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Long-Time Series in Icelandic Waters in Relation to Physical Variability in the Northern North Atlantic

by

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Abstract

This review is mainly based on two papers in the ICES journal of Marine Science Symposia (Hydro-biological Variability in the ICES area - Malmberg and Kristmannsson 1992 - and Cod and Climatic Change - Malmberg and Blindheim 1994).

These papers deal with hydrographic conditions in Icelandic waters and adjacent seas in relation to large scale pan Atlantic conditions.

Additional updated information from Icelandic waters are included in this paper and compared with hydrographic variations elsewhere along the Subpolar Gyre in the North Atlantic. Some ecological impact of the hydrographic conditions in the northern North Atlantic are also discussed.

SYMPOSIUM ON ANOMALOUS OCEANOGRAPHIC CONDITIONS

Introduction

This review is partly based on two papers, with some additional remarks, in the ICES journal of Marine Science Symposia (Hydrobiological Variability in the ICES Area - Malmberg and Kristmannsson 1992 - and Cod and Climatic Change - Malmberg and Blindheim 1994).

These papers deal with hydrobiological conditions in Icelandic waters and adjacent seas in relation to large scale pan Atlantic conditions.

Data

The hydrographic data used in the paper are partly from joint multidisiplinary Danish - Icelandic cruises into the western part of the Iceland Sea in September 1987-1991 (Anon. 1991; Fig. 1). The investigations were undertaken as a part of the international Greenland Sea Project (Meincke et al. 1990). Also routine long-time investigations in Icelandic waters are included (Fig. 2), as well as some more remote information from adjacent ocean regions. Some emphasis is laid on the hydrographic conditions in time and space in relation to ecological conditions.

Results

The joint Danish - Icelandic hydrographic program in the western Iceland Sea in September 1987-1991 (Fig. 1) and long time investigations in Icelandic waters (Fig. 2) revealed the following:

a. **The bottom water** from the north at 1000-1500 m depth flowing southwards into the Denmark Strait area was of Arctic origin (Fig. 3; t_θ = -0,8°, S>34.92; Swift and Koltermann 1988, Malmberg et al. 1990, Rudels and Quadfasel 1991, Buch et al. 1992).

b. **The intermediate water** also from the north (West Spitzbergen Current origin) at 200-600 m showed some interannual variability as regards the strength of its salinity maximum (Malmberg et al. 1990). Thus, in 1987, 1988 and 1991 salinity in the intermediate layer was above 34.92 in a wider extend, and in general with higher core values, than in 1989 and 1990 (Fig. 1; Malmberg and Blindheim 1994).

c. **The polar water** component (t<0°, S<34.7) showed by far the strongest input into the Iceland Sea in 1988 during the period 1987-1992 (Fig. 4; Malmberg and Blindheim 1994). The conditions found in the Iceland Sea in 1988 are in agreement with the hydrographic conditions found in the East-Icelandic Current, where temperature and salinity were extremely low in 1988 together with severe ice conditions in North Icelandic waters (Fig. 5; Malmberg and Kristmannsson 1992).

d. In North Icelandic waters **three different hydrographic regimes** have been identified in the water column structure (Malmberg and Kristmannsson 1992, Malmberg and Blindheim 1994):

Polar conditions (see 1979 in Fig. 6) are characterized by cold and fresh surface water - the low salinity strengthening the straticication. High maxima in temperature and salinity in intermediate and near-surface depths characterize **Atlantic** condition (see 1980 in Fig. 6) the high temperatures strengthening the stratification. Atlantic conditions may even occurre below the Polar conditions. During **Arctic** conditions (see 1981 in Fig. 6) intermediate salinity maxima are less pronounced.

These above mentioned different hydrographic conditions in North Icelandic waters are reflected in time series of the maximum salinity observed in spring in the upper 300 m layers in North Icelandic waters (S-3 in Fig. 2) during the period 1978-1994 (Fig. 7; Malmberg and Blindheim 1994). The results show periods of relatively low but moderate salinities or Arctic conditions around 1981-1983 and 1989-1990, which lead to relatively weak vertical stratification in the upper layers below the seasonal thermocline in North Icelandic waters. These hydrographic conditions may again be reflected in the conditions of the Icelandic capelin stock (Fig. 7), which feeds in the Iceland Sea (Vilhjálmsson 1994) as well as weight of cod in Icelandic waters (Fig. 7), which feeds to a high degree on capelin (Pálsson 1983).

Discussion

a. The Arctic conditions observed in North Icelandic waters in 1981-1983 have been related to the so-called "Great Salinity Anomaly" (Dooley et al. 1984, Dickson et al. 1988). It was initated during the period of Polar conditions in North Icelandic waters in 1965-1971 (Figs. 5, 8, 9) and was traced around the Subpolar Gyre in the northern North Atlantic - reaching the West-Greenland and Newfoundland waters in 1969-1972 (Figs. 12, 13), the waters off Scotland and South Iceland around 1976 (Figs. 10, 9), the waters off northern Norway around 1979 (Fig. 11) and at last North Icelandic waters again in 1981-1983 (Arctic conditions). Its possible pan-Atlantic impact on living marine resourches has been outlined by Jakobsson (1992).

b. Since 1965-1970 Atlantic, Polar and Arctic conditions have occurred in North Icelandic waters (Figs. 8, 9). The question arises if the Polar conditions in North Icelandic waters observed in 1975-1979 may be reflected in low salinities in South Icelandic waters 1985-1988 (Fig. 9) and again in the Arctic conditions found in North Icelandic waters 1989 and 1990. Hydrographic data from the Rockall Trough (Fig. 10; Ellett and Blindheim 1992) respectively in the waters off northern Norway (Fig. 11; Loeng et al. 1992) may or may not go along with this hypothesis, but these data show indeed minima in salinity in 1985-1988 respectively in 1988-1990. It should also be noted that in 1981-1983 cold periods were observed in the waters off West-Greenland and Newfoundland (Figs. 12, 13; Hovgaard and Buch 1990, Borokov and Tevs 1991). These conditions in the western regions of the northern North Atlantic were suggested to be of regional origin (Buch 1985), but they might possibly also be connected with conditions north of Iceland 1975-1979, and even in 1981-1983 (Fig. 9). Furthermore it will be interesting to follow the fate of the 1988 Polar conditions in North Icelandic waters which again may possibly be reflected in the cold years in the West-Greenland and Labrador area 1992-1994. Also, will its response be found in low salinity in South Icelandic waters around year 1996, and then once more with its impact on the Icelandic capelin stock in North Icelandic waters around year 2000?

c. Whether it is the question about large scale anomalies or just local variations, the conditions dealt with may in general be considered valuable for further studies with regard to large scale circulation and variability in the North Atlantic Subpolar

Gyre. On one hand these speculations certainly include large-scale ocean-atmospheric interaction as well as regional conditons which may strengthen or weaken the processes in the long run across the northern North Atlantic. On the other hand it is also exiting to look forward with some expectance to what will be found in future oceanographic expeditions. The aspects also stress the importance of international oceanographic research for understanding impact of the marine environment on climate and biological conditions.

d. At last, as the "Great Salinity Anomaly" could be traced as it advected around the Subpolar Gyre in the northern North Atlantic, the ecological impact of the event on several cod stocks can be compared, i.e. the stocks of Iceland, West Greenland, Newfoundland and Norway (Jakobsson 1992). On these fishing grounds the catches of cod (Table 1) declined from 1960 to 1990 of about 50%, recruitment of about 67% and spawning stock of about 75%. This indicate an increasing fishing load from 1960 to 1990 (Malmberg and Blindheim 1994). Furthermore, in Icelandic waters improving hydrographic conditions after 1990 (Figs. 8, 9) did not result in new strong year-classes of cod. It is questioned weather this fail in recruitment was due to a critically small spawning stock (Fig. 14).

e. Here it is hard to say which of the factors, fishery or environment, is most decisive of the decline in the cod stocks. The crucial difference between these two factors is, however, that while we are unable to do anything with environmental fluctuations, we should be able to manage the fishery. Careful regulations are particularly important when a fish stock is weak due to unfavourable environmental conditons. Pushed to extremes, it may not be impossible for an efficient trawling fishery to exploit a spawning stock below a critical level of abundance, from which it may take many years for the stock to be restored (Malmberg and Blindheim 1994).

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Table 1. Catches, Recruitment and Spawning Stock Biomass of Cod in Northern Waters around 1960 and 1990 (Iceland, West Greenland, Newfoundland and NE Arctic; from Jakobsson 1992).

	Catch 10^3 tn		Recruitment 10^6 n		Spawn.stock 10^3 tn	
Year	1960	1990	1960	1990	1960	1990
Iceland	450	300	300	100	700	200
W. Grl.	400	100	400	100	1000	100
Newfl.	600	300	1000	150/500	1000	300
N.E. Arctic	1000	200/500	1500	300	600	250
SUM	2450	1200	3200	1000	3300	850

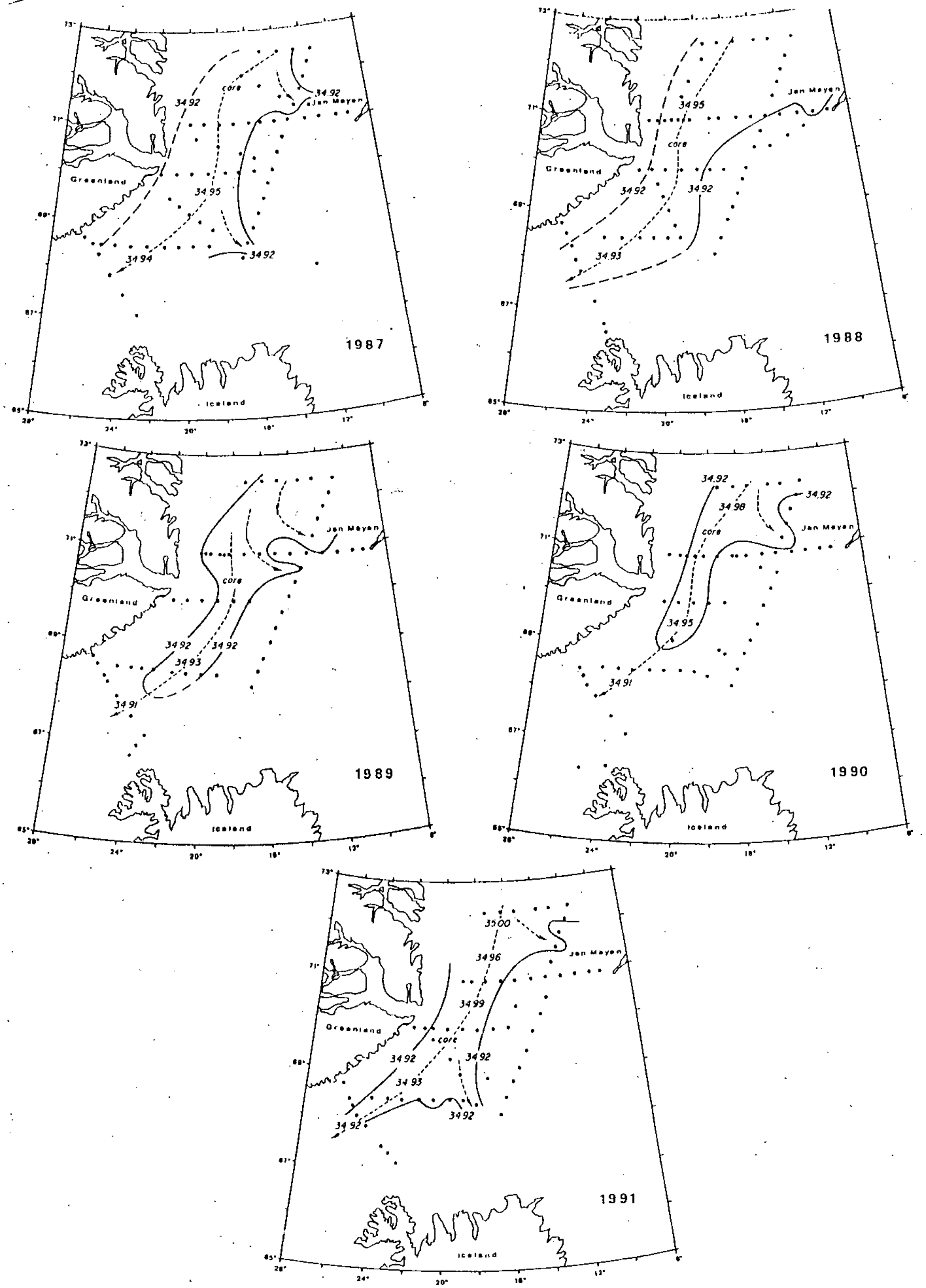

Fig. 1. Location of stations in the joint Danish-Icelandic GSP Project 1987-1991 in the western Iceland Sea and horizontal distribution of salinity maximum in the 0-500 m layer expressed by the 34.92 isohaline and the core values.

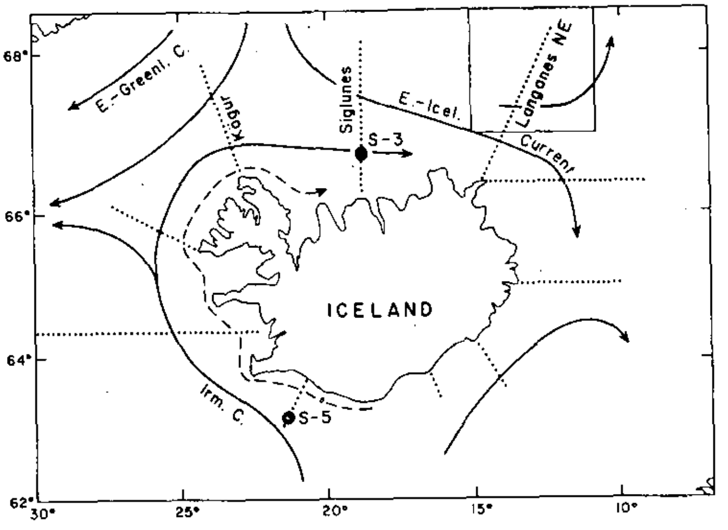

Fig. 2. Main ocean currents and location of standard hydrobiological sections in Icelandic waters. Selected areas and stations dealt with in the paper are indicated. (Malmberg and Kristmannsson 1992).

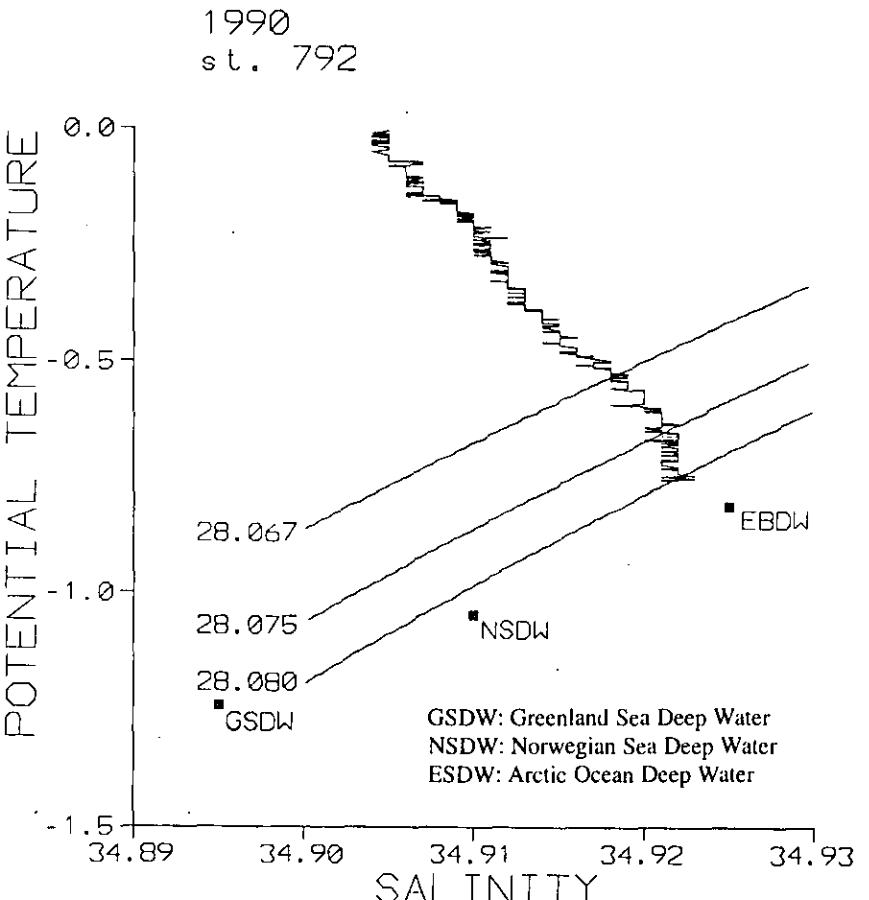

Fig. 3. Potential temperature - salinity diagram from a station of the southernmost section shown in Fig. 1. (Buch et al. 1992).

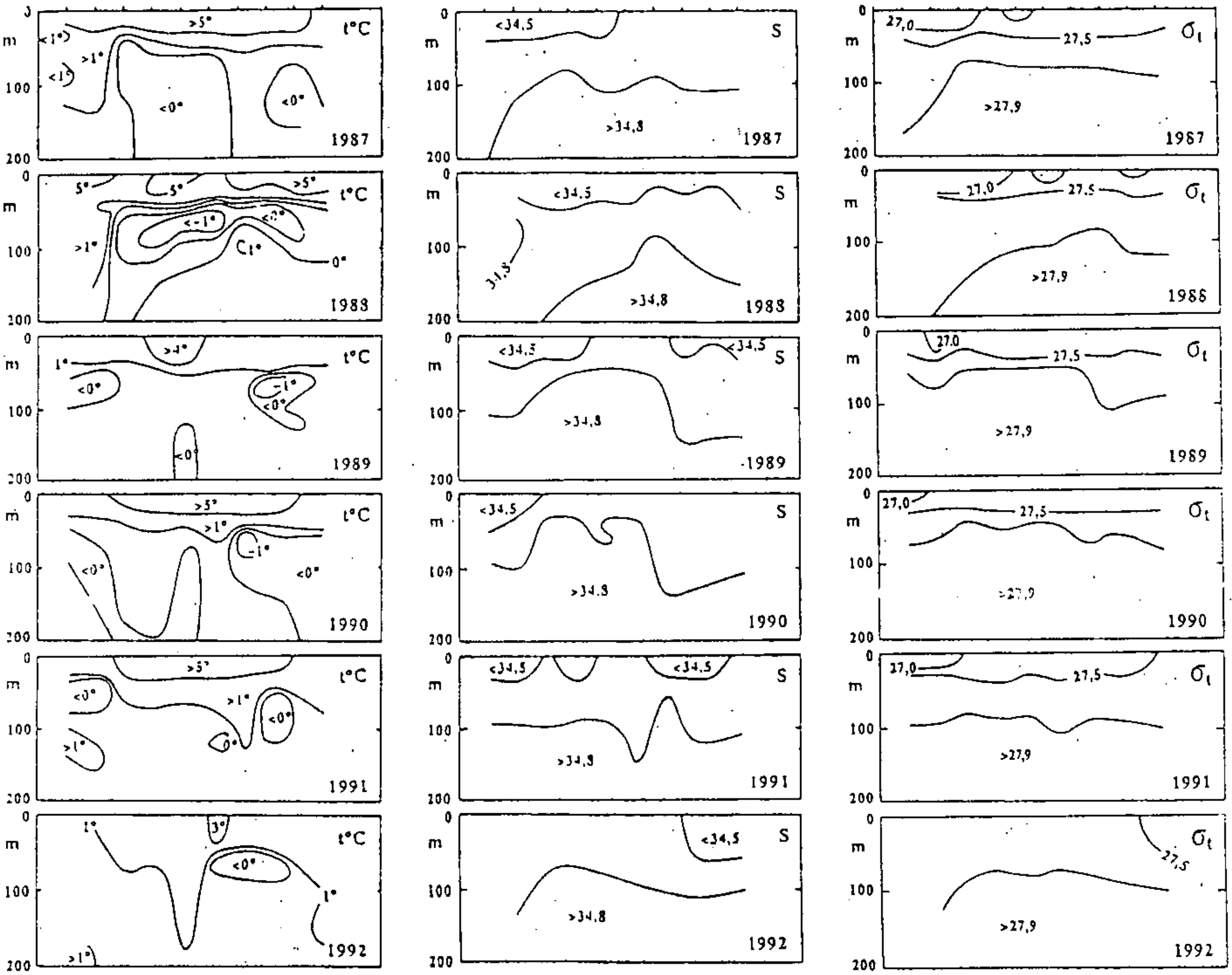

Fig. 4. Vertical distribution of temperature, salinity and density of a section across the Iceland Sea proper from 68°N to 71°N - the easternmost section in Fig. 1 - in September 1987-1991 and October 1992.

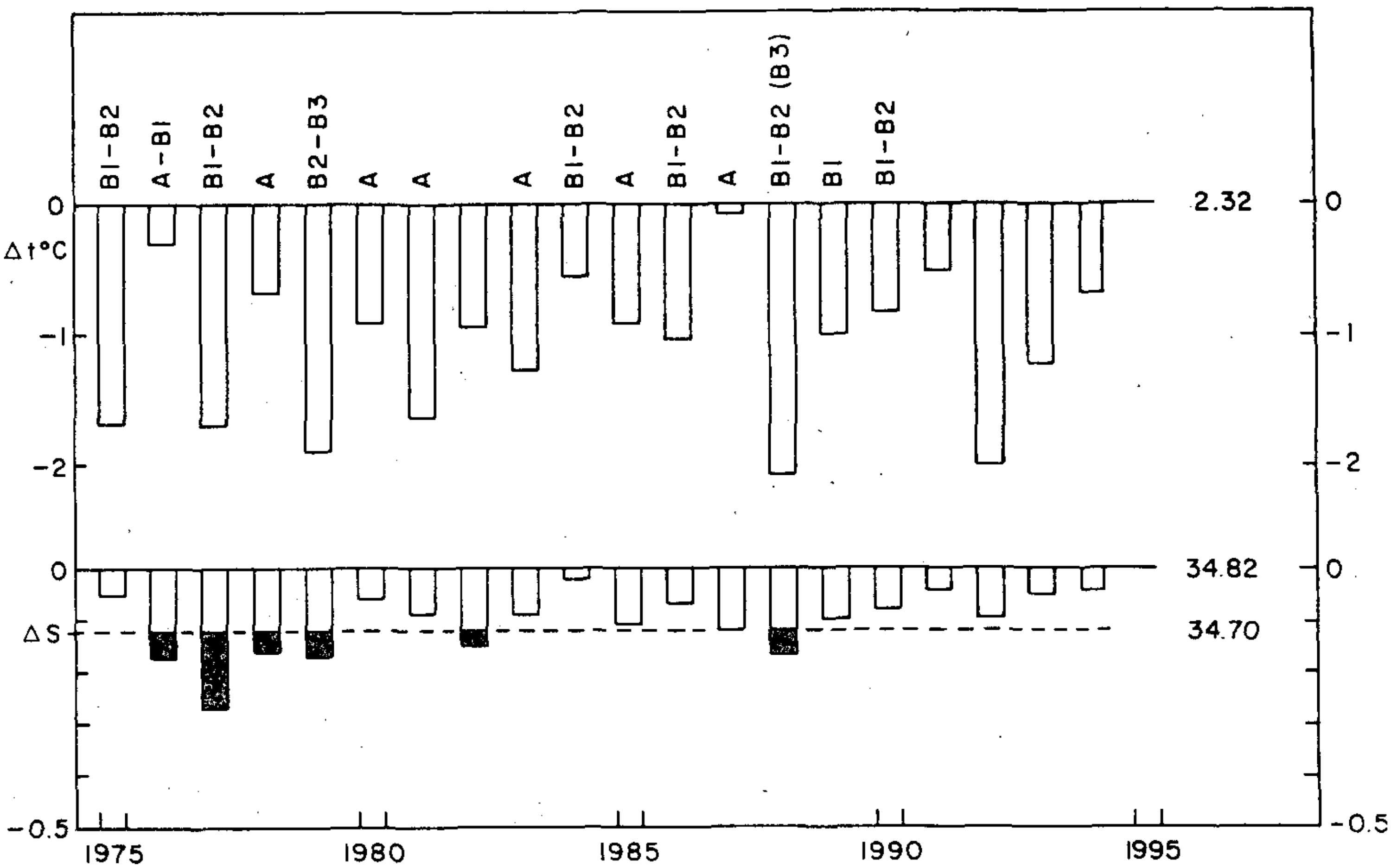

Fig. 5. Anomaly of temperature and salinity in spring 1975-1994 at a depth of 25 m in the East Icelandic Current study area shown in Fig. 2. The average for the period 1950-1958 is shown as well as a brief classification of ice years in Icelandic waters.
Key: A - ice free; B1 - insignificant ice (NW ice); B2 - moderate ice (N and NW ice); B3 - heavy ice (NW, N, E ice)(from Sigurdsson and Jakobsson 1991 and pers. comm.).

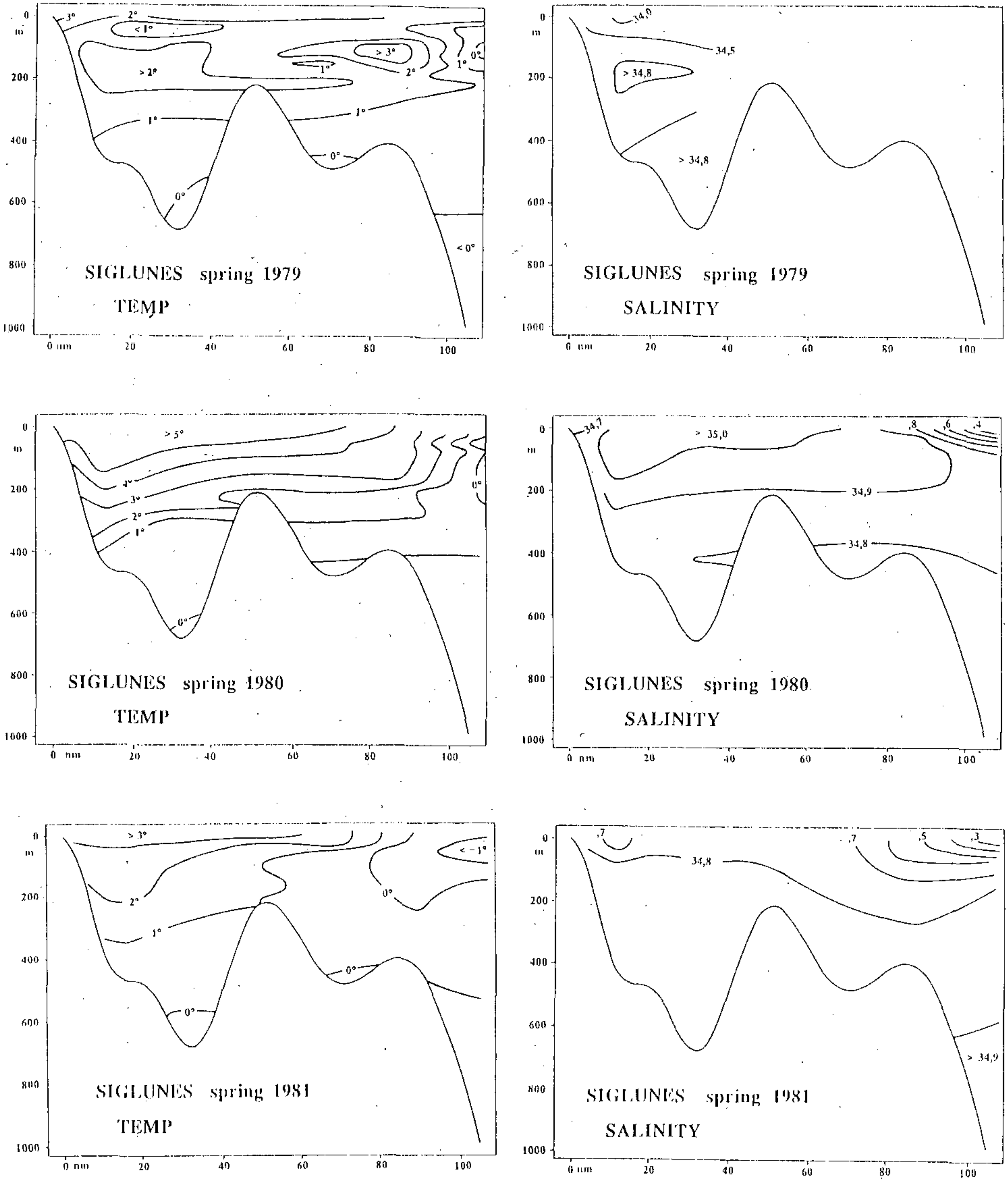

Fig. 6. Vertical distribution of temperature and salinity on a section in North Icelandic waters (Siglunes, for location see Fig. 2) in May/June 1979, 1980 and 1981. (Malmberg and Blindheim 1994).

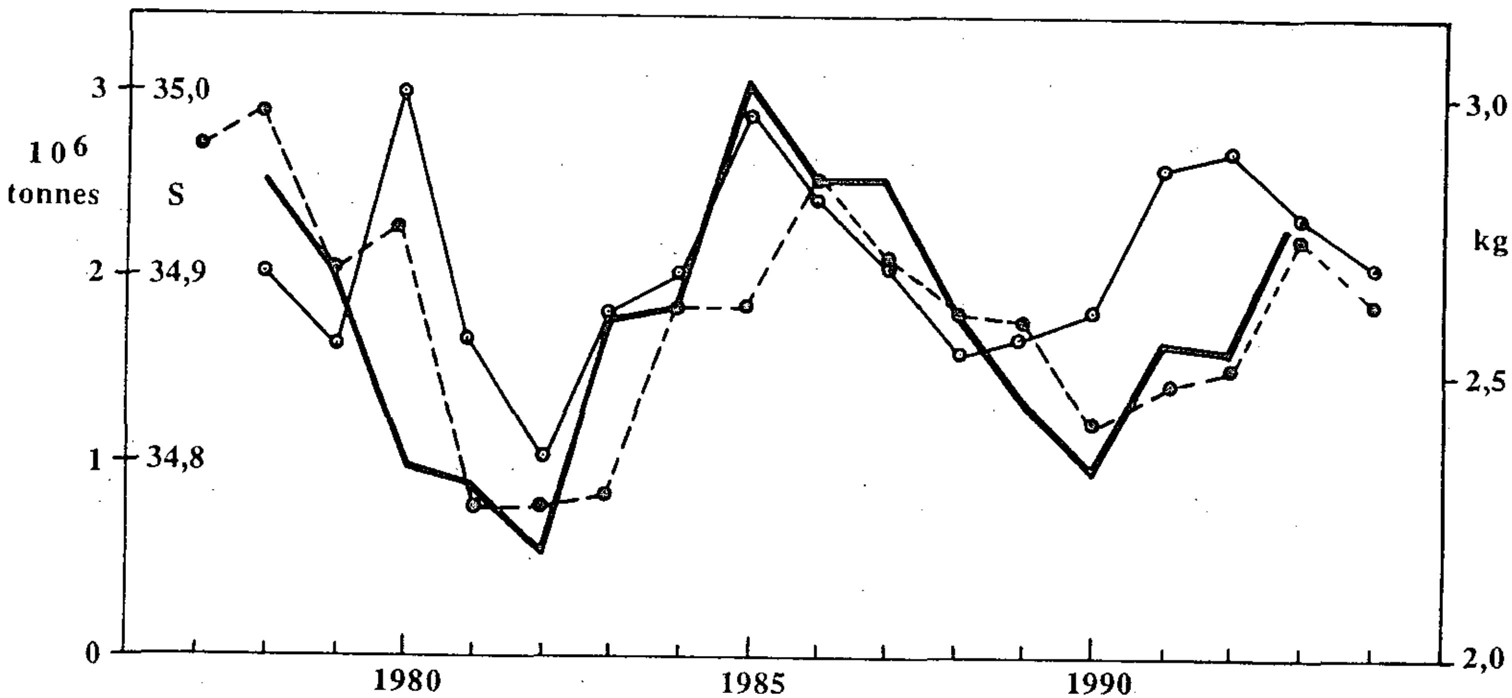

Fig. 7. a. Maximum salinity in the upper 300 m observed at a hydrographic station in North Icelandic waters (S-3, for location see Fig. 2) in May/June 1978-1994 (solid thin line).
b. The abundance of the Icelandic capelin stock in 1978-1993 (Hjálmar Vilhjálmsson, pers. comm. Solid thick line).
c. Weight of five yera-old cod in Icelandic waters in 1978-1994 (Anon. 1994, broken line).

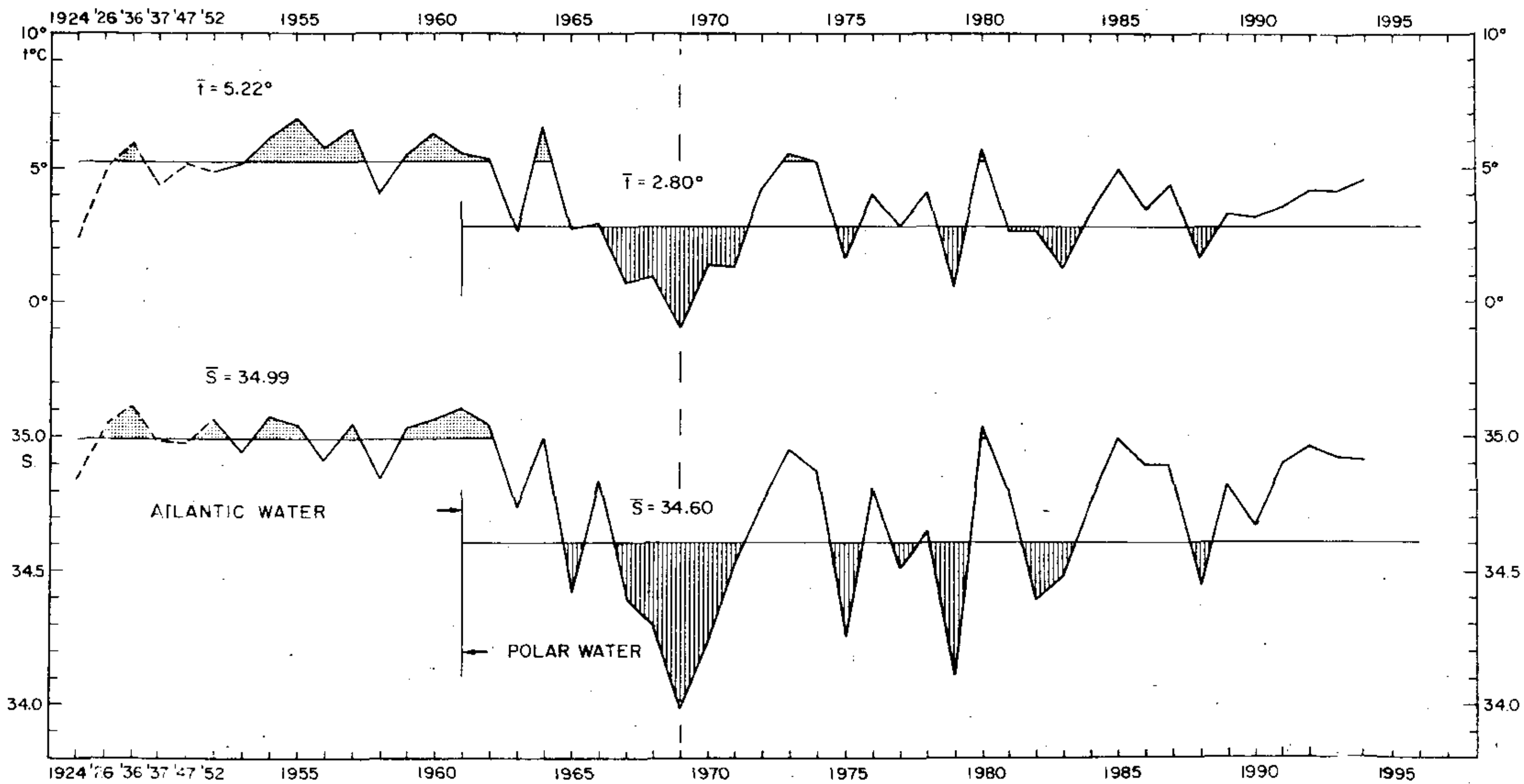

Fig. 8. Temperature and salinity at 50 m depth at a hydrographic station in North Icelandic waters (S-3, for location see Fig. 2) in May/June 1924, 1926, 1936, 1937, 1941 and 1952-1994.

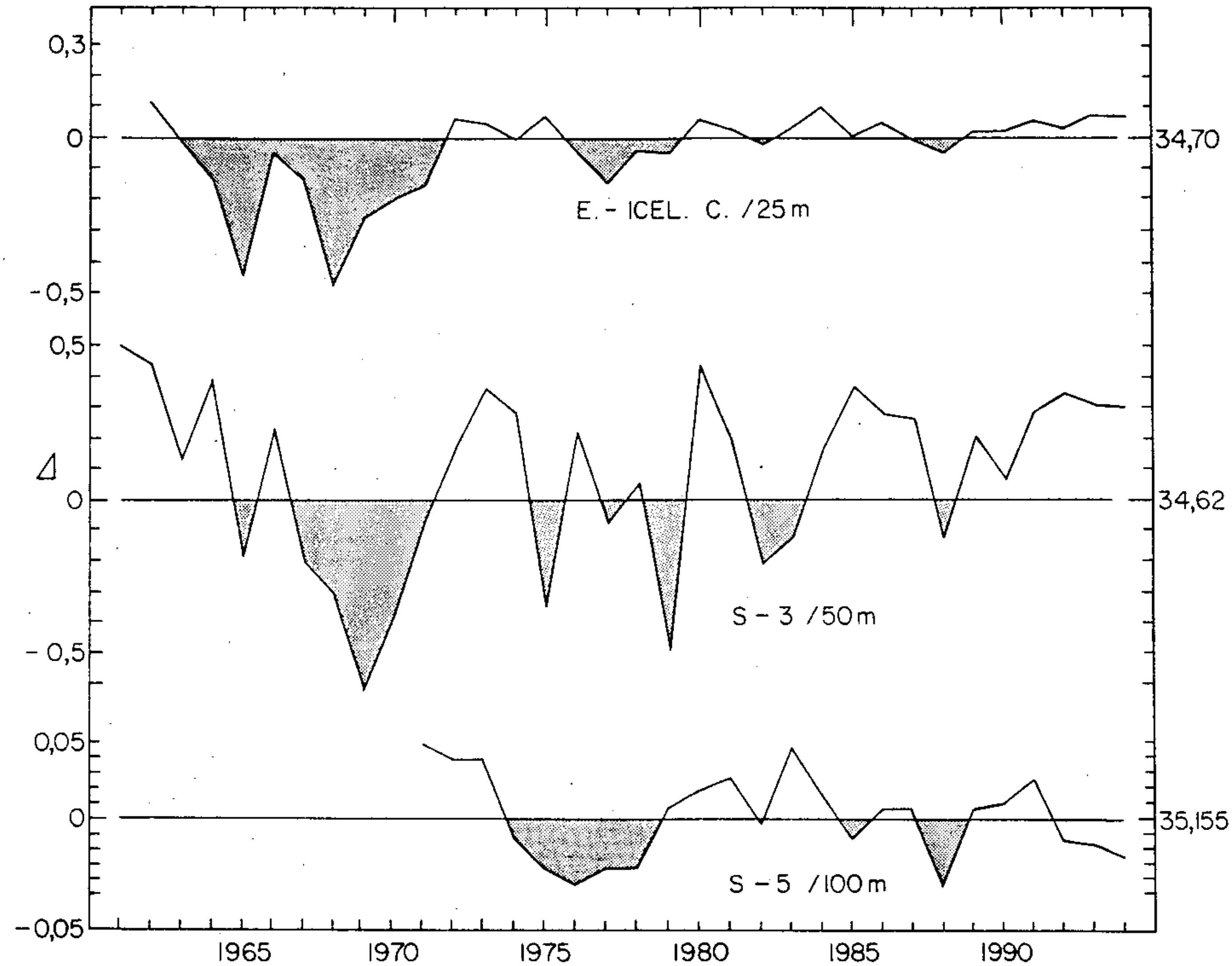

Fig. 9. Salinity deviation in spring at 25 m in the East Icelandic Current 1962-1994; at 50 m in North Icelandic waters (S-3) 1961-1994; and at 100 m in the Irminger Current south of Iceland (S-5), 1971-1994. (For location see Fig. 2).

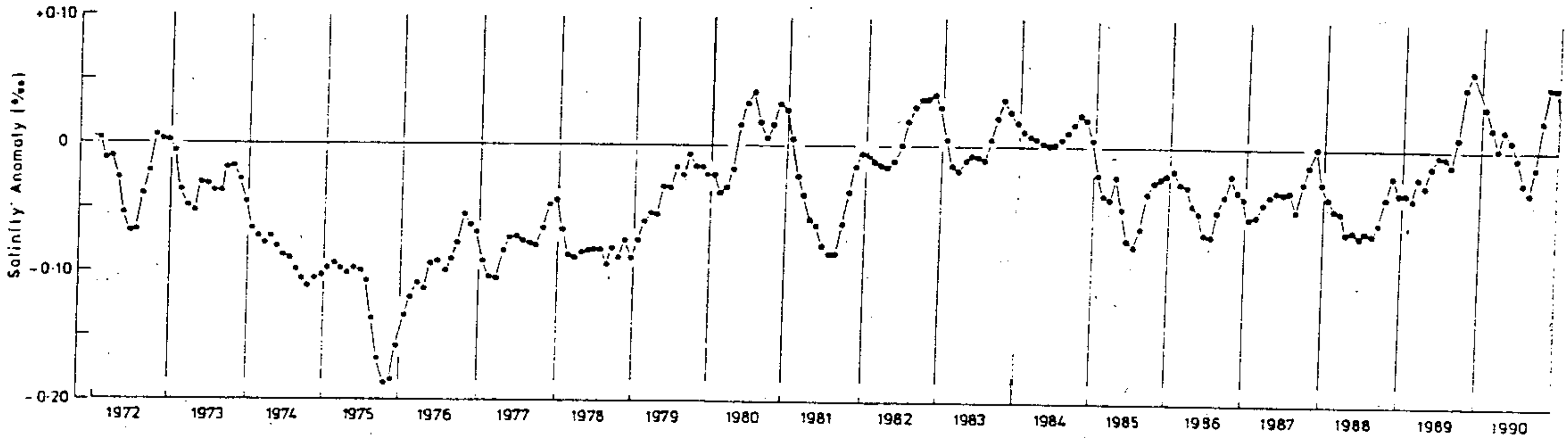

Fig. 10. Running three-monthly means of monthly salinity anomalies from 1961-1970 means for the Rockall Trough 1972-1990 (Ellett and Blindheim 1992).

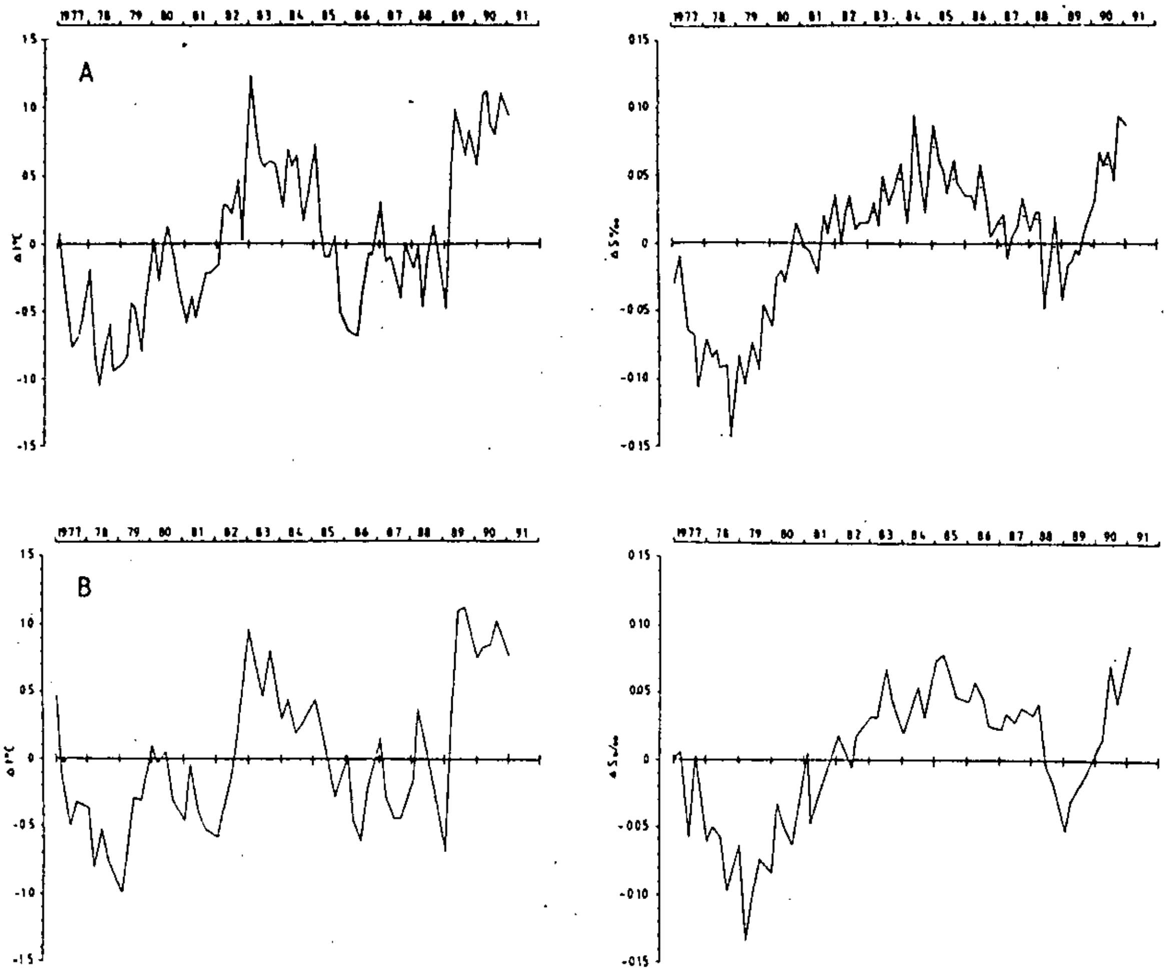

Fig. 11. Observed temperature and salinity anomalies in sections off northern Norway for the period 1977-1990 (Loeng et al. 1992).

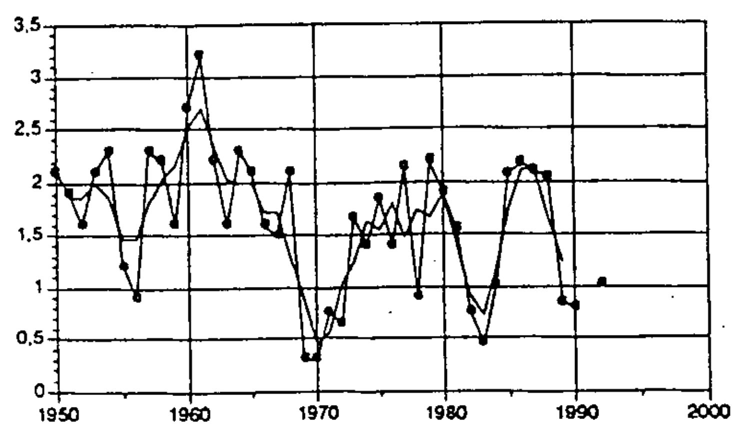

Fig. 12. Near surface sea temperature in June off West-Greenland 1950-1992 (Hovgaard and Buch 1990).

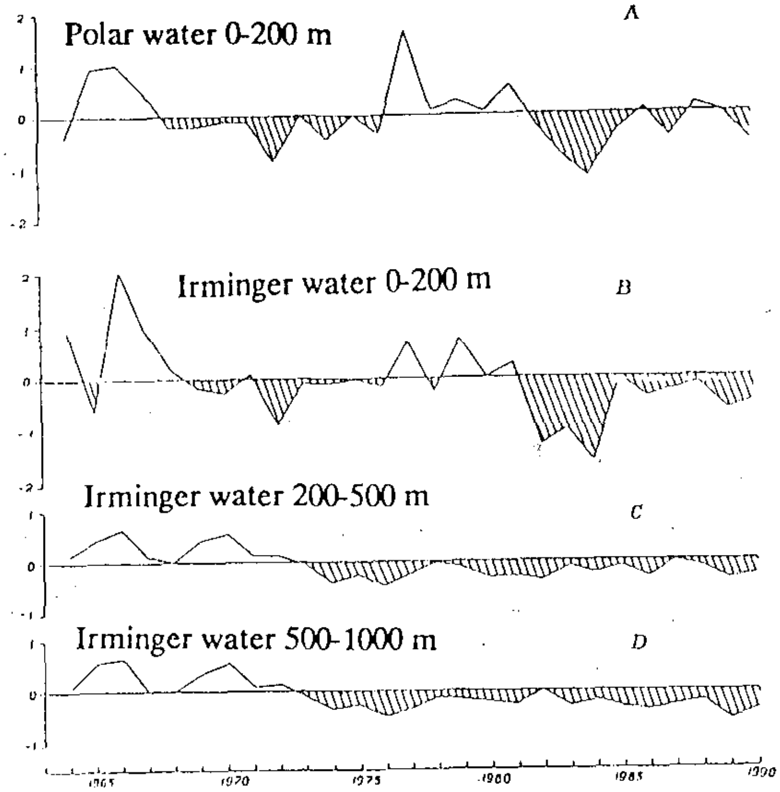

Fig. 13. Sea temperature off Newfoundland 1964-1990 (Borokov and Tevs 1991).

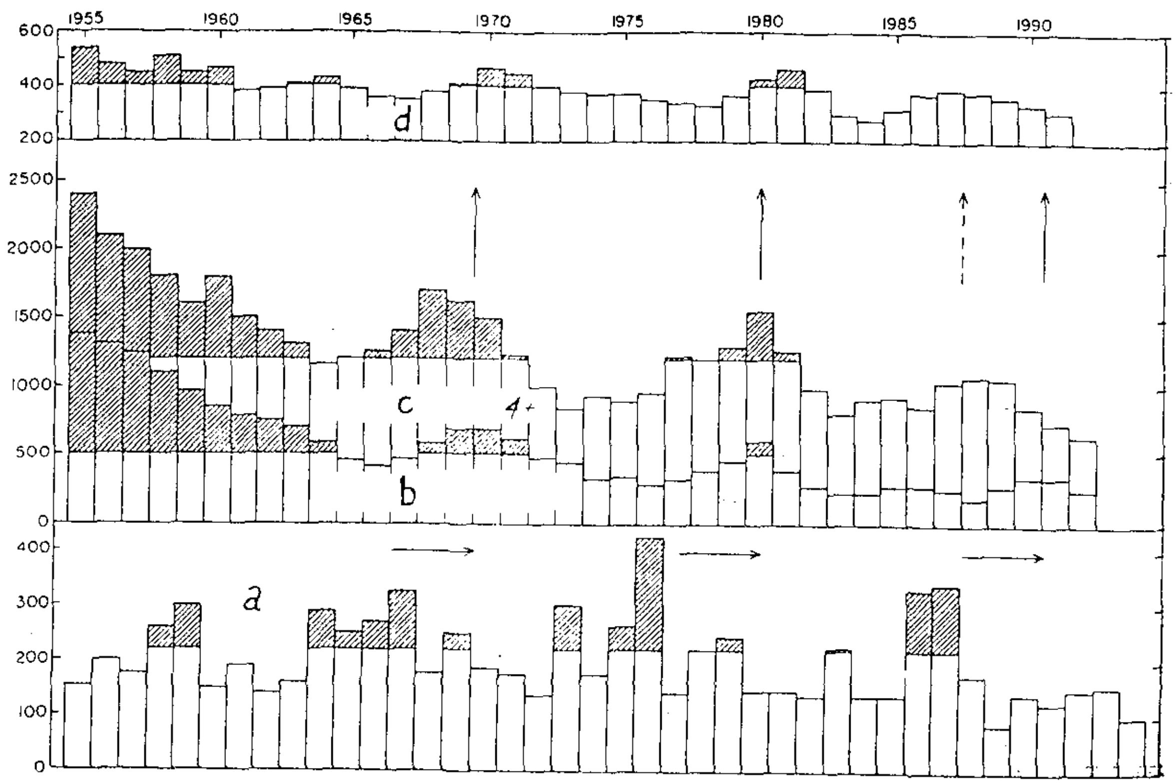

Fig. 14. Conditions of the Icelandic cod stock 1955-1991/92.

a. 3-year recruits in millions by number.

b. Spawning stock biomass in thousand tonnes.

c. Fishing stock biomass (4-years old and older fish) in thousand tonnes.

d. Catches in thousand tonnes. (Anon. 1994)

Shaded colums indicate periodic maxima observed and the arrows the time lack from 3-4 years old recruits up to the year of maximum in fishing and spawning stocks as well as catches a few years later. (Malmberg and Blindheim 1994).