# Seasonal variability and specificity of the oceanological conditions in the northern Okhotsk Sea in 1997

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## Introduction

The data obtained from four surveys undertaken in the northern part of the Okhotsk Sea in March–September 1997 (about 900 CTD stations) were analyzed.

The interest in the monitoring experiments carried out by TINRO in the Okhotsk Sea grows considerably at the present time because of discussions of the new "cold" period. The beginning of this cold period was predicted by heliomagnetic cycles happening in the early 1990s (Davydov, 1984) or in the late 1990s (Shuntov, 1985). Shuntov published data on the reorganization of the southern Okhotsk Sea biota and described the same phenomenon observed both with the sea birds and animals (Shuntov, 1994; Shuntov and Dulepova, 1996). In Shuntov's opinion, these factors were caused by the beginning of a cooling period. The oceanological conditions of recent years up to 1997 in the northern part of the Okhotsk Sea does not confirm this assertion.

## Results and discussion

It is known that the severity of winter conditions has significant influence on water structure and temperature of the northern part of the Okhotsk Sea in the layer 0–200 m. According to our data, the correlation of the sea-ice cover maximum with water temperature in spring in different sites of the shelf is characterized by the negative ratio $R = -0.65$ to $-0.80$. The temperature anomaly in intermediate cold waters remains as long as the beginning of new winter convection, at a probability of 60–70%. According to the data obtained by Chernyavsky (1992) for the period from 1954 to 1986, the waters with minimal temperature, generated by winter convection in summer are usually divided into four subsurface cold "cores" (temperature $\leq -1$°C). These are the North-Okhotsk and East-Sakhalin large cold cores, the Shelikhov Bay core and small cold cores off West Kamchatka. The cold core water with a temperature of $\leq -1$°C has higher salinity and density and shows cyclonic circulation in the dynamic topography charts. The large-scale cyclonic circulation is regularly formed around the North-Okhotsk cold core. The westward current, named the North-Okhotsk Current, and the opposite eastward current, named the North-Okhotsk Counter Current, together with the northward flow, called the West-Kamchatka Current (WKC), were observed on the borders of the North-Okhotsk cold core. The variability of size and position of the cyclones depend largely on the cold core seasonal changes, as seen on monthly averaged current charts, drafted by Luchin (1987) (Fig. 1).

A low-ice situation was observed in the Okhotsk Sea after the period 1980–1983. In the winters of 1996 and 1997, there was an unusual decrease in ice cover – down to 25–35%. In April 1997 the WKC transport in the 0–200 m layer was about

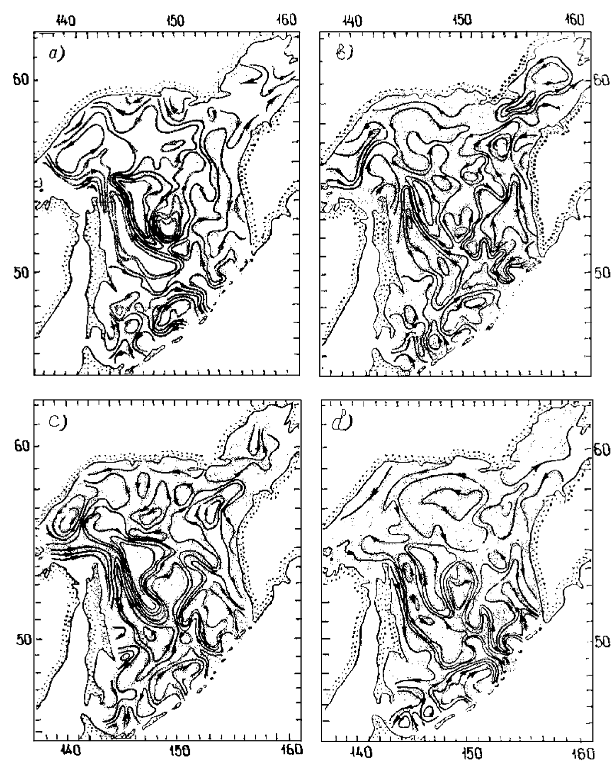


**Fig. 1** Seasonal variations of Okhotsk Sea water circulation (from Luchin (1987)). (a) June, (b) August, (c) September, and (d) November.

$0.52 \times 10^6$ $m^3/s$ (its mid-stream was observed within 154°–155°E, Fig. 2a). The same transport value was noted in April 1984–1986. In the April period from 1987–1995 its value dropped twice and rose again only in 1996, reaching $0.48 \times 10^6$ $m^3/s$. The weakness of the winter cooling intensity and WKC transport increase caused "warm" and "abnormally warm" thermal conditions throughout the shelf waters in 1997. From May to August 1997 the transport of WKC water into Shelikhov Bay was $0.28–0.20 \times 10^6$ $m^3/s$. The Compensatory Current water along the West Kamchatka coast was observed only within 57°50′–56°30′N in April and between 56°20′0–55°00′N in July.

Recent investigations show a significant reduction of the cold core areas. In April 1997, the area with the lowest water temperature of ≤–1°C covered less than 6% of the total area along West Kamchatka, whereas the average value for 1983–1997 was equal to 41%. In May 1997 the cold core area in Shelikhov Bay was equal to 39%, compared to the average value of 69%. The largest and stable North-Okhotsk cold core usually covered the average annual area of $191 \pm 23 \times (10^3\ km^2)$ in June, $160 \pm 22 \times (10^3\ km^2)$ in July, $130 \pm 18 \times (10^3\ km^2)$ in August, $115 \pm 17 \times (10^3\ km^2)$ in September, and $79 \pm 15 \times (10^3\ km^2)$ in October (in the eastern area to 146°E, 1954–1986 according to Chernyavsky's (1992) observations, and 1987–1997 according to our records). In May 1997, the North-Okhotsk cold core area covered about 75,000 $km^2$, which was equal to the October-averaged parameters. In July 1997, the North-Okhotsk cold core spread over an area of about 38,500 $km^2$ and decreased to as low as 1,300 $km^2$ in September (Fig.3). Its eastern border shifted westward from 151°–152°E in August to 146°–148°E in September.

The WKC midstream moved in a similar manner. Its northward water transport in the 0–200 m layer varied from $0.45 \times 10^6$ $m^3/s$ in August to $0.42 \times 10^6$ $m^3/s$ in September. The usually zonally orientated North-Okhotsk Current and its counter-current were not observed. Due to strong cold core destruction, geostrophic currents of the North Okhotsk Sea in July of 1997 were similar to the currents that were usually formed only in September–October as an annual average (Fig. 1c). The most abnormal phenomenon was the formation of the northward flow to the Okhotsk Sea near 143°–145°E (Fig. 2c). This flow was the North-Okhotsk counter-current which had this unique location and direction due to the abnormal rise of total heat content in the northern Okhotsk shelf waters in 1997.

Moreover, the following factors may also be of importance:

(1) Shelf water bottom salinity at the 100–200 m isobath dropped by 0.1–0.2 psu from May to September (Fig. 4). A more significant decline of the water salinity was observed in the coastal waters and in the upper layer. The salinity in the "cold halocline" has decreased compared with the data of 1996. The general salinity level of the North Okhotsk Sea has decreased as well compared with the annual average salinity.

(2) In August the shifting of the eastern border of the North-Okhotsk cold core to the Kashevarov Bank area caused a significant intensification of cyclonic circulation over the Bank.

(3) In spring 1997, the water transport of the West-Kamchatka Current to the northern Okhotsk shelf was the strongest for the past 10 years. During the summer, the width of the northern flow doubled, but the total transport remained almost unchanged.

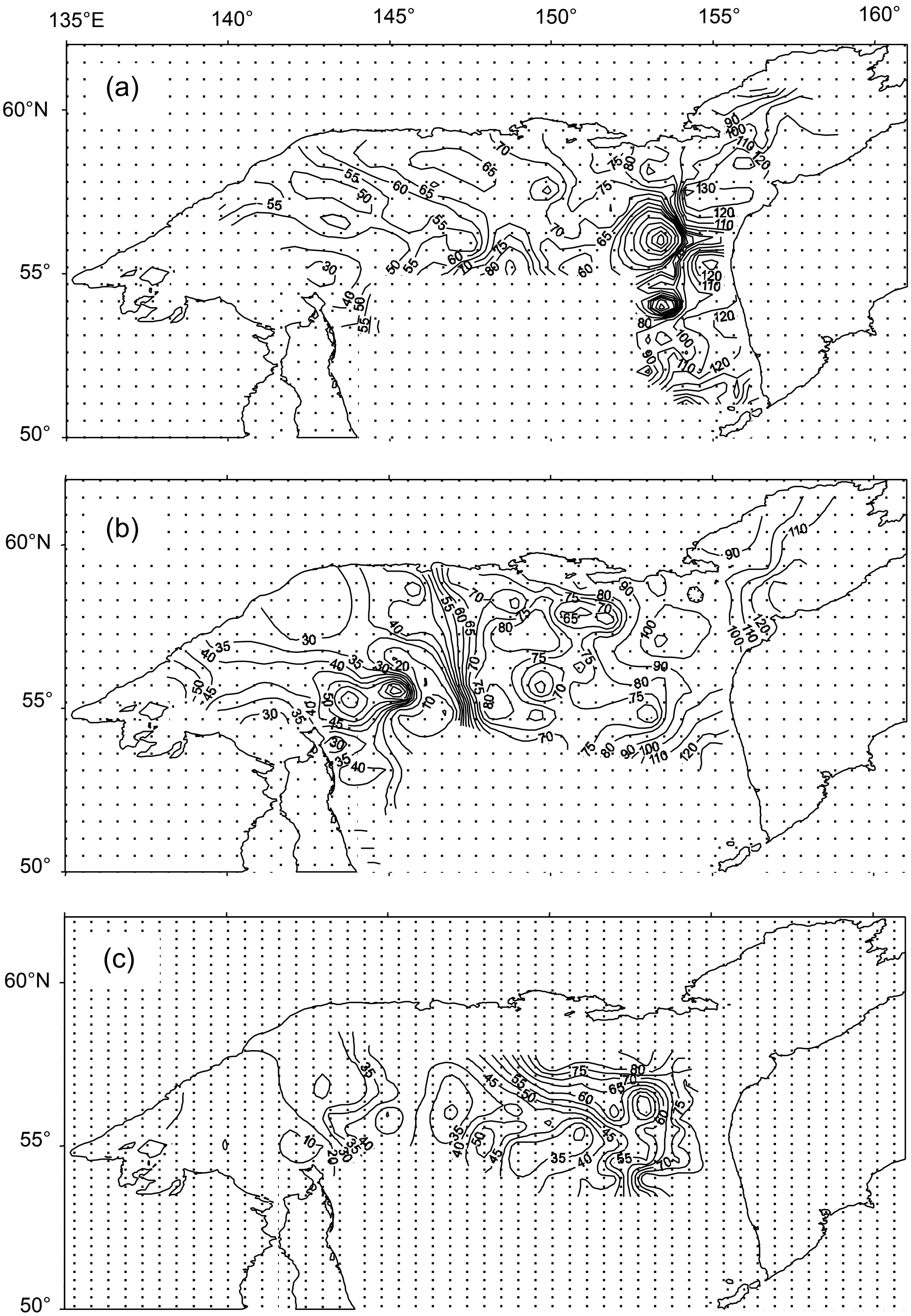


**Fig. 2** Geostrophic circulation at the surface, relative to 500 dbar. (a) April–June 1997, (b) July–August 1997, and (c) September 1997.

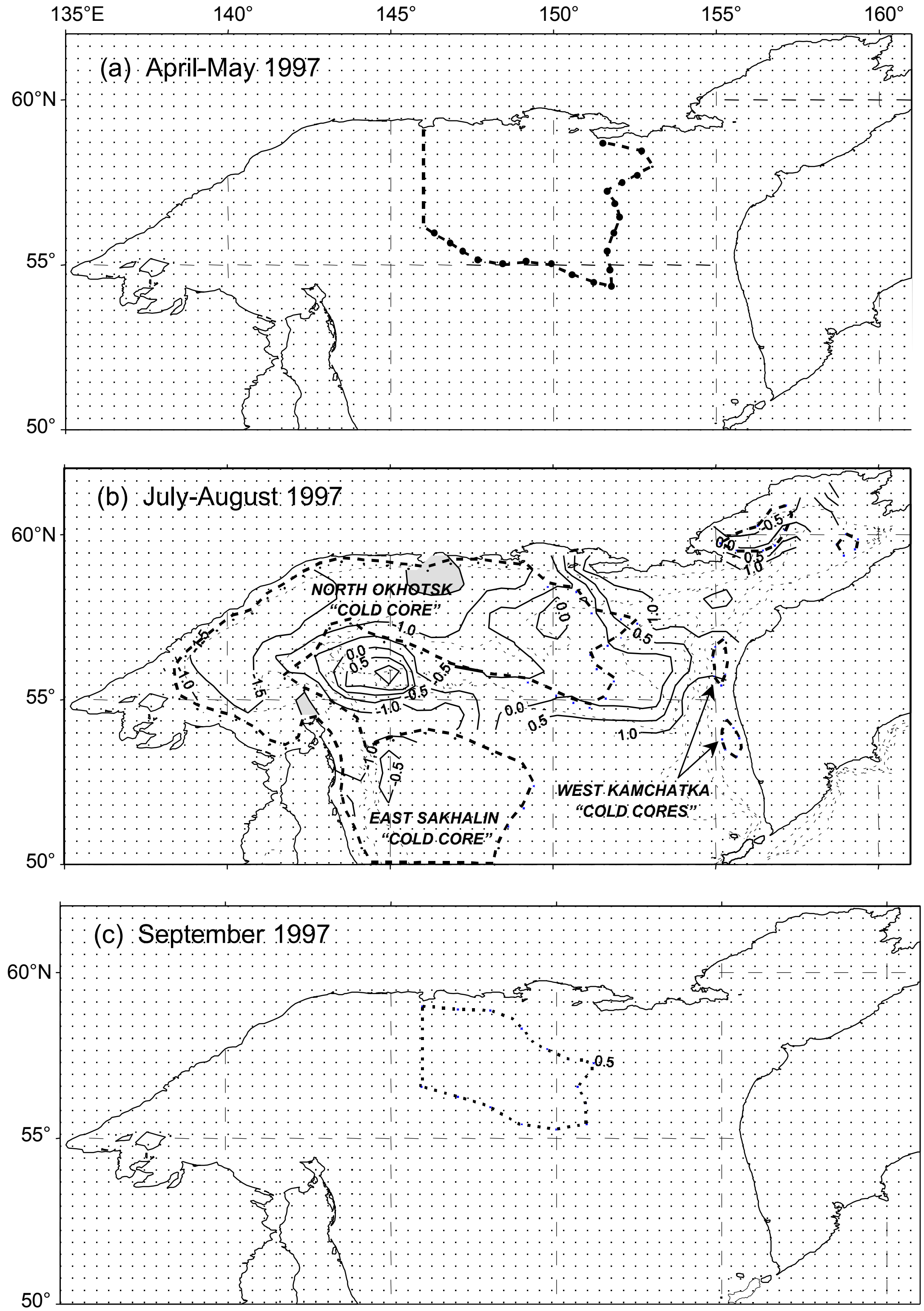


**Fig. 3** Distribution of the lowest temperature and cold core limits in 1997 (dashed area shows temperature < –1°C). Cold core limits are averaged for 1954–1983 (from Chernyavsky (1984)).

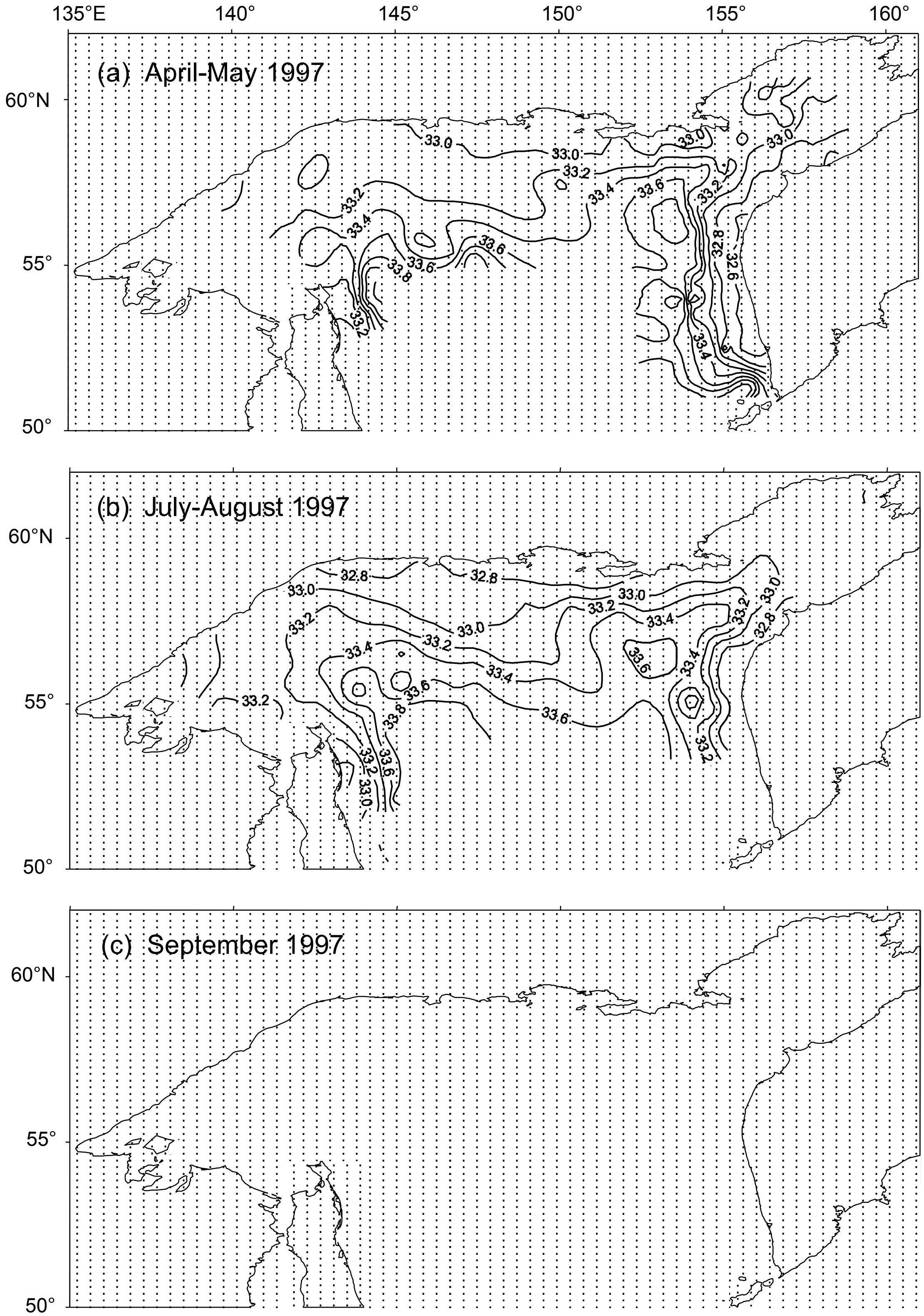


**Fig. 4** Distribution of bottom salinity in 1997.

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