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S4-A Keynote

Resilience of Coral Communities in Okinawa

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Coral reefs are declining worldwide by global climate change and local degradation of coral reef environment. In 1998, severe coral bleaching occurred worldwide in over 50 countries coincided with some of the warmest sea surface temperature on record. At Sesoko Island, Okinawa, southern Japan, extensive coral bleaching and subsequent coral mortality occurred in the summer of 1998 due to high seawater temperature (≤2.6°C than in ordinary years). As a result, coral species richness was reduced by 61% and coral cover by 85%. Most of finely branched corals such as *Acropora* and pocilloporid died through the bleaching event, while massive corals survived. Similar decline of coral communities occurred on reefs around Okinawa Island. By contrast, coral survival was high in Kerama Islands, which are located at 30 km west of Okinawa I. For recovery of coral communities after severe disturbance such as the 1998 bleaching event, coral larvae should come from healthy coral reefs where adult corals exist. In other words, sufficient supply of coral larvae is the base for resilience of coral communities-that is, their ability to absorb shocks, resist phase shifts, and regenerate after natural and human-induced disturbances. The studies of sea surface current and population genetics suggested that coral populations at Kerama Is. are coral larvae source of the Okinawa populations (the population genetics data are presented in this symposium by A. Nishikawa).

To examine whether coral larvae, especially those of *Acropora* (mostly spawners), actually come from Kerama Is. to Okinawa I., we (K. Sakai and collaborators) studied coral recruitment and coral community structure along west coast of Okinawa I. and around Kerama Is. by setting coral-larva settlement panels and surveying randomly placed quadrats since 2002. We made hierarchical sampling by setting 8 areas and 3 to 7 stations in an area in Okinawa I. and Kerama Is. Until 2005, percent cover of hard corals was less than 5% at almost all the stations in Okinawa I., and there were few mature *Acropora* colonies there. However, there was some acroporid recruitment on the panels. The density of acroporid spats was tended to be higher at the areas of Okinawa I. which were closer to Kerama Is., where coral communities had high percent cover and high species diversity. This supports the hypothesis that the source populations of *Acropora* larvae to Okinawa I. were at Kerama Is. Density of acroporid spats in Kerama Is. was similar to that in Okinawa I. However, density of pocilloporid spats (mostly brooders) was much higher in Kerama Is. than in

Okinawa I., suggesting that pocilloporid larvae disperse only short distance from the parent colonies.

High density of small (< 2 cm in diameter) *Acropora* colonies (> 40 m^{-2}) found on natural reefs at west coast of Okinawa I. during the community survey in 2002 showed great recruitment of *Acropora* in 2001. The density of the *Acropora* colonies decreased significantly from 2002 to 2003. The density further decreased to < 1 m^{-2} by 2004. Small individuals of *Acanthaster planci* were preying on the *Acropora* colonies there. These results show that coral communities degraded by coral bleaching may recover if source populations of larvae are present nearby, but the environment of the degraded reefs should be favorable to recruited corals for the resilience.

Outbreaks of *A. planci* initiated from 2001 in Kerama Is. Local divers set 5 "coral protection areas from *A. planci*", and have been removing *A. planci* from the areas. The divers successfully protect corals form the *A. planci* within the area, but corals much decreased outside of the protection areas due to predation by *A. planci*. As corals in Kerama Is. decreased, the density of acroporid spats on the panels decreased in Okinawa I.: The density of acroporid spats in 2003, 2004 and 2005 was about 20 times smaller than that in 2002. The observed great reduction in supply of coral larvae in Okinawa I. may indicate that whole coral communities within the area of larval dispersal (coral communities with in "connected reefs") lose the resilience potential rapidly when global climate change and local degradation of coral reef environment progress simultaneity.