CANADIAN HYDROGRAPHIC SERVICE. TECHNICAL REPORT
1973 - MORTIMER, A.R
C. C. I. W.
LIBRARY

CENTRAL REGION

FINAL FIELD REPORT
ARCTIC SURVEYS
CENTRAL REGION
1973

A.R. MORTIMER
HYDROGRAPHER-IN-CHARGE

PROJECT FILE NUMBER 6600-72-6

VK
595
.C3
M67
1973

CANADIAN HYDROGRAPHIC SERVICE
MARINE SCIENCES DIRECTORATE
DEPARTMENT OF THE ENVIRONMENT

FINAL FIELD REPORT

ARCTIC SURVEYS

CENTRAL REGION

1973

A. R. Mortimer

Hydrographer-In-Charge

Project File No. 6600-72-6

TABLE OF CONTENTS

PERSONNEL

A. Mortimer	Hydrographer	Mar. 12	May 10
R. Moulton	Hydrographer	Feb. 26	May 8
M. Crutchlow	Hydrographer	Mar. 12	May 10
R. Macdougall	Hydrographer	Feb. 26	May 10
D. Pyatt	Electronics Tech.	Mar. 12	May 8
J. McGirr	Gas Engineer	Feb. 26	May 10
B. Power	P.C.S.P. Labourer	Feb. 26	May 10
R. Smith	P.C.S.P. Cook	Feb. 26	May 8
E. Porco	Dominion Helicopters, 205 Pilot	Mar. 18	May 6
R. Sanders	Dominion Helicopters, 205 Engineer	Mar. 18	May 6
A. Macdonald	Dominion Helicopters, 206 Pilot	Mar. 20	May 6
J. Senuik	Dominion Helicopter, 206 Engineer	Mar. 20	May 6

VISITORS TO SURPRISE FIORD

F. Hunt	P.C.S.P.	Mar. 21
Dr. Jonkel	C.W.S.	April 13 - 14
G. Hobson	P.C.S.P.	May 4
M. Butler	A.D.M., D.S.S.	May 4

CHRONOLOGY OF EVENTS

Feb.	26	Advance party departs Burlington for Resolute.
Mar.	5	Commence establishing camp at Surprise Fiord.
Mar.	10	Surprise Fiord air temperature - $60^{o}F$.
Mar.	15	Remainder of party arrives at Surprise Fiord.
Mar.	18	205 Helicopter arrives.
Mar.	20	206 Helicopter arrives. D.C.3 bringing in fuel.
Mar.	21	Survey operations commence.
May	5	Norwegian Bay Sounding completed.
May	6	Helicopters depart.
May	7	Breaking camp.
May	11	Return to Burlington.

INTRODUCTION

Norwegian Bay is the most eastern area of water lying within the Queen Elizabeth Islands. Ellesmere Island lies to the east, Axel Heiberg Island to the north, and Devon Island to the south. Physiographically, the Norwegian Bay can be divided into two zones. Low-lying sedimentary areas are found to the west of the bay, and to the east are the foothills of the Ellesmere Island cordillera. Prior to the survey, all sounding information available was along icebreaker routes, principally from Hell Gate to Eureka Fiord, and little was known of the submarine topography of the bay.

The area was first visited by Sir Edward Belcher in 1852 with H.M. Ships Assistance and Pioneer. He entered the bay from the westward, leaving his name on Belcher Channel, and he penetrated along the south side of the bay as far as Cardigan Strait. Norwegian Bay was next visited by sledge parties from Sverdrup's Fram during the spring seasons of 1901 and 1902. These parties sledded to Axel Heiberg and Amund Ringnes Island. In the summer of 1902, the Fram managed to make the passage through Hell Gate and return to Jones Sound by way of Cardigan Strait.

Spring weather in this region is influenced by the extent and strength of the low pressure system over Baffin Bay. If this low pressure extends into Norwegian Bay, southerly winds with their associated higher temperature and poor visibility are experienced. However, generally the low pressure area does not extend as far as Norwegian Bay, and a northerly stream of cold, dry air provides good arctic spring weather. In the spring, Norwegian Bay is completely ice covered, with some older floes amongst the first year ice. South of Graham Island, under the influence of the currents through Hell Gate, the ice surface is contorted with rafting and pressure ridges. North of Graham Island the ice surface is generally smooth.

NARRATIVE

Preparations

The Arctic Survey Party is extensively supported by the Polar Continental Shelf Project (P.C.S.P.); however, the support available for the 1973 field was rather less than in previous years. This decrease in support required the acquisition of equipment and clothing, and the arranging of freight shipments and food supplies for the party. P.C.S.P. supplied the heavy camp equipment, 570 hours flying time with Bell 205 and 206 helicopters, 86 hours flying time on a Twin Otter aircraft, and the fuel necessary for these machines. Arctic clothing was obtained from suppliers in various parts of Canada. One six section Parcoll was purchased to supplement those supplied by P.C.S.P. Food supplies were ordered from Dominion Stores, Montreal, to be forwarded to Resolute throughout the period of the survey. P.C.S.P. arranged the heavy air freighting for camp and survey equipment, but some additional shipments were made direct from Burlington.

P.C.S.P. agreed to establish fuel caches as required for the survey and to freight the heavy equipment from Resolute to Surprise Fiord. Through P.C.S.P. arrangements were made for the two helicopters to be used for the survey to be fitted with R.P.S. This exercise entailed the preparation of drawings by Master Engineering Company, the fabrication and fitting of the equipment at Dominion Helicopters and flight testing for the M.O.T. These tests were not completed until March 5th.

LOGISTICS

Mr. R. Moulton and an advance party left Burlington for Resolute on February 26th. Equipment for the survey had arrived in Resolute earlier in the month, but it was not possible to start moving it in to the Surprise Fiord Camp until March 5th. Two Parcolls had been put up at Surprise Fiord in 1972; these were found to be in good condition and were invaluable at the low temperatures prevalent at the time. At Surprise Fiord there was four feet of loose powder snow on the airstrip precluding the use of a large aircraft, therefore, half of the flying time for the Twin Otter was used in establishing the camp. The remainder of the survey party arrived at Surprise Fiord on March 15th to find the camp comfortably established.

A 10,000 gallon bladder was used for aircraft fuel storage (JP4). This bladder was filled from a 700 gallon tank in a D.C.3 between the 18th and 23rd of March. It was refilled between the 20th and 22nd of April. A total of 20,200 gallons of bulk fuel was used by the helicopters. 120 drums of JP4 were cached and used at Graham Island airstrip. Diesel heating fuel for the camp was brought in drums to the camp at the start of the season, and the drums were later refilled from bulk shipments in the D.C.3. Gasoline for skidoos and Herman Nelsons was supplied in drums as required. At the end of the season the 10,000 gallon bladder was removed by the 205 helicopter to East Amund airstrip. All empty fuel drums were removed from Surprise Fiord at the end of the survey.

The Twin Otter support aircraft made six trips into Surprise Fiord during the period of the survey at approximately weekly intervals.

Food supplies and mail were brought in and garbage and empty drums were taken out. Some pilferage was experienced from the food shipments, possibly at their point of origin, Montreal. The food supplied by Dominion Stores was of good quality, but there were shipping delays. About four weeks lead time was required when ordering food. All garbage was burned and the ashes removed to Resolute for disposal.

The camp was dismantled over the period May 6th to 8th, and the site thoroughly cleaned. All equipment and Parcolls have been stored in Resolute. By May 11th all personnel had returned south.

SOUNDING

Both helicopters had arrived at Surprise Fiord by March 20th. After R.P.S. calibration, sounding work commenced on March 22nd. Spot soundings at a 2 km. grid interval were taken to define a shipping channel 20 km. wide between Hell Gate/Cardigan Strait and Eureka Sound. Additional soundings were taken in shoal areas adjacent to this channel and to search for reported shoals. Owing to (1) weakness in the spot sounding technique and (2) possible position errors for reported shoals, no indications of shoals S.E. and N.E. of Graham Island were found. Between Hell Gate and Eureka Sound spot soundings show a channel at least 100 metres deep and at least 10 kilometers wide. However, the submarine topography in this area is complicated and the reconciliation of spot sounding with ice-breaker track sounding is difficult. North of North Kent Island, there is a channel 10 km. wide and at least 50 metres deep. In support of proposed shipping activity, Eids, Blue and Bird Fiords were sounded at a 2 km. grid with additional sounding at the approaches to the Fiords. A 35 metre shoal exists south of Great

Bear Cape, but there is an 8 km. wide channel, 100 m. deep, on either side of the shoal. The entrances to the fiords appear to be restricted by shoals, but Okse Bay has adequate water for shipping and could provide sites for a landing beach and air strip.

West of Graham Island and in Massey Sound, soundings were taken at a 5 km. grid interval. Additional soundings at a 2.5 km. grid interval. Additional soundings at a 2.5 km. grid were taken in the approaches to Belcher Channel and Hendrikson Strait. Additional soundings were also taken to define a shipping channel from Cardigan Strait to Hendrickson Strait. Good Friday Bay, Surprise Fiord and part of Glacier Fiord were also sounded. Sounding operations were completed on May 5th, and the helicopters departed for K.C.I.

CONTROL

Mr. G. E. Wade established or recovered the required sounding control stations in 1972. Two new stations were established to provide control in Glacier and Blue Fiords respectively. The positioning of a station on the Bjorne Peninsula was strengthened.

TIDES

A tide gauge and three bench marks were established on the western shore of Surprise Fiord. A small plywood gauge house was built, and a heater and tide gauge installed. The gauge house was placed on the ice about 15 metres off shore, outside the seaward limit of shore/ice interaction. Of three tide gauges supplied, only one was eventually persuaded to work. Cold weather caused rubber transducer diaphragms to shatter and soldered joints in the recorder to break. However, given much loving care, attention and heat, 24 days continuous records were obtained. These records showed an 0.6 metre spring tidal range.

OCEANOGRAPHY

Four oceanographic stations were occupied in the northern half of Norwegian Bay. Salinity measurements were made with an R.S.5 conductivity meter. Temperature measurements were not possible with this instrument, as its temperature range did not extend to below $0^{\circ}C$. Surface water samples and temperatures were taken and bathythermograph casts made to 100 metres.

To help resolve differences found between ship sounding and "through ice" spot soundings, bar checks were taken along with the oceanographic observations. These bar checks were made using various echo sounder speed control frequencies both through the ice and directly in the water.

Appendix (3) contains the data and results of the oceanographic observations and bar checks.

POSITIONING SYSTEM

Motorola Range Positioning Systems were fitted on the 205 and 206 helicopters before their departure for the arctic. To ensure that maximum range was obtained, scanning antennae were used. The fitting of the scanners to the helicopters required preparation of drawings, making of brackets and testing and approval by the M.O.T. A preliminary flight test for the positioning system was made from King City. On this test, range readings were obtained regularly up to a range of 15 km., and intermittently out to 30 km. from the transponders. However, during operations in Norwegian Bay, much greater ranges were obtained. With transponders' heights in excess of 500 metres, ranges of up to 130 km. were obtained. A range of 95 km. was the maximum used for the positioning of soundings. Calibration was made over baseline lengths of up to 50 km., and analysis of the calibration data shows a likely position line error of ±10 metres at 95% confidence level.

Problems with the R.P.S. were experienced owing to low operational temperatures. It seems that the slightest fault with any equipment is exaggerated by the cold. All power cables to the transponders had to be renewed as their insulation cracked. Faults were found in the multiplexer unit of one system that had been satisfactorily field tested in Burlington. In the same unit the decode/encode system failed and could not be repaired. Also this same system had to be heated every morning to get it started whereas the other R.P.S. would start when cold.

HELICOPTERS

The 205 helicopter continues to be eminently suitable for arctic sounding operations, although for the survey no gravity measurements were made, and, therefore, the space available in the machine was under utilized. The R.P.S. worked well from the 205, although the signal was lost when the transponders were astern of the helicopter. The R.P.S. installation in the small 206 helicopter also worked well, however, the helicopter was flying at its maximum loading capacity with no margin for safety. Space in the 206 helicopter when fully loaded with personnel, R.P.S., sounding, and survival equipment is very cramped; also the helicopter heater is inadequate for arctic operations in the early spring.

OTHER EQUIPMENT

The Edo echo sounders performed well; depths in excess of 600 metres were measured through the ice. A speed control crystal in one echo sounder went off frequency necessitating additional check sounding.

The Herman Nelson forced air heaters for the helicopter proved, as usual, to be unreliable. Many hours work were spent keeping these machines operating.

The skidoos were reliable only for short journeys, and considerable effort was expended keeping them in operation.

DATA PROCESSING

Only rough plots were made in the field to show the progress of collection of bathymetry. Field notes were transcribed into a form suitable for interpretation by a keypunch operator. On return to Burlington, position and depth data was put on punch cards, processed to reduce soundings to a standard sound velocity and to apply a tidal correction, then output on magnetic tape. Field sheets were made on the Gerber plotter, only contours and shoreline being drawn by hand. This computer processing proved to be rather more time consuming than the usually manual method, however, the bathymetric data is now available on magnetic tape for chart compilation development.

COMMENTS AND CONCLUSIONS

1. Through-the-ice spot sounding technique was originally developed for use on the Arctic Ocean continental shelf and slope, where the technique gave adequate sounding coverage. However, due to an increase of shipping in the Arctic Islands, this technique has been used for want of any other suitable method, to provide sounding coverage in areas of complicated submarine topography. Even when sounding grid spacing is reduced to a minimum compatible with helicopter operations, there cannot be complete confidence that all hazards to navigation have been found. Some decrease in sounding spacing may economically be obtained by using tracked vehicles instead of helicopters for transportation. However, the ultimate solution to the problem lies in the development of sounding equipment capable of obtaining a far greater volume of bathymetric data under the conditions existing in the high arctic.

2. As noted earlier in this report, the space and lifting capacity of the 205 helicopter was not fully utilized. If at all possible, it would lead to greater efficiency to revert to the practice of previous years of taking gravity measurement as well as spot soundings.

3. In reference to echo sounder defects, bar checks taken through the ice proved to be extremely valuable. It is recommended that this practice be continued and if a 'market' exists for oceanographic data, this can be obtained through the same hole in the ice.

4. Polar bears and other wild life population counts were made for the Canadian Wildlife Service. No doubt C.W.S. would appreciate it if the practice were continued.

5. Parcolls provide very effective accommodation, but they are expensive. It may be viable to consider the construction of plywood, wood-frame buildings insulated with fibreglass mats, at the camp site. A garbage compactor would also be a useful acquisition for any future camps.

6. Conventional tide gauges are unsuitable for use during the spring in the arctic. The Frozen Sea Research Group, Victoria, have developed a gauge which is designed for all year arctic operation.

7. The extensive cooperation of P.C.S.P. personnel, especially Mr. A. Alt, Resolute base manager, is greatly appreciated.

APPENDIX

- STATISTICS -

FIELD REPORT STATISTICS:- MONTHLY..... PROJECT..... FINAL FIELD XX.....

YEAR 1973 FROM February 26 TO May 11

Establishment Arctic Surveys

H.I.C. A. R. Mortimer

	Project Number	Project Number	Project Number	Project Number
Project Name Norwegian Bay	6600 72-6			
Project Name				
Project Name				
Project Name				
Resources:				
Number of Hydrographers *	4/74			
Number of Scientists *	–			
Number of Electronic Technicians *	1/59			
No. of Student Assistants and Casuals *	–			
No. of Support Personnel (Ship's Crew, Etc.) *	7/74			
Total Personnel *	12/74			
Number of Ships	–			
Number of Launches	–			
Number of Land Vehicles (Skidoos)	2			
Number (and type) of Aircraft	See Below			
Number of Minor Support staff	–			
Other (specify)				
Aircraft (fixed wing) DC3 Twin Otter	2			
" (rotor wing) Bell 205, 206	2			

* Should provide two figures separated by a slash. The first figure being the average number on strength and the second being the man days. e.g. number of Hydrographers: 5/100 (an average of 5 Hydrographers spent 100 man days on the project).

FIELD REPORT STATISTICS:- MONTHLY ... PROJECT ... FINAL FIELD XX

YEAR 73 FROM Feb. 26 TO May 11

Establishment Arctic Surveys H.I.C. A. R. Mortimer	Project Number	Project Number	Project Number	Project Number
Time:				
Total operational days.	74			
Days actual field work.	37½			
Days lost (weather)	10½			
Days lost (Sat. Sun. Holidays)	–			
Days lost (Equipment failure)	6			
Days lost in Transit	3			
Days lost in port for Supplies, Bunker, etc.	–			
Days lost, other causes	17			
Total Man days in period (staff)	247			
Total Man days worked (staff)	247			
Man days:- (staff)				
(a) Sounding	74			
(b) Shoal Examinations	–			
(c) Wharf surveys	–			
(d) Oceanography	10			
(e) Geophysics	–			
(f) Tides & water levels	13			
(g) Collecting bottom samples	–			
(h) Horizontal Control	10			
(i) Shorelining & Low Watering	3			
(j) Data processing & office admin.	63			
(k) Sailing directions	2			
(l) Place Names	–			
(m) Current observations	–			
(n) Photo-Ident.	–			
(o) Others (specify)	–			
(p) Support Operations	64			
(q) Travel	8			

FIELD REPORT STATISTICS:- MONTHLY ... PROJECT ... FINAL FIELD ... XX

YEAR 73 FROM Feb. 26 TO May 11

Establishment Arctic Surveys H.I.C. A. R. Mortimer	Project Number	Project Number	Project Number	Project Number	To
Sounding (Linear Nautical Miles/KM):					
Ship Sounding	N.A.				
Launch Sounding	N.A.				
Other (specify) Spot Soundings	3506				
Total sounding	3506				
Reconnaissance (Track) sounding	N.A.				
Area sounded ~~(NM²)~~ (Km²)	26575				
Shoals Examined:					
Shoal Examinations (Ship)	Nil				
Shoal Examinations (Launch)	Nil				
Shoal Examinations (Sweep)	Nil				
Shoal Examinations (other) specify	Nil				
Shoal Examinations (Total)	Nil				
Navigational Aids:					
Shore Aids Positioned (including ranges)	2				
Floating Aids Positioned	Nil				
Navigational Ranges Sounded	Nil				
Navigational Ranges Drifted	Nil				
Sector Ranges Positioned	Nil				
Navigational Aids Established	Nil				

FIELD REPORT STATISTICS:- MONTHLY ... PROJECT ... FINAL FIELD XX

YEAR 73 FROM Feb. 26 TO May 11

Establishment ~~Arctic Surveys~~ H.I.C. A. R. Mortimer	Project Number	Project Number	Project Number	Project Number
Shore Control:				
Signals built	5			
Signals re-built	Nil			
Towers built	Nil			
Number of Stations occupied	10			
Number of Stations re-occupied	Nil			
Number of stations permanently marked	1			
Distance Traversed ~~(Naut)~~ (K.M.)	130			
Number of Elevations Measured	3			
Number of Heights Measured	Nil			
Number of Stations Photo Ident.	3			
Other (specify)				
Calibrations:				
No. of Calibration Stations:				
~~xxxxxxxDeccaxHi-Fixxxxxxxxx~~				
~~xxxxxxxDeccaxNavigatorxx~~				
R.P.S.	18			
No. of E/c's marked and referenced	Nil			

FIELD REPORT STATISTICS:- MONTHLY ... PROJECT ... FINAL FIELD ... XX

YEAR 73 FROM Feb. 26 TO May 11

Establishment Arctic Surveys H.I.C. A. R. Mortimer	Project Number	Project Number	Project Number	Project Number
Tide and Current Data:	1			
Recording gauges established	2			
Recording gauges recovered	1			
Staff gauges established	Nil			
Bench Marks Recovered	Nil			
Bench Marks Established	3			
Bench Marks Levelled	3			
Distance Levelled ~~xxxxxxxx~~ (KM)	1			
No. of Current Meters Set Out	Nil			
No. of Current Meters recovered	Nil			
No. of hours of Current Measurements	Nil			
(Other than with Moored Meters)	Nil			
Oceanography:				
No. of Oceanographic stations	4			
Gravity Profiles-survey (N.M.) (KM)	Nil			
Gravity Profiles-track, (N.M.) (KM)	Nil			
Magnetic Profile-survey (N.M.) (KM)	Nil			
Magnetic Profile-track, (N.M.) (KM)	Nil			
Seismic Profile-survey (N.M.) (KM)	Nil			
Seismic Profile-track (N.M.) (KM)	Nil			
Number of Water Samples	4			

YEAR 73 FROM Feb. 26 TO May 11

Establishment Arctic Surveys H.I.C. A. R. Mortimer	Project Number	Project Number	Project Number	Project Number
Bottom Samples:				
Number of bottom samples (Grab)	Nil			
No. of bottom samples (underway)	Nil			
No. of bottom samples (Armed Lead)	Nil			
No. of Cores	Nil			
No. of Samples retained	Nil			
Miscellaneous:				
No. of Dangers to Navigation, rocks ruins, pilings, etc., fixed.	Nil			
Shoreline checked ~~xNxxxx~~ (KM)	500			
Wharves surveyed	Nil			
No. of Reference buoys streamed	Nil			
No. of Reference buoys recovered	Nil			
No. of Shore Stations ~~xxxxxxxxxxxxx~~ Occupied ~~xxxxxxxxxxxxxxxx~~ R.P.S.	24			
Helicopter flying hours	599.6			

FIELD REPORT STATISTICS: MONTHLY ... PROJECT ... FINAL FIELD . XX

YEAR 73 FROM Feb. 26 TO May 11

Establishment: Arctic Surveys H.I.C. A. R. Mortimer	Project Number	Project Number	Project Number	Project Number	To
Data submitted from the field: (Include file numbers:)					
F.S. 3736, 3737, 3738					
Levelling Notes	70461				
Miscellaneous Notes	70449				
Computation Notes	70450				
Sounding Notes	70448				

APPENDIX

REPORT FOR PILOT OF ARCTIC CANADA
NORWEGIAN BAY SURVEY 1973

REPORT FOR

PILOT OF ARCTIC CANADA

NORWEGIAN BAY SURVEY 1973

INTRODUCTION

From March to May, 1973, a hydrographic survey party occupied a campsite on the west shore of Surprise Fiord, Axel Heiberg Island. Using helicopters for transportation, spot soundings were taken north from Hell Gate and Cardigan Strait to Eureka and Massey Sounds.

Operating from helicopters has both advantages and disadvantages when making observations for amending sailing directions. Although the observer obtains a good overview of the area, it is a distorted view when compared to that from the bridge of a ship. Also, the survey was conducted in the spring, when complete snow cover can obliterate undistinct coastlines and soften prominent features. It should also be noted that a spot sounding grid, even at a 2 km. interval, cannot be relied upon to fully define shoal areas and find the least depth over these areas.

NOTES ON PILOT OF ARCTIC CANADA

Volume II - Chapter XI

PAGE	LINE	COMMENTS
412	21 25	No indications of shoals were found southeastward of Graham Island nor between that island and the shoal water off the Bjorne Peninsula.
412	22	Spot soundings indicate shoal water (less than 40 metres) exists about 10 miles southwest of Great Bear Cape. The 200 metre contour lies about 6 miles off the Bjorne Peninsula and follows the trend of the coastline. A shoal area, with depths that may be less than 100 metres lies about 10 miles east of eastern most point of Graham Island.

412	23	An 11 metre shoal reported to exist half way between Graham and North Kent Islands was searched for but not found in 1973. Spot soundings in this area indicate a least depth of 35 metres.
412	48	In the spring of 1973 no indications of grounded ice on shoal water were found northeast of Graham Island.
413	1	The radar reflector beacon at Cape Torrens was not found during the 1973 survey and probably no longer exists. The beacons found to be 9 miles and 18 miles northeastward of Cape Torrens are still erect, however the later beacon's position was mischarted and has been found by trilateration to be Lat. 77-29-56 N. Long. 89-49-54 W.
413	21	Shoal water, with depths as little as 8 metres exists up to 5 miles off the east coast of Cornwall Island.
413	24	Spot soundings gave no indication of the 3.7 metre and 12.8 shoal area. In this area the 200 metre contour lies about 6 miles off the coast of the Bjorne Peninsula.
413	26	Spot soundings gave no indication of the 18.3 metre and 21.9 metre shoals; depths in the vicinity were found to be in excess of 300 metres.
414	3	A shoal area with a least depth of 7 metres exists 3 miles north of the entrance to the bay otherwise there is deep water at the approaches to the bay and the bay could provide an anchorage, landing beaches and an airstrip if required.
414	7	Grounded ice was sighted in the middle of the channel to the south of Bird Island.
414	11	The entrance to Bird Fiord is narrow and a depth of 13 metres was found on the sill of the fiord. Grounded ice was sighted at the entrance. Within the fiord depths of up to 100 metres were found but no likely landing beaches or anchorages were sighted.

414	16	A least depth of 20 metres was found at the middle of the entrance to Blue Fiord, within the fiord depths of 80 metres exist shoaling at the eastern end of the fiord to less than 20 metres.
414	23	A shoal area, with grounded ice extends south from the Bjorne Peninsula restricting the entrance to Eids Fiord. Depths of 12 metres were found on the southern side of the entrance, within the fiord depths of up to 50 metres exist off the north side of the western part of the fiord. In the upper part of the fiord there is a basin with depths of up to 80 metres.
415	7	A shoal area exists 11 miles west-southwest of Goose Point with a least depth of 14 metres.
414	28	The complicated topography of Ammonite Mountain makes it difficult to interpret on radar and of doubtfull value for position fixing.
417	46	No indications of shoal water were found off the coast between Cape Southwest and Surprise Fiord.
417	48	Should read Surprise Fiord not Bay.
418	5	Depths in excess of 100 metres exist on the eastern side of the entrance to Surprise Fiord and adequate depths for navigation appear to exist throughout the southern part of the fiord. There is an airstrip suitable for D.C. 3s on the western shore of the fiord adjacent to a small lake. Sites suitable for landing beaches can also be found in this area. The tidal range in Surprise fiord has been found to be about 0.6 metres at springs.
418	9	There is a radar reflector beacon on Sherwood Head at an elevation of 220 metres.
418	20	The beacons no longer exist.
421	1	The beacons no longer exist.

Volume III - Chapter VIII

PAGE	LINE	COMMENTS
319	23	Change 12.8 metres to read 11 metres.
319	26	A shoal bank extends northward from Fielder Pt. where a least depth of 12 metres was found 12 miles off shore.
319	31	Strong tidal currents were noted over the shoal area north of Fielder Point.
319	34	Delete this sentence. 10/10ths ice cover existed in Month/May 1973. In mid September 1973 no ice was seen in Belcher Channel. (rpt. from CCGS LOUIS ST. LAURENT).
321	2	Helicopter reconnaisance indicates the existance of this connection is doubtfull.
321	25	These islands are now charted. Their positions have been confirmed by R.P.S.
322	18	Grounded ice was observed about 2 miles west-southwestward of the unamed island. This island has been positioned by R.P.S.
322	36	This uncharted island was searched for but not found in the spring of 1973.
323	7	Deep water exists in Massey Sound and soundings in excess of 600 metres are found on the eastern side of the sound.
323	22	An islet is reported by a G.S.C. survey party in position Lat. 78-20 N. Long. 94-40 W. Its dimensions are about 40 metres by 18 metres. The elevation not known.
324	18	An adequate depth of water of navigation exists in Good Friday Bay, however, it is generally shoaler on the southern side of the Bay.

APPENDIX

OCEANOGRAPHIC DATA

OCEANOGRAPHIC DATA

NORWEGIAN BAY, 1973

PURPOSE

Four oceanographic stations were occupied in Norwegian Bay in the spring of 1973. Temperature and salinity data was collected to establish velocities for sound in water in the area. Echo sounders were calibrated with bar checks and the velocities obtained from the calibrations were compared to those calculated from oceanographic data. This velocity data was used to confirm the accuracy of the "through the ice" sounding technique.

EQUIPMENT AND METHODS

Twelve inch diameter holes were drilled in the ice with a power auger. Ice thickness varied from 1 m. (metre) to 3 m. (metres). A water sample from 3 m. beneath the ice was taken for salinity measurements. Bathythermograph measurements were made to a depth of 100 m. An R.S.5. conductivity meter was used to measure temperature and salinity to a depth of 60 m. The R.S.5. instrument only measured temperatures above 0°C (centigrade) and as salinity measurements are dependent on a knowledge of both conductivity and temperature, this instrument is of little value when water temperatures are below 0°C.

A hollow sheet steel bar check with dimensions of 10 in. x 18 in. x 1 in., suspended from its centre point, was used to calibrate the EDO 9040 echo sounders to a depth of 100 m., both through the ice and directly through water. Speed control frequencies of 120, 114, 115.2 and 116.4 KHz were used.

DATA

An abstract of the data obtained at the four stations, tabulations of the data and the associated velocity calculations (Wilson, 1960, J. Accoust. Soc. AM., 32 (10)) are to be found at the end of this report. For the calculation of sound velocity from temperature and salinity measurements the temperature obtained by B/T has been used. A graph of sound velocity versus depth is also shown.

To derive a mean sound velocity from the bar check data, a straight line least squares fit was computed from depth (x) and associated depth error (Y) for each speed control frequency used.

DISCUSSION AND RESULTS

Sound velocities, using a surface salinity only, (Pickett, 1972, M.T.S. Journal, V.6, n.6), were found to be between 1439 and 1436 m/sec. at all four stations. These velocities, with an estimated error of ±2.7 m/sec. agreed (remarkably so) with the velocities obtained with R.S.5. conductivity meter. However, the velocities obtained from both methods of salinity and temperature measurement were considerably lower than the mean velocities derived from "through the water only" bar checks. The difference of velocities obtained from the two methods must be attributed to echo sounder inaccuracies which can be as much as 0.7%. (Eaton, 1969, Sound Velocity Survey in R. St. Lawrence, C.H.S. Technical Report.) Sound velocity measurements to the bar check through the ice, as would be expected, yielded velocities up to 19 m/sec. greater than velocities found by direct through the water measurement and up to 29 m/sec. greater than velocities obtained from temperature/salinity measurements. Part of these differences is, of course, due to the change of velocity at the water/ice interface. Sounding through 3 m. of ice to a depth of 100 m. has the effect of increasing the sound velocity by 25 m/sec. The remainder of the difference in velocities must be attributed to echo sounder errors which at these stations were found to be ±0.8%.

In an attempt to estimate the accuracy of soundings taken through the ice, four parameters have been taken into account after echo sounder calibration.

1)	Effect of difference between assumed velocity and actual velocity at calibration.	±0.5%
2)	Instrument errors.	±0.8%
3)	Variations in sound velocity in survey area.	±0.2%
4)	Effect of changes in ice thickness.	±0.4%
	Sum of Errors (95% confidences).	±1.2%

1) In these measurements, an assumed velocity of 1463 m/sec. has been used.
2) In addition to the variable instrument error, a mean residual error ±1.5 m. was noted in the straight line fits for the bar checks.
3) Variations in sound velocity apply only to the Norwegian Bay area. These variations will change greatly from area to area but is ameliorated by changing speed control frequency.
4) Ice thickness varied from 1 m. to 3 m.

CONCLUSIONS

Through the ice spot soundings in the Norwegian Bay area can be shown to have an accuracy of ±1.5 m. ±1.2% depth (95% confidence level). It should be noted that this is in excess of I.H.B. and C.H.S. Specifications.

Although these errors exceed specifications, they are small compared to the discrepancies that exist between ship soundings and through the ice spot soundings in the Beaufort Sea. Therefore, the above mentioned discrepancies must be attributed to position error.

ABSTRACT OF SOUND VELOCITY DATA TO 100 M. DEPTH

STATION NUMBER	LATITUDE	LONGITUDE	DATE	VEL. FROM BAR CHECK THROUGH ICE	VEL. FROM BAR CHECK WATER ONLY	VEL. FROM TEMP. & SALINITY SURFACE SAL. ONLY	VEL. FROM TEMP. & SALINITY R.S.5. SAL.	ICE THICKNESS
1	78-06N	88-15W	21/Mar.	1468.9	1450.1	1439.2	1439.2	3 m.
2	77-30N	89-28W	22/Mar.	1463.0	1457.9	1439.3	------	1.2 m.
3	77-40N	92-10W	20/Apr.	1465.3	1465.3	1436.9	1436.8	1 m.
4	78-05	90-12	2 /May	1459.0	1449.7	1437.4	1435.4	2 m.
				(1451.8	1463.5)			
				(doubtful)				
Percent variation in sound velocity				0.6%		0.2%%		

OCEANOGRAPHIC STATION # 1 (Surface salinity only)

	TEMP.C	SALINITY	DEPTH	VEL.AT D	VEL.TO D
=-	Ø.8Ø=	3Ø.88=	Ø.ØØ=	1436.33=	1436.33
=-	Ø.8Ø=	3Ø.88=	1Ø.ØØ=	1436.52=	1436.42
=-	Ø.7Ø=	3Ø.88=	2Ø.ØØ=	1437.17=	1436.67
=-	Ø.6Ø=	3Ø.88=	3Ø.ØØ=	1437.82=	1436.96
=-	Ø.5Ø=	3Ø.88=	4Ø.ØØ=	1438.47=	1437.26
=-	Ø.4Ø=	3Ø.88=	5Ø.ØØ=	1439.12=	1437.57
=-	Ø.3Ø=	3Ø.88=	6Ø.ØØ=	1439.77=	1437.88
=-	Ø.2Ø=	3Ø.88=	7Ø.ØØ=	144Ø.42=	1438.2Ø
=-	Ø.1Ø=	3Ø.88=	8Ø.ØØ=	1441.Ø6=	1438.52
=	Ø.1Ø=	3Ø.88=	9Ø.ØØ=	1442.17=	1438.88
=	Ø.2Ø=	3Ø.88=	1ØØ.ØØ=	1442.81=	1439.24

```
                1430-----------1460-----------1490-----------1520
                  '    '    '    '    '    '    '    '    '    '

=   Ø                *

=  1Ø                *

=  2Ø                *

=  3Ø                *

=  4Ø                 *

=  5Ø                 *

=  6Ø                 *

=  7Ø                  *

=  8Ø                  *

=  9Ø                   *

= 1ØØ                   *
```

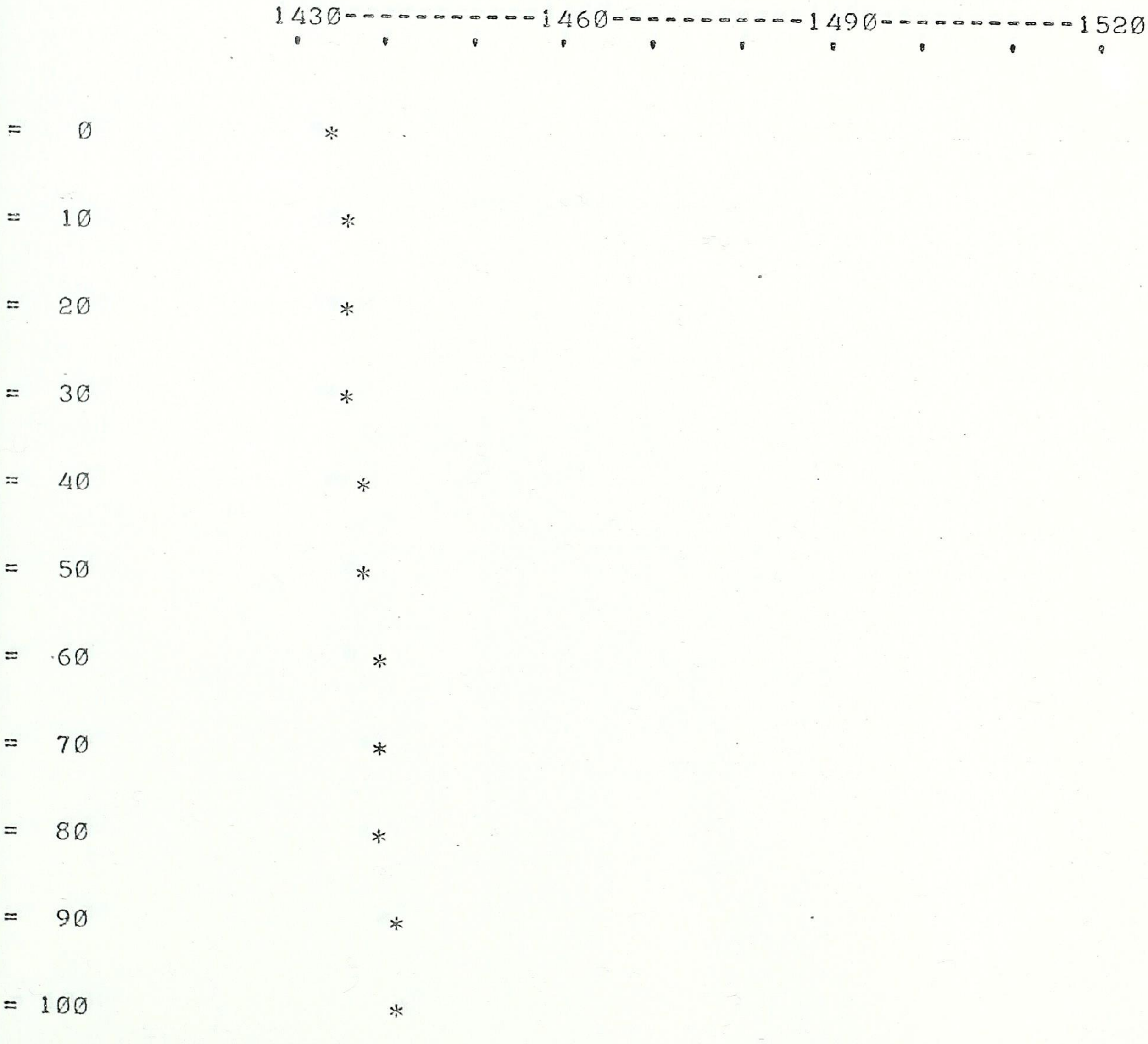
OCEANOGRAPHIC STATION # 1 (R.S.5 salinity measurements)

	TEMP.C	SALINITY	DEPTH	VEL.AT D	VEL.TO D
=-	0.80=	32.65=	0.00=	1438.65=	1438.65
=-	0.80=	32.73=	10.00=	1438.94=	1438.79
=-	0.70=	32.62=	20.00=	1439.45=	1439.01
=-	0.60=	31.50=	30.00=	1438.63=	1438.92
=-	0.50=	30.76=	40.00=	1438.32=	1438.80
=-	0.40=	30.02=	50.00=	1438.00=	1438.66
=-	0.30=	29.88=	60.00=	1438.46=	1438.64
=-	0.20=	29.88=	70.00=	1439.11=	1438.70
=-	0.10=	29.88=	80.00=	1439.76=	1438.81
=	0.10=	29.88=	90.00=	1440.87=	1439.02
=	0.20=	29.88=	100.00=	1441.51=	1439.24

```
                  1430-----------1460-----------1490-----------1520
                  '    '    '    '    '    '    '    '    '    '

=   0                 *

=  10                 *

=  20                 *

=  30                 *

=  40                *

=  50               *

=  60                *

=  70                *

=  80                *

=  90                 *

= 100                  *
```

OCEANOGRAPHIC STATION # 2 (Surface salinity only)

	TEMP.C	SALINITY	DEPTH	VEL.AT D	VEL.TO D
=-	1.30=	32.20=	0.00=	1435.69=	1435.69
=-	1.20=	32.20=	10.00=	1436.35=	1436.02
=-	1.10=	32.20=	20.00=	1437.01=	1436.35
=-	1.00=	32.20=	30.00=	1437.66=	1436.68
=-	0.80=	32.20=	40.00=	1438.79=	1437.10
=-	0.70=	32.20=	50.00=	1439.44=	1437.49
=-	0.60=	32.20=	60.00=	1440.09=	1437.86
=-	0.50=	32.20=	70.00=	1440.74=	1438.22
=-	0.40=	32.20=	80.00=	1441.39=	1438.57
=-	0.30=	32.20=	90.00=	1442.04=	1438.92
=-	0.20=	32.20=	100.00=	1442.69=	1439.26



OCEANOGRAPHIC STATION # 3 (Surface salinity only)

	TEMP.C	SALINITY	DEPTH	VEL.AT D	VEL.TO D
=-	1.50=	30.79=	0.00=	1432.89=	1432.89
=-	1.30=	30.79=	10.00=	1434.02=	1433.45
=-	1.20=	30.79=	20.00=	1434.68=	1433.86
=-	1.20=	30.79=	30.00=	1434.86=	1434.11
=-	1.10=	30.79=	40.00=	1435.52=	1434.39
=-	0.90=	30.79=	50.00=	1436.65=	1434.77
=-	0.70=	30.79=	60.00=	1437.77=	1435.20
=-	0.50=	30.79=	70.00=	1438.89=	1435.66
=-	0.40=	30.79=	80.00=	1439.54=	1436.09
=-	0.30=	30.79=	90.00=	1440.19=	1436.50
=-	0.10=	30.79=	100.00=	1441.30=	1436.93

```
                  1430-----------1460-----------1490-----------1520
                  '    '    '    '    '    '    '    '    '    '

=    0             *

=   10              *

=   20              *

=   30              *

=   40              *

=   50               *

=   60               *

=   70                *

=   80                *

=   90                 *

=  100                  *
```

OCEANOGRAPHIC STATION # 3 (R.S.5 salinity measurements)

	TEMP.C	SALINITY	DEPTH	VEL.AT D	VEL.TO D
=-	1.50=	30.17=	0.00=	1432.08=	1432.08
=-	1.30=	30.21=	10.00=	1433.27=	1432.68
=-	1.20=	30.06=	20.00=	1433.73=	1433.03
=-	1.20=	30.10=	30.00=	1433.97=	1433.26
=-	1.10=	30.35=	40.00=	1434.95=	1433.60
=-	0.90=	30.60=	50.00=	1436.41=	1434.07
=-	0.70=	31.22=	60.00=	1438.34=	1434.68
=-	0.50=	31.22=	70.00=	1439.46=	1435.27
=-	0.40=	31.22=	80.00=	1440.11=	1435.81
=-	0.30=	31.22=	90.00=	1440.76=	1436.30
=-	0.10=	31.22=	100.00=	1441.87=	1436.81

```
                 1430-----------1460-----------1490-----------1520
                  '    '    '    '    '    '    '    '    '    '

=   0             *

=  10             *

=  20             *

=  30             *

=  40              *

=  50               *

=  60                *

=  70                *

=  80                 *

=  90                 *

= 100                  *
```

OCEANOGRAPHIC STATION # 4 (Surface salinity only)

	TEMP.C	SALINITY	DEPTH	VEL.AT D	VEL.TO D
=-	1.20=	32.15=	0.00=	1436.10=	1436.10
=-	1.20=	32.15=	10.00=	1436.28=	1436.19
=-	1.20=	32.15=	20.00=	1436.46=	1436.28
=-	1.10=	32.15=	30.00=	1437.12=	1436.49
=-	1.10=	32.15=	40.00=	1437.30=	1436.65
=-	1.20=	32.15=	50.00=	1437.01=	1436.71
=-	1.60=	32.15=	60.00=	1435.28=	1436.51
=-	1.80=	32.15=	70.00=	1434.50=	1436.25
=-	0.90=	32.15=	80.00=	1438.97=	1436.56
=-	0.70=	32.15=	90.00=	1440.10=	1436.91
=-	0.30=	32.15=	100.00=	1442.15=	1437.39

```
                             1430-----------1460-----------1490-----------1520
                                '         '         '         '         '         '         '         '         '         '

=    0                               *

=   10                               *

=   20                               *

=   30                               *

=   40                               *

=   50                               *

=   60                             *

=   70                             *

=   80                                 *

=   90                                   *

=  100                                     *
```

OCEANOGRAPHIC STATION # 4 (R.S.5 salinity measurements)

	TEMP.C	SALINITY	DEPTH	VEL.AT D	VEL.TO D
=-	1.20=	30.53=	0.00=	1433.99=	1433.99
=-	1.20=	30.54=	10.00=	1434.18=	1434.08
=-	1.20=	30.66=	20.00=	1434.52=	1434.23
=-	1.10=	30.55=	30.00=	1435.03=	1434.43
=-	1.10=	30.54=	40.00=	1435.20=	1434.58
=-	1.20=	30.53=	50.00=	1434.89=	1434.63
=-	1.60=	30.64=	60.00=	1433.31=	1434.45
=-	1.80=	30.64=	70.00=	1432.53=	1434.21
=-	0.90=	30.64=	80.00=	1437.00=	1434.52
=-	0.70=	30.64=	90.00=	1438.13=	1434.88
=-	0.30=	30.64=	100.00=	1440.18=	1435.36

```
                    1430-----------1460-----------1490-----------1520
                      '    '    '    '    '    '    '    '    '    '

=   0                 *

=  10                   *

=  20                   *

=  30                   *

=  40                   *

=  50                   *

=  60                 *

=  70                 *

=  80                     *

=  90                       *

= 100                         *
```

```
 OCEANOGRAPHIC STATION # 1
THIS PROGRAM PERFORMS A STRAIGHT LINE LEAST SQUARES
FIT TO N PAIRS (X,Y) OF DATA AND GIVES THE DATA
M AND B FOR THE EQUATION Y=MX+B
THE STANDARD DEVIATION AND THE 95%CONF. LIMIT
N= :10
    X      Y
  :10     :.5
  :20     :1
  :30     :1
  :40     :1.8
  :50     :2
  :60     :3
  :70     :2.5
  :80     :2.5
  :90     :3.5
  :100     :4

M= = 0.036121212
B= = 0.193333332
STANDARD DEV(Y)= 0.325214251
95%CONF. INTERVAL(Y)= 0.637419932
FREQUENCY:120.0
ASSUMED VELOCITY= 1523.958333
CALCULATED VELOCITY= 1468.911111



N= :10
    X      Y
  :10     :1
  :20     :1.5
  :30     :2
  :40     :2.2
  :50     :3.2
  :60     :3.8
  :70     :4
  :80     :4.5
  :90     :4.5
  :100     :5.5

M= = 0.048484849
B= = 0.553333333
STANDARD DEV(Y)= 0.221625462
95%CONF. INTERVAL(Y)= 0.434385906
FREQUENCY:120.0
ASSUMED VELOCITY= 1523.958333
CALCULATED VELOCITY= 1450.069444
```

```
OCEANOGRAPHIC STATION #2
THIS PROGRAM PERFORMS A STRAIGHT LINE LEAST SQUARES
FIT TO N PAIRS (X,Y) OF DATA AND GIVES THE DATA
M AND B FOR THE EQUATION Y=MX+B
THE STANDARD DEVIATION AND THE 95%CONF. LIMIT
N= :10

    X       Y
   :10     :1
   :20     :2
   :30     :2.5
   :40     :2.5
   :50     :3
   :60     :3
   :70     :3
   :80     :4
   :90     :5
   :100     :5

M= = 0.040000000
B= = 0.900000000
STANDARD DEV(Y)= 0.365148372
95%CONF. INTERVAL(Y)= 0.715690809
FREQUENCY:120.0
ASSUMED VELOCITY= 1523.958333
CALCULATED VELOCITY= 1463.000000



N= :10

    X       Y
   :10     :1.5
   :20     :2.5
   :30     :3
   :40     :3.5
   :50     :3.5
   :60     :3.5
   :70     :3.5
   :80     :5
   :90     :5.5
   :100     :6

M= = 0.043333333
B= = 1.366666667
STANDARD DEV(Y)= 0.426006436
95%CONF. INTERVAL(Y)= 0.834972615
FREQUENCY:120.0
ASSUMED VELOCITY= 1523.958333
CALCULATED VELOCITY= 1457.920139
```

OCEANOGRAPHIC STATION #3

```
THIS PROGRAM PERFORMS A STRAIGHT LINE LEAST SQUARES
FIT TO N PAIRS (X,Y) OF DATA AND GIVES THE DATA
M AND B FOR THE EQUATION Y=MX+B
THE STANDARD DEVIATION AND THE 95%CONF. LIMIT
N= :10
   X      Y
  :10    :-1
  :20    :-1
  :30    :-1
  :40    :-2
  :50    :-2
  :60    :-1
  :70    :-2
  :80    :-2
  :90    :-2
  :100    :-2

M= =-0.012121212
B= =-0.933333333
STANDARD DEV(Y)= 0.363299507
95%CONF. INTERVAL(Y)= 0.712067034
FREQUENCY:114.0
ASSUMED VELOCITY= 1447.760417
CALCULATED VELOCITY= 1465.309028


N= :10
   X      Y
  :10    :.5
  :20    :.5
  :30    :0
  :40    :0
  :50    :0
  :60    :0
  :70    :-.5
  :80    :-.5
  :90    :-.5
  :100    :-.5

M= =-0.012121212
B= = 0.566666667
STANDARD DEV(Y)= 0.144483290
95%CONF. INTERVAL(Y)= 0.283187248
FREQUENCY:114.0
ASSUMED VELOCITY= 1447.760417
CALCULATED VELOCITY= 1465.309028
```

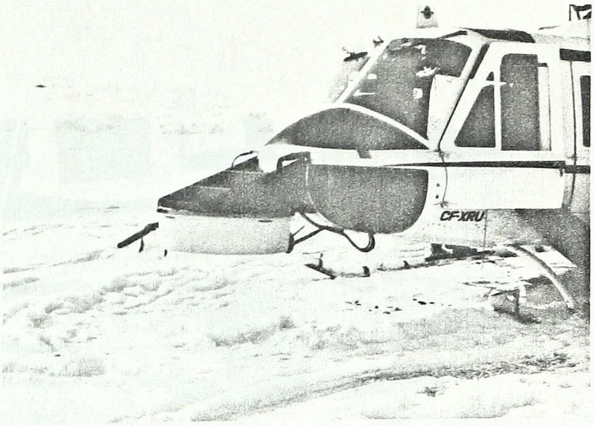
OCEANOGRAPHIC STATION # 4

```
THIS PROGRAM PERFORMS A STRAIGHT LINE LEAST SQUARES
FIT TO N PAIRS (X,Y) OF DATA AND GIVES THE DATA
M AND B FOR THE EQUATION Y=MX+B
THE STANDARD DEVIATION AND THE 95%CONF. LIMIT
N= :10
  X      Y
 :10    :0
 :20    :0
 :30    :0
 :40    :0
 :50    :0
 :60    :0
 :70    :0
 :80    :0
 :90    :0
 :100    :.5

M= = 0.002727273
B= =-0.100000000
STANDARD DEV(Y)= 0.134839973
95%CONF. INTERVAL(Y)= 0.264286346
FREQUENCY:115.2
ASSUMED VELOCITY= 1463.000000
CALCULATED VELOCITY= 1459.010000


N= :10

  X      Y
 :10    :.5
 :20    :.5
 :30    :.5
 :40    :1
 :50    :1
 :60    :1
 :70    :1
 :80    :1
 :90    :1
 :100    :1.5

M= = 0.009090909
B= = 0.400000000
STANDARD DEV(Y)= 0.155699789
95%CONF. INTERVAL(Y)= 0.305171587
FREQUENCY:115.2

ASSUMED VELOCITY= 1463.000000
CALCULATED VELOCITY= 1449.700000
```

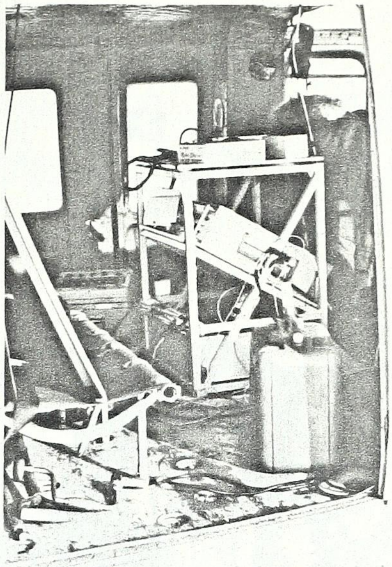
```
OCEANOGRAPHIC STATION #4

THIS PROGRAM PERFORMS A STRAIGHT LINE LEAST SQUARES
FIT TO N PAIRS (X,Y) OF DATA AND GIVES THE DATA
M AND B FOR THE EQUATION Y=MX+B
THE STANDARD DEVIATION AND THE 95%CONF. LIMIT
N= :10
    X       Y
  :10     :-.5
  :20     :0
  :30     :-.5
  :40     :0
  :50     :0
  :60     :0
  :70     :.5
  :80     :1
  :90     :1
  :100     :1

M= = 0.017878788
B= =-0.733333333
STANDARD DEV(Y)= 0.232827735
95%CONF. INTERVAL(Y)= 0.456342360
FREQUENCY:116.4
ASSUMED VELOCITY= 1478.239583
CALCULATED VELOCITY= 1451.810451



N= :10
    X       Y
  :10     :1.5
  :20     :1.5
  :30     :1.5
  :40     :1.5
  :50     :2
  :60     :1.5
  :70     :1.5
  :80     :1.5
  :90     :2
  :100     :3

M= = 0.010000000
B= = 1.200000000
STANDARD DEV(Y)= 0.380058476
95%CONF. INTERVAL(Y)= 0.744914613
FREQUENCY:116.4
ASSUMED VELOCITY= 1478.239583
CALCULATED VELOCITY= 1463.457187
```

APPENDIX

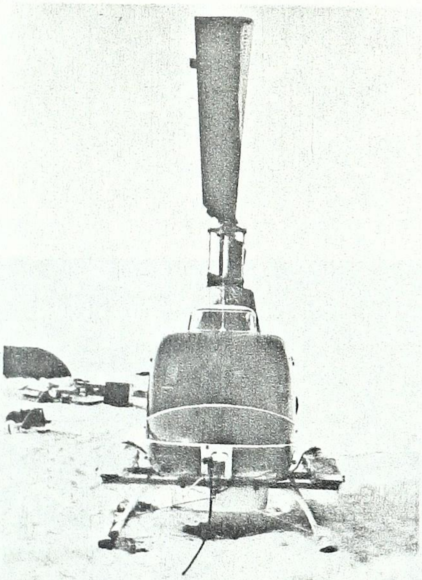
PHOTOGRAPHS AND SKETCH MAPS



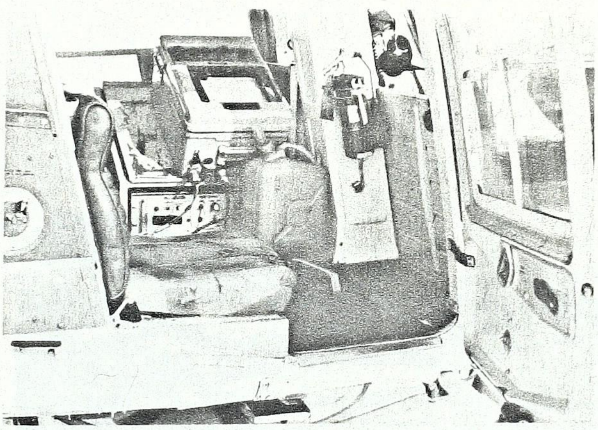
(A)



(B)



(C)



(D)

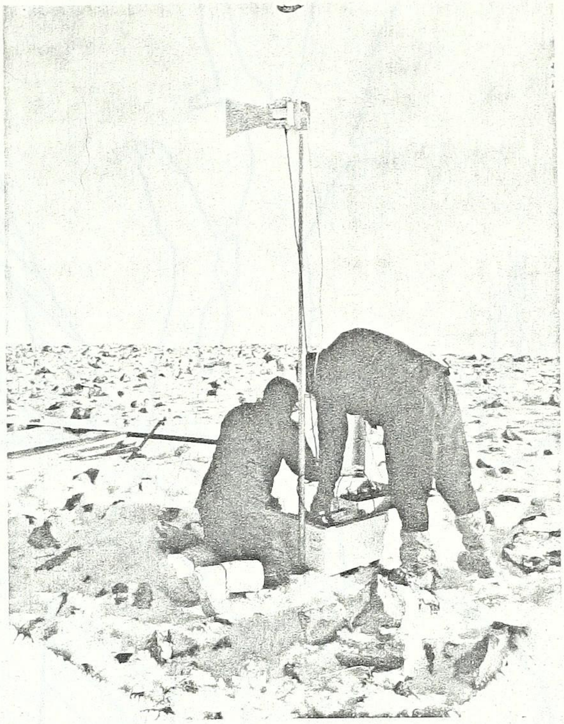
(A) R.P.S. scanner fitted on the 205 helicopter

(B) Instrumentation in the 205

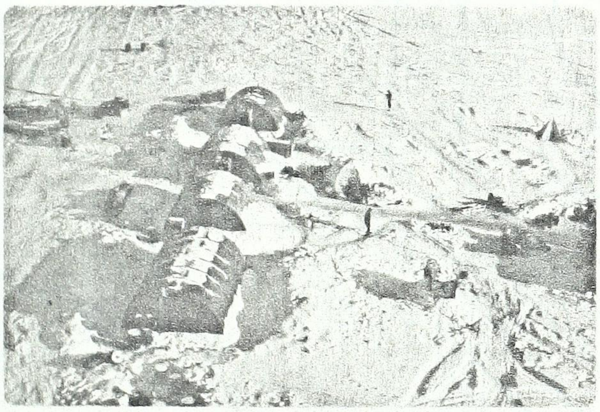
(C) R.P.S. scanner fitted beneath the 206 helicopter

(D) Instrumentation in the 206

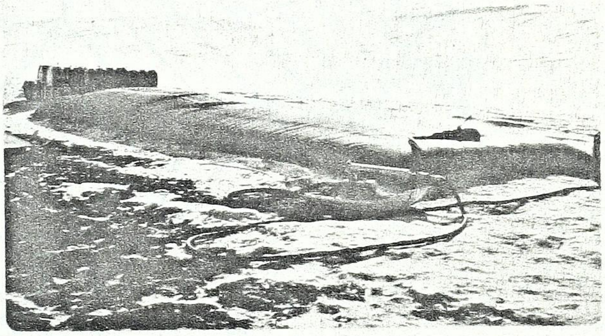
(A)



(B)



(C)



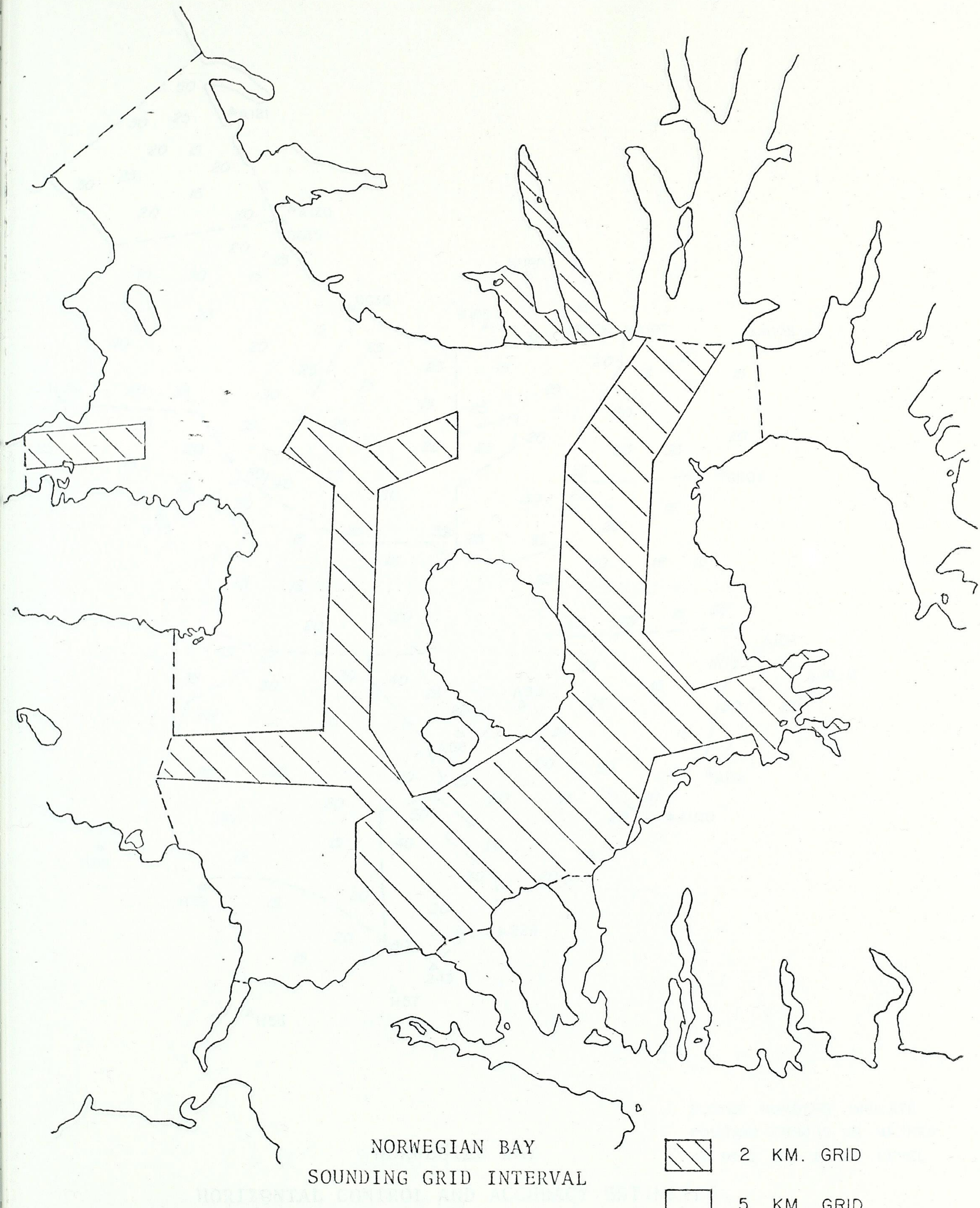
(D)

(A) Sounding in deep snow

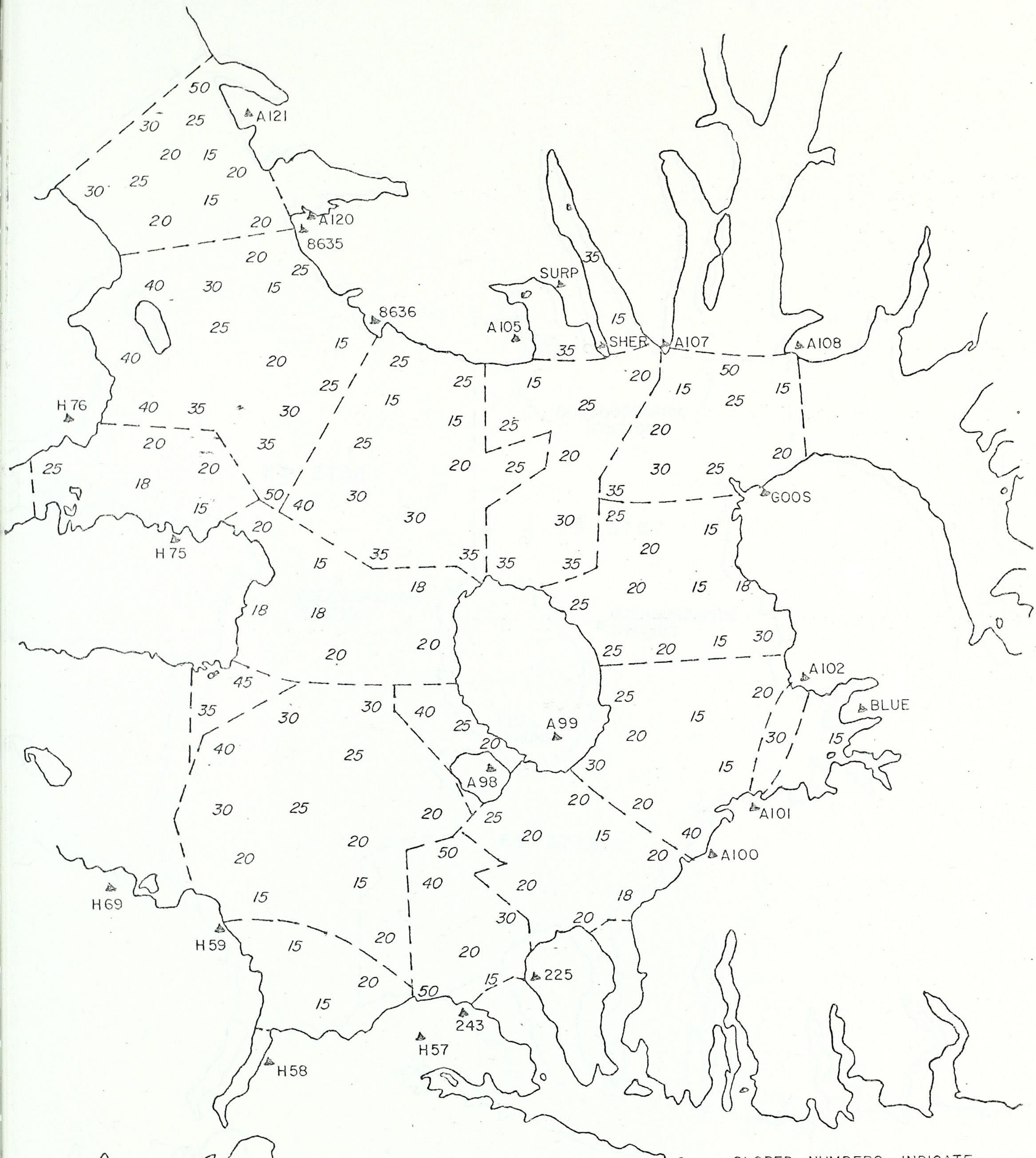
(B) Setting up an R.P.S. transponder

(C) The camp at Surprise Fiord

(D) 10,000gallon bladder for helicopter fuel

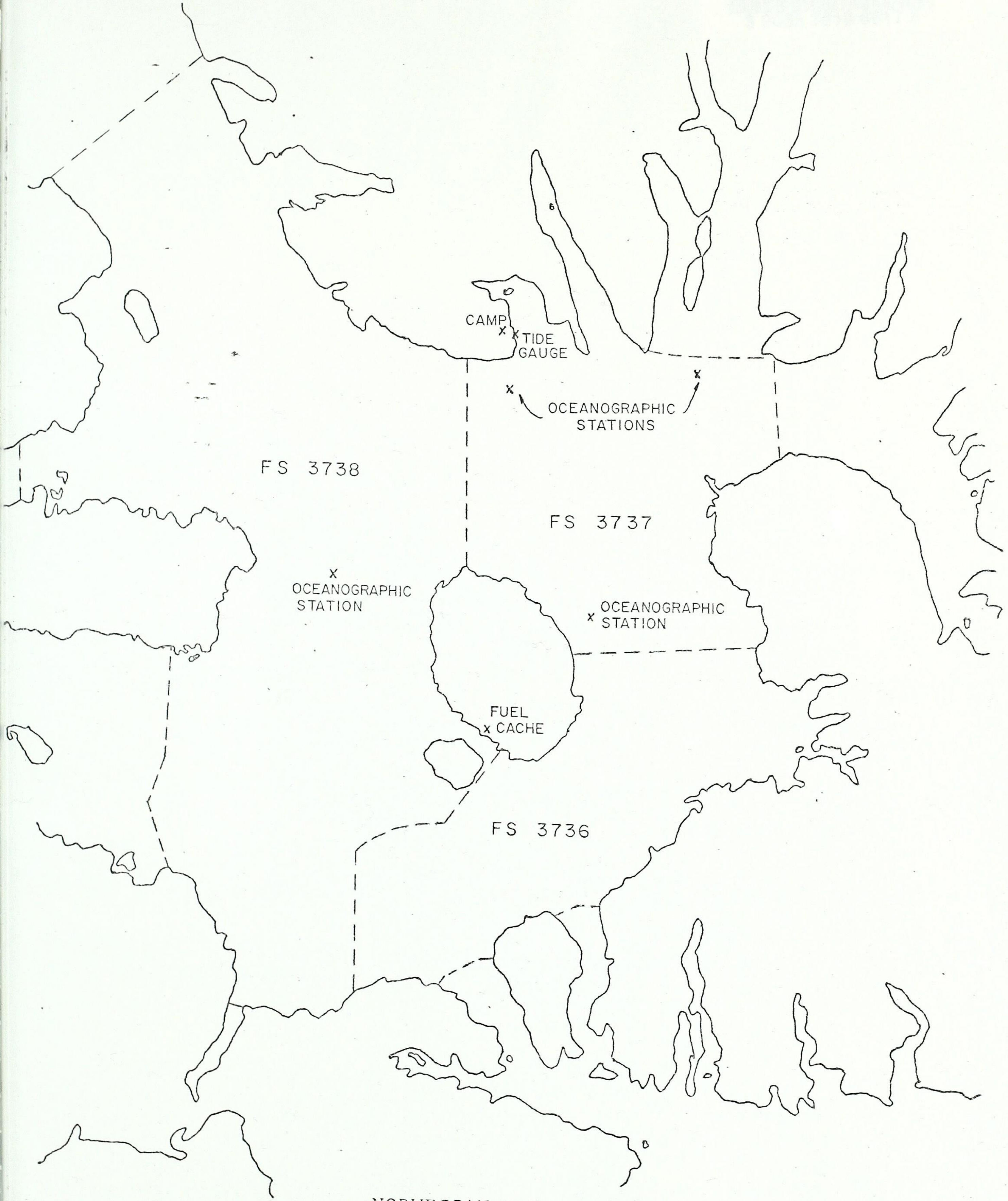


NORWEGIAN BAY
SOUNDING GRID INTERVAL



NORWEGIAN BAY

HORIZONTAL CONTROL AND ACCURACY ESTIMATES



NORWEGIAN BAY

FIELD SHEET LAYOUT AND OCEANOGRAPHIC STATIONS

Environment Canada Library, Burlington
3 9055 1018 6617 5