

# 6-2-4 Shikoku (Map 6-2-4)

**Province:** Tokushima Pref. at east, Kochi Pref. at south and Ehime Pref. at west of Shikoku **Location:** Shikoku lies at southwest of Osaka and east of Kyushu **Air temperature:** 16.6°C (annual average, at Sukumo City, Kochi Pref.) **Seawater temperature:** 21.7°C and 22.7 °C (annual average, at east off Cape Muroto and west off Sukumo, respectively) **Precipitation:** 1,990.9 mm (annual average, at Sukumo City) **Total area of coral communities:** 159.4 ha **Protected areas:** Muroto-Anan Kaigan Quasi-National Park: coastline from Cape Gamoda (Tokushima) to Cape Muroto (Kochi), including 2 Marine Park Zones; Ashizuri-Uwakai National Park: coastline from Cape Ashizuri (Kochi) to Cape Yura (Ehime), including 6 Marine Park Zones.

6-2-4-①



6-2-4-③

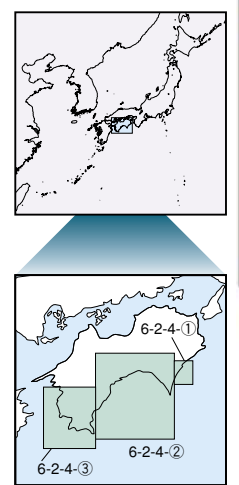
\* "号" on this map means "site".



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\* "号" on this map means "site".



## a. East of Muroto

(Map 6-2-4-①)

Fumihito Iwase

### 1 Corals and coral reefs

#### 1. Geographical features

The east coast of Shikoku, from Cape Gamoda to Cape Muroto, is composed of sedimentary rock with a layer of sand and mudstone. Crustal movements and a repeated cycle of glacial and interglacial sea-level change formed typical coastal terraces. Anan Coast is a bow-shaped, and predominantly rocky coast that stretches from Cape Kamouda to Toyo. There is a well-developed coastal terrace with 4-km-long sea cliff. The coast is characterised by capes and small bays interspersed with small islands. Comparatively, the coastline from Toyo to Cape Muroto is straight and lacks bays, capes, and islands. This raised coastline consists of ledges and large rocks that give way to a steep underwater topography with submarine valleys.

The area was designated the Muroto-Anan Kaigan Quasi-National Park in 1964. Its unique geological and subtropical vegetation is fed by the warm Kuroshio Current, which flows offshore. Benten Island off Anan City boasts a tropical plant community was selected as a national treasure in 1922. There is the beautiful underwater scenery, and coral communities that surround the islands of Oshima off Mugi and Takegashima (Is.) off Shishikui gained these two areas designated as marine park zones in 1971 and 1972, respectively.

#### 2. Coral distribution

Hermatypic corals (hereafter, corals) occur south of Hiwasa (Tokushima Prefecture 1978), and areas with more than 5 % coral cover are found at three locations within a total area of 7.25 ha: Oshima, Takegashima, and Bishago Rock off Muroto (Nature Conservation Bureau, Environment Agency 1994). Within these areas, 52 species from 12 families have been identified, (Tokushima Prefecture 1997, 2002), the most prevalent of which are *Acropora tumida*, *Lithophyllon undulatum*,

*Porites lutea*, *Goniastrea deformis*, *Physophyllia ayleni*, and *Turbinaria peltata* (Tokushima Prefecture 2002). Three-quarters of these species have encrusting morphology, and the remaining quarter has branching morphology, for example, *A. tumida* (Nature Conservation Bureau, Environment Agency 1994).

#### 3. Water quality and physical environment

The Kii channel lies between Shikoku's southeastern shore and the Kii Peninsula. The channel is connected to the Seto Inland Sea through Osaka Bay, but could be regarded as a large bay due to the existence of Awaji Island at the northern end of the channel. The flow of the ocean current entering this large bay has a predominantly counterclockwise drift. The northward flowing Kuroshio Current diverges at the tip of the Kii Peninsula, then heads westward along the bay, and turns southward along the east coast of Shikoku. At times, the Geitou Branch Current, which has a northward drift from the sea off Cape Muroto, is dominant, with occasional, infrequent appearances of coastal waters from the Seto Inland sea. However, geomorphologically the area is open to the Sea, and is characterised by combined effect of ocean and bay. The coral communities that exist near the northern boundaries of the area have bay-like characteristics (Tokushima Prefecture 1986).

#### 4. Notable species and ecosystems

A large scale communities of *Entacmaea actinostoloides* can be seen in Awa Oshima Marine Park (Site 1). In the inner bay on the west coast of Oshima, there is a large colony of *Porites heronensis*, about 7 m in height and 6-8 m width (Photo. 1). There used to be a large community of *A. tumida* in Awa Takegashima Marine Park (Site 1), but after 1981 it declined and was replaced by *Lithophyllon undulatum* (Tokushima Prefecture 1988, 1997, 2002). Large colonies of *Styloconiella guentheri* with approximately 2 m in diameter are dominant somewhere around Takegashima (Nature Conservation Bureau, Environment Agency 1994).

The beaches of the Kamouda Coast near Anan, the Ohama Coast in the vicinity of Hiwasa, and the Osato Coast near Kainan are well known spawning grounds of loggerhead turtle (*Caretta caretta*). Of the three, only the Ohama coast has been designated a National Treasure and a Tokushima Prefectural Nature Treasure (Sea Turtle Association of Japan 2001).





Photo. 1. A large colony of *Porites heronensis* (about 7 m in height and 6-8 m in width) in the inner bay on the west coast of Oshima (Is.).

## 2 Situation of usages

### 1. Tourism

Surfing and scuba diving are the most popular water sports in the area. Diving services are available in Mugi and Shishikui, Bishago Rock also attracts divers, but in lesser numbers. Area attractions include a shellfish museum at Mugi, an underwater interpretive center at Takegashima, and a glass-bottomed boat that makes excursions into the marine park. Surf fishing and boat-based fishing are popular, and charter fishing boats are available.

### 2. Fishery

The numerous ledges and the exposure to the high seas of the Pacific limit fishing mainly to fixed shore net, gill net, long-line, and single-rod fishing; shells and seaweed are collected along the shores. The population of fishermen is aging, and the production of the fishing industry is declining. Aquafarming is rare because there are few calm inner bays to accommodate it. A few aquafarms that

raise yellowtail snapper and red sea bream are located in the towns of Yuki, Kainan, and Shishikui.

## 3. Threats and disturbances

### 1. Water temperature changes

It is by the grace of the Kuroshio current that coral grows this far north. However, die-off occur when, for example, the Kii Channel brings cool inland water, or there is a seasonal winter cold wave. In February 1981, the water temperature declined to below 9°C for about 15 days, owing to the southward flow of inland water. As a result many *A. tumida* and *Pavona decussata* died (Tokushima Prefecture 1986).

### 2. Harbor construction

Construction, dredging, aquafarming, harbor improvements, and the installation of breakwater walls for shore line protection are reported to have changed the habitat around the port of Kan-no-ura. Coral communities in Awa Takegashima Marine Park, which is adjacent to the port, have experienced a decline or suffered transition to more inside-bay environments (Tokushima Prefecture 1997).

### 3. Coral-eating predators

Damage caused by the crown-of-thorns starfish (*Acanthaster planci*) and coral-eating gastropods (e.g., *Drupella fragum*) has not been noted until recently. However, in a survey of corals and other organisms conducted in 2001, predation damage by *Drupella* was reported in both the Awa Takegashima (Site 2) and the Awa Ohshima (Site 2) marine parks (Tokushima Prefecture 2002). A damage assessment plan is necessary to deal with the emergence of these gastropods.

## 4 Monitoring

The responsibility for a survey of marine park zones that was begun by the Tokushima Prefectural government in 1977 was assumed by the Marine Parks Center of Japan, but the surveying methods used have proved to be inconsistent. (Tokushima Prefecture 1977, 1978, 1986, 1988, 1997, 2002).

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## 5 Conservation

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Following the report that coral communities in Awa Takegashima Marine Park are in decline and are beginning to change into bay-like communities, Tokushima Prefecture began a survey in 2003 as part of the Nature Restoration Promotion Plan. The survey will continue until 2004, and the succeeding nature restoration and Maintenance Project will begin in 2005.

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## 6 Necessary measures

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A survey taken in the Awa Takegashima Marine Park as part of the Nature Restoration Promotion Plan produced results that are expected to lead to conservation measures. Of primary concern is the issue of predation damage by *Drupella*, especially in Oshima and Takegashima.

## b. Tosa Bay

(Map 6-2-4-②)

Fumihito Iwase

### 1 Corals and coral reefs

#### 1. Geographical features

The area from Cape Muroto to Cape Ashizuri in Kochi Prefecture is arc-shaped, forming Tosa Bay. In winter, the predominant cold north-northwest winds are blocked by the mountains, and in summer strong south-southeast winds, sometimes generated by typhoons, hit the area directly. Geologically, Tosa Bay is in the same region as the eastern coast of Shikoku. This region of sedimentary rock, consisting of a layer of sandstone and mudstone, is called the 'Shimanto Belt'.

There is an urban area centering on Kochi at the innermost part of Tosa Bay between the Monobe and Niyodo rivers. The human population decreases toward both the eastern and western ends of the bay. The shoreline of this area is mostly sandy beaches. Rocky shores increase in frequency toward the west. The large Shimanto River mouth is situated in this part of the bay.

There are seven natural parks along the coastline of Tosa Bay. From east to west, these are: Muroto-Anan Coast Quasi-National Park, Tei-Sumiyoshi Prefectural Natural Park, Yokonami Prefectural Natural Park, Susaki Bay Prefectural Natural Park, Okitsu Prefectural Natural Park, Irino Prefectural Natural Park, and Ashizuri-Uwakai National Park.

#### 2. Coral distribution

Tosa Bay is in a boundary zone between temperate and subtropical areas, featuring both warm-temperate and subtropical districts and the coral community reflects this. The community is dominated by *Acropora solitaryensis* and *Cyphastrea serailia* (Port and Harbor Section of Kochi Prefecture 1994).

Coral communities dominated by *A. solitaryensis* have been reported from the following locations: Muroto

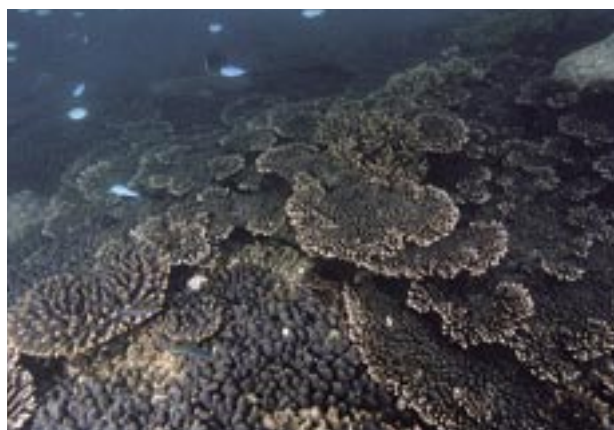


Photo. 1. Corals growing in high density behind the constructed breakwater in Tei, Yasu, Kochi Prefecture. The large colonies are mainly tabulate *Acropora*.

Port (18 species from 9 families), Murotsu Port (18 species from 7 families), Cape Gyoto (21 species from 7 families), Cape Hane (25 species from 8 families) in Muroto, Yanagare in Aki, Tei in Yasu (47 species from 11 families), south shore of Yokonami Peninsula (35 species from 11 families), Kamishima Island in Susaki, and Kamikawaguchi in Ohgata (Nature Conservation Environment Agency 1980; Fujioka 1994, Nature Conservation Bureau Environment Agency 1994, Port and Harbor Section of Kochi Prefecture 1994). Since 2000, newly discovered coral communities have been reported from Karyogo and around the Nahari Port breakwater (69 species from 11 families) in Nahari and from Nomi Bay in Susaki to Yaiga in Nakatosa.

#### 3. Water quality and physical environment

The Kuroshio Current flows from southwest to northeast at the opening of Tosa Bay. However, a counterclockwise drift is common inside the bay owing to a divaricated westward drift from Cape Muroto.

#### 4. Notable species and ecosystems

A breakwater was constructed on the rocky shore of Tei in Yasu, artificially creating a relatively calm area that is suitable for coral growth. As a result, many coral colonies, mainly tabulate *Acropora*, have grown to large sizes and high densities (Marine Parks Center of Japan 1994; Photo. 1). A similar situation occurred around Nahari Port; an offshore breakwater was constructed on the sandy shore, and a new coral community developed as a result of the relatively calm conditions and hard substrate. In these rare and interesting cases, civil engineering works have accidentally created a suitable envi-

ronment for coral communities and have fostered their settlement and growth.

## 2 Situation of usages

### 1. Tourism

Scuba diving is popular in Muroto, Karyogo, and areas from the south shore of Yokonami Peninsula to Yaiga. Dive shops in Kochi often run scuba diving day trips in the area. Around the Nahari Port breakwater, glass-bottomed boats enable tourists to view the coral communities. Local nonprofit organizations irregularly hold nature observation events, which include snorkeling and the use of glass-bottomed boats in Tei and around the Nahari Port breakwater.

### 2. Fishery

The region sustains many fisheries. Single-rod fishing for skipjack, trolling line fishing for skipjack and tuna, and encircling net fishing for dolphin fish occur offshore from Tosa Bay. Closer to the coast, methods include conventional angling, long-line fishing, and batch-net fishing for whitebait, as well as sand-borer fishing using dragnets and gill nets. Along the shallow rocky shore, people collect shells and seaweeds, and use gill nets to take lobster (*Panulirus*). Additionally, fixed shore-net fishing is conducted all over Tosa Bay, especially around Cape Muroto and Cape Ashizuri. Aquafarms are found in Nomi Bay in Susaki and in Uranouchi Bay, at the innermost region of Tosa Bay. The cultivation of sea lettuce (*Monostroma*) and green laver (*Enteromorpha*) occurs around the river mouths. Deep-water netting for jewel corals was common around Cape Muroto and Cape Ashizuri, but this practice has declined in recent years owing to the depletion of resources.

## 3 Threats and disturbance

### 1. Coral predators

Coral predation by the crown-of-thorns starfish (*Acanthaster planci*) has never been recorded in Tosa Bay. Damage caused by corallivorous gastropods (e.g., *Drupella fragum*) has been reported from areas around Muroto, but the impact appeared to be limited (Nomura 1991; Nature Conservation Bureau, Environment Agency 1994). In no case has a detailed study concerning the

effects of coral predators been undertaken.

### 2. Water temperature changes

Average water temperatures in Tosa Bay are increasing as the Kuroshio Current tends to move closer to the coast. This seems to have caused a decline of large-scale seaweeds and an expansion of coral distribution, although detailed surveys of the impact on coral distribution are lacking.

## 4 Monitoring

In 1987, a new large-scale development called the 'Marine Town Project' was planned in Tei; the plans described the construction of a new marina, bathing beach, and enlargement of the fishing port. A survey of marine organisms including corals and oceanographic conditions was initiated as part of the planning process (Port and Harbor Section of Kochi Prefecture 1989a, 1989b, 1990a, 1990b, 1990c, 1991; Kochi Prefecture Hankoku Civil Engineering Office Kochi Prefecture Hankoku Civil. 1992a, 1992b, 1992c, 1993a, 1993b). Local residents protested against the damage that would be caused to coral communities, particularly during the construction of the marina, and an additional survey was conducted to assess whether the development should proceed (Port and Harbor Section of Kochi Prefecture 1990; Marine Parks Center of Japan 1994). As a result, the project was brought to a halt. A nongovernmental nature conservation organization called 'The Association to Preserve Ohte Beach' played a major role in the protest campaign and continues local environmental education and surveillance, although their survey methods are not very systematic. Another preliminary survey was conducted in 1999 to assess the area's usefulness for environmental education (Port and Harbor Section of Kochi Prefecture 1999). In 2001, some coral communities in the area were buried by sand, and Kochi Prefecture Harbor's Section convened a study committee and survey team to investigate the cause and recommend preventative measures. Consequently, more data exist for the sea area of Tei than for any other location in Tosa Bay.

In 2002, it was reported that a new coral community developed on the offshore breakwaters around Nahari Port. In response, the Aki Kochi Civil Construction Office commenced a survey to describe the current status of coral growth. The construction of these offshore breakwaters commenced in 1975, occurred sequentially

along the coast, and is ongoing; therefore, surveys of coral settlement and growth will produce a time series that will be valuable for monitoring purposes.

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## 5 Necessary measures

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Information about the nature, distribution, and status of coral communities in Tosa Bay is still limited, except in specific areas such as Tei. Further survey work is essential to understand and monitor the coral communities of this region.

## c. Ashizuri-Uwakai

(Map 6-2-4-③)

Fumihito Iwase

### 1 Corals and coral reefs

#### 1. Geographical features

The coastline of the Uwa Sea, south of Cape Sata on the west coast of Shikoku, is ria coastline that consists of complex, steep, rocky slopes that extend underwater. However, in areas from Cape Ashizuri to Kashiwajima Island, the coastal terrace is well developed owing to upheaval. Rocky coastlines are also found in the area, but the slope of the sea floor is more gradual than that in the Uwa Sea.

The strong influence of the Kuroshio Current running eastward allows abundant subtropical marine flora and fauna to occur in the area in spite of its high latitude. The distinctive coastline, formed by upheaval and subsidence, and the beautiful scenery, produced by diverse biological communities, led to this area being designated as the Ashizuri Quasi-National Park in 1955. The Uwa Sea (Uwakai) was later added to the designated area, which became the Ashizuri-Uwakai National Park in 1972. Inside the national park, 19 marine park zones have been designated for their underwater scenery, focused on coral communities. In 1965, the Satamisaki Hanto Uwakai Prefectural Natural Park was established. In the same year, the temperate sea biotope of the Uwa Sea, including coral communities, was also designated a natural treasure of Ehime Prefecture for the Uwa Sea special marine resources.

#### 2. Coral distribution

Hermatypic corals (hereafter, corals) are most abundant on the west coast of Shikoku, and 127 species have been recorded around Cape Ashizuri in Tosashimizu (Veron 1992c; Nishihira and Veron 1995). Corals are distributed all around the rocky coasts from Cape Ashizuri to Uwajima. The highest abundance of coral is found in the areas extending from the west coast of Cape Ashizuri to Otsuki, around Okinoshima Island in Kochi, and in the

coastal area of Nishiumi Town in Ehime. In Kochi, many species of *Acropora*, such as *Acropora solitaryensis*, *A. hyacinthus*, and *A. formosa*, are commonly distributed. *Acropora* communities are also found in Ehime, but *A. formosa* is scarce; instead, most areas are dominated by Alcyonacea, an order of octocoral, and *Tubastraea micrantha*, an ahermatypic coral (Nature Conservation Bureau, Environment Agency 1995b). It is suggested that corals are also distributed to the north of Uwajima toward Cape Sata (Nature Conservation Bureau, Environment Agency 1994), but details of these communities have not yet been clarified.

#### 3. Water quality and physical environment

Okinoshima and Cape Ashizuri are promontories at the southwest tip of Shikoku, where the Kuroshio Current runs eastward. Consequently, the coast around Tosashimizu and Otsuki is under the direct influence of this warm current. The Uwa Sea is also strongly influenced by the divaricated Kuroshio Current throughout the year, which causes warm water, high salinity, and high transparency. These characteristics are also associated with the facts that there are no big rivers in the area and that water from the Seto Inland Sea is blocked by the Cape Sata.

#### 4. Notable species and ecosystems

In Minokoshi Bay in Tatsukushi, Tosashimizu, there is a huge colony of *Pavona decussata* that extends to 45 × 26 m and is designated a national natural treasure (Photo. 1). In Ushirohama in Kashiwajima, Otsuki, there is a luxuriant coral community in which 90 % or more of the cover is composed of *A. solitaryensis* (Nature Conservation Bureau, Environment Agency 1995b). From the same area, 884 species in 143 families of fishes have been recorded (Hirata *et al.* 1996), exemplifying the extreme richness of the ecosystem.

The northernmost records of many species of coral have been documented in this area (Nature Conservation Bureau and Marine Parks Center of Japan 1995). In addition, tropical species such as *Leptoseris papyracea* have been newly recorded (Hirata personal communication). It could be possible that the continuing trend of increasing seawater temperatures in this area in recent years has expanded the distribution of coral species that did not occur here previously.



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## 2 Situation of usages

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### 1. Tourism

In Tatsukushi, facilities include an underwater observatory, an aquarium, shellfish exhibition pavilions, and coral museums, which attract large numbers of tourists, and the area was designated a National Park Group Facilities' Zone. However, tourist numbers are in decline, along with a marked recent decline in coral communities. A glass-bottomed boat is also operated around Nishiumi Town Marine Park, but the number of visitors to this area is also decreasing (Sanyo-Shikoku RONC 2003). While such conventional tourism is declining, SCUBA diving is gaining in popularity. Kashiwajima is the most famous diving spot in Shikoku, and the diving population is constantly increasing along with the number of diving services. Recreational fishing on rocky shores and offshore is also common, and many recreational fishing services exist.

### 2. Fishery

The main fisheries in the Ashizuri Sea area are trolling line fishing for skipjacks, angling for mackerel and squid, and fixed shore net fishing. In the Uwa Sea area, white-bait fishing by dragnet and seine net fishing for sardines and mackerel are common. Aquaculture is also popular, taking advantage of the complex coastline; not only fish, but also bivalves, including Akoya pearl oysters (*Pinctada fucata*) and Noble scallops (*Mimachlamys senatoria*) are common. The area's production of pearl oysters is one of the most important in Japan.

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## 3 Threats and disturbances

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### 1. Crown-of-thorns starfish

A crown-of-thorns starfish (*Acanthaster planci*) extermination project has been conducted by the Ministry of the Environment (former Environment Agency) in the marine park zones since 1973. Extermination has also been funded by other agencies and conducted by volunteers; therefore, the Ministry of the Environment statistics do not cover all the eradication data for this area. Nevertheless, according to these statistics, the number of crown-of-thorns exterminated peaked during 1977–1979, and amounted to 10,000–15,000 individuals annually. These numbers later declined, and have plateaued since 1990 at around 100–500 individuals per year, mainly from Okinoshima (Sanyo-Shikoku RONC 2003). *A. planci* were observed at various points during a survey in 2003, but these sightings were not considered an outbreak (Nature Conservation Bureau, Ministry of the Environment 2003d).

### 2. Coral-eating gastropods

When the major damage by *A. planci* ended around 1990, coral predation by coral-eating gastropods, mainly *Drupella fragum*, started to be reported. Extermination programs have been carried out by local authorities, the prefectural government, the Ministry of the Environment, and volunteers (Suga 1994; Tominaga 1998). No comprehensive statistical data exist because these programs have been undertaken by many organizations and people, but the number of exterminated individuals peaked at about 100,000–200,000 per year during

Photo. 1. Large community of *Pavona decussate* at Minokoshi Bay in Tatsukushi, Tosashimizu, Kochi Prefecture.



1995–2000 (Sanyo-Shikoku RONC 2003).

An outbreak of coral-eating gastropods was observed in the Shirigai Marine Park in 1989. To address this problem, the town of Otsuki at once began a feasibility study to research the possibility of eradication and to determine the distribution and life history of corals and gastropods. The results of this study confirmed the necessity of extermination, and extermination methods were examined. In order to conserve high coral coverage in an area dominated by *A. hyacinthus* and *A. formosa*, a 50 × 50-m protected area was established based on a consideration of the resource expenditure that could be allotted to extermination. Although outbreaks of *Drupella* occurred continuously for more than ten years, intensive extermination on this protected area allowed a high average coral cover of 54 % to be maintained (Nomura and Tominaga 2001).

### 3. Sedimentation

During the Kochi southwest torrential rain that affected Tosashimizu, Otsuki, and Sukumo in September 2001, a large amount of soil flowed into the Ashizuri Sea at several different locations. The most heavily damaged area was the Tatsukushi Marine Park, where many corals inside Tatsukushi Bay died as a result of sedimentation (Kuroshio Biological Research Foundation 2002, Nature Conservation Bureau, Ministry of Environment 2003). At the Shirigai Marine Park, a landslide caused an influx of soil, burying corals (Machida 2001).

The Ministry of the Environment removed the accumulated soil in part of the Tatsukushi Marine Park, and the Ministry and the town of Otsuki did the same in the Shirigai Marine Park (Hayashi 2002; Iwase 2002). Some coral communities in areas where the soil was removed were saved, but the extent of the damage remained unclear in many other areas.

## 4 Monitoring

### 1. Reef Check

Reef Check, an international protocol for coral reef monitoring, has been undertaken in Kashiwajima since 2001, mainly by the nonprofit Kuroshio Zikken Center organization.

### 2. Monitoring by volunteer organizations

At four marine park zones in Otsuki, members of a volunteer organization, the Ashizuri-Uwakai National Park Otsuki Park Zone Volunteers' Association, are monitoring corals and coral predators on a regular basis; these volunteers implement practices, including extermination activities, to remedy any abnormalities.

## 5 Conservation

### 1. Nature Restoration Project

As previously stated, coral communities in Tatsukushi Bay, the location of four marine park sites, suffered extensive damage when a large amount of soil flowed in and accumulated during torrential rain in September 2001. In March 2002, the Ministry of the Environment removed the soil Tatsukushi Marine Park (Site 4) where a *Pavona* community designated as a natural treasure occurs. The community of *Pavona* was conserved, but it was impossible to remove all of the soil in all area of Tatsukushi Bay owing to the extent, the amount, and budget limitations. The Ministry of the Environment and Kochi Prefecture conducted surveys to investigate the extent of the damage and to take appropriate measures, and at the same time clarified the state of the coral communities (Kuroshio Biological Research Foundation 2002; Nature Conservation Bureau, Ministry of Environment 2003e). The research revealed the existence of well-developed coral communities in part of Tatsukushi Bay, despite the fact that there had already suffered flood damage. The findings suggested that if measures are taken to mitigate the influence of river runoff and human activities, the coral communities in Tatsukushi Bay may be restored. Following this result, the Ministry of the Environment started a two-year Nature Restoration Promotion Survey in 2003. After examining the results of the survey of restoration and conservation measures applied to coral communities have been examined, a natural reproduction project is scheduled to be conducted after 2005.

### 2. Coral transplantation

Coral transplantation projects have been undertaken in Tatsukushi Marine Park since 2000, with the aim of restoring the underwater scenery along a glass-bottomed boat route. Similarly, coral transplantation projects have been ongoing since 2001 in the Uwa Sea Marine Park

to aid in the recovery of coral communities damaged by *Drupella predation* and by a typhoon struck in 1993. Another transplantation project has been conducted by a volunteer organization in the Shirigai Marine Park since 1999; its aim is to recover coral communities by using coral fragments generated during the *Drupella* extermination project. The data, including those on coral growth, are available to the public (Miyazaki 2002).

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## 6 Necessary measures

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### 1. Construction of a monitoring system

The marine area of the west coast of Shikoku contains a rich coral community, eminent among the non-coral reef regions of Japan. Although as many as 19 marine park sites are designated here, but only ten of these marine park sites have a monitoring system. Moreover, outside the designated zones, information is severely limited except at dive sites. It could be possible that the structure of coral communities has largely changed in this area in recent years as a result of damage by coral predators, sedimentation, the rise of seawater temperatures, and other causes. Factors that limit monitoring include the length of the coastline, the abundance of islands to be covered, and the existence of the administrative boundary between two prefectures (Kochi and Ehime); however, it is necessary to immediately construct a region-wide monitoring system to understand the current status of the area.

### 2. Construction of an extermination system for a coral predator

In Ashizuri-Uwakai National Park, a decrease of coral coverage owing to *Drupella* predation has been noted, although this is variable between areas. It is commonly accepted that haphazard extermination is ineffective. Therefore the scientific construction and implementation of an extermination system are needed, based on the successful experience in the Shirigai Marine Park.

### 3. Regulation of marine use

Conflicts have occurred among dive shop owners, recreational fishing vessel owners, and fishermen, over the use of marine areas and the fishing port. There are also conflicts concerning culture and tradition between older local people and young diving visitors. It is necessary to promote mutual understanding and to regulate usage.