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Review of Oceanographic Conditions in Subareas 0 and 1 During the 1970-79 Decade

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Abstract

During the 1970-79 decade, temperature conditions in Subarea 1, exemplified by the mean temperature of the upper 40 m on Fylla Bank, returned to the level which prevailed before the cold period at the end of the 1960's. Seasonal trends in salinity during the 1970-79 decade revealed a periodic decrease in surface salinity in October-November on Fylla Bank, attributable to the spring outflow of fresh water from Godthåb Fjord. The results from extensive current-meter records during the summers of 1975-78 mainly confirm the general pattern of circulation in Davis Strait, based previously on dynamic topography charts. Knowledge of tides, derived from water-level measurements during the same period, was in good agreement with previously published results.

Introduction

Investigations of the oceanographic environment in Subareas 0 and 1 (Fig. 1) during the 1970-79 decade were mostly carried out in association with biological investigations and thus consist mainly of temperature and salinity measurements for the warm season of the year. Knowledge of circulation in the area is based mainly on dynamic topography charts, but current measurements were obtained in the 1975-78 period during an environmental survey program in connection with oil exploration off West Greenland.

The aim of this paper is to review the results of oceanographic observations in the two subareas during the 1970-79 decade. Surveys were performed by research vessels from Denmark, Federal Republic of Germany and the USSR. Most of the data available to the author concerns Subarea 1, which will therefore receive the greatest attention in this paper. In order to discuss the year-to-year and seasonal variations in oceanographic conditions, the Fylla Bank section was chosen as representative for Subarea 1, primarily because it is geographically situated almost in the middle of the area, and secondly because temperature and salinity observations, in most years, are made regularly at intervals through the year.

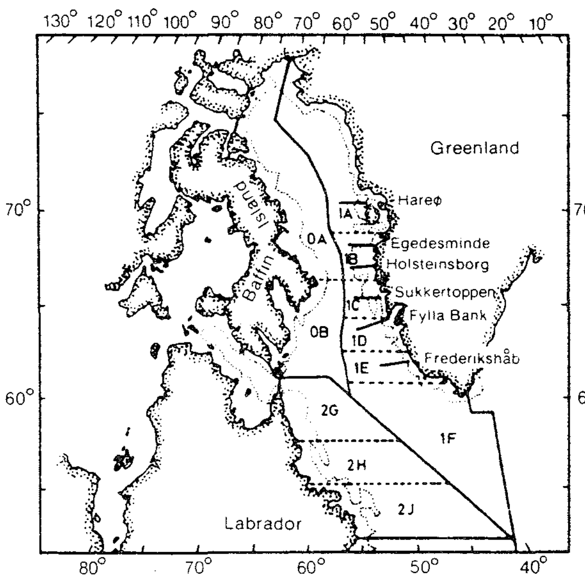

Fig. 1. Map showing the area of investigation.

Hydrographic Trends

Temperature trends on the Fylla Bank section

Oceanographic conditions along the west coast of Greenland can vary much from year to year, resulting in changes of conditions for biological production. The yearly variation may be illustrated by the mean temperature of the upper 40 m on Fylla Bank about mid-June over a period of 100 years (Fig. 2). The line at 1.8° C indicates the minimum temperature for high survival of cod larvae. It is apparent that the 1960-69 decade

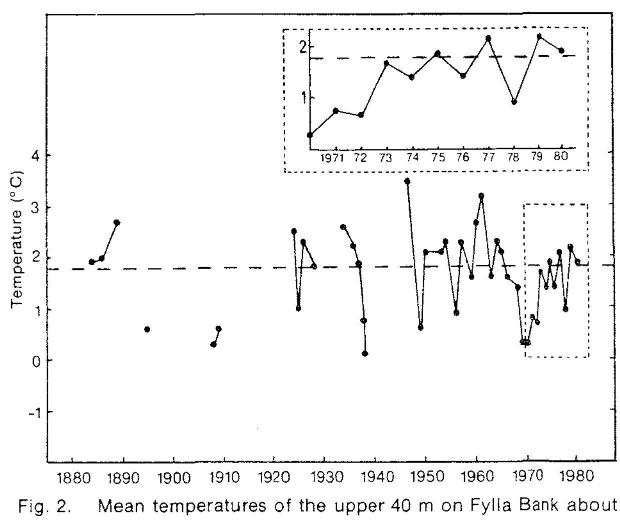

Fig. 2. Mean temperatures of the upper 40 m on Fylla Bank about mid-June, 1883-1980.

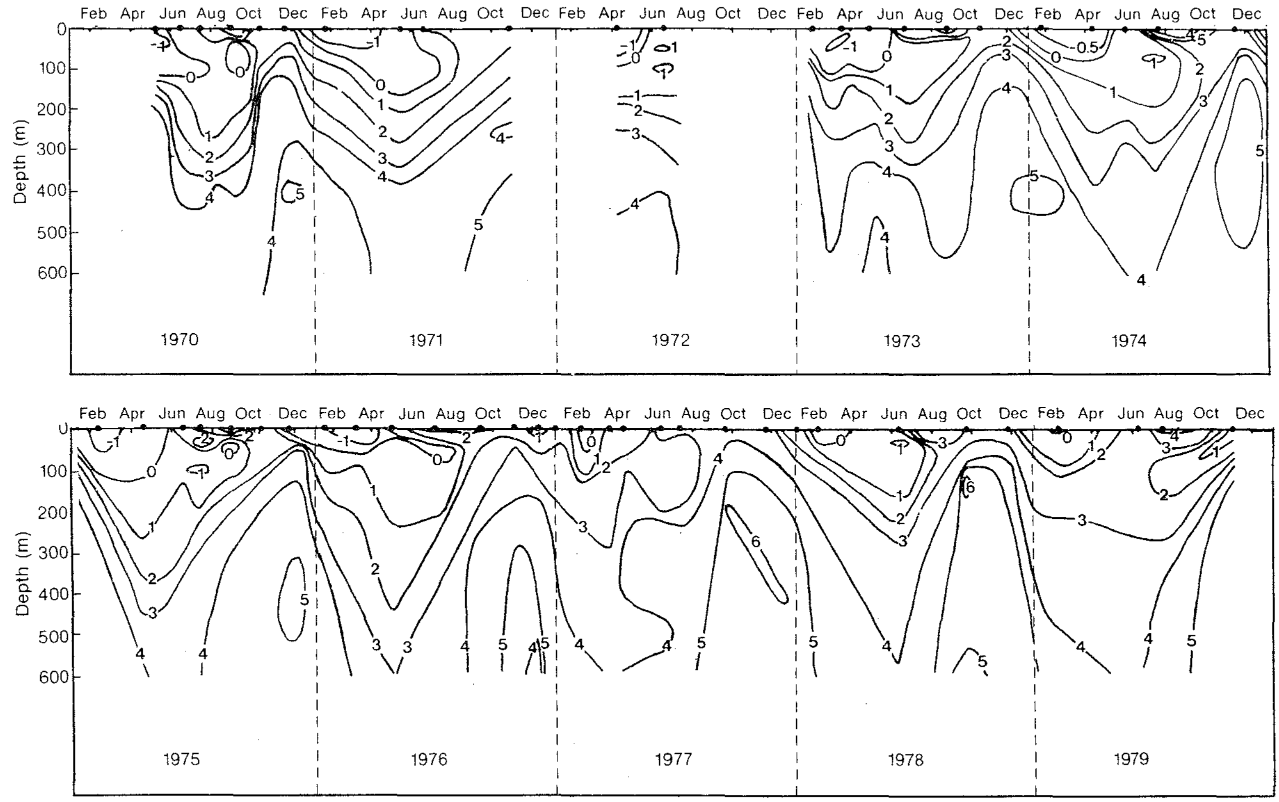

Fig. 3. Temperature distribution at Station 4 of the Fylla Bank section, 1970–79.

ended with a considerable decline in mean temperature and that the 1970–79 decade can be roughly characterized as a restoring period. Biologically, temperature conditions were favorable for survival of cod larvae only in three years of the decade.

A further impression of temperature variation during 1970–79 can be obtained from Fig. 3, which summarizes all of the temperature observations made by Gronlands Fiskeriundersogelser at Station 4 of the Fylla Bank section. A general observation is the relatively high temperature of the water below 100 m during the winter (October–April), often higher than 5° C in the whole water column below about 200 m. This indicates the dominance of Irminger Current water during that period of the year and confirms the results of Soule *et al.* (1963), who found that the mass transport of the cold (East Greenland) component of the West Greenland Current at Cape Farewell approached zero in August–September, whereas the mass transport of the Irminger component more than doubled during the same period.

In most years, a shallow thermocline develops in the summer, with maximum temperatures of 3° to 5° C and a thickness of about 40 m. During the winter, the surface layer cools to temperatures below 0° C, often below -1° C. The cooling process causes an increase in density of the water, with consequent deepening of the cold upper layer due to vertical convection. This phenomenon is clearly illustrated by observations in February-March 1975 (Fig. 3) and also by those of Svetlov (MS 1975) in March 1974 (Fig. 4).

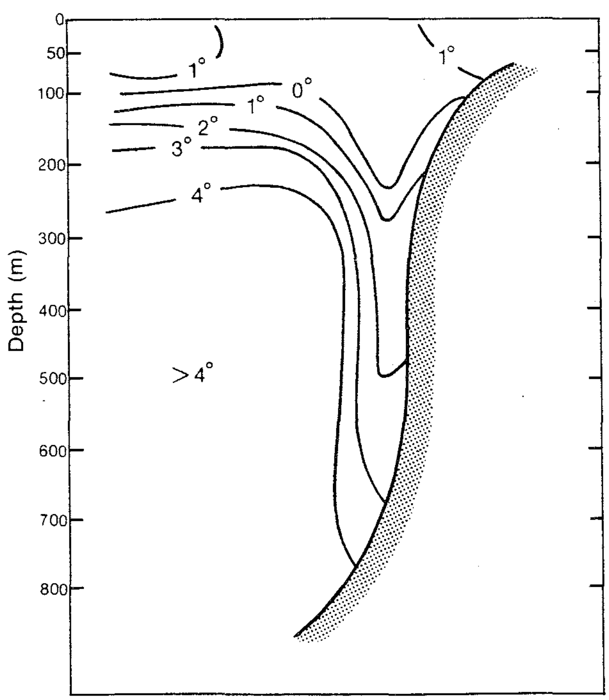

Fig. 4. Temperature distribution on the Fylla Bank section in March 1974 (from Svetlov, MS 1975).

In 1970, when the June mean temperatures were the lowest for the decade, the upper 100-m layer had temperatures below 0° C (below -1° C in part of the layer) and, even in September, temperatures were below 0° C in 30-110 m. Negative temperatures were also observed in the summers of 1975 and 1976 but in a relatively thin layer.

Generally, temperatures were between 3° and 4° C at 300-500 m in the spring (Fig. 3), but this layer was characterized by temperatures above 4° C in 1973, due possibly to a large inflow of Irminger Current water. In contrast to conditions in 1973, the water below 300 m was cold in May 1976, with temperatures below 3° C and a decrease in salinity, a phenomenon probably due to mixing with water from the Baffin Island Current. In December 1976 and 1978, a pronounced decrease in the temperature of the deep layer occurred, i.e. the cooling of the water below 400 m, which normally takes place during January-February, was accelerated in these winters for some unknown reason.

Temperature distribution along West Greenland

An impression of temperature distribution along the coast of West Greenland can be obtained from Fig. 5, which shows vertical temperature sections from Frederikshåb in the south to Hare Island in the north in July 1971, except that the Frederikshåb observations were made in mid-August. Although 1971 was a cold year and July is in the season just before the intensification of Irminger Current water in the area, clear signs of the presence of this water are found in all sections north to Hare Island. The depth, at which Irminger Current water is found, increases towards the north, and the effect of mixing with colder water during its northward passage is seen by the disappearance of the 4.5° C isotherm between Sukkertoppen and Holsteinsborg and the 4.0° C isotherm between Egedesminde and Hare Island. The presence of arctic water from the Baffin Island Current is seen at the seaward stations of the northern sections, with temperatures below 0° C (and even below -1° C) in the core at 50-100 m.

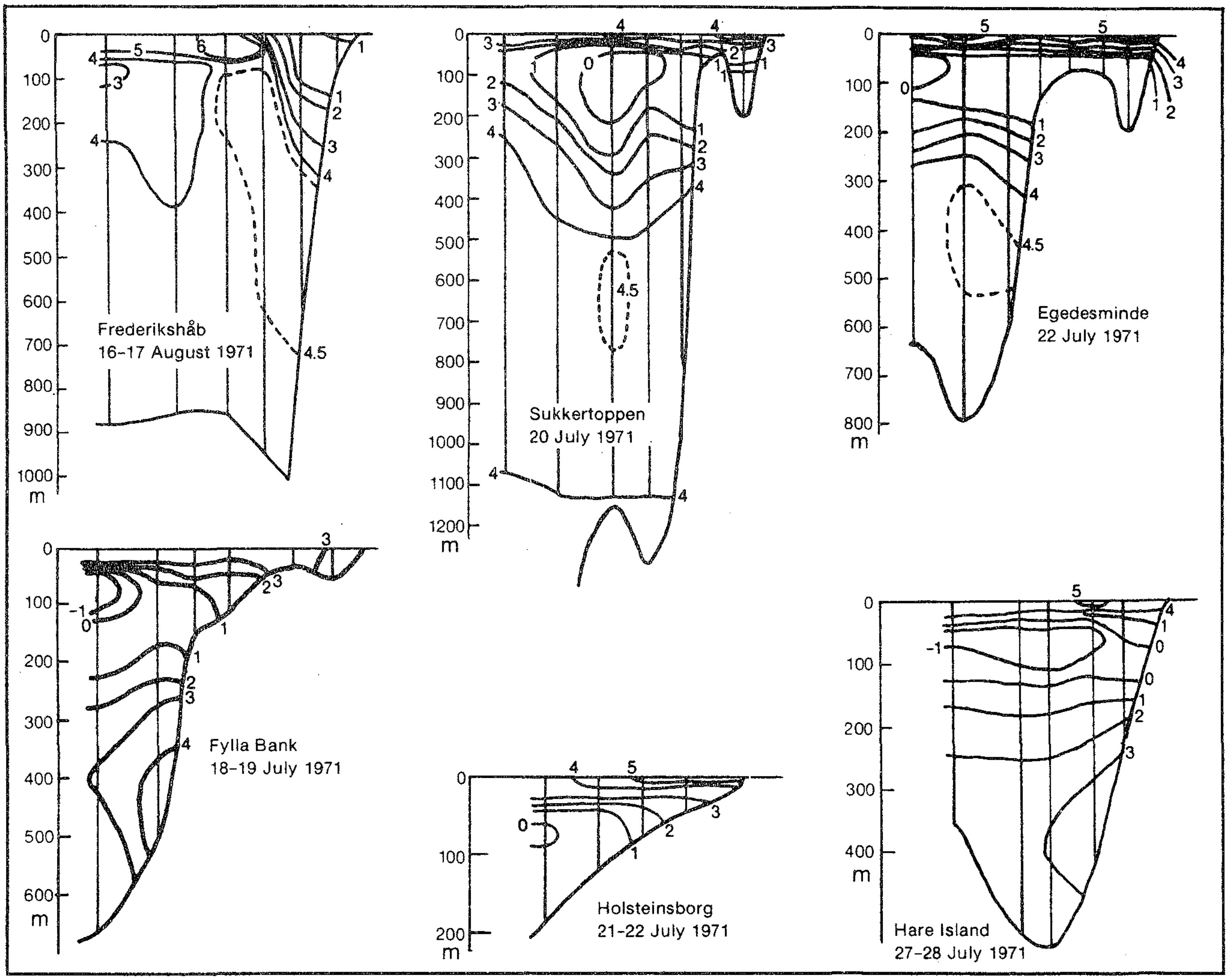

Fig. 5. Temperature distribution on six standard sections along West Greenland in the summer of 1971.

Salinity trends

Salinity variation at three depths (0, 200, and 600 m) at Station 4 of the Fylla Bank section is shown in Fig. 6 for the 1970–79 decade. As expected, the variation declined with depth, being about 2°/oo at the surface, 0.8°/oo at 200 m, and 0.2°/oo at 600 m.

An obvious feature of the salinity regime at the surface (Fig. 6) is the decrease in October-November, probably due to spring outflow from Godthåb Fjord of low salinity water which does not reach Station 4 on Fylla Bank until late in the year because of the strong northward-flowing current. The fjord origin of the less saline water is confirmed by the salinity distribution shown in Fig. 7, based on observations reported by Kudlo and Borovkov (MS 1975a). Meandering of the West Greenland Current might be another explanation for the autumn decline in salinity at Station 4, but it is unlikely that such meandering occurs so regularly each year.

No specific trend is evident in the salinity regime at 200 m, because mixing of water masses of different origins traditionally takes place in this depth and area. At 600 m, the pronounced decrease in salinity during early to mid-1976 was probably due to mixing with cold, low-salinity water of the Baffin Island Current.

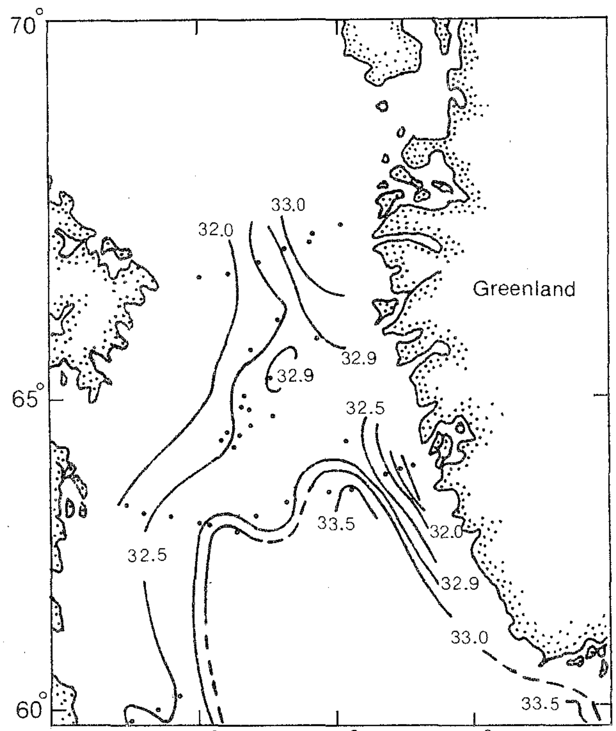

Fig. 7. Surface salinity distribution in Davis Strait, November 1973 (from Kudlo and Borovkov, MS 1975a).

Water Circulation

General current patterns

Knowledge of the circulation in Davis Strait, including the West Greenland Current, is mainly derived from analyses of oceanographic observations and the construction of dynamic topography charts. Kudlo *et al.* (1980), from USSR research vessel observations in Davis Strait during 1962–78, constructed a

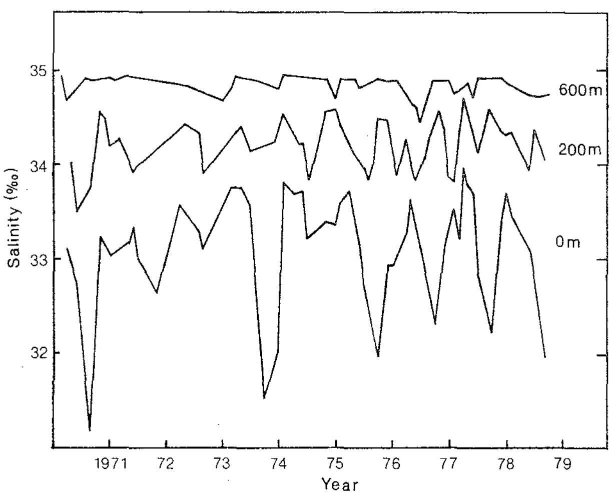

Fig. 6. Salinity trends at three different depths at Station 4 of the Fylla Bank section, 1970–79.

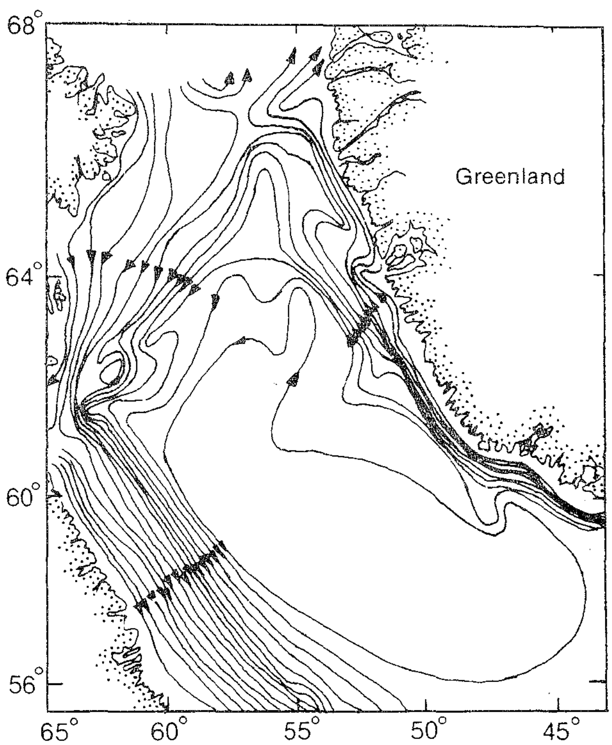

Fig. 8. Probable mean geostrophic circulation of the surface layer in Davis Strait during the warm period of the year, based on observations during 1962–78 (from Kudlo *et al.*, 1980.)

probable mean scheme of geostrophic circulation in the surface layer for the warm period of the year) April–October) (Fig. 8). Although such a scheme provides an overview of the movement of water masses in the area of interest, it represents the mean circulation for a season in which great oceanographic changes take place. Also, as the oceanographic pattern changes from year to year, the circulation undergoes yearly variation (Alekseev *et al.*, 1972). In fact, Kudlo *et al.* (1980) underline in their paper that the method of constructing the mean scheme of geostrophic circulation map was subjective.

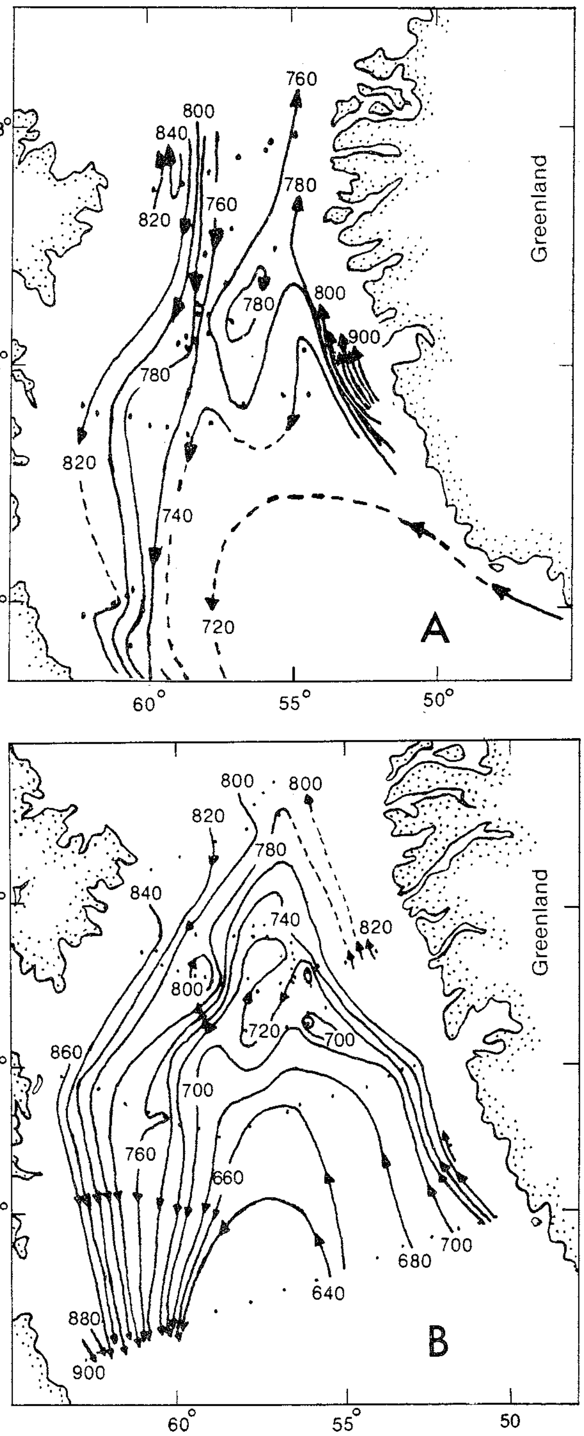

Fig. 9. Geostrophic circulation in Davis Strait, based on observations (**A**) during September–November 1973 (from Kudlo and Borovkov, MS 1975b), and (**B**) during November 1974 (from Kudlo *et al.*, MS 1976).

Of greater interest in reviewing year-to-year variation in circulation are dynamic topography charts for individual years and seasons. Two such charts are available for the 1970–79 decade, one constructed by Kudlo and Borovkov (MS 1975b) and the other by Kudlo *et al.* (MS 1976). The first chart (Fig. 9A) shows the geostrophic circulation in Davis Strait during September–November 1973. The pattern differs somewhat from the mean circulation shown in Fig. 8, in that the West Greenland Current was rather intense in 1973, whereas the Baffin Island Current was about normal. The circulation in November 1974 (Fig. 9B) was not as intense as in 1973. The West Greenland Current was broader and the westward deflection of that current began farther southward in 1974 than in 1973. Another peculiarity, particularly in Fig. 9A, is the anticyclonic gyre centered at 65° N which transports water from the central part of Davis Strait to Store Hellefiske Bank. This is supported by the presence of low temperatures in the surface layer of the Holsteinsborg section in November 1973 (Fig. 10). Both geostrophic circulation patterns (Fig. 9) show the usual meandering of the West Greenland and Baffin Island Currents in the vicinity of the Greenland-Canada Ridge.

Current measurements

Extensive current measurments at various positions along the west coast of Greenland were made in the 1970's in contrast with few sporadic observations

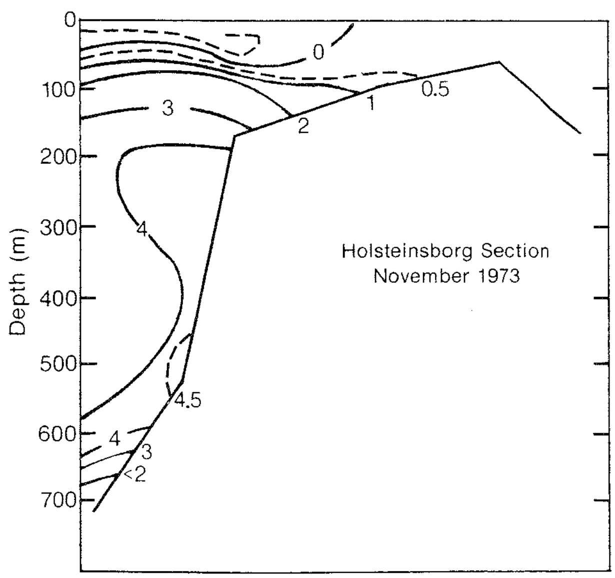

Fig. 10. Temperature distribution on the Holsteinsborg section in November 1973.

during previous decades. These measurements were made during the summers of 1975-78 as part of an investigation of environmental conditions in connection with the oil exploratory program which took place in that period. The Danish Hydraulic Institute (1979) has compiled a detailed report of these investigations. The measurements were recorded at 10-min intervals with self-recording current meters. The currents along West Greenalnd are naturally composed of a number of tidal components causing no net drift of water and a residual component generated mainly by pressure gradients. In order to evaluate the net drift of the water masses, the tidal components of the currents have been eliminated by taking the 24-hr running mean of the current observations.

The Danish Hydraulic Institute (1979), using the data collected in 1975-78, has computed and displayed, in the form of current roses, average pictures of the 24-hr mean current distribution during July-August for three depth intervals: 20-59 m, 60-240 m, and 250-410 m. The mean drift velocity vectors, calculated for two of these depth intervals, are shown in Fig. 11. The maximum value of the 24-hr mean current was approximately 30 cm/s, whereas the maximum mean drift velocity was about 20 cm/s. The highest velocities were generally found to the south of and on the banks, and the velocities tended to decrease with increasing depth.

The direction of the currents was mainly northward, with local modifications due to the general features of the bottom topography. For example, the current over the southern part of Holsteinsborg Deep, which separates Lille Hellefiske Bank and Store Hellefiske Bank, is nearly always directed northeastward parallel to the depth contour, whereas the dominating direction of the current just north of the Deep is west-north-west and west with great velocity, higher than 24 cm/s more than 25% of the time. The probable reason

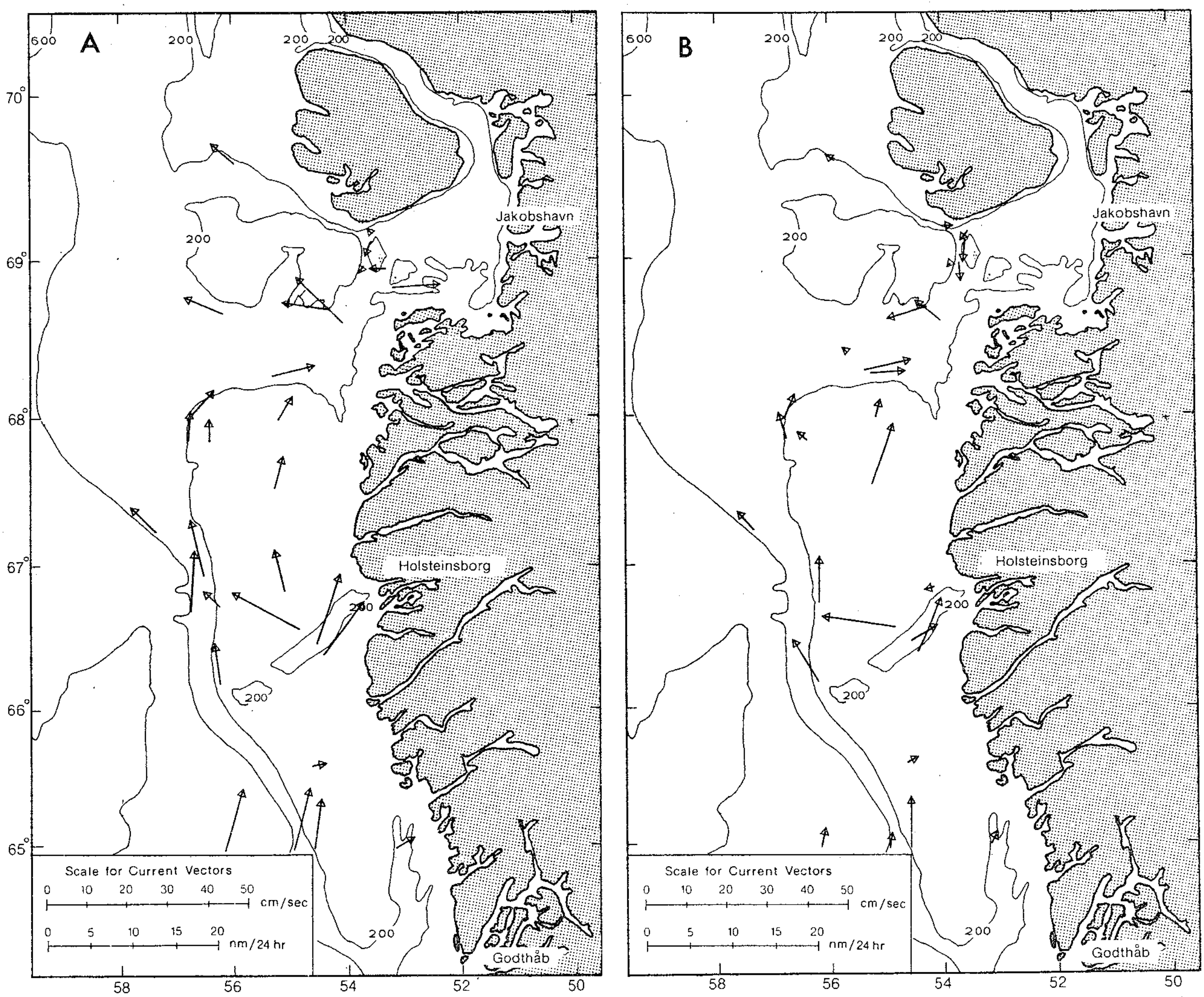

Fig. 11. Net velocity vectors for (**A**) the 20-57 m depth interval and (**B**) the 60-240 m depth interval, from measurements during the summers of 1975-78.

for this great variation in current direction within a relatively small area is that the northward-flowing water in the Deep is deflected westward and thence northward around the southern and western slopes of the shallow Store Hellefiske Bank. Upon reaching the northern edge of that bank, the current clearly follows the bottom topography, flowing into Disko Bay. The excess water in the Bay flows out following the depth contours north and south of Disko Bank.

Tides

A general description of tidal conditions in Davis Strait was given by Godin (MS 1966), who computed cotidal charts for the principal semi-duirnal (M_2) and duirnal (K_1) tidal components shown in Fig. 12. The M_2 component has an amphidromic point at about 70° N almost in the middle of the Strait. Along West Greenland, the amplitude is greatest (120 cm) in the Godthåb area and decreases to 60 cm at Disko Island. On the western side of Davis Strait, the amplitude is highest (180 cm) at the southern end of Baffin Island and decreases to 15–40 cm farther northward along the coast. The amplitude of the K_1 component is relatively small, increasing from about 10 cm near Godthåb and southern Baffin Island to about 30 cm at Disko Bay and northern Baffin Island.

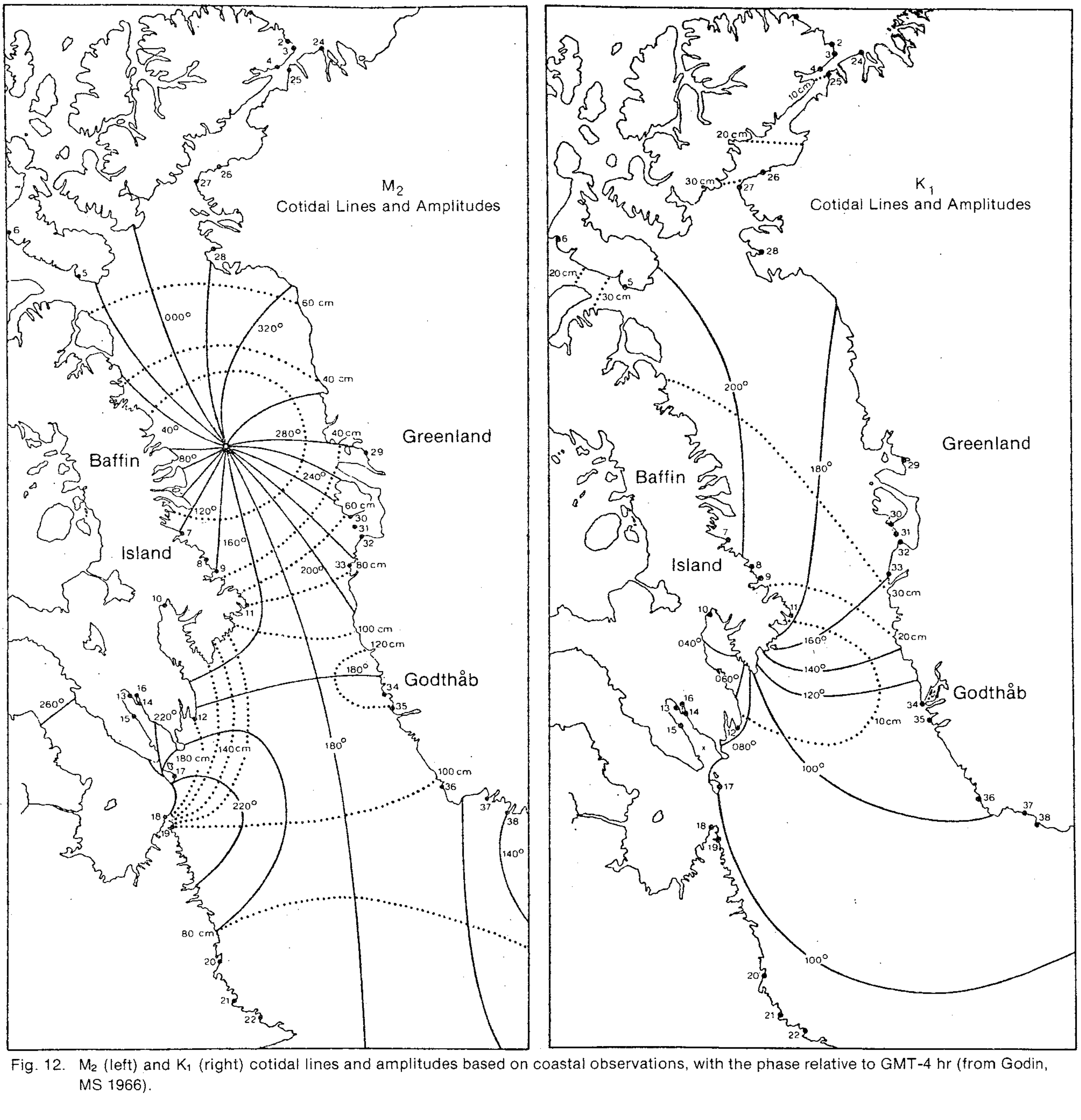

Fig. 12. M_2 (left) and K_1 (right) cotidal lines and amplitudes based on coastal observations, with the phase relative to GMT-4 hr (from Godin, MS 1966).

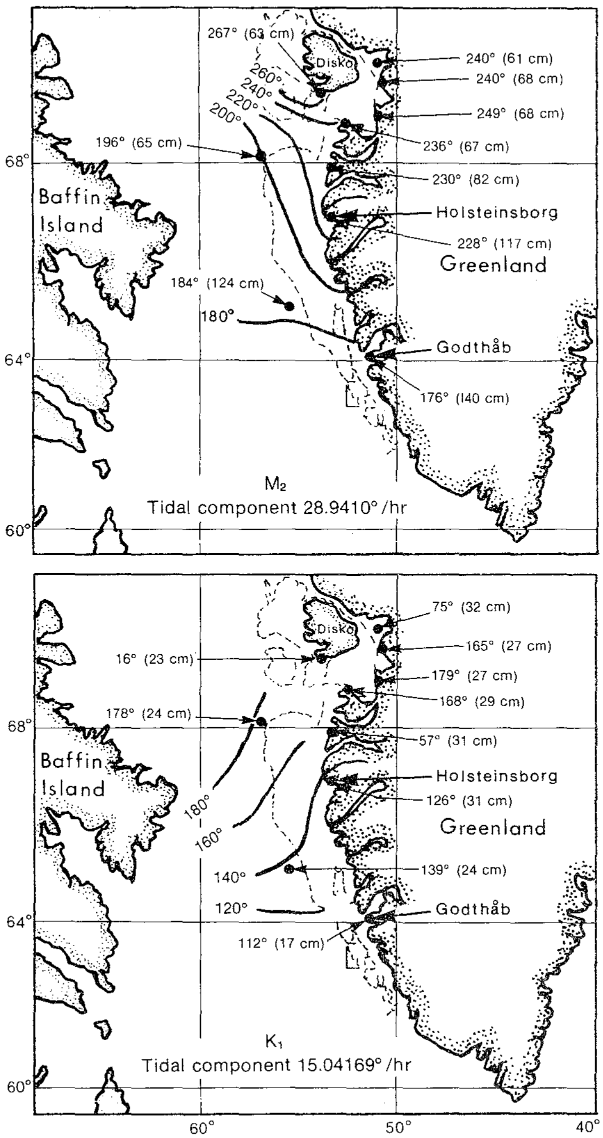

Fig. 13. M_2 (upper) and K_1 (lower) cotidal lines and amplitudes based on water level measurements during 1975–78.

During the environmental investigations in 1975–78, pressure gauges were deployed offshore near the seabed and water-level recorders were used onshore along the coast, in order to improve the knowledge of tidal conditions and to determine the tidal ranges in the areas of interest. The results of the data analysis for the M_2 and K_1 components are shown in Fig. 13. They seem to be in good agreement with the results of Godin (MS 1966).

Acknowledgements

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References

ALEKSEEV, A. P., B. P. KUDLO, V. N. YALOVLEV, A. F. FEDOSEYEV, and A. A. BARINOV. 1972. Some aspects of water circulation in the Northwest Atlantic in 1960-69. *ICNAF Spec. Publ.*, **8**: 149–165.

DANISH HYDRAULIC INSTITUTE. 1979. Environmental conditions offshore West Greenland, Vol. III. Greenland Technical Organization, 76 p.

GODIN, G. MS 1966. The tides of the Labrador Sea, Davis Strait and Baffin Bay. *Manuscr. Rep. Ser. Mar. Sci. Dir. (Can.)*, No. 2, 156 p.

KUDLO, B. P., and V. A. BOROVKOV. MS 1975a. Salinity of waters in the Davis Strait, Labrador and Newfoundland areas in 1973–74. *ICNAF Res. Doc.*, No. 78, Ser. No. 3505, 8 p.

MS 1975b. Circulation of waters in the ICNAF area in 1973–74. *ICNAF Res. Doc.*, No. 79, Ser. No. 3506, 12 p.

KUDLO, B. P., V. A. BOROVKOV, and V. D. BOYTSOV. MS 1976. Circulation and salinity of waters in the Davis Strait, South Labrador and Newfoundland areas in 1974–75. *ICNAF Res. Doc.*, No. 70, Ser. No. 3874, 14 p.

KUDLO, B. P., V. V. BURMAKIN, and V. S. STERKHOV. 1980. Geostrophic circulation of Northwest Atlantic waters from Davis Strait to Newfoundland, generalized from 1962 to 1978 data. *ICNAF Sel. Papers*, **6**: 53–54.

SOULE, F. M., A. P. FRANCESCHETTI, R. M. O'HAGAN, and V. W. DRIGGERS. 1963. Physical oceanography of the Grand Banks region, the Labrador Sea and the Davis Strait in 1962. *Bull. U. S. Cst. Guard*, **48**, 153 p.

SVETLOV, I. I. MS 1975. Some peculiarities of the temperature conditions of waters of the West Greenland and Baffin Island currents in 1974. *ICNAF Res. Doc.*, No. 77, Ser. No. 3504, 9 p.