SPATIAL STRUCTURES OF FRONTS AND EDDIES OF THE JAPAN SEA IN THE 90^{S} BY SATELLITE DATA

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Introduction

Researches of thermal fronts and eddies in the Japan Sea are of significant interest in both of scientific and practical points of view. By the present time were published many papers on spatial water structure of the Japan Sea (Uda, 1934; Suda, 1934; Istoshin, 1960; Leonov, 1960; Yarichin, 1980; Isoda *et al*., 1991; Kim & Legeckis, 1986); Danchenkov *et al*., 1997a; Ichiye & Takano, 1988; Isoda & Nishihara, 1992; Lie *et al*., 1995; Min *et al.,* 1995; Nikitin & Dyakov, 1995; Danchenkov *et al*, 1997b; Lobanov *et al*., 1997; Huh & Shim, 1987; Ostrovskii & Hiroe, 1994; Goncharenko, 1994; Isoda, 1994; Danchenkov *et al*., 1996).

Author investigated earlier (Nikitin, Kharchenko, 1990; Nikitin, Dyakov & Kazantsev, 1989) subarctic front and local fronts of the Japan Sea by data of 1986-1988. The structure of synoptic eddies and their role in an advection of subtropical waters in region of Peter the Great bay were investigated (Nikitin *et al*, 1998; Nikitin & Dyakov, 1998) also.

Data and Methods

In this paper the spatial structure of thermal fronts and eddies in western part of the Japan Sea in the 90^{s} was considered. Synoptic eddies in area close to Peter the Great Bay were studied to show important role of them in transport of warm waters to the north. For this goal the data of the 52 AVHRR IR-images in 1990-1999 from NOAA polar orbiting satellites both in high (HRPT) and low (APT) resolution modes were used. For analysis the data of shipping observations on 132 °E and 132°20' E were used too. Method of satellite IR images analysis was traditional (Recommendations.., 1984).

Results

For about 90 years the basic ways of warm water transport to the north-western Japan Sea, were considered as connected with the East-Korean Warm Current, with eddy streets on 131 °E and on 134 °E.

The horizontal size of anticyclonic eddies is 30-60 miles, vertical- 800 m. Two kinds of eddies were observed. Some of them transported warm and low salty water, another ones-warm waters with high salinity. The greatest speed was marked at north edge of eddies.

In Fig. 1 there is IR-image from the satellite NOAA-14 for March 26, 2000. On it there are many synoptic eddies a diameter of 35-80 km marked by different letters (A-H). In western part of the Japan Sea subtropical waters along 131 °E reach Peter the Great Bay.

Streamer (w) penetrates from Boltin Cape along eastern edges of eddies M, N, E and A and further to Peter the Great Bay. This warm water transport could be interrupted by northern or north-western winds. The northwestern branch of the Subarctic (Polar) front exists at northern edges of the marked eddies.

Both branches of Subarctic front are formed at the end of winter. They are observed at the IR-images and on fields of oceanographic charts (Fig. 2). On distribution of main water parameters in the western Japan Sea are seen East-Korean Current, first and second branches of Tsushima Currents, chain of warm eddies along 131 °E and fronts. The greatest gradients of temperature and salinity at the surface were marked on NW Subarctic front. The depth of coastal front was restricted by 100 m, NW Subarctic front-300 m, SE Subarctic front-400 m, front of the second branch of Tsushima Current-200 m. The maximum speed (15 cm/s) of current was watched on SE Subarctic front. The diameter of A2 eddy at the surface was about 60 miles and its depth-about 800 m.

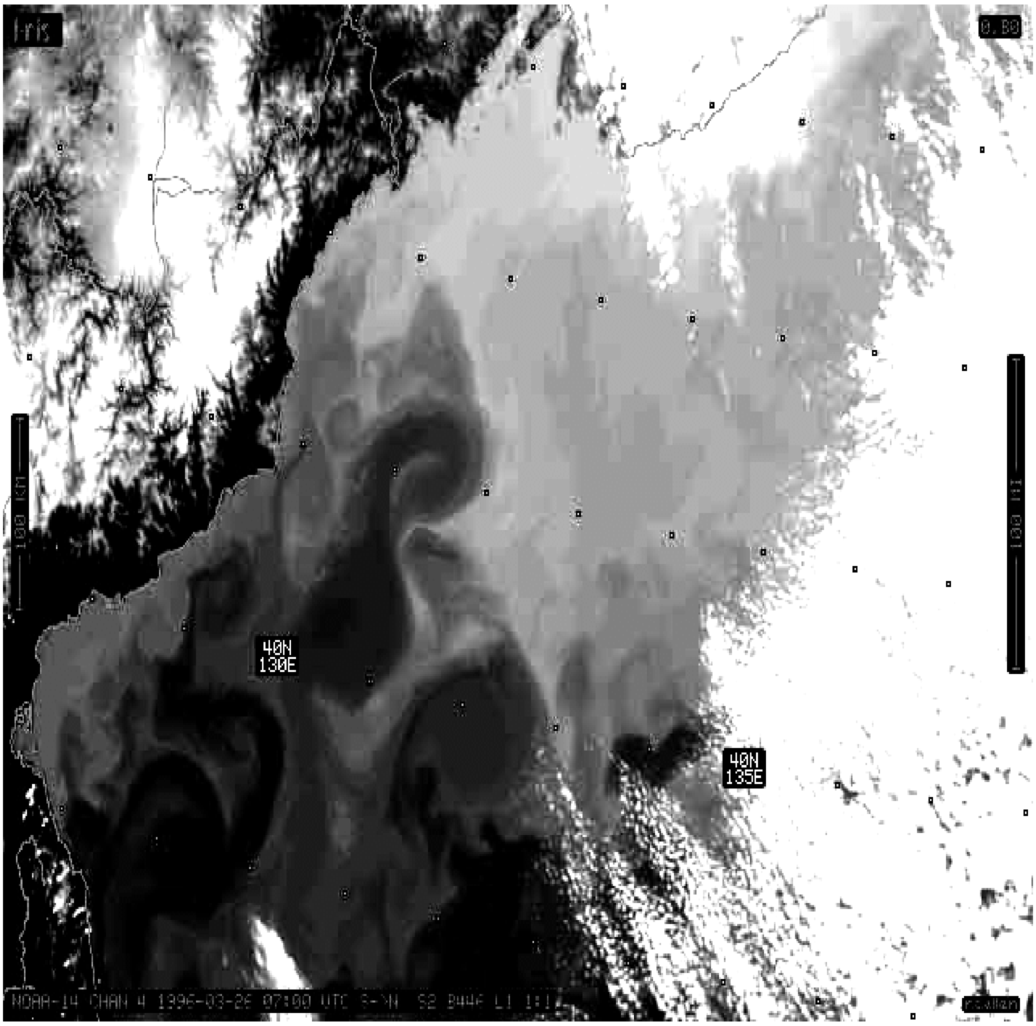

Fig. 1. NOAA-14 AVHRR infrared image of the north part of the Japan Sea by March 26, 2000

The core of low salinity (less than 33.98 ‰) water allocated between 240-320 m. To the north of eddy A2 another eddy (A1) existed. Its sizes were 30 miles and 250 m accordingly. The velocity of current in A2 eddy was 8.7 cm/s. Inside it warm and low salinity water (less than 33.95 ‰) was situated.

Eddies A1 and A2 interacted with each other. As the result of it low salinity water accumulated and further transferred in subsurface layer (75-300 m) to the south. Below 50 m at northern boundaries of these eddies the velocity decreases noticeably. At southern boundaries of eddies the velocity remains the same from the surface to 200 m level.

In northern part of waters between 75 m and 300 m core of low salinity water situates. Cold water with low salinity sinks at NW Subarctic front to depth less than 200 m. The waters in the western Japan Sea could be divided on some areas with different vertical water structures: Primorye structure, pacific structure and inter-frontal structure (Fig. 2). In March, system of streamers between eddies was seen clearly on the surface and maximal temperature gradients were seen at the Northwestern Subarctic front (Fig. 3).

It is visible, that warm subtropical waters were transported to the north by streamers in chain of eddies at 131 °E and in second branch Tsushima Current. Eddies A1 and A2 were traced as on IR-images as on hydrological sections.

The vertical size of A2 eddy was more (700 m), than of A1 eddy (200 m). On eastern edge of both eddies there was input of waters. The sinking of cold water with low salinity at NW Subarctic front was traced.

In summer as a result of the warming of the sea surface, thermal fronts become weak (Fig. 4). Subarctic front in spring does not exist as permanent line. The subtropical waters spread to the north by two eddies: at 131 °E and at 133 °E.

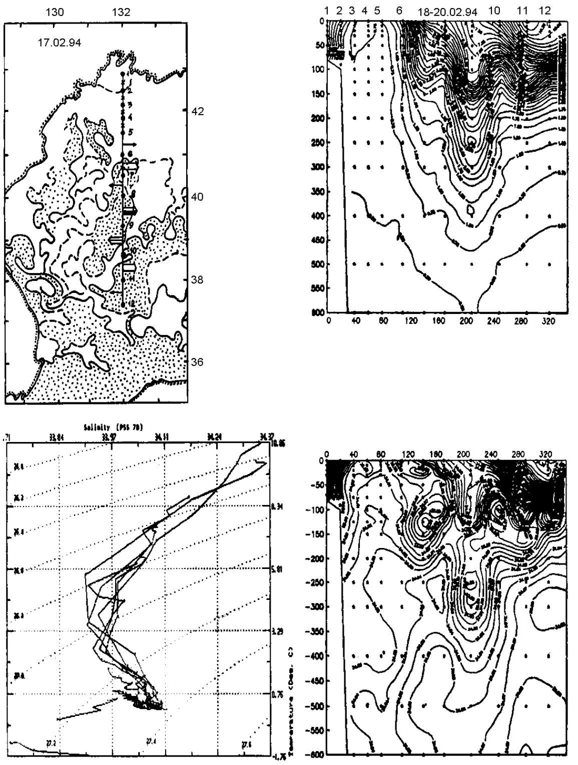

Fig. 2. Spatial structure of waters in the western part of the Japan Sea in February, 1994

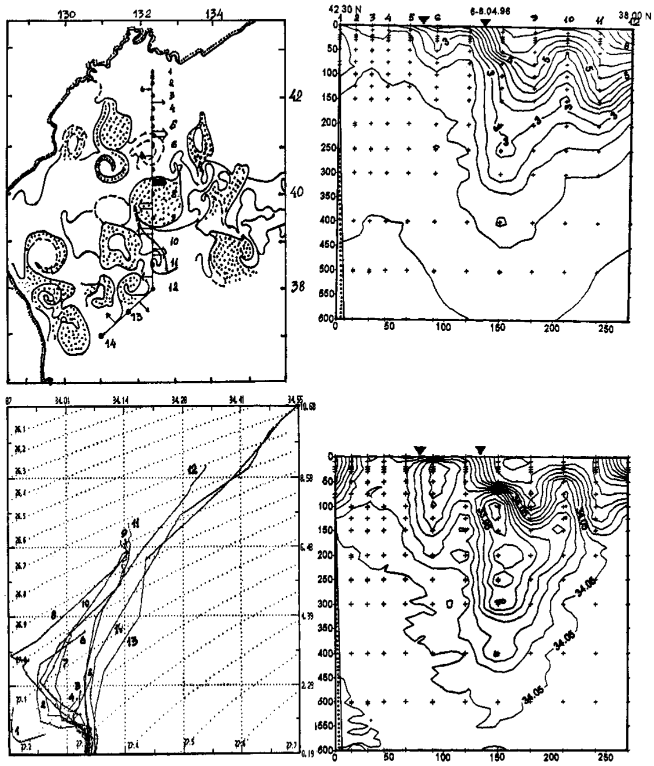

Fig. 3. Spatial structure of waters in the western part of the Japan Sea in April, 1996

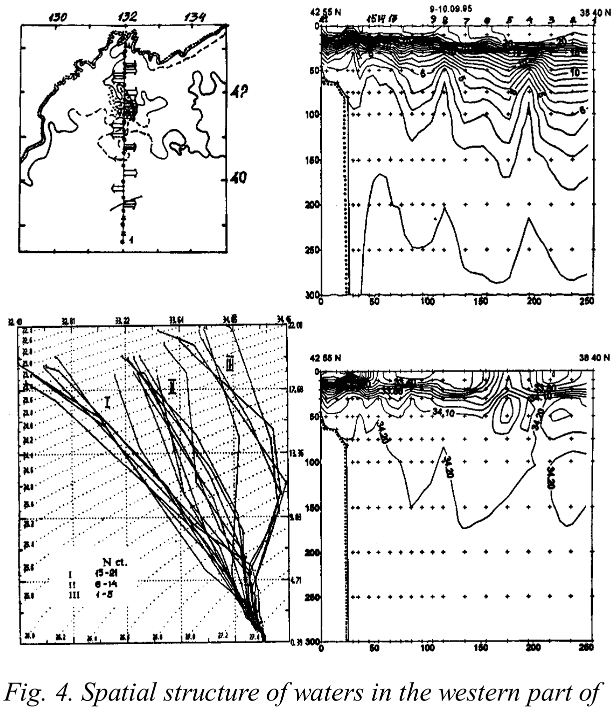

Fig. 4. Spatial structure of waters in the western part of the Japan Sea in September, 1995

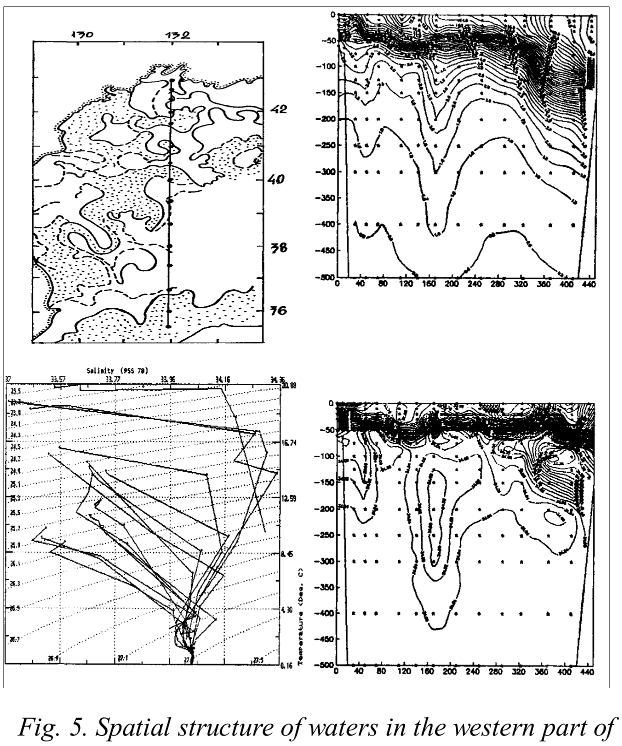

Fig. 5. Spatial structure of waters in the western part of the Japan Sea in November, 1995

In autumn Subarctic front began to form again (Fig. 5). The maximum speed of currents was marked at NW Subarctic front (10 cm/s) and at front of Tsushima Current (20 cm/s). Chain of a eddies on 131 °E from 38 °N to Peter the Great Bay was observed. Among eddies two (A1 and A2) were traced. The diameter of eddies was 80 and 60 miles, accordingly.

The A2 eddy was traced in August as well. The A1 eddy was traced down to 200 m, and A2 eddy-to 950 m.

Core of low salinity water (less than 34.00‰) was allocated between 125 m and 300 m. In August the core of high salinity (34.20‰) water was situated at 45-85 m.

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