

## Two different types of regime shift appeared in a 2900-yr record of Japanese sardine abundance

KUWAE, Michinobu<sup>2\*</sup> ; YAMAMOTO, Masanobu<sup>2</sup> ; SUGIMOTO, Takashige<sup>3</sup> ; TAKEOKA, Hidetaka<sup>1</sup>

<sup>1</sup>CMES, Ehime Univ., <sup>2</sup>Faculty of Environmental Earth Science, Hokkaido Univ., <sup>3</sup>Institute of Civilization, Tokai University,

Regime shift, revealed in climates and marine ecosystem, is one of key dynamics to predict rapid changes in marine ecosystems and fisheries resources for decades. The regime shift is defined as a relatively rapid change (occurring within a year or two) from one decadal-scale period of a persistent state (regime) to another decadal-scale period of a persistent state (Minobe 1997; King 2005). In the Pacific it has been detected in Pacific Decadal Oscillation (PDO) (Mantua et al., 1997) and species replacement between anchovy and sardine (Lluch-Belda et al., 1989). There is so far no sufficient evidence of how regime shift changes in its feature on longer timescales because of paucity of long-term high-resolution marine records in the Pacific. Here we present a 2900-year record of ecosystem regime shift in the western North Pacific using Japanese sardine abundance which can be reconstructed from fossil scales in the coastal marine sediments; timing of decreases and increases in the abundance can be used as an index of regime shift. Sardine abundance showed two different types of regime shift in the time series. One is a regime shift similar to that previously detected in the 20th century, which repeatedly occurs on interdecadal timescales. The other is a regime shift in relation to centennial-scale variability in sardine abundance, which could be followed by a centennial-scale low or high abundance period characterized by respective small or large amplitudes of decadal variations in abundance. Our estimation suggests that the maximum abundance is depleted one-quarter to one-tenth of that in the sardine regime in 1980s. Similar patterns of the latter regime shift are revealed in the time series of sardine abundance off California (Baumgartner et al., 1992) and Chile (Valdes et al. 2008), PDO index reconstructed from North America (Macdonald and Case 2005), and abnormal snow index in East Asia (Chu et al., 2008). This indicates that the latter regime shifts that we found are associated with those of marine ecosystems and climate over the Pacific. The recent high sardine abundance period lasted 200 years in the Pacific, suggesting transition to next centennial low abundance period in the near future. Careful examinations on whether the latest regime shift in 1990s is the case of the latter regime shift are important for the long-term prediction of climate and fisheries resources.

Keywords: regime shift, marine ecosystem, sardine fossil scale record, Pacific, Beppu Bay