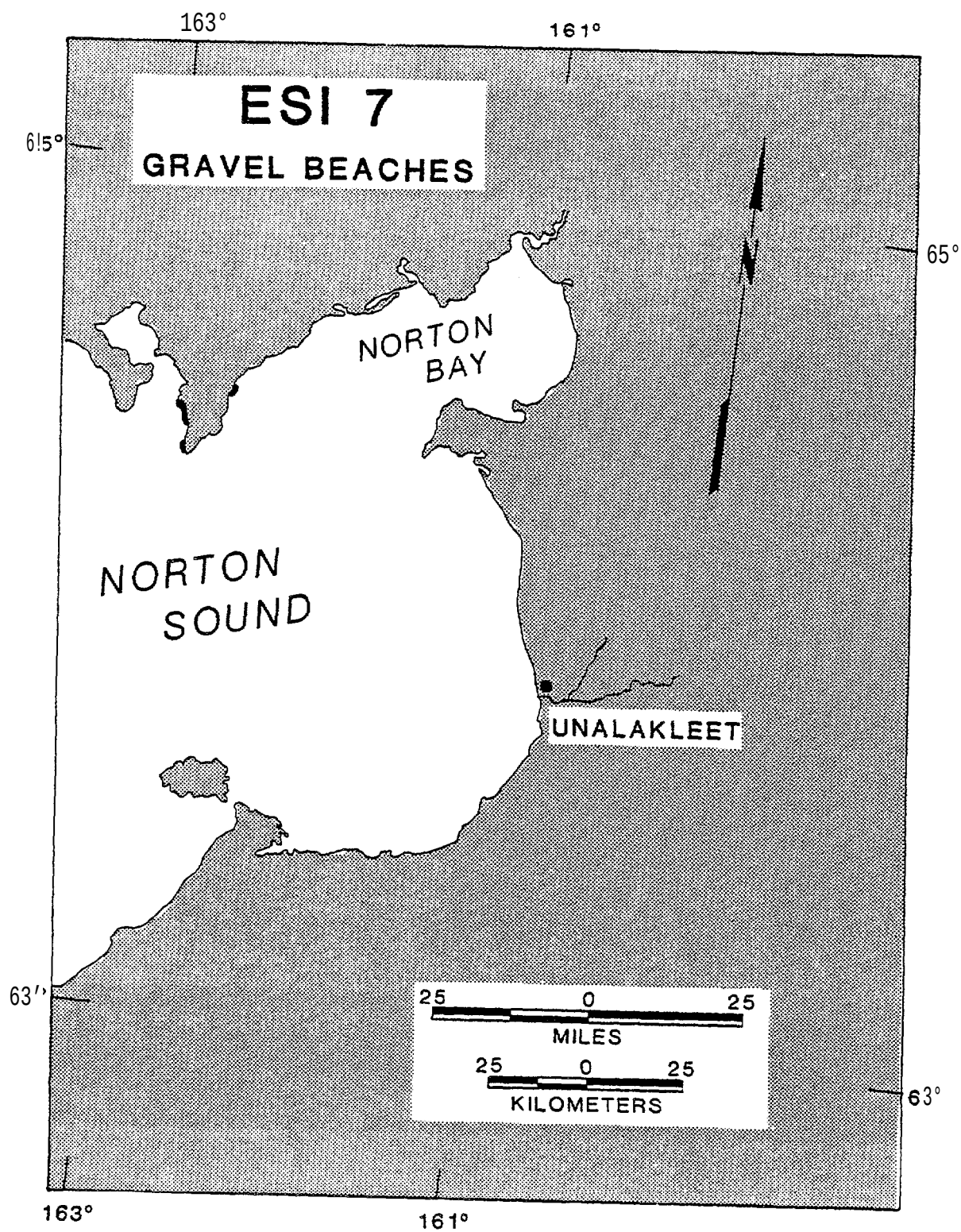


FIGURE 36. Distribution of gravel beaches in northern Norton Sound.

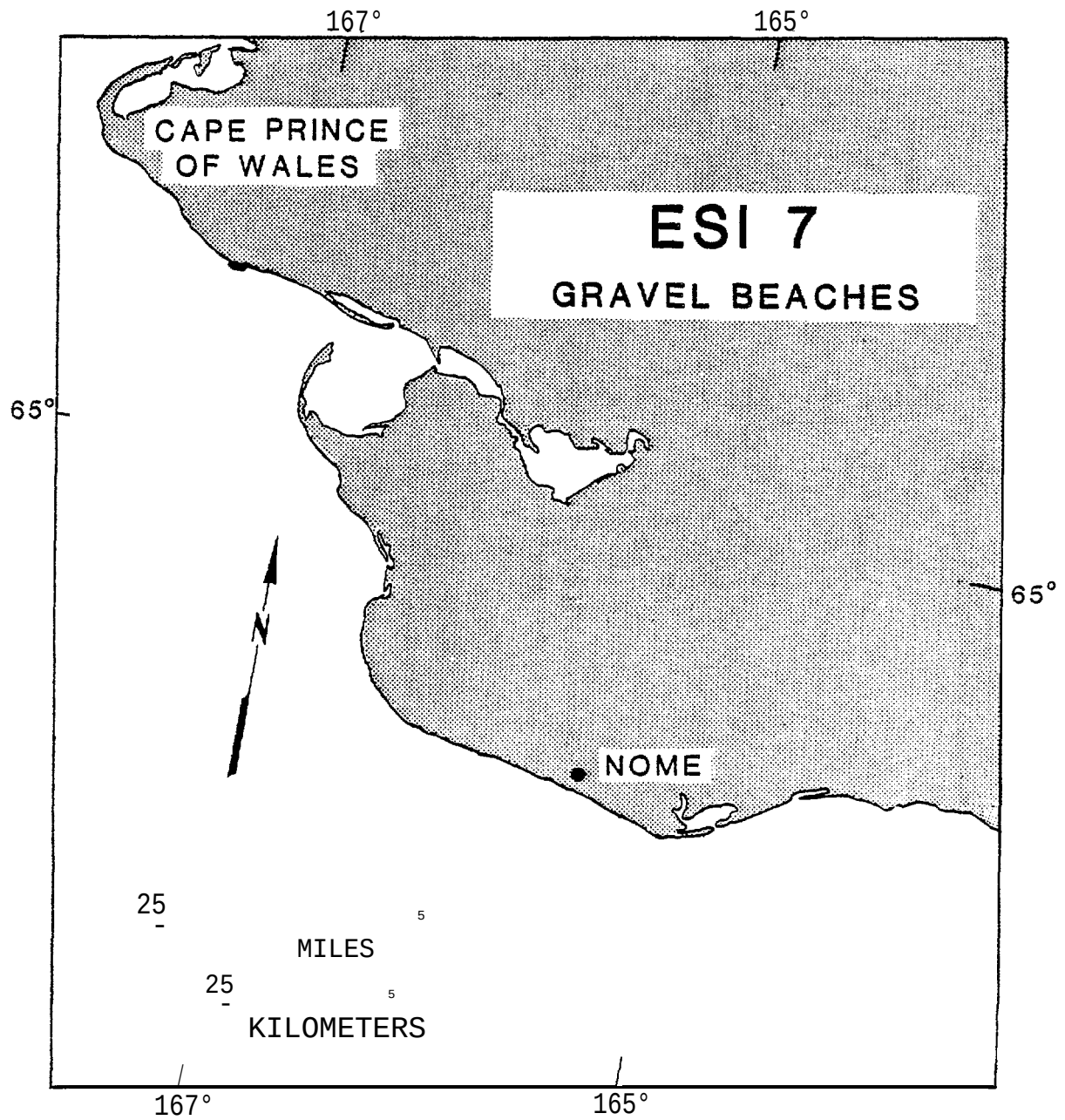


FIGURE 37. Distribution of gravel beaches in eastern Norton Sound.

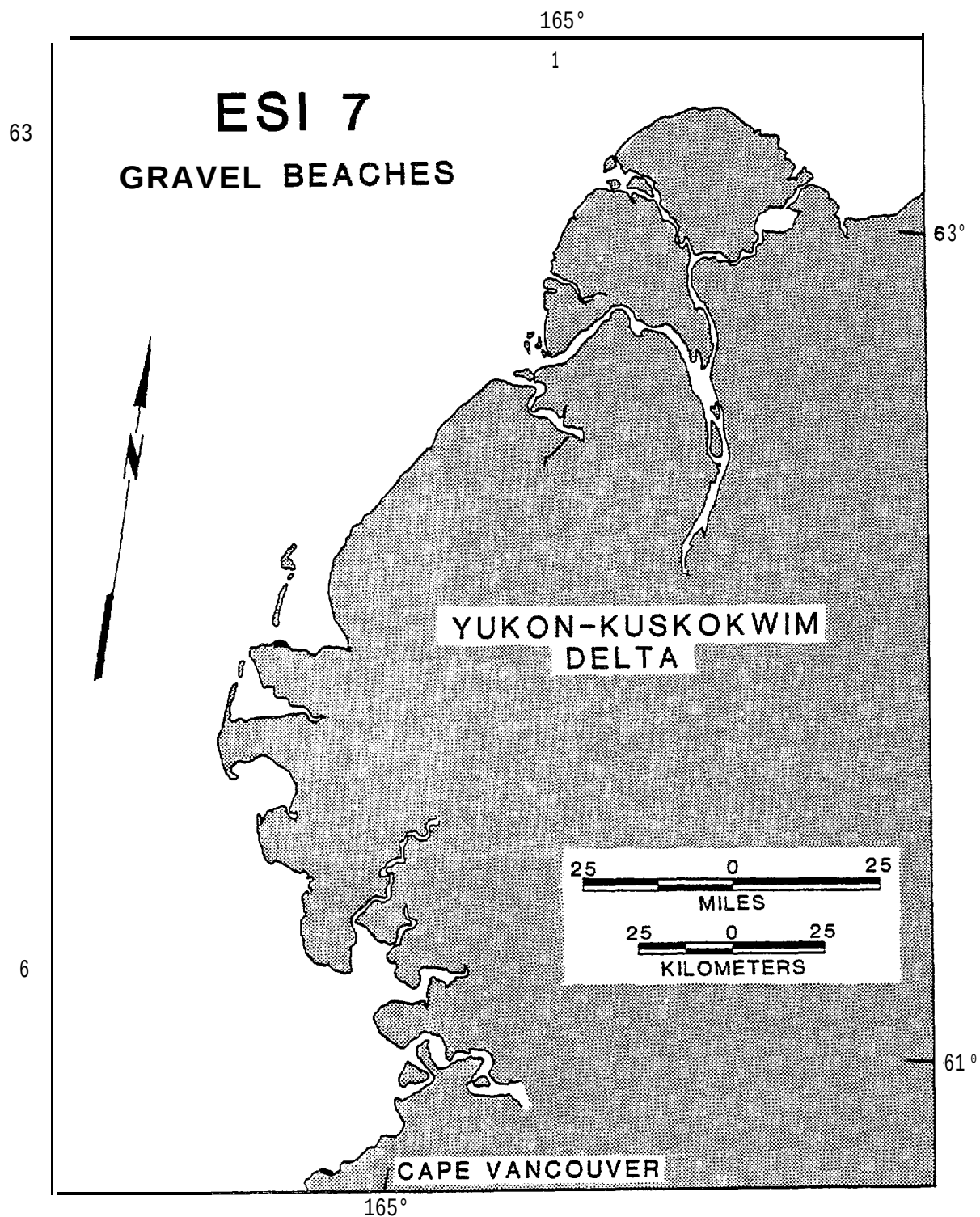


FIGURE 38. Distribution of gravel beaches in southern Norton Sound.

ESI=7a SHELTERED, MIXED SAND AND GRAVEL BEACHES

General Description

- .Represent seven percent of the total shoreline
- .Very common within the study area
- 15 stations surveyed
- .Located primarily behind spits

Biologic Description

- Attached algae (one species of brown and three species of green) are present at 22 percent of the stations
- 18 species of terrestrial vegetation, dominated by willows and grasses, are found at 77 percent of the stations
- Three marine epifaunal species (amphipods, mites, and barnacles) , three species of insects, and one species of spider are found at 62 percent of the stations
- Frequency of occurrence for any one species ranges from 7.7 to 38.5 percent of stations surveyed
- Barnacles are dominant with an average of 9/0.016 m²
- Pooled mean epifaunal density = 3.1/0.016 m², while species richness ranges from zero to three, averaging less than one species/0.016 m²
- Infauna present at 39 percent of the stations included three marine species (amphipods, polychaetes, and nematodes) , two species of insects, and one species of spider
- Insect larvae are the most common infauna; amphipods are the most common marine infauna
- Average infaunal density = 2.33/0.008 m²; average species richness = 1.3 species/0.008 m²; average frequency of occurrence for any one species = 10.3 percent
- Pelagic fish and invertebrate eggs are present at 23 percent of the stations
- Bird activity varies from low to high

Predicted oil Impact

- .Spilled oil would persist longer than along more exposed (ESI=6) mixed sand and gravel beaches
- .Oil may penetrate 40 cm into the beach

Recommended Response Activity

- .Cleanup, as a low priority, is recommended in high man-use areas, using high-pressure spraying and sediment reworking



FIGURE 39. Aerial and ground-level views of a sheltered, mixed sand and gravel beach at Brevig Lagoon. Sensitivity to oil impact is dependent upon the degree of exposure to wave activity. The exposed beach (ESI=6) would be more rapidly cleaned by waves, while the sheltered beach (ESI=7a) experiences little to no wave action from interior bay waters. The ground-level view inside Brevig Lagoon shows the gravelly nature of the beach face and absence of wave-built features (e.g., berms, log swash lines, washovers) which are present on exposed mixed sand and gravel beaches.

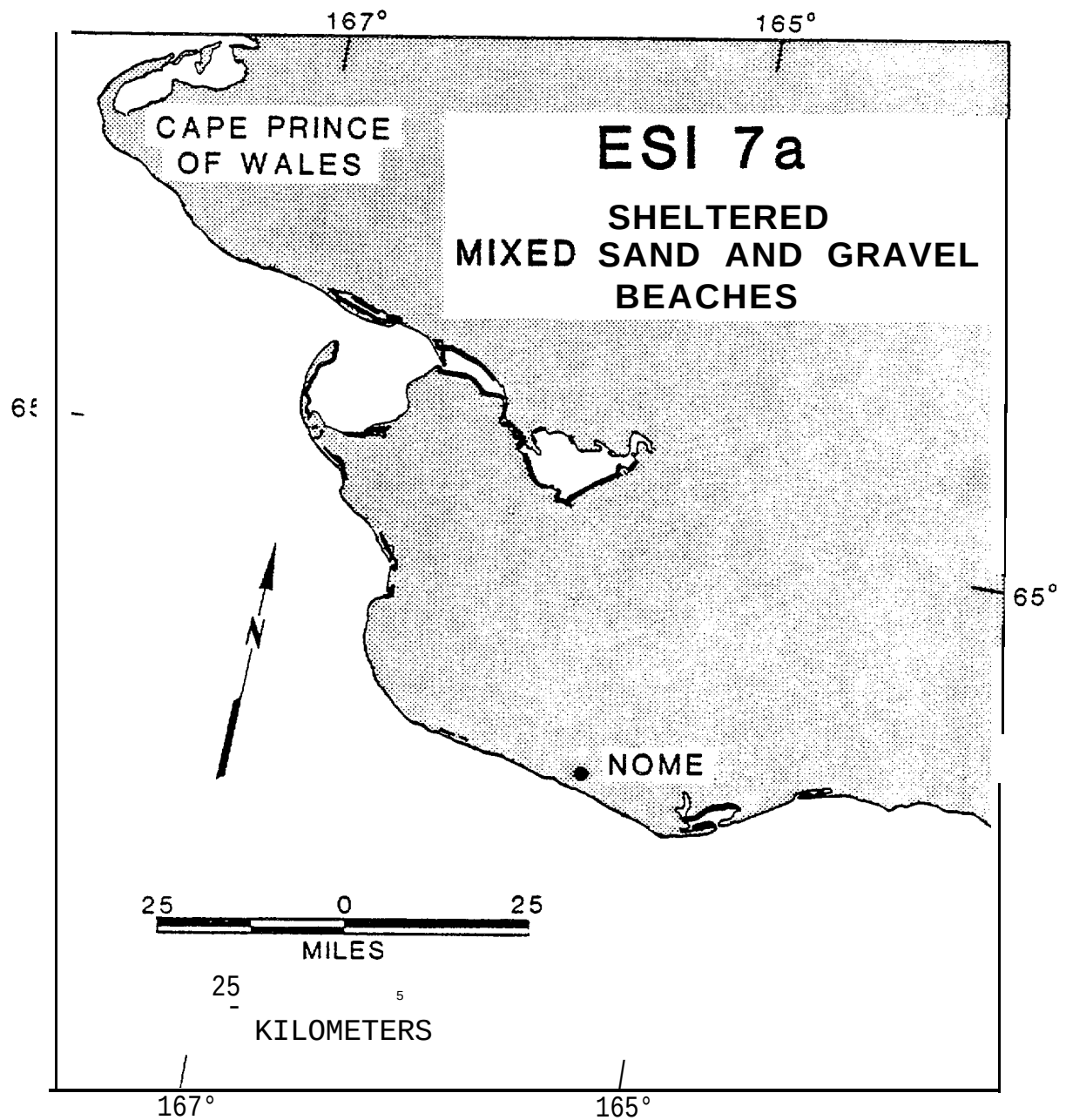


FIGURE 40. Distribution of sheltered, mixed sand and gravel beaches in northern Norton Sound.

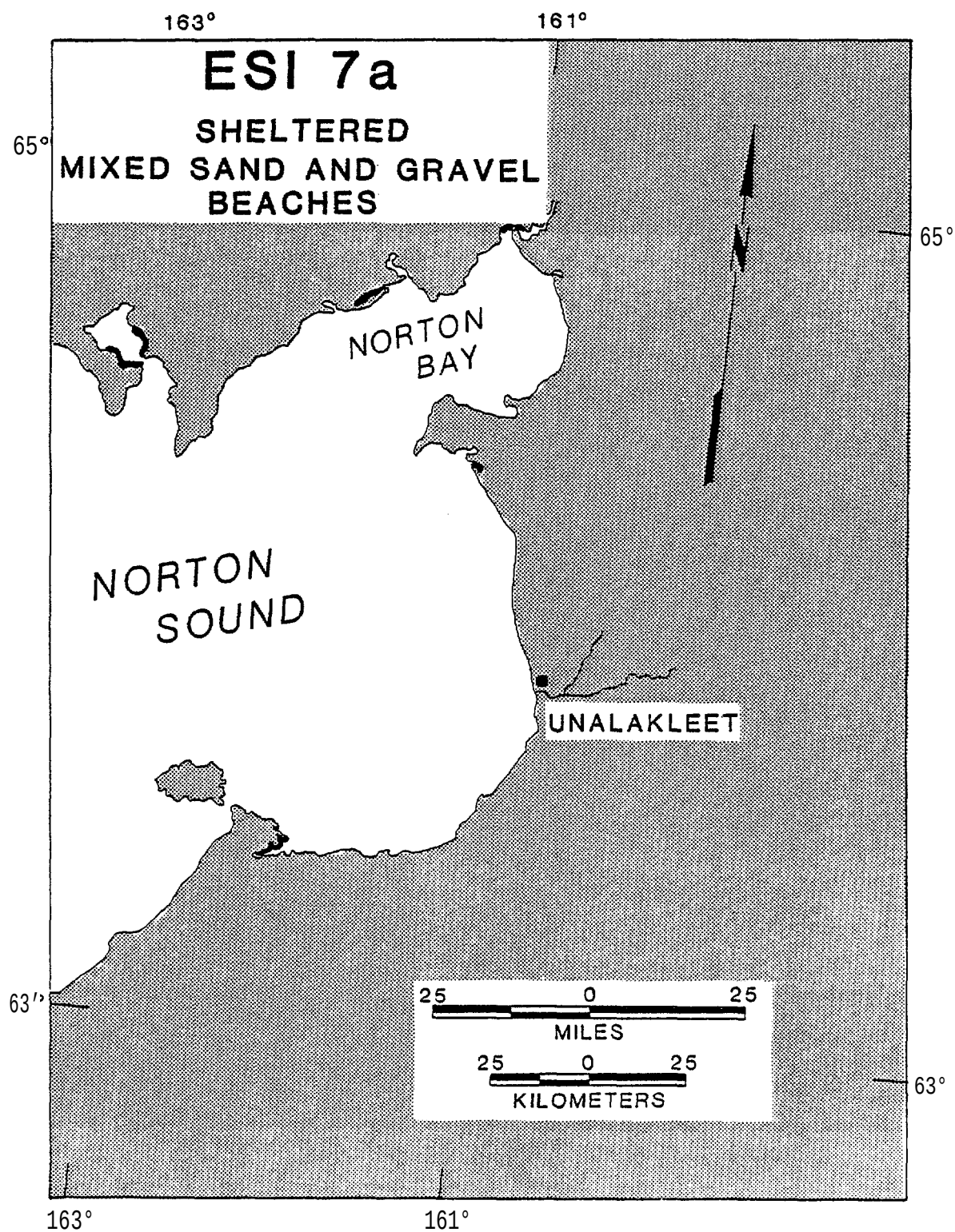


FIGURE 41. Distribution of sheltered, mixed sand and gravel beaches in eastern Norton Sound.

ESI=7b BASALT-BOULDER BEACHES (MODERATE BIOMASS)

General Description

- .Represent 2. 5 percent of the total shoreline
- Three stations surveyed
- .Primarily located east of St. Michael along areas of recent basalt flows
- .Composed of boulder-sized, basalt rocks
- . A log storm-swash is present far above the shore zone

Biologic Description

- .Contain the most extensive epifauna/algae community of the entire study area
- .Seven species of attached vegetation are present (six species of algae and one species of lichen)
- .Algal coverage averages 17 percent with Fucus being the most common
- .Three distinct vegetation zones are present
 - Verrucaria (lichen) is in the spray zone
 - A Fucus zone is along the mid- to upper-intertidal area
 - A red algae zone is along the mid- to lower-intertidal zone
- .Tundra vegetation is present behind the shoreline
- .Seven epifaunal species are present (two crustaceans, two limpets, one gastropod, one bivalve, and one anemone)
- .Barnacles are dominant, with population densities of $65.17/0.016 \text{ m}^2$
- .Pooled epifaunal densities average $66.17/0.016 \text{ m}^2$
- .Species richness ranges from zero to three species/ 0.016 m^2 , averaging $1.5 \text{ species}/0.016 \text{ m}^2$
- .No infauna are present (due to basalt substrate)
- Bird use ranges from low to moderate

Predicted Oil Impact

- Spilled oil would persist primarily in the more sheltered areas between the boulders
- Damage to algae would not be long-term
- Loss of barnacles may occur under heavy oil accumulations
- Recovery of biologic community would depend on extent of damage and the proximity of healthy organisms able to repopulate the area

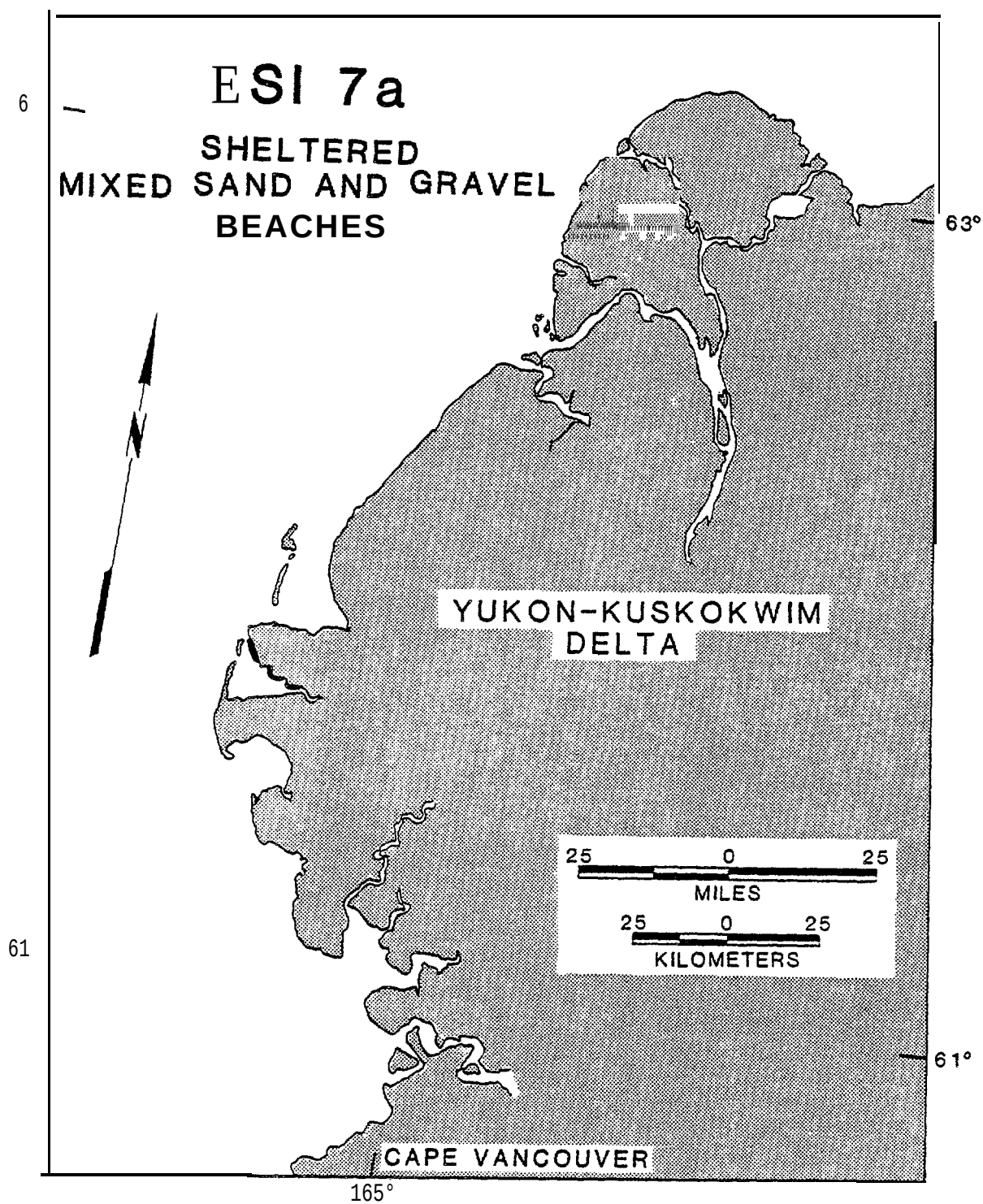


FIGURE 42. Distribution of sheltered, mixed sand and gravel beaches in southern Norton Sound.

Recommended Response Activity

- .Low- and high-pressure hosing of oiled algae is recommended
- .Removal (scraping) of algae should be avoided



FIGURE 43. Ground view of the stable, basalt shoreline east of St. Michael (left, station F-33; right, station NSS-34). The low intertidal zone has the most abundant and diverse, attached macroalgae of the study area. Spilled oil would settle into crevices and stick to the angular rock surfaces, affecting attached biota. Surface oil would be removed by storm waves, but oil in crevices may remain for several years.

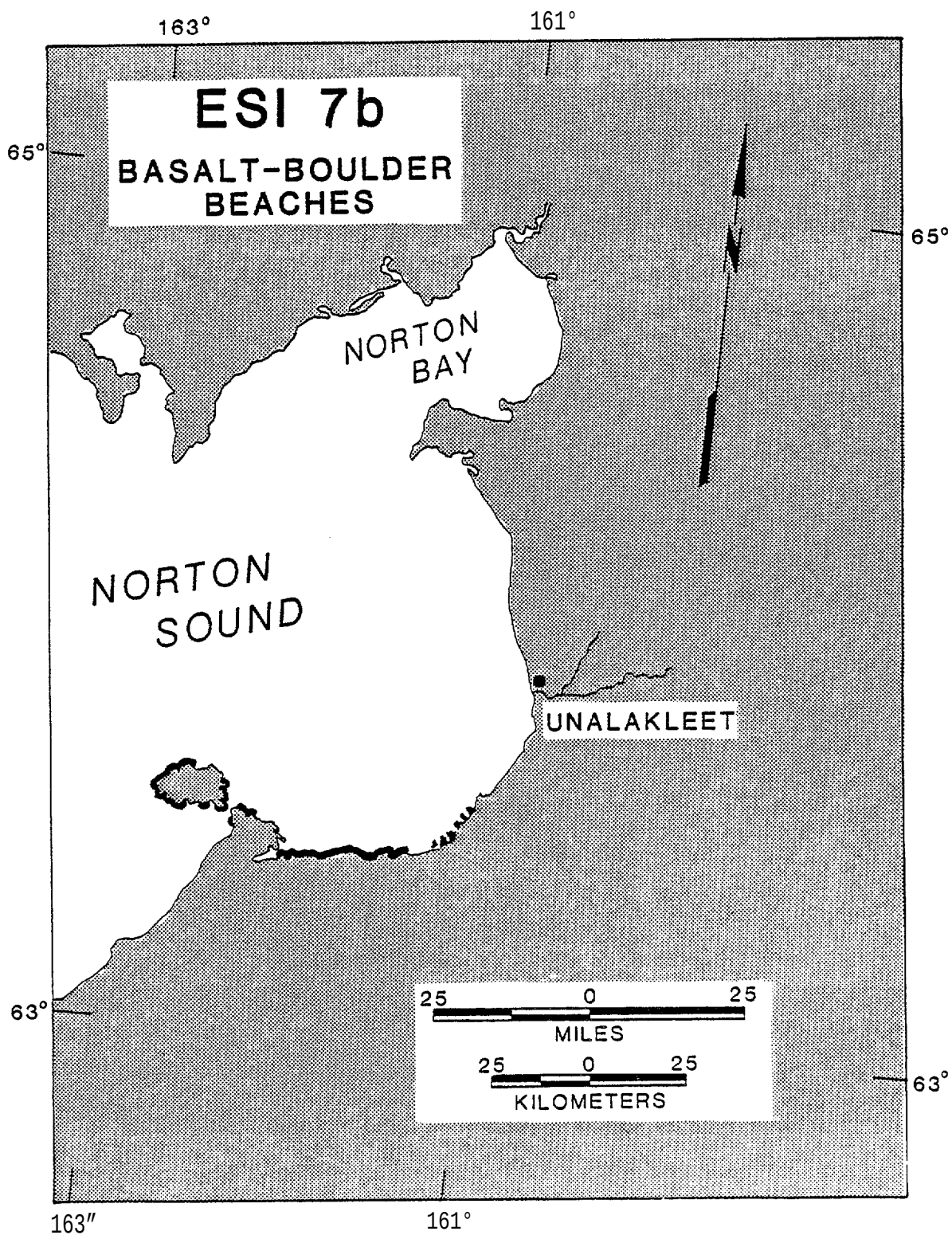


FIGURE 44. Distribution of basalt-boulder beaches is limited to the eastern portion of Norton Sound.

ESI=8 SHELTERED ROCKY SHORES

General Description

- Represent 0.5 percent of the total shoreline
- Not common in the study area
- One station surveyed
- Low wave energy environment
- Primarily located in Imuruk Basin, a freshwater system

Biologic Description

- No associated biota observed

Predicted Oil Impact

- Spilled oil would persist for several years, particularly in the very sheltered areas between the rocks

Recommended Response Activity

- Cleanup with high-pressure hosing may be necessary
- Fortunately, it is unlikely that oil would reach these interior environments



FIGURE 45. Ground-level view of a sheltered bedrock headland inside Imuruk Basin. Oil spilled in this area may persist for several years since there is insufficient wave energy to clean it naturally.

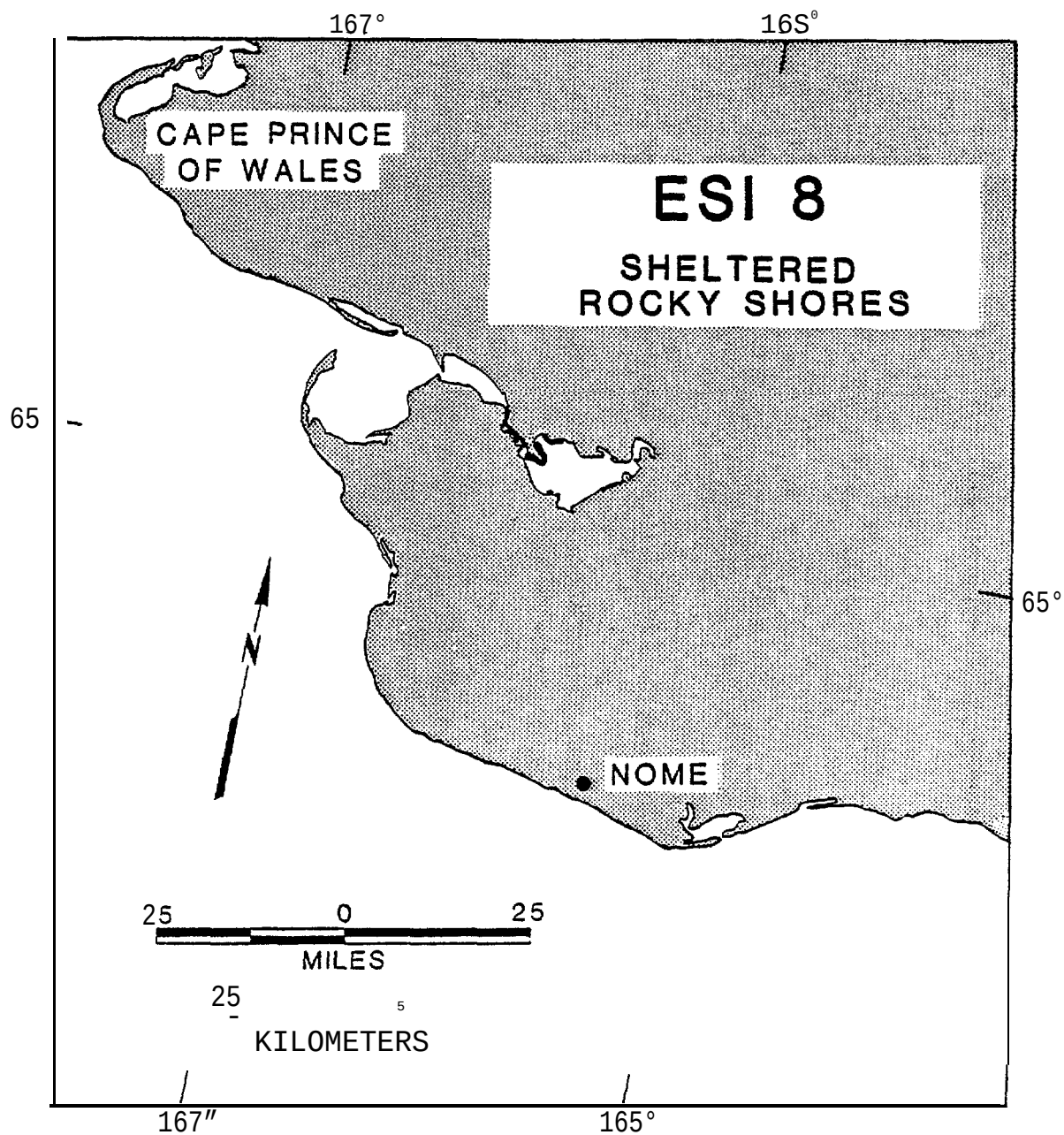


FIGURE 46. Distribution of sheltered rocky shores in northern Norton Sound. This shoreline type is not found in southern Norton Sound.

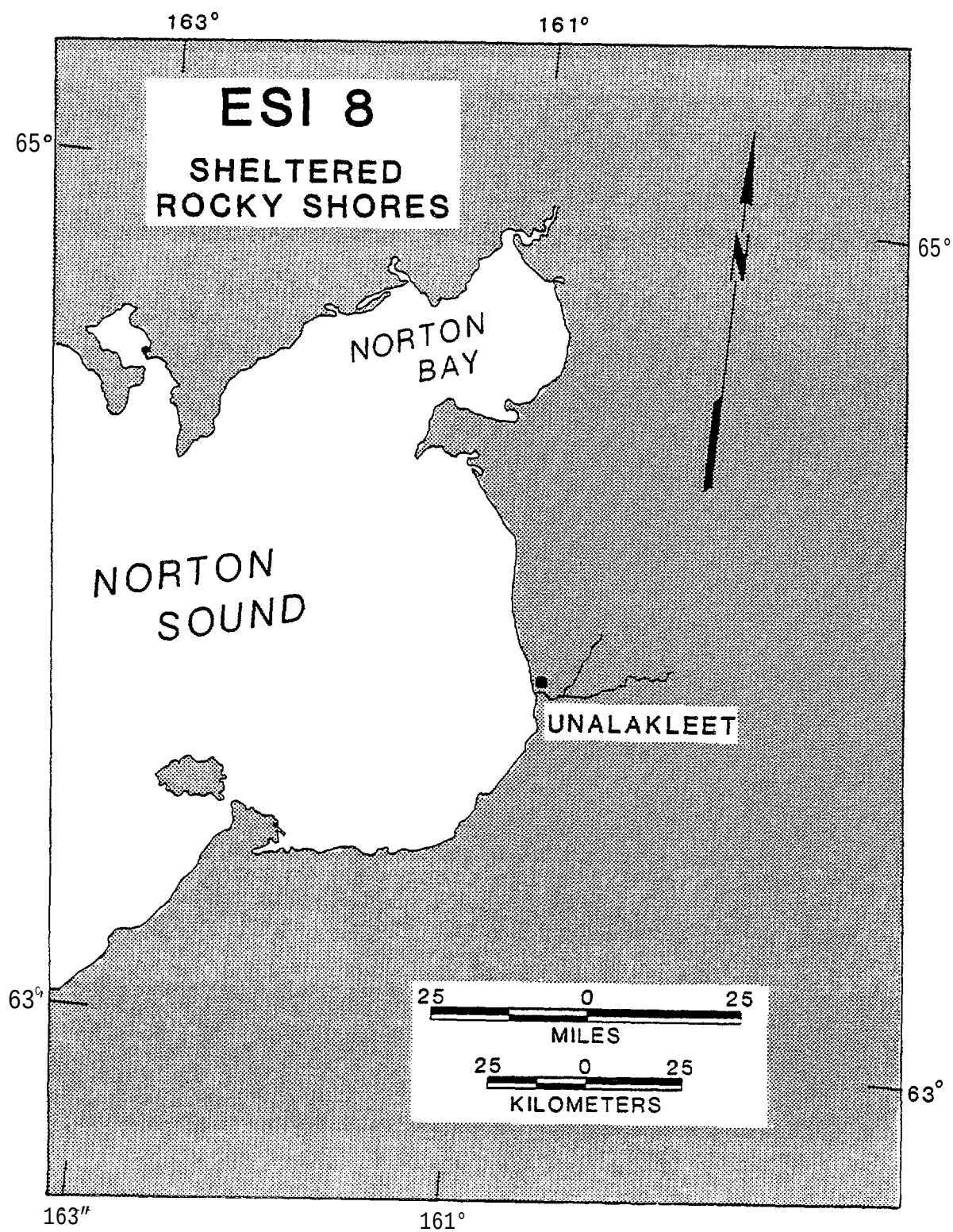


FIGURE 47. Distribution of sheltered rocky shores in eastern Norton Sound. This shoreline type is not found in southern Norton Sound.

ESI=8a ERODING PEAT SCARPS

General Description

- Represent 8.5 percent of the total shoreline
- 16 stations surveyed
- Primarily located on the Yukon-Kuskokwim delta front
- Characterized by 1-2 m wave-cut peat scarp, peat blocks of various sizes on the tidal flat in front, and rich organic matter between the blocks and against the scarp
- In many places, the area behind the scarp shows signs of high wave activity (lack of plants and deposition of logs and peat blocks)

Biologic Description

- Biologic activity is limited to three species of attached algae, three epifaunal species, and two infaunal species
- Algae only present in half the stations on the slumping peat blocks (average surface coverage = 7.0 percent)
- Enteromorpha sp. and a green filamentous alga dominate
- Epifauna in low population densities include isopods, mites, and one species of insect; isopods dominate
- Epifauna and infauna are present only at 27 percent of stations sampled
- Maximum epifaunal species richness is one species/0.016 m²
- Two infaunal species are present (isopods dominate; annelid worms average density = 0.33/0.008 m²)
- Maximum species richness = 1/0.008 m²
- Eight rooted plant species are present behind the scarp on the delta-front terrace
- Rabbits observed in delta-front vegetation
- Jellyfish are present in adjacent nearshore waters
- Moderate bird activity was observed

Predicted oil Impact

- Spilled oil would bind readily with the large amount of organic material forming thick, oil-organic mats
- Erosion of oiled organic matter during high wave conditions may cause oil to be carried to the bottom sediments

Recommended Response Activity

- If possible, open-water skimmers should be used to prevent oil from coming onshore
- Offshore dispersant application should be considered
- Oiled organic material should be removed rapidly to prevent further spread of oil offshore or into marsh areas behind the delta front

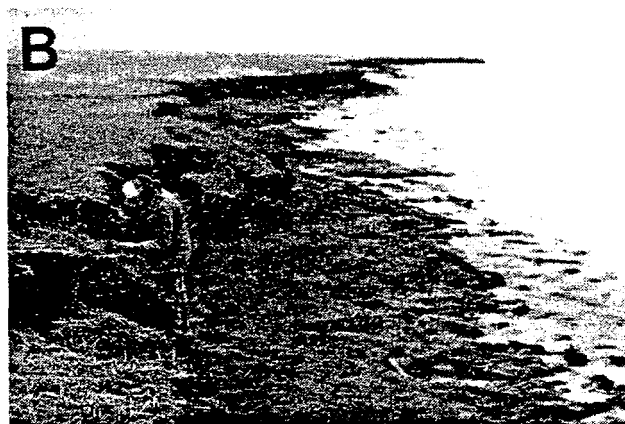


FIGURE 48. Examples of typical eroding peat scarps (ESI=8a). These eroding, delta-front shorelines exhibit a low, scalloped scarp (A, aerial view) and a wave-cut platform covered with tundra peat. Boulder-sized, vegetated peat blocks slump off the scarp (B, station F-41c) and are rounded by wave action on the platform (C, station NSS-37). Finely-divided peat detritus collects in depressions and thickly coats the platform (D, station F-48A). Combination of the water-saturated peat and proximity of critical waterfowl populations, marsh vegetation, and sheltered ponds makes this shoreline type highly sensitive to oil-spill impact. All photographs were taken along the main lobe of the Yukon delta front.

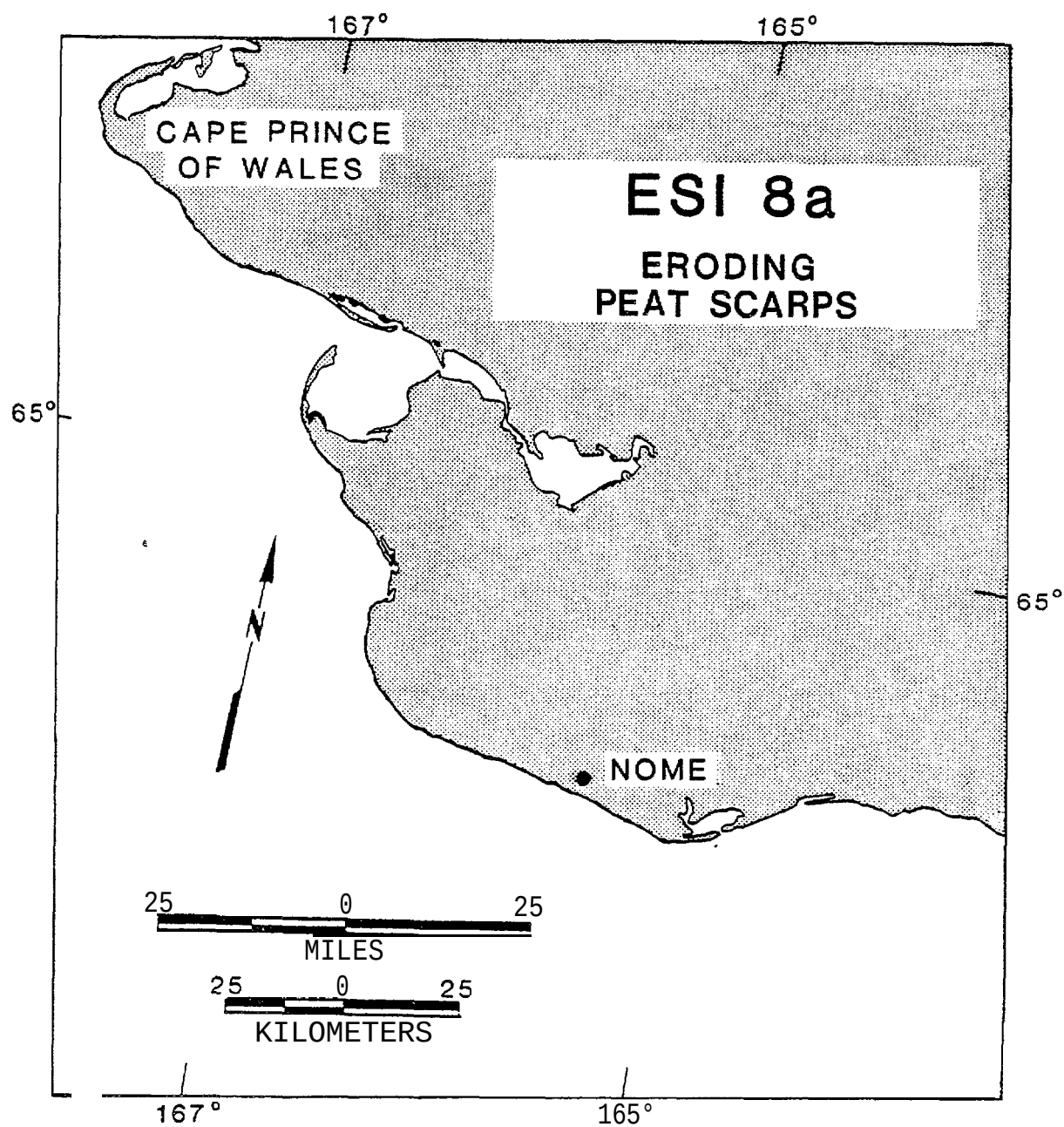


FIGURE 49. Distribution of eroding peat scarps in northern Norton Sound.

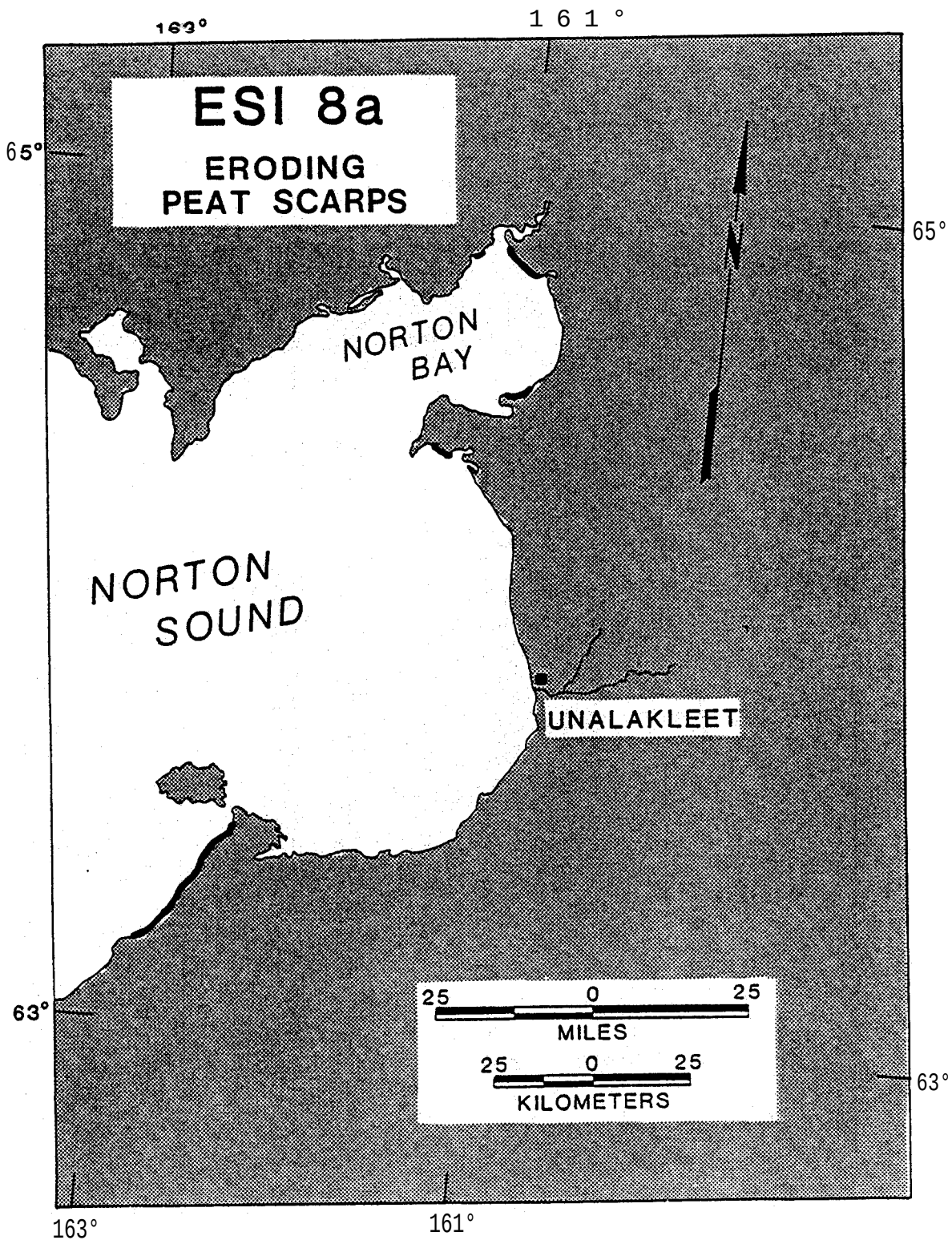


FIGURE 50. Distribution of eroding peat scarps in eastern Norton Sound.

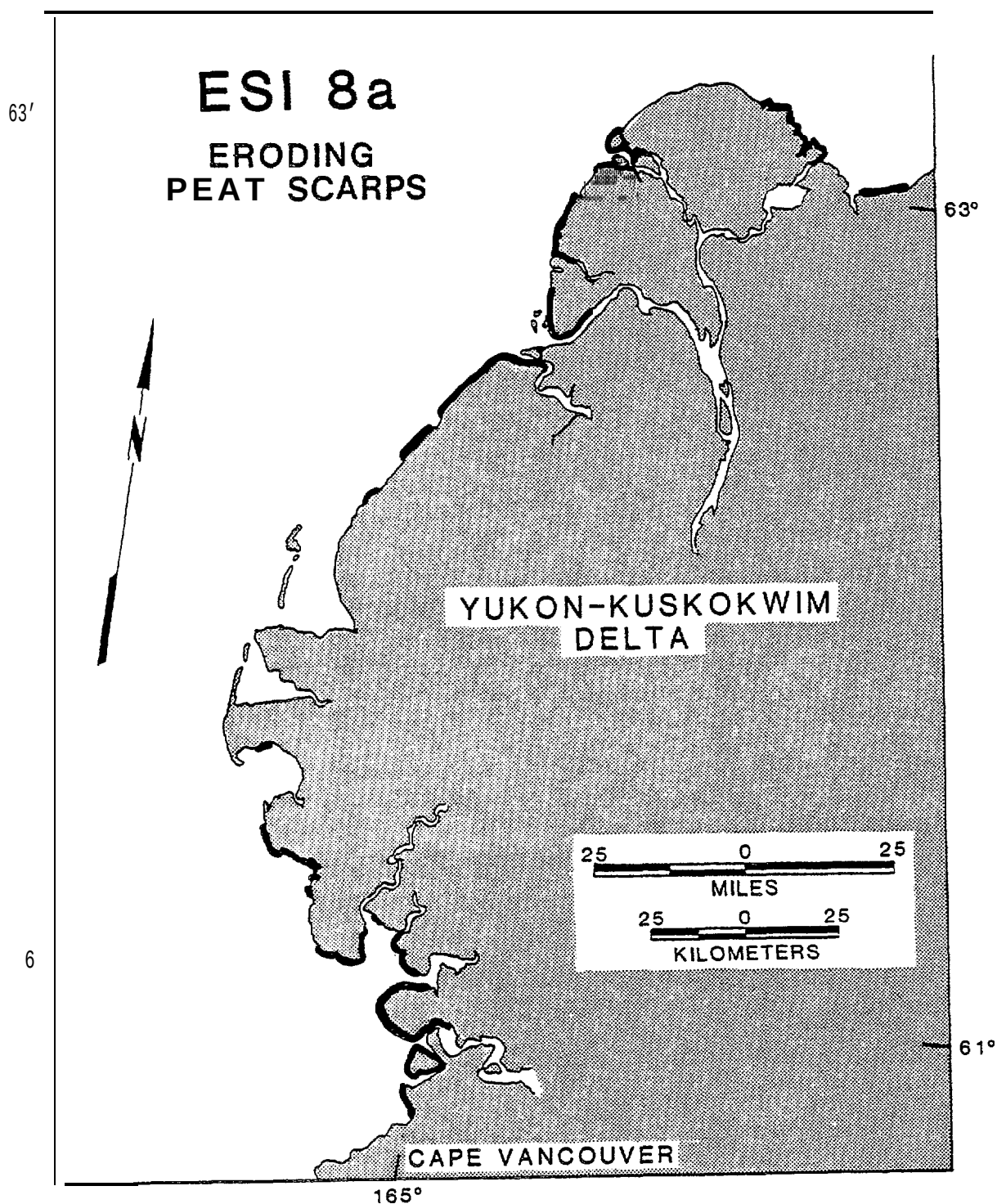


FIGURE 51. Distribution of eroding peat scarps in southern Norton Sound.

ESI=9 SHELTERED TIDAL FLATS

General Description

- Represent 15 percent of the total shoreline
- Two types are common
 - (1) Small flats located in tundra areas
 - (2) Large flats along depositional areas of the Yukon-Kuskokwim delta
- 14 stations surveyed
- Located in areas of low wave and current activity
- Primarily composed of silts, clays, and fine-grained sand

Biologic Description

- Rooted vegetation (six species) is present at half the field stations
- Epifauna and infauna are not present at 40 percent of stations, particularly along northern portion of study area
- Six epifaunal species observed (3 marine, 2 insects, and 1 spider)
- Where present, epifaunal densities average 4.3/0.016 m²; maximum species richness = two species/0.016 m²
- Six infaunal species were observed (2 crustaceans, 2 annelid worms, and 2 clams)
- Isopods are found most frequently
- Infaunal densities average 1.58/0.008 m², dominated by polychaetes and clams
- Maximum infaunal species richness = two species/0.008 m², but average only 0.7 species/0.008 m²
- In a few locations, three-spined sticklebacks fish are present in small tidal pools
- Bird activity is high, mainly in adjacent marshes and tundra

Predicted oil Impact

- Spilled oil would bind with sediment
- Long-term persistence of surface oil may occur because of limited wave activity
- Long-term oil incorporation into interstitial water may occur

Recommended Response Activity

- Open-water skimmers should be used during calm seas
- Offshore dispersant application should be considered
- Once onshore, oil removal is very difficult
- Labor-intensive cleanup recommended over heavy machinery use
- Access routes for men and machinery should be very controlled



FIGURE 52. Aerial and ground views of a sheltered tidal flat. This shoreline type is particularly common in the Yukon-Kuskokwim delta region. The tidal flat is composed of water-saturated, muddy sediments rich in organic detritus. Aquatic vegetation is commonly associated with this environment. The sheltered nature of this shoreline type prevents rapid oil removal by natural processes.

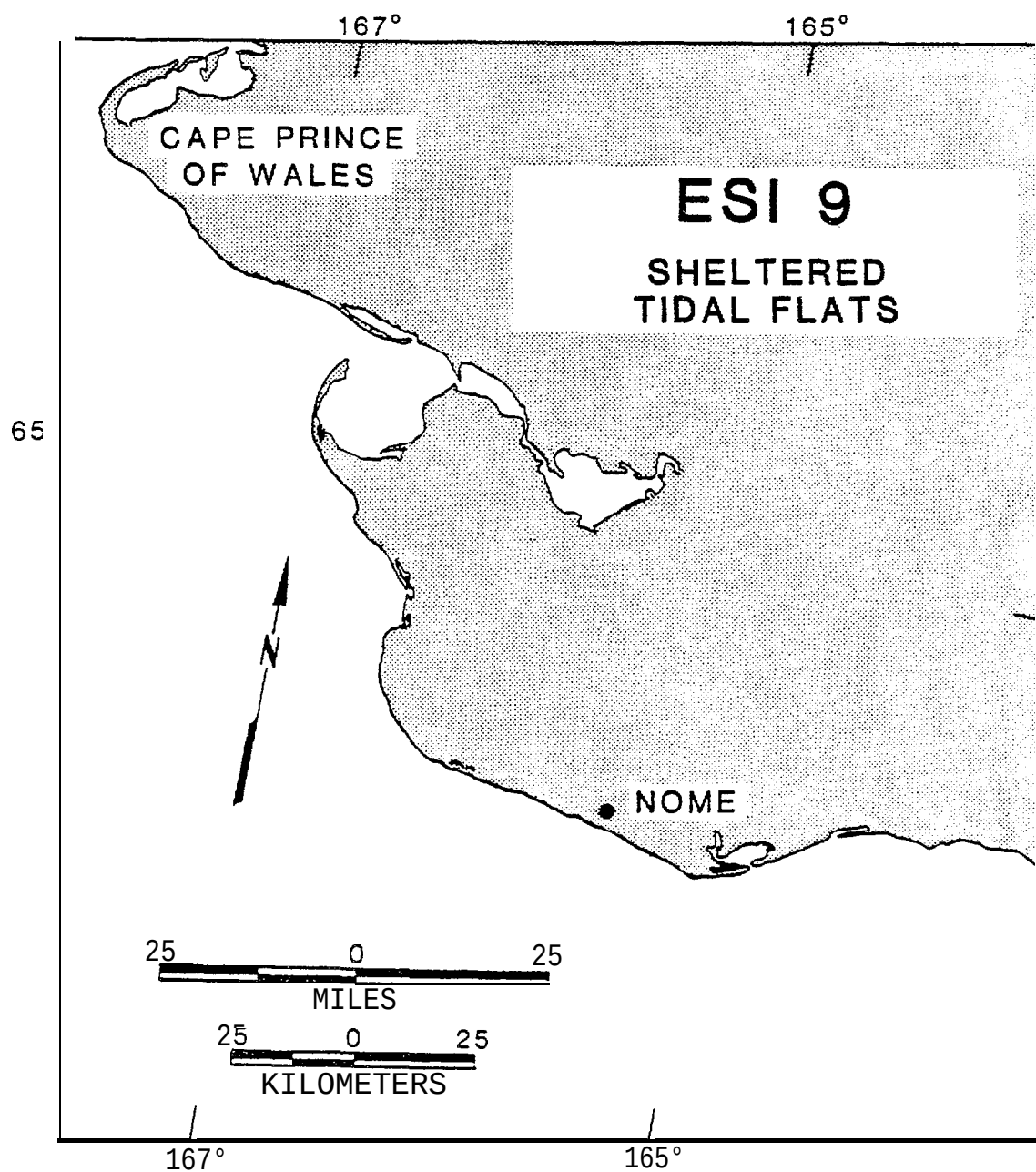


FIGURE 53. Distribution of sheltered tidal flats in northern Nor'ton Sound.

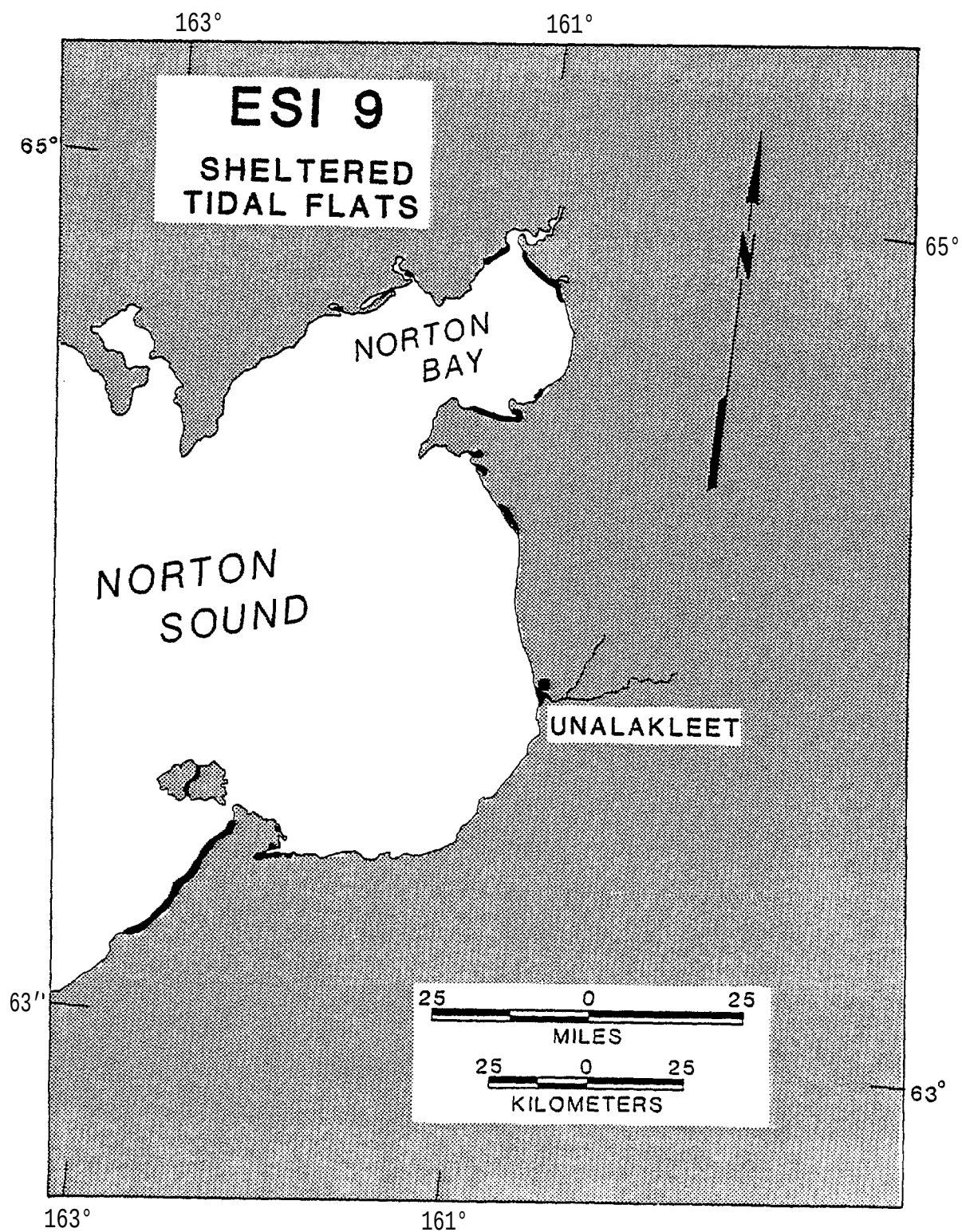


FIGURE 54. Distribution of sheltered tidal flats in eastern Norton Sound.

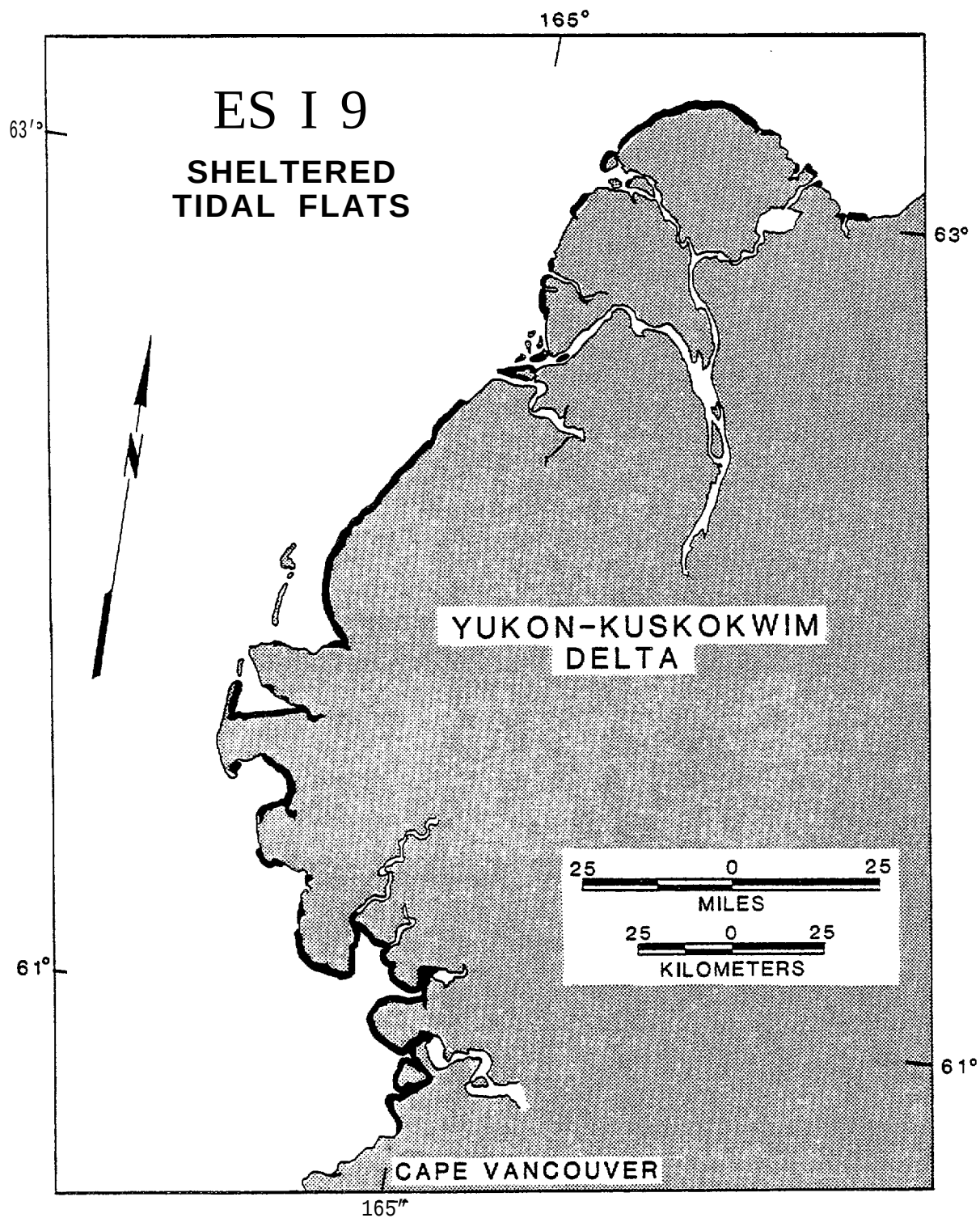


FIGURE 55. Distribution of sheltered tidal flats in southern Norton Sound.

ESI=10 MARSHES

General Description

- Represent the most common shoreline type, 26.5 percent of the total shoreline
- 15 stations surveyed
- Most common along the Yukon-Kuskokwim delta and along deltas in large bays (e.g., Golovin and Norton Bays)
- Located in low-energy environments
- Surrounding waters vary from fresh to brackish

Biologic Description

- Rooted vegetation is present at all stations; 11 species in total, but only four types (willows, grasses, sedges, and saltwort) are found at most stations
- Dominant plant types include grasses, sedges, and willows except in southern Norton Sound where the saltwort is also common
- Insects and mites were the only epifauna observed; mites are dominant with average densities of 33/0.016 m²
- Maximum epifaunal species richness = one species/0.016 m²
- No infauna were found
- Rabbits are present at some stations
- The sea grass, Zostera marina, is present at some lagoonal stations, particularly in Golovin Lagoon
- High bird activity is associated with nesting, staging, and feeding; gulls, geese, shore birds, ducks, swans, and hawks are particularly common

Predicted Oil Impact

- Spilled oil in heavy concentrations would kill marsh vegetation for several years
- Lesser concentrations may cause only short-term effects
- Bird losses would be heavy, particularly along the delta fringe

Recommended Response Activity

- Open-water skimmers should be used during low wave conditions
- Offshore dispersant application should be considered to prevent onshore impact
- Once onshore, removal of very heavy accumulations are recommended
- Use of heavy machinery should be avoided
- Manpower should be restricted to particular access routes
- Low- and high-pressure spraying recommended

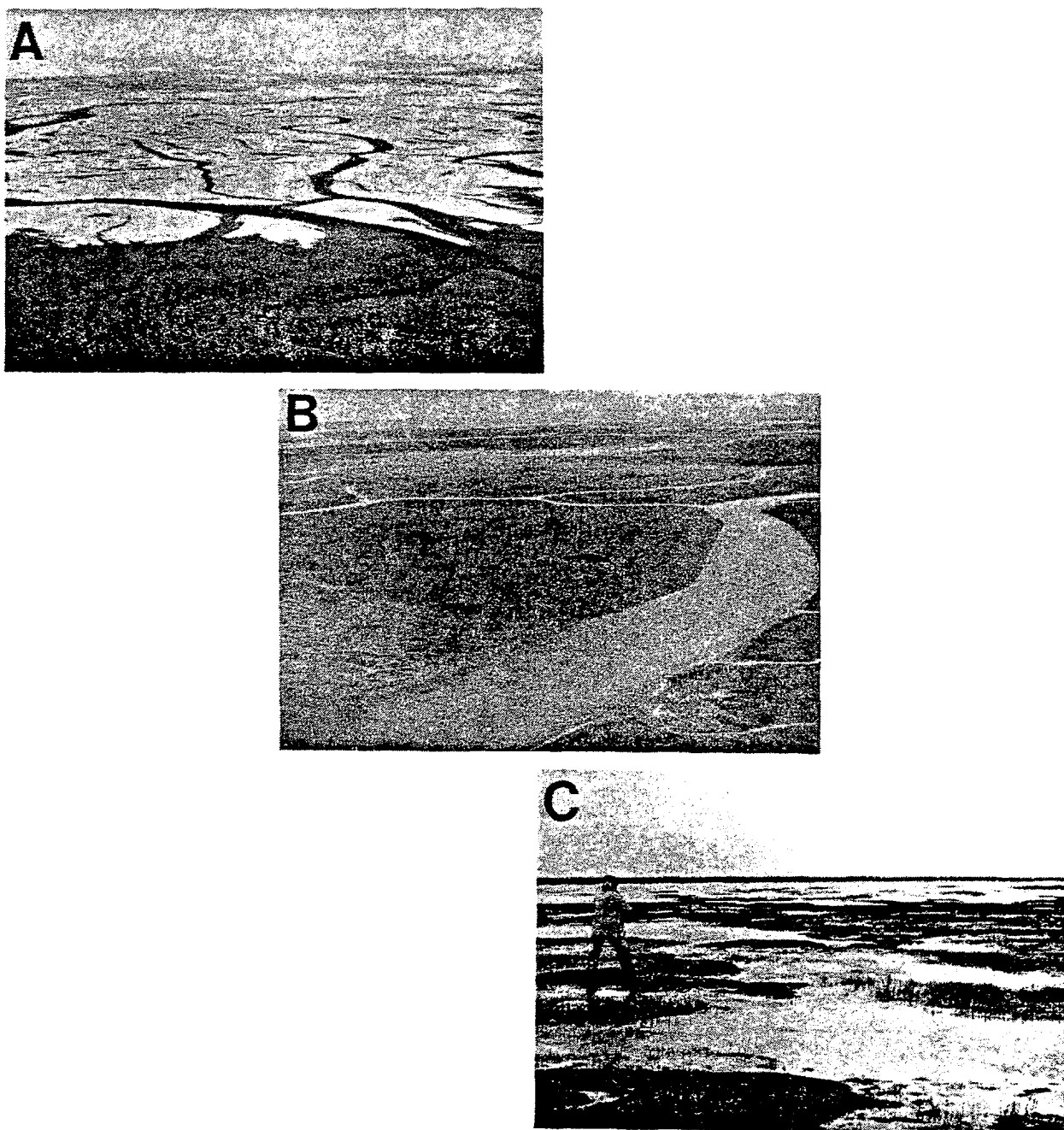


FIGURE 56. Aerial and ground views of marsh areas along the delta in Golovin Lagoon (A) and station F-39C (B). Shorelines with marsh vegetation are very common in the sheltered embayments of the study area and are the shoreline type most vulnerable to oil-spill damage. They are characterized by low flat coastlines with abundant channels and ponded water (A). Extensive marsh area becomes flooded during spring high tides by overbanking of delta distributary channels. Abundant marsh vegetation (C) and waterfowl populations common to this environment would suffer heavy damage during an oil spill.

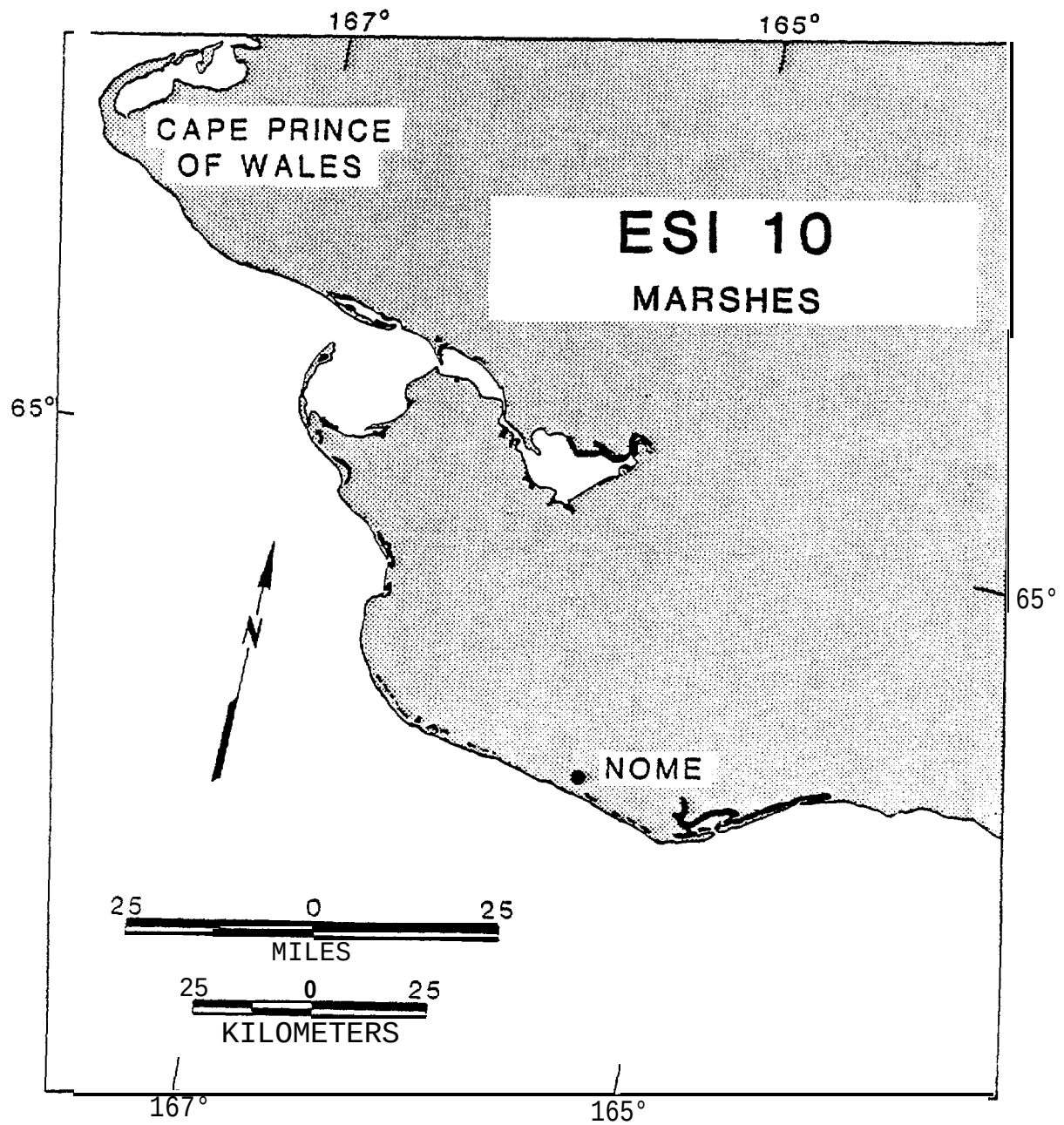


FIGURE 57. Distribution of marshes in northern Norton Sound.

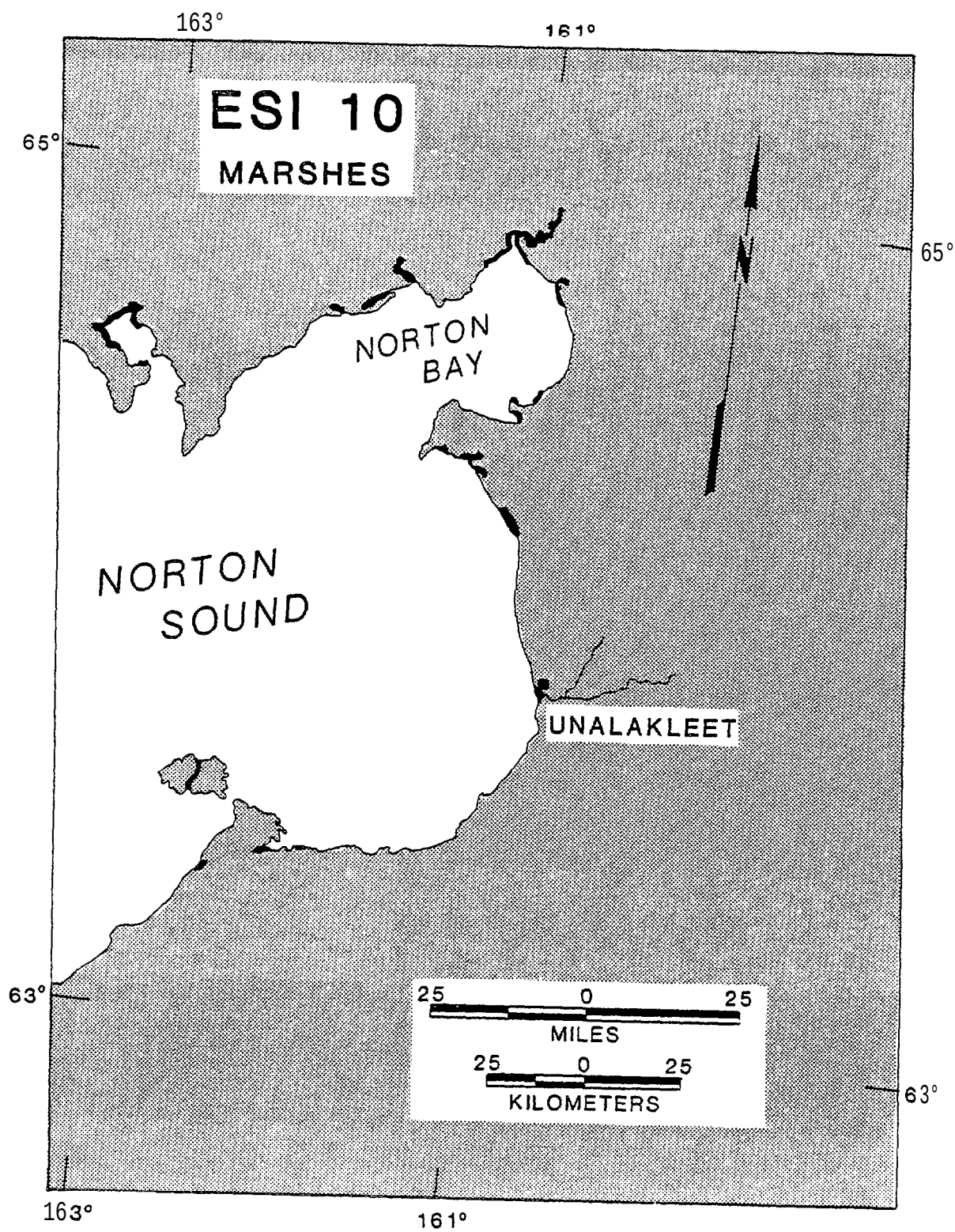


FIGURE 58. Distribution of marshes in eastern Norton Sound.

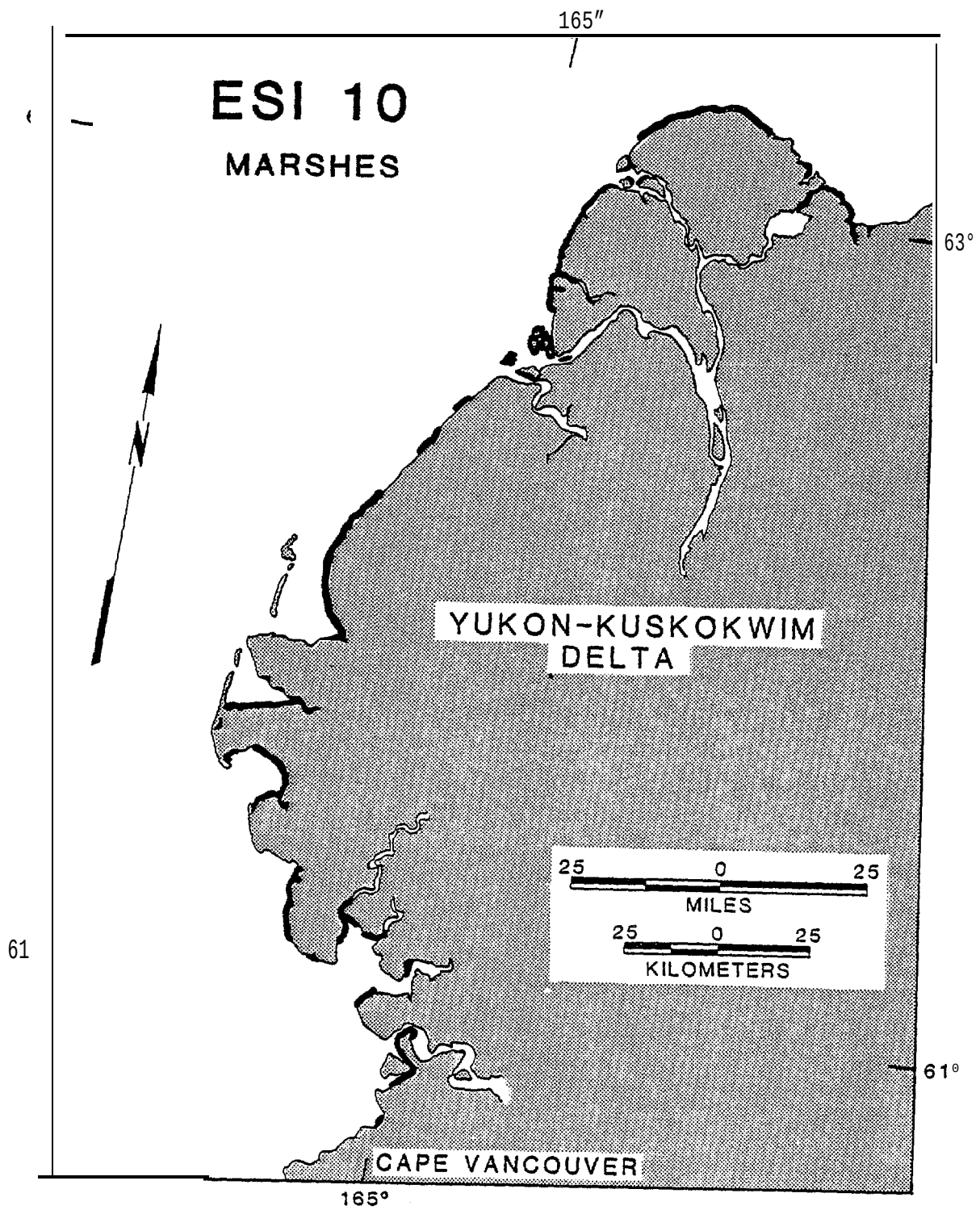


FIGURE 59. Distribution of marshes in southern Norton Sound.

Biological Resource Information

This section outlines the location, protection status, predicted oil impact, and appropriate response measures of the mammals, coastal marine birds, and finfish found in the Norton Sound/Pribilof Island region.

MARINE MAMMALS

Resident Populations

- | | | |
|--------------------------|------------------------------|---|
| ● Beluga (Belukha) whale | <u>Delphinapterus leucas</u> | - Spring, summer (after breakup) move into estuaries and up rivers |
| ● Walrus | <u>Odobenus rosmarus</u> | Summer, Besboro Island used intermittently as haulout area |
| ● Northern fur seal* | <u>Callorhinus ursinus</u> | Breeding and haulout on Pribilof Islands, spring through fall |
| ● Steller seal lion | <u>Eumetopias jubata</u> | Otter and Walrus Islands in the Pribilofs intermittently used as winter haulouts |

Protection Status

- All protected by Marine Mammal Act of 1972
- *Managed under Fur Seal Act of 1966

Predicted Impact

- Walruses and seals
 - Eye irritation (Geraci and Smith, 1976)
 - Stress through skin absorption from continued exposure observed in seals (Geraci and Smith, 1976); to our knowledge, NO walruses have been killed from exposure to oil
 - **preweaned** seal pups, which have not yet developed insulating fat layers, may experience **thermoregulatory** problems
 - Greatest impact to seals may occur during pupping season when stress is high and **preweaned** pups are present
- Whales
 - Stress may occur through ingestion of oil-contaminated food, oil intake through blowholes, eye irritation, and skin absorption

Recommended Response Measures

- Whales
 - Hazing to change swimming pattern
- Walruses
 - Hazing from haulout areas during nonbreeding status
- Northern fur seals
 - Due to size of breeding population on the **Pribilof** Islands, no entirely effective response measures can be undertaken
- Sea lions
 - Hazing from haulout areas during nonbreeding status

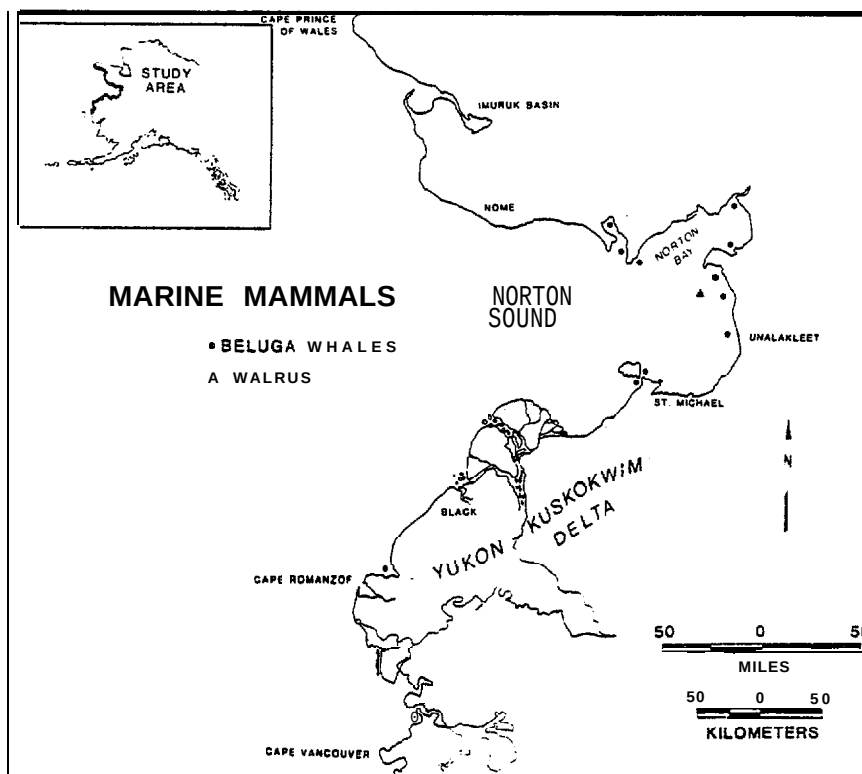


FIGURE 60. Distribution of resident marine mammals in the Norton Sound area. Distribution in the Pribilof Islands is presented separately in Figure 77.

COASTAL MARINE BIRDS

Resident Populations

- Pelagic Birds
 - Year round; offshore south of ice pack
- Diving Birds--species of special concern:
 - Double-crested cormorant Phalacrocorax auritus
 - Pelagic cormorant P. pelagicus
 - Red-faced cormorant P. urile
 - Resident; coastal
 - Resident; coastal
 - Resident; coastal
- Waterfowl--species of special concern:

(nesting and molting occur during summer; migration occurs in fall and spring)

Canada goose	<u>Branta canadensis</u>	- Nesting; molting; migration
Emperor goose	<u>Phalacrocorax canagica</u>	- Nesting; molting; migration
Black brant	<u>Branta bernicla</u>	- Nesting; molting; migration
White-fronted goose	<u>Anser albifrons</u>	- Nesting; molting; migration
Pintail	<u>Anas acuta</u>	- Nesting; molting; migration
Greater scaup	<u>Aythya marila</u>	- Nesting; molting; migration
Golden eyes		
and bufflehead	<u>Bucephala sp.</u>	- Nesting; molting; migration
Oldsquaw	<u>Clangula hyemalis</u>	- Nesting; molting; migration
Eiders	<u>Somateria sp.</u>	- Nesting; molting; migration
	<u>Polysticta sp.</u>	- Nesting; molting; migration
Scoters	<u>Melanitta sp.</u>	- Nesting; molting; migration
- Raptors--species of special concern:
 - Peregrine falcon Falco peregrinus
 - Gyrfalcon Falco rusticolus
 - Nesting; migration
 - Year round; coastal
- Shore birds--species of special concern:

Golden plover	<u>Pluvialis dominica</u>	- Nesting; migration
Black-bellied plover	<u>Pluvialis squatarola</u>	- Nesting; migration
Black turnstone	<u>Arenaria melanocephala</u>	- Nesting; migration
Ruddy turnstone	<u>Arenaria interpres</u>	- Nesting; migration
Whimbrel	<u>Numenius phaeopus</u>	- Nesting; migration
Rock sandpiper	<u>Calidris ptilocnemis</u>	- Nesting; migration
Dunlin	<u>Calidris alpina</u>	- Nesting; migration
Long-billed dowitcher	<u>Limnodromus scolopaceus</u>	- Nesting; migration
Western sandpiper	<u>Calidris mauri</u>	- Nesting; migration
Bar-tailed godwit	<u>Limosa lapponica</u>	- Nesting; migration
- Gulls and terns--species of special concern:

- Glaucous-winged gull	<u>Larus glaucescens</u>	- Resident; coastal
- Mew gull	<u>L. canus</u>	- Resident; coastal
- Black-legged kittiwake	<u>Rissa tridactyla</u>	- Nesting; offshore
- Red-legged kittiwake	<u>Rissa brevirostris</u>	- Nesting (Pribilof Islands); offshore
- Arctic tern	<u>Sterna paradisaea</u>	- Nesting; offshore
- Alcids--species of special concern:

Common murre	<u>Uria aalge</u>	- Nesting; offshore
Thick-billed murre	<u>U. lomvia</u>	- Nesting; offshore
Pigeon guillemot	<u>Cepphus columba</u>	- Nesting; coastal to offshore
Parakeet auklet	<u>Cyclorhynchus</u>	
	<u>psittacula</u>	- Nesting; offshore
Horned puffin	<u>Fratercula</u>	
	<u>corniculata</u>	- Nesting; offshore
Tufted puffin	<u>Lunda cirrhata</u>	- Nesting; offshore
Crested auklet	<u>Aethia cristatella</u>	- Nesting; offshore

Protection Status

- Migratory Bird Act
- Endangered Species Act of 1973
- Migratory waterfowl regulations

Predicted Impact

- Pelagic Birds
 - May become contaminated at night when roosting on water
 - May attempt to feed in contaminated water
 - Because of pelagic nature, birds dying from oil contamination may sink to bottom or be eaten
 - Impact would be difficult to determine
- Diving birds
 - May dive or swim into oiled waters
 - Sometimes form large feeding flocks - these would be especially susceptible to mass oiling
- Waterfowl

Coastal species would be especially vulnerable
 Emperor geese feed in seagrass flats, very shallow waters; may be oiled in water or deprived of access to seagrass beds
 Ducks dive for food and are found in coastal or offshore waters; contamination would result from swimming in oiled water; they may land in oil-calmed water for evening roost; they sometimes form large rafts which may result in massive oiling; they may dive through or surface in oiled water
 After breeding season is completed, waterfowl undergo molting and are unable to fly until feathers are replaced; they remain on the water during this time and, therefore, are highly vulnerable to contamination from oil spills
- e Raptors
 - Peregrine falcons and gyrfalcons feed on waterfowl, shorebirds, and seabirds; they are attracted to weakened birds so may feed on oil-contaminated prey
- Shorebirds
 - May feed or roost on oil-contaminated beaches
 - May ingest contaminated food
 - May ingest oil when preening contaminated feathers
- Gulls and Terns
 - Form large colonies on isolated islands or high cliffs when nesting
 - May attempt to feed in oil-contaminated water
 - Oil on feathers can be transferred to eggs
 - May roost in oiled water or on contaminated beaches
 - May ingest oil when preening contaminated feathers
- * Alcids
 - Form large colonies
 - If disturbed, will fly from nests into water
 - May attempt to land in oil-calmed water
 - Escape behavior is to dive into water
 - May feed in oiled water

Recommended Response Measures

- Hazing of birds from oiled water may be effective
- During nesting season:
 - If still early in season, birds should be driven from rookeries and a watch maintained to insure that they do not return
 - If young in nests, attempts should be made to boom around colony; however, minor disturbances may drive adults from the nests
 - Human disturbance should be kept to minimum
- Aircraft should not be operated over or near colonies
- Herd nonflying waterfowl away from spill, or capture and remove them to safety.

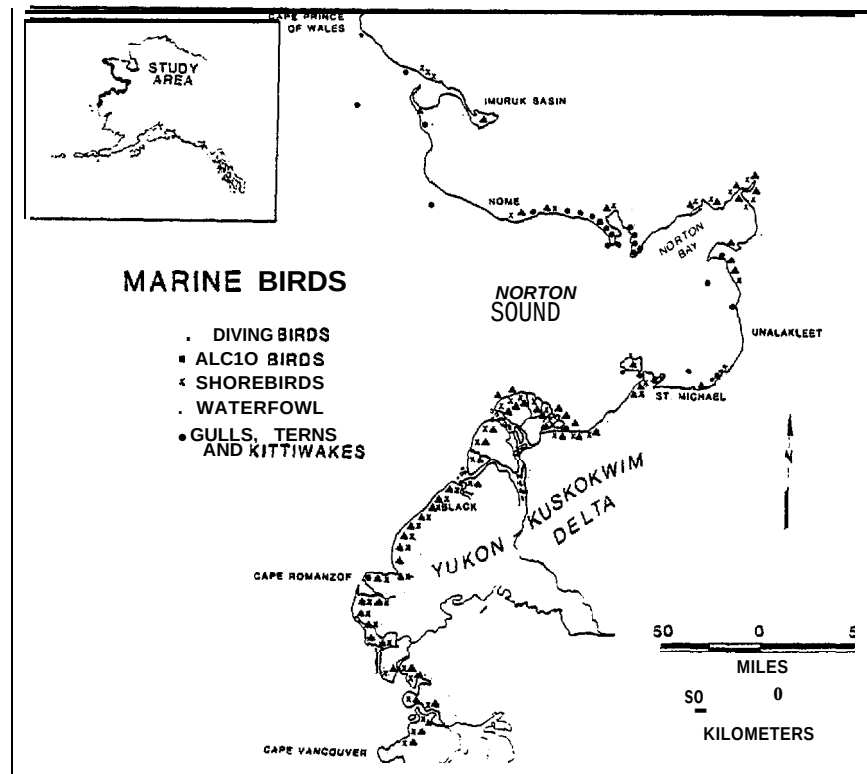


FIGURE 63.. Distribution of coastal marine birds in the Norton Sound region. Birds in the Pribilof Islands are presented separately in Figure 77.

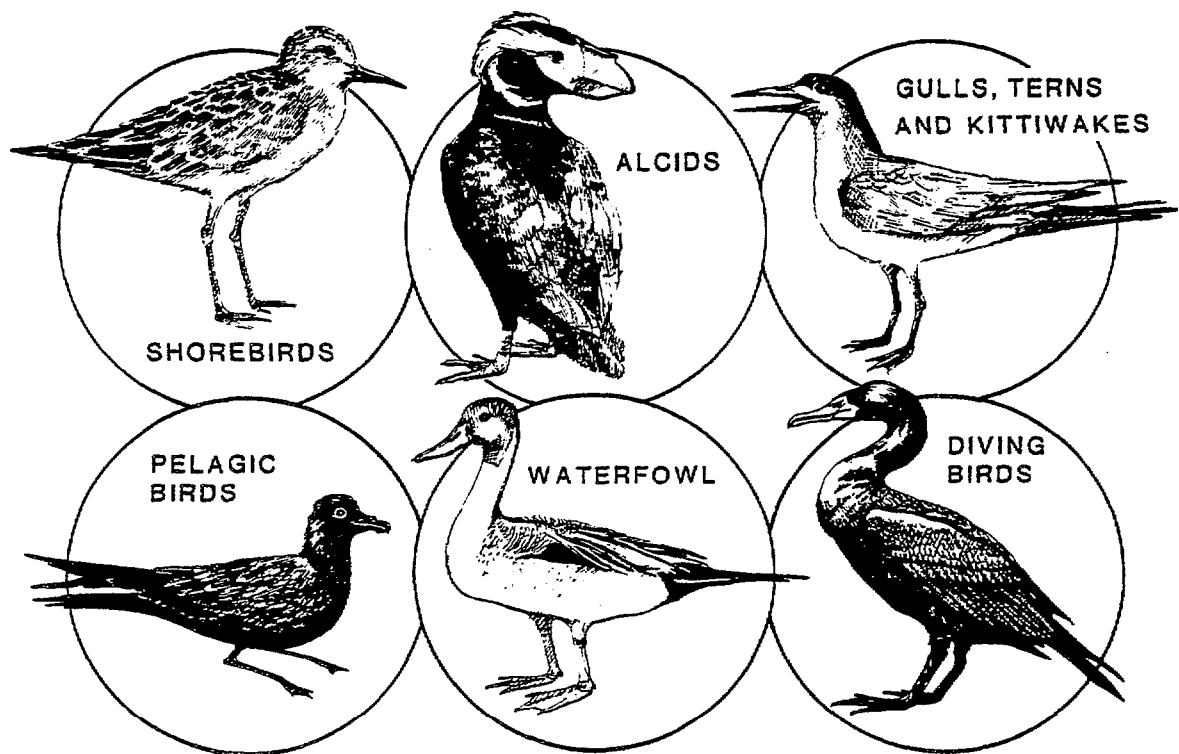


FIGURE 62. Coastal marine birds of Norton Sound.

FINFISH

Resident Populations

• Chinook salmon	<u>Oncorhynchus</u>	Spring and summer
• Sockeye salmon	<u>O. nerka</u>	Mid spring to October: a few are found north of Kuskokwim delta
• Pink salmon	<u>O. gorbuscha</u>	Spring to fall
• Chum salmon	<u>O. keta</u>	Spring to fall
• Coho salmon	<u>O. kisutch</u>	Spring to November
• Pacific herring	<u>Clupea harengus</u>	Early spring to late fall

Protection Status

- Salmon
 - Managed by State of Alaska and International Pacific Fisheries Commission
- Pacific herring
 - Utilized by foreign fisheries; no protection status given
- Salmon
 - All species susceptible during migration runs
 - Chum and pink utilize estuarine areas for egg-laying
 - Chum and pink also susceptible at egg, alevin, and juvenile stages
 - Homing mechanisms may be significantly affected by oil because they use sensitive cues
- Pacific herring
 - Lay eggs on intertidal kelps and rockweeds
 - Adults would be impacted during nearshore egg-laying process
 - Eggs attached to algae would be sensitive to oiling
 - Larvae remaining in hatching area would also be sensitive to oiling
- General
 - Fish are sensitive to contamination from oil
 - Studies on eggs, larvae, and adults have been well-documented (Kuhnhold, 1972; Lachotowich et al., 1977; Rice et al., 1977; and others)

Recommended Response Measures

- Oil should be deflected away from major fish runs
- Open-water skimmers with paravanes should be used to remove oil before it strikes fish run areas

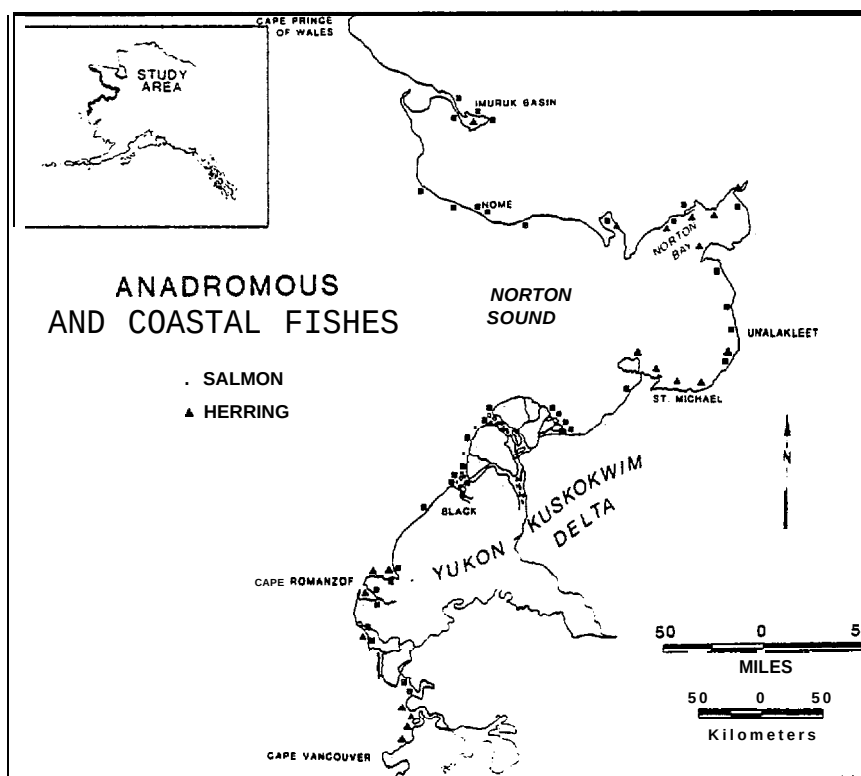


FIGURE 63. Distribution of anadromous and coastal fishes along Norton Sound shorelines.

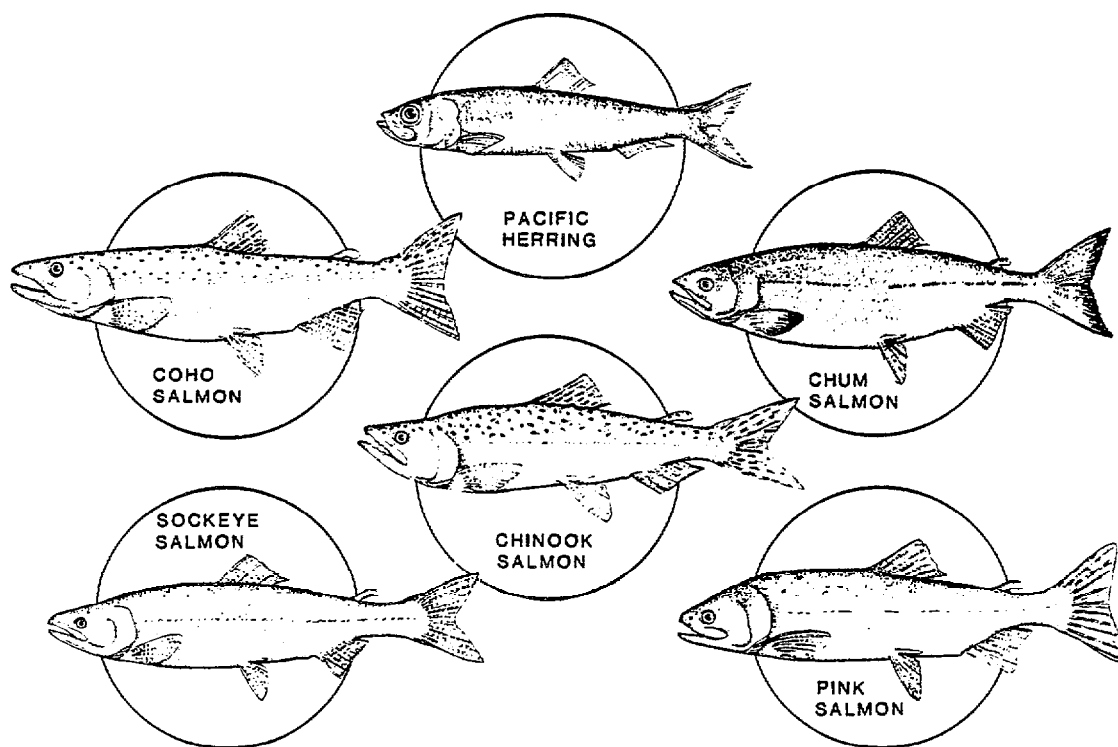


FIGURE 64. Anadromous and coastal fishes in Norton Sound.

SUMMARY OF SHORELINE TYPES

Geomorphology

In order to aid development of effective management schemes and spill-impact scenarios, ESI shoreline lengths are summarized in Table 4 for the following zones (Fig. 65):

- A Cape Princeof Wales to 3 km west of Brevig Lagoon (167 W).
- B 3 km west of Brevig Lagoon (167°W) to Cape Douglas. This area includes the interior

TABLE 4. Summary of shoreline types by section in Norton Sound. See Figure 65 and text for location of shoreline segments. The Pribilof Islands are summarized as a group.

ZONE		SHORELINE TYPE										TOTAL			
		1	2	3	4	5	6	7	7a	7b	8		8a	9	10
A	km	14.5	6.0				38.5	2.5	2.0				0.5	3.0	67.0
	%	21.5	9.0				57.5	3.5	3.0				1.0	4.5	
B	km	11.5	2.0		2.5	5.0	89.0		141.0		6.0	3.0	18.0	58.5	336.0
	%	3.0	0.5		0.5	1.3	26.5		42.0		2.0	1.0	5.5	30.0	
C	km		0.5						49.0		13.0			60.5	123.0
	%		0.5						40.0		10.5			49.0	
D	km	2.5	2.5				113.0		32.0			0.5	23.0	36.0	209.5
	%	1.0	1.0				54.0		15.5			0.0	11.0	17.0	
E	km	1.5	1.0	3.5		29.5	17.5	45.0	1.0	36.0			17.5	114.5	267.0
	%	0.5	0.5	1.5		11.0	6.5	17.0	0.5	13.5			6.5	43.0	
F	km	32.0	4.0		3.5		35.0	1.0						1.0	76.5
	%	42.0	5.0		5.0		46.0	1.5						1.5	
G	km								23.5		0.5		0.5	70.0	94.5
	%								25.0		0.5		0.5	74.0	
H	km	64.0	1.5		7.5	5.5	54.5	6.5	5.0				0.5	28.5	173.5
	%	37.0	1.0		4.5	3.0	31.5	3.5	3.0				0.5	16.5	
I	km	22.5	8.0	15.5	41.0	7.55	66.5	1.0	13.0			28.0	46.5	157.0	474.5
	%	4.5	1.5	3.5	8.5	16.0	14.0	0.0	2.5			6.0	10.0	33.0	
J	km	2.5	28.5			2.0	40.5	2.5	2.5	1.0			0.5	25.0	105.0
	%	2.5	27.0			2.0	38.5	2.5	2.5	1.0			0.5	24.0	
K	km	17.5	24.5	3.0	27.0	1.0	9.0	0.5	2.0	121.0			17.5	14.5	237.5
	%	7.0	10.5	1.5	11.5	0.5	4.0	0.5	1.0	51.0			7.0	6.0	
L	km					10.0	21.5					18.5	20.0	3.5	73.5
	%					13.5	29.5					25.0	27.0	5.0	
M	km					164.0	4.0				1.0	167.5	122.5	322.5	781.0
	%					21.0	0.5				0.0	21.5	15.5	41.0	
N	km					166.5						41.0	33.5	6a.5	329.5
	%					30.5						12.5	16.0	21.0	
O	km	4.0	6.0	123.5		232.0	21.5	6.0	13.5			53.0	172.5	190.5	822.5
	%	0.0	1.0	22.5		28.0	2.5	1.0	1.5			6.5	21.0	23.0	
P	km		30.0			84.0	9.5	1.5			4.0	91.5	206.0	80.0	506.5
	%		3.5			10.0	1.0	0.0			0.5	18.0	40.5	16.0	
TOTAL															
	km	172.5	114.5	142.0	111.0	763.0	548.5	21.5	318.5	122.0	24.5	403.0	698.5	1231.0	4670.0
	%	3.5	2.5	3.0	2.5	16.5	12.0	0.5	7.0	2.5	0.5	8.5	15.0	26.5	
PRIBILOF ISLANDS															
	km	5.0	84.5	19.0	1.5	1.0	20.0	24.0			0.5		1.5	1.0	111.0
	%	3.0	54.0	11.5	1.0	0.5	12.5	3.5			0.5		1.0	0.5	

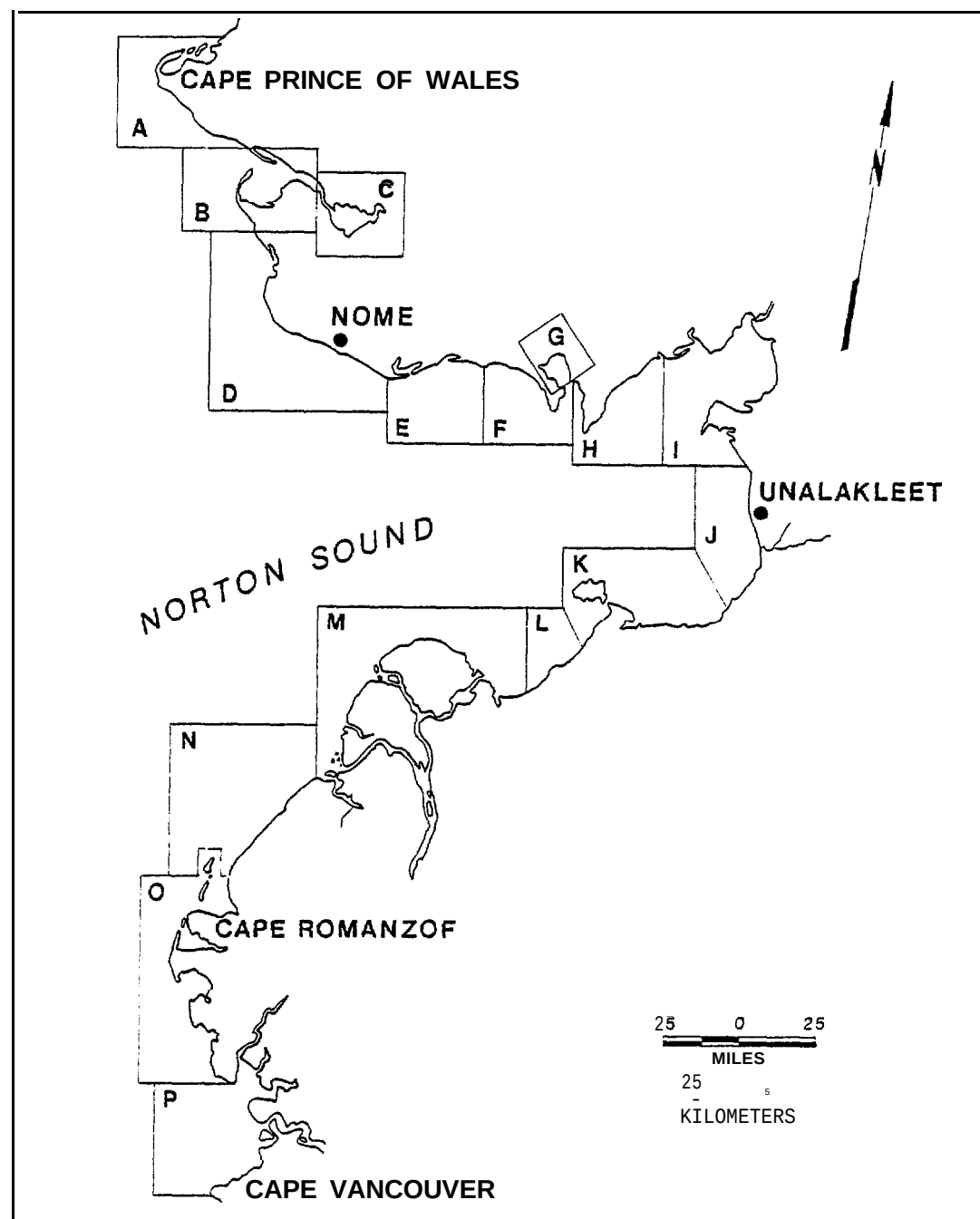


FIGURE 65. Location of shoreline summary zones presented in Table 4. See text for written descriptions of segment locations.

of Port Clarence, Grantley Harbor, and the Port Clarence Spit.

- c Imuruk Basin.
- D Cape Douglas to Cape Nome.
- E Cape Nome to Topkok Head.
- F Topkok Head to the south spit entrance to Golovin Lagoon.
- G Golovin Harbor.
- H Golovin (Cheenik) to Moses Point fishing village.
- I Moses Point fishing village to Beeson Slough (64°15'N).
- J Beeson Slough (64°15'N) to Myoukchuk Point.
- K Myoukchuk Point to 5 km south of Cape Stephens. Includes all of St. Michael Bay and Stuart Island.
- L 5 km south of Cape Stephens (63°30'N) to 3 km south of Coffee Point (63°5'30"N).
- M 3 km south of Coffee Point (63°5'30"N) to Kwikluak Channel.
- N Kwikluak Channel to 62°00'N.
- o 62°00'N to 4 km east of the Opagarak River (65°22'30"W). Includes the sand islands offshore.
- P 4 km east of the Opagarak River (65°22'30"W) to Cape Vancouver.

The greatest concentrations of oil-sensitive environments are located in the following areas:

ESI=8 SHELTERED ROCKY SHORES

-Tuksuk Channel and northwestern Imuruk Basin

ESI=8a ERODING PEAT SCARPS

-Interior Norton Bay
 -Cape Stephens to Point Romanof
 -Extensive portions of the Yukon-Kuskokwim delta shoreline

ESI=9 SHELTERED TIDAL FLATS

- Safety Sound
- Interior Norton Bay
- Cape Denbigh to Beeson Slough
- Unalakleet estuary
- Cape Stephens to Point Romanof
- Extensive portions of the Yukon-Kuskokwim delta shoreline

ESI=10 MARSHES

- Many small interior coastal marshes on the Seward Peninsula from Cape Spencer to Nome
- Eastern Imuruk Basin
- Safety Sound
- Golovin Bay
- Interior Norton Bay
- Cape Denbigh to Beeson Slough
- Unalakleet estuary
- St. Michael Bay
- Extensive portions of the Yukon-Kuskokwim delta shoreline

These areas are more thoroughly discussed in the section dealing with protection strategies.

Intertidal Biology

In comparison to the rich and diverse intertidal communities found in southeastern and central Alaska below the Aleutian chain, the floral and faunal assemblages of Norton Sound appear extremely sparse. During this survey, insects were most commonly observed, being present in all habitat types. Barnacles, amphipods, and isopods were the dominant marine epifauna, while polychaetes were the dominant infaunal species. Algae increased from almost nonexistent in the north to moderate growth, primarily *Fucus*, in the south. As discussed below according to each shoreline type, the density and distribution of intertidal biology varies not only from one habitat type to the next, but also from north to south within similar shoreline types. Previous studies of intertidal substrates of the Bering Sea region have been done by Merrel (1978), O'Clair (Hameedi, OCSEAP, pers. commun.) and Sears and Zimmerman (1977).

Exposed rocky headlands (ESI=1) in this region are exposed to ice scour for up to nine months each year. As a result, the rock faces, platforms, and leading faces of large boulders are virtually devoid of life, although first-year barnacles, sparse patches of single-celled green algae, and isolated patches of *Enteromorpha* sp. are found in the intertidal zone during summer. Lichens are lightly abundant in the supratidal spray zone. Several of the rocky headlands also serve as major bird rookeries for a variety of species.

Wave-cut platforms (ESI=2) are located primarily in moderate to high wave-energy environments. These habitats support an epifaunal population dominated by barnacles. Additionally, gastropod, bivalves, and insects are lightly abundant. Three species of infauna including nematodes, amphipods, and insect larvae are lightly abundant, usually occurring in sediment and detritus accumulated under boulders. Sparse growths of algae, including single-celled green algae, Enteromorpha sp., and Fucus sp. are present in the mid to lower intertidal zone. Lichens are found along the upper intertidal fringe. Bird activity along this shoreline type is generally low. Gulls were the most commonly observed species.

Fine-grained sand beaches (ESI=3) in the northern part of Norton Sound are devoid of infauna and epifauna except for occasional insects found in the wrack. Epifauna, primarily amphipods, and infauna (including hemichordates and clams) are present only in the more southern portion of Norton Sound near the Yukon-Kuskokwim delta complex. Jellyfish were observed occasionally on some beaches in the south. Back-beach areas in all localities are vegetated by a variety of plants, dominated by sedges, willows, and grasses. Bird activity ranges from low to high with gulls and terns being the primary species present.

Coarse-grained sand beaches (ESI=4) are virtually devoid of life. Accumulation of wrack deposits support small populations of spiders and insects which were the only species observed. Back-beach areas are vegetated primarily by grasses, sedges, and low, spreading herbaceous plants. Bird use of these areas is negligible.

Exposed tidal flats (ESI=5) contain scattered clumps of green, single-celled algae attached to small boulders scattered across the flat. Isopods, the only species of epifauna observed, range in densities from absent to light in the northern part of Norton Sound, and light to moderate in the central and southern portions. Infauna are found only at stations in southern Norton Sound; polychaete worms were the only species observed. Bird activity in the north ranges from light to moderate, but is very heavy in the delta region to the south.

Exposed mixed sand and gravel beaches (ESI=6) contain a variety of algae (including Fucus sp., Enteromorpha sp., Petrocelis sp., and Endocladia sp.) attached to boulders located along the lower intertidal zone. Rooted back-beach vegetation includes several species of grasses, sedges, willows, and moss. Various types of epifauna are present including crustaceans, gastropod, echinoderms, and bivalves. Barnacles are most commonly observed. In addition, spiders and insects are present in the shoreline deposits of decaying wrack. Infauna include polychaete worms, crustaceans, annelid worms, and nematodes. Polychaetes were the dominant infaunal

species observed. Spawned herring eggs were occasionally observed at some localities. Associated bird activity is generally low.

Gravel beaches (ESI=7) commonly become mobile under moderate to high wave conditions, which greatly inhibits colonization by intertidal organisms. Generally, no infauna or epifauna are observed in the upper intertidal zone, although the lichen, Verrucaria sp., is occasionally found in the supratidal spray zone. In the lower intertidal zone, the gravel or cobbles form a terrace on which Fucus Sp. and Enteromorpha sp. are commonly attached to large-sized cobbles. No infauna are present under the cobbles. Bird activity is minimal.

Sheltered mixed sand and gravel beaches (ESI=7a) occur primarily on the protected sides of spits and bays where very little direct wave action occurs. Although most of the observed infauna and epifauna consist of spiders and insects, some marine species (including mites, amphipods, barnacles, nematodes, and annelids) may be present. Barnacles are the dominant epifaunal species, and nematodes are the dominant infaunal species. Back-beach areas are composed of wet or moist tundra vegetation, dune grasses, or low eroding peat scarps. Occasionally, green and brown algae are attached to eroding clumps of peat. Bird use ranges from low to high and includes various species of gulls, shore birds, swans, ducks, and geese.

Basalt-boulder shorelines (ESI=7b) contain abundant fauna and flora in three distinct zones:

- 1) The lichen zone along the most landward portion of the intertidal zone is dominated by Verrucaria sp.
- 2) The barnacle/Fucus zone is in the upper to mid intertidal zone.
- 3) The red algae zone extends from the mid to lower intertidal zone.

At least seven species of epifauna are present, including crustaceans, limpets, gastropod, bivalves, and anemones. Barnacles were the most common epifaunal organism observed, extending through both the barnacle/Fucus and red algae zones. Infauna are absent due to the hard basalt substrate. Bird use ranges from low to moderate.

Sheltered, rocky intertidal habitats (ESI=8) are generally absent throughout most of Norton Sound. The few habitats of this type observed are primarily located in Imuruk Basin, a large freshwater embayment at the north end of the study area. Attached marine epifauna or infauna are sparse to

absent. Occasionally, a single-celled green alga is attached to large boulders in patchy distributions (1% coverage). Insects and gulls, both in low densities, are the primary organisms observed in these habitats.

Eroding peat scarps (ESI=8a) provide a food source in the form of organic detritus for invertebrates living in adjacent subtidal habitats. Algae, dominated by Enteromorpha sp. and a single-celled green alga, are commonly found attached to peat blocks near the eroding scarp face. Sedges and grasses are the dominant, rooted plant types on top of the scarps (described in greater detail under the marsh section). At least three species of epifauna, including isopods, mites, and insects, are present on the flat. Isopods are the dominant epifaunal species. Infauna are comprised of isopods (dominant) and annelid worms. Bird use is generally moderate and includes gulls, swans, hawks, geese, and terns.

Sheltered tidal flats (ESI=9) are found in areas protected from direct wave exposure. Enteromorpha sp., the only attached algae observed, is attached to eroded peat clumps. Grasses are the dominant rooted vegetation in adjacent tundra and marsh habitats. Six species of epifauna are present, including spiders, beetles, insects, amphipods, isopods, and mites. Infaunal species include annelid worms and clams. Polychaete worms and clams are the dominant infaunal species. Demersal fish may be present in tide pools on the surface of the flats. Bird use is heavy and includes gulls, swans, geese, hawks, shore birds, and ducks.

Marshes (ESI=10) are dominated by grasses, sedges, willows, and saltworts. In several adjacent freshwater lagoons, particularly in northern Norton Sound, sea grass (Zostera sp.) is present (also see next section). Insects and mites are the only species of epifauna commonly observed. Infauna were not observed. Bird use is high, particularly around the Yukon-Kuskokwim delta. These areas are used as nesting, staging, and feeding areas for many species of gulls, geese, shore birds, ducks, swans, and hawks.

Distinct faunal and floral differences were observed between Norton Sound and the Pribilof Islands. The Pribilofs have a noted absence of barnacles, a more dense and diverse attached algal assemblage! an absence of infauna on fine-grained sand beaches, and an absence of clams.

Nearshore Subtidal Biology

For this study, key subtidal nearshore eelgrass (Zostera marina) beds are denoted on the ESI maps. Locations are based only on previous studies of eelgrass beds. These areas in Alaska are highly productive, reaching standing-stock levels

as high as 1862 gm dry wt/m² in certain areas (McRoy, 1970) . In Norton Sound, the average standing stock of eelgrass for Safety Lagoon is 415 g dry wt/m² and 113 g dry wt/m² for Port Clarence. This difference is due more to the more southerly (less ice coverage) and less exposed nature of Safety Sound.

Eelgrass provides organic material and detritus important to the marine food chain. It also is a food source for many waterfowl and provides a substrate for fish spawning and nurseries. Eelgrass beds also aid in stabilizing bottom sediments. In Alaska, eelgrass is very hardy and survives under 1-2 m of ice in near darkness through the winter months (McRoy and Allen, 1974). Its root system is adapted to low oxygen conditions. Though the leaves may be damaged from oiling, the root system would be more resistant to oil impact (Gardner, 1978) . Most damage from oiling would probably occur to the epiphytic, open-water, and benthic organisms associated with the eelgrass community.

PROTECTION STRATEGIES

The protection strategies developed for Norton Sound and the Pribilof Islands revolve around three primary components: (1) open-water skimmers, (2) booms (both open-water and harbor), and (3) closure of small channels and washovers by sediment. The following recommendations are presented to highlight the most oil-sensitive areas and to elucidate some of the problems to be encountered. Only open-water conditions are discussed. A spill during winter ice conditions would necessitate entirely different response measures depending on spill location, ice conditions, accessibility, etc. There has already been an oil spill on St. Paul, Pribilof Islands (40,000 gal., November 1979). The response effort mobilized by the U.S. Coast Guard and SSC serves as an applied model to logistical and cold-weather problems associated with this entire region (see Reiter, 1981).

Cape of Prince Wales to Topkok Head

Within this section (Fig. 66), there are only three areas of major concern: (1) the Port Clarence embayment, (2) a string of narrow lagoons located between Cape Douglas and Cape Wooley, and (3) the Safety Sound embayment. Representative photos of each are presented in Figures 67-69. The rest of this shoreline section consists predominantly of mixed sand and gravel beaches, exposed rocky cliffs, and some wave-cut platforms. There are numerous freshwater ponds located high behind the mixed sand and gravel beaches, but only during extremely high storm surge would there be a risk of oiling. In the few cases where the marsh behind the mixed sand and gravel beach could be oiled during normal high tides, it is marked by a closure symbol to indicate that sediment should be piled along the upper beach for protection.

Port Clarence Embayment

Major critical areas within the Port Clarence embayment are located along the south end of the bay where several low-lying marshes and fine-grained tidal flats (Fig. 67) are located. Numerous waterfowl populate the area. Salmon and herring, fished by the subsistence populace, are common during seasonal migrations. Shallow-water sea grass beds are extensive, particularly within Grantley Harbor. Along the northern edge, Brevig Lagoon contains extensive sheltered marshes and tidal flats.

Booms would probably be effective at preventing oil from entering the small flats at the south end of the embayment as well as Brevig Lagoon and Grantley Harbor (see ESI maps). The addition of open-water skimmers operating in the embayment

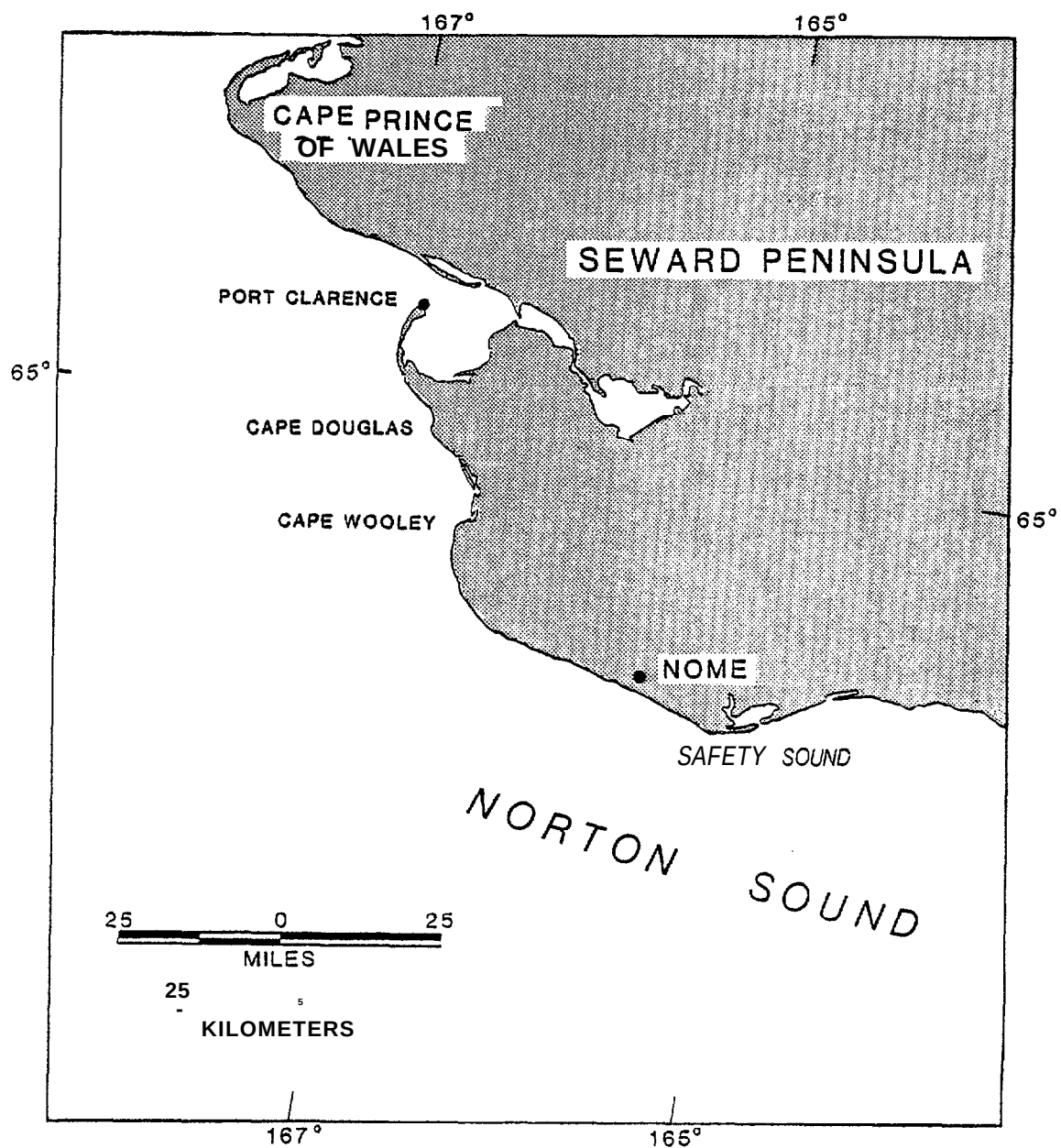


FIGURE 66. Location of reference points for major critical sites within northern Norton Sound. See text for details.



FIGURE 67.

Aerial view of the south shore of the Port Clarence embayment. The arrow points to the location of station NSs-7. The shoreline consists primarily of sheltered, mixed sand and gravel beaches fronting low-lying, sheltered tidal flats and marshes.

FIGURE 68.

Aerial view of the southernmost lagoon between Cape Douglas and Cape Wooley. Most of these inlets are small enough to be sealed during a spill. The inlet in the distance, marked by an arrow, would need booms.



FIGURE 69.

Aerial view of one of the major inlets entering Safety Sound. During high spring runoff periods, flow may be directed out of the inlet, decreasing the likelihood of interior oiling. During a spill, a series of deflection booms should be placed along the channel to protect the interior marshes and sheltered tidal flats.

would be useful in collecting accumulations of floating oil. The U.S. Coast Guard LORAN station at Port Clarence, complete with a large landing strip, would provide a base for operations.

Cape Douglas to Cape Wooley

In between these two capes, there are several lagoons in this area that open into Norton Sound and contain a fairly extensive marsh/tidal flat system (Fig. 68) . A mixed sand and gravel beach (with or without washovers) commonly fronts the lagoons. In addition to the oil-sensitive interior shoreline environments, this area supports a low population of waterfowl and shore birds.

We recommend the active inlets be closed during a spill. There is an adequate supply of nearby sediment and the inlets are quite small. Lagoonal water quality should be monitored regularly to prevent deleterious effects due to inhibited tidal flushing.

Safety Sound

Safety Sound, located 35 km east of Nome, contains a major sheltered tidal flat/marsh system which supports numerous waterfowl, shore birds, and sea birds. Sea grass beds are extensive. The lagoon is connected to Norton Sound by only two inlets. Deflection booms at each inlet would probably prevent much of the oil from entering the lagoon. An aerial view of one of the inlets is presented in Figure 69. A good gravel road, adequate for transport of men and equipment, connects the Safety Sound area to Nome.

Topkok Head to Point Romanof

Several large and relatively sheltered bays with extensive marshes are located in this section, including Golovin Lagoon, Norton Bay, the Shaktoolik River area, and the Unalakleet River estuary (Fig. 70),

Golovin Lagoon

Golovin Lagoon is well-sheltered from the high waves of Norton Sound. Two spits form the entrance to Golovin Lagoon and separate it from Golovin Bay. The entire northern shore of the lagoon consists of a very oil-sensitive, low-lying delta/marsh complex with large, shallow-water sea grass beds (Fig. 56A) . The area is used extensively by waterfowl and shore birds from late spring to early fall. Herring and several species of salmon also are seasonally common.

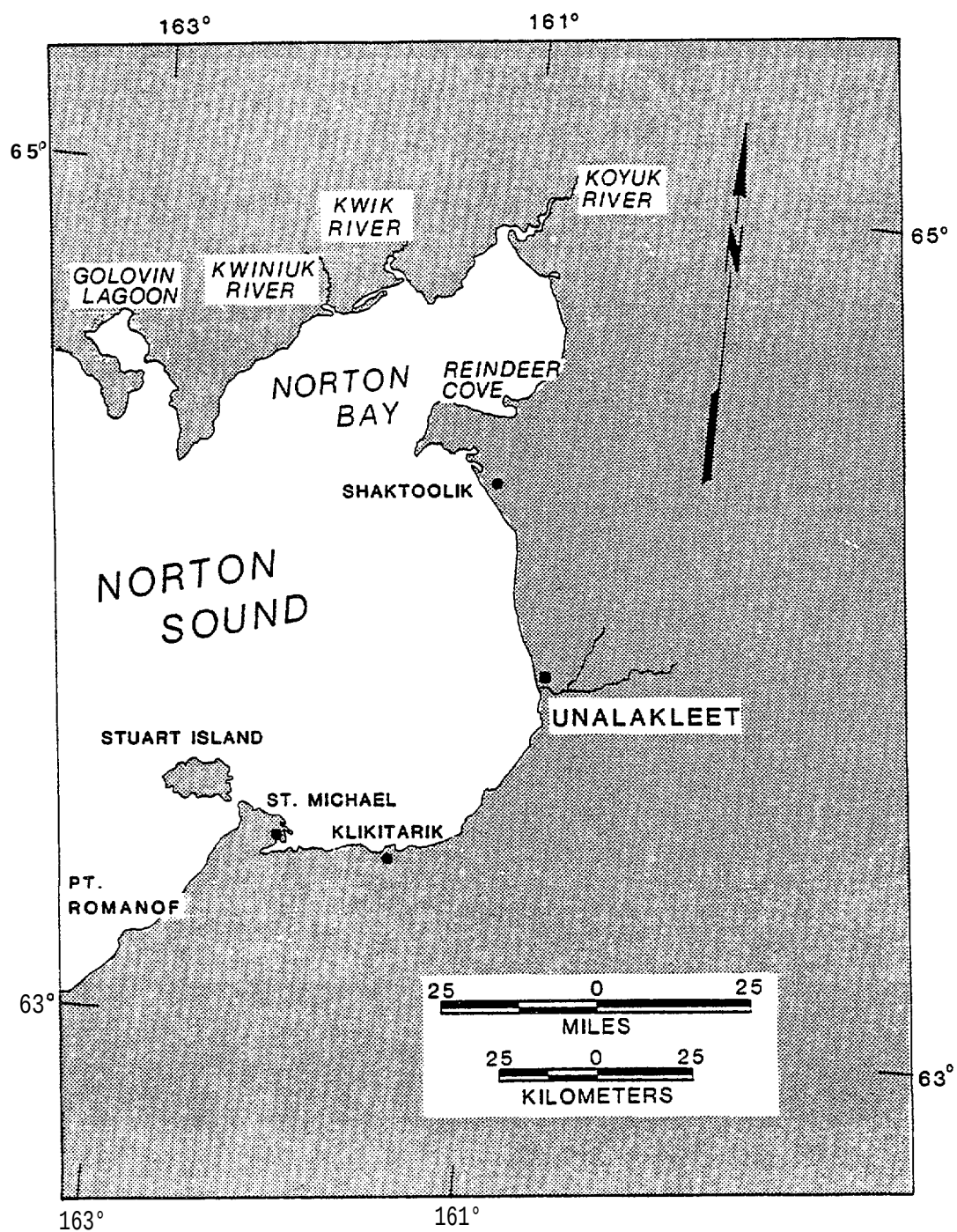


FIGURE 70. Location of reference points for major critical sites within eastern Norton Sound. See text for details on protection strategies proposed for each area.

Protection of the area during a spill would primarily involve open-water skimmers to retrieve floating oil, and deflection booms anchored to shore to capture oil passing close to shore. Unfortunately, access to the area is somewhat limited. The small airport at Golovin probably would not support large aircraft.

Norton Bay

Norton Bay contains several oil-sensitive areas, including major estuaries at Kwiniuk River (Fig. 71), Kwiniuk Inlet and Kwik River, a large delta/marsh complex associated with Koyuk River (Fig. 72), and a sheltered embayment located in Reindeer Cove at the southeast corner of the bay. All contain extensive marshes and tidal flats and are used seasonally by salmon and herring. Eelgrass is found only in Kwiniuk Inlet. Waterfowl are particularly numerous along the Kwiniuk Inlet/Kwik River section, and along the Koyuk River delta complex across the northern end of the bay. Lesser populations of birds are found in the low-lying marshes and tundra by Reindeer Cove. Shore birds are also particularly numerous within each of these areas.

These sensitive areas of Norton Bay would be very difficult to protect if a large amount of oil was approaching. The combined use of open-water booms, harbor booms, and open-water skimmers is recommended. The Kwiniuk River estuary, Kwiniuk Inlet, and Kwik River are particularly suitable for booming. Fortunately, much of the outer shoreline in this area consists of fine- to coarse-grained sand beaches which rank relatively low on the ESI. The northern end of Norton Bay would be very difficult to protect. Booms are recommended for major and minor passes, but skimmers would be required offshore. Environments that would be impacted consist primarily of marsh grasses and sheltered tidal flats. A minor amount of shoreline is composed of lower-ranking peat scarps (ESI=8a) and fine-grained sand beaches (ESI=3).

Reindeer Cove to the southeast has a few open channels lined with marsh that could be boomed during a spill. The major portion of the shoreline consists of fine-grained sand beaches fronted by more sensitive, sheltered tidal flats. Skimmers would be required.

The airstrip at the Moses Point fishing village is the only nearby location which could serve as a major supply base. The airstrip at Koyuk is a better location for access and response to an oil spill in the northern end of the bay, although it is probably able to handle only small aircraft. Access to the Reindeer Cove area is difficult; equipment would have to be flown in by helicopter, or brought by boats across the bay from Moses Point or Koyuk.

Shaktoolik River Area

This area is composed of a low-lying tundra/marsh area fronted by peat **scarps**, **fine-grained** sand beaches, and exposed tidal flats. The Ineak River, Malikfik Bay, and Shaktoolik Bay open into Norton Sound. The interior portions of each bay are the most sensitive having extensive marshes and sheltered tidal flats. Shore birds and waterfowl are common, but not as numerous as those found within Norton Bay. Salmon also use the area for **breeding**.

In the event of approaching spilled oil, booms should be placed across each inlet to protect the interior environments. Offshore skimmers may be effective; however, waves tend to be higher along the exposed portions of Norton Sound. A small landing strip is located nearby. To the south, Unalakleet has an airstrip large enough to receive heavy equipment.

Unalakleet River Estuary

The estuary behind the town of Unalakleet is the last major sensitive area in this section (Fig. 73). Behind two, exposed sand and gravel spits lies a marsh/tidal flat complex. All five species of salmon seasonally inhabit the estuary. The loss of these fish would cause severe hardship to the people living in and around Unalakleet.

Deflection booms attached to the end of each spit and aided by an open-water skimmer inside the inlet would be the minimum equipment necessary to protect this area during a spill. Fortunately, the airstrip at Unalakleet is large enough to receive heavy transport aircraft bringing such equipment.

Although there are no large stretches of highly sensitive shoreline south of Unalakleet until the Yukon delta, there are several smaller portions of the coast which warrant discussion.

Klikitarik to Stuart Island

This section along the south side of Norton Sound contains a long stretch of moderately sensitive shoreline (ESI=7b), composed of large basalt boulders with many attached species of algae and marine animals. In fact, on the Alaskan Bering Sea coast, this is the northernmost area that has a well-developed algal/epifaunal community. In addition to several small diving bird nesting areas, herring use much of the nearshore areas as breeding grounds.

Major sensitive areas along this basalt-dominated shore are few and are located primarily at Saint Michael Bay and the



FIGURE 71.
Aerial view of the large
Kwiniuk River inlet adjacent
to Moses Point.

FIGURE 72.
Aerial view of large chan-
nel and eroding peat scarps in
Norton Sound.



FIGURE 73.
Aerial view of the inlet
and estuary at Unalakleet.

Stuart Island Canal. Each area has a moderate expanse of marsh and associated waterfowl. Additionally, Saint Michael Bay contains sea grass beds and sheltered tidal flats.

Unfortunately, the entire stretch of this shoreline would be impossible to protect during an oil spill. Physical signs of the spill would persist for several years, primarily as tar within the sheltered spaces between the rocks. Recovery of epifauna and algae would also take several years, depending on the extent of damage and distance to sources of repopulation. Mobile skimmers and shore-attached deflection booms are recommended to protect Saint Michael Bay and the Stuart Island Canal. The town of Saint Michael with its moderate-sized airstrip serves as a central site for logistical support.

Stuart Island to Point Romanof

The shoreline south of Stuart Island to 1 km north of Point Romanof is composed of eroding peat scarps (high ESI ranking) with small, sheltered tidal flats. South of Point Romanof to the Yukon delta region, the shoreline has less sensitive, exposed mixed sand and gravel beaches. It is impossible to protect the entire coast between Stuart Island and Point Romanof; therefore, booms should be placed across major incoming rivers and streams as a first priority. This includes the Kwik, Kogok, and Pimikatilik Rivers. The additional support of open-water skimmers is advised, although their effectiveness would be severely limited by sea conditions and the lack of nearby supply sites.

Yukon-Kuskokwim Delta to Cape Vancouver

By far, this section of shoreline contains the greatest extent of oil-sensitive environments within the study area. This region consists of two, comparatively small bedrock units, Capes Romanof and Vancouver, surrounded by an enormous low-lying delta (Fig. 74). Three types of shoreline dominate the delta front: (1) marshes (ESI=10), (2) sheltered tidal flats (ESI=9), and (3) eroding peat scarps (ESI=8a) (see Fig. 75). Within depositional marsh/tidal flat areas, oil would be expected to persist for a very long time, possibly ten years or more. Within the eroding delta-front areas, as indicated by peat scarps, spilled oil could interact with the ubiquitous fine-grained sediments and organic matter to form denser-than-water particles. Thus, the oil spill would become an offshore as well as an onshore problem. Also, oil could be thrown up onto the marsh located landward of the scarp during storm-generated tides. Oil on top of the marsh could damage the enormous seasonal populations (greater than 100 million individuals) of shore birds and waterfowl, many of which use the delta fringe for nesting and molting. In addition, the subsistence populace of the delta use the salmon, which

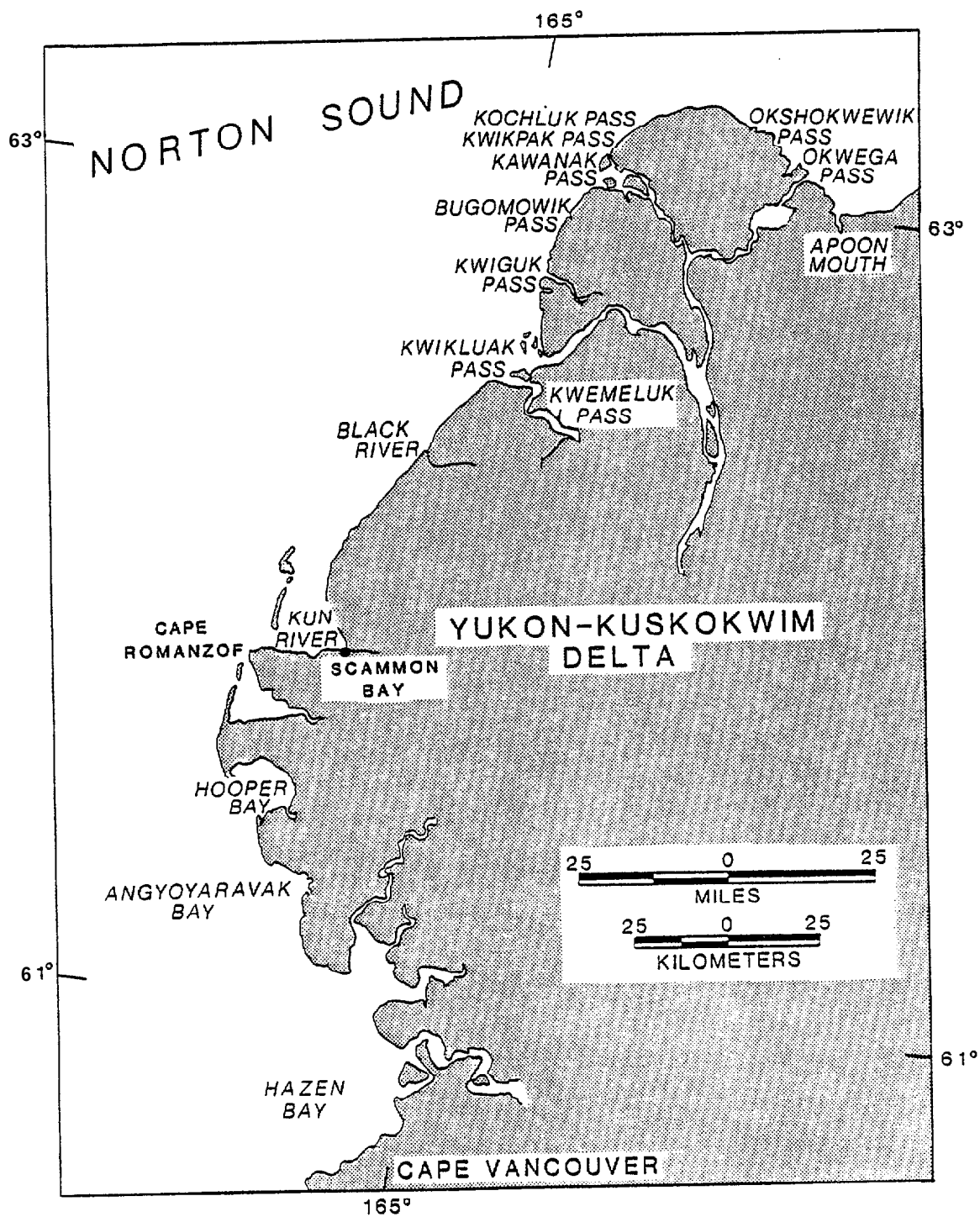


FIGURE 74. Reference sites in southern Norton Sound mentioned in the text for protection.

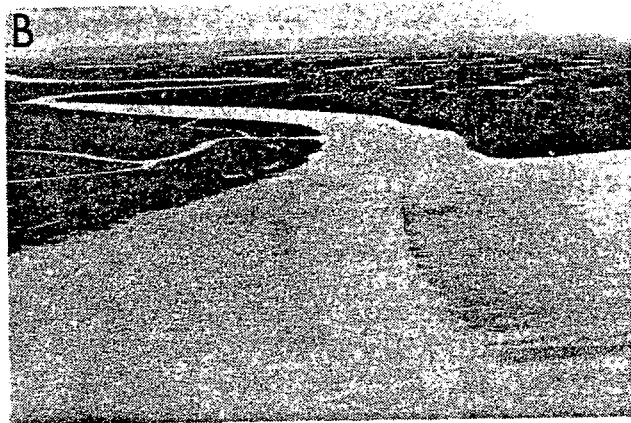


FIGURE 75. Aerial overviews of the Yukon delta. (A) 15 km north of Kwanak Pass. (B) Bugomowik Pass. (C) Kokechik River.

migrate up many of the river channels. In summary, a large spill along the delta would be devastating to the local bird, fish, and probably, human populations.

The protection strategies for the delta region involve restricting oil to the outer delta fringe so that natural processes, particularly storm-generated waves and tides, could act to remove the oil. Because of the difficulty of protecting the entire delta front, booms and skimmers should be placed to prevent oil from coming up the major river channels. (During high-runoff periods, this may not be necessary at all channels). Listed in order from north to south, major channels needing protection include Apoon Mouth, Okwega Pass, Okshokwewik Pass, Kochluk Pass, Kwikpak pass, Kawanak pass, Bugomowik Pass, Kwiguk Pass, Kawakhawk Slough, Kwikluak Pass, Kwemeluk Pass, Black River, and Kun River (see Fig. 74 and individual maps for locations). Open-water skimmers should be placed in the larger river channels to collect floating oil. This delta region is served by only a few major airstrips (e.g., Point Romanzof and Scammon Bay), but several smaller strips (e.g., Kotlik) could serve as fuel depots.

Like Scammon Bay directly north of Cape Romanzof, the presence of offshore sand islands and spits would aid in preventing oil from entering Kokechik and Hooper Bays to the south. Mobile, open-water skimmers probably would be able to operate in the sheltered waters of Scammon, Kokechik, Hooper, Angyoyacavak and Hazen Bays. In addition, booms should be placed across major river channels to prevent oil from passing up the channels. Access airstrips are available at Cape Romanzof and the town of Hazen Bay.

Pribilof Islands

The Pribilof Islands, located some 480 km from the Alaskan mainland and 290 km north of the Aleutian chain, serve as a breeding and haulout area for over one million northern fur seals and contain even greater populations of nesting sea birds (Fig. 76). Under the Fur Seal Act of 1966, the Pribilofs were established as a federal reservation (administered by NOAA-National Marine Fisheries Service) for the management of the northern fur seal populations. Under a treaty signed with Japan and the Soviet Union, over 100,000 fur seals are commercially harvested on the islands. A typical fur seal area is presented in Figure 77. Steller sea lions are also found around the Pribilofs, particularly Otter Island and recently Walrus Island, during periods when the ice pack extends south to this area (Braham et al., 1977; SOWLS et al., 1978).

An added benefit created by establishment of the federal reservation is the protection of the numerous sea bird colo-

nies on the islands. Altogether, there are almost three million nesting seabirds of 11 species, including 1.5 million thick-billed murre on St. George and most of the world's population of red-winged kittiwakes (Sowls et al., 1978).

Protection of the sensitive shoreline environments and wildlife of the Pribilof Islands involves several serious problems, including:

- 1) Isolation - spill cleanup and control equipment has to be airfreighted from Anchorage.
- 2) Bad weather and rough sea conditions, including winds up to 60 knots and 6-10 m seas in freezing to subfreezing temperatures.
- 3) Extremely numerous nesting birds and fur seals which are difficult to protect.

These problems and others were realized during response to the F/V RYOYO MARU NO. 2 oil spill during November 1979. The report by Reiter (1981) about the spill detail methods used to successfully overcome some of these concerns.

For the most part, the shorelines of the Pribilof Islands consist of steep wave-cut cliffs with boulders at their bases, gravel/boulder beaches, and several stretches of sand beaches. Only one area (Figs. 78 and 79) near the town of St. Paul has a high classification value (ESI=9 and 10) and is feasible to protect under most circumstances with standard deflection booms. The rest of the shoreline would be protectable only by offshore, mobile skimmer operation during unusually calm seas. Fortunately, shoreline recovery would be relatively rapid due to the common, high wave conditions.

Protection of the fur seals and birds on the islands is the most difficult problem; both are very likely to be damaged if a large quantity of oil comes onshore or even near shore. The extent of damage could be limited, but not eliminated, by hazing of birds and animals away from heavily oiled areas. The setup of bird-rescue centers would be partially effective in saving oiled birds. Finally, it should be noted that response efforts should be well-controlled in these areas; low-flying helicopters, nearby loud noises, etc. will commonly cause bird deaths and the loss of adult seals and pups.

Logistics for response to an oil spill in the Pribilof Islands area would be routed through St. Paul Island which contains a dirt airstrip suitable for C-130'S. The National Weather Service, National Marine Fisheries Service, and the U.S. Coast Guard (LORAN station) maintain facilities on St. Paul. The other three islands of the Pribilofs present much greater logistical problems. St. George Island contains only a very small town and dock, while Walrus and Otter Islands are



FIGURE 77.

Ground-level view of typical fur seal haulout and pupping area along a boulder-dominated shoreline on St. Paul Island, Pribilof Islands.

FIGURE 78.

Aerial view looking toward the town of St. Paul. The only section of shoreline having high sensitivity is located in the background (see closeup below). The wreck of the F/V RYOYO MARU NO. 2 is in the foreground.

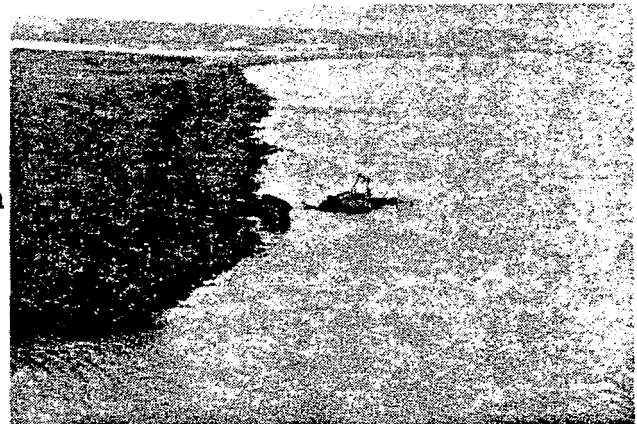


FIGURE 79.

Aerial view of the channel leading to the only area of sensitive tidal flats and marshes on St. Paul Island.

reachable only by helicopter and, during unusually calm seas,
by boat.

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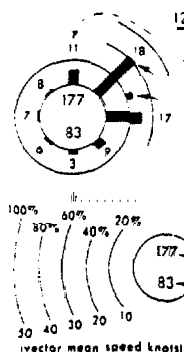
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APPENDIX I

Low-pressure center movement roses for the study area and expected storm tracks for the ice-free season (May-November) (from AEIDC, NCC, 1977). Storms generally originate from the southwesterly quadrant for all areas and are more common during the later part of the season before freeze-up. Most major storms enter the Gulf of Alaska, although a few splay off toward the eastern Bering Sea coast in summer and fall.

Legend



Low pressure center movement

12 hour movements of low pressure centers considering only closed circulations

Mean speed Printed figure at the end of each bar represents the mean speed of movement in knots toward the indicated direction.

Low pressure centers moving toward the N had a mean speed of 11 knots.

Direction frequency Bars represent percent frequency of 12 hour movements toward each direction. Each circle represents 20°.

4P, of all 12 k... movements were toward the NE.

Vector mean direction and speed Dot indicates mean vector movement. Each circle equals 10 knots.

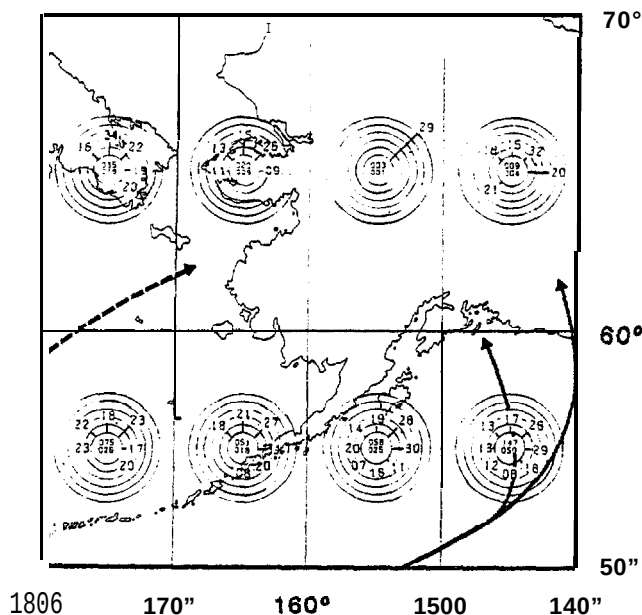
Mean vector movement of all centers was toward 70° at 12 knots.

Statistics for this rose are based on 177 twelve hour movements.

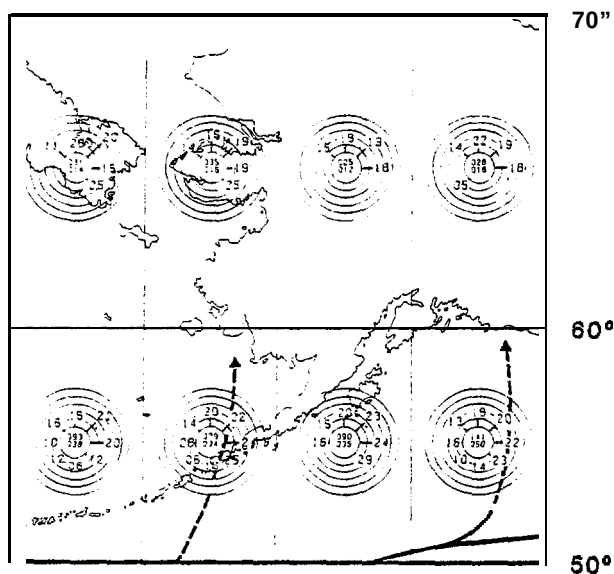
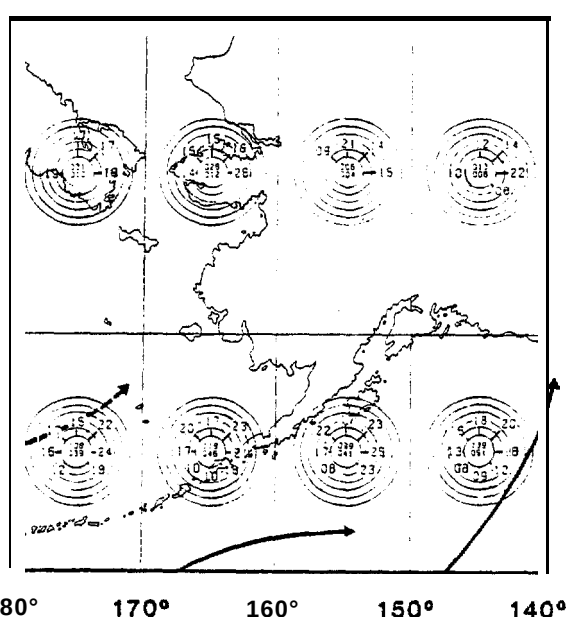
83 low pressure centers were observed in the 10° X 10° area during the 9 year period at record I 001274.

BLACK ARROWS Preferred storm tracks (solid for primary tracks, dashed for secondary tracks).

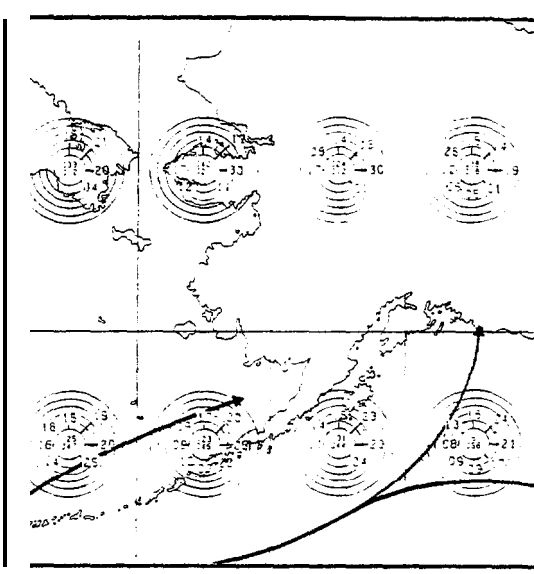
JANUARY



FEBRUARY



MARCH



APRIL

Legend

Low pressure center movement

12 hour movements of low pressure centers considering only closed circulations

Mean speed Printed figure at the end of each bar represents the mean speed of movement in knots toward the indicated direction

Low pressure centers moving toward the N had a mean speed of 11 knots

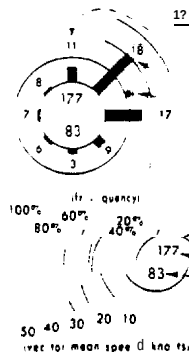
Direction frequency Bars represent percent frequency of low pressure movements toward each direction. Each circle represents 20%.

41% of all 12 hour movements were toward the NE

Vector mean direction and speed Dot indicates mean vector movement. Each circle equals 10 knots.

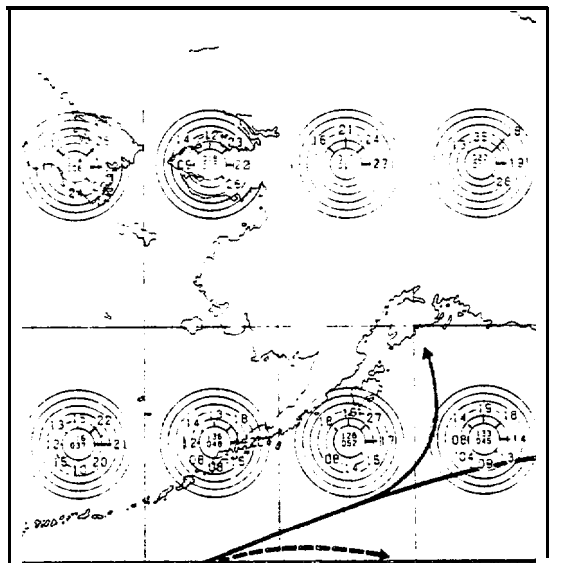
Statistics for this rose are based on 177 twelve hour movements

83 low pressure centers were observed in the 10° x 10° area during the 9 year period of record 1966-1974



BLACK ARROWS Preferred storm tracks (solid for primary tracks, dashed for secondary tracks)

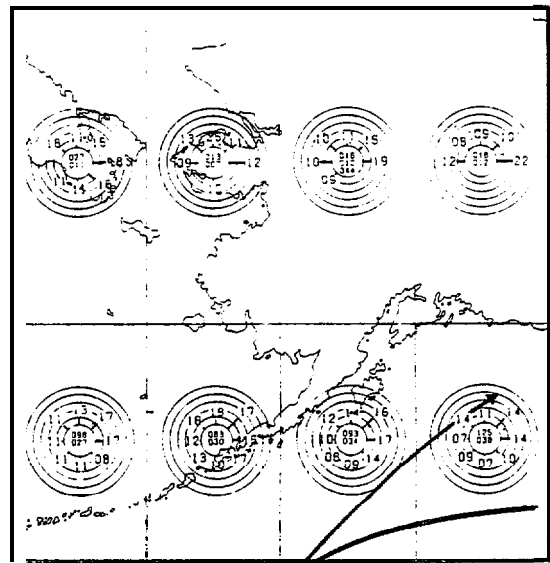
MAY



180° 170° 160° 150° 140°

JUNE

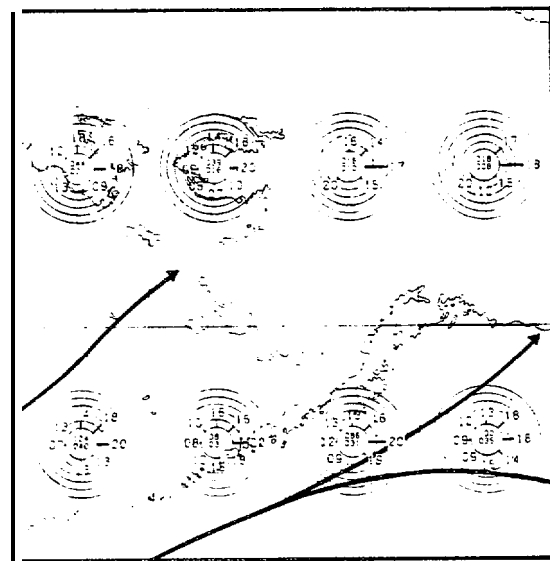
70°



60°

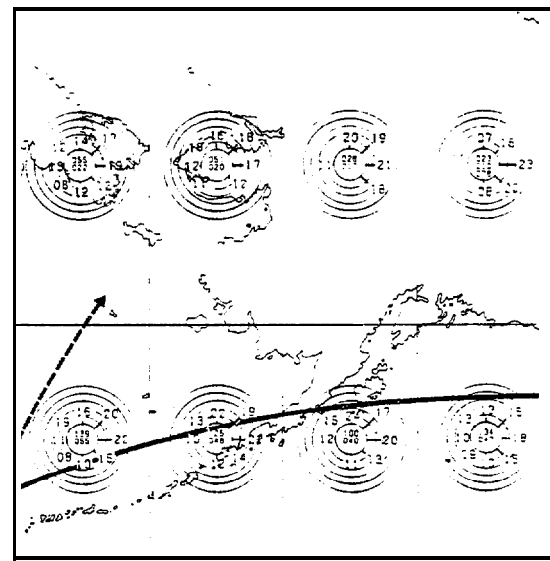
50°

180° 170° 160° 150° 140°



JULY

70°

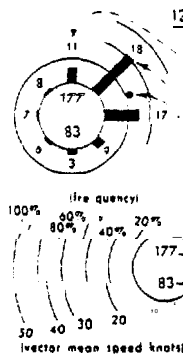


60°

50°

AUGUST

Legend



Low pressure center movement

12 hour movements of low pressure centers considering only closed circulations

Mean speed Printed figure at the end of each bar represents the mean speed of movement in knots toward the indicated direction

Low pressure centers moving toward the N had a mean speed of 11 knots

Direction frequency Bars represent percent frequency of 12 hour movements toward each direction Each circle represents 20%

41% of all 12 hour movements were toward the NE

Vector mean direction and speed Dot indicates mean vector movement Each circle equals 10 knots

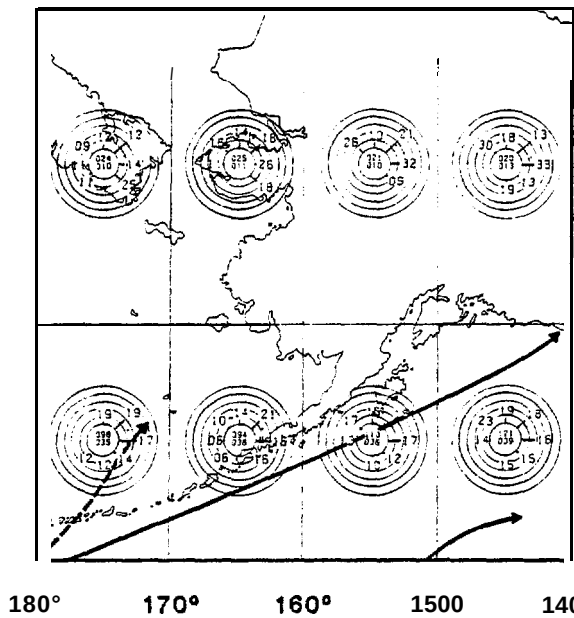
Mean vector movement of all centers was toward 70° at 12 knots

Statistics for this rose are based on 177 twelve hour movements

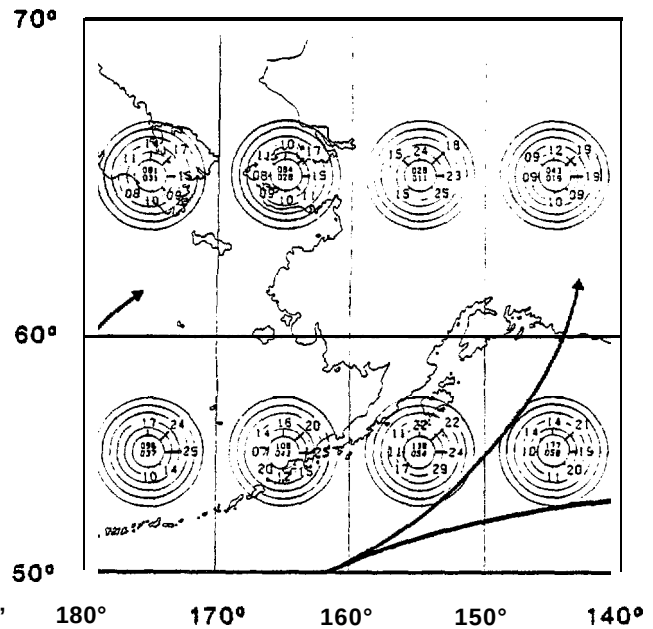
83 low pressure centers were observed in the 10° x 10° area during the 9 year period 01 record 06 12 74

BLACK ARROWS Preferred storm tracks: solid for primary tracks, dashed for secondary tracks

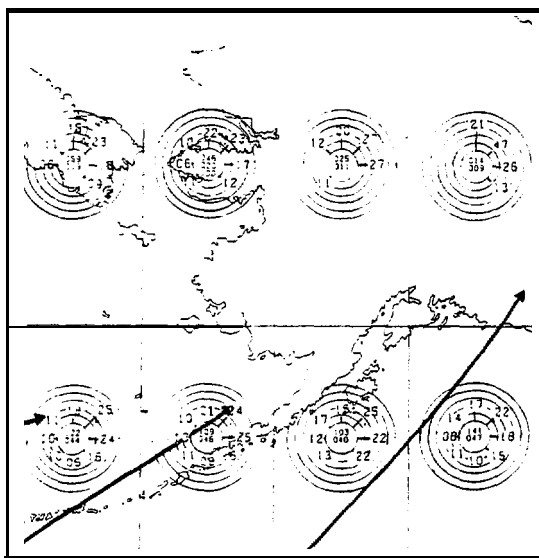
SEPTEMBER



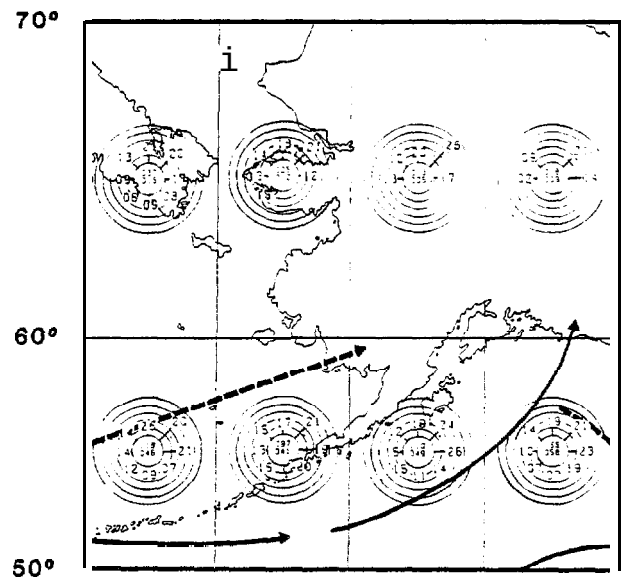
OCTOBER



NOVEMBER



DECEMBER



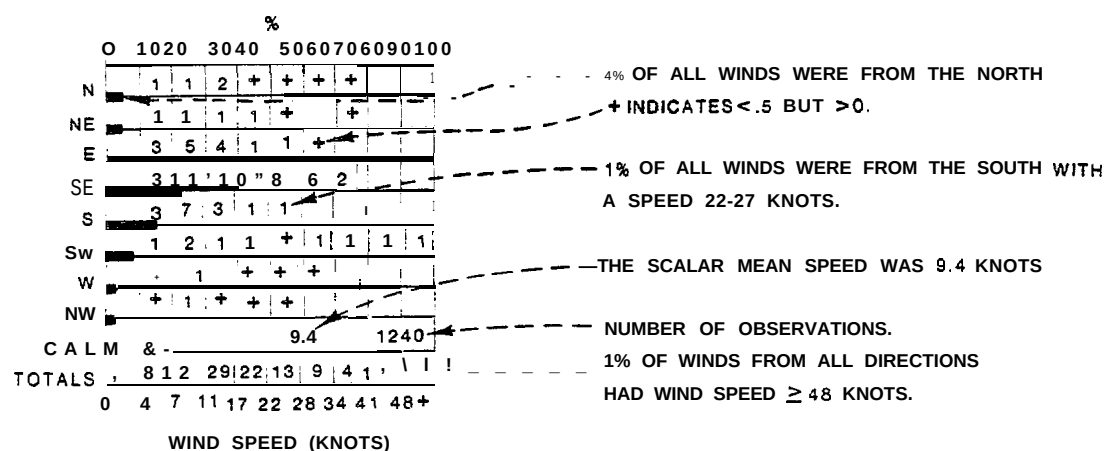
APPENDIX II

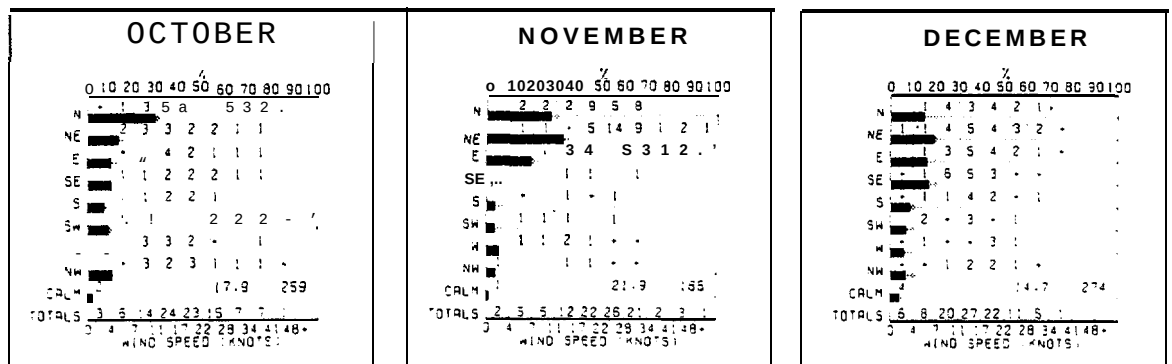
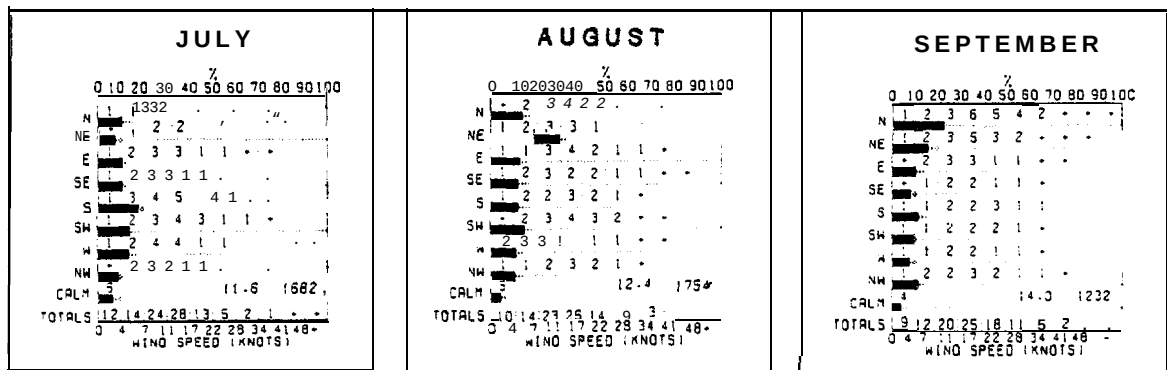
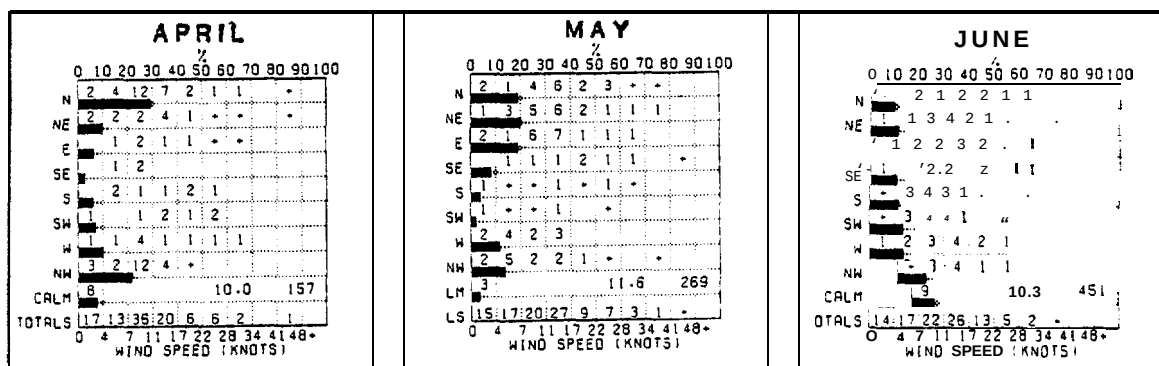
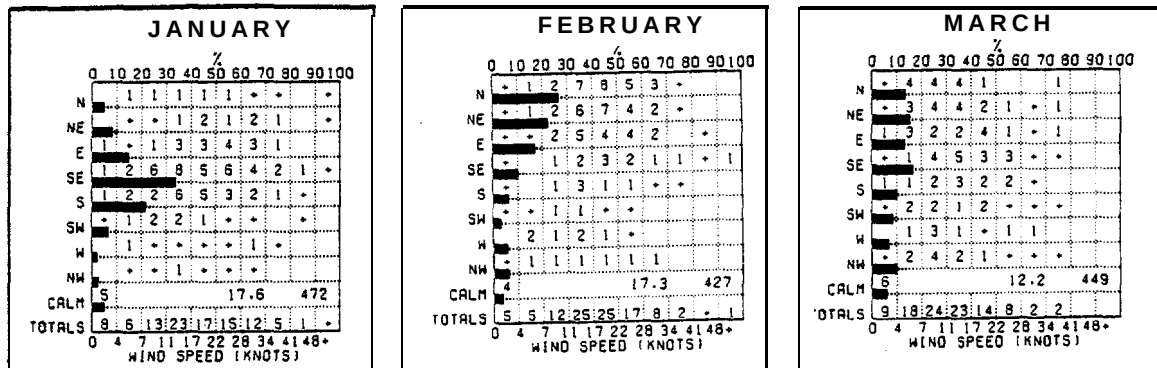
Data on wind speed and direction for selected locations during the ice-free season (May-November) (from AEIDC, NCC, 1977). Dominant wind directions in Norton Sound are northerly and easterly throughout the season with a slack period of no dominant approach in early to mid-summer. Highest velocity winds blow from the north-northeast and south-southwest and similarly shift to northerly late in the year. Wind circulation appears to oppose surface water currents in the sound during most of the ice-free season (see Fig. 5).

In the vicinity of Cape Romanzof, average winds are of higher velocity than Norton Sound with dominant approach on-shore from the western quadrant. During spring and early summer, average wind velocity is relatively low with no preferred approach direction.

Wind data for the Pribilof Islands show no dominant direction of approach. Average wind velocities are fairly high and generally exceed 20 m/sec (11 kn).

DIRECTION FREQUENCY TOP SCALE: BARS REPRESENT PERCENT FREQUENCY OF WINDS OBSERVED FROM EACH DIRECTION. SPEED FREQUENCY BOTTOM SCALE: PRINTED FIGURES REPRESENT PERCENT FREQUENCY OF WIND SPEEDS OBSERVED FROM EACH DIRECTION.





APPENDIX III

Geologic maps of the study area shoreline. Coastal bedrock geology strongly affects the intertidal substrate, and thus, the ESI rating where pre-Cambrian rocks crop out on the shoreline, rocky headlands, wave-cut platforms, and gravel beaches result (ESI 1, 2, and 7). Tidal flat and marsh shorelines (ESI 5, 9, and 10) are generally associated with Holocene fluvio-deltaic deposits.

STRATIGRAPHIC COLUMN

NORTON SOUND

Period

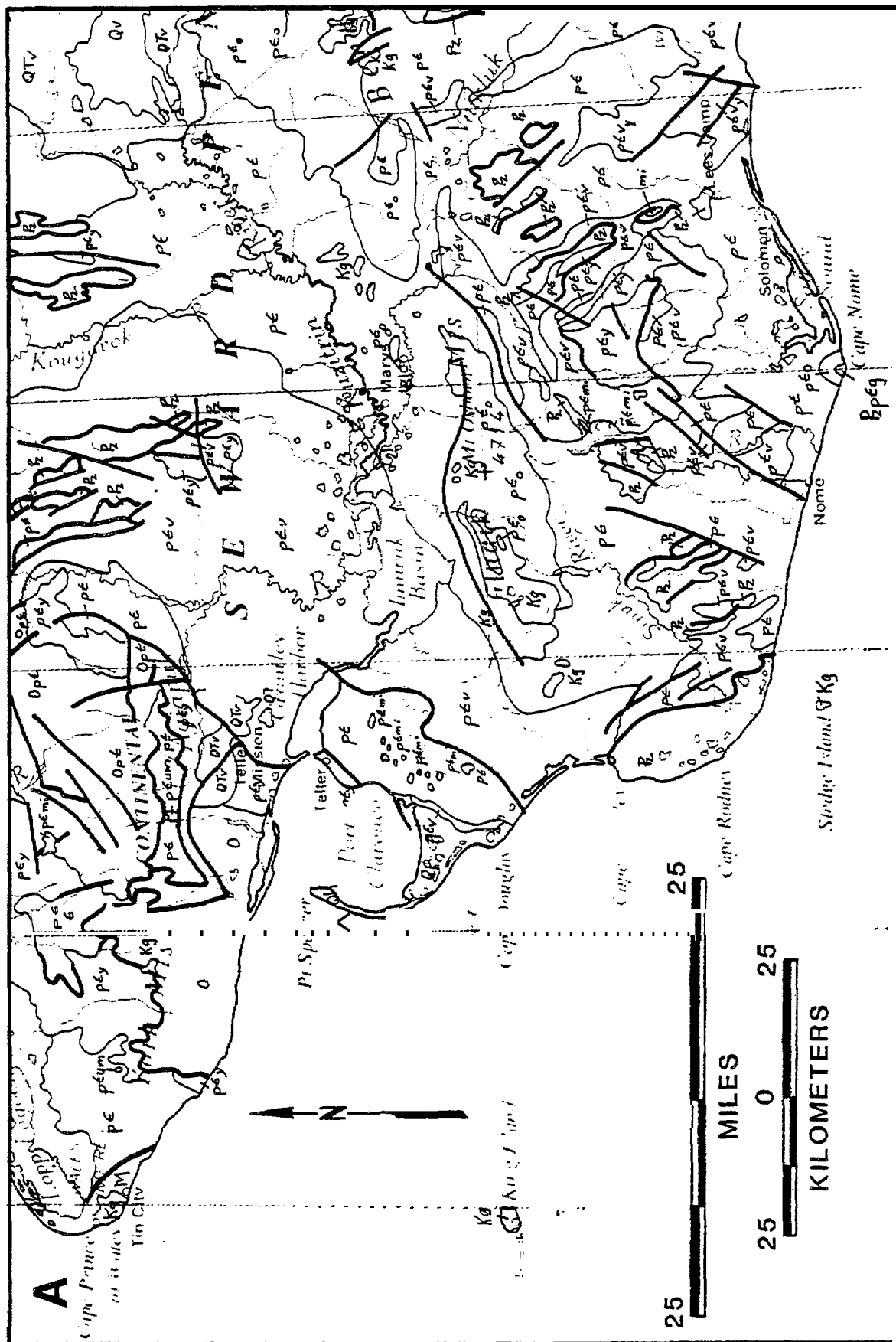
CENOZOIC	Qh	Holocene sediments
	Qp	Pleistocene sediments
	QTV	Quaternary and Tertiary volcanics
	Qv	Quaternary volcanics
	QTV	Quaternary and Tertiary volcanics

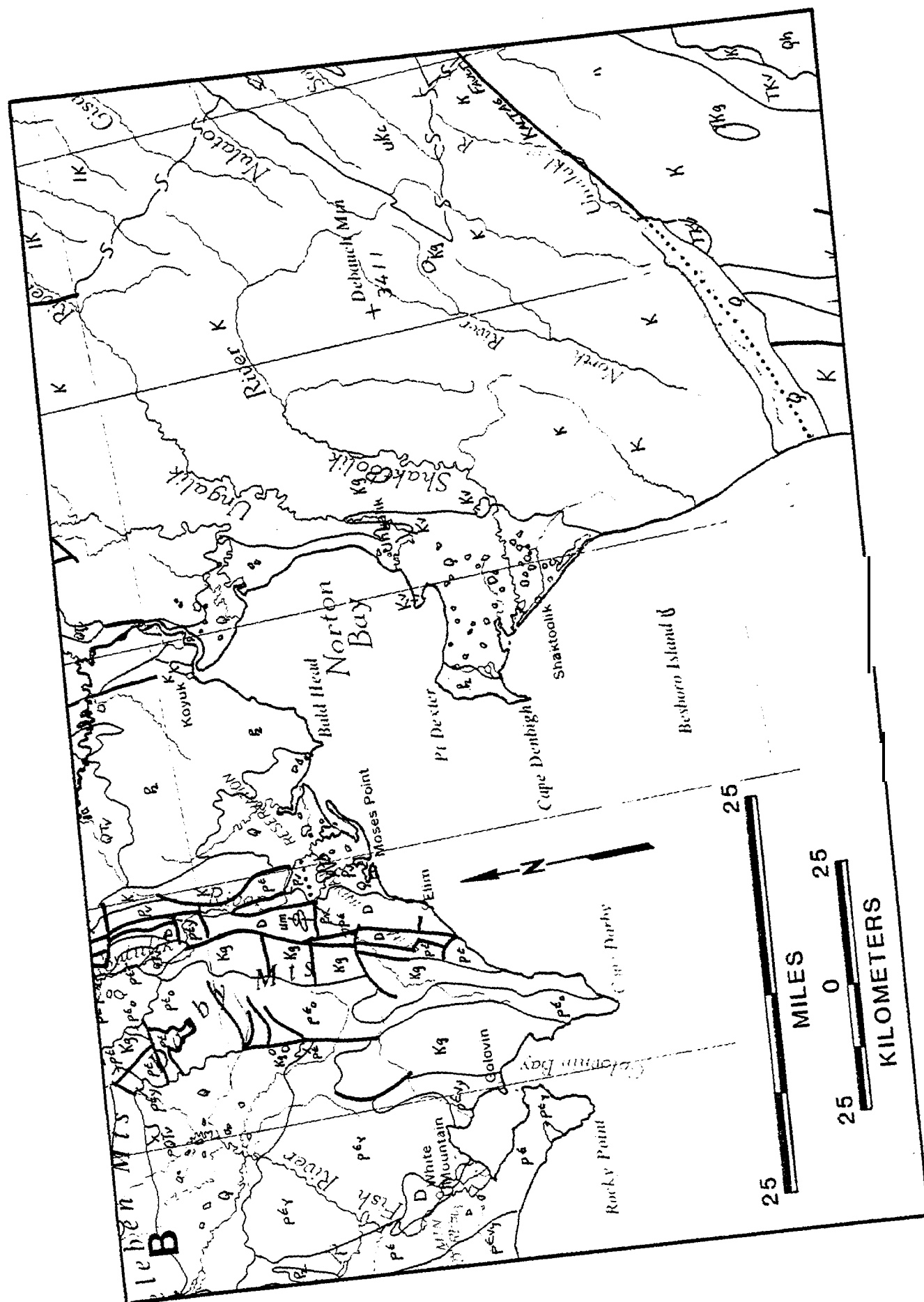
MESOZOIC	K	Cretaceous sediments
	Kv	Cretaceous volcanics
	Kg	Cretaceous Granitic rocks
	M	Mesozoic sediments

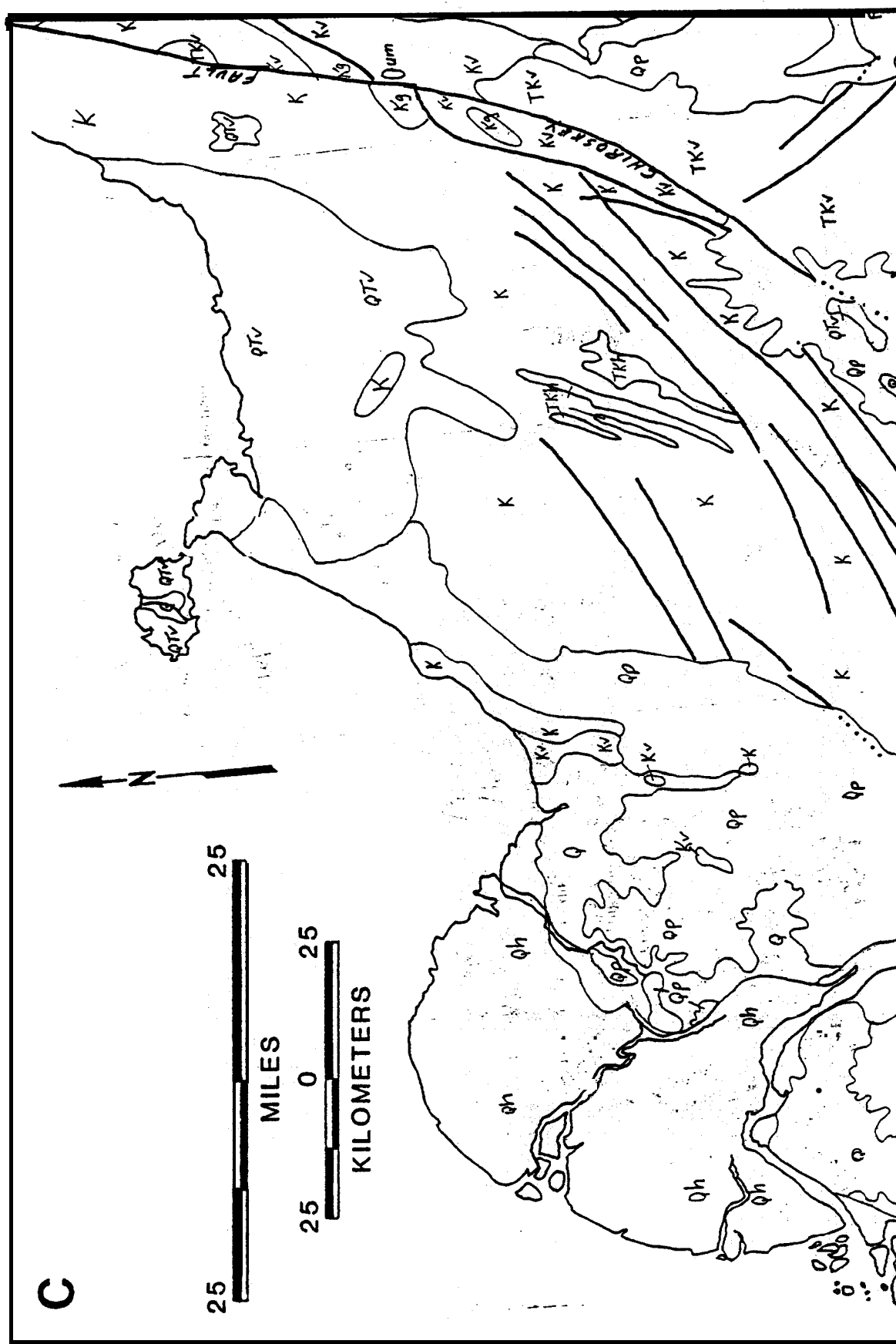
PALEOZOIC	Pv	Permian volcanics
	D	Devonian sediments
	o	Ordovician sediments
	LPz	Lower Paleozoic sediments
	Pz	Paleozoic rock sediments

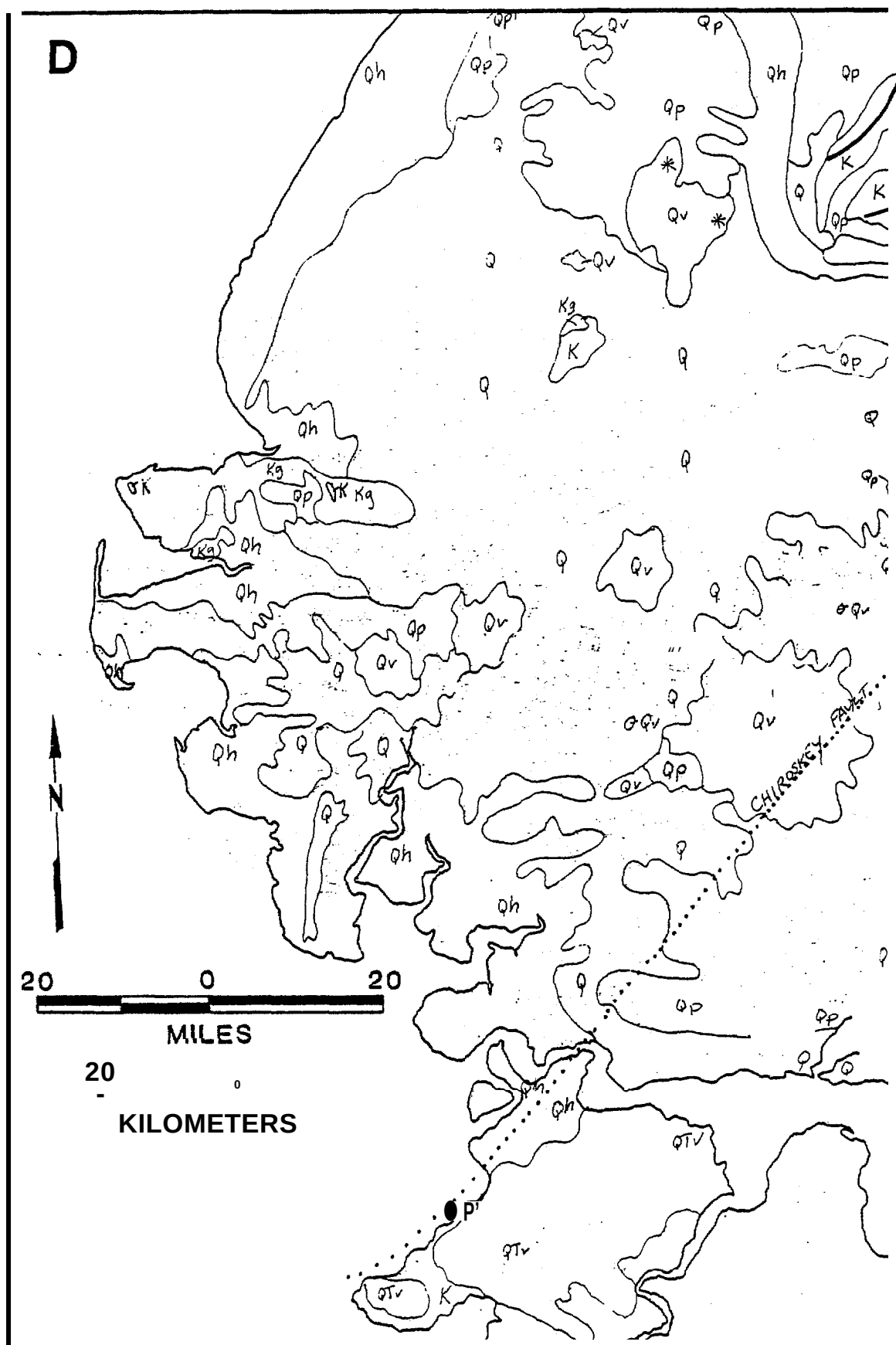
PRE-PHANEROZOIC	uPE	upper Pre-Cambrian sediments
	PE	Pre-Cambrian sediments
	PEi	Pre-Cambrian intrusive
	Pem	Pre-Cambrian Mafic rocks

UM	Ultramafic rocks - age unknown
	Volcano or Volcanic Vent
	Fault
	Fault (inferred)



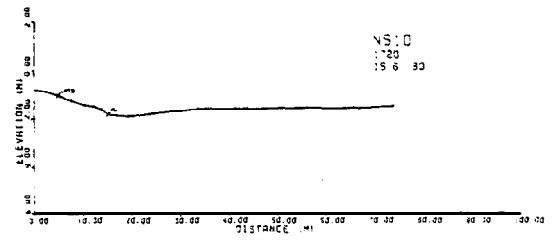
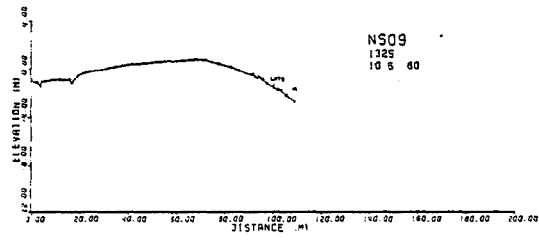
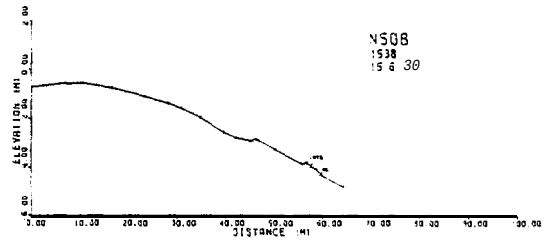
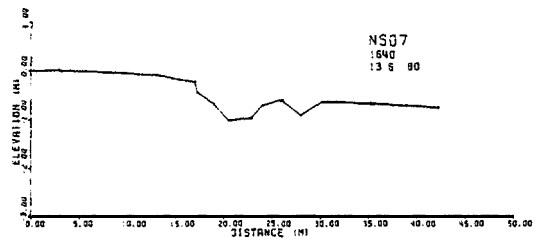
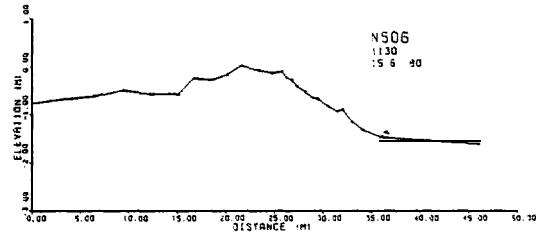
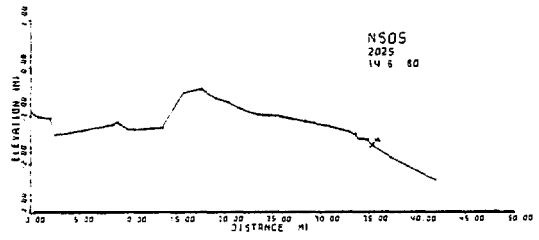
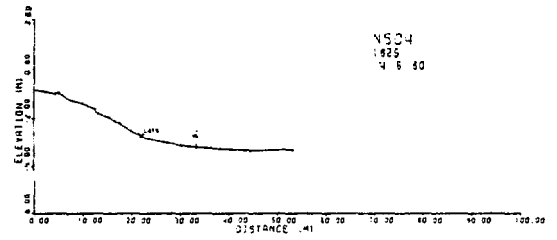
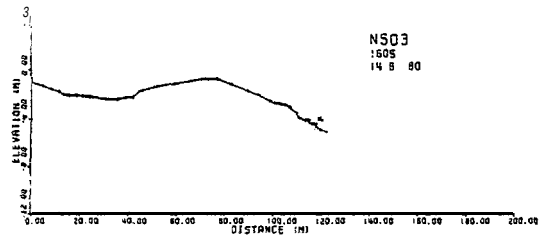
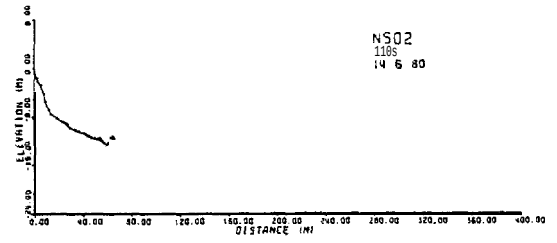
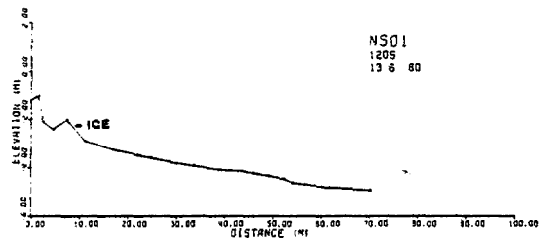


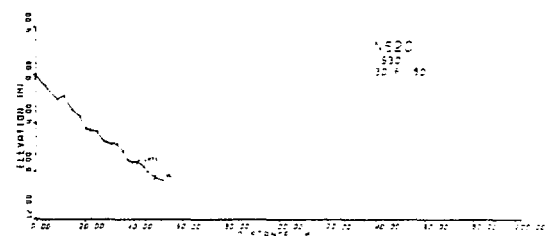
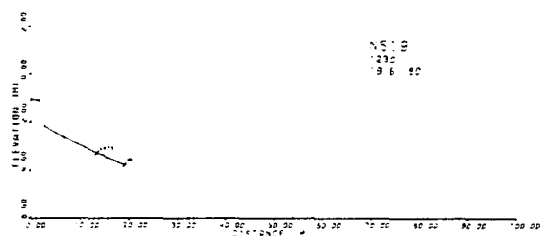
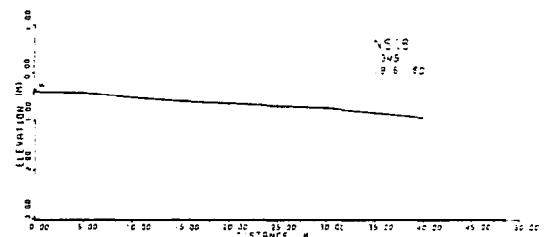
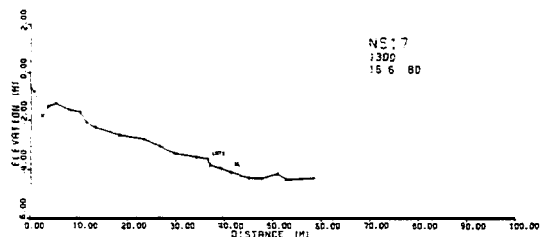
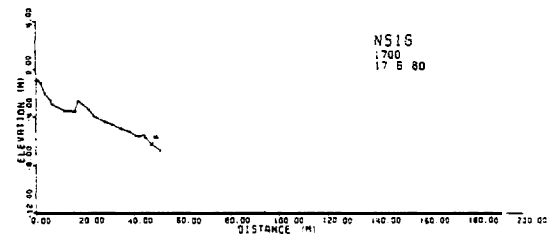
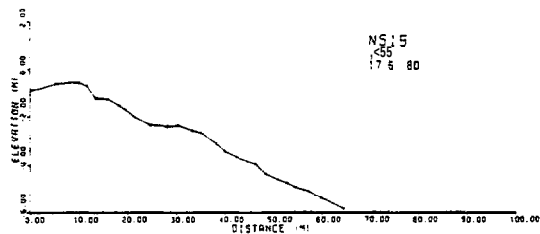
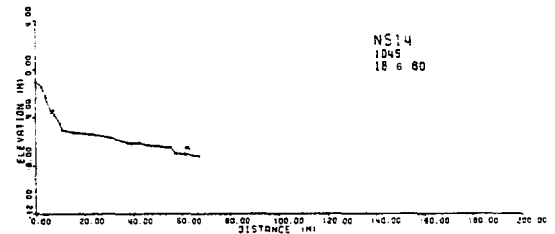
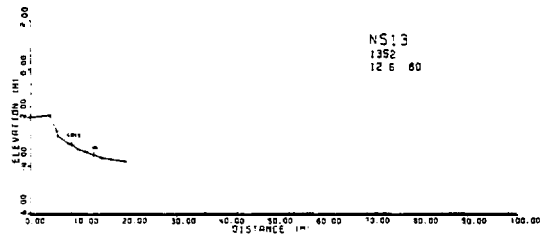
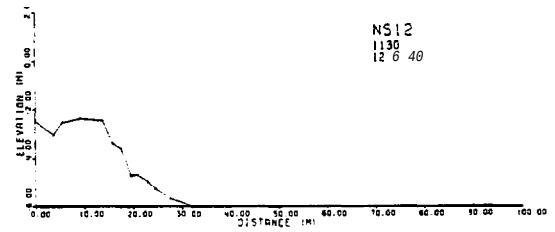
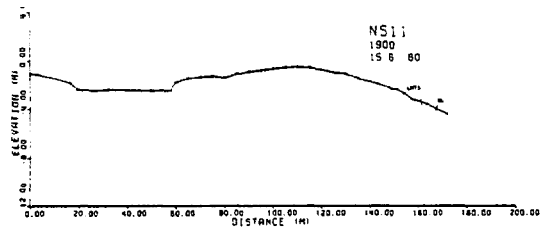


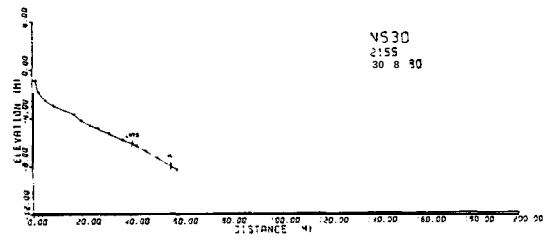
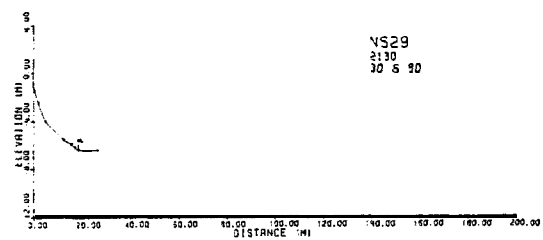
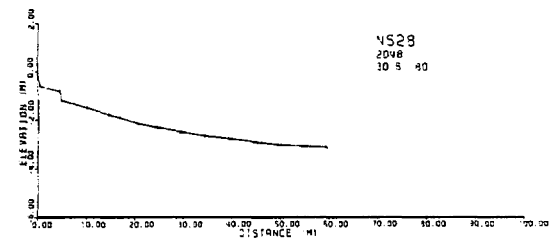
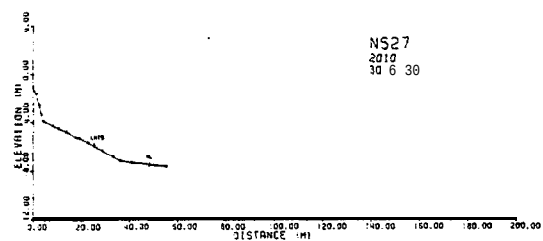
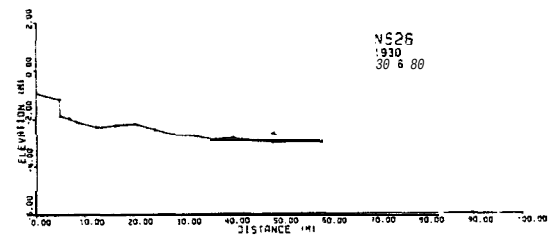
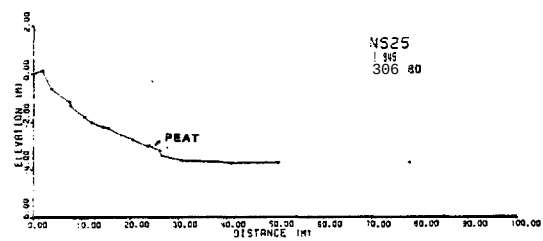
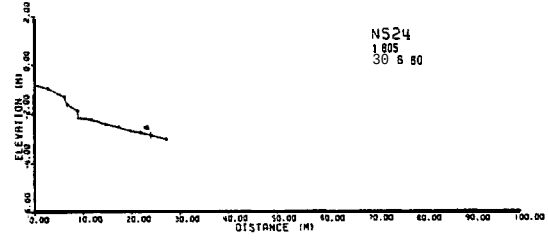
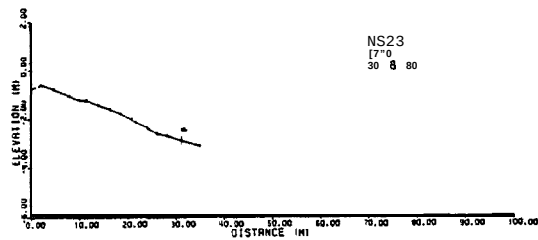
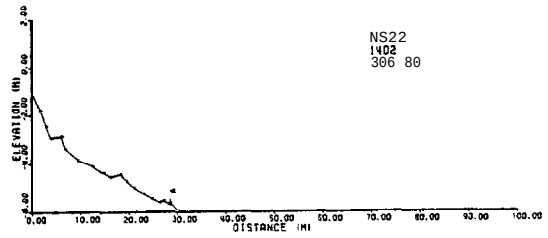
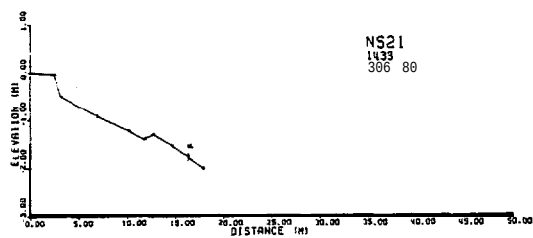


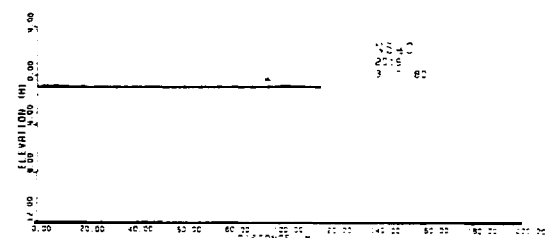
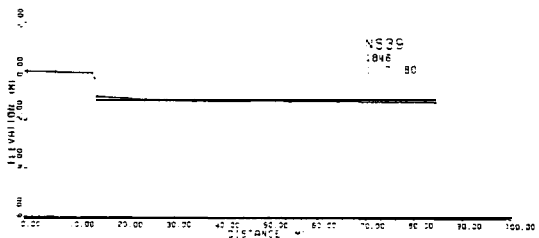
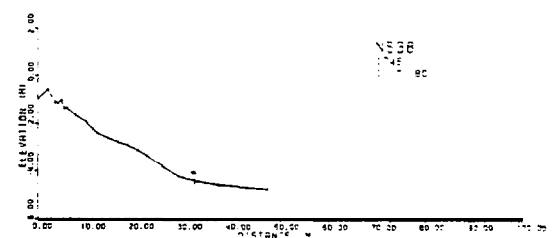
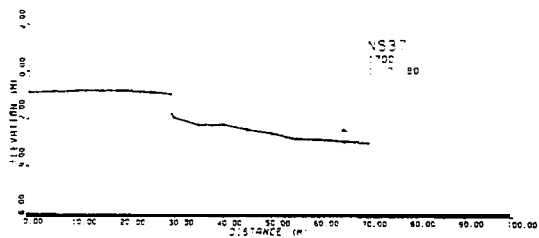
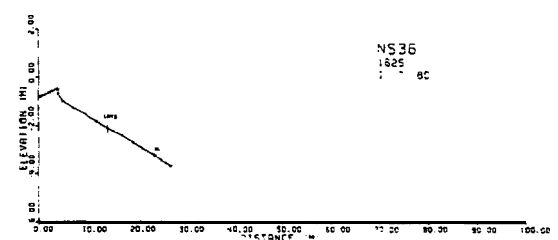
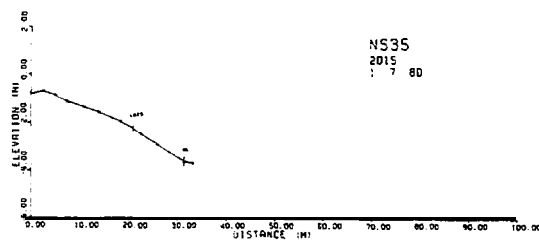
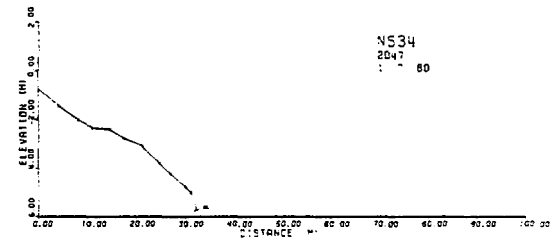
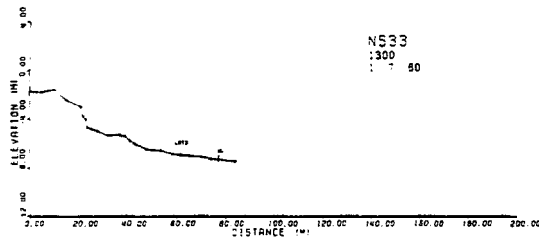
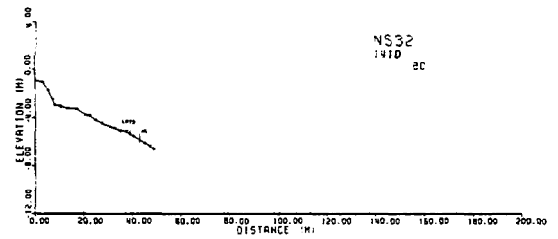
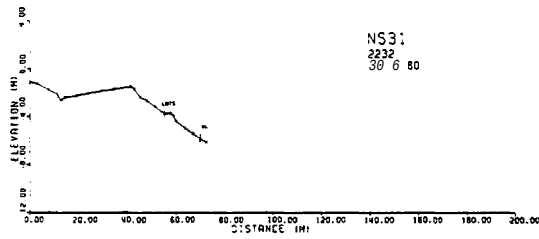
APPENDIX IV

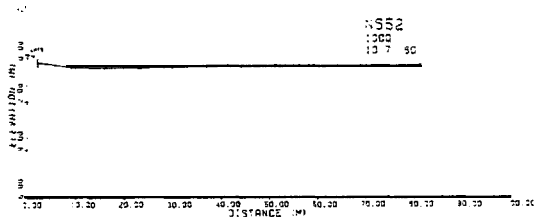
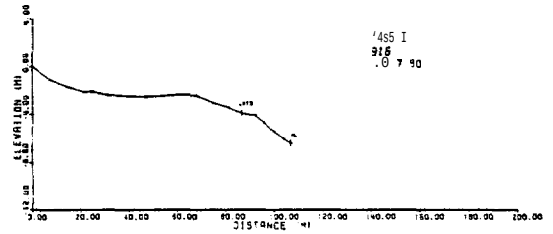
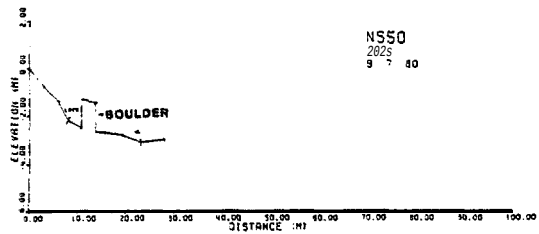
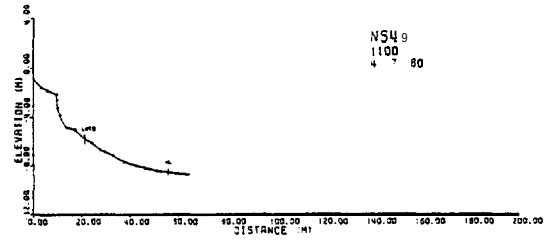
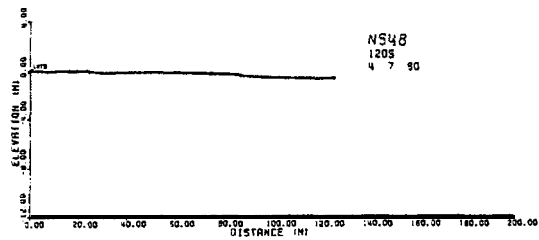
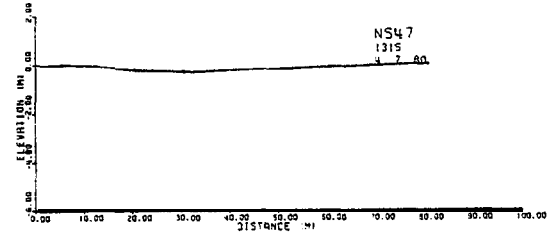
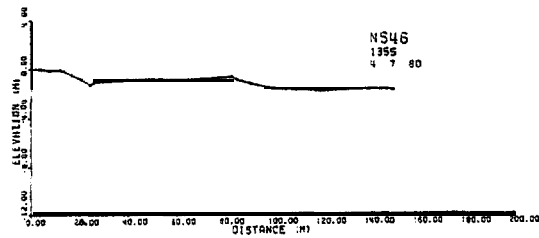
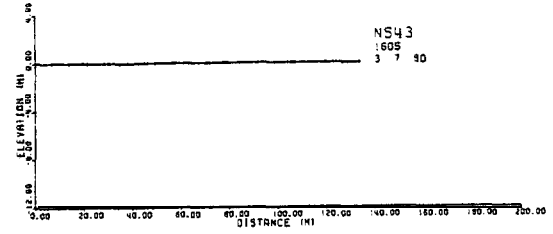
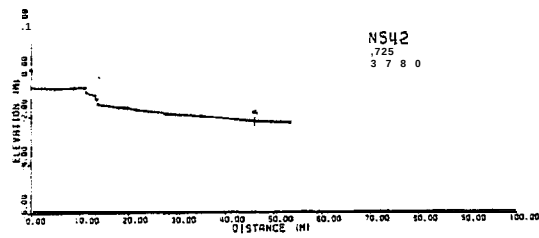
Computer-based profiles for each of the detailed ground study sites (NSS stations). Vertical exaggeration is 5x.











APPENDIX V

Summary of field ground stations and data, including a summary table and the physical and biological descriptions of all stations.

KEY TO APPENDIX v

- D - Detailed Profile Site
- R - Rapid Survey Site

Sediment Types (from Folk, 1968)

- B - Bedrock or boulders $> -8\phi$ (256 mm)
- G - Gravel and cobble -1.0 to -8ϕ (2.00-256 mm)
- SG - Sandy gravel
- gS - Gravelly sand
- (g)S - Slightly gravelly sand
- S - Sand 4.0 to -1.0ϕ (0.0625-2.00 mm)
- mS - Muddy sand
- mP - Muddy peat
- SM - Sandy mud
- msG - Muddy sandy gravel
- P - Peati or peati detritus
- pgs - Peaty gravelly sand

- x - biological samples taken

APPENDIX V. Field Station Data Summary

Station Number	ESI Map Number	Longitude (North)	Latitude (West)	Survey Type	Sediment Type	Biological Samples
NSS-1	1	65°38'00"N	168°07'00"W	D	(g) s	X
F-1	2	65°33'30"N	167°57'00"W	R	SG	
NSS-2	2	65°30'05"N	167°42'35"W	D	G	X
F-2	4	65°24'15"N	167°24'15"W	R	sG	
NSS-3	4	65°23'05"N	167°02'35"W	D	SG	
F-3	5	65°21'20"N	167°52'00"W	R	gs	
NSS-4	5	65°22'20"N	166°48'15"W	D	SG	
F-4	5	65°20'05"N	166°30'50"W	R	G	
NSS-5	6	65°15'25"N	166°18'30"W	D	sG	
F-5	6	65°16'10"N	166°05'00"W	R	gs	
NSS-6	9	65°10'40"N	165°42'30"W	D	sG	X
F-6	9	65°04'30"N	165°36'25"W	R	gs	
NSS-7	8	65°06'30"N	166°39'05"W	D	SM	X
F-7	8	65°08'55"N	166°54'50"W	R	gs	
NSS-8	5	65°16'25"N	166°52'20"W	D	gs	X
F-8	8	65°09'20"N	166°57'00"W	R	gs	
NSS-9	8	65°02'30"N	166°42'05"W	D	gs	X
F-9	11	64°56'55"N	166°33'55"W	R	gs	
NSS-10	12	64°53'15"N	166°24'00"W	D	gs	X
F-10	13	64°42'45"N	166°27'40"W	R	G	
NSS-11	13	64°36'20"N	166°17'30"W	D	(9)s	x
F-n	14	64°32'25"N	165°50'50"W	R	G/B	
NSS-12	16	64°29'40"N	165°23'00"W	D	SG	X
F-12	16	64°26'55"N	165°04'50"W	R	gs	
NSS-13	17	64°26'15"N	164°48'45"W	D	SG	X
F-13	17	64°28'45"N	164°51'20"W	R	s	X
NSS-14	18	64°31'05"N	164°42'10"W	D	SG	X
F-14	19	64°32'45"N	164°25'45"W	R	s/P	
NSS-15	19	64°33'55"N	164°09'20"W	D	gs	
F-15	20	64°34'30"N	163°51'40"W	R	SG/G	
NSS-16	20	64°33'15"N	163°32'05"W	D	SG	X
F-16	21	64°30'20"N	163°20'55"W	R	S/G	

Appendix V. Field Station Data Summary (continued)

Station Number	ESI Map Number	Longitude (North)	Latitude (West)	Survey Type	Sediment Type	Biological Samples
NSS-17	22	64°26'45"N	163°05'30"W	D	SG	x
F-17	21	64°30'20"N	163°07'10"W	R	sG	
NSS-18	21	64°35'40"N	163°18'30"W	D	mS	
F-18	21	64°37'15"N	163°08'35"W	R	SG	
NSS-19	21	64°32'40"N	163°00'25"W	D	SG	
F-19	23	64°28'55"N	162°50'00"W	R	pgs	
NSS-20	23	64°24'45"N	162°48'50"W	D	G	
F-20	23	64°22'40"N	162°40'30"W	R	SG	
NSS-21	23	64°28'35"N	162°36'20"W	D	sG	
F-21	25	64°34'10"N	162°24'55"W	R	gS/B	
NSS-22	25	64°39'30"N	162°12'35"W	D	SG	
F-22	26	64°42'00"N	161°55'55"W	R	SG	
NSS-23	26	64°42'20"N	161°49'00"W	D	SG	
F-23	27	64°45'10"N	161°50'45"W	R	gs	
NSS-24	27	64°47'40"N	161°40'45"W	D	s	x
F-24	27	64°45'15"N	161°30'30"W	R	SG	
NSS-25	28	64°49'15"N	161°19'55"W	D	SG	x
F-25	28	64°55'15"N	161°06'05"W	R	SM	
NSS-26	28	64°50'50"N	161°00'30"W	D	mP	
F-26	29	64°45'15"N	161°50'00"W	R	pgs	
NSS-27	30	64°37'36"N	160°32'30"W	D	SG	x
F-27	31	64°32'30"N	161°00'55"W	R	P	
NSS-28	32	64°29'45"N	161°10'18"W	D	(g) S	x
F-28	31	64°31'15"N	161°24'40"W	R	SG	
NSS-29	32	64°26'05"N	161°29'03"W	D	B	
F-29	32	64°23'55"N	161°18'30"W	R	s/P	
NSS-30	32	64°17'38"N	161°05'06"W	D	SG	x
F-30	33	64°12'30"N	160°57'00"W	R	G	
NSS-31	33	64°02'36"N	161°55'30"W	D	G	x
F-31	34	63°53'00"N	160°48'00"W	R	sG	
NSS-32	34	63°48'51"N	160°45'42"W	D	G	

APPENDIX V. Field Station Data Summary (continued)

Station Number	ESI Map Number	Longitude (North)	Latitude (West)	Survey Type	Sediment Type	Biological Samples
F-32	35	63°33'20"N	161°55'55"W	R	SG	
NSS-33	36	63°33'24"N	161°03'45"W	D	sG	X
F-33	37	63°28'05"N	161°24'00"W	R	B	
NSS-34	38	63°26'57"N	161°36'28"W	D	B	X
F-34	38	63°27'00"N	161°52'50"W	R	B	
NSS-35	39	63°29'12"N	162°01'48"W	D	gs	
F-35	40	63°32'20"N	162°16'10"W	R	s	
NSS-36	40	63°33'45"N	162°21'51"W	D	sG	
F-36	41	63°37'25"N	162°30'05"W	R	s	
NSS-37	39	63°23'56"N	162°25'54"W	D	SM	
F-37	43	63°14'40"N	162°38'50"W	R	P	
NSS-38	43	63°10'18"N	162°50'15"W	D	SG	
F-38	44	64°33'45"N	163°02'50"W	R	P	
NSS-39	46	63°07'12"N	163°32'18"W	D	SM	
F-39A	45	63°12'25"N	163°43'25"W	R	mP	
F-39B	46	63°15'40"N	164°56'20"W	R	ml?	
F-39C	46	63°14'30"N	164°16'20"W	R	mP	
NSS-40	47	63°07'00"N	164°33'30"W	D	mS	
F-40A	47	62°01'35"N	164°35'00"W	R	mP	
F-40B	47	62°00'30"N	164°42'30"W	R	mP	
F-40C	48	62°52'50"N	164°49'30"W	R	mP	
F-41A	49	62°44'45"N	164°51'30"W	R	mP	
F-41B	49	62°48'10"N	164°50'15"W	R	mP	
F-41C	50	62°30'35"N	164°07'30"W	R	mP	
NSS-42	51	62°21'24"N	165°21'30"W	D	SM	
F-42A	51	62°16'30"N	164°28'05"W	R	mP	
F-42B	52	62°06'50"N	165°42'10"W	R	SM/mP	
F-42C	53	61°57'45"N	164°44'25"W	R	SM/mP	
NSS-43	53	61°51'40"N	165°36'40"W	D	SM	
F-43	54	61°46'00"N	166°03'00"W	R	mP	
F-45C	55	61°32'10"N	166°01'40"W	R	mP	
NSS-46	57	61°23'51"N	165°55'30"W	D	s	

APPENDIX V. Field Station Data Summary (continued)

Station Number	ESI Map Number	Longitude (North)	Latitude (West)	Survey Type	Sediment Type	Biological Samples
F-46C	58	61°17'25"N	165°38'30"W	R	sM/mP	
NSS-47	59	61°10'20"N	165°37'30"W	D	SM	
F-47A	59	61°04'05"N	165°23'45"W	R	mP/P	
F-47B	60	61°08'25"N	165°20'35"W	R	P	
F-47C	60	61°04'45"N	165°07'25"W	R	P	
NSS-48	60	61°00'15"N	165°09'09"W	D	mS	X
F-48A	61	60°54'25"N	165°01'35"W	R	P	
F-48B	61	60°50'15"N	165°01'50"W	R	P/sM	
F-48C	63	60°42'35"N	164°58'45"W	R	P	
NSS-49	64	60°39'18"N	165°06'24"W	D	ms G	X
F-49	64	60°33'45"N	165°23'40"N	R	B/sG	
NSS-50	65	57°09'15"N	170°24'10"N	D	B	
NSS-51	65	57°08'40"N	170°17'10"W	D	s	
NSS-52	65	57°08'00"N	170°16'30"W	D	G	X
NSS-53	65	57°07'00"N	170°15'40"W	R	B	

APPENDIX V. Station Descriptions

STATION DESCRIPTIONS

NSS-1 4 km north of Cape Prince of Wales

Consists of a wide mixed sand and fine gravel beach on large depositional spit backed by fine-grained sand dunes (with permafrost). The back beach is vegetated: snow and ice are abundant on beach along mid-beach face; active beach face composed of medium- to coarse-grained sand with granules and littered with the shells of dead Mya. No intertidal infauna were observed. The subtidal area is shallow and muddy, so adult clams may be present offshore. Bird activity was light (Pigeon guillemot).

F-1 Tin City

Consists of a mixed sand and gravel beach in small depositional basin; gravel berms with 5-10 percent sand are present along lower part of beach; backed by slumping tundra peat scarps. Cobbles range up to 25 cm. A coarse-granule, fine-gravel ridge occurs at water line. No flora or infauna, and very little epifauna present on the beach. Epifauna are dominated by insects and spiders in the supratidal zone among log debris. Red algae were deposited along the high water mark.

NSS-2 1.5 km northeast of York

Consists of a mixed sand and gravel beach fronting moist tundra peat slumps: the back beach is mostly coarse-grained sand with scattered gravel: mid-beach is composed of platy cobbles overlying mixed sand and gravel; lower beach face contains medium-grained sand and fine gravel with many ice blocks: gravel overwashes protect a sheltered lagoon and grassy tundra terrace: two berms (active and ice) are present; beetles and spiders are also present. Surface and infaunal organisms were not found and there was no sign of bird activity.

F-2 Mouth of King River

consists of a fan delta outwash, having a gravel beach composed of 5-10 percent coarse-grained sand and gravel and a steep active gravel berm. No epi- or infauna present along beach, but are present on a nearby bedrock outcrop. Epi fauna are dominated by Balanus (maximum coverage 40%) in the mid- to low-intertidal zone and filamentous green algae (about 25% coverage). Bird use is low (gulls).

NSS-3 5 km east of mouth of Lost River

Located on the interior of an east- accreting bay-barrier bar. A tundra and grass terrace is fronted by a mixed sand and gravel beach. The back beach is composed of equant pebbles and granules. The upper and lower beach face have a surface shingle of flat pebbles/cobbles overlying mixed very coarse-grained sand and fine-grained gravel. Wind deflation and ice are common throughout. Numerous small gravel berms are present. The active intertidal zone and narrow low-tide terrace are composed of silty mixed sand and gravel with the silt content increasing seaward. Five distinct biological microhabitats were observed: 1) wet tundra - vegetated with grasses, Salix, mosses, and lichens; 2) lagoonal area - containing scattered logs and insects; 3) storm beach - containing scattered algae; 4) active beach - containing wrack; and 5) nearshore subtidal - no biota were observed. Bird use was low overall.

F-3 Brevig Lagoon Spit, exposed side

Consists of a mixed sand and gravel beach with a coarse-grained sand back beach and gravel beach face. Ice features, ice remnants, and scattered logs and debris are common. No infauna or epifauna were observed. Bird usage was low (only gulls).

NSS-4 Interior of Brevig Lagoon

consists of a sheltered mixed sand and gravel beach with a narrow low-tide terrace composed of the same sediment as the beach but with silty mud drape. There are four distinct habitats: 1) moist tundra with sphagnum moss, lichens, grasses and Salix, and was inhabited by spiders and mites; 2) storm activated beach where logs and insects were present; 3) active beach where no infauna or epifauna were observed; and 4) the subtidal zone which was inhabited by ribbon worms and amphipods. In fauna organisms were only found in the silty nearshore sediments. Bird use was high, dominated by white-winged scoters and wigeon ducks.

F-4 Southern Brevig Lagoon near Brevig Mission

Large mixed sand and gravel spit: 6-10 cm of well-sorted gravel overlying gravelly muds: pockets and embayments of muddy sediment with grasses; overwashes are very common. In fauna are dominated by small white nematodes; no epifauna were observed: epifauna attached to small boulders include green and brown filamentous algae, present in the low intertidal zone; bird use is low.

APPENDIX v. Station Descriptions (continued)

NSS-5 Coyote creek, interior of Grantley Harbor

Consists of two gravel spits protecting lagoonal mud flats and tundra/marsh. Sediments are composed of mixed sand and gravel with a mud drape. The spit beach is composed of coarse, gravelly sand with a few flat cobbles on the back beach [wind deflation flat]. Four distinct habitats were noted, 1) wet tundra - vegetated by grasses and Salix; 2) tide pool - inhabited by Sticklebacks and gambusia fishes and brown algae; 3) sheltered tidal flat with scattered vegetated, and 4) storm/active beach which was unvegetated. No epifauna or infauna found in any of these habitats. Bird use was moderate, with evidence indicating foraging by gulls, shore birds, and swans.

F-S North Shore of Grantley Harbor, 1.5 km north of McKinney Creek

Consists of a very narrow mixed sand and gravel beach with abundant ice patches on the back beach and a prominent gravel berm. It is bounded landward by a slumping peat scarp with a tundra-vegetated terrace above. The moist tundra was dominated by willow, Salix, grasses, spagnum moss, and lichens. Bird use was low; only offshore gulls observed.

NSS-6 Ouck Creek Delta, Imuruk Basin

Consists of a reworked delta having a low marsh tundra/bog interior with ponded fresh water. The beach and washover complex is composed of micaceous gravel and cobble with very little sand. It also has surface coating of peaty detritus eroded from peat outcrops to the east. Rocky headlands with basal boulder/cobble deposits and small pocket beaches are located to the west. Four distinct habitats are present: 1) freshwater pond inhabited by insect larvae, oligochaetes, mosquito larvae, and spiders. Small fish were also abundant, 2) wet tundra - vegetated by sedges and grasses; 3) dune ridge - vegetated by grasses and having logs at the base inhabited by spiders, and 4) active beach water - inhabited by spiders. There were no infauna present on the beach or on the near-shore sediments. Bird usage was high including gulls and numerous ducks.

F-6 South side - Imuruk Basin

Consists of a narrow, sheltered mixed sand and platy gravel at the base of a vegetated scarp.

NSS-7 2 km south of Jones Point along south side of Port Clarence.

Consists of a mixed sand and gravel beach fronting wet tundra/bog and wet marsh with a high erosional escarpment. The profile was run across a tidal flat composed of silty mud on a mixed sand and gravel base. Exposed gravel patches and muddy tidal creeks are common. A storm swash is located high on the wet tundra terrace escarpment. The wet tundra/bog habitat was dominated by spiders, mites, and black beetles. Three-spined sticklebacks fish were present in the creeks. Flora included sedges, grass, and Salix. No intertidal infauna were observed.

F-7 Interior side of Port Clarence Spit

consists of a sheltered mixed sand and gravel beach composed of gravelly medium- to coarse-grained sand. Patches of peat detritus were present on the beach surface. A peat scarp with permafrost was located behind the beach. It contained water-saturated "peat bog" at base. The terrace above the scarp is vegetated with tundra/grasses. Ponded fresh water is common along the interior. No infauna or epifauna were observed. The moist tundra was vegetated with grasses, Salix, and lichens. In the active intertidal zone, Enteromorpha was attached to eroded blocks of tundra peat. Bird activity was low.

NSS-8 Port Clarence - along the exposed terminus of spit

Consists of a mixed sand and gravel beach with abundant ice features and two prominent berms {active and spring}. The coarsest material is associated with ice features (coarse gravel and cobbles). The back beach contains a deflation flat of gravel on mixed sand and gravel. Grass is located along the back beach. A wide storm swashline on the back beach is inhabited with spiders and other insects. Several dead starfish were present in the wrack suggesting their presence offshore. No infauna or epifauna were observed in the intertidal or subtidal habitats; bird activity was low (primarily glaucous gulls).

F-B

Port Clarence Spit, exposed side

consists of a mixed sand and gravel beach with abundant ice features and ice remnants along a very irregular shoreline. It is backed by a high (4-7 m) permafrosted peat scarp. Numerous overwashes are present nearby. No marine infauna or epifauna were observed: the moist tundra above the scarp is vegetated with sedges, arctic buttercups, and Salix. No birds were present.

NSS-9

1.5 km northeast of Bridget Creek, it is located along the exposed side of a bay barrier bar.

A wide mixed sand and gravel beach/washover complex composed of gravelly coarse sand fronts a wet tundra with numerous freshwater ponds. Beach grasses lightly vegetate the back beach. A deflation flat occurs along the washover terrace. Ice features are very common on beach face. Five distinct habitats are present: 1) moist tundra - vegetated by grasses, Salix, and spagnum moss; 2) fresh water stream with brown algae; 3) wet tundra - vegetated with grasses and Salix; 4) a storm ridge vegetated with grasses and inhabited by spiders and other insects; and 5) storm and active beach/subtidal with scattered logs and bits of wood, but no organisms. No infauna were observed along the entire transect. Bird use was moderate (gulls, shore birds, and ducks).

APPENDIX V. Station Descriptions (continued)

F-9 Exposed side of bay barrier bar near Sourdough Creek

Tundra and grasses bat. a mixed sand and gravel wash-over/beach complex. Ice features and rafted sediment are common. No marine infauna were observed; only insects, among logs scattered throughout the supratidal/storm beach zones, were found. The moist tundra along the back beach was vegetated by grasses, Salix, and a yellow flower cover crop. The storm ridge was vegetated by ground cover and grasses. Bird activity was high.

NSS-10 Interior lagoon near mouth of Tisuk River

Tidal flats and tidal creeks with a tundra marsh. Moist tundra-vegetated terrace composed of interbedded sand and peat; cut by gravelly tidal flat of medium-coarse gravelly sand with abundant relict bed forms (megaripples) and rafted peat blocks. The terrace is vegetated with grass and inhabited by insects; tide pool with brown algae; amphipods on the tidal flat; high bird use area (willetts, gulls, and swans).

F-10 3 km north of Cape Rodney

Consists of a wide beach/washover complex adjacent to a grass and tundra covered outwash terrace with a wide deflation flat covered by flat gravel and cobbles, a wide storm swash of logs. The mixed sand and gravel beach contains ice features, gravel ridges, and fairly well-sorted granule/gravel along active beachface. Coarse gravel is found on active berm, grassy terrace behind is covered with scattered storm swash logs from repeated overwashes. Three distinct habitats were noted: 1) moist tundra - vegetated with grasses, lichens, and sphagnum moss and inhabited by insects; 2) storm overwash terrace back beach containing no biota, and 3) active beach - which also contained no biota. Bird use was high (primarily gulls and terns).

NSS-11 2.5 km northwest of Sinuk

Consists of a very wide mixed sand and gravel beach/washover complex in front of a hummocky, swampy interior of grass and tundra with standing fresh water. The washover grades from very coarse-grained sand/granule along the landward side to medium-grained sand at the waterline. The deflation flat of cobbles on sand extends to the active berm. A gravel ridge is prominent along the spring, high-tide swashline. Ice features are common. A storm swash is located more than 100 m landward of the distal washover lobes. Five distinct habitats are noted: moist tundra vegetated with grasses, sedges, Salix, sphagnum moss, and lichens; wet tundra vegetated with grasses and Salix, and inhabited by insects; a freshwater stream with small fish; a storm berm with logs inhabited by insects; and an active beach with no biota.

F-1: Mouth of Rodney Creek

Consists of a wave-cut bedrock platform of slates and schists with large cobbles and boulders. A mixed sand and gravel beach is located behind the platform along the upper beach face. Waves were present. A hummocky, steep tundra slope backs the beach and platform. Infauna were observed in finer sediments between the boulders above the lower beach face including flat worms, amphipods, and insect larvae. Epifauna included Balanus, Mytilus, Littorina sitkana, and Nucella. Insects were present in the wrack. Green filamentous algae were attached to the rocks along the lower intertidal zone.

NSS-12 Between Nome and Fort Davis

Consists of a high-energy mixed sand and gravel beach that fringes an outwash plain with a back beach and washover complex composed of fine-grained, well-sorted gravel. The beach face has very coarse sand and gravel with very abundant heavy minerals (garnet). Numerous river mouths discharge locally onto the active beach. This area has two distinct biological habitats: 1) sand/gravel beach which contains razor clams and polychaetes; and 2) wet tundra/bog which contains tundra vegetation and is used as a forage area by black brants, plovers, and terns. The beach face is used by grunion for spawning.

NSS-13 Port safety (Interior of Safety Sound)

Consists of narrow sheltered beach located on the interior of a small bay. Composed of medium- to coarse-grained sand and fine gravel and is backed by an actively slumping low scarp. Grasses vegetate the terrace behind the beach. Beach wrack was composed of Ulva with Chaetomorpha and invertebrate eggs attached to it. Nematode worms were lightly abundant at the waters edge; shore bird activity was light.

F-13 Interior of Safety Sound

Consists of a tundra peat terrace with slumping, permafrost escarpment terminating on a narrow, sheltered medium-grained sand beach. A heavy wrack accumulation was present at the base of the scarp. Sand along active beachface is very well-sorted with minor gravel. There were no obvious grain size trends. The intertidal beachface is wide and well-rippled. Three distinct habitats: moist tundra vegetated with sedges, Salix, and Betula; storm beach and active beach with no biota. No infauna were observed, bird use was low. The lagoonal water was slightly brackish (about 10 ppt).

NSS-14 Interior of Safety Sound

Consists of a narrow sheltered gravel beach protecting a marshy lagoon. Lagoon sediments are composed of well-sorted granules to gravel. The back beach and upper terrace are vegetated and composed of coarse-grained gravelly sand. The active beach is well-sorted gravel with a very regular

APPENDIX V. Station Descriptions (continued)

profile. Four distinct microhabitats are present: 1) moist tundra - vegetated with Salix, Betula, grasses, lichens, sphagnum moss; 2) slumping moist tundra - covered with scattered logs, vegetated with lichens, staghorn moss, grasses, and ground cover; 3) storm beach - covered with logs vegetated with grasses and ground cover, and inhabited with insects, and 4) active beach - vegetated with grasses, sedges, ground cover, and inhabited by spiders and insects. Bird use was low. The water was nearly fresh (about 5 ppt).

F-14 Interior of Solomon River Delta (Lower Delta Plain)

Wet, moist tundra/bog terrace vegetated with grasses; some tundra marsh areas dominated by grasses and Salix; terminates in a high slumping peat scarp and peat (wave-cut) platform; intermittent patches of fine well-sorted sand cover the platform transported landward from back of barrier island; in the offshore mud flat, dead Macoma clams were present but no live specimens were found; bird activity was moderate (gulls and terns); pink and chum salmon run in this area.

NSS-15 Exposed side of barrier bar at Taylor Lagoon

Consists of a grass and tundra terrace with freshwater ponds and brackish swamps fronted by vegetated dunes at the edge of a washover terrace and two storm berm/terrace complexes. Each berm has a storm/log swash and both are composed of very coarse-grained sand and gravel. The sediment grades from well-sorted granule on the back beach to gravel at the water line. Several smaller berms are also present on the beach face. No infauna or epifauna were observed. Habitats noted were: 1) moist tundra vegetated with grasses; 2) dune ridge vegetated with ground cover, sedges and grasses, logs were scattered throughout this area; 3) storm beach vegetated by ground cover; and 4) active beach with no biota. There was moderate bird activity, (gulls, black-legged Kittiwakes, and eiders).

F-15 Mouth of Silberbow Creek, 5 km west of Bluff

Consists of a sandy pocket situated between exposed headlands. Sediment types vary from a medium- to coarse-grained sand back beach and dunes to a platy cobble/gravel storm berm and an active beach face of platy cobble/gravel on mixed sand and gravel. No infauna or epifauna were observed. A moist tundra vegetated by grasses backs the beach. Bird use was light.

NSS-16 2 km east of Square Rock

Consists of a high-energy mixed sand and gravel beach with coarse gravel in the surf zone and a mixed sand and gravel (coarse-grained sand) beach face. There is a very large log-debris storm swash line piled against the vegetated back slope. No infauna or epifauna organisms were observed. Three distinct bio-zones were present: 1) moist tundra vegetated with grasses, Salix, and poplar ground cover; 2) storm beach/log berm inhabited by insects; and 3) active beach face

inhabited by insect larvae. Brown and green filamentous algae covered boulders in the lower intertidal zone. Eggs in intertidal sediments identify this locality as a spawning site for herring. Bird use was high.

F-16 1 km Southeast of Chiukak

Consists of a mixed sand and gravel beach (fine- to medium-grained sand on granule base) with a mixed sand and gravel deflation flat fronting a steep scarp in peat. There is limited overwash. Three distinct habitats are present: 1) moist tundra vegetated with grasses, sedges, Betula, and Salix; 2) storm beach with spiders and other insects present in the log swash; and 3) the active beach with no biota. No infauna were observed. Bird use was low.

NSS-17 Golovin Bay

consists of bedrock (schist) platform with a thin gravel and cobble veneer and small patches of coarse-grained sand. The active berm and vegetated slope behind the platform are composed of gravel and cobbles. Three distinct habitats are present: 1) vegetated scarp with grasses, Salix, and moss; 2) beach with scattered logs inhabited by insects; and 3) rocky intertidal platform covered with green filamentous algae, Verrucaria, Enteromorpha, and Fucus, and inhabited by insects and ... Bird use was low, but there are several rookeries nearby.

F-17 Embayment on the south side of Golovin Lagoon

Consists of a narrow mixed sand and gravel beach on a small spit. A steep vegetated slope is located behind the narrow beach. The beach is composed of platy cobbles on mixed sand and gravel with ridges of shingled cobbles in upper beach face and numerous small gravel/granule berms on the lower beach face. The sediment base is poorly sorted mixed sand and gravel (coarse-grained sand). Salinity of the nearshore water is very low. Four habitats were observed: 1) moist tundra vegetated with sedges, Betula, Salix, lichens, and sphagnum moss; 2) storm berm vegetated with grasses and having logs inhabited by insects; 3) the storm beach; and 4) active beach face each with no biota. Bird use was low (gulls). No infauna were observed.

APPENDIX V. Station Descriptions (continued)

NSS-18 Fish River lower delta plain, at the north end of Golovin Lagoon.

Consists of an extensive low-lying marsh and eelgrass area. The surface of the marsh has patches of ice rafted sediment (fine-grained sand). This is primarily a fresh water habitat with three distinct zones: 1) subaerial high marsh vegetated with sedges and ferns; 2) storm-wetted marsh with sedges and ferns; and 3) a (eelgrass) flat. No infaunal or epifaunal organisms were observed. Bird use was high (including ducks and gulls).

F-18 Northeast Golovin Lagoon

Consists of a very narrow beach fringe on a spit composed of mixed coarse-grained to very coarse-grained sand and gravel. Beach grasses are present on crest of spit. Four distinct habitats are present: 1) grassy bluff - vegetated with grasses; 2) storm heath - vegetated with grasses and ground cover; 3) active beach - vegetated with grasses; and 4) the subtidal zone. No infauna or epifauna were observed. Bird use was high including gulls, whistling swans, shore birds, and ducks.

NSS-19 1 km (0.6 mi) east of Golovin

Consists of an active sand and gravel beach on a spit backed by a low escarpment. The sediment is composed of granitic material. The crest of the back beach has a well-developed storm log swash and is lightly vegetated with beach grasses. Four biological habitats were present: 1) vegetated scarp with ground cover and grasses; 2) unvegetated back beach; 3) active beach covered with a (grass) wrack; and 4) subtidal zone with moderately abundant nematodes. Bird activity was low. No epifauna were observed.

F-19 Western Golovin Bay. 4.5 km north of Carolyn Is land

Consists of a mixed sand and gravel beach at mouth of small delta. The back beach is a wide, gravel-covered deflation flat while the active beach face is mixed sand and gravel with abundant peat detritus covering the lower beach face and low-tide terrace. No infauna were observed. Insects were noted in the supratidal zone. Bird use was low.

NSS-20 Pocket Beach in exposed rocky coast 2 km south of Golovin Mission

Consists of a very wide, steep cobble beach with very well-sorted and rounded clasts. At least four cobble berms were present. The lower (active) beach face is 90 percent well-sorted fine-grained sand with 10 percent gravel/cobbles. A tundra terrace is located behind the storm berm.

NSS-21 Small depositional basin at Portage Roadhouse

Consists of a coarse-grained sand beach backed by a vegetated (grass and trees) terrace with a scarp. Log storm swash is high and well-developed. Back beach is composed of very well-sorted sediment which coarsens seaward on active beach face from pebbly, coarse-grained sand to very well-

sorted granules at the toe of Death. Four distinct habitats are present: 1) vegetated terrace - primrose cover and broad-leaved grasses; 2) storm beach logs inhabited by insects and spiders; 3) active beach - inhabited by insects; and 4) subtidal zone in which no biota were observed. No infauna were observed at this station. Bird use was high (mostly gulls).

F-21 3 km northeast of Walla wall.

Consists of a coarse-grained sand veneer on a bedrock platform (bedded limestone) adjacent to rocky terraces and exposed headlands. Potholes and sediment-filled depressions are common on the intertidal portion of the platform. The sediment is 80 percent coarse- to very coarse-grained sand, 20 percent medium-fine platy gravel. There are numerous berms and low erosional scarps in the sediment veneer. It also contains a well-developed storm swash of logs and associated debris. The entire beach is backed by terrestrial vegetation (bushes).

X5.5-22 Mouth of Iron creek, 9 km west of Moses Point

Mixed sand and gravel beach backed by eroding peat scarp and a tundra-vegetated terrace. Scarp is actively slumping but well-vegetated. A storm swash composed of logs and cobbles is located at the foot of the scarp. The upper beach face is a narrow pebble deflation flat sitting on a mixed sand and gravel base. The beach face is composed of mixed sand and gravel with patches of coarse-grained sand. The toe of the beach is composed of fairly well-sorted gravel. Two prominent gravel/pebble ridges are present. Four distinct habitats were noted: 1) moist tundra scarp vegetated with Betula, Salix, lichens, grass, Equisetum, and spruce seedlings; 2) storm beach with spiders and other insects on decaying logs; 3) active beach with red mites in the wrack zone; and 4) subtidal zone in which no biota were observed. No infauna were present. Birds are present (gulls).

F-22 Exposed marsh at Kwiniuk Inlet

Beach and washover complex composed of mixed sand and gravel (very coarse-grained sand/granules). The back shore, a wide deflation flat, is composed of uniform poorly-sorted sediment. Overwashing is extensive. There are well-developed accreting offshore ridge- and-runnels. Scattered shell material is located on the active beach face surface. Marsh and wet-tundra vegetation is located landward of washover babes. Some vehicular traffic and road grading has occurred atop the back beach deflation flat.

NSS-23 Kwiniuk Inlet spit, beach/washover complex

Located on the sheltered side of a spit. Consists of a grass-covered gravel terrace opening seaward onto a mixed sand and gravel beach with multiple gravel berms and swash-lines. Sand is poorly-sorted and medium-grained. Gravel clasts are very flat and well-rounded. No infauna were ob-

APPENDIX V. Station Descriptions (continued)

served. Epi fauna were dominated by spiders, mosquitoes, and other insects. Bird use was low. Primary vegetation types are grasses and ground cover. Enteromorpha lightly covers portions of the low Intertidal zone. The salinity was about 5-10 ppt.

F-23 Tubutulik River delta front in Kwiniuk Inlet

Consists of stable vegetated tundra sloping down to a mixed sand and gravel beach. Surface sediment is very coarse sand/granule with good sorting atop a poorly sorted mixed sand and gravel base. Exposed intertidal shoals seaward of the beach are composed of mixed sand and gravel.

NSS - 24 Kwik River.

Consists of a delta fronted by a steep eroding scarp in peat. There is a compact clay platform covered with a dark, silty mixed sand and gravel veneer. Sediments are very poorly sorted. Sediments are reduced except for an exceedingly thin surface veneer. Sediments coarsen seaward. A storm awash is present well landward of the scarp on the tundra terrace. The salinity was approximately five Percent. Infauna are dominated by nematodes and isopods. Epifauna are dominated by insects and mosquitoes. Dominant vegetation is sedge on the vegetated tundra scarp and Enteromorpha attached to peat blocks in the intertidal zone. Bird use was low.

F-24 Pocket beach in Lee of Bald Head

Consists of a mixed sand and gravel beach with no landward scarp. It is composed of very coarse-grained and fine gravel with a 10-20 cm veneer of platy, well-rounded cobbles and gravel. Two large coarse berms are present on the beach face. A rocky headland is located to the west.

NSS-25 10 km southwest of Koyuk Inlet, Western Norton Bay

Consists of a grass-vegetated, sandy terrace grading seaward onto an unvegetated terrace. A mixed sand and gravel veneer on a peat platform with peat outcrop is located at the beach toe. The tidal flat is composed of mixed sand and gravel grading seaward to mud. Some flat angular cobbles and gravel/granules are associated with beach face berms. The infauna are dominated by red annelid worms near the surface of the tidal flat and amphipods in the tidal flat and the tide-pool sediments. Sticklebacks fish are present in tide pools. The epifauna are dominated by isopods which are present on the surface of the tidal flat. Bird use was low.

F-25 Interior mouth of Koyuk River.

Consists of a lower delta plain/tidal flat on a clay platform. It has a sediment veneer composed of slightly sandy clay which is water-saturated. The surface is highly irregular with ponded water and patches of peaty detritus. Small ripples cover the tidal flat surface. No scarp protects the marsh and grasses landward. Insects are very common. Amphipods and polychaetes are moderately abundant.

NSS-26 10 km southeast of Koyuk Inlet, western Norton Bay

Consists of a lower delta plain with a vegetated peat terrace terminating in an eroding peat scarp. It is fronted by a narrow peaty mud tidal flat. Peat blocks and finely-divided detritus are common on the mud flat. Sediments are very boggy and water-saturated. No epifauna were observed. Infauna were dominated by isopods. Epifauna composed of two species of attached algae: green filamentous algae, and Enteromorpha - both were attached to blocks of peat. Bird use was low. Reindeer use this area.

F-26 9 km south of Inglutalik River

Consists of a mixed sand and gravel washover/beach complex developed on an actively eroding peat platform. Abundant peat chunks and fine detritus cover the beach face which is composed of medium- to coarse-grained sand and platy pebbles/gravel clasts over coarse-grained sand and granules. Numerous eroding peat scarps are present on the washover terrace.

NSS-27 Shoreline of outwash plain 10 km north of mouth of Ungalik River.

Consists of a grass-covered terrace and scarp, fronted by a mixed sand and gravel beach and bedrock platform. Low-tide terrace. The back beach contains flat pebble shingle on well-sorted medium sand. Sediments coarsen to mixed sand and gravel at beach toe. Low tide exposes a platform of vertically dipping slate and phyllite outcrop covered with a thin mud veneer. Epifauna dominated by mosquitoes and isopods in the mid intertidal zone. Infauna are dominated by isopods in the mid intertidal zone and by Macoma baltica in the subtidal habitat. The warp was vegetated with several species of grass. Attached aquatic vegetation was dominated by Enteromorpha present in the low intertidal zone. Bird use was low.

F-27 Destructional marsh shoreline 3 km east of Island Point

Consists of a wave-cut platform of clay and peat backed by a high slumping peat scarp. The platform is locally covered with a thin veneer of peat detritus and minor amounts of fine-grained sand. All platform material is water-saturated and boggy. The site is fairly sheltered.

NSS-28 South side of Reindeer Cove

Consists of a fine-grained sand beach backed by a tundra and beach grass vegetated terrace; slumping, vegetated peat scarp with a platform of interbedded clay at its base. The lower beach face and platform sediment veneer grades rapidly seaward from sand to mud with increasing peat content and water saturation of sediments. The tidal flat is dominated by infauna, including isopods in the upper intertidal zone, and clams (including Macoma, Mya, and amphipods in the lower intertidal zone. Bird activity was low to moderate.

APPENDIX V. Station Descriptions (continued)

F-28 2.5 km southwest of Point Dexter

Pocket beach between headlands composed of well-sorted gravel with minor sand. The sand content increases slightly going seaward. There are numerous gravel berms.

NSS-29 7 km north of Cape Denbigh

Consists of a pocket beach between eroding rocky headlands composed of boulders at the foot of a vegetated bedrock escarpment. Basal sediment is composed of very coarse-grained, mixed sand and gravel which tapers seaward to a well-sorted, fine-grained sand, low-tide terrace. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 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1161, 1162, 1163, 1164, 1165, 1166, 1167, 1168, 1169, 1170, 1171, 1172, 1173, 1174, 1175, 1176, 1177, 1178, 1179, 1180, 1181, 1182, 1183, 1184, 1185, 1186, 1187, 1188, 1189, 1190, 1191, 1192, 1193, 1194, 1195, 1196, 1197, 1198, 1199, 1200, 1201, 1202, 1203, 1204, 1205, 1206, 1207, 1208, 1209, 1210, 1211, 1212, 1213, 1214, 1215, 1216, 1217, 1218, 1219, 1220, 1221, 1222, 1223, 1224, 1225, 1226, 1227, 1228, 1229, 1230, 1231, 1232, 1233, 1234, 1235, 1236, 1237, 1238, 1239, 1240, 1241, 1242, 1243, 1244, 1245, 1246, 1247, 1248, 1249, 1250, 1251, 1252, 1253, 1254, 1255, 1256, 1257, 1258, 1259, 1260, 1261, 1262, 1263, 1264, 1265, 1266, 1267, 1268, 1269, 1270, 1271, 1272, 1273, 1274, 1275, 1276, 1277, 1278, 1279, 1280, 1281, 1282, 1283, 1284, 1285, 1286, 1287, 1288, 1289, 1290, 1291, 1292, 1293, 1294, 1295, 1296, 1297, 1298, 1299, 1300, 1301, 1302, 1303, 1304, 1305, 1306, 1307, 1308, 1309, 1310, 1311, 1312, 1313, 1314,

APPENDIX V. Station Descriptions (continued)

nacle zone - dominated by Balanus, 3) Fucus zone - dominated by Fucus, Balanus, Ulva, and Enteromorpha, 4) Red algae zone - dominated by Rhodomela and other algae including Polysiphonia, Cladophora, and Enteromorpha, amphipods, Littorina sitkana, Mytilus, Notacmea. Limpets were also present.
 _ was the dominant sedentary epifauna and Littorina
 _ was the dominant mobile epifauna. Infauna were absent. Bird use was low.

F-34 1 km west of Five Mile Point

Seaward terminus of basalt flow which fractures into a narrow boulder beach at water line; small grassy terrace in mid-beach.

NSS-35 St. Michael

Consists of a medium-grained sand beach composed of basalt fragments. The back beach is bounded by a vegetated beach grass terrace composed of well-sorted medium-grained sand with about five peccant surface gravel. Sediments coarsen seaward to coarse-grained sand (lower beach face) and granule (water line, active intertidal zone) where sorting is retained throughout. Fucus is present in several swash lines. several well-sorted gravel berms are present on the beach face. In fauna and epifauna are absent. Back beach is vegetated with ground cover and grasses. Bird use was low (gulls observed).

F-35 Pocket beach 2 km east of Cape Stephens

Consists of very coarse-grained, very well-sorted beach composed of basalt, sits at the base of a steep vegetated scarp, surface sediment has no gravel. Three swash lines of wood, Mytilus and Fucus are present.

NSS-36 South side Stuart Island.

Consists of a mixed sand and gravel beach, composed of basalt fragments located in a small embayment. It has a vegetated terrace and low escarpment landward. The beach contains a medium- to coarse-grained sand veneer over mixed sand and gravel, both of which coarsen seaward. A few gravelly berms and light storm swash are present. Nearshore sediments are gravelly. No infauna or epifauna were observed. Back beach was vegetated with grasses and ground cover. Bird use was low.

P-36 Northern Stuart Island, mouth of Stuart Island Canal

The station is located adjacent to a small river carrying a fairly well-sorted bedload of very coarse-grained sand/granule-sized (no gravel) basalt fragments. The system is highly constructive and sediments are reworked at the shoreline into a wide beach and a series of ebb-oriented shoals. The sediment is highly angular.

NSS-37 St. Michael Canal

Consists of a lightly vegetated clay and peat scarp in an erosional delta front. In front of the scarp is a clay wave-cut platform with abundant peat blocks and detritus on a mud drape. Overwashing of scarp is widespread with much sediment and Peat detritus washed onto the vegetated terrace. No infauna or epifauna were observed throughout the intertidal zone. The scarp was vegetated with Distichlis grass. Enteromorpha was attached to some peat blocks in the upper- to mid- intertidal zone. Bird use was low.

F-37 4 km east Nokrot

Located on an eroding outwash plain with a low-lying marsh and flooded wet-tundra terrace which terminates in a steep, slumping peat scarp about 0.5 m high. Overwashing is extensive with many wood fragments and peat chunks present well into the interior marsh and on the low-tide terrace. No infauna or epifauna were observed. The scarp was vegetated with grasses. No algae were observed. Bird use was low.

NSS-38 3 km south Pt. Romanof

Located along an exposed outwash terrace. Consists of a wide mixed sand and gravel (basalt) beach bounded landward by a vegetated mixed sand and gravel escarpment. It has three distinct storm swash berms composed of gravel, cobble, and logs. The back beach has patches of gravel and cobble on a coarse- to medium-grained mixed sand and gravel base. There are small peaty clay outcrops on the back beach. Surface sediment coarsens to cobble/boulder at waterline. Several gravel ridges are present subtidally. There is abundant peat detritus in and atop of sediments near the waterline. One species of amphipods was found in the lower intertidal zone. The back beach was vegetated with grass and Equisetum. Epifauna were absent. Bird use was low (some gulls present).

F-30 7 km southwest of Coffey Point

Consists of an erosional delta front with a peat scarp. The ripper terrace is thickly vegetated with tundra and masses. In front of the actively slumping scarp, there is a wide peat wave-cut platform covered with a thick coating of water-saturated Peat detritus and blocks. Overwash is limited. In fauna were absent. Epifauna were limited to one isopod. Bird use was low.

F-39A 5.5 km east of Okshokwewhik Pass

Consists of an erosional delta front similar to F-41C. In fauna/epifauna were dominated by moderate to high densities of isopods on the surface of the flat. Vegetated scarp inhabited by grasses, Salix, a palm-leaf plant, and Caryophyllaceae. Rabbits were also observed near upper scarp. No clams were observed. Bird use was heavy, primarily swans, hawks, and gulls.

APPENDIX V. Station Descriptions (continued)

F-398 4.5 km east of Uwik Slough

Consists of a depositional type delta front shore line with a vegetated terrace with no scarp; extremely flat profile. There is a zone of dead vegetation near the water line. Inland it is marshy. At the high tide line, no infauna and epifauna were observed. The plant community was diverse. Bird use was high.

F-39C Mouth of Elongozhik Slough

Consists of a depositional-type delta front shoreline similar to F-39B with a wide zone of dead vegetation at the waterline. Marsh vegetation was dominated by grasses and Salicornia. No infauna or epifauna were observed. This is a prime nesting area for Canada geese. Bird use was high.

NSS-40 Mouth of Mahtkwingak Slough

Consists of a depositional delta front similar to F-39B. Tidal flat sediments are fine-grained sandy muds, but the sand component is much less than five percent. In fauna are dominated by two species: amphipods on the upper surface of flat, and isopods on the lower surface of the flat. Fringing marsh vegetation composed of grasses and Salicornia. The water was relatively fresh. Bird use was moderate to high with gulls and Canada geese present.

F-40A South Side of Kawanak Pass

This is an erosional delta front shoreline with an actively slumping scarp. Fishing activity was high. No infauna or epifauna were observed. The scarp was vegetated with Salix and spagnum moss, which are also present on slumping blocks. Bird use was low, only gulls were observed.

F-40B South Side of Kawanak Channel

Flooded depositional delta front shoreline with a 10-20 cm non-erosional escarpment which is vegetated with the same plants as the terrace. Two inland storm swash lines are less than 100 m from the water line. No infauna or epifauna were observed. The scarp was vegetated with Salix and a sedge. Bird use was low.

F-41A Mouth of Elukozuk Slough

Consists of a depositional delta front shoreline with many old peat chunks eroded and redeposited on the terrace. These are now vegetated with tundra and moss. There is no evidence of overwash. High tide; no infauna or epifauna were observed. The scarp was vegetated with Salix, sedge, and moss. Bird use was low.

F-41B East side Caseyss Channel

This is a depositional shoreline with bushes and marsh vegetation. No infauna or epifauna were observed. Marsh vegetation was composed primarily of sedge, Salix, and

Equisetum [horse tails]. Bird use was moderate: gulls were observed.

F-41C South side Acharon channel

This is located along an erosional delta front with a 2 m peat scarp landward of a wave-cut platform and muddy tidal flat. Overwash is limited to several tens of meters. The clay platform and tidal flat is covered with water-saturated peat detritus. In fauna and epifauna were composed of heavy densities of isopods on the surface of the tidal flat. No organisms were observed in the slumping blocks of tundra. Moist tundra vegetation was dominated by Salix and grasses. Bird use was low, primarily whistling swans and shore birds. No clams were observed.

NSS-42 Mouth of Black River

This is an erosional delta front with a muddy tidal flat. Grasses and sedge vegetate the upper terrace which also has overwashes of logs and mollusk shells. The storm swashline is 100-200 m landward. There is a low, erosional scarp behind a scarp platform of interbedded peat and clay. The surface sediment is water-saturated mud with abundant peat and wood detritus. Peat crops out 20-30 m seaward of scarp. In fauna were dominated by isopods on the tidal flat surface, Mya and Macoma shells were present on the lower tidal flat. Carex and grass are abundant. The supratidal fringe. Bird use was moderate.

F-43A Kwikak

Consists of an erosional delta front with a low scarp and very abundant overwashes. Shells cover the grassy terrace [about 50%]. The storm swash is about 200 m landward of the scarp. Muddy offshore bar seaward. Bird use was high. Infauna were dominated by Mya and Macoma clams. Epifauna dominated by isopods on the surface of the bar. A wide bladed grass was growing above and along the fringe of intertidal zone. Bird use was heavy (mainly Canada geese and shore birds).

F-42B 5 km south of Melatolik Creek

Located along a depositional type delta front, this station contains a sedge-vegetated peat platform with about 100 m of overwash. A muddy tidal flat is seaward with large flooded areas and lightly vegetated shoals. The flat is heavily dissected with tidal creeks and channels. The scarp is vegetated with sedge, and insects were observed at the base. No infauna were observed. Bird use was heavy (gulls, swans, and ducks).

F-42C 15 km northeast of the Kun River mouth

This station is a wide, tidal flat similar to NSS-43 bounded landward by a 2 m slumping peat scarp. Erosion and overwashing are active as evidenced by the abundant sediment, peat fragments, and shells on the terrace. The storm swash is well-developed, located 50-100 m inland of the scarp. Vegetation was dominated by wide blade grass and cover grass along the supratidal fringe. Insect burrows were present

APPENDIX V. Station Descriptions (continued)

along the scarp. On the surface of the flat there were many dead *Mya* clams and cockle shells, although no live clams or cockles were observed. Bird use was heavy.

NSS-432 km north of the Kun River mouth

Consists of a very wide tidal flat bounded landward by sedge patches about 10 cm high with no erosional scarps. These vegetated patches are smaller and less numerous seaward. The tidal flat is composed of water-saturated mud with no sand. Desiccation fractures are common along the entire surface and appear relict. A slimy brown algae coats most of the sediment surface. Beneath a very thin (few millimeters) oxidized layer, sediments display mottled oxidation/reduction but no infauna are present. This is a high bird use area (abundant tracks). Epifauna were dominated by amphipods and insects on the tidal flat surface. Yukon grass was observed at the upper supratidal fringe. This area is a feeding ground for many different shore bird species.

NSS-46 South Hooper Bay spit, exposed side

consists of very wide tidal flat composed of very well-sorted fine-grained sand as a series of accreted ridges, backed by a well-sorted fine-grained sand beach. There is active erosion of vegetated back beach. The beach surface is littered with shell, wrack and angular gravel/pebbles of vesicular basalt and there are well-developed dunes and dune grasses behind the beach. Infauna were dominated by moderately abundant *Mya* clams and hemichordates throughout the surface of the tidal flat. Epifauna were absent. Dune vegetation was dominated by a wide blade grass. Bird use was heavy, being a nesting area for terns.

F-46C Interior Angyoyarak Bay at the mouth of Kashunuk River

This is an erosional delta front shoreline with back beach grass terraces bounded by a low scarp and mudflat of water-saturated silty mud. There is visible erosion of the grassy terrace at the scarp. No infauna or epifauna were observed (due to the lack of time). The marsh scarp was vegetated with sedges and grasses. Bird use was moderate, primarily terns.

NSS-47 9 km south of Tutakoke River mouth

Consists of a depositional delta front shoreline of sedge- and grass-vegetated marsh grading onto a boggy water-saturated mud flat. A filamentous green algal-mat is commonly present on sediment surface. One worm, a nematode or polychaete, was found. Epifauna were dominated by brown insects heavily abundant on the surface of the flat. The tundra scarp was vegetated with sedges, willow, *Salix*, and grass. Bird use was heavy, including geese, gulls, and shore birds.

F-47A 2.5 km east of Opagarak River mouth

Consists of an erosional delta front shoreline with a 1.5-2 m scarp in vegetated peat. Interbedded peat and clay

crop out seaward as a platform coated with water-saturated peat debris. Slumping and overwash are common at the scarp. No infauna or epifauna were observed. The tundra scarp was vegetated with sedge. Bird use was high, including gulls, geese, and swans.

F-47B Hazen Bay, 1.5 km north of the Aprothluk River mouth

This is a depositional delta front shoreline composed of a compacted clay platform bounded landward by young grasses. No infauna or epifauna were observed. The high marsh was vegetated with sedges. A green filamentous algae was attached to eroding blocks of peat. Bird use was high, including Canada geese, swans, and gulls.

F-47C 2.5 km southeast of Aknerkochik River mouth, Hazen Bay

Consists of an erosional delta front shoreline with a 1.5 m scarp in peat. Blocks of peat are slumped seaward and washed landward onto the vegetated terrace. No infauna were observed. Many jellyfish were washed up on the surface of the tidal flat. Epifauna were dominated by mites in the marsh vegetation. The scarp was vegetated with a short sedge and wide grass. A green filamentous algae was attached to slumping tundra blocks. Bird use was moderate with gulls and Canada geese present.

NSS-48 Mouth of Azun River, Hazen Bay

This is a wide tidal flat composed of an outcropping clay platform which is compact landward and boggy (more water-saturated) seaward. It is bounded landward by a narrow beach composed of silty sand rich in finely-divided organic debris. Behind the beach is a grass/sedge vegetated terrace. One serpulid worm was in the upper intertidal portion of flat and isopods were found on the mid to lower intertidal portion of flat. Epifauna were dominated by mites in the newly emerging marsh grasses. The older more interior marsh was vegetated with a sedge. There may be clams present subtidally or numerous empty *Siliqua*, and *Solen* clam shells are present. Bird use was very heavy, including numerous gulls, Canada geese, and shore birds.

F-48A Mouth of Ninglick River, Hazen Bay

Consists of a tidal flat composed of compacted clay covered with small 10 cm ripples, bounded landward by a low, wide, slumping scarp in peat. Peat blocks are overwashed onto the vegetated terrace. No infauna were observed other than annelid worms found on the surface of the slumping tundra (probably washed up from subtidal habitats). The scarp was vegetated with sedges. The slumping eroding tundra has attached green filamentous algae. Several *Macoma* shells observed on surface of flat. Bird use was low, (gulls present)

APPENDIX V. Station Descriptions (continued)

F-48B Mouth of Ninglick River on Kigik Island

Consists of a tidal flat composed of water-saturated silty silt backed by a low erosional peat scarp. Peat blocks are present on the tidal flat and landward of the scarp on the vegetated terrace. No infauna or epifauna were observed. The terrace was vegetated with sedges. Attached green filamentous algae were present on eroding peat slump blocks. Bird use was high with gulls and shore birds.

F-48C Hazen Bay near Ukak

Consists of a tidal flat composed of water-saturated mud bounded by a low erosional scarp in tundra peat. Peat at scarp is both slumping seaward and being ripped up and transported landward onto the vegetated terrace by overwash. Clams may be present subtidally. The marsh scarp was vegetated with wide blade grass and green algae. Bird use was high with gulls and shore birds present.

NSS-49 2 km northeast of Cape Vancouver

Consists of boulder beach at base of a rocky escarpment composed of basalt. Boulders are well-imbedded in a very coarse-grained sand and shell. In fauna dominated by polychaetes on the lower intertidal portion of the tidal flat. In the rocks above the tidal flat, there were numerous attached epifauna including Mytilus. Amphipods were found in the sediments beneath many of these boulders. Attached vegetation includes Verrucaria, brown filamentous algae, green filamentous algae, Enteromorpha, and Petrocelis. Bird use was moderate.

NSS-50 Southwest Point, St. Paul Island

consists of a wave-cut platform with heavy attached growth, bounded by a steep boulder beach composed of very well-rounded volcanic rock fragments to 2 m diameter on a base of mixed cobble and boulders. Robust kelp beds offshore and tide pools are common.

NSS-51 west English Bay, St. Paul Island

Fine-grained sand beach composed of well-sorted basaltic rock fragments. several berms and swashlines of algal wrack are present. Behind the beach, dunes are well stabilized and are tens of meters high. There is a wide back beach deflation terrace with common incipient dunes. The beach is cusped, with a steep profile and subjected to high waves.

NSS-52 salt lagoon Interior, St. Paul Island

Consists of a marsh /tidal flat complex within a sheltered bay. Thick grasses and reeds terminate in a low scarp. The tidal flat is a fine-grained sand and has abundant wrack.

F-52 Village Cove, St. Paul Island

Consists of a steep boulder composed of angular to well-rounded basalt boulders to 2 m. Grain size increases seaward. There was heavy attached growth in the intertidal zone.

APPENDIX V. (continued)

GRAIN-SIZE DATA			
NSS- STATION NO.	GRAPHIC MEAN ($M_z; \phi$)	INCLUSIVE DEVIATION	STANDARD ($\sigma; \phi$)
1	1.11 Medium sand	.89 MS	
3	-1.31 Granule	2.73 VPS	
4	-0.47 Very coarse sand	1.47 Ps	
5	-0.93 Very coarse sand	2.07 VPS	
6	-0.35 Very coarse sand	1.97 VPS	
7	4.03 Coarse silt	1.80 P S	
8	0.98 Coarse sand	0.56 MWS	
9	0.87 Coarse sand	0.92 M S	
10	1.22 Medium sand	0.41 WS	
11	1.15 Medium sand	0.69 MWS	
12	-1.12 Granule	1.68 Ps	
13	-0.40 Very coarse sand	2.57 VPS	
14	-1.80 Granule	0.76 MS	
15	1.82 Medium sand	1*54 Ps	
16	-0.82 Very coarse sand	0.69 MWS	
17	-1.40 Granule	2.42 VPS	
18	6.73 Fine silt	2.37 VPS	
19	-0.86 Very coarse sand	2.04 VPS	
21	-0.40 Very coarse sand	1.09 Ps	
23	-1.72 Granule	1.57 P S	
25	-0.17 Very coarse sand	2.03 VPS	
25TB	6.40 Fine silt	2.60 VPS	
27	-1.62 Granule	2.50 VPS	
28	2.72 Fine sand	0.60 MWS	
30	-2.09 Pebble	2.72 VPS	
32	-2.28 Pebble	1.50 Ps	
33	-2.40 Pebble	2.18 VPS	
35	-0.23 Very coarse sand	0.91 MS	
36	-0.55 Very coarse sand	1.83 PS	
37	5.20 Medium silt	1.80 PS	
38	-0.33 Very coarse sand	1.85 PS	
39	6.03 Fine silt	2.40 VPS	
42	4.06 Coarse silt	1.89 PS	
43	4.53 Coarse silt	2.14 VPS	
46	2.73 Fine sand	0.28 WS	
47	4.50 Coarse silt	2.98 VPS	
48	5.93 Medium silt	2.83 VPS	
51	0.96 Coarse sand	0.30 VWS	
52	2.15 Fine sand	0.34 Vws	

VP s = very poorly sorted
 Ps = poorly sorted
 MS = moderately sorted
 Mws = moderately well-sorted
 WS = well sorted
 Vws = very well sorted

APPENDIX V. (continued)

 WEIGHT PERCENT ORGANIC MATERIAL IN SELECTED
 SAMPLES HAVING OBVIOUS DETRITAL COMPONENTS

NSS- STATION NO.	WEIGHT PERCENT ORGANICS LOST
7	25.6
18	.3
25TB	.08
37	17.9
39	.2
42	16.3
43	.1
47	23.5
48	.2
49	14.3

APPENDIX VI
SPECIES LIST

This list of common and scientific names is intended to be consistent with our ESI format throughout the United States. Therefore, not all the names listed are present in this study area.

MAMMALS

1	Northern (Steller) Sea Lion	<u>Eumetopias jubatus</u>
2	Harbor Seal	<u>Phoca vitulina</u>
3	North Pacific Fur Seal	<u>Callorhinus ursinus</u>
4	Killer Whale	<u>Orcinus orca</u>
5	Pacific Blackfish	<u>Peponocephala electra</u>
6	Pacific Harbor Porpoise	<u>Phocoena phocoena</u>
7	Sea Otter	<u>Enhydra lutris</u>
8	River Otter	<u>Lutra canadensis</u>
9	Beluga Whale	<u>Delphinapterus leucas</u>
10	Manatee	<u>Trichechus manatus</u>
11	Fin Whale	<u>Balaenoptera physalus</u>
12	Minke Whale	<u>Balaenoptera acutorostrata</u>
13	Humpback Whale	<u>Megaptera novaeangliae</u>
14	Gray Seal	<u>Halichoerus grypus</u>
15	Bearded Seal	<u>Erignathus barbatus</u>
16	Walrus	<u>Odobenus rosmarus</u>

BIRDS

- A Numerous Species of Birds
- B Shorebirds
- C Waterfowl
- D Diving Birds
- E Wading Birds

BIRDS

1	Common Loon	<u>Gavia immer</u>
2	Arctic Loon	<u>Gavia arctica</u>
3	Red-throated Loon	<u>Gavia stellata</u>
4	Red-necked Grebe	<u>Podiceps grisegena</u>
5	Horned Grebe	<u>Podiceps auritus</u>
6	Eared Grebe	<u>Podiceps caspicus</u>
7	Western Grebe	<u>Aechmophorus occidentalis</u>
8	Double-crested Cormorant	<u>Phalacrocorax auritus</u>
9	Brandt's Cormorant	<u>Phalacrocorax penicillatus</u>
10	Pelagic Cormorant	<u>Phalacrocorax pelagicus</u>
11	Whistling Swan	<u>Olor columbianus</u>
12	Western Canada Goose	<u>Branta canadensis</u>
13	Black Brandt	<u>Branta nigricans</u>
14	White-fronted Goose	<u>Anser albifrons</u>
15	Snow Goose	<u>Chen hyperborea</u>
16	Mallard	<u>Anas platyrhynchos</u>
17	Pintail	<u>Anas acuta</u>
18	Green-winged Teal	<u>Arenaria carolinensis</u>
19	Rock Pigeon	<u>Columba livia</u>
20	Northern Shoveler	<u>Spatula clypeata</u>

21	Canvasback	<u>Aythya valisineria</u>
22	Greater Scaup	<u>Aythya marila</u>
23	Lesser Scaup	<u>Aythya affinis</u>
24	Goldeneye	<u>Bucephala clangula</u>
25	Barrow's Goldeneye	<u>Bucephala islandica</u>
26	Bufflehead	<u>Bucephala albeola</u>
27	Old Squaw	<u>Clangula hyemalis</u>
28	Harlequin Duck	<u>Histrionics histrionics</u>
29	White-winged Scoter	<u>Melanitta deglandi</u>
30	Surf Scoter	<u>Melanitta perspicillata</u>
31	Common Scoter	<u>Oidemia nigra</u>
32	Common Merganser	<u>Mergus merganser</u>
33	Red-breasted Merganser	<u>Mergus serrator</u>
34	American Coot	<u>Fulica americana</u>
35	Parasitic Jaeger	<u>Stercorarius parasiticus</u>
36	Glaucous-winged Gull	<u>Larus glaucescens</u>
37	Western Gull	<u>Larus occidentals</u>
38	Herring Gull	<u>Larus argentatus</u>
39	California Gull	<u>Larus californicus</u>
40	Ring-billed Gull	<u>Larus delawarensis</u>
41	Mew Gull	<u>Larus canus</u>
42	Bonaparte's Gull	<u>Larus Philadelphia</u>
43	Heermann's Gull	<u>Larus heermanni</u>
44	Thayer's (Herring) Gull	<u>Larus argentatus thayeri</u>
45	Common Tern	<u>Sterna hirundo</u>
46	Common Murre	<u>Uris aalge</u>
47	Pigeon Guillemot	<u>Cepphus columba</u>
48	Marbled Murrelet	<u>Brachyramphus marmoratum</u>
49	Cassin's Auklet	<u>Ptychoramphus aleutica</u>
50	Rhinoceros Auklet	<u>Cerorhinca monocerata</u>
51	Tufted Puffin	<u>Lunda cirrhata</u>
52	Wilson's Phalarope	<u>Steganopus tricolor</u>
53	Northern Phalarope	<u>L o b i p e s lobatus</u>
54	Great Blue Heron	<u>Ardea herodias</u>
55	Whimbrel	<u>Numenius phaeopus</u>
56	Spotted Sandpiper	<u>Actitis macularia</u>
57	Wandering Tattler	<u>Heteroscelus incanum</u>
58	Greater Yellowlegs	<u>Totanus melanoleucus</u>
59	Lesser Yellowlegs	<u>Totanus flavipes</u>
60	Red Knot	<u>Calidris canutus</u>
61	Pectoral Sandpiper	<u>Calidris melanotos</u>
62	Least Sandpiper	<u>Calidris minutilla</u>
63	Dunlin	<u>Calidris alpina</u>
64	Short-billed Dowitcher	<u>Limnodromus griseus</u>
65	Long-billed Dowitcher	<u>Limnodromus scolopaceus</u>
66	Western Sandpiper	<u>Calidris mauri</u>
67	Sanderling	<u>Calidris alba</u>
68	Black Oystercatcher	<u>Haematopus bac hmani</u>
69	Semi-palmated Plover	<u>Charadrius semipalmatus</u>
70	Killdeer	<u>Charadrius vociferus</u>
71	Black-bellied Plover	<u>Pluvialis squatarola</u>
72	Surfbird	<u>Aphriza virgata</u>
73	Ruddy Turnstone	<u>Arenaria interpres</u>

74	Black Turnstone	<u>Arenaria melanocephala</u>
75	Belted Kingfisher	<u>Megaceryle alcyon</u>
76	Northern Bald Eagle	<u>Haliaeetus leucocephalus</u>
77	Osprey	<u>Pandion haliaetus</u>
78	Northwestern Crow	<u>Corvus caurinus</u>
79	Cormorant	<u>Phalacrocorax</u> Sp.
80	Arctic Tern	<u>Sterna paradisaea</u>
81	Horned Puffin	<u>Fratercula corniculata</u>
82	Glaucous Gull	<u>Larus hyperboreus</u>
83	Kittiwake	<u>Rissa</u> sp.
84	Parakeet Auklet	<u>Cyclorhynchus psittacula</u>
85	Pigeon Auklet	<u>Cepphus columba</u>
86	Least Tern	<u>Sterna albifrons</u>
87	Little Blue Heron	<u>Florida caerulea</u>
88	Great Egret	<u>Casmerodius albus</u>
89	Snowy Egret	<u>Leucophoyx thula</u>
90	Black-crowned Night Heron	<u>Nycticorax nycticorax</u>
91	Glossy Ibis	<u>Plegadis falcinellus</u>
92	Great Black-backed Gull	<u>Larus marinus</u>
93	Cattle Egret	<u>Bubulcus ibis</u>
94	Louisiana Heron	<u>Hydranassa tricolor</u>
95	Roseate Tern	<u>Sterna dougallii</u>
96	Leach's Petrel	<u>Oceanodroma leucorhoa</u>
97	Green Heron	<u>Butorides virescens</u>
98	Laughing Gull	<u>Larus atricilla</u>
99	Red-faced Cormorant	<u>Phalacrocorax urile</u>
100	Black-legged Kittiwake	<u>Rissa tridactyla</u>
101	Aleutian Tern	<u>Sterna aleutica</u>
102	Fork-tailed Storm Petrel	<u>Oceanodroma furcata</u>
103	Common Eider	<u>Somateria mollissima</u>
104	Murre	<u>Uris</u> sp.
105	Thick-billed Murre	<u>Uria lomvia</u>
106	Ancient Murrelet	<u>Synthliboramphus antiquum</u>
107	Peregrine Falcon	<u>Falco peregrinus</u>
108	Kittlitz's Murrelet	<u>Brachyramphus brevirostre</u>
109	Crested Auklet	<u>Aethia cristatella</u>
110	Dovekie	<u>Plautus alle</u>
111	Least Auklet	<u>Aethia pusilla</u>
112	Black Guillemot	<u>Cepphus grylle</u>
113	Gyr Falcon	<u>Falco rusticolus</u>
114	Sabine's Gull	<u>Xema sabinii</u>
115	White Ibis	<u>Eudocimus albus</u>
116	Roseate Spoonbill	<u>Ajaia ajaja</u>
117	Great White Heron	<u>Ardea occidentals</u>
118	Brown Pelican	<u>Pelecanus occidentals</u>
119	Frigate Bird	<u>Fregata magnificent</u>
120	Yellow-crowned Night Heron	<u>Nyctanassa violacea</u>
121	Anhinga	<u>Anhinga anhinga</u>
122	Scarlet Ibis	<u>Eudocimus ruber</u>
123	Southern Bald Eagle	<u>Haliaeetus leucocephalus</u>
124		
125	Light-footed Clapper Rail	<u>Rallus longirostris</u>
126	Noddy Tern	<u>Anous stolidus</u>

127 Sooty Tern
 128 Blue-faced Booby
 129 Northern Fulmar
 130 Red-legged Kittiwake
 131 Crested Auklet
 132 Wood Stork
 133 Black Skimmer
 134 Gull-billed Tern
 135 Sandwich Tern
 136 Caspian Tern
 137 Royal Tern
 138 Forster's Tern
 140 Belding Savannah Sparrow
 141 American Avocet
 142 Black-necked stilt
 143 Xantus' Murrelet
 144 Ashy Storm Petrel
 145 Elegant Tern
 146 Black Storm Petrel

Sterna fuscata
Sula dactylatra
Fulmarus glacialis
Rissa brevirostris
Aethia cristatella
Mycteria americana
Rynchops niger
Gelochelidon nilotica
Sterna sandvicensis
Sterna caspia
Sterna maxima
Sterna forsteri
Passerculus sandwichensis
Recurvirostra americana
Himantopus mexicanus
Endomychura mypoleuca
Oceanodroma homochroa
Sterna elegans
Oceanodroma melania

FISHES

1 Pacific Herring
 2 Chinook Salmon (King)
 3 Coho Salmon (Silver)
 4 Pink Salmon (Humpy)
 5 Sockeye Salmon (Red)
 6 Chum Salmon (Dog)

Clupea harengus pallasii
Oncorhynchus tshawytscha
Oncorhynchus kisutch
Oncorhynchus gorbuscha
Oncorhynchus nerka
Oncorhynchus keta

SHELLFISH

1 Soft Shell Clam

Mya arenaria

**FAIRWAY
ISLAND**

BERING
+
STRAIT
+

**NORTHERN
BOUNDARY
OF
STUDY
AREA**

LOPP
LAGOON

PRIMARY SOURCES OF BIOLOGICAL DATA

BOWS ADQD (1976), C-45; ARNETON (1977); GUSEY (1980) AND USFWS (1978).
MAMMAL S GUSEY (1980) BEAMAN & BURNS (in press)
C-50 MONTGOMERY (1974) (2); C-51 (1-5-80); C-52 (1974-1975); C-53 (1976); C-54 (1977); C-55 (1978)

REQUEST FOR
 BUREAU OF LAND MANAGEMENT
 ANCHORAGE ALASKA
 2011

124 QMVAIS 1 INCEP
 RESEARCH IN AMERICAN INSTITUTE INC
 NEW YORK 20

EXPLORED WINDMILLS
2 WAVE CUT 17 AFFORDS
FINE CUT 17 AFFORDS
TO DRAINED
..... FERTILE LOW MOUNTAINS
EXPLORED WIND AND WAVES
DRAINED WAVE
F. SHELTERED WIND BAND
29 SHELTERED ROLLER BEACHES
SHELTERED ROCKY SHORES
..... GROUND PEAT SCUMPS
9 LITTED TIDAL PLANT
10 MARSHES
..... ROOM LOCATIONS
127 RECOMMENDED CLOSURE
.....
STATION LOCATIONS
D - DETAINED SURVEY
O - RAPID SURVEY

..... ANISM
MARSHAL
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FISHER
SHELTER
.....
FLUORIDE
.....
..... INDICATES AFFORDS
.....
..... RESPONSIBILITY
..... LOCAL
..... SPECIFIC LOCATION
SOCIOECONOMIC DR.
..... C. ANIS
ONSHORE
OFFSHORE
..... ALSO IN SITES
.....
.....

FSIMAP + 1

ID by the Army Map Service
 Prepared for this use by the Geological Survey
 Data provided by USGS M05/M06A and USCE
 Originally by photogrammetric methods from aerial photographs
 in 1950. Map not field checked.
 Aerial hydrographic data compiled by USGS & GS
 Information is not intended for navigational purposes.
 Source: Transverse Mercator projection, 1927 North American Datum
 2000 feet grid based on datum coordinate system, zone 9
 1) Army Universal Transverse Mercator grid used.
 2. Shown in blue
 Lines represent uncharted and unmarked locations
 determined by the Bureau of Land Management
 U.S. K.R. Rabbit River Migration
 are land area less within Warren Indian Reservation

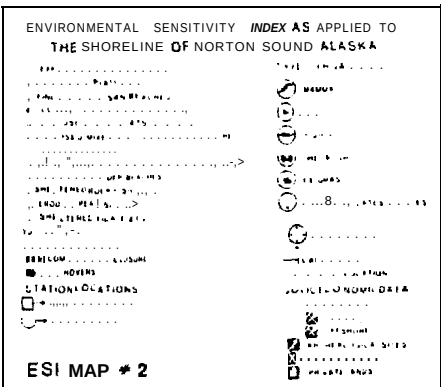
SCALE 163uf

CONTOUR INTERVAL 50 FEET

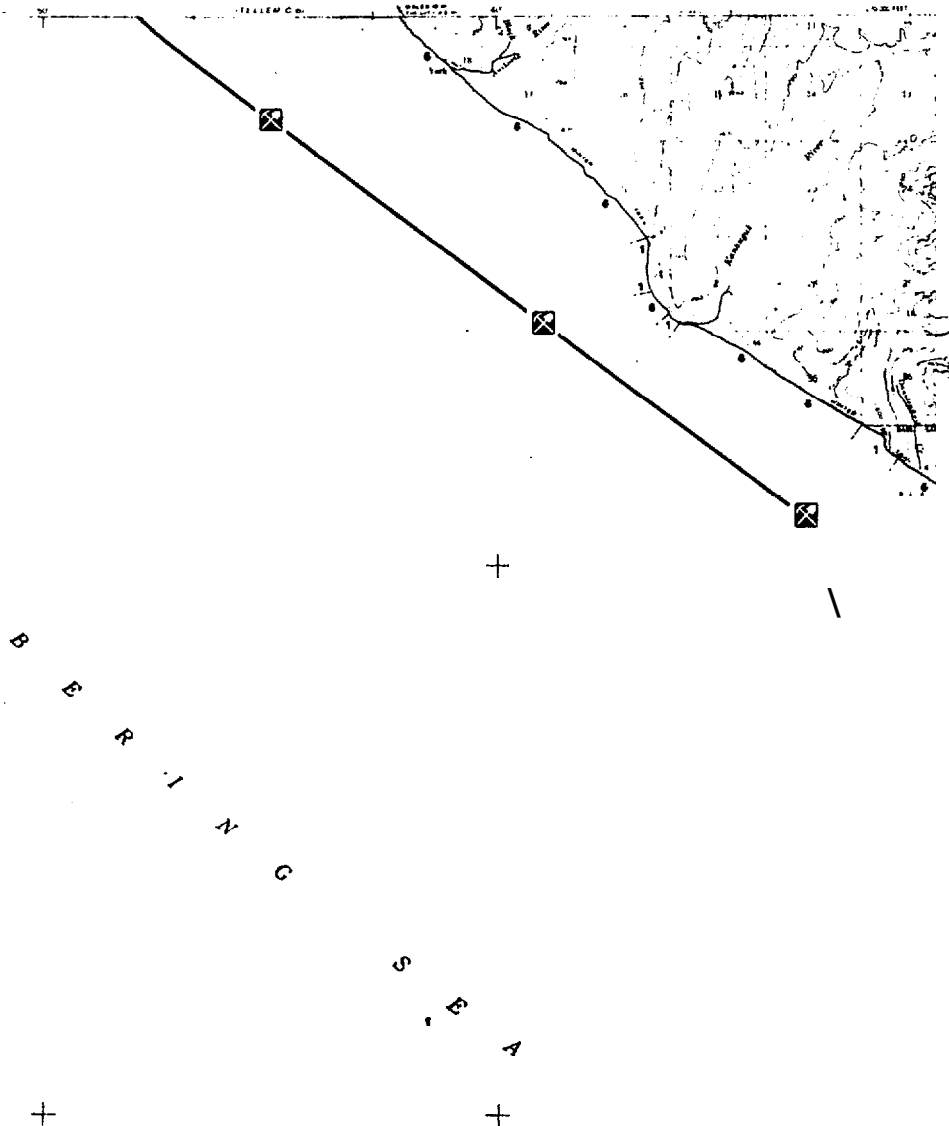
FOR SALE BY U.S. GEOLOGICAL SURVEY
FAIRBANKS, ALASKA 99701, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST.

TELEPHONE ALASKA

1950

[illegible]

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COLUMBIA, SOUTH CAROLINA
803-766-7327



ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF NORTON SOUND, ALASKA

- | | |
|--|-------------------------|
| 1. EXPOSED ROCKY | TYPE OF ORGANISM |
| 2. WAVE-CUT PLATFORMS | (M) MAMMALS |
| 3. FINE-GRAINED SAND BEACHES | (B) BIRDS |
| 4. COARSE-GRAINED SAND BEACHES | (F) FISHES |
| 5. EXPOSED TIDAL FLATS (O. BOMASSI) | (S) SHELLFISH |
| 6. EXPOSED MUD SAND AND GRAVEL BEACHES | (E) EELGRASS |
| 7. GRAVEL BEACHES | (Q) INDICATES SPECIES |
| 8. SHUTTERED MUD SAND AND GRAVEL BEACHES | (S) SEASONALITY |
| 9. BASALT-BOULDER BEACHES | (L) LOCAL |
| 10. SHELTERED ROCKY SHORES | (S) SPECIFIC LOCATION |
| 11. PEAT SCARPS | SOCIOECONOMIC DATA |
| 12. SHELTERED FLATS | (C) CLAIMS |
| 13. BARRIERS | (O) ONSHORE |
| 14. BOOM LOCATIONS | (O) OFFSHORE |
| 15. RECOMMENDED CLOSURE | (X) RARE OR CASUAL SITE |
| 16. WASHOVERS | (A) ANDING TROPS |
| 17. STATION LOCATIONS | (P) PRIVATE LANDS |
| 18. DETAILED SURVEY | |
| 19. RAPID SURVEY | |

ESI MAP # 3

and by the Army Map Service
shall be used only by the Geological Survey
and by USGS, USFWS and USFS
reprints by other agencies: requests from aerial photographs
in 1950. Map not held checked
Used topographic data compiled by USGS
information is not
right: Translated
TO last grid based on Alaska coordinate system, zone 8
near: Universal Transverse
3. shown in blue
I map represent unclassified and unclassified locations
intended by the Bureau of Land Management
in 1950 and 1951. Current River Number

APPROXIMATE SCALE
ON 1:63,360

FOR SALE BY U.S. GEOLOGICAL SURVEY
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TOPOGRAPHIC MAPS AND STUDIES IN 1:63,360 SCALE ON REQUEST

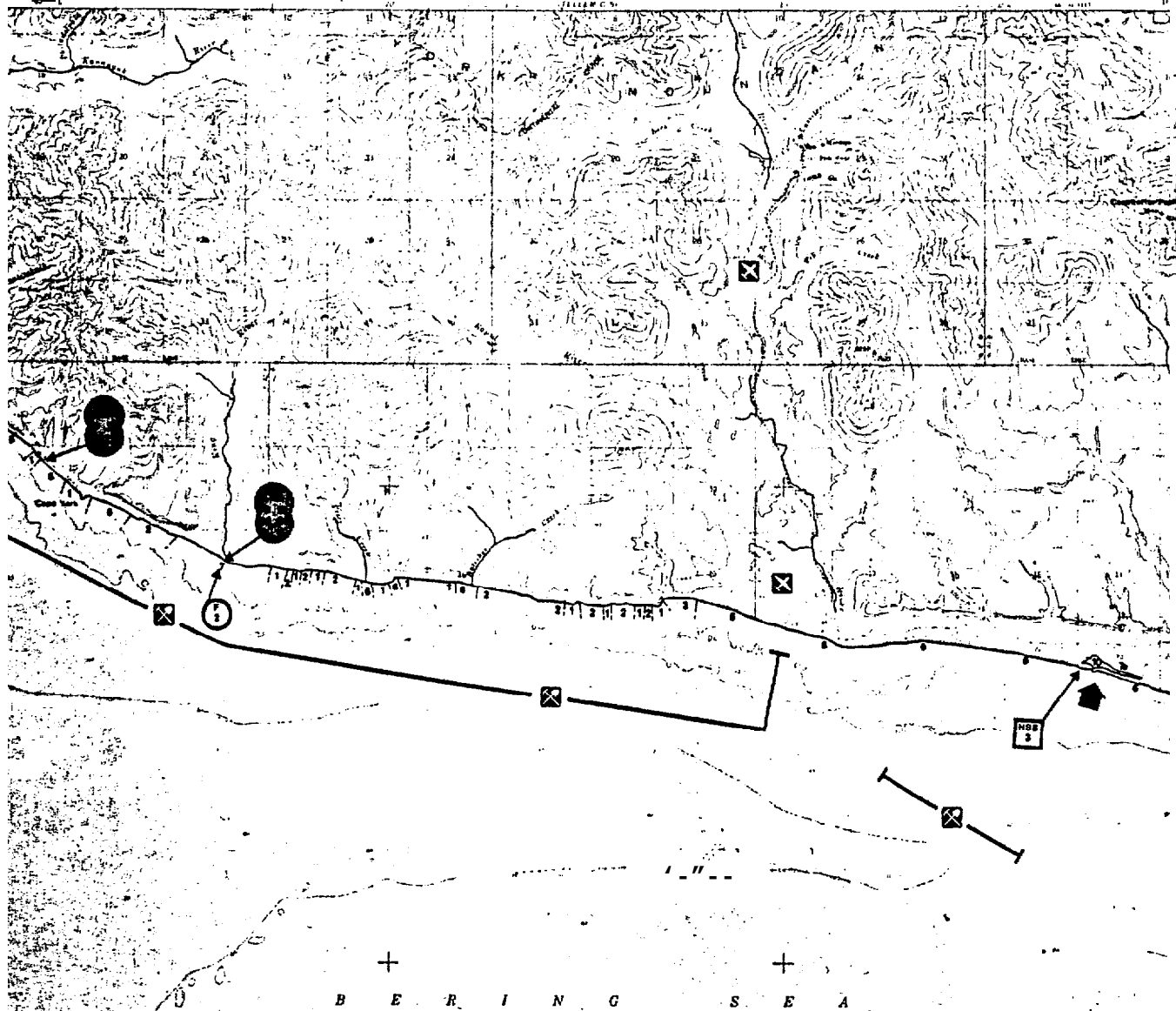
ROAD CLASSIFICATION
1:63,360

TELLER (B-6) ALASKA
1:63,360
1950

PRIMARY SOURCES OF BIOLOGICAL DATA
BIRDS: JONES (1977), JONES (1977), JONES (1977), JONES (1977), JONES (1977)
MAMMALS: BERRY (1979), BERRY (1979), BERRY (1979), BERRY (1979), BERRY (1979)
FISH: BARTON (1979), BERRY (1979), BERRY (1979), BERRY (1979), BERRY (1979)

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ANCHORAGE, ALASKA

PREPARED BY
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29204-1229



ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF NORTON SOUND, ALASKA

- | | |
|--|--|
| <p>1. GRAVE-DUT PLATFORMS</p> <p>2. PINE-GRADED SAND BEACHES</p> <p>3. GRADED-GRADED - BEACHES</p> <p>4. TOTAL PLATE BEACHES</p> <p>5. SPOILED SAND AND GRAVEL BEACHES</p> <p>6. GRAVEL BEACHES</p> <p>7. UNDEVELOPED SAND AND GRAVEL BEACHES</p> <p>8. GRAVEL BEACHES</p> <p>9. SANDY-ROCKY BEACHES</p> <p>10. SANDY-ROCKY BEACHES</p> <p>11. SANDY-ROCKY BEACHES</p> <p>12. SANDY-ROCKY BEACHES</p> <p>13. SANDY-ROCKY BEACHES</p> <p>14. SANDY-ROCKY BEACHES</p> <p>15. SANDY-ROCKY BEACHES</p> <p>16. SANDY-ROCKY BEACHES</p> <p>17. SANDY-ROCKY BEACHES</p> <p>18. SANDY-ROCKY BEACHES</p> <p>19. SANDY-ROCKY BEACHES</p> <p>20. SANDY-ROCKY BEACHES</p> <p>21. SANDY-ROCKY BEACHES</p> <p>22. SANDY-ROCKY BEACHES</p> <p>23. SANDY-ROCKY BEACHES</p> <p>24. SANDY-ROCKY BEACHES</p> <p>25. SANDY-ROCKY BEACHES</p> <p>26. SANDY-ROCKY BEACHES</p> <p>27. SANDY-ROCKY BEACHES</p> <p>28. SANDY-ROCKY BEACHES</p> <p>29. SANDY-ROCKY BEACHES</p> <p>30. SANDY-ROCKY BEACHES</p> <p>31. SANDY-ROCKY BEACHES</p> <p>32. 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SANDY-ROCKY BEACHES</p> <p>97. SANDY-ROCKY BEACHES</p> <p>98. SANDY-ROCKY BEACHES</p> <p>99. SANDY-ROCKY BEACHES</p> <p>100. SANDY-ROCKY BEACHES</p> | <p>TYPE OF ORGANISM</p> <p>1. MAMMALS</p> <p>2. BIRDS</p> <p>3. FISHES</p> <p>4. SHELLFISH</p> <p>5. REPTILES</p> <p>6. AMPHIBIANS</p> <p>7. MARINE INVERTEBRATES</p> <p>8. PLANTS</p> <p>9. FUNGI</p> <p>10. BACTERIA</p> <p>11. VIRUSES</p> <p>12. PROTOZOA</p> <p>13. ALGAE</p> <p>14. FLOWERS</p> <p>15. FRUIT</p> <p>16. SEEDS</p> <p>17. SPERMATOPHYTES</p> <p>18. GYMNOSPERMES</p> <p>19. ANGIOSPERMS</p> <p>20. MONOCOTYLEDONS</p> <p>21. DICOTYLEDONS</p> <p>22. GROSSNOMES</p> <p>23. LEGUMINOSAE</p> <p>24. RUBIACEAE</p> <p>25. UMBELLIFERAE</p> <p>26. ASTERACEAE</p> <p>27. COMPOSITAE</p> <p>28. LILIACEAE</p> <p>29. ORCHIDACEAE</p> <p>30. PAPAVRACEAE</p> <p>31. SOLANACEAE</p> <p>32. BRASSICACEAE</p> <p>33. CARYOPHYLLACEAE</p> <p>34. ROSACEAE</p> <p>35. MALVACEAE</p> <p>36. GERANIACEAE</p> <p>37. CUCURBITACEAE</p> <p>38. CONVULSACEAE</p> <p>39. EUPHORBIACEAE</p> <p>40. LOGANIACEAE</p> <p>41. MENISPERMACEAE</p> <p>42. BORAGINACEAE</p> <p>43. APOCYNACEAE</p> <p>44. VERBACEAE</p> <p>45. LABIATAE</p> <p>46. SCROPHULARIACEAE</p> <p>47. CONVULSACEAE</p> <p>48. EUPHORBIACEAE</p> <p>49. LOGANIACEAE</p> <p>50. MENISPERMACEAE</p> <p>51. BORAGINACEAE</p> <p>52. APOCYNACEAE</p> <p>53. VERBACEAE</p> <p>54. LABIATAE</p> <p>55. SCROPHULARIACEAE</p> <p>56. CONVULSACEAE</p> <p>57. EUPHORBIACEAE</p> <p>58. LOGANIACEAE</p> <p>59. MENISPERMACEAE</p> <p>60. BORAGINACEAE</p> <p>61. APOCYNACEAE</p> <p>62. VERBACEAE</p> <p>63. LABIATAE</p> <p>64. SCROPHULARIACEAE</p> <p>65. CONVULSACEAE</p> <p>66. EUPHORBIACEAE</p> <p>67. LOGANIACEAE</p> <p>68. MENISPERMACEAE</p> <p>69. BORAGINACEAE</p> <p>70. APOCYNACEAE</p> <p>71. VERBACEAE</p> <p>72. LABIATAE</p> <p>73. SCROPHULARIACEAE</p> <p>74. CONVULSACEAE</p> <p>75. EUPHORBIACEAE</p> <p>76. LOGANIACEAE</p> <p>77. MENISPERMACEAE</p> <p>78. BORAGINACEAE</p> <p>79. APOCYNACEAE</p> <p>80. VERBACEAE</p> <p>81. LABIATAE</p> <p>82. SCROPHULARIACEAE</p> <p>83. CONVULSACEAE</p> <p>84. EUPHORBIACEAE</p> <p>85. LOGANIACEAE</p> <p>86. MENISPERMACEAE</p> <p>87. BORAGINACEAE</p> <p>88. APOCYNACEAE</p> <p>89. VERBACEAE</p> <p>90. LABIATAE</p> <p>91. SCROPHULARIACEAE</p> <p>92. CONVULSACEAE</p> <p>93. EUPHORBIACEAE</p> <p>94. LOGANIACEAE</p> <p>95. MENISPERMACEAE</p> <p>96. BORAGINACEAE</p> <p>97. APOCYNACEAE</p> <p>98. VERBACEAE</p> <p>99. LABIATAE</p> <p>100. SCROPHULARIACEAE</p> |
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ESI MAP + 4

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800-255-5850

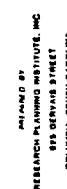
TELLER (B-5) ALASKA
1:62,500 SERIES (TOPOGRAPHIC)

PRIMARY SOURCES OF GEOLOGICAL DATA
BOSCH, LOUIS (1972); J. J. JENSEN (1972); BERRY (1972); J. J. JENSEN (1972)
MANNING, JAMES (1972); J. J. JENSEN (1972); BERRY (1972)
PINK, RAYMOND (1972); BERRY (1972); JENSEN (1972); MANNING (1972); WOODWARD

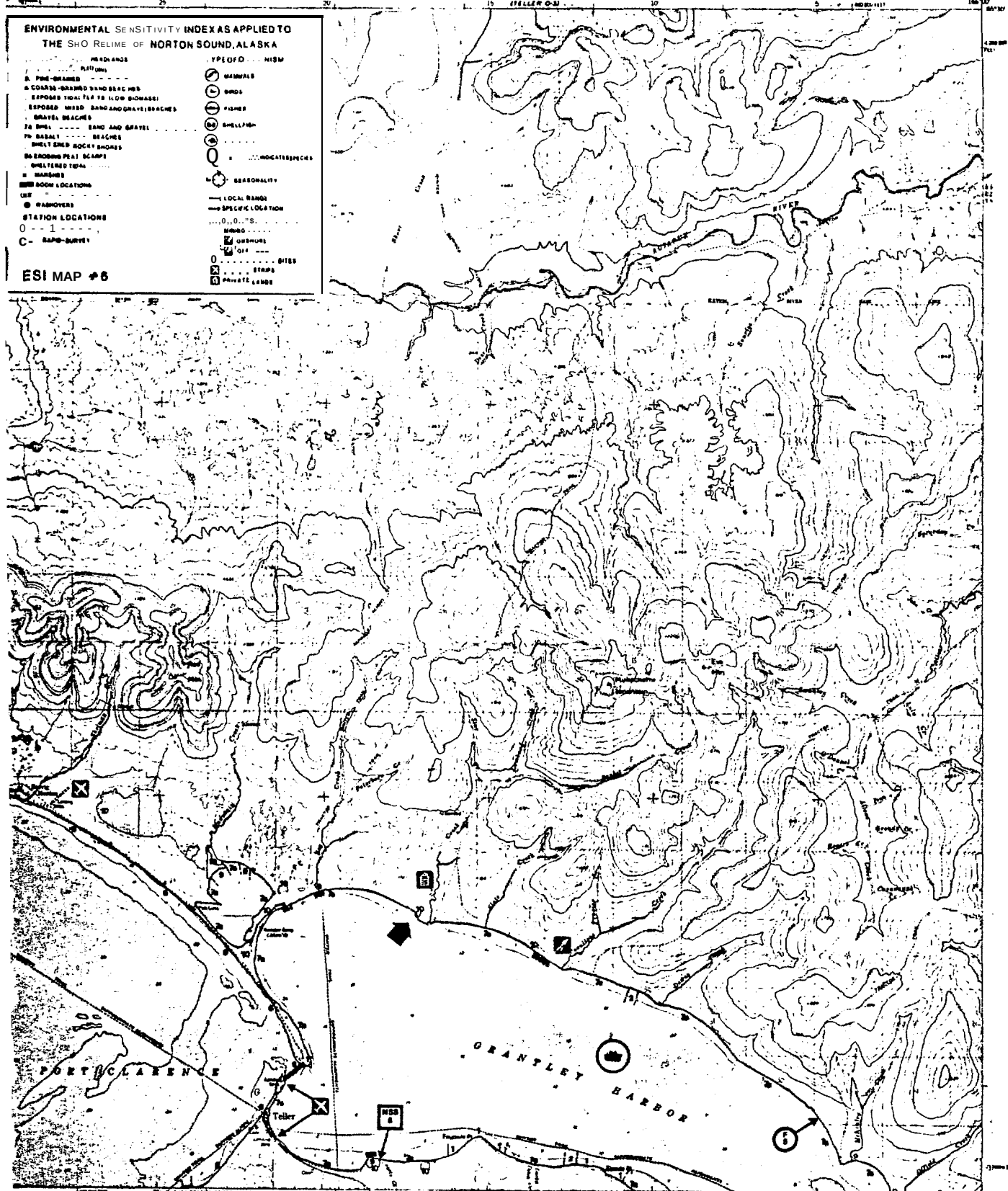
PREPARED FOR
BUREAU OF LAND MANAGEMENT
ANCHORAGE, ALASKA
AND
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

PREPARED BY
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COLUMBIA, SOUTH CAROLINA
29204-2920

ESI MAP • 5



TELLER (B-4) ALASKA

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 August 14, 1961, from the Bureau

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TELLER (B-3) ALASKA
#0015-#1000/15-30
1990

PRIMARY SOURCES OF BIOGEOCAL DATA

MAILED FOR
BUREAU OF LAND MANAGEMENT
ANCHORAGE, ALASKA

step

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
OCEAN CONSERVATION DIVISION
OCEANIC RESOURCES MANAGEMENT PROGRAM
ANCHORAGE, ALASKA

REF ID: A63474

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CONTINENTAL SHELF

TELLER IA SQUADRON

GRANTLEY HARBOR

PRIMARY SOURCES OF BIOLOGICAL DATA
BIRDS: 1974-1975 (1975) A. J. ARNOLD (1975) GUST (1975) and USFWS (1975)
MAMMALS: GUST (1975) SEAMAN & BURNS (in press)
FISH: BARTON (1975) GUST (1975) LEBON (1975) WATSON (1975) WOLOFKA & PEREIRA (1977)

PREPARED BY
BUREAU OF LAND MANAGEMENT
ANCHORAGE, ALASKA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
OCEANIC CONTINENTAL SHELF ASSESSMENT PROGRAM
ANCHORAGE, ALASKA

PREPARED BY
RESEARCH PLANNING INSTITUTE, INC.
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COLUMBIA, SOUTH CAROLINA
803-799-7322

ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF NORTON SOUND, ALASKA

- SYMBOLS
- 1. FINE GRAINED SAND
 - 2. COARSE GRAINED SAND
 - 3. GRAVEL
 - 4. GRAVEL
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SI MAP #7

1. FINE GRAINED SAND
2. COARSE GRAINED SAND
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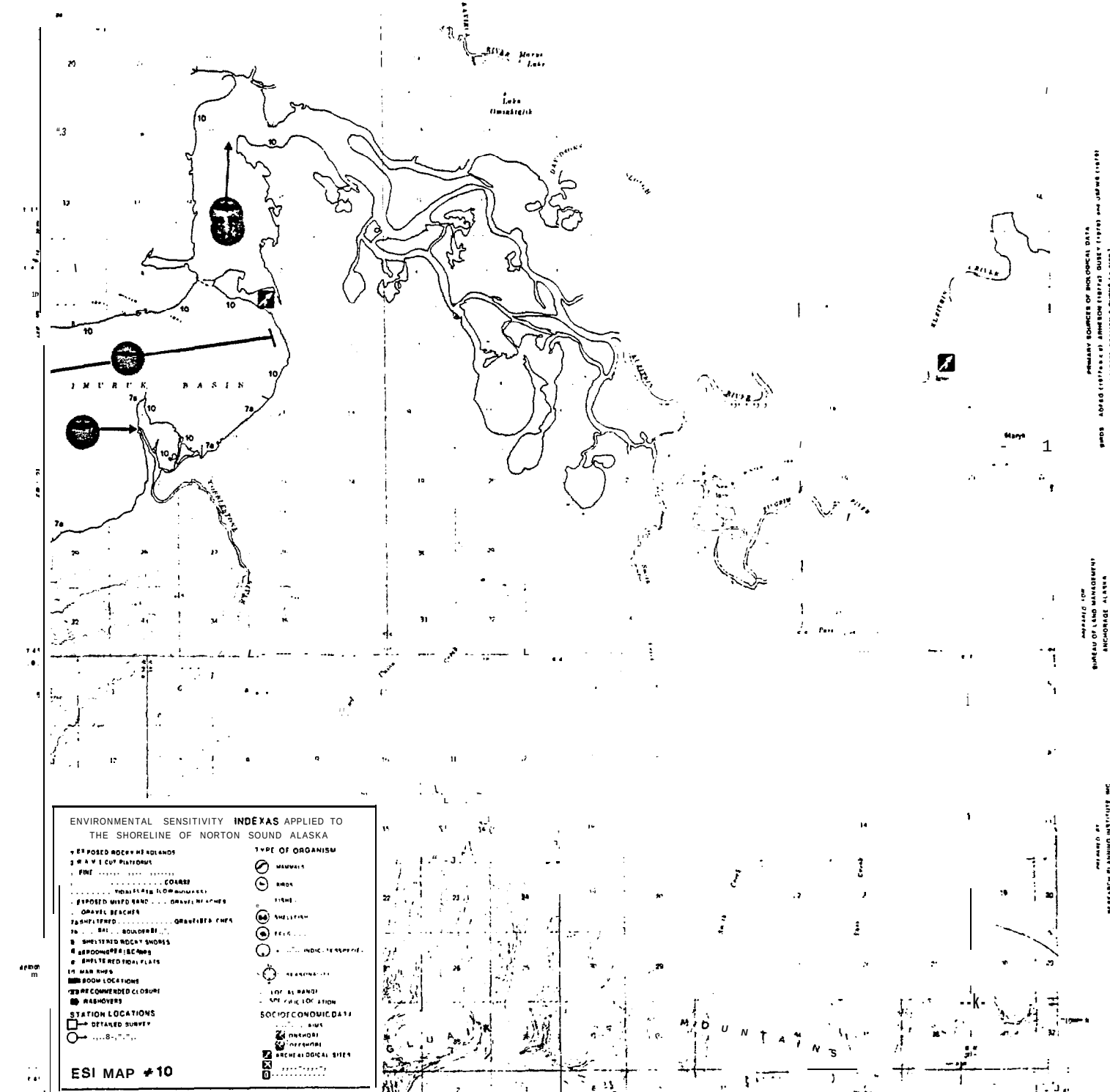
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106°30'



010000



PRIMARY SOURCES OF BIOLOGICAL DATA
BIRDS ADDED (1975) BY JAMES H. GIBSON (1975) AND JAMES H. GIBSON (1975)
MAMMALS ADDED (1975) BY JAMES H. GIBSON (1975) AND JAMES H. GIBSON (1975)

PREPARED FOR
BUREAU OF LAND MANAGEMENT
ANCHORAGE, ALASKA

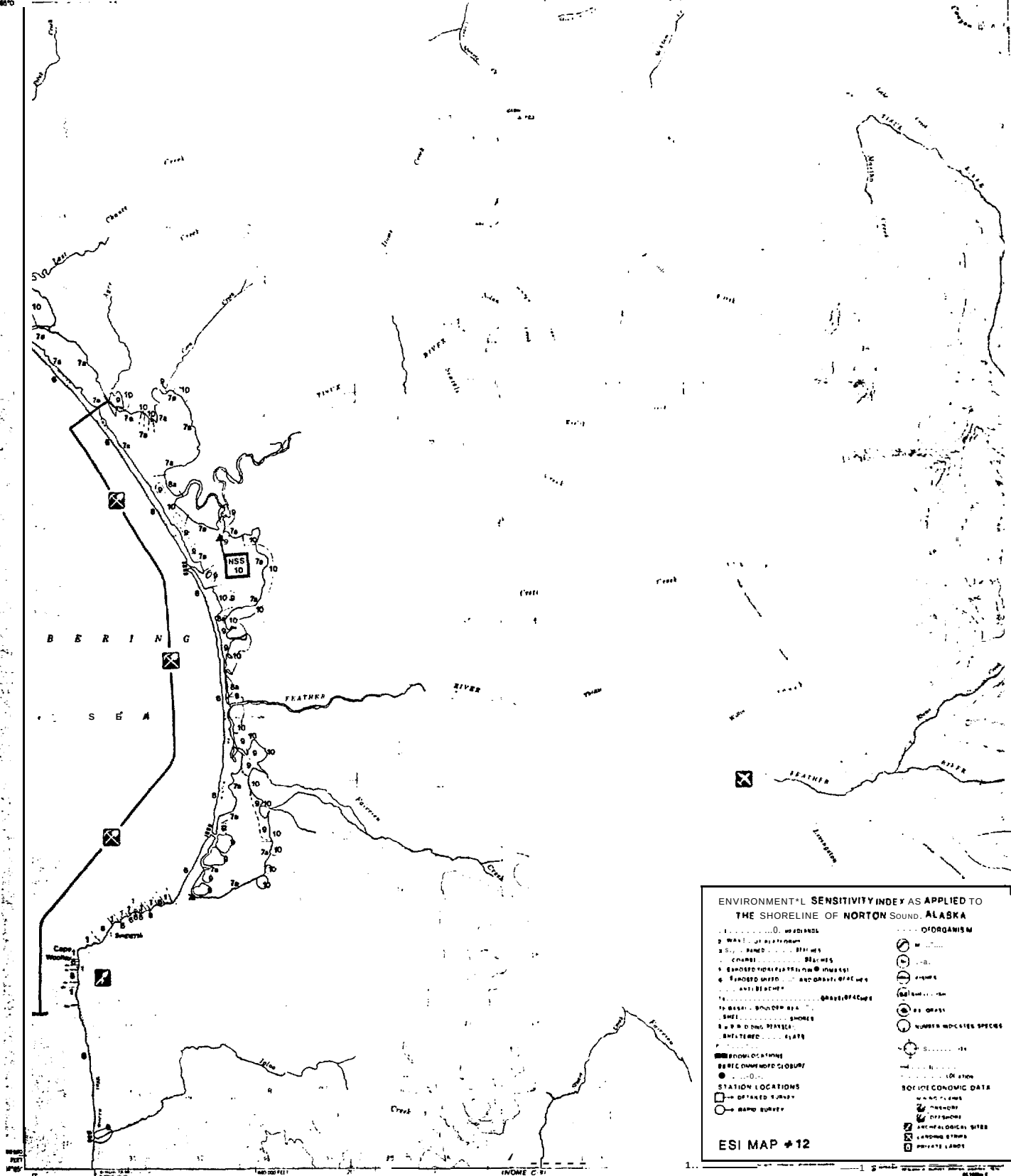
PREPARED BY
RESEARCH PLANNING DIVISION, MC
ALBUQUERQUE, NEW MEXICO

Map made by the Army Map Service
Published for civil use by the Geological Survey
Control by USGS, WASHINGTON, D.C.
Topography by the Geological Survey, 1961
Spectrophotometric data (revised by USGS)
This information is not intended for navigation purposes
Unpublished Topographic Maps are available from the
USGS, 1215 North 17th Street, Anchorage, Alaska 99501
100% water transfer from USGS, 1215 North 17th Street, Anchorage, Alaska 99501
Date 3/1/76
Land area appropriate to the map is shown in green
Shaded in green
Faint R. 13 and R. 14 River from Alaska
State boundaries are indicated

CONTAINS INTERIOR WATER
FAIRBANKS ALASKA 99701 DENVER COLORADO 80275 RESTON VIRGINIA 2209
FOR SALE BY U.S. GEOLOGICAL SURVEY
U.S. GEOLOGICAL SURVEY, WASHINGTON, D.C. 20540

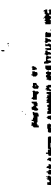
TELLER ALASKA

ALL INFORMATION CONTAINED HEREIN IS UNCLASSIFIED



ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF NORTON SOUND, ALASKA

1. 0-1000' WADSWORTH	10. 0-1000' WADSWORTH
2. 1000-2000' WADSWORTH	11. 0-1000' WADSWORTH
3. 2000-3000' WADSWORTH	12. 0-1000' WADSWORTH
4. 3000-4000' WADSWORTH	13. 0-1000' WADSWORTH
5. 4000-5000' WADSWORTH	14. 0-1000' WADSWORTH
6. 5000-6000' WADSWORTH	15. 0-1000' WADSWORTH
7. 6000-7000' WADSWORTH	16. 0-1000' WADSWORTH
8. 7000-8000' WADSWORTH	17. 0-1000' WADSWORTH
9. 8000-9000' WADSWORTH	18. 0-1000' WADSWORTH
10. 9000-10000' WADSWORTH	19. 0-1000' WADSWORTH
11. 10000-11000' WADSWORTH	20. 0-1000' WADSWORTH
12. 11000-12000' WADSWORTH	21. 0-1000' WADSWORTH
13. 12000-13000' WADSWORTH	22. 0-1000' WADSWORTH
14. 13000-14000' WADSWORTH	23. 0-1000' WADSWORTH
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16. 15000-16000' WADSWORTH	25. 0-1000' WADSWORTH
17. 16000-17000' WADSWORTH	26. 0-1000' WADSWORTH
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36. 35000-36000' WADSWORTH	45. 0-1000' WADSWORTH
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41. 40000-41000' WADSWORTH	50. 0-1000' WADSWORTH
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197. 196000-197000' WADSWORTH	206. 0-1000' WADSWORTH
198. 197000-198000' WADSWORTH	207. 0-1000' WADSWORTH
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203. 202000-203000' WADSWORTH	212. 0-1000' WADSWORTH
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213. 212000-213000' WADSWORTH	222. 0-1000' WADSWORTH
214. 213000-214000' WADSWORTH	223. 0-1000' WADSWORTH



NAME IC-31. ALASKA
 PHONE - 914600/12130
 m

NAME (C-2) QUADRANGLE
ALASKA
1 83 360 REVERB (TOPOGRAPHIC)

[illegible]

- **MEMBERS**
- **MEMOS**
- **FILES**
- **RELATIONS**
- **TELEPHONS**
- **NUMBERS AND CIPHERS SPECIFIC**
- **PERSONALITY**

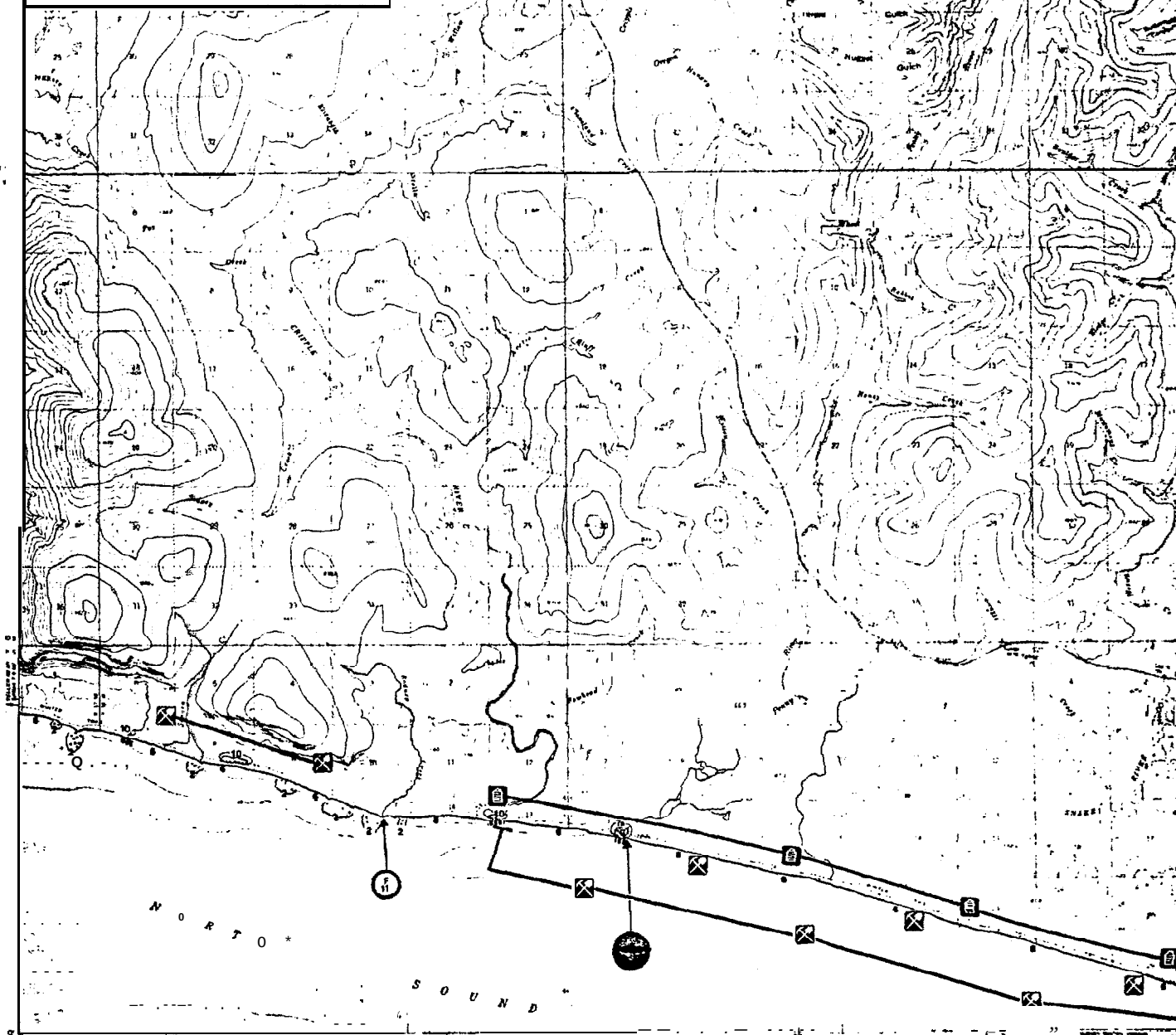
→ SPECIFIC LOCATION

SOCIOECONOMIC DATA

MINING CLAIMS

 MINERALS

ESI MAP # 14



199 000 1277

collected by the Army Map Service
submitted for civil use by the Geological Survey

USGCS

1. Integrity by photogrammetric methods from aerial photographs
taken 1950. Map not field checked.

2. Collected hydrographic data compiled from USGCS charts.

This information is not intended for navigation purposes.

Universal Transverse Mercator projection, 1973 North American datum.

1000 foot grid. Contour interval 20 feet. Scale 1:
50000. United Nations Transverse Mercator grid, 1973.

Zone 2, shown in blue.

1. Land lines represent surveyed and unsurveyed locations
established by the Bureau of Land Management.

2. Public R-24, Rural Street Protection.

3. Little changes are indicated.

[illegible]

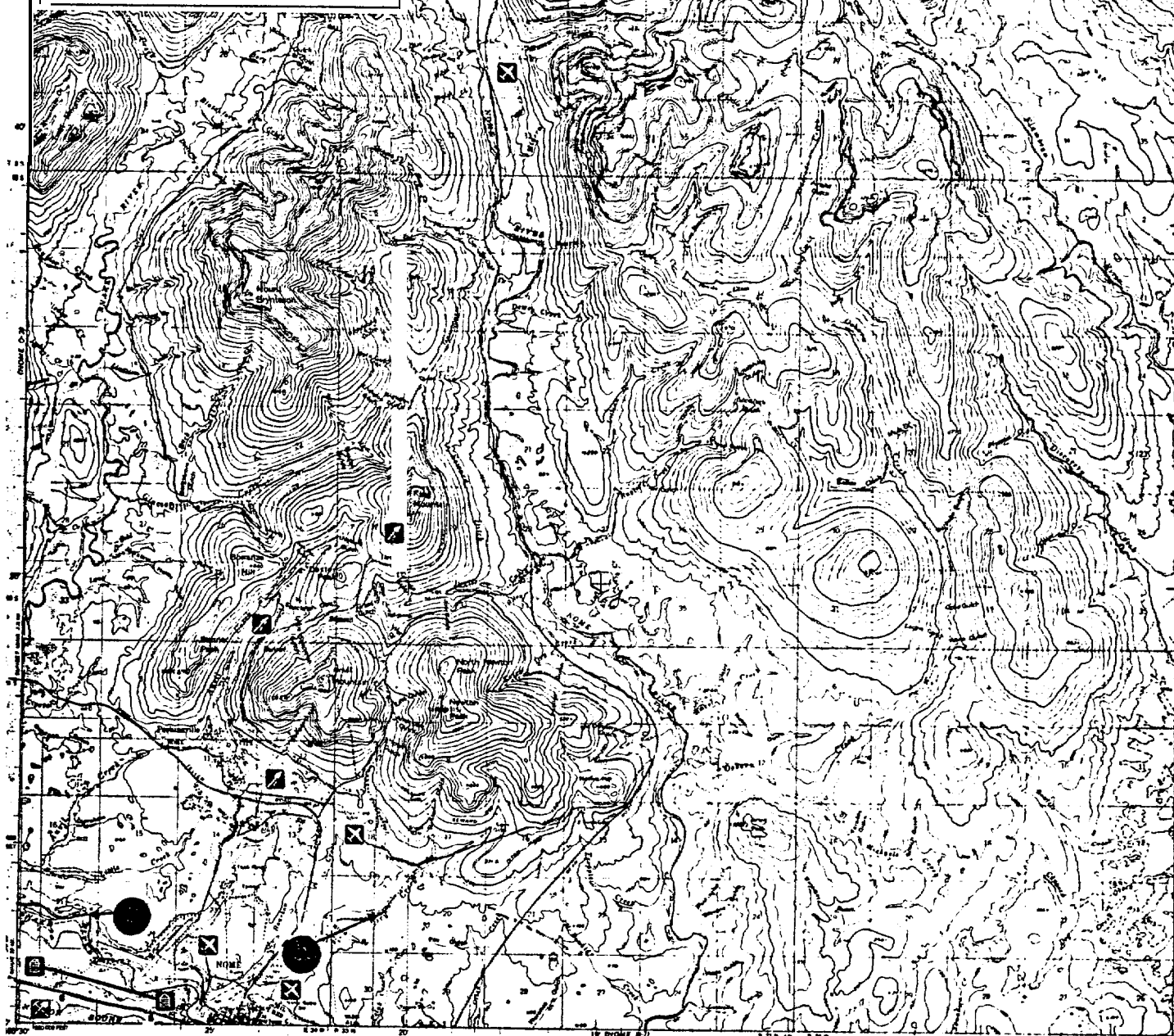
NOME IC-21 ALASKA
#6430-#16530/15430
P550

Class: A D 5 6 (1972, 2, 3, 4) AMMISON (1979) DUEY (1979) and USFWS (1979)
 Comments: DUEY (1979) STAMM & MORGAN (in press)

NOT A PART OF

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RESEARCH PLANNING INSTITUTE INC

1. ...0... ROCKY REEF SHORES
 2. ... CUT PLATFORMS
 3. FINE-GRAINED ... BEACHES
 4. COARSE-GRAINED ... BEACHES
 5. EXPOSED ... (FLOW MASSES)
 6. EXPOSED ... AND BARREL BEACHES
 7. ... BEACHES
 8. SHELTERED MIXED ... " ... BEACHES
 9. BARREL-BOULDER BEACHES
 10. SHELTERED ROCKY SHORES
 11. GROOVING REEF SCALPS
 12. SHEETED TIDAL FLATS
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 1. Issued by the Army Map Service
 2. Published for civil use by the Geological Survey
 3. Created by USACGS and USCE
 4. Topography by photogrammetric methods from aerial photographs
 taken 1950. Map not held outside
 5. Selected hydrographic data compiled from USCGC S-25 Survey
 7444 (1959). This information is not intended for
 6. Navigational purposes
 7. Source: American Republics Project 1977 North Atlantic Ocean
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APPROXIMATE 1984
DECLARATION YEAR

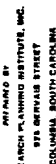
CONTOUR INTERVAL 50 FEET

DEPTH (M) : 7.0
 DISTANCE (M) : 100.0
 DISTANCE (M) : 100.0
 DISTANCE (M) : 100.0

FOR SALE BY U S GEOLOGICAL SURVEY
99701, DENVER, COLORADO 80225 OR WASHINGTON, DC 20042
CONTRACTS/ORDERS MUST BE FULFILLED BY 06/01/87

ROAD CLASSIFICATION
 ———— Light duty
 Unimproved dirt

NOME (C-1), ALASKA



ESI MAP # 18

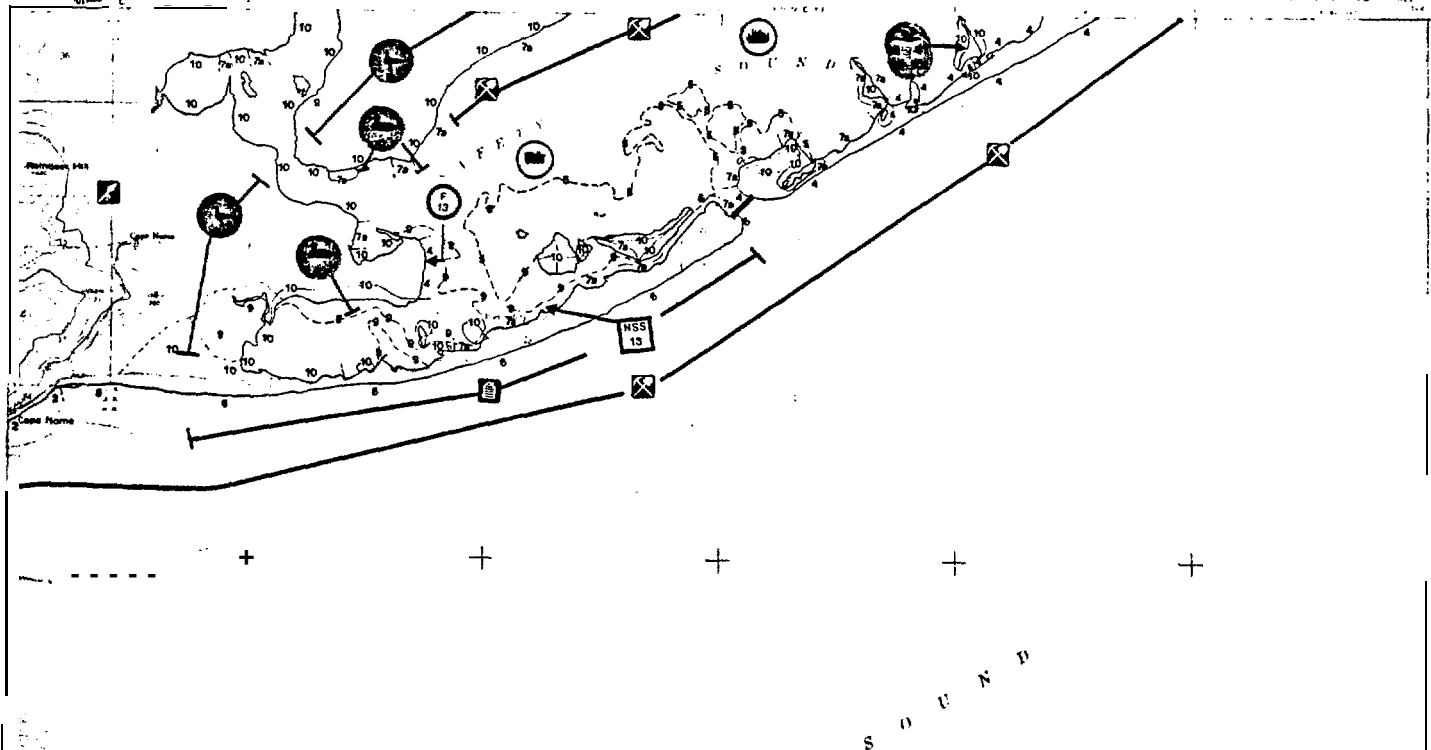
EXPOSURE INTERVAL 50 FEET
 CORRECTION FOR TIDE 0.00 METERS
 DEPTH 0.00 METERS
 FOR SALE BY U.S. GEOLOGICAL SURVEY
 ALASKA 99701 CENVER - 80225 ON WASHINGTON, D.C. 20242

NAME (B-1). ALASKA
4-4, 5-9 1076, 15-10
1960

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SOLOMON ISLANDS QUADRANGLE
A 444
1:250,000 SERIES (TOPOGRAPHIC)



N O R T O N

ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF NORTON SOUND, ALASKA

- | | |
|--|----------------------|
| 1. EXPOSED ROCKY ISLANDS | TYPE OF ORGANISM |
| 2. WAVE-CUT PLATFORMS | MAMMALS |
| 3. FINE-GRAINED SAND BEACHES | BIRDS |
| 4. COARSE-GRAINED SAND BEACHES | FISHES |
| 5. EXPOSED TIDAL FLATS (LOW INWASH) | SHELLFISH |
| 6. EXPOSED MIXED SAND AND GRAVEL BEACHES | SPERMATOPHYTES |
| 7. SHELTERED MIXED SAND AND GRAVEL BEACHES | NUMBER SPECIES |
| 8. SHELTERED FINE-GRAINED SAND BEACHES | SEASONALITY |
| 9. SHELTERED COARSE-GRAINED SAND BEACHES | LOCAL RANGE |
| 10. ARSHES | SPECIFIC LOCATION |
| POON LOCATIONS | SOCIOECONOMIC DATA |
| WASHOVERS | MINING CLAIMS |
| STATION LOCATIONS | ONSHORE |
| RADIO-SURVEY | OFFSHORE |
| | ARCHAEOLOGICAL SITES |
| | LANDING STRIPS |
| | PRIVATE LANDS |

ESI MAP # 17

Revised by the Army Map Service
Published for sale by the Geological Survey
by USGS, USGSAS and USGS
Map by photogrammetric methods from aerial photographs
1953. Map not for sale.

Contour hydrography by USGSAS
Universal Transverse Mercator projection 1907 North American datum
20,000 foot grid based on Alaska coordinate system, zone 5
1000 foot Universal Transverse Mercator grid lines
Zone 5, shown in blue
Land area (unimproved) and unimproved locations
Contributed by the Bureau of Land Management
Tells 1-12, Ketchikan River Mouth
Auto-shading the selected

CONTINUED INTERIOR OF EYE
1:250,000 SERIES (TOPOGRAPHIC)
NATIONAL SECURITY AGENCY OFFICE OF
GEOGRAPHIC INFORMATION SYSTEMS
FOR SALE BY U.S. GEOLOGICAL SURVEY
FARMERS' ALASKA 1970 BOWEN COLORADO 1972 OF RYTON VIRGINIA 1977
A PUBLISHED BY THE GEOLOGICAL SURVEY

POSS CLASSIFICATION
UNCLASSIFIED

SOLOMON ISLANDS ALASKA
N 64° 15' - N 64° 30' E 154° 30'

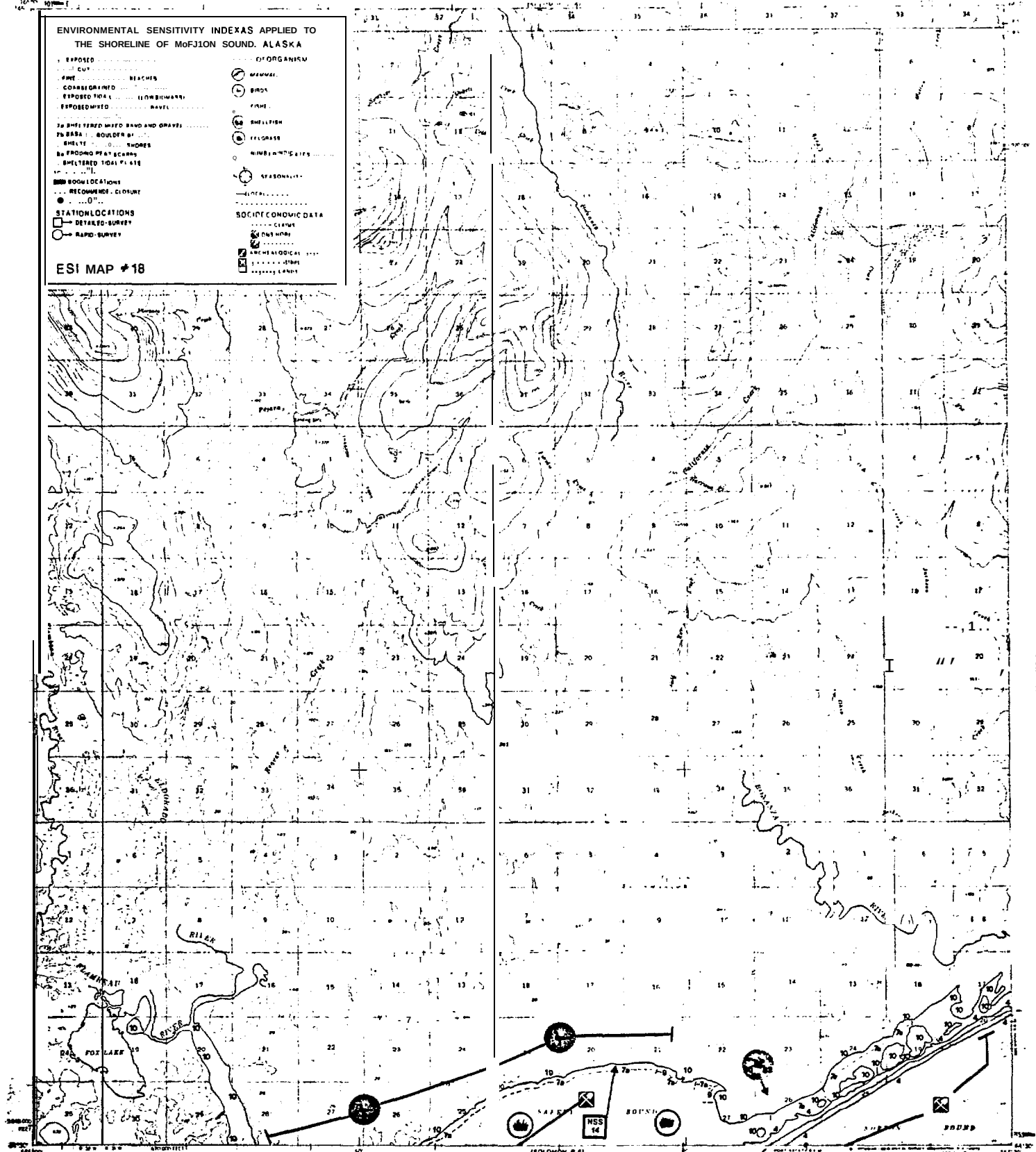
PRIMARY SOURCE OF BIOLOGICAL DATA
GARDNER, ADRIAN (1972) B.C. J. ANTHROPOLOGY (1971) BERRY (1972) and USGS (1973)
1:250,000 SERIES (TOPOGRAPHIC)

APPROVED FOR
BUREAU OF LAND MANAGEMENT

PREPARED BY
U.S. GEOLOGICAL SURVEY

ENVIRONMENTAL SENSITIVITY INDEXES APPLIED TO
THE SHORELINE OF MOJON SOUND, ALASKA

- ES I MAP #18
- EXPOSED CUT
 - FINE BEACHES
 - COARSE GRAINED
 - EXPOSED ROCK (LOW BARRIER)
 - EXPOSED MIXED
 - 7A SHELTERED MIXED SAND AND GRAVEL
 - 7B SAND BOULDER
 - SHELTERED SHORES
 - 8A PROTRUDING ROCKS
 - SHELTERED TIDAL FLATS
 - 8B ROCK LOCATIONS
 - RECOMMENDED CLOSURE
 - STATION LOCATIONS
 - DETAILED SURVEY
 - RAPID SURVEY
 - ORGANISM
 - BIRD
 - FISH
 - SHELLFISH
 - PLANT
 - MINERAL
 - SEASONALITY
 - LOCALITY
 - SOCIOECONOMIC DATA
 - CLIMATE
 - LAND USE
 - ARCHAEOLOGICAL
 - LAND OWNERSHIP
 - LAND USE



ed by the Army Map Service
for use by the Geological Survey
by USGS, USCGS, and USACE
maps by photographic methods from aerial photographs
1950. Map not field checked.
Selected bathymetric data compiled from USCGS (1951)
This information is not intended for navigation purposes.
General Transverse Mercator projection, 1927 North American datum
1:10,000 feet and based on Alaska coordinate system, zone 8
1000 meter Universal Transverse Mercator grid lines
zone 8 shown in blue
Land lines represent unimproved and uncharted locations
established by the Bureau of Land Management
Scale 1:12,500 feet

APPROXIMATE MEAN
DECLINATION, 1950

SCALE 1:12,500
CONTOUR INTERVAL 50 FEET
DRAINED AREA WITHIN 1/4 MILE
CATCHMENT AREA
DEPTH CURVES AND SOUNDINGS IN FEET
FOR SALE BY U.S. GEOLOGICAL SURVEY
FAIRBANKS, ALASKA 99701 DENVER, COLORADO 80225 OF WASHINGTON D.C. 20542
A SERIES OF ENVIRONMENTAL SENSITIVITY MAPS AND STUDIES IS AVAILABLE ON REQUEST

SOLOMON IC 61, ALASKA
1950

PRIMARY SOURCES OF BIOLOGICAL DATA
BIRDS: 1950-1951, 1952-1953, 1954-1955, 1956-1957, 1958-1959, 1960-1961, 1962-1963, 1964-1965, 1966-1967, 1968-1969, 1970-1971, 1972-1973, 1974-1975, 1976-1977, 1978-1979, 1980-1981, 1982-1983, 1984-1985, 1986-1987, 1988-1989, 1990-1991, 1992-1993, 1994-1995, 1996-1997, 1998-1999, 2000-2001, 2002-2003, 2004-2005, 2006-2007, 2008-2009, 2010-2011, 2012-2013, 2014-2015, 2016-2017, 2018-2019, 2020-2021, 2022-2023, 2024-2025, 2026-2027, 2028-2029, 2030-2031, 2032-2033, 2034-2035, 2036-2037, 2038-2039, 2040-2041, 2042-2043, 2044-2045, 2046-2047, 2048-2049, 2050-2051, 2052-2053, 2054-2055, 2056-2057, 2058-2059, 2060-2061, 2062-2063, 2064-2065, 2066-2067, 2068-2069, 2070-2071, 2072-2073, 2074-2075, 2076-2077, 2078-2079, 2080-2081, 2082-2083, 2084-2085, 2086-2087, 2088-2089, 2090-2091, 2092-2093, 2094-2095, 2096-2097, 2098-2099, 2100-2101, 2102-2103, 2104-2105, 2106-2107, 2108-2109, 2110-2111, 2112-2113, 2114-2115, 2116-2117, 2118-2119, 2120-2121, 2122-2123, 2124-2125, 2126-2127, 2128-2129, 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SOLOMON IC 31 QUADRANGLE
ALASKA
1:250,000 SERIES (TOPOGRAPHIC)

[illegible]

SOLOMON (C3).ALASKA
#4430-W 16300/15.30
1200

N O R T O N S O U N D

ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF NORTON SOUND, ALASKA

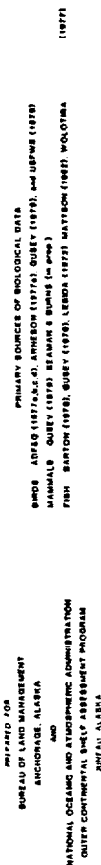
- | | |
|--|--|
| <p>1. FINE GRAINED SAND BEACHES</p> <p>2. COARSE GRAINED SAND BEACHES</p> <p>3. EXPOSED TIDAL FLATS (LOW MASS)</p> <p>4. GRAVEL BEACHES</p> <p>5. 75% SPLITTED WOOD BANDS - RAFT BEACHES</p> <p>6. 75% BASAL - BOULDER BEACHES</p> <p>7. 75% BASAL - BOULDER BEACHES</p> <p>8. 75% BASAL - BOULDER BEACHES</p> <p>9. 75% BASAL - BOULDER BEACHES</p> <p>10. 75% BASAL - BOULDER BEACHES</p> <p>11. 75% BASAL - BOULDER BEACHES</p> <p>12. 75% BASAL - BOULDER BEACHES</p> <p>13. 75% BASAL - BOULDER BEACHES</p> <p>14. 75% BASAL - BOULDER BEACHES</p> <p>15. 75% BASAL - BOULDER BEACHES</p> <p>16. 75% BASAL - BOULDER BEACHES</p> <p>17. 75% BASAL - BOULDER BEACHES</p> <p>18. 75% BASAL - BOULDER BEACHES</p> <p>19. 75% BASAL - BOULDER BEACHES</p> <p>20. 75% BASAL - BOULDER BEACHES</p> <p>21. 75% BASAL - BOULDER BEACHES</p> <p>22. 75% BASAL - BOULDER BEACHES</p> <p>23. 75% BASAL - BOULDER BEACHES</p> <p>24. 75% BASAL - BOULDER BEACHES</p> <p>25. 75% BASAL - BOULDER BEACHES</p> <p>26. 75% BASAL - BOULDER BEACHES</p> <p>27. 75% BASAL - BOULDER BEACHES</p> <p>28. 75% BASAL - BOULDER BEACHES</p> <p>29. 75% BASAL - BOULDER BEACHES</p> <p>30. 75% BASAL - BOULDER BEACHES</p> <p>31. 75% BASAL - BOULDER BEACHES</p> <p>32. 75% BASAL - BOULDER BEACHES</p> <p>33. 75% BASAL - BOULDER BEACHES</p> <p>34. 75% BASAL - BOULDER BEACHES</p> <p>35. 75% BASAL - BOULDER BEACHES</p> <p>36. 75% BASAL - BOULDER BEACHES</p> <p>37. 75% BASAL - BOULDER BEACHES</p> <p>38. 75% BASAL - BOULDER BEACHES</p> <p>39. 75% BASAL - BOULDER BEACHES</p> <p>40. 75% BASAL - BOULDER BEACHES</p> <p>41. 75% BASAL - BOULDER BEACHES</p> <p>42. 75% BASAL - BOULDER BEACHES</p> <p>43. 75% BASAL - BOULDER BEACHES</p> <p>44. 75% BASAL - BOULDER BEACHES</p> <p>45. 75% BASAL - BOULDER BEACHES</p> <p>46. 75% BASAL - BOULDER BEACHES</p> <p>47. 75% BASAL - BOULDER BEACHES</p> <p>48. 75% BASAL - BOULDER BEACHES</p> <p>49. 75% BASAL - BOULDER BEACHES</p> <p>50. 75% BASAL - BOULDER BEACHES</p> <p>51. 75% BASAL - BOULDER BEACHES</p> <p>52. 75% BASAL - BOULDER BEACHES</p> <p>53. 75% BASAL - BOULDER BEACHES</p> <p>54. 75% BASAL - BOULDER BEACHES</p> <p>55. 75% BASAL - BOULDER BEACHES</p> <p>56. 75% BASAL - BOULDER BEACHES</p> <p>57. 75% BASAL - BOULDER BEACHES</p> <p>58. 75% BASAL - BOULDER BEACHES</p> <p>59. 75% BASAL - BOULDER BEACHES</p> <p>60. 75% BASAL - BOULDER BEACHES</p> <p>61. 75% BASAL - BOULDER BEACHES</p> <p>62. 75% BASAL - BOULDER BEACHES</p> <p>63. 75% BASAL - BOULDER BEACHES</p> <p>64. 75% BASAL - BOULDER BEACHES</p> <p>65. 75% BASAL - BOULDER BEACHES</p> <p>66. 75% BASAL - BOULDER BEACHES</p> <p>67. 75% BASAL - BOULDER BEACHES</p> <p>68. 75% BASAL - BOULDER BEACHES</p> <p>69. 75% BASAL - BOULDER BEACHES</p> <p>70. 75% BASAL - BOULDER BEACHES</p> <p>71. 75% BASAL - BOULDER BEACHES</p> <p>72. 75% BASAL - BOULDER BEACHES</p> <p>73. 75% BASAL - BOULDER BEACHES</p> <p>74. 75% BASAL - BOULDER BEACHES</p> <p>75. 75% BASAL - BOULDER BEACHES</p> <p>76. 75% BASAL - BOULDER BEACHES</p> <p>77. 75% BASAL - BOULDER BEACHES</p> <p>78. 75% BASAL - BOULDER BEACHES</p> <p>79. 75% BASAL - BOULDER BEACHES</p> <p>80. 75% BASAL - BOULDER BEACHES</p> <p>81. 75% BASAL - BOULDER BEACHES</p> <p>82. 75% BASAL - BOULDER BEACHES</p> <p>83. 75% BASAL - BOULDER BEACHES</p> <p>84. 75% BASAL - BOULDER BEACHES</p> <p>85. 75% BASAL - BOULDER BEACHES</p> <p>86. 75% BASAL - BOULDER BEACHES</p> <p>87. 75% BASAL - BOULDER BEACHES</p> <p>88. 75% BASAL - BOULDER BEACHES</p> <p>89. 75% BASAL - BOULDER BEACHES</p> <p>90. 75% BASAL - BOULDER BEACHES</p> <p>91. 75% BASAL - BOULDER BEACHES</p> <p>92. 75% BASAL - BOULDER BEACHES</p> <p>93. 75% BASAL - BOULDER BEACHES</p> <p>94. 75% BASAL - BOULDER BEACHES</p> <p>95. 75% BASAL - BOULDER BEACHES</p> <p>96. 75% BASAL - BOULDER BEACHES</p> <p>97. 75% BASAL - BOULDER BEACHES</p> <p>98. 75% BASAL - BOULDER BEACHES</p> <p>99. 75% BASAL - BOULDER BEACHES</p> <p>100. 75% BASAL - BOULDER BEACHES</p> | <p>TYPE OF ORGANISM</p> <p>1. MAMMALS</p> <p>2. BIRDS</p> <p>3. FISHES</p> <p>4. SHELLFISH</p> <p>5. ELLERMAN</p> <p>6. NEW RESEARCH ATLAS</p> <p>7. NEW RESEARCH ATLAS</p> <p>8. NEW RESEARCH ATLAS</p> <p>9. NEW RESEARCH ATLAS</p> <p>10. NEW RESEARCH ATLAS</p> <p>11. NEW RESEARCH ATLAS</p> <p>12. NEW RESEARCH ATLAS</p> <p>13. NEW RESEARCH ATLAS</p> <p>14. NEW RESEARCH ATLAS</p> <p>15. NEW RESEARCH ATLAS</p> <p>16. NEW RESEARCH ATLAS</p> <p>17. NEW RESEARCH ATLAS</p> <p>18. NEW RESEARCH ATLAS</p> <p>19. NEW RESEARCH ATLAS</p> <p>20. NEW RESEARCH ATLAS</p> <p>21. NEW RESEARCH ATLAS</p> <p>22. NEW RESEARCH ATLAS</p> <p>23. NEW RESEARCH ATLAS</p> <p>24. NEW RESEARCH ATLAS</p> <p>25. NEW RESEARCH ATLAS</p> <p>26. NEW RESEARCH ATLAS</p> <p>27. NEW RESEARCH ATLAS</p> <p>28. NEW RESEARCH ATLAS</p> <p>29. NEW RESEARCH ATLAS</p> <p>30. NEW RESEARCH ATLAS</p> <p>31. NEW RESEARCH ATLAS</p> <p>32. NEW RESEARCH ATLAS</p> <p>33. NEW RESEARCH ATLAS</p> <p>34. NEW RESEARCH ATLAS</p> <p>35. NEW RESEARCH ATLAS</p> <p>36. 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ESI MAP # 22

U.S. Army Map Service
for Civil Use by the Geological Survey

USGCS, USGS, and USACE
Photographs by the Geological Survey
from 1949-1950. Map not for sale.
Selected photographic data compiled from USGS & USACE (1950)
and (1955). The information is not intended for navigation purposes.
Universal Transverse Mercator projection. 1927 North American datum.
10,000 feet and based on Alaska coordinate system. 1927
and 1955. 1:50,000 scale.
Land area represented unimproved and unimproved features
represented by the Bureau of Land Management
File # 13. 1:50,000 scale.

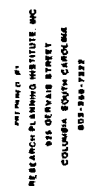
CONTAINING INTERPRETATION
OF THE DATA
FOR SALE BY U.S. GEOLOGICAL SURVEY
FAIRBANKS, ALASKA 99701 DENVER, COLORADO 80225 ON WASHINGTON D.C.
1950



MAP 23

FOR SALE BY THE GEOGRAPHIC SURVEY.
FAIRBANKS ALASKA 99701 DENVER COLORADO BOULDER WASHINGTON D. C. 20247

RESEARCH PLANNING INSTITUTE, INC.
495 GUYANA STREET
COLUMBIA, SOUTH CAROLINA

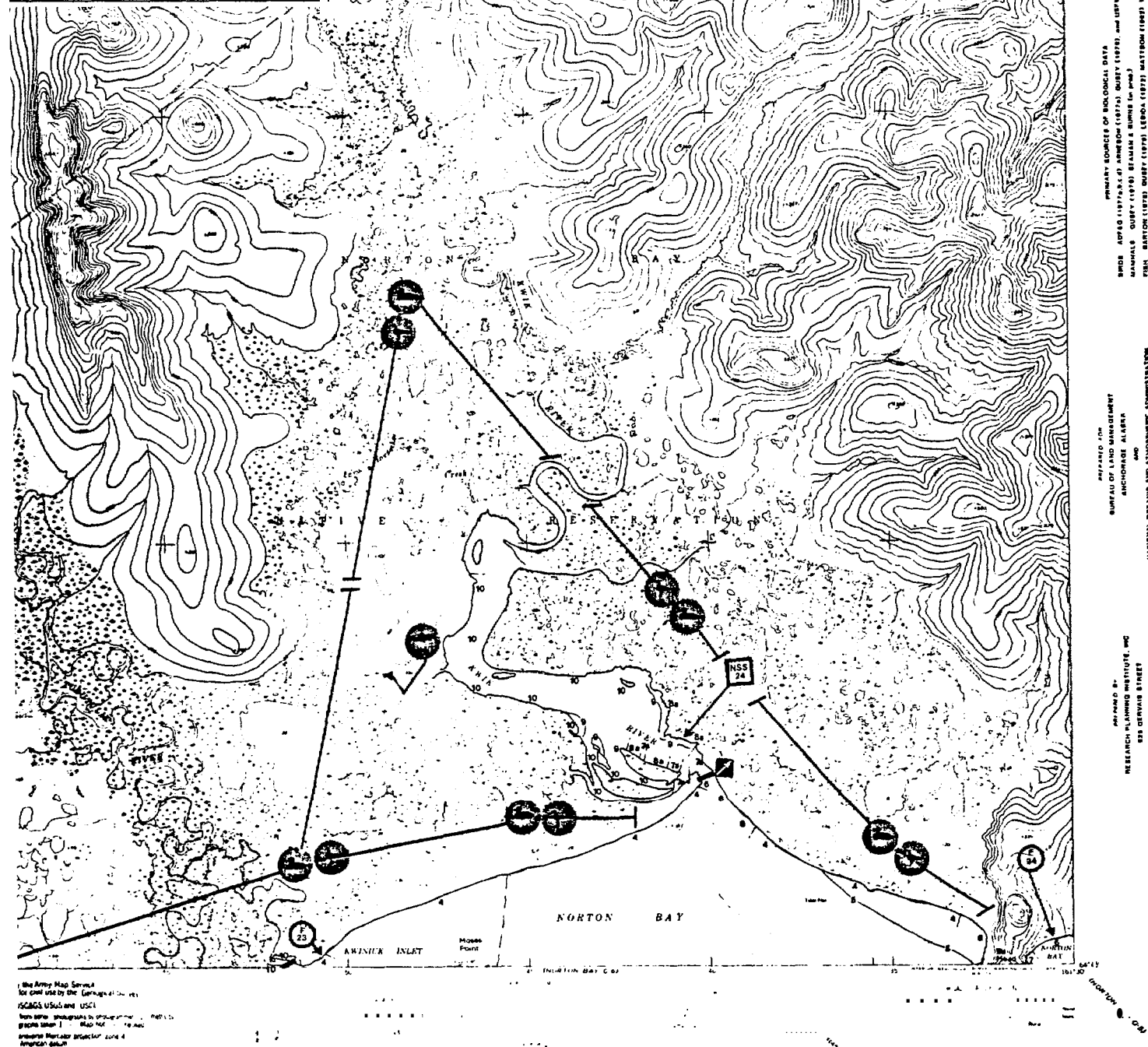


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ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF NORTON SOUND, ALASKA

EXPLORED	TYPE OF CHUANIS M
WAVE CUT PLATFORM	1. BEACH
FINE GRAINE SAND AND GRAVEL	2. SHES
COARSE SAND AND GRAVEL	3. SHELL-FISH
EXPOSED TIDAL FLATS AND BAYS	4. SHELLS
EXPOSED SAND AND GRAVEL	5. SHELLS
GRAVEL BEACHES	6. SHELLS
SHELLTERED WOOD	7. SHELLS
GRAVEL AND SAND BEACHES	8. SHELLS
BEACHES	9. SHELLS
BEACHES	10. SHELLS
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ESI MAP #27



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ANCHORAGE, ALASKA
AND
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
OCEANIC CONTINENTAL SHELF ASSESSMENT PROGRAM
ANCHORAGE, ALASKA

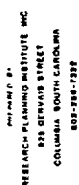
RESEARCH PLANNING INSTITUTE, INC.
333 CLEVELAND STREET
COLUMBIA, SOUTH CAROLINA
29204-0001

PRIMARY SOURCES OF BIOLOGICAL DATA
BIRDS: ADAMS (1972), BIRDS (1972), BIRDS (1972), and USFWS (1972)
MAMMALS: GURRY (1972), BIRDS (1972), BIRDS (1972), BIRDS (1972), BIRDS (1972)
FISH: BARTON (1972), BIRDS (1972), BIRDS (1972), BIRDS (1972), BIRDS (1972)



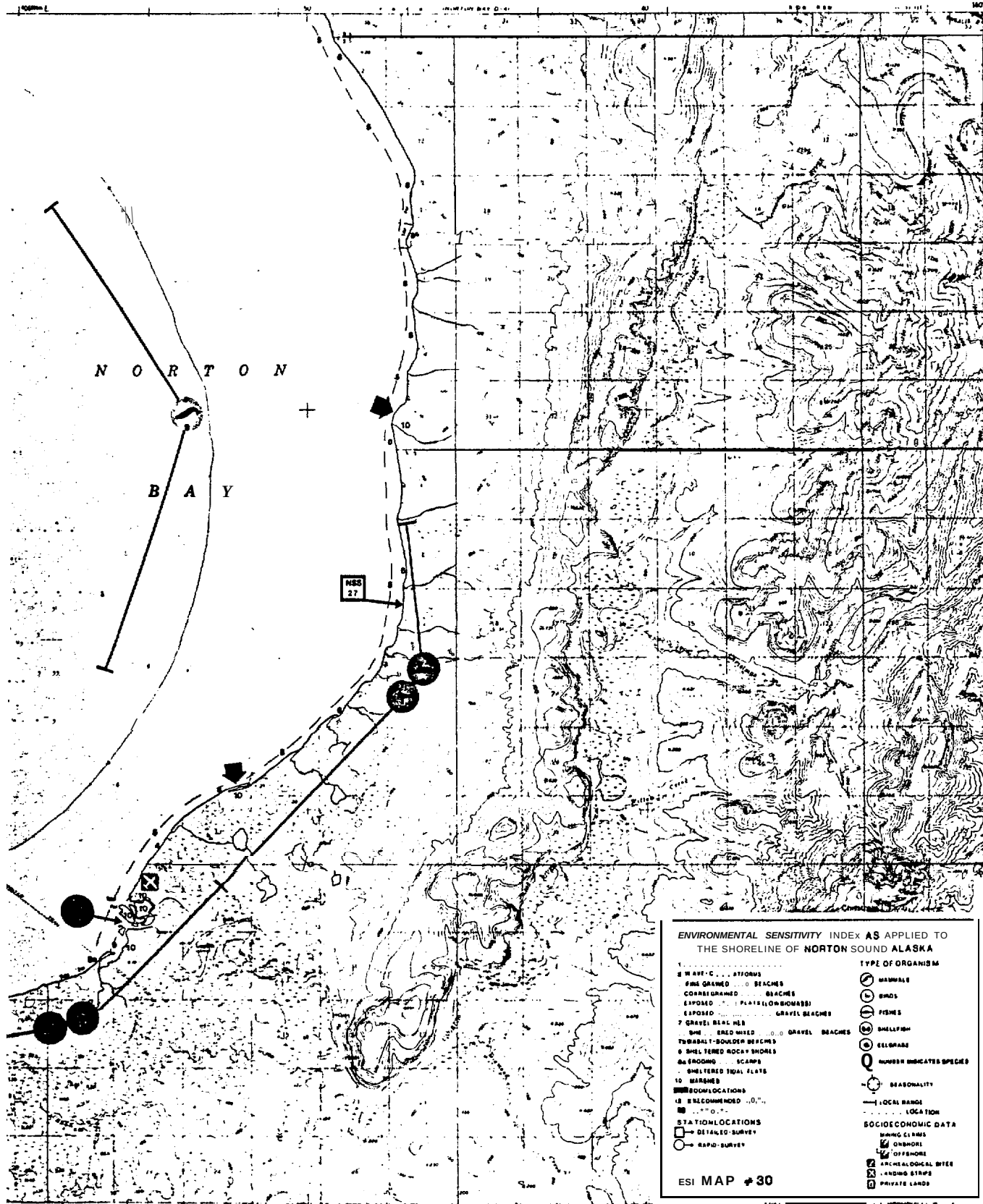
FOR SALE BY U.S. GEOLOGICAL SURVEY
FAIRBANKS ALASKA 99701 (DINER CLOTH) BU. 12 DR. WASHINGTON D.C. 20242

NORTON BAY (D-5) ALASKA



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طبعة ١٩٨٠

NORTON BAY, D-4, ALASKA
NOV 4 1965
1965



ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF NORTON SOUND ALASKA

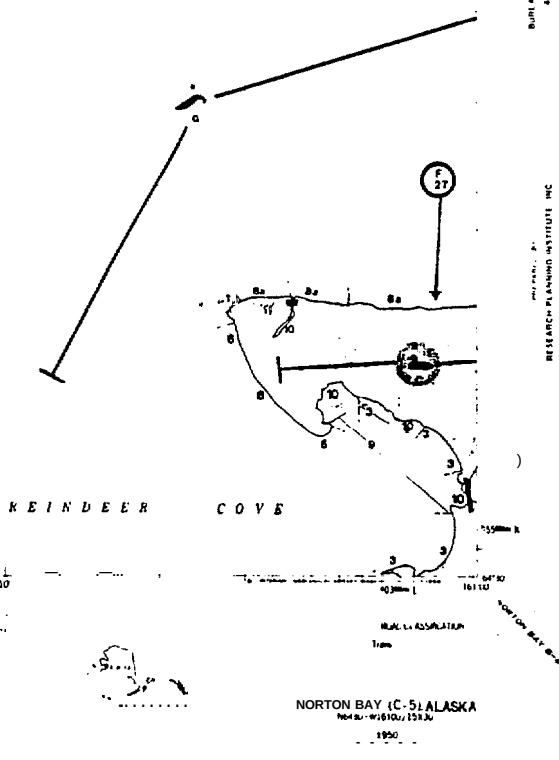
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2. CORREGRAINED BEACHES	MAMMALS
3. EXPOSED PLATELON (BIOMASS)	BIRDS
4. EXPOSED GRAVEL BEACHES	FISHES
5. GRAVEL BEACHES	SHELLFISH
6. GRAVEL MIXED BEACHES	REPTILES
7. TUBALIT-BOULDER BEACHES	AMPHIBIANS
8. SHELFED ROCKY SHORES	PLANTS
9. SCROOING SCUMPS	NUMBER INDICATES SPECIES
10. SHELFED TIDAL FLATS	SEASONALITY
11. MARSHES	LOCAL RANGE
12. BOOM LOCATIONS	LOCATION
13. RECOMMENDED LOCATION	SOCIOECONOMIC DATA
STATION LOCATIONS	OWNERSHIP
DETAILED SURVEY	ARCHAEOLOGICAL SITES
RAPID SURVEY	LANDING STRIPS
	PRIVATE LANDS

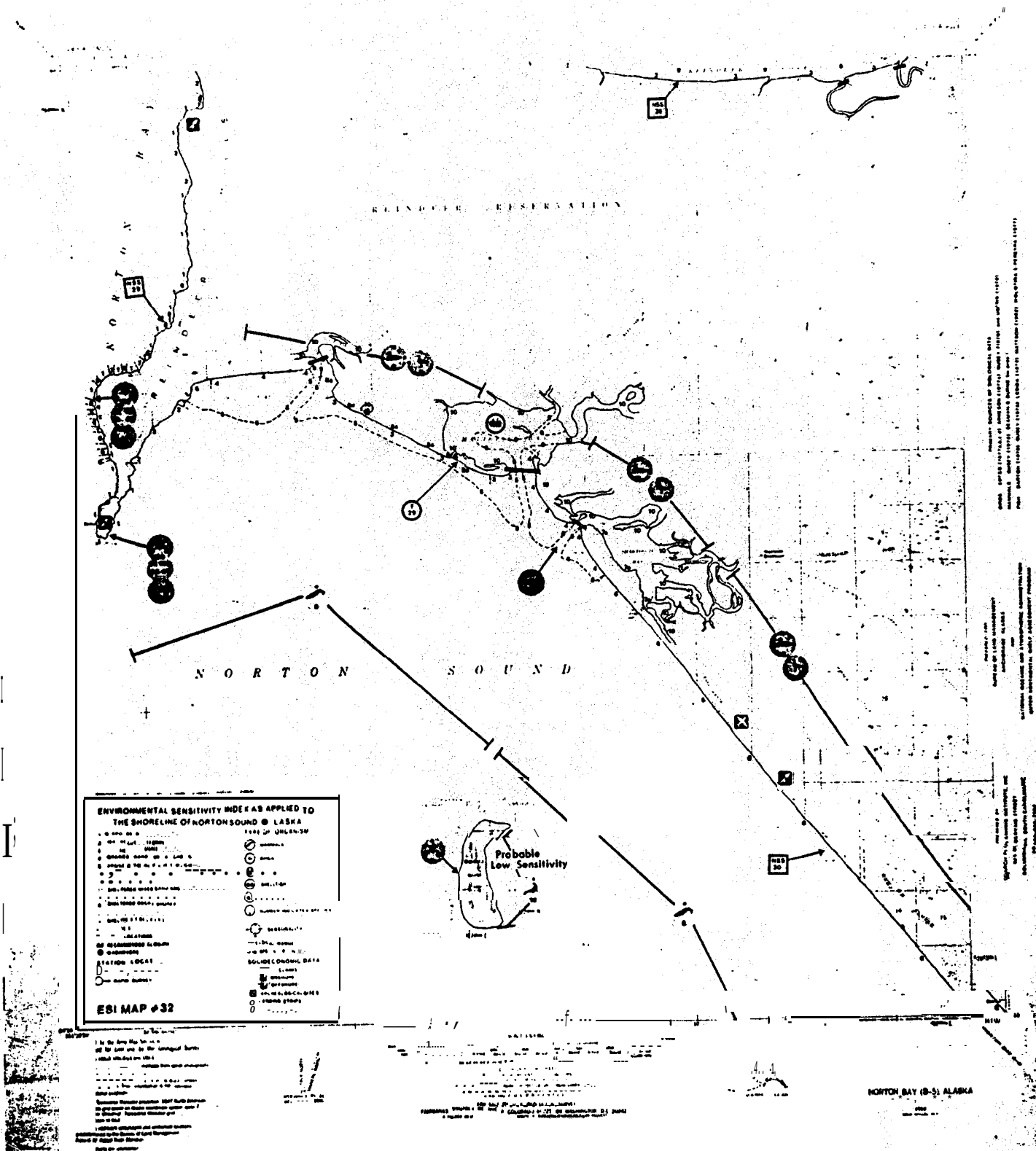
ESI MAP #30

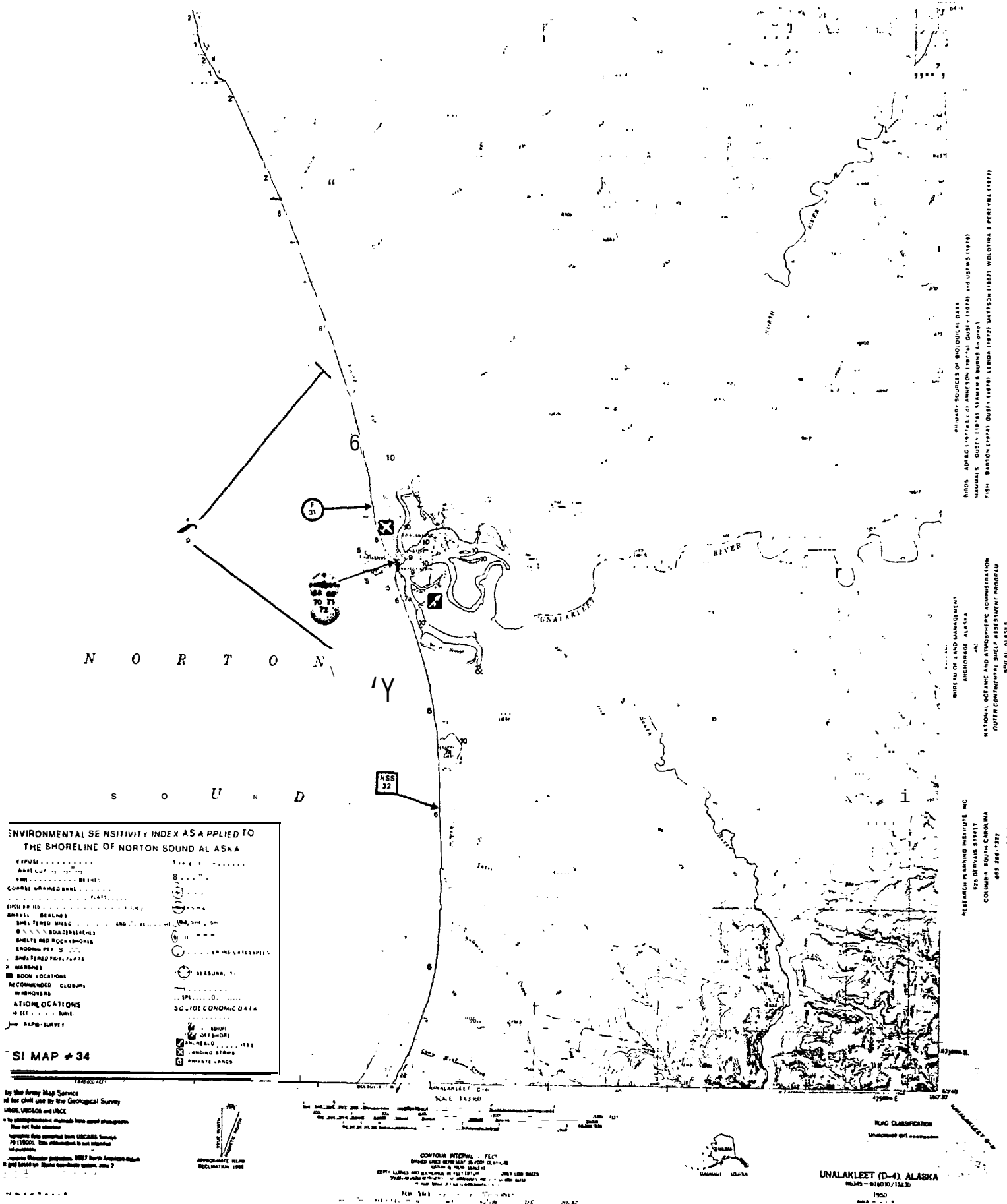
PRIMARY SOURCES OF BIOLOGICAL DATA
BIRDS: BOYD (1977), ALAN (1977), BUEY (1979), and USFWS (1979)
MAMMALS: BOYD (1977), BUEY (1979), and USFWS (1979)
FISHES: MARTON (1979), BUEY (1979), and USFWS (1979)
SHELLFISH: BOYD (1977), BUEY (1979), and USFWS (1979)
REPTILES: BOYD (1977), BUEY (1979), and USFWS (1979)
AMPHIBIANS: BOYD (1977), BUEY (1979), and USFWS (1979)
PLANTS: BOYD (1977), BUEY (1979), and USFWS (1979)

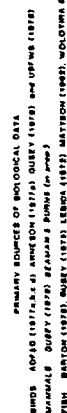
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COLUMBIA, SOUTH CAROLINA









TYPE OF ORGANISM

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 FUNGI

 PLANTS

 ANIMALS

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 NUMBER OF INDIVIDUALS SPECIES

 SEASONALITY

 LOCAL RANGE

 SPECIFIC LOCATION

SOCIOECONOMIC DATA

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1. The first group of people who are not allowed to enter the country are those who are considered to be a threat to national security. This includes anyone who is a member of a terrorist organization, or who is involved in espionage or sabotage. It also includes anyone who is a member of a criminal organization, or who is involved in drug trafficking or money laundering.

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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803 736-1999

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MAP # 36

S O C I E T Y

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RESEARCH PLANNING INSTITUTE INC.
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UNALAKLEET (C-5, ALASKA
ACJS 416, 1548)
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U.S. GEOLOGICAL SURVEY
 ALASKA DIVISION
 FAIRBANKS, ALASKA

1:50,000 1:50,000



ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF NORTON SOUND, ALASKA

- 1. BAY, BEACH, BLVD.
- 2. MUD FLATS, SAND FLATS, SAND BEACHES
- 3. TIDAL WETLANDS, MARSHES, SWAMPY AREAS
- 4. OPEN WATERS
- 5. FRESHWATER WATERS, RIVERS, LAKES, STREAMS
- 6. CULTIVATED AREAS
- 7. URBAN AREAS
- 8. FORESTED AREAS
- 9. OPEN AREAS
- 10. OTHER AREAS

MAP #37

Army Map Service
 Aligned by the Geological Survey
 and USGS

Photographic medium (1:50,000)
 Map prepared 1952. Map not held in stock.
 Horizontal projection (1957)
 Map on Alaska coordinate system (Zone 1)
 Not 1:50,000 horizontal grid

Unpublished and unclassified location
 Bureau of Land Management
 Fairbanks

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 8 PAGES 1:50,000 SCALE 1:50,000 1:50,000

UNALAKLEET (B-5), ALASKA
 1:50,000 1:50,000

PRIMARY SOURCE OF BIOLOGICAL DATA
 BIRDS ADRIAN (1964), ADRIAN (1974), GUSTY (1978) and USFWS (1978)
 MAMMALS GUSTY (1978), ADRIAN (1978) and USFWS (1978)
 FISH GUSTY (1978), ADRIAN (1978) and USFWS (1978)

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 ANCHORAGE, ALASKA

RESEARCH AND TRAINING INSTITUTE INC.
 1000 UNIVERSITY STREET
 ANCHORAGE, ALASKA

UNALAKLEET (B-61 ALASKA
No 315 - W 4130 15410



PRIMARY SOURCES OF BIOLOGICAL DATA

REPORT FOR
BUREAU OF LAND MANAGEMENT
ANCHORAGE ALASKA

40 000 000

RO NMENTAL SENSITIVITY INDEX AS APPLIED TO HE SHORELINE OF NORTON SOUND ALASKA

- [illegible]

MAP 39

Army Map Service
and use by the Geological Survey
and USGS

agreements between the two agencies
started 1962. Map set held almost
a 50-year project. 1977 North American
and an Alaska coordinate system, also 7
in Northern Hemisphere and take
it.

Information and technical assistance
a Bureau of Land Management
from Alaska.

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A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

SAINT MICHAEL (B-1) ALASKA

1962

Map No. 40

ADDITIONAL INFORMATION

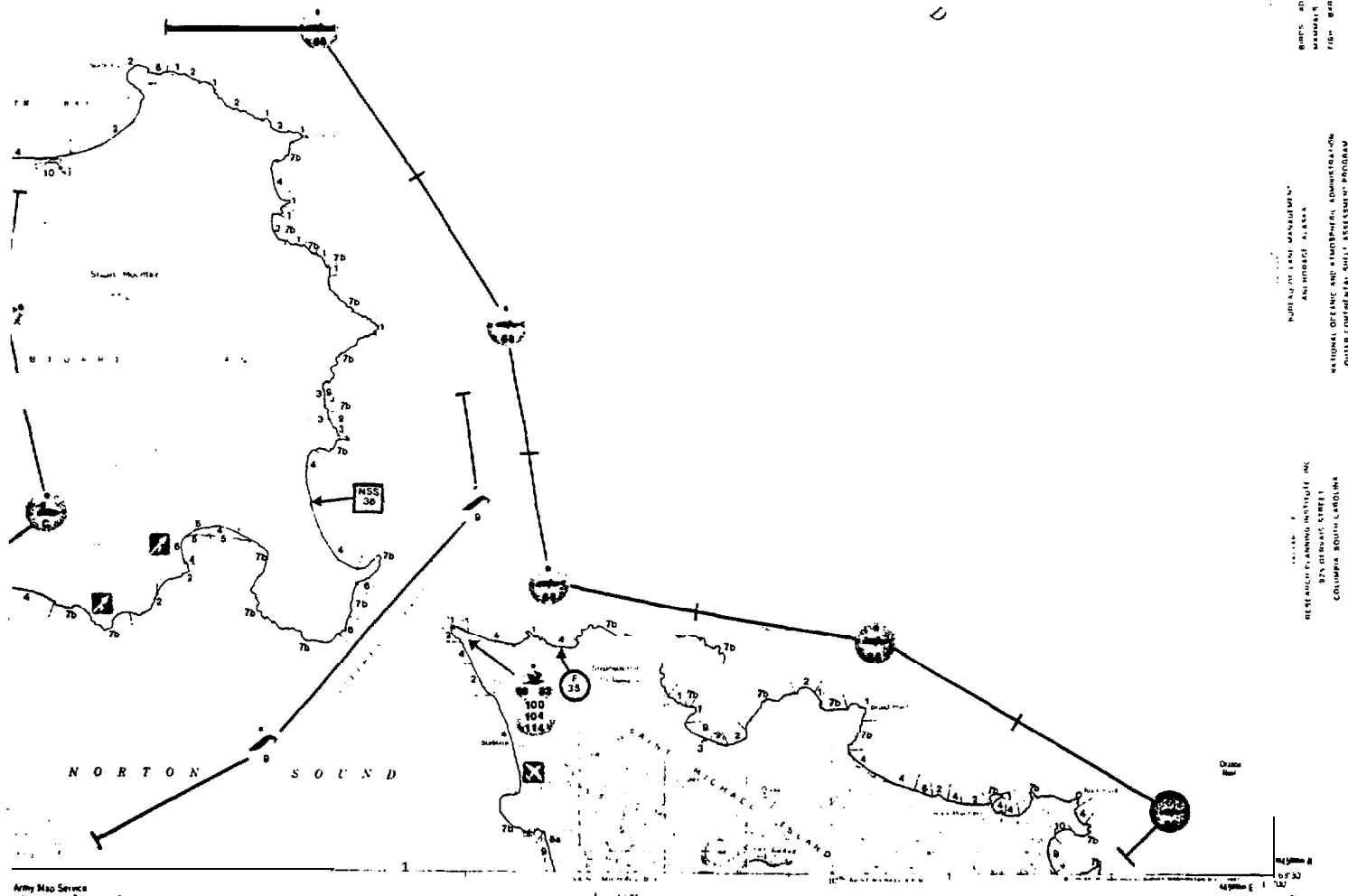
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF NORTON SOUND, ALASKA

Symbol	Description
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MAP # 40

O R T O A

S O U N D



Army Map Service
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and Alaska Department of Fish and Game
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or State and local agencies
of Bureau of Land Management

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COLORADO BOULDER, WASHINGTON D.C. 20242

SAINT MICHAEL (C-1), ALASKA
NO. 30-10000-1000

1962

PRIMARY SOURCES OF BIOLOGICAL DATA
BIRDS: ADAMS (1972), ADAMS (1974), DUELL (1978) and USFWS (1981)
MAMMALS: DUELL (1978), ADAMS (1974) and USFWS (1981)
FISH: BARNUM (1974), DUELL (1978), LEMMON (1972), WATSON (1982), WOODWARD (1982)

NATIONAL SYSTEM OF LAND MANAGEMENT
BUREAU OF LAND MANAGEMENT
ALASKA
NATIONAL OFFICE AND ALASKA REGIONAL ADMINISTRATION
OUTER CONTINENTAL SHELF ADMINISTRATION PROGRAM
405 238 1327

RESEARCH PLANNING INSTITUTE INC.
3075 UNIVERSITY STREET
COLUMBIA, SOUTH CAROLINA
29204-1127

[illegible]

MAP +42

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use the Geoglyph ... Su
... code

WIDE 1007 Map not found
variable program 1972
use Alaska coordinate system
Framingham

various and converted to show
value of Land Management
Division.

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PRIMARY SOURCES OF BIOLOGICAL DATA

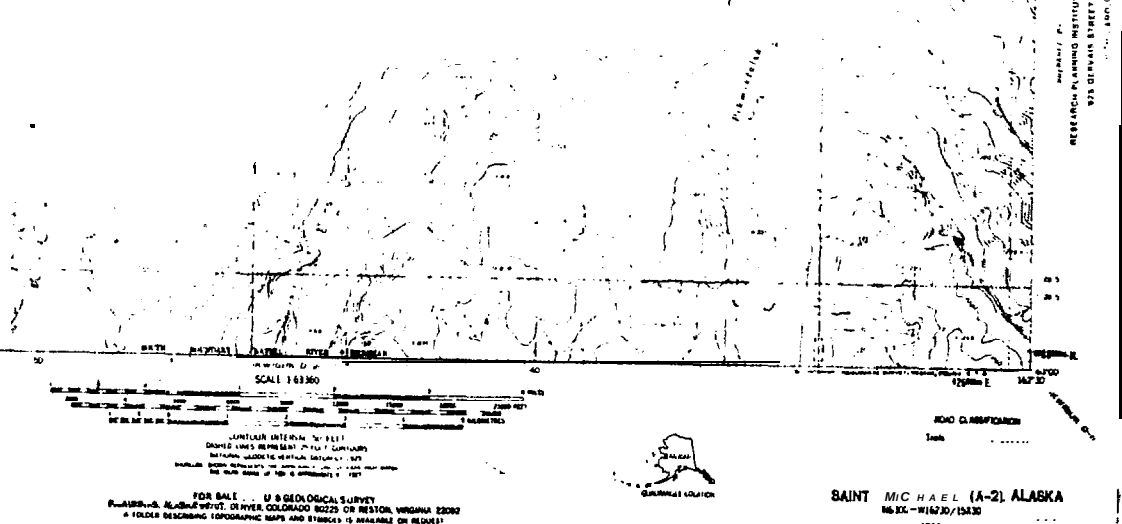
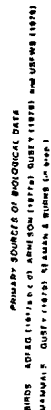
RECORDS ADDED (1976-81): ANDERSON (1977a), GUSTAF (1979) AND USFWS (1978);
ANDERSON & GUSTAF (1979), REAGAN & BUNNIS (in press).

MAPS: 1. GUSTAF (1978), LEMING (1972), MANNING (1967), MCHUGH & MANNING (1967).

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ANCHORAGE 44-50-A
25

1. *Alnus* *glabra* *Mill.*
2. *Alnus* *incana* *Mill.*
3. *Alnus* *glabra* *Mill.*
4. *Alnus* *glabra* *Mill.*

SAN JIM HALL, B. ALASKA
1952

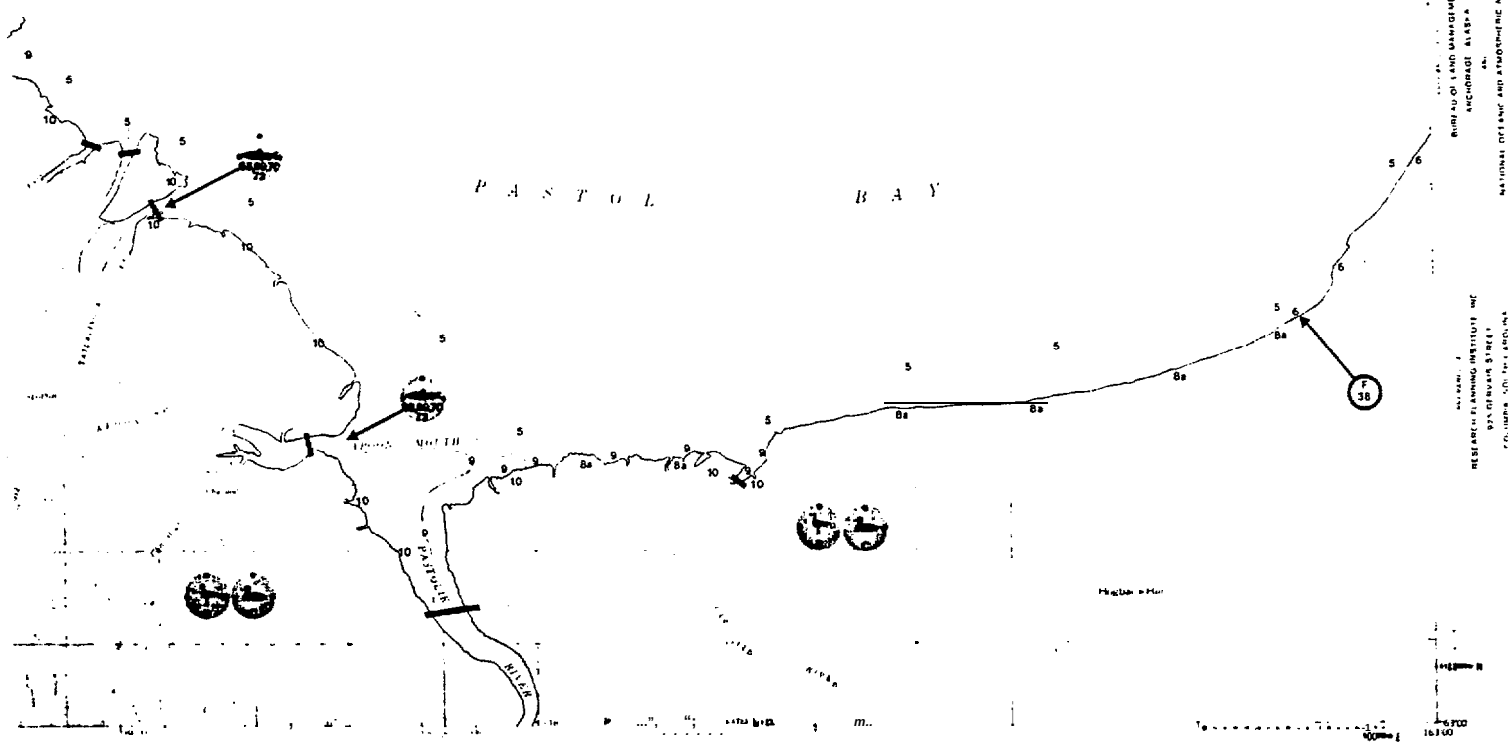


MAP # 44

S O U N D

0.4.

PRIMARY SOURCES OF BIOLOGICAL DATA



- Army Map Service
first used by the Geological Survey
and now USGS

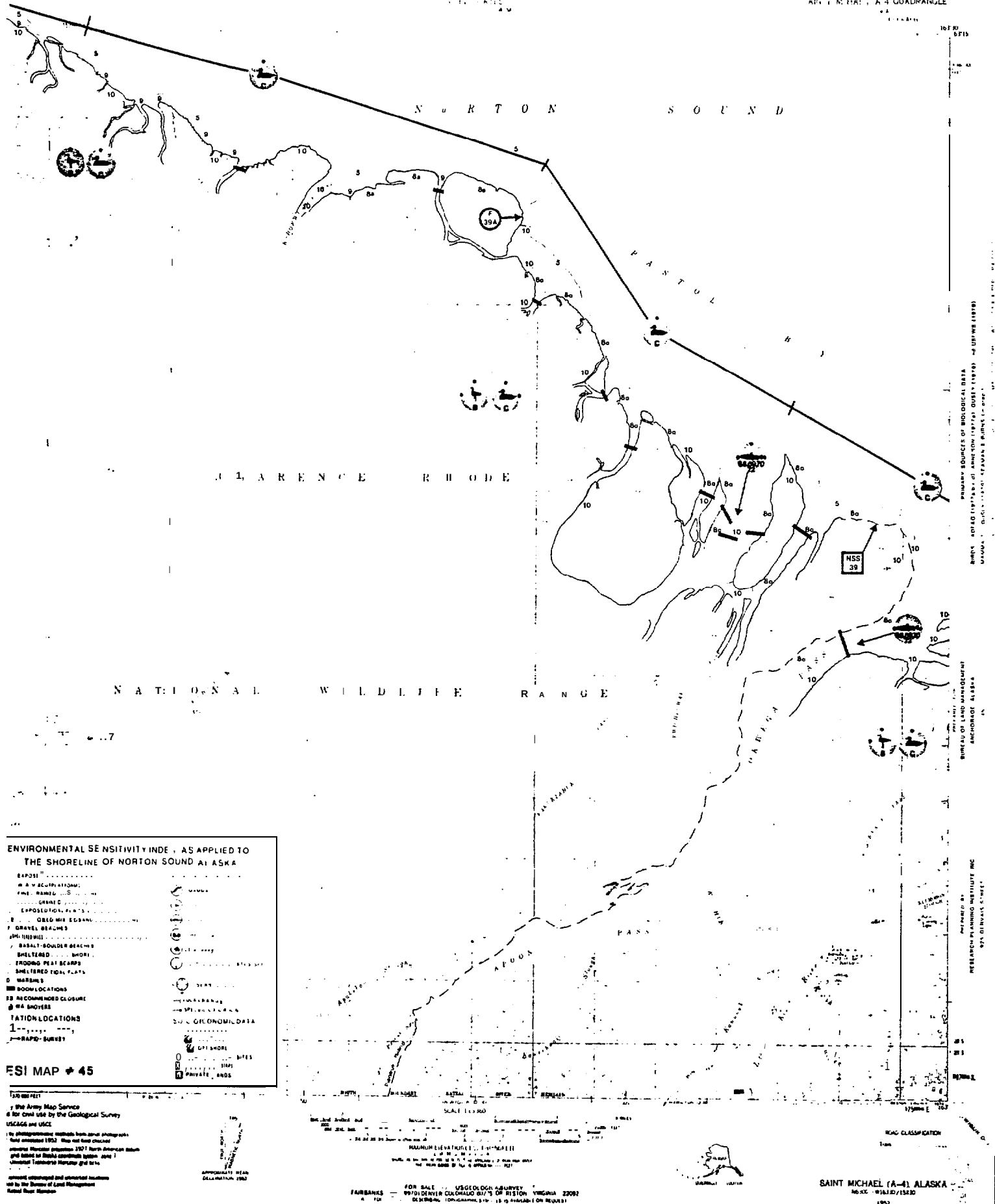
hydrographic estimates from actual observation
1920s - 1930s constructed 1:50,000 scale maps, but not
----- 1960s -----
based on Altimeter sounding system data
- real Transverse Mercator grid basis

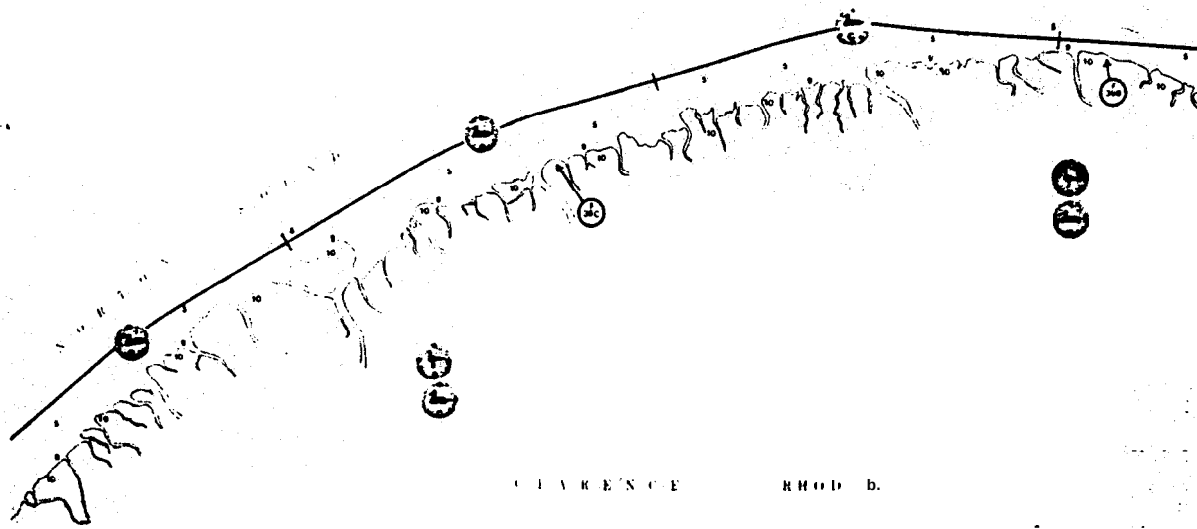
is of unimproved and uncharted locations
the Bureau of Land Management

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SAINT MICHAEL [A-3, ALASKA
MOBILE - 016 JUL, 1948

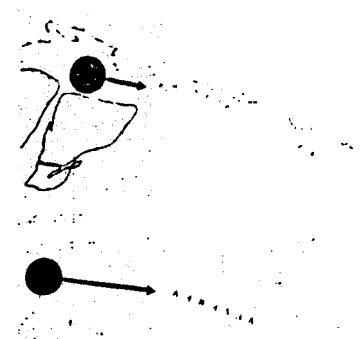
1952





CLARENCE RHOD. D.

NATIONAL U11.1, 1.11K1 RANGE



Report by the Army Corps of Engineers
 Prepared for the Alaska Department of Fish and Game
 by the Alaska Department of Fish and Game
 1964

ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF NORTON SOUND, ALASKA

Symbol	Description
1	1. HIGHLY SENSITIVE
2	2. MODERATELY SENSITIVE
3	3. MODERATELY SENSITIVE
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ESI MAP #46

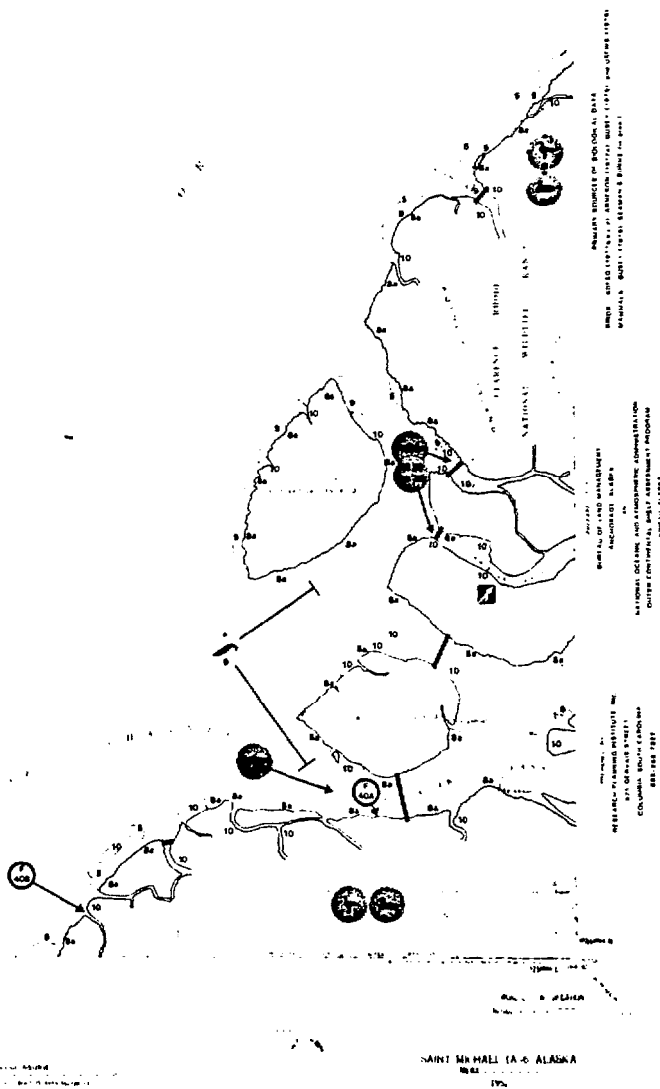
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 Date: 1964
 By: [illegible]
 For: [illegible]

Project: SHORELINE SENSITIVITY INDEX
 Date: 1964
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 For: [illegible]

Project: SHORELINE SENSITIVITY INDEX
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 By: [illegible]
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NORTH MAP #46 ALASKA

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KWIGUK (C-6) ALABAMA
1922-1923, 1924

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PRIMARY SOURCE OF BIOLOGICAL DATA
SOURCE: ADAPTATION OF BIOLOGICAL DATA FROM THE BERING SEA
NORTH PACIFIC OCEANIC AND ATMOSPHERIC ADMINISTRATION
NORTH PACIFIC OCEANIC AND ATMOSPHERIC ADMINISTRATION
NORTH PACIFIC OCEANIC AND ATMOSPHERIC ADMINISTRATION
NORTH PACIFIC OCEANIC AND ATMOSPHERIC ADMINISTRATION

ADAPTATION OF BIOLOGICAL DATA
SOURCE: ADAPTATION OF BIOLOGICAL DATA FROM THE BERING SEA
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ADAPTATION OF BIOLOGICAL DATA
SOURCE: ADAPTATION OF BIOLOGICAL DATA FROM THE BERING SEA
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NORTH PACIFIC OCEANIC AND ATMOSPHERIC ADMINISTRATION
NORTH PACIFIC OCEANIC AND ATMOSPHERIC ADMINISTRATION
NORTH PACIFIC OCEANIC AND ATMOSPHERIC ADMINISTRATION

ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF NORTON SOUND, ALASKA

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- 1. HIGHLY SENSITIVE
- 2. MODERATELY SENSITIVE
- 3. MODERATELY RESISTANT
- 4. HIGHLY RESISTANT
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ESI MAP # 51

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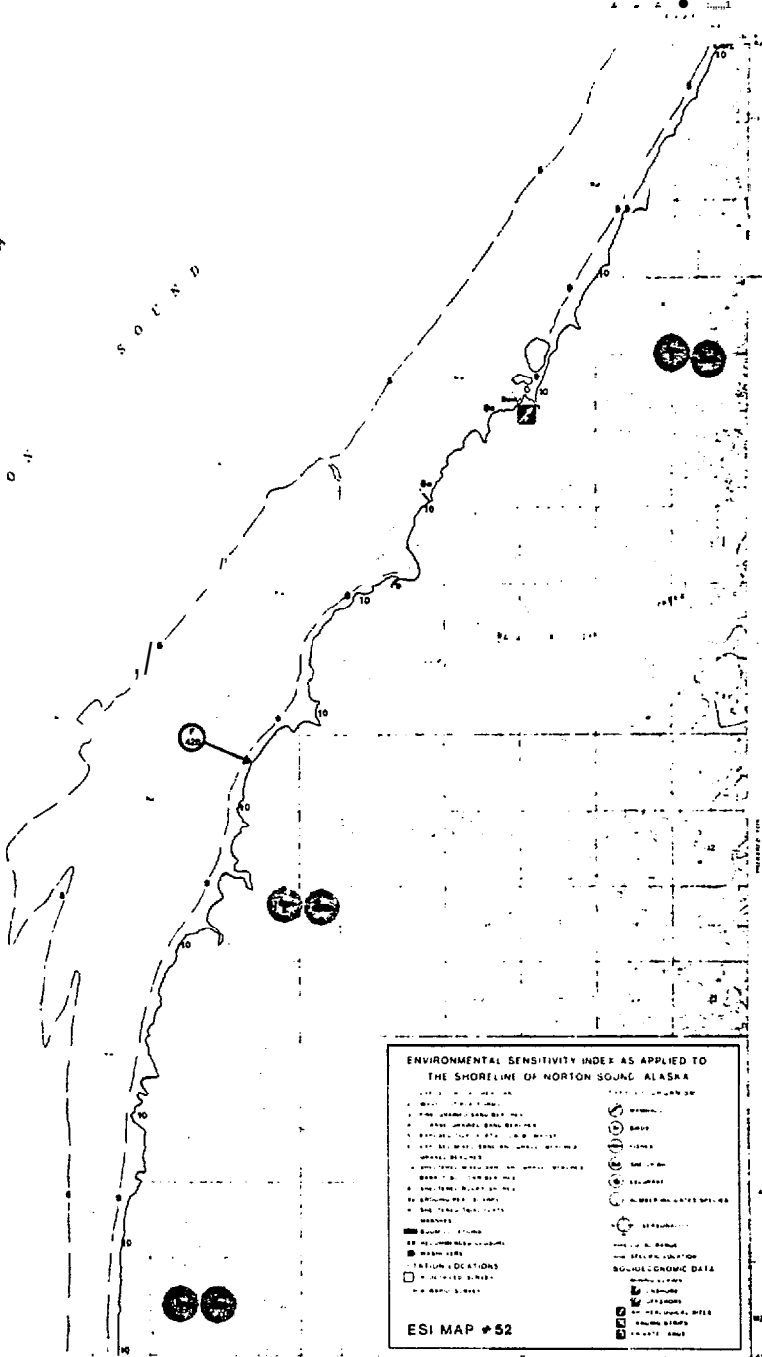
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BERING

NORTON



ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF NORTON SOUND, ALASKA

ES I MAP #52

Legend:

- 1. FINE GRAINED SAND BEACHES
- 2. COARSE GRAINED SAND BEACHES
- 3. GRAVEL BEACHES
- 4. COARSE GRAINED SAND AND GRAVEL BEACHES
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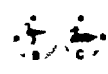
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BLACK (A-2), ALASKA
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Geological Survey
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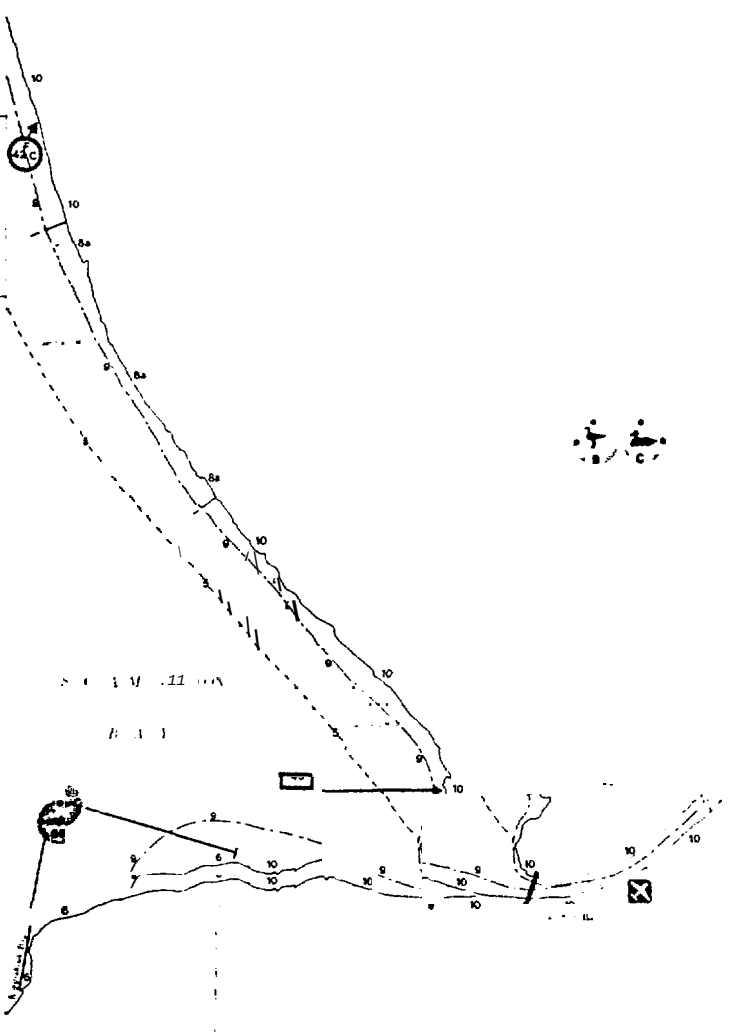
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Secondary Source: U.S. Geological Survey
Tertiary Source: U.S. Geological Survey
Quaternary Source: U.S. Geological Survey
Quinary Source: U.S. Geological Survey
Sextenary Source: U.S. Geological Survey
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Octenary Source: U.S. Geological Survey
Nonary Source: U.S. Geological Survey
Decenary Source: U.S. Geological Survey

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U.S. Department of the Interior



ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF NORTON SOUND, ALASKA

ES I MAP + 53

Scale: 1:50,000

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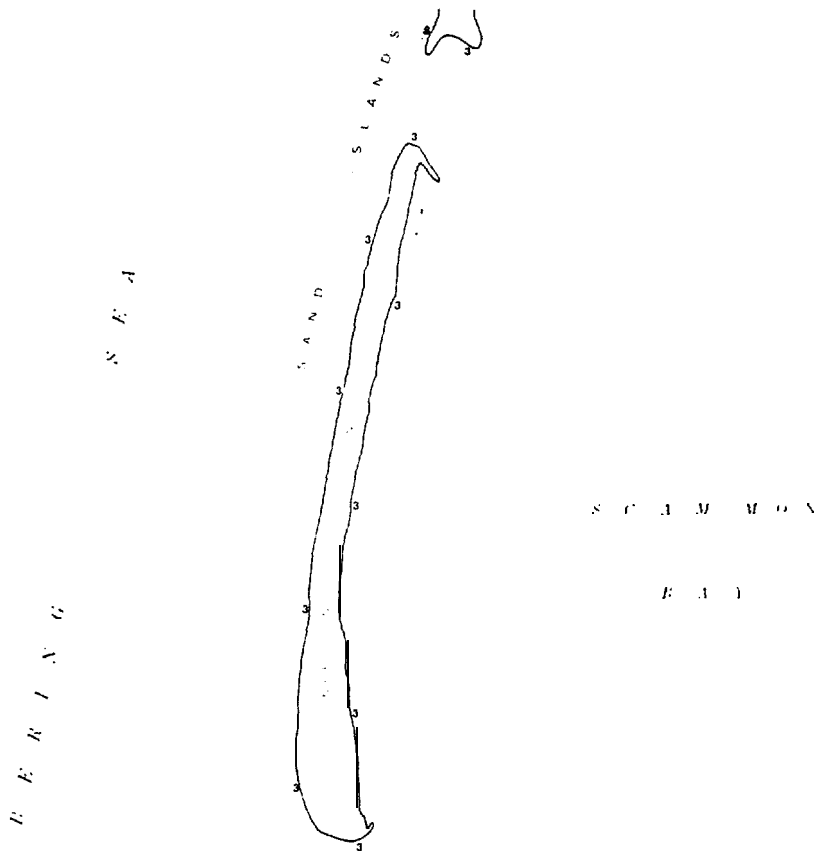
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- 5. SHELFED SAND AND GRAVEL BEACHES
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LAWRENCE R. HODGKINS
NATL WILDLIFE REFUGES

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Topography by photogrammetric methods from aerial photography
from 1951 and 1953 base and 1952 Map No. 1000
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for use in any other manner
10,000 feet
General Topography
Land use represents unimproved and unimproved locations
photographed by the Bureau of Land Management
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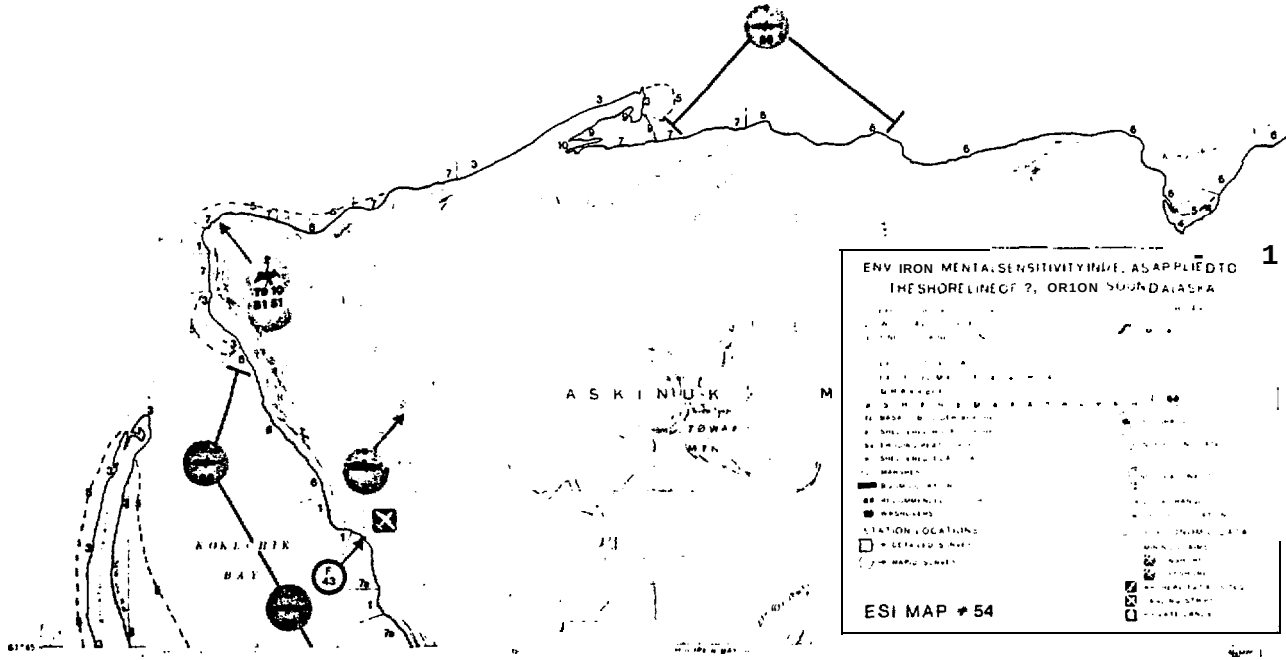
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88. SHELFED GRAVEL BEACHES
89. SHELFED GRAVEL BEACHES
90. SHELFED GRAVEL BEACHES
91. SHELFED GRAVEL BEACHES
92. SHELFED GRAVEL BEACHES
93. SHELFED GRAVEL BEACHES
94. SHELFED GRAVEL BEACHES
95. SHELFED GRAVEL BEACHES
96. SHELFED GRAVEL BEACHES
97. SHELFED GRAVEL BEACHES
98. SHELFED GRAVEL BEACHES
99. SHELFED GRAVEL BEACHES
100. SHELFED GRAVEL BEACHES

HOOPER BAY (D-2), ALASKA
1:50,000
1952
UNITED STATES 1952



PRIMARY SOURCES OF BIOLOGICAL DATA
 BIRDS: EISEN (1972) & J. ADAMS (1972) BIRDS: EISEN (1972) & J. ADAMS (1972)
 MAMMALS: DUFFY (1972) MAMMALS: DUFFY (1972) MAMMALS: DUFFY (1972)
 FISH: RANTON (1972) FISH: RANTON (1972) FISH: RANTON (1972)

REPORT OF THE MANAGEMENT
 NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
 OCEANIC ENVIRONMENTAL QUALITY ASSESSMENT PROGRAM
 JUNE 1974 ALASKA

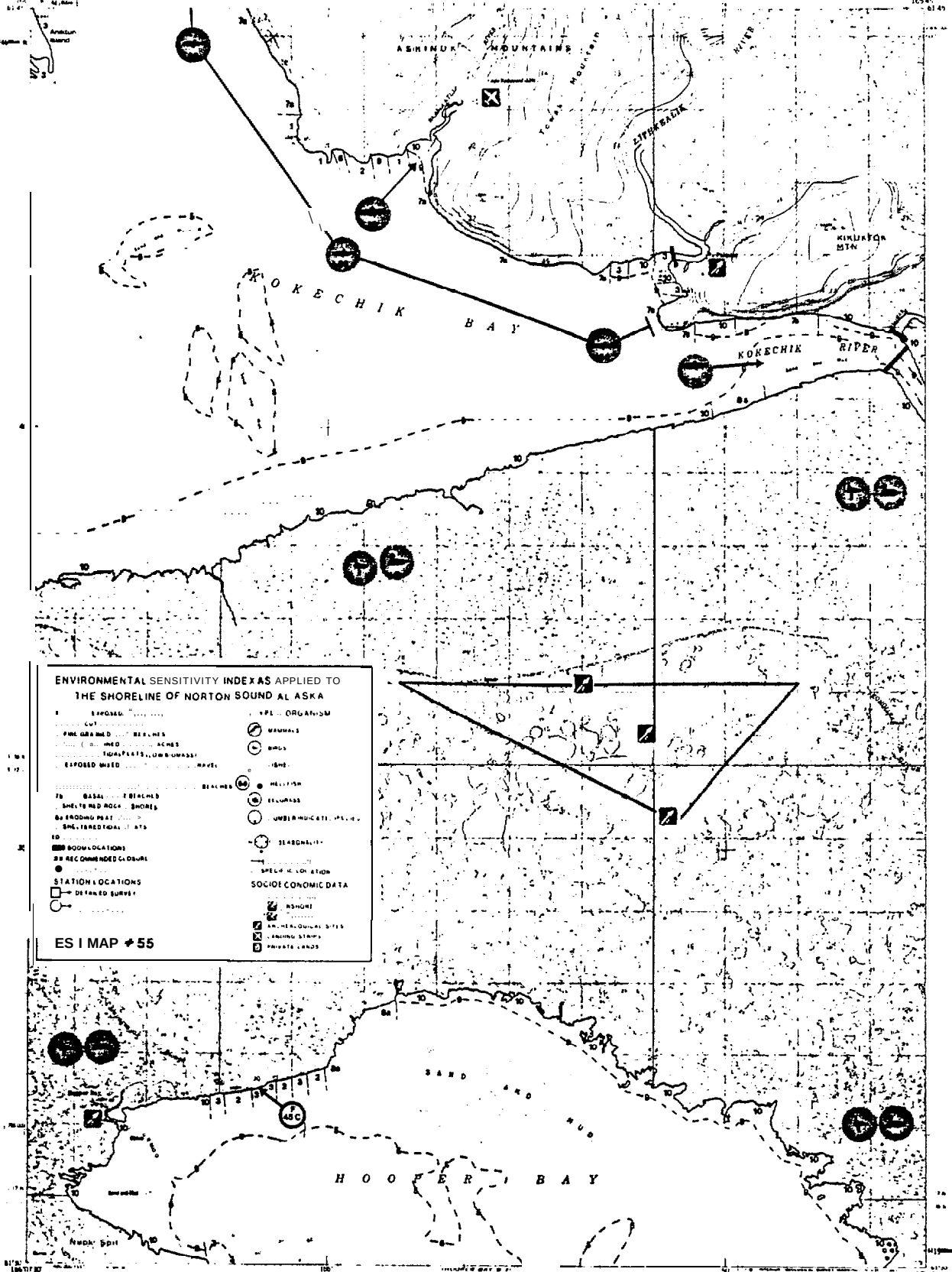


REPORT OF THE MANAGEMENT
 NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
 OCEANIC ENVIRONMENTAL QUALITY ASSESSMENT PROGRAM
 JUNE 1974 ALASKA

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

UNITED STATES
GEOLOGICAL SURVEY

HOOPER BAY (C-3) QUADRANGLE
ALASKA
7.5-MINUTE TRIANGULAR AREA



ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF NORTON SOUND ALASKA

1. EXPOSED 2. FINE GRAINED 3. TIDAL FLATS, LOW UNWASH 4. EXPOSED MUD 5. BEACHES 6. SHELFED ROCK SHORES 7. SHELFED FLATS 8. SHELFED TIDAL FLATS 9. BOOM LOCATIONS 10. RECOMMENDED CLOSURE 11. STATION LOCATIONS 12. OBTAINED SURVEY	13. BASAL 14. BEACHED 15. SHELFED ROCK SHORES 16. SHELFED FLATS 17. SHELFED TIDAL FLATS 18. BOOM LOCATIONS 19. RECOMMENDED CLOSURE 20. STATION LOCATIONS 21. OBTAINED SURVEY	22. TYPE ORGANISM 23. MAMMALS 24. BIRDS 25. FISH 26. MOLLUSKS 27. ELLUMINUS 28. UNIDENTIFIED SPECIES 29. SEASONALITY 30. SPECIAL LOCATION 31. SOCIOECONOMIC DATA 32. RESERVE 33. ANTI-ORIGINAL SITES 34. LANDING STRIPS 35. PRIVATE LANDS
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ES I MAP #55

PRIMARY SOURCE OF BIOLOGICAL DATA

BIRDS: ADAMS (1977), ADAMS & HARRISON (1977), BUSEY (1979) and USFWS (1979)

MAMMALS: BUSEY (1979), SECAMAN & BURKE (in press)

FISH: BARTON (1979), BUSEY (1979), LEBOW (1977), MATTSON (1982), WOLODIN & PEREIRA (1977)

PREPARED FOR

BUREAU OF LAND MANAGEMENT
ANCHORAGE, ALASKA
AND
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ALBUQUERQUE, ALABAMA

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COLUMBIA, SOUTH CAROLINA
29204-7822

Maped by the Army Map Service
Published for civil use by the Geological Survey
1st ed. by USGS, 1955

From 1950 and 1952 Map not to scale

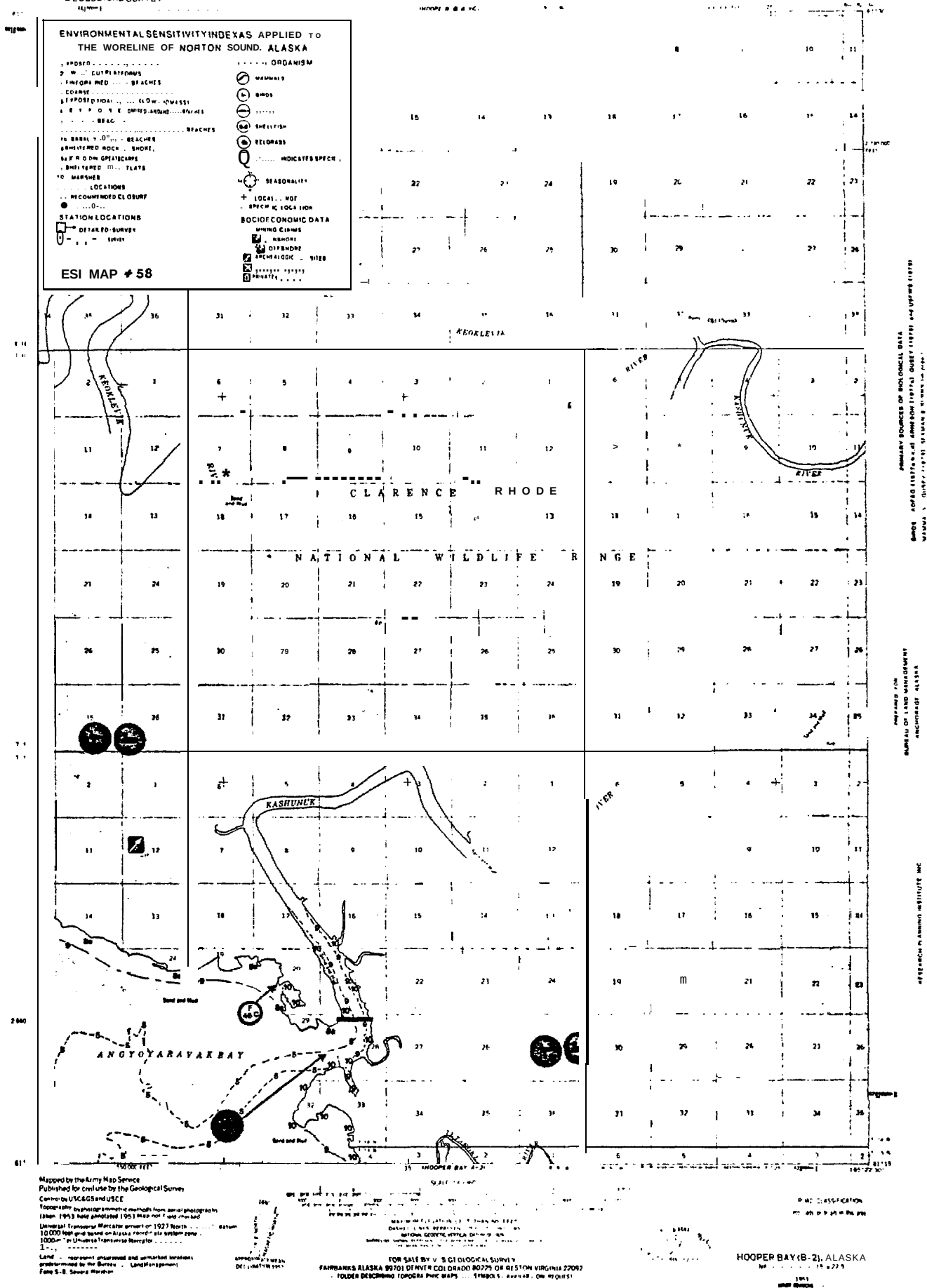
Unpublished from: North Polar projection, 7.5 degree
1:50,000 scale based on Alaska coordinate system zone 18
1950 datum

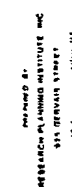
Unpublished and
unpublished to the Bureau of Land Management
Folios 17 and 18, 30meters Meridian

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HOOPER BAY (C-3) ALASKA
No. 8170045 15427
1952

HOOPER BAY (B 2 QUADRANGLE
41 ---,
L 13110 SERIES SITOPGRAPHIC)





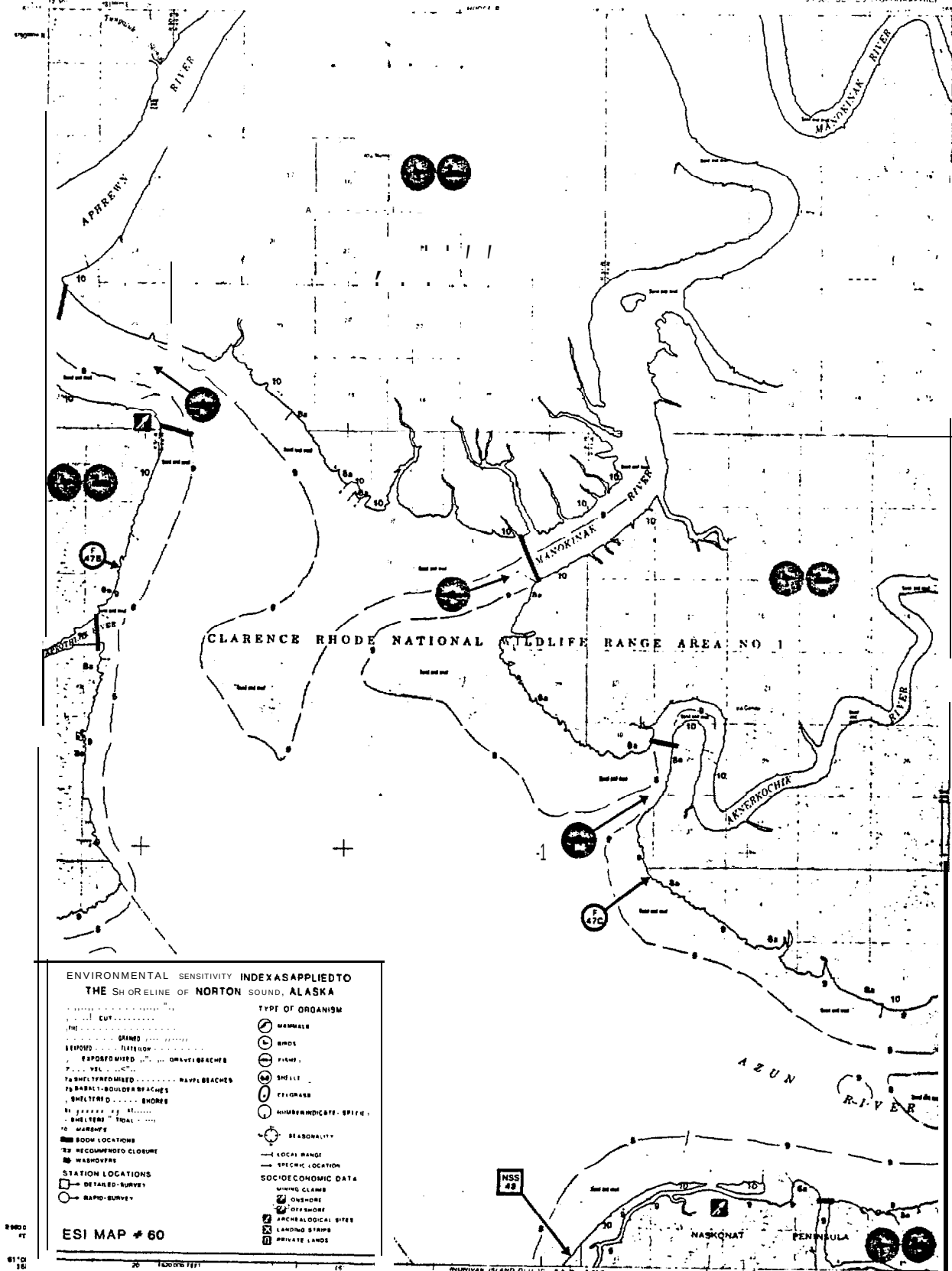
ESI MAP #59

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HOPPER BAY (A-21) ALASKA
 .0 224
 1952

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DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HOOPER BAY (A1) QUADRANGLE
ALASKA
1:50,000 SERIES (TOPOGRAPHIC)



ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF NORTON SOUND, ALASKA

- TYPE OF ORGANISM**
- 1. MAMMALS
 - 2. BIRDS
 - 3. FISHES
 - 4. SHELLS
 - 5. PLANTS
 - 6. INVERTEBRATES
 - 7. REASONABILITY
 - 8. LOCAL RANGE
 - 9. SPECIFIC LOCATION
- SOCIOECONOMIC DATA**
- 10. MINING CLAIMS
 - 11. ON-SHORE
 - 12. OFF-SHORE
 - 13. ARCHAEOLOGICAL SITES
 - 14. LANDING STRIPS
 - 15. PRIVATE LANDS
- STATION LOCATIONS**
- 16. DETAILED SURVEY
 - 17. RAPID SURVEY
- ES I MAP # 60**

by the Army Map Service
and published by the Geological Survey
under USGS and USFS

Topography: 1. American methods from aerial photographs
1949-1950 and 1952 data collected 1942. They are not checked
University of Alaska, Fairbanks, 1957 North American Datum
10,000 feet. Based on Alaska c. 1950 datum, zone 9
1000 meters Universal Transverse Mercator grid facts
zone 3, 1000 meters datum

Land areas represent unimproved and unimproved locations
predetermined by the Bureau of Land Management
Folio 6-B, Second Edition

APPROVED
DECEMBER 1950

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A POLAR REGIONAL TOPOGRAPHIC MAP, 1:50,000 SCALE, 1950

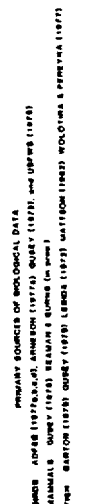
HOOPER BAY (A1), ALASKA
1:50,000 SCALE, 1950

PRIMARY SOURCES OF BIOLOGICAL DATA
MAMMALS: ADAMS (1977), ADAMS (1977), ADAMS (1977), ADAMS (1977), ADAMS (1977)
BIRDS: ADAMS (1977), ADAMS (1977), ADAMS (1977), ADAMS (1977), ADAMS (1977)
FISHES: ADAMS (1977), ADAMS (1977), ADAMS (1977), ADAMS (1977), ADAMS (1977)
SHELLS: ADAMS (1977), ADAMS (1977), ADAMS (1977), ADAMS (1977), ADAMS (1977)
PLANTS: ADAMS (1977), ADAMS (1977), ADAMS (1977), ADAMS (1977), ADAMS (1977)
INVERTEBRATES: ADAMS (1977), ADAMS (1977), ADAMS (1977), ADAMS (1977), ADAMS (1977)

PREPARED BY
BUREAU OF LAND MANAGEMENT
ANCHORAGE, ALASKA

RESEARCH PLANNING INSTITUTE INC
1115 DENALI STREET
ANCHORAGE, ALASKA

1954



OUTER CONTINGENTAL SHELF ASSESSMENT
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 RESEARCH PLANNING INSTITUTE, INC.
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 COLUMBIA SOUTH CAROLINA
 292-280-1327

Edited and published by the Geological Survey
Control in USC&GS and USGS

Topography by photogrammetric methods; photographs taken 1952, 1953 and 1957; map annotated 1954 Map not field checked

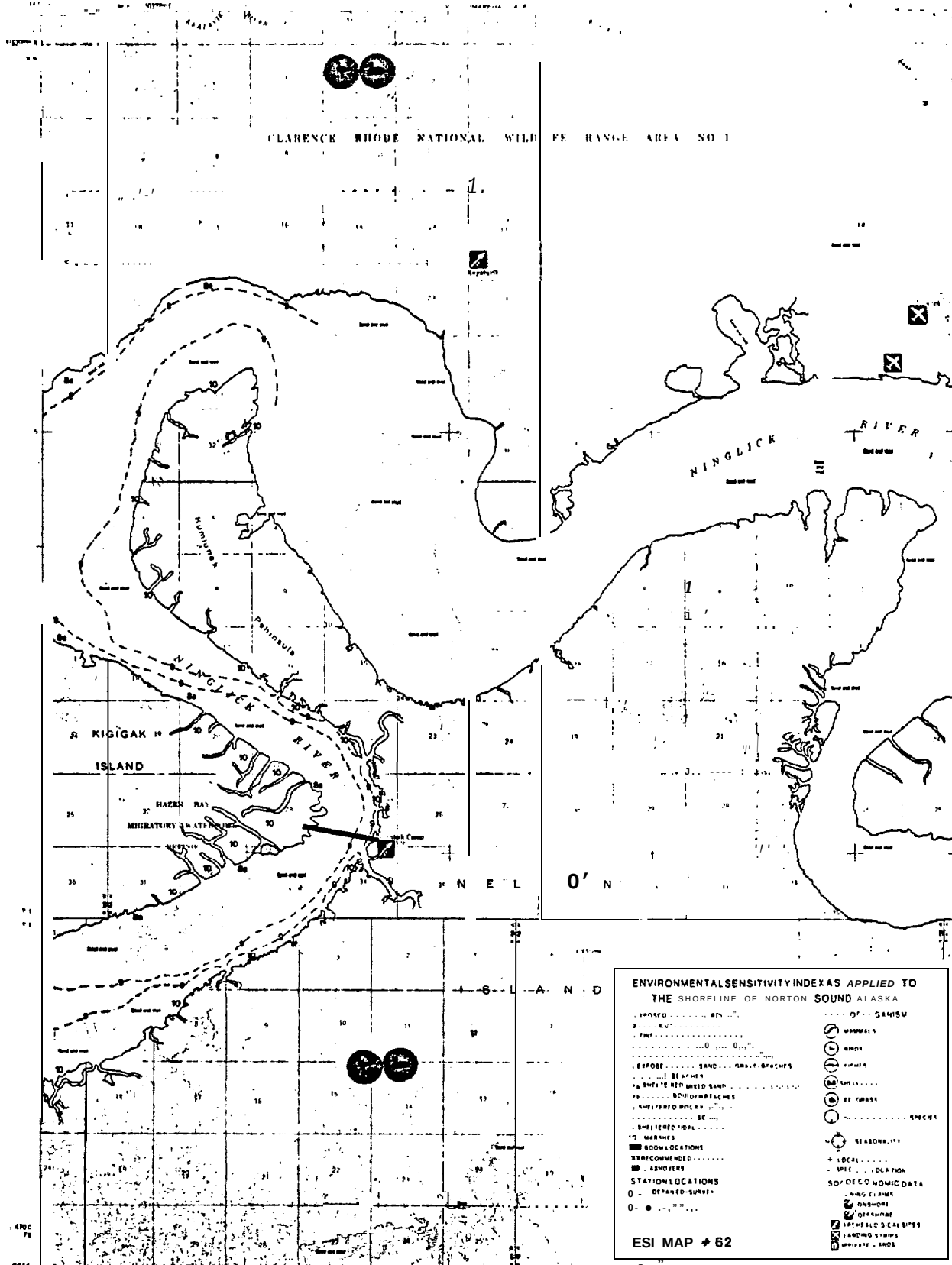
Univers: T_1 — protection 1927 North American datum
10,000 foot grid based on Alaska coordinate system zone 8
1000-meter Universal Transverse Mercator
Zone 3 shown in blue

Land lines represent unsurveyed and unsurveyed locations
determined by the Bureau of Land Management
Folio S-S, Second Edition

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NUNIVAK ISLAND (D-1), ALASKA
 440-151225



PRIMARY SOURCES OF BIOLOGICAL DATA
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MAMMALS: GUSTY (1978), GUSTY (1979), GUSTY (1980) and GUSTY (1981)
FISH: BARTON (1978), GUSTY (1979), GUSTY (1980) and GUSTY (1981)
PLANTS: GUSTY (1978), GUSTY (1979), GUSTY (1980) and GUSTY (1981)

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29204-1000

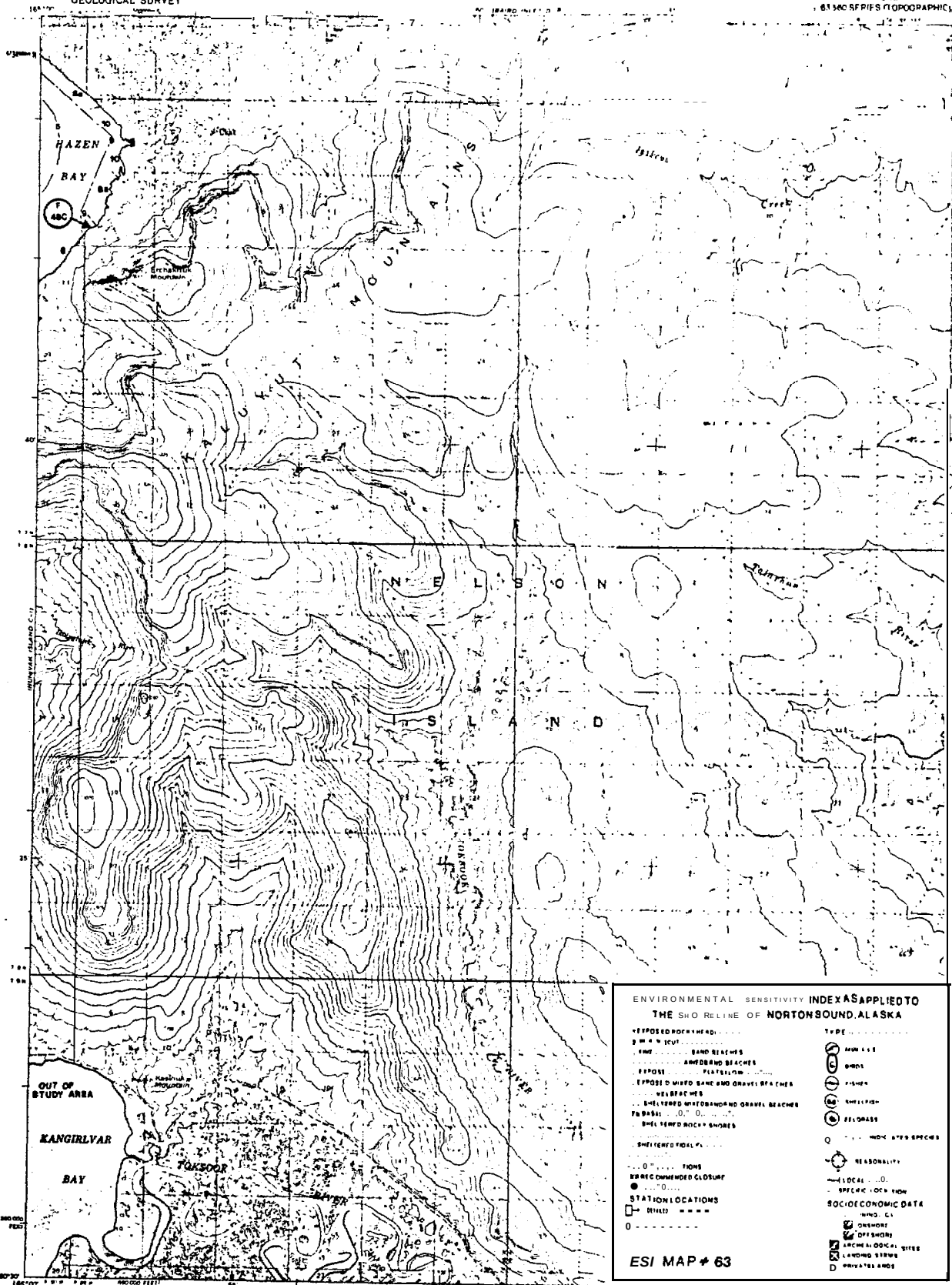
Map by the Army Map Service
Published by the Geological Survey
NORTON SOUND, ALASKA
Graphs by photogrammetry from aerial photographs
1957 field photos 1958 May not field photos
Universal Transverse Mercator projection North American datum
Zone 18N
1000 meter Universal Transverse Mercator grid
Zone 3 shown in blue
Land area measured and water area locations
determined by the Bureau of Land Management
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A. J. JONES (1976), J. J. JONES (1977), GUSTY (1978) and GUSTY (1979)

BAIRD INLET (D-8) ALASKA
1:50,000
1984

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

BAIRD INLET (C-8) QUADRANGLE
ALASKA
61 560 571 572 (TOPOGRAPHIC)

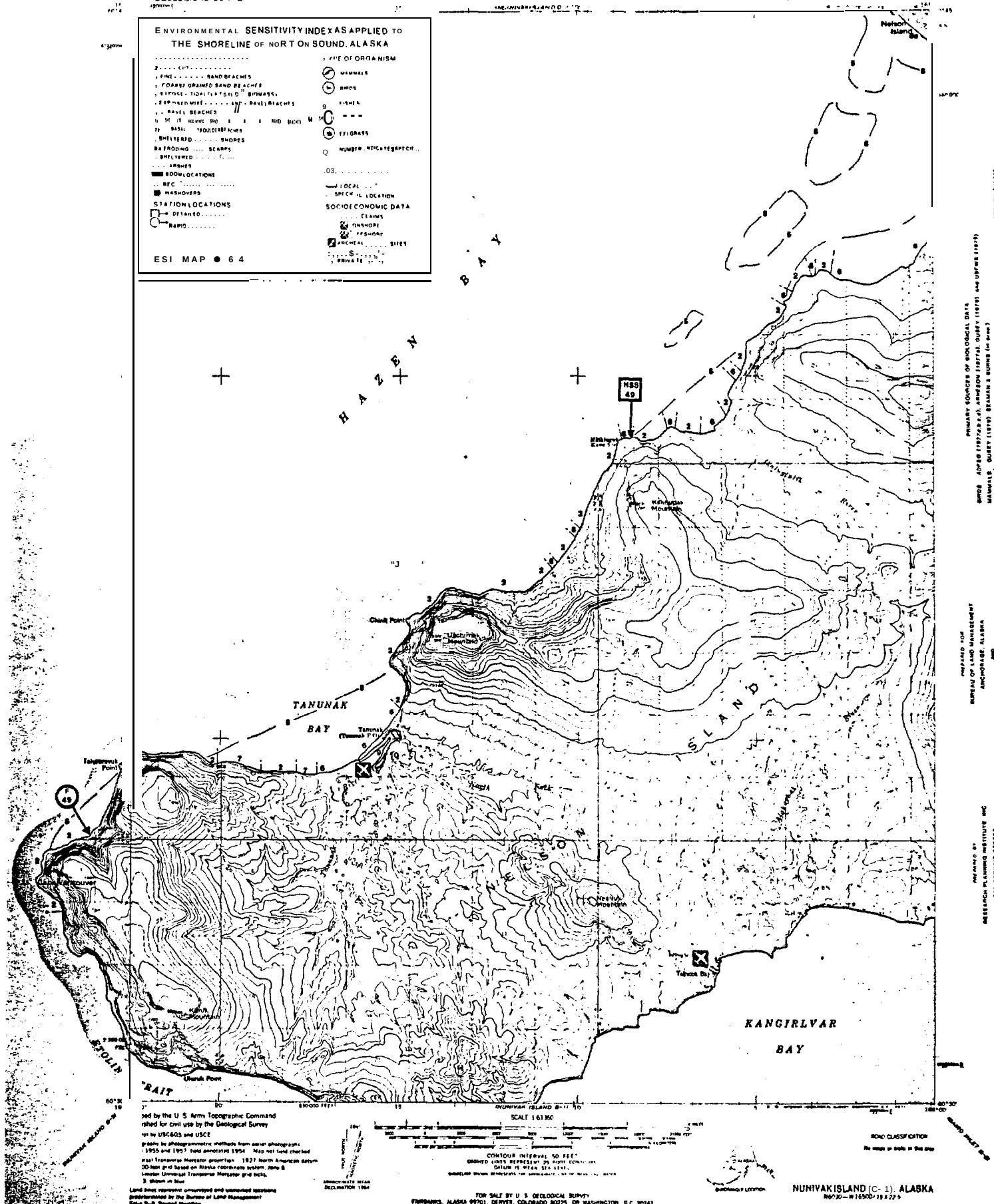


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NUHIVAK ISLAND (c 1) QUADRANGLE
ALASKA
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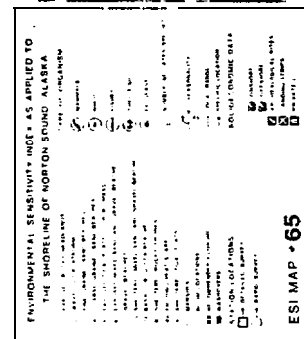


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NUNIVAK ISLAND (C-1), ALASKA
N 67°30' - N 165°00', 13 x 22 1/2

192



4. *Chloris* (L.) Trin. *Chloris* (L.) Trin. *Chloris* (L.) Trin.
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СОВЕТСКИМ ИНТЕРЕСАМ. ПОСЛЕДОВАТЕЛЬНОСТЬ
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СТВИЯМ, НЕ ПОДЛЕЖАЩИМ ОЦЕНКЕ С ТОЧКИ
ЗРЕНИЯ НАШЕЙ СТРАНЫ. ЭТО НЕ ДОПУСТИМО.
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