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REPORT OF THE ARCTIC ICE OBSERVING AND FORECASTING PROGRAM-1971--ETC(U)
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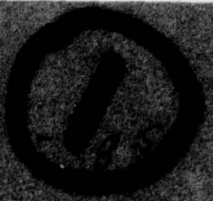
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NAVAL OCEANOGRAPHIC OFFICE SPECIAL PUBLICATION 70 (71)

2/18/77



REPORT OF THE
ARCTIC ICE OBSERVING
AND FORECASTING PROGRAM—1971

MAY 1974

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↳ This report of the last

Arctic. The last of this series was conducted

ABSTRACT

↳ The ice program conducted during 1971 in the North American Basin by the Naval Oceanographic Office presented. Methods of collection and dissemination of ice data, ice forecasting, forecast verification, and interpretation of satellite ice observations are discussed. Sea ice distribution in the eastern Arctic was generally normal or slightly heavier than normal. Expected dates for escorted and unescorted entry into 5 selected eastern Arctic ports were forecasted. Conditions for escorted entry into 3 of these ports occurred as predicted. Escorted entry at the 2 remaining ports occurred 1 to 9 days later than forecast. Conditions for unescorted entry also occurred as predicted at 3 of these ports. Unescorted entry was possible 6 days later than forecast at one port and 20 days earlier than forecast at the fifth port. Ice conditions in the western Arctic were heavier than normal for the third consecutive year, especially in the Bering Sea during spring. Ice conditions, based on aerial and satellite data in the eastern and western sectors of the Arctic and data observed over the Arctic Basin during 2 BIRDS-EYE missions, are shown graphically in separate appendices.

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10 PETER A. MITCHELL

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FOREWORD

This annual report, the twentieth and last of a series, summarizes the ice program conducted during 1971 by the Naval Oceanographic Office principally in support of Military Sealift Command resupply operations in the eastern Arctic and Commander Alaskan Sea Frontier in the western Arctic. Extensive ice data acquired by aerial reconnaissance, ice-breakers, and satellite photography were used to prepare ice forecasts. Satellite photography has proven in recent years to be an invaluable tool for supplementing aerial reconnaissance and to provide continuous coverage enabling the forecaster to observe movement of ice edges, opening and closing of leads, and formation of other significant ice-related features. These data, together with historical information, make possible a comprehensive accumulation of ice information which is an asset to ice forecasting and necessary to the overall efficient planning and success of arctic operations.


P. V. PURKRABEK
Captain, U.S. Navy
Commander

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PART I - EASTERN ARCTIC

1. GENERAL

Resupply of the eastern Arctic during 1971 was conducted by the Military Sealift Command (MSC). MSC ships carried bulk cargoes to Goose Bay, Sondre Stromfjord, Itivdleq, Thule, and Kulusuk. These locations and other place name references in the text are presented in figure 1. For presentation purposes, the North American Arctic is divided into three major regions each of which is subdivided into ice reconnaissance areas as shown in figure 2. The eastern region was resupplied by MSC, the western region by commercial shipping, and the central region by the Canadian Department of Transport (DOT).

2. ICE FORECASTING

The U.S. Naval Oceanographic Office (NAVOCEANO) conducted a long-range ice forecasting program in support of MSC eastern Arctic operations. This program included the long-range seasonal ice outlook* and 15- and 30-day forecasts used to amend the long-range outlook. Short-range forecasts and ship ice routings were provided by the Naval Weather Service.

a. Long-Range Ice Outlook

The long-range ice outlook for the eastern Arctic was designed to provide an estimate of ice conditions during the resupply season for planning a generalized and tentative arctic shipping schedule. The outlook was based initially on evaluation of oceanographic and climatic factors affecting ice formation, growth, and drift. Forecasts of ice disintegration and predicted trends were then based on comparison of this evaluation with historical data.

In addition, a comprehensive aerial survey of the Labrador Sea, Davis Strait, and Baffin Bay from 20 through 24 March provided information on distribution, age, and topography of the ice. Data extracted from ESSA 9 and ITOS I satellite photographs between 22 and 25 March provided information for the Labrador Sea, the east Greenland coast and the Denmark Strait. The current environment was compared to historical ice conditions to determine possible analogies. After incorporation of this information, predicted trends for the opening of the various ports were related to normal dates when ice concentrations would permit ships to safely enter these ports with and without icebreaker assistance.

The outlook also contained prognosticated mid-monthly ice charts for May through August, together with envelopes of minimum and maximum ice edges observed since 1953. The outlook was presented at a briefing of COMSCLANT and was distributed to other cognizant commands.

*U.S. Naval Oceanographic Office, The Eastern Arctic Ice Seasonal Outlook, 1971, H. O. SP-60(71). April 1971.



FIGURE 1 PLACE NAME CHART

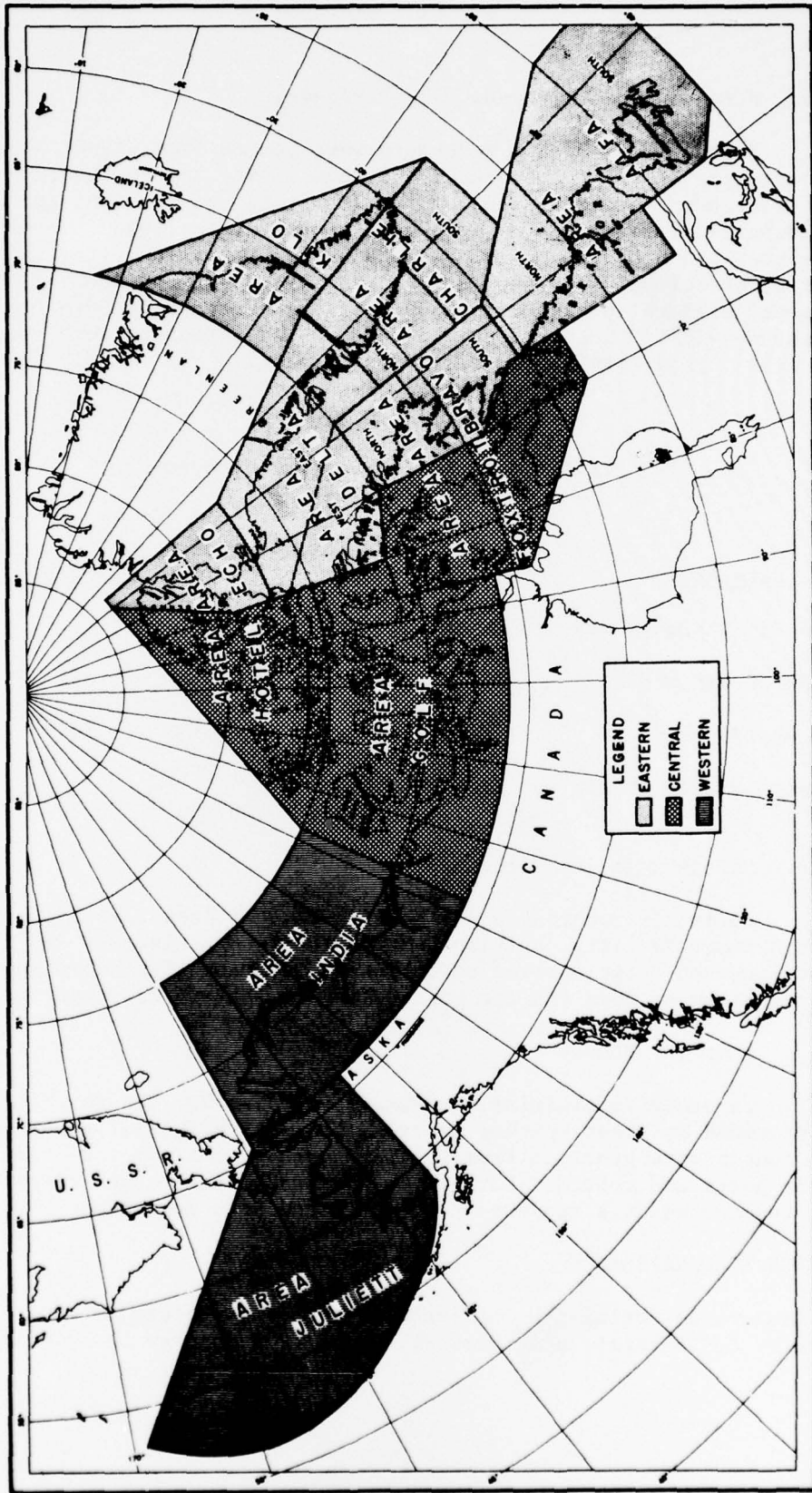


FIGURE 2 RESUPPLY AND ICE RECONNAISSANCE AREAS

b. Fifteen- and Thirty-Day Ice Forecasts

Fifteen- and 30-day forecasts were issued from NAVOCEANO via radioteletype (RATT) twice monthly between 21 May and 22 November. These forecasts were revisions of the long-range outlook and contained more detailed information on ice edge, concentration, and floe size. Forecasts were based on aerial reconnaissance, satellite data, ship reports, historical ice information, and ESSA 30-day prognostic charts of the mean sea-level pressure and 700-millibar-height departure from normal. Commencing with 20 October, the 15- and 30-day forecasts were freezeup forecasts. Forecasts are summarized in table 1.

Table 1

Fifteen- and Thirty-Day Ice Forecasts
Eastern Arctic, 1971

<u>Site-Area</u>	<u>Period</u>	<u>Number</u>		<u>Total</u>
		<u>15-Day</u>	<u>30-Day</u>	
Goose Bay-Labrador Sea	1 May-21 June	7	7	14
	20 Oct-22 Nov			
Sondre Stromfjord	21 May- 7 June	5	3	8
	20 Oct-22 Nov			
Thule-Baffin Bay	21 May-20 Aug	10	10	20
	20 Oct-22 Nov			
Kulusuk-Denmark Strait	21 Jun- 6 Aug	<u>4</u>	<u>3</u>	<u>7</u>
		26	23	49

c. Short-Range Ice Forecasts

Forecasts covering a period of 5 days or less were issued by the Fleet Weather Facility, Suitland, Maryland. Ice advisories and forecasts commenced when ships entered operational areas and terminated when shipping was completed or when the ice was no longer a hazard to shipping.

d. Ship Ice Routes

In order to minimize ice damage to shipping, ice routing service was provided by Fleet Weather Central, Norfolk, Virginia. Optimum track ship routes were provided from the last port of call in the Atlantic to arctic ports and return. During the periods of icebreaker escort, routes were terminated at a rendezvous point in the port approaches.

3. ICE RECONNAISSANCE

Long-range aerial ice reconnaissance of the eastern Arctic was provided by P3A aircraft stationed at Bermuda. A summary of regular flights

and hours flown over each reconnaissance area each month, including transit time, is given in table 2. Flight hours for each mission were apportioned to the various reconnaissance areas. Immediate tactical support was provided by icebreaker-based helicopters which made local ice observations.

Table 2

Ice Reconnaissance Flights, Eastern Arctic, 1971

Month	Flts.	Total							Hours of Ice Obs.
		Hours	ALFA	BRAVO	CHARLIE	DELTA	ECHO	KILO	
Feb	1	9.3	0	0	0	0	0	9.3	6.0
March	3	23.7	3.9	3.8	4.5	8.6	0.9	2.0	13.8
April	4	29.6	8.7	3.2	3.9	7.4	1.9	4.5	17.3
May	1	9.0	2.0	1.5	2.0	0	0	3.5	3.2
June	7	48.6	11.8	7.4	1.9	16.0	2.2	9.3	22.9
July	7	53.4	9.6	6.5	11.6	11.5	1.8	12.4	16.5
Aug	4	26.8	0	1.8	0	3.7	0	21.3	12.4
Sep	1	9.0	0	0	0	0	0	9.0	3.5
Oct	5	36.9	0	0	0	5.2	0.6	31.1	10.4
Nov	6	47.8	0	3.3	3.9	19.4	1.1	20.1	16.4
Dec	<u>1</u>	<u>10.2</u>	<u>2.1</u>	<u>4.5</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>3.6</u>	<u>5.9</u>
Totals	40	304.3	38.1	32.0	27.8	71.8	8.5	126.1	128.3

Several other sources of ice reconnaissance data over the eastern Arctic augmented the data obtained by P3A flights. These included 4 U.S. Coast Guard flights in January listed in table 3, in which Navy ice observers participated. Other supplementary ice reconnaissance data covered initial and terminal legs of Project BIRDS EYE missions and Danish ice reconnaissance conducted primarily along the south and east Greenland coasts including 83 flights totaling approximately 385 hours. Some Canadian observations in Baffin Bay and Labrador Sea were also utilized.

Table 3

Participation in U.S. Coast Guard Flights,
Eastern and Western Arctic, 1971

Month	Flts.	Total						Hours of Ice Obs.
		Hours	ALFA	BRAVO	CHARLIE	INDIA	JULIETT	
Jan	4	25.0	18.6	1.7	4.7	0	0	10.4
Mar	1	6.5	0	0	0	0	6.5	4.0
May	3	33.0	0	0	0	0	33.0	12.1
June	<u>1</u>	<u>10.1</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>6.9</u>	<u>3.2</u>	<u>3.1</u>
Totals	9	74.6	18.6	1.7	4.7	6.9	42.7	29.6

4. SUPPORTING PROJECTS

a. Project BIRDS EYE

In conjunction with research and development of ice forecasting techniques for the Arctic Basin and to provide ice forecasting support, Project BIRDS EYE consisted of a series of seven ice reconnaissance missions (BE 1-71 through BE 7-71), with several flights in each mission, over the North American Arctic. BIRDS EYE missions totaling 42 flights for approximately 460 hours were conducted on standard tracks primarily over the Arctic Basin. Data from BIRDS EYE missions 1 through 5 were included, where applicable, in the charts presented in appendixes A and C. BIRDS EYE 6-71 and 7-71 data are presented in appendix E.

b. Classified Operations

The following forecasts were issued to a military command for two continuing classified projects in specific geographical areas:

March - seven short-range wind and ice forecasts
September - one 15-day ice forecast
October - two 15- and 30-day ice forecasts
November - two 15- and 30-day ice forecasts
December - one 15-day ice forecast

5. OBSERVED ICE CONDITIONS

Ice conditions observed by aerial reconnaissance in the eastern North American Arctic are presented in appendix A. Ice data were obtained primarily from U.S. aerial ice reconnaissance, including BIRDS EYE flights, supplemented by U.S. Coast Guard flights and Danish aerial reconnaissance. Ice conditions observed by satellite in the eastern North American Arctic are presented in appendix B.

Fast ice in Itivdleq broke up within its normal range as forecasted by the outlook. However, the escorted and unescorted trends for Sondrestrom were 9 and 6 days later than forecast, respectively, owing to temperatures that were lower than those forecasted for May and the first week of June. Ice concentration in the approaches to Goose Bay decreased to less than six-eighths by 15 June, 1 day later than forecasted in the outlook. Unescorted entry to Goose Bay occurred as predicted on 8 July, 15 days later than normal, because of the predominance of onshore drift along the Labrador coast during April through June. Ice concentration in the Thule approaches decreased to less than six-eighths by 16 July, resulting in normal escorted entry into Thule as predicted in the outlook. Open to very close pack ice persisted in central and northern Baffin Bay until the end of July. Thus, the later than normal unescorted entry date of 1 August forecasted in the outlook was verified.

Escorted entry into Kulusuk was normal as predicted by the outlook; but the wider than normal ice pack north of Kulusuk, combined with large quantities of multi-year ice north of 66°N, still posed great potential for later drift into the Kulusuk approaches. However, this potential drift never materialized even though the pack ice north of 66°N remained unusually extensive into August owing to anomalous light and variable and offshore winds during July along the east Greenland coast. Consequently, unescorted entry into Kulusuk was possible by 3 August, 20 days earlier than forecast by the outlook. Verification of the long-range outlook is given in table 4.

Table 4

Long-Range Ice Outlook Verification, 1971

<u>Escorted Entry*</u>			
<u>Port</u>	<u>Normal</u>	<u>Predicted Trend</u>	<u>Observed</u>
Itivdleq	17 April	Normal (+4 days)	14 April
Sondre Stromfjord	29 May	Earlier (2 to 5 days)	5 June
Goose Bay	5 June	Later (5 to 9 days)	15 June
Thule	12 July	Normal (+4 days)	16 July
Kulusuk	14 July	Normal (+4 days)	15 July
<u>Unescorted Entry**</u>			
<u>Port</u>	<u>Normal</u>	<u>Predicted Trend</u>	<u>Observed</u>
Itivdleq	1 May	Normal (+4 days)	30 April
Sondre Stromfjord	7 June	Earlier (2 to 5 days)	11 June
Goose Bay	23 June	Later (10 to 15 days)	8 July
Thule	23 July	Later (5 to 9 days)	1 August
Kulusuk	18 August	Later (5 to 9 days)	3 August

*Concentration in approaches 6/8 or less and fast ice, if any, in port well weakened.

**Concentrations in approaches and port 1/8 or less.

PART II - WESTERN ARCTIC

1. GENERAL

During the 1971 resupply season in the western Arctic, short-range ice forecasting support was provided by the Fleet Weather Facility at Suitland, Maryland. NAVOCEANO was responsible for providing long-range forecasts in support of military and oceanographic operations.

2. ICE FORECASTING

A total of forty-eight 15- and 30-day ice forecasts for the north Alaskan coast and the Bering and Chukchi Seas were issued throughout the year. Forecasts were issued twice monthly and included information in ice pack edges, concentrations, stages of development, and ice thickness for 6 specified points. Twenty-six forecasts were sent to COMALSEAFRON, 12 to COMHAWSEAFRON, and 10 to Fleet Weather Facility, Kodiak, Alaska.

3. ICE RECONNAISSANCE

Aerial reconnaissance was conducted over areas INDIA and JULIETT by P3A aircraft stationed at Adak, Alaska; by Project BIRDS EYE aircraft from Eielson AFB, Fairbanks, Alaska; and by utilizing flights by the Arctic Research Laboratory (ARL) from Point Barrow. Additional ice data were obtained by 5 U.S. Coast Guard flights listed in table 3, in which Navy ice observers participated. A summary of P3A flights and hours flown, including ARL missions, for each month over each area and annual totals is presented in table 5. Flight hours for each mission were apportioned to reconnaissance areas INDIA and JULIETT.

4. OBSERVED ICE CONDITIONS

Ice conditions observed by aerial reconnaissance in the western North American Arctic are presented in appendix C. The data were obtained primarily by scheduled aerial reconnaissance and were supplemented by BIRDS EYE flights 1-71 through 5-71. Ice conditions observed by satellite in the western North American Arctic are presented in appendix D.

Table 5

Ice Reconnaissance Flights, Western Arctic, 1971

<u>Month</u>	<u>No. of Flts</u>	<u>Total Hours</u>	<u>INDIA</u>	<u>JULIETT</u>	<u>Hours of Ice Obs.</u>
Feb	1	11.0	6.0	5.0	5.5
Mar	2	15.8	8.7	7.1	6.2
April	2	19.5	0	19.5	13.4
June	1	8.5	0	8.5	4.0
July	6	39.3	39.3	0	13.4
Aug	7	40.7	40.7	0	14.6
Sept	2	11.9	11.9	0	3.4
Oct	2	14.5	13.5	1.0	4.1
Nov	1	9.1	5.3	3.8	5.2
Dec	<u>3</u>	<u>24.8</u>	<u>4.9</u>	<u>19.9</u>	<u>12.3</u>
Totals	27	195.1	130.3	64.8	82.1

PART III - SATELLITE OBSERVATIONS

1. GENERAL

Ice information, including ice edges, concentrations, and large leads or water openings, was interpreted from satellite photographs between 3 March and 22 September. The data for the eastern and western Arctic and Canadian Archipelago are presented in appendixes B and D, respectively.

Ice data derived from ESSA 9, ITOS I, and NOAA I satellite photographs may disagree with aerial reconnaissance data in some cases; however, discrepancies do not always indicate incorrect satellite ice information. Ice edges may be plotted incorrectly owing to navigational problems aboard the aircraft. The width of the ice pack sometimes appears less extensive in a satellite photograph than the width shown on an aerial reconnaissance chart for the same area during an equivalent time period. This specific discrepancy is due to the interpreter's inability to observe ice of less than 3 oktas concentration along an ice edge in the 1971 series of satellite photographs. Many leads and large openings observed within the pack ice are labeled "ice free to 3 oktas," unless the analyst was well assured that the area contained no ice, in which case the area was labeled "ice free". The notation "ice free to 3 oktas" generally infers that the center of the area is ice free and that concentrations of 1 to 3 oktas of ice are present along the periphery of the area.

Concentrations within the pack were interpreted by the analyst without reference to aerial reconnaissance data. Concentrations cannot be interpreted to the nearest okta with current resolution, except for fast ice or where the analyst is confident that compact pack ice (8 oktas) exists; therefore, concentrations are analyzed in ranges of oktas as shown in appendixes B and D. Analysis of ice conditions covered by extensive cloud cover or under conditions of poor illumination was not possible; therefore, areas of arctic darkness or extensive cloud cover are labeled with the appropriate symbols. Ice edges can be observed occasionally through thin cloud cover; however, the concentrations within the pack ice are difficult to ascertain. When such cases arise, a cloud symbol outlines the pack ice and terminates at the ice edge.

Continuous satellite coverage of the Arctic, along with consistent interpretation of the satellite data, permits observation of significant changes. Movement of ice edges, opening and closing of flaw or shore leads, changes of concentration, and gradual expansion of large water openings, such as the North Water Area, can be observed.

2. DISSEMINATED SATELLITE DATA

From 23 May until 22 September NAVOCEANO prepared a total of 72 weekly satellite ice charts for the eastern Arctic, the Canadian Archipelago, and the western Arctic showing ice edges, concentrations and water openings. A total of 468 charts was mailed to various government and private agencies during this period. Data were also extracted from these charts and transmitted via radioteletype (RATT) message to icebreakers and cognizant commands.

APPENDIX A
EASTERN ARCTIC AERIAL
RECONNAISSANCE ICE CHARTS

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KEY TO ICE SYMBOLS USED IN PLOTTING ICE FEATURES

TOTAL CONCENTRATION

	Ice free
	<1 okta* (open water)
	1-<3 oktas (very open pack)
	3-<6 oktas (open pack)
	6-<7 oktas (close pack)
	7-<8 oktas (very close pack)
	8 oktas (compact pack)

CONC	=	Concentration
CRK	=	Crack
CRKS	=	Cracks
FRCT	=	Fracture
FRCTV	=	Very Small Fracture
FRCTS	=	Small Fracture
FRCTM	=	Medium Fracture
FRCTL	=	Large Fracture
LVL	=	Level Ice
NDTR	=	Not Determined
NOPG	=	No Openings in Ice
OPWR	=	Open Water
SCTD	=	Scattered
SD	=	Snow Depth
T	=	Ice Thickness

COVERAGE BY SIZE

$C = \frac{c}{n_1 n_2 n_3}$	
C = total concentration	
SS/NL	= New Ice or Nilas
n ₁ PK	= Pancake < 3 m
CK	= Brash, Small Cake, Cake < 20 m
SF	= Small Floe 20—100 m
n ₂ MF	= Medium Floe 100—500 m
BF	= Big Floe 500—2000 m
VF	= Vast Floe 2—10 km
n ₃ GF	= Giant Floe > 10 km
Fast	= Fast Ice
Example:	7 = total concentration
7	1 = okta all pancake ice
124	2 = oktas small and medium ice floes
PK	4 = oktas big, vast, and giant ice floes








STAGE OF DEVELOPMENT

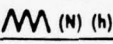
A
oktas predominant, oktas secondary

AGE	AVERAGE THICKNESS
SS = Frazil, Grease, Slush, Shuga	
NL = Ice Rind, Dark Nilas, Light Nilas	— < 5—10 cm
G = Gray	----- 10—15 cm
GW = Gray-White	----- 15—30 cm
FL = Thin First-Year	----- 30—70 cm
FM = Medium First-Year	----- 70—120 cm
FT = Thick First-Year	----- > 120 cm
SY = Second-Year	
MY = Multi-Year	

Example:	A SFM3G
A	= Stage of development
SFM	= 5 oktas Medium First-Year
3G	= 3 oktas Gray
* One okta equals one-eighth ice concentration	

TOPOGRAPHY

	Rafted or Finger-Rafted Ice
	Hummocks
	M(N) New Ridges
	M(W) Weathered Ridges
	M(V) Very Weathered Ridges
	M(A) Aged Ridges
	M(C) Consolidated Ridges


Example:  (N) (h)
(n)

(h) height of ridges in meters
(n) tenths coverage on ice

STAGE OF MELTING

FPD	= Few Puddles
MPD	= Many Puddles
FTH	= Few Thaw Holes
MTH	= Many Thaw Holes
DRI	= Dried Ice
ROT	= Rotten Ice
FLO	= Flooded Ice

UNDERCAST

 Limit





THICKNESS OF ICE & SNOW

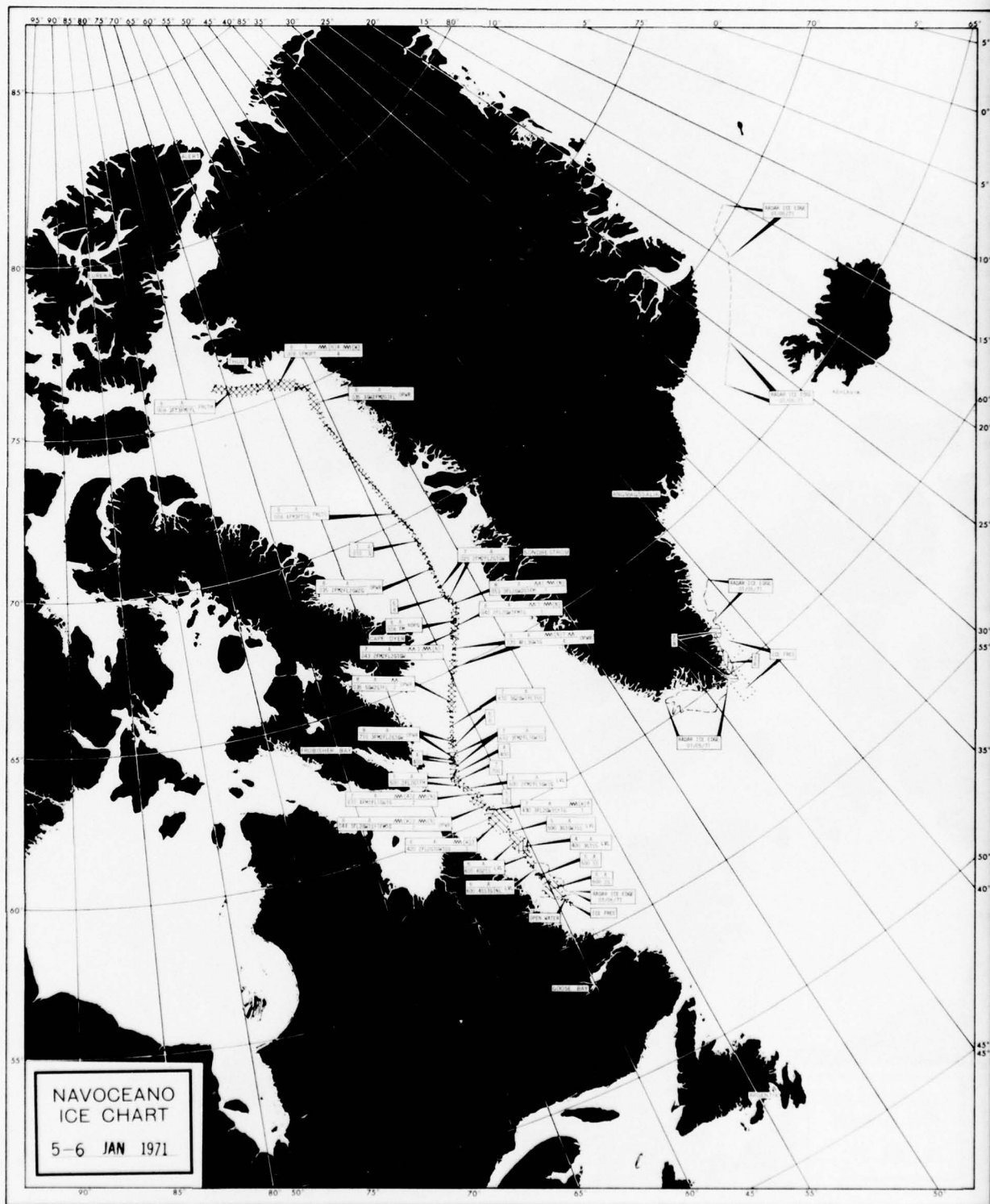
t_E = ice thickness in cm
s = snow depth in cm

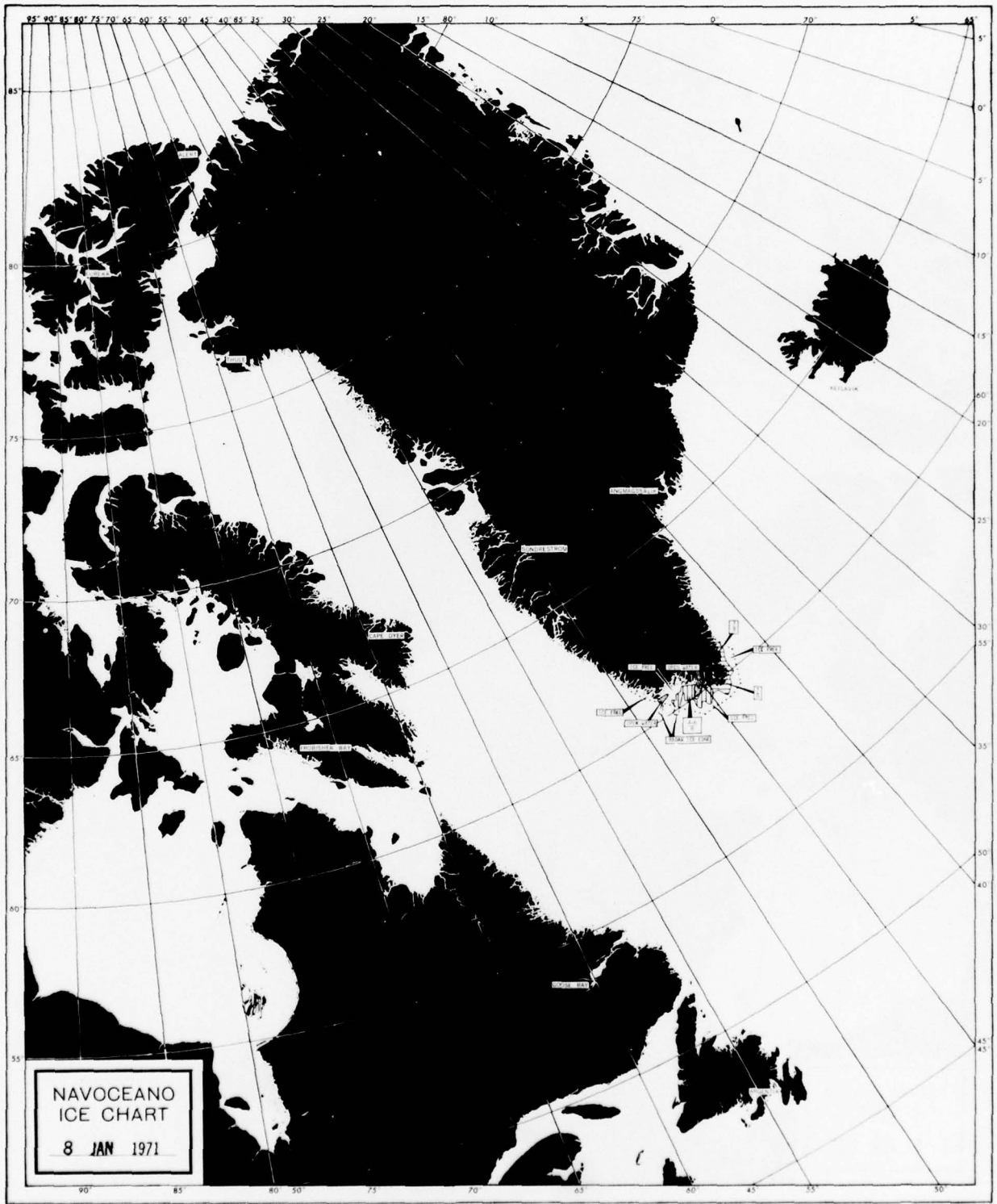
PHENOMENA

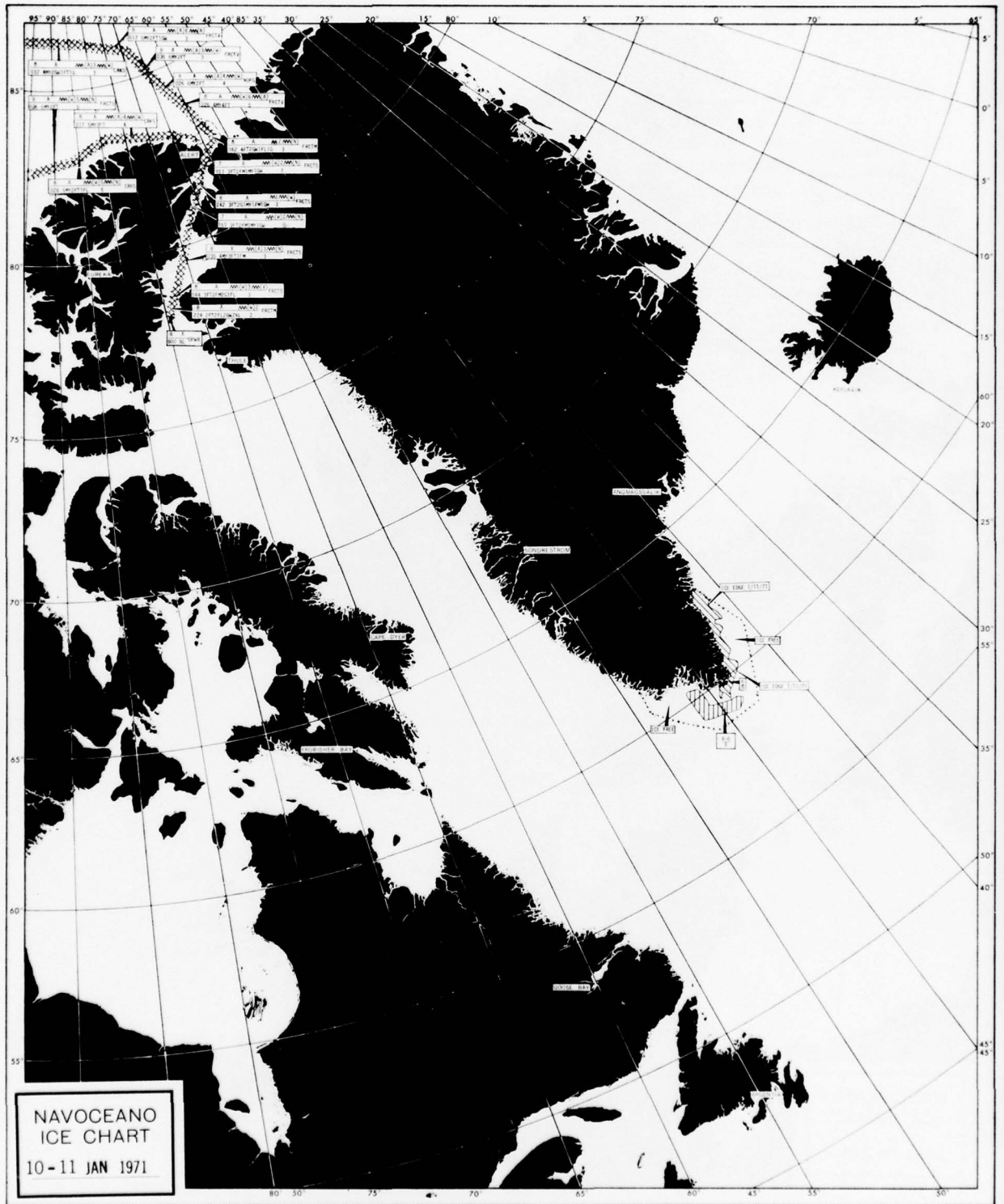
	crack
	fracture
	polynya
	lead
	△(n) icebergs
	△(n) bergy bits & growlers
(n) = number in area	

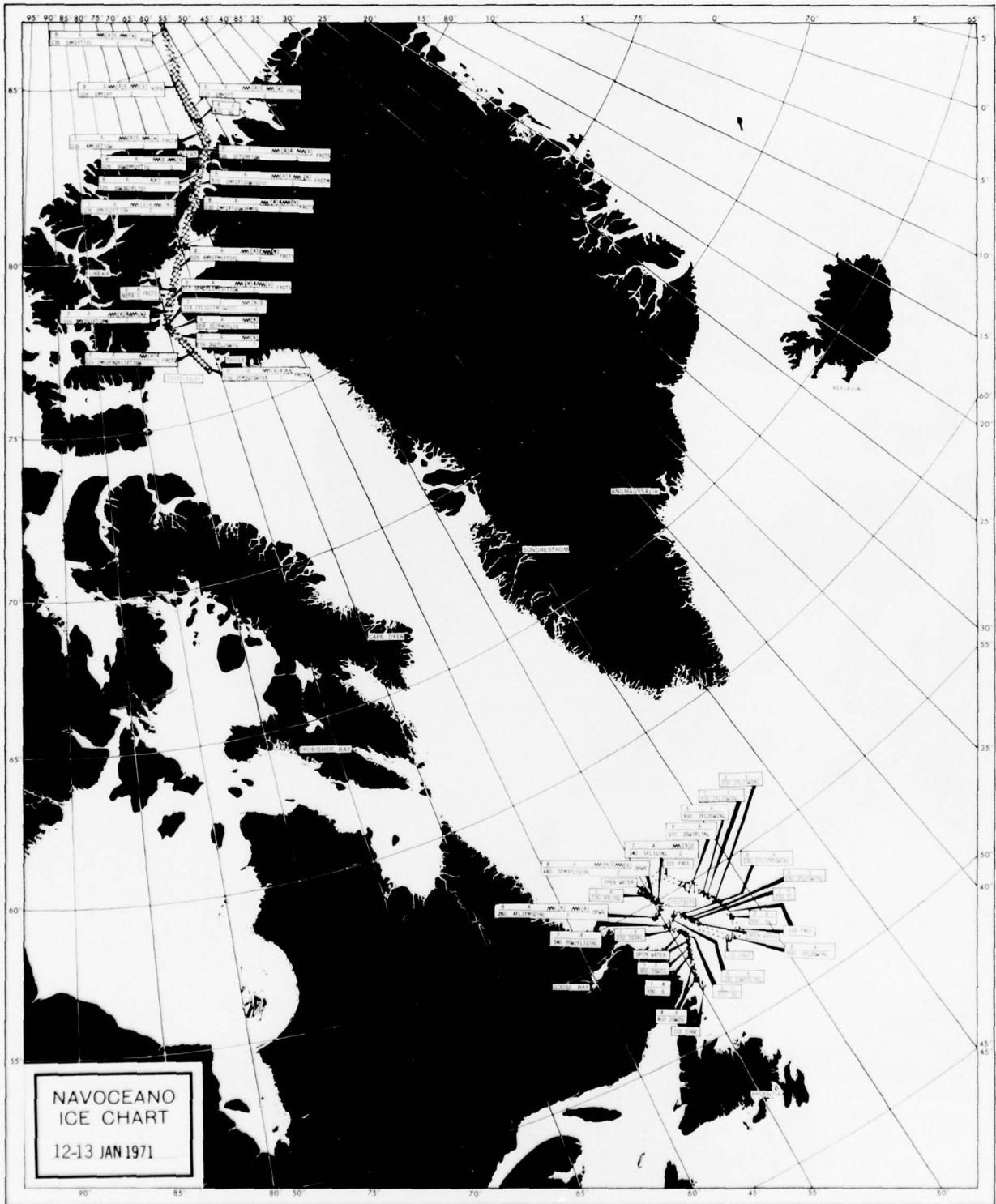
ICE EDGE

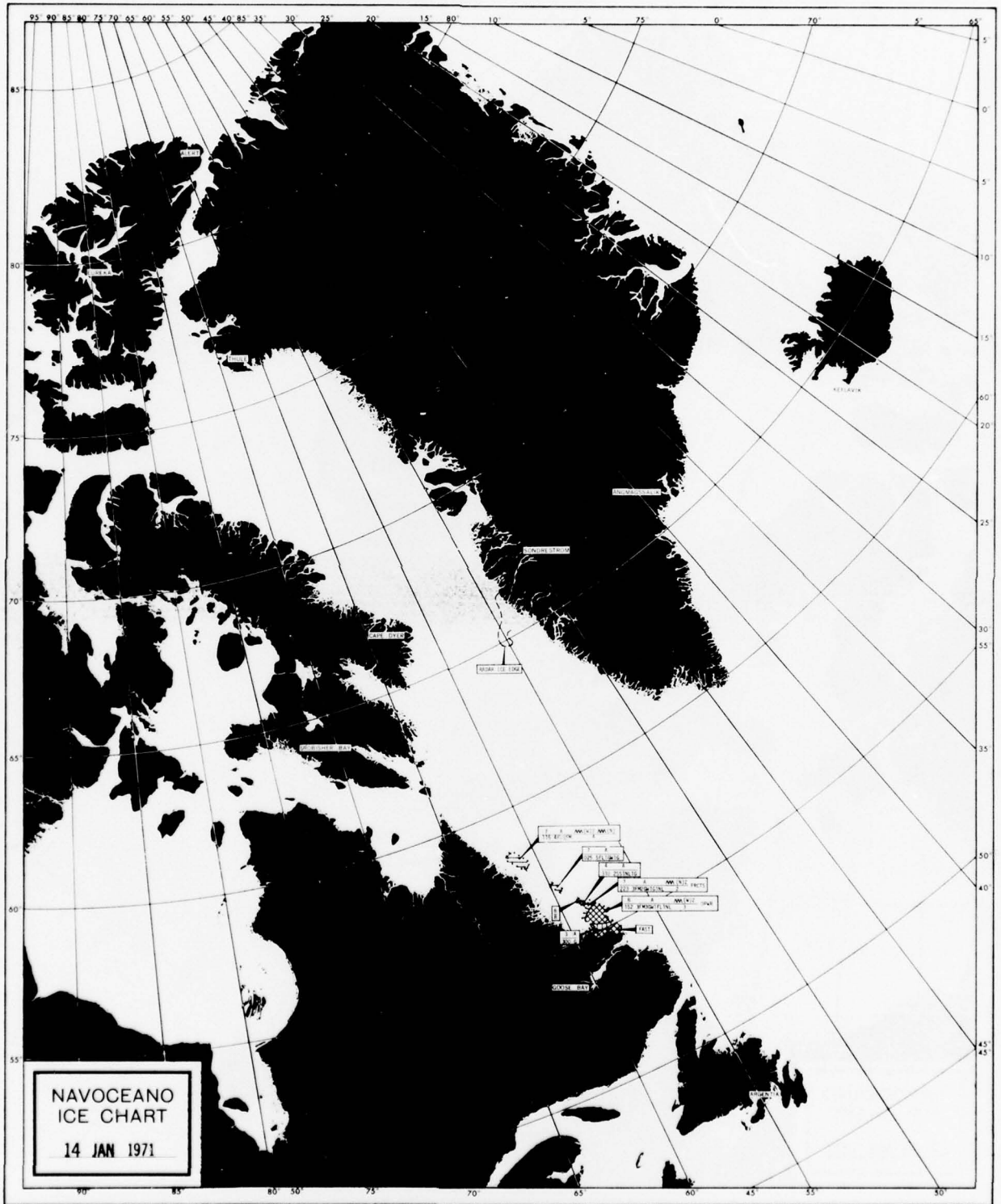
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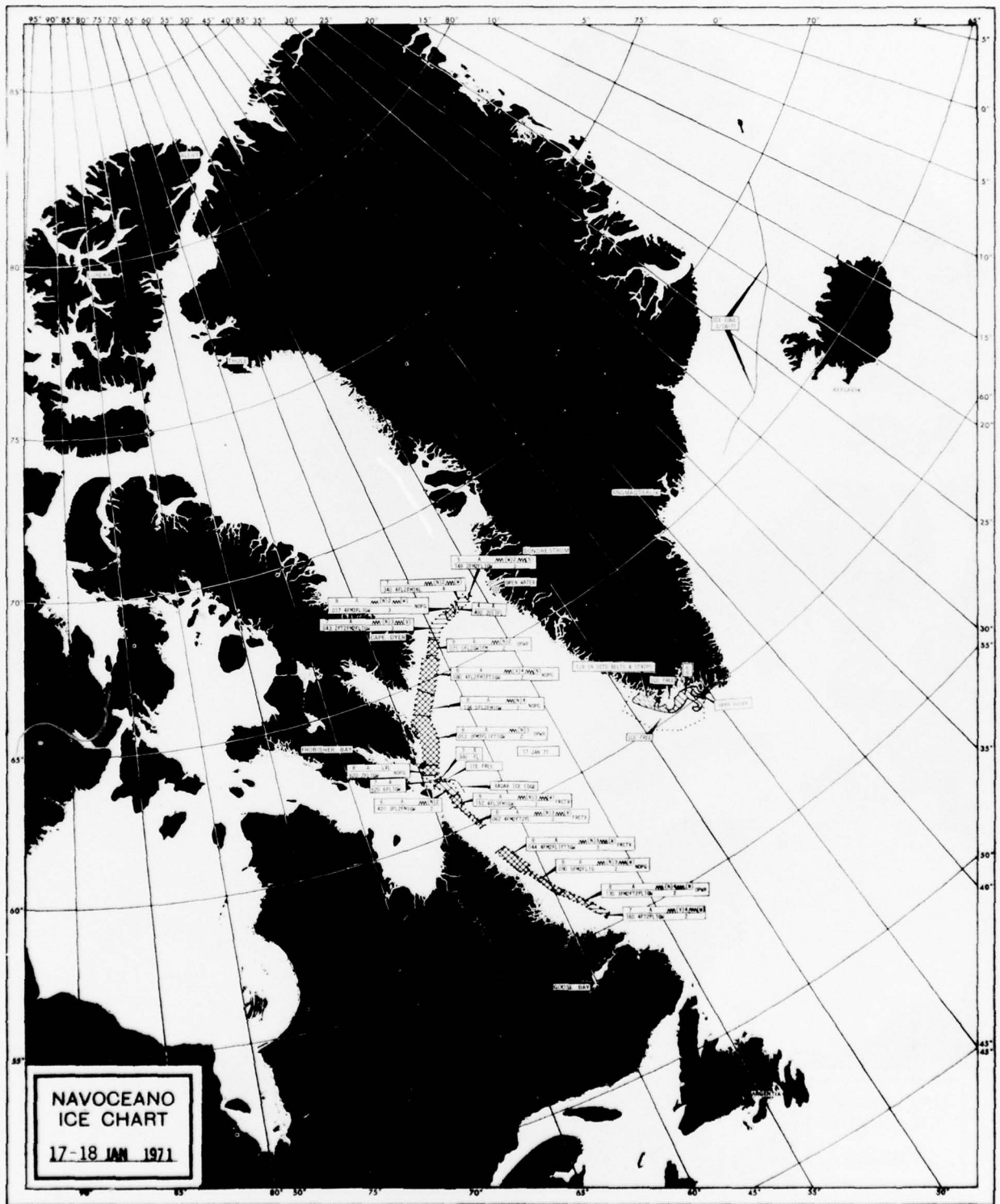


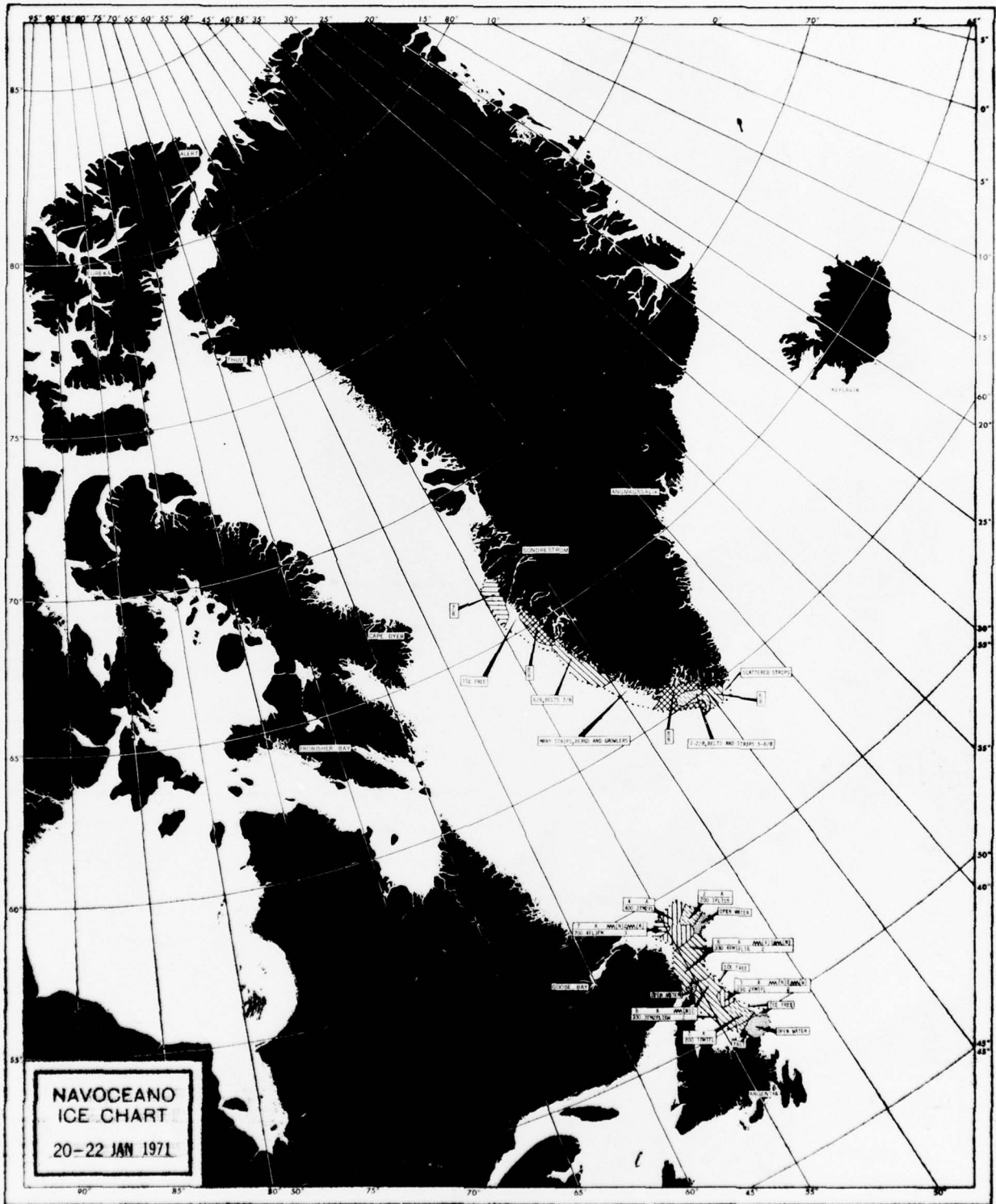


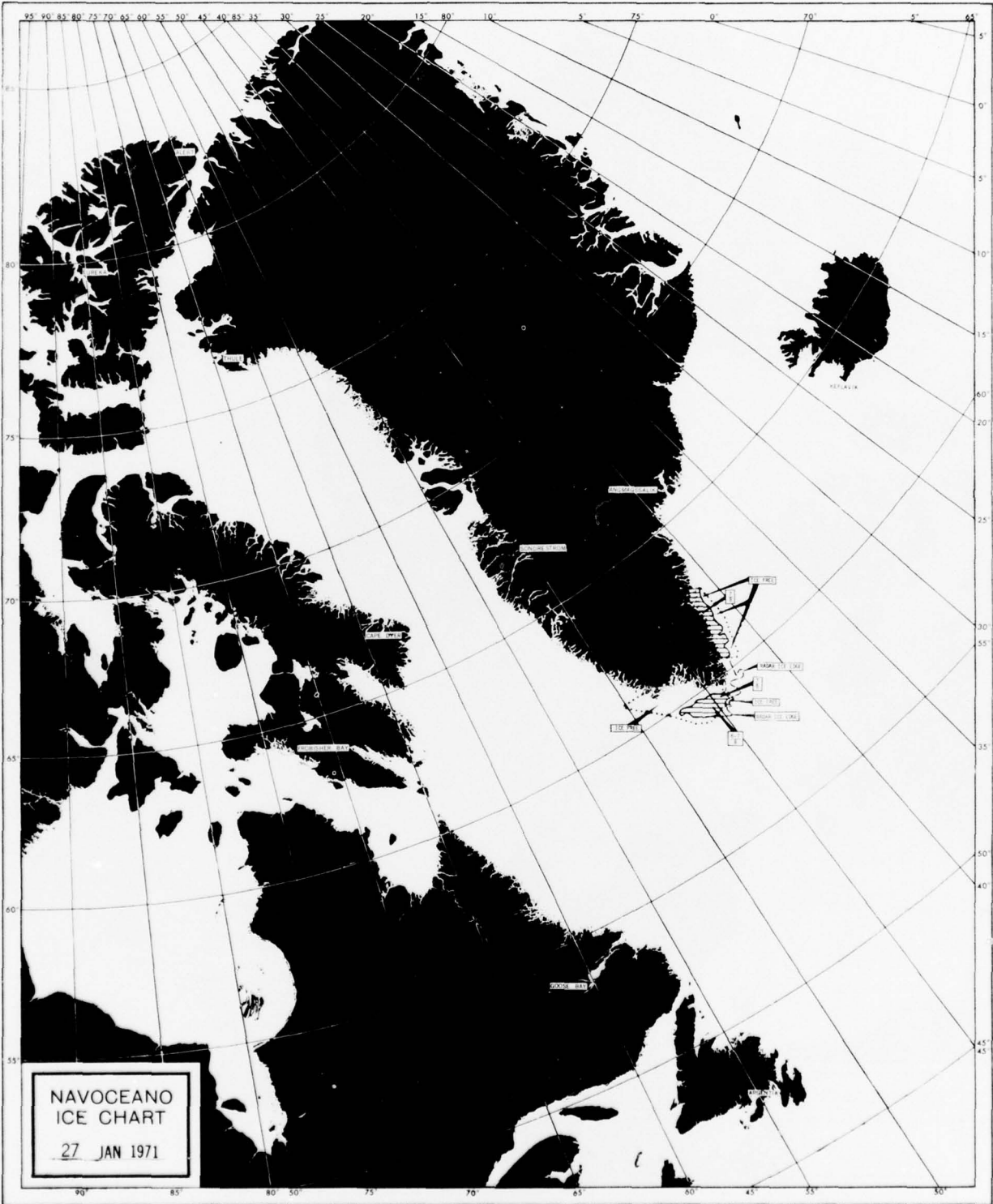


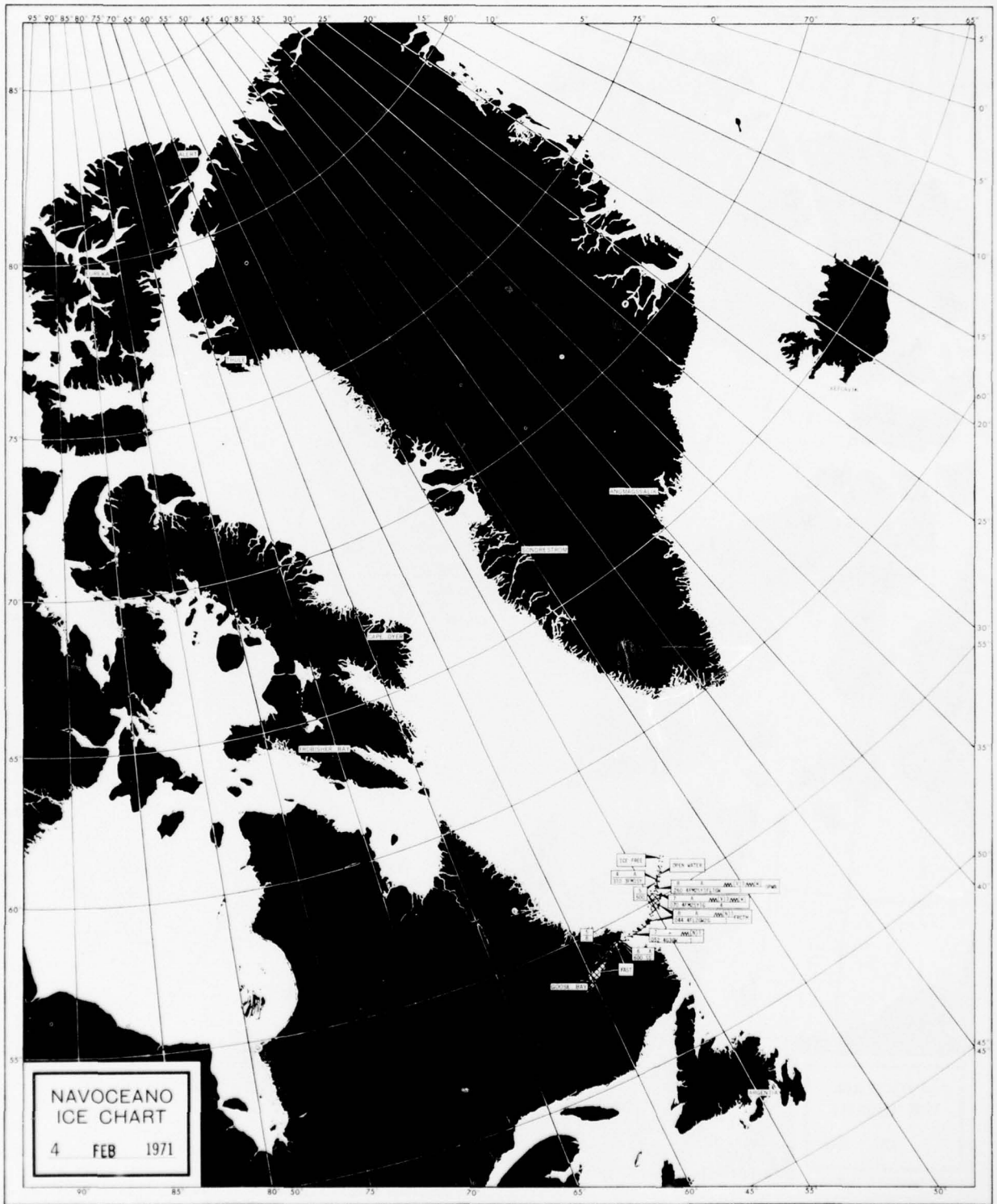


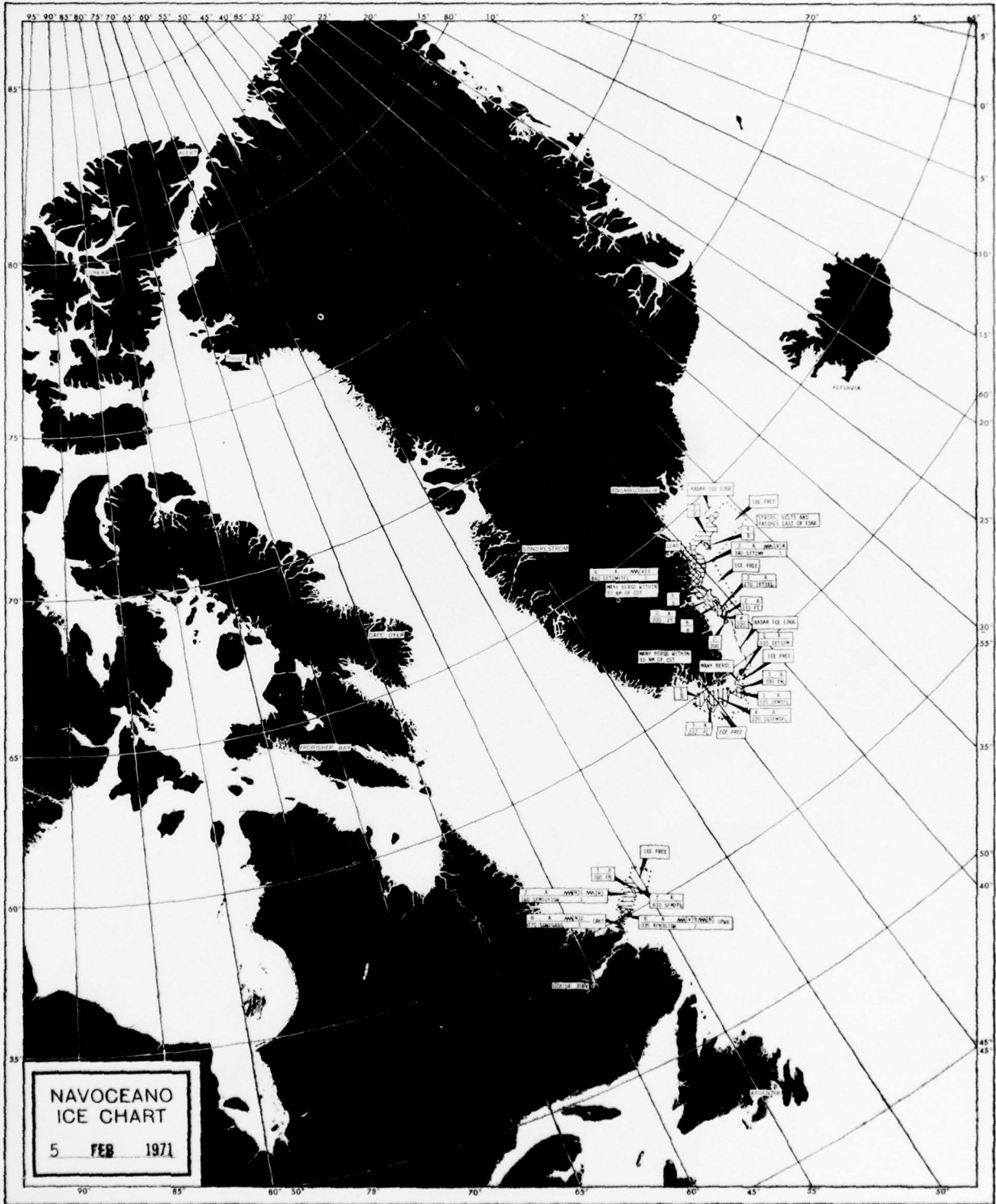


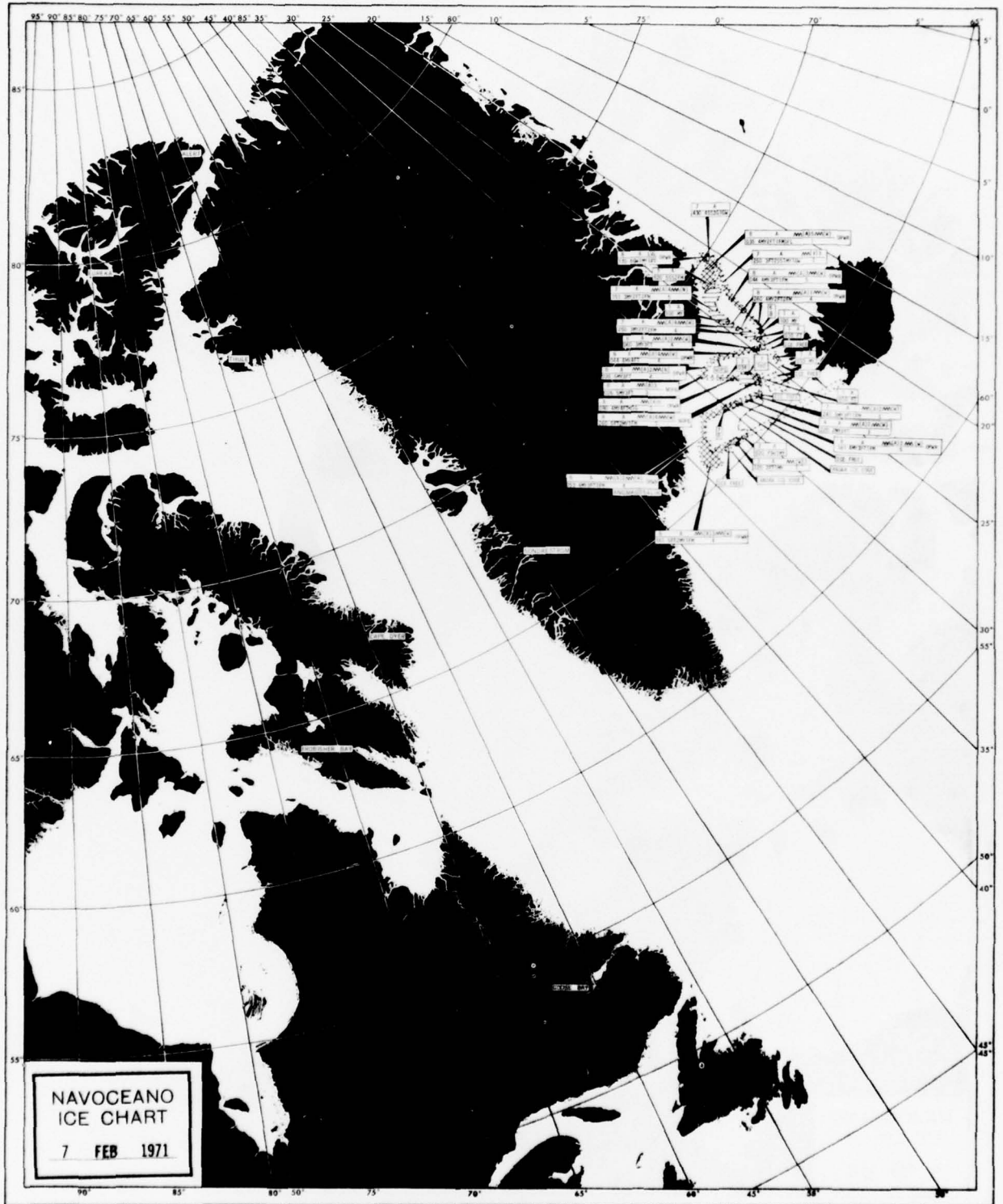


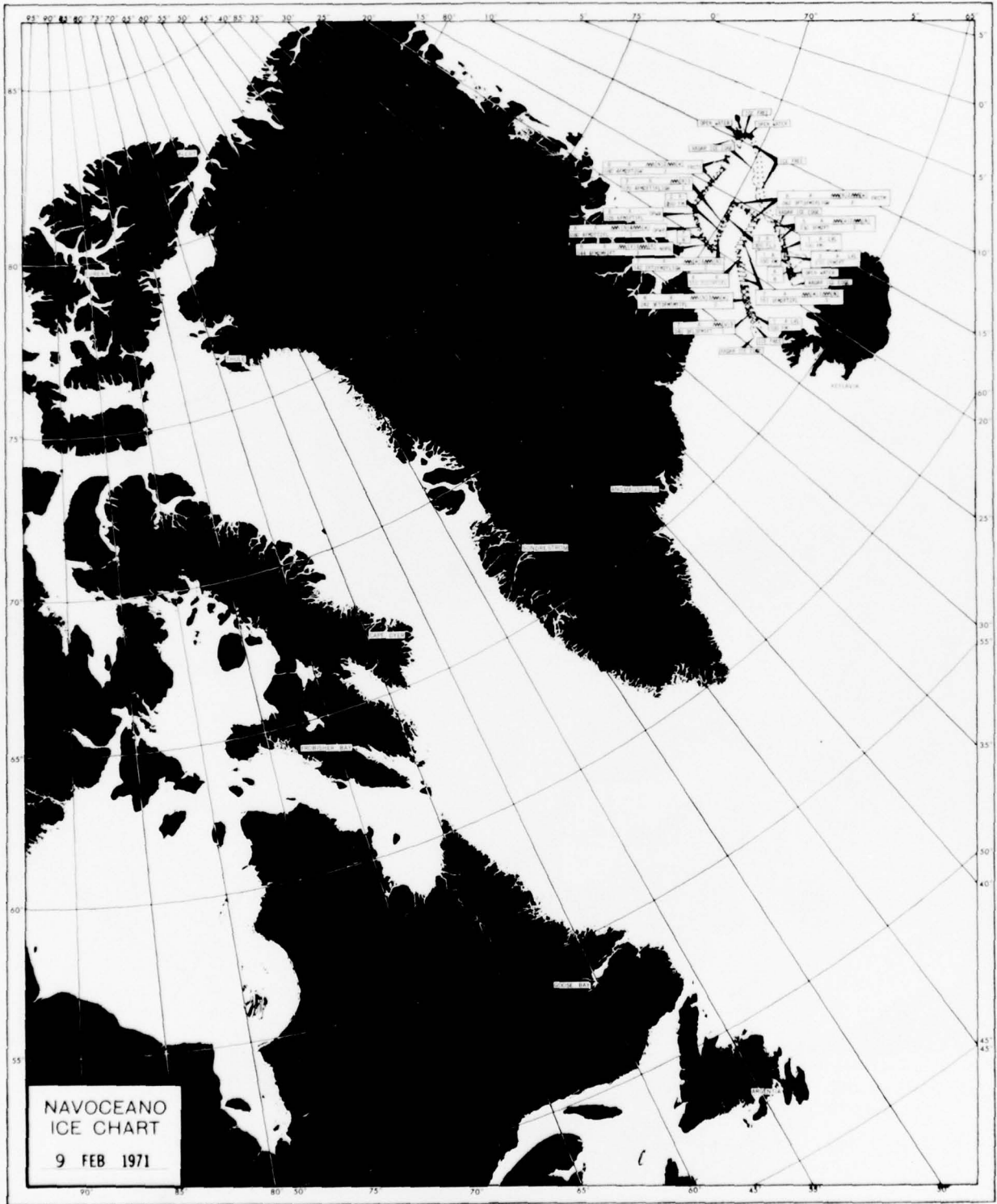


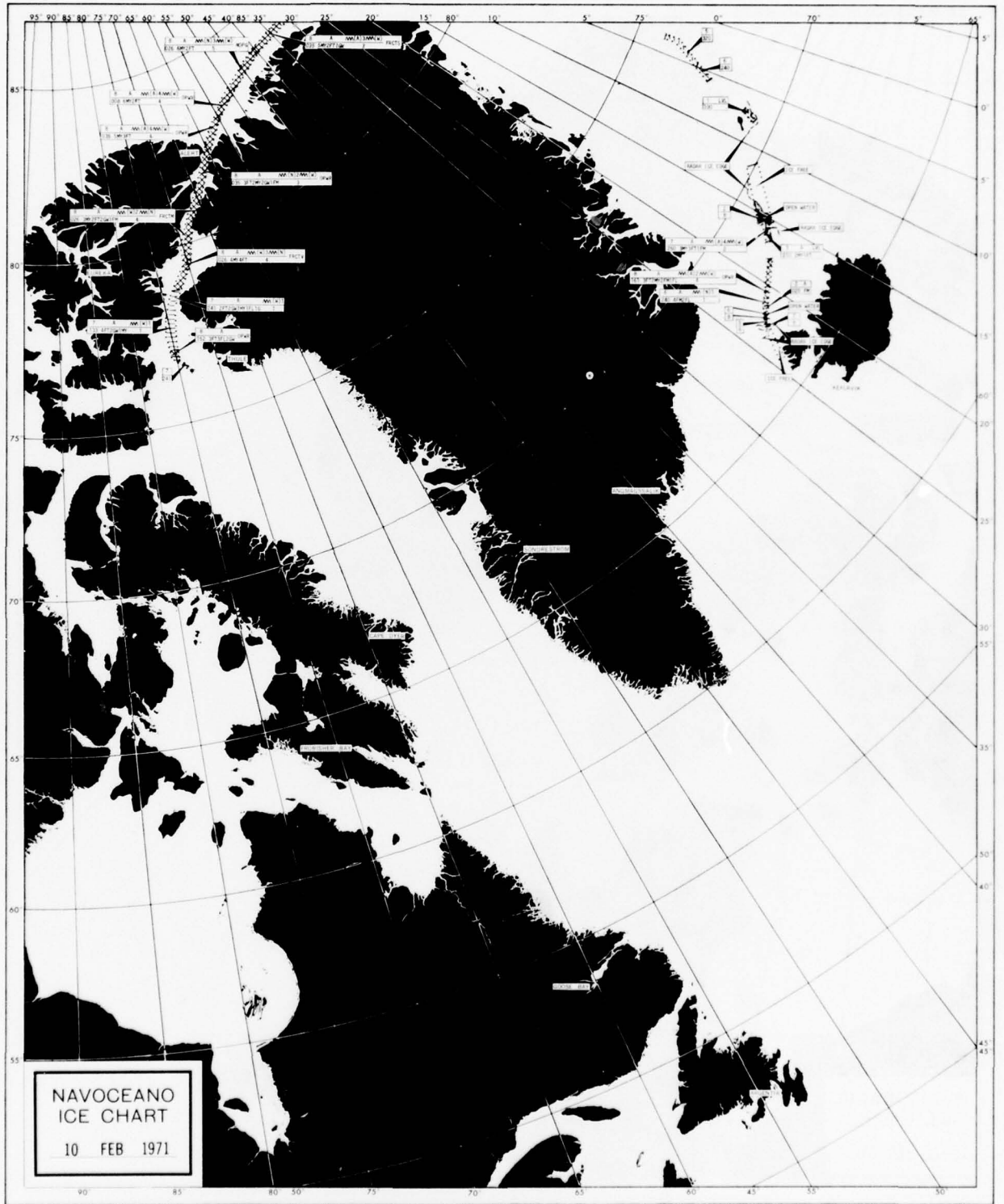


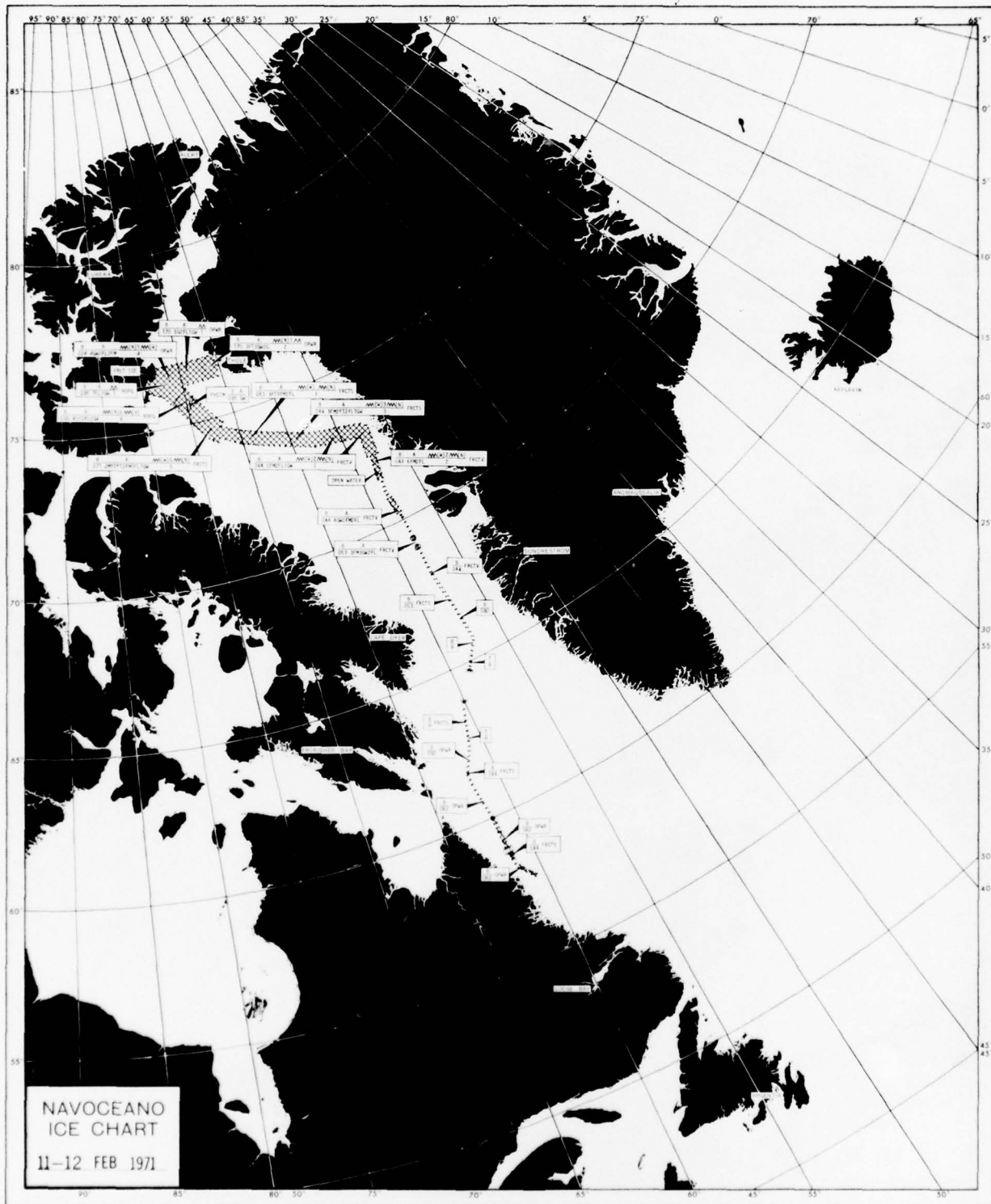


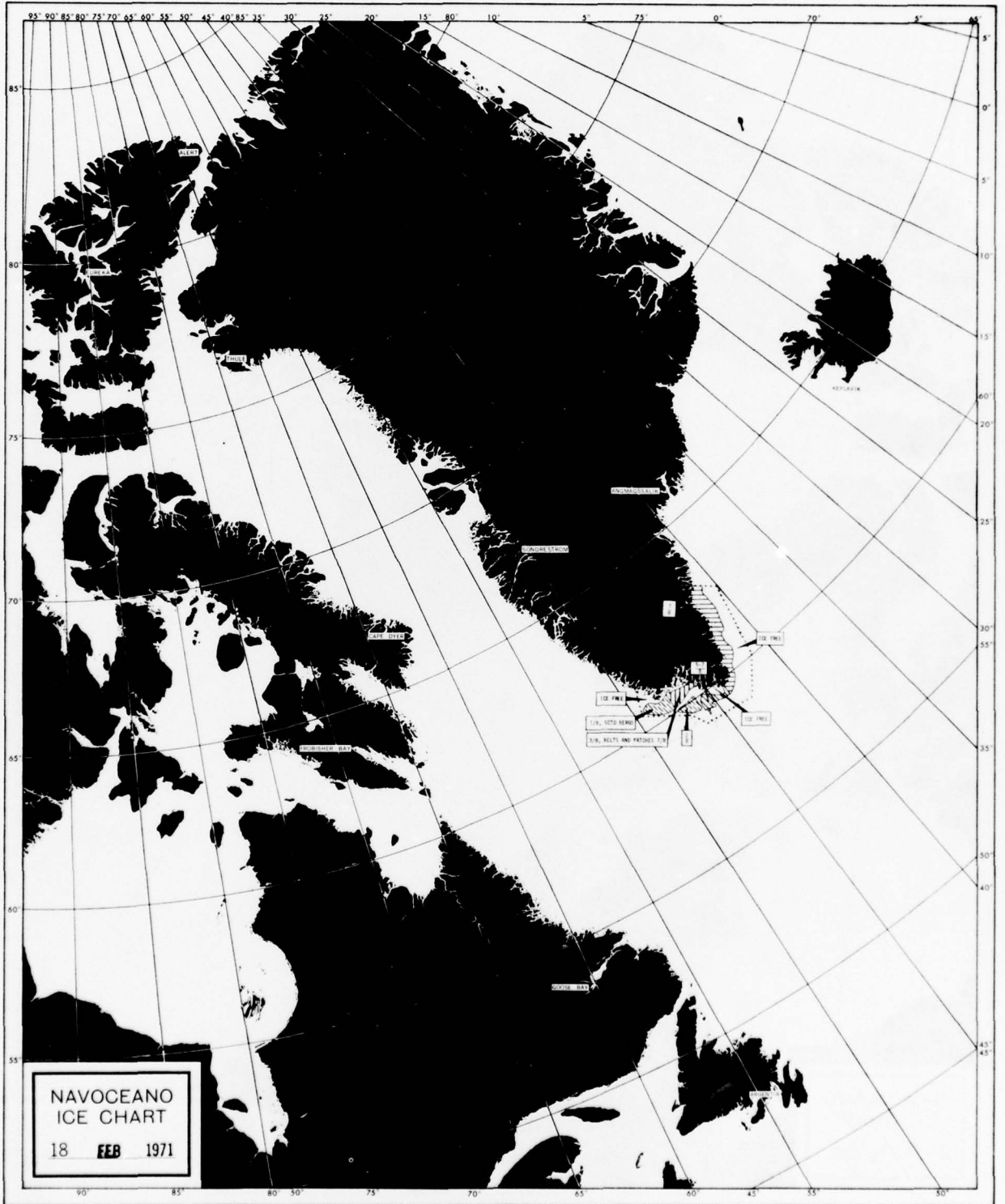


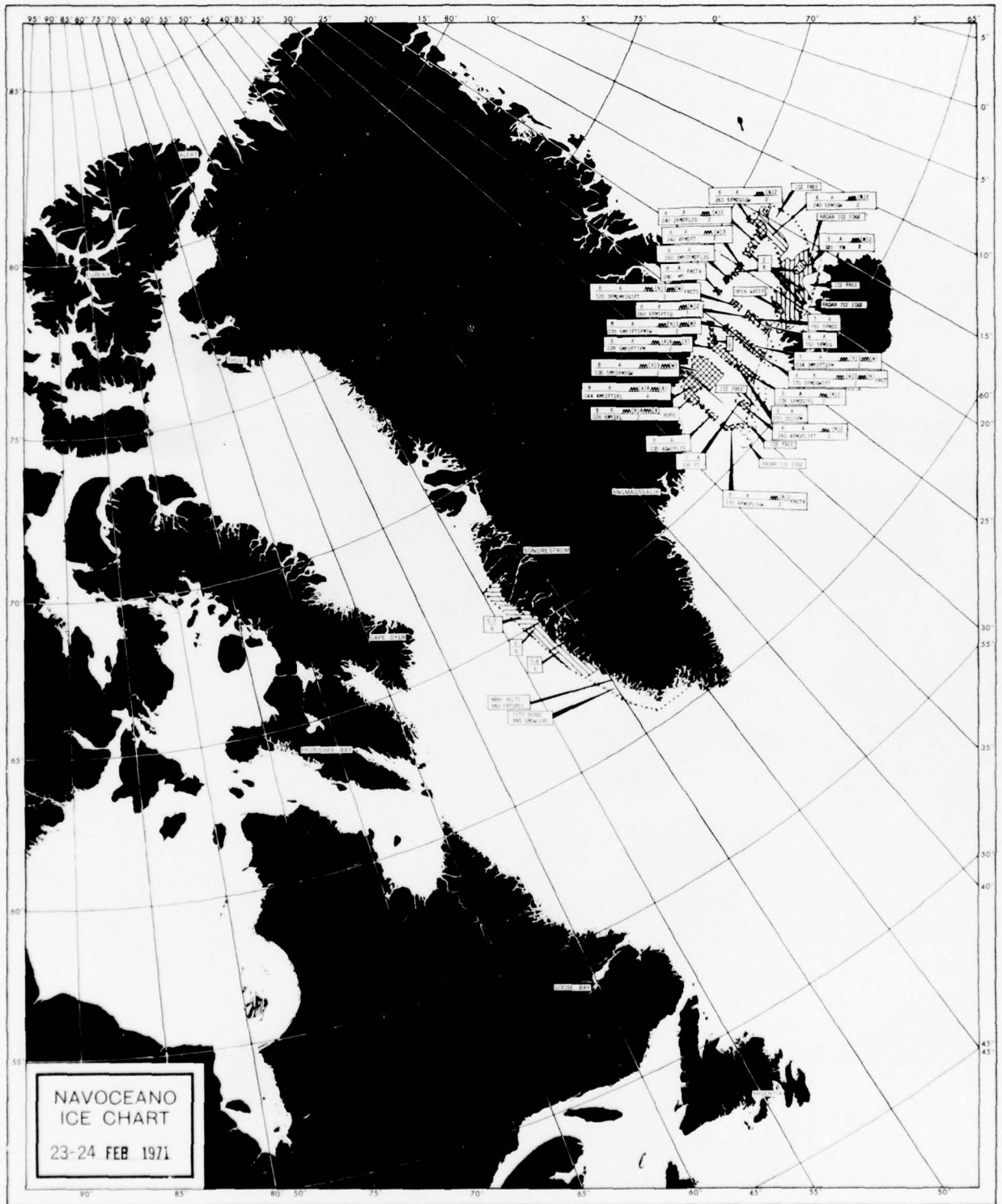


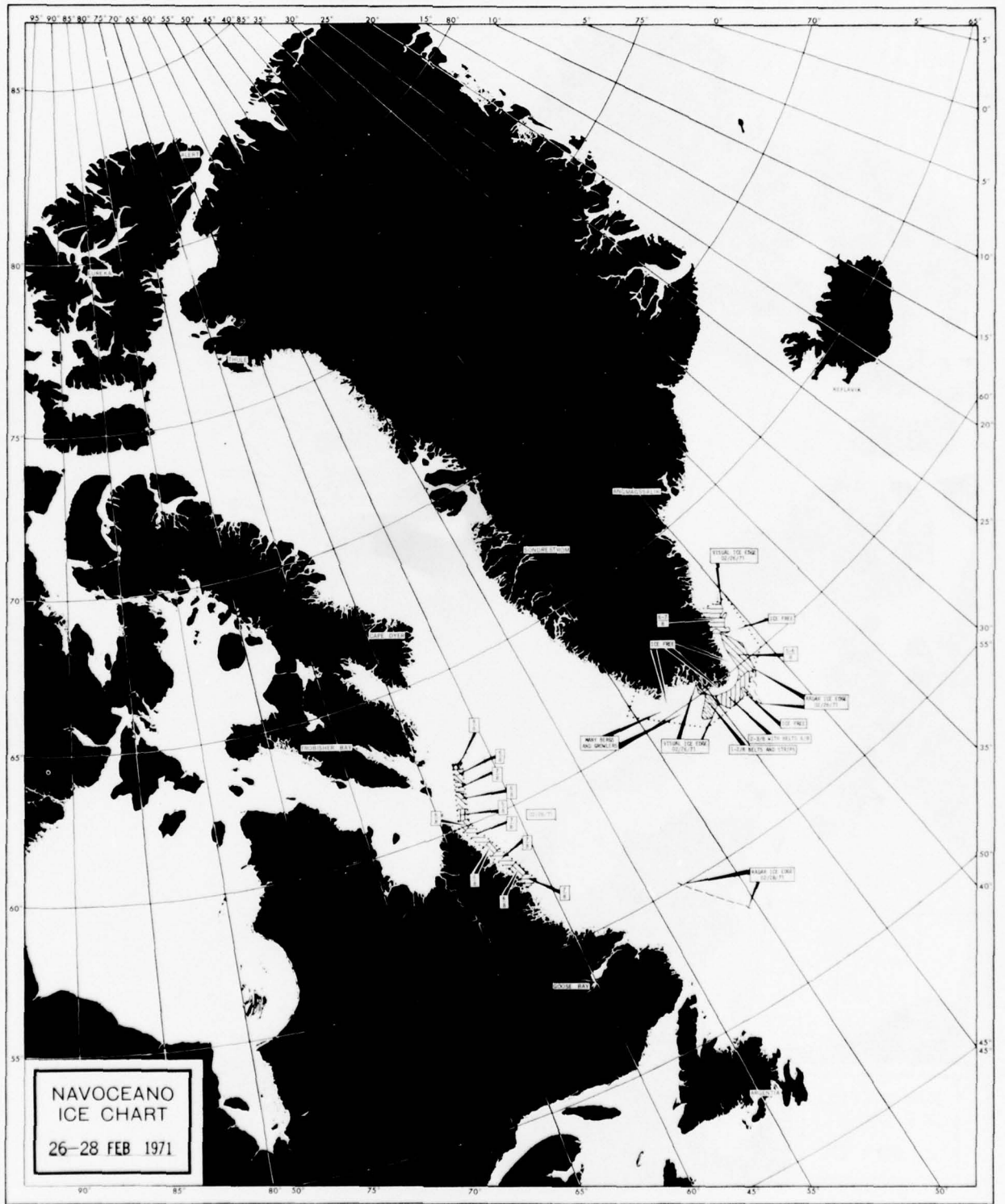


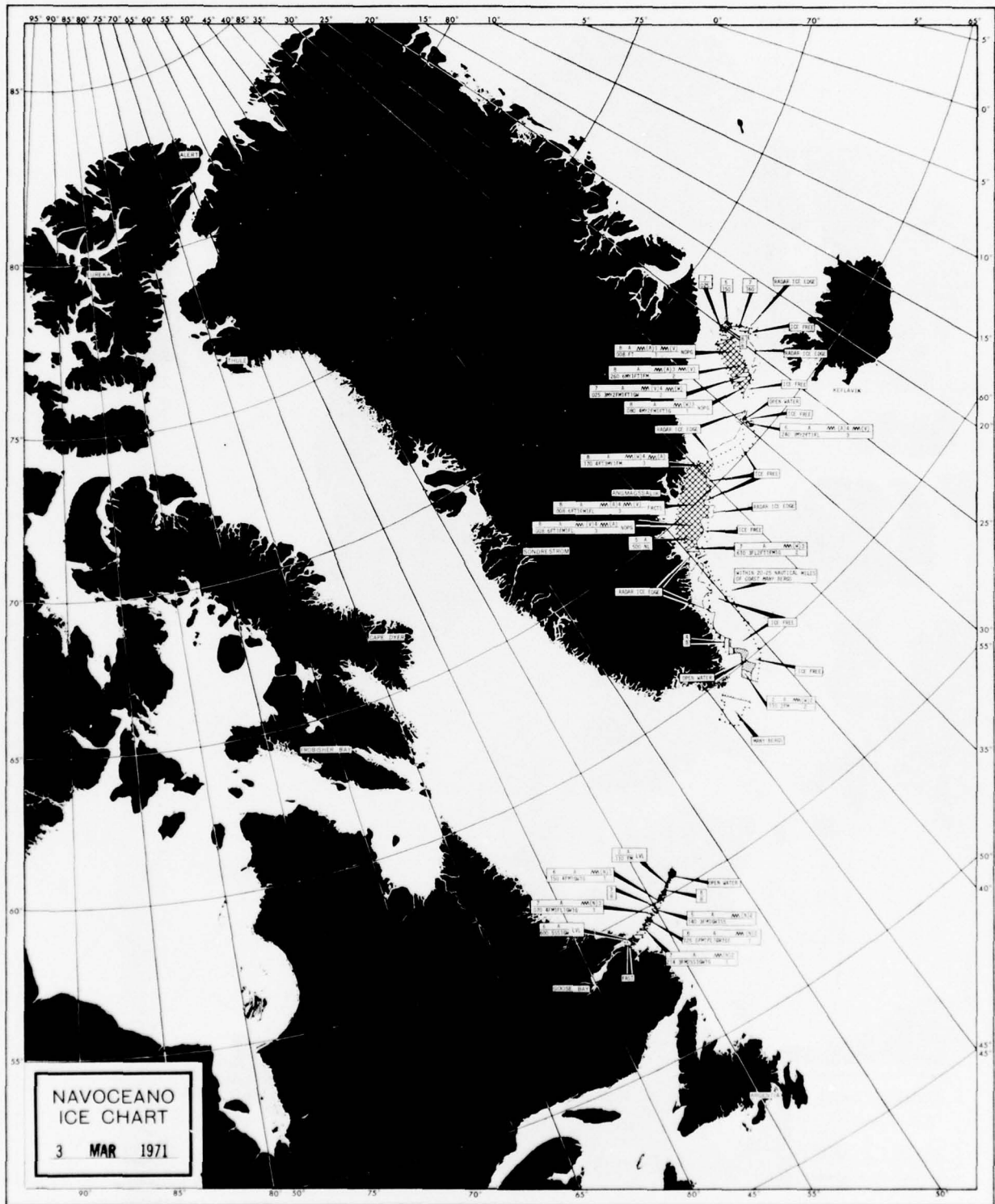


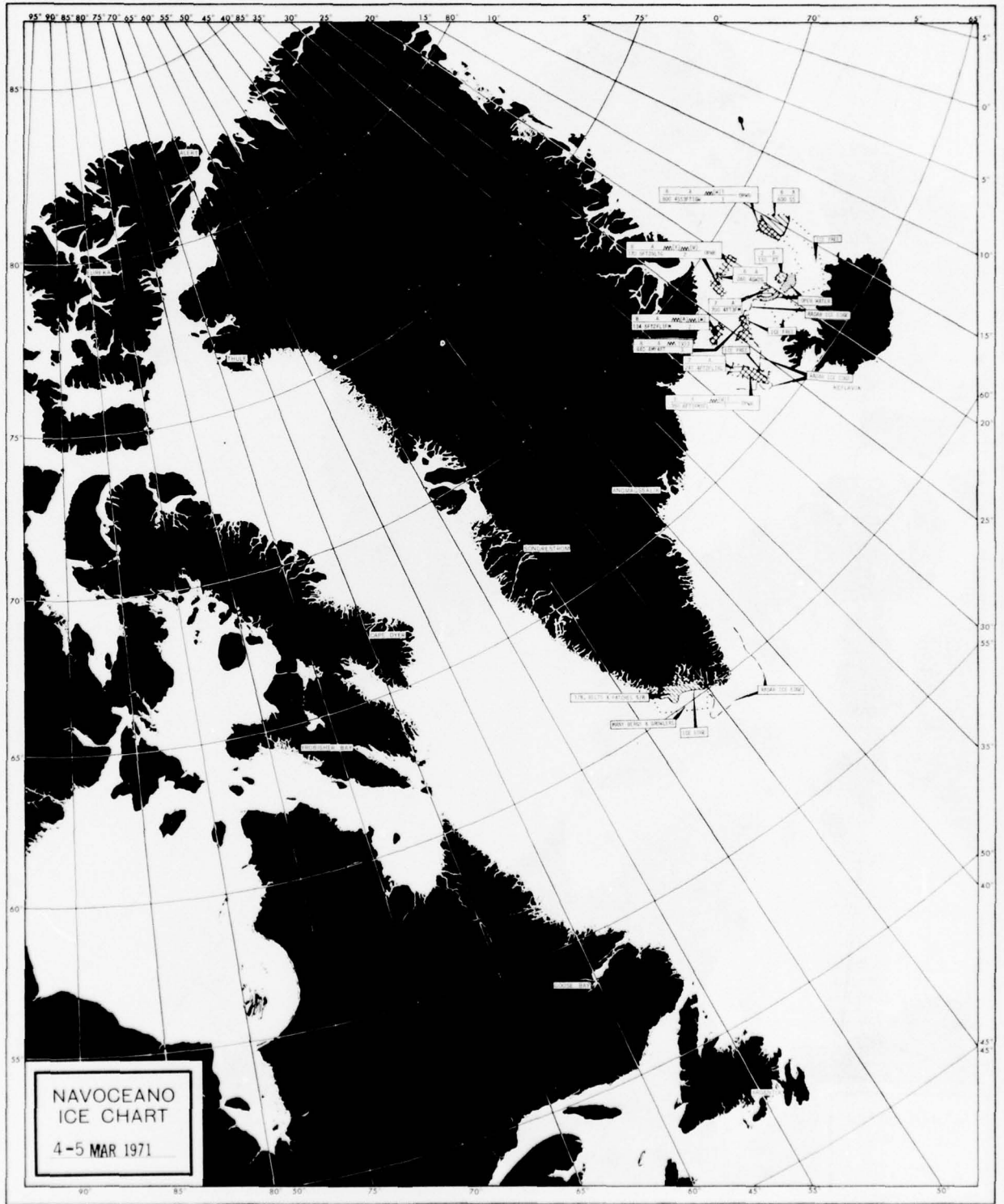


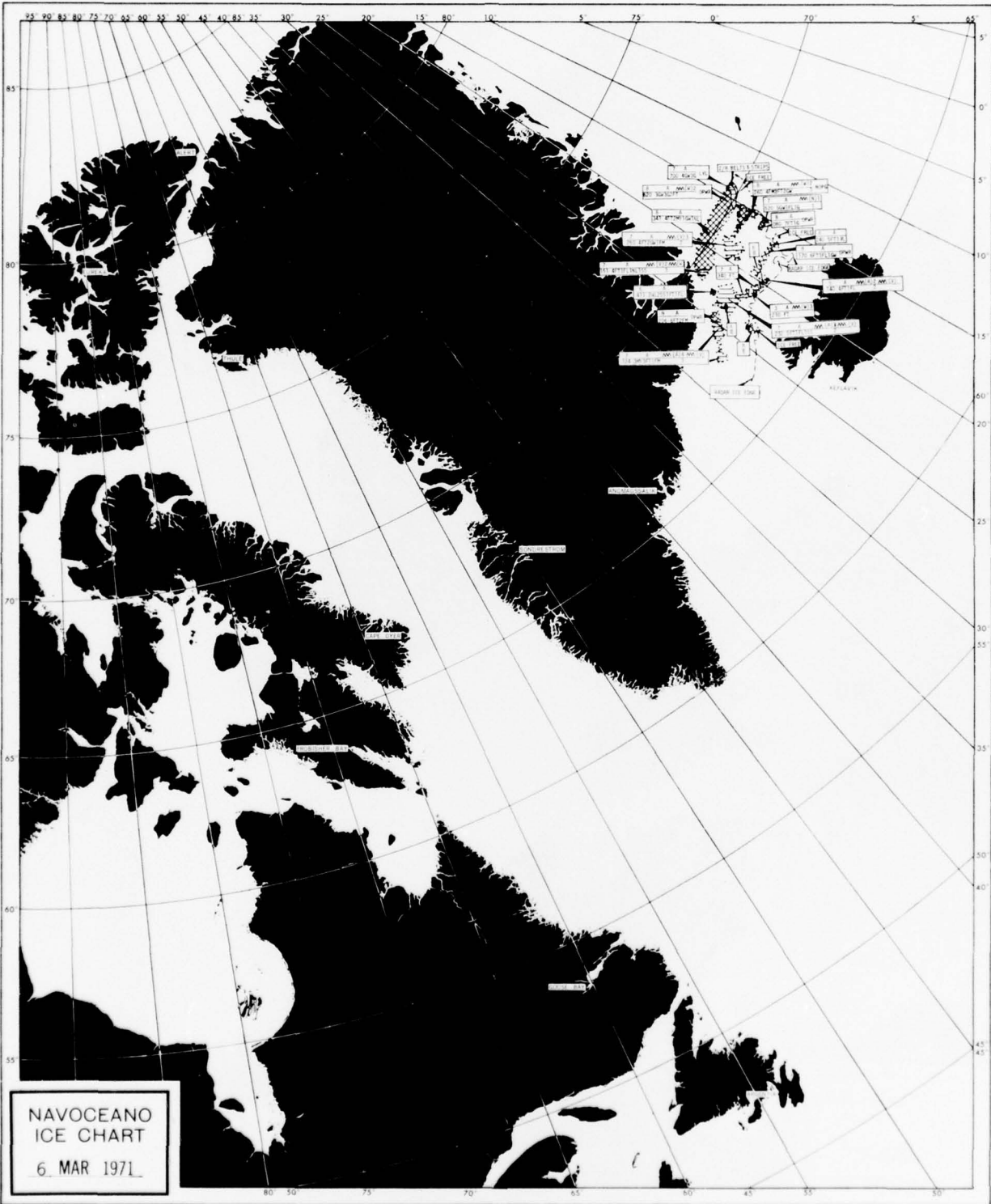


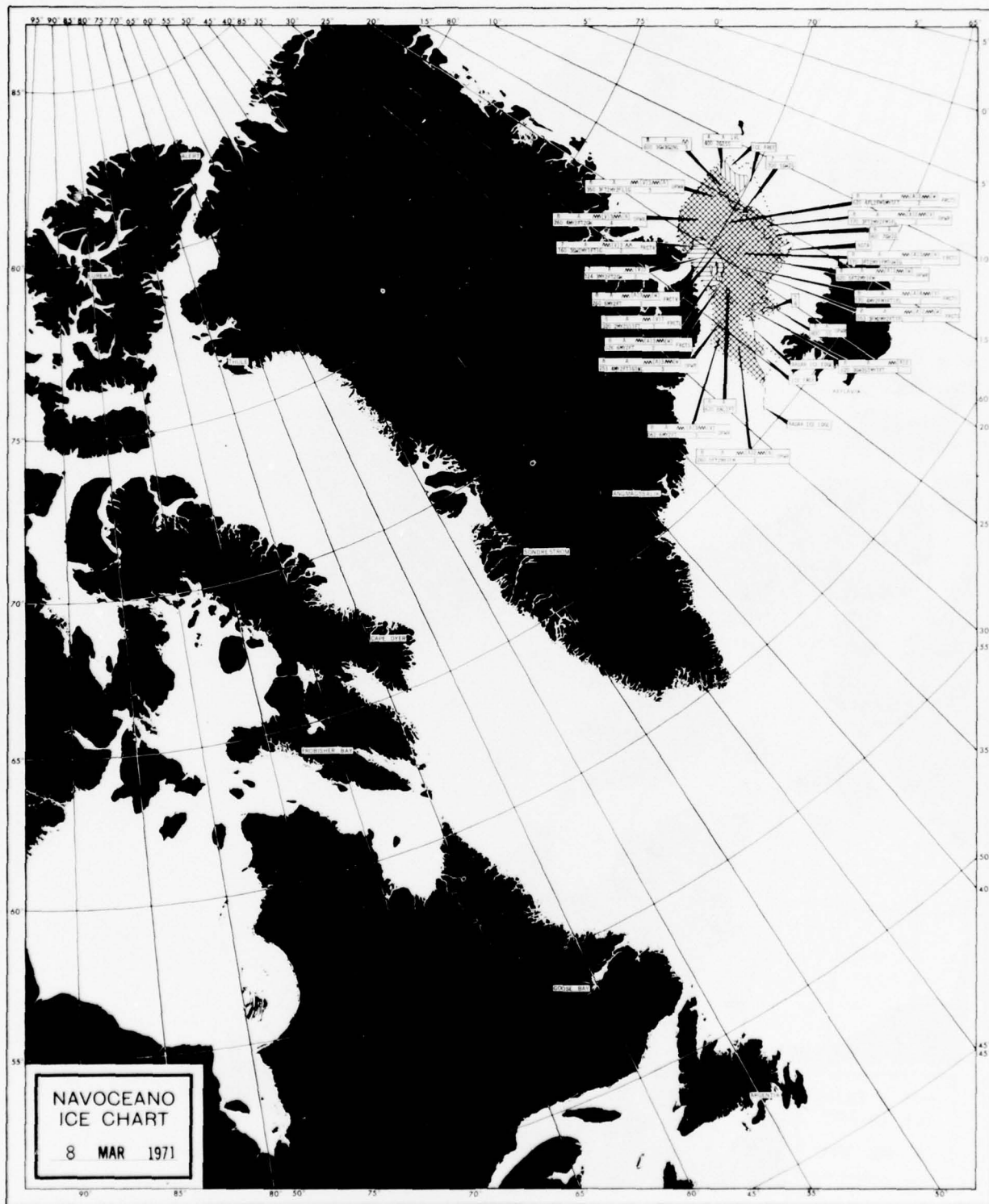


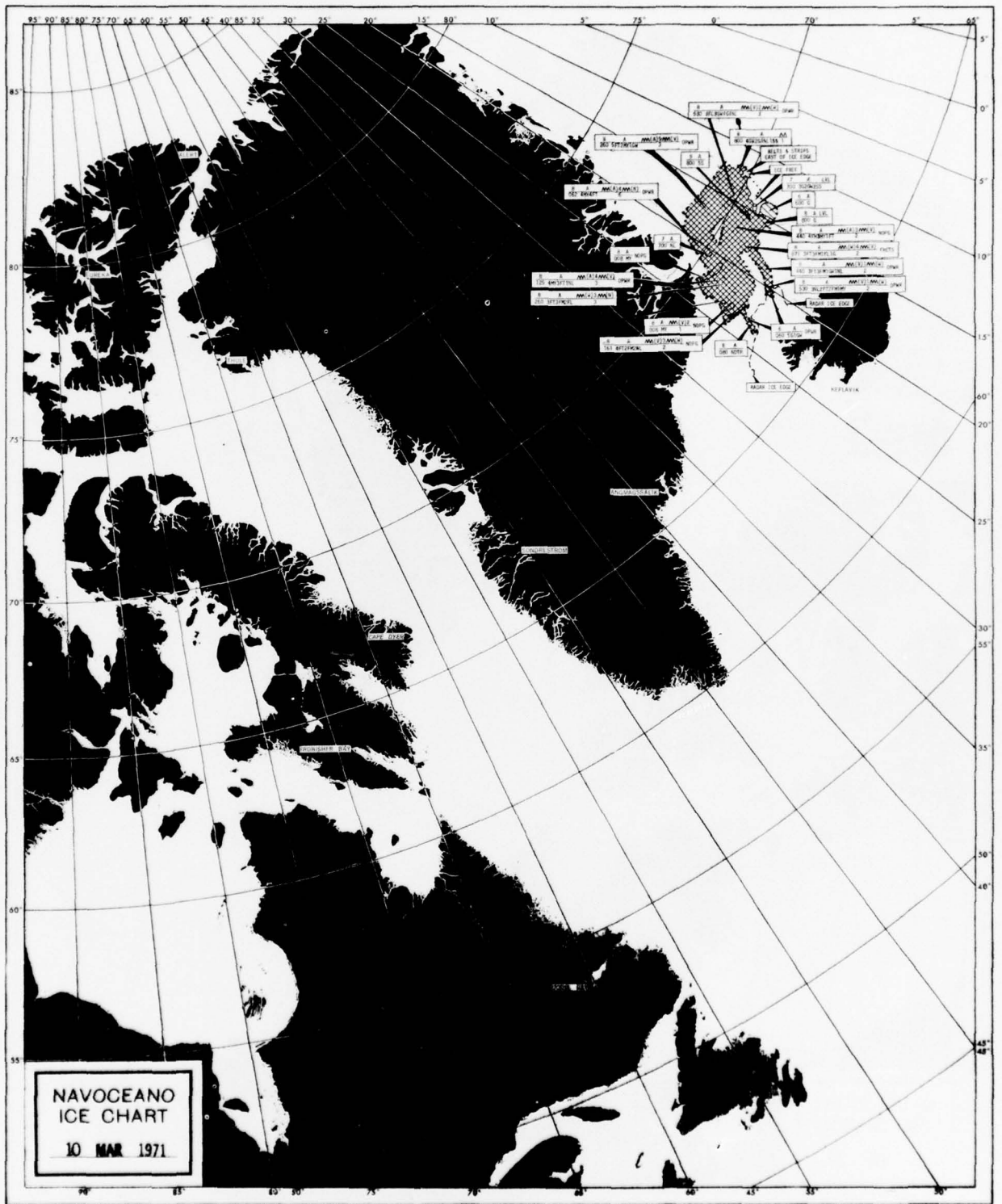


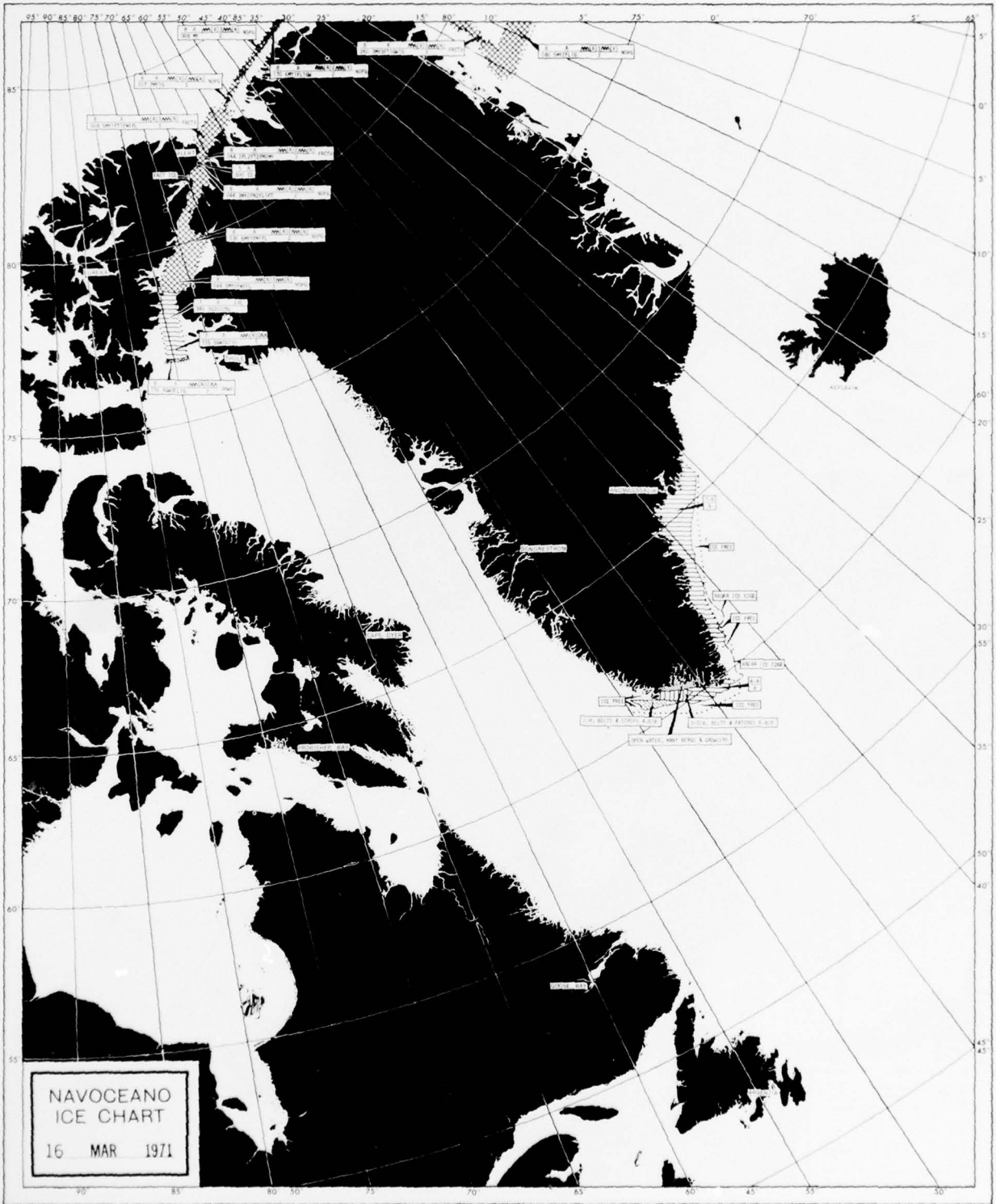


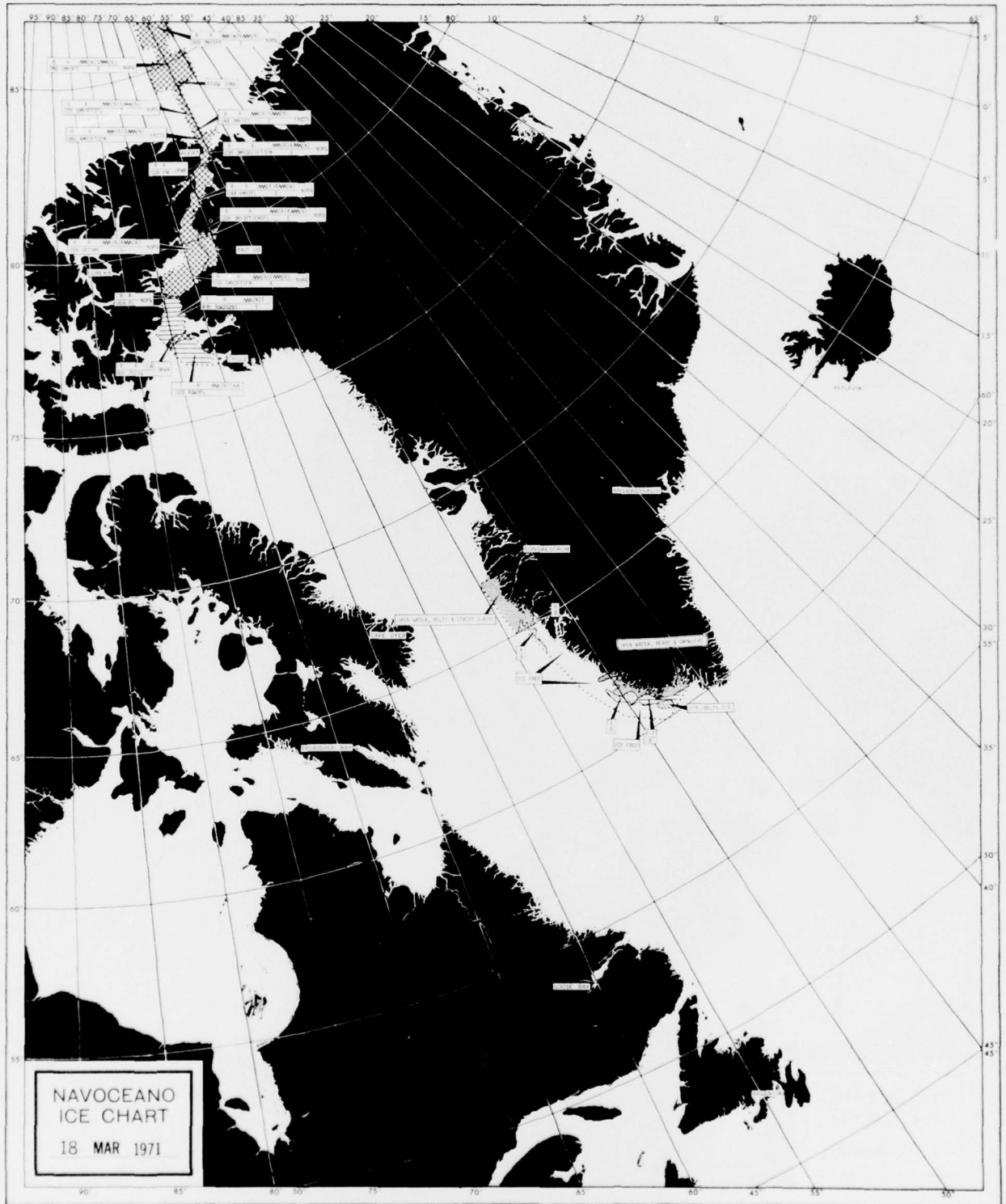


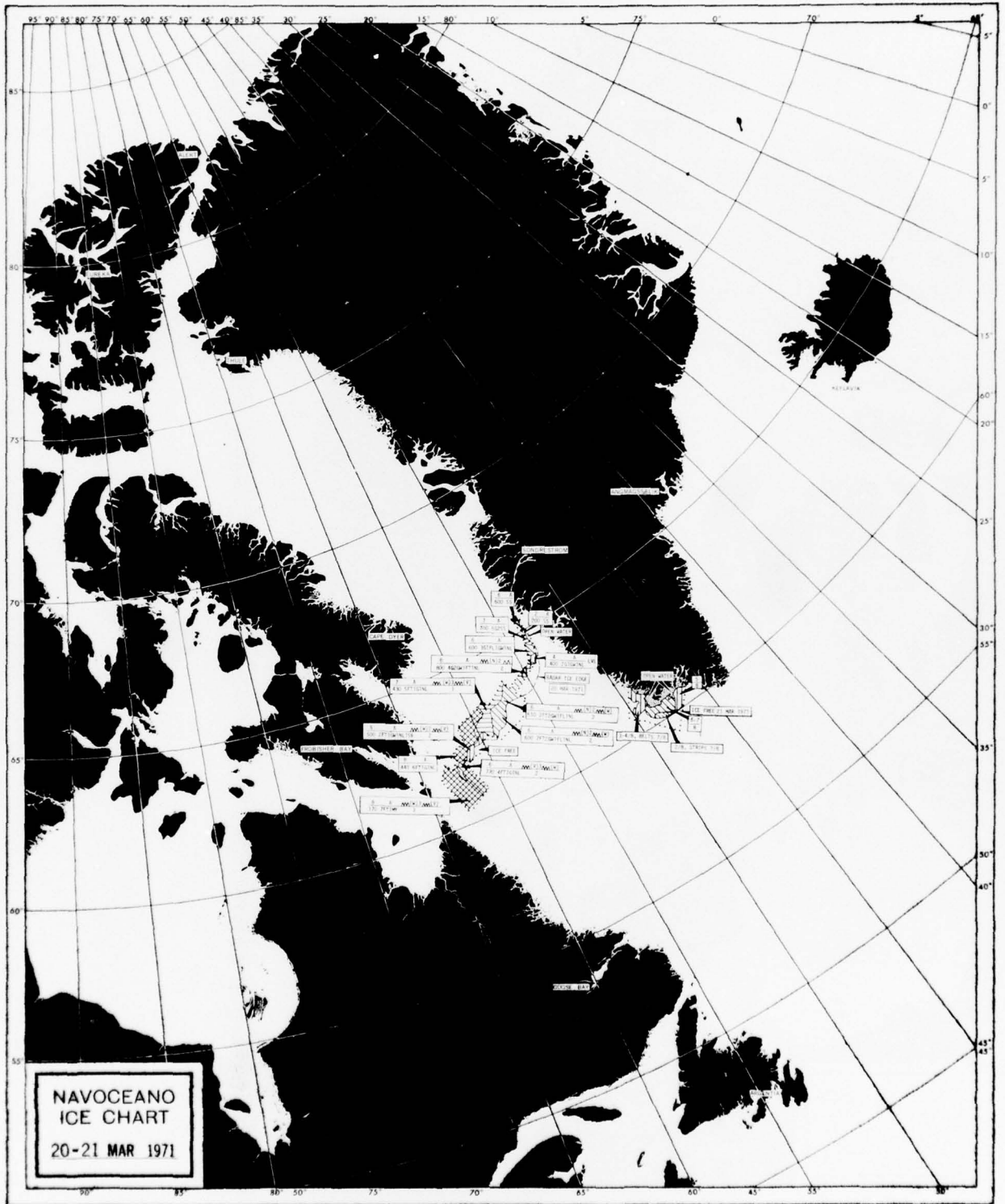


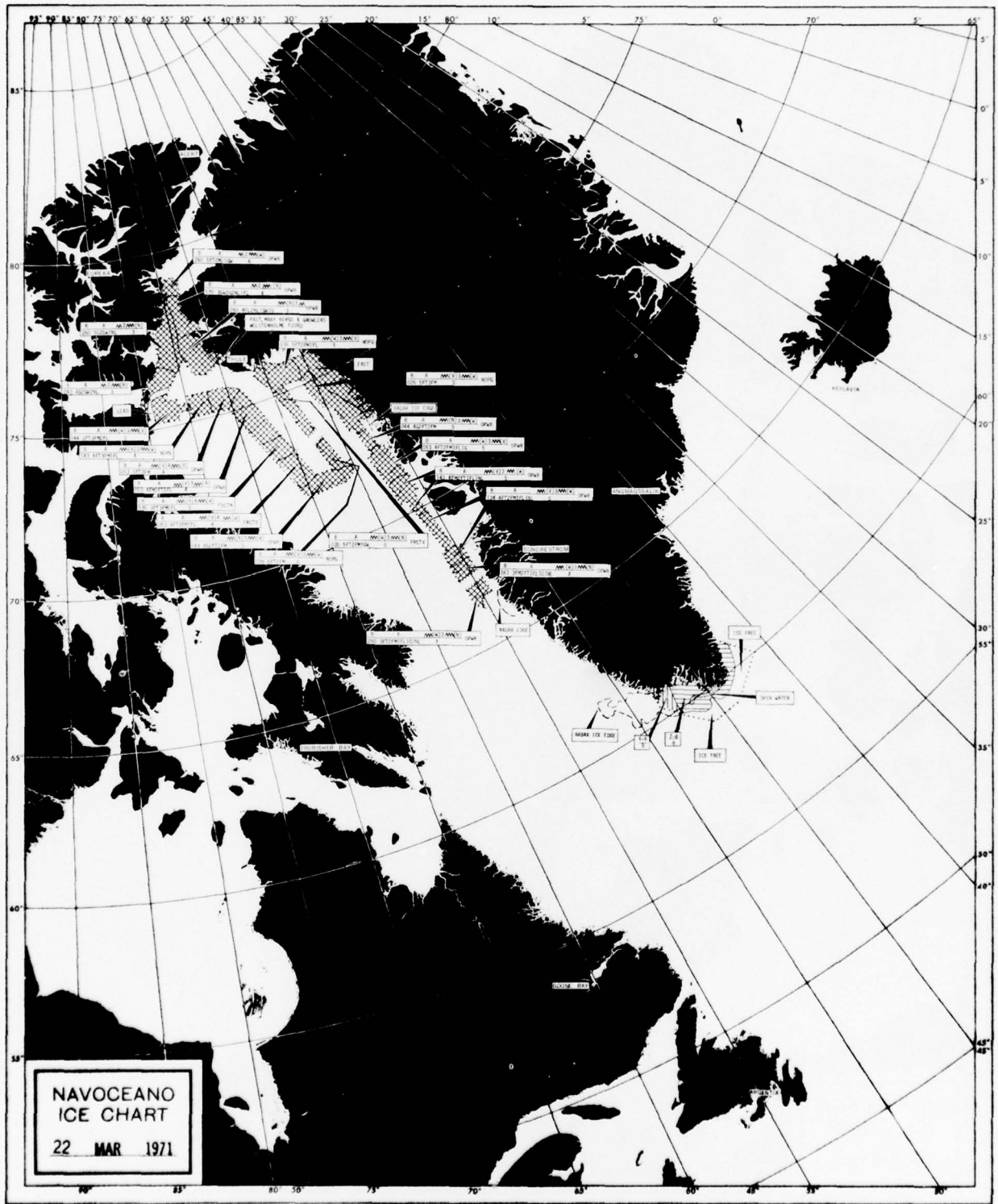


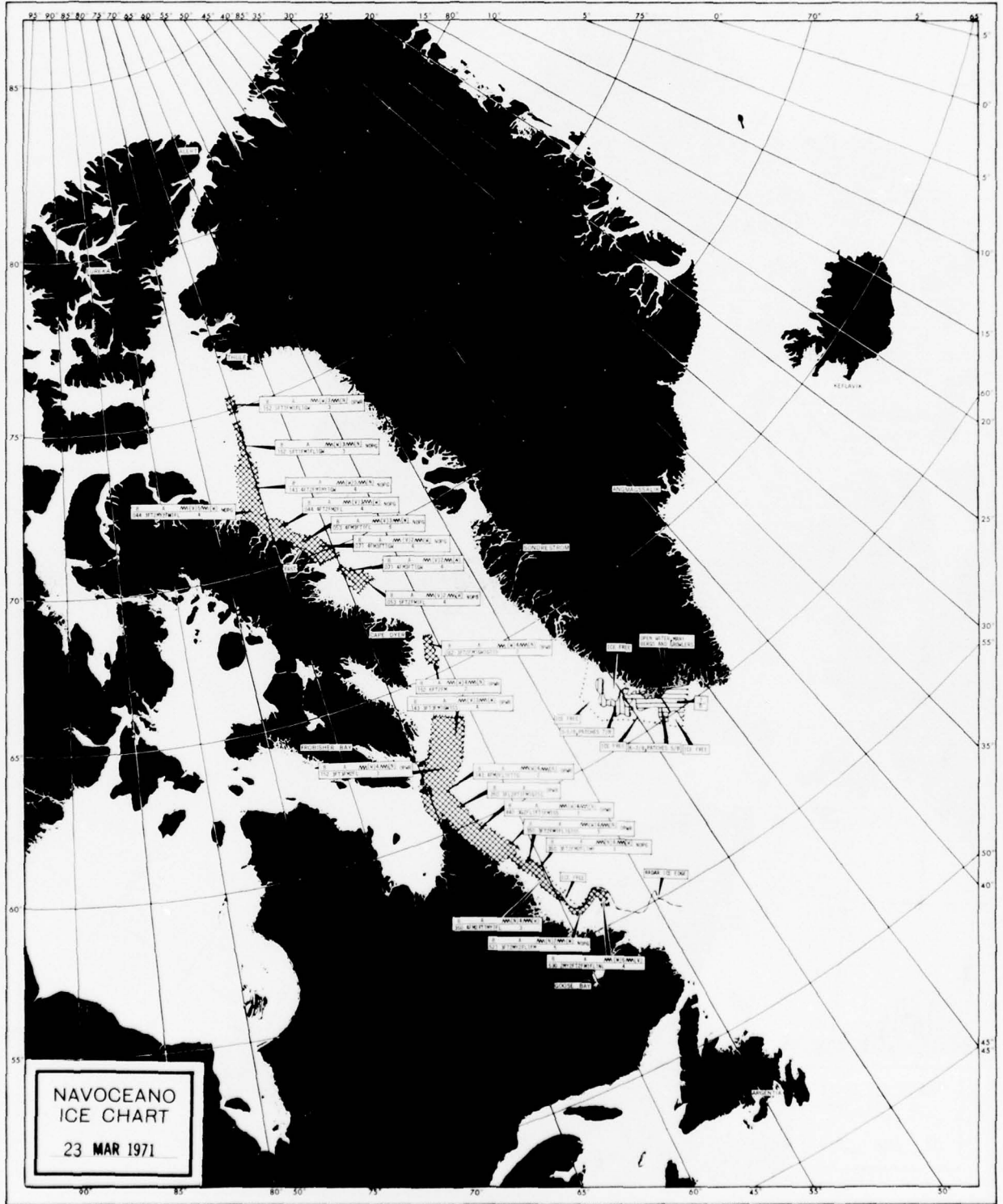


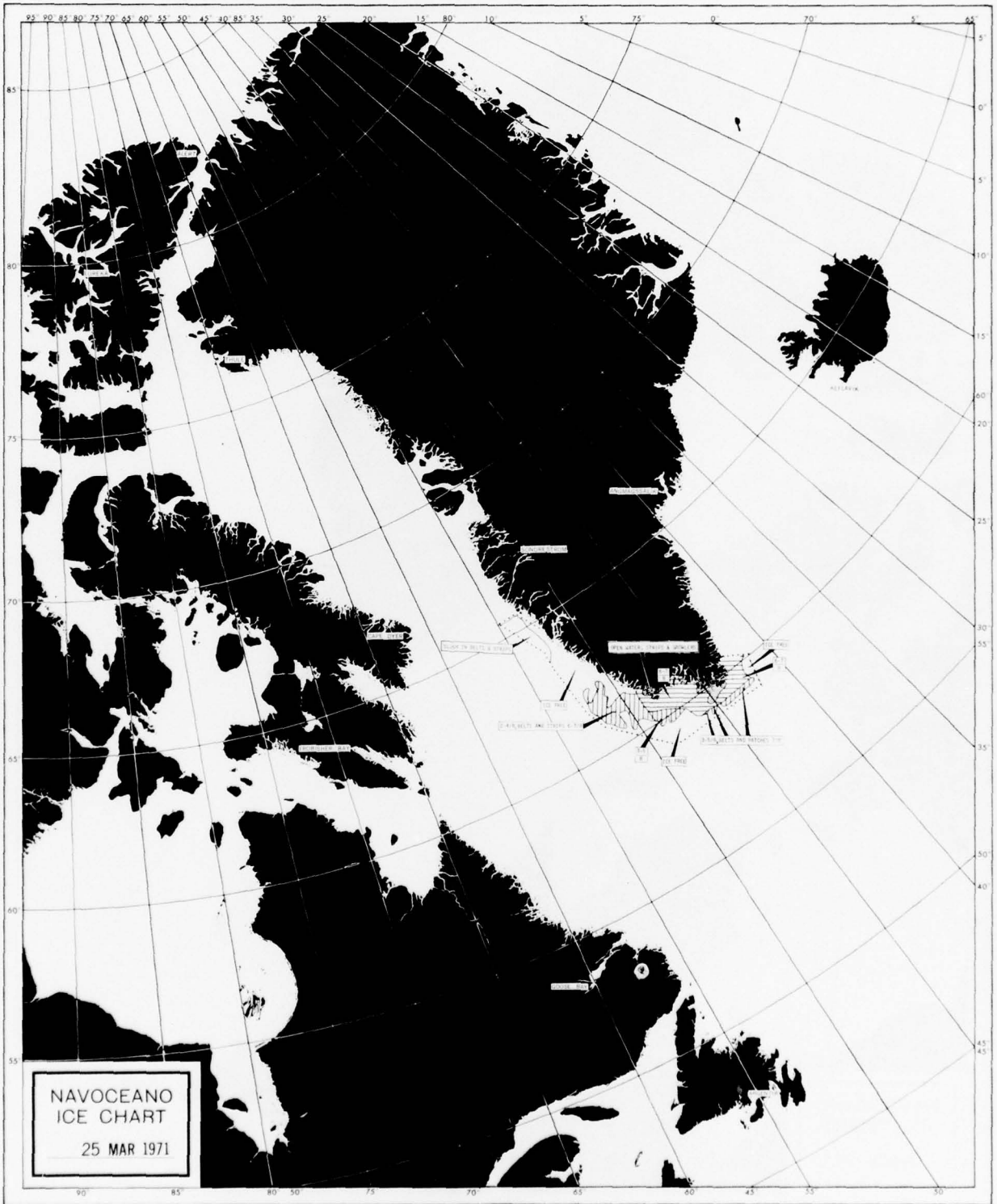


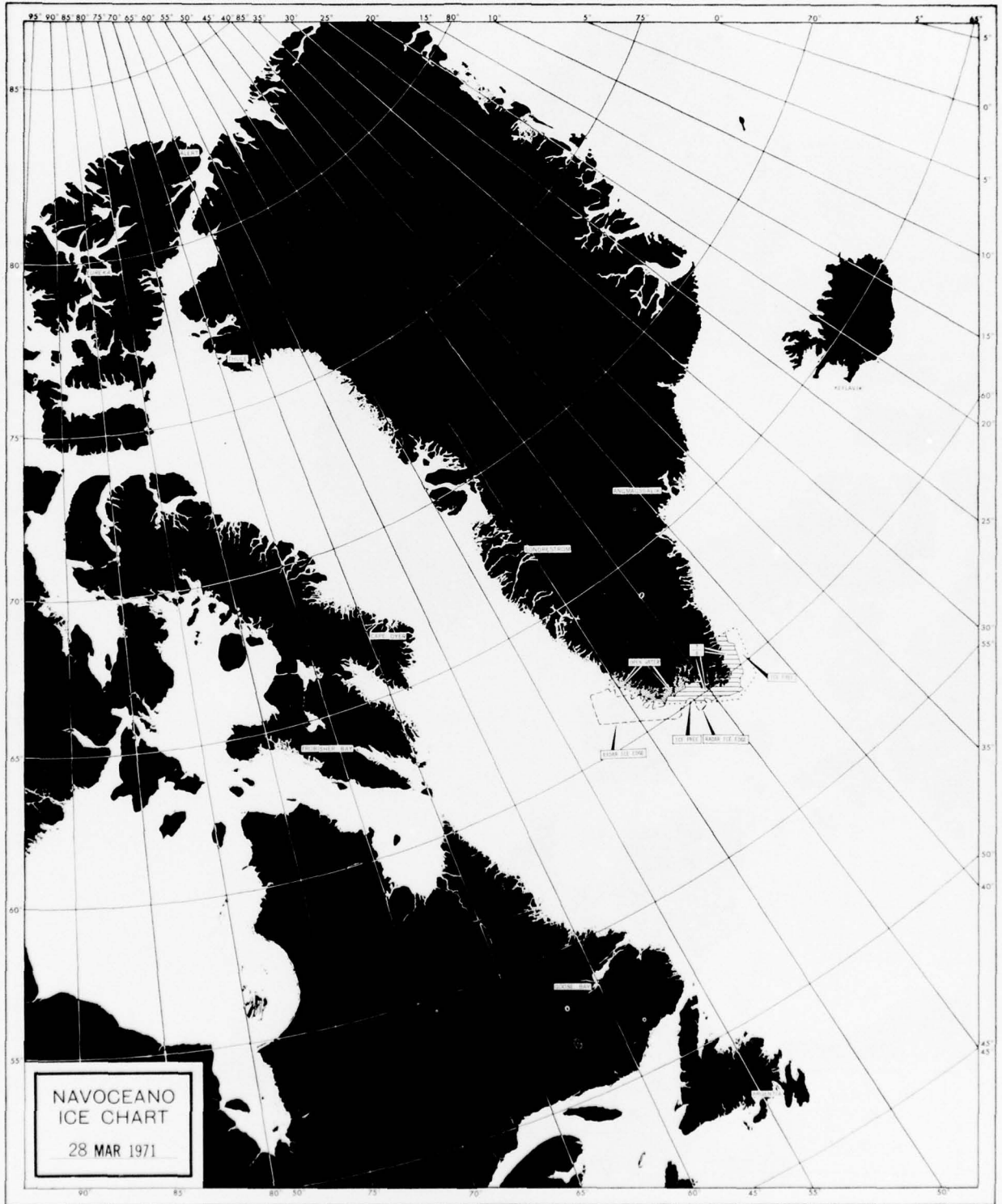


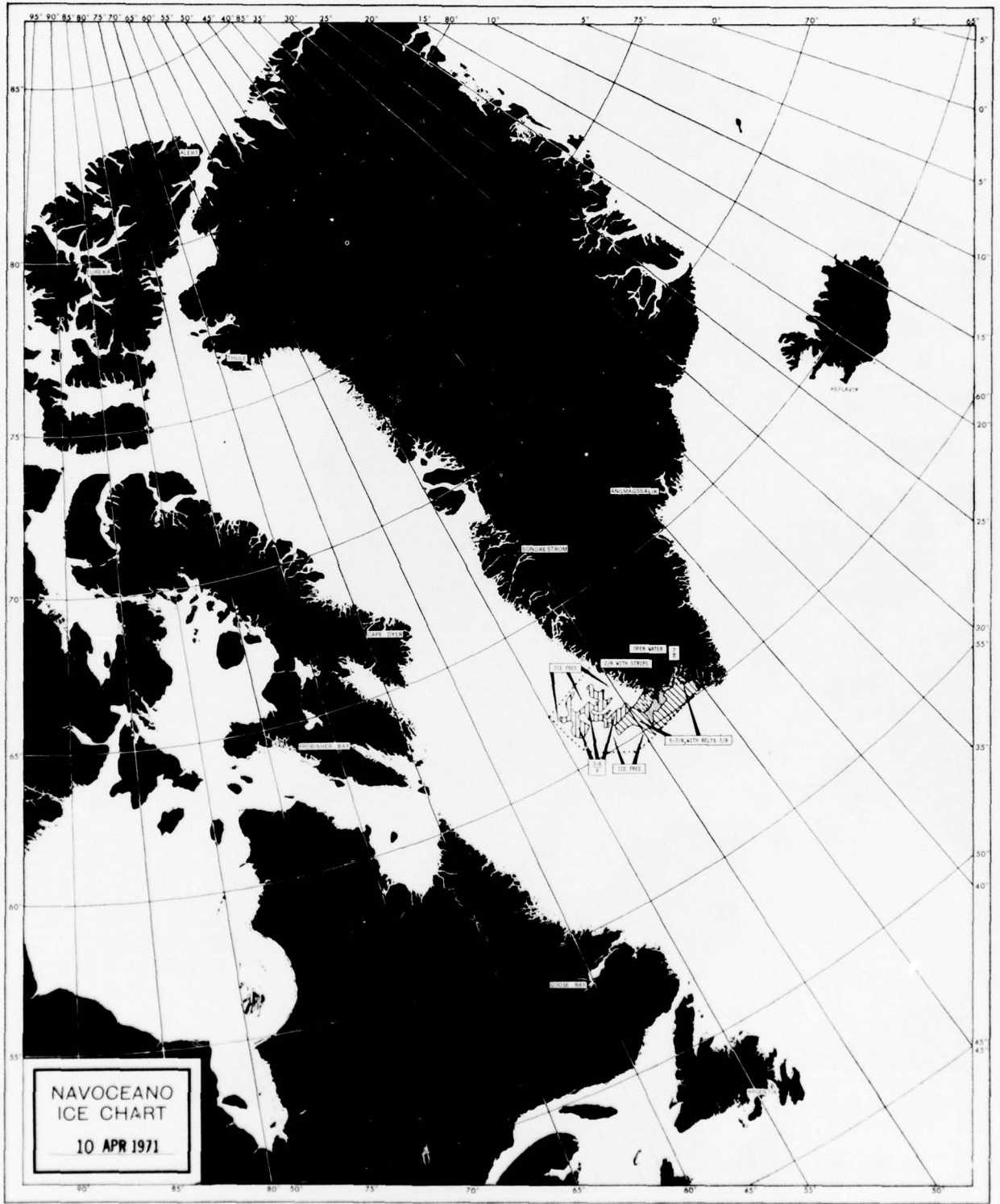




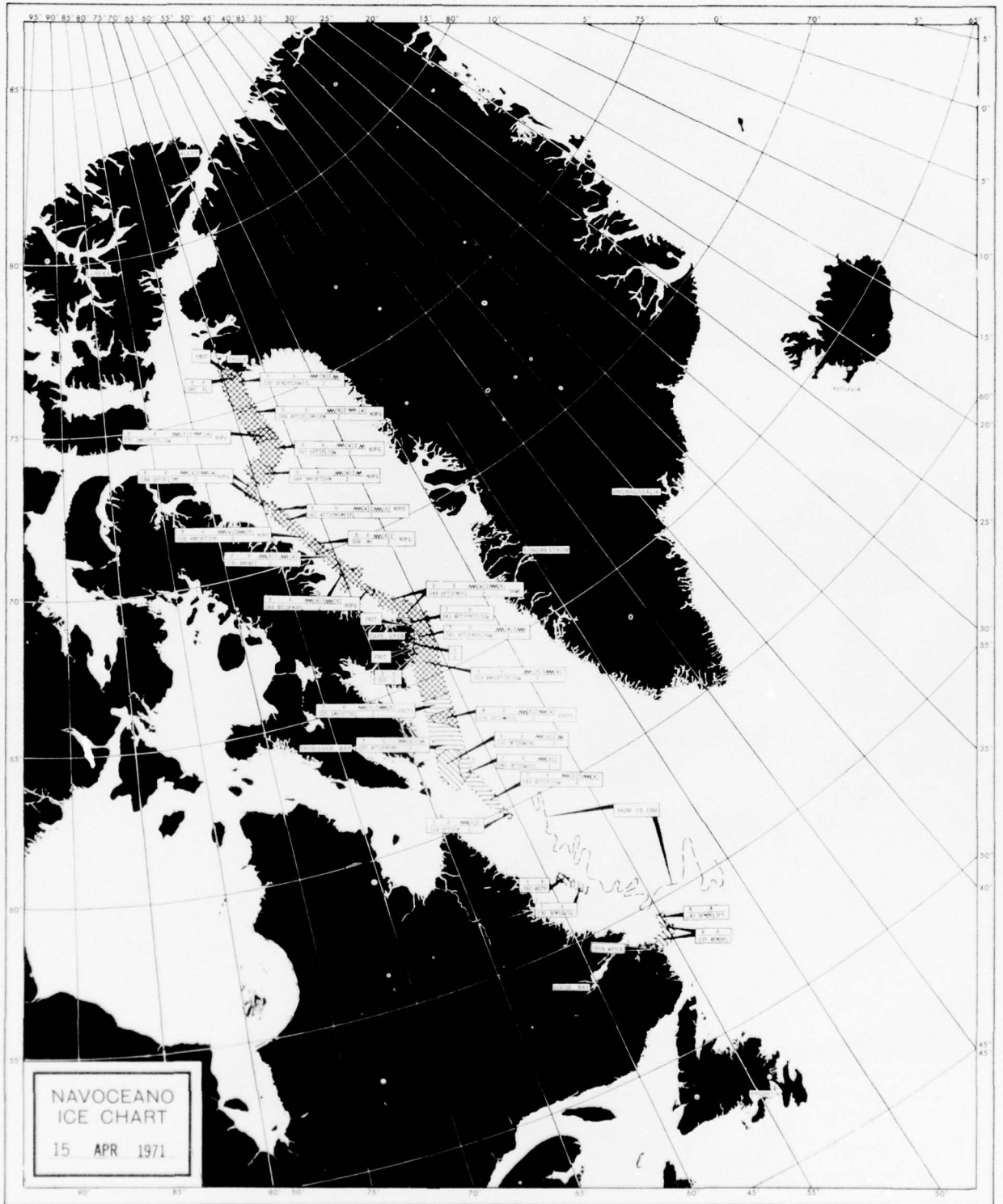


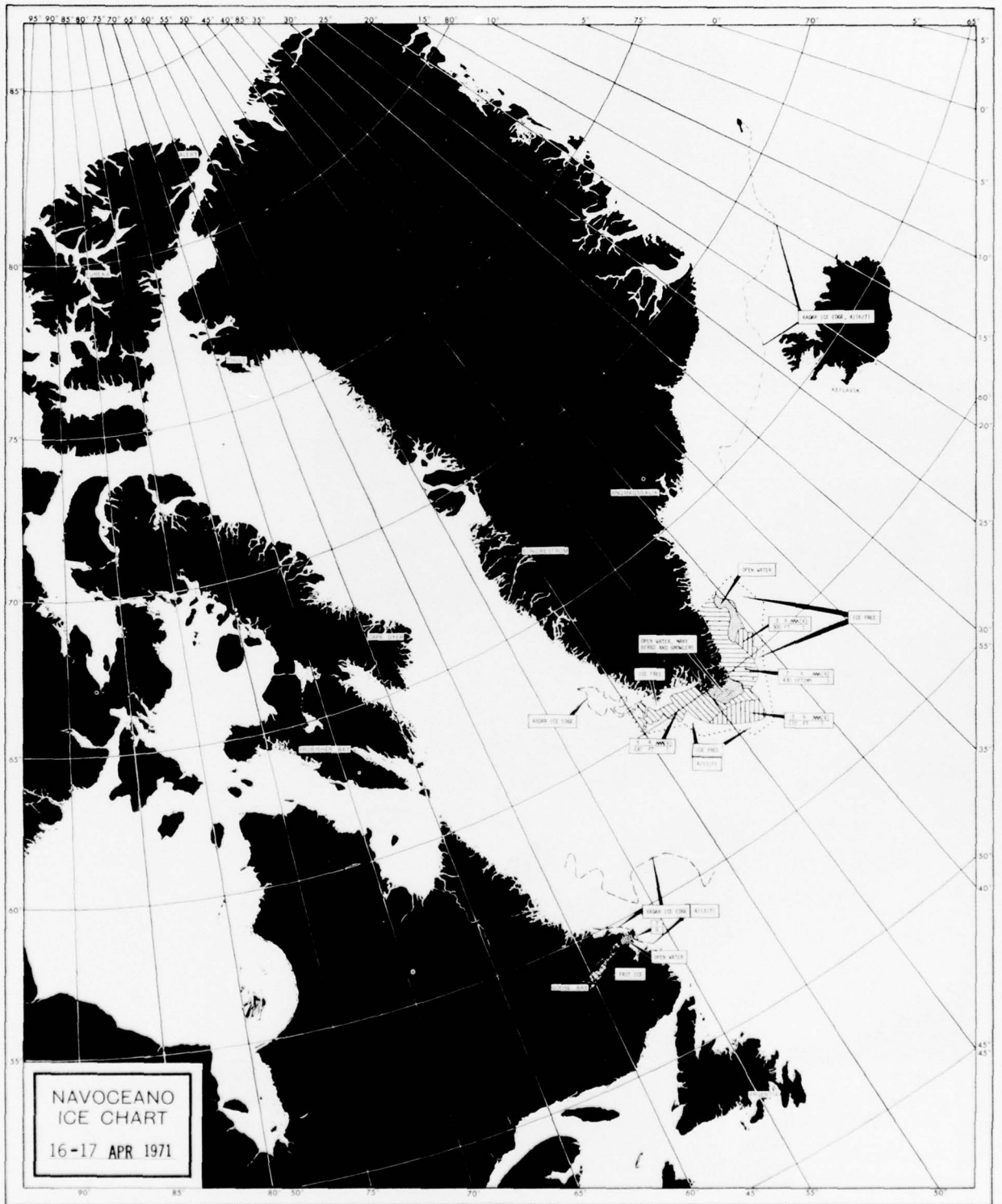


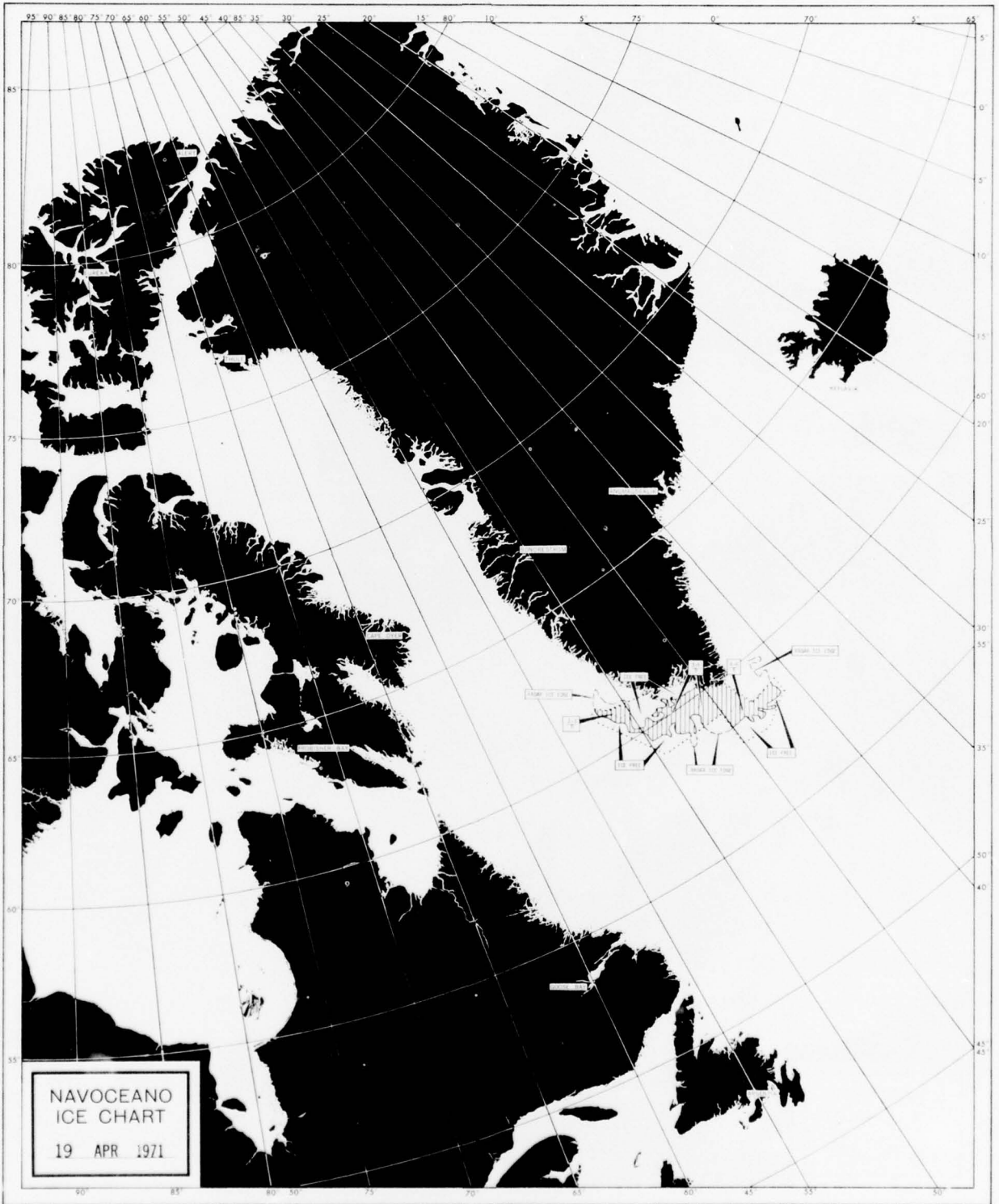


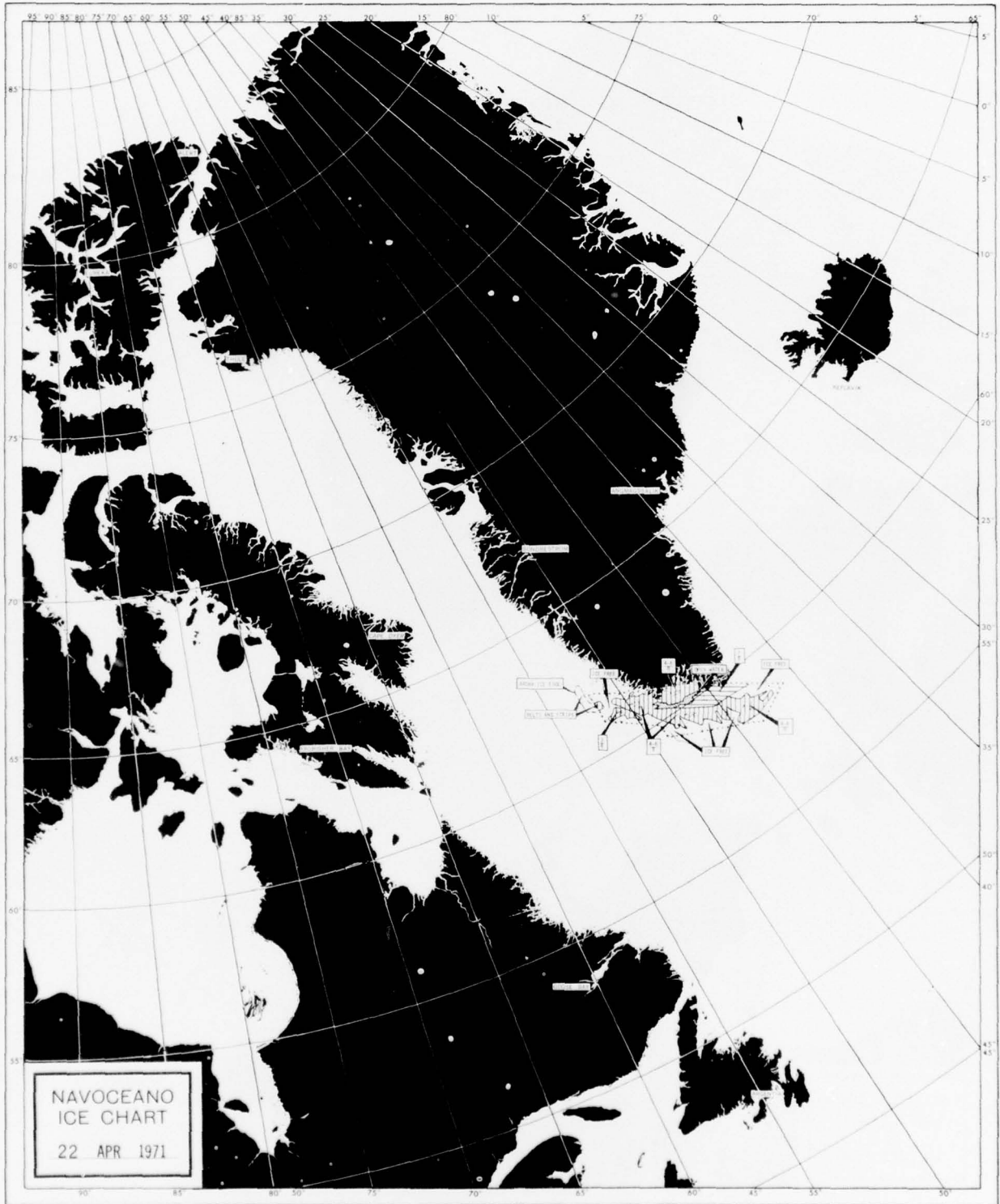


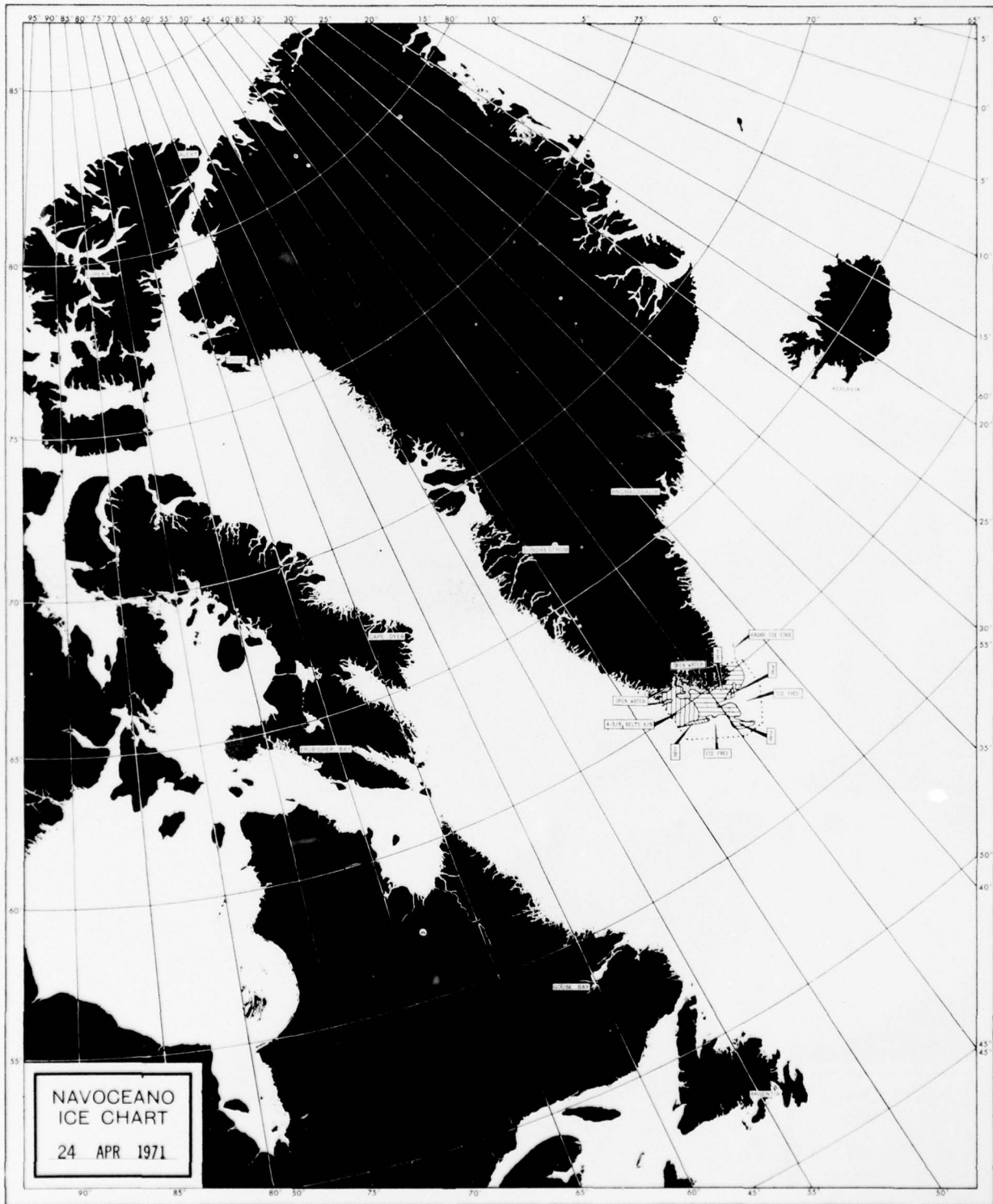


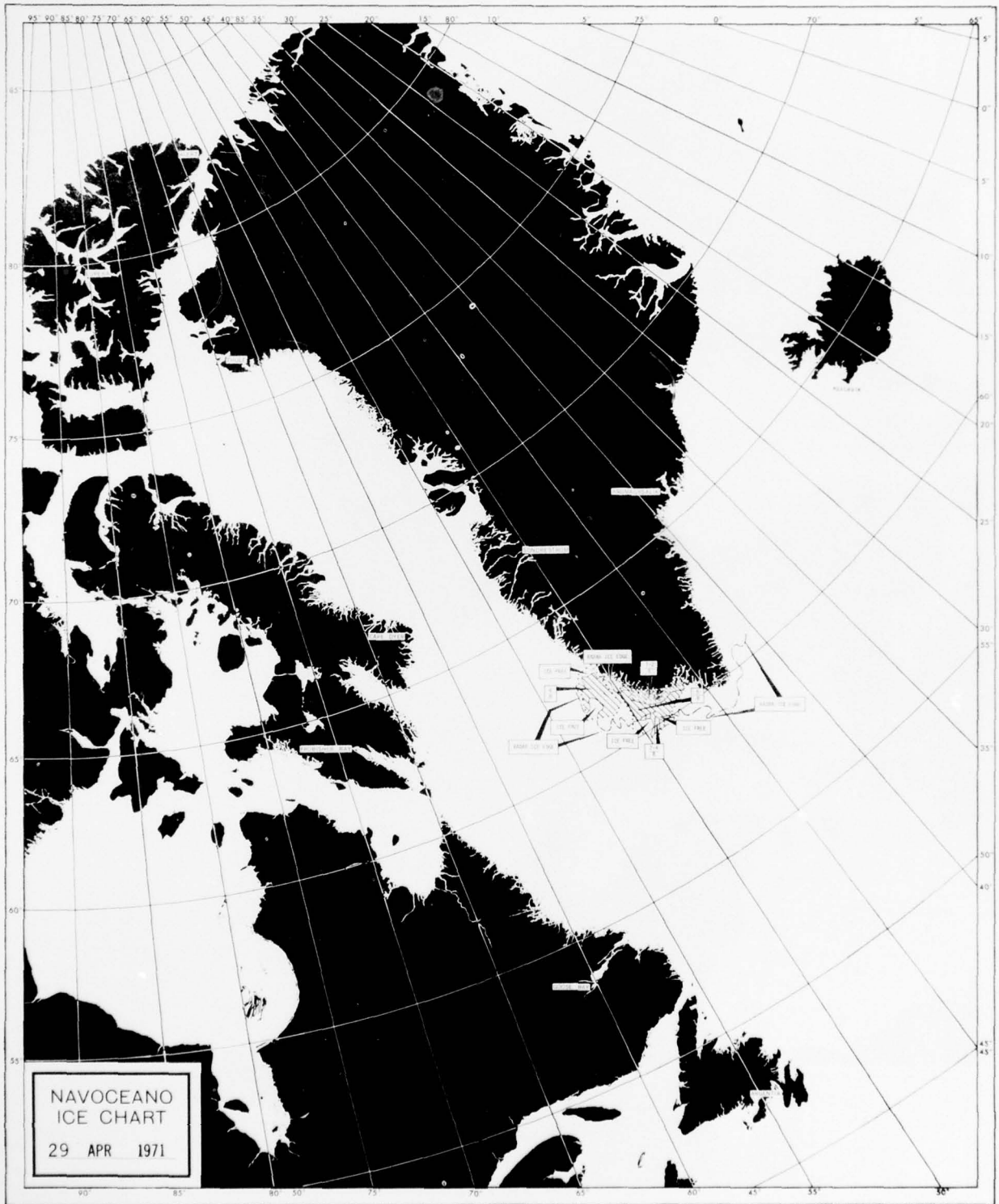


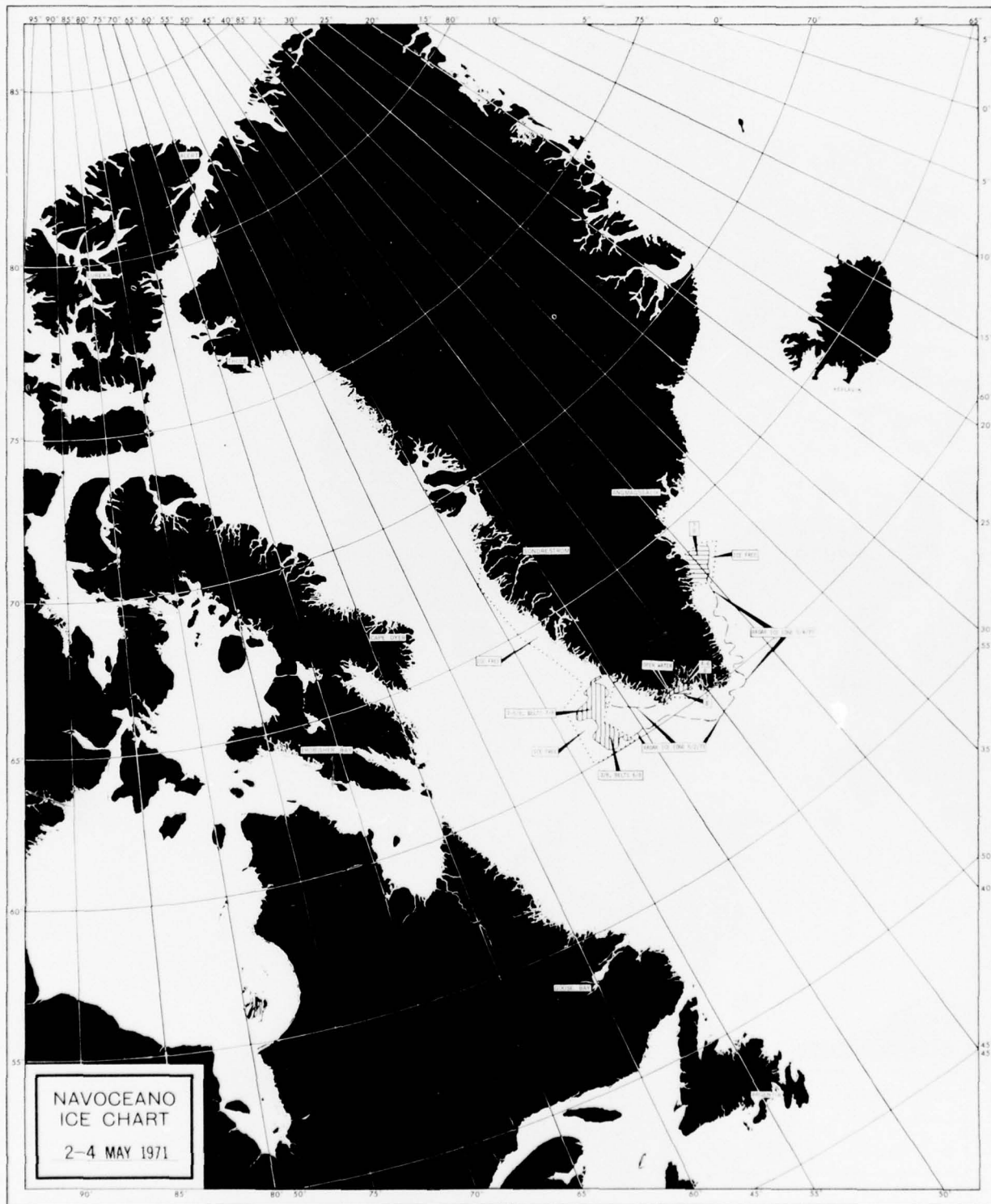


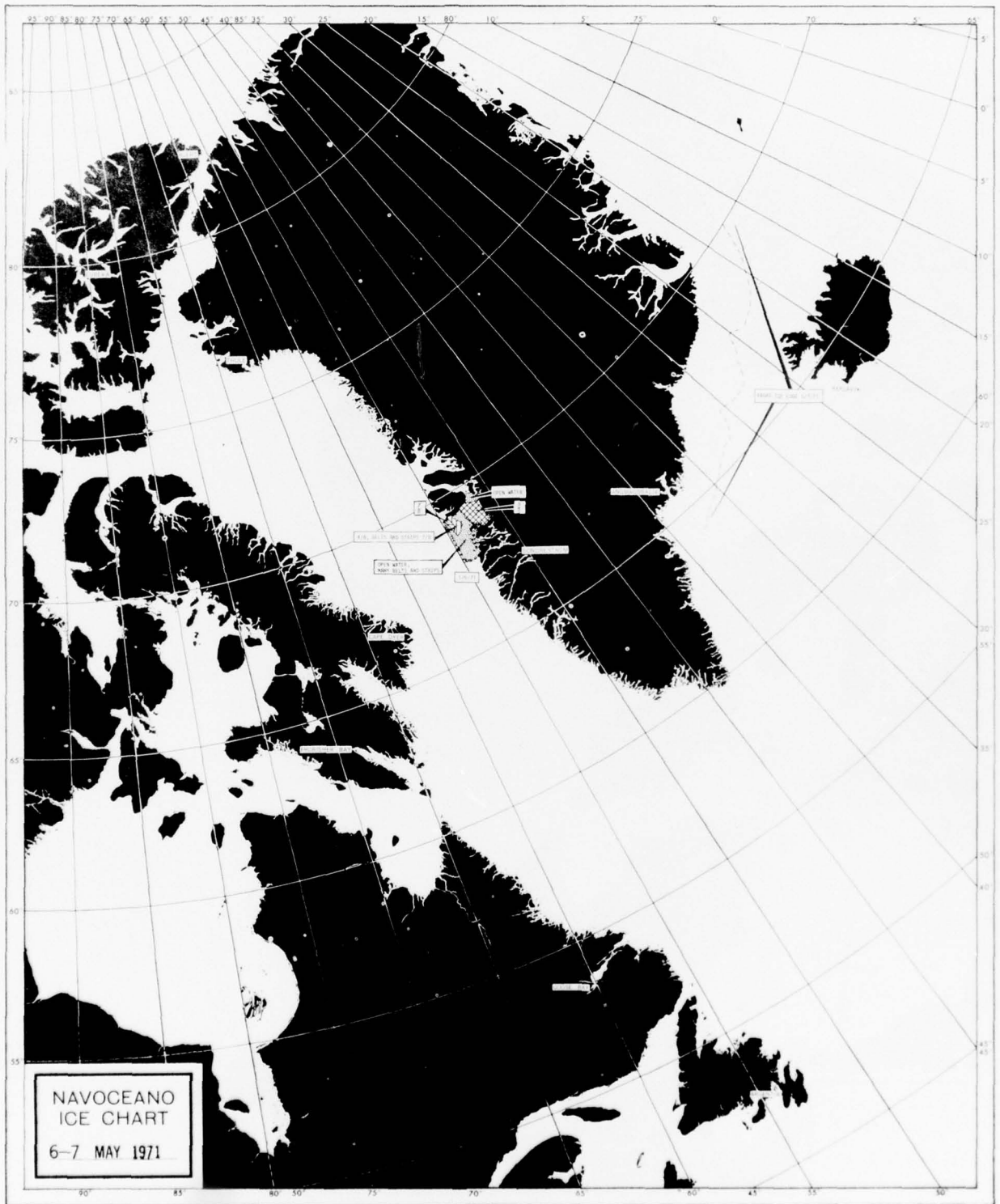


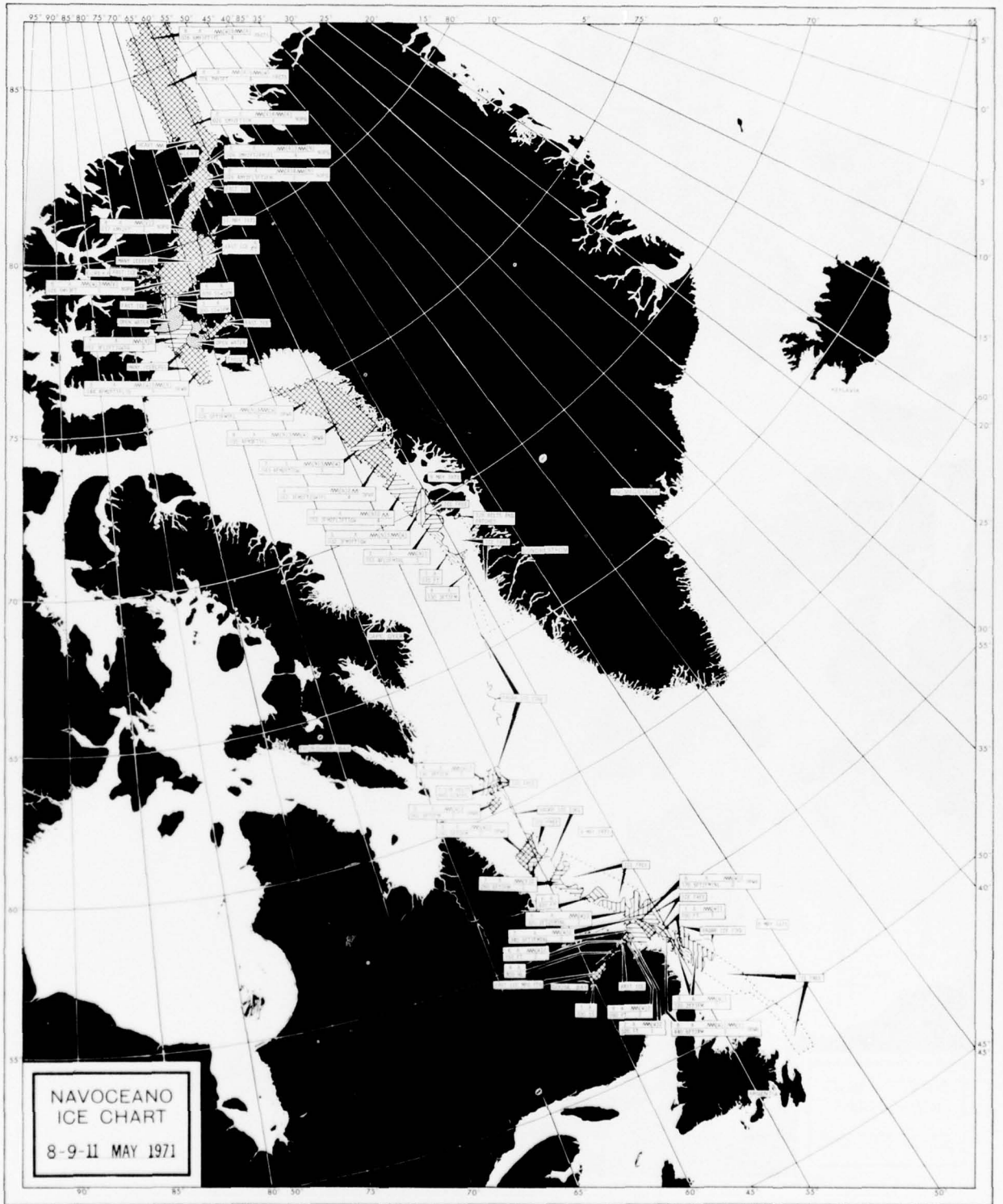


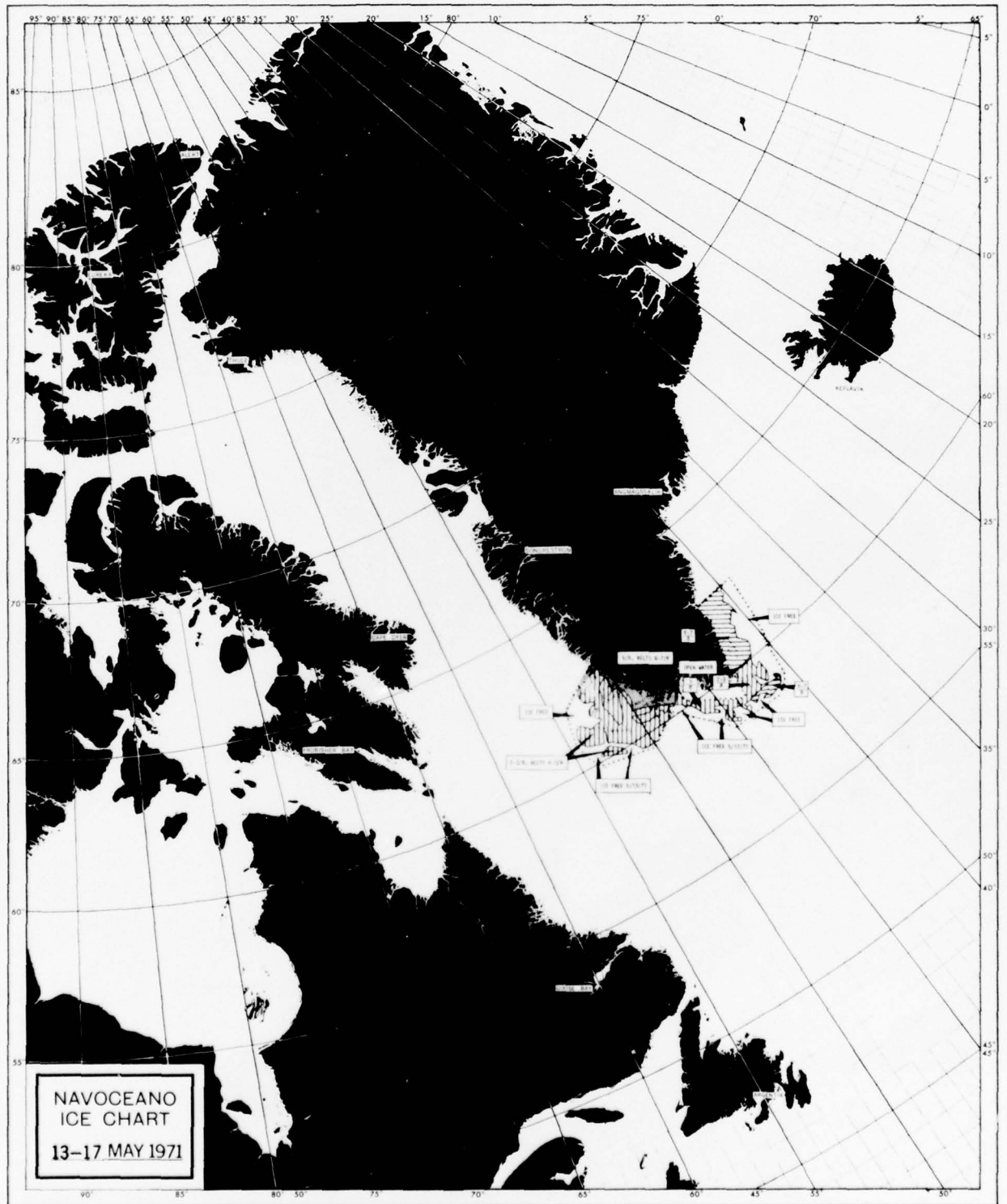


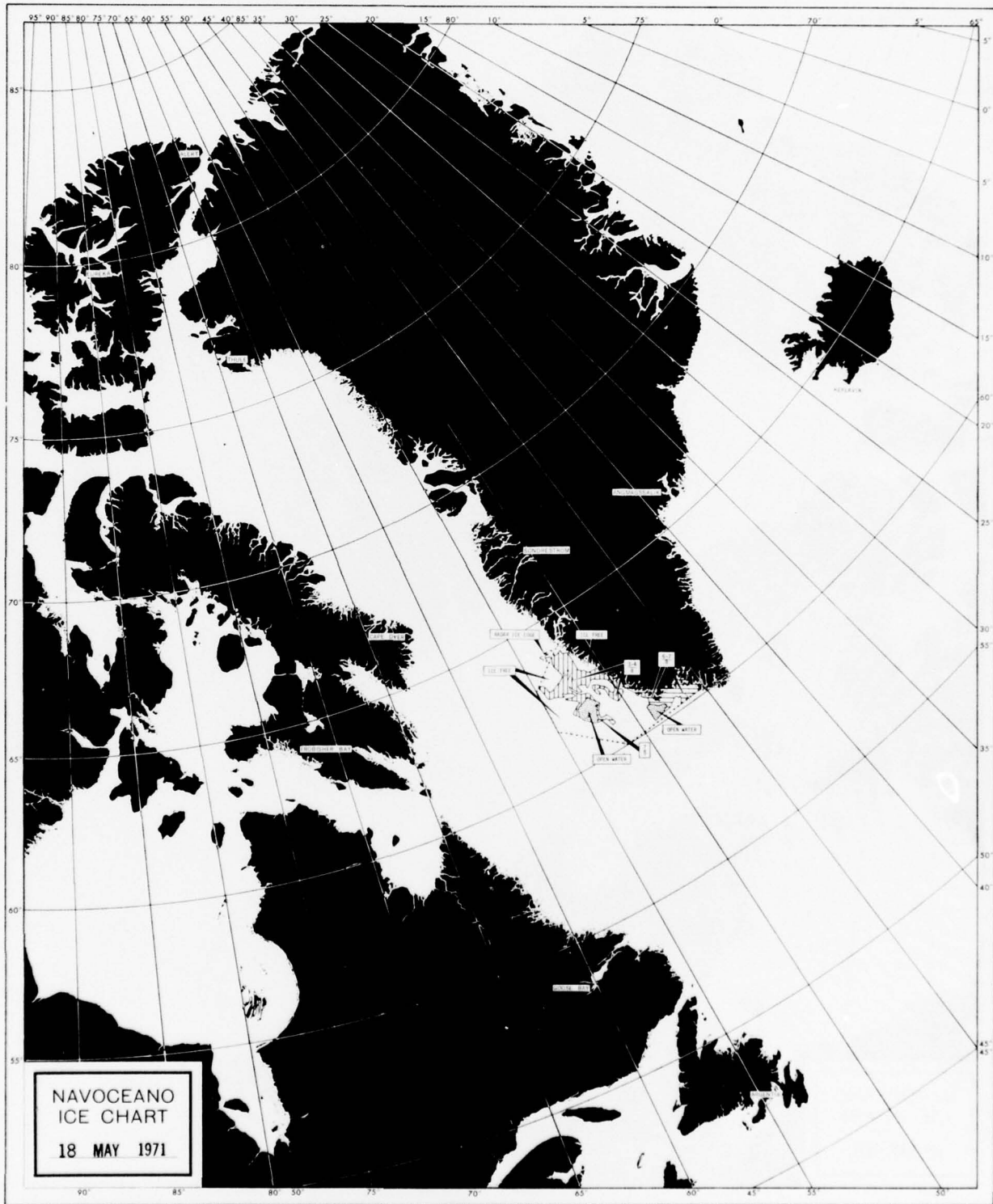


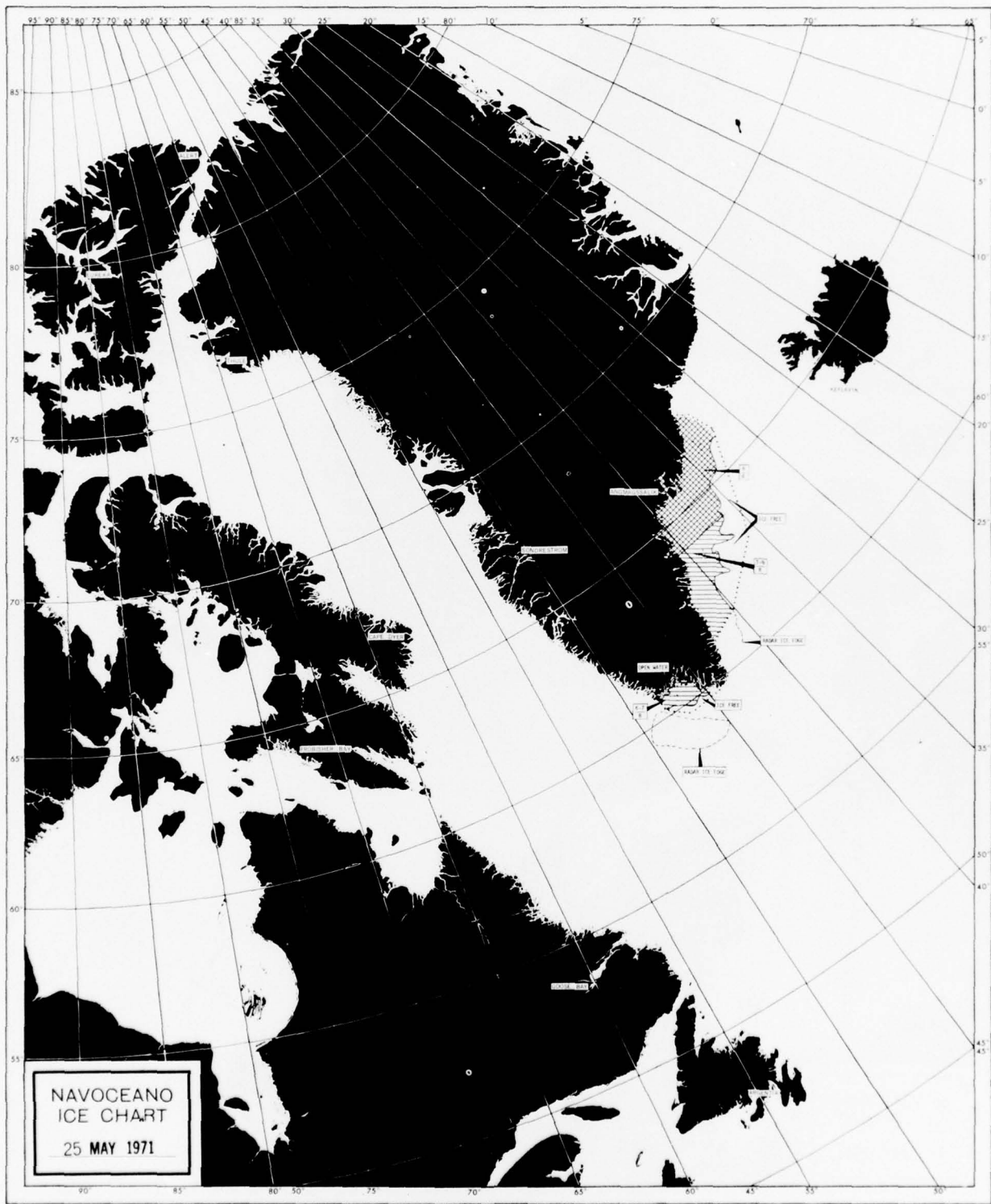


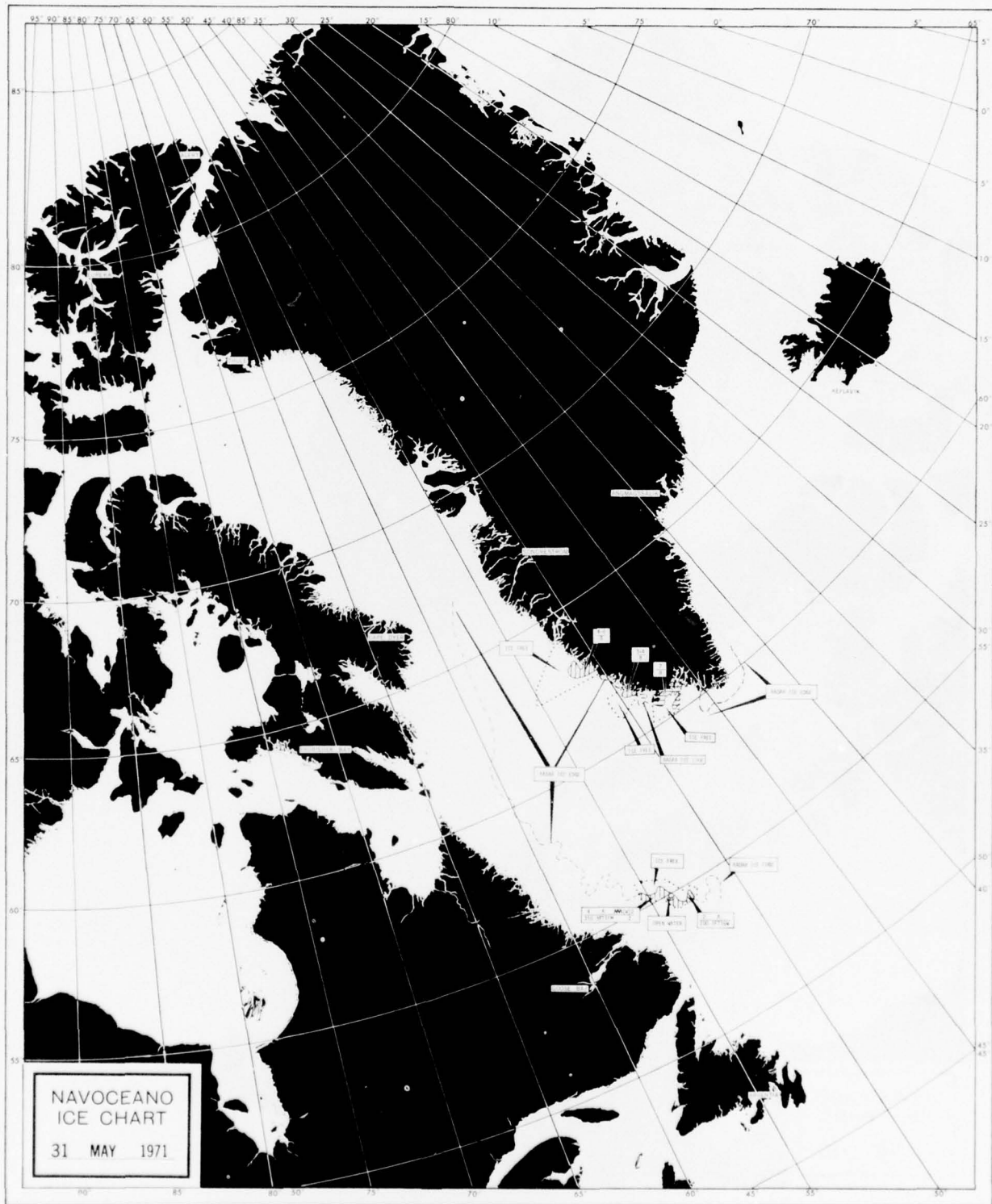


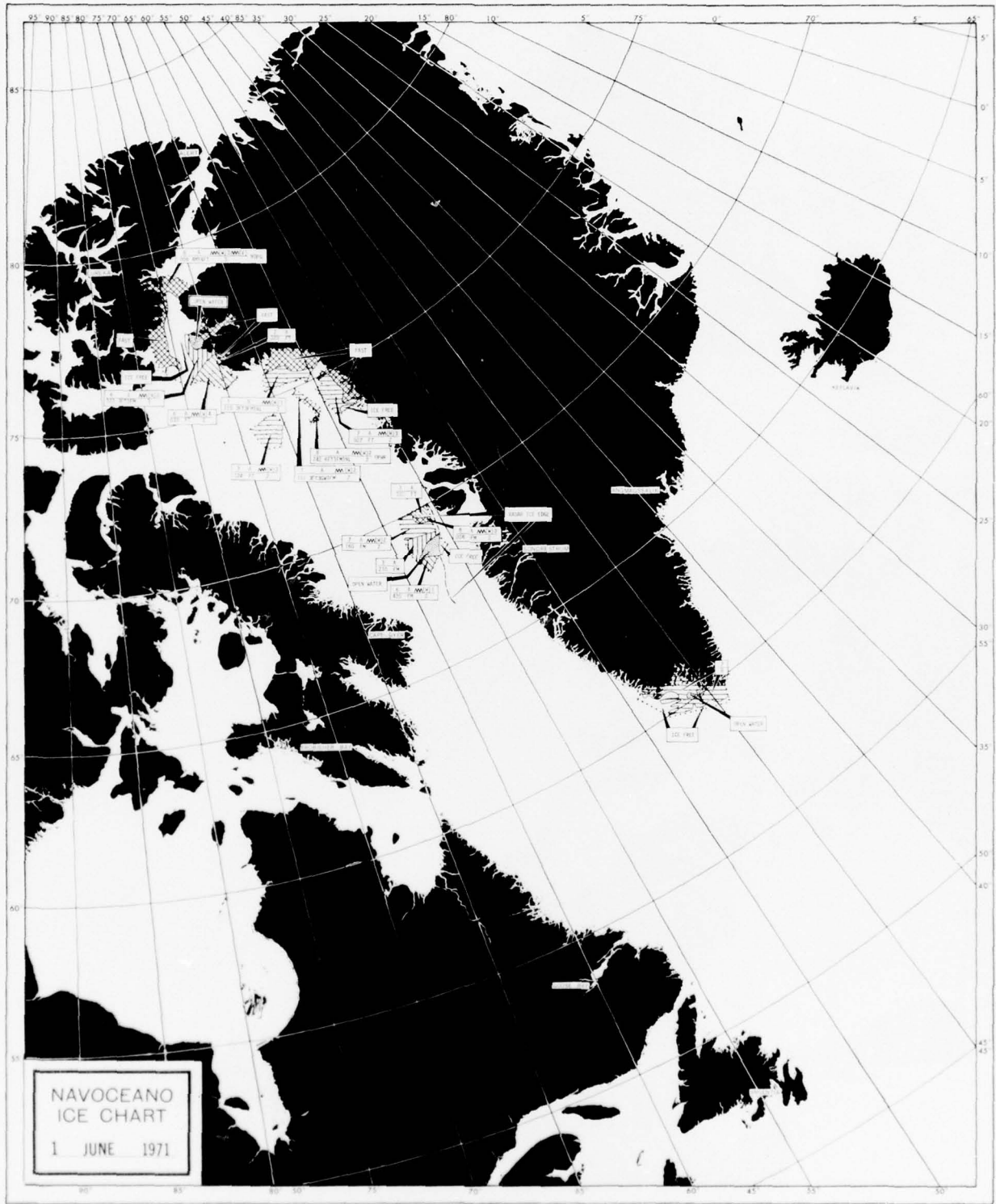


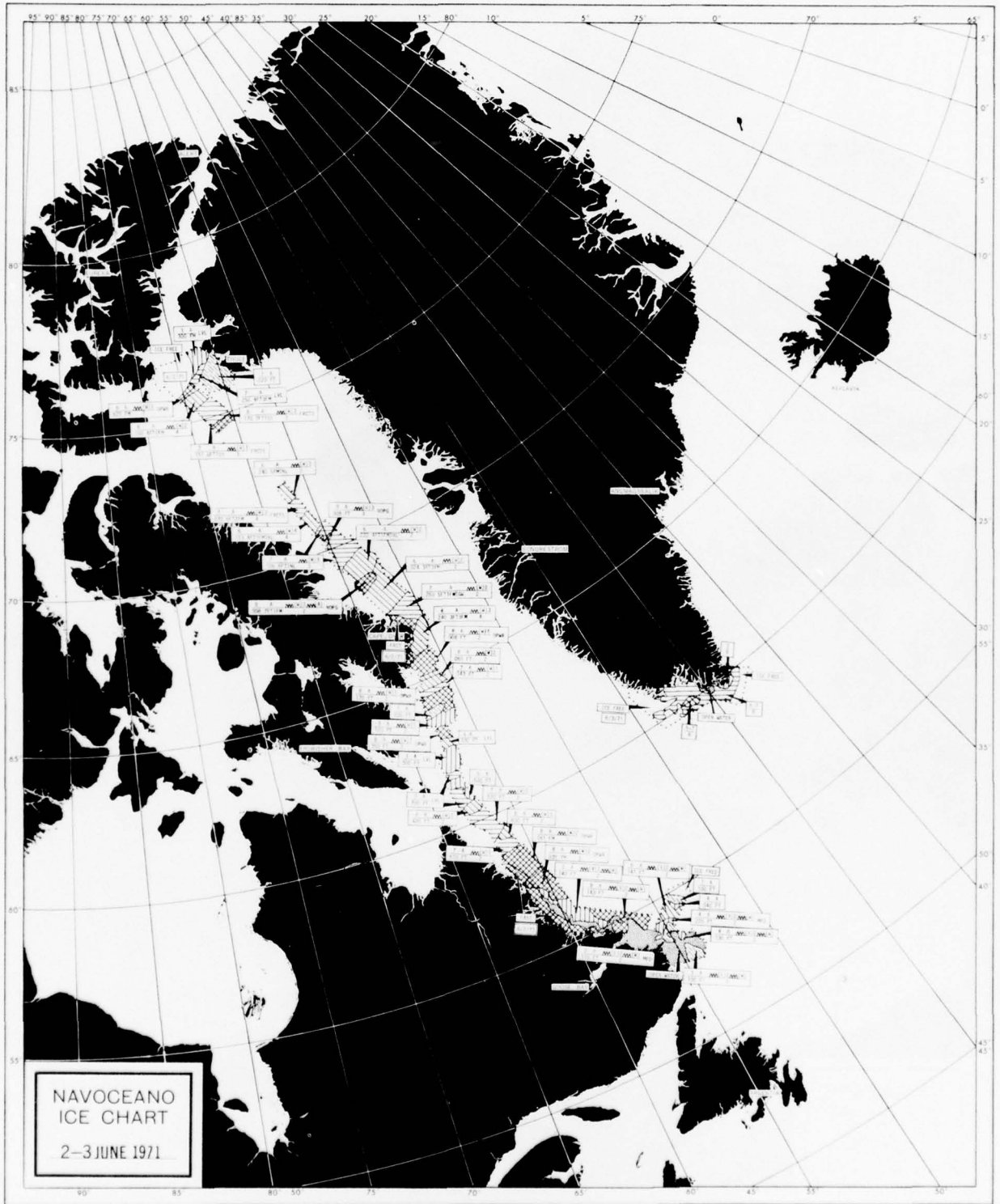


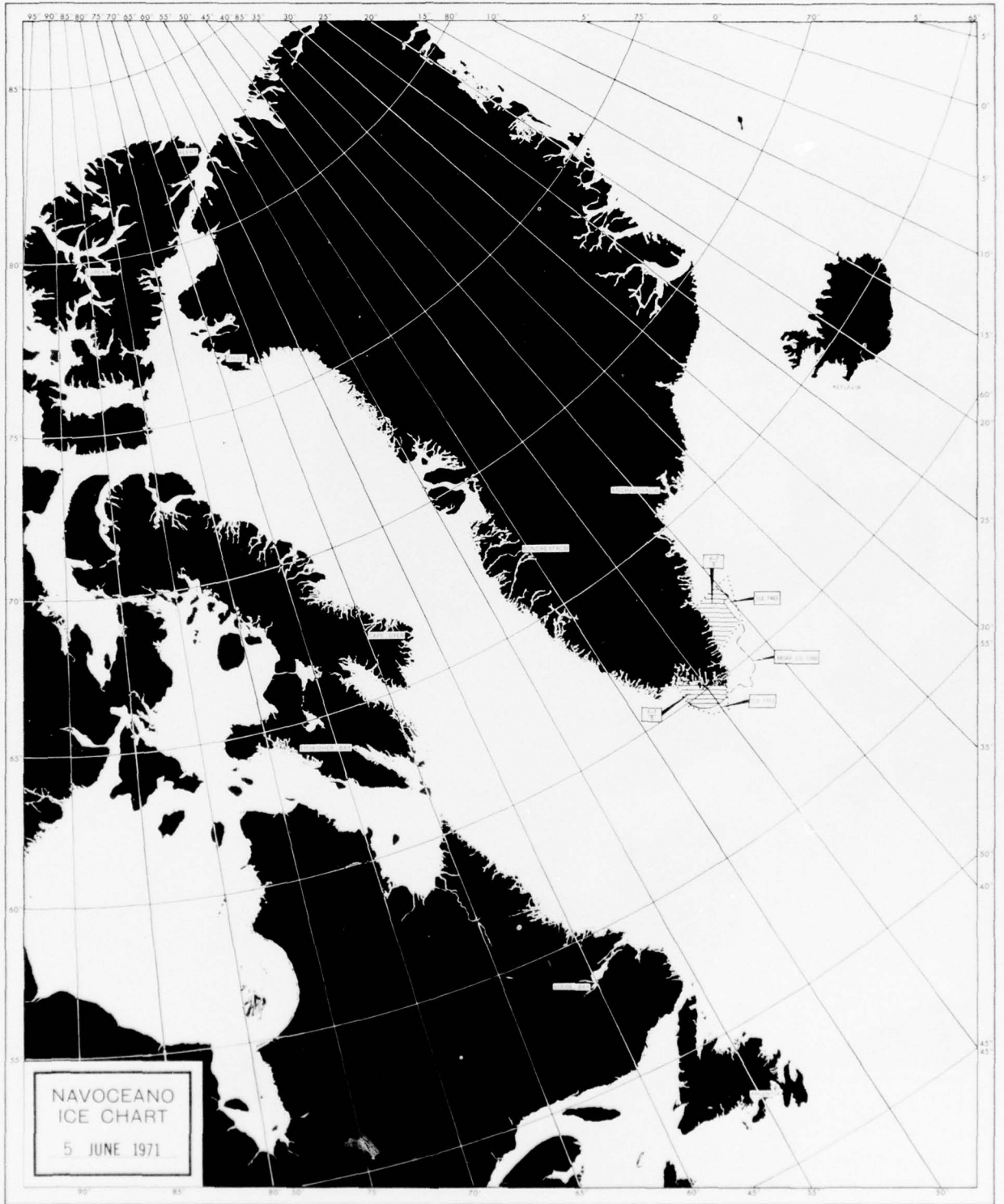


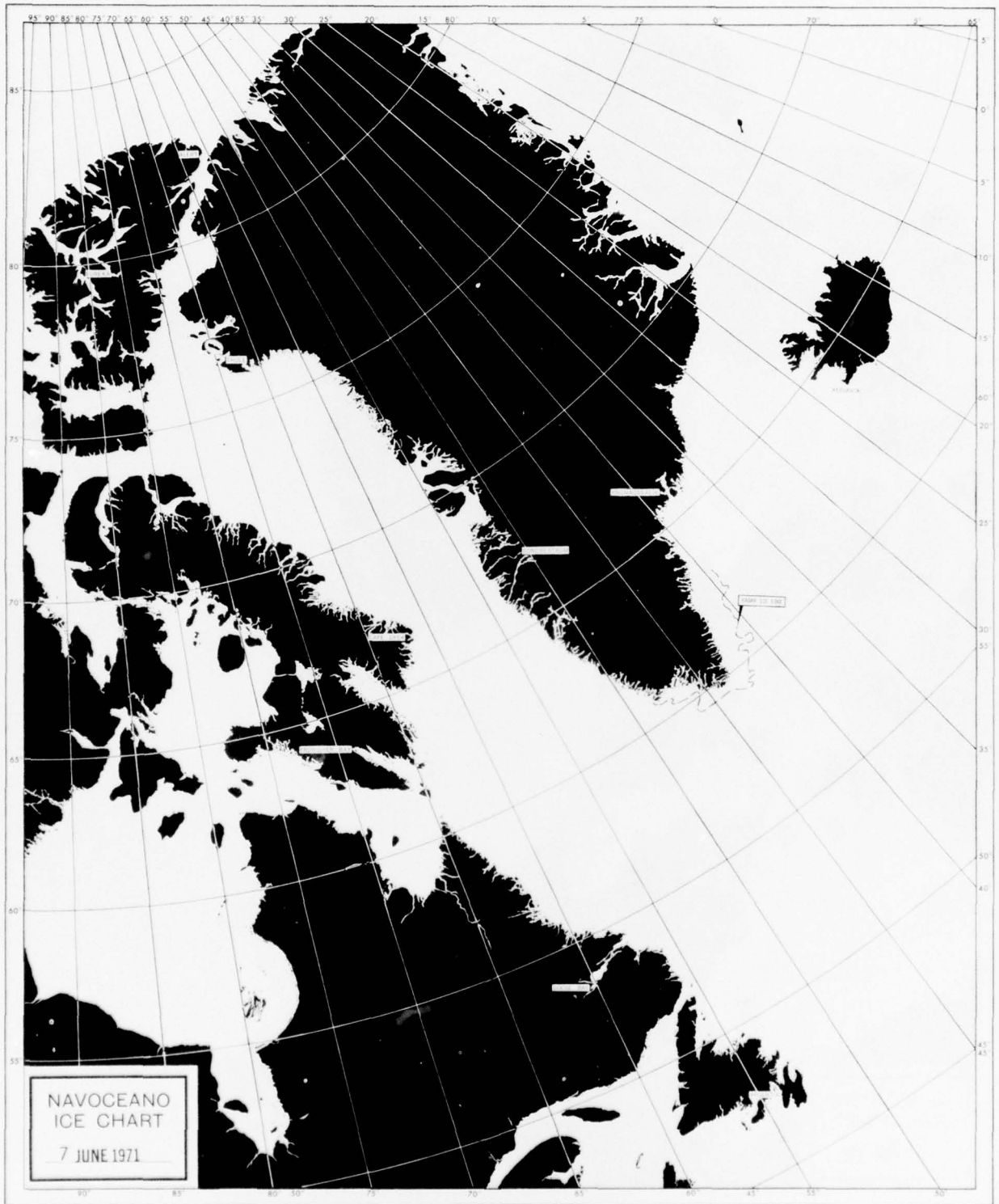


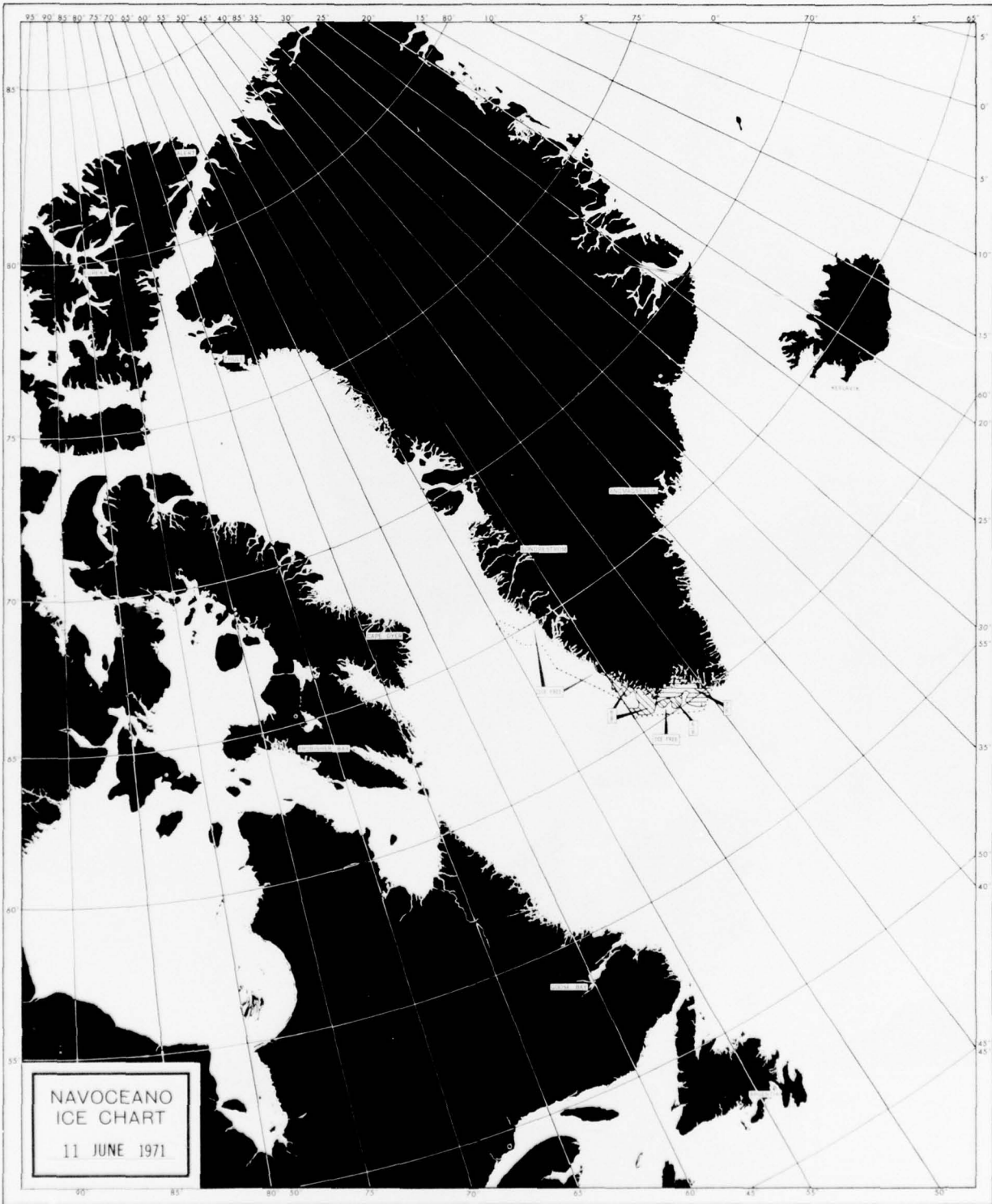


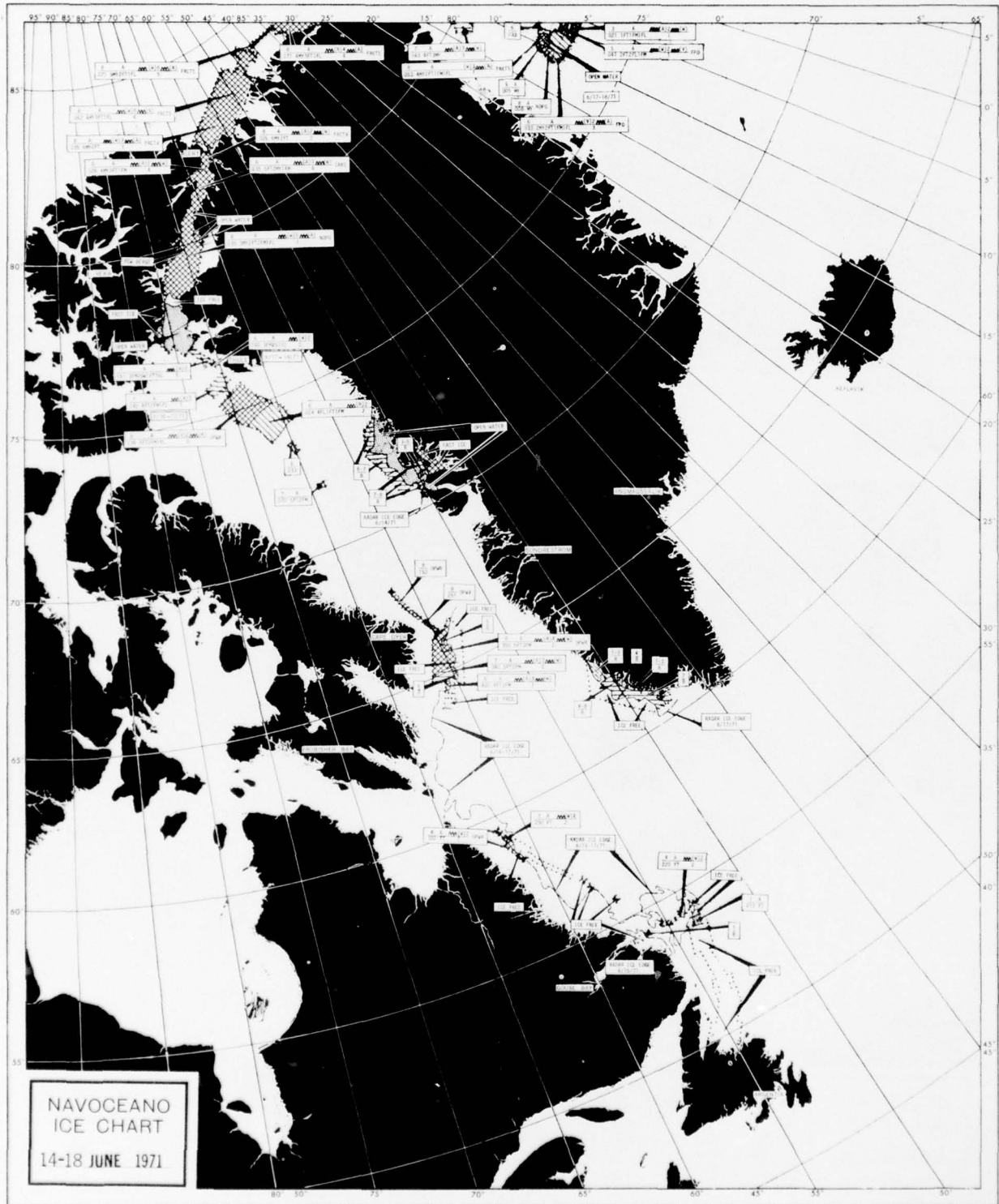


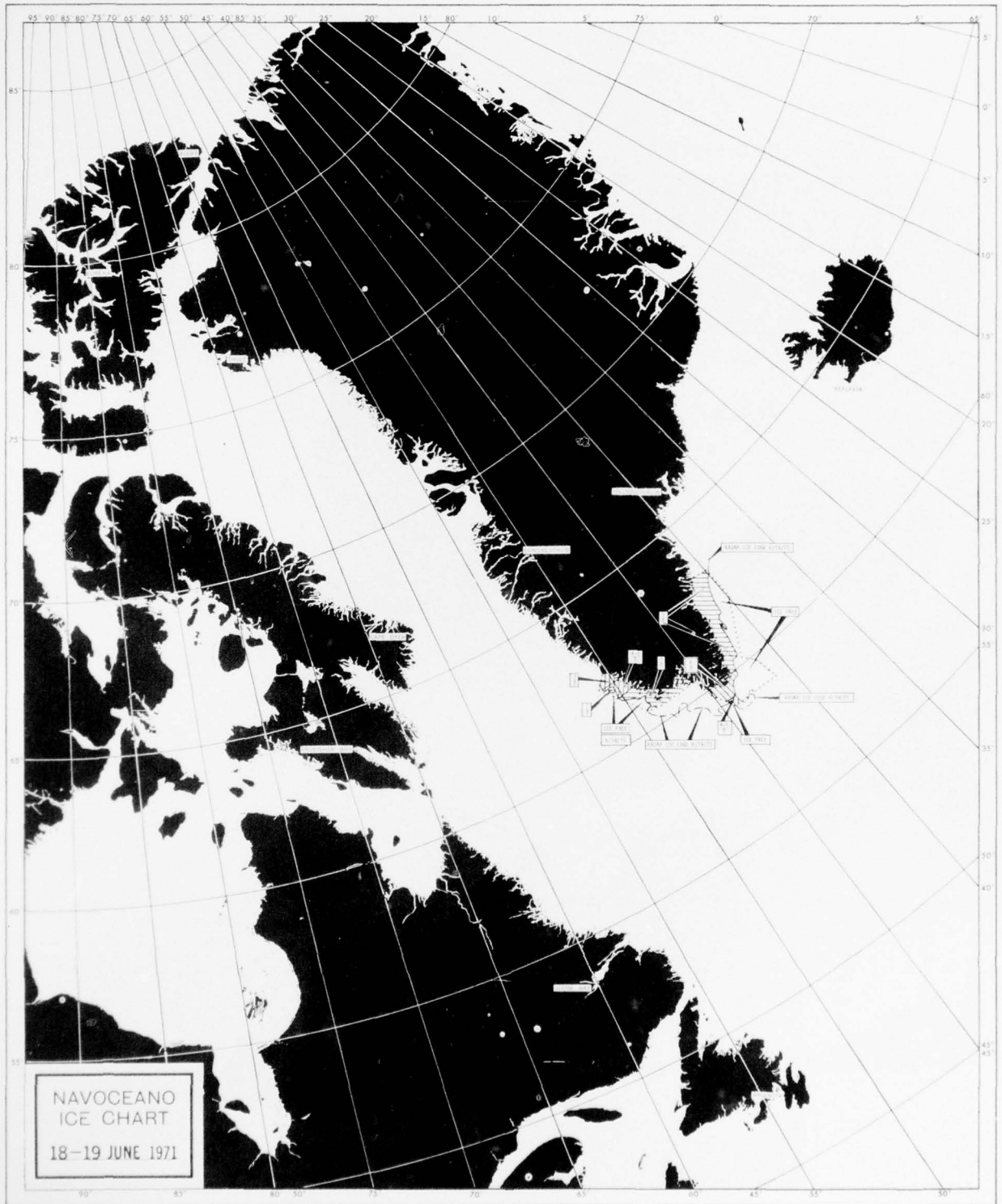




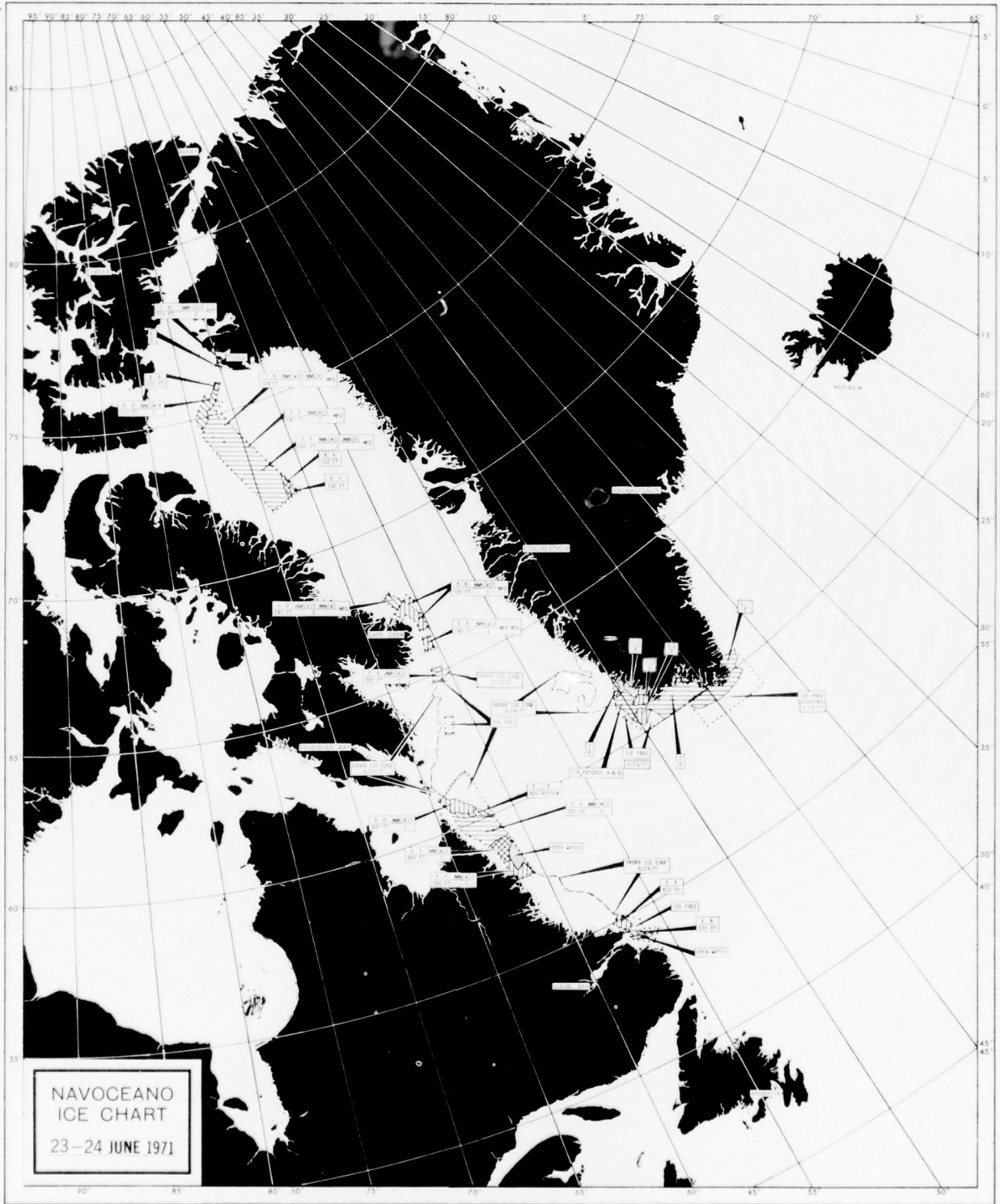


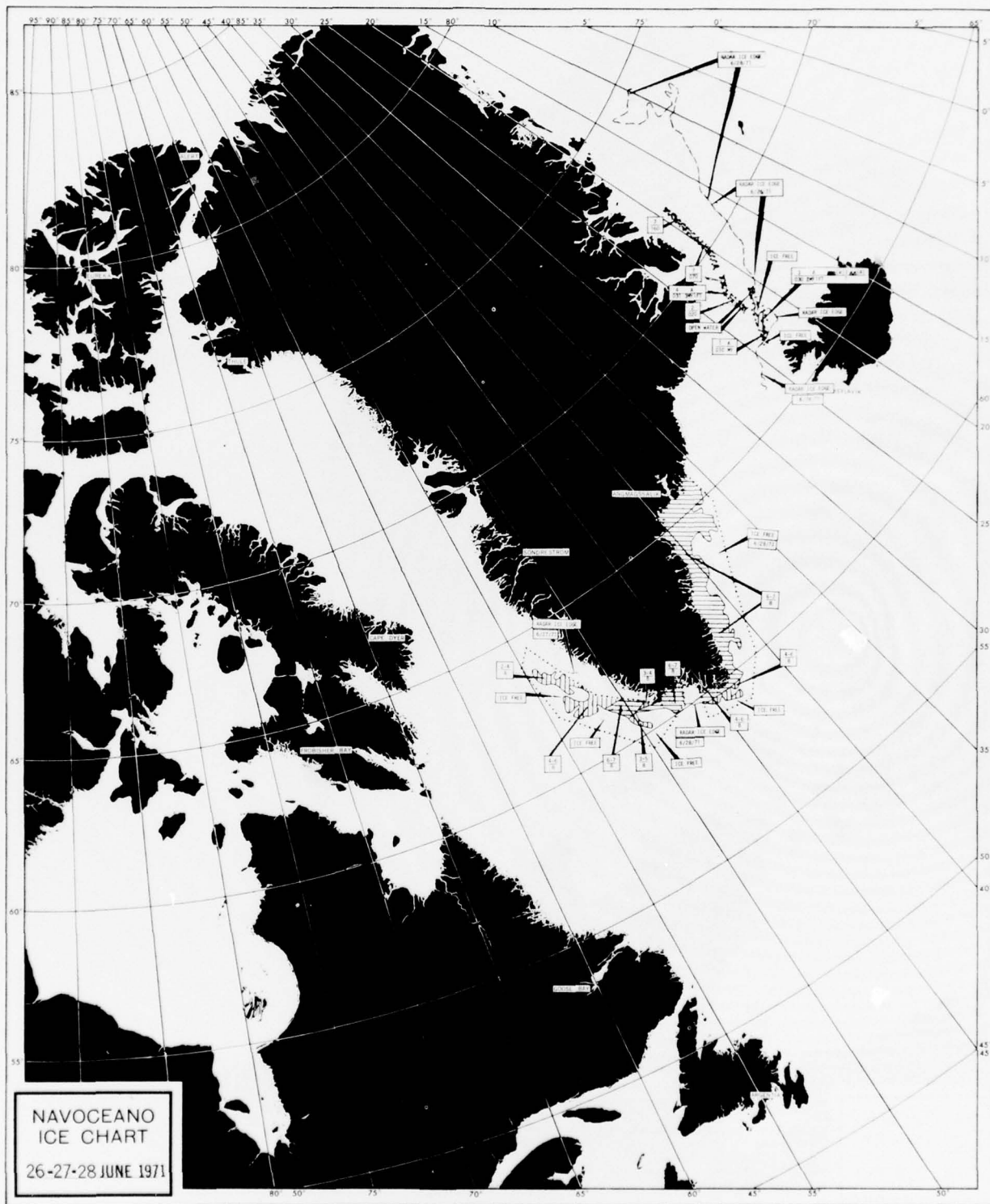


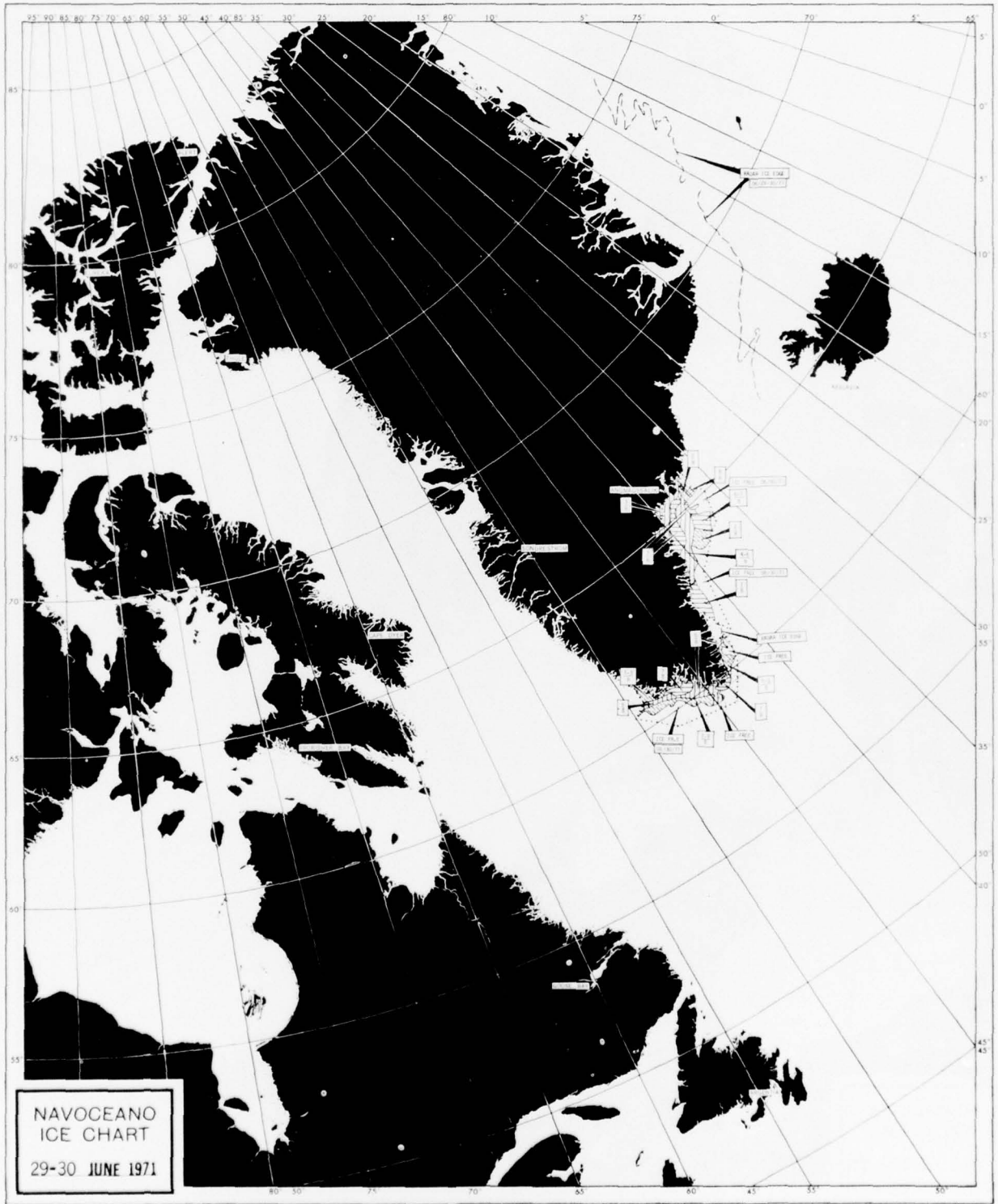




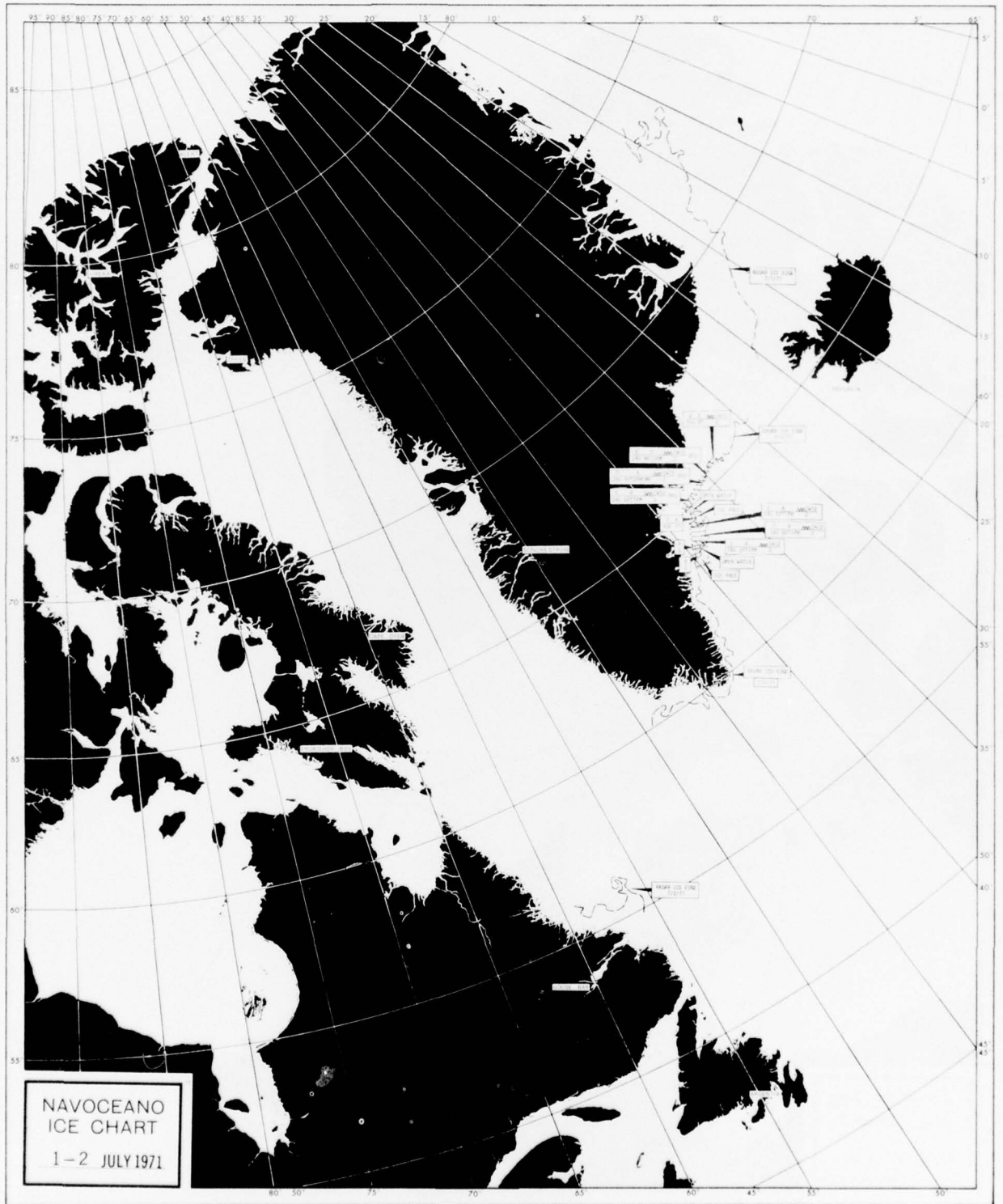


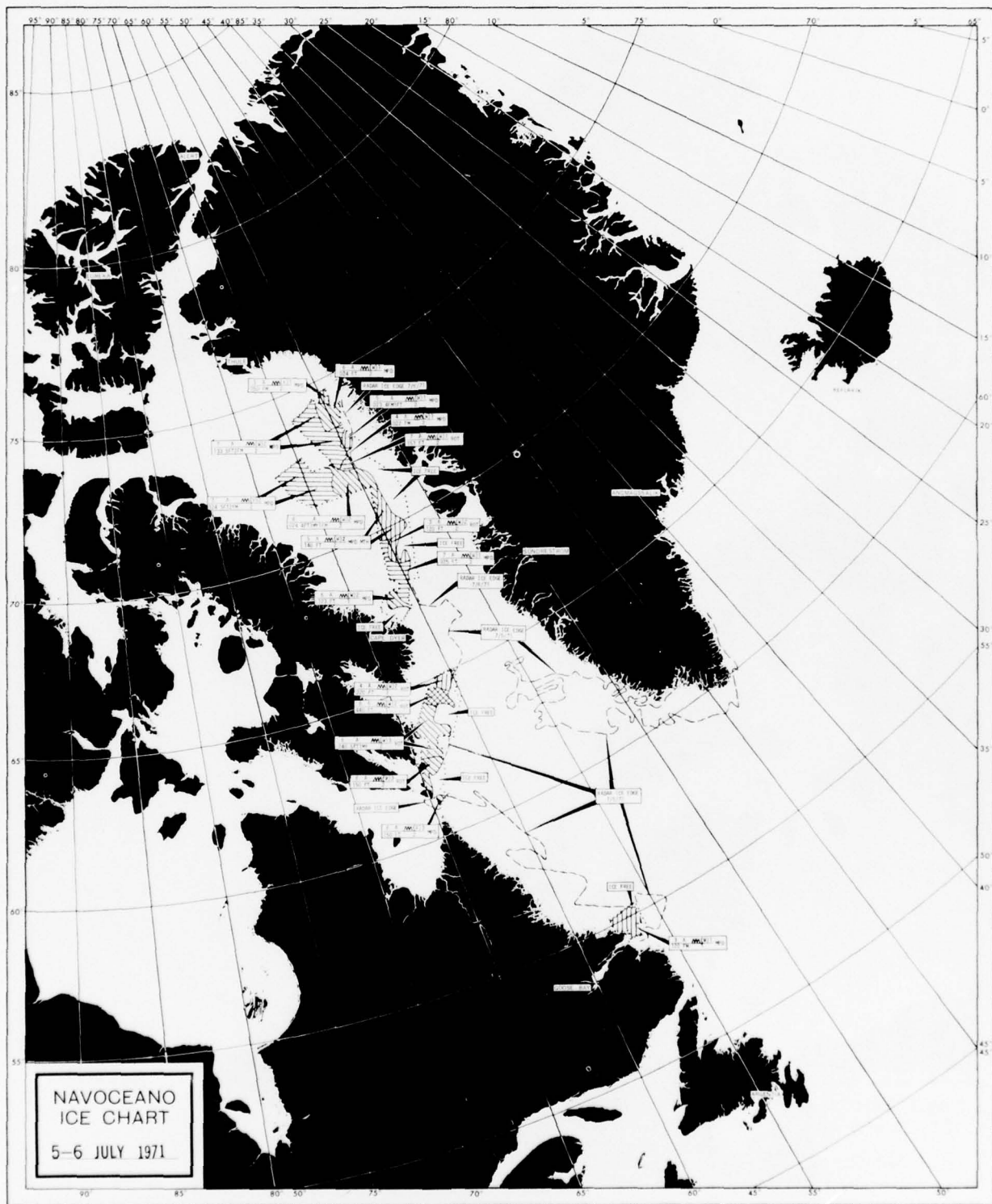


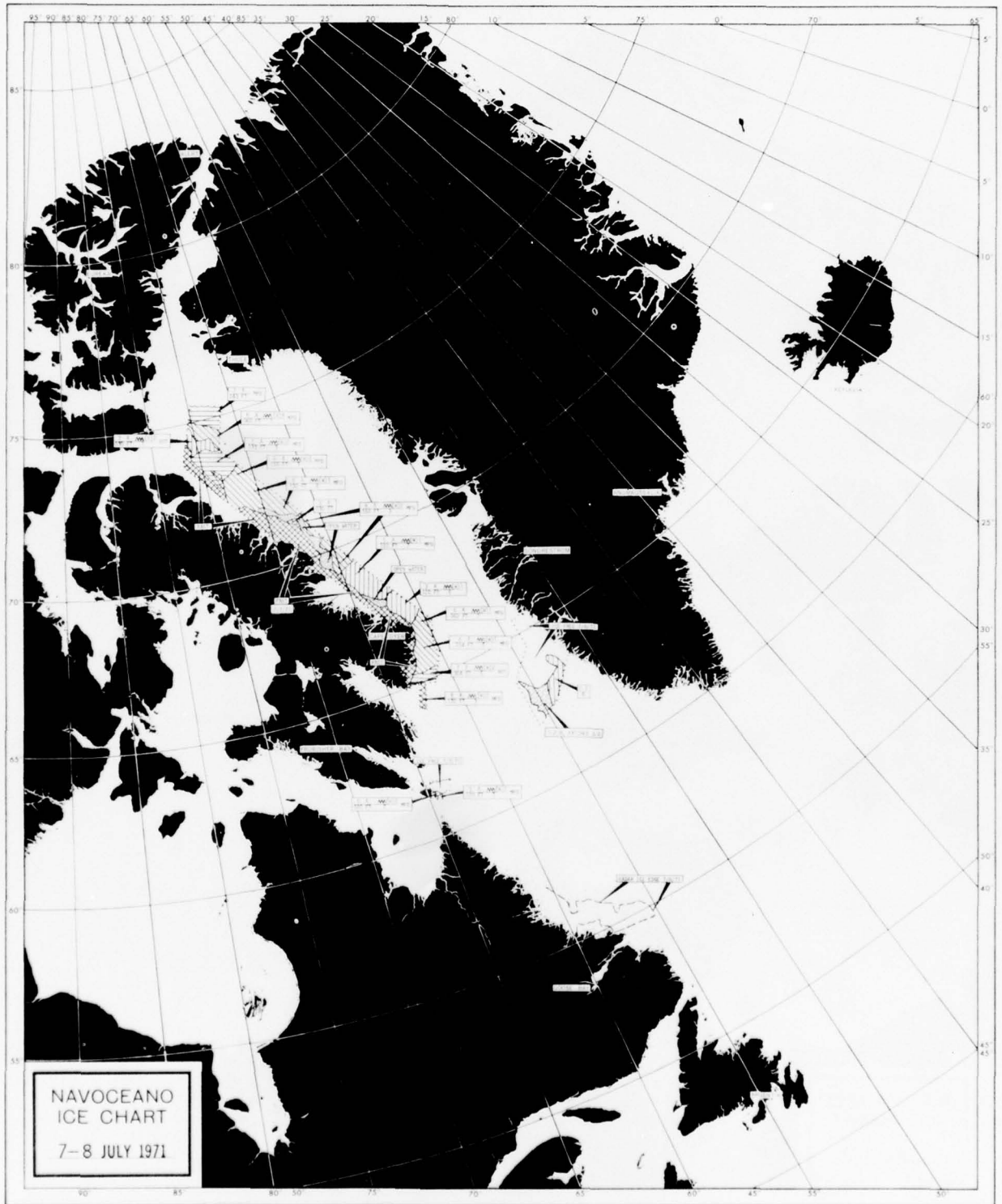


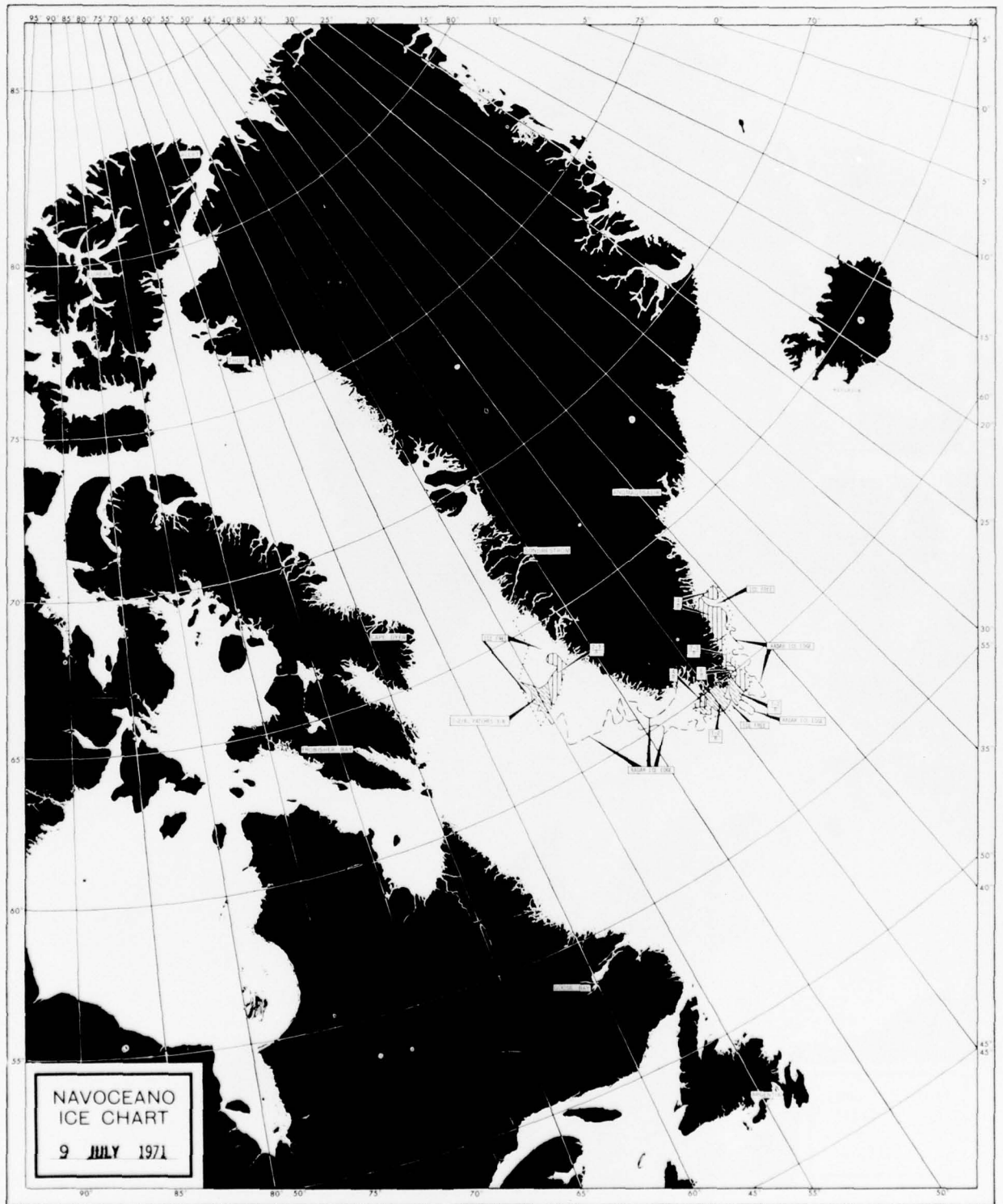


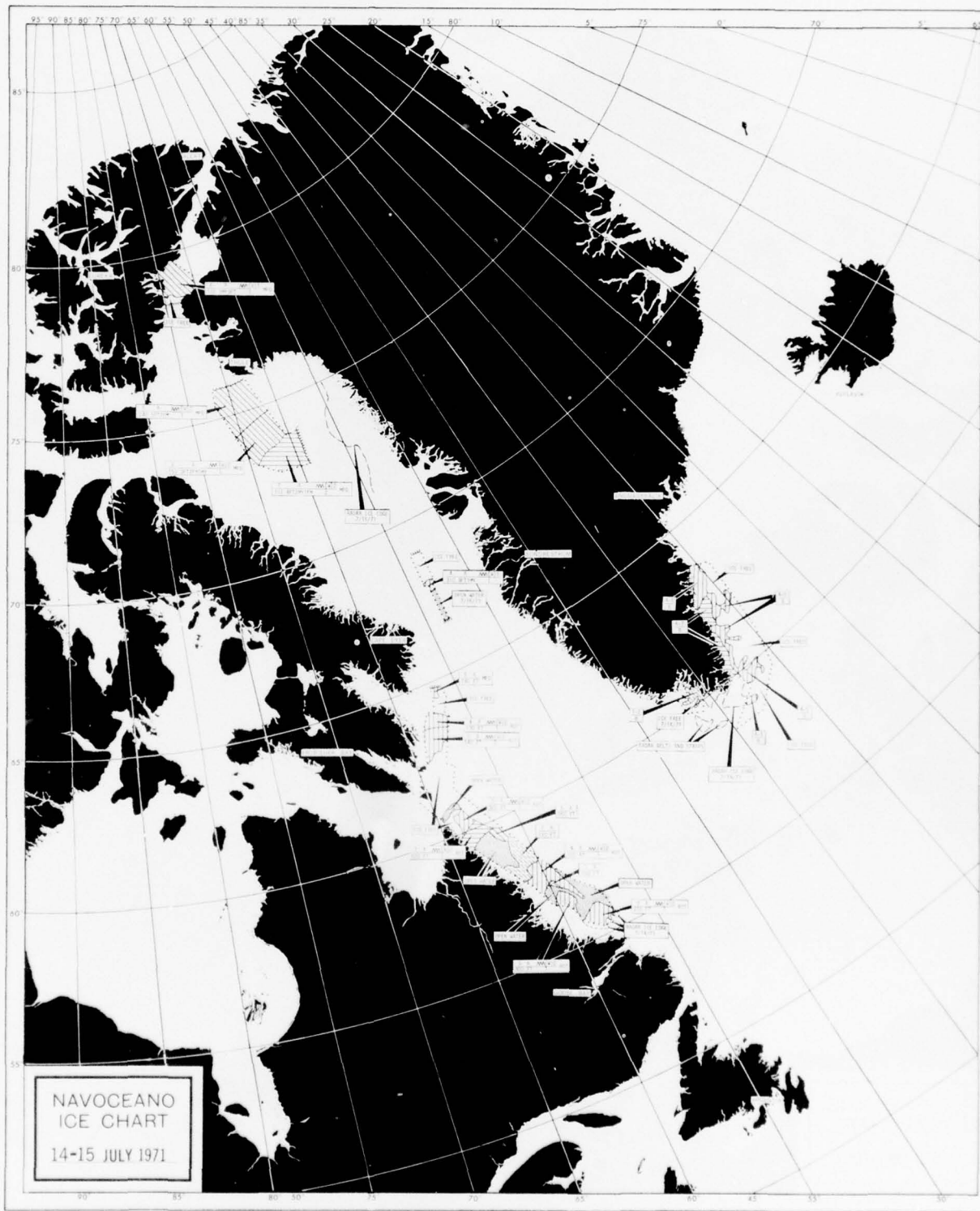
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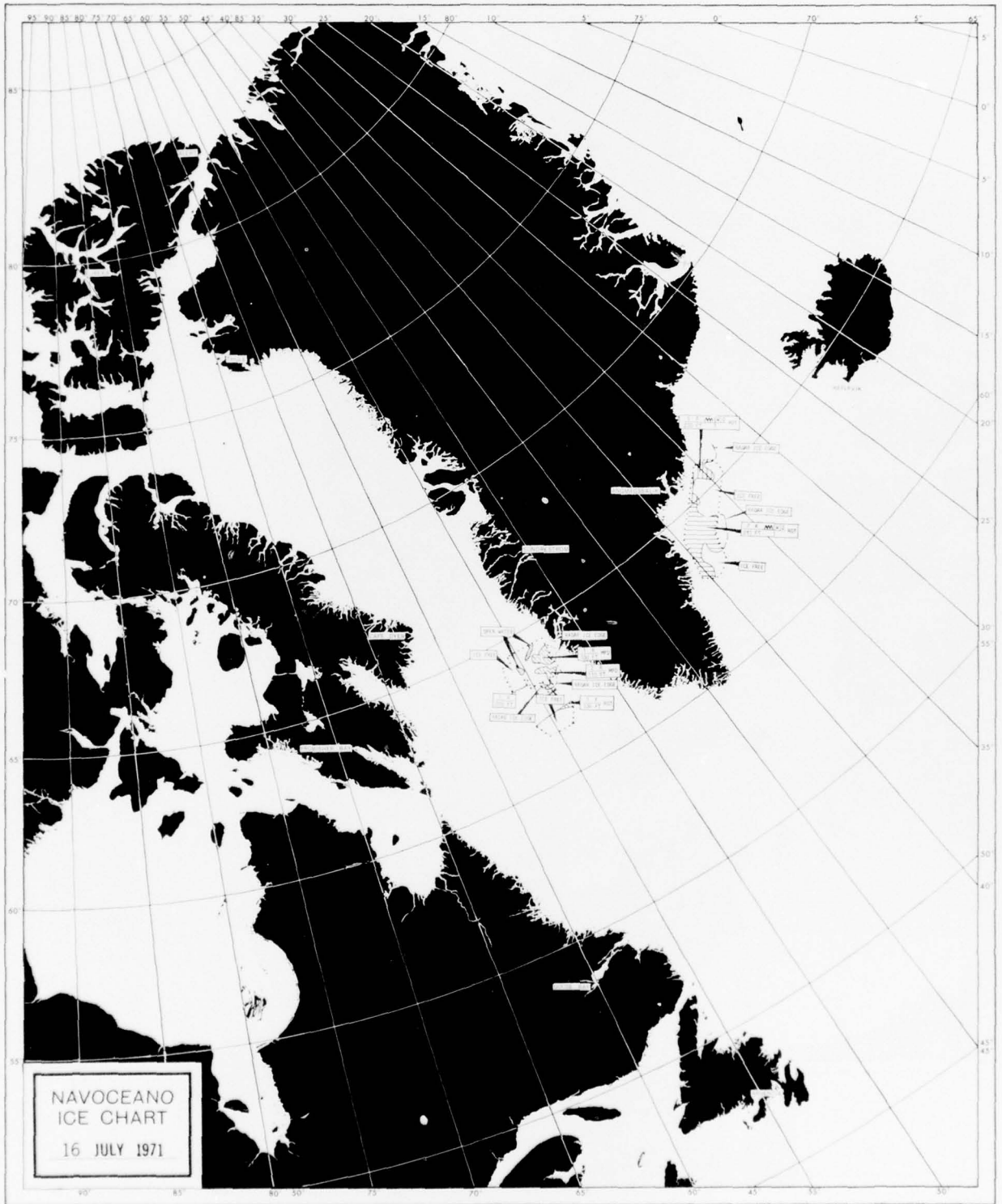


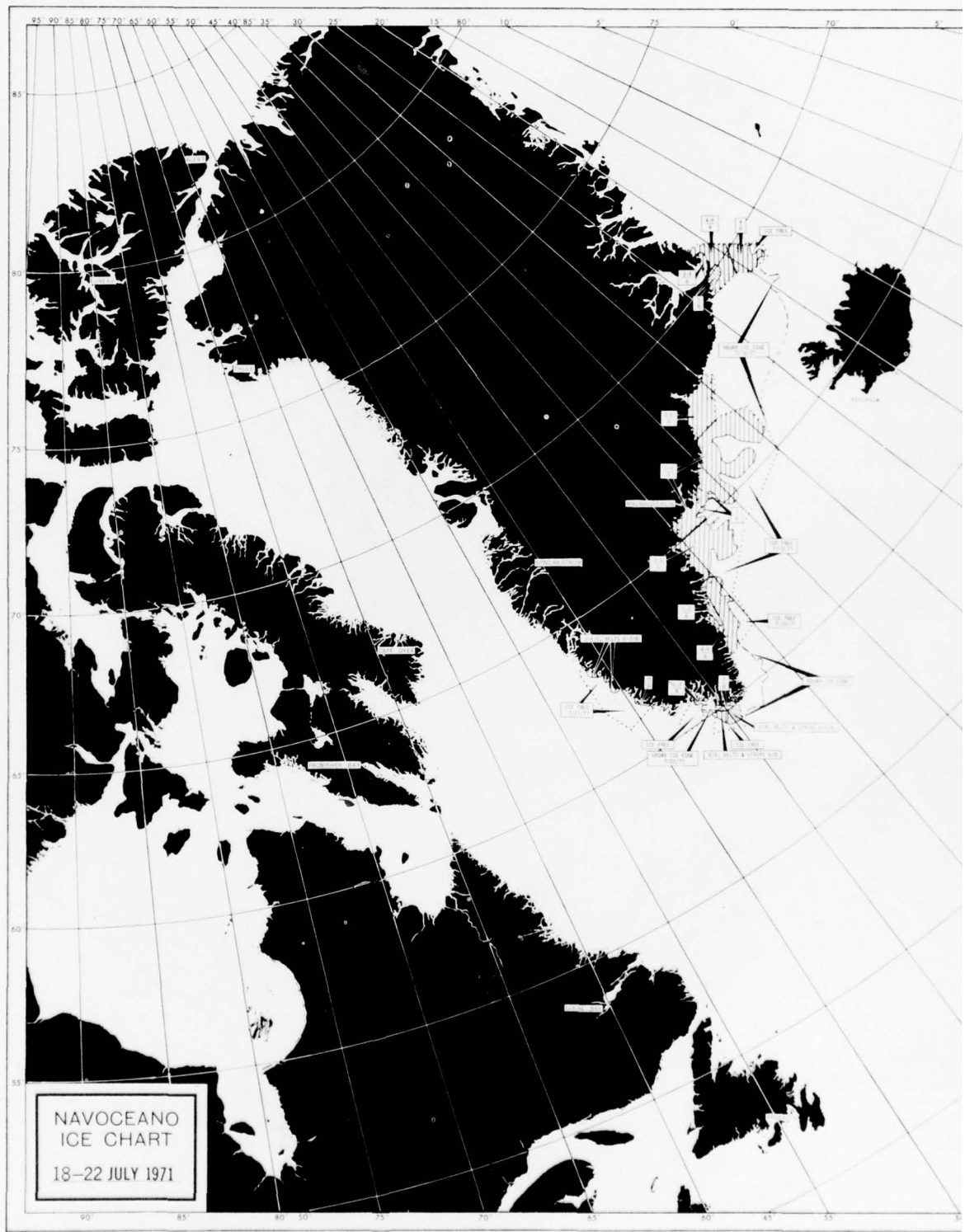




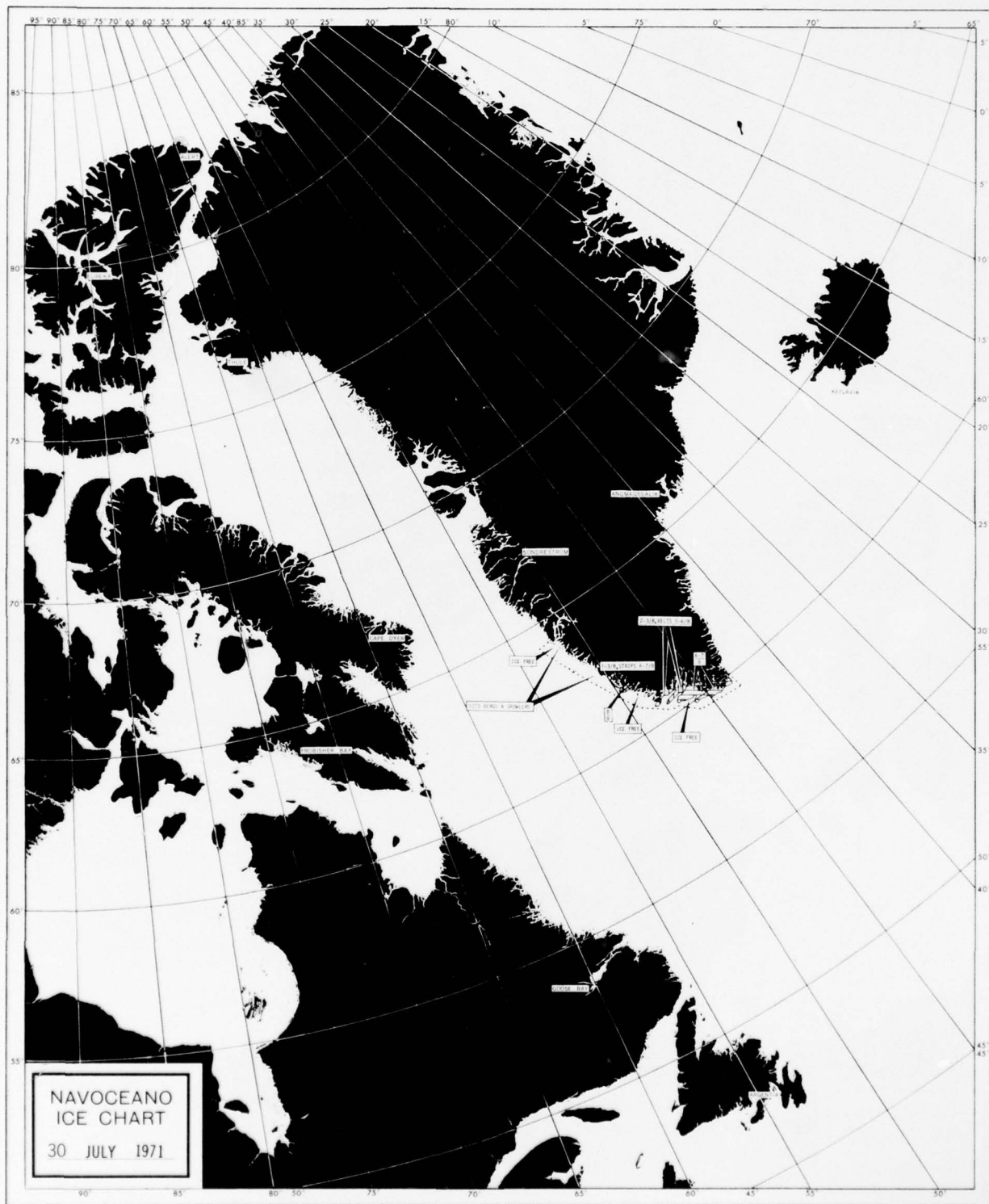


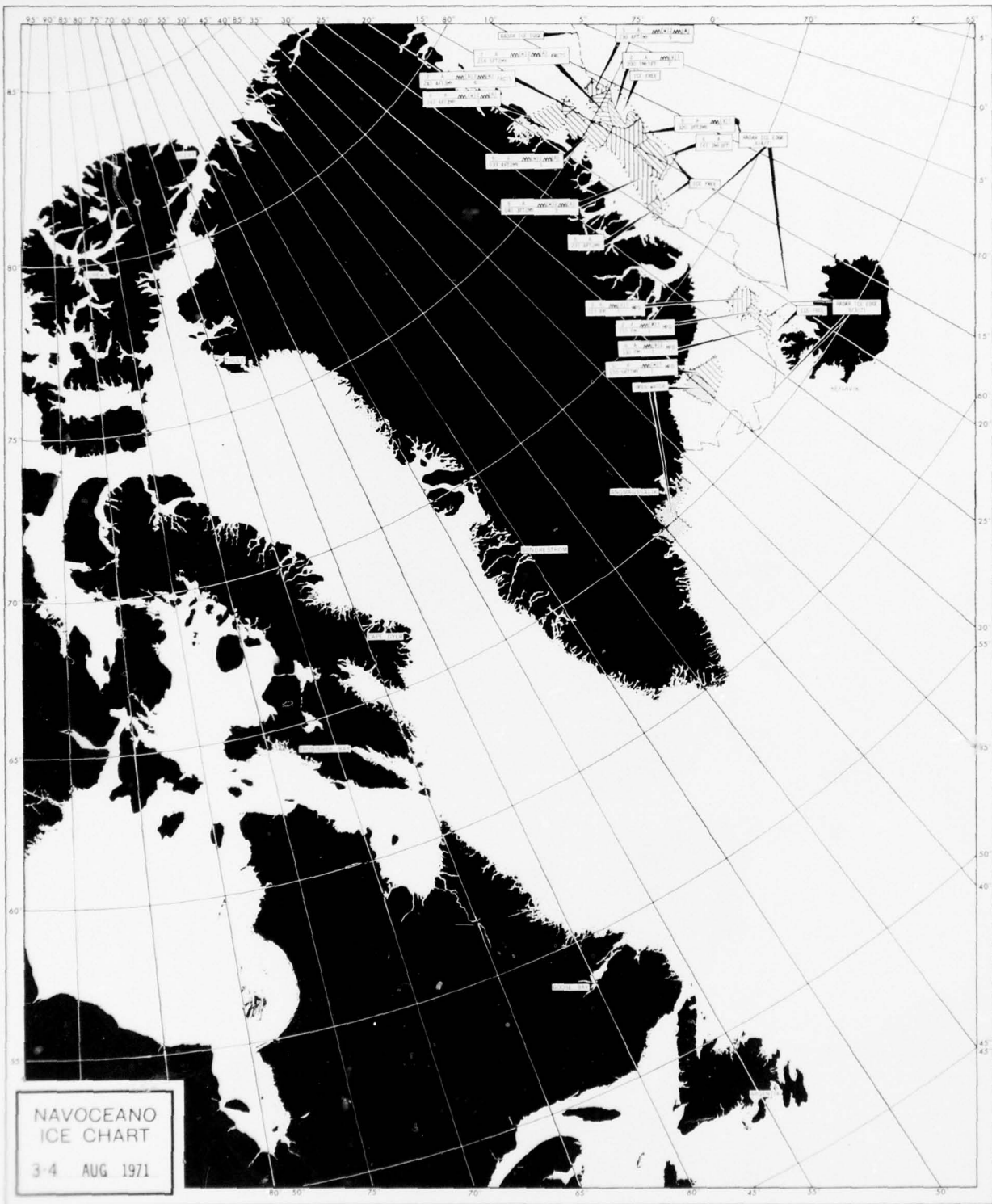


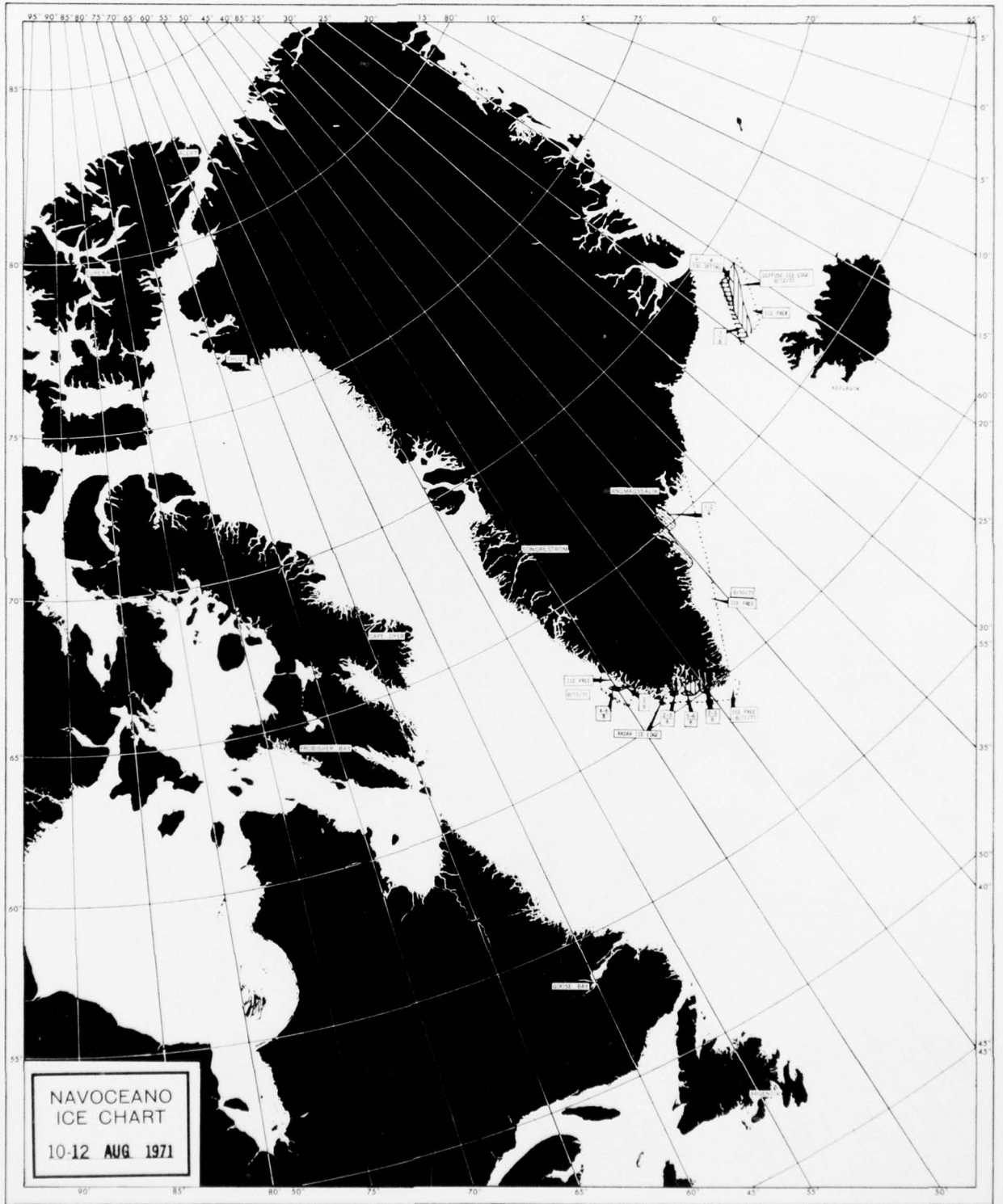


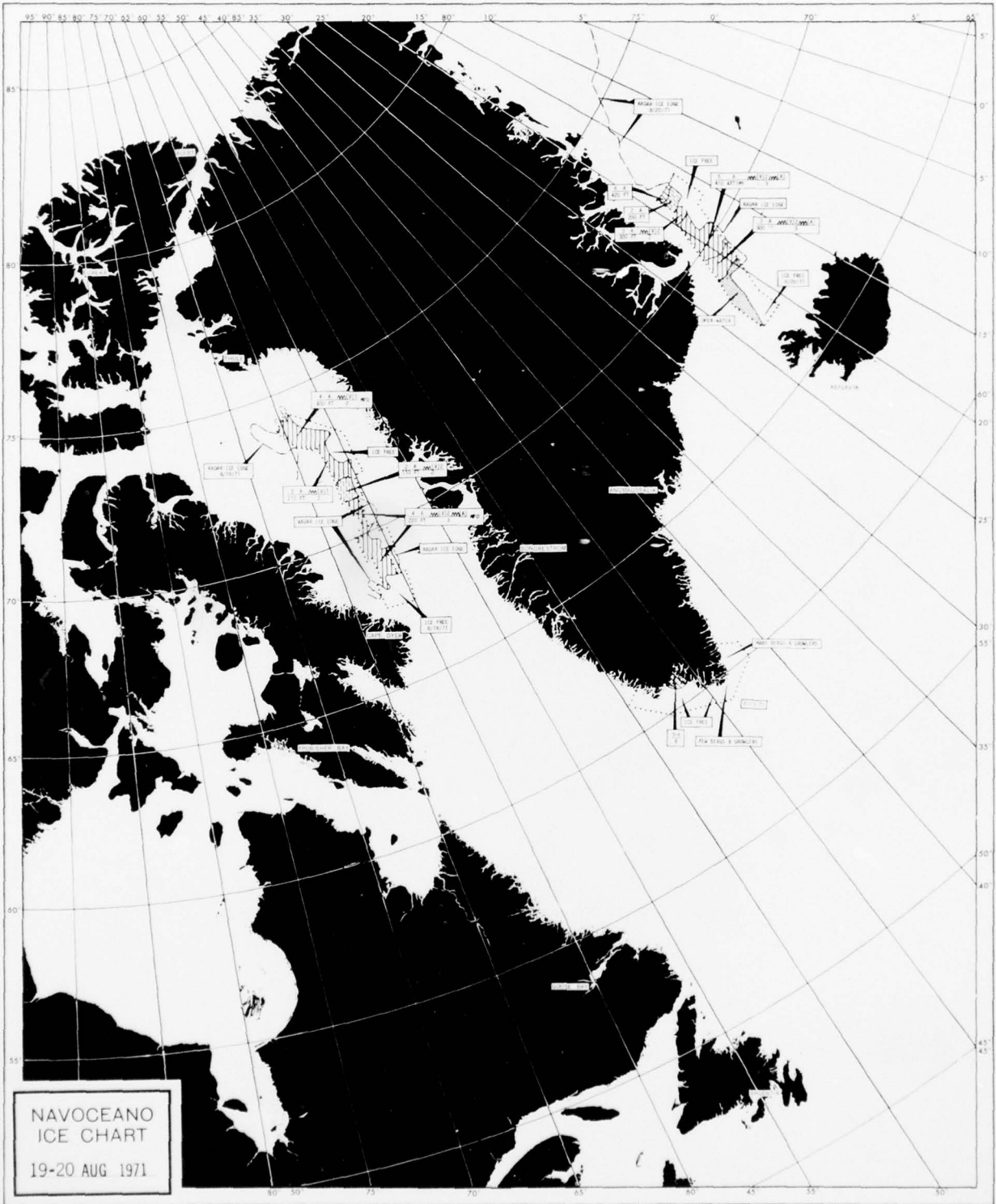


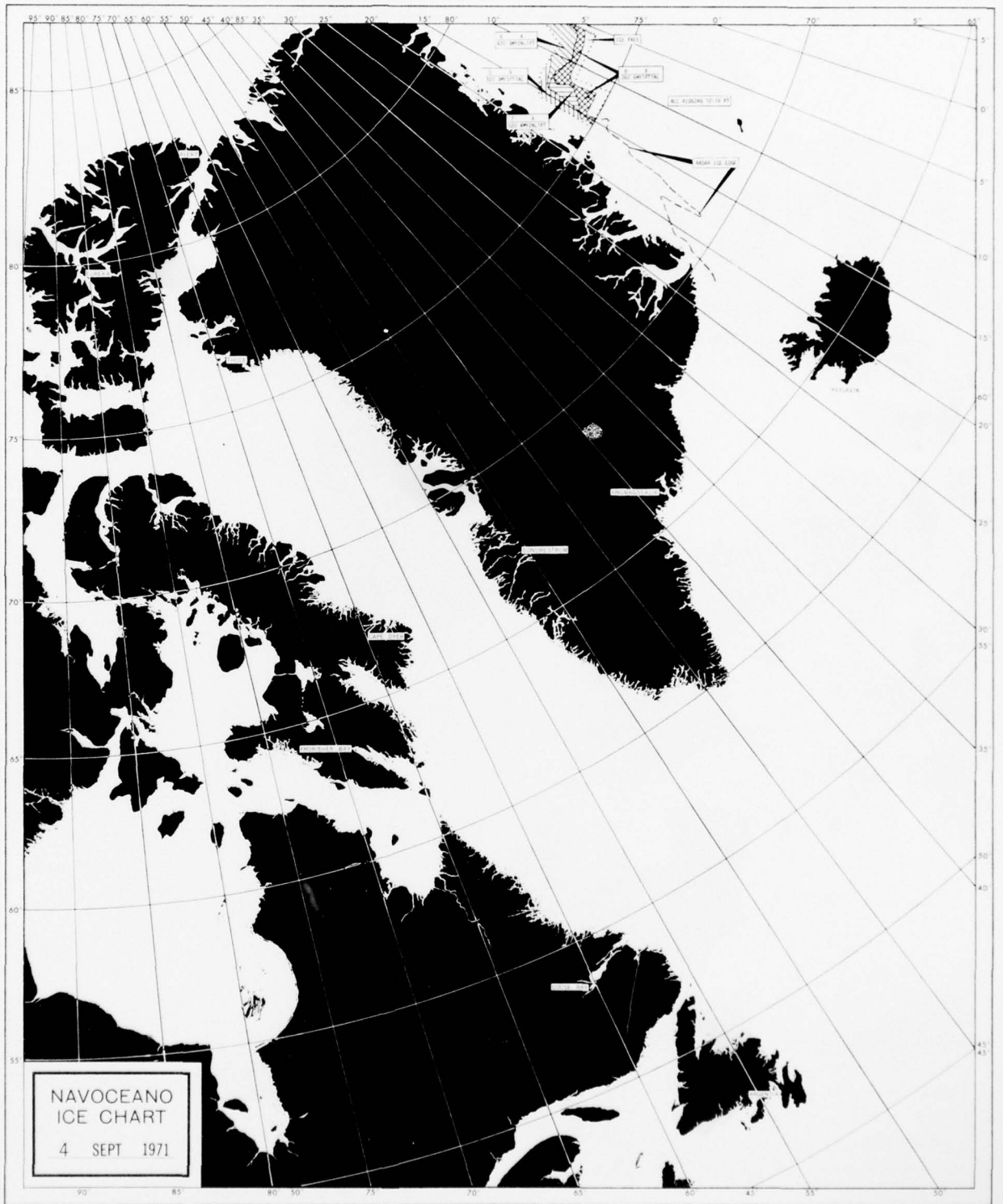


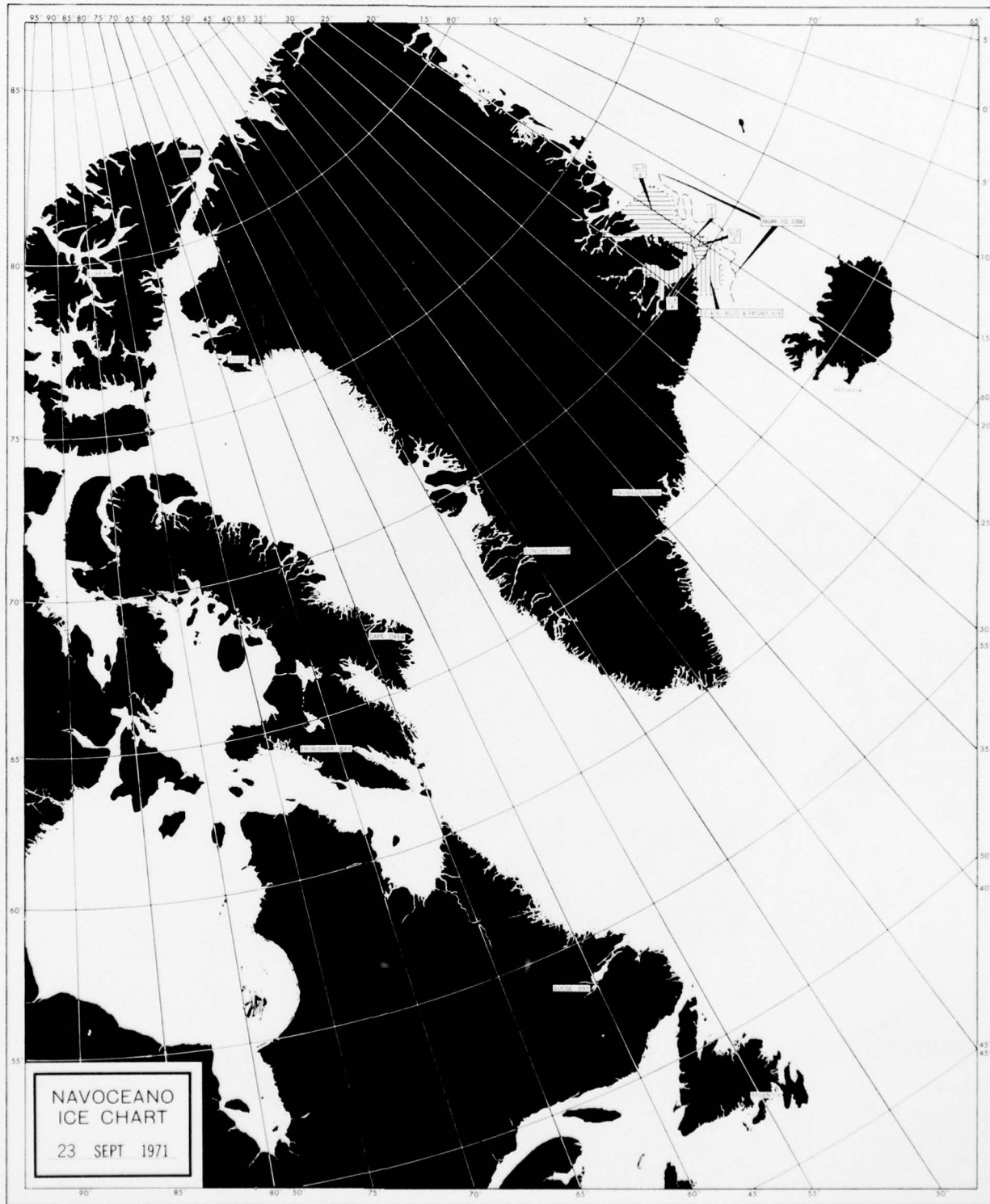


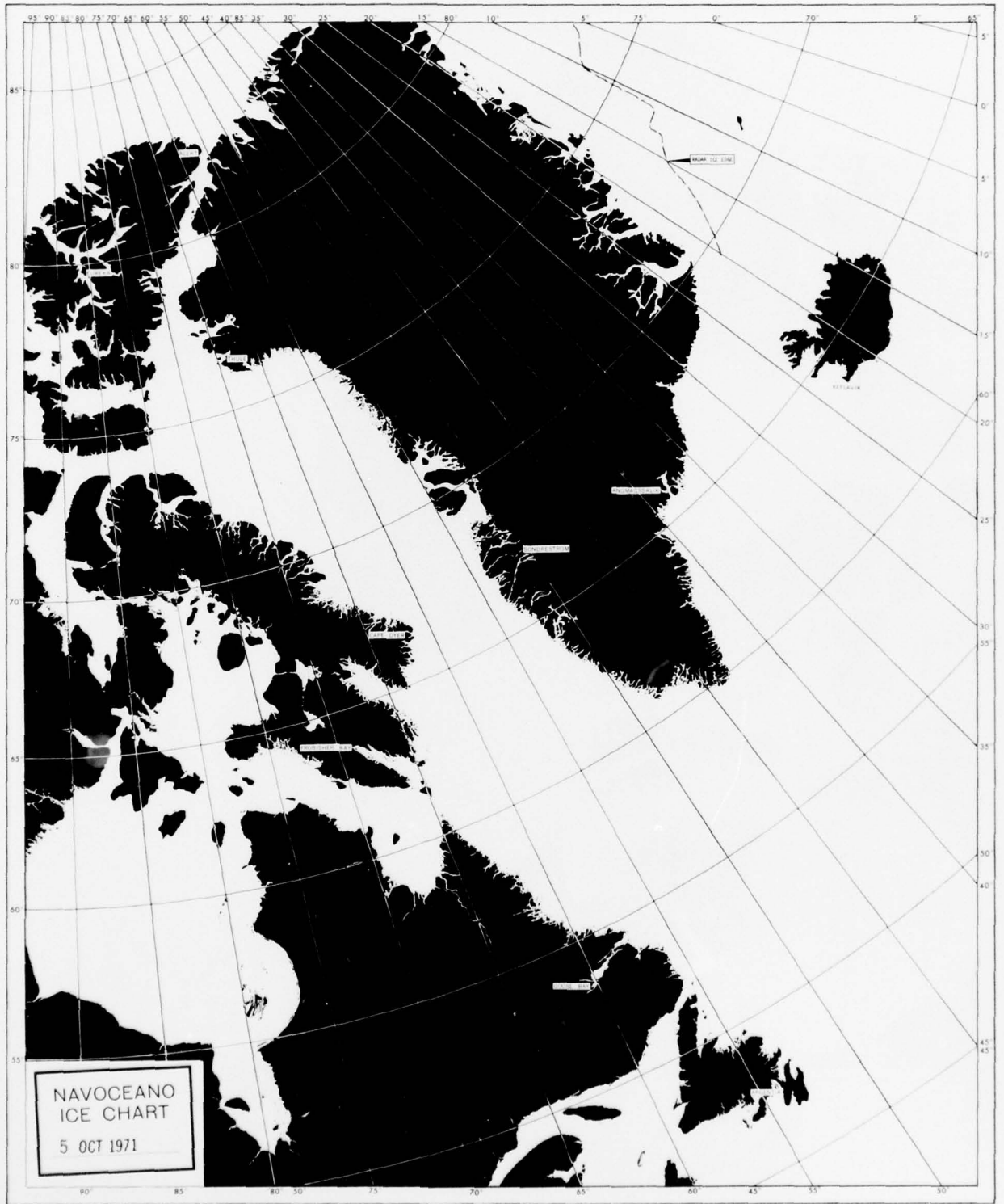


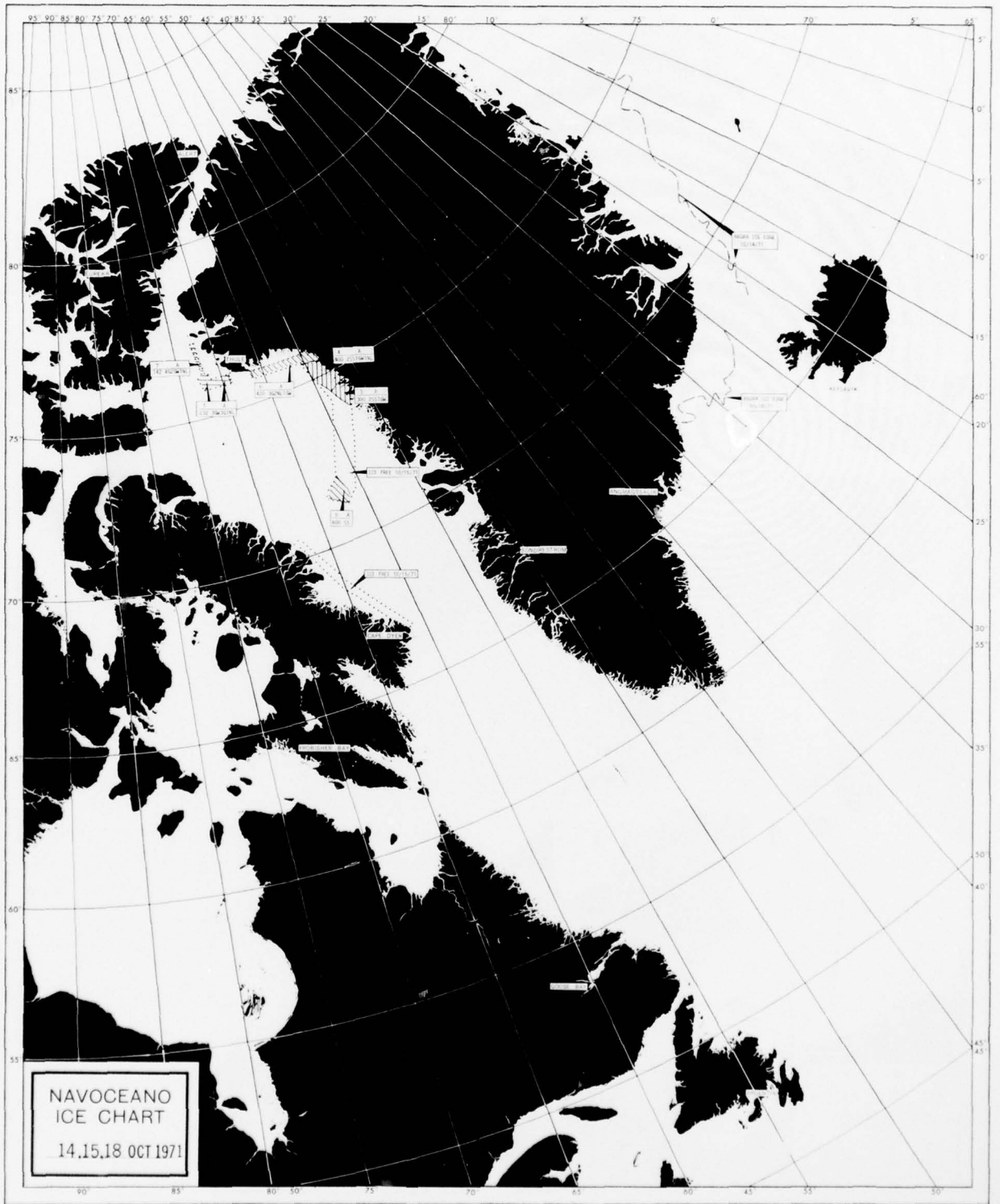


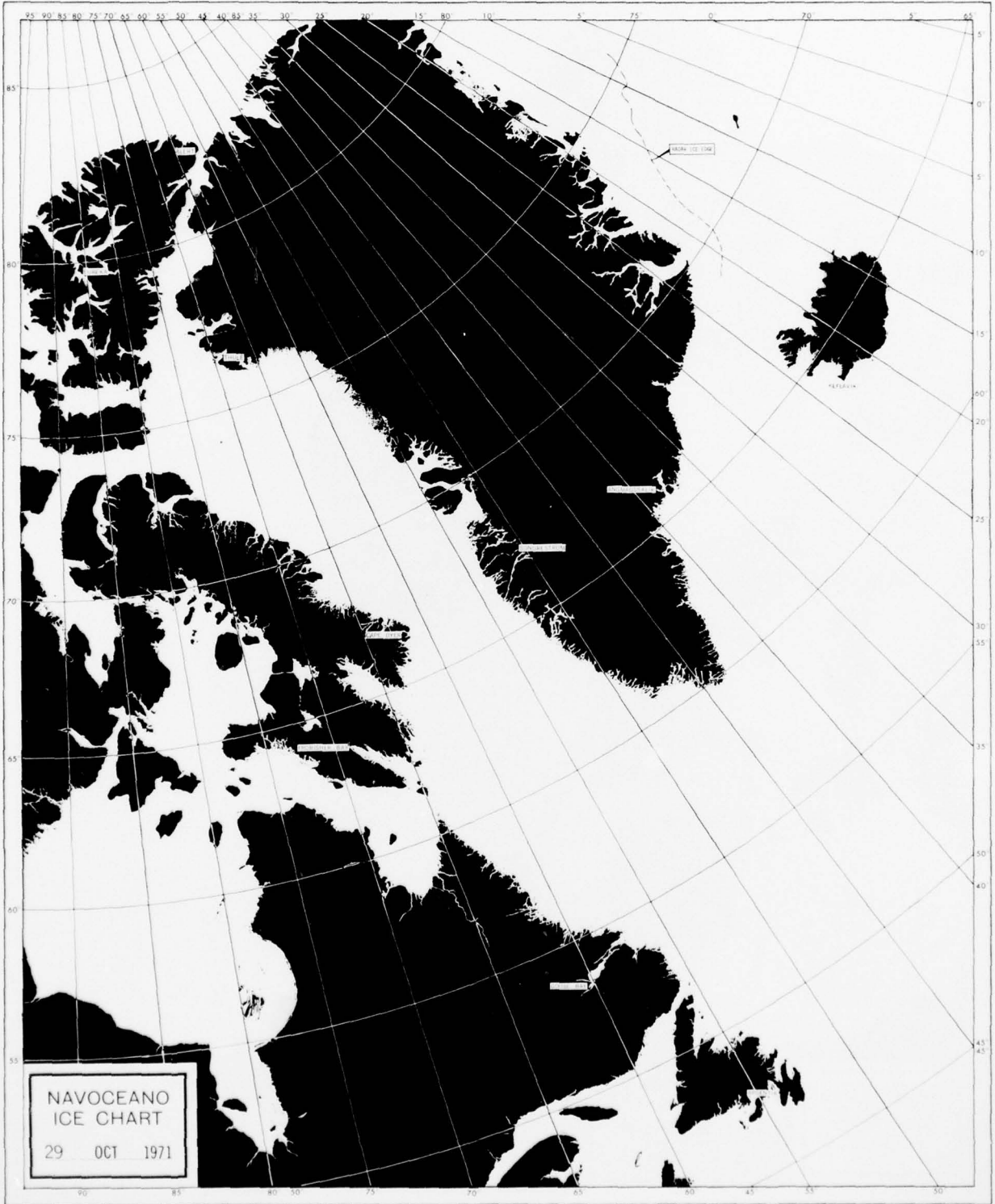


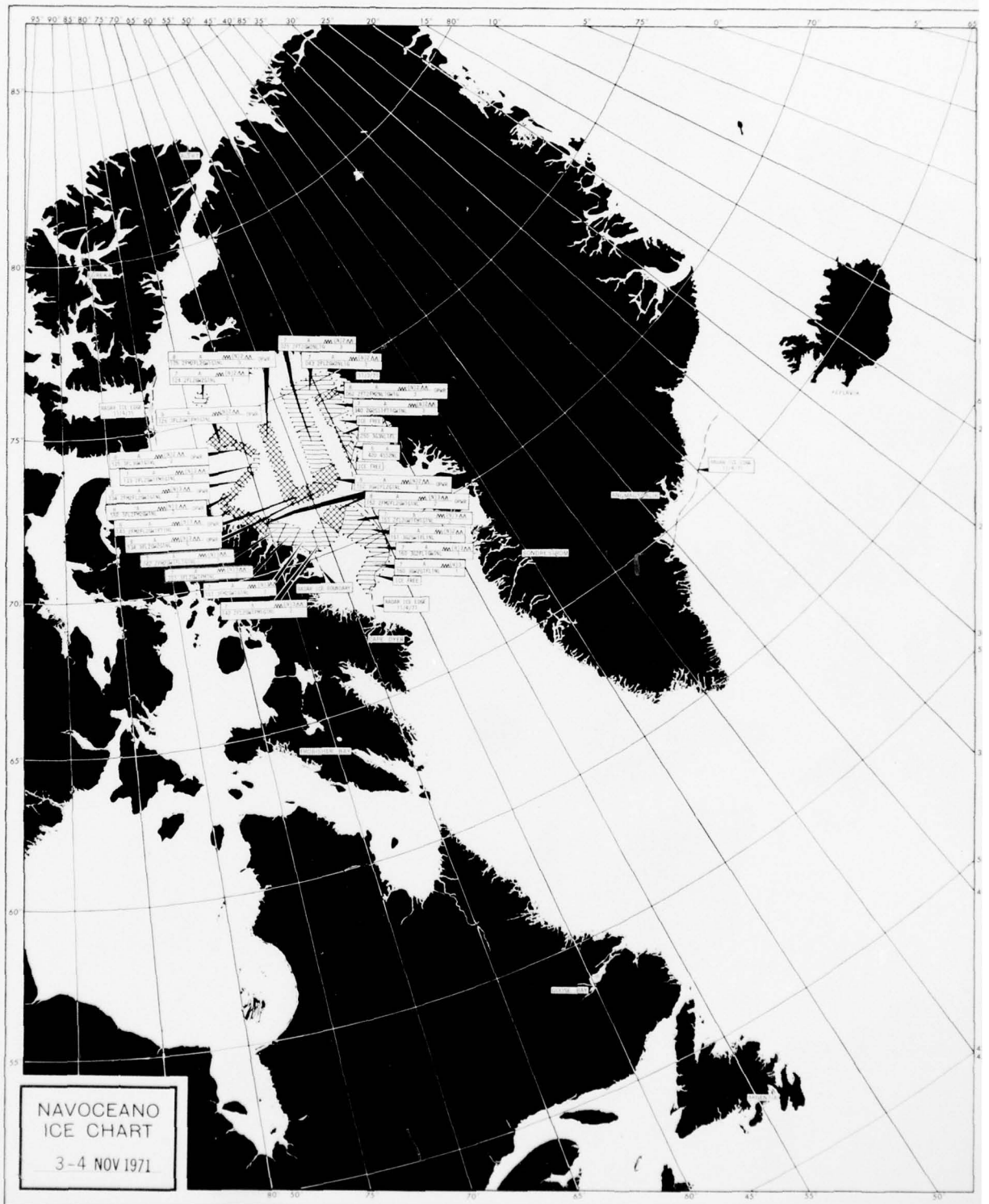


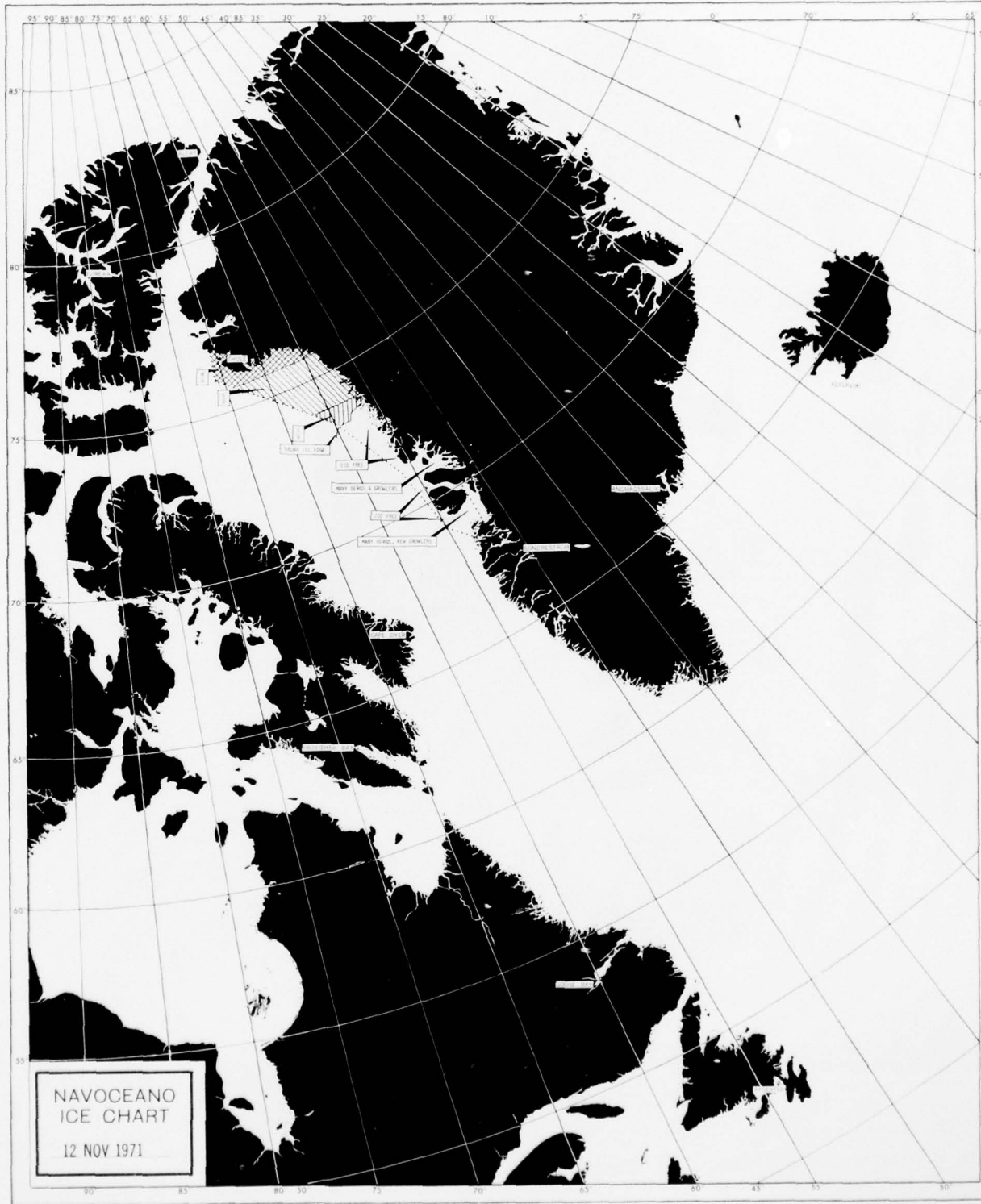


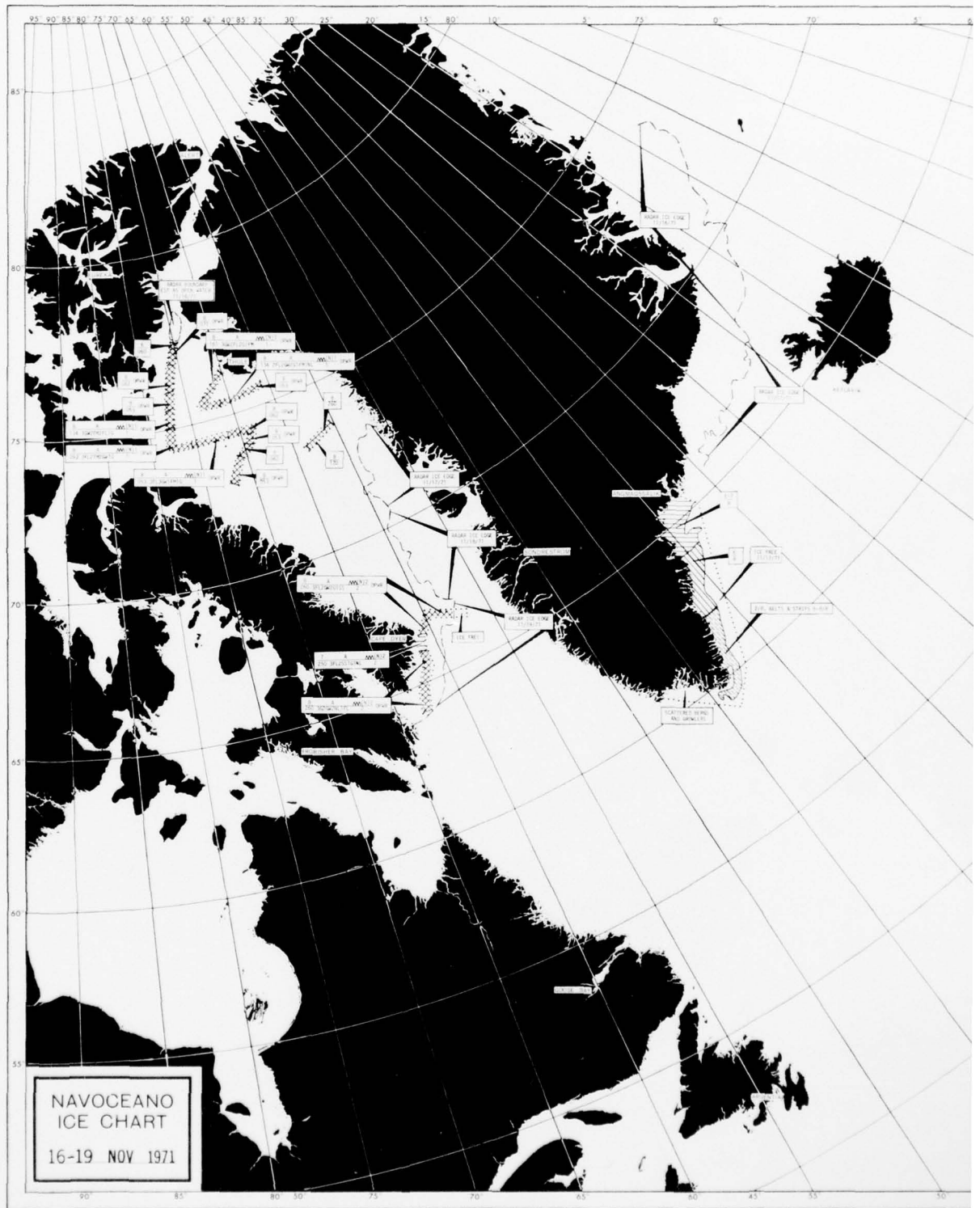






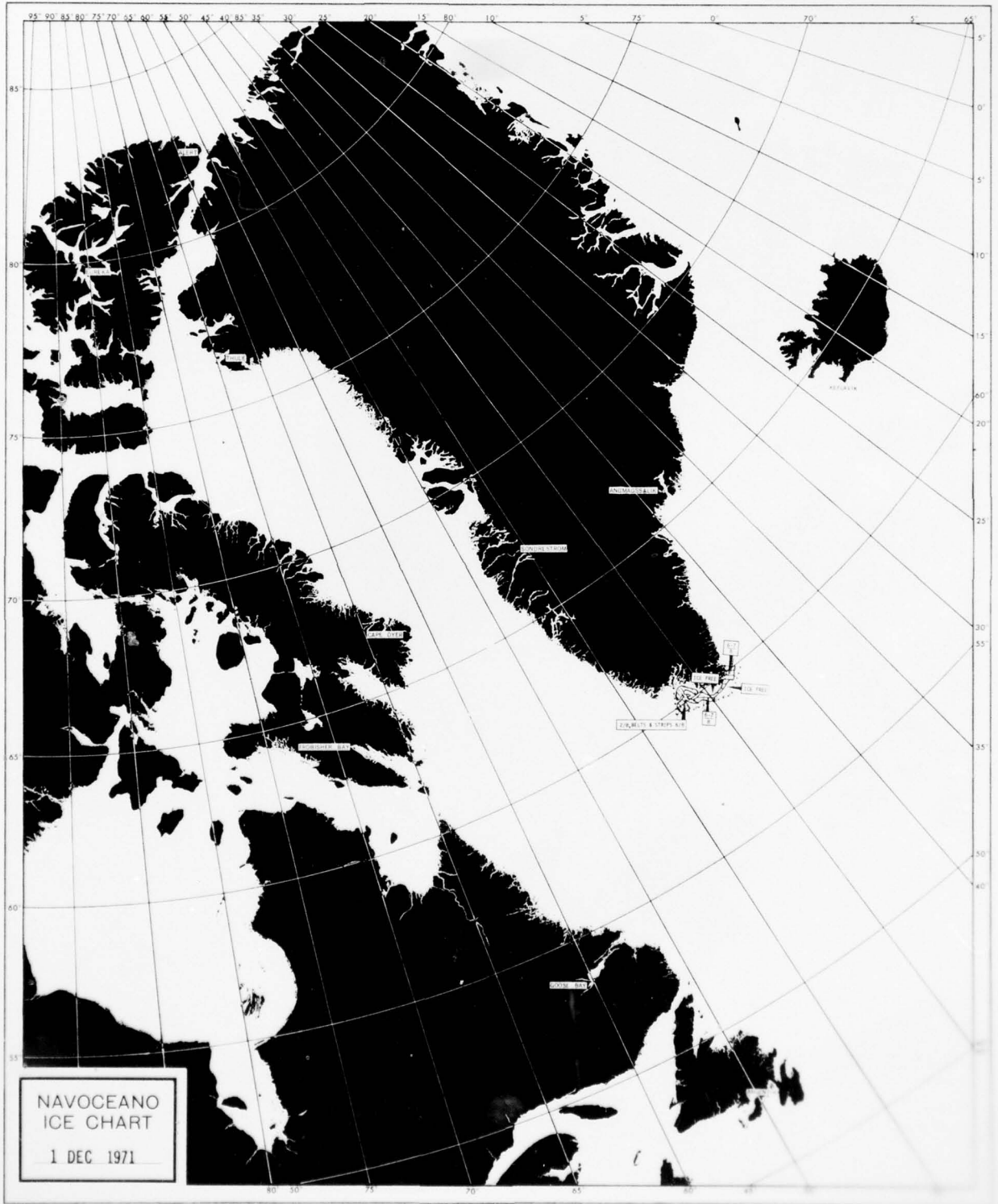








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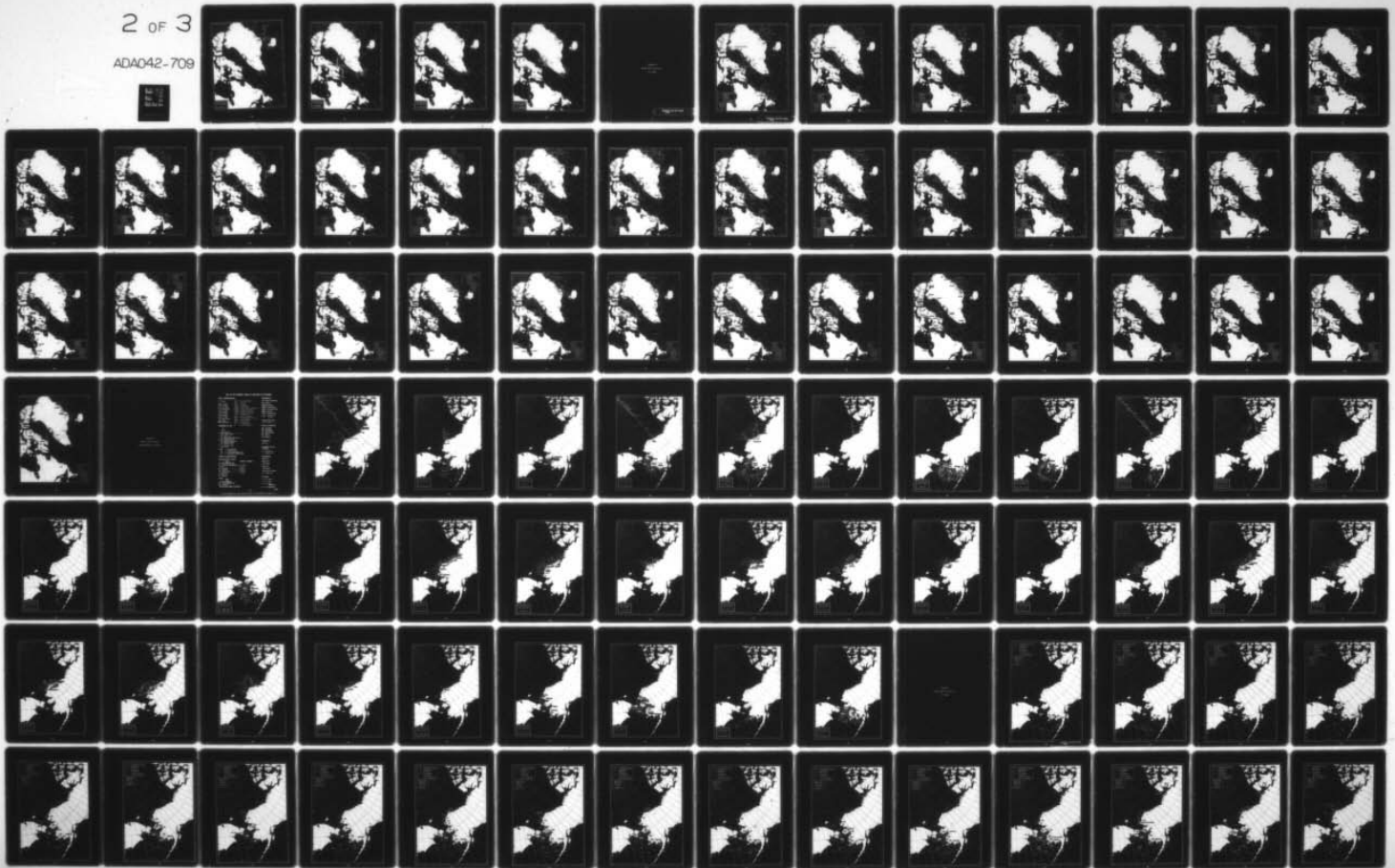
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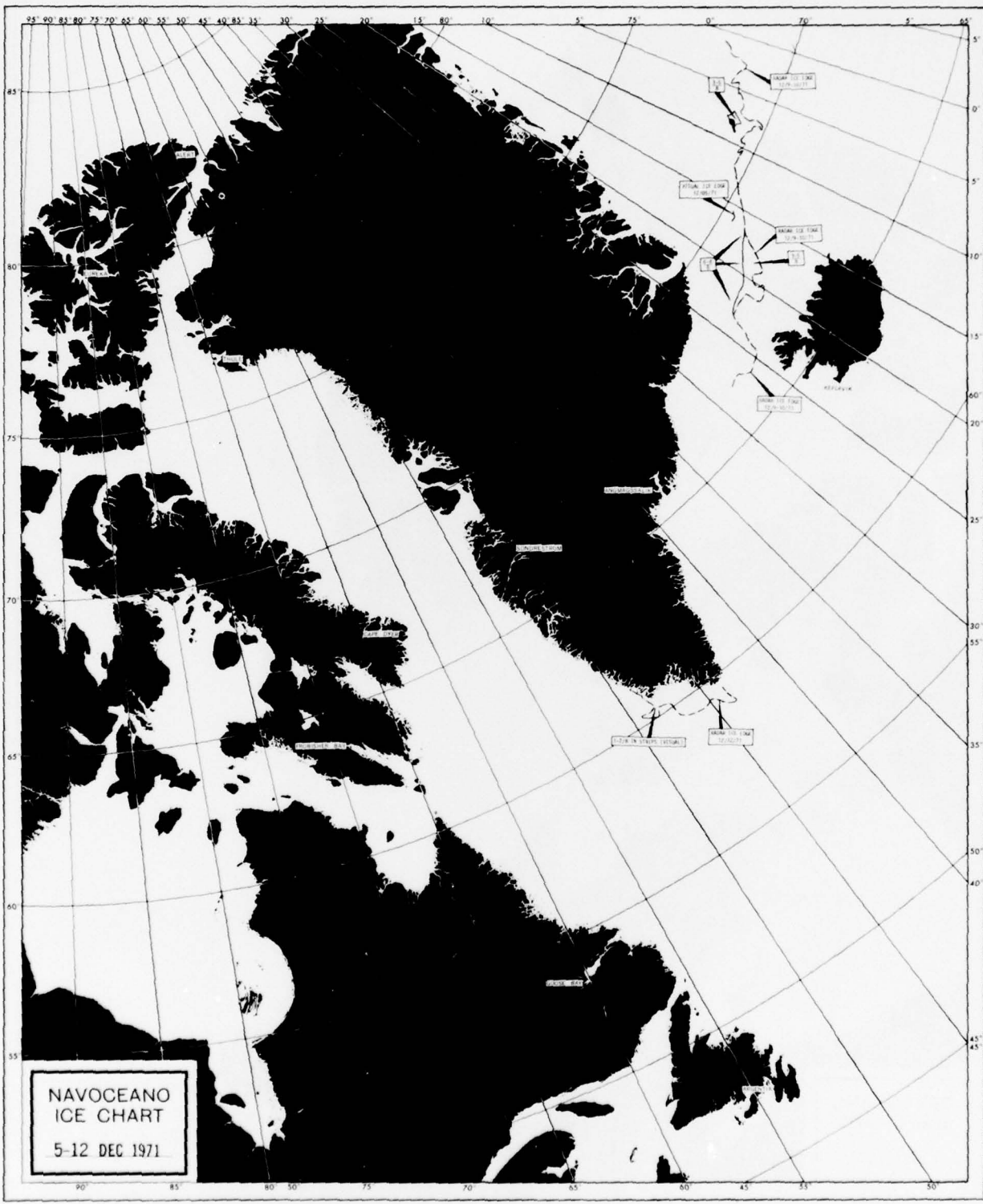
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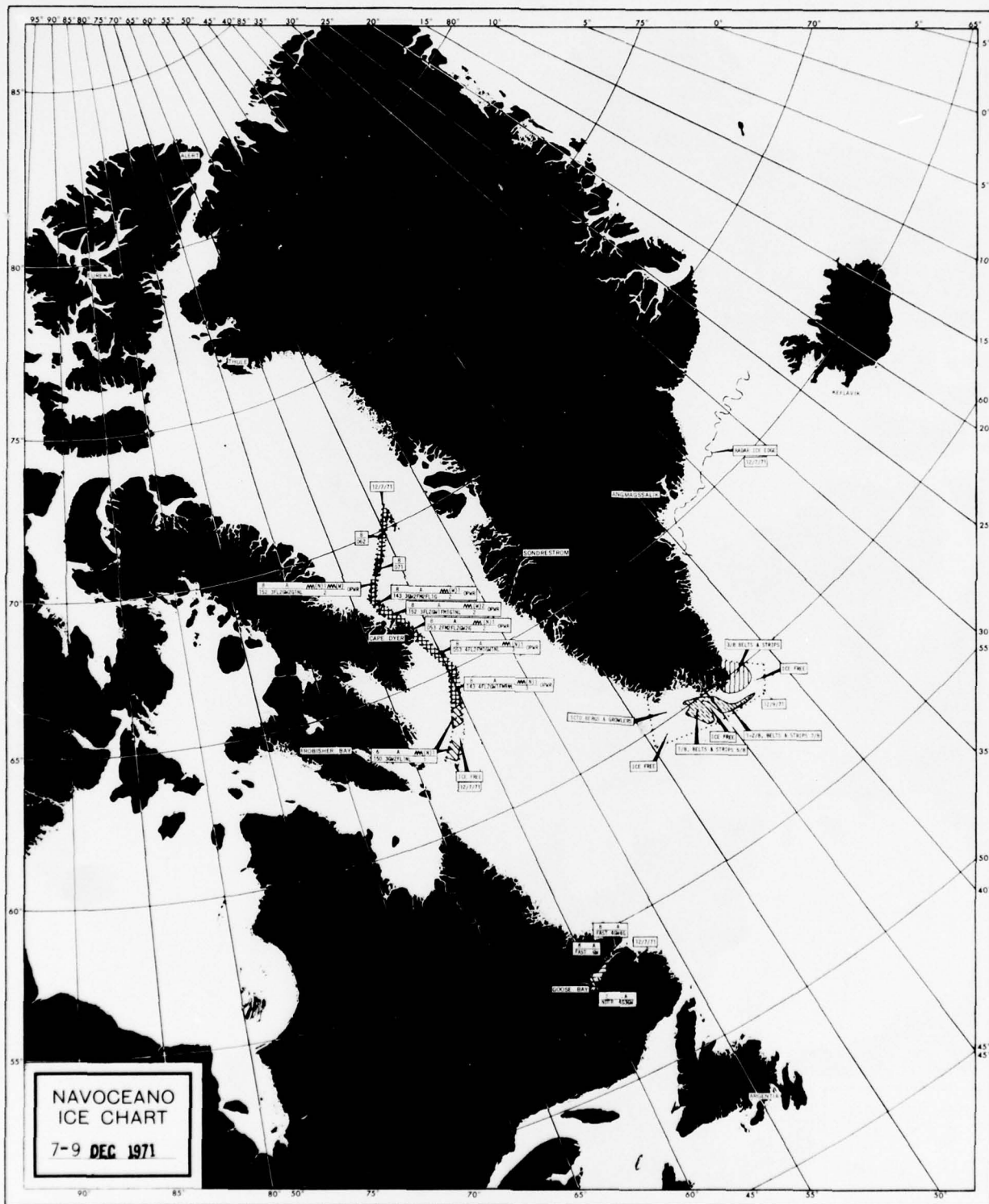
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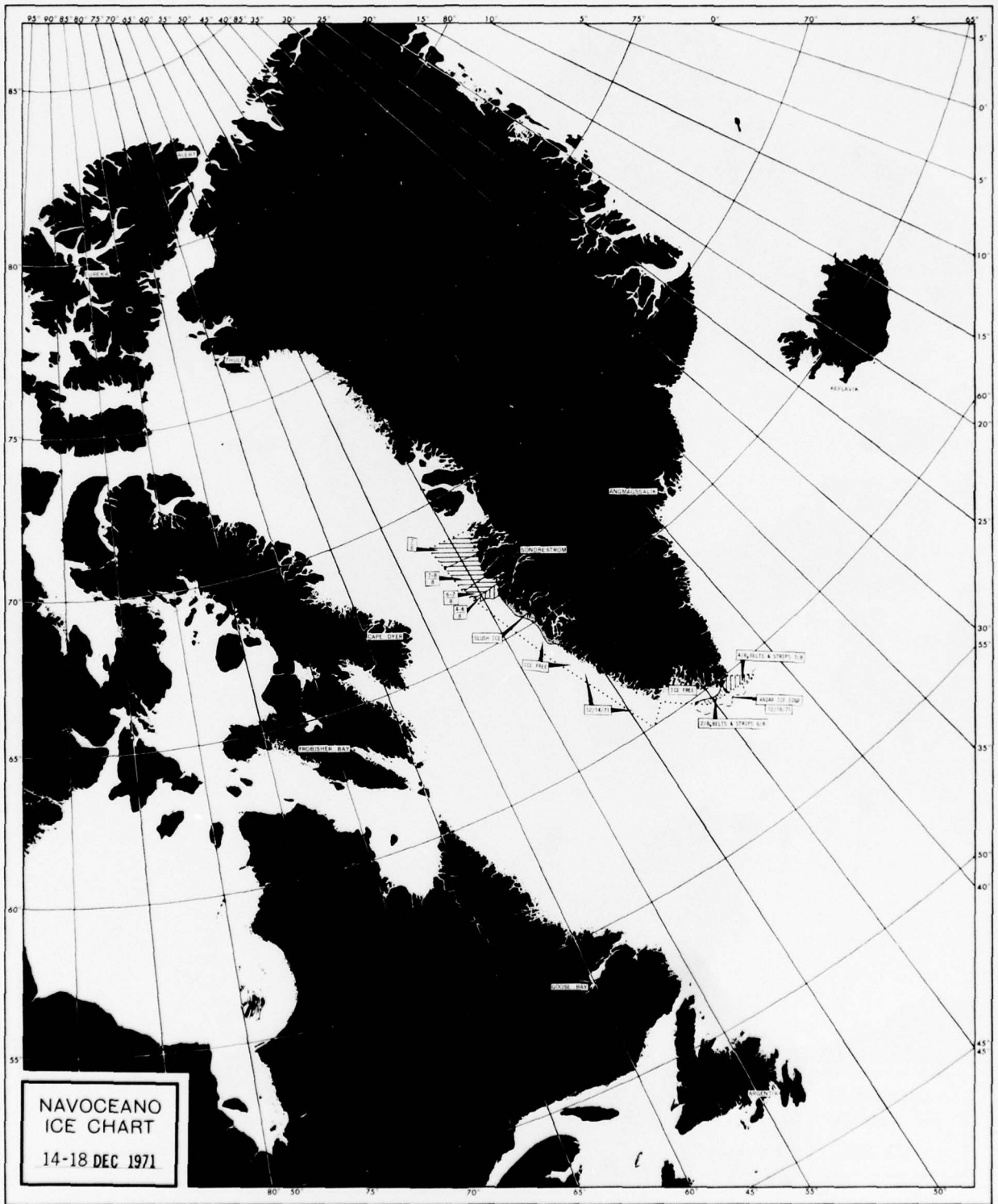
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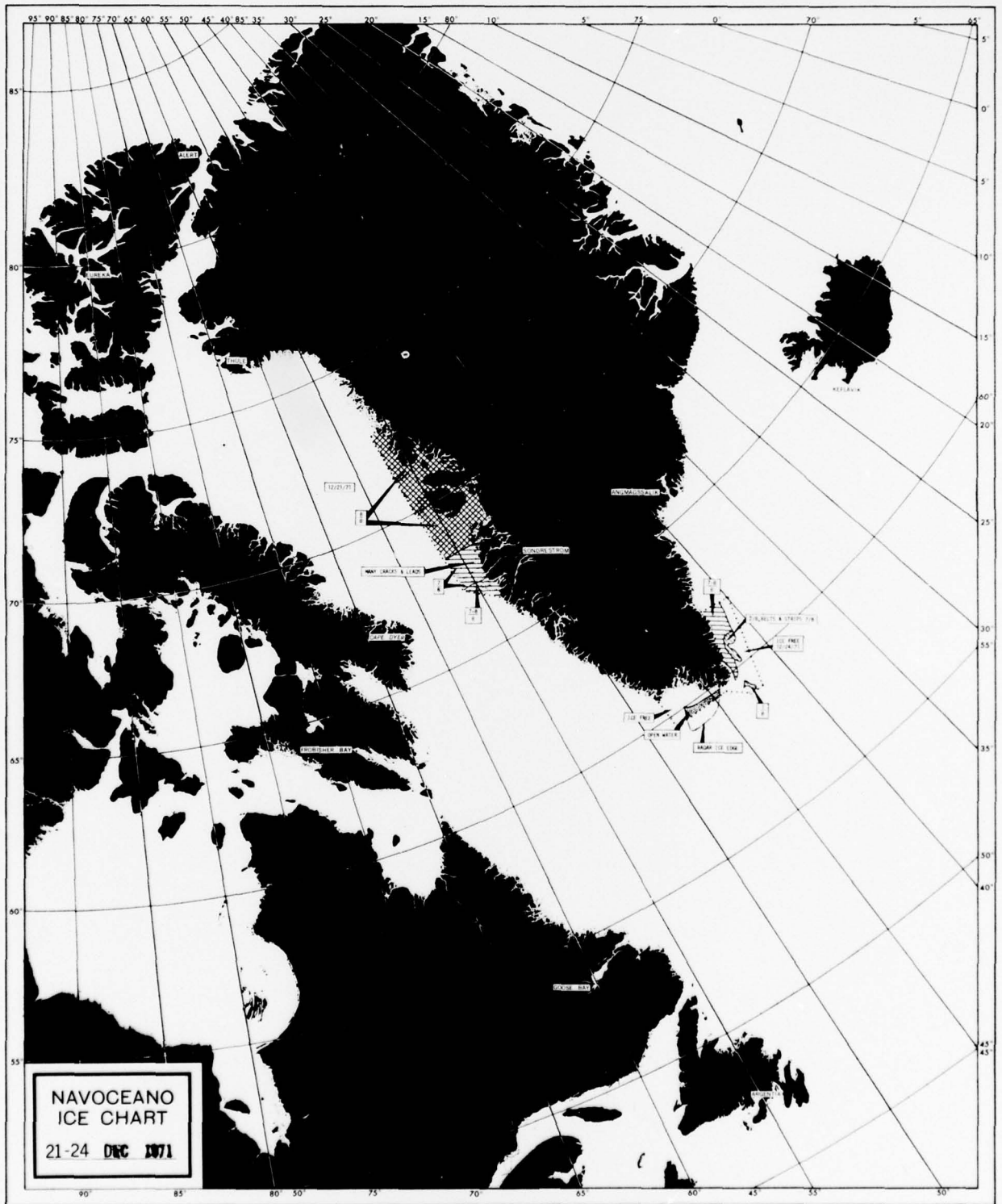
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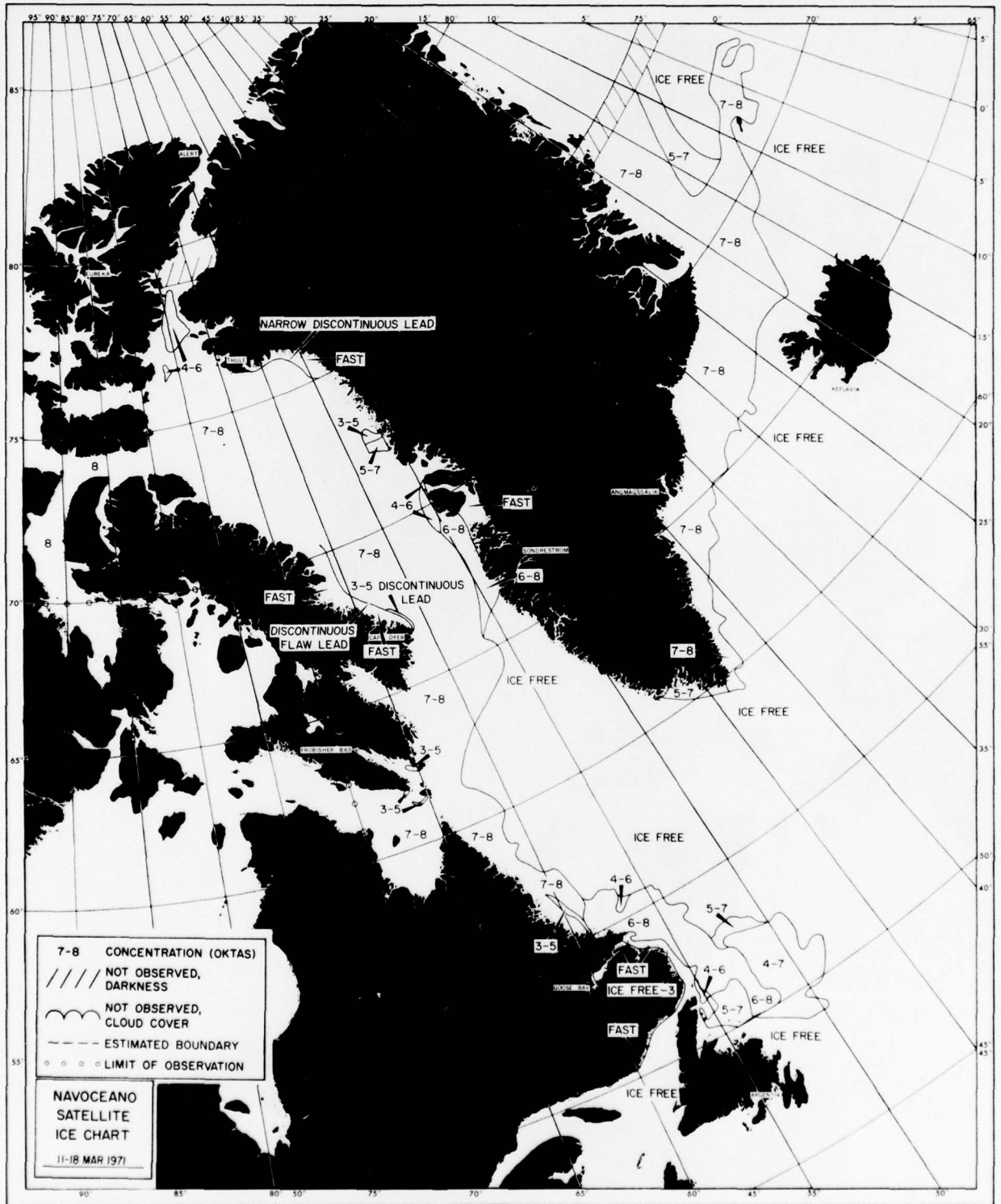


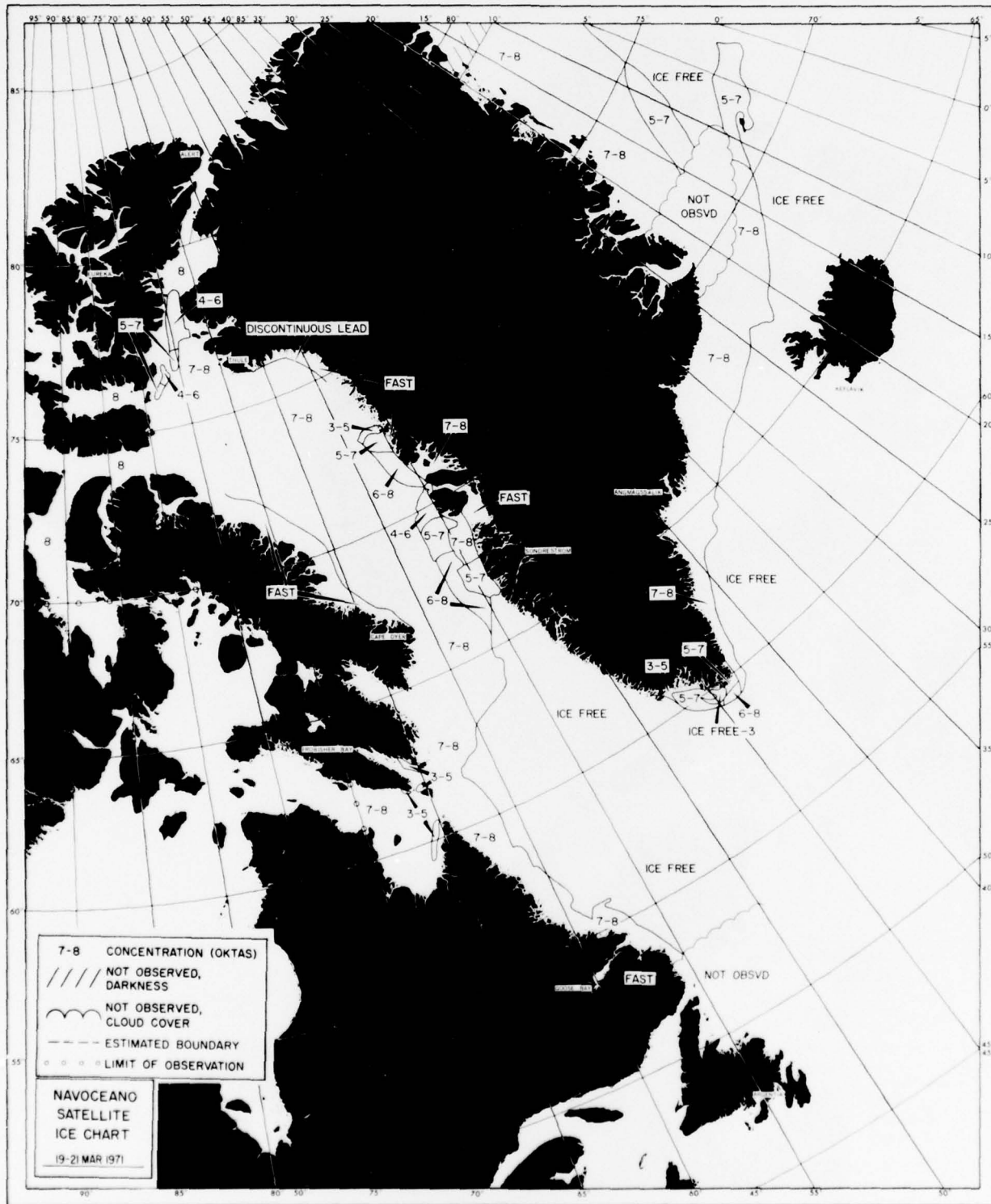


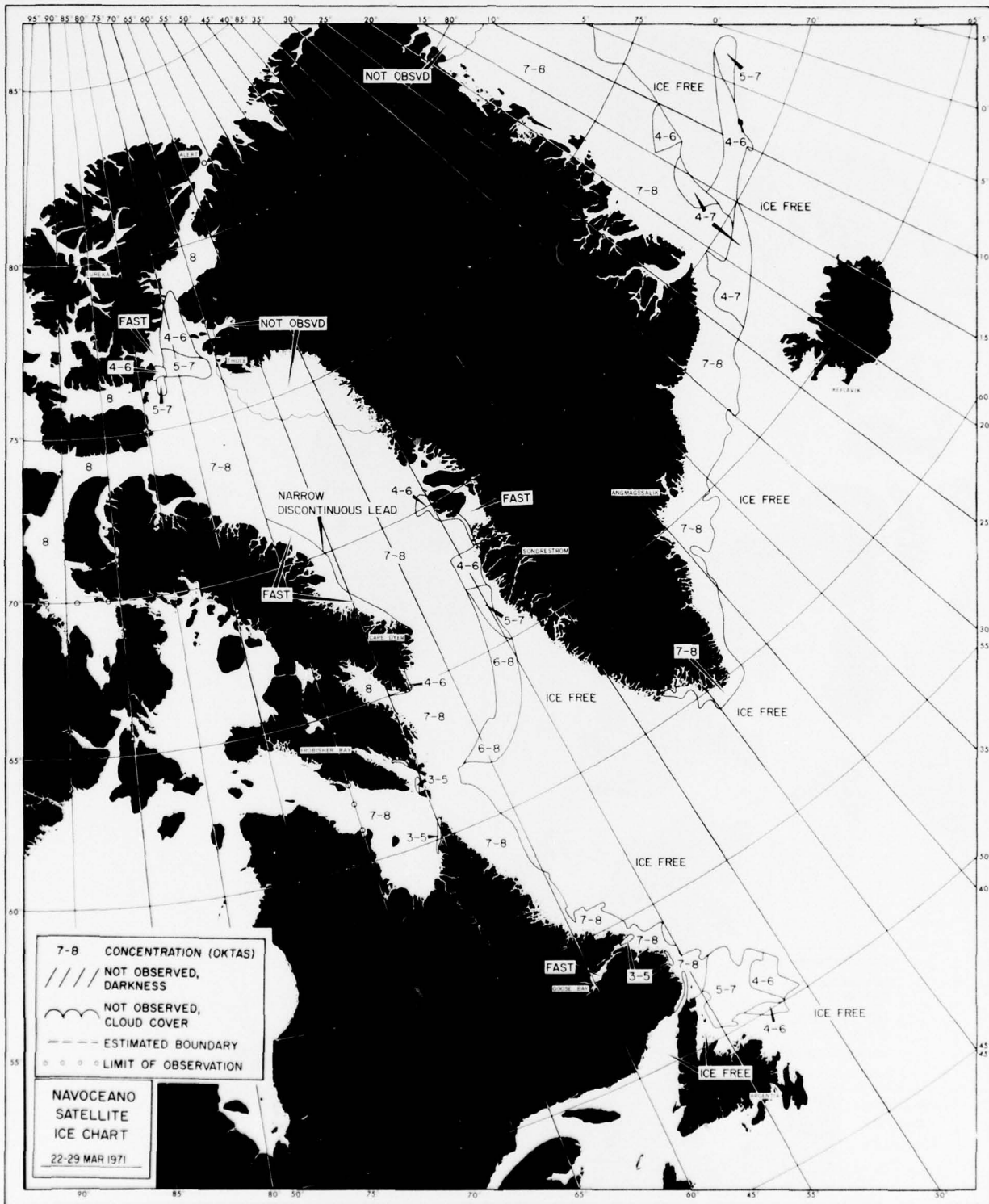


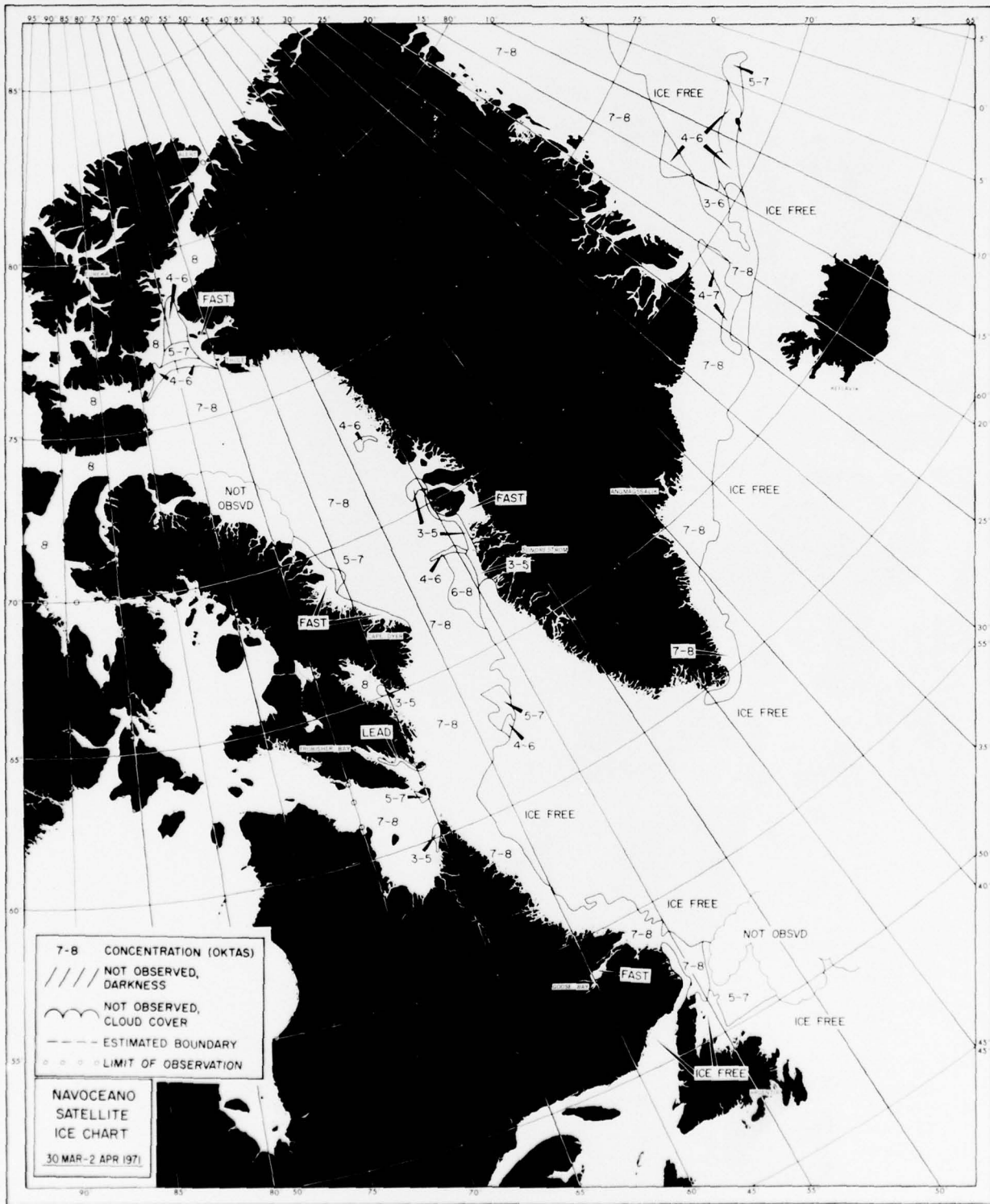
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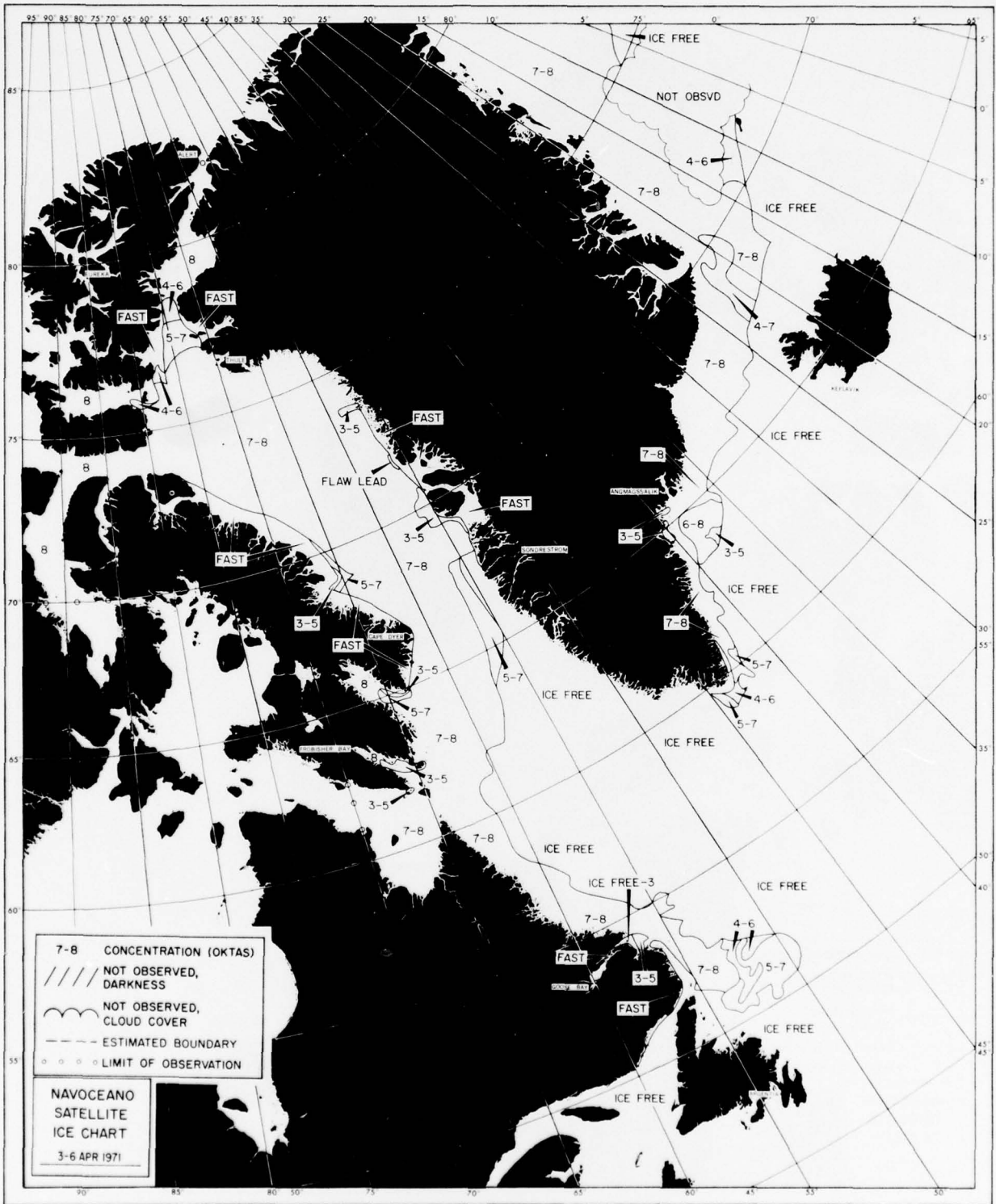
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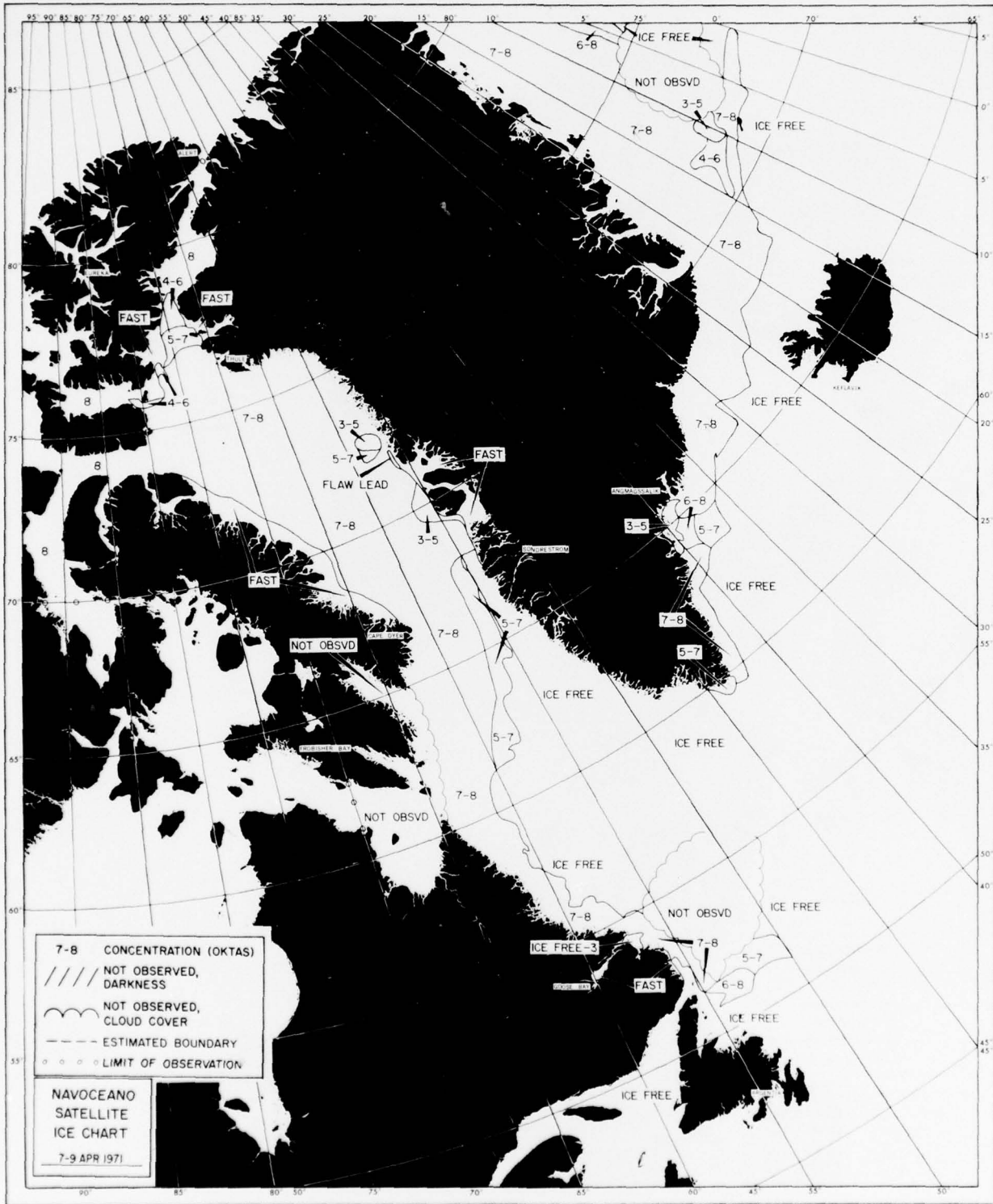


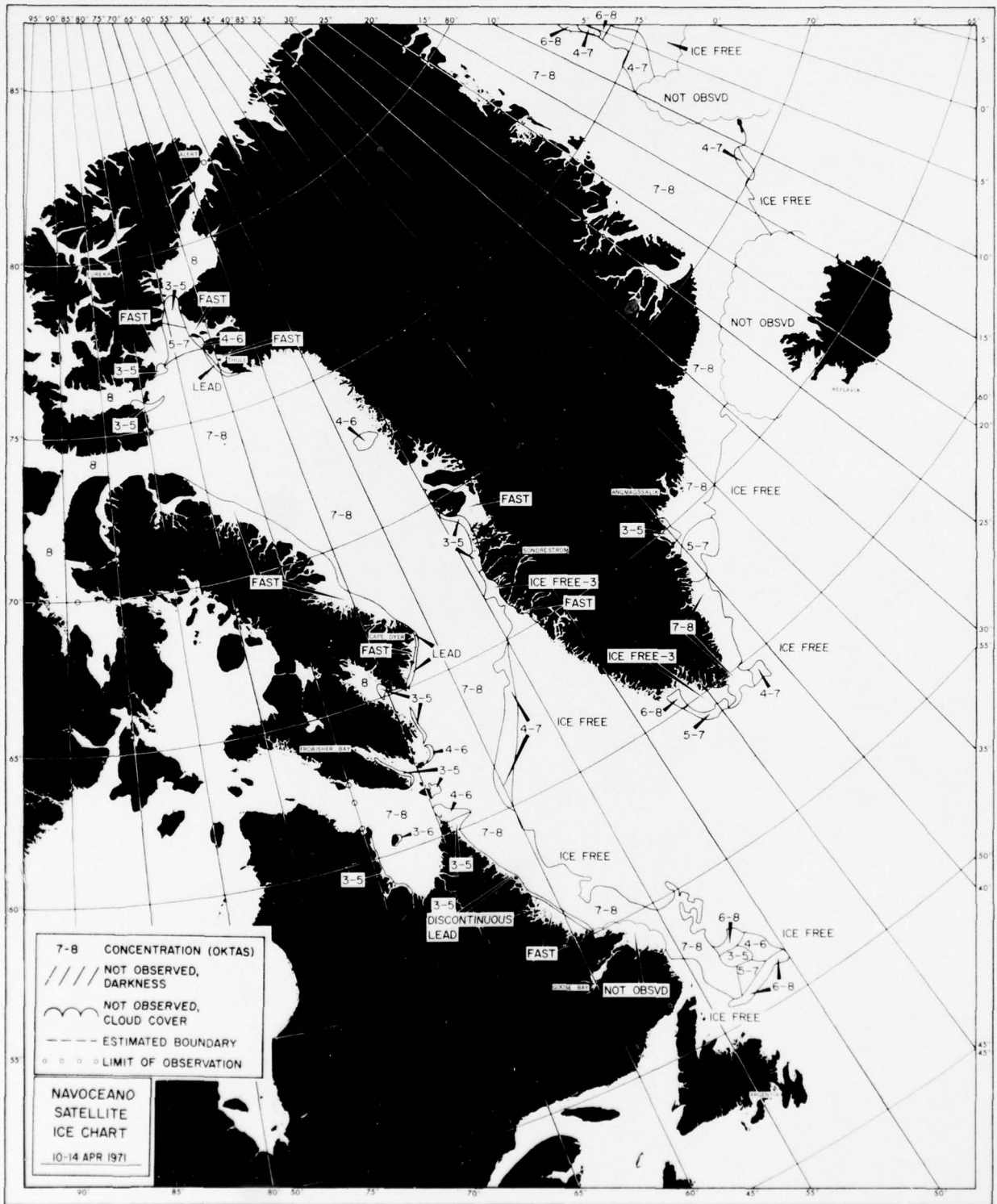


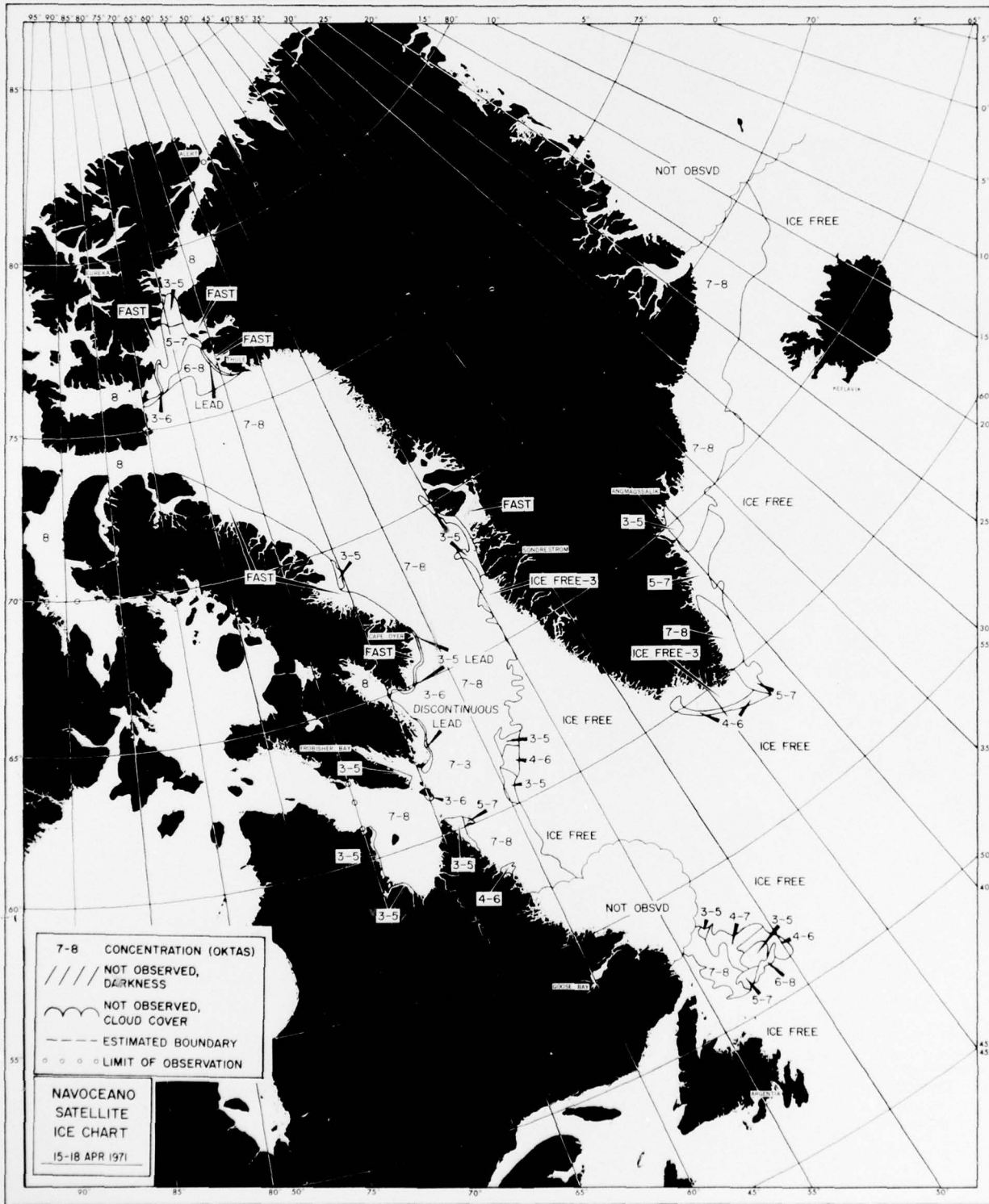


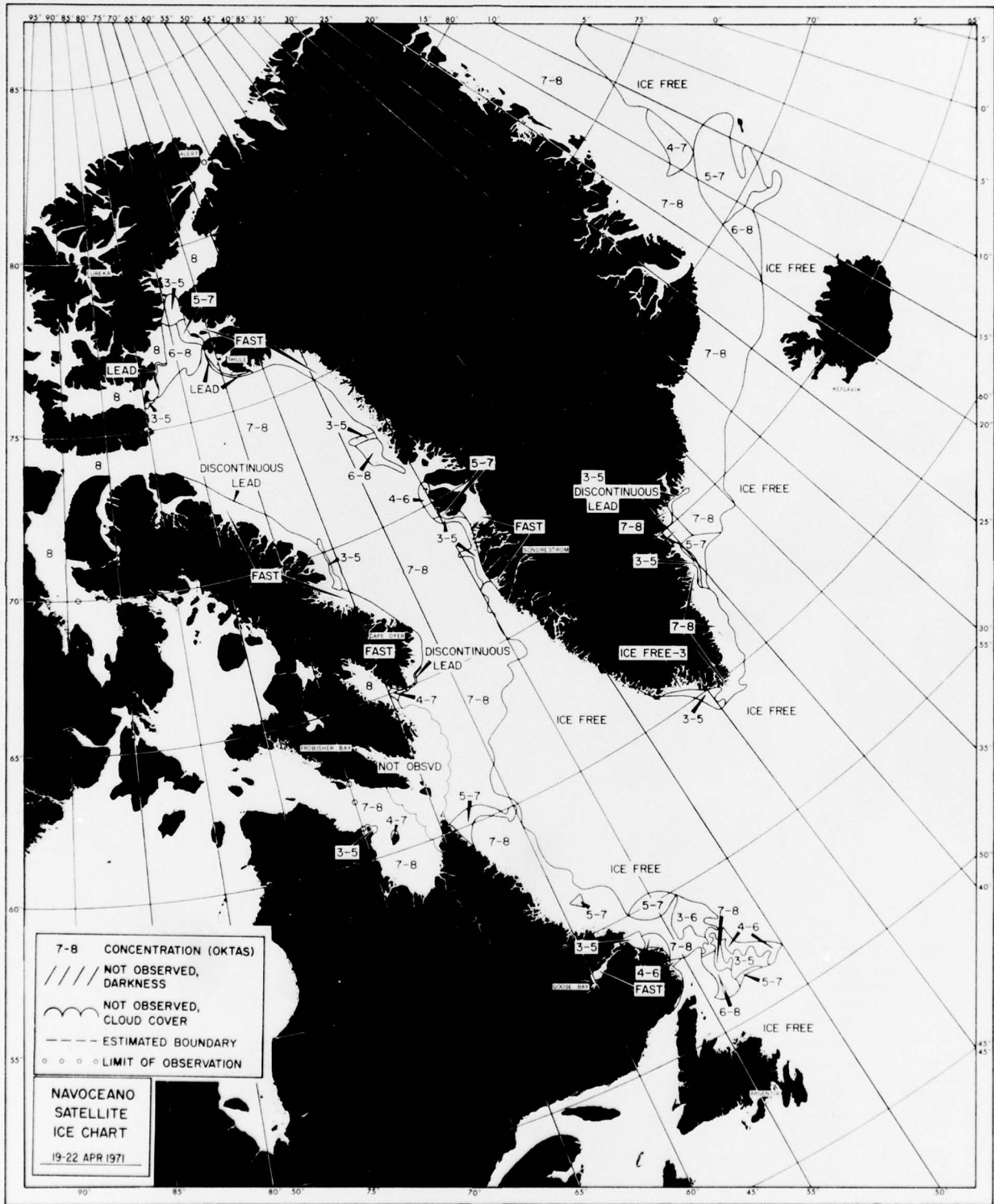


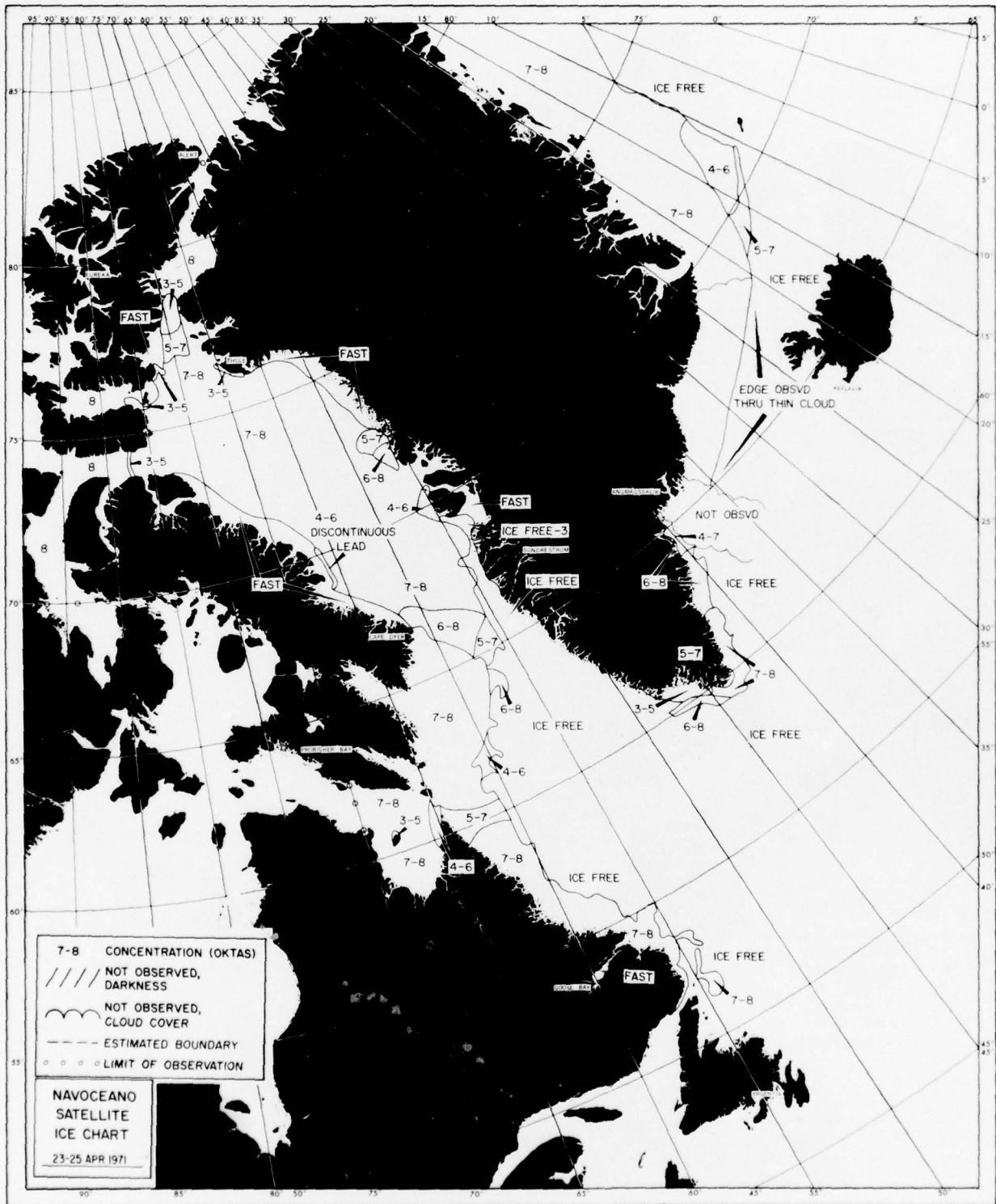


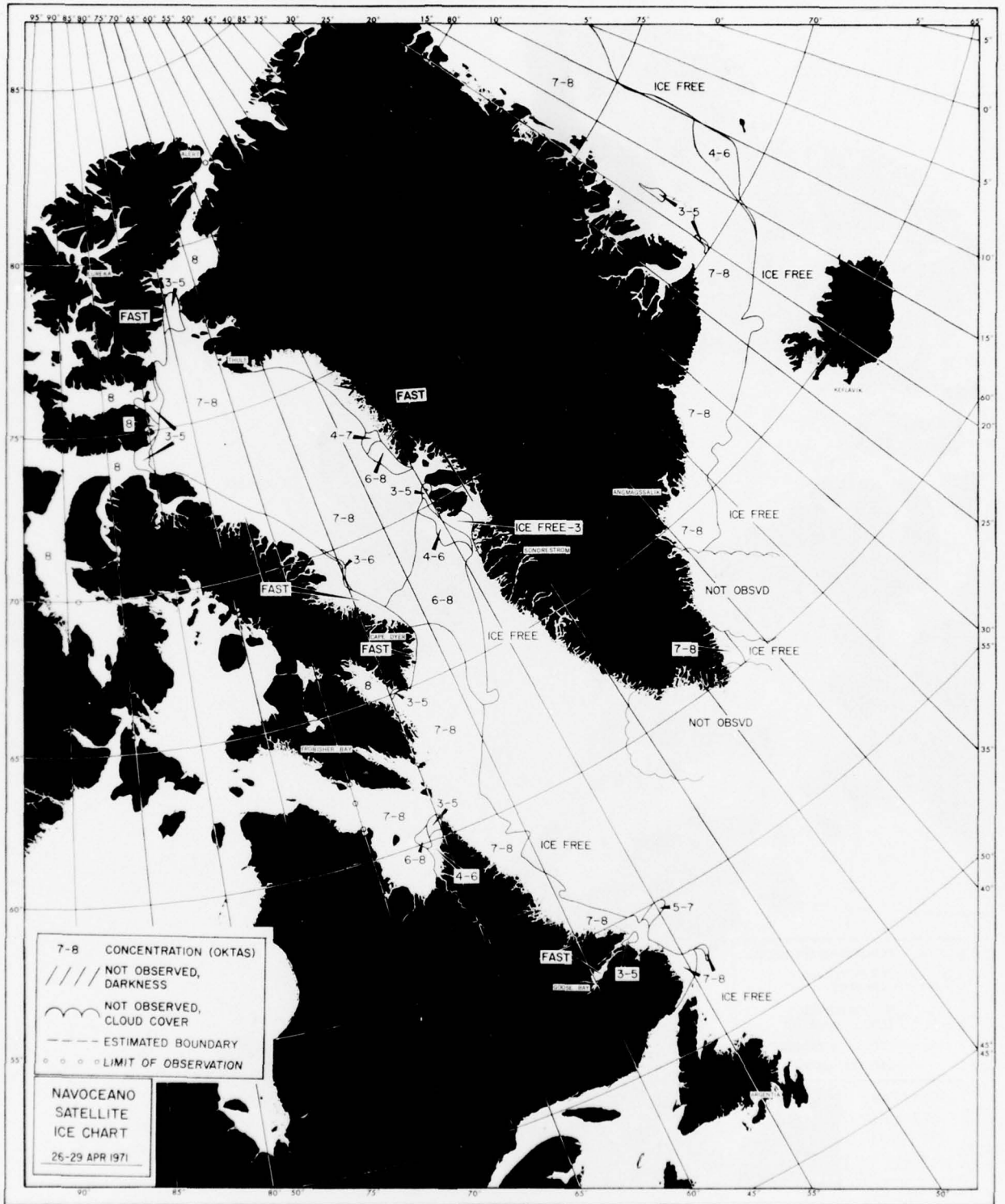


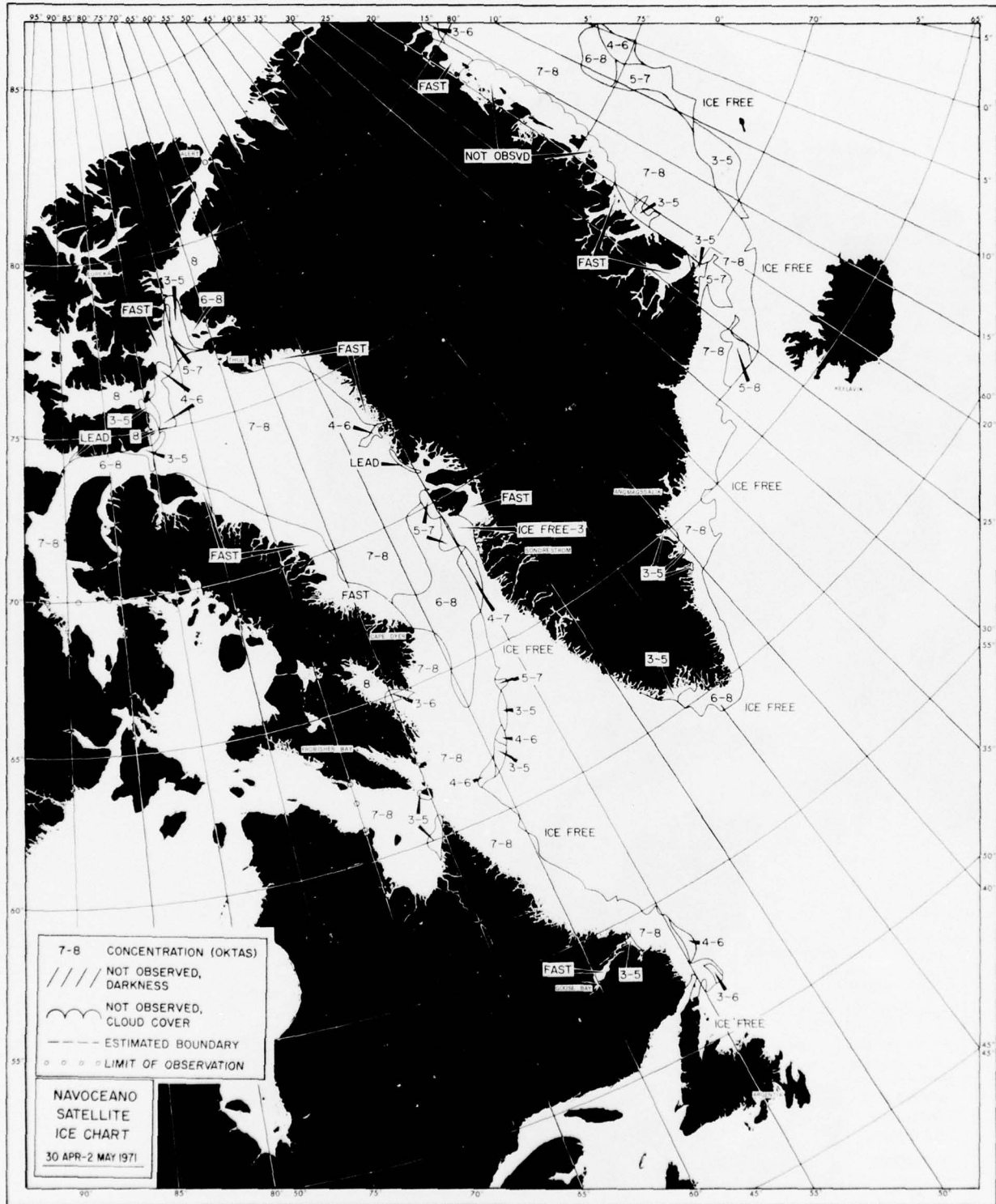


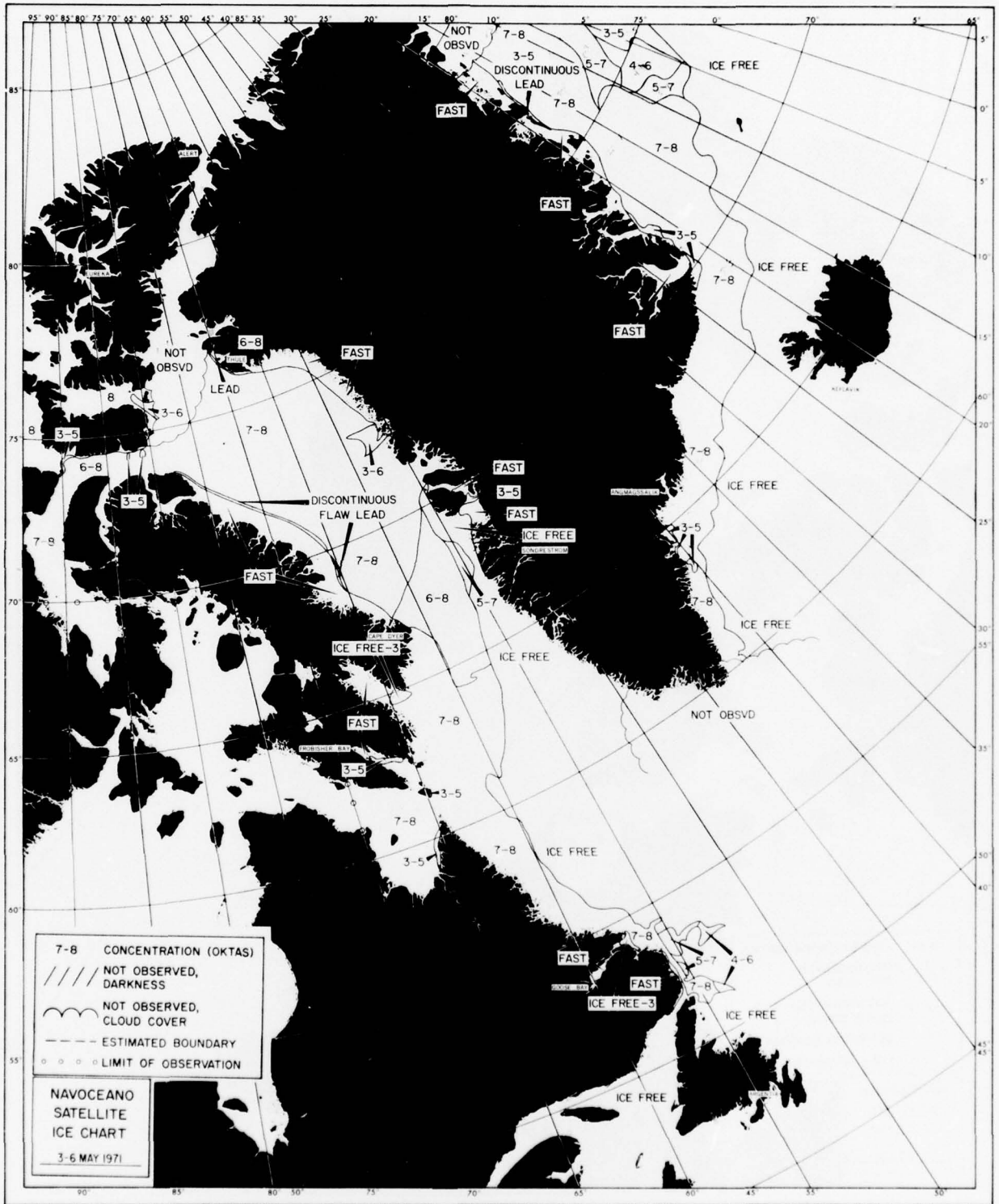


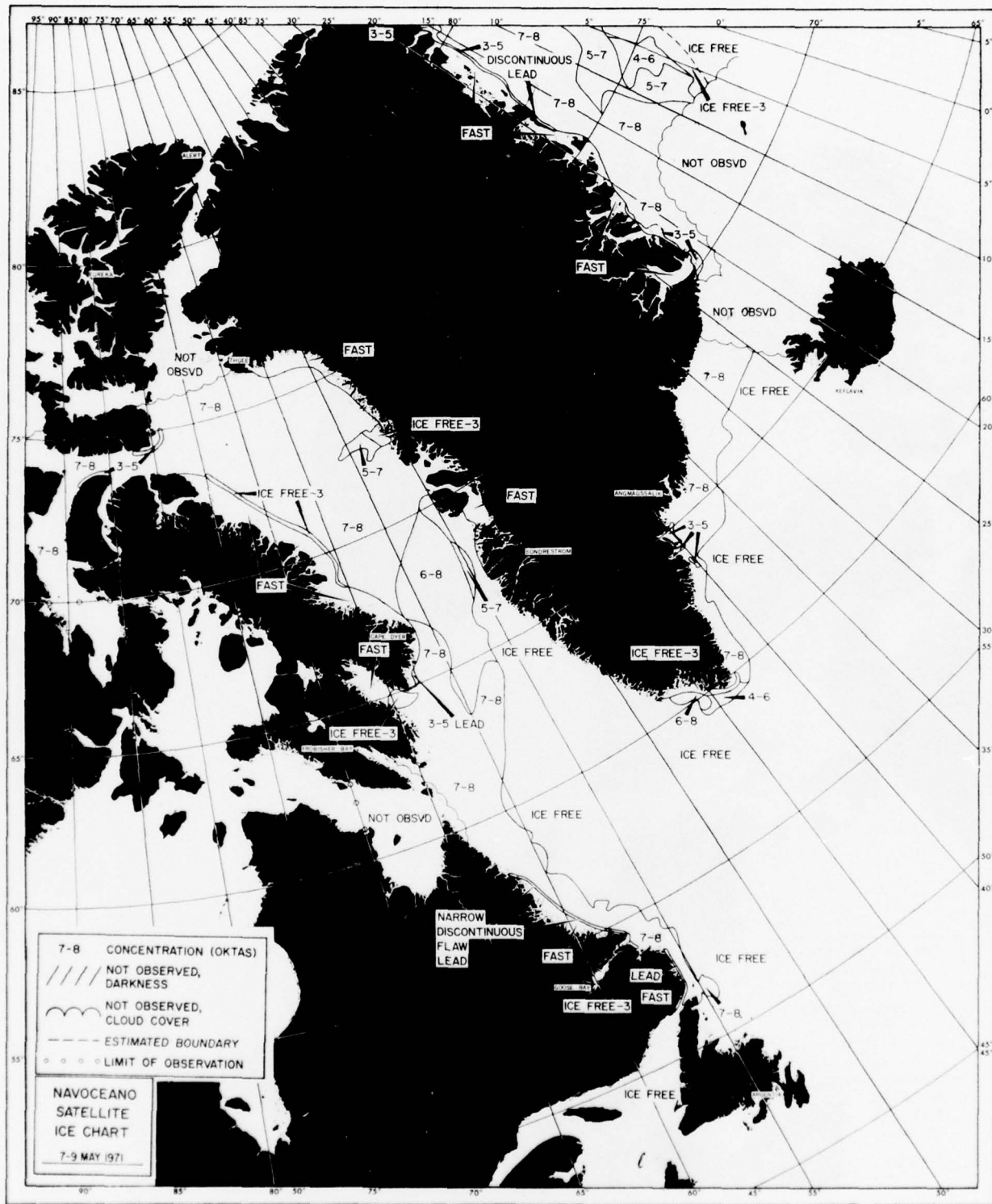


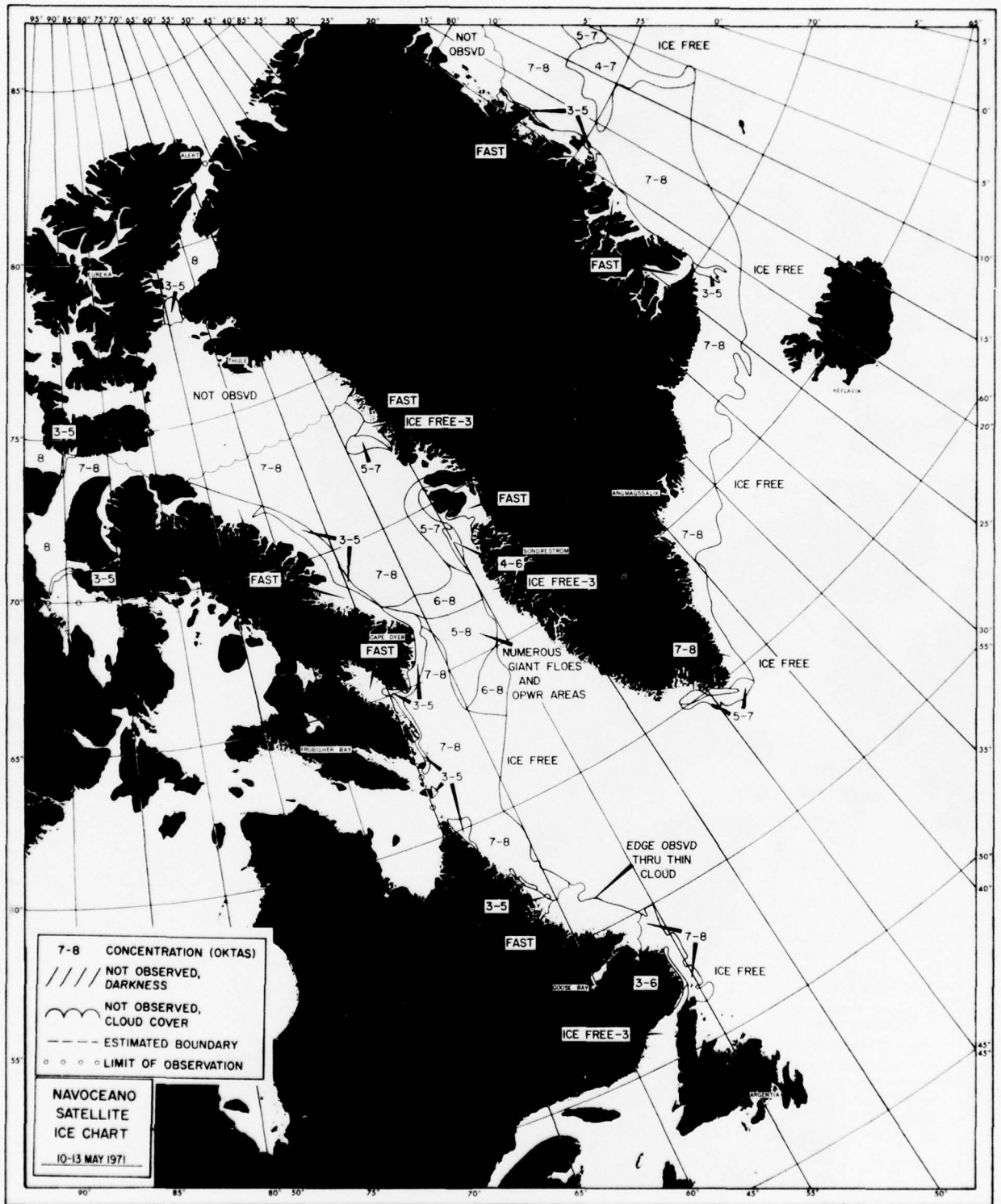


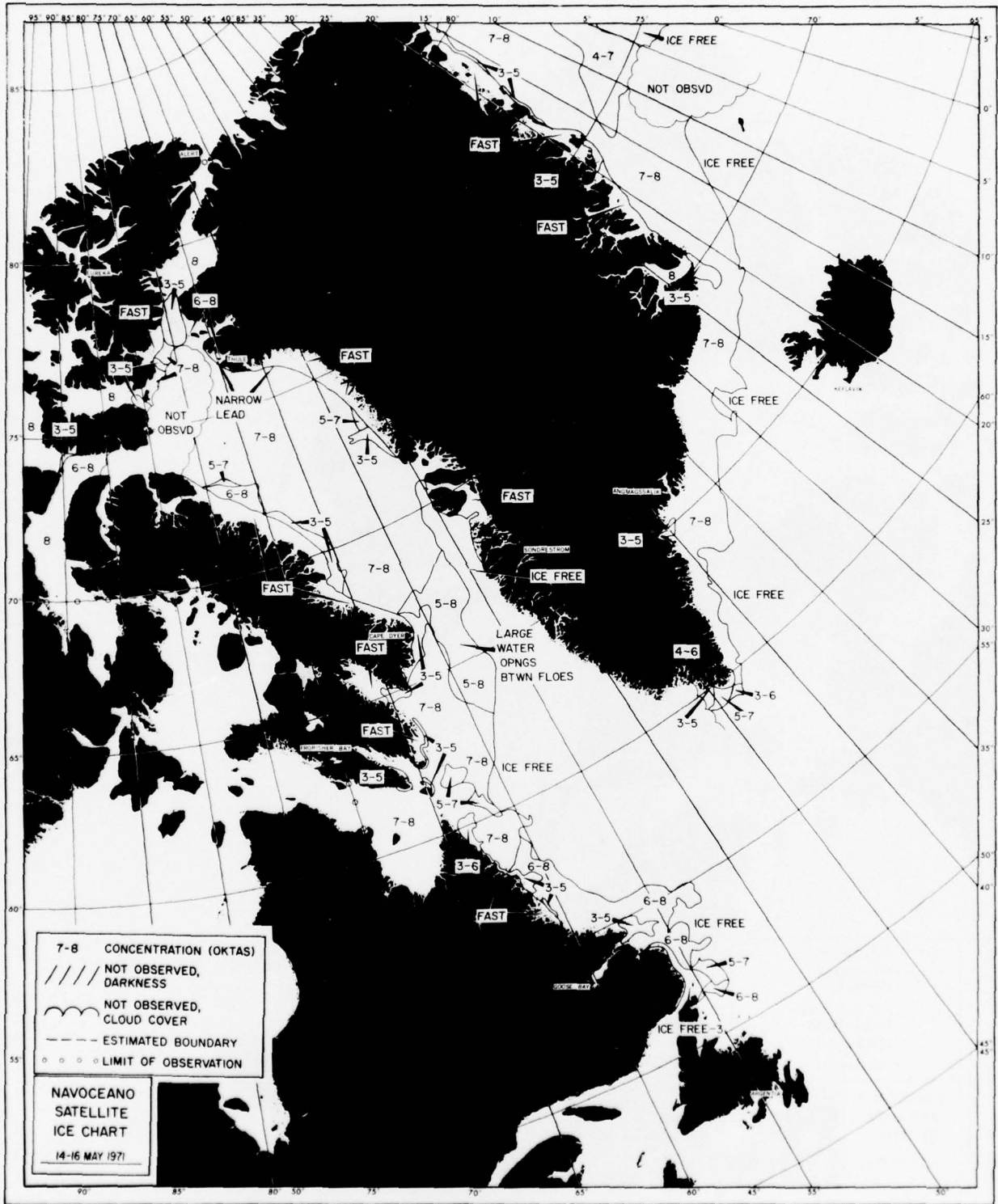


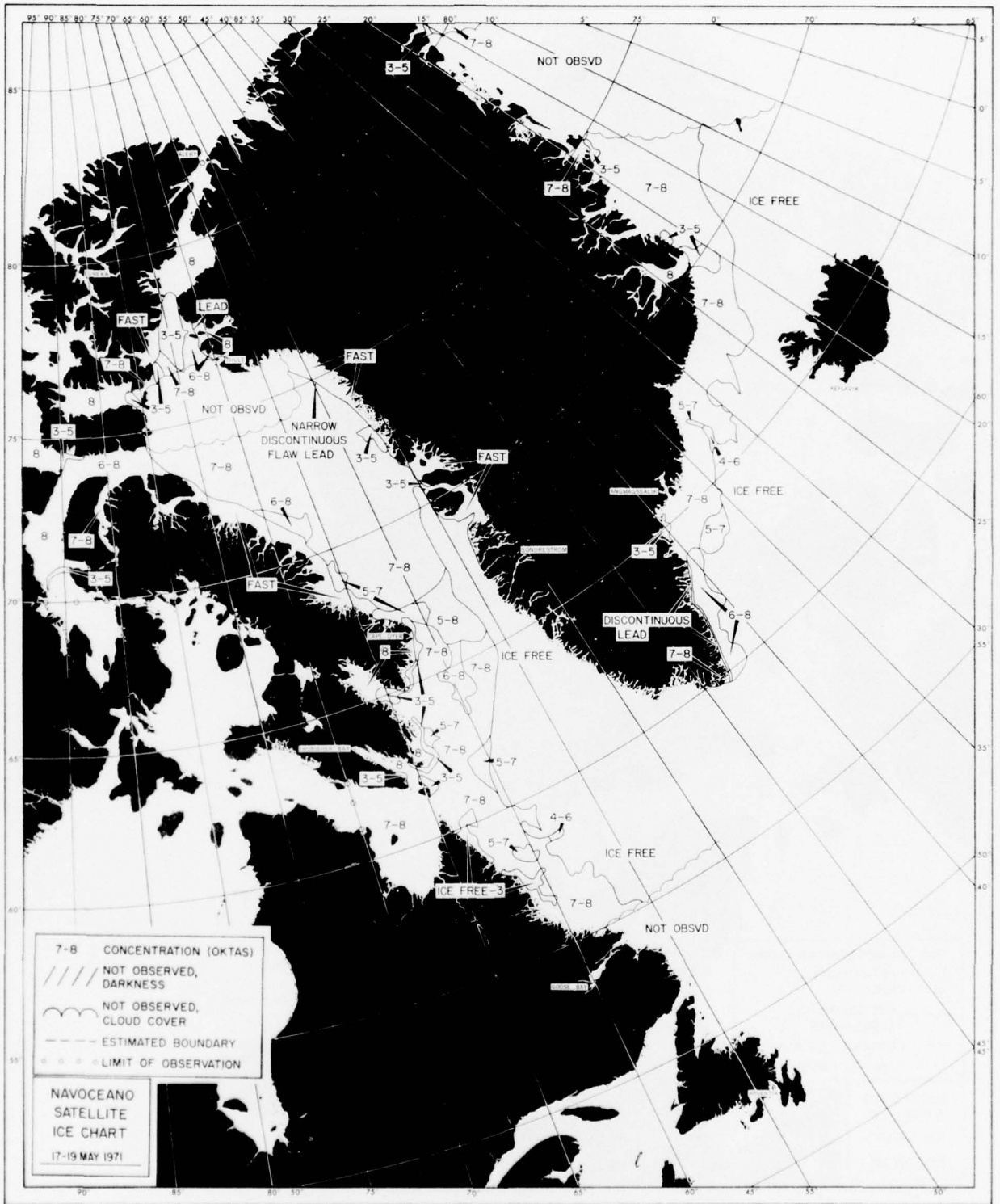


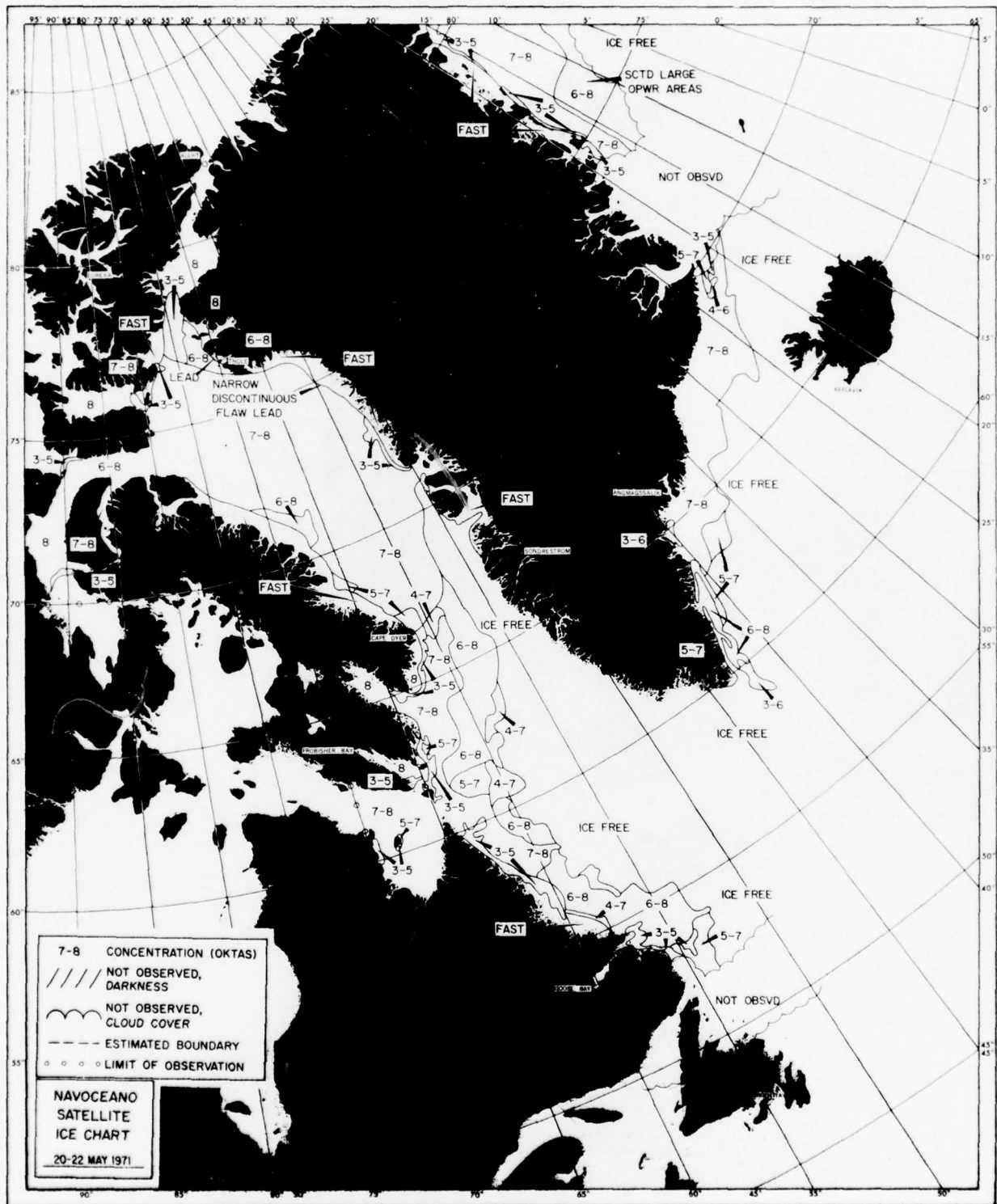


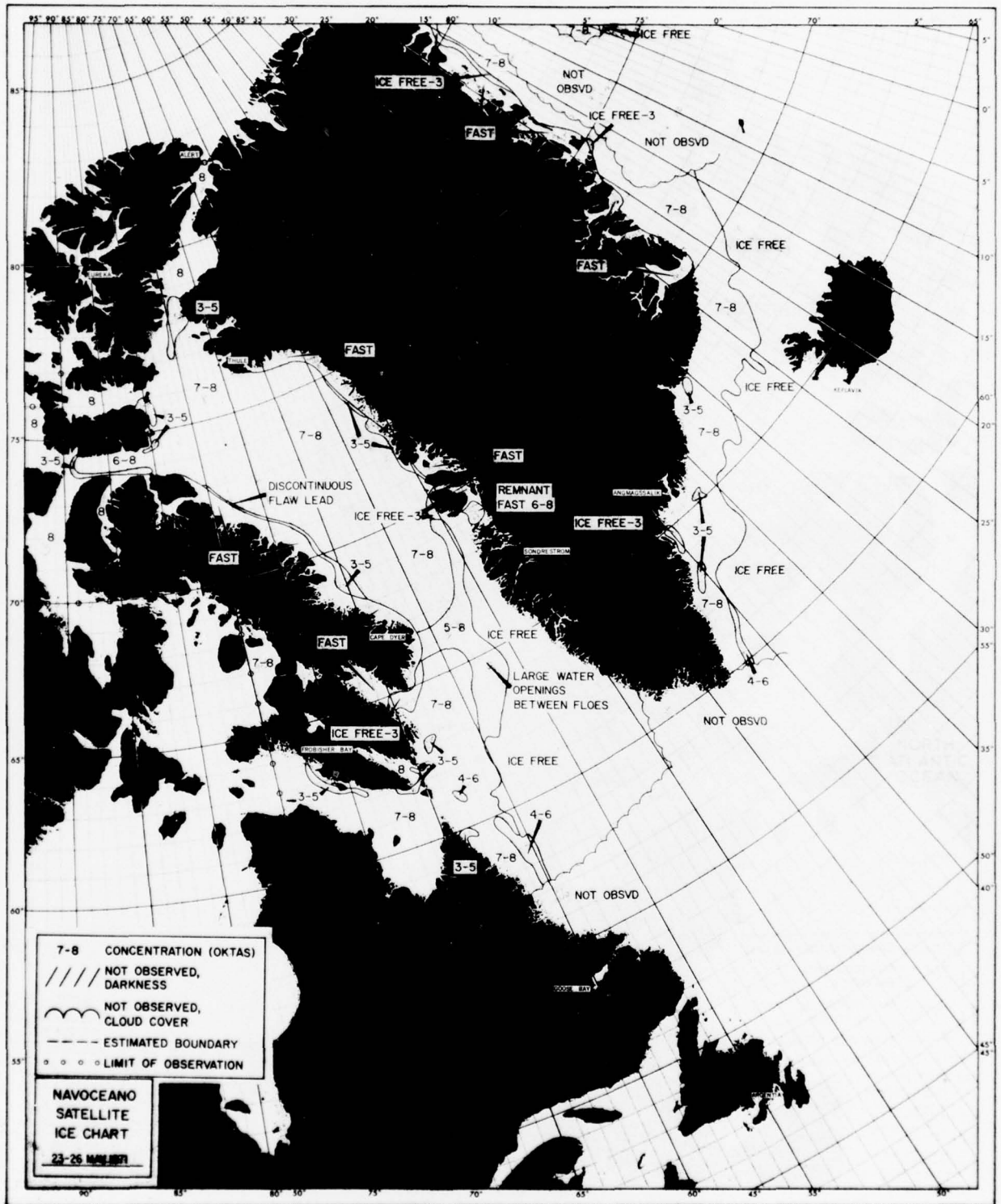


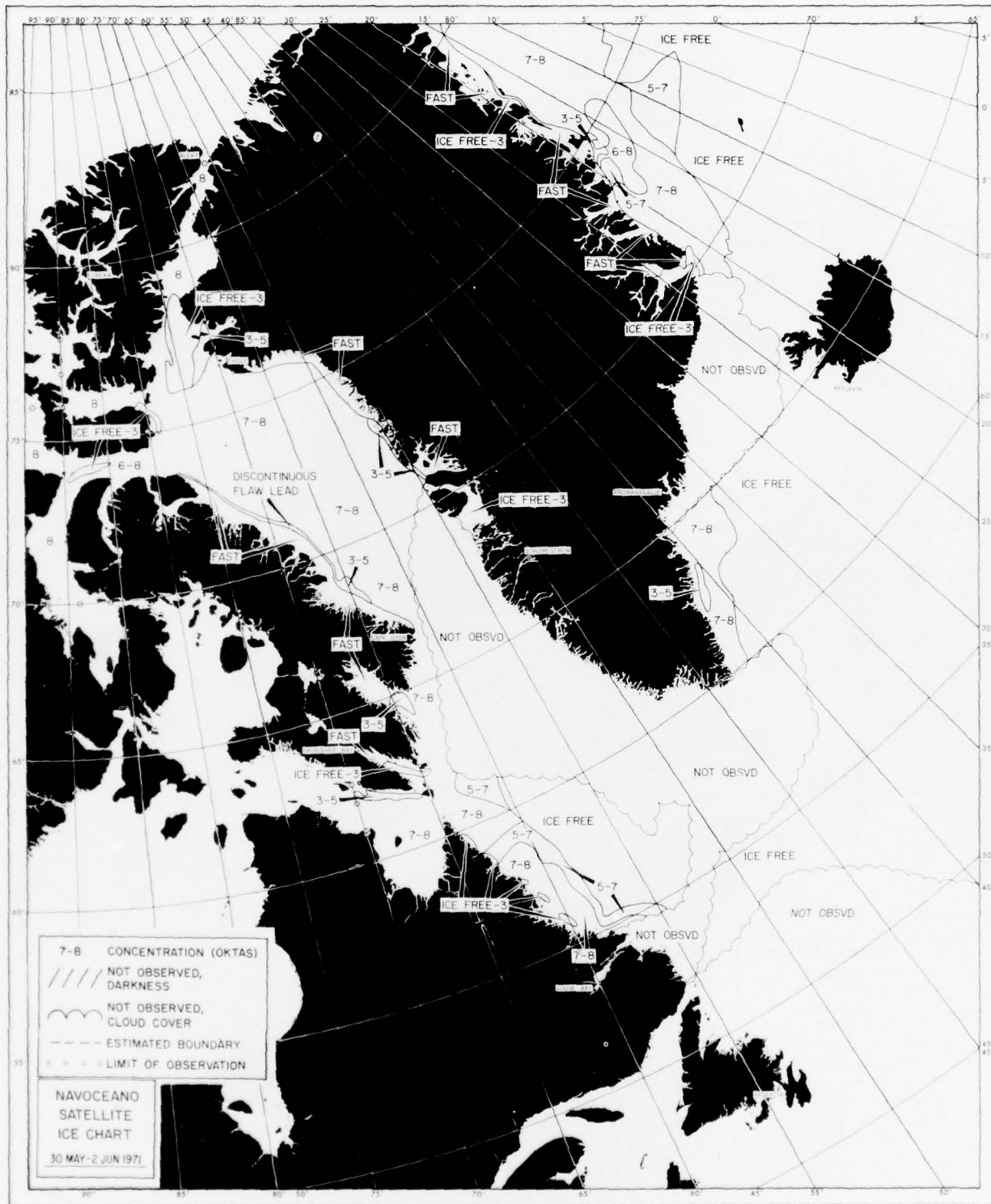


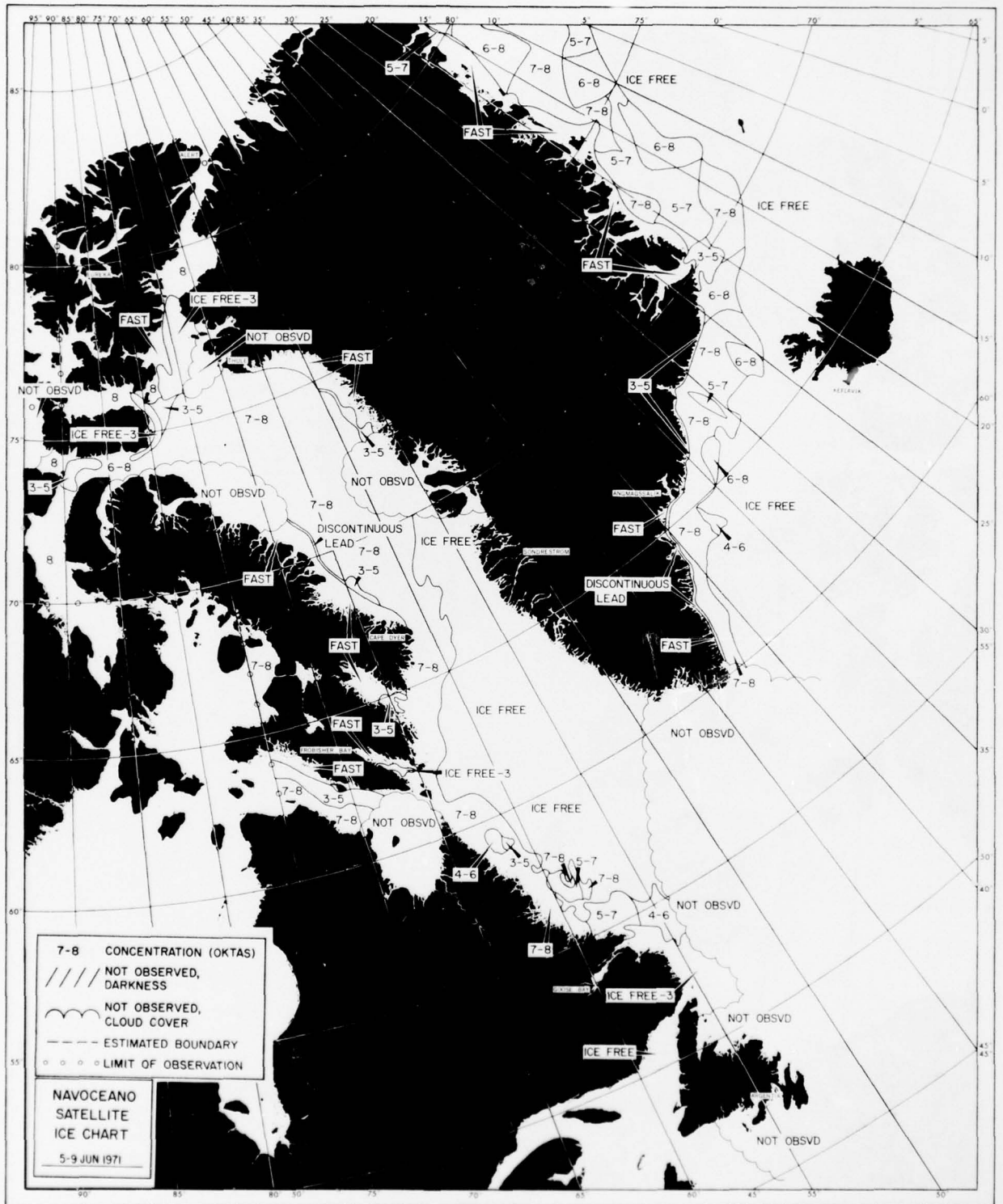


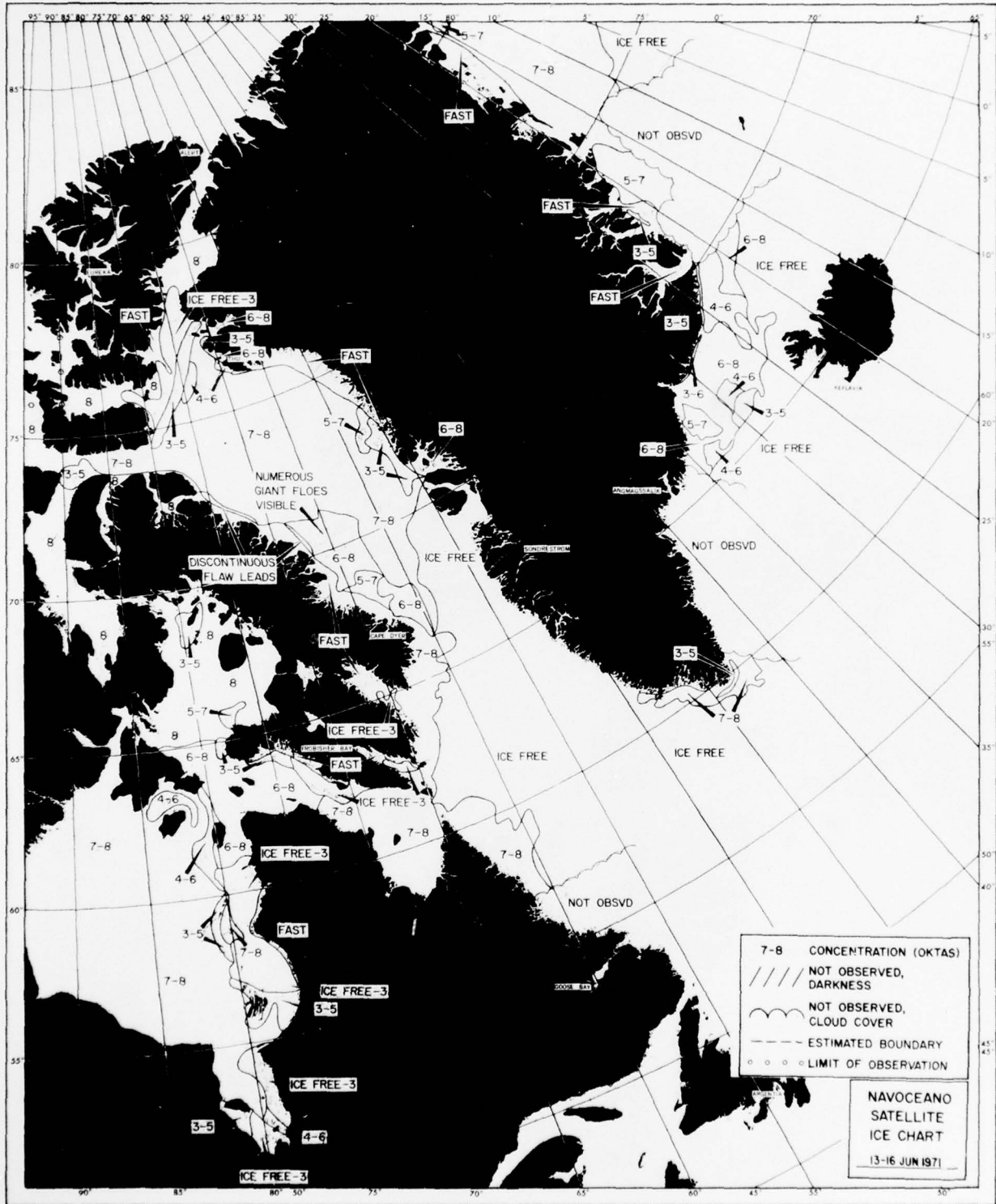


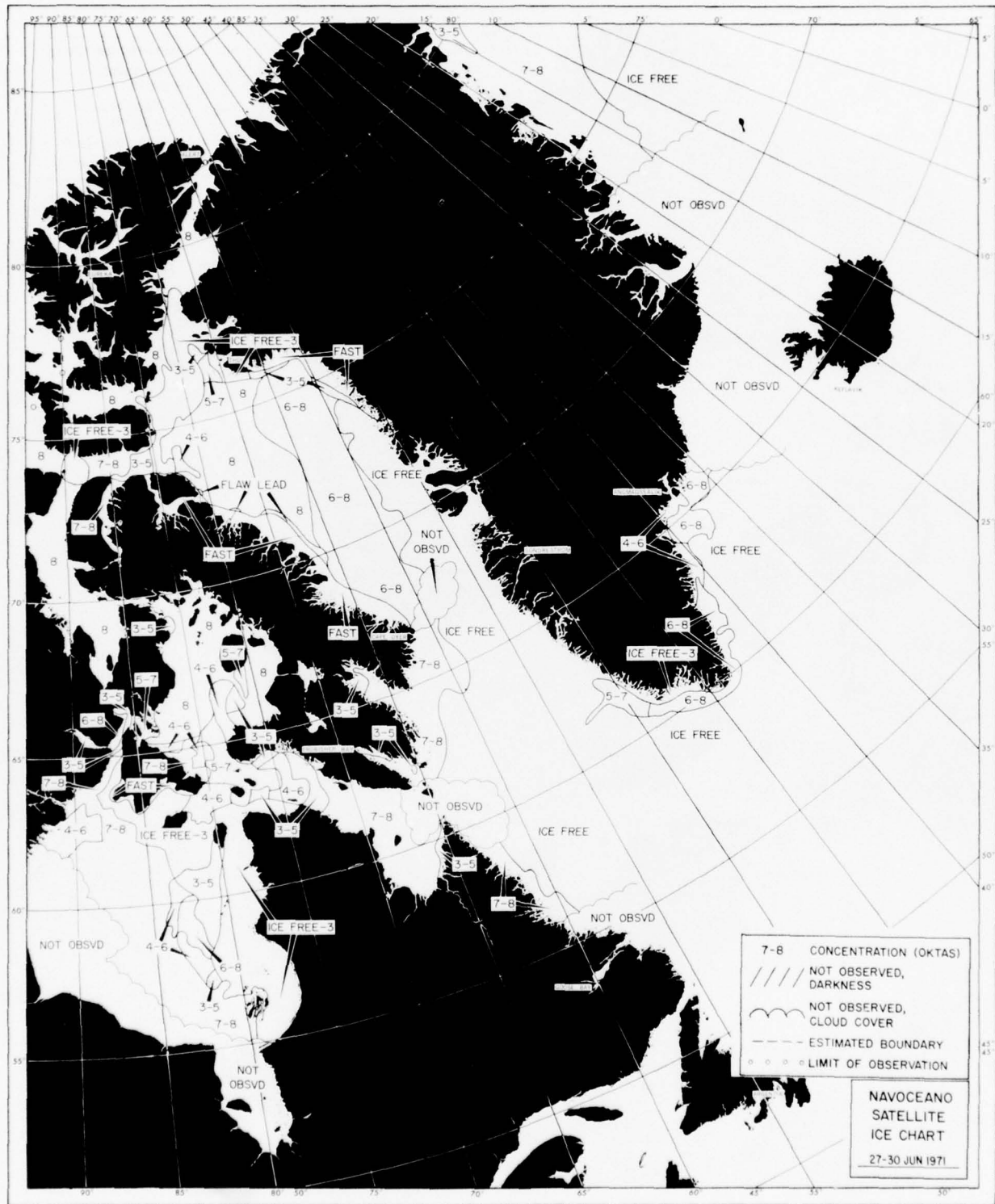


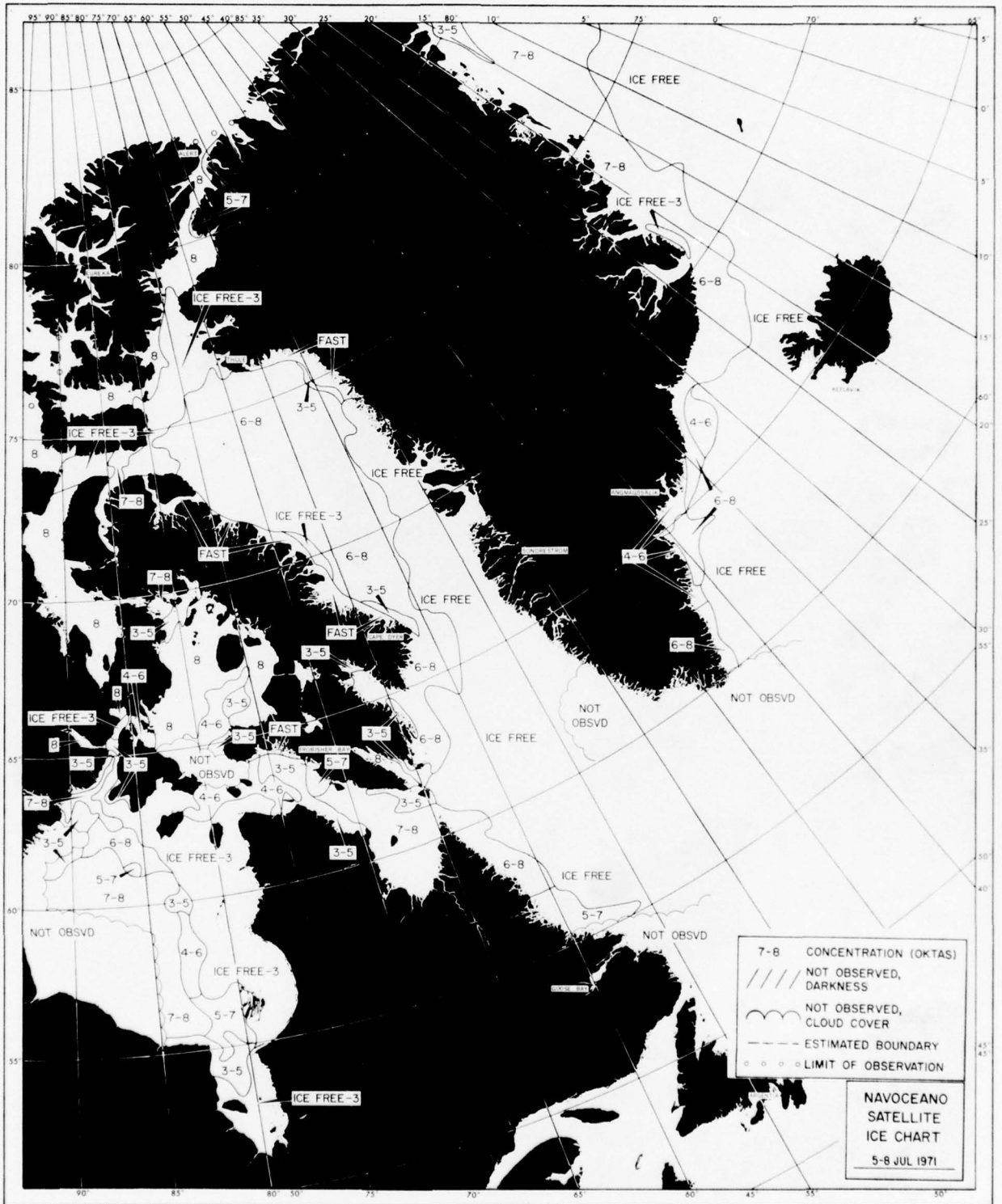


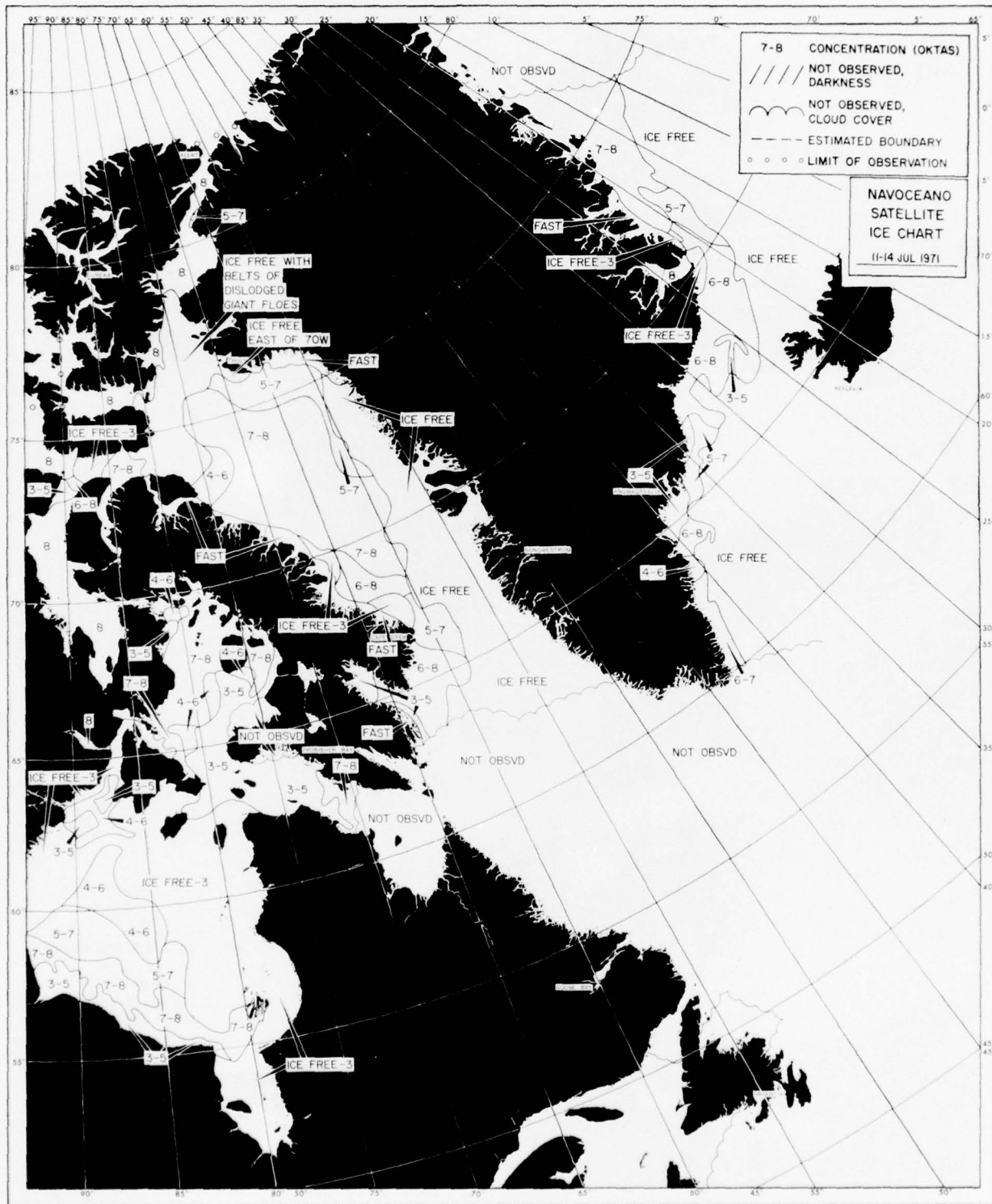


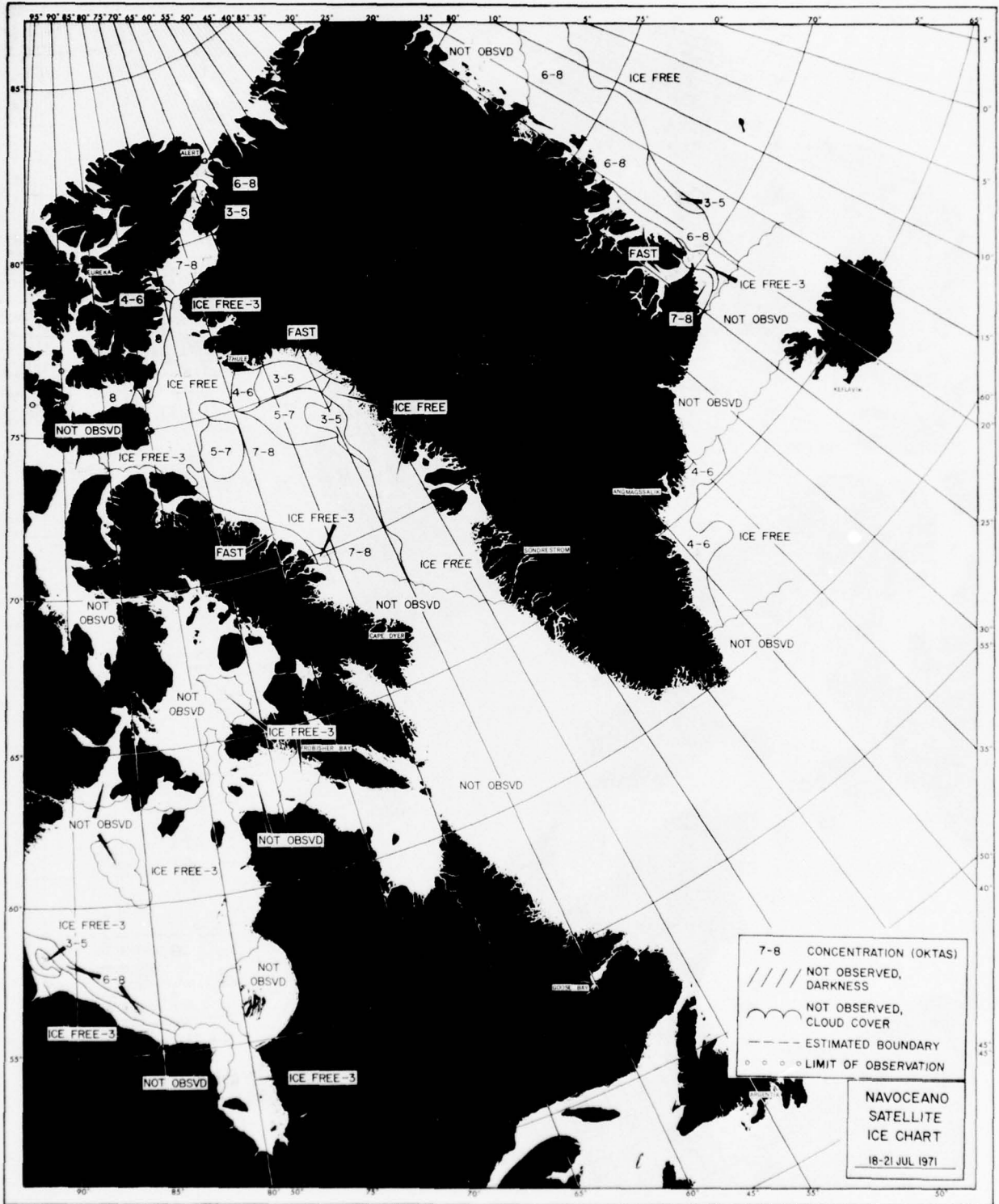


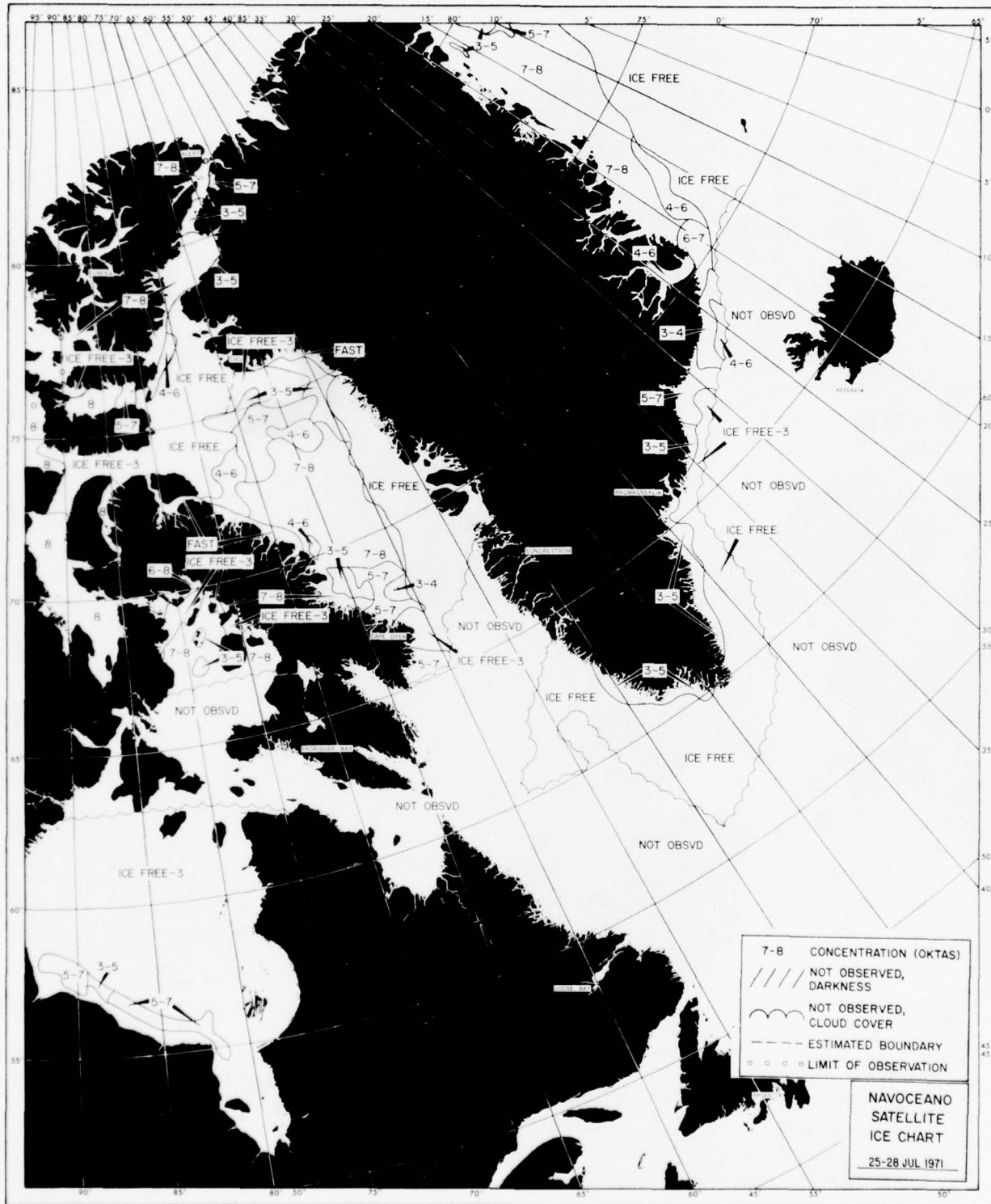


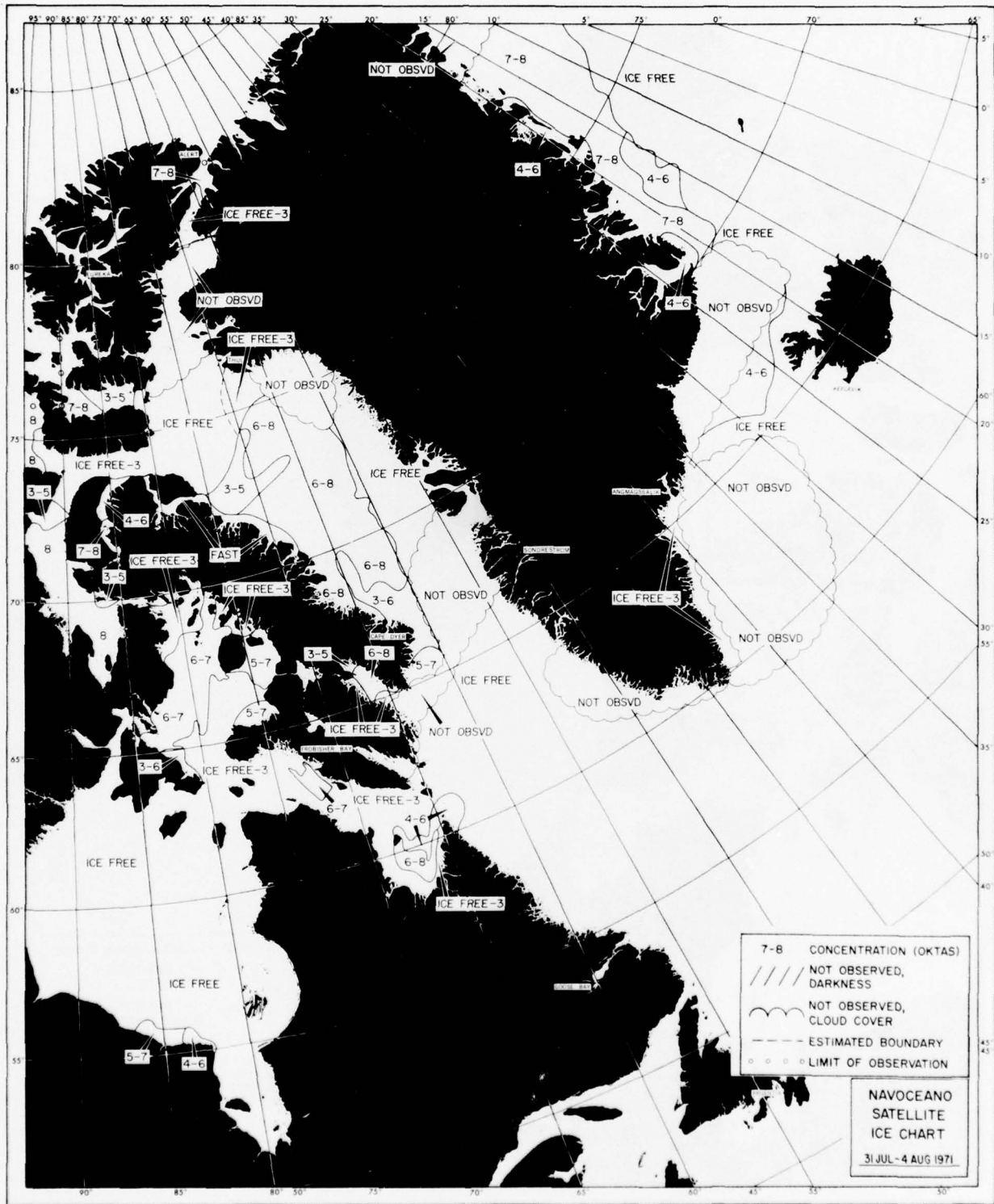


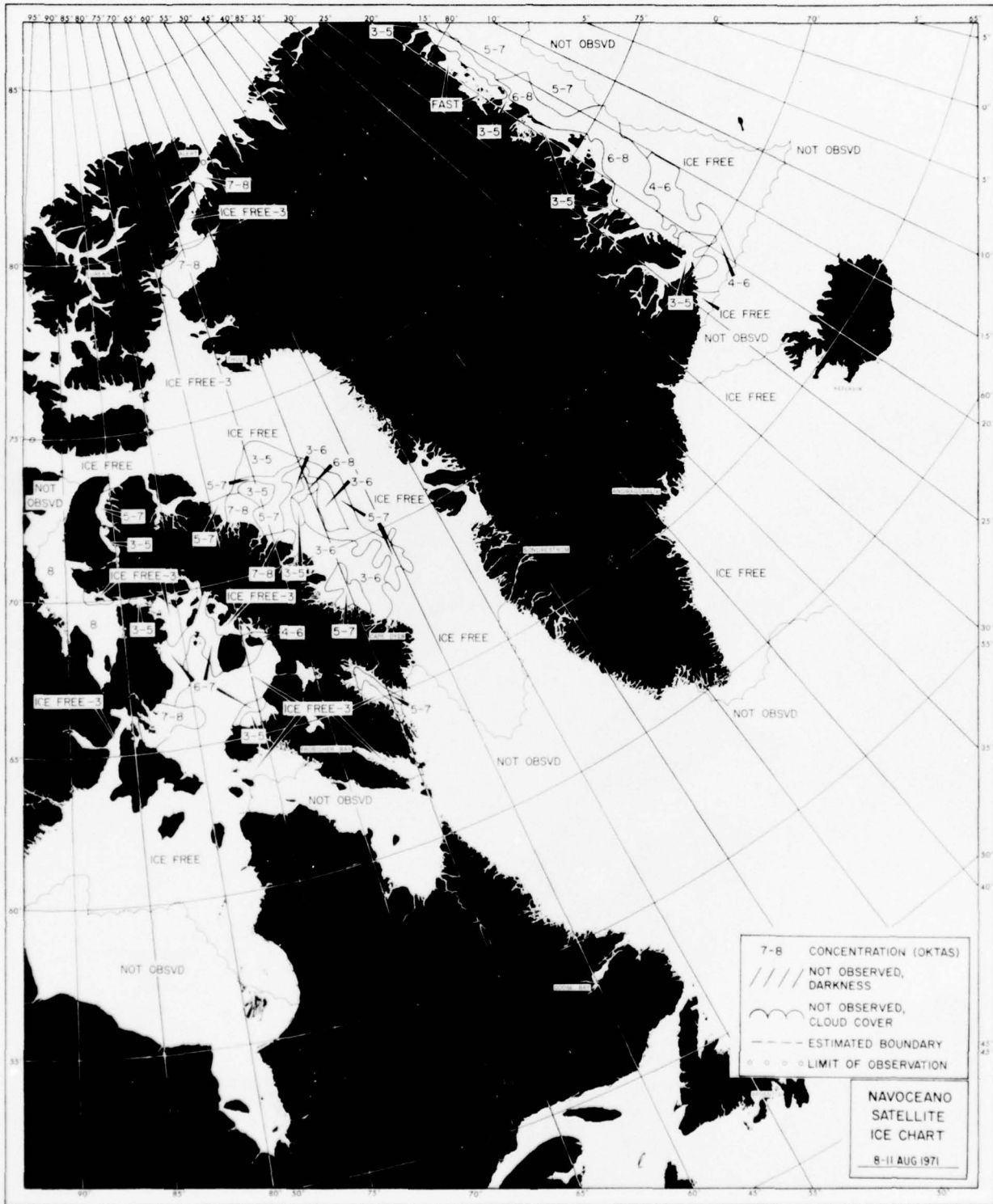


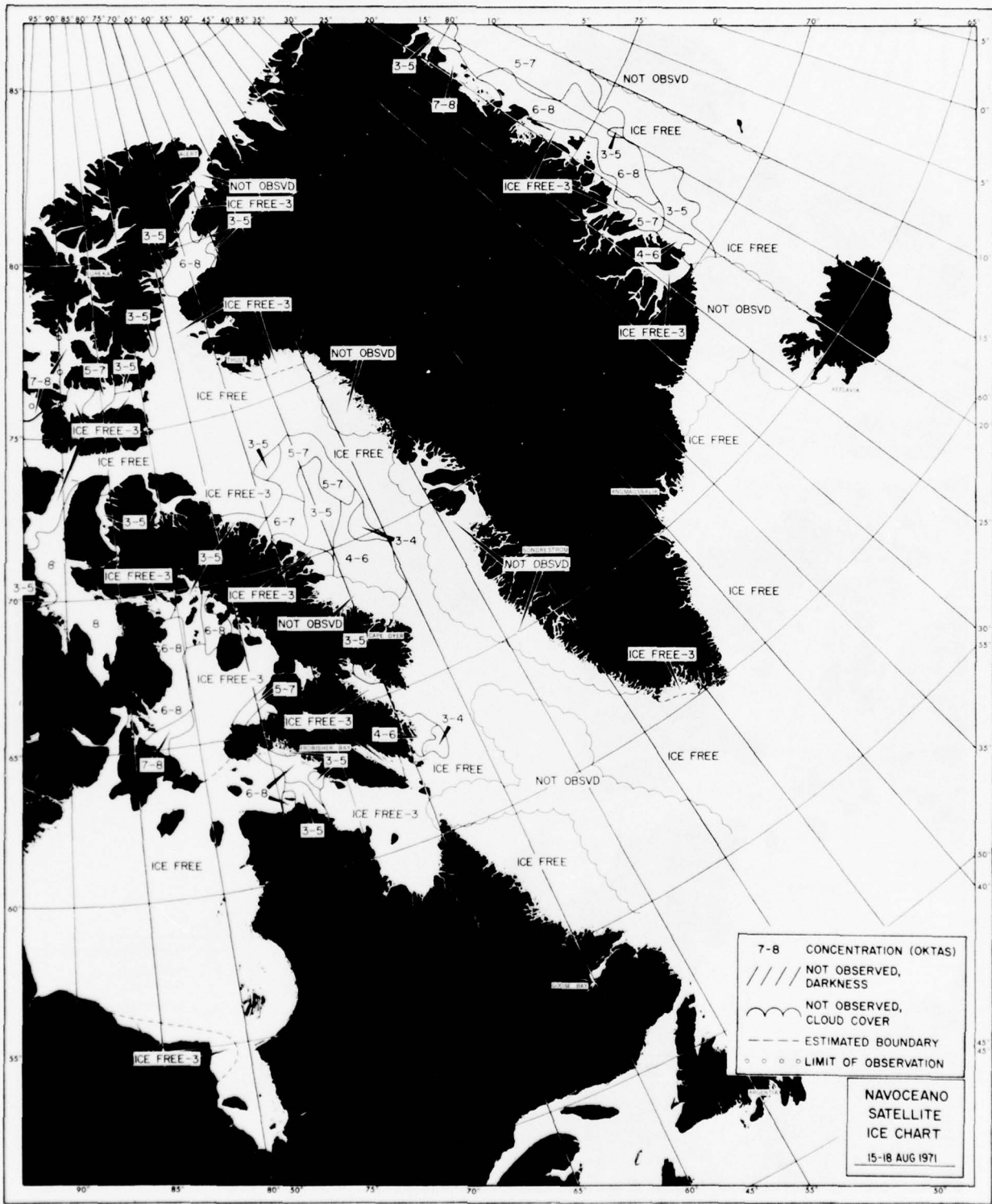


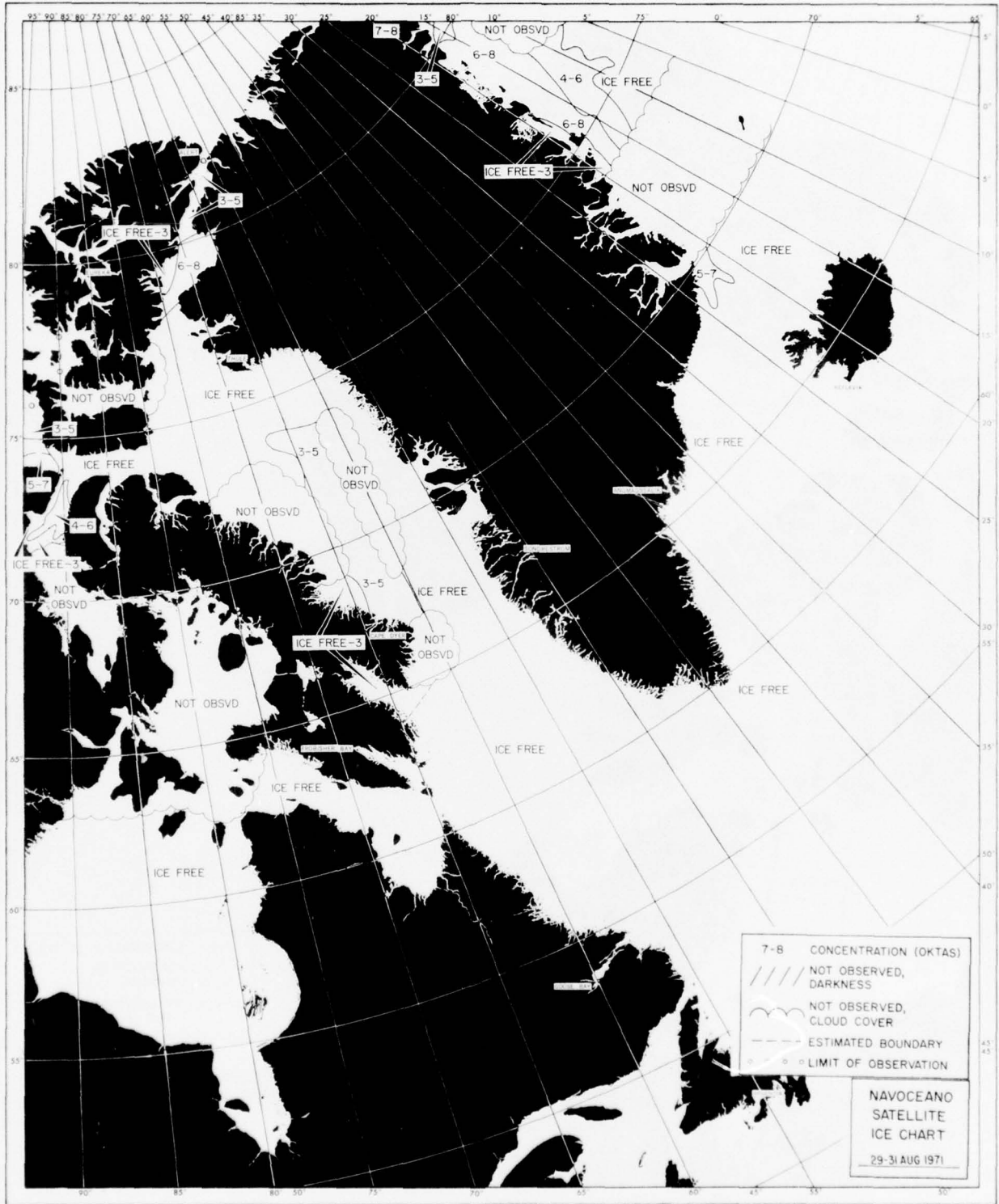


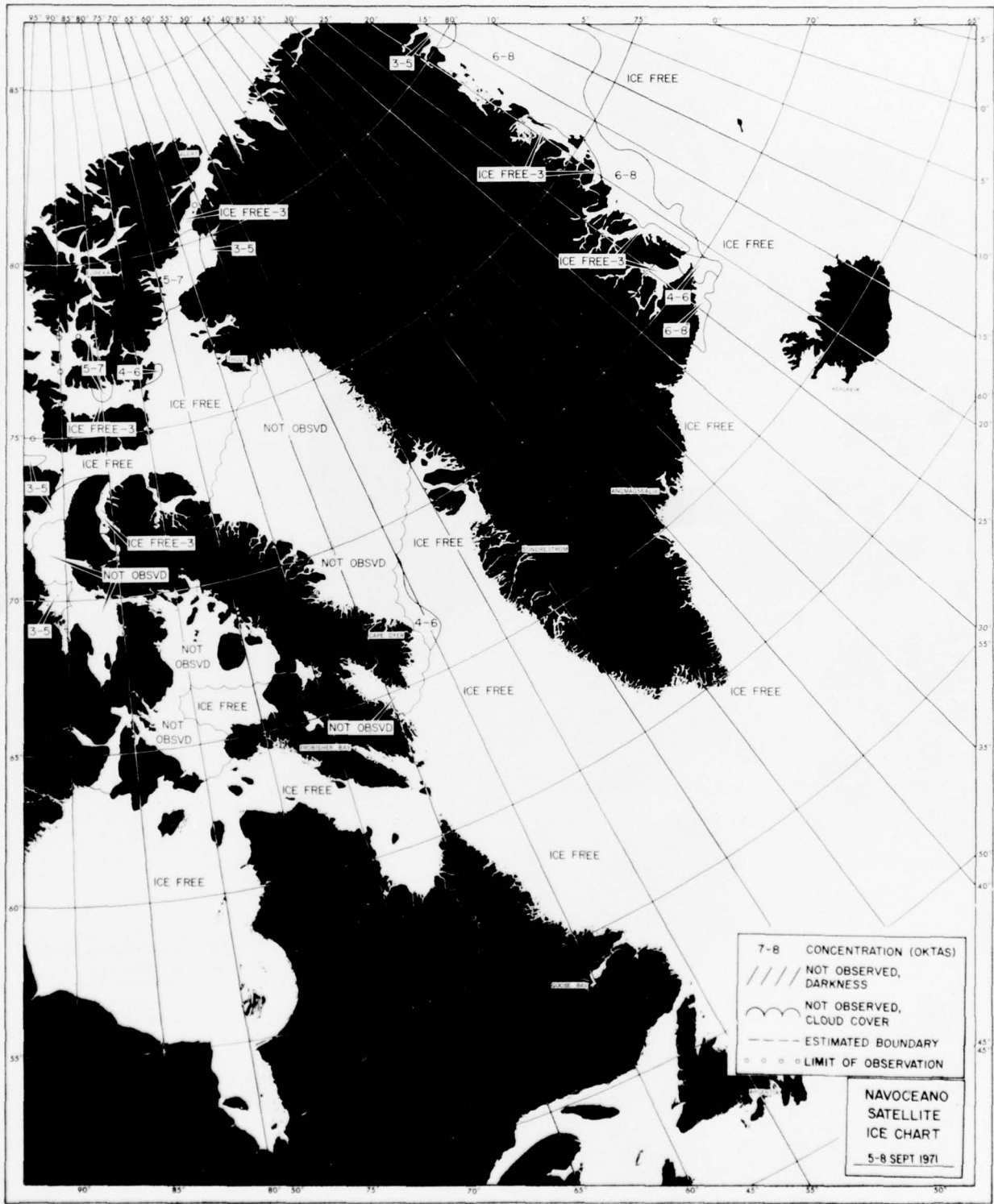


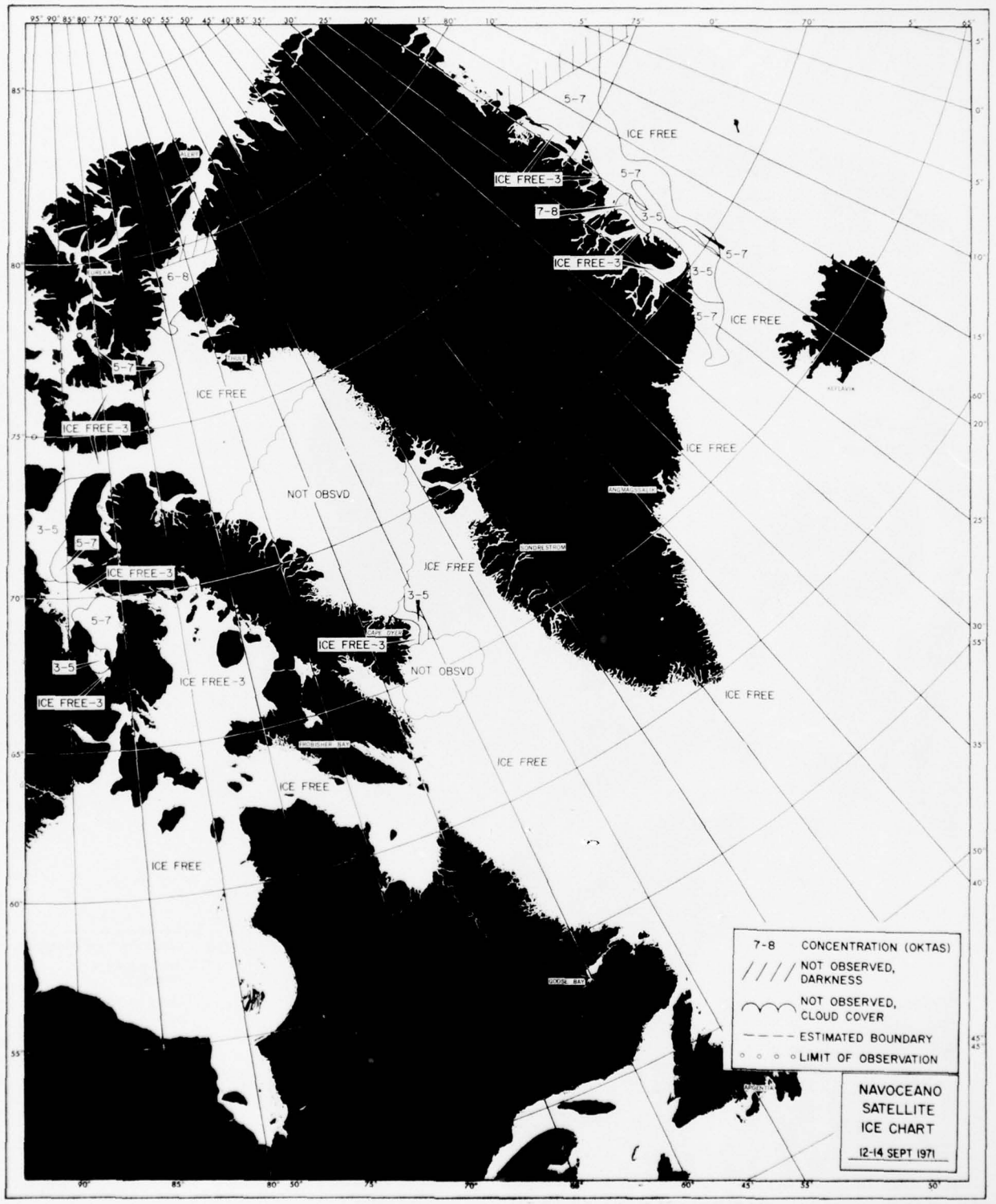


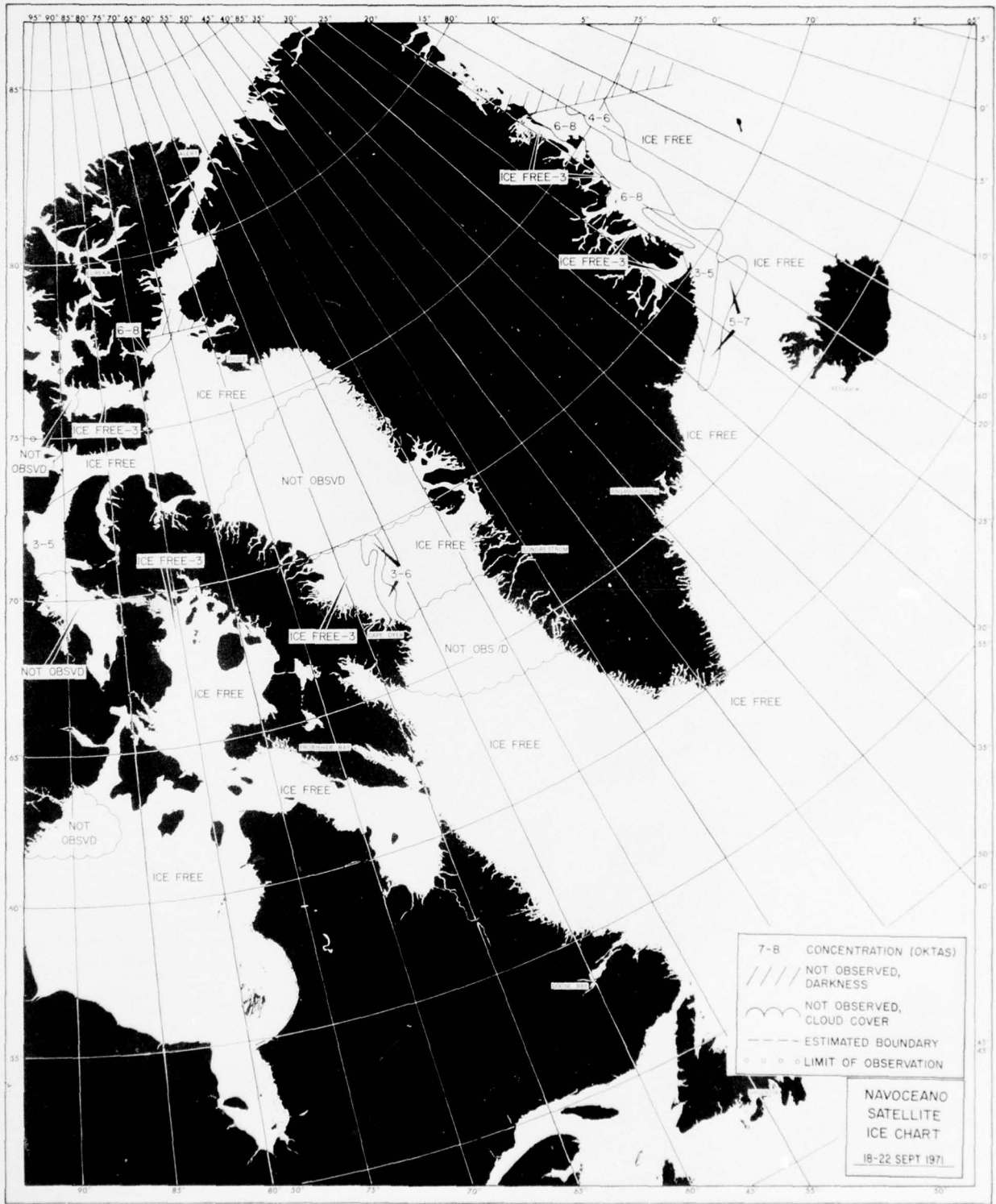



















APPENDIX C
WESTERN ARCTIC AERIAL
RECONNAISSANCE ICE CHARTS

KEY TO ICE SYMBOLS USED IN PLOTTING ICE FEATURES

TOTAL CONCENTRATION

	Ice free	CONC = Concentration
	< 1 okta* (open water)	CRK = Crack
	1- < 3 oktas (very open pack)	CRKS = Cracks
	3- < 6 oktas (open pack)	FRCT = Fracture
	6- < 7 oktas (close pack)	FRCTV = Very Small Fracture
	7- < 8 oktas (very close pack)	FRCTS = Small Fracture
	8 oktas (compact pack)	FRCTM = Medium Fracture
		FRCTL = Large Fracture
		LVL = Level Ice
		NDTR = Not Determined
		NOPG = No Openings in Ice
		OPWR = Open Water
		SCTD = Scattered
		SD = Snow Depth
		T = Ice Thickness








COVERAGE BY SIZE

$\frac{C}{n_1 n_2 n_3}$	
C = total concentration	
SS/NL = New Ice or Nilas	
n ₁	PK = Pancake < 3 m
CK = Brash, Small Cake, Cake < 20 m	
SF = Small Floe 20-100 m	
n ₂	MF = Medium Floe 100-500 m
BF = Big Floe 500-2000 m	
VF = Vast Floe 2-10 km	
n ₃	GF = Giant Floe > 10 km
Fast = Fast Ice	
Example:	7 = total concentration
7	1 = okta all pancake ice
124	2 = oktas small and medium ice floes
PK	4 = oktas big, vast, and giant ice floes

STAGE OF DEVELOPMENT

A	
oktas predominant, oktas secondary	
AGE	AVERAGE THICKNESS
SS = Frazil, Grease, Slush, Shuga	
NL = Ice Rind, Dark Nilas, Light Nilas	— < 5-10 cm
G = Gray	----- 10-15 cm
GW = Gray-White	----- 15-30 cm
FL = Thin First-Year	----- 30-70 cm
FM = Medium First-Year	----- 70-120 cm
FT = Thick First-Year	----- > 120 cm
SY = Second-Year	
MY = Multi-Year	
Example:	$\frac{A}{SFM3G}$
A = Stage of development	
SFM = 5 oktas Medium First-Year	
3G = 3 oktas Gray	
* One okta equals one-eighth ice concentration	

TOPOGRAPHY

	Rafted or Finger-Rafted Ice
	Hummocks
	M(N) New Ridges
	M(W) Weathered Ridges
	M(V) Very Weathered Ridges
	M(A) Aged Ridges
	M(C) Consolidated Ridges
Example:	$\frac{M(N)(h)}{(n)}$

(h) height of ridges in meters
(n) tenths coverage on ice

STAGE OF MELTING

FPD = Few Puddles
MPD = Many Puddles
FTH = Few Thaw Holes
MTH = Many Thaw Holes
DRI = Dried Ice
ROT = Rotten Ice
FLO = Flooded Ice





UNDERCAST

 Limit





THICKNESS OF ICE & SNOW

t_E = ice thickness in cm
s = snow depth in cm

PHENOMENA

	crack
	fracture
	polynya
	lead
	Δ(n) icebergs
	Δ(n) bergy bits & growlers
(n) = number in area	

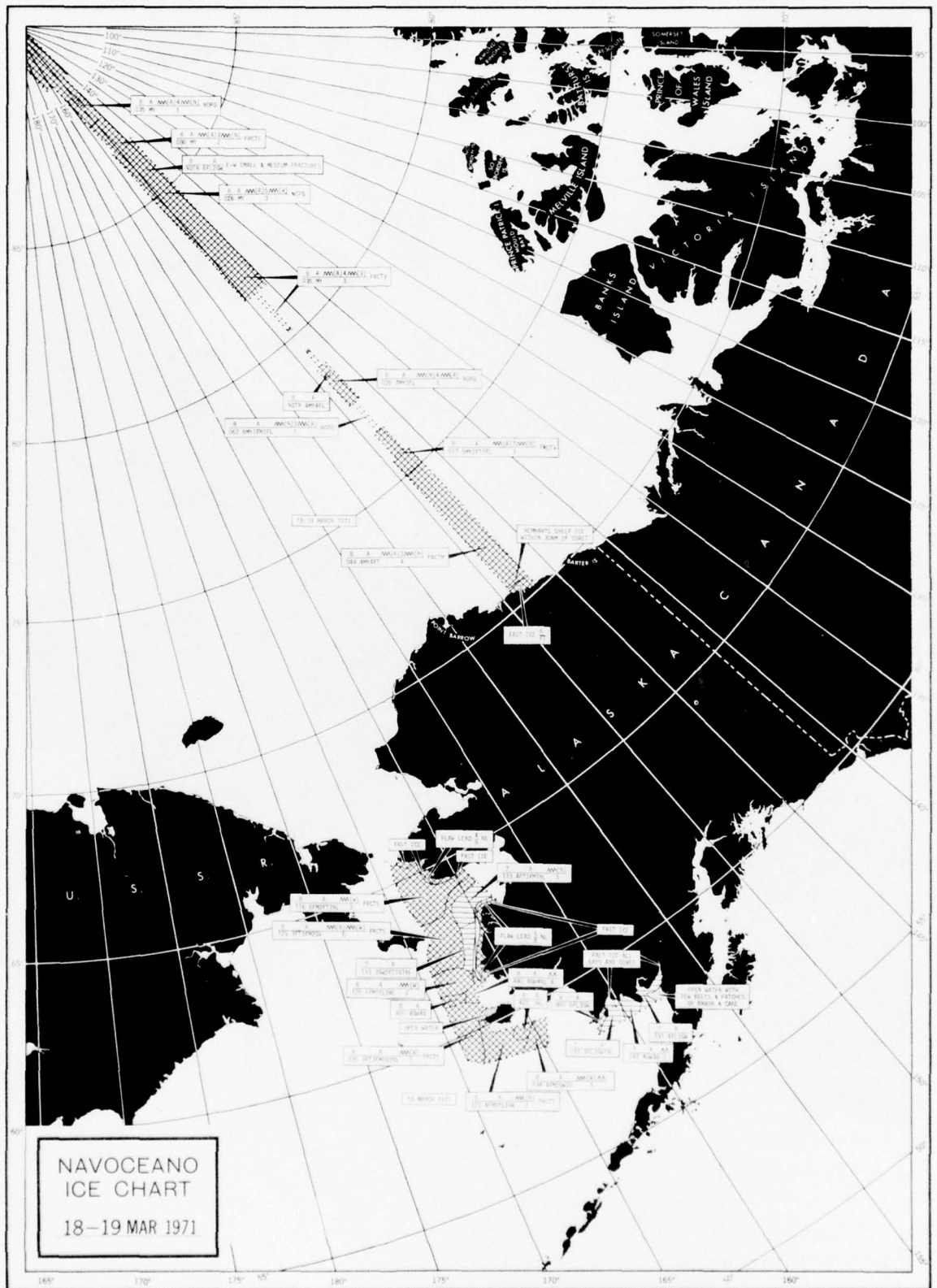
ICE EDGE

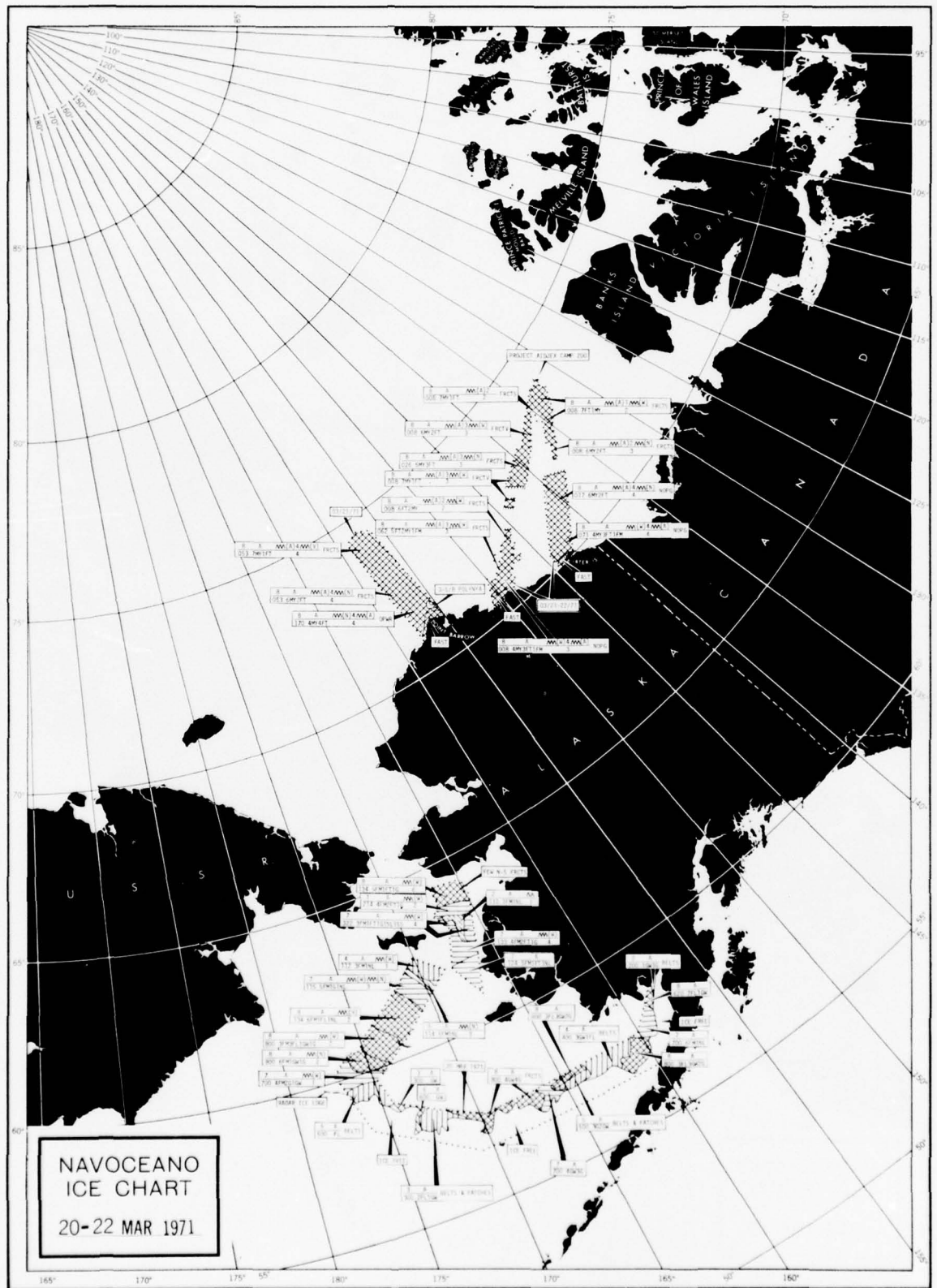
	observed
	radar
	limit of observed data
	satellite data







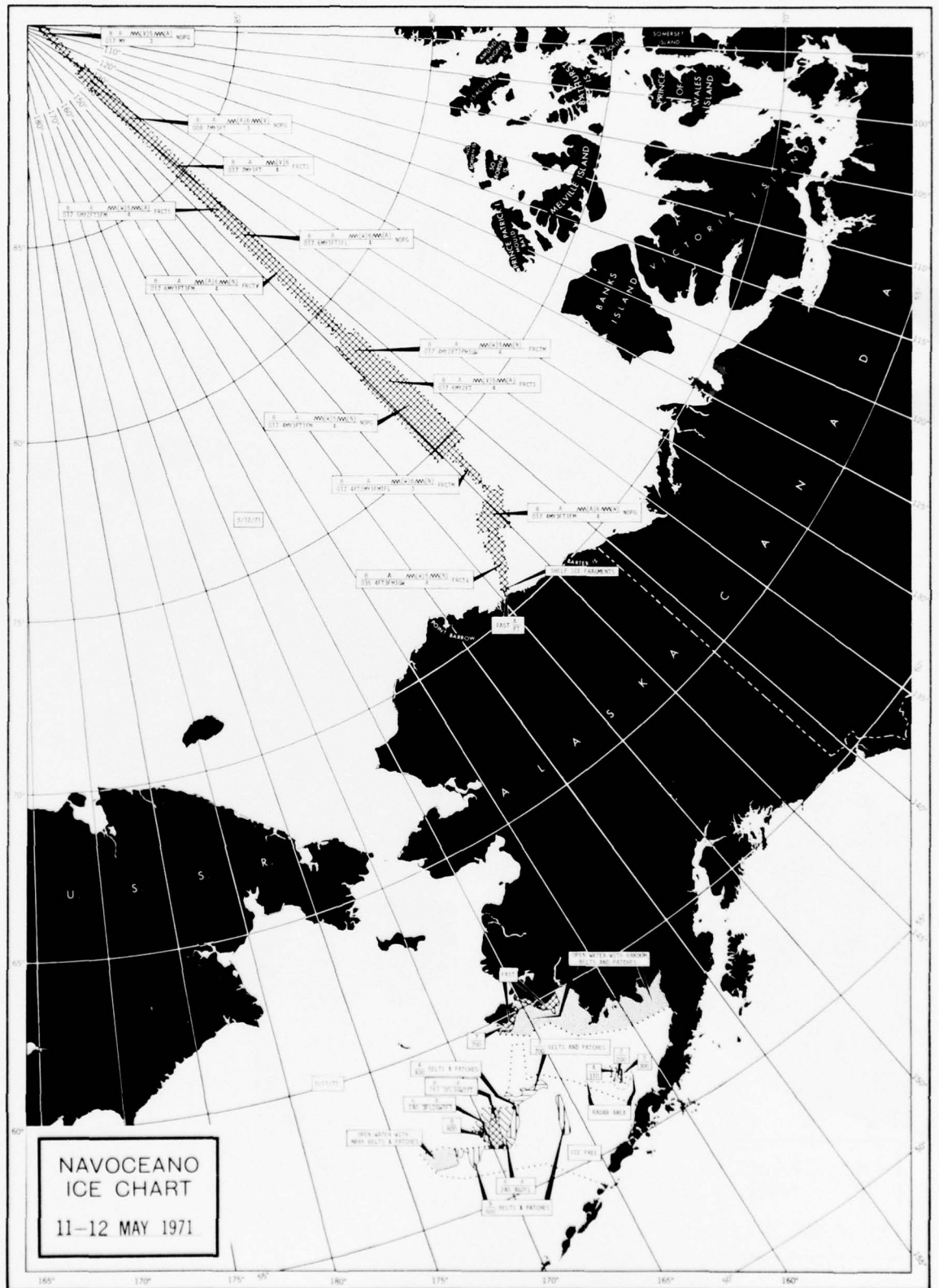




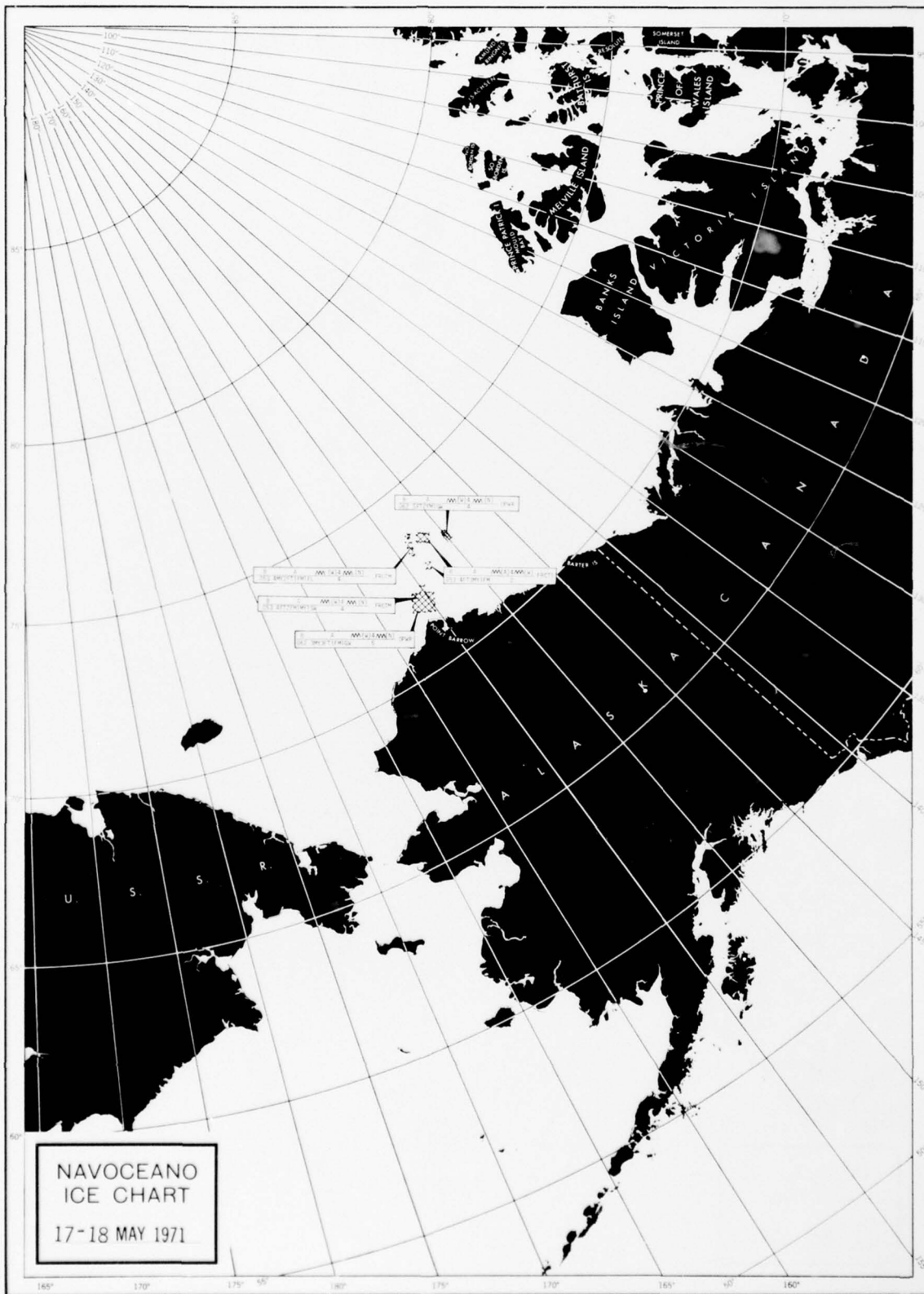
















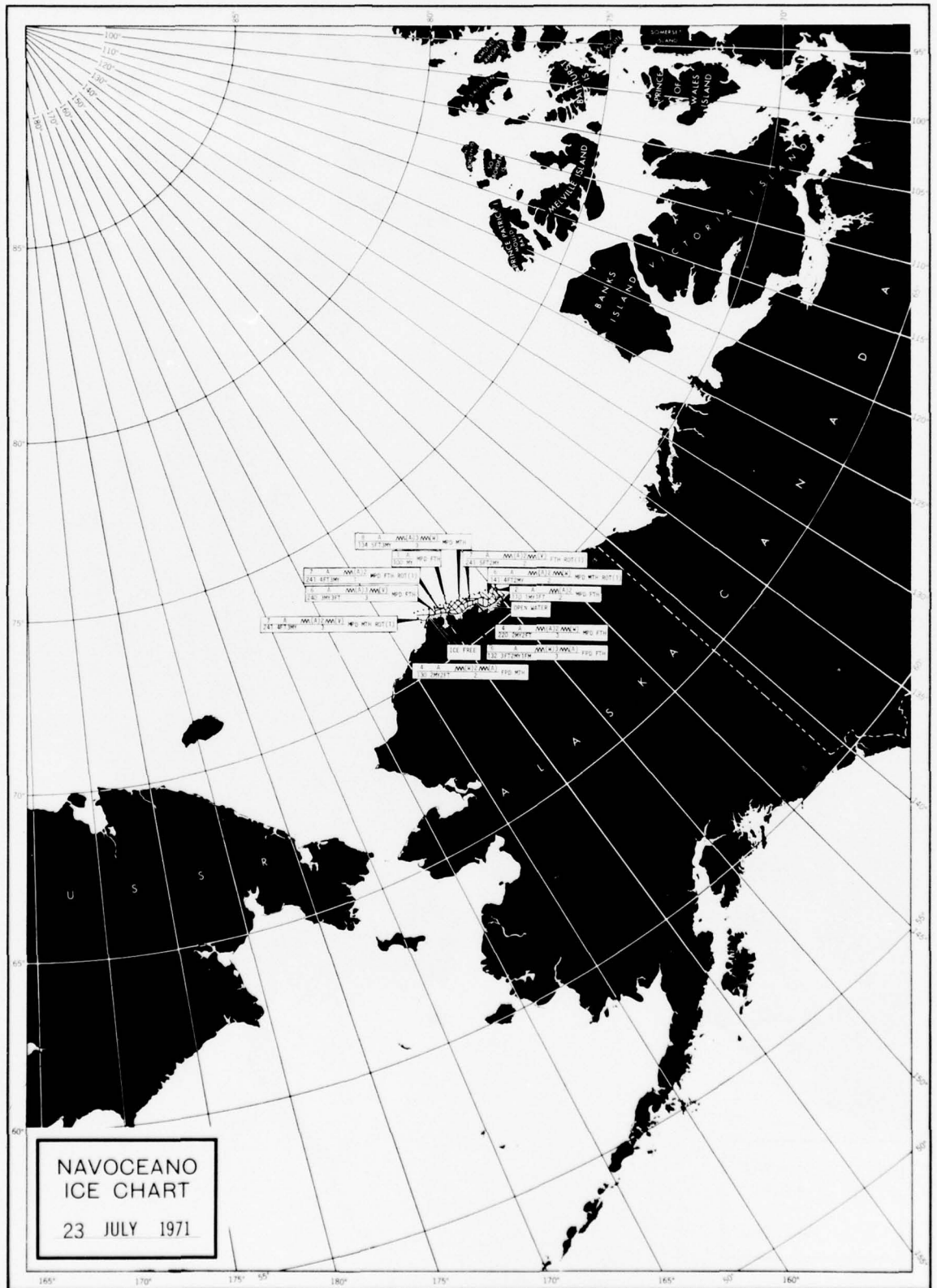










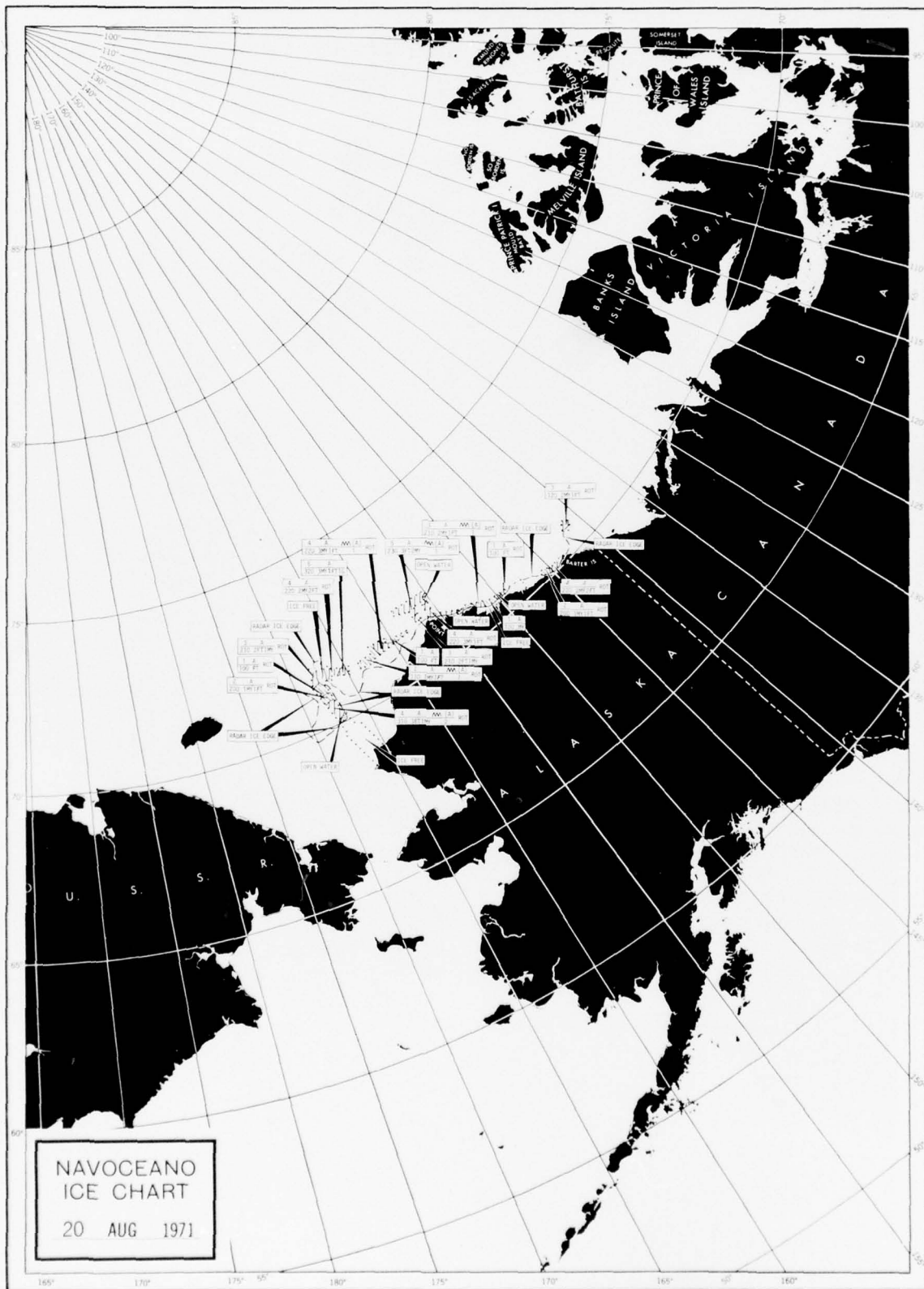






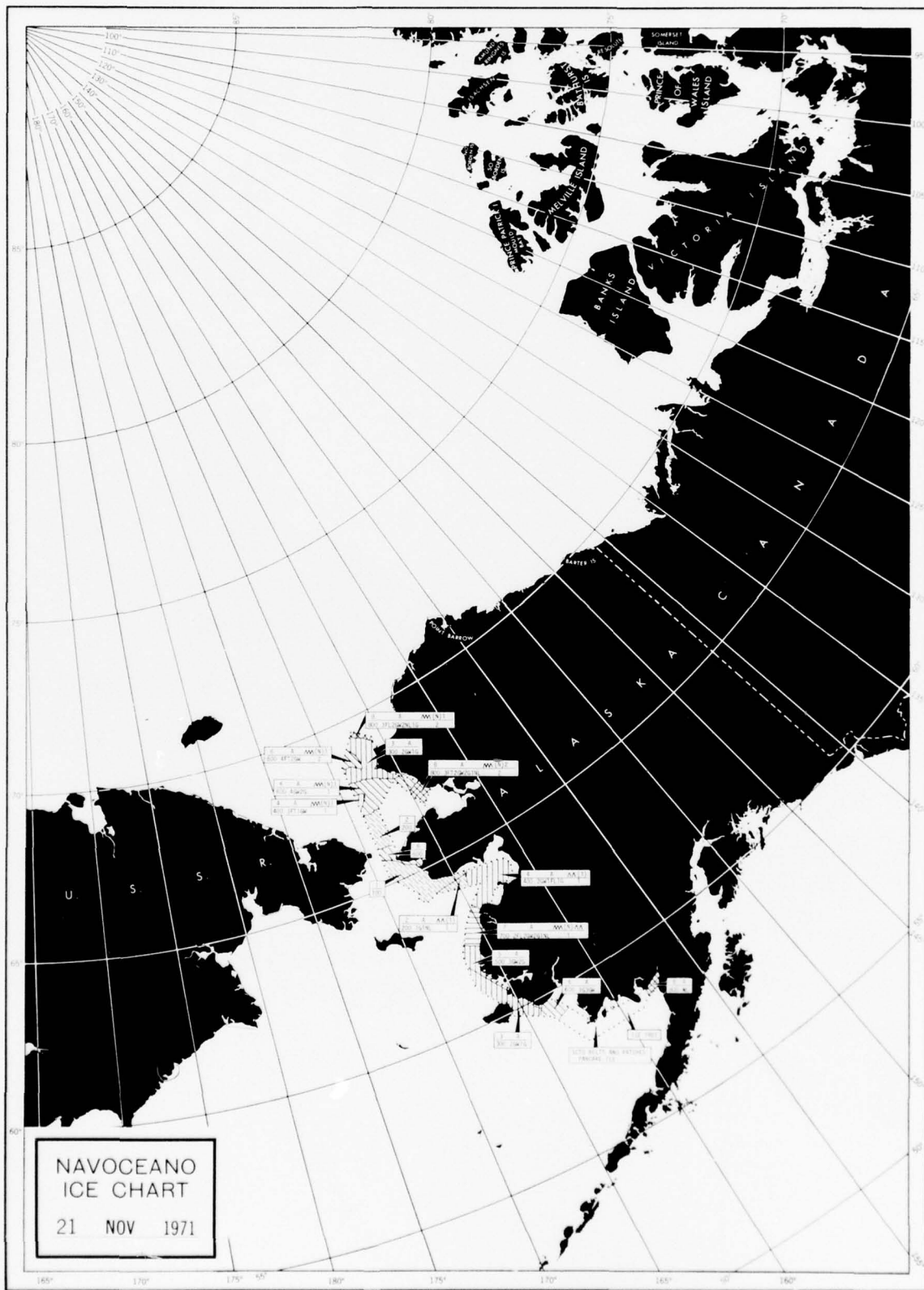








NAVOCEANO
 ICE CHART
 4-7 SEPT 1971



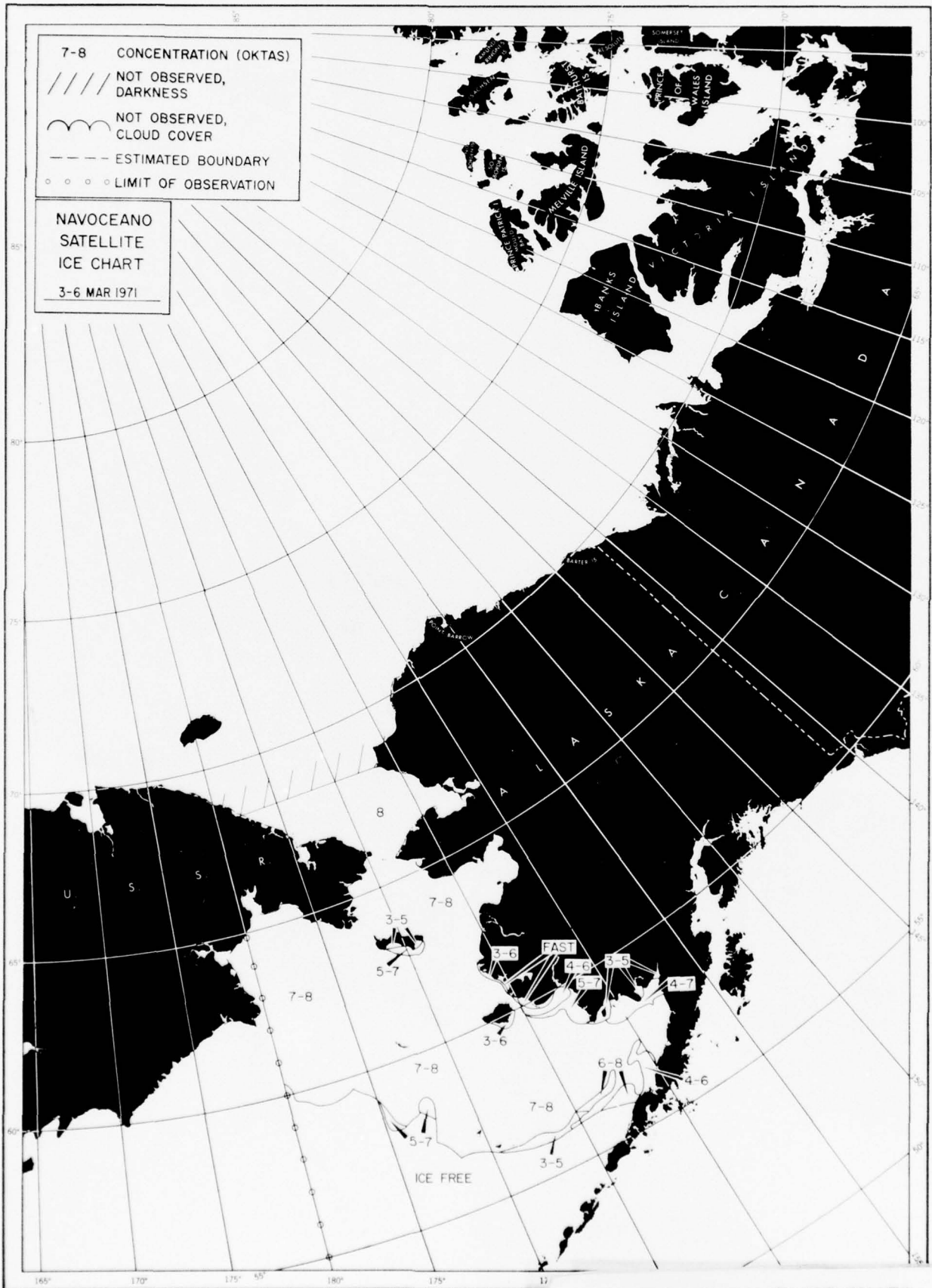
NAVOCEANO
ICE CHART
21 NOV 1971

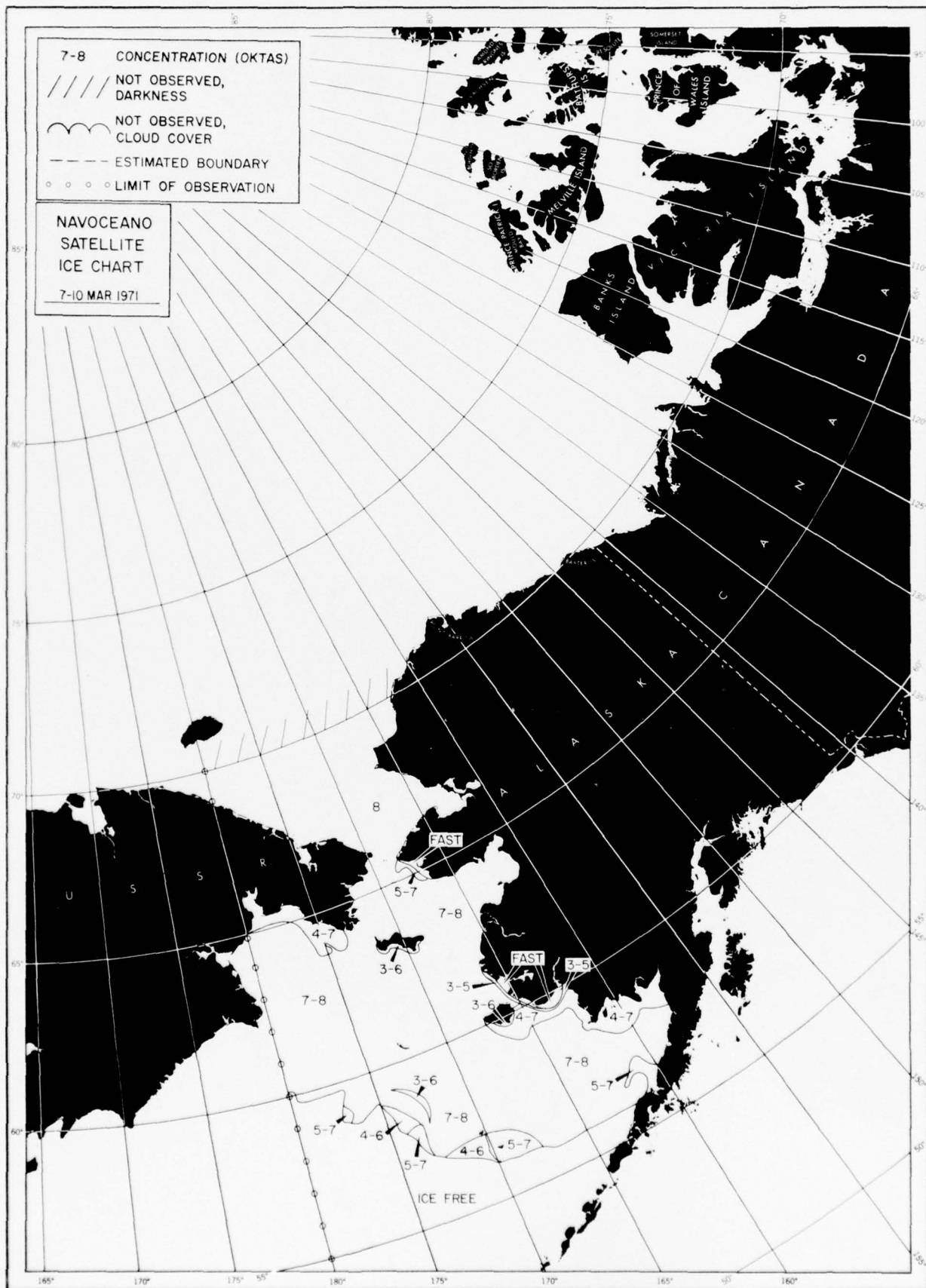


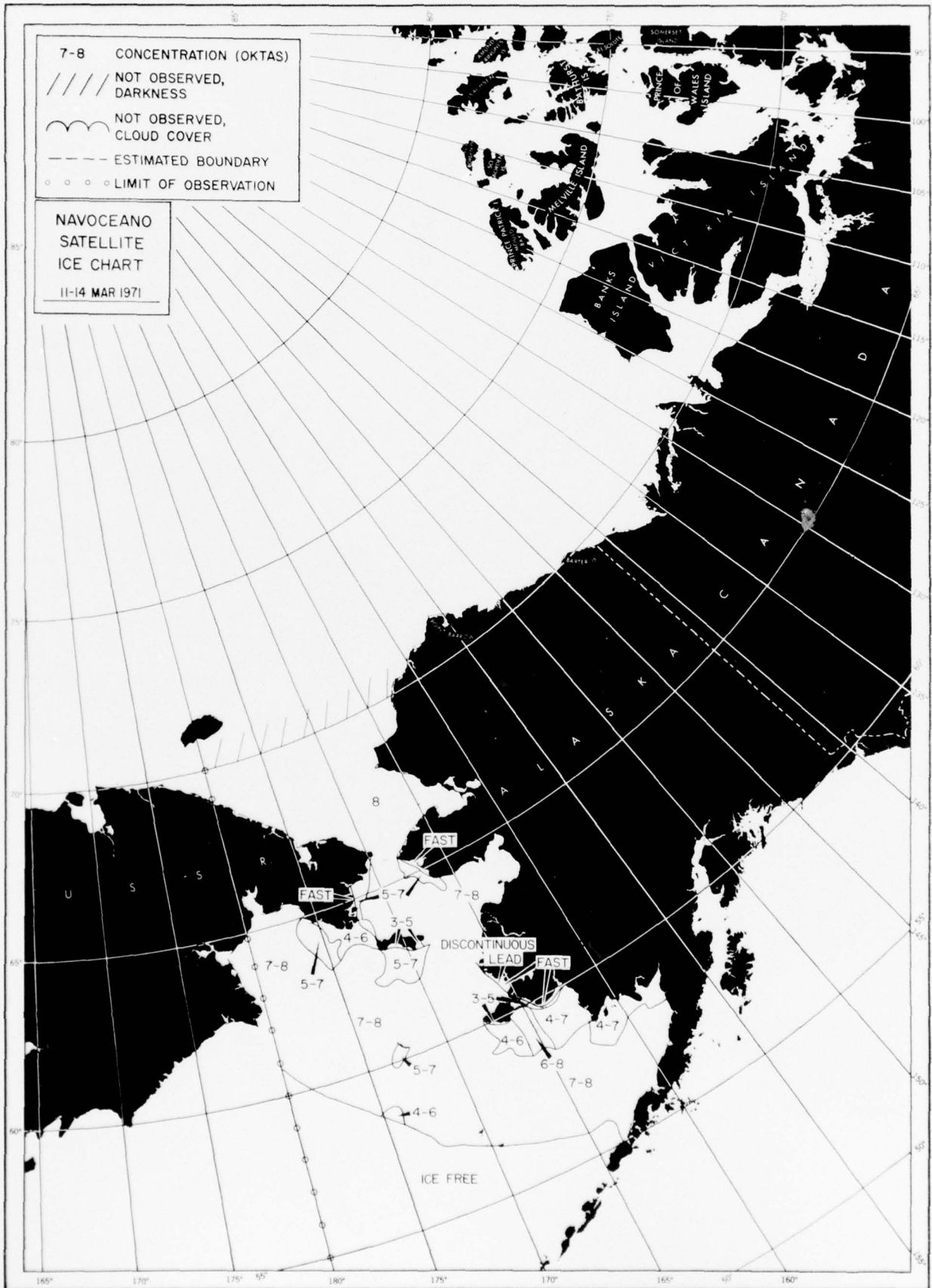


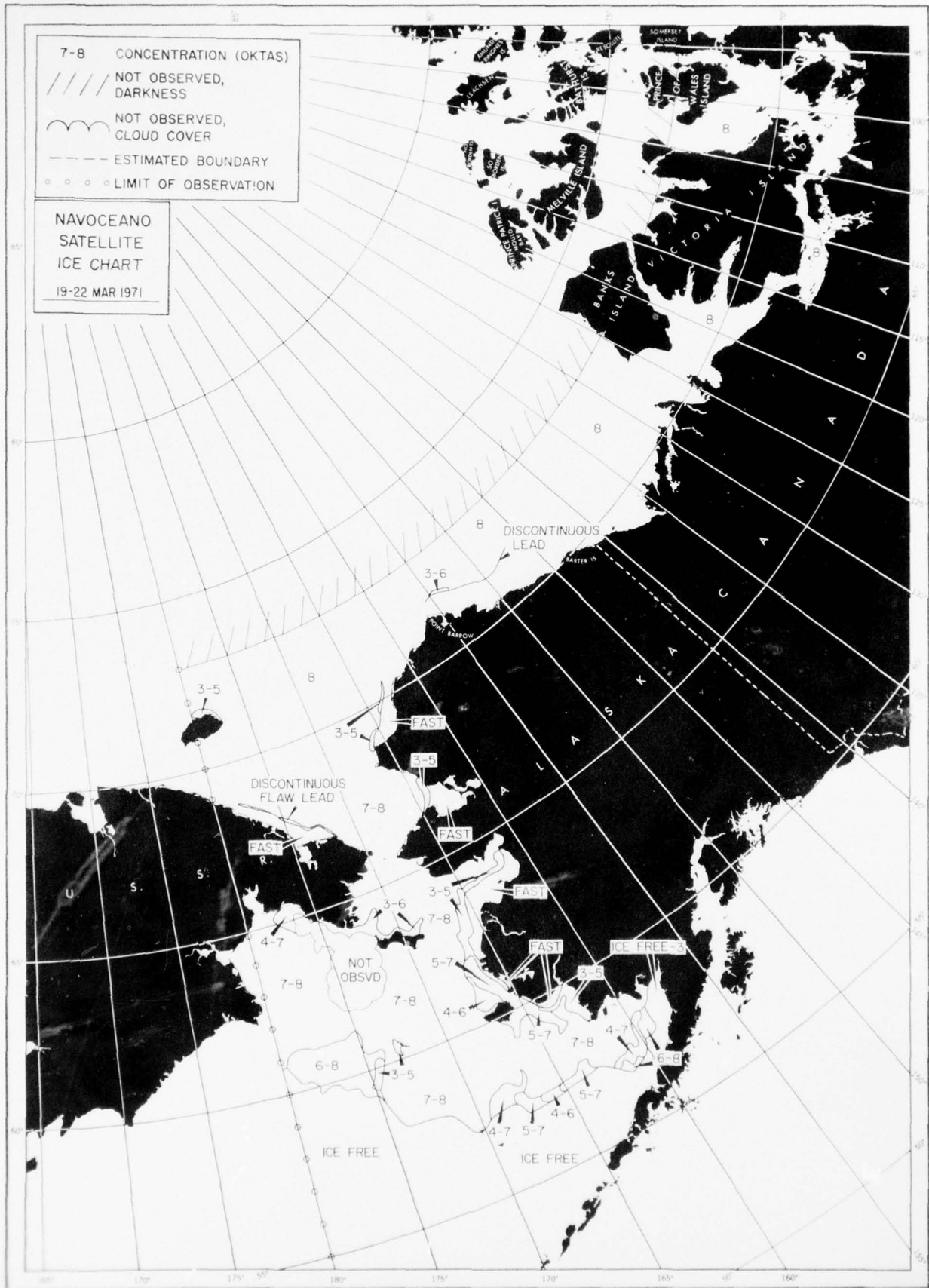


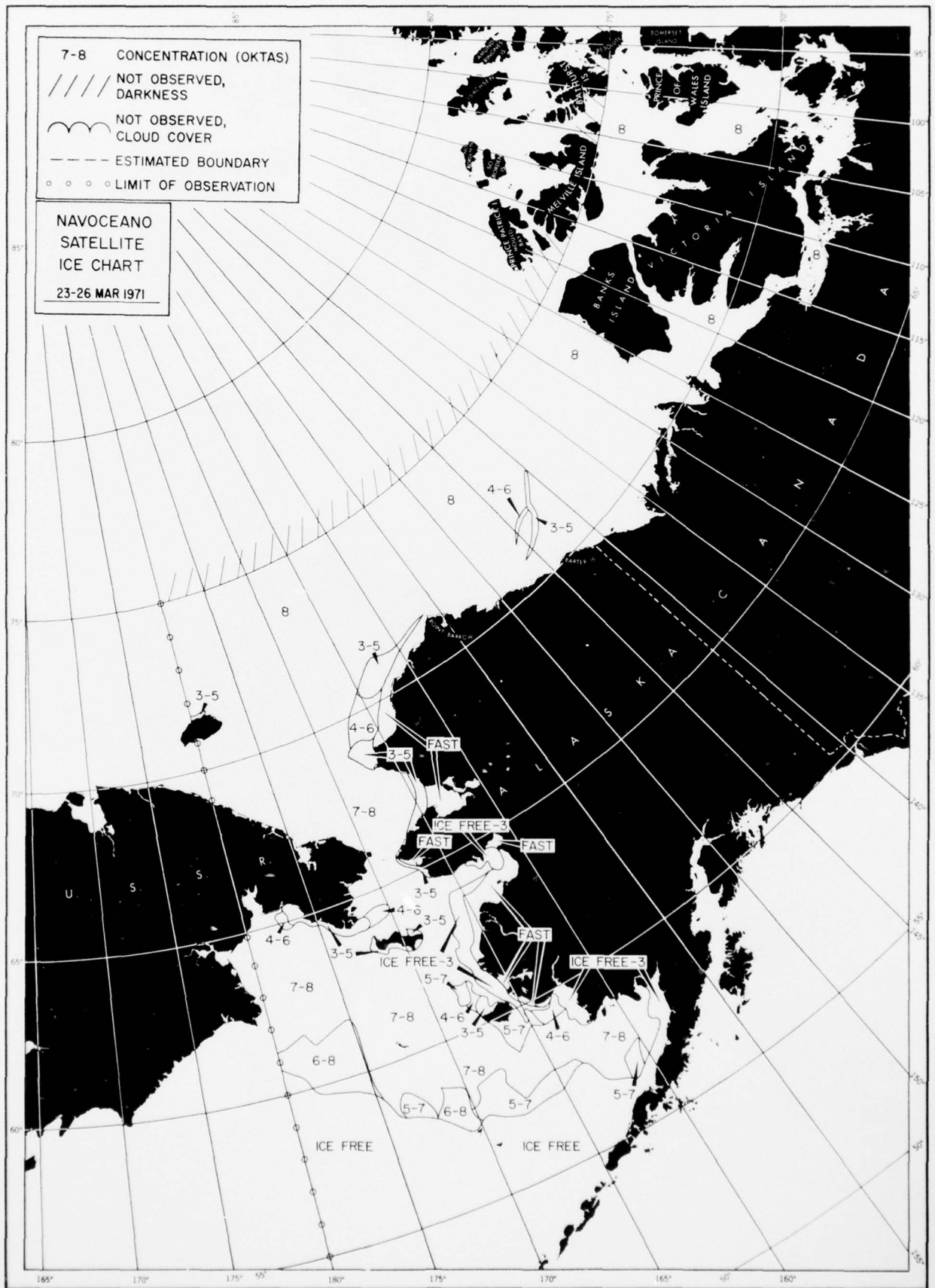
APPENDIX D
WESTERN ARCTIC SATELLITE
ICE CHARTS

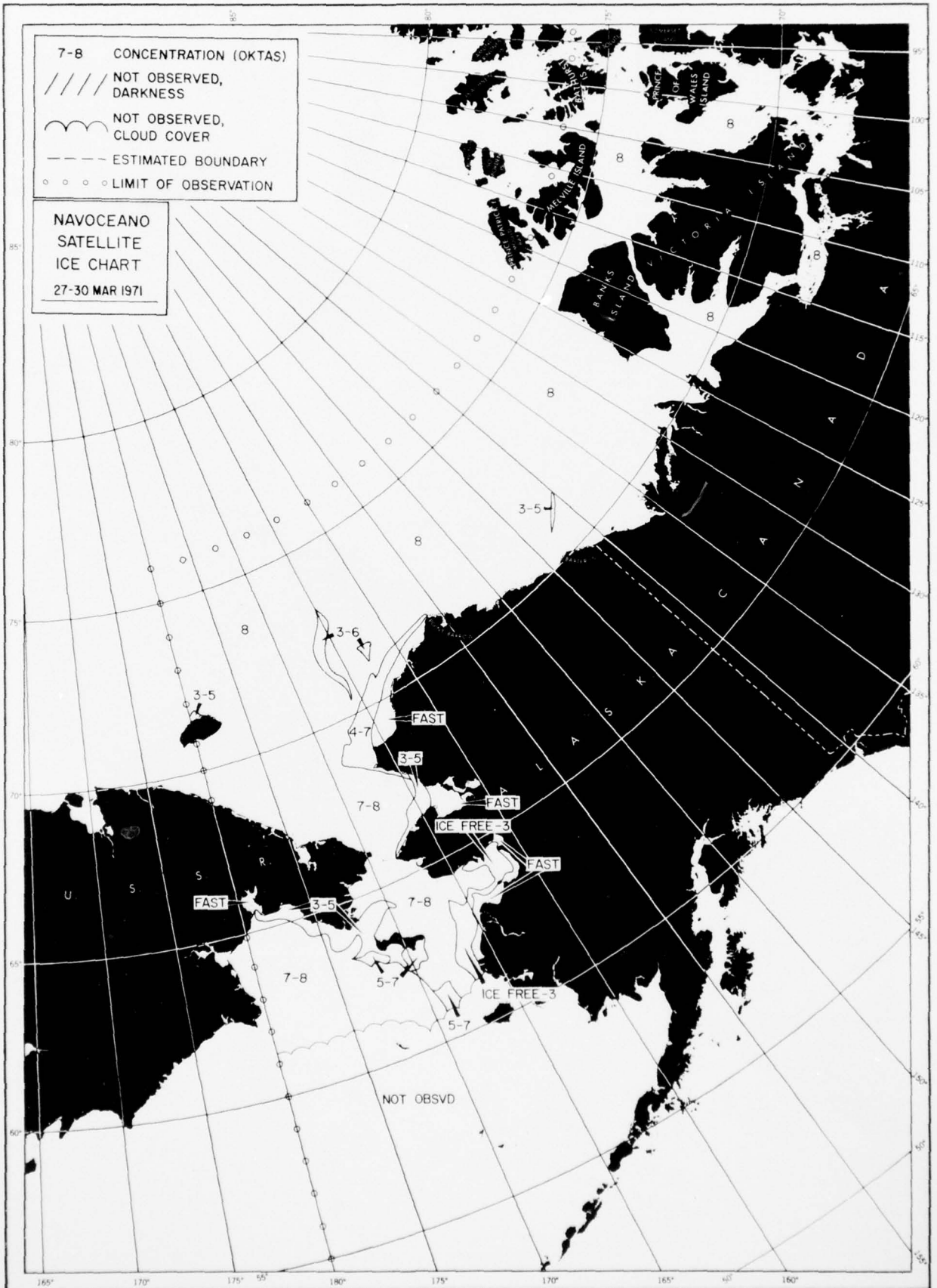


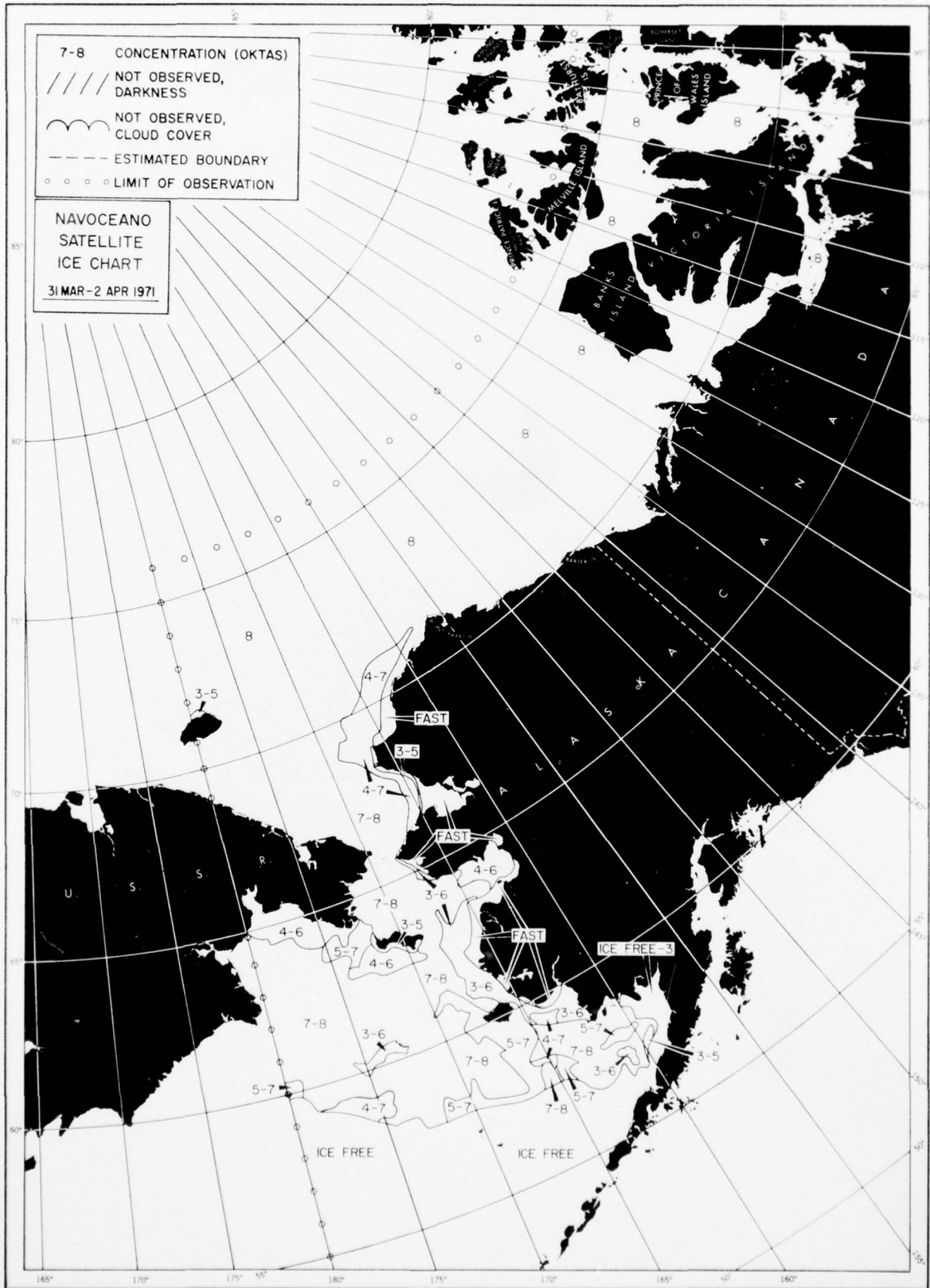


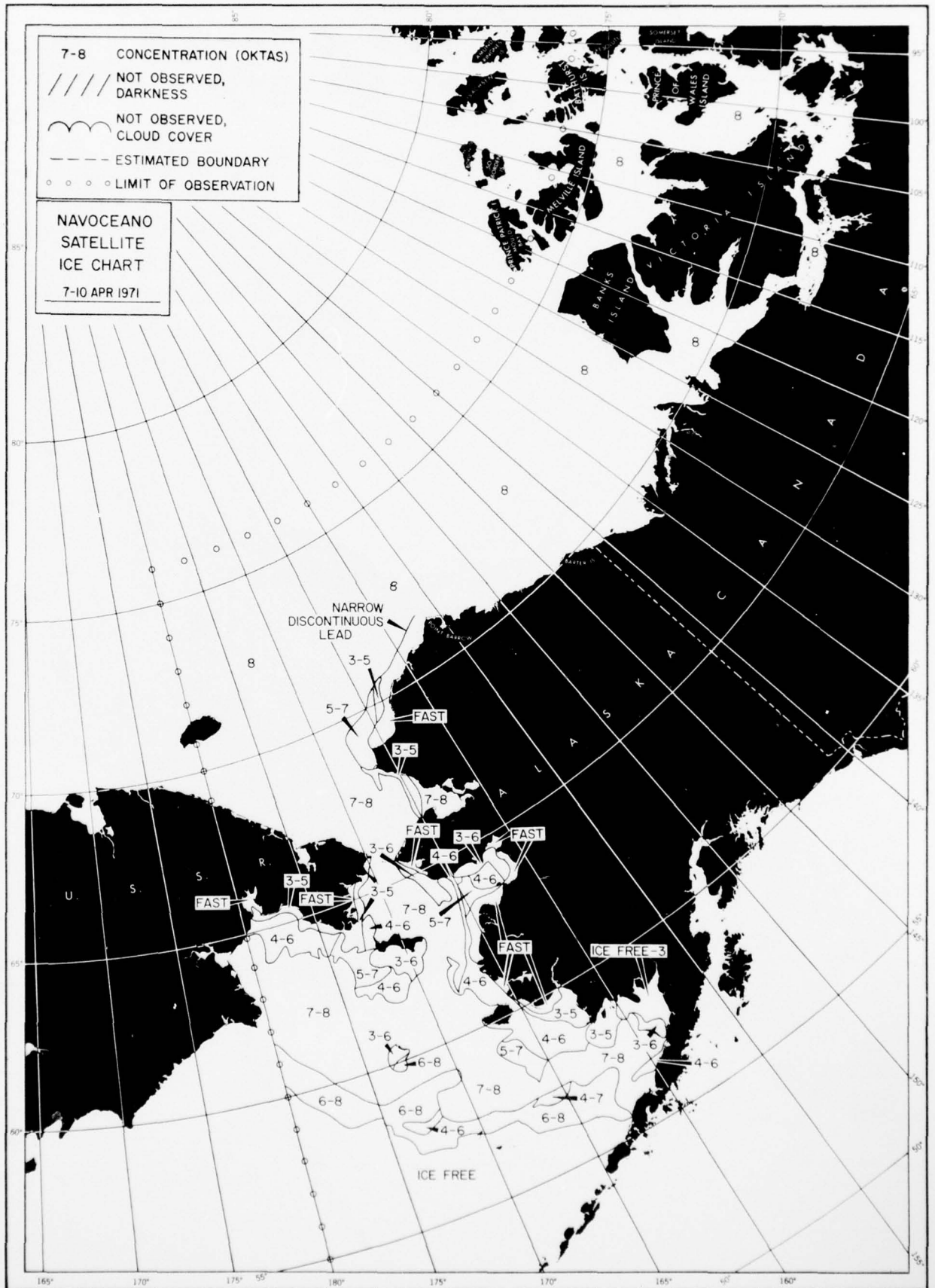


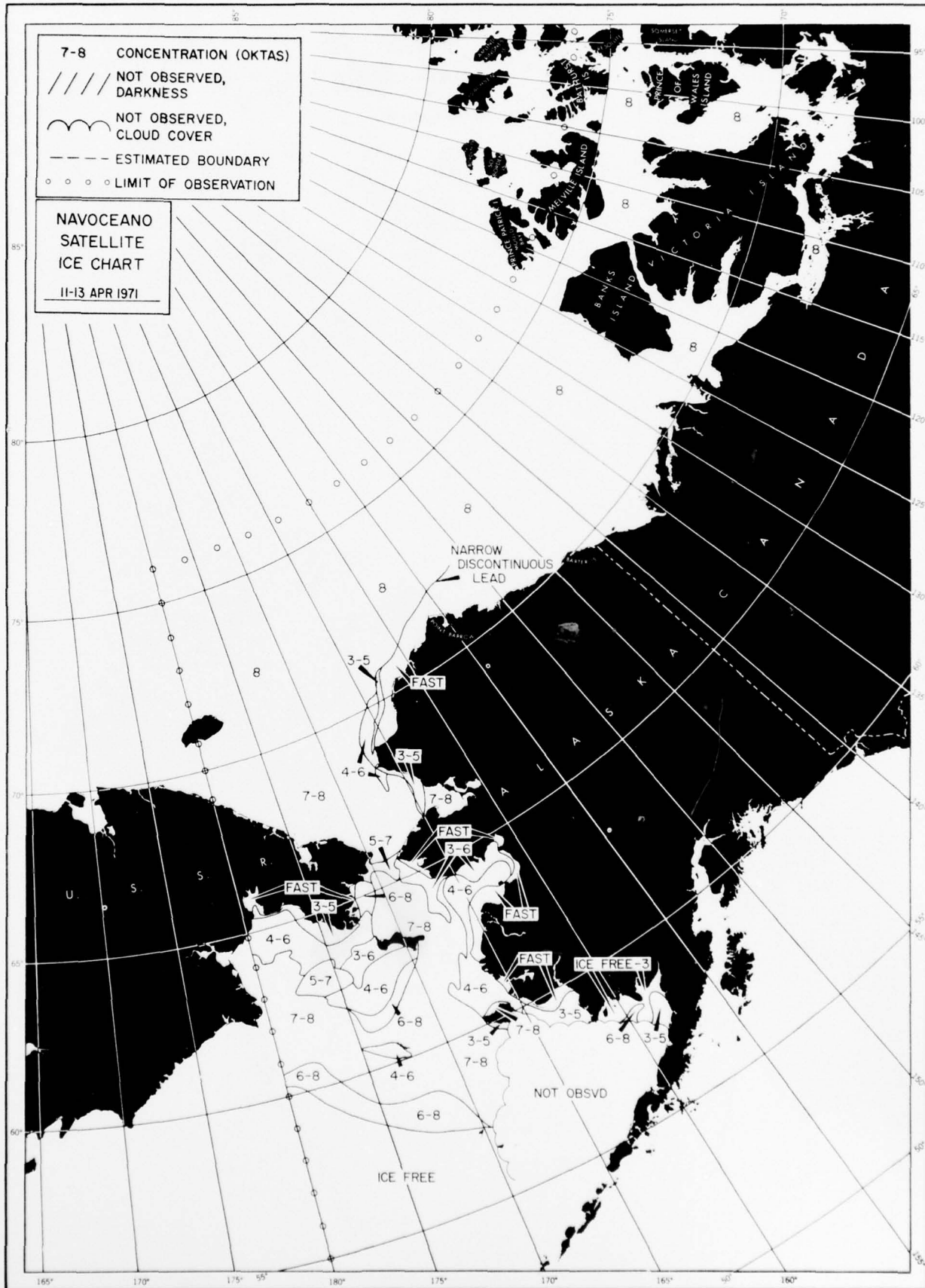






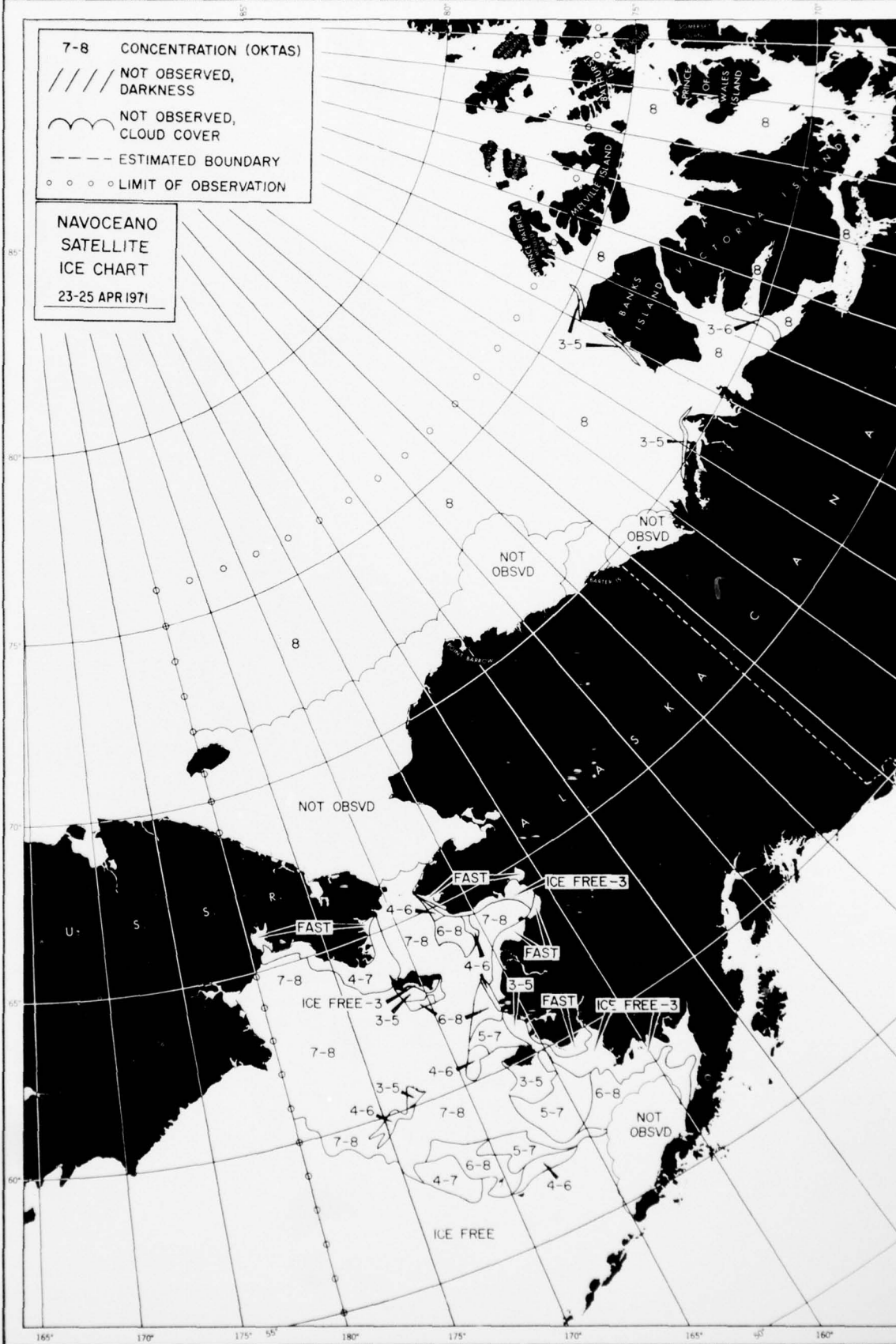




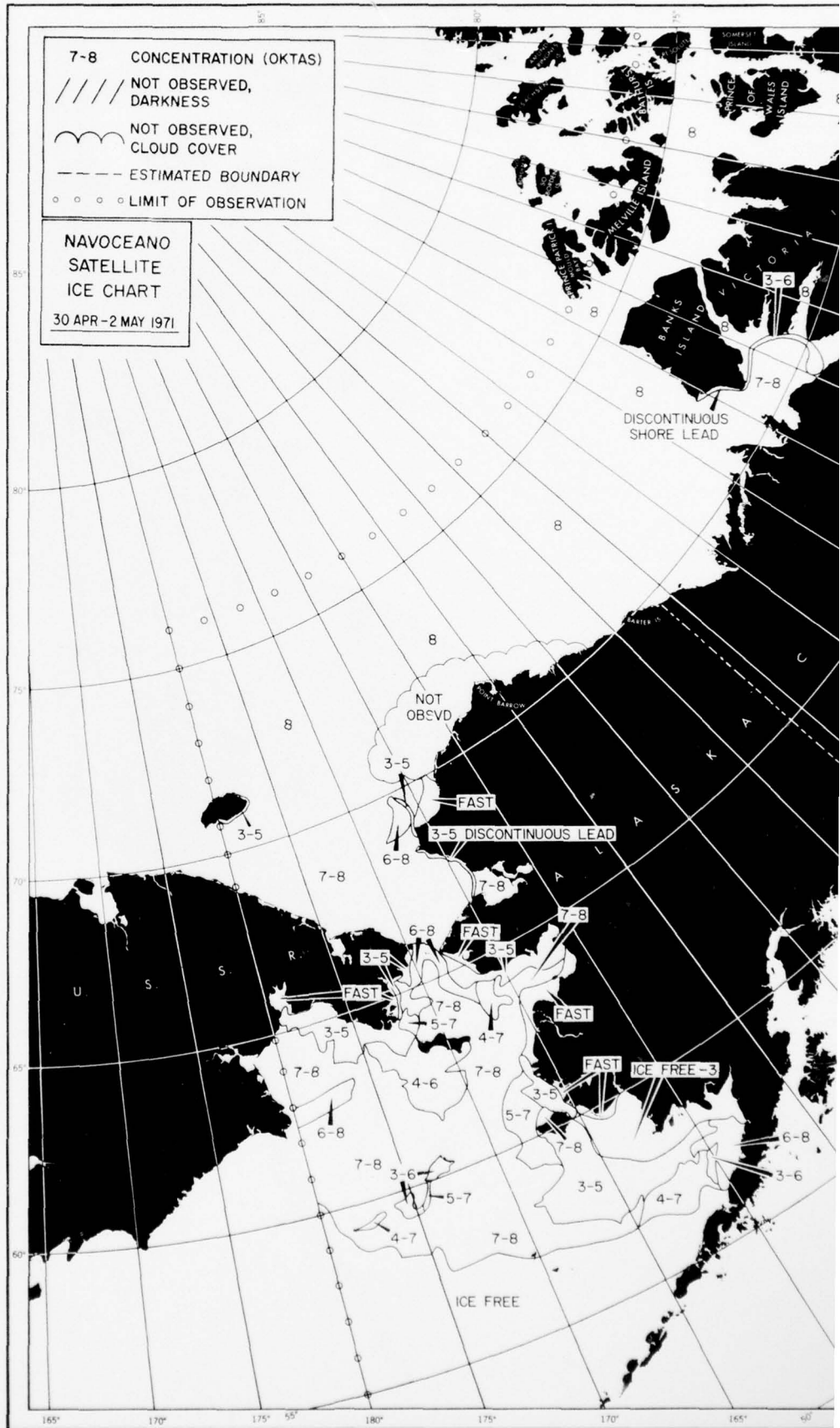


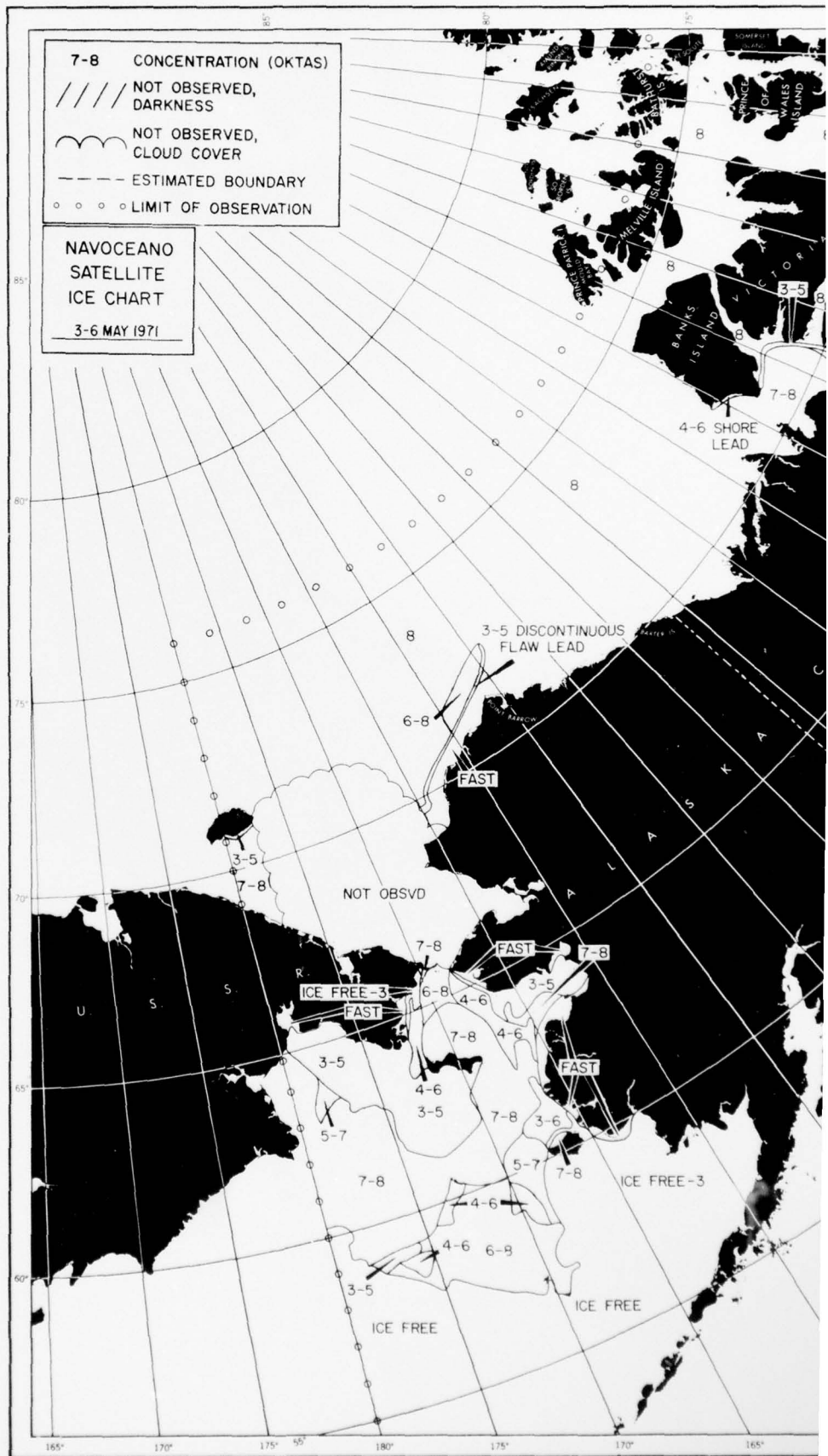
7-8 CONCENTRATION (OKTAS)
 // // // NOT OBSERVED, DARKNESS
 ~~~~~ NOT OBSERVED, CLOUD COVER  
 - - - - ESTIMATED BOUNDARY  
 ○ ○ ○ ○ LIMIT OF OBSERVATION

NAVOCEANO  
 SATELLITE  
 ICE CHART  
 23-25 APR 1971











AD-A042 709

NAVAL OCEANOGRAPHIC OFFICE WASHINGTON D C  
REPORT OF THE ARCTIC ICE OBSERVING AND FORECASTING PROGRAM-1971--ETC(U)  
MAY 74 P A MITCHELL  
N00-SP-70(71)

F/G 8/12

UNCLASSIFIED

NL

3 OF 3

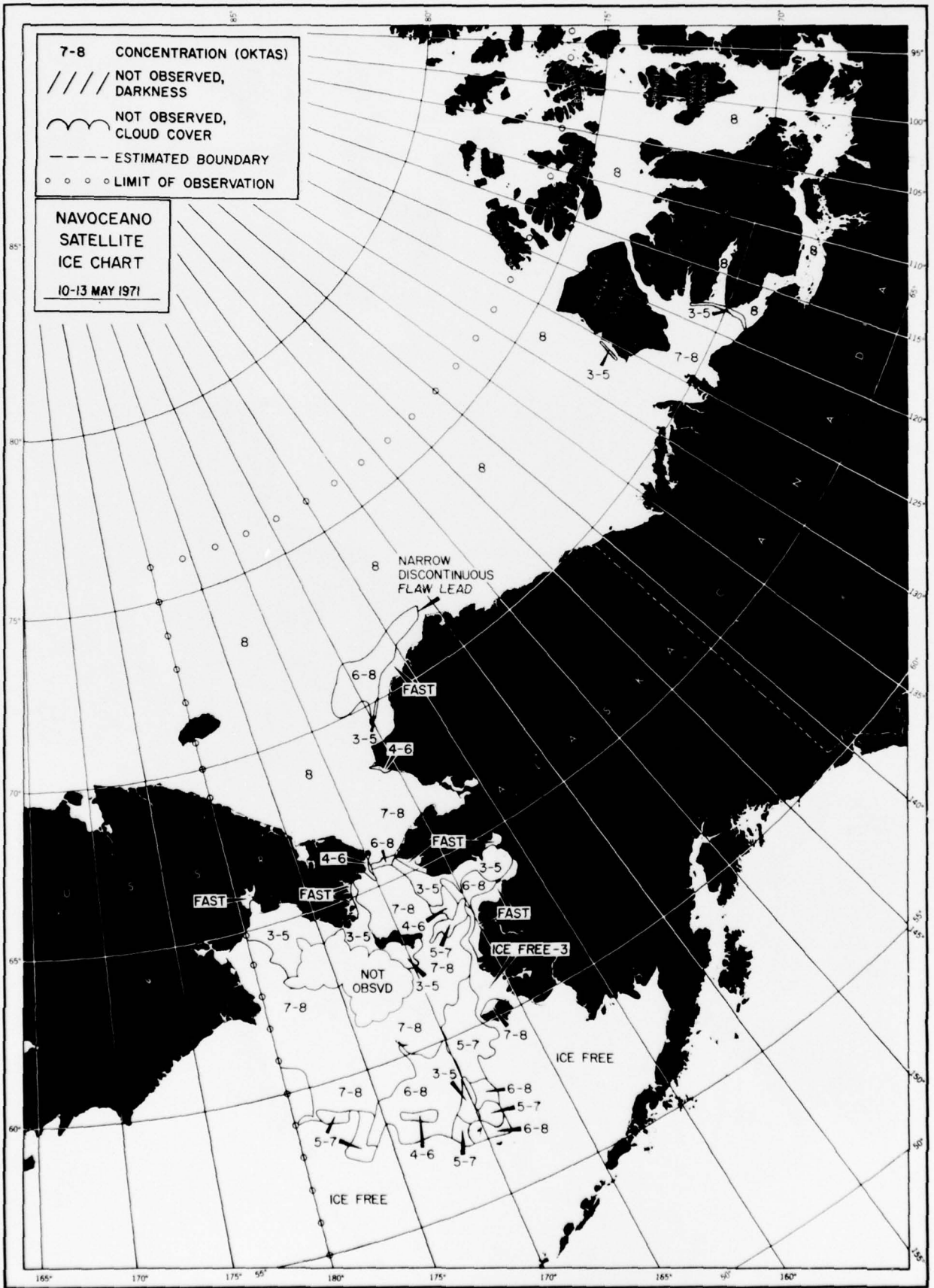
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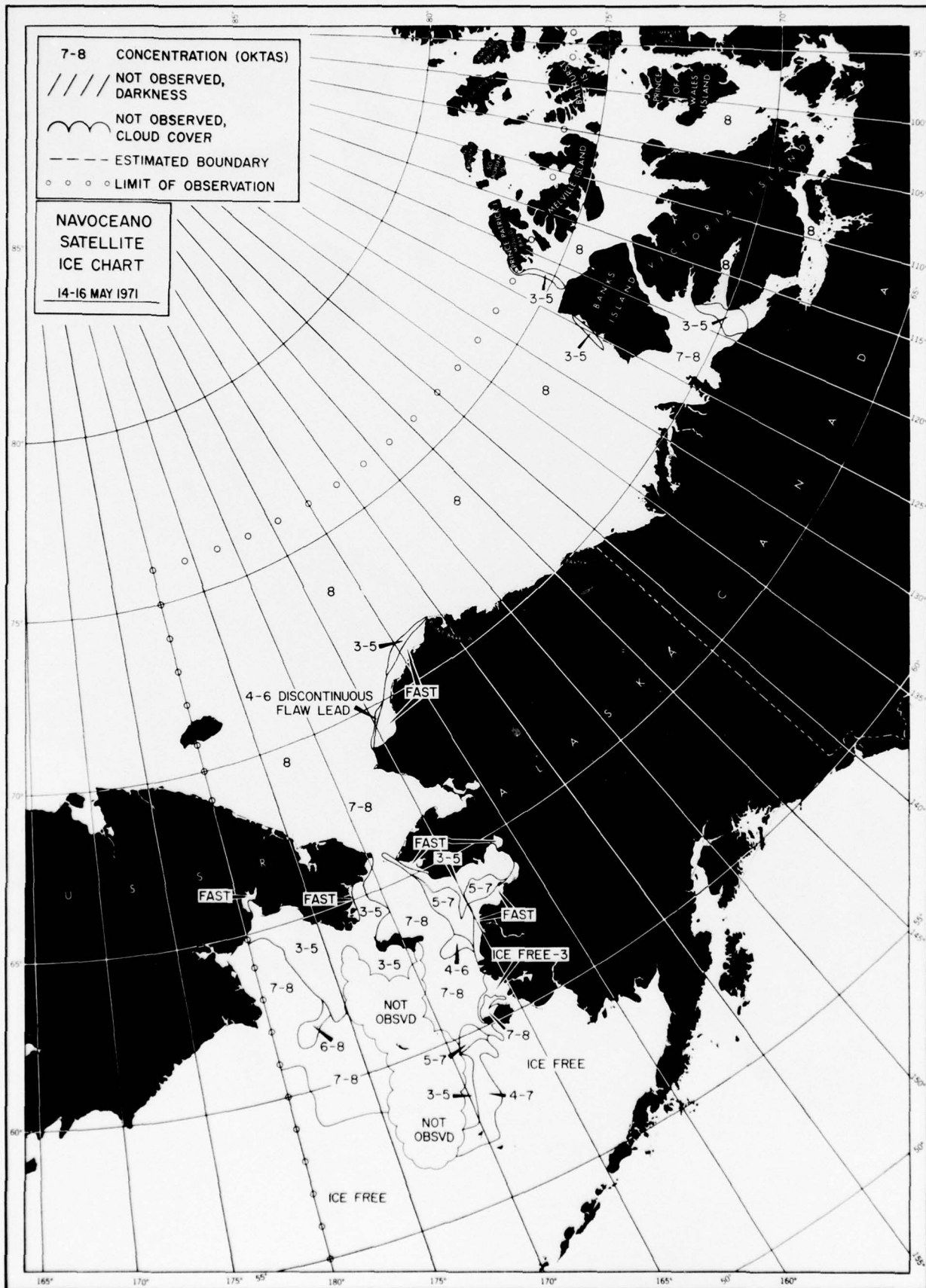


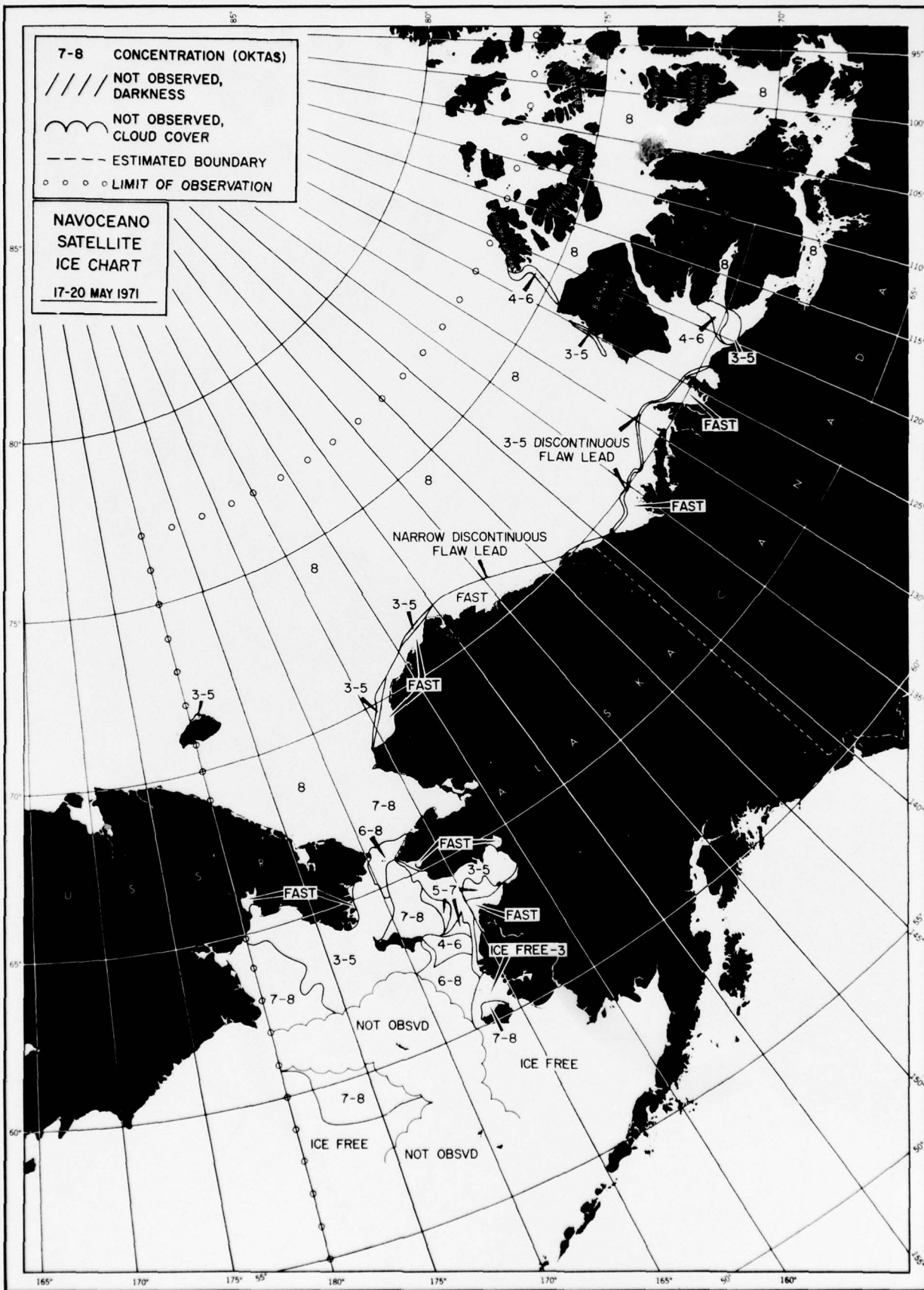
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DATE  
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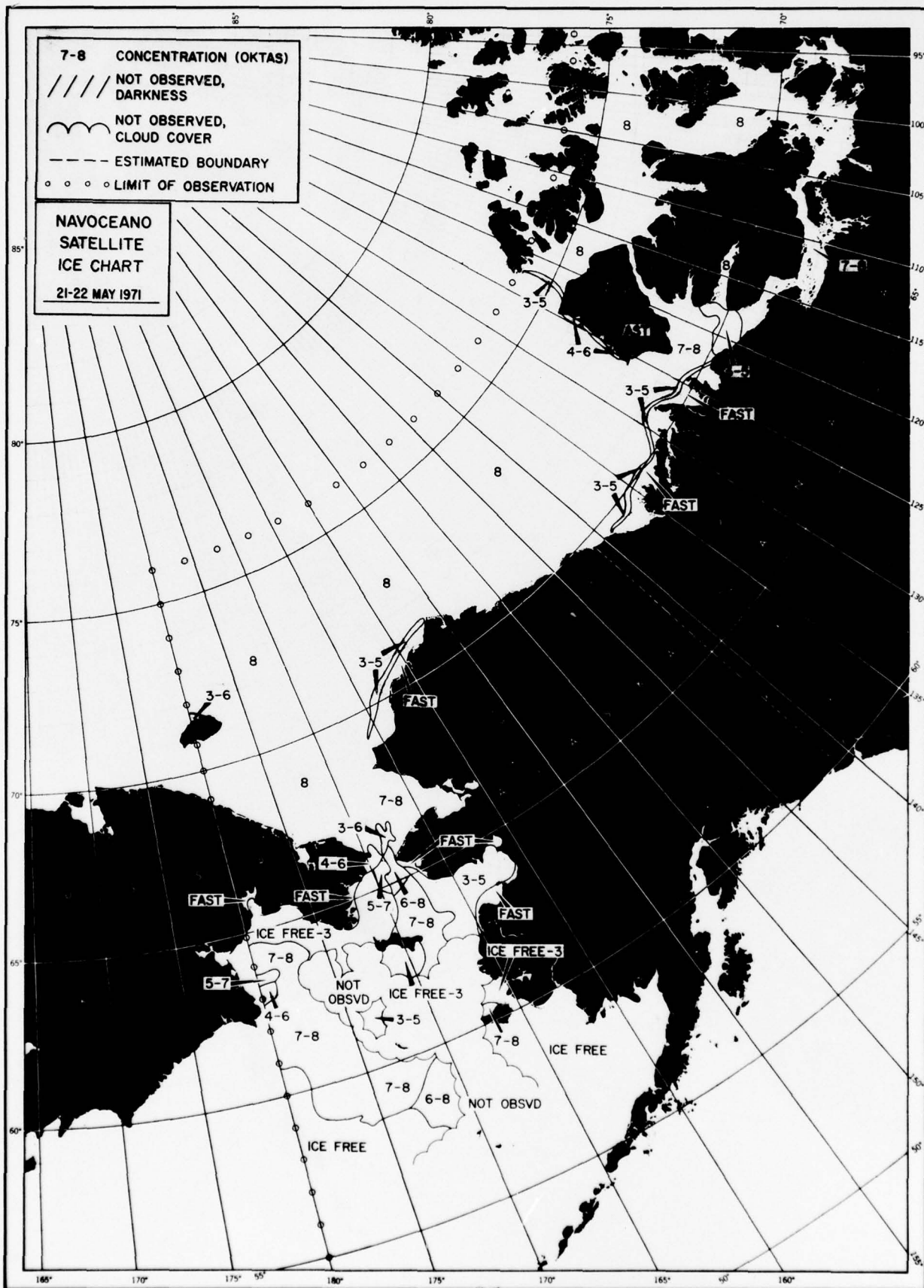
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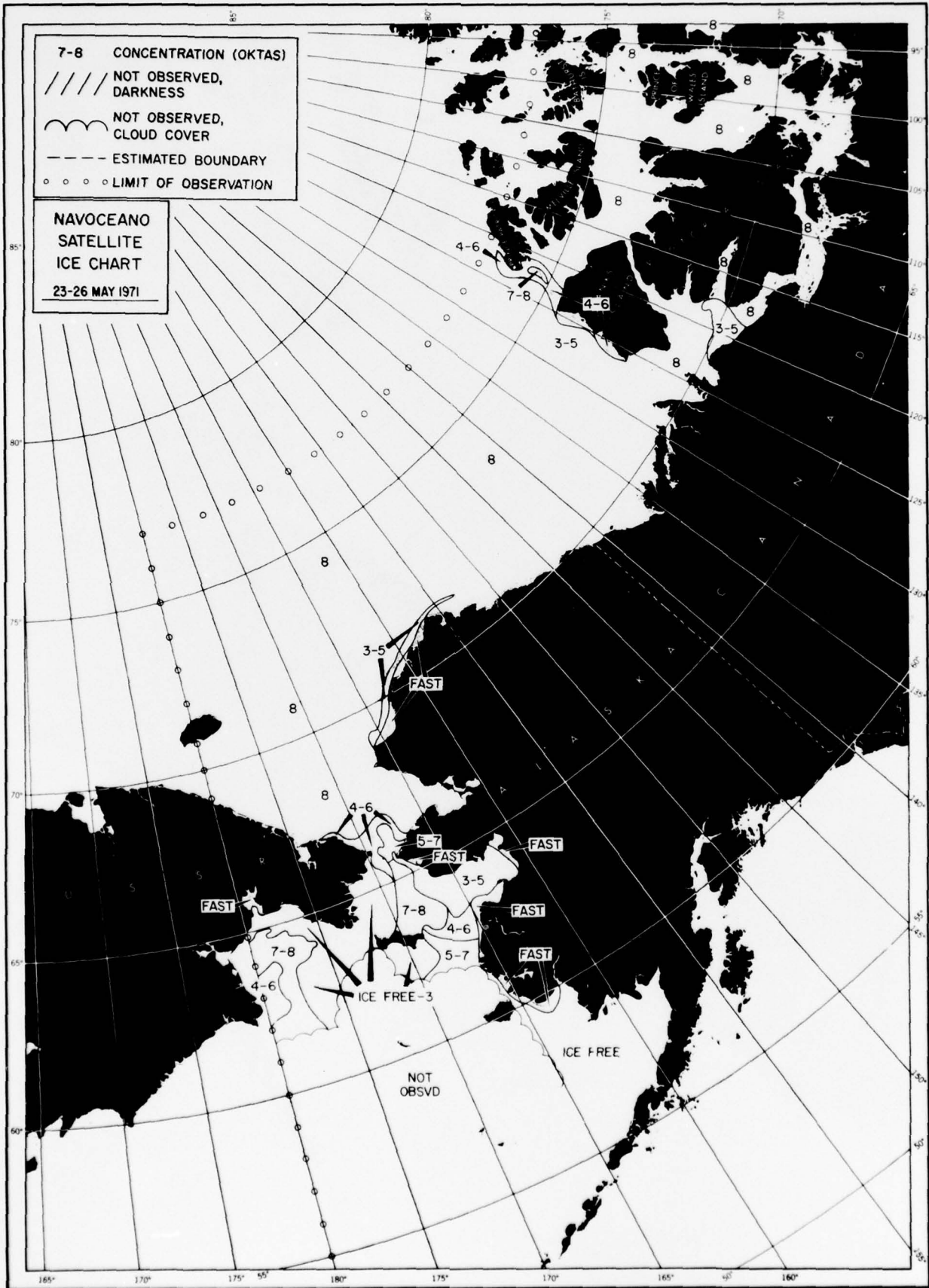
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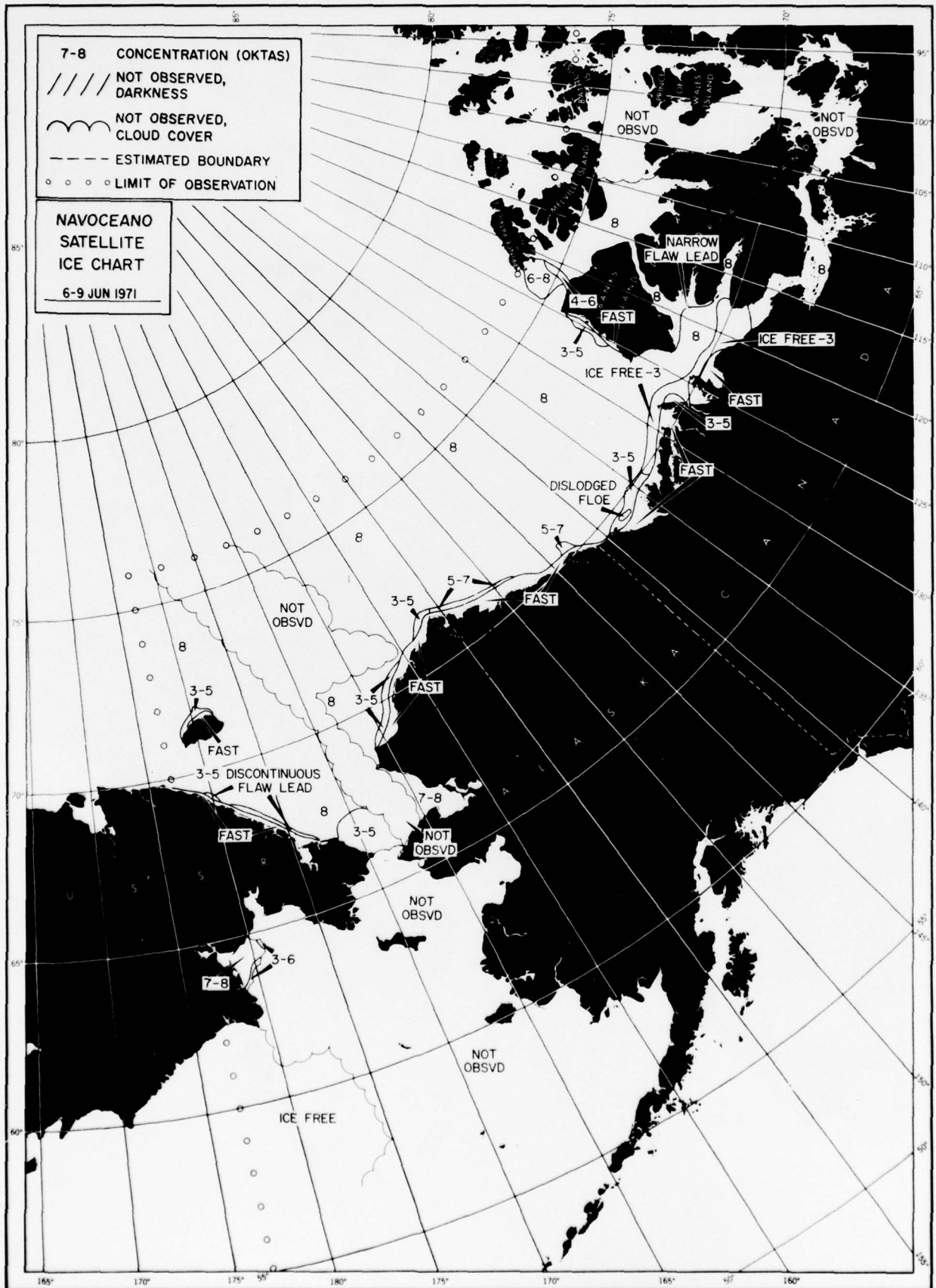




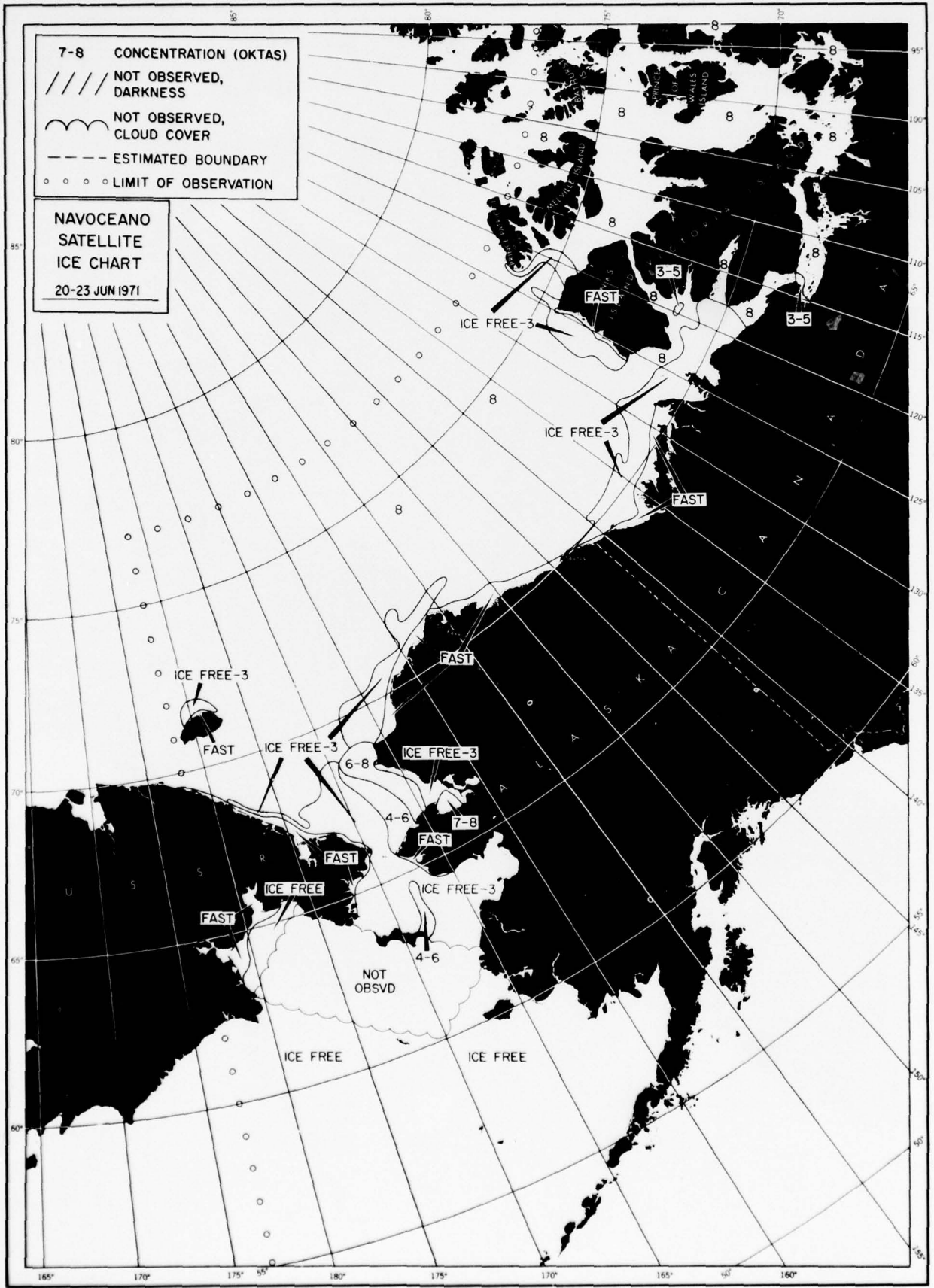


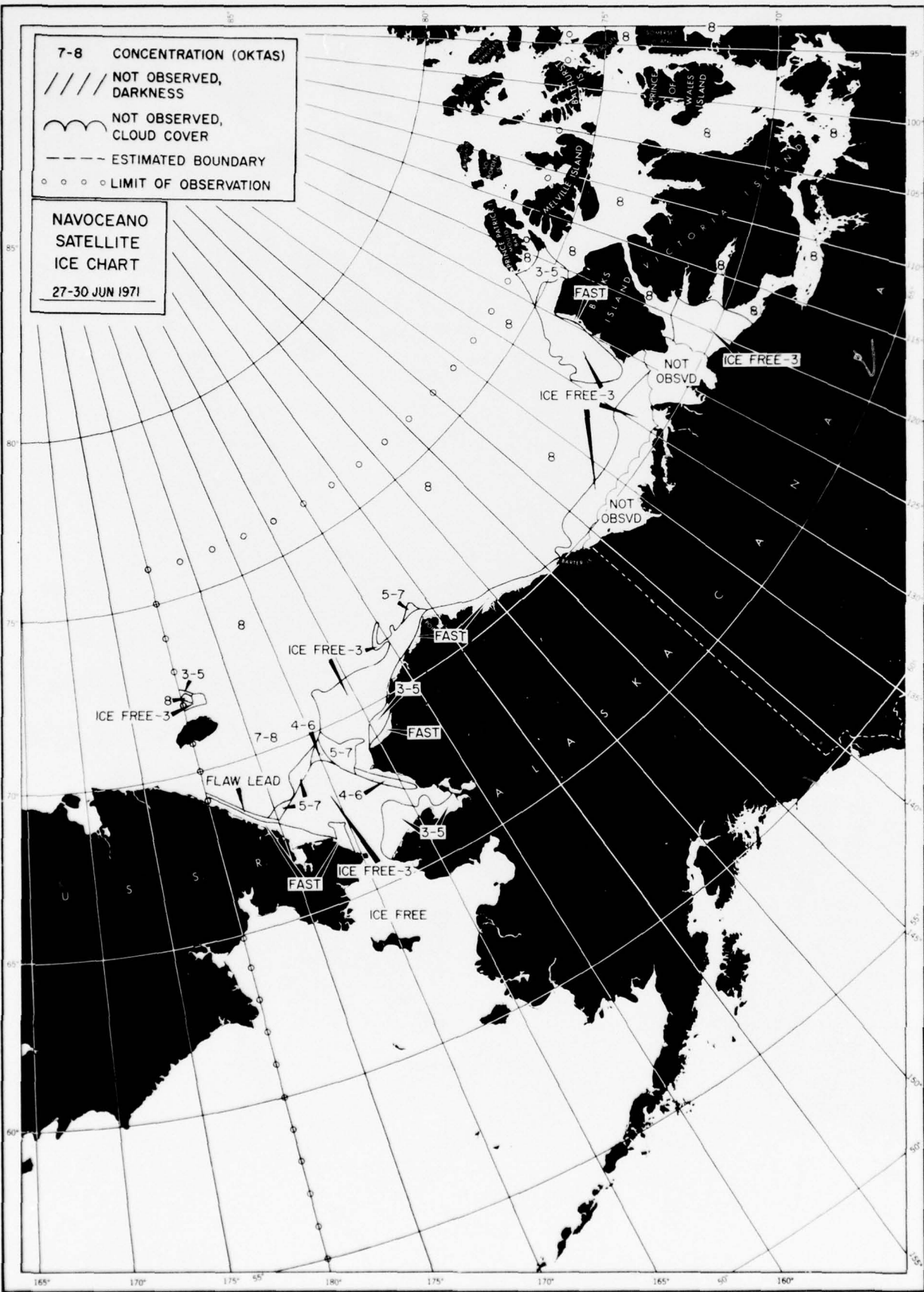




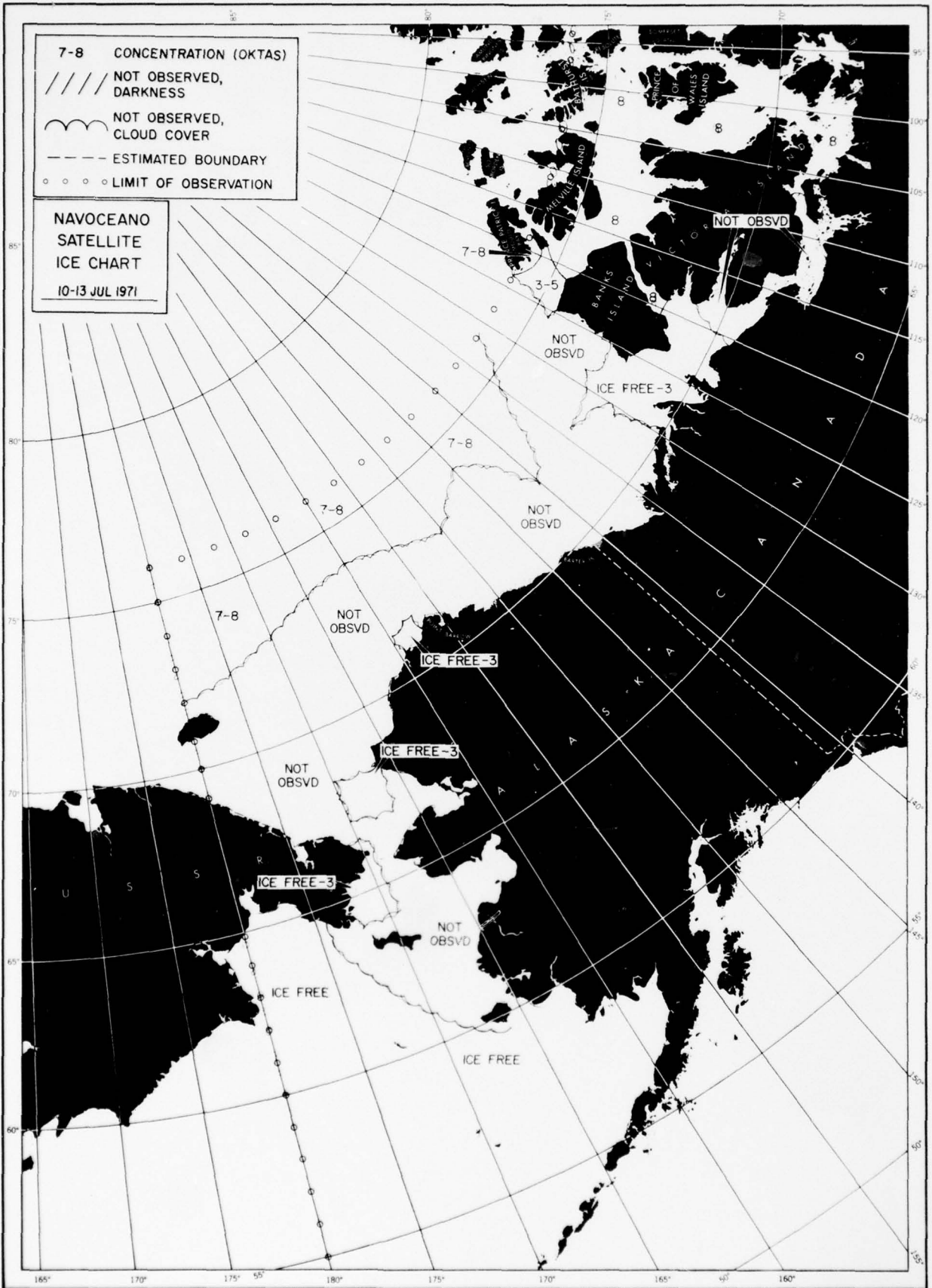




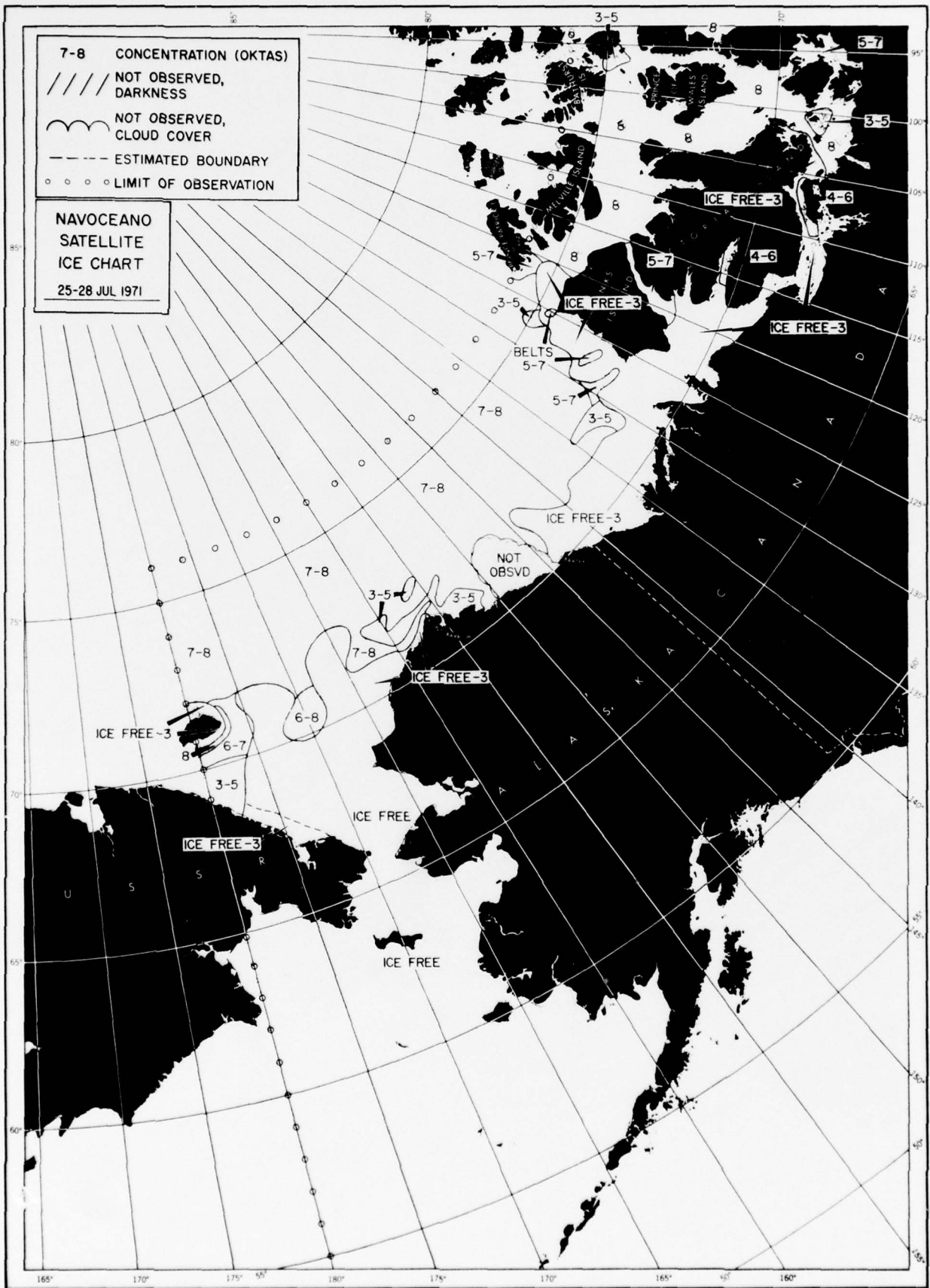


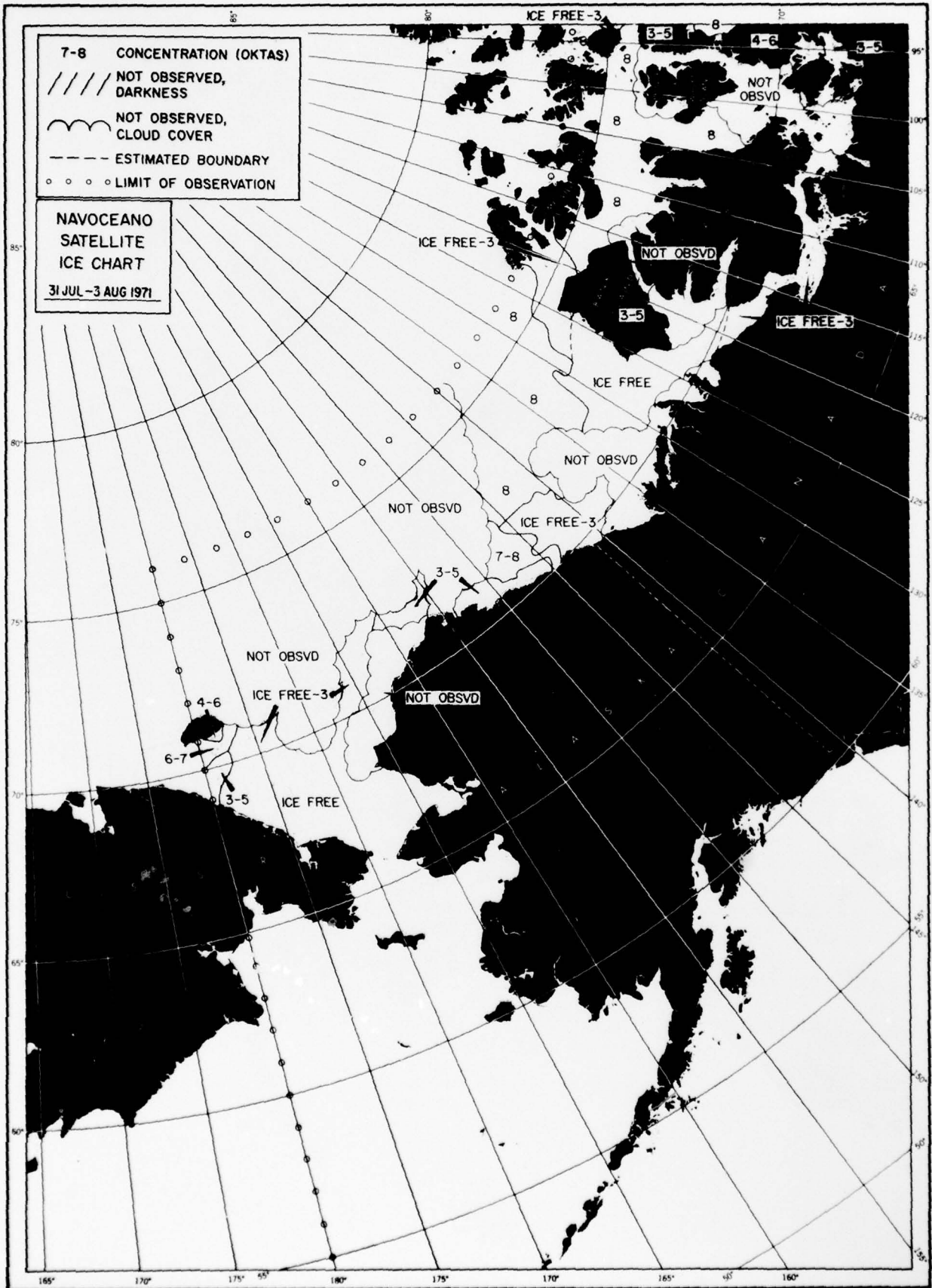


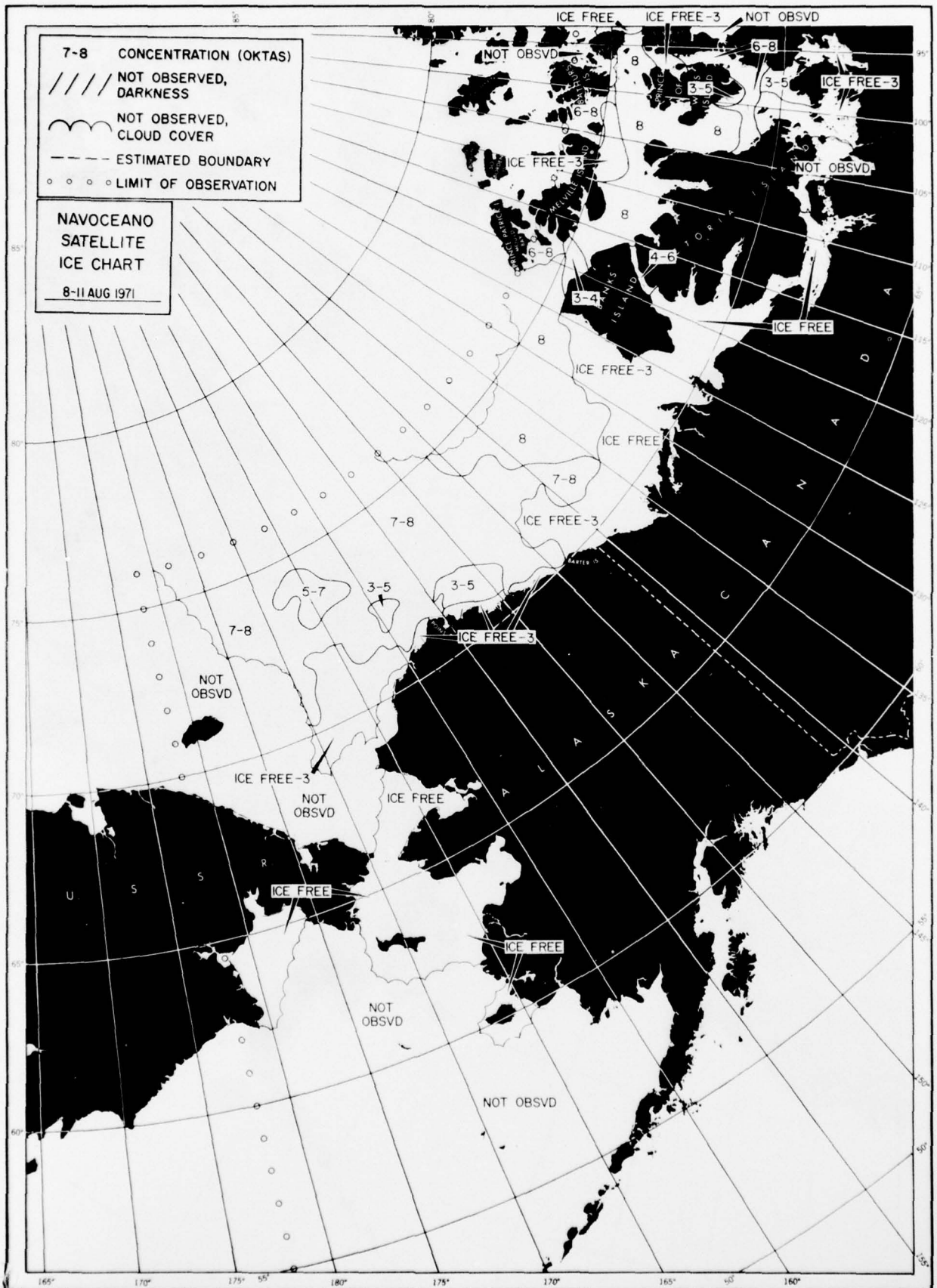




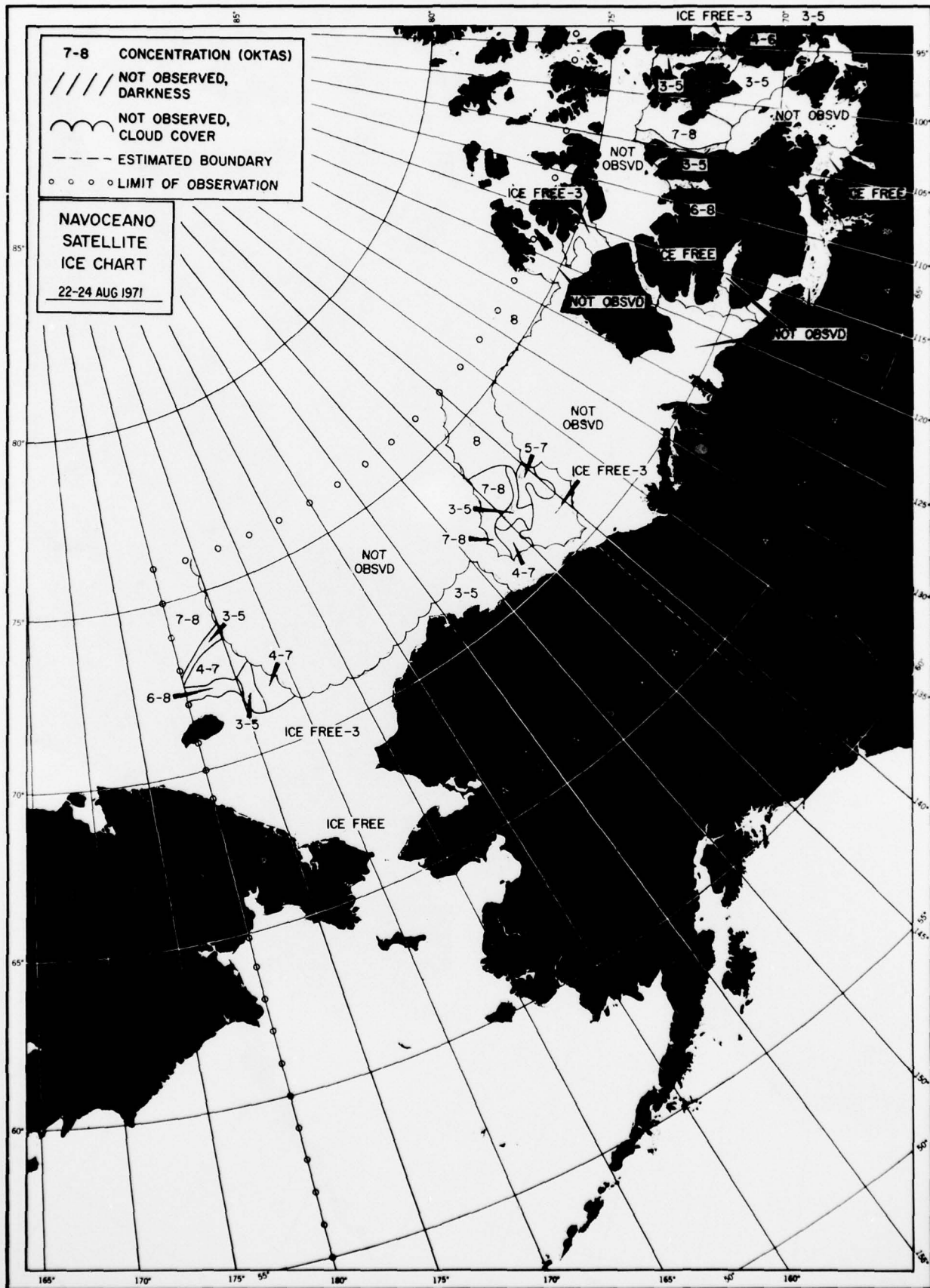


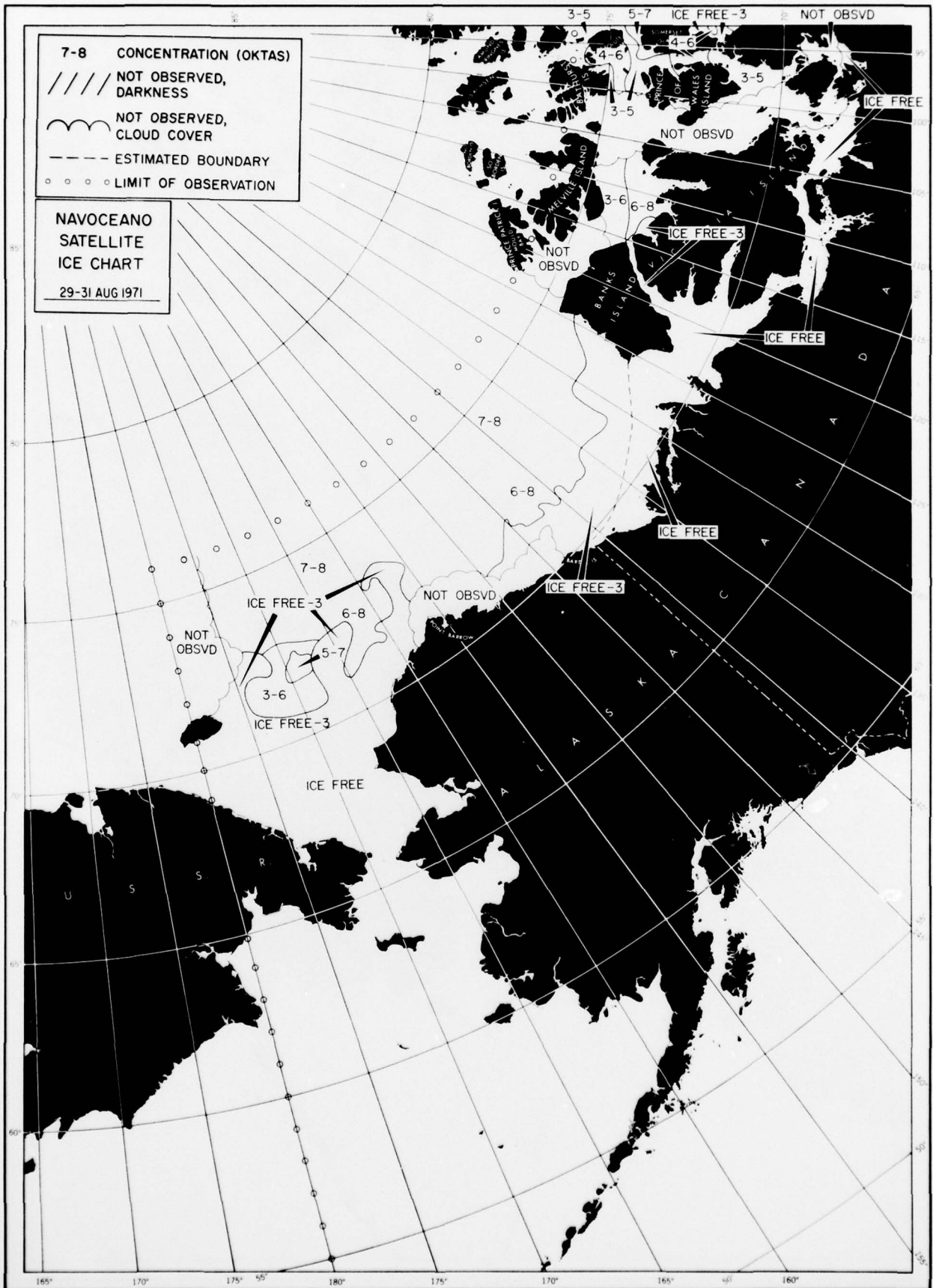


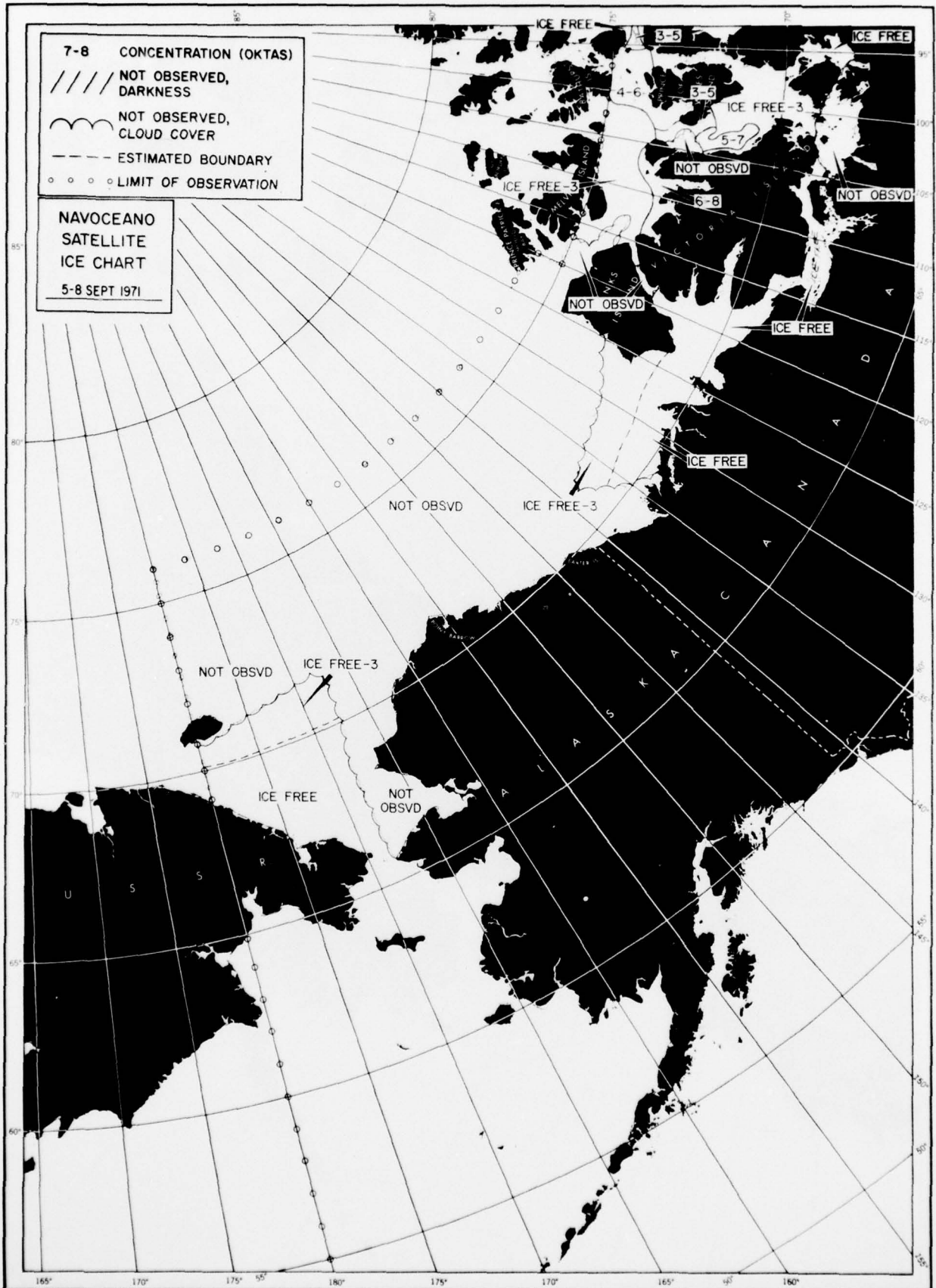


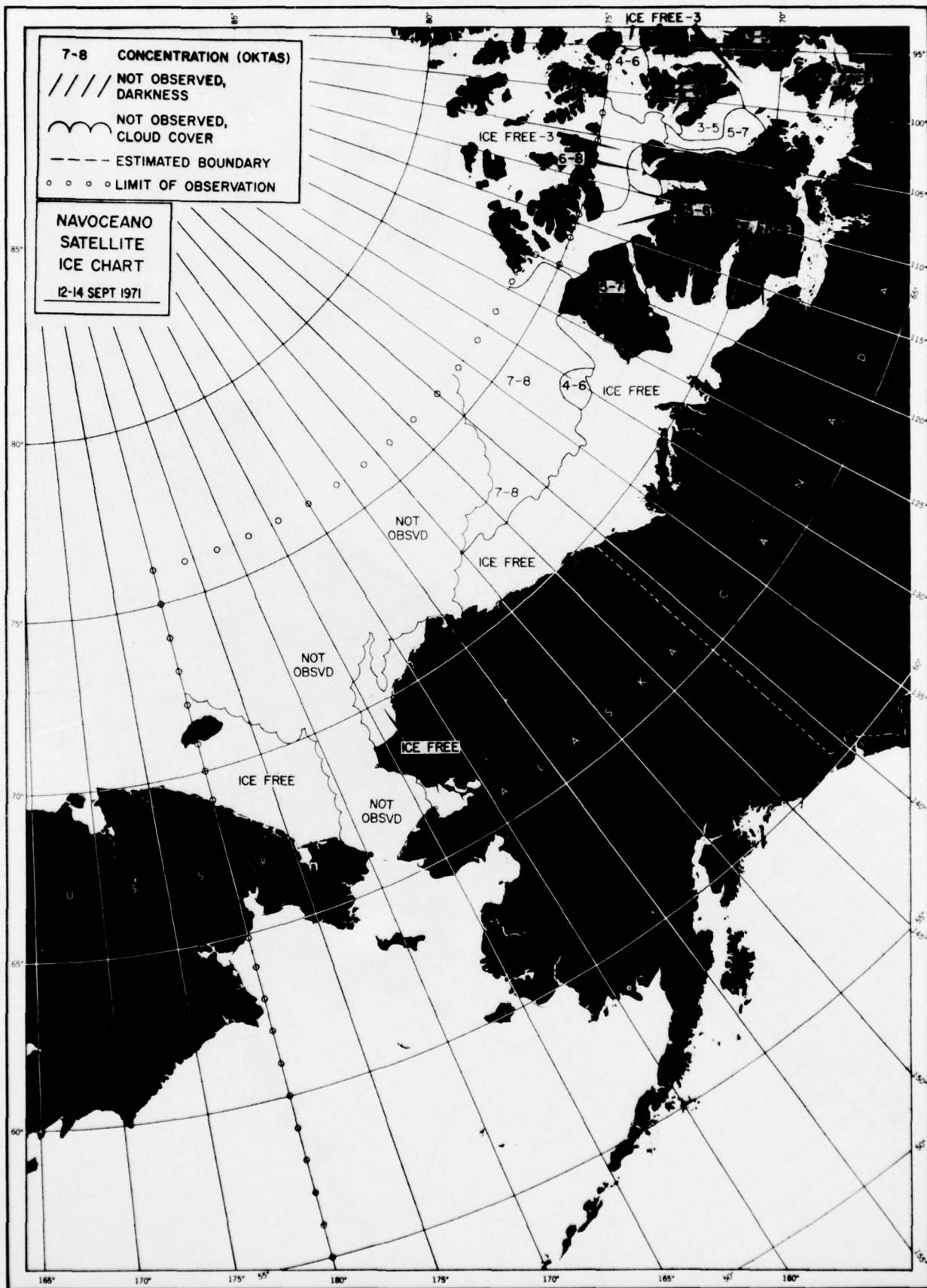


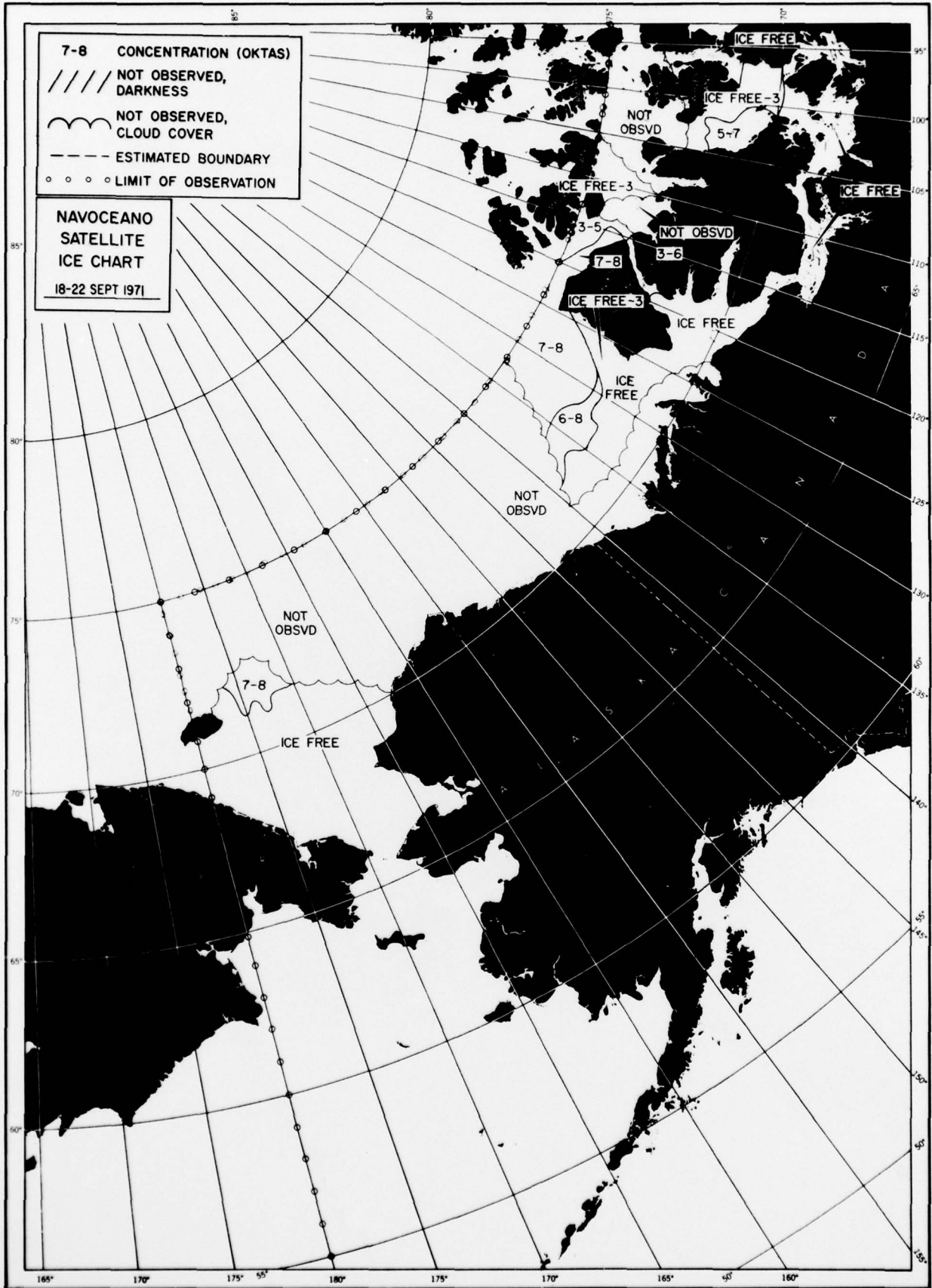












APPENDIX E

PROJECT BIRDS EYE MISSIONS 6-71 AND 7-71

ICE CHARTS

## KEY TO ICE SYMBOLS USED IN PLOTTING ICE FEATURES

### TOTAL CONCENTRATION

|                                                                                   |                                 |
|-----------------------------------------------------------------------------------|---------------------------------|
|  | Ice free                        |
|  | <1 okta*<br>(open water)        |
|  | 1-<3 oktas<br>(very open pack)  |
|  | 3-<6 oktas<br>(open pack)       |
|  | 6-<7 oktas<br>(close pack)      |
|  | 7-<8 oktas<br>(very close pack) |
|  | 8 oktas<br>(compact pack)       |

|       |   |                     |
|-------|---|---------------------|
| CONC  | = | Concentration       |
| CRK   | = | Crack               |
| CRKS  | = | Cracks              |
| FRCT  | = | Fracture            |
| FRCTV | = | Very Small Fracture |
| FRCTS | = | Small Fracture      |
| FRCTM | = | Medium Fracture     |
| FRCTL | = | Large Fracture      |
| LVL   | = | Level Ice           |
| NDTR  | = | Not Determined      |
| NOPG  | = | No Openings in Ice  |
| OPWR  | = | Open Water          |
| SCTD  | = | Scattered           |
| SD    | = | Snow Depth          |
| T     | = | Ice Thickness       |

### COVERAGE BY SIZE








|                         |                                          |
|-------------------------|------------------------------------------|
| $\frac{C}{n_1 n_2 n_3}$ |                                          |
| C                       | = total concentration                    |
| <hr/>                   |                                          |
| SS/NL                   | = New Ice or Nilas                       |
| n <sub>1</sub> PK       | = Pancake <3 m                           |
| <hr/>                   |                                          |
| CK                      | = Brash, Small Cake, Cake <20 m          |
| <hr/>                   |                                          |
| SF                      | = Small Floe 20—100 m                    |
| n <sub>2</sub> MF       | = Medium Floe 100—500 m                  |
| <hr/>                   |                                          |
| BF                      | = Big Floe 500—2000 m                    |
| VF                      | = Vast Floe 2—10 km                      |
| n <sub>3</sub> GF       | = Giant Floe >10 km                      |
| Fast                    | = Fast Ice                               |
| <hr/>                   |                                          |
| Example:                | 7 = total concentration                  |
| 7                       | 1 = okta all pancake ice                 |
| 124                     | 2 = oktas small and medium ice floes     |
| PK                      | 4 = oktas big, vast, and giant ice floes |

### STAGE OF DEVELOPMENT

|                                    |                                     |                               |
|------------------------------------|-------------------------------------|-------------------------------|
| $\frac{A}{AGE}$                    |                                     | $\frac{A}{AVERAGE THICKNESS}$ |
| oktas predominant, oktas secondary |                                     |                               |
| <hr/>                              |                                     |                               |
| SS                                 | = Frazil, Grease, Slush, Shuga      |                               |
| NL                                 | = Ice Rind, Dark Nilas, Light Nilas | — — — — — <5—10 cm            |
| G                                  | = Gray                              | ----- 10—15 cm                |
| GW                                 | = Gray-White                        | ----- 15—30 cm                |
| FL                                 | = Thin First-Year                   | ----- 30—70 cm                |
| FM                                 | = Medium First-Year                 | ----- 70—120 cm               |
| FT                                 | = Thick First-Year                  | ----- >120 cm                 |
| SY                                 | = Second-Year                       |                               |
| MY                                 | = Multi-Year                        |                               |

|                                                |                             |
|------------------------------------------------|-----------------------------|
| Example:                                       | $\frac{A}{SFM3G}$           |
| A                                              | = Stage of development      |
| SFM                                            | = 5 oktas Medium First-Year |
| 3G                                             | = 3 oktas Gray              |
| * One okta equals one-eighth ice concentration |                             |

### TOPOGRAPHY

|                                                                                     |                             |
|-------------------------------------------------------------------------------------|-----------------------------|
|  | Rafted or Finger-Rafted Ice |
|  | Hummocks                    |
|  | (N) New Ridges              |
|  | (W) Weathered Ridges        |
|  | (V) Very Weathered Ridges   |
|  | (A) Aged Ridges             |
|  | (C) Consolidated Ridges     |

Example:  $\frac{M(N)(h)}{(n)}$

(h) height of ridges in meters  
(n) tenths coverage on ice

### STAGE OF MELTING

|     |                   |
|-----|-------------------|
| FPD | = Few Puddles     |
| MPD | = Many Puddles    |
| FTH | = Few Thaw Holes  |
| MTH | = Many Thaw Holes |
| DRI | = Dried Ice       |
| ROT | = Rotten Ice      |
| FLO | = Flooded Ice     |







### UNDERCAST

 Limit





### THICKNESS OF ICE & SNOW

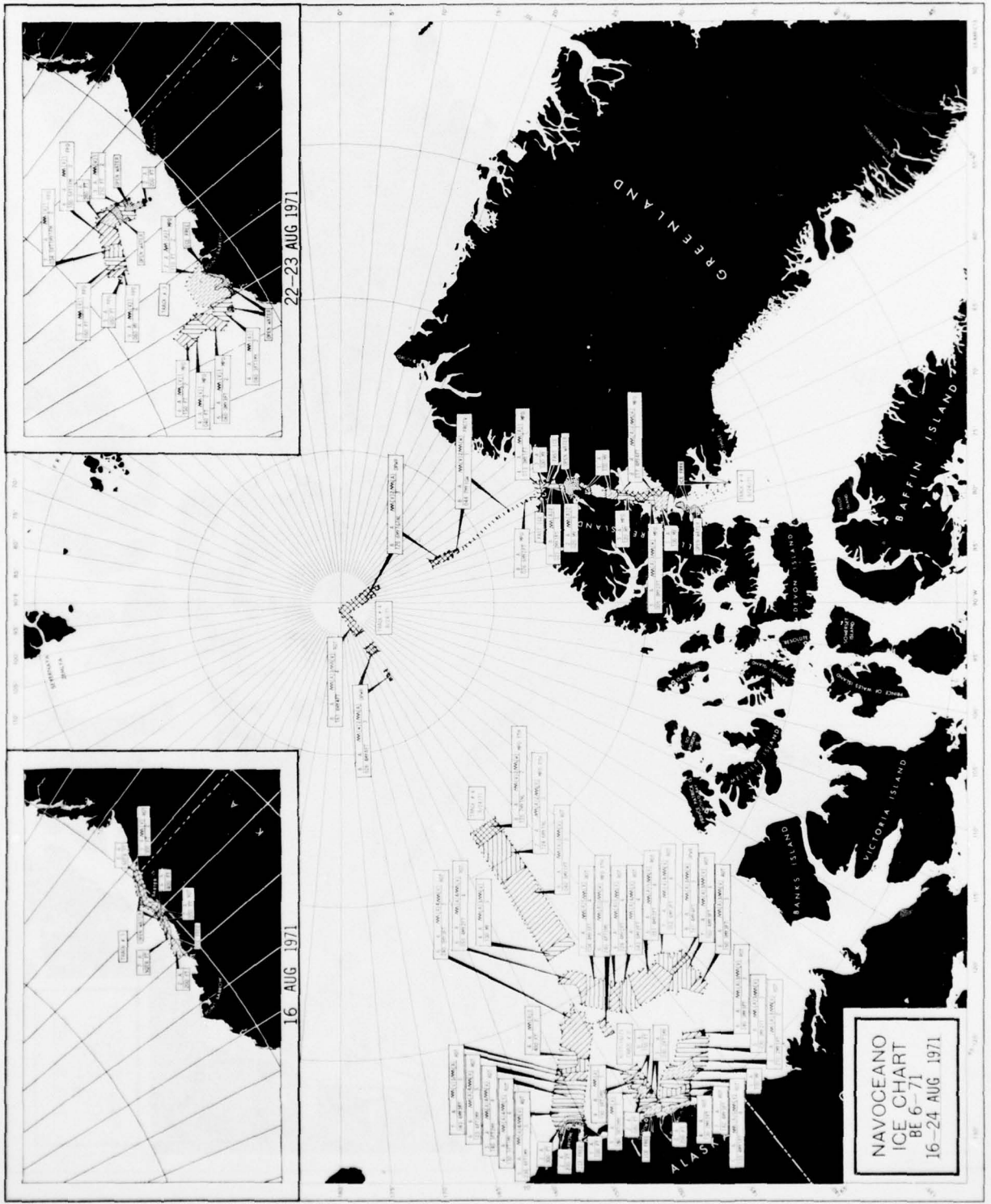
t<sub>E</sub> = ice thickness in cm  
s = snow depth in cm

### PHENOMENA

|                                                                                       |                           |
|---------------------------------------------------------------------------------------|---------------------------|
|  | crack                     |
|  | fracture                  |
|  | polynya                   |
|  | lead                      |
|  | (N) icebergs              |
|  | (N) bergy bits & growlers |
| (n) = number in area                                                                  |                           |

### ICE EDGE

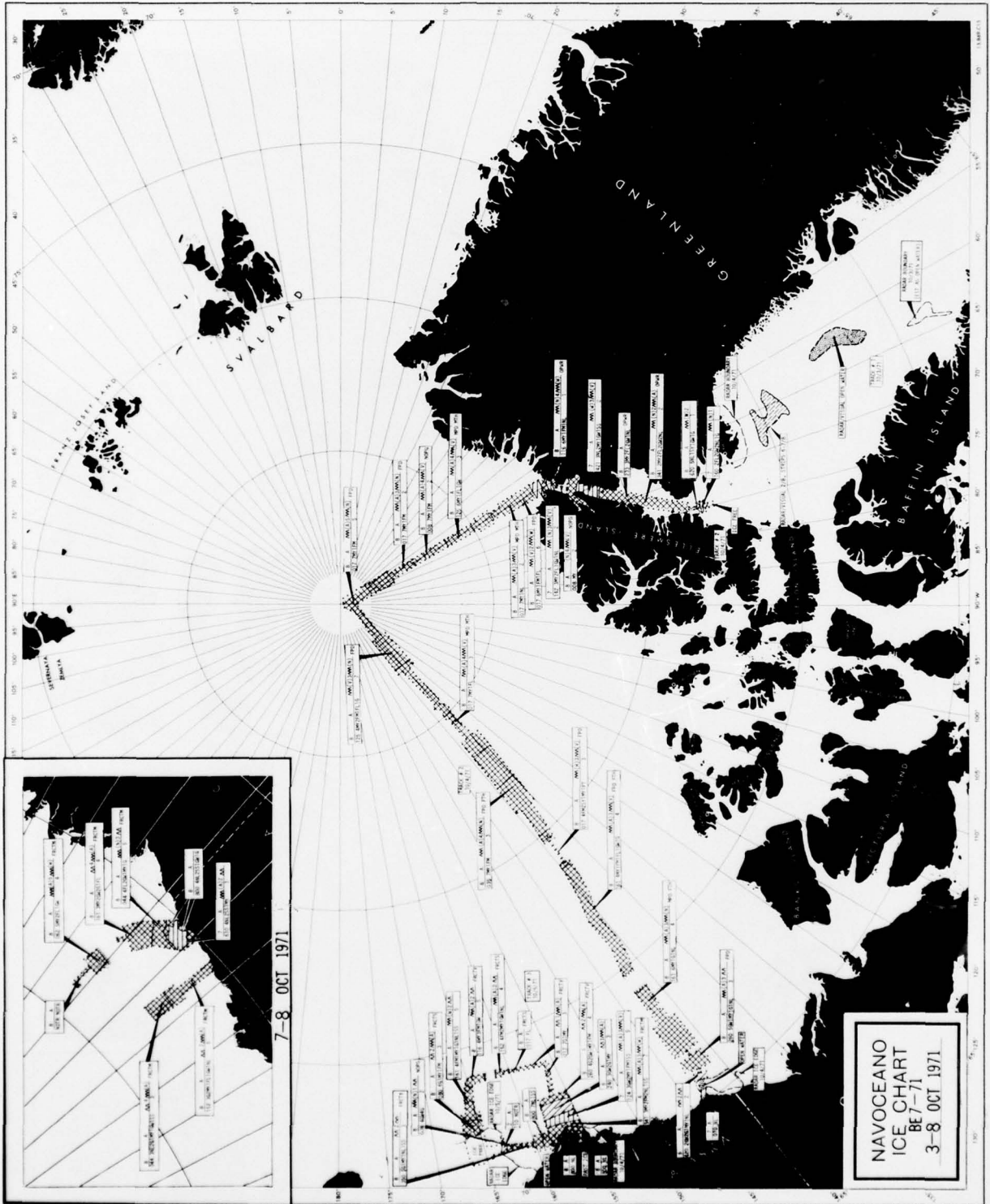
|                                                                                       |                        |
|---------------------------------------------------------------------------------------|------------------------|
|  | observed               |
|  | radar                  |
|  | limit of observed data |
|  | satellite data         |



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| Ice Forecasting - Arctic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | Oceanography - Arctic                                                          |
| Ice Observation - Arctic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | Project BIRDSEYE                                                               |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       |                                                                                |
| <p>The ice program conducted during 1971 in the North American Arctic by the Naval Oceanographic Office is presented. Methods of collection and dissemination of ice data, ice forecasting, forecast verification, and interpretation of satellite ice observations are discussed. Sea ice distribution in the eastern Arctic was generally normal or slightly heavier than normal. Expected dates for escorted and unescorted entry into 5 selected eastern arctic ports were forecasted. Conditions for escorted entry into 3 of these ports occurred</p> |                       |                                                                                |

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as predicted. Escorted entry at the 2 remaining ports occurred 1 to 9 days later than forecast. Conditions for unescorted entry also occurred as predicted at 3 of these ports. Unescorted entry was possible 6 days later than forecast at one port and 20 days earlier than forecast at the fifth port. Ice conditions in the western Arctic were heavier than normal for the third consecutive year, especially in the Bering Sea during spring. Ice conditions, based on aerial and satellite data in the eastern and western sectors of the Arctic and data observed over the Arctic Basin during 2 BIRDSEYE missions, are shown graphically in separate appendixes.

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