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INTERIM TECHNICAL REPORT
BATHYMETRIC MAPPING
ICP-1

ENVIRONMENTAL SOCIAL PROGRAM, NORTHERN PIPELINES

Work carried out by the Canadian Hydrographic Service,

Fisheries and Marine Service

Department of the Environment

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1. SUMMARY

A prime need of any engineering design for underwater structures is a detailed knowledge of the sea floor topography. This knowledge is also of importance when studying environmental effects, not so much as an entity by itself but because bathymetry must be considered when studying the total physical regime. The placement of current meters, the dynamics of the marine environment and the general quality of the water may all be affected to some degree by the shape of the sea bed.

In assessing the environmental disturbances that may be caused when laying and maintaining a gas pipeline it is necessary to carefully examine the section of the sea floor along which the pipe may be placed, including the various alternatives available. While ice scouring may perhaps be considered more in the domain of the geologist than the hydrographer, a careful sounding program may reveal the roughness of the sea floor, including any abnormalities such as rock ridges or canyons. The sides of the channels will require study to determine their slope and other features.

A first phase of any hydrographic survey is to establish a geodetic framework both in the horizontal plane and the vertical plane. Fortunately, there already exists in the Arctic Islands a considerable amount of horizontal control. These points must be located and if a greater density is required it can be extended from the existing network. The vertical control is sparse and tidal datums and ranges still must be determined for the more remote areas.

During March through to May, 1975 horizontal control points were recovered at potential pipeline crossing sites in the area of Franklin Strait, Peel Sound, Byam Channel, Austin Channel and Belcher Channel. Using helicopters, it was also possible to examine the ice surface in these areas in order to decide whether tracked vehicles could be effectively employed for the sounding operation. It appears that the ice surface in Franklin Strait and the north end of Peel Sound is so rough that tracked vehicle use would be difficult, if not impossible. The other areas mentioned, assuming similar conditions in 1976, would permit tracked vehicle use.

As part of the preparation for sounding operations two equipment evaluations were carried out. At Rea Point, trials were conducted with a tracked vehicle and a through ice sounding system. This total system showed considerable promise but requires further development before it can be used for continuous profile measurements. Accordingly, it is not planned to utilize it in 1976 for pipeline crossing surveys.

A second trial involved a self recording submersible tide gauge for use beneath the ice. This trial was carried out successfully in John Richardson Bay, Ellesmere Island. Tidal measurements will form an essential part of the marine studies. The vertical movement of the ice surface during pipe construction must be studied and also all depths will be reduced to a common datum.

The work to date has all been of a preparatory nature leading up to the depth measurement program which it is planned to carry out in the spring and summer of 1976. It seems, on the basis of preliminary investigations that a combination of through ice and ship operations will be the most rewarding with respect to obtaining the bathymetric, geologic and physical oceanographic data.

2. INTRODUCTION

This study is directed towards the measurement of bathymetry and vertical tidal movement at the marine crossings along the proposed pipeline route. From the information available it appears that a number of alternative routes are still being examined. At the time of writing the favoured route extends from the Sabine Peninsula on Melville Island, across to Bathurst Island, thence to the northern end of Prince of Wales Island. It would cross at the northern end of Peel Sound onto Somerset Island and then lead south down the Boothia Peninsula. From that point the decision whether to go eastwards and down the east shore of Hudson Bay or continue down the western side of the Bay, has not been made.

Along the favoured route, marine crossings exist at Byam Channel, Austin Channel, the west end of Barrow Strait, Baring Channel, Peel Sound and Bellot Strait.

Alternatives to the presently favoured route include a crossing to Little Cornwallis Island and across Cornwallis Island, then across the east end of Barrow Strait to Somerset Island. An earlier alternative was to traverse the length of Prince of Wales Island and then cross Franklin Strait to the Boothia Peninsula. That alternative would by-pass Bellot Strait but it is understood this has been abandoned because of the environmental sensitivity of Prince of Wales Island and engineering difficulties anticipated in Franklin Strait.

The major alternative route or perhaps more correctly the second gathering line of the entire system, is from King Christian Island. At present this branch is being given lower priority than the Melville Island branch. The route would go from King Christian Island, onto the southern end of Ellef Ringnes Island and then to Cornwall Island, possibly via the southwestern extremity of Amund Ringnes Island. Crossing the Grinnell Peninsula it would then cross to Bathurst Island where it would join the first branch.

The route from King Christian Island would also include several marine crossings. These include Danish Strait, Hassel Sound, Hendriksen Strait, Belcher Channel and Penny Strait.

With the exception of Belcher Channel this study has not included the marine crossings on the King Christian Island branch. Prior to the start of this study plans had been made to carry out a quite detailed survey of Belcher Channel based on a number of reasons which include its potential as a pipeline crossing site.

As it will be noted in the next Section, two marine crossings have already been surveyed in some detail. These are Barrow Strait and Bellot Strait. For other crossings only very limited data is available.

The study will be conducted in two phases:

a) To establish the geodetic framework on shore in the vicinity of the marine crossings. To examine the available technology. This work is covered by this interim report and is being carried out during 1975.

b) To measure a series of bathymetric profiles at all marine crossings and to measure the vertical movement of the tide at each crossing for at least 29 days in order to develop tidal predictions. This work will be carried out in 1976. At this time it is planned to conduct some of the work from the ice surface during the spring and to carry out additional work in conjunction with geological studies, from a ship, during the summer. These operations will be covered by the final report.

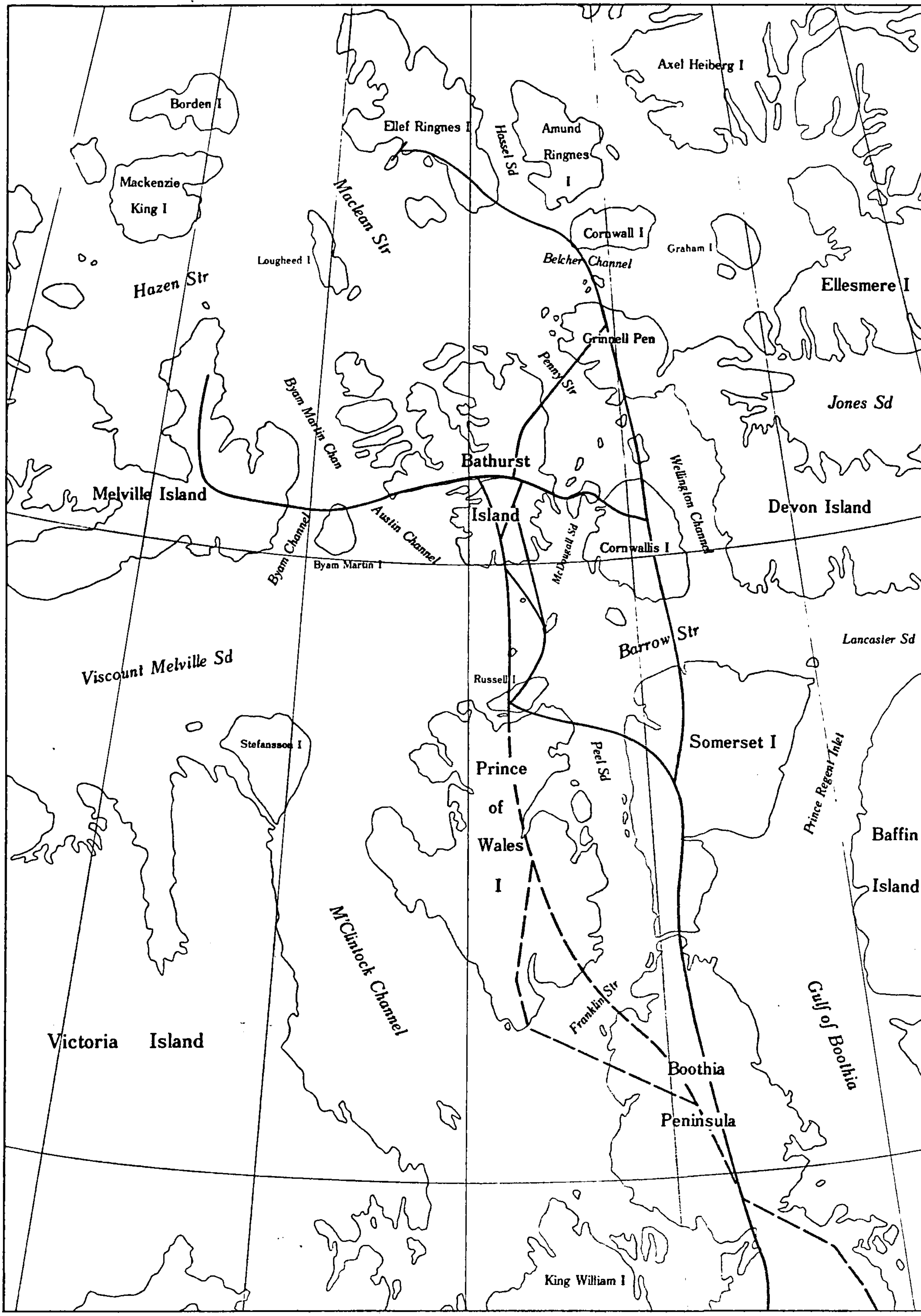

Figure 1. General Map of Proposed Pipeline Routes

3. CURRENT STATE OF KNOWLEDGE

Bathymetry

Much of the existing data which has been collected has been drawn up on hydrographic field sheets. Field sheets of the area are shown in figure 2. Table 1 gives the density of the data on the field sheets. Field sheets 4325, 3182, 3125, 4489 and 4490 contain the results of systematic ship surveys and, consequently, the data is closely spaced and of a good order of accuracy. Furthermore, the sounding lines are continuous profiles and normally are oriented perpendicular to the axis of the channels. Field sheets 3266, 3176, 3738, 3736 and 3737 contain the results of spot soundings measured through the ice. The measurement of the depth through the ice will normally be as accurate as depths measured by ship. However, the positioning of the data on field sheets 3266 and 3176 A/B is low in accuracy as the back cover of a Decca Lambda positioning chain was used.

Areas shown blank in figure 2 are where no systematic hydrographic survey has been carried out. Charts of the area show soundings in some of these areas. Such data was obtained from miscellaneous ships passing through the area. These data are of variable quality and many consist of a single line of soundings positioned by radar and measured by an uncalibrated sounding machine.

We have recently become aware of some well controlled data collected in 1974 at the northern end of Peel Sound from an icebreaker. A further program is being arranged for 1975.

Tidal

During the past years, thirteen tide gauging stations were investigated in the Arctic Archipelago. Observations were conducted for periods varying from 15 days to a complete year. Table 2 lists these gauging stations and provides a measure of the tidal range. Permanent gauges are located at Resolute and Spence Bay. Figure 3 shows the location of the gauges in the pipeline area. It can be seen that no information is available for the immediate areas of Byam and Martin Channel and the crossing at the north end of Peel Sound may bear investigation. As a point of interest, our information that strong currents exist in Bellot Strait is supported by the fact that the tidal range at False Strait on the west side of the Boothia Peninsula is 2.7 feet while the tidal range at Fort Ross on the east side is 9.8 feet.

4. STUDY AREA

Previously described in Section 2.

5. METHODS AND SOURCES OF DATA

The measurement of bathymetry and associated data such as tides is being carried out in two phases. 1975 was utilized to establish the geodetic framework on shore and to evaluate various instruments and vehicles. Provided funds are available the actual depth and tide measuring operations will take place in 1976.

Fortunately there is a solid net of geodetic control covering most of the Arctic islands. This control was originally established by the Army Surveys. It was established by tellurometer traverses, generally following the coastline of all the major islands. This control exists in all the potential crossing sites as can be seen in figures 4, 5 and 6.

TABLE 1

FIELD SHEET COVERAGE

The attached sketch shows the areas surveyed, with the field sheet limits, their scales and year surveyed. The S.S. on sketch stands for spot soundings - done by Polar Continental Shelf Project. The other sheets are standard surveys.

Remarks:-

F.S. 3125	The sounding lines are 4,000 feet apart.
F.S. 3182	The sounding lines are 3,000 feet apart.
F.S. 4325	The sounding lines are 7,500 feet apart.
F.S. 4324	The sounding lines are 2,000 feet apart.
F.S. 4484	The sounding lines are 7,500 feet apart.
F.S. 4483	The sounding lines are 1,500 feet apart.
F.S. 3282	The spot soundings are on a 1 1/4 stat. mile grid. (2 km).
F.S. 3287	Only four runs across the strait approaches - 5 to 6 stat. miles apart and the spot soundings on the runs are 1.5 to 4 stat. miles apart.
F.S. 3176A/B	The spot soundings are on a 6.3 stat. mile (10 km) grid.
F.S. 3266	Ditto as for F.S. 3176 A/B.
F.S. 3218	The spot soundings are irregularly spaced - being from a minimum of 2,000 to a maximum of 15,000 feet apart.
F.S. 3219	As above except for a minimum of 500 to maximum of 3,600 feet apart.
F.S. 3738	The spot soundings are spaced apart from a minimum of 1 1/2 to a maximum of 4 statute miles.
F.S. 2785	The sounding lines are 400' and less in the east end of the Strait and up to 1,000' on the east side of the F.S.
F.S. 2784	The sounding lines are from 200' to 800' apart.
F.S. 2786	The sounding lines are 1200' apart.
F.S. 4243	The sounding lines are 200' apart.

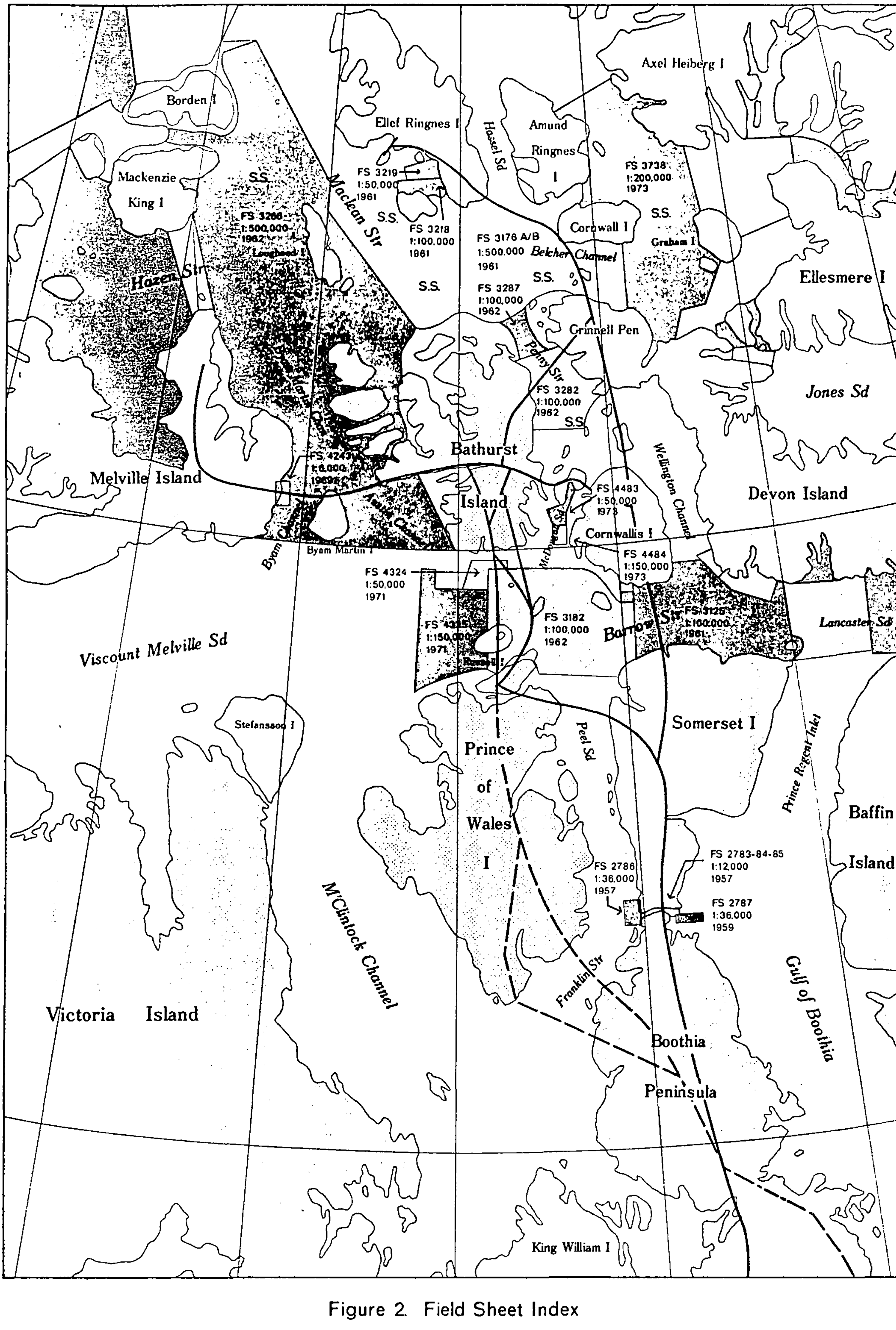

Figure 2. Field Sheet Index

TABLE 2 AVAILABLE TIDAL INFORMATION IN ARCTIC-CENTRAL REGION

STATION NO.	LOCATION	LAT.	LONG.	ANALYSIS	TIDE RANGES		
				Period (days)	MEAN TIDE	LARGE TIDE	
5490	Rigby Bay	74 33	90 10	2x15	6.1	9.6	4.6
5500	Radstock Bay	74 43	91 05	15	6.1	9.6	4.2
5510	Beechy Island	74 43	91 54	29	5.9	9.0	4.0
6150*	Spence Bay	69 32	93 31	112	0.6	0.9	1.1
5930	Fort Ross	72 01	94 14	15	6.5	9.8	4.2
5560	Resolute	74 41	94 54	369	4.3	6.8	3.4
6100	False Strait	71 59	95 10	15	1.7	2.7	3.0
6780	Northumberland Sound	76 52	96 42	29	1.9	2.8	0.9
6765	Airstrip Point	76 05	97 44	29	3.3	5.1	1.9
5600	Cape Capel	75 02	98 02	31	3.7	5.7	2.5
5615	Hamilton Island	74 12	99 10	15	1.8	2.8	1.7
6910	Isachsen	78 47	103.32	29	0.9	1.3	1.0
5645	Winter Harbour	74 47	110.48	29	3.2	5.1	1.6

* Permanent Gauges

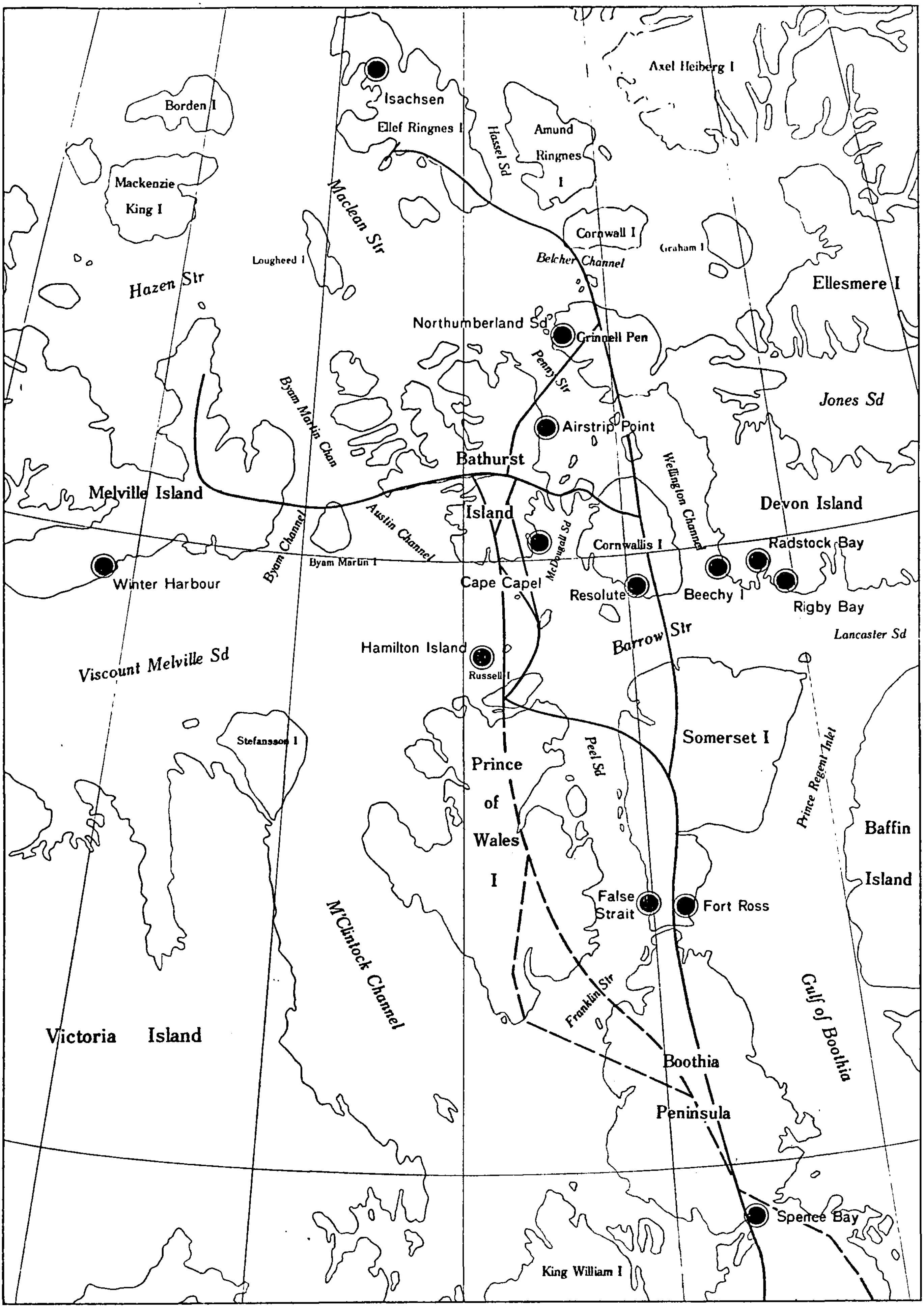

Figure 3. Location of Tide Gauge Sites

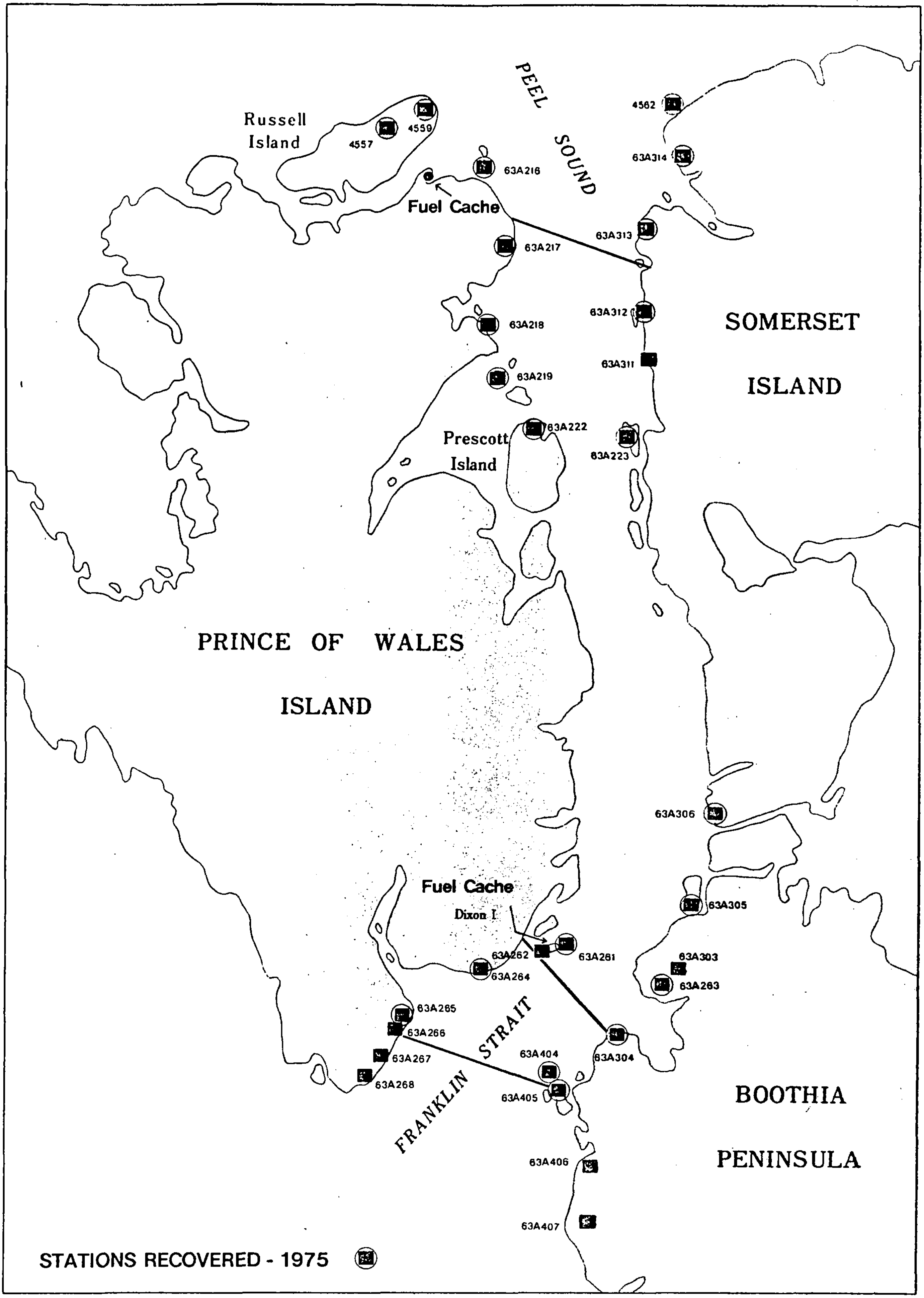

Figure 4. Geodetic Control (Peel Sound and Franklin Strait)

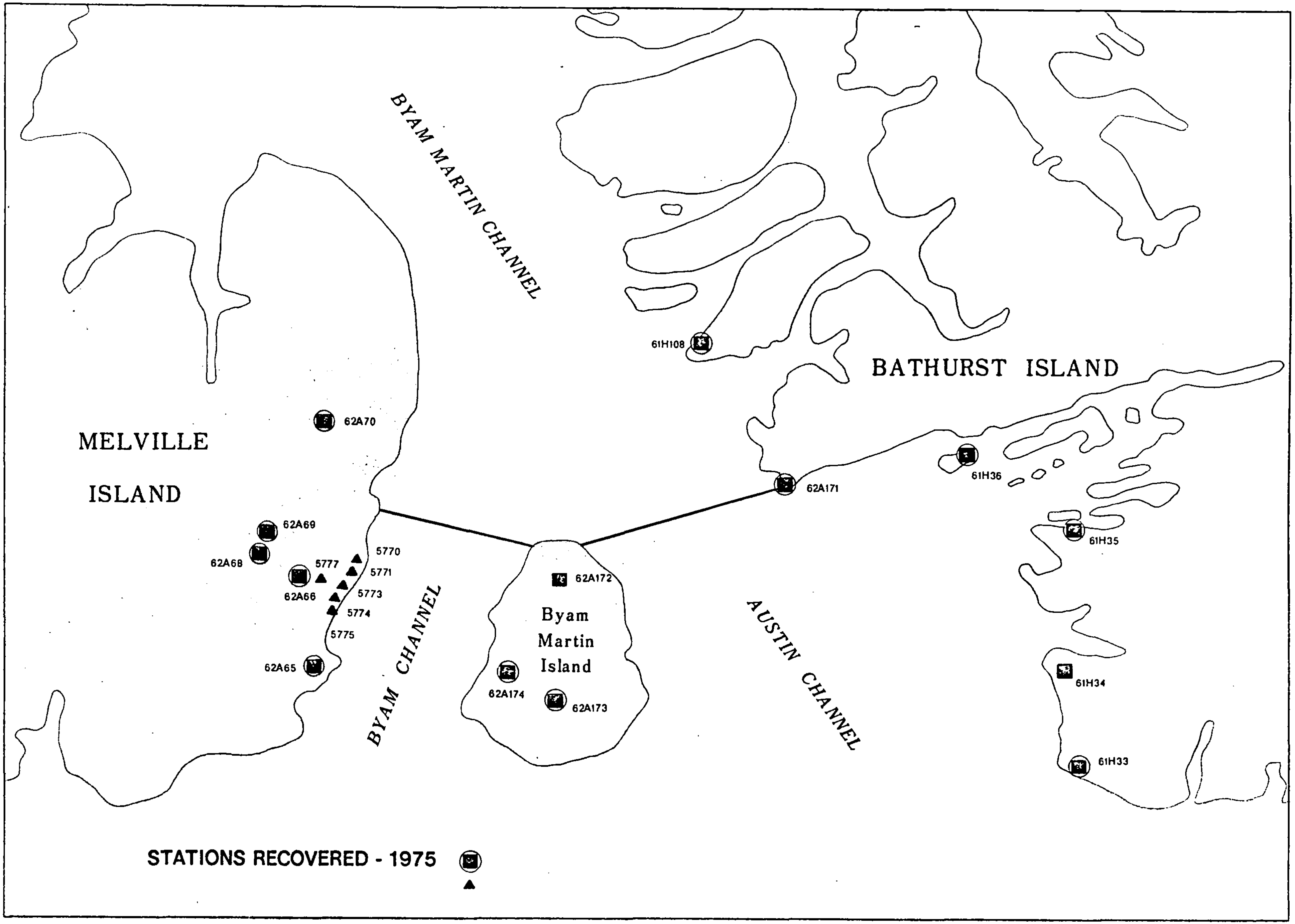

Figure 5. Geodetic Control (Byam and Austin Channels)

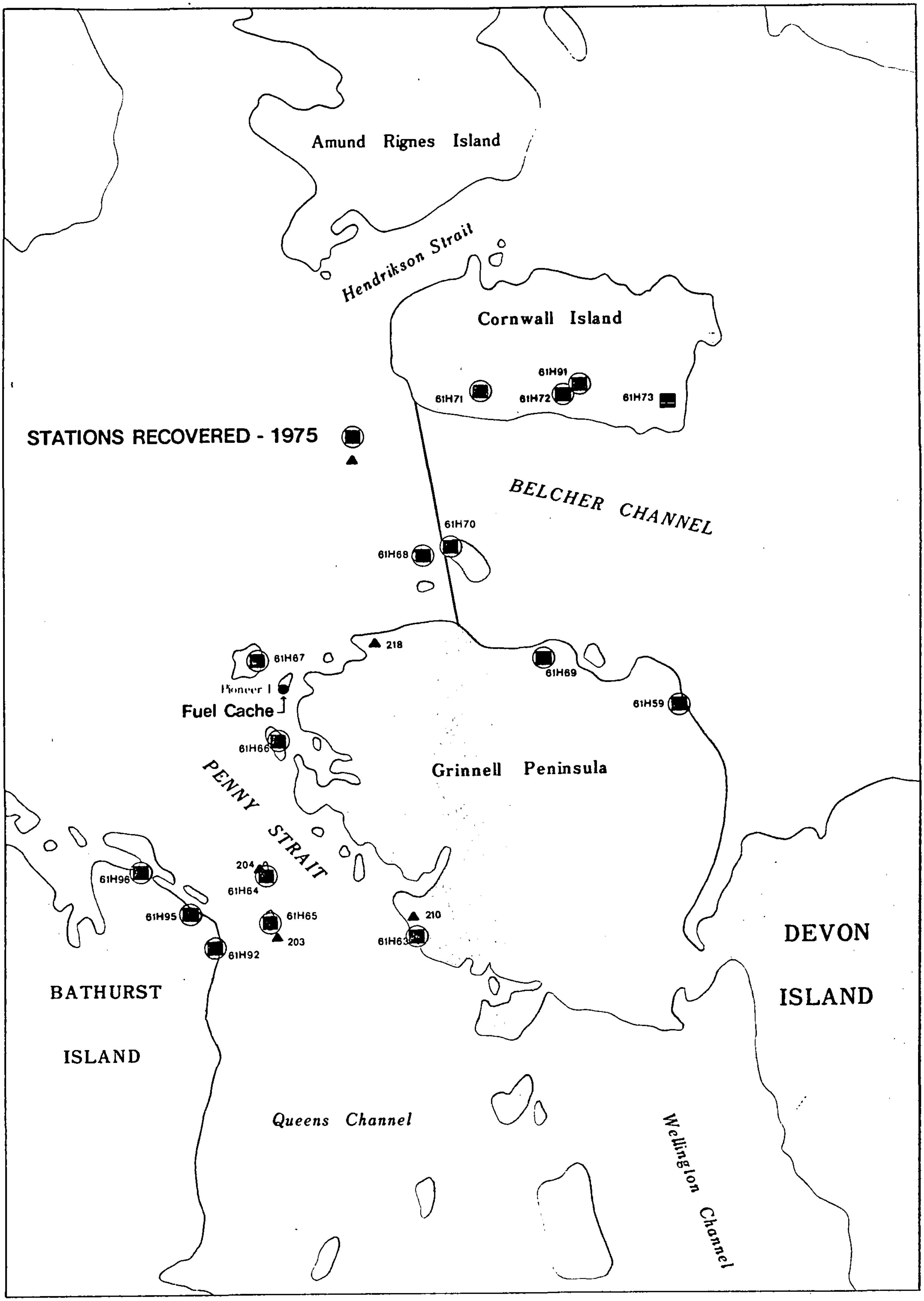

Figure 6. Geodetic Control (Belcher Channel)

Operations in March through to May were directed towards the recovery of these geodetic points which are monumented with aluminum stakes or brass tablets. No additional control points were established as it was felt that the existing control would be sufficient as a basis for extension over the sea ice using Motorola RPS (range positioning systems).

In addition to recovering the horizontal geodetic control a reconnaissance was made using the helicopters to locate suitable future camp sites and also to study the condition of the ice surface. In view of the possibility of using tracked vehicles on the ice for sounding operations it was necessary to investigate the state of the ice with respect to pressure ridges, snow ridges or open water

The following discusses each area individually:

Peel Sound and Franklin Strait

Operations conducted May 9-10. Helicopter time expended 17.7 hours and Twin engined Otter 4.3 hours.

A suitable site for a Hercules landing strip was located on the long narrow lake west of Back's Bay on Prince of Wales Island.

At Franklin Strait geodetic control points 63A266, 63A267, 63A268 and 63A406 were not recovered due to snow cover. Points 63A265, 63A266, 63A267 and 63A268 are on low ground and the navigating transponders will probably have to be set up on towers to obtain any range. Apparently Polar Gas used points 63A261 and 63A405 for their operations.

Ice conditions along the southern and northern crossing sites in Peel Sound and Franklin Strait were considered too rough for tracked vehicles with considerable ice ridging. However 1/2 mile north of the northern crossing a smooth section existed. At the centre crossing, in the vicinity of Dixon Island vehicle crossing was feasible although the ice was rough.

All geodetic points recovered are identified on figure 3 and a complete list of all points recovered and their co-ordinates is contained in Table 3.

If it appears that a pipeline may cross Baring Channel at the northern end of Peel Sound and if a study is required, the geodetic control will have to be established by an extension of the existing network. This channel is suitable for vehicle crossing with hard packed snow drifts.

Byam Channel and Austin Channel

Operations conducted April 24-25. Helicopter time expended 10.7 hours. During this period lodging was provided by the Polar Gas camp at Rea Point and meals provided by the Panarctic camp.

Geodetic point 62A172 was not recovered due to snow cover but all other points in the area, as shown in figure 5, were recovered.

Byam and Austin Channels had little pressure ridging and were considered suitable for using vehicles.

TABLE 3

GEODETIC CONTROL POINTS

Peel Sound

Geodetic Point	Agency	Latitude	Longitude	UTM Zone	Northing	Easting	Monument Type	Recovered
4557	C.H.S.	74-04-22.45	98-03-35.71				Bronze tablet	x
4559	C.H.S.	74-05-43.86	97-40-19.35	14	8222988.8	540618.4	"	x
63A216	A.S.E.	73-53-58.88	97-10-26.10	14	8201553.4	556520.1	Alum. post	x
63A217	A.S.E.	73-41-37.20	96-56-44.44	14	8178810.6	564373.3	"	x
63A218	A.S.E.	73-27-16.38	97-12-19.86	14	8151882.4	557034.8	"	x
63A219	A.S.E.	73-18-29.74	97-10-54.80	14	8135591.8	558281.8	"	x
63A222	A.S.E.	73-09-10.64	96-49-41.32	14	8118654.6	570246.1	"	x
63A223	A.S.E.	73-06-31.29	95-49-47.44	15	8114610.6	480251.4	"	x
63A311	A.S.E.	73-19-44.06	95-37-14.48	15	8138847.5	416104.2	"	
63A312	A.S.E.	73-28-08.39	95-39-10.37	15	8154507.8	415767.6	"	x
63A313	A.S.E.	73-43-19.75	95-34-11.13	15	8182611.6	419620.3	"	x
63A314	A.S.E.	73-56-11.17	95-15-04.20	15	8206100.3	430482.9	"	x
4[illegible]62	C.H.S.	74-01-40.26	95-15-09.15	15	8216294.0	430825.8	Bronze tablet	x

Franklin Strait

Geodetic Point	Agency	Latitude	Longitude	UTM Zone	Northing	Easting	Monument Type	Recovered
63A306	A.S.E.	73-01-20.75	95-05-58.23	15	7992527.6	472684.1	Alum. post	x
63A305	A.S.E.	71-14-02.76	96-33-21.72	14	7905107.8	587734.2	"	x
63A303	A.S.E.	71-37-16.41	95-20-47.50	15	7948120.0	417438.3	Alum. plug	
63A263	A.S.E.	71-33-30.81	95-43-49.39	15	7941704.3	403623.9	Alum. post	x
63A304	A.S.E.	71-23-10.98	96-07-09.75	14	7922765.7	602591.0	"	x
63A404	A.S.E.	71-19-45.61	96-44-33.18	14	7915463.4	580645.1	"	x
63A405	A.S.E.	71-14-02.76	96-33-21.72	14	7905107.8	587734.2	"	x
63A406	A.S.E.	70-57-47.10	96-19-44.46	14	7875250.3	597212.2	"	
63A407	A.S.E.	70-50-28.14	96-17-14.51	14	7861730.1	599335.6	"	
63A268	A.S.E.	71-21-32.63	98-41-49.14	14	7917301.0	510810.5	"	
63A267	A.S.E.	71-22-32.26	98-30-55.76	14	7919190.6	517270.7	"	
63A266	A.S.E.	71-28-38.64	98-15-20.25	14	7930635.5	526393.5	"	
63A265	A.S.E.	71-30-13.58	98-08-32.01	14	7933630.1	530372.4	"	x
63A264	A.S.E.	71-39-13.38	97-25-20.69	14	7950863.7	555418.9	"	x
63A262	A.S.E.	71-40-25.98	96-56-19.02	14	7953624.2	572332.2	"	
63A261	A.S.E.	71-40-37.02	96-47-46.81	14	7954142.5	577310.3	"	x

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BYAM CHANNEL - AUSTIN CHANNEL

Geodetic Point	Agency	Latitude	Longitude	UTM ZONE	Northing	Easting	Monument Type	Recovered
[illegible]-H-33	A.S.E.	75-01-07.92	100-11-25.11	14	8325902.3	465654.2	Alum. post	x
61-H-34	A.S.E.	75-11-47.21	100-21-00.39	14	8345810.8	461495.2	"	
[illegible]-H-35	A.S.E.	75-26-28.28	100-18-40.66	14	8373088.4	463206.5	"	x
[illegible]-H-36	A.S.E.	75-32-41.04	100-21-37.32	14	8385546.5	434242.7	"	x
62-A-171	A.S.E.	75-30-58.68	102-38-41.61	13	8382370.1	565736.9	"	x
[illegible]-H-108	A.S.E.	75-46-41.86	103-15-48.30	13	8410996.0	547619.4	"	x
[illegible]-A-173	A.S.E.	75-08-20.85	104-11-26.79	13	8339134.2	523167.4	"	x
62-A-174	A.S.E.	75-11-46.51	104-24-34.50	13	8345434.4	516839.8	"	x
62-A-65	A.S.E.	75-10.56.37	106-00-20.42	13	8344040.0	471290.6	"	x
[illegible]-A-66	A.S.E.	75-19-26.23	106-07-41.73	13	8359903.1	468092.4	Bronze T.	x
[illegible]-A-172	A.S.E.	75-21-42.74	104-09-58.99	13	8363996.0	523515.8	Alum. P	
62-A-68	A.S.E.	75-25-20.65	106-20-15.80	13	8371009.1	462417.7	Alum. post	x
[illegible]-A-69	A.S.E.	75-26-47.04	106-16-54.14	13	8373651.5	464049.2	"	x
62-A-70	A.S.E.	75-36-43.65	105-50-13.63	13	8391918.7	476780.1	"	x
(5[illegible]70) REA	C.H.S.	75-21-51.04	105-37-51.46	13	8364182.4	482203.3	"	x
(5[illegible]71) MEL	C.H.S.	75-20-54.77	105-39-21.85	13	8362446.1	481475.9	"	x
(5[illegible]73) BOB	C.H.S.	75-20-08.63	105-42-35.98	13	8361033.6	479936.2	"	x
(5774) [illegible]WELL	C.H.S.	75-19-46.63	105-41-54.13	13	8360347.9	480256.7	"	x
(5[illegible]75) NOD	C.H.S.	75-19-21.64	105-42-15.66	13	8359575.4	480078.4	"	x
(5[illegible]77) HOP	C.H.S.	75-19-49.40	105-51-08.38	13	8360490.7	475905.6	"	x

BELCHER CHANNEL - NORTHERN PENNY STRAIT

Geodetic Point	Agency	Latitude	Longitude	UTM ZONE	Northing	Easting	Monument Type	Recovered
[illegible]-H-73	A.S.E.	77-30-15.06	93-34-27.93	15	8602962.6	486125.2	Alum. post	
61-H-72	A.S.E.	77-31-30.73	94-48-23.51	15	8605911.0	456442.6	"	x
[illegible]-H-91	A.S.E.	77-33-26.98	94-43-45.63	15	8609457.2	458409.4	"	x
[illegible]-H-71	A.S.E.	77-31-30.33	95-31-18.07	15	8606534.5	439207.5	"	x
61-H-70	A.S.E.	77-14-39.38	95-33-55.35	15	8575269.1	436785.8	"	x
61-H-68	A.S.E.	77-13-06.69	95-52-45-14	15	8572757.5	428917.4	"	x
[illegible]-H-59	A.S.E.	76-50-43.46	93-39-46.56	15	8529471.1	483157.9	"	x
61-H-69	A.S.E.	76-55-37.79	94-47-37.68	15	8539190.6	454711.8	"	x
218	P.C.S.P.	77-01-32.10	96-15-36.43	14	8551083.2	568648.7	"	x
[illegible]-H-67	A.S.E.	77-01-22.52	97-11-48.04	14	8549879.7	545200.7	"	x
[illegible]-H-66	A.S.E.	76-50-54.19	97-10-59.15	14	8530421.3	546142.6	"	x
61-H-64	A.S.E.	76-36-15.76	97-08-54.11	14	8508231.5	547880.0	"	x
[illegible]204	P.C.S.P.	76-34-20.09	97-08-46.82	14	8499649.2	548046.1	"	
[illegible]-H-65	A.S.E.	76-31-45.45	97-13-58.53	14	8494788.8	545946.2	"	x
203	P.C.S.P.	76-29-24.09	97-06-46.62	14	8490505.5	549205.0	"	x
61-H-96	A.S.E.	76-36-18.07	98-32-40.30	14	8502596.0	511779.0	"	x
[illegible]-H-95	A.S.E.	76-31-14.04	98-04-33.37	14	8493314.6	524044.5	"	x
61-H-92	A.S.E.	76-27-40.11	97-44-05.43	14	8486849.7	533061.2	"	x
210	P.C.S.P.	76-26-36.12	95-59-46.45	14	8486513.6	578569.4	"	x
[illegible]-H-63	A.S.E.	76-26-23.68	95-49-42.58	15	8485901.6	425993.0	"	x

Barrow Strait

No operations were carried out to recover geodetic control in the Barrow Strait area but it is known from previous operations that a considerable amount of control is available. There is also a detailed survey of the area and the need for additional bathymetry there is less than other crossing areas.

The ice was smooth in some sections but there were many areas with severe ice ridging.

Belcher Channel and North Penny Strait

Although not identified as a high priority pipeline crossing site, Belcher Channel requires a hydrographic survey for a number of reasons. It lies on the shipping routes from Jones Sound to the Ringnes Islands and also is on the route from Penny Strait to Eureka Sound. Further to these reasons, it also has some interest as a potential pipeline crossing site from the Ringnes Islands to the Grinnell Peninsula.

Operations were conducted on March 12. Helicopter time expended 9.9 hours and Twin Otter time 2.8 hours.

Because of a shortage of general bathymetry control was recovered along both shores of Belcher Channel and both shores of Northern Penny Strait.

Potential camp sites were located at Napier Bay and Village Bay.

Control points were recovered as shown in figure 6. Point 61H73 on the south-east corner of Cornwall Island was not located due to snow cover, however, its existence is known from previous operations in 1972.

Regarding the ice surface condition in Belcher Channel, there was little ridging and it appeared suitable for vehicles.

Development of tracked vehicle sounding system

In order to study the bathymetry along pipeline routes in detail it is considered desirable to obtain continuous profiles. While this information is obtainable using echo sounders from ships, the use of the ships themselves may be difficult, if not impossible, in certain years and in certain areas. Polar Gas has utilized ships and point out that when the area is clear of ice the data gathering is swift. However, frequently the presence of numerous ice floes, makes it difficult to carry out a systematic survey. An alternative exists in sounding from the frozen sea surface. After developments by Marsden in the late fifties, hydrographers working with the Polar Continental Shelf Project have refined the technique. For a decade now, spot soundings have been measured through the ice using a helicopter as a platform. It was discovered that Banister Technical working as consultants for Polar Gas had extended this technique to using it with a tracked vehicle.

In order to study the potential of tracked vehicles and the BANQUES (Banister and Caulfield Quantum Estimating System) with respect to measuring bathymetry both along pipeline routes and navigational corridors, a contract was let to Banister Technical Services.

A series of experiments were carried out at Rea Point during the period April 22 to May 8. The trials demonstrated the capability of the existing system to provide closely spaced spot depths along a profile. Data were also collected in order to extend the design for continuous measurements along profiles.

Although the prospects for this system are to be viewed optimistically the complexity and cost of developing an operational system rule out its use for the 1976/77 season. The alternative approach is to use the spot sounding technique with a helicopter as a platform and to sample at close intervals along the proposals. It is possible that some economy may be achieved by using skidoos to transport the sounding equipment in some areas.

Testing a Self-Contained Tide Gauge

Existing knowledge of tides in Arctic waters is limited as has been explained previously. Until recently considerable difficulties were encountered in measuring tides in ice covered or partially ice covered waters. All the instruments available required a sensor in the water, a recorder at some accessible point on shore and a pressure or electric cable joining the two units. Damage occurred frequently to the joining cable from chafing of the ice. The twenty-nine day records required for making an analysis were consequently difficult to obtain.

Recent developments by various companies, notably Aanderaa, have led to the production of a gauge that has both the sensor and the recording system enclosed in one unit. This unit can be placed on the sea floor and recovered at a later date. In order to examine the potential of this equipment for tidal measurements in ice covered waters a unit was installed near the mouth of John Richardson Bay, Ellesmere Island. The gauge was located in 46 feet of water and recorded the tide level every 15 minutes. The gauge operated successfully and will be used in any bathymetry studies in the pipeline crossing areas.

6. RESULTS

Geodetic Control - Sufficient geodetic control was recovered at all potential crossing sites for future sounding operations.

Development of tracked vehicle sounding system - Field trials indicate that this technology is feasible for closely spaced soundings along profiles. However the time required to develop a continuous profiling system will be too lengthy and the cost too great to make its use practical for sounding along the pipeline routes in 1976/77.

Testing a Self-Contained Gauge - Field tests show that the Aanderaa self-contained tide gauge will be suitable for use in conjunction with the bathymetric studies.

7. DISCUSSION

The scarcity of bathymetric data in the Arctic poses a problem to navigators and engineers alike. Several years ago engineers from Montreal Engineering Company approached the Canadian Hydrographic Service to obtain both all the available data and information on any special technology used for surveying Arctic waters. At that time Montreal Engineering Company was employed as a consultant to the Polar Gas consortium. For a period of about two years very little information was received from either of these groups. It was known that various engineering studies were underway along the pipeline routes. In the winter of 1974/75 Polar Gas released considerable information concerning their engineering studies. Profiles of the bathymetry along several crossings were made available to the government. Limited details of the techniques used for obtaining the data were also made available. Considerable discussion took place on whether ships or over-ice vehicles were the most suitable platform for obtaining the data. The experience of Polar Gas indicates that a combined program will probably be the most productive.

The question asked from the outset was whether or not there was really a need for additional bathymetric data in order to predict any detrimental environmental disturbance in the event of a gas pipeline being built. It appeared, for instance, that should the pipe break at the bottom of a marine crossing, it would cause little or no damage to any fish or wildlife. However, if the pipeline did break after completion it would require heavy equipment and personnel being brought back to the scene once more to carry out the repair. Since this in itself would be a disturbance, any measures that would ensure the integrity of the pipeline would be beneficial. Furthermore, the bathymetry was required for other studies. These included current measurement studies where not only was a knowledge of the bottom topography required for actually placing the meters but it was also required for any modelling studies.

From the point of view of the engineering design the pipeline must be supported at frequent intervals as long unsupported spans are not acceptable. To this end it is essential to locate any trenches or protusions on the sea floor. Ice scouring is best seen on sidescan sonar records. This device can be most suitably deployed from a ship, although Polar Gas did in fact use the system in a trench they had cut through the ice.

It seems probable that the land-sea interface will cause some particular problems for the pipeline engineer. One technique that may be employed is to drag the pipe along the sea bottom. If this was the case, the slope of the shoreline would be required, where the pipe enters and goes under the water. Also, at the land-sea interface, the vertical movement of the tide could be a problem. During periods of ice cover the ice itself will move up and down with the tide and will possibly cause tide cracks to appear. These fissures, running parallel to the shore may cause difficulties in laying the pipe. Unless the pipeline is well buried it could be damaged by the periodic vertical movement of the ice against the shore.

Out of the above considerations it has been decided that a knowledge of the bathymetry in the form of continuous profiles is needed at each proposed crossing. Also, that vertical tidal movement must be measured. The bathymetric profiles should extend from dry land to dry land. In the immediate area of a proposed crossing up to three profiles should be measured. On each side of these three profiles a series of more widely spaced profiles should be measured in order to examine what alternatives are available. Tidal observations can be taken from the ice surface at one point in the immediate crossing area.

There will be considerable interplay with the geologists. Their interests will be primarily in the sub-bottom sediment layers. The techniques of the hydrographer may be extended to cover some of their work. They will be particularly interested in information on ice scouring, which, as it has been remarked earlier, can be most readily detected by sidescan sonar operated from a ship.

8. CONCLUSIONS

As this interim report only covers Phase I, the preparatory operations, no conclusions are available.