

Note on large-scale environmental changes and its possible influence to the ecosystem in the Southern Ocean

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<Remarkable Environmental Changes> Recently, the number of serious reports on environmental changes in the Southern Ocean has been increasing as the global warming progresses (IPCC, 2007). Temperature in the Antarctic Peninsula area became warm approximately 10 times faster than the mean rate of the global warming over the past 50 years (Vaughan *et al.*, 2001; British Antarctic Survey, 2006). Antarctic sea ice decline (Curran *et al.*, 2003), ice sheets melting (Shepherd and Wingham, 2007), and snow melting (NASA, 2007) have been reported. Warming of water temperature occurred in the Southern Ocean (Levitus *et al.*, 2007; Gille, 2002; Aoki *et al.*, 2003; Marshall *et al.*, 2006). Freshening of the Antarctic Surface Water and the Antarctic Bottom Water formed in the Indian and Pacific sector in the Antarctic Ocean (Jacobs *et al.*, 2002; Rintoul, 2007; Ozaki *et al.*, personal communication, 2006; Yabuki *et al.*, 2007).

<Changes of the Southern Ocean Ecosystems> In contrast, there are papers on ecological changes of Antarctic krill (*Euphausia superba*) (Siegel and Loeb 1995; Loeb *et al.* 1997; Naganobu *et al.* 1999 and Atkinson *et al.* 2004). These papers indicated decline of krill stock in accordance with environmental/ecological changes (climate, oceanography, phytoplankton and competitive species) in mainly the Antarctic Peninsula area, where relatively a lot of data are available. Krill is a key feed for the Antarctic marine food chain. Populations of its predators, such as Adelie penguin and Emperor penguin, remarkably declined, except for the Ross Sea in high latitudes (Croxall *et al.*, 2002). It is presumed that the change of the predator population might reflect responses to regional climate change by the global warming.

<Ecological Changes for Southern Bluefin Tuna?> Although geographical distribution and fishing grounds of southern bluefin tuna (*Thunnus maccoyii*) are located between approximately 10S and 50S, which includes the Antarctic Front at approximately 50S most northerly. The area must be influenced by the environmental changes in the Southern Ocean. The same kind of interactions between environmental and ecological changes in the Southern Ocean may be found for the ecology of southern bluefin tuna. French group found relationships between nine species of seabirds and seal populations and regional climate changes by global warming in the southern Indian Ocean, which is near and/or overlapped the habitat of southern bluefin tuna (Weimerskirch *et al.*, 2003). Long-term monitoring analyses for variability of southern bluefin tuna stock such as weight-at-length (Ito, 2001), integrated water temperature of the foraging depth, and spawning areas should be noted in conjunction with regional environmental changes influenced by global warming as an alternative approach.

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