Deoxygenation in the intermediate layer in the Kuril region of the northwestern Pacific Ocean

The changes in oxygen content indicators are considered based on 10 expeditions in 2014-2023 along the section along the Kuril Islands to assess interannual variability. A significant trend in decreasing oxygen content at the 500 and 1000 m horizons is revealed. The revealed changes are consistent with the concept of deoxygenation of the northern Pacific Ocean in the process of changing the thermal regime.

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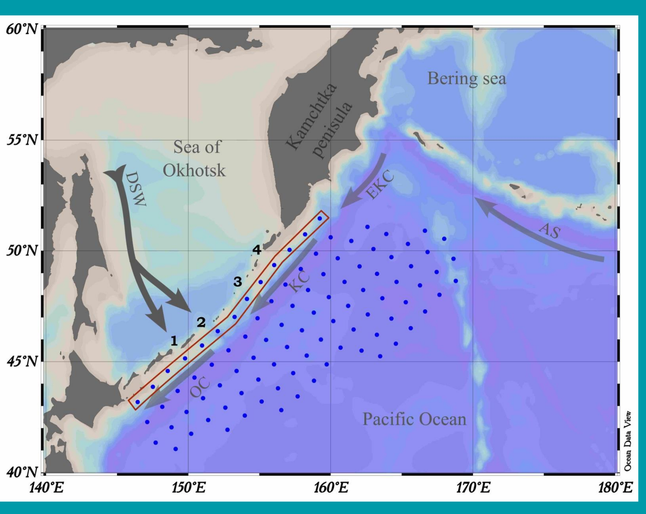
Intro

The content of dissolved oxygen is an important indicator of the status of the water area. In the World Ocean, the content of dissolved oxygen has decreased by 2% over the past 50 years due to the global warming. In the northwestern Pacific Ocean (NWPT), oxygen enriches the intermediate layer with waters inflowing through the southern Kuril Straits. Therefore, analysis of the dissolved oxygen content in this water area is an urgent task.

Objectives

- No estimates of changes in dissolved oxygen in the Pacific waters adjacent to the Kuril Straits have been previously conducted.
- Research in this region is limited and new data are urgently needed to understand current processes.
- The objective is to study trends in dissolved oxygen concentrations based on data obtained over 10 years of research in the Kuril region of the northwestern Pacific Ocean.

Materials and Methods



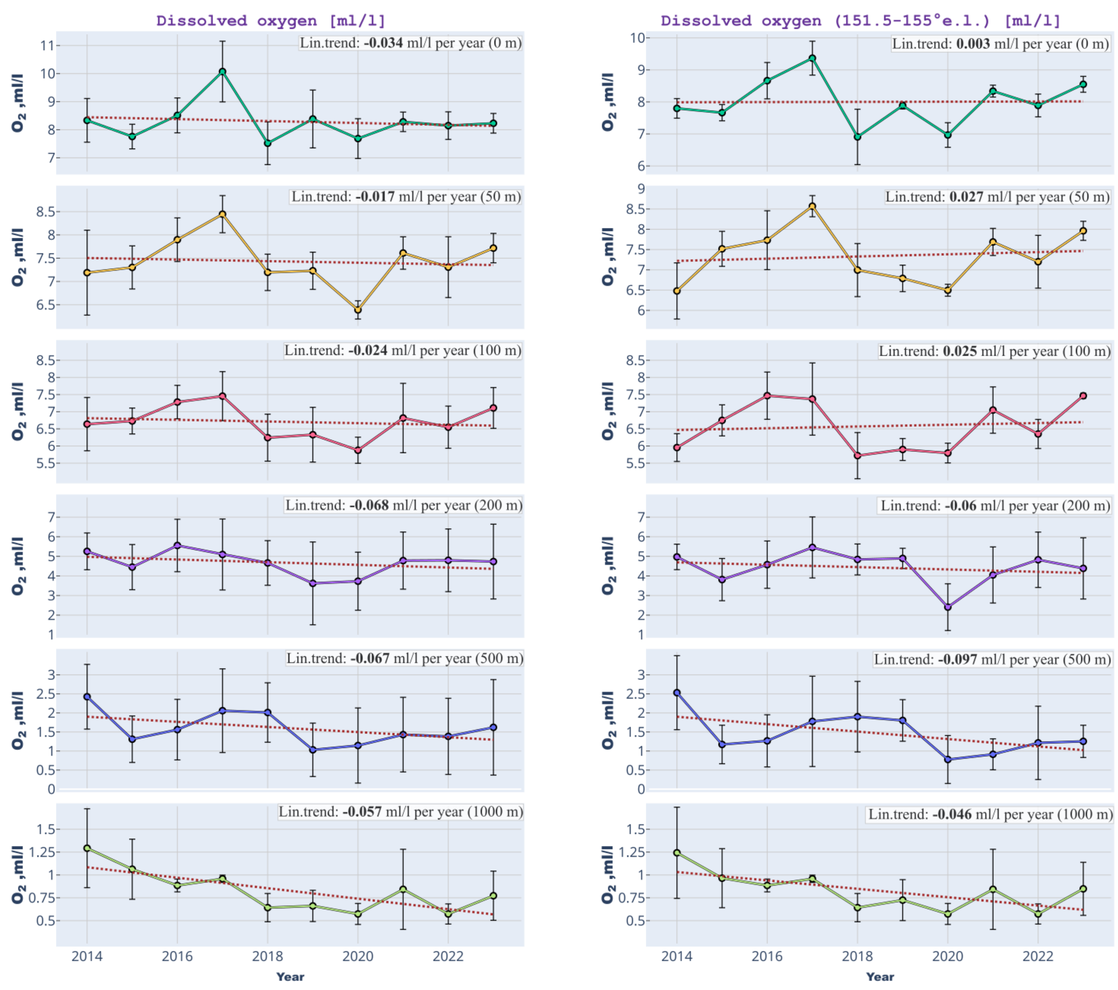
Layout of the R/V TINRO survey stations in the North-West Pacific Ocean. The red line marks the section along the Kuril Islands. The dark arrows show the direction of movement of the intermediate waters formed in the Sea of Okhotsk. The main straits are marked with numbers: 1 – Friza Strait, 2 – Bussol Strait, 3 – Kruzenshtern Strait, 4 – Fourth Kuril Strait.

- Water samples for determination of dissolved oxygen by the modified Winkler method were taken at standard horizons.
- For analysis, the measurement results at 106 stations were selected, a total of 626 determinations.
- The significance of trends was determined based on the significance test of the determination coefficient R^2, which was determined using the Spearman rank correlation coefficient. Additionally, the significance of trends was determined using the nonparametric Mann-Kendall test using the pyMannKendall library in the Python programming language.

Analysis & Results

In the Oyashio region, the decrease in oxygen in the subsurface and intermediate layers is subject to different mechanisms. In the layer located at the lower boundary of the CIL, the high rate of decrease in dissolved oxygen is primarily explained by a decrease in winter convection in the area located north of the Oyashio Current, i.e. in the Kuril-Kamchatka Current. In the intermediate layer of the ocean in this area, the decrease in dissolved oxygen is explained by a decrease in the formation of bottom shelf waters in the Sea of Okhotsk, associated with a decrease in ice cover, as a result of which the transport of dissolved oxygen with newly formed intermediate waters through the southern Kuril Straits decreases.

Our results confirm the action of these mechanisms. The trend towards a decrease in oxygen throughout the section in the 500-1000 m layer has high values (-0.06 ml/l per year), and in the middle of the section at the stations located opposite the Bussol and Kruzenshtern Straits, we find the maximum value of the linear trend (-0.097 ml/l per year) at the 500 m horizon, in the layer where water is transported to the intermediate layers of the Pacific Ocean from the Sea of Okhotsk.



Conclusions/Future Directions

The revealed trends in the interannual variability of dissolved oxygen content in the Kuril region of the northwestern Pacific Ocean are consistent with the concepts of deoxygenation of the deep layers of the Pacific Ocean during climate warming, but specify the mechanism of deoxygenation. In the studied region, deoxygenation is most noticeable in the intermediate layer, which is associated with the action of the ventilation mechanism of this layer by slope convection of the Sea of Okhotsk.

It was shown that the greatest statistically significant trend of decreasing dissolved oxygen concentration (-0.06 ml/l per year) was observed at the 500 and 1000 m horizons, which is probably associated with a decrease in the influx of newly formed intermediate waters from the Sea of Okhotsk due to the weakening of slope convection as a result of a decrease in the volume of formation of bottom shelf waters under conditions of warming winters and a decrease in ice cover.

Since the change in the thermal regime in the North Pacific continues, it can be assumed that in the foreseeable future the identified trends in changes in hydrochemical parameters in the Kuril region of the North-West Pacific Ocean will worsen.

References

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