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THE ENVIRONMENTAL GEOLOGY AND GEOMORPHOLOGY OF THE GULF OF ALASKA COASTAL PLAIN AND THE COASTAL ZONE OF KOTZEBUE SOUND

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Project Title: The Environmental Geology and Geomorphology of the Gulf of Alaska Coastal Plain and the Coastal Zone of Kotzebue Sound

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I. Task Objectives of Kotzebue Sound Project:

A. To produce three maps, with explanations, which will display certain baseline data necessary for an environmental assessment of the regions. The maps will be constructed from various types of remote sensing data.

1. Environmental geologic map of the entire forelands from Cape Prince of Wales to Cape Lisburne which will include the lowlands of the Kobuk Delta, the Noatak Delta, and the Kotzebue Moraine.

2. A coastal landforms map of the region identifying and describing important geomorphic features.

3. A map which indicates potential tectonic and geomorphic harzards.

B. To produce a report on the unique geologic setting of the Kobuk Delta indicating the possible effects (beneficial and adverse) of petroleum related development in the area. .

C. Direct the acquisition of remote sensing data of the area for Cannon, Hayes and other investigators.

D. Construct a mosaic of the area of sequential LANDSAT data for Cannon, Hayes, and other investigators.

E, Construct an annotated mosaic of the "area from SLAR imagery.

II. Introduction:

Environmental "geologic data must be displayed in spatial format if a realistic evaluation is to be made of an area. If changes are induced, natural environments respond in all dimensions. Therefore, components of natural environments must be displayed in a spatial framework which portrays

their degree of physical association. This makes it necessary to display environmental information on maps, because point values cannot convey a complete indication of the degree of interface between components, This is important if predictive model studies are to be made of the area. Sequential information is needed if rates and magnitudes of change are to be included in an environmental evaluation. This demand of sequential observations makes it necessary that the most neoterical data be obtained of the area of investigation.

A geomorphic history is based. on the construction of a chronology of geomorphic events. Spatial information and sequential observations of large portions of the coastal zone is necessary in order to construct a chronology. Landforms are the products of the manner in which the energy of geomorphic agents (such as wind, water, and ice) is expended upon terrestrial materials. Since geomorphic agents interact to various degrees at or near the earth's surface, a variety of landforms can be generated in almost any locality. Landforms are, therefore, a record of the geomorphic agents which have dominated or are presently dominating the patterns of energy interchange at some point on the earth.

The assemblage of landforms and the geomorphic processes which are effected, as a result of the creation of the assemblage, form that which is termed "the environment" of a particular area on the earth's surface. The identification of a landform or of an assemblage of landforms provides information about the environment which can be used to evaluate the natural history of the environment and to appraise the impact of induced changes.

III . Current State of Knowledge:

The Chukchi Sea Coastal Forelands from Cape Prince of Wales to Cape Lisburne have been studied by several people during the last thirty years. However, most of these investigations were related to sea level fluctuations and the archeological imporance of the Bering Land Bridge. There are two outstanding collections of data about the area: 1) Wilimovsky, N. J., and Wolfe, J. N., 1966, eds., Environment of the Cape Thompson region, Alaska: U.S. Atomic Energy Commission; 2) Hopkins, D. M., 1967, cd., The Bering Land Bridge: Stanford University Press. Both of these books contain abundant point data about the region. The Chukchi Sea Forelands are quite deserving of intense study because they exhibit a complex history of sea level fluctuations. This history is unique because both tectonic and eustatic changes in sea level are recorded. The record exists because the geomorphic processes which usually destroy the indicative features in *a* short time are retarded by the effects of the arctic winter.

IV. Study Area:

The Chukchi Sea Forelands consist of geomorphic features that show regular deposition is occurring in some areas, while intense erosion is occurring in other areas. A nearly complete range of depositional or erosional features appears to exist between the extremes.

The forelands are divided into four geomorphic divisions for this investigation. The four divisions are: 1) Lisburne Headlands, 2) Kivalina Coastal Complex, 3) Kotzebue Sound, and 4) Shishmaref Barrier Island-Beach Systems,

The northern most division is the Lisburne Headlands which extend south from Cape Lisburne to Kilikralik Point. Erosion is so intense in this division that it is dangerous to work in the area because landslides (rockfalls) can be observed daily.

The Kivalina Coastal Complex includes the stretch of coast from Kilikralik Point southeastward to Cape Krusenstern. The major geomorphic features of this division are Point Hope, Cape Thompson, Kivalina Lagoon, and Cape Krusenstern.

The Kotzebue Sound division includes several major geomorphic features which border the Sound. Starting at Cape Krusenstem and going clockwise around the Sound, the major geomorphic features are Sheshalik Spit, Noatak Delta, Baldwin Peninsula, Hotham Inlet, Kobuk Delta, Eschscholtz Bay, Goodhope Bay, and Cape Espenberg. This range of features indicates that the geomorphic history of Kotzebue Sound is quite complex. Kotzebue Sound itself is a shallow, sediment-filled embayment. The major portion of its sediments come from the Kobuk and Noatak Rivers. Minor contributions of, sediments come from the Selawik and Buckland Rivers.

The southernmost division is the Shishmaref Barrier Island-Beach System. This division extends southwestward from Cape Espenberg to Cape Prince of Wales. The major geomorphic features are the large lagoons and inlets, and the sheltering chain of barrier islands. Abandoned beach ridges and the volcanic maars of the Devil Mountain area are minor, but nonetheless important geomorphic features.

v. "Sources, Methods and Rationale of Data Collection:

The following lists the data sources and the methods planned to produce the products:

1. Evaluate existing literature and correspond with on-going projects in the area.

2. Search for and interpret any existing raw data on erosion and deposition.

3. Comparison of sequential mapping of coastal areas.

4. Photogeologic interpretations of low-altitude aerial photography.

5. Comparison of sequential LANDSAT imagery.

6. Geomorphic interpretation of radar imagery.

7, Low altitude aerial reconnaissance, this is very important part of ground truth measurements and map unit verification.

8. Identification of major shoreline processes.

9. Evaulation of historical records,

10. Identification of the materials which comprise the shoreline features.

11. Field observations and measurements of shoreline changes from previous and current studies.

12. Interpretation of the shoreline morphostratigraphy.

13. Compilation of a landforms map of the region.

14. Compilation of an environmental geologic hazards map of the region.

15. Compilation of a shoreline stability map.

16. Construction of an environmental energy flow model for the region.

17. Analysis of the future effects of natural processes and man-induced effects.

The preceding statements are an outline of an approach to meet the scientific objectives and establish information which is to be displayed or discussed in the products. The initial step is to make a temporary identification of the existing landforms. The second step therefore is to verify the landform identification. The landform verification is approached by utilizing the principles of the concept of multiple working hypotheses. In some cases the landform verification will necessitate ground reconnaissance. The verification of other landforms may call. for a regional look at the geomorphic system. Often in geomorphology the answers are found outside of the area of specific interest. A delta quite often reflects factors that exist in the watershed of the streams at points somewhat removed from the delta itself. Therefore just looking at the delta itself will never answer all the questions. Directions of sampling, evaluation, and interpretation continually change as information is collected and exchanged.

VI. Results:

A. Low-altitude, color IR photography was acquired of the area by NOS. This is excellent photography and should provide a tremendous amount of useful information to P.I.'s other than Cannon and Hayes. The archaeologists, biologists, and oceanographers in the OCS program can view this photography at the Geophysical Institute, University of Alaska, Fairbanks.

B. Five overlapping strips of radar imagery were acquired of the Kobuk Delta, Single strips of radar "imagery were also acquired of the coastline from Cape Prince of Wales to Cape Lisburne.

c. Because of the range in types of landforms and intensity of geomorphic processes in the area of investigation, the study area was divided into four main geomorphic divisions (see section IV. Study Area).

D. Wave action in the larger lagoons is intense enough to generate longshore currents within the lagoons. The longshore currents have sufficient energy to transport materials and are therefore reshaping shorelines inside the lagoon.

E. Ice effects appear to be minor along the shorelines.

F. Lakes appear to form as a function of time in programing shorelines. The suspected process is dewatering and subsequent compaction of unconsolidated materials.

G. Prior to the 3 meter rise in sea level some 4,000 years ago, the Noatak and Kobuk Rivers had built a delta between Sheshalik Spit and Baldwin Peninsula. The drowned distributary channels of this delta apparently influence the present flow of water from Hotham Inlet and the Noatak River into Kotzebue Sound.

VII . Discussion:

The need for neoteric data of the coastal zone was satisfied with the acquisition of radar imagery and low-altitude, color and color IR aerial photography of the area. LANDSAT imagery of the area was acquired covering the time span of 1972 through 1975. There exists LANDSAT imagery of both break-up and freeze-up seasons.

In order to facilitate discussion and mapping, the coastal zone is divided into four geomorphic divisions. Figure 1 shows the two northern divisions, the Lisburne Headlands and the Kivalina Coastal Complex. The Lisburne Headlands is the smallest of the four divisions. However, within this division the most intense erosion is occurring.

The Kivalina Coastal Complex exhibits a large range of features and processes. Materials are eroded from the Cape" Thompson area and distributed in both directions along the coast from the Cape. As the result of "Project Chariot", Cape Thompson and the Kivalina Coastal Complex have been documented in great detail (Wilimovsky and Wolfe, 1966). Since most of the field work for "Project Chariot" was done seventeen years ago, it is being used as a reference to geomorphic changes for this investigation. Raised shorelines in this division attest to a long history of shoreline changes (Hopkins, 1967). Throughout this division the barrier islands in front of the narrow lagoons all show features caused by washover during storms . Both fan deltas and washover rills occur on the lagoon side of the

barrier islands, The washover materials (mainly gravels) are pocked with numerous depressions, five to thirty centimeters deep and twenty to one hundred and forty centimeters across. These features are microkettles formed by the melting of ice under the washover materials. The ice is from chunks tossed up by storms and from the formation of the kaimoo. Kaimoo is the name given by the Eskimo to the ice and gravel rampart formed at the onset of winter on the surface of the beaches. The kaimoo has a significant effect on coastal processes because its formation marks the end of effective wave action on the upper part of the beach.

Point Hope is presently being built out on the south side by sediments from Cape Thompson. The north side of Point Hope is, at present, only being maintained with sediments carried off of the apex of the point and with minor sediments from the Kukpuk River. The effects of recent undercutting and erosion are exhibited along most of the north side of the point. The unconsolidated materials of Point Hope apparently rest on a broad wave-cut bench of bedrock.

In the southeastern part of this division are various geomorphic features which indicate that the Noatak River at one time emptied into the Chukchi Sea, at the present site of Killikmak Creek, twenty-five kilometers north of Cape Krusenstern. Tectonic uplift blocked the flow of the Noatak River and created a large lake in the depression where the village of Noatak is located. The lake was breached to the south and the present outlet of the Noatak River was established. The dates of these events are not yet clear to this investigator. However, the abandoned shorelines of the lake might provide artifacts which would help date the events.

After the establishment of the Noatak River outlet into Kotzebue Sound (the third geomorphic division), the Noatak and Kobuk Rivers jointly built a large delta between the Baldwin Peninsula and Sheshalik Spit (Figure 2). About 4,000 years ago *sea* level rose nearly three meters and the delta was submerged. The outline of the delta can be clearly seen on the bathymetric charts of the sound. The flow of water from the Noatak and Kobuk Rivers is presently still influenced by the distributary channels of that submerged delta. This can be seen on the LANDSAT imagery in Figure 3.

The last rise in sea level drowned the lower Kobuk River valley and created Hotham Inlet and the large lakes that branch off it. Sequential data indicates that the large lakes are increasing in area, probably due to the melting of permafrost by the incursion of sea water.

The fourth geomorphic division, the Shishmaref Barrier Island-Reach System (Figure 4) differs from the other geomorphic divisions in several aspects. One outstanding aspect is that the beach materials are mainly sand, whereas on the other beaches, gravel predominates. Geomorphic features indicate major transport of materials towards the ENE and storm waves have built large washover fan deltas into the lagoons.

References

Hopkins, D. M., cd., 1967, The Bering Land Bridge: Stanford University Press.

Wilimovsky, N. J., and Wolfe, J. N., eds., 1966, Environment of the Cape Thompson region, Alaska: U.S. Atomic Energy Commission.

VIII . Conclusions:

Due to the retarding effect of the Arctic climate some geomorphic features (such as old shorelines and deltas) have been uniquely preserved. The delineation of past shorelines and deltas will perhaps indicate potential archaeological sites.

The coastal zone exhibits a large range of geomorphic features and within the coastal zone the interaction of major geomorphic processes is complex. Due to this complexity, consideration of environmental problems and potential developments within the coastal zone will have to be done on a location by location basis. Environmental assessments must be made by geomorphic divisions with special attention being given to specific features within the divisions.

Ix. Need for Further Study:

A. The formation of lakes as a function of time in beach materials.

B. The compaction or consolidation of sediments in the region.

c. The relative chronology of major geomorphic events.

D. The draining of lakes in some specific areas.

E. The potential effects of *wave* action in large lagoons.

F. The stability of the large deltaic features.

G. The natural future evolution of the region.

x. Summary of 4th Quarter Operations:

A. Began preparation of first draft of maps.

B. Continued interpretative analysis of remote sensing data.

C.,. Participated in OCS Beaufort/Chukchi Sea synthesis meeting at Barrow.

D. Made preparations for pre-break-up and break-up ice studies.

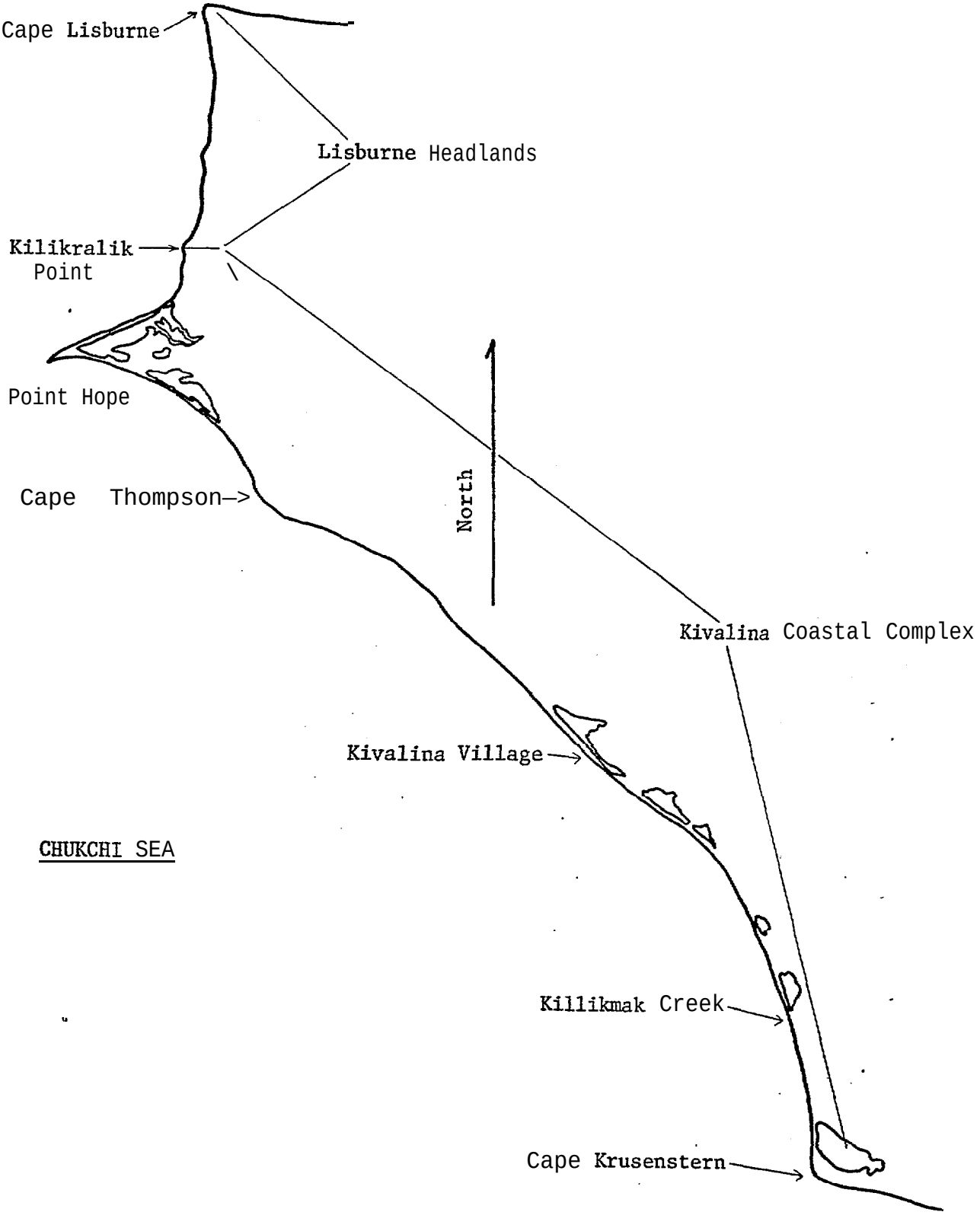

Figure 1. Major features of the two northern geomorphic divisions, the Lisburne Headlands and the Kivalina Coastal Complex.

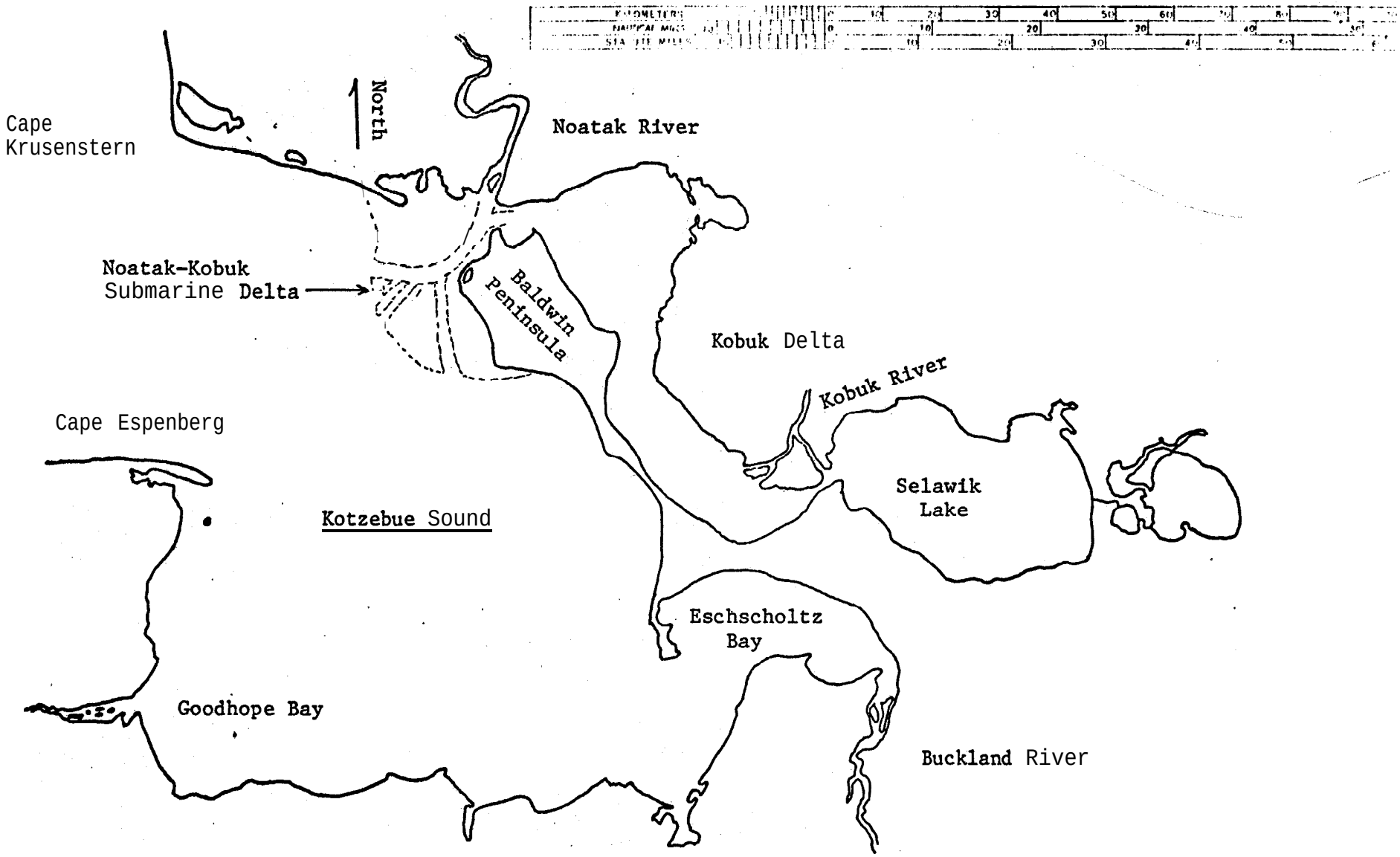

Figure 2. Major features of Kotzebue Sound.

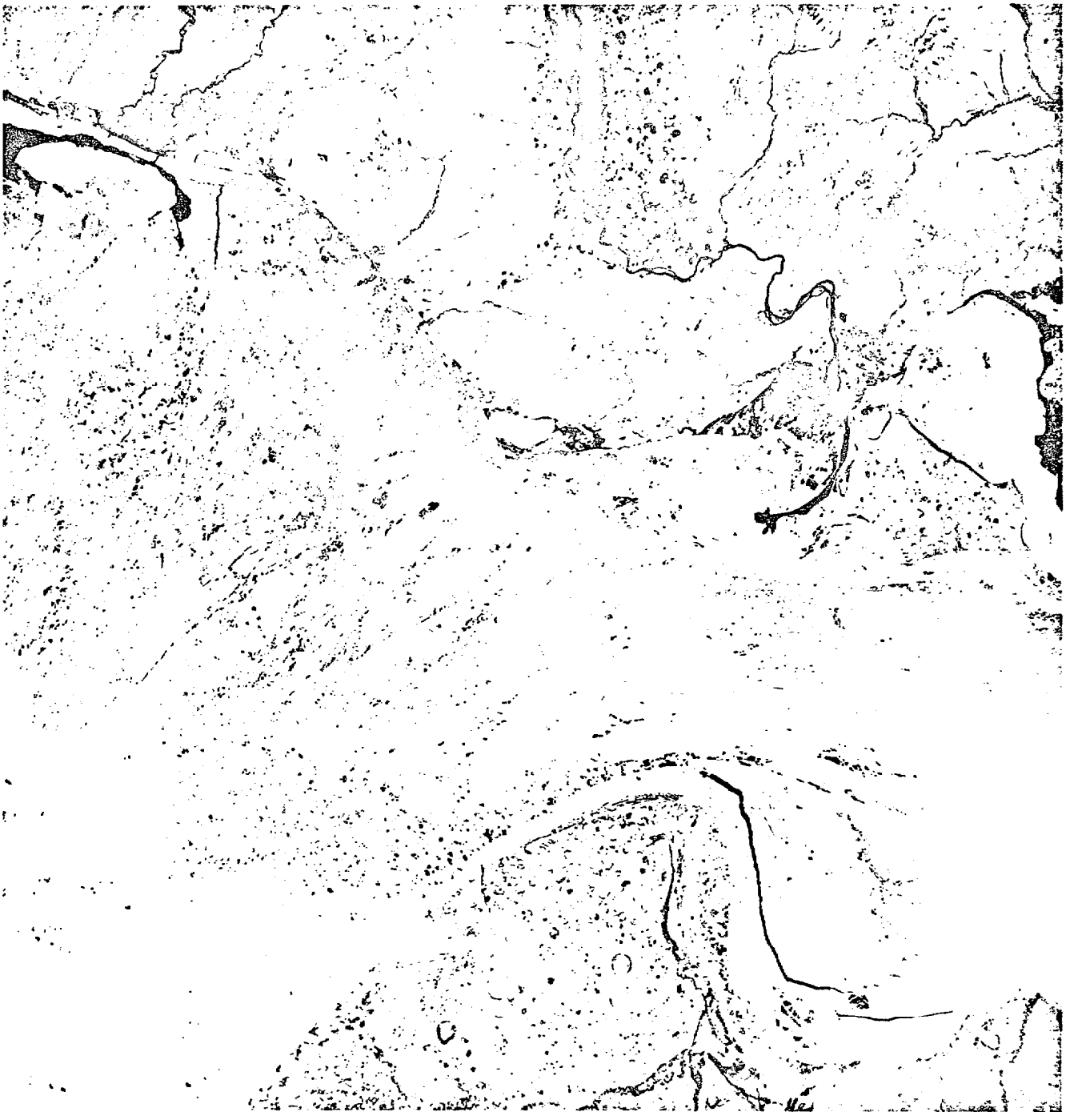

Figure 3. LANDSAT image of Kotzebue Sound. Date Ø2JUN73, Frame number 1314-22043, Band 7, scale is same as Figure 2. Dark area extending from Noatak River past Kotzebue and into sound is open water over channel in submarine Noatak-Kobuk delta.

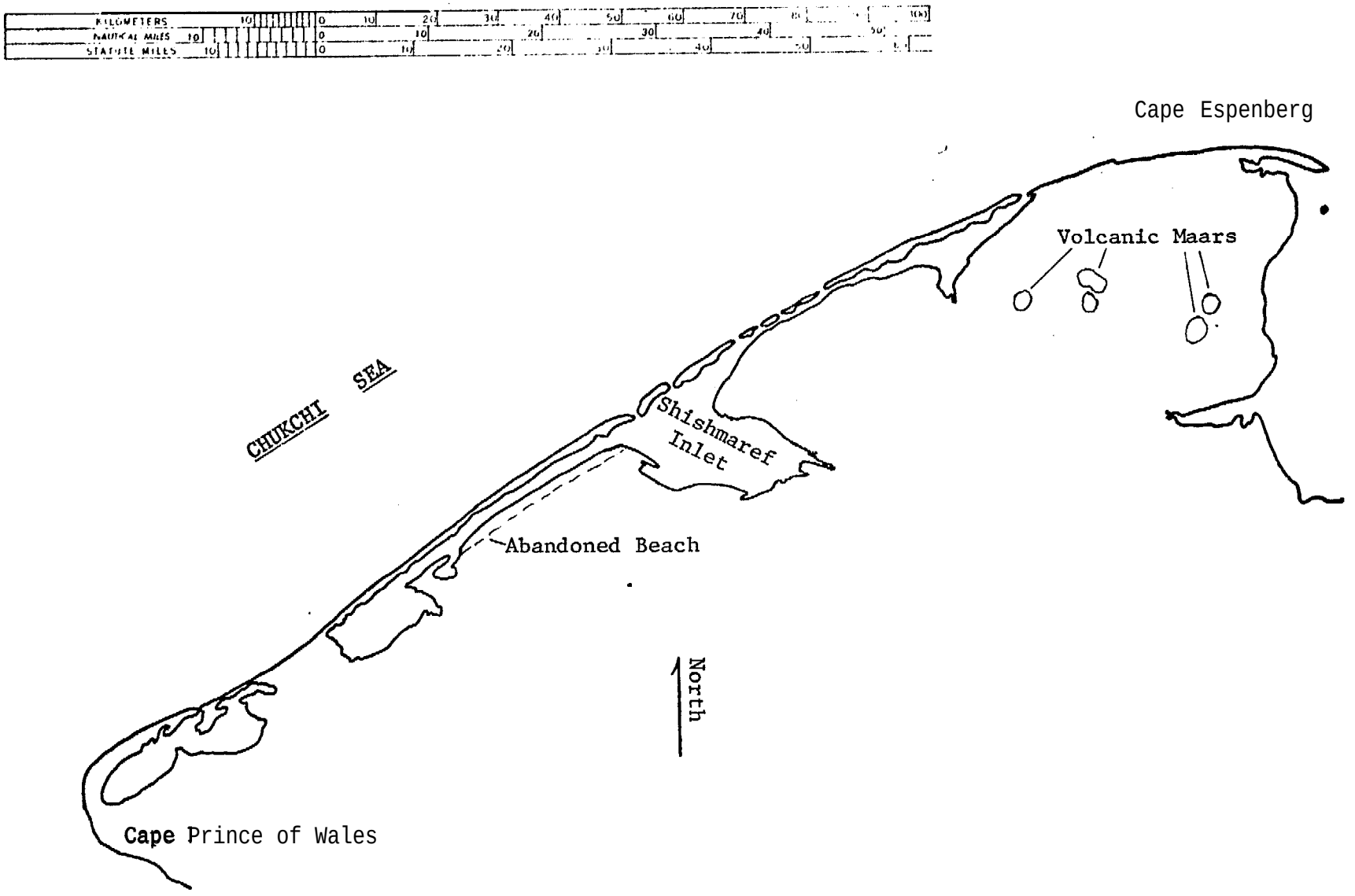

Figure 4. Major geomorphic features of Shishmaref Barrier Island-Beach System.

OCS COORDINATION OFFICE

University of Alaska"

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 6 **R.U.** NUMBER: 99

PRINCIPAL INVESTIGATOR: Dr. P. Jan Cannon

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable

NOTE: 1 Data Management Plan has been approved by M. Pelto; we await approval by the Contract Officer.