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Temperature and salinity of surface water at a coastal measuring point, Isbjörnhamna, Spitsbergen

ABSTRACT: Results of measurements of temperature and salinity of surface waters of the Hornsund (South Spitsbergen) carried out at a coastal point of the Isbjörnhamna Bay during the winter expedition 1979/80 of the Polish Academy of Sciences are discussed. Courses of both parameters, their variability, mean values and distributions are analyzed.

Key words: Arctic, Spitsbergen, sea water, temperature and salinity.

Range and method of measurements

Measurements of surface water temperature and salinity in the Hornsund were carried out during the expedition of Polish Academy of Sciences to Spitsbergen in 1979/80 (Swerpel S., Lubomirski K.) in two periods:

1) autumn-winter series: from November 19, 1979 to January 27, 1980,
2) winter-spring series: from March 14, 1980 to June 25, 1980.

The measuring point was situated near the Isbjörnhamna shore. Measurements and sampling were carried out every day at 12 GMT. Temperature was measured with the water mercury thermometer. At the same time water samples were taken for salinity analyses, which were carried out after return home by R. Moroz, Maritime Department of the Institute of Meteorology and Water Management, with a use of the Bisset-Berman laboratory salinometer.

The earlier surface water temperature measurements in the Isbjörnhamna Bay were carried out at a coastal point during the expedition of the Gdańsk University in summer 1975 and sporadically during the winter expedition 1978/79 of the Polish Academy of Sciences.

Variation of surface water temperature

The highest measured value of the surface water temperature (Fig. 1) was equal +5.8°C (June 23, 1980) and the lowest one was −2.3° (December 6, 1979). The arithmetical mean from measurements in particular months was the lowest in December (−1.9°C) and the highest in June (−0.3°C). Mean values of temperature in particular months are presented in the T-S diagram (Fig. 4A, B).

In the autumn-winter season the temperature values showed slight deviations from the mean value. In November a gradual decrease of the water

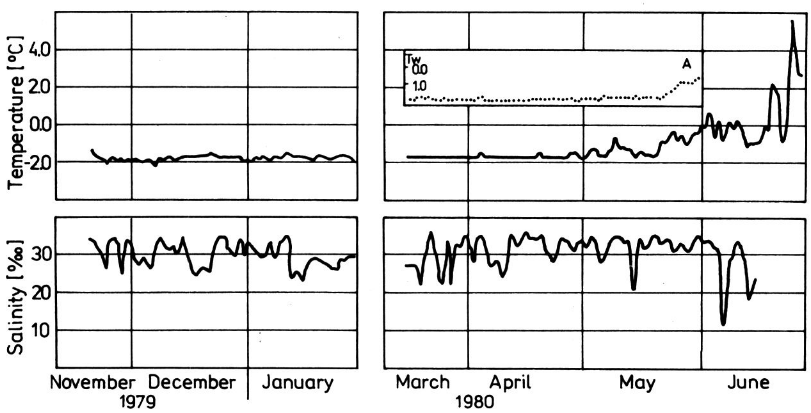

Fig. 1. Changes of surface sea water temperature and salinity measured in Isbjörnhamna (Hornsund) at 12 GMT. A — mean daily temperature of surface sea water at Grönfjorden (Barentsburg Station).

temperature was observed. It was the first freezing stage of the sea surface water. The freezing temperature of the sea surface water for a salinity in Hornsund is to be calculated according to the following formula (Thompson 1932):

$$t_{freez} = 0.0966\ Cl + 0.0000052\ Cl^2$$

where: t_{freez} — freezing temperature drop

Cl — sea water chlorinity for

25‰: −1.350°C,
31‰: −1.684°C,
33‰: −1.796°C,
35‰: −1.909°C, respectively.

The measurements proved that water was supercooled in that period.

In March and April the temperature rise became stabilized. The measured values amounted almost unchangingly to −1.8°C, despite considerable changes in the water salinity. Few rises of temperature were connected with a weaker ice cover in the bay in consequence of ice translocation, rainfall or snow-and-rainfall.

The ice cover exerts the strongest effect on a formation of the constant surface water temperature in winter. It plays the role of a filter for atmospheric processes and phenomena influencing the sea surface (Fig. 2).

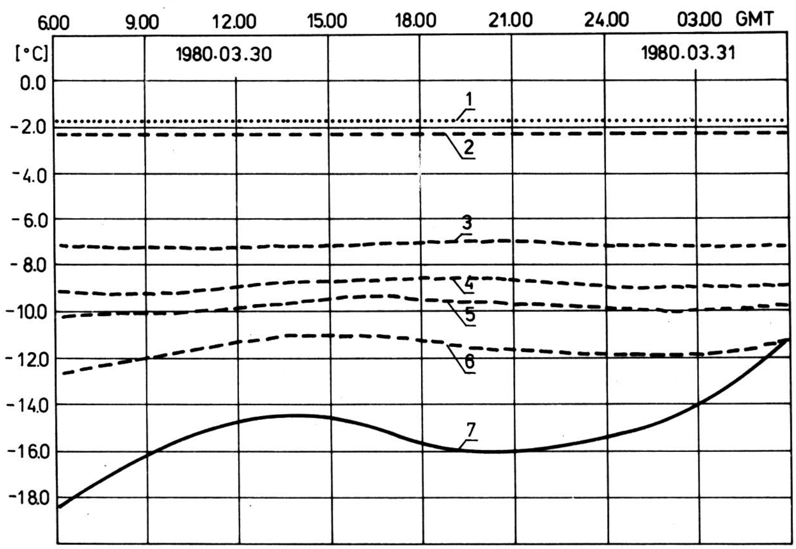

Fig. 2. Example of temperature changes in the section of air-sea ice-sea; Isbjörnhamna, March 30—31, 1980

1 — surface water temperature below sea ice; temperature within sea ice at depths of: 2 — 50 cm, 3 — 20 cm, 4 — 10 cm, 5 — 5 cm, 6 — 1 cm, 7 — air temperature at a meteorologic station. Thickness of sea ice at a measuring point is 60 cm

The greatest deviations of temperature from the mean value were observed in May and June. In this period a gradual recession of the fiord ice cover took place. A variability of temperature was at first small. It occurred mainly due to increasing insolation, recessing ice cover, its melting, wind and sea processes, which caused mixing of surface waters as well as to runoff. In June strong fluctuations of temperature occurred, caused by alternately intensive insolation and draft of sea ice on the bay surface.

The diagram of surface water temperature and mean daily air temperature at the Hornsund Station is presented in Fig. 3. There is no distinct interrelation of either element within a wide range of negative temperature below 0°C. This occurs mainly due to existence of the ice cover in the fiord (*cf.* Fig. 2).

A relationship between both variables could be only perceived for the mean daily air temperature of over −2°C (Fig. 3). It could be characterized by the correlation coefficient which was calculated for May and June for +0.64, being even much higher than its critical value for small values of the significance level. Its value amounted for the period of measurements from June 10, 1980 to June 25, 1980 to +0.78 proving a distinctly positive relationship between the both variables.

In Fig. 1A the course of mean daily surface water temperature at Grönfjorden (Barentsburg Station) is presented. Due to averaging, the course

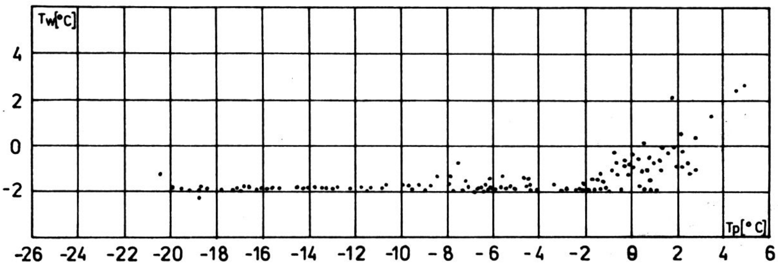

Fig. 3. Diagram of mean daily air temperature Tp (Hornsund Station) and of surface sea water temperature in Isbjörnhamna at 12 GMT

is more smoothed than that in the diagram for Hornsund, nevertheless it shows approximate variability tendencies. This could bear evidence of the effect of periodical tendencies in macroscale processes, such as sea circulation, insolation, atmospheric circulation, etc. on the surface waters in both fiords.

Variation of surface water salinity

The highest measured value salinity (Fig. 1) amounted to 35.67$^0/_{00}$ (March 21, 1980) and the lowest one to 11.73$^0/_{00}$ (June 5, 1980). The arithmetical mean for measurements in particular months showed the highest value in May (32.00$^0/_{00}$) and the lowest one in June (27.79$^0/_{00}$).

Contrary to temperature, the course of surface water salinity changes was greatly differentiated in the whole period. It depended on many factors, such as sea ice cover in the bay, sea ice type, atmospheric precipitation, water circulation and waves, snow and ice melting or runoff.

During occurrence of shuga or grease ice on the sea surface a distinct drop in salinity was observed. The salinity drop by several promilles (*e.g.* in samples taken on November 23 and 27, or on December 25—29, 1979) was observed, particularly after intensive precipitation and at formation of shuga. Sea surface salinity was close to oceanic one, if there was no sea ice cover or the latter was very stabilized.

In spring (April, May) the salinity value fluctuations were smaller.

Considerable deviations from the oceanic value are connected more rarely with the shuga and more frequently with an increasing runoff and sea ice melting (11.7‰ — June 5, 1980, 17.2‰ — December 6, 1980).

Statistical T-S diagram

The statistical T-S diagram (Fig. 4) was used for the T-S analysis of surface water (Mamayev 1975).

Water samples were counted at intervals of $\Delta T = 0.5°C$ — $\Delta S = 1‰$. Frequency of the observations (in per cent) was inscribed into corresponding squares of ΔT, ΔS and the freezing temperature line for surface water was plotted according to the formula of Thompson (1932).

T-S mean monthly values for November approximate the freezing temperature ($-1.684°C$ for 31‰) whereas mean values for December and January prove distinctly the occurrence of a supercooled surface water.

The frequency curve shows the single distinct temperature maximum within the interval of $-2.0°C \leq T < -1.5°C$, occurring in over 80% of all samples in the series. The salinity occurrence frequency distibution is characterized by a lack of any distinct maximum.

In the winter-spring series of measurements the temperature and salinity distributions are distinctly asymmetric. The salinity distribution assumes the highest values within the interval of $33‰ \leq S < 34‰$ and is distinctly expanded. This is caused by the runoff influence. The water temperature is characterized by the distinct maximum within the interval of $-2.0°C \leq T < -1.5°C$. In this measurement series no samples within the intervals below $-2.0°C$ have been found.

The point of mean T and S values is in March at the left side of the line denoting the freezing temperature; water is still supercooled. In April the mean sample values approximate the freezing temperature, being higher from it in May and June.

The diagram shows two kinds of transformations in that period: the first when water temperature increases at stabilized (close to oceanic) salinity values and the second with changes of the T-S sample values due to simultaneously increasing temperature and decreasing salinity. Two processes are responsible for that, *viz.* intensified insolation and inflow of waters from melting ice and snow.

T-S diagram for the period of summer 1975 is also presented (Siwecki, Swerpel 1979). The T-S distributions show distinct maxima whereas the layout of samples in the diagram is concentrated around squares of the maximum frequency of the observations.

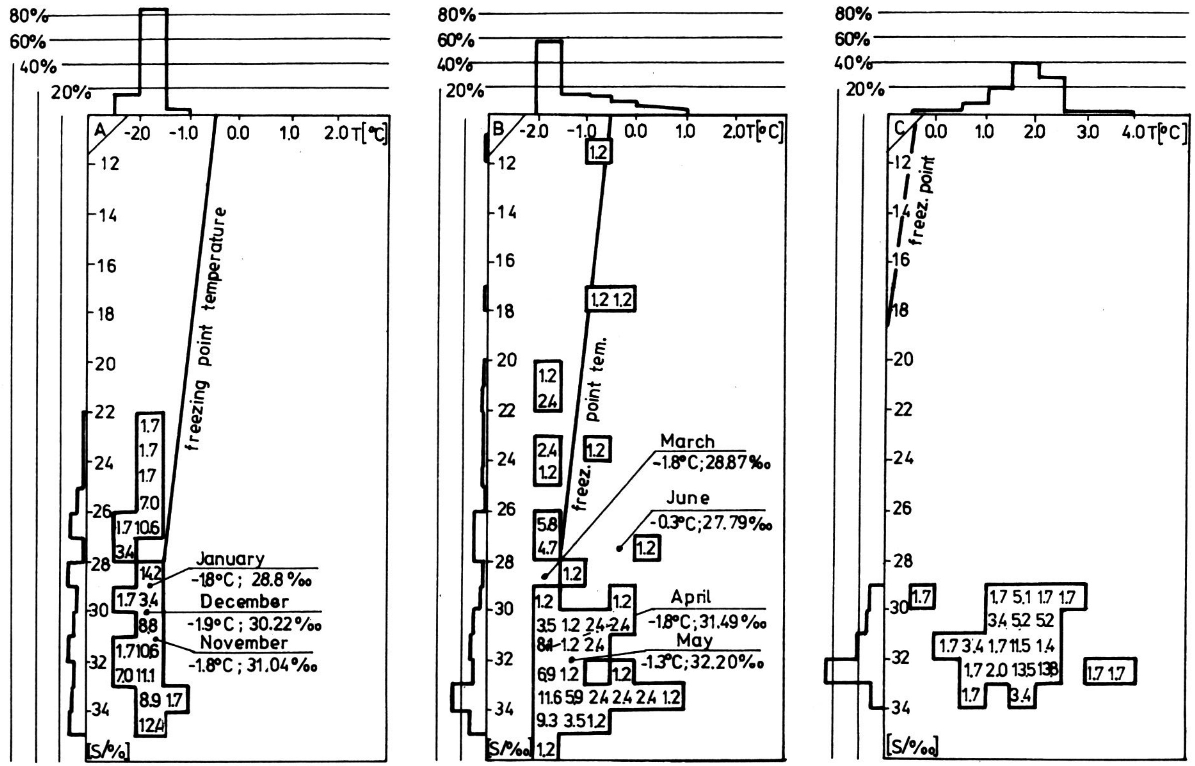

Fig. 4. Statistical T-S diagrams for measurements of temperature and salinity of surface sea water at the measuring point of Isbjörnhamna. Specification for the period: A — November 19, 1979 to January 27, 1980, B — March 14, 1980 to June 131 1980, C — July 15, 1975 to September 10, 1975 (R. Siwecki and S. Swerpel 1979). Occurrence frequency of samples is presented within the intervals of $\Delta T = 0.5°C$, $\Delta S = 1‰$ (in per cent). Position of samples of mean values for particular months is marked

Recapitulation

A distinct variability of T-S parameters of surface water samples occurs in particular seasons. A linear distribution with a distinct temperature maximum in the autumn-winter period is more dissipated in spring whereas the occurrence of the samples is determined by insolation and melting of snow and ice. In summer the distribution is concentrated around mean values of the sample.

Oceanic waters predominating in the fiord are connected with the West Spitsbergen and East Spitsbergen sea currents (Herman 1974). They are most distinct in the coastal zone during the summer season. Their influence vanishes in the autumn-winter season. This is connected with sea ice formation. During the polar winter the surface water is distinctly supercooled.

During the spring-summer season the processes affecting a formation of thermohaline properties of surface water are the most intensive. The sea ice melting is accompanied by a large runoff. At the same time, owing to intensified insolation, a rise of surface water temperature occurs.

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Резюме

В статье приводится анализ измерений температуры и засоления поверхностной воды в фиорде Горнсунд, проведенных во время экспедиции Польской Академии Наук на Шпицберген в 1979/80 гг. Измерительный пост был заложен у берега бухты Исбьёрнхамна. На рис. 1 приводится диаграмма изменчивости температуры и засоления в двух периодах измерений: осенне-зимнем и зимне-весеннем.

Средняя месячная для температуры была самой высокой в июне (−0,3°C), а для засоления — в мае (32,20‰). Самые низкие величины средних были отмечены соответственно в декабре (−1,9°C) и июне (27,79‰).

Для зимних месяцев (декабрь — апрель) диаграмма температуры стабилизована с величнами разряда −1,8°C. Основное влияние на это положение оказывал ледяной покров выполняющий роль фильтре против воздействия атмосферных явлений и процессов на поверхности моря (рис 2). Взаимосоотношение температуры воздуха и температуры воды можно было наблюдать для величин температуры воздуха выше −2°C (рис. 3).

Диаграмма T-3 (рис. 4) показывает положение средних месячных образцов поверхностной воды по отношению к линии определяющей температуру замерзания. Наблюдалось переохлаждение морской воды в период декабря-марта. Диаграмма показывает два вида преоблазования поверхностных вод в период поздней весны: рост температуры при почти неизменном засолении (влияние инсоляции) и рост температуры по мере снижения засоления (влияния таяния снежного покрова и морского льда).

Streszczenie

W artykule przedstawiono analizę pomiarów temperatury i zasolenia wody powierzchniowej w fiordzie Hornsund wykonanych podczas ekspedycji PAN na Spitsbergen (1979—80). Punkt pomiarowy był zlokalizowany przy brzegu Isbjörnhamna. Fig. 1 przedstawia wykresy czasowej zmienności temperatury i zasolenia w dwóch okresach pomiarowych: jesienno-zimowym i zimowo-wiosennym.

Średnia miesięczna dla temperatury była najwyższa w czerwcu (−0.3°C), dla zasolenia zaś w maju (32.20‰). Najniższe wartości średnich zanotowano odpowiednio: w grudniu (−1.9°C) i w czerwcu (27.79‰).

Dla miesięcy zimowych (grudzień — kwiecień) wykres temperatury jest ustabilizowany, o wartościach rzędu −1.8°C. Główny wpływ na to miała pokrywa lodowa spełniająca rolę filtra dla oddziaływania zjawisk i procesów atmosferycznych na powierzchnię morza (fig. 2). Wzajemny związek temperatury powietrza z temperaturą wody daje się zauważyć dla wartości temperatury powietrza powyżej −2°C (fig. 3).

Diagram T-S (fig. 4) przedstawia położenie średnich miesięcznych prób wody powierzchniowej względem linii wyznaczającej temperaturę zamarzania. Obserwowano przechłodzenie wody morskiej w okresie grudzień-marzec. Diagram wskazuje na dwa rodzaje transformacji wód powierzchniowych w okresie późnej wiosny: wzrost temperatury przy prawie niezmiennym zasoleniu (wpływ radiacji słonecznej) i wzrost temperatury wraz ze spadkiem zasolenia (wpływ tajania pokrywy śnieżnej i lodu morskiego).

Praca została wykonana w ramach problemu MR.II.16.B.