The State of the Far East Seas during the 1997/98 El Niño Event

A.S. Krovnin,[1] G. P. Vanyushin,[1] M. Yu. Kruzhalov,[1] G.V. Khen,[2]
M.A. Bogdanov,[1] E.I. Ustinova,[2] V.V. Maslennikov,[1] A.M. Orlov[1]
B.N. Kotenev,[1] V.V. Bulanov[1] and G.P. Muriy[1]

[1] *Russian Federal Research Institute of Fishery and Oceanography (VNIRO)*
17 V. Krasnoselskaya, Moscow 107140, Russia
e-mail: akrovnin@mx.iki.rssi.ru

[2] *Pacific Research Fisheries Centre (TINRO-Centre)*
4, Shevchenko Alley, Vladivostok 690600, Russia

Oceanographic conditions, mainly temperature fields, in the Bering and Okhotsk Seas in 1997/98 are compared with those in previous, non-El Niño years (1995–1996). The study is based on monthly sea surface temperature (SST) maps constructed at the Russian Federal Research Institute of Fishery and Oceanography (VNIRO) as part of the program on the use of satellite and ship data to monitor the dynamics of SST in various fishing areas of the world ocean. The main purpose of the program is to provide the Russian fishery community with operative and monthly information on the state of environment in regions where the Russian fleet operates. Also, data of several oceanographic surveys conducted in the western Bering Sea in 1995–1997 are used. Figure 1 demonstrates the variability in mean monthly SST anomalies in the Northwest Pacific for 1997.

As is seen, the El Niño signal appeared in April, 1997 and reached it maximum in October, when positive SST anomalies in the central Sea of Okhotsk and northwestern Bering Sea exceeded 3°C. Figure 2 shows differences in mean winter (left panel) and mean summer (right panel) SST and sea level pressure (SLP) values between 1996 and 1995, 1997 and 1996, 1998 and 1997.

The maps allow one to identify some features of climatic variability in the region for 1996–1998. The warming started in winter, 1996 and was observed on most of the investigated region. The only exception was the area off Kamchatka, at the northwestern part of the Bering Sea, and the eastern

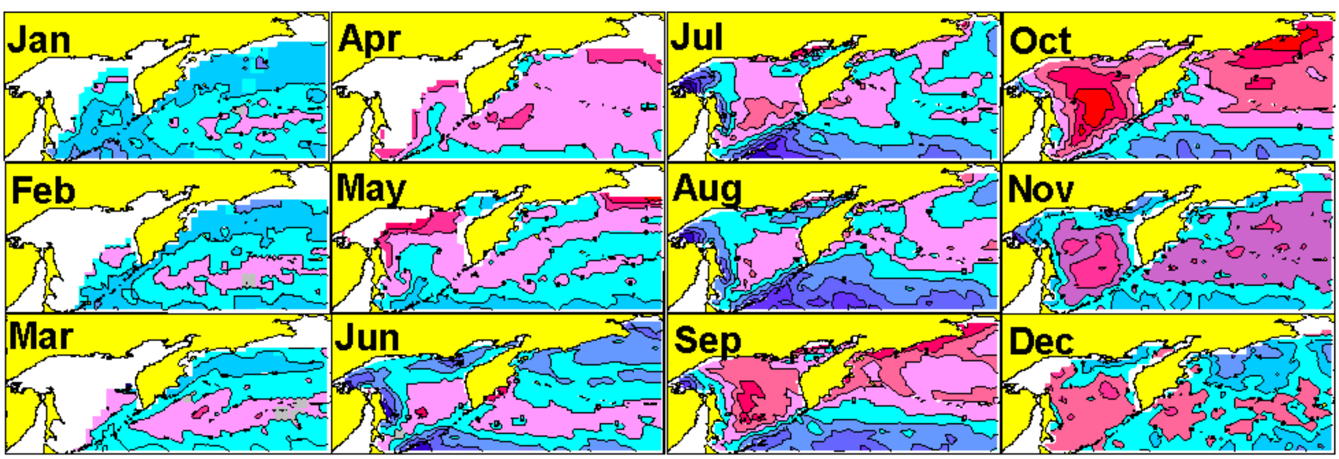

Figure 1. *Variability of SST anomalies in the Northwest Pacific during 1997 (by satellite data).*

Sea of Okhotsk. In 1997 warming was observed in the whole Northwest Pacific, including the Bering and Okhotsk Seas. Positive differences between 1996 and 1997 exceeded 1.0–1.5°C. Quite the opposite situation was noted between the cold seasons of 1998 and 1997. In fact, SST decreased over the whole Northwest Pacific (about 1–2°C), and ice cover area increased.

These changes in SST patterns corresponded to changes in the character of the atmospheric circulation. Thus, if in 1996 the northwestern Bering Sea was affected by the northeastern periphery of the Siberian High with a prevalence of the northern winds and corresponding decrease in SST, in 1997 this part of the sea was under influence of the eastern periphery of a large cyclonic formation with predominately southern winds. In 1998 the atmospheric situation was very similar to that of 1996 (Figure 2, left panel).

The development of atmospheric and oceanic processes in the summer seasons of 1996–1998 was somewhat different from that in winter (Figure 2, right panel). The clear lessening of the East Kamchatka Current was observed in 1996. Compared with 1995, 1996 showed positive SST differences of 1–2°C in its core. The same situation was observed in summer, 1997. Differences in mean summer SST between 1997 and 1996 in the western Bering Sea exceeded 3°C. However, cooling that started in the Northwest Pacific in 1998 was more pronounced in summer than in winter. A decrease in SST in Anadyr Bay and off Navarin Cape in the Bering Sea exceeded 3°C

Changes in ice conditions during 1996–1998 were also considered which allowed one to identify some anomalous events occurring in the Bering and Okhotsk Seas during the El Niño in 1997 (Figures 3 and 4).

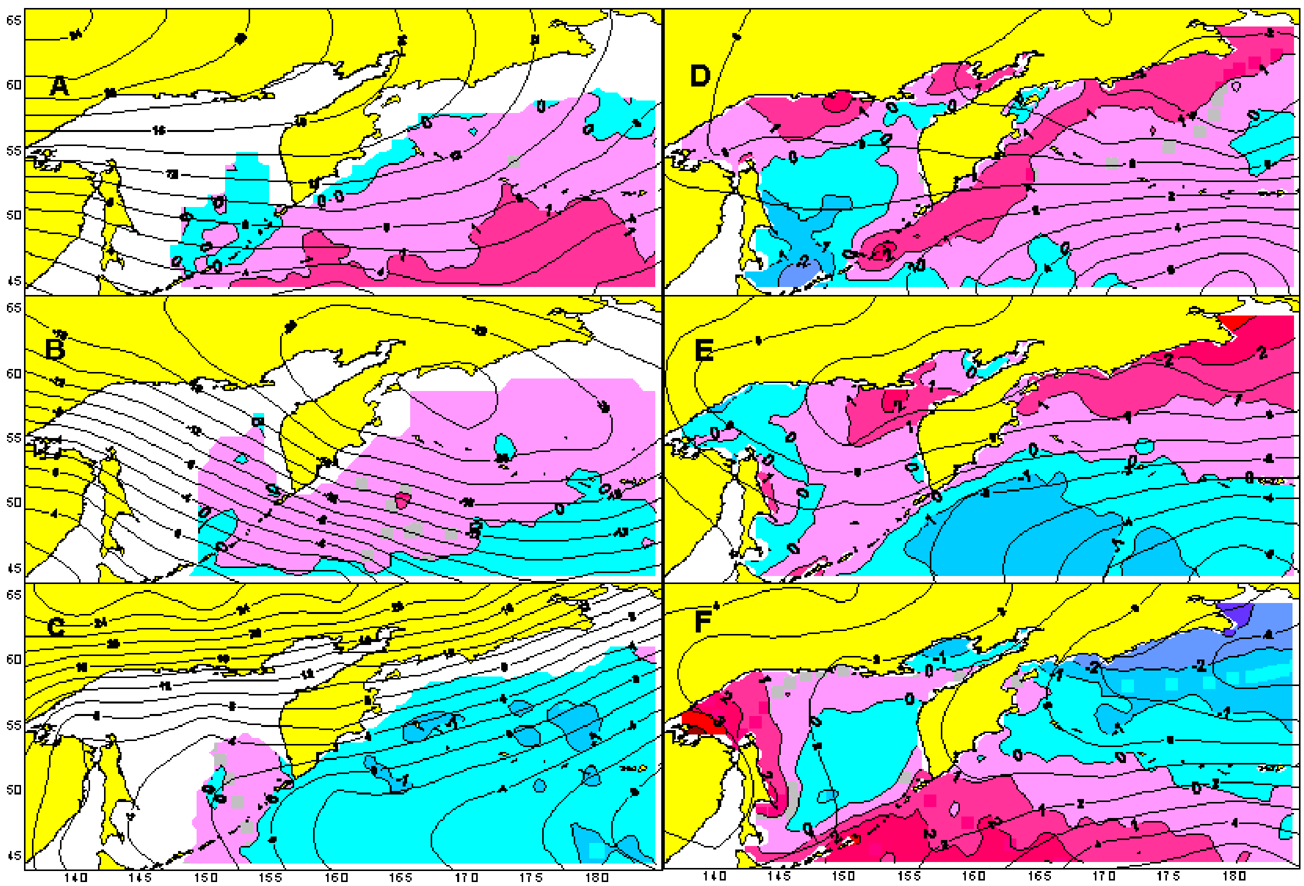

Figure 2. *Differences in mean winter (left panel) and mean summer (right panel) SST and SLP values between (A, D) 1996 and 1995, (B, E), 1997 and 1996, and (C, F) 1998 and 1997.*

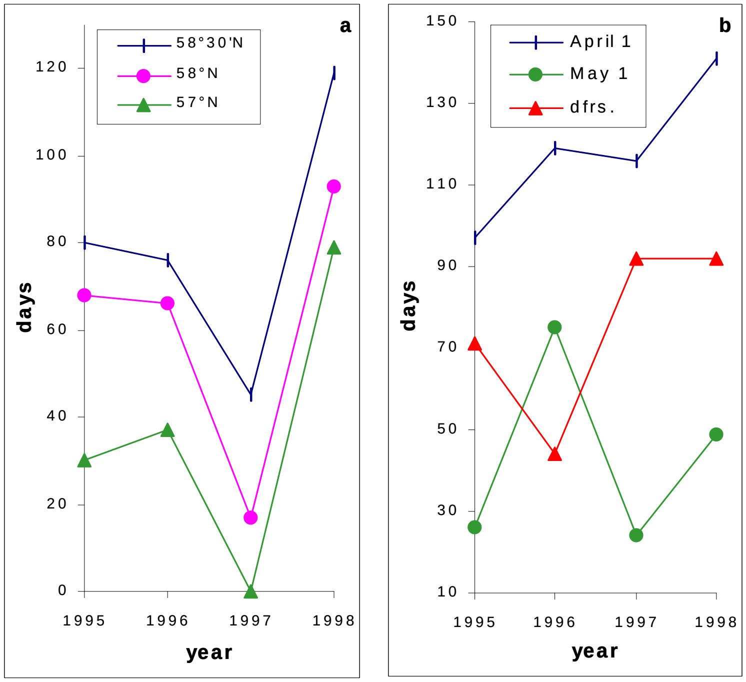

Figure 3. *Duration of the ice period in the eastern Sea of Okhotsk ("eastern channel") at (a) different latitudes and (b) numbers of 1° ´ 1° squares covered by ice on April 1 and May 1 and their differences for 1995–1998.*

For example, in 1997 the northern boundary of the so called "eastern channel" (aquatory permanently free of ice during the cold season in the eastern Sea of Okhotsk) did not cross 57°N, while in 1998 the boundary was located south of this latitude for 80 days (Figure 3a). The rate of decreasing ice area in the sea was highest in 1997–1998 compared with 1995–1996, as is demonstrated by differences in the number of 1° × 1° squares covered by ice between April 1 and May 1 (Figure 3b).

Duration of the ice period around St. Matthew Island in the Bering Sea decreased beginning in 1996, and in 1998 it equaled 48 days compared with 138 days in 1996 (Figure 4a). 1997 was also characterized by the early retreat of the ice boundary to the north of 63°N in both the western and eastern Bering Sea. If, in 1996, ice boundary crossed the western Bering Sea at 63°N in mid-June, in 1998 this occurred in the third ten-day period of April (Figure 4b). Thus, the difference was about 55 days. Also, in the western region of the sea a decrease in the ice cover area in 1997 started on February 17, while in 1996 it began on April 15, and in 1998, on March 15 (Figure 4c).

Results of joint Russian–Japanese surveys conducted in June and September, 1997 onboard of Japanese trawler *Tenyo Maru 78* in the northwestern Bering Sea showed some significant anomalies in the development of oceanographic conditions. First, the core of Warm Intermediate Layer (WIL), in both June and September, was located at depths of 320–370 m which was by 30–100 m shallower than that found from Arsenyev's data (1967) and by 50–100 m shallower compared with values given in the atlas prepared by Sayles et al. (1978). Along with the rising of the core, an increase in WIL temperature and a decrease in its salinity were observed. The values of sea water temperature in the WIL core along the 180° meridian were 3.80–4.00°C, while in previous years the temperatures did not exceed 3.70–3.75°C. Salinity decreased by 0.05 psu and greater. The mean long-term salinity in the region is 33.80 psu. In 1997 its mean values were only 33.72 psu. Such a decrease in salinity is possibly associated with the change in the character of WIL transformation in the Olutorsky-Navarinsky region. Oceanographic parameters in this region are similar to those for the Pribyloff-Matthew continental slope.

In all, positive sea water temperature anomalies in 1997 were about 1.0–1.5°C in the surface layer, 0.5–0.7°C in the core of Cold Intermediate Layer, and 0.1–0.3°C in the Warm Intermediate Layer.

El Niño effects were apparently observed in the western Bering Sea in 1998 as well. Despite the surface thermal conditions in this region being close to normal, temperature values in WIL remained high. Along the continental slope off the Koryaksky coast and Navarin area values exceeded 3.80°C. As in 1997, the location of the WIL core was exclusively shallow, 230–280 m (cruise of *R/V Professor Kaganovsky*, August–November, 1998). In 1998 the significant lessening of the Kamchatka Current was also observed. There was a negative water exchange balance via the Kamchatka Strait between the Bering Sea and North Pacific: in the 0–1000 m layer outflow equaled 0.97 Sv, while inflow was 1.52 Sv, and the resulting flow was –0.55 Sv. Even taking into account the seasonal lessening of the Kamchatka Current, the result is amazing.

We consider that one of the 1997/98 El Niño effects was an appearance of a typically American fish species to the Asian coast. In 1997, rex sole (*Errex zachirus*) which was recorded there only once (Kulikov, 1964) spread over almost the entire basin (Figure 5a). Compared with previous years, large-sized (mean length 54.8 cm) arrowtooth flounder (*Aterestes stomias*) also became a widely common species in the western Bering Sea (Figure 5c). According to similarity of the size composition of both the species with that in the eastern Bering Sea, we could assume that the warming associated with the El Niño event led to an extension of these species westwards.

In 1997–1998, a large record number of northern rockfish (*Sebastes polyspinis*) (Figure 5b) and dusky rockfish (*Sebastes ciliatus*) (Sheiko and Trabenkova, 1998) occurred in Pacific waters off the northern Kurils; these waters also revealed juvenile arrowtooth flounder (Figure 5d) and sablefish. Earlier, all the four species were never registered, or were accidentally caught there. Because these species have pelagic larvae and juveniles, one can suppose their larvae or juveniles were transported from the Aleutian area to the North Kurils by currents in previous years. However, they were not recorded off the Kurils earlier. The similarity in size composition of captured fish with those off the Aleutian Islands may indicate their Aleutian genesis.

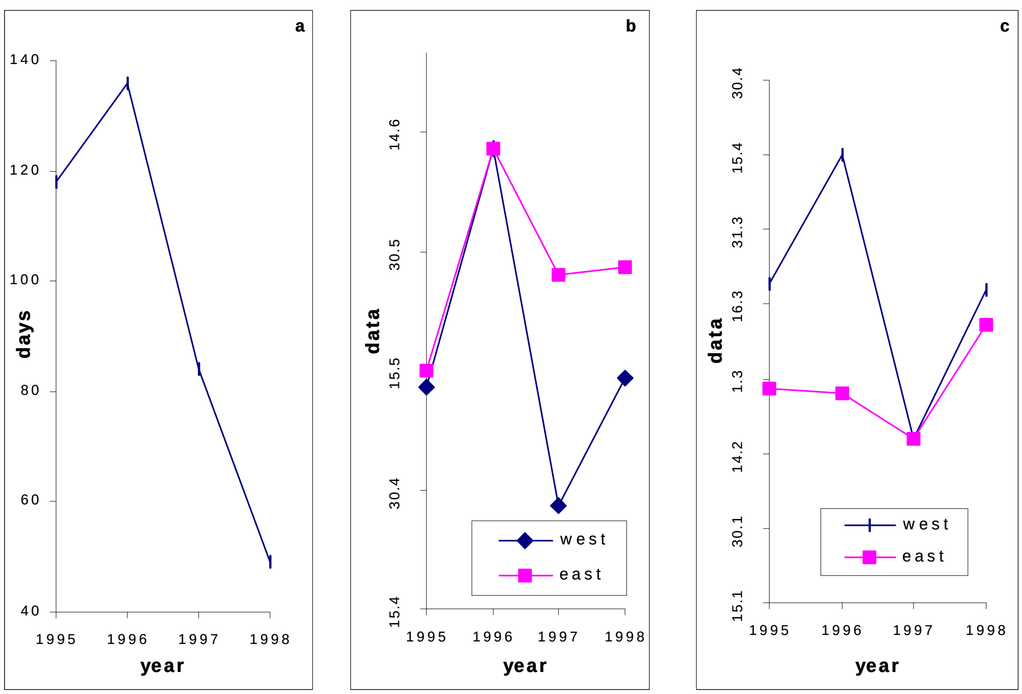

Figure 4. *(a) Duration of the ice period around St. Matthew Island; (b) dates when the ice boundary crossed 63°N; (c) dates when the ice cover started to decrease, in the Bering Sea.*

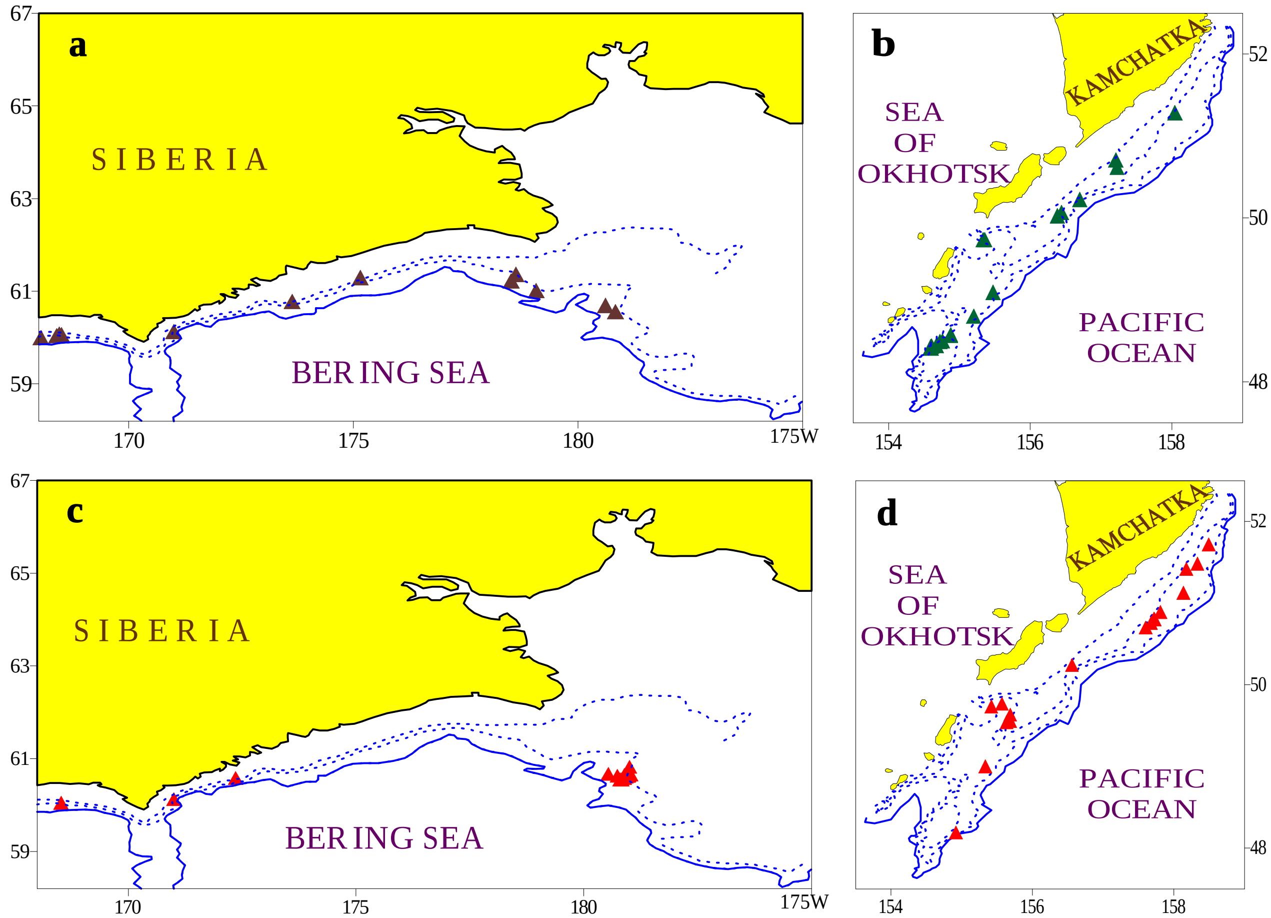

Figure 5. *Records sites (triangles) of (a) rex sole and (c) arrowtooth flounder in the western Bering Sea in 1997, and (b) northern rockfish and (d) arrowtooth flounder in Pacific waters off the North Kurils and southeast Kamchatka in 1998. The continuous line shows the 1000-m isobath.*

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