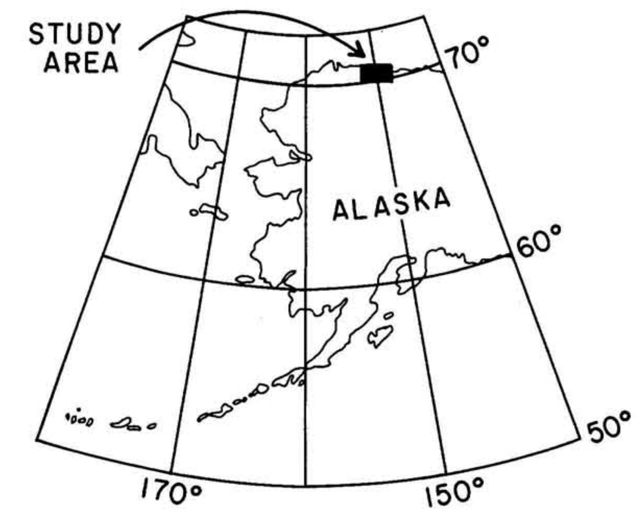
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

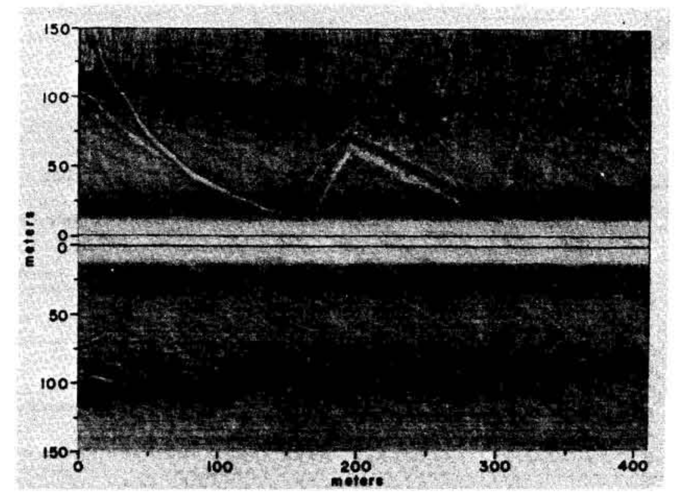
MISCELLANEOUS FIELD STUDIES
MAP MF-532

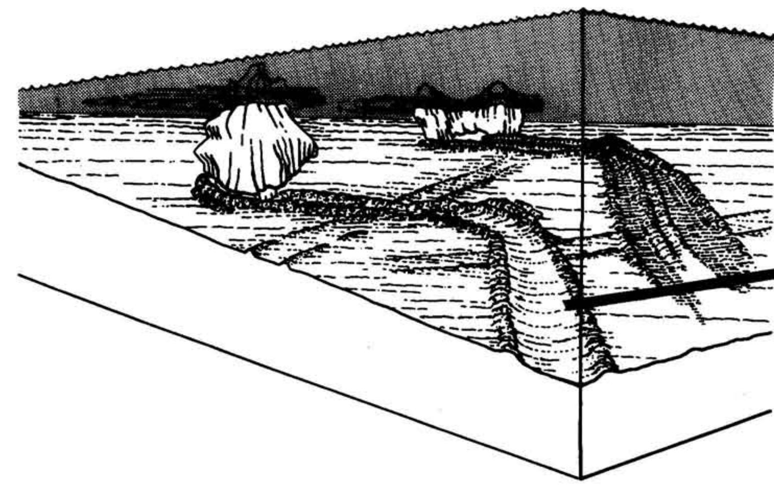


INTRODUCTION

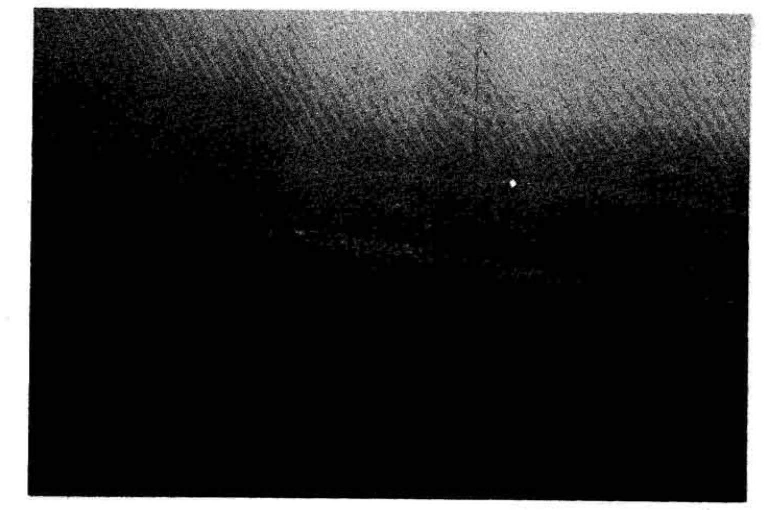
Early investigations of arctic shelf regions led to the hypothesis that certain micro-relief forms are related to the action of grounded ice (for example, Rex, 1955). Since the introduction of side-scan sonar as a tool for ocean-floor surveys, a number of workers have described the occurrence of linear bottom features produced by grounded ice. Such features have been found on modern polar shelves (Skinner, 1971; Pelletier and Shearer, 1972; Kovacs, 1972; Reimnitz and Barnes, 1972; Brooks, 1973), and as relict features (Berkson and Clay, 1973; Belderson and Wilson, 1973, Belderson and others, 1973. Studies of core samples, high-resolution seismic profiles, and diving observations indicate that the sediments of the Beaufort Sea Shelf are highly distorted by the action of grounding ice, and that the recurrence rate of gouging is very high. It has also become evident that grounding ice is contributing considerably to the sediment transport processes on modern Arctic shelves.

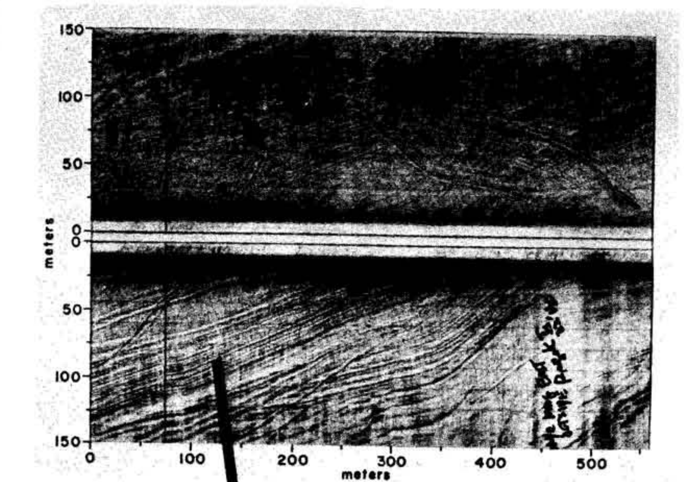
Sediments from similar environments exposed on the continents today should also contain the record of ice gouging and related processes. Thus it has become apparent that drifting ice is an important agent influencing the sedimentary structures and the sediment transport regime of Arctic shelves today and has been in the past. The diagrams presented here, with supporting evidence in the form of side-scan sonar records, and ice and bottom photos, demonstrate the most prevalent processes and types of bottom features observed on the continental shelf off northern Alaska. As the map shows, most of the shelf is affected by these processes today.

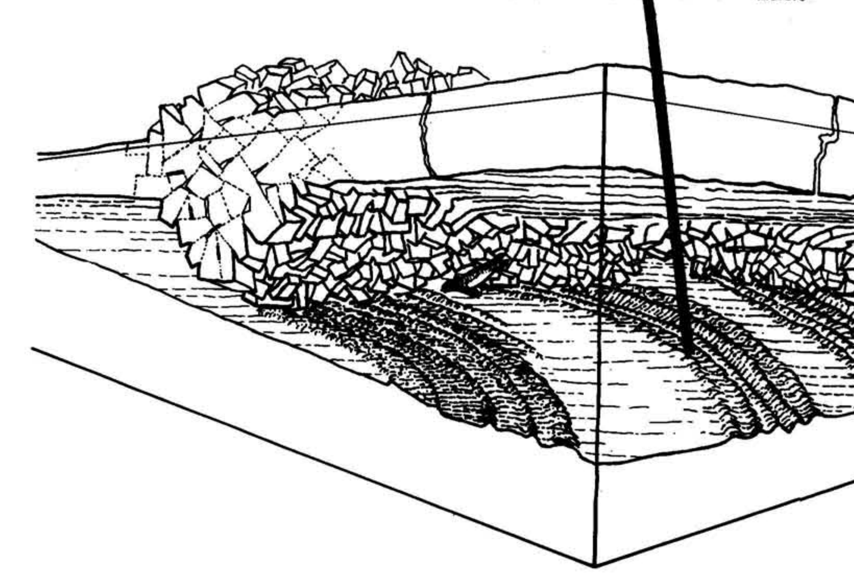




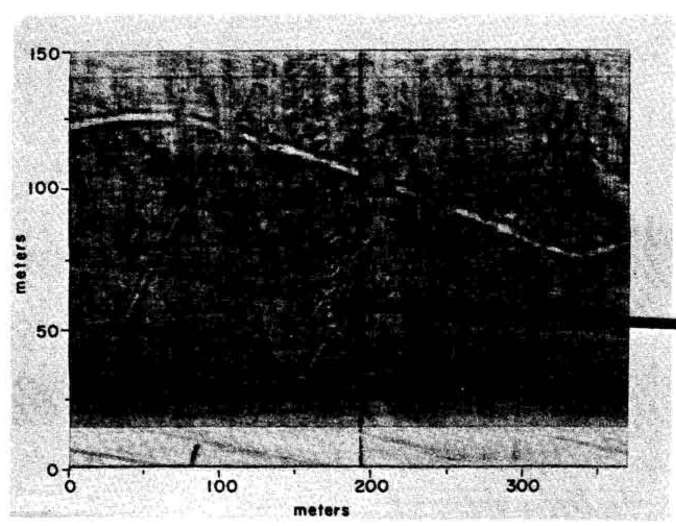
A. The most common bottom features are grooves that single pieces of ice cut in unconsolidated sediments, ranging from mud to coarse gravel. The sonograph demonstrates how a gouge may change shape due to rotation of the cutting tool. The underwater photo shows an 80-cm-wide gouge in medium-grained sand.

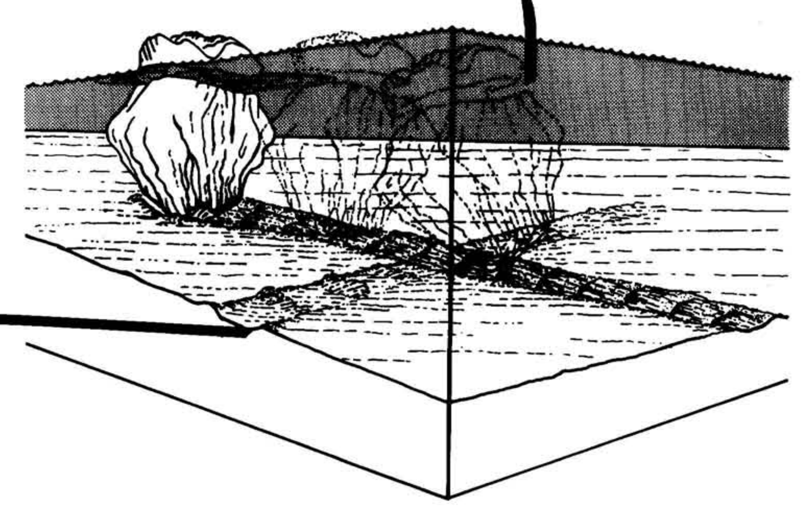




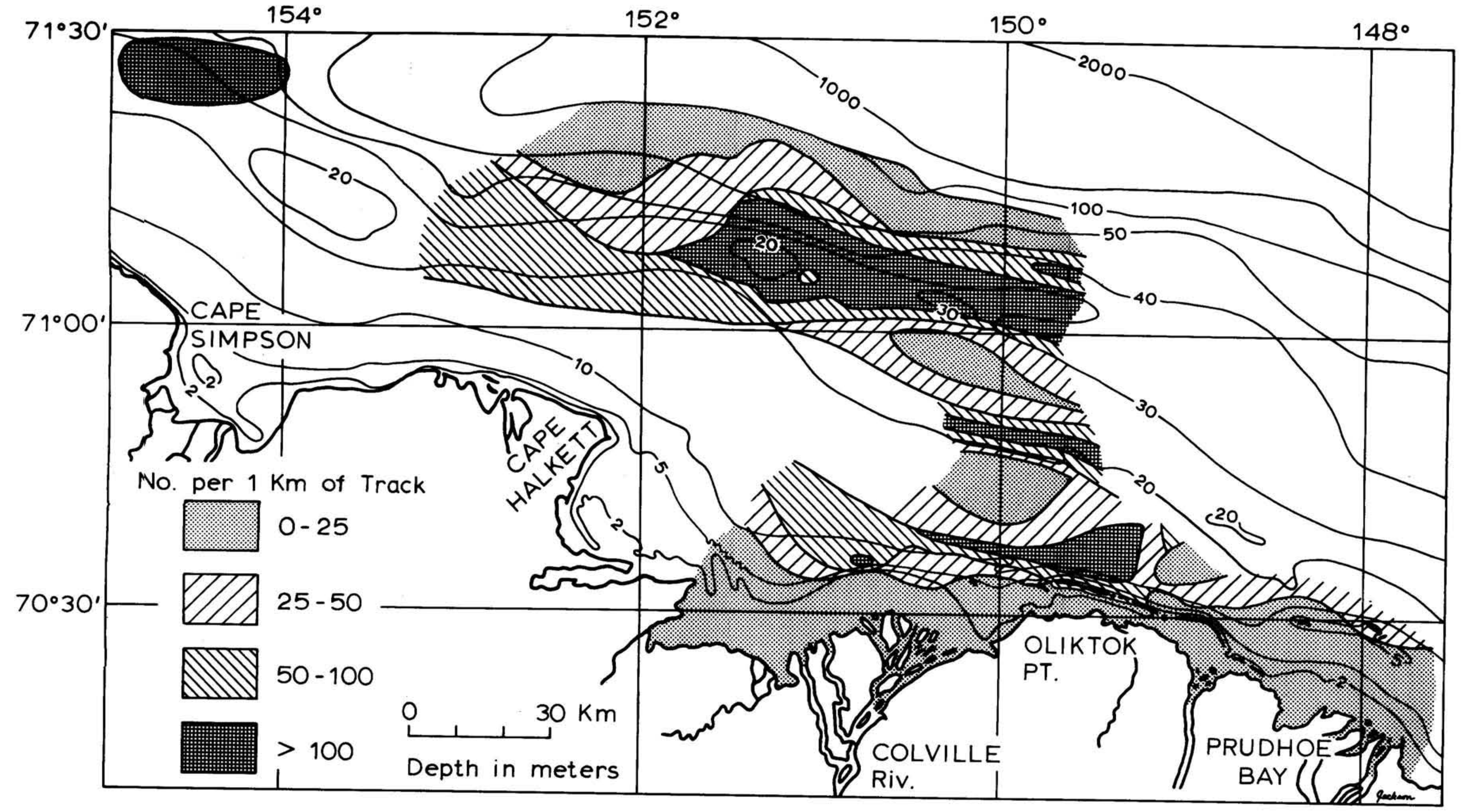


F. Pressure ridge keels "rake" the bottom, creating the parallel furrowing seen here. Under the influence of wind, current, and local bottom relief, the movement of the ridge can change direction. In the photo from the inner shelf at a depth of 8 meters, these parallel grooves are 50 to 75 cm apart, cut into coarse gravel.

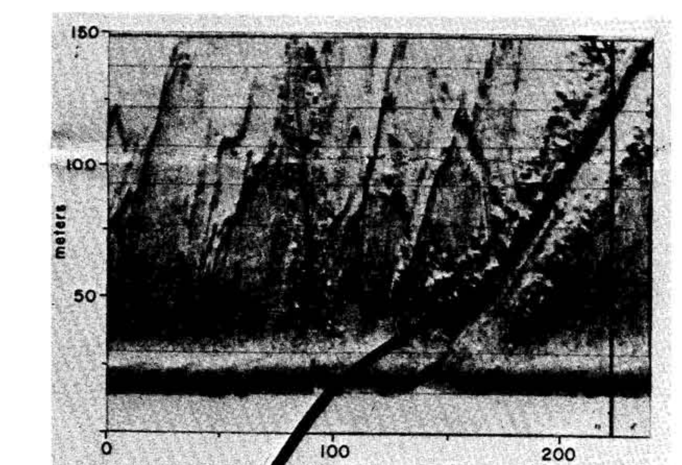


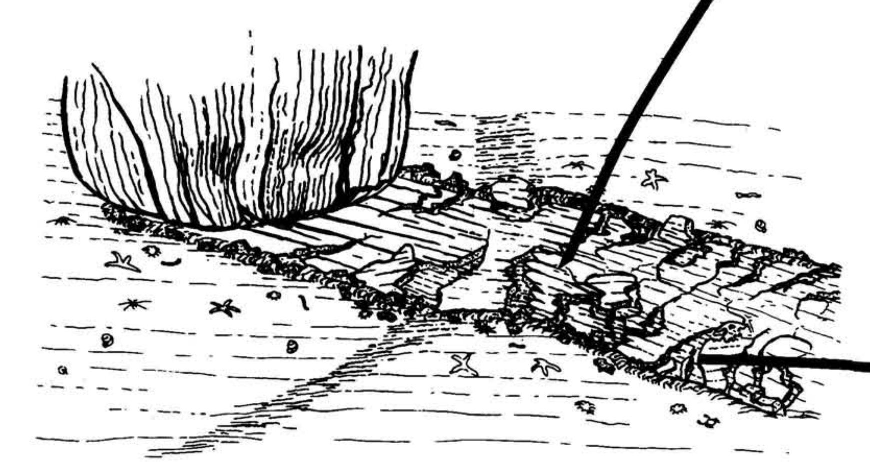


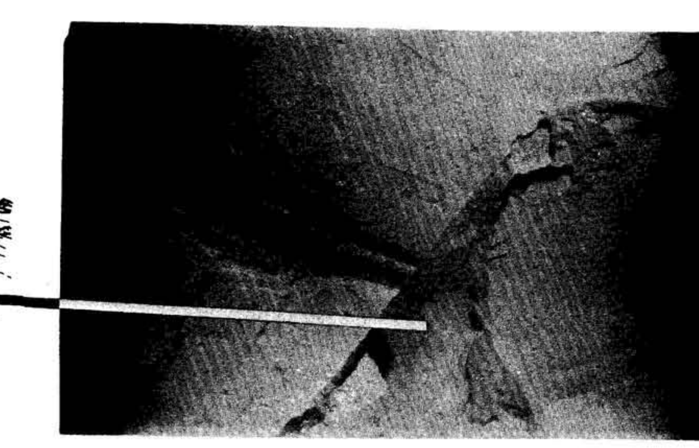
B. Metastable chunks of ice touching the bottom sometimes wobble, creating regularly spaced bottom features. Also illustrated are notches formed at sea level by wave action during the summer. Grounded ice often is marked by elevated swash notches, which may indicate the depth range traversed by the ice after grounding.



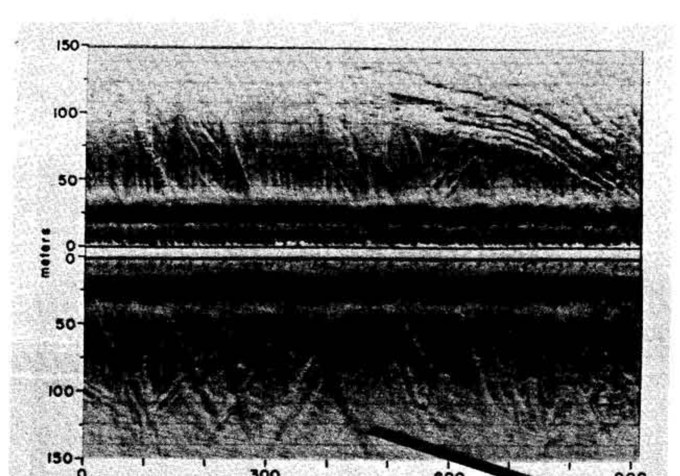
Map of ice-gouge density. Sonographs indicate a varied intensity of ice-bottom interaction on different parts of the shelf. The distribution and density of ice gouges were determined from side-scan sonar records of the Beaufort Sea shelf. All gouges on these records, covering a 300-m-wide swath of the sea floor, were counted for 1-km segments of ship's track. These values were converted to represent numbers of gouges on a hypothetical track normal to the dominant trend. See Barnes and others (1973) for the location of tracklines on which the interpretation is based.

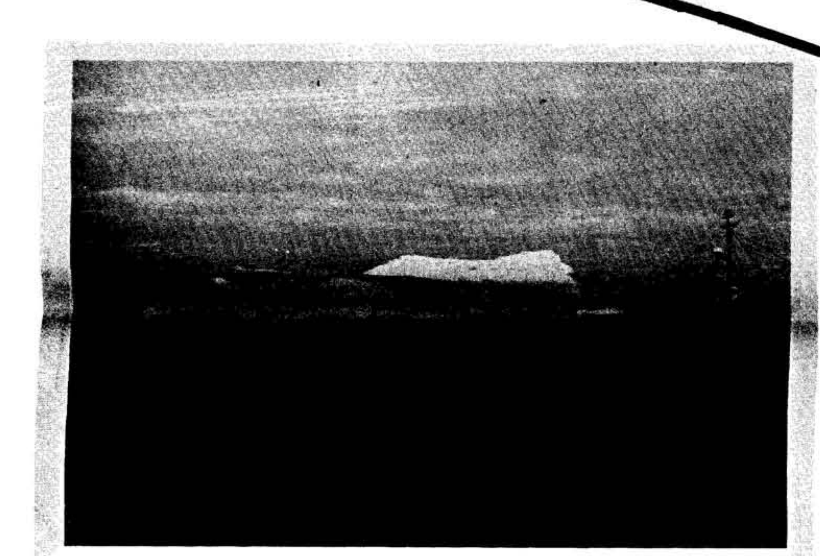


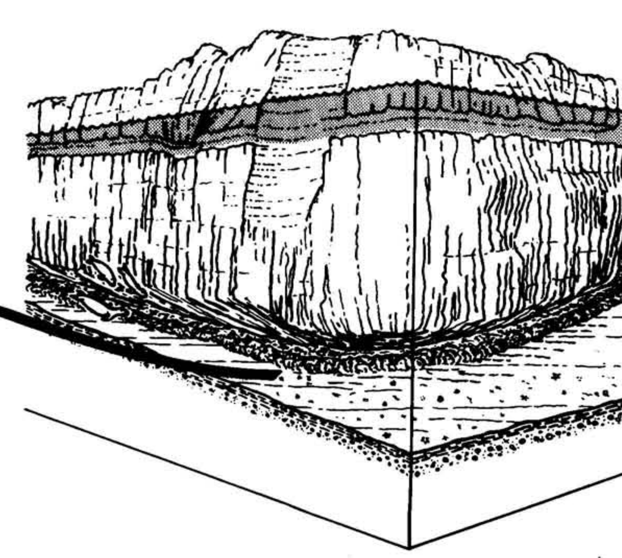




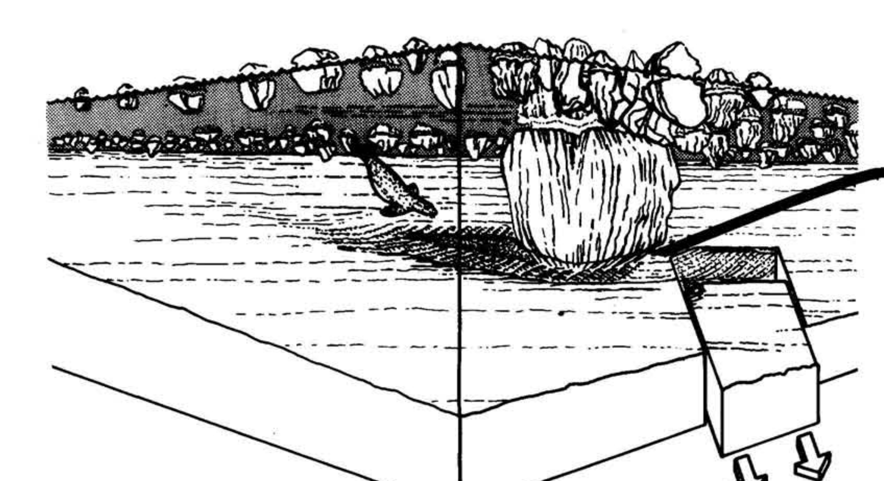
E. In areas where pre-Holocene, over-consolidated sediments are at or near the surface, the movement of ice dislodges blocks of sediment in a random manner. The sonograph illustrates the irregular form of gouges and ridges created in such areas. The diagram and photograph illustrate how grounded ice can devastate the benthic organisms in the area.

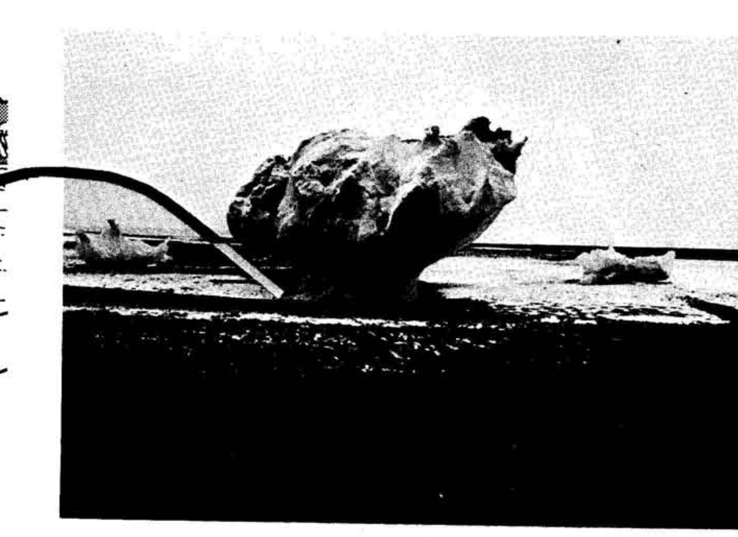






C. Relatively flat bottomed ice islands create characteristic wide and flat bottom grooves on the central and outer shelf. Diving observations at the front of one ice island indicate a 1-meter-high gravel-mud "push moraine," representing material from the surficial mud and underlying gravel (Reimnitz and others, 1972). The benthic fauna, abundant on the surrounding bottom, is absent on the moraine and within the groove.





D. Current scour occurs around grounded ice on the inner shelf, where flow velocities of 2 to 3 knots are common. Under such conditions, turbid-water wakes and flow patterns in the surficial drift ice are pronounced. If the ice and its scour depression continue to move, a sequence of cut-and-fill structures will develop in the sediment. The photograph shows such current scour on a barrier island, following a 3-meter drop in sea level after a storm surge (Reimnitz and others, 1972).

BOTTOM FEATURES AND PROCESSES RELATED TO DRIFTING ICE
ON THE ARCTIC SHELF, ALASKA

by
Erk Reimnitz, Peter W. Barnes, and Tau Rho Alpha
1973

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