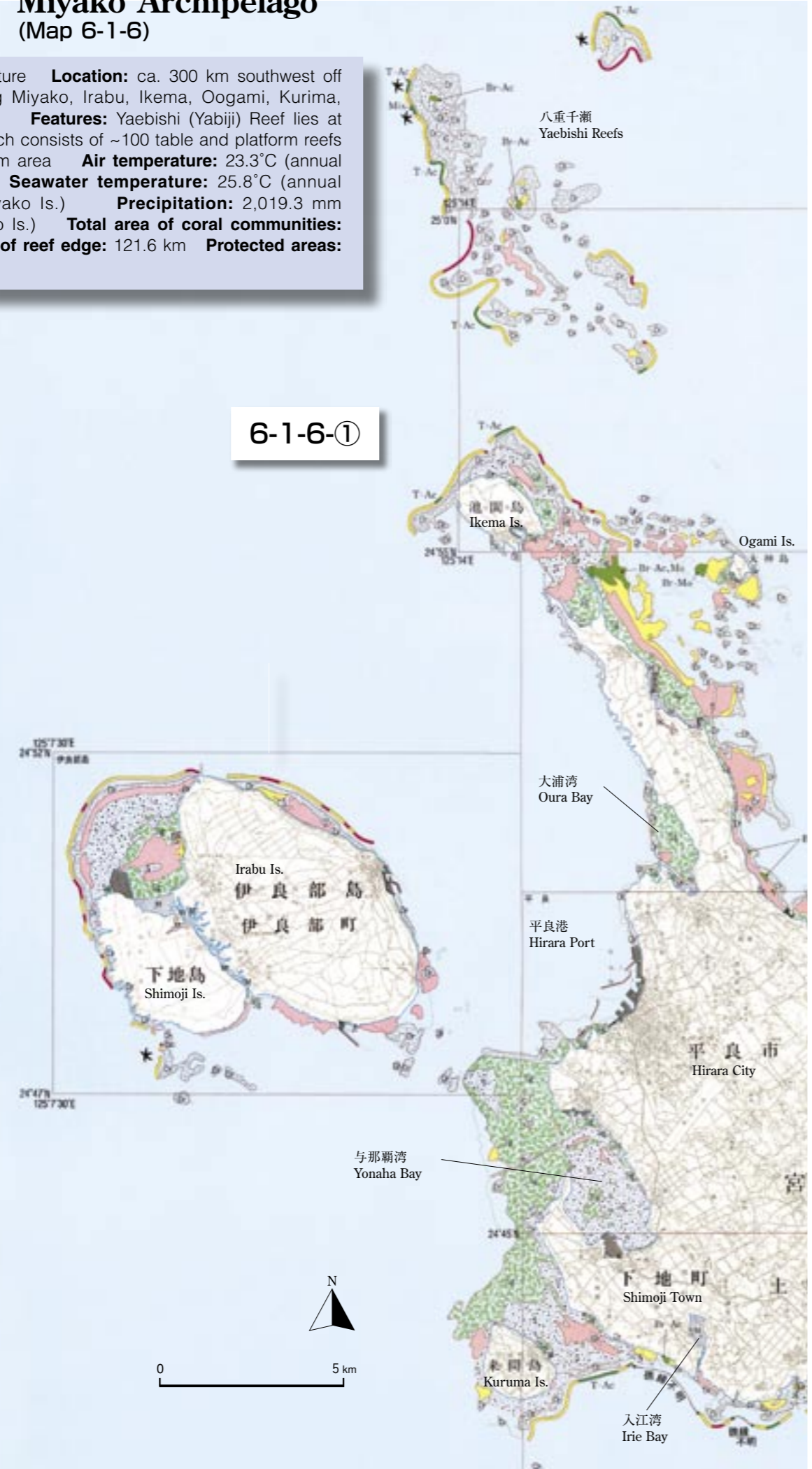


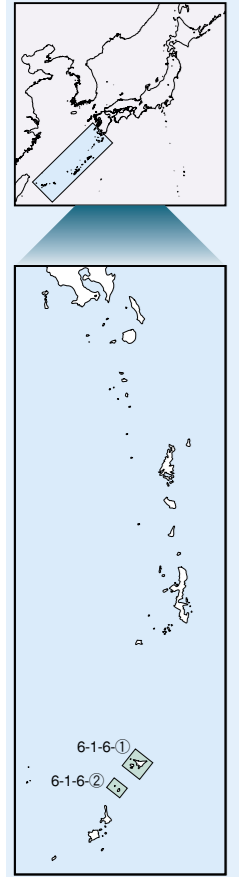
6-1-6 Miyako Archipelago (Map 6-1-6)

Province: Okinawa Prefecture **Location:** ca. 300 km southwest off Okinawa Island, including Miyako, Irabu, Ikema, Oogami, Kurima, Minna and Tarama Island. **Features:** Yaebishi (Yabiji) Reef lies at north of Miyako Island, which consists of ~100 table and platform reefs scattered in a 10 × 6.5 km area **Air temperature:** 23.3°C (annual average, at Miyako Is.) **Seawater temperature:** 25.8°C (annual average, at south off Miyako Is.) **Precipitation:** 2,019.3 mm (annual average, at Miyako Is.) **Total area of coral communities:** 1,957.1 ha **Total length of reef edge:** 121.6 km **Protected areas:** none

6-1-6-①



6-1-6-②



Miyako Archipelago

(Maps 6-1-6-①, ②)

Kenji Kajiwara, Hisashi Matsumoto

1 Corals and coral reefs

1. Geographic features

The Miyako Archipelago is comprised of coral reef limestone (the Pleistocene Ryukyu Group), based on lower stratigraphic divisions of mudstone and sandstone (the Pliocene Shimajiri Group; Nakamori 1982).

Miyako Island is the largest in the archipelago. To the west are the major islands of Irabu and Shimoji, which are surrounded by small islands such as Kurima, Ikema and Ogami. Reefs in the Miyako Archipelago consist mainly of fringing reefs around these islands, although many patch reefs occur between islands.

Miyako Island is triangle-shaped with western, southern and northeastern coasts. Coral reefs have developed along the northeastern coast (Photo. 1). Tsufutsuwa Reef is a 2.5-km-long patch reef that is located centrally along this coast, off Pisseokanzaki. Towards the northern end of this coast is a group of patch reefs around Ikema and Ogami Islands. North off of Ikema Island is Yabiji Reef, which consists of ~100 table and platform



Photo. 1. Landscape of coral reef at Agari-hennazaki, Miyako Island

reefs scattered in a $\sim 10 \times 6.5$ -km² area (Photo. 2). The southern coast of Miyako Island has sheer cliffs, and the reefs here are comparatively narrow. Relatively shallow (20–50 m depth) and calm water lies between the western coast of Miyako Island and Irabu Island. However, reefs are not well developed here; instead, the sea bottom is a gradual slope that is covered with coral sand and rubble. The sandy or muddy bottom of Yonaha Bay, in the southwest of Miyako Island, is only a maximum of 5 m deep, and sandy stretches are home to the largest seagrass bed in Okinawa (902 ha; Nature Conservation Division, Okinawa Prefecture 1999).

Irabu and Shimoji islands are surrounded by weakly developed reefs, with sandy bottoms and flat bare rocks also present. Many submerged patch reefs occur to the south and around Kurima Island. Tarama and Minna islands are surrounded by relatively simple fringing reefs, and the sea bottom is mostly covered with flat bare rocks. Sandy bottoms are found to the north of Minna Island.

2. Coral distribution

Coral fauna of the Miyako Archipelago is not well described. In terms of hermatypic corals, 302 species from 61 genera and 17 families have so far been reported or recognized (Matsumoto 1992; Nishihira and Veron 1995; Hirara City 2003; Matsumoto personal communication) in this area. Although this number of species constitutes at least 50 species less than that is known to occur in the Yaeyama Archipelago or Okinawa Islands, this is probably reflective of the fact that relatively few studies have been carried out in the Miyako Archipelago. Owing to the structurally complex and relatively pristine nature of the area's coral reef habitats, it is expected that future investigations will uncover coral species biodiversity similar to that of other Okinawan reefs.

The percentage of coastal sea bottom within the Miyako Archipelago that is covered by coral communities is 18.2 % (3703.4 ha), which is relatively low (34.4 % (3707.4 ha) is bare rock, 25.5 % (2749.8 ha) is sandy, and 20.2 % (2180.5 ha) is covered by seagrass or algae; Nature Conservation Bureau, Environment Agency 1994). Coral coverages of generally < 5 % occur on the western coast of Miyako Island and around Irabu and Shimoji islands. By contrast, branching *Porites* colonies cover more than 50 % of the southern reef flat of Tarama Island and the northern reef flat of Minna Island. Off the southern coast of Kurima Island, the northeastern coast of Miyako

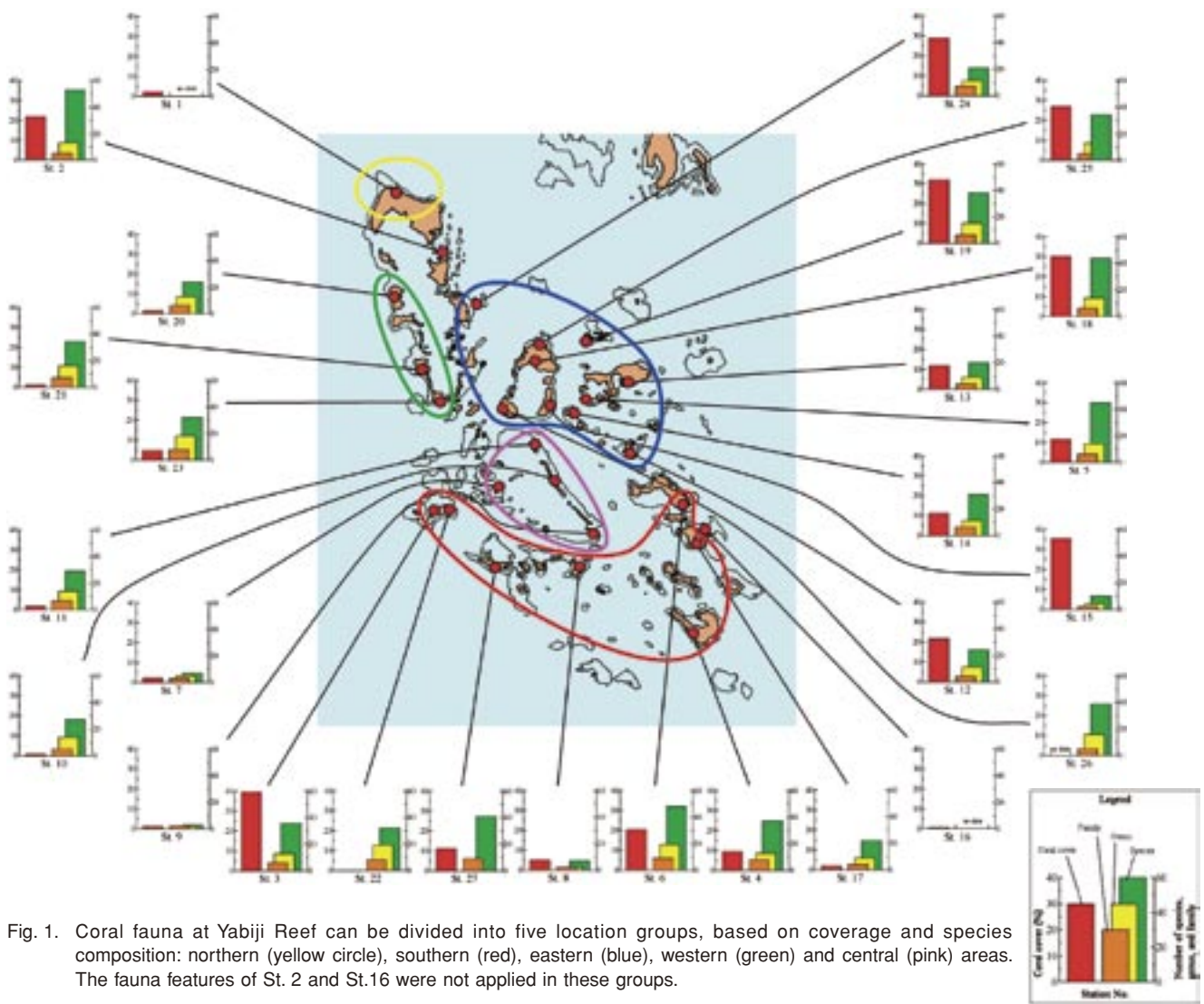


Fig. 1. Coral fauna at Yabiji Reef can be divided into five location groups, based on coverage and species composition: northern (yellow circle), southern (red), eastern (blue), western (green) and central (pink) areas. The fauna features of St. 2 and St.16 were not applied in these groups.

Island, and around Yabiji Reef and Ikema and Ogami islands, coral cover is also > 50 %. These areas are mostly dominated by branching and tabulate *Acropora* and/or branching *Porites*. Branching *Montipora* dominates in some locations along the southern coast of Miyako Island.

The coral fauna of the reef edge and reef flat of Yabiji Reef has been investigated, and it has been suggested that the coral communities of this area can be classified into five categories, on the basis of location (Hirara City 2003; Fig. 1). In northern communities, only encrusting corals were found at reef edges. Heavy winter sea conditions, generated by seasonal winds from the north, probably render this habitat unsuitable for branching or tabulate corals. Southern communities were dominated by many small colonies of branching *Acropora*, many of which appeared to have died quite recently, as their

skeletal structures were still easily distinguishable. The reason for their death remains unclear. Eastern coral communities were characterized by large colonies of branching *Acropora* and *Montipora*; this is probably due to the prevailing calm sea conditions that result from the protective influence of numerous patch reefs. Many massive Faviidae and encrusting *Montipora* spp. have been found amongst western coral communities. These reefs face the open sea, and consequently wave action is probably a strong influence. Central coral communities were dominated by small colonies of branching *Acropora*, and by relatively low coverage. The sea bottom was found to be mostly covered with sand and/or rubble, and sedimentation is probably a major influence on this habitat. Since the reef slope fauna has yet to be investigated, it is likely that the coral species biodiversity of Yabiji Reef is higher than that has been reported thus far; it is probably similar to that of other Okinawan reefs. Yabiji



Photo. 2. Low tide at Kijaka, part of Yabiji Reef in the Miyako Archipelago.

Reef is also important because of its healthy state; its isolation means that anthropogenic disturbances are kept to a minimum, and its proximity to the sea means that water temperatures remain below those that cause mass bleaching events.

3. Water quality and physical environment

The Miyako Archipelago is mostly flat, with a single river of sufficient size to be visible on a 1/25,000 scale topographical map (published by Geographical Survey Institute of Japan). The Urai River is ~500 m in length and is located near the northwestern coast of Miyako Island. Complex groundwater veins are a characteristic feature of Miyako Island, and groundwater exudes at some points both terrestrially (mainly around the southern cliffs) and from the sea bottom in coastal waters (little is known of these locations).

4. Notable species and ecosystems

Okinawa's largest seagrass bed (902 ha) is in Yonaha Bay. Plant species mainly consist of turtle grasses' *Thalassia hemprichii*, *Cymodocea rotundata* and *Syringodium isoetifolium*. In 1999 this was designated a strict nature reserve, according to guidelines for natural environment conservation (Nature Conservation Division, Okinawa Prefecture 1999).

There are almost no long rivers on Miyako Island, and therefore suitable habitats for mangroves are scarce. Even the largest mangrove swamp zone, on the northern coast at Shimajiri, is only ~2 ha in area. *Rhizophora stylosa* mangroves dominate, although *Bruguiera gymnorrhiza*, *Kandelia candel* and *Avicennia marina* also occur here. These Miyako Island *A. marina* are at the northern limit of their natural distribution (Hatushima 1975).

This mangrove swamp has been designated a geographically valuable Japanese wetland (Nature Conservation Bureau, Ministry of the Environment 2002a).

Fudeiwa Island, a small rocky island northeast of Ikema Island, is an important breeding ground for sea birds such as terns and gannets.

2 Situation usages

1. Tourism

SCUBA diving is popular, and there are more than 50 dive operators, mainly based on Miyako Island. Dive sites are established not only at places where corals are abundant, such as Yabiji Reef, but also in areas where there are underwater caves and where coral distribution is limited, such as around Shimoji Island. Snorkeling is popular at Aragusuku, Yoshino, and Bora on the southeastern coast of Miyako Island. Fish-feeding (especially damselfish and butterfly fish) is common in these areas. Coastal or offshore gamefishing is also popular around the archipelago.

For around three days, each April, 2000-3000 tourists use large ferries to land on Yabiji Reef (see Section 4-2). During ebbing spring tides, tourists take part in reef walking.

2. Fishery

Three fishery cooperatives have fishing rights in the waters of the Miyako Archipelago. Approximately 50 demarcated areas of sandy reef flats and sea grass beds around Miyako and Irabu islands have been specifically designated for aquafarming of 'mozuku' (*Nemacystus decipiens* and *Tinocladia crassa*).

From 1981-2001, 52 steel or concrete artificial fish breeding reefs were installed throughout the archipelago. Hatchery-raised juveniles of desirable species (e.g., swimming crab, sea urchin, emperor fish, button shell and giant clam) have been released into the coastal waters of the archipelago to supplement natural stocks. These juveniles were produced at the Sea-Farming Center of Hirara City, Miyako Island, the Okinawa Prefectural Sea Farming Center on Okinawa Island, the Fishery Experiment Stations of Okinawa Prefecture on Okinawa and Ishigaki islands, and the General Fishery Research Center (the former Japan Sea Farming Association) on

Ishigaki Island.

The major fisheries in the archipelago include longline and trawl fishing (for swordfish and tuna), pole and line fishing (for snappers, groupers and skipjack), dive fishing (for groupers, parrotfish, lobsters, giant clams, top shells, octopus and sea urchins), crab trapping (for swimming crabs), “drive-in” fishing (diving fishermen drive fish such as fusiliers into a net), and single hook fishing (using fist-sized stones as disposable weights for deep sea fishing, targeting species such as snappers and sea bream). Giant clams, top shells, octopus, sea urchins and seaweeds are collected from reefs at low tide by gleaners. Aquaculture for mozuku and prawns (*Penaeus japonicus*) also occurs. “Drive-in”, gleaning, and fishing with single hooks are the traditional methods.

3. Others

Since 1997, the Sea-Farming Center of Hirara City has run work-study classes for high grade elementary school students, which involve the release of cultured juvenile fish (Photo. 3). These classes aim to raise environmental awareness of the need for the conservation of fishery resources. Training for voluntary coral reef guides has been available since 2001 in Hirara, with the objective of decreasing the destructive impact of the annual Yabiji Reef landing tour. Program participants have established an NGO called the “Reef Interpretation Society, Miyako Islands” and, since 2002, have conducted reef observation events and exhibitions for residents that emphasise the importance of the natural and cultural aspects of coral reefs. Other relevant work-study classes are available at some schools. For example, students at Karimata Junior High School can experience traditional drive-in-fishing methods.

3 Threats and disturbances

1. Crown-of-thorns starfish (*Acanthaster planci*)

Outbreaks of crown-of-thorns starfish (COTS) in the archipelago were reported from 1957–1959 (Nature Conservation Bureau, Environment Agency 1973), and also through the 1970s and 1980s, when outbreaks occurred all around Okinawa Island. However, there are almost no detailed records regarding the scale or the progression of the outbreaks, or regarding the status of coral communities before and after the outbreaks. No



Photo. 3. Elementary school children releasing juvenile sea urchins (*Tripneustes gratilla*) as part of a work-study class. This program aims to educate the public about environmental conservation issues, including the need for management of fishery resources in the Miyako Archipelago.

outbreaks have been observed since these events.

2. Bleaching

During the world-wide beaching event in 1998, mass coral bleaching occurred in the Miyako Archipelago. Intense bleaching and subsequent colony death was observed, predominantly affecting *Acropora* species. Although detailed data from before and after the event do not exist, a comparison of coral coverage in 1992 and 1999 suggests degradation of coral communities (Fujiwara and Kondo 2000). Studies of subsequent recovery patterns have not been conducted. In 2001, a warm water mass developed near Okinawa and another bleaching event was observed. However, this did not seem to lead to mass mortality.

3. Sedimentation

Although terrestrial soil run-off from various stretches of the coast of Miyako Island does occur after heavy rainfall, the amount of sedimentation is generally low. Omija *et al.* (1993) evaluated that the average suspended particles in sea sediment (SPSS - an index of the amount of soil run-off) was 9.5 kg/m³, observed over nine stations around Miyako and Irabu islands. This is quite low compared to the 40.1 kg/m³ evaluated from 233 stations throughout the rest of Okinawa. Probable reasons for the low SPSS in the Miyako Archipelago, where most of the land area has been developed, include the highly water-permeable soil (called Shimajiri-maaji) and the general flatness of the island, together with the absence of large rivers.

4. Others

According to the Marine Biotic Environment Surveys, 69.7 ha of coral reef area were reclaimed for port construction in the period 1987–1991 (Nature Conservation Bureau, Environment Agency 1994). Another 69 ha were reclaimed up until 2002, mainly at Hirara and the town of Shimoji. The largest single reclamation project of recent years involved 32 ha for a resort facilities site, undertaken by the city of Hirara, from 1995 to 2002.

4 Monitoring and conservation

1. Current state of research

Hirara has monitored coral community coverage changes (with species identification to genus level) at four stations on Yabiji Reef since 1999. Since 2000, a Japanese NGO, Coral Network, has promoted Reef Check (a world-standardized-method survey of coral reefs) in the Miyako Archipelago.

In October 2003, the COTS Table of Miyako Marine Dangerous Organisms Consortium developed a framework for monitoring COTS outbreaks. The monitoring methods follow those of the Rapid Survey Manual (Nature Conservation Division, Okinawa Prefecture 2002).

2. Current conservation measures

The city of Hirara is promoting environmental conservation, fishery protection, and tourism as part of a project monitoring the impacts of the annual Yabiji Reef landing tour. The project includes observations of coral community status, investigation of actual impacts of tourism, and a test introduction of volunteer reef guides. Guidelines regulating tourism on this reef will shortly be developed (see Chapter 4–5 for details).

The COTS Table includes the Miyako Branch Office of Okinawa Prefecture, six municipalities, three fishery cooperatives, diving services, and other organizations. Members discuss the monitoring framework, selection of protective zones, extermination methods, and other COTS countermeasures.

5 Notes

There is no research organization based in the Miyako Archipelago, and consequently very little coral reef status information is available, as compared to other locations in the Okinawa Islands or Yaeyama Archipelago. No marine protected areas (or similar reserve sites) have been designated in the Miyako Archipelago.