Reproducing migration history of Japanese sardine using otolith $\delta^{18}O$ and a data assmilation model

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Using the combination of otolith oxygen stable isotope ratio ($\delta^{18}O$) and data assimilation model, a new method to reproduce migration histories of Japanese sardine (*Sardinops melanostictus*) was developed. Firstly, dependence of otolith $\delta^{18}O$ on temperature was examined for the first time for Japanese sardine. Juveniles were reared in three different water temperature (14.6, 18.7, 22.0 °C) for a month. Sagittal otoliths were collected and areas formed in latest 28 days were extracted by micromill for $\delta^{18}O$ analysis. $\delta^{18}O$ of rearing water was also measured and a linear relationship between otolith $\delta^{18}O$ and temperature was determined as follows: $\delta_{otolith} = \delta_{water} - 0.186\ (T) + 2.770$, $r^2 = 0.91$ (1).
Secondly, the distribution of seawater $\delta^{18}O$ in the western North Pacific and relationship between salinity was investigated. During 2012-2015, surface water samples were taken from 90 different locations for $\delta^{18}O$ analyses. Surface $\delta^{18}O$ showed a clear poleward gradient and linear regression analysis revealed that $\delta^{18}O$ and salinity were strongly correlated: $\delta_{water} = 0.601(S) - 20.564$, $r^2 = 0.93$ (2), which enabled us to estimate seawater $\delta^{18}O$ from salinity. These results were essential to convert the otolith $\delta^{18}O$ profile into migration history. Micro-volume $\delta^{18}O$ analysis and our original microsampling technique enabled us to extract otolith $\delta^{18}O$ profile in a temporal resolution of 10-15days through whole life of juveniles approximately 200 days post hatch. For dates corresponding to each value of the profile, surface temperature and salinity in the range of 30-55 °N, 130-180 °E were extracted from FRA-ROMS, a data assimilation ocean model which reproduce ocean environment realistically. Temperature and salinity in each grid were converted into otolith $\delta^{18}O$ value using Eq. (1) and (2). Grids in which the calculated otolith $\delta^{18}O$ value was equivalent to actually analyzed value were considered to be the location of the individual on the date. Movements of the juveniles reproduced by this method clearly showed the northward migration from the Kuroshio-Oyashio transition zone to the Oyashio region and the estimated location on the date approached to the actual sampling point, which indicated the high accuracy of the method.

Keywords: sardine, otolith oxygen stable isotope, data assimilation model

