PORT AND OCEAN ENGINEERING UNDER ARCTIC CONDITIONS
TECHNICAL UNIVERSITY OF NORWAY

CANADIAN ARCTIC SEA/AIR BASE AT RADSTOCK BAY, DEVON ISLAND, N.W.T.

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ONTARIO,
CANADA

CANADIAN ARCTIC SEA/AIR BASE AT

RADSTOCK BAY, DEVON ISLAND, N.W.T.

(Author's Remarks

Due to the Conference restrictions, some items had to be omitted in the printing of the Proceedings; however, photostat copies of these omissions are available from the author upon request.

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1000 CONCEPT DEVELOPMENT, SURVEYS, ENGINEERING AND ECONOMICS OF THE PLANNED ARCTIC SEA/AIR BASE AT RADSTOCK BAY ON DEVON ISLAND, NORTHWEST TERRITORIES, CANADA

1100 Concept

The concept of an arctic sea/air base developed in the summer of 1968 while I was reviewing existing means of transportation in light of the reported accelerated exploration activities for oil and gas in the Canadian Arctic Islands. The topic of arctic marine traffic was familiar to me as I had researched (1954 to 1958) sub-surface aspects of arctic marine traffic.

For the Arctic Sea/Air Base initially tactical support considerations had prevailed, but in sum total - due to the vacillating nature of exploration activities - the indication evolved that it would be more appropriate to project fundamental and long-range strategic transport requirements of industrial/commercial activities in such remote and undeveloped areas regarded as a sub-continent of arctic islands with all this would imply.

1110 Objectives. -Hypothesizing that (strategically) the proper location for a base and terminal is at or near the center of the activity area (in this group of arctic islands), the following broad objectives were established:

1.) Maximum accessibility for existing surface vessels with various degrees of ice-operating capabilities.

2.) Sufficient depth of approaches from the oceans to permit navigation of the largest surface vessels planned.

3.) Sufficient depth to permit under-ice approaches as well as loading and unloading operations of cargo and tanker submarines of substantial dimensions. see A-1-2

4.) For dock installation, most suitable shore-line and foundation conditions and minimum ice movements, permitting seasonal and year-round arctic stationing of ice-breakers and submarine support vessels.

5.) Suitable as pipe line terminal with corresponding connecting hinterland.

6.) Land area available for base installations to be most suitable from a foundation aspect for construction

1110 of runways for aircraft as well as for construction and erection of supporting and processing facilities.

7.) A base area topographically suitable for air-cushion transport vehicles.

8.) Last but not least, the location to be conducive to step-by-step gradual economical development of facilities, providing an interim service income potential and thus reducing the overall investment risk.

The fact of the existing government station at Resolute Bay, practically in the center of the Arctic Island group, did not affect the studies, as there appeared at best only point 6.) satisfied, and just partially at that.

1200 Preliminary Study

Between Nov. 68, and March 69, efforts were concentrated on collecting available published and unpublished reference material on the Parry Channel as well as Jones
see Sound. As a result of the analysis, Radstock Bay on S.W.
A-1-1 Devon Island appeared to be a location warranting a de-
A-5 tailed study.

It was found that this area had already been subject to several studies of which the most comprehensive one, in respect to the objectives outlined above, was presented in the Geographical Paper No. 37 of the Department of Mines and Technical Surveys, Ottawa, 1964, prepared by R. T. Gajda and entitled Radstock Bay, N.W.T., Compared with Resolute Bay, N.W.T., as a Potential Airbase and Harbour.

Numerous discussions were held and opinions solicited from surveyors, meteorologists, climatologists, mariners, aircraft operators and others who on one or more occasions had visited and viewed Radstock Bay.

By July 69, it was realized that the many outstanding questions on pertinent details and accurate descriptions could only be answered by a site investigation. However, the funding of such an investigation was beyond my private means and reasonable ways had to be found for financing an expedition to Radstock Bay.

1300 Expedition For Site Investigation

With the industrial/commercial potential of this site evidenced by the studies so far progressed, I applied to the Canadian Government for a lease-purchase of the most suitable terrain in the Radstock Bay area, which - by the way - is not the terrain envisaged in the Report No. 37 mentioned above. Having received a favourable indication I then solicited for backers for the funding of the site-investigation, eventually succeeded, and as a result, Arctic Lifelines Ltd. was incorporated.

By the end of Sept. 69, all detailed arrangements for the site investigation expedition were completed and the appropriate team selected as follows:

C. K. Bell	Ships Broker	New York, U.S.A. (Birmingham Bell, Inc.)
J. Bones	Geomorphologist	Hamilton, Ontario. (McMaster University)
P. Koester	Prof. Diver	Montreal, Quebec. (Atlas Diving Co. Ltd.)
N. Miller	Naval Architect	New York, U.S.A. (States Marine Lines, Inc.)
T. Sluymer	Civil Engineer	Niagara Falls, Ont. (H.G. Acres Consultants,Ltd.)
H.A.R. Steltner Leading the team	Marine Engineer	St. Catharines,Ont. (Steltner Dev. & Mfg. Co. Ltd.)

A comprehensive investigation was expected due to the maturity of the participants representing a variety of professions.

The team left Montreal for the first time on Oct. 3, 69, for Resolute Bay, Cornwallis Island, but, due to the weather conditions there, another stay in Montreal followed and one in Frobisher Bay. We did not arrive in Resolute Bay until Oct. 7, reaching Radstock Bay the following day - Oct. 8. (Total weight of equipment, instruments and supplies taken was 840 Kg.)

1310 Highlights of Efforts. -(Site investigation Oct. 8 to 15; see A-3-4 ff)

1320 Summary of Investigations. -The results of our investigations and observations are summarized as follows:

1321 Land Aspects. -(8 items, for details see A-7; A-10-3; A-6-2)

1322 Marine Aspects. -(8 items, for details see A-6-1)

1323 Meteorological Observations. -(2 items, especially concerning cloud level in relation to flying limitations; A-2)

1324 Human and Environmental Aspects. -(5 items, for details see A-11 and -12)

1400 Conclusions Based on Investigations

The conclusions drawn from all investigations so far were:

1.) At the selected Radstock Bay location all strategic objectives as set out initially for an arctic sea/air base appear to be met and satisfied, particularly in reference to the deep approaches, excellent anchoring conditions, suitable shore-line and foundation conditions, and topographical and land-surface characteristics.

2.) The very low elevation above see level of the area projected for the aircraft runway is of particular significance for extending an economical aircraft operation, as well as for providing an alternate landing facility for commercial scheduled air lines during the frequent periods of adverse and marginal flying conditions at Resolute.

3.) Designing of any docking facilities must be preceeded by an ice-movements' study of the Bay and adjacent Barrow Strait.

4.) Full and detailed planning, engineering and market study efforts were warranted now, in order to provide a basis for judging and deciding the timing and conditions for commencement of a gradual economic development.

1500 Planning and Engineering Efforts After the Expedition

The efforts immediately following the expedition were:

1.) Arctic Lifelines Ltd. proceeded with my application for a Land-Lease/Purchase which was then granted in December 1969 with the prime-condition that a total of $100,000 must be invested in Radstock Bay within the three years following, subject to full payment of the annual lease fees.

2.) A market study to determine origin, tonnage, cube, type and distribution of exploration material requirements in the Arctic Islands.

3.) Assessment of transfer methods for dry and liquid cargo from ship to shore.

4.) Assessment of unitizing, handling, stowage, transfer, storage and FAS aircraft handling methods.

5.) A complete review of all references and data col-
see lected and produced, and extraction of references and data
A-7 directly relevant to planning and engineering for an arc-
A-3 tic sea/air base, including production of a 5000:1 topo-
(1 to 8) graphical detail map of the area; geological analysis of
gravel specimen collected; production of two relief models,
A-4 one for the area Radstock Bay to Erebus Bay and the other
(1 to 3) one for the projected base area.

6.) Based on detailed objectives and requirements
worked up from the above studies, assessments and reviews,
it was decided to proceed with the first-phase designs of
the arctic Sea/Air Base on the basis of handling and stor-
see ing about 15,000 tons of fuel, 10 - 25,000 tons of dry
A-6-1 cargo, 850 m^3 heated storage; aircraft landing control,
servicing and fueling facilities; residence facilities
for staff and transients for 100 persons; power generating
capacity of 650 KW; and a system of total environmental
protection for all effluents and residues.

7.) The evolving plan and details included all construction details, schedules, description of alternate compensating measures for critical sub-phases during initial construction, and it was projected that the base could be set up and activated (and receive cargo) in a period of 10 weeks by applying modular and sectional construction concepts throughout.

1600 Economic Assessment of Arctic Sea/Air Base Radstock Bay

(Economical Analysis - prepared on the basis of completed engineering plans - and Cash Flow Projection is discussed; also time and cost involved with the subject Total Concept Development effort)

2000 RADSTOCK BAY ICE STUDY 1970

2100 General Explanations

Point 3.) of the conclusions from all investigations (paragraph 1400 above) indicated a need for collecting ice movement information for the break-up and freeze-up periods. This was required to establish a basic understanding of the natural occurrences as a basis from which, in conjunction with Lancaster Sound ice information, acceptably reliable operational forecasts for surface vessel operations in Radstock Bay could be made. In addition, the characteristics of ice movements in the Bay needed to be known in order to provide design information for any of the projected waterside or dock installations.

The action and interaction of tide, currents, winds, water- and air-temperature, all influenced by local topography, sea and bay bottom characteristics and depth of water, were recognized as contributing factors for the ice moving out of Radstock Bay; and the objective of the study was to observe how the ice break-up was affected by the foregoing.

Under an information-for-assistance exchange agreement with the Geography Department of the McMaster University I generally supported their 1970 geomorphological expedition to Radstock Bay, also provided equipment and specifications to obtain a movie-sequence record of the Radstock Bay and adjacent Barrow Strait during the ice break-up period, as well as other relevant information.

From July 14 to Aug. 15, 1970, the McMaster team shot 77 sequences of the ice break-up and ice movements. Enclosed (in the Appendix) are my notes of the main observations made during the analysis of these movie-sequences.

see A-8

2200 <u>Analysis of Movie-Sequences</u>

For analyzing these movies the following method was used: The movie pictures were viewed in an editor in still-picture fashion and observations from each sequence plotted on separate charts in accordance with the colour-intensity appearing on the pictures.

The colour intensity descriptions of <u>white</u>, <u>light</u>, <u>medium</u> and <u>dark</u> represent light reflections from the ice and ice-water surface.

These differences in light reflections are associated with a degree of presence of water that may have originated by either ice melting or fractures through the ice cover and the degree of ice floe separation.

Also, the light reflections of a "solid" floe-ice surface are subject to changes primarily caused by wind and current whereby ice floes rafting under lateral pressure distributions would thus be noticeable from the pictures.

2300 <u>Summary of Observations</u>

In the following the observations are summarized:

1.) While the Bay was still covered with ice floes, the colour intensity patterns were distinctly different north and south of a line commencing at the west side of the Bay, about 4600 m north of Cape Liddon, to Patrol Point on the opposite shore.

North of this line, distinct bands, 500 to 900 m wide, of various colour intensities alternate, running in an east to west direction. South of the line, identical bands curve south into Barrow Strait, about parallel to the west shore of the Bay and commencing at almost a right angle from the bands north of the line.

2.) The first substantial "lead" developed on July 17 and 18, on the east side of the Bay, advancing along the shore to Patrol Point, where it was approximately 1000 m wide, then arching south, with an approximate width of 5000 m at the mouth of the Bay. The lead had the general appearance of a spear-head, and developed in accordance with the directions of light reflection bands described above.

see A-8-2

2300 3.) The second substantial lead developed on Aug. 6; and the third on Aug. 8. Both these leads developed

see right across the Bay parallel to each other and in line

A-8-3 with the directions of reflection bands already described.

4.) The Bay, south of a line from Palmer Shoal (N of C.T.) to Patrol Point, was practically free of ice by Aug. 9; and by Aug. 15 the entire Bay was free of ice.

2400 <u>Lancaster Sound - Barrow Strait Ice Information 1970</u>

During the observation period the Lancaster Sound and Barrow Strait break-up situation was reported as follows: (Information from a letter, Ice Forecasting Control, Halifax.)

". . . The North Water of Smith Sound was relatively slow to expand in June and by July 9 had reached only as far as longitude 83 W in Lancaster Sound. There were some fractures in the ice northeast of Prince Leopold Island at this time but the remainder of the area was solidly covered.

"In the following week the section from 83 to 90 W did break (by 18 July) and the final section from 90 W to Cornwallis Island began to move by 24 July. At this stage the fast ice of Radstock Bay was reported still in position.

"The next aerial report of western Lancaster Sound on 8 August indicated open water in the Bay but one tenth ice was reported at the entrance on 12 August and 4 tenths on 15th. This last was probably the result of break-up in Barrow Strait and subsequent eastward ice drift. Open water is reported to have redeveloped on 17 and on 18 August.

"At Resolute Bay, mean air temperature rose above freezing about June 24, 10 days later than normal, but the accumulations of melting degree days in mid July and in mid August were close to the long term average. During the period of your study mean surface wind flow was from the northeast which is one of the reasons for the late break-up of Lancaster Sound . . . "

91^{o} W is approximately the center-line of Radstock Bay.

2500 Deductions From Movie Interpretation

The movie sequence interpretation led to the following deductions:

1.) Fragmentation of ice cover inside the Bay is caused by the interaction of tides, by increasing insolation and by rising air temperatures.

2.) Fragmentation of ice cover in the outer Bay is caused by the same influences plus a current-caused shear-action at this part of the Bay, induced by the westerly current reported north in Lancaster Sound and apparently in Barrow Strait, plus the winds adding relative pressure and expansion components in a southerly and northerly direction.

see A-8 (2 to 5)

3.) Locations where ice-floe pressure on the shore was observed are located well south of the area projected for dock installations.

2600 Discussion of Causes and Effects

Weighing all these causes and what could be termed local or micro effects, it appears that the westerly current north in Lancaster Sound and Barrow Strait is of predominant influence to the break-up and outward movement of ice from the outer Bay, with the winds contributing as either attenuating, neutral or retarding factors. I am not certain to what degree the tide contributes to the fragmentation of the ice cover in the outer Bay.

see A-9 (1 to 8)

Due to the surrounding topography, the effects of wind on the movements of ice within the Bay are difficult to assess without synoptic measurements of directions and velocities. The only indication that wind does have an effect are the slight angular changes in the observed directions of the various bands of light reflections pivotting on a point about 3500 m off-shore, south of Caswall Tower. The observation that the bands running towards the south essentially maintained their direction, appears to contribute to the assumption that the westerly current north in Lancaster Sound and Barrow Strait branches off towards northwest into the outer part of Radstock Bay, turns to the south at the line Caswall Tower - Patrol

see A-8 (2 to 5)

2600 Point, and runs parallel to the shore, converging with the main flow of this particular current which is proceeding in a westerly direction.

This movement of the current in the outer Bay would explain the directional stability of the observed bands of light reflection and would confirm my deduction that this current has a predominant influence on the ice-break-up and ice-movements in Radstock Bay.

As a southerly current along the west shore of the Bay has been previously observed, the early lead extension at the southern part of the west shore appears to be a direct result.

2700 Summary - Ice Study

Generally, the ice cover in the whole of Radstock
see Bay was sufficiently fragmented to expand directly in
A-8 relation with the rate of expansion and ice-floe trans-
7 & 8 port in Lancaster Sound and Barrow Strait; it is significant and perhaps characteristic for Radstock Bay ice that the floes from the entire Bay moved rapidly into the Barrow Strait at practically the first opportunity.

The same has been observed, and was reported to me verbally, for the two previous break-up seasons as well (1968 and 1969).

The break-up and movement of ice in the Bay does
see not appear to affect the shore lines in the project area
A-8 in a negative sense. Any dock construction should be
4 & 5 projected parallel to the shore in the area previously and tentatively selected.

From the ice reports on Lancaster Sound and Barrow Strait and the observations made at Radstock Bay it can
see now be deducted that an ice-strengthened vessel could
A-8 have proceeded to Radstock Bay during the last week of
(6 to 8) July 1970 as was in fact scheduled for a 1970 base activation.

3000 SUMMARY

3100 Radstock Bay as an Arctic Sea/Air Base

Marine transportation to and from the Canadian Arctic Islands via Baffin Bay is in the middle of an experi-

3100 mental phase and most of the present practical efforts supporting exploration activities are tactically oriented. The Manhattan voyages and the Submarine Studies, however, I classify as efforts towards a strategic solution.

The future role of the Radstock Bay location in a strategic solution for arctic transportation can be based on the following:

see A-8 (6 to 8) 1.) The Arctic Islands' area in terms of surface vessel transport shows a natural division as to water surface conditions:

There is a natural maximum accessibility until Radstock Bay is reached. West and north of Radstock Bay then, accessibility is sharply reduced and practically confined to single, individual voyage attempts even under average ice conditions; and in years of adverse ice conditions surface marine transport appears not economical there.

2.) Resource activity in the Canadian Arctic Archipelago north of the Parry Channel has not yet reached the production stage, although there appears little doubt that it will be reached in the near future.

3.) The physiographical situation of the islands north of the Parry Channel appears to be conducive to pipe-line transportation of gas and crude oil, and a gathering system terminating at Radstock Bay would benefit from Devon Island's extent, N and NW, almost to the center of the Archipelago. The present State of the Art of pipelining appears to be sufficiently advanced to project such a gathering system.

4.) Irrespective of what method of arctic transportation will be settled upon in the future - most likely a combination of several modes of transportation - a prime base in this strategically located part of the Arctic will become mandatory in any strategic consideration.

3200 <u>Radstock Bay Area as a Focal Point of Interest and Importance for Applied Science</u>

As a result of my studies, I feel compelled to draw general and specific attention to the greater Radstock Bay area for the following reasons:

3200 1.) In the eastern portion of Barrow Strait, three currents converge: the North Water current from Baffin Bay, Polar Water through Wellington Channel, and Polar-Arctic Water through the western part of Barrow Strait.

see A-9 (1 to 8)

In my mind, the two foremost questions are:
First, does the Baffin North water current extend beyond a line due south Resolute?
Second, what is the nature of occurrence, frequency, and magnitude of ice-dams in Barrow Strait, and what reciprocal effects are there oceanographically, meteorologically, and climatically?

2.) The Radstock Bay area appears to me as a showcase and exhibit of environmental history; not only for physiography but oceanography, recent human history, marine biology, as well as archeology; in other words, for all relevant subjects and disciplines of Applied Science.

see A-10 (1 to 3) A-11 1 & 2 A-12

I would like to classify this area as a prime indicator area for natural occurrences and phenomena where all studies can be directly applicable to engineering efforts concerned with the commercial development of the arctic area.

3300 <u>Conclusion</u>

In support of my presentations I have enclosed a comprehensive appendix and I trust it to contain material stimulating further critical review and assessment, and perhaps further action as well.

The complexities of the present and future technological advances demand total concept investigations and the resulting engineering and assessment efforts must take into consideration the broad spectrum of Applied Science.

In my presentations I trust to have fairly projected a total concept approach to a current practical task.

4000 ACKNOWLEDGEMENTS

The brevity required of this presentation does not permit individual reference to the numerous sources of information. However, for specific thought-provoking and inspiring discussions I am indebted to:

Captain Charles, who surveyed in 1960-61 the area presented in this paper.
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Otaco Ltd., Orillia, for their co-operation and provision of an amphibious all-terrain vehicle and trailer, free of charge, awaiting transport to Radstock Bay for continued studies.

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Fearnley and Eger Inc., N.Y.
Delta Marketing and Shipping Inc., N.Y.

This presentation affords me an opportunity to express my gratitude and to say a heartfelt "thank you" to all individuals, corporations and government agencies for their support of my efforts spanning many years of study.

APPENDIX

A-1-1	General Orientation Map
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1 to 7	Notes of Main Observations 1970 Ice Break-Up Radstock Bay (For movie-recordings, July 14 to Aug. 15, 70, camera position and operation as well as method of analysis is described; on 15 significant movie-sequences visually perceptible details of the progressive ice deterioration and corresponding meteorological conditions are logged.) (Not included here.)

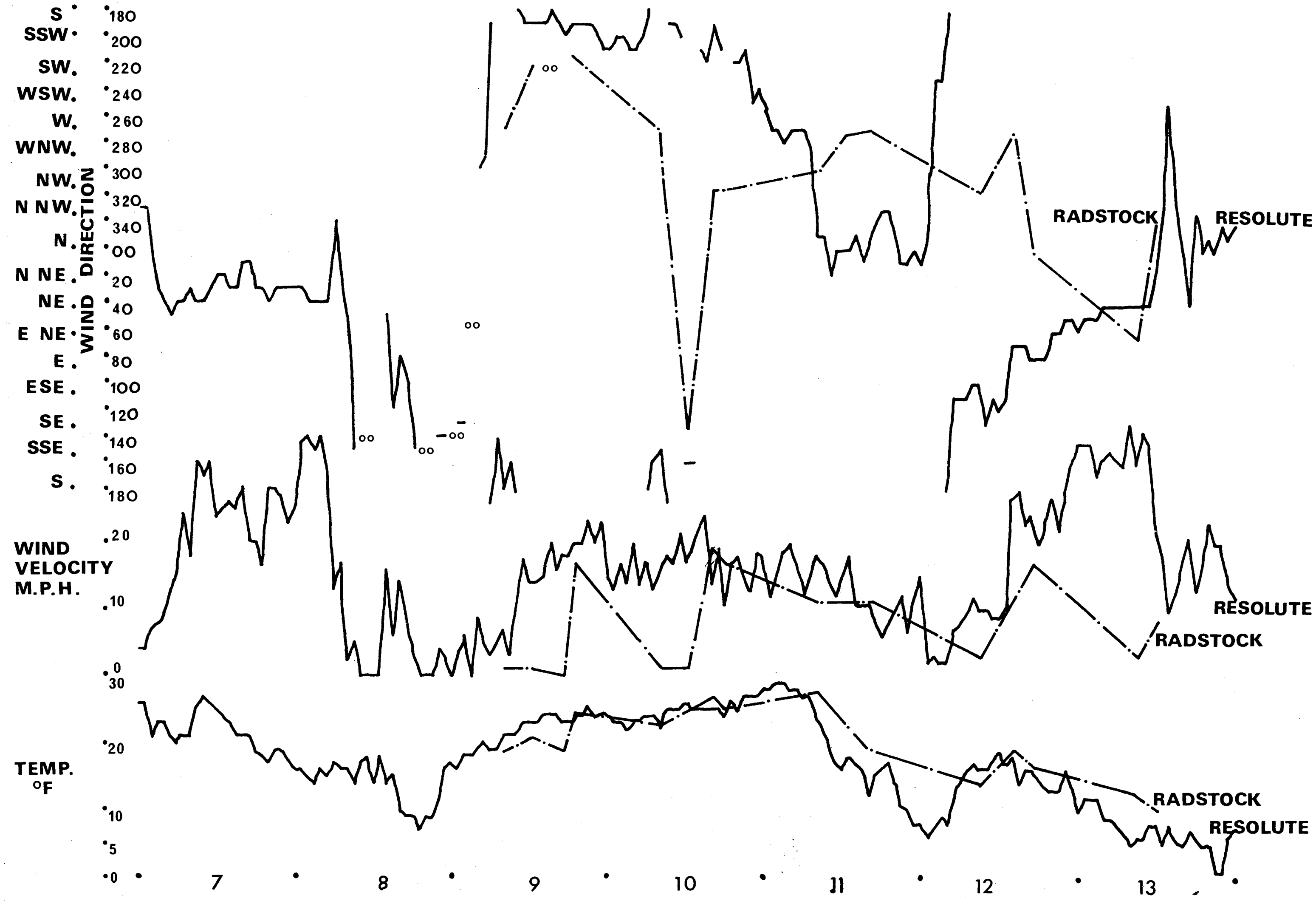
Notes on Submarine Operation in the Canadian Arctic Islands

For commercial submarine operations, the presently available data are insufficient for planning safe and economical submarine traffic.

Ice-thickness and anomalies, current and thermal structure forecasting is equally as important to submariners as meteorological forecasting for pilots of aircraft and for navigators of surface vessels.

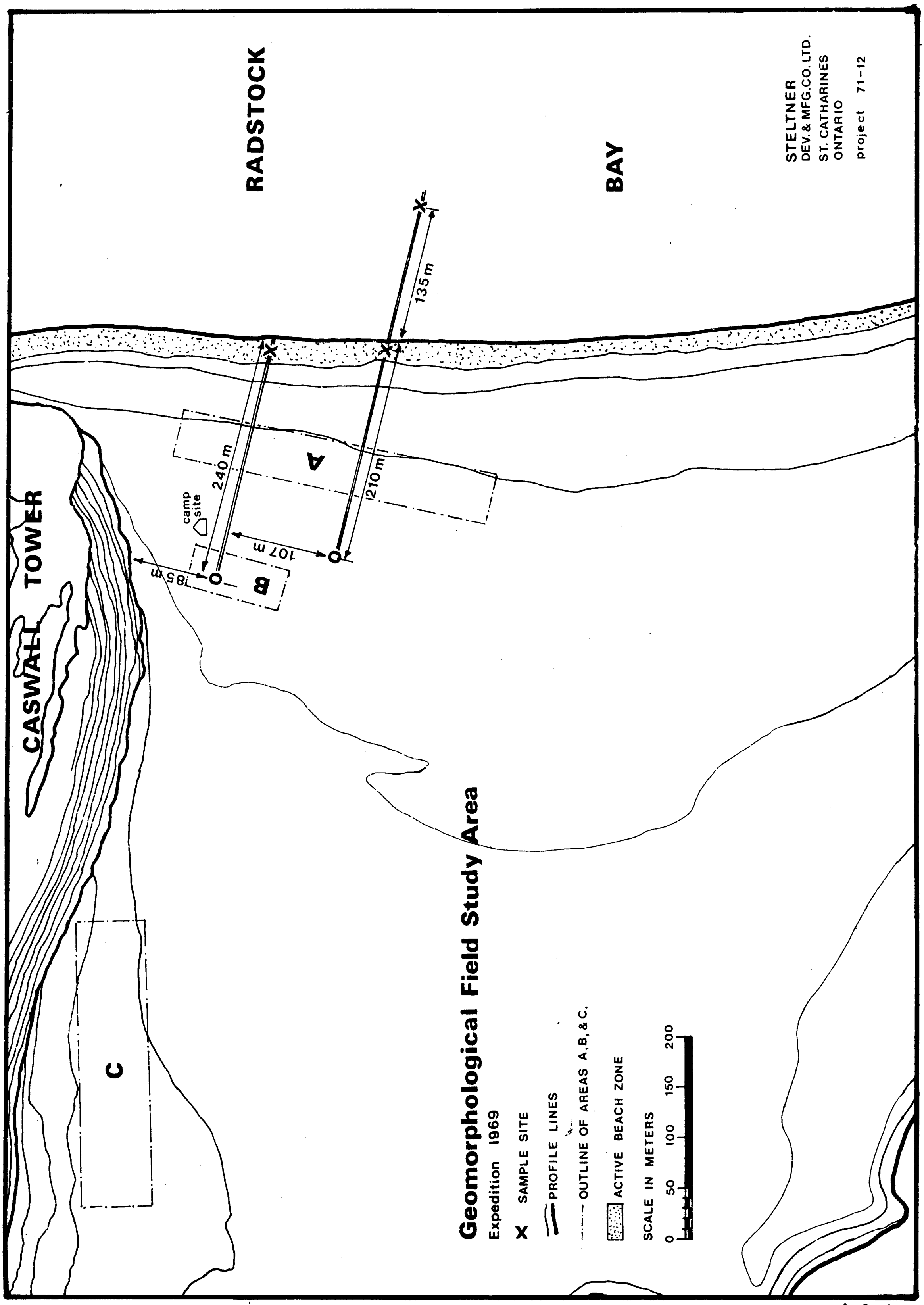
Whether or not the various governments will partially or wholly de-classify sufficient relevant data from their records for commercial planners or operators, can at this stage only be surmised.

METEOROLOGY GRAPH

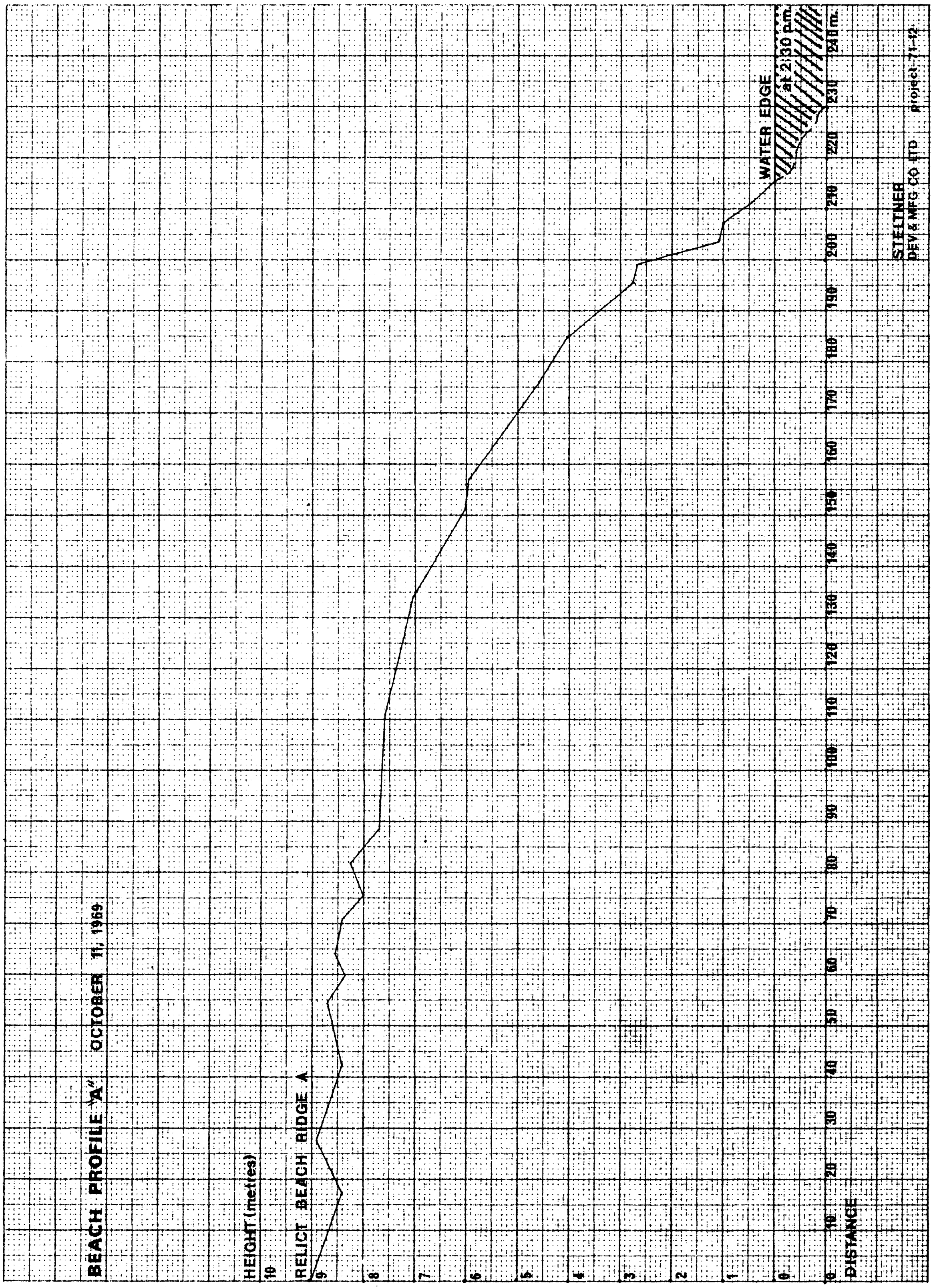


A-2 OCTOBER 1969

STELTNER DEV. & MFG. CO. LTD. project 71-12


RADSTOCK
BAY
CASWALL TOWER
STELTNER
DEV. & MFG. CO. LTD.
ST. CATHARINES
ONTARIO
project 71-12
135 m
240 m
210 m
107 m
185 m
camp site
A
B
C
Geomorphological Field Study Area
Expedition 1969
X SAMPLE SITE
PROFILE LINES
OUTLINE OF AREAS A, B, & C.
ACTIVE BEACH ZONE
SCALE IN METERS
0 50 100 150 200

A-3-4


BEACH PROFILE "A" OCTOBER 11, 1969
HEIGHT (metres)
RELICT BEACH RIDGE A
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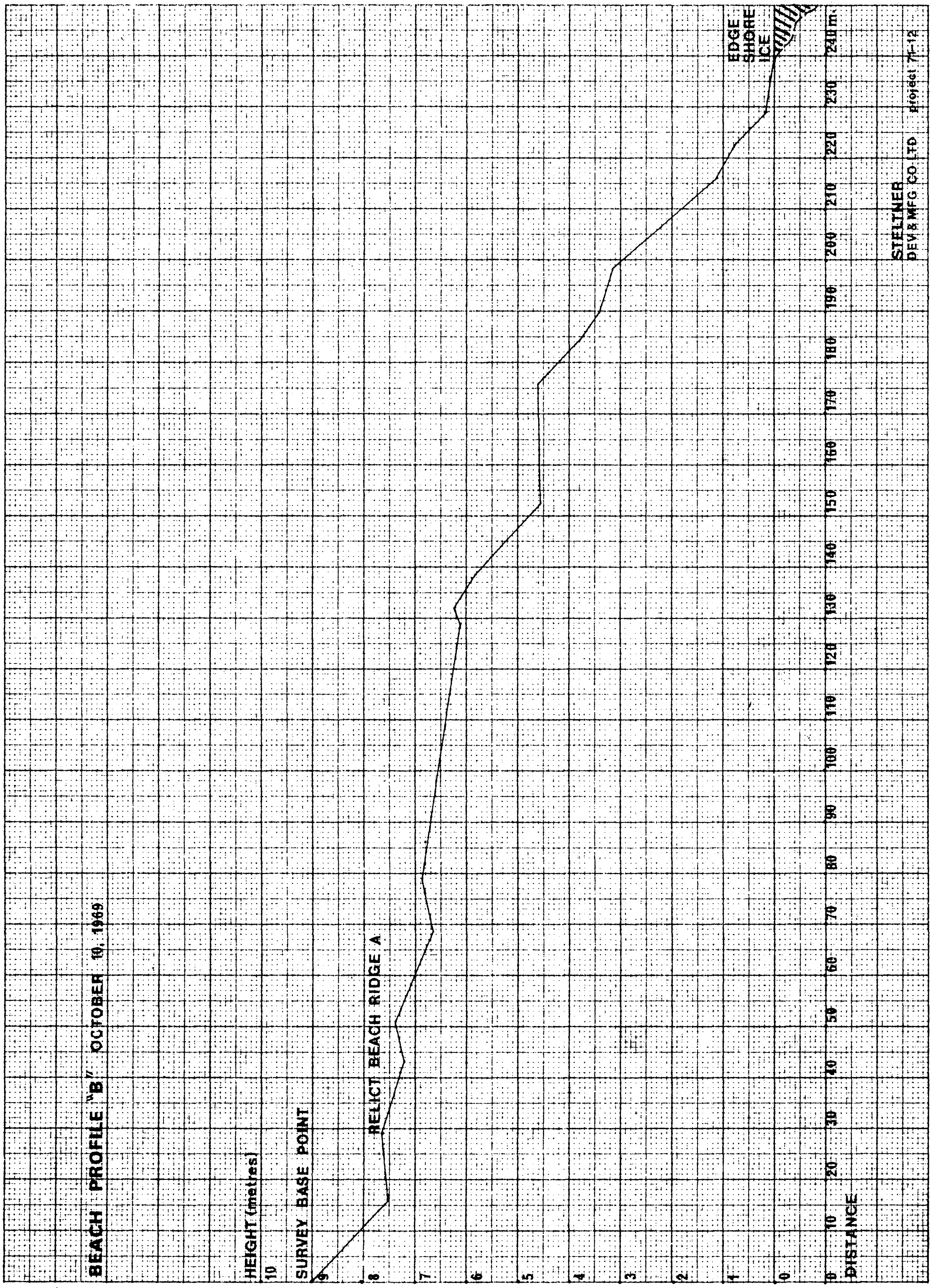
DISTANCE
240 m.
STEILTNER
DEV & MFG CO LTD
project 71-12

A-3-5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HEIGHT (metres)
SURVEY BASE POINT
RELICT BEACH RIDGE A
EDGE SHORE ICE
DISTANCE
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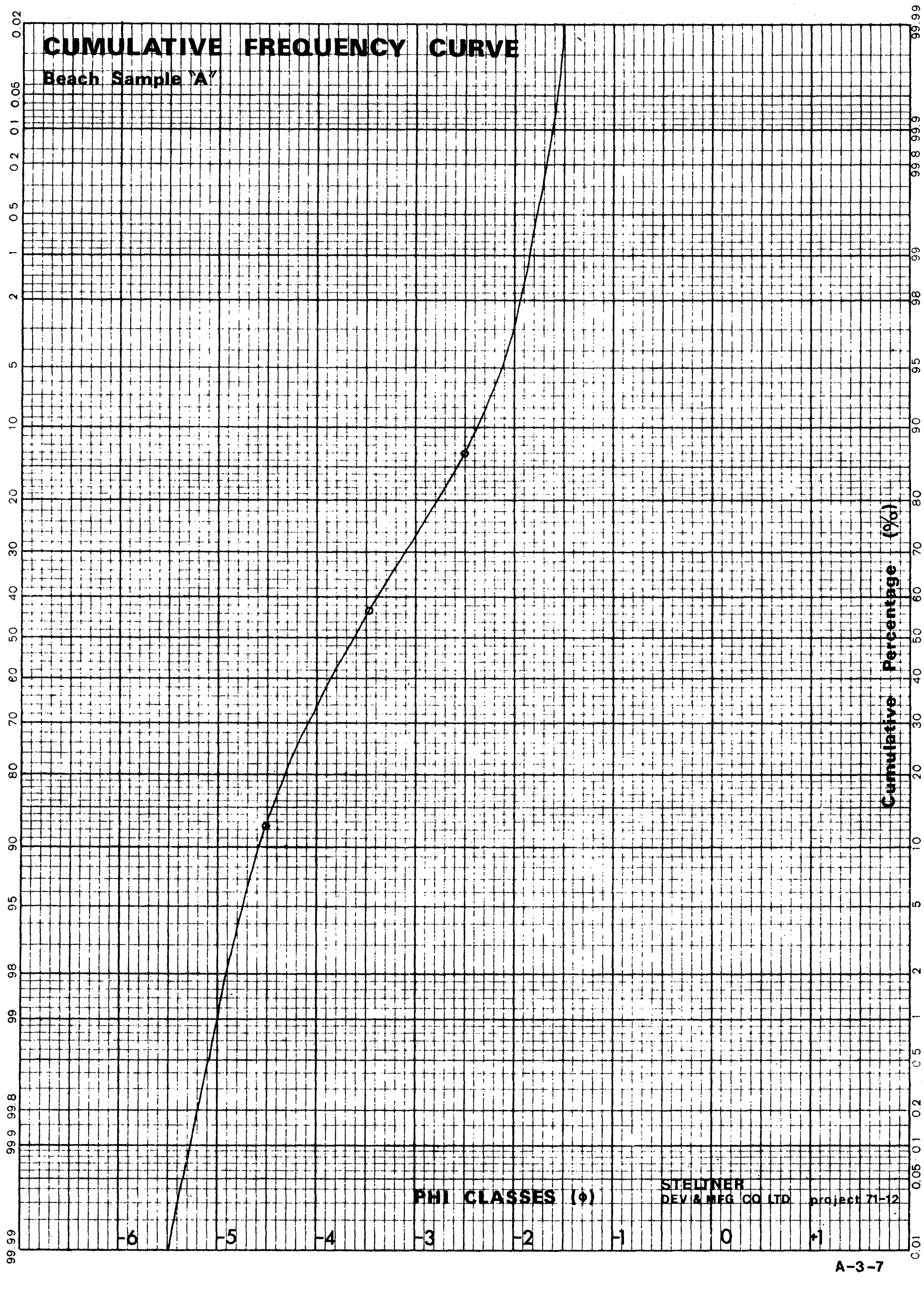
STELTNER DEV & MFG CO LTD
Project 71-12

A-3-6


CUMULATIVE FREQUENCY CURVE
Beach Sample "A"
PHI CLASSES (ϕ)
-6
-5
-4
-3
-2
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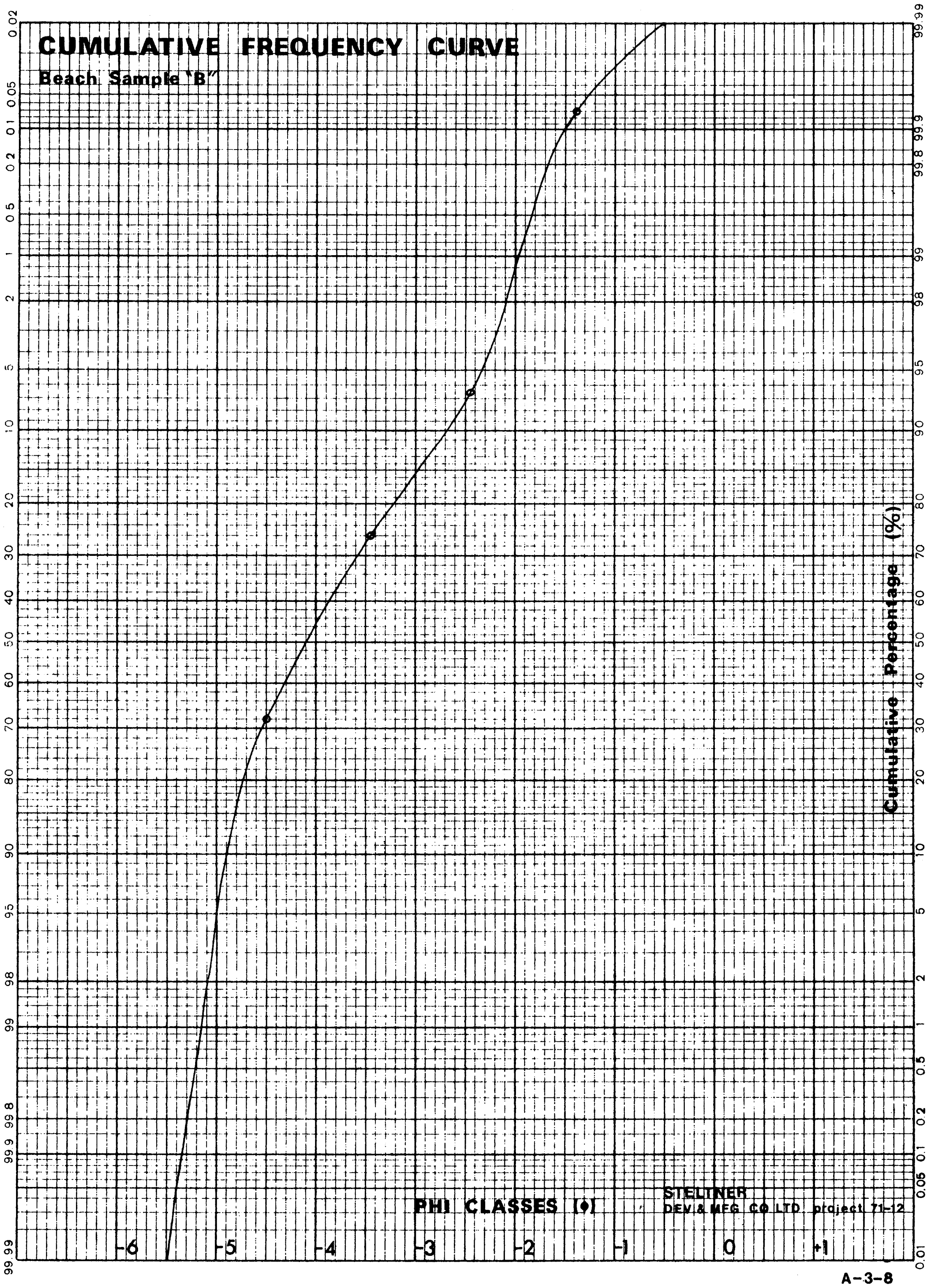
+1
Cumulative Percentage (%)
STELTNER
DEV & MFG CO LTD
project 71-12

A-3-7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Beach Sample "B"
PHI CLASSES (ϕ)
STELTNER
DEV & MFG CO LTD project 71-12
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-4
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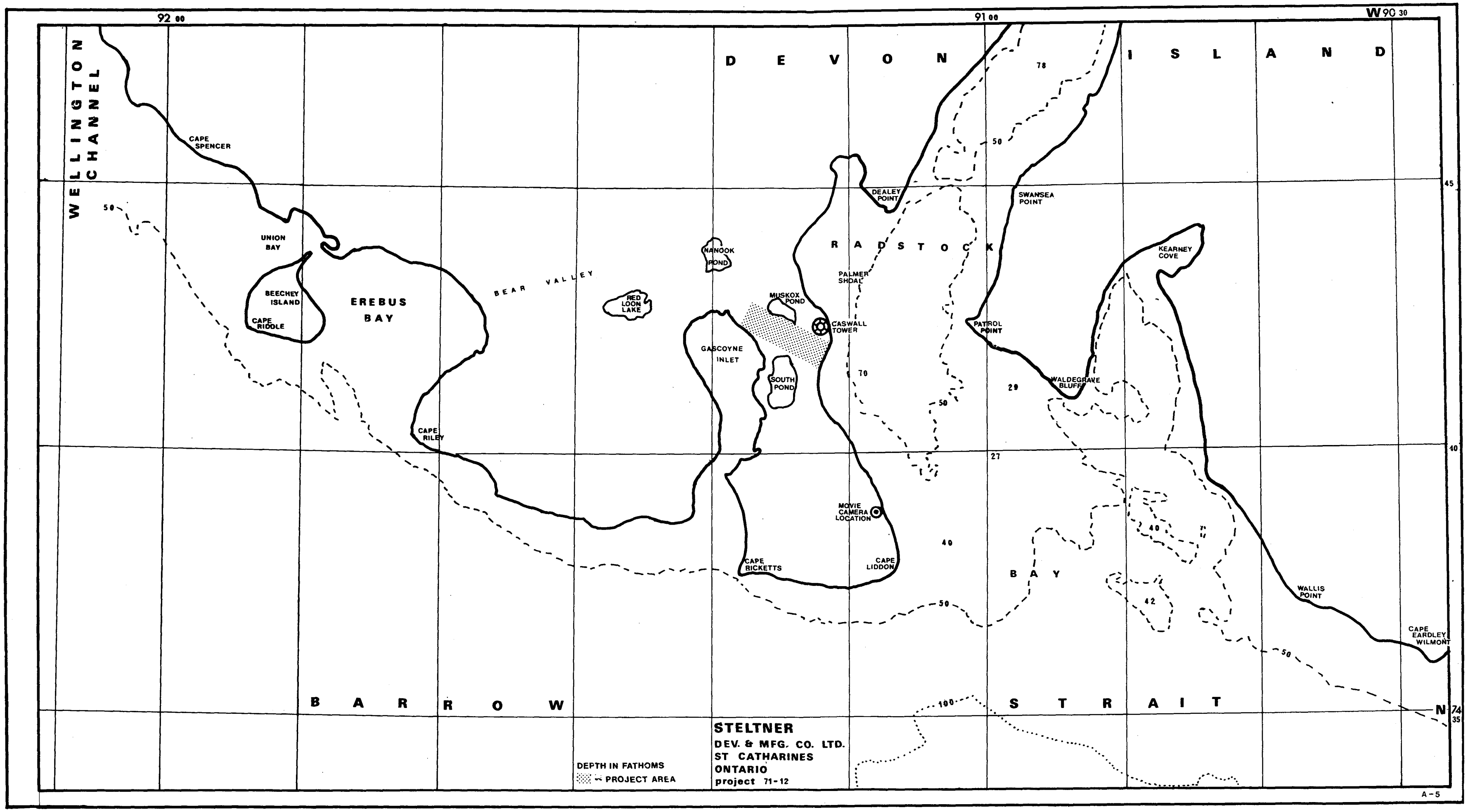
-2
-1
0
+1
Cumulative Percentage (%)

A-3-8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91 00
W 90 30
D E V O N I S L A N D
W E L L I N G T O N C H A N N E L
CAPE SPENCER
UNION BAY
BEECHEY ISLAND
CAPE RIDDLE
EREBUS BAY
BEAR VALLEY
CAPE RILEY
RED LOON LAKE
NANOOK POND
MUSKOX POND
GASCOYNE INLET
SOUTH POND
CASWALL TOWER
PALMER SHOAL
DEALEY POINT
R A D S T O C K
B A Y
SWANSEA POINT
PATROL POINT
WALDEGRAVE BLUFF
KEARNEY COVE
WALLIS POINT
CAPE EARDLEY WILMOT
MOVIE CAMERA LOCATION
CAPE RICKETTS
CAPE LIDDON
B A R R O W S T R A I T
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42
100
DEPTH IN FATHOMS
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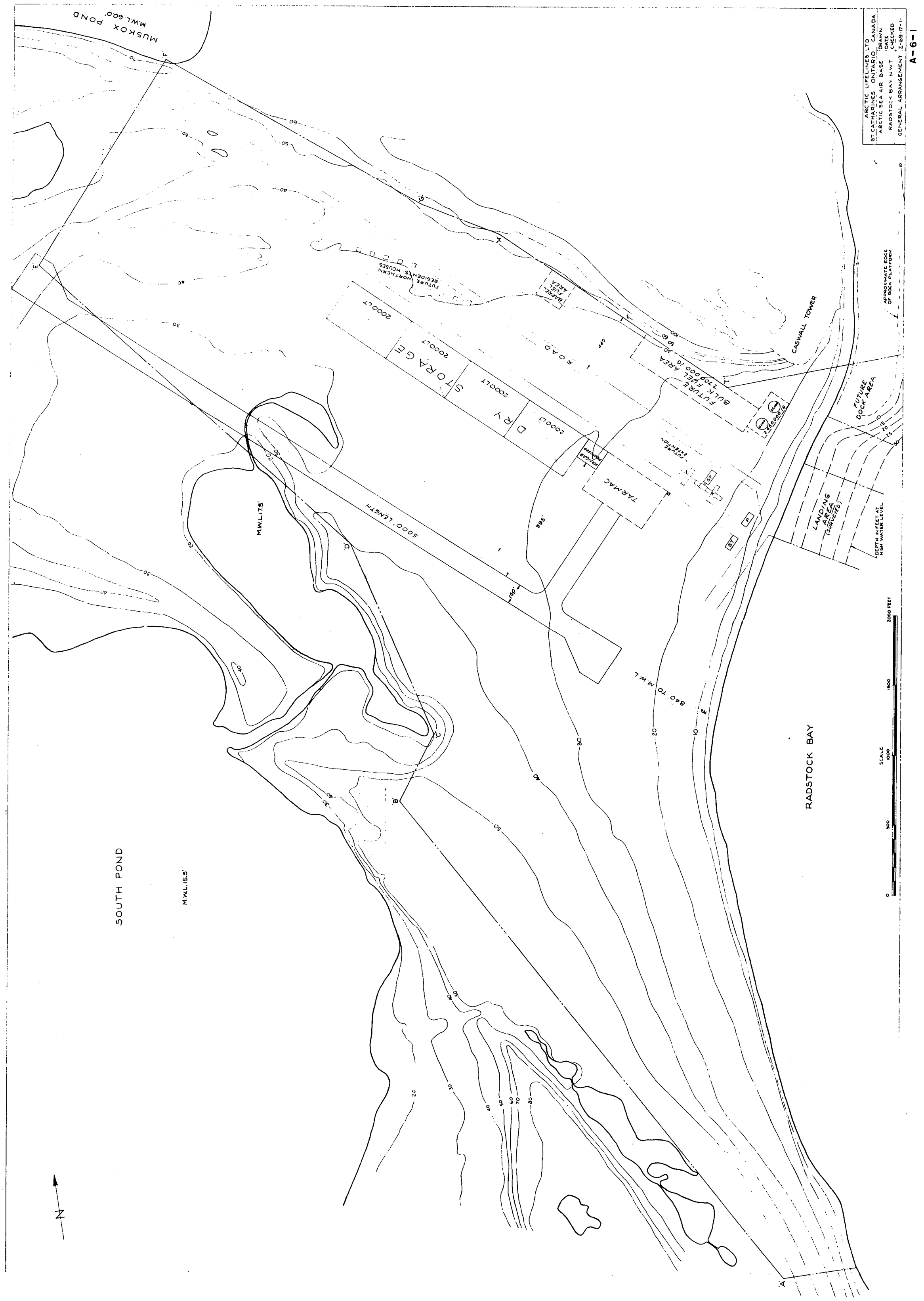
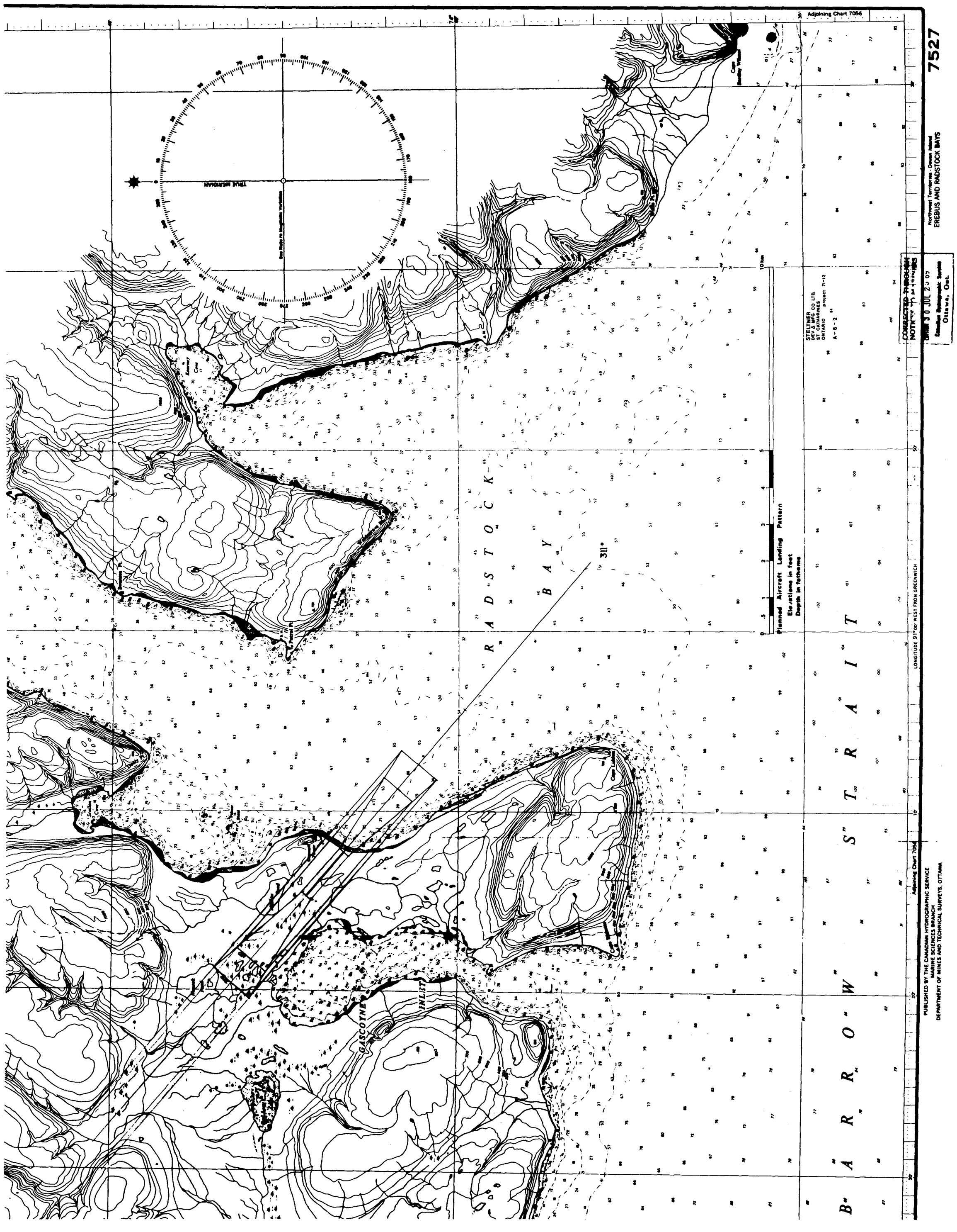
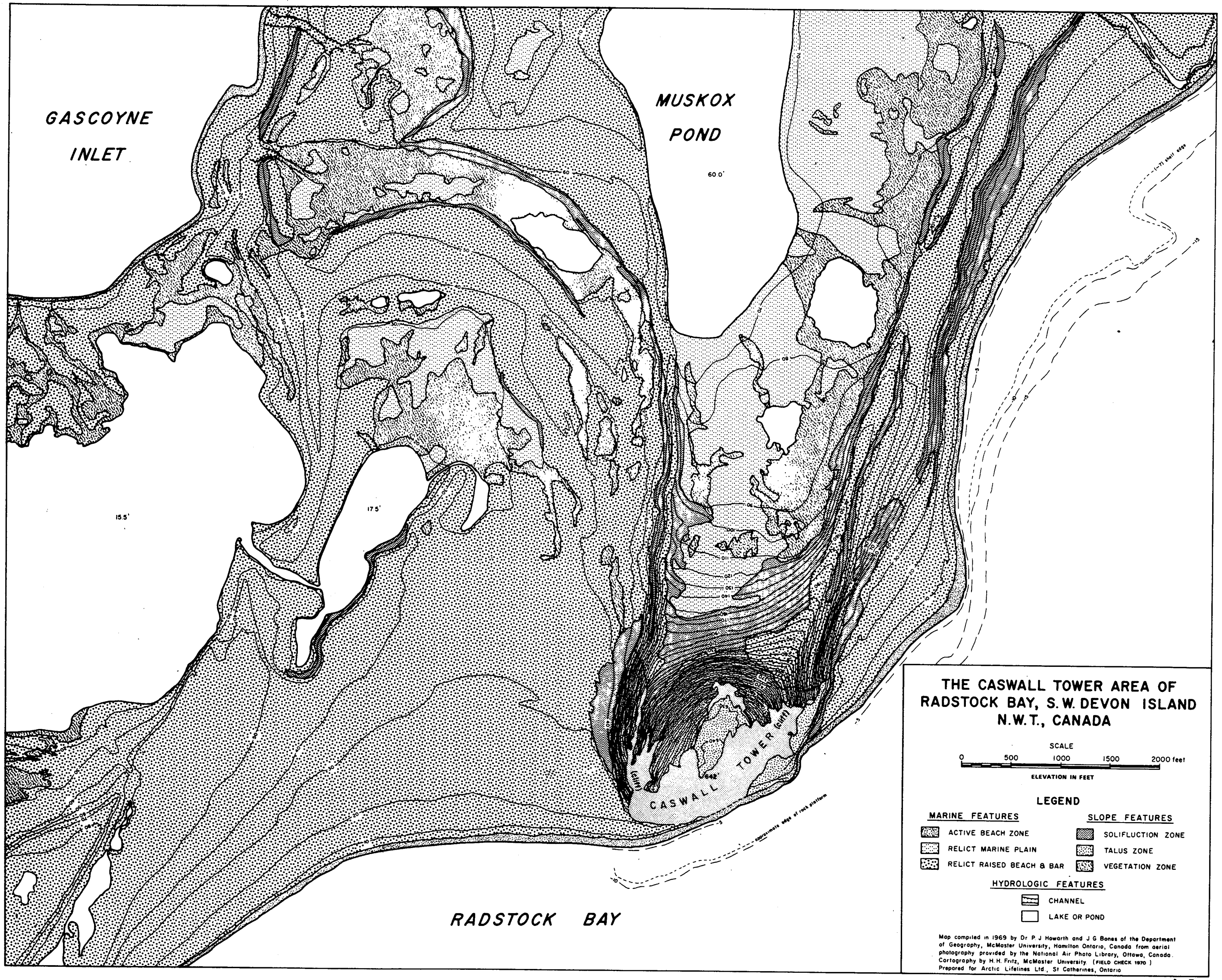
DEV. & MFG. CO. LTD.
ST CATHARINES
ONTARIO
project 71-12
A-5

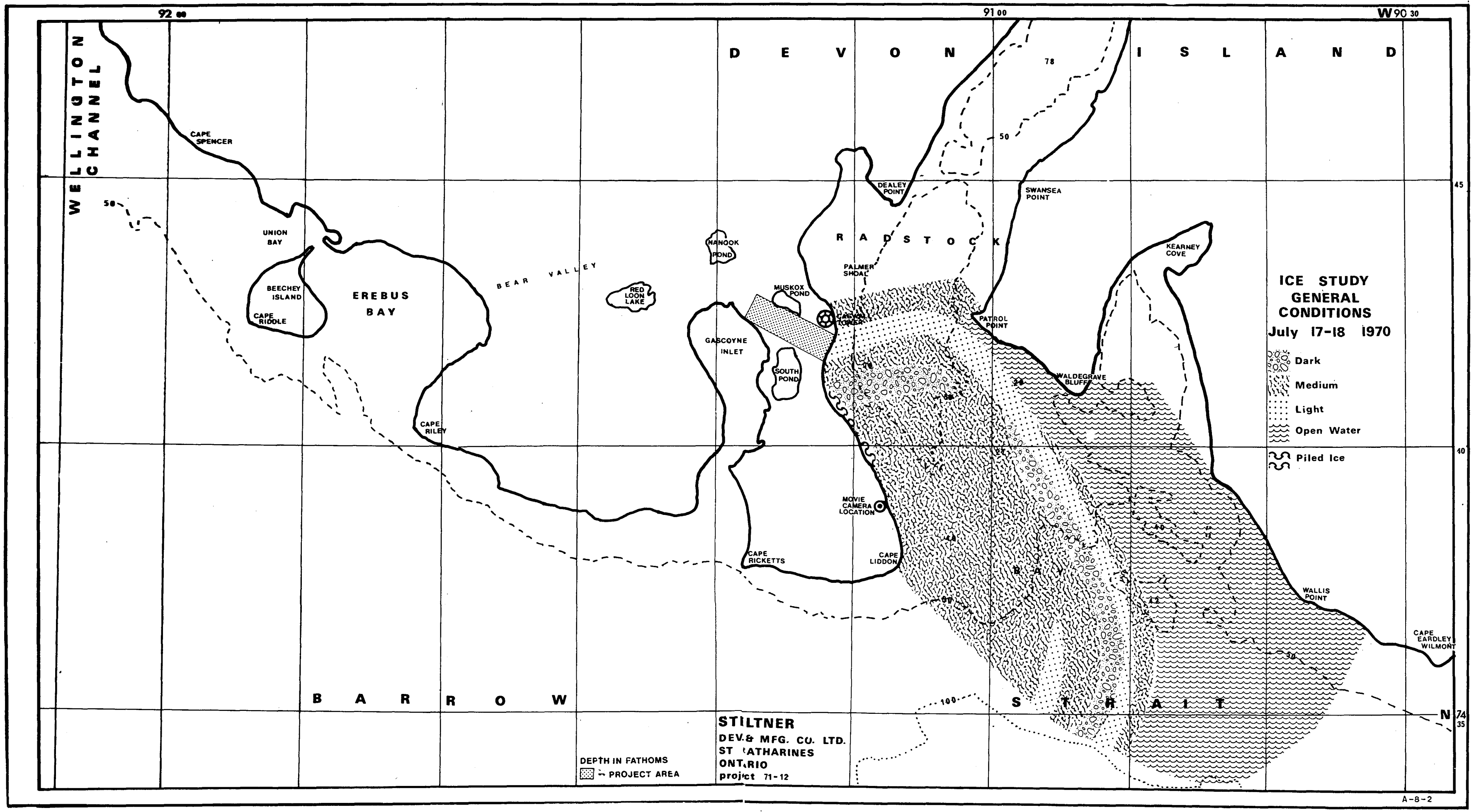

ARCTIC LIFELINES LTD
ST. CATHARINES ONTARIO CANADA
ARCTIC SEA AIR BASE
RADSTOCK BAY N.W.T.
GENERAL ARRANGEMENT
A-6-1
MUSKOX POND
MWL 60.0'
CASWALL TOWER
FUTURE DOCK AREA
LANDING AREA (SURVEYED)
FUTURE BULK FUEL AREA
DRY STORAGE
ROAD
TARMAC
5000' LENGTH
840' TO M.W.L.
MWL 17.5'
RADSTOCK BAY
SOUTH POND
MWL 15.5'
SCALE
N

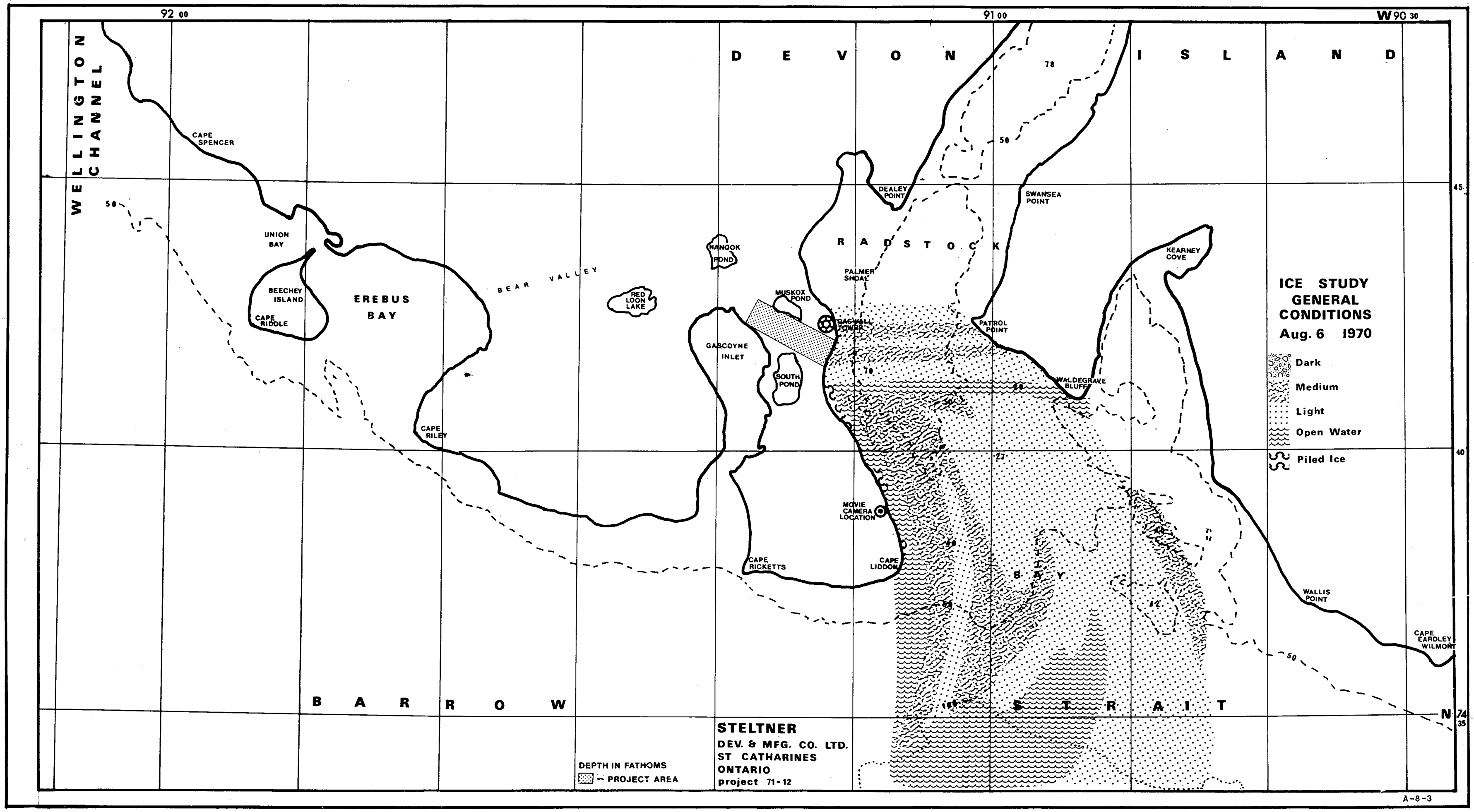


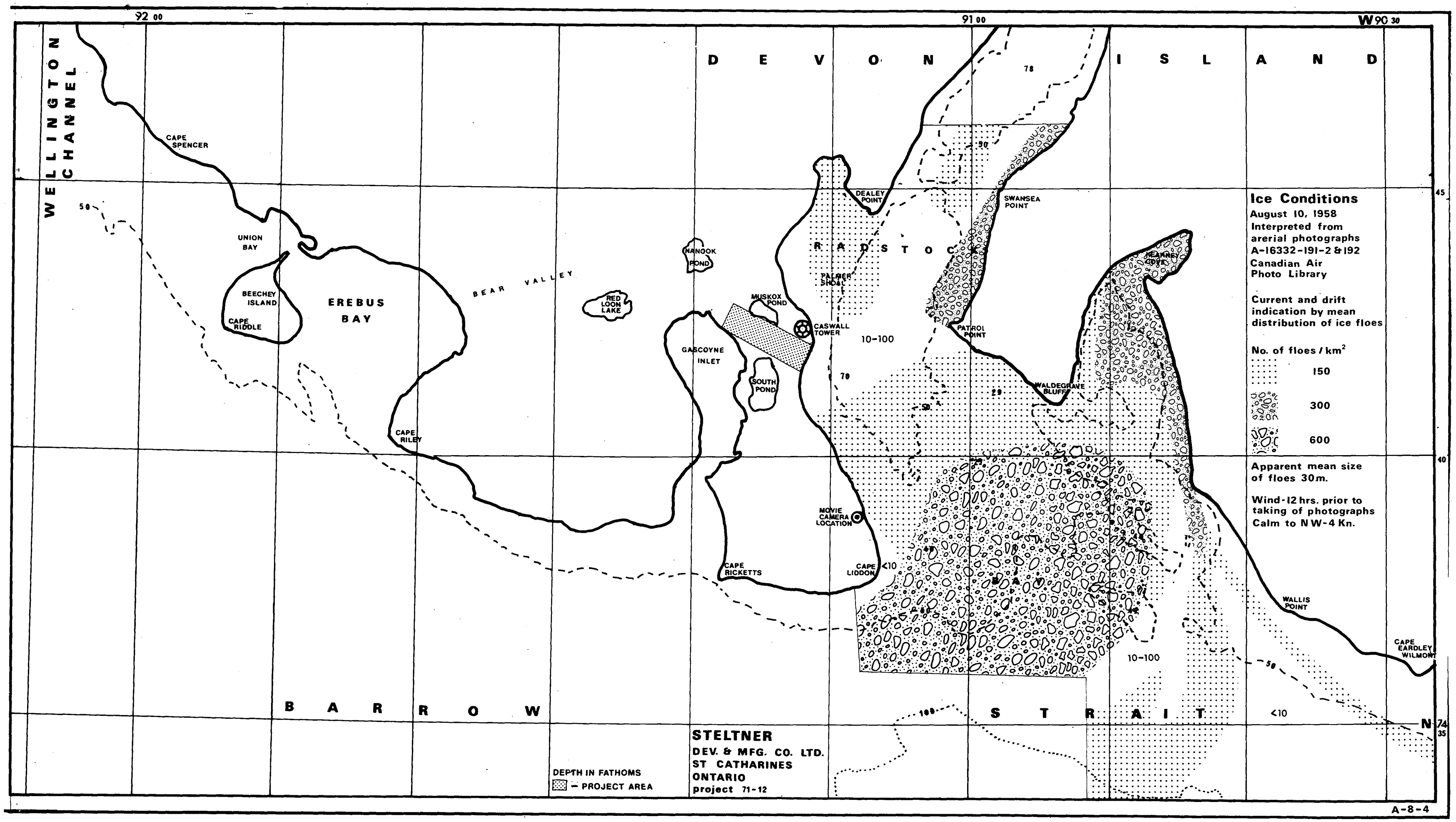
7527
Adjoining Chart 7056
RADSTOCK BAY
BARROW STRAIT
GASCOYNE INLET
311°
Planned Aircraft Landing Pattern
Elevations in feet
Depth in fathoms
ERFBUS AND RADSTOCK BAYS
PUBLISHED BY THE CANADIAN HYDROGRAPHIC SERVICE

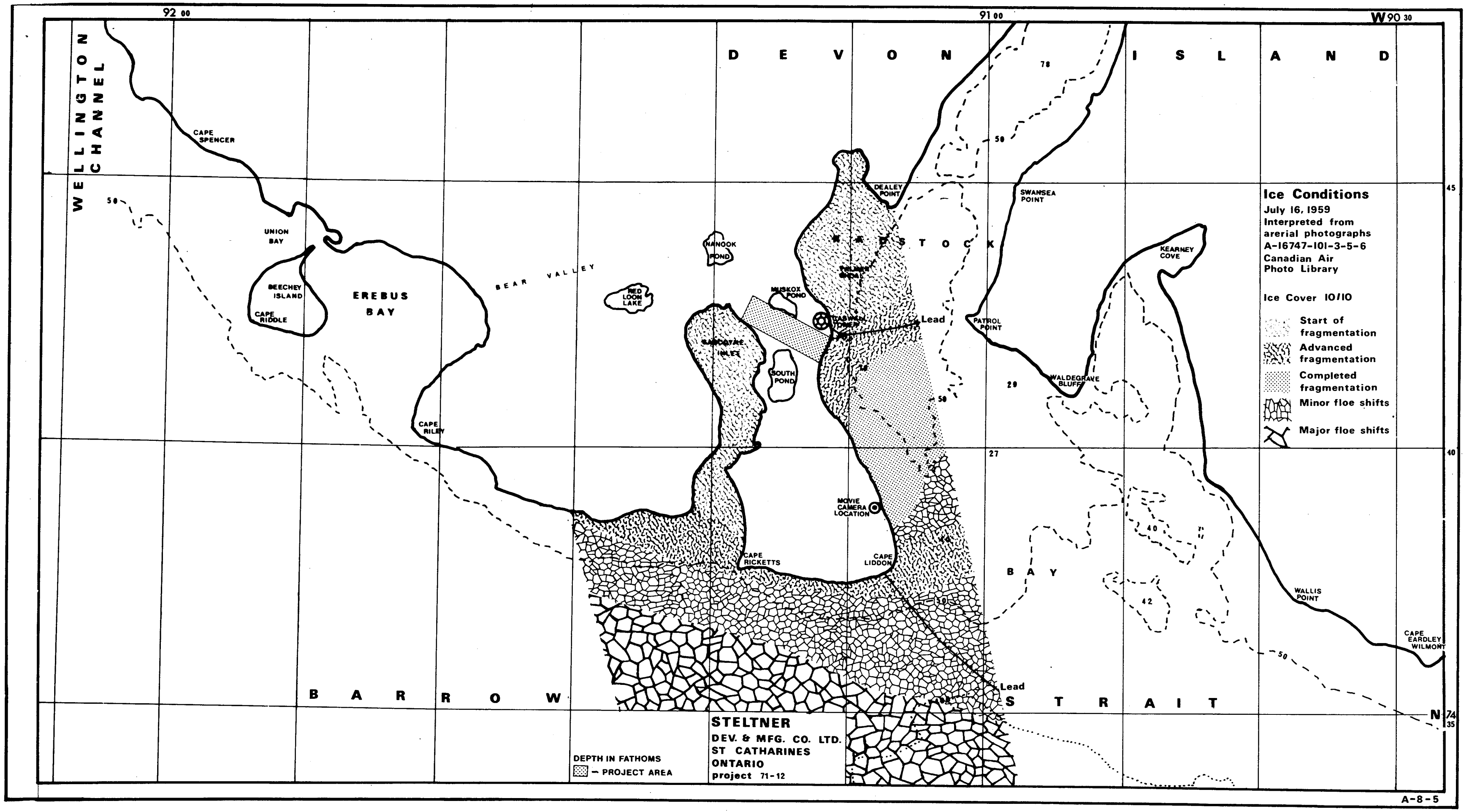

GASCOYNE INLET
MUSKOX POND
60.0'
15.5'
17.5'
CASWALL TOWER
(cliff)
RADSTOCK BAY
THE CASWALL TOWER AREA OF RADSTOCK BAY, S. W. DEVON ISLAND N.W.T., CANADA
SCALE
0 500 1000 1500 2000 feet
ELEVATION IN FEET
LEGEND
MARINE FEATURES
ACTIVE BEACH ZONE
RELICT MARINE PLAIN
RELICT RAISED BEACH & BAR
SLOPE FEATURES
SOLIFLUCTION ZONE
TALUS ZONE
VEGETATION ZONE
HYDROLOGIC FEATURES
CHANNEL
LAKE OR POND
Map compiled in 1969 by Dr P. J Howarth and J G Bones of the Department of Geography, McMaster University, Hamilton Ontario, Canada from aerial photography provided by the National Air Photo Library, Ottawa, Canada. Cartography by H. H. Fritz, McMaster University. (FIELD CHECK 1970)
Prepared for Arctic Lifelines Ltd., St Catherines, Ontario

A-7


ICE STUDY
GENERAL
CONDITIONS
July 17-18 1970
Dark
Medium
Light
Open Water
Piled Ice
WELLINGTON CHANNEL
DEVON ISLAND
BARROW STRAIT
RADSTOCK
CAPE SPENCER
UNION BAY
BEECHEY ISLAND
CAPE RIDDLE
EREBUS BAY
BEAR VALLEY
CAPE RILEY
NANOOK POND
RED LOON LAKE
GASCOYNE INLET
MUSKOX POND
SOUTH POND
PALMER SHOAL
DEALEY POINT
SWANSEA POINT
PATROL POINT
KEARNEY COVE
WALDEGRAVE BLUFF
MOVIE CAMERA LOCATION
CAPE RICKETTS
CAPE LIDDON
WALLIS POINT
CAPE EARDLEY WILMOT
DEPTH IN FATHOMS
PROJECT AREA
STILTNER
DEV.& MFG. CO. LTD.
ST CATHARINES
ONTARIO
project 71-12
A-8-2
92 00
91 00
W90 30
N74 35
45
40


ICE STUDY
GENERAL
CONDITIONS
Aug. 6 1970
Dark
Medium
Light
Open Water
Piled Ice
W 90 30
91 00
92 00
45
40
N 74 35
D E V O N I S L A N D
WELLINGTON CHANNEL
B A R R O W S T R A I T
R A D S T O C K B A Y
EREBUS BAY
UNION BAY
BEECHEY ISLAND
CAPE RIDDLE
CAPE SPENCER
BEAR VALLEY
RED LOON LAKE
NANOOK POND
MUSKOX POND
SOUTH POND
GASCOYNE INLET
CAPE RILEY
CAPE RICKETTS
CAPE LIDDON
MOVIE CAMERA LOCATION
PALMER SHOAL
DEALEY POINT
SWANSEA POINT
PATROL POINT
WALDEGRAVE BLUFF
KEARNEY COVE
WALLIS POINT
CAPE EARDLEY WILMOT
STELTNER
DEV. & MFG. CO. LTD.
ST CATHARINES
ONTARIO
project 71-12
DEPTH IN FATHOMS
-- PROJECT AREA
A-8-3


92 00
91 00
W 90 30
WELLINGTON CHANNEL
DEVON ISLAND
BARROW STRAIT
RADSTOCK
CAPE SPENCER
UNION BAY
BEECHEY ISLAND
CAPE RIDDLE
EREBUS BAY
BEAR VALLEY
NANOOK POND
RED LOON LAKE
MUSKOX POND
CASWALL TOWER
GASCOYNE INLET
SOUTH POND
CAPE RILEY
DEALEY POINT
PALMER SHOAL
SWANSEA POINT
PATROL POINT
WALDEGRAVE BLUFF
HEARNEY COVE
MOVIE CAMERA LOCATION
CAPE RICKETTS
CAPE LIDDON
WALLIS POINT
CAPE EARDLEY WILMOT
10-100
<10
Ice Conditions
August 10, 1958
Interpreted from arerial photographs A-16332-191-2 & 192
Canadian Air Photo Library
Current and drift indication by mean distribution of ice floes
No. of floes / km²
150
300
600
Apparent mean size of floes 30m.
Wind-12 hrs. prior to taking of photographs Calm to NW-4 Kn.
N 74 35
45
40
DEPTH IN FATHOMS
- PROJECT AREA
STELTNER
DEV. & MFG. CO. LTD.
ST CATHARINES
ONTARIO
project 71-12
A-8-4


92 00
91 00
W90 30
DEVON ISLAND
WELLINGTON CHANNEL
CAPE SPENCER
UNION BAY
BEECHEY ISLAND
CAPE RIDDLE
EREBUS BAY
BEAR VALLEY
CAPE RILEY
RED LOON LAKE
NANOOK POND
MUSKOX POND
SOUTH POND
DEALEY POINT
SWANSEA POINT
PATROL POINT
WALDEGRAVE BLUFF
KEARNEY COVE
WALLIS POINT
CAPE EARDLEY WILMOT
CAPE RICKETTS
CAPE LIDDON
MOVIE CAMERA LOCATION
Lead
Lead
BAY
BARROW STRAIT
Ice Conditions
July 16, 1959
Interpreted from
arerial photographs
A-16747-101-3-5-6
Canadian Air
Photo Library
Ice Cover 10/10
Start of fragmentation
Advanced fragmentation
Completed fragmentation
Minor floe shifts
Major floe shifts
DEPTH IN FATHOMS
– PROJECT AREA
STELTNER
DEV. & MFG. CO. LTD.
ST CATHARINES
ONTARIO
project 71-12
A-8-5
45
40
N 74 35

Comments To Satellite Photograph, July 15, 1969

The satellite photograph was provided by the Nimbus II Project under the NASA Program and made available to this effort by the courtesy of the Polar Oceanography Division of the U.S. Naval Oceanographic Office.

This picture appears to show that the North Water in the Baffin Bay merges with the waters of the partially open Lancaster Sound. There appears to be an ice dam in Barrow Strait along a line, about N to S, east of Griffith Island, and it appears that the Wellington Channel ice is still fast.

Messrs. Schule and Wittmann already presented in Vol. 39, No. 3 of the Transactions, American Geophysical Union, June 1958, that each year, some time after December, ice dams impede the normal W to E flow just W of Resolute Bay.

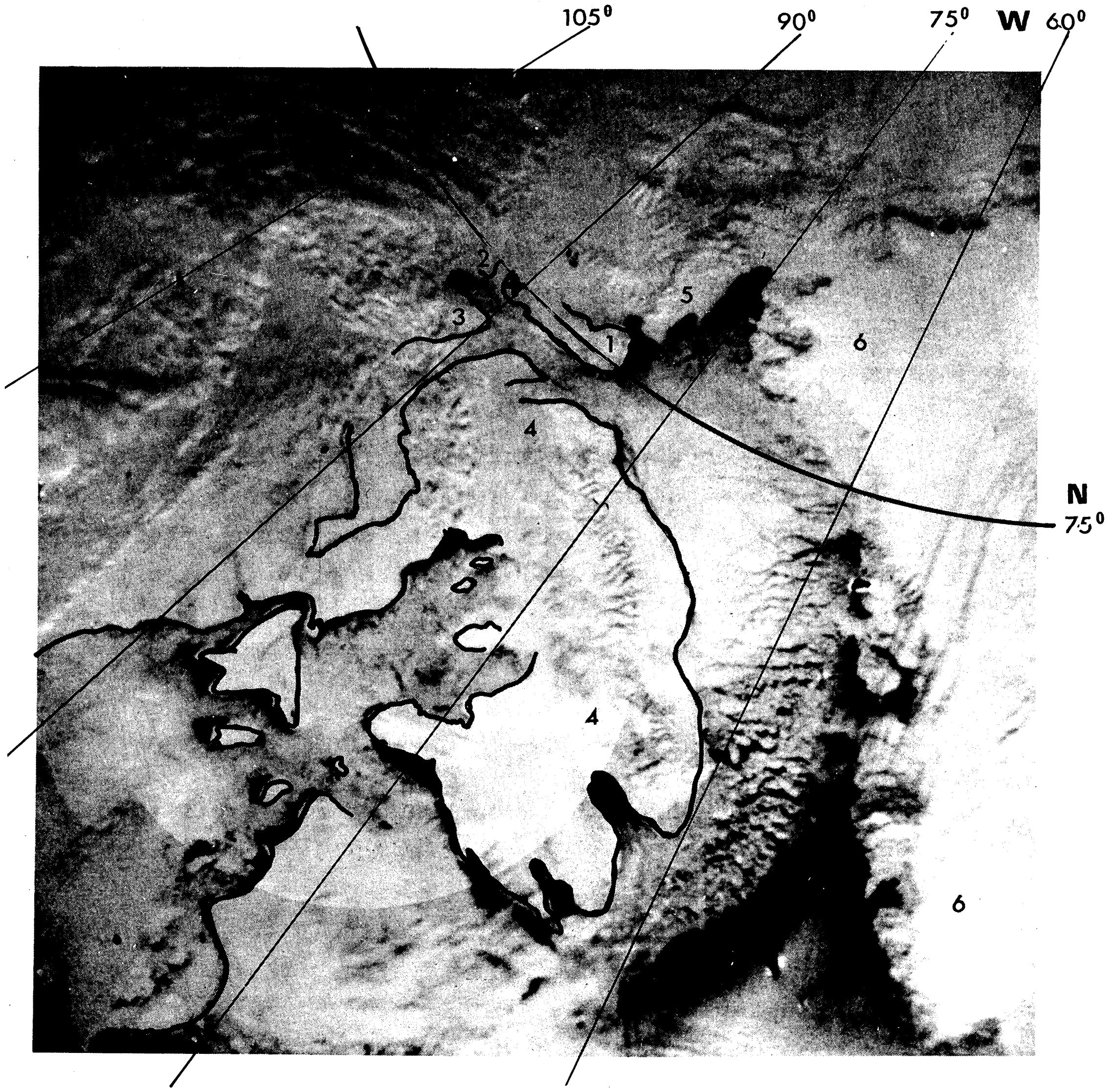
A-8-6

Comments To Satellite Photographs, July 18, 1970

These satellite photographs were made available by courtesy of the Polar Oceanographic Division of the U.S. Naval Oceanographic Office.

In both pictures the North Water in the Baffin Bay can be clearly identified as merging with the waters of the Lancaster Sound.

Both photos bear further evidence to the break-up and movement of ice in Lancaster Sound to 90° W. This was the period of the first development of a substantial lead in outer Radstock Bay.



✚ RADSTOCK BAY
1 DEVON I.
2 CORNWALLIS I.
3 SOMERSET I.
4 BAFFIN I.
5 ELLESMERE I.
6 GREENLAND

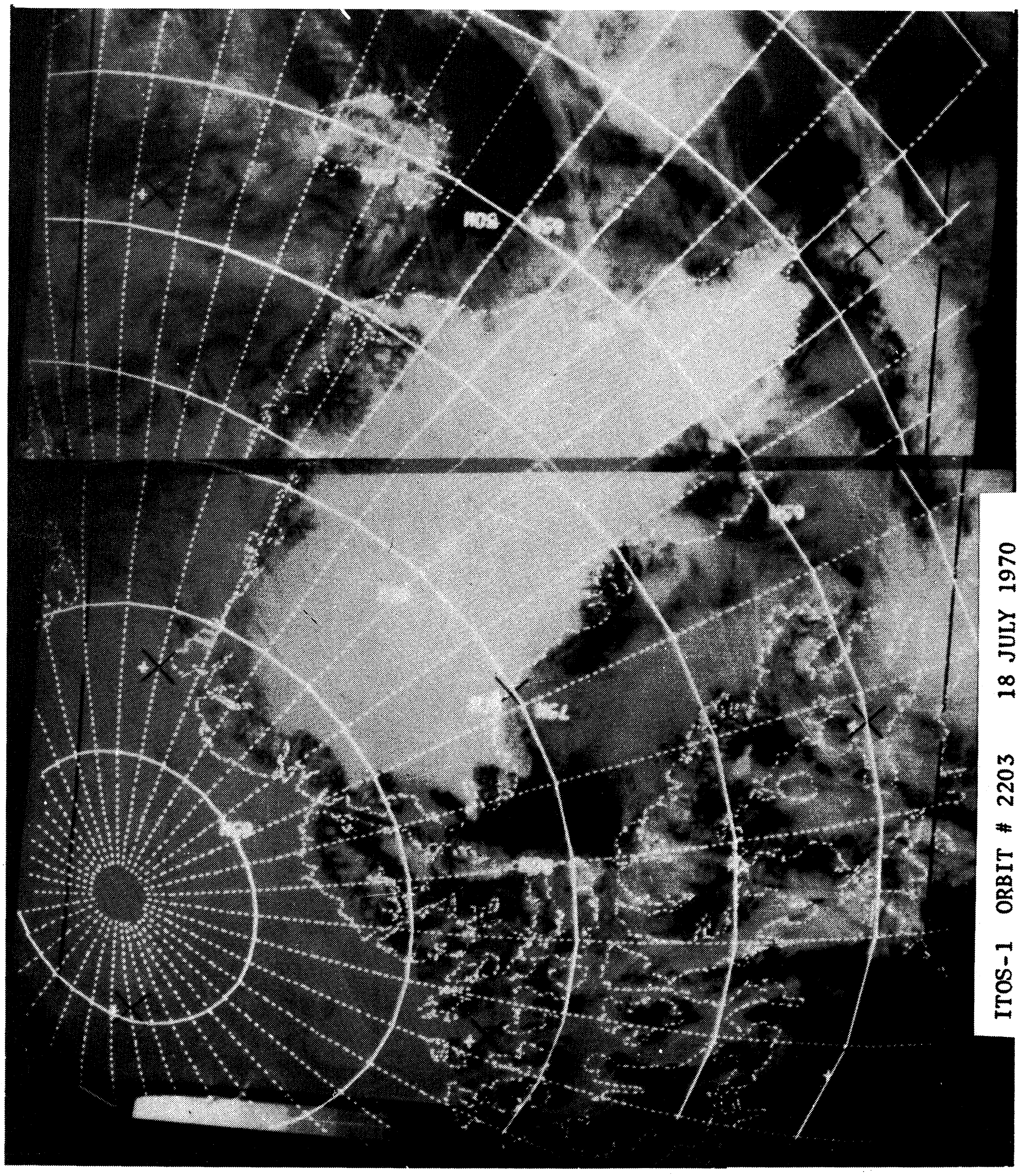
OVERLAY TO A SATELLITE PHOTOGRAPH SHOWING BAFFIN BAY, LANCASTER SOUND, FOXE BASIN, AND PART OF HUDSON BAY.

Photo Date - July 15, 1969

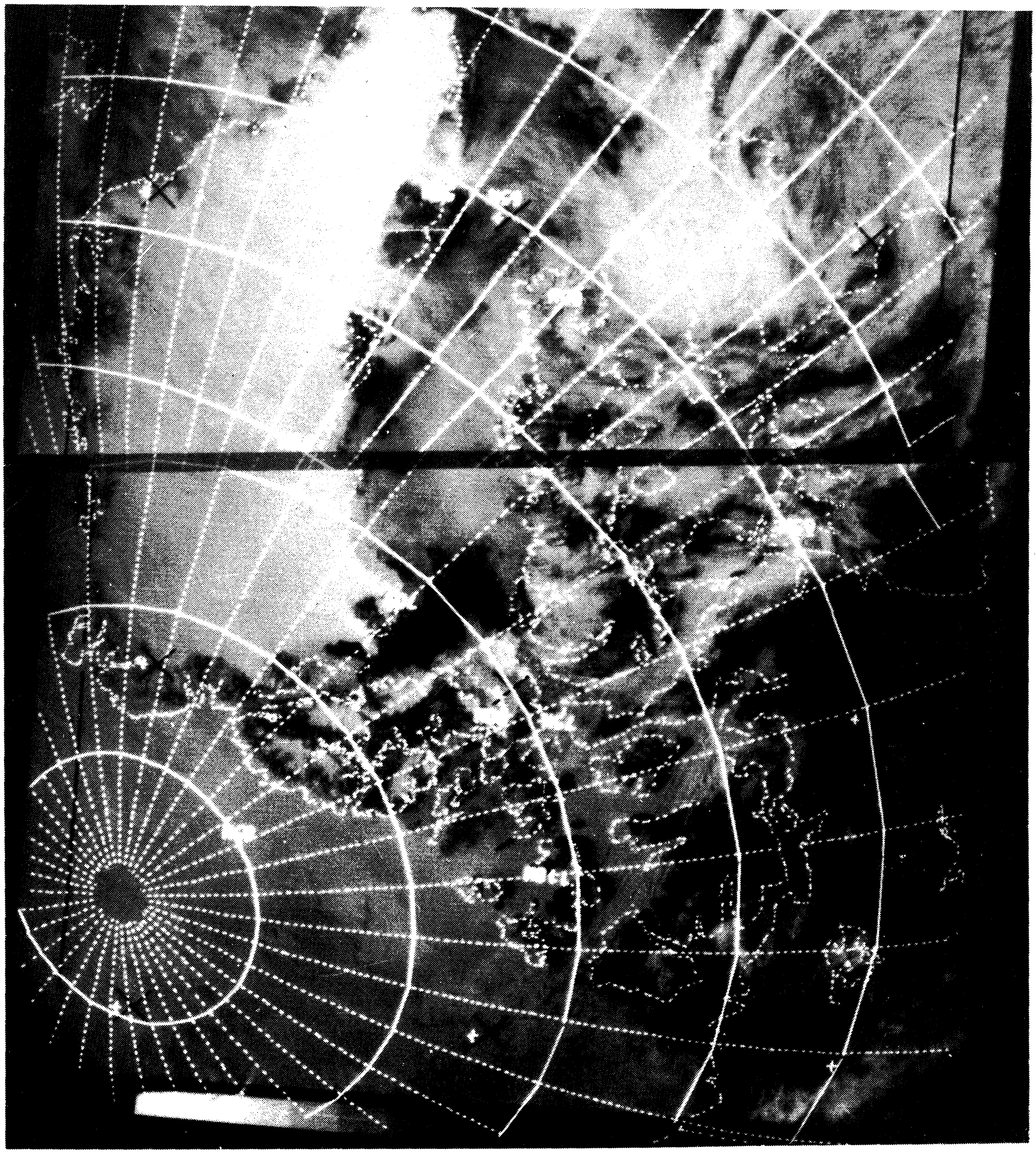
PHOTO PROVIDED BY NIMBUS II PROJECT UNDER THE NASA PROGRAM AND MADE AVAILABLE BY COURTESY OF THE POLAR OCEANOGRAPHY DIVISION OF THE U.S. NAVAL OCEANOGRAPHIC OFFICE.

STELTNER DEV. & MFG. CO. LTD.
St.Catharines, Ontario
Project 71-12

A-8-6



Courtesy U.S. Naval Oceanographic Office Polar Oceanography Division A-8-7



ITOS-1 ORBIT # 2204 18 July 1970

Courtesy U.S. Naval Oceanographic Office Polar Oceanography Division A-8-8

Barrow Strait - Temperature Salinity Density

The following TSD graphs represent all such information on this area that appears to be available.

Before discussing the information contained in these graphs I would like to point out that the purpose of collecting this information was to assess such results of analysis which are directly relevant for the planning of marine and submarine operations in the Radstock Bay area.

From the graphs the following is noted:

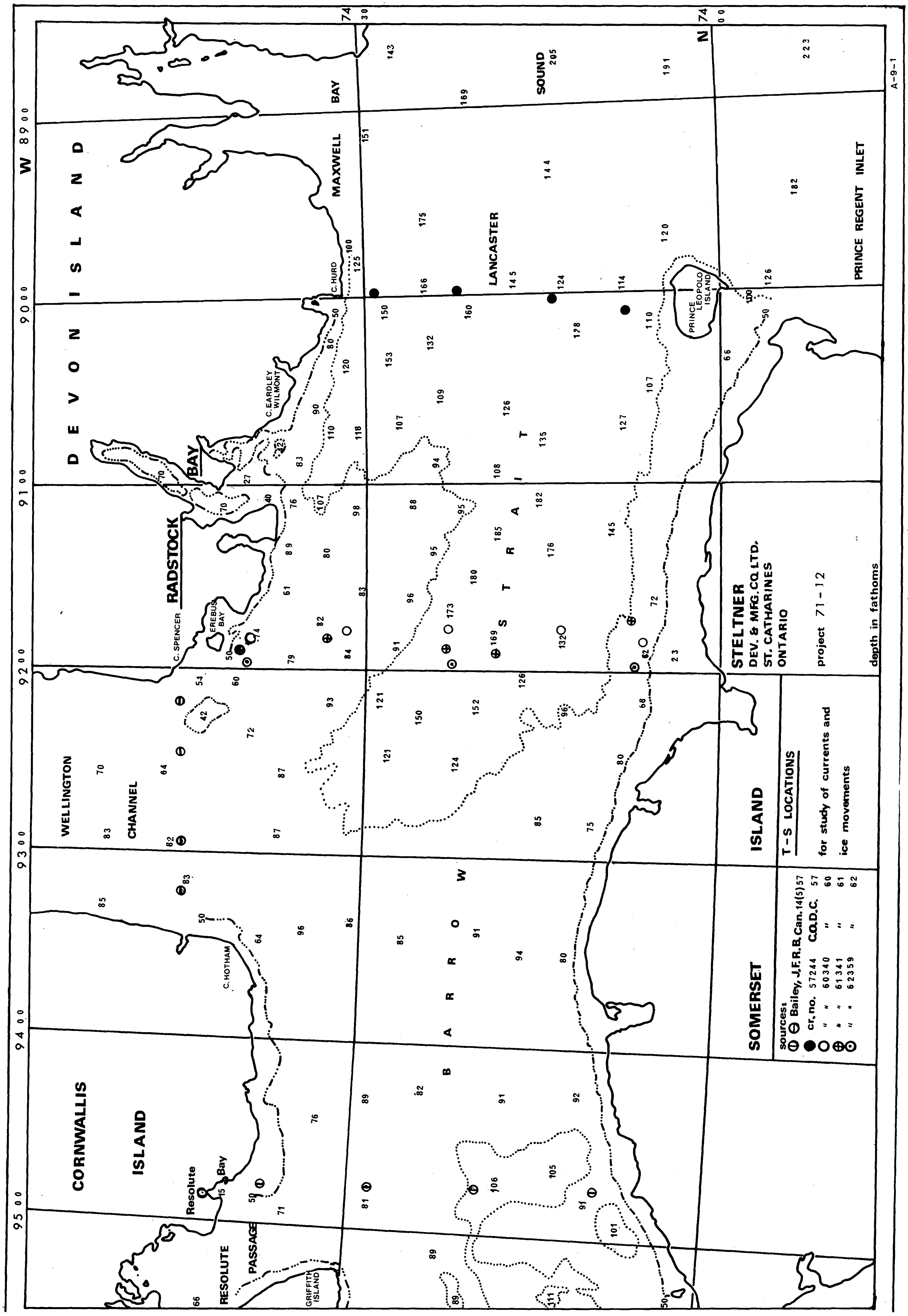
1.) Below about 200 m, the density decreases from E to W, and the salinity decreases from E to W as well.

2.) The stations S of Beechey Island have been occupied in three successive years: 1960, 1961, and 1962; these stations are fairly closely spaced.
Comparing the three cross-sections, the one presenting the 1962 data appears not to conform to the pattern shown on the other graphs presenting the 1960 and 1961 data. This apparent non-conformity I would explain as caused by the 4 to 6 tenths coverage of drift-ice traversing this section during the period Aug. 8 - 10, 1962. During the period between July 17 and Aug. 8, 1962, open water was reported throughout the area and then again on Aug. 13, 1962. In 1961, open water was reported throughout this area on Aug. 3.
In 1960, open water was reported for Aug. 9, with a tongue of ice projecting southeast from the south end of Wellington Channel.

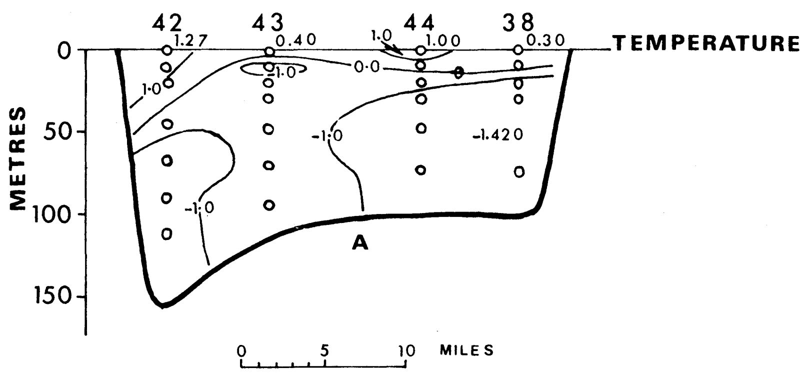
3.) The Barrow Strait S and E of Beechey Island appears to be subject to intensive convection mixing apparently caused by the convergence of opposing and bisecting currents; for example, from May 22 - 24, 1962, an open patch of water was reported N and E of Prince Leopold Island.

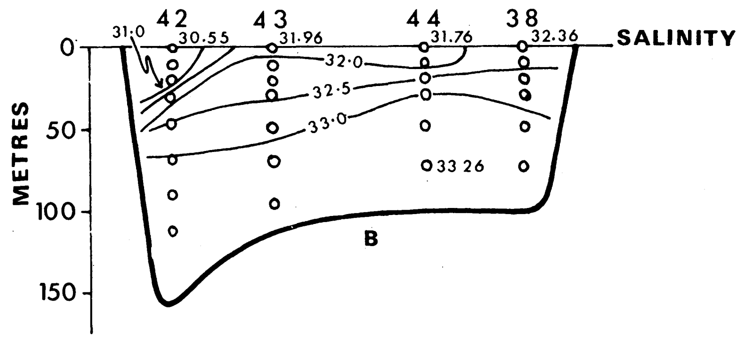
4.) Looking for natural indicators to identify water movement I have noted verbal reports of kelp-growth at the shores of SW Devon Island and the SE shores of Cornwallis Island; and only relatively insignificant occurence of kelp at the north shore of Somerset Island. This would give rise to the assumption that the west current from the north side of Lancaster Sound extends to the Resolute Passage.

5.) In reference to the occurrence of ice dams, the observed development of a horseshoe-shaped patch of open water between Cornwallis, Griffith and Somerset Islands on July 5, 1960, could be taken as an indication of the existence of such ice dams. A somewhat similar observation was made on Aug. 5, 1961, at the same location. (These observations quoted are only two examples.)



DEVON ISLAND
CORNWALLIS ISLAND
WELLINGTON CHANNEL
RADSTOCK BAY
MAXWELL BAY
LANCASTER SOUND
BARROW STRAIT
SOMERSET ISLAND
PRINCE REGENT INLET
RESOLUTE PASSAGE
GRIFFITH ISLAND
PRINCE LEOPOLD ISLAND
Resolute Bay
C. SPENCER
C. HURD
C. EARDLEY WILMOT
C. HOTHAM
EREBUS BAY
W 89 00
90 00
91 00
92 00
93 00
94 00
95 00
74 30
N 74 00
A-9-1
STELTNER
DEV. & MFG. CO. LTD.
ST. CATHARINES
ONTARIO
project 71-12
depth in fathoms
T-S LOCATIONS
for study of currents and ice movements
sources:
Bailey, J.F.R.B. Can. 14(5)57
cr. no. 57244 C.O.D.C. 57
" " 60340 " 60
" " 61341 " 61
" " 62359 " 62





See chart A-9-1 for reference ①

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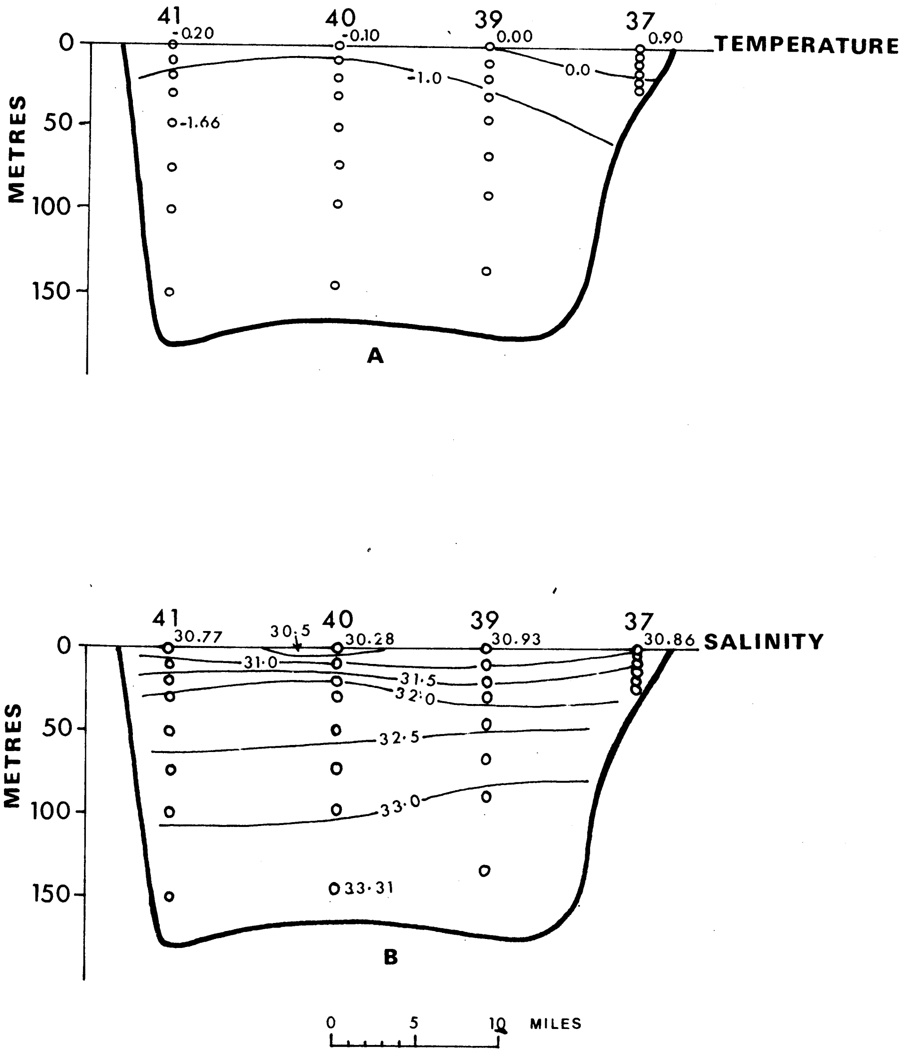
A-9-2



See chart A-9-1 for reference

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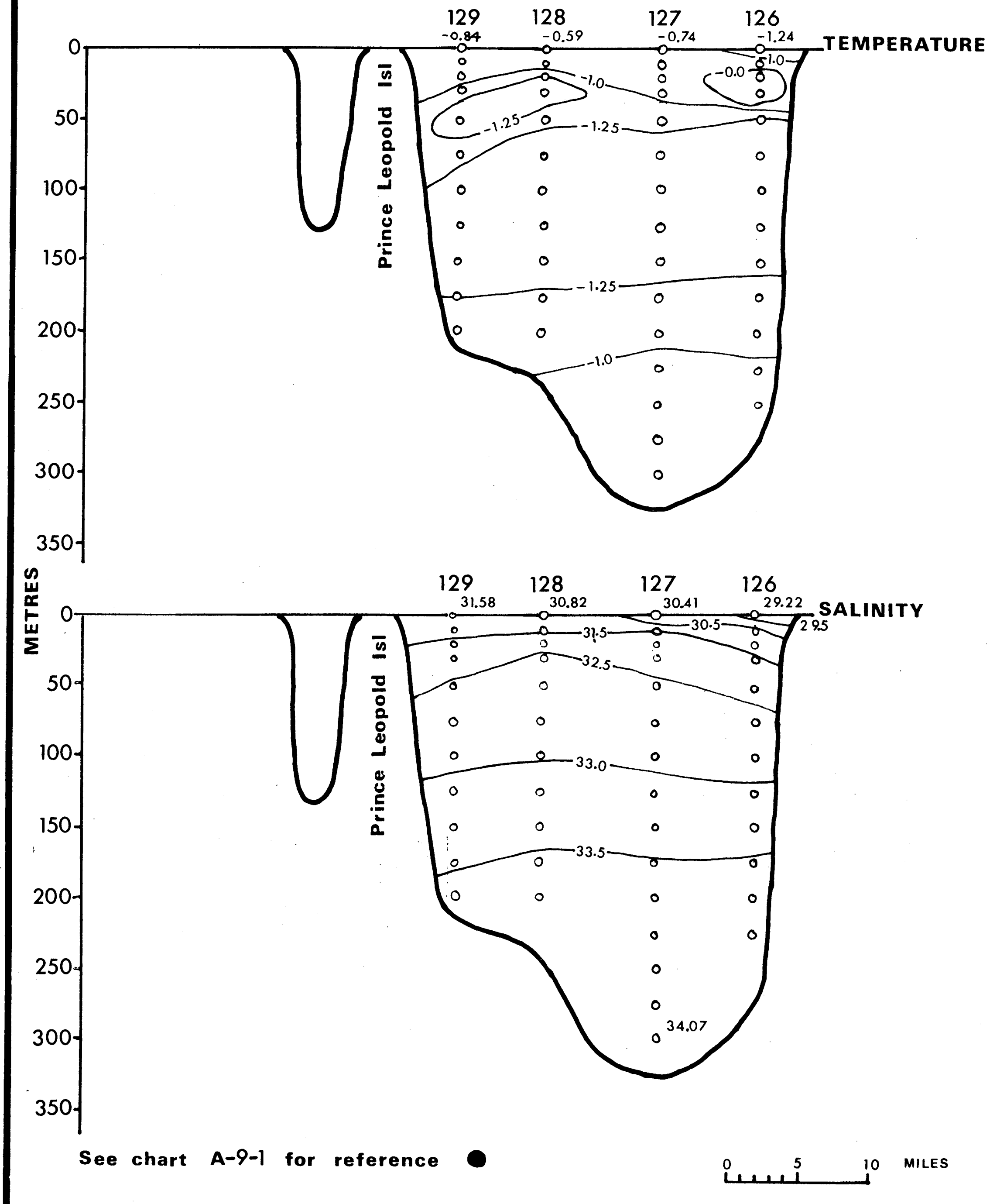
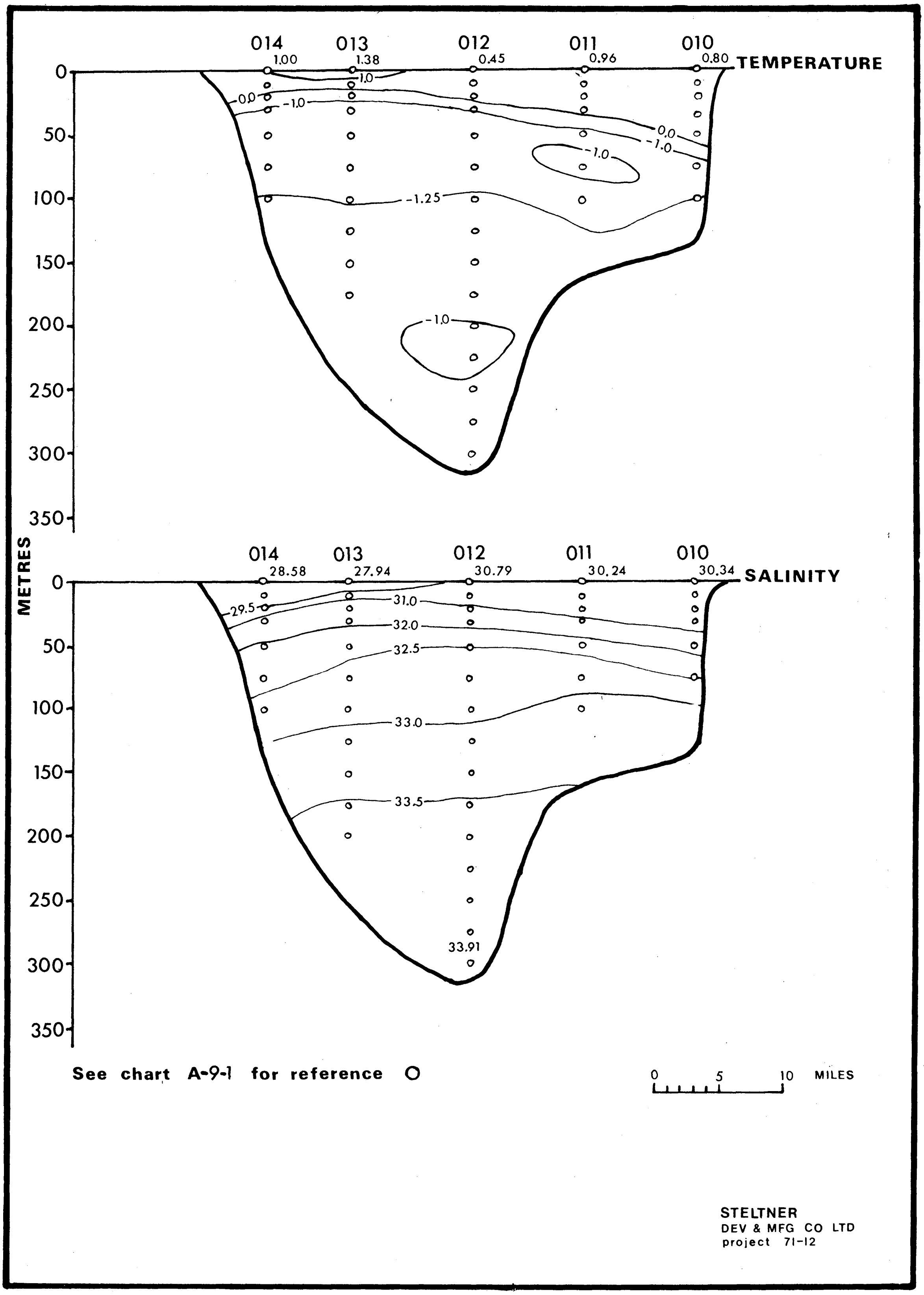
A-9-3



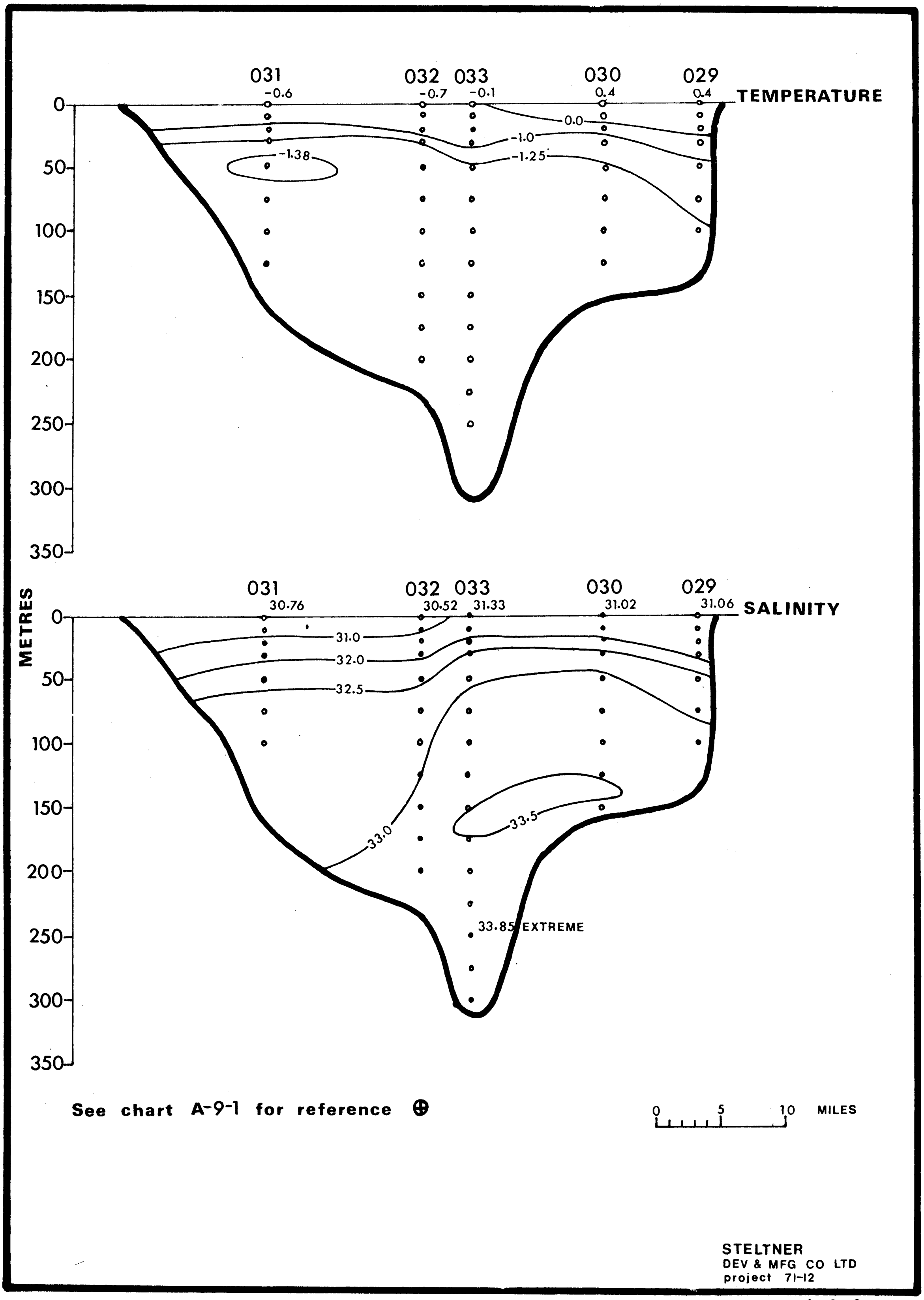
STELTNER
DEV & MFG CO LTD
project 71-12

A-9-4



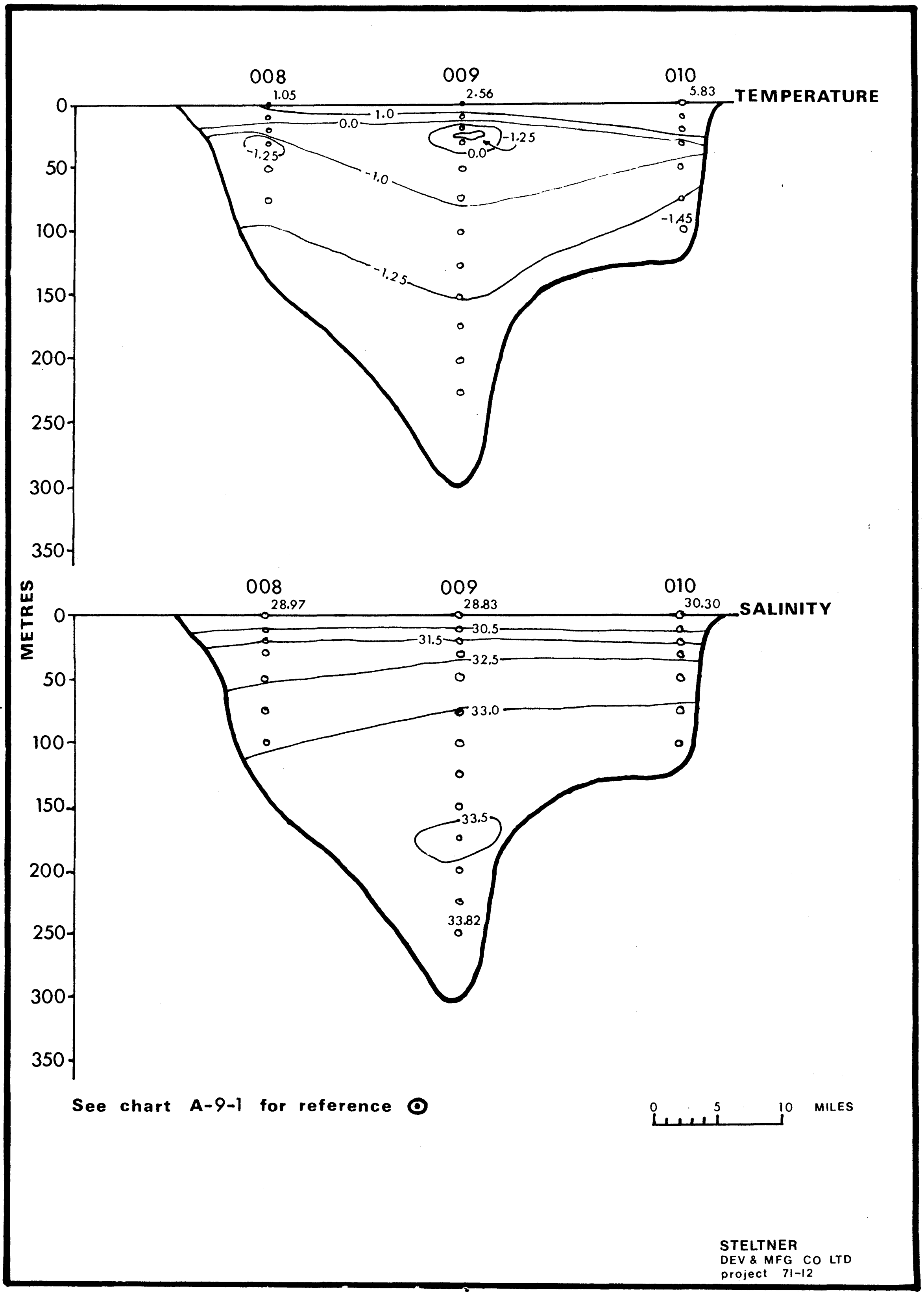
014
013
012
011
010
1.00
1.38
0.45
0.96
0.80
TEMPERATURE
0
50
100
150
200
250
300
350
1.0
0.0
-1.0
-1.25
-1.0
METRES
014
013
012
011
010
28.58
27.94
30.79
30.24
30.34
SALINITY
29.5
31.0
32.0
32.5
33.0
33.5
33.91
See chart A-9-1 for reference O
0 5 10 MILES
STELTNER
DEV & MFG CO LTD
project 71-12

A-9-5

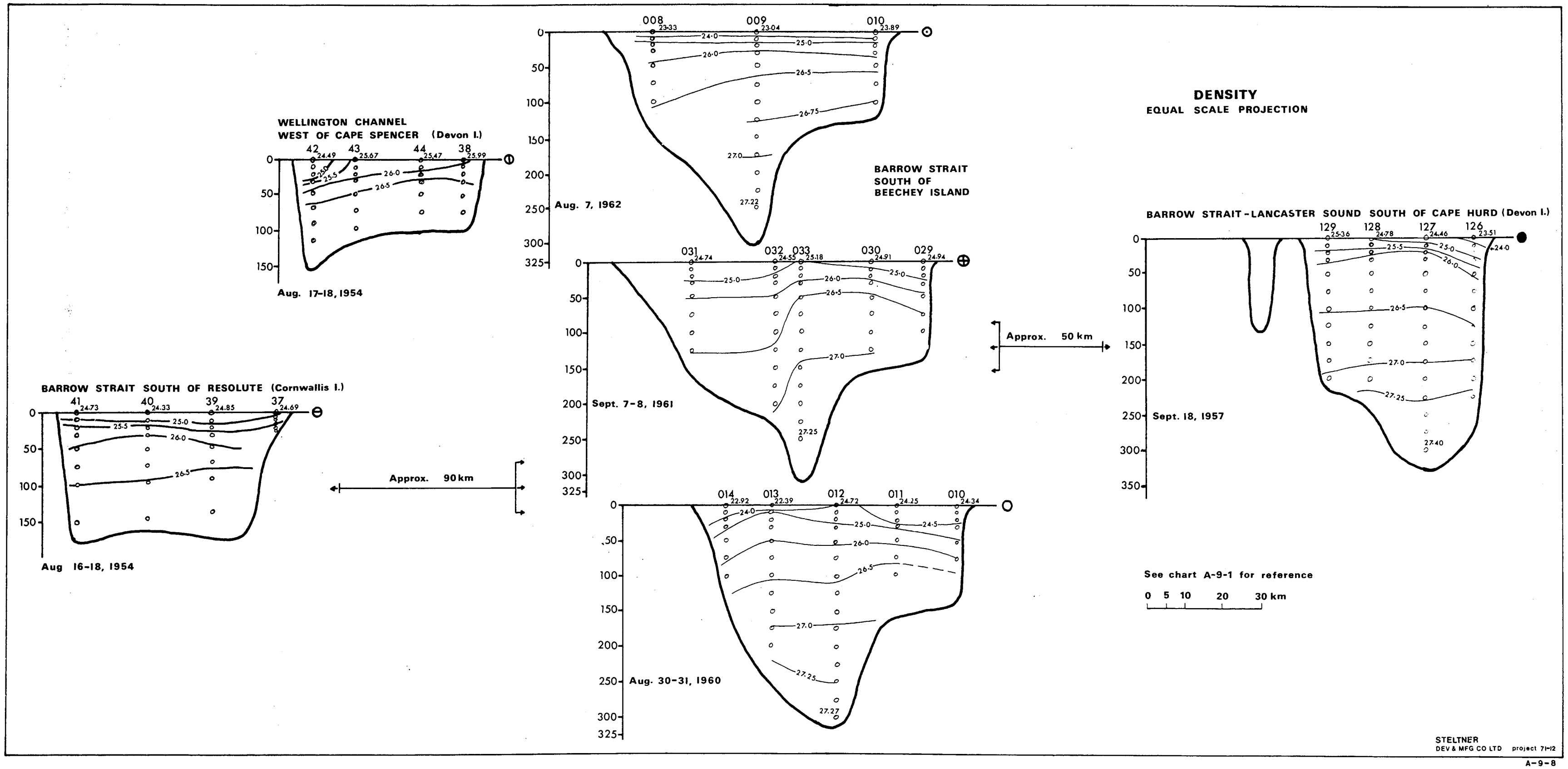


031
032
033
030
029
-0.6
-0.7
-0.1
0.4
0.4
TEMPERATURE
0.0
-1.0
-1.25
-1.38
0
50
100
150
200
250
300
350
METRES
30.76
30.52
31.33
31.02
31.06
SALINITY
31.0
32.0
32.5
33.0
33.5
33.85 EXTREME
See chart A-9-1 for reference ⊕
0 5 10 MILES
STELTNER
DEV & MFG CO LTD
project 71-12

A-9-6


008
009
010
TEMPERATURE
1.05
2.56
5.83
1.0
0.0
-1.25
0.0
-1.25
-1.0
-1.45
-1.25
METRES
0
50
100
150
200
250
300
350
SALINITY
28.97
28.83
30.30
30.5
31.5
32.5
33.0
33.5
33.82
See chart A-9-1 for reference
0 5 10 MILES
STELTNER
DEV & MFG CO LTD
project 71-12

A-9-7



DENSITY
EQUAL SCALE PROJECTION
WELLINGTON CHANNEL
WEST OF CAPE SPENCER (Devon I.)
Aug. 17-18, 1954
BARROW STRAIT SOUTH OF RESOLUTE (Cornwallis I.)
Aug 16-18, 1954
Approx. 90 km
BARROW STRAIT
SOUTH OF
BEECHEY ISLAND
Aug. 7, 1962
Sept. 7-8, 1961
Aug. 30-31, 1960
Approx. 50 km
BARROW STRAIT - LANCASTER SOUND SOUTH OF CAPE HURD (Devon I.)
Sept. 18, 1957
See chart A-9-1 for reference
0 5 10 20 30 km
STELTNER
DEV & MFG CO LTD project 71-12
A-9-8

Comments on Isostatic Recovery

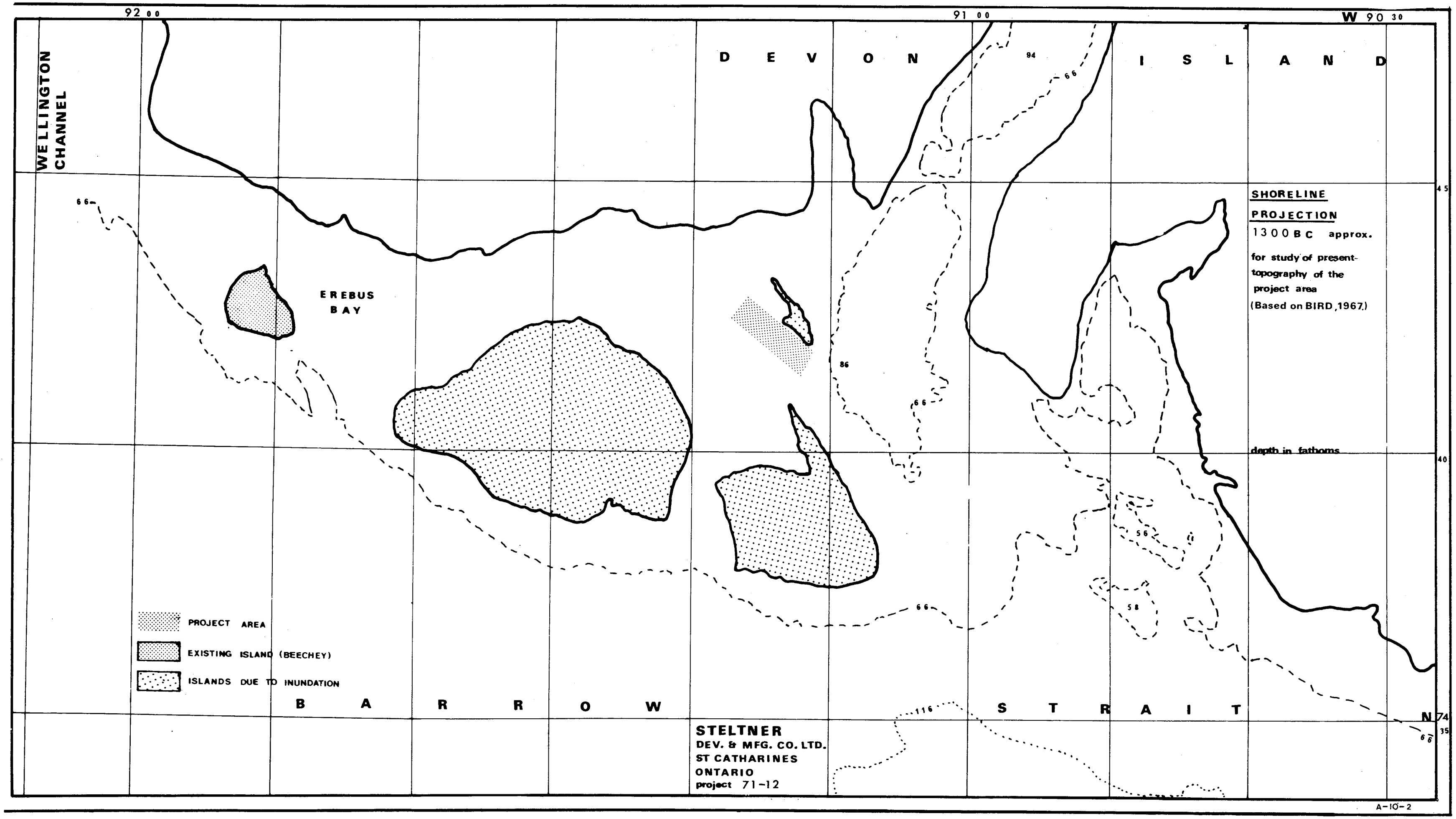
It is attempted with these illustrations to draw the attention of researchers, presumably of several disciplines, to the interesting topographical features of the Gascoyne Inlet - Bear Valley - Caswall Tower area.

Fig. A-10-1 projects a hypothetical state of inundation of this area by 30 m of water above the present level (J. B. Bird - isostatic recovery - 1967).

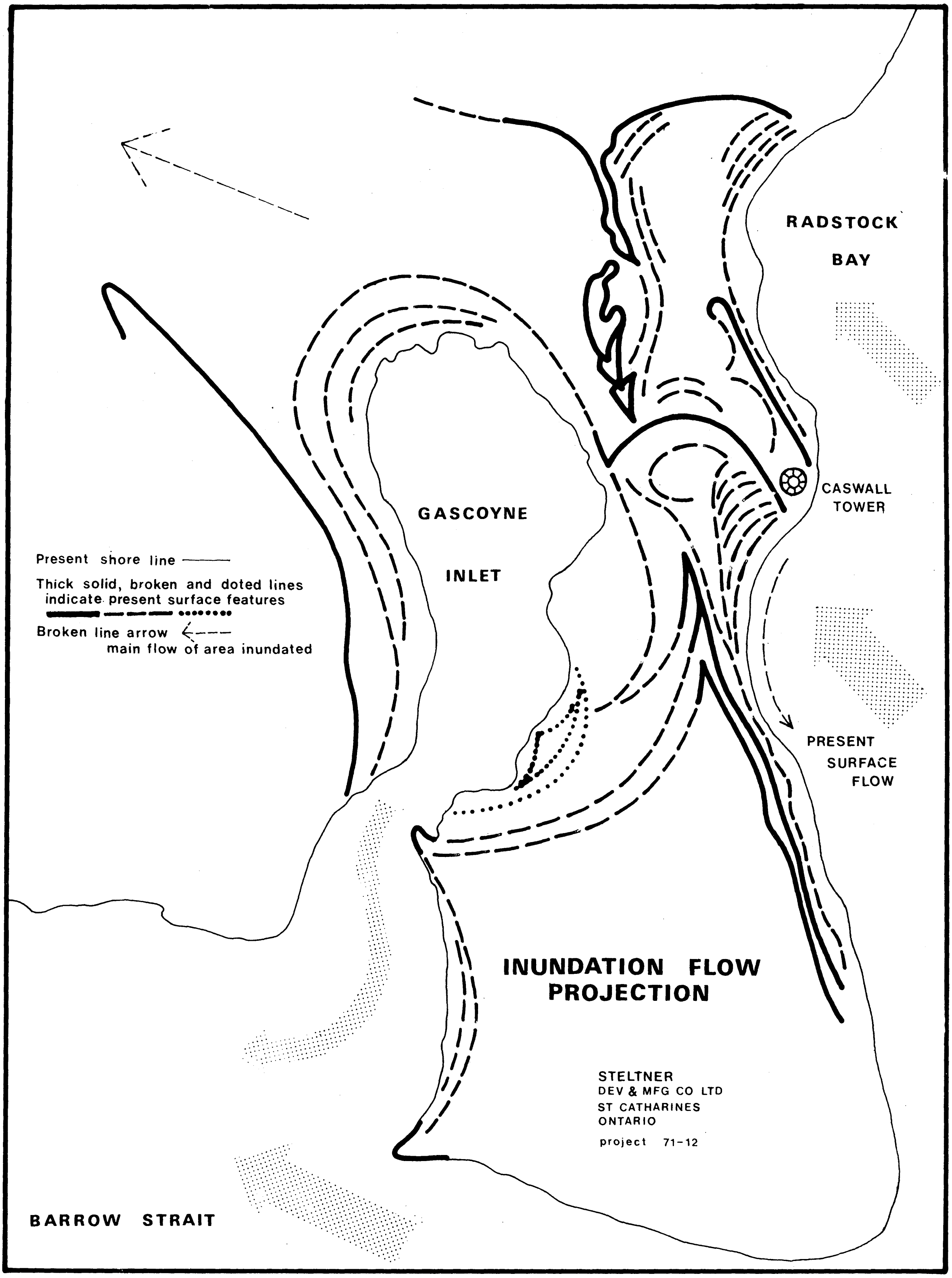
Fig. A-10-2 is an attempt to illustrate a hypothesis that the westerly currents participated in the shaping of the above-mentioned area's topography by first proceeding all the way through to Erebus Bay, later on exiting through the throat of Gascoyne Inlet, and eventually turning in Radstock Bay as appears to be still the case today.

The water transport (and subsequent heat exchange) in this entire area was obviously reduced to quite a degree by the gradual emergence of the land.

Surmising that the currents observed today existed three or four thousand years ago, and esentially had the same direction, it is reasoned that more and relatively warmer water advected into this area resulting in a greater heat exchange from the larger water surface.



92 00
91 00
W 90 30
WELLINGTON CHANNEL
DEVON ISLAND
EREBUS BAY
BARROW STRAIT
SHORELINE PROJECTION
1300 B C approx.
for study of present-topography of the project area
(Based on BIRD, 1967.)
depth in fathoms
PROJECT AREA
EXISTING ISLAND (BEECHEY)
ISLANDS DUE TO INUNDATION
STELTNER
DEV. & MFG. CO. LTD.
ST CATHARINES
ONTARIO
project 71-12
N 74 35
45
40
66
94
86
56
58
116
A-10-2


RADSTOCK BAY
CASWALL TOWER
GASCOYNE INLET
Present shore line
Thick solid, broken and doted lines indicate present surface features
Broken line arrow
main flow of area inundated
PRESENT SURFACE FLOW
INUNDATION FLOW PROJECTION
STELTNER
DEV & MFG CO LTD
ST CATHARINES
ONTARIO
project 71-12
BARROW STRAIT

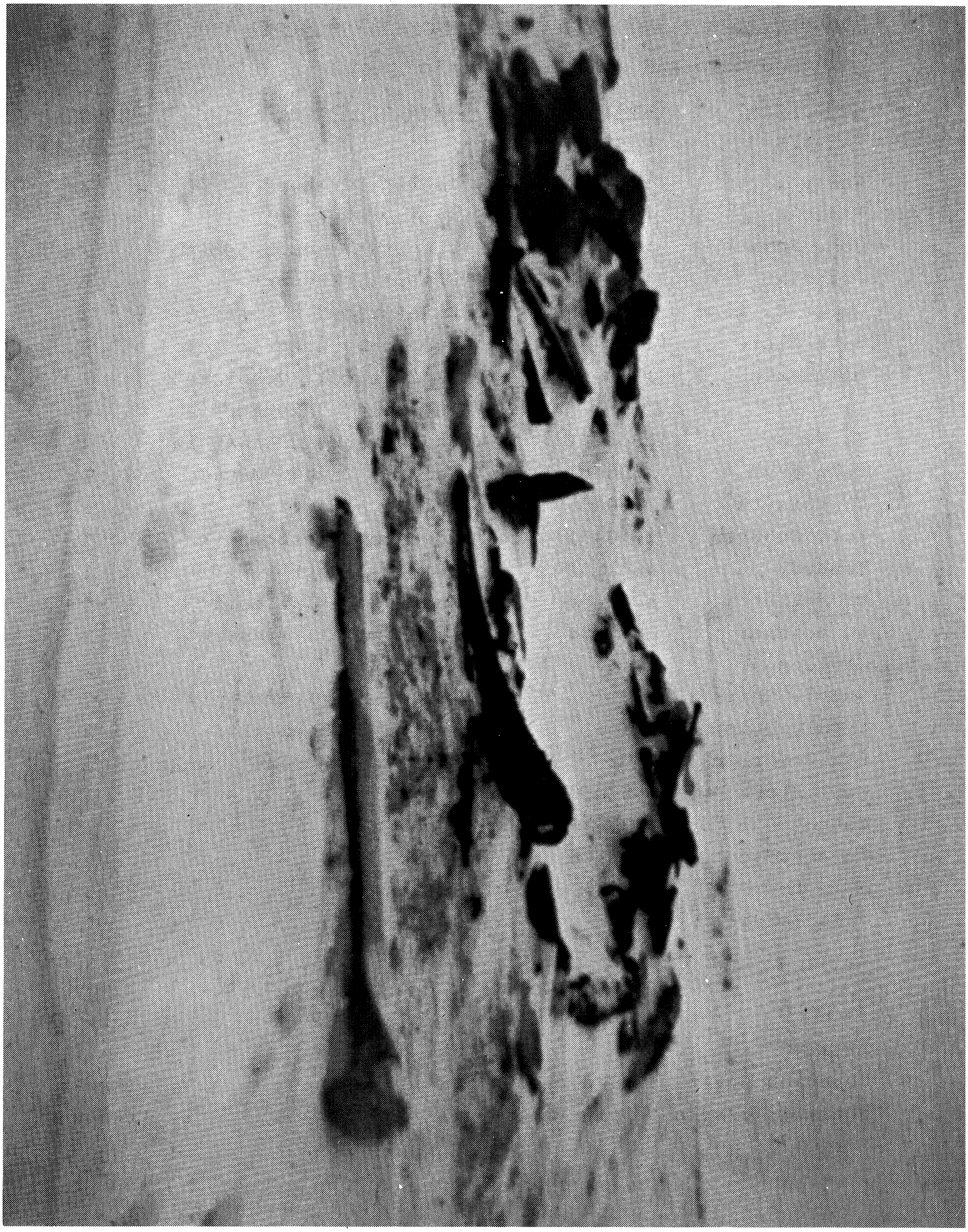
A-10-3

Notes On Ring Sites

In reference to Fig. A-3-4, in area A, six ring sites were observed which, though deteriorated, are still visible. In area B four ring sites were identified, of which three are fairly well preserved. In area C, eleven sites were counted and it is at this location that whale bones and artifacts were found on the surface. We did not further investigate the ring sites, nor did we remove any artifacts. One piece of whale bone was taken along as a specimen for dating and other tests.

In any event, I would strongly recommend that these and other such sites be placed under government protection as historical sites and marked with durable signs, to prevent chance visitors from destroying these remnants before they are properly investigated.

Others visiting the general area of Erebus Bay to Radstock Bay reported ring sites at Erebus Bay and the mouth of Gascoyne Inlet, but precise locations and numbers of ring sites were not established.



A

HISTORIC EVENTS IN AREA

Beechey Island and Southwest Devon Island Area:

-moorings and shelters of ships.

Commander Or Capt.	Expedition Period	Names of Ships	Number Of Ships
Parry	1818-20	"Hecla" "Griper"	2
Parry	1824-25	"Hecla" "Fury"	2
John Ross	1829-33	"Victory" "supply ship"	2
Franklin	1845-	"Erebus" "Terror"	2
James C. Ross	1848-49	"Enterprise" "Investigator"	2
R. McClure	(1850-54)	crew only after rescue	
H. Austin	1850-52	"Assistance" "Resolute"	
		"Intrepid" "Pioneer"	4
W. Penny	1850-52	"Lady Franklin" "Sophia"	2
John Ross	1850-51	"Felix", Yacht "Mary"	2
C. Forsyth	1850	"Prince Albert"	1
E.D. DeHaven	1850-51	"Advance" "Rescue"	2
Kennedy	1851-52	"Prince Albert"	1
H. Kellet	1852-54	"Resolute" "Intrepid"	2
E. Belcher	1852-54	"Assistance" "Pioneer"	2
(Pullen)		"North Star"	1
Supply Ships	1853	"Breadalbane" "Phoenix"	2
Supply Ships	1854	"Talbot" "Phoenix"	2
Dr. McCormick	1852	in a "whale boat"	1
McClintock	1857-59	"Fox"	1
Young	1875-76	"Pandora"	1
R. Amundsen	1903-06	"Gjoa"	1
A.P. Low	1904	"Neptune"	1
J.E. Bernier	1906 first time "...returning many times since. . ."	"Arctic"	1
Larsen	1944	"St. Roch"	1
Canadian Gov't.	1922 (about)		Unknown
Whaling Vessels	-1910 (about)		Unknown

Dr. Hans R. Kivisild Foundation of Canada Engineering Corporation Limited Toronto, Canada

Mr. Chairman, Ladies and Gentlemen,

To open the discussions on interaction between ice and structures, I would like to review the use of data on ice properties in obtaining engineering criteria.

There are several vital aspects of ice action on structures. Ice may erode exposed faces through wear. Local pressures may be high enough to damage exposed members. Individual concentrated loads may break structural elements. The total thrust from an ice floe or an ice sheet may cause the collapse of the structure. A rising ice sheet may pull out piles and other substructure members. The weight of ice bustles may result in severe loads.

Various properties of ice govern each of these phases of the ice action depending on the shape and size of the structure in contact with ice.

In a collision of an ice floe of a limited size and moderate velocity, plastic effects may be limited to local crushing in the ice, with no full face failures in either the structure or in the ice floe. In this case the collision forces will depend partly on the ability of the ice face to distribute load and largely on the elasticity of ice and the structure.

There are various shapes of elements which cause the failure of an ice sheet in bending. A thrust limited by this type of failure is governed largely by the tensile strength of ice, although shearing forces also play an important role in local effects.

The maximum contact pressures between an ice sheet and a structure depend on the support capacity of the face of ice under the concentrated force spread over a limited area. For this kind of loading an analysis could be carried out which is similar to geotechnical bearing pressure calculations.

There are a number of effects such as point loads, line loads and uniform pressure on a fully aligned ice sheet which all depend on the strength of ice in uniaxial compression in plane strain conditions.

In all these cases the total effect depends on the rate of loading in addition to the shape and size factors mentioned above. It is very costly and nearly impossible to cover by full size tests the range of conditions that should be considered in engineering. Therefore it is important to understand the rheology of ice and to develop a system whereby small scale results can be interpreted to yield data for full scale action.

In the meeting at this conference in sessions on properties of ice and on the interaction between ice and structures such methods were given for different aspects in various papers such as "Ice Forces on an Isolated Circular Pile" by R. Frederking, and L.W. Gold; "Forces in Moving Ice Fields", By A. Assur; "An Arctic Ice Model Basin-Design, Construction, and Operating Experience", by R.Y. Edwards Jr., J.W. Lewis and D.L. Benze; "The Interpretation of Small Scale Strength Data for Ice", by K.R. Maser; and "Large Deformation, Dynamic, Plane Stress Analysis of Ice Structure Interaction" by G.S. Sidhu, S. Hanagud and B. Ross.

There were also important portions of other papers dealing with the same matter.

We may conclude that knowledge is being accumulated to explain past experience and to forecast the anticipated action of various ice formations on structures.

May I forecast that the next step in the gathering of engineering data on ice will be the development of methods for the direct measurement of ice properties such as elastic properties, shear strength, tensile strength, compressive strength, support capacity, and plastic flow parameters in the field, with evaluation of the influence of tensile and compressive prestress, temperature effects and other relevant factors.