COASTAL RECONNAISSANCE FOR MARINE TERMINAL PLANNING IN THE HIGH ARCTIC

VOLUME I MAIN REPORT

COASTAL RECONNAISSANCE FOR MARINE TERMINAL PLANNING IN THE HIGH ARCTIC

VOLUME I – MAIN REPORT

by

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Cover: Field observations along the coasts of the east-central Arctic Islands in support of marine terminal planning. Top left, the unloading of a supply ship at Rea Point, Melville Island. Bottom left, preparation for diving operations, for the collection of nearshore bottom information along Byam Channel. Top right, reconnaissance and detailed beach surveys were often conducted using helicopters. Bottom right, interaction of sea ice and shore -15 m high ice piles occur along sections of northern Somerset Island.

SUMMARY AND RECOMMENDATIONS

Sources of oil and gas in the Canadian High Arctic are in areas which lie within the zone of multi-year sea ice. Since the ice may prevent year round transport of the oil and gas by vessels, transshipment terminals may be required in areas of less ice severity. At the transshipment points the oil or gas could be transferred from ice-breaking ships or pipelines to ice-strengthened bulk carriers. The present report is a compilation of the coastal information needed for a preliminary selection and assessment of possible marine transshipment terminals. The coastlines examined included those of the east-central Arctic islands, particularly along the Lancaster Sound-Viscount Melville Sound (Parry Channel) corridor.

The first part of this study is a synthesis of coastal information for the study area using existing information. Slope, bathymetry, geology and geomorphic information are plotted, across a 3 km wide strip of coast, on 15 sets of 1:250,000 scale maps. In the main text, the four basic parameters are discussed with respect to marine terminal planning in each map-area. Coastal slope is examined to assess the potential for support facilities, e.g., airstrip. Bathymetry is used to discuss approach channels, accessibility to potential sites and navigational hazards. Geologic and geomorphic information is used where available to indicate the availability and accessibility of construction aggregates, shoreline stability and the direction of longshore transport.

The second part of the report includes detailed coastal field observations completed by Geological Survey personnel along select stretches of coastline within the Arctic Islands. Observations are presented from parts of Bathurst, Byam

Martin, Lowther, Melville, Russell and Somerset Islands. Also included are specific marine terminal site selection studies for Radstock Bay, Devon Island and Makinson Inlet, Ellesmere Island. Terrain mapping and a geomorphic study of King Christian and Ellef Ringnes Islands indicates ground surface stability in the areas of potential gas fields. The areas underlain by the Christopher geologic formation were found to be especially unstable and prone to frequent slope failure.

This report provides a basic coastal data base to which reference can be made in the event of future development along the coasts of the east-central Arctic Islands. From the synthesis of coastal information presented, criteria required to evaluate the suitability of a marine terminal were drawn and a preliminary selection and assessment of potential marine transshipment terminals was made. One of the most important criteria not available for much of the Arctic was nearshore bathymetry. Consequently, it is strongly recommended that future coastal studies include nearshore surveys.

From the study area, fourteen sites are recommended as potential marine transshipment terminals or staging areas (Table 1, fig. 1). Selection of the sites was made primarily from a geologic and geomorphic standpoint. Each of the sites was examined (Chapter II) using a set of design criteria (Appendix 1) drawn from previous marine terminal studies and the available coastal information. Both the design criteria and the list of potential marine terminals were reviewed and approved by port engineers of the Department of Public Works. In many cases the assessment of the sites was based on very little quantitative information and therefore detailed field observations are recommended should one of the sites be chosen for further study.

Bridport Inlet, Melville Island has already been selected by Petro-Canada as the site for a gas processing and liquefaction plant and consequently the transshipment terminal for gas from Melville Island. The additional potential transshipment terminals recommended in this report are for the transporting of oil and gas from the Sverdrup Basin. Four sites were selected on each of Devon and Bathurst Islands and four from islands south of Parry Channel (Table 1, fig. 1). Each are discussed more fully in Chapter II. Of these sites, based on coastal information, Radstock Bay, Devon Island and/or Bateman Bay or the bay south of Bass Point, Bathurst Island are recommended as having the best potential as transshipment terminals within the study area.

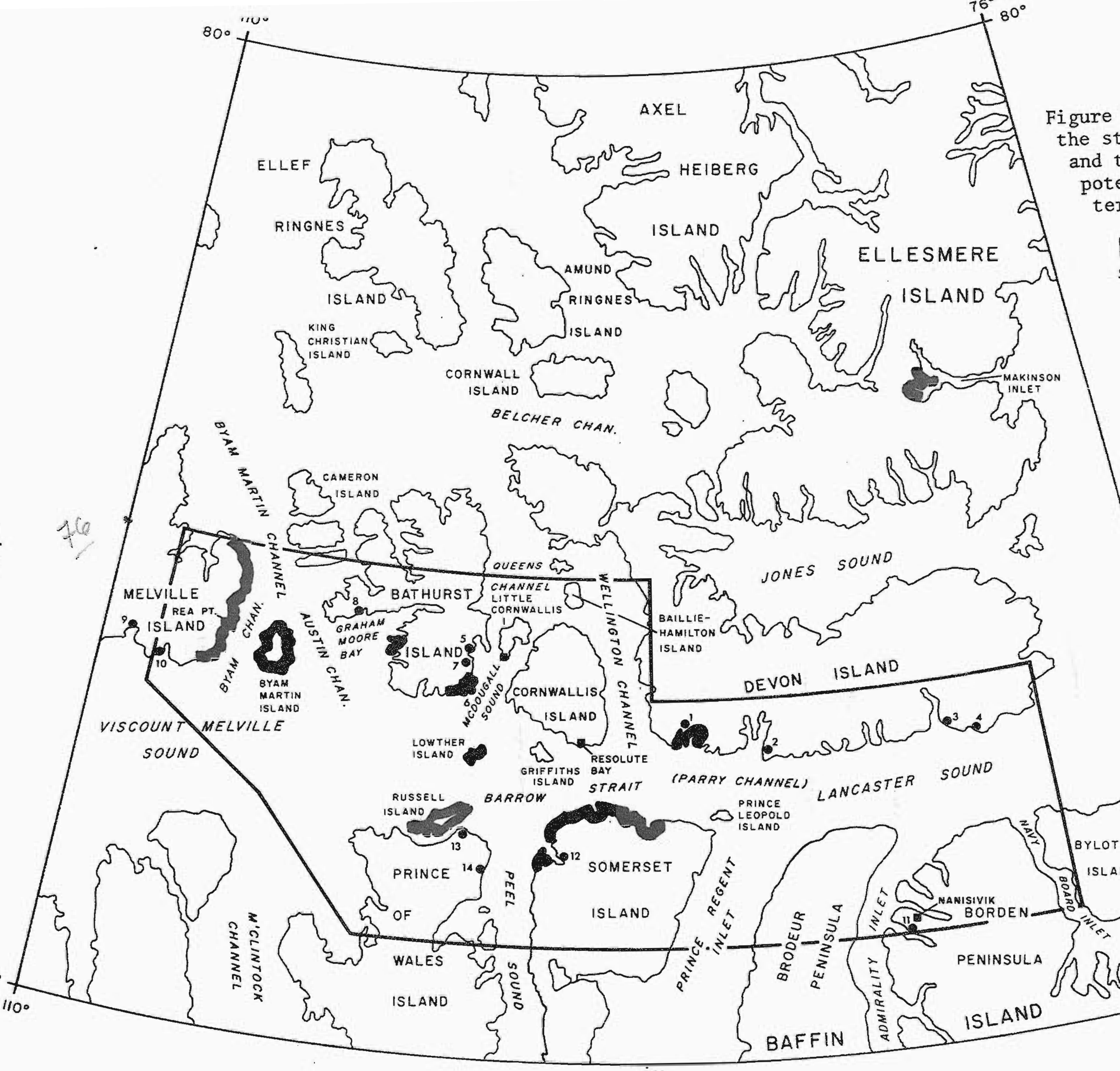

Figure 1. Location map of the study areas (outline and the recommended potential marine terminal sites.

■ Detailed study sites.

-iv-

TABLE I POTENTIAL MARINE TERMINAL SITES, LISTED ACCORDING TO ISLAND. Locations are shown in figure i.

Potential Marine Terminal	Bathymetric Information	Accessibility	Shelter	Anchorage (based on Water Depth)	Length of Open Water Season (estimated)	Landing Beaches	Availability Construction Materials	Potential Airstrip	Fresh Water Supply	Additional Comments
Devon Island										
1. Radstock Bay	Excellent	Excellent	Excellent	Good	80	Excellent	Excellent	Excellent	Excellent	Poor anchorage in northern part of bay
2. Maxwell Bay	Excellent	Excellent	Poor	Poor	85	Good	Good	Poor	Poor	
3. Croker Bay	Good	Excellent	Poor	Poor	129	Good	Good	Excellent	Good	Calving Glaciers
4. Dundas Harbour	Excellent	Good	Limited	Good	129	Good	Good	Limited	Poor	once used as a R.C.M.P. post
Bathurst Island										
5. Bateman Bay	Limited	Good	Good	Good	49	Limited	Good	Good	Good	
6. Freemans Cove	Good	Limited	Good	Good	49	Good	Good	Excellent	Limited	Shoals to east of entrance
7. Inlet south of Bass Point	Limited	Good	Excellent	Good	49	Good	Good	Limited	Good	
8. Graham Moore Bay	None	Limited	Good	Good	48	Good	Limited	Good	Poor	
Melville Island										
9. Bridport Inlet	Selected by Petro-Canada as the site for a gas processing and liquification plant. Detailed field studies have been completed by Petro-Canada.									
10. Skene Bay	None	Good	Poor	-	44	Good	Good	Good	Good	
Baffin Island										
11. Arctic Bay	Excellent	Good	-	Good	-	Excellent	Good	Limited	Good	Inuit Settlement
Somerset Island										
12. Aston Bay	None	Good	Poor	-	-	Good	Excellent	Poor	Good	Some years Bay remains ice covered
Prince of Wales Island										
13. Baring Channel	Limited	Good	Limited	-	-	Good	Excellent	Good	Good	Possible site also on south Russell Island
14. Back Bay	None	Good	Good	-	-	Good	Good	Good	Good	

CONTENTS

Page

CHAPTER III

Page

Page

Page

VOLUME II

MAPS

VOLUME III

PHOTOGRAPHS

LIST OF FIGURES

Page

Page

LIST OF TABLES

Chapter I

INTRODUCTION

OBJECTIVES

Seven gas fields with marketable gas reserves of 16 trillion cubic feet have been discovered in the Sverdrup Basin area (Heatherington, 1977). Furthermore, three oil wells have been completed on Cameron Island indicating high oil producing rates of several thousand barrels per day which may prove to be the first commercial field in the arctic islands. Studies are now being conducted to assess the feasibility of an all marine transportation system for the removal of oil and gas from the Sverdrup Basin to southern Canadian markets. Because the source areas lie far within the zone of multi-year sea ice, year round activity may not be possible using ships. Alternatives to the all marine system are the use of pipelines or ice-breaking ships to carry the gas or oil to zones of lesser ice severity, where ice-strengthened carriers could be used. A need for the present study arose because of the possible requirement for transshipment terminals or staging areas for pipeline construction, within the areas of lesser ice severity. This study focuses on the shores adjacent to and along the Lancaster Sound-Viscount Melville Sound (Parry Channel) corridor (fig. 1). The study was carried out for the Strategic Studies Branch of the Department of Transport. The objectives of the research were:

(1) to provide a data base of basic coastal information for the study area outlined (fig. 1) to which reference could be made in the event of future development along the coasts investigated.

(2) to present a compilation of all detailed coastal studies in the arctic islands, previously completed by personnel from the Geological Survey of Canada.

(3) to make a preliminary selection and assessment, using the above coastal information, of potential marine terminal sites for the transshipment of oil and/or gas from pipelines or ice-breaking vessels to ice strengthened carriers along or adjacent to the Parry Channel corridor.

OUTLINE AND USE OF VOLUMES

The present report has been divided into three volumes: a text, an atlas of coastal maps and a series of oblique coastal photos.

Volume I describes the coastal characteristics of the central, high arctic islands. In chapter II a synthesis of general coastal information based on existing material is presented for the study area outlined (fig. 1). This chapter provides a complete description of each map presented in volume II and discusses, from a geologic and geomorphic standpoint, the potential of specific sites as marine transshipment terminals or staging areas for pipeline construction. Chapter II also furnishes references that supply a user with additional information beyond the scope of the maps presented in volume II. In chapter III detailed coastal studies previously completed in the arctic islands by personnel from the Geological Survey are presented. From a relatively broad data base, criteria required to evaluate the suitability of an area for a marine terminal have been selected and applied to each of the study areas. The problem of site selection and evaluation has been approached from a coastal process and morphology as well as geologic point of view.

Volume II of the report is a series of maps (referred to in the text as M1, M2, M3 etc.) consisting of three copies of each 1:250,000 National Topographic Series (NTS) map sheet. The first of each set (e.g. M1a) is entitled "Slope and

Bathymetry" and divides a 3 km coastal strip into slope categories that enable a user to evaluate, at a glance, areas of coastline that may be accepted or rejected from further study. All existing nearshore bathymetric information and tidal data have been included on these maps. The second map in each set (e.g. M1b) shows the distribution of the rock types in the 3 km coastal strip. Although greatly generalized, the "geology" map provides an indication of the availability and suitability of quarry stone. The final map of the set '(e.g. M1c)' provides physiographic and geomorphic information of the coast as determined from air photographs.

Volume III is comprised of oblique air photos of select coastal areas that have been studied by Geological Survey personnel. Each page is referred to as P1, P2, P3, etc. and the photos are keyed for each page numbering 1 through 16 (e.g. P15: 3-8 refers to the photo volume page 15, pictures 3 to 8). A description, location and date are given for each photo on the back of the preceding page. A selection of underwater photographs for several areas are also included to provide the user with information on the nearshore bottom characteristics.

ACKNOWLEDGMENTS

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Chapter II

COASTAL RECONNAISSANCE MAPPING

by. W.B. Barrie

INTRODUCTION

This chapter reviews the methods and rationale of the mapping, presents a description of the physiography and bathymetry of the study area outlined on Figure 1 and considers, in greater detail, the conditions which led to the selection of the potential marine terminal sites listed in Table 1. The entire area consists of fifteen topographic maps at the scale 1:250,000; the discussions which follow relate to individual map sheets beginning with west to east coverage along northern Parry Channel (i.e. Viscount Melville Sound-Barrow Strait-Lancaster Sound) followed by west to east coverage along southern Parry Channel. This order has also been maintained in the accompanying map volume (see Vol.II, Map 1a, b, c to Map 15a, b, c).

METHODS AND RATIONALE

Slope and Bathymetry*

Methods

Slope

The slope of land surfaces lying within 3 kilometres of the coast has been determined from an analysis of contour spacing. The slopes are plotted on each map sheet according to the following categories: 'A', <5°; 'B', 5- 10°; 'C', 11-20°; 'D', >20°.

(*See volume II, Map 1a-15a)

Bathymetry

The major source of bathymetric information has been Navigation Charts published by the Canadian Hydrographic Service. Selected depths and the 20, 30, 50 and 100 m isobaths have been transferred from the charts to each map sheet. The accuracy of this transfer process is somewhat limited because of different map scales. Narrow passages between land masses and areas with depths less than 100 metres have been shown where information allowed. Blank spaces and irregular gaps between soundings signify that no soundings have been taken in these areas (Pilot of Arctic Canada, Vol. I, 1970). Some of these gaps have been filled as a result of recent bathymetric surveys and publication of the 'National Resource Series' bathymetric maps by the Canadian Hydrographic Service. Six of these maps have been included in the report (see maps M16 to M21).

Where the closest soundings to a blank spot are deep, it may be assumed that the water in the blanks is also deep; however, where they are shallow, or where it can be seen from the rest of the map that shoals or reefs are present, extrapolation of bathymetry into blank areas is difficult. In waters where rocks abound it is always possible that a survey, however complete and detailed, may have failed to find every hazard to navigation (Pilot of Arctic Canada, Vol. I, 1970).

Mean and large tidal ranges are provided for those secondary or reference ports which are assumed to be most representative of the area covered by each map sheet. The Canadian Tide and Current Tables: Arctic and Hudson Bay (Canadian Hydrographic Service, 1976, p. 4) define mean tide range as "the difference between the heights of higher high water and lower low water at mean tides" and large tide as "the difference between the heights of higher high water and lower low water at large tides".

Rationale

Coastal slope information is critical when considering locations for airstrips, roads, townsites and other facilities associated with a marine terminal. Initially, slope is an essential determinant of an area's suitability for use as a construction site.

Very important for the design of open sea-coast harbours are the approach channels, entrance, and basins. Certain navigational and hydraulic aspects must be considered including channel and entrance depths, channel width and channel alignment with respect to shoaling, littoral drift, and the requirements of navigation (Brunn, 1973). Detailed hydrographic surveys have been completed for portions of the study area but, as indicated above, there remain numerous gaps in the data. Nevertheless, because of the emergent and juvenile nature of most arctic coasts, on shore aspects of the coastal geology and topography are similar to those offshore, and coastal slopes and relief can be used as fairly reliable indicators of slope and topography in adjacent offshore regions where bathymetric information is not available.

River, tidal and wind-generated currents, and wave action are important hydraulic aspects which have been considered during the geomorphologic mapping and throughout the detailed site specific reports presented in Chapter III.

Geomorphology*

Methods

Vertical aerial photographs at the scale of 1:60,000 were used as a means of interpreting the geomorphology of a 3 km wide coastal strip throughout the study area. Features and processes identifiable at this scale were mapped directly onto the National Topographic System 1:250,000 scale map sheets.

(*See volume II, Map 1c-15c)

Flights of raised beach ridges are a prominent feature of many of the coastal regions in the study area. Some of the more well-developed traces have already been indicated on the topographic sheets but close examination of the air photographs revealed the existence of many other less conspicuous beach ridges. These have been identified on the geomorphology maps with their spacing and orientation depicted as accurately as possible.

Coastal ice-pushed ridges are also a common feature in the study area but could not be identified on the air photographs. They reach their greatest magnitude when there is moving pack ice inshore for a major part of the year. They are strikingly developed in Parry Channel (Viscount Melville Sound, Lancaster Sound and Barrow Strait) but are relatively rare in the enclosed waters of this area where the ice is fast in the winter and breaks up quickly in the summer (Bird, 1967).

Extremely steep slopes in the coastal areas have been indicated on the geomorphology maps as either cliff or bluff/headland. 'Cliff' is used to indicate a continuous and nearly vertical face of rock, whereas, the 'bluff/headland' designation signifies a steep bank or slope. Within the study area, cliffs and bluffs (or headlands) vary in magnitude from low inconspicuous slopes at the margin of a coastal plain or streamcut bank to escarpments or talus slopes hundreds of metres in height. All cliffs and bluffs fall into slope category 'D' (i.e. slope angle >20°) on the 'Slope and Bathymetry' map series.

Tundra and swale ponds and freshwater lakes not already marked on the topographic sheets have been indicated on the geomorphology maps. In most instances their small sizes and large numbers prevented accurate representation. Tidal flats, shoals and offshore areas exhibiting signs of deposition and depositional features resulting from fluvial action (e.g. alluvial fans, valley fill, deltas), glacial action (e.g. moraines, eskers), and mass wastage (e.g. talus) have also been indicated.

The direction of longshore currents has been plotted on the maps using as indicators the orientation of drifting ice, the direction of advance of coastal depositional forms, stream deflection and sediment plumes.

Rationale

In the design of an arctic marine facility it is particularly important to predict future shoreline stability. The ability to make such a prediction requires knowledge of the present geomorphological configuration of each coastal area and an understanding of the processes responsible for development and change.

Assessment of an area's suitability as a marine terminal site is greatly influenced by the availability and accessibility of construction aggregates. There are a number of features indicated on the geomorphology maps which are capable of providing sand and gravel for construction purposes. Flights of raised beaches are widespread throughout the study area; if closely spaced, they also provide excellent, well-drained construction sites with good permafrost characteristics (Bird, 1967). Spacing is controlled for the most part by slopes: steeper slopes contain more closely spaced ridges.

Uplifted and active deltas are a second important source of construction materials. Outwash from retreating valley glaciers and local icecaps filled estuaries in the sea or formed alluvial fans and deltas. Today these sands, gravels, and cobbles form elevated deltas or have been dissected by rivers to produce terraces (Bird, 1967). The depositional lowlands of presently active river valleys are also composed of extensive deposits of sand and gravel.

Wherever present, eskers; ground, lateral and end moraines; and talus deposits may provide a source of construction aggregates. Talus slopes occur throughout the eastern portion of the study area where the shorelines are dominated by upland and limestone coasts. Eskers are an uncommon feature in the study area with confirmed occurrences only on western, northern and eastern Prince of Wales Island and southern Russell Island. Permanent ice, in the form of valley glaciers or icefields, is found only on Bylot, Baffin, and Devon Islands. Most valley glaciers are accompanied by extensive terminal and lateral moraines whereas small icefields usually exhibit debris-free edges and have no moraines. The margins of larger icefields may contain slight amounts of morainic debris (Bird, 1967).

Port facilities should not normally be built downdrift of a large source of material such as a river, an estuary or an eroding shore. With this in mind, tidal estuaries and flats, accumulation shoals, rivers actively discharging sediment and the direction of longshore currents, and thus in many cases littoral drift, have been indicated.

Lakes are not a dominant feature of the Arctic Islands. Where land ice now exists, occasional impoundment lakes are to be found occupying the heads of fiords or inland valleys. Near the height of land on some of the islands, notably Devon Island, small upland ponds are found while on other islands such as Cornwallis, Prince of Wales and Melville, small lakes or ponds exist near sea level. Tundra ponds, swale ponds and lakes have been indicated on the geomorphology maps, bearing in mind the importance of year-round supplies of fresh water.

Geology*

Methods

Geological maps and reports published by the Geological Survey of Canada were used to list the predominant rock types occurring along the 3 km wide coastal strip. Each unit represents one or more formations in which the relative proportions of the principal rock types differ from those of adjacent areas. For example, the unit represented by "3, 4, 5" on page M1b of Volume II indicates that the major rock types are "sandstone, siltstone, and shale"; whereas, the adjacent unit "3" suggests that sandstone is predominant rock type. Drift and unconsolidated sediments of the Quaternary period and glacial ice have also been mapped.

Rationale

Local geology affects foundation and excavation conditions, the availability of construction materials, water supply (both surface and underground except in arctic regions where the ground exhibits a permanently frozen condition), and the final selection of building sites. The rock types indicated on the maps provide a basis for the further study of the quality and supply of building stone, rip rap, crushed rock, gravel and sand; the purity and runoff characteristics of surface waters; and the engineering properties of the bedrock.

MAP DESCRIPTIONS

Byam Channel

Physiography

The Byam Channel map sheet (Vol. II, M 1a, b, c) includes Byam Martin Island and eastern Melville Island. "Plateau" and "coastal lowland" are the two physiographic units that comprises the study area.

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* See volume II, Map 1b-8b, 10b-15b; bedrock geology mapping not available for Dundas Harbour Map 9b

Melville Island

<u>Upland Areas</u>: Eastern Melville Island is characterized by a dissected undulating plateau with east trending ridges separated by wide, flat-floored valleys. Elevations range between 120 and 250 metres above sea level except in the Spencer and Baldwin Walker Ranges flanking Weatherall Bay. The highest point on eastern Melville (385 metres) occurs east of Weatherall Bay on a sharp southeast trending ridge.

The northern half of the Spencer Range comprises a fault which is quite distinctive from the surrounding terrain. A wall-like bluff rises 359 metres above the south shore of Weatherall Bay and, according to Tozer and Thorsteinsson (1964), the south side of this bluff is a fault-line scarp. On the western side of Weatherall Bay there are small bluffs which are also related to faults, and steep cliffs rise to over 300 metres above sea level along the inland coasts of the East Arm. Cliffs rise 90 metres above sea level along parts of Skene Bay and Beverley Inlet on the southeast coast.

The drainage pattern is predominantly dendritic and largely controlled by east-west structural lines of folded sediments. The rivers and streams are deeply incised and most of the larger rivers have broad, flat alluvium-filled valleys. There are few lakes in the plateau region except around Beverley Inlet and Weatherall Bay. Polygonal ground and tundra ponds occur in abundance throughout eastern Melville, notably towards the coast.

Tozer and Thorsteinsson (1964) found isolated deposits of till up to 46 metres thick near Winter Harbour on Dundas Peninsula. No thick deposits were observed in other parts of the island; however, most of southern and southeastern Melville contains areas where outliers of mainly, or entirely, Laurentide till, probably of pre-Wisconsin age, are common (Tozer and Thorsteinsson, 1964; Fyles, 1965).

Coastal Lowland: A lowland region, varying in width from 1 to 12 kilometres, follows the southern and eastern coasts of Melville Island from Skene Bay to beyond Towson Point. The land surface rises gently from the sea to meet the outer edge of the plateau. There are numerous streams along the coast, most of which are normal to it. Along the south and southeast coasts are a number of large and actively extending deltas. King Point and Nelson Griffiths Point are particularly good examples.

Flights of raised beaches dominate the coastal landscape except on the surfaces of active deltas. Innumerable small lakes, tundra ponds and swale ponds have formed along the coast, and polygonal ground occurs in most regions.

Byam Martin Island

Byam Martin Island is slightly domed in outline and its low coasts rise gently inland to elevations of from 60 to 150 metres. There are no outstanding relief features on the island. The drainage pattern is predominantly dendritic and structurally controlled by east striking bedrock. Most rivers are incised and actively transporting large quantities of sediment toward the coasts. This has resulted in the formation, and the now active extension, of large deltas such as those found at Langley Point and Cape Gillman. Numerous short streams flow normal to the coasts.

Steep bluffs rise to over 60 metres south of Fanshawe Point and along the valleys of some of the larger rivers.

Flights of raised beaches up to 60 metres above sea level dominate the coastal regions except on the surface of active deltas. The intervening swales are usually ponded and lagoons have formed along the shoreline.

Bathymetry

Byam, Byam Martin and Austin Channels, and Viscount Melville Sound are relatively free of navigational hazards except close inshore. Mid-channel depths range from 50 to over 240 metres. The 30 m isobath lies within 2 kilometres of the shoreline along eastern and southern Melville and within the upper portion of Weatherall Bay. A narrow zone of shallow water exists inshore along most of eastern and southern Melville extending up to 1 kilometre off the front of deltas at King Point and Nelson Griffiths Point. Extensive zones of shallow water exist up to 8 kilometres off northern, southeastern and southwestern Byam Martin Island and about 10 kilometres off eastern Melville Island between Rea Point and Consett Head.

An unexamined shoal area, named Keene Bank, lies in central Austin Channel approximately 40 kilometres east of Byam Martin Island. The minimum water depth over this shoal is approximately 7 metres.

Tidal data from Winter Harbour on Dundas Peninsula and Cape Capel on southern Bathurst Island suggest a mean tide range of 0.9 to 0.97 metres and a large tide range of about 1.6 metres.

Viscount Melville Sound probably has a general flow of water to the east. Current observations in southern and eastern Viscount Melville Sound in 1970 and 1971 revealed a strong easterly current whose velocity approached 1.5 metres per second (Pilot of Arctic Canada, Vol. III, Supplement No.5, 1976).

Potential Marine Terminal*

Skene Bay

Skene Bay is located on southeastern Melville Island. It is entered between Palmer Point and a point 11 kilometres northwest of Ross Point. The bay is

* See also Chapter III, page 282.

rectangular in shape measuring 10 kilometres across and extending 8 kilometres inland. Two narrow inlets extend further inland from the head of the bay, the largest of which has been named Beverley Inlet.

Two potential marine terminal sites have been selected, one on either side of the entrance of Skene Bay.

Navigation: Little is known with respect to water depths in Skene Bay except that a single line of soundings across its entrance indicated depths of between 18 and 73 metres (Pilot of Arctic Canada, Vol.III, 1968). A shoal having between 6 and 7 metres of water over it lies 1.6 kilometres west of Ross Point. Beverley Inlet, although steep-sided, is thought to have shallow water throughout its length.

Airstrip: The lowland region along the western side of Skene Bay, north of the peninsula ending at Palmer Point, provides two potential sites for an airstrip. One trends north for approximately 2.5 kilometres and the other trends east for over 4 kilometres. The coasts slope gradually inland and are covered by closely spaced raised beach terraces. Approach paths are unrestricted except north and east of Skene Bay where the shoreline rises abruptly to elevations in excess of 180 metres.

The coastal lowlands located 4 kilometres northwest of Ross Point are also suitable for an airstrip. It could be oriented northwest-southeast, up to 3 kilometres in length, and would have unrestricted approach paths except to the north where elevations of 100 metres are attained 2.5 kilometres inland.

Wharf: The small inlet north of Palmer Point would be an ideal location for mooring facilities if water depths are adequate. There are other sites further into

Skene Bay which may also be adequate but lack sufficient bathymetric information for a complete appraisal.

Soundings in excess of 30 metres have been made within 1 kilometre of shore along the eastern entrance to Skene Bay. Mooring facilities could be located close to the site of a potential airstrip but the coastline affords limited shelter and may, therefore, prove unsuitable.

Construction Material: The western shore of Skene Bay is generally a low, gradually sloping sand and gravel environment capable of providing an adequate and readily accessible supply of construction materials. In addition, there are minor alluvial deposits at the mouths of two nearby small streams.

Construction materials can be obtained along the eastern entrance to Skene Bay from raised beach deposits as well as from extensive alluvial deposits at the mouth of the river entering near the southeast end of the potential airstrip.

Water Supply: A large lake, measuring an estimated 1.7 km^2, lies less than 1 kilometre from the proposed airstrips along western Skene Bay. From the air photos it appears deep enough to provide a continuous year-round supply.

There are several small and possibly deep lakes less than 1 kilometre from the proposed airstrip along the eastern entrance to the bay. The adequacy of these fresh water sources must be established from ground investigations.

Graham Moore Bay

Physiography

The Graham Moore Bay map sheet (Vol.II, M 2a, b, c) includes Alexander Island, Ile Marc, Bradford Island, the southwestern half of Massey Island, and western Bathurst Island. The eastern portion of Byam Martin Island was considered as part of the Byam Channel map sheet (Vol.II, M 1a, b, c). The map area encompasses two physiographic units, namely, "ridged upland" and "plateau/dissected plateau" (Roots, from Fortier et al., 1963).

Plateau/Dissected Plateau

The region from Hooker Bay south to Cape Cockburn forms part of a highly dissected plateau which encompasses all of southern Bathurst Island. Roots (from Fortier et al., 1963) has described the region south of De La Beche Bay as a dissected plateau characterized by lowland with mesas and buttes. It differs from the main plateau region in that it is composed of two distinct surfaces: a broad, flat lowland surface, with elevations generally less than 30 metres, and two mesas which are the remnants of an upland plateau. The mesas rise to elevations of 151 and 186 metres. Except for a mesa-like feature southeast of Playfair Point, the terrain north of De La Beche Bay is gently undulating and slopes gradually upwards from the coast to elevations of between 90 and 150 metres.

The drainage pattern throughout both regions is predominantly dendritic and numerous closely-spaced upland streams of no great length flow normal to the coastline. Several medium-sized shallow lakes and innumerable tundra ponds occur in the area, particularly towards the south. Flights of raised beaches and intervening swale ponds extend over 5 kilometres inland and reach elevations in excess of 60 metres.

The plateau surface is largely covered with unconsolidated material, some of which is rubble developed more or less in place, the balance being essentially marine in origin.

Ridged Upland

The remainder of the map sheet north of Hooker Bay, and including Bradford Island, Ile Marc, Alexander Island and the southern half of Massey Island, falls into a ridged upland physiographic unit. The most striking feature of this region is the effect that bedrock structure has had upon the landscape. Peninsulas, inlets, island strings, ridges and valleys are aligned with the westerly trending folds of the Parry Islands fold belt. Erskine and May Inlets are an exception in that they cut across the ridges and valleys at right angles to the regional strike of the strata.

The upland region ranges in elevation between 60 and 300 metres except along the coasts where a lowland area of varying width usually prevails. The slopes of the ridges are mostly of gentle to moderate steepness except along the escarpment faces where bluffs often rise to elevations approaching 120 metres. In addition, stream erosion has resulted in the formation of rocky steep-sided gorges as much as 150 metres deep. The drainage pattern is predominantly trellis with the major streams flowing in the hollows created by the synclines and short, steep tributaries flowing down the anticlinal slopes (Taylor, 1956). Lakes are sparse in the upland regions but numerous small lakes occur near the coast, and there are several large lakes on Alexander Island.

Bedrock exposures are abundant throughout the map area but nowhere do they cover large areas. In extensive flat areas underlain by limestone or sandstone the surface is composed entirely of frost-shattered, coarse felsenmeer. "In extensive areas where the bedrock is shale and shaly siltstone, the surface usually is covered by very fine rock fragments, and by much soil and plant cover" (Kerr, 1974, p.7). Many of the larger river valleys contain extensive deposits of alluvium and are flanked on both sides by coalesced alluvial fans. Large deltas have formed at the mouths of rivers entering Dundee Bight and Erskine Inlet, and most of the small streams entering Boyer Strait from Alexander and Massey Islands have produced minor deltas.

Bathymetry

Except close inshore, deep water occurs throughout Austin and Byam Martin Channels and in the straits and inlets of northwest Bathurst Island. Austin Channel is deep and navigable by vessels of any draught except in the vicinity of Keene Bank where there are shoals with least water depths of less than 8 metres. Mid-channel depths range between 183 and 329 metres throughout the length of Byam Martin Channel. Reconnaissance surveys indicate that there are depths of 36 to 179 metres in Pell Inlet, Boyer Strait, Pearse Strait and the northern half of Erskine Inlet. Little is known concerning depths in southern Erskine Inlet, Dundee Bight and Bracebridge Inlet.

There is shallow water in the nearshore zone along most of western Bathurst. It extends up to 1 kilometre offshore but is usually restricted to within 250 metres of the coastline. Numerous small and often low-lying islands in Bracebridge Inlet and Graham Moore Bay present a hazard to navigation.

Tidal data from Cape Capel on the southeast Bathurst coast suggest a mean tide range for the map area of 0.97 metres and a large tide range of less than 1.6 metres.

Potential Marine Terminal

North Shore Graham Moore Bay

Along the north shore of Graham Moore Bay there is a small unnamed bay just north of Bradford Island. The shores of the bay are low and gradual sloping.

Navigation: There are no soundings available within the bay but a hydrographic map (No. 7830) indicates the 30 m isobath lies just to the west of the bay along the west end of Bradford Island. Shallow waters, within 200-300 m of shore, are observed on the air photos of the area. Although Bradford Island provides shelter to ships from mobile sea ice in Austin Channel, it also severely restricts ship maneuverability into and within the bay.

Airstrip: Low land along the peninsula at the east side of the bay or across the eastern head of the bay provide good sites for an airstrip. However numerous small ponds along the peninsula will necessitate considerable infilling inorder to build the strip.

Wharf: More bathymetric soundings within the bay will be required before a decision on wharf location can be made.

Construction Materials: Sandstone and limestone bedrock underlie the shores and the close proximity of bedrock to the ground surface may result in a scarcity of materials.

Water Supply: There are no lakes and only one sizeable river in the area which would only provide water in the summer. Consequently, the scarcity of a good water supply puts serious limitations on the development of marine facilities in this bay.

McDougall Sound

Physiography

The McDougall Sound map sheet (Vol.II, M 3a, b, c) includes Little Cornwallis Island, eastern, central and southern Bathurst Island, parts of western Cornwallis Island; and Crozier, Milne, Wood, Truro, Baker and Neal Islands. The area can be divided into three distinctive physiographic units, namely, "plateau" and "ridged upland" of Bathurst Island, and "coastal plain" of Little Cornwallis and Cornwallis Islands.

Plateau

The boundary between the plateau and the ridged upland regions of Bathurst Island is not well-defined but is generally assumed to be represented by a line which runs from Hooker Bay on the west coast to Markham Point near the head of McDougall Sound. West from Allison Inlet lies a region which Roots (from Fortier et al., 1963) has described as a "dissected plateau-lowland with mesas and buttes". It is in an advanced stage of dissection and transformation to a coastal lowland and differs from the main plateau region in that it is composed of two distinct surfaces: a broad flat lowland surface, with elevations generally less than 30 metres, and an upland surface in the form of mesas and buttes rising to elevations greater than 150 metres. There are no visible remnants of the upland surface, except on the adjacent map sheet to the west, but the lowland region is easily distinguished. Raised beach traces extend inland for more than 3 kilometres and tundra ponds and small lakes occupy more than 20 square kilometres of the interior region.

The less 'mature' portion of the plateau region, stretching east and north from Allison Inlet as far as McDougall Sound, is rather flat and featureless in the central part, but towards the south and east coasts the topography is highly dissected and experiences much greater variation in local relief.

The plateau ranges in elevation between 120 and 340 metres with steep bluffs occurring along the south coast, in the vicinity of Dyke Acland and Bedford Bays, and along the valley sides of many of the streams flowing through the southeastern coastal regions.

The southern coastline is fairly regular except for indentations caused by Allison Inlet, Dyke Acland Bay and Freemans Cove. However, the eastern coast is extremely irregular in outline from Cape Capel to the head of McDougall Sound. It is dominated by features which have become aligned with the north-northwest striking bedrock. These include long peninsulas, elongated islands and straight strike sections of coast. In addition, many of the streams and rivers flow along the same general strike (Taylor, 1956). Elsewhere the predominant drainage pattern is dendritic.

Raised beaches are a prominent feature near the coasts. They often extend over 5 kilometres inland and up to 90 metres above sea level. Deltas have formed at the mouths of streams and rivers entering Barrow Strait and Viscount Melville Sound, and the lower reaches of many of the larger rivers have become choked with alluvial material.

According to Roots (Fortier et al., 1963) the surface of the plateau is largely covered with unconsolidated material, some of which is undoubtedly rubble developed in place. Overburden thicknesses are not known.

The majority of lakes in southeastern Bathurst Island are found within 10 kilometres of the coast and most of these occur around Freeman's Cove and north of Bedford Bay. There are innumerable swale ponds along the coasts.

Ridged Upland

North of a line which follows the Variscan River across to the head of McDougall Sound is a region which Roots (from Fortier et al., 1963, p.582) has described as "ridged upland in which topography and drainage clearly demonstrate the bedrock structure". Except for a 15 to 20 km wide strip of the east coast along Crozier Strait and Queen's Channel, the ridged upland consists of ridges and valleys trending east-northeast. The most prominent of these valleys is referred to as the "Bracebridge Goodsir Depression" and also as "Polar Bear Pass". The elevation of the upland region ranges between 90 and over 240 metres with the most rugged topography occurring in the vicinity of Dundee Bight, where cliffs rise over 210 metres above the shoreline. The slopes of the upland ridges are mostly of moderate to gentle steepness and even on the escarpment faces, cliffs are rare and low.

A trellis drainage pattern has developed with the major streams flowing in the hollows created by the synclines and short, steep tributaries flowing down the anticlinal slopes (Taylor, 1956). Many of the rivers and streams have cut narrow, rocky gorges more than 150 metres deep and considerable deposition has occurred in their lower reaches. Polar Bear Valley contains several large lakes and innumerable small lakes and tundra ponds.

A 15 to 20 km wide strip of the eastern Bathurst coast consists of ridges and valleys with an east-northeast trend. This region is considerably more subdued than the uplands to the west with elevations ranging between 60 and 150 metres. Bluffs occur along a straight strike stretch of coast from Brooman Point to Black Point. Elsewhere, the land slopes gently inland until it reaches the western portion of the ridged upland. The boundary between these two units "lies in a confused upland zone of small irregular hills, largely blanketed with unconsolidated material and cut by mainly east-flowing streams with an irregular dendritic pattern" (Roots, from Fortier et al., 1963, p.584). There are numerous tundra ponds in Polar Bear Valley and innumerable swale ponds and small lakes along the coasts.

Raised beach traces occur along most of the eastern Bathurst coastline and at the head of McDougall Sound as well as along the shores of Bracebridge Inlet and parts of Dundee Bight. They occur up to 10 kilometres inland along Polar Bear Pass and often attain elevations greater than 90 metres above sea level. Beach ridges and deltas, both uplifted and recent, are outstanding features along the coast north from Black Point.

Much of the eastern portion of the uplands is covered by felsenmeer or by glacial and marine sands and gravels. Bedrock exposures are not extensive, occurring along stream cuts and on a few of the north trending ridges. Extensive marine and alluvial deposits occur along the coast north from Black Point.

Most of the western uplands surface is composed of rubble of local origin. Bedrock exposures are numerous but do not cover large areas.

Coastal Plain

Little Cornwallis Island and the west coast of Cornwallis Island, from Pioneer Bay to Marshall Peninsula, are low-lying coastal plains whose elevations rarely exceed 90 metres. Their land surfaces slope gently seaward and exhibit several rounded hills with elevations ranging between 120 and 400 metres. Low cliffs exist along parts of the Cornwallis Island coast.

The drainage pattern is largely dendritic but partly structurally controlled. Most streams flow through generally well-graded stream channels, commonly several kilometres in length, before reaching the sea (Thorsteinsson, 1958). Both islands are dotted with innumerable lakes and ponds.

The generally flat coastal slopes are covered with flights of raised beaches and intervening swale ponds for distances of up to 8 kilometres inland. According to Taylor (1956) the raised beaches on Cornwallis Island are composed of rounded to angular limestone and dolomitic pebbles and cobbles. He also states that the beach deposits vary from very thin, with bedrock projecting through, to deposits 9 metres thick, observable along stream cuts.

Bathymetry

The sea bottom topography is very irregular between Cornwallis and Bathurst Islands. Deep water exists in McDougall Sound, Queens Channel and Crozier Straits, with mid-channel depths ranging as follows: McDougall Sound - 100 to 300 metres; Queens Channel - 30 to 60 metres; Crozier Strait - 78 to 340 metres. Depths of less than 30 metres have been sounded in Berkeley and Pullen Straits.

Numerous islands encumber the passage from Queens Channel to Viscount Melville Sound. Many have areas less than 1.0 km^2 and maximum elevations of less than 30 metres. There are also a number of extensive shoal areas and offshore sand bars, notably off the coasts of southeastern Bathurst and southern Little Cornwallis Islands. The irregular coastline of southeastern Bathurst Island includes several large inlets, such as Freemans Cove, where water depths are greater than 30 metres. The coasts of Little Cornwallis and Cornwallis Islands are also very irregular but bathymetric information is sparse.

Tidal data from Cape Capel, on the southeast tip of Bathurst Island, and Driftwood Bay, about 20 kilometres north of Rapid Point, suggest a mean tide range for the map sheet of 0.97 metres and a large tide range of between 1.13 and 1.6 metres.

A current along the eastern side of McDougall Sound sets continually northward, slacking only at about low water. Pilot of Arctic Canada reports a flood current velocity of about 1.0 metre per second. "A current setting continually northeastward through Pullen Strait has been reported" (Pilot of Arctic Canada, Vol. III, 1968, p.301). The strong southward flow of water passing through Queen's Channel may result in the generation of southward flowing currents in Crozier Strait. The general flow of water through Barrow Strait is from west to east. The eastward setting ebb tide has an estimated velocity of 1.5 metres per second (Pilot of Arctic Canada, Vol. III, 1968). Viscount Melville Sound probably has a generally eastward flow of water.

Potential Marine Terminals*

There are few bays or coves which have been sounded for water depths along southern Bathurst Island. Freemans Cove, the only place where ships are known to have unloaded supplies, is a location where soundings have been completed in some detail.

Three locations are suggested as potential sites for a marine terminal, namely, Freemans Cove, Bateman Bay, and the inlet entered immediately south of Bass Point. Hooker and De La Beche Bays and Allison Inlet are unsuitable because of nearshore shoals and implied shallow waters offshore. Dyke Acland Bay is unsuitable because of shallow water off its entrance and a rugged shoreline.

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* See also Chapter III, page 222.

Freemans Cove

Freemans Cove, lying 8 kilometres west of Cape Evans, is 3 kilometres wide at its entrance and extends 15 kilometres northeast into Bathurst Island.

Navigation: Depths of less than 20 metres have been recorded along both sides of the entrance, but a narrow channel of 20 to 30 metres depth provides access into the cove where depths exceed 50 metres.

Sea ice leaves Freemans Cove much later than the waters further south around Baker Island. The first lead to develop extends from the small peninsula at the western side of the entrance. In situ melting of sea ice occurs at the extreme north end of the cove before the ice floats out of the main body of the cove.

Airstrip: A series of 4 or 5 ATCO trailers and a gravel airstrip about 1000 metres long are located on the small peninsula at the southwest corner of the cove. The airstrip could probably accomodate aircraft of up to Hercules size.

Wharf: Along the west side of the small peninsula at the entrance to the cove is a good landing beach, and probably the site used by barges to transport the heavy machinery which was used to build the airstrip. Depths adjacent to this landing beach are thought to be less than 10 metres. A wharf would best be located off the north end of the peninsula where deep water occurs within a kilometre of shore.

Construction Materials: The underlying bedrock is generally less than a few metres from the surface (P. Kurfurst, pers. comm., 1977). For the most part, the bedrock is a uniform unit of fine-grained calcareous quartz siltstone but ungraded intervals of well laminated grey to black calcareous shale, and fine-grained quartz sandstone also occur. The cove's southeast shore is generally a low, gradually sloping sand and gravel environment. Farther north, dolomitic rocks are found along with andesite dykes. Nearshore shoals and alluvial deposits are greater at the northwest end of the cove. The western shore of the cove is again very low and gradually sloping but the beach sediments are much coarser and boulders and bedrock exposures are observed on the small headlands. Much of the coast is covered by vegetation.

Water Supply: A large lake is situated at the northwest end of Freemans Cove but to support facilities at the southwest end of the cove would require an estimated 8.0 kilometres of pipeline. There are other substantial year-round sources of fresh water nearby but several small rivers could provide summer supplies.

Bateman Bay

Bateman Bay, located between Daniell and Bass Points, is 3.8 kilometres wide and 6.3 kilometres long. The north side of the entrance has water depths less than 20 metres but the southern side has depths greater than 50 metres. Harbour facilities and buildings could best be located at the northwest end of the bay.

Navigation: The waters leading to Bateman Bay generally exceed 50 metres and in many places exceed 100 metres in depth thus providing access free of shoals and navigational hazards. The best route into Bateman Bay lies north of the Neal Islands. Once inside the bay ships must avoid the shallower northern sector and proceed along the south shore to the west end of the bay.

Sea ice often melts within the bay prior to breakup in McDougall Sound. The wide entrance to the bay does not restrict the removal of ice by winds once McDougall Sound has become ice free. In 1976 the bay was free of ice by August 20th.

Wharf and Airstrip: Final selection of sites would depend on actual field observations but it appears that an airstrip trending northwest could be located along the raised beaches in the northwest corner of the bay. Wharf facilities would be required if the beach areas were not widened by machinery. Based on air photos the shoreline is a very narrow active beach backed by low but moderately steep bluffs and a series of raised beach terraces.

Construction Materials: Bedrock types are variable within the bay. At Daniell and Bass Points and along the far western shore of the bay are dolomitic rocks. Along the well-developed raised beaches of the north shore the sediments are siltstone, shale and argillaceous limestone. In the small valley at the northwest corner of the bay there is quartz sandstone of the Hecla Bay formation. Sand and gravel are available but bedrock appears to occur just beneath the surface in most areas.

Water Supply: The lake in the valley at the northwest end of the bay is near the proposed airstrip and appears, from the air photos, to be deep enough to provide year-round supply.

Unnamed Inlet South from Bass Point.

The inlet immediately south of Bass Point is 3 kilometres wide at its entrance and extends 4 kilometres inland before four separate arms branch out in different directions.

Navigation: The outer portion of the inlet and the approaches to it through McDougall Sound have charted depths exceeding 75 metres. The Neal Islands, lying 6 to 10 kilometres off the entrance, are the only navigational hazards in the area. Depths of less than 30 metres have been charted in the two innermost bays but the two large bays to the north and south, just inside the entrance, can accomodate vessels draughting more than 30 metres of water. Anchorages are available providing shelter from all directions, and there are good beaches suitable for dry-ramp landings (Pilot of Arctic Canada, Vol. III, 1968).

Airstrip: The plateau region inland from the inlet provides a number of sites suitable for the construction of an airstrip capable of handling large aircraft. The terrain is such that an access road between the airstrip and the port facility could be built without serious difficulty. It may be feasible to construct an airstrip on the peninsula forming the southern entrance point to the inlet, but this and other sites within easy access of a port facility require ground analysis before their suitabilities can be determined.

Construction Materials: Flights of raised beaches cover the coastal regions up to 90 metres above sea level. These and deltaic deposits can provide adequate and readily accessible sources of sand and gravel for construction.

Water Supply: There are numerous small lakes in the area, many of which appear, from the air photographs, to be deep and capable of providing continual year-round supplies of fresh water.

Baillie-Hamilton Island

Physiography

The Baillie-Hamilton map sheet (Vol. II, M 4a, b, c) comprises Baring, Houston Stewart and Baillie-Hamilton Islands, a thin section of eastern Devon Island, and the northern half of Cornwallis Island. The map region encompasses three major physiographic units, namely, "plateau", "coastal plain" and "coastal lowland".

Plateau

Devon Island: The west coast of Devon Island from Bowden Point to Dragleybeck Inlet comprises a plateau whose elevation varies between 180 and 240 metres. Most of the coastline is rimmed by 120 to 150 m high scree-banked cliffs.

The coasts are continuous except for indentations caused by numerous small valleys and three major inlets, namely, Griffin and Dragleybeck Inlets and Macormick Bay. The surface of the plateau has been deeply incised by a dendritic network of streams and rivers. Except in their lower reaches, the valleys are narrow and steep-walled and in some cases have been cut up to 90 metres into the plateau. The larger rivers enter Wellington Channel through broad, U-shaped, and often alluvium-filled, valleys. There are a number of small inland lakes throughout the region north of Domville Point.

Flights of raised beaches occur along the coasts except where vertical cliffs face directly onto Wellington Channel. They are particularly well-developed in the vicinity of Eden Point and Griffin Inlet and often reach over 90 metres above sea level.

The surface of the plateau consists of a thin veneer of rubble and is almost completely barren of plant life.

Cornwallis Island: Most of the eastern half of Cornwallis Island is a remnant of a plateau. The eastern boundary of the plateau is formed by the cliffed coast along Wellington Channel but the highly dissected nature of the plateau surface prohibits a clear definition of its western and northern boundaries.

The plateau surface is undulating and ranges in elevation between 150 and 270 metres, decreasing towards the north. The coastline is fairly regular, interrupted only by Read Bay, Helen Haven and the valleys of streams entering Wellington Channel. It is bounded along most of its length by cliffs and bluffs rising up to 240 metres above sea level

Several large streams cross the plateau and have cut deep, steep-walled valleys in their upper reaches. Their lower reaches are characterized by broad, flat alluvium-filled valley floors. Many of the streams entering Wellington Channel have formed outwash surfaces and deltas. The drainage pattern is predominantly dendritic with some evidence of structural control along the northwest-striking bedrock.

There are numerous lakes within 15 kilometres of the coast, some of which are over 5 kilometres long, but few exist further inland. Thorsteinsson (1958, p. 15) suggests that "terminal moraines several tens of feet in thickness" contributed to the formation of the Laura Lakes inland from Snowblind Bay. Innumerable swale ponds and tundra ponds dot the region and lagoons are a prominent feature along the coast.

Flights of raised beaches are conspicuous features along the coasts, particularly north of Decision Point. They can be observed along the valleys of major rivers and streams entering Wellington Channel and often exist over 90 metres above sea level.

Baillie-Hamilton Island off the north coast of Cornwallis Island is also a remnant of the plateau. The rough-textured surface of the plateau has an average elevation of about 150 metres. Cliffs and bluffs rising up to 150 metres above sea level mark the shoreline around most of the island, interrupted only by the valleys of streams entering the sea.

The streams on the island have cut narrow, steep-walled valleys and most have built deltas at their mouths. The foreshore is covered with innumerable raised beach traces and intervening swale ponds. Numerous small lakes appear on the plateau surface. According to Thorsteinsson (1958, p. 17) "the raised beaches are composed of rounded to angular limestone and dolomite pebbles and cobbles." He also states that "the thickness of the beach deposits varies from very thin with bedrock projecting through, to deposits 30 feet (9 metres) thick as observed along streams-cuts." The balance of Cornwallis Island is covered with a mantle of felsenmeer mixed with clay or of felsenmeer only (Thornsteinsson, 1958).

Coastal Plain

The western half of Cornwallis Island is a lowland area of rolling hills. It is a region considerably more mature than the plateau of eastern Cornwallis. The land surface slopes gently seaward with elevations rarely exceeding 150 metres. The shores are commonly low and flat and very irregular, broken by numerous inlets and small bays.

The drainage pattern is largely dendritic but partly structurally controlled. The streams are smaller and less deeply incised than in other parts of the island due largely to lower gradients. The lower reaches of several of the larger streams, such as the Abbott River, have become choked with alluvium and deltas have formed at their mouths.

Striking examples of raised beaches occur along the northwest coast where they can be found up to 10 kilometres inland and over 90 metres above sea level. Lagoons, swale ponds, tundra ponds and lakes are in abundance along the coasts. Beach deposits vary in thickness from very thin with bedrock projecting through, to deposits 9 metres thick as observed along stream-cuts.

Coastal Lowland

North of Dragleybeck Inlet, on the west coast of Devon Island, the upland surface, which forms the edge of the plateau, diverges inland and is separated from Wellington Channel by a coastal lowlands. The width of the lowland varies between 7 and 20 kilometres (see also Bear Bay West, NTS map sheet 58H, not included in this study).

The lowland is mostly covered with unconsolidated material (Roots, from Fortier et al., 1963). A network of meandering streams crosses the lowland surface and broad, braided channels often reach up to 7 kilometres inland. Four extensive deltas have been formed along Wellington Channel and outstanding series of raised beaches extend up to 9 kilometres inland and over 60 metres above sea level. Much of the lowland region is dotted with innumerable small ponds and lakes, especially inland from Baring Bay and southeast of Owen Point.

Bathymetry

Except close inshore, deep water exists in Wellington Channel, Maury Channel, Queens Channel and Sophia Channel. Mid-channel depths range as follows: Wellington Channel - 120 to 330 metres; Maury Channel - 45 to 250 metres. Couch Passage, north of Baillie-Hamilton Island, has not been surveyed and an extensive zone of shallow water lies southwest from Houston Stewart Island, effectively preventing the entrance by deep draught vessels into Pullen Strait from either Maury Channel or Queens Channel.

Deep water exists close inshore along eastern Cornwallis Island, western Devon Island and around most of Baillie-Hamilton Island. Shoals exist about 2 kilometres off Macormick Bay and to a lesser extent off the delta fronts of several large rivers flowing into Wellington Channel from Devon Island.

Tidal data from Beechey Island and Resolute suggest a mean tide range for the map area of 1.3 to 1.71 metres and a large tide range of 2.1 to 2.71 metres.

Northeastward setting currents have been reported through Pullen Strait. An easterly set persists in Maury Channel with velocities of 1.5 metres per second on the flood. The movement of water in Wellington Channel is predominantly southward into Barrow Strait. This southward flow exists across the entire width of the channel but is strongest on the western side where its maximum velocity is 0.75 metres per second. A general southward flow of water passes through Queens Channel (Pilot of Arctic Canada, Vol. III, 1968).

Lowther Island

Physiography

The Lowther Island map sheet (Vol. II, M 5a, b, c) includes the northern half of Russell Island and six mid-channel islands in Barrow Strait, namely, Lowther, Young, Garrett, Hamilton, Browne and Somerville Islands. Each will be considered separately.

Northern Russell Island

Northern Russell Island can be divided into a coastal lowland region and an upland plateau.

Ranging in width between 1 and 5 kilometres, the coastal lowland extends east, from Krabbé Point to Palmerston Point, and south from Cape Walker. The entire region lies below the marine limit and flights of closely spaced raised gravel beaches and pockets of marine fines feature prominently (Netterville *et al*., 1976).

Numerous parallel stream channels enter Barrow Strait normal to the coast and a number of lakes have formed southeast of Krabbé Point. The plateau of northern Russell comprises all of the central portion of the island and extends to the northeast coast where steep bluffs, reaching 240 metres above sea level, face Barrow Strait from Palmerston Point to Cape Walker. According to Netterville *et al*. (1976, p. 151) the upland surface is composed of coarse, well-rounded, bouldery gravel felsenmeer, and "where sandstones and carbonates occur, the surface veneer is a pebbly silty sand which is difficult to distinguish from till".

Numerous lakes and ponds occur on the surface of the plateau which averages about 180 metres in elevation.

Lowther Island

Lowther Island is the largest of the midchannel islands in Barrow Strait. It is 20 kilometres long and 9 kilometres across at its widest point. The topography is very irregular and consists of numerous mesa-like features, a partially cliffed coastline and a ridge trending northeast along the length of the island. The elevation of the mesas ranges between 120 and 180 metres while the island's maximum elevation is 198.4 metres. Cliffs rise to over 120 metres along the north coast and approximately 60 metres northeast from Gourdeau Point. The remainder of the island is fringed by low, gently sloping bluffs.

Flights of raised beaches cover most of the island surface up to 90 metres above sea level. There are numerous lagoons and swale ponds near the coast and over a dozen small lakes in the upland regions of the island. Polygonal ground occurs in the northern and southern regions of the island at elevations of approximately 120 metres.

The drainage pattern is dendritic and exhibits structural control in some areas. The two major rivers on the island flow into inlets which indent the western coastline. Both have formed deltas at their mouths.

Young Island

Situated 28 kilometres southwest of Lowther Island, Young Island measures 11 kilometres long and 4 1/2 kilometres wide. It is irregular in outline and very low, having a maximum elevation of 20 metres. The southern part of the island rises to a ridge of limestone with a steep south slope.

The island is completely covered with closely spaced raised beach traces and intervening swale ponds. Shoals extend for a short distance off most of the coastline.

Garrett Island

Garrett Island lies 25 kilometres northwest of Lowther Island. It is 6 1/2 kilometres long and 3 kilometres wide. Low, gently sloping bluffs form much of the coastline from which the island rises, steeply on the north and south, to a rounded summit of 107.6 metres (Pilot of Arctic Canada, Vol. III, 1968). There are numerous lagoons, ponds, lakes, and several small streams on the island. Raised beach traces cover the entire island reaching almost to its summit.

Hamilton Island

Hamilton Island is situated 20 kilometres northwest of Krabbé Point on Russell Island. It is 2 1/2 kilometres long, 1 kilometre wide and attains a maximum elevation of 23 metres. Steep, low bluffs form the southern coast but slope gently towards the north. The island is covered with raised beaches and innumerable swale ponds. Shoals occur off the northwest coast.

Browne Island

Browne Island lies 7 kilometres south of Cape Rosse, western Cornwallis Island. It is 4 kilometres long and 1 3/4 kilometres wide. Precipitous cliffs, rising to 157.3 metres, flank the southern half of the island but slope uniformly down to the headland which forms the northern end of the island. Raised beach traces are prominent along the uncliffed portions of the island and are in evidence at elevations greater than 90 metres above sea level. There are numerous swale ponds on the island and shoal water exists for a short distance off the northeast coast.

Somerville Island

Somerville Island lies 9 kilometres south of Browne Island. It is 4 kilometres long and 3.5 kilometres wide. The island has moderately steep sides and a level top whose maximum elevation is approximately 82 metres. Raised beaches cover the island and innumerable swale ponds exist in the lower levels. Several lakes have formed near the summit of the island.

Bathymetry

The bottom contour in Barrow Strait is very irregular and a number of shoals have been charted in the vicinity of Lowther and Young Islands over which water depths range as low as 1.5 metres. Elsewhere, sounded depths range between 150 and 275 metres and deep water generally exists within 2 kilometres of shore. The following shoals have been charted in mid-channel Barrow Strait: 'Young Shoal', with 13.4 metres of water over it, lies 7 kilometres east of Young Island; a 23.8 metre shoal lies 13 kilometres east-northeastward, and another 23.8 metre shoal lies 5 kilometres southwest of Young Island; 'Lowther Shoal', with a least depth of 1.5 metres, lies 8 kilometres east of Lowther Island.

Tidal data from Hamilton Island suggest a mean tide range for the map area of 0.55 metres and a large tide range of 0.79 metres. The general flow of water through Barrow Strait is from west to east. The eastward setting ebb tide has an estimated velocity of 1.5 metres per second (Pilot of Arctic Canada, Vol. III, 1968).

Resolute

Physiography

The Resolute map sheet (Vol. II, M 6a, b, c) includes Griffith Island, the northern coast of Somerset Island between Garnier Bay and Limestone Island, and the southern third of Cornwallis Island. The thin strip of coast along western Devon Island will be considered as part of the Maxwell Bay map sheet.

Griffith Island

Griffith Island is situated in Barrow Strait approximately 15 kilometres southwest of Resolute. It rises to an upland surface approximately 190 metres above sea level with steep bluffs flanking most of the eastern and southeastern shoreline. The western and northern coasts are more subdued, being characterized by flights of raised beaches reaching up to 90 metres above sea level.

The streams on Griffith Island exhibit a dendritic drainage pattern with small lakes forming their headwaters.

Northern Somerset Island

The northern Somerset coast from the western side of Garnier Bay to Limestone Island comprises two major physiographic units, namely, "plateau" and "coastal lowland".

Plateau: Mesa-like remnants form the major portion of northern Somerset Island. They give rise to steep bluffs, such as at Cape Rennell and Gifford Point, and are interrupted by two large inlets (Cunningham Inlet and an unnamed inlet 30 kilometres to the east) and by the valleys of streams entering Barrow Strait.

Comprised of flat-lying sedimentary strata, the plateau ranges in elevation between 150 and 300 metres above sea level. Its surface configuration is one of rounded hills with gently undulating slopes and a relief, above the tops of the gorges of incised streams, of as much as 150 metres (Roots, from Fortier et al., 1963).

According to Netterville et al. (1976) the plateau surface is mantled by a 1 to 3 metre thick accumulation of rubble, most of which varies from moderately stony to very stony silt. There are a number of lakes on the plateau surface between Garnier Bay and Cunningham Inlet and polygonal ground occurs in several locations south of Cape Anne.

The drainage pattern is dendritic and numerous small rivers flow from the plateau to lowland areas through steep gullies or gorges. Cunningham Inlet forms the beginning of a topographic trough, from 5 to 8 kilometres in width, which extends inland for more than 15 kilometres.

Coastal Lowland: A coastal lowland region, varying in width from less than 1 kilometre to greater than 5 kilometres, extends inland from the shores of Barrow Strait to meet the upland plateau, with elevations rarely exceeding 90 metres. The transition from lowland to plateau is fairly well-defined in some areas by steep bluffs (e.g., Cape Rennell and the vicinity of Cunningham Inlet). Elsewhere the land rises gently from the shore to form well-rounded, inland hills.

Excluding Garnier Bay, which falls on the next lower map sheet, Cunningham Inlet and an unnamed inlet 30 kilometres to the west are the only major indentations along the northern Somerset coast. Several braided streams, the largest of which is the Cunningham River, flow through a wide valley trough into Cunningham Inlet. In the west, two large deltas, one of which has been named Cape Anne, extend into Barrow Strait and are covered by raised beaches.

Raised beaches are well-developed along most of northern Somerset Island, often reaching more than 90 metres above sea level. West from Garnier Bay numerous lakes have formed in the depressions between successive beach levels. In this region lagoons and tundra ponds are abundant within 2 kilometres of shore.

Taylor (1974a), in a coastal process study of northern Somerset Island, reports that the coast is substantially affected by storm wave activity and by the movements of sea ice.

Cornwallis Island

Southern Cornwallis Island can be divided into two main physiographic units, namely, "central upland" and "coastal plain" (after Taylor, 1956).

Central Upland: The eastern half of Cornwallis Island comprises a plateau. Its elevation increases towards the east, ranging from about 150 metres in the vicinity of Bacon River to over 300 metres along the east coast of the island. The plateau surface is essentially a gently rounded bald dome of rock. As a result of glaciation only isolated patches of drift occur on the plateau surface.

From Cape Hotham north to the edge of the map sheet a steep escarpment parallels the coast along Wellington Channel. Except for a few small streams, Barlow Inlet and the broad U-shaped valleys of two rivers form the only breaks in the escarpment.

The drainage pattern is predominantly dendritic but exhibits some structural control towards the east coast. Streams flowing into Wellington Channel are deeply incised. They have steep gradients and relatively few tributaries and are fast flowing. Alluvial deposits occur at the mouths of Shellabear and Goodsir Creeks and above a small lake northwest of Depot Point.

Little or no foreshore occurs along the east coast but there are traces of raised beaches up to 90 metres above sea level around Depot Point and south from Barlow Inlet. A major landslide has occurred at Cape Hotham and another of lesser significance north of Barlow Inlet.

The south coast of Cornwallis Island is more subdued and exhibits a fairly gentle transition from coast to upland plateau. Numerous incised streams flow into Barrow Strait and most of these have small lakes at their headwaters. A series of lakes, named the Trafalgar Lakes, and extensive alluvial deposits have formed inland from Assistance Bay. In addition, over a dozen lakes form the headwaters of the Mecham River and its tributaries.

Flights of raised beaches, extending up to 4 kilometres inland, are a prominent feature along the Barrow Strait coast. According to Taylor (1956, Vol. VII, p. 18) "these raised beaches are composed of rounded to angular limestone and dolomitic pebbles and cobbles." He also states that the beach deposits vary in thickness from very thin, with bedrock projecting through, to over 9 metres thick.

Coastal Plain: The coastal plain occupies the slopes of Cornwallis Island below the margins of the central uplands. Stretching north and west from Resolute and reaching up to 30 kilometres inland, it is essentially a lowland area of rolling hills. The shoreline facing Resolute Passage is very irregular and includes numerous islands, bays and peninsulas. Outliers of the upland plateau reach elevations of 190 and 130 metres at Cape Martyr and Sheringham Point, respectively. Elsewhere, the average elevation is approximately 100 metres above sea level.

The drainage pattern is dendritic and exhibits some structural control. Most of the streams and rivers flowing into the coastal plains are only moderately incised in their upper reaches and flow through broad, flat alluvium-filled valleys in their lower courses. Many have formed large deltas and alluvial fans. There are numerous lakes near the coast with few existing more than 5 kilometres inland.

Bathymetry

Except close inshore, charted depths in Barrow Strait, Wellington Channel and Resolute Passage range from 100 to 300 metres. Shoal water occurs up to 3 kilometres offshore along the northern Somerset coast and parts of the coast west of Garnier Bay are fronted by barrier ridges and lagoons. Depths of 4 to 39 metres exist in Cunningham Inlet but less than 2 metres of water has been charted in the narrow entrance channel on the western side of the inlet.

Deep water is reported to exist within 1 kilometre on all sides of Griffith Island. Shoals occur up to 2 kilometres offshore along most of southern Cornwallis Island but deep water exists within 1 kilometre of the eastern coastline.

Barlow Inlet has a deep basin but a rocky ledge, over which there is no more than 4.6 metres of water, lies across its entrance. Resolute Bay has depths of up to 27 metres but shoals encumber the full width of the entrance. Allen and Becher Bays are shallow and contain numerous small islands and drying bars.

The general flow of water through Barrow Strait is from west to east. The eastward setting ebb tide has an estimated velocity of 1.5 metres per second. The movement of water in Wellington Channel is predominantly southward into Barrow Strait. The flow is strongest on the western side of the channel, experiencing a maximum flood velocity of about 0.75 metres per second (Pilot of Arctic Canada, Vol. III, 1968).

Potential Marine Terminal

Resolute Bay

Resolute Bay on the south coast of Cornwallis Island is entered between Sight Point and Prospect Point approximately 4 kilometres further south. The bay extends inland for about 3.5 kilometres to its head and averages 3 kilometres in width. The Mecham River flows through a large delta into the northeastern side of the bay.

Navigation: The bay has a general depth of about 20 metres but shoals encumber the full width of the entrance with a minimum depth of 9 metres in the channel between shoals. Anchorage may be obtained in the northern part of the bay, in depths up to 27.4 metres, on a mud and shale bottom but the holding ground is reported to be poor (Pilot of Arctic Canada, Vol. II, 1968).

Wharf: Existing harbour facilities at Resolute Bay include temporary gravel jetties on the west side of the bay for the landing of LCM's and for stern mooring of tankers discharging petroleum products via a sea line. On the east side of the bay there is a gravel jetty with an oil drum face for the unloading of general cargo (Girgrah *et al*., 1975).

Conclusions: The settlement at Resolute, whose population in 1971 was 261, lies along the western side of the bay. A gravel road connects the settlement and harbour to an arctic class "A" airport and associated facilities located 4 kilometres to the north. Supplies of water and construction aggregates would have to be found if demands for future development and expansion of the marine terminal at Resolute Bay, were made. The major factor restricting such development is insufficient water depths in the bay.

Maxwell Bay

Physiography

The Maxwell Bay map sheet (Vol. II, M 7a, b, c) includes Prince Leopold Island and the southwest sector of Devon Island from Graham Harbour to Stuart Point. The narrow portion of northern Somerset Island will be considered as part of the Cape Clarence map sheet.

Prince Leopold Island

Prince Leopold Island is a mesa-like plateau that measures about 11 kilometres long and 7 kilometres wide. Steep cliffs form its coast, rising approximately 270 metres above sea level to a broad, flat summit.

Drainage on the island is largely structurally controlled. A major north trending valley has been incised and forms a cliff-walled gorge up to 180 metres deep. The coastal regions of this depression form the only major lowland surfaces on the island. Both are covered by flights of raised beaches up to 80 metres above sea level. Elsewhere, the coastal cliffs are protected by a narrow beach.

According to Netterville et al. (1976) the surface of the plateau is largely covered with a 1 to 3 metre thick accumulation of moderately stony to very stony silt.

Southwestern Devon Island

Southwestern Devon Island is dissected along the coast and major valleys but is almost featureless in parts of the interior. The coast is indented by two large fiords and numerous bays and is characterized by almost continuous cliffs up to 460 metres high. The plateau surface is smooth with relatively little relief and ranges in elevation between 240 and 360 metres above sea level.

The drainage pattern is predominantly dendritic but there is evidence of subparallel drainage as well as structurally controlled drainage patterns (Roots, from Fortier et al., 1963). Most streams have developed broad, flat outwash-filled valley floors and deltas. Radstock River and the river entering Lancaster Sound at Fellfoot Point are particularly good examples. There are numerous lakes at the heads of Maxwell and Radstock Bays and Gascoyne Inlet. Beach ridges and intervening swale ponds are dominant features of the low-lying coastal regions.

An icecap measuring approximately 120 km^2 lies 4 kilometres northeast of Rigby Bay. There are also two small icefields in the same region, both measuring less than 8 square kilometres. There are no glaciers reaching the sea from these ice caps.

Towards the southwest coast of Devon Island the cliffs are intermittent, found mainly at headlands. A bare rock bench, largely covered with beach and outwash deposits and talus, forms the only extensive low ground on southern Devon. Lying between Radstock and Erebus Bays, it appears to be a wave cut platform above which Beechey Island, Caswall Tower and Cape Riley rise as isolated remnants of the plateau (Roots, from Fortier et al., 1963).

Most of the coastal cliffs are protected by narrow beaches and only on the headlands are they exposed to marine agencies, the most significant of which is sea ice (Roots, from Fortier et al., 1963). Wherever coastal slopes are low or where valleys interrupt the cliffed edge of the plateau, flights of raised beaches cover the land surface. They are best developed around the flanks of the plateau remnants at Cape Riley where they are found up to 90 metres above sea level.

The upland surface consists for the most part of felsenmeer with bedrock exposures common. Southwest Devon Island is characteristically barren of vegetation.

Bathymetry

Except close inshore, deep water exists throughout Lancaster Sound and Barrow Strait with mid-channel depths ranging between 150 and 400 metres. The 30 metre isobath lies within 3 kilometres of shore along the coast of southern Devon Island, within 4 kilometres of the northern Somerset shoreline and within 1 kilometre of Prince Leopold Island.

Deep water exists throughout most of Radstock and Maxwell Bays. Erebus and Rigby Bays, Gascoyne Inlet, and several unnamed bays have charted depths which are generally less than 30 metres.

Tidal data from Radstock Bay and Rigby Bay suggest a mean tide range for the map area of between 1.7 and 1.8 metres and a large tide range of about 2.8 metres.

The movement of water and ice in Barrow Strait and Lancaster Sound is from west to east. A strong surface current moves eastward along the south side of Lancaster Sound at an estimated velocity of 88 kilometres per day (1.0 metre per second) (Pilot of Arctic Canada, Vol. II, 1968).

Potential Marine Terminals

Radstock Bay

For detailed information regarding the suitability of Radstock Bay as a marine terminal see Bornhold *et al.* (this report, chapter III, page 90).

Maxwell Bay

Maxwell Bay is located on southern Devon Island and is entered between Fellfoot Point and Cape William Herschel, 22 kilometres further west. Two arms, extending 43 and 35 kilometres inland, form its head and four islands lie in the centre of the eastern arm.

Deep water has been charted throughout most of Maxwell Bay and there are several natural harbours within the bay which can provide anchorage, shelter and good landing beaches. However, there are no extensive lowland areas suitable for the construction of an airstrip and, except to the northeast, sources of fresh water are scarce.

Maxwell Bay cannot, therefore, be recommended as a potential marine terminal, particularly in view of its proximity to Radstock Bay where conditions are almost ideal.

Powell Inlet

Physiography

The Powell Inlet map sheet (Vol. II, M 8a, b, c) includes the south-central sector of Devon Island from the headlands east of Cumming Inlet to the unnamed bay west of Blanley Bay.

The south coast of Devon Island forms a smooth curve broken by fiords and bays and flanked by nearly continuous coastal cliffs rising up to 600 metres above sea level. The area comprises a plateau of relatively soft sedimentary rocks ranging in elevation between 360 and 600 metres. The plateau is relatively featureless in the interior but along the coasts eight major valleys have been excavated. These are characteristically broad, flat and alluvium-filled with smooth walls and truncated faces. Near-vertical cliffs rise up to 500 metres above deep talus banks to the level of the plateau.

Various stream patterns are present but drainage is for the most part controlled by the north-south trend of gently west-dipping strata. Most streams have developed cliff-walled valleys which taper headwards to sharp ravines and are flat and alluvium-filled in their lower courses. Extensive deltas have formed at the mouths of many of the larger rivers. An excellent example of this occurs in Stratton Inlet where a broad deltaic plain is threatening to seal off the head of the Inlet, trapping a 3 square kilometre lake behind it.

There are three large lakes in the valley extending north from Powell Inlet but few lakes of any size occur elsewhere on the map sheet. Swale ponds are commonly found in low-lying coastal regions. Roughly 50 per cent of the land area on the map sheet is covered with ice, most of which forms a southwestern extension of the Devon Icefield. Ice tongues reach tidewater in Blanley Bay and Cuming Inlet and at three headland locations. Numerous other ice tongues reach to within 2 kilometres of tidewater.

Most of the coasts along southern Devon Island are formed of scree-banked sedimentary cliffs and are protected by narrow beaches. Only on the headlands are they exposed to marine agents, the most significant of which is sea ice (Roots, from Fortier et al., 1963). Wherever coastal slopes are low or where valleys interrupt the cliffed edge of the plateau, flights of raised beaches cover the land surface. They are best developed east from Cape Bullen and around the unnamed bay west of Blanley Bay where they occur up to 60 metres above sea level.

The upland surface consists for the most part of felsenmeer with bedrock exposures common. Southern Devon Island is characteristically barren of vegetation.

Bathymetry

Deep water exists throughout Lancaster Sound with mid-channel depths ranging between 390 and 620 metres. The 30 metre isobath lies within 1 kilometre of the shoreline along all of southern Devon Island and deep water exists to the heads of Cumming, Powell, Burnett, Stratton, and Hobhouse Inlets, and Blanley Bay. There is no data available for the two unnamed bays on the map sheet.

Tidal data from Dundas harbour and Rigby Bay suggest a mean tide range for the map area of between 1.7 and 1.8 metres and a large tide range of 2.77 to 2.87 metres. The movement of water and ice in Lancaster Sound is from west to east. A strong surface current moves eastward along the south side of Lancaster Sound at an estimated velocity of 88 kilometres per day (1.0 metre per second). At the mouth of Lancaster Sound a warmer ingoing or westward-moving surface current flows along the south shore of Devon Island (Pilot of Arctic Canada, Vol. II, 1968).

Dundas Harbour

Physiography

The Dundas Harbour map sheet (Vol.II, M 9 a, c) includes the southeastern sector of Devon Island from Philpots Island to Croker Bay and consists of two physiographic units, namely, "plateau" and "highland".

Plateau

The plateau surrounding Croker Bay has become highly dissected and now forms a series of mesas and buttes. The plateau and remnant surfaces are flat and relatively featureless, ranging in elevation from 300 to 430 metres, and are characterized by talus-banked cliffs rising up to 490 metres above sea level. A broad, flat alluvium-filled valley extends north from the head of Dundas Harbour and the entrance to Croker Bay and is flanked on either side by coastal plains extending up to 7 kilometres inland. The elevation of the coastal plains rarely exceeds 80 metres and their surfaces are covered with flights of raised beaches and intervening swale ponds.

The drainage pattern is predominantly dendritic but exhibits some structural control. Most streams have developed cliff-walled valleys, which taper headwards to sharp ravines, and are flat and alluvium-filled in their lower courses. The river entering the head of Dundas Harbour follows a braided course through an outwash plain measuring over 6 kilometres in length and about 2 kilometres in width. Deltas have formed at the mouths of many of the rivers entering Croker Bay and Lancaster Sound west of Cape Home.

Three arms of the Devon Icefield discharge into the head of Croker Bay and have resulted in the formation of several large ice-dammed lakes. Innumerable swale ponds and a number of small lakes have formed on the coastal plains flanking the entrance to Croker Bay but few lakes occur on the plateau surface.

Wherever coastal slopes are low, such as at the entrance to Croker Bay, or where valleys interrupt the cliffed edge of the plateau, flights of raised beaches cover the land surface. They are best developed in the coastal plains marking the eastern and western shores of the entrance to Croker Bay where they extend up to 4 kilometres inland and over 60 metres above sea level.

Highland

The eastern end of Devon Island as far west as Dundas Harbour is an ice-covered highland area which forms part of the Baffin-Ellesmere Mountains (Roots, 1963, from Fortier et al). These highlands are characterized by cliffs and bluffs in the coastal regions while almost the entire inland region is covered by a smooth, relatively thin mantle of ice whose maximum elevation is over 1200 metres.

Philpots Island and the coastal regions north and west from Cape Sherard are the only extensive areas of lowland in eastern Devon Island. Philpots Island is a hilly peninsula joined to the mainland by a low narrow isthmus. Except for a 240 m high pinnacle on the northern end of the island, elevations rarely exceed 60 metres. The coasts north and west from Cape Sherard are low and featureless with elevations of less than 120 metres up to 5 kilometres inland. Further west, bluffs rising 60 metres above sea level face Lancaster Sound and elevations greater than 900 metres are attained less than 2 kilometres inland. Narrow beach zones occur along some sections of the coast, particularly in the vicinity of Johnson Bay.

The predominant drainage pattern is dendritic. Many of the streams and rivers flow through shallow, V-shaped valleys and show evidence of deposition along their lower courses. Numerous valley glaciers flow towards Lancaster Sound and Baffin Bay from the Devon Icecap and four of the largest ones reach tidewater. In addition, a 12 kilometre wide lobe of the icecap extends into Baffin Bay, almost to the point of isolating Bethune Inlet. Features associated with the glaciers include broad lateral and end moraines and sediment-laden meltwater streams. The tidewater glaciers exhibit extensive calving.

Philpots Island is dotted with innumerable lakes, ponds and coastal lagoons and a few small lakes occur in the Cape Sherard region. Beach ridge traces and associated swale ponds are in evidence along a few short sections of coast but are rarely found at elevations greater than 50 metres. Bedrock exposures are common throughout the region.

Bathymetry

Deep water exists throughout Lancaster Sound with mid-channel depths ranging between 620 and 800 metres. The 30 m isobath lies between 2 and 6 kilometres offshore along the coasts west and north from Cape Home, on the western side of the entrance to Croker Bay. Shoals extend off the eastern side of the entrance but deep water can generally be found within 2 kilometres of shore. Deep water has been charted up to 13 kilometres into Croker Bay. Although there is no published data beyond this point it can be assumed that navigable depths exist to the head of the bay. (S. Blasco, pers. comm., 1977).

A 1.5 kilometre wide zone of deep water extends almost to the head of Dundas Harbour but Pilot of Arctic Canada (Vol. II, 1968, p.260) reports that "the bottom is, however, very irregular and pinnacles rise abruptly from deep water." Johnson Bay is reported to have depths exceeding 30 metres but only over small areas. Deep water exists within 1 kilometre of shore from Croker Bay as far east as Cape Warrender. Bathymetric information is only available to within 4 kilometres of the coast from Cape Warrender to Philpots Island but it can be assumed that deep water lies close to shore.

Tidal data from Dundas Harbour suggest a mean tide range for the map area of 1.8 metres and a large tide range of 2.87 metres. The movement of water and ice in Lancaster Sound is from west to east. A strong surface current moves eastward along the south side of Lancaster Sound at an estimated velocity of 88 kilometres per day (1.0 metre per second). At the mouth of Lancaster Sound a warmer ingoing or westward-moving surface current flows along the south shore of Devon Island (Pilot of Arctic Canada, Vol. II, 1968). Polar water from Jones and Smith Sounds flows southward along eastern Devon Island with average surface velocities of from 0.12 to 0.2 metres per second (Dunbar, 1951).

Potential Marine Terminals

Dundas Harbour

Dundas Harbour extends approximately 9 kilometres into the southeastern coast of Devon Island. It is 2.4 kilometres wide at its entrance, between Morin and Lemieux Points, and averages about 2 kilometres in width. A broad glacial valley extending 10 kilometres further inland forms the northern end of the harbour. Most of the shoreline is rugged and steep, rising over 400 metres above sea level within a kilometre of the coast.

Dundas Harbour was initially selected as a potential marine terminal but further investigations revealed that it is only partially suitable for such development. Deep water exists over most of its extent and several points of anchorage are available. There are landing beaches along the southeastern and western shores and the lowland region along the harbour's western shore offers conditions suitable for an airstrip. Although somewhat irregular in topography, the potential airstrip measures 3 kilometres long by 500 metres wide and is located 1 kilometre from an unlimited supply of outwash sand and gravel.

In spite of these advantages Dundas Harbour does not possess a year round supply of potable fresh water and the west side of the harbour, adjacent to the potential airstrip, has shoaled up to 1 kilometre offshore as a result of sediment carried by glacial meltwater.

Croker Bay

Croker Bay is located on southeastern Devon Island and is entered between Cape Home and an unnamed point 8 kilometres west of Dundas Harbour. It is 23 kilometres wide at the entrance and narrows to 4 kilometres at its head, approximately 42 kilometres inland. Two large glaciers discharge into Croker Bay, one on the eastern shore about 30 kilometres from the entrance and the other at the head of the bay.

Navigation: Water depths of up to 350 metres have been charted in the southern third of Croker Bay. Deep water has been reported to exist up to the head of the bay (S. Blasco, pers. comm., 1977). An extensive shoal stretches north along the western side of the bay and 7 kilometres eastward of Cape Home. A smaller shoaled area extends up to 2 kilometres offshore along the eastern entrance to the bay.

Icebergs calving from the two large glaciers near the head of the bay are a hazard to navigation.

Airstrip: The coastal plains lying behind both shores in the southern part of Croker Bay offer several sites for the construction of an airstrip. Pressman et al. (1961) suggested a site in the Rosamand River area but conditions on the eastern shores of the bay are more favourable in terms of freshwater supply and bathymetry.

The most suitable location for an airstrip is about 10 kilometres inside the eastern entrance. Widely-spaced raised beaches are a prominent feature of the area. The strip would be oriented to the northwest with approaches unobstructed except to the east where cliffs and bluffs rise up to 430 metres above the surface of the plain.

Wharf: There are no suitable natural harbours in Croker Bay and therefore the potential of the area as a marine terminal is severely inhibited. The coast in the vicinity of the proposed airstrip is slightly convex in shape with no indentations and is exposed to the open waters of Lancaster Sound.

Construction Materials: A large alluvial fan 7 kilometres from the coast could supply adequate quantities of sand and gravel for construction purposes. Raised beach deposits up to 60 metres above sea level are an additional source of construction aggregates.

Water Supply: There are numerous lakes and swale ponds south of the proposed airstrip. Because most of these are shallow and probably freeze to the bottom in winter, some form of storage facility would be required to ensure year round supply.

Baldwin Head

Physiography

The Baldwin Head Map sheet (Vol. II, M 10a, b, c) includes the northwestern third of Prince of Wales Island and comprises two physiographic units, namely, "plateau" and "coastal lowland".

Plateau

The westernmost extension of the Jones-Lancaster plateau borders on Drake and Smith Bays in northwestern Prince of Wales Island and the surface is characterized by low, rounded hummocks and gentle slopes leading to wide shallow valleys. Its elevation ranges from 90 to 180 metres above sea level. The transition from plateau to lowland is gradual, except near the head of Drake Bay where bluffs form the edge of the plateau.

The most abundant surficial materials are moderately stony silty sand and marine sand and silt with bedrock outcrops restricted to river cuts (Netterville _et al._, 1976). Numerous small lakes and ponds dot the surface and the drainage pattern is extremely irregular.

Beach ridge traces extending over 90 metres above sea level flank the edges of the plateau, except near the head of Drake Bay. Polygonal ground commonly occurs on the plateau surface.

Coastal Lowland

To the west, north, and south of the plateau region there is a lowland area which lies almost entirely below the marine limit and is characterized by a low relief hummocky till surface. The surface is dominated by glacial and marine landforms which include drumlins and fluting, eskers, moraines and flights of raised beaches. The coasts are broken by numerous bays, inlets and peninsulas.

The drainage pattern is very irregular and innumerable lakes and ponds dot the lowland surface. Polygonal ground occurs throughout the area.

According to Netterville et al (1976) the surface is composed of very stony till with a sand and silt matrix. Gravel beaches and pockets of marine fines occur below elevations of approximately 90 metres.

Bathymetry

Bathymetric data for M'Clintock Channel and Viscount Melville Sound are sparse, especially in the nearshore regions. Depths off the entrance to Reliance Bay range between 35 and 83 metres within 10 kilometres of shore. A line of soundings extending southeastward from the entrance to Ommanney Bay indicated depths ranging from 80 to 336 metres, and increasing into M'Clintock Channel. Numerous small islands and shoal areas exist close to shore throughout northwestern Prince of Wales Island.

Tidal data from Hamilton Island in the eastern entrance to Viscount Melville Sound suggest a mean tide range for the map area of 0.55 metres and a large tide range of 0.79 metres. In 1970 a strong easterly current with an estimated velocity of 1.5 metres per second was observed off the northern end of Stefansson Island (Pilot of Arctic Canada, Vol. III, Supplement Number 5, 1976).

Baring Channel

Physiography

Northern Prescott Island, southern Russell Island and the northeastern two thirds of Prince of Wales Island are included in the Baring Channel map sheet (Vol. II, M 11a, b, c). Physiographically, the area can be divided into three units, namely, "plateau", "upland" and "coastal lowland".

Plateau

Over two thirds of the land area on the map sheet comprises plateau including Russell, Edgeworth, Lock and Vivian Islands, the western half of Prescott Island, and a major portion of Prince of Wales Island.

The plateau is best developed between Baring Channel and the northern side of the entrance to Browne Bay, and on Russell, Lock, and Prescott Islands where it attains elevations from 240 to 340 metres. Horizontally bedded bedrock has been dissected to produce a series of mesas. The surface of the mesas consists of bouldery gravel felsenmeer, whereas, the surface veneer in the lowland areas between the mesas is a pebbly silty sand.

Drainage is joint controlled and radial from the plateau tops (Netterville et al., 1976). Many of the streams flow in broad, gently sloping valleys with little entrenchment. Depositional features are common in the lower reaches of the larger rivers. There are numerous small lakes in the plateau region and in the intervening lowland areas.

Flights of raised beaches are prominent along the coasts bordering the plateau region. They commonly reach 90 metres above sea level and, in some cases, it is estimated that they attain elevations of over 120 metres.

West of a line running southeast from Mecham Island towards Prescott Island, the plateau region is characterized by low rounded hummocks and gentle slopes leading to wide shallow valleys. The elevation rarely exceeds 200 metres and averages about 120 metres.

The most abundant surficial materials are moderately stony silty sand and marine sand and silt; bedrock outcrops are restricted to river cuts (Netterville et al., 1976). Lakes are numerous and the drainage pattern is deranged. Deltas have formed at the mouths of the larger rivers.

Raised beach traces are found along the coasts and up to 11 kilometres inland. They have been identified up to 120 metres above present sea level.

Lowland

There are lowland areas along the shores bordering Browne Bay and inland from Back Bay towards Arabella Bay on Baring Channel. In addition, there are small sectors of lowland in the vicinity of Reliance Bay near the western entrance to Baring Channel and in the southwest corner of the map sheet around the head of Smith Bay. These areas generally have elevations less than 60 metres and are dominated by raised beaches and innumerable lakes and ponds.

The dominant surficial material is a till composed of slightly stony silty sand and overlain throughout most of the region by 1 to 10 metres of marine silts and sands which, in places, are also slightly stony (Netterville et al., 1976). Drainage is poor and polygonal ground is common throughout the lowlands.

Many of the rivers and streams flowing through the plateau region into the lowlands have built deltas at their mouths which has resulted in extensive nearshore shoaling.

Upland

The upland area of the Baring Channel map sheet comprises the eastern half of Prescott Island. It is rocky and rugged, rising to elevations of over 340 metres. The Peel Sound shoreline is marked by 180 metre vertical cliffs.

According to Netterville et al. (1976, p.150) "more than 60 per cent of the surface is composed of intensely jointed and frost-cracked bedrock. It has a veneer of stony rubble composed of pebbles and cobbles set in a silt and sand matrix". They also state that concentrations of silt and sand are found in depressions and deposits of silt and sand up to 3 metres thick are found in large valleys.

The shoreline of the small bay on the northeast tip of Prescott Island is dominated by raised beaches to an elevation of about 60 metres. In no other coastal area could raised beaches be identified. The drainage pattern is structurally controlled and numerous small lakes occupy bedrock basins (Netterville et al., 1976).

Bathymetry

Mid-channel depths of 200 metres or greater occur in Peel Sound northward from Prescott Island. Available bathymetric information, which provide soundings to within 5 kilometres of the shores of Prince of Wales Island, indicate water depths well in excess of 100 metres.

Browne and Back Bays have not been surveyed but are known to have shallow water up to 1 kilometre offshore. Numerous islands, particularly in Browne Bay, encumber navigation.

A single line of soundings along most of the length of Baring Channel revealed a minimum depth of 25 metres and an average depth of about 70 metres. Minor shoaled areas exist close inshore off the mouths of the larger rivers.

Tidal data from Hamilton Island and False Strait suggest a mean tide range for the map area of 0.5 to 0.55 metres and a large tide range of 0.79 to 0.8 metres. Pilot of Arctic Canada (Vol. III, 1968) reports that a strong northerly set was experienced in two separate seasons eastward of midchannel in Peel Sound.

Potential Marine Terminals

Baring Channel

Baring Channel, which separates Russell Island from the northern side of Prince of Wales Island, is 56 kilometres long and averages between 5 and

7 kilometres wide. Its eastern entrance lies between Cape Hardy and Cape Walker. A line of soundings taken through the channel in 1960 indicated a minimum water depth of 25.6 metres and an average depth of about 60 metres (Pilot of Arctic Canada, Vol. III, 1968). The low isthmus which joins the peninsula projecting northeastward into Baring Channel with Prince of Wales Island has been selected as a potential marine terminal.

Navigation: Except for shallow water close to shore, particularly in the vicinity of Cape Walker, there are no navigational hazards to be encountered upon entering Baring Channel from the east. Midchannel depths within the eastern entrance range between 71 and 80 metres.

Airstrip: There are two possible locations for an airstrip. The first is oriented east across the isthmus, is approximately 1.6 kilometres long and lies less than 30 metres above sea level. A line of steep cliffs to the south and east (approximately 365 metres ASL) and 210 m high hills to the north are the major obstacles to approaching aircraft. Approaches should, therefore, be made either from the west or from the northeast.

The second potential airstrip lies southwest of the peninsula on a narrow but relatively flat coastal plain. The plain is continuous along northern Prince of Wales Island and measures between 300 and 400 metres in width. The airstrip would be oriented northeast with approaches from the south and east restricted by cliffs and bluffs. A number of small intermittent streams flowing into Baring Channel have resulted in minor dissection of the surface of the coastal plain.

Wharf: There are good landing beaches and potential wharf sites along the coasts in the vicinity of the suggested airstrips. The western end of the isthmus is probably most suitable in terms of shelter and water depth but field investigation would be essential before the final location could be selected.

Construction Materials: Extensive alluvial fan deposits have formed along the southern margin of the isthmus in close proximity to the suggested airstrip and wharf locations. Flights of raised gravel beaches are prominent in many areas.

Water Supply: One large lake (0.25 km^2 surface area) and numerous smaller ones are located on the isthmus. Most appear shallow and thus probably freeze to the bottom during winter. This problem could presumably be overcome by some form of heated storage or by increasing the depth of the reservoir.

Back Bay

Back Bay is located along the northeastern coast of Prince of Wales Island. Entered between Whitehead Point and a point 9 kilometres to the north, the bay extends 13 kilometres inland. Two peninsulas project into the bay about 7 kilometres inside the entrance, constricting the width of the bay to 2 kilometres.

The coastal lowland on the north side of the bay just inside the entrance has been selected as a potential marine terminal.

Navigation: There is no available bathymetric data for Back Bay. Soundings of over 180 metres have been made in Peel Sound approximately 14 kilometres off the entrance to the bay. Air photographs indicate that there is a shallow zone which extends, on the average, about 150 metres from shore; the inner portion of Back Bay is thought to be predominantly shallow. The outer portion of the bay contains several small islands but these should not constitute a hazard to vessels destined for the suggested terminal site along the north shore.

Airstrip: Sloping gradually inland, the coastal lowlands along the north shore of Back Bay provide several ideal locations for an airstrip. Partially vegetated raised beach traces dominate the landscape. East and west approach paths are virtually unrestricted, but to the north and south, remnants of plateau rise over 300 metres above sea level.

Wharf: There are good landing beaches and potential wharf sites along the north shore of the bay. Shallow water extends up to 150 metres offshore, beyond which no information is as yet available. The 1.5 kilometre wide inlet which forms the northernmost extension of Back Bay should be examined as it may prove to be a good landing and mooring area.

Construction Materials: According to Netterville et al. (1976) slightly stony marine sands and silts overlie most of this area and vary in thickness from less than 1 metre to more than 10 metres, thickening coastward. Flights of closely spaced raised gravel beaches occur throughout the area and constitute an excellent source of sand and gravel for construction purposes.

Water Supply: There are two major freshwater lakes within easy access of the north shore of the bay. One is located about 0.5 kilometres from shore just inside the northern entrance and has an estimated surface area of 0.64 km^2. The other lies northwest of the bay approximately 3 kilometres from shore and has a surface area greater than 2 km^2. Both lakes are deep and capable of providing a year-round supply.

Somerset Island

Physiography

Including all of central and most of western Somerset Island, this map sheet (Vol.II, M 12a, b, c) can be roughly divided into three physiographic units, namely, "plateau", "coastal lowland", and "upland".

Plateau

Except for a 25 kilometre wide strip of the coast stretching north towards Aston Bay, the land area shown on the map sheet comprises plateau. It is built of flat-lying sedimentary strata and ranges in elevation from 240 to 460 metres. The surface configuration is one of rounded hills with gently undulating slopes and a relief, above the tops of the gorges of incised streams, of as much as150 metres.

Netterville et al. (1976) reports that the upland surface is mantled by a 1 to 3 metre thick accumulation of rubble, most of which varies from moderately stony to very stony silt.

Rivers in the interior (e.g.: Creswell and Elwin Rivers) flow in shallow, broad, often alluvium-filled valleys and have relatively low gradients. Those nearer to the coast (e.g.: Hunting, Aston, Garnier and Cunningham Rivers) are deeply entrenched and flow through steep-sided gorges. The overall drainage pattern is predominantly dendritic.

There are numerous lakes and ponds around Aston Bay, Garnier Bay and east of the East Creswell River but few exist in the central portion of the plateau. Raised beaches are well-developed in the coastal regions of Garnier and Aston Bays, where they can be found up to 60 metres above sea level.

Coastal Lowland

The lowland area of Somerset Island stretches north from Creswell Bay almost to the south shore of Aston Bay. It averages 15 kilometres in width and is bordered by the plateau on the east and the upland on the west.

The eastern transition from lowland to plateau is gradational but fairly well defined, whereas, the lowland to upland transition in the west is less conspicuous (Roots, from Fortier et al., 1963).

The topography is characterized by low, rounded hills separated by broad valleys. A number of large lakes, including Fiona Lake, occur in the area. The drainage pattern is predominantly dendritic.

According to Netterville et al. (1976) most of the bedrock in this region is concealed by a veneer of surficial materials, consisting mainly of both bouldery till and felsenmeer.

Upland

A 10 to 20 kilometre wide strip of the Somerset coast, extending south from Cape Granite, constitutes an upland area. The region is underlain by Precambrian crystalline rocks.

The upland surface is hilly and rocky and much more highly dissected than the adjacent lowland area. Drainage is structurally controlled trending north, parallel to bedrock boundaries and foliation, and northwest, parallel to either a fracture or joint system (Netterville et al., 1976). Innumerable ponds and lakes in the area testify to the disorganized drainage conditions.

Netterville et al. (1976, p.148) state that "surficial materials are thin and discontinuous. By far the most prevalent material is felsenmeer, interspersed with thin patches of bouldery till." "The coast of the upland is bold and rocky, rounded in profile, without cliffs, and with rocky offshore islands that are the counterpart of the hills inland" (Roots, from Fortier et al., 1963, p.117).

Discontinuous traces of raised beaches can be found along the coast and marine sediments are apparent at the valley mouths of the larger rivers entering Peel Sound.

Bathymetry

Charted depths in Peel Sound exceed 200 metres within 10 kilometres of the Somerset Island shoreline. Aston Bay has not been surveyed but deep water probably exists throughout most of the bay.

Garnier Bay, on the northeast corner of the map sheet, is generally shallow except for a small zone in the centre of the bay which has depths greater than 30 metres.

Tidal data from Cunningham Inlet (R.B. Taylor, pers. comm., 1977) and Port Leopold suggest a mean tide range for the map area of 1.2 to 1.62 metres and a large tide range of 1.7 to 2.5 metres. Pilot of Arctic Canada (Vol. III, 1968) reports that, in two separate seasons, a strong northerly current was experienced eastward of midchannel in Peel Sound.

Potential Marine Terminal

Aston Bay

Aston Bay is located on northwestern Somerset Island and is entered between Pressure Point and Cape Granite. The bay is approximately 14 kilometres wide at its entrance and narrows gradually to 1.7 kilometres at its head, 32 kilometres to the southeast. There are four large inlets off the bay and three major rivers draining into it, including the Aston River and the Hunting River.

Aston Bay was initially selected as a potential area for the siting of a marine terminal. Although no bathymetric surveys have been carried out it is assumed that the bay had deep water throughout most of its length. There are a number of good landing beaches and potential wharf sites and supplies of fresh water and construction aggregates are abundant and readily accessible.

However, further study of the area failed to reveal suitable locations for an airstrip capable of handling large aircraft and the orientation of the bay affords little protection from northwesterly winds and ice movement. According to Bird (1967) Aston Bay lies in the maximum zone of occurrence of coastal ice pushed ridges. It is therefore suggested that Aston Bay does not provide conditions amenable to the development of a marine terminal.

Cape Clarence

Physiography

The Cape Clarence map sheet (Vol. II, M 13a, b, c) covers a portion of the west coast of Brodeur Peninsula and most of northeastern Somerset Island. Both of these areas comprises "plateau".

Brodeur Peninsula

Brodeur Peninsula is a monotonously flat and featureless plateau with a thin drift cover. Streams are deeply incised near the coast but all, except the major rivers, flow in indistinct depressions in the interior (Craig, 1965). The horizontal sedimentary rocks of the peninsula have resulted in a steep and fairly even coastline with only a few relatively minor indentations, including Port Bowen, Port Neill and Jackson Inlet. Near vertical cliffs rise to 240 metres or more above sea level along most of the coast.

The plateau surface is comprised for the most part of gravelly rubble with a scant vegetation cover. Polygonal ground and other periglacial features are uncommon.

Several dozen small lakes lie on the plateau surface, most of which have surface areas less than 0.4 km^2. Drainage is well-developed and reflects a dendritic pattern. The rivers entering Prince Regent Inlet flow through broad, flat alluvium-filled valleys whose walls are steep and usually talus covered.

Few lowland areas exist along the coast except at the mouths of the larger rivers and where small deltas and spits of unconsolidated material have been formed. Flights of raised beaches occur on gently sloping surfaces and often reach 90 metres above sea level.

Northeastern Somerset Island

The plateau extends from Two Rivers Bay to a point approximately 30 kilometres west of Cape Admiral M'Clintock. It is built of flat-lying sedimentary strata and bounded on the east by almost continuous cliffs which face Prince Regent Inlet and rise to over 330 metres above sea level. West from Cape Clarence the cliffs are discontinuous and form bluffs between which a coastal lowland, 1/2 to 5 kilometres in width, connects the plateau with the shore.

The surface of the plateau is smooth, nearly flat and is sharply incised by a dendritic network of narrow V-shaped gorges. Netterville et al. (1976) reported that the upland surface is mantled by a 1 to 3 m thick accumulation of rubble, most of which varies from moderately stony to very stony silt. They also stated that the dominant materials in the coastal lowland west from Cape Clarence are marine silts and sands along with many gravel beach ridges. "The silts are commonly rich in ground ice, and display several flow-slide scars" (Netterville *et al.*, 1976, p. 149). Polygonal ground occurs in several areas south of Mount Rosamond.

Batty Bay, Elwin Bay, and Port Leopold are the only interruptions along the almost perfectly regular eastern Somerset coastline. The Elwin and Batty Rivers flow into Elwin Bay and Batty Bay, respectively, and occupy large well-developed valleys which extend for considerable distances inland. The stream valleys in eastern Somerset are steep-walled and commonly form cliff-walled gorges. Elsewhere, the valley walls are talus and rubble.

There are numerous lakes in the vicinity of Batty Bay and several large lagoons in Rodd Bay and west of Cape Admiral M'Clintock. Raised beaches and intervening swale ponds are well-developed along the northeastern coast and in the lowland areas formed by streams entering Prince Regent Inlet.

Bathymetry

Prince Regent Inlet is free of navigational hazards and mid-channel depths average over 400 metres. The 200 m isobath is never more than 5 kilometres from shore except in the small bays and inlets and along the Somerset coast northwest from Cape Clarence where depths of between 8 and 20 metres extend up to 3 kilometres offshore. Port Bowen and Port Neill have charted depths greater than 30 metres. Jackson Inlet has not been sounded but probably contains deep water. There are no deep water inlets along eastern and northeastern Somerset Island.

Tidal data from Port Leopold suggest a mean tide range for the map area of 1.62 metres and a large tide range of 2.5 metres. A surface current enters Prince Regent Inlet between Prince Leopold Island and Cape Clarence and flows down the west side. Part of this current turns northward along the eastern side of the inlet, and the remainder turns southward through the Gulf of Boothia (Pilot of Arctic Canada, Vol. II, 1968).

Potential Marine Terminals

Port Bowen and Jackson Inlet, situated on the western coast of Brodeur Peninsula, were initially selected as potential sites for the location of a marine terminal. Both sites can accomodate deep draught vessels if shelter or temporary anchorage is required, however, manoeuvring space is limited, landing sites are few, and airstrips could only be constructed on the plateau, 240 metres above sea level.

Port Bowen

Port Bowen is 2 kilometres wide at its entrance, narrowing gradually to 1 kilometre at its head which lies 5 kilometres inland. A broad, flat alluvium-filled valley, traversed by a braided stream, extends 2 kilometres further inland. The shores of Port Bowen are very steep, rising abruptly over 210 metres above sea level to a flat and featureless plateau. Except for the valley at the head of the inlet, the only lowland regions are a few small deltas at the mouths of streams entering the inlet. Pilot of Arctic Canada (Vol. II, 1968) reports that the inlet is deep but a 2 m shoal lies close to the southern entrance point; a shoal area extends almost 1 kilometre off the northern side of the inlet 2.5 kilometres inside the entrance. A small island lies in the middle of this shoal.

Jackson Inlet

Jackson Inlet extends 9 kilometres into Brodeur Peninsula and measures 1.5 kilometres wide at its entrance, narrowing to 0.75 kilometres at its head. A broad, flat alluvium-filled valley extends 8 kilometres further inland from the head of the bay. The Jackson River follows a heavily braided pattern through the valley before discharging into the inlet. The shores of Jackson Inlet are steep, rising abruptly over 240 metres above sea level to a flat and featureless plateau. Except for the valley at the head of the inlet, the only major lowland region is a large delta which has formed at the southern entrance point.

Arctic Bay

Physiography

The Arctic Bay map sheet (Vol. II, M 14a, b, c) includes northern and northeastern Brodeur Peninsula and northwestern Borden Peninsula, all of which comprises the plateau.

Brodeur Peninsula

The northern and northeastern section of Brodeur Peninsula is a monotonously flat and featureless plateau with a thin drift cover. Precipitous cliffs rise to 490 metres along the coast, interrupted by small gullies and occasional river valleys. West from Cape York the coastal cliffs are more subdued and rarely exceed 240 metres in elevation.

The larger rivers flow through deeply incised, alluvium-filled valleys and have formed extensive deltas. Drainage is well-developed and reflects a dendritic pattern. Flights of raised beaches are found in the lowlying areas at the mouths of the larger rivers and in narrow zones of lowland bordering the coasts.

Six icefields ranging in size from 30 to 50 square kilometres are located along the eastern coast of Brodeur Peninsula, but none of these comes within 1.5 kilometres of the shore.

Borden Peninsula

The topography on Borden Peninsula is much more complex than on Brodeur Peninsula, a reflection of more variable bedrock geology. Whereas the coastline of Brodeur Peninsula is steep and fairly even with few indentations, the western coast of Borden Peninsula is broken by a series of inlets which penetrate deeply inland. Adams Sound and Strathcona Sound extend over 48 kilometres inland while Baillarge Bay and Victor Bay are 23 and 11 kilometres deep, respectively. The coasts of Adams Sound and Baillarge Bay are marked by steep cliffs rising up to 730 metres above sea level while those of Strathcona Sound and Victor Bay are more subdued, rarely attaining heights greater than 425 metres. The plateau surface, at an elevation of approximately 550 metres, is flat and featureless with a thin drift cover.

Numerous rivers drain into Adams Sound, Baillarge Bay and Strathcona Sound, the largest being those which enter at the heads of the inlets. These rivers flow through wide and relatively flat, alluvium-filled valleys. Flights of raised beaches can be seen in the vicinity of Victor Bay and south from Cape Cunningham. Along the valley sides of the large inlets, isolated traces of raised beaches can also be identified.

Bathymetry

There are no known navigational hazards in either Lancaster Sound or Admiralty Inlet except close inshore and off the northeastern tip of Uluksan Peninsula. Strathcona Sound, Adams Sound and Victor Bay have been charted and deep water (i.e., greater than 30 metres) extends from their entrances to their heads. Baillarge Bay has not been officially surveyed but, according to Pilot of Arctic Canada (Vol. II, 1968), depths are reported to shoal from 550 metres at the entrance to 55 metres about 0.8 kilometres from the head.

Tidal data from Arctic Bay and Strathcona Sound suggest a mean tide range for the map area of 1.6 metres and a large tide range of 2.7 metres. A strong surface current moves eastward along the south side of Lancaster Sound with an estimated velocity of 1.0 metre per second (Pilot of Arctic Canada, Vol. III, 1968).

Potential Marine Terminals

Baillarge Bay

Baillarge Bay extends 23 kilometres into Borden Peninsula from a point 40 kilometres south of the entrance to Admiralty Inlet. The bay is 4.5 kilometres wide at its entrance and narrows gradually to slightly less than 1.5 kilometres at its head.

Navigation: Depths in the bay range from 550 metres at the entrance to 55 metres about 0.8 kilometres from the head.

On August 10, 1958, when the most recent air photographs were taken, the head of Baillarge Bay was severely choked with ice to a distance of 5.5 kilometres. The dominant wind direction during the navigation season (i.e., August to

September) is northwest and presumably this caused drift ice from either Admiralty Inlet or Lancaster Sound to accumulate in the bay. Frequent recurrence of this phenomenon would prove unsatisfactory in terms of navigation.

Airstrip: In terms of suitability for the development of aircraft landing facilities, prevailing topographic conditions are borderline and possibly inadequate. The only potential landing strip is located at the head of the bay on an alluvial fan which measures 2500 metres long and 900 metres wide at mid-section. In order to construct a suitable landing surface considerable levelling and a diversion channel to accomodate river discharge would be required. Aircraft approach paths are from the northwest and southeast, measuring roughly 6 kilometres long by 3 kilometres wide, and are restricted on either side by 600 m high cliffs.

Construction Materials: Modern alluvial deposits and uplifted deltas are extensive and capable of providing a readily accessible supply of construction aggregates.

Water Supply: There are three freshwater lakes within 8 kilometres of the bayhead. They constitute approximately 0.1 km^2 of water surface but all three are shallow; the two largest lakes (i.e., 0.06 km^2 and 0.03 km^2) are located on the plateau surface at an elevation of 550 metres. Two rivers which discharge into the head of Baillarge Bay represent the only other sources of freshwater in the area. Year-round flow is improbable and high levels of suspended sediment during breakup create a purification problem. This could be overcome by means of an artificial reservoir and settling basin.

Adams Sound

Adams Sound, entered between Cape Cunningham and the southwestern tip of Uluksan Peninsula, extends southeastward into western Borden Peninsula for approximately 61 kilometres. It is about 5 kilometres wide at the entrance and gradually narrows to just under 1 1/2 kilometres in width at its head. A wide flat valley continues 5 kilometres further inland. The width of the navigable entrance to Adams Sound is reduced to about 4 kilometres by two zones of less than 20 metres water depth, one extending south from Uluksan Peninsula, the other extending northwest from Cape Cunningham. Water is deep throughout the length of the sound, with depths ranging from 90 metres to over 350 metres. According to Pilot of Arctic Canada (Vol. II, 1968) a shoal the full width of the sound is situated about 5 kilometres from its head; it has a reported water depth of 1.8 metres.

The shores of Adams Sound are steep and high over most of its length, ranging from 240 to 670 metres above sea level. Several rivers discharge into the sound, the largest of which enters at its head through an alluvium-filled valley.

There are two potential marine terminals in Adams Sound, namely Arctic Bay and Johnston Harbour.

Arctic Bay

Arctic Bay indents the northern shore of Adams Sound about 13 kilometres inside the entrance. It is entered between Oulouksione Point, which rises steeply to about 210 metres, and Holy Cross Point, a low sharp point about 2.6 kilometres southeastward. The bay extends northward for about 4.8 kilometres from Holy Cross Point and has a width of about 2.8 kilometres. The settlement of Arctic Bay, whose population in 1971 was 293, is located on the northwestern end of the bay on a low sandy beach backed by high hills (Pilot of Arctic Canada, Vol. II, 1968).

Navigation: Depths in Arctic Bay are fairly regular. Two locations in the centre of the bay have charted depths greater than 100 metres, with a gradual shoaling towards the shores. The entrance channel is about 1.3 kilometres wide and the harbour basin is approximately 6 square kilometres in area. The holding ground for anchorage is reported to be excellent in the northwest part of the bay and a good gravel beach for landing supplies exists in front of the settlement (Pilot of Arctic Canada, Vol. II, 1968).

Airstrip: A landing strip has been excavated from the bluffs which form the western shore of the bay. The landing surface is not more than 6 metres above sea level and its length (approximately 490 metres) and width (less than 23 metres) render it unsuitable for use by large aircraft. Low level air photography taken during July of 1976 indicate excavation activity at the southern end of the runway resulting in an extension of the runway by approximately 150 metres.

Construction Materials: Supplies of construction materials should more than satisfy the demands of future development and expansion of a marine terminal at Arctic Bay. Community gravel supplies are presently being extracted from an excavation at the southern end of the airstrip. The only other sign of gravel extraction activity is located 1.2 kilometres from the townsite along the east side of the bay.

Water Supply: According to Pilot of Arctic Canada (Vol .II, 1968) the community obtains fresh water from a small stream during open season and ice is used during freezeup. However, there are two freshwater lakes within 1 kilometre northwest of the town which could provide a year-round supply of water. Both lakes have an approximate surface area of 0.04 km^2 and probably do not freeze to the bottom during winter. A two-wheel track skirts one lake and passes within 160 metres of the other, providing ready access by tank truck or pipeline construction equipment.

Johnston Harbour

Johnston Harbour is located 5 kilometres further southeast from Holy Cross Point. It extends about 2.8 kilometres eastward along the north shore of Adams Sound and has an approximate width of 1.2 kilometres. The entrance channel is about 610 metres wide and the harbour basin is approximately 1.0 km^2 in area, with an average depth of about 59 metres. The surrounding topography is not amenable to the development of marine terminal support facilities.

Conclusions: Arctic Bay and Johnston Harbour are quite adequate in terms of marine accessibility but do not have topographic conditions suitable for the development of air support facilities. There are possibilities for aircraft landing sites on the plateau west of Arctic Bay. A two wheel track which now leads from the community to this area could be developed as an access road but at considerable expense. Similarly, the highland region north of Johnston Harbour has potentially suitable landing sites, all of which would require expensive access roads.

Victor Bay

Victor Bay, entered close westward of Strathcona Sound between Graveyard and Victor Points, is about 5.2 kilometres wide at its entrance and extends south-southwesterly for about 12 kilometres. It was initially chosen as one of a number of sites potentially suitable for the development of a marine terminal and, in many respects, is an attractive site for such development. Water depths in the bay are greater than 50 metres, except very close to shore. The shores along the bay are moderately steep except near the head where there are conditions suitable for development of shore support facilities. Sources of fresh water and construction aggregates are available nearby and a two wheel track links Victor Bay with the community of Arctic Bay. However, the northwest-southeast orientation of the bay exposes it to prevailing winds and ice. On July 31, 1976 low level air photography revealed brash ice and small floe ice covering approximately 7/10ths of Victor Bay while on the same date less than 1/10th of Arctic Bay to the south was covered by ice. During the open water season northerly winds will tend to move drift ice down through Admiralty Inlet from Lancaster Sound and into Victor Bay.

The suitability of Victor Bay for development as a marine terminal is questionable in view of its undesirable sea ice regime.

Strathcona Sound

Of all the locations examined in the study area, Strathcona Sound is the most suitable site for the development of a marine terminal and related facilities. The development of a lead-zinc mine on Strathcona Sound has resulted in the construction of a minerals handling wharf, an Arctic class "B" airport, a town site and associated access roads and facilities. If desirable, the marine facilities could be expanded to accommodate other users.

Navy Board Inlet

Physiography

The Navy Board Inlet map sheet (Vol. II, M 15 a, b, c) includes all of northern and parts of eastern Borden Peninsula, Baffin Island, and western Bylot Island. The map can be roughly divided into four major physiographic units, namely, "coastal plain", "plateau", upland", and "highland".

Coastal Plain

A coastal plain of varying width extends from a few kilometres northeast of the mouth of Elwin Inlet to the midpoint of Navy Board Inlet. The western side of Bylot Island has also been included in this unit (Craig, 1964).

Flights of raised beaches are a prominent feature in the coastal areas and have been found up to 120 metres above sea level. Cliffs breached by a number of ravine-like stream valleys rise over 30 metres above a narrow beach zone. Beyond the cliffs the land rises to rolling country about 180 to 240 metres high. The transition from coastal plain to inland plateau occurs approximately 11 kilometres south from the coast.

Craig (1964) reports that drift cover is heavy in the Borden Lowland. The larger rivers, such as Charles Yorke River, enter the coast through alluvium-filled valleys and have formed extensive deltas. Polygonal ground is found commonly throughout the coastal area.

Plateau

Most of Borden Peninsula south from the North Borden Lowland comprises plateau. Steep sea cliffs with heights of over 760 metres margin the plateau along

Elwin Inlet. Except along the valleys of the larger rivers, elevations in excess of 300 metres are found within 11 kilometres of the north coast of the peninsula. Along the western shore of Navy Board Inlet cliffs rise to over 600 metres above a narrow coastal plain. The highest point in the area, 1310 metres, is the summit of the icecap east of Elwin Inlet (Blackadar, 1970).

The surface of the plateau consists of a thin layer of till-like material whose composition varies depending on the nature of the underlying bedrock (Craig, 1964). Drainage is generally well-developed in the plateau. The larger rivers flow in broad, flat-floored valleys with scree-covered valley sides, but the upper reaches of these and the smaller streams may be turbulent and narrowly V-shaped.

Upland

The upland and region extends south along a 16 to 25 km wide section of Eastern Borden Peninsula from the shore opposite Canada Point on Bylot Island. North of Low Point there is a large icefield of approximately 180 km^2. Five glaciers approach Navy Board Inlet from this icefield, four of which extend into the inlet. A narrow coastal plain continues south from Low Point.

Highland

The Byam Mountains of northwest Bylot Island rise sharply from the sea to elevations ranging from 600 to over 1200 metres. The highland region is mostly ice-covered and numerous valley glaciers flow toward Lancaster Sound and Navy Board Inlet. Associated with these are end and lateral moraines and extensive outwash surfaces.

Bathymetry

There are no known navigational hazards in either Lancaster Sound or Navy Board Inlet except close inshore and at the northern entrance to Navy Board Inlet. Charted depths range from 100 to over 800 metres in Lancaster Sound and from 70 to over 400 metres in Navy Board Inlet. Tidal data from Dundas Harbour, Milne Inlet and Strathcona Sound suggest a mean tide range for the map area of 1.6 metres and a large tide range of 2.9 metres. Tide rips are reported to exist across the entrance to Navy Board Inlet and in the vicinity of the Wollaston Islands (Pilot of Arctic Canada, Vol. II, 1968).

At the northern entrance to Navy Board Inlet depths of less than 30 metres have been sounded 3.2 kilometres east of Adams Island; the remaining 8 kilometre section of entrance has depths greater than 30 metres, and generally, greater than 50 metres.

Shoal areas extend up to 1.6 kilometres off the delta fronts of most of the large rivers entering Navy Board Inlet and also off the delta fronts of two rivers which enter Admiralty Inlet southwest of Cape Joy.

A strong surface current moves eastward along the south side of Lancaster Sound with an estimated velocity of 1.0 metre per second (Pilot of Arctic Canada, Vol. III, 1968).

Potential Marine Terminals

Tay Bay

Tay Bay, on the northwestern coast of Bylot Island, was initially selected as a potential site for the development of a marine terminal. However, further investigations revealed several factors which make Tay Bay unsuitable for such development.

Although the site is acceptable in terms of navigational requirements the topography of the surrounding coastal area is unsuitable for shore support facilities. There is also some indication of silting in the bay by material carried out from two large valley glaciers.

Elwin Inlet

Elwin Inlet is one of a series of fiords which penetrates deeply into western Borden Peninsula. Although initially considered potentially suitable for the development of a marine terminal, further study failed to reveal conditions amenable to the development of air support facilities. The inlet was found favourable for large vessel navigation and anchorage but suitable aircraft landing strips could not be identified and approach paths are severely restricted by 600 metre high cliffs along both sides of the inlet.

According to Pilot of Arctic Canada (Vol. II, 1968 and Supplement Number 3, 1974) the inlet has not been sounded but the water is reported to be very deep in the lower reaches. The inlet should prove valuable in terms of providing safe shelter and suitable anchorage during storms.

POTENTIAL MARINE TERMINALS – SUMMARY AND CONCLUSIONS

In the central Canadian Arctic Islands there is presently only two major service ports in operation – Resolute Bay, Cornwallis Island and Nanisivik, Baffin Island. The latter port was recently opened for the shipment of ore from the new lead and zinc mine. In the past, supply ships have also serviced Panarctic Oils Ltd. at the Rea Point terminal, Melville Island and Arvik Mines Ltd on Little Cornwallis Island. These ports could possibly be expanded to support the demands of the oil and gas industry, but the objective of this study is to select alternative port sites with better natural conditions for use by large bulk carriers. The selection of potential terminal sites depends not only on the physical characteristics of a site but also the mode of transport that is used to transport the oil and gas. It is assumed the main sources of oil and gas will be Cameron Island and Melville and King Christian Islands. If a pipeline is used to carry the oil and gas to areas of less ice severity, then because of the high cost of a submarine pipeline across Parry Channel, greater importance is given to potential terminal sites north of the channel. If however an all pipeline mode of transport is used to transport oil and gas to southern markets, then staging areas for construction materials will be required along the entire route.

During the compilation of physical coastal information specific sites were selected and examined in more detailed to assess their suitability as marine terminals. Each of the sites, was discussed with the accompanying map sheet (Chapter II), according to the design criteria outlined in appendix I. Since field studies were conducted only in Radstock Bay, Devon Island and near Freemans Cove, Bathurst Island, the assessment of the suitability of most sites was

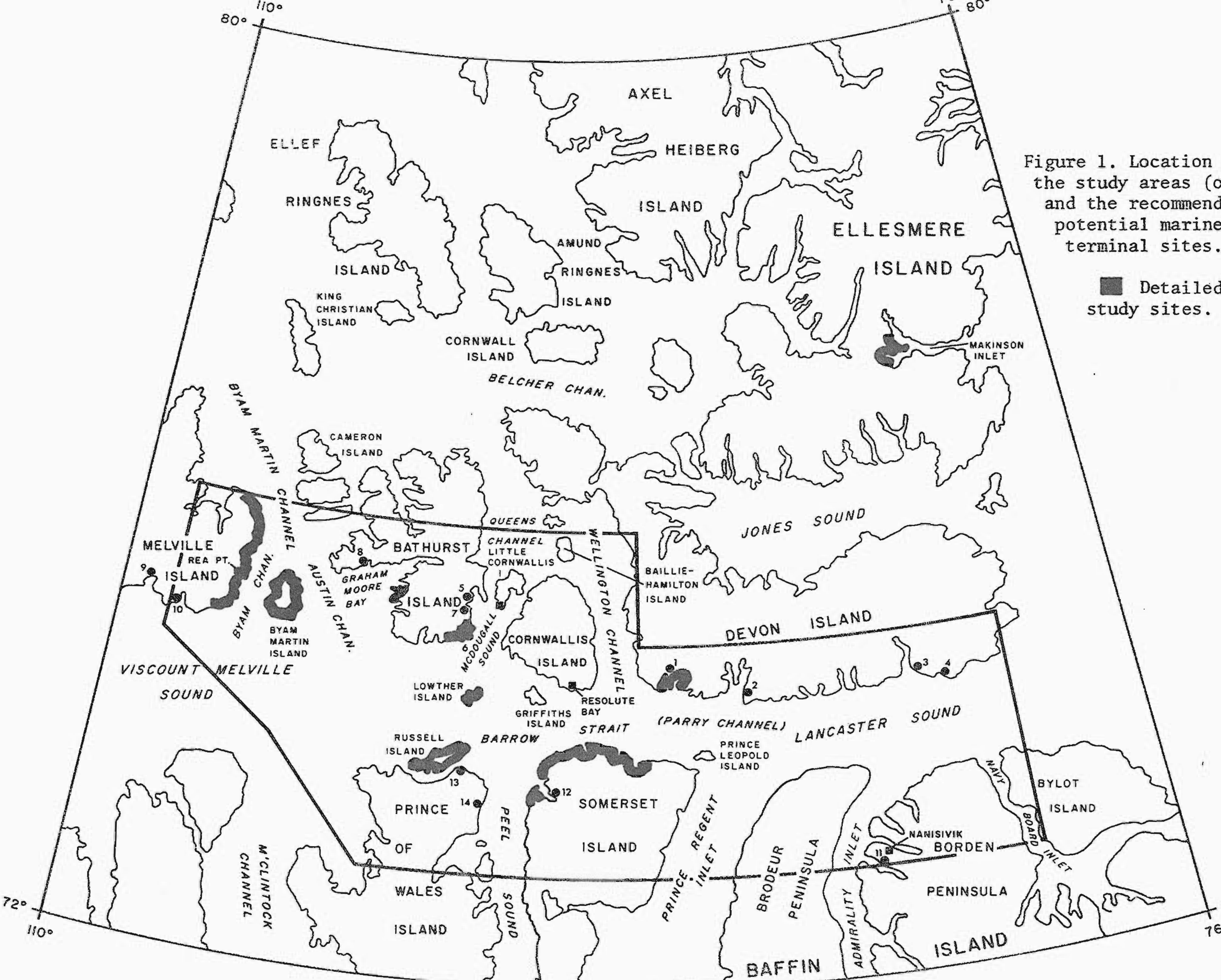


Figure 1. Location map of the study areas (outlined) and the recommended potential marine terminal sites.

■ Detailed study sites.

TABLE I POTENTIAL MARINE TERMINAL SITES, LISTED ACCORDING TO ISLAND. Locations are shown in figure 1.

Potential Marine Terminal	Bathymetric Information	Accessibility	Shelter	Anchorage (based on Water Depth)	Length of Open Water Season (estimated)	Landing Beaches	Availability Construction Materials	Potential Airstrip	Fresh Water Supply	Additional Comments
Devon Island										
1. Radstock Bay	Excellent	Excellent	Excellent	Good	80	Excellent	Excellent	Excellent	Excellent	Poor anchorage in northern part of bay
2. Maxwell Bay	Excellent	Excellent	Poor	Poor	85	Good	Good	Poor	Poor	
3. Croker Bay	Good	Excellent	Poor	Poor	129	Good	Good	Excellent	Good	Calving Glaciers
4. Dundas Harbour	Excellent	Good	Limited	Good	129	Good	Good	Limited	Poor	once used as a R.C.M.P. post
Bathurst Island										
5. Bateman Bay	Limited	Good	Good	Good	49	Limited	Good	Good	Good	
6. Freemans Cove	Good	Limited	Good	Good	49	Good	Good	Excellent	Limited	Shoals to east of entrance
7. Inlet south of Bass Point	Limited	Good	Excellent	Good	49	Good	Good	Limited	Good	
8. Graham Moore Bay	None	Limited	Good	Good	48	Good	Limited	Good	Poor	
Melville Island										
9. Bridport Inlet	Selected by Petro-Canada as the site for a gas processing and liquification plant. Detailed field studies have been completed by Petro-Canada.									
10. Skene Bay	None	Good	Poor	-	44	Good	Good	Good	Good	
Baffin Island										
11. Arctic Bay	Excellent	Good	-	Good	-	Excellent	Good	Limited	Good	Inuit Settlement
Somerset Island										
12. Aston Bay	None	Good	Poor	-	-	Good	Excellent	Poor	Good	Some years Bay remains ice covered
Prince of Wales Island										
13. Baring Channel	Limited	Good	Limited	-	-	Good	Excellent	Good	Good	Possible site also on south Russell Island
14. Back Bay	None	Good	Good	-	-	Good	Good	Good	Good	

qualitative. Detailed field studies would be required should one of the sites be finally chosen for further study as a marine terminal. Information vital to marine terminal planning that was not available for most sites was bathymetry, especially in the nearshore, local climatic conditions and estimates of longshore transport of sediment.

From the total number of sites examined fourteen have been chosen to have the best potential as marine transshipment terminals (Table 1). Each of the potential sites was chosen solely from a geologic and coastal geomorphic standpoint. The potential terminal sites have been grouped according to geographic location, i.e. by island, compared to each other and ranked in importance.

Devon Island: Four sites are suggested as potential marine terminals but of these, field studies have only been completed at Radstock Bay (chapter III). Nevertheless Radstock Bay is recommended as the best site for the future development of a transshipment terminal. There is poor anchorage in the upper reaches of Radstock Bay but in the proposed terminal site – Caswell Bay (fig. 14) anchorage, wharf site and manoeuverability are all good to excellent. The physical conditions for support facilities are also excellent. Only shelter is questionable and it is afforded to some degree by Palmer shoal to the south and Dealy Point to the north.

The alternatives to Radstock Bay are Maxwell Bay, Dundas Harbour and Croker Bay. Maxwell Bay has poor shelter, poor anchorage because of depths, and little flat land for support facilities. Dundas Harbour gives only limited shelter and both it and Croker Bay are fringed by high shores and calving glaciers. Sea ice moves in and out of all the sites, including Radstock Bay, during the open water season.

Cornwallis Island: No new sites are recommended, however Resolute Bay is already in use on this island. Shallow depths at the entrance to the bay prohibit the passage of large bulk carriers but the port could be used as a staging area if pipeline construction occurs.

Bathurst Island: Four potential terminal sites were selected on Bathurst Island, of these only Freemans Cove is known to have been previously used by ships to unload supplies. Freemans Cove has the disadvantages of a narrow entrance which prevents the early removal of ice, and shoals occur to the east of the entrance. Bateman Bay and the bay to the south of Bass Point both afford good shelter, adequate depths, good anchorage and manoeuverability. However a very important wildlife area, Polar Bear Pass across Central Bathurst Island would have to be avoided if a pipeline were used to transport the oil and gas to southeast Bathurst Island. Graham Moore Bay on the west coast of Bathurst Island has the distinct advantage of proximity to Cameron Island but the disadvantages outweigh this advantage. There is shallow water depths, poor manoeuverability and much worse ice conditions compared to south-eastern Bathurst Island. Using physical criteria Bateman Bay or the bay to the south of Bass Point have the best potential as marine transshipment centres.

Melville Island: During the writing of this report Bridport Inlet was chosen by Petro-Canada for its proposed gas processing and liquification plant. Thus Bridport Inlet will be the transshipment terminal for at least the Melville Island gas resources. Rea Point and Skene Bay were examined as potential terminal sites but they appear rather poor alternatives to Bridport Inlet. Rea Point has very deep nearshore but has no shelter from mobile sea ice. Skene Bay also provides very little shelter from ice and there is little bathymetric information for the bay.

<u>South of Parry Channel</u>: The sites examined south of Parry Channel have less potential because of distance from present oil and gas source areas and because of less ideal physical conditions for a marine terminal. These locations could become important as staging areas or transshipment terminals if local demands arise e.g. the building of a pipeline.

On Baffin Island alternatives to Nanisivik were examined, however all but Arctic Bay were discarded because they had poor physical conditions for port development. Arctic Bay is a relatively large settlement and because it offers good shelter and landing beaches, supply ships could continue to unload there.

Aston Bay, Baring Channel and Back Bay on Somerset and Prince of Wales Islands have potential as terminal sites but until a demand arises for terminal facilities in that area, there is little chance of development.

Chapter III

DETAILED STUDIES FROM FIELD OBSERVATIONS

INTRODUCTION

In this chapter coastal and fiord information pertinent to marine terminal planning has been extracted from previous and ongoing work of Geological Survey personnel. Included are detailed studies from Radstock Bay (Devon Island), Makinson Inlet (Ellesmere Island), Lowther Island, Russell Island, northern Somerset Island, Hooker Bay (Bathurst Island), southern Bathurst Island, and eastern Melville and western Byam Martin Islands, and terrain mapping of King Christian and southern Ellef Ringnes Islands.

Data on beach morphology, sediments and beach changes, active layer thickness, sea ice characteristics, nearshore bathymetry and nearshore bottom materials have been assembled where possible. Ancillary matters such as sand and gravel sources, wharf and airstrip sites, water supply and navigation have also been reviewed.

RADSTOCK BAY, DEVON ISLAND

by B.D. Bornhold, P. McLaren and R.B. Taylor

Introduction

Radstock Bay (Fig. 2) has been considered as a possible site for a harbour and airbase for several years (Gajda, 1964; Steltner, 1971) and appears to compare favourably with existing facilities in this part of the Canadian Arctic, such as Resolute Bay, Pond Inlet and Arctic Bay. This report is based on earlier studies of the physiography and suitability of the area as a port site, on bedrock mapping

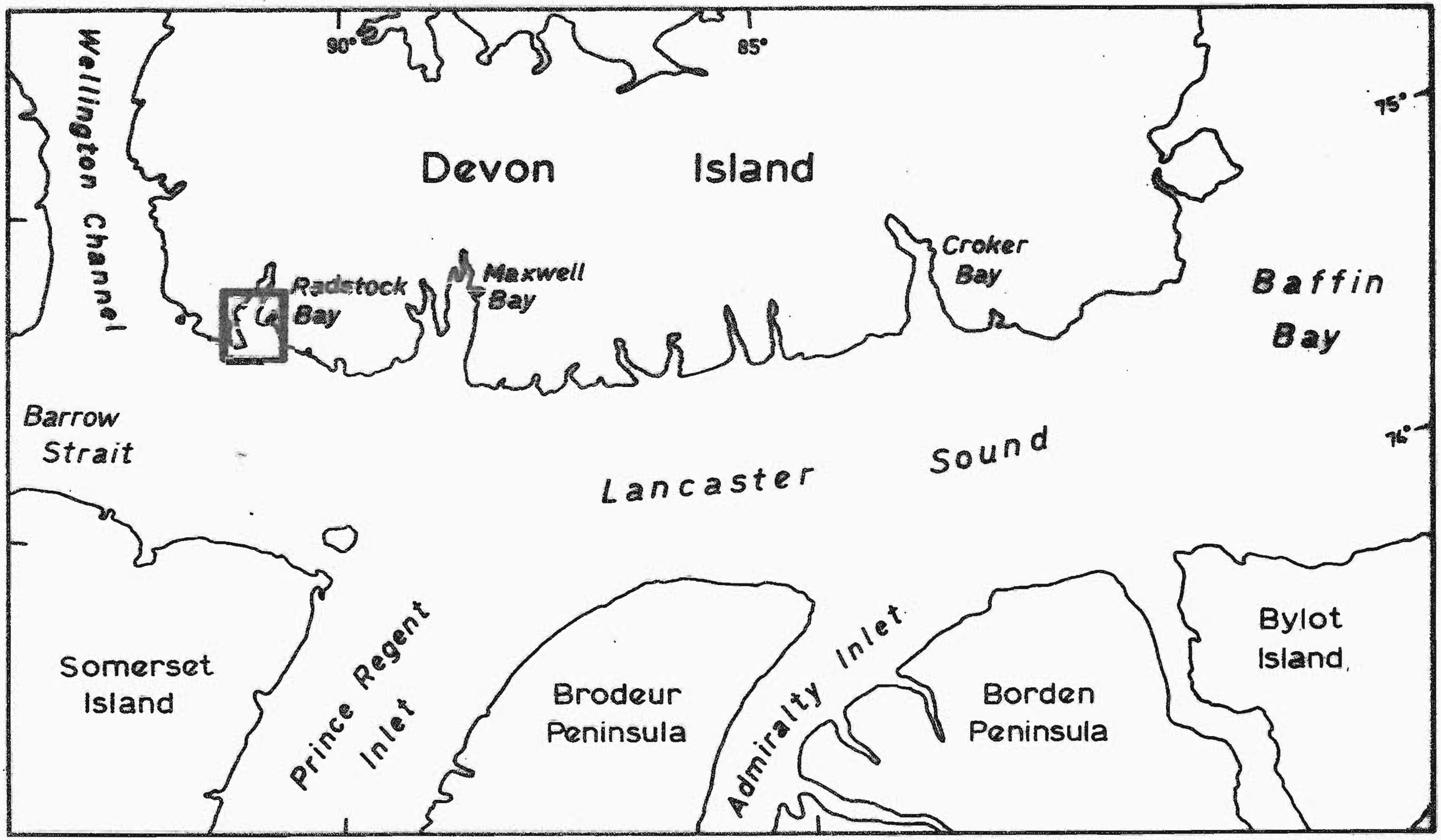


Figure 2. Location map of Radstock Bay, Devon Island, N.W.T.

(Fortier et al., 1963), on studies of shoreline materials and processes carried out by a variety of workers from McMaster University, and on unpublished data collected by the Geological Survey on coastal and offshore geology.

The report will be restricted to southwestern Radstock Bay, the area extending from Cape Liddon north to Scallon Cove (M 7). The bay lying between Caswall Tower and Dealy Point will be informally called 'Caswall Bay' in this report and the plateau northwest of Caswall Bay will be called 'McLaren Bluff'.

Physiography

Southwestern Radstock Bay is characterized by a high, incised plateau area to the north which is bounded by steep cliffs and separated from small plateau remnants to the south by low, flat valleys (Fig. 3, 4). The largest of these valleys, Bear Valley (P1: 15-16; P2: 2)*, is 4 km wide and extends from Caswall Bay to Erebus Bay (12 km) running north of Caswall Tower, Gascoyne Inlet, and the plateau area west of Gascoyne Inlet. The plateau north of Bear Valley and the mesa northwest of Cape Liddon rise to over 300 m. Caswall Tower is somewhat lower at about 210 m above sea level.

The plateaux are composed of nearly flat-lying, fossiliferous limestones of the Read Bay (Silurian) formation. The lowest beds (15 m) are argillaceous limestones with limestone conglomerates and breccias. Above these are 90 m of fossiliferous, thicker bedded limestones which, in turn, are overlain by 90 m of very cherty, thick-bedded limestones.

Bear Valley is relatively flat and lies at an elevation of less than 15 metres, except in a small area immediately west of Muskox Lake where 30-metre

* Refers to photos 15 and 16 on page 1 of vol. III and photo 2 on page 2 of vol. III

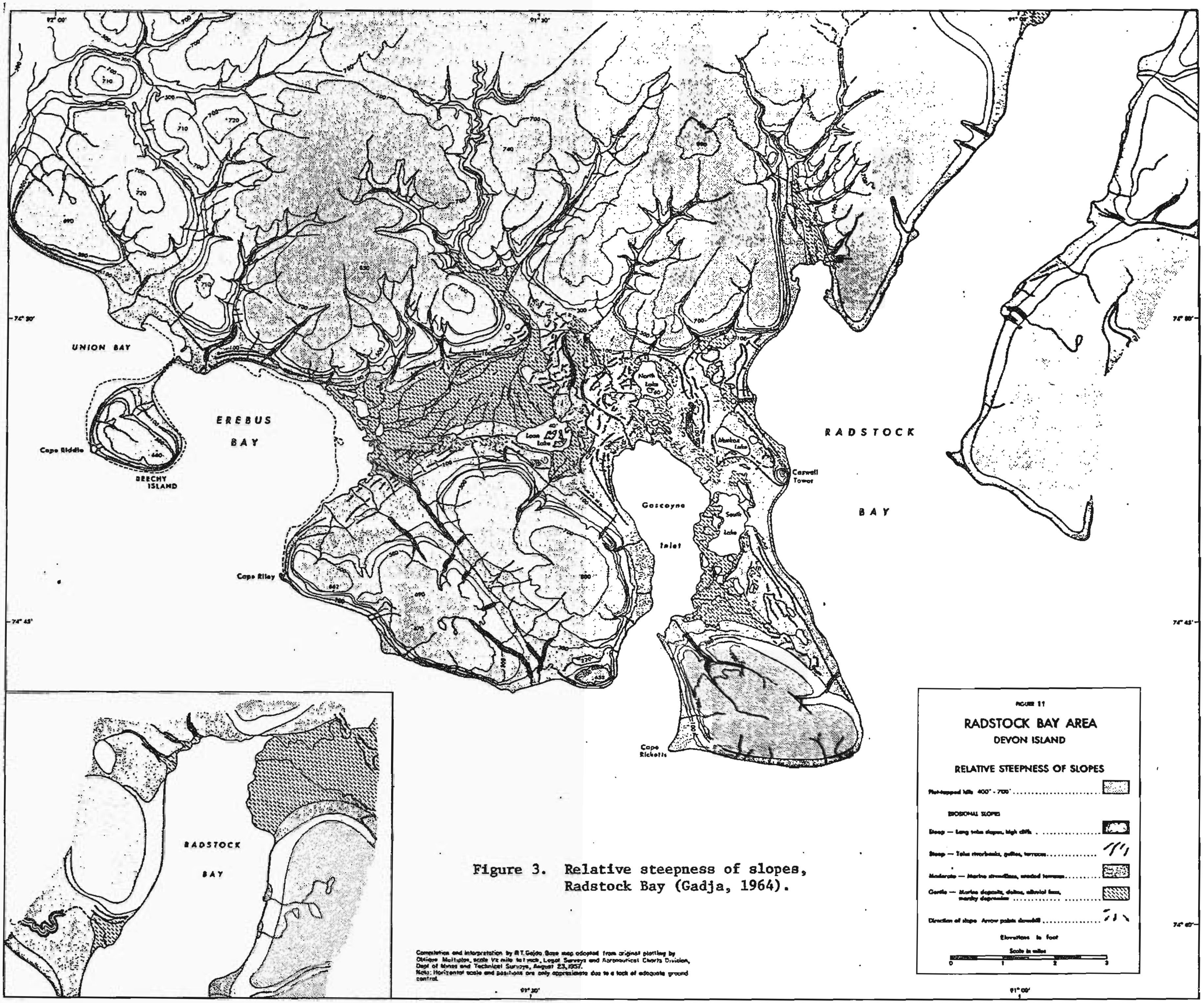


Figure 3. Relative steepness of slopes, Radstock Bay (Gadja, 1964).

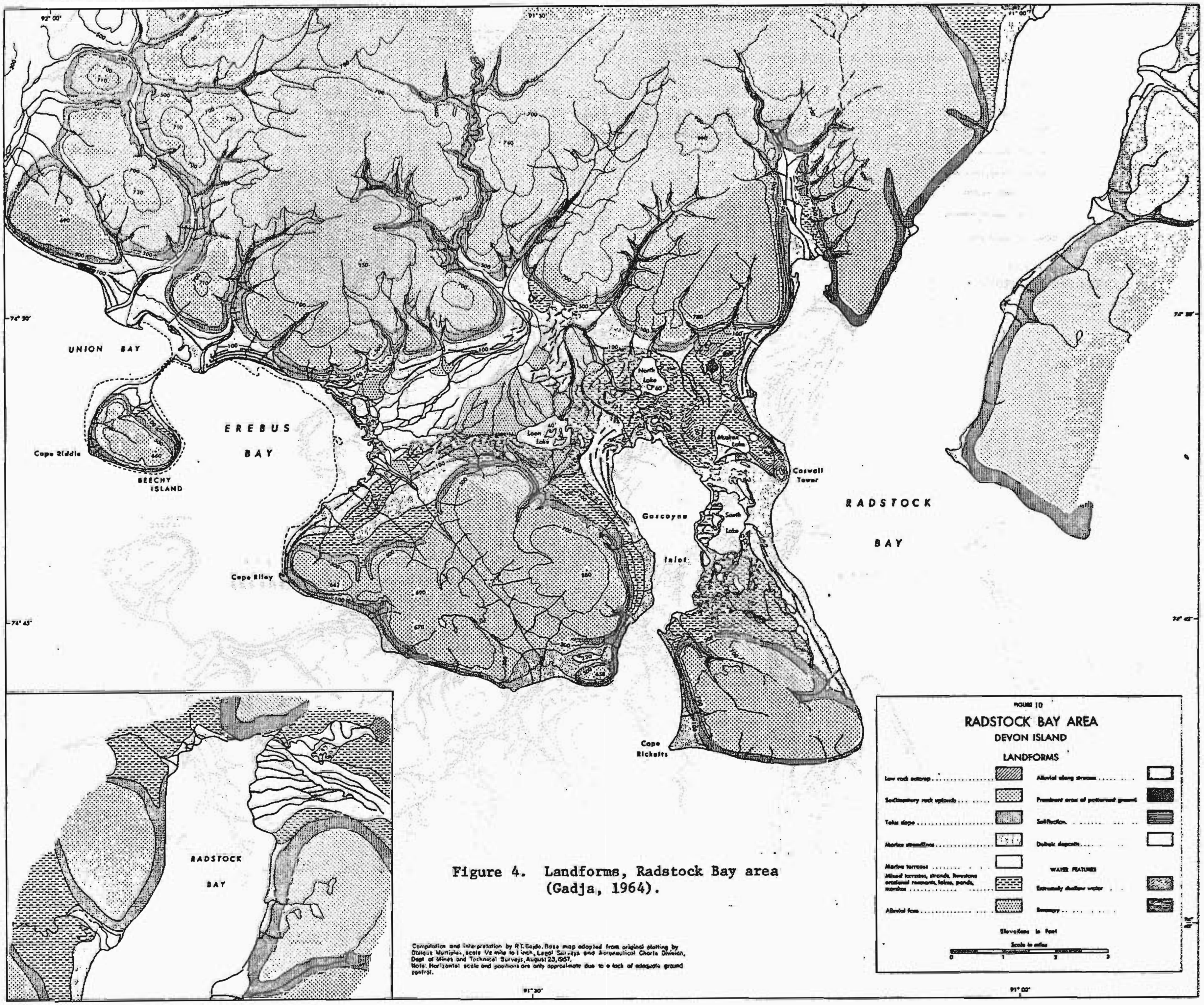


Figure 4. Landforms, Radstock Bay area (Gadja, 1964).

elevations are attained. The valley is filled with deltaic and alluvial fan sediments north and west of Loon Lake (Fig. 4). East of Loon Lake the valley is covered with raised marine beaches, marshes and ponds. Alluvial fans border the plateau on the north side of the valley. A more detailed description of Bear Valley is contained in Gajda's (1964) report. The area south of Bear Valley, between Caswall Tower and the plateau north of Cape Liddon and Cape Ricketts, is covered primarily with marine beach deposits, marshes, and ponds. Alluvial, deltaic and nearshore marine sediments are found in the broad valley north of Scallon Cove.

Three major rivers (longer than 5 km) and numerous smaller ones occur in the area. The largest has three main tributaries originating on the plateau north of Bear Valley and flows across the western half of the valley into Erebus Bay. Another large river flows from the plateau across central Bear Valley into Loon Lake and Gascoyne Inlet. A large river flows southward through a broad valley into northern Scallon Cove.

Four large lakes occur in Bear Valley - Loon Lake, North Lake, Muskox Lake and South Lake. Though no detailed soundings have been made in these lakes, it appears that Muskox and South Lakes are very shallow. North Lake is about 8-10 m deep and Loon Lake is probably 5 to 10 m deep.

Bathymetry

This description of the bathymetry in Radstock Bay is based on the Canadian Hydrographic Service field sheet 3012 compiled in 1960 and on echo-sounding results obtained from the launch FULMAR in August 1976. The track coverage upon which Map M 23 and Figure 6 are based is shown in Figure 5.

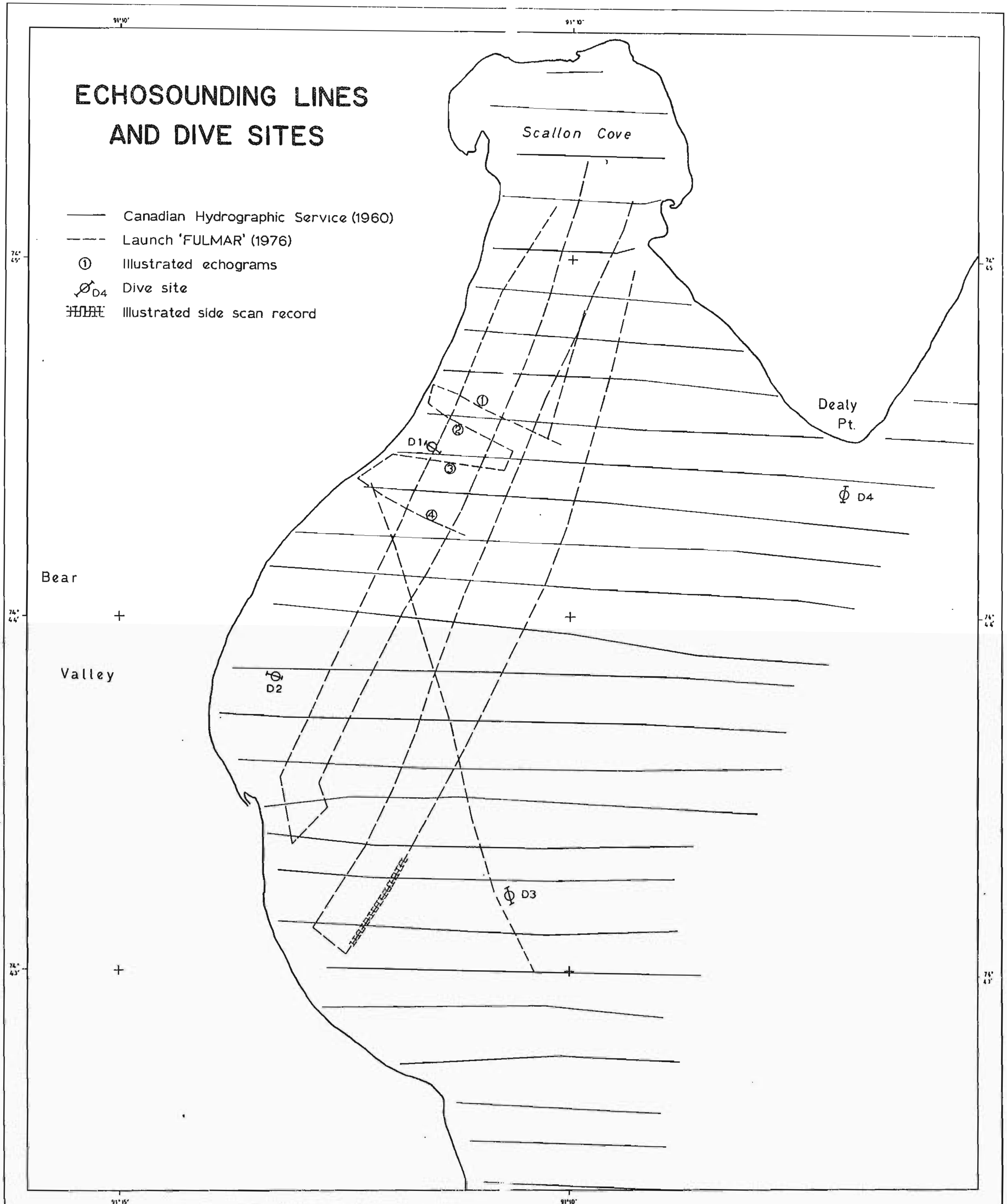


Figure 5. Track chart and dive sites, Caswall Bay.

Beyond 0.5 to 1.0 km from shore, water depths in southern Radstock Bay generally exceed 50 m except in Caswall Bay (Map M 22). A sill extending across the mouth of Radstock Bay from Cape Liddon to Patrol Point lies at about 75 m depth and separates an enclosed basin (130 m) in southern Radstock Bay from the deeper waters of Lancaster Sound.

Moderate to steep nearshore slopes border the western shore of Radstock Bay for about 5 km north from Cape Liddon (P1: 6). The 20-m isobath is located 200-250 m offshore. A broad, shallow nearshore zone is present in a small embayment extending south 3 km from Caswall Tower; water depths of less than 3 m extend over 500 m offshore in the centre of the bay (P1: 8-9).

Caswall Bay is a small isolated basin (55 m) west of southern Radstock Bay (Map M 24). It is bounded on the southeast by Palmer Shoal, a narrow, steep-sided bank rising to within less than 2 m of the surface and joined to Devon Island north of Caswall Tower. Nearshore slopes along the southwest side of the bay are more gentle than those on Palmer Shoal with water depths of less than 20 m extending more than 500 m offshore (P1: 13). Immediately south of McLaren Bluff at the north side of Bear Valley precipitous offshore slopes occur beyond a narrow, nearshore ledge, in apparent continuity with the adjacent cliffs of the limestone plateau (P2: 2-3). Four bathymetric profiles approximately perpendicular to the shoreline are shown in Figure 6; the locations of these echosounding lines are shown in Figure 5.

A sill 12 m deep east of 'McLaren Bluff' separates Scallon Cove (averaging 35 m deep) from Caswall Bay. An unusually deep (>50 m), very small "hole" was discovered in Scallon Cove near the eastern side. Shallow bays and gentle nearshore slopes mark the northern perimeter of Scallon Cove (P2: 6-12).

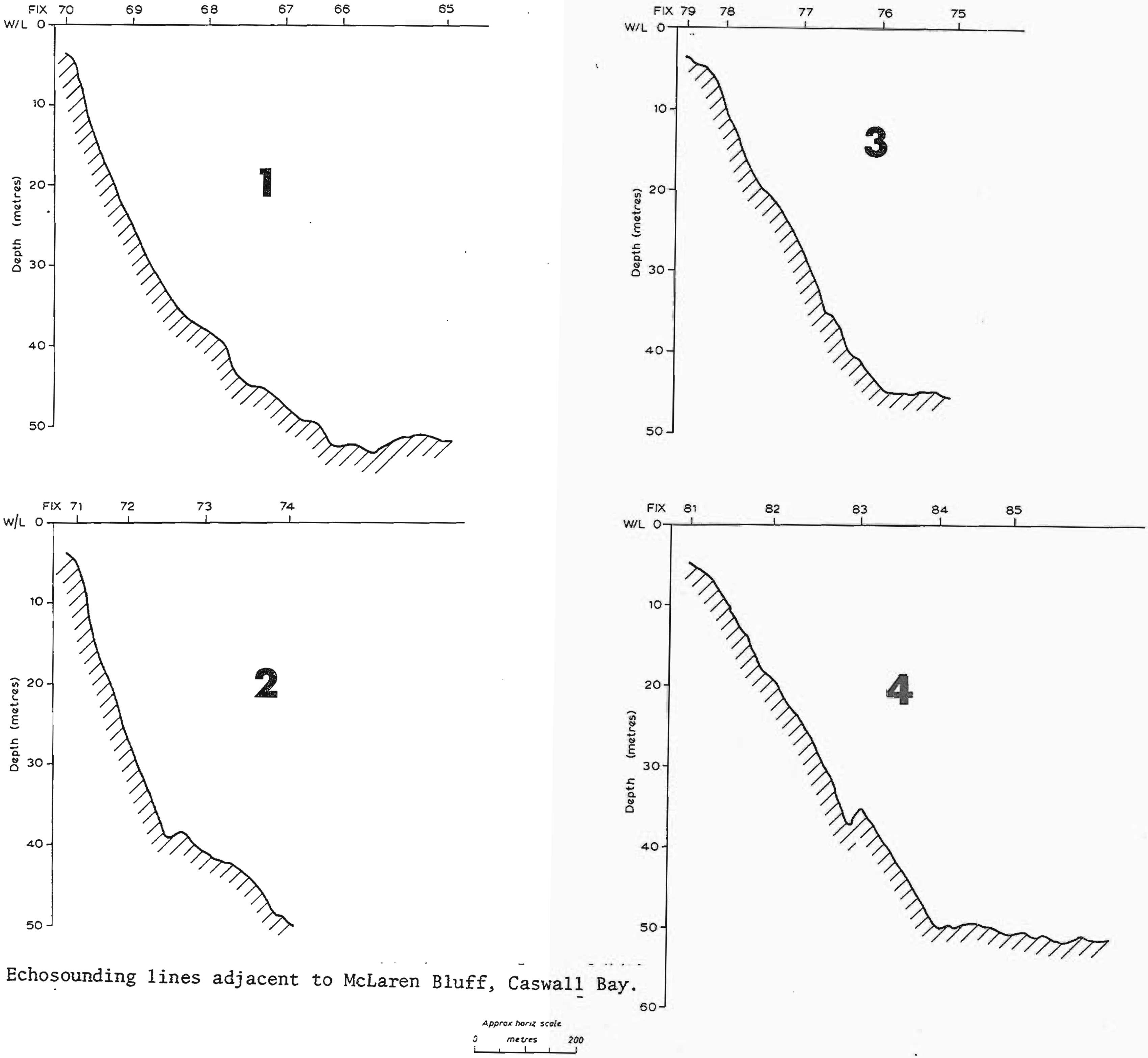


Figure 6. Echosounding lines adjacent to McLaren Bluff, Caswall Bay.

A sill approximately 500 m wide and 24 m deep lies between Dealy Point (P2: 14-16) and Palmer Shoal and separates the deeper waters in Caswall Bay (55 m) from those in Radstock Bay (Map M23).

North of Dealy Point, in Radstock Bay, very steep nearshore slopes are dominant to depths exceeding 80 m within 200 m of the shore (P2: 15).

Oceanography

Tides

The tides in Radstock Bay are mixed semi-diurnal with a spring range of 2.8 m and mean range of 1.74 m. These values were recorded at Patrol Point along the eastern shore of Radstock Bay (Hydrographic Chart No. 7527).

Waves

In Radstock Bay, locally generated, short-period waves of 2 to 3 second period are most commonly found mixed with longer period waves. The latter are generated over a fetch of approximately 26 km from the NE and 150 km from the SE.

Prevailing winds in July and August, as recorded at Resolute Bay, Cornwallis Island are offshore, i.e. from the NW. Between 1973 and 1975, however, SE winds prevailed during August. Thus, longer period waves from the SE were probably more frequent in Radstock Bay during those years.

Sea Ice Conditions

Sea ice breakup in Radstock Bay usually occurs in three stages (Fig. 7): (1) ice breaks away from the entrance to the bay south of a line between Waldegrave Bluff and the north end of Cape Liddon; (2) ice leaves from south of a line between Caswall Tower and Patrol Point; (3) ice leaves from the upper bay (Fig. 7). Freezing generally follows a reverse sequence.

TABLE 2 Length of Open Water Season 1972-1976 in Radstock Bay

YEAR	SEA ICE BREAKUP	SEA ICE FREEZEUP	NO. OF DAYS OF OPEN WATER
1972	None north of (1)*	-	0
1973	(x)July 26 (south of (2)) (N)Aug. 14 (whole bay)	October 3	50 - 69
1974	(x)July 27 (south of (2))	(x)October 15	65 - 80
1975	(x)July 18 (south of (2)) July 29 (north of Caswall) Aug. 17 (ice still at N. end of bay)	Sept. 17 (new ice) Sept. 30 (fast ice)	31 - 61 44 - 74
1976	July 28 (south of (2)) Aug. 15-16 (whole bay)	Sept. 15 (shoreline) Oct. 10 (whole bay)	31 - 74

*See Fig. 7.
(x)P. Latour (pers. comm.)
(N)D. Nettleship (pers. comm.)

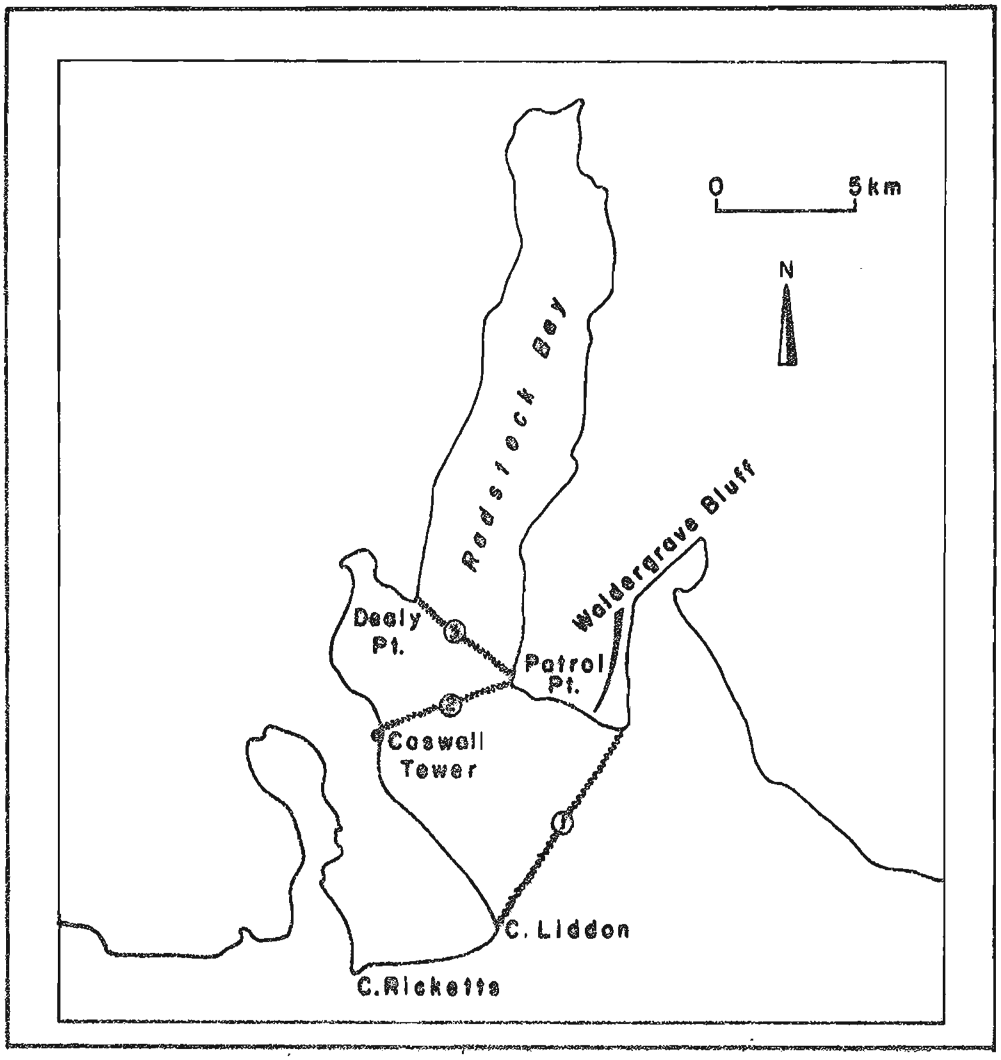


Fig. 7. Stages of sea ice breakup Radstock Bay.

The rate of ice removal from Radstock Bay is dependent upon the prevalence of northerly winds. The time difference between the second and third stages of ice removal was observed to range from three to fourteen days.

The length of open water season for Radstock Bay has been calculated by several authors using various methods of interpreting secondary sea ice information. McCann (1973) noted for the years 1948 to 1963 a mean open water season of 41-64 days and for 1960 to 1971 an average of 56 days. Carlisle (1971) found that open water lasted from 26 to over 50 days but averaged 44. During 1972 to 1976 sea ice conditions have been observed by P. Latour and D. Nettleship of Canadian Wildlife Service (pers. comm., 1976) and by R. Taylor (Table 2). The mean open water season, depending on location within the bay, was 44 to 71 days (excluding 1972). In 1972 sea ice never left Radstock Bay north of the Waldegrave Bluff-Cape Liddon line. In contrast, 80 days of open water occurred in 1974 from July 27 to October 15.

Even after general sea ice breakup, fast ice may line the shores thus protecting the beach sediments from wave action. An icefoot has been observed along the Radstock Bay shoreline every year between 1968 and 1972 but was best developed in 1970. In that year the icefoot had an average width and thickness of 16.2 m and 2.2 m, respectively.

Coastal Environments

Materials and Processes

Littoral processes and beach profile changes were examined along an 8 km length of beach between Cape Liddon and Caswall Tower. A reconnaissance of the shoreline along Caswall Bay showed similar beach characteristics. Observations made on the beach south of Caswall Tower can, therefore, be generally applied to the northern beach.

Sediment sampled along the active beach in 1967, 1970 and 1976, contained very little sand. The mean grain size ranged from -3$\emptyset$ to -5$\emptyset$ (8-32 mm), were moderately to poorly sorted, and were less rounded than similar beach gravels found on temperate climate beaches. A general decrease in clast size was observed from the upper to lower foreshore and from Cape Liddon to Caswall Tower (McCann and Owens, 1969). Similar trends were found in 1976 suggesting littoral transport of sediment northward from the cliffs at Cape Liddon.

Nearshore morphology and sediments were also examined along this shoreline in 1976 (Fig. 8). A rock platform fringes the shoreline, its seaward edge coinciding with the 2.0 to 2.5 m isobath. North of Cape Liddon the width of this platform varies from 60 m at beach profile 1 (Fig. 9a&b) to 300 m offshore of profile 12. Only at profiles 9 and 10 is the platform absent. There, the nearshore slopes steeply to a depth of 16 m. A thin veneer of blocky, angular pebbles and cobbles was generally found over the rock bottom. Nearer Cape Liddon, bedrock outcrops were more common and the cobbles and pebbles sampled were covered by a calcareous red alga which suggested an immobile pebble or cobble pavement. At the seaward edge of the platform a small gravel bar was detected on the echograms.

In contrast a large accumulation of pebbles and coarse sand was sampled offshore from profiles 13 to 15. Onshore this area is characterized by well-developed flights of raised beaches. The wide, shallow nearshore platform that extends off profile 12 (Fig. 9b) may act as a natural groin and aid in the trapping of sediment in the Caswall Tower area. The only other location with significant sediment accumulation is off profiles 7 and 8.

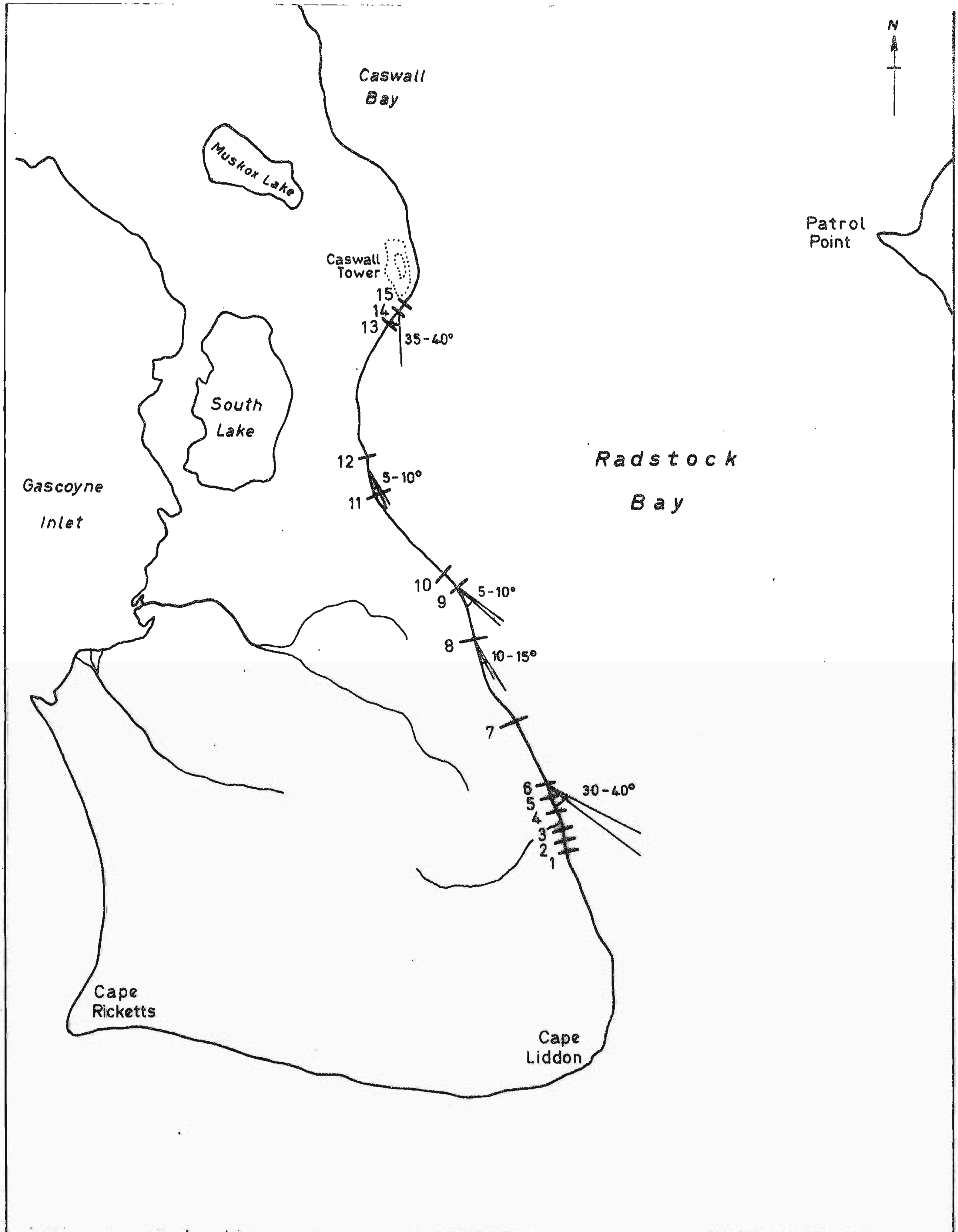


Figure 8. Beach profile locations Cape Liddon to Caswall Tower, Radstock Bay.

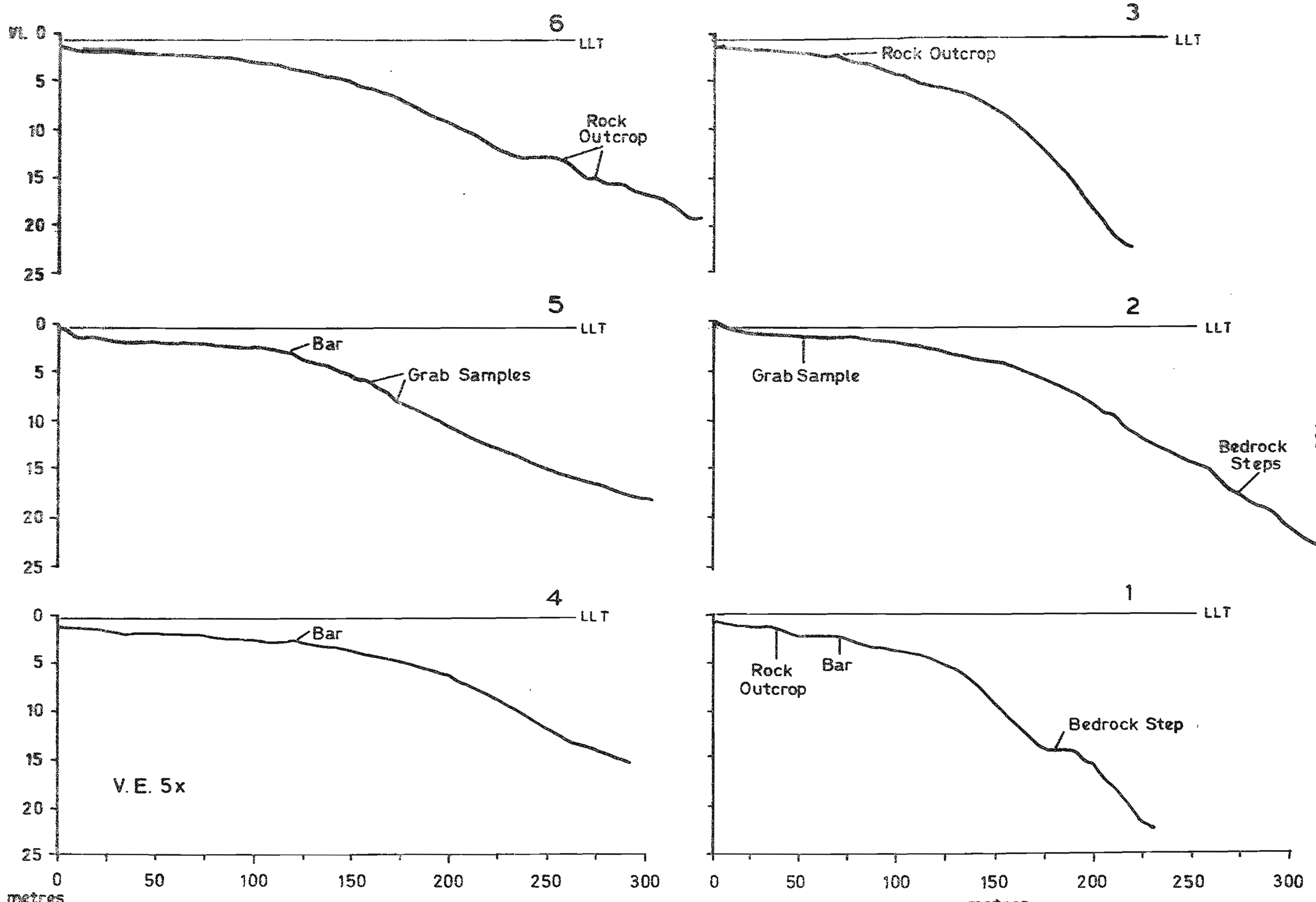


Figure 9a. Nearshore profiles of established beach profiles, Cape Liddon to Caswall Tower, Radstock Bay.

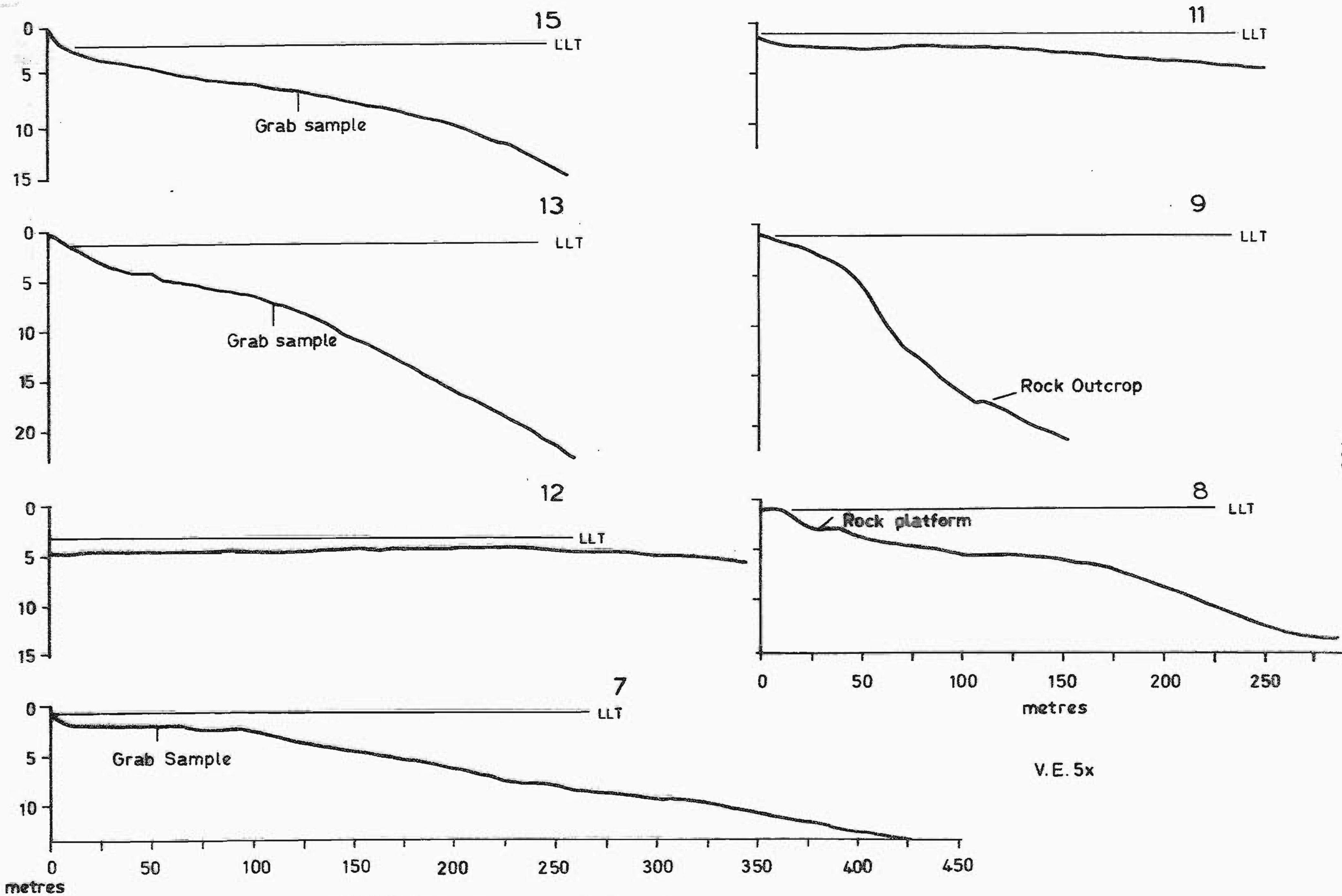


Figure 9b. Nearshore profiles of established beach profiles, Cape Liddon to Caswall Tower, Radstock Bay.

Aerial photographs and hydrographic charts also show a nearshore platform along Caswall Bay and a shoal 1 to 1.5 km offshore. Beach morphology and the northward extension of Palmer shoal suggest northwest transport of sediment under the influence of dominant SE waves. Underwater observations by P. McLaren in Caswall Bay provide a more detailed picture of the nearshore in the area.

Beach Stability

In order to assess rates of beach erosion or accretion, especially under different wave conditions, a series of fifteen profiles was established in 1970 (Carlisle, 1971) along the shore between Cape Liddon and Caswall Tower. These profiles were frequently resurveyed between 1970 and 1972, usually after storms. With the resurveying of the profiles in 1976, longer term changes can now be calculated. Rates of change were calculated using a planimeter to measure the area between two successive survey lines. This change was then converted to a volumetric measure by assuming a one-metre strip of beach normal to the shoreline along each profile.

Although arctic beaches are considered low energy environments, considerable change can occur when the beaches are subjected to storm waves. In Radstock Bay storm waves from the two dominant fetch directions, the SE and NE, have been observed as have their effects on the beach.

The largest recorded storm occurred in August 1969 when SE winds of 36-80 km/hr blew over a fetch of 130 to 150 km. Initially, waves of approximately 1 m height at breaker point and 3.4 second period transported sediment upslope forming a tidal ridge of 0.6 m height. At the peak of the storm McCann (1973) reported waves of 6-7 second period and breaker heights of 1.0-1.3 m. At that time the beach slope at profiles 1 to 6 was combed down lowering the profile, above MHTM, by 0.3 to 0.5 m. Net sediment transport, based on movement by marked pebbles, was to the north.

On August 22-23 and 25-26, 1976 winds of 33-74 km/hr blew from the N-NE generating waves of 2.5 to 4.5 second period with a maximum breaker height of 0.9 m. Beach sediments were transported upslope where a high tide ridge of 0.2 to 0.3 m height was built on each of the four days. Although sequential surveys of the beach profiles were not completed after the storm, thus precluding numerial assessment of change, some observations can be made. Wave fronts, observed August 26, 1976, show that waves from the NE refract around the nearshore platform extending from Caswall Tower; thus less direct wave energy is expended on the beach at profiles 13 to 15. In contrast, at profiles 9 and 10 (Fig. 8 and 10), because of their exposed location and the deeper nearshore, waves break directly on the beach causing erosion at this location.

From the above observations it appears that constructive waves are those with less than a 5 second period and a 1.0 m breaker height. Waves of greater magnitude have a destructive effect on the beach.

Net beach profile change over the period 1970 to 1976 was less than 12.5 m^3 at any one location (Table 3). Shoreline accretion occurred south of Caswall Tower between profiles 15 and 11 and to a lesser extent at profiles 7 and 8 (Fig. 10 and 11). Over the long term, the beach is experiencing erosion at the south end adjacent to Cape Liddon and accretion nearer Caswall Tower. Beach sediment characteristics also reflect the net northward transport. Over short time intervals (e.g. after one storm), accretion or erosion could occur anywhere along the shoreline depending on wave and sea ice conditions (Taylor, 1972).

During storms, waves transport sediment back and forth along this beach; over the long term, however, slightly more is carried northward. A radiocarbon

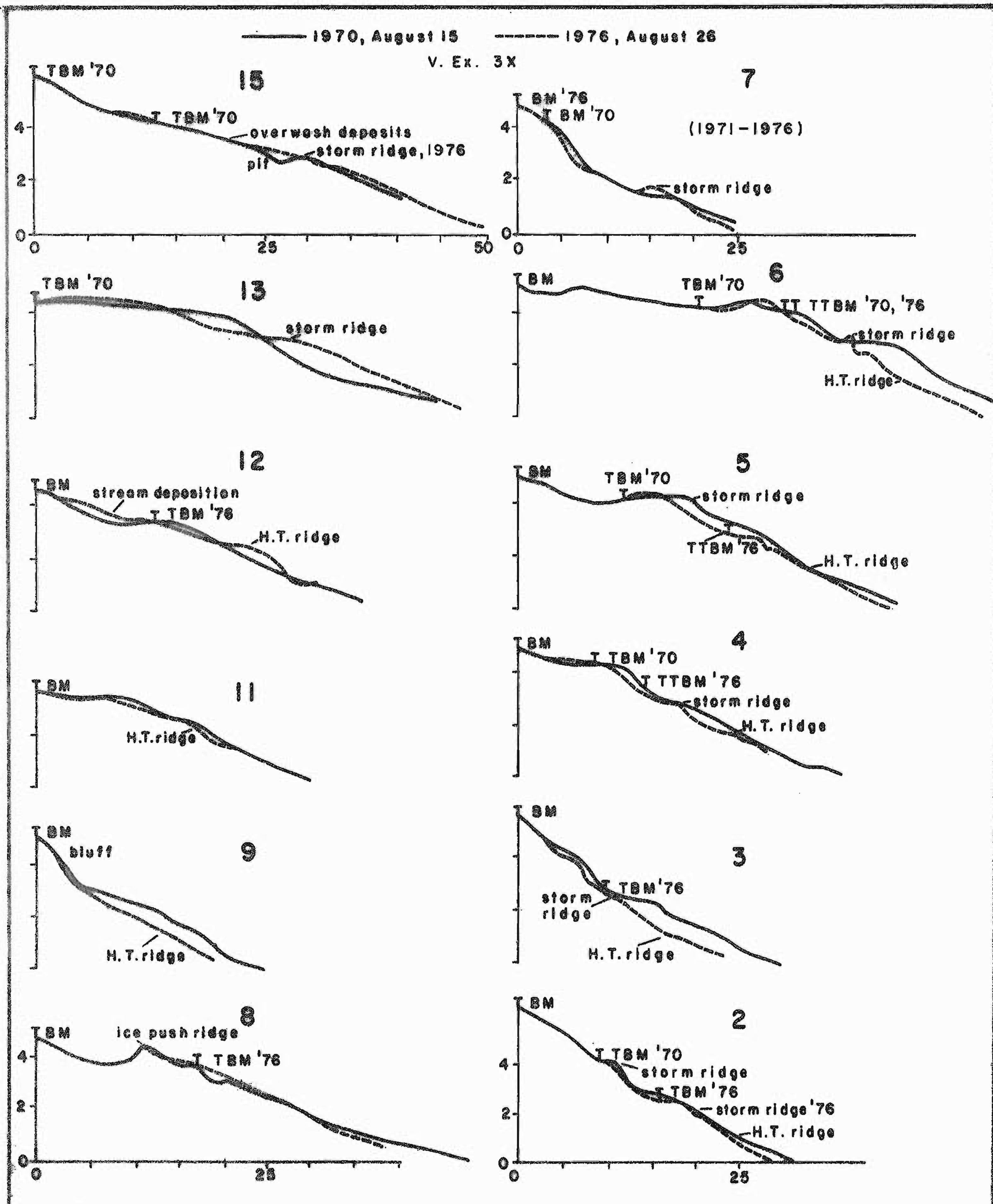


Figure 10. Beach profile change 1970-1976, Radstock Bay.

TABLE 3 Net Beach Profile Change 1970-1976
Radstock Bay, N.W.T.

PROFILE	NET CHANGE (m^3)	PROFILE	NET CHANGE (m^3)
1*	-	9	-7.83
2	-3.71	10*	-
3	-9.24	11	-3.42
4	-3.77	12	+4.15
5	-6.39	13	+9.96
6	12.17	14*	-
7	+1.33	15	+1.67
8	+1.48		

*Profiles not surveyed in 1976.

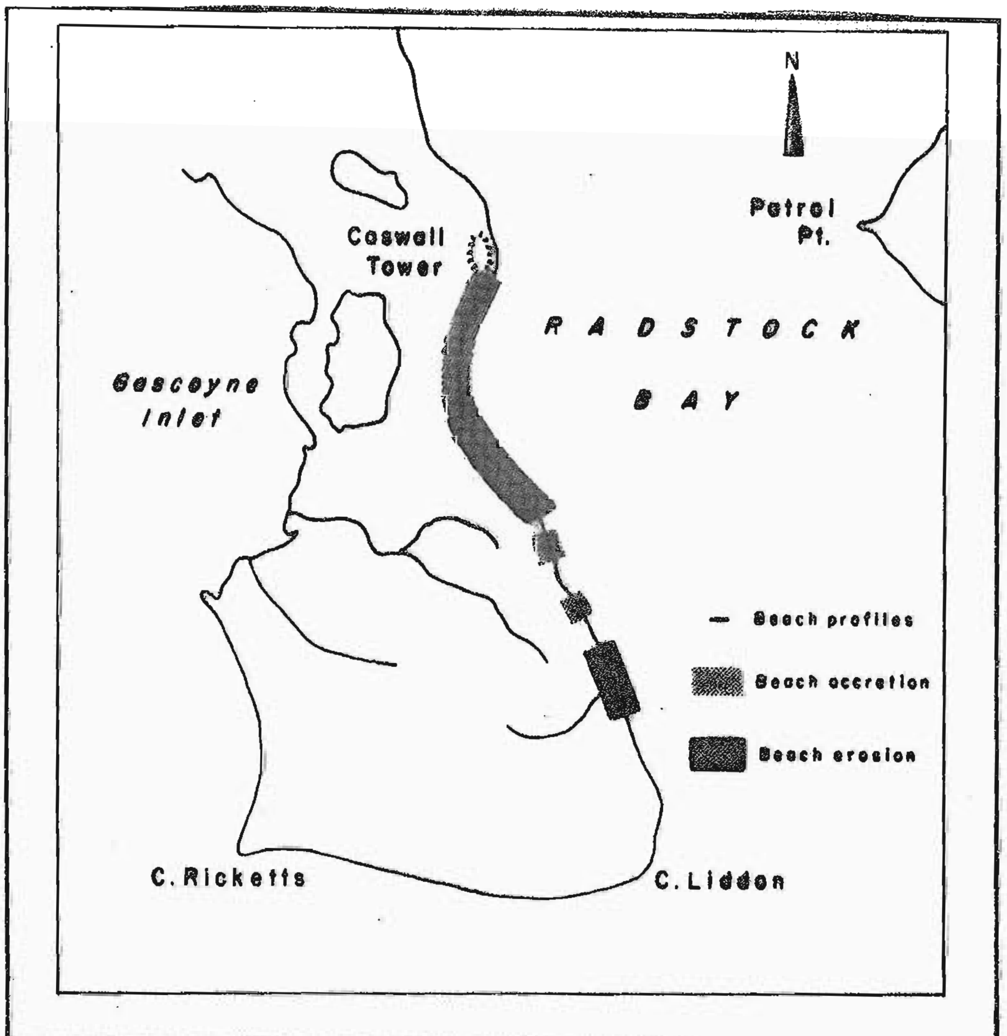


Fig. 11. Zones of beach accretion and erosion, Cape Liddon to Caswall Tower, Radstock Bay.

date (GSC 1402) of a piece of wood found in a raised beach at 12.2 m above sea level adjacent to Caswall Tower suggests continuous beach development during the past 4000 years.

Smaller changes probably occur along the beaches of Caswall Bay because of the shelter provided by Dealy Point and Palmer Shoal to NE and SE waves, respectively.

Ice Action

During a storm from the SE in August 1969, masses of sea ice were pushed and piled to heights of 16 m up the talus slope of Cape Liddon (McCann and Owens, 1970). Ice push scars and ridges are common along the beach but the only area containing large concentrations of ice push ridges is Cape Ricketts. McCann and Owens (1970) surveyed a series of ice-cored gravel mounds up to 7.0 m above sea level at Cape Ricketts and observed sea ice rafted as far as 40 m inland. Ice push ridges usually observed along the shores of Radstock Bay rarely exceed heights of 1.0 m. Similarly, beach pits caused by the melting of buried ice seldom exceed a diameter and depth of 1.0 m.

Active Layer Thickness

On the gravel raised beaches the thickness of the active layer varied from a few centimetres in June immediately after snow melt, to over 50 cm by mid-August. Thicknesses recorded across the present beach showed that the frost table continued to deepen in September as air temperatures fell below freezing, but in the backshore the frost table rose rapidly to the surface. A maximum active layer of 1.2 m was observed at low tide level in late September, 1971. Generally, the thickness of the active layer remains less than one metre along the coastal areas of

Radstock Bay. Ground temperatures collected on slopes farther inland suggested shallowest active layers on east and north facing slopes. In early afternoon, temperature differences between north and south facing slopes sometimes reach 11°C.

Nearshore Diving Observations

Dive Site One

D_1 - Proposed port location (Fig. 5).

Water depth: 12 to 20 metres.

Slopes: Above 12 m water depth, bottom slopes steeply seaward at approximately 30°. Below 12 m, slope becomes less at approximately 10° to 15°.

Substrate: Above the break in slope at 12 m water depth, up to 85% of the bottom is covered with subrounded to angular gravel, cobbles and boulders (P25:5). The matrix consists of sand and silt. Below 12 m, gravel decreases (P25:2, 3) and the fine sand covering increases. Occasional boulders are, however, still present (P25:5).

A core taken by divers at 18 m penetrated only 45 cm. A radiograph of the unopened core shows a gravelly mud, the largest pebble being 5 cm in diameter. Unbroken shells are also present.

Bottom Features: No ice scour tracks observed. On the steep slope above the 12 m water depth some areas of minor slumping or avalanching are present. Slump scars were typically less than 4 m wide and approximately 5 cm deep.

Remarks: Construction of a wharf facility in this area will have to take into account (i) the stability of the steep slopes and (ii) the thickness of the gravelly mud overlying bedrock. If thick enough, the gravelly mud may be an ideal substrate for secure pilings. The minor avalanching observed on the steep slopes should be investigated but it is doubtful that slope instability will preclude wharf construction at this site. Side scan sonographs (Fig. 12) from farther south show features that may be attributed to small-scale avalanching.

Dive Site Two

D_2 - Caswall Bay (Fig. 5).

Water depth: 11 metres

Slopes: The bottom is gently undulating, sloping seawards at approximately 3°.

Substrate: Approximately 80% of the surface of the substrate is covered by a boulder, cobble and gravel pavement overlying a sandy mud (P25:7-11).

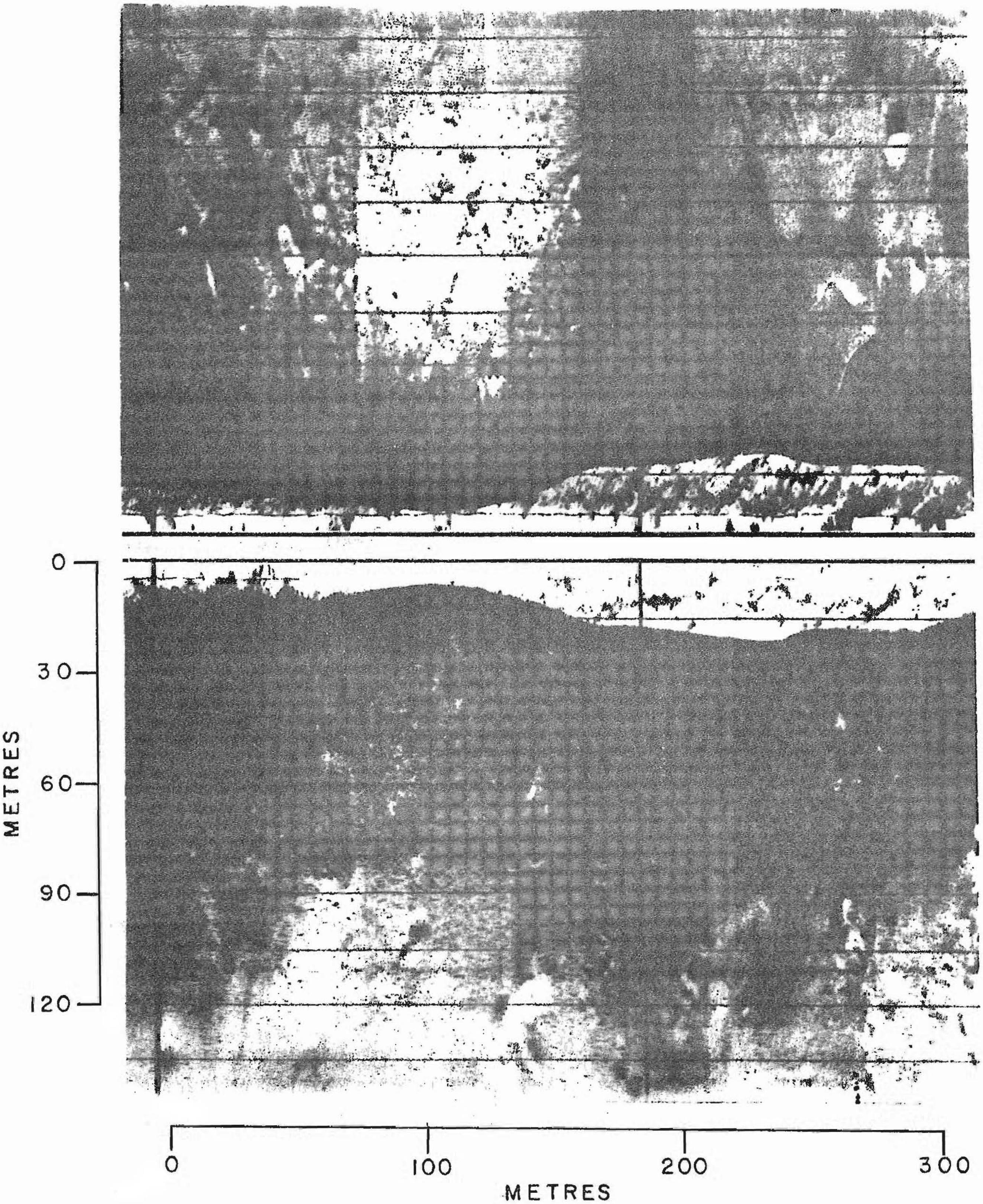


Figure 12. Side scan sonograph of bottom features in Caswall Bay (see Fig. 5).

A core collected in an area where the pavement was lacking, penetrated 65 cm. A radiograph shows a gravelly mud containing clasts up to 4.5 cm in diameter.

Bottom Features: Very minor and indefinite ice scour tracks are present. The bottom is essentially undisturbed.

Dive Site Three

D_3 - On seaward side of Palmer Shoal (Fig. 5).

Water depth: 9 to 15 m.

Slopes: Generally, the bottom slopes seawards at approximately 5°. In areas of ice scouring, oversteepened banks were observed to be greater than 30°.

Substrate: The surface is essentially identical to D_1 and D_2 (P25:13-16; P26:1, 2). Radiographs of 3 cores, however, show the gravelly mud to be from 25 to 55 cm thick overlying a sediment containing considerably less gravel.

Bottom Features: The bottom showed considerable modification and disturbance by ice scouring. Several large ice scour tracks were over 3 m deep, 15 m wide and 35 m long.

Remarks: The evidence of ice scour features indicates that Palmer Shoal acts as an important barrier inhibiting large ice blocks from entering Caswall Bay. It is suggested that a marine installation in Caswall Bay (Fig. 5) will be largely protected from significant ice effects.

Dive Site Four

D_4 - Dealy Point (Fig. 5).

Water depth: 20 metres

Slopes: The steep sides of Dealy Point (Fig. 5) continue to slope steeply seaward at greater than 10°. In ice scour areas, oversteepened banks were observed to be greater than 30°.

Substrate: The bottom is covered with a veneer of gravel, cobbles and boulders (P26:4-11).

Bottom Features: Similar to D_3 (Fig. 5) the bottom showed evidence of major ice scouring (P26:9-11). Ice scour tracks were up to 3 m deep, 15 m wide and 40 m long.

Remarks: The spectacular evidence of ice scour features re-emphasizes the protected environment of Caswall Bay where virtually no ice scour features were observed.

Suitability for Marine Terminal

Construction Materials

The lower, less cherty, massive limestones of the Read Bay formation are an abundant and excellent source of quarry stone for rip rap or other construction needs. They are exposed in cliffs to the north and south of Bear Valley within a short distance of any planned marine terminal facility in Caswall Bay or southwestern Radstock Bay.

Sand and gravel are in abundant supply for roads, airstrips, or other uses in the raised marine beaches or alluvial fans found over much of Bear Valley. The site proposed by Gajda (1964) for an airstrip lies northwest of Loon Lake (Fig. 13) and is a flat area covered with coarse, angular limestone gravel ranging from 2 to 15 cm in size. Roads throughout the valley could be readily routed to take advantage of close aggregate supply and the good foundation conditions that raised beach and alluvial fan materials provide.

Navigation

Cape Liddon, Caswall Tower and Dealy Point (P1 and P2) are all conspicuous landmarks and permit safe entry into Radstock Bay in almost all weather conditions (Pilot of Arctic Canada, Vol. II, 1968).

Waters in southern Radstock Bay are deep enough (>70 m) to permit vessels to pass directly from Lancaster Sound northwestward to the entrance to Caswall Bay on a course of 335°.

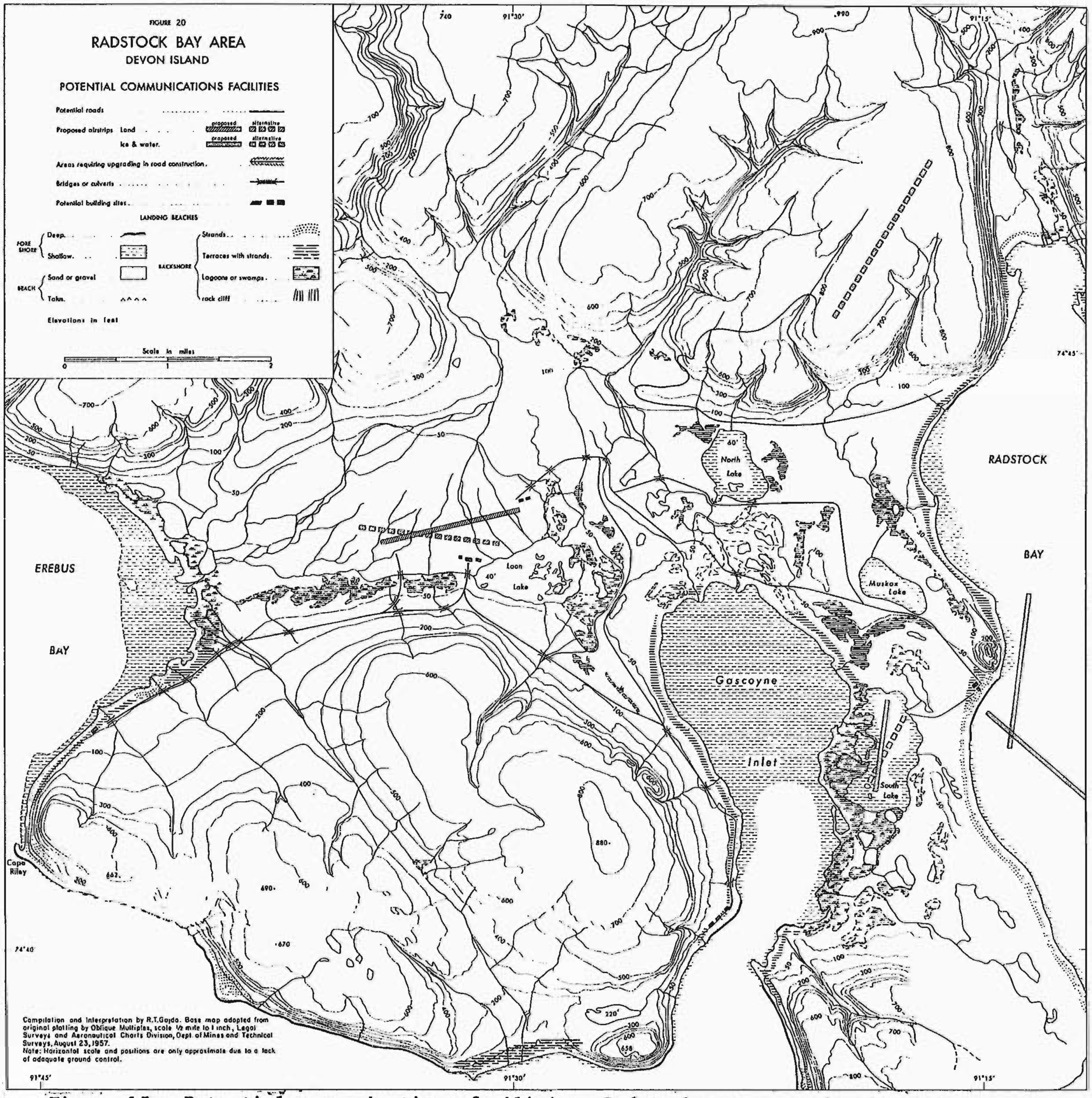


Figure 13. Potential communications facilities, Radstock Bay area. (Gajda, 1964).

Water depths in Caswall Bay exceed 23 m except on Palmer Shoal or in very nearshore areas. The entrance between Dealy Point and Palmer Shoal (between 20 m isobaths) is 1660 m wide, at a depth of 24 m, permitting conventional tankers up to 200,000 DWT class to enter the bay (Fig. 14). The distance from the entrance of Caswall Bay to the western side below McLaren Bluff is 1700 m.

Wharf Site

From the standpoints of bathymetry, proximity to onshore facilities and building materials, ship manoeuvring, and protection from ice and seas, the most suitable sites for a wharf appear to be in northwestern Caswall Bay, southeast or east of McLaren Bluff (Fig. 14). Here a shallow nearshore zone (<2 m) is bounded by very steep slopes to depths of over 50 m. The 20 m isobath lies within 200 m of the shore southeast of McLaren Bluff and a shoal area (<2 m) extends 700 m eastward from the bluff. Wharves over 500 m in length could be constructed at either of the two localities shown in Figure 14. Both would be easily accessible to onshore facilities in Bear Valley by road.

Palmer Shoal offers protection for much of the northern part of Caswall Bay by intercepting swells and ice coming from Lancaster Sound to the southeast. The two possible wharf sites are protected from the dominant northwesterly winds by McLaren Bluff.

Ships entering Caswall Bay from Radstock Bay would have to turn through 85°-110° in order to berth at the wharf sites indicated in Figure 14. The distance from the 20-m isobath on the west side of Palmer Shoal to the more southerly of

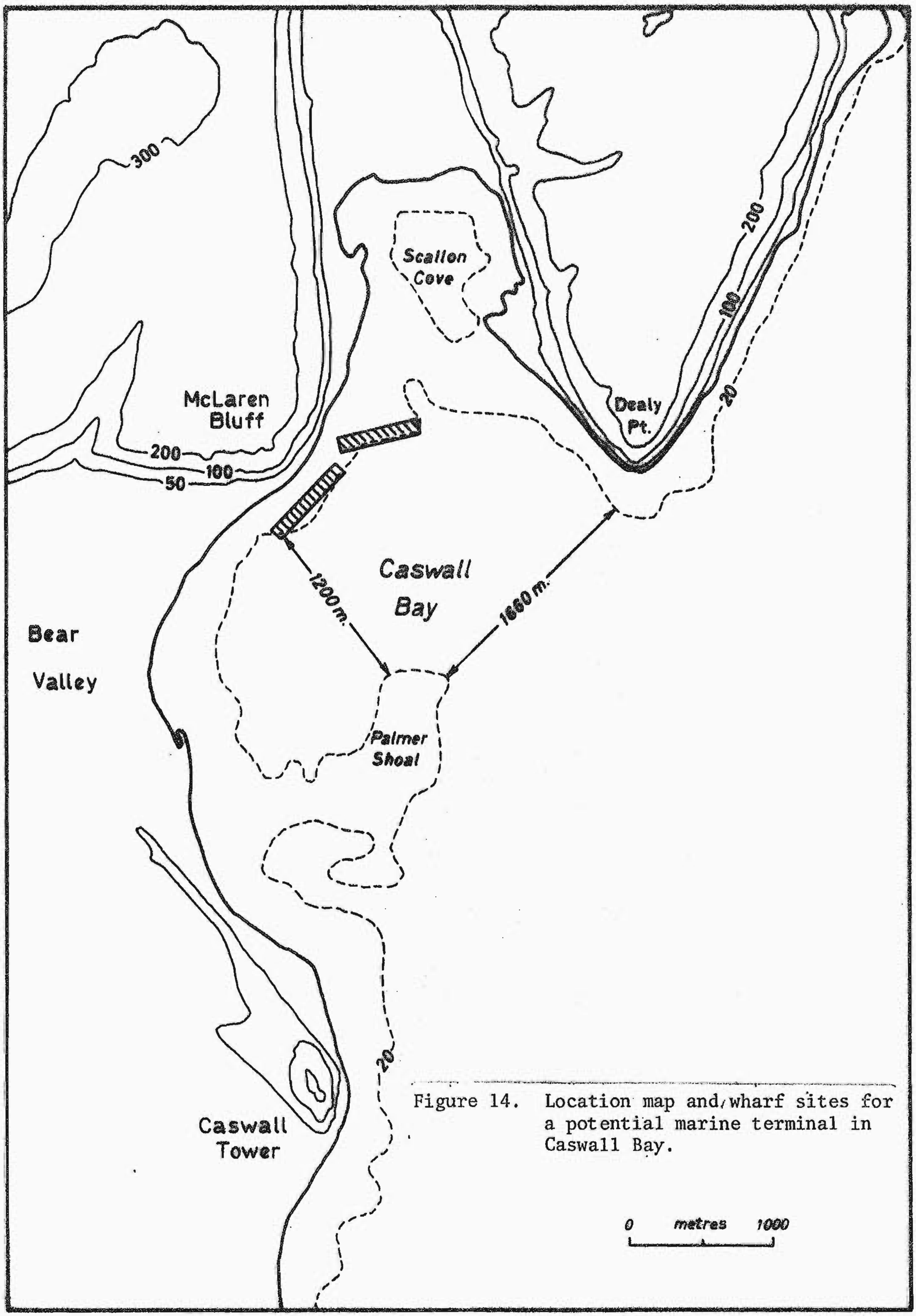


Figure 14. Location map and wharf sites for a potential marine terminal in Caswall Bay.

the two proposed wharf sites is 1200 m. Ships having to wait before entering Caswall Bay could proceed up Radstock Bay past Dealy Point where excellent protection from winds and ice is available.

Airstrip

The best location for an airstrip is in Bear Valley on the alluvial fan northwest of Loon Lake (Fig. 13). An area 4 km long (E-W) and nearly 3 km wide (N-S) of flat terrain is available with an abundant local supply of gravel from which to construct and maintain an airstrip. The principal disadvantage of this location is that it is more than 7 km from any harbour facilities on Caswall Bay.

Approaches to an airstrip northwest of Loon Lake are very good to both the east and west providing a glide path of more than 25 km from either direction.

An alternate site would be on the plateau north of Bear Valley at an altitude of about 250 m. This location would have the advantage of being above low-lying cloud or fog prevalent in the area, but the disadvantage of requiring an access road up to the plateau.

Water Supply

Although more detailed surveys of the lakes in the area will be required, it appears the North Lake (Fig. 13) provides the best potential source of fresh water. The lake is 8 m deep, does not freeze to the bottom during winter (Gajda, 1964) and probably contains at least 5000 m^3 of fresh water.

The other lakes in the area appear to be shallow but may be possible supplementary sources of fresh water.

MAKINSON INLET, ELLESMERE ISLAND

by R.B. Taylor

Introduction

If a new marine terminal were to be developed along the south or east coast of Ellesmere Island, then Makinson Inlet, opening eastwards onto the 'North Water' and thence to Baffin Bay, is one of the coastal areas which could be considered. The following is an evaluation of possible terminal sites within Makinson Inlet and a summary of known secondary information about coastal, marine and sea ice conditions. Field data was obtained in 1972 during a three week reconnaissance of Swinnerton Peninsula (Fig. 15). Most of this information is contained in a larger report written for Department of Environment on the hydrological aspects of the Vendom Fiord-Makinson Inlet area (McCann et al., 1972).

Physiography

The general coastal morphology of Makinson Inlet (Fig. 16) is such that no suitable marine terminal sites could be identified east of Swinnerton Peninsula. The entrance and main east-west section of the inlet are bordered by high, steep, talus-banked mountains, frequently separated by glacier tongues, many of which extend into the sea (P3: 2, 3). The inlet divides 56 km from the entrance, at Swinnerton Peninsula, into a southwestern arm, 27 km long, and a northwestern arm, 42 km long. The southwest arm is bordered primarily by dissected plateau country, fringed by raised beach terraces and large deltas (P3: 4, 5), but the coast of the northwest arm, particularly on the eastern shore, remains steep, though there are numerous large stream deltas.

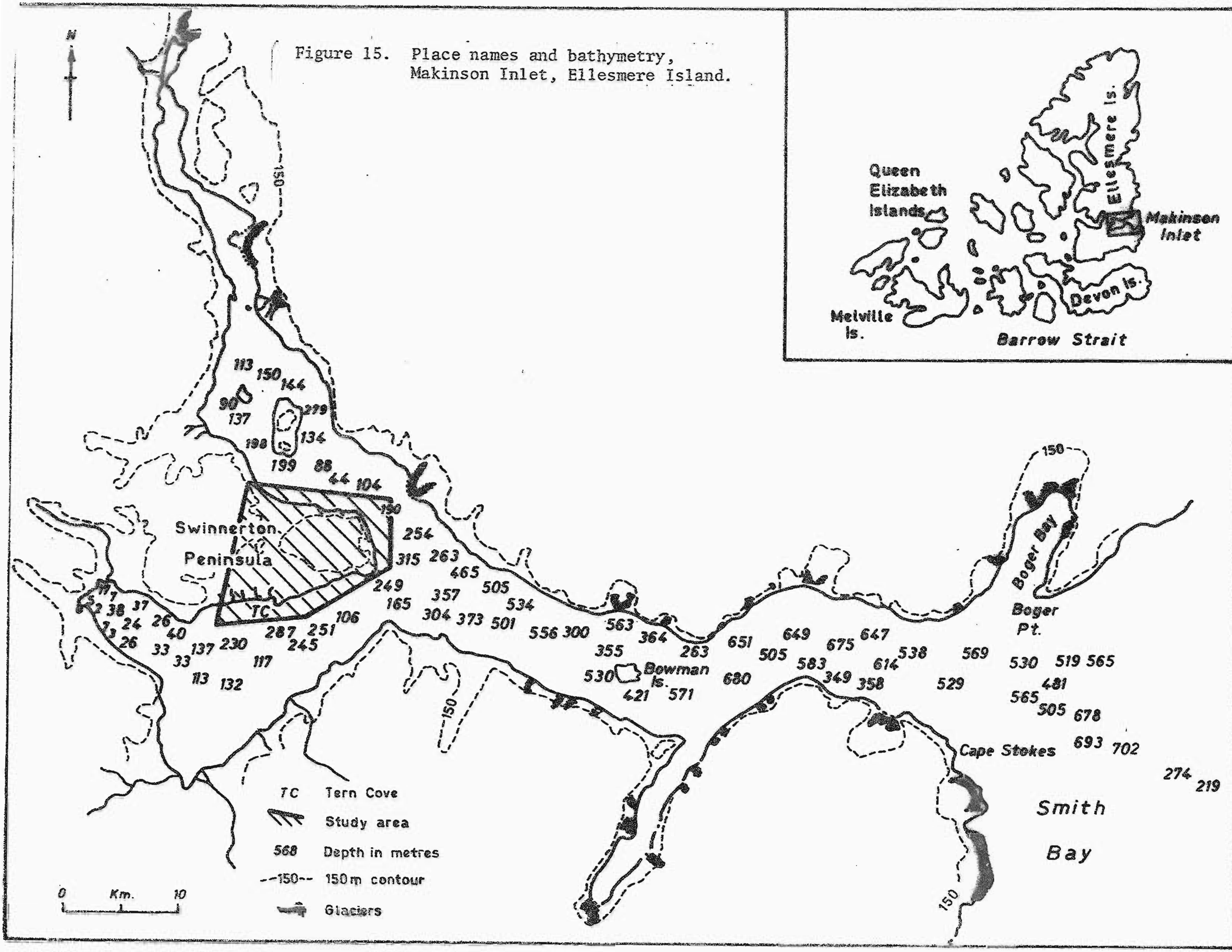


Figure 15. Place names and bathymetry, Makinson Inlet, Ellesmere Island.

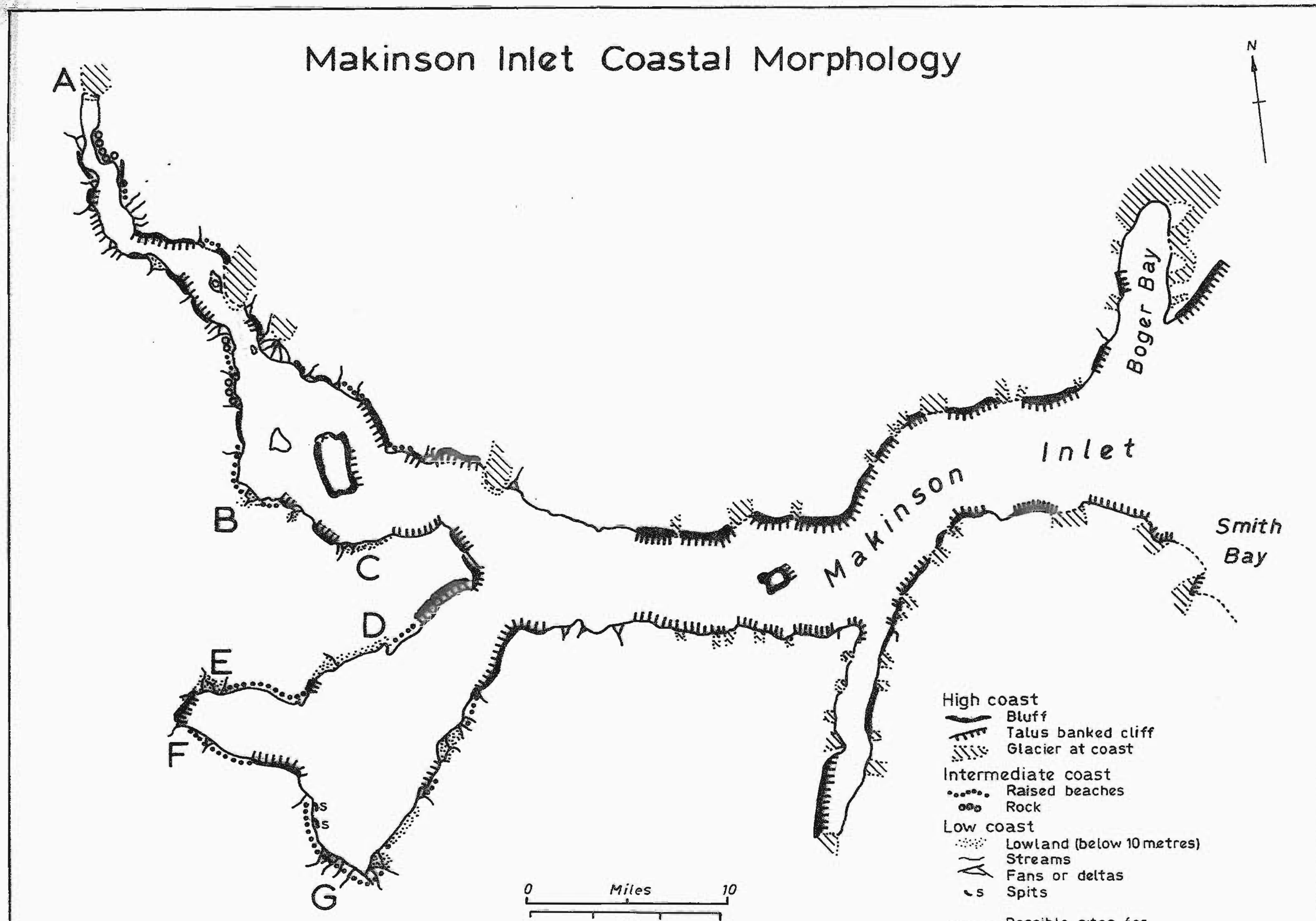


Figure 16. Coastal morphology, Makinson Inlet.

Considering the general conditions of coastal morphology, seven possible marine terminal sites may be suggested (Fig. 16, A-G) along the two inner arms of Makinson Inlet. However, consideration of particular conditions at each of the seven localities effectively reduces the number of sites to two. Site A may be disregarded because of the proximity of the glacier and the narrow, shallow head of the inlet; site B does not provide a sufficient area of level terrain; sites E and F provide level ground and easy access to the west and the Vendom Fiord coastline, but are at the head of a shallow bay, though site E is otherwise acceptable; site G provides level terrain but the large rivers have discharged considerable sediment into the bay, creating a very shallow nearshore zone. Sites C and D are the best of the original seven sites, site D being the better of the two in view of the greater area of level ground at this location.

Bathymetry

The most recent bathymetry of Makinson Inlet is from Canadian Hydrographic chart 7302 (1974). The main entrance channel to the inlet is deep throughout its entire length. Depths of over 500 m are recorded at the entrance (Fig. 15), and off the tip of Swinnerton Peninsula 230 m depths are shown. Shallower depths are encountered in both arms of the inlet which shoal to less than 30 m at their heads. In terms of bathymetry it appears that Swinnerton Peninsula could easily be reached by large tankers but difficulties could arise if a terminal site were selected more than 15 km into either arm.

Oceanography

Tides

Tidal observations within the Arctic Archipelago are very limited and it is doubtful that any measurements have been made in Makinson Inlet. Accordingly, a

TABLE 4
Tidal Characteristics
Comparisons of Makinson Inlet with Resolute and Pim Island

Location	HIGHER MEAN TIDE	HIGH WATER LARGE TIDE	LOWER MEAN TIDE	LOW WATER LARGE TIDE	MEAN WATER LEVEL	RANGE MEAN TIDE
Resolute Bay*	1.60	2.00	0.30	-0.10	1.00	1.30
Pim Island*	2.19	2.80	0.61	0.12	2.19	2.86
Makinson Inlet (proposed values based on Observations)	2.02	-	0.47	-	-	2.46

*published values

Location	MEAN HIGH+ TIDE	MEAN LOW+ TIDE	MEAN WATER LEVEL	RANGE MEAN TIDE	PERIOD (hours)
Resolute Bay°	1.46	0.59	0.97	0.82	10
Pim Island°	2.28	-0.06	2.30	2.22	12
Makinson Inlet (observed values)	2.11	0.04	0.98	1.90	12 1/2

°predicted values

+level of average tide above or below mean water level

NOTE: All heights given in meters.

brief examination of daily tidal changes was carried out at 'Tern Cove' from 1500 EST, July 24 to 1730 EST, July 25, with measurements of water level every half hour. For purposes of analysis the Makinson data were compared with predicted values of tidal height and times for Pim Island (Smith Sound), the closest secondary port, and Resolute Bay, the tidal reference port (Fig. 17, Table 4).

It is apparent that mixed, mainly semi-diurnal tides occur at all 3 localities, and that the range at Makinson is greater than at Resolute but less than at Pim Island. The estimated range of mean tide for the Makinson site is 2.46 m. The Makinson site and Pim Island are situated on a major sea channel, Smith Sound, while the study site lies within a fiord linked to the sea by a narrow channel. It is considered that phase differences may exist between northern Baffin Bay and inner Makinson Inlet, and that there may be independent oscillations within the inlet governed by the period of the basin.

Waves and Currents

No known wave or current observations have been made in the inlet except for one attempt made in 1971 from the CCGS Louis S. St. Laurent. Sadler (1972) reported that a Plessy current meter was lowered off the tip of Swinnerton Peninsula but that the current was less than the threshold of this instrument (i.e. 3 cm/sec).

Sea Ice

Ice cover data for Makinson Inlet is very meagre, as the aerial ice reconnaissance flights in the past have concentrated on major shipping channels, such as Lancaster Sound - Barrow Strait. The account which follows is a compilation of sea ice data from several sources; ERTS satellite imagery was not examined.

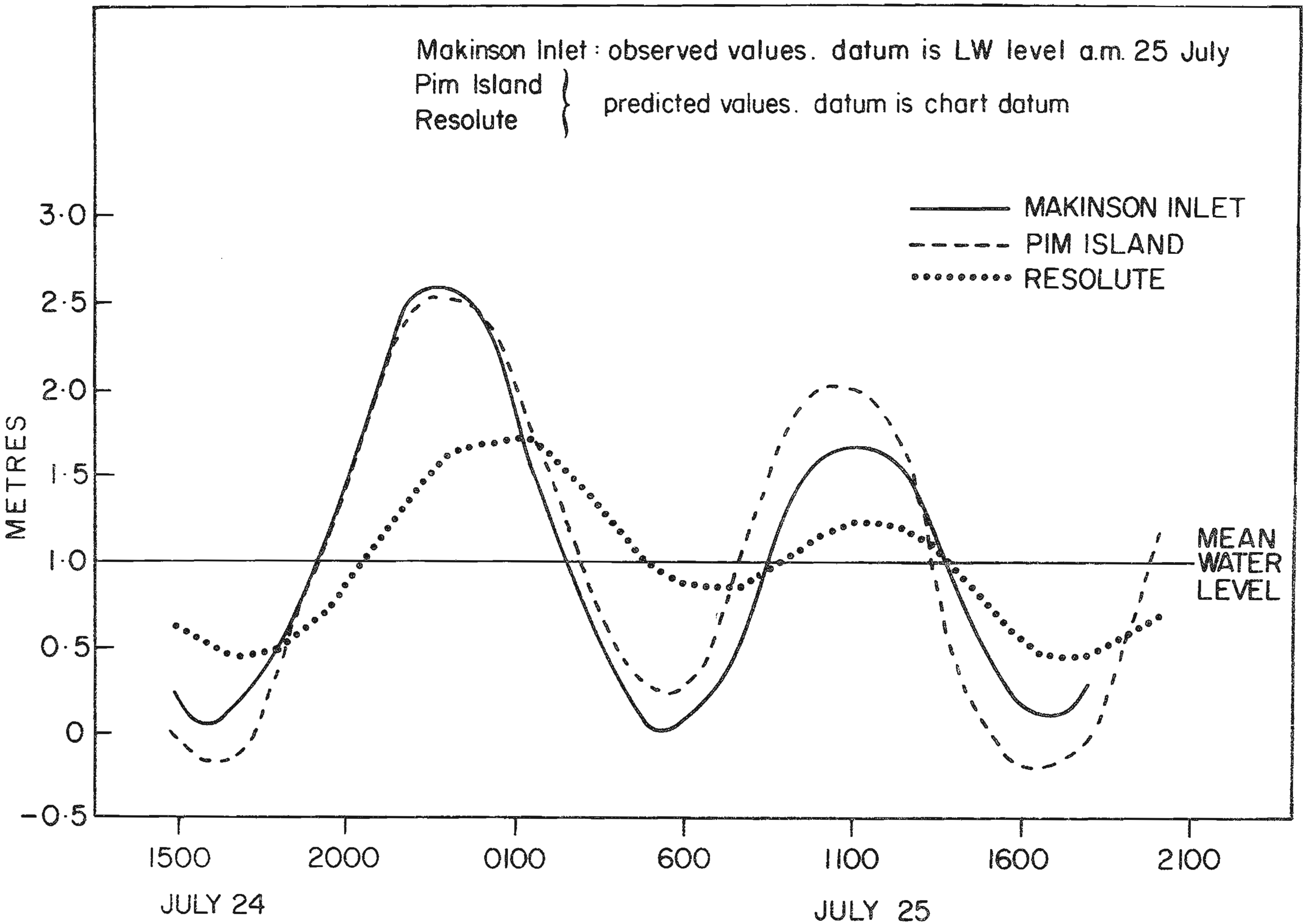


Figure 17. Tidal observations, Makinson Inlet, Ellesmere Island.

Table 5
Length of Open WaterSeason in
MAKINSON INLET AND SMITH BAY,
1965-1976

YEAR	BREAKUP		FREEZEUP		NO. OF DAYS
1965-72	Smith Bay	Aug 11	Smith Bay	Sept 22	42
	Makinson	Aug 21	Makinson	Sept 28	38
1973	Smith Bay	Aug 15	Smith Bay	Oct 3	49
	Makinson	Aug 22	Makinson	Sept 26	35
1974	Smith Bay	Aug 22	Smith Bay	Sept 18	27
	Makinson	Aug 7	Makinson	Sept 18	42
1975	Smith Bay	Aug 13	Smith Bay	Oct 8	56
	Makinson	Aug 13	Makinson	Oct 8	56
1976	Smith Bay	Sept 22	Smith Bay	Sept 29	7
	Makinson	Aug 25	Makinson	Sept 29	35

Ice data for the years 1946 to 1958 is summarized in Swithinbank's Ice Atlas (1960). The information was collected for specific locations within the Archipelago and unfortunately the nearest station to Makinson Inlet was east of Smith Bay, within the 'North Water'. It is possible, therefore, to obtain an assessment of typical ice conditions in the approaches to the inlet, but not for the inlet itself. In general, ice breakup in the approach areas had occurred by June 30, but could occur as early as June 1 (1955 and 1956) or as late as July 15 (1957). Sea ice freezeup usually began about September 15, but could occur as early as August 1 (1953) or as late as October 1 (1956). An average of 77 navigable days per season was calculated for the period of record, if ice-strengthened ships or ships assisted by ice breaker were used. The navigation season was only 60 days for non-strengthened ships, and increased to 110 days for ice breakers alone.

Sea ice conditions within the inlet were analyzed for 1959 using aerial photography flown during that year. On July 17 the upper portion of the northwest arm contained only 2-4/10 cover but near Swinnerton Peninsula the inlet was ice-locked. Icebergs and bergy bits were numerous, especially at the junction of the two channels. By August 17 open water existed throughout the inlet.

A summary of sea ice conditions was completed using ice observations collected by Ice Central and Polar Continental Shelf, Ottawa. Figure 18 illustrates ice cover during the third week of each of the months July (A), August (B) and September (C) from 1965-72.

The approaches to Smith Bay in the area of the 'North Water' (Dunbar, 1969) are usually open by early July, but Smith Bay-Makinson Inlet remains blocked by solid ice until at least the end of July.

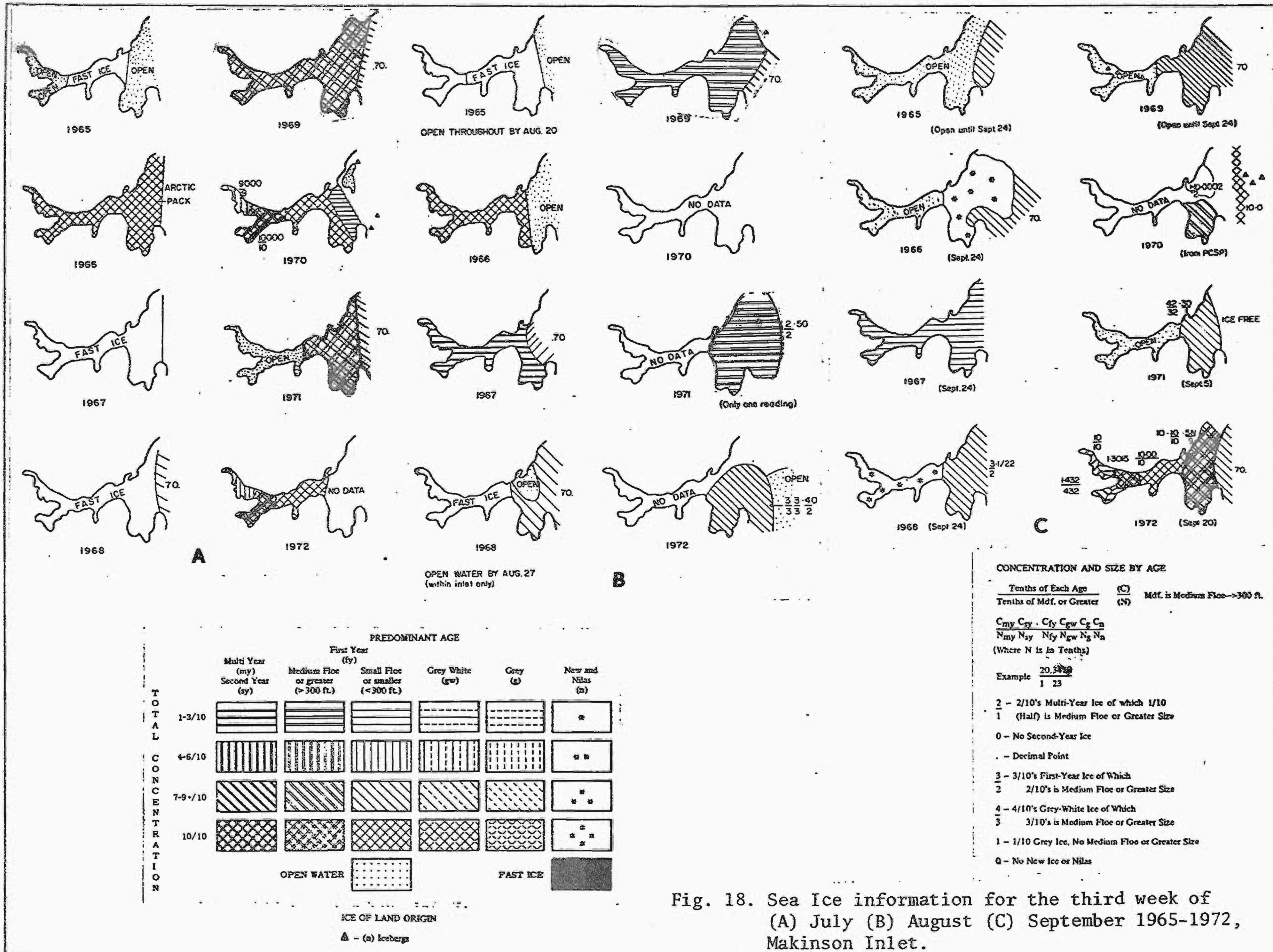


Fig. 18. Sea Ice information for the third week of (A) July (B) August (C) September 1965-1972, Makinson Inlet.

Within Smith Bay an area of open water is usually developed along the north coast by late July or early August. The extent of open water varies from year to year depending on the type of ice frozen in the bay the previous fall and the contemporary ice conditions within the 'North Water'. Open water could conceivably extend from July 30th to October 7 (69 days) in a very good year but the observable trend has been for Smith Bay to be open by August 20 and to be sealed off by pack ice by September 24. Arctic pack ice usually enters Smith Bay from Smith Sound-Kane Basin by mid-September and in many cases has built a narrow but strong ice barrier across the entrance (1971). Consequently, even though open water occurs in Makinson Inlet, penetration by ships through Smith Bay may be seriously hampered. In some years a barrier of multi-year ice and glacial ice also builds up within the entrance to Makinson Inlet.

Inner Makinson Inlet, particularly the NW and SW arms, is usually open by the end of July due to an influx of warmer water from several large rivers (Fig. 19). From 1965-72 the average number of open water days was 38 and from 1973-76 slightly longer at 42 days. Normal open water season extends from mid to late August until late September (Table 5). It is thought that most of the ice formed within the Inlet also melts in situ. The narrow entrance and ice conditions in Smith Bay make the export of ice from the inlet very difficult even with suitable winds. Figure 19 illustrates the ice conditions during the field reconnaissance of the inlet in 1972.

Ice cover data for Bay Fiord and Baumann-Vendom Fiord were compiled to provide some measure of comparison with conditions in Makinson Inlet. Fast ice usually remains solid in both west coast fiord complexes until the end of July. Bay

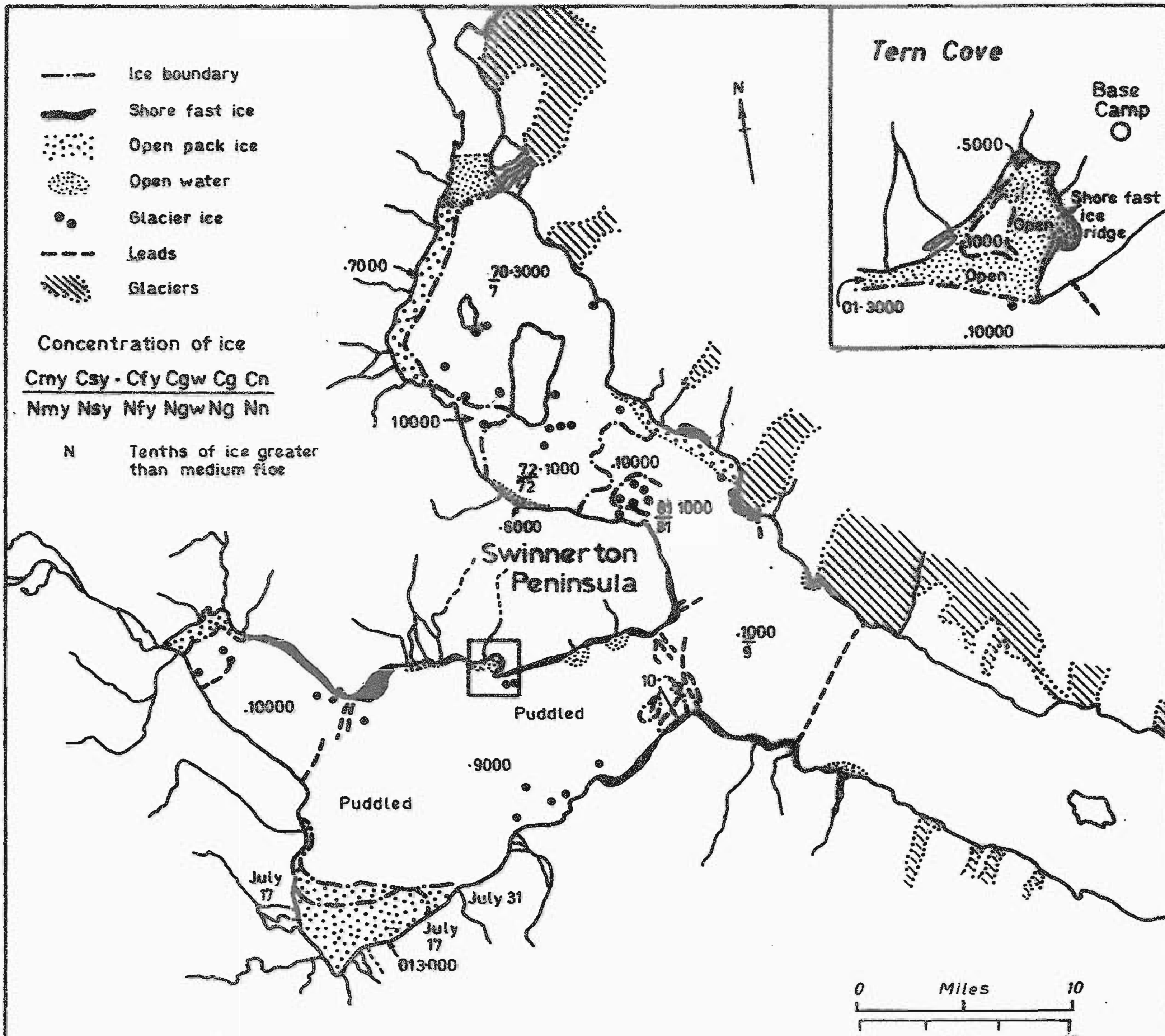


Fig. 19. Sea ice cover, late July 1972, Makinson Inlet.

Fiord is normally open by August 20 and in many years by August 1, but Baumann-Vendom Fiord is essentially not open until the first week of September. Young and new ice usually forms in both fiords by September 24 and they tend to be frozen solid by October 8. Typical navigation periods are: Bay Fiord - 35 days, with a maximum of 55 days; Baumann-Vendom Fiord - 20 to 25 days. It appears that, in addition to having more difficult access, the west coast fiords are much less suitable for navigation than Makinson Inlet.

Coastal Environment

Materials and Processes

Seven beach profiles were surveyed along the shoreline of Swinnerton Peninsula, three on the south shore and four on the north (Fig. 20). Profiles A and F (Fig. 21) are typical of shorelines with many stream channels: both contain a tidal lagoon, backed by low beach or dune ridges, and show low, flat relief. The barrier beach ridges damming the main lagoons have been created by normal processes of longshore transport of beach material and are usually breached by small inlets opposite the main stream channels. Former lagoons farther inland have been infilled by alluvium which dries out in summer. Profiles B and C are located on the north and east shores of 'Tern Cove'; the former is characterized by a series of tidal ridges built by refracting waves and the latter by a steep, narrow, active beach zone and a narrow tidal lagoon. Profiles D and G are representative of the beaches near or beneath the plateau slopes; both are characterized by a narrow active beach zone, backed by raised beach terraces. Profile E is representative of the wide relatively flat shore at the northern end of Black Band Valley (P3:8). A feature common to most profiles is the steep beach slope just above mean high tide level, the product of coarse sediment size and dominance of locally generated short period waves. Nearshore profiles were not completed but soundings through cracks in the ice suggested depths less than 2 m within 75 m of shore along 'Tern Cove'.

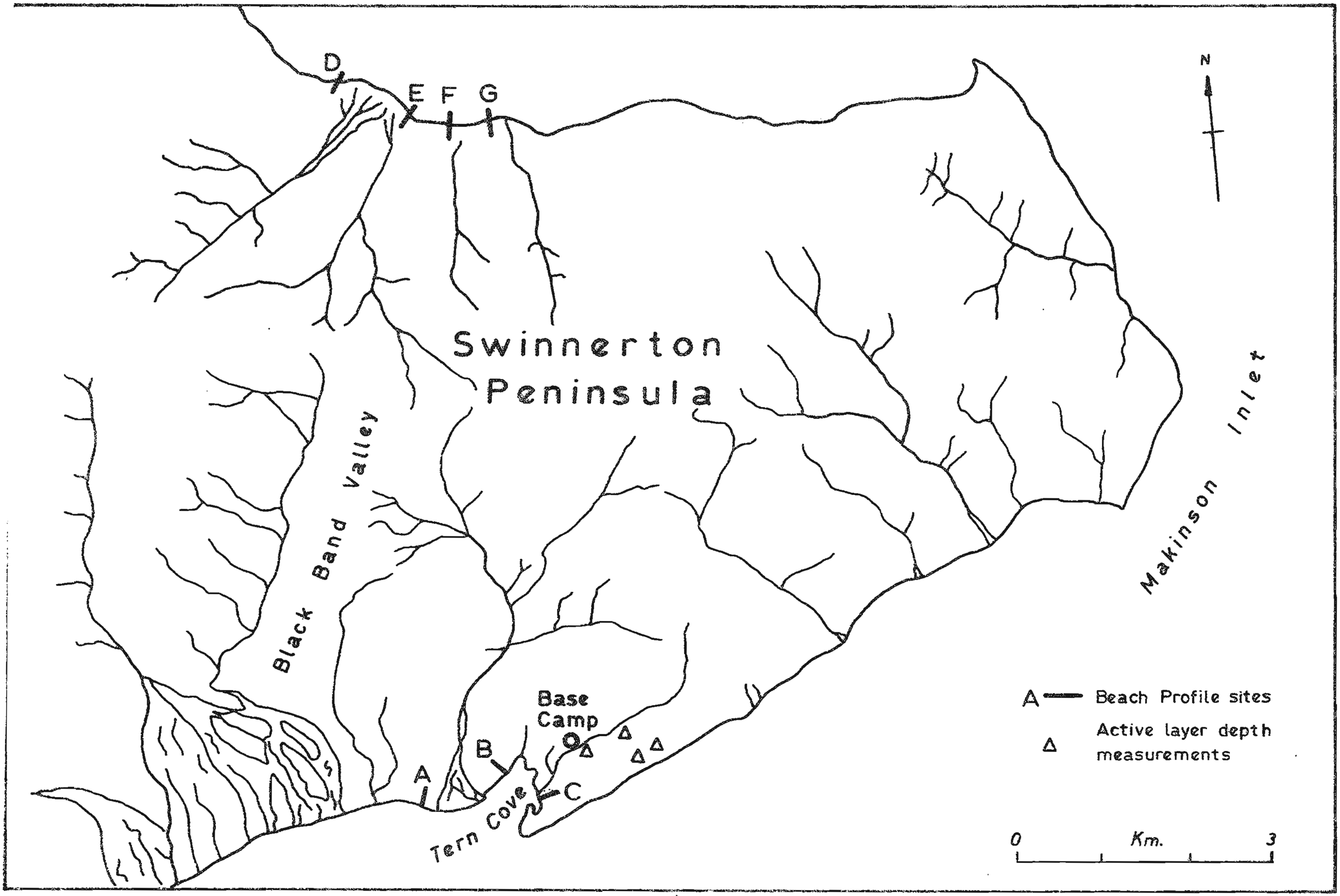


Figure 20. Beach profile locations and sites of active layer measurements, Swinnerton Peninsula, Makinson Inlet.

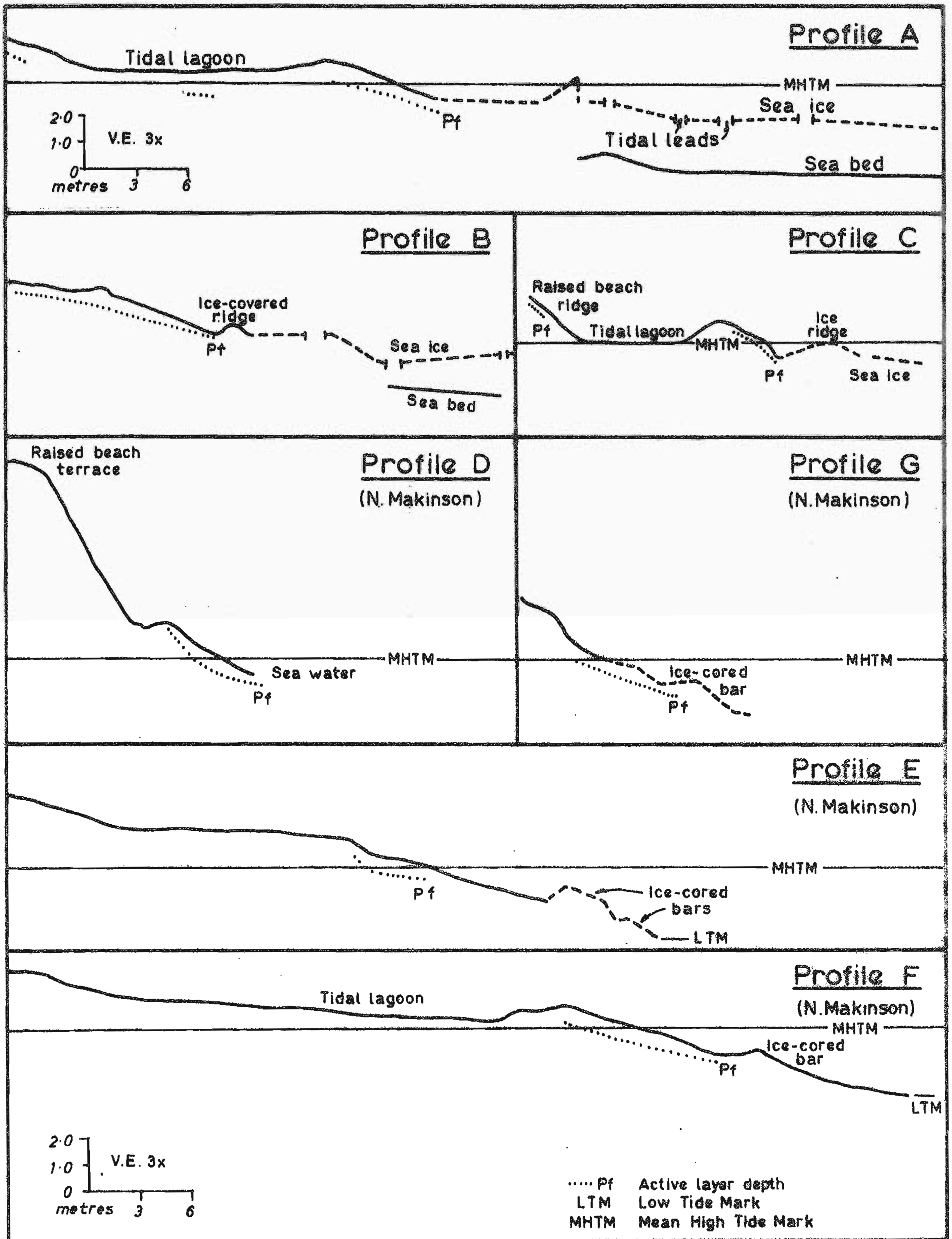


Figure 21. Beach profiles, Swinnerton Peninsula, Makinson Inlet.

TABLE 6
Sediment Size Data for Beach Samples, Swinnerton Peninsula

PROFILE & SAMPLE	$\bar{X}$ ϕ	$\bar{X}$ (mm)	σ	SK	K	% OF SAND
South Shore of Swinnerton Peninsula						
A 1 (raised beach)	-4.22	20.0	1.26	1.63	4.31	<5%
2 (HHWM)	-3.24	9.0	0.99	2.78	10.60	<5%
3 (MHWM)	-2.41	5.5	0.83	3.59	16.29	<5%
4 (on ice)	-0.48	1.4	3.04	-0.18	-1.81	50%
B 1 (Dune No 1)	-2.84	7.0	1.39	0.84	0.85	<5%
2 (HHWM)	-3.09	8.0	0.71	-0.03	-0.24	<5%
3 (MHWM)	-4.63	25.0	0.67	0.70	2.58	<5%
4 (on ice ridge)	-3.39	10.0	1.34	0.68	1.13	12%
C 1 (HH to MHWM)	-3.27	9.5	0.64	-0.17	-0.33	<5%
North Shore of Swinnerton Peninsula						
D 1 (HHWM)	-3	8.0	1.50	-	-	0%
E 1 (raised beach)	-3.86	14.0	1.23	2.47	8.16	5%
2 (HHWM)	-3.40	10.0	1.58	1.72	2.52	6%
3 (MHWM)	-4.45	23.5	1.73	1.92	3.28	7%
4 (LWM)	-2.81	7.0	1.63	1.02	0.63	8%
F 1 (raised beach)	-2.5	6.0	1.50	-	-	<5%
2 (HHWM)	-3.0	8.0	1.50	-	-	<5%
3 (MHWM)	-2.0	4.0	1.50	-	-	5-10%
G 1 (raised beach)	-3.0	8.0	0.75	-	-	5-10%
2 (HHWM)	-3.5	12.0	1.50	-	-	-
3 (MHWM)	-3.0	8.0	1.00	-	-	<5%

Explanation

$\bar{X}$ = mean
σ = standard deviation
SK = skewness
K = kurtosis

Beach sediments were collected at selected sites along the beach profiles and at two locations on the nearshore ice. Results of grain size analysis are shown in Table 6. In general, the beach sediments along the south shore of Swinnerton Peninsula are composed of poor to moderately sorted gravels. The proportion of sand in the beach samples is small but ranges from 12% to 50% in the sediment collected from nearshore ice. These sediments have been transported offshore by streams during flood discharge (P3:9, 10). The sediment on the floor of 'Tern Cove' (not sampled) was observed to be a compacted sandy silt. The beach sediments at the east end of Swinnerton Peninsula are of large cobble size, a function of their proximity to a sediment source, the talus-banked plateau slope and rock shoreline (P3:6).

The range of sediment sizes along the north shore of the peninsula was similar to that along the south shore though there were no significant trends in mean size or sorting across or along the beach zone. This difference suggests that the south shore is an area of greater wave action (i.e. more open water over a longer fetch). Longshore transport of sediment occurs on both shores but a major source of sediment is the input from rivers at flood stage (P3:9, 10).

The bedrock geology of this area is only at the field stage. In broad terms, the bedrock is Precambrian at the eastern end of the inlet and probably Mesozoic sandstones and shales of the Eureka Sound Formation on Swinnerton Peninsula.

Ice Action

During late July fast ice still lined the beach. The icefoot was variable in width and had a maximum thickness at low tide level of 2.5 m. Since the icefoot is not disrupted by tidal fluctuations it had only been eroded adjacent to stream outlets.

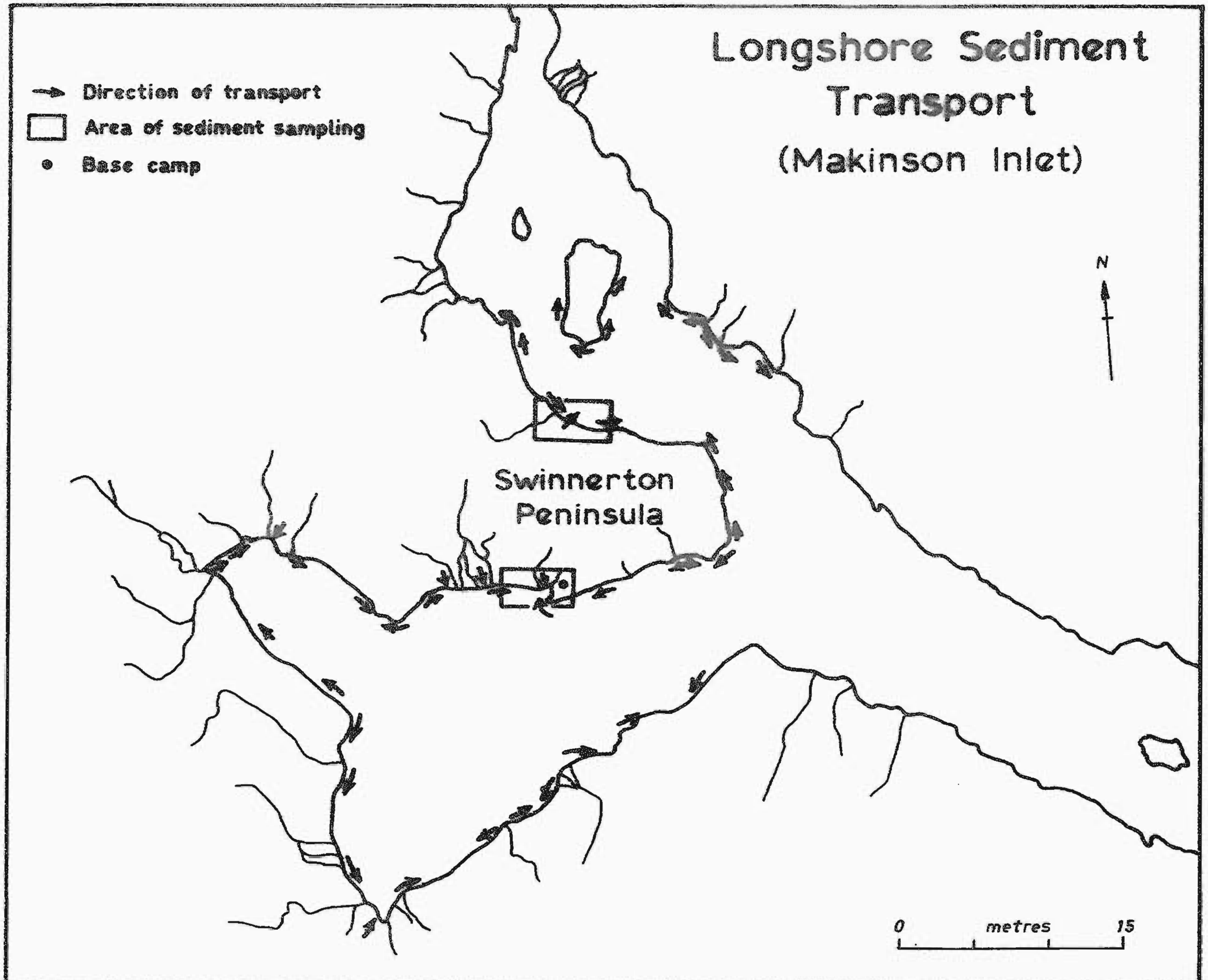


Figure 22. Longshore sediment transport directions, Makinson Inlet.

The ice 'fracture zone', which was 60 to 120 m wide was well defined by a series of tidal cracks and leads. It was here that the destruction of ice proceeded most rapidly, especially where spring meltwaters drained into the cracks and leads.

A well-developed icefoot was absent at profiles C, E and F; instead, an ice ridge covered by beach or fluvial sediments was observed just above or below mean high tide level. An accumulation of 20 cm of sediment protected the ice core from ablation. Ice floes up to 30 m in diameter often became grounded on the ridges and produced an irregular ice barrier between beach and offshore zones serving to protect the beach from wave action and ice push (P3:9).

Active Layer Thickness

The thickness of the active layer beneath the beach was determined at each of the profile sites by means of a hand auger. Measurements were made along profiles A, B and C on July 20 and along profiles D to G on July 27 (Table 7). The greatest depth to the frost table was usually found at higher high water mark (mean depth, all sites = 50.1 cm), and values decreased both landward and seaward of that point. On the first raised beach ridge depths ranged from 34 to 45 cm and, at the seaward end ofthe profiles, from 15 to 46 cm. Although the greatest thicknesses were recorded at site A, which is south-facing, aspect and sediment size appear to play only a minor role in determining the thickness of the active layer. Spot measurements through the silts and sands of the tidal lagoons gave active layer thicknesses of 90 cm.

Measurements of the thickness of the active layer at a variety of non-beach sites was carried out on July 26 on the south side of the peninsula (Fig. 20). The greatest depths (61 to 69 cm) were recorded in dry stream channels and adjacent

TABLE 7
Depth of Active Layer at Beach Sites, Swinnerton Peninsula

BEACH PROFILE	RAISED BEACH RIDGE	TOP OF ACTIVE BEACH	HHWM	MHWM	EDGE OF ICE OR WATER	MEAN DEPTH	MEAN GRAIN (ϕ)	ASPECT
A	45.0	70.0	67.0	-	46.0	57.0	-3.29	S
B	-	31.0	45.0	38.0	15.0	32.2	-3.52	SE
C	34.0	-	26.0	27.0	30.0	29.2	-3.27	W
D	-	25.0	46.0	52.0	23.0	36.5	-3.00	N
E	-	46.00	56.0	57.0	19.0	44.5	-3.63	N
F	-	60.0	61.0	55.0	23.0	49.7	-2.50	N
G	-	-	50.0	56.0	30.0	45.3	-3.10	NW
Mean Depth	39.5	46.4	50.1	47.5	26.6	-	-	-

NOTE: Depths are in centimetres.

patches of vegetated ground composed of sandy silt. On the raised beach terraces, composed of angular gravels, values were less (31 to 34 cm) and very shallow depths were recorded in the large contraction cracks of the ice wedge polygons.

Suitability for a Marine Terminal

Selected terminal sites C and D have wide, relatively flat coastal lowlands fronted by a narrow active beach. Beach sediment is mainly gravel (sandstone), 4.0-24.0 mm in diameter, with sand (0.25-1.0 mm) occasionally significant.

If an overland pipeline were constructed it would probably reach the coast at or near terminal site E (Fig. 16) at the south-west arm of the Inlet. The shallowness of the offshore may force an extension of the pipeline to site D where deeper water is found and flat, low-lying land is more extensive.

The other proposed sites, A, B, C, F, G, are at a disadvantage because of shallow offshore waters, narrowness of seaward approach, difficulty of overland access, absence of extensive level land or exposure to sea ice. At present, site D appears to be the most promising, though sites E and G should also be examined.

In terms of water supply, should the Swinnerton Peninsula be selected as a site for a marine terminal, the short flow season and low discharges of the streams, plus their sometimes turbid nature will present difficulties. There are no lakes of any size and only a few small ponds, so water would have to be piped from one of the lakes or large rivers further west. The only hydrological condition which might prove hazardous for oil pipeline construction across the area is the wide expanse of braided stream channels found on the southern side of 'Black Band Valley'.

Large gaps in knowledge for Makinson Inlet concern bathymetry and oceanography. Published offshore depths are restricted to mid-channel and little is known of nearshore depths, especially at the possible terminal sites. Secondly, there is a lack of current and tidal information within the inlet. It is suggested that future research in Makinson Inlet include:

(1) monitoring of tidal fluctuations,

(2) detailed echo sounding in the nearshore, especially near Swinnerton Peninsula.

(3) measurement of nearshore and offshore currents

(4) field reconnaissance of beach and nearshore conditions at alternative terminal sites.

LOWTHER ISLAND

by R.B. Taylor

Physiography

Lowther Island, located in central Barrow Strait (Fig. 23) between Bathurst and Russell Islands is the largest of the mid-channel islands. It is 18 km long, 8 km wide and except for the southeastern and northern ends is fringed by gradual sloping gravel raised beaches. At Gourdeau Point (P4: 9, 10), southeastern Lowther, cliffs rise to 91 m but are fronted by a wide, well-developed gravel beach. The upland surface and raised beach terraces of northern Lowther are composed of coarse angular gravels and characterized by step-like exposures of bedrock.

There are two small bays on the island but both lie on the uncharted (bathymetry) western shore. The interior of the island is low with gently rolling hills rising to the north and south-central parts where maximum elevations of 172 m and 198 m are reached. Drainage from the interior lakes is to a large extent controlled by fault structures.

Lowther Island was first visited in 1974 for the purpose of establishing four beach profiles. Return visits were made in 1975 for eight days and in 1976 long enough to resurvey the beach profiles.

Bathymetry

It is evident from hydrographic chart 7829 that very little is known about the nearshore depths, particularly along the western shore (Fig. 24). The 30 m isobath generally occurs within one kilometer of the eastern shore and the 100 m isobath is closest to shore at the north and south ends ofthe island. On the western

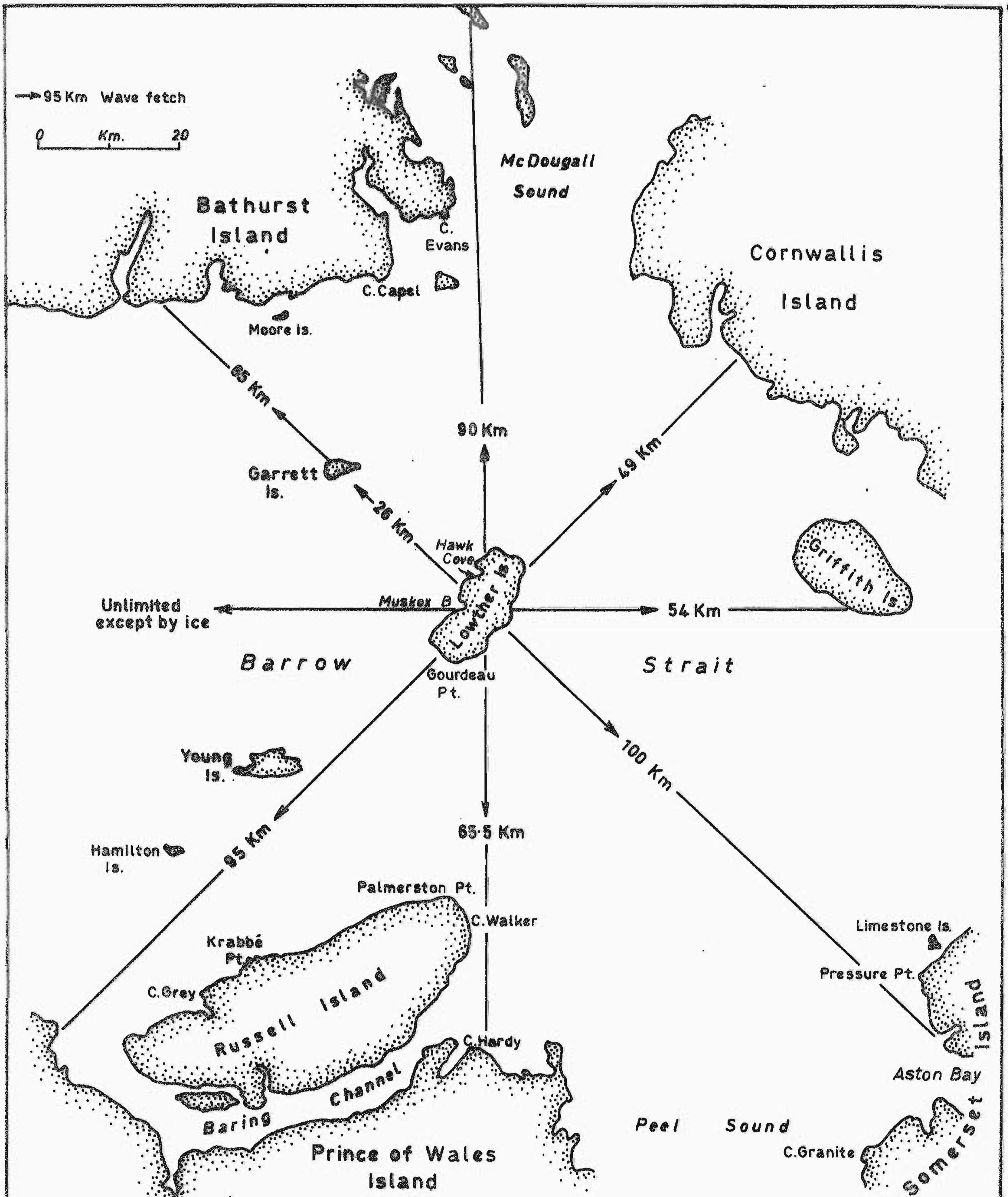


Figure 23. Place names and wave fetch Lowther Island.

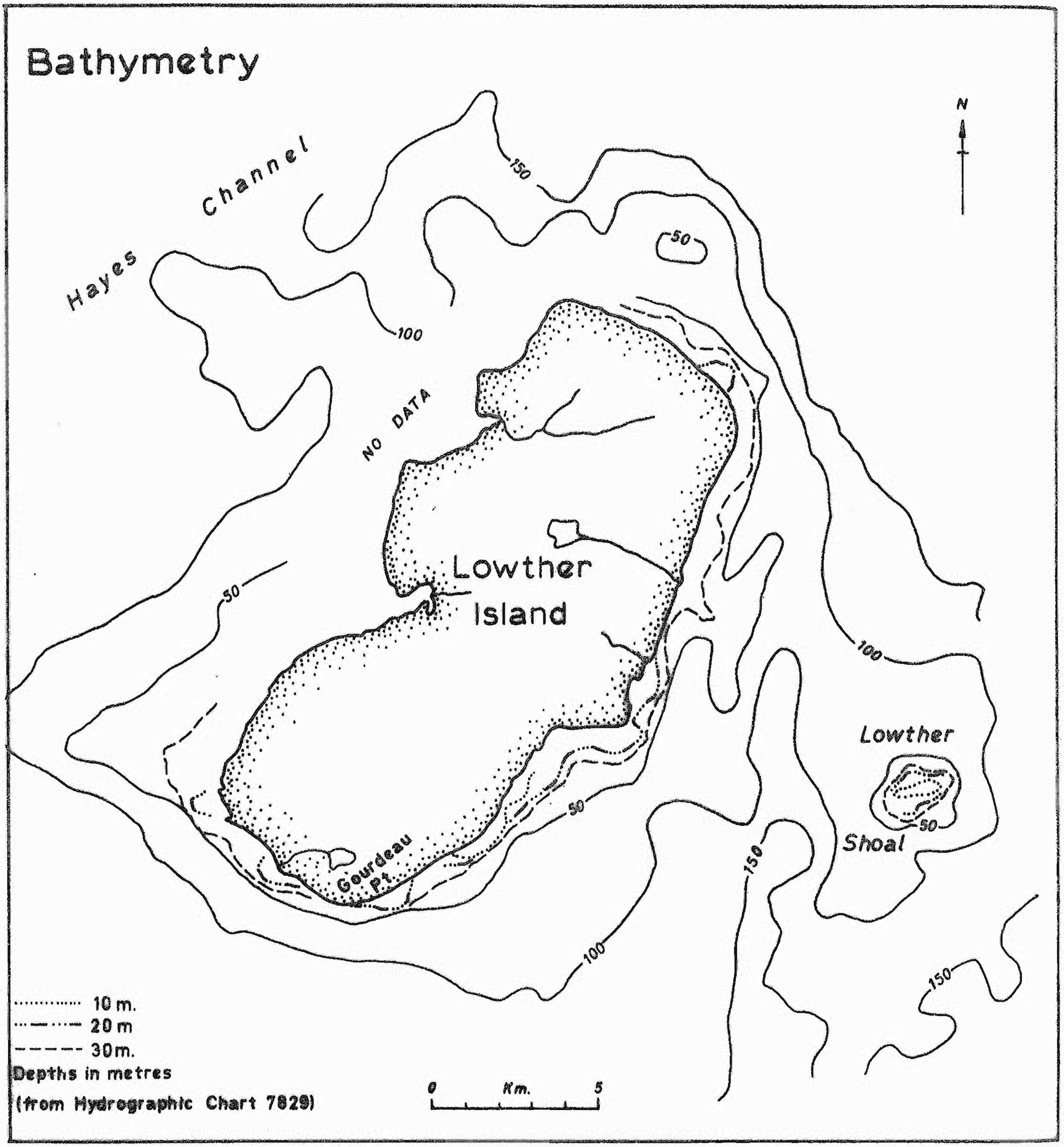


Figure 24. Bathymetry, Lowther Island.

shore the closest isobath shown is 50 m and it lies as much as 2.8 km offshore. From observations of sea ice characteristics it is also apparent that the shallow nearshore depths extend further off the western than eastern shore, excluding Lowther Shoal. At a distance of 8 to 9 km off the east coast, water depths become less than 2 m on the Lowther Shoal (Fig. 24). However, since depths increase rapidly to over 50 m and the shoal itself is small in area it probably does not present a great hazard to shipping. The shoal is usually well marked by grounded ice.

Oceanography

Tides

Very little oceanographic data have been collected from the vicinity of Lowther Island. Mean tidal range is between 0.97 m recorded at C. Capel, Bathurst Island and 0.55 m recorded on Hamilton Island (Fig. 23).

Currents

A general drift of sea ice eastward in Barrow Strait suggests an eastward flowing current. On two occasions sea ice was observed to be moving rapidly eastward around the northern end of the island even though strong northeasterly winds were blowing and the tides were at flood stage. Blake and Lewis (1975) illustrate with bottom photos a lag gravel surface of angular rock fragments at water depths of 122 to 125 m off SE Lowther Island. They attributed the absence of fines to scouring action by strong bottom currents.

Waves

Excluding the presence of Young and Garrett Islands, wave fetch is greater than 50 km in all directions and unlimited to the west (Fig. 23). However, the continual occurrence of sea ice, particularly to the west, severely restricts the generation of large waves.

Sea Ice

In the vicinity of Lowther Island sea ice cover during the summer is extremely variable because of the continual influx of ice into eastern Barrow Strait from adjacent channels. Since Lowther Island is west of the Barrow Strait Polynya (line between Griffith and N.W. Somerset Island Fig. 25 and 26), sea ice breakup rarely commences before the end of July. However, narrow shore leads can form earlier. Sea ice breaks up initially at the northeast or southeast corner of the island and finally along the western shoreline. Complete open water probably does not exist along these shores for more than a few days at a time. Nevertheless an estimate of the maximum number of days that waves could rework the beaches was made using secondary sea ice information (Table 8). The average was 35 days/year for the period 1972 to 1976. Similarly, between 1965-71 an estimate of annual open water season was found to be less than 37 days (Taylor, 1972).

Fields of hummocky ice characterize the winter ice surface off western Lowther Island and nearshore grounded ice ridges, although more common on the west shore, can be found on all shores (P4: 2, 3). In addition, large multi-year ice blocks are often observed grounded nearshore. It can be concluded that the interaction between sea ice and nearshore bottom is probably great.

Fig. 25. Sea ice cover, central Barrow Strait, July 17, 1976.

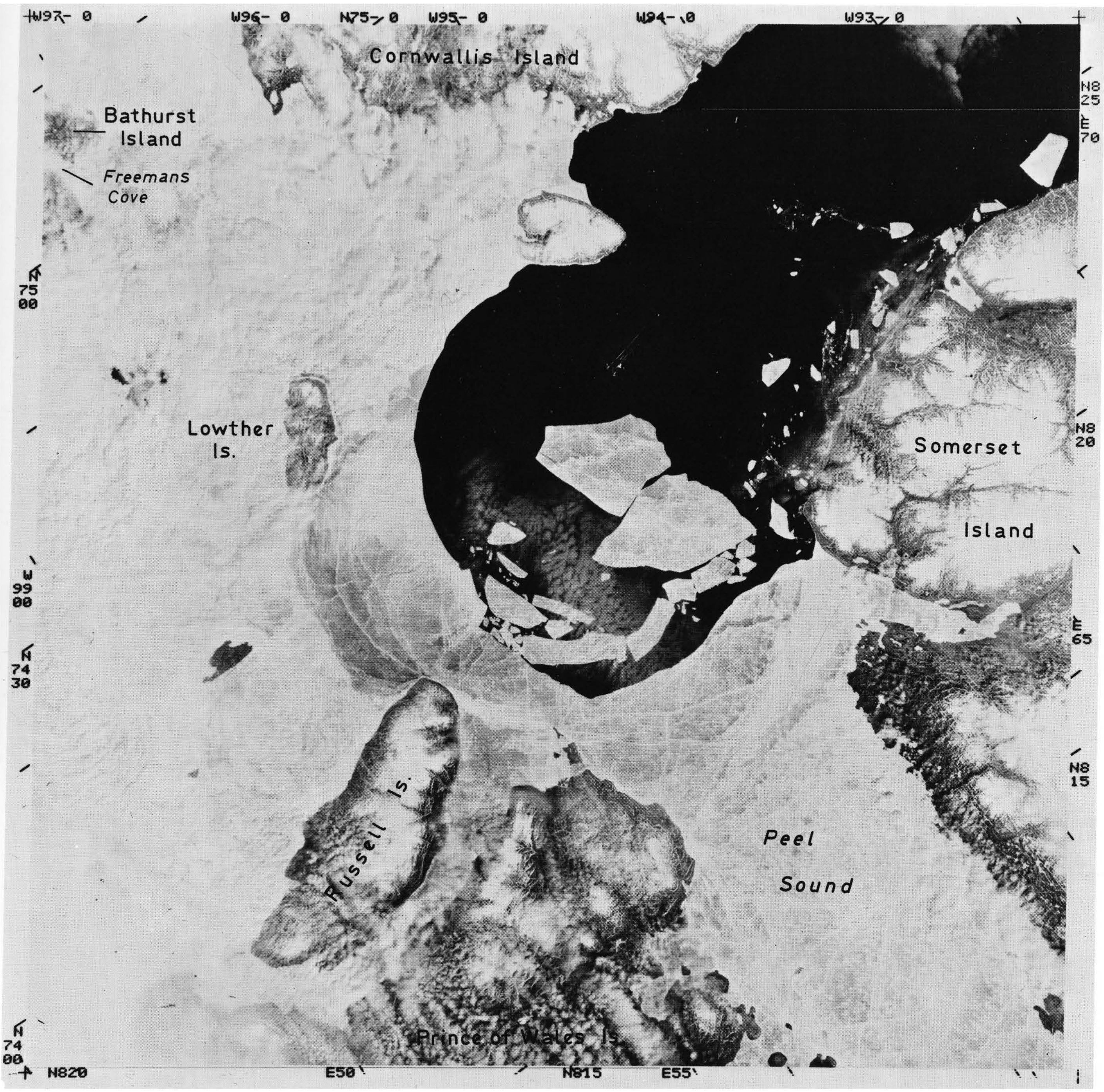


Fig. 26. Sea ice cover, Central Barrow Strait, August 31, 1976.

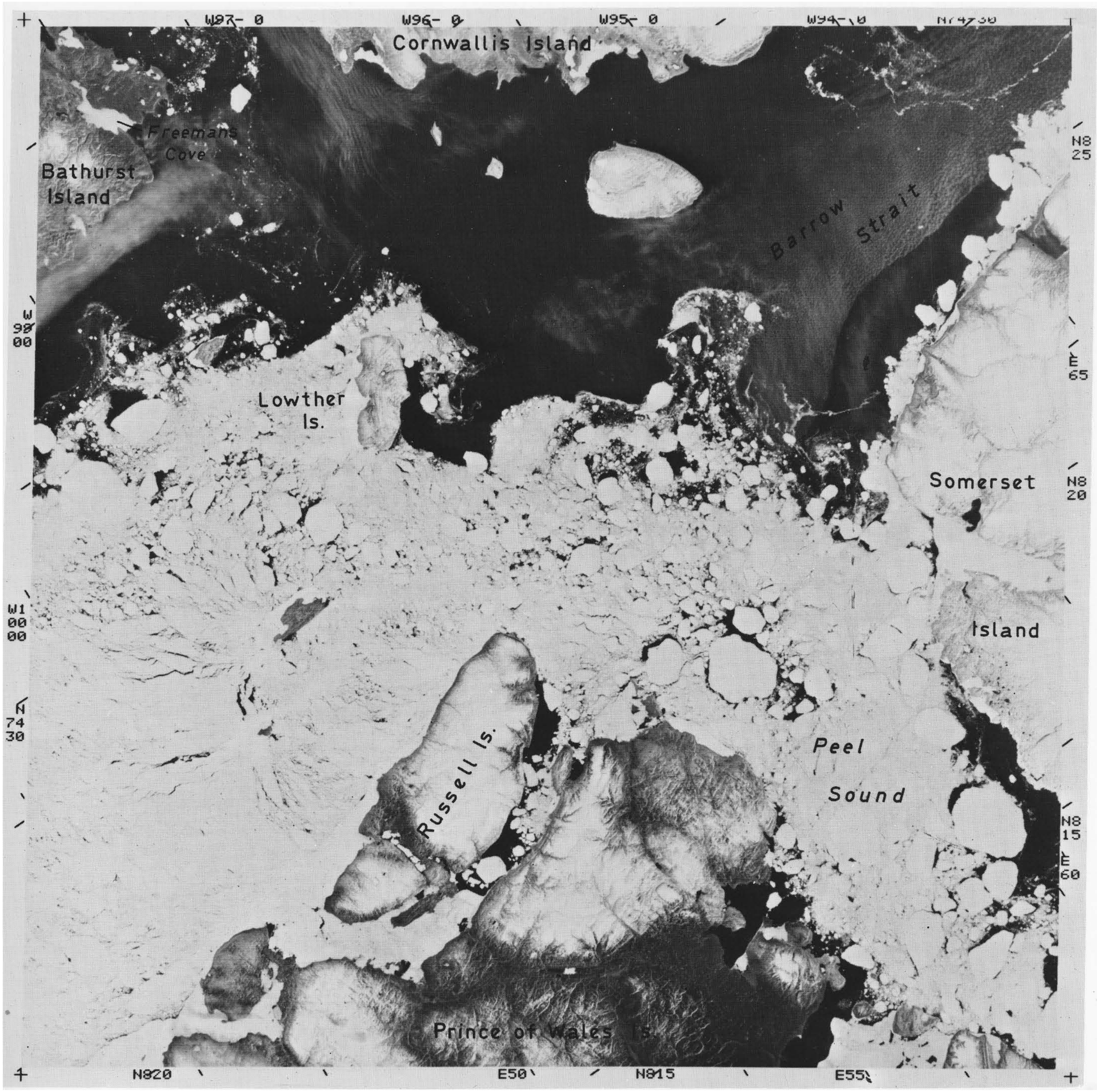


TABLE 8
Length of Open Water Season, Lowther Island

YEAR	BREAKUP	FREEZEUP	NO. OF DAYS
1972	Aug. 23 (N. end)	Sept 22	30
1973	Aug. 22 (east) Sept. 1 (all sides)	Sept. 26	26-35
1974	Aug. 7 (east side) Sept. 11 (all sides)	Sept. 25	14-49
1975	July 18 (SE corner) Aug. 6 (east)	Oct. 8 (beach freezeup earlier)	63
1976	July 28 (offshore, eastside) Aug. 30 (onshore, eastside) Sept. 15 (all sides but SW)	Sept. 29	14-31

Coastal Environment

Materials and Processes

Flights of gravel raised beaches formed by marine processes during isostatic uplift compose by far the largest proportion of the Lowther shoreline. Apart from the cliffs on the southeastern shore and a moderately high bluff at a few other localities (Fig. 27) the only other distinctive beach form is the rocky shore platform. These rock platforms are found at the northwestern and southwestern corners of the island and near the reef knoll on the east central side ofthe island (P4:8). Having resisted wave and ice erosion the dolomitic rock platforms form finger-like projections out from the main shoreline (P4: 5, 12). Average relief of the platforms across the beach is 1 to 2.5 m (P4:5). Blocky fine gravels resulting from solutional and frost weathering of the platform are transported alongshore. However, the majority of beach gravels which form the pocket beaches adjacent to the platforms at the northwest and southwest end of the island are limestone. The source of these limestone gravels is offshore.

Rocky shore platforms are also found along the raised beaches behind their modern counterparts and offshore. A bedrock platform of unknown rock type extends 75 m off the northwest corner of the island. Similar shore platforms were observed on southern Bathurst Island and these also were formed of dolomite assigned to the Disappointment Bay geologic formation.

Normal littoral processes appear to be much greater along the eastern than the western shoreline of the island. For instance, very large ridge and swale features occur on the east coast while much narrower beaches and smaller ridges are found on the west coast. Beach profile 2, (Fig. 28) and photo P4:6 and 7 illustrate the east coast while beach profile 3 and 4 represent the west coast.

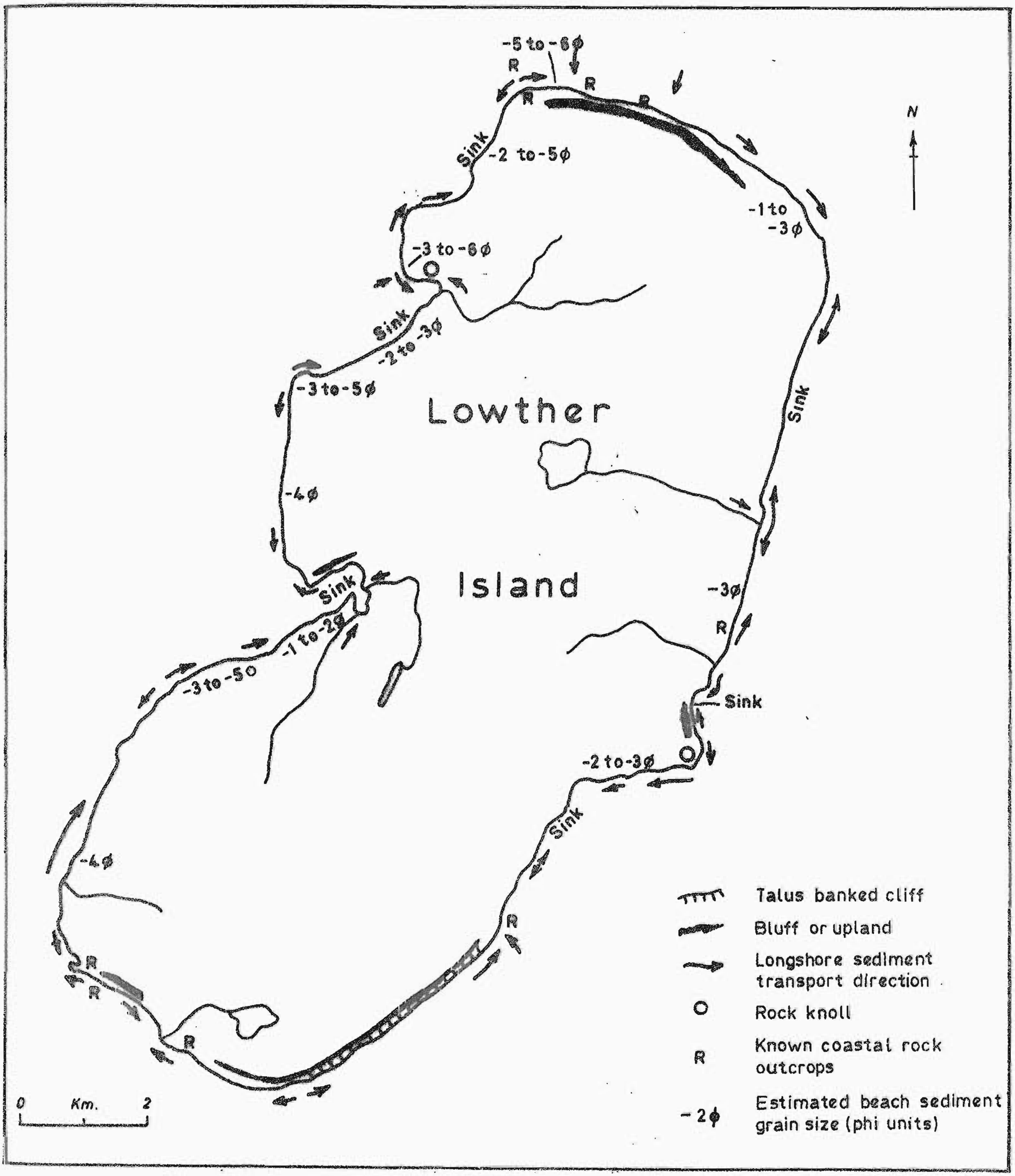


Fig. 27. Coastal morphology and longshore sediment transport directions, Lowther Island.

Foreshore widths of 17 and 19 m are found on the east shore but only 9 to 12.5 m on the western shore. In addition, the highest storm ridge above sea level was 2.45 m at profile 2 but since the maximum tidal range only approximates 1.58 m then the eastern shore must have experienced storm surges or large swells in the last few years. Large storm waves could rework the western shores of the island but the chances are minimized by the presence of sea ice.

Further evidence of increased wave action on the eastern shore is provided by the beach fronting the cliffs at Gourdeau Point. Kelp and a lack of compaction in the uniform size beach gravels of the backshore suggest overwash deposits and considerable reworking by waves. Beach pitting and two-metre high storm ridges on the north coast of the island also suggest storm wave activity.

Beach sediment varies considerably along the coast because of different underlying bedrock found on the island. Although the transport of sediment alongshore is variable during any one year depending on sea ice conditions and prevailing wave direction, the dominant direction of transport has been indicated on Figure 27. Directions were determined by examining beach form, eg. beach ridges and beach sediment size and type. Probable location of sediment source and deposition are also included on Figure 27.

On northern Lowther Island the beach sediments at the base of the rocky shore platform are subangular to subrounded limestone pebbles of -4 to -6ϕ. In contrast dolomite sediments originating from the platforms are only -1 to -2ϕ. Further from the source the beach sediments become mixed.

Sediment collected from beach profile 2 was platy sandstone of -3 to -4ϕ size but the lower beach was mixed sand and gravels. Bedrock outcrops of red sandstone are found a few hundred metres south of profile 2. The proportion of sandstone to dolomite or limestone sediments decreases towards the northeast corner of the island where the latter two rock types prevail. Dolomitic rock outcrops again occur at the headland near the reef knoll on east central Lowther. Beach sediments below the cliffs at Gourdeau Point show traces of sandstone but limestone pebbles of the Blue Fiord formation predominate (P4:11). Mixed sandstone and dolomite beach sediments occur between the reef knoll and Gourdeau Point.

Along southern Lowther bimodal sand and gravels are observed. The gravels originate from the rock outcrops just offshore, particularly near the bluff and shore platforms, while the sand comes from thinly laminated sandstone outcrops on the east side of the large river.

Limestone gravels are found along the southwestern part of the island. The gravels became progressively finer from the rock platform to the southern corner of 'Muskox Bay' where coarser gravels occur again. The proportion of finer sediments and sand again increased toward the head of 'Muskox Bay'.

Whereas the limestone gravels south of Muskox Bay were from the Blue Fiord geologic formation, the much coarser and angular limestone gravels sampled at profile 4 were thought to come from the Disappointment Bay formation. It is here that a distinct well-developed raised beach complex with a steep foreshore slope has formed. Little or no vegetation covers the area.

Along the shore immediately south of 'Hawk Cove' the limestone gravels disappear and a mixture of sandstone, siltstone and sandy dolomite gravels occur. These beach sediments closely resemble those of southeastern Lowther Island.

Beach sediments north of 'Hawk Cove' become mixed with pinkish limestone, from the Snowblind formation exposed nearby, and dolomite sediments similar to those derived from the rocky shore platforms. The raised beach sediments are very angular and rock outcrops are common.

Beach Stability

Four profiles were established in August 1974 across each of the four shores of the island. Subsequent surveys were completed in late July 1975 and mid-August 1976. Changes in beach profile were measured between successive surveys using a planimeter. Only at the north end of the island was any appreciable change measured. At profile 1 (Fig. 28) 5.5 m^3 of sediment was removed from the irregular, ice pushed and pitted profile between August 1, 1974 and July, 1975 (P4:15). Less than 0.5 m^3 of erosion was experienced at profile 2 and a similar amount of accretion at profile 3. No measurable change occurred at profile 4 over the two years and only minor changes were experienced at the other three profiles between 1975 and 1976. On all three visits to profiles 3 and 4 fast ice lined the lower beach indicating a general lack of littoral processes along western Lowther Island. A gravel-cobble nearshore bottom was observed offshore of each profile and a rock platform occurred further offshore of profile 4. Within 20 m of shore the steepest nearshore slopes were 4° and 7°, observed at profiles 1 and 4 respectively.

Ice Action

A well-developed icefoot lines the Lowther coast each year. Based on measurements collected in 1974 the width of the icefoot was 16.7 m with a range in width of 4 m. Icefoot thickness at the first lead was as much as 2.7 m at profile 4

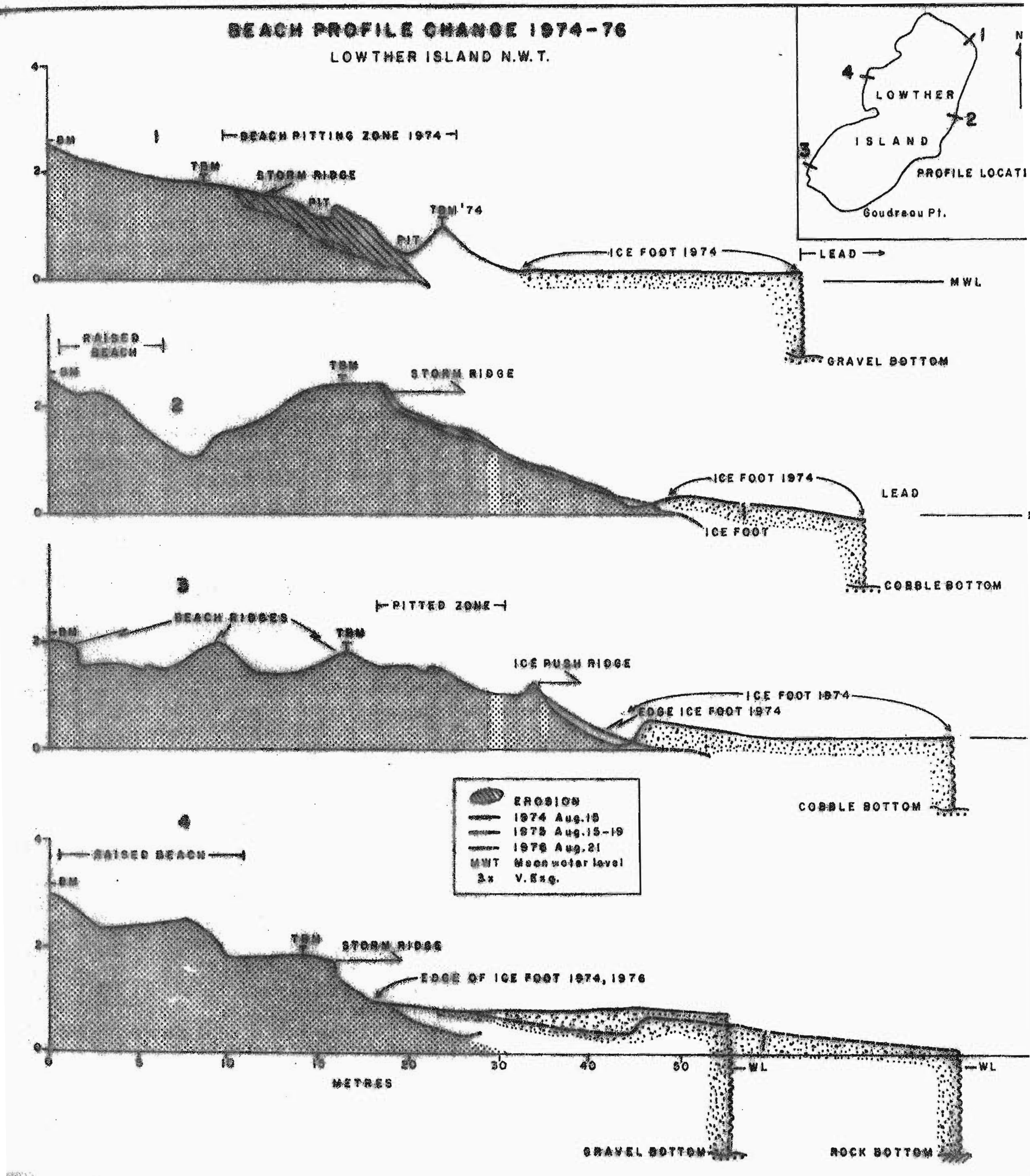


Figure 28. Beach profile change 1974-1976, Lowther Island.

but averaged 1.4 m at the other three profiles. Duration of the icefoot is longest on the west shore however a submerged, fast ice ridge was still present at or just below low tide level at profiles 1 and 2 in mid-August 1976.

In 1974, sea ice ridges or fences were observed along the icefoot at Gourdeau Point (P4:10) and along the nearshore off southwestern and western Lowther Island. Estimated height of the ridges was 3 to 5 m (P4:2). In addition, during 1974 the entire length of the north and east shore of the Island was covered by ice pits and small ice pushed ridges. In general the height of these ridges was less than 1.0 m. By 1975 wave action had combed down most of the shoreline creating a smoother beach profile but minor ice rafting and ice push recurred in 1975 and 1976.

Active Layer Thickness

Active layer thicknesses were measured using a hand auger at each of the profiles in 1974 and 1975. The mean depth of all sites measured was 0.27 m which was much shallower than depths recorded on Bathurst and Somerset Islands. Greatest mean depth (0.33 m) was observed along the southwestern part of the island at profile 3 but the difference between the other profiles was less than 0.2 m. Generally the beach slope covered by ice push ridges or ice pits had a deeper active layer probably because the beach sediments had been disturbed.

Suitability for a Marine Terminal

Construction Materials

Beach sediments vary from resistant blocky dolomite to platy sandstone and siltstone. Sand is available, but it is mixed with gravels. Main sources of sand are in the interior and east coast of the island. Gravels and cobbles up to -6∅ size are also available. However, the presence of numerous rock outcrops along the coast and further inland suggests a thin layer of marine sediments and thus a general shortage of aggregates. At the large river flowing across east central Lowther Island less than a metre of marine sediments covered the bedrock on the raised beach. The largest sources of beach sediment appear to be adjacent to the cliffs on southeastern Lowther and perhaps along the northeastern part of the island where the large beach ridges occur.

Navigation and Wharf Sites

Very little is known about the nearshore depths along Lowther Island and even though the 30 m isobath occurs within one kilometre of the east shore there is little protection from moving sea ice. The only bays lie on the west side of the island where sea ice and shallow depths prohibit harbour facilities.

Airstrip

The raised beaches are sometimes narrow, irregular and often covered by frost cracks but small aircraft could land without difficulty on the eastern side of the island. The sandy texture of some of the upland surfaces of northern Lowther are suitable for landing except in early spring when the surface is wet and unstable. The low relief of the island and well-developed raised beaches provide little barrier to movement of vehicles or future construction.

Water Supply

Several lakes and streams cross the island but only the large lake in the centre of the island appears to be of sufficient size to support large scale human activity.

Summary

Even though good port facilities are absent, Lowther Island, because of its location in central Barrow Strait, could be subject to pollutants from tanker ships. In addition the island could be a link for a pipeline crossing Barrow Strait. Consequently, beach morphology and sediments have been examined in view of the possibility of pipeline construction activities or shoreline clean-up due to an oil spill.

RUSSELL ISLAND

by R.B. Taylor

Physiography

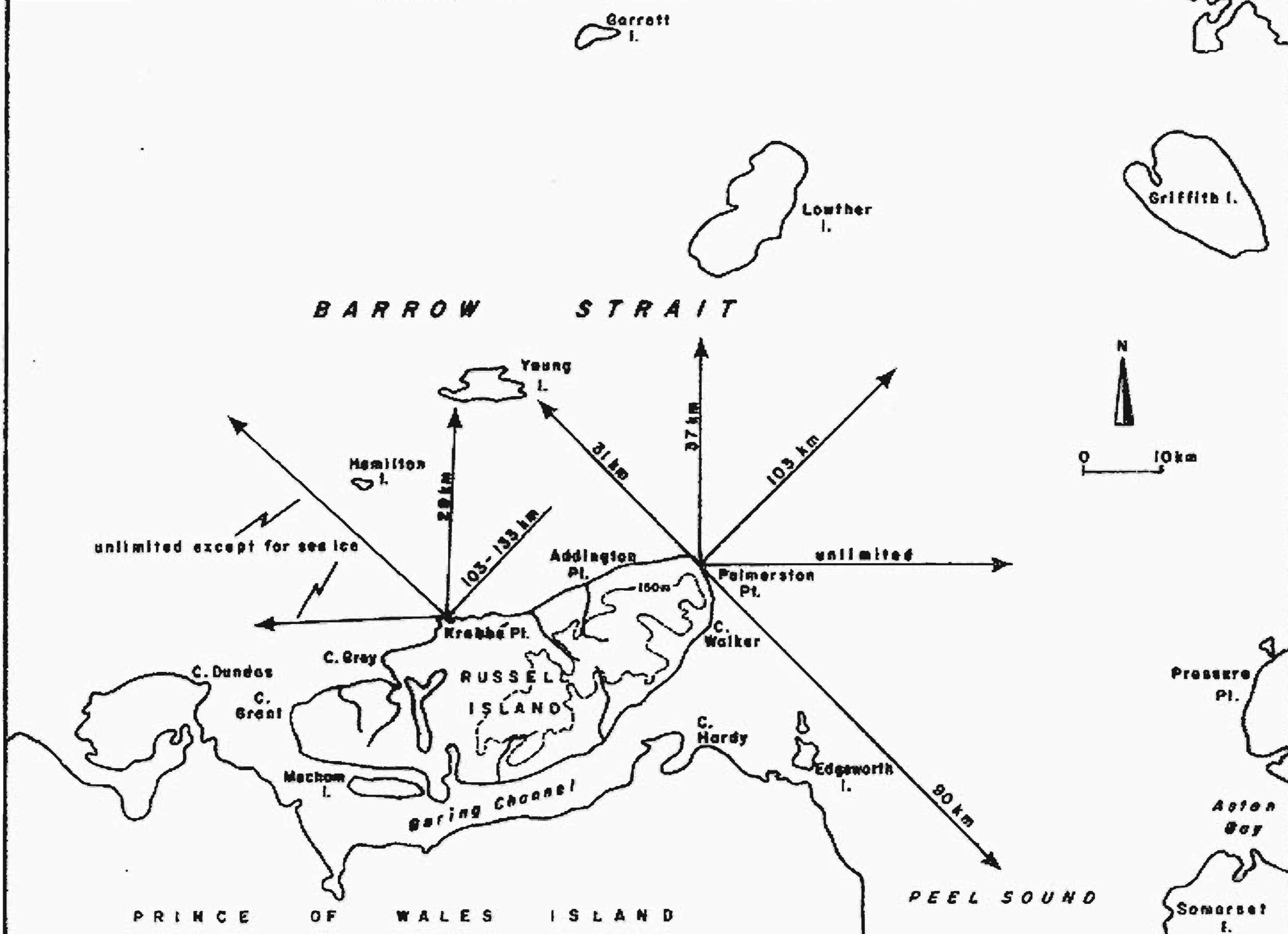
Russell Island, lying 5 km north of Prince of Wales Island, is 53 km long and has a maximum width of 21 km. Coastal relief is greatest at the eastern tip of the island where cliffs of over 200 m back narrow, steep gravel beaches (P5:2, 3). Elsewhere sand and gravel raised beaches of low to moderate relief line the coast (P5:5, 7, 12). The island is nearly divided in two by a series of lakes and inlets which run north-south between Cape Grey and Baring Channel (Fig. 29). Numerous rivers flow from the upland surface in the interior of the island and lakes are most abundant in the lowland between Krabbé Point and Cape Grey (P5:11).

Russell Island is underlain by Paleozoic rocks primarily from the Peel Sound formation which is subdivided into three regions across the island. The eastern 18 km of the island is conglomerate and boulder conglomerate of which the cliffs at C. Walker are composed. Rocks on the western 29 km of the island are limestone and dolomite, mainly carbonate facies of the Peel Sound formation, but probably include some beds equivalent to the Read Bay formation (Blackadar, 1967, Map 3-1967). The remainder, a slice across the centre of the island, is red sandstone, sandy limestone and sandy shale. The slight variation in underlying bedrock is reflected in the range of beach sediments observed along the shores (P5:10, 14, 15).

Bathymetry

Few soundings have been completed along Russell Island. A single line of depths measured through Baring Channel record shallowest depths of 26 m but most

Figure 29. Place names and wave fetch, Russell Island.



of the mid-channel exceeds 50 m. Dow (1955) reports a few more soundings in Baring Channel but the horizontal control of his records is poor. Across the entrance to the channel at Bellot Cliff, Dow shows depths of 18 to 80 m from north to south. He also reports that the bottom of Baring Channel is uniformly of hard clay and is excellent holding ground for ships.

Little is known about the offshore regions along western Russell Island. Along the northeastern and eastern ends of the island a shoal extends northward from Krabbé Point but since it was sighted from the air, depths are unknown.

Oceanography

Tides

A mixed semi-diurnal tide with a range of 0.55 to 0.79 m was measured at the nearest tidal station, Hamilton Island, 20 km NNW of Krabbé Point (Canadian Hydrographic Service, 1976). These tidal measurements probably are applicable to all but the south shore of Russell Island. A difference in the tidal period and range probably occurs in Baring Channel because of its shape and location.

Currents

Published information on offshore currents is non-existent, however some brief measurements of nearshore currents were completed by the author. During a flood tide, currents within 25 m of shore were easterly at 0.03 to 0.07 m/second. A slightly stronger current was observed moving east beyond 25 m from shore. Sea ice was observed to move westward in Baring Channel during a flood tide and at C. Walker ice offshore moved south during an ebb tide and nearshore ice flowed north.

Waves

No information on wave parameters is known. Maximum possible wave fetch ranges from 6-10 km in Baring Channel to an unlimited length east and northwest of the island. Islands in mid-Barrow Strait limit wave fetch to less than 40 km north of Russell Island (Fig. 29). However in reality the nearly continuous presence of sea ice offshore severely restricts the length of wave fetch.

Based on beach observations only, the eastern portion of the island showed signs of substantial annual wave activity.

Sea Ice

During most seasons polynyas develop off Palmerston Point and C. Grant by July 28. In other years, such as 1962, they developed as early as July 6. Sea ice breaks up off the eastern end of the island in late July and Baring Channel ice begins to break soon after. Open water is intermittent along the northern shore of Russell Island because of continual influx of sea ice from the west. However, during several seasons open water existed around the entire island by the first week of September. During the past few years new ice has formed in the nearshore by mid-September but fast ice did not cover Baring Channel until mid to late October (Atmospheric Environment Service, 1975, 1976).

Coastal Environment

Materials and Processes

The shoreline of Russell Island was examined using all-terrain motorcycles in late July, 1975. Observations were made of beach form, sediments and the effect of sea ice and littoral processes on shoreline stability.

Beaches of Russell Island can be divided into four general types based on morphology, sediment type and the dominant process reworking them (see Fig. 30).

The four types are: (a) the high cliffed east coast which is frequently reworked by large storm waves (P5: 2, 3, 9);

(b) northeast, and southeast shores which exhibit wave-built features on a conglomerate gravel beach, (P5:4, 5, 6, 10)

(c) low relief southern shoreline with mixed sand and fine gravel beaches which are only reworked by small locally wind generated waves, (P5:7, 8)

and (d) moderate to low relief northern coast with sand, gravel and boulder beaches which are subjected to severe ice push and only minor littoral processes (P5:11 to 16).

(a) Along the eastern end of the island between Palmerston Point and C. Walker well developed steep cobble beaches from 240 m high boulder conglomerate cliffs. Conglomerate beach sediments range from fine gravels to large cobbles The entire beach zone as far as 50 m inland has been reworked by storm waves which is evident from the irregular, pitted beach of loose, noncompacted sediment.

Depth of the pits indicated that 2.0 to 2.5 m of mobile sediment are available for reworking by waves. The raised beaches at the foot of the cliffs are narrow, steep-sided and 1 to 2 m in elevation. At several localities scree from the

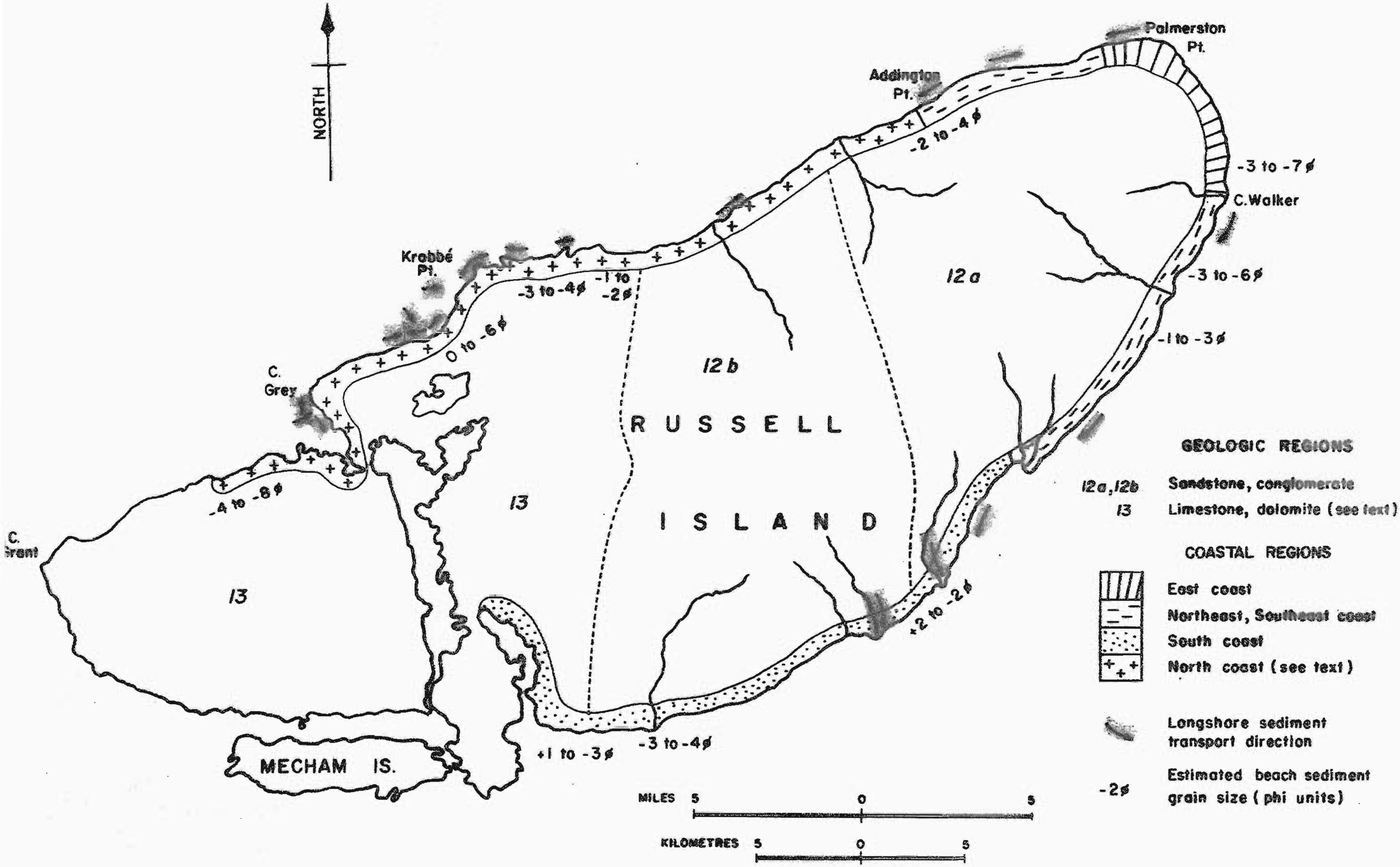


Figure 30. Geology, coastal types, and longshore sediment transport direction, Russell Island.

coastal cliffs and beach gravels cover shore fast ice. At Palmerston Point the beach is covered by a permanent snow patch extending approximately 0.5 km alongshore.

Although sea ice often grounds offshore, the eastern shore is predominantly built and reworked by waves. The conglomerate cliffs provide an ample supply of sediment for beach development.

(b) The northeastern shoreline to Addington Point and the southeastern shoreline to a point 15 km west of C. Walker constitute the second beach type. Here the beaches are composed primarily of conglomerate gravels but, near river outlets and areas where red sandstone is interbedded with the conglomerate outcrops, a mixed sand and gravel beach occurs. The active beach is either backed by a wide zone of well-developed raised beach terraces or a 0.5 to 2.5 m bluff (P5:6) which is the seaward limit of a steeper soliflucted slope. In both cases a plateau slope of 120 and 152 m occurs further inland. The active beach is 6-20 m in width; the narrowest beaches are backed by a low sand or gravel bluff.

Refracted beach ridges and tidal ridges suggest that these shores are primarily shaped by littoral processes.

(c) Further west to the large inlet which nearly bisects Russell Island (Fig. 30) the south shore is low and gradually sloping. The active beach is 3 to 10 m wide, less than 2 m in relief and backed by a gradual slope covered by vegetation. Near the larger rivers a wide sand plain exists but further east and west the beach sediments change to a mixture of fine gravel and sand. The sandy beaches have a hard compacted surface and the foreshore slope is characterized by minute tidal ridges which suggest reworking by small waves. The backshore shows signs of reworking by larger waves at some time in the past. Wave fetch is limited to less than 10 km but steep, short period waves could be generated by SW to SE winds. The absence of any large scale ice push or ice ridge features indicates that sea ice has little effect on this shoreline.

The red sand and gravel beaches change to a grey silty-limestone and siltstone gravel beach approximately 4 km east of the large inlet on Russell Island. The beach remains low but the sediments are coarser and more platy in shape. Boulders and cobbles become more common on the small headlands and fine chips of flaky gravel constitute much of the lower foreshore sediments. This type of beach continues northward along the inlet, however, in the embayments there is a larger proportion of sand sediments and also wider intertidal flats. Sections of the inlet shore are eskers covered by a thin layer of raised beach deposits.

(d) The northern shore of Russell Island, west of Addington Point, is a low to moderate relief coast which is modified by both sea ice and waves. The effects of sea ice are greatest along the coast west of Krabbé Point.

East of Krabbé Point the beach sediments vary from a mixture of grey siltstone and red sandstone to only red sandstone, then to a mixture of sandstone and conglomerate gravels nearer Addington Point. Outcrops of thin to medium bedded red sandstone are found in each of the river valleys beneath 1 to 2 m of unconsolidated material. Outcrops were also found along the beach ridges just west of Addington Point.

In some places, such as Krabbé Point (P5:12), waves have reworked the beaches sufficiently to build small tidal ridges and a relatively smooth slope. The rest of the shoreline is characterized by a more irregular foreshore slope of poorly sorted sediments, some of which are ice pushed deposits and others left by melting ice blocks which had rafted onshore. Ice push features are also common across the backshore and raised beaches. Near Krabbé Point the raised beach ridges are more irregular in shape and enclose numerous small ponds.

West of Krabbé Point the shoreline changes from a low, poorly developed muddy-gravel beach environment to very coarse 'felsenmeer' gravel-boulder beach near Cape Grey (P5:13). Bedrock, which is exposed along the backshore, accounts for the rocky 'felsenmeer' appearance. The beach sediment west of Krabbé Point is grey siltstone and silty limestone and dolomite. In 1975 these beaches were almost continuously fronted by grounded sea ice ridges with piles of mud to boulder sized material (P5:16). The beach zone affected by recent ice push was 20 to 25 m wide.

Along the small bay west of C. Grey there are small, narrow poorly developed sand beaches at the head of the bay. Instead of a normal beach foreshore the low vegetated sandy-gravel shore is fronted by a continuous line of ice pushed ridges of mud to gravel sized sediments (P5:14). These ridges of sediment have closed off intertidal areas and left shallow tundra ponds.

West of this bay the beach returns to a rocky, barren sandy dolomite shore. Sharp angular gravels are found on the raised beaches and angular to rounded cobbles (P5:15) are found on the narrow active beach. Travel further west to C. Grant was prohibited by the rough terrain of sharp angular gravels.

Beach Stability

Three profiles were established in 1975 along northern Russell Island (Fig. 31) but sequential surveys of these profiles have not been completed. Quantitative measurements of beach change are therefore not possible.

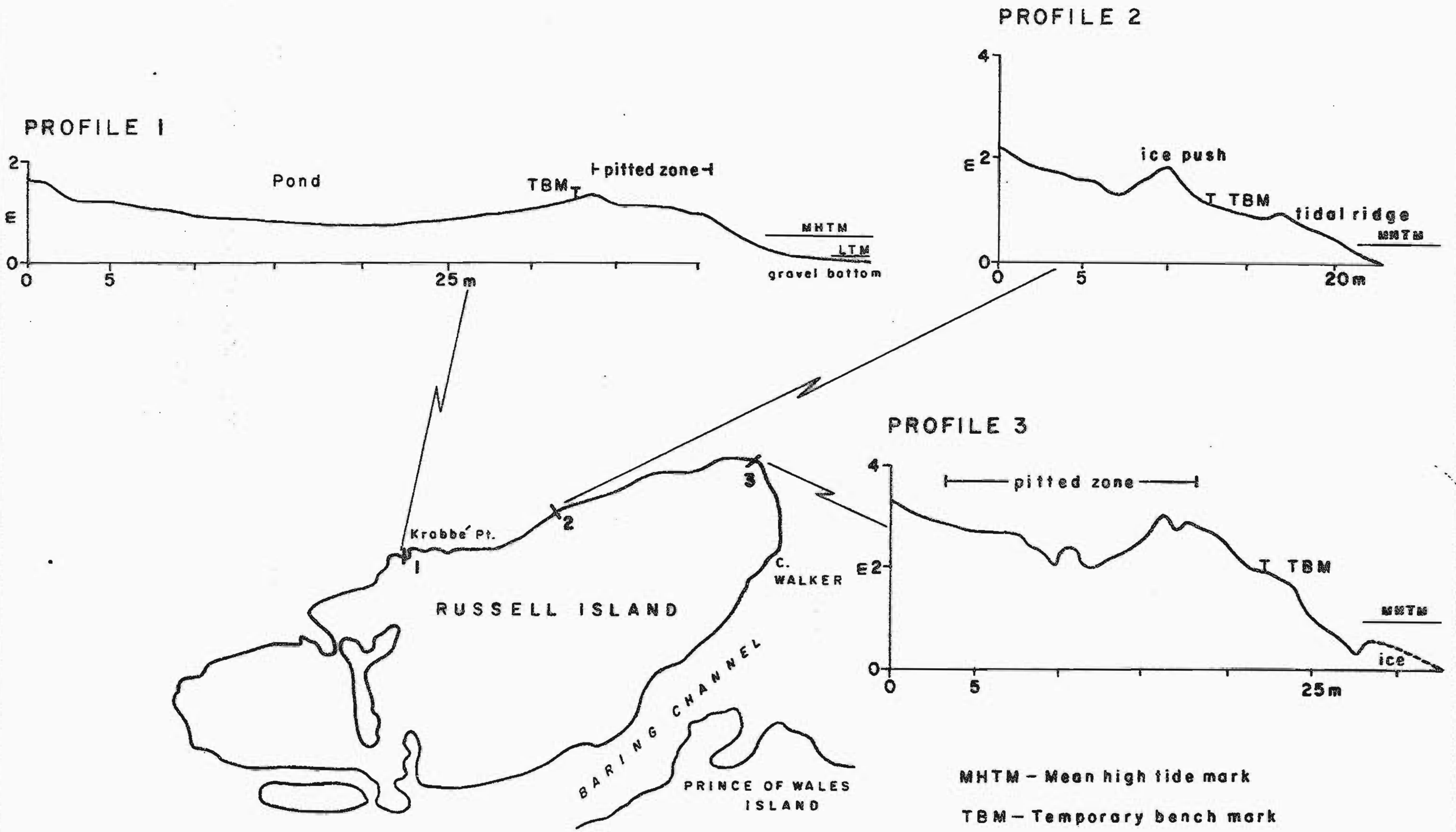


Figure 31. Beach profiles, 1975, Russell Island.

Based on field observations of sediment sorting and beach form it is apparent that littoral processes rework the beaches every year along the east and south shores of the island. Waves probably only rework the northern beaches during years of light sea ice cover. During more severe ice years the northern shore is more affected by sea ice pressures than littoral processes.

The east shore between Palmerston Point and C. Walker is thought to experience the greatest beach change because of thick deposits of loose sediment and evidence of modification by storm waves. The northwestern shore near C. Grey is more affected by sea ice which produces ridges of sediment alongshore which can be later reworked by waves.

From air photos the raised beach ridges suggest variable directions of sediment transport along northern Russell Island but along the southeast shore the dominant direction is to the west. In areas of considerable ice push the sediment source is offshore and the dominant direction of sediment movement is onshore. Some locally generated waves may move this sediment short distances along shore.

Ice Action

Frequency of grounded ice ridges and ice pushed mounds suggests that the effect of sea ice is much more pronounced on the northern and eastern shores than on the southern shore of Russell Island. Ice pushed mounds of 1 to 2 m relief were observed along the entire northern shore of Russell Island both on active and raised beaches.

As along northern Somerset Island grounded sea ice ridges were built at several places along northern Russell Island. Ice ridges up to 6 m in height were built along the shore at C. Grey (P5:16), Krabbé Point and Addington Point. Ice ridges were formed onshore and 100 m offshore of Addington Point while at C. Grey a series of 2 or 3 barriers of ice occurred an estimated 200 m offshore. The irregular beach slope and continuous piles of sand, gravel and boulders pushed up by ice along the coast from Krabbé Point to the bay just west of C. Grey suggests that sea ice plays the dominant role of beach building along this part of the island.

Further east between Palmerston Point and C. Walker, some grounded multiyear ice blocks and ice ridges were observed but the predominant feature was an almost continuous array of large ice pits occurring as much as 50 m inland. Most of the pits were less than 1 m in depth and diameter but a few were 2 m deep by 3.5 m wide.

Active Layer Thickness

A uniform mean active layer thickness of 0.39 m was measured across all three beach profiles on July 28, 1975. Thicknesses were measured using a hand auger. The shallowest active layer was recorded at water level and the maximum thickness, 0.66 m, was recorded at the edge of a pond on a raised beach terrace. Across the beach foreshore the active layer was thickest between mean and high tide mark where depths of 0.42 to 0.58 m were found. Although measurements were only collected once, they are thought to be representative of active layer thicknesses across the beaches of Russell Island during late July.

Suitability for a Marine Terminal

There are no natural harbours along Russell Island, however all but the eastern shores are low and wide enough to provide reasonably good landing beaches.

The only site where nearshore depths are thought to be too shallow is off Krabbé Point. There is probably little reason for locating a terminal on Russell Island but if facilities are planned for this island then the eastern and northern shores should be avoided because of the frequent occurrence of ice ridges and sea ice rafting.

Southeast Russell Island probably presents the best location for future development. Sea ice breaks up earlier, medium to coarse cobbles provide good construction aggregates and there are well-developed raised beaches for construction of an airstrip. The presence of a large river also provides a good summer water supply.

SOMERSET ISLAND

by R.B. Taylor

Introduction

Detailed investigations of beach form, sediment and profile change were completed along the coast between Garnier Bay and Pressure Point from 1973 to 1976. In addition, a brief reconnaissance was made of the shore further east to C. Admiral McClintock and west to C. Granite.

Physiography

Fifty-five percent of the length of coast between Garnier Bay and Aston Bay (Fig. 32) consists of well developed sequences of gravel raised beaches. Of this amount sixteen percent are backed by plateau slopes which reach 150 m in elevation within a kilometre of the shoreline. Cliffed shores are limited to four localities: Pressure Point, just west of Cunningham and 'Trebor' Inlets and at C. Rennell. All localities except for C. Rennell are fronted by a narrow active beach. Low sandy beaches, e.g. 'Peel Sound Lowland', tundra ponds and emerged barrier beach ridges constitute a further thirty-one percent of the coast. Barrier ridge-lagoon complexes are best exemplified along the shore between Garnier Bay and 'Trebor Inlet'. The remainder of the coast is composed of river deltas.

The interior of northern Somerset is almost completely covered by a Paleozoic upland surface underlain by limestone and dolomite assigned to the Read Bay formation. A small area between Pressure Point and 5 km east of Cape Anne is underlain by conglomerates, red sandstone and siltstone of the Peel Sound formation. The 'Peel Sound Lowland' formed within this area is a wide sandy plain backed by pseudo-badland topography (P9:9, 10, 11).

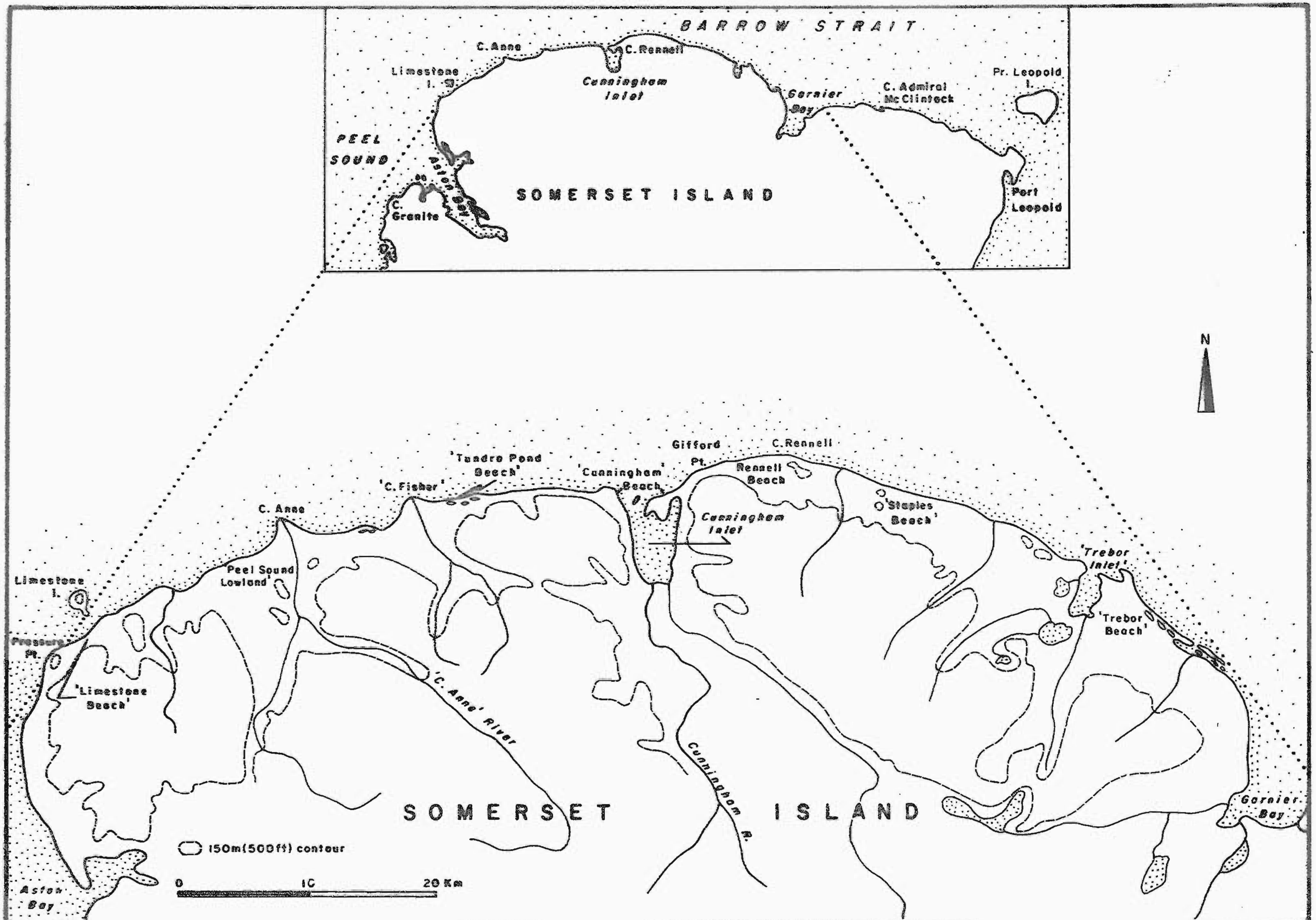


Figure 32. Beach place names, northern Somerset Island.

West and south of Aston Bay there are two additional regions divided on the basis of geology. The first is along western Aston Bay where raised beaches and low bluff coast prevail. Underlying this area are Proterozoic dolomite, sandstone, siltstone and cherty dolomite hence the beach sediments are different from those of northern Somerset. Lastly, at Cape Granite rocky headlands and pocket beaches occur (P10:5 to 8). The beaches consist of grus with a grain size approximating the size of crystals (2-5mm) in the granitic parent rock. The sand size material derived by breakdown of individual crystals provides the matrix of this fine pebbly gravel whose depth varies from less than 1 m to more than 2 m (Netterville et al., 1976).

Lakes are most common between Garnier Bay and Cunningham Inlet. Several rivers cut across the north coast of Somerset Island, the largest of which are the Cunningham, Garnier, 'Cape Anne' and Aston rivers. Except for the rivers flowing across the 'Peel Sound Lowland', all contain clear water except at peak flood stage.

Bathymetry

Offshore along northern Somerset Island bathymetric information is relatively complete, as shown by Hydrographic charts FS31255C (1961), 7503 (1972) and Natural Resource map 26240-A (1976). Soundings are fewest in the nearshore and no depths are published for Aston Bay.

The 20 m isobath lies 0.5 to 1.5 km offshore along Somerset Island between 'Peel Sound Lowland' and 'Trebor Inlet' and increases to 2.5 km offshore farther east of 'Trebor Inlet'. The most extensive nearshore platforms are generally offshore of the tundra pond or barrier ridge-lagoon coastal morphologies.

Water depths of less than 5 m are found in the western part of Garnier Bay; the entrance to the bay, except for a narrow channel on the east side, is less than 20 m depth. Similarly, the entrance to Cunningham Inlet is flanked by depths of less than 5 m. A narrow channel, which is nearly cut off on the seaward end by shoals, extends through the entrance of the inlet to the main body but even this channel is less than 10 m deep. The main part of the inlet is deeper than 15 m and reaches a maximum depth of 39 m along the western side.

Oceanography

Tides

A mixed semi-diurnal tide occurs along northern Somerset Island. Mean tidal range is 1.61 m at Port Leopold on the NE corner of the island and 1.2 m at the entrance to Cunningham Inlet. A brief monitoring of tides at 'Staples Beach' in 1972 indicated a mean tidal range of 1.28 m. Along Barrow Strait tidal ranges progressively decrease towards the west; this is thought to be the case along northern Somerset Island even though data is not available from the northwestern end of the island.

Currents

In the 1800's Young observed a 1.5 m/second current setting east through the channel between Limestone Island and Pressure Point (Pilot of Arctic Canada, Vol. II, 1968). In the nearshore off the NW headland of Cunningham Inlet easterly currents of only 0.03 to 0.3 m/second were estimated using drogues. Much stronger currents of up to 0.85 m/second were recorded in the entrance channel to the inlet. Tidal currents are the dominant current along this coast and from ice observations the net movement of water is eastward.

Waves

Wave fetch is limited to less than 81 km to the NW by Cornwallis and Griffith Island and less than 100 km to the NE because of Devon Island. However, north of 'Staples Beach' a fetch of over 120 km is possible, given open water conditions in Barrow Strait and Wellington Channel.

No continuous record of wave parameters has been kept nor is one available for northern Somerset Island. Generally, wave heights and periods were visually estimated during storms but it was not until August 1975 that daily wave observations were collected. Unfortunately during the 1975 and 1976 observations low energy wave conditions existed because of sea ice offshore. During these two seasons waves of less than 5 second period and 0.2 m height were recorded at the beach.

The largest recorded storm occurred in August 1974 when easterly 45-72 km/hr winds coincided with maximum spring tides. Waves of estimated 8-14 second period and over 1 m height struck the open coast along Barrow Strait and 2 to 3 second waves of up to 1 m were recorded within Cunningham Inlet.

Sea Ice

Information on sea ice cover along northern Somerset Island prior to 1974 was acquired from observations collected by sea ice observers of Atmospheric Environment Service and Polar Continental Shelf Project (Lindsay, 1975). From 1974-76 concentrations of sea ice were mapped by the author whenever a helicopter was available for use and by using Landsat imagery.

The breakup of ice along Somerset Island is dependent upon the removal of sea ice form Lancaster Sound-Barrow Strait. During the past five years ice has

TABLE 9

Length of Open Water Season 1972-76, N. Somerset Island

YEAR	BREAKUP	FREEZEUP	NO. OF DAYS
1972	July 26	Sept. 7	43
1973	July 24	Oct. 3	71
1974	July 22	Oct. 2	72
1975	July 9	*Sept. 10	63
1976	July 20	*Aug. 31	42
		Mean	58

*Sea ice lined coast preventing waves reaching coast even though new ice melted in early September.

TABLE 10
Depth of Active Layer at Beach Sites, Northern Somerset Island

LOCATIONS	DATE	MEAN THICKNESS	(max)	DATE	MEAN THICKNESS	(max)
Limestone 3	6/7/74	20	(32)	24/8/74	27	(47)
Peel Sound 2	7/7/74	28	(34)	24/8/74	60	(82)
Tundra Pond 2	7/7/74	24	(31)	22/8/74	32	(49)
Cunningham 3	19/7/74	22	(27)	30/8/74	37	(44)
Rennell 2	9/7/74	18	(25)	8/8/74	22	(42)
Staples 3	4/7/74	18	(32)	26/8/74	44	(63)
Trebor 3	10/7/74	24	(38)	no	data	

NOTE: Depths are in centimetres

broken up in Barrow Strait by early July and as early as mid-June in 1974 and 1976. Shorefast ice clung to the Somerset coast until the third week in July except in 1975 when it was melted by July 9. Prevailing winds in the strait influence the summer ice conditions, hence wave fetch. For instance, in 1972 and 1976 nearly continuous NW to WNW winds blew and kept large concentrations of ice along the northern Somerset coast for most of the summer. In contrast, prevailing SE winds in August 1974 blew sea ice away from the Somerset coast.

In general, nearshore ice begins to re-form by mid-September but sustained winds could delay final freezeup. Therefore, the average length of the open water period along the study area between 1972-76 was 58 days (Table 9).

Sea ice generally breaks up in Garnier Bay and Cunningham Inlet by the first week in August but breakup is delayed in Aston Bay until late August. In 1976 the sea ice never left Aston Bay. During the past four seasons ice has begun to reform in all three bays by mid-September.

Coastal Environment

Materials and Processes

Most of the shoreline exhibits sequences of gravel raised beach deposits, with individual ridges generally less than 1 m high, but extending to 100-120 m above sea level. The modern or active gravel beach varies considerably in width and foreshore slope depending on sediment size and the degree of reworking by waves or sea ice. Generally steeper slopes are associated with coarser beach sediments and areas affected by sea ice grounding. On 'Staples Beach', which is representative of most of the gravel beaches on northern Somerset Island, average width and slope of the foreshore was 7-10 m and 7°-8°, respectively.

Beach sediments were sampled at each of the 41 established beach profiles on August 24, 1974. The sediment was collected from the raised beach and mean and low tidal levels. Except for the sediment collected from 'Peel Sound Lowland' the average sediment size was -2.0 to -5.0ϕ (4 to 32 mm). The proportion of sand in each sample was small except in areas of considerable rill wash or adjacent streams or tundra ponds. At 'Peel Sound Lowland' mixed sand and gravel beaches were found with sediment ranging from +1.4 to -3.9ϕ (0.38 to 16 mm). The bimodal nature of sediment is a result of the exposures of sandstone and conglomerate rock at the headlands and fluvial deposits transported seaward from the inland hills.

This red sandy beach, with ripple marks and sand bars built across the nearshore, constitutes the only known example of a true sand beach environment along eastern Barrow Strait. Intertidal flats, as wide as 25 m are also characteristic of this environment.

The proportion of gravel in the beach sediment increases toward the edges of the lowland and adjacent to the stream outlets. The beaches became narrower and the raised beach ridges became more prominent with increasing proportions of gravel.

Although not unique as a coastal type along Barrow Strait, the complex of barrier ridges, lagoons and ponds between 'Trebor Inlet' and Garnier Bay forms a coastal environment different from the rest of northern Somerset Island (P7:1-6). These beach ridges occur on a wide nearshore platform where a water depth of 2 m extends several hundred metres offshore. The barrier beach ridges are 60 to 70 m in width and have been built from 1.4 to 2.6 m above sea level. Many of the smaller ridges are subject to breaching and overwash by waves. Small local waves generated within the lagoons or ponds also rework the inner shores of the ridges.

It was observed during aerial surveys that exposures of bedrock extend seaward from the more developed beach ridges, particularly those trending NE-SW. A preliminary hypothesis is that these exposures of rock, perpendicular to the shoreline, act as natural groins trapping beach sediment as it is transported along shore by waves. Increasing accumulations of sediment in the nearshore and beach zones are reworked by waves, many of which have been refracted as they pass over the nearshore platforms, creating the intricate pattern of beach ridges parallel to shore. Secondary beach ridges are also formed by small waves formed locally within the lagoons. The present extensions of beach ridges both east and west suggest longshore transport of sediment in both directions by waves. The largest barrier beach ridges have been built by waves over a substantial time period as the shores emerged with isostatic uplift.

Rocky shore platforms, similar to those found on Bathurst Island, also extend perpendicular to the shoreline east of Garnier Bay. The rock platforms are composed of dolomitic limestones which appear to be less resistant to weathering and erosion than the platforms on Bathurst. Beach sediments have accumulated between the ends of the rocky promentories forming beach ridges running east-west. Lagoons, then tundra ponds are created as the ridges close off the waters between the promentories.

Beach ridges were also built parallel to shore across other extensive nearshore platforms to either side of 'Cape Fisher' (P6:3; P9:1-3). Tundra ponds have been formed behind these beaches as the lagoons were closed off from the sea.

There were no clear trends in beach sediment size or sorting for any distance along shore which could suggest a variable direction of longshore transport of sediment over short distances. However general trends in sediment size were observed across the beach profile. Across the beaches west of Cunningham Inlet the beach gravels progressively decreased in size downslope; however, across the beaches east of Cunningham Inlet the coarsest sediment was observed near low tide level.

The different trend in sediment size across the beach is attributed to the storm of August 16-19, 1974 when waves severely eroded the beaches east of Cunningham Inlet but caused little change to the more western beaches. From the sediment analysis it is apparent that the coarser gravels were combed downslope and deposited at the base of the foreshore. Changes to the beach profile are dealt with in more detail in the following section on beach stability.

Beach Stability

Initially in 1972 and 1973 coastal investigations were limited to 'Staples Beach' but after July 1974 beach profiles were established along the entire coast between Garnier Bay and Pressure Point (Fig. 32). These profiles were resurveyed as the shorefast ice melted and whenever they were subjected to storm waves during the summer seasons of 1972-76.

Between July 1972 and August 1973 'Staples Beach' experienced only minor change. Sediment accretion occurred across the upper foreshore and northwest facing shores were subject to ice push during July 1973. Ice steepened the upper beach slope and broken blocks of ice were left beneath the resultant gravel ridges. Net profile change from July 1972 - August 1973 did not exceed 3.1 m^3 at any one profile.

Snow and ice still covered much of the lower beach slope in early July 1974 but field observations again suggested minor changes. The ice pushed ridges were lowered in height as the ice blocks melted and slight erosion and accretion was measured at various profiles along 'Staples Beach'.

The first storm waves to rework the northern Somerset shoreline occurred on July 22-25 when waves of 7 to 8 second period broke up much of the shorefast ice, some of which was thrown up onto the upper foreshore. Breaking waves combined with oscillating sea ice eroded the mid to upper beach slope and sediment was deposited at the base and sides of grounded ice blocks or remnant shorefast ice. Net erosion did not exceed 1 m^3 at any one profile.

After July 25, until the next survey on August 14, 1974, locally generated waves of 0.5 to 1.0 second period smoothed the beach slope filling in pits left by melting brash ice. Shorefast ice still protected 'Rennell Beach' from wave action but elsewhere along the coast tidal ridges were built indicating movement of beach sediment upslope.

From August 16-19, 1974 strong 45 to 72 km/hr winds from the ESE to NE generated 8 to 14 second period waves in Barrow Strait which had a minimal sea ice cover of 3/10. These waves, combined with maximum summer tides, produced the greatest changes to the northern Somerset coast since 1972. In Cunningham Inlet choppy, 1 m high, 2 to 3 second waves modified the western shore and transported sediment north along shore. Along Barrow Strait the greatest beach changes were experienced by NE facing shores, especially those east of Cape Rennell. At 'Staples Beach' sediment, kelp and brash ice were deposited in the backshore and a large gravel ridge was built at the top of the foreshore, commonly over ice blocks. Sediment accretion occurred at profiles located on the northwest side of embayments or the western side of nearshore shoals. Erosion was greatest on easterly facing shores which were more directly aligned with the angle of wave approach. Volumetric beach profile change varied from $-18.7 m^3$ to $+14.8 m^3$ at 'Staples Beach' and longshore transport of sediment was to the west.

Further west along northern Somerset Island less beach change was experienced because of the more oblique angle of wave approach. At 'Rennell Beach' a maximum of $6.8 m^3$ of erosion occurred at one spot while at 'Cunningham Beach' and 'Tundra Pond Beach' net change was less than $2 m^3$. Erosion occurred on the mid to lower beach foreshore, exposing bedrock at several 'Cunningham' profiles and a storm ridge was built at HHTL.

After August 22 winds and waves from a WNW to NNW direction were smaller and more constructive. The lower foreshore was partially rebuilt along with three tidal ridges. Storms occurring in September had less affect on the beach because of a narrow accumulation of mobile ice along shore. Nevertheless, nearshore sediments were entrained and transported shoreward and the sea ice was broken down into brash ice. Both sediment and ice were transported upslope during a second storm from the NW on September 9-13, 1974. Whereas waves from the E had eroded profiles 1 and 2 of 'Staples Beach' in August, these NW waves in September returned the sediment, filled in the lower foreshore and added sediment to the previously built storm ridge. Accretion was as much as $15 m^3$ at profile 1 on 'Staples Beach' but less than $5 m^3$ at any one profile on 'Cunningham Beach' or 'Tundra Pond Beach' (Fig. 32).

Shorefast ice left the northern Somerset coast on July 9, 1975 exposing a very irregular, pitted and mound beach profile which resulted from the September 1974 storms. The beach profiles were not resurveyed again until early August because of the absence of medium to high energy waves. The beach slope was smoothed out and, although waves built several small beach ridges during higher tidal levels in early August, beach change was minimal. At all of the surveyed beaches less than 5 m^3 of change was recorded at any one profile. Heavy snow fall and calm cold conditions in early September resulted in a rapid coastal freezeup in 1975.

East Barrow Strait contained open water in early June 1976 which permitted the generation of waves early in the season. In late June storm waves threw nearshore sediments, kelp and brash ice up onto the icefoot and backshore of beaches lining northern Somerset Island. However, no change occurred to the beach slope because of the presence of an icefoot until at least July 20. Prevailing WNW-NW winds throughout August virtually closed off the Somerset coast with 7-9/10 ice cover. For the rest of the season the only wave action of any size occurred in Cunningham Inlet which remained open because the shallow entrance prevented sea ice from entering. During the three seasons 1974 to 1976 the greatest beach changes were experienced in 1974 along the Somerset coast.

Net beach profile change has not been fully analysed over the three year period however some trends are now evident. Slight erosion was experienced at 'Limestone Beach' while accretion occurred along both 'Peel Sound Beach' and 'Tundra Pond Beach'. Further east along the Somerset coast greater and more variable changes were experienced. For example, east of Cunningham Inlet, at 'Staples Beach', the maximum net change at one profile from 1974 to 1976 was 15 m^3. However, the extent of change at any one location west of Cunningham Inlet was less than 4 m^3.

Storms of similar magnitude blowing from the east or west generally resulted in similar amounts of change to the beach, however waves from one direction eroded the beach, while waves from the other direction built up the beach. This suggests a back and forth movement of sediment along shore which would account for the smaller net beach change over the longer term than over one major storm. The dynamic equilibrium of these beaches could be upset by the construction of coastal engineering structures.

Ice Action

The entire northern Somerset coast has been affected to some degree by sea ice. Ice push and ice melt features were found onshore and sea ice ridging, rafting and scouring of the sea bed were observed in the offshore.

The smaller scale ice push and ice melt features can occur virtually anywhere along this shoreline whereas the larger ice-formed features were observed on northwest facing capes and headlands. In particular, from 1974 to 1976, six locations were observed to be most frequently subjected to sea ice pressures. They were Limestone Island - Pressure Point, Capes Anne and 'Fisher', 'Cunningham shoal', 'Rennell Beach' and 'Staples Beach' (Fig. 32).

In July sea ice usually breaks up in Barrow Strait and moves eastward. This is followed by an influx of sea ice from adjoining channels. Prevailing winds over Barrow Strait in July are from the NW quadrant. These can combine with the cold arctic current flowing south through Wellington Channel to push most of the sea ice against the northern Somerset shoreline.

Figure 33 Sea ice ridges and icepush, northwest shore of 'Cape Fisher' Somerset Island.

The occurrence of sea ice ridging and rafting was least in 1974 because open water prevailed in Barrow Strait for most of the summer. Only on July 26-31, when large quantities of ice were blown out of Wellington Channel against the Somerset coast, did ice ridging occur. Ice ridges were best developed on July 9-12, 1975 and July 12, 1976. Ridges averaging 3-15 m in height were formed on the nearshore shoals, on grounded multi-year ice blocks or across the beach slope. The largest ice ridge was observed on July 12, 1976 just east of C. Rennell. Using a helicopter altimeter, the height of the ice pile was estimated to be 24-30 m.

During both years the ice ridges were built as the tides rose to their highest level of the month. Formation of the ridges is rapid and, once begun, is generally continuous. For instance, a 12.0 m high ice ridge was built along 'Cunningham Shoal' in less than 4 hours.

Where the ice ridges were built onshore, ice blocks were often forced inland causing extensive ice push to the beach.

The most extensive and long lasting set of ice ridges were formed on the NW side of 'Cape Fisher' (P9:1 and Fig. 33). In July of 1973 ice piled into ridges approximately 11 m high and as far as 15 to 60 m inland. One large ice floe was forced 185 m inland across the beach. These ice ridges, because they formed above normal wave action, lasted 3 years and were only melted by solar radiation. In contrast, ridges formed in the nearshore or on the beach slope were eroded quickly in 10 to 40 days and 60 days respectively, given wave action. The 15 m high ridge at C. Rennell was eroded over 3 days of continuous wave action in August 1975.

Multi-year ice blocks and ice island fragments also ground in the nearshore along Somerset Island throughout the summer season as sea ice floats eastward through Barrow Strait. Normal ice push and ice melt features which occur throughout the summer generally do not exceed 1 m in height or depth respectively. Ice push scars are oriented to the NE and NW and only affect the shoreline morphology for any length of time if they occur above HHTM.

The continual presence of ice impinging on the northern shore of Somerset Island through the open water season limits wharf selections to bays or inlets but some shelter can be obtained along the NE facing shores of capes or headlands.

Active Layer Thickness

A detailed survey of active layer thickness across the modern beach was completed using a hand auger in 1974 across each of the beach profiles. Depths were recorded most frequently at 'Cunningham' and 'Tundra Pond' beach while at the other beaches measurements were only collected at the beginning and end of the melt season. At the first two beaches the active layer thickness progressively increased from a mean of 0.18 m in late June 1974 to 0.37 m on August 30 and by September 11, 1974 air temperatures below -1.8°C reduced the active layer to 0.29 m. In table 10 active layer thickness is listed for one representative profile from each beach at the beginning and end of the 1974 melt season. Initially the average thickness of the active layer was 0.22 m but spot measurements indicated thicknesses of up to 0.38 m. By late August active layer depths had increased to an average of 0.40 m.

The thickest active layer was recorded across the sandy beaches of the 'Peel Sound Lowland' where a maximum thickness of 0.82 m and average of 0.60 m was measured in late August of 1974. The sand was better able to absorb and retain the incoming solar radiation than was the more porous coarse gravels along the other profile locations.

An examination of measurements collected in 1975 and 1976 at the same beach profiles showed a similar range in active layer thickness. However, because of the early spring melt in 1975 the active layer was thicker at the beginning of July than in 1974 but in both years beach freezeup occurred in early September. The only difference found in 1976 was the shallow active layer occurred in late August. Shallower depths occurred because of the snowfall and colder air temperatures experienced at that time.

Active layer thickness was also measured in 1975 on the various terrain units of Somerset Island by Netterville et al. (1976). In the regions of northern Somerset the range of values found was 0.35 to 0.75 on the upland surface and 0.40 to 0.73 on the coast. These values for the coastal zone were slightly greater than those in Table 10 because the measurements were primarily made on the raised beaches which had been free of snow longer than the beach foreshore.

Ground temperatures were also monitored across the beach slope at Cunningham Inlet from 1974-76. The maximum depth penetration of the 0°C isotherm occurred in mid to late August. The deepest penetration was 0.82 m in August 1974 but generally ground temperatures greater than 0°C were restricted to above a depth of 0.50 m.

In summary, the frost table is nearest the surface on the lower foreshore in spring but in fall, when temperatures have fallen below zero, the frost table returns to the surface quickest across the upper beach and backshore. Fall freezeback of the lower foreshore is delayed by waves and the moderating influence of the sea.

Suitability for a Marine Terminal

Introduction

Natural harbours with depths greater than 10 m are nonexistant along the northern Somerset coast. Nevertheless, in the event that shallower draft barges are utilized to transport supplies to the Arctic, both Garnier Bay and Cunningham Inlet are examined in terms of their suitability as port locations.

Garnier Bay

Garnier Bay is 6 km wide at the entrance and extends 6.6 to 7.0 km southeastward where limestone hills and plateau slopes rising to 330 m in elevation outline the head of the bay (P6:12, 13, 14). A 3 to 6 m high rock escarpment is mapped along the backshore along parts of the east and west side of the bay, and flights of raised beaches occur above the escarpment (P6:15).

Construction Materials

The bedrock surrounding Garnier Bay has been mapped as argillaceous and silty limestone of the Read Bay formation (Fortier *et al.*, 1954). A closer examination of the bedrock exposed on the northeast headland revealed a dolomitic limestone of yellow brown colour and 'sugary' surface texture.

The beach deposits are generally angular limestone shingle of -3 to -5ϕ size but nearer the rock outcrops of northeastern Garnier Bay the sediments range up to boulder size and become less platy and more blocky in shape. The presence of bedrock along shore, offshore and in the backshore suggests the presence of only a thin veneer of beach gravels. Sand and gravel would be available from the two large river deltas at the head of the bay. Finer sands and silts may be available in limited amounts from the lagoons and ponds between 'Trebor Inlet' and Garnier Bay.

Navigation

Very shallow depths at the entrance to the bay restrict usage to barges or ships with shallow draft. One narrow channel of just over 20 m depth extends to a deep section of the bay near its head. Maximum depths are shown as 50 m on Hydrographic field sheet 31255C (1961) but as 31 m on Hydrographic chart 7503

(1972). Depths of less than 5 m line both shores of the bay and extend into the central part from the western shore. However, if the ships entering the bay could anchor behind these shoals some protection from drifting sea ice would be provided.

Sea ice breakup in the bay is variable but open water generally occurs by late July or early August. New ice is often found reforming in the bay by mid-September.

Wharf Site

Two possible sites where wharfs could be built out to the deeper channel would be off the rocky northeast headland or along the south side of the shoal on the western side of the bay. Neither site is ideal and landing barges would probably provide a better means for unloading equipment. The first site is directly in line of sea ice drifting into the bay under prevailing northwest winds. The second choice lacks a wide beach for roads or storage of freight. The only extensive raised beaches occur at the northwest or northeast corners of the bay.

Airstrip

Pressman et al. (1961) chose a site along the beach ridges back from 'Trebor' beach as a possible location for a 1524 m (5000 ft) emergency aircraft landing strip. There are no obstructions to flight within approach limits in either a WNW or ESE direction. However, numerous ponds in the area would limit development of any large town or storage facilities.

Water Supply

The best source of water would be from the two large rivers entering the head of Garnier Bay. The numerous ponds in the area are too small and too shallow to support any year round population.

Cunningham Inlet

Cunningham Inlet is 7.6 km long and 6.1 km wide at its entrance, tapering to 3.1 m wide at its head. The inlet is bounded on both sides by 182 - 213 m high plateau slopes which are lined by raised beach terraces. There are only two narrow channels entering the inlet and one is less than 2 m deep. The rest of the entrance to the inlet is closed off by a tombolo and a small island.

Construction Materials

The most widespread sources of aggregates are the limestone beach deposits but the largest single source of sand and gravel is the Cunningham River Delta. South of the inlet, within the river valley, are substantial deposits of sand and silt. Bedrock is exposed along the entrance and shores of the inlet but most of the inlet floor is covered by very fine silt and clay.

Navigation

Shallow water depths at the entrance to the inlet prohibit all but shallow draft barges from entering the inlet. A 0.5 km wide channel enters the inlet but depths at the seaward end are less than 2 m at low tide. The southern end of the channel is over 10 m deep and depths of over 15 m are found throughout the main body of the inlet.

Sea ice breakup generally occurs at the entrance and delta in early July and most of the sea ice leaves the inlet by early August.

The high relief coast provides good fixes for radar but the low peninsula and small island at the entrance could prove hazardous to ships.

Wharf Sites

No site is safe from sea ice pressures near the entrance to the inlet. During the open water season sea ice drifts in and out of the inlet with the changing tides. Even the small embayments along the western shore of the inlet are catch basins for drifting sea ice.

Airstrip

The only extensive beach ridges suitable for construction of an airstrip are found at the northwest corner of the inlet adjacent to the entrance.

Water Supply

The only substantial supply of water would be from the Cunningham river but it is thought to cease flow during winter. A large lake exists southeast of the inlet toward Garnier Bay which could provide a year-round water supply.

Other Possible Sites

The only other large bay along northern Somerset Island is Aston Bay but because of the lack of bathymetric data and long periods of sea ice cover it has been eliminated as a possible terminal site.

If supplies or equipment must be landed and stored along northern Somerset Island, the northwest shores of major capes and headlands should be avoided because of frequently recurring large ice ridges (Fig. 33). As an alternative, cargo could be stored about 300 m inland along the more sheltered northeast facing shores of capes or headlands.

BATHURST ISLAND

by R.B. Taylor

Introduction

Coastal processes and beach morphology were examined in detail at two locations on Bathurst Island. In 1972 and 1974 Hooker Bay on west central Bathurst Island was examined and in 1974 and 1976 the coastline of Intrepid Passage and McDougall Sound along southeastern Bathurst Island was studied. An aerial reconnaissance was also completed in 1974 along the coast between the two detailed study areas.

Hooker Bay, West Bathurst Island

Physiography

Hooker Bay lies between two types of coastal environments. To the south is a low, flat featureless plain which is crossed by many small streams. Near De la Beche and Peddie bays (Fig. 34) the broad sandy beaches rise gently to a low vegetated plain further inland (P11:2, 8, 9). Although the land surface remains low (90 to 125 m) several kilometres inland there are three prominent hills rising up to 186 m a.s.l.. The hills occur at C. Cockburn, south of De la Beche Bay and just south of Hooker Bay. The underlying bedrock of most of southwestern Bathurst Island is quartz sandstone of the Hecla Bay formation (Kerr, 1974).

North of Hooker Bay there is a much more irregular coastline with numerous islands and peninsulas extending in an east-west direction. The beaches of Bracebridge Inlet are narrower and the coastal relief is steeper and higher (60-150 m). Rock outcrops are frequently observed along the shores of the islands in Bracebridge Inlet. Bedrock varies between sandstone, siltstone and limestone of five different geologic formations.

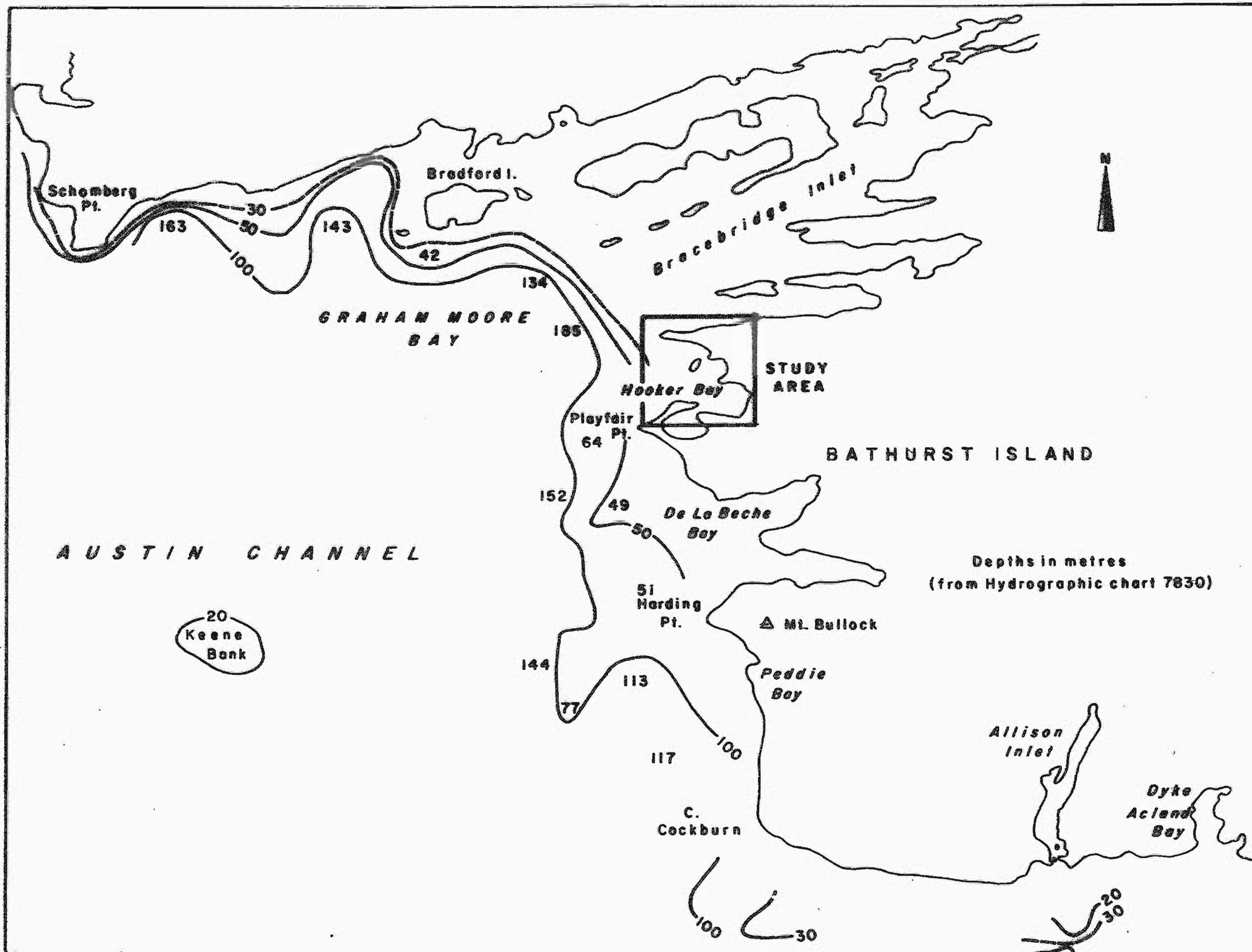


Figure 34. Place names and bathymetry, western Bathurst Island.

Bathymetry

No depths are published for Hooker Bay, Bracebridge Inlet or De la Beche Bay. The scarcity of the data presented on Hydrographic chart 7830 (1974) suggests that very little is known about the nearshore bathymetry along western Bathurst Island. It can only be assumed that depths within the bays are less than 30 m which is the shallowest isobath plotted. An examination of air photos shows that nearshore shoals and tidal flats occur within Hooker Bay and De la Beche Bay.

Nearshore depths greater than 100 m are encountered off Cape Cockburn and in Graham Moore Bay. A very large shoal known as Keene Bank (Fig. 34) is observed in mid-Austin Channel but it is too distant to affect coastal processes within Hooker Bay.

Oceanography

Tides

A brief examination of the daily tidal oscillations was conducted in front of the base camp at Hooker Bay, between the hours of 10:00 C.S.T. August 6th to 03:00 C.S.T. August 7th 1972. Measurements of the water level were obtained every half hour, using an level and surveying staff. The data from Hooker Bay was, for purposes of analysis, compared to the predicted tidal heights and times for Winter Harbour (Viscount Melville Sound), the closest appropriate secondary port, and Tuktoyaktuk, the tidal reference port (Table 11).

A mixed semi-diurnal tide occurs at all three locations and the mean range in tide is less than 1.0 m. Mean tidal range was greatest at Winter Harbour (0.97 m) and least at Tuktoyaktuk (0.18 m); Hooker Bay had a range of 0.68 m (Fig. 35). The tidal period, a function of geographical position, was longest at Hooker Bay (13 hours) and shortest at Tuktoyaktuk (11.5 hours).

TABLE 11

Comparisons of Hooker Bay with Tuktoyaktuk and Winter Harbour

LOCATION	HIGHER HIGH WATER MEAN TIDE	HIGHER HIGH WATER LARGE TIDE	LOWER LOW WATER MEAN TIDE	LOWER LOW WATER LARGE TIDE	MEAN WATER LEVEL	RANGE MEAN TIDE
Tuktoyaktuk*	0.60	0.70	0.30	0.20	0.40	0.30
Winter Harbour*	0.37	0.64	-0.24	.40	0.49	0.91
Hooker Bay (proposed values)	0.39	-	0.15	-	-	0.68

*published values

	MEAN HIGH TIDE	MEAN LOW TIDE	MEAN WATER LEVEL	RANGE MEAN TIDE	PERIOD (IN HOURS)
Tuktoyaktuk†	0.06	0.12	0.54	0.18	11.5
Winter Harbour†	0.34	0.60	0.83	0.97	12.0
Hooker Bay°	0.25	0.39	0.39	0.65	13.0

† predicted values

° observed values

NOTE: All heights given in metres

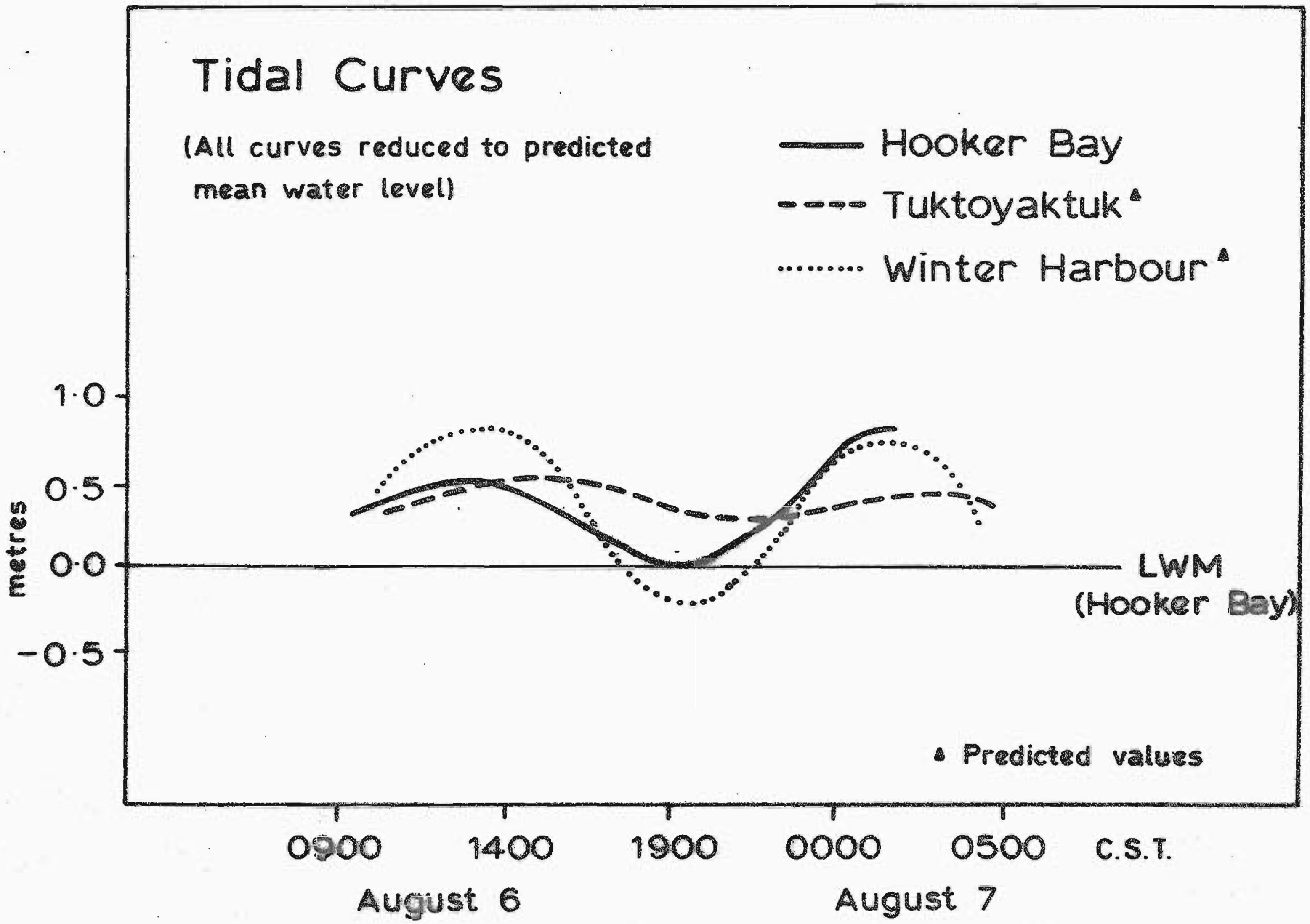


Figure 35. Tidal information, Hooker Bay, Bathurst Island.

Currents

There is no published current data, but, from observations of the general drift of sea ice it is apparent that there is a dominant south-flowing current in Austin Channel.

Waves

No information is available.

Sea Ice

Ice observations conducted by Atmospheric Environment Service and Polar Continental Shelf (Lindsay, 1975) provide the only sea ice record prior to 1972. However, Landsat imagery now provides an additional source of ice data. No information is available for ice cover in the small bays but some general comments can be made about seasonal ice conditions along western Bathurst Island.

In July the channels and inlets are completely covered with multi-year or thick winter (first year) ice and, except for the initial formation of tidal cracks and leads and the melting of surface snow, little breakup occurs. By mid-August the bays contain open water or at least a well-developed shore lead. In addition, sea ice starts to break up in Austin Channel and open water extends northward from the south end of the Channel. Early ice breakup often occurs off the southwest corner of Bathurst Island where a polynya forms in mid-July. Open water can also expand from Bracebridge Inlet, creating open water in Graham Moore Bay by late August, even though sea ice is still present in Austin Channel. Maximum open water conditions occur in the first two weeks of September.

An estimate of the average open water season offshore from Hooker Bay is 25 to 30 days, from late August to late September. Waves formed locally within the bay can operate on average for as many as 44 days.

Freezeup probably occurs early within Hooker Bay because of its shallow bathymetry and sheltered location from larger waves generated in Austin Channel.

Coastal Environment

Materials and Processes

The area of detailed beach investigations extended from the southwest corner of Bracebridge Inlet to the south shore of Hooker Bay (Fig. 34).

Beach morphology varied with different facing shorelines. Along the northern side and west end of the peninsula a narrow 2 to 4 m wide active beach is backed by a 0.5 to 1.5 m bluff (P11:3, 4) and a moderately steep backshore. The lower part of the backshore slope is covered by vegetated solifluction debris with permanent snow patches marking the upper limit of solifluction. Rock outcrops observed at the end of the peninsula also extend offshore forming a shallow nearshore platform.

Along the southern shores of the peninsula the active beach becomes progressively wider and has a flatter backshore toward the heads of the bays.

At the head of Hooker Bay the wide, sandy-gravel beaches are cut by numerous small intermittent streams and one large stream. Wide intertidal flats (P11:7) with some boulders or rock outcrops are exposed at low tide, especially adjacent to the major stream outlet.

Beach sediments, which were sampled at each of the profiles (Fig. 36), varied in size from -1 to -3.5∅ and sediment sorting in each of the samples was poor to very poor. Sorting, which provides an indirect measure of wave energy, testifies to the short open water season and the sheltered position of Hooker Bay from large waves.

Beach sediments became progressively coarser from the head of the bays to the end of the peninsulas. Sediment also increased in size upslope from MHTM. It is thought that the finer sediments were combed down the beach slope and deposited on the lower half where greater reworking by small local waves transported the finer sediments alongshore.

In 1972 the beach foreshore slope was very irregular and underlain by patches of ice (P11:6) while in 1974 the beach slope was much smoother and the upper beach sediments were finer. Both observations suggested more reworking by waves in 1973-74 than in 1971-72.

From the sediment characteristics it is hypothesized that there are two main source areas: i) bedrock exposed at the ends of the peninsulas and ii), from the basins drained by the larger streams.

Beach Stability

In 1972 a series of ten profiles were established along the coasts of the study area (Fig. 36). Each was selected to represent the different facing shorelines and various beach morphologies observed during initial observations. For example, profiles G, H and J represent the wide low beaches at the heads of the bays (Fig. 36).

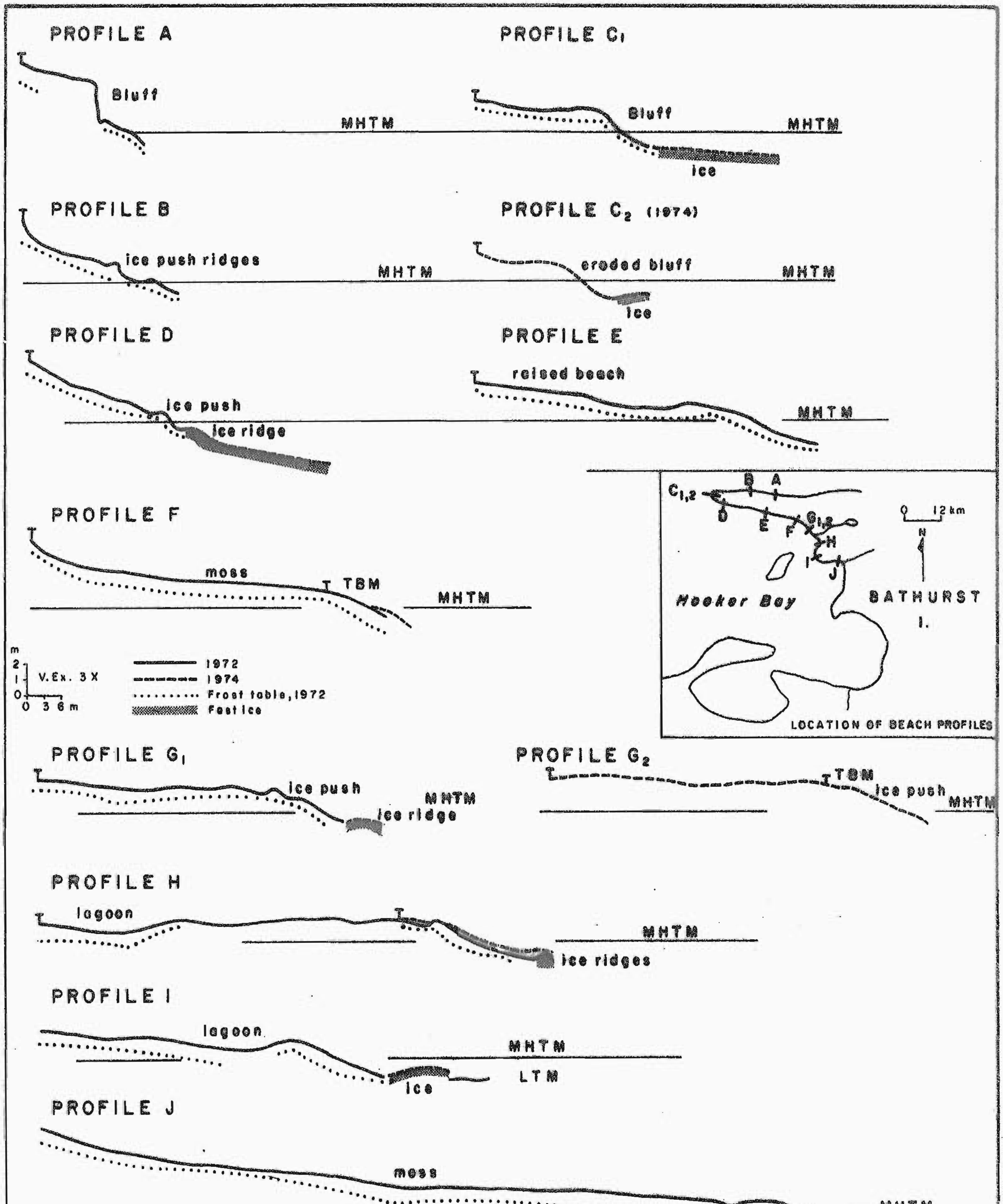


Figure 36. Beach profile locations and changes, 1972-74, Hooker Bay, Bathurst Island.

On August 1, 1974 the study area was revisited for several hours during which four profiles were resurveyed and some general beach observations were made.

The low bluffs backing the active beach near profile C had been eroded by waves and sediment had been added to the lower beach slope. Unfortunately the beach marks at C had disappeared so quantitative measurements could not be made.

In general, the beach slope had been smoothed out along the rest of the study area and small amounts of sediment accretion had occurred. The presence of shorefast ice and ridges of sediment along the mid-beach slope, which accumulated against the fast ice during the spring, suggested little or no wave action by August 1, 1974. Therefore, the small changes surveyed at profiles F and H represent change over the 1972 and 1973 open water seasons. Accretion of less than 0.5 m^3 occurred at the top of profile F but the whole beach face at profile H was built up by 2.1 m^3 of sediment. In the nearshore off profile I (P11:6) the lower beach had been smoothed out but pockets of fractured bedrock and fast ice still existed just as they did in 1972. Difficulty in re-alignment of profiles surveyed at G also prevented quantitative analysis of change. Beach change caused by waves is thought to be minor except during abnormally long open water seasons.

Ice Action

Multi-year ice and ice ridges were found along the western entrance to Hooker Bay but within the bay only flat first year ice occurred. A thick icefoot similar to that found along northern Somerset Island was absent along the shores; a wide shore lead existed in its place. Icefoot development is inhibited here because of the microtidal range of 0.68 m and the gradually sloping intertidal beach. It is thought that a different type of icefoot called a Kaimoo forms along these shores. The Kaimoo has been described along Alaskan beaches by Rex (1964) and consists of an accumulation of frozen swash and beach sediments.

Shorefast ice was also observed in the form of a ridge at and below low tide level at profiles H and I. The ridge of ice was discontinuous along the shore and covered by 0.1 to 0.3 m of beach, fluvial, or ice rafted sediments. Since these ice ridges were found in both 1972 and 1974 it suggests that they can form every year or exist for more than one season. In terms of the effect on coastal processes the shorefast ice ridge protected the lower beach from grounding sea ice and prevented waves, when present, from reworking the lower beach sediments.

Ice push ridges or mounds of various sizes had been created all along the investigated shorelines. The push ridges found along the north and south shores of the peninsula were small (0.5 m in height, 1-4 m wide) and usually occurred at HHTM. The alignment of the major axis of the push ridges was N and NE on the north facing shores and S or SW on the south facing shores. Ice was also observed to push freshly fractured bedrock from the nearshore to the upper part of the beach slope at profile C.

With only a small number of large ice push ridges and an absence of ice pitting the major effect of sea ice on the plan or profile of the beach is that of its mere presence and the prevention of a long period of open water and resultant wave action.

TABLE 12
Depth of Active Layer at Beach Sites, Hooker Bay, 1972

BEACH PROFILE 1972	RAISED BEACH RIDGE	TOP OF ACTIVE BEACH	HHTM	MHTM	EDGE OF ICE OR WATER	MEAN DEPTH	MEAN SEDIMENT SIZE (ϕ)
A (Aug. 10)	75.0	37.0	35.0	38.0	40.0	49.5	-3.53
B (Aug. 10)	82.0	35.0	31.0	40.0	34.0	44.4	-2.52
C (Aug. 2)	43.0	43.0	28.0	--	15.0	34.8	-2.70
D	54.0	--	25.0	--	25.0	37.6	-3.58
E	43.0	33.0	35.0	39.0	21.0	35.6	-3.01
F	47.0	37.0	66.0	71.0	68.0	55.1	-2.83
G (Aug. 2)	44.0	--	34.0	33.5	12.0	35.4	-1.94
(Aug. 10)	39.0	--	38.0	44.0	--	39.2	-1.94
H	54.0	34.0	49.0	32.0	14.0	37.8	-1.64
I	50.0	39.0	44.0	51.0	18.0	45.4	-3.19
J	51.0	37.0	45.0	50.0	50.0	47.9	-1.68
Mean Depth	52.9	36.9	39.1	44.3	29.7	--	--

NOTE: Depths are in centimetres

Active Layer Thickness

Active layer thicknesses were measured across each of the beach profiles during the first week of August. Depths were greatest on the raised beach or on top of the vegetated bluff where 0.53 m was recorded (see Table 12). Across the foreshore the thickest active layer in 1972 was 0.44 m at MHTM and the layer became shallower both further up and down slope. In contrast, active layer depths in 1974 were over 0.60 m at MHTM and the depth at water level was not necessarily the shallowest. For instance, at profile F a depth of 0.73 m was recorded on August 1. However in 1972, because of the presence of shorefast ice ridges, the shallowest depths did occur at the waters edge. Average active layer thicknesses for each profile varied from 0.35 to 0.49 m in 1972 and unless ice was present, very little difference in thickness was found on different facing beaches.

Southeast Bathurst Island

Physiography

Coastal relief is low and subdued with elevations rarely exceeding 120 m. An irregular coastline with many elongated islands and long peninsulas is found in McDougall Sound but a more regular shoreline characterizes southern Bathurst. Four large bays indent the coastline, the largest of which is Freemans Cove (Fig. 37). The study area is almost completely covered by two geological formations, the Bathurst Island formation with siltstones and sandstones and the Disappointment Bay formation with porous to vuggy dolomite.

Bathymetry

Detailed nearshore soundings for southern Bathurst Island are very scarce; the only nearshore depths shown on Hydrographic Chart 7830 (1974) are off Cape Capel and east of Allison Inlet. Shoals exist 5 km off Allison Inlet and a reef is charted offshore of Dyke Acland Bay (Fig. 37).

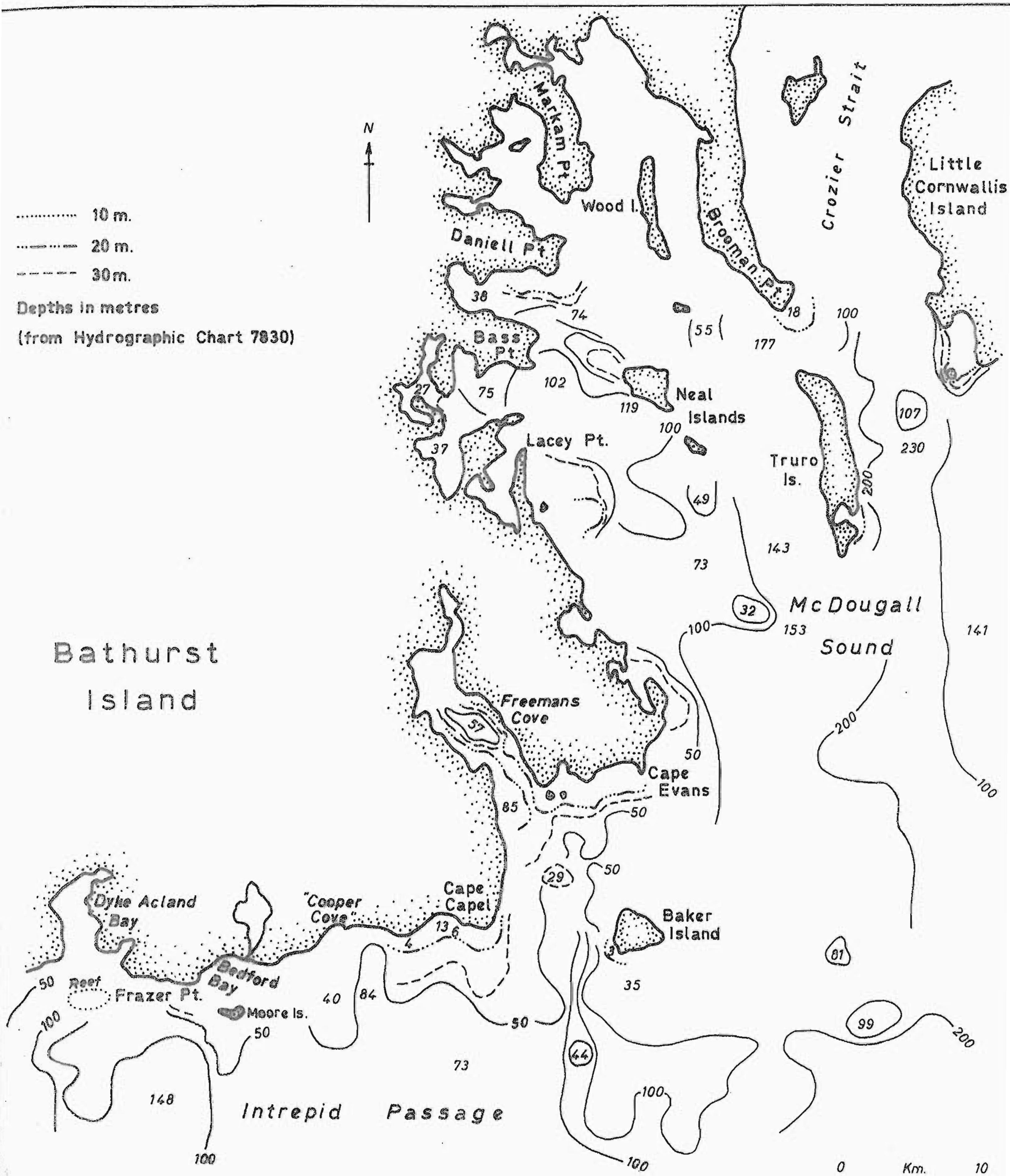


Figure 37. Place names and bathymetry, southeastern Bathurst Island.

The entrance to Freemans Cove has a narrow channel over 20 m deep but the shores and head of the cove are shallower. A depth of 57 metres is shown for a small section in the centre of the cove. Shallow water of less than 20 m is also observed as much as 2 km offshore along the shoreline west of Cape Evans.

With only a few exceptions, depths within the interisland channels of McDougall Sound are over 30 m and much of the sound is deeper than 100 m (Fig. 37). The northern end of McDougall Sound around Markham Point and Wood Island is still uncharted.

Oceanography

Tides

A mean tidal range of 0.97 m and large range of 1.58 m has been recorded at a site 3.0 kilometres west of Cape Capel (Hydrographic Service, 1976). The high and low tides occur approximately 50 minutes after they are recorded at Resolute Bay, Cornwallis Island. The tides are of a mixed semi-diurnal type.

Currents and Waves

No published information on waves or currents is known to exist, however, a few field observations were made. During an ebb tide, dye was injected into the nearshore a few hundred metres off C. Capel on July 30, 1974. An easterly setting current with an approximate velocity of 0.15 m was measured.

Observations of wave parameters were collected at each beach profile as part of the study of coastal processes. Generally the waves were less than 4 second period with breaker heights of less than 0.3 m. The small size of the waves was a result of the ever-present sea ice offshore and lack of strong winds during the field observations.

At one oceanographic station 13 km SE of Baker Island on August 8, 1962 waves of 1.5 m amplitude were formed by NNE winds of 29 km/hr (Oceanographic data Centre, 1974).

Sea Ice

Sea ice maps from Ice Central, Ottawa and from Landsat imagery were examined to estimate the number of open water days offshore from the study area. Much of the information is general and when checked against personal field notes the ice maps proved wrong. Nevertheless, a general estimate of 40-50 days of open water per season occurred between 1972 and 1976 (see Table 13).

Early ice breakup areas or polynyas occurred off the south tip of Cape Capel, off 'Hydrographic 1' profile and the north end of Baker Island. Freemans Cove and the small bays north of Cape Evans are the last to become free of ice. The lateness of ice removal is because of the 'bottleneck' configuration of these water bodies which prevents ice from floating out into McDougall Sound. However, a shore lead does exist in these bays by early August.

Waves usually begin to rework the beaches in the first or second week of August and new ice forms along the coast by late September. Ice breakup was earliest in 1975 when open water occurred by July 16 in McDougall Sound and by July 23 in the remainder of the area. Latest breakup of ice was approximately August 23 in 1972, which was known as a particularly bad ice year.

TABLE 13
Length of Open Water Season, 1972-1976, S.E. Bathurst Island

YEAR	BREAK UP	FREEZE UP	NO. OF DAYS
1972	Aug. 16 Broken ice Aug. 23 (open) (not McDougall)	Sept. 27	35
1973	Aug. 4 (C. Capel)	Sept. 19 (new ice McDougall)	35
	Aug. 22 (all)	Sept. 26 (all)	53
1974	July 19 (C. Capel only) Aug. 1 Aug. 21 (Freemans Cove)	Sept. 25	56
1975	July 16 McDougall July 23 (all)	Sept. 30 (coastal waters may be earlier)	69
1976	Aug. 16 Aug. 31 (Freemans still has ice)	Sept. 22	37
		Mean =	48 days

Coastal Environment

Material and Processes

During 1974 and 1976 field observations were made of beach morphology and sediment type along the coast between Freemans Cove and Bedford Bay. Beach profile stations were established in 1974 and the profiles were resurveyed in 1976.

In terms of coastal morphology the shorelines can be divided into three general types: the low gradual sloping beach with a wide intertidal zone, the convex shaped bluff or hill shoreline and the rocky headland or rocky shore platform type.

The first type of beach environment is the low gradual sloping beach with a wide intertidal zone which is best exemplified by the shoreline near Cape Evans (Fig. 37). Here the 30 m contour is up to a kilometre from the waterline and the backshore is characterized by tundra ponds, intermittent drainage and raised beach swale ponds. Offshore bars, ridges and spits are commonly found built in the shallow nearshore zone across the extensive intertidal flats (P12:4, 5, 6). This coastal type is typical of areas in SE Bathurst Island with underlying bedrock of sandstone and siltstone.

The second coastal type can be found within any of the geological formations of southeast Bathurst. Gradual sloping convex shaped bluffs or low steep-sided bluffs are found over most of the study area. The best examples are Cape Capel (P12:7) and the elongated peninsulas and islands of McDougall Sound. These shorelines resemble those observed in Bracebridge Inlet on western Bathurst Island. Usually the narrow active beach is backed by either a narrow backshore and then a bluff or just the bluff which extends to the active beach. These slopes often reach an elevation of 33 m, can be vegetated and surficially dissected by rills and striped patterned ground. Bedrock is often exposed, especially near the beach-bluff interface.

Bedrock is also exposed at the waterline when the backshore bluff extends to the sea. The shoreline between 'Cooper Cove' and Cape Capel is backed by raised beach terraces outlined by bedrock outcrops or by bluffs with steps of bedrock exposed up the slope.

The shorelines with the greatest relief are composed of the more resistant dolomite, for example Truro and Neal Islands.

Rock shorelines which make up the third coastal type are only found where outcrops of more resistant dolomite or andesite occur at the waterline. Rocky promontories and headlands with pocket beaches were observed between the eastern headland of Bedford Bay and 'Cooper Cove' (P11:13, 14, 15). There, the rocky headlands are slowly eroded by frost shattering and wave action and the shallow deposits of eroded sediments form pocket beaches in the small embayment (P11:14).

Slight variations of coastal morphology can be found, such as the beach zone along 'Cooper Cove', but these three types best characterize the coast of south-eastern Bathurst Island.

Beach sediments which are closely related to the underlying bedrock, varied in size and type along the shore under study. On the east side of Brooman Point, McDougall Sound, angular, dolomitic beach shingle was sampled. The size of the beach shingle was -1 to -6ϕ (2 to 64 mm). In contrast, at Cape Evans the beach sediments were a platy, dark coloured sandstone mixed with considerable quantities of shell fragments. However, sediment size was similar, -1 to -5ϕ. Numerous accumulation features along the shoreline near Cape Evans indicate a dominant longshore transport of sediment east along the south shore and south along the east shore. Grounded sea ice offshore of several of the spits suggests shallow water extends further offshore and that perhaps the spits are extending along bedrock outcrops in the nearshore. Similar wide intertidal flats and nearshore beach ridges are found near the two large river outlets in northwestern Freemans Cove and around 'Cape Capel 7' beach profile (Fig. 38). There the proportion of fine sediments is much greater primarily because of input of sediment from nearby rivers.

Along the islands of McDougall Sound, i.e. Neal and Truro Island, the beaches have been building in a south to southeast direction. In 1976 waves generated by northwest winds were observed entraining nearshore sediments and resultant sediment plumes were moving southeast around the headlands of the islands. It is suggested that the dominant transport of sediment is south and southeast within McDougall Sound.

The western shore of Freemans Cove is composed of sand and gravel except at the headlands where gravel and rock outcrops are exposed at the base of the low bluffs. Boulders and larger proportions of gravel along eastern Freemans Cove suggest a close proximity to bedrock in the coastal zone.

Samples of beach sediment collected along the shores underlain by sandstone and siltstone of the Bathurst Island geologic formation were a mixture of sand and gravel of +3 to -5ϕ (0.12-32 mm) grain size. Generally the raised beach sediments were coarse, angular sandstone shingle and the present foreshore sediments were slightly finer and contained higher proportions of sands. Very large slabs of

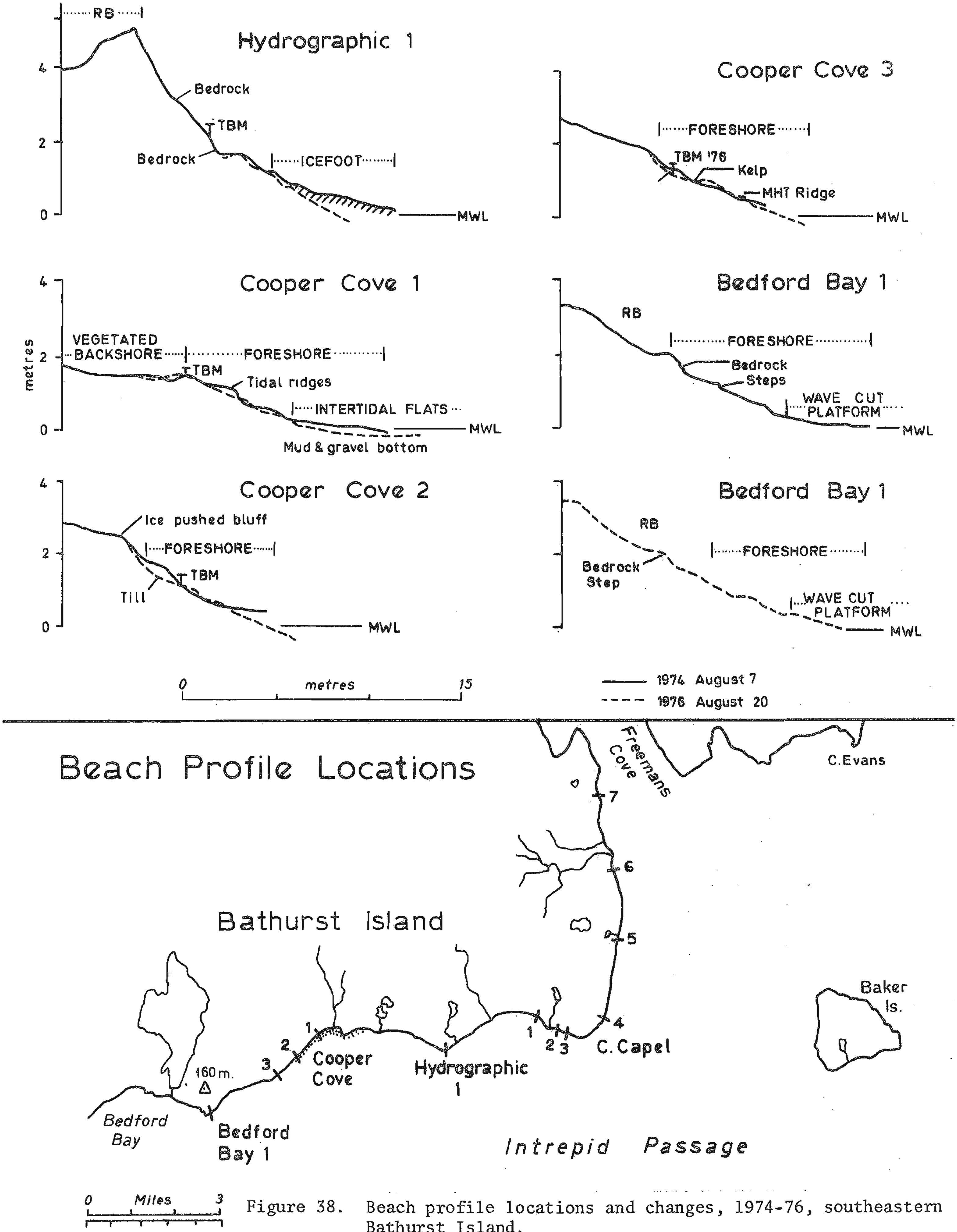


Figure 38. Beach profile locations and changes, 1974-76, southeastern Bathurst Island.

sandstone shingle were found along the backshore of C. Capel profiles 4 to 6 (Fig. 39) because of the exposure of thin to medium bedded sandstone along the entire backshore and at the base of C. Capel itself.

A nearshore platform extends approximately 400 m offshore of C. Capel to a depth of 1.2 m. On the bottom a thin veneer of sand and gravel with scattered boulders cover all but a few bedrock exposures. Kelp is observed in large concentration along the bottom as it slopes further offshore.

Further west as far as 'Cooper Cove' the beach sediments are very coarse and bedrock outcrops of 1.5 to 2.0 m height are exposed along the bluff shoreline. Isolated exposures of resistant andesite produce narrow sections of rocky shore.

The underlying bedrock from 'Cooper Cove' to Bedford Bay is dolomite. The cream white to yellowish beach sediments are generally finer and less platy in shape than sediments found near C. Capel. Pocket beaches built from eroded rock promontories are similar to those observed on Lowther Island except the weathered rock breaks into finer blocks and they are a whiter colour. The rock exposed beneath low tide is a yellowish red colour like the rock platforms on Lowther Island.

Along 'Cooper Cove' the beaches are composed of mixed sand and gravel. In the nearshore, intertidal flats increase in width toward the head of the cove where a maximum width of 0.4 km occurs. Black organic silts occurred across the intertidal flats and were also found 0.56 m below the beach surface at profile 1 (Fig. 38). Offshore bars and kelp beds parallel the southeast facing shoreline.

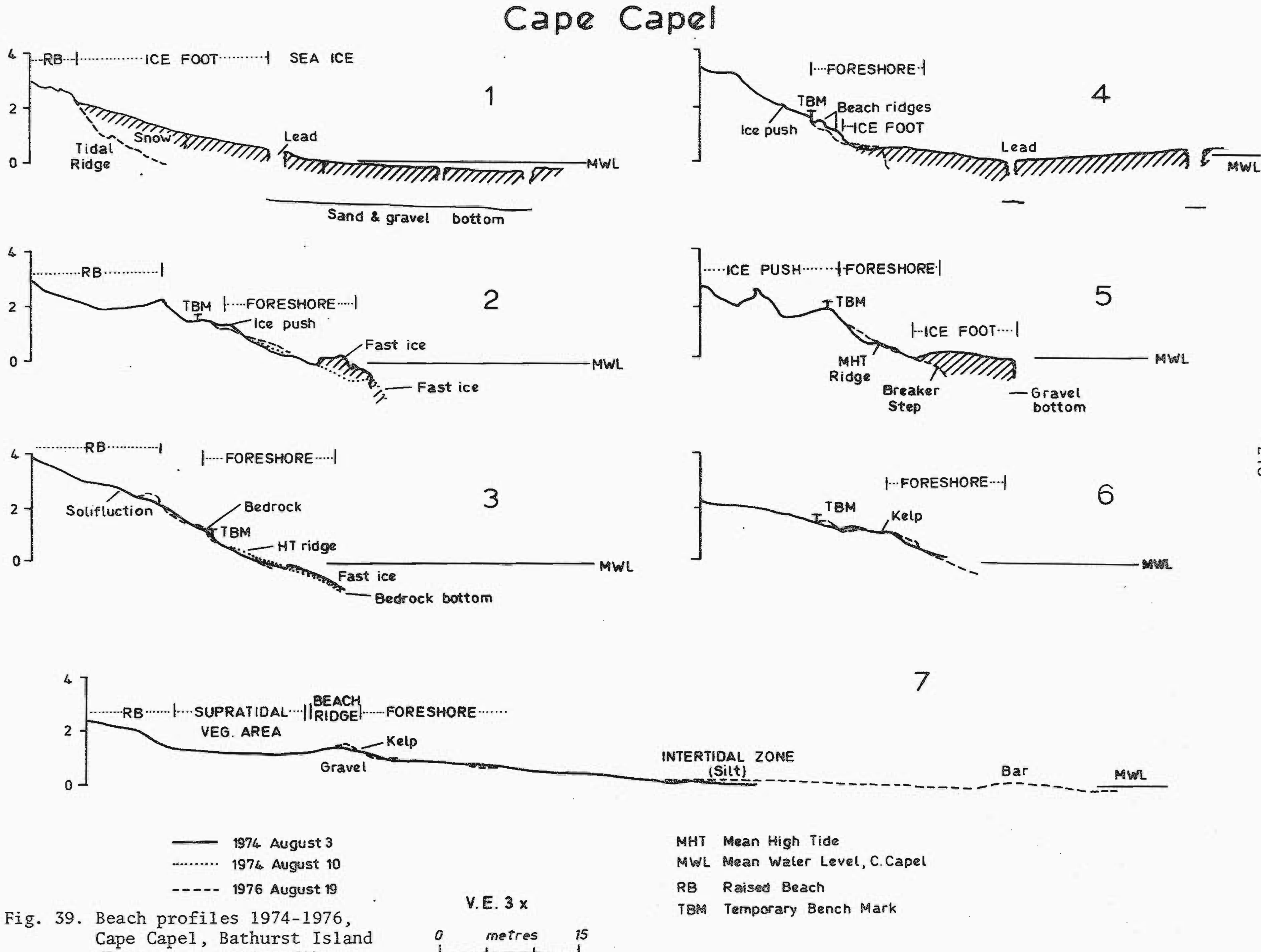


Fig. 39. Beach profiles 1974-1976, Cape Capel, Bathurst Island (Locations on Fig. 38).

In 1976 waves from the southwest were actively reworking the beach at profile 3 (Fig. 38) and transporting sediment northeastward. The presence of sandstone pebbles along this beach suggest sources from the east or inland (via the river) hence eastward transport of coastal sediment also occurs.

Beach Stability

Twelve beach profiles were established in 1974 along the coast between Freemans Cove and Bedford Bay (Fig. 38). Each of the profiles was chosen to represent the adjacent shoreline morphology and shores subject to waves from different directions. Beach change was calculated by comparing sequential surveys of each of the profiles made in August of 1974 and 1976.

Profiles 4 to 7 (C. Capel) are located in a semi-sheltered coastal zone because of Baker Island lying just offshore. The remainder of the profiles are located along the open coast of Barrow Strait.

Since only two surveys were made of these beaches, i.e.: during 1974 and 1976, the changes calculated represent a net profile change over two years, not necessarily the maximum change that could occur during any one storm. Less than 2 m^3 of net change occurred at any one profile. The small difference suggests that either there has been a lack of waves, particularly storm waves, to rework these shores or the beach at each of the profiles has recovered from any greater changes that occurred during specific storms. The former is thought to explain the present findings.

Measured changes in beach profile were greatest along the southeast facing shore of 'Cooper Cove' and the headland at 'Hydrographic 1' profile (Fig. 38). Erosion occurred across the upper beach of 'C. Capel 4' profile. Along the more sheltered shores where C. Capel profiles 5-7 are located, accretion in the form of a storm ridge occurred; however, this positive change amounted to less than 1 m^3. The profile, 'Bedford Bay 1' could not be accurately re-aligned because of the lack of a second benchmark. Nevertheless, photos taken in 1974 and 1976 show that the foreshore slope had been smoothed out but actual beach change was minimal.

Ice Action

Shorefast ice was observed along the shores of the study area in early August 1974. The icefoot was best developed along shores where snow accumulates; i.e., the base of bluffs or along the rocky shore platforms. At locations where waves had eroded the icefoot (eg: Fig. 39, Cape Capel 2 and 3) an ice-cored gravel ridge was still observed at or near low tide mark. The ice was generally covered by 10 to 15 cm of gravel and its duration on the beach is not known. Similar shorefast ice ridges have been observed elsewhere in the eastern Arctic including Hooker Bay, Bathurst Island (Taylor, 1976).

Sea ice was often observed grounded on the nearshore platform along most of the study area but two shore areas were most affected by ice: the shores between C. Capel profiles 4 and 6 and the southeast facing shore of 'Cooper Cove'. In the first area ice pushed ridges were found along the entire shoreline but their size rarely exceeded 1 m in height and 4-5 m in width and length. In 1974 along 'Cooper Cove' ice floes had planed wide areas of the beach surface pushing sediment upslope and building ridges of gravel well upslope on the vegetated solifluction slope. Additional ice push had occurred near the south end of 'Cooper Cove' in 1976.

Only one ice ridge was observed in 1974 and it was built of 1 m thick ice blocks rafted up onto the wide icefoot just east of 'Cooper Cove'. The fast ice

TABLE 14
Depth of Active Layer at Beach Sites - 1974, 1976, S.E. Bathurst Island

BEACH PROFILE	RAISED BEACH	TOP OF ACTIVE BEACH	HHTM	MHTM	WATER LEVEL	MEAN DEPTH
Cape Capel						
1 (1974)	25	20	-	-	-	23
(1976)	22	27	-	46	49	36
2(1974)	25	36	34	31	22	29
(1976)	37	42	-	66	58	51
3	47	Bedrock	15	21	14	24
	-	"	24	26	26	25
4	40	21	ice	ice	17	26
	12	11	ice	ice	3 (ice)	8
5	18	27	43	40	32	32
	33	21	-	44	34	33
6	39	33	39	36	-	37
	25	25	29	57	61	39
7	33	56	47	38	24	39
	-	52	-	46	56	51
Hydrographic						
1 (1974)	-	16 (rock)	12	6	5 (ice)	9
(1976)	-	16 (rock)	43	48	35	35
'Cooper Cove'						
1 (1974)	51	47	30	26	53	41
(1976)	65	26	52	68	56	53
2	54	36	37	51	53	46
	-	44	49	62	38	48
3	50	41	38	48	47	44
	-	36	46	56	26	41
Bedford Bay						
1 (1974)		NO INFORMATION				
(1976)	36	48	-	63	-	49
Mean Depth						
(1974)	38	33	33	33	30	32
(1976)	33	32	40	53	40	39

NOTE: Depths are in centimetres

protected the shore from any damage. In 1976 open water existed along most of the open coast but not in the small bays. Ridges of ice were spotted approximately 5 km north of C. Evans and along the east shore of the small island south of Lacey Point, McDougall Sound. At both locations the ridges of ice reached estimated heights of 4 m.

Based on observations made during two short field seasons, the east and southeast facing shores appear to be most affected by sea ice ridging or rafting.

Active Layer Thickness

At each of the beach profiles active layer thickness was measured in 1974 and 1976 using a hand auger. In some cases measurements were taken twice in 1974. On July 30 and August 10, 1974, the average thickness across the beach slope was 0.29 and 0.31 m, respectively. In 1976, on August 19, the average thickness was 0.39 m. Many of the recorded depths were shallow because of the presence of bedrock just below the beach surface. Maximum depths were measured in 1976 along south facing beach slopes, particularly those not shaded by backshore bluffs. For instance, a maximum depth at 'C. Capel 2' profile was 0.66 m and at 'Hydrographic 1', only 0.48 m. In 1974 the active layer was thickest across the backshore while in 1976 it was thickest across the foreshore (Table 14).

Suitability for a Marine Terminal

In the study area the best locations for port facilities are found along southeastern Bathurst Island. Freemans Cove, Bateman Bay, and the unnamed inlet south from Bass Point on McDougall Sound were chosen as the best possible sites (Fig. 37). They are discussed in detail in the section on port facilities for the Bathurst Island map sheet (Page 25).

Southern Bathurst Island

Physiography

The low, flat marine plain observed south of Hooker Bay on western Bathurst Island continues along southern Bathurst Island from C. Cockburn to Allison Inlet (P11:2, 8, 9, 10). The sandy plain rises gently inland and is dotted by numerous ponds and streams. Between C. Cockburn and Allison Inlet the nearshore is shallow with wide intertidal flats and exposed sand and gravel beach ridges (P11:10). In 1974 the icefoot along this section of coast was lined by piles of broken ice and the nearshore bottom was considerably scoured. The suggestion is that there is substantial interaction between ice and the seabed along this shore. Lindsay (1969) observed that ice island fragments seem to concentrate in the vicinity of Cape Cockburn.

Allison Inlet is approximately 1.6 km wide and 14.5 km long. On the west side of the entrance the shores are low but on the east side a 45 to 61 m high bluff extends almost a kilometre along shore (P11:12). Islands at the entrance create three channels into the inlet but each is less than 30 m wide (Pilot of Arctic Canada, V.III, 1968). A low narrow ridge of gravel is also observed offshore of the entrance.

Four kilometres east of Allison Inlet and as far as Dyke Acland Bay the coastal morphology changes to flights of well-developed raised beaches. At the western entrance to Dyke Acland Bay a steep, 150 m high slope occurs. The shoreline along the remainder of the bay is rugged with a narrow beach backed by low bluffs or hills. General coastal relief is 33 m within 0.25 km of the waterline. Beach sediments within Dyke Acland Bay travelling west to east change from limestone to dolomite to siltstones and shale (Kerr, 1974).

Further east towards Bedford Bay the shoreline is similar to that found near C. Capel with narrow gravel beaches backed by a 33 m high bluff. The interior does not rise above 150 m in elevation. A well-developed gravel spit at Frazer Point (Fig. 37) indicates that sediment transport is predominantly towards the east. Shallow nearshore waters are observed on airphotos of the coast between Dyke Acland and Bedford Bays. Moore Island, lying offshore from Bedford Bay, is composed of a series of gravel raised beaches.

EASTERN MELVILLE AND WESTERN BYAM MARTIN ISLANDS

by P. McLaren

Introduction

The coasts of Byam Channel (M25) were studied in detail by personnel from the Geological Survey of Canada during the summer of 1973, 1974 and 1975 in anticipation of an inter-island pipeline crossing. A comprehensive analysis of the coastal environments is given in McLaren (1977). Interim reports have been published by McLaren (1974a, 1975), McLaren et al. (1975) and Taylor (1974b, 1976). Finally, if future development is considered on these islands, Barnett et al. (1975) provide exhaustive terrain and sensitivity maps which should be consulted.

Physiography

The geology of Melville and Byam Martin Islands has been mapped by Tozer and Thorsteinsson (1964) and Kerr (1974), respectively, with modifications of the former by Barnett et al. (1975). Both coastal regions consist of folded interbedded sandstones, siltstones and shales. Fold axes trend east. In general, the rock types are friable and easily weathered, although in places there are resistant bedrock headlands such as Robertson and Kay Points (Fig. 40; P20:14). Within a rock formation, changes in lithification can occur. For example, a sandstone formation may be a ridge former in one location and a valley floor in another.

The terrain is characterized by east trending ridges which are broad and flat-topped. They are separated by wide flat-floored valleys which have steep sides and an average relative relief of 90 m. Locally (within the drainage basins that empty into Byam Channel), the east trending ridges are less pronounced, and in

Figure 40. Robertson Point, an example of a bedrock headland. Superimposed on the bedrock, which is striking east into Byam Channel, there are traces of raised boulder beaches. A gravel beach continues from the headland towards the north but quickly disappears. The background is a vegetated sandflat. Note the stable shorelead and the nearshore ice still frozen to the bottom. GSC photo 202953-Z taken July 11, 1973.

spite of the dominating structure, the drainage is characteristically dendritic, indicating a general homogeneity of the rock formations. Maximum elevation (385 m) is found in the Baldwin Walker Range to the north (M1) where there is a small ridge of resistant limestone. This elevation is exceptional and the plateaux are about 150 m high.

Bathymetry

Bathymetric data for Byam Channel is limited to a general reconnaissance (Hydrographic Service, Chart 7830) at 1:500,000 and two field sheets (4220B, 4243). Except for field sheet 4243, which details a small area in the vicinity of Rea Point (M1), detailed bathymetry near the coastline is lacking.

The Melville coast from Ross Point to Richardson Point (M1) and most of Byam Martin Island appears to have a broad shallow shelf adjacent to the shoreline. Based on available data and diving observations the 20 m isobath can be as much as 5 km from shore in these areas. From Richardson Point to Domett Point (M25) the 20 m isobath is nearer the shoreline at approximately 0.75 km.

In the central portion of Byam Channel there is ample depth for shipping and navigation. The available charts show maximum soundings of greater than 200 m and depths are generally about 100 m.

Oceanography and Climate

Winds

Wind data are available from Rea Point (M1) since 1972 (Environment Canada, 1972-1974). On monthly mean pressure charts, pressures are consistently low on the west coast of Greenland and higher to the area northwest of Mould Bay on Prince Patrick Island. The pressure gradient is strongest from September to May and results in average wind speeds of 7-8 km/hr with a prevailing wind direction of NW. to N. The gradient is weakest during June, July and August, and although average wind speeds remain the same the prevailing direction is random and can vary from N.-NW. to S. Peak winds of over 40 km/hr are common and nearly always blow from the prevailing direction. They can occur anytime during the year. Terrain also has a large effect on wind direction in the Arctic Islands. The NW. orientation of Byam Martin Channel and the N orientation of Byam Channel serve to guide the prevailing winds along these dominant directions.

Currents and Tides

In Byam Channel, currents are from the north, probably reflecting the prevailing wind direction. On entering Viscount Melville Sound, flow is divided into east and west directions. Eastward currents continue through Parry Channel. The westward flow remains close to the south shore of Melville Island before sweeping in a counter-clockwise turn to follow in an eastward direction.

Lindsay (1969) documents the movements of an ice island fragment, T-1, which in September of 1959 was 60 km north of Lougheed Island. It drifted south into Byam Martin Channel and into Viscount Melville Sound where it drifted west as far as Winter Harbour. From there it moved eastward and south into M'Clintock Channel.

Diving observations indicated that currents were either small or non-existent. Most often currents estimated at 10-15 cm/sec were felt under the ice in shallow water less than 4 m. They were invariably parallel to shore and their direction coincided with the ebb and flood tide. Occasionally ripple marks were observed in fine sand indicating that these currents were able to attain 30-40 cm/sec. In deeper dives, currents were rarely felt except on August 5, 1974, at a location near Robertson Point. Here tidal currents were estimated at 50 cm/sec.

Tide data were obtained for varying numbers of days at Ross Point, Little Point, Robertson Point and May Cove (M1). Analyses carried out by Dr. G. Godin, Environment Canada, indicate a semidiurnal tide with an amplitude that decreases steadily from Viscount Melville Sound, north into Byam Channel. Maximum tides measured from south to north at the four stations were 1.2, 1.1, 0.98, and 0.76 m respectively. The tide appeared to be simultaneous over the area.

Currents attributable to tides were measured at water depths of 107 m in the middle of Byam Channel. Maximum velocities ranged from 20 cm/sec to 46 cm/sec and tended to increase with depth. Although direction measurements were meaningless due to the proximity of the North Magnetic Pole, the variation in the successive values of velocity showed an irregular but semidiurnal pattern (Polar Gas, pers. comm.).

Temperature, Ice Thickness and Precipitation

Mean daily temperatures (Fig. 41) are based on six years of data from the Rea Point meteorological station (Environment Canada, 1969-1974). July and August are the only months where the mean goes above freezing and July is the warmest month with a mean of 4.4°C. Temperatures drop rapidly to a minimum low of -35.6°C in February.

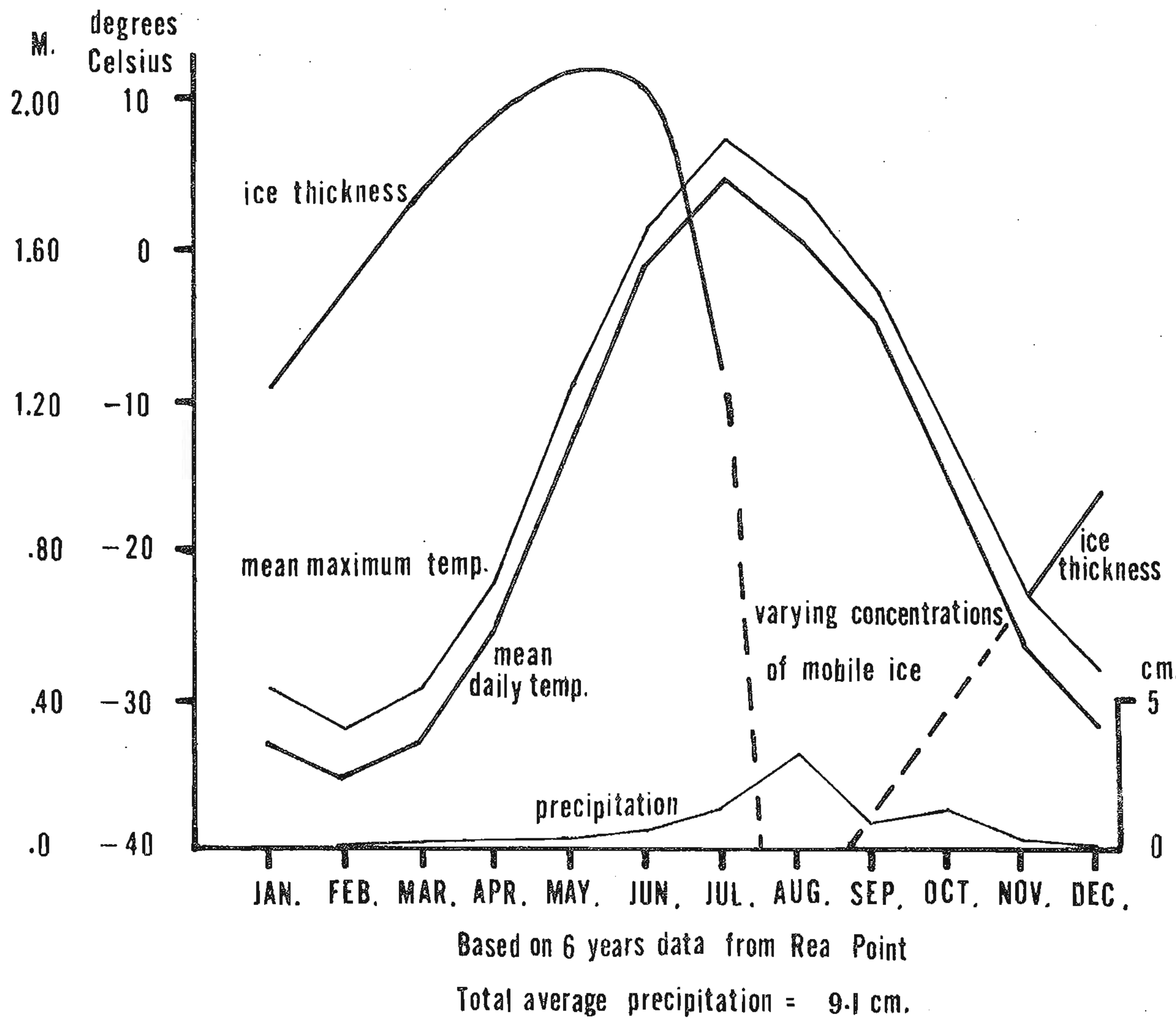


Figure 41 Average temperature, precipitation and ice thickness at Rea Point, eastern Melville Island.

Superimposed on the temperature curve (Fig. 41) is a generalized average ice thickness curve for the Queen Elizabeth Islands (Lindsay, 1969). The two curves indicate a time lag between minimum air temperature and maximum ice thickness. The generalized maximum ice thickness of 2.08 m agrees well with research on the ice thickness in Byam Martin Channel during the spring of 1973 (Polar Gas, pers. comm). The curve suggests that no ice exists between the third week in July and the second week in August. However, during this time there will be varying concentrations of mobile ice.

Total monthly precipitation (Fig. 41) increases directly with temperature and the amount of open water. The average yearly total however, is only 9.1 cm which classifies the region as a desert.

Ice Regime and Pattern of Breakup and Freezeup

An ice reconnaissance of central Parry and Byam Channels has been available each year since 1960 (Environment Canada, Ice Forecasting). During winter in Byam Martin Channel, the sea is covered with approximately 80% old ice, although there are increasing percentages of first year ice southwards into Byam Channel. The ice thickness curve (Fig. 41) shows continuous ice cover over the region for at least nine months of the year. During this time the interisland ice is shorefast and no major movement takes place (Swithinbank, 1960). Breakup usually occurs in July though variations from season to season are too large to determine a more precise date. Significant ice movement is confined to August and September with some motion during storms in October and possibly November.

Breakup and general ice movement are controlled by winds and currents and, therefore, the overall pattern proceeds each summer from the southeast to the northwest. Clearing of ice from Parry Channel develops in varying degrees each year depending on summer winds, the previous summer's breakup, and to a small extent on temperature. The clearing develops as an extension of open water in northern Baffin Bay and progresses westward to 98°W between Bathurst and Prince of Wales Islands. Further west, clearing is less complete, regular and brief.

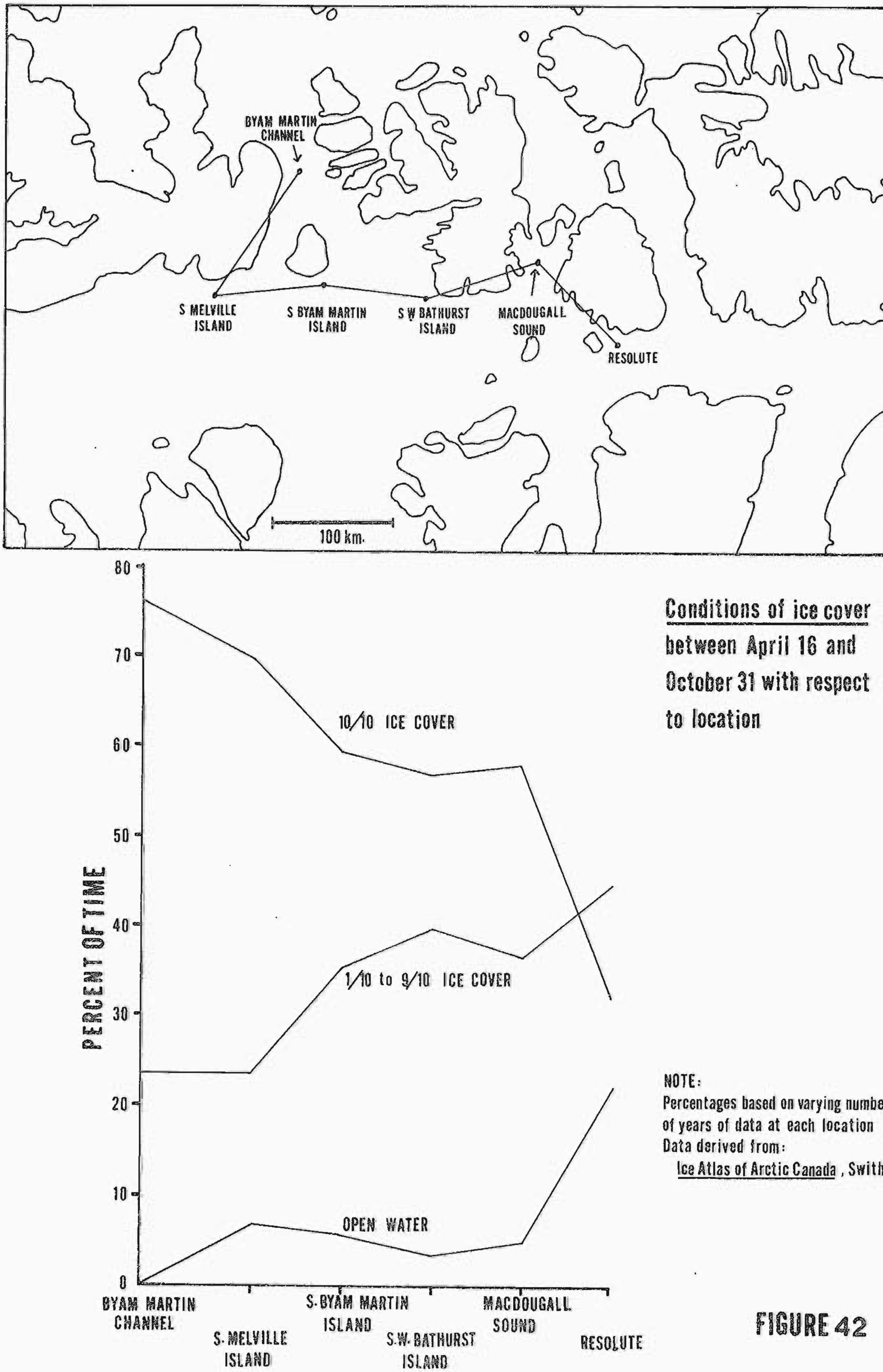
Floes of young polar ice, arctic pack ice, and sometimes ice island fragments can intrude into Viscount Melville Sound through McClure Strait and Byam Martin Channel. Although these floes are nearly always completely melted in Barrow Strait and Lancaster Sound, they frequently remain in Viscount Melville Sound. Very extensive clearing of ice will often be followed by a year of restricted breakup since polar floes from Byam Martin Channel can then readily enter the area.

Generally, freezeup of Parry Channel proceeds in the reverse direction. Thus the number of ice-free days in a year generally decreases from east to west (Fig. 42). In some years the formation of young ice in October is sufficient to restrict further ice movements, and Viscount Melville Sound probably supports a consolidated ice cover after mid-November.

Coastal Environments

Introduction

The coasts bordering Byam Channel are presently emerging with respect to sea level at the rate of approximately 0.4 cm/yr. The nature of the shoreline is,



Conditions of ice cover between April 16 and October 31 with respect to location

NOTE:
Percentages based on varying numbers of years of data at each location
Data derived from:
Ice Atlas of Arctic Canada, Swithinbank, 1960.

FIGURE 42

therefore, at least partly dependent on the nearshore topography and bottom characteristics. After initial aerial reconnaissance observations, three principal coastal types were defined as follows (M25):

(i) Sandflat coast which constitutes 45% of the present shoreline;

(ii) Raised beach coast which has been subdivided into
(a) raised beaches perched on rock (11% of the shoreline) and
(b) raised beaches perched on sand (22% of the shoreline);

(iii) Delta coast which has also been subdivided into
(a) active deltas (15% of the shoreline) and
(b) uplifted inactive deltas (7% of the shoreline).

Each coastal type has been divided into coastal units (Table 15) comprising an uplifted, inactive (in terms of marine processes) portion, and a backshore and foreshore which comprise the beach. Within the coastal units, morphologic units such as supratidal flats, berms, interbeach lagoons, etc., have been treated as sub-environments. Definitions for the terminology used have been taken from the Glossary of Geology (American Geological Institute, 1973) and rigorously applied.

Sandflat Coast

Morphology

The sandflat coast (Figs. 43 and 44) is characterized by a smooth, gently sloping sandy facies, the average slope of which is 1° (±.7°). It extends from the present shoreline, inland to an average elevation of 20 ± 8 m and has a width of 1.2 ±0.5 km (Table 15). The inland edge of the sandflat is usually delimited by a break in slope between the uplifted sediments and the steeper hillsides.

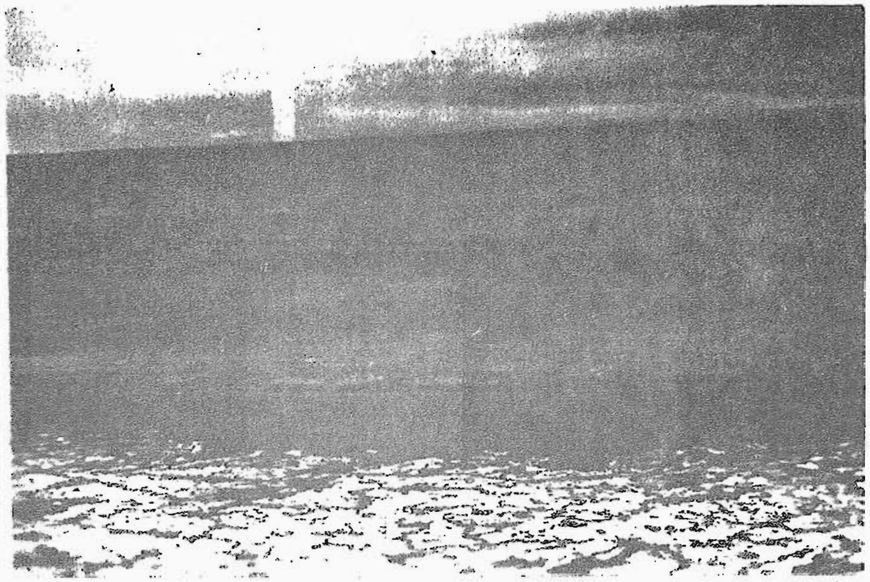


Figure 43. Typical sandflat coastline located north of Richardson Point (M1). GSC photo 202951-R taken July 11, 1973.

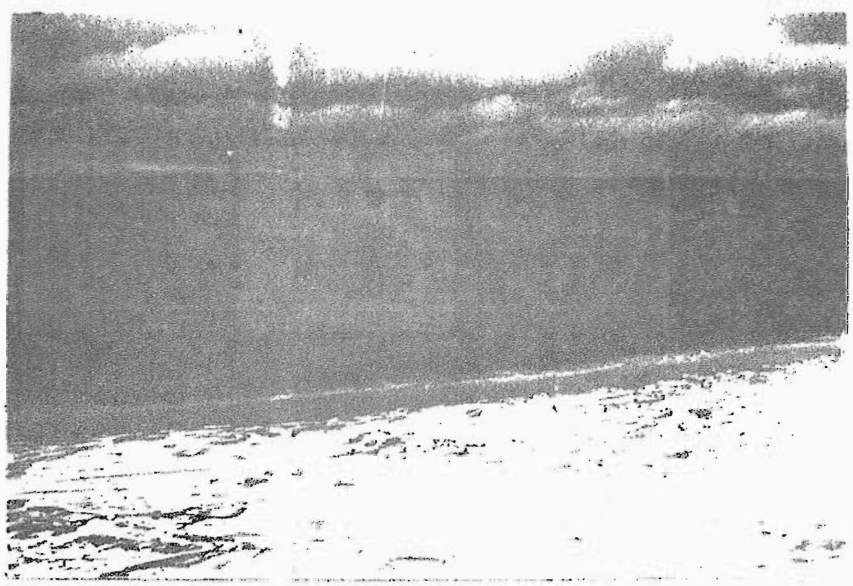


Figure 44. Sandflat coastline in the vicinity of Boat Beach (M1). Note the difference in vegetation cover from that in Fig. 43. GSC photo 202951-G taken July 11, 1973.

The flatness and uniformity of the sandy facies commonly preclude distinction of backshore and foreshore units from the older uplifted sandflat. On several measured profiles the width of the beach exceeds 140 meters (Fig. 45) which is probably neither uncommon nor near the maximum. The uplifted sandflat usually becomes progressively more vegetated inland, although the percent cover is too variable to use as a guide to estimate either the maximum elevation of storm surges or the relative age of the uplifted portion. Sheet wash and rill erosion during the spring melt and after rain are probably responsible for the variability of the vegetation cover. In areas devoid of vegetation, the uplifted sandflat frequently has a pebble and shell veneer which is the result of deflation. Often this pebble veneer allows small erosional mounds several centimeters high to develop among the rill channels.

The uplifted sandflat adjoins a backshore of extremely variable width (Fig. 45). The latter can be divided into two morphologic units; a supratidal flat which is rarely inundated and a low berm whose width averages 23 $\pm$21 m. The foreshore, which contains a beach face sloping at 2 $\pm$0.9°, occasionally develops minor ridge and runnel systems (Fig. 45, profile 8). When ice conditions permitted, a gently sloping (1.2 $\pm$0.3°) low tide terrace was observed (Table 15).

Sediment Characteristics

Examination of the grain size characteristics (Table 15) of the morphologic units indicate the following:

(i) Gravel size material occurs in small quantities in the uplifted and supratidal sandflats. Thirty-seven per cent of samples from these two morphologic units contained from 3 to 6 per cent gravel. No gravel was observed in either the berm or beach face.

TABLE 15
Summary of Coastal Morphologic and Sedimentologic Characteristics

Table 15: Summary of Coastal Morphologic and Sedimentologic Characteristics									SEDIMENT PARAMETERS									
GENERAL COASTAL CHARACTERISTICS				BEACH PROFILE MORPHOLOGY					GRAVEL (>-1Ø)			SAND (<-1Ø)						
												TEXTURE			MOMENT MEASURES			
COASTAL TYPE	Mean. max. elev. (m)	Mean slope (°)	Mean width (Km)	COASTAL UNIT	MORPHOLOGIC UNIT	Mean width (m)	Mean relief (m)	Mean slope (°)	Mean % gravel	Mean size	Mean sorting	Mean % sand	Mean % silt	Mean % clay	Mean size	Mean sorting	Mean skewness	No. of samples
Sand flat	[illegible] ± 8	1 ± 0.7	1.2 ± 0.5	uplifted sand flat	N/A	N/A	N/A	1.8 ± 0.7	1 ± 2	-2.63 ± .40	0.92 ± .04	71 ± 22	22 ± 16	7 ± 6	3.86 ± 1.03	2.06 ± .95	2.23 ± 1.75	8
				backshore	supratidal flat	N/A	N/A	0.7 ± 0.5	1 ± 2	-2.45 ± .27	1.19 ± .57	82 ± 16	14 ± 12	5 ± 4	3.37 ± .73	1.82 ± .77	2.94 ± 1.58	11
					berm	23 ± 21	N/A	0.2 ± 0.3	0 0	N/A	N/A	94 ± 3	4 ± 3	2 ± 1	2.67 ± .23	1.37 ± .27	4.49 ± .93	9
				foreshore	beach face	N/A	N/A	2.0 ± 0.9	0 0	N/A	N/A	91 ± 8	8 ± 7	2 ± 2	2.75 ± .33	1.53 ± .43	3.71 ± 1.27	5
					ridge	3 ± 2	0.1 ± 0.0	3.4 ± 1.4	- -	-	-	-	-	-	-	-	-	8
					low tide terrace	23 ± 22	N/A	1.2 ± 0.3	- -	-	-	-	-	-	-	-	-	5
Raised beach	30 ± 11	2 ± 0.8	1.3 ± 0.7	uplifted raised beach complex	raised beach top	3 ± 1	N/A	flat	41 ± 19	-2.71 ± .46	.89 ± .15	80 ± 10	15 ± 8	5 ± 3	2.78 ± .71	2.46 ± .61	1.90 ± 1.03	9
					raised beach face	N/A	0.8 ± 0.6	4.7 ± 2.3	31 ± 18	-2.60 ± .52	.91 ± .14	77 ± 10	17 ± 7	6 ± 3	3.03 ± .72	2.60 ± .60	1.76 ± .96	9
					interbeach lagoon	11 ± 11	N/A	flat	8 ± 8	-2.41 ± .47	.83 ± .21	80 ± 11	15 ± 8	5 ± 3	3.45 ± .50	2.15 ± .44	2.45 ± .99	13
				backshore	berm	[illegible] ± 3	N/A	flat	56 ± 11	-3.04 ± .46	.96 ± .08	83 ± 9	13 ± 7	4 ± 2	2.65 ± .75	2.40 ± .48	1.88 ± .75	9
				foreshore	beach face	N/A	N/A	8.5 ± 6.3	49 ± 31	-3.15 ± .82	.94 ± .29	84 ± 6	12 ± 5	4 ± 2	2.60 ± .47	2.35 ± .58	2.05 ± .85	9
Delta	?	Flat	?	uplifted delta flat	N/A	N/A	N/A	flat	2 ± 4	-2.33 ± .36	.69 ± .04	84 ± 15	13 ± 14	3 ± 2	3.23 ± .58	1.62 ± .38	3.63 ± 1.26	12
				backshore	supratidal delta flat	N/A	N/A	flat	3 ± 5	-2.23 ± .25	.77 ± .14	82 ± 10	12 ± 5	6 ± 5	3.36 ± .59	2.18 ± .73	2.69 ± 1.24	8
				foreshore	beach face	N/A	N/A	3.1 ± 1.1	3 ± 6	not enough samples containing gravel		93 ± 8	6 ± 7	2 ± 2	2.60 ± .59	1.53 ± .32	3.89 ± 1.09	6

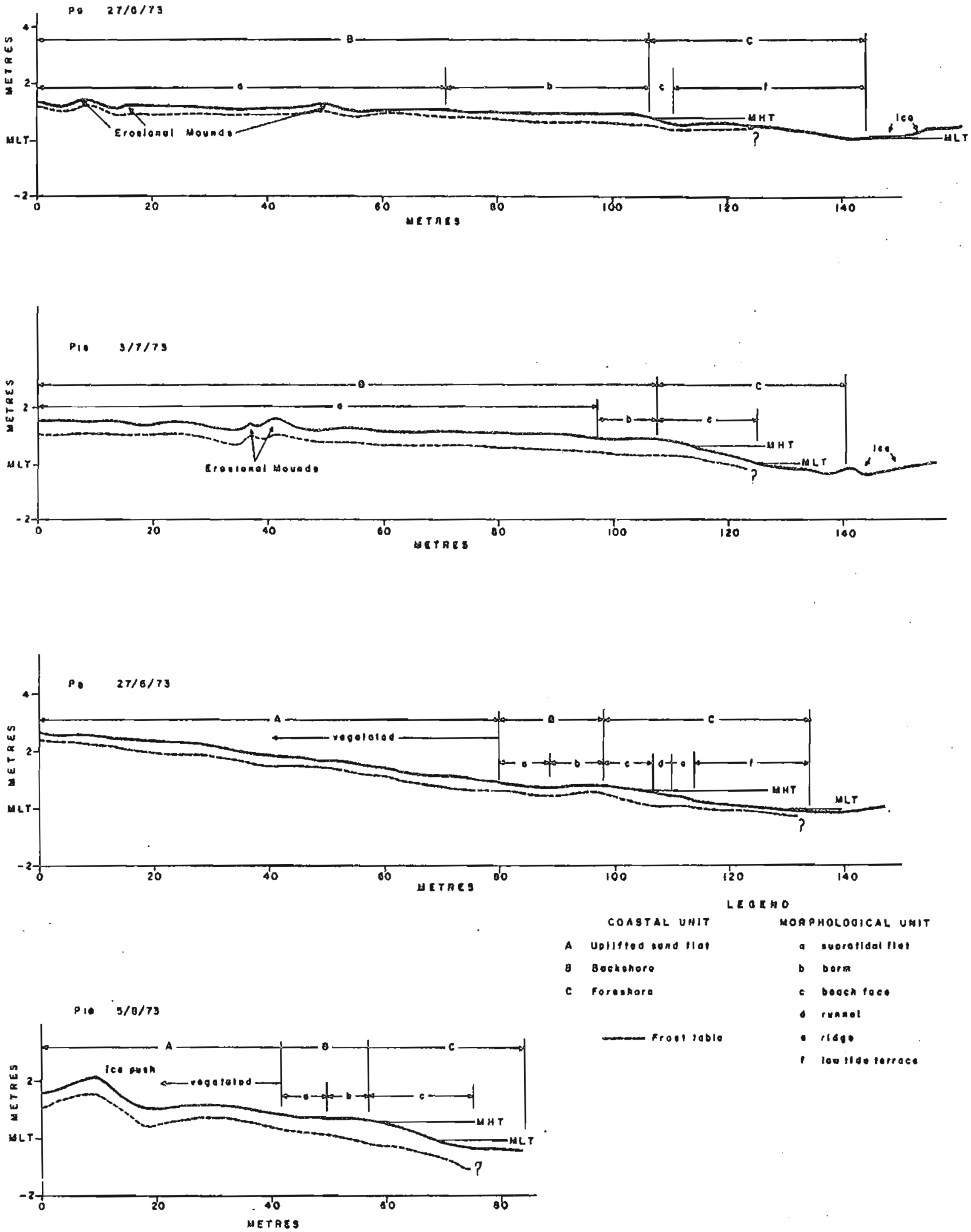


Figure 45 Characteristic beach profiles of a sandflat coast.

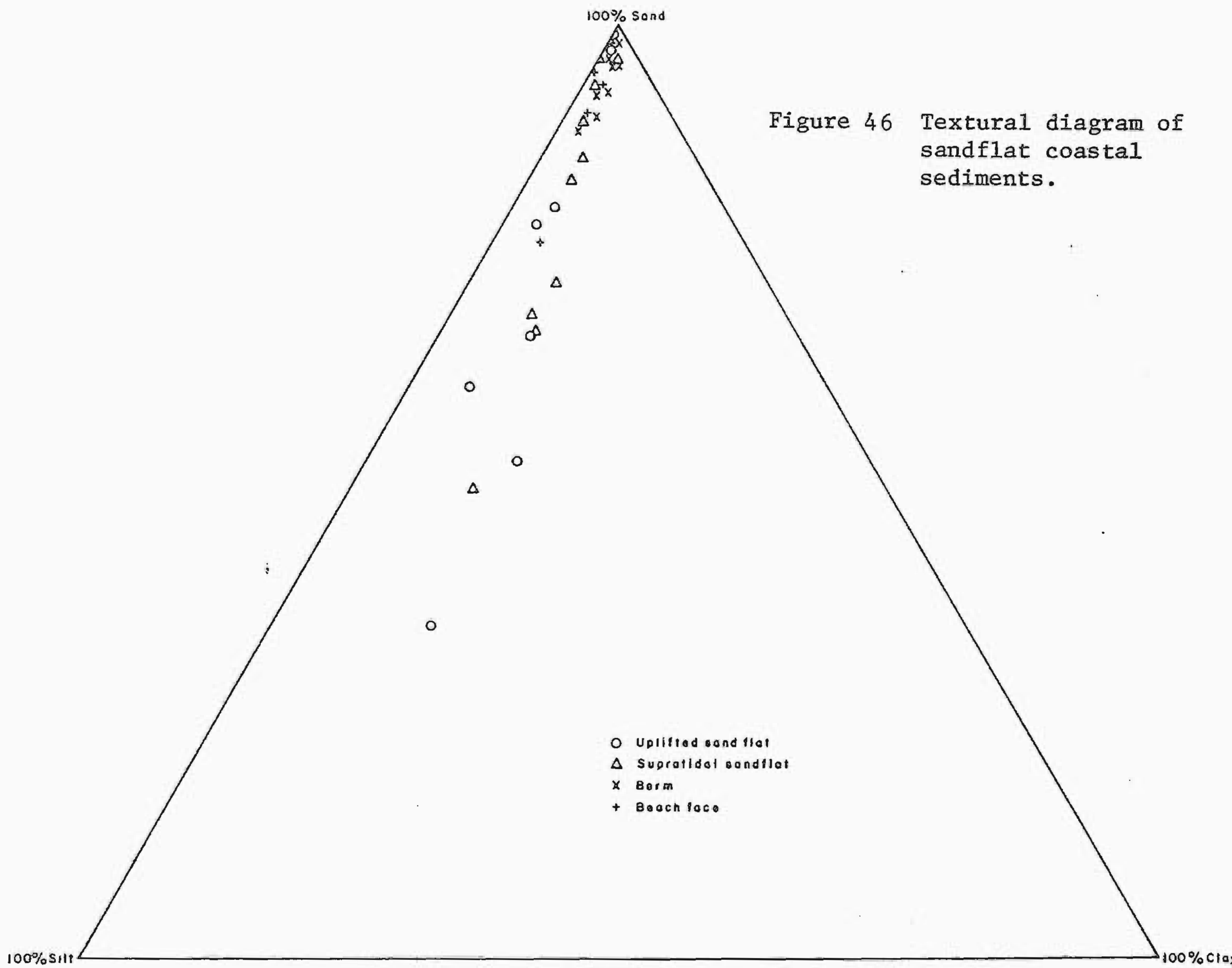


Figure 46 Textural diagram of sandflat coastal sediments.

(ii) The sub-environments consist predominantly of sand and silty sand (Fig. 46). Only the berm is entirely sand (i.e. greater than 80% sand). There are no significant differences in the textural parameters between the beach face, supratidal and uplifted sandflat. The berm, however, contains significantly less silt and clay (Table 15). Similar to the delta sands, the sandflat sub-environments consist of a strongly positive skewed, poorly sorted, fine and very fine sand (Table 15).

Raised Beach Coast

Morphology

As the name implies, a raised beach coast (P15:8-11) is characteristized by a series of well-defined beach ridges, composed primarily of gravel, that extend from the shoreline to an average elevation of 30 ±11 m. The average width and slope are 1.3 ±0.7 km and 2 ±0.8° respectively. The numbers of beach ridges range from 7/km to 28/km and average 16 ±6/km. Their average relief is 0.8 ±0.6 m.

Unlike the sandflat and delta coasts, the coastal and morphologic units are easily distinguished from each other (Fig. 47). The uplifted raised beach complex, no longer susceptible to marine processes, has been divided into the following morphologic units (Table 15); i) a raised beach top which has an average width of 3 ±1 m, ii) a raised beach face which has an average slope of 4.7° ±2.3° and iii), an interbeach lagoon. The latter is analogous to a swale which is a shallow trough-like depression between ridges and is aligned roughly parallel to the coastline. The term "interbeach lagoon" is used instead of swale because at the time of formation it may have characteristics which define a lagoon. With emergence, the interbeach lagoon can become intertidal and supratidal until it is removed from marine processes althogether. Once uplifted, meltwater can frequently form ponds in them. They average 12 ±11 m in width and are usually less than 1 m deep.

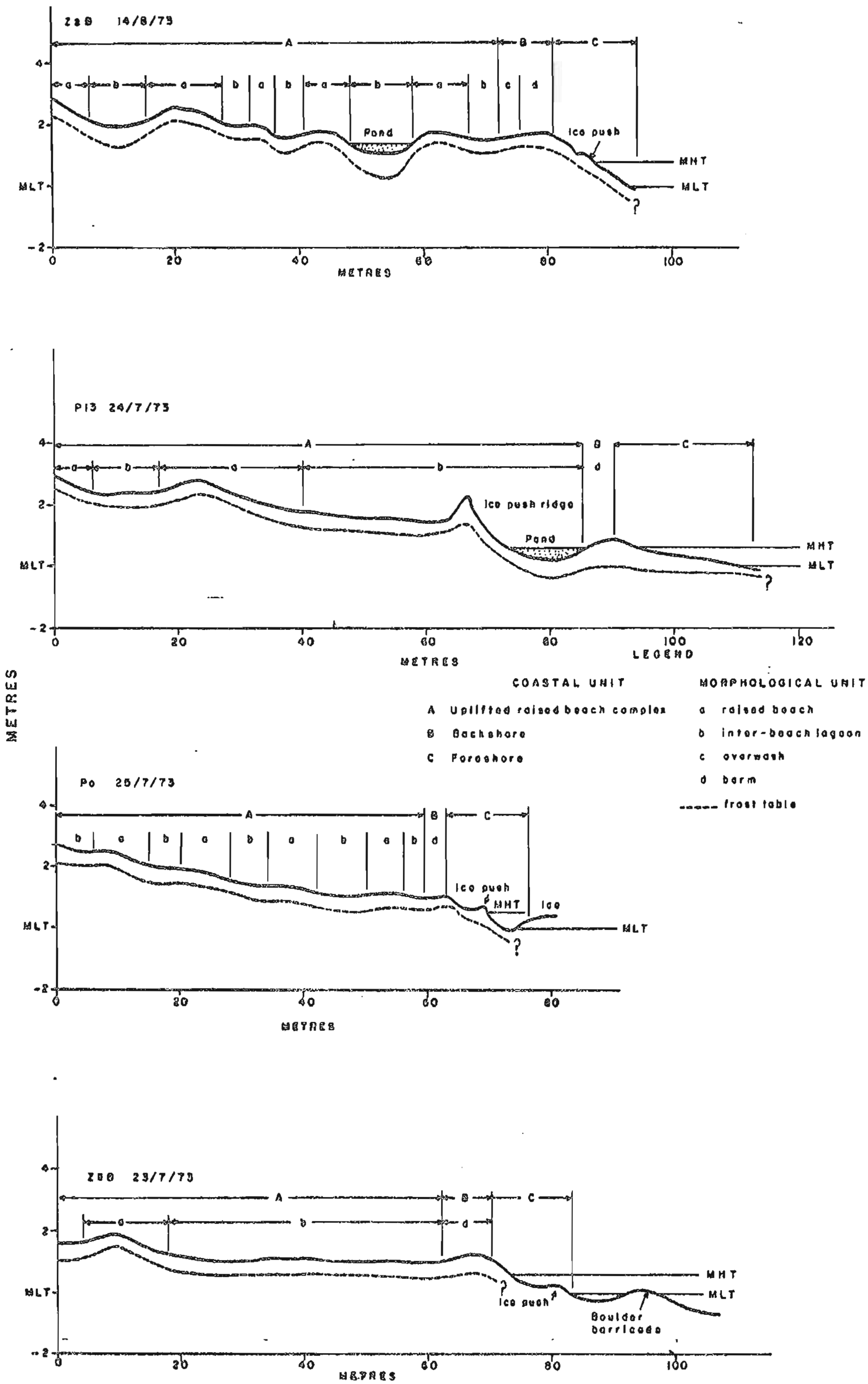


Figure 47 Characteristic beach profiles of a raised beach coast.

The backshore of the raised beach coastal type usually contains only a berm (6 ± 3 m wide) but can include an overwash deposit and the most seaward interbeach lagoon. The high percentage of gravel ($49 \pm 31\%$) that makes up the beach allows a steep sloping foreshore ($8.5° \pm 6.3°$) which frequently contains ice push deposits (Fig. 47). These consist of ridges often several meters long and up to a meter high. They run parallel to shore and can be found far above mean high water, the result of winds piling ice over the beach which, in turn, cause gouging, transportion and deposition of sediment.

When the raised beaches are perched on rock, such as on rocky headlands (Fig. 40), the foreshore can contain two more morphologic units: (i) An ice push boulder barricade, which is a special form of ice push ridge, can form at or below mean low tide (Z4B, Fig. 47) and consists of a steep boulder ridge that parallels the shore for several hundred meters. (ii) A boulder and cobble pavement, which is a veneer of broken bedrock underlying the boulder barricade, forms the floor of a prototype interbeach lagoon between the beach and ice push boulder barricade. The large size of the clasts in both these units made representative sampling impossible and therefore they are not included in Table 15.

Sediment Characteristics

The presence of gravel size and larger clasts in all the morphologic units of the raised beach coast differentiates this coastal type from the other. The mean percent gravel ranges from $49 \pm 31\%$ in the beach face to $8 \pm 8\%$ in the interbeach lagoons (Table 15), which is significantly higher than in any other sub-environment. The following observations apply to the textural properties of the raised beach coast:

(i) The ice push boulder barricade, which forms the seawardmost morphologic unit where the raised beaches are perched on rock (M25), consists predominantly of boulders with little or no fine material present (Fig. 48). The lithology of the boulders invariably reflects the underlying bedrock. Characteristically, the clasts are angular and show little sign of weathering.

(ii) The boulder and cobble pavement, also found only where raised beaches are perched on rock, is identical to the boulder and cobble bottom found adjacent to the rocky headlands in the nearshore. The clast size is generally smaller than the boulder barricade and consists predominantly of gravel and cobbles. The sharp angularity of the cobbles indicates little mechanical weathering (Fig. 49).

(iii) The present beach face of the raised beach coastal type contains a highly variable gravel content that ranges from 94% to 11% (Fig. 50). Generally a higher gravel content is found on the beaches that are overlying rock as opposed to those overlying sand. The former contains pebbles unique to the local bedrock, whereas beaches that are perched on sand can contain a number of lithologies including granite erratics. Many of the clasts show evidence of abrasion, being often sub-angular to sub-rounded. Frost shattering, however, tends to fracture other clasts into flat, angular rock fragments (Fig. 51).

(iv) The berm top is characterized by a more consistent percentage of gravel than the beach face (Fig. 50). It ranges from 40% to 72% gravel. Like the beach face, lithology is dependent on the closeness of bedrock to the surface; only one rock type is observed if the beach overlies rock.

Figure 48. Ice push boulder barricade. GSC photo 203123-C.

Figure 49. Boulder and cobble pavement. GSC photo 202123-D.

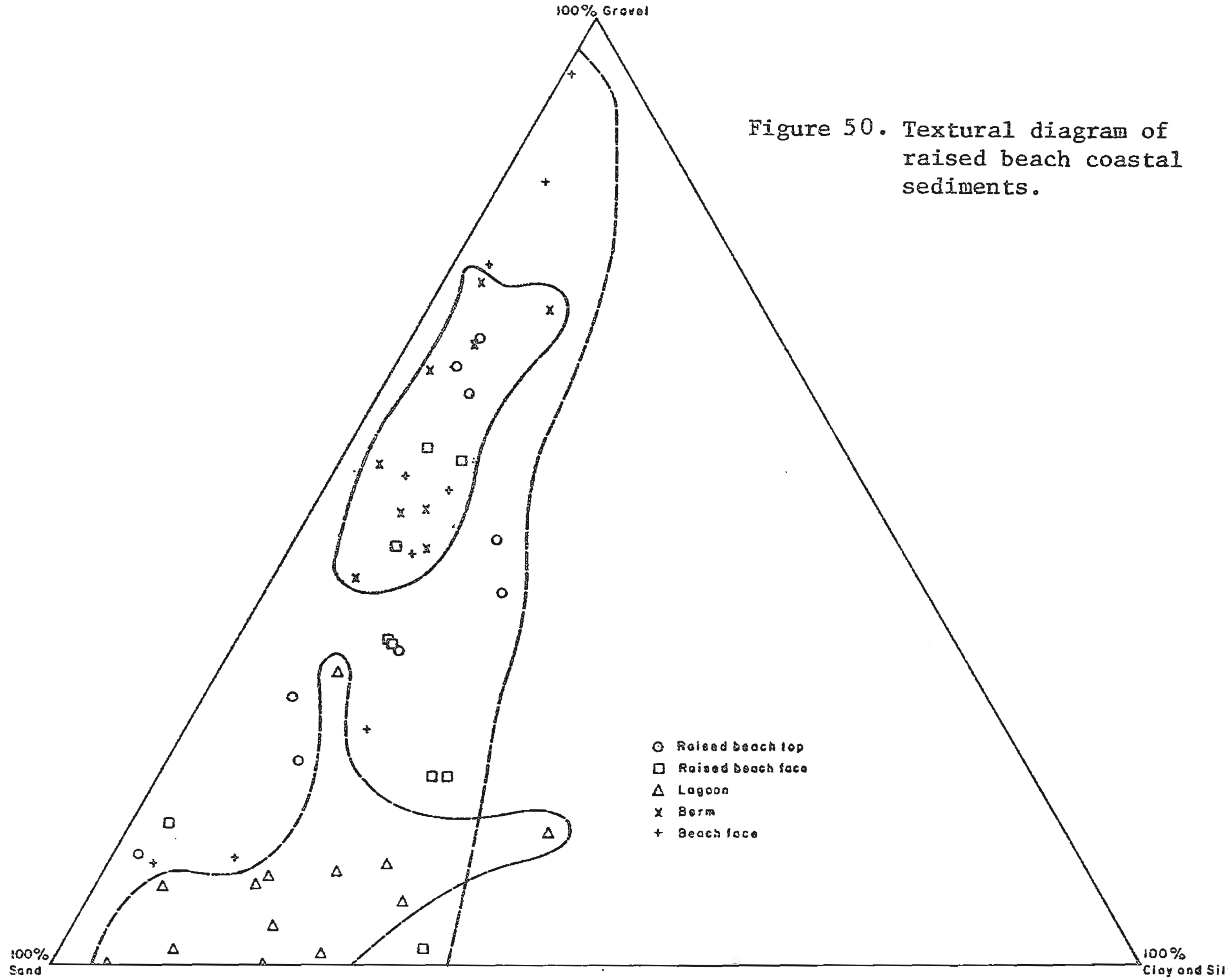


Figure 50. Textural diagram of raised beach coastal sediments.

(v) The lagoon contains least gravel (8 ±8%) and is texturally distinct from the sub-environments (Fig. 50).

(vi) The percentage of gravel in the raised beach face and raised beach top is not significantly different from that found in the present beach face and berm (Table 15, Fig. 50). The gravel is, however, somewhat finer (Table 15) which is due to frost action which tends to break apart the clasts. This produces a slightly more angular gravel.

(vii) A separate examination of the sand size and smaller sediment indicates that the textural properties of the sub-environments are essentially the same. The percent sand ranges from 77 ±10% to 85 ±6% and is predominantly very poorly sorted, coarsely skewed, fine and very fine sand (Table 15).

Delta Coast

Morphology

Each of the drainage basins shown in Figure 52 is terminated by an active delta (Fig. 53). In many cases, the present rivers have cut through raised delta sequences (Fig. 54) showing them to consist predominantly of foreset beds dipping at 10° or more, thus classifying them as Gilbert deltas (Gilbert, 1890). Diving observations on the active fronts (McLaren, 1975) showed similar dips (13° to 15°) indicating that the present deltas are the same type as those which have been uplifted.

The subaerial size of the active deltas ranges from 7 km^2 to 570 km^2, the largest being at King Point. Shearer (1974) has described the major components of these deltas and used the delta at Nelson Griffiths Point as a type example. These components include an upper and lower alluvial plain, the active delta and an uplifted delta plain.

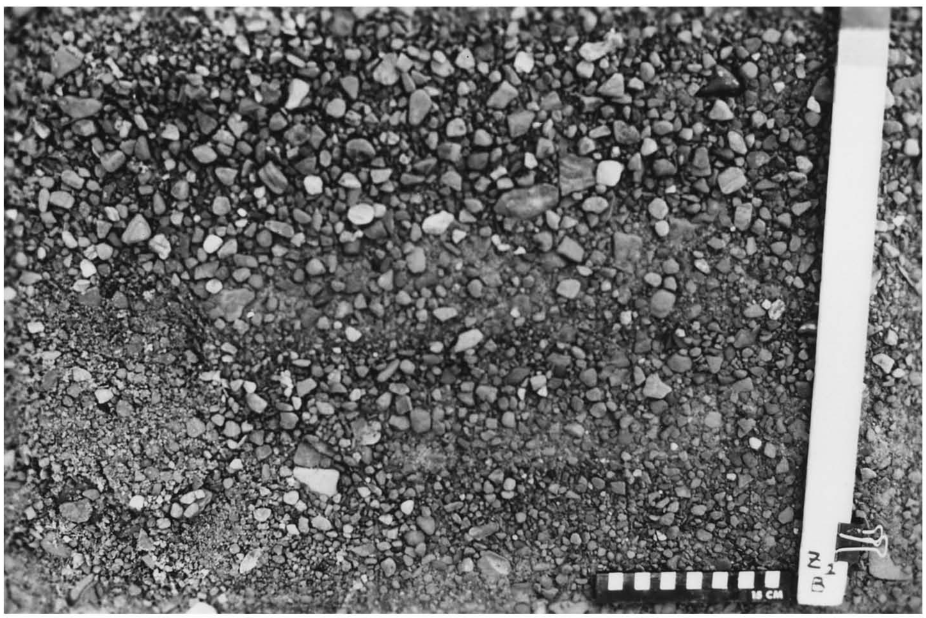


Figure 51. Typical beach face sediments from a raised beach coastal type. GSC photo 202123-E.

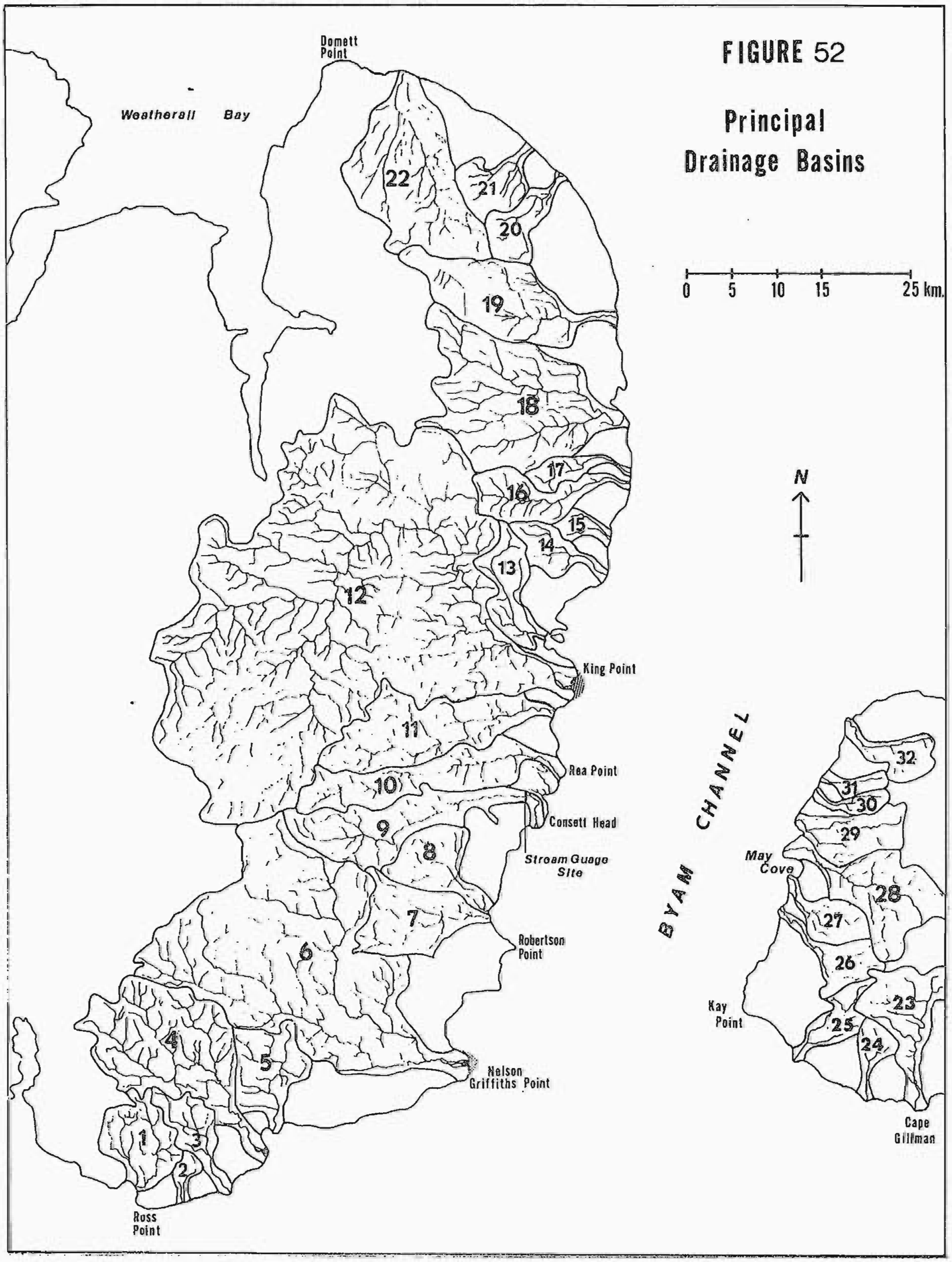


FIGURE 52
Principal
Drainage Basins
0
5
10
15
25 km.
N
Domett
Point
Weatherall Bay
King Point
Rea Point
Consett Head
Stream Guage
Site
Robertson
Point
Nelson
Griffiths Point
Ross
Point
BYAM CHANNEL
May
Cove
Kay
Point
Cape
Gillman
1
2
3
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Figure 53. Delta at Nelson Griffiths Point. GSC photo 202954-D taken on July 11, 1973.

Figure 54. Raised delta foreset beds exposed at Nelson Griffiths Point. GSC photo 202954-A taken July 12, 1973.

The upper alluvial plain begins at the point where the river is no longer confined within narrow valley walls and a braided stream pattern develops. It is characterized by longitudinal bars (Smith, 1970) that are rhomboid or diamond shaped in plan with their long axes parallel with the flow. They are found on the surfaces of the flood plain and are active only during high discharge. Their composition is medium gravel with a sand matrix (Shearer, 1974).

The lower alluvial plain can be distinguished from the upper portion by the numerical decrease in longitudinal bars and increase in transverse bars, which are tabular bodies that grow by downstream migration of foresets more or less perpendicular to current direction (Smith, 1970). Composed primarily of sand, they have less relief and greater mobility than the bars of the upper alluvial plain. This results in a more ephemeral stream pattern in the lower reaches. The alluvial plain continues to slope gently seaward to a water depth of approximately 3 m where a sharp break in slope occurs (Fig. 55) marking the junction with the delta foresets. Diving observations indicate that the steep slope terminates at a depth of approximately 10 m.

The distribution and extent of the uplifted inactive deltas are not as easily delineated. In many cases they so resemble uplifted sandflats (Fig. 56 and 57) that an exact outline of the deposit is difficult to determine. Generally, the immediate coast surrounding an active delta is an inactive delta front. The longest stretch of coast under this classification extends from Consett Head to King Point (M25). Vegetation is as variable as on the uplifted sandflats and the major difference between the two is the slope of the foreshore which, for the inactive delta coast, is a former delta front and, therefore, steeply dipping at greater than 10°. Ships docking at Rea Point are able to take advantage of the steeply sloping bottom and can come all the way to the shoreline to unload.

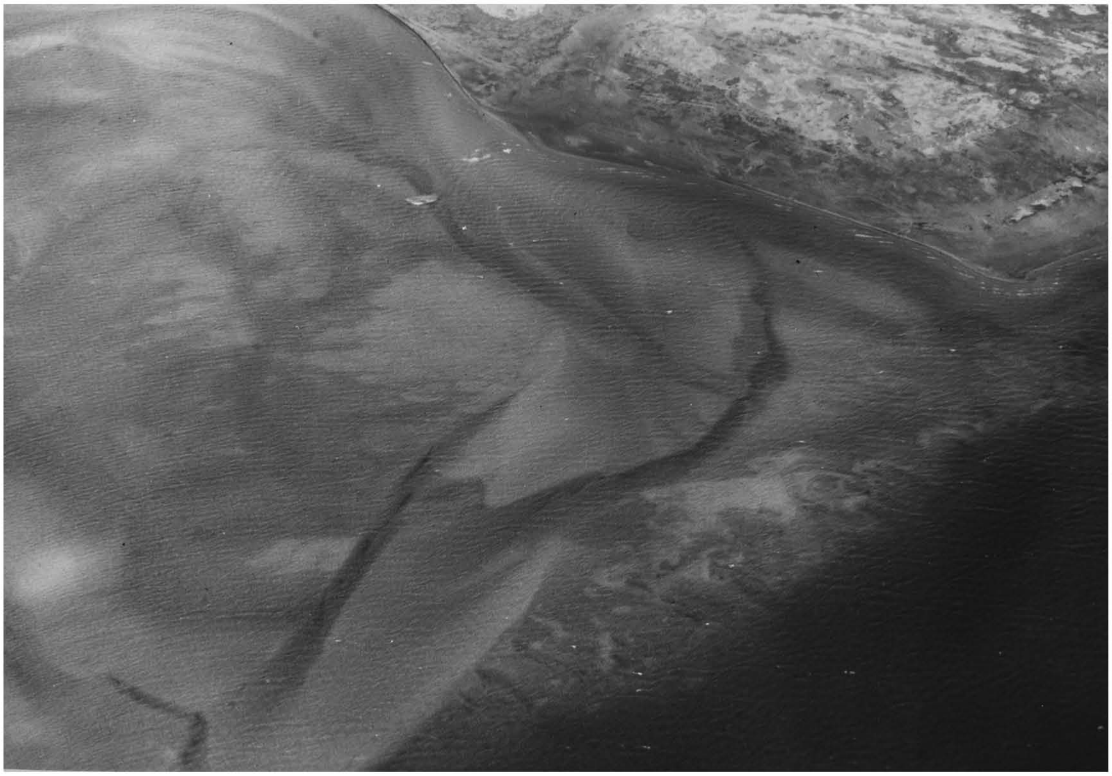


Figure 55. Delta Front at Consett Head River. The sudden change in water depth occurs at approximately 3 m and marks the break in slope between topset and foreset beds of a Gilbert delta. Note the minor ice scour features at the break in slope. GSC photo 202593-P taken on July 11, 1973.

Figure 56. Uplifted, inactive delta flat in vicinity of Rea Point. GSC photo 202953-V taken on July 11, 1973.

The delta coast is divided into an uplifted delta flat, a backshore that comprises a supratidal delta flat, and a foreshore or beach face (Fig. 57, Table 15).

Except for the beach face which slopes at $3.1 \pm 1.1°$, the backshore and foreshore are essentially flat and of widths too variable to obtain meaningful measurements.

Sediment Characteristics

No attempt has been made to differentiate between sediments of the uplifted, inactive deltas and the active deltas. Since samples from the active deltas are, in reality, from locations adjacent to the principal river mouth, little difference would be expected. Analyses of these three morphologic units does not imply a total absence of other features. Berms and ridge and runnel systems are occasionally present on the beach, but insufficient grain size data exist to analyze them as separate morphologic units. The grain size parameters indicate the following:

(i) Gravel size material is occasionally present in all three sub-environments (Table 15). Eighty-one percent of all delta coast samples contained no gravel; in the remaining samples, the amount of gravel ranged from 4 to 16 per cent.

(ii) The texture of the three sub-environments is predominantly sand and silty sand (Fig. 58). The beach face appears to have a higher percentage of sand when compared to the uplifted and supratidal delta flats; however there are no significant differences among the textural parameters. The sediment consists of a strongly positive skewed, poorly sorted, fine and very fine sand.

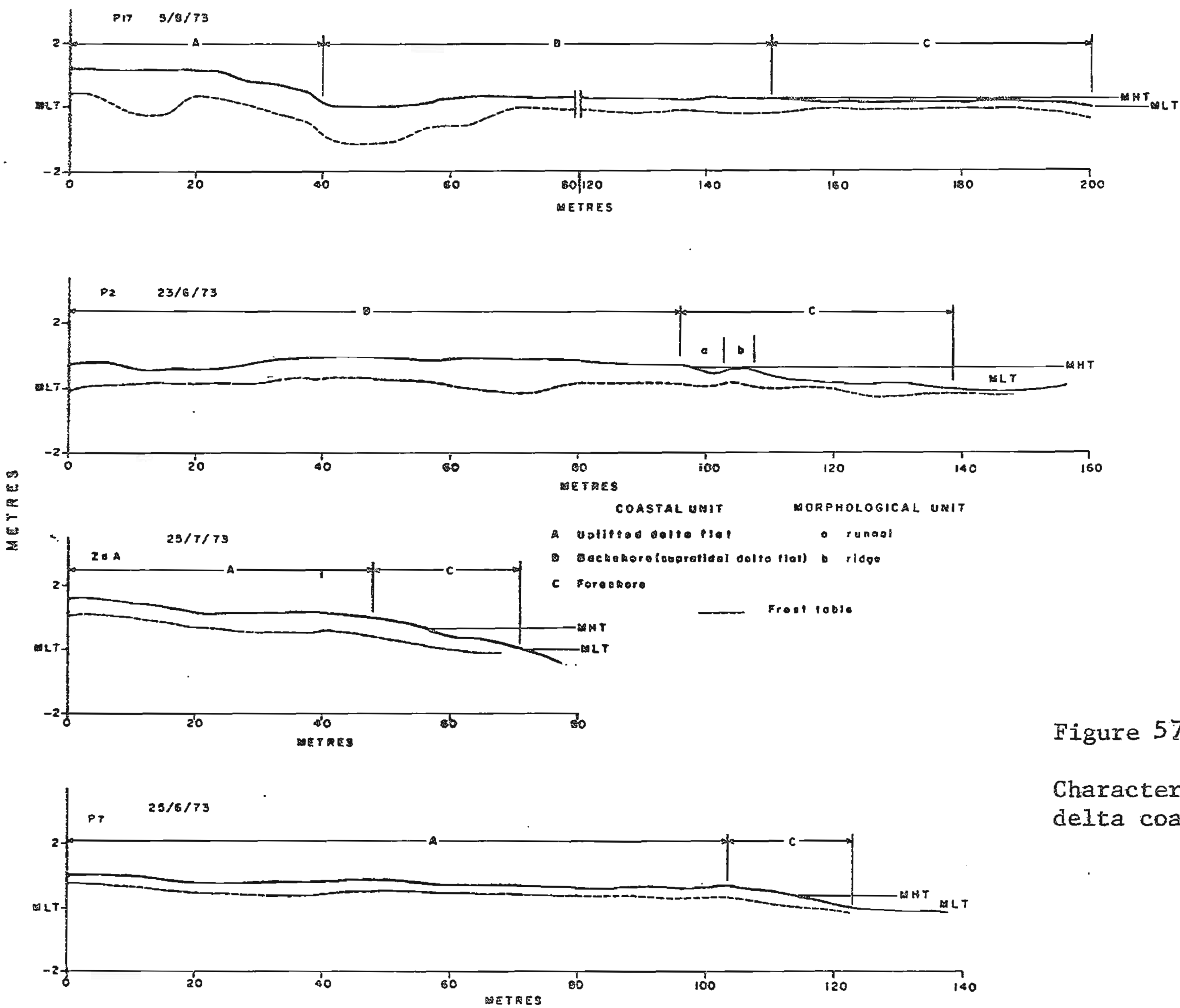


Figure 57

Characteristic profiles of a delta coast

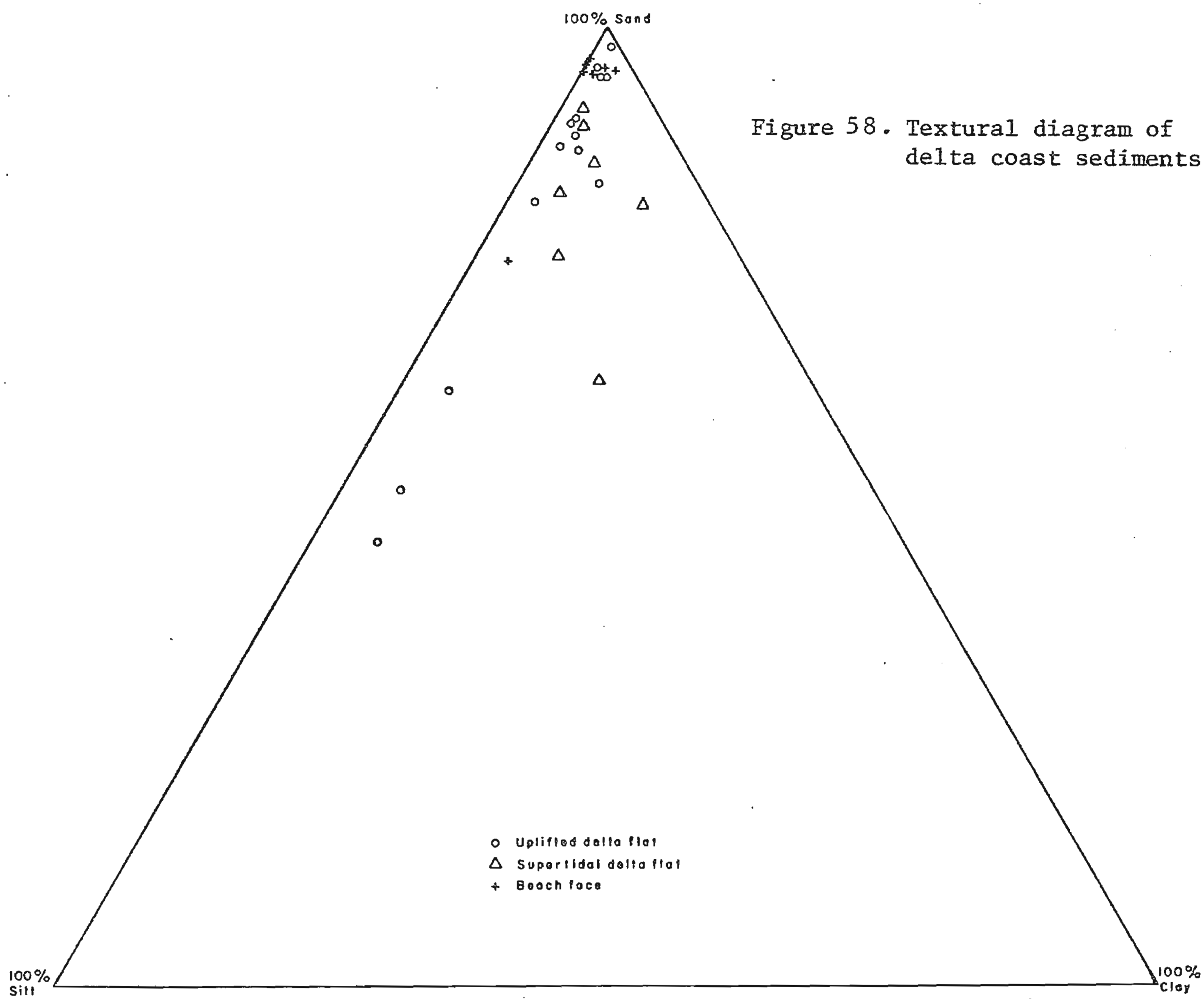


Figure 58. Textural diagram of delta coast sediments.

Nearshore Environment and Effects of Grounding Ice on the Bottom

Cobble Bottom

Bottoms consisting of a pavement of pebbles, cobbles, and occasional boulders were observed by SCUBA (McLaren and Frobel, 1975) at DH8, 11, 15, 17, 20, 21 and 22 (Fig. 59). With the exception of DH8, which was opposite Nelson Griffiths delta, all were adjacent to a raised beach coastline. Invariably, the cobble pavement reflected lithologies found at the adjacent coast (Fig. 60). Observations at DH11, 20 and 22 indicated that rocky headlands such as Robertson Point (Fig. 40) probably continue offshore as bedrock bottoms with an overlying cobble pavement. A fine-grained sediment cover was usually absent but the friable nature of the Hecla and Griper Bay sandstone sometimes resulted in a sandy matrix among the pebbles and cobbles. At DH11, the sand was sufficiently thick to take one short core of 25 cm.

All rocky bottoms contained some evidence of ice scouring (Figs. 61 and 62). Commonly, scour tracks were apparent by the absence of kelp (Laminaria) normally attached to the undisturbed bottom (Fig. 61). Scour bottoms tended to be shallow (30 to 60 cm deep), flat and wide (1 to 13 cm). A debris of broken pelecypod and sea urchin shells frequently accumulated in the scour bottom (Fig. 62). Low (generally <50 cm in height above undisturbed bottom), lateral and terminal embankments consisted of gravel, cobbles and boulders of the pre-existing pavement (Fig. 63) as well as occasional boulders of freshly torn-up bedrock (Fig. 64).

Where fine sediment was present in sufficient quantity, a veneer of compressed sand and silt was commonly "smeared" along the sides and bottom of the scour track. This veneer commonly contained grooves and striations (Fig. 65).

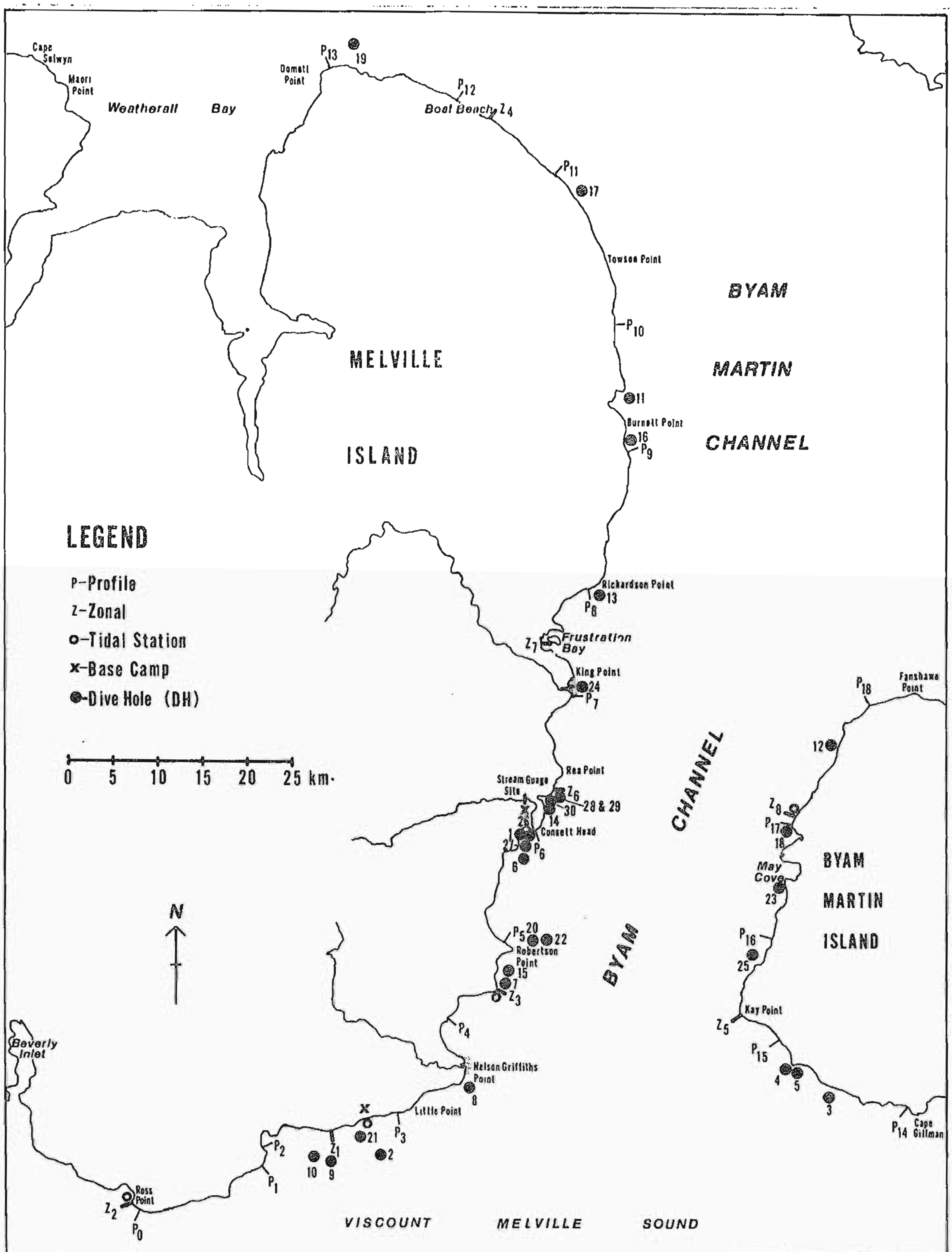


Figure 59. Dive site locations.

Torque readings from a vane shear meter imbedded in the surface sediment, expressed as sediment shear strength (kg/cm^2), illustrate the difference between compressed fines on the scour bottom and the loose, newly ploughed-up sediments on the lateral embankments (Table 16).

The heterogeneous nature of the cobble bottom causes the shear strength values shown in Table 16 to be very approximate and the true values, particularly for the scour bottom, are probably very much higher. In most attempts to take measurements in the scour, the divers were unable to press the shear vanes into the sediment at all. Nevertheless, the mean values for the scour bottom and lateral embankment are significantly different at the 0.05% confidence level and clearly demonstrate the compression in the scour bottom and the disturbed nature of the embankments.

Shallow Sandy Bottom

A sandy facies originating at the sandflat coastal type and sloping at nearly 2° to a depth of approximately 7 m was observed at DH 4 and 16 (Fig. 59). The sand bottom was adjacent to both active and inactive delta coasts (DH14, 23 and 24) where the slope was steeper (>10°). On one occasion the sandy facies was found adjacent to a raised beach coastal type (DH18).

At two dive sites, DH 4 and DH 16, opposite a sandflat coast, ripple marks were seen forming under the influence of strong tidal currents moving parallel to shore. Since currents in deeper water were uncommon, it is believed that the ice cover tends to dampen vertical tide motion and to constrict the available nearshore space for lateral water movements. Hence, as a flood-tide progresses, there would be a corresponding increase in currents in the shallow depths. Both dives took

Figure 60. Example of a cobble bottom made up of hecla Bay sandstone. DH8 (Fig. 59), water depth 11 m. GSC photo 202955-O.

Figure 61. Scour tracks visible through the water near Burnett Point (Fig. 50). Black areas are kelp attached to rock which is absent inside the tracks. GSC photo 202954-Y.

TABLE 16

Vane shear readings (kg/cm^2)[1] from a cobble bottom (DH 11)[2]

	Scour bottom	Lateral Embankment
	.10	.02
	.09	.03
	.14	.04
	.14	.03
	.20	.03
		.06
Mean	.14 ± .04	.04 ± .01

[1] kg/cm^2 appears to be the most common metric measurement of shear strength (see Marine Geotechnology, 1976, Vol. 1). More correctly this measurement should be expressed as kilograms force/cm^2 (1 kg/cm^2 = 98.1 kPa = 14.2 psi).

[2] Penetration depth of shear vane into sediment = length of shear vane = 1.9 cm.

TABLE 17

Vane shear readings (kg/cm^2) from a sand-silt-clay bottom (DH 1)[1]

	Undisturbed bottom	Scour bottom	Lateral embankment
	.04	.09	.02
	.04	.08	.02
	.04	.07	.01
	.04	.09	.01
	.03	1.01	.02
	.04		.02
	.04		
Mean	.04 ± .00	.09 ± .01	.02 ± .01

[1] Penetration depth of shear vane into sediment = length of vane = 1.9 cm

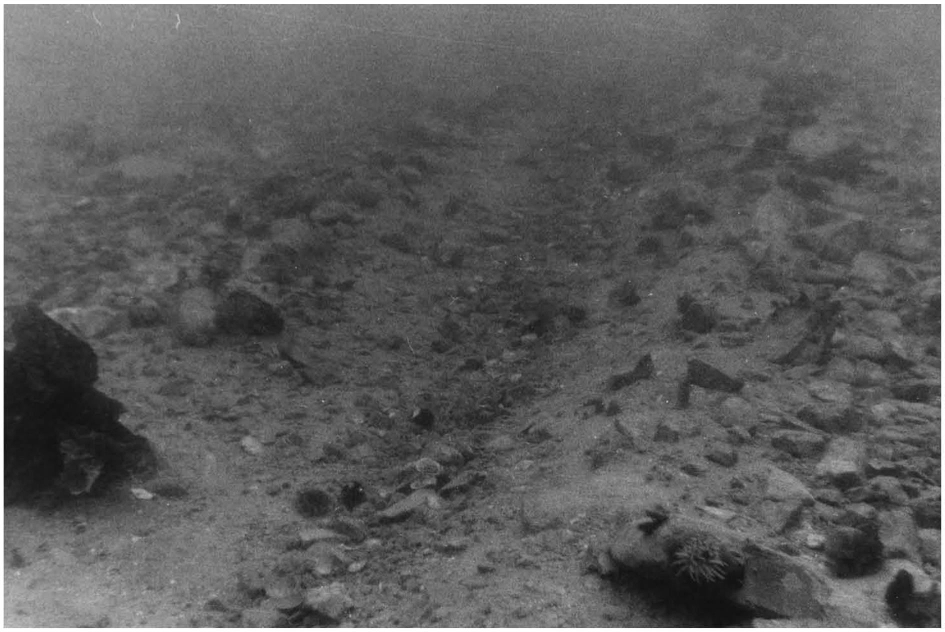


Figure 62. Small scour track in cobble bottom atDH20, water depth 8 m. Note shell and rock debris in scour bottom. GSC photo 202955-P.

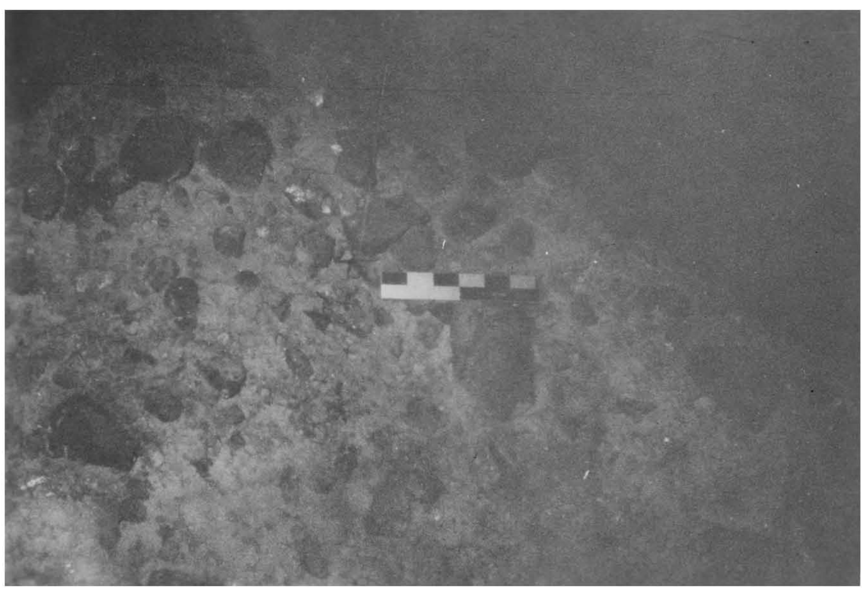


Figure 63. Terminal embankment in cobble bottom, DH17 water depth 21 m. Scale is 30 cm long. GSC photo 202954-X.

Figure 64. Boulder of Hecla Bay sandstone recently torn up from underlying bedrock by ice scouring. Scale is 30 cm long. GSC photo 202955-I.

Figure 65. Striated side of a lateral embankment in a cobble bottom. Relief is approximately 89 cm. GSC photo 202955-M.

place directly seaward of large ice fences grounded onshore (Fig. 66). Surprisingly, there was little evidence of ice scour. It is suggested that ice pans moving towards shore begin to buckle and form ridges as the shoreward edge of the ice pack grounds. The ice fence builds upwards at the shoreline with little or no further movement through the sediment. The presence of nearshore, under-ice currents may be sufficient to infill and obliterate any scour tracks that may occur.

On active delta fronts (DH23 and 24), the sandy facies continued offshore to somewhat deeper depths of 9 to 10 m. Slopes of 10 to 13 degrees were measured. The break in slope between the topset and foreset beds occurred at approximately 3 m and was a natural place for pack ice to ground. Similar to the observations on the submarine sandflat, major scour was not apparent, although the sand at the change in slope appeared to be compacted and compressed. Cores were hard to take here compared with locations deeper on the foreset beds where the sand was looser. Accumulations of land-derived organic debris were common in depressions or swales found on the delta front (Fig. 67).

Only one dive (DH14) was made on an inactive delta front. The bottom appeared to be gently undulating with small, 1 metre wide and 10 cm deep, valleys running towards shore. If these represented scour tracks, they had been much subdued. Similar to the previous sandy bottoms, gravel sized sediment or larger was extremely rare or absent.

The shallow sandy bottoms have been discussed together regardless of their genesis because of their textural similarity. Clearly a delta forefront has a different origin from a submarine continuation of a sandflat coast. Insufficient diving observations were made to indicate how frequently a sandy bottom occurs

Figure 66. Dive taking place (DH_4) immediately seaward of an ice fence grounded onshore. GSC photo 202955 taken on June 23, 1974.

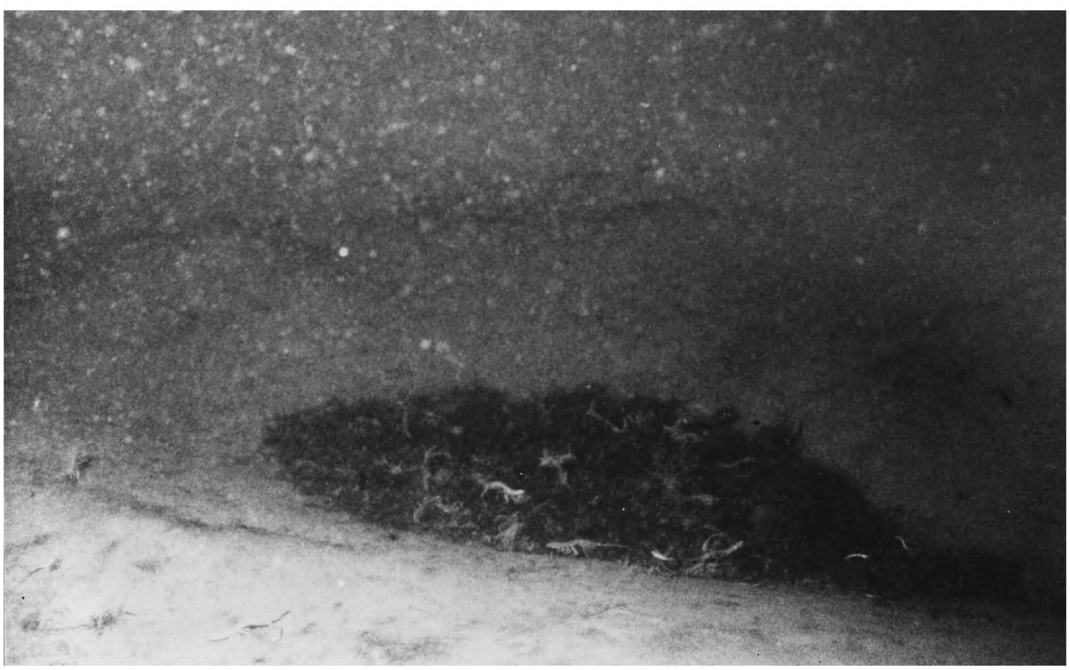


Figure 67. Accumulation of land-derived organic debris in a swale on a delta forefront. Isopods are feeding on the organic matter. GSC photo 202955-J.

adjacent to a raised beach coast. Certainly it is never found at a bedrock headland. It is likely that a raised beach coast does have a sandy nearshore but it is probably less thick and less continuous than those found on the other coastal types.

Sand-Silt-Clay Bottom

Adjacent to all the coastal types, the most ubiquitous type of bottom consisted of a poorly sorted sand-silt-clay facies (DH1, 2, 3, 5, 6, 7, 9, 10, 12, 13, 19 and 25). It was commonly found offshore from the 7 to 10 m isobath and was present at the deepest dives of 26 m. At most locations, pebbles and cobbles of local bedrock origin were observed both resting on the bottom and in cores. On only one occasion in Viscount Melville Sound (DH2) was a single small erratic of granite discovered.

Such bottoms were highly variable with respect to the degree of ice scouring. Completely undisturbed bottoms were present at DH6, 9, 10, and 25 (Fig. 68). Other locations (DH3, 5, and 13) appeared as a gently undulating bottom (Fig. 69), consisting of subdued parallel valleys up to several metres wide with less than a metre of relief. The topography is believed to be the result of former ice scouring but it is unknown how long it might take for a new scour to lose its sharpness of relief or for vegetation to re-cover a freshly exposed surface.

Two types of freshly scoured bottoms were observed; those in which the surface appeared to be so churned by ice activity that undisturbed areas did not exist (DH7, 12 and 19; Fig. 70), and those where a scour, its embankments, and an undisturbed bottom could all be clearly defined (DH1 and 2, Fig. 71). In the latter, scour was observed to reach depths of 1.5 m and to produce lateral embankments up to 2 m high. More commonly, however, they exhibited less than 1 m of total

Figure 68. A vegetated, undisturbed sea bottom in the sand-silt-clay facies. DH25, water depth 24 m. GSC photo 202842-T.

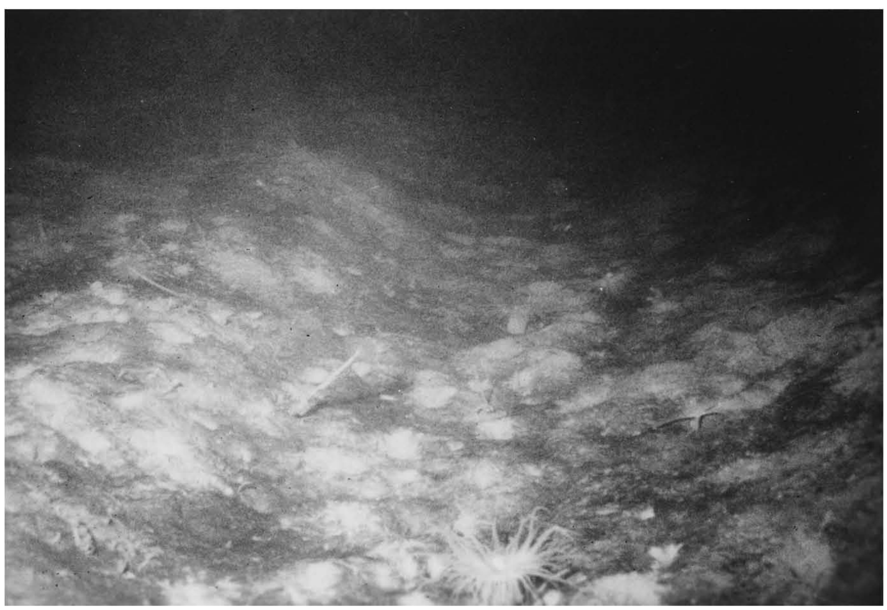


Figure 69. An "old" scour track in the sand-silt-clay facies. Note the vegetated bottom and subdued relief. A sea anemone is in the foreground. DH13, water depth 13 m. GSC photo 202842-S.

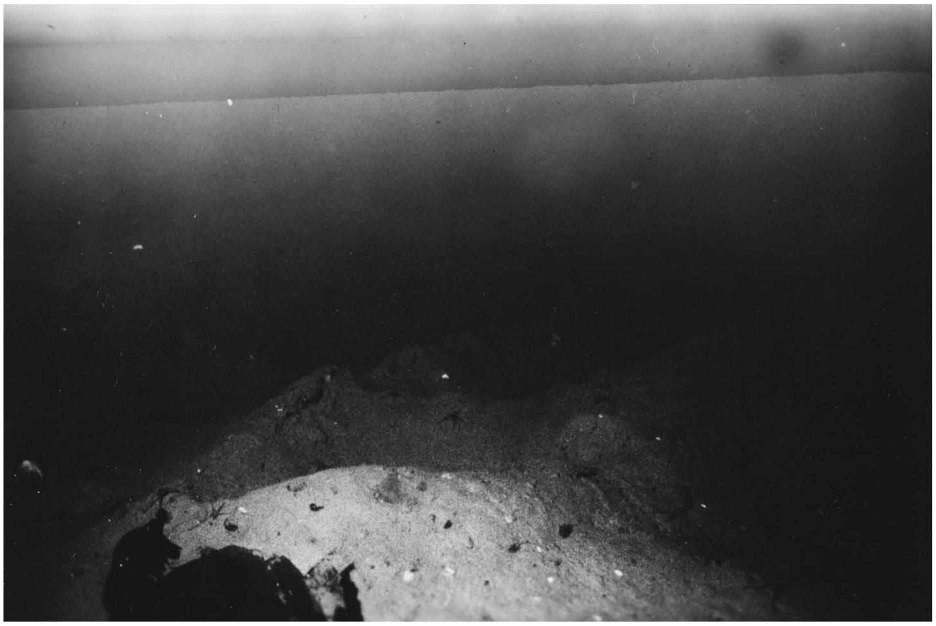


Figure 70. Totally disturbed bottom in the sand-silt-clay facies consisting of a confused agglomeration of ice scour embankments. DH12, water depth 26 m. GSC photo 202842-R.

Figure 71. A grounded ice block and its associated lateral and terminal embankments. The lateral embankment is approximately 80 cm high. DH2, water depth 15 m. GSC photo 202842-Q.

relief. Diving methods were insufficient to measure successfully the width of scour tracks which would be limited only by the size of an ice block at its base. One relatively small ice block at DH1 (Fig. 72) was 34 m across, although numerous others were considerably larger. Generally, the scours that could be easily observed were less than 10 m wide.

As previously described, the weight of a moving ice block greatly compressed the sediment within the scour bottom to such a degree that it was frequently impossible to take cores. By contrast the embankments were more loosely compacted than either the track or the undisturbed sediment beyond the scour. Values from a vane shear meter illustrate the differences in sediment shear strength obtained in the various scour morphologies (Table 17). The scour bottom has a shear strength of approximately .09 kg/cm^2 which is twice as great as an undisturbed bottom (.04 kg/cm^2) and nearly five times greater than a recently produced lateral embankment (.02 kg/cm^2).

The scour track was frequently striated and grooved (Fig. 73). In some instances transverse fissures 15 to 30 cm wide were formed in the newly compressed sediment by the frictional drag of the lee side of the moving ice block (Figs. 74 and 75).

Where stationary ice blocks and their associated scours were seen together, the block had commonly settled into the sediment to form a scour crater deeper than the linear scour bottom formed while the block was in motion. A crater embankment would completely surround the ice block (Figs. 75 and 76) even on the upstream side of its previous motion. Thus the linear scour bottom terminated by disappearing under the crater embankment. Where ice had melted back from the embankment sides, the walls were seen to be highly compressed and consolidated

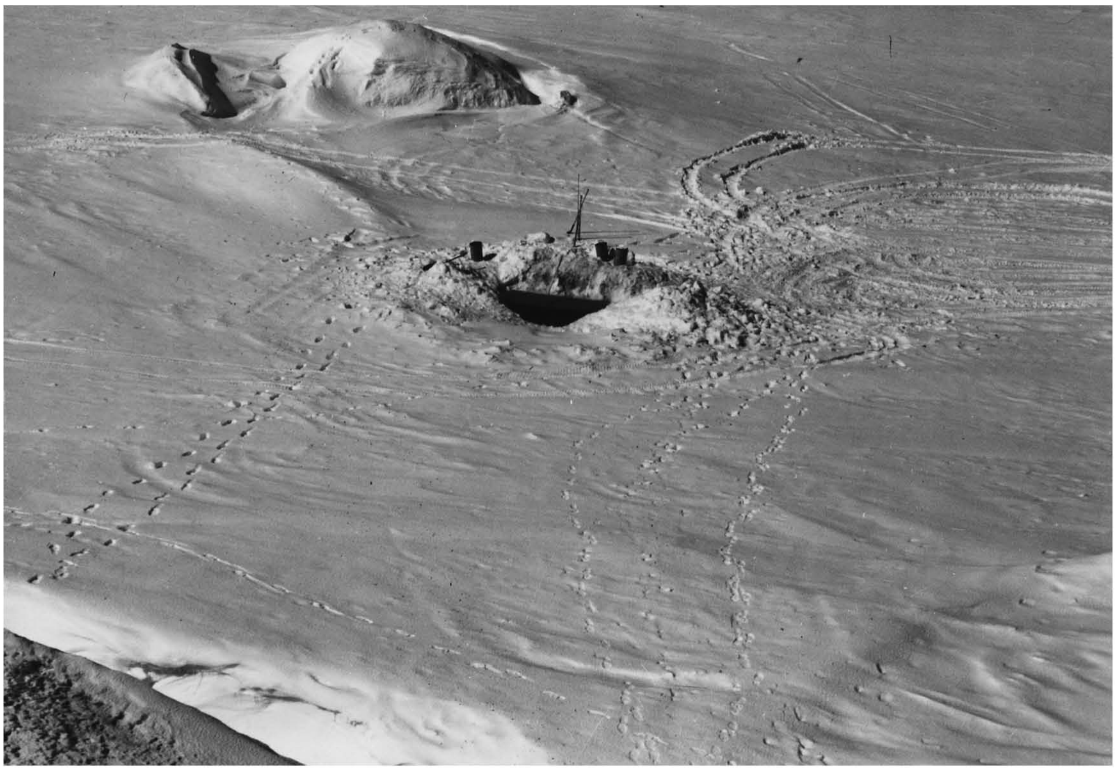


Figure 72. A small ice block grounded at DH1. Width is approximately 34 m. GSC photo 202955-H.

Figure 73. Parallel grooves in a scour bottom formed in the sand-silt-clay facies. Note the absence of burrows. DH2, water depth 15 m. GSC photo 202842-P.

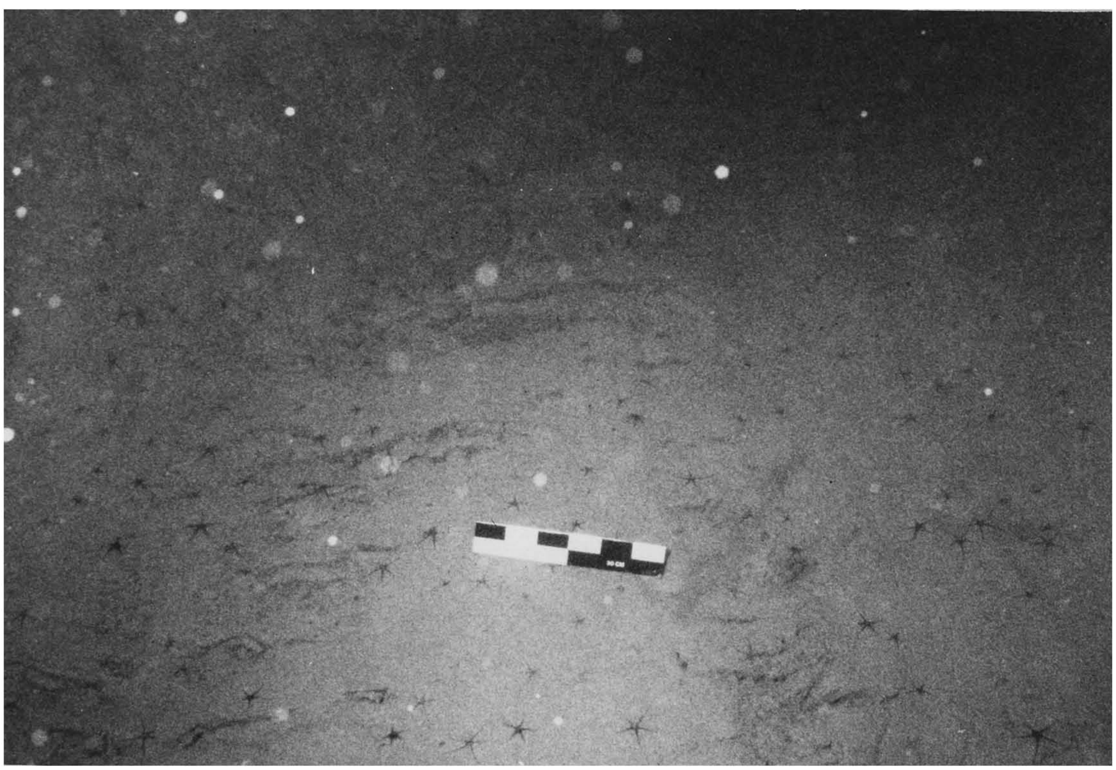
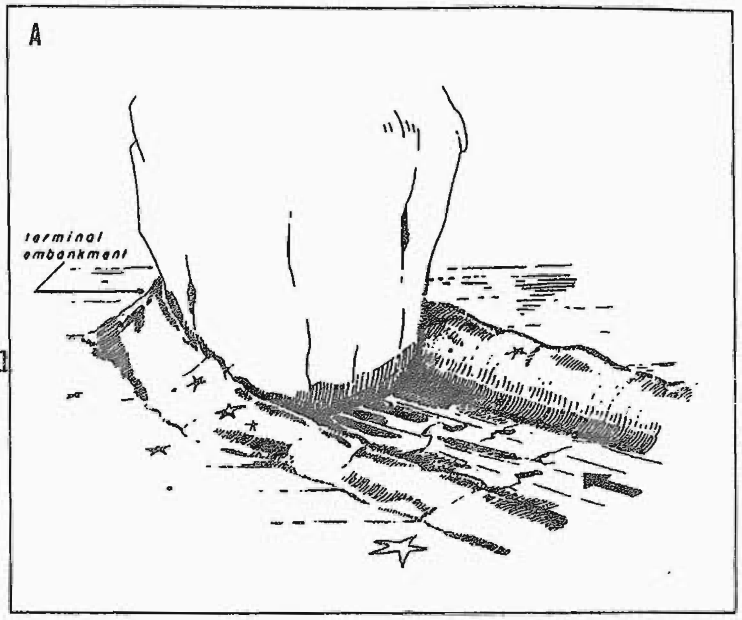
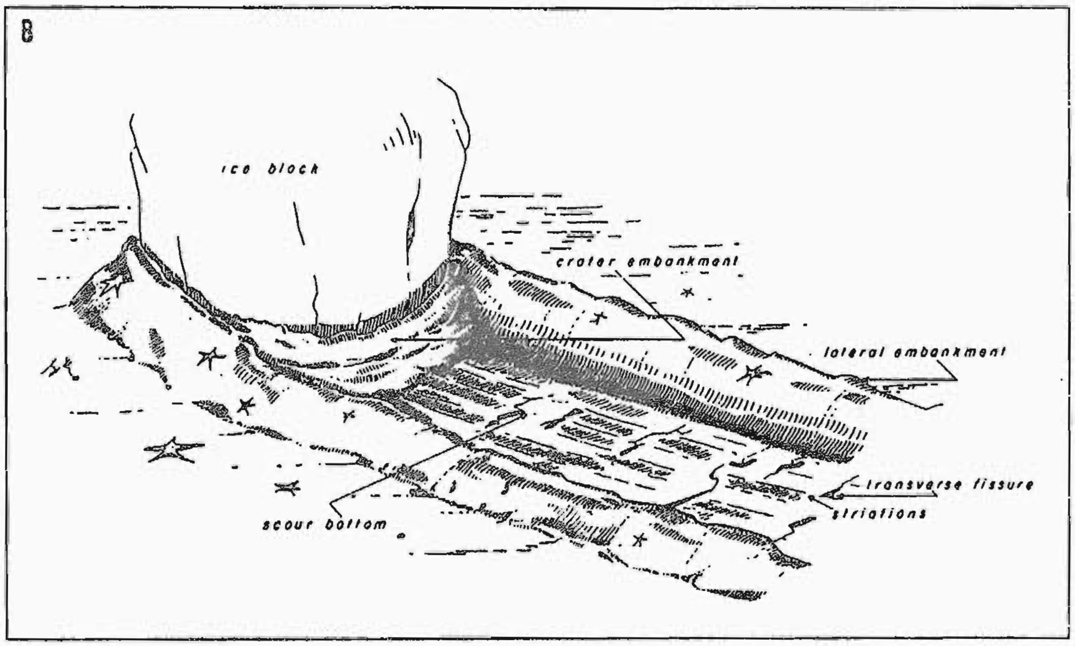


Figure 74. Transverse fissures in a scour bottom. Scale is 30 cm long. DH1, water depth 11 m. GSC photo 202955-F.

Figure 75. A: Diagrammatic sketch of an ice block moving through the substrate.

B: The same block has come to a halt and downward vertical pressures form an ice scour crater.





(Fig. 77). The full depths of such craters are unknown but on one occasion at DH1, vertical walls 3 m deep were measured. At this same crater, which was observable because the ice had melted back sufficiently to swim into it, a soft infill of sediment was accumulating. This was the only instance where active sedimentation within an ice-produced feature was observed. Probably, it was the result of unstable embankment material slumping down the steep walls. The infill had identical grain size characteristics to the surrounding sediment.

The overall impression gained from the diving observations of a totally disturbed sand-silt-clay bottom was of chaotically churned, compressed and torn apart sediment with a confused conglomeration of scour tracks and embankments. The embankments contained compressed, equidimensional (20 to 40 cm) blocks of sediment derived from former scour tracks. Many of the heaved-up blocks still had grooves and striations visible indicating they were previously part of a scour bottom.

Sediment Characteristics

Only two samples were obtained from cobble bottoms, a core from DH11 and a sample that was scooped from the bottom by hand into a bag at DH15 (Table 18). The two samples, containing 36 and 18 per cent gravel respectively, were too few to average for a representative textural description of the cobble bottom substrate.

The shallow sandy bottom is characterized by poorly sorted (1.91 ±0.46∅), very fine sand (mean grain size 3.59 ±0.87∅) consisting of approximately 79% sand, 15% silt and 6% clay (Table 18, Fig. 78). All the samples showed a strong positive skewness (3.41 ± 1.36) indicating a tendency for the grain size distribution to have a tail towards the fine material.

Figure 76. Crater embankment completely surrounding the base of a grounded ice block. DH2, water depth 15 m. GSC photo 202955-D.

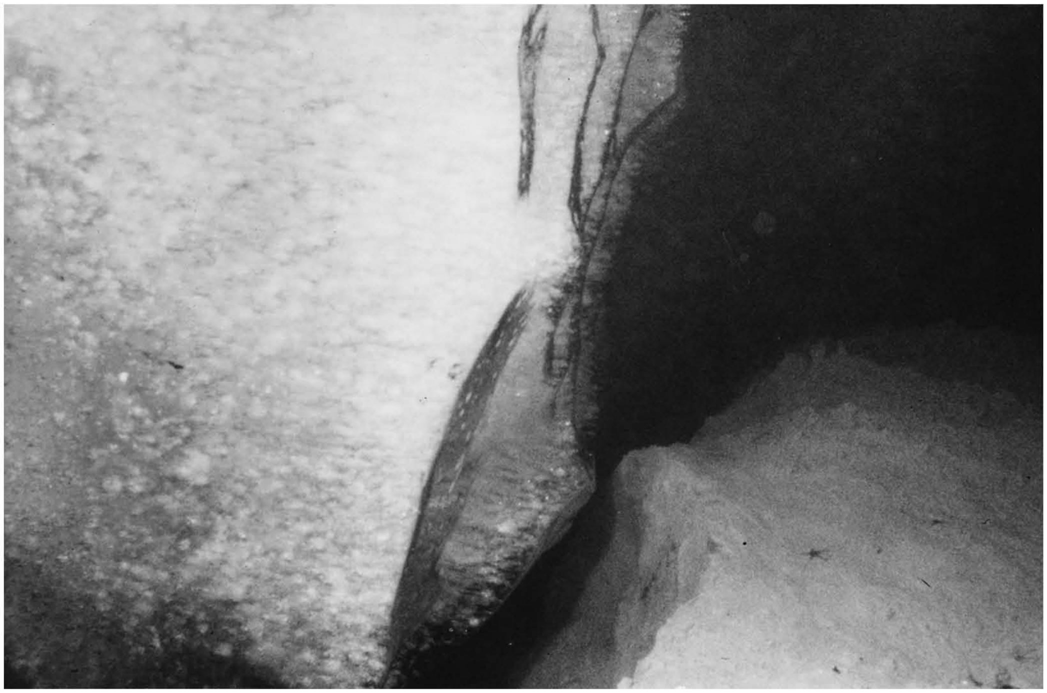


Figure 77. Grounded ice block and compressed inside wall of the crater embankment. DH7, water depth 13 m. GSC photo 202955-C.

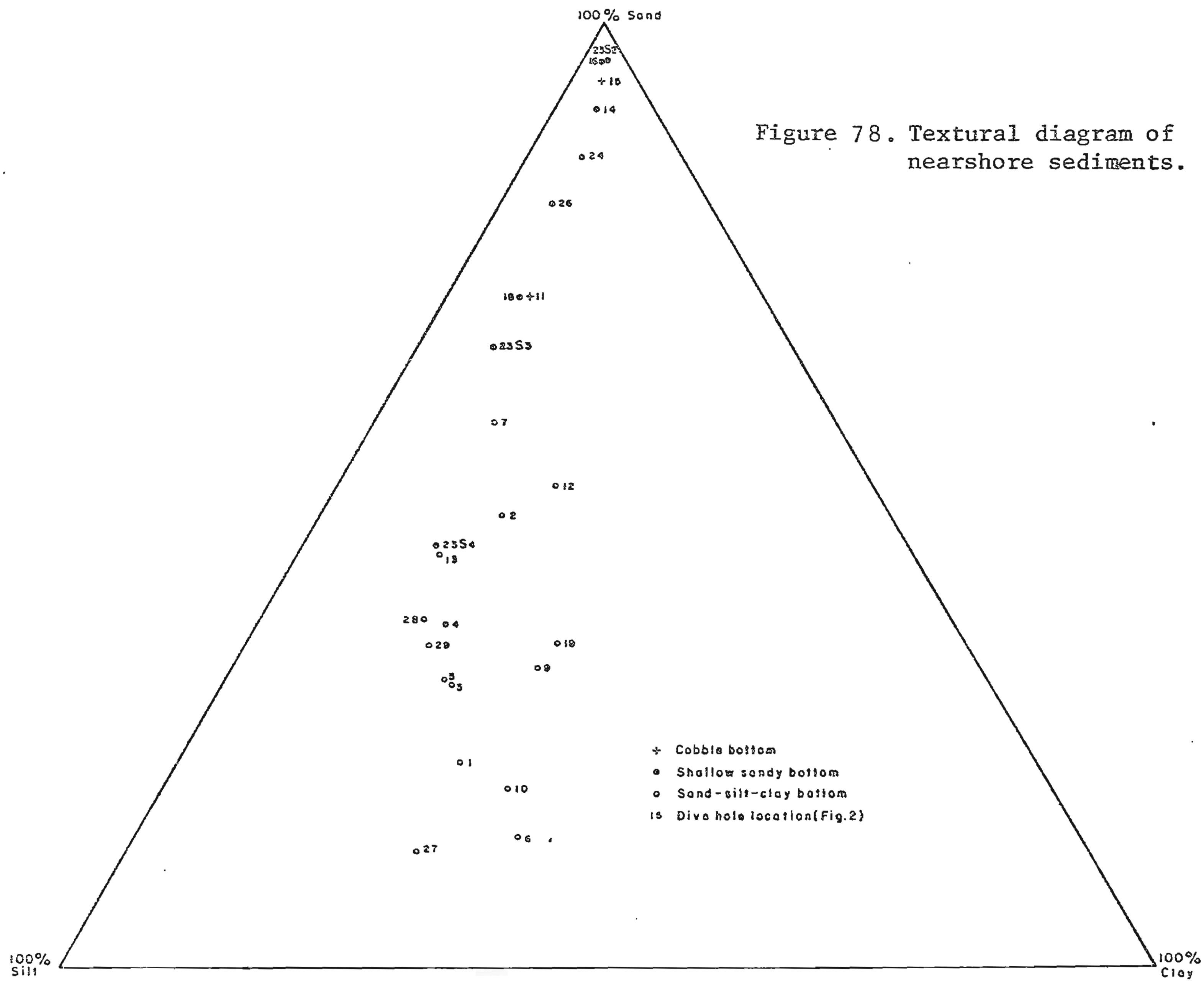


Figure 78. Textural diagram of nearshore sediments.

TABLE 18
Average Grain Size Characteristics for Nearshore Samples, Byam Channel

		TEXTURE			MOMENT MEASURES (> - 1Ø)			
TYPE OF BOTTOM	DIVE HOLE	%SAND	%SILT	%CLAY	MEAN SIZE	SORTING	SKEWNESS	DEPTH(m)
Cobble Bottom	DH11	71	21	8	3.93	2.51	1.75	9
	DH15	94	3	3	3.08	1.60	4.03	6
Shallow Sandy	DH4	37	46	17	5.50	2.89	0.83	3
Bottom	DH14	91	5	4	2.74	1.69	3.64	5
	DH16	96	2	2	2.65	1.42	4.87	7
	DH18	71	22	7	3.94	2.35	1.91	7
	$DH_{23}S_2$	96	2	2	2.79	1.28	5.06	3
	$DH_{23}S_3$	66	27	7	4.33	2.20	1.99	5
	$DH_{23}S_4$	45	43	12	5.12	2.62	1.37	9
	DH24	86	9	5	3.41	1.89	3.19	5
	DH26	81	14	5	3.71	1.85	3.09	14
	Mean	79 ± 18	15 ± 14	6 ± 4	3.59 ± 0.87	1.91 ± 0.46	3.14 ± 1.36	6 ± 3
Sand-Silt-Clay	DH1	22	52	26	6.58	3.07	0.51	11
Bottom	DH2	48	35	17	5.17	3.23	0.81	15
	DH3	30	49	21	5.99	3.21	0.38	14
	DH5	30	49	21	5.92	3.21	0.39	14
	DH6	14	51	35	7.33	3.03	0.16	24
	DH7	58	31	11	4.56	2.57	1.64	13
	DH9	32	40	28	6.52	3.47	0.26	20
	DH10	19	49	32	7.05	3.20	0.45	25
	DH12	51	29	20	4.61	2.70	0.77	26
	DH13	44	43	13	5.01	2.72	1.26	13
	DH19	34	37	29	6.32	3.48	0.26	18
	DH27	12	61	27	7.01	2.78	0.45	15
	DH28	37	48	15	5.21	2.69	1.29	12
	DH29	34	49	17	5.61	2.85	0.98	12
	Mean	33 ± 14	45 ± 9	22 ± 7	5.92 ± 0.92	3.02 ± 0.30	0.69 ± 0.45	17 ± 5

The mean grain size of the sand-silt-clay bottom (5.92 ±0.92) indicates that the sediment is predominantly medium silt with an average composition of 33% sand, 45% silt and 22% clay (Table 18, Fig. 78). It is very poorly sorted (3.02 ±0.30Ø) and has a considerably less positive skew than the shallow sandy bottom (0.69 ±0.45). Gravel composition of the cores ranged from 0% to 22%.

Coastal Permafrost Regime

Implications of Offshore Bottom Permafrost

Permafrost refers to rock or sediment which has a mean annual temperature of less than 0°C, whether or not inter-granular ice bonding is present. Its presence in offshore sediments can have considerable influence on the design of facilities to be used in northern waters. For example, pipelines are potentially subject to damage by differential movement of a thaw-bulb which might extend to 30 m from the pipe, or by differential freezing and frost heave around a chilled pipeline (Hunter *et al.*, 1976). The consequences of engineering failures on structures such as offshore drill rigs due to differential subsidence are far greater than onshore in terms of loss of human life, environmental damage and rectification costs. Permafrost knowledge will, therefore, be of extreme importance in designing offshore and coastal bottom and sub-bottom structures.

Evidence of Offshore and Coastal Permafrost

There is little published information on the occurrence of offshore permafrost in the arctic islands. Sea water in these regions tends to be below the freezing point of fresh water. Even after spring melt, Taylor (1976) measured sea water temperatures from -0.7°C to -1.5°C in the bay at Z_7 (Fig. 59). Ongoing studies by Judge (pers. comm.) indicate that seabottom temperatures throughout the archipelago are below 0°C and therefore ice bonding will be possible if the substrate contains fresh water.

On one occasion at DH4, in shallow water (<3 m) close to the ice-sediment interface, ice crystals were observed attached to the sandy substrate (Fig. 79 and 80) and appeared to be growing off the bottom. Similar in structure to rosette crystalline aggregates they have been termed "brine rosettes". The salinity of the melted ice was only 4.5 ppt suggesting that fresh meltwater from onshore was perhaps seeping through the nearshore sediment and freezing on contact with the colder brine.

Massive clean ice imbedded in a lateral embankment was observed during a dive near Resolute Bay. In this case the ice had clearly originated from the larger ice block that had produced the scour track. It is suggested that during the scouring process ice may become buried and remain for long periods of time in the sediment.

Direct information obtained by drilling and piston coring in the offshore is generally confidential. Polar Gas (pers. comm.) has indicated that ice bonded sediments are not present in the top 1 to 8 m in Byam Channel. An exception to this occurred only 20 m from the Byam Martin coast where 6.5 m of frozen till lay above sandstone bedrock. This till was described as predominantly clay with a relatively high wet density of 2.2 gm/cc.

Onshore, hand augering at each established beach profile (Figs. 59, 45, 47 and 57) indicated that the frost table above high water was characteristically less than one meter below the surface. In fine deposits, such as in interbeach lagoons, this value appeared to increase to over 2 m, whereas, in poorly sorted, coarse beach deposits, this level rose to approximately 0.5 m. An analysis of grain size relationships with frost table depth, however, failed to verify these observations.

Figure 79. Brine rosette hanging on the underside of the ice surface at DH 4. Identical ice structures were observed attached to the sandy substrate. GSC photo 202665-W.

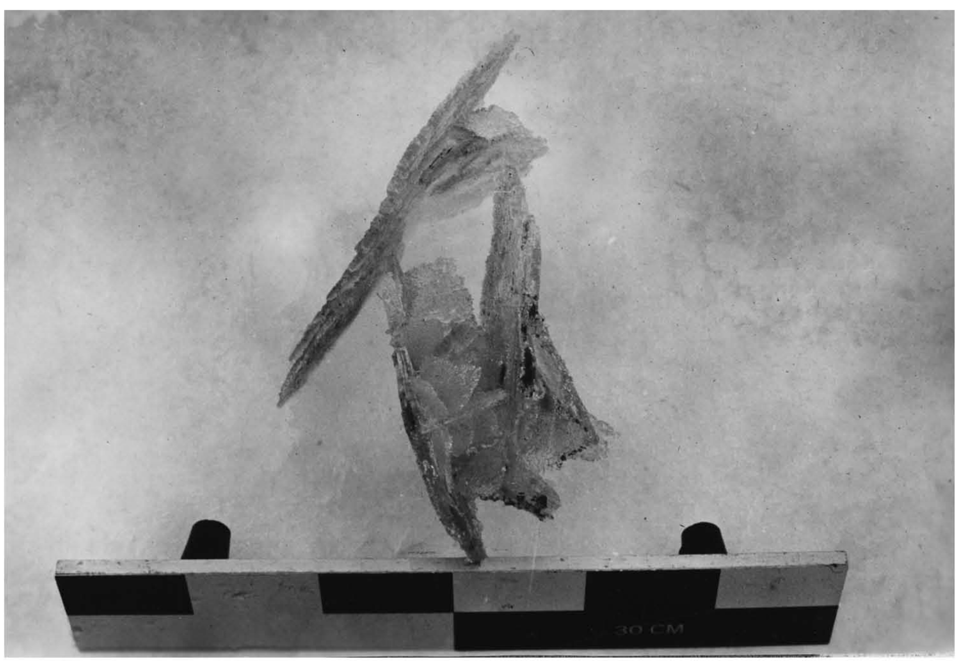


Figure 80. Close-up of ice crystal structure found in rosette formation pictured in Figure 79. GSC photo 202665-V.

Hand augering in the intertidal and subtidal zones showed the frost table becoming rapidly deeper. In most cases, the top of frozen ground was either absent or too deep to determine from augering (>2.0 m). Two drill holes at Rea Point, in uplifted delta sand deposits, showed the base of ice-bonded sediment at 18.9 m and 12.8 m (Polar Gas, pers. comm.). The holes were at 34 m and 5 m from the shoreline, respectively, suggesting that the permafrost may be pinching out towards the channel.

Shallow seismic and electrical resistivity techniques were used by McLaren et al. (1975) in an attempt to determine if offshore frozen ground is present in Byam Channel. The velocities observed for bedrock (sandstone), known to be frozen, range from 2.9 km/sec to 4.1 km/sec. In the nearshore, velocities lie between 2.4 km/sec and 3.4 km/sec, slightly lower than those found on land. Although lower velocities would be expected if frozen ground was absent in the nearshore, there is too much overlap in the ranges to differentiate clearly between frozen and unfrozen sub-marine bedrock. The rapid descent of the frost table in the intertidal zone revealed by augering, the apparent pinching out of the base of permafrost from bore hole data, the possible presence of brine in the subaerial bedrock, and the regional history of previous submergence beneath an insulating blanket of seawater suggest the absence of frozen ground beneath Byam Channel.

Summary Process Model

Deglaciation of Byam Channel occurred at least 10,200 years ago with the breakup of either the Innuitian ice sheet or local Melville Island ice caps or both. It is speculated that during deglaciation much ice was rapidly removed by the calving of glacier fronts into the increasingly open, inter-island channel system, notably through Byam Channel and the northwest passage. The release of glacial debris by melting ice deposited at least 6 m of glacial-marine sediment in Byam Channel which is characterized by a mixture of sand (33%), silt (45%) and clay (22%) as well as varying amounts of pebbles and cobbles of local bedrock origin. In some areas of the channel, probably topographic highs, this sand-silt-clay facies is now absent indicating that currents, at the time of deglaciation, were too strong to allow deposition, or the sand-silt-clay facies has since been eroded away leaving a cobble pavement overlying bedrock.

Since deglaciation, the coasts have emerged approximately 100 m and they appear to be still undergoing isostatic recovery at a rate of approximately 0.35 cm/yr. During the Holocene, drainage into Byam Channel has resulted in the growth of deltas consisting predominantly of sand, which have prograded during emergence. The river basins are hydrologically similar and it is suggested that sediment yields from each river are proportional to its size. Based on data from the Consett Head River, it is estimated that a total of 233.66×10^7 kg of suspended sediment entered Byam Channel in 1974. Of this amount a large portion was probably deposited in the delta fronts while the remainder either accumulated in the deeps (>100 m) or was carried away by surface currents. Sedimentation rates in the whole channel are probably much less than 0.23 mm/yr and there has been little or no Holocene accumulation on the sand-silt-clay facies between the 7 and 100 metre isobaths.

Sand from the delta fronts can be transported by currents over the sand-silt-clay facies adjacent to the coastline. Transport probably occurs in winter by under-ice tidal currents which are augmented in the shallow water. The sand, in transit, comes to rest in those regions of the coasts where energy levels are too low for futher transport. This shallow sandy facies extends from the shoreline to the 7 m isobath, approximately.

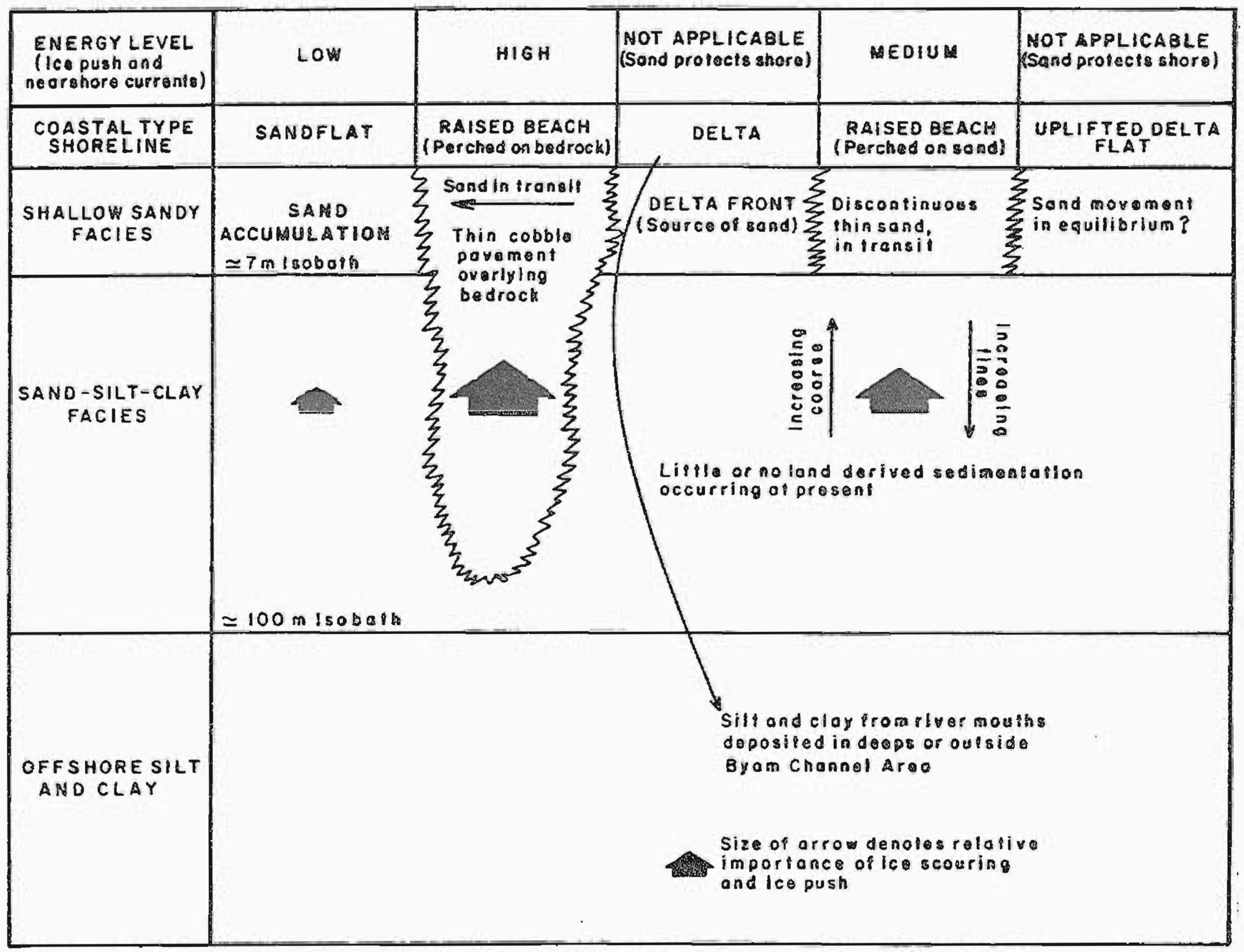


Figure 81. Diagrammatic summary model of the Melville and Byam Martin Island coasts

The present coastal types are dependent on emergence, the nature of the nearshore materials, and the amount of ice action on the shoreline. Where the sand-silt-clay facies is absent, energy levels in terms of ice scouring and currents are highest. The shallow sandy facies cannot remain in a high energy environment. Ice push enables boulders and cobbles of bedrock material to be deposited near the shoreline in the form of an ice push boulder barricade. As emergence occurs the barricade, acted on by waves, frost action and probably further ice push, becomes the present beach. Continued emergence produces a raised beach which consists predominantly of gravel and is perched on a cobble pavement.

In other parts of the coast the sand-silt-clay facies is present and ice push can deposit the facies, including the gravel and larger material, onto the beach. Wave action winnows the fines, leaving a gravel beach which again, is able to maintain its geomorphic form after emergence is complete. Occasionally, the shallow sandy facies may be present. If it is thin (<3 m), ice can scour deeply enough to reach either the sand-silt-clay facies or bedrock, still enabling gravel beaches to form. These beaches may be perched on sand which is the emerged shallow sandy facies.

Where the shallow sandy facies is thick (>3 m), ice is incapable of scouring deeply enough to bring gravel to the beach. Thus only sand can be added to the beach by ice push. Without a gravel component, the beach does not maintain its morphologic form after emergence. The shallow sandy facies, when uplifted, becomes the sandflat coastal type.

Grain size analyses and field observations indicate that: (i) coastlines consisting of raised beaches perched on rock receive the highest energy with respect to currents and ice push, (ii) where raised beaches are perched on sand, energy levels are intermediate, (iii) sandflat coasts receive the lowest amounts of energy, (iv) nearshore currents are capable of transporting all size fractions of sand found on the delta fronts to the sandflat coast, and (v), longshore transport cannot move gravel and larger size material any significant distance; hence, raised beaches are confined to those areas where gravel has been added to the beach by ice push (Fig. 81).

Suitability for a Marine Terminal

Construction Materials

The bedrock available for construction purposes in the coastal region consists of friable, easily weathered sandstones, siltstones and shales. In general, these lithologies are poor materials for aggregate or rip rap. Resistant bedrock headlands such as Robertson and Kay Points (Fig. 40) are exceptions; here, the sandstone is thickly bedded and well cemented. Such localities are not, however, good port sites due to the lack of protection from waves and ice action.

The flights of raised beaches (P15:8-13) are a source of gravel. A single raised beach may average 2 km in length, 0.8 m high and 3 m wide, yielding 4800 m^3 of aggregate. The minimum total aggregate at a location such as Kay Point (M25) would be 76800 m^3. The locations of these sources are also not desirable port sites.

Navigation

The lack of bathymetric data is probably the single most limiting factor in choosing a suitable port site. The existing information suggests that access to the coast by large ships requiring a 20 metre depth for manoeuvring and docking may not be possible unless considerable expense is taken to (i) dredge navigation channels or (ii) construct facilities from the shore to a suitable depth. The latter might require a wharf up to a kilometre long.

Airstrip

The general flatness of the Melville and Byam Martin Island coasts would allow airstrip construction at most locations. A sand runway at Rea Point is already in existence. This is built on flat, uplifted delta sands.

The raised beach coast would probably require the most expensive modification to build an airstrip. However, there is a readily available source of gravel which, if used, may provide a more maintenance-free airstrip and be cheaper in the long term. Simplest construction, such as at Rea Point, would be on the sandflat coasts and uplifted delta coasts.

Water Supply

Lakes large enough to provide a permanent water supply are non-existent. The rivers are also not large enough to maintain continuous flow throughout the winter. Water supply will, therefore, need to be provided from a reservoir. The establishment at Rea Point is using a reservoir successfully, relying on spring run-off and the flow of several small rivers to keep it filled. The abundance of large and small rivers would enable construction of a reservoir virtually anywhere.

Potential Sites

Although it is admitted that the lack of nearshore bathymetric data makes the following discussion somewhat academic, several points can be made concerning the relative desirability of various locations. For example, all shoreline structures will be subject to damage by ice. The raised beach coast (M25) is the most prone to heavy ice effects and should be avoided. The sandflat coast, on the other hand, will be influenced least by the forces of ice.

On this criterion, a port site should be located on a sandflat coast. To further minimize ice effects, the sandflat coast should be within an embayment, or facing east and southeast, to protect the site from prevailing winds. Three possible sites meeting these requirements are shown on M25. Each of the sites are protected from the dominant north-south flow of ice during the summer and fall months. They are also in sufficiently large bays to be inside the shorefast ice during freezup. The principal disadvantage of the sandflat locations is the absence of a nearby aggregate source.

KING CHRISTIAN AND SOUTHERN ELLEF RINGNES ISLANDS*

by D.A. Hodgson

Introduction

This report outlines some of the basic data necessary for land management in the study area. The impetus has been provided by discoveries of natural gas at a number of sites on King Christian Island and both onshore and offshore of southwest Ellef Ringnes Island.

Dominant material-genetic units and landforms (Hodgson, 1975) are described and are displayed in Figure 82. The small scale of presentation requires much generalization of units, particularly in the case of Holocene coastal plain sediments. The descriptive units, together with observations on active geomorphological processes, form a basis for a discussion on the susceptibility of the terrain to man-induced disturbance. Finally, some observations of the Quaternary history are reported.

Field work for 1976 was intended to be based on traverses up to 50 km long, to be run by Honda A.T.C. 90's towing trailers carrying a shallow drill and fly camp equipment. Extensive snow cover until mid-July and subsequent slow drying-out of the active layer under generally overcast and cool conditions, however, restricted ground traverses to within 10 km of three camp locations (Fig. 82). Thirty hours of helicopter time used in the field area partially overcame transport difficulties. Field observations were made of: (a) landforms, materials, processes, and vegetation at surface sites, with pits being dug to the frost table; (b) stratigraphy,

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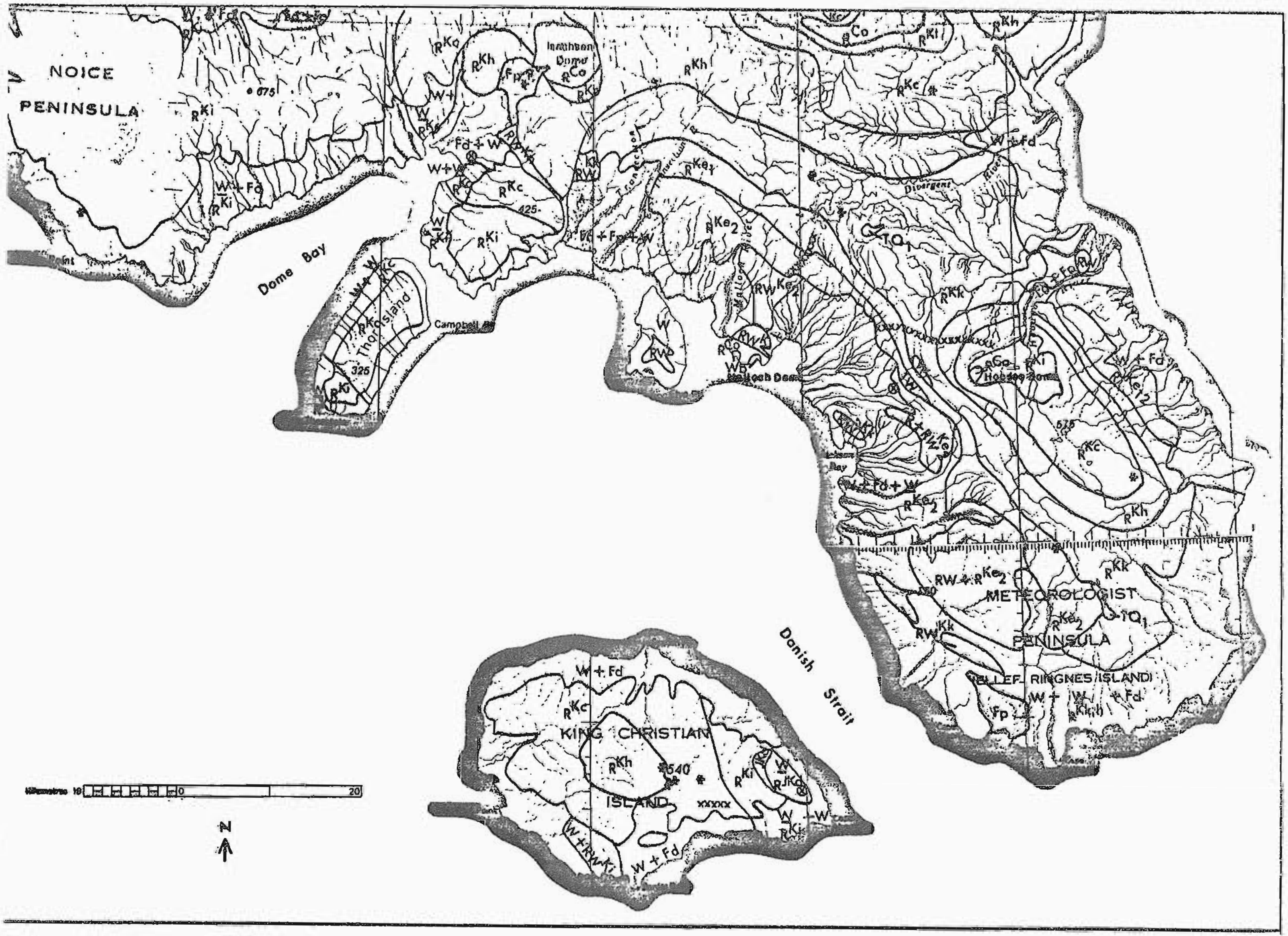

LEGEND

Fd Deltaic-marine sediments
Fp Fluvial sediments
W Marine sediments, undifferentiated
Wb Beach sediments
W/R Marine sediments, thin or discontinuous over rock
TQ Late Tertiary or Quaternary gravels
  TQ_1 or * Flat lying or knobby
  xxxx Ridged

⊗ Camp site

R Rock, residual weathered bedrock
RW Marine-washed bedrock
Superscripts:
  Ke_1 Eureka Sound Formation - upper member
  Ke_2 Eureka Sound Formation - lower member
  Kk Kanguk Formation
  Kh Hassel Formation
  Kc Christopher Formation
  Ki Isachsen Formation
  JKd Deer Bay Formation
  Co Diapir (source in Otto Fiord Formation)

Where the areas of two or more map-units are too small to be delineated separately at the map scale, compound units are used. Components of compound units are listed in order of decreasing area.

Figure 82. Surficial material-genetic map-units, King Christian and southern Ellef Ringnes islands.

and particularly ice content of cores obtained by drilling to a maximum 2.5 m depth with a CRREL-type auger; and (c) natural stream cuts - of which a surprising number were present in coastal plain sediments.

Material -Genetic Units

A division of the landscape into areas exposed to Quaternary marine processes and areas at higher elevations that were not affected is evident. The boundary roughly follows the upper limit of Holocene marine deposition. This limit subsequently has been uplifted to ca. 40 to 50 m above present sea level on King Christian Island and the Meterologist Peninsula of Ellef Ringnes Island, declining northwards to ca. 30 m at Dome Bay.

In this section two items should be noted: 1) colluvium is not identified because slope processes do not significantly change the material-genetic units and 2) morainal material (including till) was not identified anywhere in the study area.

Above the Marine Limit

The landscape is controlled by the bedrock - a succession of Mesozoic and Cenozoic clastic strata, generally deformed into northwest trending broad folds, with major anticlines commonly cored by diapirs. The surface is formed of scarplands, rolling plains, and low plateaus, slightly to moderately dissected by drainage lines which are essentially normal to the coasts. Slopes are less than 5 degrees other than on scarps, immediately adjacent to drainage lines, or where diapirs are present. Surficial material is composed of residual weathered bedrock; rare outcrops of resistant strata occur.

The following map-units are based on rock-stratigraphic units, which in general have a fairly uniform lithology. Boundaries follow the stratigraphic unit boundaries established by Stott (1969) for Ellef Ringnes, with the exception of the Hassel-Christopher contact which follows the revision suggested by Balkwill (1973), and by Balkwill (1974) for King Christian Island. A further description of landforms and processes on Ellef Ringnes Island is given by St-Onge (1965).

Diapirs (Co): independent, commonly dome shaped massifs, visually prominent because of relief of 50 to 200 m and a high albedo. The cores are formed by gypsum, anhydrite, and (at depth) halite, with the Carboniferous Otto Fiord Formation as the probable source (Davies, 1975). Also present are minor intercalated limestones and gabbro and basalt intrusions. The strata of peripheral formations are steeply inclined on the margins of the dome.

Where diapiric rocks are exposed, the surface materials are chiefly large crystals to grains of gypsum, solution-pitted outcrop, and minor limestone and intrusive rock rubble. The surface is commonly highly dissected by fluvial processes and solution, with slopes greater than 10 degrees. Peripheral formations are included in the diapir unit where slopes are steep and partially overrun by talus of diapiric rocks. Hoodoo Dome is exceptional in that it still has a cover of Isachsen sandstone.

Deer Bay Formation (JKd): a dark grey to black papery silty shale, which contains increasing amounts of fine grained sand towards the top of the unit. It is only present at the surface on King Christian Island, and there it is largely reworked or covered by marine sediments. The surficial material above the marine limit is an impermeable clayey silt, which is commonly poorly drained, with fine sandstone beds near the contact with the Isachsen Formation.

<u>Isachsen Formation</u> (Ki): mainly fining upwards cycles of poorly to noncemented fine to coarse grained sandstone, with minor siltstone, shale, and coal. The lower part of the formation is massive quartzose sandstone, locally well cemented. Surficial material is dominantly loose sand with strike-aligned bands of silty sand, silt, and clayey silt where cyclic successions of inclined sediments are exposed. Although generally noncemented (weathered?) to at least a depth of 2 m, a discontinuous cover of cemented sandstone fragments, probably of lag origin, is present.

The landscape is rolling, fluvially dissected, with a succession of minor scarps. Scarps and steep slopes in well cemented sandstone are locally 50 m high. Mesas, buttes, and hoodoos are common where flat lying to gently inclined sandstone is exposed on valley sides or coastal slopes. Stream channels are broad and are composed chiefly of sand. The unit is generally well drained.

<u>Christopher Formation</u> (Kc): chiefly shale, divided by Balkwill (1974) into two informal members, the lower being more silty than the upper, separated by an interval of glauconitic sandstone. Surficial material is silty clay, which has a fine granular to blocky structure to a 50 cm to a 2 m depth,and is underlain by platy shale fragments. There are small areas of sandstone and mudstone lag cover, and local concentrations of shattered mudstone and ironstone nodules occur in stream courses.

The landscape is rolling, with the slightly more resistant intervals coring strike-aligned ridges; it is more rounded, though not topographically lower, than adjacent sandstone formations. Drainage is generally poor, with some wet sedge/moss areas. The thixotropic clay forming the active layer over much of the unit did not dry out in the summer of 1976.

Hassell Formation (Kh): a succession of generally poorly cemented, brightly coloured, fine to coarse grained sandstones, with minor siltstone, shale, and coal beds. The surficial material is chiefly sand, over poorly or noncemented bedrock; there are minor outcrops of well cemented sandstone or siltstone and narrow strike-aligned bands of finer material. The landscape is composed of gentle slopes and a succession of minor scarps, with some local dissection. It is more subdued than the Isachsen Formation as there are proportionately fewer resistant beds. Drainage is generally good.

Kanguk Formation (Kk): black silty shale, with minor beds of light weathering bentonite near the base of the formation. Surface material is partially weathered bedrock composed of silt, clay, and platy fragments of shale. A discontinuous lag cover of shattered brown ironstone nodules and siltstone and sandstone fragments is conspicuous on level areas. The shale is highly acidic, and the one core for which pH values are available provide a reading of 3.6 at both 20 cm and 150 cm depths, i.e. above and below the 25 cm-deep frost table (see also Balkwill and Hopkins, 1976).

The dominant relief feature is an almost continuous escarpment, controlled by siltstone beds which divide the formation into upper and lower members. The scarp cliff is commonly 20 m and locally 50 m high and is broken only by water gaps. A second scarp developed near the base of the formation is discontinuous, but where present it is just as prominent as the first. Most of the unit varies from overall gentle slopes to extensive level areas where beds are flat lying. Fluvial dissection is locally significant, with steep sided gullies advancing headwards along the rectilinear pattern ice-wedge troughs which are so distinctive on this formation. The active layer is moderately well drained except on the bentonite (cf. Christopher shale).

Eureka Sound Formation (Ke):

Ke_1 informal lower member: sandstone, well to noncemented and shaly mudstone. Surficial material is dominantly sand, silt, and minor clay, with bands of outcrop or lag cover of sandstone and mudstone. The map-unit is chiefly one of long gentle slopes and some low scarps. Areas of moist, well vegetated fines have a 'horse tail' drainage pattern. The distinctive icewedge trough pattern, subdued landforms, and finer surficial material differentiate the lower member from the upper.

Ke_2 informal upper member: sandstone, poorly to noncemented, with minor beds of gravel, lignite, and carbonized wood. Surficial material is composed of unconsolidated fine to medium grained sand, with a discontinuous lag gravel cover, and local gravel deposits. The surface is rolling, with a succession of minor scarps and some steep slopes where drainage is incised. The unit is well drained.

Late Tertiary or Quaternary Gravel (TQ): Scattered unconsolidated gravelly deposits unconformably overlie Mesozoic sediments and commonly are capping rocks. Two units are recognized - but only on the basis of morphology as no good exposures were observed. Test pits or cores are needed to assess the composition, structure, and volume of granular materials. It is difficult to assign the smaller deposits to either unit on the basis of airphoto interpretation, therefore they are identified on Figure 82 by the same symbol (*). The ridges which form unit TQ_2 are shown by the symbol "xxxx". Precise limits of deposits are difficult to define from superficial inspection or airphoto analysis as mass movement processes transport gravel downslope over underlying bedrock units. St-Onge (1965) also had described these deposits.

$\underline{TQ_1}$: flat lying, locally knobby, gravelly sediments up to 2 km^2 in area, though generally much smaller. The gravel is round to subangular, granule to boulder size material, predominantly quartzose sandstone, but includes limestone, intrusive rocks, granite, and rare noncarbonized wood. The matrix of fine sand to clay normally makes up more than half of the deposit; thickness is possibly greater than 5 m where knobs occur, otherwise it is much thinner. Deposits occur on regional topographic highs, preferentially on the primary divides of the Meteorologist Peninsula, and in the centre of King Christian Island. The largest deposit is at 230 m and overlies and protects Kanguk shale, which in adjacent areas is 100 m lower in elevation. Drainage is good at the margins of deposits (note little fluvial dissection) but may be poor on level areas.

Deposits are possibly residuals from extensive fluvially deposited sediments of Quaternary or older age. Similar though far more extensive deposits in western Ellesmere and eastern Axel Heiberg islands are possibly coeval. Stott (1969) noted gravels overlying and thus postdating the Beaufort Formation in northern Ellef Ringnes.

$\underline{TQ_2}$: linear, in places winding, ridges of gravelly material up to 15 km in length, though commonly broken by several water gaps in this distance. Orientation is between west and southwest. Where observed, surface material is granular to boulder size, round to angular quartzites, siltstone, mudstone, gabbro, rare limestone, and granite. The matrix of silty sand comprises less than half the deposit near the surface but is possibly the dominant material below the frost table. No sense of direction of sediment transport was determined. Gravel covered portions of ridges appear to be 50 to 200 m wide and 5 to 20 m high. This could be a gross overestimate of cross-sectional area if, as is likely, considerable erosion has taken place subsequent to emplacement of the deposit and gravel has slumped downslope.

Deposits occur on local topographic highs and minor divides down to, but not below, the marine limit. It is unlikely that deposition occurred preferentially on the highs, and thus a measure of subsequent erosion is available. For example, the gravel ridge northwest of Hoodoo Dome intersects the main scarp of the Kanguk shale. The scarp, which is 50 m high, has retreated at least 1 km (by lateral river erosion) since gravel deposition.

Below the Marine Limit:

Sedimentary Environments of the Coastal Plain

A coastal plain, commonly 5 to 15 km wide with a typically flat to gently concave profile of less than one degree, lies between the present shoreline and the marine limit. Development required one or more lengthy marine inundations to plane the variety of underlying bedrock lithologies. Closely spaced subparallel drainage lines have been extended seawards as the plain emerged during the Holocene, and channels are now commonly incised 2 to 15 m.

In addition to washed bedrock, there are fluvial, deltaic, beach, and undifferentiated marine sediments. Each of these units is described; however, they are commonly not mapped separately in Figure 82 both for reasons of scale and because of the difficulty of defining boundaries between the sedimentary environments.

Sediments vary in thickness from discontinuous veneers to deltaic beds more than 15 m thick. Composition is greatly influenced by underlying bedrock lithologies, and for fluvial and deltaic sediments, by the materials in the drainage basin. The dominant surface material below the marine limit is fine sand or silt.

Marine-Washed Bedrock (RW): a morphologically subdued form of the bedrock units previously described. KTe_2 sediments are locally reworked into sand and gravel beach ridges at elevations close to the marine limit.

Marine Sediments - Undifferentiated (W, $\frac{W}{R}$): generally featureless sediments, excluding mappable deltaic, fluvial, or beach landforms, and including nearshore sediments, marine reworked underlying material (chiefly bedrock), possibly thin beach deposits left by the regressing shoreline, some deltaic sediments from minor drainage lines, and windblown and ice-rafted sediments.

Littoral currents appear to be weak or nonexistent. There is no evidence of longshore drift at the modern shoreline, and where bedrock contacts under the coastal plain make an acute angle with the shoreline and are not covered by deltaic sediments, the lithological boundary is commonly reflected by overlying marine sediments. This is exemplified by the sharp Ki/JKd contacts on Thor Island, the adjacent area of Ellef Ringnes, and the south shore of King Christian Island. Where contacts parallel the shore (e.g., west side of Meteorologist Peninsula), the underlying lithologies may not be apparent from the composition of overlying sediments as contacts have been blurred by the retreating shoreline.

Sediment composition varies from medium sand to silty clay in massive to finely laminated deposits. Sediments are generally more than 1 m thick, with a transitional contact to underlying bedrock, and feather out towards or at the upper marine limit.

Drainage varies from good to poor, depending on slope and materials. Some wet sedge/moss areas are present, and ponding may occur in ice-wedge troughs.

Beach Sediments (Wb): Ridge and swale development is limited by short fetches in ice-infested waters and by deflation of the available material, which is commonly coarse silt and sand size. Areas of closely spaced ridges can be identified on airphotos to ca. 10 m above present sea level and to 3 km inland; but ground inspection shows that the ridges, developed in sandy material, have only a slight morphological expression.

The modern shoreline zone is narrow - 5 to 15 m, other than on modern deltas. This is a function of the small (ca. 25 cm) mean tidal range. Surface material is dominantly sand for all coasts, although where underlying material is fine grained, the beach sand may be only a veneer 15 cm thick. A few ice-push ridges were found on all coasts; ridges were up to 50 cm high and extended to several metres inland from the highwater mark.

There are exceptions to the above observations. The modern beach at the foot of Malloch Dome is gravel, with ice-push ridges to 1 m high, and flights of gravel beaches rise to 30 m above sea level. Gravel beach ridges also are developed on hills underlain by the upper member of the Eureka Sound Formation, close to the marine limit, inland from Jackson Bay, Ellef Ringnes Island. At Cape Abernethy, King Christian Island, a gravel ridge (spit?) extends 3 km inland.

Deltaic-Marine Sediments (Fd): Deltas of larger rivers have prograded as much as 10 km, each within a 1 to 2 km-wide zone, in the course of Holocene uplift. Modern arcuate deltas thrust up to 2 km beyond the adjacent coastline, indicating little wave or current erosion or lateral deflection of the channels. The generally planar raised delta surfaces show that these quiet conditions have existed throughout much of the Holocene.

A topographic profile of the coastal plain parallel to the shoreline shows the delta surfaces rising above adjacent marine sediments. The rise is commonly less than the thickness of the deltaic sediments, indicating that some rivers occupy valleys cut in bedrock.

The modern channel is commonly incised 5 to 15 m into older deltaic sediments underlain by bedrock. Channel widths of 10 m are common on minor tributary streams, and channels on the largest rivers are up to 1 km wide. The inclination of channel banks varies from 3 to 90 degrees.

Channel bank exposures typically show stratified sand and silty sand, sometimes with minor interbedded silt, clay, or organic material. This sequence is underlain by massive deltaic-marine clay or clay-silt. The sandy topset beds vary from a thin veneer over thick basal clay, to a thick unit overlying thick or thin basal clay. Successions of clay over sand, thick interbedded sand and clay, or sediments composed entirely of shaly fragments also have been noted. Source materials within the drainage basin determine the deltaic sediment composition and the fine/coarse sediment ratio. Where overlain by deltas, the upper metre of Eureka Sound Formation, poorly or noncemented sandstone, on the west side of the Meteorologist Peninsula, appears to have been reworked and incorporated into a basal sandy bed prior to being overlain by the clay deltaic-marine sediments.

In general, raised delta surfaces are well drained because of their elevation above adjacent sediments and their relative coarse composition. Ponding, however, may occur in ice-wedge troughs on extensive level areas.

Fluvial Sediments (Fp): Active channel zone fluvial sediments cover 10 per cent of the coastal plain. Peak stream discharge, which occurs during snowmelt, is contained within a single, well-defined channel, which, as previously noted, may be up to 1 km wide. At lower water stages flow is restricted to one or more much narrower channels, 0.5 to 1 m deep. As with deltaic and undifferentiated marine sediments, sediment composition is controlled by underlying and upstream materials.

The only area of fluvial sediment large enough to be identified as a simple unit in Figure 82 is east of Cape Allison, Ellef Ringnes Island. At this locality unconfined and braided channel flow occurs over ca. 20 km^2 of sand.

Permafrost

Ground ice in the upper 1 to 2 m of the permafrost was examined in cores from the 63 holes drilled. A preliminary inspection of core logs shows no clear relationship between ground-ice content and materials or vegetation. Similar results have been obtained from programs conducted elsewhere in the Arctic Islands. Excess ice content can be highly variable within a single core of the same material. Values range from 0% excess ice (pore ice, or nonfrozen water which is not uncommon) to bands of ice 50 cm thick. No massive ground ice was encountered, other than in ice wedges.

Ice wedges up to 5 m wide and 10 m deep are assumed to lie under all polygonal and rectilinear pattern troughs. No relationship has been established between the dimensions of a trough and the size of the underlying wedge. Wedges also may have no surface manifestation if for example the active layer is greatly disturbed by mass movement or deflation. Trough networks are present over much of the map-area.

An active layer develops between snowmelt in late June-early July and freezeup in late August. Maximum depth of the frost table ranges from 20 to 45 cm for most units. In sand or gravel, which is either well drained or saturated by subsurface water flow in a stream channel zone, the active layer may be 1 m thick.

Vegetation and Wildlife

Vascular plants were collected, and percentage cover was estimated at a number of sites on most of the material-genetic units. Both above and below the marine limit, much of the sandstone and Kanguk shale were nearly devoid of vegetation. Elsewhere the cover was generally sparse. Certain localized areas have a moderate cover of vascular plants and a continuous vegetation cover including mosses and lichens.

Two areas in particular are botanically diverse and also support the only **Salix arctica** observed. These are the southern and western coastal margins of Malloch Dome and the deltaic sediments at the head of Dome Bay. At the latter area at least one muskox, two wolves, and a variety of wildfowl were observed.

Geomorphic Processes

Active geomorphic processes include weathering by physical disintegration, mass wasting, fluvial, eolian, and coastal processes, as well as nivation. No attempt will be made here to weigh the relative efficacy of processes; instead some of the more interesting processes and resultant landforms will be described.

Weathering

Bedrock, whether or not disturbed by mass erosion, is commonly physically disintegrated to at least a 1 to 2 m depth. This depth greatly exceeds the present maximum thaw depth; however, it does not necessarily imply a formerly thicker active layer. Breakdown could have been accomplished during accretion of ground ice, as well as by frost shattering.

The weathered residual material and rock surface is normally smooth, however, irregularities can develop. Hoodoos are common where certain better cemented units of the Isachsen Formation are flat lying. Development is assumed to result from nivation and fluvial erosion along joints, possibly aided by eolian abrasion. Near the base of the Christopher Formation in east-central King Christian Island, a row of strike-aligned mounds to 1.5 m high and 5 m in diameter (Fig. 83) can be traced across the island down to about 35 m elevation on both northern and southern coastal plains. The mounds are diagenetic concretions (H.R. Balkwill, pers. comm.) surrounded by shale. Their presence below the Holocene marine limit indicates either that they have been uncovered by weathering and mass erosion of surrounding shale in the course of the Holocene or, less likely, that the marine inundation and later regression of the shoreline was sufficiently rapid that the concretions were not planed off.

Figure 83. Concretions uncovered by weathering and erosion of surrounding Christopher Formation shale, King Christian Island.

Mass Movement

Solifluction is undoubtedly an active process; however, lobes were rarely observed, possibly because of the generally low inclination of slopes and the sparse vegetation cover. Both sorted and vegetated stripes are common.

The earthflow is the most striking type of mass movement. It occurs preferentially on fine grained materials, on slopes from less than 1 to 10 degrees with or without vegetation, and most commonly occurs below the marine limit although numerous earthflows were noted above the marine limit on the Christopher Formation. The basal shear zone is at the frost table and usually is in clay or silty clay, but in places failure may occur in fine sand. The thickness of the sliding material is thus rarely greater than 50 cm although the area of material that moves may be as great as 500 m^2. On river banks, undercutting of the toe of the slope is also a factor, although earthflow failures rarely occur on steeply undercut banks. Saturation of the active layer takes place during snowmelt; however, the layer is probably too thin for earthflows to be initiated at this time. They occur later in the summer, provided unusually heavy or extended rainfall saturates the active layer which is then at maximum thickness. It is likely that in summers with only light rain no failures occur.

In 1976 many earthflows occurred north of Jackson Bay during a period of intermittent rain (ca. 10 mm recorded at Isachsen, 100 km to the northwest) from July 30 to August 1, approximately two weeks after the end of snowmelt. Some slides reoccupied scars from earlier years. Figure 84 shows a few of the many hundreds of earthflows activated in these two days on river banks cut in marine-deltaic sediments. No retrogressive thaw flowslides were observed, possibly indicating a general absence of massive ground ice.

Terrain Sensivity

Although parts of the study area are highly susceptible to terrain disturbance, the net effect on the sparse vegetation and low density of wildlife probably would be slight. The few botanically diverse areas, however, should not be disturbed. The rivers seem an unlikely habitat for fish because of the short flow period, high sediment loads, and the acidic water where Kanguk shale is drained. Coastal waters were not considered in this study.

Of greater concern is the effect of a number of the geomorphologic processes on roads or pipelines. Some potential problems are: scouring of channel beds in the numerous water courses; initiation of gullies by concentrating runoff; failure of river banks; failure, particularly by earthflow, of any slope on the

Figure 84 a, b. Earth flows in marine-deltaic sediments, subsequent to rainfall of July 30-August 1, 1976, north of Jackson Bay, Ellef Ringnes Island. The basal shear zone is at the frost table.

Christopher Formation or on fine grained coastal plain sediments; abrasion by windblown sand; corrosion, due to high acidity, on or downstream from the Kanguk Formation.

Quaternary History

No direct evidence of Pleistocene glacial erosion or deposition was found in the study area; topography appears to be chiefly a product of fluvial processes, mass wasting, and marine planation. A thick cover of weathered residual bedrock is present (though the rate of weathering is unknown); no morainal deposits have been found on the surface, incorporated in residual material, or underlying marine, deltaic, or fluvial sediments.

The flat lying gravel deposits (TQ_1), if remnants of widespread fluvial sediments, explain the presence of any exotic lithologies in lag deposits. These gravel caps also appear undisturbed by glaciation. A glacial origin for the gravel ridges (TQ_2) has yet to be proven, despite their esker-like form. If they are fluvioglacial sediments, the degree of erosion subsequent to emplacement makes a late Quaternary age unlikely.

Nevertheless, there is strong indirect evidence of glaciation. Some adjacent interisland channels have a trough-like form, and Balkwill et al. (1974) describe striations and striated erratics on adjacent Amund Ringnes Island, although the age of these features is unknown. The amount of uplift of King Christian and southern Ellef Ringnes Islands during the Holocene, however, seems only explainable by isostatic rebound from an ice cover of late Quaternary age.

England (1976) has suggested that much of this uplift is recovery from isostatic depression peripheral to the late Quaternary margins of the Greenland Ice

Cap and enlarged Ellesmere and Axel Heiberg Island ice caps. On the basis of Walcott (1970), England considered the limit of the peripheral depression to be 180 km. King Christian Island, however, is 600 km beyond the suggested margin of Greenland ice, 200 km from the nearest coast of Axel Heiberg Island, and at least 400 km beyond the northern limit of Laurentide ice. Thus the 30 to 50 m or more of emergence in the Holocene is best explained by rebound from an ice cover over the islands and intervening channels, as in the concept of the Innuitian Ice Sheet proposed by Blake (1970), rather than by the influence of distant ice sheets. The lack of glacial landforms may be a consequence of the ice sheet being cold based (i.e. frozen to the underlying material), perhaps due to a low mean annual temperature. Another possibility is that locally thicker ice centres developed over higher land (the present islands) and there was little ice flow at these locations.

Radiocarbon age determinations are available for four surface samples collected by D.A. St-Onge on Ellef Ringnes Island. Astarte borealis valves from the southwest corner of the Noice Peninsula, at 22 m, are 7350 ± 200 years old (L–643B; St-Onge, 1965); Astarte borealis and Hiatella arctica from the south end of the Meteorologist Peninsula, at 33 m, are 8500 ± 200 years old (L-643A; St-Onge, 1965); a further determination on Astarte borealis shells, collected near the preceding sample L-643A, provided a date of 8370 ± 200 years (GSC-1846; Lowdon and Blake, in press); and driftwood in the same vicinity at 25 ± 5 m is 8320 ± 140 years old (GSC-999; Blake, 1970).

Two shell samples collected in 1976 have been dated. A Mya truncata valve on the surface at 42 m in southcentral King Christian Island (77°45.25'N, 101°37.25'W) is 8900 ± 140 years old (GSC-2386). The sample dated was taken from one of a number of valve clusters and fragments, each representing one or two paired valves, surrounded by silty clay. The sediment, of marine or deltaic origin, extends to 48 m in elevation at this location. This age determination provides a minimum age and elevation for the highest Holocene sea level.

Mya truncata valves taken 8 m below the top of an exposure in deltaic sediments with the surface at 33 m, 12 km north of Jackson Bay, Ellef Ringnes Island (78°12.25'N, 100°46.75'W) are 7640 ± 120 years old (GSC-2383). In the exposure, which is typical of deltas on coastal plain, interbedded silt, sand, and minor clay overlie massive dark grey clay with shells, which in turn unconformably overlies Eureka Sound Formation sediments. The shells were taken from the lower metre of clay. The age determination shows that the basal clay in at least this deltaic sequence is Holocene in age. It also provides a maximum age for sea level at 33 m at this location. The shells are surprisingly young in comparison with the three samples from a similar elevation at the south end of Meteorologist Peninsula - particularly the driftwood, which is usually contemporaneous with the shoreline on which it is deposited.

On southeast King Christian Island, shells and possible beach ridges are evidence of marine overlap to at least an 80 m elevation. Above ca. 45 m, however, shells tend to be notably thicker and more incrusted and pitted than those at lower elevations. Although no age determinations are available yet, the shells at higher elevations do appear similar to those collected elsewhere in the Arctic Islands which have provided infinite ages. The local abundance on the surface and the presence of pairs make glacial transport unlikely; but with an ice cover and no basal ice movement, preservation of shells in situ is possible.

In the event of such an ice cover, then the late Quaternary high sea level would initially overlap the ice, and the only marine sediments to be expected would be in subsequent offlap deposits. On the other hand if no ice cover was present, some evidence of onlap would be expected in the form of sediments and anomalously old dates underlying Holocene offlap deposits. No such evidence has been found, and even if regressive shoreline processes eroded much of the onlap sediments, some should be preserved where deltaic offlap deposits were built beyond the (shallow) wave base - and it is in such deltaic deposits that many of the best exposures are cut.

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APPENDIX I

The following is a list of criteria used to make a preliminary selection and assessment of the potential marine terminal sites discussed in chapter II. Knowledge of each of the criteria used varied considerably from place to place and in many instances qualitative assessments had to be made using aerial photographs and related information. The list of criteria was compiled from coastal engineering texts, e.g. Brunn (1973), from previous arctic port studies, e.g. Department of Public works (DPW) (1971), Girgrah et al (1975) and after consultations with port engineers of the Marine Directorate of Department of Public Works. The assumption was made that the marine terminals would be for bulk carriers of 75,000 to 200,000 M^3 capacity LNGC's (liquified natural gas carriers) or up to 300,000 DWt metric ton VLCC's (very large crude carriers) which have a draft of 13 to 25 m laden.

The following marine design criteria were used:

(1) Bathymetry: Water depths amenable to safe operations of bulk carriers should exist in the approach channels to the port. Furthermore sufficient nearshore depths should exist for the construction of berthing facilities or single point mooring. In this report 30 m depths were selected as the minimum operating conditions in the approach channels.

(2) Accessibility: the site should provide unrestricted approach with few navigational hazards. Also there should be sufficient room to manoeuver bulk carriers of 300 m length without interfering with the operation of the terminal. In this report accessibility was assessed in terms of the number of navigational hazards and the width of the approaches to the terminal site.

(3) Shelter: the terminal site should provide adequate shelter from strong winds and mobile sea ice. The assessment also considers the ease in which sea ice moves in and out of the terminal site during the navigation season.

(4) Anchorage: water depths should be no more than twice the draft of the vessel and there should be good holding ground.

(5) Length of Open Water Season: sites are assessed in terms of the number of days between ice breakup and freezup. In most cases the only information is for the adjacent shipping channel. The duration of open water depends on the configuration of the bay or inlet and the ease with which winds can remove the ice once the adjacent channels become ice free.

(6) Landing Beaches: wide beaches with moderate slopes and adequate nearshore depths for lighterage were looked for to unload the initial shipment of supplies and equipment.

(7) Construction aggregates: the land near the terminal site should have abundant coarse aggregates and gravels for infill of wharf facilities and the construction of support facilities e.g. airstrips.

(8) Suitable Terrain for Support Facilities: sites were assessed for sufficient low, flat relief for the construction of a 5000' (1525 m) airstrip and other necessary ancillary installations and living accomodations. A slope of 5° to 10° (slope category B on maps in volume II) was generally thought most suitable. Good drainage of the land and foundation conditions were qualitatively assessed from aerial photographs and geological maps.

(9) Water Supply: a year round source of potable water is necessary. Most rivers provide only a source of water during the summer, hence deep lakes were looked for.

Additional physical factors which are important in the selection of a marine terminal site are meteorological parameters e.g. strength of winds, number of days of fog, wave parameters, longshore transport of sediment, currents, tides and engineering properties of the soils and nearshore sediments. Each of these criteria require on site field investigation and are beyond the scope of the present study. The aim of this report is to present a preliminary selection of marine terminal sites which are recommended for further study if the demand arises. The latter criteria would form part of the final detailed study of the recommended sites listed in this report.

APPENDIX II

Potential Marine Terminal	Aerial Photographs (NAPL)* Flight line	Photo number
Radstock Bay	A16332:	102-109; 188-192
	A16747:	101-112
Strathcona Sound	A16259:	45-47
	A16262:	52,53,76,77,142,143
	A16308:	43-45
	A16972:	73-75
	A22468:	7-22, 52-63; 165-172
	A22470:	9-15
	A22471:	159-179; 226-245
	A24427:	116-125; 130-134
Resolute	A16194:	112-114
	A24427:	40-102
Adams Sound	A16259:	40-44
	A16262:	47-49; 81-83
	A16308:	37-40
	A16972:	20-25; 68-72
	A16992:	20-33
	A24532:	22-27; 38-42; 48-52
Baring Channel	A16188:	30-31; 36-39
Bateman Bay	A16202:	162-163
	A16203:	73-75
Victor Bay	A16972:	23-25; 70-73
	A22468:	28-34; 42-48; 179-181
	A22570:	1-3
	A22471:	192-197; 211-217
	A24532:	26-29; 42-45
Skene Bay	A16766:	55-62; 94-98
Back Bay	A16188:	43-47; 55-59; 81-83
	A16873:	74-80
Croker Bay	A16784:	36-46
	A16684:	21-30; 38-45
Unnamed inlet south from Bass Point	A16203:	8-10; 74-76

Maxwell Bay	A16752:	134-143; 146-150; 191-197
Aston Bay	A16121:	10-12; 167-173
	A16194:	163-165
	A16837:	74-76
	A23053:	8-15; 35-37
	A24228:	1-5
Freemans Cove	A16203:	3-8; 77-80
Dundas Harbour	A16689:	90-92
	A22104:	24-29
Baillarge Bay	A16262:	55-58
	A16972:	83-88
Elwin Inlet	A16262:	61-63; 149-154
	A16305:	4-10
Port Bowen	A16081:	60-62; 69-71
Tay Bay	A16047:	58-61; 68-71
Jackson Inlet	A16081:	62-64
	A16201:	197-198

*National Air Photo Library