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GEOGRAPHICAL PAPER No. 20

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W. A. Black

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Department of Mines and
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The C.G.S. *d'Iberville* steaming north in open pack ice in the central Norwegian Bay area.

PREFACE

This report is the result of the third ice reconnaissance survey of the Eastern Arctic carried out during the summer of 1958 when the northern supply ship, C.G.S. d'Iberville made her annual voyage in those waters.

The report of the 1958 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.

THE QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1959

A REPORT ON SEA ICE CONDITIONS IN THE EASTERN ARCTIC, SUMMER 1958

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 mission to Resolute, and to Eureka in northern Ellesmere Island in August, 1958.* It also outlines the relationship of ice conditions to the prevailing climatic influences that were experienced in August in the Eastern Canadian Arctic.

Ship-board ice reconnaissance was supplemented by aerial ice reports issued by the ice observers of the Meteorological Branch, Department of Transport. Flight coverage was provided by aircraft of the Royal Canadian Air Force. A special flight was made at the request of Captain C.A. Caron on August 11, to seek a route through the Baffin Bay ice fields. Again on August 17, a 5-hour ice reconnaissance flight was made to determine the condition of the ice fields in Hell Gate passage, Norwegian Bay and Eureka Sound. The ship's helicopters were regularly used on the northbound passage to determine local ice conditions in Baffin Bay, Norwegian Bay, Eureka Sound and Slidre Fiord.

The writer wishes to acknowledge the cooperation given by the ice observers of the Meteorological Branch, by RCAF personnel, and particularly by Captain C.A. Caron and officers of the d'Iberville, and also by the crew of the ship's helicopters.

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* For an account of previous ice conditions see Bibliography

REGIONAL CLIMATIC CONDITIONS

Normal, mean monthly temperatures for parts of the Eastern Canadian Arctic are given in Table I. Thawing conditions were more prevalent in June than freezing conditions, except in the western parts of the Queen Elizabeth Islands. Temperatures above freezing gave rise to surface puddling, whereas temperatures below freezing resulted in the formation of glimmer and newly formed sea ice. In July and August, as temperatures reached the 40's, ice deterioration advanced rapidly. The low August temperature for Baffin Bay (see Table I) may have been caused by the high incidence of fogs and extensive ice fields that minimized the warming influences. The deterioration of the ice fields ceased in early September and, with the rapid fall in temperature, ice forming and growth processes advanced rapidly. In Baffin Bay, the ice forming processes operated more slowly at this time.

TABLE I

Mean Monthly Temperatures (F.°)

Area	June	July	August	September
Eureka Sound Area	36	42	40	22
Western Queen Elizabeth Is.	32	41	40	22
Viscount Melville-Lancaster Sds.	35	42	42	26
Baffin Bay	35	42	36	30
Monthly Av.	34.5	41.7	39.5	25

Associated with the period of maximum temperatures were long hours of sunlight. For example, at Resolute, sunlight accounted for 47 per cent of the hours of July, 30 per cent for August, and less than 6 per cent for September. Generally sunny skies and clear weather are associated with high pressure air masses. The mean air pressure reached a maximum of 1016 to 1020 mb. for August before declining. The numerous fiords and channels of the Arctic islands usually develop

local weather conditions that diverge considerably from the regional pattern.

In the Eastern Canadian Arctic, air temperatures from June to September were above normal. In the Baffin Bay area above normal temperatures averaged 2 degrees for June, 2 degrees for July, 0 to 2 degrees for August and were normal for September. Above normal temperatures in the Queen Elizabeth Islands were higher, with the mean temperature being within 2 degrees of normal for June, over 2 degrees for July, 2 to 6 degrees for August and from 2 to 4 degrees for September. Above normal temperature conditions had existed in the Arctic throughout the winter and spring months. These abnormal temperatures had a bearing on the large quantities of ice that were released into Baffin Bay, and also for the early break-up and thin distribution of ice in Lancaster Sound, Barrow Strait, Jones Sound, Norwegian Bay and Eureka Sound. In the latter areas the season was estimated to be at least 2 weeks ahead of the 1957 season.

The general east-to-west direction of the July isotherms showed that southern Davis Strait was 2 to 3 degrees higher than northern Baffin Bay. By August the entire range in temperature between southern Davis Strait and Nansen Sound was less than 5 degrees. However, the September isotherms showed that southern Davis Strait experienced temperatures 8 degrees higher than the northern Baffin Bay-Lancaster Sound area and that temperatures in the latter area were 8 degrees higher than the Sverdrup Islands-Slidre Fiord area. Such narrow fluctuations in temperature, particularly in August, between the northern parts of Baffin Bay and southern Davis Strait have a positive bearing on the extensive ice coverage that was encountered there. The wide range in the September temperatures indicated the rapid change that took place in a short period of time between thawing and freezing processes in the northern part of the area.

There was a gradation in temperatures between the eastern and western water

areas of the Queen Elizabeth Islands. In July the eastern parts of the islands temperatures were 1 to 2 degrees higher than the western parts. By August there was a 3-degree to 4-degree difference and by September the range had increased from 4 to 8 degrees. This range in temperatures between the eastern and western parts of the Queen Elizabeth Islands coincided with the prevailing ice conditions encountered. Thus, in August, light ice coverage and open water were predominant in the Eureka Sound-Norwegian Bay areas; whereas, in the western bays and channels ice coverage exceeded 9/10 concentration. The September range of temperatures indicated that ice consolidation was more advanced than in the eastern channels of the Queen Elizabeth Islands.

GENERAL ICE CONDITIONS
(Figures 1,2,3,4)

Ice conditions throughout the re-supply mission area were variable. On August 4 the Baffin Bay ice extended from the Baffin Island coast eastward to about the 61st meridian. Open pack ice with a concentration of 1/10 to 5/10 flanked the eastern edge of the ice field; the heaviest ice concentration, 5/10 to 8/10, extended westward to Baffin Island. By August 11, the close pack ice moving southward from Smith Sound was breached about 74° 30' N by an area of open ice with concentrations of 1/10 to 4/10. The forecast for August 22 indicated that the Baffin Bay ice would extend northward from the coast at Clyde Inlet as a rectangular wedge, with ice concentrations varying from very open to close pack. Although the area of close pack ice was assumed to lie well to seaward, actually an area of close pack ice, 5/10 to 8/10, lay against the Baffin coast in the vicinity of Clyde Inlet on August 26.

In Lancaster Sound and Barrow Strait on August 4, extensive open water areas separated areas of pack ice of 1/10 to 3/10 and 7/10 concentrations. Ice coverage

in Jones Sound varied from 5/10 to 8/10 with the heaviest concentration on the southern side of the sound. By August 9 Lancaster and Jones sounds were almost ice free. After August 16 belts of ice continued to drift eastward into Lancaster Sound from Barrow Strait, and southward into the sound from Wellington Channel and into the northeastern entrance of the sound from Baffin Bay. Jones Sound on August 17, was mainly ice free.

The 'North Open Water' of Baffin Bay on August 4, consisted only of two large areas of water, one at the eastern entrance to Lancaster Sound, and one east of Jones Sound. A belt of ice varying in concentration from 2/10 to 7/10 separated the two bodies of water. On August 9, the 'North Open Water' area extended from the eastern entrance of Lancaster Sound northeastward to Smith Sound. By August 11 a broad movement of ice southward from Smith Sound extended over the open water area and pushed into the eastern entrance to Lancaster Sound. By August 22 this ice had drifted southward, leaving northern Baffin Bay virtually ice free except for scattered floes, bergy bits and icebergs.

Norwegian Bay on August 5, was 9/10 covered; by August 9 ice coverage varied from 3/10 in the south to 9/10 in the central area and to open water in the northern part of the bay. Ice coverage on August 17 of 7/10 to 9/10 concentration covered the eastern side of the bay, the remainder of the bay being largely open water or covered with open pack ice. On August 20, ice coverage in the southern part of the bay varied from 1/10 to 5/10; however, by August 23 the open water that had covered the northern half of the bay, together with surface areas of less than 1/10 ice concentration almost extended to Hell Gate passage.

Hell Gate passage and Cardigan Strait on August 4, were from 1/10 to 5/10 ice covered; on August 5, ice concentration was from 1/10 to 3/10. On August 9, both passages were ice free. By August 17 ice again began to move through the

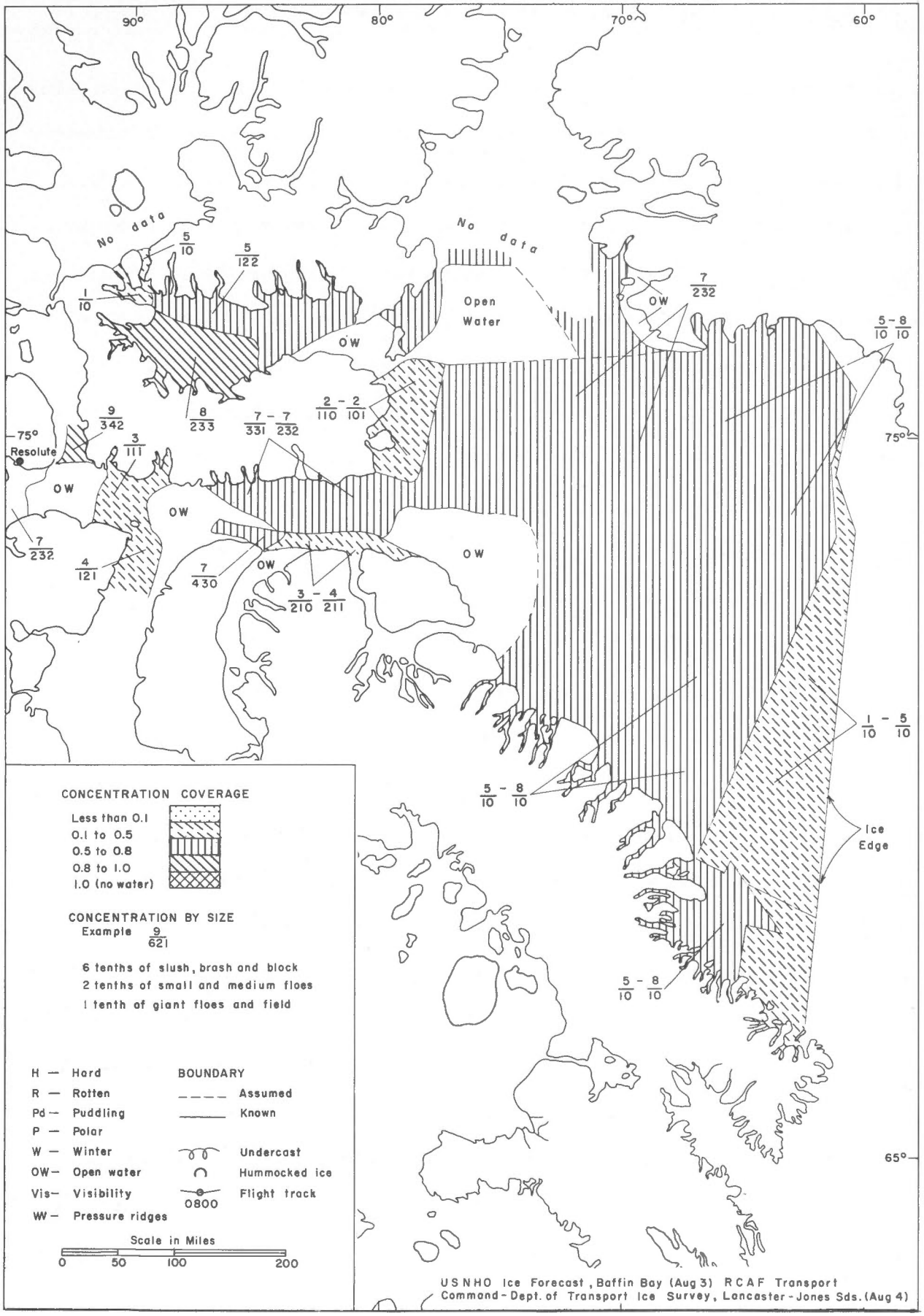

Figure 1. Ice Distribution, Davis Strait–Baffin Bay, August 3; Lancaster Sound–Jones Sound, August 4.

passages from Norwegian Bay. Thus on August 20, ice coverage in Hell Gate varied from 1/10 to 7/10, and by August 23 the concentration in this passage had increased markedly, with patches of ice occupying the western end of Jones Sound.

Ice concentration in Eureka Sound on August 5, varied from 3/10 in the southern part, to open water areas in the central part, and to 8/10 in the northern part of the sound. The southern one-third of Eureka Sound on August 9 was ice free; however, in the remainder of the sound ice concentrations were from 5/10 to 8/10 with ice drifting rapidly southward from Nansen Sound. By August 17 open water extended from Norwegian Bay to Stor Island; ice coverage of 1/10 to 3/10 extended to the northern entrance of the sound. Nansen Sound was mainly open water. On August 20-21 ice coverage on the upper two-thirds of the sound varied from 1/10 to 8/10, but by August 22 the ice in this area was reduced to 1/10 coverage except for scattered areas of 1/10 to 8/10 concentration.

In Slidre Fiord, on August 5, ice concentration of 5/10 occupied the southern half of the fiord; the northern part was ice free. By August 9 concentrations in the southern part of the fiord had increased to 7/10, whereas the northern part still remained ice free. On August 17, ice coverage of 7/10 occupied the eastern two-thirds of the fiord, but the entrance area of the fiord was ice free. Ice coverage in the fiord on August 21, varied from 1/10 to 3/10 in the western third of the fiord, to 5/10 to 9/10 in the eastern two-thirds; however, by August 22, the outgoing tide had carried out much of the ice except from the eastern end.

In contrast to the 1957 summer season, ice conditions in Baffin Bay were unusually heavy with the ice fields extending through August into September. As 1/10 to 2/10 of the ice coverage consisted of heavy, hummocked floes, it appeared that much of the ice had entered Baffin Bay from northern sources through Smith Sound. Except for the hummocked ice, the ice coverage consisted of small to medium floes,

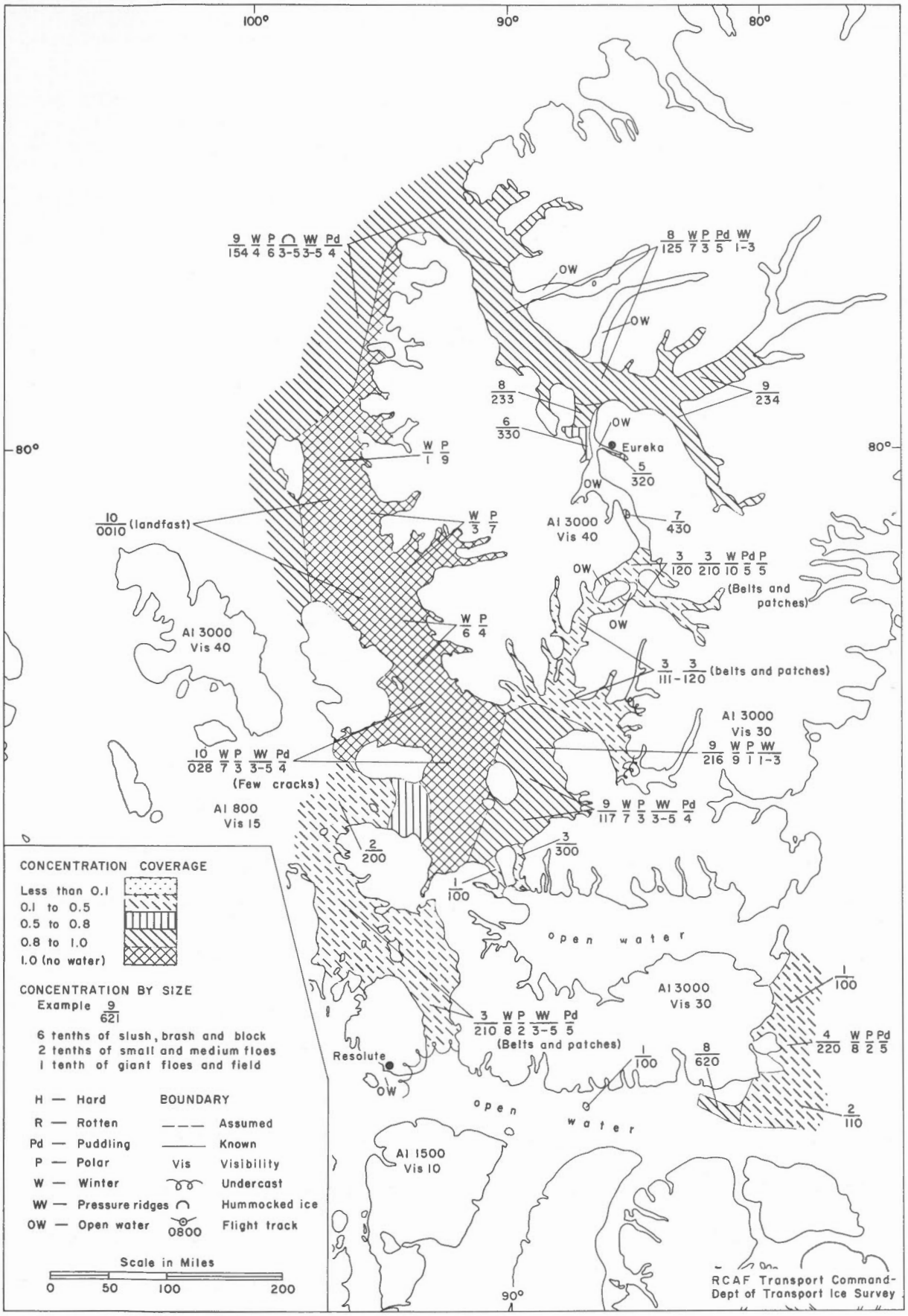

Figure 2. Ice Distribution in the Central Canadian Arctic, August 5.

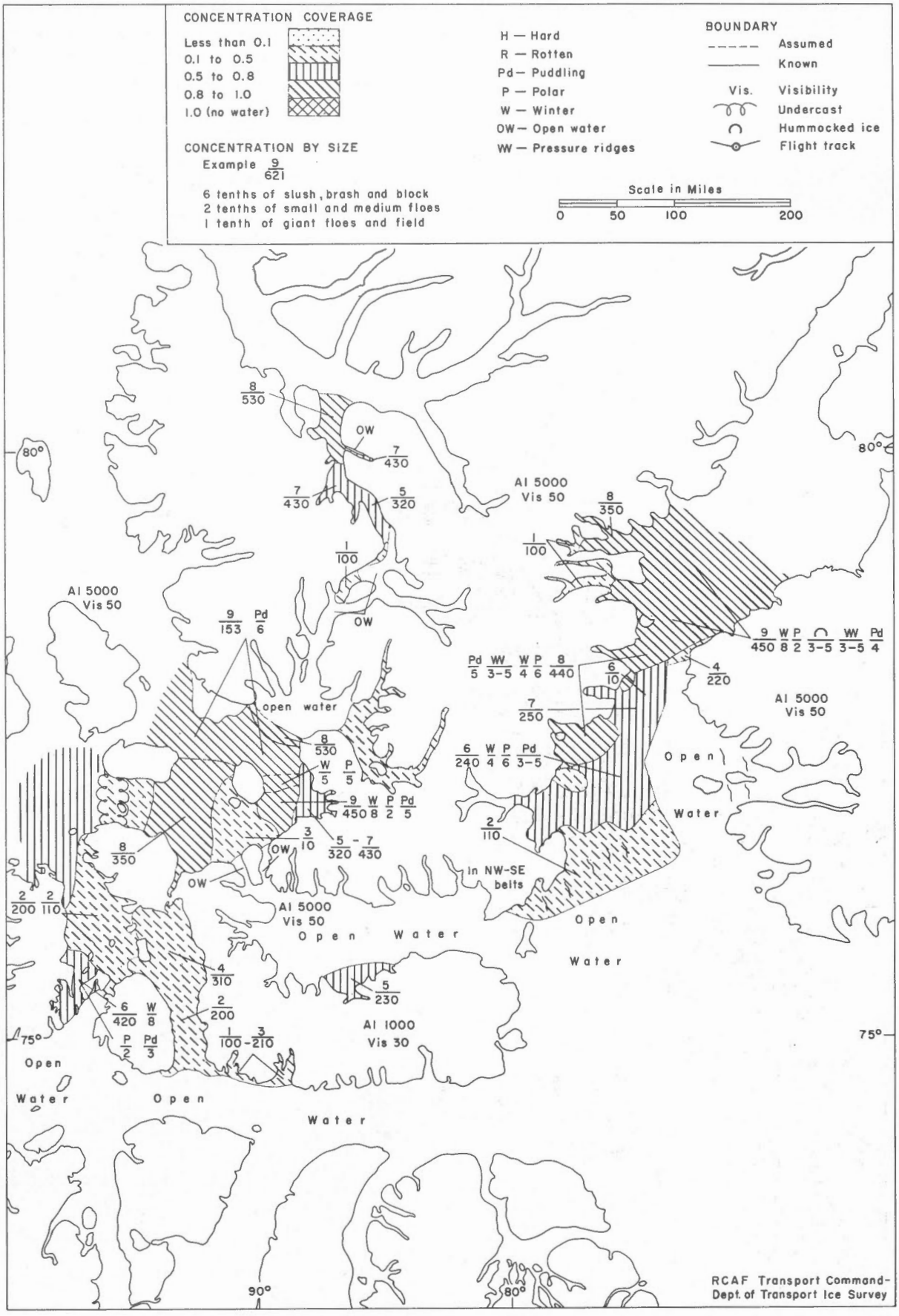

Figure 3. Ice Distribution in the Central Canadian Arctic, August 9.

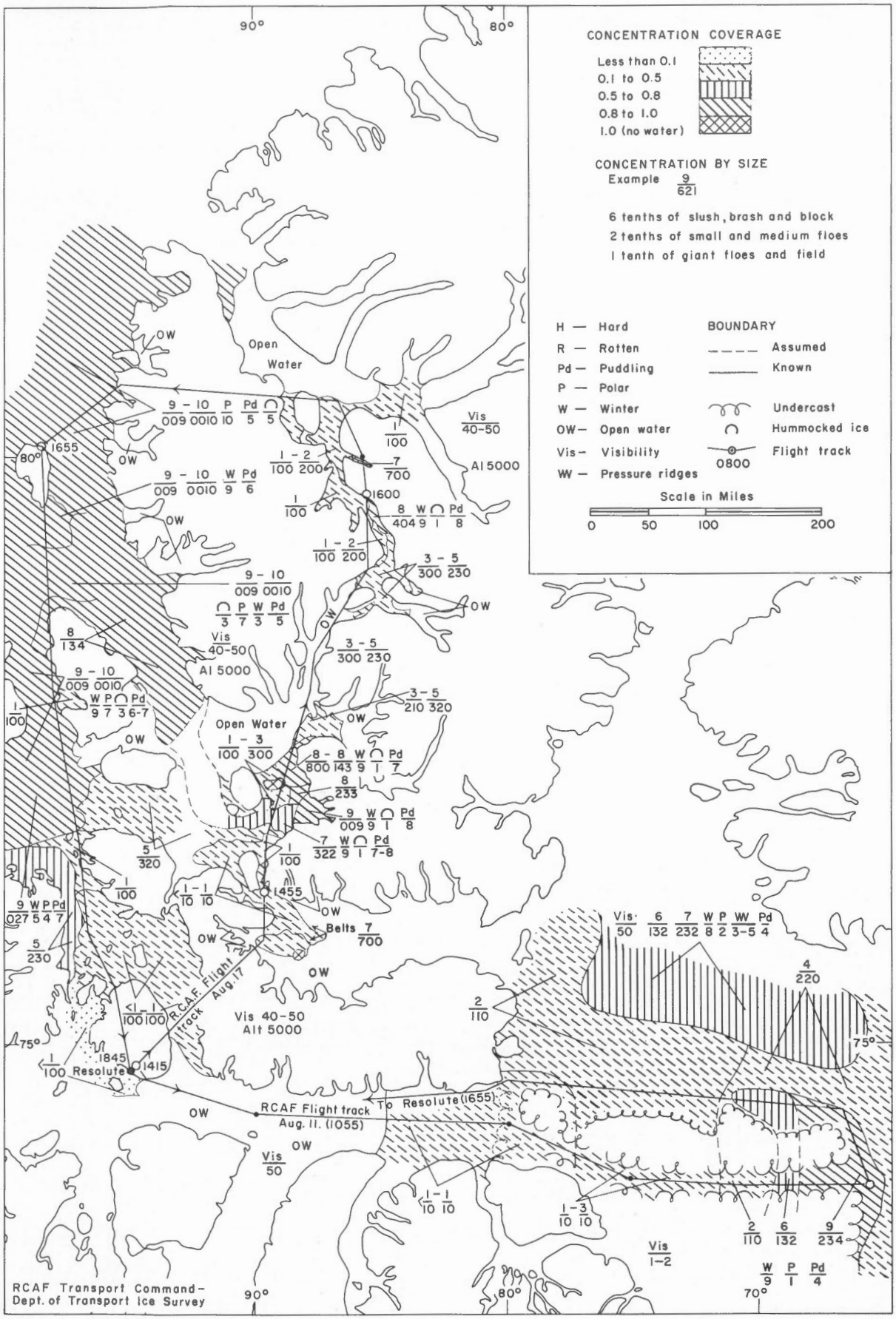

Figure 4. Ice Distribution in the Central Canadian Arctic, August 11, 17.

4/10 to 5/10 puddled and from 2 to 3 feet thick. In the channels and bays extending from Barrow Strait to Eureka Fiord ice conditions in 1958 were considerably lighter, with similar ice coverage being about 2 weeks earlier than in 1957. The ice generally consisted of small to medium floes, although large floes and fields were experienced in Norwegian Bay. Flat, rotten, winter ice was generally 1 to 2 feet thick, with hard, hummocked, ice from 4 to 7 feet thick. Surface puddling varied from 5/10 to 8/10 of the ice surface. Icebergs and bergy bits were scattered throughout the area of the re-supply route, but were particularly concentrated in northeastern and northwestern parts of Baffin Bay.

ICE CONDITIONS: BAFFIN BAY-DAVIS STRAIT
(Figure 5: August 5-14)
(Figure 6: August 25-28)

Ice Distribution

The ice forecast for August 3 (Figure 1), indicated that the ice pack would lie to the west of 60° 30' W and extend from the Baffin coast northward to the Greenland coast. Concentrations forecast along the ice edge showed a range from 1/10 to 5/10, but to the west of this, ice concentrations varied from 5/10 to 8/10.

The ship's course during the northbound voyage from August 5 to 7 lay to the east of the pack in open water. From August 7 to 15 the ship passed through ice until it entered Lancaster Sound. Along the ice edge ice concentrations of 1/10 alternated with areas of 1/10 to 3/10; small to medium floes predominated. To the west, ice coverage varied from 5/10 to 9/10 with large floes and fields predominating (Figure 5).

The pack-covered area was gradually reduced so that the forecast of August 22 showed that the ice would occupy a rectangular wedge extending northward of Clyde Inlet. On the return journey of August 26, the ship passed through the southern

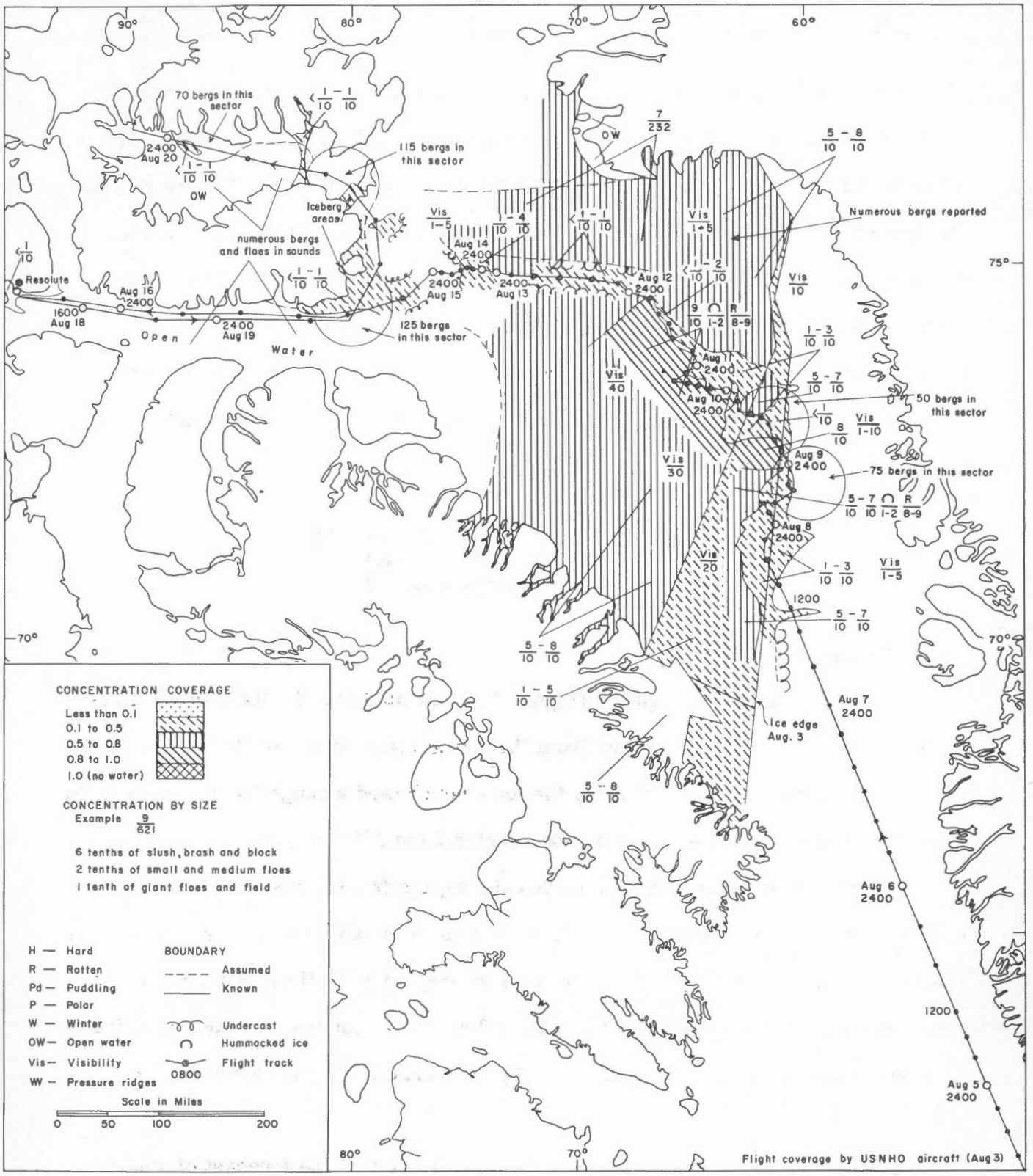

Figure 5. Ice Distribution, Davis Strait–Baffin Bay, August 5–14; Lancaster Sound–Jones Sound, August 15–20.

part of the wedge. Ice concentration varied from 5/10 to 8/10, and small to medium floes predominated (Figure 6).

Factors Affecting Distribution

The rapid deterioration of ice fields depends upon air and water temperatures supported by wind and wave action. Movement of the ice is related to the direction and velocity of the prevailing winds, tides and currents.

The heavy ice concentration encountered by the ship in Baffin Bay resulted from the release of heavy ice through Smith Sound. Local weather conditions favoured a slow deterioration of the ice. Foggy weather prevailed during 67 per cent of the period, and overcast and cloudy weather for 32 per cent, thereby reducing the amount of insolation to about 1 per cent.

Winds tend to drive ice floes into strings and belts or to open up a pack by driving the ice outward. During the northbound voyage 50 per cent of the winds blew from the W-NW-N quadrant and provided an explanation for the open scattered pack that bordered the eastern edge of the ice fields. On the return journey NE-E-SE winds were predominant. Wind speeds were generally from 1 to 10 m.p.h. but calms were frequent; occasionally wind speeds exceeded 11 m.p.h. The extensive coverage of close pack that covered much of Baffin Bay was brought about for the most part by weak winds.

In conjunction with local weather conditions the slow disintegration of the Baffin Bay ice resulted from the state of the sea. From August 7 to 14, and August 25 to 26 there was no swell and the surface was calm and glassy. In the open water areas the swells were less than 6 feet and the surface of the sea was broken only by ripples and occasionally by wavelets.

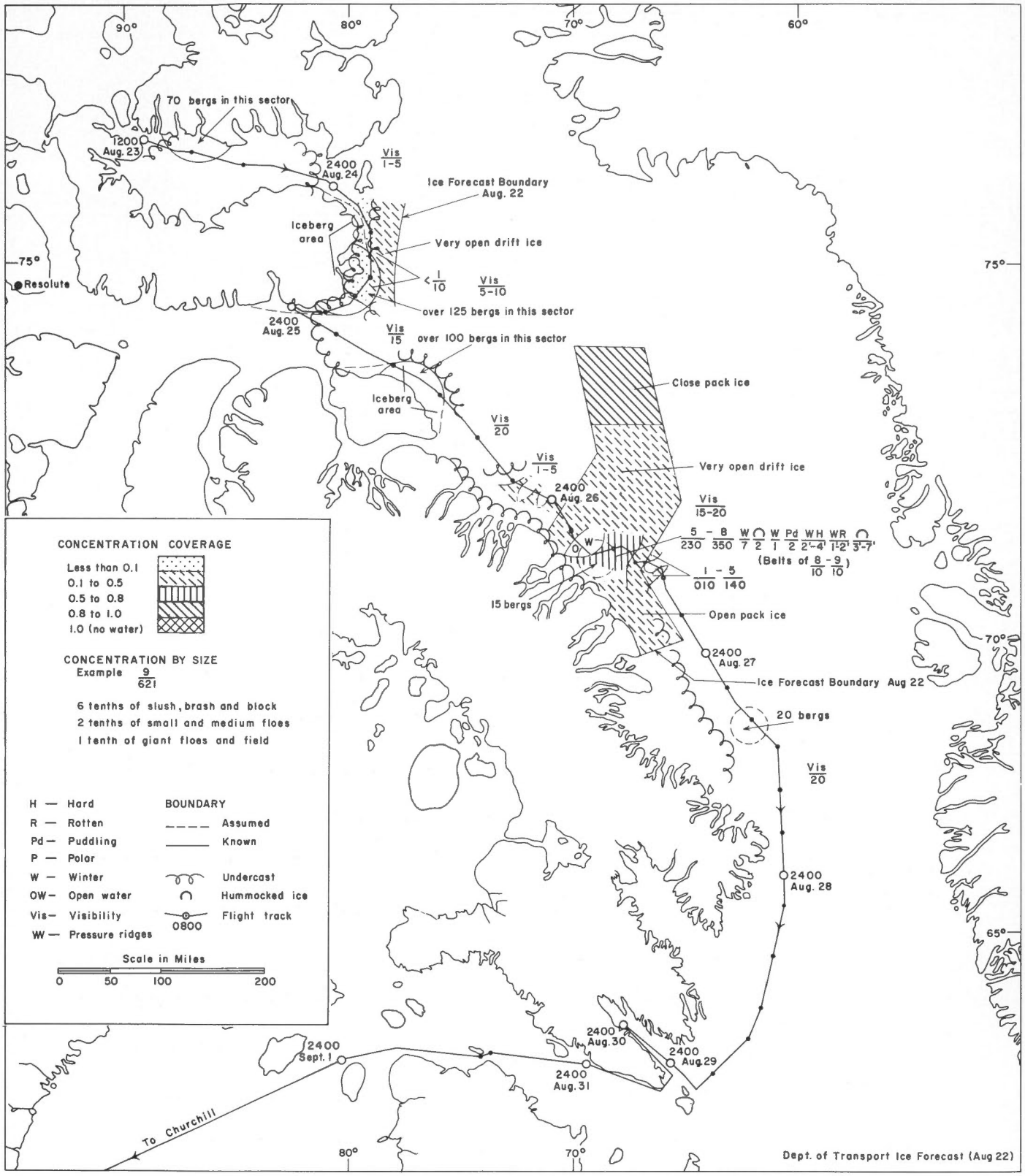

Figure 6. Ice Distribution, Jones Sound, Baffin Bay and Davis Strait, August 23–30.

TABLE II

Daily temperatures, Baffin Bay - Davis Strait, August 5-14, 25-28

Day	Air (F.°)			Surface Water (F.°)			Sub-surface Water (F.°)		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Aug. 5	38	46	42.6	42	45	43.0	42	45	42.8
Aug. 6	37	43	39.6	39	43	42.5	36	42	39.6
Aug. 7	29	40	35.5	31	39	34.0	30	38	33.8
Aug. 8	30	36	35.1	31	34	31.6	29	36	32.3
Aug. 9	27	42	33.5	29	33	31.1	29	34	31.5
Aug. 10	30	46	37.0	29	32	30.3	28	32	29.8
Aug. 11	30	41	34.6	29	30	29.3	28	30	28.8
Aug. 12	29	36	31.5	28	32	29.5	28	31	29.3
Aug. 13	30	34	31.8	31	32	31.5	30	33	30.8
Aug. 14	30	33	30.8	29	33	31.6	29	32	30.1
Aug. 25	30	41	34.1	34	37	36.0	35	38	39.8
Aug. 26	28	39	33.0	29	36	31.8	29	38	32.1
Aug. 27	32	41	36.3	36	37	36.8	36	39	37.1
Aug. 28	38	48	42.1	37	41	39.6	38	40	39.6
Daily Av.	31.3	40.4	35.5	33.8	36	34.2	31.9	36.3	34.1

Air temperatures stood well above freezing but were variable (Table II). The average minimum air temperature was 31.3°F., average maximum 40.4°F. and daily average was 35.5°F. As the temperatures for the northbound voyage were similar to those recorded on the southbound voyage, the general air temperatures for the intervening part of August were uniform. Of some 84 recordings taken during the 14-day period at regular 4-hour intervals, 28 per cent dropped to 32°F. or lower. In the ice covered areas about 50 per cent of the readings recorded freezing temperatures; whereas, in the ice free areas minimum temperatures generally stood well above freezing. Minimum air temperatures recorded over water tended to be 7 to 8 degrees higher than those recorded over ice; for maximum temperatures the range was from 10 to 15 degrees. Temperatures were sufficiently low from August 7 to 14 for glimmer ice to form on the fresh water surface pools and for new ice to form over the sea water. Thawing temperatures prevailed sufficiently from

day to day for puddling to reach 1/10 to 2/10 on hummocked floes, and from 3/10 to 5/10 on level winter floes.

Surface and sub-surface* water temperatures followed a pattern that corresponded closely to air temperatures (Table II). Water temperatures recorded in the ice free area of Baffin Bay were considerably higher than those recorded within the ice fields. About 25 per cent of the surface water and 28 per cent of the sub-surface water temperatures recorded within the ice fields were 29°F. or lower. Thawing processes were thus frequently interrupted by daily periods of freezing conditions.

Table III indicates temperature effectiveness for air, surface and sub-surface waters. The daily heat accumulative temperature for air was 7.8°F., for

TABLE III

Daily heat accumulative temperatures, Baffin Bay-Davis Strait, Aug. 5-14; 25-28

Date	Air (F.°)*	Surface Water (F.°)**	Sub-surface Water (F.°)**
Aug. 5	20	29	29
Aug. 6	16	24	20
Aug. 7	5	12	10
Aug. 8	2	7	7
Aug. 9	5	4	5
Aug. 10	12	3	2
Aug. 11	7	1	0
Aug. 12	1	2	1
Aug. 13	0	5	5
Aug. 14	-1	4	3
Aug. 25	7	13	15
Aug. 26	3	7	9
Aug. 27	11	15	17
Aug. 28	22	20	20
Daily Av.	7.8	10.4	10.2

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

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

* Sub-surface water temperatures are taken at the ship's intake, located 26 feet below the surface.

surface water 10.4°F. and for sub-surface water 10.2°F. The accumulative daily heat level for the entire period was positive (above freezing). However, in the areas of the ice fields the temperature levels were considerably lower - 4.0°F. for air, 5.1°F. for surface water and 5.3°F. for sub-surface water. Although the temperatures were positive, the duration of thawing conditions maintained an advantage over freezing conditions.

The daily average cumulative temperature range of air, surface water and sub-surface water is given in Table IV. Highest temperatures for air occurred from 1200 to 1600 hours. For surface and sub-surface waters the temperatures were remarkably uniform, but in the ice fields the highest temperatures generally occurred from 1200 to 2400 hours, and in open water areas from 0400 to 1200 hours.

TABLE IV

Baffin Bay - Davis Strait, August 5-14, 25-28

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.	33.3	35.0	39.8	38.2	34.2	33.0
B. Av. cum. temps.	33.4	34.6	34.8	34.0	34.5	33.6
C. Av. cum. temps.	33.9	33.8	34.3	33.3	33.8	34.3

The cumulative effect of low insolation, low wind speeds, calm sea and the daily occurrence of effective freezing conditions was to retard thawing of the Baffin Bay ice fields.

ICE CONDITIONS: LANCASTER SOUND - BARROW STRAIT
(Figure 5: August 15-18)

Ice Distribution

The ice survey of August 3 (Figure 1), indicated that deterioration of the ice fields was occurring simultaneously throughout the area rather than progressing from east to west. Concentrations generally varied from 3/10 to 7/10. The ice fields disappeared rapidly and from August 5 onward the Lancaster Sound-Barrow Strait area was mainly ice free (Figures 2,3,4).

The ship's course to and from Resolute between August 15 and 18 was mainly in open water except for scattered patches of ice where concentrations were less than 1/10. This ice entered Lancaster Sound from Wellington Channel and Barrow Strait, continued to drift eastward and disappeared shortly after entering the sound. During most of August, open pack ice continued to drift in and out of the sound from Baffin Bay.

The harbour at Resolute was ice free except for scattered floes aground off the Eskimo village.

Factors Affecting Distribution

The rapid disappearance of the ice fields in Lancaster Sound-Barrow Strait area may be explained in part by high air and water temperatures. Local weather conditions favoured a rapid deterioration of the ice; for the period August 15 to 18 sunny, clear, weather with occasional overcast periods prevailed. Similar weather conditions were reported during the first half of August.

During the period August 15 to 18, 42 per cent of the winds recorded blew from a SW-W-NW quadrant with speeds of 1 to 6 m.p.h.; the remaining 58 per cent of the recordings indicated calms.

The sea during this period had no swell, and its surface was calm and glassy. Tidal action seemed strong because of the eastward drift of the ice during calms (about 2 m.p.h.).

Air temperatures recorded corresponded to those taken in the ice free waters of southern Baffin Bay (Table V). The average minimum air temperature was 37.5°F., average minimum 50.2°F. and daily average was 43.3°F. Of some 24 recorded temperature readings taken during this 4-day period none reached 32°F, the lowest being 33°. This reading was taken at the eastern entrance to Lancaster Sound. On the basis of the high temperatures experienced at this time and the clear, sunny, weather that prevailed during the first half of August, conditions were unusually favourable for the deterioration of the ice fields in the channels and bays of the Queen Elizabeth Islands.

TABLE V

Daily temperatures, Lancaster Sound - Barrow Strait, August 15-18

Day	Air (F.°)			Surface Water (F.°)			Sub-surface Water (F.°)		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Aug. 15	33	45	39.3	35	37	35.8	34	36	35.1
Aug. 16	39	50	44.1	35	40	38.1	33	38	34
Aug. 17	40	53	46.3	37	38	37.5	31	34	32.3
Aug. 18	38	53	43.8	36	40	38.5	32	38	34.8
Daily Av.	37.5	50.2	43.3	35.7	38.7	37.4	32.5	36.5	34.0

Surface and sub-surface water temperatures followed a similar pattern to air temperatures (Table V). No temperatures were recorded below 29°F. These high water temperatures were favourable for the rapid deterioration of ice entering the Barrow Strait-Lancaster Sound area.

Table VI indicates temperature effectiveness for air, and for surface and sub-surface waters. The daily heat accumulative temperature for air was 23.7°F., for

surface water 16.5°F. and for sub-surface water 11.0°F. The high levels of positive heat accumulation were well above those for Baffin Bay but were similar to those recorded in the ice free area of the southern part of the Bay. Only in the sub-surface waters were the heat levels similar. The high heat levels were maintained in both Lancaster Sound and Barrow Strait and account for the rapid reduction of the ice as it drifted into these channels.

TABLE VI

Daily heat accumulative temperatures, Lancaster Sound-Barrow Strait, Aug. 15-18

Date	Air (F.°)*	Surface Water (F.°)*	Sub-surface Water (F.°)*
Aug. 15	14	14	12
Aug. 16	25	17	13
Aug. 17	29	17	7
Aug. 18	27	18	12
Daily Av.	23.7	16.5	11.0

* See Table III.

Table VII indicates the daily average cumulative temperature range for air, surface water and sub-surface water. Highest air temperatures occurred in the early afternoon, and lowest temperatures before dawn. For surface and sub-surface

TABLE VII

Lancaster Sound - Barrow Strait, August 15-18

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.	37.5	40.5	49.2	47	45.7	40.7
B. Av. cum. temps.	36.5	37.7	38	38	37.5	37
C. Av. cum. temps.	35.5	32.7	33	34.7	34.2	34.2

waters the temperatures were relatively uniform, but surface water temperatures tended to be higher from 1200 to 2400 hours; sub-surface temperatures tended to be higher from 1600 to 0400 hours. Thus the most effective thawing conditions generally occurred from noon to about midnight.

The cumulative effect of clear, sunny, skies together with high air and water temperatures was to rapidly reduce the ice fields that existed in this area in the early part of August.

ICE CONDITIONS: JONES SOUND - EUREKA SOUND (Figures 7,8,9: August 20-23)

Ice Distribution

The main changes in the distribution of sea ice in this area from August 4 to August 24 are shown in Figures 1 to 6. Figures 7 to 9 show the details of the ice coverage on the ship's northbound and southbound voyages to and from Eureka at Slidre Fiord.

Air reconnaissance on August 4 (Figure 1), indicated that Jones Sound was largely ice covered. The air reconnaissance of August 5, (Figure 2), showed Jones Sound to be open water, and Wellington Channel, Queen's Channel, Penny Strait and the western part of Belcher Channel to have ice concentrations of 2/10 to 3/10. Ice concentrations in northern Norwegian Bay and Eureka Sound were also light, varying from extensive open water areas to ice coverage of 3/10. Between these two major areas of light ice coverage lay a large area of heavy concentrations that extended from Norwegian Bay diagonally northwestward to the Arctic Ocean. Ice coverage varied from 9/10 to 10/10, and consisted mainly of giant floes and fields. This ice varied in age from 7/10 winter and 3/10 polar to 1/10 winter and 9/10 polar; pressure ridging varied from 3/10 to 5/10 and surface puddling amounted to 4/10 of the ice surface. On this date sharp cracks, indicative of imminent break-up

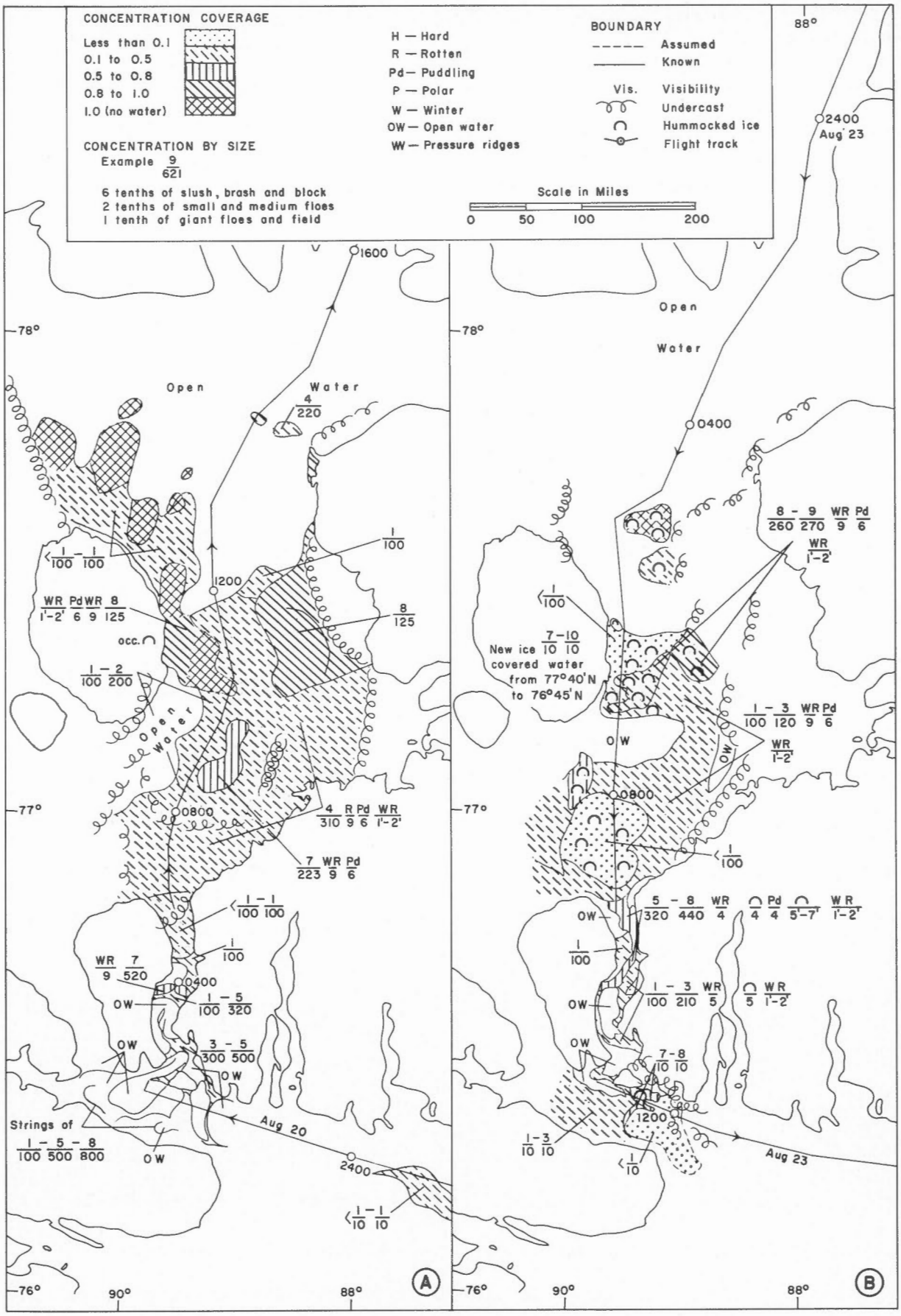

Figure 7. A. Ice Distribution, Jones Sound, Hell Gate and Norwegian Bay, August 20.

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

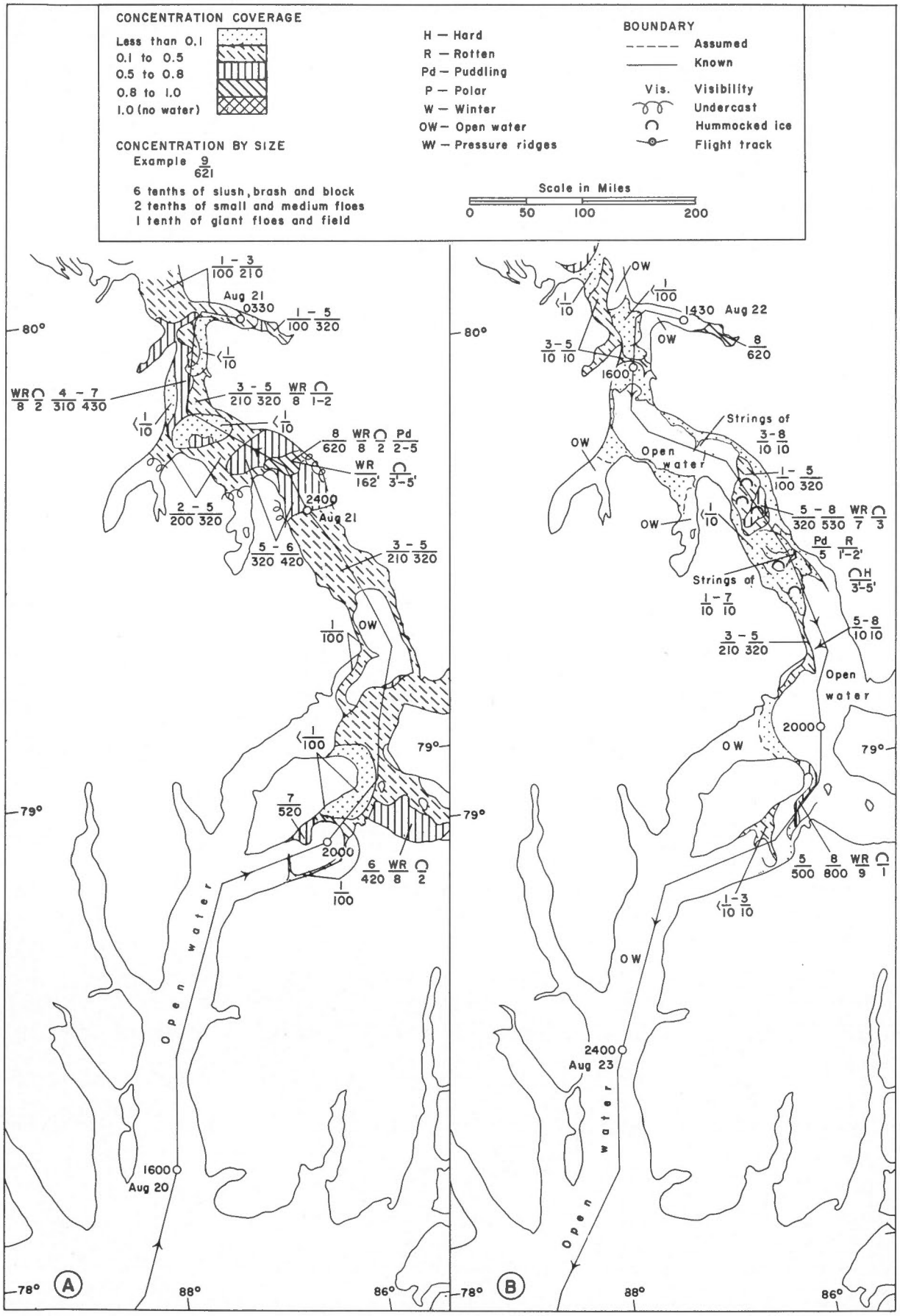

Figure 8. A. Ice Distribution, Eureka Sound, August 20.

B. Ice Distribution, Eureka Sound, August 22.

appeared in the ice surface in the western part of Norwegian Bay. By August 9 the extensive ice coverage of Norwegian Bay had been reduced, with ice concentrations varying from 3/10 to 9/10.

The ice reconnaissance flight of August 17 (Figure 4), showed that the reduction in ice coverage had extended well to westward before heavy field concentrations were encountered in the western part of the area. In the Norwegian Bay-Eureka Sound area the ice coverage was reduced mainly to concentrations of 1/10 to 5/10; only in the extreme western parts of Norwegian Bay were there concentrations greater than 5/10. In this area surface water puddling varied from 7/10 to 8/10 on the ice surface, so that the ice was in an advanced stage of deterioration.

The ship's course during the northbound voyage, August 20, from Hell Gate passage to Slidre Fiord is shown on Figures 7A and 8A. The ice encountered in the southern part of Norwegian Bay was light (1/10 to 4/10), mostly rotten ice, with a thickness of 1 to 2 feet; surface puddling amounted to 6/10. In Eureka Sound the main ice concentrations were in the northern part and varied from 1/10 to 8/10; most of this ice was rotten, with a thickness of about 1 to 2 feet; surface puddling was about 5/10. Hummocked or polar ice scattered through the winter ice occupied from 1/10 to 2/10 of the ice surface. This ice had a thickness of 4 to 7 feet; surface puddling was from 2/10 to 3/10.

The ship's course during the southbound voyage, August 23, from Slidre Fiord to Hell Gate passage is shown on Figures 7B and 8B. The ice conditions in Norwegian Bay on August 23 were essentially similar to those observed on the northbound journey, the essential difference being a reduction of the ice surface. Rotten ice was predominent in the bay except in Hell Gate passage where hummocked or polar ice accounted for 4/10 to 5/10 of the ice surface. Extensive belts of 'working' ice occurred in Hell Gate passage where the large ice floes were rapidly breaking up and discharging

into Jones Sound as block and small floes. Although in Eureka Sound the main concentrations lay in the northern part of the sound, there was, however, a major reduction of the ice cover, with ice free and open water areas having an ice coverage less than 1/10. Large areas of 'working' ice occurred in the vicinity of Cape Depot. Both the winter and hummocked ice that drifted southward in Eureka Sound originated near the western end of Nansen Sound. The ice front in Nansen Sound gradually moved westward with large masses of ice breaking off from time to time and drifting southward through Eureka Sound.

Ice coverage in Slidre Fiord on August 5 was 5/10, on August 9 was 7/10, and on August 17 the fiord was 7/10 covered. When the icebreaker entered the fiord on August 21 the fiord was 8/10 ice covered; when the ship departed on August 22 the ice in the fiord amounted to 3/10. The ice in the upper part of the fiord east of the weather station consisted of 7/10 to 8/10 winter ice, with surface puddling varying from 4/10 to 7/10. Among the winter ice there were large floes of hummocked or polar ice accounting for 3/10 to 6/10 of the ice surface. Most of this ice had entered the fiord recently and was, therefore, mainly in the mid-section of the fiord (Figure 9).

Factors Affecting Distribution

The rapid disappearance of the ice fields in Jones Sound and the substantial reduction of the ice cover in the Norwegian Bay-Eureka Sound areas may be explained in part by the high air and water temperatures. For the period August 19 to 24 local weather conditions tended to favour the deterioration of the ice; 27 per cent of the period was foggy, 36 per cent cloudy, and 37 per cent was sunny and clear.

During this period about 42 per cent of the air recordings were calms. The winds were light and blew from the W-NW-N quadrant with speeds of 1 to 6 m.p.h.;

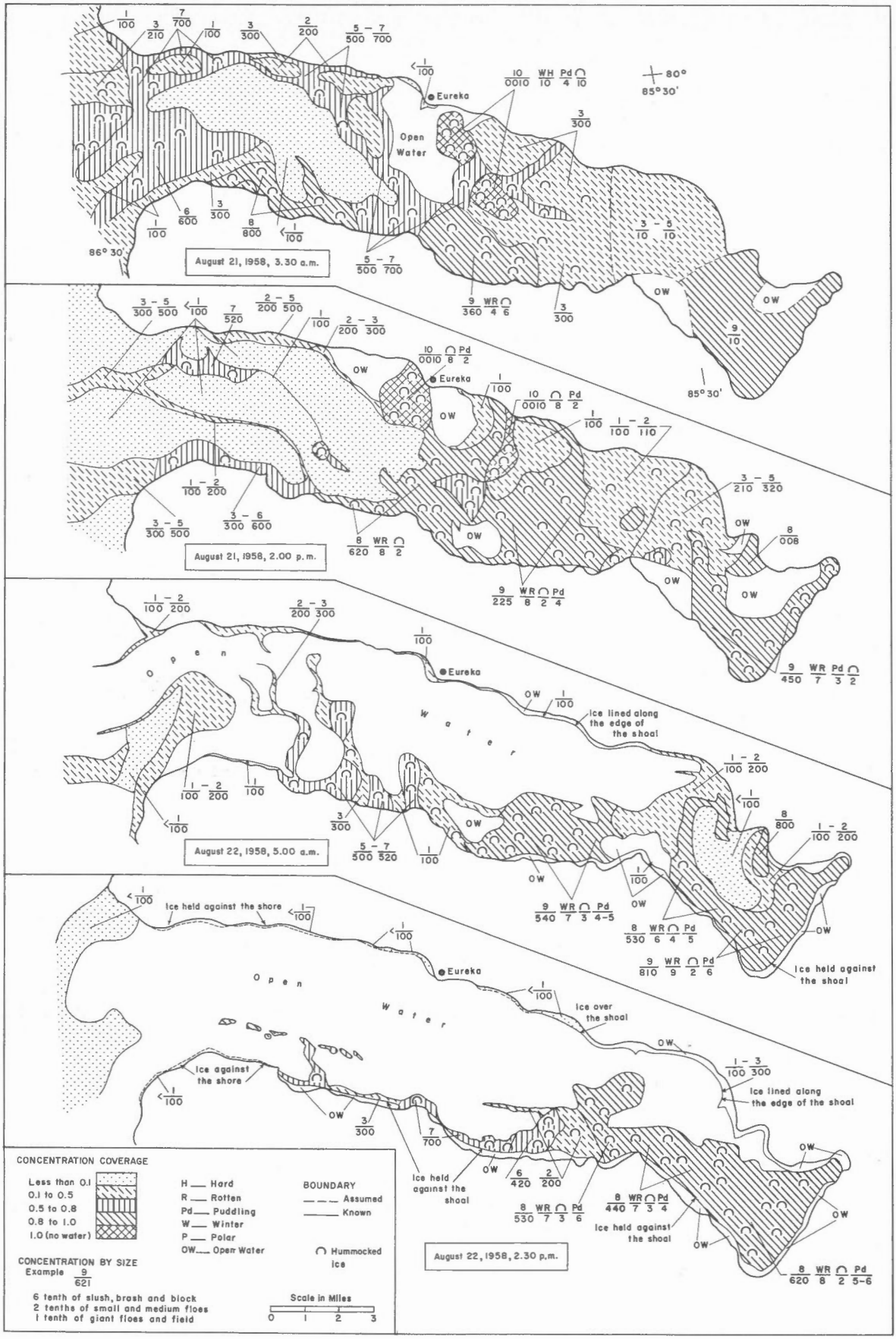

Figure 9. Ice Distribution in Slidre Fiord, August 21, 22.

southeast winds with speeds of 4 to 10 m.p.h. were important in the southern part of the area.

The sea, wherever it was ice free, possessed no swell and its surface was calm and glassy. Tidal action seemed strong as was indicated by areas of 'working' sea ice in Hell Gate passage, in Eureka Sound near Cape Depot and in the rapid movement of ice from Slidre Fiord on August 22.

TABLE VIII

Daily temperatures, Jones Sound - Slidre Fiord, August 19-24

Date	Air (F.°)			Surface Water (F.°)			Sub-surface Water (F.°)		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Aug. 19	38	49	42.8	36	38	37.5	34	40	36.6
Aug. 20	33	42	38	30	36	34	30	39	33.8
Aug. 21	38	48	46.8	32	37	35.3	30	32	31.3
Aug. 22	42	48	44.6	31	33	32.1	31	39	33.0
Aug. 23	32	42	36	29	37	34.6	30	39	35.1
Aug. 24	30	42	35	34	36	35.1	34	36	33.3
Daily Av.	35.5	45.1	40.5	32.0	36.1	34.8	31.5	37.5	33.8

Air temperatures generally stood above freezing (Table VIII). The average minimum air temperature was 35.5°F., average maximum 45.1°F. and daily average 40.5°F. These temperatures were from 4 to 5 degrees higher than the Baffin Bay temperatures. There was little or no difference between readings taken on the northbound and southbound journeys. The highest temperatures were recorded on August 21 and 22 when the ship was anchored in Slidre Fiord. Of the thirty-six recordings of air temperatures taken during the 6-day period only four dropped to 32°F. or lower; these were recorded in the southern part of the area on the return journey. There was no apparent difference in the readings taken, either in ice congested or ice free areas. High temperature conditions must have prevailed during August in order to reduce a 10/10 ice surface to an ice coverage mainly of 3/10 or less. The

immediate effect of the high temperatures was to produce a large proportion of rotten ice, and for surface puddling to amount to 6/10 to 7/10 of the ice surface.

The range between the surface and sub-surface water temperatures was much narrower than that between the water and air temperatures. The range for surface water was about 4 degrees, and sub-surface water 6 degrees (Table VIII). The average temperature for surface water was 34.8°F. and of sub-surface water 33.8°F. Although the daily average was above 30°F. there was only one recording in surface and sub-surface water temperatures lower than 30°F. This temperature recorded on August 23 was sufficient for glimmer ice to form on fresh water surface pools and for new ice to form over the calm, glassy sea. Temperatures in ice covered areas tended to be from 3 to 5 degrees lower than those recorded in open water.

Table IX indicates temperature effectiveness for air, surface and sub-surface water. The daily heat accumulative temperature for air was 16.6°F., for surface water 8.1°F. and for sub-surface water 8.8°F. Although temperatures were positive, the high heat level of the air indicated that air temperatures were more effective as a thawing agent than water temperatures.

TABLE IX

Daily heat accumulative temperatures, Jones Sound-Slidre Fiord, Aug. 19-24

Date	Air (F.°)	Surface Water (F.°)*	Sub-surface Water (F.°)*
Aug. 19	23	14	14
Aug. 20	11	6	8
Aug. 21	22	9	2
Aug. 22	26	4	10
Aug. 23	10	6	9
Aug. 24	8	10	10
Daily Av.	16.6	8.1	8.8

* 30°F. is used to make the calculation for the freezing point of sea water.

Table X indicates the daily average cumulative range of air, surface water and sub-surface water. Highest temperatures for air occurred in the afternoon from 1600 to 2000 hours. Temperatures were remarkably uniform for surface and sub-surface water; however, maximum surface water temperatures occurred from 1200 to 2000 hours and sub-surface temperatures from 1600 to 2400 hours. In each of the three categories maximum temperatures usually occurred in the afternoon. The relatively high pre-dawn temperatures were a result of additional insolation afforded by the 24-hour long day and especially during clear, sunny, weather.

The cumulative effect of high temperatures and moderately high insolation together with local currents was to hasten the deterioration of the ice fields in the Jones Sound-Slidre Fiord area.

TABLE X

Jones Sound - Slidre Fiord, August 19-24

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.	36.3	36.0	40.5	42.6	42.8	38.3
B. Av. cum. temps.	33.8	34.5	35.0	35.6	35.8	34.0
C. Av. cum. temps.	33.8	33.3	32.5	34.8	35.6	35.0

ICEBERGS
(Figures 5,6)

Icebergs were encountered throughout the entire route north of Hudson Strait except off southeast Greenland. During the northbound and southbound passage

between Jones Sound and Hudson Strait visibility was frequently poor and radar location of icebergs was limited to a 10-mile range. The greatest concentration of icebergs existed in the northeastern and northwestern parts of Baffin Bay. A count of 75 bergs was made northwest of Cape Cranstown straddling the ice free area and the pack ice; a second congested area was observed shortly thereafter. This concentration was the southern extension of a tongue of bergs that extended south from Melville Bay.

Thereafter, the count of bergs was considerably reduced (35) partly because of limited visibility. A second concentration of bergs occupied the eastern entrance of Jones Sound; here, a count of 115 bergs was made, the number diminishing toward South Cape. Westward, a second congestion of icebergs occurred in the vicinity of Cape Storm, resulting in part from the set of the Jones Sound and Norwegian Bay currents. A third concentration of icebergs numbering 125 lay off the southeast coast of Devon Island. From this area the icebergs drifted westward along the north shore of Lancaster Sound, but 75 per cent of them drifted southeast toward Bylot Island. A fourth concentration of bergs lay off the east coast of Bylot Island where a count of 100 bergs was made. The east coast of Baffin Island, where numerous glaciers enter the sea, was obscured by fog and undercast. Local areas with the count varying from 5 to 20 bergs were encountered, indicating that a stream of bergs paralleled the Baffin coast. In the vicinity of Cape Dyer the number dropped to about 25 bergs per day. Scattered bergs and bergy bits were sighted in Norwegian Bay, Eureka Sound, Slidre Fiord and Nansen Sound. The large number of bergs released from the glaciers entering the waters of Baffin Bay probably resulted from the above-normal climatic conditions that existed in this area during the season.

SEA ICE CONDITIONS IN THE EASTERN ARCTIC, 1958

SUMMARY

The summer of 1958 indicated that milder weather conditions covered the eastern Arctic than in the comparable 1957 season. Mean temperatures in Baffin Bay-Davis Strait in 1958 were 2 degrees higher for air, but were 1 to 2 degrees lower for water. This latter condition resulted mainly from the extensive ice sheet that covered much of Baffin Bay, and was sustained in part by the prevailing fog and undercast that covered the area. In Lancaster Sound mean temperatures for air were 7 degrees, surface water 5 degrees and sub-surface water 1 degree, higher than in 1957. In this area clear, sunny, weather was prevalent and the ice fields melted rapidly. For the Jones Sound-Eureka Sound area temperatures were more favourable for the deterioration of the ice fields in 1958. Mean temperatures for air were 6 degrees, for surface water 4 degrees and for sub-surface water 3 degrees, higher than in 1957. Sunny, clear, weather was prevalent and light ice coverage was encountered.

Aerial ice survey reports were important in assisting the northern supply ships to complete their missions. The information when plotted on charts provided a regional picture of ice conditions that existed in various parts of the Arctic at a given date. Later surveys indicated the new patterns of ice distribution, and therefore, the amount and nature of the change that had taken place from the previous survey. The ice conditions observed during helicopter flights provided a picture of the immediate, local situation. Both types of ice charts resulting from the aerial survey and from the shipboard reconnaissance are included in this report. These show the changing pattern of ice coverage and show how such reports may be used to navigate successfully, rather than to navigate 'blindly', in arctic waters. Aerial ice reports, together with additional climatic factors, provided the basis for computing ice forecasts conducted by the Meteorological Branch.

Aircraft and ice observer teams were available to provide direct support. The importance of this type of assistance may be illustrated by the following example: ice and fog had slowed the progress of the C.G.S. d'Iberville's convoy; magnetic interference had resulted in unsatisfactory reception of messages, and heavy fog and undercasts had hampered the aerial ice survey in northern Baffin Bay. On August 11, an aerial reconnaissance flight reported directly to the ship that the convoy should follow a 35-mile broad belt of light ice that lay to the north. The belt consisted of 1/10 to 4/10 concentration extending in an east to west direction through heavy pack ice at approximately 75°N. latitude (Figure 5). The convoy followed this advice and passed through safely to Lancaster Sound.

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, but 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, usually not less than 6 feet thick.

(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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Plate 1.

The freighter, *Brazilian Prince*, slowly pushing aside an ice floe in Baffin Bay enroute to Resolute.

Plate 2.

The helicopter was indispensable for local ice patrols.

Plate 3.

Regional ice surveys in the Canadian Arctic were carried out by Meteorological Branch ice observers in aircraft of the RCAF Transport Command. A Lancaster is shown passing over Slidre Fiord.

Plate 4.

C.G.S. *d'Iberville* convoying the freighter and oil tanker through open pack ice in northern Baffin Bay.

Plate 5.

This glacier, with a 2-mile front, rises in the Colin Archer Peninsula and enters Jones Sound a short distance west of Cape Hawes. The string of ice in the foreground has drifted into the sound from Hell Gate passage.

Plate 6.

Hummocked ice drifting south in Eureka Sound is rapidly disintegrating.

Plate 7.

Large floes of hummocked ice were prevalent in Baffin Bay. Surface puddling on the hummocked ice averaged about 1/10 to 2/10.

Plate 8.

Winter ice in an advanced state of deterioration. Water has melted through ice that was covered by puddles. Low temperatures have resulted in glimmer ice forming on the puddles.

Plate 9.

'Working' ice in Baffin Bay is indicated by the ragged outlines of individual floes. Ice coverage is 9/10.

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