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WINTER ICE RECONNAISSANCE IN NARES STRAIT, 1970-71

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ABSTRACT

Six flights were made over Nares Strait during the winter of 1970-71 to determine the date of consolidation of the ice cover. A combination of radar scope photography and visual observations was used to record the conditions. The report describes the results of these flights and relates them to historical data.

RESUME

L'auteur a fait six vols le long du Détroit Nares pendant l'hiver 1970-71 pour déterminer la date de la consolidation de la glace. La méthode utilisée consistait en une combinaison de photographies de radar et d'observations visuelles. Ce rapport donne les résultats de l'opération et présente des comparaisons avec les données historiques.

ICE TERMINOLOGY

The following terms from the WMO nomenclature, referring to age and thickness categories of ice, may be unfamiliar to some readers.

Nilas

A thin elastic crust of ice up to 10cm thick.

Young Ice

Ice in the transition stage between nilas and first-year ice.
Grey ice - young ice 10-15cm thick.
Grey-white ice - young ice 15-30cm thick.

First-year Ice

Sea ice of not more than one winter's growth, thickness 30cm - 2m.

Old Ice

Sea ice that has survived at least one summer's melt. Most topographic features are smoother than on first-year ice.
Second-year ice - has survived one season only.
Multi-year ice - has survived at least two seasons; may be 3m or more in thickness.

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INTRODUCTION

Between 4 December 1970 and 1 March 1971 six flights with Argus aircraft of Maritime Command were made to observe ice conditions in Nares Strait, the channel separating Ellesmere Island from Greenland (Fig.1). The flights were part of the regular Northern Patrol programme of the Canadian Forces, and were spaced for the most part at two-week intervals, on 4 December, 18 December, 13 January, 2 February, 14 February and 1 March.

Observations were made by radar scope photography, complemented by such visual observations as could be obtained in the prevailing light conditions. The technique is far from new, radar scope presentation of ice and arctic terrain having been described twenty years ago by Greenaway (1951), but it worked fairly well, the visual observations being sufficient to resolve the major ambiguities characteristic of the radar image. The radar used was an ASV-21 and the scope cameras were set up and operated by the air photo sections of the two bases involved, CFB Greenwood and CFB Summerside.

This is believed to be the first time that a systematic attempt has been made to record ice conditions through the dark period in or adjacent to the Canadian Arctic Archipelago. The object of the project was not any detailed analysis, for which neither the radar nor the visual observations would have been adequate, but simply to establish how long the ice remained in motion in the channel before becoming stabilized into the landfast condition typical of the spring period. Most channels are believed to become landfast some time in December or January, but difficulty of observation has discouraged actual investigation. The work was undertaken as a preliminary contribution to a study of ice drift in Robeson Channel by the Defence Research Establishment Ottawa. As a side benefit, it was hoped to establish to what extent the North Water was a recognizable feature in the dark period.

The North Water is an area of open water well known to exist in spring in Smith Sound (Dunbar 1969), when its head is a well-defined curve running northward into Kane Basin between Pim Island and the Greenland coast (Fig.2). Its southern boundary, which consists of a gradual transition into the complete pack ice cover in Baffin Bay, retreats southward in May and June, the open water extending south at this early date often as far as Cape York in Greenland and Lancaster Sound on the west. In the dark period, however, its existence was known only from the experience of Eskimos and of explorers who have wintered in the area, and the extent of its development was uncertain.

On each flight Nares Strait was traversed twice, northbound and southbound, radar scope photography being carried out both ways. Exposures were made every minute through Smith Sound and Robeson Channel, and every three minutes the rest of the way, except on the first flight, when no photos were taken in Kane Basin or Kennedy Channel. The writer watched the scope on the northbound leg and made visual observations from the excellent nose position in the Argus on the southbound leg, taking notes by tape recorder.

A plot was made of conditions as observed by radar on each flight and compared to the tape-recorded visual observations. The quality of imagery varied quite considerably from one flight to another, owing mainly it is thought to the condition and quality of the individual radar involved. Thus, some flights were more easily plotted than others, and one was completely unplottable. Even the best, however, had questionable features, and usually there was a sufficient difference between the presentation on northbound and southbound legs to raise doubts as to the accuracy of the plots. There was also variability in the agreement between radar and visual observations. For these reasons, analysis of the radar plots has not been attempted except in the demarcation of the head of the North Water, which always showed up clearly and unequivocally, presumably because the contrast was so great. For the rest a verbal description of conditions observed will be given, supplemented by discussion of individual points of interest.

The radar presentation was basically a black-and-white one, the black representing smooth areas and the white, rough. Thus open patches or very young ice, the presence of which can be taken as evidence that the ice is still in motion, showed up as black, while thicker ice appeared white. However, this interpretation is not infallible, as a smooth patch of first-year ice frequently shows as a black patch too. Thus the radar alone, without any visual observations, would not be a reliable guide to ice conditions.

In the light conditions prevailing in winter, visual observations were also frequently on the black-and-white scale. In the absence of moonlight it was possible to differentiate black patches, which could be open water or new ice (nilas), white patches, which could be anything over about 30cm thick, and some vague grey tones which were somewhere between the two. On the rare occasions when we had moonlight, it was possible to see ridges and differentiate fairly well between first-year ice and old ice, besides having a better chance of relating the intermediate tones to the usual visual grey-scale. Lateral visibility was limited to a quite narrow band on each side of the aircraft, but even in the poorest conditions encountered it was possible to check whether the black patches on the radar scope were actually water (or thin ice) or smooth ice of greater thickness.

Because of these restrictions of visibility, use of the term "open" has been avoided unless it is reasonably sure that it really was, the preference being to talk of "black" or "dark" patches. The word "openings", however, seems irreplaceable by any other, so it has been used to include all leads and polynyas with dark colour, whether open or covered with nilas.

Observations did not extend south of about 77°00N on any flight. Thus the southern limit of the North Water was never observed. This is in any case a very hard limit to pinpoint because the increase in age and concentration is so gradual that any boundary line is likely to be arbitrary.

FLIGHT I

4 December 1970

Time: Northbound - 77°30N - 2254Z
82°30N - 0033Z (5 Dec)

Southbound - 82°30N - 0105Z
77°30N - 0244Z

(Note: Local time is about Z-4.5)

Flight altitude: 3,600 feet

Winds: Northbound - S of c80°N, SE-SW at 8 knots (4m/sec)
N of 80°N, light and variable

Southbound - N of c80°N, NW-N at 25-27 knots (c13m/sec)
S of 80°N, NE at 12-15 knots (6-8m/sec)

Visibility: Clear, except for cloud (and turbulence) over North Water, no moon.

Observed conditions

This being the first flight of the series, the technique was not fully developed, and as a result less information was obtained than on subsequent flights. A clear picture, however, emerged of a highly unstable ice cover.

Robeson Channel, Hall Basin: Robeson Channel and Hall Basin had many open polynyas and leads and patches of grey ice. Orientation of leads was mixed but with a tendency to run across the channel. Just where the channel opens into the Lincoln Sea there was an area with many leads, and also a brief patch of air turbulence, noted both northbound and southbound, which might have been due to open water.

Kane Basin, Kennedy Channel: No scope photography was carried out in this area on this flight, but in general Kennedy Channel was similar to Robeson Channel. Kane Basin had fewer openings but was far from stable.

Smith Sound: The entire area from 77°30N to the head of Smith Sound was covered by pack ice containing a high proportion of young and new ice and with many open leads, mainly oriented across the channel. The clear-cut ice bridge normally forming the head of the North Water in spring was not present, but the edge was nevertheless easily traceable by a discontinuous series of openings, arching northward in the classic curve between Pim Island and the Greenland coast. This showed up well on the radar (Fig.3) and was confirmed visually on the southward trip, when it was noted that although the ice to the north was not entirely consolidated there was a strongly marked lead, south of which the character of the ice changed abruptly from an ice cover with breaks in it to a water surface covered with perhaps eight-tenths pack ice, of which at least half was grey ice or younger. The cross-channel leads tended to be dark on the north side and grey on the south. This is normal with a northeast wind, and is due to the removal downwind of the new ice as it forms. Towards the south, the tendency to cross-channel orientation became rather less marked.

FLIGHT II

18 December 1970

Time: Northbound - 77°00N - 1703Z
82°30N - 1930Z

Southbound - 82°30N - 2006Z
77°00N - 2144Z

Flight altitude: Northbound - 1500 feet
Southbound - 7000 feet

Winds: Northbound - S of c79°30N, N-NNE at 6-11 knots (3-6m/sec)
N of 79°30N, SE-E at 3-8 knots (2-4m/sec)

Southbound - SE-E at 11-21 knots (6-11m/sec)

On the northbound flight a local effect was observed at the narrows of Smith Sound, where the wind swung round from about 20° starboard to dead ahead, or straight down-channel.

Visibility: Good vertical visibility, with some restriction of oblique vision owing to ice crystal haze.

Observed conditions

The best radar imagery and photography of the series were obtained on this flight, but there was still enough difference between northbound and southbound presentation to make plotting an exercise in frustration.

Robeson Channel: From the radar, there seemed to be more dark patches than on the previous flight, including the same concentration of openings at the head of the channel. A particularly large patch,

oriented almost north-south, lay off Lincoln Bay (Fig.4). Unfortunately no visual observations were obtained in this part of the strait.

About a week before this flight, six large corner reflectors had been dropped on the ice from a C-130, and it had been hoped to be able to pick them up on the radar. However, in spite of an extra run down the channel the radar operator was unable to detect any of them.

Hall Basin: On the radar there were a considerable number of dark patches, especially down the Greenland coast and off Cape Baird. The Greenland side was too far away to verify visually, but around Cape Baird there were certainly open or recently-open polynyas. There was a considerable amount of grey ice present, some showing new cracks, and in general the ice was much more broken up than on the first flight, suggesting that the weather in the last week had been stormy. This was not, however, borne out by the synoptic charts, which showed calm conditions in this area over the previous four days, though before that there had been westerly winds between 10 and 34 knots (5 and 17 m/sec) for nine days.

Kennedy Channel: Conditions were similar to those in Hall Basin, and much of the ice was much fractured. A big dark patch was observed close to Hans Island. The southern part of the channel had dark patches amounting to as much as two-tenths at times, but the overall cover was about nine-tenths first year and older, becoming virtually ten-tenths at the entrance to Kane Basin.

Kane Basin: There were fewer openings in Kane Basin than farther north but cracks and leads did occur. On approaching the North Water the first signs were a series of cracks running parallel to the curve of the ice bridge. A few grey patches also began to appear, and then the frost smoke heralding the head of the North Water.

Smith Sound: Conditions were similar to those of Flight I, except that the ice bridge at the head had formed, temporarily as it turned out, and the area immediately to the south of it was more open and the ice in it more consistently young (Figs.5, 6). The concentration in this area, which was about 20 nm wide, was about five-tenths and there was frost smoke over it. Lead orientation, here and throughout the North Water area, was generally cross-channel, and all leads were open (or nearly open) on the north side, the colour becoming gradually lighter towards the south side. To the southward the concentration increased and the average age of the ice became gradually greater, till south of 78°N the predominant age seemed to be first year.

FLIGHT III

13 January 1971

Time: Northbound - 77°30N - 1800Z
82°20N - 2030Z

Southbound - 82°20N - 2039Z
77°30N - 2209Z

Flight altitude: Northbound - 2000 ft rising to 5000 ft with cloud tops.

Southbound - 5000 ft to 79°00N, then 2000 ft.

Wind: NE at 26-50 knots (13-25m/sec)

Visibility: Undercast but with vertical visibility and clear patches. Full moon.

Observed conditions

This was a frustrating flight because the benefit of brilliant moonlight was largely lost through the presence of cloud and haze. In clear patches the light was sufficient for a clear view of ridges and it was, therefore, often possible to tell first-year from old ice. It was also a very interesting flight because of the strong winds encountered, which were no doubt responsible for the number of openings in the ice. (Synoptic charts showed that fairly strong winds had in fact prevailed for some time.) They also had a startling effect on our ground speed, which rose from 150 to 220 knots when we turned round at the head of the channel. In view of the stormy conditions, it is quite probable that most of the dark patches seen were really open.

Robeson Channel: Visibility was poor in this area, but enough could be seen straight downwards to ascertain that there were many leads and polynyas, both in Robeson Channel and in the Lincoln Sea immediately to the north.

Hall Basin: Conditions were much the same as in Robeson Channel, with visibility variable but generally poor. There were perhaps rather fewer openings, but the radar showed what appeared to be a very large one east of our track (Fig.7).

Kennedy Channel: Visibility improved greatly and it could be seen that the northern part of the channel was full of leads and polynyas aligned in the direction of the channel. These were also clearly shown on the radar pictures (Fig.8). South of Hans Island there was an area with few openings but it was only about twelve miles wide, and south of Franklin Island the channel was so open that there was frost smoke.

Kane Basin: The ice in Kane Basin was much more stable than farther north, with a coverage of nine tenths. Cracks and grey patches, however, were not infrequent. At times visibility cleared enough to be able to see ridges, which looked very large and widespread.

Smith Sound: On this flight the head of the North Water was again reduced to a series of disconnected leads and polynyas, as on Flight I, and it did not show very clearly on radar. Visually, however, there was the same abrupt change from more or less complete cover in Kane Basin to leads and broken ice with a very high proportion of young ice. Again there was turbulence and frost smoke, and the cross-channel leads were open on the north side and progressively greyer towards the south. Similar conditions, with the average age of the ice gradually increasing, continued to 76°30N, where observations ceased.

FLIGHT IV

2 February 1971

Time: Northbound - 77°30N - 2000Z
82°20N - 2209Z

Southbound - 82°20N - 2209Z
77°30N - 2350Z

Flight altitude: 1500 feet

Winds: Northbound - WSW at 76°30N, NW at 77°30N, then N-NNE. Speeds 10 knots (5m/sec) to 80°N, then 25-32 knots (13-16m/sec).

Southbound - NNE-NE at 28-39 knots (14-20m/sec).

Visibility: Moonlight, mostly clear but with patches of haze.

Observed conditions

On this flight visual conditions were good but the radar returns from the ice were very poor. It was the only flight for which virtually no ice information could be plotted from the photographs; only the head of the North Water showed up at all clearly, and even that less so than usual. The following notes are, therefore, entirely visual.

Robeson Channel: There was a wide lead across the head of Robeson Channel and many black and grey patches throughout. Most leads tended to be oriented across the channel and to be most open on the north side, refreezing on the south. Moonlight made it possible to see ridges, and they were many and formidable.

Hall Basin: Somewhat hazy, but it was possible to see that the cracks and grey patches were much fewer. Ridges were no longer visible.

Kennedy Channel: Visibility was improving and ridges just beginning to be visible. Near the north end of the channel there were dark patches oriented in the direction of the channel. As in Robeson Channel there was much black and grey. Very heavy multi-year floes were also not uncommon, and there was very heavy ridging in the first-year ice. A large black patch was present south of Hans Island.

Kane Basin: Openings were fewer, with quite a number of grey patches but few black ones. The pattern of big massive multi-year floes, heavily ridged first-year ice and smooth patches of young ice persisted and was indeed typical of the whole strait. Cracks were observed throughout, randomly oriented, and sufficiently frequent that it was seldom that none were in sight. The zone with most cracks was between 79°50N and 79°10N, where one lead ran parallel to the track for about three miles. This lead was open on the east side, and refreezing on the west. As the wind at flight altitude was almost directly on our tail this suggests there may have been an easterly deflection at the surface, possibly due to the katabatic effect of the Humboldt Glacier. Between this and the North Water there were hardly any cracks or grey patches.

Smith Sound: The ice bridge had reformed across the head of Smith Sound and for the first time no ice older than grey to grey-white was observed north of about 78°00N. Immediately south of the bridge there was what appeared to be an open lead, then about six to seven-tenths ice of gradually increasing age, at first all nilas, graduating southward to grey and then grey-white. A little north of 78°00N the age seemed to be approaching the white or first-year stage. Large open areas were observed to about 76°00N, and considerable quantities of young ice and openings to well south of 75°00N.

FLIGHT V

14 February 1971

Time: Northbound - 77°00N - 1730Z
82°00N - 1934Z

Southbound - 82°00N - 1934Z
77°00N - 2133Z

Flight altitude: 1700 feet

Winds: Northbound - S of 79°N, SSE at 20-25 knots (10-13m/sec).
N of 79°N, SSE light to 7 knots (4m/sec).

Southbound - N of 79°N, NNE at 10 knots (5m/sec).
S of 79°N, SW at 19 knots (10m/sec).

Visibility: Twilight, overcast, becoming thin and broken in southern part of strait, frost smoke over North Water.

Observed conditions

On this flight for the first time there were signs that the ice was becoming more stable. Apart from the North Water there were none of the large black patches observed on other flights, though quite a lot of large grey patches.

Robeson Channel: The light condition in this part of the strait was just barely twilight, only a little better than darkness, and the overcast made everything look flat and lacking in contrast. The coast was visible on both sides, but very dimly and not all the time. There were as usual a number of leads at the entrance to the Lincoln Sea, but in Robeson Channel much fewer than before. Two fairly large dark patches that appeared on the radar were not identified visually, but

there were a number of grey patches, many with new cracks in them. A narrow lead with a fairly wide associated grey patch appeared to extend right across the channel south of Lincoln Bay and there was a fracture zone at the south end of the channel extending diagonally from our track in an almost due south direction.

Hall Basin: Similar conditions were observed here: a few leads and cracks and considerable grey patches but less than on previous flights.

Kennedy Channel: The light improved as the southward leg advanced and a faint sunset (or sunrise) glow began to appear to the south. Ridges became visible for the first time. In the north part of the channel there were many grey patches and cracks, more than in Robeson Channel. The cracks ran in various directions, but as before in this area the predominant trend was up-and-down channel rather than across, the latter direction being more typical in Robeson Channel and Smith Sound.

The largest dark patch seen was northwest of Hans Island and there were cracks radiating from the island, the largest of them running towards the coast of Greenland. A triangular dark patch appeared on the radar to the southeast of Hans Island and was identified visually as a grey patch with small cracks in it but was not prominent (Fig.9). There were cracks around Franklin Island too, and also some very heavy old floes. At the south end of the channel there was a well-marked cross-channel lead open on the south side and greying towards the north, reflecting the southeasterly wind direction.

Kane Basin: As usual Kane Basin presented a more stable cover than any other part of the strait. Nevertheless there were signs of movement in the form of recent and refrozen cracks and patches of young ice amounting to up to two tenths, which constituted potential weak spots. With the improving light the general pattern noted farther north was confirmed: a conglomeration of multi-year floes (about 5/10), first-year ice in an extreme state of deformation, and smooth patches of younger ice (about 2/10).

An interesting example of the apparent lack of effect of floe age and thickness on deformation processes was observed where a crack ran through an area of first-year ice surrounding a heavy old floe. Only the very edge of the old floe lay in its track, but the crack went straight through rather than make the minor deflection that would have been necessary to go round it (Fig.10).

Smith Sound: On the southward leg the turbulence was very marked as we approached the North Water, which was clearly demarcated by the usual ice bridge (Fig.11), and frost smoke was very copious. The ice was very rough to within about five miles or so of the open water, where it became smooth and light grey. This smooth ice was not visible on the radar, which thus showed a slightly false line. The same situation was noted on the next flight (q.v.).

A note on the nature of the ice bridge might be of interest. It is often referred to as an ice jam, with the suggestion that the pack ice gets jammed in the narrows of Smith Sound and cannot get through. This is not so. The bridge forms because the pack ice in Kane Basin consolidates and ceases to move at all, while in Smith Sound, apparently, the strong wind and current continue to carry the young ice south as it forms. Thus the ice bridge is in no sense a jam, but an ordinary fast-ice edge, and the curving form may have something to do with the strength of the arch as an engineering form. It will be seen that on Flights V and VI (Figs.11, 12) there was in fact no well developed curve, and it may be normal for this to become more marked as the spring wears on (Fig.2). But the foundations of it, as it were, were apparent in the northward-trending line at the coast on each side.

The ice in the North Water was much as on Flight IV, but this time, as a result of the southerly winds, the open part of the leads was on the south side, with increasing ice towards the north. Concentration varied from six to nine tenths and age as usual increased southwards. Owing to the build-up of frost smoke, which extended to about 2000 feet and inhibited all but straight down visibility, visual observations were cut short a little to the south of 78°00N.

FLIGHT VI

1 March 1971

Time: Northbound - 77°00N - 1800Z
82°30N - 2005Z

Southbound - 82°30N - 2017Z
77°00N - 2225Z

Flight altitude: 2000 feet

Winds: S of c80°N, ENE-NNE at 12-40 knots (6-20m/sec).
N of c80°N, WSW at 6-10 knots (3-5m/sec)

Visibility: Good, almost daylight.

Observed conditions

On this flight the light was so good that the radar was really unnecessary, but for purposes of comparison it was used and photographed as before. For the first time it could be said that the ice was consolidated and stable from the head of the North Water up to the middle of Robeson Channel. The series of flights was, therefore, terminated, but another flight, made a month later for other reasons, made it possible to reconfirm the stable condition of the ice, which by then extended right to the Lincoln Sea.

Robeson Channel: The northern part of Robeson Channel was very much broken up but without much open water between the floes. A few small open patches with frost smoke over them were observed close to the coast of Ellesmere Island near the entrance to the Lincoln Sea, and a discontinuous line of leads formed a northward curve between a point a few inches SE of Cape Sheridan and the Greenland coast. About three tenths of the ice in this part of the channel was very heavy multi-year floes, most of the rest first-year and grey-white.

Just south of Wrangel Bay a lead, with frost smoke, ran right across the channel (Fig.13) and south of this lead there was a drastic change to completely consolidated ice with no cracks and a lower proportion of grey-white than farther north. There was no ice younger than grey-white. The first-year ice was very heavily ridged.

Hall Basin: Conditions were the same as in southern Robeson Channel. Grey-white ice was the youngest present, which however accounted for about three to four tenths of the cover and might lead to renewed movement if wind conditions became strong enough in the next few days to break it up.

Kennedy Channel: Conditions remained the same. The ice throughout was well snow-covered, but a few patches on the old floes had blown clear and showed clear blue in colour. There were no openings anywhere in Kennedy Channel, but south and east of Hans Island there was a fair amount of smooth grey-white ice. This probably accounts for the very clearly marked black triangle visible on the radar both northbound and southbound (Fig.9) (cf. Flight V).

Kane Basin: In Kane Basin the weak patches formed by grey-white ice were fewer, and the proportion of multi-year higher (about five tenths), otherwise conditions remained unchanged. No openings of any sort were observed, and the first-year ice was extremely heavily ridged.

Smith Sound: Smith Sound was more open than on any other flight. The actual ice cover varied from about four to nine tenths, but the ice was so thin, and in most parts so broken up, that a pronounced swell was visible from 2000 feet and the crew, specialists in maritime patrols, estimated a sea state 2 in the narrows between capes Isabella and Alexander. The strong northerly wind was reflected in large strings of new ice in the open patches, oriented up and down channel with the wind. As usual the age of the ice increased steadily southward, and was markedly all of the same age at any given point. First-year ice did not predominate until south of the latitude of Thule. Frost smoke was present but wispy, and turbulence was encountered intermittently.

The ice bridge at the north end of the strait had the exact same form as on Flight V, and again the radar failed to see the southernmost strip of the ice forming it (Fig.12). This was confirmed by a photograph taken on the southward leg. This photograph was unfortunately too dark for reproduction, but another taken on 1 April (Fig.14) shows exactly the same ice limits.

Summary of observations

Ice conditions remained unstable, with apparently repeated opening, ridging and refreezing, throughout Nares Strait up to the beginning of February, showing little variation during this period. On 14 February (Flight V) a rather more stable situation was noted, and by 1 March (Flight VI) the entire strait from the head of Smith Sound north was consolidated, with the exception of the north half of Robeson Channel. The date of consolidation of this portion is uncertain but it was probably within a week or so of the beginning of March. At any rate, by 1 April an unbroken and unmoving ice cover extended from the North Water to the head of Robeson Channel, where there was a break and patches of open water. This feature, separating the Robeson Channel ice from the Arctic Ocean pack ice, is often present and is somewhat comparable to the normal break. or flaw, that separates any fast ice area from contiguous pack ice, and that opens up to form a flaw lead when the winds are offshore (or in this case, off-channel). However, it is not limited to periods when the Robeson Channel ice is shorefast, but is often observed when it is in motion, and it may also be connected with an increase in current velocities in the entrance to the narrow channel. At least part of the time it is apparently more analogous to the head of the North Water, the Arctic Ocean ice appearing unbroken and the Robeson Channel ice moving away from it (Fig.15).

The narrowest parts of the strait, Robeson and Kennedy channels, tended to show the most black patches, but Hall Basin was very little different. Kane Basin had consistently less openings than the rest, particularly the southern half, and was the first part of the strait to consolidate. Smith Sound, the area of the North Water, was the most open area, as was to be expected, and became more distinctively open as the ice farther north consolidated.

Winds: It is one of the known facts about Nares Strait that it is a place where two tides meet, those from north and south meeting in northern Kane Basin in the latitude of Cape Fraser. This same line is also of meteorological significance, dividing the influence of the Baffin Bay Trough from that of the Arctic High in the winter months. This is pointed up by the fact that on four of the six flights of the series a change of wind was observed around 79-80°N. The surface synoptic charts for the period 1 December 1970 to 1 March 1971 indicate that there were 47 days when the winds were essentially the same

throughout the strait, and 44 when they were different in the north and south sections, though on five of these the difference was not very great and was probably cancelled out by topographic funnelling at ground level.

Table I attempts an analysis of the wind data, to the limited extent that this seems justified in view of the very sparse network of stations on which the synoptic charts are based, the extent of the topographic influence on winds at the surface, and the katabatic effect of the Greenland icecap. The following observations, however, seem to be justified.

In the southern part of the channel there was a much larger proportion of days with a down-channel wind component than with an up-channel, whereas in the northern part this preponderance was much less and there were twice as many calm days. Furthermore in the north the down-channel and up-channel winds were of approximately equal average strength, whereas in the south the down-channel winds were appreciably stronger. Conclusions cannot be drawn from one season's records, but it may be worth pointing out that if these figures are at all typical they present a convincing confirmation that the North Water is essentially a flaw polynya due to the continuous removal of young ice by wind and current.

Another point that arises from Table I is that the winds in general were extremely strong. Winds actually encountered were as high as 50 knots on one flight and had maximum force of from 27 to 40 knots on three others. According to the synoptic charts the winds in Smith Sound on the days before and after Flight IV reached 100 knots (NE), the maximum for the winter, while for a 10-day period in January they never fell below 25 knots.

It would appear that this high incidence of storms, together with the fact that at freeze-up time the channel normally contains considerable numbers of very tough and thick old floes, is mainly responsible for the lateness in consolidation of the ice. The stormy winds acting on the heavy floes keep breaking up the younger ice which forms between them until most of the available spaces are filled with heavily ridged first-year ice, after which the remaining spaces fill up with smooth ice. It seems from the historical record that in some years this last phase is never quite completed, but this was not the case in 1970-71.

TABLE I

Wind Data for Nares Strait (2000-ft level)
1 December 1970 to 1 March 1971

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	% of daily winds with down-channel component	% of daily winds with up-channel component	% of other winds	% of calm days	Average wind speed (knots)		% 20 kn. and over		% 50 kn. and over	
					Down-chan. (Col.1)	Up-chan. (Col.2)	Down-chan.	Up-chan.	Down-chan.	Up-chan.
North part of channel (N of c80°N)	45	28	4	22	24	23	59	63	4	4
South part of channel (S of c80°N)	74	15	1	10	30	23	71	62	13	0

Comparison with previous records

At the beginning of this paper it was stated that the work described represented the first systematic attempt to observe ice conditions in Nares Strait through the dark period. This is true, but parts of the strait have been described in the past by wintering explorers, and it is of some interest to note their observations. For the sake of completeness observations from March, after the return of daylight, to break-up, have also been included.

Two points common to all the accounts of explorers strongly confirm the 1970-71 observations. The first is the strength of the winds in winter; almost every wintering party speaks of frequent storms, usually from the northeast or southwest, and this is true of all parts of the channel except eastern Kane Basin. In particular it is true of the Smith Sound area, where Etah, wintering place of many expeditions, is frequently described as among the stormiest spots in the Arctic.

The second point is that all those who have sledged in any part of Nares Strait talk of very heavy ridging, of multi-year floes and varying amounts of smooth young ice, exactly as observed in 1970-71 (Figs.16, 17).

Robeson Channel, Hall Basin: The USS Polaris, under C.F. Hall, wintered in 1871-72 in Polaris Bay on the east coast of Hall Basin (Fig.16) (Davis 1876). All winter varying amounts of open water and young ice were observed, and in February it was noted that it would have been impossible to cross the strait. This situation persisted until 4 May, when it was noted that despite a northeast gale the ice failed to move. On 19 May a reconnaissance revealed no open water. The ship was released from her winter position on 26 June, so there was at most a month without movement.

In 1875-76 Sir George Nares wintered in this area with two ships, the Alert west of Cape Sheridan and the Discovery at Discovery Harbour (Nares 1878). Owing to the distance of these points from the channel and the normal absence of winter travel, there are no direct observations of conditions in the channel during the dark period, though Nares mentions frost smoke north of Cape Sheridan on 12 January. The first sledge parties travelled through Robeson Channel and across Hall Basin in late March and found no sign of any movement

or of open water, much to the astonishment of the Eskimo Hans, who had been with Hall's expedition. Another party crossed the north end of Robeson Channel in mid-April without encountering open water.

Signs of melt first appeared in June, but it was not until late July that the ice started to move, and the last party crossed Hall Basin, with great difficulty, in the second week in August, using a boat and sledge.

The next expedition to this area was that of Greely, who occupied Nares' site at Discovery Harbour, which he called Fort Conger, in 1881-83 (Greely 1886). In the first winter, an attempt to sledge across the channel in early November was stopped by open water, after which there is no mention of Robeson Channel until 23 February, when the first of many trips across it was made on unmoving ice. In 1882-83 there is no mention in Greely's account until 10 March, when the channel was frozen fast.

Peary sledged up and down Nares Strait many times between 1898 and 1901, and in 1900-01 he wintered at Fort Conger. He makes no mention of Robeson Channel in the dark months, but had several spring observations: on 4 May 1899, from Cape Murchison, he could see no leads and conditions were so rough he gave up his intention to sledge to Greenland. In 1900 he crossed Robeson Channel and sledged up the Greenland coast in mid-April, finding an open lead about 3 miles wide a few miles north of Cape Brevoort, running across to Ellesmere Island north of Lincoln Bay; on his return about 10 June the open water stretched down to the south side of Newman Bay. In early April 1901, sledging north from Fort Conger up the Ellesmere coast, he found the ice too rough and turned back at Lincoln Bay. In 1902 he left Fort Conger on 24 March and sledged north to the Arctic Ocean, finding open water across Robeson Channel extending up the coast from a little north of Wrangel Bay nearly to Cape Sheridan, so that he had to travel on the narrow icefoot. In 1905, wintering at Cape Sheridan, he had open water at the head of Robeson Channel at Christmas, and on 28 December the ship was rolling in a swell from a strong southerly gale; the ice continued to move in and out all January. In 1908-09 Peary again wintered at Cape Sheridan but he makes no mention of open water this time. Two sledge parties crossed from Cape Union to Cape Brevoort in late December and back in January and February without difficulty (Peary 1898, 1903, 1907, 1910).

Finally in 1917, Knud Rasmussen travelled up the west side of the channel at the beginning of May, encountering no open water anywhere (Rasmussen 1927).

This information is summarized in Table II(a). In this table the frequent mentions of open leads and polynyas across the head of Robeson Channel have not been included, as this is a common feature at all times of year. The ice in Robeson Channel and Hall Basin has been little observed in the dark period but frequently sledged across in the period March to June, and one year in late February. During this period it will be seen that conditions were generally not unlike the 1970-71 winter, though sometimes the ice was consolidated earlier. The 1871-72 season seems to have been exceptionally open. In the other two years with open conditions, 1899-1900 and 1901-02, the open water was apparently in the north half of Robeson Channel only, the rest of the area having shorefast ice, and may be thought of as a southward displacement of the flaw lead, though it is not clear from what cause. A similar condition was observed in 1971 on Flight VI.

Kennedy Channel: No party has ever wintered in Kennedy Channel, but it has been traversed by many. A party from Kane's expedition, wintering in Kane Basin, travelled up the east coast in June 1854 till stopped by water at Cape Constitution. Here on 24 June the whole width of the channel was open with swell and white caps, and from here south there was only a narrow icefoot between the cliffs and the moving pack ice. Again in April 1855 Kane saw water sky in this direction from the ice in Kane Basin (Kane 1856).

In 1861 Hayes sledged up the west coast of Kane Basin and at his farthest north in mid-May met with thin unsafe ice (Hayes 1867). From a hill he saw open cracks and water sky to the north and east and was convinced he was standing on the shores of the "Open Polar Sea", a concept popular at the time. Unfortunately, it is by no means clear where he was. If his positions are correct he was at the head of Kennedy Channel off Cape Baird; but his calculations have been questioned by many, and Greely, having studied his account and a drawing made on the spot, claims he was at Cape Joseph Good, at the southern end of Kennedy Channel. This certainly seems to fit better many points in the description. In either case, it was a likely place for thin ice. At Cape Baird, however, it would have been more likely to be to the south and east (Fig.18).

It was in this area that Hall's expedition found young ice scarcely able to bear their sledges on 3 April 1872. Two days later about 30 miles north of Franklin Island they met with open water to the limit of visibility.

Dr. Pavy of Greely's expedition sledged from Discovery Harbour to Carl Ritter Bay between 27 October and 5 November 1882 but was unable to go farther because of open water. He reported the ice in Kennedy Channel in motion.

Peary, who did more winter sledging than almost any traveller, first traversed Kennedy Channel between 29 December 1898 and 6 January 1899. He had to travel on the narrow icefoot on the Ellesmere Island coast, but unfortunately does not mention whether this was because of open water in the strait or rough ice conditions. The same is true of the return trip in the second half of February. These are marked "F?" in Table II(b) on the grounds that if the ice was moving he was likely to have said so. On a second trip to Fort Conger in late April, returning May 23, rough ice was definitely the problem; on May 4 at the north end of the channel he thought it too rough to attempt a crossing to Greenland. In 1900 he sledged through the channel in March and found it full of shorefast rough ice, as it was again in 1901, when he was sledging supplies up to Fort Conger from early May to mid-June. In 1902 he made the trip in March, when again it was shorefast, but the ice was smoother than usual.

Peary travelled always on the west side of the channel and so did not see the area in the southeast part where Kane's party had found open water. The next visitor, Ekblaw of MacMillan's expedition, travelled down-channel in June 1915. After negotiating two large leads near Cape Baird on 7 June, he crossed the channel and found open water and thin ice between Cape Constitution and Franklin Island (MacMillan 1918). Rasmussen, however, in April 1917, sledged up the Greenland coast without seeing any open water.

Finally in 1935 Moore and Stallworthy, of an Oxford University expedition led by Noel Humphreys, travelled up Kennedy Channel on the Greenland side, finding the "usual open water" at the southeast entrance to the channel frozen over. This open area, first found by Kane's expedition, had since been visited on many occasions by Eskimo hunting parties, hence the "usual". This was in mid-April; returning by the same route in mid-May they found a large open patch (Shackleton 1937).

Table II(b) shows that in the spring months there is a tendency for some open water to be present in Kennedy Channel. This is normally at the south end of the channel and sometimes also at the north end. It should be stressed, however, that an "0" in the table does not mean the whole channel is in motion.

Kane Basin: The first expedition to winter in Kane Basin was that of Kane, at Rensselaer Bay, where he spent two years, 1853-55. Kane makes no mention of any open water in late fall or winter in Kane Basin. In fact, his problem was the opposite one, that the ice, though it broke up in August, did not loosen sufficiently to release his ship, and he had to spend a second winter which had not been planned and finally to abandon his ship and retreat by sledge and boat. Observations in winter were of necessity restricted to the area close around Rensselaer Bay and therefore cannot be considered representative for all Kane Basin, but parties travelled in the eastern part of the basin in every month from March to July 1854 and in April 1855 without encountering any openings except as reported above at the entrance to Kennedy Channel. In May 1854 Hayes sledged north across the west side, encountering very rough ice but no openings. The only time leads and young ice interfered with sledging was in late September 1853 along the coast east of Rensselaer Bay.

The next to travel in Kane Basin was Hayes in 1861. From a base in Foulke Fiord he visited Rensselaer Bay in March and sledged across Kane Basin and up the Ellesmere coast in April and May. In mid-May he found new ice, some of it thin enough to be unsafe, and small open patches at various points between Cape Louis Napoleon and Kennedy Channel.

Peary wintered in Kane Basin in 1898-99, at Cape D'Urville. At the end of October he started sledging supplies northward, getting as far as Cape Wilkes. He had to travel on the icefoot because the ice beyond was in motion. After this he followed this icefoot route in late December and in February, but without mentioning whether the ice was still in motion or just too rough for sledging, as was the case on his later trips in April and May. In March 1900 he sledged up the west side of the basin from Pim Island, in 1901 from early May to mid-June he was ferrying supplies up the same route, and in March 1902 he repeated the same journey, returning in late May; no open water was apparently seen on any of these trips.

TABLE II

Winter and Spring Ice Conditions in Nares Strait from Explorers' Reports

(a) Robeson Channel - Hall Basin

Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1871-72	O	O	O	O	O	O	F	B
1875-76	-	-	-	-	F	F	F	F
1881-82	O	-	-	F	F	F	F	F
1882-83	-	-	-	-	F	-	-	-
1898-99	-	-	-	-	-	-	F	-
1899-1900	-	-	-	-	-	O/F	-	O/F
1900-01	-	-	-	-	-	F	-	-
1901-02	-	-	-	-	O/F	-	-	-
1916-17	-	-	-	-	-	-	F	-

(b) Kennedy Channel

1853-54	-	-	-	-	-	-	-	O
1854-55	-	-	-	-	-	O	-	-
1860-61	-	-	-	-	-	-	O	-
1871-72	-	-	-	-	-	O	-	-
1882-83	O	-	-	-	-	-	-	-
1898-99	-	F?	F?	F?	-	F	F	-
1899-1900	-	-	-	-	F	-	-	-
1900-01	-	-	-	-	-	F	F	F
1901-02	-	-	-	-	F	-	F	-
1914-15	-	-	-	-	-	-	-	O/F
1916-17	-	-	-	-	-	F	-	-
1934-35	-	-	-	-	-	F	O/F	-

(c) Kane Basin

1853-54	F	F	F	F	F	F	F	F
1854-55	F	F	F	F	F	F	F	F
1860-61	-	-	-	-	F	F	O/F	F
1898-99	O	F?	-	F?	-	F	F	F
1899-1900	-	-	-	-	F	-	-	-
1900-01	-	-	-	-	-	F	F	F
1901-02	-	-	-	-	F	-	F	-
1914-15	-	-	-	-	-	-	-	F
1916-17	-	-	-	-	-	F	-	-
1934-35	-	-	-	-	-	-	F	-

Key: O - Ice seen open or in motion at one or more points.
F - Ice seen to be shorefast at one or more points.
O/F - Both open and fast ice observed.
B - Break-up occurred during month.
F? - For explanation see text.

Ekblaw in June 1915, Rasmussen in April 1917, and Moore and Stallworthy in May 1935 all crossed the eastern part of Kane Basin without seeing any water.

The record (Table II(c)) shows fairly consistent fast ice conditions from March onwards. This is very much to be expected in this area, which is well known from summer records to be the most consistently icebound part of the strait, especially the eastern part, which seems to be out of the main line of current and ice movement. The west half of the basin, on the direct line from Kennedy Channel to Smith Sound, is generally more likely to open up. The one experience of thin and near-open conditions encountered by a sledging party in Kane Basin, that of Hayes in 1861, seems to have been rather unusual, and affected only a very small part of Kane Basin.

Smith Sound: Smith Sound has had many wintering parties, some by design, others because the ice in Kane Basin prevented them getting farther north. They are in fact too many to itemize, but they are listed in Table III, together with their wintering places. The list is not exhaustive; some expeditions which wintered in the area published no record of winter ice conditions in Smith Sound. For instance Peary in 1901-02, to whom wintering had by that time become routine, merely states that the winter passed uneventfully. Sverdrup, who wintered on the west side of Pim Island where there is no open water, was interested only in westward exploration (Sverdrup 1904). He mentions only that some Eskimos who visited him in February or early March had to make a northward detour across the head of Smith Sound on the way home and go overland at Cape Alexander. Further research would undoubtedly unearth other accounts, for instance in the journals of RCMP posts.

All those listed, except Sverdrup, speak of open water in some part of the sound through the winter months, or in one case (Kane) of frequent water skies and fogs in that direction. The most complete records come from those wintering closest to the edge of the water: Hayes, the Polaris survivors, and Greely, all of whom make frequent reference to it. When storms broke up the fast ice, both Hayes and the Polaris party were within one or two miles of the water, and the crippled Polaris itself was carried off the beach on May 30. The most open year of those with records was probably 1915-16, when MacMillan seems to have had a more than usual incidence of people falling through thin ice and of overland detours to avoid open water

on the Greenland coast. The worst year was 1854-55, when the north limit of the open water seems to have been somewhat farther south than usual, and when the Eskimos suffered much because their usual hunting grounds along the Greenland coast froze over. The three gaps in the March to May observations in Table III are due to the fact that the observers had left the area before March.

Along the Greenland coast fast ice of varying width and age was usually available for sledging, but there was almost always water close up to Cape Alexander, necessitating an overland detour, and the same was often true of Cape Parry and the west end of Northumberland Island. The various capes north of Foulke Fiord were also sometimes problem areas, particularly early in the season. For the Ellesmere Island coast we have only four years with any records, but they show a similar picture. Bessels of the Polaris party sledged down to Baird Inlet in 1873, but gives no record of conditions on the west side; Greely in November 1883 found open water with white caps south of Cape Isabella; and MacMillan in March and April 1917 found open water at capes Herschel, Isabella and Paget and had to detour inland. Cook, returning to Cape Inglefield in 1909 after wintering in Jones Sound, had open water some miles offshore even at the southeast point of Ellesmere Island, but he does not mention any overland detours (Cook 1911).

The northern limit of the North Water is surprisingly well documented. Table III shows 11 years in which crossings of Smith Sound have been made, in months ranging from December to May. In many cases one mark represents several crossings. Peary and MacMillan in particular made multiple crossings to lay supply depots. With only one exception all reports refer to the northward-curving edge round which they had to detour to go from Cairn Point to Pim Island; the exception is Hayes when with Kane's expedition in 1854, and he crossed diagonally from the vicinity of Bache Peninsula, so he would not have to detour. He was unaware of water, but did however mention being enveloped in a thick fog, and that in itself is suggestive. Most parties were able to go north and west from Cairn Point, but Bessels in April 1873 had to detour to Rensselaer Bay to get round the open water.

TABLE III

SMITH SOUND

Winter and Spring Records and Sledge Crossings

Year	Open Water Reported		Crossings						Expedition and Winter Base
	Nov-Feb	Mar-July	Dec	Jan	Feb	Mar	Apr	May	
1853-54	X	X						X	Kane - Rensselaer Bay
1854-55	X	X							Kane - Rensselaer Bay
1860-61	X	X							Hayes - Foulke Fiord
1872-73	X	X					X		Polaris - Lifeboat Cove
1883-84	X	X							Greely - Cape Sabine
1894-95	X								Peary - Inglefield Gulf
1898-99		X				X			Sverdrup - Pim I. (Eskimo trip)
1899-1900	X			X	X				Peary - Etah
1907-08	X			X	X				Cook - Cape Inglefield
1908-09	X	X					X		Cook - Jones Sound
1913-14	X	X	X		X			X	MacMillan - Etah
1914-15	X	X				X			MacMillan - Etah
1915-16	X	X				X		X	MacMillan - Etah
1916-17	X	X				X	X		MacMillan - Etah
1934-35	X	X					X	X	Oxford Univ. - Etah

All this ties in very well with the results of the 1970-71 winter flights, and also with the various air reconnaissance and satellite data available for the daylight period. It suggests that the character of the North Water has not changed very much over the last 120 years, and shows that considerable information on conditions even in the dark period has long been available to those prepared to dig for it.

Conclusions

From the foregoing it appears that the ice in Nares Strait has a strong tendency to be later in consolidating than that of most of the channels of the Canadian Arctic Archipelago, and that this is probably due to the intensity of storm activity during the winter months combined with the presence of heavy multi-year floes in the channel at freeze-up. Historical records show that conditions can be quite variable and that the 1970-71 season appears to have been fairly "normal" in the sense of being neither particularly early nor particularly late.

The extent of the development of the North Water through one winter has been shown, and has proved so closely to coincide with historical accounts that it is probably fairly typical. However, it is hoped to be able to continue the series for another year or two, perhaps with the addition of more sophisticated sensors as they become available.

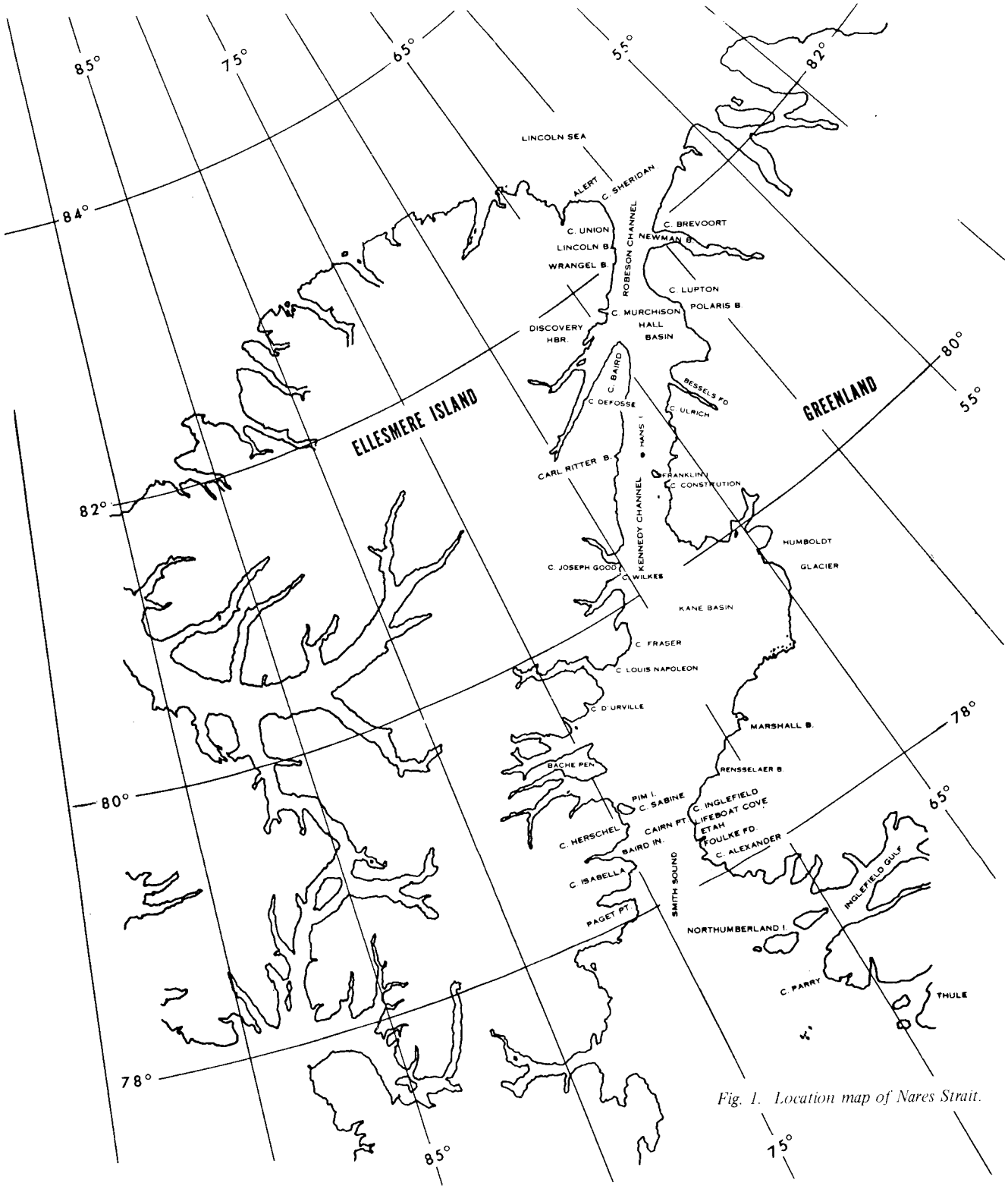

Fig. 1. Location map of Nares Strait.

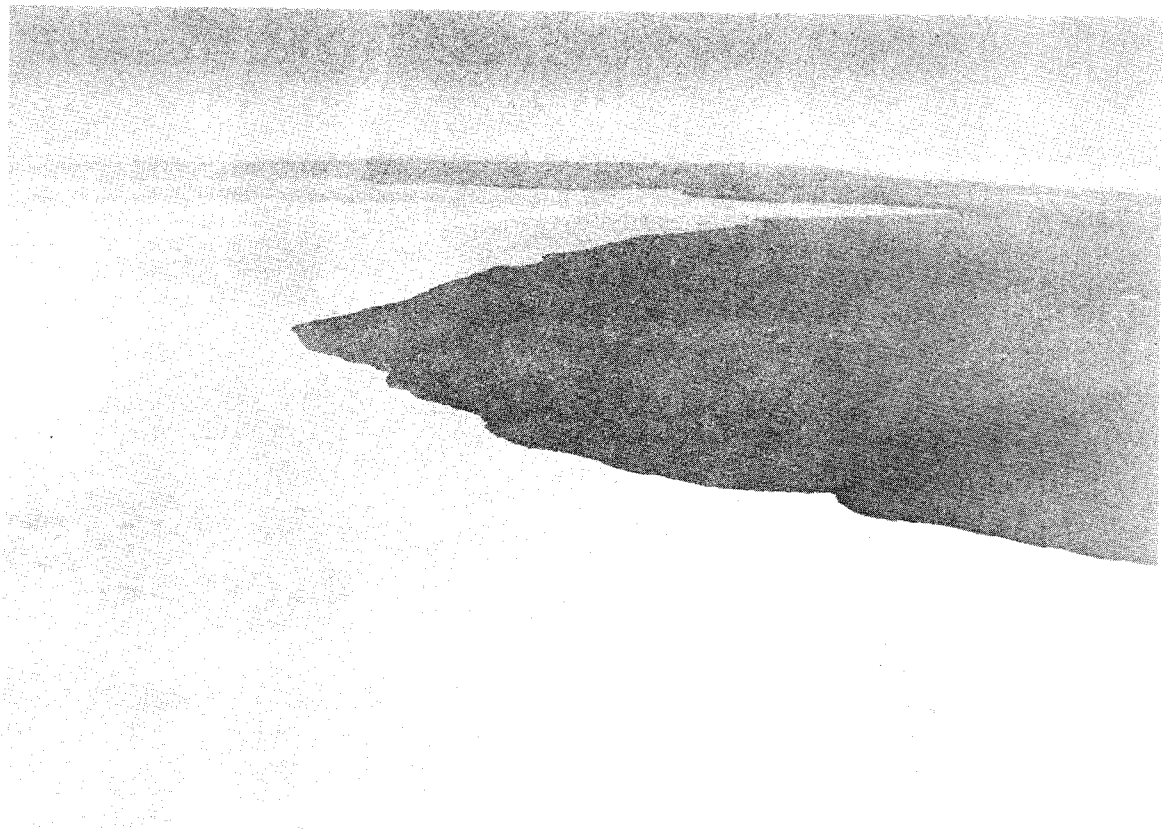

Fig. 2. The head of the North Water in June 1950, looking towards Greenland from north of Pim Island.

Canadian Forces photo, 20,000 ft.

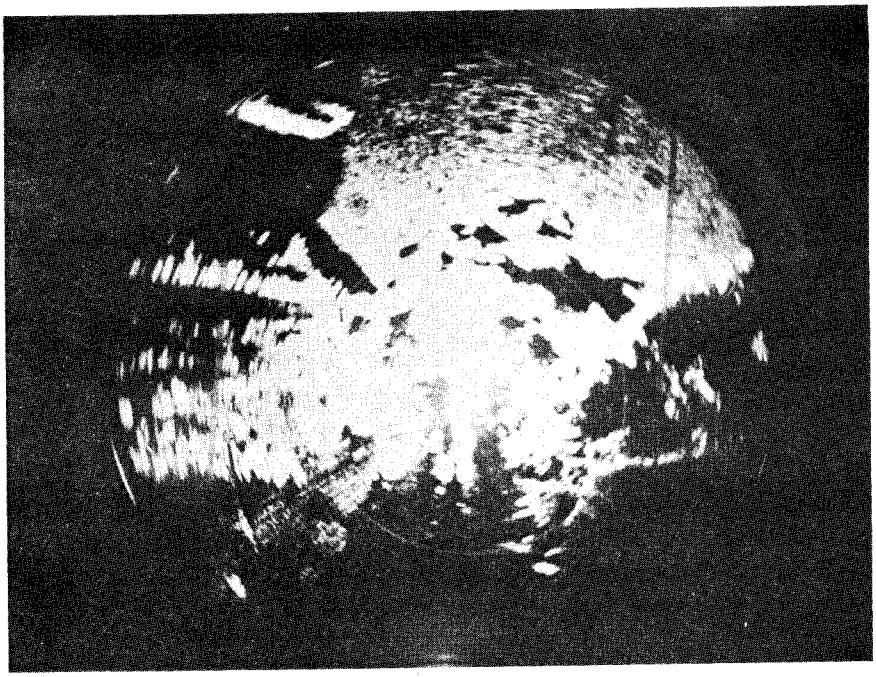

Fig. 3. Radar presentation of the narrows of Smith Sound on Flight I, showing the series of polynyas marking the head of the North Water. The black strip at the left side is not a polynya but the radar shadow thrown by Pim Island (arrow).

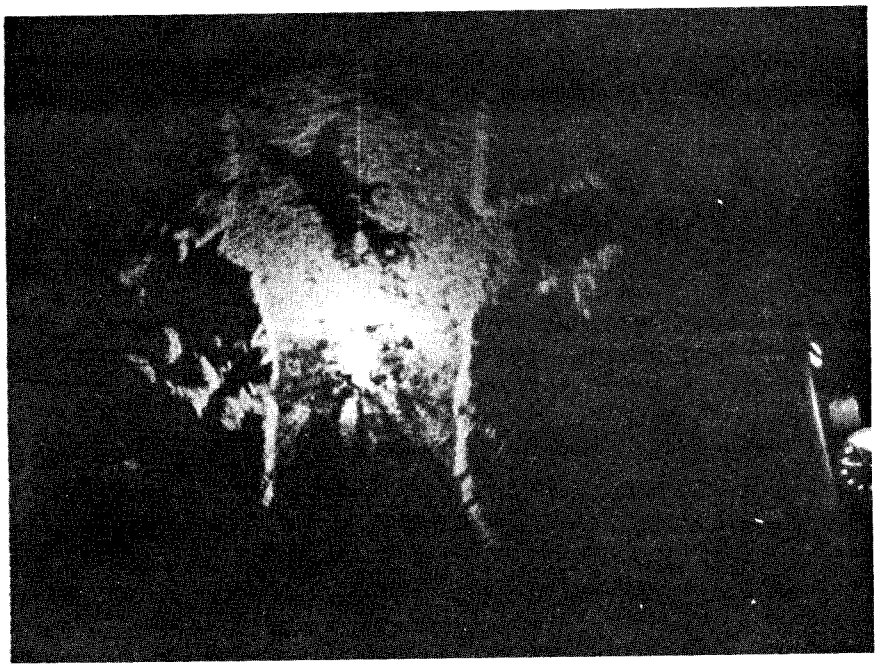

Fig. 4. Radar presentation of Robeson Channel, Flight II, heading north, showing a large open or near-open patch. Newman Bay is on the right, and opposite is Lincoln Bay.

Note: All radar pictures are oriented with the more northerly part of the channel at the top.

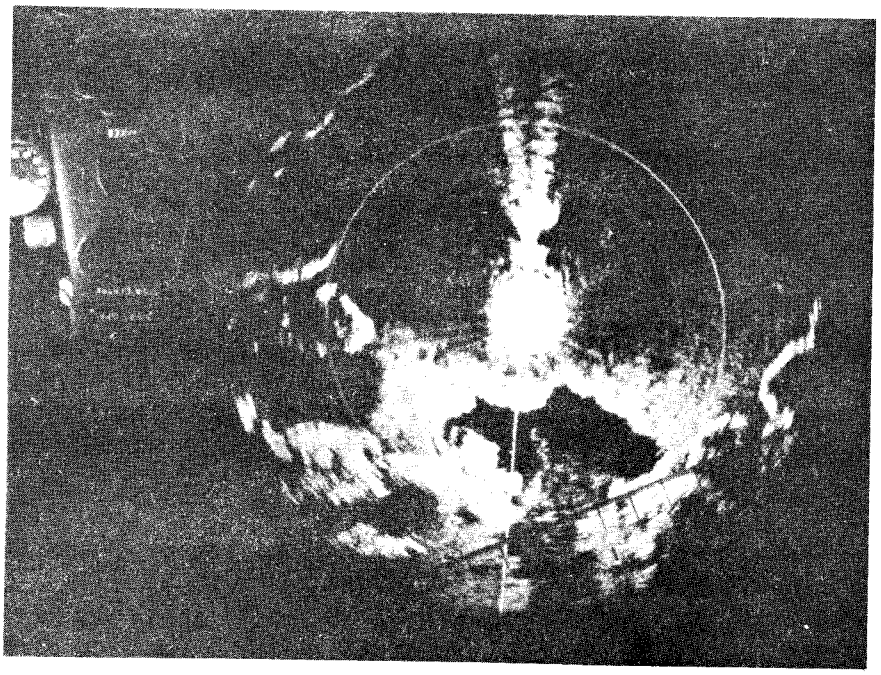

Fig. 5. Head of North Water, Flight II southbound, 72-mile range, showing the open area extending to between Cape Inglefield and Rensselaer Bay on the Greenland side and running north from Pim Island on the west. The black area was shown by visual observation to be open only near the north edge, the rest contained about 5/10 mostly new and young ice. Farther south the channel seems to be more open on the east than the west side. Cape Herschel is at bottom left, just below Pim Island, the coast of which is partly masked by ice clutter. The black areas in the inlets on the left are not open, but are caused partly by relatively smooth ice and partly by radar shadow cast by the land areas.

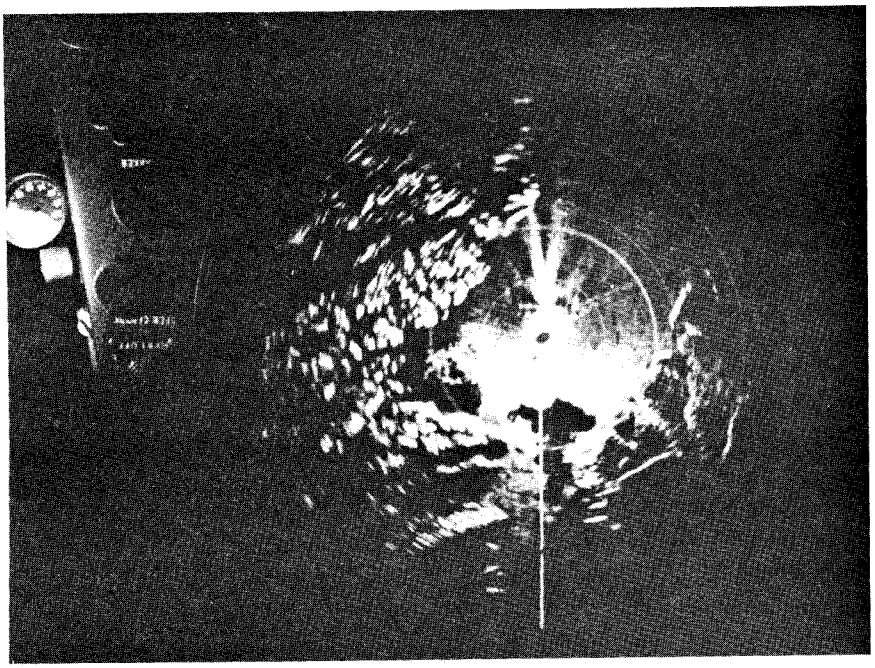

Fig. 6. The same as Fig. 5 at 170-mile range, showing the west coast of Kane Basin to Cape Fraser and the east coast to beyond Marshall Bay.

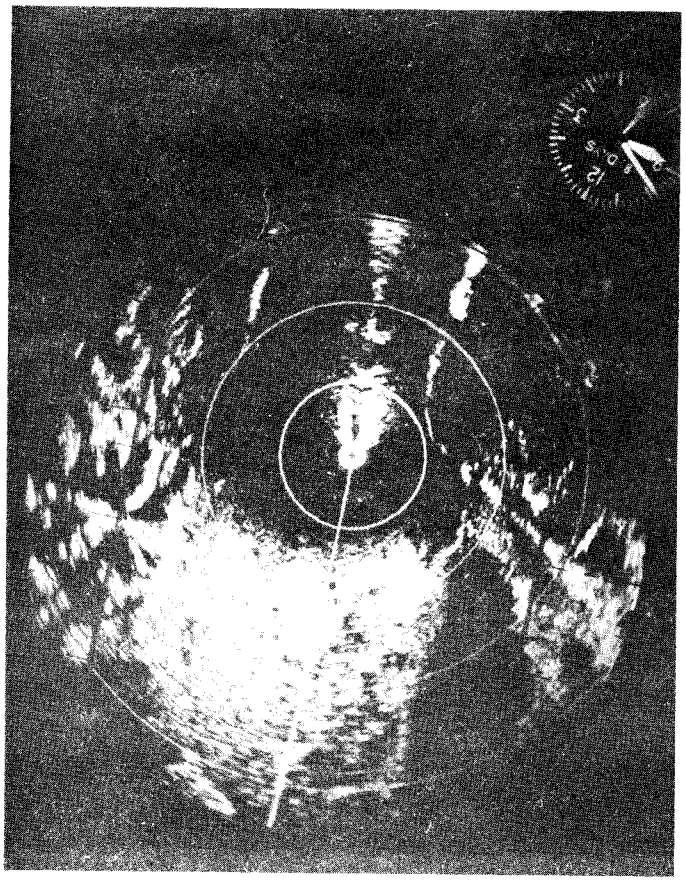

Fig. 7. Hall Basin, Flight III southbound, showing what appears to be a large open area on the east side of the basin. It was not possible to confirm this visually. Cape Lupton is at upper right, Cape Baird bottom left.

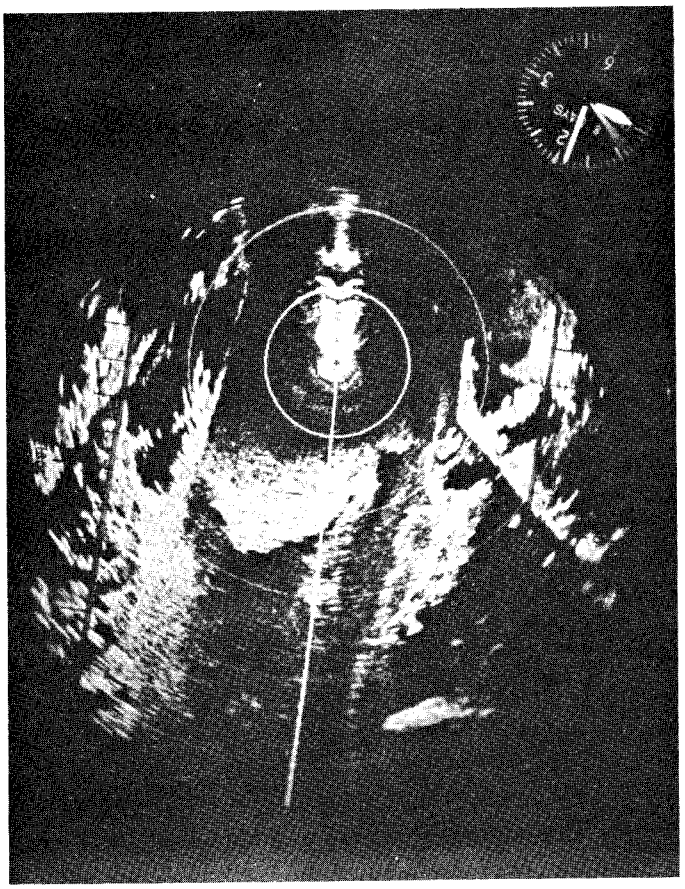

Fig. 8. Kennedy Channel, Flight III southbound., showing open patches oriented up and down channel. Cape Defosse is on the left, Cape Ulrich on the right.

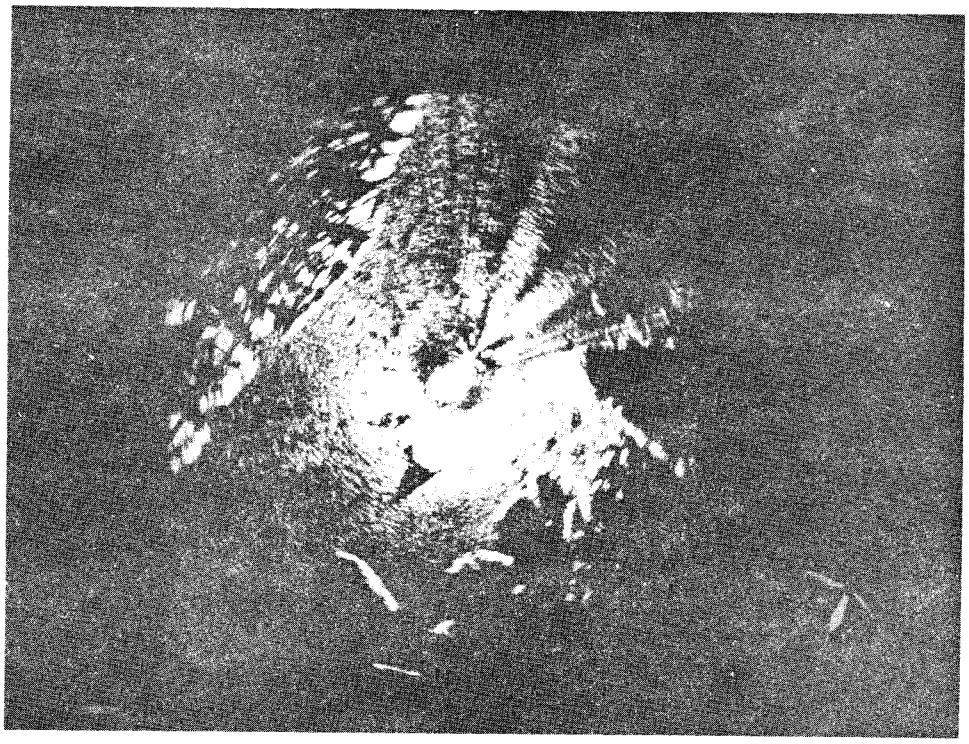

Fig. 9. Kennedy Channel, Flight VI southbound, showing a triangular dark patch that appeared in the same place on Flight V. The north side of Franklin Island appears at the bottom on the east side of the channel and Hans Island is in the small dark patch north of the triangle. No open area was seen here by visual observation, but there was a smooth grey patch that might account for the triangle.

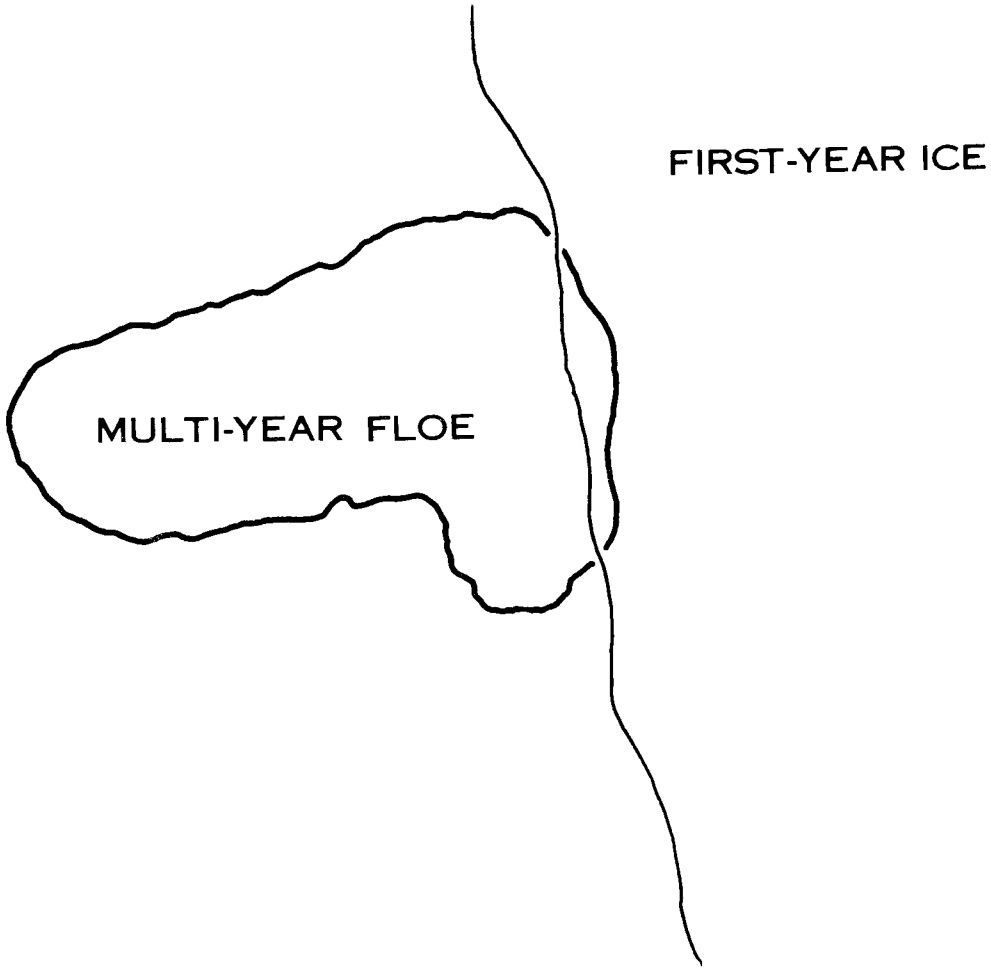

Fig. 10. Diagram showing a crack in first-year ice going directly through the edge of a multi-year floe that lay in its path. Observed in Kane Basin on Flight V.

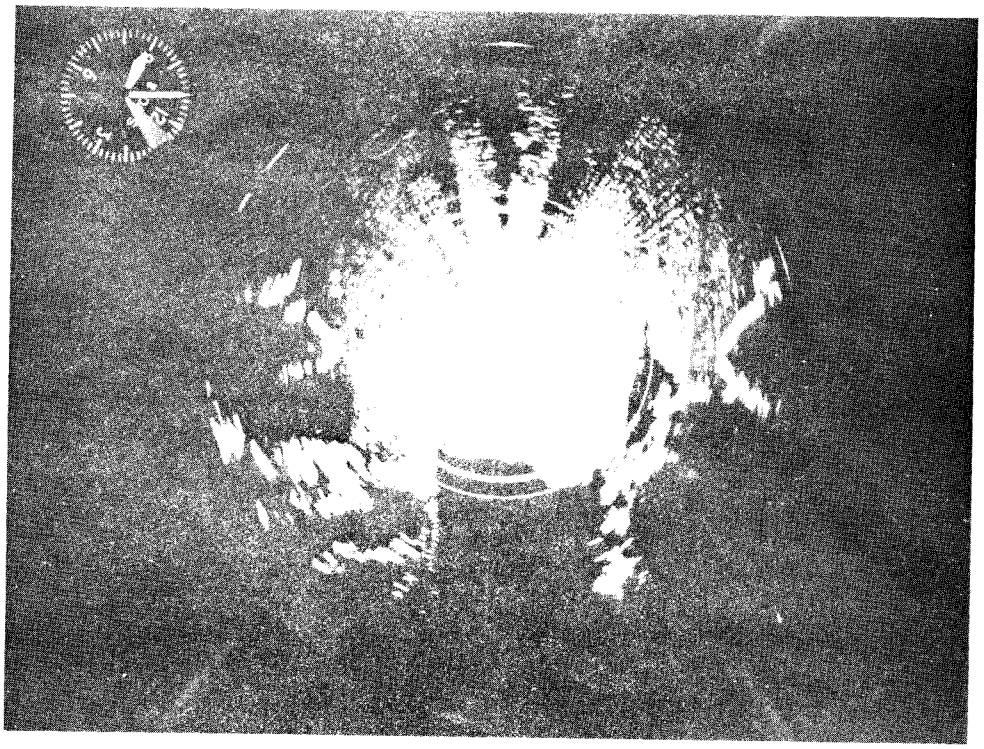

Fig. 11. The head of the North Water, Flight V southbound. Compare the shape of the north edge with that in Fig. 12. The dark patch on the right northeast of the North Water was not open and must represent smooth ice. It was also observed on Flight VI.

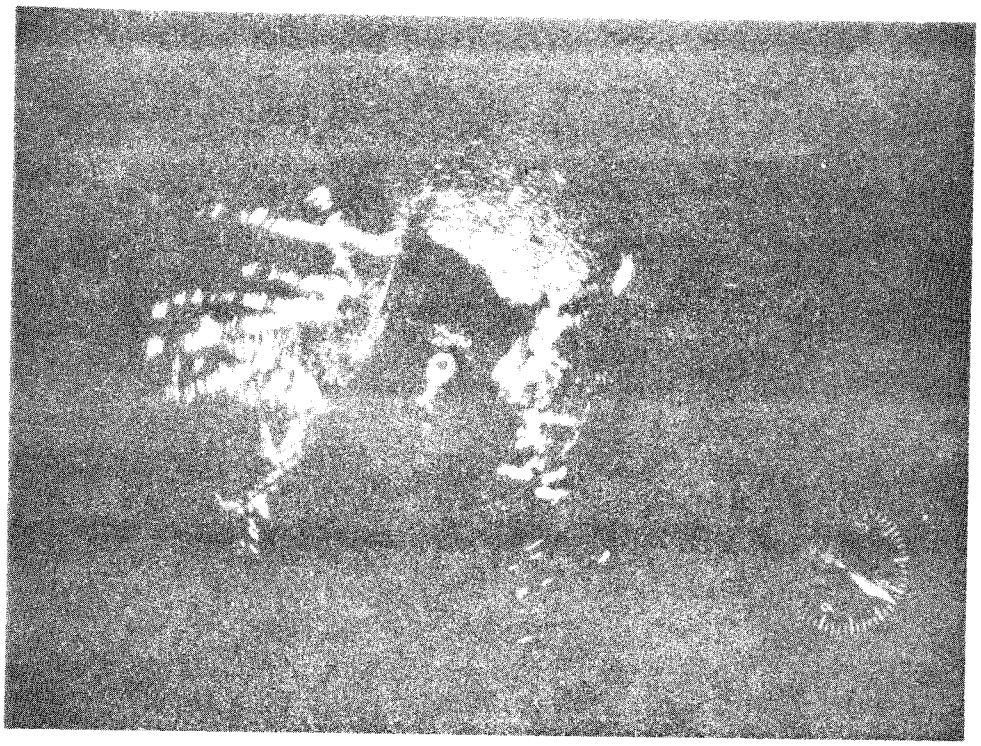

Fig. 12. The head of the North Water, Flight VI northbound, showing exactly the same form as on Flight V (Fig. 11). It will be seen that there was not at this time a curving edge, though it does jut northwards at both coasts. See also Fig. 14.

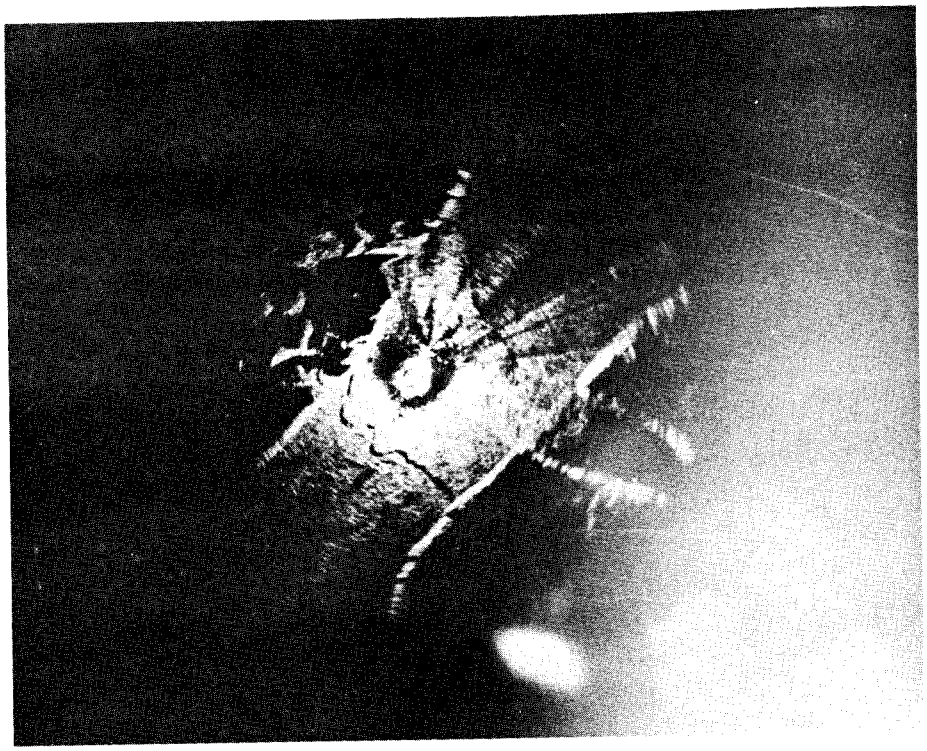

Fig. 13. Robeson Channel, Flight VI southbound, showing the fracture running across the channel from just north of Wrangel Bay. Newman Bay may be seen on the Greenland coast and Lincoln Bay on Ellesmere Island just astern of the aircraft. The ice north and south of the lead was quite different, but this does not show up on the radar presentation.

Fig. 14. The head of the North Water looking towards Pim Island. This picture was taken on 1 April, but an identical picture, too dark for reproduction, was taken on Flight VI. A comparison of this with Figs. 11 and 12 shows that the actual edge of the ice, starting just south of Pim Island, does not appear on the radar presentation which shows only the edge of the rough ice just visible running north from the northeast corner of the island.

6,000 ft.

Fig. 15. The head of Robeson Channel, looking east, showing the open lead frequently found here. At this time at least it did not represent an offshore flaw lead with Arctic Ocean pack ice moving off from channel fast ice with an offshore wind. On the contrary the Arctic Ocean ice in the area is almost unbroken, and shows no sign of offshore movement either in the foreground or on the Greenland coast, whereas the Robeson Channel ice is broken up and in motion, apparently under the influence of a southward circulation.

Canadian Forces photo, 20,000 ft., 24 June 1950.

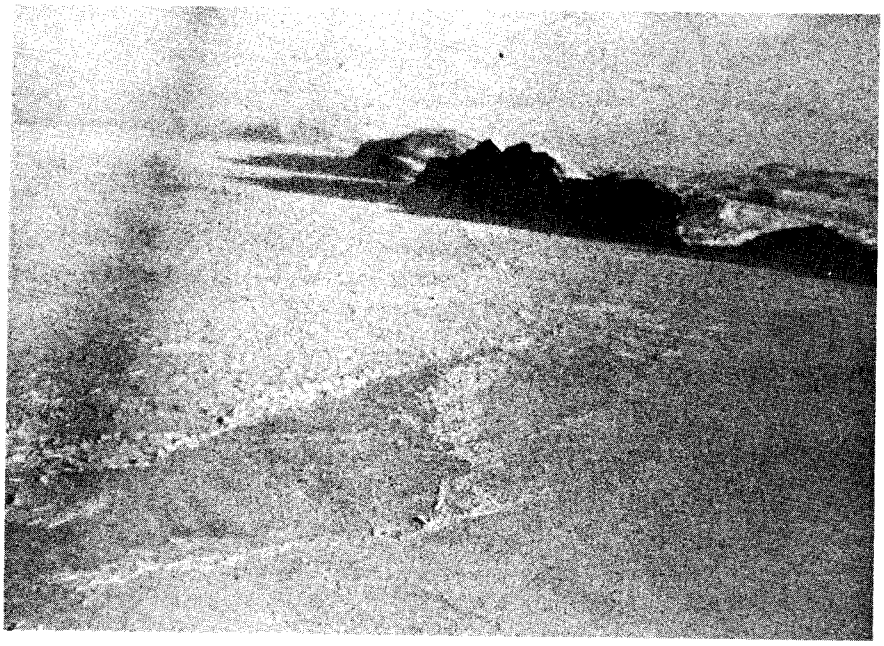

Fig. 16. Cape Lupton, looking northeast along the coast of Robeson Channel, showing typical heavily ridged first-year ice and, in the foreground, smooth ice of more recent formation. This is roughly the area of the dark patch in Fig. 7.

1 April 1971, 3,000 ft.

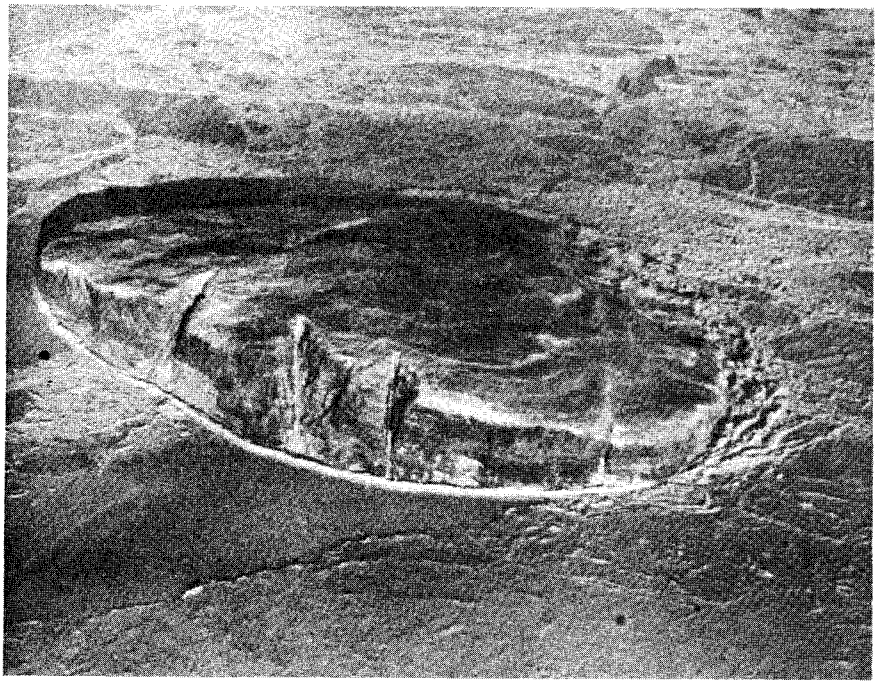

Fig. 17. Hans Island, looking west. In the foreground is a multi-year floe with a patch of smooth young ice beyond it, while beyond the island on its northwest side is an area of hummocked first-year ice. Note the very heavy pile-up of ice on the north shore of the island, showing the predominantly southerly flow in the channel.

1 April 1971, 5,000 ft.

Fig. 18. Kennedy Channel looking east, showing open water at the head of the channel.

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Six flights were made over Nares Strait during the winter of 1970-71 to determine the date of consolidation of the ice cover. A combination of radar scope photography and visual observations was used to record the conditions. The report describes the results of these flights and relates them to historical data.

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