Disturbed coral reefs and the effects upon the structure of fish communities at Ishigaki Island, Japan

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SUMMARY: We have monitored the fish fauna and coral cover at permanent transects on a reef flat, an offshore moat near a reef flat, and a moat near shore at Urasoko Bay, Ishigaki Isl., Japan. In August 1998, we observed severe coral bleaching on the reef. We compared the fish fauna before and two years after this coral bleaching episode to examine the effects of the coral bleaching on fish community structure, and particularly upon fishes of the family Pomacentridae. The benthic substrata on the reef flat and offshore moat consisted mostly of living Acropora spp. before the summer of 1998, however, most of the living coral had died after the coral bleaching. In contrast, the benthic substrata at the near shore moat consisted mostly of dead coral rubble and sand, with several microatolls of massive Porites sp corals. This living coral was not affected by the bleaching episode. On the reef flat, herbivore pomacentrids, Stegastes fasciolatus and Pomacentrus bankanensis, were abundant until two years after the coral bleaching. In the offshore moat, however, the planktivorous pomacentrid Pomacentrus moluccensis, whose abundance decreased on the reef flat after the coral bleaching, was abundant after the coral bleaching. This change was probably dependent upon the remaining of structural complexity of the remaining coral branches in the offshore moat during the two years after the coral bleaching. In the near shore moat, omnivorous Pomacentrus sp. (Japanese name: Minami-isosuzumedai) was abundant in the surveys before and after the coral bleaching.

KEY WORDS: ichthyofauna, Pomacentridae, coral reef, coral bleaching effect

INTRODUCTION

Since 1995, we have monitored the fish fauna on permanent transects at Urasoko Bay, north of Ishigaki Island, Okinawa, Japan. In August 1998, we observed severe coral bleaching on the reef around Ishigaki Island, and analyzed the short-term changes in the structure of a fish community on the reef flat area, following that coral bleaching.1

The objective of this study was to examine the effects of a severe coral bleaching episode on the benthic substrata and residents fish communities, particularly pomacentrids, which are considered to be important keystone species of the coral reefs,2 at

Fig. 1. Maps of study area.
permanent transects at Urasoko Bay, before and two years after the coral bleaching of the summer of 1998.

MATERIALS AND METHODS

Station 1 of the study site is located on an outer reef flat, approximately 700 m from the shoreline. Water depth ranged from approximately 1 m at low tide to 2 m at high tide. The other transect, station 3, and station 10, were located offshore and near shore in the moat, approximately 200 m and 100 m from the shoreline respectively. Depths were similar to those at station 1 (Fig. 1). Fishes were censused by direct observations made between October 1997 to October 2000 at Station 1 and Station 10, and from March 1999 to November 2000 at Station 3. Every fish 2 m either side of the transect line (100 m Station 1 and 10, 50 m Station 3) was identified to species and recorded. Census time for one transect was approximately 90-180 minutes. All surveys were made at high tide, between 1000 and 1400 h. Each transect was censused four times during each study period.

Coral cover was quantified with the Line Intercept Transect technique at three transects from 1997 to 2000 (see Shibuno et al.3). Corals were identified to genus, and coral skeletons covered by algae were defined as dead coral. The structural complexities of corals at station 3 were compared between the surveys of July 2000 and a control site by calculation of an unevenness index. This index was defined from the mean of standard deviations of vertical distances between the substrate and the standard level surface every 10 cm within a quadrat (50 cm × 60 cm) that was set every 5 m on the transect line. The unevenness indices for the control site were obtained from an undisturbed area in the offshore moat of Itona, located approximately 3 km north east of Urasoko Bay, in August 2001.

RESULTS

Coral communities

After the coral bleaching, the percentage cover of corals was reduced from 37.7% in July to 2.5% in October 1998 at station 1, and from 53.1% in July 1998 to 1.2% in March 1999 at station 3 (Table 1). The percentage cover of Acropora had decreased from 35.2% in July to 0% in March 1999 at station 1, and from 52.4% in August 1998 to 0.1% in March 1999 at station 3, and all colonies of branching Acropora at the both transect lines were dead in March 1999. The percentage cover of Acropora at station 1 recovered to 3.3% in December 2000. In October 1998, one month after the extensive mortality of corals, a large proportion of dead corals was covered with filamentous algae. By the following spring, the filamentous algae had changed to turfing algae or coralline algae. In comparison, the benthic substrata at station 10, consisted mostly of dead coral rubble and sand, with several microatolls of massive Porites. Most of these living corals were not

Table 1 Percentage cover of corals on stations 1, 3 and 10

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Fig. 2 Structural complexity of corals as measured by unevenness index of substrate at station 3 in July 2000. Open bars: control bleached. The percentage cover at station 10 did not differ before and after the coral bleaching.

At station 3, unevenness indices for July 2000 were significantly less than those of the control (p<0.05 U-test, two-sided), however, the structural complexity of dead branching coral skeletons remained for two years after the coral bleaching (Fig. 2).

Fish communities

In terms of numbers of individuals of pomacentrids per transect, station 3 in the offshore moat had more than five times as many as both Station 1 on the reef flat or station 10 in the near shore moat.

At station 1, Stegastes fasciolatus, Pomacentrus moluccensis, Plectroglyphidodon dickii, and

--- Chrysiptera rex
--- Pomacentrus philippinus
--- Pomacentrus bankanensis
--- Pomacentrus moluccensis
--- Pomachromis richardsoni
--- Plectroglyphidodon dickii
--- Stegastes fasciolatus
--- Pomacentrus chrysurus
--- Pomacentrus sp.
--- Pomacentrus moluccensis
--- Pomacentrus sp.
--- Plectroglyphidodon lacrymatus
--- Chrysiptera cyanea
--- Pomacentrus amboinensis
--- Chrysiptera plagiometopon
--- Chrysiptera cyanea
--- Neoglyphidodon melas
--- Pomacentrus sp.
--- Pomacentrus moluccensis
--- Pomacentrus amboinensis

Fig. 3 The number of individuals of dominant pomacentrid fishes at Stations 1, 3 and 10.
Pomacentrus bankanensis were abundant in the surveys in October 1997 and April 1998 before the coral bleaching. The number of S. fasciolatus and P. bankanensis, however, increased 2-3 times in the surveys after the coral bleaching. Pomacentrus moluccensis and P. dickii decreased in the surveys after the coral bleaching. At station 3, P. moluccensis was abundant in surveys after April 1999. At station 10, Pomacentrus sp. (Japanese name: Minami-isosuzumedaip was abundant in surveys before and after the coral bleaching. The number of individuals of Pomacentrus sp. increased in the surveys in November 1999 and October 2000.

DISCUSSION

The benthic substrata on the reef flat and offshore moat consisted mostly of living Acropora spp before the summer of 1998, however, most of the living coral had died after the coral bleaching. In contrast, the benthic substrata at the near shore moat consisted mostly of dead coral rubble and sand, with several microatolls of massive Porites. This living coral was not affected by the bleaching episode. Fujioka reported that coral mortality caused by bleaching was not uniform across Urasoko Bay, as the degree of coral damage by bleaching differed among coral species. In the offshore moat, where branching Acropora was dominant before the coral bleaching, the structural complexity of dead coral branches was maintained for two years after the coral bleaching, even though the dead coral skeletons were covered with coralline algae.

The pomacentrid fish fauna and their population changes differed among habitats. At the reef flat, herbivorous Stegastes fasciolatus and Pomacentrus bankanensis, both of which increased in number just after the coral bleaching, were abundant until two years after the coral bleaching. This outcome resulted probably from an increase in algal biomass on the outer reef caused following the coral bleaching. Two acanthurids, Ctenochaetus striatus and Acanthurus nigrofuscus, also increased in numbers just after coral bleaching on the reef flat. Most of living corals had died in the summer of 1998 both on the reef flat and in the offshore moat. On the reef flat, the planktivore Pomacentrus moluccensis decreased in number directly after the coral bleaching. However, this pomacentrid was abundant in the offshore moat after the coral bleaching. This pomacentrid fish utilizes corals as nests or shelters and probably to advantage of the remaining structural complexity of coral skeletons of branching Acropora in the offshore moat.

ACKNOWLEDGMENTS

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REFERENCES