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LONG-RANGE ICE OUTLOOK
EASTERN ARCTIC (1965)

OCEANOGRAPHIC PREDICTION DIVISION

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U. S. NAVAL OCEANOGRAPHIC OFFICE
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ABSTRACT

An outlook of expected sea ice conditions in the eastern North American Arctic is presented for the period mid-May through mid-August 1965. Oceanographic and climatic data for the Eastern Arctic were analyzed in terms of sea ice growth during the past winter. These analyses, combined with the observed ice conditions for the period 25 March through 6 April, and a comprehensive study of historical ice and climatic information formed the basis for the 1965 Ice Outlook. Evaluation of this information indicates that present ice conditions in the Labrador Sea and along the Newfoundland Coast are similar to those observed in 1957 and 1962. Although the ice is quite heavy in Baffin Bay, 1957 appears to be an analogous year for that area. Goose Bay and Kulusuk are expected to open for escorted shipping later than normal, whereas Thule, Sondre Stromfjord, and Itivdleq should have nearly normal opening dates. In terms of the 1964 ice season, Goose Bay will open two to three weeks later than last year, Sondre Stromfjord and Itivdleq about the same as last year, and Thule about one month earlier than in 1964. Kulusuk will open about one week later than last year.

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I. INTRODUCTION

The Long-Range Ice Outlook for 1965 presents a written and graphic description of the expected ice conditions during the forthcoming operations of the Military Sea Transportation Service (MSTS) in the eastern Arctic. Prognostic monthly ice charts showing the expected distribution of sea ice from mid-May through mid-August are presented.

The Outlook is developed initially from an evaluation of oceanographic and climatic conditions prevailing during the growth season. Utilizing known empirical and theoretical relationships, these factors are used to quantitatively determine thickness, character, and distribution of the ice developed during the winter.

In addition, a comprehensive aerial survey of the entire area from 25 March to 6 April provides information on distribution, age, and roughness of the ice under consideration. A comparison is then made between the current environment and ice conditions experienced in preceding years to determine if an analogous situation exists. Incorporating this information with the 30-day prognostic sea level pressure pattern, ice conditions are projected for one month. Thereafter, the monthly charts are developed by assuming environmental conditions will be similar to those observed during the analogous year.

Opening dates for ports of major interest in MSTS resupply operations are given in table 1, and a more detailed description of expected ice characteristics are given in the text. Place names used in this text are shown in figure 1.

II. ANALYSIS OF ENVIRONMENTAL DATA

A. Oceanography

The time of initial freezing and the subsequent rate of growth of sea ice depend on the thermal and saline structure of the sea after the time of heat budget reversal. These characteristics, along with the air temperatures expressed in cumulative degree days of freezing, snow cover, and radiational cooling, were considered to determine the heat loss and resultant ice growth. Dates of theoretical initial ice formation and ice thickness on 15 March based on these computations are presented in figure 2.

B. Climatology

Throughout the ice growth period, the ice drift depends on the mean sea level circulation which is controlled by the path of the migratory pressure systems. The ice growth period is considered to be the time from 15 October to 15 March. From mid-

October to 1 February the mean wind patterns throughout the entire area were near normal. However, a slight deviation from the normal east and northeasterly flow during this period was observed in the northeastern portion of Baffin Bay where light southeasterly flow was dominant. This abnormal southeasterly flow continued until mid-March when some return to normal was evident. In the Labrador Sea, a sharp departure from the normal north to north-westerly flow occurred during February when anomalous southerly winds prevailed. With the advent of March, the flow returned to near normal with north to northeasterly winds. Normal on-shore flow remained along the East Greenland Coast until February when a high pressure ridge replaced the Icelandic Low causing offshore flow north of 70N and southerly flow south of 70N. The wind regime in this area returned to near normal during the first week in March.

Vectors representing average ice drift for the entire ice growth period were computed for selected points within the area and are shown in figure 3. In Baffin Bay and Davis Strait, magnitudes and directions approximated those computed in 1964. The magnitudes of the vectors along the Labrador Coast were less than in 1964 and were oriented parallel to the shore. Along the East Greenland Coast, the directions of the vectors were normal but of less magnitude than in 1964. The computed ice growth in figure 2 shows that the theoretical ice thickness along the West Greenland Coast north of 71N and in Melville Bay was 10 to 20 inches thicker than the normal 30 to 60 inches. Along the Baffin Island Coast from Bylot Island to the vicinity of Cape Hooper, the thickness was computed at 50 to 60 inches which was near normal. From Cape Hooper to Cape Dyer, the ice, which is normally 40 to 50 inches thick, was 10 inches thicker than normal. Along the Labrador Coast ice thicknesses were about 10 to 20 inches, which was near normal.

III. PRELIMINARY SURVEY OF ICE CONDITIONS

A. General

Preliminary ice reconnaissance was flown during the period 25 March through 6 April 1965. One P3A aircraft of PATRON 44 departed Argentia, Newfoundland and surveyed the ice in the Labrador Sea, Davis Strait, and Baffin Bay. A U. S. Navy aircraft attached to COMBARFORLANT in Keflavik, Iceland reconnoitered the area along the East Greenland Coast. Project BIRDS EYE and Danish ice reconnaissance during this period supplemented the ice data taken over this area. Results of this survey are shown in figure 4. A legend showing the ice terminology and symbols is presented in figure 5.

B. Comparison of Observed Ice Boundaries

An outstanding feature of the pack boundary during 1965 was its similarity to the 1962 boundary, especially along the Labrador Coast. Also, in the area just to the north of Hopedale, the pack was narrower than observed at any time since 1954. In the area from Resolution Island to the West Greenland Coast, the boundary was considerably farther north than in 1964.

Another striking feature of 1965 was the extreme width of the pack in the Norwegian Sea and Denmark Strait, the latter ice extending to the north coast of Iceland. At no time during the period from 1955 to 1964 had this ever occurred. Ice boundaries observed during the preliminary reconnaissance are shown in figures 6 through 8.

C. Observed Ice Conditions

1. Newfoundland and Labrador Coasts

Within the observed area southeast of Belle Isle, the pack consisted generally of 3 to 6 tenths concentration with areas of open water in the vicinity of Cape Bauld, along the coast from Fogo Island to Cape Bonavista, and along the outer pack boundary south of 51N. The age was predominantly thick winter with secondary stages of medium winter and slush ice. In the Strait of Belle Isle, the concentration was 2 to 3 tenths consisting mainly of thick and medium winter in addition to slush and other forms of young ice.

In the area between Belle Isle and the Goose Bay approaches, very open to close pack ice extended 50 to 80 miles seaward. All ice consisted chiefly of 70 percent thick winter and 30 percent young and medium winter ice. Fast ice was observed in Lake Melville and in the interior of Hamilton Inlet. In the eastern approaches to Hamilton Inlet, a large open water area was observed.

Fast ice extended along the Labrador Coast from Hopedale to 60N within all bays and coves and generally seaward to the outer islands. Offshore from Hamilton Inlet to Cape Chidley, generally close to very close thick and medium winter ice with moderate ridging prevailed. A very open pack ice area developed in the vicinity of Cape Chidley and along the outer pack boundary east of Saglek.

2. Baffin Bay

a. Baffin Island Coast

From the northern portion of Bylot Island to Cape Mercy, fast ice extended seaward 10 to 15 miles off the outer

caples. Fast ice also extended 5 to 10 miles off the coast from the south shore of Cumberland Sound to Loks Land. Within Frobisher Bay, fast ice extended north and northwestward from the island chain in mid-bay. Mostly medium winter ice was present in the central and southeastern portion of the bay.

From 64N to 72N, the predominant age was thick winter ice. Occasional young polar floes were observed thruout this area with moderate to heavy ridging from Loks Land to Bylot Island. An area of weakness was evident adjacent to the fast ice from Cape Dyer northward to Broughton Island where 8 to 10 tenths coverage of 60 percent medium winter and 40 percent thick winter ice was observed. An ice free area within the pack was observed approximately 50 miles southeast of Resolution Island.

b. Central and Northern Baffin Bay

Because of the remnant pack from the 1964 season, approximately 60 to 70 percent young polar ice was observed in Melville Bay and approximately 20 percent in the remainder of the area. The predominant age was thick winter ice which consisted mostly of big and vast floes. Refrozen cracks and leads oriented southeast to northwest were evident from 74N 65W to 75N 71W. Moderate to heavy ridging with a heavy snow cover was observed on all the ice. The North Open Water prevailed in the west-central portion of Baffin Bay from 75N to 7930N with a tongue of lesser concentration also observed southward of 75N to Bylot Island. The concentration of the North Open Water consisted chiefly of 7 to 9 tenths medium winter ice with some young ice and slush also present.

c. West Greenland Coast

The fast ice boundary extended southward to the vicinity of Egedesminde. North of 70N, very close pack concentrations of thick winter and young polar ice with moderate to heavy ridging were observed in the offshore pack. From 65N to 70N, concentrations generally ranged from 8 to 9 tenths consisting of thick and medium winter ice with some forms of young ice. In the approaches to Sondre Stromfjord, a 30-mile wide area of open pack ice was observed. Southward and adjacent to this open pack area a large area of open water extended seaward to 56W.

Fast ice in Itivdleq Fjord extended about 14 miles west of the site to 53.3W. Further westward, a 3-mile wide area of open water was observed. From the open water area to the outer approaches of the fjord, fast ice of predominantly medium winter concentration was observed.

Fast ice containing few cracks was observed in the upper half of Sondre Stromfjord northeast of Kap Look. In the lower half

of the fjord from Kap Look to the entrance at Simiutak Island, generally open to close pack ice was observed. The age was predominantly medium winter with secondary stages of young ice.

3. East Greenland

The pack boundary extended from a point 120 miles seaward of the West Greenland Coast at approximately 61N around the southern tip of Greenland and northeastward 30 to 50 miles seaward to 65N. The boundary then extended east-northeastward until it reached the northern coast of Iceland at 6610N 2330W and continued northeastward to 70N 10W. Owing to adverse weather conditions only a partial coverage of the ice concentrations was observed. However, it is believed that 9 to 10 tenths storis* and thick winter ice exists throughout the area with open pack ice along the outer pack boundary.

IV. OUTLOOK

A. General

Ice conditions determined by environmental conditions and confirmed by preliminary reconnaissance were quite similar to those observed in 1957 in Baffin Bay and the Labrador Sea. A striking similarity also exists between 1962 and 1965 in the Labrador Sea. Extensive amounts of polar ice remaining from the 1964 season were observed in Melville Bay. An analogy exists between the prognostic mean sea level pressure chart for April and the observed patterns for the same period during 1957. Accordingly, the prognostic ice conditions for mid-May through mid-August, shown in figures 9 through 12, reflect conditions observed during those years.

* Remnants of fused pressure ridges of polar ice drifting southward from the Arctic Ocean.

TABLE 1

OPENING DATES FOR HARBORS

<u>HARBOR</u>	<u>ESCORTED*</u>	<u>UNESCORTED**</u>
Itivdleq	1 May	15 May
Sondre Stromfjord	30 May	9 June
Goose Bay	20 June	10 July
Thule	10 July	24 July
Kulusuk	15 July	20 August

* Concentration in approaches less than 8/10 and fast ice, if any, in harbor well weakened

** Concentration in approaches 1/10 or less

1. Newfoundland - Labrador Sea

Extending southward from Cartwright to the vicinity of Cape Bonavista, ice conditions by mid-May should consist of mainly open and very open pack with some close pack present. North of Cartwright to Cape Chidley, concentrations should be mostly close pack except for Hamilton Inlet in which open water is already present. The usual bands of fast ice will be present in the bays and inlets along the coast. After mid-May warmer temperatures should cause considerable weakening of some remnant ice in the extreme western portion of Hamilton Inlet, Lake Melville, and Terrington Basin.

By mid-June, a considerable amount of very open and open pack ice will remain from Hamilton Inlet to St. Anthony. By this time, the inner approaches to Goose Bay should be essentially ice free. However, the outer approaches to Goose Bay should remain congested with open and close pack ice due to the incursion of heavy concentrations from the Hopedale area. Goose Bay should be open for escorted shipping about 20 June. By 10 July the Goose Bay approaches should be ice free except for possible scattered patches of very open pack occasionally drifting into that area.

By mid-July only remnant patches of very open and open pack ice should be observed from Hopedale to Saglek Bay. Some widely scattered patches of very open pack may yet remain southward of Cartwright.

2. Davis Strait and Baffin Island Coast

Little change in this area from the close to very close pack ice observed during the early reconnaissance should occur by mid-May. Fast ice will be evident in all bays and inlets along

the Baffin Island Coast. Some recession in the outer pack boundary should be evident, and variable concentrations of very open and open pack should appear along the outer edges of the boundary.

By mid-June owing to increasing temperatures, considerable weakness in the ice concentrations in this area are likely to be observed. A shore lead from Bylot Island to Cape Hooper, and open water areas in the entrance to Hudson Strait and the approaches to Frobisher Bay and Cape Dyer should have developed by this time. The position of the outer pack boundary should change very little because of the southward drift of ice. However, much very open and open pack ice should be observed along the outer edge of the boundary.

The southern portion of the ice boundary should have receded considerably, extending northward from Resolution Island by mid-July. Large concentrations of close pack ice, although well rotted, will still be present in Davis Strait and Baffin Bay, and the shore lead from Bylot Island will be more extensive.

By mid-August, the remnant pack ice along the Baffin Island Coast should consist of large concentrations of open pack along with the normal open water and very open pack ice areas. These heavier than usual concentrations of ice will be a result of the southward drift of large amounts of polar ice in Melville Bay and the thicker than normal formation of winter ice in Baffin Bay.

3. Central and Northern Baffin Bay

The only appreciable change in the ice concentration in this area, by mid-May, will be a slight enlargement of the North Open Water. By mid-June, rapid enlargement is expected due to the disintegration of the dominant young and medium winter ice covering this area. The remainder of Baffin Bay should be covered with predominantly close pack concentrations. By this time many leads and cracks are expected to have formed, especially in the Middle Passage and Southabout Route.* Due to the large percentage of young polar ice, Northabout Route is expected to remain heavily congested at this time.

Increasing temperatures and westward drift should result in rapid disintegration during the latter part of June and early July. Concentrations in Melville Bay should be primarily

*Southabout Route - The track from Upernavik to 73N 69W then northward to Thule. This track was utilized for the first time in 1964 because of the prolonged severe ice conditions along the normal operating tracks in Melville Bay.

open pack by 10 July with areas of close pack remaining in the Northabout Route until mid-July. Melville Bay should be essentially safe for escorted shipping by 10 July and safe for unescorted shipping by 24 July. However, belts and patches of variable concentrations are expected to remain in this area until approximately 1 August.

By mid-August, Melville Bay should be completely ice free with only remnant open and very open pack remaining in central Baffin Bay.

4. West Greenland Coast

Northward advection of relatively warm water and warmer than normal air temperatures indicate that the West Greenland lead should extend to 70N by mid-May and to nearly 75N by mid-June. By mid-July the shipping route along the coast to Kap Seddon should be ice free.

5. East Greenland Coast

Heavy concentrations of polar ice north of 65N and northeast winds will increase the southward advection of ice throughout May and June. Increased melting during the latter part of June and the first two weeks of July should reduce concentrations south of 65N to primarily open pack ice by mid-July. Variable concentrations of very open and open pack ice should continue to drift into the Kulusuk approaches until 20 August.

B. Harbors

1. Goose Bay

Colder than normal temperatures during the winter has resulted in greater than average ice growth. As a result disintegration of ice in Lake Melville and Terrington Basin should be somewhat retarded. During the last week in May open water should be evident in Terrington Basin and Lake Melville and by 10 June the inner approaches to Goose Bay are expected to be ice free.

2. Itivdleg

Early reconnaissance has already shown signs of breakup. Although data verifying breakup of this site are quite sparse, warmer than normal temperatures during the ice growth period, tidal action, and northward development of the West Greenland lead should result in fast ice breakup and permit escorted shipping by 1 May and unescorted shipping by 15 May.

3. Sondre Stromfjord

An early discharge of ice seaward of Kap Look should occur as a result of warmer than normal temperatures during the winter and the fact that no fast ice was present in this portion of the fjord. However, fast ice over the remainder of the fjord should breakup at a nearly normal rate. By 30 May, ice in the anchorage area should be well broken up and become less than 8 tenths. However, temporary congestion in the fjord north of Kap Robinson should occur approximately 4 June when general breakup of the fjord ice is expected. By 9 June the entire fjord is expected to become ice free.

4. Thule

Fast ice in North Star Bugt is expected to become well puddled by 1 July and breakup is expected to begin by 7 July. Thereafter some influx and efflux of ice should occur but by 20 July, owing to net offshore winds, North Star Bugt should become sea ice free. Many icebergs, however are expected to remain in the harbor approaches.

5. Kulusuk

Southward advection of storis ice and wind drift along shore will result in the presence of variable concentrations at Kulusuk throughout much of the disintegration season. Early reconnaissance has indicated that the concentrations are quite heavy. Therefore, even though the accumulation of frost degree days is near normal, the Kulusuk approaches should not become safe for escorted shipping until 15 July. Concentrations, varying from 4 to 8 tenths will continue to be advected into the approaches until about 20 August at which time unescorted shipping into Kulusuk may be expected.

V. GENERAL INFORMATION

A. Brief on Icebergs

The glaciers of Greenland are the source of almost all bergs encountered in the area. Because of their great draft, bergs tend to be more responsive to deep currents than to surface winds. Accordingly, nearly all icebergs sighted south of 65°N along West Greenland originate from glaciers on East Greenland and tend to move southward along the southeastern coast of Greenland, northward along West Greenland, and southward along the Baffin Island and Labrador Coasts. The distance covered by bergs drifting from the southwestern coast of Greenland to southern Newfoundland is about 1800 miles and requires about 3 years to traverse. However, most bergs disintegrate or are trapped in the many indentations along the Baffin Island and Labrador Coasts, so that only about 1 in 20 bergs survive the journey.

Owing to offshore currents, the coastal area between Godthaab and Holsteinsborg is relatively free of icebergs. The heaviest concentration of bergs north of Holsteinsborg and Egedesminde occurs in the vicinity of Disko Bugt, especially during June and July. Accordingly, many of the bergs in Baffin Bay and in the western Labrador Sea are believed to originate from this area.

B. Freezeup Information

Freezeup information including dates of initial ice formation, as well as an average of all the dates at specific sites for a number of individual years, is presented in figure 13. The freezeup information applies to the immediate harbor or coastal sector of the site indicated. Although initial ice generally does not hamper shipping, the dates provided give some indication as to the beginning of freezeup in various areas and of the variability that exists from year to year.

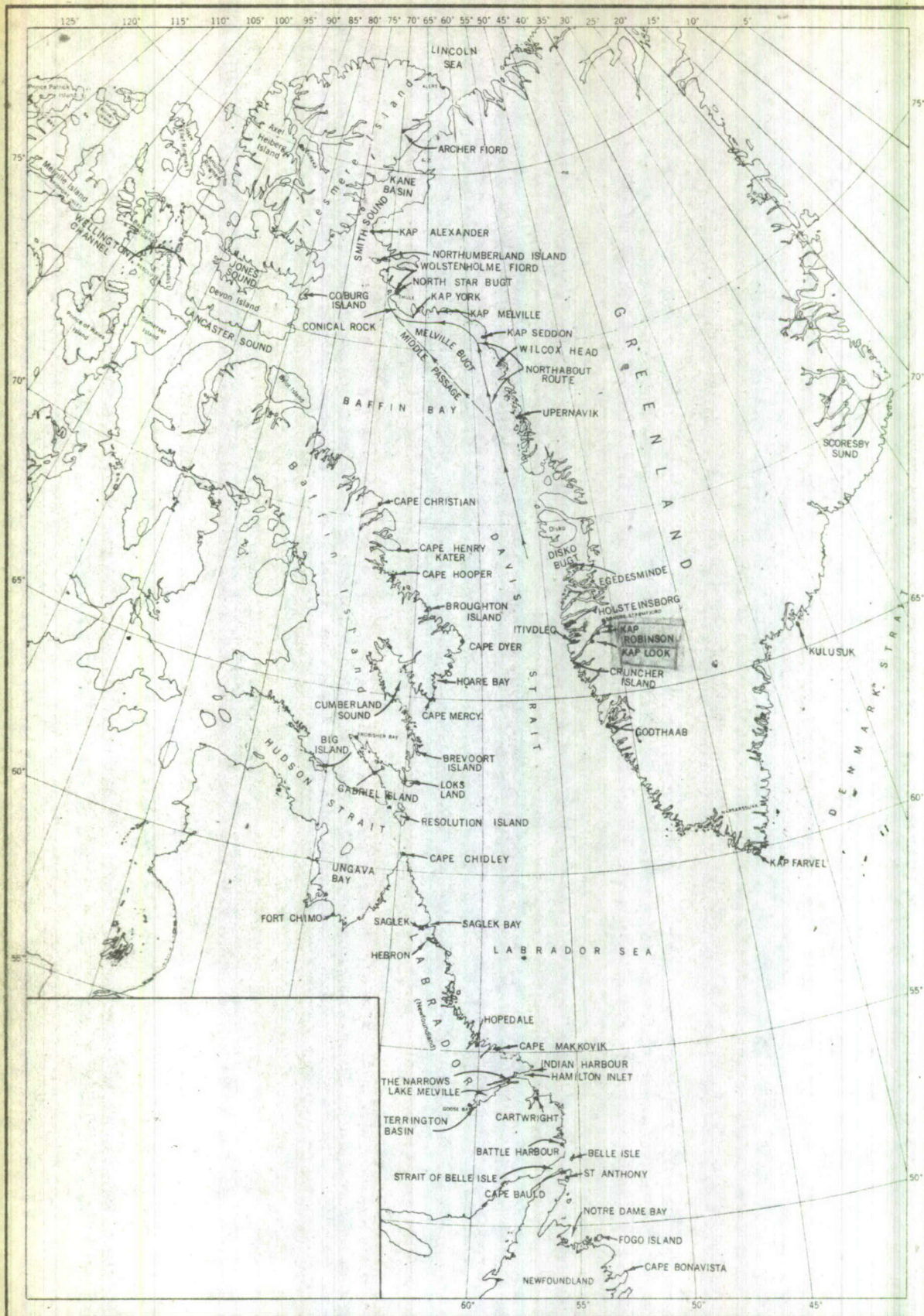


FIGURE 1 PLACE NAME CHART

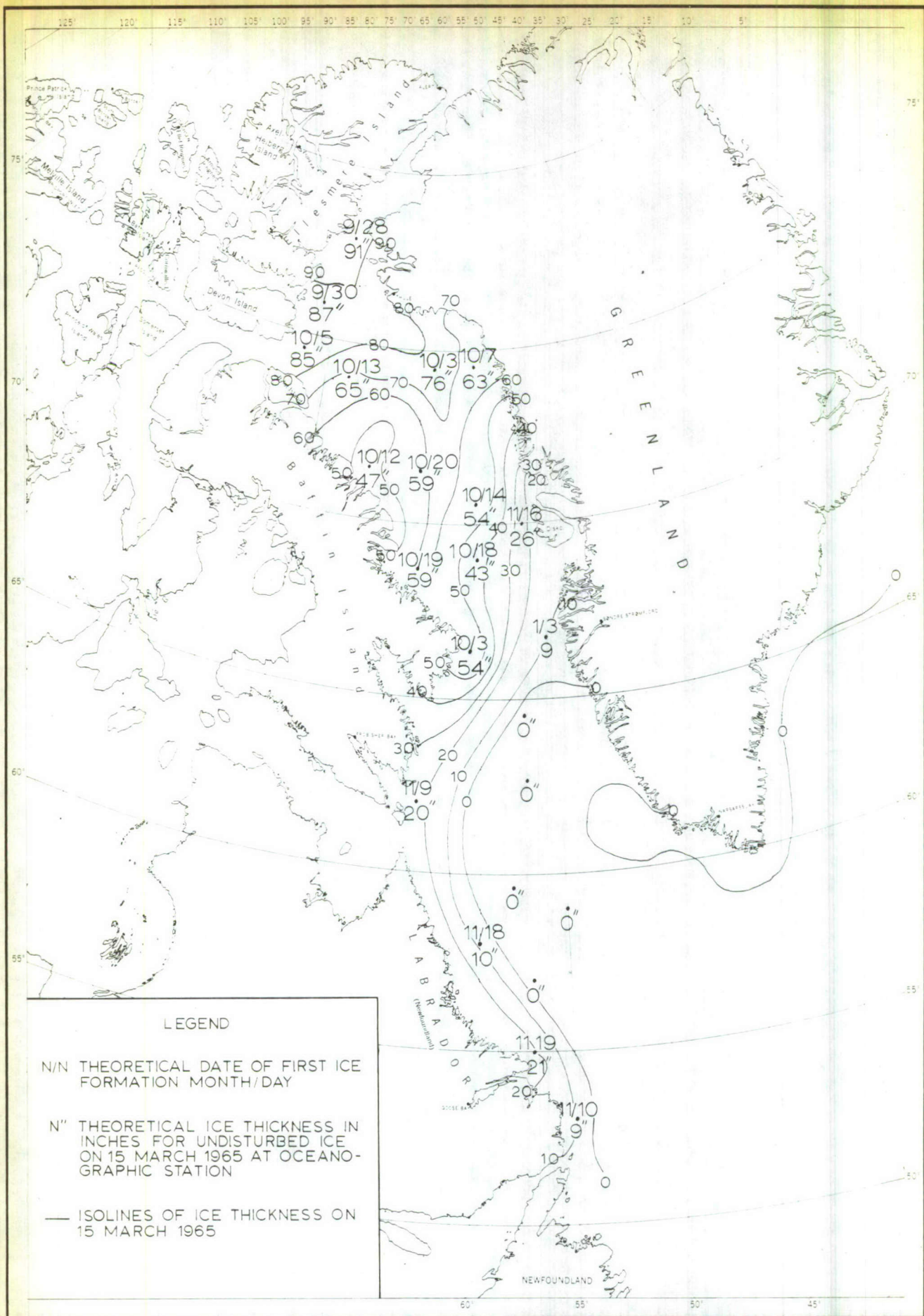


FIGURE 2 COMPUTED ICE THICKNESS FOR UNDISTURBED ICE ON 15 MARCH 1965

KEY TO ICE SYMBOLS

TOTAL CONCENTRATION

	Ice free
	< 0.1 (open water)
	0.1 thru 0.3 (very open pack)
	0.4 thru 0.6 (open pack)
	0.7 thru 0.9 (close pack)
	1.0 fast or (very close pack)

COVERAGE BY SIZE

$\frac{C_n}{n_1 n_2 n_3}$		
Cn = total concentration		
SL =	Slush	
BSH =	Brash	< 2m (< 6.6 ft)
n ₁ SCAKE =	Small Ice Cake	< 2m (< 6.6 ft)
PK =	Pancake Ice	30 cm—3 m (12 in—9.8 ft)
CAKE =	Ice Cake	< 10 m (< 32.8 ft)
n ₂ SMF =	Small Ice Floe	10—200 m (32.8—656 ft)
MDF =	Medium Ice Floe	200—1,000 m (656—3,281 ft)
n ₃ BGF =	Big Ice Floe	1—< 10 km (3,281 ft—< 5.4 nm)
VAF =	Vast Ice Floe	> 10 km (> 5.4 nm)

Example: 9 = total concentration
 $\frac{9}{243}$ 2 = tenths all brash ice
 BSH 4 = tenths, small and medium ice floes
 3 = tenths, big and vast ice floes

STAGE OF DEVELOPMENT

A	
tenths predominant, tenths secondary	
AGE	AVERAGE THICKNESS
IC = Ice Crystals	
SL = Slush	< 5 cm (< 2 in)
IR = Ice Rind	< 5 cm (< 2 in)
PK = Pancake	< 5 cm (< 2 in)
Y = Young	5—15 cm (2—6 in)
MW = Medium Winter	15—30 cm (6—12 in)
TW = Thick Winter	> 30 cm (> 12 in)
WT = Winter	15 cm—2 m (6 in—6.6 ft)
PL = Polar	< 3 m (< 9.8 ft)
YP = Young Polar	< 2.5 m (< 8.2 ft)
AP = Arctic Pack	> 2.5 m (> 8.2 ft)

Example: $\frac{A}{7MW3SL}$

A = Stage of development
 7MW = 7 tenths Medium Winter
 3SL = 3 tenths Slush

BOUNDARY

	observed
	radar
	limit of observed data

TOPOGRAPHY

	rafted
	ridged
	hummocked
Examples: $\frac{M}{(n)} - \frac{M}{(n)} +$	
+ after symbol indicates average height is 10 ft. or greater.	
- after symbol indicates average height is less than 10 ft.	
(n) tenths coverage on ice	

STAGE OF MELTING

PD
(n) + (n) F
PD = puddling
(n) = tenths coverage on ice
(n) F = tenths coverage on ice, Frozen
Examples:
$\frac{PD}{3}$ = 3 tenths puddling
$\frac{PD}{3F}$ = 3 tenths frozen puddles
TH = thaw holes — same
(n) entry procedure as above

UNDERCAST

	Limit
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THICKNESS OF ICE AND SNOW

$\frac{T}{n}$	= ice thickness in inches
$\frac{SD}{n}$	= snow depth in inches
$\frac{S}{n}$	= snow cover in tenths

PHENOMENA

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

FIGURE 5

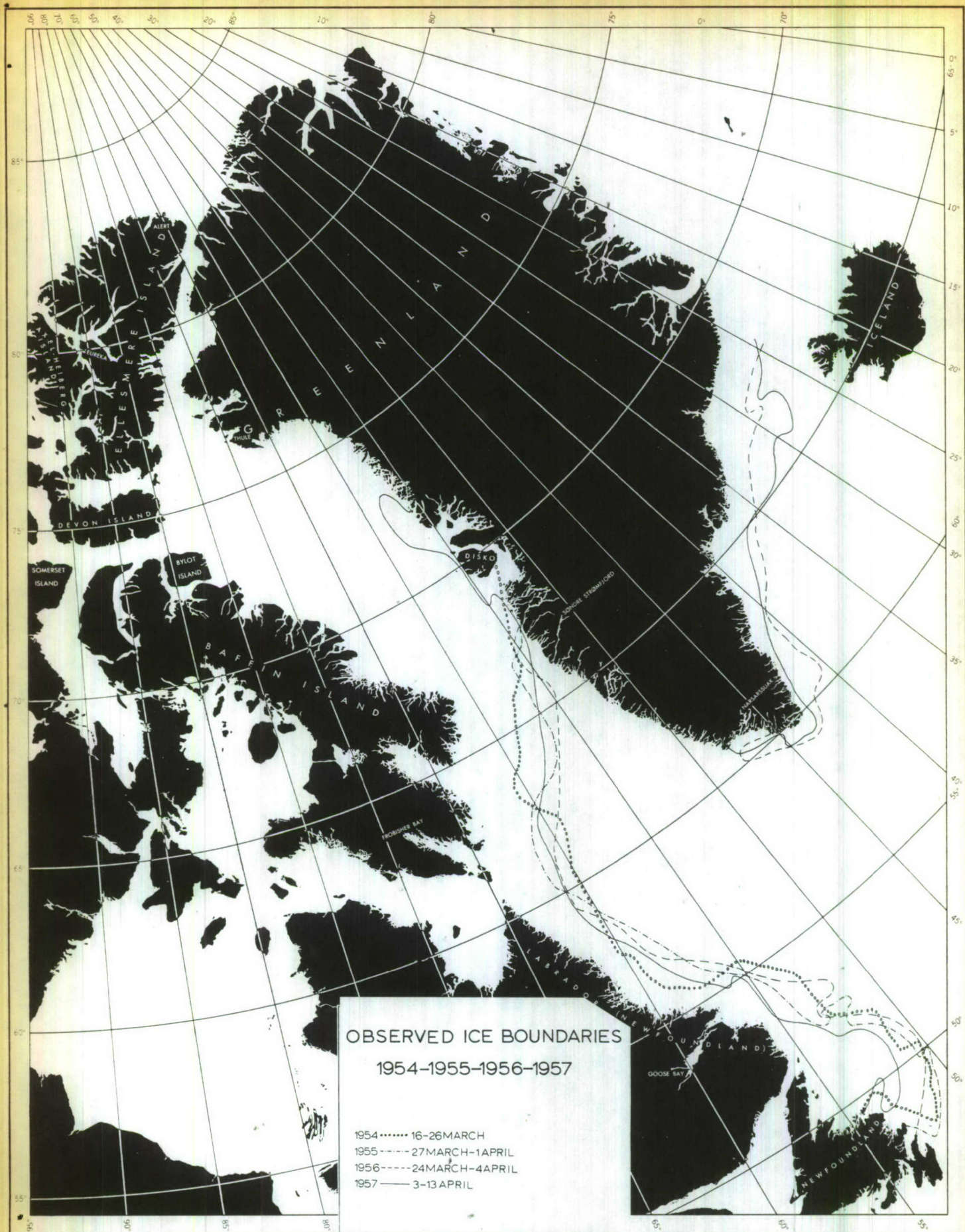


FIGURE 6 COMPARISON OF OBSERVED ICE BOUNDARIES ON PRELIMINARY RECONNAISSANCE IN 1954, 1955, 1956 AND 1957

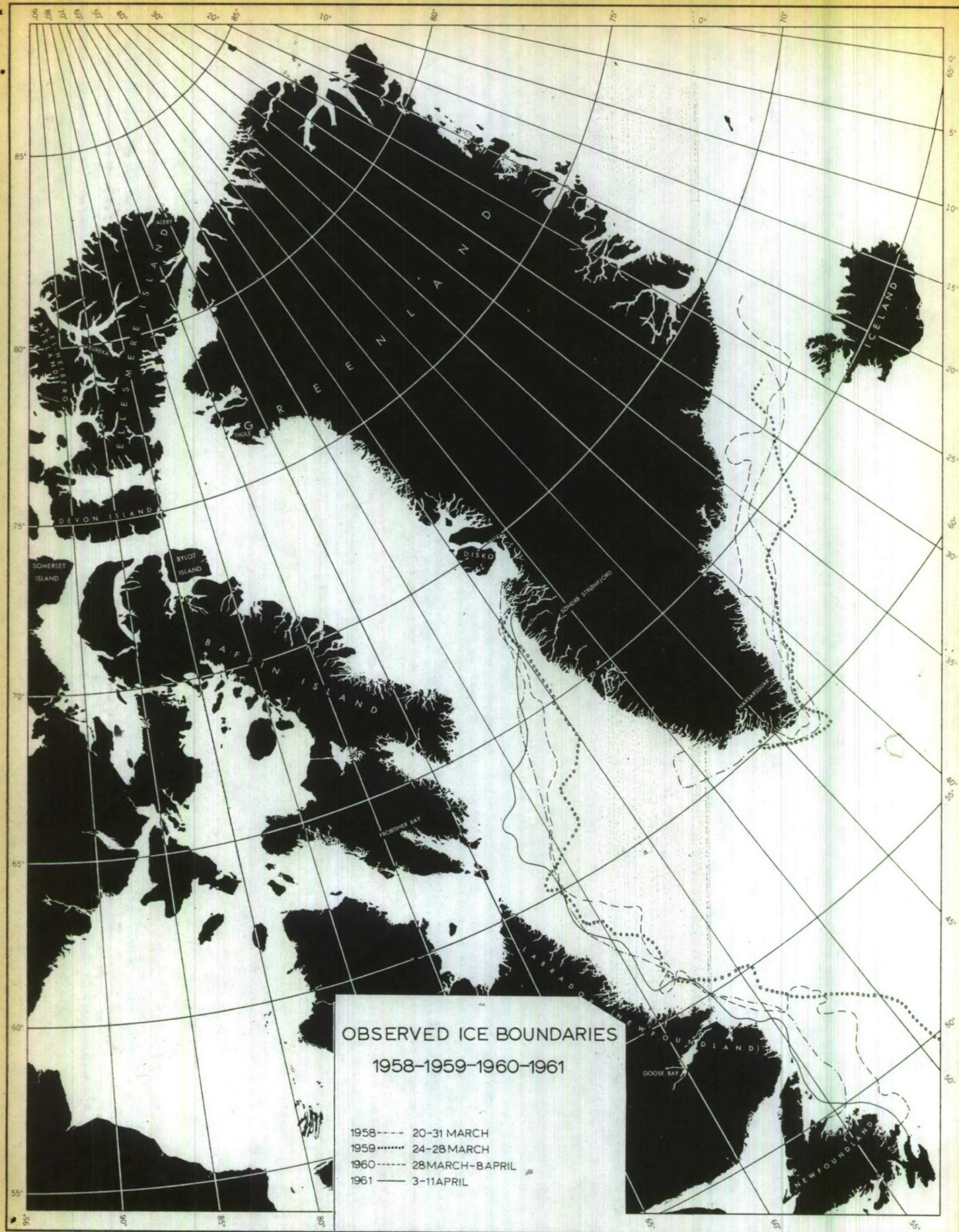


FIGURE 7 COMPARISON OF OBSERVED ICE BOUNDARIES ON PRELIMINARY RECONNAISSANCE IN 1958, 1959, 1960 AND 1961

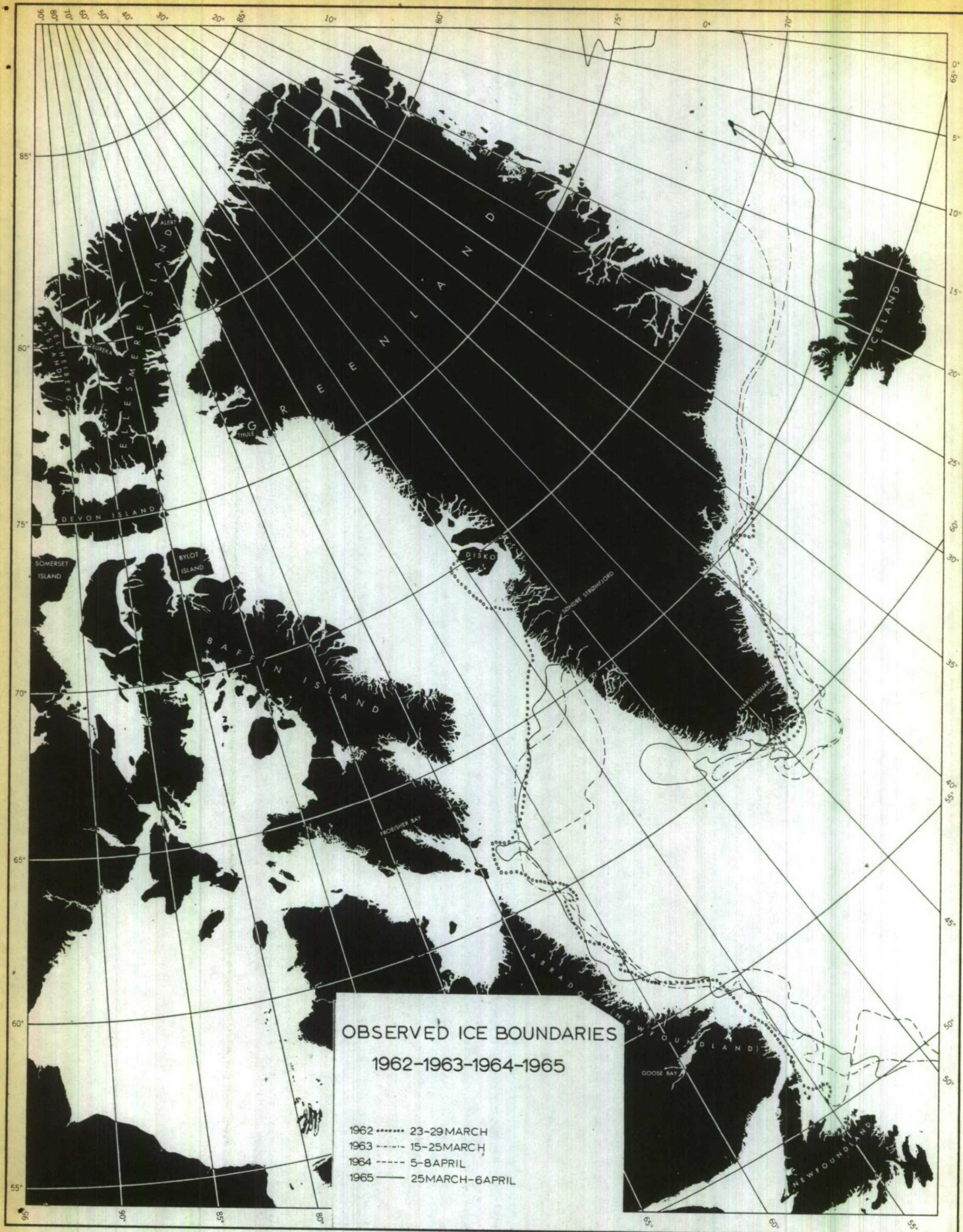


FIGURE 8 COMPARISON OF OBSERVED ICE BOUNDARIES ON PRELIMINARY RECONNAISSANCE
IN 1962, 1963, 1964 AND 1965

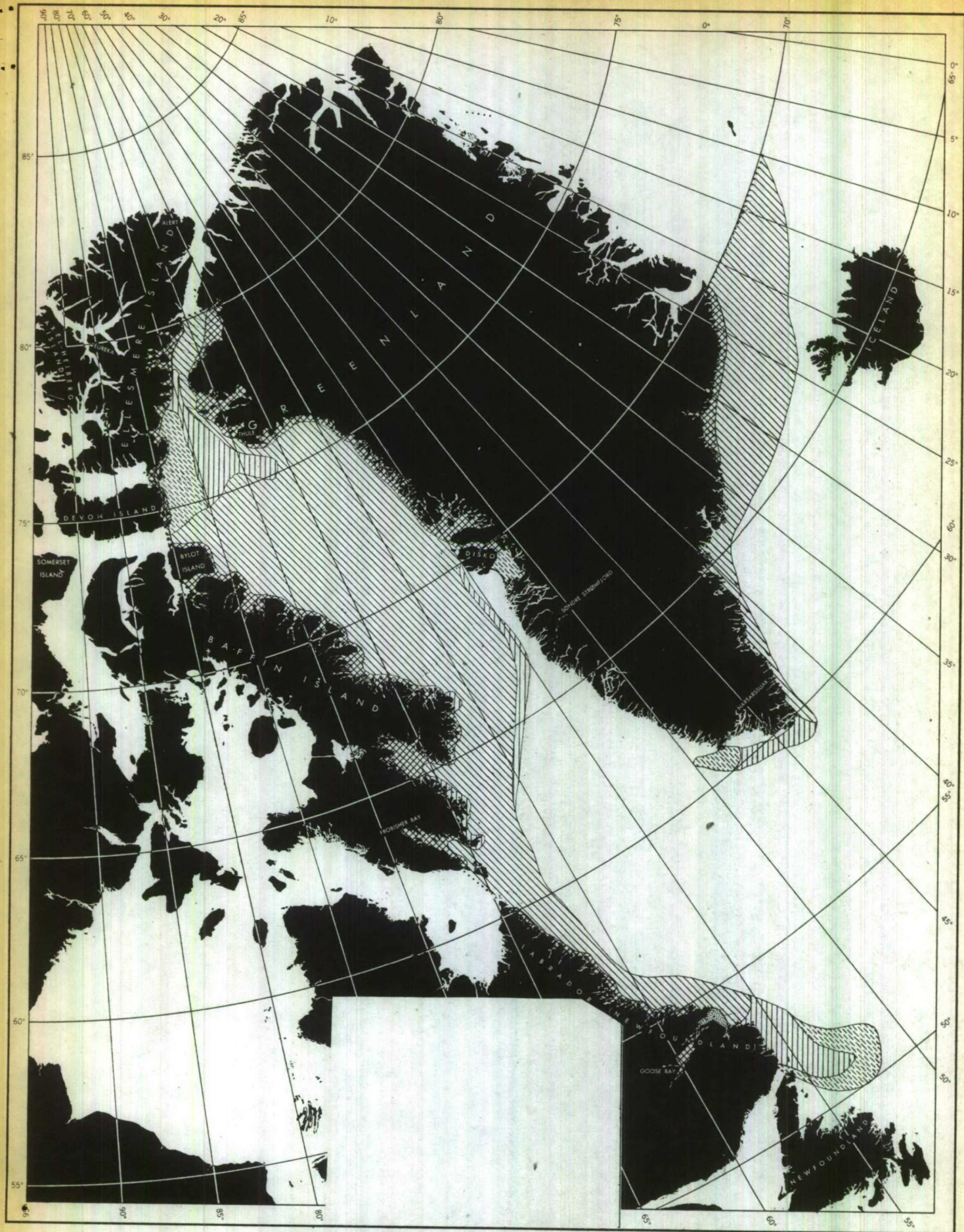


FIGURE 9 PROGNOSTIC ICE CHART MID-MAY 1965

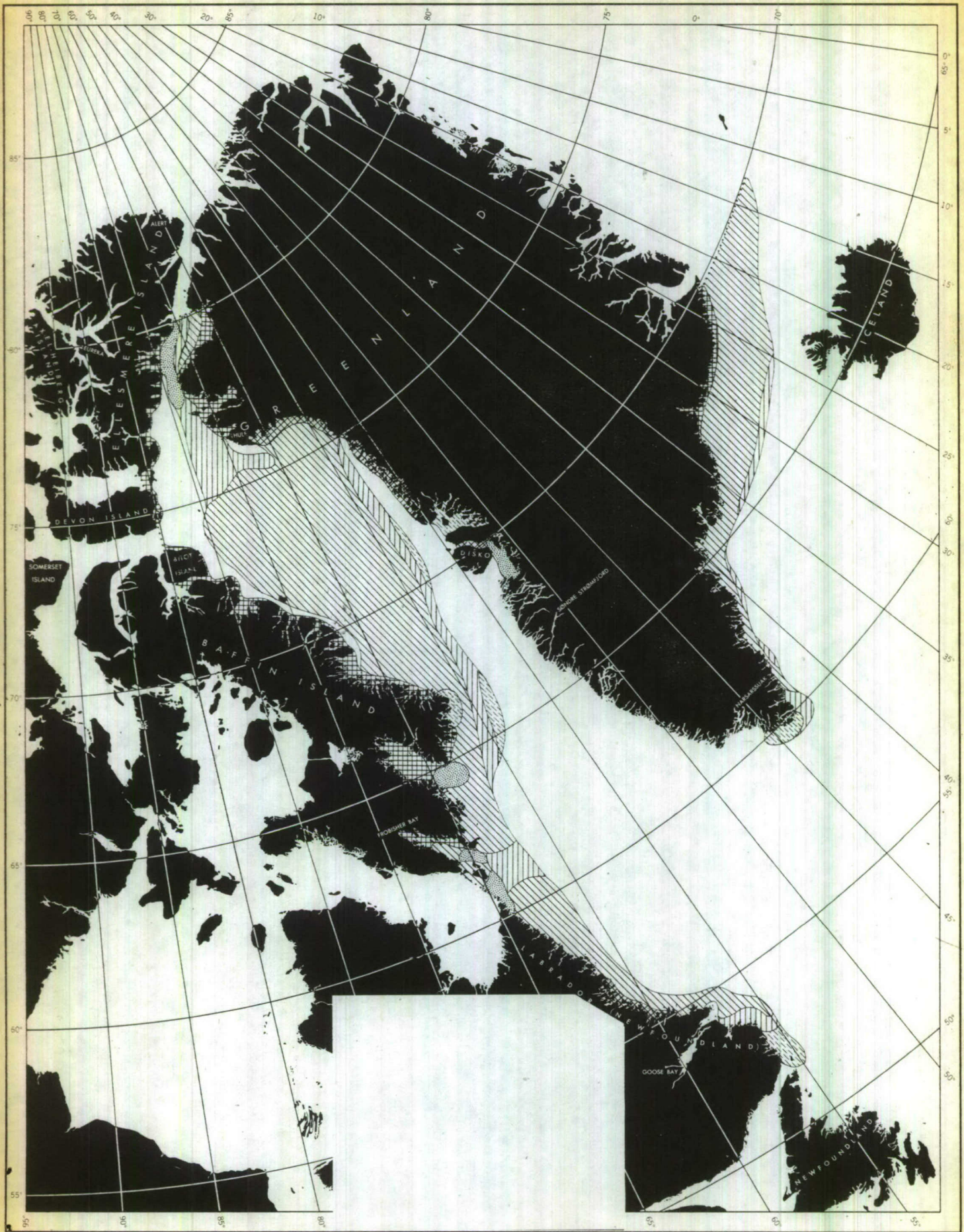


FIGURE 10 PROGNOSTIC ICE CHART MID-JUNE 1965

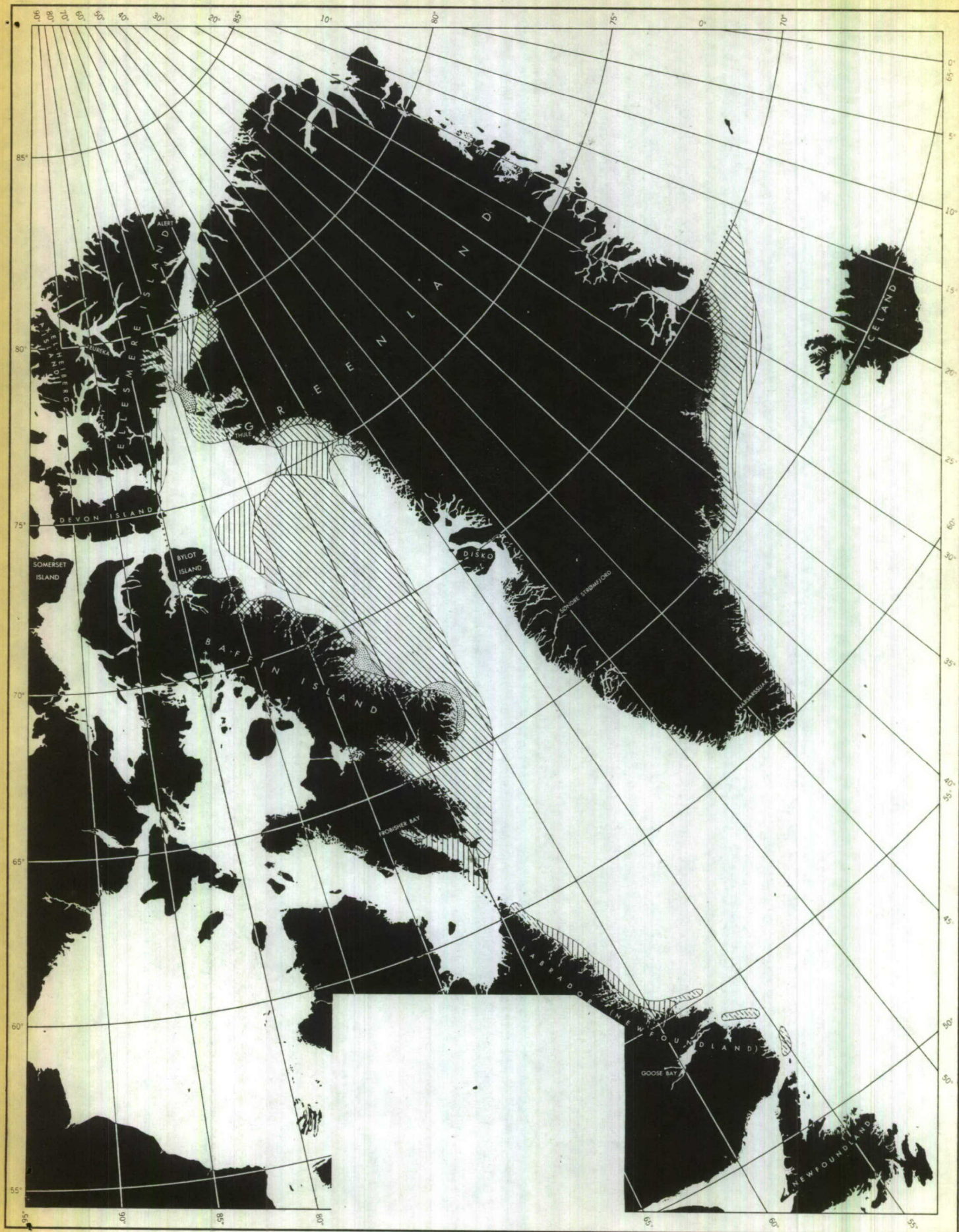


FIGURE 11 PROGNOSTIC ICE CHART MID-JULY 1965

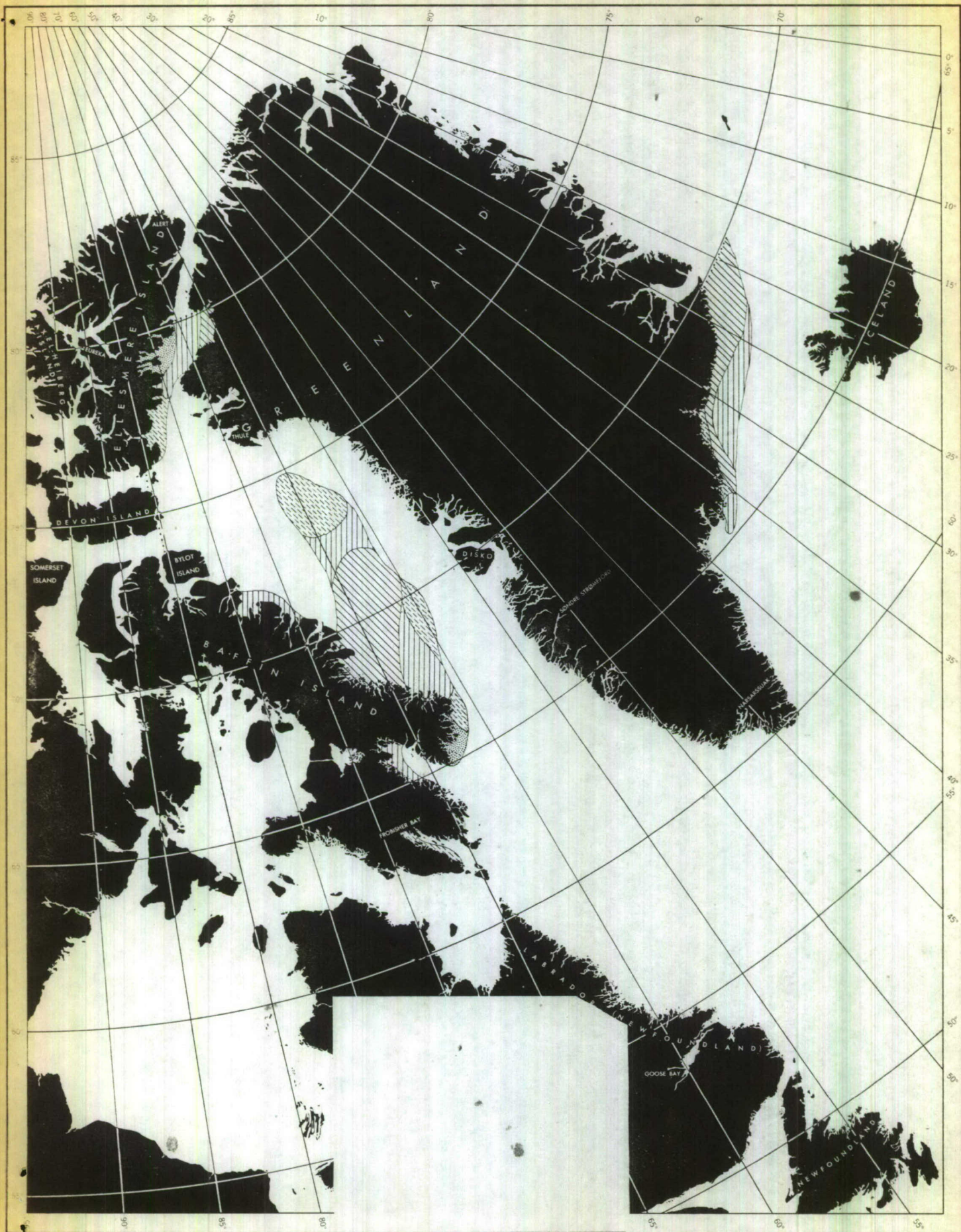


FIGURE 12 PROGNOSTIC ICE CHART MID-AUGUST 1965

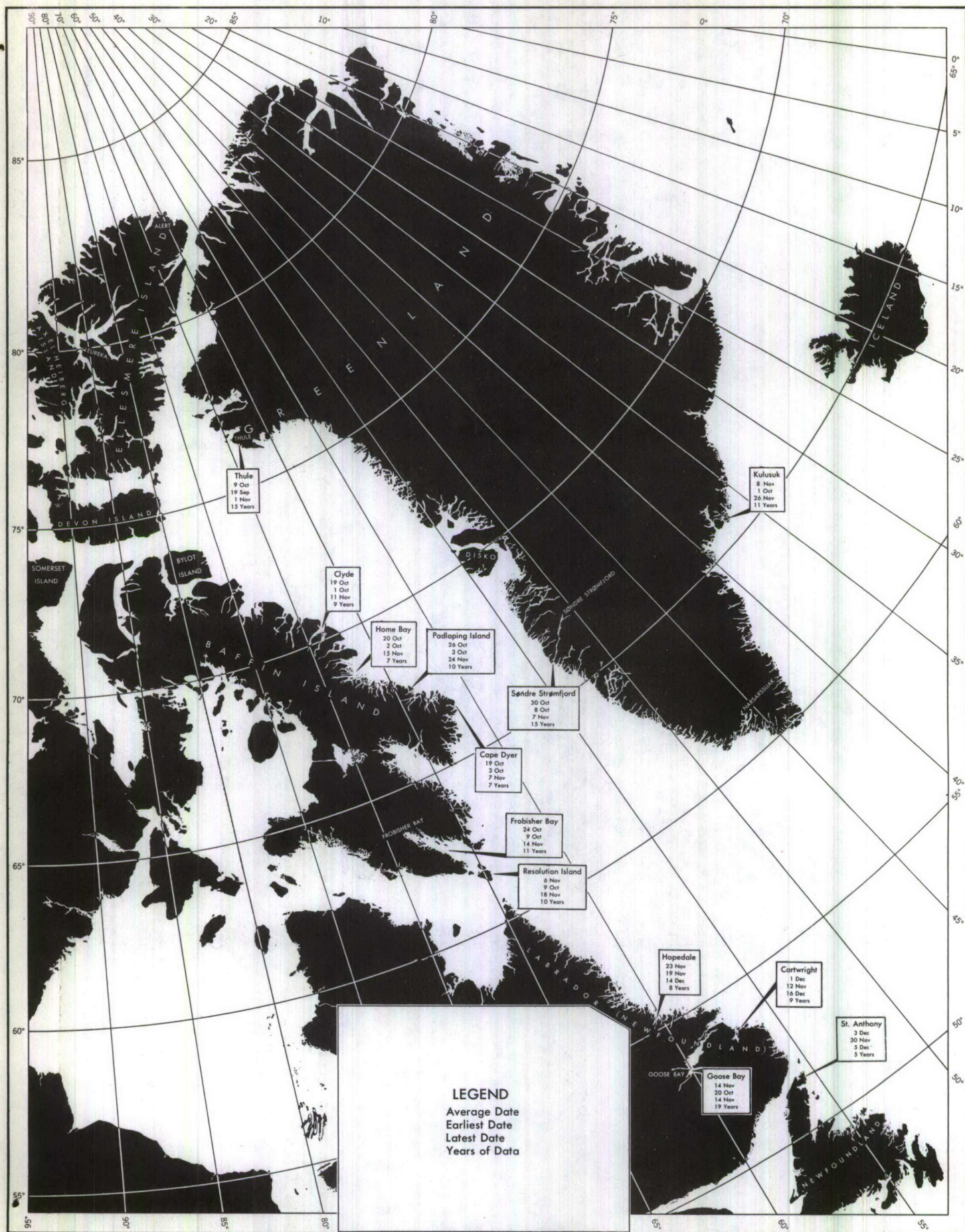


FIGURE 13 DATES OF INITIAL FREEZUP