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SPECIAL PUBLICATION

REPORT OF THE ARCTIC ICE OBSERVING
AND FORECASTING PROGRAM—1963

*Forecasting Branch
Oceanographic Prediction Division*

MAY 1965



U. S. NAVAL OCEANOGRAPHIC OFFICE
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A B S T R A C T

The ice program conducted by the Oceanographic Office principally in support of 1963 MSTs Arctic Operations is covered by this report. Methods of collection and dissemination of ice data, ice forecasting, forecast verification, and various allied ice projects are discussed. A summary of ice conditions in the North American Arctic is given graphically for 6-day periods from January through December.

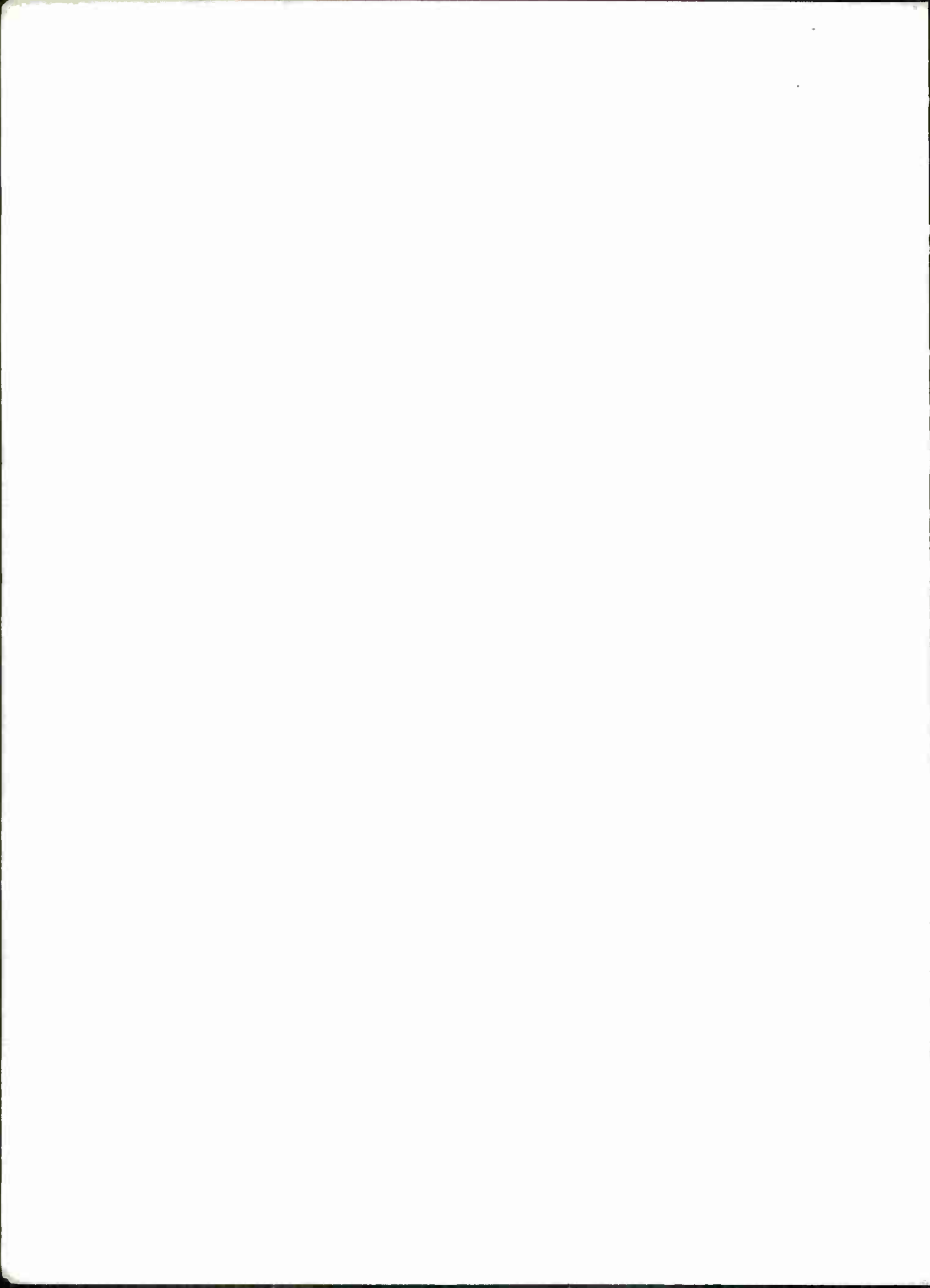
FOREWORD

This publication is the twelfth in a series of annual reports on ice observing and forecasting programs conducted by the Oceanographic Office. These programs, in addition to providing direct support to resupply operations conducted by the Military Sea Transportation Service, have provided a comprehensive collection of ice information.

This historical information, accumulated primarily by aerial reconnaissance, has not only been extremely valuable in preparation of ice forecasts but is necessary to the overall efficient planning and successful execution of Arctic operations.



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CONTENTS

Page

FOREWORD	111
FIGURES	vi
TABLES	v

PART I - EASTERN ARCTIC

1. General	1
2. Ice Forecasting	1
a. Long-Range Ice Outlook	1
b. Thirty-Day Ice Forecasts	1
c. Short-Range Ice Forecasts	1
d. Ship Ice Routes	5
e. Special Briefings	5
3. Ice Reconnaissance	5
4. Communications	7
5. Supporting Projects	7
a. Oceanography	7
b. SUBICEX 1-63	7
c. USCGC EVERGREEN	7
d. Project BIRDS EYE	7
6. Observed Ice Conditions	9

PART II - WESTERN ARCTIC

1. General	11
2. Ice Forecasting	11
a. Long-Range Outlook	11
b. Short- and Long-Range Ice Forecasts	11
3. Ice Reconnaissance	11
4. Communications	11
5. Supporting Projects	13
a. USCGC NORTHWIND	13
b. USS STATEN ISLAND	13
6. Observed Ice Conditions	13

APPENDIXES

Appendix A. Eastern Arctic Ice Charts	17
Appendix B. Danish Ice Reconnaissance Charts	77
Appendix C. Western Arctic Ice Charts	149

TABLES

Table 1. Long-Range Ice Outlook Verification	9
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FIGURES

Page

1. Ice Forecast Sectors	2
2. Place Name Chart	3
3. Summary of Ice Forecasts for Eastern and Western Arctic - 1963 . .	4
4. Summary of 1963 Aerial Ice Reconnaissance, Eastern Arctic	6
5. Oceanographic Stations Taken by USS ATKA (AGB-3), Eastern Arctic, May - June 1963	6
6. Oceanographic Stations Taken by USS EDISTO (AGB-2), Eastern Arctic, July - August 1963	8
7. Oceanographic Stations Taken by CCGC LABRADOR, September - October 1963	8
8. Summary of 1963 BIRDSEYE Aerial Ice Reconnaissance	10
9. Summary of 1963 Aerial Ice Reconnaissance, Western Arctic	10
10. Oceanographic Stations Taken by USCGC NORTHWIND (WAGB-2), Western Arctic, August - September 1963	12

PART I - EASTERN ARCTIC

1. General

The ice forecasting and observing program, designed to support Military Sea Transportation Service (MSTS) resupply operations in the Eastern Arctic during 1963, was conducted by the U.S. Naval Oceanographic Office (NAVOCEANO). The major geographic areas and forecast sectors into which the North American Arctic has been divided for purposes of this study are shown in figure 1. As in past years, MSTS, the Canadian Department of Transport (DOT), and commercial shipping companies conducted resupply operations in the eastern, central, and western areas (figure 1), respectively. Place names referred to in the text are presented in figure 2.

2. Ice Forecasting

The various phases of the overall ice forecasting program in support of MSTS Eastern Arctic resupply operations were coordinated by NAVOCEANO.

a. Long-Range Ice Outlook

The Long-Range Ice Outlook, Eastern Arctic, published during April 1963, was designed to give MSTS a general picture of expected ice conditions during the resupply season. In addition to being distributed to all cognizant commands, the Long-Range Outlook was presented at formal briefings to COMSTS and COMSTSLANTAREA. Forecasts of ice disintegration and opening dates were based on climatic and oceanographic factors affecting ice conditions during the previous fall and winter, a study of similar historical data along with a comprehensive aerial survey of ice conditions from 15 to 25 March, and the latest 30-day weather forecast issued by the U.S. Weather Bureau. Opening dates were determined by estimating times when ice concentrations would permit ships to enter various ports with and without icebreaker escort. Historical freezeup dates and iceberg information were also included in the Outlook.

b. Thirty-Day Ice Forecasts

These long-range forecasts, issued from NAVOCEANO, began on 20 May and continued until 20 November. These forecasts were revisions of the Long-Range Outlook based on aerial ice reconnaissance, historical ice information, and the Weather Bureau 30-day outlooks. Forecasts made later in the season contained freezeup information.

c. Short-Range Ice Forecasts

The 5-day forecasts from NAVOCEANO began on 28 May. From 10 June until 25 July, 48-hour and 5-day forecasts were prepared at the NAVOCEANO ice forecast facility in Argentia. The 48-hour forecasts were issued daily by radioteletype, and the 5-day forecasts were issued three times a week

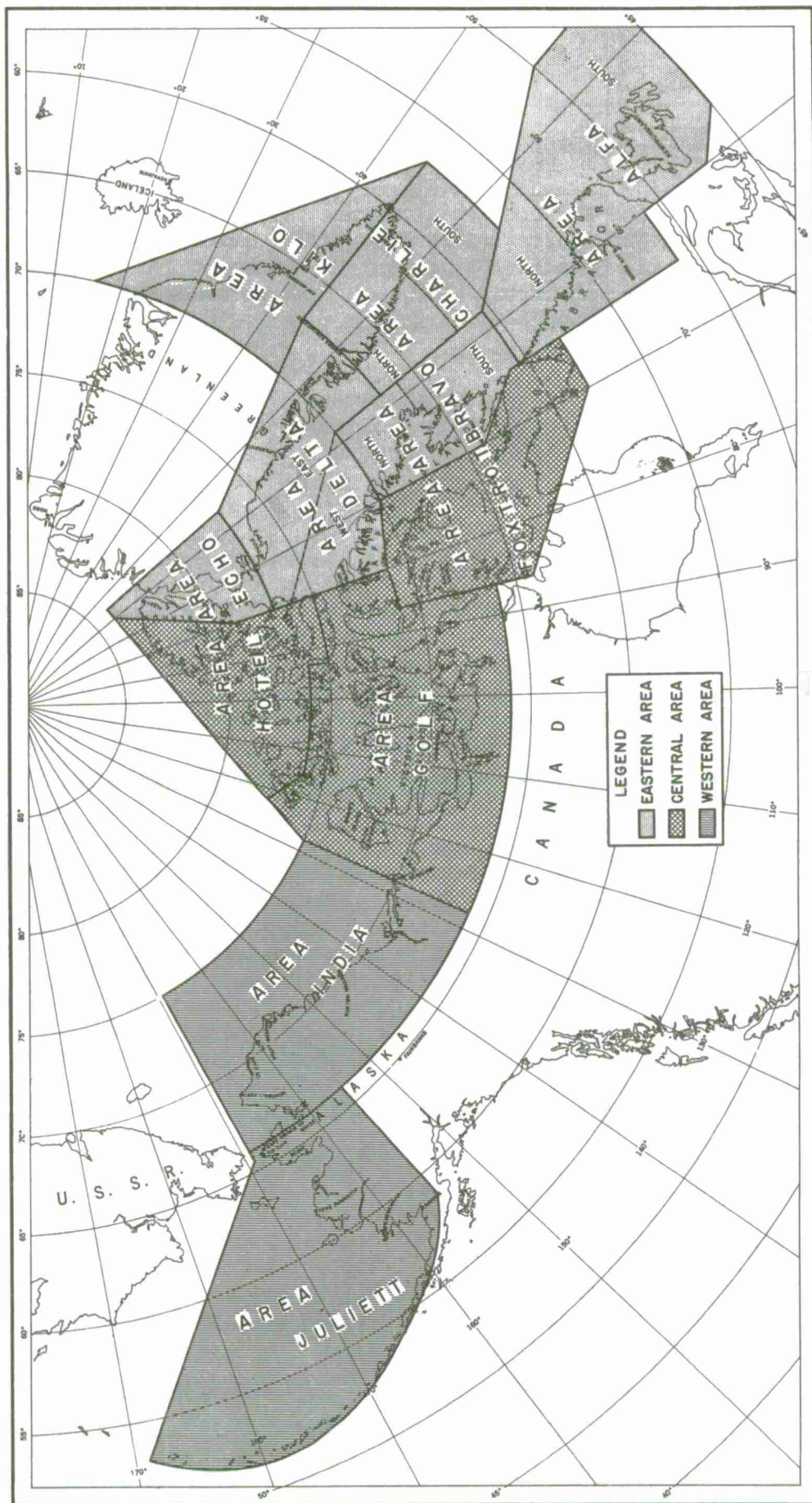
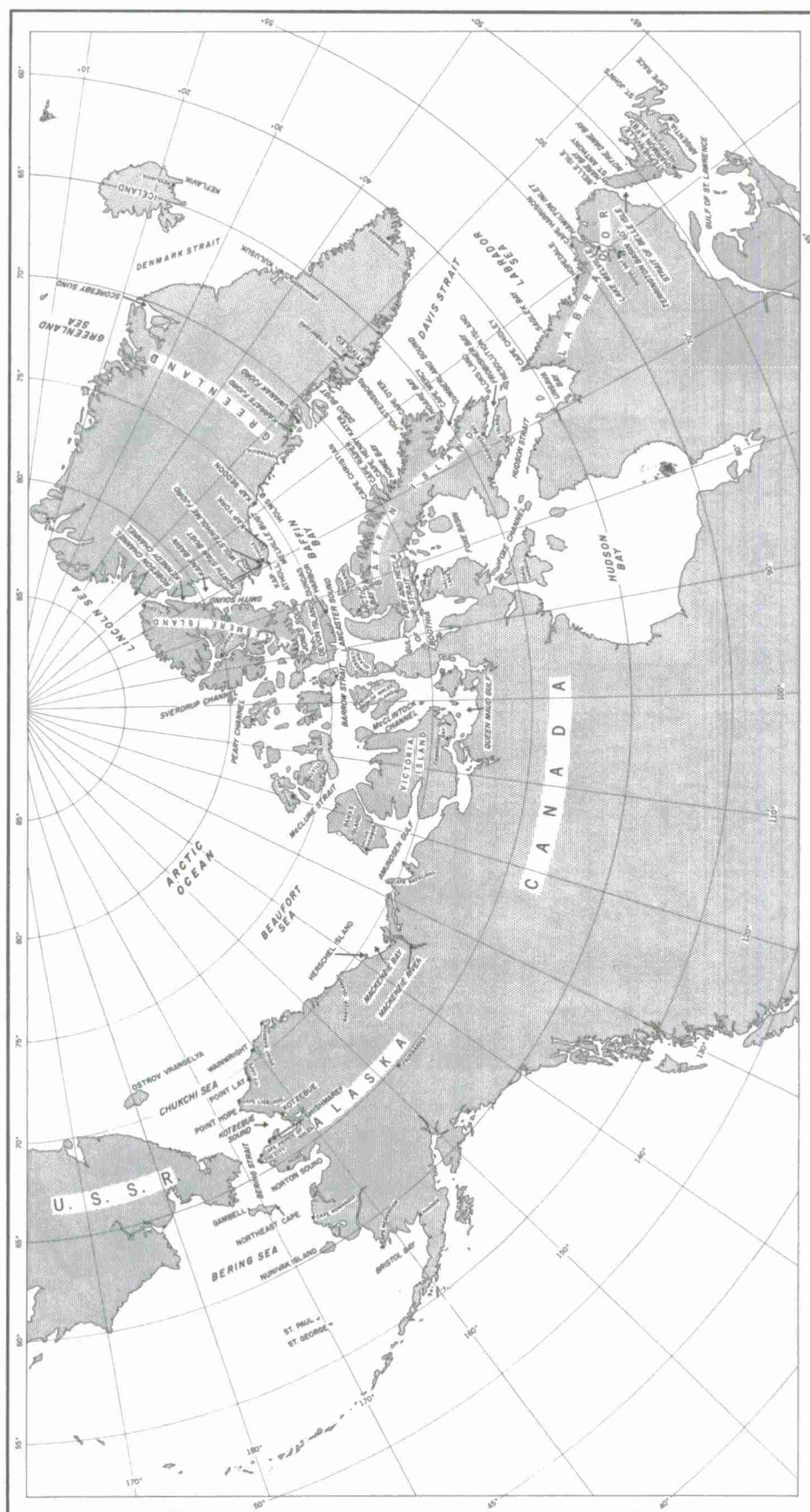


FIGURE 1 ICE FORECAST SECTORS



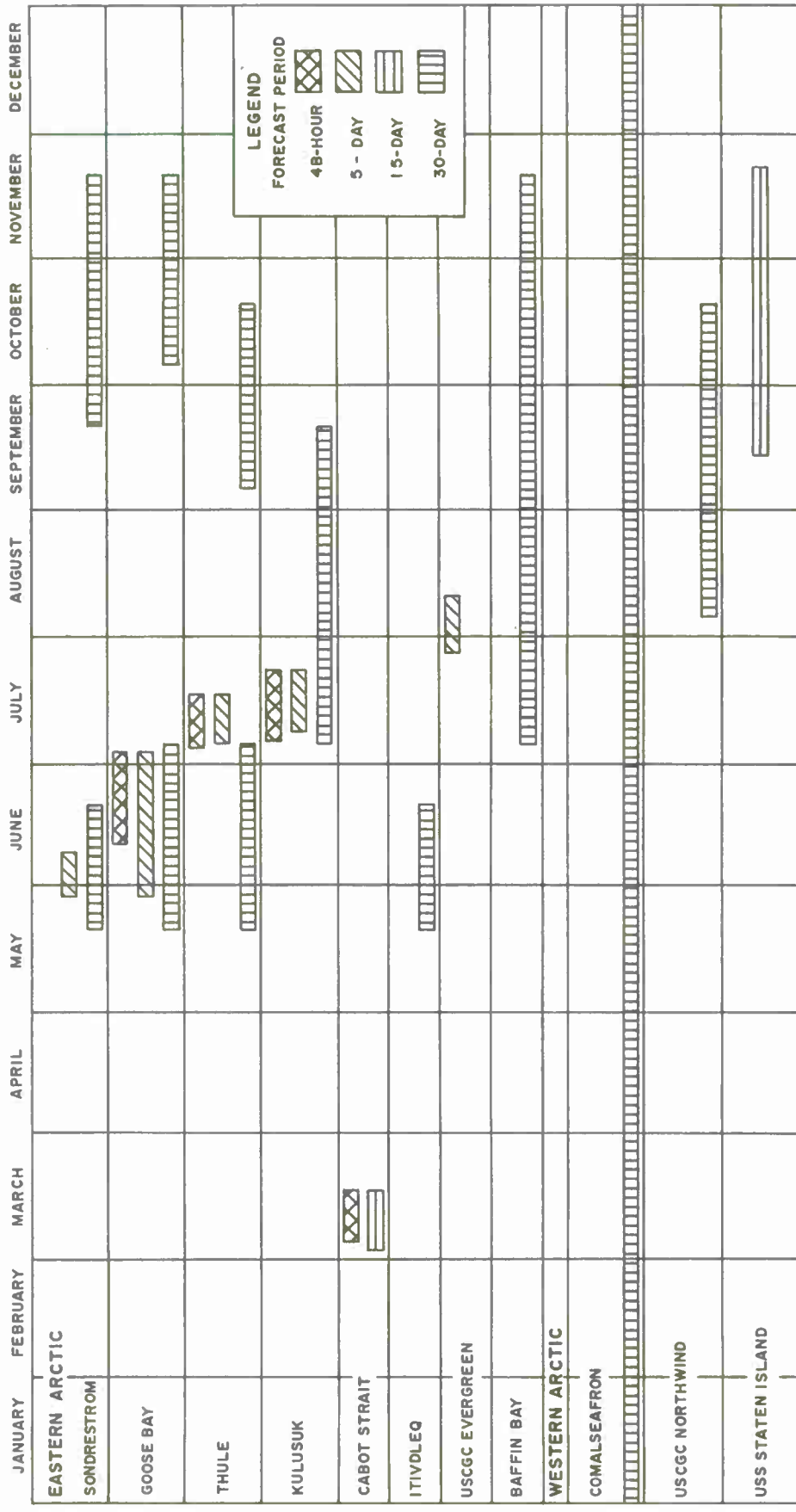


FIGURE 3 SUMMARY OF ICE FORECASTS FOR EASTERN AND WESTERN ARCTIC—1963

as 3-day outlooks appended to the daily forecasts.

Charts of observed and 48-hour prognostic ice conditions were transmitted by radio facsimile. These charts provided tactical support to ships engaged in resupply operations and presented areas of optimum ice navigation. Ice forecasts for both the eastern and western Arctic are summarized in figure 3.

d. Ship Ice Routes

As in previous years, ship ice routing service was provided from NAVOCEANO and the field station in Argentina. Routings were prepared for ships from the continental United States (CONUS) to Arctic ports and return and for intra-Arctic operations. Within the Arctic, routes terminated where icebreaker escort was provided.

Routes above 45°N included areas of significant sea ice and iceberg concentrations, whereas routes south of 45°N were primarily affected by weather.

The ice forecaster monitored all routed ships and recommended necessary route changes. The ships in turn transmitted daily situation reports (SITREPS) to the ice forecast facility.

From 6 May to 13 November, NAVOCEANO and Argentina issued a total of 114 ship ice routes.

e. Special Briefings

At various times during the operation of the Argentina Ice Forecast Facility, special briefings on Arctic ice conditions were given to personnel of the Argentina Coast Guard Air Detachment, to the Commanding Officer of the USCGC EVERGREEN, and to the Naval Weather Service.

3. Ice Reconnaissance

Aerial ice reconnaissance during the 1963 resupply season was provided primarily by SP2E aircraft patrol squadrons stationed at Argentina and Keflavik. These aircraft conducted long-range ice reconnaissance of the eastern Arctic.

Immediate tactical support was provided by icebreaker-based helicopters which made local ice observations. Ice reconnaissance on initial and terminal legs of BIRDS EYE flights supplemented the ice data gathered on SP2E flights.

Figure 4 shows the numbers of hours flown and numbers of flights made over each eastern sector during each month of 1963 as well as the monthly and annual totals. Figure 4 includes data gathered by the U.S. Coast Guard flights as well as those portions of the Canadian reconnaissance flown over the U.S. operational areas. Not included in figure 4 is a large portion

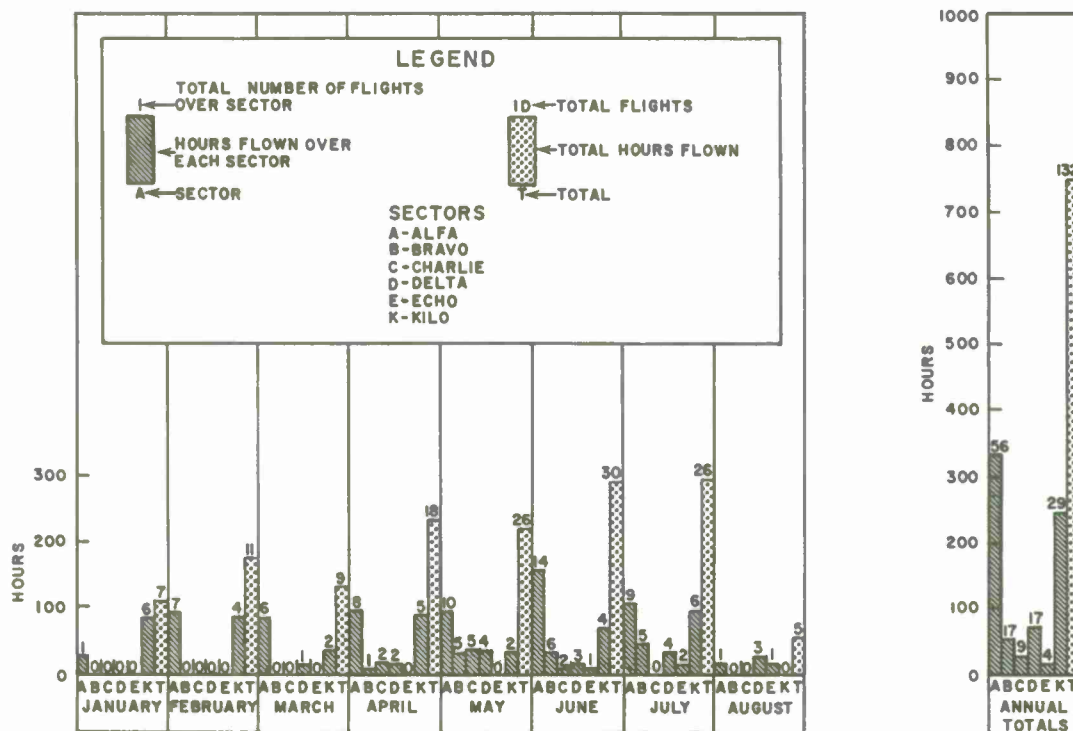


FIGURE 4 SUMMARY OF 1963 AERIAL ICE RECONNAISSANCE, EASTERN ARCTIC

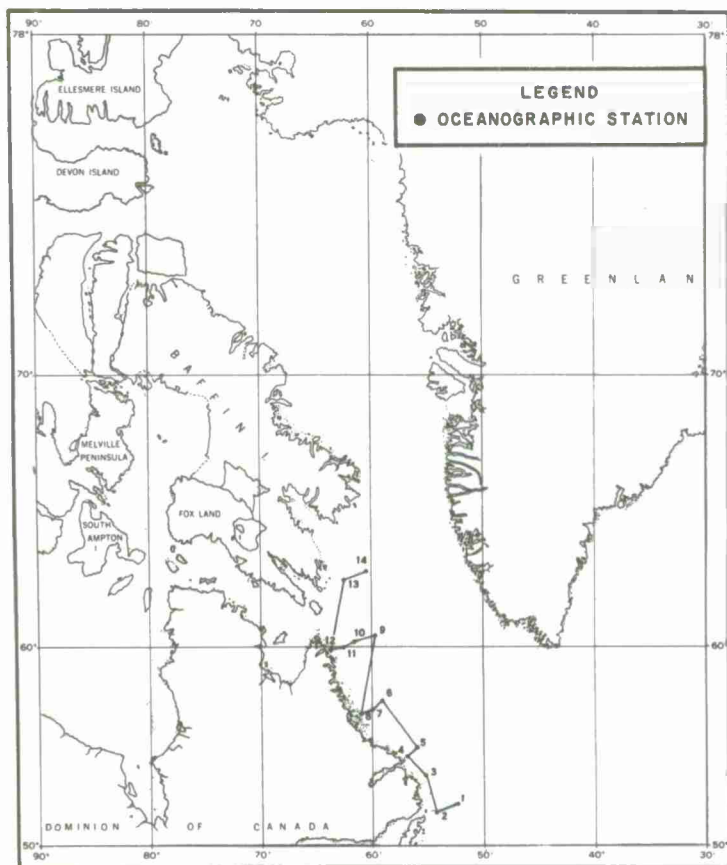


FIGURE 5 OCEANOGRAPHIC STATIONS TAKEN BY USS ATKA (AGB-3), EASTERN ARCTIC, MAY-JUNE 1963

of the reconnaissance over sector KIL0 that was conducted by Danish flights. Although Danish flights were not specifically scheduled for MSTs support, they yielded much useful data.

4. Communications

In addition to the MSTs leased voice and facsimile Arctic network, the communications system also included Navy and Air Force facsimile and radioteletype facilities.

Facsimile ice charts were transmitted from the ice forecast facility to ships and intra-Arctic ports via Goose Bay and Frobisher Bay radio, whereas word messages were transmitted to CONUS and ships by the Navy Communications Center at Argentina.

Ships experienced some difficulty in receiving good facsimile charts both from Goose Bay and Frobisher Bay.

5. Supporting Projects

a. Oceanography

During May and June the USS ATKA occupied 14 oceanographic stations in the Labrador Sea before severe hull damage forced her to retire. The USS EDISTO occupied 103 stations in the Norwegian Sea during July and August. The Canadian icebreaker LABRADOR occupied 131 oceanographic stations in Baffin Bay, Davis Strait, and the Labrador Sea during September and October. These data were used to compute initial ice formation dates and ice thickness estimates for the 1964 Long-Range Outlook. Stations occupied by United States and Canadian ships are presented in figures 5 through 7.

b. SUBICEX 1-63

From 4 to 17 March, NAVOCEANO provided forecasting support to COMSUEBIV 102 which was operating in the vicinity of Cabot Strait. In addition to a 15-day outlook, seven 48-hour forecasts were prepared for this exercise.

c. USCGC EVERGREEN

Ice forecasting support was provided for the EVERGREEN'S survey of the Ward Hunt Ice Island in Kennedy Channel. From 27 July until 10 August, four 5-day forecasts were prepared at NAVOCEANO for the EVERGREEN. The ice island was located at 80°55'N, 67°W on 12 July. The island became dislodged and broke up on 24 July.

d. Project BIRDS EYE

As part of the continuing program of data collection for research and development of ice forecasting techniques, eight BIRDS EYE flights covering

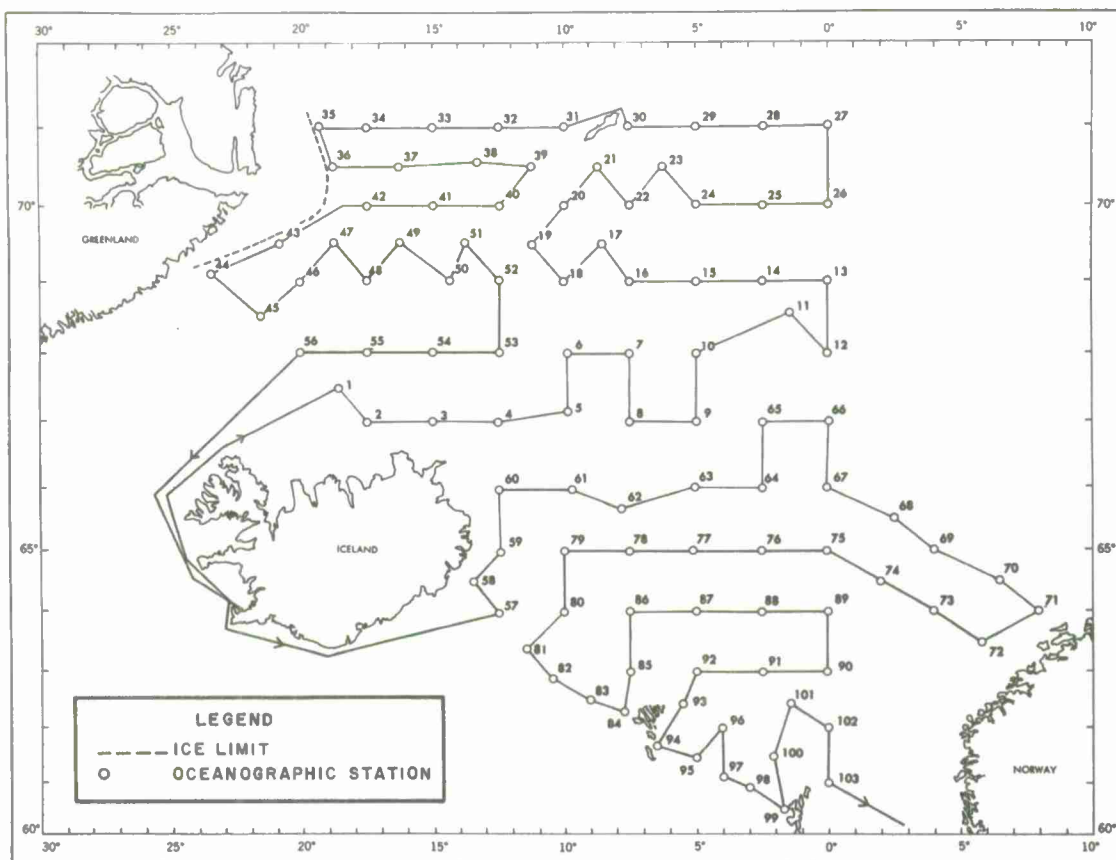


FIGURE 6 OCEANOGRAPHIC STATIONS TAKEN BY USS EDISTO (AGB-2), EASTERN ARCTIC, JULY-AUGUST 1963

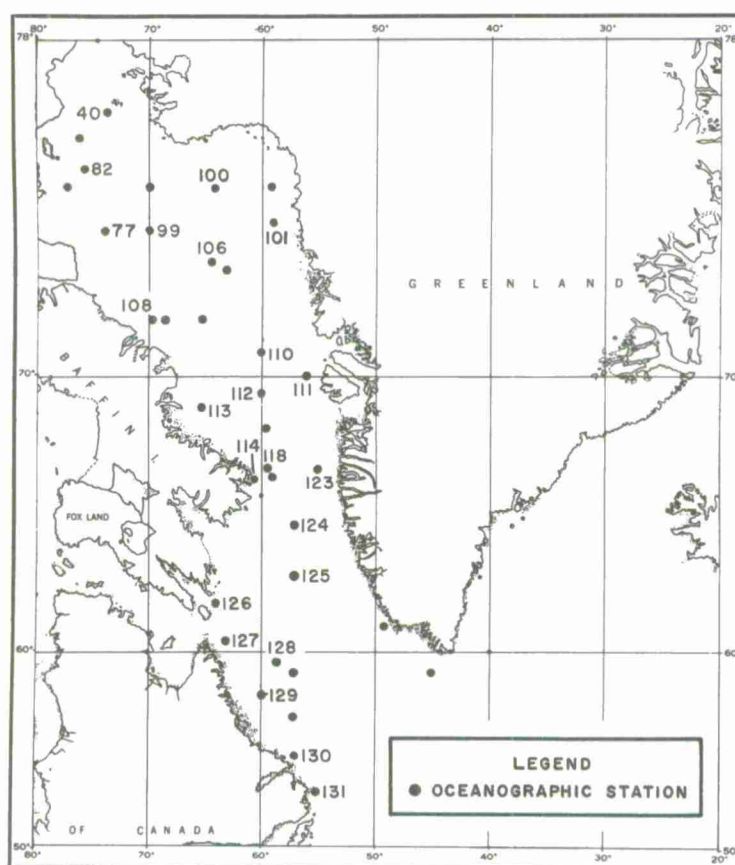


FIGURE 7 OCEANOGRAPHIC STATIONS TAKEN BY CCGC LABRADOR, SEPTEMBER-OCTOBER 1963

a total of 699 hours were conducted primarily over the polar basin during 1963. A summary of BIRDS EYE aerial reconnaissance is shown in figure 8. Data collected on each BIRDS EYE flight are published as special informal reports.

6. Observed Ice Conditions

Ice conditions observed in the eastern North American Arctic are shown in appendix A. The ice data, presented over 6-day periods, were obtained primarily from U.S. aerial ice reconnaissance supplemented by Canadian and Danish reconnaissance. Danish ice reconnaissance charts are presented in appendix B.

The outstanding feature of the ice season was the Ward Hunt Ice Island lodged in Kennedy Channel until late July. The island was first observed in northern Kennedy Channel on 25 February during a BIRDS EYE flight. It subsequently became lodged between Hans and Ellesmere Islands and was closely observed until breakup on 24 July. The ice island acted as a block and resulted in consolidated ice to the north and anomalous open water to ice-free conditions in Kane Basin during most of the season.

Near normal ice conditions existed over most of the eastern Arctic except for Goose Bay. Less than eight-tenths concentration occurred in the Goose Bay approaches about 23 June or about two weeks later than normal. Unescorted entry occurred about 10 days later than normal. Forecast and observed opening dates are shown in table 1.

Opening Dates				
Station	* Escorted		**Unescorted	
	1963 Outlook	Observed	1963 Outlook	Observed
Goose Bay	25 June	23 June	10 July	6 July
Thule	30 June	10 July	15 July	23 July
Kulusuk	20 July	16 July	15 August	15 August
Sondrestrom	25 May	20 May	1 June	8 June
Itivdleq	1 May	Prior 1 May	5 May	Prior 1 June

* <8/10 concentration

** <1/10 concentration

Table 1 Long-Range Ice Outlook Verification 1963

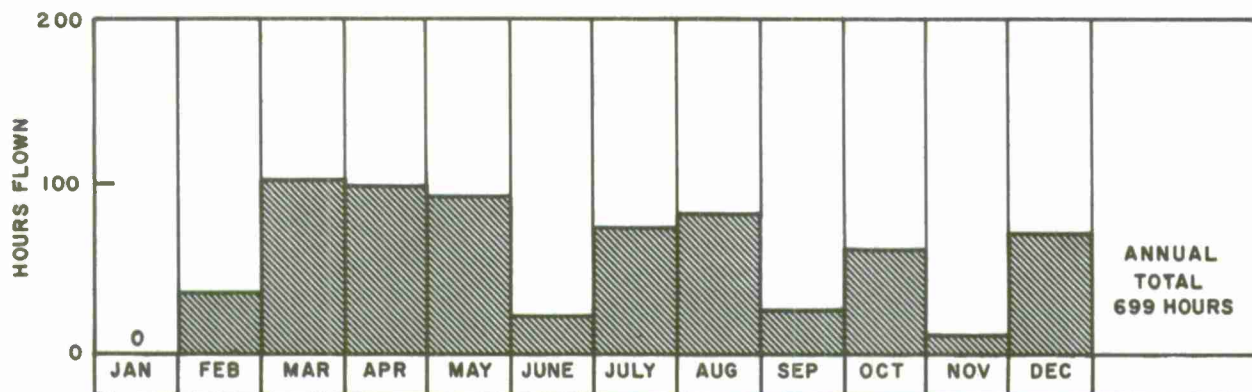


FIGURE 8 SUMMARY OF 1963 BIRDSEYE AERIAL ICE RECONNAISSANCE

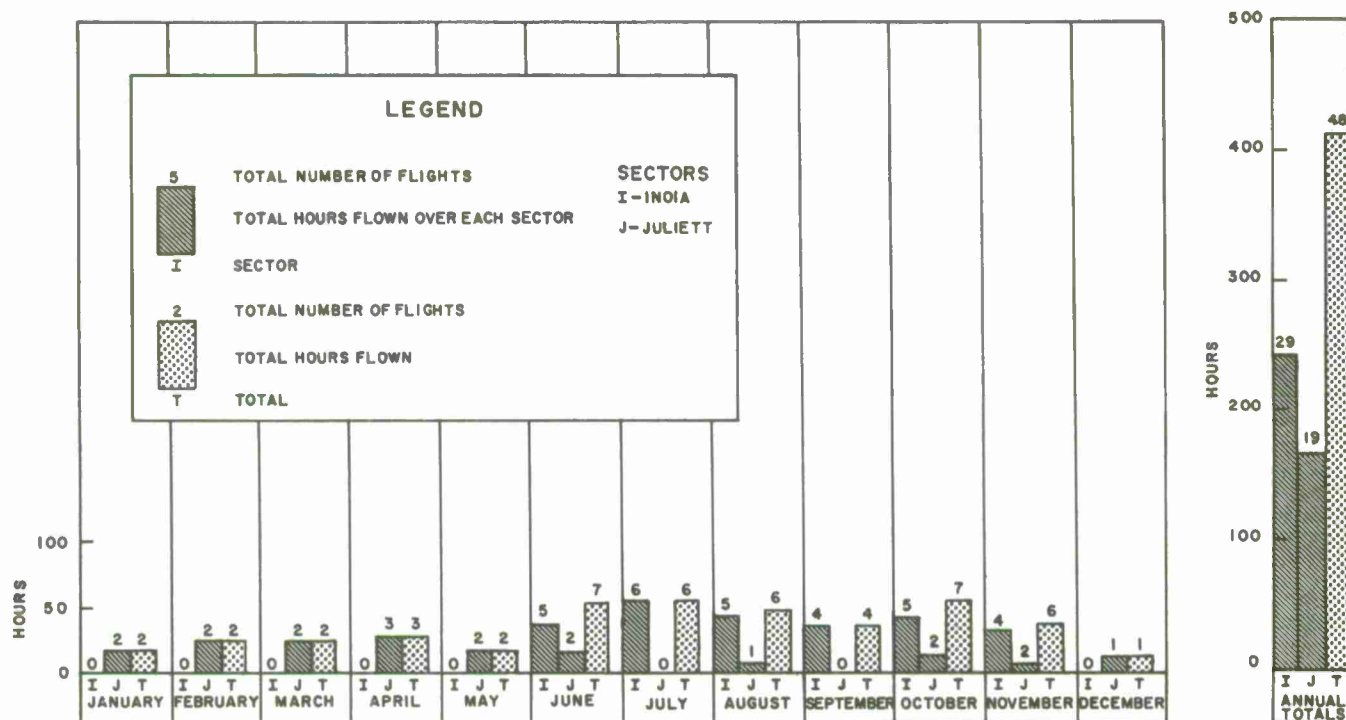


FIGURE 9 SUMMARY OF 1963 AERIAL ICE RECONNAISSANCE, WESTERN ARCTIC

PART II - WESTERN ARCTIC

1. General

Resupply operations were conducted by U.S. and Canadian commercial shipping companies, therefore, ice forecasting and reconnaissance supported military and oceanographic operations.

2. Ice Forecasting

a. Long-Range Outlook

No formal long-range outlook (SP-60 series) was published for the western Arctic in 1963. Only general long-range conditions were described during oral briefings for COMSTS and COMSTSLANT.

b. Short- and Long-Range Ice Forecasts

Thirty-day ice forecasts for the north Alaskan coast and the Chukchi and Bering Seas were issued twice monthly to COMALSEAFRON throughout the year. The forecasts included pack boundaries, concentrations, and ice thickness for specified points. A total of twenty-four 30-day ice forecasts was issued.

Four 30-day and five 15-day forecasts were provided for the USCGC NORTHWIND and USS STATEN ISLAND cruises conducted during summer and autumn of 1963.

Beginning with the 1963 season, the Naval Weather Service assumed responsibility for short-range ice forecasting in the western Arctic. Fleet Weather Central, Kodiak, provided short-range ice forecasting and ship routing service in the western Arctic.

3. Ice Reconnaissance

Aerial ice reconnaissance over sectors India and Juliett was conducted primarily by SP2E long-range aircraft under the command of COMALSEAFRON. These flights were conducted twice monthly throughout the year. In addition, monthly BIRDS EYE flights supplemented the long-range data. Short-range ice reconnaissance was conducted by ship-based helicopters.

A summary of hours flown and the number of flights made over each western sector for each month during 1963 as well as the monthly and annual totals is presented as figure 9.

4. Communications

Because no local support was required for Alaskan resupply operations, communications consisted of existing U.S. Navy and Air Force circuits which were used to transmit all traffic between Washington and the western Arctic.

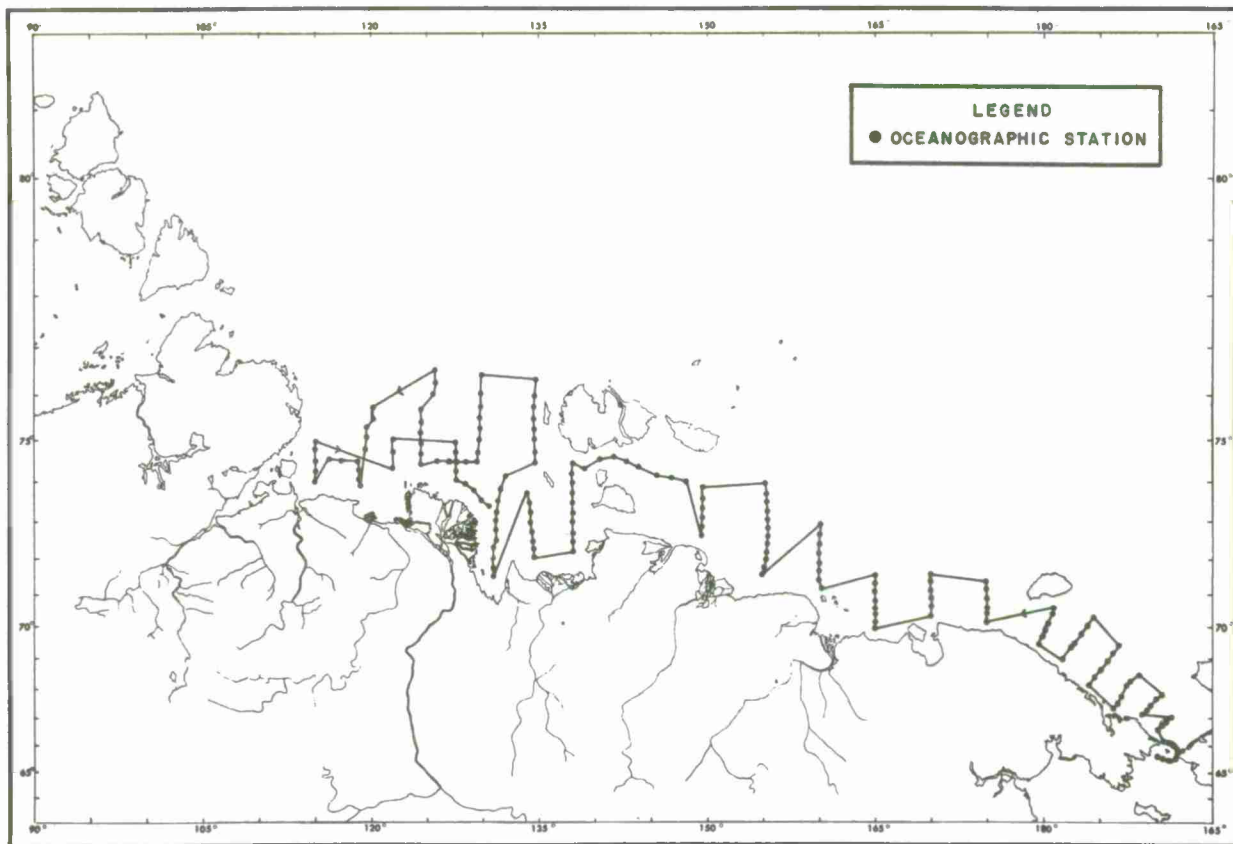


FIGURE 10 OCEANOGRAPHIC STATIONS TAKEN BY USCGC NORTHWIND (WAGB-202), WESTERN ARCTIC, AUGUST-SEPTEMBER 1963

5. Supporting Projects

a. USCGC NORTHWIND

From 9 August until 19 September the USCGC NORTHWIND conducted an oceanographic cruise along the north Siberian coast in the East Siberian and Laptev Seas. In addition to taking oceanographic stations, detailed observations and photographs of existing ice conditions were made. A NAVOCEANO oceanographer was aboard the NORTHWIND throughout the entire cruise. Figure 10 shows the locations of the stations occupied by the NORTHWIND. Ice conditions observed by the NORTHWIND during its cruise are included in appendix C.

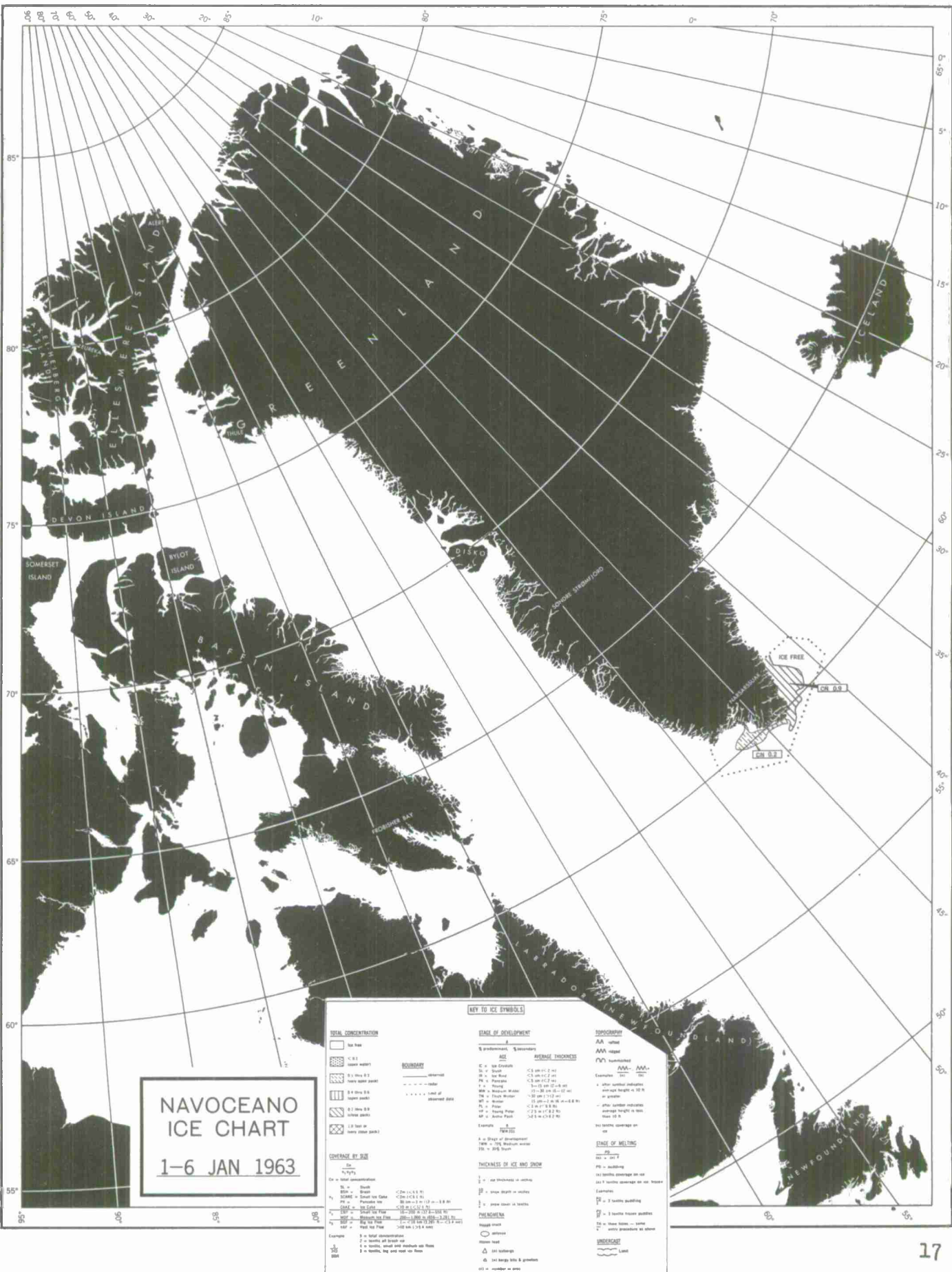
b. USS STATEN ISLAND

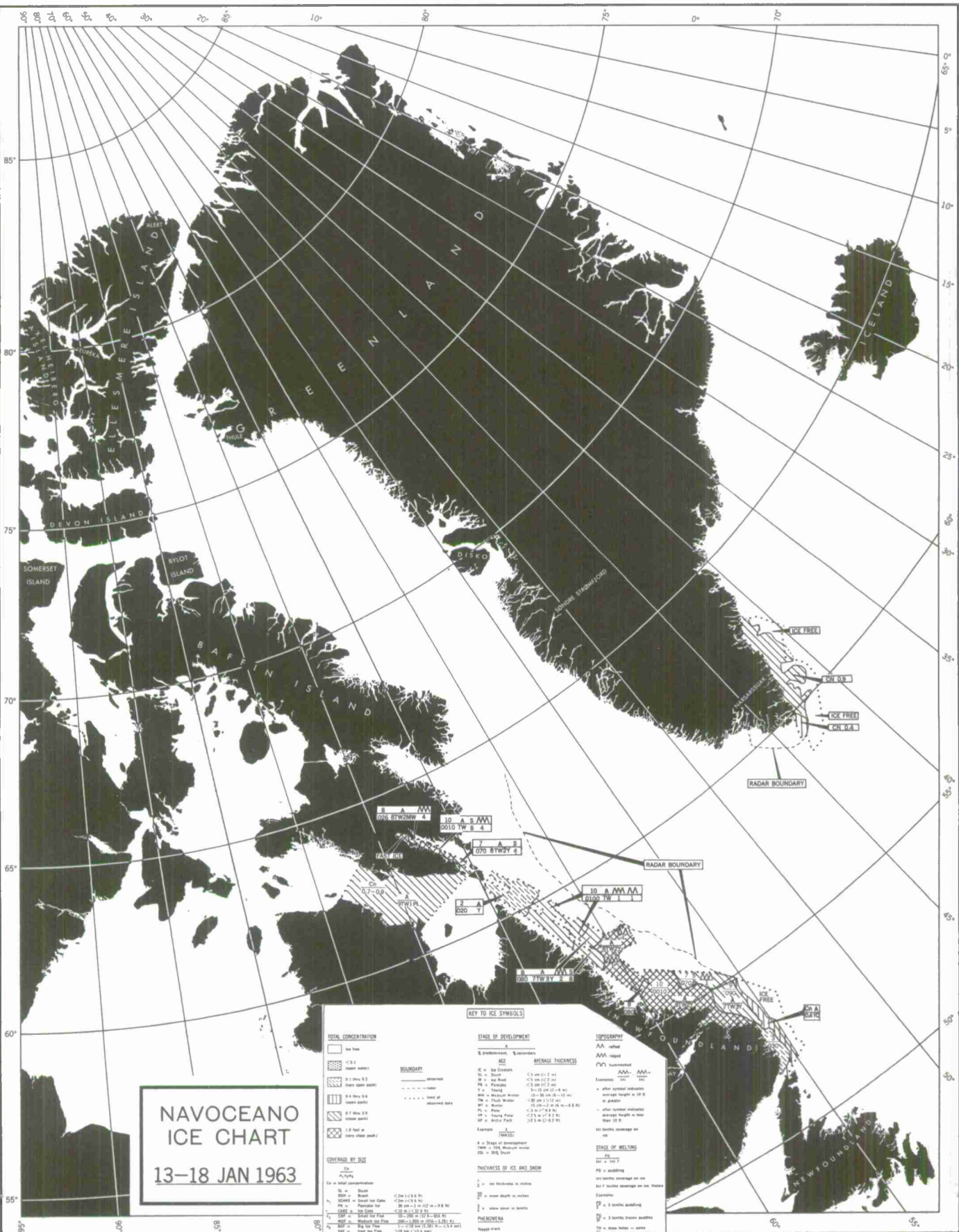
From 13 September to 22 November the USS STATEN ISLAND conducted a cruise in the Chukchi Sea. The oceanographic data obtained from these cruises are on file at the National Oceanographic Data Center, Washington, D.C.

6. Observed Ice Conditions

Ice conditions in the western North American Arctic are presented in appendix C.

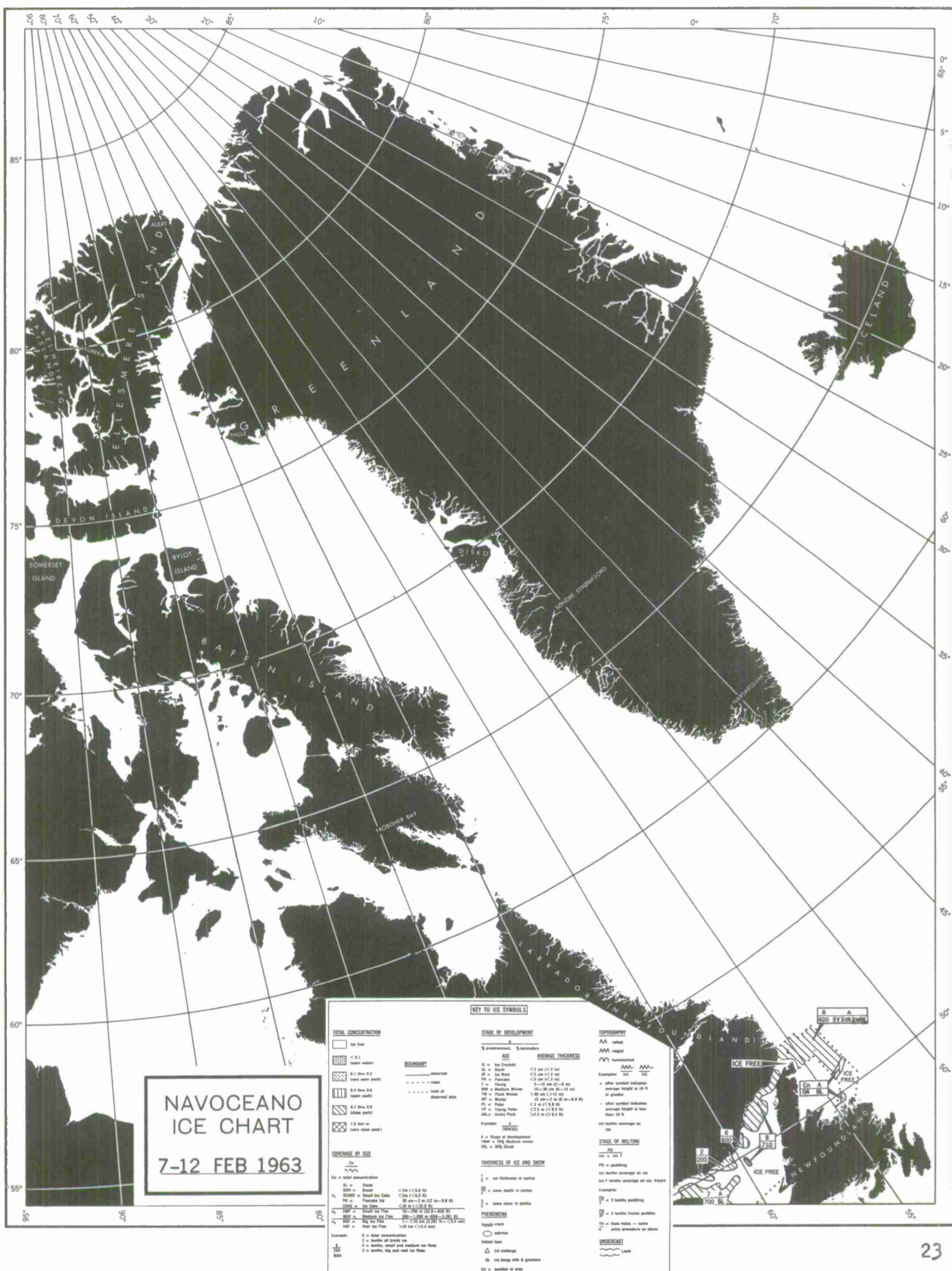
APPENDIX A
EASTERN ARCTIC ICE CHARTS

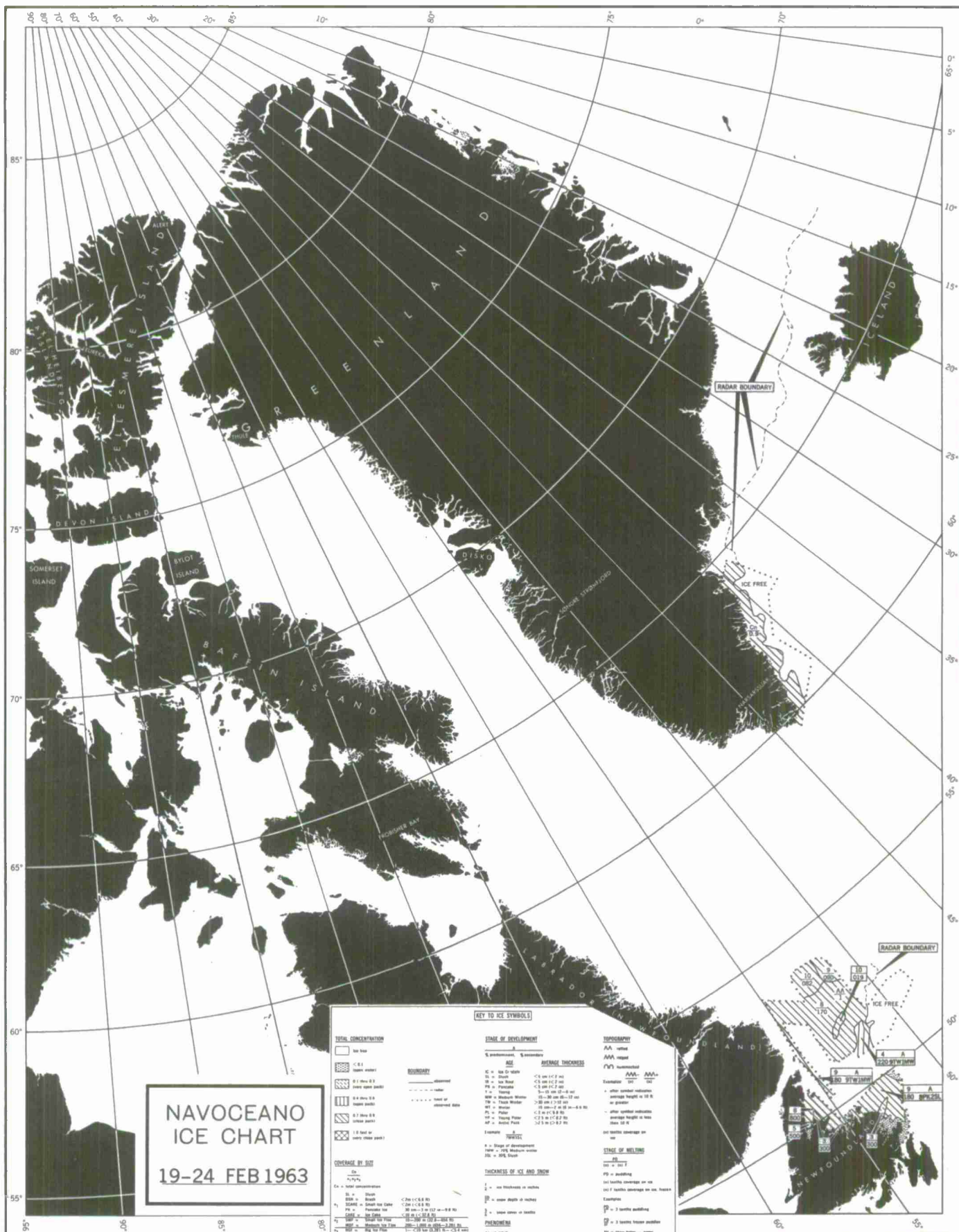




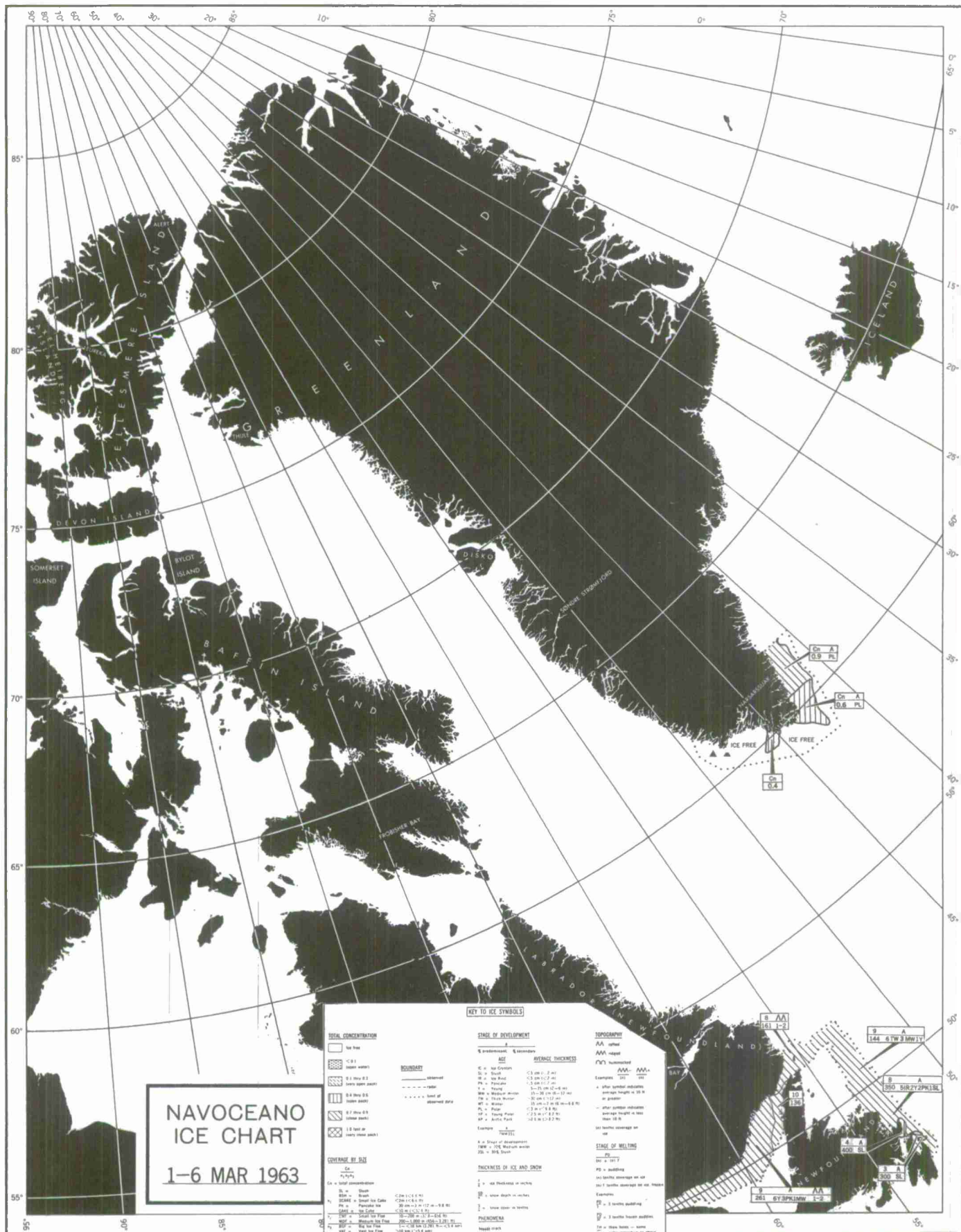
NAVOCEANO ICE CHART 13-18 JAN 1963

KEY TO ICE SYMBOLS	
TOTAL CONCENTRATION	STAGE OF DEVELOPMENT
0-5 6-10 11-15 16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 56-60 61-65 66-70 71-75 76-80 81-85 86-90 91-95 96-100	0-5 6-10 11-15 16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 56-60 61-65 66-70 71-75 76-80 81-85 86-90 91-95 96-100
BOUNDARY	THICKNESS OF ICE AND SNOW
0-5 6-10 11-15 16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 56-60 61-65 66-70 71-75 76-80 81-85 86-90 91-95 96-100	0-5 6-10 11-15 16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 56-60 61-65 66-70 71-75 76-80 81-85 86-90 91-95 96-100
COVERAGE BY DATE	PHENOMENA
0-5 6-10 11-15 16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 56-60 61-65 66-70 71-75 76-80 81-85 86-90 91-95 96-100	0-5 6-10 11-15 16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 56-60 61-65 66-70 71-75 76-80 81-85 86-90 91-95 96-100
EXAMPLES	STAGE OF MELTING
0-5 6-10 11-15 16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 56-60 61-65 66-70 71-75 76-80 81-85 86-90 91-95 96-100	0-5 6-10 11-15 16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 56-60 61-65 66-70 71-75 76-80 81-85 86-90 91-95 96-100





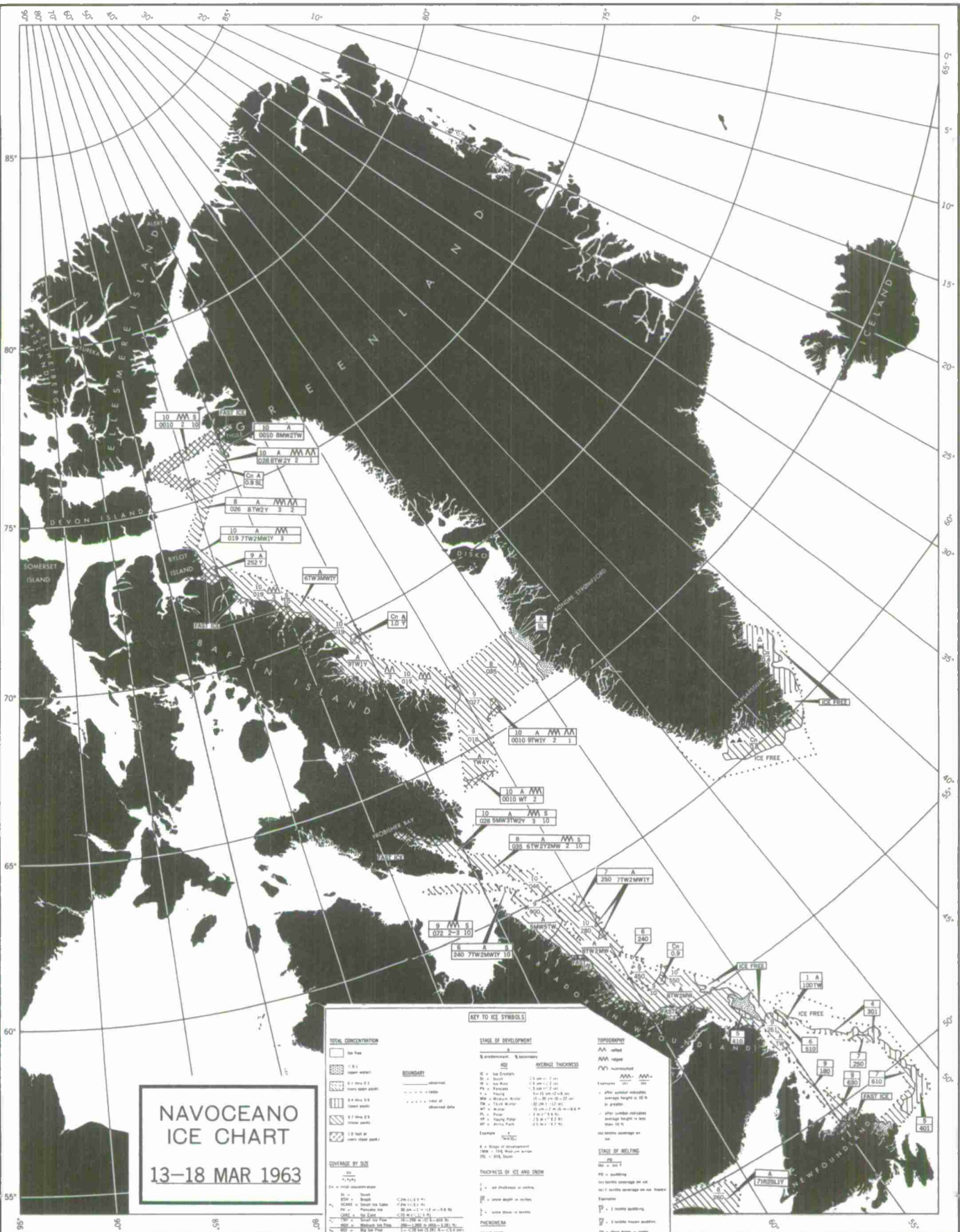


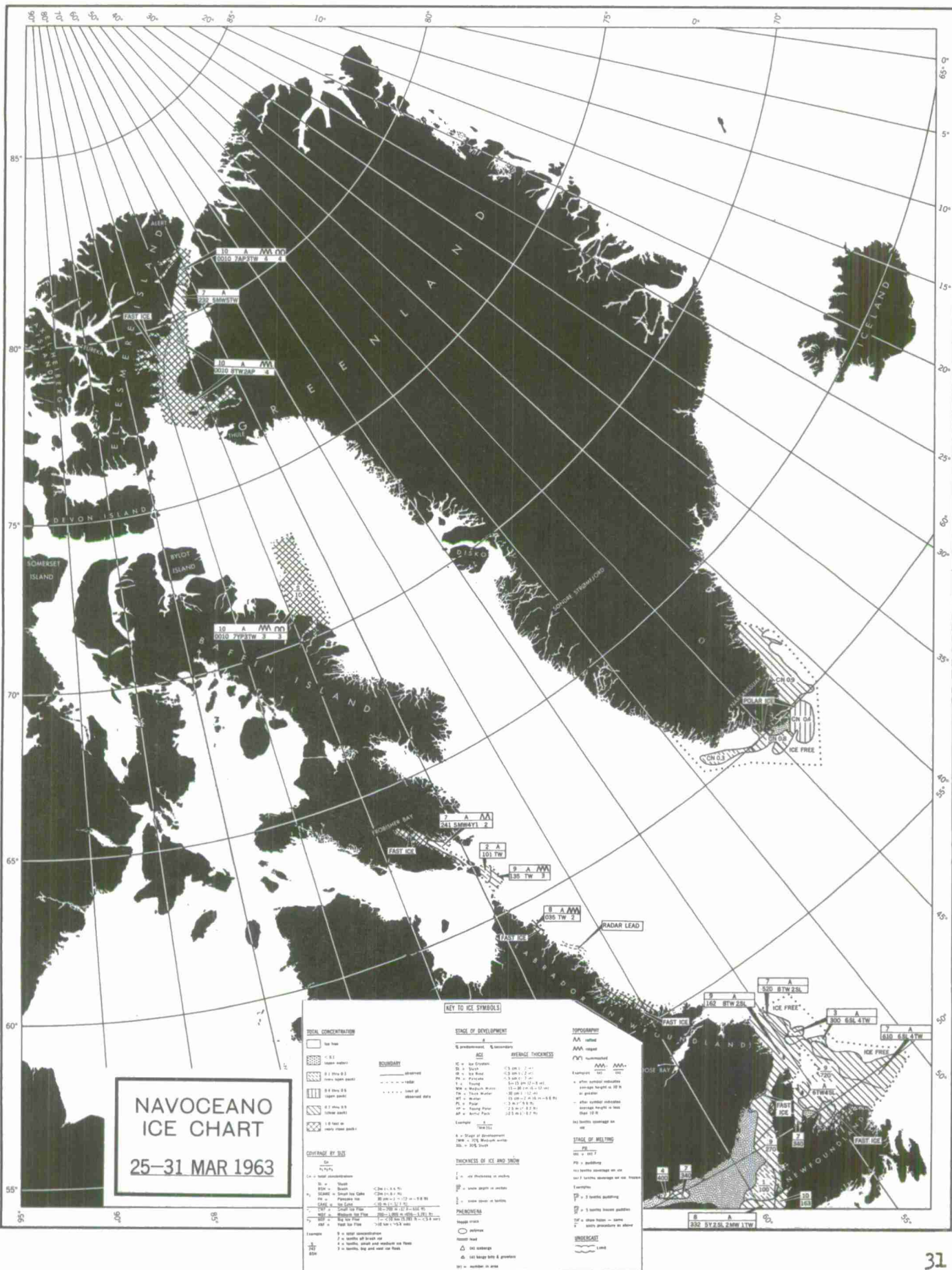


NAVOCEANO ICE CHART 1-6 MAR 1963

KEY TO ICE SYMBOLS	
TOTAL CONCENTRATION	
	Ice free
	0.1
	0.2
	0.3
	0.4
	0.5
	0.6
	0.7
	0.8
	0.9
	1.0
STAGE OF DEVELOPMENT	
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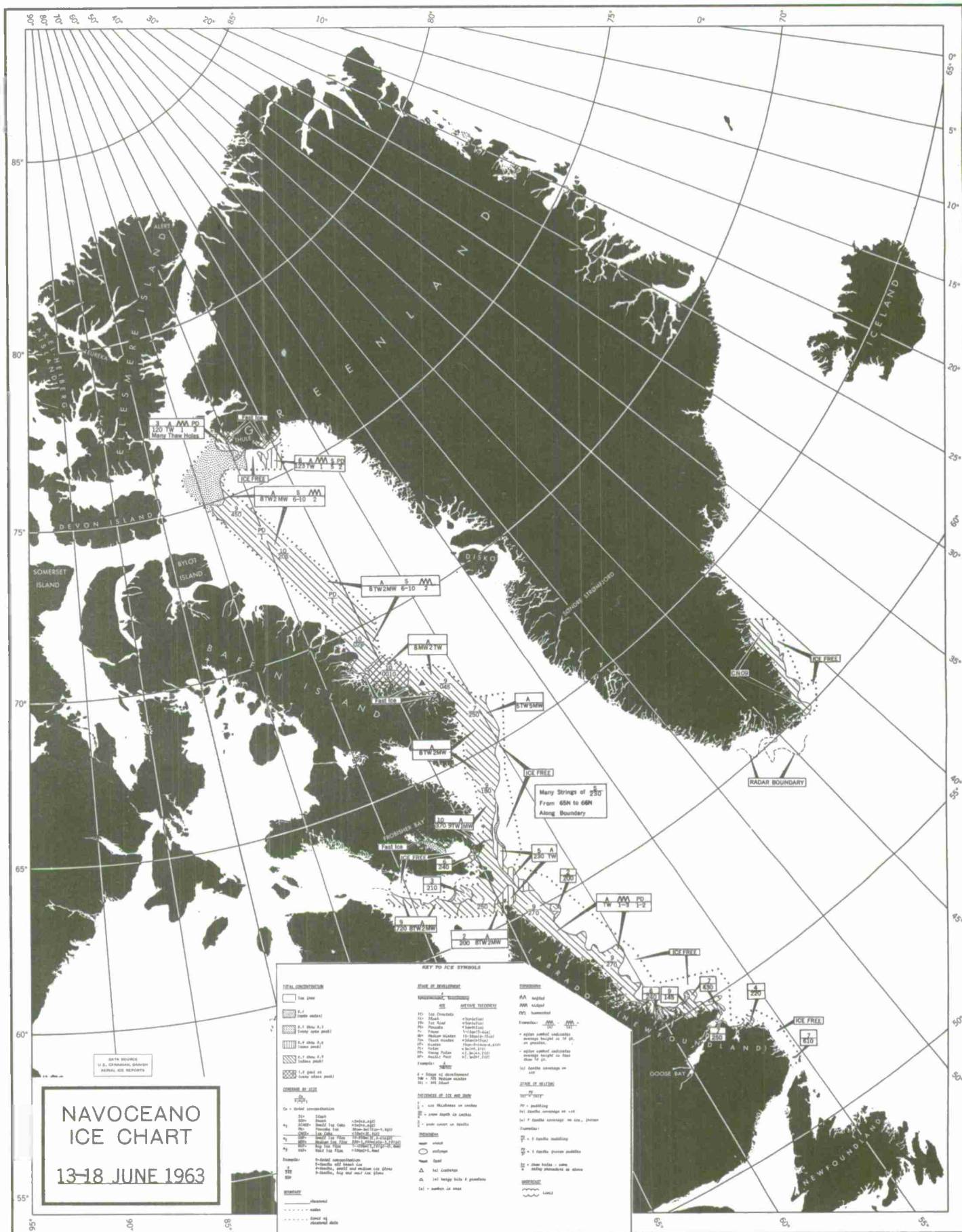






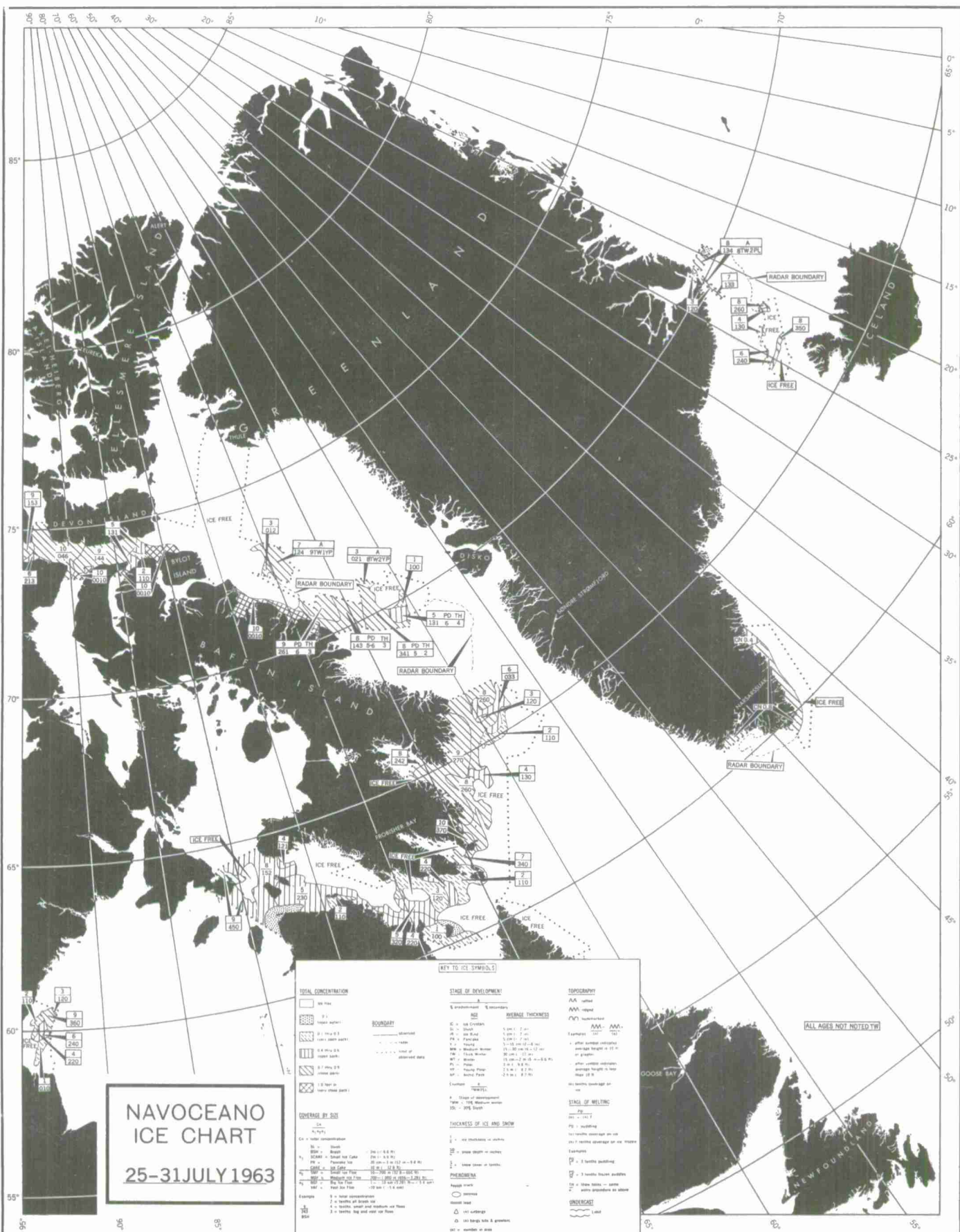


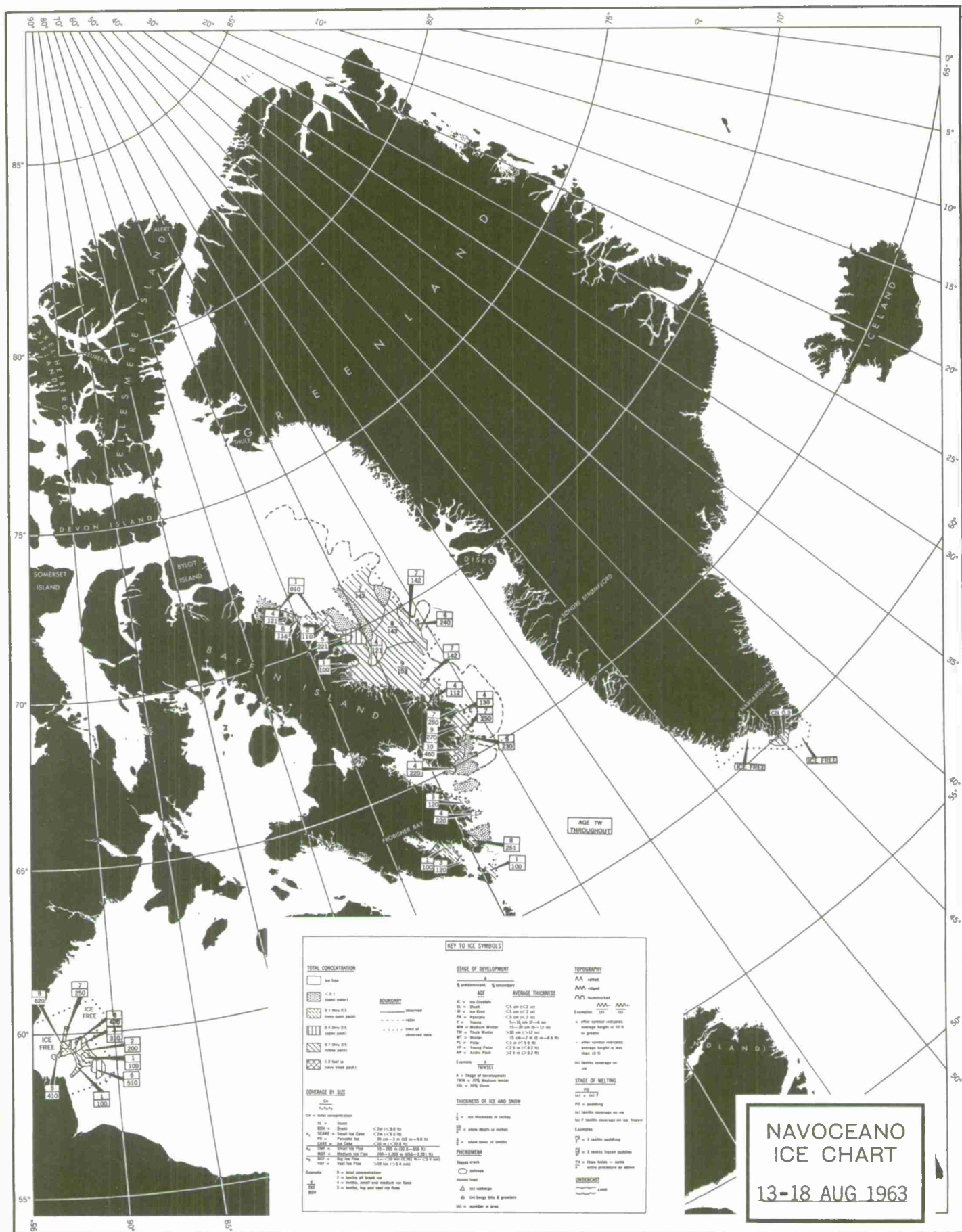




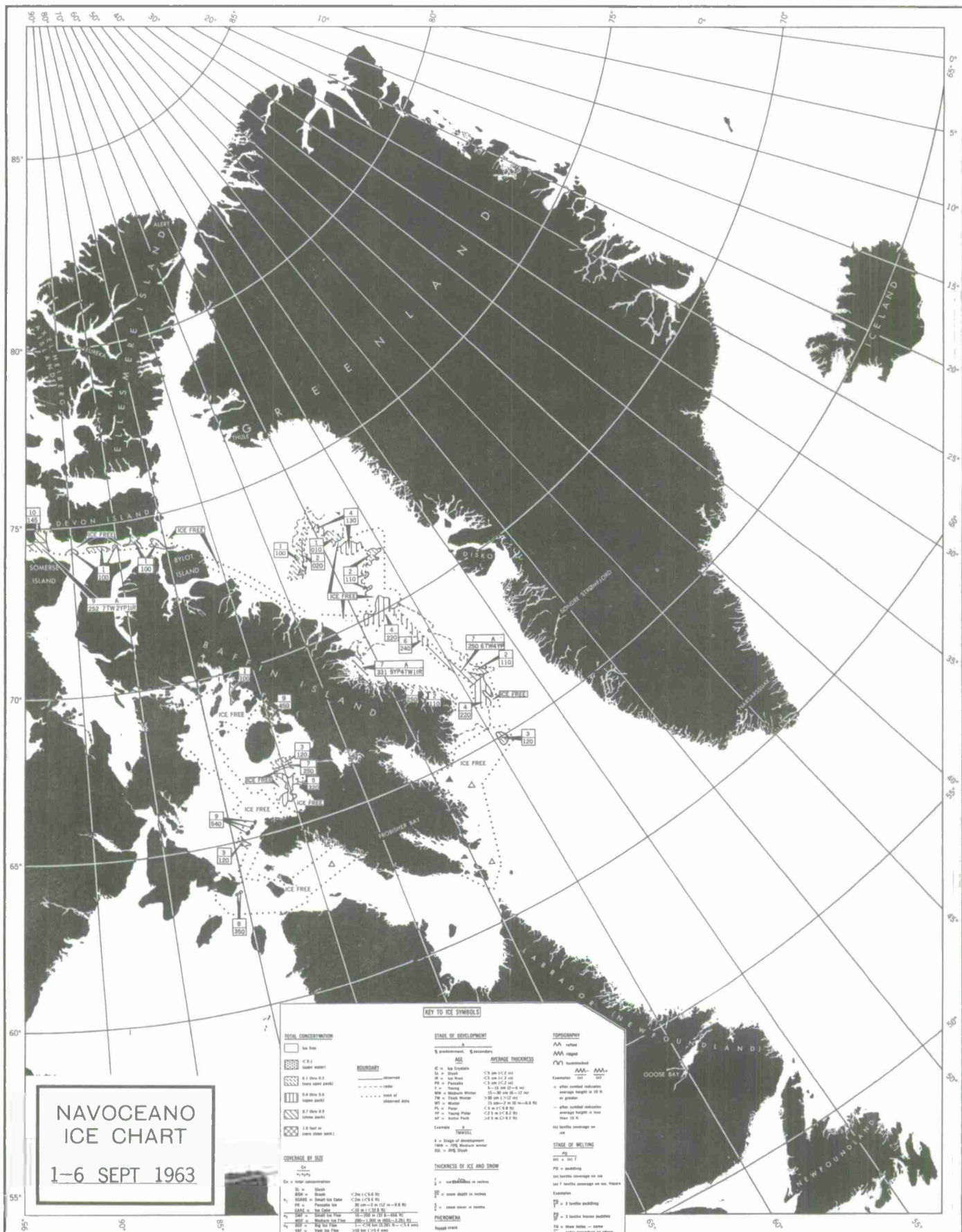


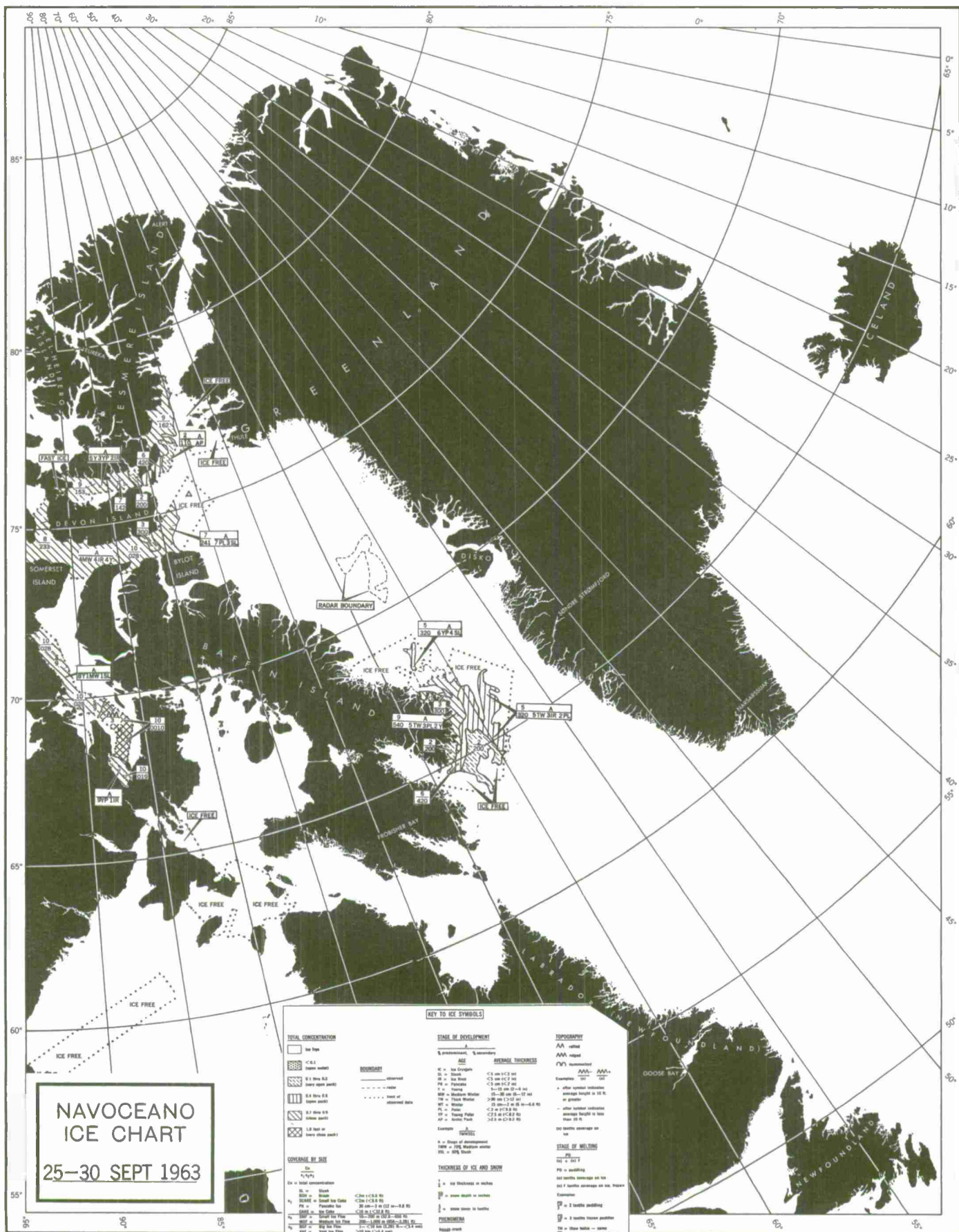


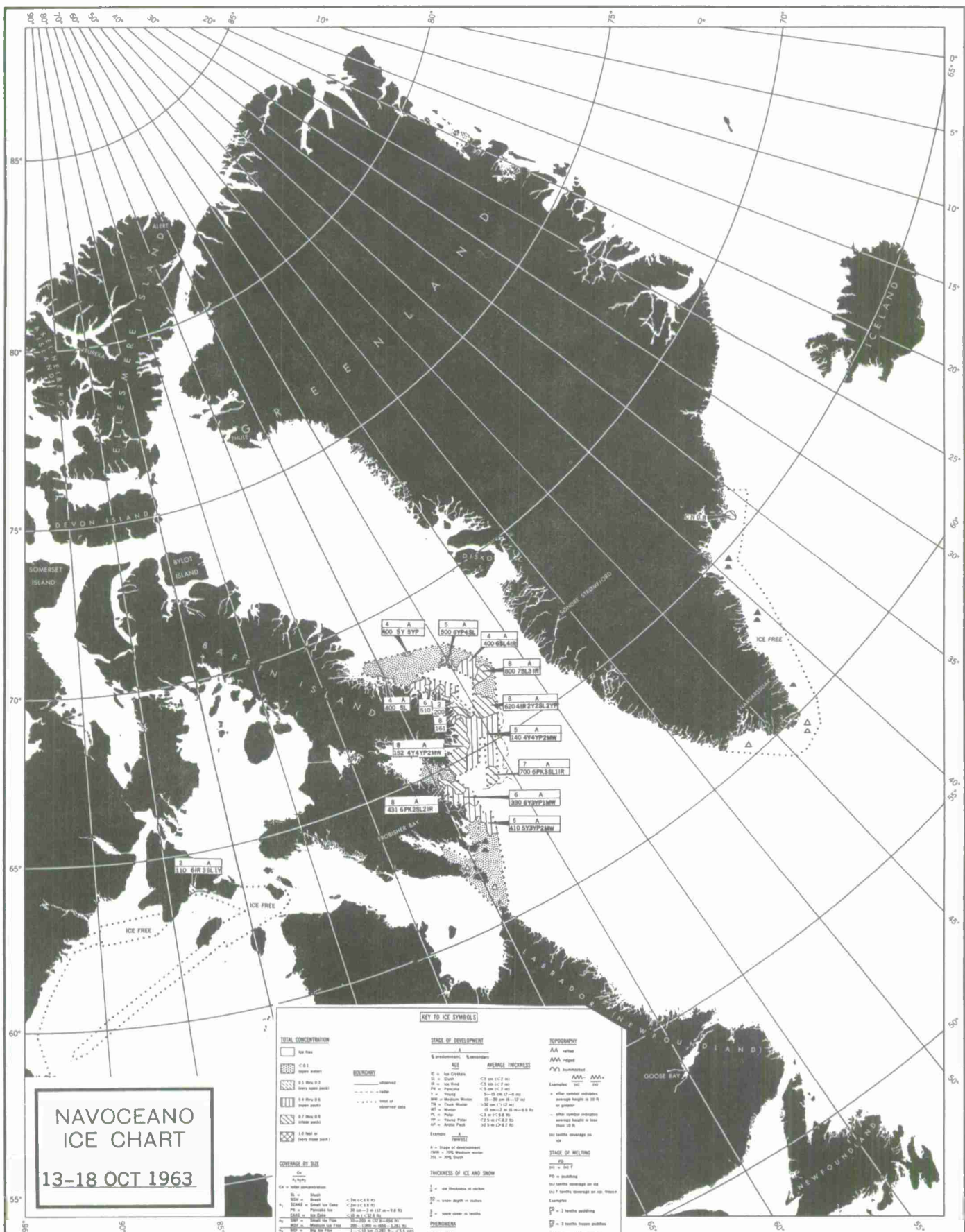






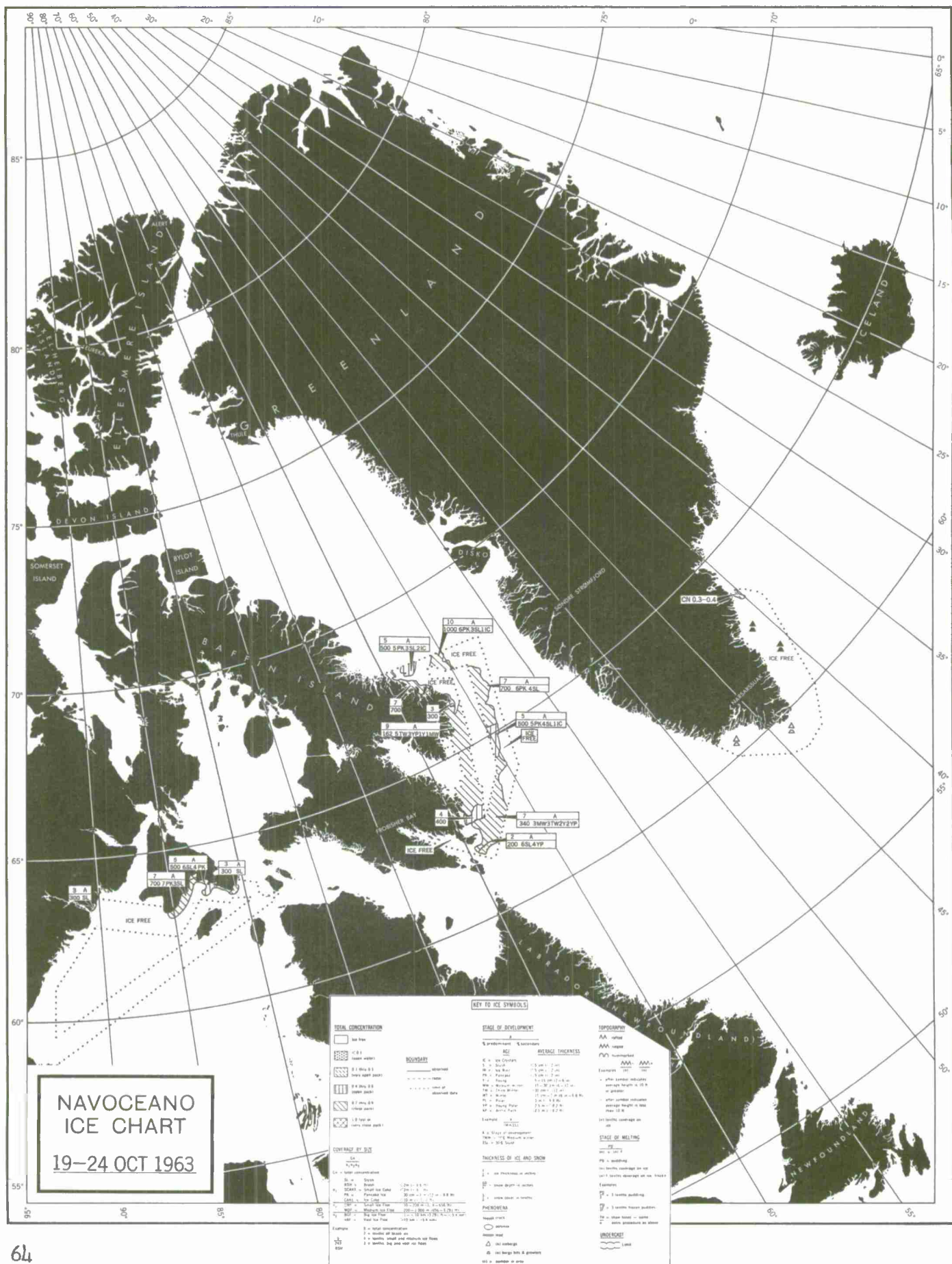


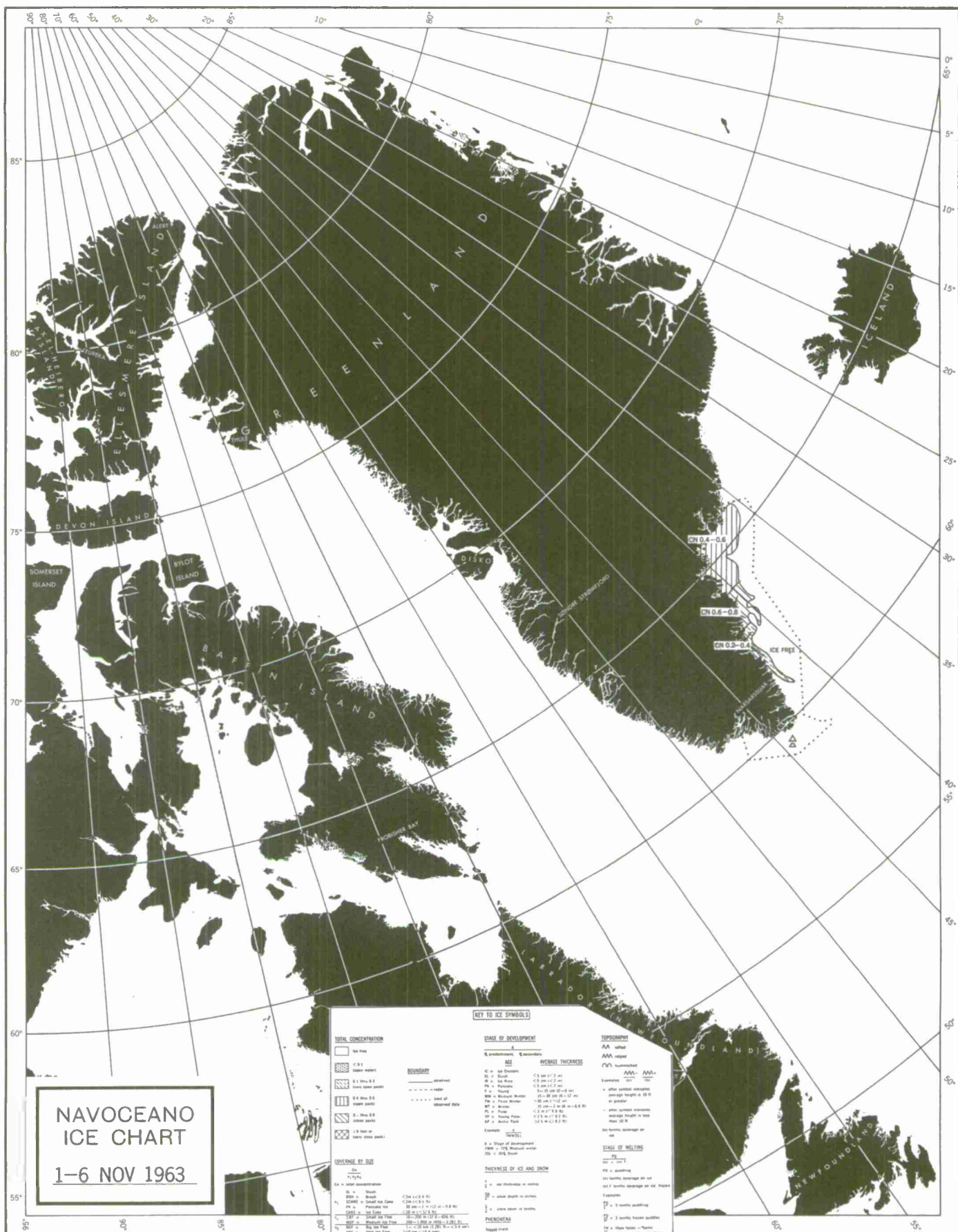


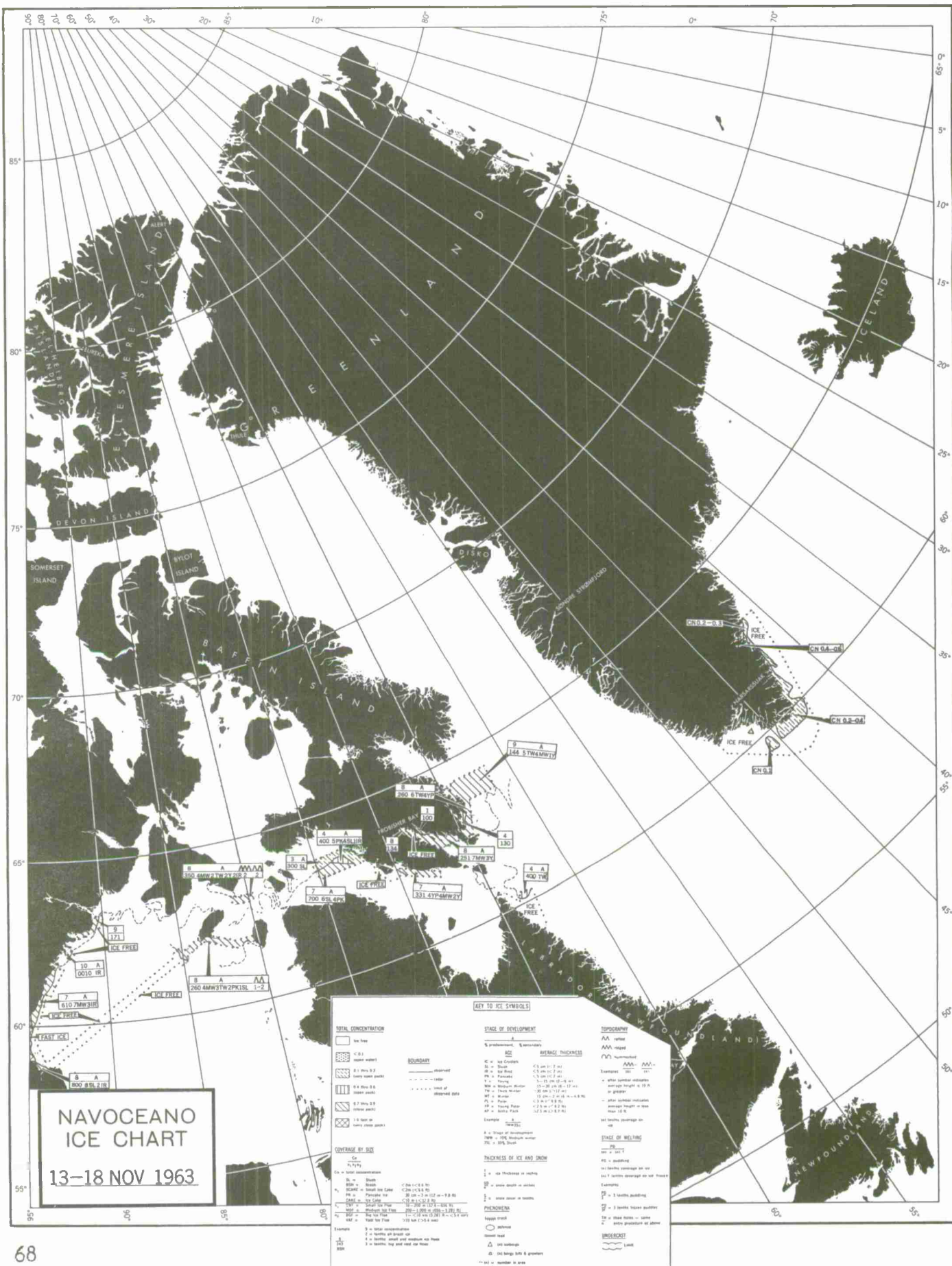


NAVOCEANO
ICE CHART
13-18 OCT 1963

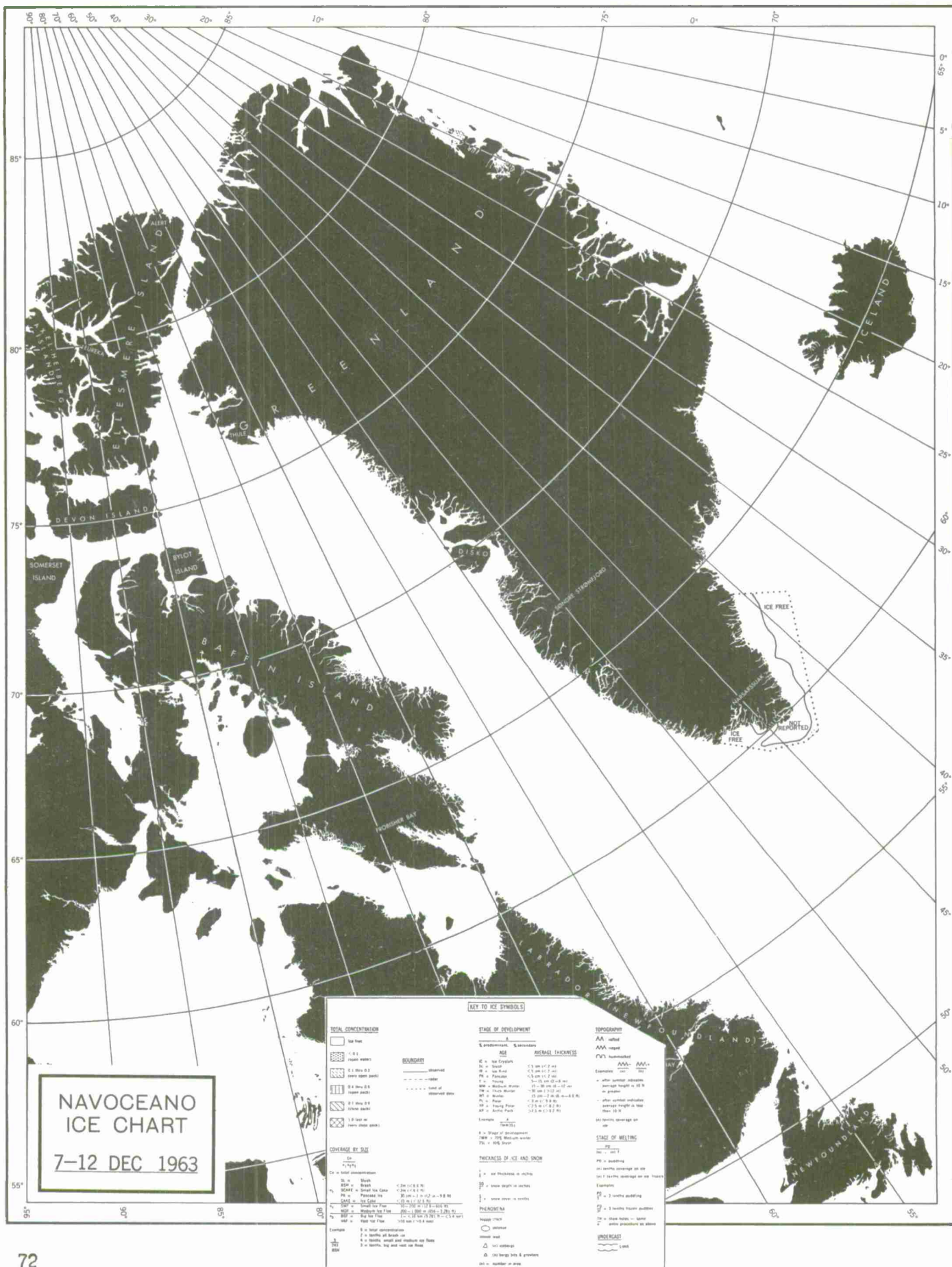
KEY TO ICE SYMBOLS	
TOTAL CONCENTRATION	
	Ice free
	0-15% ice concentration
	16-30% ice concentration
	31-45% ice concentration
	46-60% ice concentration
	61-75% ice concentration
	76-90% ice concentration
	91-100% ice concentration
STAGE OF DEVELOPMENT	
	1st stage
	2nd stage
	3rd stage
	4th stage
	5th stage
	6th stage
	7th stage
	8th stage
	9th stage
	10th stage
	11th stage
	12th stage
	13th stage
	14th stage
	15th stage
	16th stage
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	298th stage
	299th stage
	300th stage











NAVOCEANO ICE CHART

7-12 DEC 1963

TOTAL CONCENTRATION

- Ice free
- 0-10
- 11-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- 81-90
- 91-100

COVERAGE BY SIZE

- 0-10
- 11-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- 81-90
- 91-100

KEY TO ICE SYMBOLS

STAGE OF DEVELOPMENT

- 0-10
- 11-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- 81-90
- 91-100

THICKNESS OF ICE AND SNOW

- 0-10
- 11-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- 81-90
- 91-100

TOPOGRAPHY

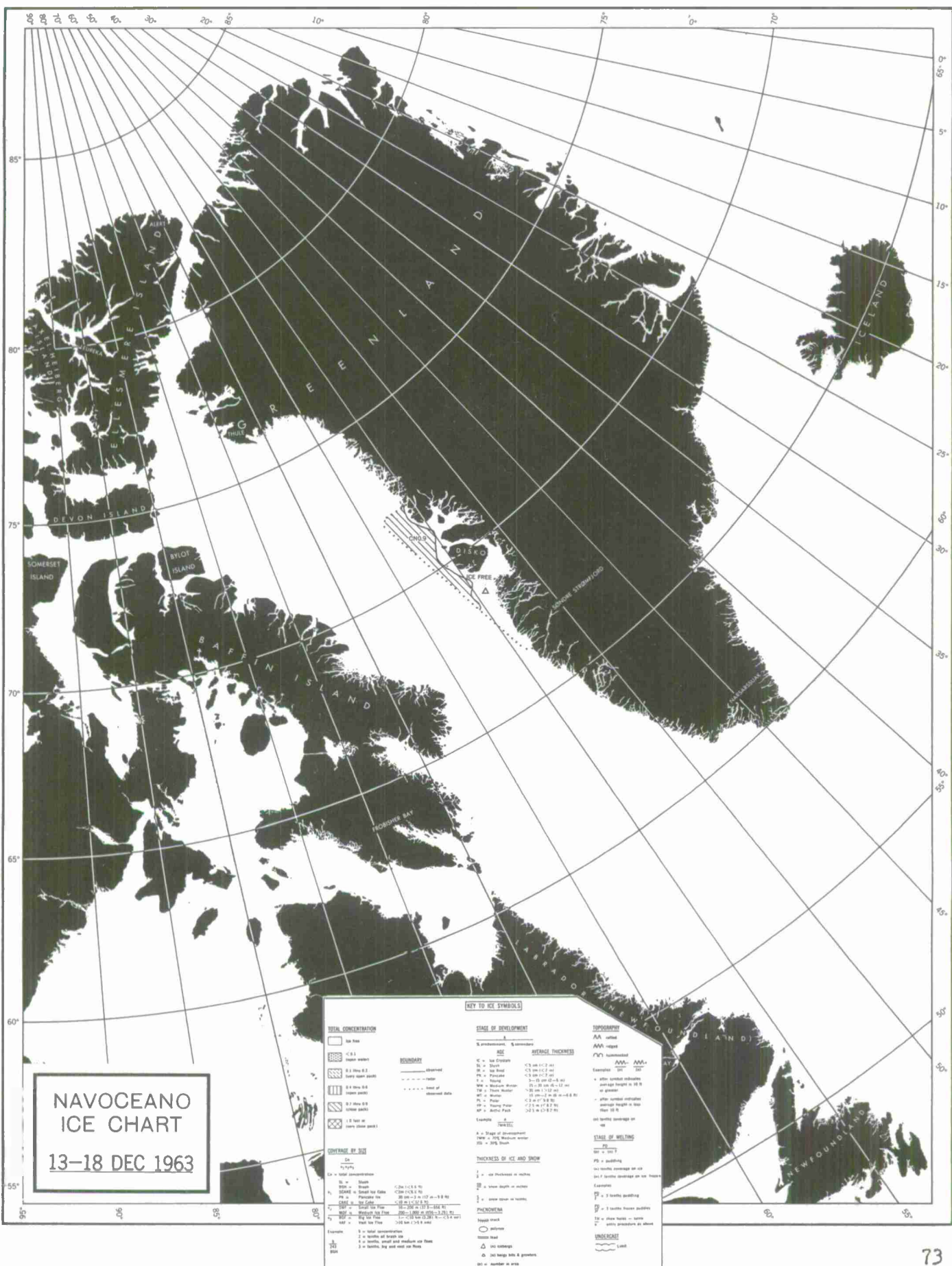
- 0-10
- 11-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- 81-90
- 91-100

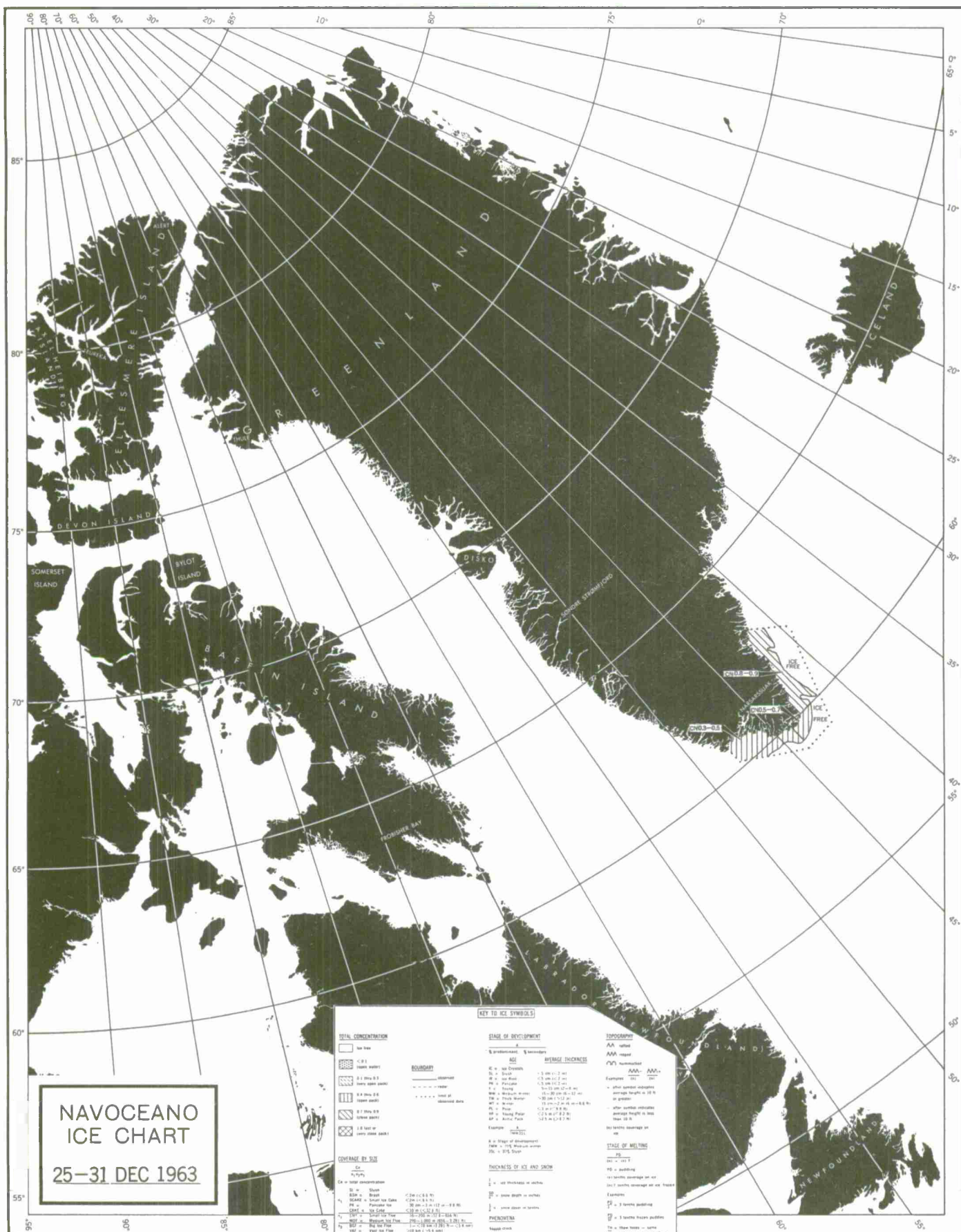
STAGE OF MELTING

- 0-10
- 11-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- 81-90
- 91-100

INDEX

- 0-10
- 11-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- 81-90
- 91-100





APPENDIX B

DANISH ICE RECONNAISSANCE CHARTS

MINERVA MIKROFILM A/S

DANISH ICE RECONNAISSANCE

ICE CENTRAL NARSSARSSUAQ

GREENLAND

1963

THE DANISH METEOROLOGICAL INSTITUTE
NAUTICAL DEPARTMENT
GAMLEHAVE ALLE 22
CHARLOTTENLUND
DENMARK

LEGEND

COVERAGE (CONCENTRATION)

	Ice free
	<0.1 (open water)
	0.1 thru 0.4 (scattered ice)
	0.5 thru 0.7 (broken ice)
	0.8 thru 0.9 (close ice)
	1.0 (consolidated or fast ice)

COVERAGE BY SIZE

$\frac{Cn}{n_1, n_2, n_3}$	
n_1	tenths of slush, brash, and block
n_2	tenths of small and medium floes
n_3	tenths of giant floes and field
Example: $\frac{9}{243}$ BSH	
9	= total concentration
2	= tenths all brash ice
4	= tenths, small and medium ice floes
3	= tenths, big and vast ice floes

ICE OF LAND ORIGIN

- ▲ Icebergs—many (>20)
- △ Icebergs—few (<20)
- ▲ Bergy bits (>50) and growlers (>100)
- △ Bergy bits (<50) and growlers (<100)
- ✕ Single iceberg

THICKNESS AND SNOW COVER

Thickness: $\frac{T}{n}$ where n =feet and inches

Snow cover: $\frac{S}{n} \frac{S}{C} \frac{S}{D} \frac{S}{O}$

n =depth to nearest inch

C=ice uniformly snow covered

D=snow cover in drifts

O=no snow cover present

AGE

A
% dominant, % secondary
Sl=Slush W=Winter ice
Y=Young ice P=Polar ice
Examples: $\frac{A}{60W, 40P}$ etc.

TOPOGRAPHY

^^ Rafted ice
^^ Ridged ice
ooo Hummocks
Extent: H=very extensive
L=few present

When no entry appears beneath symbol extent is moderate
Examples:

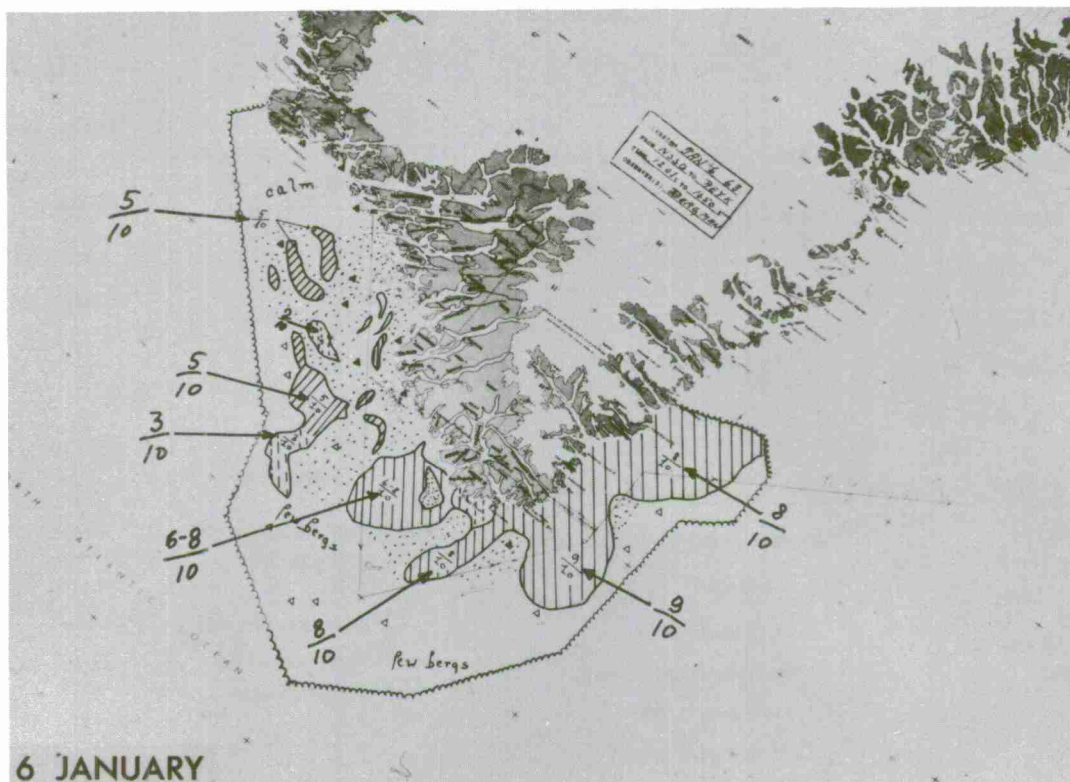
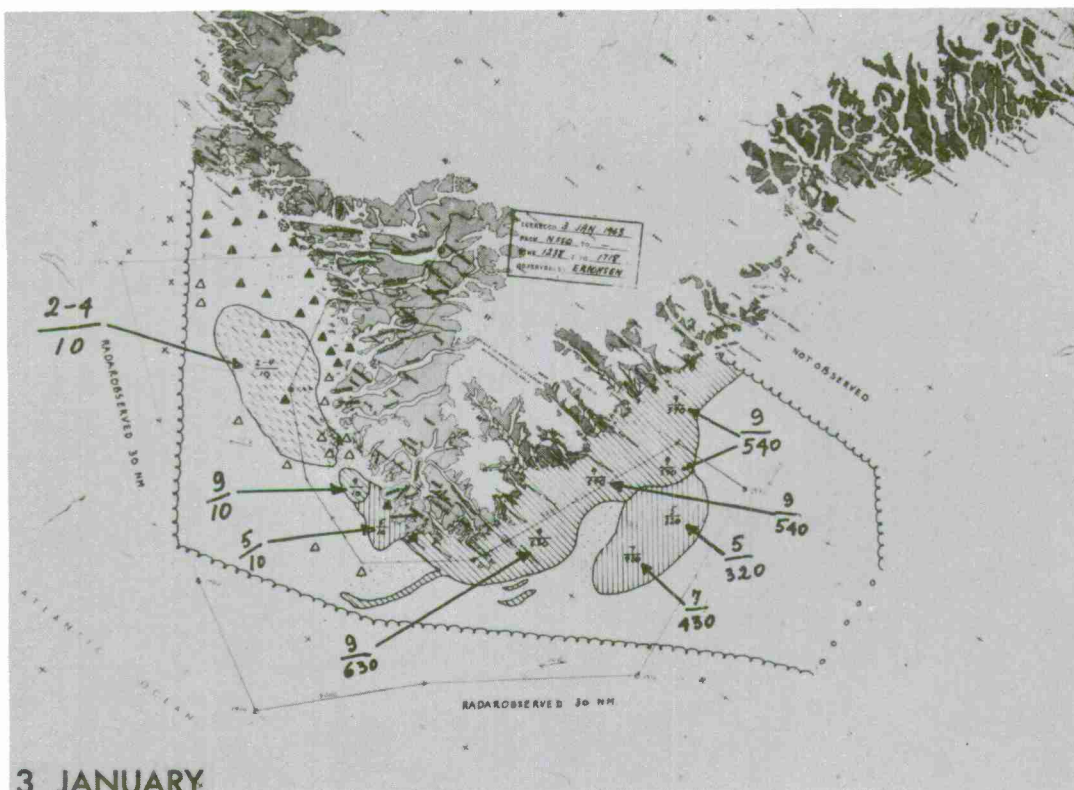
^^ = very extensive ridging
^^ = moderate rafting
ooo = few hummocks

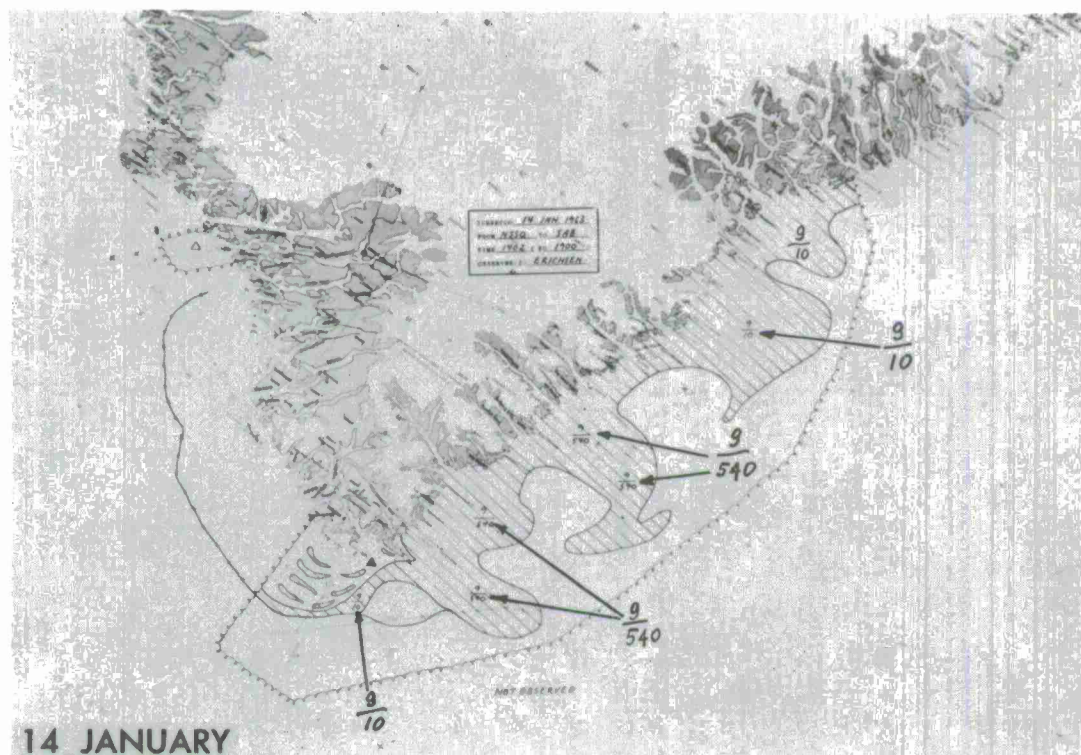
WATER FEATURES

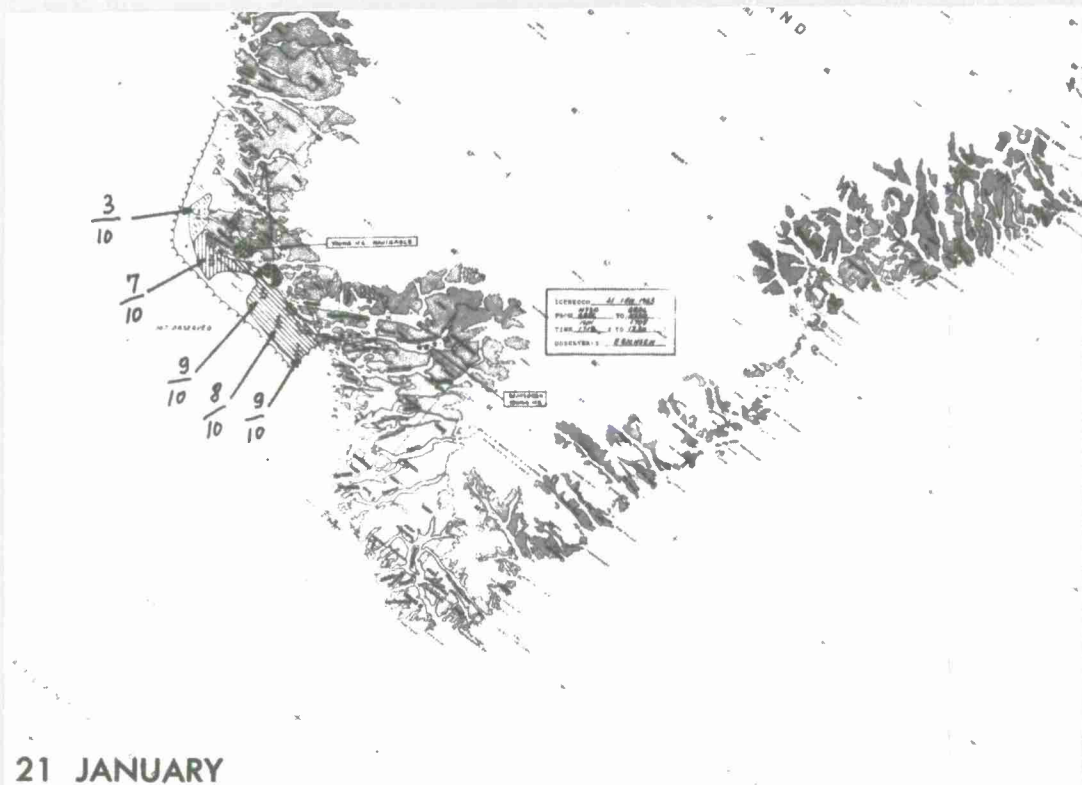
Pd
Puddles: dominant amount in tenths unless frozen or rotten
F=Frozen R=Rotten
Examples: $\frac{Pd}{3} \frac{Pd}{F} \frac{Pd}{R}$
*** Crack ~~~~ Lead
o Polynya

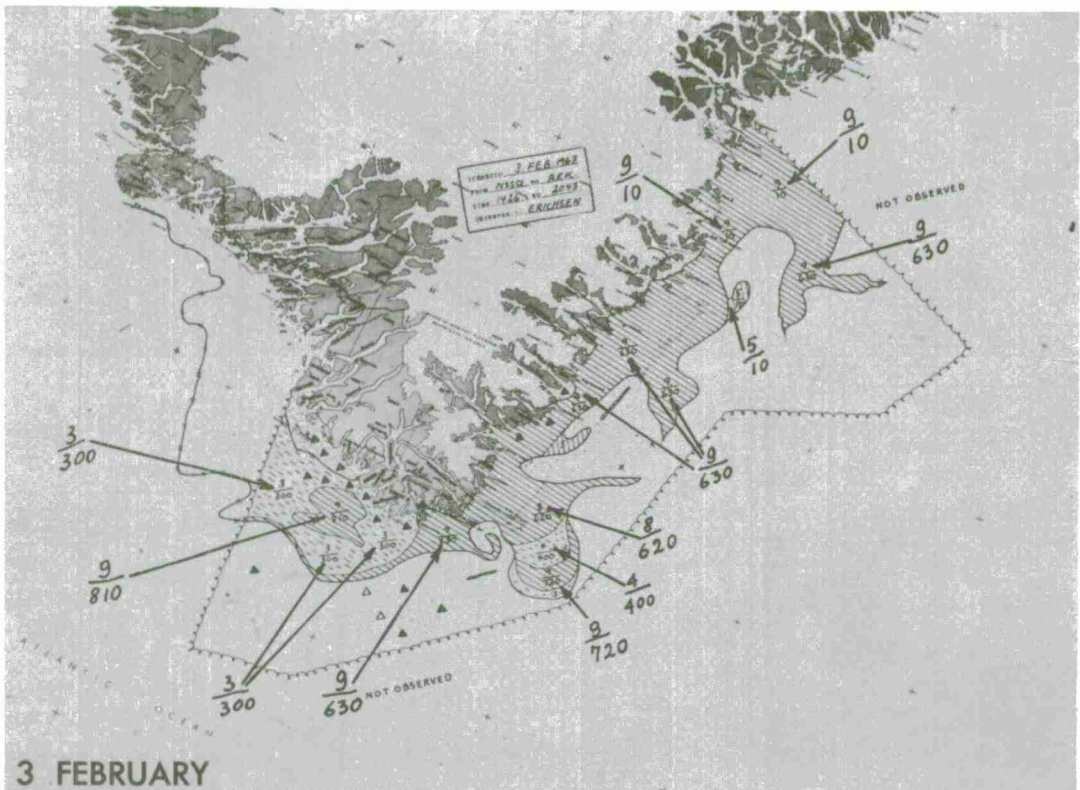
BOUNDARY

— Observed
--- Estimated
- - - - Radar observed
o o o o Limit of observed data
{ } UNDERCAST
Undercast (limits)

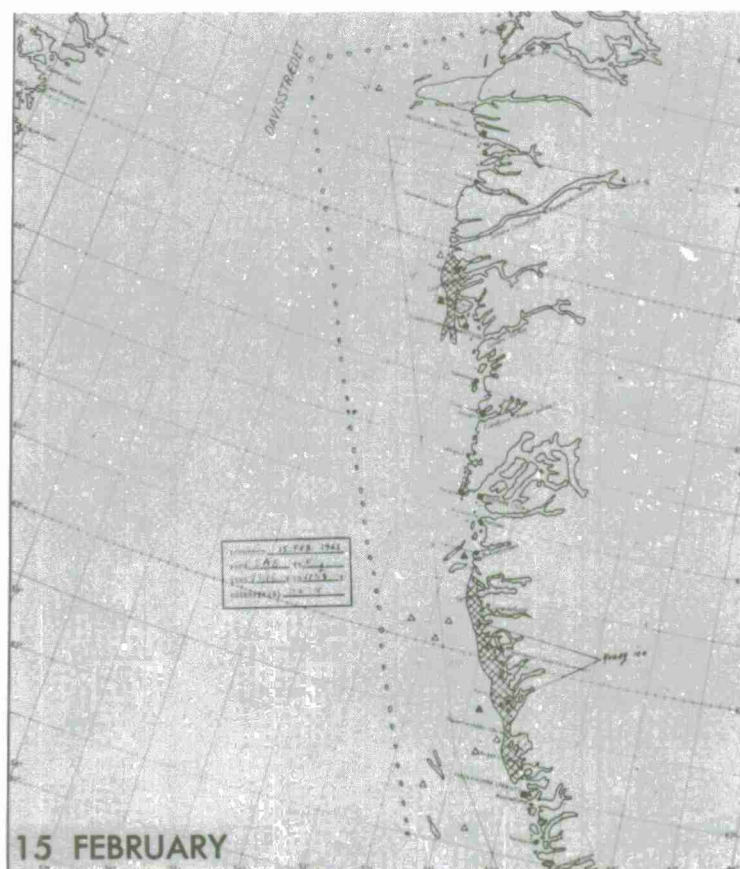
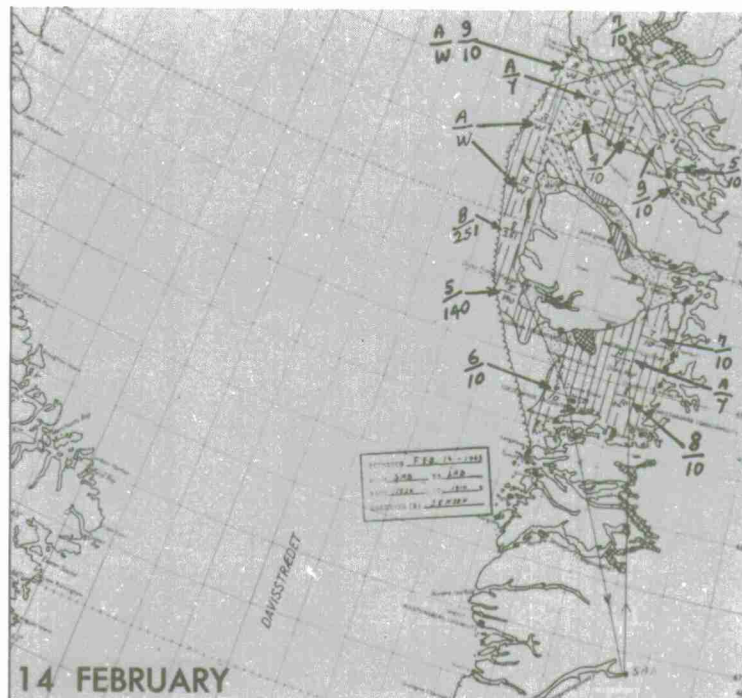


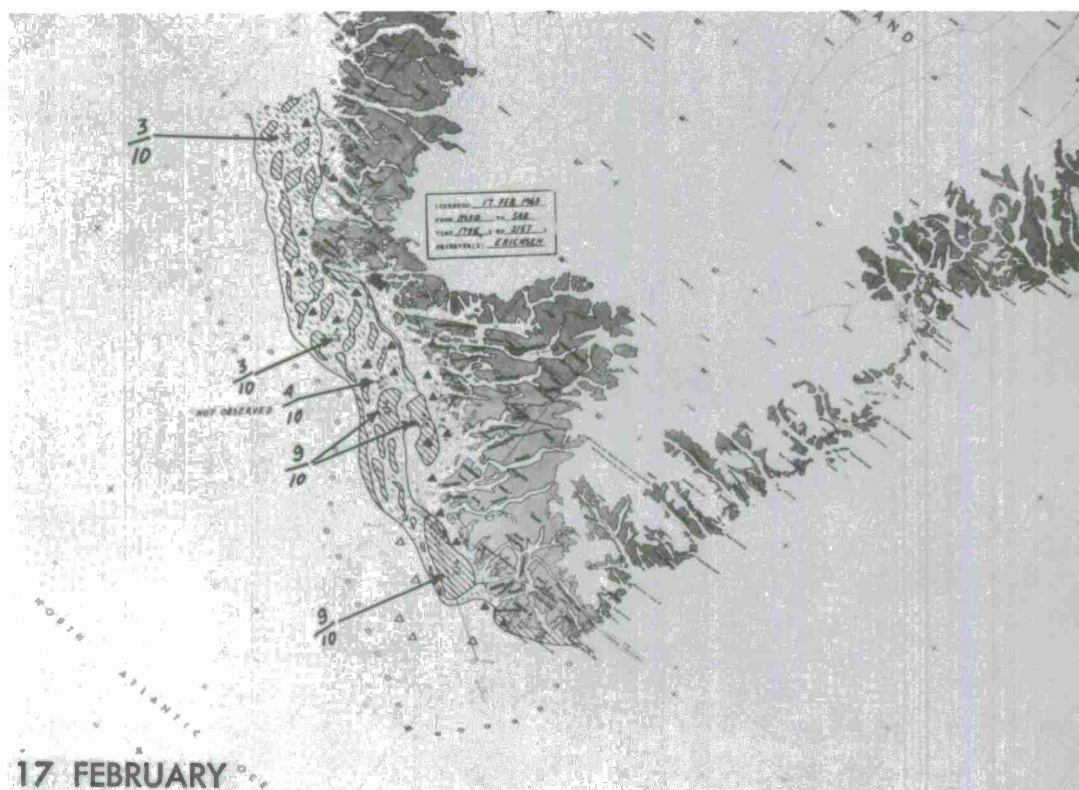
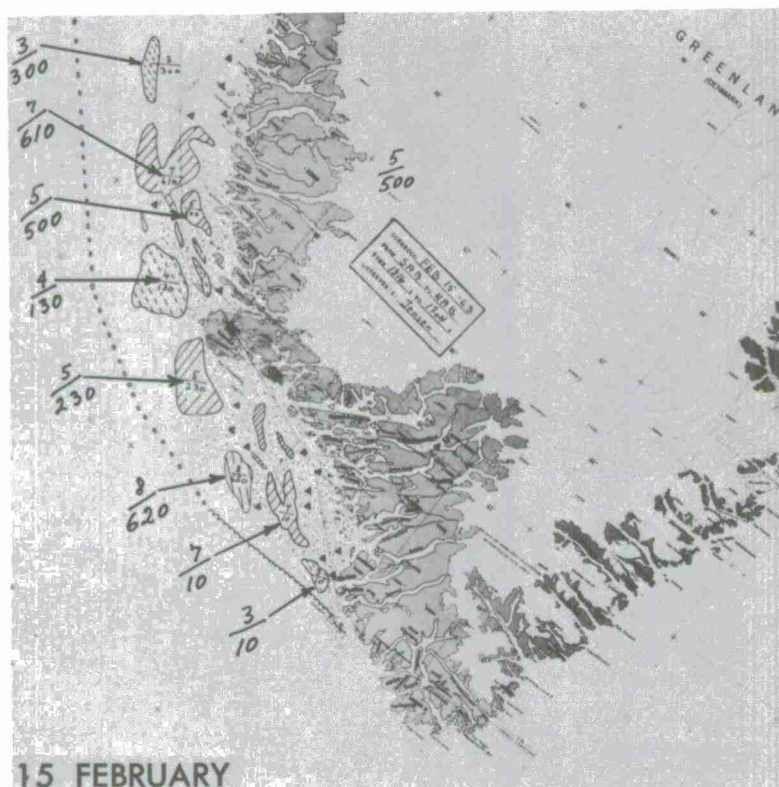


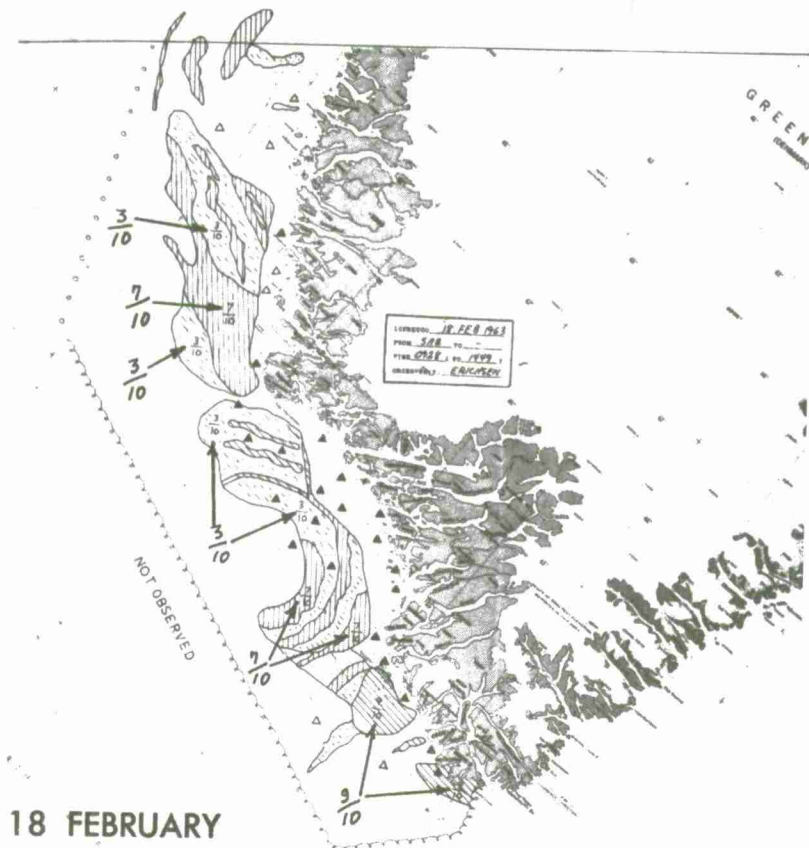




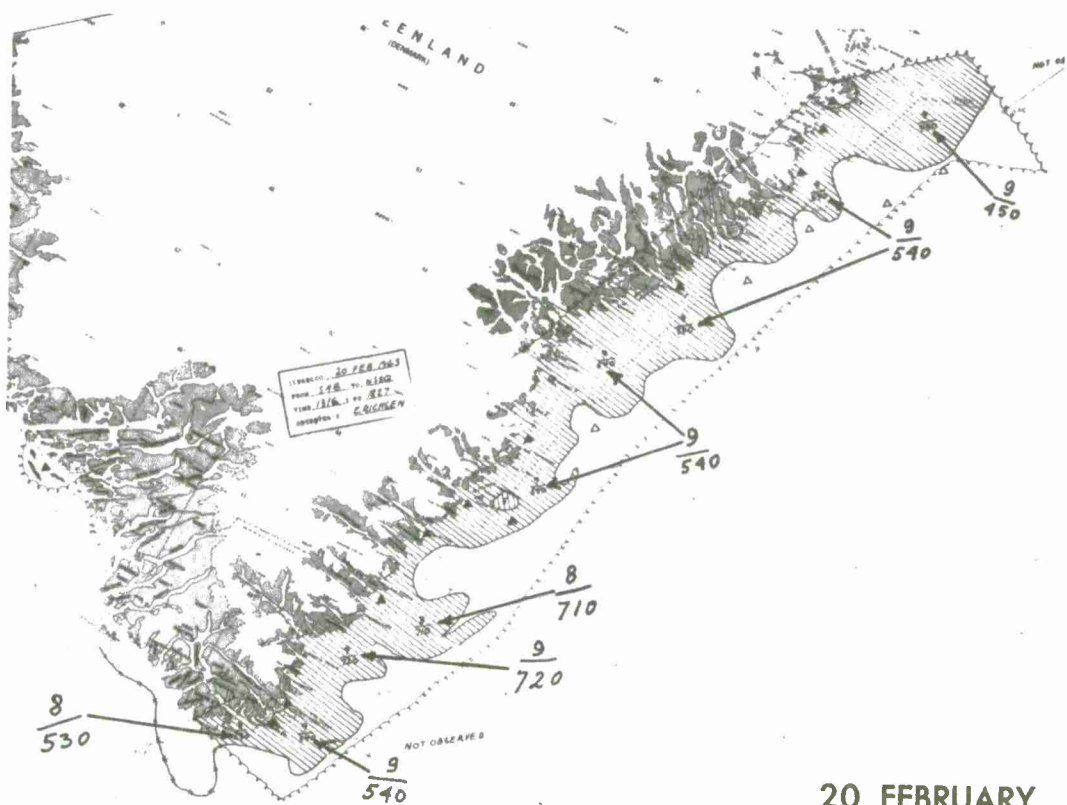




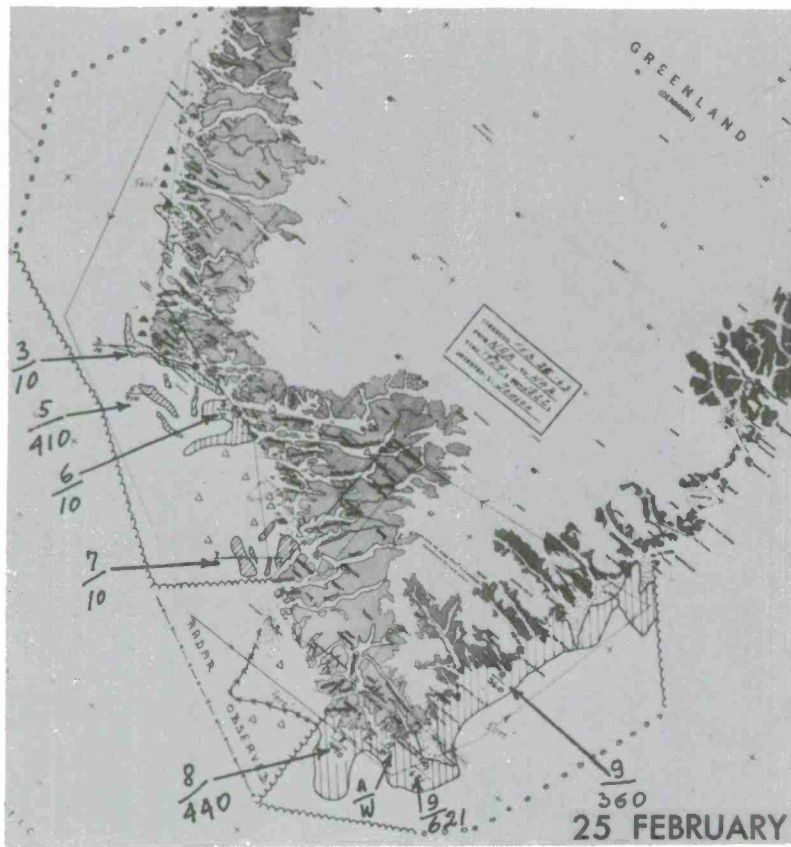


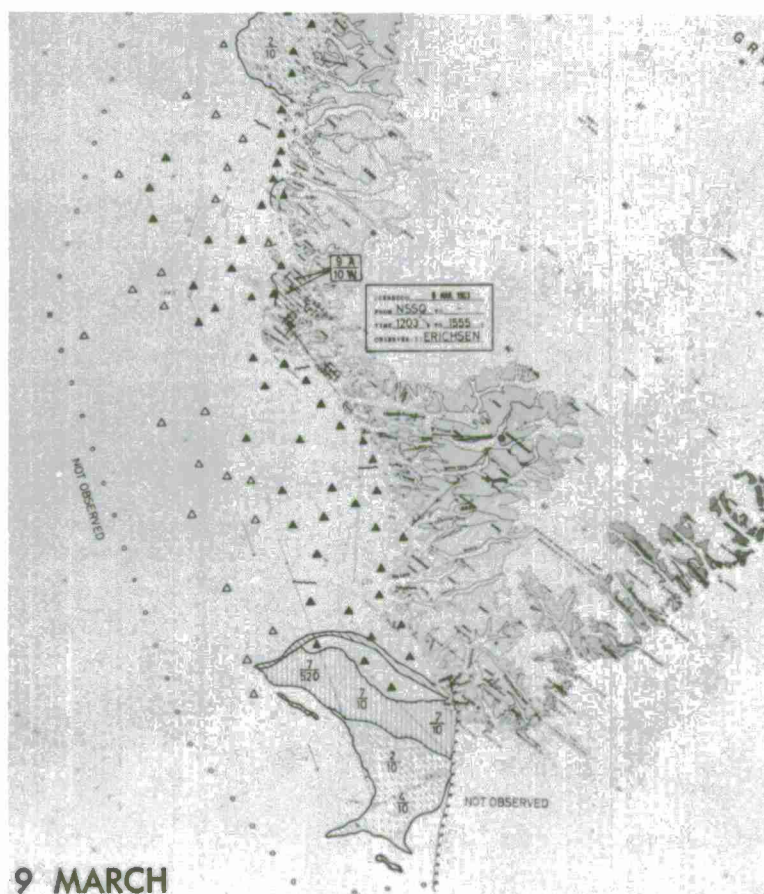
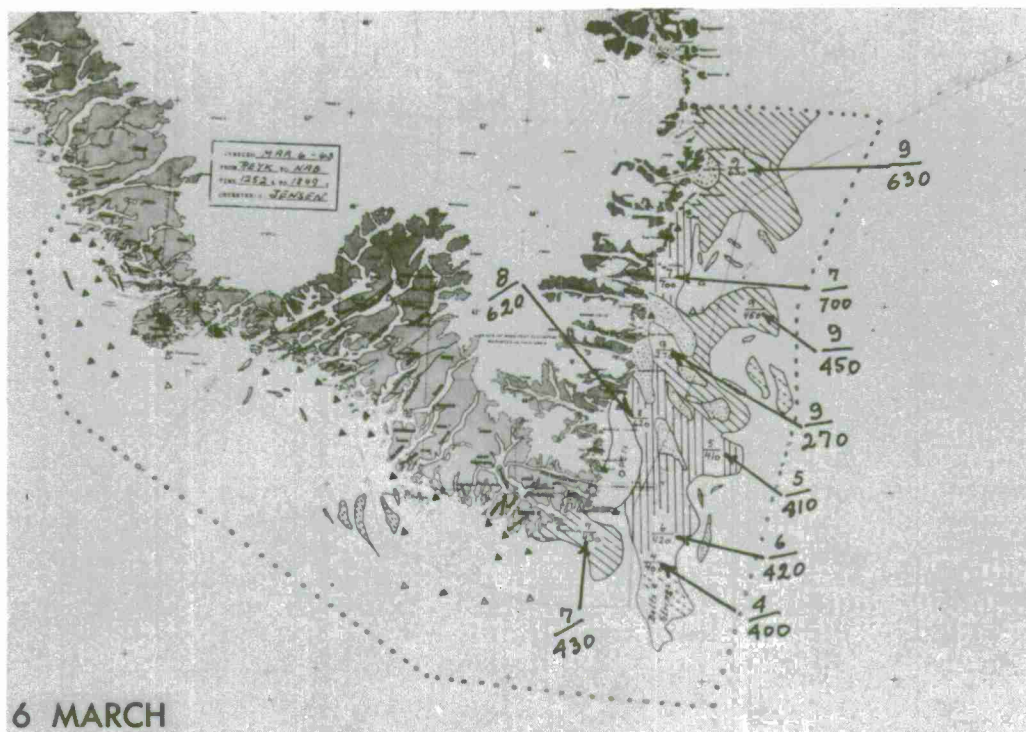


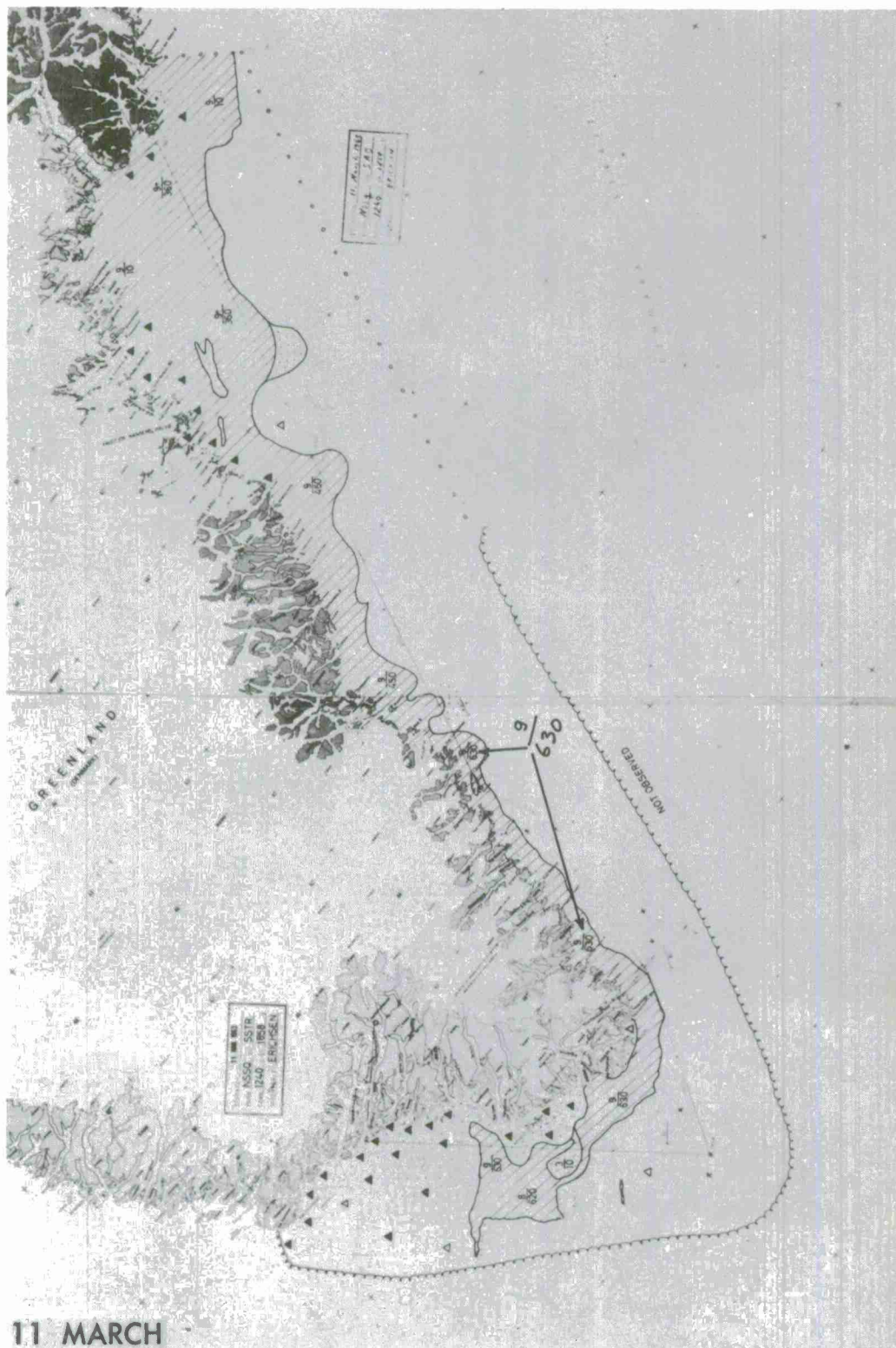
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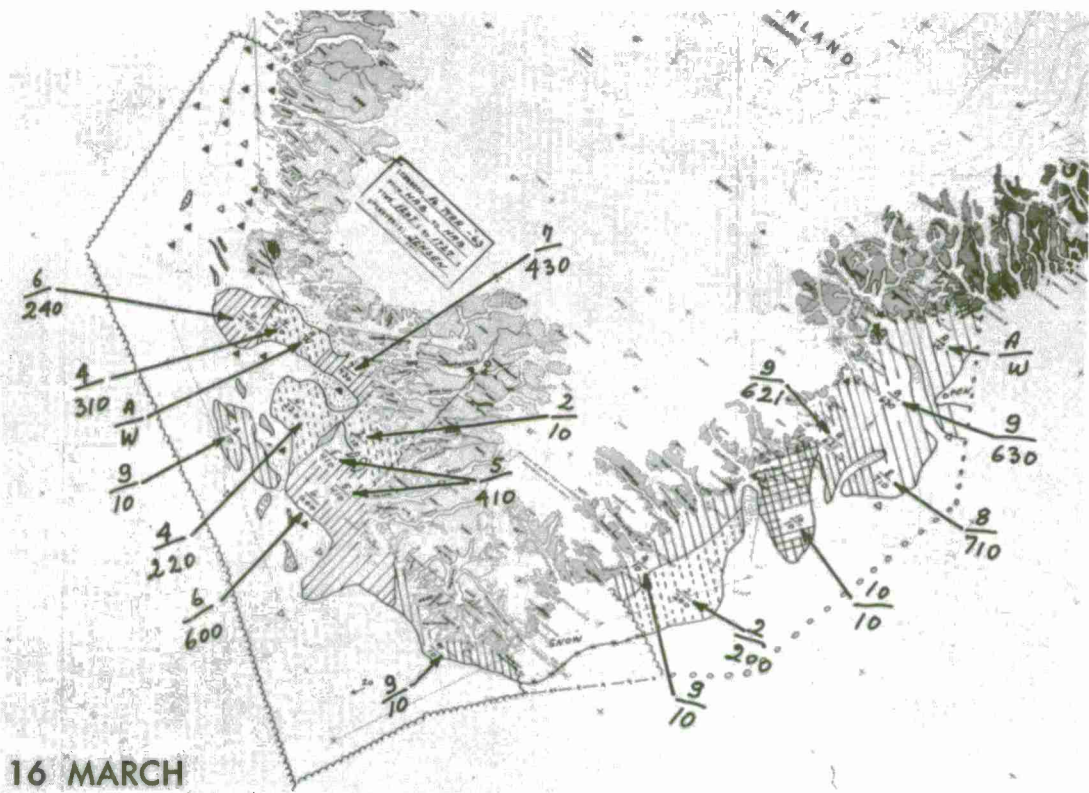
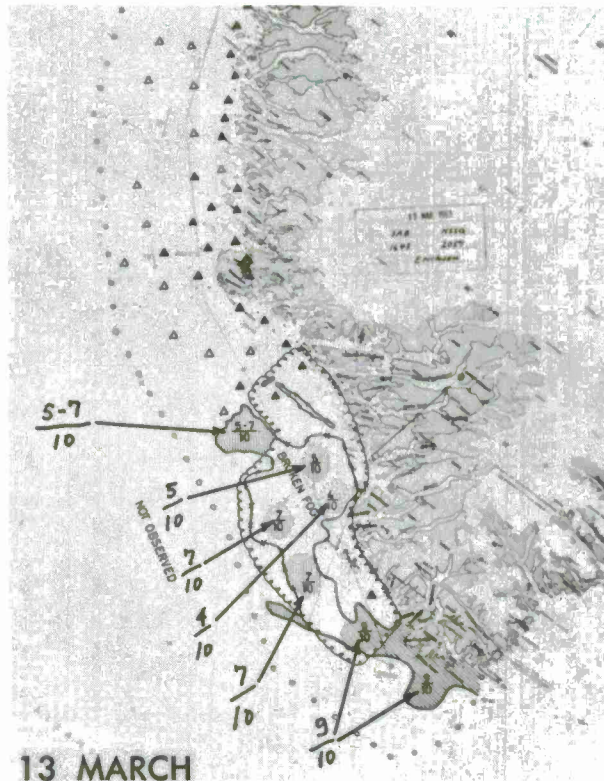


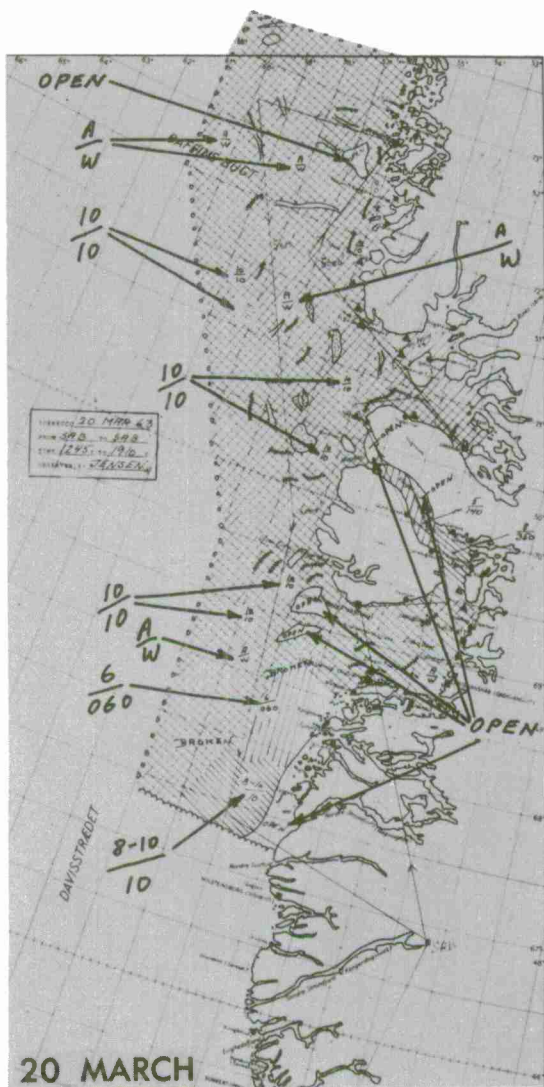
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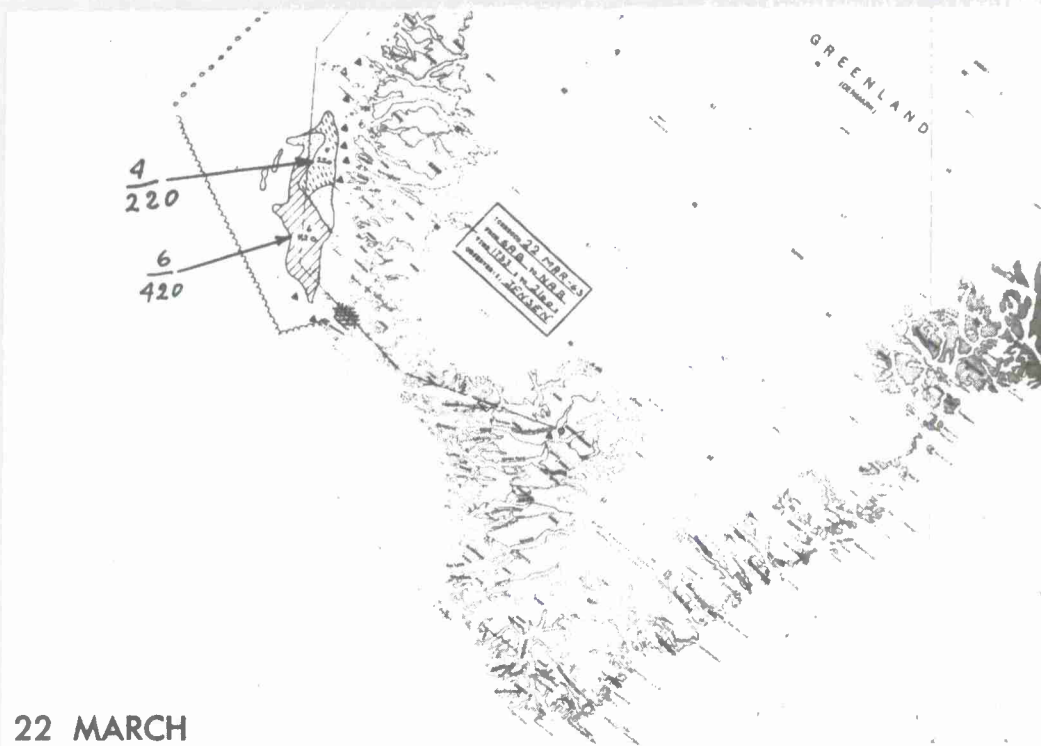




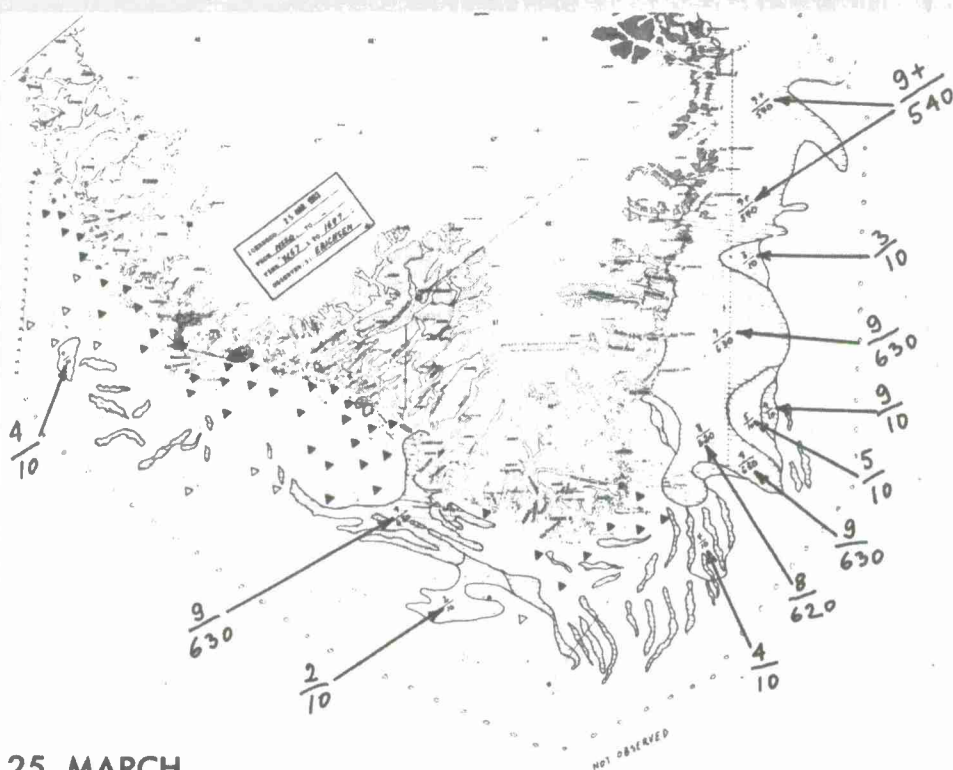
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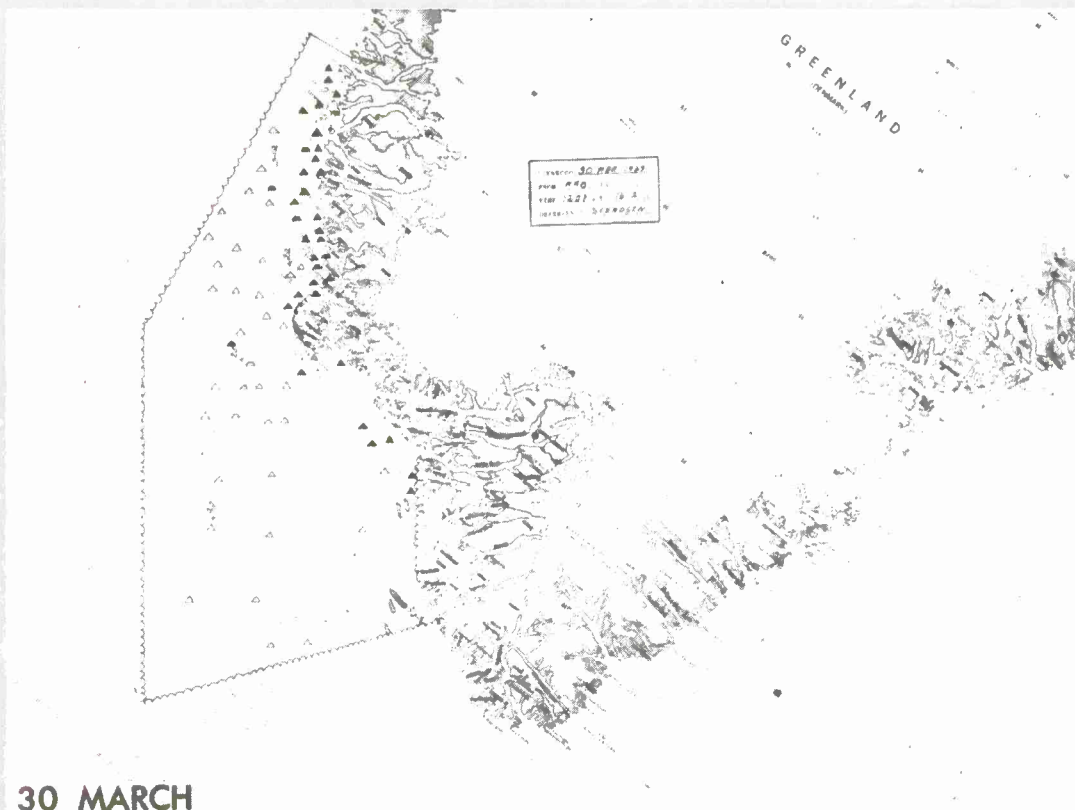
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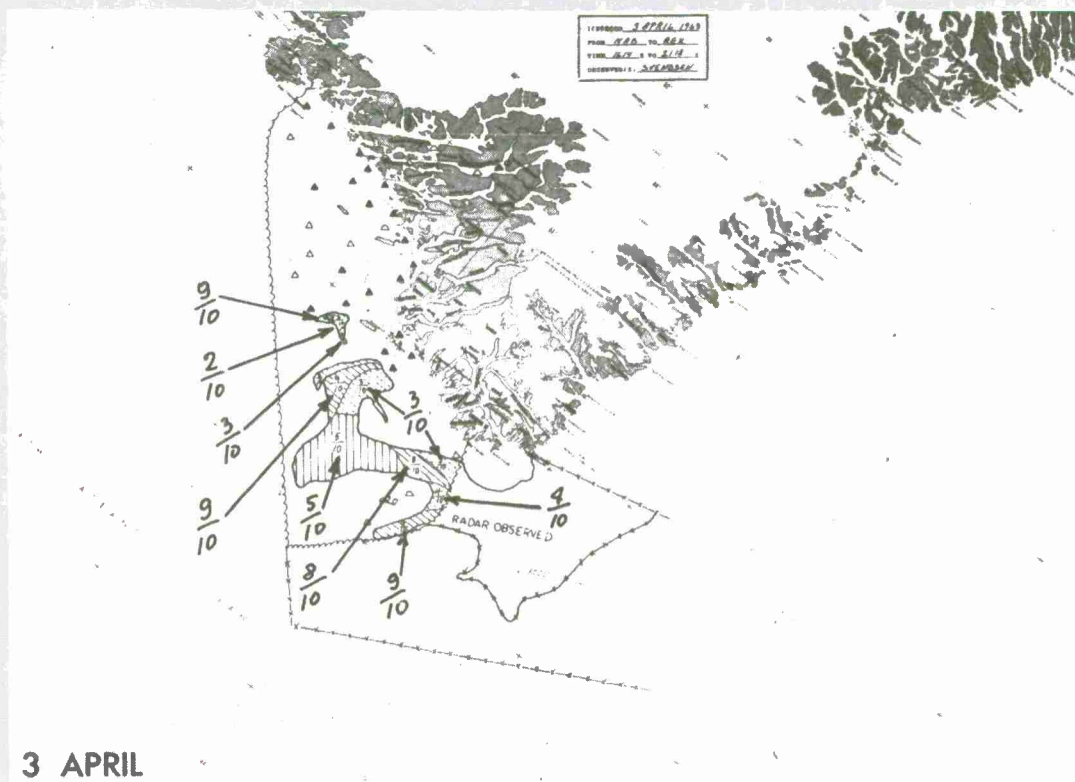
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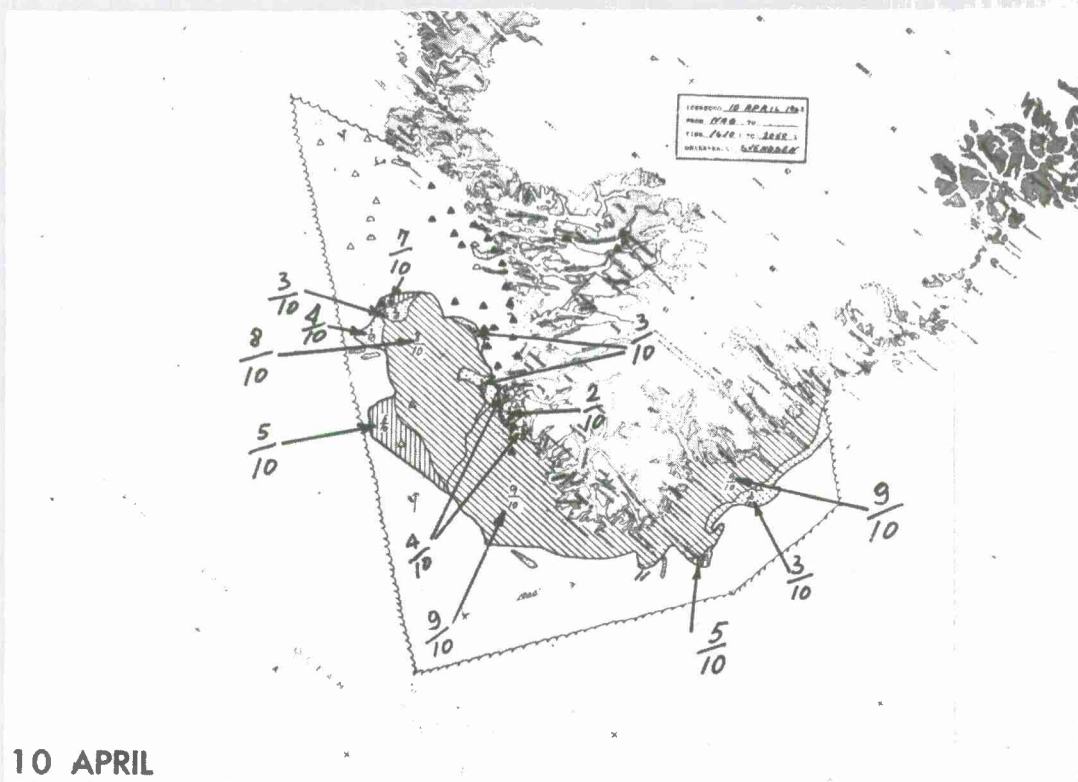
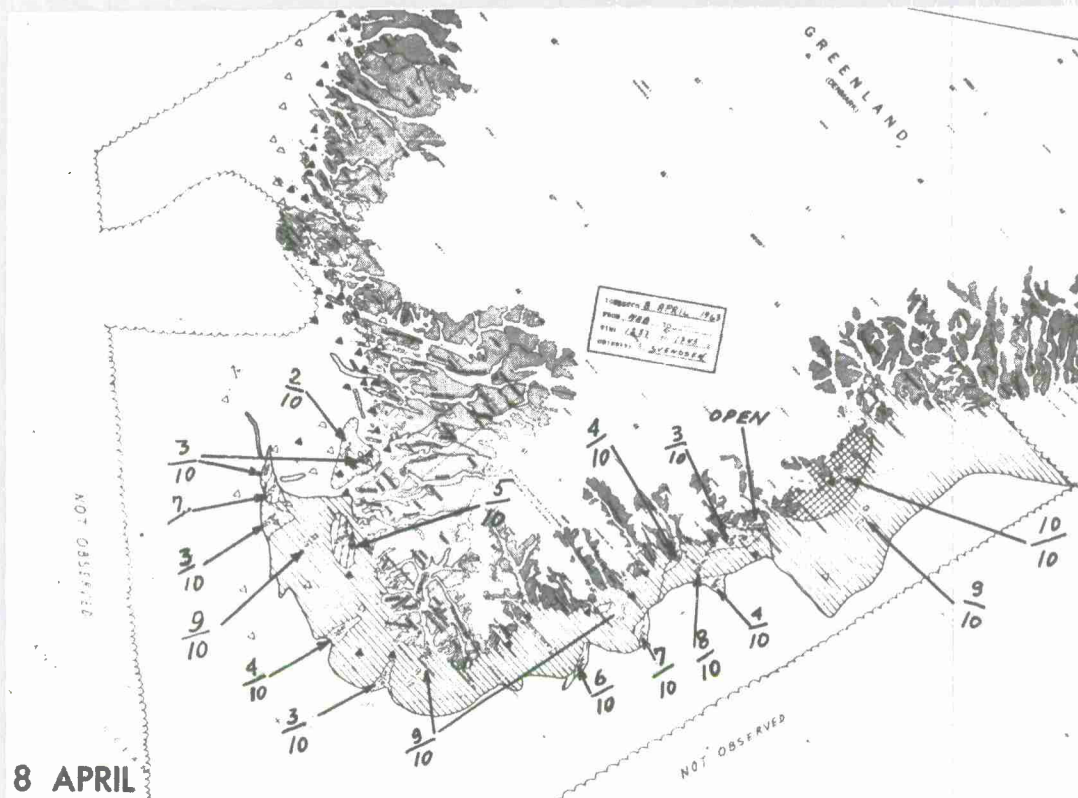
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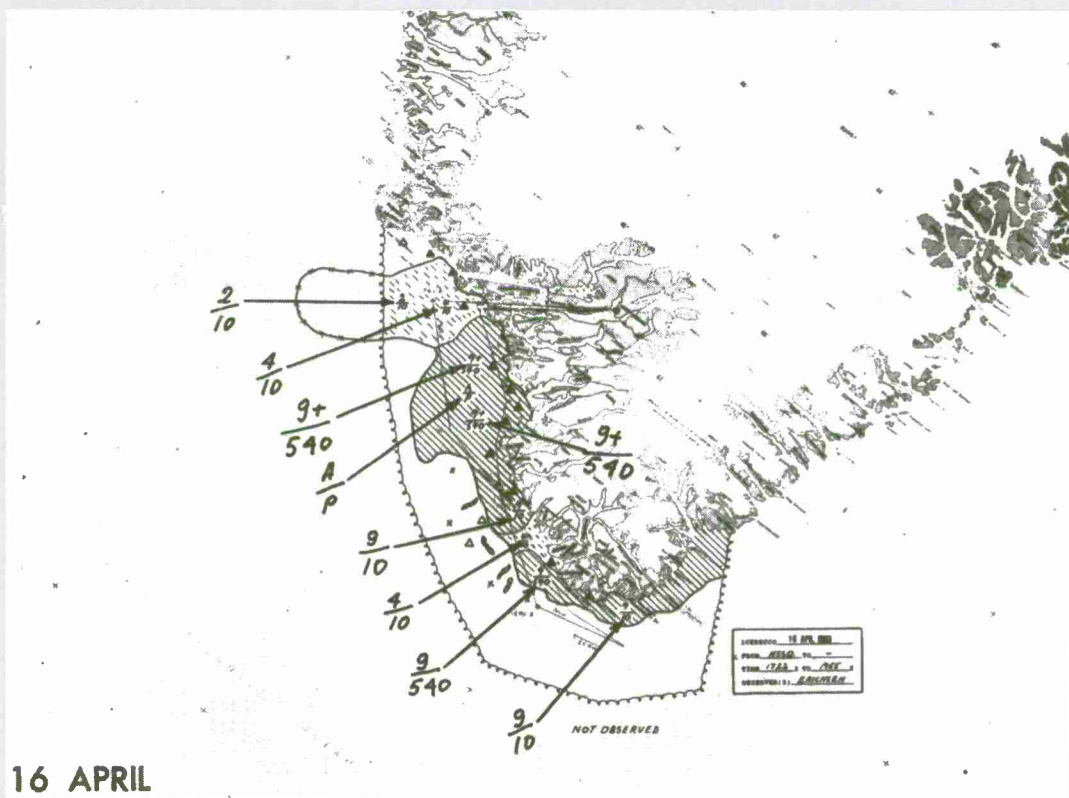
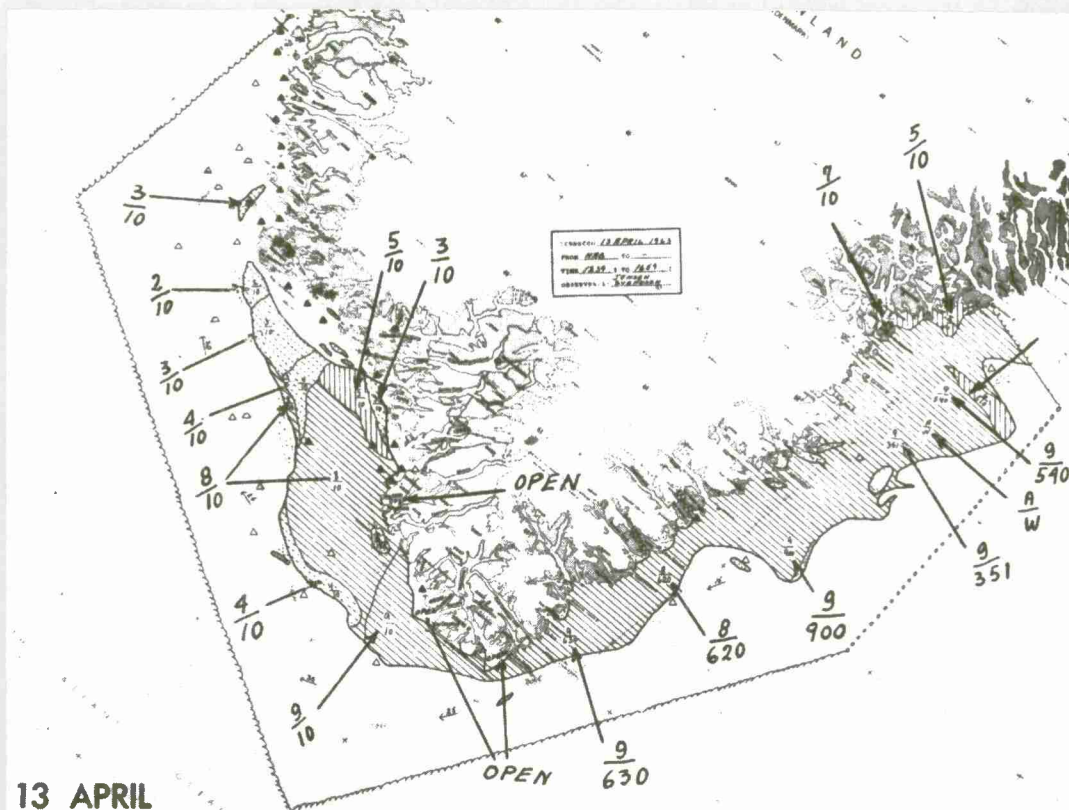


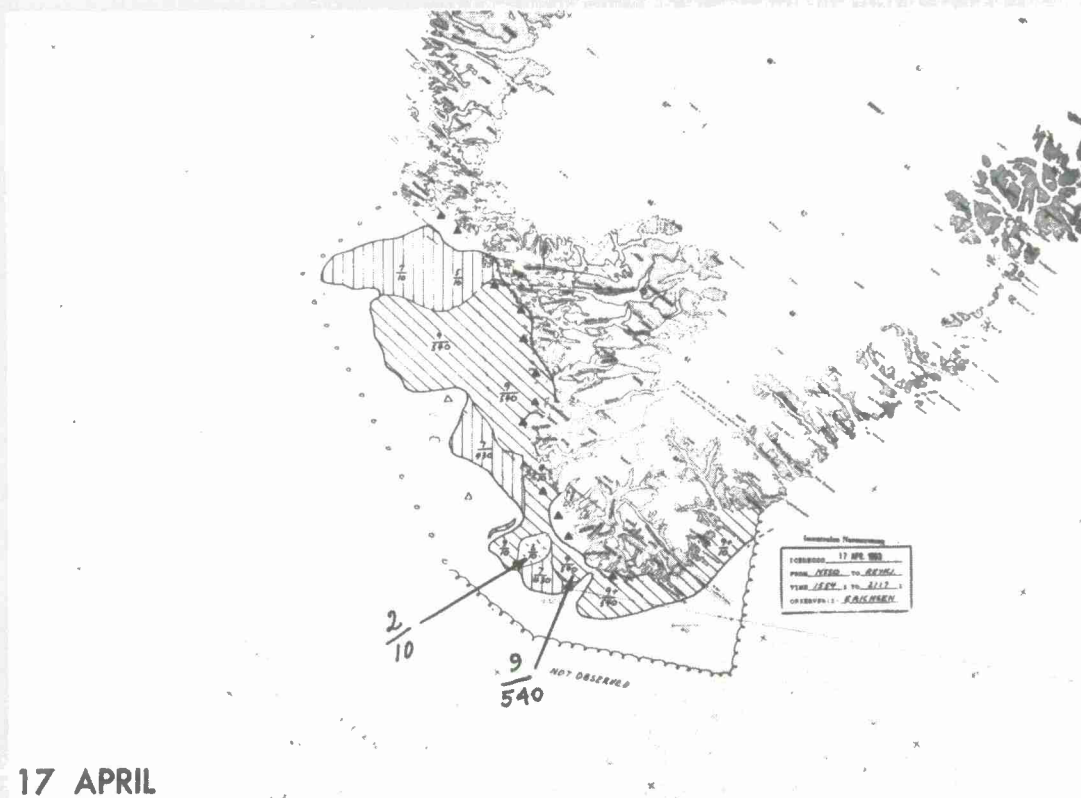
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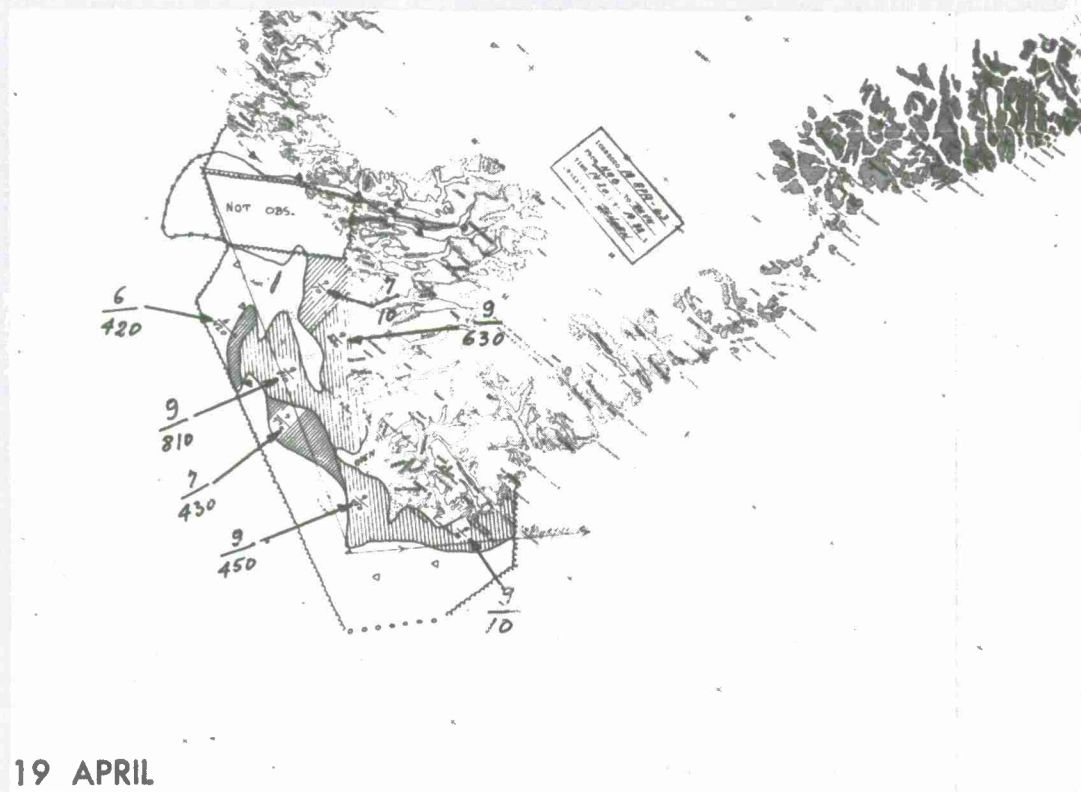
3 APRIL



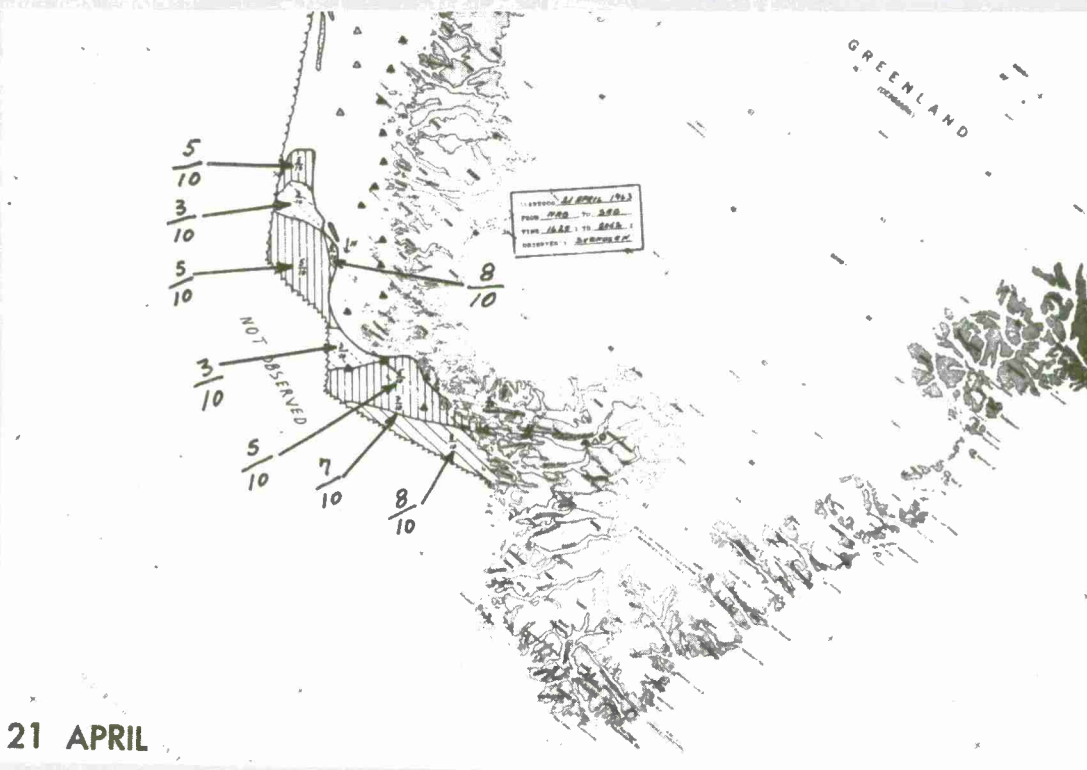
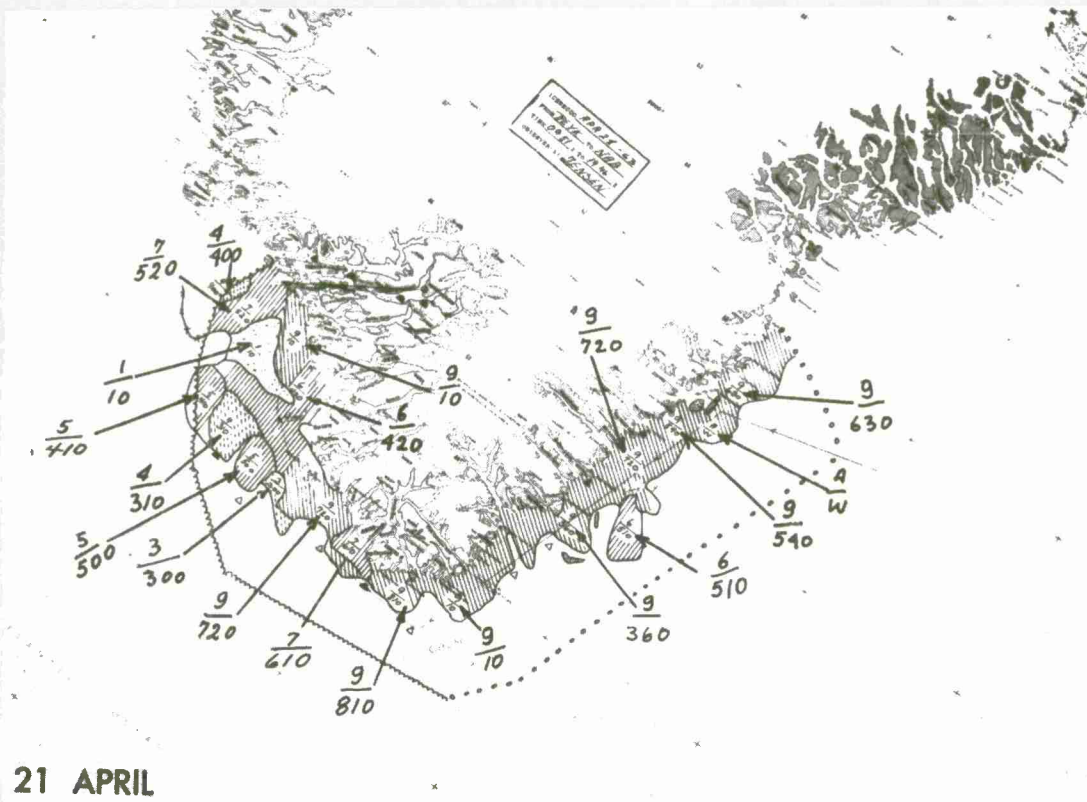


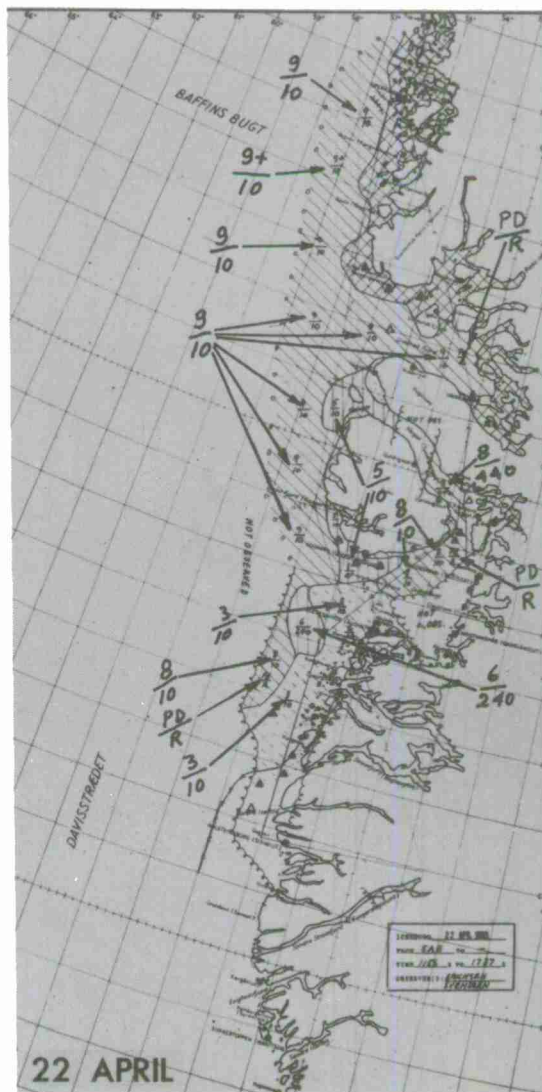
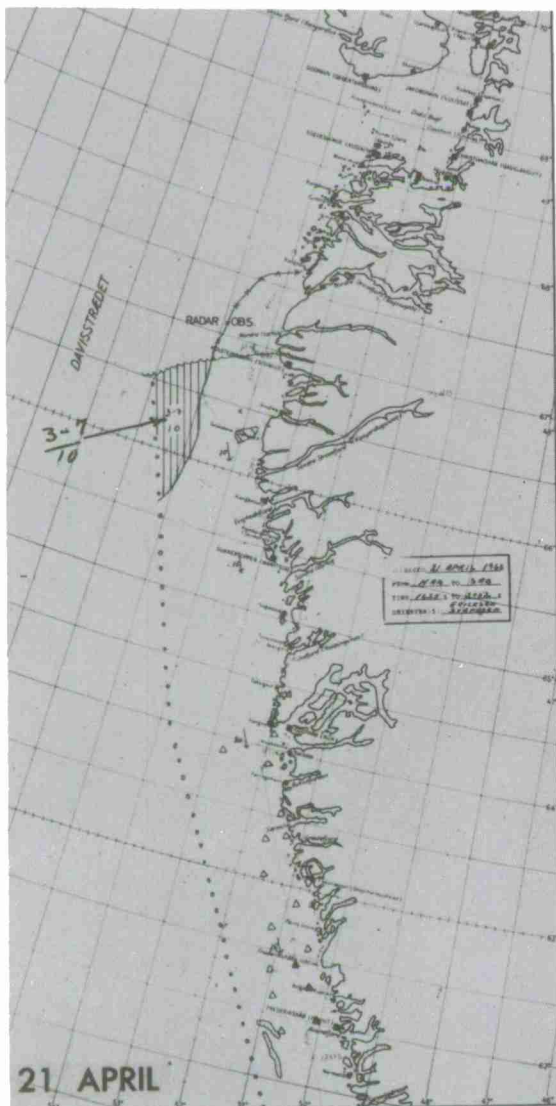


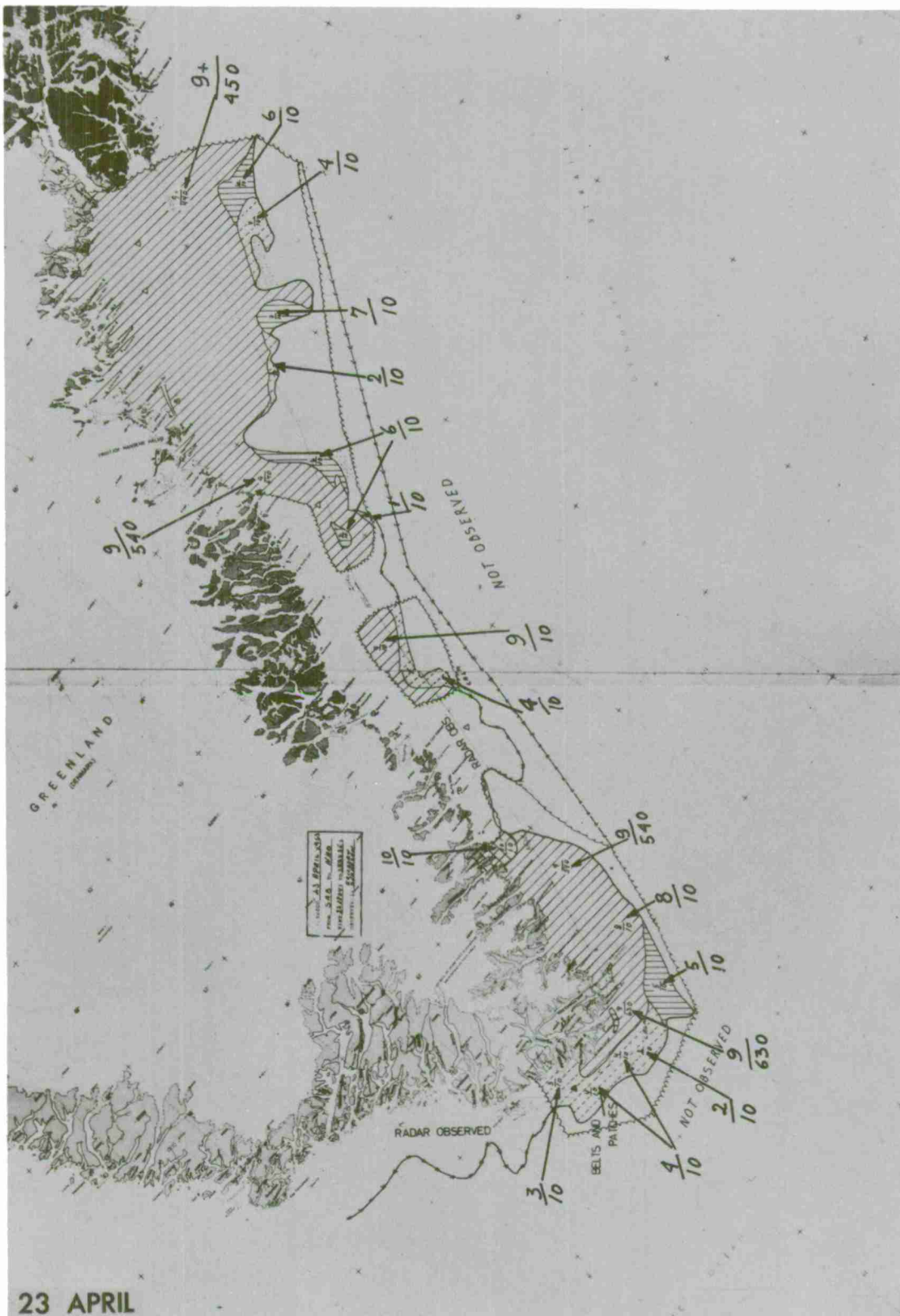
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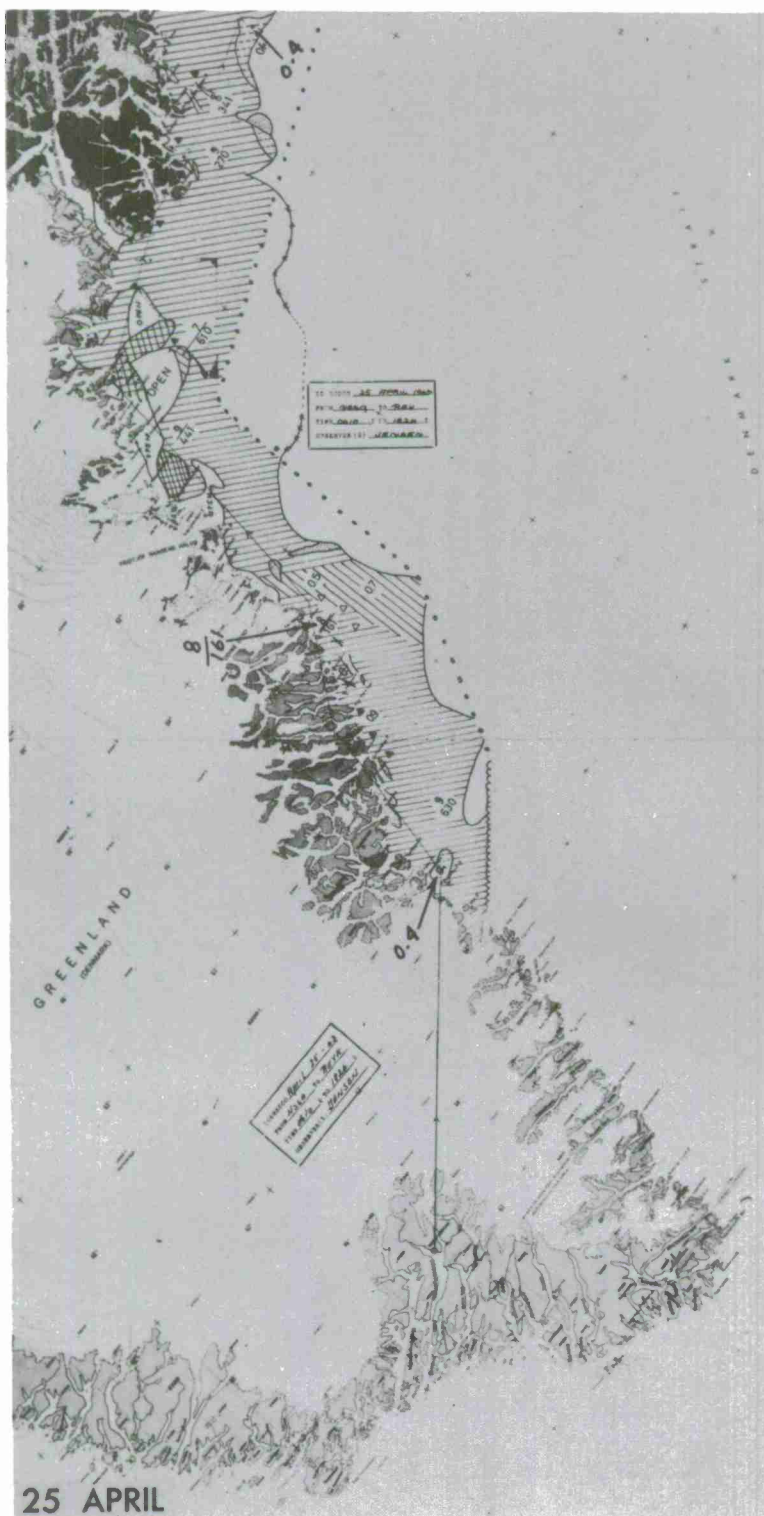


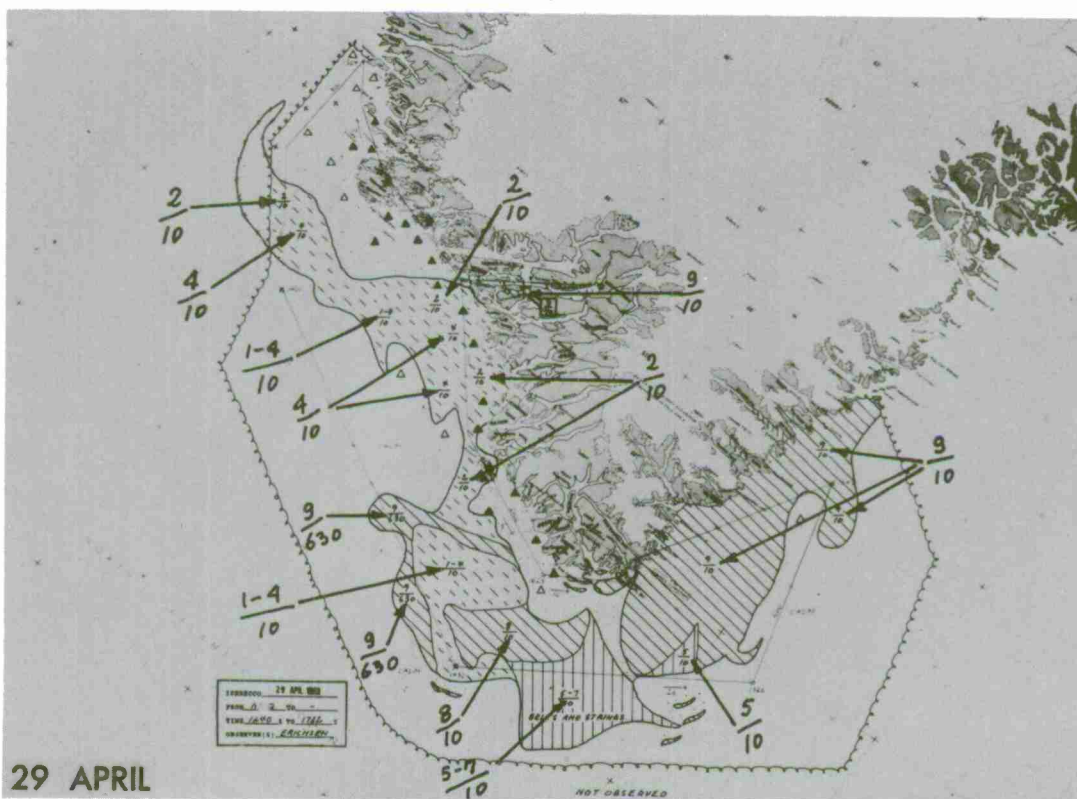
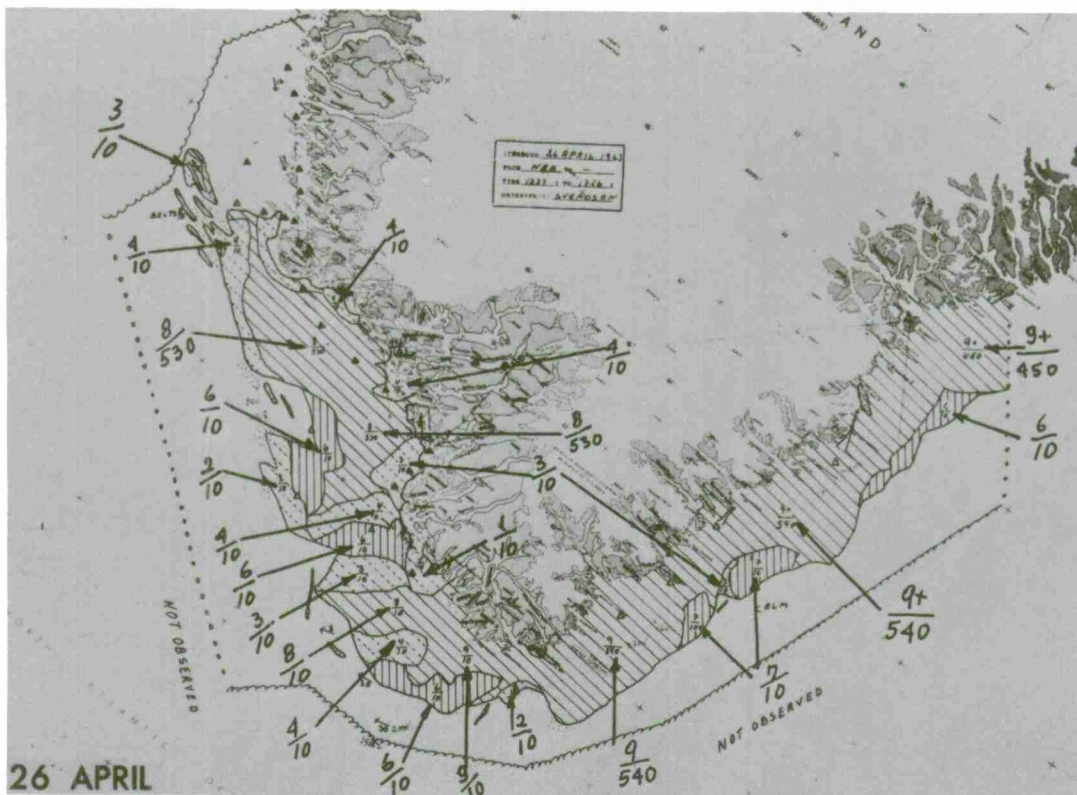
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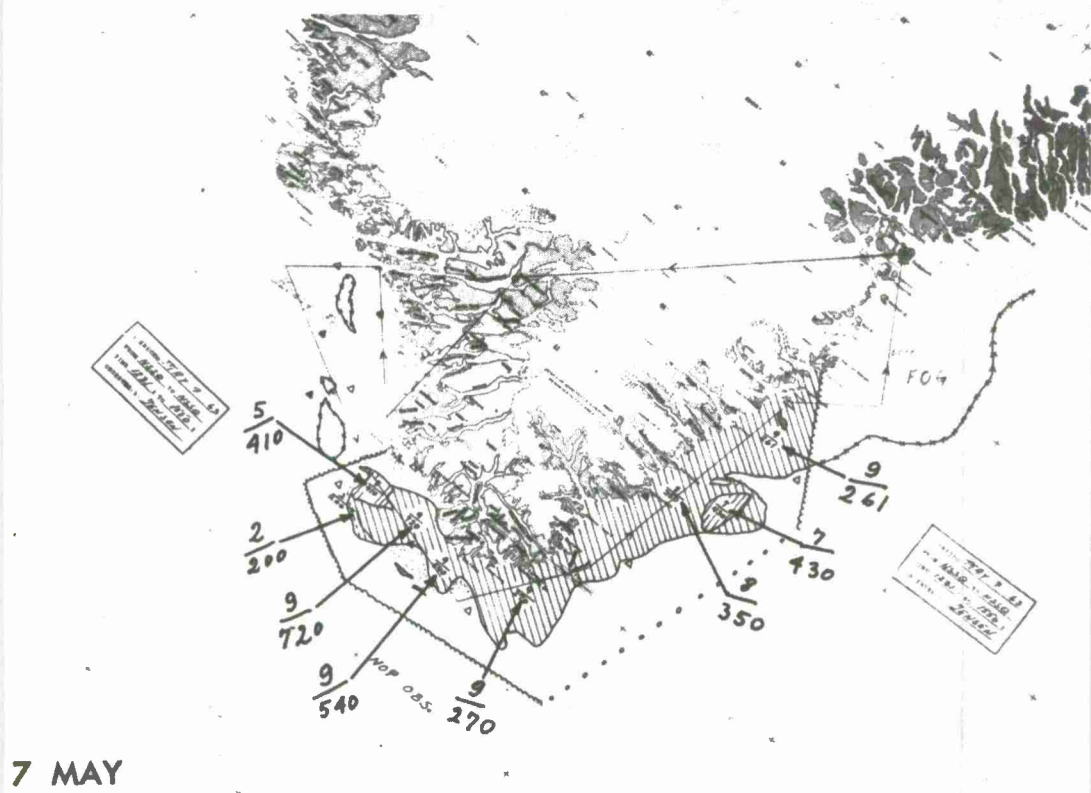
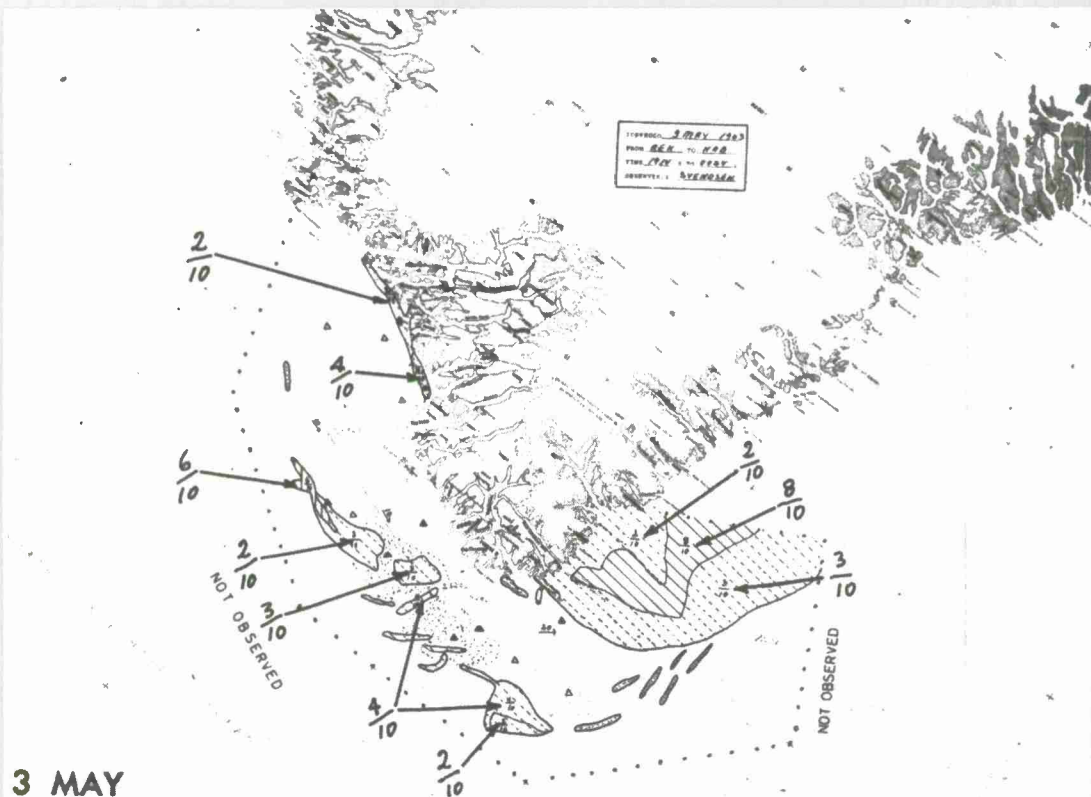


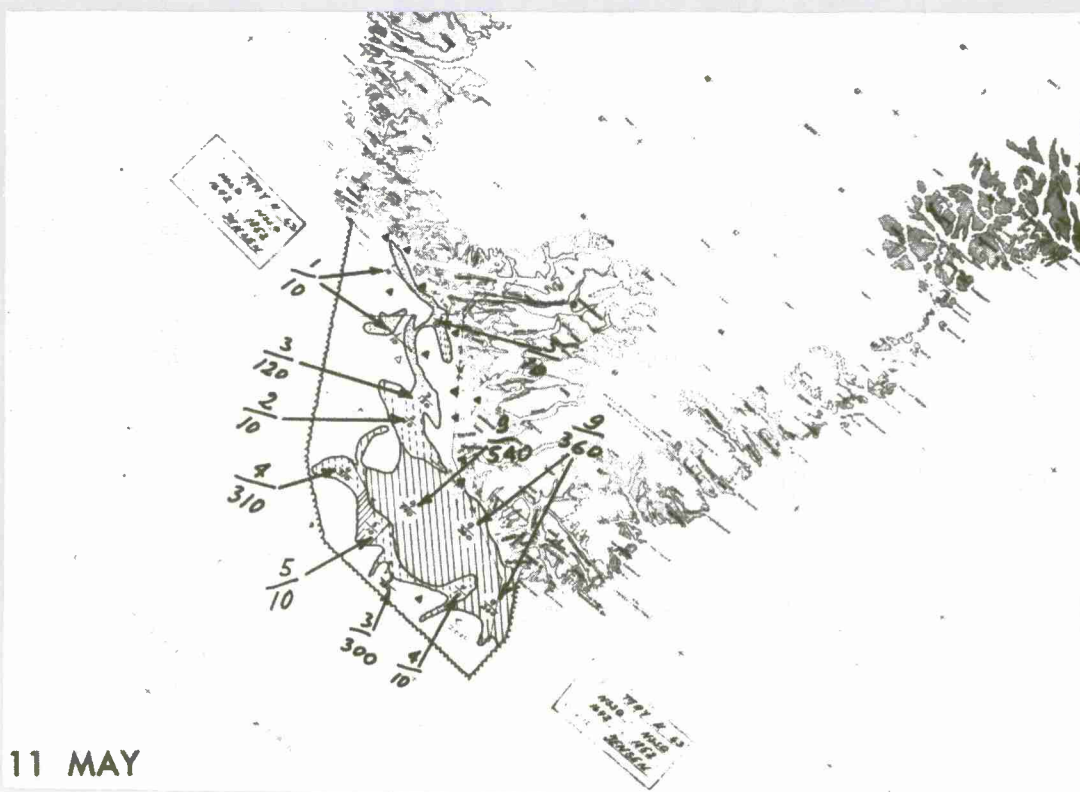
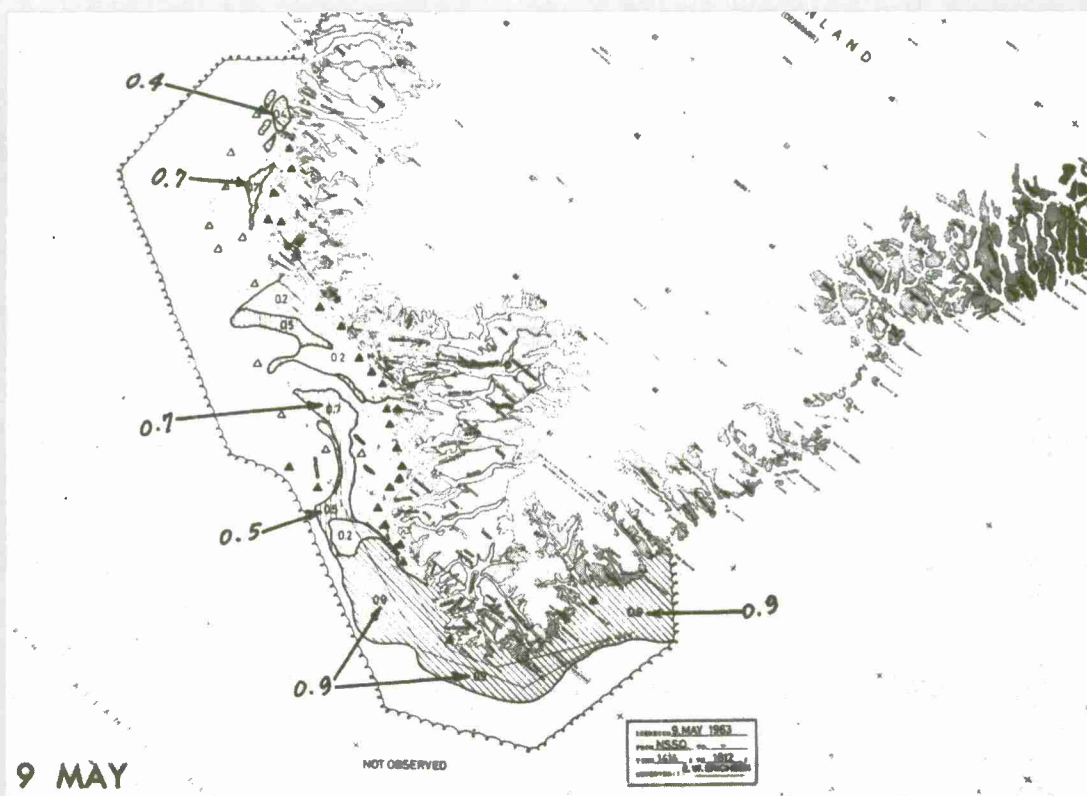


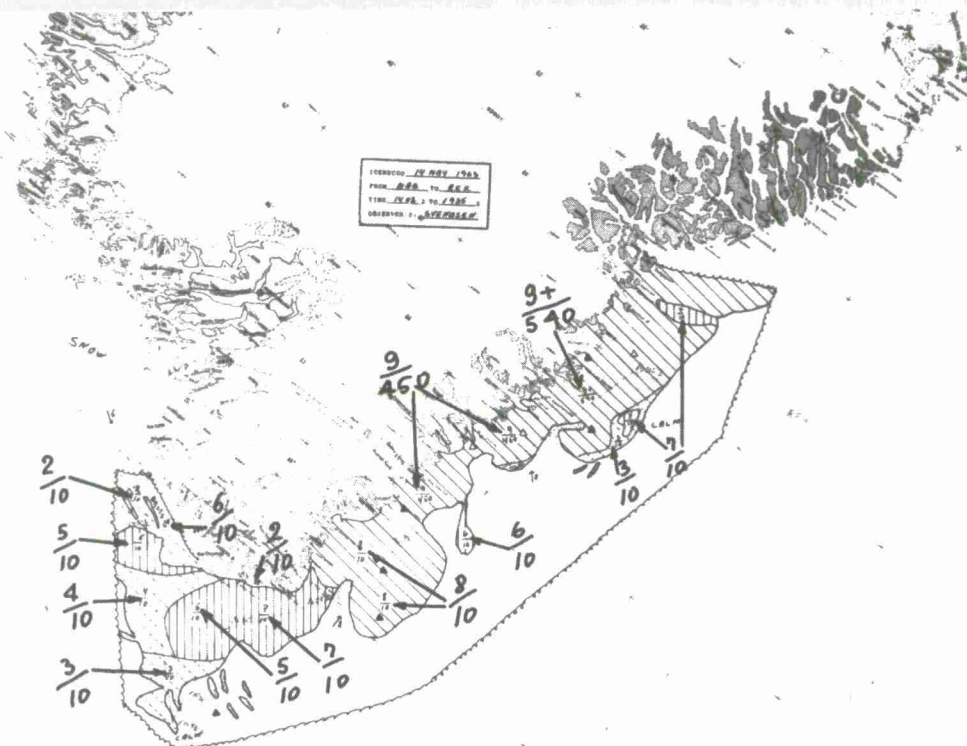




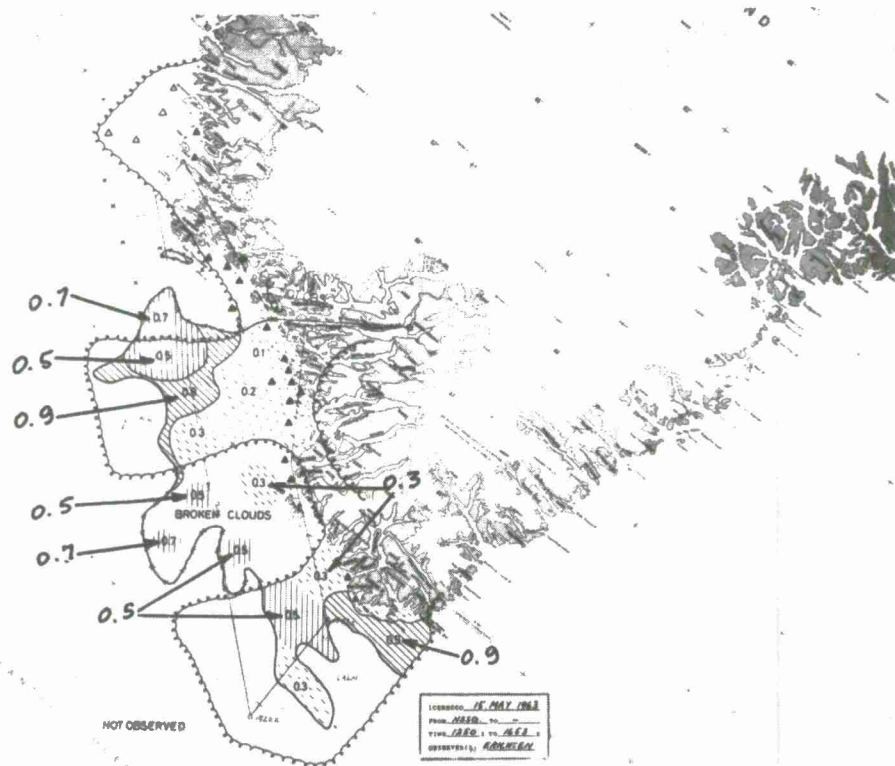




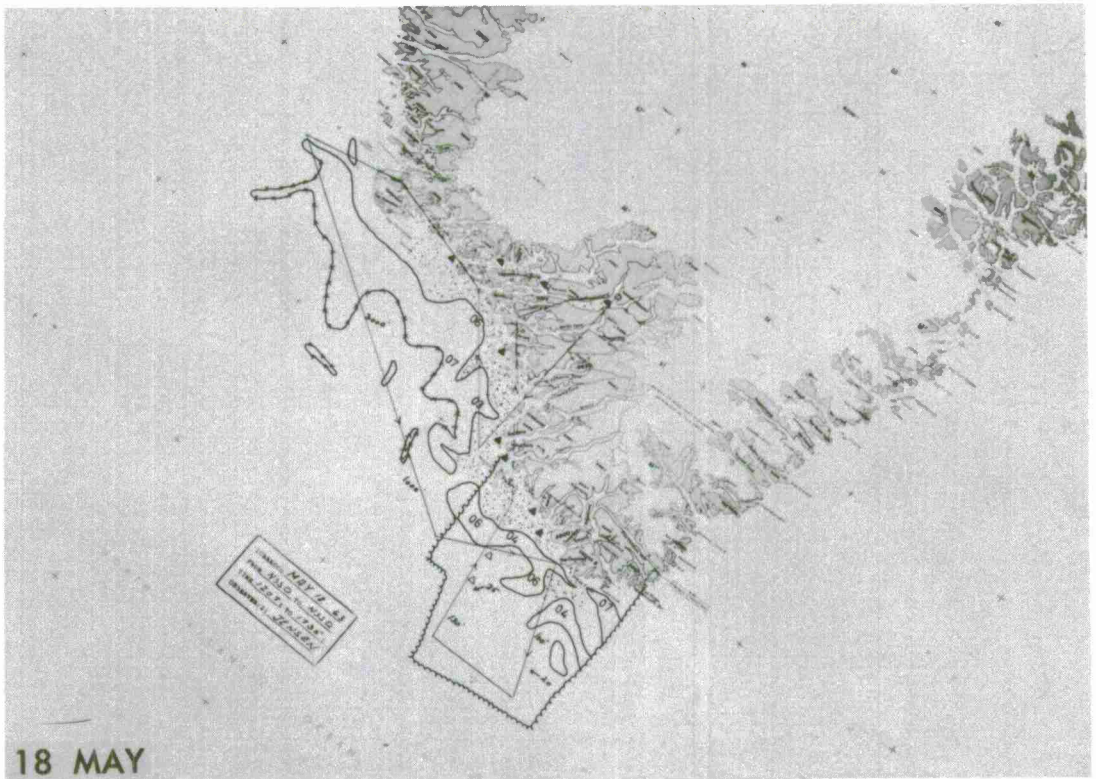




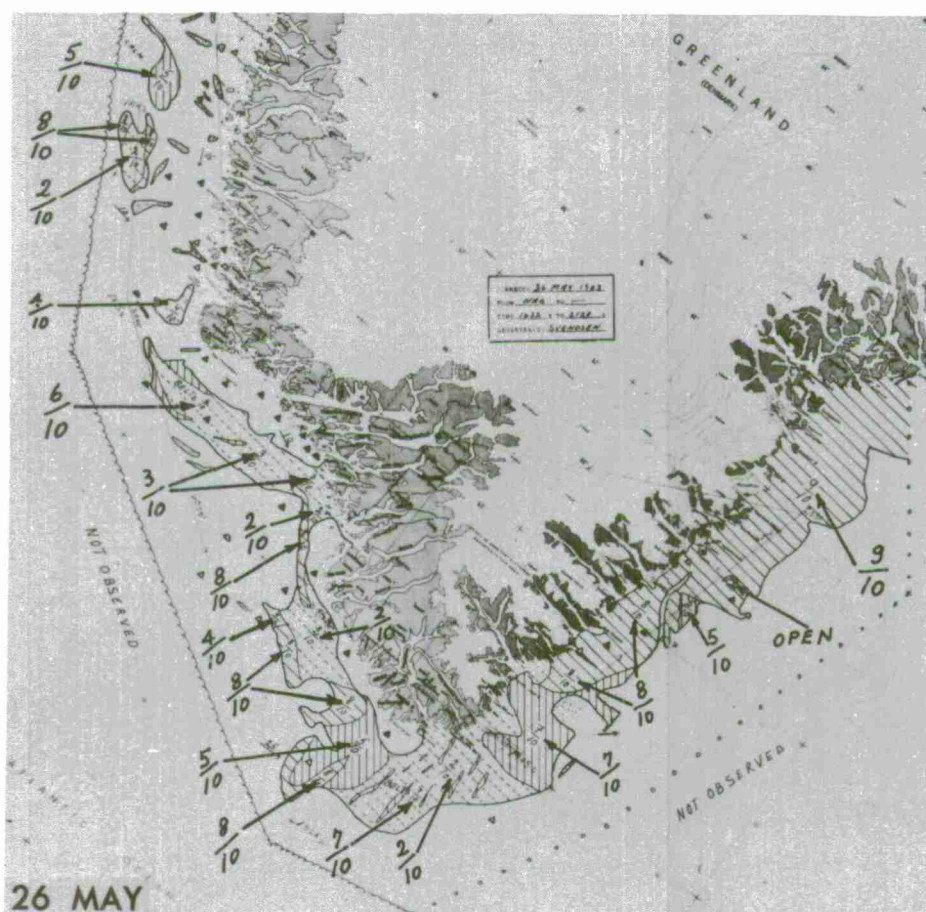
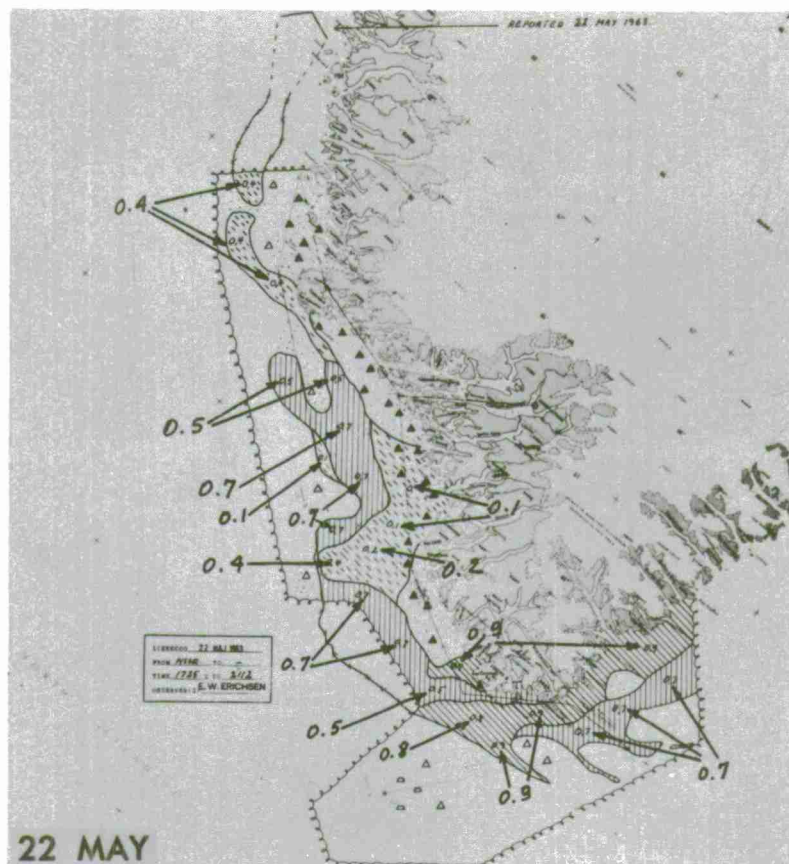
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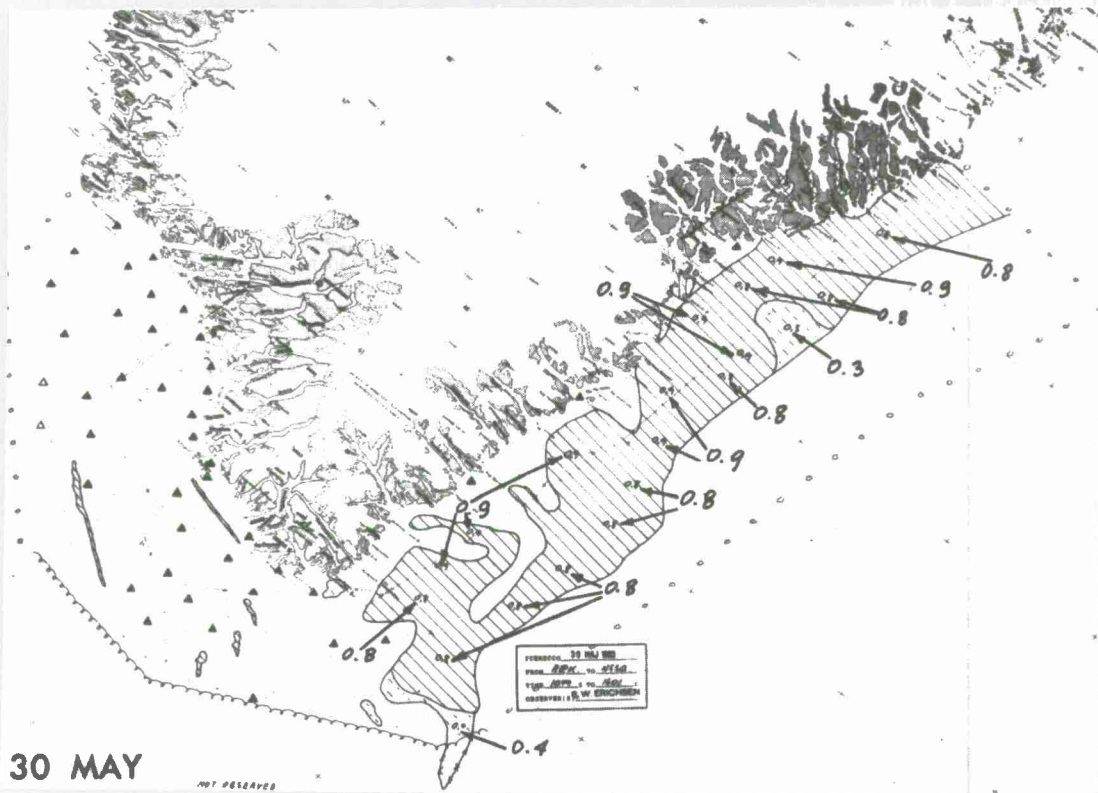
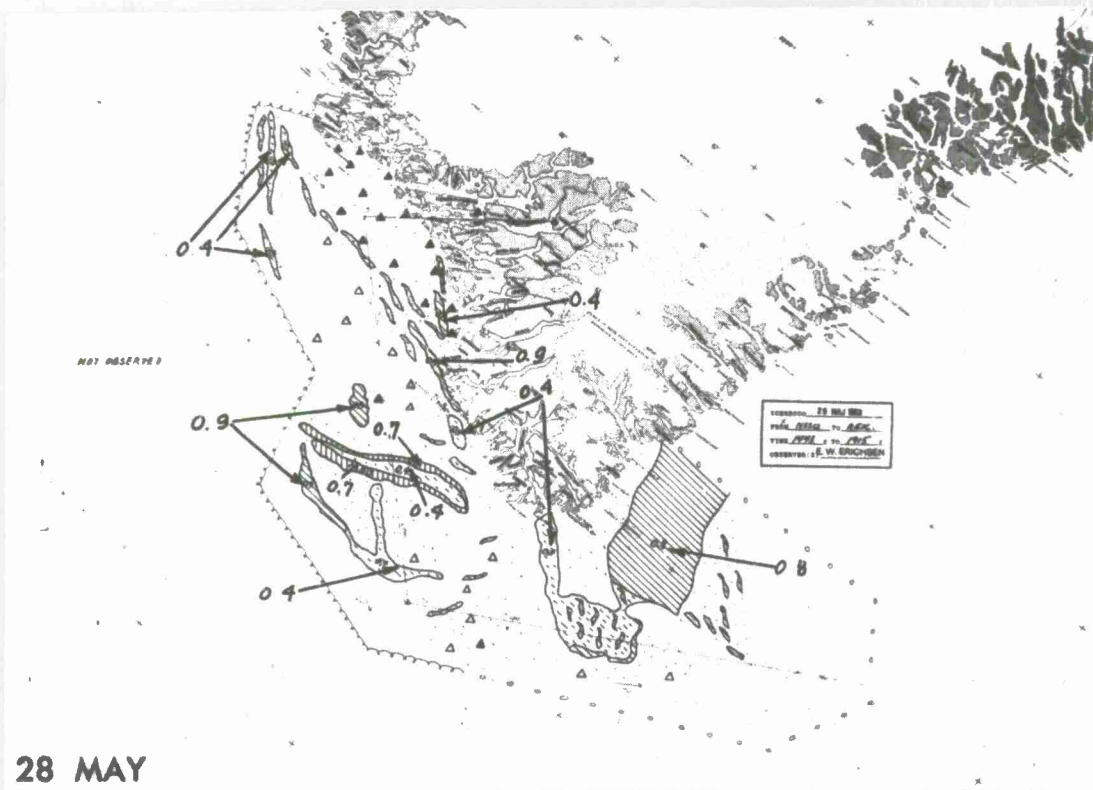


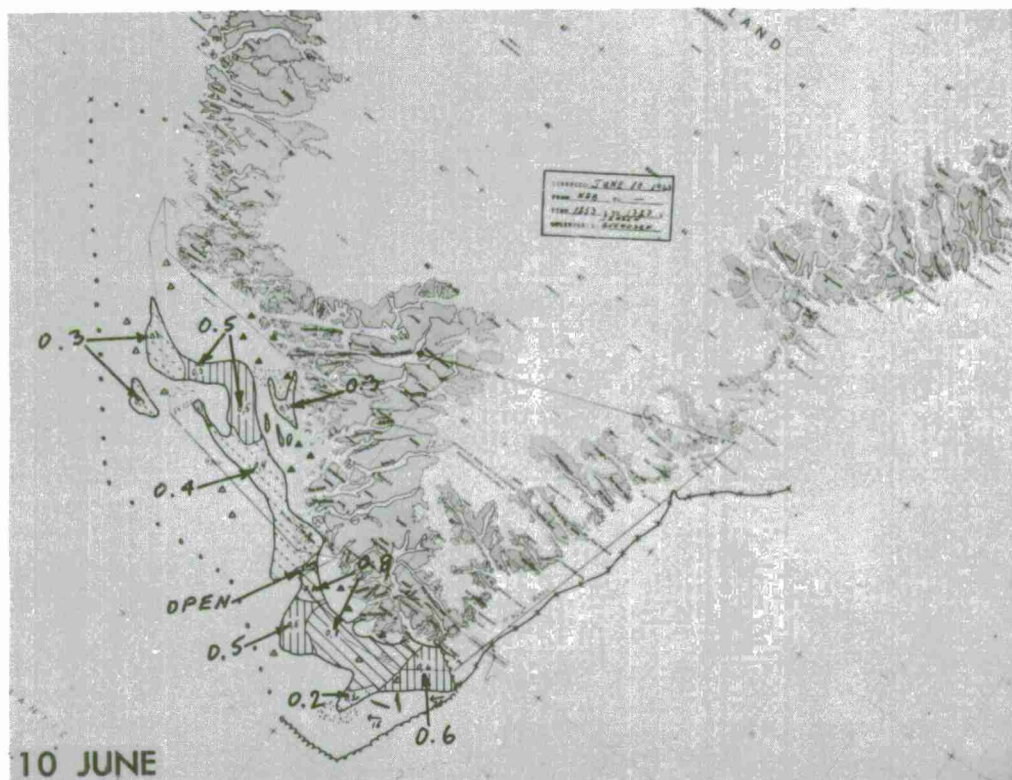
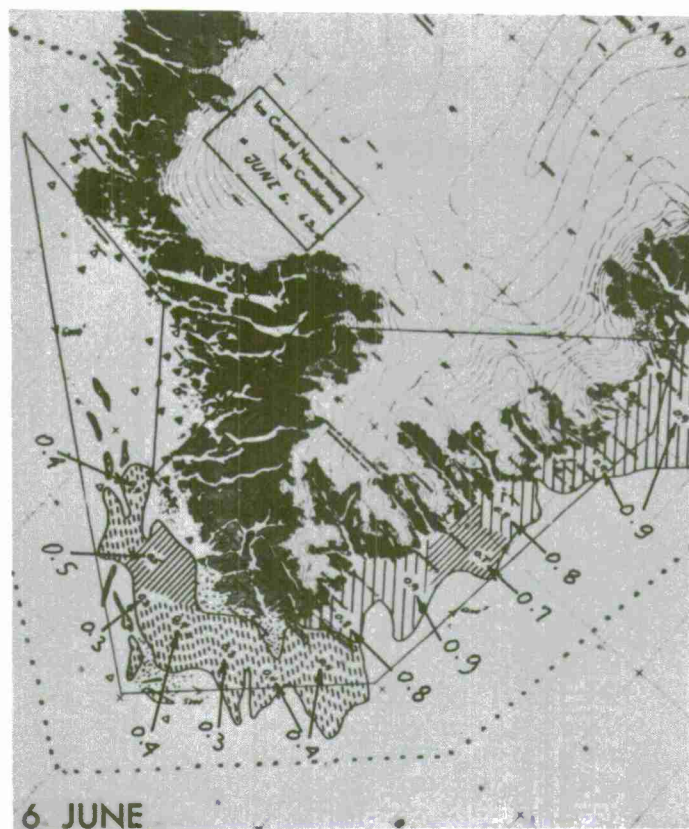
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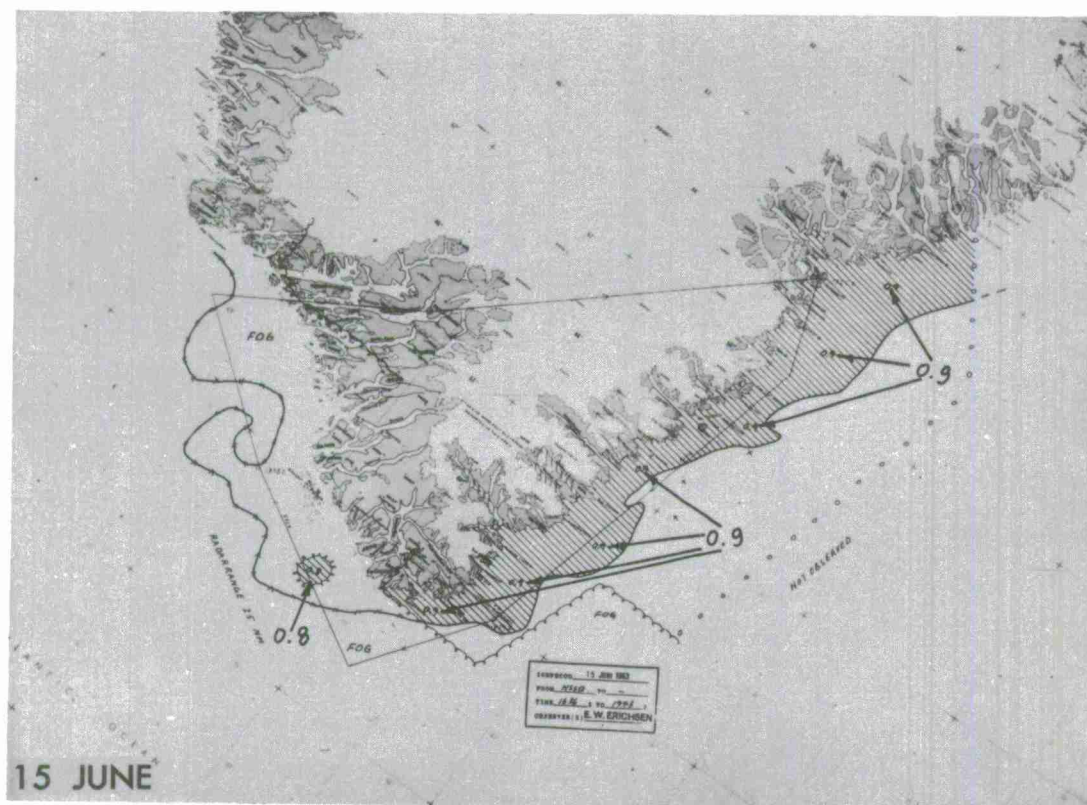
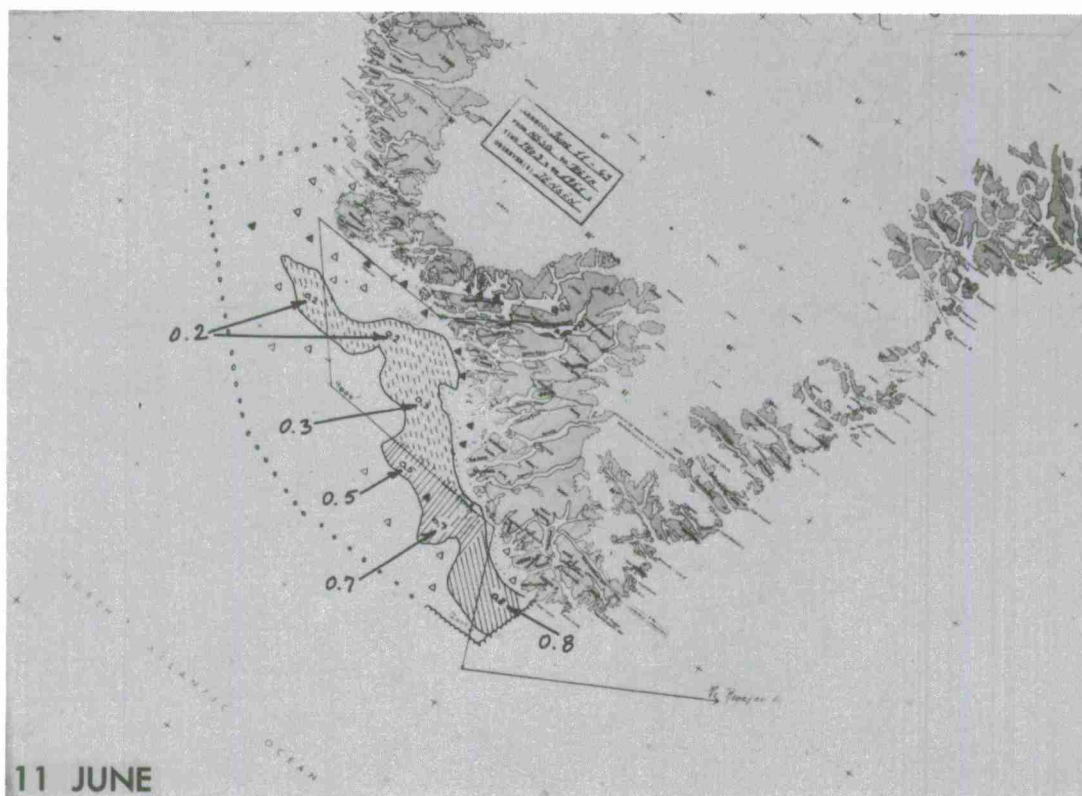


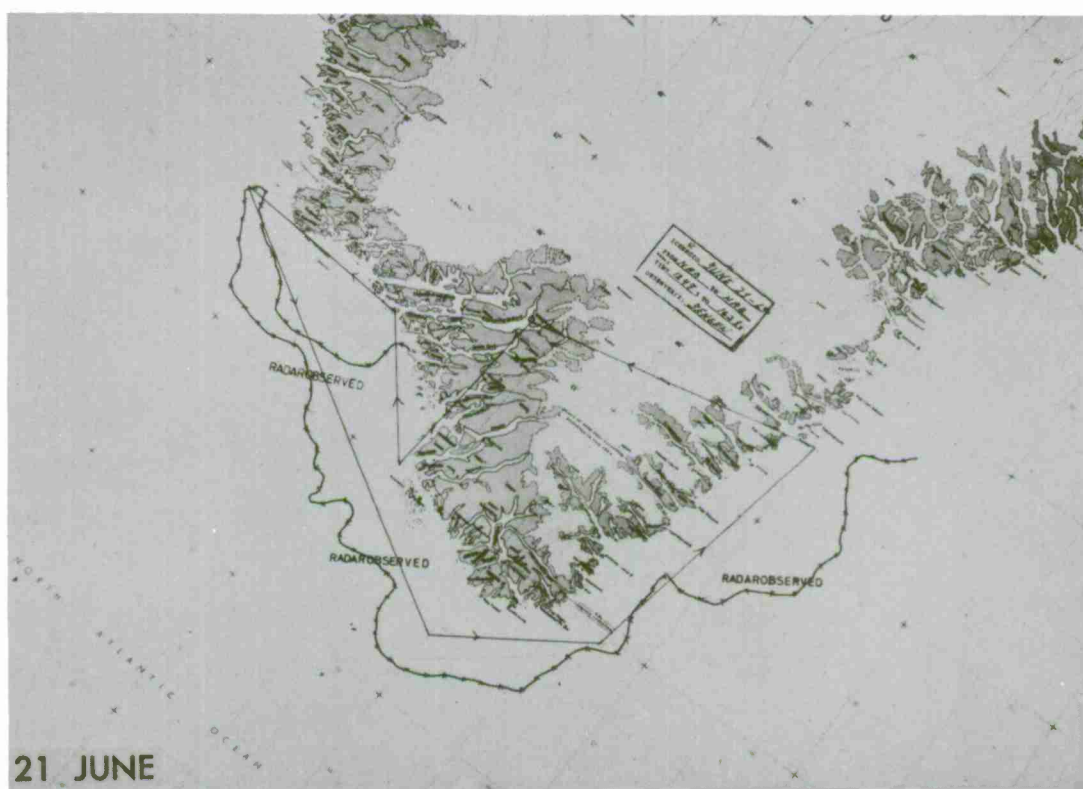
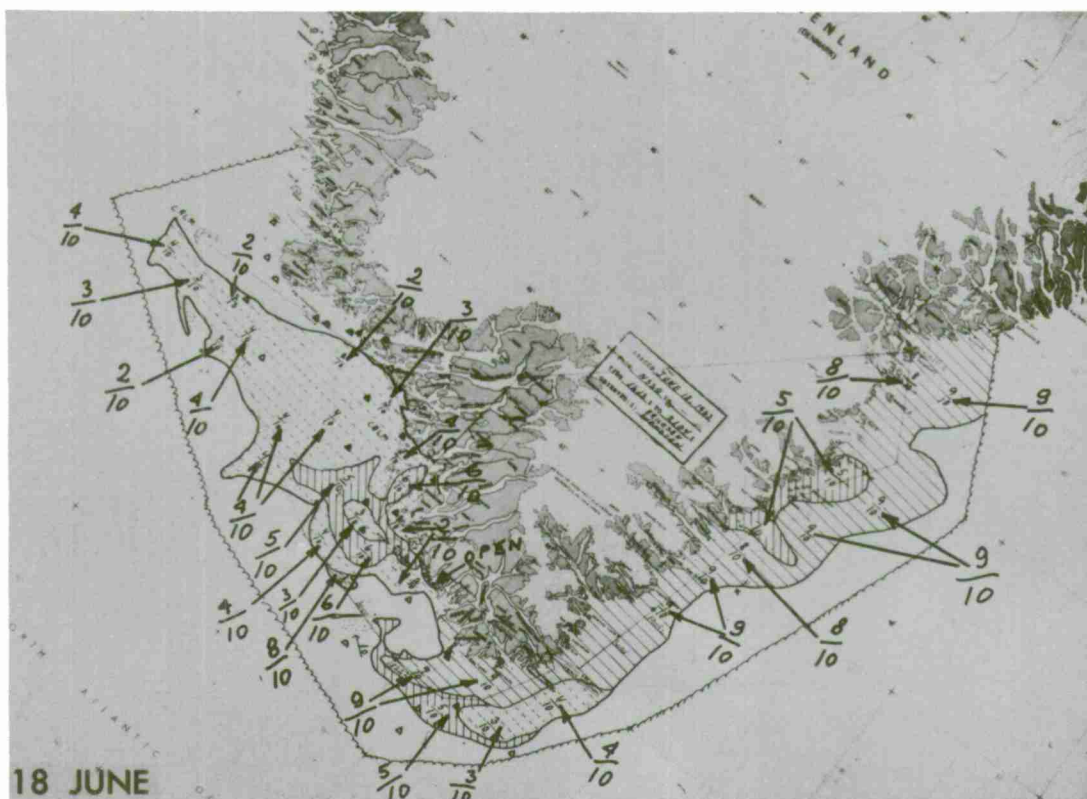


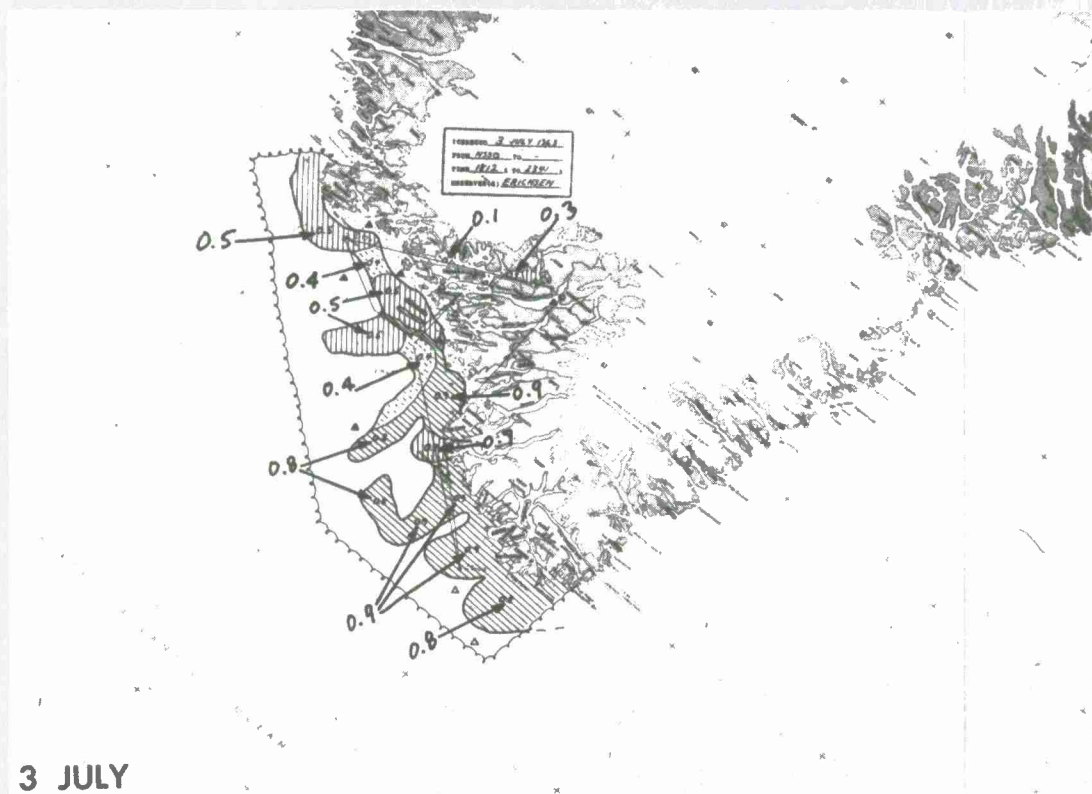
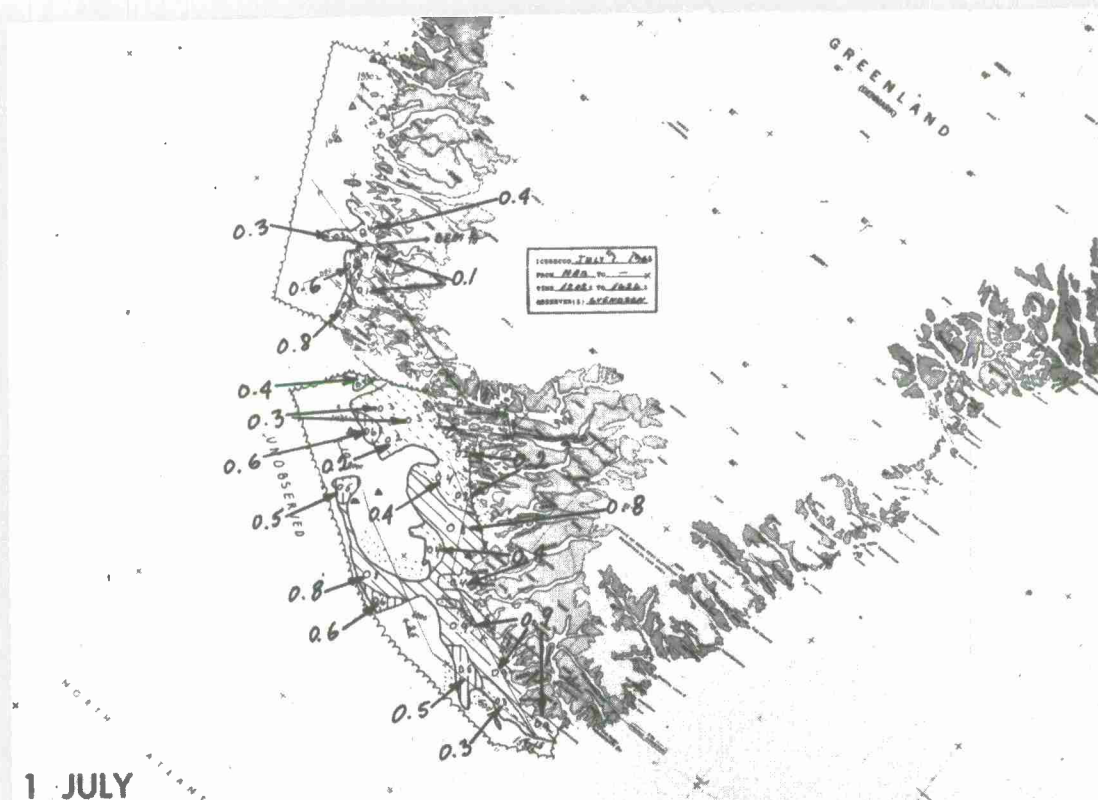


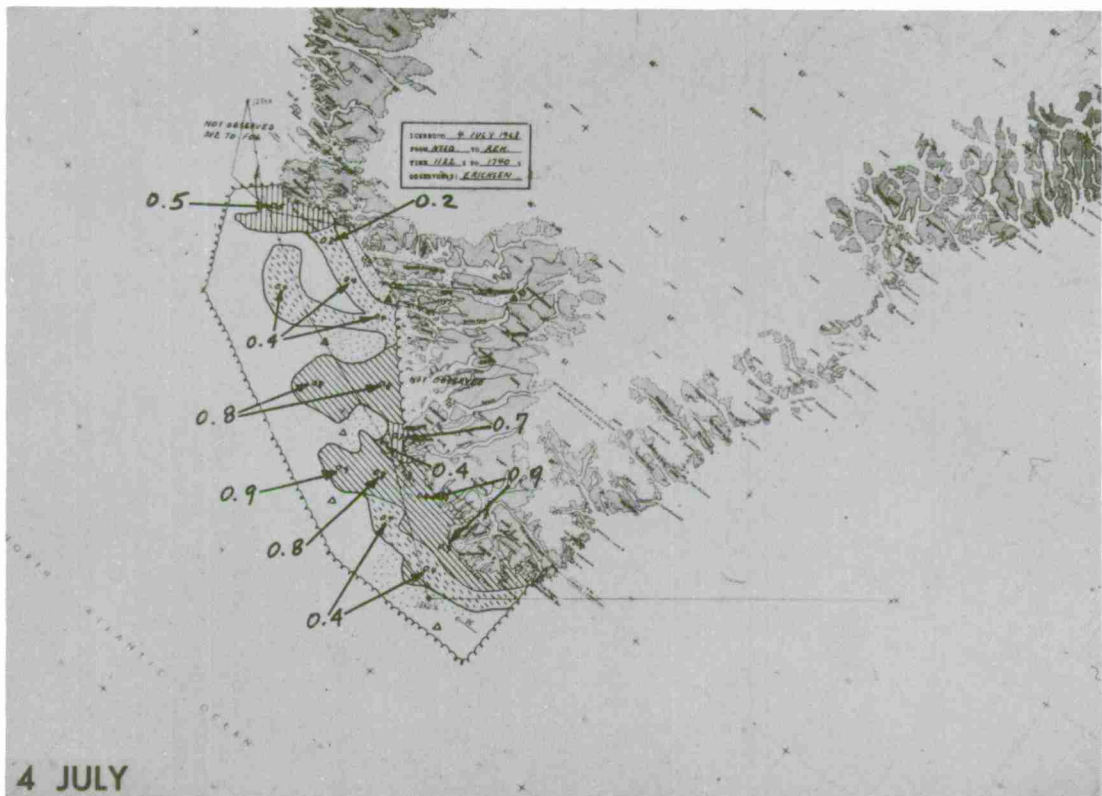


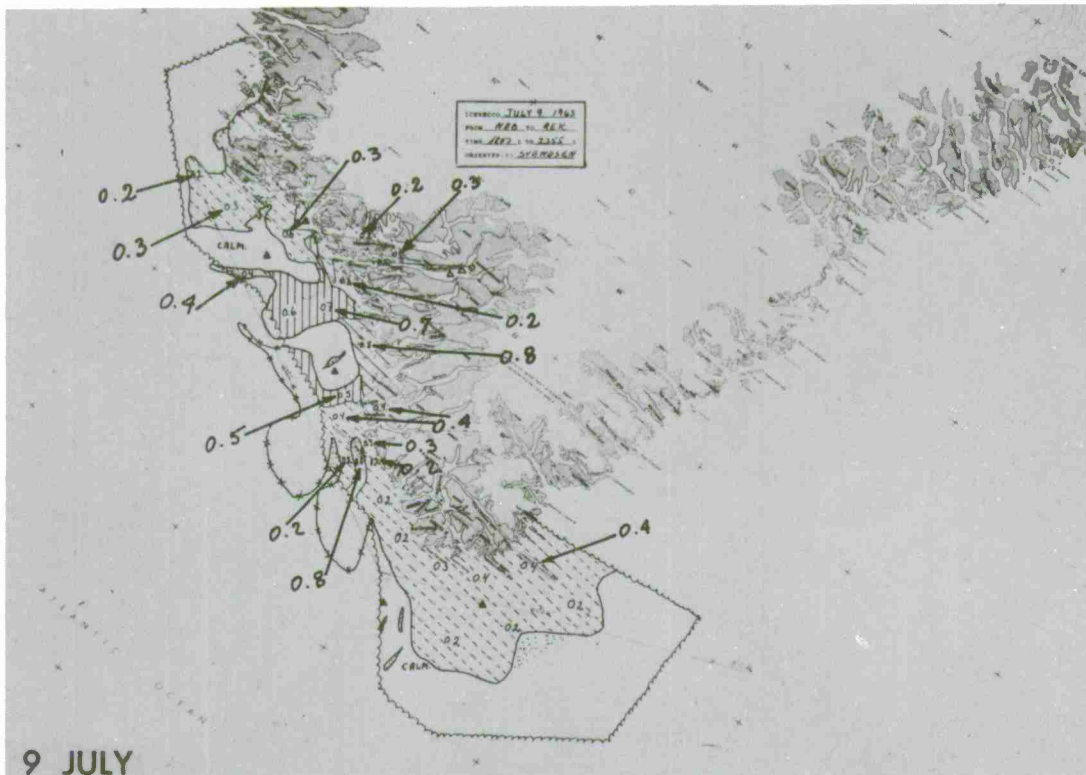


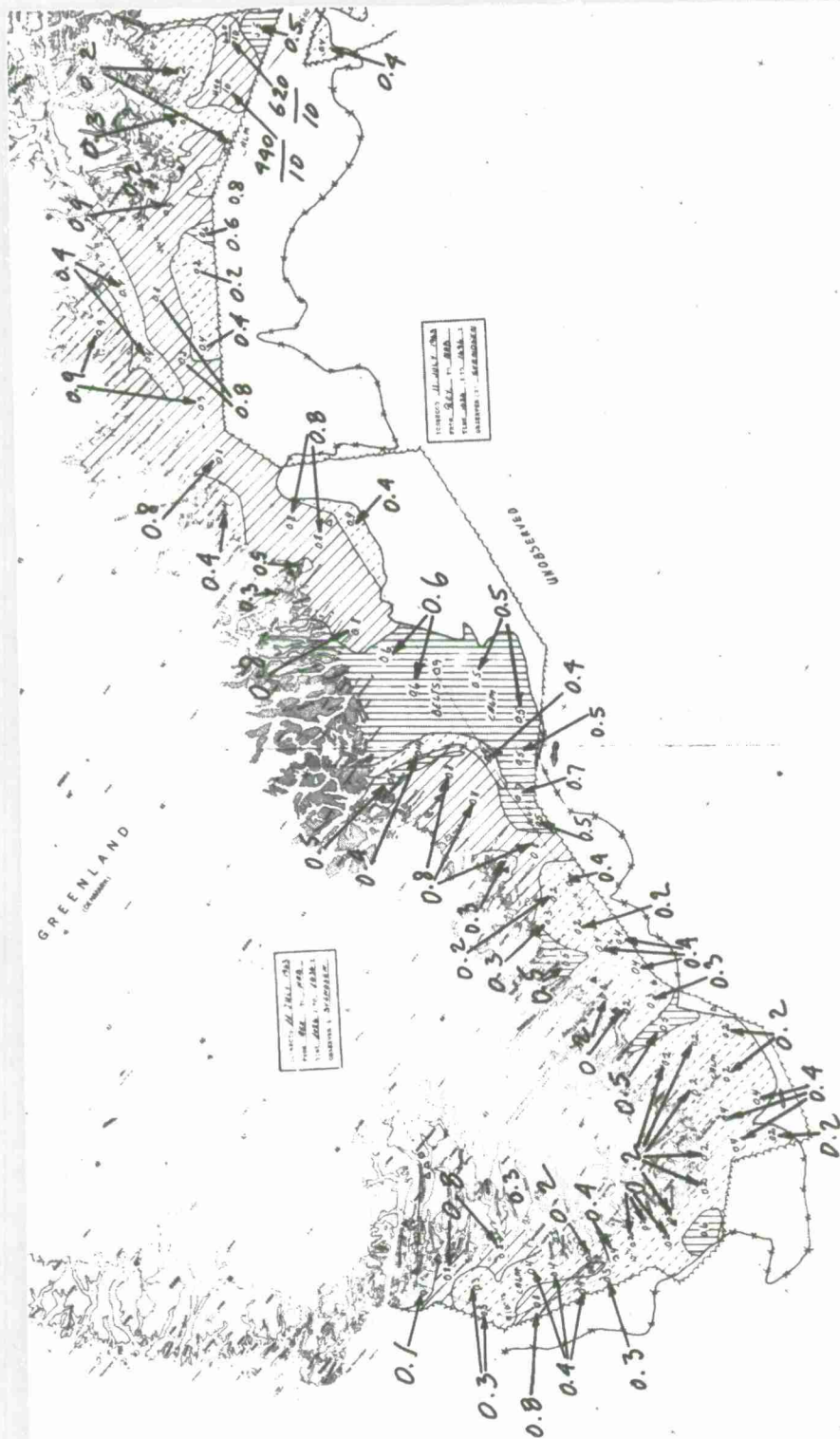




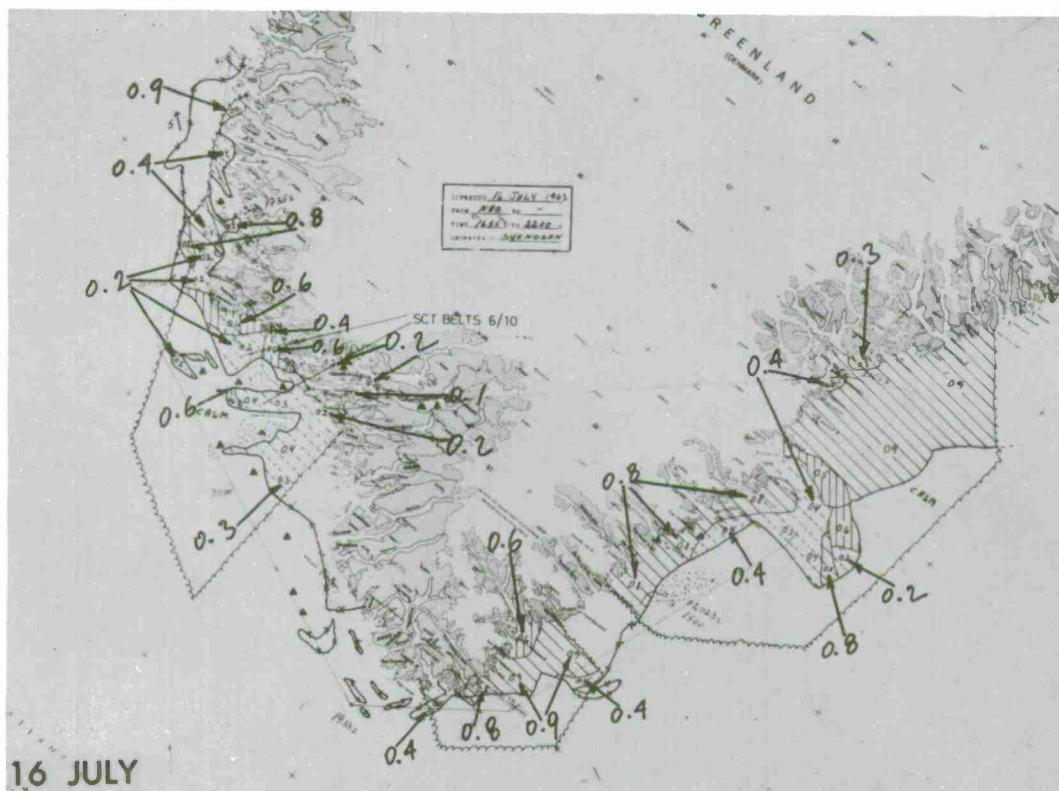
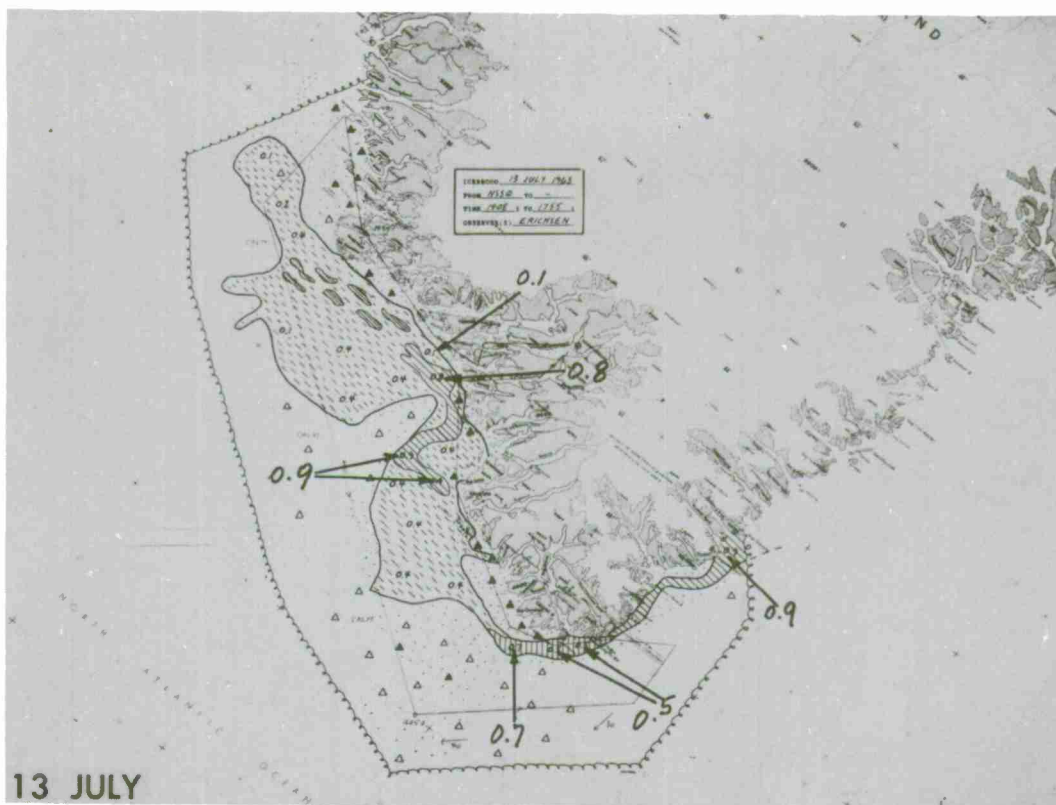


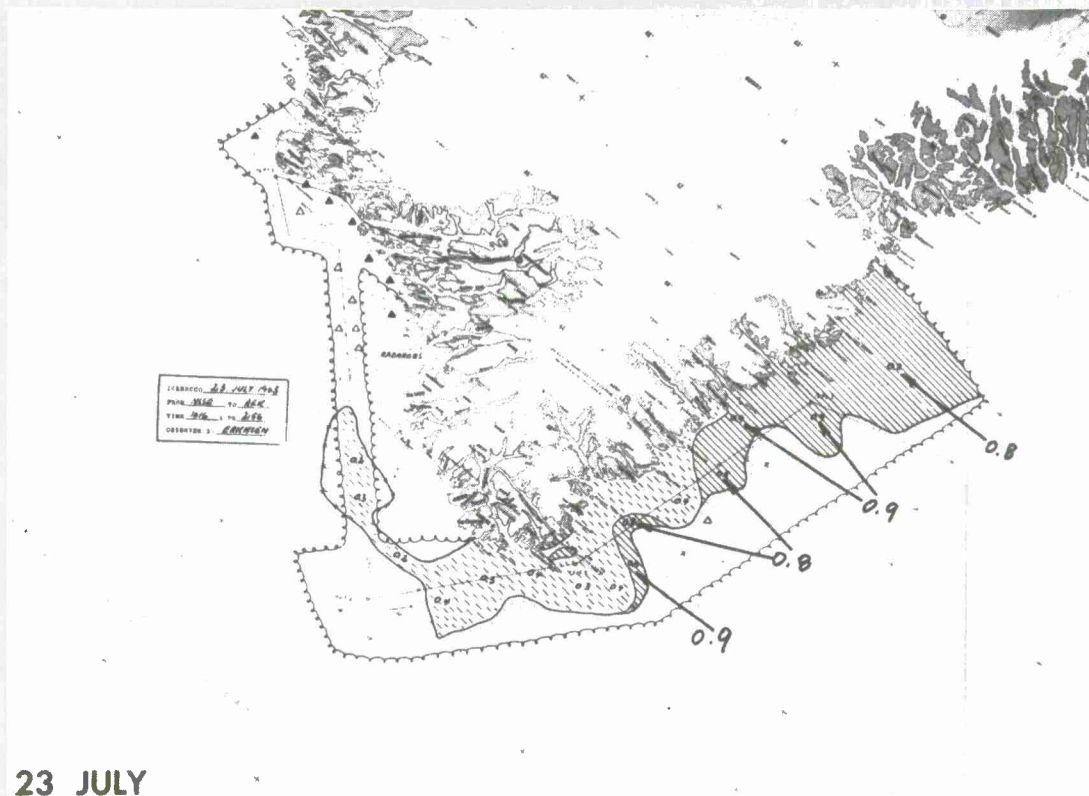
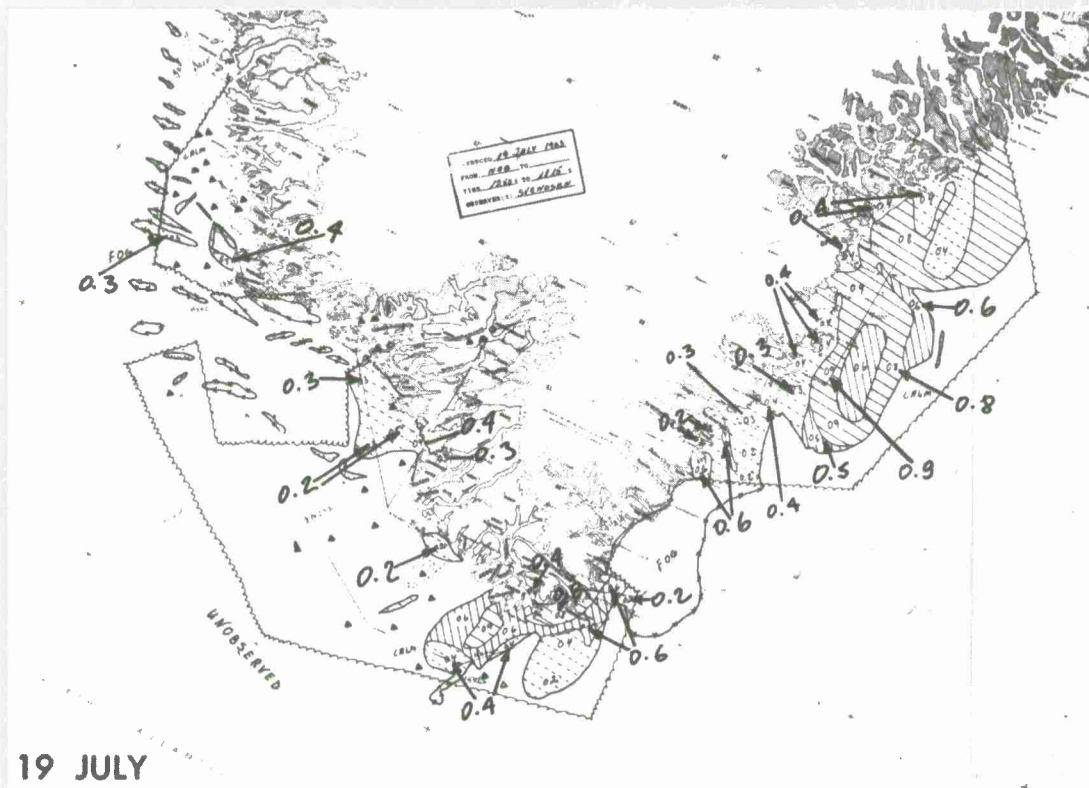


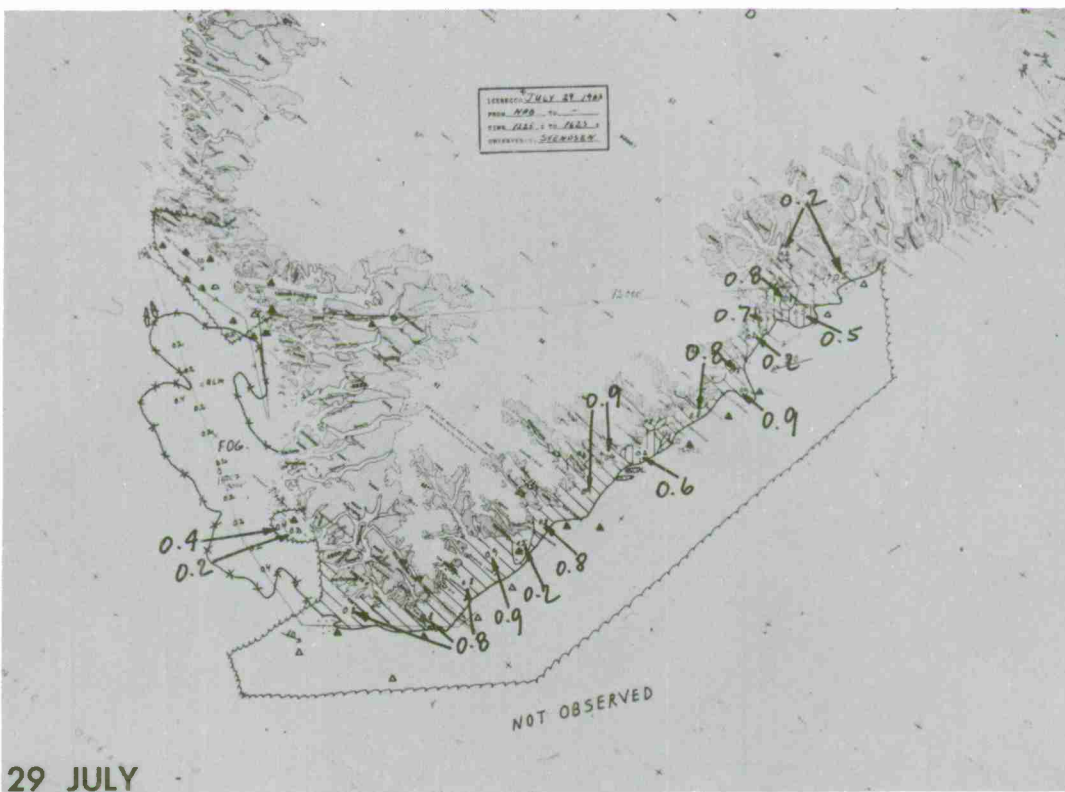
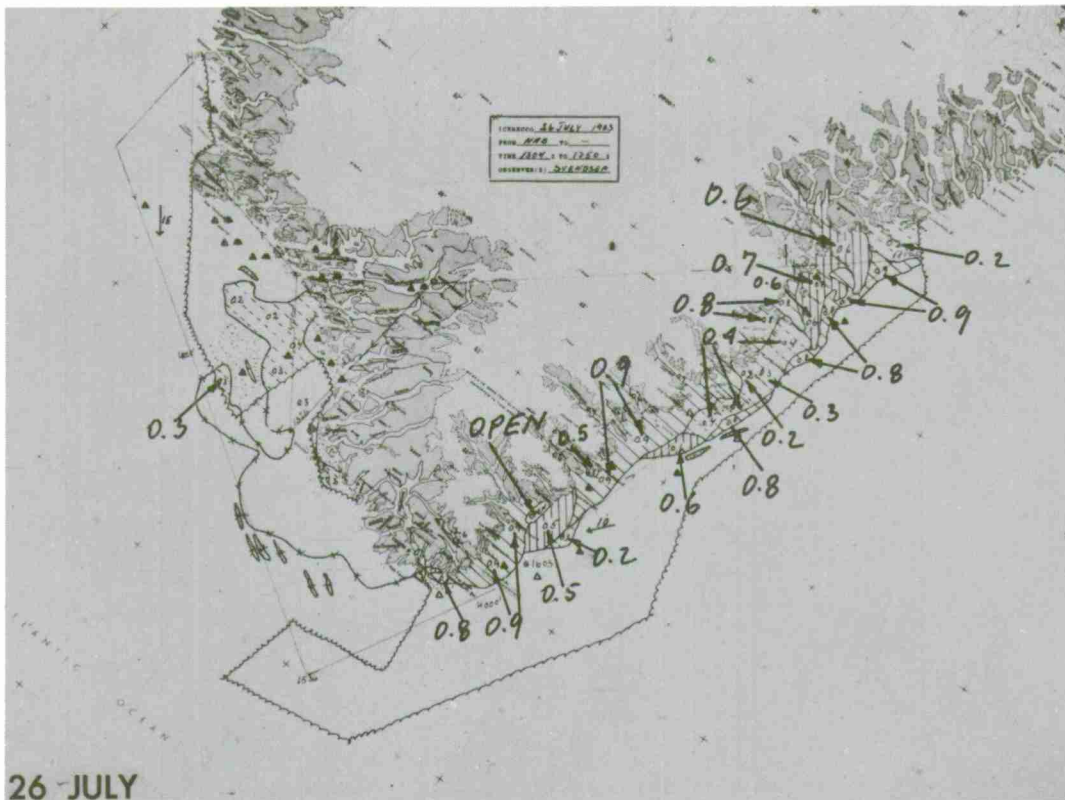


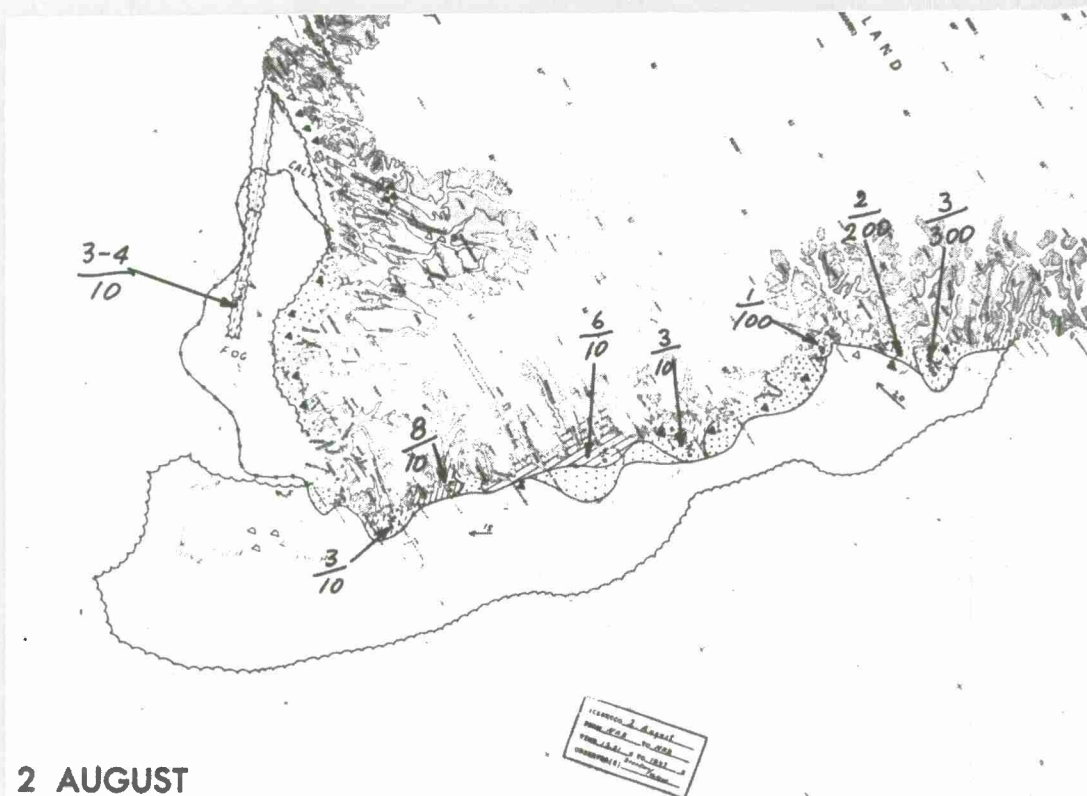


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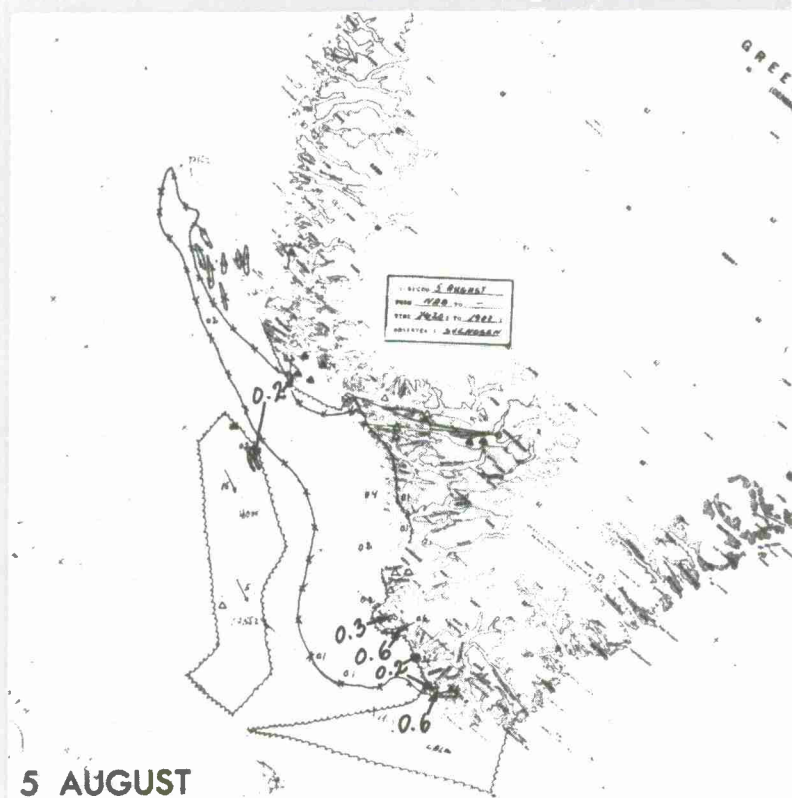




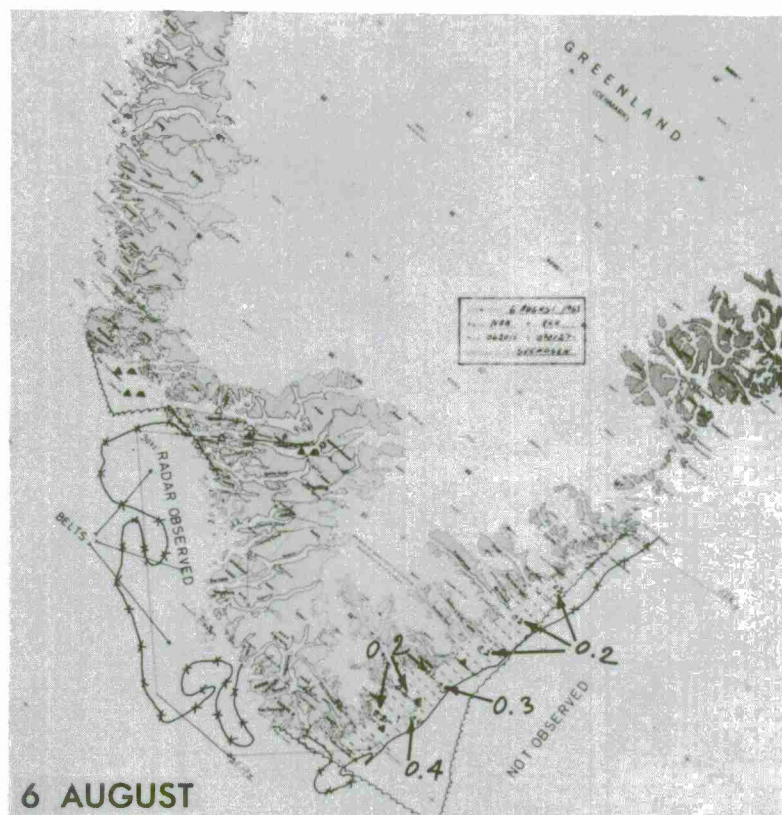


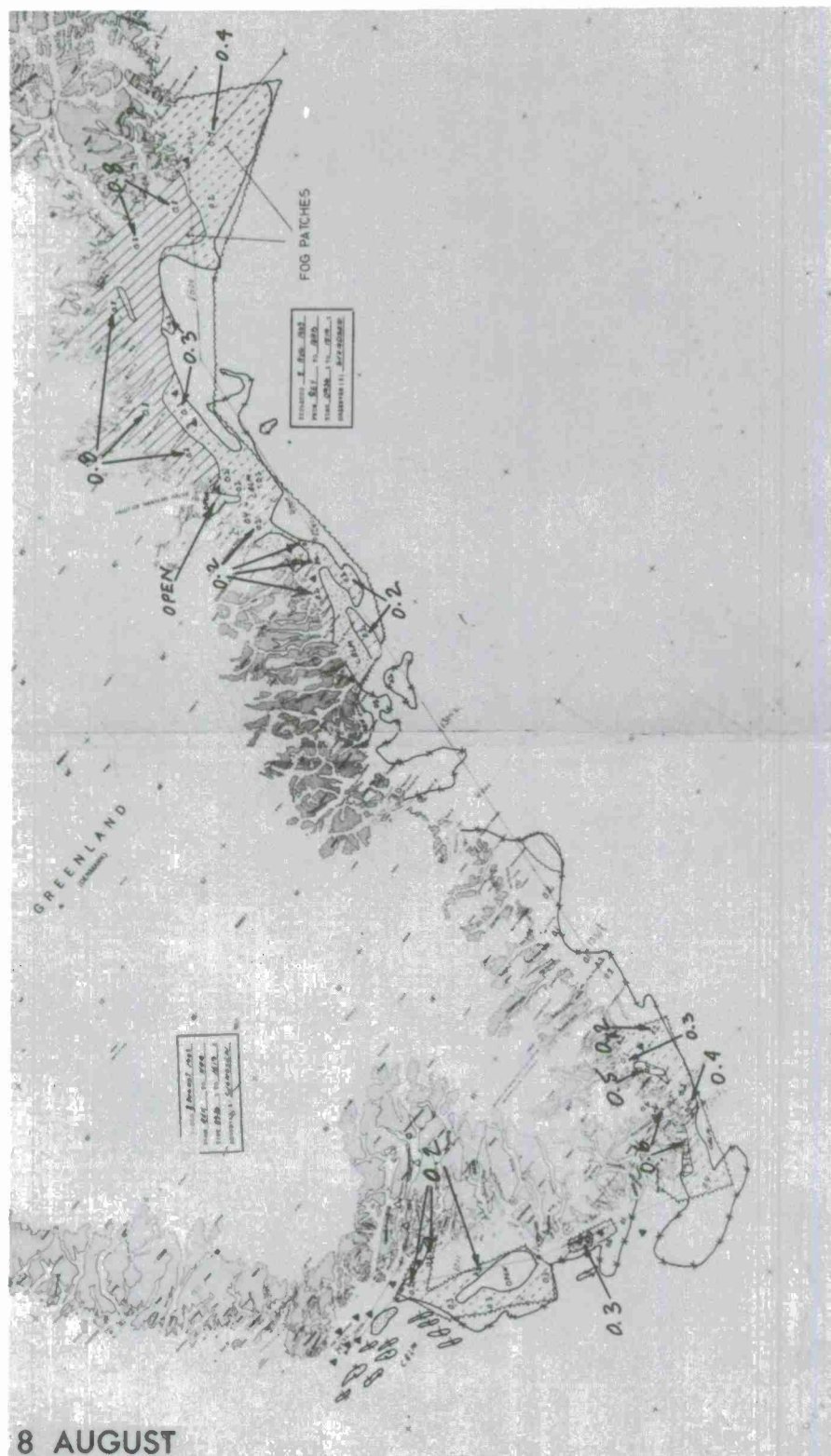


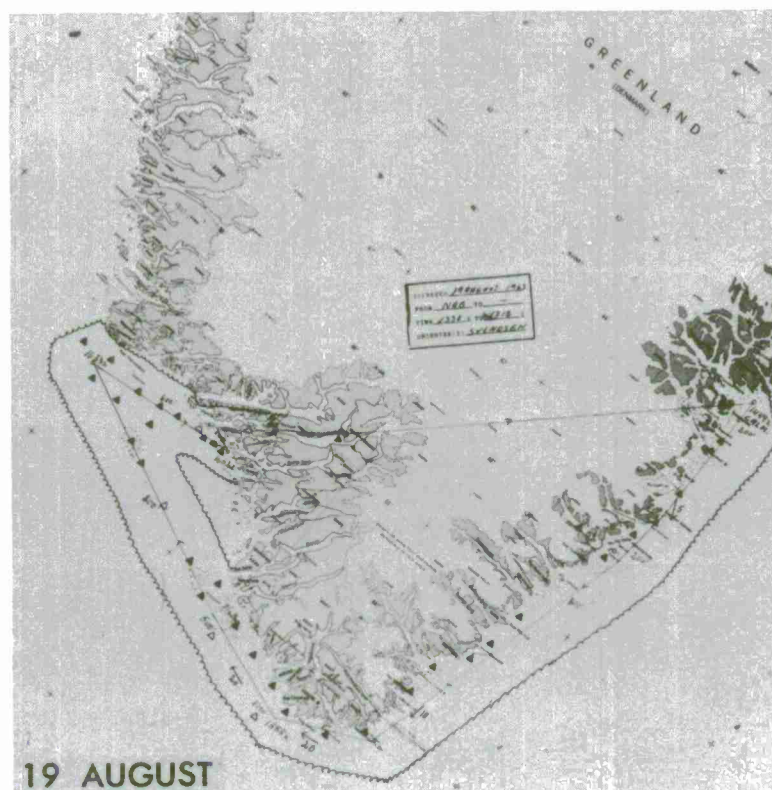
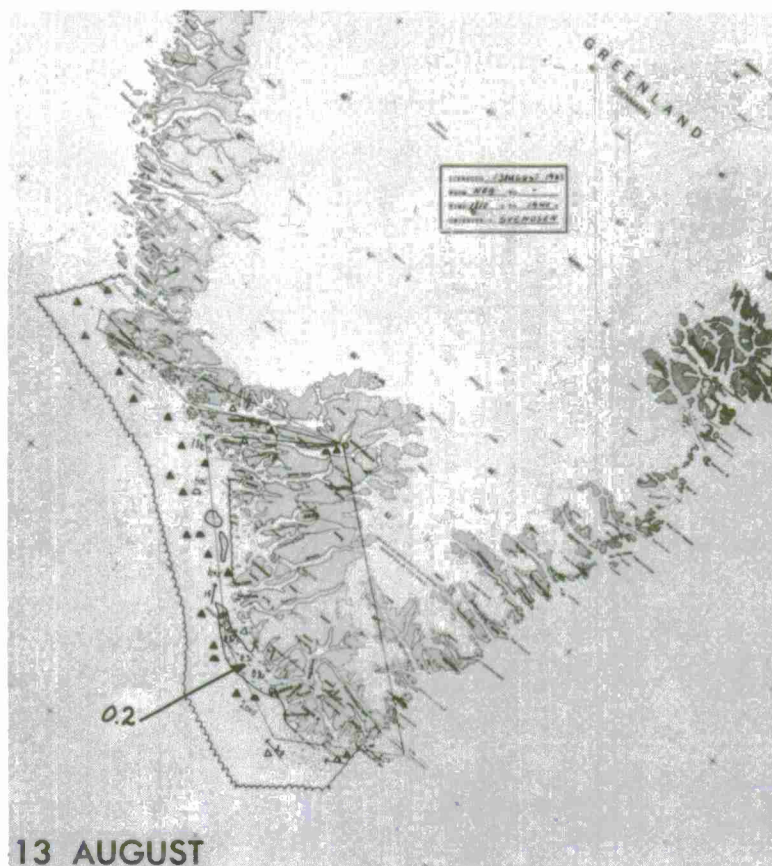
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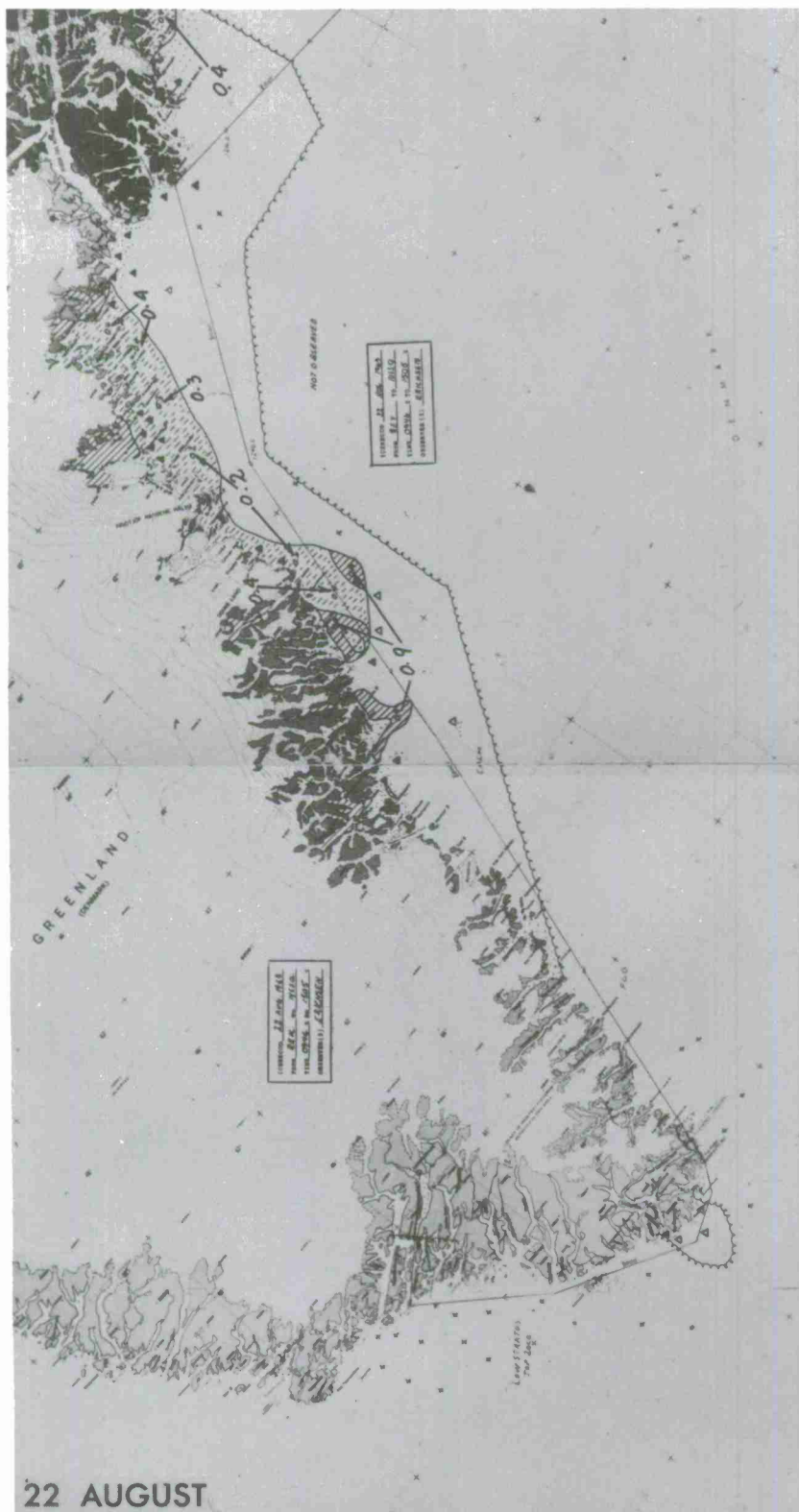


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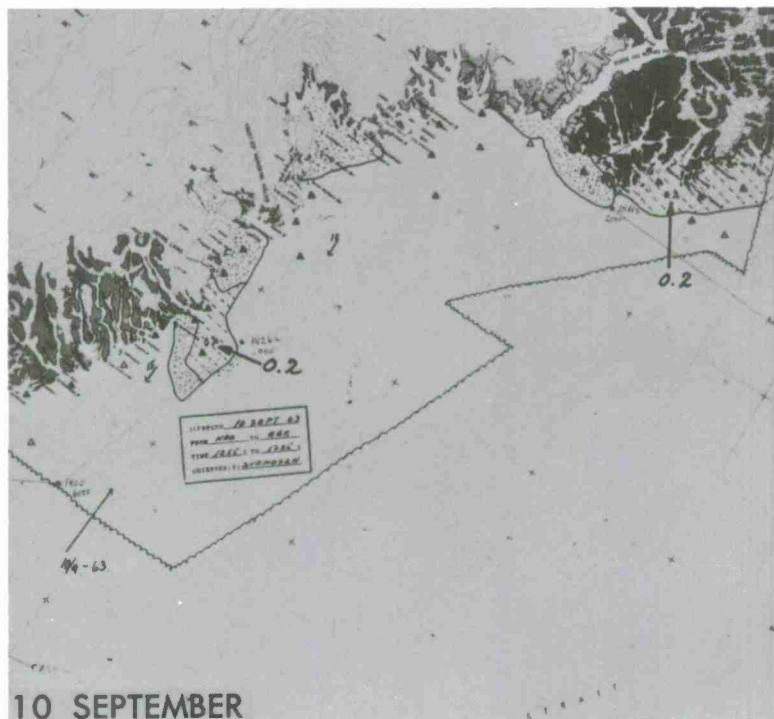
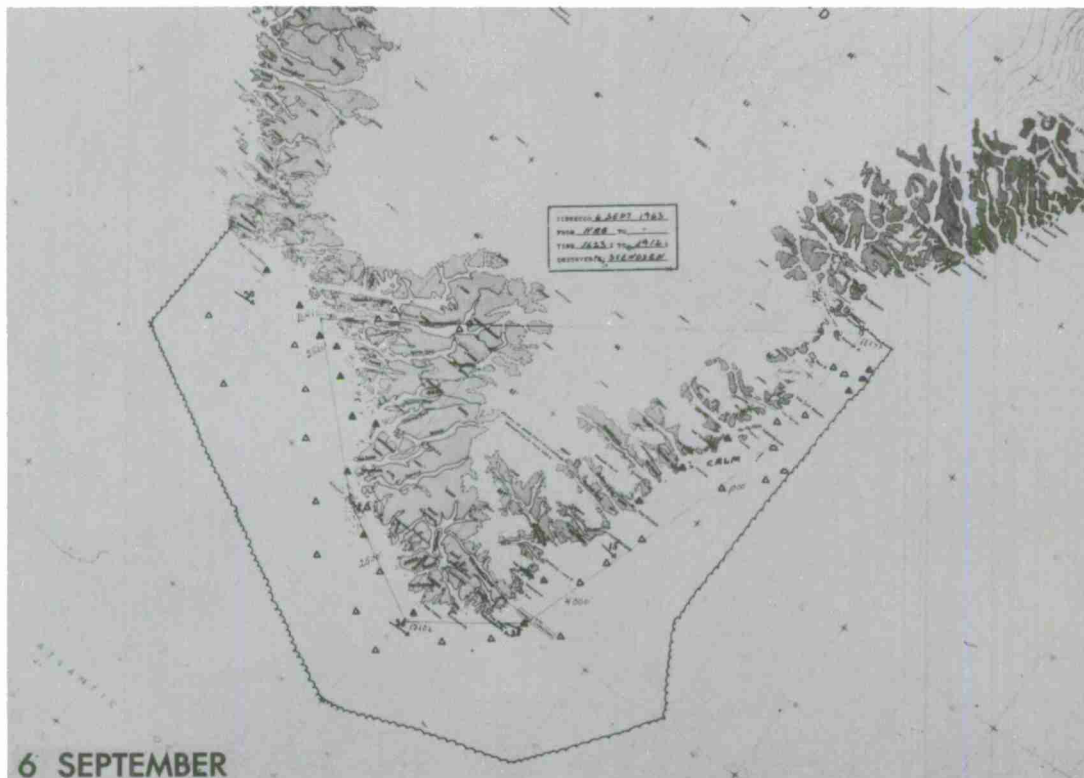


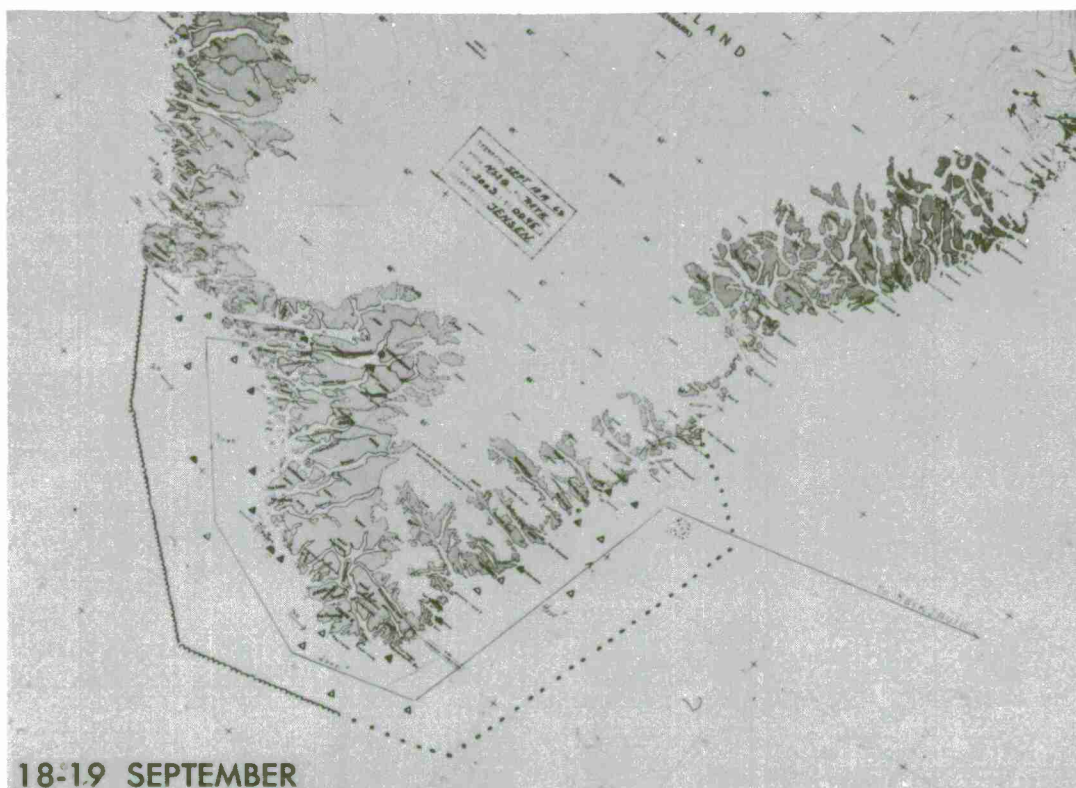








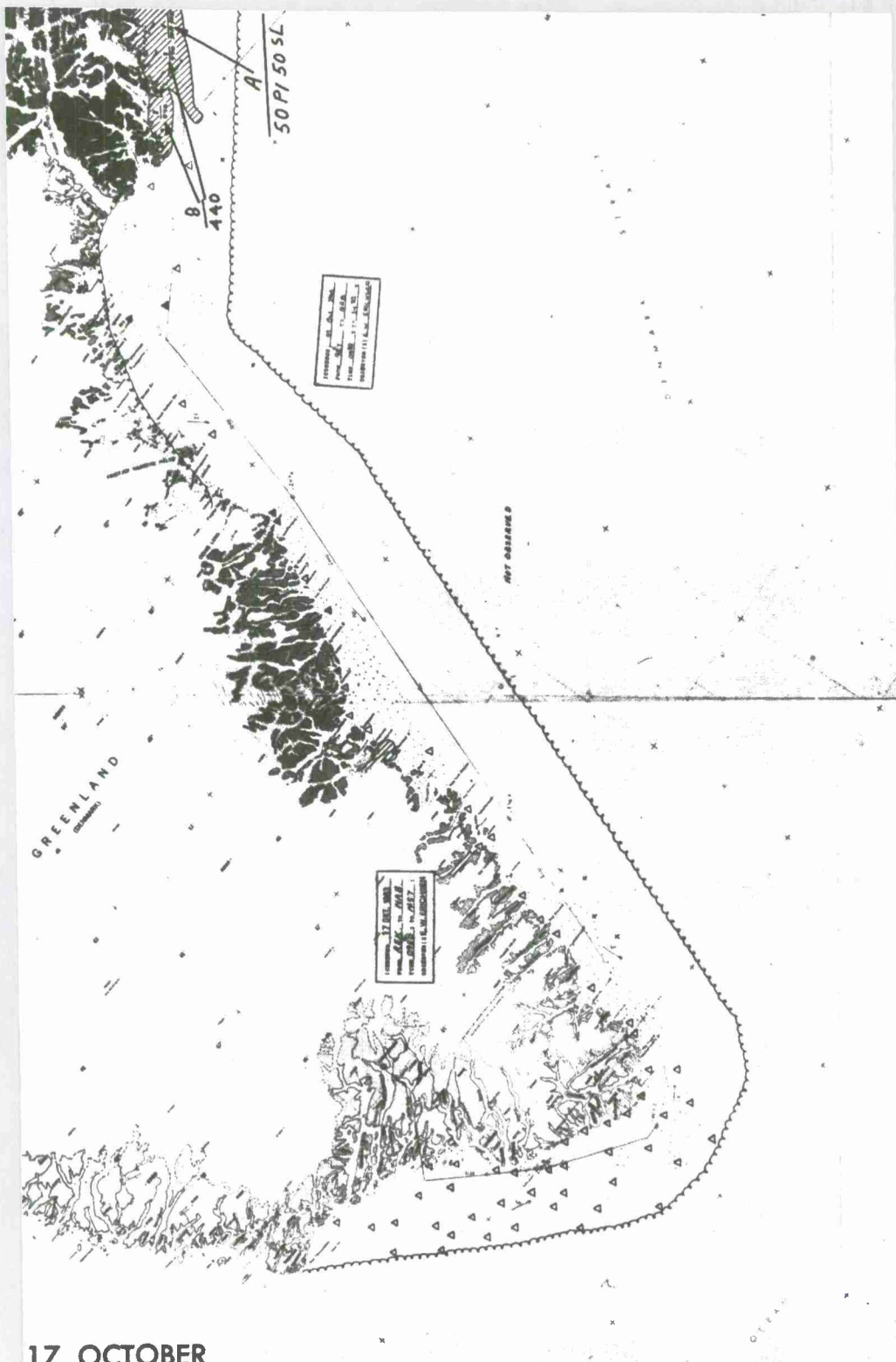


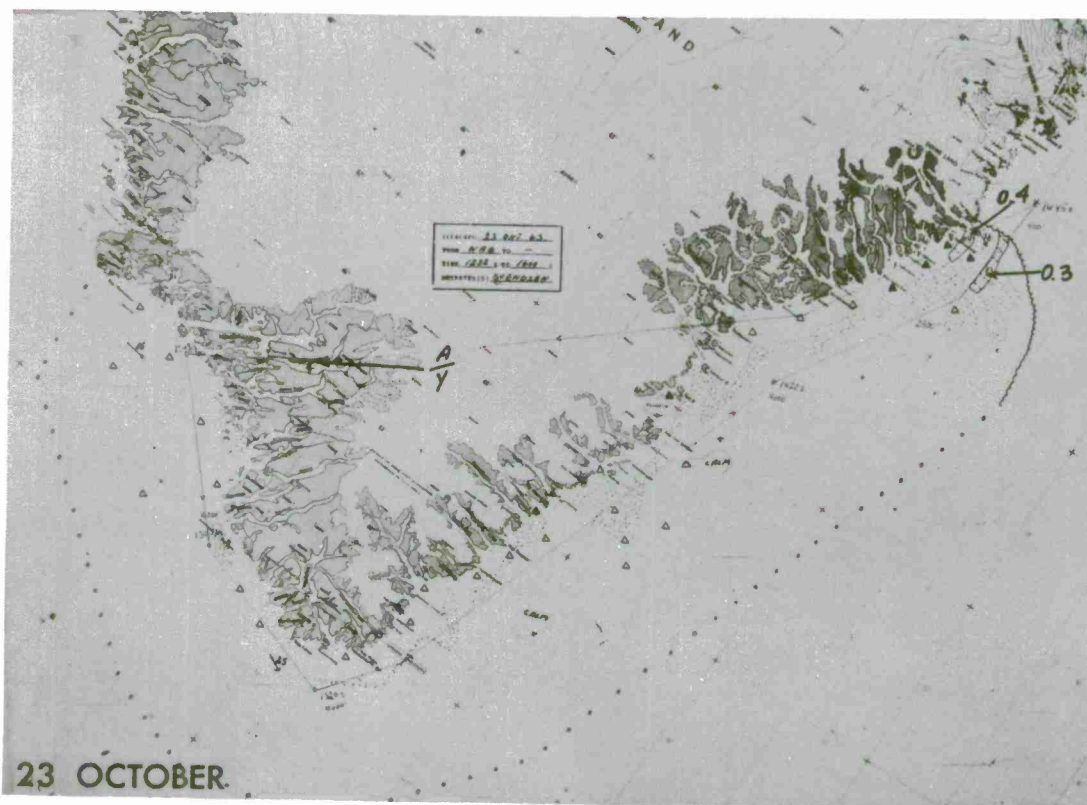




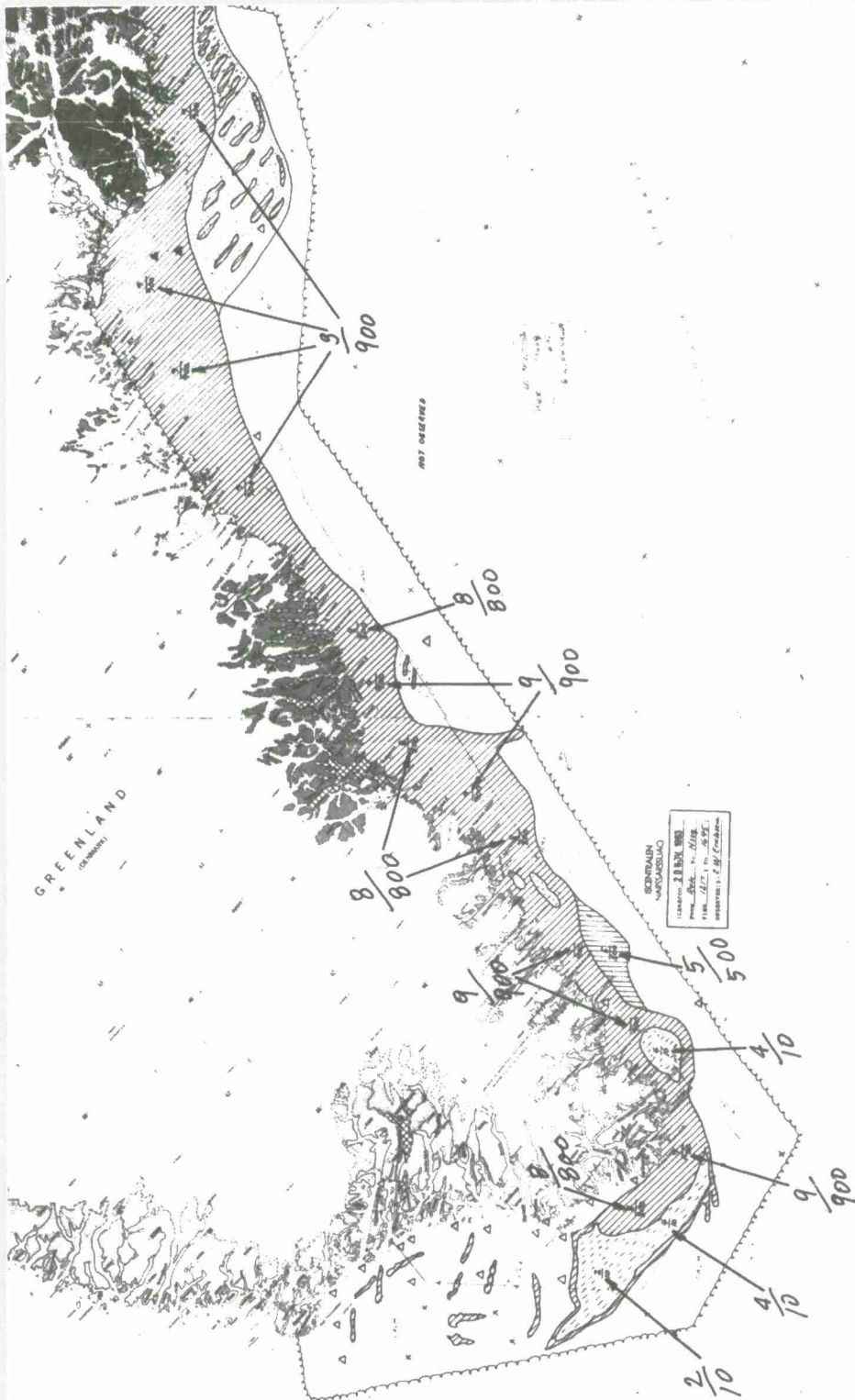






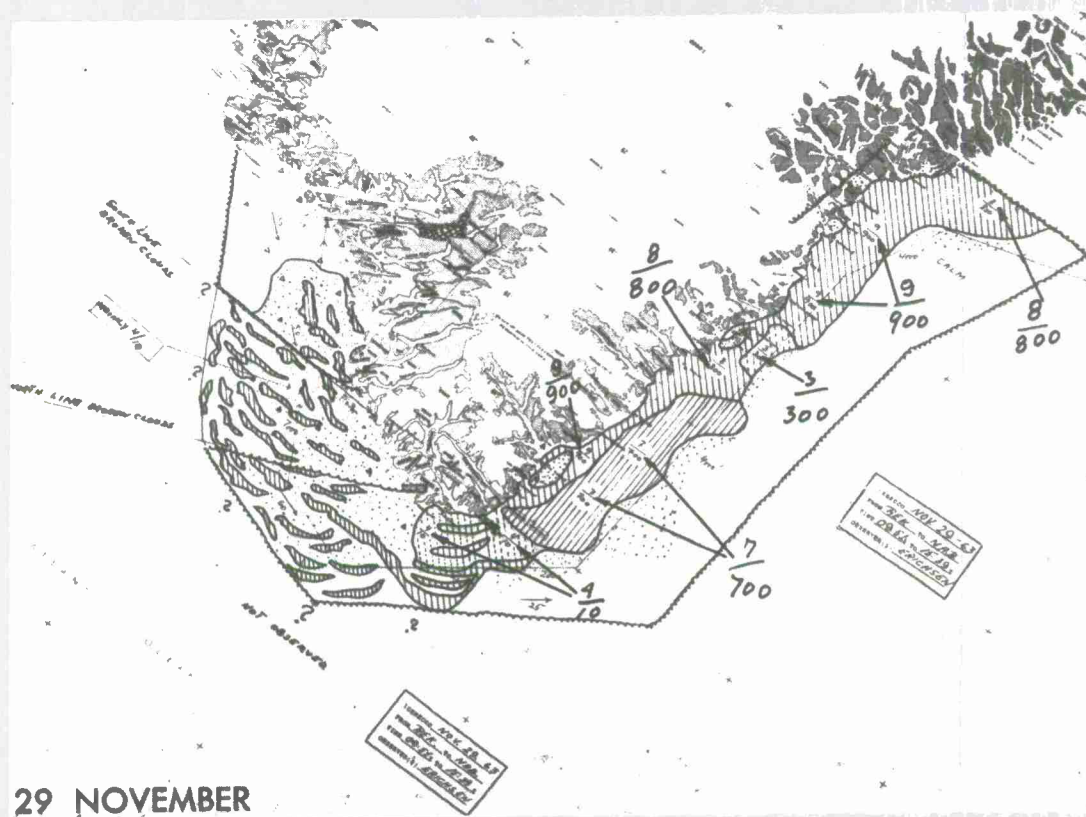
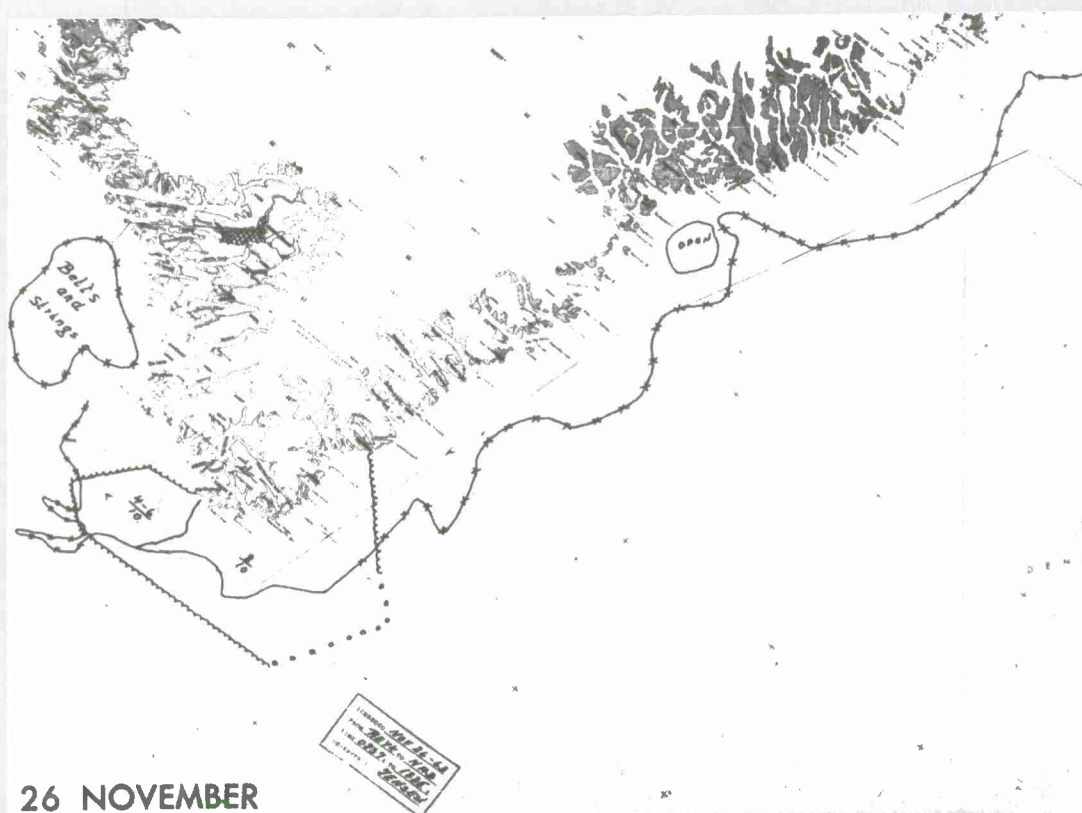


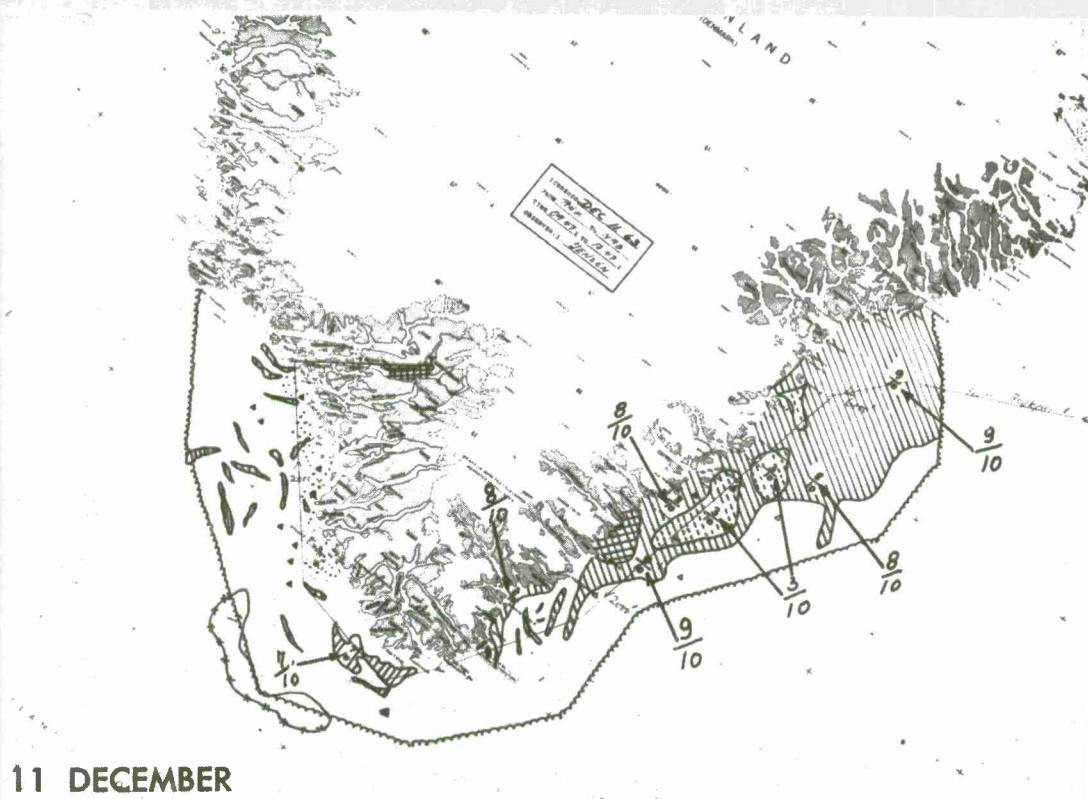
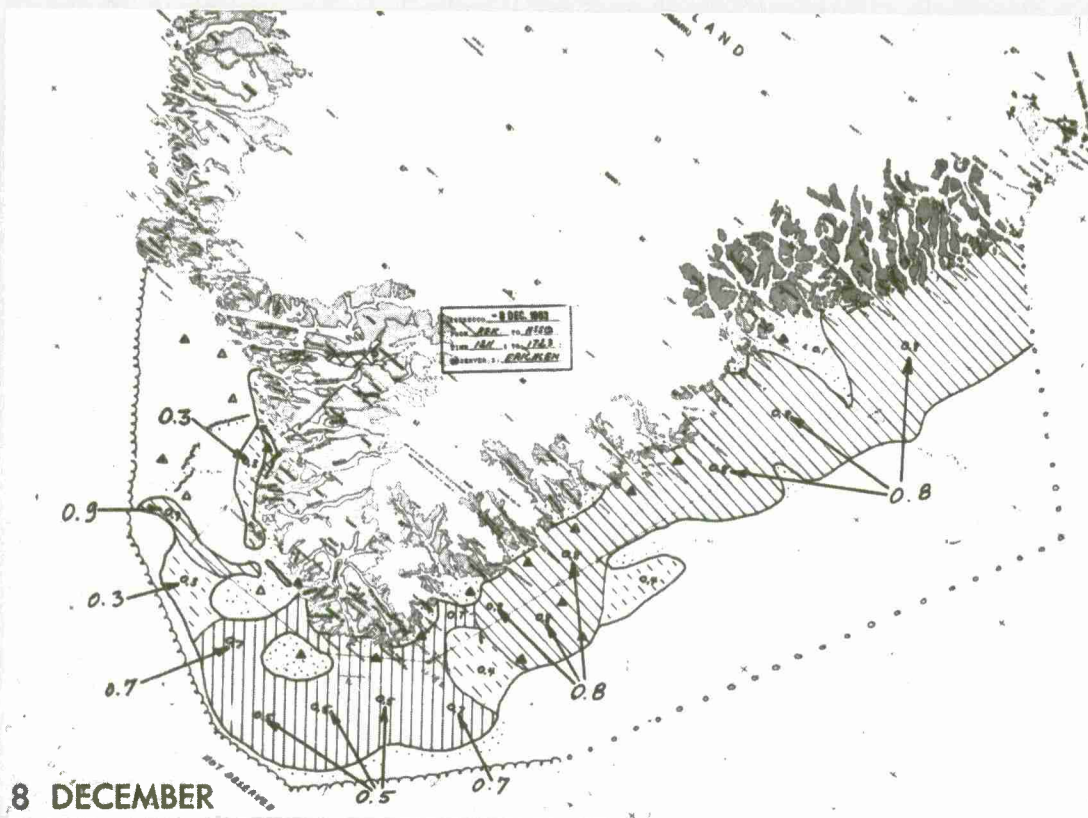


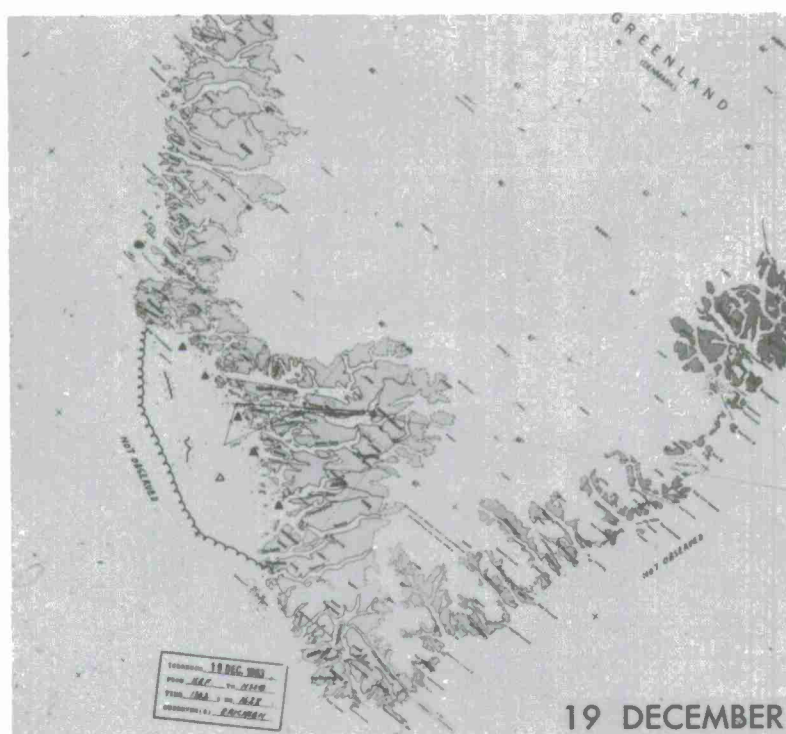
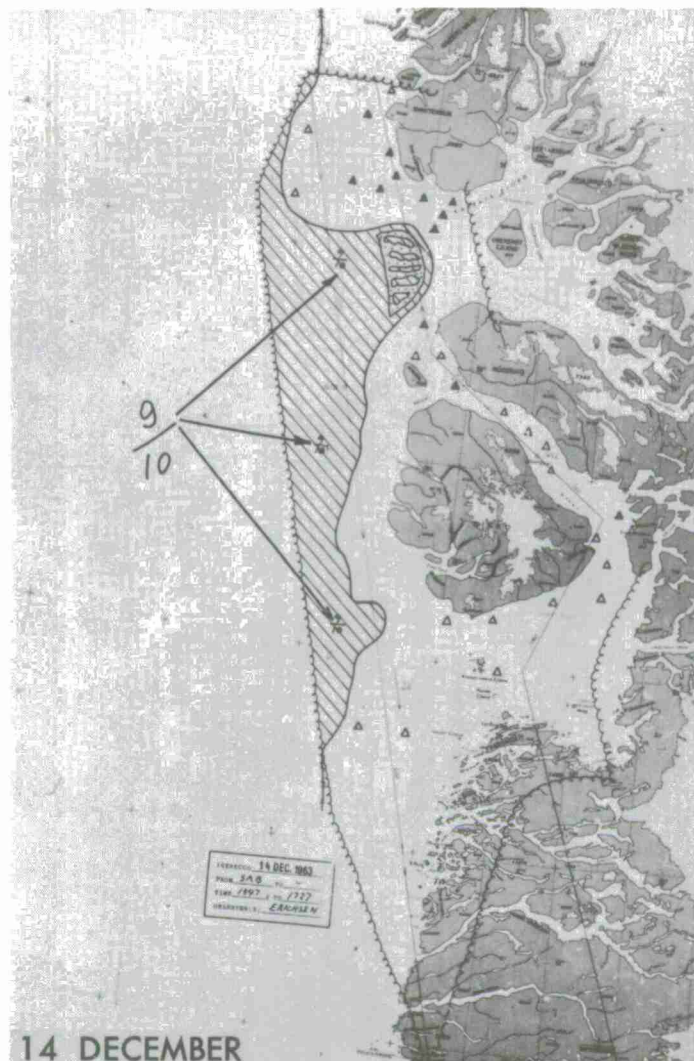


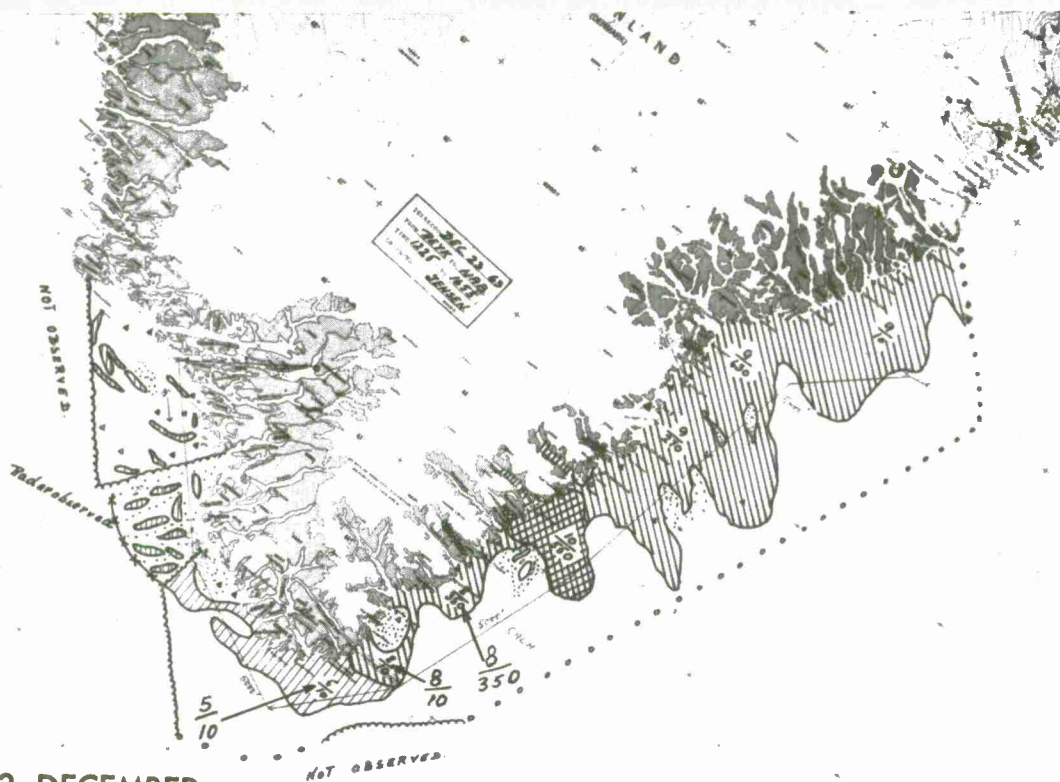
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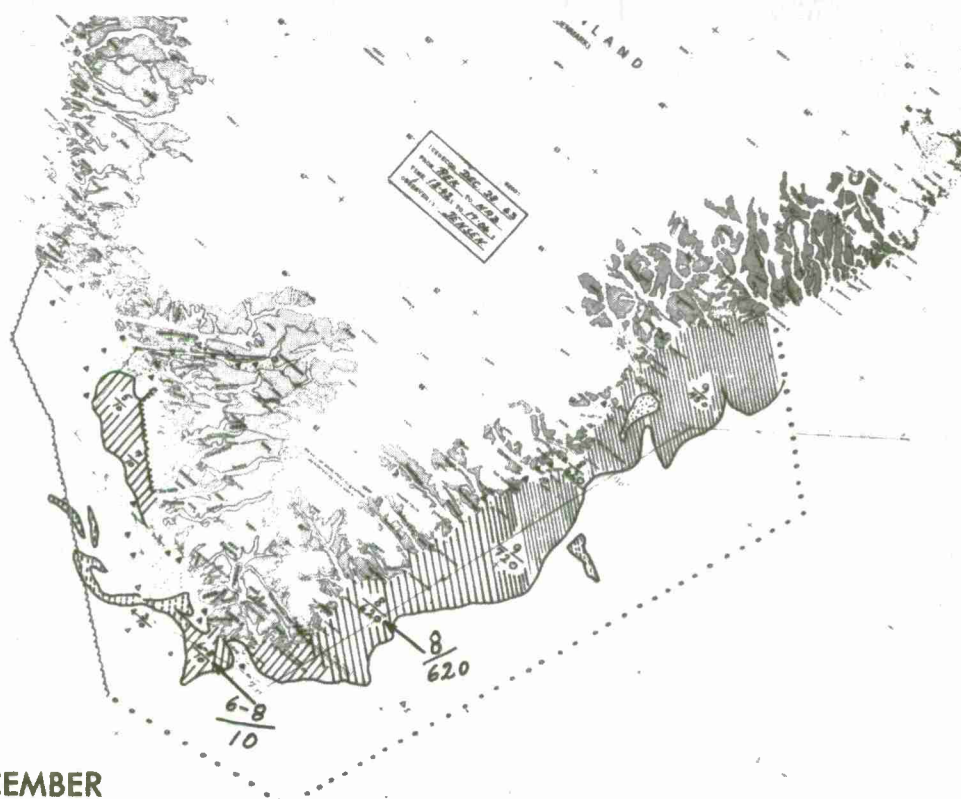








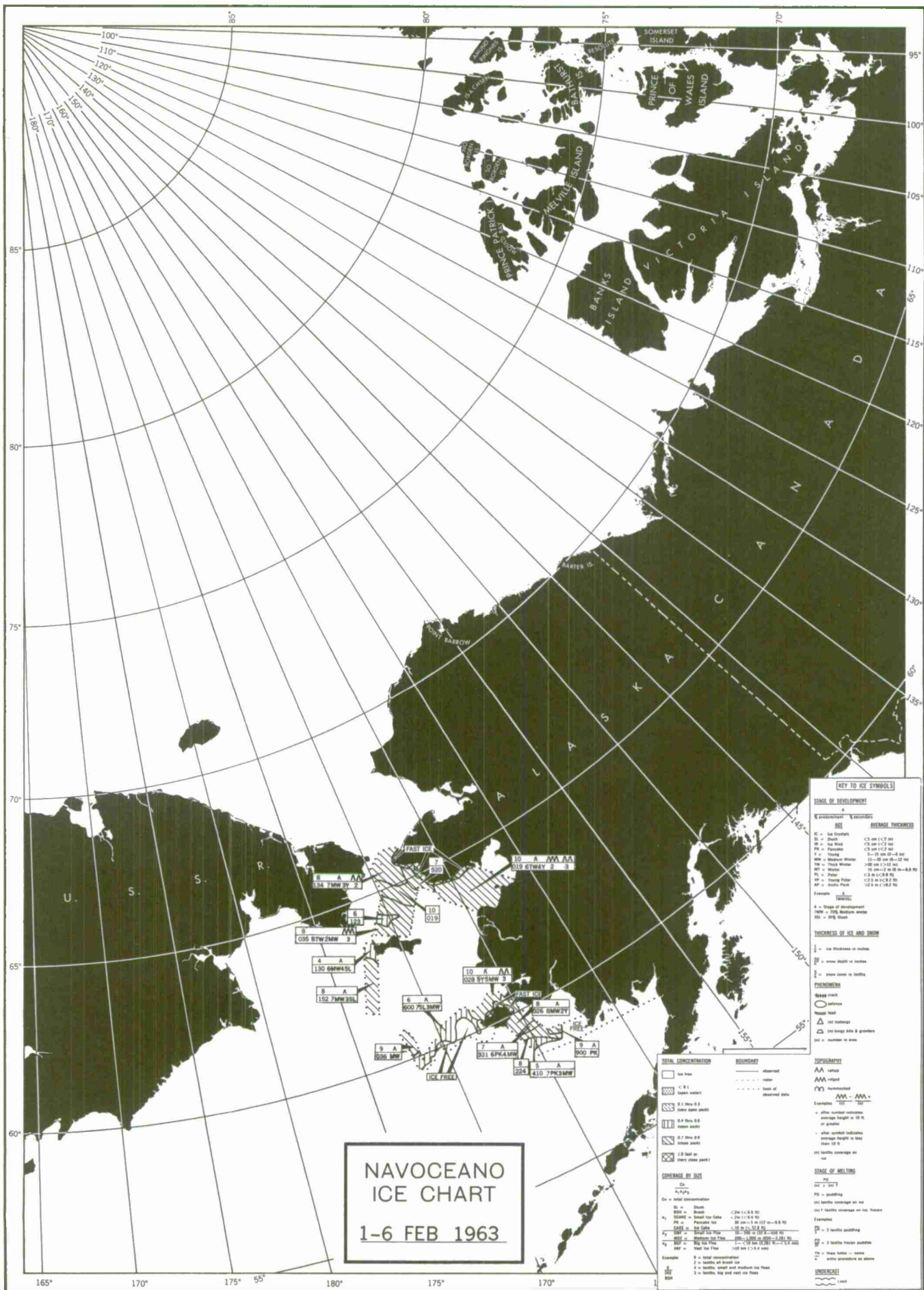
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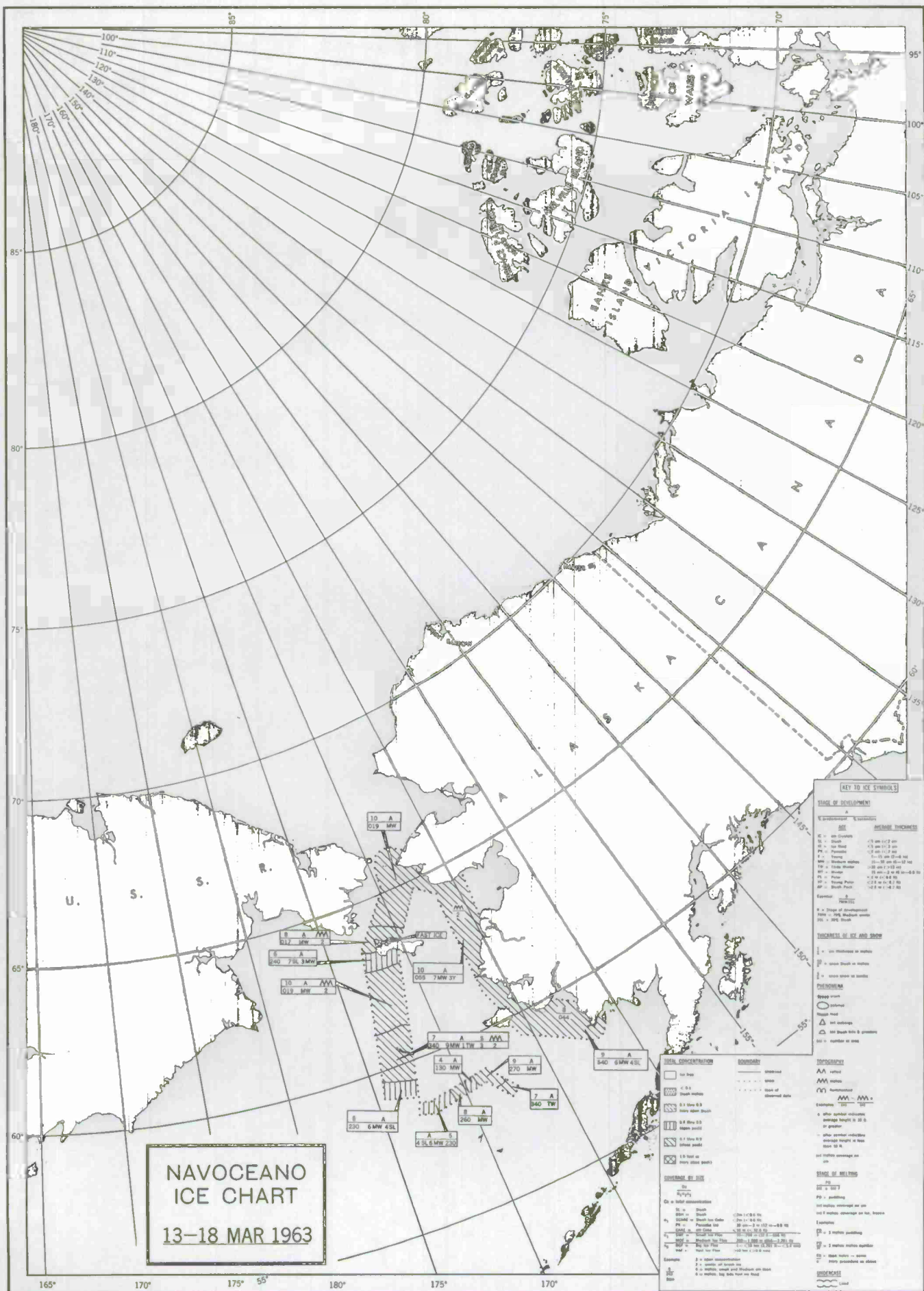
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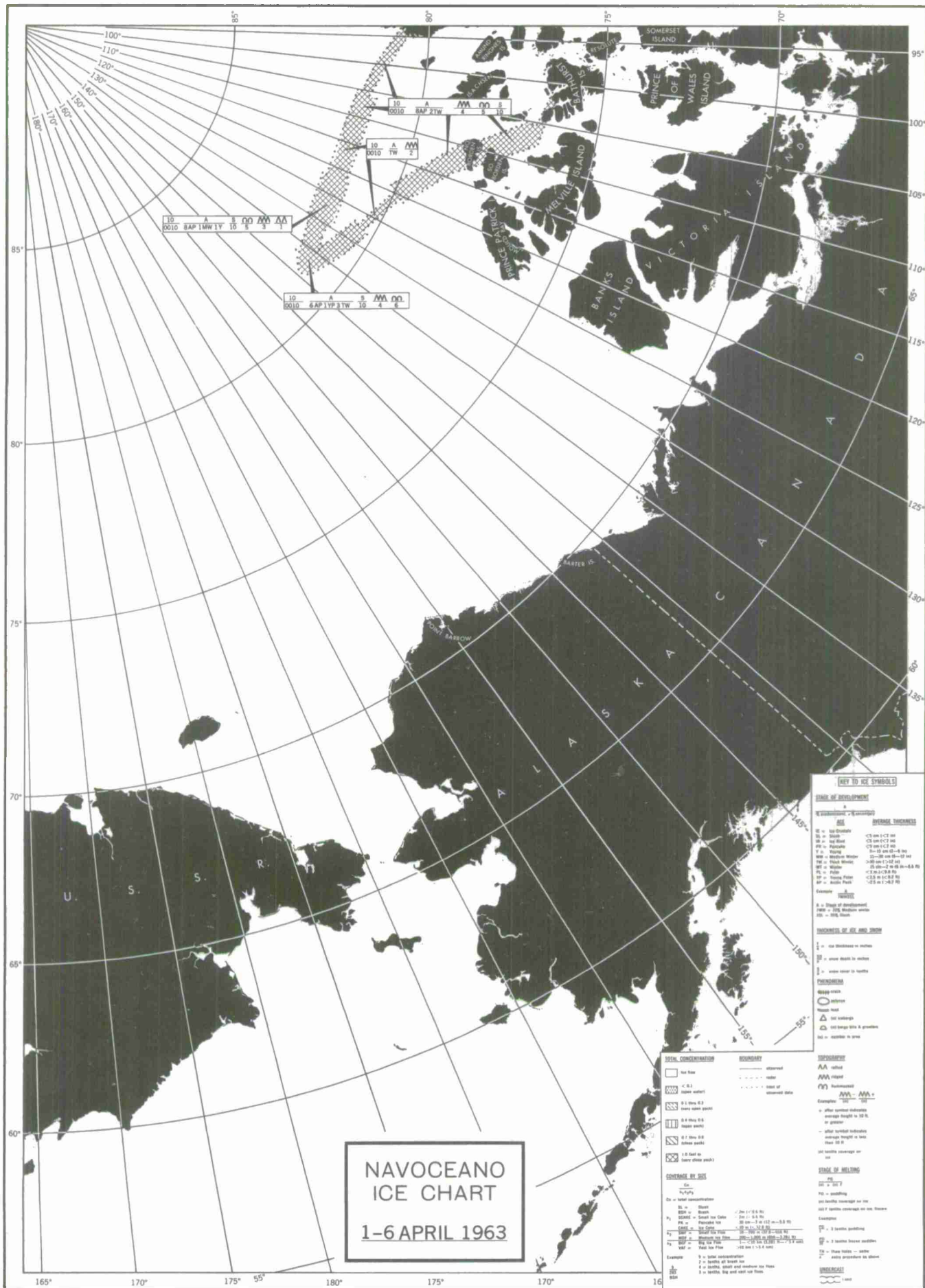
APPENDIX C

WESTERN ARCTIC ICE CHARTS









NAVOCEANO
ICE CHART
1-6 APRIL 1963

(KEY TO ICE SYMBOLS)

STAGE OF DEVELOPMENT	
ICE	ICE THICKNESS
10 = Ice boundary 11 = 100 ft 12 = 100 ft 13 = 100 ft 14 = 100 ft 15 = 100 ft 16 = 100 ft 17 = 100 ft 18 = 100 ft 19 = 100 ft 20 = 100 ft 21 = 100 ft 22 = 100 ft 23 = 100 ft 24 = 100 ft 25 = 100 ft 26 = 100 ft 27 = 100 ft 28 = 100 ft 29 = 100 ft 30 = 100 ft 31 = 100 ft 32 = 100 ft 33 = 100 ft 34 = 100 ft 35 = 100 ft 36 = 100 ft 37 = 100 ft 38 = 100 ft 39 = 100 ft 40 = 100 ft 41 = 100 ft 42 = 100 ft 43 = 100 ft 44 = 100 ft 45 = 100 ft 46 = 100 ft 47 = 100 ft 48 = 100 ft 49 = 100 ft 50 = 100 ft 51 = 100 ft 52 = 100 ft 53 = 100 ft 54 = 100 ft 55 = 100 ft 56 = 100 ft 57 = 100 ft 58 = 100 ft 59 = 100 ft 60 = 100 ft 61 = 100 ft 62 = 100 ft 63 = 100 ft 64 = 100 ft 65 = 100 ft 66 = 100 ft 67 = 100 ft 68 = 100 ft 69 = 100 ft 70 = 100 ft 71 = 100 ft 72 = 100 ft 73 = 100 ft 74 = 100 ft 75 = 100 ft 76 = 100 ft 77 = 100 ft 78 = 100 ft 79 = 100 ft 80 = 100 ft 81 = 100 ft 82 = 100 ft 83 = 100 ft 84 = 100 ft 85 = 100 ft 86 = 100 ft 87 = 100 ft 88 = 100 ft 89 = 100 ft 90 = 100 ft 91 = 100 ft 92 = 100 ft 93 = 100 ft 94 = 100 ft 95 = 100 ft 96 = 100 ft 97 = 100 ft 98 = 100 ft 99 = 100 ft 100 = 100 ft	<100 ft 100-150 ft 150-200 ft 200-250 ft 250-300 ft 300-350 ft 350-400 ft 400-450 ft 450-500 ft 500-550 ft 550-600 ft 600-650 ft 650-700 ft 700-750 ft 750-800 ft 800-850 ft 850-900 ft 900-950 ft 950-1000 ft 1000-1050 ft 1050-1100 ft 1100-1150 ft 1150-1200 ft 1200-1250 ft 1250-1300 ft 1300-1350 ft 1350-1400 ft 1400-1450 ft 1450-1500 ft 1500-1550 ft 1550-1600 ft 1600-1650 ft 1650-1700 ft 1700-1750 ft 1750-1800 ft 1800-1850 ft 1850-1900 ft 1900-1950 ft 1950-2000 ft 2000-2050 ft 2050-2100 ft 2100-2150 ft 2150-2200 ft 2200-2250 ft 2250-2300 ft 2300-2350 ft 2350-2400 ft 2400-2450 ft 2450-2500 ft 2500-2550 ft 2550-2600 ft 2600-2650 ft 2650-2700 ft 2700-2750 ft 2750-2800 ft 2800-2850 ft 2850-2900 ft 2900-2950 ft 2950-3000 ft 3000-3050 ft 3050-3100 ft 3100-3150 ft 3150-3200 ft 3200-3250 ft 3250-3300 ft 3300-3350 ft 3350-3400 ft 3400-3450 ft 3450-3500 ft 3500-3550 ft 3550-3600 ft 3600-3650 ft 3650-3700 ft 3700-3750 ft 3750-3800 ft 3800-3850 ft 3850-3900 ft 3900-3950 ft 3950-4000 ft 4000-4050 ft 4050-4100 ft 4100-4150 ft 4150-4200 ft 4200-4250 ft 4250-4300 ft 4300-4350 ft 4350-4400 ft 4400-4450 ft 4450-4500 ft 4500-4550 ft 4550-4600 ft 4600-4650 ft 4650-4700 ft 4700-4750 ft 4750-4800 ft 4800-4850 ft 4850-4900 ft 4900-4950 ft 4950-5000 ft 5000-5050 ft 5050-5100 ft 5100-5150 ft 5150-5200 ft 5200-5250 ft 5250-5300 ft 5300-5350 ft 5350-5400 ft 5400-5450 ft 5450-5500 ft 5500-5550 ft 5550-5600 ft 5600-5650 ft 5650-5700 ft 5700-5750 ft 5750-5800 ft 5800-5850 ft 5850-5900 ft 5900-5950 ft 5950-6000 ft 6000-6050 ft 6050-6100 ft 6100-6150 ft 6150-6200 ft 6200-6250 ft 6250-6300 ft 6300-6350 ft 6350-6400 ft 6400-6450 ft 6450-6500 ft 6500-6550 ft 6550-6600 ft 6600-6650 ft 6650-6700 ft 6700-6750 ft 6750-6800 ft 6800-6850 ft 6850-6900 ft 6900-6950 ft 6950-7000 ft 7000-7050 ft 7050-7100 ft 7100-7150 ft 7150-7200 ft 7200-7250 ft 7250-7300 ft 7300-7350 ft 7350-7400 ft 7400-7450 ft 7450-7500 ft 7500-7550 ft 7550-7600 ft 7600-7650 ft 7650-7700 ft 7700-7750 ft 7750-7800 ft 7800-7850 ft 7850-7900 ft 7900-7950 ft 7950-8000 ft 8000-8050 ft 8050-8100 ft 8100-8150 ft 8150-8200 ft 8200-8250 ft 8250-8300 ft 8300-8350 ft 8350-8400 ft 8400-8450 ft 8450-8500 ft 8500-8550 ft 8550-8600 ft 8600-8650 ft 8650-8700 ft 8700-8750 ft 8750-8800 ft 8800-8850 ft 8850-8900 ft 8900-8950 ft 8950-9000 ft 9000-9050 ft 9050-9100 ft 9100-9150 ft 9150-9200 ft 9200-9250 ft 9250-9300 ft 9300-9350 ft 9350-9400 ft 9400-9450 ft 9450-9500 ft 9500-9550 ft 9550-9600 ft 9600-9650 ft 9650-9700 ft 9700-9750 ft 9750-9800 ft 9800-9850 ft 9850-9900 ft 9900-9950 ft 9950-10000 ft

BOUNDARY

- observed
- - - - - radar
- - - - - other
- - - - - estimated data

CONTOUR BY DATA

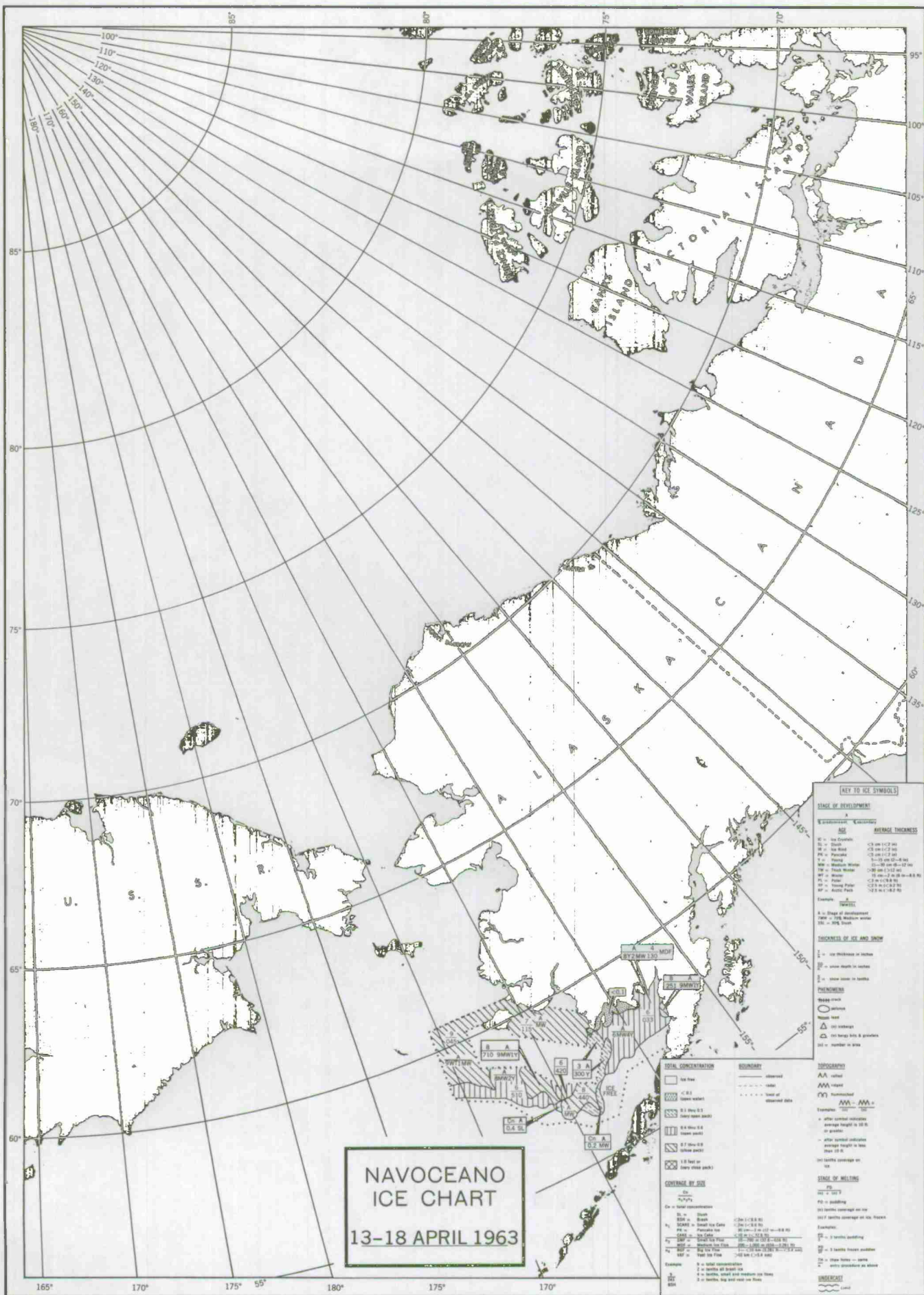
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- 20 = 200 ft
- 30 = 300 ft
- 40 = 400 ft
- 50 = 500 ft
- 60 = 600 ft
- 70 = 700 ft
- 80 = 800 ft
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- 100 = 1000 ft
- 110 = 1100 ft
- 120 = 1200 ft
- 130 = 1300 ft
- 140 = 1400 ft
- 150 = 1500 ft
- 160 = 1600 ft
- 170 = 1700 ft
- 180 = 1800 ft
- 190 = 1900 ft
- 200 = 2000 ft
- 210 = 2100 ft
- 220 = 2200 ft
- 230 = 2300 ft
- 240 = 2400 ft
- 250 = 2500 ft
- 260 = 2600 ft
- 270 = 2700 ft
- 280 = 2800 ft
- 290 = 2900 ft
- 300 = 3000 ft
- 310 = 3100 ft
- 320 = 3200 ft
- 330 = 3300 ft
- 340 = 3400 ft
- 350 = 3500 ft
- 360 = 3600 ft
- 370 = 3700 ft
- 380 = 3800 ft
- 390 = 3900 ft
- 400 = 4000 ft
- 410 = 4100 ft
- 420 = 4200 ft
- 430 = 4300 ft
- 440 = 4400 ft
- 450 = 4500 ft
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- 600 = 6000 ft
- 610 = 6100 ft
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- 640 = 6400 ft
- 650 = 6500 ft
- 660 = 6600 ft
- 670 = 6700 ft
- 680 = 6800 ft
- 690 = 6900 ft
- 700 = 7000 ft
- 710 = 7100 ft
- 720 = 7200 ft
- 730 = 7300 ft
- 740 = 7400 ft
- 750 = 7500 ft
- 760 = 7600 ft
- 770 = 7700 ft
- 780 = 7800 ft
- 790 = 7900 ft
- 800 = 8000 ft
- 810 = 8100 ft
- 820 = 8200 ft
- 830 = 8300 ft
- 840 = 8400 ft
- 850 = 8500 ft
- 860 = 8600 ft
- 870 = 8700 ft
- 880 = 8800 ft
- 890 = 8900 ft
- 900 = 9000 ft
- 910 = 9100 ft
- 920 = 9200 ft
- 930 = 9300 ft
- 940 = 9400 ft
- 950 = 9500 ft
- 960 = 9600 ft
- 970 = 9700 ft
- 980 = 9800 ft
- 990 = 9900 ft
- 1000 = 10000 ft

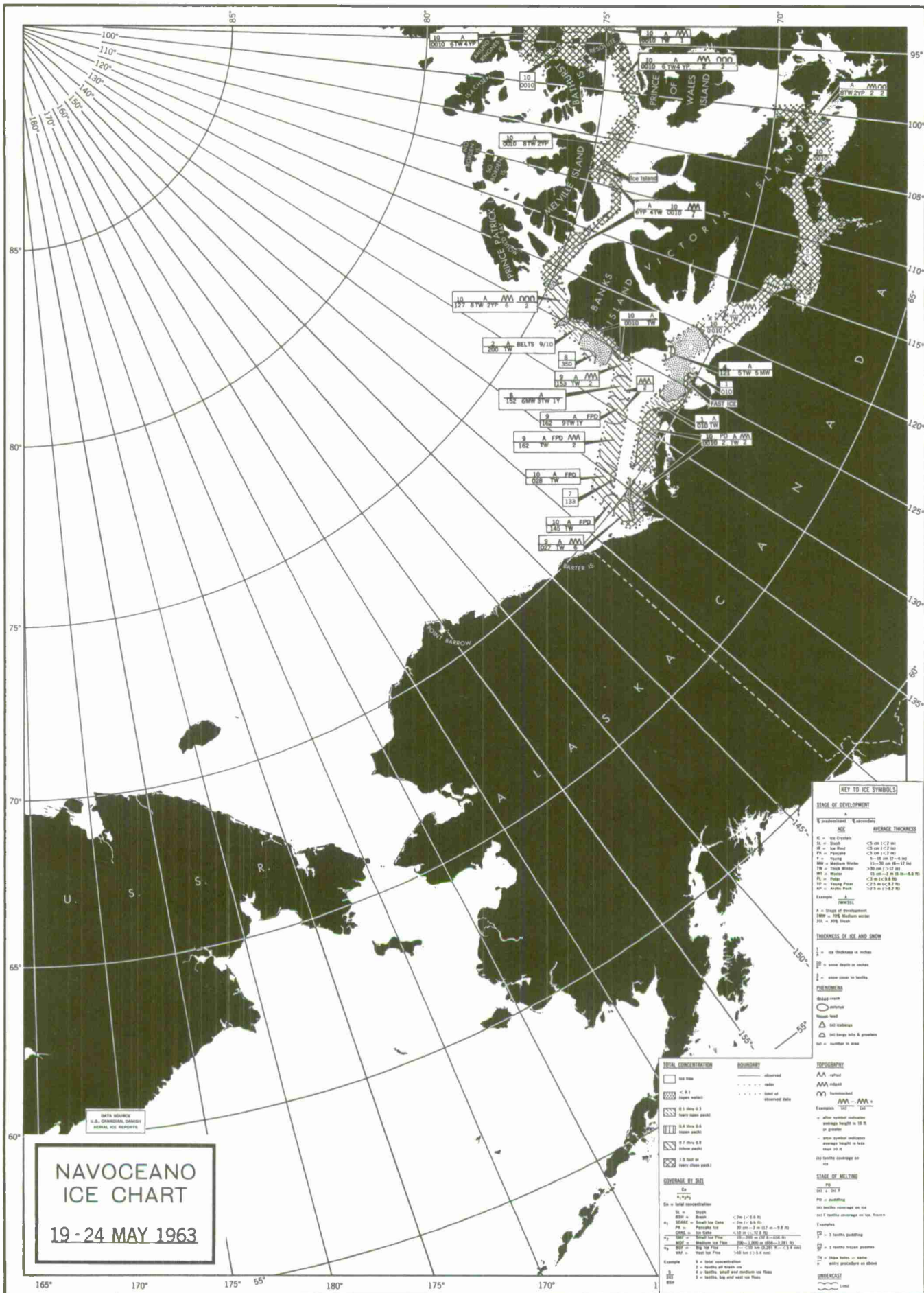
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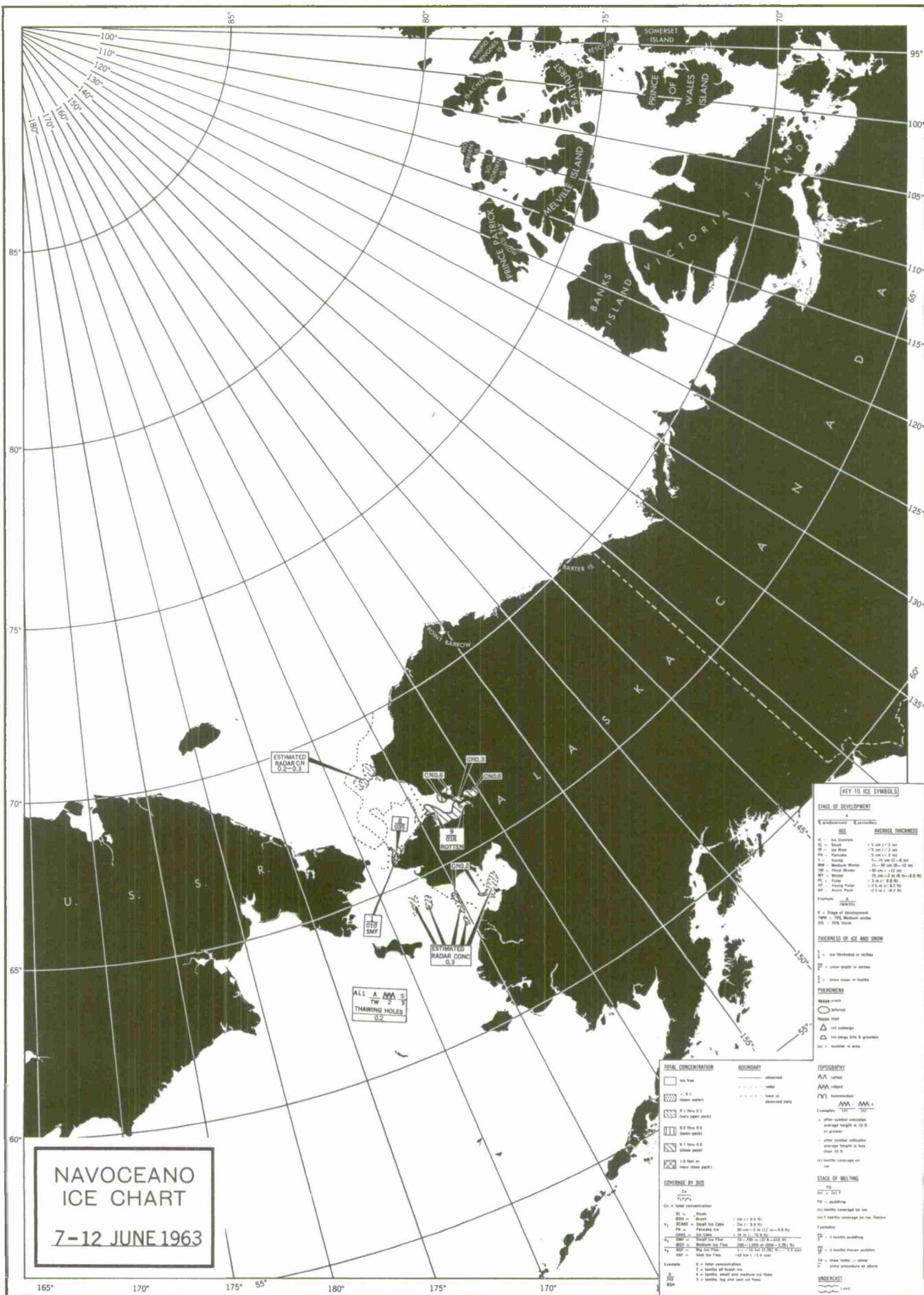
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- 2 = 200 ft
- 3 = 300 ft
- 4 = 400 ft
- 5 = 500 ft
- 6 = 600 ft
- 7 = 700 ft
- 8 = 800 ft
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- 10 = 1000 ft
- 11 = 1100 ft
- 12 = 1200 ft
- 13 = 1300 ft
- 14 = 1400 ft
- 15 = 1500 ft
- 16 = 1600 ft
- 17 = 1700 ft
- 18 = 1800 ft
- 19 = 1900 ft
- 20 = 2000 ft
- 21 = 2100 ft
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- 92 = 9200 ft
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- 98 = 9800 ft
- 99 = 9900 ft
- 100 = 10000 ft

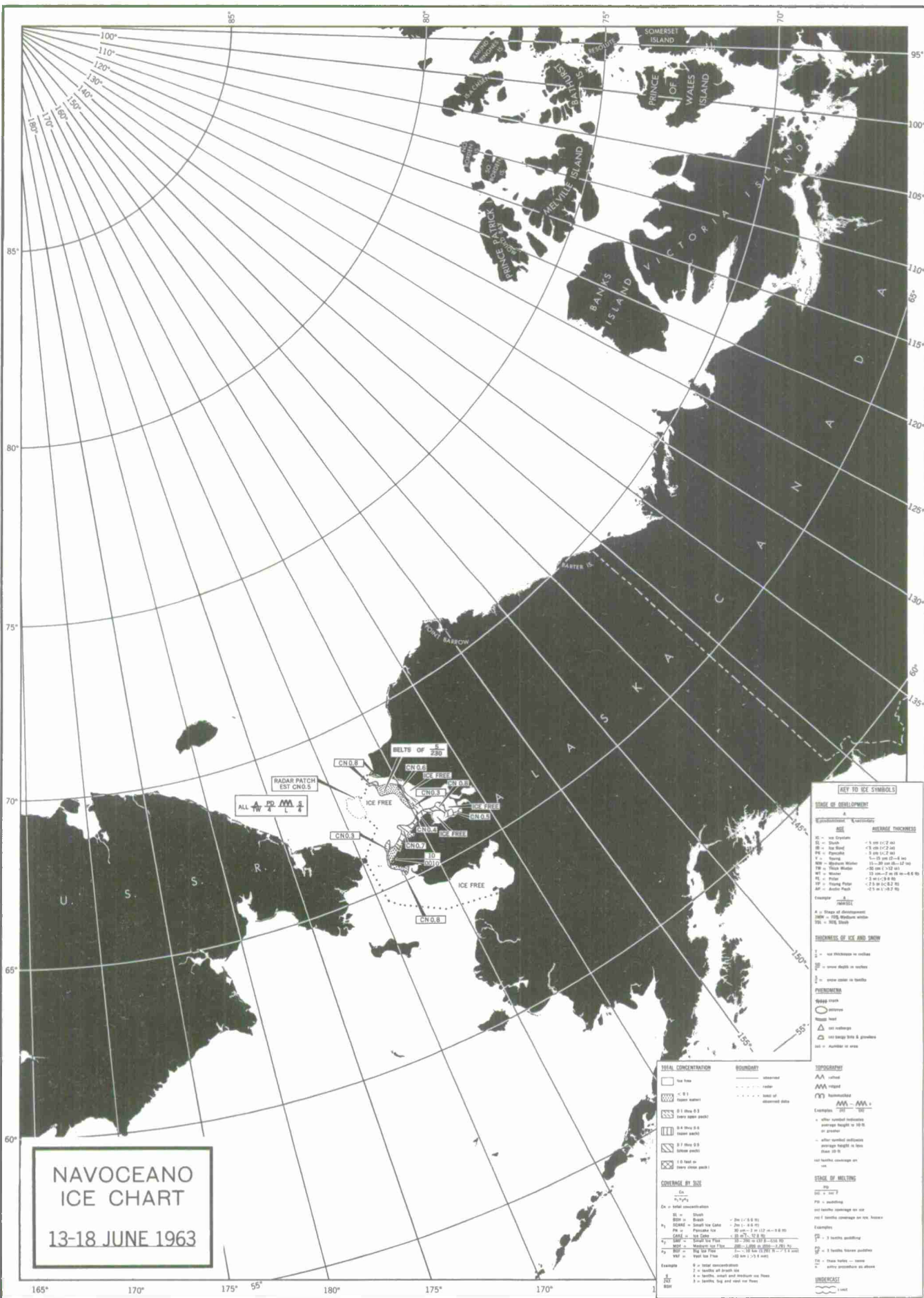
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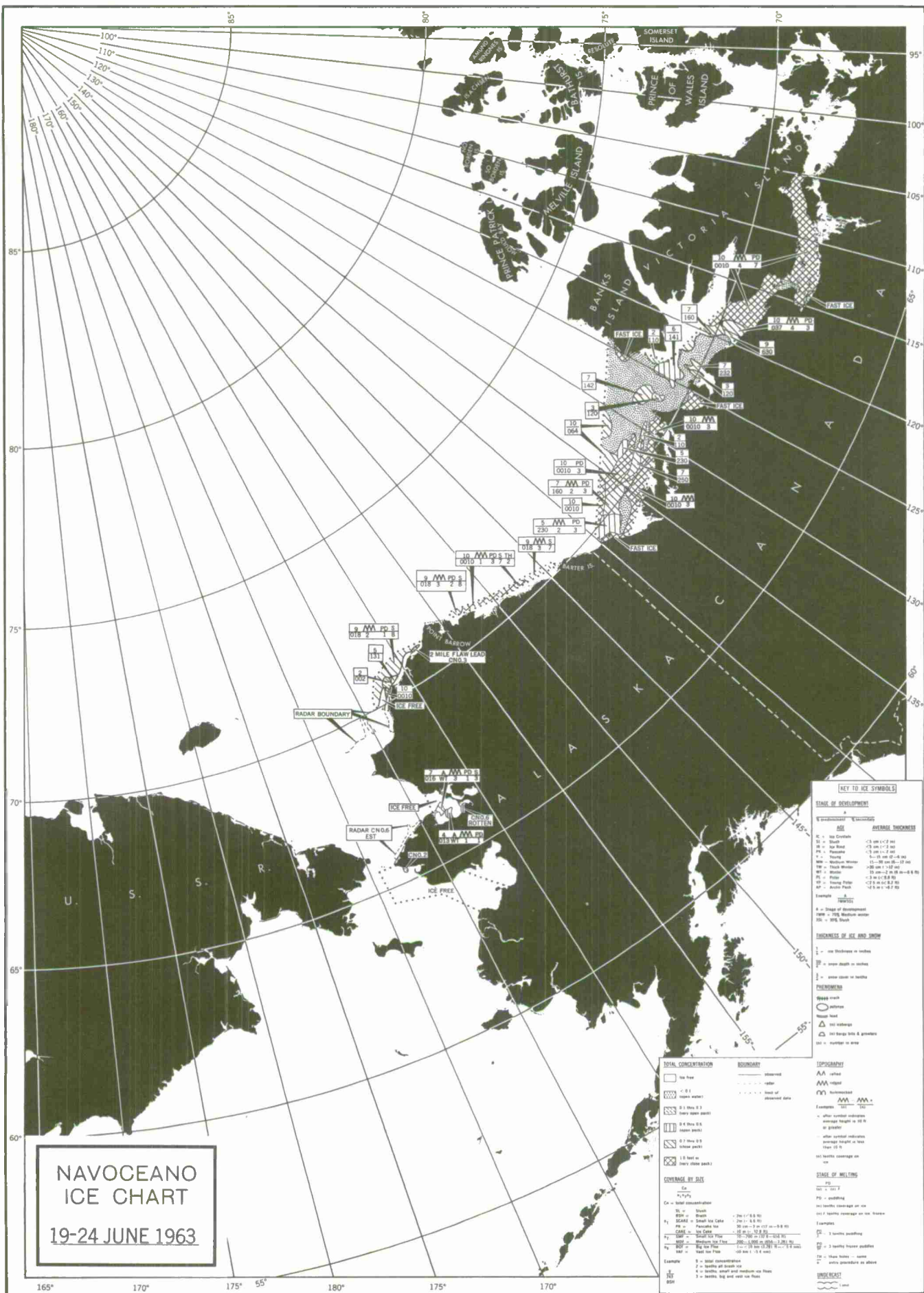
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- 97 = 9700 ft
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- 99 = 9900 ft
- 100 = 10000 ft

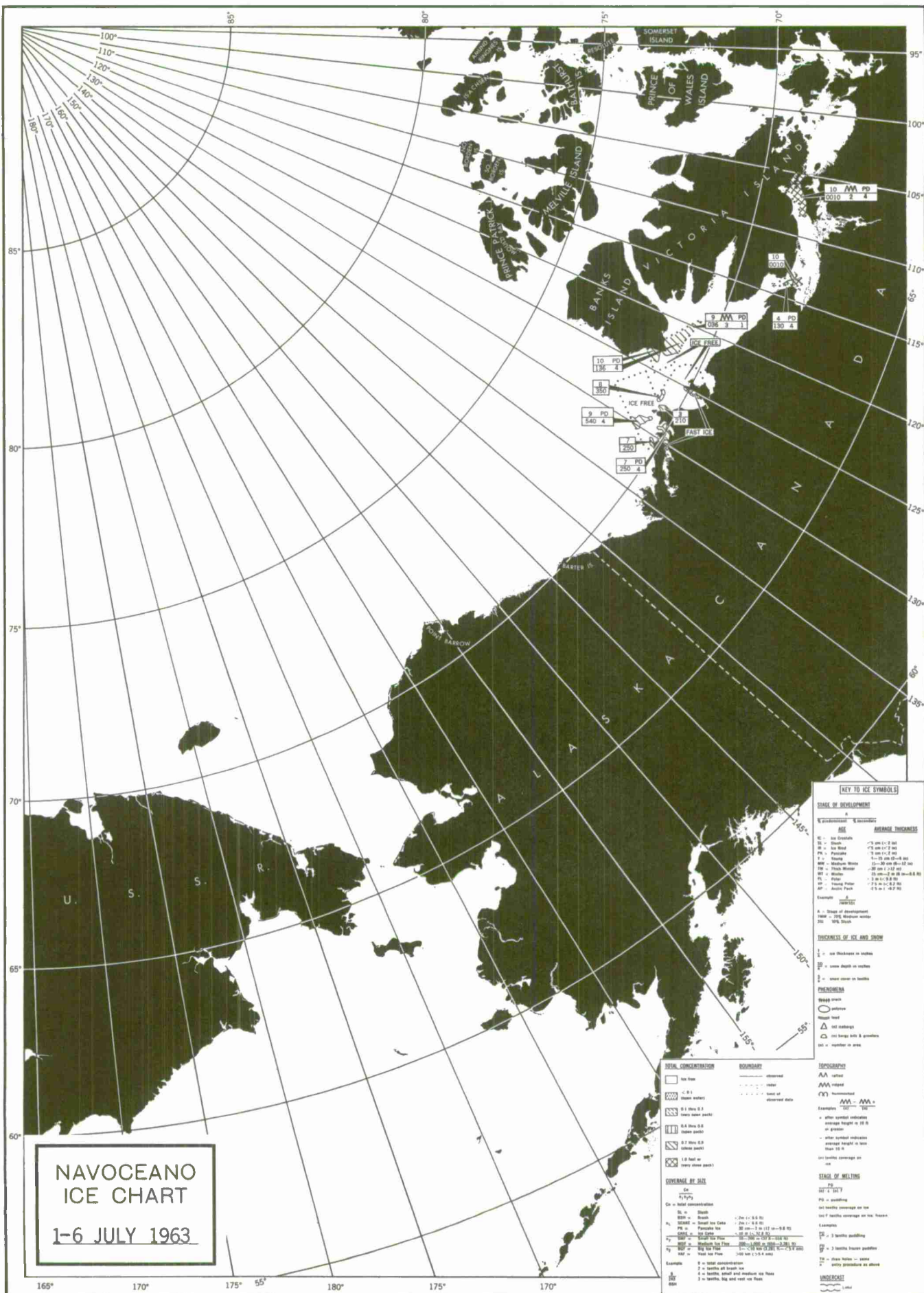


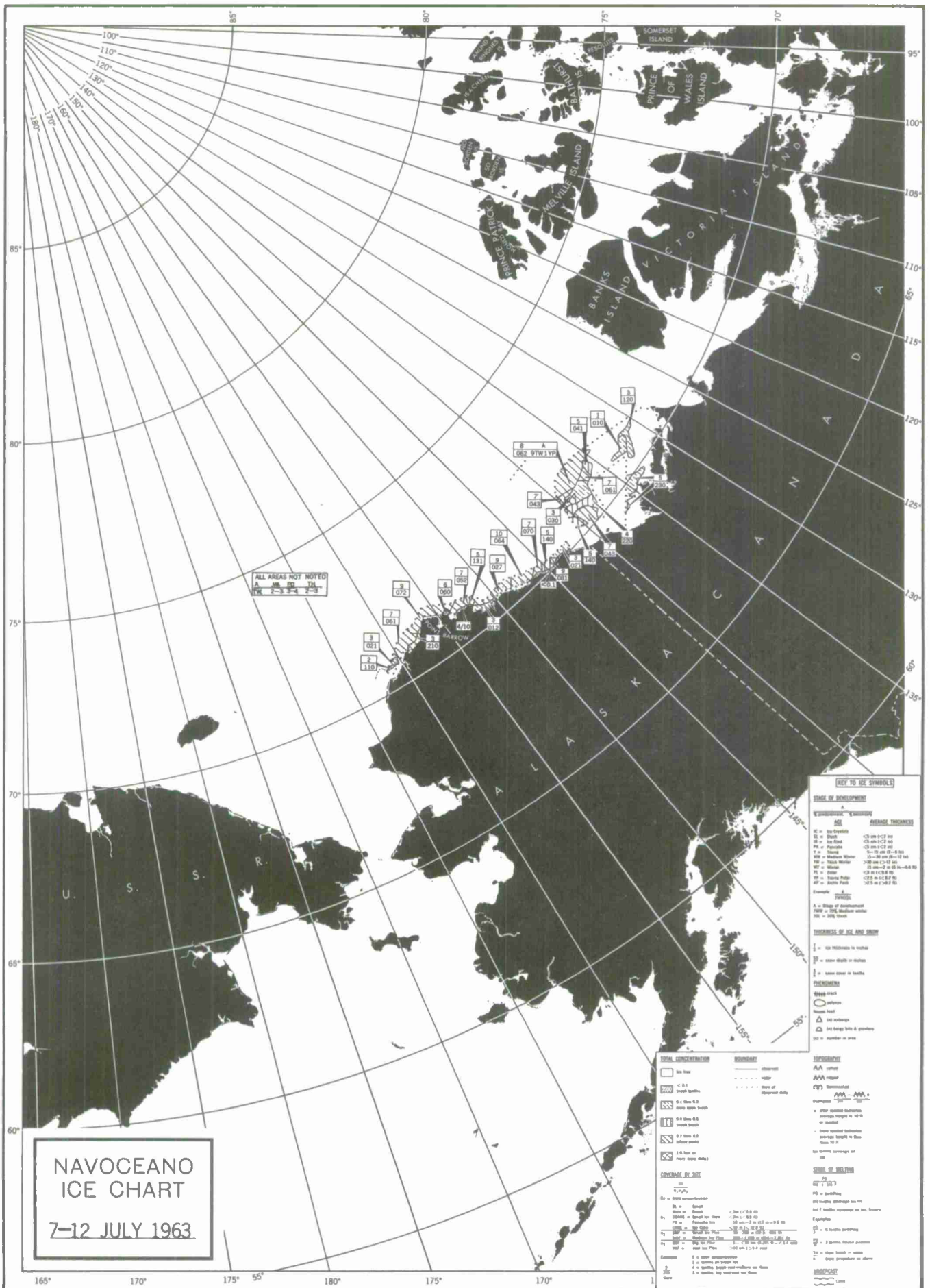


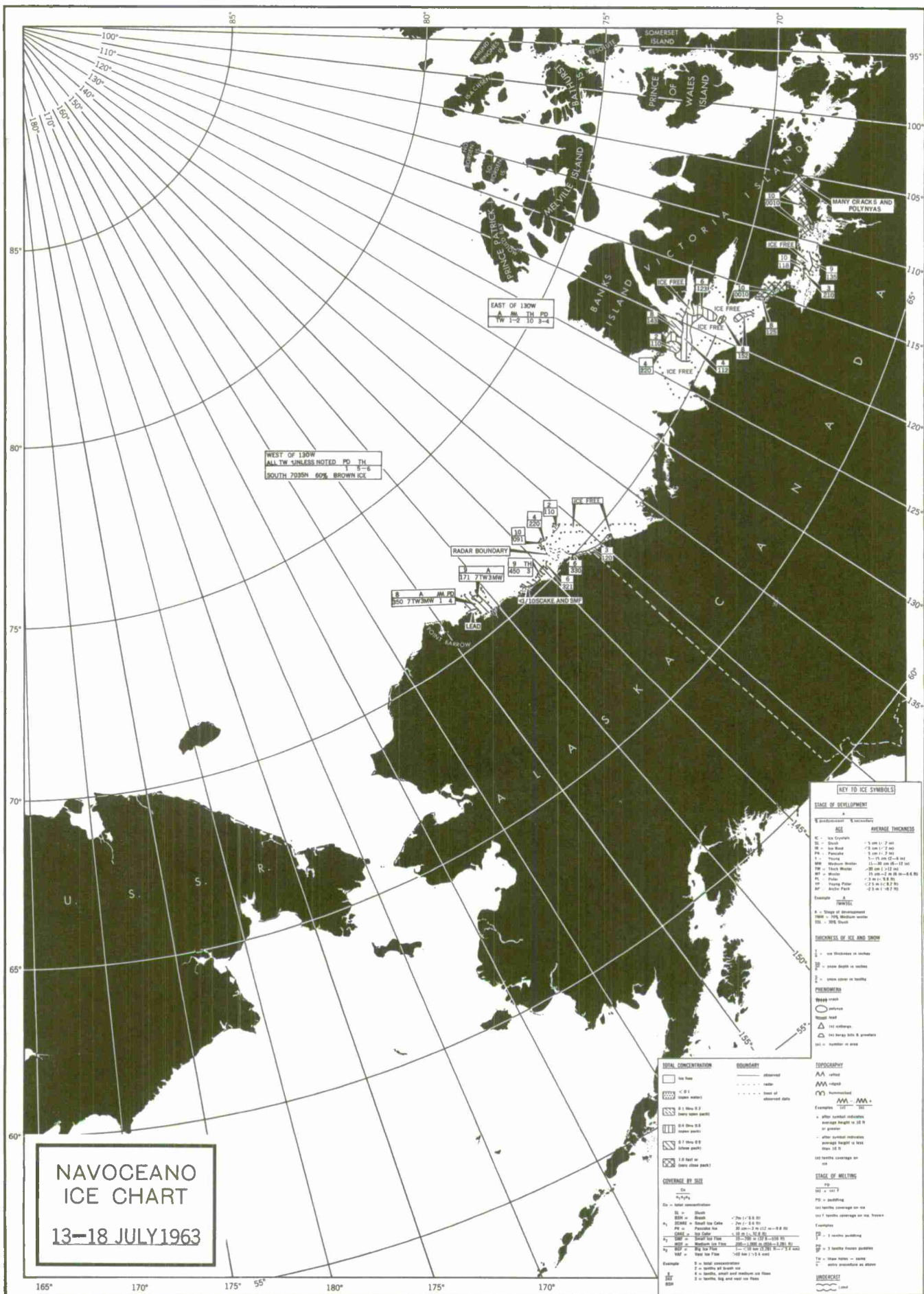


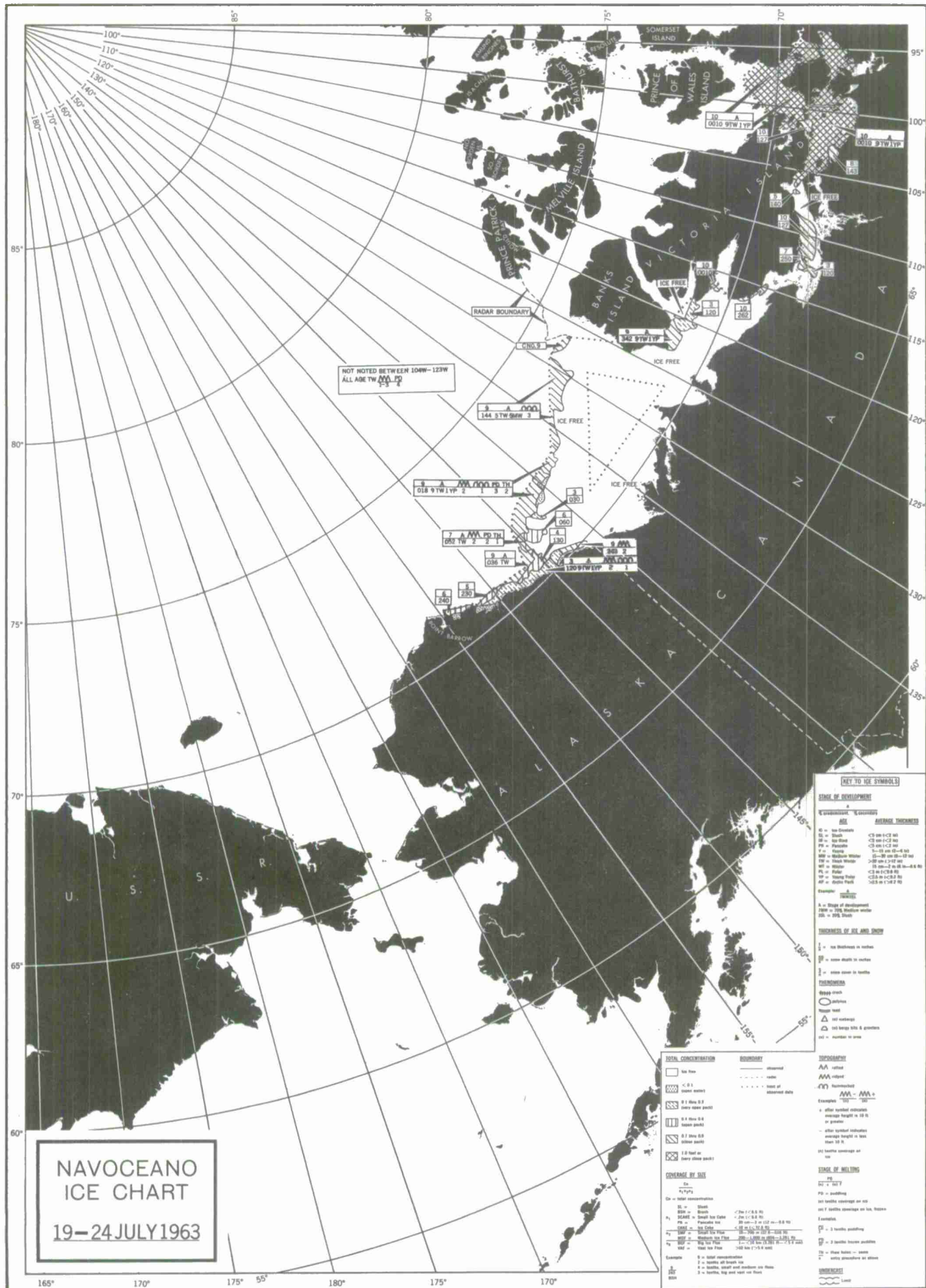












KEY TO ICE SYMBOLS

STATE OF DEVELOPMENT

AGE

AVERAGE THICKNESS

THICKNESS OF ICE AGE

CONCENTRATION

BOUNDARY

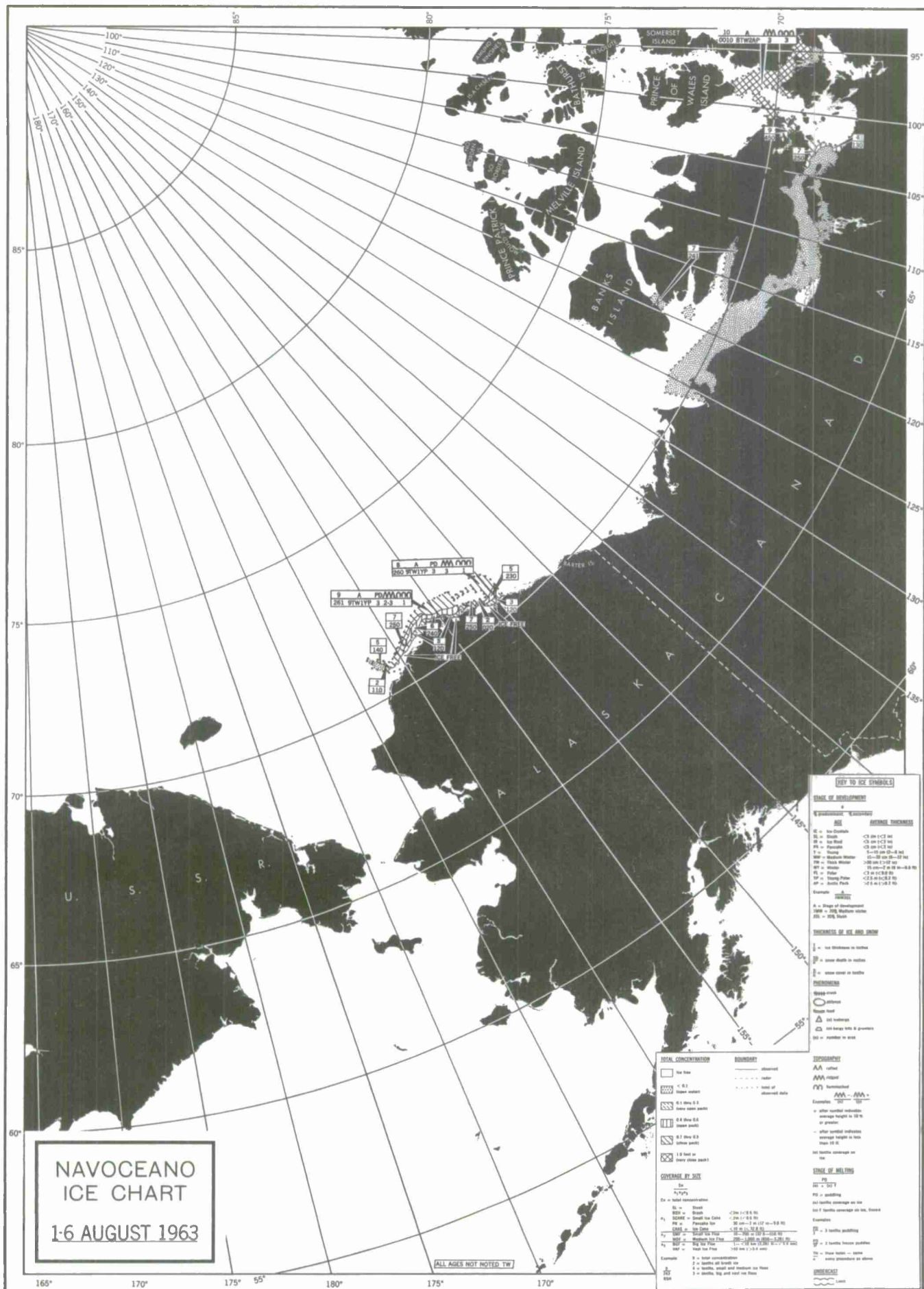
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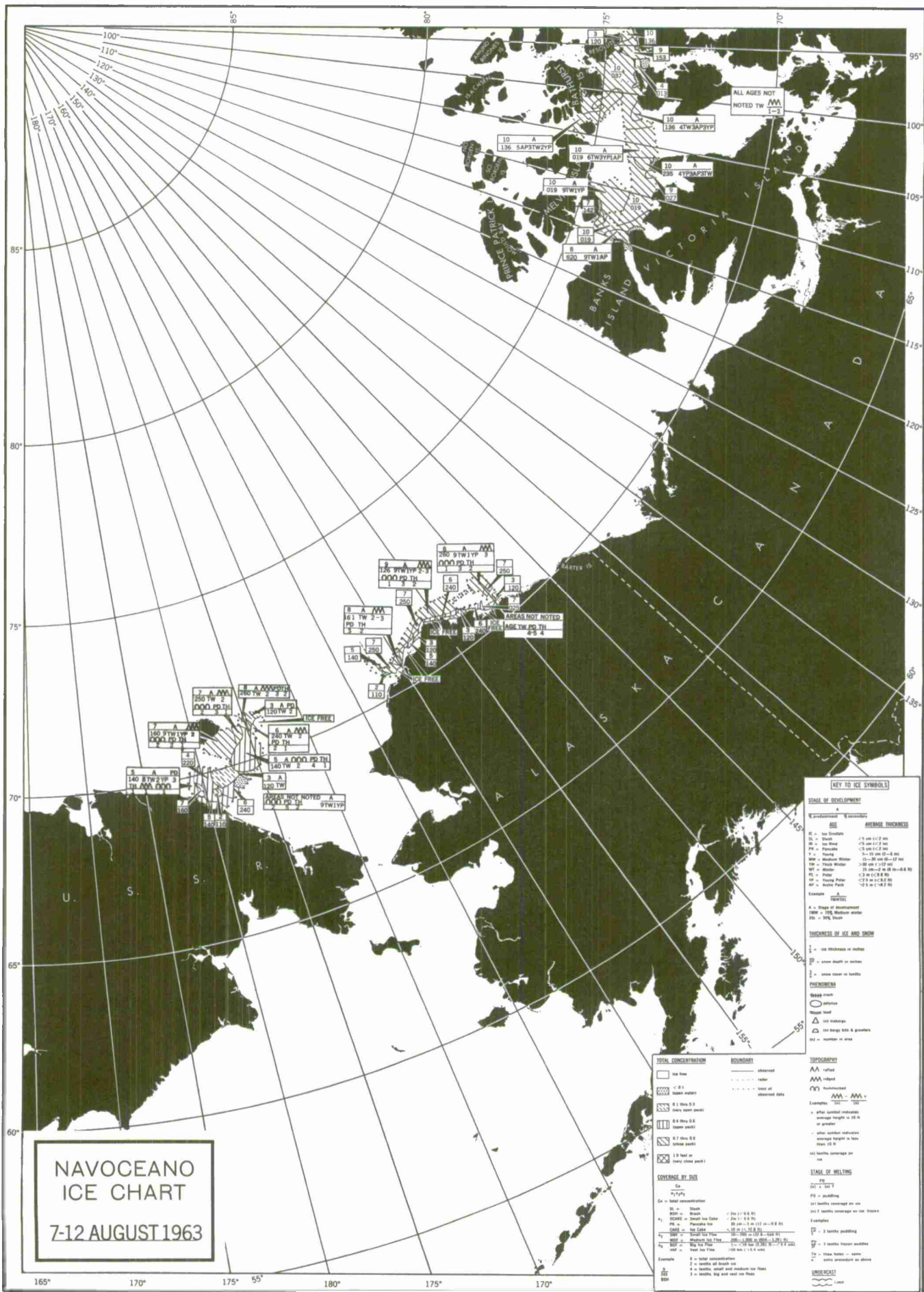
STAGE OF MELTING

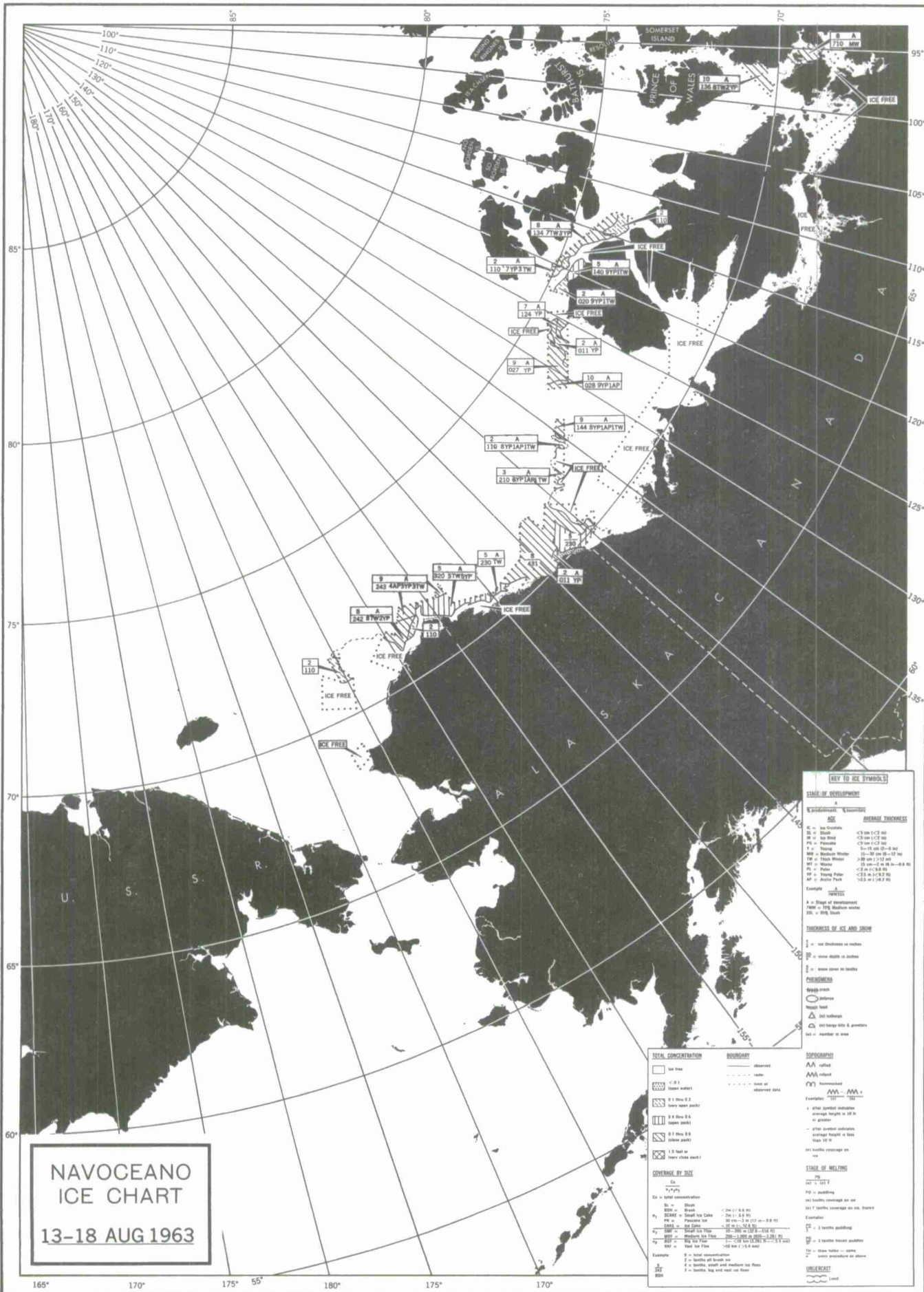
TOPOGRAPHY

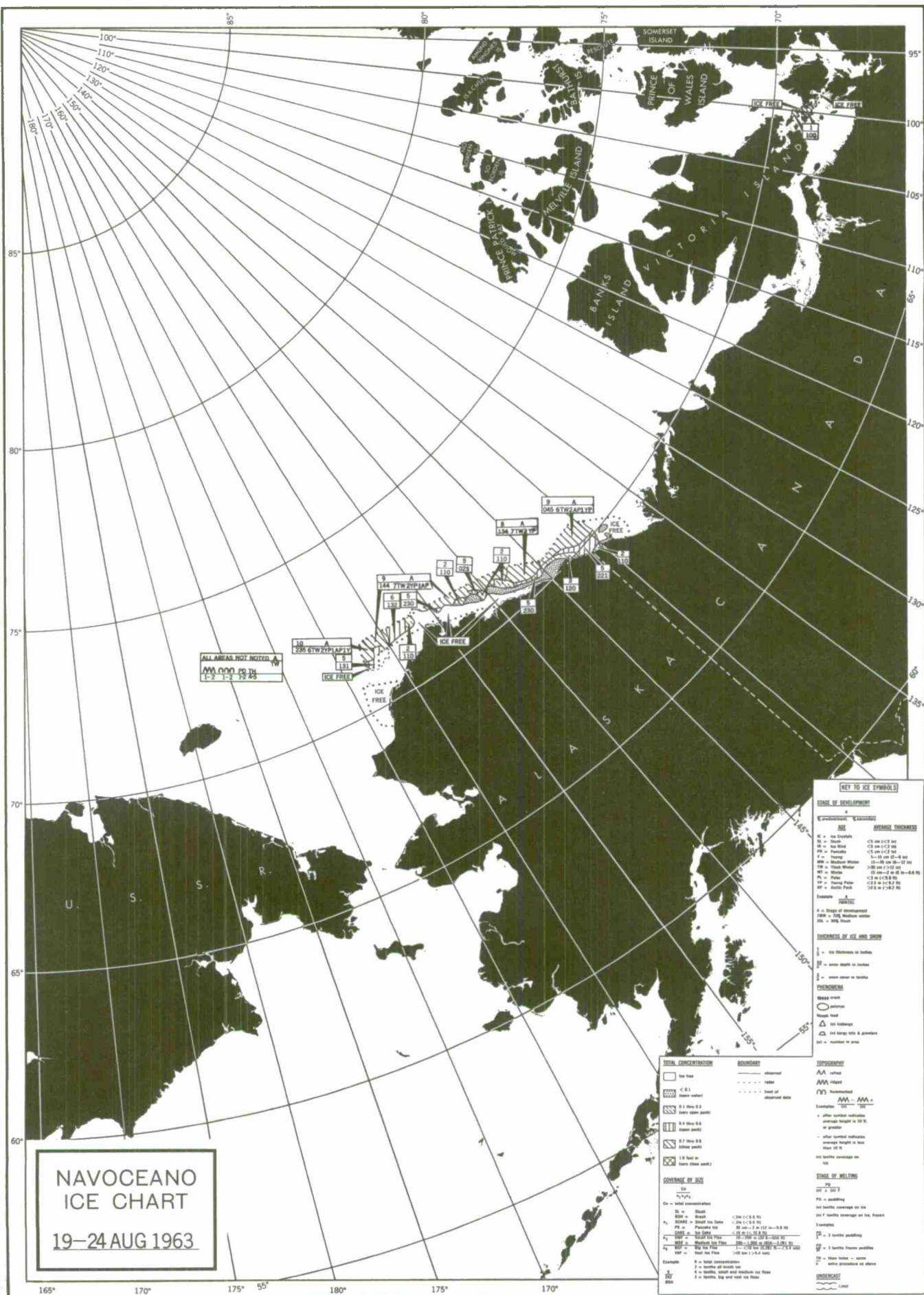
UNDEVELOPED

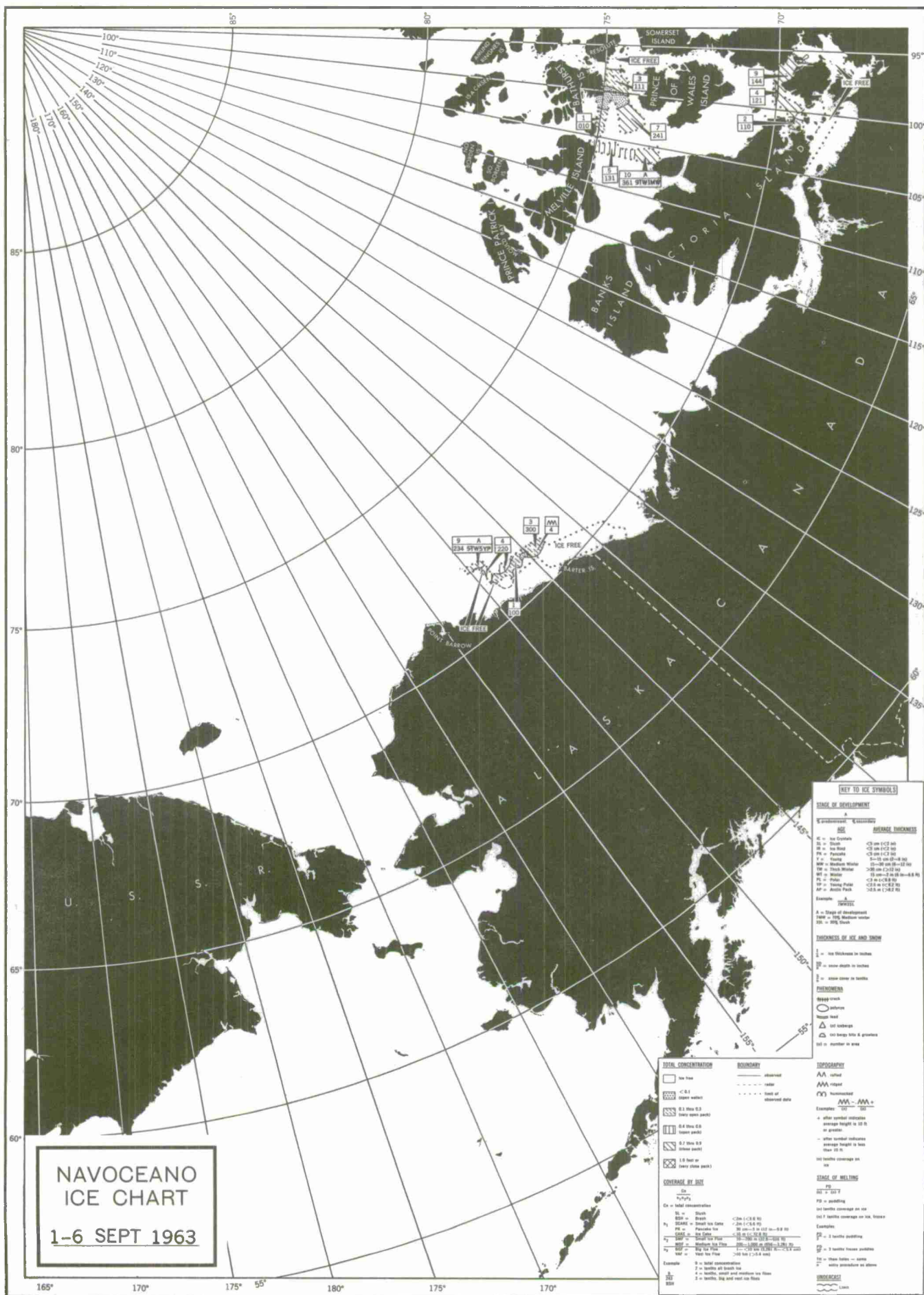
NAVOCEANO
ICE CHART
19-24 JULY 1963

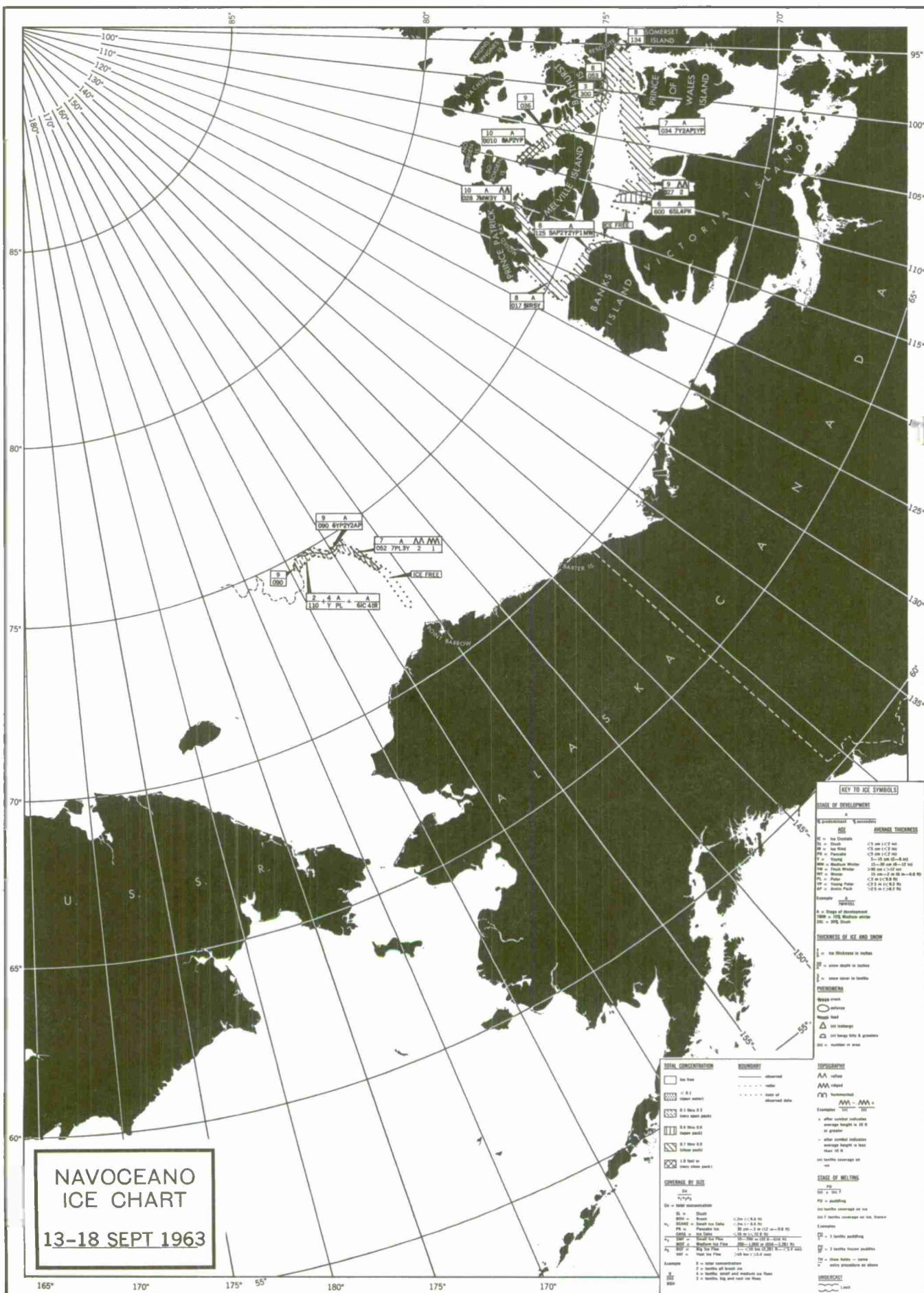


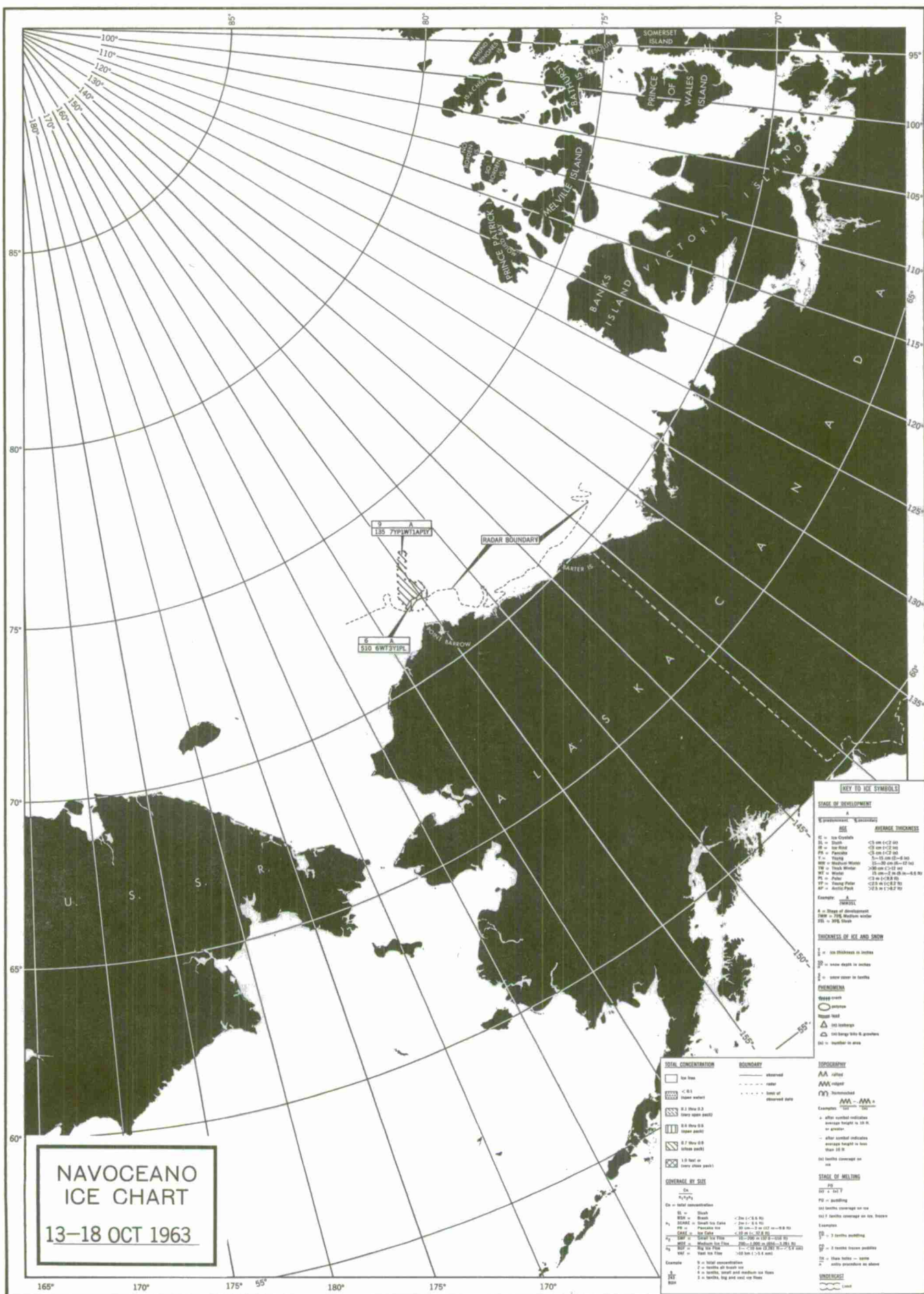












KEY TO ICE SYMBOLS

STAGE OF DEVELOPMENT

STAGE OF DEVELOPMENT	SYMBOL	THICKNESS
Ice Growth	1-3	1-3 m (3-9 ft)
Ice	4	4 m (13 ft)
Ice	5	5 m (16 ft)
Ice	6	6 m (19 ft)
Ice	7	7 m (23 ft)
Ice	8	8 m (26 ft)
Ice	9	9 m (29 ft)
Ice	10	10 m (33 ft)
Ice	11	11 m (36 ft)
Ice	12	12 m (39 ft)
Ice	13	13 m (43 ft)
Ice	14	14 m (46 ft)
Ice	15	15 m (49 ft)
Ice	16	16 m (52 ft)
Ice	17	17 m (56 ft)
Ice	18	18 m (59 ft)
Ice	19	19 m (62 ft)
Ice	20	20 m (66 ft)
Ice	21	21 m (69 ft)
Ice	22	22 m (72 ft)
Ice	23	23 m (76 ft)
Ice	24	24 m (79 ft)
Ice	25	25 m (82 ft)
Ice	26	26 m (86 ft)
Ice	27	27 m (89 ft)
Ice	28	28 m (92 ft)
Ice	29	29 m (96 ft)
Ice	30	30 m (99 ft)
Ice	31	31 m (102 ft)
Ice	32	32 m (106 ft)
Ice	33	33 m (109 ft)
Ice	34	34 m (112 ft)
Ice	35	35 m (116 ft)
Ice	36	36 m (119 ft)
Ice	37	37 m (122 ft)
Ice	38	38 m (126 ft)
Ice	39	39 m (129 ft)
Ice	40	40 m (133 ft)
Ice	41	41 m (136 ft)
Ice	42	42 m (139 ft)
Ice	43	43 m (143 ft)
Ice	44	44 m (146 ft)
Ice	45	45 m (149 ft)
Ice	46	46 m (153 ft)
Ice	47	47 m (156 ft)
Ice	48	48 m (159 ft)
Ice	49	49 m (163 ft)
Ice	50	50 m (166 ft)
Ice	51	51 m (169 ft)
Ice	52	52 m (173 ft)
Ice	53	53 m (176 ft)
Ice	54	54 m (179 ft)
Ice	55	55 m (183 ft)
Ice	56	56 m (186 ft)
Ice	57	57 m (189 ft)
Ice	58	58 m (193 ft)
Ice	59	59 m (196 ft)
Ice	60	60 m (200 ft)
Ice	61	61 m (203 ft)
Ice	62	62 m (207 ft)
Ice	63	63 m (210 ft)
Ice	64	64 m (214 ft)
Ice	65	65 m (217 ft)
Ice	66	66 m (221 ft)
Ice	67	67 m (224 ft)
Ice	68	68 m (228 ft)
Ice	69	69 m (231 ft)
Ice	70	70 m (235 ft)
Ice	71	71 m (238 ft)
Ice	72	72 m (242 ft)
Ice	73	73 m (245 ft)
Ice	74	74 m (249 ft)
Ice	75	75 m (252 ft)
Ice	76	76 m (256 ft)
Ice	77	77 m (259 ft)
Ice	78	78 m (263 ft)
Ice	79	79 m (266 ft)
Ice	80	80 m (270 ft)
Ice	81	81 m (273 ft)
Ice	82	82 m (277 ft)
Ice	83	83 m (280 ft)
Ice	84	84 m (284 ft)
Ice	85	85 m (287 ft)
Ice	86	86 m (291 ft)
Ice	87	87 m (294 ft)
Ice	88	88 m (298 ft)
Ice	89	89 m (301 ft)
Ice	90	90 m (305 ft)
Ice	91	91 m (308 ft)
Ice	92	92 m (312 ft)
Ice	93	93 m (315 ft)
Ice	94	94 m (319 ft)
Ice	95	95 m (322 ft)
Ice	96	96 m (326 ft)
Ice	97	97 m (329 ft)
Ice	98	98 m (333 ft)
Ice	99	99 m (336 ft)
Ice	100	100 m (340 ft)

THICKNESS OF ICE AND SNOW

1 = Ice thickness in inches

2 = Snow depth in inches

3 = Snow cover in inches

4 = Ice thickness in feet

5 = Snow depth in feet

6 = Snow cover in feet

7 = Ice thickness in meters

8 = Snow depth in meters

9 = Snow cover in meters

10 = Ice thickness in centimeters

11 = Snow depth in centimeters

12 = Snow cover in centimeters

13 = Ice thickness in millimeters

14 = Snow depth in millimeters

15 = Snow cover in millimeters

16 = Ice thickness in micrometers

17 = Snow depth in micrometers

18 = Snow cover in micrometers

19 = Ice thickness in nanometers

20 = Snow depth in nanometers

21 = Snow cover in nanometers

22 = Ice thickness in angstroms

23 = Snow depth in angstroms

24 = Snow cover in angstroms

25 = Ice thickness in fermis

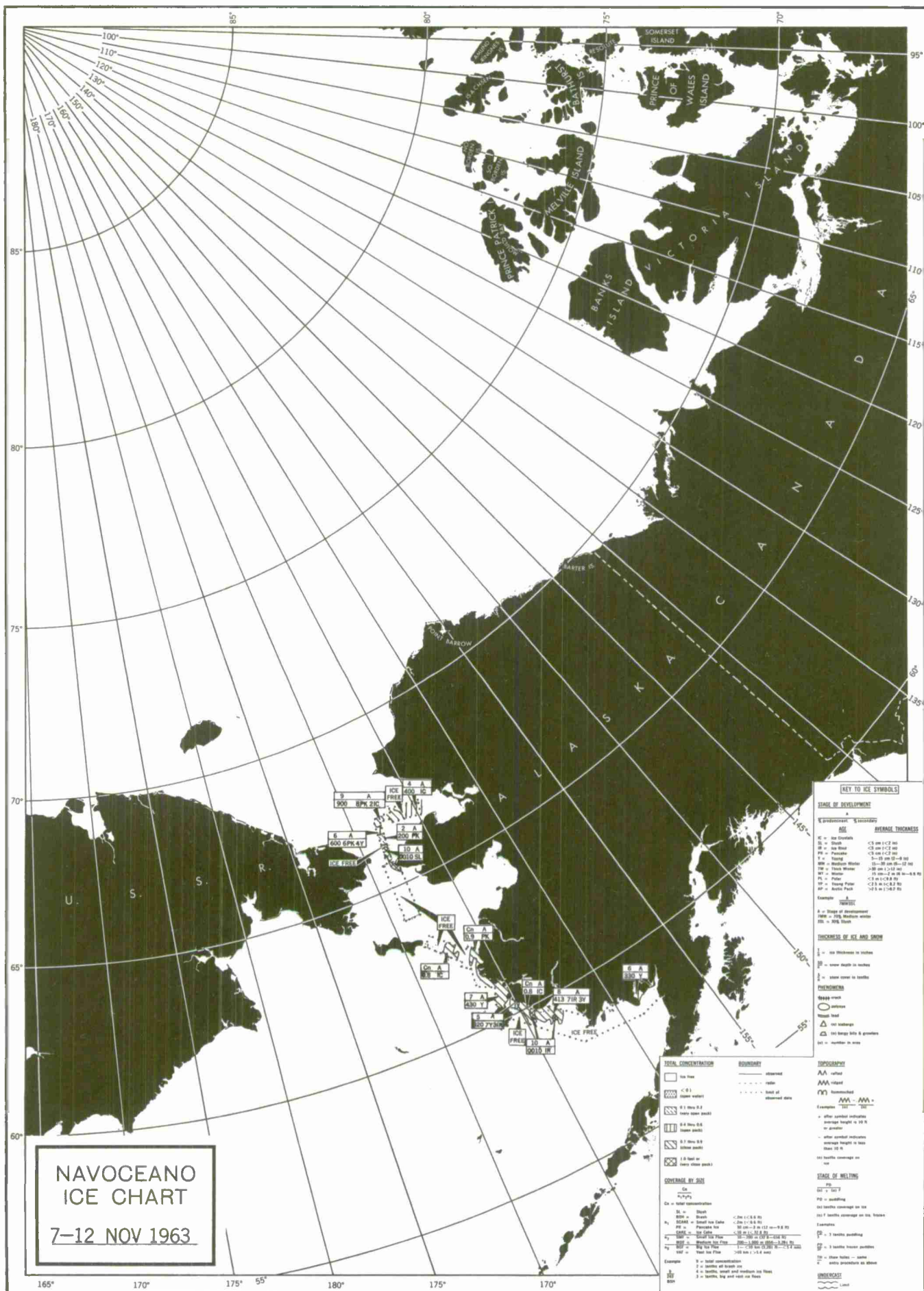
26 = Snow depth in fermis

27 = Snow cover in fermis

28 = Ice thickness in light years

29 = Snow depth in light years

30 = Snow cover in light years





U.S. Naval Oceanographic Office.
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