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A Report on Sea Ice Conditions in the Eastern Arctic, Summer 1957

W. A. Black

GEOGRAPHICAL BRANCH
[Dep]artment of Mines and
[Tec]hnical Surveys, Ottawa

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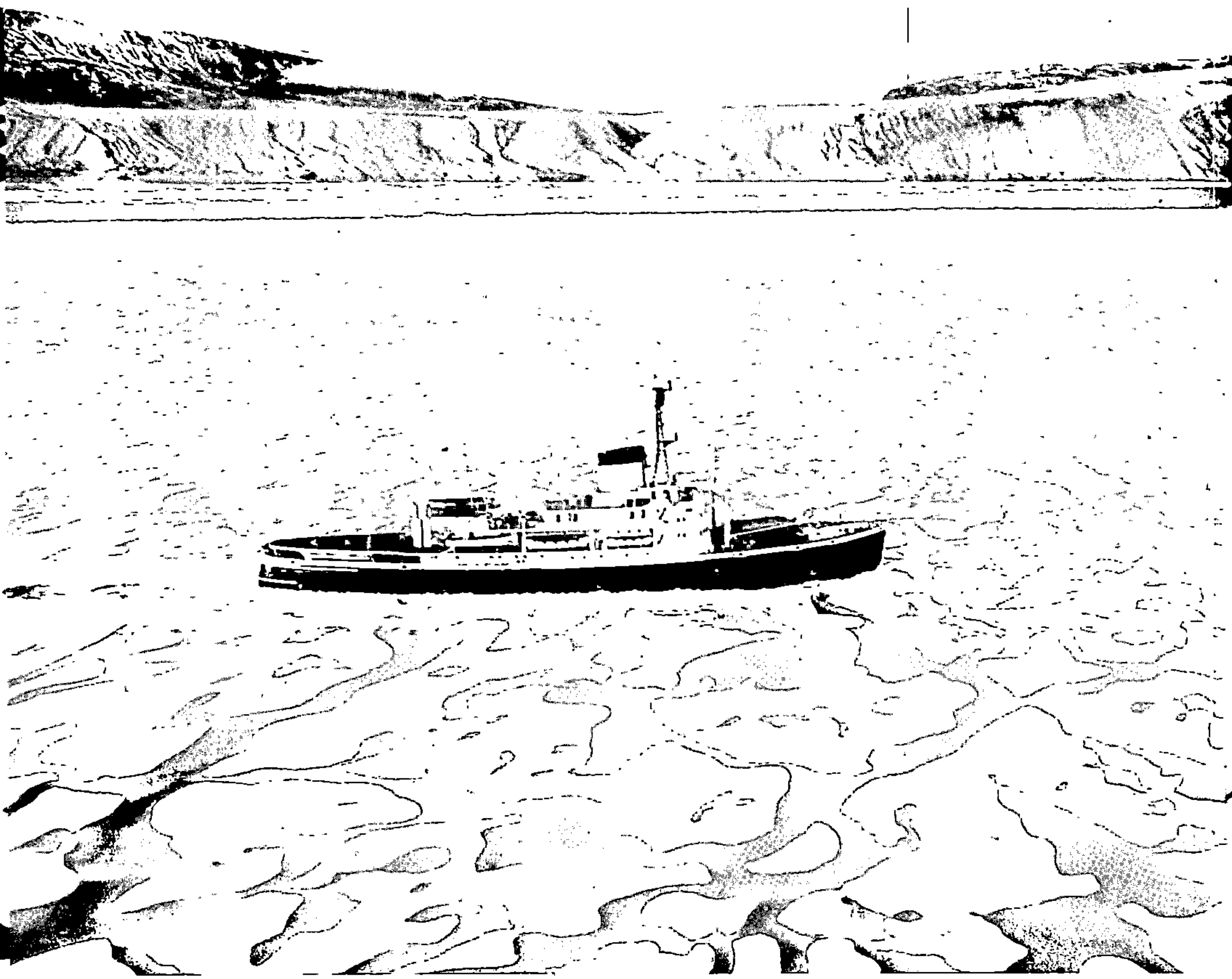

The C.G.S. d'Iberville *pushing through a field of puddled winter ice near Cape Depot, Eureka Sound, in latitude 79° 35′ N.*

PREFACE

As part of the Canadian Ice Distribution Survey, the Geographical Branch has been collecting data on the condition and distribution of sea ice. This report is the result of the second ice reconnaissance survey carried out during the summer of 1957 when the northern supply ship C. G. S. d'Iberville made her annual voyage to the Eastern Arctic.

The report of the 1957 ice reconnaissance survey is published to provide a picture of the nature, conditions and distribution of the ice encountered by Canadian Government ships on their annual re-supply mission. Its purpose is to record the special problems that ice presents to the ships engaged in this work in Canada's Eastern Arctic waters.

N. L. Nicholson,
Director,
Geographical Branch.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1958

A REPORT ON SEA ICE CONDITIONS IN THE EASTERN ARCTIC, SUMMER 1957

INTRODUCTION AND ACKNOWLEDGMENTS

This report describes the sea ice conditions encountered by the Department of Transport ship, the C.G.S. d'Iberville, on her annual re-supply voyage to Resolute and Eureka between August 1 and September 6, 1957.* The writer observed the condition of sea ice encountered, noted variations from the previous year, and the effect of the prevailing ice conditions upon ship navigation.

Ship-board ice reconnaissance was supplemented by aerial ice reports issued by the United States Navy Hydrographic Office ice observers at Thule for August 8, 11, 12, 15, 19 and 26, particularly for the Baffin Bay, Lancaster Sound, Jones Sound, Norwegian Bay, Eureka Sound and Smith Sound areas. The R.C.A.F. provided a Lancaster aircraft at the request of Captain C.A. Caron for a 2-hour ice reconnaissance flight on August 17. The flight was made to determine the condition of the ice in Hell Gate passage and Norwegian Bay prior to the sailing of the d'Iberville into these waters. Also at the request of Captain Caron, U.S. Navy aircraft were flown to ascertain the condition of the ice in Smith Sound and Kane Basin on August 23 and 25. On August 21, 22 and 23 the writer made flights on the ship's helicopters over Slidre Fiord, north of Cape Depot on Eureka Sound to Slidre Fiord and the northern part of Norwegian Bay.

The writer wishes to acknowledge the cooperation of the U.S.N. ice observers and D.W. Hall, Department of Transport ice observer, of R.C.A.F. personnel, Captain C.A. Caron and officers of the d'Iberville, and Department of Transport

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* For an account of previous ice conditions see Bibliography, page 5.

helicopter crews. The photographs illustrating this report were taken by E.J. Grant, National Film Board.

GENERAL ICE CONDITIONS ENCOUNTERED

Throughout the area covered by this report ice conditions were variable. On August 8, the Baffin ice pack extended eastward of the 60th meridian to within 40 miles of the Greenland coast. The heaviest ice lay in the southern two-thirds of the area. On August 15, the pack had a concentration of 3/10 to 5/10. On the return journey (August 27, 28 and 29), only a few scattered remnants lay close to the Baffin shores; the main pack, consisting of scattered ice and patches, lay well to seaward.

Lancaster Sound was open on August 11. Barrow Strait on August 15 was from 1/10 to 4/10 ice covered. Belts of ice, separated by extensive areas of open water, continued to drift eastward into Lancaster Sound. On the ship's departure from Resolute patches of scattered ice were passed in Lancaster Sound on August 18, and on August 25, at the entrance to Baffin Bay.

At the entrance to Jones Sound, August 12, ice coverage was 2/10 followed by open water with scattered ice and belts, except in the western part of the sound where ice coverage was 7/10. On the northward journey, August 20, Jones Sound was ice-free except at the western entrance to Cardigan Strait and Hell Gate. On the southward journey, Jones Sound was open except for the ice that poured into the western end of the sound through the straits. A belt of ice lay across the eastern entrance of the sound.

Throughout the entire period ice continued to jam through Hell Gate passage.

Norwegian Bay on August 12 was 8/10 to 9/10 covered; on August 20, coverage was 9/10 to 10/10. On August 20 open water lay off the east coast of Graham Island; the northern part of the bay leading to Eureka Sound was open. These two areas of open water had joined together by August 23. Areas of block and small floes alternated with areas of field; extensive areas of hummocked ice were present.

Eureka Sound was 3/10 to 7/10 covered on August 12, and on August 21 and 23 ice coverage of approximately 8/10 was concentrated in the northern half of the sound.

Slidre Fiord, from August 21 to 22, was 5/10 covered with the ice jammed into the eastern half of the fiord. Throughout the period ice continued to drift in and out of the fiord.

On August 23, the arctic pack (6/10) extended across Smith Sound and northward through Kane Basin; with a coverage of 8/10, it extended southward to Coburg Island. On August 26, coverage was reduced to 4/10 and 5/10 except in the sound where it had increased to 8/10.

In Baffin Bay, Lancaster Sound, Barrow Strait and Jones Sound the ice consisted of small to medium floes with a considerable amount of hummocked ice. In the Hell Gate-Norwegian Bay-Eureka Sound area approximately half the ice consisted of small to medium floes, the remainder being large floes and fields. Hummocked ice accounted for almost half of the ice surface and was 7 to 10 feet thick. Extensive pans or large floes varying from half a mile to 2 miles long were generally from 3 to 5 feet thick; surface puddling covered from 5/10 to 7/10 of the surface. Icebergs and bergy bits were scattered throughout the reconnaissance area but were particularly concentrated in the northeastern part of Baffin Bay.

The significant features of ice conditions as they affect ship navigation are summarized at the end of the report.

GENERAL WEATHER CONDITIONS

The weather and temperature conditions cover the period August 7 to August 29, from the time the icebreaker passed north of Resolution Island to her return to Hudson Strait on August 29.

During this period there were 15 days when the sky was overcast or obscured by low-lying fog; the remaining 8 days were clear. Of the recorded wind directions; 43 per cent of the winds blew from the west and northwest, 39 per cent were equally from the southeast, southwest or were calms, and the remaining 18 per cent were equally from the north, northwest and east. Wind velocities were variable; 14 per cent were 0 m.p.h., 45 per cent 1-10 m.p.h. and 33 per cent from 11-21 m.p.h. Occasionally wind speeds exceeded 21 m.p.h.; as on August 19 in the afternoon when 34-40 m.p.h. winds arose. Average air temperatures declined from 37.5° F. in the Baffin Bay area to 33.9° F. in the Jones Sound-Slidre Fiord area; average surface water temperatures also declined from 35.8° F. in the Baffin Bay area to 30.6° F. in the Jones Sound-Slidre Fiord area. The temperature of the sub-surface water* though slightly higher than the surface water generally paralled the surface water temperatures. A steady decline northward was noted in daily heat accumulated temperatures of the air, of the surface water and of the sub-surface water, and the lowest readings were reached in the Jones Sound-Slidre Fiord area.

SELECTED ICE TERMINOLOGY

(a) The system and symbols of ice reporting used in this report are those of the U.S. Navy Hydrographic Office.

(b) Concentration by size: The first digit indicates tenths of brash and block, the second digit, tenths of small to medium floes and the third digit, tenths of giant floes and field. Example: 621 concentration indicates 6/10 brash and block, 2/10 small to medium floes and 1/10 giant floes and field. Total ice coverage 9/10.

(c) Young or very young ice: Newly formed level ice, usually transparent or may be opaque.

(d) Winter ice: Usually more or less unbroken, level sea ice of the current winter's growth.

(e) Polar ice: Usually ice of more than one winter's growth; the details of pressure ridges are subdued to form hummocks, the thickness of which is usually not less than 6 feet.

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* This water temperature was taken at the ship's intake, 26 feet below the water's surface.

(f) Puddles: Depressions in floe ice filled with water melted from the surface of the ice. In this study puddling is expressed in 10ths coverage.

(g) Rotten ice: Ice that has become honeycombed in the course of melting.

Note:- Though the puddles may melt through the ice, the ice still may be very hard.

(h) Ram: An underwater projection of ice.

(i) Glimmer ice: Newly-formed ice within a crack or hole of older ice, or in the puddles upon older ice.

(j) Floe: A piece of sea ice. In terms of size a small floe is from 30 to 600 feet across; a medium floe is 600 to 3,000 feet; a large, or giant floe or pan is 3,000 feet to 5 miles, and an ice-field an area of sea ice greater than 5 miles across.

(k) Block: A fragment of sea ice from 6 to 30 feet across.

(l) Brash: Fragments of floating ice, less than 6 feet across, resulting from the wreckage of other forms of ice.

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ICE CONDITIONS: BAFFIN BAY-DAVIS STRAIT
(Figure 1: August 7-13; 27-29.)

Ice Distribution

The ice report of August 8 showed the ice pack lying off the east coast of Baffin Island. The boundary of the pack extended eastward (67° 15' N. 63° 00' W.) from the Baffin coast to 68° 00' N. 59° 50' W., thence northward to parallel the Greenland coast as far as 74° 00' N. 60° 00' W. This report did not give any details on the concentration of the ice in the pack.

The ship's course from August 7 to 13 lay to the east of the pack. During the northbound voyage the ship passed through three extensions of the pack off Cape Walsingham, off Disko Island, and off the entrance to Melville Bay. In these areas ice concentrations were generally about 1/10 to 3/10, with belts of 4/10 to 5/10 with small to medium floes predominating. Many of the ice floes were hummocked, possessed extensive rams and exceeded 5 feet in thickness.

The aerial ice survey report of August 15 showed the pack to be occupying approximately the same position. The ice edge lay off Cape Dyer and extended irregularly northward to 75° 20' N. 66° 40' W. In the central third of the pack the ice had a concentration of 5/10 (131); in the northern third 4/10 (130-220) and in the sourthern third 3/10 (120).

A report of August 26 showed the Baffin Bay pack to be considerably reduced in area and for the most part lying off the Baffin coast. The ice generally consisted of scattered patches of ice up to 20 miles in width. On the return journey of August 28, the ship passed through two small areas of scattered ice with a concentration of 1/10 in the vicinity of 70° N. latitude.

Factors Affecting Distribution

The rapid disintegration of the ice depends upon air and water temperatures supported by wind and wave action; the movement of the ice is closely related to the direction and velocity of the prevailing winds and water currents.

The low concentration of ice encountered along the ship's track was chiefly the result of wind action. Winds tend to drive ice floes into strings and belts or to open up a pack by driving the ice outward. Along the ship's track from Port Burwell to 72° 00' N., winds from the northeast and southeast were predominant. Wind speeds were generally from 7 to 16 m.p.h., but calms were frequent during this period. North of 72°, north and northwest winds of 7 to 16 m.p.h. prevailed.

Air temperatures stood well above freezing but were variable (Table I). The

TABLE I

Daily temperatures, Baffin Bay-Davis Strait, Aug. 7-13, 27-29

	Air (F.°)			Surface Water (F.°)			Sub-surface Water (F.°)		
Day	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Aug. 7	37	41	39.5	33	37	34.8	32	37	35.
Aug. 8	40	42	40.6	32	40	35.	32	40	35.1
Aug. 9	36	43	38.6	36	38	36.8	32	38	34.8
Aug. 10	32	39	35.8	33	33	33.	32	35	33.
Aug. 11	30	42	37.1	36	41	38.6	37	44	40.6
Aug. 12	35	44	38.1	40	43	41.3	35	45	39.8
Aug. 13	36	42	39.1	34	42	38.3	36	41	38.5
Aug. 27	34	40	37.2	32	35	33.1	33	39	37.
Aug. 28	33	37	35.1	32	35	32.8	32	39	35.
Aug. 29	31	37	34.	32	36	34.6	33	38	36.1
Daily Av.	34.4	40.7	37.5	34	38	35.8	33.4	39.6	36.4

average minimum temperature was 34.4° F., average maximum 40.7° F. and daily average 37.5° F. Of some sixty readings taken during the 10-day period at regular 4-hour intervals, one reading dropped to 31° F. and one to 30° F. No trends were evident to indicate any change with increasing latitude, and the southbound journey followed a similar pattern to that recorded from August 7 to 13. As the average temperatures stood well above freezing, the air moving over the ice pack must have been effective in the disintegration of the ice. This was also evidenced in the amount of puddling that reached about 3/10 in hummocked floes and 5/10 in level floes.

Surface water and sub-surface water temperatures followed a pattern that corresponded closely to air temperatures. The most significant feature of the water temperatures was that all minimum temperatures stood well above 29° F. and had the effect of quickening the disintegration of the ice. This process goes on at a rapid rate when air temperatures remain above freezing throughout the 24-hour period and also when the temperature of surface waters is well above freezing.

Temperature effectiveness for air, surface water and sub-surface water are given in Table II. The average daily heat accumulative temperature for air was

TABLE II
Daily heat accumulative temperatures, Baffin Bay-Davis Strait, Aug. 7-13, 27-29

Day	Air (F.°)*	Surface Water (F.°)**	Sub-surface Water (F.°)**
Aug. 7	14	12	11
Aug. 8	18	14	14
Aug. 9	15	16	12
Aug. 10	7	8	9
Aug. 11	8	19	23
Aug. 12	15	25	22
Aug. 13	14	18	19
Aug. 27	10	9	14
Aug. 28	6	9	13
Aug. 29	4	10	13
Daily Av.	11.1	14.0	15.0

* Daily heat accumulation for air is the sum of the difference of minimum and maximum temperatures from 32° F.

** 29° F. as the freezing temperature of sea water is used to make the calculation for sea water.

11.1° F., for surface water 14.0° F. and for sub-surface water 15.0° F. The accumulative daily heat level was positive and therefore above freezing. The higher average level of the water temperatures indicate that they were more effective in the disintegration of the ice field than air temperatures.

The daily average cumulative temperature range of air, surface water and sub-surface water is given in Table III. Highest temperatures for air occurred from 0800 to 1600 hours, for surface water from 1600 to 2000 hours, and for sub-surface water from 1600 to 2400 hours.

TABLE III

Baffin Bay - Davis Strait, August 7-13, 27-29

A. Cumulative air temperatures (F.°)
B. Cumulative surface water temperatures (F.°)
C. Cumulative sub-surface water temperatures (F.°)

Hours	0400	0800	1200	1600	2000	2400
A.						
Av. cum. temps.	36.6	38.6	38.8	38	37	37.2
B.						
Av. cum. temps.	35.8	36.1	35.2	36.3	36.1	35.6
C.						
Av. cum. temps.	36.2	36.2	35.4	36.6	36.9	37.4

ICE CONDITIONS: LANCASTER SOUND
(Figure 2: August 14-18)

Ice Distribution

On August 11, Lancaster Sound was open with an extensive shore lead extending westward past Cape Hotham on the south side of Cornwallis Island. On August 12 (Figure 3), the ice from Barrow Strait had pushed eastward into Lancaster Sound. On August 15, a wedge of ice had extended northeastward to block the entrance of Wellington Channel; the western edge of the ice extended westward south of Griffiths Island. Ice concentration was from 1/10 to 4/10 comprising small to medium sized floes. A large part of the ice consisted of rotten winter ice and was in an advanced stage of disintegration; the remainder consisted of hummocked floes. On August 16, open water extended westward into Barrow Strait; from Cape Capel the ice edge extended diagonally across Barrow Strait. South of this edge it varied from 7/10 to 9/10 coverage consisting of 124 to 009 concentration. From August 15 to 18, bands of ice of 1/10 continued to drift eastward and disintegrated shortly after entering Lancaster Sound. On August 27, a belt of ice that lay at the northern entrance to the sound had probably drifted southward from the vicinity of Coburg Island.

At Resolute, the harbour was ice-free, except for the floes that were aground off the Eskimo village and extended along the line of shoals across the entrance to the harbour. Ice concentrations were 7/10 consisting of small floes from 7 to 10 feet in thickness.

Factors Affecting Distribution

In the Lancaster Sound area from August 14 to 19, and from August 25 to 26, winds blew from the southwest, west, and northwest with velocities of 7 to 21 m.p.h. These winds were moving the pack ice eastward through Barrow Strait in large belts, towards Lancaster Sound. Under a 17 m.p.h. wind, ice drifted eastward past the harbour at Resolute at approximately 1½ m.p.h.; during a calm, the movement of the ice was imperceptible.

Air temperatures stood well above freezing (Table IV). The average minimum

TABLE IV

Daily temperatures, Lancaster Sound, Aug. 14–19, 25–26

	Air (F.°)			Surface Water (F.°)			Sub-surface Water (F.°)		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Aug. 14	38	44	43	38	40	39.3	35	40	38.5
Aug. 15	32	36	34.1	30	31	30.	30	34	31.5
Aug. 16	31	34	33.	30	30	30.	30	30	30.
Aug. 17	30	35	31.8	30	30	30.	30	30	30.
Aug. 18	32	42	37.1	29	35	31.1	30	33	31.5
Aug. 19	33	38	35.8	31	36	33.1	32	36	33.6
Aug. 25	35	40	38.1	32	37	34.8	32	39	35.6
Aug. 26	31	41	36.5	30	34	33.3	30	34	33.
Daily Av.	32.7	38.7	36.2	31.2	34.1	32.7	31.1	34.5	32.9

temperature was 32.7° F., average maximum 38.7° F. and the daily average 36.2° F. Of the forty-eight temperature readings taken during this period nine were recorded from 30° F. to 32° F. Temperatures were only slightly lower than those encountered in Baffin Bay, indicating that air conditions in this area also were favourable for the disintegration of the pack ice.

In the Lancaster Sound area, surface water and sub-surface water temperatures followed closely together and also paralleled air temperatures (Table IV). With the exception of one reading water temperatures were above 29° F.

Temperature effectiveness for air, surface water and sub-surface water is given in Table V. Temperatures were positive; the average daily heat accumulative temperature for air was 7.5° F., for surface water 7.4° F. and sub-surface water 7.6° F. The near coincidence of air and water temperatures indicate there was little difference between them as effective instruments in the disintegration of ice. Although temperature levels in Barrow Strait were low, they were substantially higher in Lancaster Sount (Table IV) and accounted for the rapid reduction of ice that drifted eastward into the sound.

TABLE V

Daily heat accumulative temperatures, Lancaster Sound, Aug. 14-19, 25-26

Day	Air (F.°)*	Surface Water (F.°)*	Sub-surface Water (F.°)*
Aug. 14	18	20	17
Aug. 15	4	3	6
Aug. 16	1	2	2
Aug. 17	1	2	2
Aug. 18	10	6	5
Aug. 19	7	9	10
Aug. 25	11	11	13
Aug. 26	8	6	6
Daily Av.	7.5	7.4	7.6

*See Table II

The daily average cumulative temperature range is given in Table VI. The period of highest air temperatures occurred from 1200 to 1600 hours, for surface water from 0400 to 0800 hours and for sub-surface water from 0400 to 2400 hours. Although the temperature range is relatively small the lowest temperatures occurred during the period of the lowest declination of the sun. On the average, thawing temperatures continued throughout the 24-hour period.

TABLE VI

Lancaster Sound, August 14-19, 25-26

A. Cumulative air temperatures (F.°)
B. Cumulative surface water temperatures (F.°)
C. Cumulative sub-surface water temperatures (F.°)

Hours	0400	0800	1200	1600	2000	2400
A.						
Av. cum. temps.	34.2	35.7	38.4	38.2	36.2	34.2
B.						
Av. cum. temps.	33.4	33.0	32.9	32.7	32.5	32.2
C.						
Av. cum. temps.	33.9	33.0	33.2	33.4	32.7	31.7

ICE CONDITIONS: RESOLUTE - NORWEGIAN BAY - EUREKA SOUND AREAS (Figure 3: August 12)

In Wellington Channel, air reconnaissance of August 12 indicated that two-thirds of the channel was ice-covered with a concentration in the ice pack varying from 1/10 to 8/10. Open water extended westward to include Queens Channel. As early as April 24, Department of Transport ice observers had reported open water in the vicinity of Baillie Hamilton Island.

Ice coverage in Jones Sound on August 12 varied from 2/10 to 7/10; approximately one-third of the sound was open water with ice distributed in scattered patches in its central part. Ice coverage of 7/10 extended into Hell Gate passage. A belt of 5/10 ice occupied Cardigan Strait and extended northward to Graham

Island. West of this belt, Belcher Channel was 8/10 covered, and to the east Norwegian Bay was 8/10 covered, becoming 9/10 in the northern three-quarters of the bay.

In Eureka Sound ice coverage varied from 3/10 to 7/10; the central part of the sound was open water.

(Figure 2: August 17)

The major change in the distribution of the ice from the previous flight consisted chiefly in its disappearance from Wellington Channel. Open water areas in Jones Sound were broken by ice of 2/10 to 4/10 coverage enclosing belts of 8/10 concentration. Ice coverage of 4/10 to 9/10 occupied Hell Gate. Heavy undercast prevented any observation of ice conditions in Norwegian Bay.

(Figure 4: August 19)

The main change in ice distribution from the previous flight consisted primarily in the disappearance of ice from Jones Sound except at the entrance to Cardigan Strait and Hell Gate. Ice concentration of 8/10 covered Belcher Channnel and Norwegian Bay to 77^{o} 45' N. Open water extended northward into Eureka Sound; however, light scattered ice of less than 1/10 coverage extended northward to Hay Point; ice coverage in the remainder of the sound was 8/10.

ICE CONDITIONS: JONES SOUND - EUREKA SOUND
(Figures 5A, 6A: August 20, 21)

Variation from Previous Reconnaissance of August 19

Ice continued to pour into the western end of Jones Sound from Norwegian Bay through Cardigan Strait and Hell Gate. In Norwegian Bay the major change was in the occurrence of an extensive water area lying east of Graham Island. Extensive belts of 'working' ice, particularly in the southern and northern parts of the bay, indicated that the Norwegian Bay ice field was rapidly breaking up. Open water extended from Norwegian Bay into Eureka Sound as far north as 79° 00' N. North of this latitude ice concentrations stretched northward past Slidre Fiord.

Ice Distribution

Ice concentration of 3/10 (210) with belts of 7/10 (520) covered the western end of Jones Sound. In the 'Gate' pack ice of 8/10 to 9/10 concentration was broken by local areas of open water and by lesser ice concentrations.

Throughout Norwegian Bay ice concentration varied from 7/10 to 10/10. In the southern part of the bay ice concentrations of 630 alternated with concentrations of 009; in the central part ice concentrations of 250 alternated with 007, and 630 alternated with 009; in the northern part an extensive field of 0010 lay on the east side of the bay and concentrations of 630 alternating with 009 lay to the west and north of the field. Concentrations of 630 or 250, consisting of block and small floes, represented 'working' or disturbed ice. In contrast, concentrations of 007 to 009 consisting of large floes and field represented undisturbed ice. The Norwegian Bay ice varied from 2/10 to 8/10 level winter ice. The area of level winter ice was greatest in the southern part of the bay.

Surface ice puddling was widespread throughout Norwegian Bay and on the ice that passed into Jones Sound. Puddling varied from 5/10 to 6/10 with local belts of 8/10. About 1/10 to 2/10 of the surface was composed of rotten winter ice and was associated with areas of advanced puddling. This ice was grey in colour, honeycombed in structure and about 1 to 1½ feet thick in the puddled areas. About 1/10 to 2/10 of the puddles had melted through the ice. Under the crust-covered areas, the ice thickness varied from 2 to 4 feet, was blue-green in colour and substantially harder.

Hummocked ice occupied about 1/10 of the total ice surface in the southern part of the bay and about 8/10 in the northern part. In this latter area about 2/10 was polar ice. The polar hummocked floes, in contrast to the hummocked winter ice, were whiter and more massive in appearance and generally exceeded 8 feet in thickness. The winter hummocked ice varied in thickness from 5 to 7 feet. Surface puddling amounted from 1/10 to 2/10. Ice in Norwegian Bay does not entirely disappear during the short summer, but is reduced in coverage to less than 5/10.

The puddles were covered by young ice (glimmer ice) about a half an inch thick; in the open water areas very young ice was actively forming. The ice surface that separated the puddles consisted of a heavy crust of hard-packed, coarse crystals from 4 to 12 inches thick.

In Eureka Sound, the main pack ice varied in concentration from 8/10 to 10/10 with medium to large floes and pans predominating. Many of the pans reached a width of several miles. The amount of hard and rotten ice appeared to be fairly evenly distributed; this ice contained about 1/10 to 2/10 polar ice. Surface puddling varied from 2/10 to 5/10 and the puddles were covered by a 1 to 2-inch layer of glimmer ice.

ICE CONDITIONS: JONES SOUND - EUREKA SOUND
(Figures 5B, 6B: August 22-24)

<u>Variation from Previous Reconnaissance of August 20, 21</u>

The changes in the distribution of the ice consisted in the extension of the ice tongue in Eureka Sound to the southern end of Stor Island and the appearance of an extensive area of open water in the sound north of 80° 00' N. In Norwegian Bay, open water extended southward from Eureka Sound on each side of Graham Island and northwestward in the direction of Haig-Thomas Island. Because of an extensive polar hummocked ice field that had drifted across the entrance to Hell Gate passage, thereby blocking the drift of smaller floes southward, Hell Gate was about three-quarters ice free. In addition, scattered ice of 1/10 coverage lay at the western end of Jones Sound.

Ice Distribution

In Eureka Sound small medium floes (520) alternated with large floes and field (126). The current in the sound appeared to be rapid, about 5 to 6 m.p.h. A pan of massive hummocked polar ice was observed on August 21 at the entrance to Slidre Fiord; on August 22 it lay south of Cape Depot, the rate of drift being about 1 3/4 m.p.h. An extensive area of 'working' ice was located between Cape Moka and Cape Depot where the sound bends sharply to the southeast.

In Norwegian Bay ice varied from 8/10 to 10/10 coverage with extensive pans and field predominating. Hummocked ice occupied about 8/10 of the ice surface in the north, and 2/10 in the south. Polar hummocked floes were scattered throughout the area. Surface puddling varied from 2/10 to 6/10, and these puddles were covered by young ice 2 to 3 inches thick. Ice in the 'Gate' was concentrated in the southern half of the passage; coverage was 1/10 with belts of 8/10. Hummocked floes of 1/10 to 2/10 coverage were scattered among the winter ice of block and small floes.

The rapid extension of the open water area in Norwegian Bay between August 20 and August 23 was an indication that the bay ice was rapidly breaking up. The occurrence of the polar field at the northern entrance of Hell Gate inferred an ice drift from Belcher Channel towards the exit channels of Cardigan Strait and Hell Gate.

ICE CONDITIONS: SLIDRE FIORD
(Figure 7: August 21, 22)

Slidre Fiord on August 16, was ice free. On August 19, ice coverage was 1/10, and on August 20, was 7/10. When the icebreaker entered the fiord on August 21 open water extended east of Eureka. The inner half of the fiord was ice-filled.

Three helicopter flights were flown on August 21 and 22 to determine the nature, movement and distribution of the fiord ice, (Figure 7).

Ice Distribution

The upper part of the fiord above the station was covered by winter ice that was

8/10 to 9/10 rotten. The ice was from 2 to 3 feet thick and was about three-quarters puddled. Scattered throughout were a number of bergy bits and pieces of polar ice 5 to 8 feet thick.

From August 21 to August 22 when the ship was unloading supplies at Eureka, winds blew steadily from the west with speeds of 11 to 21 m.p.h. These wind speeds were sufficient to counteract the outward movement of ice in the fiord, and to hold it at its eastern end. The winds also brought ice into the fiord from Eureka Sound. It was not until near the end of the second day that ice drifting into the fiord began to hamper unloading operations.

Factors Affecting Distribution

Lancaster and Jones sounds are extensions of Baffin Bay and possess relatively similar temperature conditions. There is also a similarity in their salinity content that amounts to about 5 ounces per imperial gallon. The physical conditions in the Norwegian Bay-Eureka Sound area are quite different; the temperatures are substantially lower and the salinity content is about 2 ounces per imperial gallon.* As a result, a temperature of 30° F. for this area is used here as the freezing point of water.

During the period August 20 to 24, winds generally blew from the west and northwest, the predominating velocities being of 4 to 10 and 11 to 21 m.p.h. The weather from August 20 to 21 was cloudy and overcast; from August 22 to 24 it was clear and sunny. In the Jones Sound-Eureka Sound area the effect of wind upon the ice was difficult to determine, except in conjunction with other factors.

Although minimum temperatures were below freezing, the average air temperatures were above freezing (Table VII). The average minimum temperature was 30.4° F., average maximum 36.6° F. and the daily average 33.9° F. Thirty tempera-

* The salinity tests were made by P. McMorran, Chief Engineer of C.G.S. d'Iberville.

ture recordings were made, of which only twelve registered temperatures of 32° F. or lower, indicating that thawing conditions were slightly more prevalent than freezing conditions.

In the Norwegian Bay-Eureka Sound area, surface water and sub-surface water temperatures were essentially similar and approximately 3 F. degrees lower than air temperatures (Table VII). The average temperature of surface water was 30.6° F. and of sub-surface water 30.7° F. Although the daily average temperature was normally over 30° F., sixteen recordings of surface water and fifteen of sub-surface water read 30° F. or lower. Thus one-half of the readings showed freezing conditions to exist.

TABLE VII

Daily temperatures, Jones Sound - Slidre Fiord, August 20-24

Day	Air (F.°)			Surface Water (F.°)			Sub-surface Water (F.°)		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Aug. 20	30	34	32.3	29	30	29.8	29	30	29.8
Aug. 21	32	34	32.6	30	32	31.1	30	32	31.0
Aug. 22	30	37	33.6	30	32	30.6	30	32	31.5
Aug. 23	32	38	34.6	29	32	30.3	29	32	30.
Aug. 24	28	40	36.6	30	32	31.1	29	33	31.6
Daily Av.	30.4	36.6	33.9	29.6	31.6	30.6	29.4	31.8	30.7

Temperature effectiveness for air, surface water and sub-surface water for the area are given in Table VIII. Temperatures were positive; the average daily heat accumulative temperature for air was 3° F., for surface water 1.2° F. and for sub-surface water 1.2° F. The near proximity of temperatures to the freezing point indicated a slim margin of thawing conditions. Throughout the period as temperatures approached coincidence air temperatures were higher and accounted for the formation of surface-ice puddles.

TABLE VIII

Daily heat accumulative temperatures, Jones Sound - Slidre Fiord, August 20-24

Day	Air (F.°)	Surface Water (F.°)	Sub-surface Water (F.°)
Aug. 20	0	-1	-1
Aug. 21	2	2	2
Aug. 22	3	2	2
Aug. 23	6	1	1
Aug. 24	4	2	2
Daily Av.	3	1.2	1.2

The daily average cumulative temperature range for air, surface water and sub-surface water is given in Table IX. Highest temperatures for air occurred from 1200 to 1600 hours and for surface water from 0800 to 1200 hours. The range of temperature for sub-surface water was .8° F.

TABLE IX

Jones Sound - Slidre Fiord, August 20-24

A. Cumulative air temperatures (F.°)
B. Cumulative surface water temperatures (F.°)
C. Cumulative sub-surface water temperatures (F.°)

Hours	0400	0800	1200	1600	2000	2400
A. Av. cum. temps.	31.	34.2	35.2	35.6	34.4	33.6
B. Av. cum. temps.	30.6	31.4	31.0	30.2	30.6	30.6
C. Av. cum. temps.	30.4	31.2	30.8	30.8	31.2	30.4

The low temperatures experienced undoubtedly provide an explanation for the small proportion of rotten ice that was observed in this area. They provide an explanation for the formation of young ice (glimmer ice) 2 to 3 inches thick on the surface puddles whose waters are relatively fresh, and also for the relatively small proportion of puddles that had melted through the ice. The water temperatures of approximately 30° F. would also explain the formation of newly-formed ice that was frequently observed in open water areas. Temperatures in Jones Sound were several degrees higher than those in Norwegian Bay and Eureka Sound.

ICEBERGS

Throughout the voyage from the Strait of Belle Isle to Slidre Fiord icebergs were encountered. However, during the northbound and southbound passage between Lancaster Sound and the Strait of Belle Isle visibility in general, was poor and radar location of icebergs was limited to a 10-mile range. About fifteen icebergs were sighted off the Labrador coast between 51° 01' N.; thereafter, icebergs numbered from five to ten per day. The greatest concentration existed in Baffin Bay at the entrance to Melville Bay; a count of sixty bergs was made in a field of bergy bits and heavy floes. A second concentration of bergs was seen off the east coast of Devon Island from Cape Warrender on the south coast to Ward Point on the north coast; at 2000 hours a count of twenty-five bergs was made; this part of the Devon Island coast is a breeding-ground for bergs. A third concentration of bergs lay scattered along the south coast of Ellesmere Island. Scattered icebergs and bergy bits were sighted in Eureka Sound, Pond Inlet and Navy Board Inlet.

CONCLUSION

Navigation through sea ice presents special problems. In general,icebreaker escort appears necessary for ocean-going freighters when ice coverage reaches 4/10. However, ice coverage is rarely uniform over an extended area, thus an ice coverage of 1/10 or less may frequently contain strings and belts of heavy ice with concentrations varying from 5/10 to 9/10. During the 1957 season the convoy held well to the west Greenland coast and such ice encountered was unavoidable. Low-lying fog patches were of frequent occurrence in Davis Strait and Baffin Bay, and reduced the speed of the convoy in this area.

For supply ships to complete their missions, they must depend in large measure on aerial ice survey reports. During the voyage into Lancaster Sound aerial ice reports were not available, and this caused considerable concern to the ship's officers. Although reports were received too late to be of value to the convoy they are incorporated in this report to show the changing pattern of the ice coverage in Davis Strait and Baffin Bay.

The importance of aerial ice survey reports can be illustrated by the following examples: Captain Caron had received instructions that after completing the voyage to Eureka, the ship was to proceed to Alexandria Fiord in Smith Sound. On August 23, an aerial ice report (Figure 8), indicated a coverage of 6/10 in Smith Sound which would enable the ship to reach and return from Alexandria Fiord. However, an ice report on August 26 (Figure 8), showed this area to have a coverage of 8/10 and ice concentration of 224. The ice consisted of 7/10 polar and 3/10 winter; moreover, pressure ridging was heavy (6/10 to 9/10), the amount of hummocked ice was moderate (3/10 to 5/10) and the amount of puddling 3/10. These ice conditions indicated that it would be unsafe to risk the vessel; accordingly, the voyage to Alexandria Fiord was not attempted.

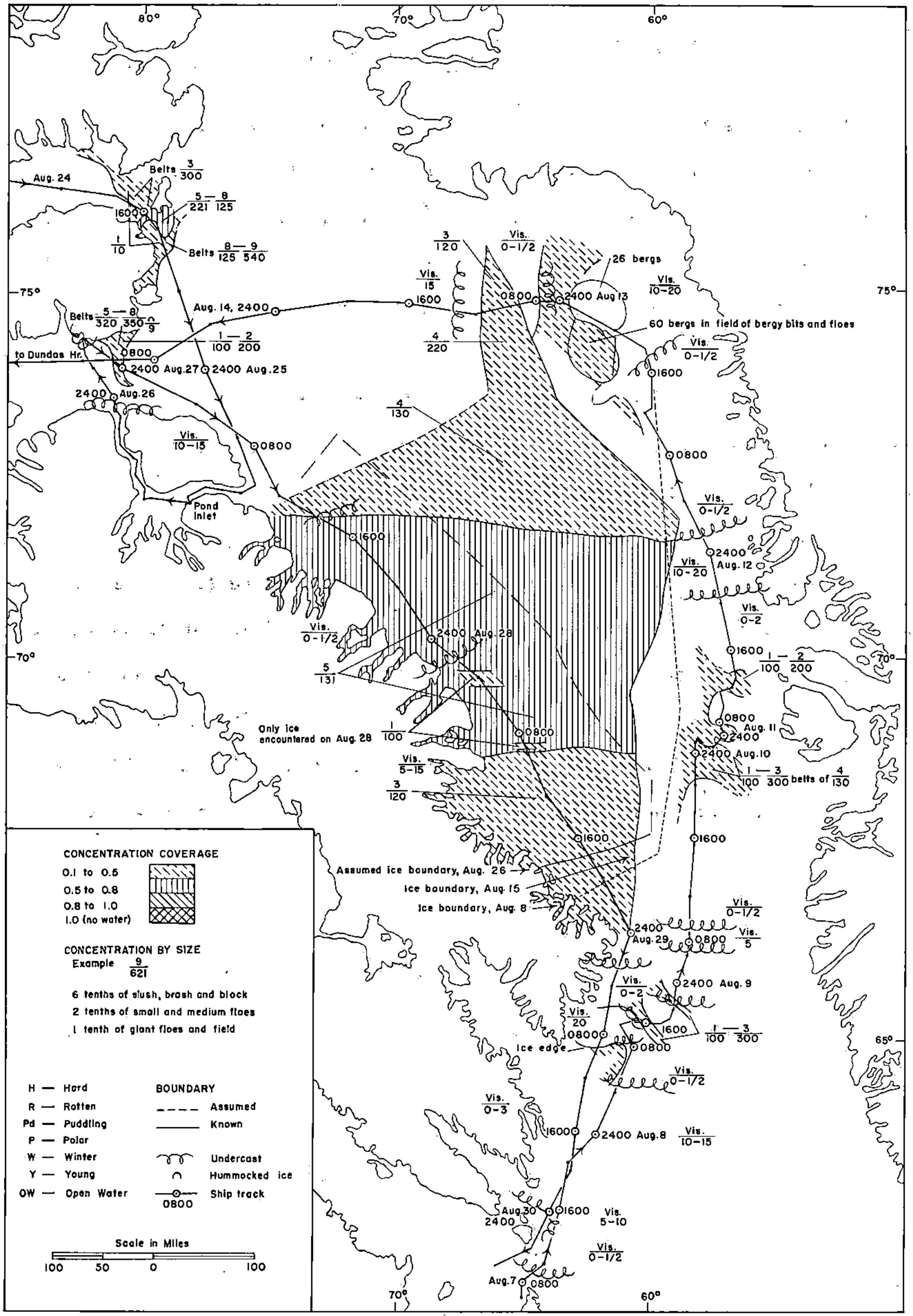


Figure 1

Ice Distribution, Davis Strait-Baffin Bay, August 7-14, 24-30.

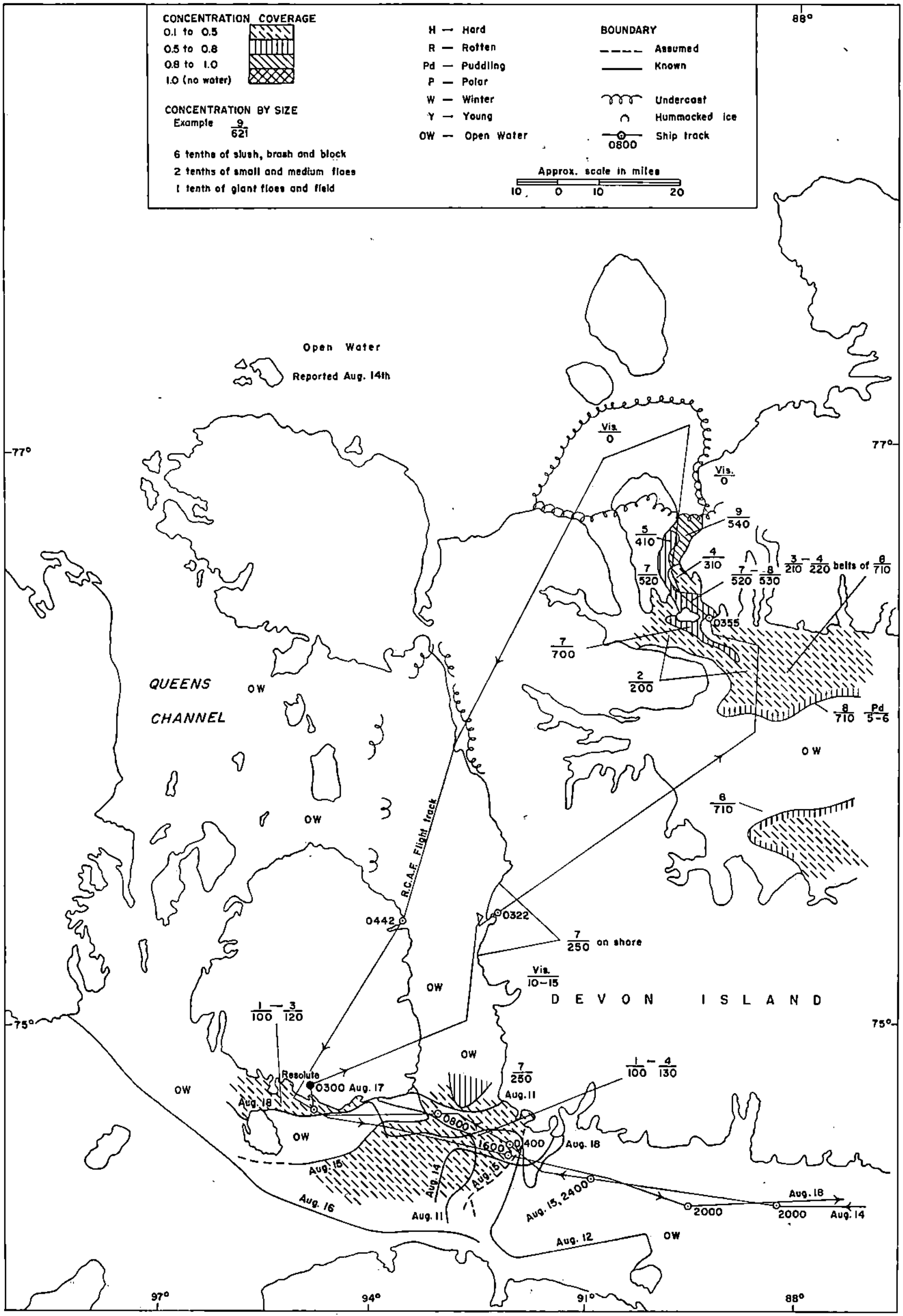


Figure 2

Ice Distribution, Lancaster Sound, Jones Sound, Wellington Channel and Norwegian Bay, August 14-18.

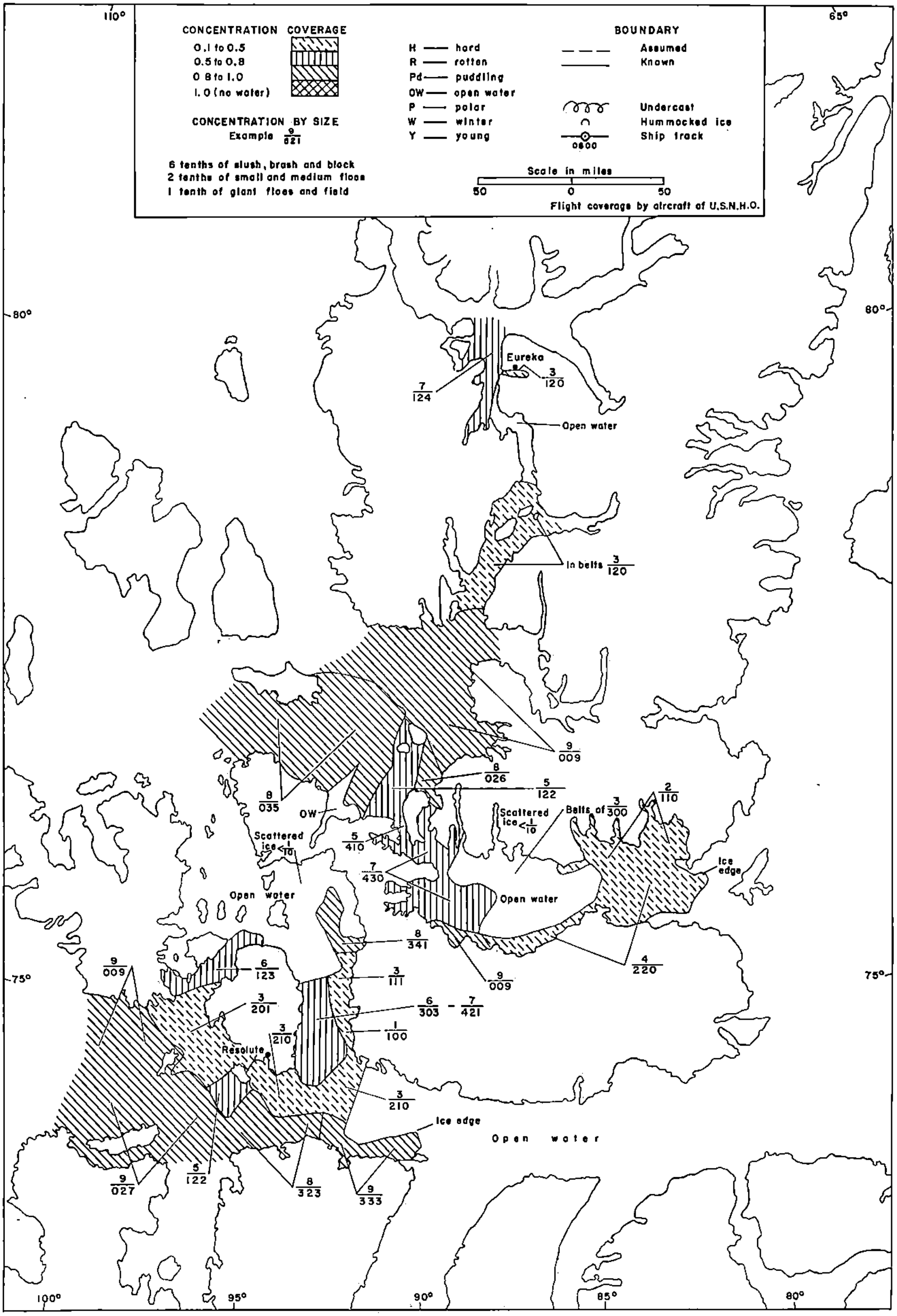


Figure 3

Ice Distribution, Lancaster Sound-Eureka Sound Area, August 12.

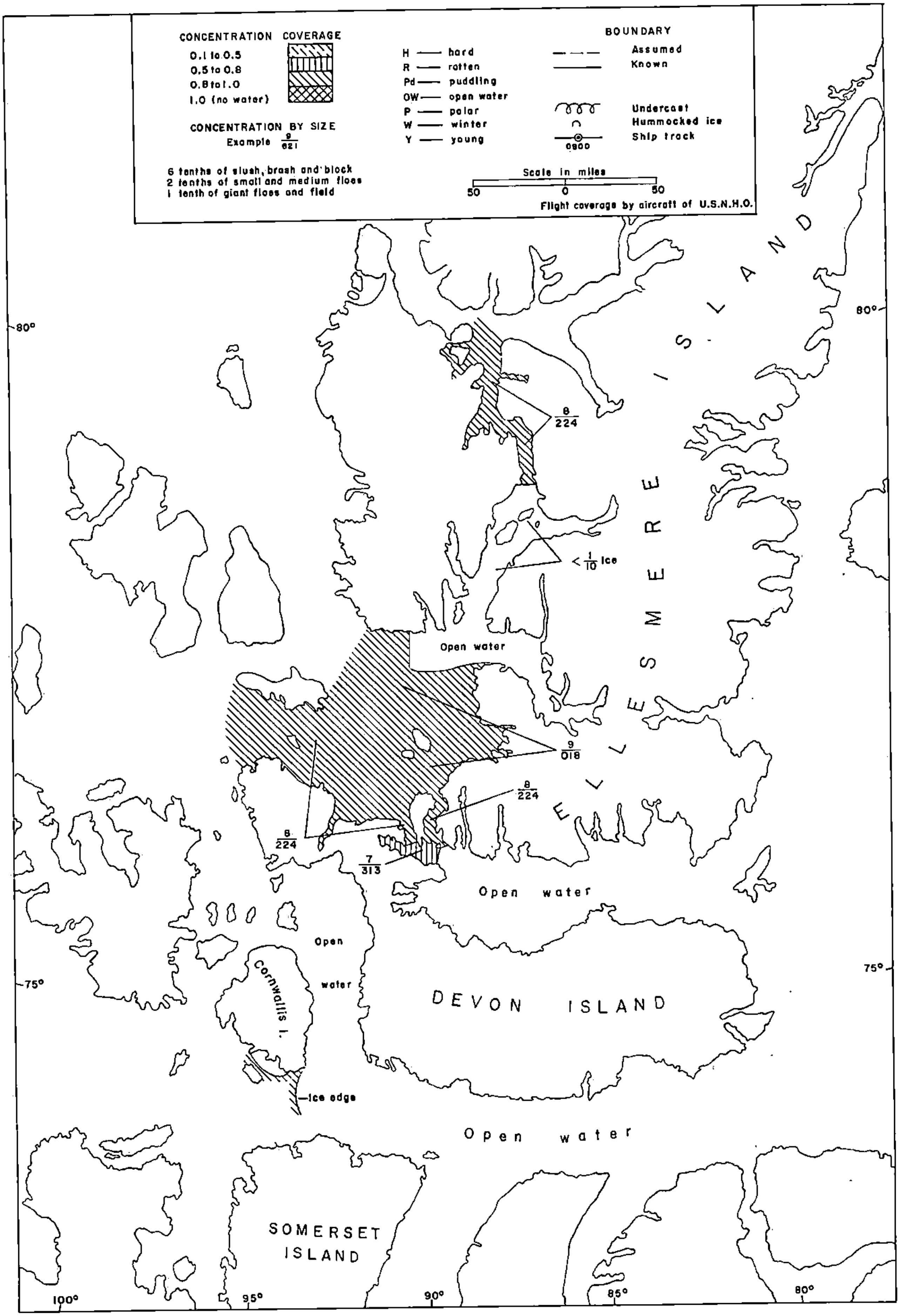


Figure 4

Ice Distribution, Lancaster Sound-Eureka Sound Area, August 19.

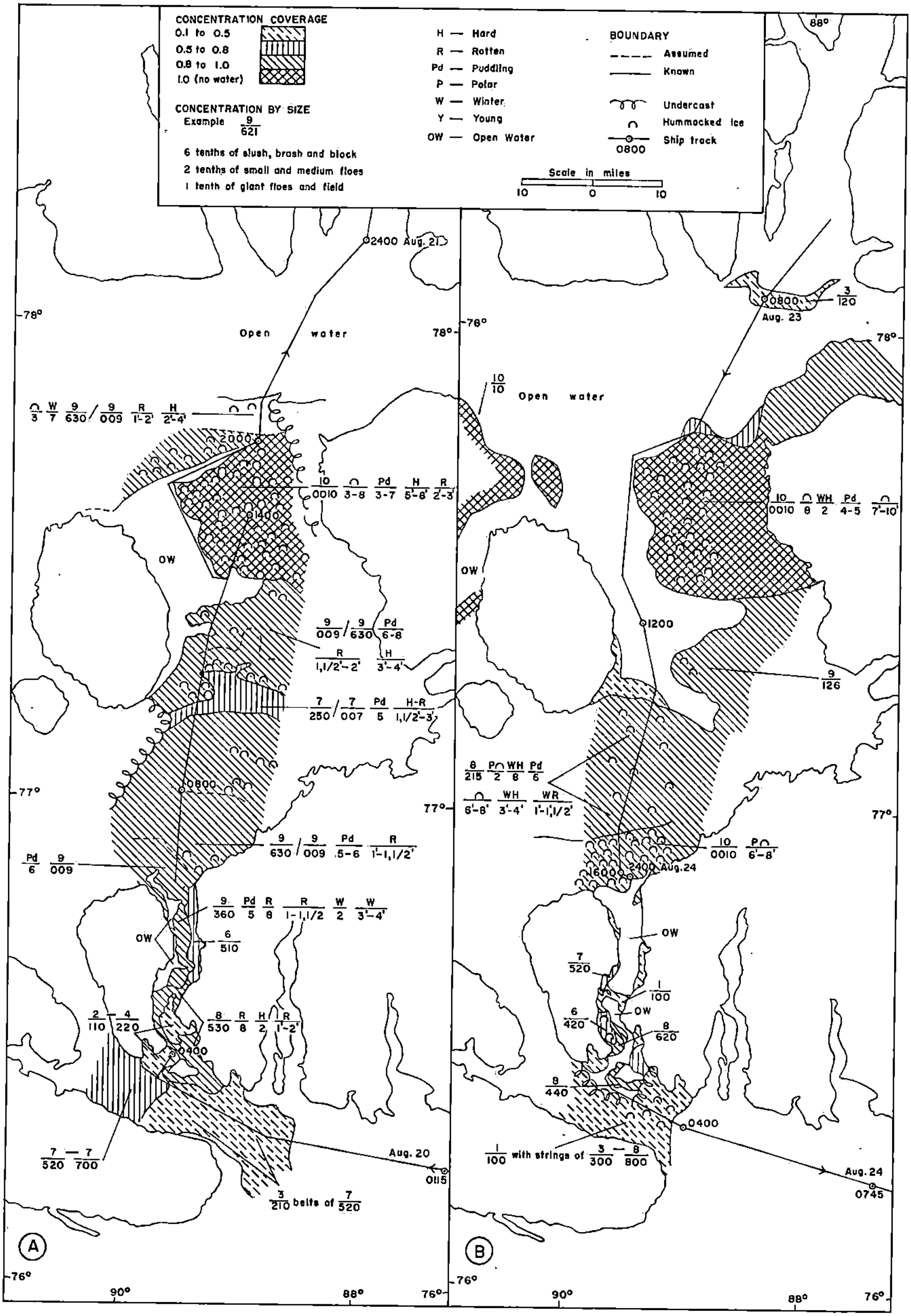


Figure 5

A. *Ice Distribution, Jones Sound, Hell Gate and Norwegian Bay, August 20.*

B. *Ice Distribution, Jones Sound, Hell Gate and Norwegian Bay, August 23-24.*

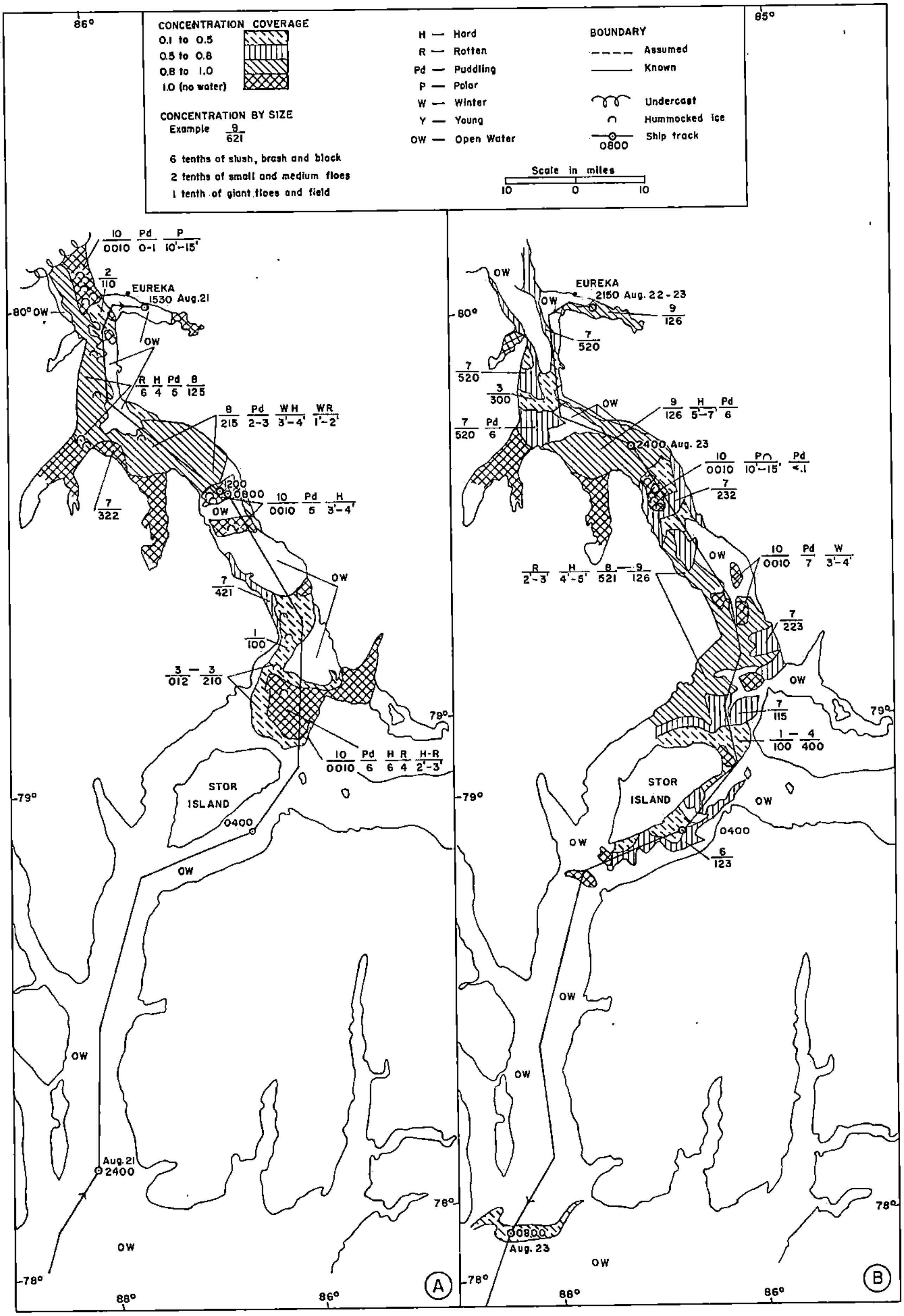


Figure 6

A. Ice Distribution, Eureka Sound, August 21.

B. Ice Distribution, Eureka Sound, August 22-23.

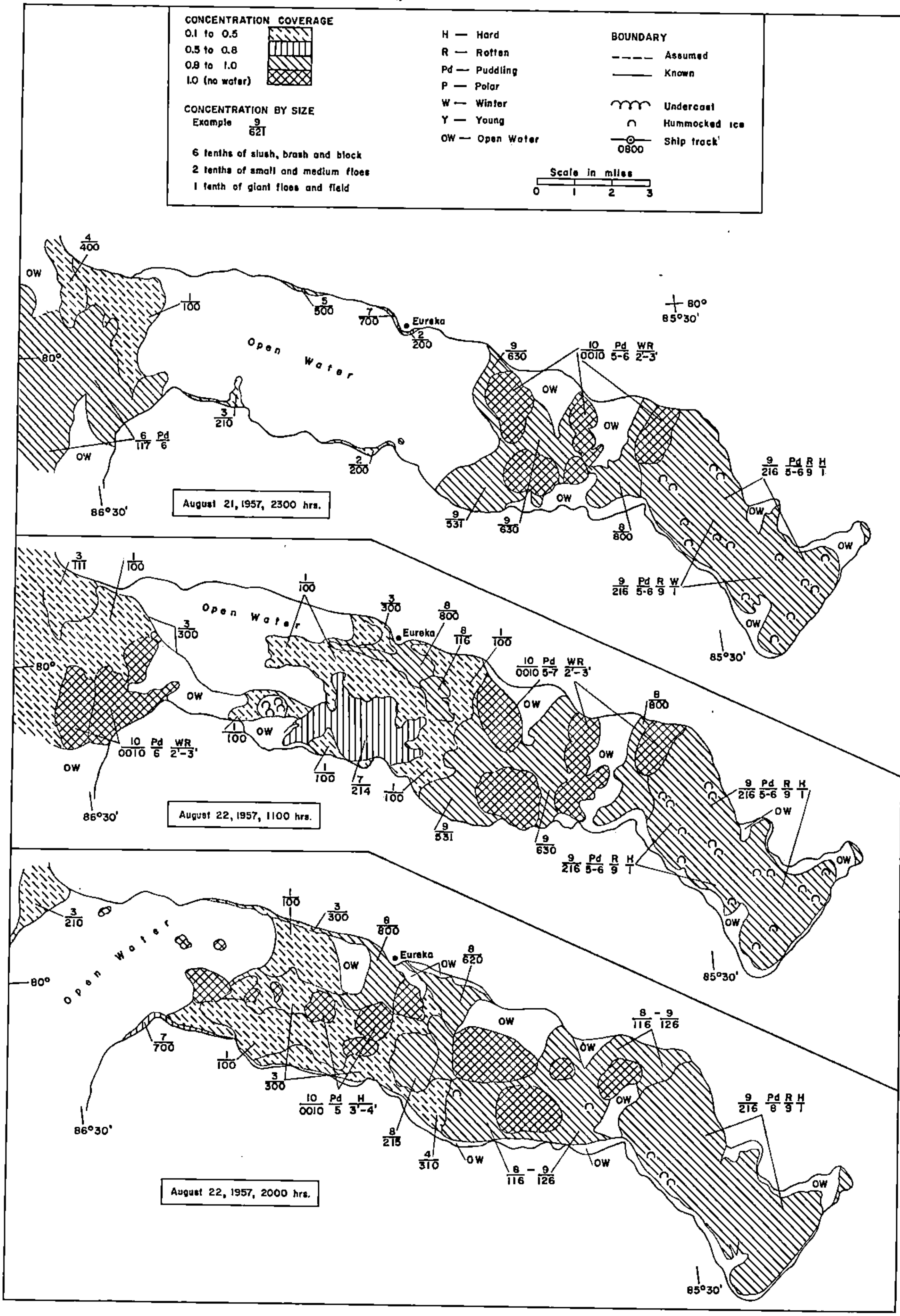


Figure 7

Ice Distribution in Slidre Fiord, August 21-22.

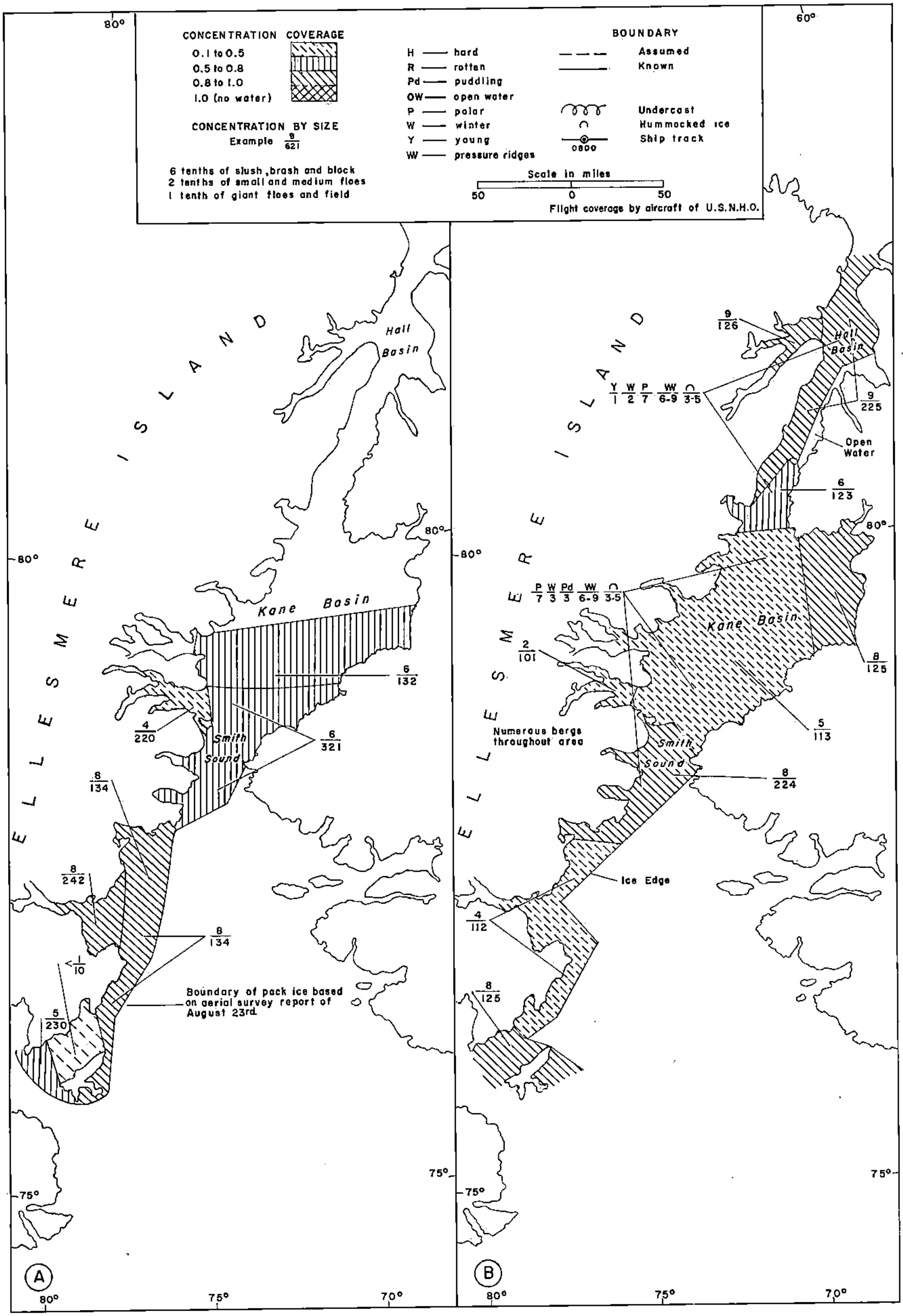


Figure 8

A. Ice Distribution, Smith Sound Area, August 23.

B. Ice Distribution, Smith Sound Area, August 26.

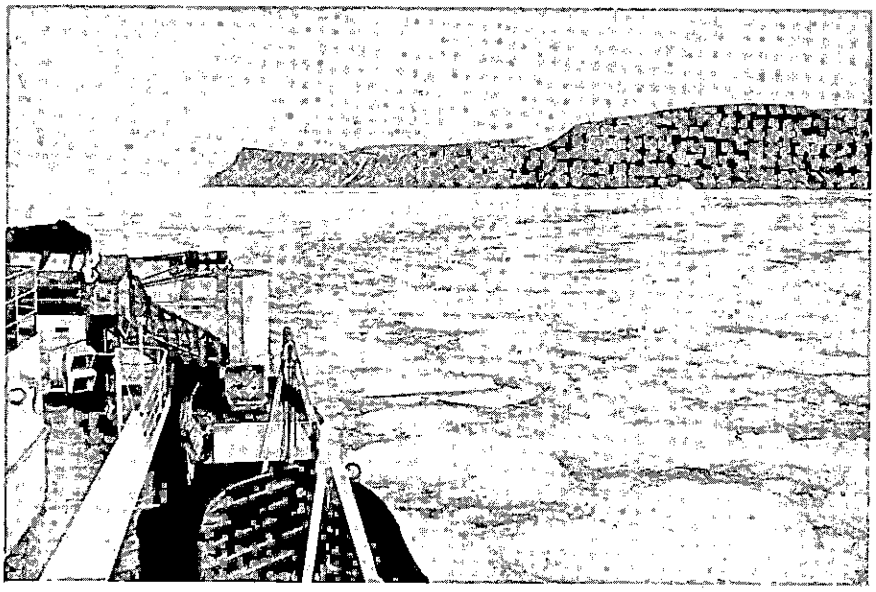


Figure 9

Calf Island, in the background, divides Hell Gate passage into two ice-congested channels. Ice coverage shown in 9/10, consisting of brash and block, and small to medium floes.

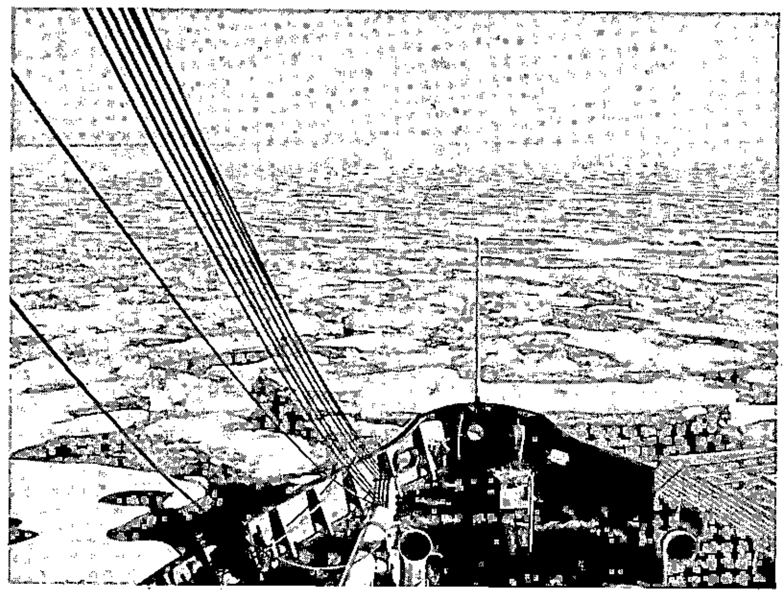


Figure 10

The icebreaker is pushing through the southern part of an extensive ice field in Norwegian Bay. In the foreground, rotten winter ice, 2 to 4 feet thick, is beginning to break up.

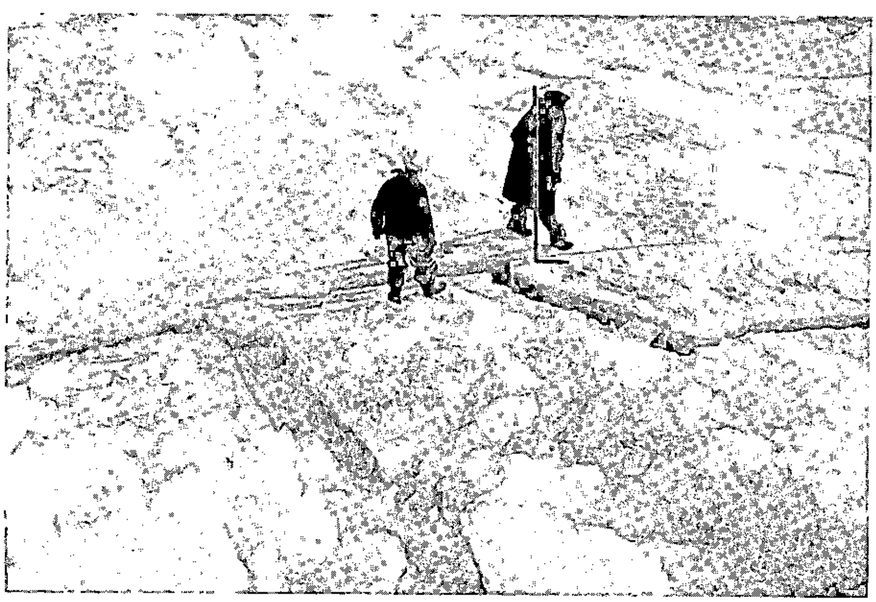


Figure 11

On August 20 the icebreaker reached 77° 45′ N. in Norwegian Bay before the field of massive winter and polar hummocked ice prevented farther progress northwards. The ice in the foreground was 7 to 10 feet thick and has been broken by the force of the icebreaker.

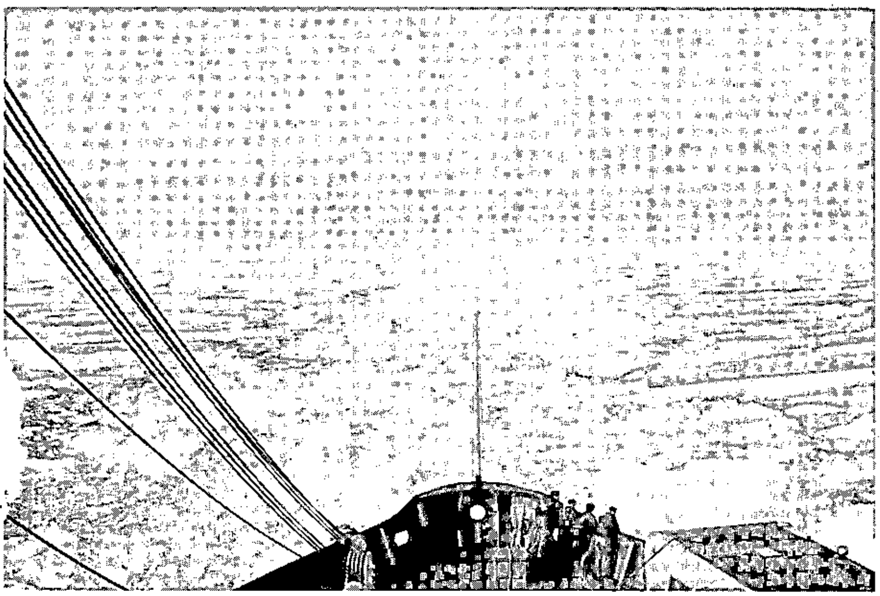
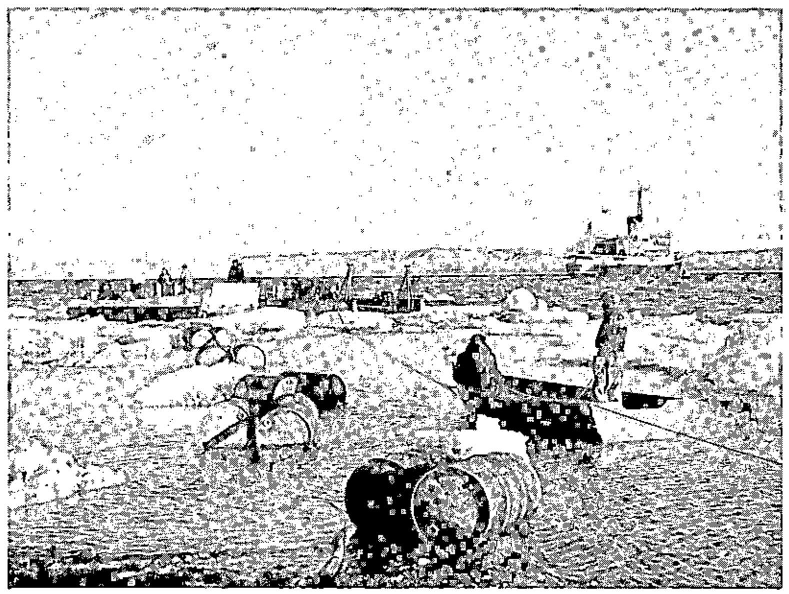


Figure 12

The ship's track is shown through a heavy icefield in northern Norwegian Bay. When further northward progress was prevented the ship had to retreat astern along its northbound track. Broken ice remains congested in the ship's wake and impedes progress.

Figure 13

Floes scattered along the shore of Slidre Fiord off Eureka prevent the barges from getting inshore to unload supplies. Fuel from the oil barge is carried by a pipeline supported by empty steel barrels.



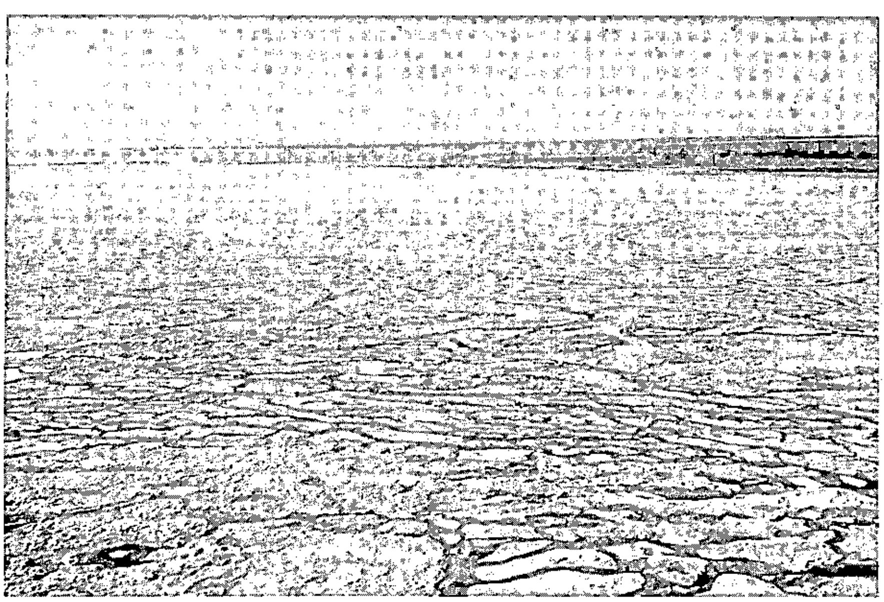


Figure 14

The icefield that covered the northern part of Norwegian Bay on August 23 was composed of 8/10 hummocked ice. Polar hummocked ice is visible (lower left); surface ice puddling is from 2/10 to 3/10.

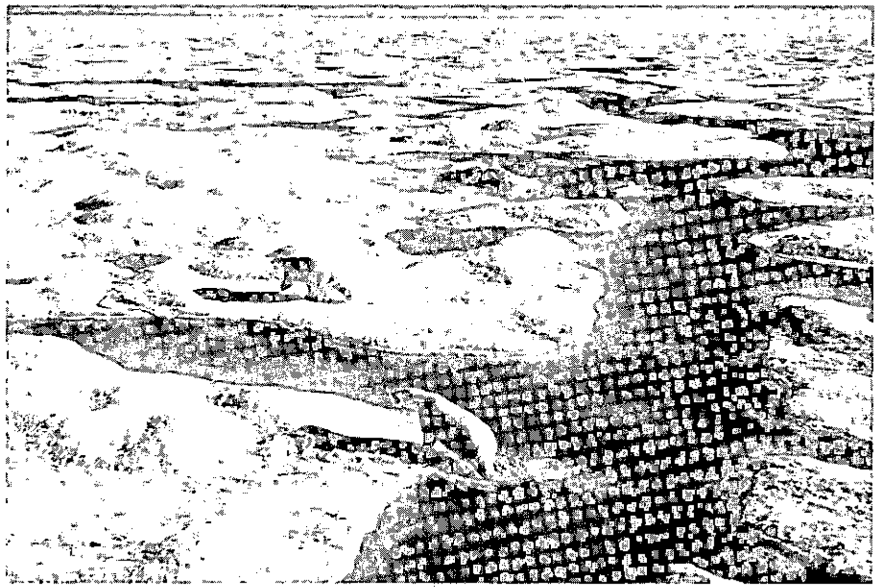
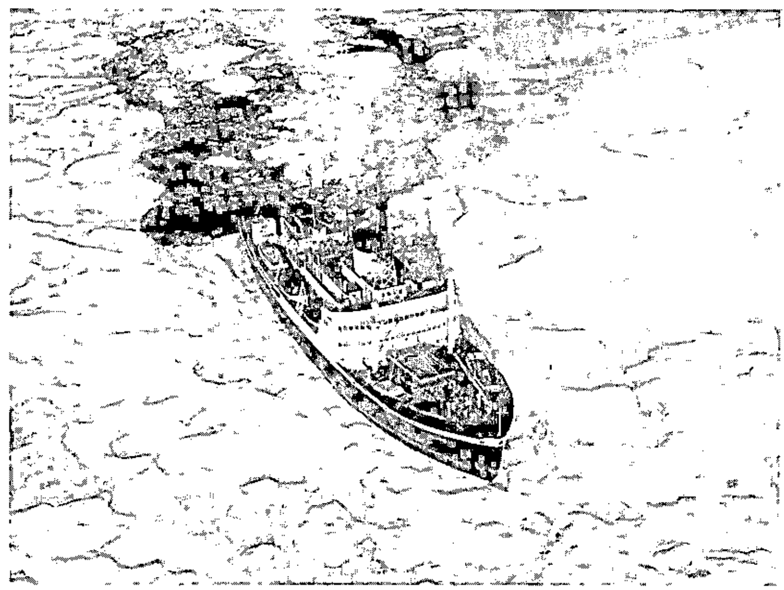


Figure 15

Hummocked ice in central Norwegian Bay varied from 5 to 8 feet in thickness. Low temperatures resulted in young or glimmer ice 1 to 2 inches thick, forming over surface puddles, that were almost sufficient to support the weight of the bears.

Figure 16

A mass of hard hummocked ice lying across the bow of the icebreaker impedes progress. The ship is drawing astern in order to ram the ice.



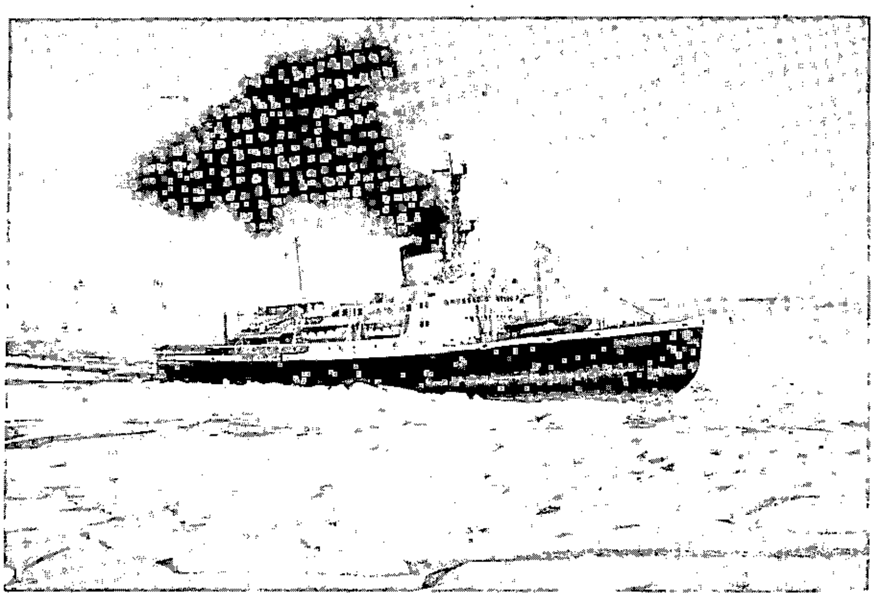


Figure 17

The icebreaker has driven well up on a mass of hummocked ice, 5 to 7 feet thick, and capable of withstanding the impact of a 5,000-ton vessel running in under full power at about 5 knots. As total ice coverage was 10/10, there was little room for manoeuvring and frequent rammings were necessary to break through.