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Report of the International Ice Patrol Service in the North Atlantic Ocean

SEASON OF 1973

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REPORT OF THE INTERNATIONAL ICE PATROL SERVICE IN THE NORTH ATLANTIC OCEAN

Season of 1973

CG-188-28

FOREWORD

Forwarded herewith is Bulletin No. 59 of the International Ice Patrol describing the Patrol's services, and ice observations and conditions during the 1973 season.

R. H. Scarborough
Chief, Office of Operations

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TABLE OF CONTENTS

Preface v
International Ice Patrol 1973 1
Aerial Ice Reconnaissance 4
Communications 6
Ice Conditions, 1973 Season:
  September 1972 9
  October - November 1972 9
  December 1972 9
  January 1973 9
  February 1973 10
  March 1973 11
  April 1973 11
  May 1973 12
  June 1973 12
  July 1973 13
  August 1973 13
Oceanographic Conditions, 1973 14
Discussion of Iceberg and Environmental
  Conditions During 1973 Season 16
Research and Development, 1973 20
List of Participating Nations' Ships reporting
  Ice and Sea Temperatures 21

Appendices
  Iceberg Casualties, 1800-1973 . . . . . .A-1
  Iceberg Drift from Surface Currents B-1

PREFACE

This report is 59th in a series of annual reports on the International Ice Patrol Service in the North Atlantic Ocean. It contains information on Ice Patrol organization, communications and operations, on ice and environmental conditions and their relationship in 1973, and a listing of iceberg casualties to shipping, 1800 - 1973.

The author of this report, Lieutenant Douglas W. CROWELL, USCG acknowledges ice and weather data provided by the Canadian Department of the Environment, weather data provided by the U.S. National Weather Service, weather and oceanographic data provided by the U.S. Naval Weather Service, and oceanographic data provided by the U.S. Coast Guard Oceanographic Unit. Acknowledgement is also made to Yeoman First Class Bruce S. COLLINS, USCG, Yeoman Third Class Philip T. KEITH, USCG, Marine Science Technician First Class Neil O. TIBAYAN, USCG, Marine Science Technician Second Class Raymond J. EVERS, USCG, Marine Science Technician Third Class James M. GAYNOR, USCG, and Marine Science Technician Third Class Larry D. STARK, USCG for their assistance in the preparation of the manuscript and illustrations for this report.

The continued generosity and cooperation given by the Canadian Forces in permitting the International Ice Patrol to utilize their facilities at Summerside, Prince Edward Island is again gratefully acknowledged.

INTERNATIONAL ICE PATROL, 1973

The 1973 International Ice Patrol Service in the North Atlantic Ocean was conducted by the United States Coast Guard under the provisions of Title 46, United States Code, Sections 738, 738a through 738d, and the International Convention for the Safety of Life at Sea, 1960, Regulations 5 through 8. The International Ice Patrol is a service for observing and disseminating information on ice conditions in the Grand Banks Region of the Northwest Atlantic Ocean. During the ice season, the southeastern, southern and southwestern limits of the regions of icebergs in the vicinity of the Grand Banks of Newfoundland are guarded for the purpose of informing passing ships of the extent of this dangerous region. The International Ice Patrol also studies ice conditions in general with emphasis on the formation, drift and deterioration of icebergs, and assists ships and personnel requiring aid within the limits of operation of the Ice Patrol forces.

The International Ice Patrol is directed from the Ice Patrol Office located at the U.S. Coast Guard Base, Governors Island, New York. The Office gathers ice and environmental data from a variety of sources, maintains an ice plot, forecasts ice conditions, prepares the twice-daily Ice Bulletin, replies to requests for special ice information, and executes operational control of the Aerial Ice Reconnaissance Detachment, the Ice Patrol oceanographic cutter, and the Surface Patrol cutter when assigned.

Vice Admiral Benjamin F. ENGEL, U.S. Coast Guard, was Commander, International Ice Patrol. Captain Eugene A. DELANEY, U.S. Coast Guard, was directly responsible for the management of the Patrol.

A single pre-season flight was made in mid-January 1973. The Aerial Ice Reconnaissance Detachment was deployed to Canadian Forces Base, Summerside, Prince Edward Island on 24 January and returned to the United States on 28 July 1973.

The 1973 Ice Season officiall ommenced at 0000 GMT, 24 January, when the first Ice Bulletin was issued, and continued until the final Bulletin was issued at 0000 GMT, 31 July 1973. The twice-daily Ice Bulletins were broadcast by the International Ice Patrol Communications Station Boston/NIK, U.S. Naval Radio Station Norfolk/NAM, Canadian Maritime Command Radio Station Mill Cove/CFH, and Canadian Coastal Radio Station St. John's/VON. The Ice Bulletin was

included in the U.S. Marine Information Broadcast for the High Seas of the North Atlantic, a voice broadcast originating from the U.S. Coast Guard Communications Station Boston/NMF. A facsimile ice chart was broadcast from Boston once each day. Iceberg information was also included on the regularly scheduled radio facsimile broadcasts of Naval Radio Norfolk/NFAX, CANMARCOM/CFH, Radio Bracknell/GFE, Radio Hamburg/DGC and Radio Quickburn/DGN.

The U.S. Coast Guard Cutter EVERGREEN, Commanded by Lieutenant Commander Martin J. MOYNIHAN, U.S. Coast Guard, conducted oceanographic cruises for the Ice Patrol during 3 - 26 April, 8 - 29 May and 13 June - 14 July. Approximately 13 days of the final cruise were devoted to a special survey that provided field data and verification to the Labrador Current model developed by Commander Ronald C. KOLLMEYER, U.S. Coast Guard. This may become a useful input to the iceberg drift program.

For the second consecutive year a surface patrol was required. USCGC HAMILTON, commanded by Captain James H. SWINT, U.S. Coast Guard, assumed the first Surface Patrol duties on 10 March while enroute home port after completing Ocean Station CHARLIE duties. HAMILTON was relieved on 17 March and the following cutters continued the surface patrol:

USCGC DECISIVE 17 - 31 March; 13 - 29 June
Commanded by Commander John B. EKMAN, U.S. Coast Guard

USCGC ALERT 31 March - 11 April
Commanded by Commander Robert C. NICHOLS, U.S. Coast Guard

USCGC STEADFAST 11 - 24 April; 2 - 5 May
Commanded by Commander Royce R. GARRETT, U.S. Coast Guard

USCGC OWASCO 24 April - 2 May; 21 - 26 May
Commanded by Commander Robert G. MOORE, U.S. Coast Guard

USCGC DEPENDABLE 5 - 21 May; 26 May - 1 June
Commanded by Commander Richard D. THOMPSON, U.S. Coast Guard

USCGC VIGOROUS 1 - 13 June
Commanded by Commander Richard W. MICHAELS, U.S. Coast Guard

USCGC MENDOTA 29 June - 10 July
Commanded by Commander Robert GILLESPIE, U.S. Coast Guard

On 10 July, with icebergs no longer a threat below 44°N, the surface patrol was terminated.

During the 1973 Season an estimated 847 icebergs drifted south of 48°N, a heavy season that was equal in length to last years record of 189 days.

AERIAL ICE RECONNAISSANCE

During the period 5 September 1972 to 31 August 1973 a total of 83 ice observation flights were flown. Pre-season flights made in January accounted for 6 flights, and the remaining 77 flights were made during the ice season. There was no requirement for any post-season flights. The objective of the pre-season survey was to study the iceberg distribution patterns in the Labrador Sea and to evaluate the iceberg potential of the developing ice season. The season flight objectives were to locate the southwestern, southern, and southeastern limits of icebergs, to evaluate the short term iceberg potential of the waters immediately north of the Grand Banks, and occasionally to study the iceberg distribution along the Labrador Coast. The flight statistics shown in Table 1 do not include the flight time required to make the passages between U.S. Coast Guard Air Station, Elizabeth City, North Carolina and the operating bases for crew relief or aircraft maintenance.

Table 1 - Aerial Ice Reconnaissance Statistics
September 1972 to August 1973

Month	Number of Flights	Flight Hours
PRESEASON		
September-December	0	0
January	6	34.2
Preseason total	6	34.2
SEASON		
January	4	28.0
February	10	54.9
March	14	94.5
April	12	83.6
May	17	113.5
June	11	65.3
July	9	44.7
August	0	0
Season total	77	484.5
Annual total	83	518.7

Aerial ice reconnaissance was accomplished by U.S. Coast Guard HC-130-B (Lockheed Hercules) four-engine aircraft from the Coast Guard Air Station at Elizabeth City, North Carolina. During the iceberg season, the aircraft operated out of Canadian Forces Base Summerside, Prince Edward Island; Torbay Airport, St. John's Newfoundland; and Gander Airport, Newfoundland.

On 24 January the Ice Reconnaissance Detachment deployed to Summerside from Elizabeth City. Occasionally, during periods of good visibility, the aircraft operated from St. John's or Gander. Although these Newfoundland airports are some 500 miles closer to the Grand Banks than Summerside, the overall cost of lodging and fuel, as well as the outstanding services offered by the Canadian Forces Base at Prince Edward Island made it economical to return there at most opportunities. The main base remained at Summerside until 28 July when the Detachment returned to the United States.

COMMUNICATIONS

Ice Patrol communications included ice reports, environmental conditions, Ice Bulletins, special ice advisories, a daily facsimile chart, and the administrative and operational traffic necessary to the conduct of the Patrol. The Ice Bulletin was transmitted by teletype from the Ice Patrol Office in New York twice each day to over 30 addressees, including those radio stations which broadcast the Bulletin. These stations were the U.S. Coast Guard Communications Station Boston/NIK/NMF, U.S. Naval Radio Station Norfolk/NAM, Canadian Coastal Radio Station St. John's/VON and Canadian Forces Maritime Command Radio Station Mill Cove/CFH.

Coast Guard Communications Station Boston transmitted the Bulletin by CW at 0018 GMT on 5230 and 8502 kHz and at 1218 GMT on 8502 and 12750 kHz. After a 2-minute series of test signals the transmissions were made at 25 words per minute and then repeated at 15 words per minute. An abbreviated version of the Ice Bulletin was included in the Western North Atlantic High Seas Broadcast (voice) from Boston on 8765.4 (8764.0) kHz upper side band mode at 0130, 0730, 1330 and 1930 GMT and on 8764.0 kHz double side band mode at 0200, 0800, 1400 and 2000 GMT. During the season a statement was included in every fourth day's voice broadcast requesting comments on the usefulness of presenting ice information in this manner. No replies were received from the maritime community, thus it is anticipated that the use of the Western North Atlantic High Seas Broadcast for dissemination of Ice Patrol information will be discontinued. Coast Guard Communications Station Boston/NIK also transmitted a daily radiofacsimile broadcast depicting the locations of icebergs and sea ice at 1600 GMT simultaneously on 8502 and 12750 kHz at a drum speed of 120 revolutions per minute.

Special broadcasts were made by Canadian Coastal Radio Station St. John's/VON as required when icebergs were sighted outside the limits of ice between regularly scheduled broadcasts. These transmissions were preceded by the International Safety Signal (TTT) on 500 kHz.

Merchant ships calling to transmit ice sightings, weather and sea surface temperatures were requested to use the regularly assigned international call signs of the Coast Guard Ocean Stations, East Coast AMVER Radio Stations, or Canadian Coastal Radio Station St. John's/VON. All Coast Guard Stations were alert to answer NIK/NIDK calls, if used.

Ice information services for the Gulf of St. Lawrence, as well as the approaches and coastal waters of Newfoundland and Labrador, were provided by the Canadian Department of the Environment from December until approximately late June. Ships obtained ice information by contacting the Ice Operations Officer, Sydney, Nova Scotia via Sydney Marine Radio/VCO or Halifax Marine Radio/VCS.

Communications statistics for the period 5 September 1972 through 31 August 1973 are shown in Table 2.

Table 2 - COMMUNICATIONS STATISTICS

Number of ice reports received from ships	842
Number of ships furnishing ice reports	317
Number of ice reports received from commercial aircraft .	37
Number of sea surface temperature reports	381
Number of ships furnishing sea surface temperature reports.	100
Number of ships requesting special ice information . . .	33
Number of NIK Ice Bulletins issued	378
Number of NIK facsimile broadcasts	188

Of the one-hundred ships furnishing Ice Patrol with special sea surface temperature observations, the ten most outstanding contributers were:

M/V Atlantic Span/SLPN
M/V Scandic Wasa/SMIK
M/V Transamerica/DHPT
M/V Leonardo Da Vinci/ICLN
M/V Ivo Vojnovic/YTEI
USCGC SHERMAN/NMMJ
M/V Ritva Dan/OZBM
M/V Banija/YTEK
M/V Hilla/GRHT
M/V St. Margaret/GHJM

TABLE 3 - Estimated Number of Icebergs South of Latitude 48°N, Season of 1973

	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTAL
1973	4*	0	0	6	54	110	134	212	159	151	19	1	850(847)
Total 1946-1973	9	2	4	11	64	237	895	2563	2257	1444	313	39	7,838
Average 1946-1973	0	0	0	0	2	9	32	92	81	52	11	1	280
Total 1900-1973	255	109	110	91	184	688	2997	7408	9340	4962	1509	428	28,081
Average 1900-1973	3	1	2	1	3	9	41	100	126	67	20	6	379

*Three(3) of these icebergs actually drifted south of 48°N during the 1972 Ice Season; however, they are listed here to provide statistical continuity.

ICE CONDITIONS, 1973 SEASON

September

When the 1972 Ice Season officially closed on 4 September, three icebergs had already drifted south of 48°N. The computer plot was maintained and no further intrusion of icebergs occurred south of 48°N until 19 September when an iceberg was reported in position 47°50'N 39°45'W. A total of seventeen other icebergs were reported during September, mostly in the Strait of Belle Isle, its eastern approaches, and along the coast of Labrador.

October - November

During October, 29 icebergs were reported to the Ice Patrol Office located from the Strait of Belle Isle northward. November, however, showed 4 of its 33 iceberg reports to be south of the Strait. The southernmost of these was reported to be in position 50°50'N 53°11'W on 11 November.

December

Only 17 iceberg reports were received, but there were several significant sightings: one of 24 December off Cape Spear, Newfoundland and two icebergs off Cape Race on 30 December. It was estimated that 6 icebergs drifted south of 48°N during this month. These reports prepared the Ice Patrol office for what was to be its earliest commencement date in history and are attributable to the very early sea ice cover which developed along the Labrador coast and in the Strait of Belle Isle. The rapid growth and drift of sea ice in the vicinity of St. John's continued during the month with its eastern limit near 50°W by the end of December.

January

Icebergs continued to move south and sea ice continued its rapid growth spreading southeastward throughout the northern portion of the Grand Banks during the first two weeks of January, extending to 46°30'N 46°W. An offshore wind induced drift component kept the heavier ice away from the coast south of Fogo Island but there was now sea ice in most of Newfoundland's bays. Close pack ice in the transitional stage from Grey-White to First Year ice blocked the approaches to Notre Dame Bay west of Fogo Island. During the period 9 - 19 January a preseason survey was made along the Labrador and

Baffin Island coasts and the waters east of Newfoundland. The flight tracks and observed icebergs are shown in figure 1. The area south of Hamilton Inlet, normally iceberg free in early January, had an extremely high concentration of 264 icebergs, seven of which were south of 48°N. Northward to Hudson Strait only 64 icebergs were sighted, 5 less than normal. Between Hudson Strait and just north of Cape Mercy, Baffin Island only 53% of the 251 iceberg normal distribution was observed, however, over 3 times the normal amount of icebergs were counted in Davis Strait. The latitudinal distribution is illustrated graphically in figure 2. On the basis of this preseason survey plus seven additional ship reports of icebergs south of 48°N, Ice Patrol forces were deployed to Canadian Forces Base, Summerside, Prince Edward Island and services were initiated on 24 January, the earliest commencement date in Ice Patrol history. The initial ice reconnaissance flights on 25, 27 and 28 January located a total of 66 bergs, 13 growlers and 18 radar targets as shown in figure 3. The southernmost iceberg of this month reached 44°52'N 47°30'W on 28 January. Meanwhile ships continued to report icebergs far to the southeast of Flemish Cap, reaching the easternmost limit of the month at 46°07'N 41°02'W on 30 January as shown in figure 4. It was estimated that a total of 54 icebergs drifted south of 48°N during January.

February

The southern and eastern limits of sea ice off the coast of Newfoundland receded during February to where the southern edge of the heavy pack ice at the end of the month lay north of 48°N. During the first eighteen days of the month, only four observation flights were conducted due to poor on scene weather generated by predominant southwesterly winds. These winds also prevented any significant southerly iceberg movement and promoted an eastward dispersal towards Flemish Cap, distributed northward as shown in figure 5. Of significance in this same figure is that the northern portion of the Grand Banks is relatively iceberg free, which lessened the iceberg threat for the remainder of the month. Figure 6 shows the sea ice conditions as well as the southernmost and easternmost icebergs of the month, which both occurred on 28 February. They had drifted to positions 44°06'N 48°51'W and 46°47'N 38°32'W, respectively. It is estimated that 110 icebergs drifted south of 48°N during February, 22 times the monthly average.

March

At the begining of March, new ice had spread southward to near 47°30'N 47°W and in the coastal area to near Cape Race. Iceberg drift continued to be southerly and easterly until the easternmost iceberg of the season reached 46°52'N 37°59'W before melting on 6 March. The ice conditions at this time are shown in figure 7. Ice observation flights on 7, 8 and 11 March located a total of 36 bergs, 12 growlers and 5 radar targets as shown in figures 8 and 9. With icebergs already south of the Tail of the Banks, a Surface Patrol was started on 10 March. The iceberg conditions on 11 March as shown in figure 10 had the southernmost iceberg for the month in position 41°23'N 48°31'W. By mid-March the pack ice extended from Cape Freels to near 45°30'N 46°30'W to 47°40'N 45°W and then northwestward. During the second half of March, mean northerly winds east of Newfoundland caused the sea ice to drift southward and carried it past St. John's, blocking access to this harbor for much of the period. A tongue of ice drifted around the eastern edge of the Grand Banks and by the end of March extended south to near 44°50'N. Ice observation flights on 24, 28 and 29 March, as shown in figure 11, located a total 234 icebergs. A flight on 31 March north of the Strait of Belle Isle to Hamilton Inlet located an additional 74 bergs. These indicated a potential of over 300 icebergs to intrude upon the Grand Banks during the next six to eight weeks. During the month of March, an estimated 134 icebergs drifted south of 48°N.

April

During early April concentrations of sea ice below 48°N showed some signs of deterioration; however, the southern tongue of open pack ice extended as far south as 43°30'N on 3 April as shown in figure 12. By mid-April the central pack (6 oktas or more) had moved southward to 45°N, with little change to the extent of the tongue of sea ice. Ice observation flights on 17 and 18 April (figure 13) revealed iceberg concentrations on the northeast corner of the Grand Banks along the eastern slope, a distribution ideal for maximum southward iceberg movement. Before the end of the month, a strong northerly wind had packed ice onto the coast from the Avalon Peninsula to Belle Isle. North of latitude 49°N, the ice edge retreated westward, but over the northern Grand Banks area the sea ice extended eastward to near 48°W, some 150 miles beyond its average limit. These conditions brought the southernmost iceberg of the month to 40°40'N 49°04'W by the end of April These sea ice and iceberg conditions are shown on figure 14. During April an estimated 212 icebergs drifted south of 48°N.

May

Continued northeasterly winds promoted more southerly iceberg drift. A ship report of two icebergs west of 40°W extended the limits of all known ice to encompass over 250,000 square miles south of 48°N on 7 May, as shown in figure 15. This date also represented the southernmost iceberg of the season at 39°46'N 50°W as well as the easternmost bergs of the month, two at 42°41'N 39°27'W. On 5 May a ship reported the southernmost ice for the season, a growler in position 37°12'N 49°W or some 1250 miles due east of the Virginia coast. After the first week of May, offshore wind induced drift developed along the coast of Newfoundland, loosening the sea ice south of latitude 49°N and developing leads along the coast, finally reopening St. John's harbor. Ice observation flights on 14, 15 and 17 May (figure 16) located a total of 123 icebergs, 6 growlers and 64 radar targets concentrated on the Grand Banks and its eastern slope. For the remainder of the month, the average surface winds were from the southwest over the Grand Banks, contributing no significant southward iceberg drift and lessening the iceberg threat to mariners crossing south of the Tail of the Banks. By the end of the month, sea ice remained along the Newfoundland coast from Cape Freels to the Strait of Belle Isle. The Strait was clear of sea ice and open to unrestricted marine traffic on 30 May. It is estimated that 159 icebergs drifted south of 48°N during this month.

June

Iceberg conditions on the first of June (figure 17) were still very serious with 344 icebergs on plot south of 48°N (155 bergs south of 46°N) many of which had crossed this parallel during April and not yet deteriorated. Ice reconnaissance flights on 7 and 8 June covered the area between 47°N and 50°N to give an indication of the iceberg potential for the remainder of the month. This area was last flown on 14 May and was not reflown due to the prevailing fog conditions. Figure 18 shows the 137 icebergs, 10 growlers and 10 radar targets located on these flights indicating that, in spite of the early commencement, Ice Patrol would continue for at least another month. Sea ice rapidly receded within Notre Dame Bay until it became clear by mid-month. Mid-June also had the southernmost and easternmost icebergs for the month located in positions 42°02'N 48°14'W (15 June) and 44°52'N 41°25'W (18 June), respectively. A good sequence of ice observation flights on 19, 20 and 21 June (figure 19) revealed only 58 icebergs, 14 growlers and 4 radar targets, however, with icebergs still south of the Tail of the Banks, the Surface Patrol was continued. During June 151 icebergs were estimated to have drifted south of 48°N.

July

The iceberg condition in the begining of July, as shown in figure 20, still had 76 icebergs south of 48°N. With four radar targets at the Tail of the Banks, the Surface Patrol continued until the fog lifted and subsequent searches by the Coast Guard cutter failed to locate any ice. Thus on 10 July, with icebergs no longer a threat south of 44°N, the Surface Patrol was terminated. Intermittent ice observation flights throughout the month, limited due to on scene weather, monitored the retreating iceberg limits. Then on 25 and 26 July flights with very good visibility failed to locate any icebergs. The four icebergs on figure 21 were reported by a ship subsequent to the 26 July flight and were the only icebergs remaining in the vicinity of the Grand Banks to threaten North Atlantic shipping. These bergs subsequently drifted south of 48°N before melting during the first week of August. Thus notification was given the maritime community and Ice Patrol services ended on 31 July. During this month an estimated 19 additional icebergs drifted south of 48°N.

August

Although the Ice Patrol services had officially terminated, the Ice Season terminates on 31 August for statistical purposes with the new season begining 1 September. During the remainder of the month many iceberg reports were received from ships approaching the Strait of Belle Isle, the southernmost of which were two icebergs located just south of 51°N on 28 August. One berg drifted south of 48°N during August which brought the statistical total for the 1973 season to 847 icebergs (plus 3 which were left over from the 1972 season).

OCEANOGRAPHIC CONDITIONS, 1973

Three oceanographic cruises during the periods 3-26 April, 8-29 May and 13 June - 14 July were conducted by the U.S. Coast Guard Oceanographic Unit in support of the International Ice Patrol aboard USCGC EVERGREEN (WAGO 295). Approximately 13 days of the final cruise were devoted to special surveys that provided field data and verification to a Labrador Current model, developed by Commander Ronald C. KOLLMEYER, USCG. Salinity and temperature data were collected to a depth of at least 1000 meters (bathymetry permitting) using a Salinity-Temperature-Depth (STD) Sensor System. Data were recorded on magnetic tape using a digital data logger for further processing upon return to the Coast Guard Oceanographic Unit, Washington, D.C. From processed data, charts of dynamic topography of the sea surface relative to an assumed 1000 decibar level of no motion were constructed (figures 22-27). Only the 7-22 April and 1-4 July dynamic topography charts show the prominent features of the general circulation pattern on the Grand Banks. The Labrador Current can be seen slowing southward along the eastern slope of the Grand Banks near the 1000 meter depth contour. To the east is a dynamic trough separating the colder Labrador Current from the opposite flowing North Atlantic Current.

The April survey (figure 22) shows the dynamic trough just east of the Labrador Current separated into two dynamic lows as a result of the North Atlantic Current, an interesting phenomenon not shown on the average or normal dynamic topography for the month. This intrusion lessened the velocity of the core of the Labrador Current in the vicinity of 45°N to less than half its normal of about 35 cm/sec, yet at 150 kilometers north and south of this location, average velocities were determined.

The survey area in May as shown in figure 23 was apertured with anomalous dynamic highs. Associated geostrophic currents exceeded 50 cm/sec in the vicinity of 45°N 48°W where a dynamic trough is normally located. Evidence of a portion of the Labrador Current is present on the southeast corner of the Grand Banks, however, its presence further north along the 1000 meter contour is weakly defined at best. The North Atlantic Current in the eastern portion of the survey area was approximately in its normal location. Its velocities approached 100 cm/sec or approximately twice their average values.

The 1-4 July survey of 3 oceanographic sections (figure 24) compared reasonably well with the June normal dynamic topography chart, thus the previous month's average current values were assumed in the entire Grand Banks area and continued for the remainder of July.

The remaining figures (25-27) are 60-mile squares of concentrated oceanographic stations for the previously mentioned Labrador Current model. The resulting dynamic topography is very detailed, as expected, and does not compare well with either the June normal nor the contours obtained from the much wider spaced stations surveyed 1-4 July. They do point out three very important factors. First, the closer the oceanographic stations, the greater the detail, but the smaller the area that can be surveyed in the same amount of time. Second, the greater the station spacing, the larger the area that can be surveyed, but the dynamic contours are more averaged - producing a chart with less defined features. Finally, each of these special surveys exhibits different dynamic contours, and although they are spaced only four days apart, they indicate a rapidly changing surface current structure.

The above discussion was based on preliminary data collected during the surveys. A more detailed analysis of the oceanographic conditions of the Grand Banks in 1973, including water temperatures, geostrophic currents, and volume transport will be published in the U.S. Coast Guard Oceanographic Report series, CG-373.

DISCUSSION OF ICEBERG AND ENVIRONMENTAL CONDITIONS

1973 ICE SEASON

After last year's heaviest iceberg season record of 1587 bergs south of 48°N, the 1973 season total of 847 seems small, yet is still almost four times the 1946-1972 normal! Thus the contributing factors, including the number of icebergs available to drift south of 48°N latitude, the strength and duration of the northwesterly winds producing a southerly iceberg transport, the development of the features of the Labrador Current (already discussed in the Oceanographic Conditions, 1973 section), and the deterioration of icebergs are analyzed in the following paragraphs.

The January pre-season iceberg survey previously refered to in figure 1, although presenting an obvious requirement to start an early season with 264 icebergs south of Hamilton Inlet, did not allow for more than a normal potential of iceberg severity for the remainder of the ice season, considering an iceberg drift of 10-15 miles per day along the Labrador Coast. However, under unusual conditions with a very strong northwesterly wind it is possible for iceberg drifts of 24 or more miles per day to occur. At this point it is sufficient to say that a January pre-season iceberg count only as far north as Cape Dyer from the Strait of Belle Isle is inadequate and future surveys will have to be made further north along the Baffin Island coast to obtain a total potential iceberg count for the ice season.

Figure 28a. shows the November 1972 Icelandic Low located approximately 700 miles northeast of Keflavik (over 1000 miles east of its normal position in the Denmark Strait), with a mean pressure of 994 mb. A major trough extended west-southwestward from the Low, across Iceland to the southern tip of Greenland. A second major trough extended from the tip of Greenland, southward, and then southwestward to the U.S. East Coast. This easterly shift of the major pressure center resulted in winds from the north, rather than the northeast in the vicinity of Davis Strait, but with little change in magnitude. This would allow southerly movement at an average rate without grounding on the Baffin Island coast.

December of 1972 as shown in figure 28b. has the Icelandic Low positioned at 62°N 30°W, slightly east of its normal location. Its mean pressure was 985 mb, significantly lower than the normal of 1000.7 mb. This resulted in a 18 mb. tighter gradient between the center of the Low and the Labrador coast and the impedous to push icebergs further south than normal.

In figure 28c. the January Icelandic Low is again dominant, in its mean position near Cape Farewell (Kap Farvel), but with a 985 mb. pressure remaining significantly below its normal. As last month, the pressure gradients were greater than the climatological mean. The climatic normal for February as shown in figure 28d. has the Icelandic Low near 59°N 39°W (about 150 miles southeast of Cape Farewell) at 1004 mb. The actual sea level pressure was quite different. The main center of the Icelandic Low was far to the northeast, over the Norwegian Sea near 71°N 13°E at 992 mb. In what can be interpreted as a secondary center, just off Keflavik, Iceland, the pressure was 998 mb. A sharp ridge of low pressure extended from this secondary center southward over Newfoundland. Although the resulting pressure gradients were again greater than normal, they were significantly less than the previous two months.

In figure 28e. the March Icelandic Low was located between Cape Farewell and Iceland, only about 300 miles northeast of its usual 1004-mb. position and 4 mb. lower than normal. However, when combined with a 1019-mb. high pressure center over northern Greenland, much larger wind gradients than normal resulted across the Labrador Sea, almost equal to the January magnitudes. As spring is the time of change and unsettled conditions, so was the mean pressure chart of April as shown in figure 28f. With highs and lows interchanged, a large positive anomoly was created north of 45°N along the Newfoundland and Labrador coasts. For the first time in many years a large negative gradient (winds from the southeast) was predominent.

The Icelandic Low was undefined as frequently occurs in May (figure 28g.), with both the Azores-Bermuda and Greenland Highs slightly higher than normal. A resulting positive anomoly over the Labrador coast identified continued southeasterly winds, although of a lesser magnitude than the previous month. In figure 28h. the mean pressure pattern in the North Atlantic in June was shifted northward and eastward. The Icelandic Low was over Iceland (more than 1000 miles northeast of its average position on the coast of Labrador) and 4 mb. less than normal. Slightly above normal pressure gradients resulted along the Labrador coast.

The mean pressure pattern for July 1973 (figure 28i.) was as close to its normal as meteorlogically possible. The Bermuda-Azores High was 4 mb. higher than normal but the isobars were almost perpendicular to the Labrador coast indicating southwesterly winds and no further southerly iceberg drift wind component. Winds were from the west-southwest over the Grand Banks providing little southward movement to the remaining icebergs and enabling Ice Patrol to close out the season by the end of the month. The pressure chart for August as shown in figure 28j. is included for continuity. The pressure pattern was near normal, but with the Icelandic Low of 1005 mb. and a 1017 mb. high centered over Greenland, the isobars are much closer providing for a much greater than normal southerly flow along the Labrador coast. The previous month's warmer temperatures took their toll on the iceberg population, however, in that only one additional iceberg drifted south of 48°N.

Northwesterly winds have a profound effect on icebergs and their drift. These winds create a southerly component of wind induced iceberg drift, accentuate the volume transport (and velocity) of the Labrador Current, reduce the air and sea surface temperatures, and spreads and develops sea ice to the south and east of Newfoundland. To determine and assign numerical values to the existing wind conditions, surface pressure gradients (differences in atmospheric pressure along a geographically orientated line) may be used. Six such gradients are labeled in figure 29. Gradients 1 and 2 measure the winds off the coast of Labrador which are important in setting up the drift for transporting icebergs to the general area northeast of Newfoundland. Gradient 3 measures the component which assists or impedes icebergs as they drift along the eastern slope of the Grand Banks. Gradient 4 is a measure of the influence of the generally westerly winds along the northern slopes of the Grand Banks. This is important in drifting the icebergs away from the northeast Newfoundland coast and into the Labrador Current. If, however, they are too strong (or persistent) when the bergs reach the northeast corner of the Grand Banks, they may be carried eastward out of the Labrador Current and into warmer waters which drift generally northeastward. Gradients 5 and 6 provide a pre-season indication of potential iceberg drift south and across Davis Strait, respectively.

Figure 30. shows Gradients 5 and 6 for both the 1972 (not analyzed last year) and 1973 pre-season periods of September to February and continued through April. It is more than apparent that from the end of November and continuing until the middle of April, 1972 more than twice the average wind gradient provided southerly drift for icebergs from far to the north of Davis Strait. These northern icebergs, previously uncounted in the January pre-season survey, were given an impedous to reach the Grand Banks, a journey not possible under normal environmental conditions. This five month anomaly also extended the iceberg season to the longest on record by providing a constant flow of icebergs out of Baffin Bay.

Now looking at the 1973 season statistics on the same figure, only two months of excessive positive deviation are noted, preceeded by over a month's negative (southerly winds) gradient. Thus icebergs north of Davis Strait were subjected to normal or above drift rates after the January pre-season flights. Pressure gradient 6, although less negative than normal, indicates that the iceberg transport across Davis Strait must also be taken into account.

Referring now to the graphical representation of figure 31, Gradients 1 and 2 are extremely above normal from the first of December through the first of April. Thus the icebergs previously refered to from north of Davis Strait continued their southward drift at excessive rates. Near average gradients in the late spring and early summer months provide for continued iceberg movement south to the vicinity of 48°N, but not at the rate of the previous year. Coupling these with Gradients 3 and 4 as shown, provides for another very long season, equalling the previous year's in length, but falling short of its magnitude.

As expected from the exceptionally strong northwesterly winds, air temperatures along the Baffin Island, Labrador and Newfoundland coasts were exceptionally low beginning in December which accumulated excessive frost degree days as shown in figure 32. A frost degree day is defined as one day at a temperature one Fahrenheit degree below 32° (e.g., one day at 25°F would be seven frost degree days). Similarly, a melting degree day is one day at a temperature of one Fahrenheit degree above 32°. The rapid accumulation of melting degree days along the Labrador Coast (Hopedale and Cartwright) correlate with the southerly winds as evidenced by negative gradients (1 and 2, refered to in the previous paragraph) during April and May. Newfoundland melting degree days finally reached a normal accumulation coinciding with the end of the 1973 Ice Season.

RESEARCH AND DEVELOPMENT, 1973

During the 1973 Ice Season a final evaluation of the AN/DPD-2 Side-Looking Airborne Radar (SLAR), provided by the U.S. Coast Guard Research and Development Center, Groton, CT., was conducted. SLAR appears to be the only all-weather iceberg detection device available for the Ice Patrol, however a production model is necessary in lieu of the research SLAR that was tested due to operational considerations, i.e., repair parts readily available, real-time film processing, etc. A valuable report entitled "Iceberg Classification Using Side Looking Airborne Radar" by L. D. FARMER was published last year from the 1970 and 1971 data gathered during ice reconnaissance flights. The information contained therein remains unchanged to date and is available from the National Technical Information Service, Springfield, VA. 22151 (Order Number AD 742653). Commander, International Ice Patrol will continue efforts to obtain an operational Side-Looking Airborne Radar to significantly improve iceberg detection and identification capabilities.

Also during the 1973 season a newly developed air-deployable surface current probe was tested for its usefulness in determining iceberg drift. Due to various failures in the camera and current probes, as well as the inability to relocate icebergs and identify the dye patches, proper evaluation was not possible. However, some valuable observations and recommended improvements for future experiments were obtained. The Technical Report (Project 736411 of the Coast Guard Research and Development Center) "Iceberg Drift from Surface Currents" by Dr. J. P. WELSH, Jr. and Lieutenant S. M. PHILLIPS, USCG is included in this Bulletin as Appendix B.

ICE AND SEA SURFACE TEMPERATURE REPORTS
RECEIVED FROM SHIPS OF PARTICIPATING NATIONS
DURING 1973

BELGIUM	ICE	SST
LOVERVAL	3	4
CANADA		
CCGS BAFFIN	1	
CCGS d'IBERVILLE	1	
CCGS HUDSON	1	
CCGS JOHN A. MACDONALD	2	
CCGS LOUIS S. ST. LAURENT	3	
CSS DAWSON	1	
HMCS IROQUOIS	1	
IMPERIAL QUEBEC	1	
PORTE ST. LOUIS	1	
SIR HUMPHREY GILBERT	1	
DENMARK		
ESTRID	1	
LEINSTER BAY	1	2
PACIFIC SKOU	1	1
RITVA DAN	17	12
SAIMA DAN	1	2
SONJA	1	
FINLAND		
FINNFOREST	1	
KEPPO	1	
SOLANO	1	
FRANCE		
AMPERE	6	9
ANDROMEDE	1	
ATLANTIC COGNAC	1	1
ATLANTICA MARSEILLE	1	
CATHERINE	1	1
CETRA LYRA	1	1
CHARLES LD		1
COMMANDANT BOURDAIS	1	1
CYROS	1	
FRANCOIS LD	2	
LOIRE	10	9
MONT LOUIS	5	
ONDINE	1	
PENERF	1	
PENHIR	2	

FEDERAL REPUBLIC OF GERMANY	ICE	SST
AEGIR	1	
ALMUT BORNHOFEN	1	
ALSTER EXPRESS	4	
ANNA WESCH	1	
ANTJE SCHULTE	1	1
ATLANTIC CINDERELLA	2	
BOCKENHEIM	7	3
BUCHENSTEIN	1	
BUNTENSTEIN	1	
BUNTENTOR	1	
CAROLA REITH	1	1
CONSTANTIA	2	
EDE FOLDENFJORD	2	
ELBE EXPRESS	5	
GRETHE REITH	1	1
GRIESHEIM	1	
HAMBURGER DAMM	1	
HAMBURGER WALL	1	
HAVELLAND	1	
HEINRICH SCHULTE	2	
HERMAN SCHULTE	1	
JOSELIN	2	
MAIN EXPRESS	1	1
MARITA LEONHARDT	2	
MATTHIAS REHDER	1	
MOSEL EXPRESS	4	
MUNCHEN	4	
NORDWELLE		2
OLDENDORF	3	
POLAR ECUADOR		2
POLARLIGHT	3	
RHEIN EXPRESS	3	1
SLOMAN SENIOR	2	
SUSANNE FRITZEN	1	
SUSANNE REITH	1	
TILLY RUSS	4	
TRANSAMERICA	4	15
TRANSCANADA	1	
URSULA SCHULTE	3	
WALTER HERVIG	8	
WESER	1	
GREAT BRITAIN		
ALBRIGHT EXPLORER	1	
ALBRIGHT PIONEER	2	

	ICE	SST
ASIA LINER	1	
ATLANTIC CAUSEWAY	2	
ATLANTIC CONVEYOR	2	2
AVONFIELD	1	
BAMBURGH CASTLE	1	
BEL-HUDSON	1	1
BISNES	1	
BOSTON YORK	1	
CAPE FRANKLIN	1	
CAPE HOWE	8	1
CAPE NELSON	1	
CP AMBASSADOR	3	
C.P. DISCOVERER	7	
C.P. EXPLORER	16	
C.P. TRADER	6	
C.P. VOYAGEUR	11	1
CHEVIOT	1	
CHILTERN PRINCE	1	
COUNTY CLARE	2	
DALHANNA	3	
DART AMERICA	7	2
DART ATLANTIC	1	
DROXFORD	2	
DUKESGARTH	1	
DUNKYLE	1	
EDENMORE		9
EXPLORER	2	
FINNISH WASA	1	4
FORTUNA	2	
GLENPARK	1	
HARFLEET	1	
HECTOR	1	
HELEN MILLER	1	
HILLA		11
IDA LUNDRIGAN	1	1
INISHOWEN HEAD	8	
KING ALFRED	1	
LA PAMPA	1	
LAURENTIAN FOREST	5	
LOTTINGE	1	
LUNDRIGAN	1	1
MANCHESTER CASCADE	1	
MANCHESTER CHALLENGE	2	
MANCHESTER CONCEPT	3	
MANCHESTER CONCORDE	7	1
MANCHESTER COURAGE	7	
MANCHESTER CRUSADE	4	
MANCHESTER QUEST	5	
MANCHESTER VIGOUR	6	

	ICE	SST
MANISTEE	1	
MONKSGARTH	1	
NEWFOUNDLAND	2	
QUEEN ELIZABETH II	2	
QUEENSGARTH	9	
RIO COBRE	1	1
ROSEWOOD	1	
ST. MARGARET	9	10
SALTNES		4
SANTONA	5	
SEASTAR	1	
SILVERDON	1	
SUSAN CONSTANT	1	3
SUSAN MILLER	1	
VANCOUVER TRADER	2	
WELSH HERALD	1	
CALL SIGN - GOOH	1	
GREECE		
ADELFLOTIS	2	
AEGIS FAITH	1	1
AGIOS NICOLAOS IV	1	
ARISTEIDES	1	
ASHBURN	1	
BUENA FORTUNA		1
CAPETAN KOSTIS	1	
ERATO	1	
ERON	1	
EURYGENES	1	
FEDERAL SEAWAY	1	
FILIA	1	
ICAROS	1	
ITHAKI ISLAND	1	
KOUTOURIARIS	1	
LCKOMEDIS	1	1
LEONIS HALCOWSSIS	1	1
MARYLISA	2	3
MICHALAKIS	1	1
MICHALISK	1	
PERICLES HALCOUSSIS	2	
REA		1
REGALSON	1	
ISRAEL		
ZIM HAIFA	1	
ITALY		
ADRIANA AUGUSTA	1	
ANNA BIBOLINI	1	

	ICE	SST
BENEDETTA F	1	
GOLFO DI PALERMO	2	
LENONARDO DA VINCI		14
MICHELANGELO		7
POLINNIA	1	
PORTORIA		2
VELA	1	
JAPAN		
JAPAN MAGNOLIA	3	
KANETOSHI MARU		2
TANSEI MARU		1
TOKEI MARU	1	
ZENKOREN MARU NO.2		1
LIBERIA		
AEGEAN SKY	4	
ARGO LEADER	1	
CALEDONIA	1	
CAPE PALMAS	2	
COSMOPOLITAN	1	
EASTERN GLORY	1	
ERMIS		1
GOLDEN JASSON	1	
GRISCHUNA		5
IIKONTAK	1	
MARATHONIAN	1	
MAREDALE	1	
MAST COURIER	3	
MELTEMI	3	1
MOZART	1	
NAVITRADER	1	1
NEW FRONTIERS	4	
NICOLAS MARIS	1	
OGDEN EXPORTER	1	4
OSWEGO PLANTER	1	
REGINA OLDENDORFF		2
SACHA		2
ST. ATHINA	1	
STOLT ATLANTIC		2
STOLT NORNESS		2
THARROS	1	
TRENTWOOD	2	1
VOLTA PEACE	1	
NETHERLANDS		
ADRIATIC	1	
HNLMS ISAACS WEERS		1
HNLMS TIJGER HAAI		1
MEERDRECHT	2	
MOORDRECHT	5	

	ICE	SST
POLEDYK	1	
SCHOUWEN	1	1
SOLENDREAT	1	
TUBAL	2	
NORWAY		
ANINA	1	1
BELLAMI	1	1
CLARO	2	
DAGRUN	1	1
DYVI OCEANIC	1	
DYVI PACIFIC	2	
EK	4	
FERNFIELD	2	
FOLDENFJORD	1	
FOSSUM	1	
GAUSDAL		2
HAPPY DRAGON		2
HARDANGER	2	
HAVJARL	1	
LEIKVIN	1	
RANENFJORD	1	6
RUDOLF OLSEN	1	
SAGAFJORD	3	2
TANABATA		1
TOPDALSFJORD	1	
VISTAFJORD	1	
WESTBULK	1	
WILFRED	1	
PANAMA		
ASIA FIDELITY	1	
AURALIS	2	2
ESSO SCRANTON	4	
MARDINA COOLER	1	
SEE GERMANY	3	
SPAIN		
CASTILLO MANZANARES	1	
LUCHANA	1	1
RIVADEMAR	2	
SWEDEN		
ARVIDSJAUR	3	
ATLANTIC SONG	1	
ATLANTIC SPAN	12	57
ATLANTIDE	7	
FINLAND	1	
GRIPSHOLM	1	
MONTMORENCY	2	
SCANDIC WASA	1	18

UNITED STATES OF AMERICA	ICE	SST
AMERICAN ALLIANCE		1
AMERICAN COURIER	1	
AMERICAN LEADER	1	
EXPORT FREEDOM	1	
LIGHTNING	2	
SEA-LAND McLEAN	1	
TEXAS SUN	1	
U.S. COAST GUARD		
USCGC BIBB	18	
USCGC BOUTWELL	9	7
USCGC CHASE	6	
USCGC CHAUTAUQUA	7	3
USCGC DEPENDABLE	3	1
USCGC DUANE	32	
USCGC EDISTO	1	
USCGC ESCANABA	6	
USCGC EVERGREEN	33	
USCGC HAMILTON	18	2
USCGC INGHAM	1	
USCGC MORGENTHAU	10	
USCGC MUNRO	4	
USCGC OWASCO	22	7
USCGC PONTCHARTRAIN	6	5
USCGC RED BEECH	1	1
USCGC SHERMAN	13	13
USCGC SOUTHWIND	2	1
USCGC SPENCER	2	1
USCGC TANEY	1	1
U.S. NAVY		
USS INTREPID	1	
USNS MAUMEE	1	
USNS MIRFAK	1	
USNS PVT. JOHN R. TOWLE	4	
USNS SCHULKILL	2	1

YUGOSLAVIA	ICE	SST
BANIJA	2	11
BOSANKA	1	8
IVO VOJNOVIC	1	14
KOPER	4	5
KRAS	2	
KRPAN	1	
PIRAN	3	6
SISAK	1	

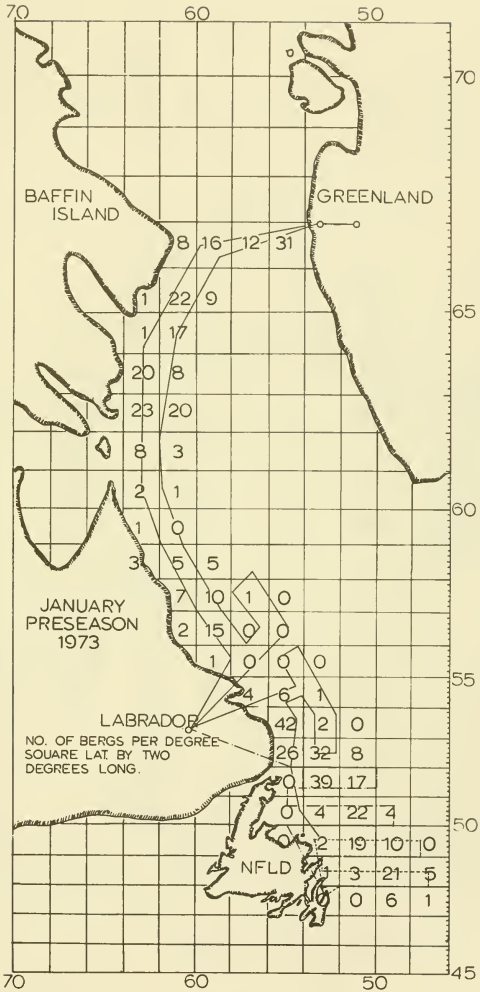


Figure 1.—Pre-season Iceberg Survey 9–19 January 1973.

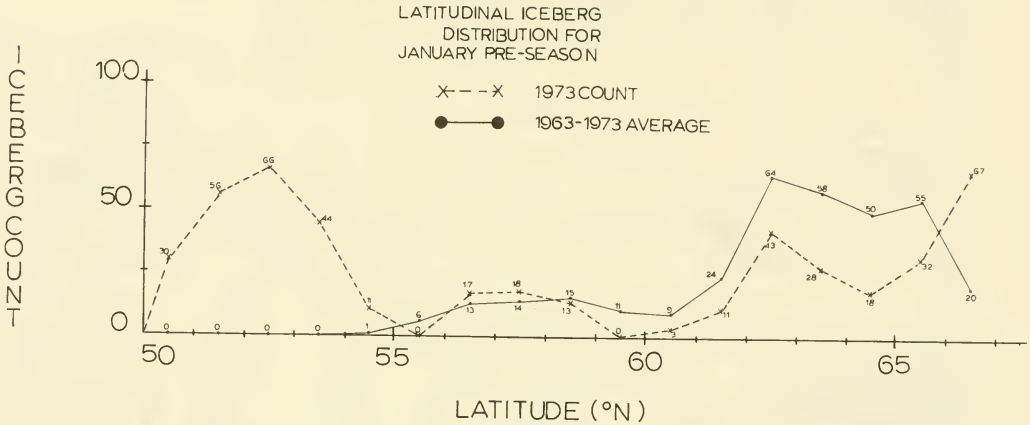


FIGURE 2.—Latitudinal Iceberg Distribution, January Preseason Flights.

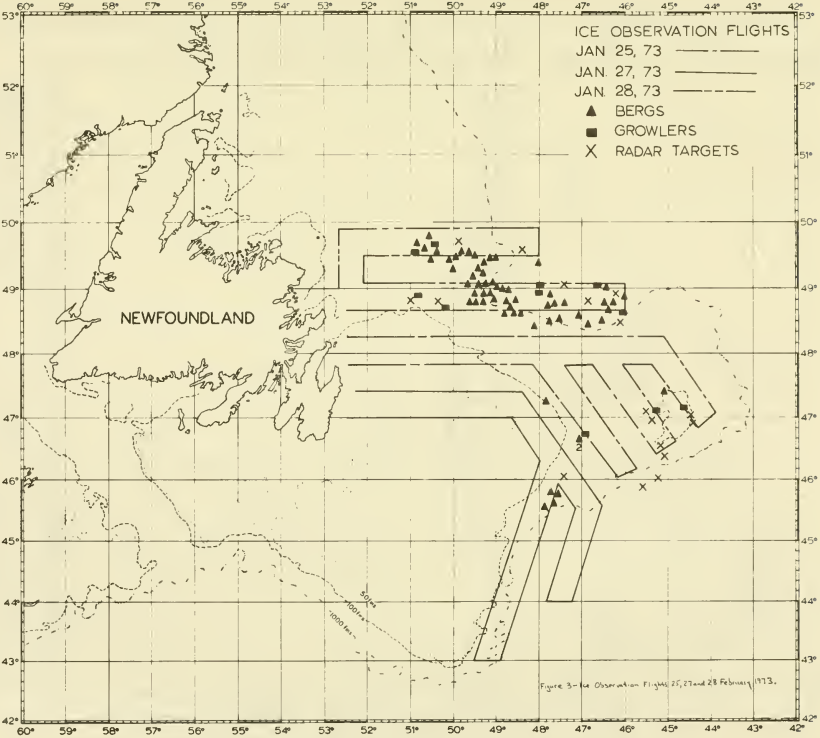


FIGURE 3.—Ice Observation Flights 25, 27, and 28 February 1973.

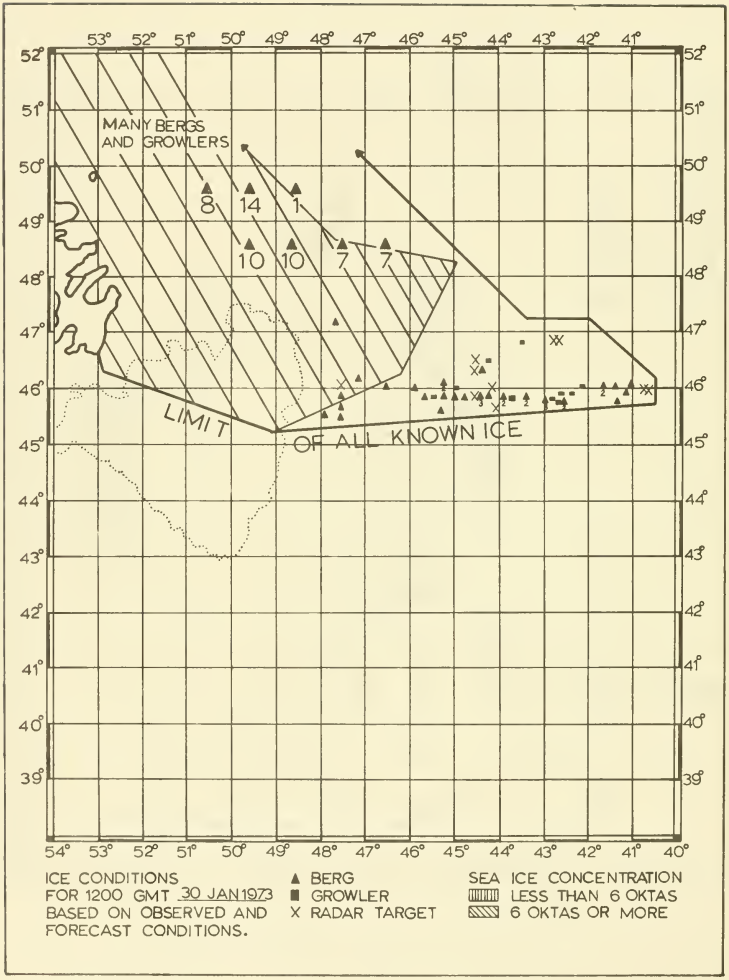


Figure 4.—Ice Conditions, 1200 GMT 30 January 1973.

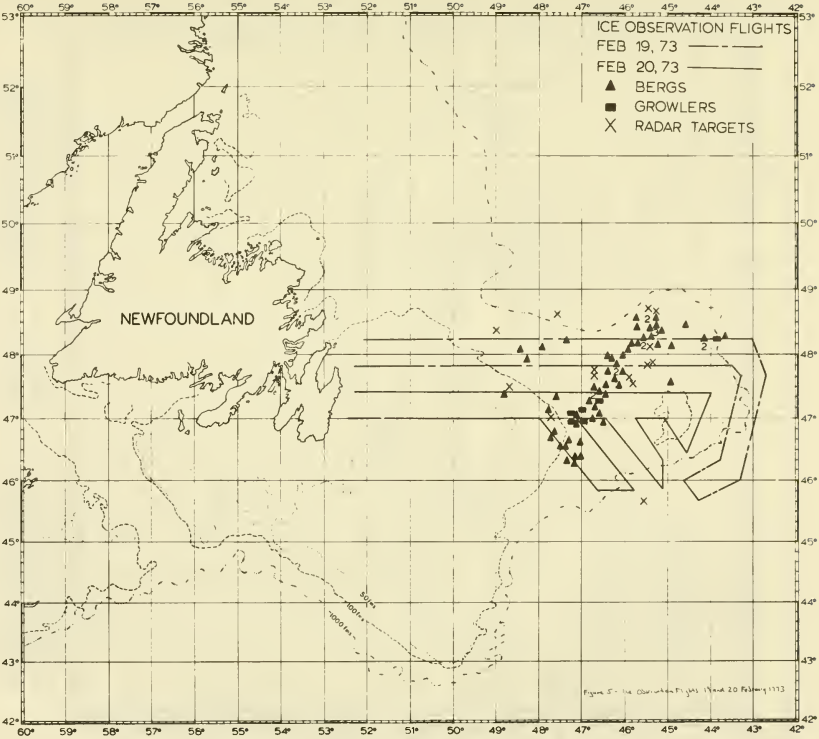


FIGURE 5.—Ice Observation Flights 19 and 20 February 1973.

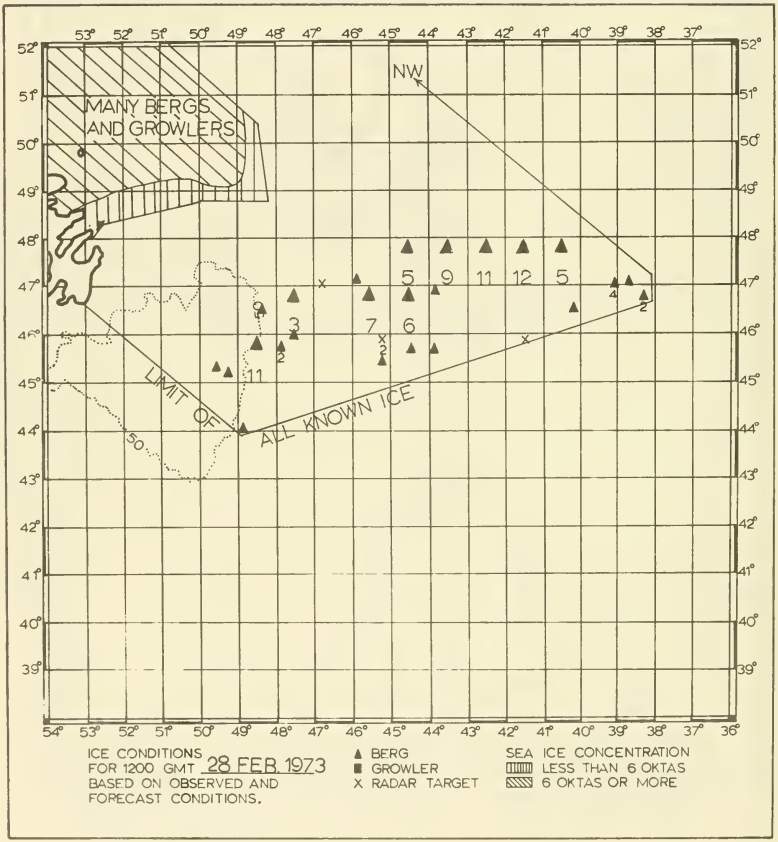


Figure 6.—Ice Conditions, 1200 GMT 28 February 1973.

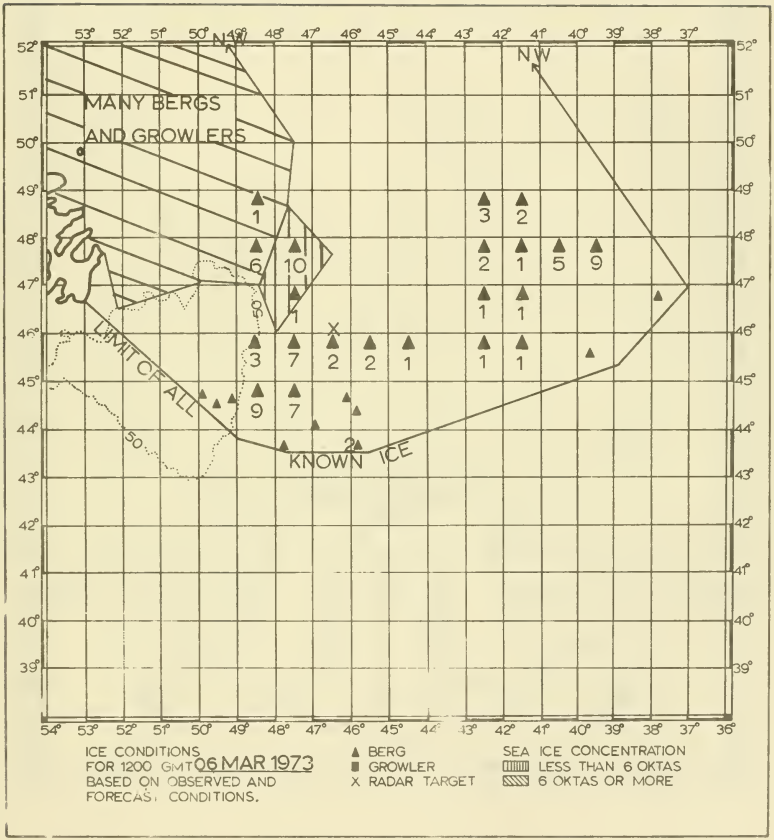


Figure 7.—Ice Conditions, 1200 GMT 6 March 1973.

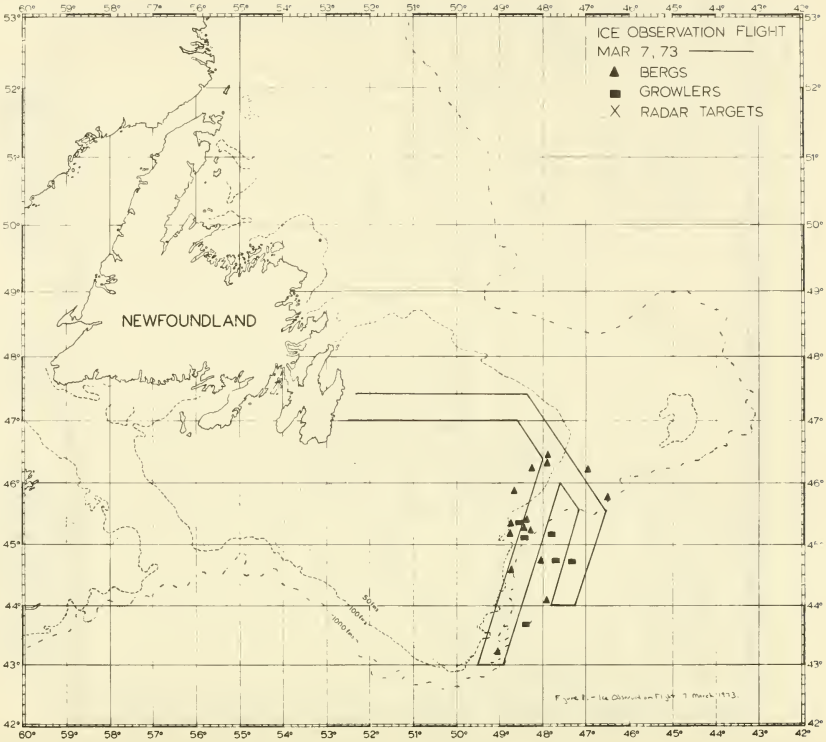


FIGURE 8.—Ice Observation Flight 7 March 1973.

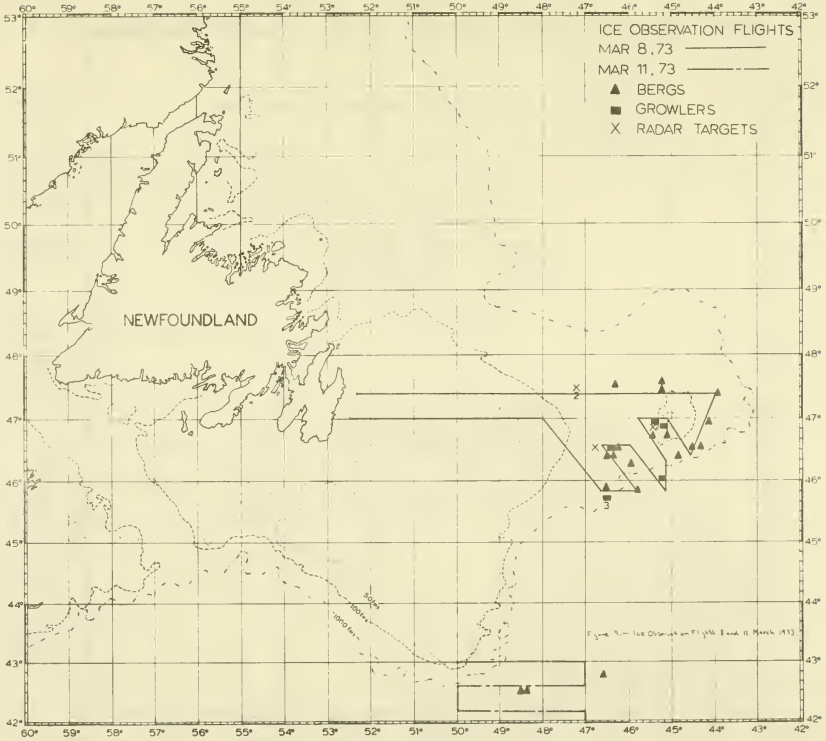


FIGURE 9.—Ice Observation Flights 8 and 11 March 1973.

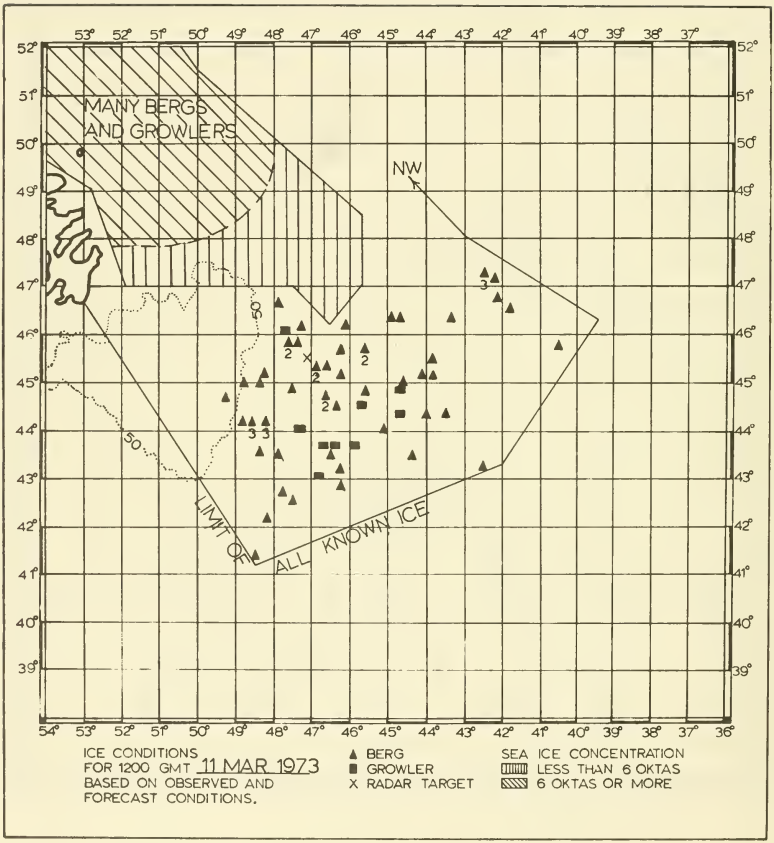


FIGURE 10.—Ice Conditions, 1200 GMT 11 March 1973.

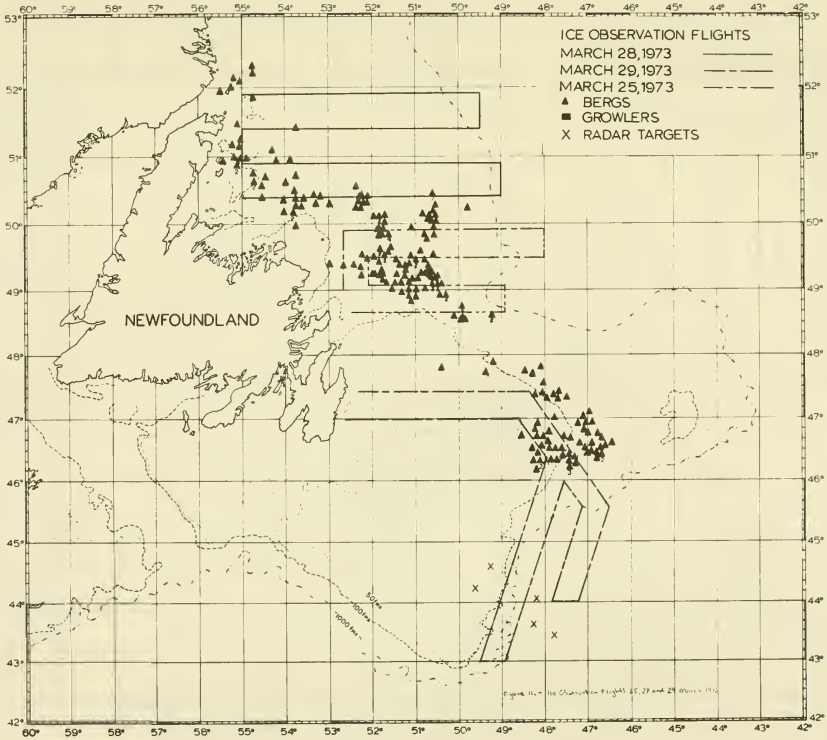


FIGURE 11.—Ice Observation Flights 25, 28, and 29 March 1973.

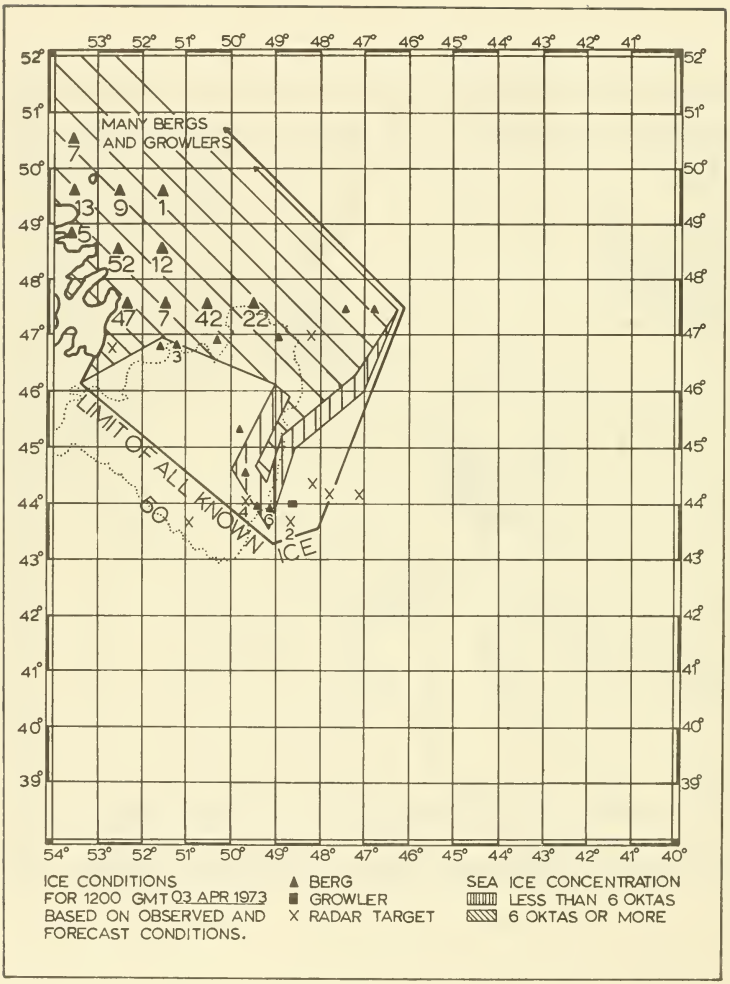


FIGURE 12.—Ice Conditions, 1200 GMT 3 April 1973.

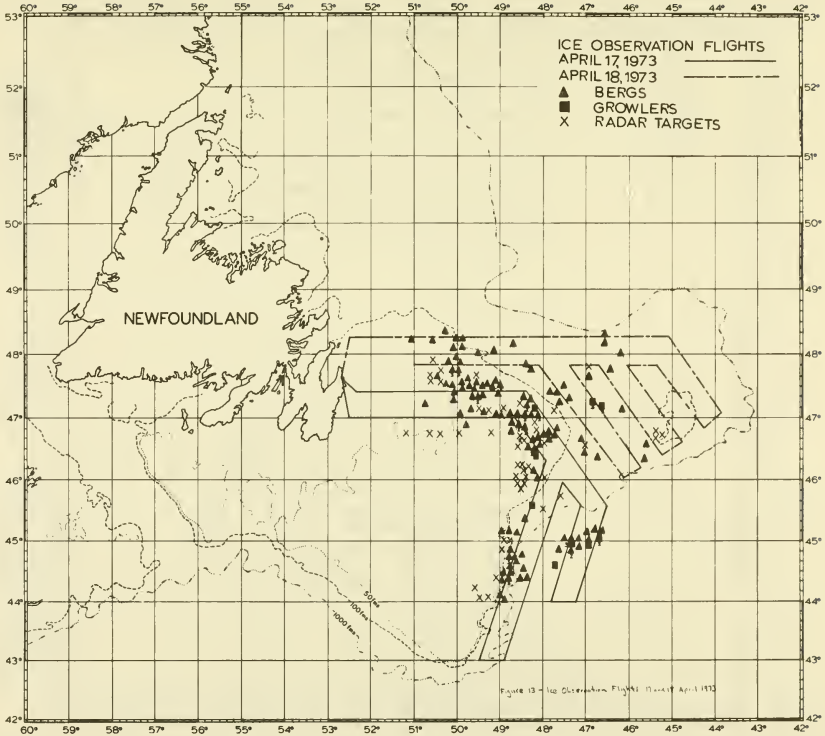


FIGURE 13.—Ice Observation Flights 17 and 18 April 1973.

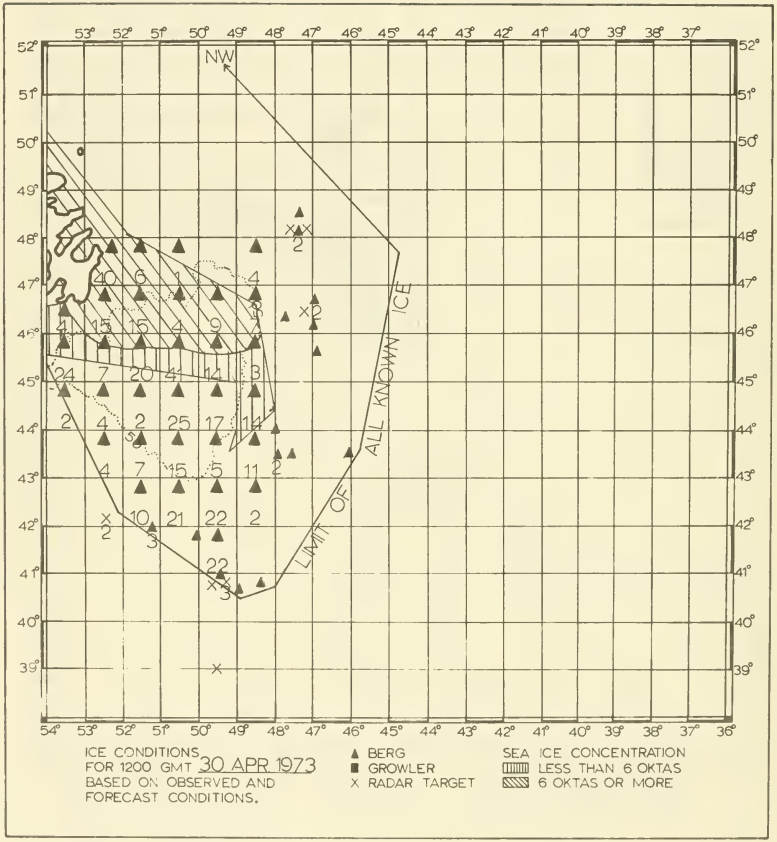


Figure 14.—Ice Conditions, 1200 GMT 30 April 1973.

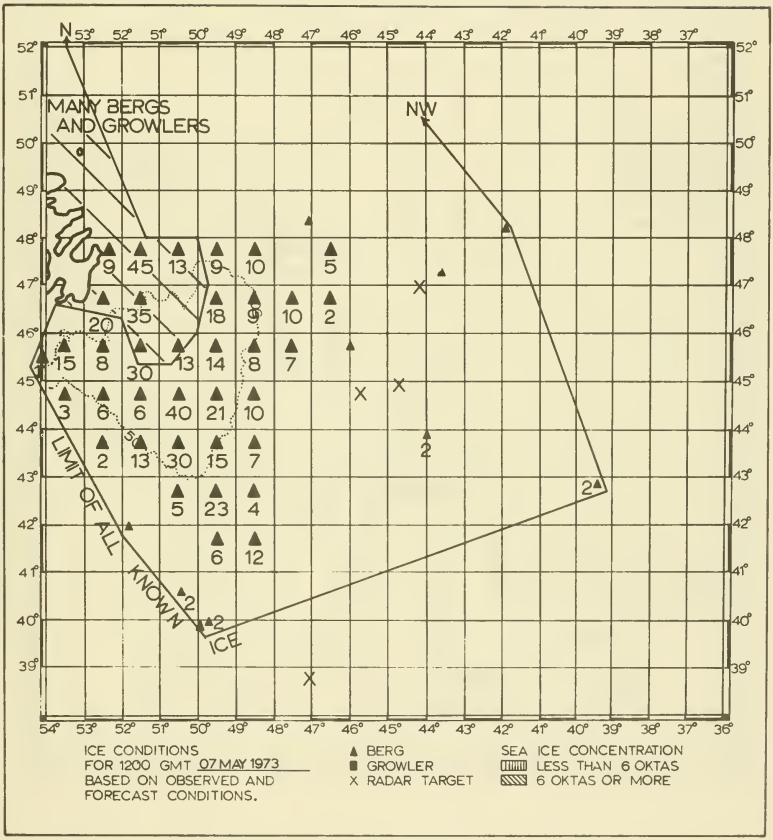


Figure 15.—Ice Conditions, 1200 GMT 7 May 1973.

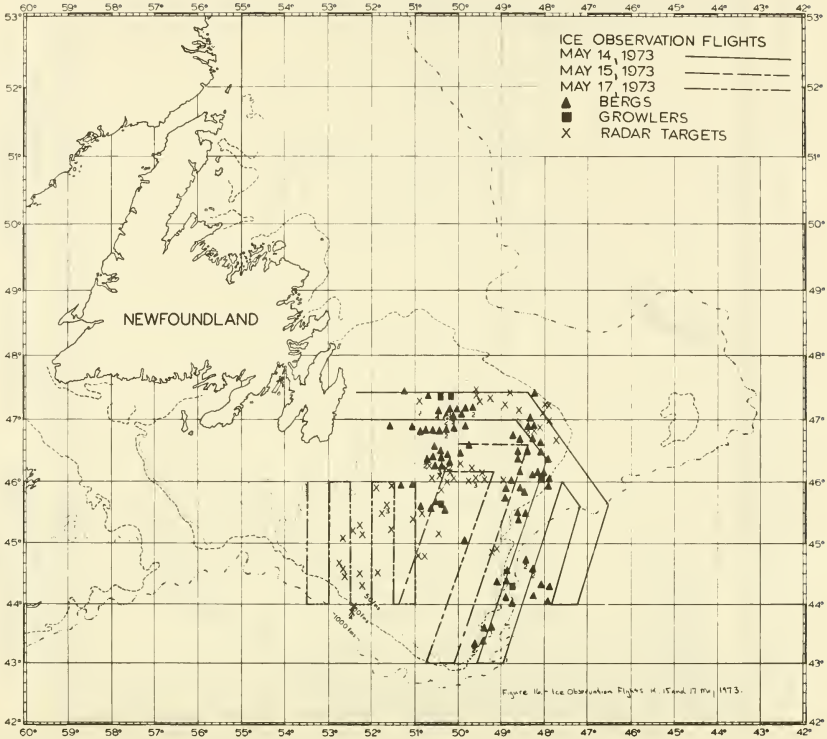


FIGURE 16.—Ice Observation Flights 14, 15 and 17 May 1973.

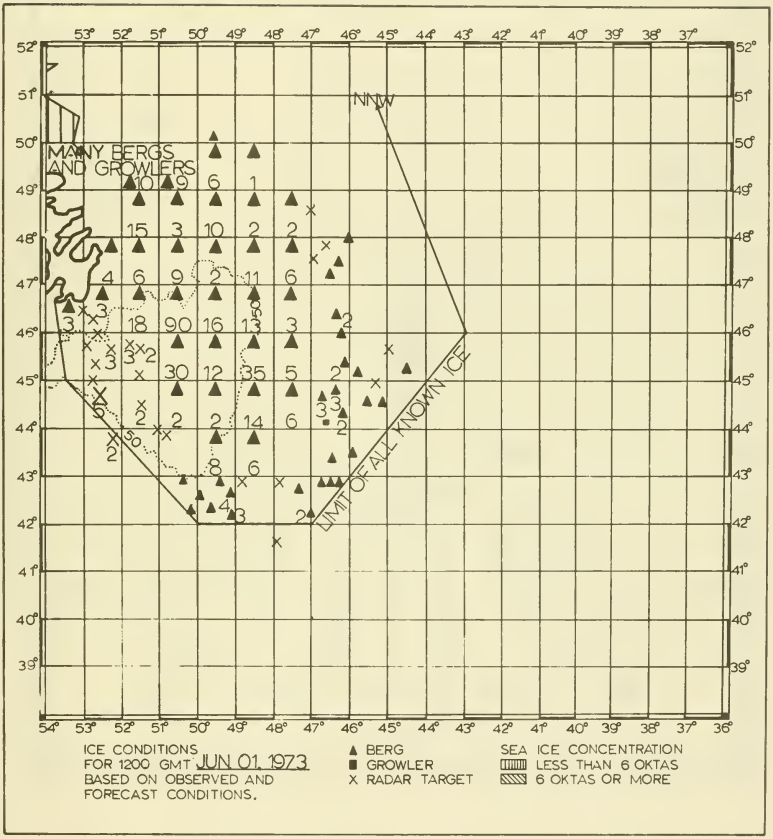


Figure 17.—Ice Conditions, 1200 GMT 1 June 1973.

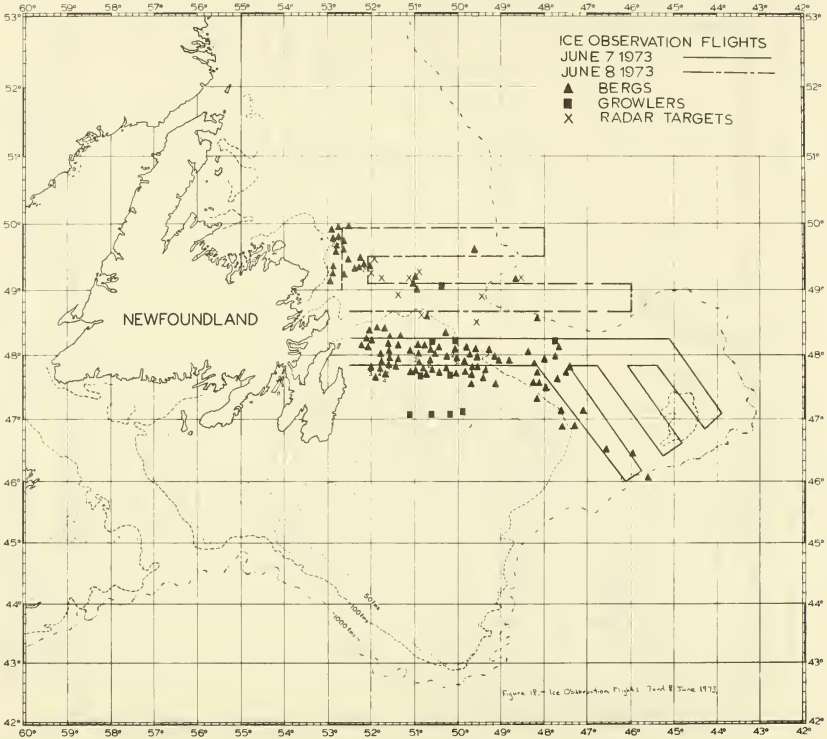


FIGURE 18.—Ice Observation Flights 7 and 8 June 1973.

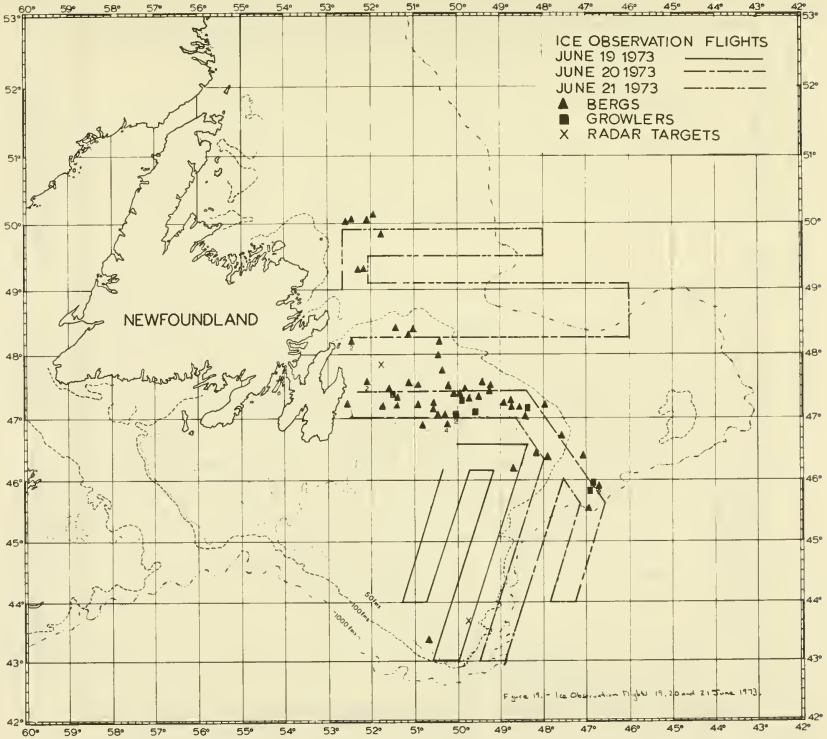


FIGURE 19.—Ice Observation Flights 19, 20, and 21 June 1973.

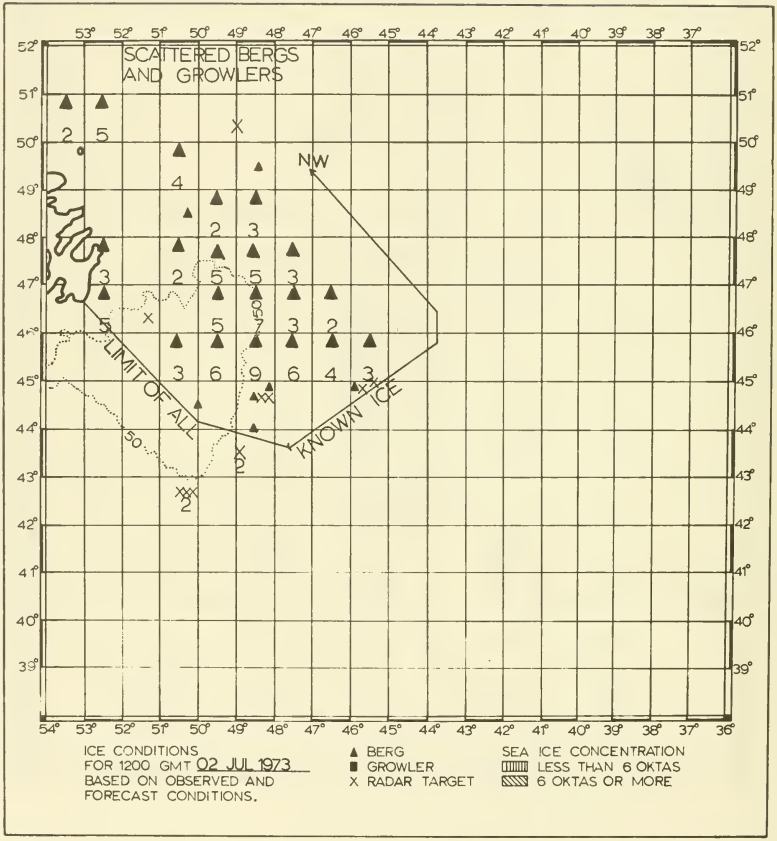


FIGURE 20.—Ice Conditions, 1200 GMT 2 July 1973.

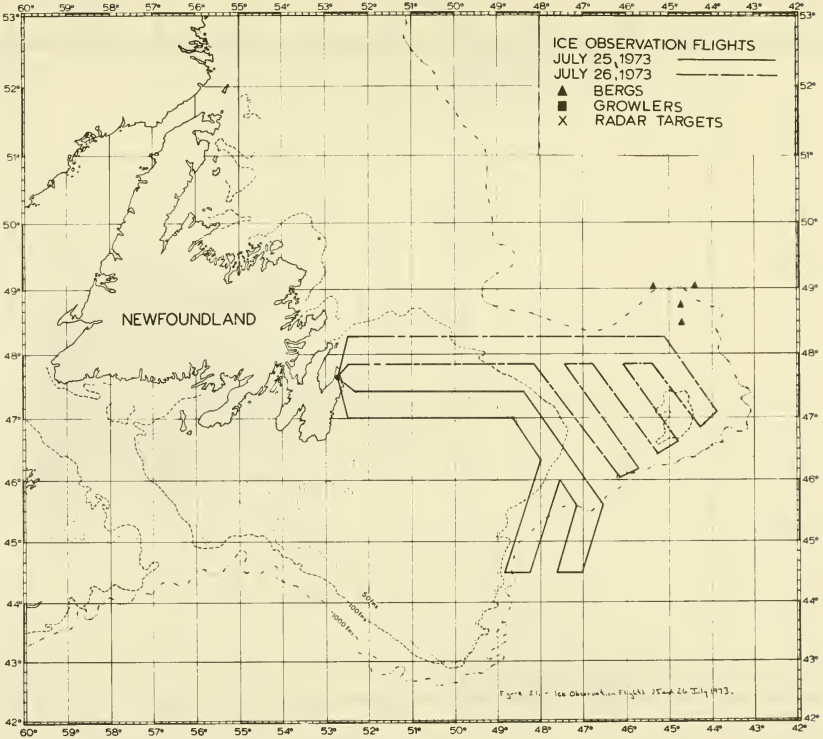


FIGURE 21.—Ice Observation Flights 25 and 26 July 1973.

FIGURE 22.—Dynamic Topography of the Sea Surface with reference to the 1000 Decibar Level. First Cruise, April 1973.

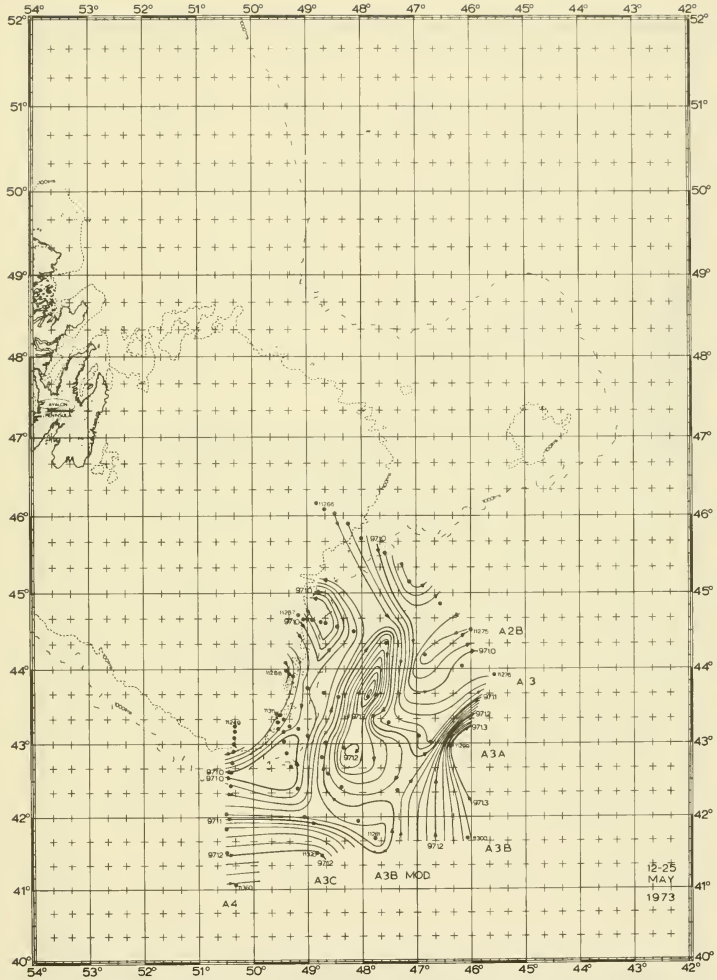


FIGURE 23.—Dynamic Topography of the Sea Surface with reference to the 1000 Decibar Level. Second Cruise, May 1973.

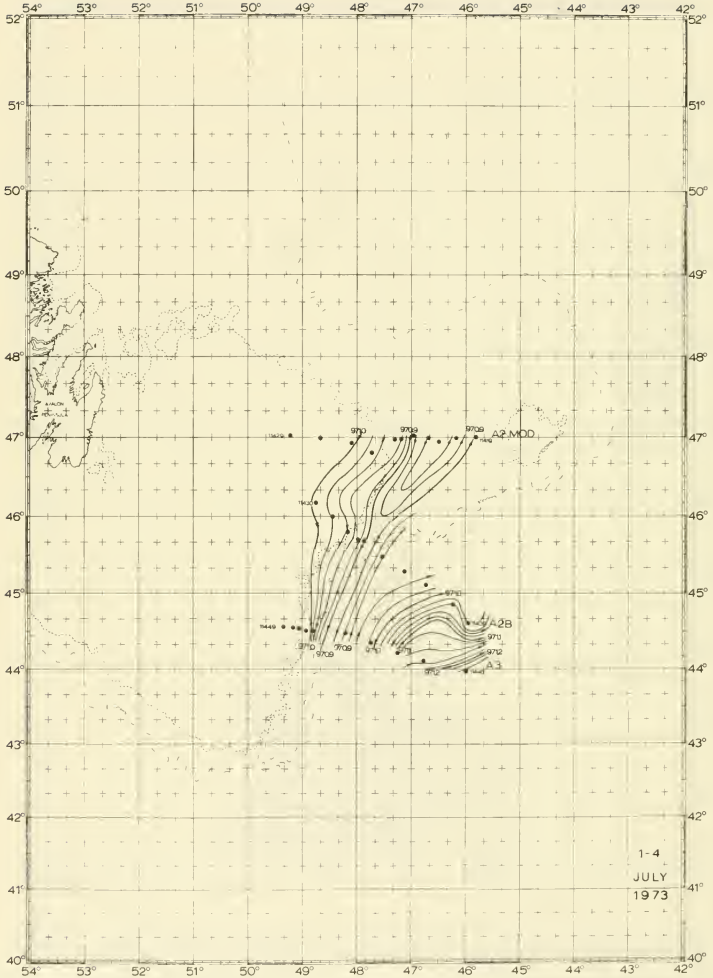


FIGURE 24.—Dynamic Topography of the Sea Surface with reference to the 1000 Decibar Level. Third Cruise, July 1973.

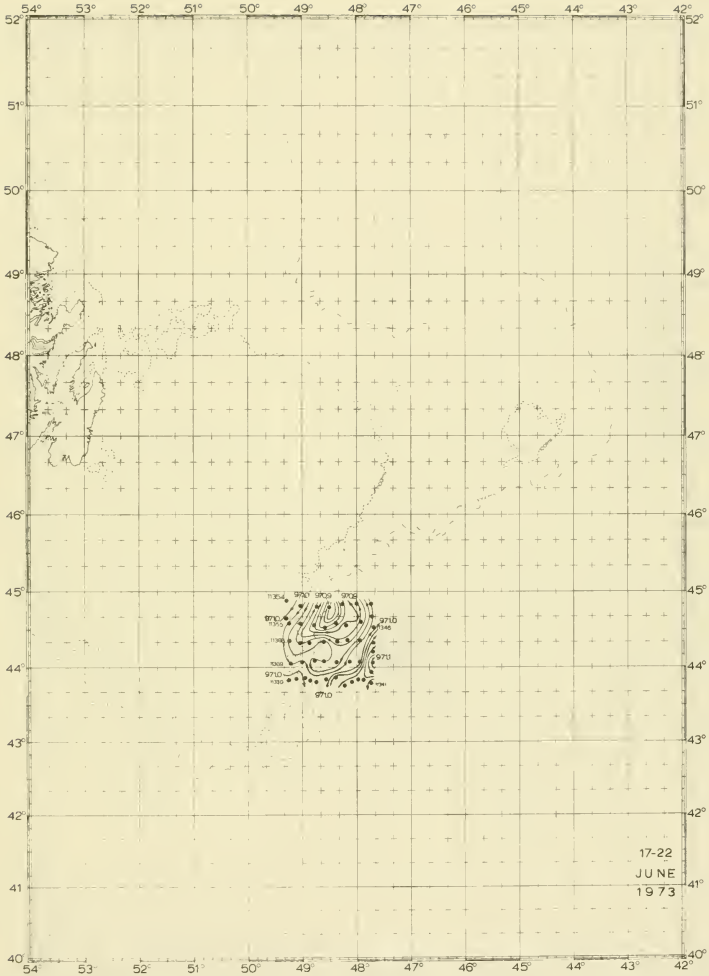


FIGURE 25.—Dynamic Topography of the Sea Surface with reference to the 1000 Decibar Level. First Special Survey, 17–22 June 1973.

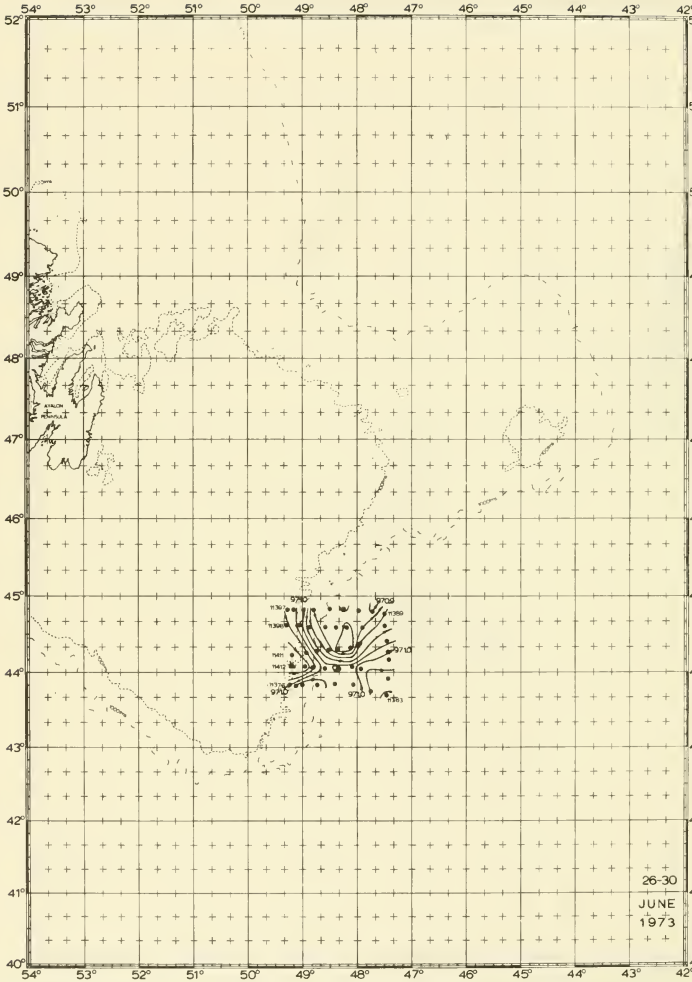


FIGURE 26.—Dynamic Topography of the Sea Surface with reference to the 1000 Decibar Level. Second Special Survey 26–30 June 1973.

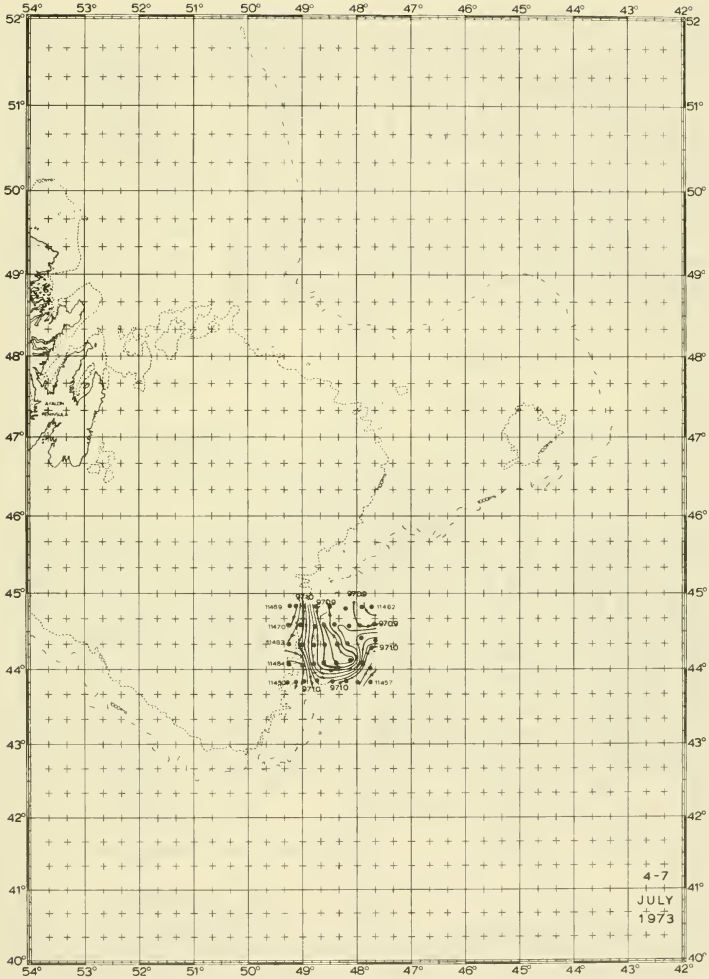


Figure 27.—Dynamic Topography of the Sea Surface with reference to the 1000 Decibar Level. Third Special Survey, 4–7 July 1973.

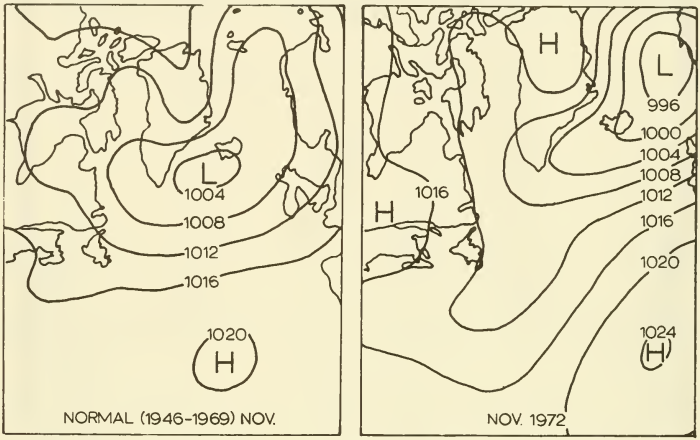


FIGURE 28a.—November Normal and 1972 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

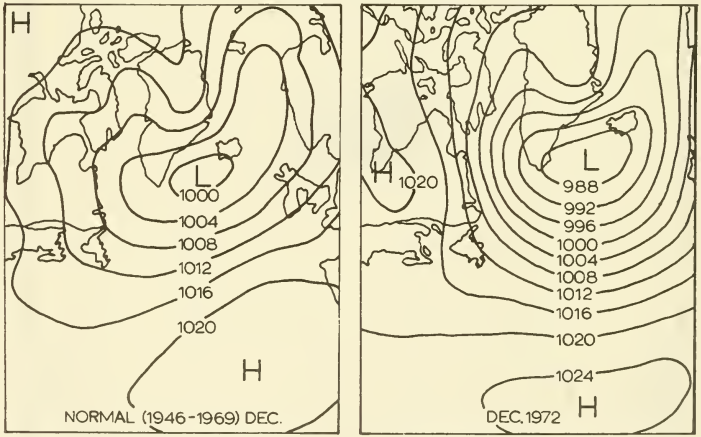


FIGURE 28b.—December Normal and 1972 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

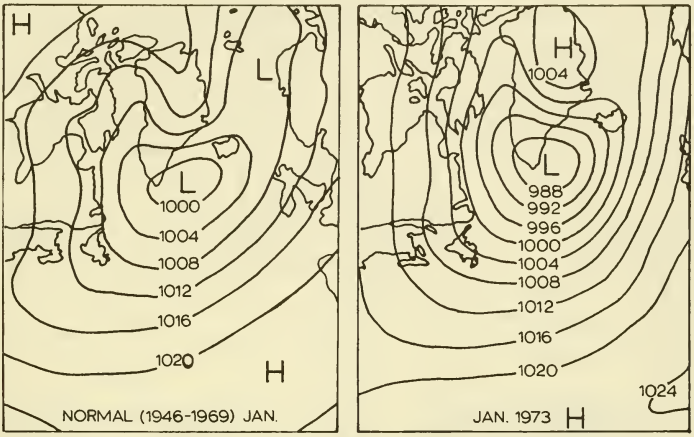


FIGURE 28c.—January Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

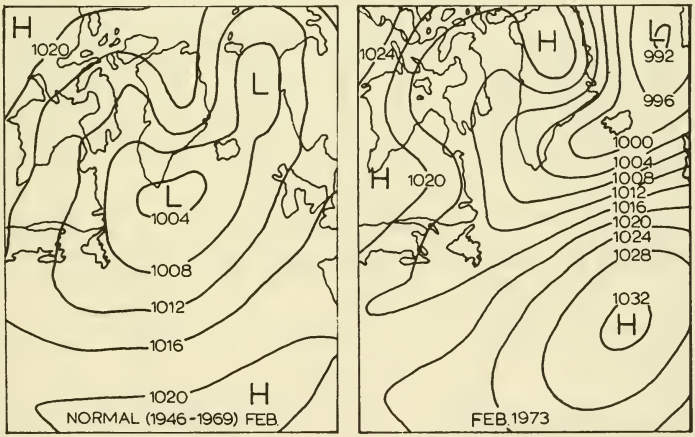


FIGURE 28d.—February Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

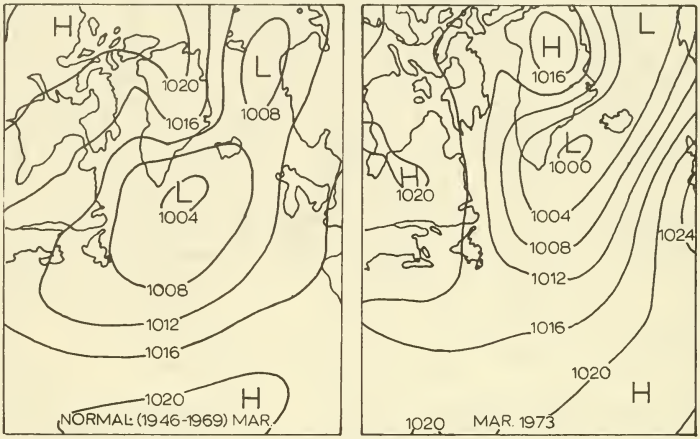


FIGURE 28e.—March Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

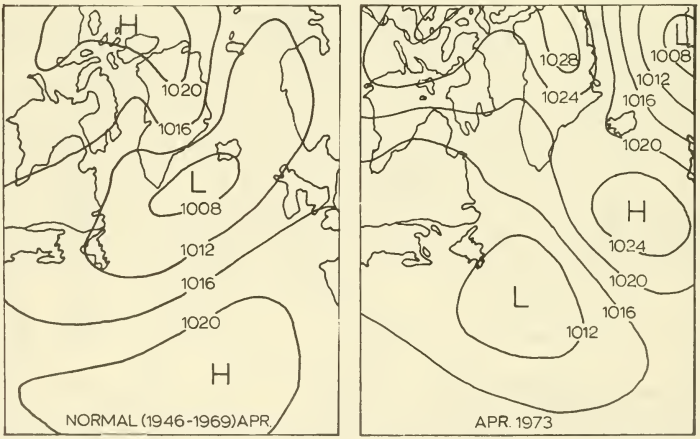
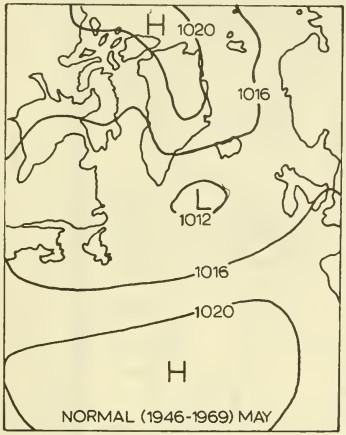


FIGURE 28f.—April Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.



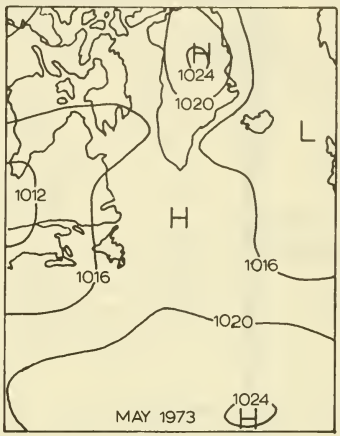
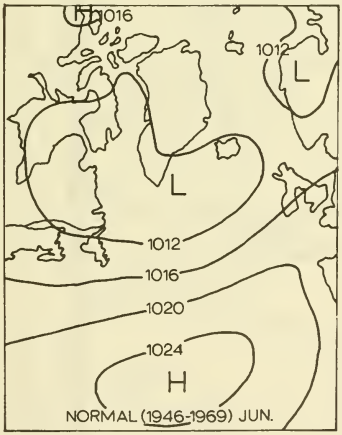


FIGURE 28g.—May Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.



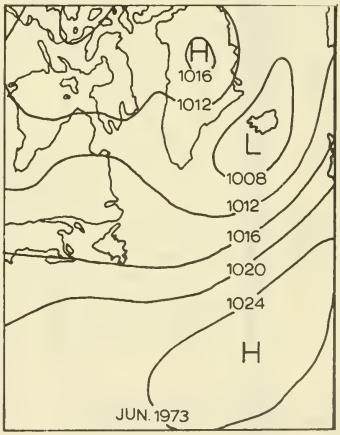


FIGURE 28h.—June Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

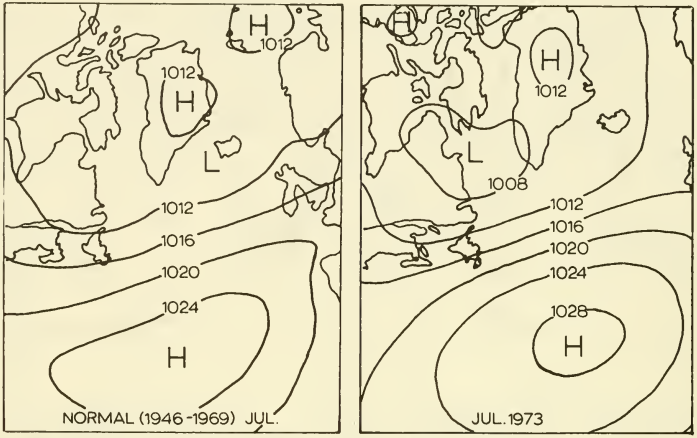


FIGURE 28i.—July Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

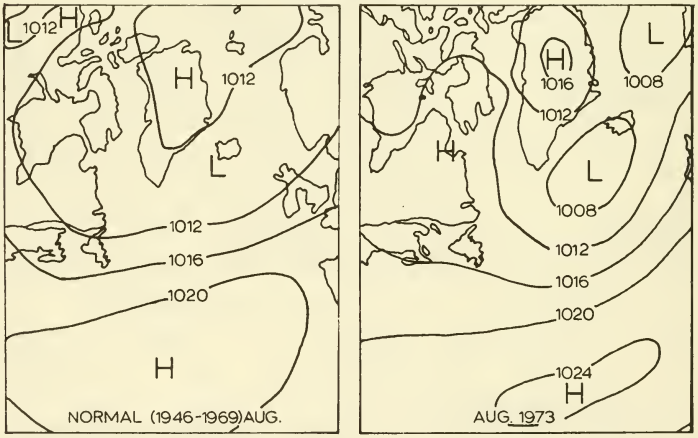


FIGURE 28j.—August Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

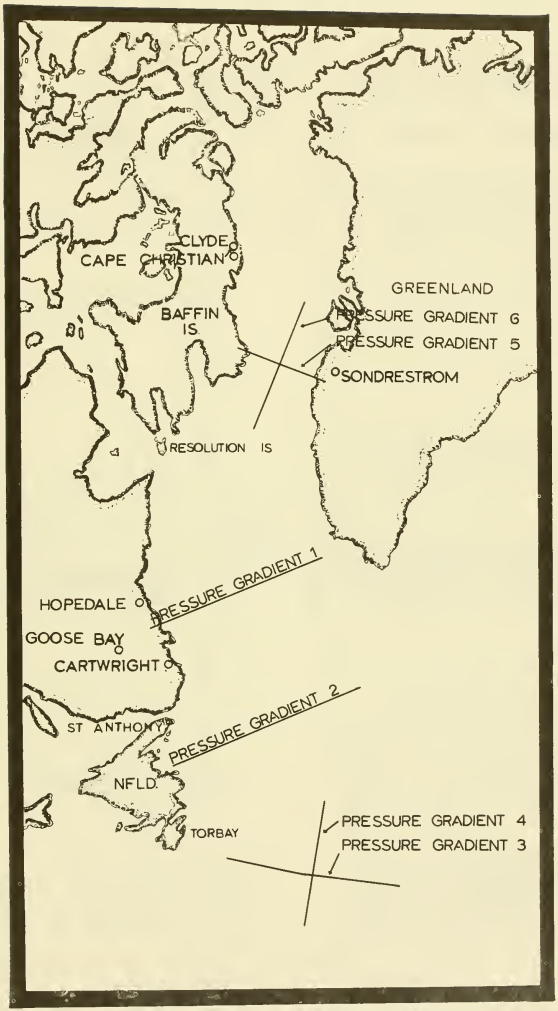


FIGURE 29.—Pressure Gradients Monitored by International Ice Patrol.

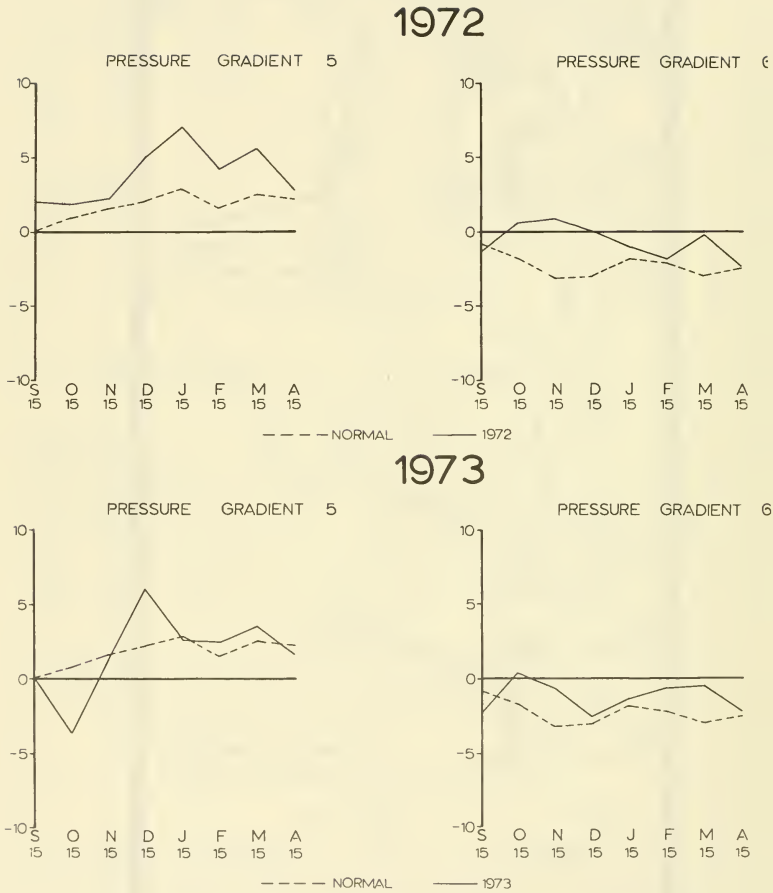


FIGURE 30.—Pressure Gradients 5 and 6.

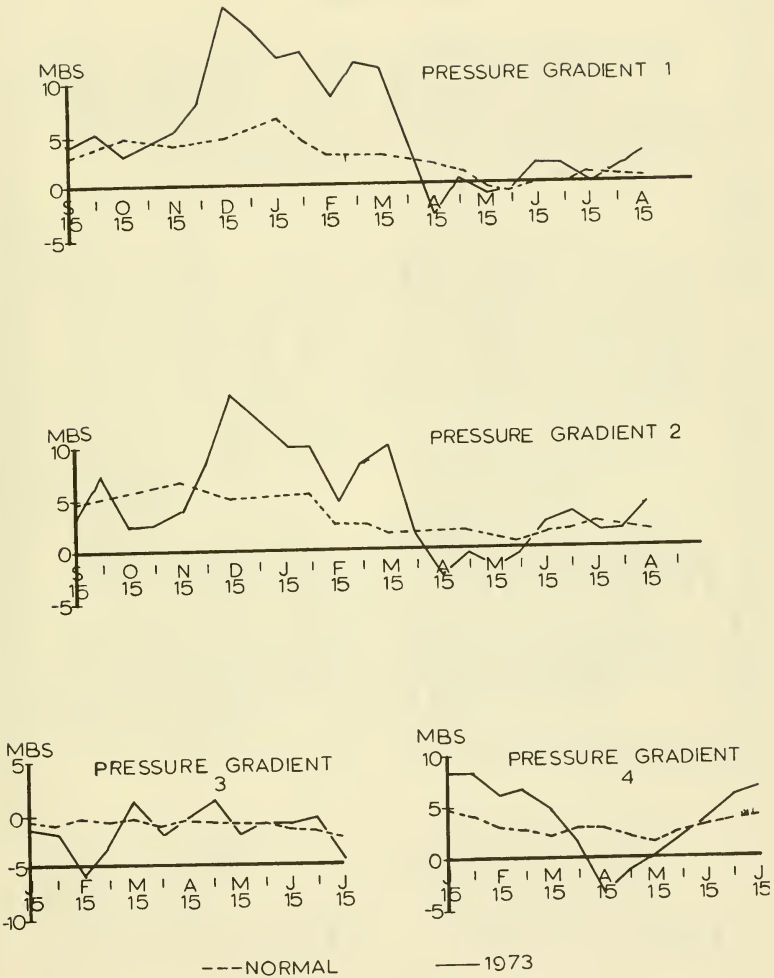


FIGURE 31.—Pressure Gradients 1–4.

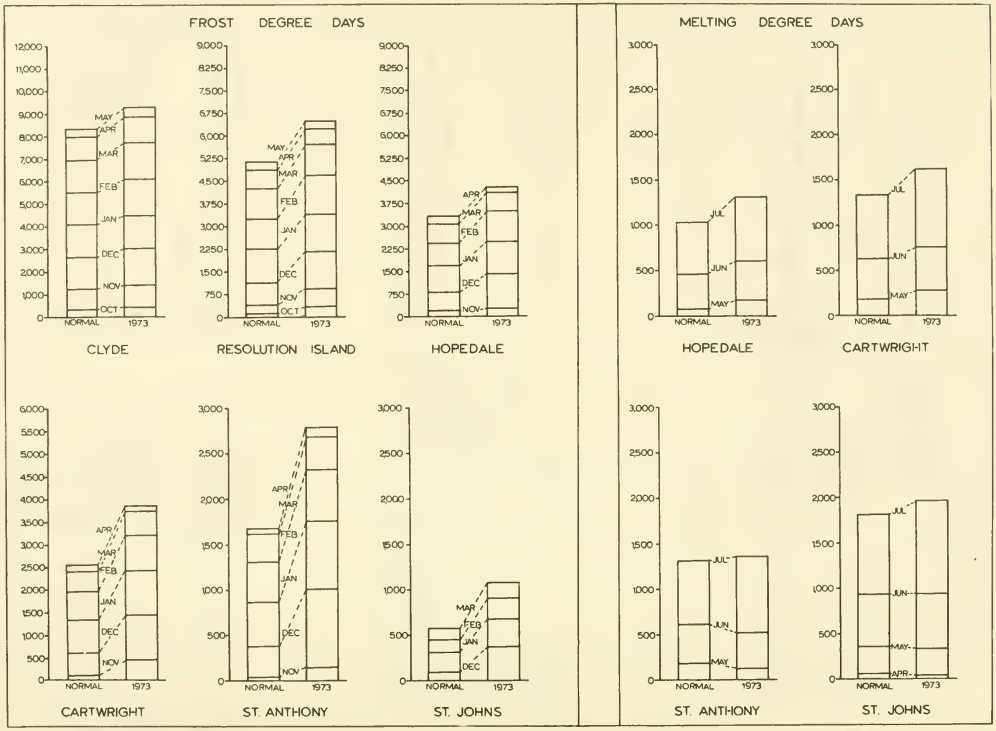


FIGURE 32.—Frost Degree Day and Melt Degree Day Accumulations Calculated from Monthly Mean Fahrenheit Air Temperatures.

APPENDIX A
ICEBERG CASUALTIES

Over 61 years have elapsed since the tragic sinking of the RMS TITANIC, the international clamor from which brought about the International Ice Patrol. In conducting an extensive literature search for other iceberg related casualties, letters, newspaper accounts and the files of Lloyds have been reviewed. These results are tabulated on the following pages to present the reader an awesome display of the death and destruction brought upon mankind by one of natures formidable creations.... the iceberg.

Neither the 19 incidents in the hundred years before nor the 37 incidents in the 61 years after the TITANIC are meant to be all inclusive. There have been undoubtedly many instances of "brushing" against icebergs with damage so minor as to not require reporting as well as occasions of iceberg damage that were never reported. There are also ships which have left port on trans-Atlantic voyages and been claimed by the ocean without report. Some of these are undoubtedly attributable to icebergs. Readers with information on iceberg casualties not included on this list or amplifying data on the categories labeled as unknown are invited to send them to Commander, International Ice Patrol, Building 110, U.S. Coast Guard Support Center, Governors Island, NY 10004.

Because of the above, a reasonable statistical analysis of the data is not possible. It is interesting to note, however, that in over half the reported incidents the ships either sank or were abandoned. What is important, is the fact that not one reported iceberg casuality has occurred in the vicinity of the Grand Banks of Newfoundland outside the eastern, south-eastern and southern limits of all known ice as published by the International Ice Patrol. In the column "GRAND BANKS AREA?" a YES indicates the casualty occurred within the limits of all known ice; a NO indicates that the casualty occurred in a different geographical location.

TABLE OF ICE INCIDENTS

DATE	POSITION	GRAND BANKS AREA?	DESCRIPTION OF INCIDENT	LIVES LOST/ INJURIES	DAMAGE
1818-1838	UNK	UNK	Packet WILLIAM BROWN hit iceberg, 16 survivors were thrown from lifeboat	UNK	Ship sank.
January 29, 1856	UNK	UNK	Wood Paddle Steam Ship PACIFIC hit iceberg	186 lives lost	Ship sank.
January 30, 1856	5 days out of Liverpool	YES	Iron Paddle Steam Ship PERSIA hit iceberg at 11 knots.	UNK	16ft of bow flatten.
February,1856	UNK	YES	Iron Paddle Steam Ship PERSIA hit growler and sea ice	UNK	Tore away paddle wheel legs and sponson.
January 29 or 30, 1870	Left Halifax January 28	YES	SS CITY OF BOSTON hit iceberg	177 lives lost	Ship Sank.
January 1880	Grand Banks	YES	SS ARIZONA hit iceberg	None	Minor Damage.
June 2, 1882	20 miles south of Cape Race	YES	SS ASHDRUBAL hit iceberg	UNK	Ship Sank.
January 2, 1884	46-00N 46-20W	YES	SS NOTTING HILL hit iceberg	None	Ship Abanoned.
May 7, 1885	Grand Banks	YES	SS ANNIE CHISTINE hit iceberg	UNK	Ship Sank.
July 18, 1893	Grand Banks	YES	Wood Barque MARTHA hit iceberg	UNK	Ship Condemned.
April 25, 1894	North Atlantic	YES	Wood Barque RUTH PALMER hit iceberg	UNK	Ship Sank.
May 18, 1896	Off Cape Race	YES	Wood Barque ALICE M. CLARIDGE hit iceberg	UNK	Ship Sank.
1896	160 miles off Cape Race	YES	Wood Barque VALBORG	UNK	Ship Abanoned.
August 19, 1896	North Atlantic	YES	SS MOLDAVA hit iceberg	UNK	Ship Sank.
April 17, 1905	Grand Banks	YES	Wood Schooner SAINT GEORGES hit iceberg	UNK	UNK
April 24, 1906	North Atlantic	YES	SS ANGELO PERUVIAN hit iceberg	UNK	Ship Sank.
July 26, 1906	Strait of Belle Isle	NO	Wood Schooner STELLA B. WOOD hit iceberg	UNK	Ship Sank.
1908	North Atlantic	YES	Wood Barque COLOMBA LOFARD hit iceberg	UNK	Ship Condemned.

DATE	POSITION	GRAND BANKS AREA?	DESCRIPTION OF INCIDENT	LIVES LOST/ INJURIES	DAMAGE
April 11, 1912	10mi from TITANIC sinking	YES	SS NIAGARA (saw 500 foot iceberg)	UNK	Holed by iceberg.
April 14, 1912	4146N 5014W	YES	RMS TITANIC hit iceberg	1513 lives lost	Ship Sank.
1913	Grand Banks	YES	SS MOUNT TEMPLE hit iceberg	UNK	UNK
May 1914	East of Cape Race	YES	SS ROYAL EDWARD hit iceberg	None	Extensive damage to bow.
May 29, 1914	4529N 4820W	YES	Wood Schooner GOLFINHO hit iceberg	UNK	Ship Sank.
May 25, 1919	4713N 5122W	YES	SS CASSANDRA hit iceberg	None	Forward Compartments flooded.
January 28, 1922	Voyage Liverpool to Newscastle N.S.W. Australia	UNK	SS GARTHFORCE hit iceberg	UNK	Damaged sold as hulk.
April 24, 1923	4857N 4755W	YES	SS LE RAYMOUND hit iceberg	None	Ship Sank.
April 25, 1923	4615N 4405W	YES	SS ET BRETAGNE hit iceberg	None	Ship Sank.
June 23, 1925	Tail of the Grand Banks	YES	SS SAUGUS hit iceberg	None	Ship Sank.
May 1928	Northern Grand Banks	YES	SS MONTROSE hit iceberg	2 lives lost	Extensive damage to forecastle.
July 20, 1929	Tail of the Grand Banks	YES	SS VIMEIRA hit iceberg	None	Extensive damage to bow plates and propeller.
May 17, 1933	Off Cape St. Francis	YES	SS SEIRSTAD hit iceberg	UNK	Ship Sank.
October 11, 1933	Labrador Sea	NO	Wood Schooner MAIA hit iceberg	UNK	Caught Fire and Sank.
April 11, 1935	Labrador Sea	NO	Wood Schooner SAINT COULOMB hit iceberg	UNK	Ship Sank.
October 1, 1935	Hudson Strait	NO	SS BRIGHT FAN hit iceberg	UNK	Ship Sank.
July 17, 1937	Strait of Belle Isle	NO	SS CAIRNGLEN hit iceberg	None	Minor Damage.
June 9, 1939	150 miles east of St. John's, Newfounded	YES	Wood Schooner BEN-HUR hit iceberg	UNK	Caught Fire and Abandoned.

DATE	POSITION	GRAND BANKS AREA?	DESCRIPTION OF INCIDENT	LIVES LOST/ INJURIES	DAMAGE
August 7, 1939	5158N 5418W	NO	SS BEAVERHILL hit iceberg	None	Minor Damage.
January 9, 1940	Denmark Strait	NO	SS BAHIA BLANCA hit iceberg	UNK	Ship Sank two days later.
March 19, 1943	5805N 4415W	NO	SS SVEND FOYN hit iceberg	UNK	Ship Sank two days later.
June 14, 1944	Davis Strait	NO	F/V MARIA PRECIOSA hit iceberg	UNK	Ship Sank.
May 29, 1945	4308N 4918W	YES	Convoy O.N. 303 encountered an iceberg in fog. 4 ships hit iceberg, 20 ships collided with each other.	None	Slight Damage.
June 24, 1946	Grand Banks	YES	F/V COMMANDANTE TEN REIRO hit iceberg	None	Ship Sank.
June 6, 1948	4800N 5220W	YES	M/V NEVADA hit iceberg	None	$35,000 damage.
September 1952	Davis Strait	NO	F/V RIO CAIMA hit iceberg	UNK	Ship Sank.
February 4, 1957	48 miles east of Cape Breton	NO	M/V PETIT hit iceberg	UNK	Ship Sank.
January 30, 1959	5930N 4300W	NO	M/V HANS HEDTOFT hit iceberg	95 lives lost	Ship Sank.
May 24, 1959	4700N 5230W	YES	M/V LYDIA MARIA hit 20'x 100' iceberg at 9 knots	None	Extensive dry-docking required.
May 1960	Off Newfoundland	YES	M/V QUEENSGARTH hit iceberg	None	Hold Flooded.
November 25, 1965	Off Kap Farvel, Greenland	NO	M/V BURGERMEISTER SMIDT hit iceberg	UNK	Ship Sank.
April 23, 1967	Off Newfoundland	YES	M/V BATORY hit iceberg	None	7ft hole 15 feet below water-line.
June 1968	Chance Harbor, Newfoundland	NO	Ice fell from iceberg onto small boat	1 life lost	Boat crushed.

DATE	POSITION	GRAND BANKS AREA?	DESCRIPTION OF INCIDENT	LIVES LOST/ INJURIES	DAMAGE
April 22, 1969	Near Greenland	NO	Unknown German M/V hit iceberg	None	Bow holed.
July 1970	Baffin Bay	NO	USCGC WESTWIND struck iceberg	None	Minor Damage.
April 23, 1971	5304N 5214W	NO	F/V SANTA ISABELL hit iceberg	None	UNK
August 12, 1972	40 miles east of Cape Bauld, Nfld.	YES	M/V RATTRY HEAD hit iceberg	None	Minor Damage.
February 3, 1973	Near Grand Banks 45°48'N 46°23'W	YES	M/V HAVJARL hit iceberg	None	Extensive Bow Damage.
May 7, 1973	Near Newfoundland coast	YES	M/V NAVI CHAMPION hit iceberg	None	Ruptured 4 meters in forepeak.

APPENDIX B

ICEBERG DRIFT FROM SURFACE CURRENTS

by Dr. J.P. Welsh, Jr. and LT S.M. Phillips, USCG
(U.S. Coast Guard Research and Defelopment Center)

Introduction

The operational requirements of the International Ice Patrol (IIP) are to locate icebergs that menance the North Atlantic shipping lanes off the Grand Banks of Newfoundland and to predict their movement. A computerized iceberg drift model has been developed to assist in the performance of these requirements. This model, developed from first principles and checked with observational iceberg drift data, will produce relatively precise positions when supplied with precise values of current, wind velocity, iceberg mass, drag coefficients, values for sail area, and immersed cross section area.

The objective of this iceberg drift study was to determine by field tests the usefulness of an expendable surface current probe for determination of iceberg drift as it applies to IIP needs. This recently developed air-deployable device measures surface current precisely, rapidly, and inexpensively.

The method of determining the surface current is illustrated in Figure 1. An expendable probe is launched, and on contacting the sea surface a surface marker (SM in Figure 1) separates and floats on the surface. This serves simply to mark the location of the measurement. The remainder of the probe is carried to the bottom by its weight and from its fixed location on the bottom, releases two floats (marked F1 and F2 in Figure 1) with a predetermined time delay between them. The floats return to the surface by their own buoyancy. At the surface these floats emit fluorescein dye to aid in visual location on the surface. The surface current and direction are obtained by the following relationships.

$$\text{Surface current} = \frac{\text{Separation of F1 and F2}}{\text{Time delay between float releases}}$$

$$\text{Surface current direction} = \text{direction from F2 to F1}$$

(Broida and Richardson, 1972)

It is also possible to determine volume transport per unit width if the depth of the water is known and the distance from SM to F1 is determined.

Procedures

During the 1973 iceberg season two field experiments with the expendable surface current probe were conducted. An IIP C-130 aircraft equipped with a CA14 aerial camera and inertial navigation system (INS) was made available on an opportunity-only basis. The field test procedures consisted of selecting a "young", plateau type iceberg which is not grounded and is in an area where the water depth is not greater than 1000 meters (as indicated on bathymetric chart). The position of the selected iceberg was recorded from the INS.

A figure eight flight maneuver with the iceberg at the intersection (Figure 2) served as an efficient deployment pattern. The preferred ground speed and altitude of the aircraft during deployment were 150 knots and 1000 feet respectively.

The measurement technique is based on the release of floats containing dye at predetermined time intervals. The probe containing three floats, timer, and parachute is dropped from the aircraft into the water. The first float is released on the surface. The appearance at the water surface of the remaining two floats is dependent on the actual water depth and the preset time. The aircraft time on station is directly related to the actual water depth where the drop occurs. For example, if the water depth is 500 meters, the on-station time would be not less than 25 minutes. The total time on station included deployment of four current probes as in Figure 2, the photography run, and dye marking of the iceberg. Dye marking the iceberg assists in identification of the iceberg on succeeding tests.

The primary data recorder for this experiment was the CA14 aerial camera. The flight pattern for the photography runs was similar to that of the launch pattern (as indicated in Figure 2), so that film sequencing would be in proper order for interpretation. After the launch, the oceanographer was to assist with the sighting of the floats and the completion of a Surface Current Data sheet. The Surface Current Data sheet provides the parameters to interpret and analyze the photography.

The experiment was to be repeated in exactly the same manner at a later date on the same iceberg. The subsequent location and identification of the iceberg would provide "surface truth" for the predictive technique used in this experiment.

Conclusions

Due to the failures in the data recording camera the current probe, iceberg relocation, dye patch identification, and personnel, it is not possible to properly evaluate the expendable surface current probe for determination of iceberg drift from these experiments. However, some worthwhile observations can be made.

The experiment on 14 and 15 May 1973 showed that "in flight" identification of floats was possible. The observed surface current direction and the INS-indicated iceberg drift during the experiment were approximately equal. Predictive capabilities were lost due to camera failure and the resultant inability to measure surface current velocity.

Further experimentation on 23 June with an operative camera indicated that surface currents could be accurately measured with the available equipment and procedures. The comparison of actual iceberg drift and the measured surface current could not be made due to failure to relocate the iceberg.

The data obtained from the experiments on 29 and 30 June is questionable. Failure to unambiguously identify the dye patches and properly complete the Surface Current Data sheet results in speculative interpretation of the data. This interpretation shows a large difference between the average indicated surface current of 1.6 knots, 002°T and the observed iceberg drift of 0.6 knots, 137°T. This large difference could be explained by the fact that icebergs have been observed to trail a wake, indicating movement relative to the surface current.

The observed failure rates for the five deployments were 25%, 25%, 75%, 100% and 50% respectively. The average failure rate for all deployments was 52%. Failures can be attributed to a variety of causes, including malfunction of the parachute, malfunction of the probe (presumably the clock), strong bottom currents, and the inability of personnel to differentiate among the dye patches.

Recommendations

Further experimentation is necessary to evaluate the expendable surface current probe for determination of iceberg drift. In future experiments only two probes should be deployed to determine the surface current. The probes should be at least 1/2 mile north and south or east and west of the iceberg to be clear of the iceberg wash. Deployment of two probes in such a manner would reduce the ambiguity in photo interpretation. Malfunctions in the probe should also be easily observed by aircraft personnel, allowing rapid decisions on the quality of the deployment. This, of course, will require longer on-station time.

A more sophisticated probe has been developed which permits the determination of differences between surface current and currents averaged over three preselected subsurface layers. This probe would be ideal for future experiments. The relative movement of an iceberg to the surface currents as indicated by iceberg wakes requires investigation of the sub-surface currents. The more sophisticated probe has this capability.

A capability to rapidly process the film should be investigated. This could result in an improved basis for an on-scene decision to repeat a test series. Failures in the camera or photographic techniques would also be quickly identified. In addition, an estimated float separation should be made and recorded on the data sheet during the photographic run.

Reference

Broida, S. and W.S. Richardson, 1972. Surface Current Measurements by Expended Probes, U.S. Coast Guard Technical Report Project 726520, June 1972: 7p.

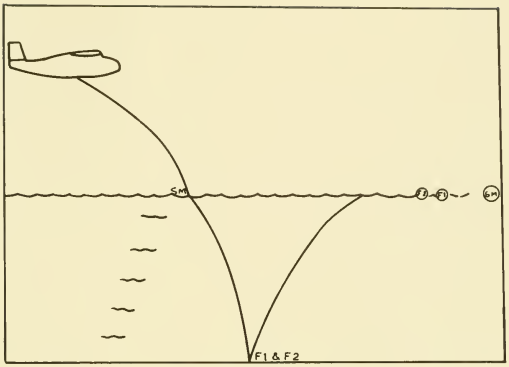


Figure 1
Use of Probe From Aircraft
(Broida and Richardson, 1972)

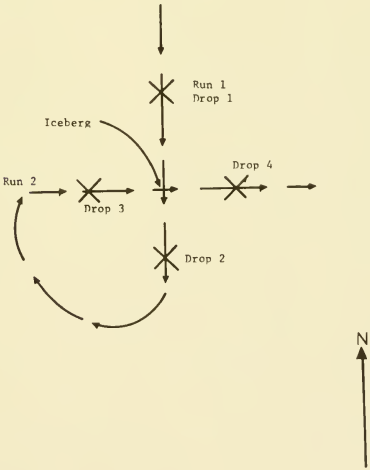


Figure 2
Flight pattern for deployment and photography
of surface current measurements probes.

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