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11D The boom and bust of urchins and starfish

The decline of the sea urchin *Diadema setosum* affected by multiple disturbances in the inner Gulf of Thailand

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Abstract. A long-term coral reef monitoring program at Khang Khao Island, Chonburi Province in the inner Gulf of Thailand, has been carried out since 2007. The survey in March 2009 showed that the average of population density of the sea urchin *Diadema setosum* was 14.0±1.1 individuals.m^{-2}. The elevated seawater temperatures in 2010 caused the mass coral bleaching in the Gulf of Thailand but the population density of *D. setosum* (surveyed in July 2010) was still maintained at 16.0±1.0 individuals.m^{-2}. Densities of *D. setosum* in September 2010 and August 2011 were significantly decreased, 9.5±0.8 individuals.m^{-2} for the former and 5.2±1.4 individuals.m^{-2} for the latter. The survey in August 2011, the exceptional rainfall year, showed that salinity of the upper water layer dropped to 10.1 psu while salinity of the lower water layer was 23.1 psu. The low salinity also caused mass coral bleaching around Khang Khao Island, especially the corals *Pocillopora damicornis* and *Acropora* spp., as well as impacts on bivalves, such as *Spondylus* cf. *versicolor* and sea cucumbers. This study suggests that the long-term population maintenance of *D. setosum* and other reef associated fauna depends on frequency and severity of multiple disturbances. The impacts of low salinity on coral communities in the Gulf of Thailand should be studied in details for improving our understanding on coral reef ecosystem.

Key words: bleaching, salinity, sea urchin, coral reef, Gulf of Thailand.

Introduction

Coral communities have long been exploited through fishing activities or extensive or semi-intensive mariculture and are thus of great economic value. From an ecological point of view, coral communities in estuaries and coastal wetlands can be defined as critical transition zones, given their position between terrestrial, freshwater and marine interfaces (Levin et al. 2001; Fernandez et al. 2006). These zones can provide important ecosystem services such as shoreline protection, habitat and food for migratory and resident animals and recreational areas for coastal human populations (Burke et al. 2011). Such coral communities are considered to be particularly vulnerable environments to climatic or hydrological fluctuations. This is the consequence of the shallowness of water masses coupled with an interface position between marine and watershed water bodies leading to continuous disturbances such as tidal variations, and chaotic freshwater discharges which may be daily, seasonal or annual, often resulting in environmental crises (Kjerfve, 1994). Therefore benthic macroinvertebrate populations living in those areas are exposed to intensive environmental stresses, potentially leading to mortality. It is predicted that these stresses will become more frequent as a result of ongoing changes, especially climate warming and inappropriate land use.

Grazing animals, especially sea urchin and fish are known to play a major role in the ecology of coral reef habitats (Tsuchiya et al. 1986; Hughes 1994; Lirman 2001; Williams and Polunin 2001; Coppard and Campbell 2007) by altering the distribution, relative abundance and species composition of marine algae. Consequently sea urchin grazing is recognized as an important factor in restoring and maintaining re-colonization of corals because it can protect corals from competition with other benthic organisms (Glynn et al. 1979; Dumas et al. 2007). *Diadema setosum* is the most dominant marine benthic invertebrate on coral communities in the Gulf of Thailand (Sakai et al. 1986; Tsuchiya et al. 1986; Yeemin et al. 2009). A long-term coral reef monitoring program at Khang Khao Island, Chonburi Province in the inner Gulf of Thailand has been carried out since 2007 so it provides an opportunity to investigate population dynamics of *D. setosum* on the coral communities. In this paper we addressed mass mortality of the sea urchin in the inner Gulf of Thailand following an anomalous low salinity event in 2011.

Material and Methods

The study site was established at Khang Khao Island, (latitude 13◦06'24"N to 13◦07'0"N and longitude 100◦8'45"E to 100◦49'0"E) in the inner Gulf of Thailand (Fig. 1). The island is approximately 60 km from the Chao Phraya river-mount, so it is affected by freshwater run-off during the rainy season in May-October. Coral communities around Khang Khao Island develop in shallow water areas, about 4-6 m in depth. The dominant corals are *Porites* spp., *Platygyra* spp. and *Favia* spp. We surveyed macrobenthic invertebrates along the three belt-transects, 30 m long and 1 m wide in March 2009, July 2010, September 2010 and August 2011. The severe coral bleaching phenomenon occurred in 2010 because of anomaly high sea surface temperature (Yeemin et al. 2010). An exceptional rainfall event and subsequent heavy flooding occurred in July - December 2011. The annual rainfall was about 24 % above normal (1,947.9 mm versus 375.4 mm) (Thai Meteorological Department, 2012) . The environmental factors were measured at the study sites during the study periods. Macrobenthic invertebrates within the belt-transects were identified and counted for calculating population density. In this paper, we reported only the data on population density of *D. setosum*. We tested the data for normality and homogeneity of variances and compared the influence of time by one-way ANOVA. Turkey HSD was used to test significant differences between groups.

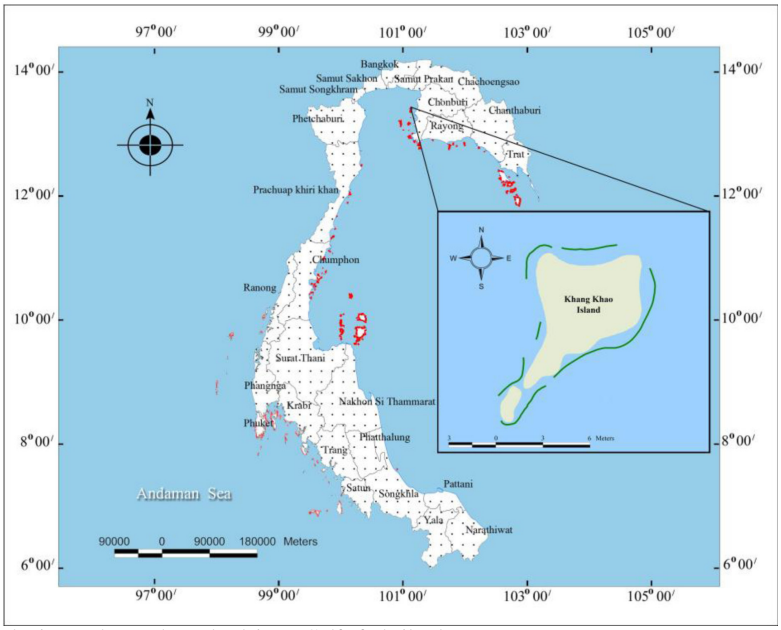

Figure 1: Map of the study site at Khang Khao Island, inner Gulf of Thailand.

Results

The survey in August 2011 showed that salinity of the upper water layer dropped to 10.1 psu while salinity of the lower water layer was 23.1 psu The normal salinity at the study site was about 31-32 psu (Fig. 2).

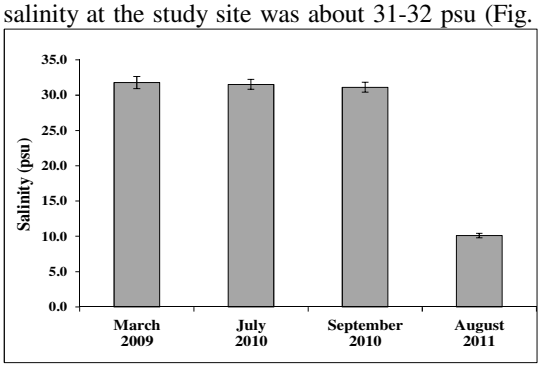

Figure 2: Salinity at Khang Khao Island during the study periods.

The survey in March 2009 showed that the average of population density of the sea urchin *D. setosum* was 14.0±1.1 individuals.m^{-2}. The elevated seawater temperatures in 2010 caused the mass coral bleaching in the Gulf of Thailand but the population density of *D. setosum*, re-surveyed in July 2010, was still maintained at 16.0±1.0 individuals.m^{-2}. However its densities were statistically different between study periods (Table 1). The population densities in September 2010 and August 2011 were dramatically decreased, 9.5±0.8 individuals.m^{-2} for the former and 5.2±1.4 individuals.m^{-2} for the latter (Fig. 3). The low salinity event also caused high mortality of corals, especially *Acropora* spp. and *Pocillopora damicornis* which died over 60%. The low salinity slightly affected a thorny oyster *Spondylus* cf. *versicolor* and a sea cucumber *Holothuria leucospilota*, with mortality rates less than 5% (Fig. 4).

Source of variation	df	Mean square	*F*	*p*
One-way ANOVA test				
Times	3	69.575	15.082	0.001*
Within times	8	4.613		
Total	11			

*Significant difference (P<0.05), df: Degree of freedom

Table 1: Population densities of the sea urchin *Diadema setosum* were surveyed in March 2009, July 2010, September 2010 and August 2011. Results of one-way ANOVA examining the influence of time on density of the sea urchin.

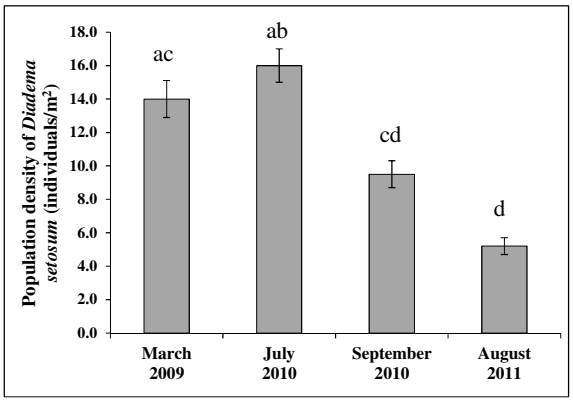

Figure 3: Population densities (Mean ± SD) of *Diadema setosum* at Khang Khao Island. Different letters are significantly different (Tukey HSD *test*, p<0.05).

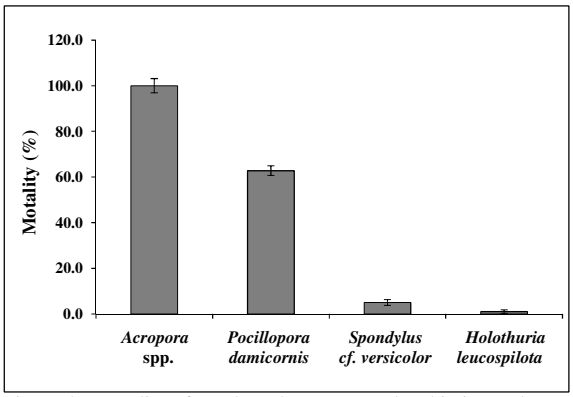

Figure 4: Mortality of corals and some macrobenthic invertebrates caused by the low salinity event at Khang Khao Island.

Discussion

The results show that the 2010 coral bleaching and the 2011 heavy flooding events induced the decline in the sea urchin population. We did not find dead bodies of *D. setosum* in 2010 but mass mortality of sea urchins was obviously observed in 2011. The decline of *D. setosum* population in 2010 may be due to their migration to the deeper sandy bottom. However we observed high density of juvenile sea urchins at our study sites during the re-survey in early 2012. It is probably due to a high recruitment episode of this sea urchin. Sea urchins usually have mechanisms to maintain the population in highly environmental variable habitat, especially their high population dynamics, high recruitment rate and migration. A previous study emphasizes the importance of substrate characteristics in shaping the density distribution with related to species characteristics and environmental gradients (Dumas et al. 2007). It should be noted that there is a high potential of sediment and nutrient loads to the marine ecosystems during floods and their subsequent impacts (Wallace et al. 2011).

In complex systems like coral communities, small scale heterogeneity may be responsible for most of the observed variability. Therefore adequate study scales are needed to ensure correct interpretation of what is observed at larger areas. Moreover, temporal variability should be carefully considered because variations of sea urchin densities may have occurred during the study period. Populations of *D. setosum* on coral communities in the inner Gulf of Thailand can achieve high population density so they can play a major role in coral ecosystems through ecosystem processes, especially bio-erosion and grazing pressure. Understanding the key mechanisms that regulate *D. setosum* populations is a challenging aspect for coral reef management, in particular in the face of increasing climate changes.

In conclusion, we suggest that the long-term population maintenance of *D. setosum* and other reef associated fauna depends on frequency and severity of multiple disturbances. The impacts of low salinity on coral communities in the Gulf of Thailand should be studied in details for improving our understanding on coral reef ecosystem.

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