The ocean acidification trend in the western equatorial Pacific for the past three decades

*Masao Ishii[1], Daisuke Sasano[1], Naohiro Kosugi[1], Katsuya Toyama[1], Hideyuki Nakano[1], Hisayuki Yoshikawa Inoue[2], Keith B Rodgers[3]

1.Meteorological Research Institute, Japan Meteorological Agency, 2.Hokkaido University, 3.Princeton University

The western zone of the tropical Pacific Ocean includes the “Coral Triangle”, which comprises the most important coral habitats on Earth with maximum marine biodiversity. One of the emerging issues that broadly threatens the coral reef ecosystems over the tropical and subtropical oceans is ocean acidification. Acidification is the consequence of not only the approximately 25% anthropogenic CO_2 emissions being absorbed by the ocean, but also with land use changes. A direct manifestation is the lowering of the pH of the ocean (increasing acidity) and the saturation level of the calcium carbonate minerals aragonite and calcite, which are important components of skeletal materials for many marine organisms including corals. Here we demonstrate the occurrence of ocean acidification in the warm western equatorial zone of the Pacific with the data of CO_2 system measurements over the past ~30 years since mid-1980s. In surface water within 125ºE-160ºW, 5ºS-5ºN, the partial pressure of CO_2 was increasing at a mean rate of +1.15 ±0.08 µatm yr^{-1} while that in the atmosphere was +1.74 ±0.01 µatm yr^{-1}. Total alkalinity, being salinity-normalized at S=35, has not shown any significant trend towards increasing or decreasing levels since early 1990 (NTA = 2296.6 ±3.8 µmol kg^{-1}). They are indicative of the increase in salinity-normalized dissolved inorganic carbon (NDIC) at +0.67 ±0.08 µmol kg^{-1} yr^{-1}, lowering of pH at -0.0011±0.0001 yr^{-1} and a reduction of saturation index of aragonite (Ωarag) and calicite (Ωarag) at -0.0097±0.0007 yr^{-1} and -0.0064±0.0005 yr^{-1}, respectively. The trend towards increased preformed_NDIC (+0.63 ±0.11 to +0.73 ±0.12 µmol kg^{-1} yr^{-1}) has also been observed on density classes of 23.0 –25.5σ_θ in the Equatorial Undercurrent that delivers waters to the equatorial divergence, and subsequently through transport in the South Equatorial Current to the surface of the warm western zone. Results of the measurements and numerical simulations with an ocean biogeochemistry / general circulation model suggest that equatorward transport of anthropogenic CO_2 by the shallow meridional overturning circulation from both hemispheres is an important process for the acidification in the equatorial Pacific. It is subsequently transported back into the subtropics and is considered to be contributing to the CO_2 increase and ocean acidification in the surface layers of the subtropical ocean.

Keywords: ocean acidification, equatorial Pacific

