Coral bleaching, geological ranges, and adaptation to high sea surface temperatures

K. Sugihara¹, Y. Iryu² and T. Nakamori²

¹Department of Earth System Science, Faculty of Science, Fukuoka University, Fukuoka, 814-0180, Japan

²Institute of geology and paleontology, Graduate School of Science, Tohoku University, Sendai, 980-8578, Japan

Abstract: Coral bleaching was described in Kikai-jima (Kikai Island) in October, 1998. Mortality of coral species belonging to the families Acroporidae and Pocilloporidae was the highest of all scleractinian corals in this island. In contrast, some species of the genera *Psammocora* and *Pavona* were never or seldom damaged. These results were similar to those observed in the other Indo-Pacific regions. Significant differences in mortality among families could be attributed to their geological ranges. The species that were free from appreciable damages by bleaching belong to the families which first appeared in the geological periods when the climate was globally warm (greenhouse periods).

Key words: coral bleaching, Kikai-jima, tolerance, high seawater temperature, first appearance

INTRODUCTION

Mass bleaching and high mortality of corals have been reported from major Indo-Pacific reef provinces since the 1997-1998 ENSO (El Niño-Southern Oscillation) event (Huerkamp *et al.* 1998; Jaubert *et al.* 1998; Obura and White 1998; Teleki *et al.* 1998; Berkelmans and Oliver 1999). In Japan, the coral bleaching corresponding to this ENSO event was first noticed in the shallow lagoon of Ishigaki-jima, Ryukyu Islands (Ryukyus) at the end of July, 1998 (unpublished data). The bleaching extended to the reef slope of this island in August. It was also reported from the other islands, such as Okinawa-jima (Nakano, personal communication) and Kudaka-jima (Nishihira, personal communication) at the beginning to in the middle of August, and Kikai-jima (this study) at the end of August to the beginning of September. This trend clearly shows that the bleaching events gradually spread northward within the Ryukyus.

Scleractinian corals have a symbiotic relationship with zooxanthellae and coral bleaching is recognized as a loss of zooxanthellae and/or their pigments (Glynn 1993; Brown 1997). Gleason (1993) indicated that bleaching events can cause selective mortality and stress on susceptible species. There are many reports which noted differences in the tolerance to bleaching among different coral genera and species (Fisk and Done 1985; Brown and Suharsono 1990; Jokiel and Coles 1990; Gleason 1993; Obura and White 1998; Huerkamp *et al.* 1998). These differences also arise among neighboring colonies of the same species and even within a single colony (Gleason 1993). Rowan and Knowlton (1995) showed that some coral species can act as hosts of several zooxanthella species, although before this study it was widely accepted that corals harbor only one symbiont. They noted that these zooxanthella species exhibit intra-colony zonation with depth. Based on the relationships between zooxanthella diversity and

coral bleaching patterns within hosts, Rowan et al (1997) noted that some coral species were protected from bleaching by hosting an additional symbiont that was more tolerant of high irradiance and temperature.

In this study, we focused on susceptibility and mortality in coral species to the bleaching. We investigated differences in the degrees of bleaching among different coral species in Kikai-jima in October, 1998. We discuss the geological ranges and first appearance of coral families and genera within the geological record, and examine these facts in the light of the 1998 bleaching event. We test the hypothesis that taxa with the longest geological record (i.e., ranges) are more tolerant to coral bleaching than those with shorter ranges. The former may have experienced and survived repeated global warming and thus are more adapted to high water temperatures, and hence coral bleaching, than the latter with shortest geo-

logical ranges.

METHOD

The Ryukyus are situated to the southwest of mainland Japan, where the climate is subtropical. Our study site, Kikai-jima, is located in the northern part of the Ryukyus (Fig. 1-4). The annual mean atmospheric and surface water temperature around this island are 21.5 °C and 24.4°C, respectively (Iryu et al. 1995). This island is rimmed by raised Holocene coral reefs (Hanzawa 1935; Konishi et al. 1974; Nakata et al. 1978; Ota et al. 1978; Sasaki et al. 1998; Webster et al. 1998) and the present-day reefs.

Veron (1992) discriminated three major faunal groups of hermatypic corals within the Ryukyus; they are, from south to north, Yaeyama, Okinawa, and Amami Groups (Fig. 1-A). He pointed out that species diversity of

Fig. 1 Map showing the location of the study site within Kikai-jima, Ryukyu Islands

corals decreases with increasing latitude. Kikai-jima belongs to the Amami group, where 220 hermatypic coral species were reported.

Three sites (Shidooke, Kadon, and Kamikatetsu) were investigated on the modern reefs of Kikai-jima in order to describe the coral bleaching event in October, 1998 (Fig. 1-B). We recorded hermatypic coral species and their conditions

within the study sites from the tide pools on the shore, to the shallow part of reef slope (0-5 m deep) by snorkeling. The investigated areas on the shallow reef slope at each site were set up with a 50 m rope. A tide pool whose area is approximately $5 \times 10 \text{ m}^2$ was investigated at Shidooke site. Two smaller pools (about $2.5 \times 5 \text{ m}^2$) and one bigger pool ($10 \times 25 \text{ m}^2$), which

might be formed by fusion of three small ones, were observed at Kadon and Kamikatetsu site, respectively. We counted numbers of coral colonies belonging to 31 species under 14 genera, and recorded their tolerance of bleaching. A total of 624 colonies greater than 10 cm in diameter were selected to compare the differences in the susceptibility among adult colonies. The corals were grouped into four categories based on their tolerance of bleaching: 1) All or most of colonies were dead from bleaching and covered with filamentous algae; 2) Whole colonies were bleached but soft tissues were still alive; 3) Colonies were more or less bleached and the degree of bleaching was different among neighboring colonies, and

within a single colony of the same colonies; and 4) Few or none of the colonies were damaged by the bleaching.

RESULTS

A total of 107 species under 34 genera were recorded at the three sites (Appendix). Neither species composition nor their habitats were different among the three sites. In the tide pools, *Montipora digitata* and *Pavona decussata* were the most dominant corals, associated with *Pocillopora damicornis*, *Montipora hispida*, *Montipora aequituberculata*, *Acropora microphthalma*, *Porites* spp., *Goniopora* spp., and *Psammocora contigua*. *Pocillopora verrucosa*,

Table 1 Differences in the tolerance to bleaching among major coral species in Kikai-jima, Ryukyu Islands. Four types of bleaching were recognized: 1) All or most of the colonies were completely dead and covered with filamentous algae; 2) Whole colonies were bleached but soft parts were still alive; 3) Colonies were more or less bleached and the degree of bleaching was different from colony to colony and within a single colony; and 4) Few or none of the colonies were damaged. Abbreviations, TP and SRS, indicate the tide pool and shallow reef slope, respectively

Family	Genus	Species	Number of colonies	Type of bleaching	Habitat
Pocilloporidae	<i>Pocillopora</i>	<i>P. damicornis</i>	12	1	TP
		<i>P. verrucosa</i>	78	1	SRS
		<i>P. eydouxi</i>	10	1	SRS
Acroporidae	<i>Montipora</i>	<i>M. digitata</i>	68	3	TP
		<i>M. hispida</i>	10	2	TP
		<i>M. aequituberculata</i>	34	2	TP
	<i>Acropora</i>	<i>A. palifera</i>	44	2	SRS
		<i>A. monticulosa</i>	28	1	SRS
		<i>A. gemmifera</i>	16	2	SRS
		<i>A. digitifera</i>	22	2	SRS
		<i>A. microphthalma</i>	12	1	TP
		<i>A. pulchra</i>	24	2	TP
		<i>A. tenuis</i>	8	1	TP
		<i>A. hyacinthus</i>	26	3	SRS
	<i>Porites</i>	<i>P. lobata</i>	6	3	TP and SRS
		<i>P. australiensis</i>	14	3	TP
		<i>P. lutea</i>	4	3	TP and SRS
		<i>P. cylindrica</i>	12	3	TP
Siderastreidae	<i>Goniopora</i>	<i>G. tenuidens</i>	24	2	TP and SRS
		<i>P. contigua</i>	12	4	TP
	<i>Psammocora</i>	<i>P. digitata</i>	4	4	TP
Agariciidae	<i>Pavona</i>	<i>P. decussata</i>	42	4	TP
		<i>P. minuta</i>	10	4	SRS
		<i>P. venosa</i>	14	4	TP
Faviidae	<i>Favia</i>	<i>F. speciosa</i>	16	3	TP and SRS
	<i>Favites</i>	<i>F. abdita</i>	18	3	TP and SRS
	<i>Goniastrea</i>	<i>G. retiformis</i>	22	2	SRS
	<i>Platygyra</i>	<i>P. daedalea</i>	9	3	SRS
	<i>Montastrea</i>	<i>M. curta</i>	14	3	SRS
	<i>Cyphastrea</i>	<i>C. serailia</i>	5	4	TP
	<i>Echinopora</i>	<i>E. gemmacea</i>	6	4	TP

tabular to encrusting forms of *Acropora* (*A. palifera*, *A. monticulosa*, *A. gemmifera*, and *A. hyacinthus*), and massive to encrusting faviid corals (*Favites abdita* and *Goniastrea retiformis*) dominated the shallow part of the reef slope.

Table 1 shows the differences in susceptibility to bleaching among major coral species. There appeared to be no differences in damage caused by bleaching between in the tide pools and on the shallow reef slope. *Pocillopora damicornis*, *Pocillopora verrucosa*, *Acropora monticulosa*, *Acropora microphthalma*, and *Acropora tenuis* were included in Type 1.

Montipora aequituberculata, *Acropora palifera*, *Acropora pulchra*, *Goniopora tenuidens*, and *Goniastrea retiformis* were characterized as Type 2. Type 3 encompasses *Montipora digitata*, *Acropora hyacinthus*, massive form of *Porites* spp., *Porites cylindrica*, *Favia speciosa* and *Favites abdita*. *Psammocora contigua*, *Pavona decussata*, *Pavona minuta*, *Cyphastrea serailia* and *Echinopora gemmacea* were not, or seldom, bleached, and thus were included in Type 4.

DISCUSSION AND CONCLUSIONS

Mortality of pocilloporid and acroporid corals was the higher than other coral species observed at Kikai-jima. Especially, *Pocillopora damicornis*, *P. verrucosa*, and *P. eydouxi* were dead at a higher rate. Such a high mortality for *Pocillopora* species has been previously reported during bleaching events in other Indo-Pacific regions (Fisk and Done 1985; Jokiel and Coles 1990; Brown and Suharsono 1990; Gleason 1993; Huerkamp *et al.* 1998).

All *Acropora hyacinthus* colonies were susceptible to partial bleaching; dead or highly damaged colonies were not found. This is in marked contrast to other *Acropora* species, all of which were completely bleached. It was reported that *A. hyacinthus* mortality was rather higher than that of other species in the Thousand Islands, Indonesia (Brown and Suharsono 1990) and Moorea, French Polynesia (Gleason 1993). Further investigations are needed to clarify how much *A. hyacinthus* is damaged by bleaching on the different depths and habitats. The degrees of *Montipora digitata* and *Porites* spp. bleaching varied considerably from colony to colony. This result is in concordance with those reported by Brown and Suharsono (1990) and Gleason

(1993).

Few of the *Pavona minuta* colonies and none of the *Pavona decussata* and *Psammocora contigua* colonies were damaged at Kikai-jima. Bleaching damage of *Pavona venosa* and *Psammocora digitata* was also relatively lower than that of other species. These results may be comparable with low mortality of *Psammocora stellata* (Glynn 1990) and *Pavona gigantea* and *Pavona clavus* (Huerkamp *et al.* 1998).

Glynn (1993) suggested that scleractinian evolution is concerned with the ability of corals to adapt to various environmental stresses caused by global climatic changes. Bleaching events and an increase in their frequency may be considered as possible indicators of global climatic changes. Coral taxa with longer geological ranges may have experienced and survived such stresses or impacts repeatedly in the past.

From this point of view, we examined the first appearances of coral families in the fossil record. The Pocilloporidae and Acroporidae first appeared in the Late Cretaceous (100 to 67 million years ago). The oldest known occurrences of the Poritidae and the Siderastreidae including *Psammocora* are mid-Cretaceous (120 to 100 million years ago). The Agariciidae encompassing *Pavona* and the Faviidae including *Favia*, *Cyphastrea*, and *Echinopora* have been recovered back to Middle Jurassic (170 million years ago) (Wells 1956). Veron (1995) reviewed the fossil records of scleractinian corals based on current taxonomic concepts and gave a new interpretation on their evolution. He noted that the first occurrences of the Siderastreidae and Agariciidae were Late Cretaceous and that Acroporidae extend back to Middle Jurassic. However, he stated that the fossil evidence for the Jurassic origin of Acroporidae was inconclusive and that the extant genera are Cenozoic (< 67 million years ago) in origin except for *Astreopora*. It is worth while to note that the families which appeared in the Jurassic (Faviidae) and Cretaceous (Poritidae, Siderastreidae, and Agariciidae) include the modern coral species with a relatively greater tolerance of bleaching caused by high seawater temperature. In contrast, the Acroporidae, "Cenozoic family", encompasses the present-day species comparably less tolerant of bleaching. It is widely accepted that the climate was globally warmer in the Jurassic to Cretaceous than that in Cenozoic (Fisher 1982; Crowley and North 1991;

Frakes *et al.* 1992).

Consequently, there exists a possibility that the coral species tolerant of bleaching are included in families whose origins evolved in warmer geological periods.

The odd exception to the rule is the family Pocilloporidae. Although the Pocilloporidae family has its origin in Triassic to lower Jurassic (cool to warm period, Fischer 1982; warm period, Frakes *et al.* 1992), based on the morphological affinities with the Astrocoeniidae (Veron *et al.* 1996), the modern *Pocillopora* species have a low tolerance to bleaching. Here, we should consider that the three major genera within the Pocilloporidae (*Pocillopora*, *Stylophora*, and *Seriatopora*) are distinguished by their long-distance larval dispersion and rafting characteristics (Veron 1995), and thus showing widespread dispersed as dominant genera throughout the Indo-Pacific regions. Such superiority in reproduction might have enabled them to survive the warmer periods by migrating into milder habitats.

At the genus level, there seems to be no relationships between the coral tolerance to bleaching and their geological records. This is clearly shown by the evidence that the genera *Pocillopora*, *Acropora*, *Montipora*, and *Porites* have different types of susceptibility to bleaching (Table 1), although their oldest occurrences are Eocene in age (55 to 37 million years ago). However, the first occurrences of many coral genera are not well-determined at present. If the ages are dated more precisely, the first appearances may be concentrated in periods when the climate was globally warmer such as during the early Eocene or early Miocene.

In conclusion, the species in the families Pocilloporidae and Acroporidae showed the highest mortality in the 1998 bleaching event at Kikai-jima, while poritid, siderastreid, agariciid, and faviid species were less damaged; this is a common phenomenon among bleaching events in the Indo-Pacific regions; the differences in the tolerance to bleaching among coral families may be related to their geological ages, and the environmental conditions in which they first appeared.

REFERENCES

- Berkelmans R, Oliver JK (1999) Large-scale bleaching of corals on the Great Barrier Reef. *Coral Reefs* 18: 55-60
Brown BE, Suharsono (1990) Damage and recovery of

- coral reefs affected by El Niño related seawater warming in the Thousand Islands, Indonesia. *Coral Reefs* 8: 163-170
Brown BE (1997) Coral bleaching: causes and consequences. *Coral Reefs* 16: S129-S138
Crowley TJ, North GR (1991) *Paleoclimatology*. Oxford University Press, New York 339 pp
Fischer AG (1982) Long-term climatic oscillations recorded in stratigraphy. In: Berger W (ed) *Climate in earth history*. National Academy of Sciences, Washington DC pp 97-104
Fisk DA, Done TJ (1985) Taxonomic and bathymetric patterns of bleaching in corals, Myrmdon Reef (Queensland). *Proc 5th Int Coral Reef Congr, Tahiti* 6: 149-154
Frakes LA, Francis JE, Syktus JI (1992) *Climate modes of the Phanerozoic*. Cambridge University Press, Cambridge, 274 pp
Gleason MG (1993) Effects of disturbance on coral communities: bleaching in Moorea, French Polynesia. *Coral Reefs* 12: 193-201
Glynn PW (1990) Coral mortality and disturbances to coral reefs in the tropical eastern Pacific. In: Glynn PW (ed) *Global ecological consequences of the 1982-83 El Niño-southern oscillation*. Elsevier Oceanography Series, Amsterdam pp 55-126
Glynn PW (1993) Coral reef bleaching: ecological perspectives. *Coral Reefs* 12: 1-17
Hanzawa S (1935) Topography and geology of the Ryukyu Islands. *Sci Rep Tohoku Univ, 2nd ser (Geol)* 17: 1-61
Huerkamp C, Glynn PG, Ducroz L, Mate JL (1998) Responses of five Eastern Pacific reef building coral species to experimentally elevated temperature. *Int Soc Reef Stud Euro Mtg, Perpignan, 1-4 September, Progr Abst, p 96*
Iryu Y, Nakamori T, Matsuda S, Abe O (1995) Distribution of marine organisms and its geological significance in the modern reef complex of the Ryukyu Islands. *Sediment Geol*, 99: 243-258
Jaubert J, Rougerie F, Cadot D (1998) Mass bleaching and mortality of corals in French Polynesia during the 1997-1998 ENSO event. *Int Soc Reef Stud Euro Mtg, Perpignan, 1-4 September, Progr Abst, p 97*
Jokiel PL, Coles SL (1990) Response of Hawaiian and other Indo-Pacific reef corals to elevated temperature. *Coral Reefs* 8: 155-162
Konishi K, Omura A, Nakamichi O (1974) Radiometric coral ages and sea level records from the Late quaternary reef complexes of the Ryukyu Islands. *Proc 2nd Int Coral Symp* 2: 595-613
Nakata T, Takahashi T, Koba M (1978), Holocene-emerged coral reefs and sea-level change in the Ryukyu Islands. *Geogr Rev Japan*, 51A: 81-108 (in Japanese with English abstract)
Obura DO, White KV (1998) El-Niño related coral bleaching in Eastern Africa, March to May 1998. *Int Soc Reef Stud Euro Mtg, Perpignan, 1-4 September, Progr Abst, p 137*
Ota Y, Machida H, Hori N, Konishi K and Omura A (1978), Holocene raised coral reefs of Kikai-jima (Ryukyu Islands) - An approach to Holocene sea level study. *Geogr Rev Japan*, 51A: 109-130 (in Japanese with English abstract)

- Rowan R, Knowlton N (1995) Intraspecific diversity and ecological zonation in coral-algal symbiosis. *Proc Natl Acad Sci USA* 92: 2850-2853
- Rowan R, Knowlton N, Baker A, Jara J (1997) Landscape ecology of algal symbionts creates variation in episodes of coral bleaching. *Nature* 388: 265-269
- Sasaki K, Omura A, Ota Y, Murase T, Azuma T, Kobayashi M, Ikura K (1998) Holocene regressive coral reef terraces at the Northern Shidooke Coast of Kikai Island, Central Ryukyus. *The Quat Res* 37: 349-360 (in Japanese with English abstract)
- Teleki KA, Spencer T, Bradshaw C, Spalding MD (1998) Coral bleaching in the Western Indian Ocean - a sign of the times? *Int Soc Reef Stud Euro Mtg, Perpignan, 1-4 September, Progr Abst*, p 176
- Veron JEN (1992) Conservation of biodiversity: a critical time for the hermatypic corals of Japan. *Coral Reefs* 11:13-21
- Veron JEN (1995) Corals in space and time: the biogeography and evolution of the Scleractinia. University of New South Wales Press, Sydney 321 pp
- Veron JEN, Odorico DM, Chen CA, Miller DJ (1996) Reassessing evolutionary relationships of scleractinian corals. *Coral Reefs* 15: 1-9
- Webster JM, Davis PJ, Konishi K (1998) Model of fringing reef development in response to progressive sea level fall over the 7000 years - (Kikai-jima, Ryukyu Islands, Japan). *Coral Reefs* 17: 289-308
- Wells JW (1956) Scleractinia. In: Moore RC (ed) *Treatise on invertebrate paleontology. Coelenterata*. Geological Survey of America and University of Kansas Press, pp 328-440

(Date of acceptance: August 11, 1999)

地質学的観点からみた造礁サンゴ類の白化現象

杉原 薫¹・井龍康文²・中森 亨²

¹福岡大学理学部地球圏科学科地学分野

²東北大学大学院理学研究科地圏進化学講座

琉球列島では1998年に大規模な造礁サンゴ類の白化現象がおこった。われわれは、鹿児島県喜界島において白化に対する造礁性サンゴの耐性について詳細に検討した。その結果、ミドリイシ科のミドリイシ属とハナヤサイサンゴ科のハナヤサイサンゴ属の致死率が最も高かった。一方、ヤスリサンゴ科のアミメサンゴ属およびヒラフキサンゴ科のシコロサンゴ属は、白化の影響をほとんど受けていなかった。これらの結果は、これまでに他のインド・太平洋地域から報告されている結果とよく一致する。このような分類群による白化への耐性の違いは、各分類群の系統と関連していると思われる。すなわち、科レベルでは、出現した地質時代が古いものほど白化に対して強い耐性を有するのに対し、地質学的に新しい時代に出現したものほどダメージが大きいという傾向が読みとれた。また属レベルでは、白化に対して強い耐性を示したもののほとんどが、地球史の中でも温暖な時期（温室期）に出現した可能性が大きい。

Appendix List of hermatypic coral species at the study sites (Shidooke, Kadon and Kamikatetsu), Kikai-jima

<i>Pocillopora damicornis</i>	<i>Acropora austera</i>	<i>Pavona decussata</i>	<i>Caulastrea furcata</i>	<i>Leptoria phrygia</i>
<i>Pocillopora verrucosa</i>	<i>Acropora aspera</i>	<i>Pavona minuta</i>		
<i>Pocillopora meandrina</i>	<i>Acropora pulchra</i>	<i>Pavona varians</i>	<i>Favia pallida</i>	<i>Oulophyllia crispa</i>
<i>Pocillopora eydouxi</i>	<i>Acropora tenuis</i>	<i>Pavona venosa</i>	<i>Favia speciosa</i>	
	<i>Acropora selago</i>		<i>Favia fava</i>	<i>Montastrea curta</i>
<i>Seriatopora hystrix</i>	<i>Acropora hyacinthus</i>	<i>Gardineroseris planulata</i>	<i>Favia rotumana</i>	<i>Montastrea magnistellata</i>
	<i>Acropora nana</i>		<i>Favia maritima</i> ?	<i>Montastrea valenciennesi</i>
<i>Stylophora pistillata</i>	<i>Acropora nasuta</i>	<i>Coeloseris mayeri</i>		
	<i>Acropora florida</i>		<i>Favites chinensis</i>	<i>Leptastrea purpurea</i>
<i>Montipora digitata</i>		<i>Pachyseris rugosa</i>	<i>Favites abdita</i>	<i>Leptastrea transversa</i>
<i>Montipora turgescens</i>	<i>Astreopora myriophthalma</i>	<i>Pachyseris speciosa</i>	<i>Favites halicora</i>	
<i>Montipora hispida</i>	<i>Astreopora gracilis</i>		<i>Favites flexuosa</i>	<i>Cyphastrea serailia</i>
<i>Montipora informis</i>		<i>Fungia</i> sp.	<i>Favites complanata</i> ?	<i>Cyphastrea microphthalma</i>
<i>Montipora aequituberculata</i>	<i>Porites lobata</i>		<i>Favites pentagona</i>	
<i>Montipora</i> sp.	<i>Porites australiensis</i>	<i>Galaxea fascicularis</i>	<i>Favites russelli</i>	<i>Echinopora gemmacea</i>
	<i>Porites lutea</i>			<i>Echinopora pacificus</i>
<i>Acropora palifera</i>	<i>Porites cylindrica</i>	<i>Acanthastrea echinata</i>	<i>Goniastrea retiformis</i>	
<i>Acropora gemmifera</i>	<i>Porites lichen</i>	<i>Acanthastrea hillae</i>	<i>Goniastrea edwardsi</i>	<i>Euphyllia glabrescens</i>
<i>Acropora samoensis</i> ?	<i>Porites horizontalata</i>		<i>Goniastrea</i> —	<i>Euphyllia ancora</i>
<i>Acropora monticulosa</i>	<i>Porites</i> sp.	<i>Lobophyllia hemprichii</i>	<i>Goniastrea favulus</i>	
<i>Acropora digitifera</i>		<i>Lobophyllia corymbosa</i>	<i>Goniastrea pectinata</i>	<i>Turbinaria frondens</i>
<i>Acropora robusta</i>	<i>Goniopora tenuidens</i>		<i>Goniastrea australensis</i>	<i>Turbinaria reniformis</i>
<i>Acropora danai</i>	<i>Goniopora</i> sp.	<i>Symphyllia recta</i>		
<i>Acropora nobilis</i>		<i>Symphyllia radians</i>	<i>Platygyra daedalea</i>	<i>Millepora platyphylla</i>
<i>Acropora grandis</i>	<i>Psammocora contigua</i>		<i>Platygyra sinensis</i>	<i>Millepora exaesa</i>
<i>Acropora formosa</i>	<i>Psammocora digitata</i>	<i>Hydnophora exesa</i>	<i>Platygyra ryukyuensis</i>	<i>Millepora tenella</i>
<i>Acropora acuminata</i>		<i>Hydnophora microconos</i>	<i>Platygyra pini</i>	
<i>Acropora microphthalma</i>	<i>Coscinaraea columna</i>		<i>Platygyra contorta</i>	