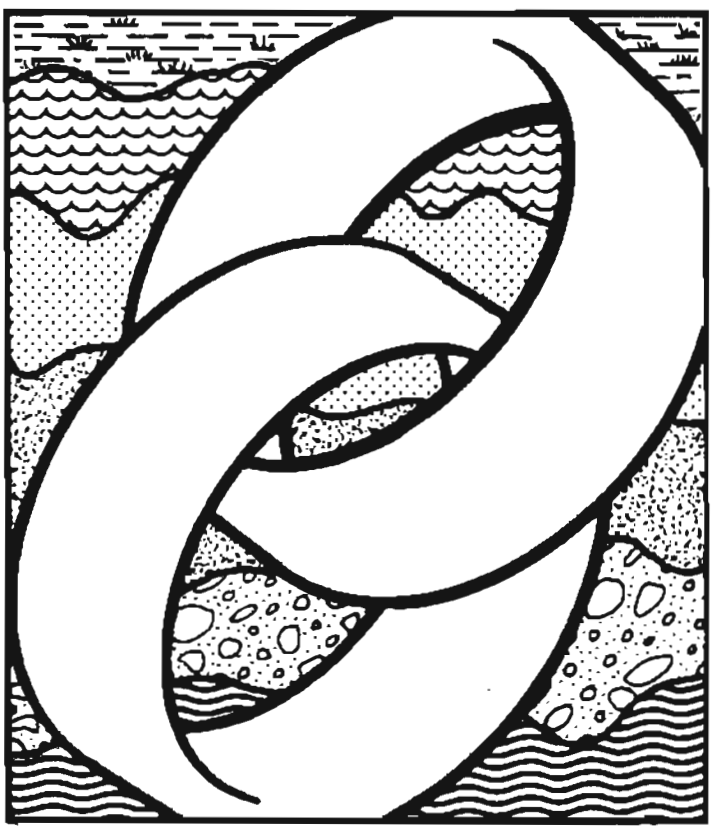
Proceedings of the 1989 Exclusive Economic Zone Symposium on Mapping and Research: Federal-State Partners in EEZ Mapping

U.S. GEOLOGICAL SURVEY CIRCULAR 1052



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MILLINGTON LOCKWOOD, National Oceanic and Atmospheric Administration, and
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A View of Sea-Floor Mapping Priorities in Alaska From the Mining Industry

Mark A. Bronston
Western Gold Exploration and Mining Company

INTRODUCTION

The shallow waters off the coast of Alaska, which are defined as water depths of less than 100 m, represent a tremendous potential resource for the exploitation of hard minerals from the seabed. The Exclusive Economic Zone (EEZ) Proclamation of 1983 provides the framework for exploring and commercially developing potential marine placer ore bodies.

The vast extent of the metalliferous regions known to be glaciated makes the task of focusing on the most prospective areas a difficult problem for industry. Although it is not the intent of this paper to suggest that Federal agencies should take an active role in proving ore reserves, it is in the interest of the United States to inventory the hard-mineral resources within the EEZ. In this regard, the mapping and the evaluation of potential offshore placer deposits within the EEZ should be a priority for the U.S. Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA).

This paper outlines the criteria necessary for the mining industry to prioritize those areas in the Alaska EEZ in which to conduct sea-floor mapping programs. Three specific high-priority areas are outlined, and recommendations regarding geophysical and drilling equipment, data processing, and resource evaluation also are discussed.

CRITERIA FOR EXPLORATION PRIORITIES

For the purposes of hard-mineral exploration within the Alaska EEZ, the areas of greatest economic interest have been selected by using the following criteria:

- Areas adjacent to known mineralized terrains on land.
- Areas where Quaternary glaciation would be the principal mechanism for offshore sediment transport.
- Areas that have water depths of less than 100 m.

The areas of primary interest, which fulfill the criteria outlined above are as follows, in order of priority:

- Offshore Nome on the southern coast of the Seward Peninsula.
- Offshore northeastern Gulf of Alaska from Cape Suckling to Cape Fairweather.
- The shelf area south of Kodiak Island and east of the Shelikof Strait.

AREA 1—OFFSHORE NOME

Near Nome, the area within a 6-mi radius of Anvil Mountain has produced approximately 5 million oz of gold from glaciofluvial and glaciomarine placers (Nelson and Hopkins, 1972; Cobb, 1984b). Glaciated areas east of Nome near Solomon and Bluff also have recorded significant gold production from placer deposits onshore. Figure 1 illustrates the known occurrences of lode and placer gold and platinum in the coastal regions of Alaska.

Since 1985, mining activity by Western Gold Exploration and Mining Company, Limited Partnership (West Gold), has verified the existence and the viability of glaciomarine gold placers offshore Nome within lands administered by the State of Alaska (Bronston, 1990). In excess of 100,000 oz of gold has been recovered from the seabed by the Mining Vessel *Bima* during the first full 3 production years of the West Gold operation.

The presence of economic gold concentrations in the offshore environment within the 3-mi State limit and the favorable potential for additional deposits in the adjacent EEZ make the Nome area from Cape Rodney on the west to Cape Darby on the east (fig. 2) the first priority for sea-floor mapping and exploration within the Alaska EEZ.

AREA 2—NORTHEASTERN GULF OF ALASKA

The presence of gold on the beaches from Cape Yakataga to Yakutat Bay has been documented since the early 1900's. Although relatively unexplored, regional bathymetric studies by NOAA indicate the area possesses a broad continental shelf that extends well into the EEZ. The adjacent coastal regions have been heavily glaciated during the Quaternary. Figure 3 illustrates the maximum extent of

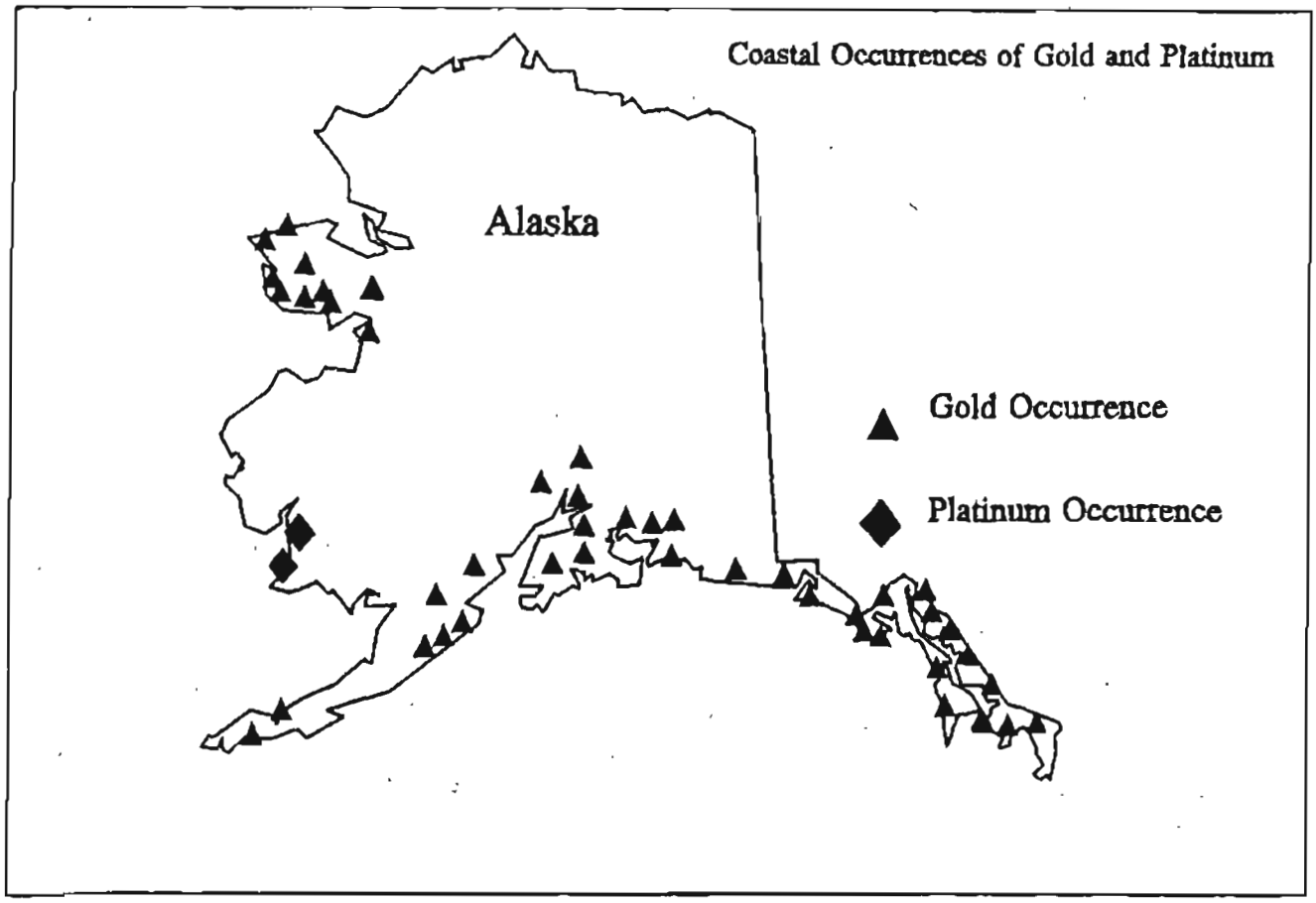

Figure 1. Coastal occurrences of gold and platinum. Modified from Cobb (1960, 1984a, b).

Quaternary glaciations in Alaska superimposed on the gold and the platinum occurrences in figure 1. The area from Cape Suckling on the northwest to Cape Fairweather on the southeast (fig. 4) is of particular interest for gold and heavy-mineral placers.

AREA 3—SOUTHERN SHELF OFF KODIAK ISLAND

This area is located on the Continental Shelf south of Kodiak Island and within the 100-m isobath (fig. 5). Although this area is virtually unexplored for its marine placer potential, it is included because of its proximity to potential epithermal lode sources in heavily glaciated terrain. Gold in beach sands has been reported in the Trinity Islands south of Kodiak Island.

The high-energy sea state and tidal forces may represent efficient physical processing conduits for the concentration of precious-metal and heavy-mineral placers. However, this area is known for its difficult sea conditions, which could make exploration and mining activities difficult logistically.

EXPLORATION METHODOLOGIES

In any sea-floor mapping program, the primary tools are geophysical; these are supplemented by drills and other sea-floor sampling devices for verification. The use of modern digital recording and signal processing equipment and techniques for high-resolution sea-floor mapping applications (Graul and others, 1989; Matthias and Newton, 1990) should become the mainstay of future USGS and NOAA mapping efforts. The following geophysical instrumentation should be utilized:

- Two- and three-dimensional, multichannel, high-resolution, digital, seismic surveys.
- Digital swath bathymetry.
- Digital sidescan sonar (Q-Mips).
- Digital 3.5- to 7.0-kHz subbottom profiling.
- Digital marine magnetometer.

All systems should be recorded in the appropriate industry standard format on media, which can be readily utilized by the public, such as nine-track magnetic tape, floppy disk, and CD-ROM. Line spacing should be regional in scope, and the emphasis should be placed on evaluating large areas of potential mineral-bearing sea-floor sediments.

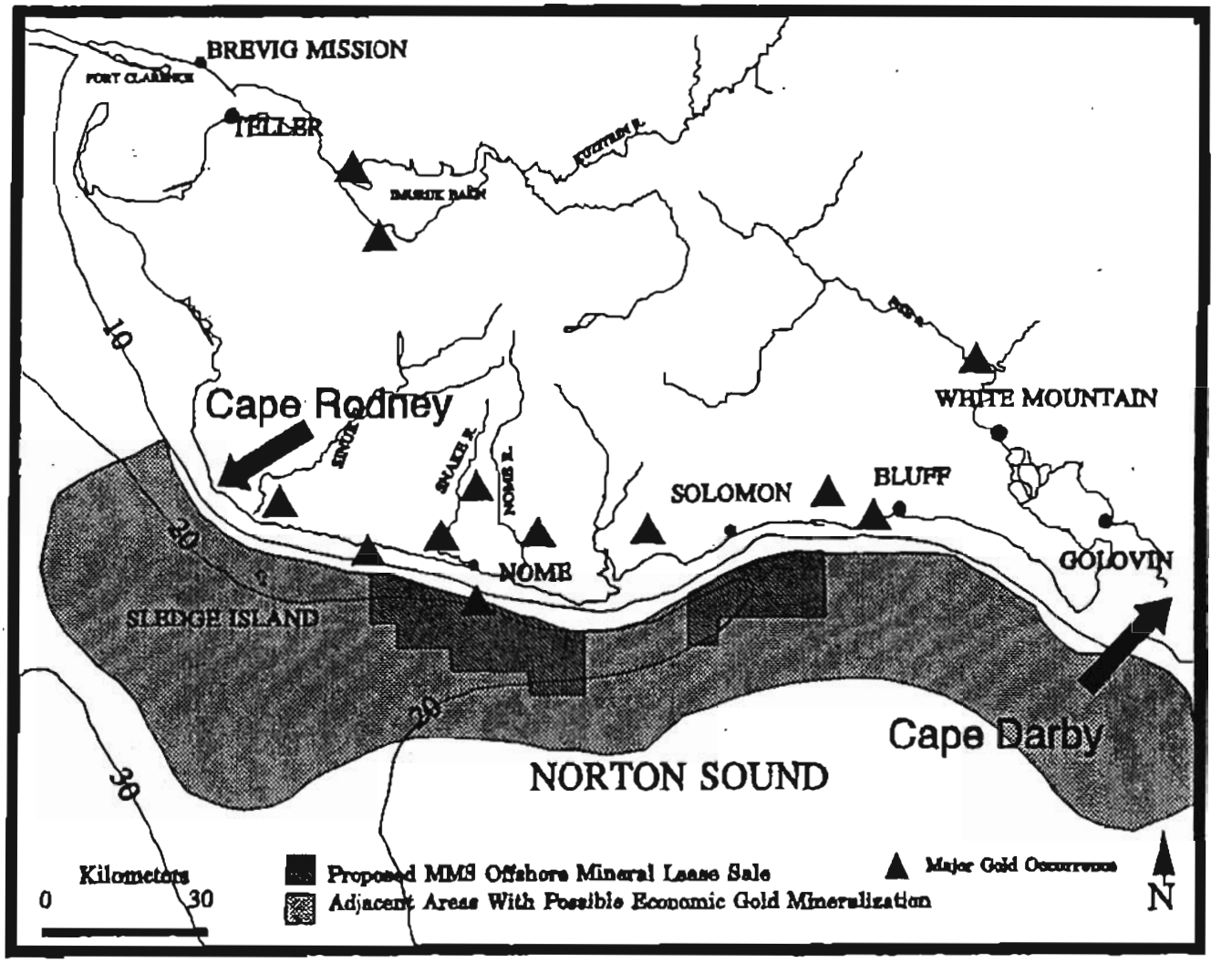

Figure 2. Nome priority exploration areas.

DRILLING AND SAMPLING

Following geophysical evaluations, prospective areas should be evaluated to determine the areal size, the grade, and the mineralogy of potential placer deposits. Sea-floor sampling programs may be reconnaissance in nature if a pipe dredge or a bottom grab sampling technique is used. Although these techniques do not provide a reliable point-specific grade of the deposit (as they are restricted to the relatively unconsolidated surface sediments), they do give a relative indication of the abundance of the mineral of interest in a given area. These techniques are quick and relatively inexpensive compared to offshore drilling programs.

In areas where sea-floor surface sampling indicates that a placer of considerable economic importance may exist, a drilling program is the most effective means of determining the three-dimensional distribution of the resource. Drill types that have been shown to be effective in sampling marine placers are as follows:

- The Becker hammer drill is used off the ice and in relatively calm, shallow water (Daily, 1969; Bronston, 1990). The Becker drill is particularly effective in glacial terrains that have indurated sediments and coarse sedimentary lithologies.
- The remote placer drill is used for reconnaissance and development drilling in rough seas and rocky substrates to a maximum of 6 m depth (Woolsey and Noakes, 1989).
- The vibracore is used in well-sorted sediments in deep water.
- The vibrahammer is used in coarse sea-floor sediments in deep water.

SAMPLE PROCESSING

Sea-floor samples collected during bottom sampling and drilling programs should be processed by using mining

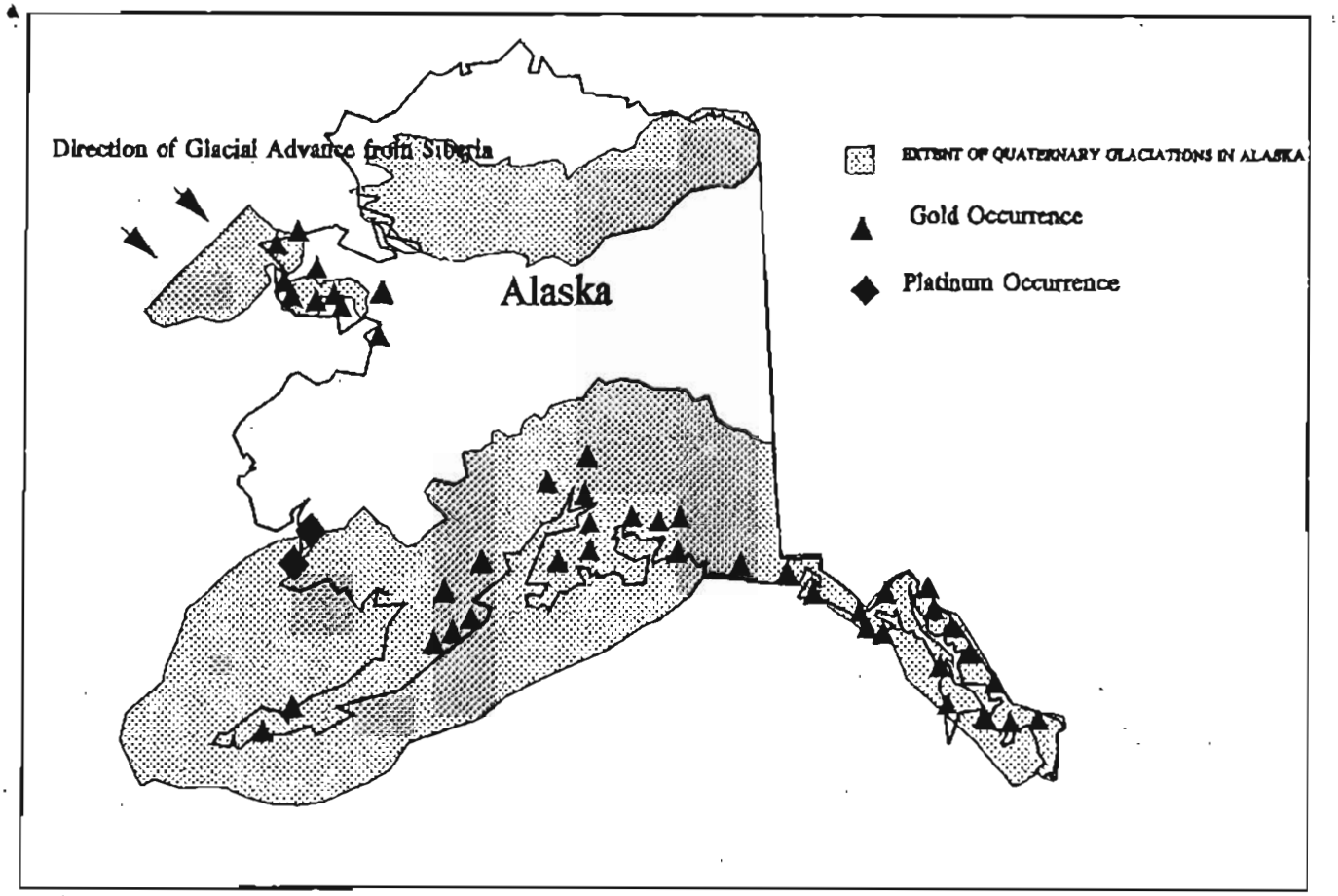

Figure 3. Maximum extent of Quaternary glaciations superimposed on gold and platinum occurrences. Modified from Cobb (1960, 1984) and Pewe (1975).

industry standard procedures. In particular, precious-metal-bearing placer sediments should be concentrated by using gravity separation techniques, and the gold particles counted, amalgamated, and weighed. Other analysis techniques, such as fire assay and atomic absorption, should be avoided because they do not accurately represent the grades that would be recovered by gravity methods on a mining vessel. Ore grades should be reported as metal content per standard unit volume; for example, in milligrams per cubic meter or ounces per cubic yard.

BULK SAMPLING

If a potential mineral deposit is discovered during exploration and resource evaluation programs and if it is of major economic significance, then a bulk sampling program may be invaluable in verifying the drill-indicated grades and the physical nature of the deposit. Bulk samples may be taken by using a hydraulic clam shell excavator mounted on a barge or by a robotic underwater miner; the latter is similar to the alluvial mining "tramrod" tested at Nome by West Gold in 1989. Bulk sampling programs, though expensive, will confirm the horizontal and the vertical grade distributions of the deposit and may be useful as prototype mining tests. A bulk sampling system should be interfaced with a gravity separation system similar to those used on commercial mining vessels so that accurate metal recoveries may be calculated.

CONCLUSIONS

The EEZ adjacent to Alaska represents a large potential resource for hard minerals that are concentrated in marine placer deposits. The mapping and the evaluation of these deposits should be a priority for the USGS and NOAA.

Geophysical and bottom sampling surveys should be conducted in areas adjacent to known mineralized terrains where water depth is less than 100 m and where glaciation would be the agent for the transport of metal-bearing sediments offshore. On the basis of these criteria, the areas offshore Nome, the northeastern Gulf of Alaska, and the shelf south of Kodiak Island should be of particular interest.

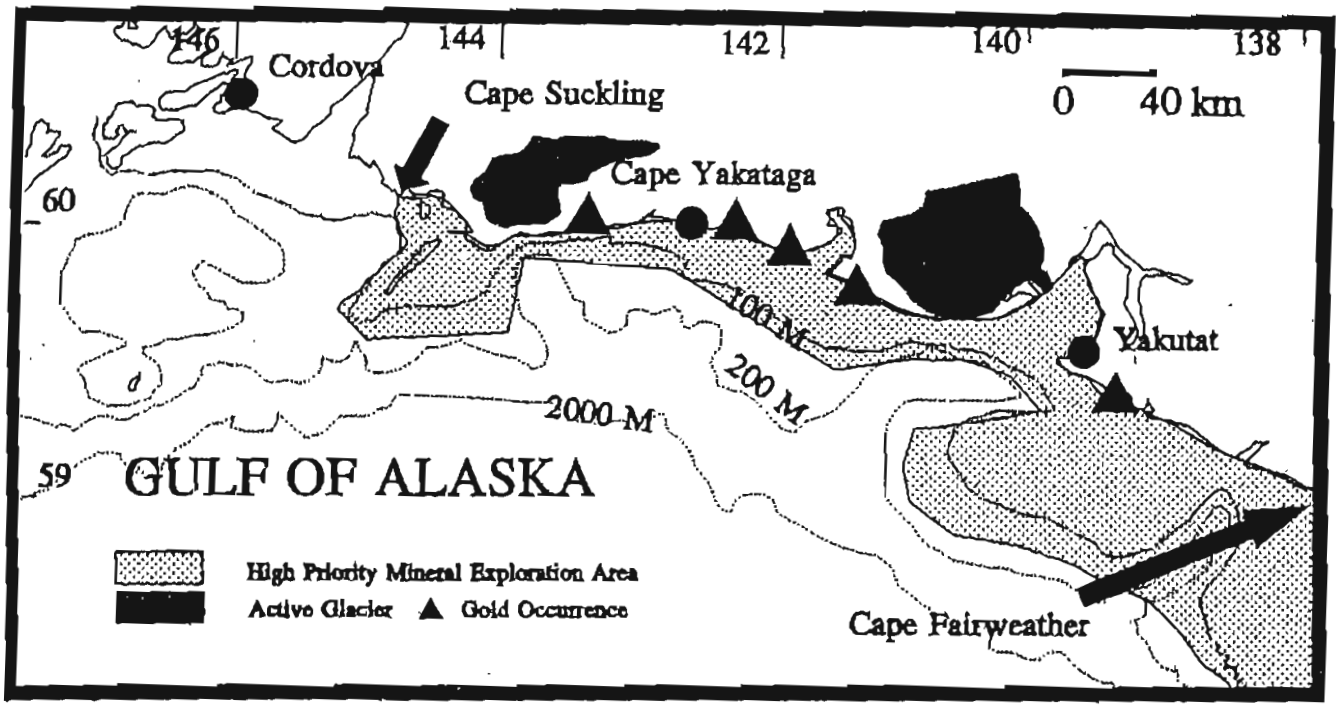

Figure 4. Priority exploration area for the northeastern Gulf of Alaska.

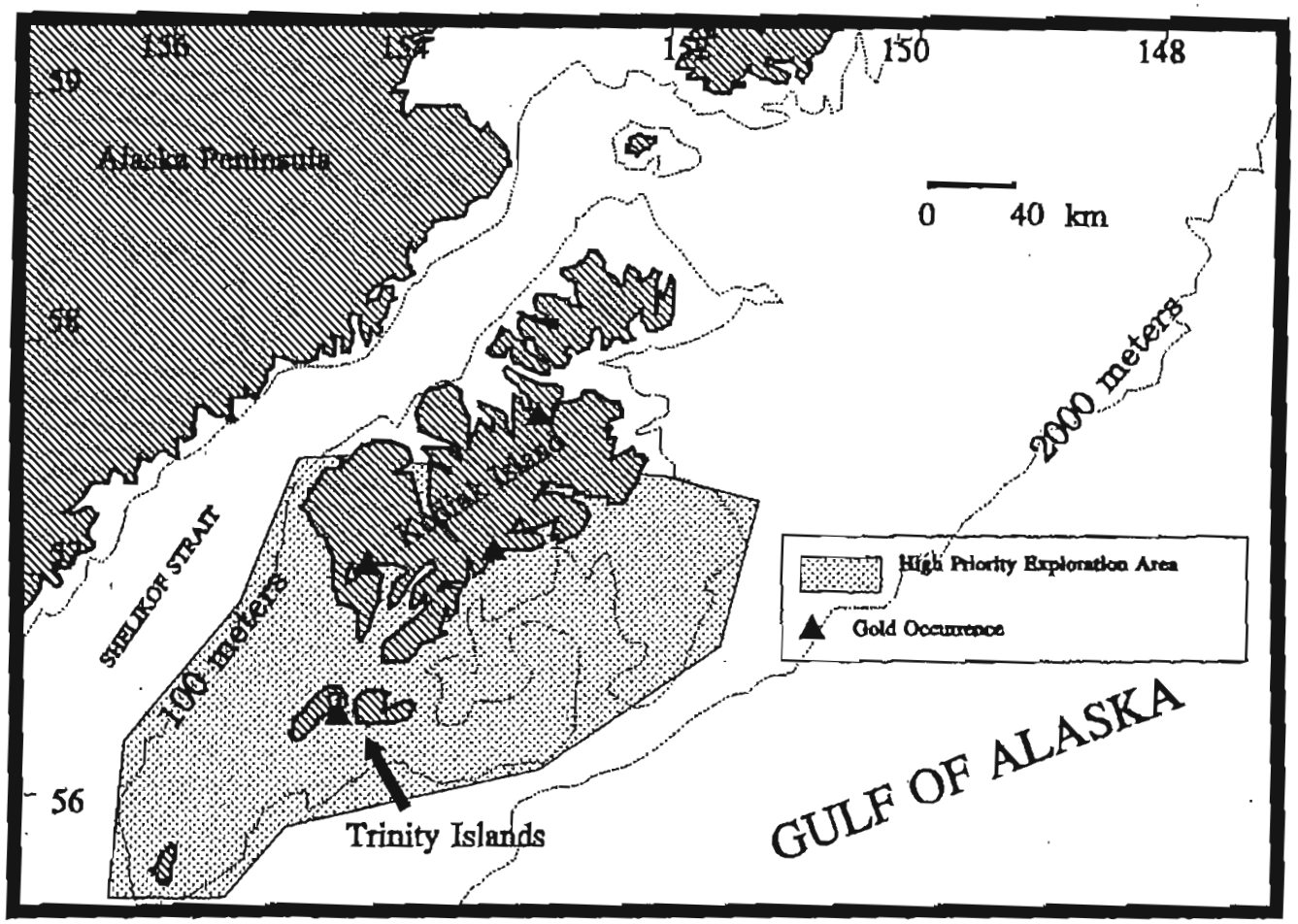

Figure 5. Priority exploration area for the Kodiak Shelf.

State-of-the-art, digital, geophysical, acquisition hardware should be utilized for reconnaisance surveys and followed by bottom sampling for verification. Deposits of potential economic importance should be drilled to define the extent of the resource and bulk sampled to verify drill-indicated grades. Evaluation of the resources discovered should be completed to standard mining industry specifications.

Following the criteria stated in this paper, a sea-floor mapping program in Alaska would establish an inventory of hard-mineral resources within the Alaska EEZ and would benefit the United States by expediting the development of hard minerals from the seabed, thereby decreasing our dependence on foreign supplies.

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Mapping Requirements for Planning the Outer Continental Shelf Mining Program Norton Sound, Alaska, Lease Sale

Irven F. Palmer, Jr.
Minerals Management Service

Abstract

Preparations are being made by the Alaska Outer Continental Shelf Regional Office of the Minerals Management Service to conduct the first Outer Continental Shelf Mining Program lease sale to be held anywhere in the United States—in Norton Sound. Past gold mining activity and the present prelease process, which is being coordinated with the State of Alaska, are discussed. The various mapping and graphics products used in preparation for the Norton Sound mining sale are emphasized. Future mapping needs along the Alaskan coast that would delimit the State-Federal boundary are presented.

INTRODUCTION

More than 4.5 million troy oz of gold have been recovered from onshore placer deposits in the Nome District since 1899. Most of the recovery was from strandline deposits, such as the modern beach at Nome or the ancient beaches further inland. The gold was initially eroded from lode deposits on the Seward Peninsula and reworked by fluvial, glacial, and marine processes. During the Pleistocene, advancing glaciers moved coarse gold particles onto the Continental Shelf of Norton Sound. Enrichment factors, such as marine scour and fluvial erosion, have reworked some of the gold from the glacial deposits into minable placers. Since 1986, gold ore has been dredged in State waters within the area covered by glacial deposits. The maximum annual recovery to date was 36,700 troy oz in 1987.

In the Federal Outer Continental Shelf (OCS), submerged beach ridges occur on the seabottom at depths of 21, 24, and 27 m. Buried ancient channels also are recognizable on seismic profiles. It is possible that enriched placer deposits similar to those mined onshore may exist in Federal waters. The distribution of glacial deposits is based on the mapping of surficial sediments and the interpretation of seismic profiles. Because subsurface samples from the OCS are sparse, there is little information on ore grade and ore-body volume in Federal waters.

On the basis of available data, the highest potential blocks in the proposed sale area are those closest to the gold-bearing glacial deposits offshore Nome. The 21- and 24-m beach ridges occur within these blocks, as well as buried channels that may contain gold eroded from the nearby glacial deposits. Following Inspiration Gold, Inc.'s, very successful 1987 offshore gold dredging season in State waters, it was a natural followup for them to begin planning the acquisition of more leases.

PRELEASE PROCESS

The process was initiated in November 1987 when Inspiration Gold, Inc., wrote a letter to the Assistant Secretary for Land and Minerals Management of the Department of the Interior requesting a leasing program for gold mining in the OCS near Nome, Alaska. (Since 1987, West Gold has succeeded Inspiration Gold, Inc., through reorganization of the company.) West Gold (and its predecessor companies) have conducted offshore gold-dredging in State waters near Nome since 1985. In anticipation of an OCS mineral sale, the Governor of Alaska, in a letter of November 1987, requested that the Secretary of the Interior establish a joint Federal-State task force similar to the one established in the State of Hawaii for similar purposes. The Governor requested a task force:

> ...to evaluate the feasibility of development of mineral resources in waters adjacent to our coast and to develop technical guidelines and procedures for the safe, effective, and environmentally sound exploration and mining of such resources...review of economic feasibility and look at information needs for EIS development...[and] identify renewable and nonrenewable resources that are present in Norton Sound and possible use conflicts.

The Secretary of the Interior responded to the Governor's request by agreeing to establish a Federal-State task force. The Secretary of the Interior designated the Director of the Minerals Management Service (MMS) to implement the program. The presale process bears some resemblance

to that for oil and gas sales, but there are some substantive differences in the leasing process and in the postlease operations as set forth in new regulations.

A Request for Information and Interest and a Notice of Intent to prepare an Environmental Impact Statement (EIS) was published. Nominations were received, and an area was identified on which to prepare an EIS, a draft EIS was published, and a public hearing was held. The remaining steps include a rewrite of the EIS after acquisition of new water-quality data, a proposed leasing notice, a review by the State of Alaska, the leasing notice, and the sale, probably in the first quarter of 1991.

STATE COORDINATION

Implementation of the program began with a meeting between the MMS and the State Division of Governmental Coordination staff to work out details for the Federal-State task force. It was agreed that the task force would be called the "Coordination Team," or CT. The membership list for the CT was finalized in February 1988—31 members from Federal, State, and local agencies and interest groups.

An agreement was signed between the MMS and the State of Alaska to transfer $120,000 to the State to cover expenses of staff from several State agencies attending six proposed meetings through the course of the prelease process and for time to review documents. From the beginning, the MMS envisioned the CT primarily as a forum for the exchange of information and a channel for comments on offshore mining policy formulation. The CT has been integrated into all major steps of the prelease process, including scoping, review of the draft EIS, review of the EIS rewrite, and so forth. The coordination process is continuing, and it is working.

MAPPING AND GRAPHICS

As stated above, preparations for the first OCS mining sale have proceeded along steps similar to preparation for an OCS oil and gas sale. The *Federal Register* Notice on the Request for Information and Interest and the Notice of Intent to Prepare an EIS was accompanied by a map of the Norton Sound area that was based upon Official Protraction Diagrams (OPD). The OPD maps depict a rectangular grid of potential leasing blocks approximately 3 mi on a side. On the basis of the Universal Transverse Mercator projection, the maps are at a scale of 1:250,000. These lease block diagrams are sold to the public for common planning purposes and are extensively used in all planning documents by the MMS (fig. 1). In addition, these OPD maps, which show the proposed sale outline, are used extensively as illustrations for all comments received and for correspondence.

Concurrently with the Request for Information and Interest, an in-house assessment of the potential mineral resource lease was being made by using available geological and geophysical information. In this case, seismic and borehole data from proprietary and U.S. Geological Survey sources were used. Figure 2 shows a submerged strandline and a subsea channel.

After the assessment, subbottom geomorphic features were mapped in relation to distribution patterns of particulate gold derived from sea-floor sediment samples. These maps were constructed to be compatible with the OPD's used to depict the proposed lease sale area (fig. 3).

During the scoping meetings, maps of the proposed sale area are used to portray known oceanographic and biological data and to record areas of special concern to local residents. During the writing of an EIS, these maps are refined and published as part of the EIS and provide the reader with essential information needed to clarify the text. Figures 4 through 6 are examples of maps in the draft EIS. The scale of the maps is adjusted so that the resource can be shown in relation to the proposed sale area and to accommodate the normal 8- by 11-in. EIS page size. Other examples of graphics used to supplement the EIS maps and text are shown in figures 7 and 8.

The MMS base map requirements are largely being met internally. The OPD maps are generated by the MMS's offshore survey group in Denver. The geological and geophysical data are generally received from OCS permittees at a scale of 1:96,000, or 1 in. = 8,000 ft. The various divisions and regions within the MMS then use a number of different computer mapping systems to change scales and manipulate the data. Computer-assisted design graphics applications are also in wide use within the organization.

Future plans call for the MMS to standardize its general-purpose mapping needs by adopting a geographic information system. Also planned are evaluations and feasibility studies for utilization of interactive computer work stations for manipulation of geological and geophysical data. Cartography and drafting throughout the organization are being upgraded to utilize the new computer-assisted design programs, such as AUTOCAD.

FUTURE MAPPING NEEDS

The State of Alaska and the MMS regularly conduct oil and gas lease sales along the coastal zone of Alaska. In addition, the State has ongoing offshore mining, and the MMS has an offshore mining sale in progress. At many places along the Alaskan coast, especially to the west and the north, nautical charts either are out of date or have inappropriate scales. A vigorous coastal zone mapping program to delimit salient points for establishing the State-Federal boundary would be of great help to the State of Alaska and the Department of the Interior. Present and

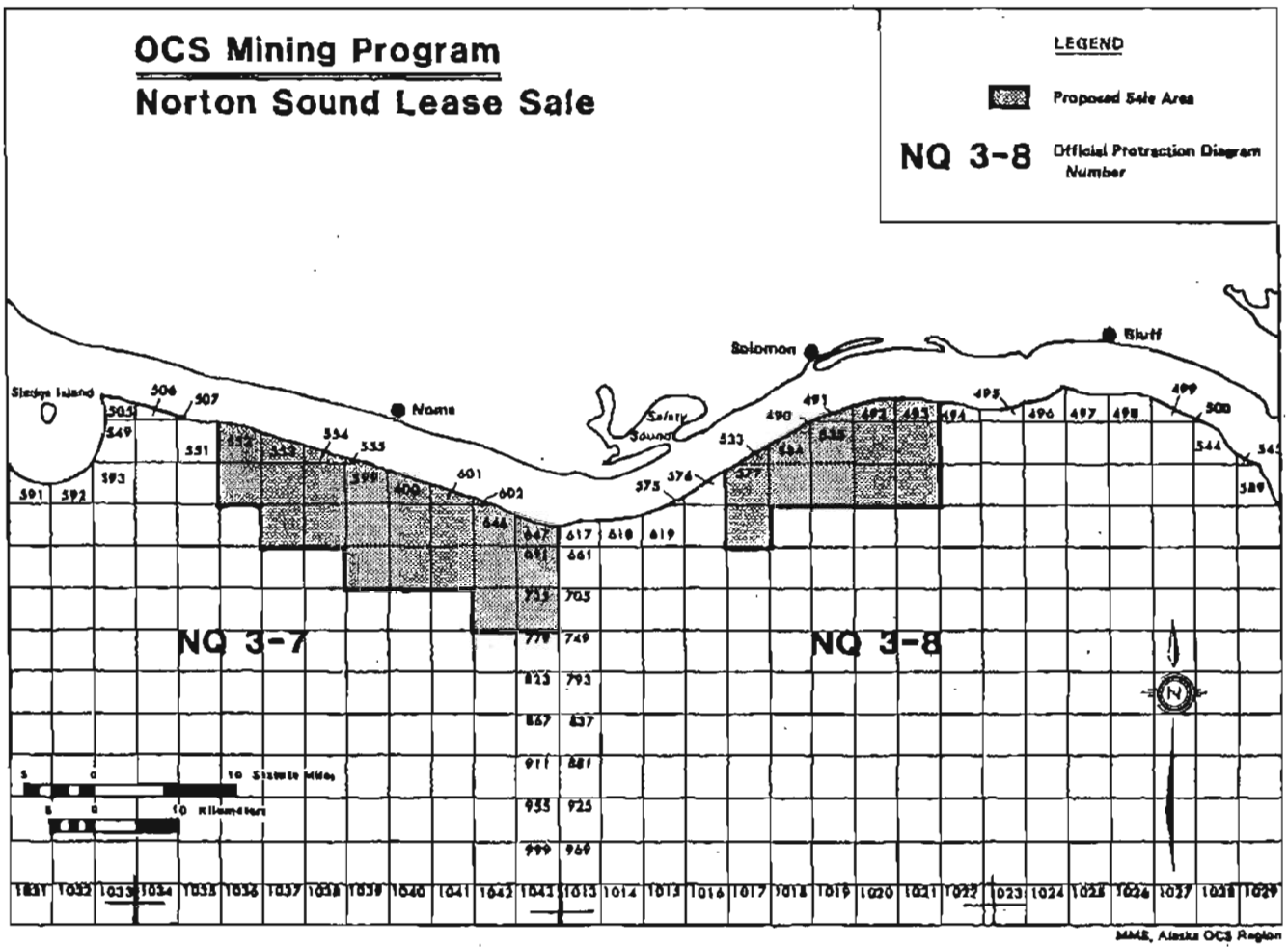


Figure 1. Lease block locations for the Norton Sound area.

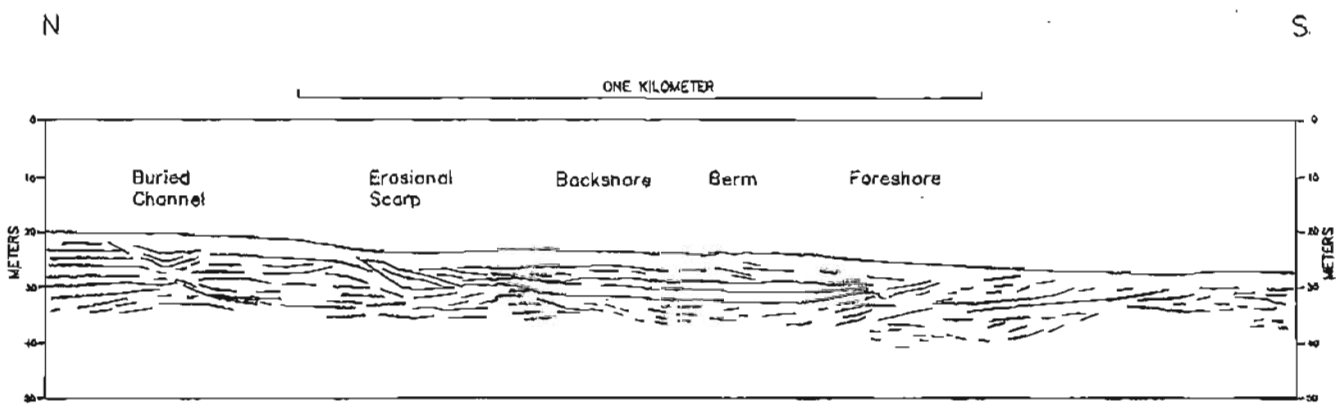


Figure 2. Line drawing of seismic profile across the 24-m beach from the survey conducted in 1976 by the U.S. Geological Survey. The beach deposits are probably 5 to 6 m thick at the berm and nearly 1 km wide.

future offshore leasing schedules should be used to set priorities for this work. At this time, it appears that the Alaskan shoreline areas should be surveyed in priority order, as depicted on figure 9.

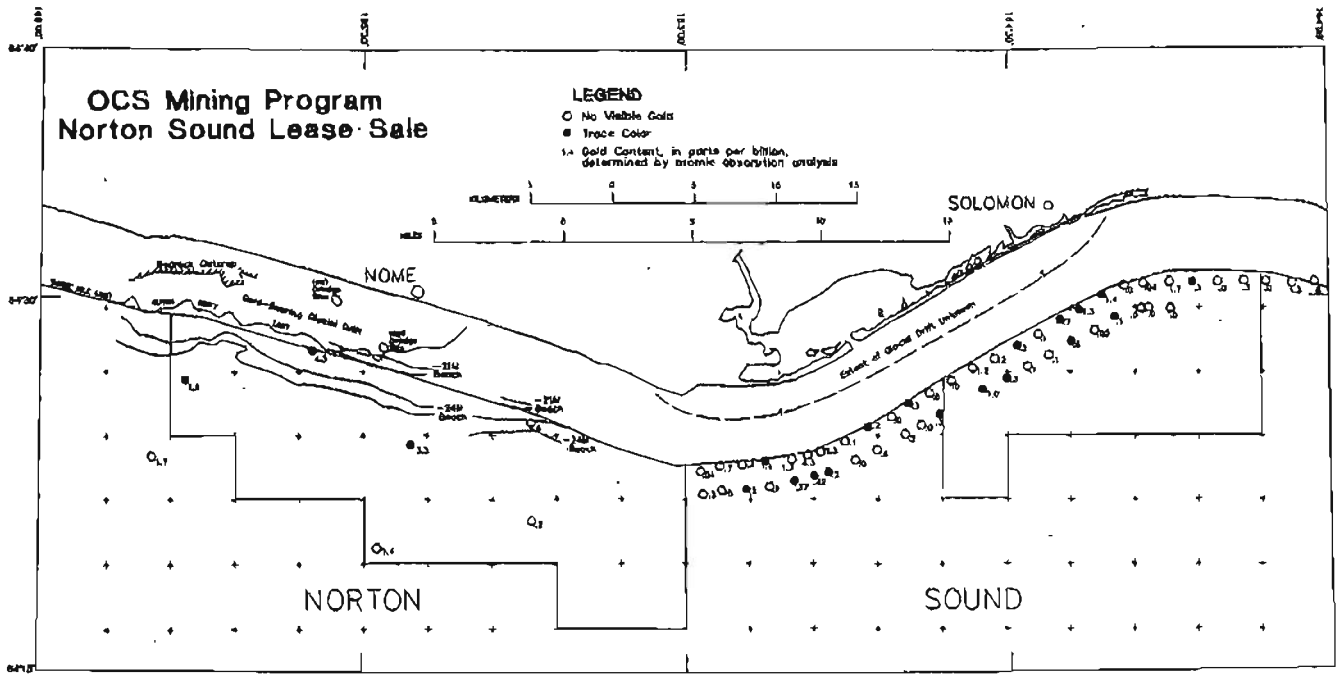


Figure 3. Distribution of particulate gold in sea-floor sediment samples beyond the 3-mi limit; modified from Nelson and Hopkins (1972). Location of submerged beach ridges and gold-bearing glacial drift; from Tagg and Green (1973).

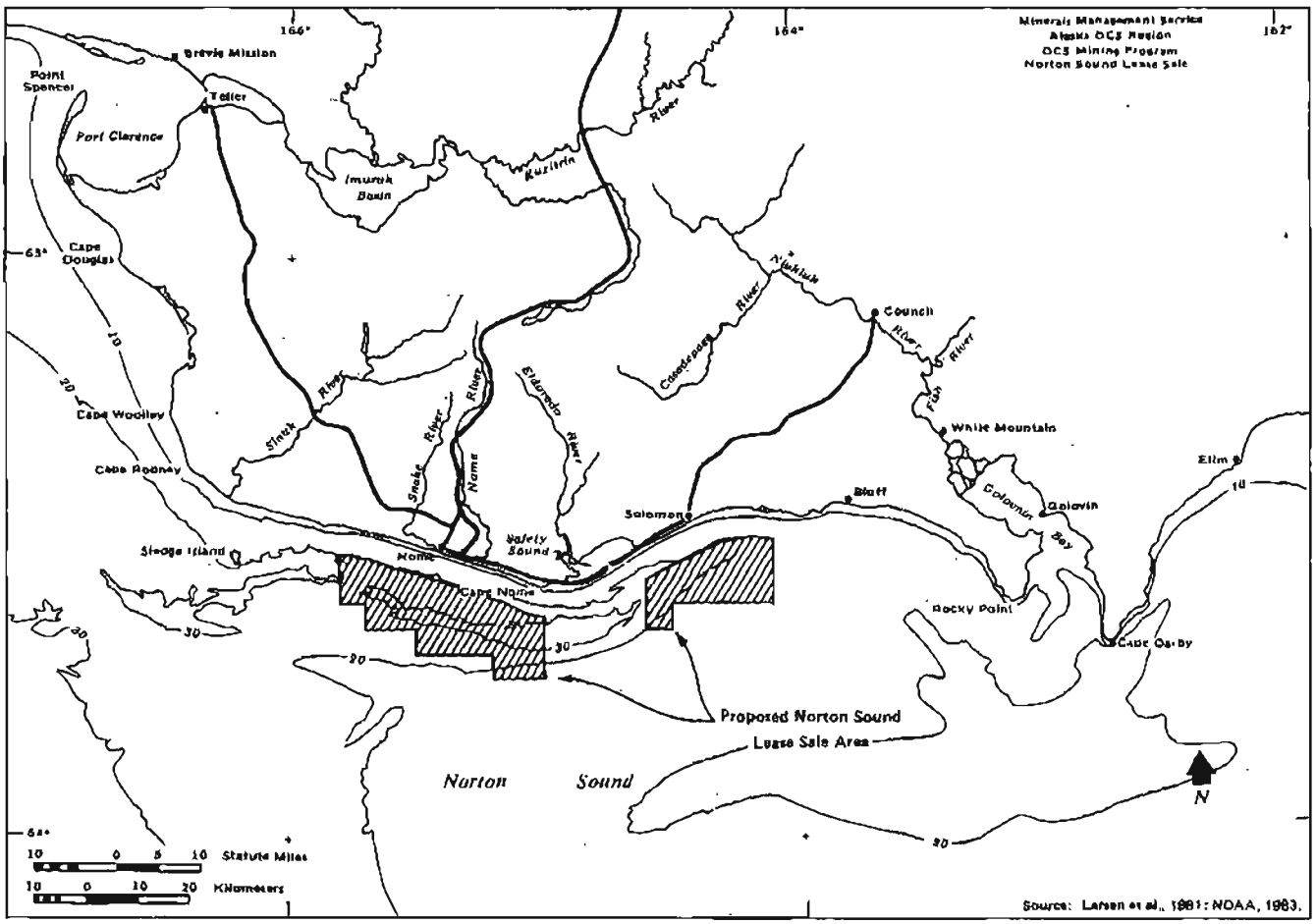


Figure 4. Generalized bathymetry (in meters) of the Norton Sound area.

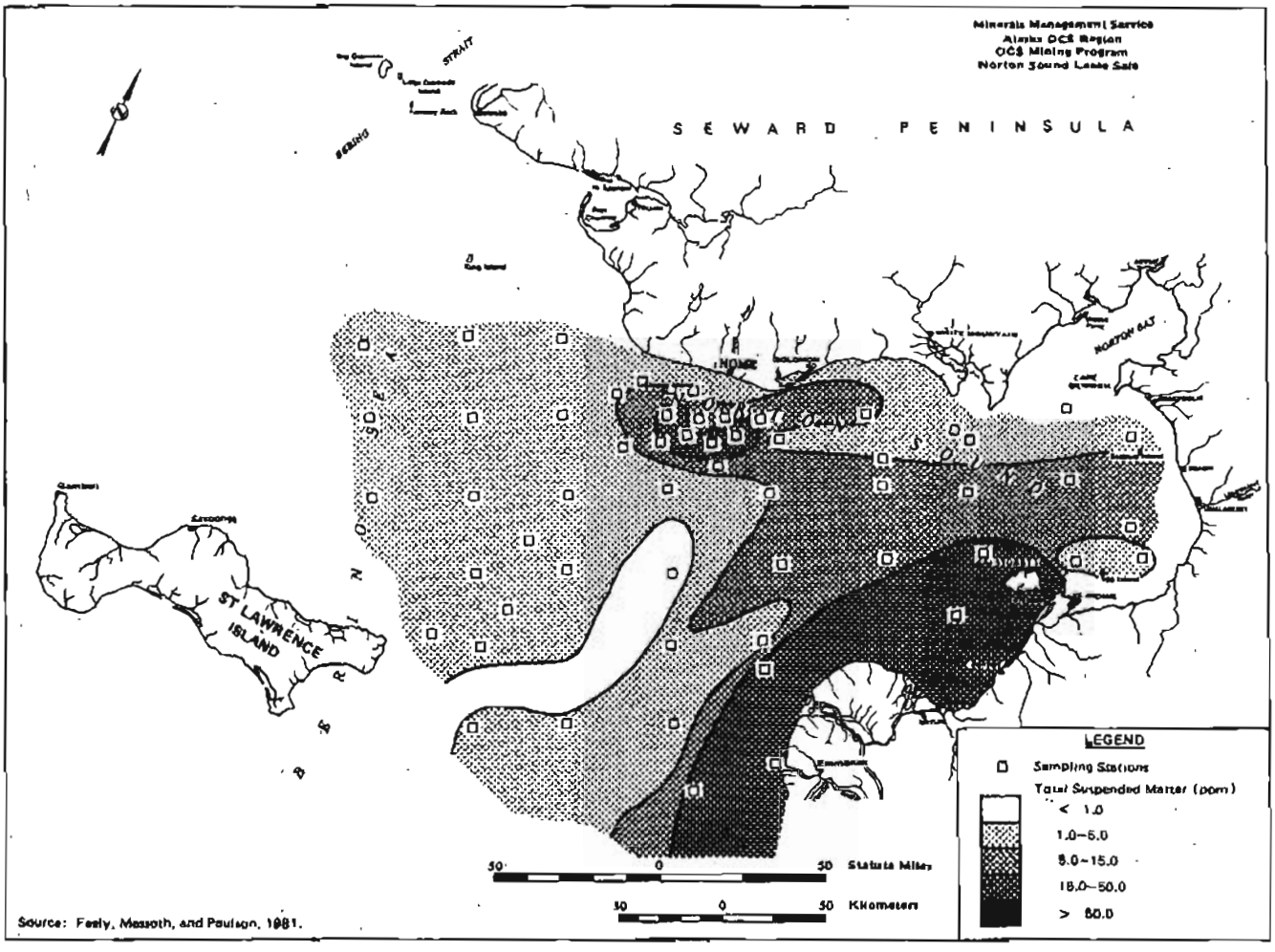


Figure 5. Distribution of suspended matter at 5 m above the bottom in Norton Sound, July 7–18, 1979.

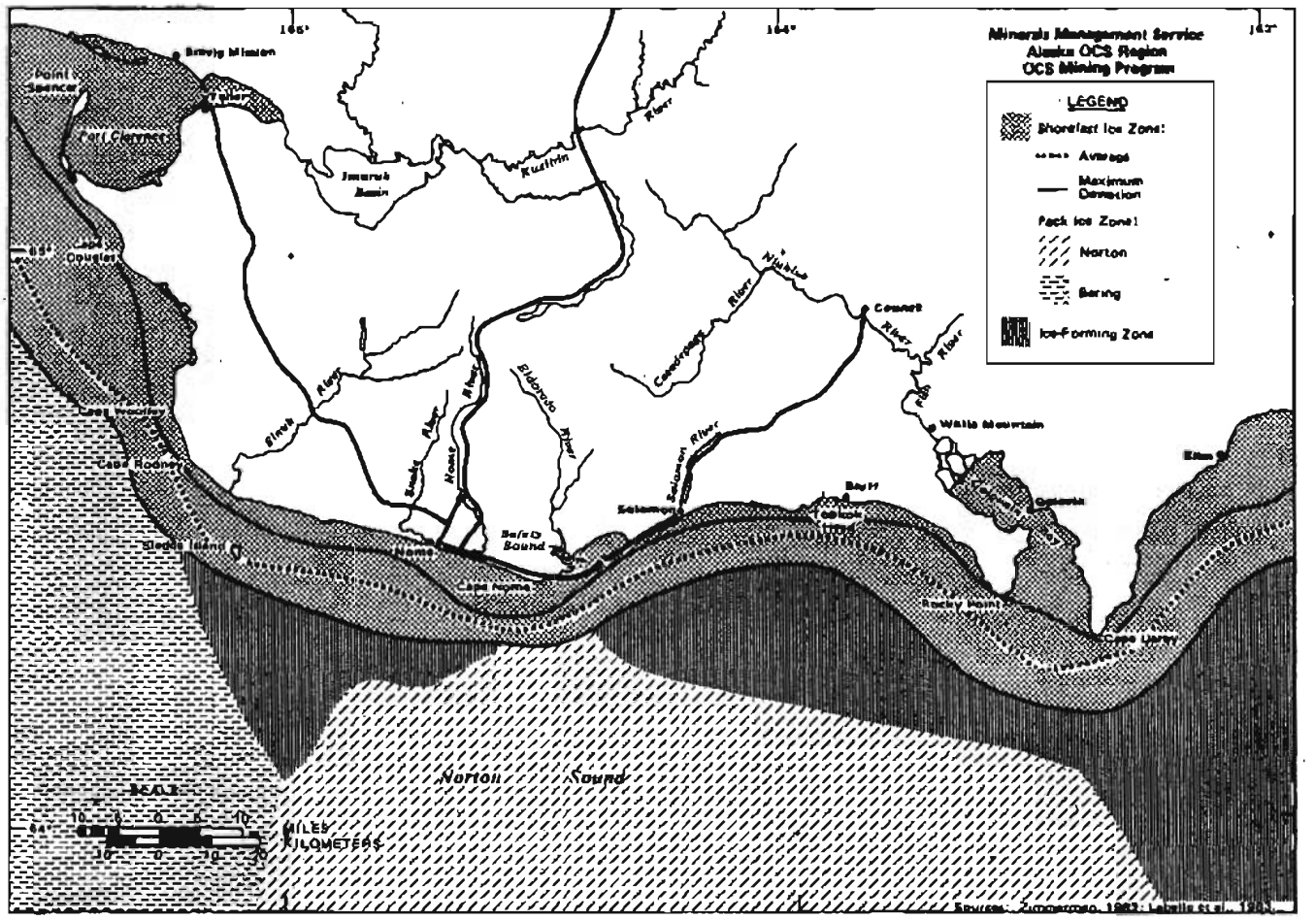
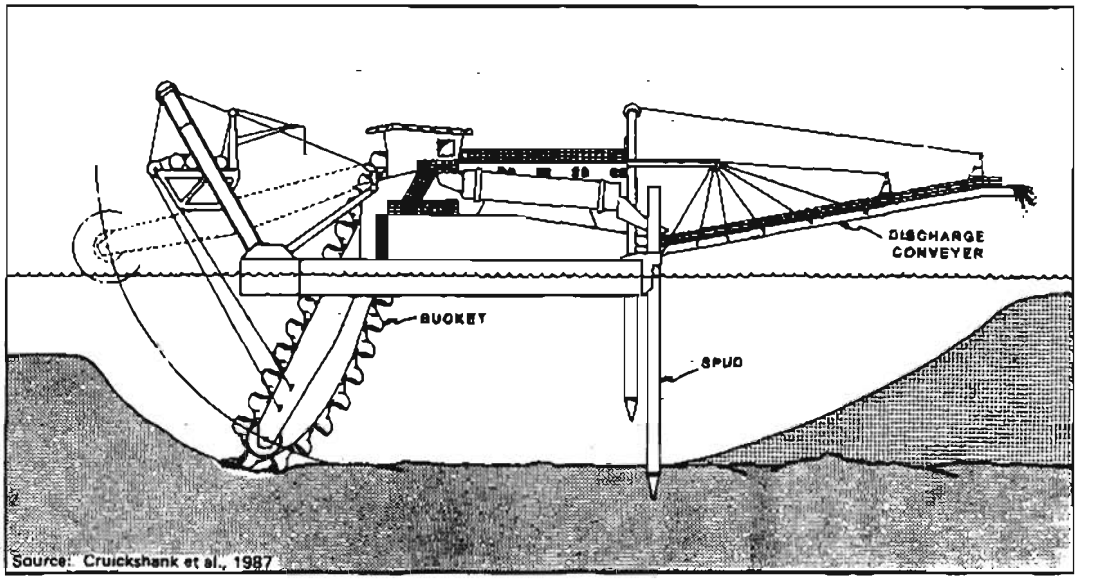


Figure 6. Sea-ice zonation in Norton Sound.



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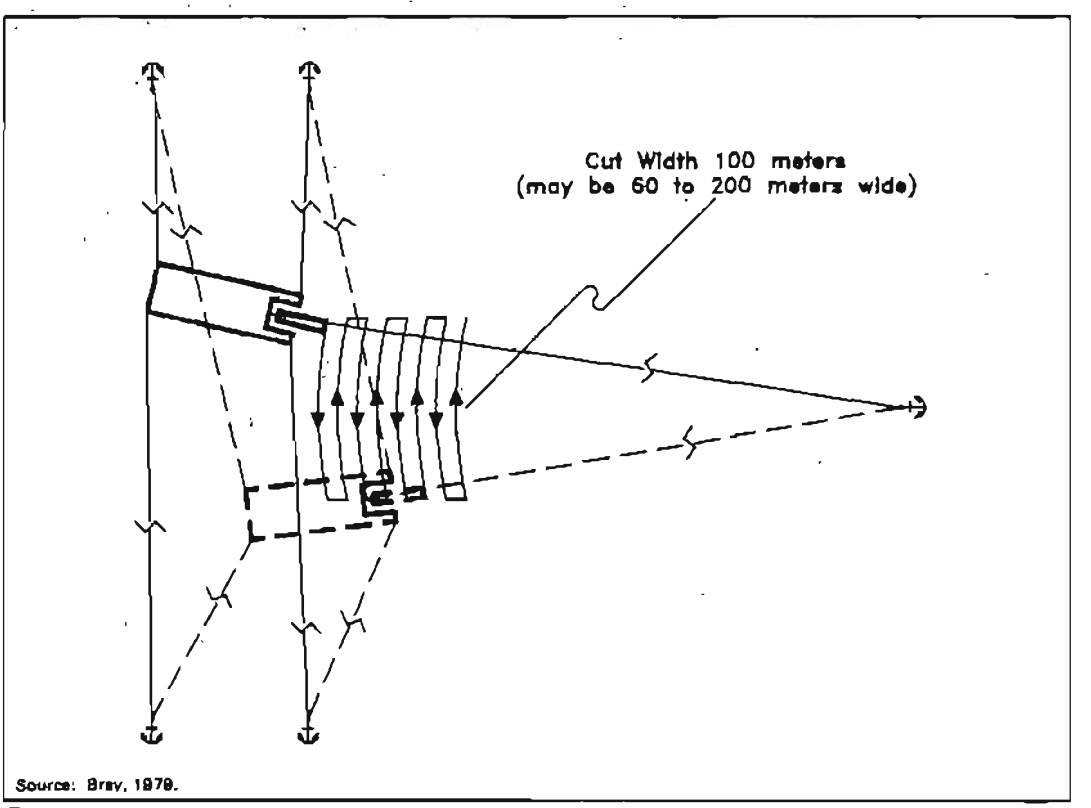

B

Figure 7. Bucket ladder dredge. *A*, Gold mining in sheltered waters. Note: Spuds are used to control dredge movement in shallow waters. Anchors would be used to control dredge movement in the deeper, more exposed waters of the lease sale area. *B*, Operations.

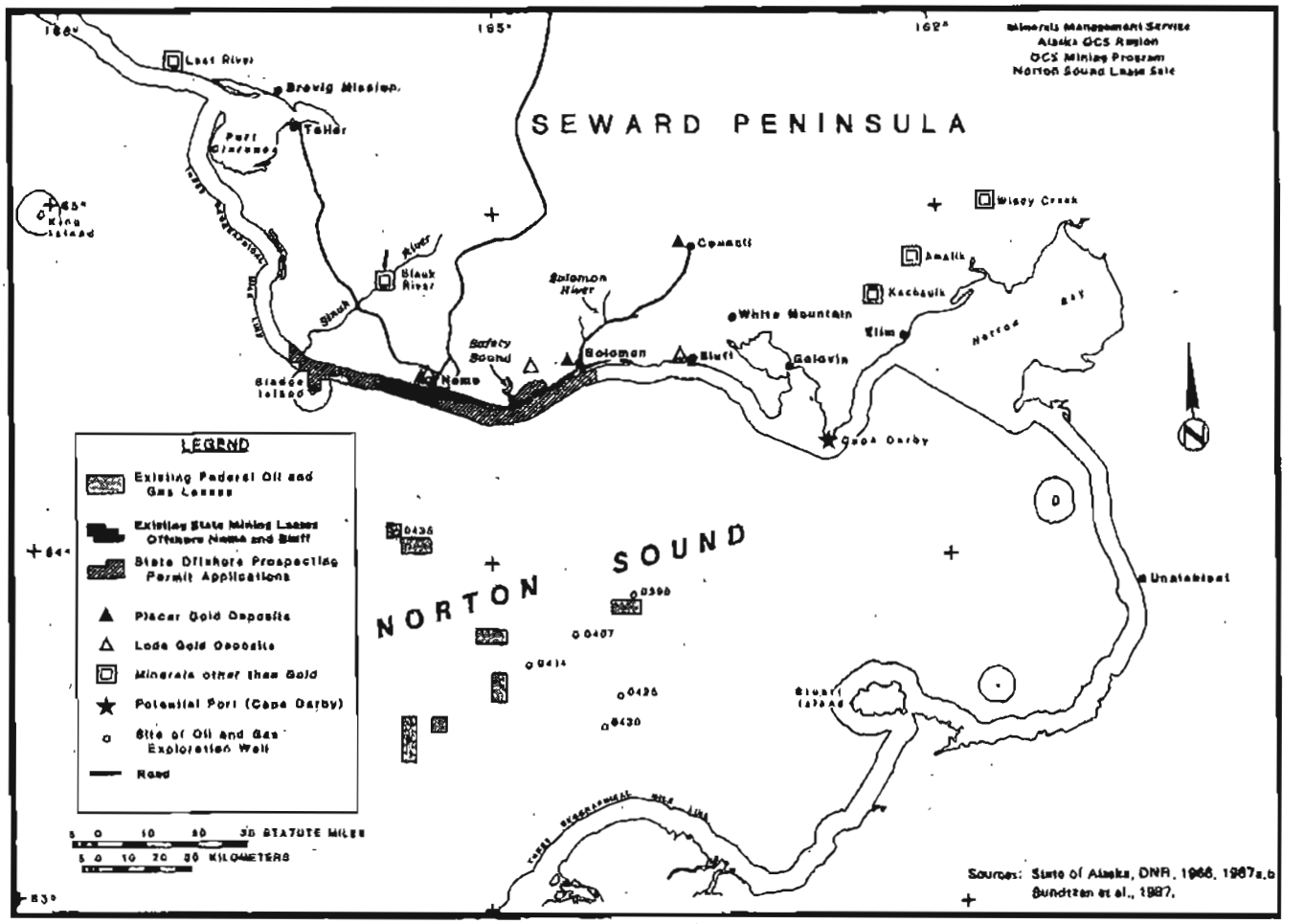

Figure 8. Activities and significant mineral deposits in the Nome area that are included in the cumulative case.

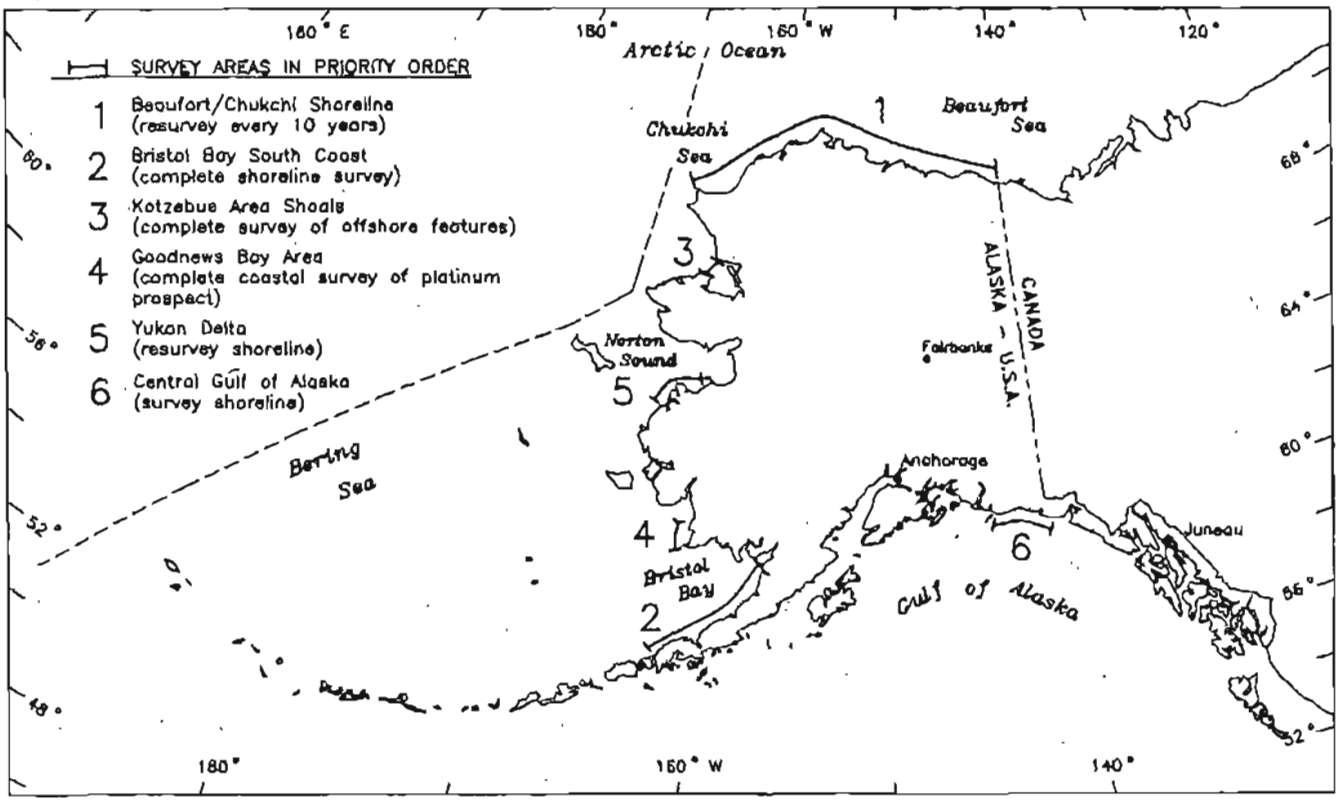

Figure 9. Recommendations for National Ocean Service 10-yr plan, survey priorities for Alaska Federal-State boundary needs.

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