親潮域における溶存酸素の長期変動と周期変動とその西部北太平洋への広がり

Trends of oxygen with bidecadal oscillations in the Oyashio region and its propagation to the western North Pacific

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Over the past decades, secular trends toward decrease in dissolved O_2 have been observed in a variety of regions and depths in the North Pacific [Keeling et al., 2010, and references therein]. In the western North Pacific, O_2 decrease has been markedly found around 26.8σ_θ that corresponds to the core of North Pacific Intermediate Water (NPIW) along the 137°E section [Takatani et al., 2012] and the 165°E section [Sasano et al., 2015]. NPIW is formed in the subsurface of the Kuroshio-Oyashio Interfrontal Zone in the region offshore of northern Japan, and the Oyashio water is considered as one of the source of NPIW. In the Oyashio region, Ono et al. [2001] have found the trends toward increase in AOU and its bidecadal oscillations between 26.7σ_θ and 27.2σ_θ using time series data for the period of 1968–1998 in winter. They speculated that the reduction of ventilation caused the decreases in O_2. However, because the depth of isopycnal horizon of 27.2σ_θ is much deeper than that of 26.7σ_θ and does not outcrop in the western North Pacific, it is necessary to improve our understanding of these controlling factors. In this study, the controlling factors of secular trends in dissolved O_2 in the Oyashio region was investigated based on long-term hydrographic and biogeochemical measurements made over 1954–2014. We also evaluated the bidecadal oscillations in dissolved O_2 in the Oyashio region. Through the comparison of secular trends and bidecadal oscillations with those along the 165°E section, their propagation from the Oyashio region to the wide range of the western North Pacific was evaluated.
Significant linear trends toward decreasing O_2 were detected between 26.6σ_θ and 27.5σ_θ in the Oyashio region. The contribution of the decrease in the saturation concentration of O_2 due to warming was small (<10%). The largest decreasing rate in O_2 was found on 26.7σ_θ (-0.72 ±0.11 μmol kg^{-1} yr^{-1}) while it was attributed to a deepening effect of isopycnal horizons by approximately 33%. Because this density corresponds to temperature minimum layer formed in winter convection in the subarctic zone and surface density in winter has been decreasing, the decreasing O_2 around 26.7σ_θ would be predominantly attributed to the reduction of ventilation. At 27.0σ_θ, O_2 decline would be attributed to that in the Sea of Okhotsk where O_2 has been decreasing in this density due to the decrease in the formation of dense shelf water (DSW) in association with the decrease in sea ice forming. In deeper layers with densities up to 27.5σ_θ, O_2 decreases would also be explained by the reduction of DSW that propagates through diapycnal mixing in the Bussol' Strait. Furthermore, the O_2 reduction in deep layer might be attributed to the increasing contribution of Western Subarctic water through strengthening of the Aleutian Low. In the Oyashio region, bidecadal oscillations of O_2 have been observed in 26.6σ_θ–27.5σ_θ. The periodicities were almost constant at 16.4–19.6 years, and were vertically synchronized within 1 year. Along the 165°E section, the bidecadal oscillations were also found horizontally in 30°N–42.5°N on 26.8σ_θ with a time lag of 1–3 years from the Oyashio region, and vertically in 40°N up to the subtropical OML at 27.5σ_θ. It suggests that the bidecadal oscillations extended horizontally and vertically to the regions where the subarctic water influences. These results demonstrate that the western subarctic North Pacific is playing an important role as an origin for secular trends and natural variability in dissolved O_2.

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