Surface temperatures of the Barents Sea

LARS MIDTTUN

Midttun, L. 1990: Surface temperatures of the Barents Sea. *Polar Research 8*, 11–16.

Temperature conditions in the Barents Sea are determined by the quality and quantity of the inflowing Atlantic water from the west and by processes taking part in the Barents Sea itself, in particular as a consequence of winter cooling and ice formation. The field of inflow to the Barents Sea during the period 1977–1987 has been studied. The surface winter temperatures within the Barents Sea vary in parallel with variations in the deeper layers of the inflowing water masses, whereas the surface temperatures in summer have a different variation pattern which is most likely dependent on the summer heating process.

Lars Midttun, Fiskeridirektoratets Havforskningsinstitutt, P.O. Box 1870 Nordnes, N-5024 Bergen, Norway;
May 1989 (revised September 1989).

The temperature conditions in the Barents Sea are determined by the quality and quantity of the water masses flowing into the sea from the west, but also by processes taking place in the sea itself. The inflowing, relatively warm water is strongly cooled during the winter and the surface gradually freezes. The northern Barents Sea is therefore ice covered in winter. As a consequence of cooling and ice formation, the water becomes denser, sinks and gradually mixes deeper in the water column. In shallower areas, this vertical convection may extend to the bottom, and results in the formation of bottom currents transporting cold and dense water out of the Barents Sea. During the summer, the sea ice in the north gradually melts resulting in the formation of a low salinity surface layer, which slowly warms up. This process leads to the formation of surface currents transporting the light surface water out of the Barents Sea. The main pattern in the surface current system is illustrated in Fig. 1 (from Loeng 1988a). The boundary between the cold Arctic water masses in the north and the warmer subarctic water masses of the southern Barents Sea is called the Polar Front.

The western field of inflow

The inflow of water masses from the west has regularly been observed in a section between Fugløya in Troms and Bjørnøya (Fig. 1).

In 1978, current observations were made using 9 anchored buoy stations along this section line. All stations were comprised of Aanderaa meters at various depths between the surface and the seabed. The experiment was run for nearly two months in the autumn, and the average observed currents are presented in Fig. 2 (from Blindheim 1989). Near the Norwegian coast the coastal current flows eastwards at an average speed of c. 25 cm/sec (c. 0.5 knot). In the central field, between 72°N and 73°N, Atlantic water also flows eastwards at velocities near 10 cm/sec. The total water transport through the section into the Barents Sea was, in this period, as much as 3 Sv (i.e. $3 \times 10^6\ m^3/sec$).

Outflow from the Barents Sea consists of: 1) surface water in the upper 100 m layer near Bjørnøya and 2) dense bottom water on the northern slope of the Bjørnøya Channel. The total westward transport is 1.2 Sv, of which 0.8 Sv is dense bottom water.

Thus, more water flows into the Barents Sea than out through this section. The surplus, c. 2 Sv, must consequently be transported out of the Barents Sea through the straits between Svalbard, Frans Josef Land and Novaya Zemlya. Midttun (1985) has shown outflowing dense bottom water between Frans Josef Land and Novaya Zemlya, but a quantification of this bottom current has, as yet, not been possible.

Temperature and salinity in the section Fugløya-Bjørnøya have, since 1977, been recorded regularly six times a year. The mean temperatures of the 50–200 m layer in the central part of the section (71°30'N–73°30'N) have been calculated for each of these six periods (Fig. 3). As we have

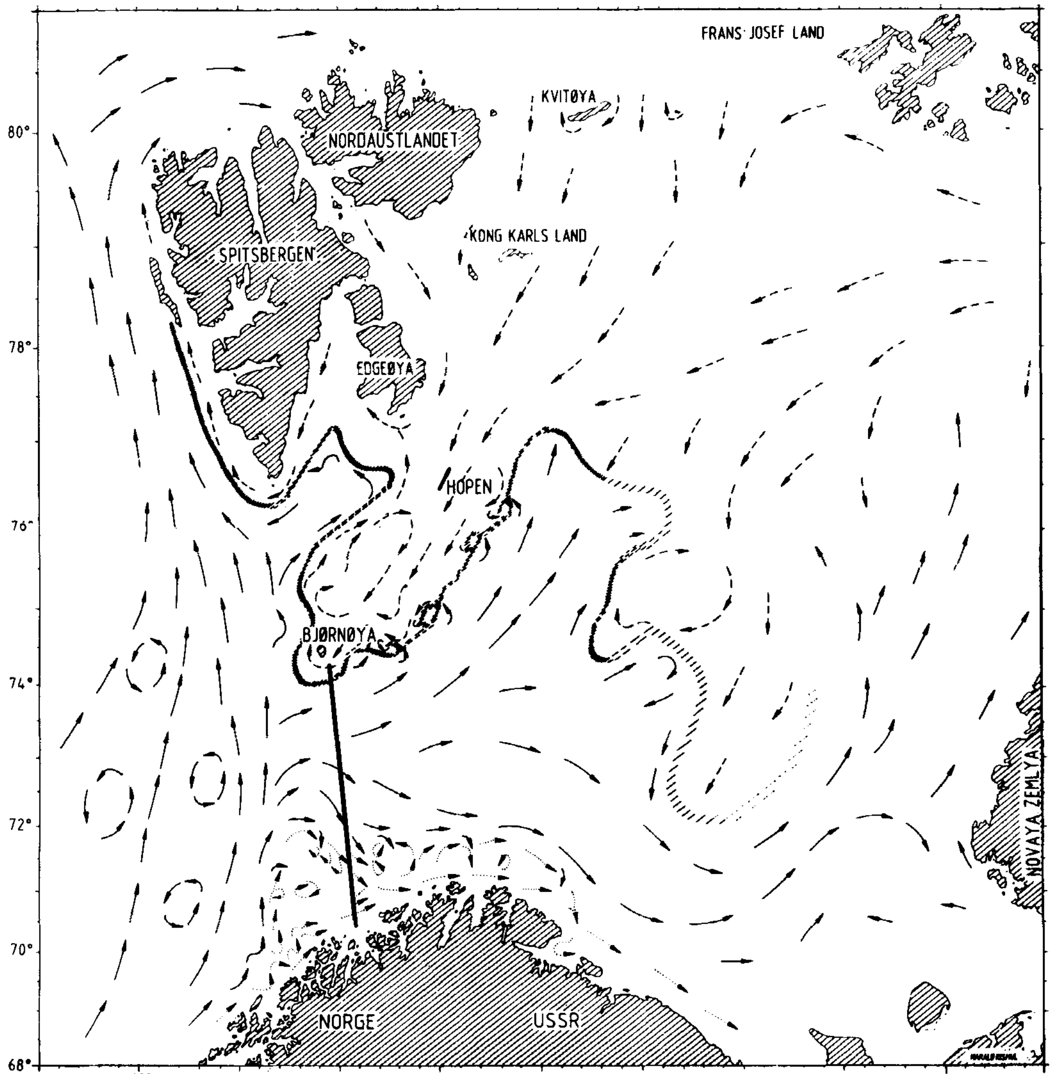

Fig. 1. Surface current in the Barents Sea. Solid arrows: Atlantic water current, dashed arrows: Arctic water current, dotted arrows: coast water currents. The Polar Front is indicated by shading. Location of the Fugløya-Bjørnøya section is shown (after Loeng 1988).

seen, the temperature in this layer has a normal yearly variation of c. 1.3°C. The temperature is highest in September–October and lowest in March–April. However, the large standard deviations indicate variations from year to year (i.e. *anomalies*, Δt°C), and these are presented in Fig. 4. Periodic variations evidently occur over a number of years, with a 'cold' period in 1977–1982, followed by a warm period until 1985. The warmest year was 1983. Parallel fluctuations have been recorded in sections further east in the Barents Sea (Midttun 1989) and in the Kola section observed by the USSR and where the observation series were started as early as 1900. Observations from this Russian section show that a *normal* based on the years 1977–1987 is slightly

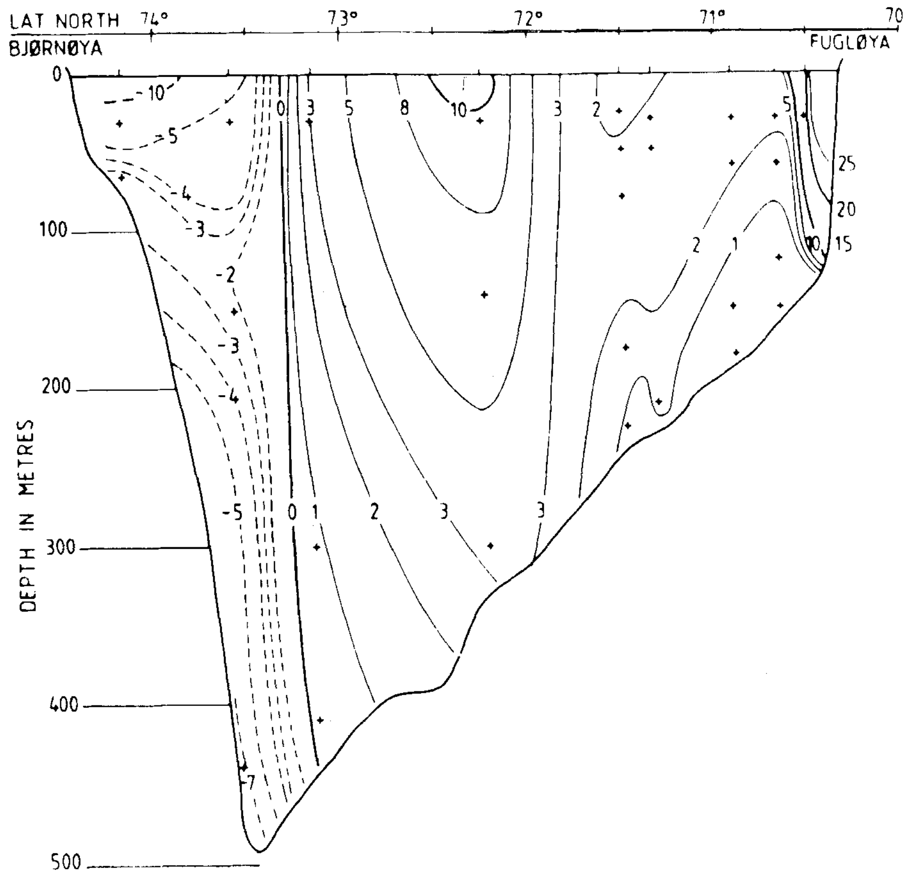

Fig. 2. Currents through the Fugløya-Bjørnøya section in September–October 1978. Velocity in cm/sec. Observation points are indicated (+). Solid lines: current towards east, dashed lines: current towards west (after Blindheim 1989).

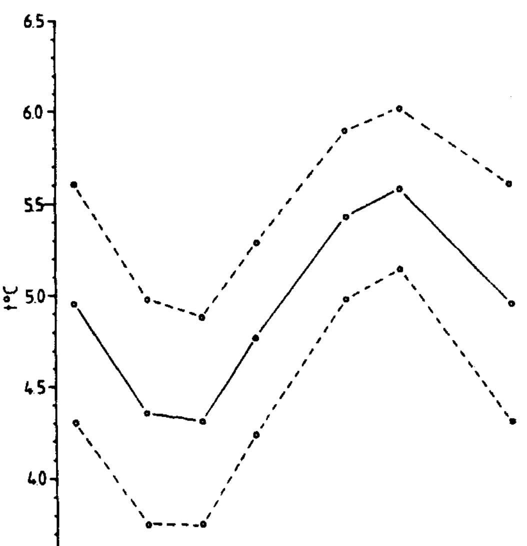

Fig. 3. Mean annual temperature variation in the 50–200 m layer between 71°30′N and 73°30′N along the Fugløya-Bjørnøya section.

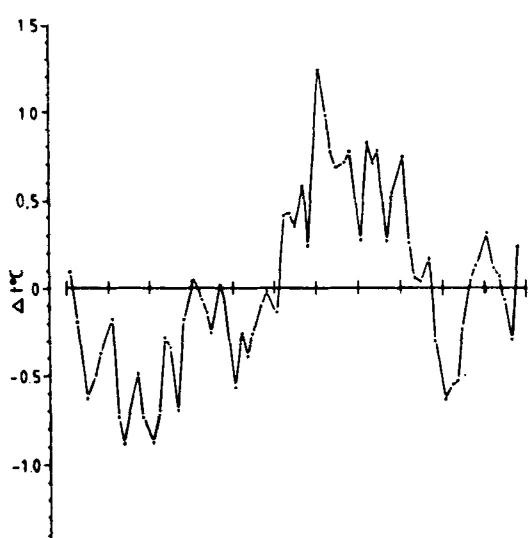

Fig. 4. Temperature anomalies at 50–200 m in 1977–1987 along the Fugløya-Bjørnøya section.

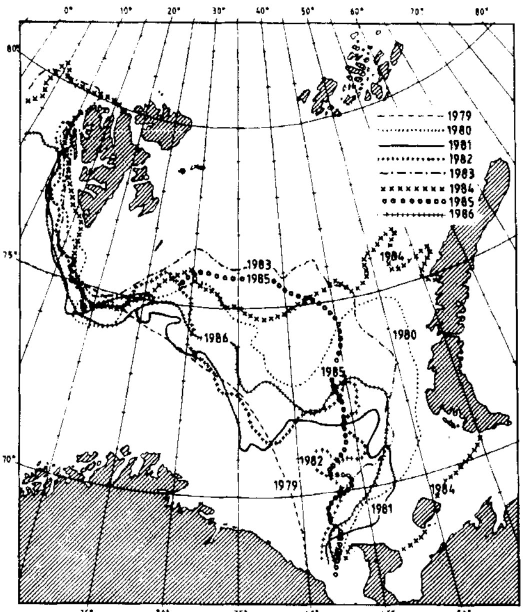

Fig. 5. Maximum winter ice coverage in the Barents Sea 1979–1986.

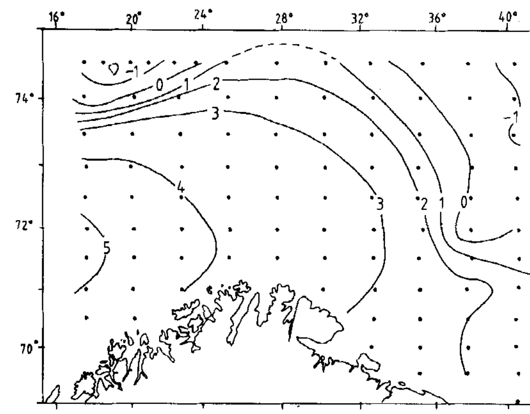

Fig. 6. Mean winter surface temperatures of the Barents Sea 1977–1987. Grid net indicated.

lower than that based on measurements made between 1920–1980. It is thus likely that our 1977–1987 'normal' is lower than the *long-term normal.*

The variability of temperature and salinity off the coast of northern Norway has previously been compared with those of the Kola section data set by Midttun (1969).

Winter surface-temperatures

As mentioned earlier, the northern arctic part of the Barents Sea freezes in winter and the ice cover is normally most extensive in March. C. 2 m of ice form each winter in the northernmost area of the Barents Sea (Nansen 1906; Midttun 1985). The Norwegian Meteorological Institute (DNMI) prepares weekly maps of the ice border in the Barents Sea and the maximum ice coverage for the years 1979–1986 is presented in Fig. 5. The variations are greatest in the central and eastern parts of the Barents Sea. Ice coverage was largest in 1979 and smallest in 1983 and 1984.

With basis in observations collected during research vessel surveys carried out in February–March 1977–1987, it has been possible to construct charts of surface temperatures for all the years. With some interpolations it has also been possible to prepare matrices for temperatures at standard stations each year and to calculate mean values for all the standard stations (Fig. 6). The surface temperature at ice covered stations has been estimated to be −1.8°C.

By taking the mean value of all the 92 standard station values each year as a yearly temperature index, the year-to-year variation can be presented

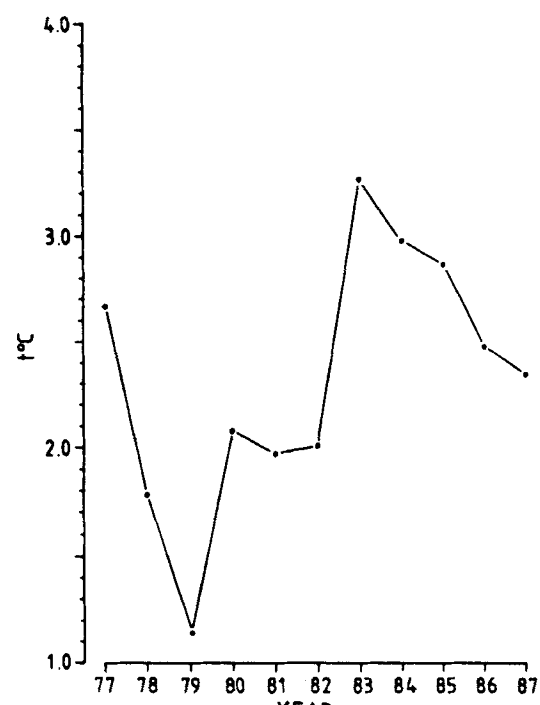

Fig. 7. Variations of winter surface temperatures of the Barents Sea 1977–1987.

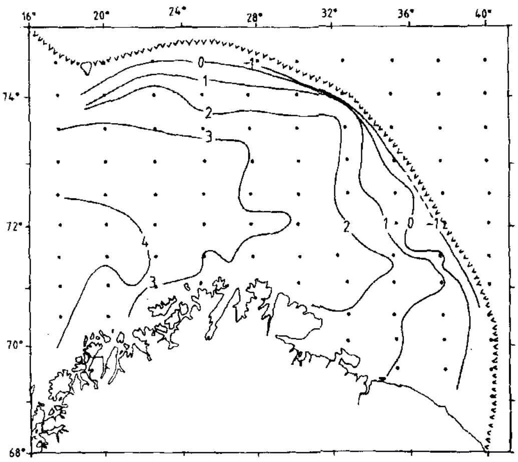

Fig. 8. Winter temperatures and ice border in the Barents Sea in the cold winter of 1979. Grid net indicated.

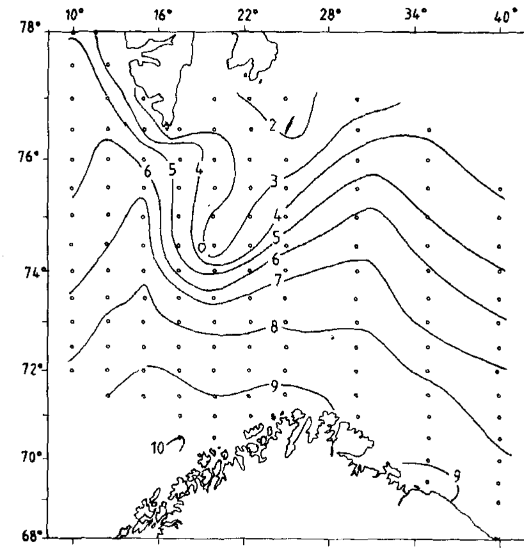

Fig. 9. Mean summer surface temperatures of the Barents Sea 1967–1987. Grid net indicated.

(Fig. 7). The temperature indices vary over a range of more than 2°C. The coldest year was again 1979 and the warmest was 1983. The variations in winter surface temperatures through the years 1977–1987 resemble the variations found at deeper layers in the Fugløya-Bjørnøya section (cf. Fig. 4).

The surface temperature conditions of the coldest year (1979) are presented in Fig. 8. The indicated ice border is the average location observed in March 1979 as published by DNMI.

Summer surface-temperatures

An international fish survey with several research vessels from Norway, the USSR and the UK (until 1976) has been carried out every year since 1967 between 20 August and 10 September. Observations collected during these surveys form the basis of the present summer temperature analysis (Fig. 9). The data sets are standardized in the

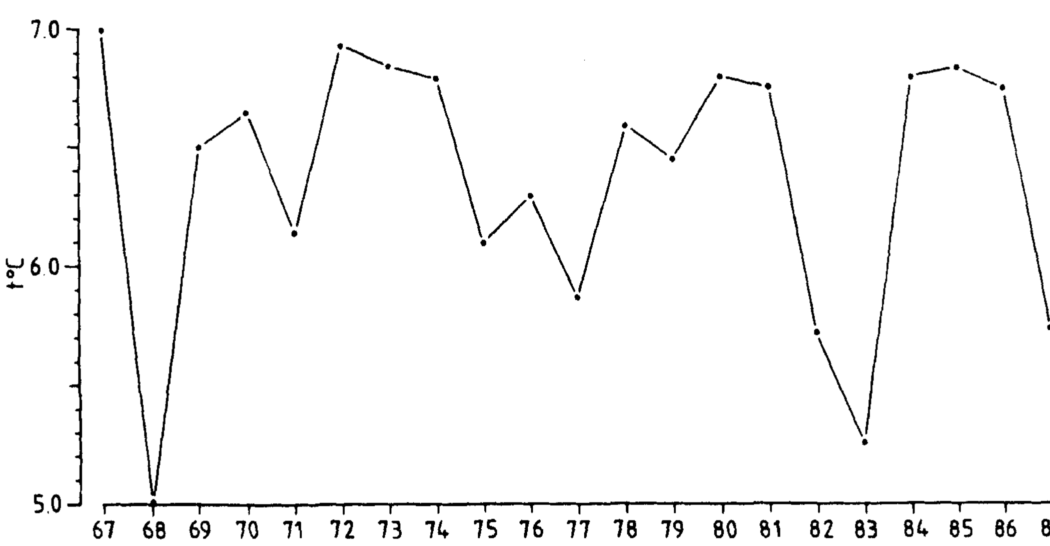

Fig. 10. Variations of summer surface temperatures of the Barents Sea 1967–1987.

same way as the winter data sets. The summer grid net covers a somewhat larger part of the Barents Sea, but at a lower density in the eastern part of the area. Temperature indices have also been calculated for the years 1967–1987 (Fig. 10). Temperatures vary over a range of 2°C, but the variation pattern is apparently quite different from the variation in the winter surface temperature (cf. Fig. 7). Most striking is the difference for 1983, a year of maximum winter temperatures but extremely low summer temperatures.

The most likely conclusion is that surface temperatures in summer are determined by local conditions where the incoming heat radiation plays the most important role, while the winter temperatures are related to the inflow of warm Atlantic water from the west.

Biological effects

The effect of oceanographic conditions on distribution and population dynamics of commercial fish stocks in the Barents Sea was the subject of a symposium held in Murmansk in 1986 (Loeng 1987). Other relevant studies are Sætersdal & Loeng (1987) and Loeng (1988b).

In short, these analyses conclude that the high temperature in the 50–200 m water column of the Kola section, which is representative for inflowing water masses, generally favours an easterly distribution and better growth in the fish stocks of the Barents Sea. Strong year classes of cod, haddock and herring are more often born in 'warm' years than in 'cold'.

Acknowledgements. – The author wishes to thank Karen Gjertsen, Ingrid Byrkjedal, Ellen Sophie Lauvås, Øivind Østensen and Harald Kismul for valuable help with the preparation of this paper.

References

Blindheim, J. 1989: Cascading of Barents Sea bottom water into the Norwegian Sea. *Rapp. P.-v. Réun. Cons. int. Explor. Mer 188*, 49–58.

Loeng, H. (ed.) 1987: The effect of oceanographic conditions on distribution and population dynamic of commercial fish stocks in the Barents Sea. *Proceedings of the third Soviet-Norwegian Symposium Murmansk, 26–28 May 1986.* Institute of Marine Research, Bergen.

Loeng, H. 1988a: Current conditions in the Barents Sea. *Arctic Pilot 7*, 150–159.

Loeng, H. 1988b: The influence of climate on biological conditions in the Barents Sea. *NAFO SCR Doc. 88/83.*

Midttun, L. 1969: Variability of temperature and salinity at some localities off the coast of Norway. *Progress in oceanography 5*, 41–54.

Midttun, L. 1985: Formation of dense bottom water in the Barents Sea. *Deep-Sea Research 32(10)*, 1233–1241.

Midttun, L. 1989: Climatic fluctuations in the Barents Sea. *Rapp. P.-v. Réun. cons. int. Explor. Mer 188*, 23–35.

Nansen, F. 1906: Northern Waters: Captain Roald Amundsen's oceanographic observations in the Arctic seas in 1901. *Videnskabs-Selskapets Skrifter I, Matematisk-Naturv. Klasse. 1906 (3).* 145 pp.

Sætersdal, G. & Loeng, H. 1987: Ecological adaptation of reproduction in Northeast Arctic cod. *Fish. Res. 5*, 253–270.