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PHYSIOGRAPHY OF LOWER COOK INLET, ALASKA

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INTRODUCTION

Cook Inlet is a large tidal inlet located in south-central Alaska, extending from Anchorage to the Pacific Ocean. The inlet is part of a larger structural and sedimentary basin containing sedimentary and volcanic deposits of late Paleozoic to Holocene age (Evans and others, 1972). The major morphologic elements of the area were established during the late Tertiary (Karlstrom, 1964), with Pleistocene glaciers repeatedly covering most of the inlet, eroding the folded bedrock and depositing blankets of unconsolidated sediment.

Bathymetry of the region is complex and reflects boths its geologic history and the influence of present circulation patterns. In order to facilitate description, the authors have developed a physiographic picture of lower Cook Inlet (Fig. 1).

Although severe winter storms will induce waves that can influence the shallower parts of the bottom, the main agents of watermass movement up and down the inlet are tidal currents. According to Muench and others (1977), circulation in lower Cook Inlet is controlled by the westerly flow in the northeast Pacific that is driven by a sea surface slope generated by the west-flowing Alaska current. Large tidal and wind-induced currents are superimposed on this mean flow. Flood-driven tidal currents move through Kennedy Entrance; part of the water mass moves northward along the Kenai Peninsula, and part flows westward and then turns south into Shelikof Strait. The south-running ebb flow runs strongest down the western side of lower Cook Inlet. Details about currents in lower Cook Inlet do not exist in the open literature, although it is known that surface as well as bottom flow directions can be very complicated, the latter being strongly influenced by local bathymetry.

Sediments in the northern part of lower Cook Inlet are relatively coarse, gravel to boulder-bearing sands, that grade southward to sand and finally to muddy sand (Bouma and others, 1976, 1978a). The boundary between sand and muddy sand is at the base of Lower Cook Ramp, a feature discussed in the next section. The sand forms a thickening wedge to the south and contains numerous bedforms (Bouma and others, 1977a, b, 1978b). Each group of bedforms, consisting of distinct type(s) and size(s), covers a relatively small field, generally elongate in the general tidal flow direction. The largest bedforms occur in water depth ranging from 30 to 130 m with uncertainties in their major evolutionary causes and modifying effects.

Scanning electron microscope observations on quartz grain surface textures reveal three major causative groups for the textural features observed: glacial origin, mechanical impact, and chemical solution/precipitation. The analysis indicates that net dispersal of grains out of the field of large bedforms is minor (Hampton and others, 1978; Bouma and others, 1978b).

PHYSIOGRAPHY

The bathymetry of lower Cook Inlet between Kalgin Island in the north and a line from the Kenai Peninsula to Augustine Island can be generally described as having sloping sides forming a channel-like feature near the center that deepens toward the south (Fig. 1). Near the line between Kenai Peninsula and Augustine Island a ramp is located, increasing the waterdepth abruptly from about 7 m to 130 m. At the base of this ramp a basin starts that extends in southerly direction. This basin is bounded on the east by Kennedy and Stevenson Entrances, both having a complicated bottom morphology.

The above-given description is not adequate for detailed geologic or biologic environmental studies and a more detailed description of the physiographic provinces is required.

The bathymetry is best described when one divides lower Cook Inlet into a number of physiographic provinces, each characterized by specific bathymetric features. For easy reference, names have been given to each physiographic province. Boundaries have been selected along isobaths where possible.

Names of the provinces consist of a combination of a nearby geographic name on land and a common marine term.

In this report, submarine geographic features are given geographic names to aid in physiographic description. Because we believe these names will have utility in future undersea studies, the names were submitted to the Board on Geographic Names for formal acceptance. Because we have received no response as of June 1978, usage of the names herein should be considered informal.

Northern Lower Cook Inlet

The northern part of lower Cook Inlet contains a central depression (Lower Cook Channel) that bifurcates to the north about Kalgin Island. This depression is bounded by shelf-like platforms on the eastern and western sides. The southern boundary of northern lower Cook Inlet is taken at a sudden increase in depth at the Lower Cook Ramp (compare Figs. 2 and 3).

Lower Cook Channel

This central depression covers about one third of the northern part of lower Cook Inlet and is locally the most prominent physiographic feature. Its eastern side starts at about 45-50 m depth from where the gradient begins to steepen. Its western boundary starts closer to the 30 m isobath and bulges outward toward the south to include the western boundary of the area covered by sand waves (Fig. 4). The narrowest part, between Anchor Point and Chinitna Bay-Oil Point, has a slope of about 0.27° at the eastern side and a steeper slope of 1.5° to 7° on the western side. Some of these slopes on the western side are the steepest in lower Cook Inlet. Although the western slope may appear to be structural, our seismic records do not indicate any faults, which leads to the interpretation that it is erosional.

The deepest part of Lower Cook Channel has small local basins in excess of 80 m. At the latitude of Seldovia this deeper part becomes very narrow, whereas to the south it forms a triangle that terminates at lower Cook Ramp. This subprovince, bounded by the 60 m isobath, is indicated as a dashed line on Figure 3.

Although we have no circulation data from this area, we noticed an increase of surface flow velocities near the axis of the lower Cook Channel. A foam line with large pieces of debris, including trees, indicates the presence of a convergence zone in the water column that likely is bathymetrically controlled.

The sediments in the northern part of the channel are gravelly sands, except in the center where thick sands are shaped into large sand waves. Past the constriction, formed by the 60 m isobaths, the area covered by large bedforms increases (compare Figs. 2, 3 and 4).

The bathymetric and morphologic variations in the Lower Cook Channel can be best described by dividing this area into the Lower Cook Channel bounded by the 60 m isobath, and an Eastern and Western Lower Cook Channel slope.

Western and Eastern Kalgin Channels

Lower Cook Channel bifurcates in the north into two channels, divided by a shoal extending from Kalgin Island. Of the two, the eastern channel is less well developed with a few minor depressions over 70 m deep and a high sill at the latitude of southern Kalgin Island. The eastern side is more irregular with small basins over 80 m deep and with steep slopes on both sides. This deepening may either be an old feature or it relates to ebb flow hugging the western side and finding a narrow passage between Kalgin Island and Harriet Point.

Kalgin Platform

The eastern and western Kalgin Channels are separated by the Kalgin Platform, a narrow shoal surrounding Kalgin Island to a depth of about 20 m and extending 20 km to the south, displaying a very gentle slope to that waterdepth, beyond which the slope increases to an averages gradient of 0.57-0.76°.

Tuxedni Platform

A narrow platform is present between Western Kalgin Channel and the eastern shore with a bulge in its southern part. This widening may have a deltaic origin or possible Early Holocene age or even slightly older since the northern outlet of Tuxedni Bay is nearly filled with morainal material.

Tuxedni Channel

This channel forms a small isolated feature dividing the platform along the western shore of northern lower Cook Inlet into two areas. It is a southeast continuation of the subaerial channel already bearing this name. Tuxedni Bay extends inland into the Chigmit Mountains and drains not only part of these mountains but also contains at its inland terminal a large swampy area with extensive tidal mudflats. Off-running ebb waters flow out through Texedni Channel forming a surface mud plume into Cook Inlet. The southern inlet between the island (Chisik Island) and the mainland of Illiamna contains a sill constructed of typical glacial material.

Chinitna Platform

From Tuxedni Channel south a widening platform covers a large part of lower Cook Inlet and includes a major part of eastern Kamishak Bay. A subprovince within the Chinitna Platform could be constructed around Augustine Island although a distinct boundary cannot be constructed along a single isobath. Future research may deliniate the coverage of volcanic flows and a province based on their extent may be considered.

For easy reference we placed an arbitrary dividing line through this province, dividing it into a northern and southern part. Little or no public information exists about the surficial sediments in this large province, although a large number of grab samples were collected aboard the NOAA vessel "Surveyor" during September 1976 (Pulpan and Kienle, 1977).

Ninilchik Platform

Another large platform is found on the eastern side of northern lower Cook Inlet that extends into the northern half of Kachemak Bay. It is also divided into a northern and a southern sector, the southern one having a slightly more irregular topography and also being characterized by several types of bedforms (Bouma and others, 1978b).

Southern lower Cook Inlet

This part of lower Cook Inlet is bounded primarily by escarpments forming a basin in its center. Detailed bathymetric information is not available to determine how this basin extends into Shelikof Strait.

Lower Cook Ramp

The most striking physiographic feature within lower Cook Inlet is the ramp whose base separates generally sandy sediments to the north from more muddy sand to the south, as well as the southern boundary of bedform fields. The ramp starts at a depth of about 70 m and terminates at about 120-130 m, with slopes ranging from 0.3° to 0.6°. The ramp has a "boomerang" shape with its (apex) towards the north, more or less lining up with the axis of Lower Cook Channel.

The top of the eastern part of the ramp is devoid of large bedforms. Farther down slope, the smooth bottom changes to medium-sized bedforms, going over into large ones, which in turn become smaller and die out at the base of the ramp.

Douglas Slope

A steep slope with angles varying from 1.2° to 2.5° marks the western side of southern lower Cook Inlet. Lower Cook Ramp continues into southern Douglas Slope leaving a narrow or no platform along Cape Douglas. A channel enters from the west through the southern part of Kamishak Bay, and the southwest side of this channel forms the northern Douglas Slope.

This slope narrows and steepens toward the southwest where it joins the Lower Cook Ramp - Southern Douglas Slope area.

Barren Platform

The eastern side of southern lower Cook Inlet is bounded by a shoal. The central part of this shoal, Barren Platform, is characterized by irregular bathymetry with many fault scarps, horsts and grabens, and a few blocks that are uplifted to form islands.

The bathymetry beyond the 90-100 m isobath generally becomes more regular than the shallower area, due to a cover of unconsolidated sediment, masking the older formations. Shallow zones or ridges extend from the Barren Platform to the north, south and east.

North Barren Ridge

A shallow ridge extends from the Barren Islands in a northerly direction toward the end of lower Cook Ramp, thereby separating Kennedy Entrance from Douglas Deep.

This ridge may be a significant feature in guiding the direction of water motion, deflecting part of the incoming flood waters to the north. The importance this ridge may have on the circulation is reason to give its own physiographic recognition.

Shuyak Platform

This is the name given to an irregular province connecting the Barren Platform with the Kodiak Island group. It is a relative shoal area with some shoals as shallow as 80 m, with an average depth of 120-130 m, flanked by deeper areas on both sides.

Douglas Deep

The central area of southern lower Cook Inlet is occupied by the Douglas Deep. It starts in the north at the base of Lower Cook Ramp as a gradually deepening area that can be divided into an eastern and a western part. Near southern Douglas Slope the western part forms an elongate basin (Douglas Basin), being slightly over 150 m deep. On the western side it forms a depression or series of depressions, that are in excess of 200 m deep and are clustered under the name Shuyak Basin. A rather steep slope (average 2.5°) connects this basin with Shuyak Platform.

Eastern lower Cook Inlet

The eastern part of lower Cook Inlet includes the areas known as Stevenson Entrance in the south and Kennedy Entrance in the north, with the Barren Island dividing them. Although Stevenson Entrance terminates against the Shuyak Platform, Kennedy Entrance runs far into lower Cook Inlet. The eastern part of lower Cook Inlet, as defined here, also includes the area along the Kenai Peninsula and the southern part of Kachemak Bay.

Stevenson Entrance

This is the southern part of the connection of lower Cook Inlet with the Pacific Ocean north of the Kodiak Island group. It consists of morphologically elongate highs and lows trending 105° - 285°. It contains areas that are in excess of 200 m deep. On the western end the sea bed climbs to a mean depth of 120-130 m, and is locally shallower, onto the Shuyak Platform.

East Barren Ridge

A series of shoals more or less aligned, about 60-80 m above their adjacent surroundings and extending from the Barren Platform in an easterly direction, is called the East Barren Ridge. It forms a boundary between Stevenson and Kennedy Entrances.

Kennedy Entrance

The northern passage from the Pacific Ocean to lower Cook Inlet is known as Kennedy Entrance. Between the Barren Islands and the Chugach Islands the deepest part has depths in excess of 190 m in an otherwise flat basin. To the east the sea bed consists of two channels less deep than the basins on both the eastern and western sides. The two channels are separated by a 25 km long ridge with local peaks being about 55 m below the sea surface.

The area known as Kennedy Entrance extends into lower Cook Inlet as Northern Kennedy Entrance for more than 60 km. It forms an indentation to the north between lower Cook Channel and Southern Ninilchik Platform at about the 60 m contour interval. The deep portion between the Barren Islands and the Chugach Islands gradually becomes shallower, being bounded between the Kenai Peninsula Platform and the Northern Barren Ridge before it becomes bounded by the southward extensions of 60 m shoals.

Kenai Peninsula Platform

This is a narrow zone adjacent to the Peninsula. Because few data on its bathymetry are available, no subdivisions can therefore be attempted at this time.

Kachemak Channel

A rather narrow and deep depression forming the connection between northern Kennedy Entrance and inner Kachemak Bay east of Homer Spit is known as Kachemak Channel. It forms the connection to inner Kachemak Bay. A similarity can be observed between this channel and Lower Cook Channel in that it also contains a number of depressions along its axis and that is has a constriction near its mouth (Fig. 1). The U-shape of the channel and the Pleistocence history of the area (Karlstrom, 1964), point to the Kachemak Channel forming as a glacial trough.

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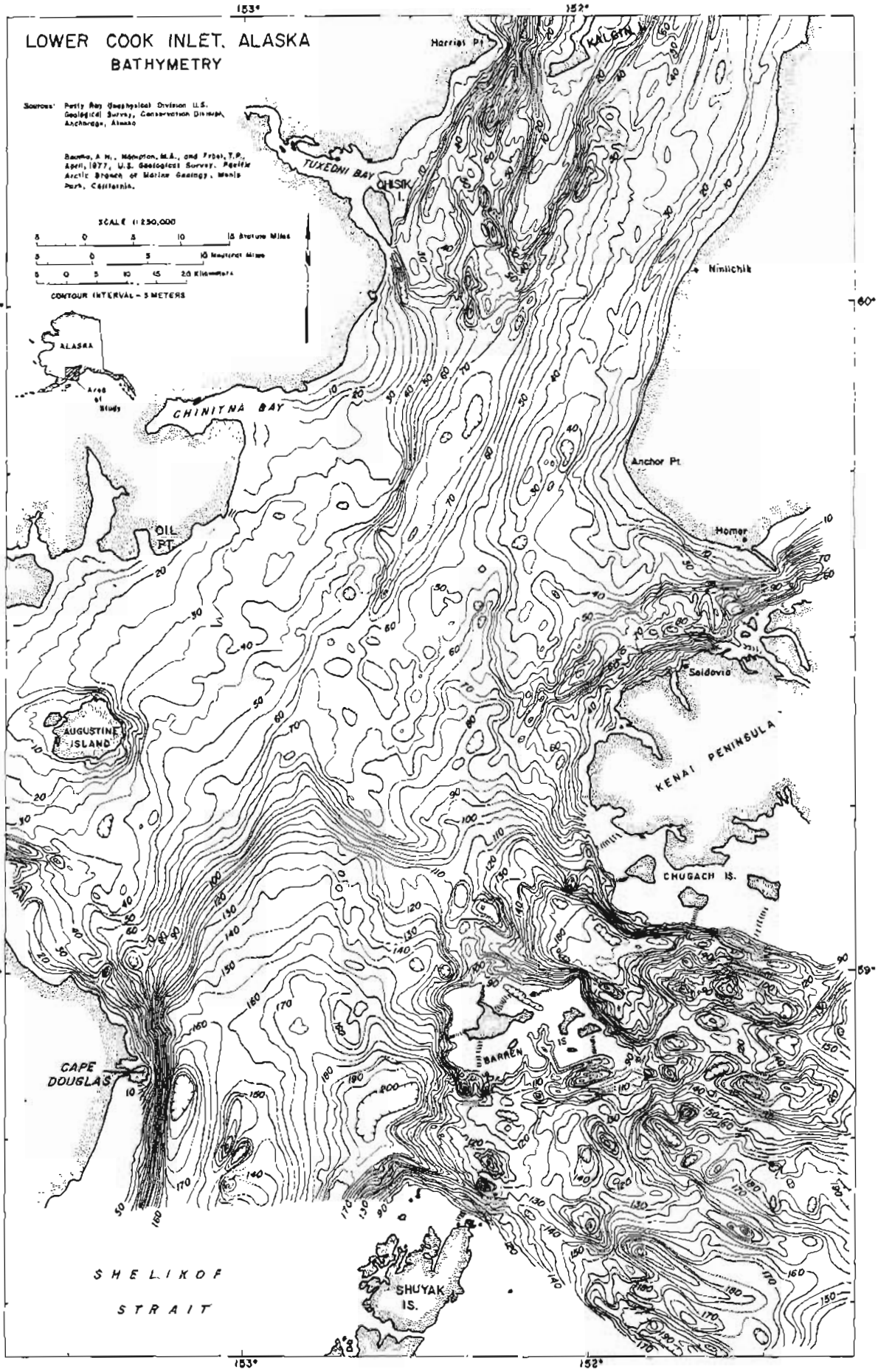

Figure 1. Bathymetry of lower Cook Inlet, Alaska. Redrafted in 5-m intervals after Petty Ray Geophysical, Inc. and C & GS Boatsheets. (After Bouma and others, 1978a,b).

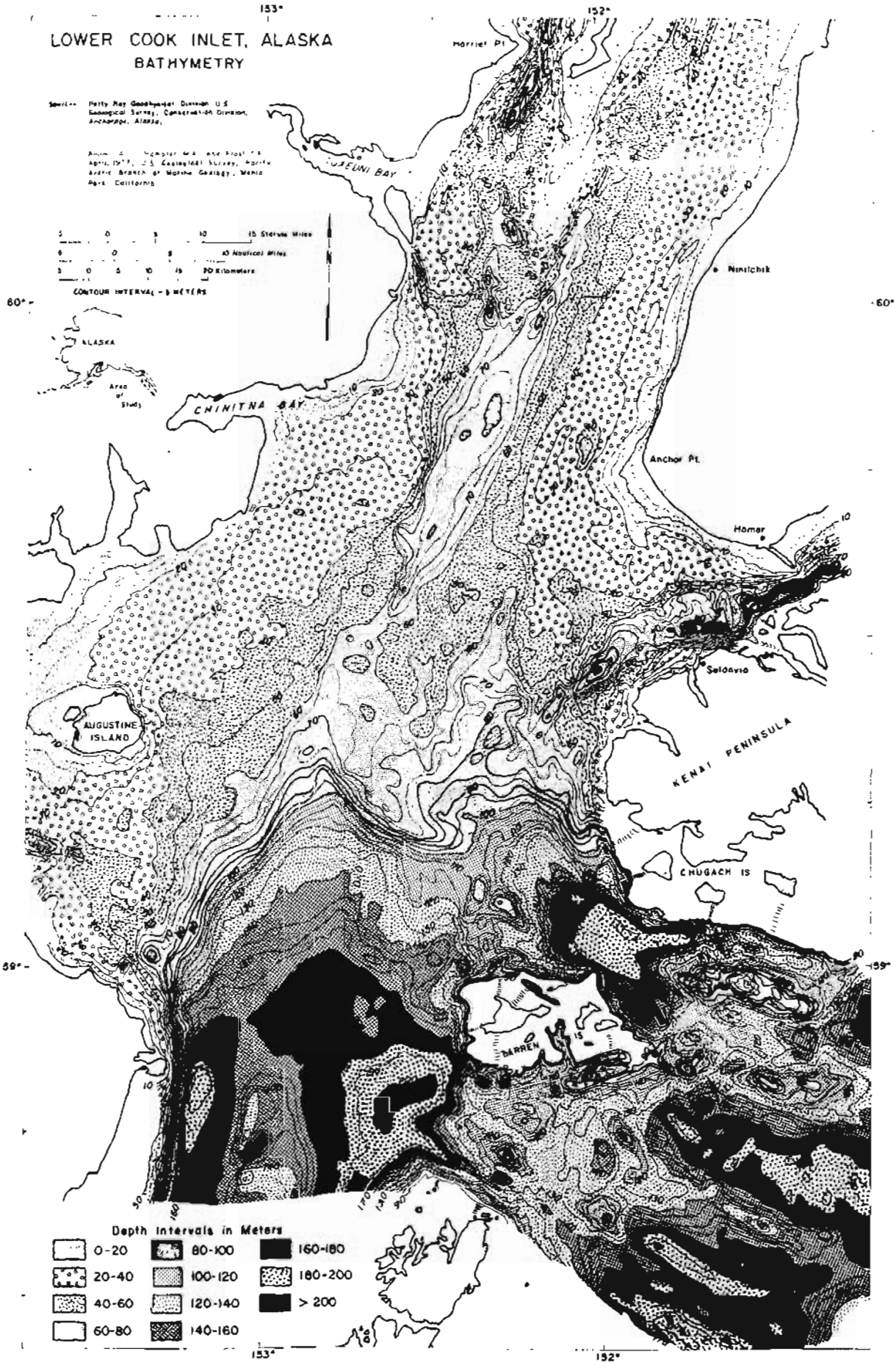

Figure 2. Depth zones in lower Cook Inlet based on 20-m bathymetric intervals.

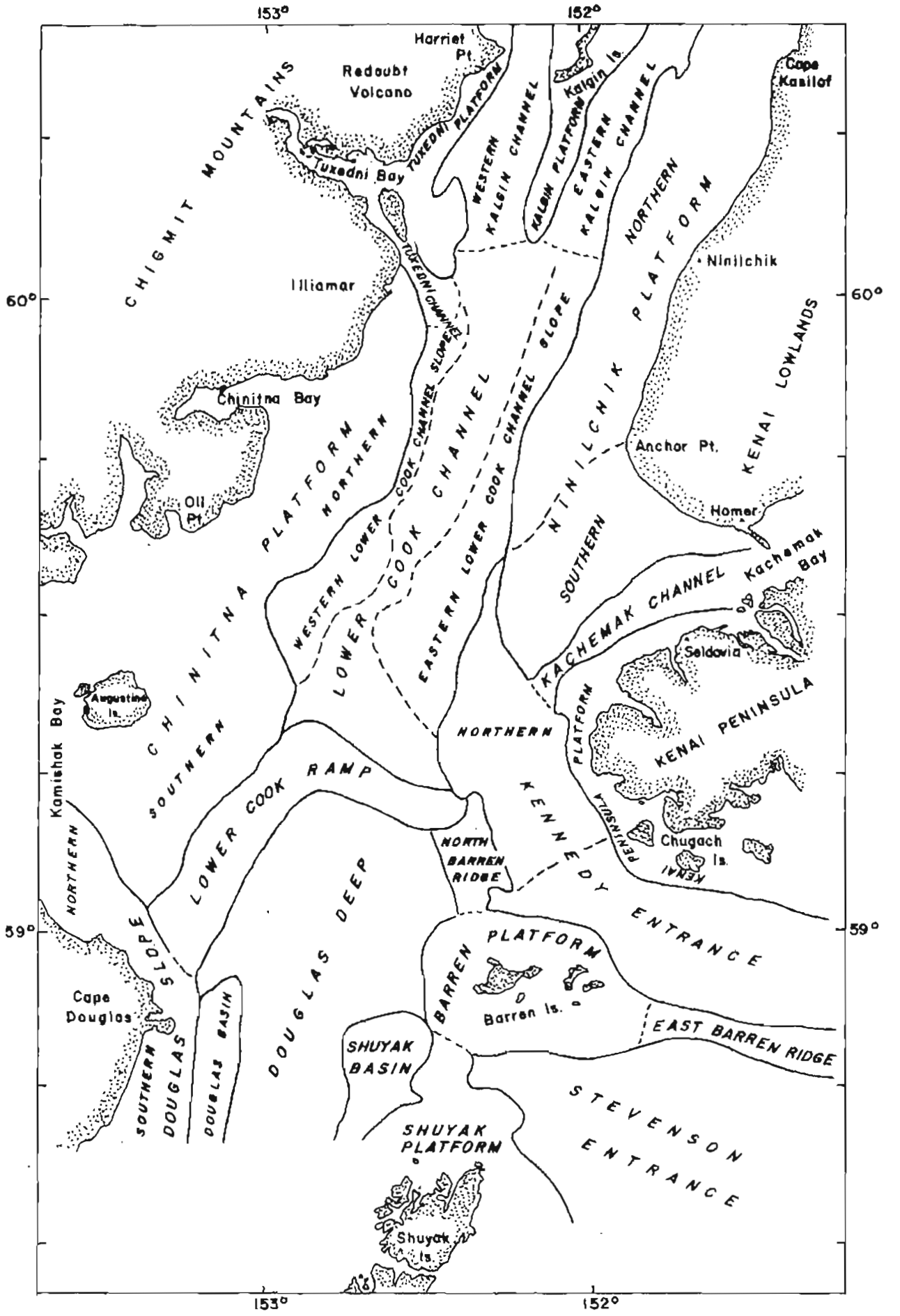

Figure 3. Physiography of lower Cook Inlet, Alaska.

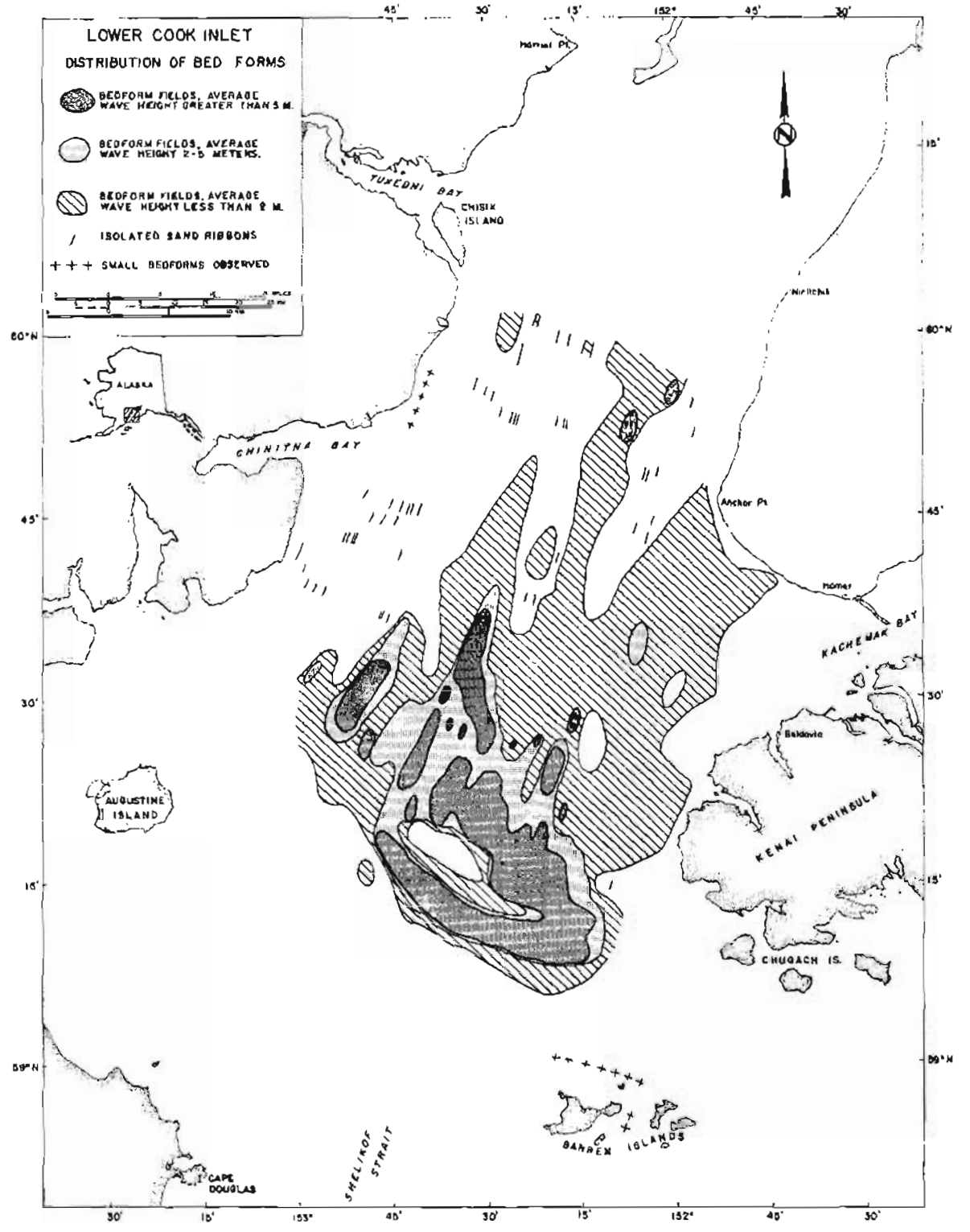

Figure 4. Preliminary map of lower Cook Inlet with a simplified plot of the distribution of major size groups of bedforms. (After Bouma and others, 1978a,b).