GEOPHYSICAL AND BIOLOGICAL RECONNAISSANCE OF ROCK HABITATS IN EASTERN CAMDEN BAY, BEAUFORT SEA, ALASKA

by

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TABLE OF CONTENTS

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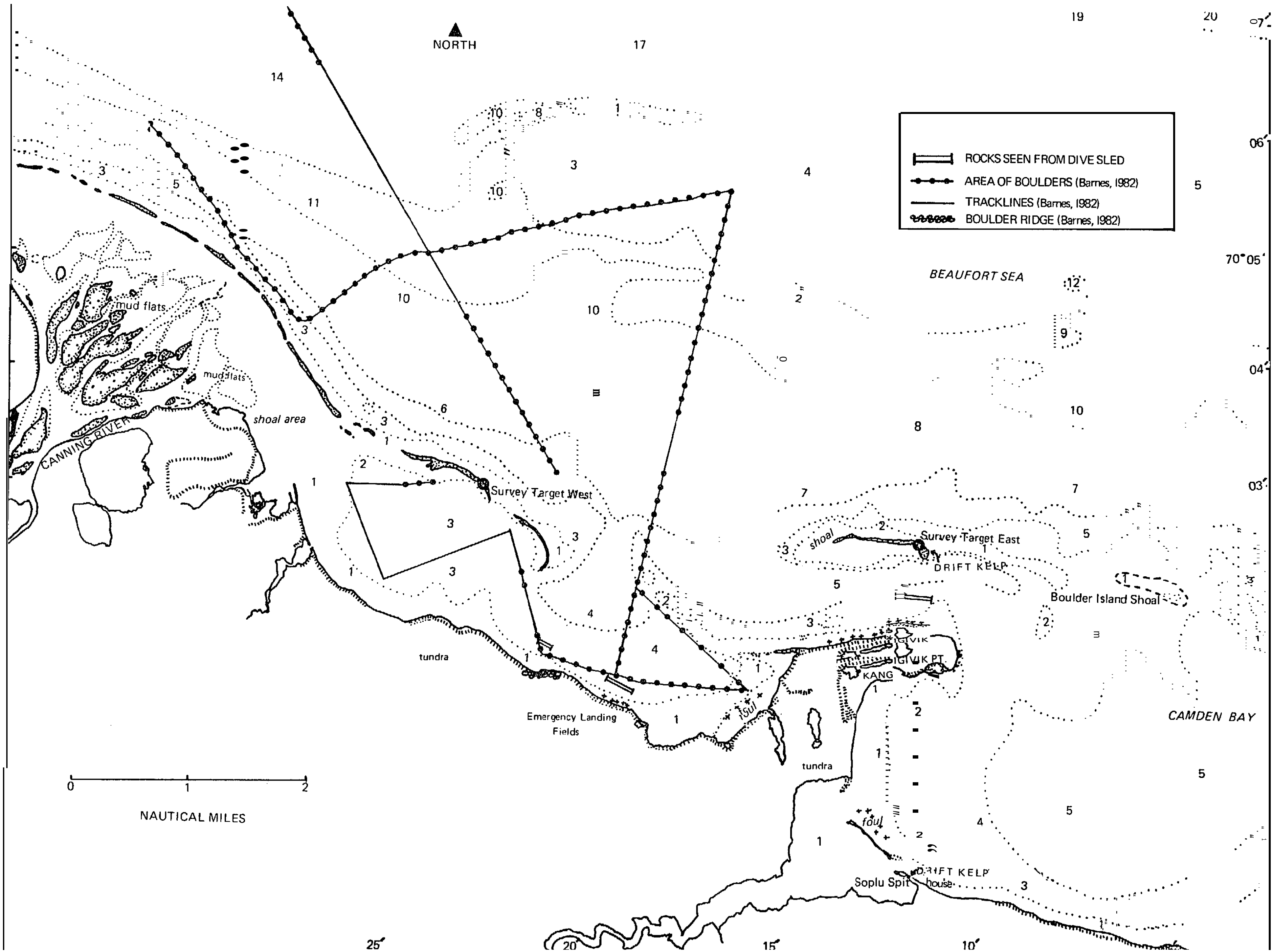
I. SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OIL AND GAS DEVELOPMENT

This report presents the results of a 10 day geophysical and biological survey in western Camden Bay, in the Alaskan Beaufort Sea. The primary objective of this survey was to confirm the existence of boulders and cobbles on the seafloor as reported by Barnes (1981; 1982). The survey area extended from the eastern edge of the Canning River (mud flat area) to Kangigivik Point and seaward to the 14 m contour line (Fig. 1). A solid boundary of pack ice prevented any survey work seaward of the 14 m contour. We had proposed to examine the seabed to the 18 m contour.

Diving traverses, spot dives, and interpretation of fathometer records indicate the absence of boulders and cobbles in the survey area, except in shallow water (2-4 m) directly northwest of Kangigivik Point. Dredge hauls made throughout the survey area also yielded no attached macroalgae except in the immediate region of Kangigivik Point. The existence of attached macroalgae and invertebrate life in western Camden Bay therefore has been visually documented only in the nearshore region in water depths less than 4 m (Dunton and Schonberg, 1982). Our results contradict the work of Barnes (1981), who reported boulders offshore, and the reasons for this disagreement are discussed.

We did collect large amounts of drift kelp following storms on the beaches southeast of Kangigivik Point and on the eastern shore of the barrier island offshore of Kangigivik Point. It appears that the source of this drift kelp is not entirely from the shallow areas north and west of Kangigivik Point. The rocks in these shallow waters support few mature healthy plants of *Laminaria solidungula* (Dunton and Schonberg, 1982; this study). Instead a second source must be present, and based on discussions with E. Reimnitz (USGS), the source is likely a submerged shoal east of Kangigivik Point, which was formerly known as Boulder Island. In our beachcombing efforts to the west of Kangigivik Point to the Canning River delta, macroalgae were seldom seen. Thus it appears that the major source of drift kelp is to the east of Kangigivik Point.

Figure 1, The study area extended from the eastern edge of the Canning River (mud flat area) to Kangigivik Point and seaward to about the 14 m contour line (as far north as sea ice permitted). The occurrence of rocks on the seabed reported by Dunton and Schonberg (1982, from diving observations) and Barnes (1982, from geophysical data) is shown. Depths are listed in meters.



NORTH
ROCKS SEEN FROM DIVE SLED
AREA OF BOULDERS (Barnes, 1982)
TRACKLINES (Barnes, 1982)
BOULDER RIDGE (Barnes, 1982)
BEAUFORT SEA
mud flats
mud flats
shoal area
CANNING RIVER
Survey Target West
Survey Target East
shoal
DRIFT KELP
Boulder Island Shoal
IGIVIK PT.
KANG
tundra
tundra
Emergency Landing Fields
foul
foul
CAMDEN BAY
DRIFT KELP
Soplu Spit
house
NAUTICAL MILES
0
1
2
70°05'
06'
04'
03'
25'
20'
15'
10'

It is difficult to assess the size and possible significance of any kelp bed east of Kangigivik Point, although it seems likely that it is limited to the vicinity of the Boulder Island shoal. Collection of drift kelp along Soplu Spit, south of Boulder Island (Fig. 1) indicated that 72 kg of kelp washed up on the beach, equivalent to 5,400 square meters of "boulder patch" type seabed, assuming the drift material represents 10% of the actual bed itself. Based on the importance of this area to industry for oil and gas development, it may become necessary to investigate the small area in the vicinity of the Boulder Island shoal to confirm the presence of rocks with attached kelp. The possible significance of the benthic macroalgae to the nearshore trophic system in western Camden Bay is thus difficult to predict without; (1) accurate knowledge of the size of the kelp bed, and (2) the degree by which invertebrate consumers of Camden Bay depend on carbon derived from kelp.

II. INTRODUCTION

General Nature and Scope of Study

The primary goal of the benthic survey in western Camden Bay was to provide information on the spatial distribution of cobbles and boulders and the utilization of these substrates by epilithic organisms as kelp, red algae, soft corals, sponges, etc. The survey area extended from the eastern edge of the Canning River to Kangigivik Point and seaward to the 14 m contour line, as far north as sea ice conditions permitted (Fig. 1). A Ross SL-500 recording fathometer was used in conjunction with diving observations to map the character of the seabed.

Specific Objectives

1. Confirm the existence of cobbles and boulders previously reported by Barnes and Ross (1980) in eastern Camden Bay through visual (diving) examination of rock patches.

2. Determine the overall extent of cobbles and boulder distribution in western Camden Bay in water depths greater than 6 m using an acoustical system and a diving sled.

3. Visually confirm through diving the presence (or absence) of biota associated with rock substrata, and describe both the composition and relative abundance of the biotic assemblages.

Relevance to Problems of Petroleum Development

In Stefansson Sound, the presence of an abundant and diverse flora and fauna associated with cobbles and boulders resulted in special protection for the Boulder Patch from industrial activity related to petroleum exploration. The kelp in the Boulder Patch contributes the largest fraction of carbon in this area, and this carbon source is utilized by many invertebrate consumers. The presence of a similar kelp community in western Camden Bay may thus require similar attention, depending on its size and composition.

III. CURRENT STATE OF KNOWLEDGE

Kelp as a Carbon Source

Although peat derived from terrestrial marine primary production supplies nearly all of the carbon used in arctic marine foodwebs (Schell et al., 1982). Most of this carbon is supplied by phytoplankton, but benthic microalgae and ice algae also contribute carbon on a less consistent temporal and spatial scale. The discovery of the Boulder Patch and its large population of flora and fauna by E. Reimnitz in 1971, also led to the discovery of another marine carbon source of unknown magnitude -- kelp. Subsequent long-term in situ productivity studies indicated that the carbon contribution made by kelp in the Boulder Patch doubled the amount of carbon available to consumers in that region (Dunton et al., 1982). It also appears that kelp is an alternate food source for many animals that rely on phytoplankton. Thus, the kelp communities found in association with "boulder patches" may not only be. unusual but do supply a source of carbon that is utilized by organisms that are eaten by birds, fish, and marine mammals (Dunton and Schel 1, 1982).

Cobbles and Boulders in Western Camden Bay

The presence of cobbles and boulders in eastern Camden Bay was first reported by Barnes and Ross (1980). Subsequent investigation of the seabed using underwater television showed that the rocks supported a diverse benthic community (Barnes, 1981). This benthic community appeared similar to the Boulder Patch (Reimnitz and Ross, 1979; Dunton etal., 1982) in the types of organisms present. In August 1981, some of the nearshore boulder ridges described by Barnes (1981) were examined by divers (Dunton and Schonberg, 1982). Their short examination revealed patchy occurrences or rocks where Barnes (1981) had indicated but the benthic fauna and flora was not comparable in density or diversity to that of the Boulder Patch. However, only a few rock patches were examined, and these were in relatively shallow water (less than 3.5 m depth). Biological assemblages are more likely to possess a greater luxuriance in deeper water which affords greater protection from the thick winter ice sheet.

From monographs, Barnes and Ross (1980) identified several locations where boulders and cobbles exist on the seabed in deeper water (Fig. 1). None of these locations were examined visually. The existence of the rocks offshore is based entirely on two transect lines which extend nearly four nautical miles offshore. In this study, we attempted to rediscover the locations that contain rocks on the seafloor.

IV. STUDY AREA: BEAUFORT SEA (100 PERCENT)

The study area for this project is western Camden Bay, between longitude 145°30′ and 145010′, in water depths ranging from 5 to 14 m (Fig. 1). Calibration of geophysical instruments was conducted at OCSEAP DS-11 in Stefansson Sound, and directly northwest of Kangigivik Point in western Camden Bay (water depth 2-4 m).

V. SOURCES, METHODS, AND RATIONALE OF DATA COLLECTION

Geophysical survey data and samples were collected from the R.V. Proteus, a 25 foot Boston Whaler leased to OCSEAP by Arctic Marine Research Associates. The vessel carried a crew of four, was fully canvassed and powered by twin 140 HP outboard engines. Navigation equipment included a Furuno 16 mile radar, flasher fathometer, compass, and RDF (radio direction finder). Mast, boom and outriggers provided a means to tow and retrieve trawl equipment from the stern, port, or starboard sides.

Geophysical Survey

Geophysical coverage along 92 km of trackline was obtained across the study area shown in Figure 1. The acoustical system used was a Ross 200 Khz recording fathometer (Model SL-500). This instrument has been used successfully in previous studies in Stefansson Sound to locate boulder patches. It uses a narrow beam 200 Khz transducer and produces a paper copy fathogram. Boulders and cobbles on the seafloor are indicated on traces by elongate return signals and by slight surface roughness. All survey tracklines were established using a compass and radar fixes from natural and artificial land targets. Radar targets were placed on two offshore barrier islands (Fig. 1). Navigation fixes are generally accurate within ±200 m.

Calibration

A comprehensive calibration of the Ross SL-500 preceded the geophysical survey. Instrumental calibration was conducted both at DS-11 in Stefansson Sound and directly northwest of Kangigivik Point in western Camden Bay. At both locations, divers' observations of the seafloor were correlated with the character of signal returns recorded on the Ross SL-500. The sensitivity of the instrument was adjusted to obtain maximum signal clarity for rocky and nonrocky bottom types.

Direct Seabed Observations

Divers conducted direct underwater observations of the seabed along some 4 km of survey trackline and on 13 dives. The diving observations were used to interpret distinct signal returns or to confirm our interpretations of traces recorded by the Ross SL-500. Observations were made by towing a diver on a specially constructed sled (Fig. 2) or by a diver swimming along the bottom at a designated site.

Biological Sampling

Biological samples were collected by divers, and by three types of sampling gear towed behind the boat. These included an epibenthic sled, a plankton net, and a Pope sled, a specially designed sled for sampling the bottom. The Pope sled was built in the field by Dan Pope, one of the divers, after he had accidentally lost the epibenthic sled on a transect made 8 km offshore. The Pope sled was constructed of 5 cm mesh vexar and was of the same size and shape of the epibenthic sled it replaced.

VI. RESULTS AND DISCUSSION

Surficial Bottom Features

Table 1 lists the five predominant bottom types encountered in western Camden Bay. Each bottom type is characterized by a distinct signal return on the Ross SL-500 trace. Figures 3 and 4 show signal returns that are characteristic of bottoms that contain rocks or are dominated by unconsolidated sediments. Rocky bottoms were characterized by irregularly elongated signals and by slight surface roughness.

Diving observations revealed that most of the topographical relief shown in the Ross SL-500 traces could be attributed to ice gouging. The most spectacular traces obtained were attributed to gouging by large deep draft ice which formed deep V-shaped furrows in the seafloor (Fig. 5). A second trace, showing a rough bottom, actually reflected a pattern of shallow (15-40 cm) furrows in a crisscross pattern on the seafloor (Fig. 5). This was also attributed to ice gouging, but of a more frequent nature that did not involve large bergs.

Figure 6 shows the trace which led to the discovery of “buttes”, unusual topographical features which may be the result of crisscross ice gouging (E. Reimnitz, personal communication). The buttes in western Camden Bay are flat-topped, have vertical dimensions of 0.1 to 0.5 m and have horizontal dimensions of 0.50 to 2.0 m. They are composed of mud,

Figure 2. Dan Pope preflight the diving sled used for surveying the seafloor in this study. Photograph by Alan Paulson.

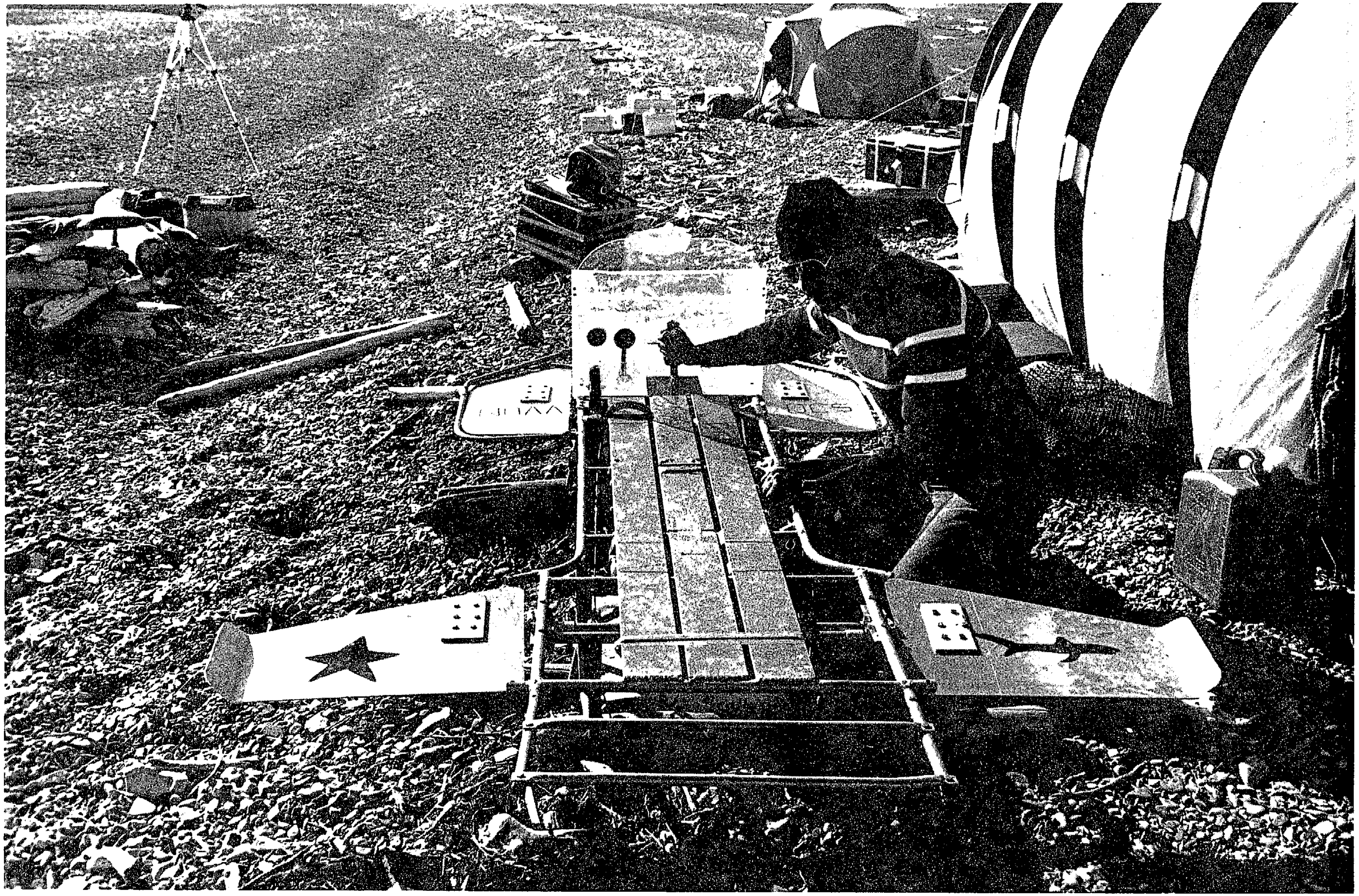


TABLE 1. The predominant bottom types encountered in the geophysical survey of western Camden Bay. The corresponding Ross SL-500 trace for each bottom type is indexed by Figure number.

Bottom-Type	Description	Location of Ross SL-500 trace
Smooth	Flat, mud or sand, with occasional ripple marks.	Figure 3, 4
Rough	Crisscross ice gouging. Haphazardly arranged furrows 15-40 cm deep in sand or mud.	Figure 5
Deep Ice Gouge	Larger scale relief in seafloor, attributed to deep draft ice.	Figure 5
Butte	Flat topped topographical features rising vertically 0.1 to 0.5 m above seafloor. Mud with occasional rocks.	Figure 6
Rock	Pebbles, cobbles, or boulders on muddy bottom. Kelp infrequent.	Figure 3, 4

Figure 3. The Ross SL-500 depth recorder trace of a boulder patch (top) near DS-11 in Stefansson Sound and a smooth seafloor surface (bottom). Rocky bottoms are characterized by irregularly elongated signals and by slight surface roughness. The reason for the occurrence of the diffuse, lighter colored marks above the bottom trace is currently unknown.

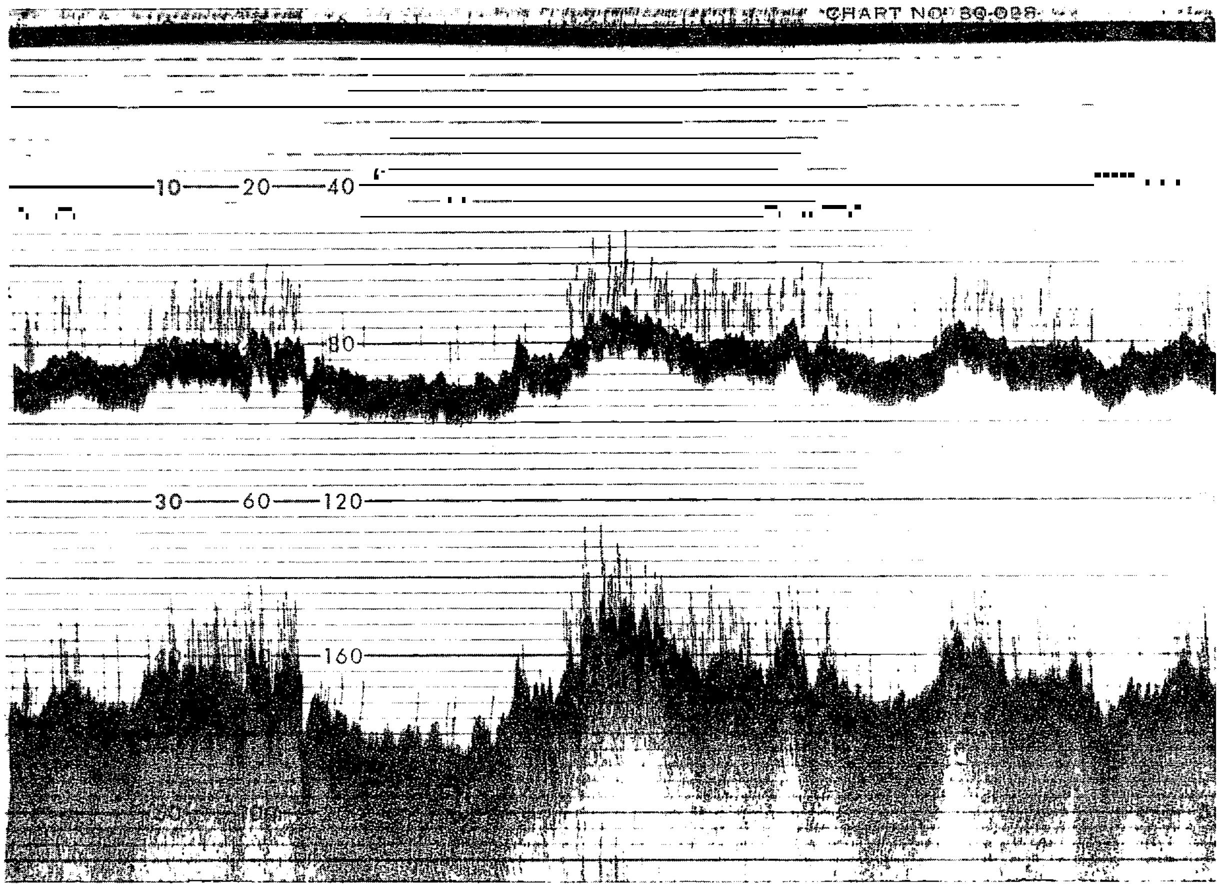
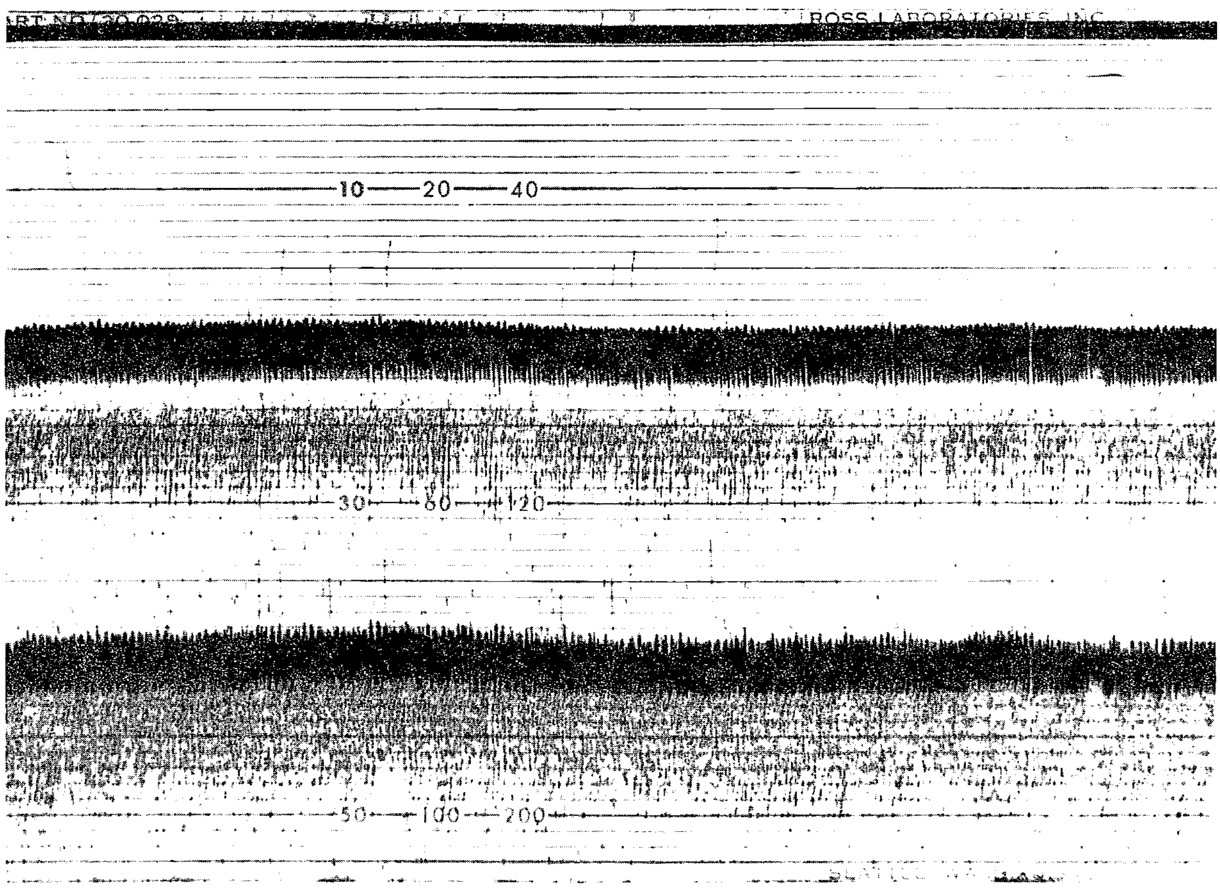


CHART NO. 80-028
10
20
40
80
30
60
120
160



ROSS LABORATORIES, INC.
10
20
40
30
60
120
50
100
200

Figure 4. Ross SL-500 trace of the seafloor along a survey line northwest of Kangigivik Point (See Fig. 8 for location of survey line).

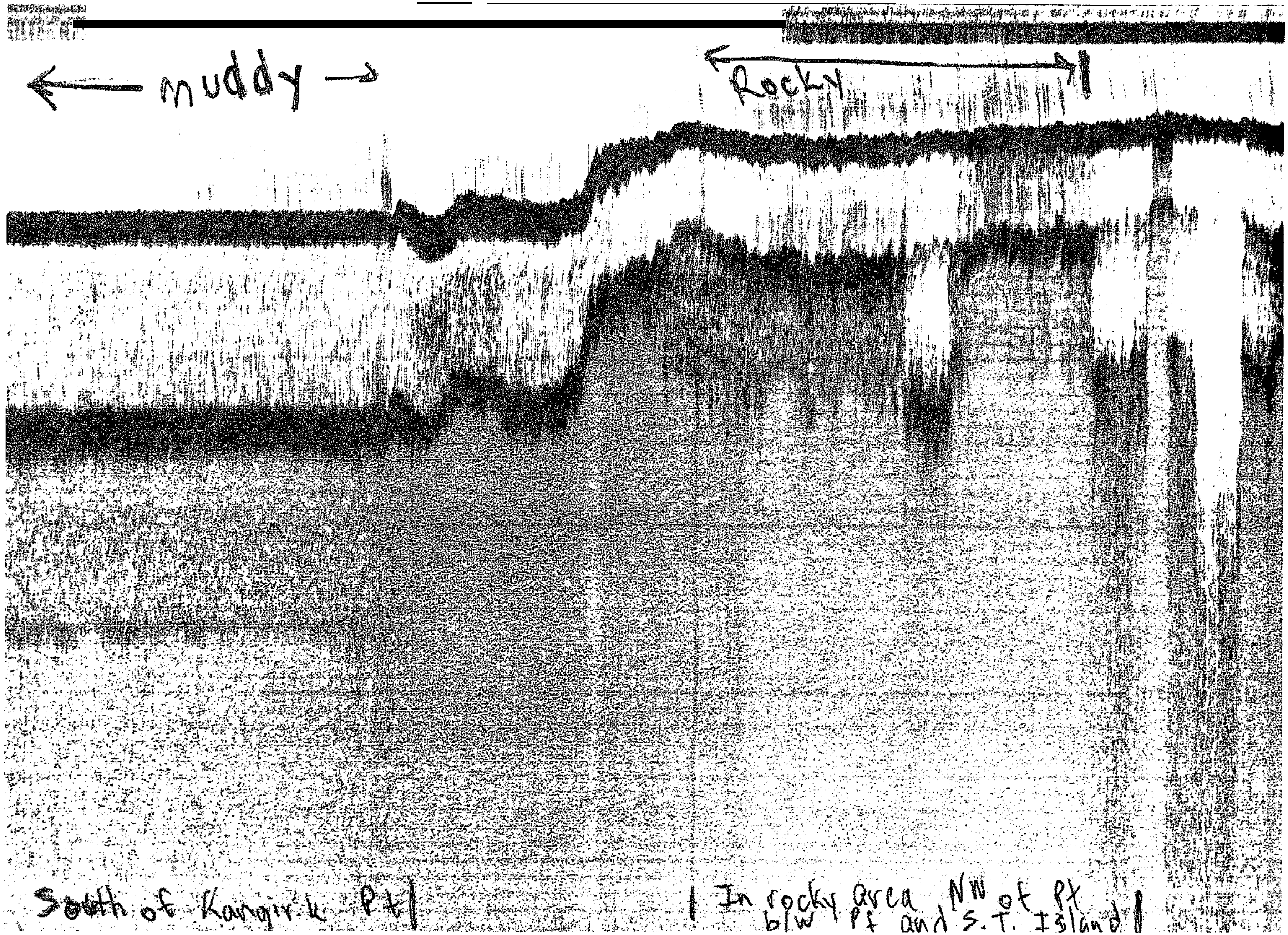
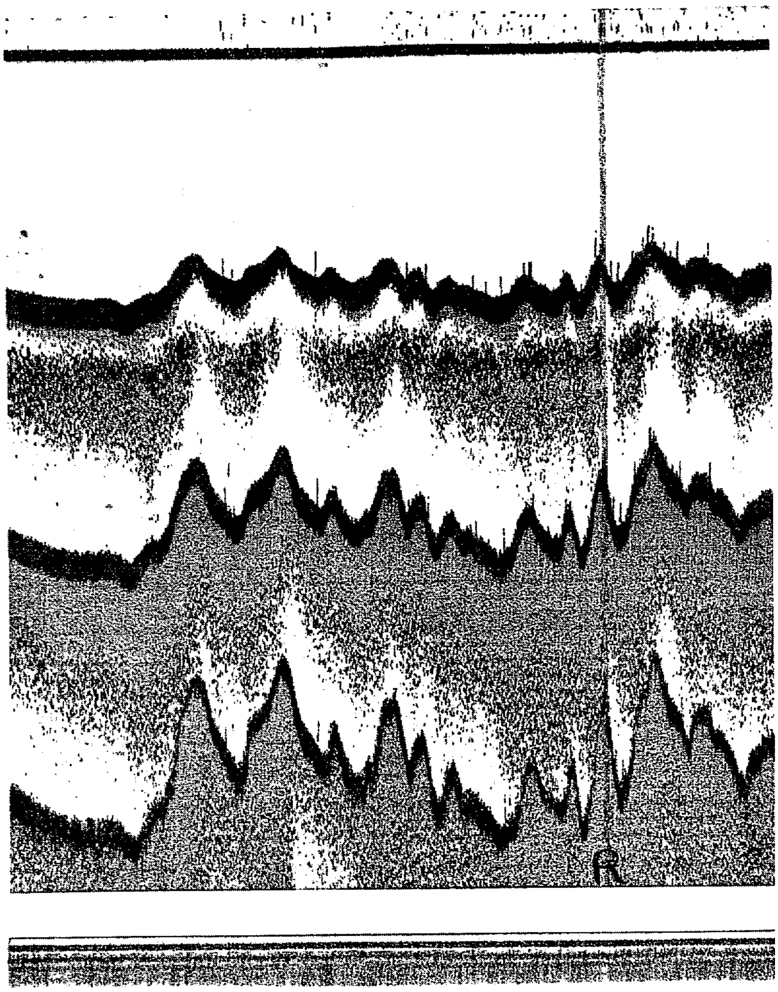

muddy
Rocky
South of Kangirk Pt
In rocky area NW of Pt
b/w Pt and S.T. Island

Figure 5. A Ross SL-500 trace of ice gouging caused by deep draft ice (top) contrasts the "rough bottom" trace (bottom) which is attributed to the crisscross pattern of furrows on the seafloor observed by divers. We believe this haphazard pattern of furrows is due to frequent shallow draft ice gouging, which we refer to as "crisscross ice gouging."



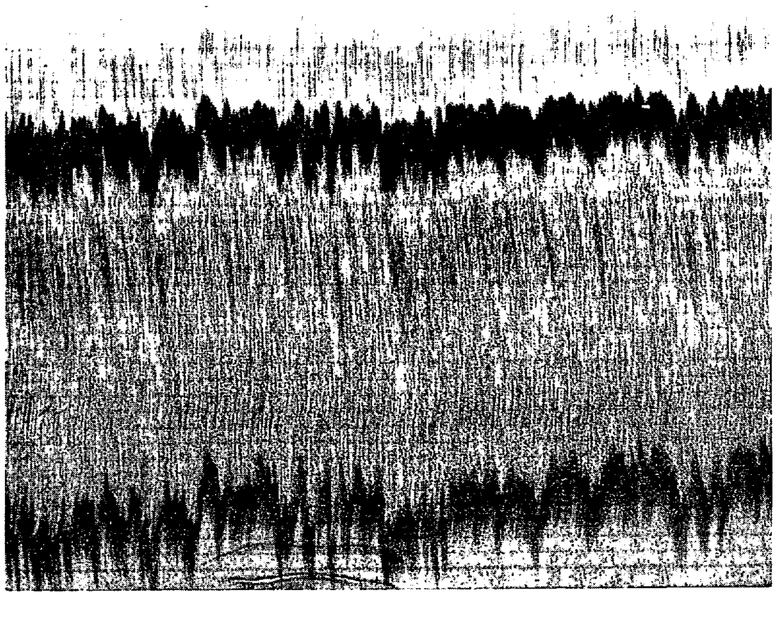
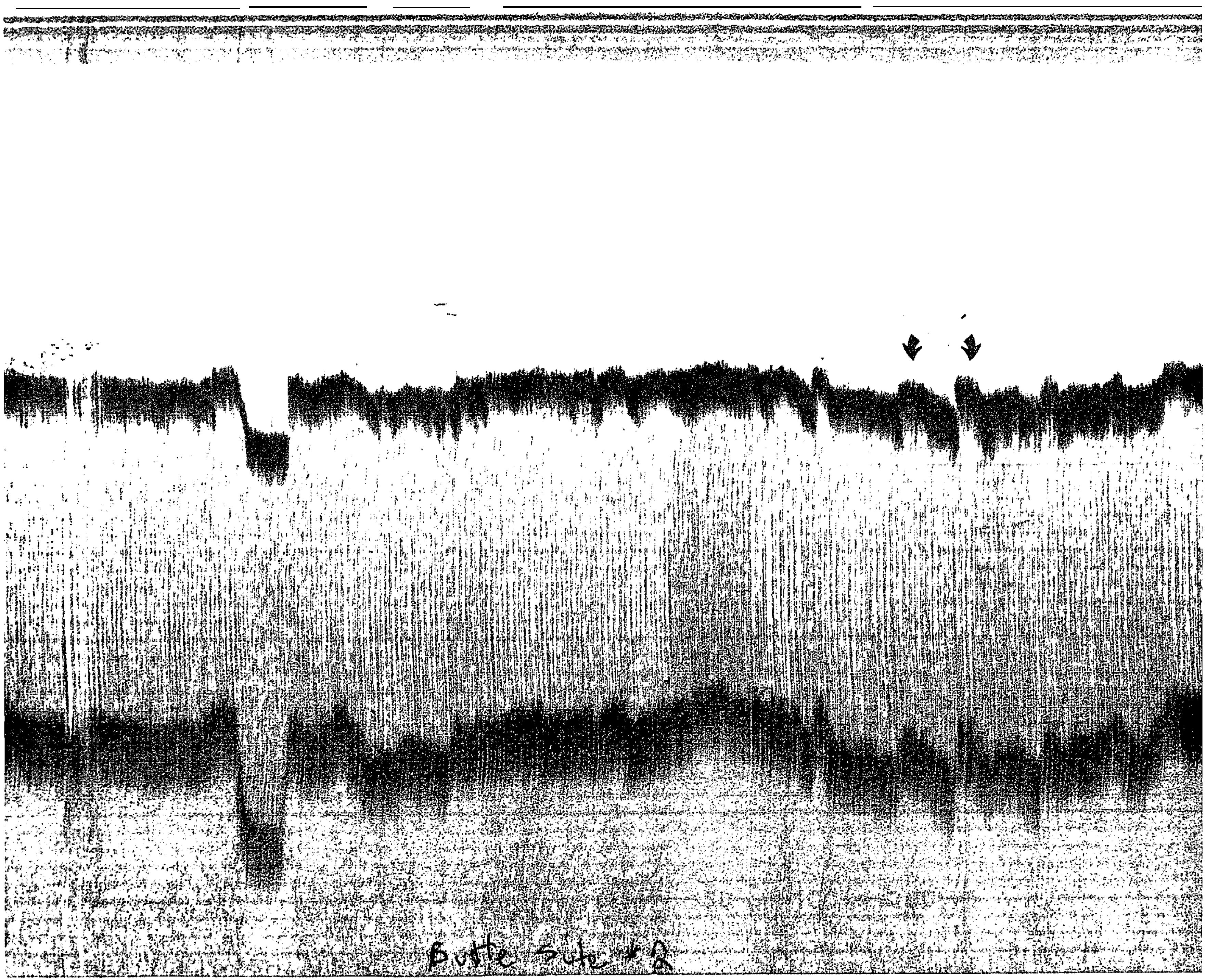


Figure 6. The Ross SL-500 trace of the buttes located by divers. Vertical dimensions of individual buttes (marked) range from 0.2 to 0.5 m and have horizontal dimensions of 1.0 to 2.0 m.


Butte Site #8

although rocks (pebbles, cobbles, or boulders) were occasionally seen amongst them. Kelp blades and other species of algae were observed in troughs surrounding some buttes.

Direct Seabed Observations

The location of dive sled transects and spot dives made during the survey are shown in Figure 7. The observations recorded from the dives on the character of the seafloor are summarized at the various sites. These observations indicate that rocks are extremely rare offshore. Drift algae was also rarely collected by the divers.

Rough sea conditions during most of the project, together with rain and snow accompanied by strong southwesterly storms, limited underwater visibility to less than 0.5 m on all dives. As a result, no attempts were made to photograph the major bottom features that characterize western Camden Bay.

Trackline Coverage

A total of 92 km of geophysical tracklines and 4 km of direct seabed observations was covered during survey operations (Fig. 8). A solid boundary of floating pack ice precluded the collection of data north of the 14 m contour line. The northernmost transect was accomplished by following the edge of the floating ice pack to a shallow 10 m shoal covered with grounded ice. The collection of data westward of this point was prevented by grounded ice along the entire shoal (Fig. 9). Dense floating ice was common along most of the survey lines.

Rock Cover and Sea Floor Topography

The topography and composition of the seafloor in western Camden Bay, based on geophysical survey data, bottom samples, and dive notes is shown in Figure 10. Rock cover in the area surveyed, based on geophysical data and diving observations, is almost nonexistent. Rocks of various sizes were occasionally observed at the butte sites, and pebbles were infrequently observed by divers at other locations.

However, when rocks were located by divers, they were bare of macroscopic attached fauna or flora.

Ice gouging appears to a frequent occurrence in the area surveyed (Fig. 10). Nearly 40% of all the geophysical data reflects ice gouging. Protection from ice scour and disruption from deep draft ice is one of the requirements for the establishment of a kelp community in the Beaufort Sea (Dunton et al., 1982). Thus, it is doubtful that such a community could exist in the surveyed area regardless of rock cover.

The results of this survey contradict the offshore (but not inshore) work of Barnes (1982), who reported boulders and cobbles offshore in depths ranging from 4 to 13 m (Fig. 1). However, Barnes based his results on his interpretation of side-scan sonar data which showed images of boulder-like objects, but no confirmation of these objects were made by divers. It is possible that the interpretation of Barnes is correct, but such boulders would have to be fairly infrequent. It is also possible that topographical features such as buttes could be confused as boulders on a side-scan image.

Fauna and Flora Collected

The fauna and flora collected by divers and various sampling equipment in this survey will be listed in our final report. Animals and benthic macroalgae commonly found on hard rock substrata were rarely collected except in the vicinity of Kangigivik Point. Since the area around Kangigivik Point 'has been studied previously (Dunton and Schonberg, 1982), no biological data will be included from this region.

Drift Kelp on Surrounding Beaches

Despite the absence of rocks and kelp in the area surveyed, and the general absence of kelp in the rocky area northwest of Kangigivik Point, large amounts of kelp drifted onto two nearby beaches following storms (Fig. 11). We noted drift kelp on Soplu Spit and on the eastern end of Survey Target Island East, north of Kangigivik Point (Fig. 1). We did not observe kelp as drift on any of the other beaches in the survey area.

Figure 7. The character of the seafloor at various locations in western Camden Bay based on spot dives and diving sled transects.

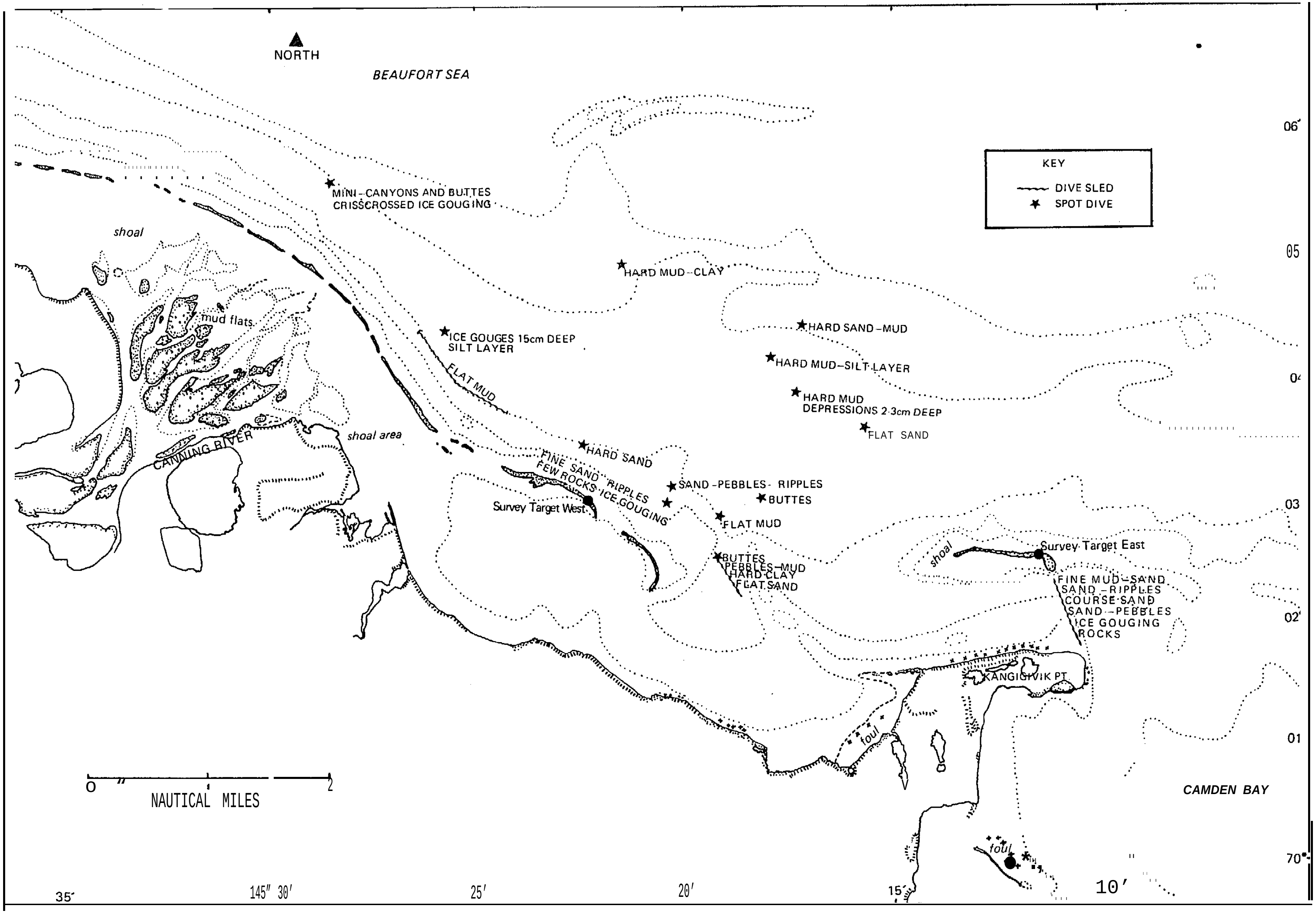

NORTH
BEAUFORT SEA
KEY
DIVE SLED
SPOT DIVE
MINI-CANYONS AND BUTTES
CRISSCROSSED ICE GOUGING
shoal
HARD MUD-CLAY
mud flats
ICE GOUGES 15cm DEEP
SILT LAYER
HARD SAND-MUD
HARD MUD-SILT LAYER
FLAT MUD
HARD MUD
DEPRESSIONS 2-3cm DEEP
FLAT SAND
shoal area
CANNING RIVER
HARD SAND
FINE SAND RIPPLES
FEW ROCKS ICE GOUGING
SAND-PEBBLES- RIPPLES
BUTTES
Survey Target West
FLAT MUD
shoal
Survey Target East
BUTTES
PEBBLES-MUD
HARD CLAY
FLAT SAND
FINE MUD-SAND
SAND-RIPPLES
COURSE SAND
SAND-PEBBLES
ICE GOUGING
ROCKS
KANGIGIVIK PT
foul
foul
CAMDEN BAY
0
2
NAUTICAL MILES
06′
05
04
03
02′
01
70°
35′
145° 30′
25′
20′
15′
10′

Figure 8. The location of geophysical survey lines, showing the usage of the epibenthic sled, dive sled, Pope sled, and plankton net along various line segments.

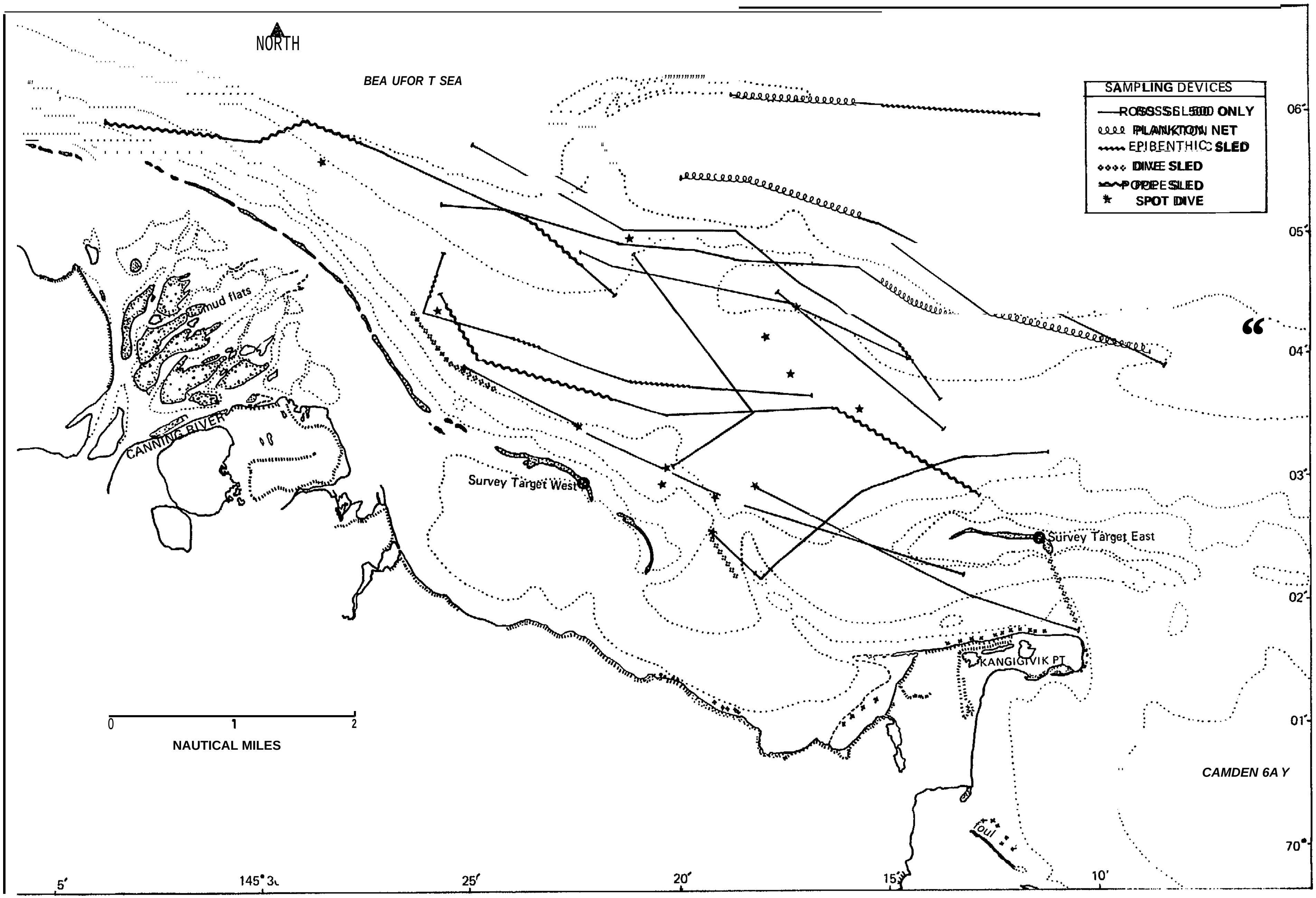
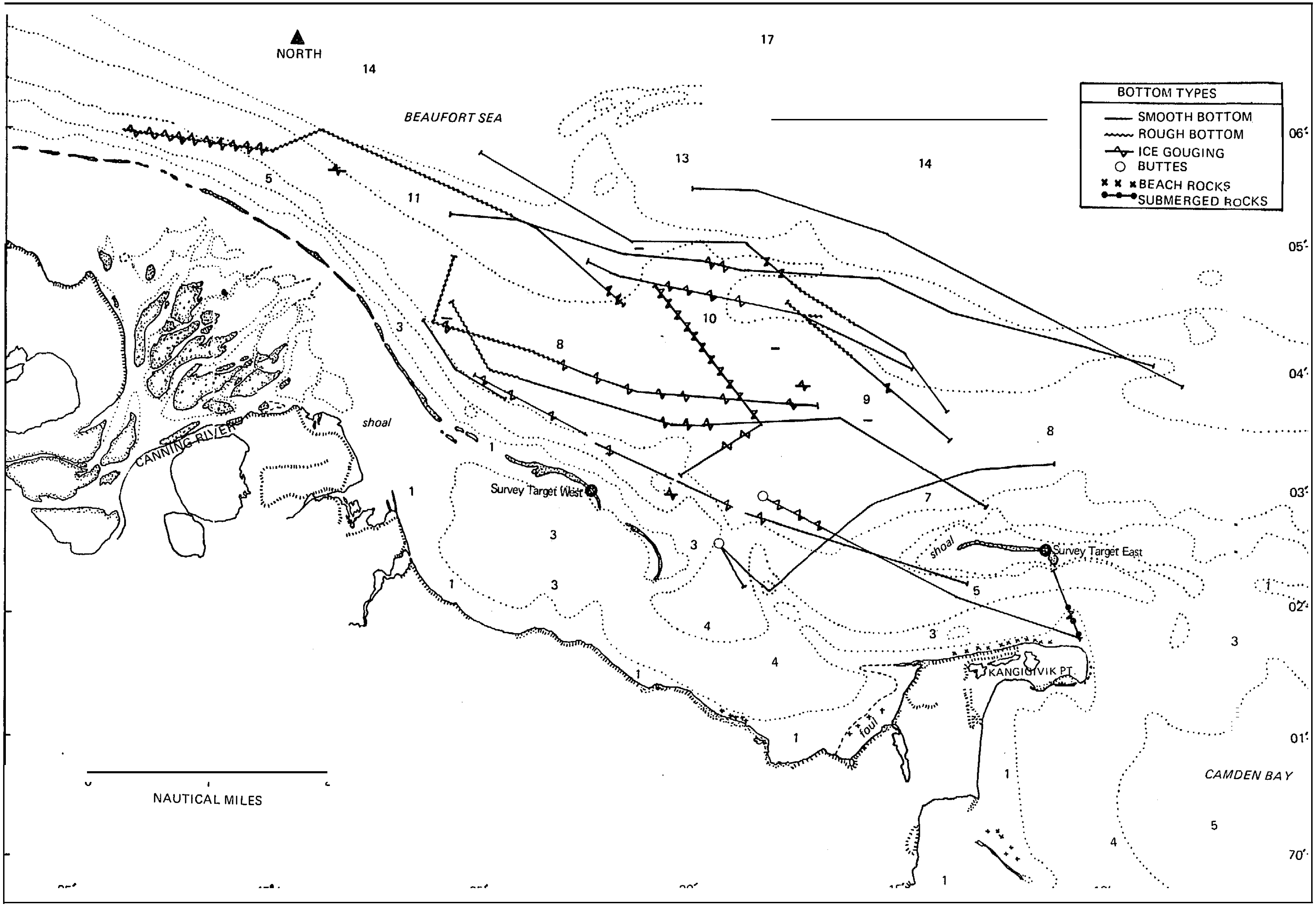

NORTH
BEAUFORT SEA
SAMPLING DEVICES
ROSS SLED ONLY
PLANKTON NET
EPIBENTHIC SLED
DIVE SLED
POPE SLED
SPOT DIVE
mud flats
CANNING RIVER
Survey Target West
Survey Target East
KANGIGIVIK PT
CAMDEN BAY
foul
0
1
2
NAUTICAL MILES
06'
05'
04'
03'
02'
01'
70°
5'
145° 30'
25'
20'
15'
10'

Figure 9. Paul Plesha (holding binoculars) and Ken Dunton (with sextant) re-establish the western terminus of our most northerly transect. Grounded ice prevented further movement to the west (or to the right in this photograph). Extremely thick floating ice (on left) prevented any diving along this transect. Photograph by Alan Paulson.

Figure 10. The topography and composition of the seafloor in western Camden Bay based on geophysical survey data, bottom samples, and dive notes. The occurrence of rocks (cobbles or boulders) on the seafloor is denoted by solid circles. Rough bottom is interpreted as crisscrossed ice-gouged furrows in the seafloor (based on diving observations, see text and Fig. 5). Depths shown in meters.



NORTH
BEAUFORT SEA
BOTTOM TYPES
SMOOTH BOTTOM
ROUGH BOTTOM
ICE GOUGING
BUTTES
BEACH ROCKS
SUBMERGED ROCKS
CANNING RIVER
shoal
Survey Target West
Survey Target East
KANGIGIVIK PT.
foul
CAMDEN BAY
NAUTICAL MILES
06'
05'
04'
03'
02'
01'
70'

Figure 11. Large amounts of kelp drifted onto the eastern end of survey target island east (north of Kangigivik Point), following a storm on August 2 and 3. Much of the drift on the beach is *Lamb.aria solidungula* but the large 3 m long specimen held by Paul Plesha is *Alaria esculenta*.

We were able to examine the drift plants on Survey Target Island East on August 4, before they had become desiccated, and found the specimens large and healthy. Their condition contrasts the small and ragged plants we collected in situ northwest of Kangigivik Point a few days earlier. It appeared that at least. some of the plants stranded in drift lines had come from another area.

A week earlier, we noticed large amounts of kelp in a drift line on the seaward side of Soplu Spit. The kelp was slightly desiccated, so it was difficult to assess its size and health. In an attempt to quantify the amount which had been deposited on the beach, we collected all kelp within ten 1 m^2 plots along the beach (Fig. 12). The algae from each plot was bagged and later weighed in the laboratory. The mean dry weight of the kelp in the 10 plots was 22.5 g. Over 600 meters of shoreline this translated to 72 kg of kelp (wet weight). In a conservative estimate, the material cast onto the beach probably represents less than 10% of the kelp bed itself. If the mean biomass of kelp is 137 g m^{-2} in a typical boulder patch (Dunton et al., 1982), then the size of the unknown kelp bed in Camden Bay is approximately 5,400 square meters.

The most likely source for such a kelp bed is a submerged shoal east of Kangigivik Point, formerly known as Boulder Island. This shoal was brought to our attention by Erk Reimnitz (USGS) following a discussion of our observations concerning the possible source of drift kelp in this area. Reimnitz also recalls kelp in association with this island several years ago. The size of the shoal (about 25,000 square meters) and the observations of Reimnitz indicate that it may support a small kelp bed.

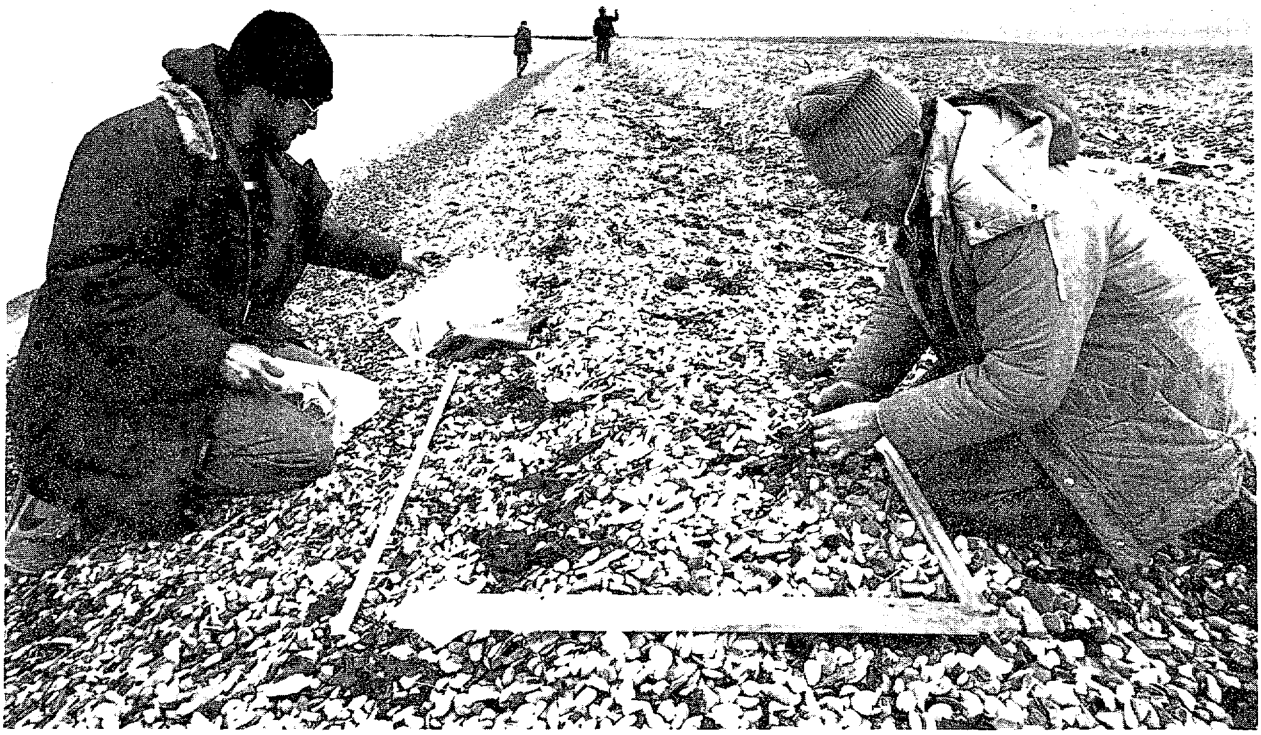


Figure 12. Dan Pope (left) and Paul Plesha (right) collect dried kelp recently cast up on the beach in a 1 m^2 area on Soplu Spit. Photograph by Alan Paulson.

NEEDS FOR FURTHER STUDY

The only unsolved mystery for this area is the source of large amounts of drift kelp on beaches east of the survey area. It appears that the only possible source for this kelp is in the vicinity of the Boulder Island shoal, but this is speculative at best.

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