30-year variation of temperature and salinity in the Seto Inland Sea isolated from the climate change in the surrounding ocean

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Using oceanographic data archived in the Marine Information Research Center Ocean Dataset 2005, linear trends of both temperature and salinity from 1963 to 1993 were computed at each grid cell with a horizontal scale of 1/6° over the Seto Inland Sea, Japan. The linear trends were thereafter multiplied by 31 years to compute the increments of temperature and salinity during this period. Over the course of 31 years, summer temperatures decreased significantly both at the sea surface (−1.2 ˚C/31y averaged over the area) and the bottom (−1.7 ˚C/31y), while salinity increased at the sea surface (0.46/31y) and bottom (0.41/31y). In addition, it was found that steric heights computed using temperature and salinity in summer (see Methods) mostly decreases over the Seto Inland Sea during the 31 years (−0.57 mm/y).
It is unlikely that these 31-year trends were caused by surface heat and freshwater fluxes through the sea surface. Of particular interest is the salinity increase, which was revealed in the bottom layer as well as the surface layer. Apparently, this is unlikely to be caused by a secular trend of freshwater flux into the upper layer (precipitation minus evaporation, and/or river runoff). The reasonable explanation is that the dense (cool and saline) Kuroshio intermediate water, uplifted near the coast over the period 1963 through 1993, intruded into the bottom layer of the Seto Inland Sea. The above-mentioned trends were restricted within the Seto Inland Sea. The temperature increment south of Japan was mostly zero during the same period in summer. Moreover, the sea surface height (SSH) within the same area in summer showed an increase of 0.2 (2.0) mm/year during the same period.
In the southwestern Japan Islands, the oceanographic properties of shallow coastal waters exposed to the south are vulnerable to Kuroshio fluctuations that act as outer boundary conditions. The reconstructed SSH data (ReSSH; Hamlington et al., 201, 2112) map averaged over 10 years from 1963 to 1972 suggests that a cold eddy was located off the Kyushu and Shikoku Islands, Japan. However, in the ReSSH map averaged over the period 1984−1993, the cold eddy identified 20 years earlier had mostly disappeared, and it was replaced with a warm eddy. The transition to the warm eddy suggests that the surface speed (hence, volume transport) of the Kuroshio Current south of Japan had increased during the period 1963−1993, because of the recirculating geostrophic flow around the eddy. A geostrophic adjustment associated with the increasing Kuroshio transport results in the thermocline tilting and resultant temperature decreases (salinity increase) close to the Japan Islands. This is consistent with the temperature decrease (salinity increase) in the Seto inland Sea, potentially caused by the subsurface intrusion of the Kuroshio intermediate water. It is however a difficult task to uncover the possible cause(s) of the eddy transition south of Japan; Note that the Kuroshio meander off the Enshu Nada was apparently not a cause, because it is located far east of the Seto Inland Sea. To uncover the cause(s) of the 31-year eddy activity south of Japan, we have to investigate the secular SST/SSH variation, at least, ten times longer than the period in the present study, and it is unfortunately beyond the scope of the conventional physical oceanography.

Keywords: 30-year variation of temperature and salinity, Seto Inland Sea

