10. Status of Coral Reefs in East and North Asia (China, Hong Kong, Taiwan, South Korea and Japan)

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Abstract

- Coral reefs in East and North Asian countries showed an overall decline caused by bleaching, crown-of-thorns-starfish and typhoons together with human stresses since 2004;
- Coral reef monitoring is well established in Japan, Hong Kong, Taiwan and Hainan Island in China. National and state governments support annual monitoring programs on coral reefs associated with local scientific networks in these countries. However, socioeconomic monitoring has not been established in the region;
- Some extensive research on corals was conducted in China and South Korea and regular monitoring has been planned;
- All countries have targeted MPA enhancement and integrated coastal management at local level to reverse the coral degradation;
- The ‘Coral Reef MPAs of East Asia and Micronesia’ database was developed in 2007 to collect and renew baseline information of MPAs in this region;
- Regional workshops on MPA networking are planned from 2008 to 2010 to achieve WSSD 2012 goals of enhanced MPA networks;
- East and North Asia and South-east Asian countries recognized a need for regional coordination and networking to improve conservation during Okinawa ICRS in 2004 and are establishing a regional core network of scientists;
- The network organized the first Asia Pacific Coral Reef Symposium in Hong Kong in 2006 and the second symposium will be held in Phuket, Thailand in 2010.
**INTRODUCTION**

East and North Asian countries comprising mainland China, Hong Kong, Taiwan, Korea and Japan, lie to the north of the coral triangle of highest marine diversity. Countries, especially Japan and Taiwan, gain coral reef larvae from the warm Kuroshio Current that flows northward to Tokyo Bay, although coral distribution is patchy on that coastline and no true coral reefs form. Taiwan has 300 coral species and Japan has more than 400 species. Hainan Island, China, the southern-most part of the region (18–20°N), is quite tropical, especially in the south where there are well developed fringing reefs; these, however, are threatened by the rapid growth of tourism and development, increasing sedimentation and marine pollution. Only the southern part of Korea is influenced by a branch of the Kuroshio Current and corals are restricted to Jeju Island, the most southern island of South Korea. Soft coral is dominant in the area with few hard corals (16 species, most growing at Jeju Island).

Coral reefs are well developed around Hainan Island of China, Taiwan, and Ryukyu Islands of Japan and people rely on coral reef resources. The northern areas of Japan and Korea are seaweed dominant ecosystems with patchy coral communities but these are attractions for diving and snorkelling tourists. It appears that coral communities in these areas are expanding because of rising water temperatures. In contrast, macro-algal cover has increased in about half of the survey sites in Taiwan, accompanied by higher sedimentation loads and increased water turbidity, suggesting continuous reef degradation and a possible phase shift from coral-dominated to algal-dominated reef communities.

The ‘Status 2004’ report described China, Taiwan and Hong Kong as having healthy corals in the 1980s but noted that they were declining due to the human stresses of sedimentation and...
sewage from land due to economic growth. There were some exceptions such as Yongxing Island and Xisha Island in China; Chinwan, Penghu Island, Hsiangjiaowan and Lutao in Taiwan. Fisheries resources were also declining rapidly due to destructive fishing practices and overfishing. The coral reefs of Okinawa, Japan were seriously damaged by a crown-of-thorns starfish (COTS) outbreak in the 1970s and 1980s. Although corals had recovered well by the mid-1990s in Sekisei Lagoon, they had not recovered in Okinawa due to sedimentation from red soil erosion. In 1998 both healthy and non-healthy coral reefs were equally damaged after bleaching during high water temperatures. Since then, bleaching has occurred frequently to continually stress the coral reefs. In addition, COTS again appeared in large numbers at the Amami Islands in 2000 and spread by the Kuroshio Current to the Okinawa area and further north.

The longest monitoring program in this region started at Sekisei Lagoon, Okinawa, Japan in 1983; this has continued to 2008 as part of a national program of ecosystem monitoring. From 2003 it has expanded to all major coral habitats in Japan to monitor coral reef health. The Taiwanese Coral Reef Society started Reef Check monitoring in 1997, with government funding support since 2001. In 1997 Hong Kong also started coral monitoring at MPA sites by the Chinese University of Hong Kong and the government agency. Although regular coral monitoring has not been conducted in Korea, the government is planning a monitoring program on soft coral habitats at Jeju Island in 2008. Although some foreign researchers have made sporadic surveys on corals in China since the 1950s, coral monitoring only started at Hainan Island in the early 2000s.

Coral conservation and management have improved in Japan since the establishment of ICRI in 1994. Taiwan recognized the importance of coral conservation and management in 1997 and started establishing MPAs. Coral research in China was emphasized when Hainan Island was designated as a National Park in 1990 and coral studies have gradually improved, along with more focus on National Parks and coastal conservation. Although there are differences in progress on management activities, participation in the GCRMN has improved national coral conservation. The GCRMN framework has also enhanced inter-regional cooperation between SEA and East and North Asia, formulating a larger network of the two regions.

**Status of Coral Reefs: 2008**

**China:** The condition of Chinese coral reefs was regarded as quite healthy before the 1980s, with coral cover exceeding 70% at Luhuitou in Sanya in the 1960s and at Yongxing Island and Xisha Island in the 1970s. For example, coral cover at Daya Bay was 76% in 1984. However, the environment of coral reefs has been changed by rapid economic growth, such that coral cover at Daya Bay dropped to 32% in 1991. Since 1991, coral cover has remained stable around 30% until 2007 as the figure on the next page illustrates. An intensive coral survey at Sanya National Coral Reef Natural Reserves in 2006 also showed declining coral cover since 1984.

**Taiwan:** Coral reefs at 49 sites in 9 regions were surveyed in Taiwan between 2004 and 2007 using Reef Check methods and video transects. Hard coral cover showed wide variability, with the highest cover at North Sanxiantai on the east coast of Taiwan (66.7%), Yehyo of Lanyu (50.2%), Chaikou of Lutao, and eastern reef slope of Dongsha Atoll (52.5%). If soft coral cover is included, flourishing coral reef communities were observed at several sites of Lutao, Lanyu, and Dongsha Atoll. The northern and eastern reef slopes of Dongsha Atoll show the most scenic underwater images, with coral cover of 78% and 85% respectively. However, coral cover at 24
of the 49 sites was lower than 30%, indicating that these reefs, which occur in favorable tropical environments in the south and south-east of Taiwan, were under severe stress or had been heavily damaged. The lowest coral cover sites were less than 10%; all were in the lagoon of Dongsha Atoll which was severely damaged by mass coral bleaching in 1998. Overall, monitoring is showing a general trend of declining coral cover on Taiwanese reefs. Macro-algal cover has increased at about half of the survey sites in parallel with higher sedimentation loads and water turbidity. This suggests that reef degradation is continuous and a possible phase shift from coral-dominated to algal-dominated reef communities. Though a few sites in the lagoon of Dongsha Atoll showed signs of recovery from the 1998 bleaching event, mass bleaching was again encountered in 2008 on many of the already stressed coral reefs. Coral reefs in Kenting have experienced the most severe bleaching with over 50% of coral suffering from bleaching in the shallow waters. The lagoon of Dongsha Atoll is also heavily impacted by the 2008 bleaching event.

Coral cover at Daya Bay, Guangdong (just north of Hong Kong), China, was particularly healthy in 1984 with 76% cover, but has dropped to around 30% and remained relatively unchanged for the last 16 years. In order to compare coral percent cover between different years, only cover data in the middle part of the Daya Bay (Dalajia and Xiaolajia islands), were chosen because all studies covered these two islands.

**Hong Kong:** A long term coral monitoring programme has been established in A Ma Wan, Tung Ping Chau Marine Park, Hong Kong, since May 1997. The coral community has experienced repeated tropical cyclones: between 1997 and 1999 the highest frequency of severe tropical cyclones to hit Hong Kong, including the strongest cyclone since 1984. *Cyphastrea serailia, Goniopora lobata, Montipora peltiformis* and *Pavona decussata* were the dominant species most affected by the cyclones; since then there has been a significant shift in the coral community structure from *Platygrya*-Goniopora to Pavona-Platygrya. The original coral community was relatively stable and resistant to short-term disturbances but not to repeated long-term ones.

**Japan:** Japan has had a national coral reef monitoring program since 2003 at 22 sites with 2 occasional sites assessed every 5 years. Coral cover declined from 2005 to 2007 in coral reef and
non-reef areas; the average of all sites was 30.4% in 2004, increasing to 33.9% in 2005, decreasing to 32.4% in 2006 and further decreasing to 27.1% in 2007. The major causes for this decline were outbreaks of COTS, typhoons, and bleaching from high water temperatures. The first outbreak of COTS was in Amami around 2000 and annual monitoring has shown increasing numbers in Sekisei Lagoon since 2000. Outbreaks have also occurred at Kerama Islands, Yabiji and Sekisei Lagoon from 2004 to 2006. However, this outbreak of COTS seemed to end in 2007 at Kerama Islands with coral cover starting to increase. COTS populations at Amami Islands and Yabiji were still high in 2007 and coral cover was declining. COTS have also damaged coral communities at a non-reef site in Kushimoto in 2004 and 2005. In 2004 a strong typhoon hit Kushimoto and coral cover was further decreased. Sekisei Lagoon had typhoon damage in 2004 and 2005; there was no coral growth during these 2 years. There was large-scale bleaching in Sekisei Lagoon in 2007 and coral cover declined rapidly. Okinawa still had quite low coral cover in 2007, showing a gradual trend in declining coral cover since 2004.

This chart shows that coral cover, as an average of all monitoring sites in Japan between 2004 and 2007, has stayed relatively constant despite crown-of-thorns starfish plagues and typhoons. However, coral cover is still much less than it was before the 1998 mass coral bleaching depleted many coral reefs.

South Korea: Since 1974 the distribution of corals has been surveyed and now 137 species of corals have been reported with 3 additional species added in 2007: 16 species are listed as stony coral and 15 coral species have been designated as preservation species by the Natural Environment Preservation Act. Notably, 67 coral species are restricted to Jeju Island. Korea has designated 11 areas as MPAs but only the southern parts of Jeju Island have a focus on corals. In some parts of Jeju Island algae have replaced soft corals since 2000: this may be due to changes in current speeds following the construction of the harbor extension.
STATUS OF REEF FISH AND FISHERIES

China: A survey in Hainann in 2006 noted 102 reef fish species, mainly Pomacentridae, Labridae, Chaetodontinae, Apogonidae, and Scaridae. The dominant species were Dascyllus reticulates, Pomacentrus sp., Apogon sp., Stegastes obreptus, Abudefduf sexfasciatus and Chromis notata. Fish body lengths ranged from 1 to 10 cm, except 31 individuals which were more than 20 cm long, and 9 more than 30 cm (these were less than 1% of the total number of fish observed). Only 31 high commercial value grouper fish were observed and only 2 were more than 20 cm long. No other large commercial species were found. Coral reef fish density was low in the Sanya coral reef protected area, with average fish density being about 1 fish per m². Fish numbers and density were also low around Xi Island and Dong Island of Sanya Bay, and Xipai of Yalong Bay, where the coral reefs were severely damaged. Species diversity and density of reef fish was highest in Yalong Bay (Dongpai and Yezhu Island); followed by Luhuitou, Da Donghai and Xiao Donghai, near the Sanya River and Damaoshui River estuaries. Thus there is serious fishing pressure and over-fishing in all Sanya waters: there were also low numbers of giant clam (Tridacna sp.) and cowries (Maturitia and Cypraea spp.) which also suggests over-fishing.

Taiwan: Commercially important fish species were in low abundance at all sites from 2004 to 2007. Only at Dongsha Atoll, where fishing is restricted and enforced by Taiwan’s Coast Guard Administration, were there any large sized jacks. Indicator species such as humhead wrasse, bumphead parrotfish, and barramundi were absent from all 49 reef sites monitored. Groupers were recorded at a few sites at Kenting and Dongsha Atoll, but were of small size and in very low abundance. Snapper abundance was also very low (1–2/100 m²) at a few sites. Similarly, butterflyfish abundance was much lower than most Indo-Pacific reef sites (1–4/100 m²), compared to overall fish abundance (6–8/100 m²). These low densities of fish indicate over-fishing to supply seafood markets and the aquarium trade.

Fish catches in Okinawa Prefecture, Japan have steadily declined from a peak in the 1970s for both in-shore and off-shore fisheries (data from Statistical Information Center of Ministry of Agriculture, Forestry and Fisheries: http://www.pref.okinawa.jp/suisan/4topic/1suisangyou/6catch-syurui.xls)
Japan: In the Okinawa prefecture, the main area of coral reef distribution, total fish catch has rapidly declined since 1978 and the coastal fisheries catch has also decreased gradually since 1998. The Ministry of the Environment and the Subtropical Research Institute in 2006 reported that stocks of *Lethrinus nebulosus*, *Plectropomus leopardus*, and *Epinephelus merra* have been decreasing in Okinawa, based on catch and effort ratios. Local fishermen have also reported resource degradation and reduced fish catches.

Korea: Approximately 250 species of fish have been identified at the Jeju Island MPA including some tropical species that appear to be increasing gradually because of warming waters reaching Korea.

**Stress and Damage to Coral Reefs**

**Sediments and nutrients:** The Biodiversity Survey in China 2006 showed that river discharges to Yulin Bay and Sanya Bay caused significant damage to the surrounding coral reefs compared to Yalong Bay which has little runoff and where coral reefs are healthy. Increased runoff and consequent algal blooms are the major issues in the Sanya area. Coastal areas of Taiwan have been under extensive infrastructure development with the growing populations including aquaculture, agriculture, resort building, etc. As a consequence, soil erosion is high, leading to frequent landslides in rain and typhoon seasons and massive sediment flows into reef areas. Monitoring has shown clear reef damage adjacent to drainage systems by coastal highway construction. Sewage from most coastal towns and villages is often discharged over reefs without proper treatment; sewage and sediment pollution is increasing rapidly and resulting in algal proliferation and coral losses. A major disturbance to coral reefs in Japan is red soil erosion from rivers, coastal constructions and farms in Okinawa. Prefectural regulations control the soil discharges from construction sites, but runoff from the agricultural farms remains a major issue. Untreated sewage from coastal villages and nutrient discharge from the livestock industry also stress the reefs. Major threats to marine life, including reefs in Korea, are suspended material from the land due to coastal development and construction, and land-based organic pollution.

**Development Damage to Coral Reefs:** According to a report by Renlin Zou, 95% of live corals on fringing reefs around Hainan Island were destroyed before the Sanya coral reef natural reserve was established by China. Many coral reefs were mined for construction materials and cement, and live corals were collected as souvenirs; resulting in huge reef damage, with more than 200 m coastal erosion, and with the loss of 200 coconut trees and seawater intrusion into Bangtang village, Wenchang County. Extensive coral destruction by seaweed culture was observed in Qianhai County. Coral dredging is also another issue in Sanya City. Coastal development including reef reclamation, coral dredging, construction of artificial reefs and breakwaters cause the main damage to corals in Japan. Anchoring by large cargo ships also damages coral reefs in Okinawa. Port construction and land reclamation are considered the major potential threats to the MPA of Seogwipo in Korea.

**Destructive Fishing and Over-fishing:** All coral reef fishes surveyed in Sanya, China, in 2006 were small (length range, 1–10cm) with few target fish – clear indications of major over-fishing. Although blast-, poison and electro-fishing have been officially banned, these illegal fishing practices still occur, especially in southern and eastern Taiwan and offshore islands. Gill nets are used frequently in most reef areas and many nets are lost and continue 'ghost' fishing.
Bottom-trawlers have caused severe damage to coral reefs in Penghu Islands and bycatch is a serious problem as fishers are using smaller mesh nets to boost catches. Over-fishing is very obvious as most commercially important fish are absent from most reefs. There are preventive measures, including patrols by the coast guard in protected waters to reduce illegal fishing, however, the effectiveness of law enforcement varies considerably. Dynamite and cyanide fishing were common in Japan after World War II until the early 1970s, but these are not apparent now. However, spear fishing with scuba tanks and hookah is degrading fisheries resources. Over-fishing and unsustainable fishing methods, such as spearing, are still common activities in Korea although they are decreasing. Commercial fish farming is increasing and may result in pollution.

**Marine tourism activities:** Marine recreation is increasing in popularity, especially in southern Taiwan and offshore islands. This fast growing tourist population is adding more stress to reefs with development to expand tourism infrastructure ultimately leading to terrestrial runoff, poor water quality and solid wastes. Trampling and mechanical breakage of corals by boats, snorkellers and scuba divers is another serious problem, and tourists demand quality seafood thereby putting greater pressures on diminishing fish stocks. Some diving areas have been closed to allow recovery from tourist impact at Kerama Islands, Japan, and the community in Shiraho village has developed guidelines for snorkellers to reduce coral damage. Unsustainable tourism is also a major threat for reefs in Korea including recreational diving and a tourist submarine which physically damages marine organisms, especially soft corals. However, the government is preparing a management plan to reduce tourist impacts.

**Coral Bleaching and Diseases**

There have been no reports of serious coral bleaching or coral diseases recently in China, however, corals in shallow waters in Weizhoudao, Guangxi Zhuang Autonomous Region die regularly with the cause apparently being high water temperatures in summer and low temperatures in winter. Mass coral bleaching was observed in Kenting, southern Taiwan, in the summer of 2007 due to prolonged sea surface temperatures over 29.5°C beginning in late June. By late July over 45 species of hard corals, mainly *Millepora* and *Acropora* spp., were bleaching with approximately 70% of coral colonies displaying various levels of bleaching. No disease outbreaks were reported prior to 2004, however, some large-scale diseases were observed in 2005 due to pollution caused by increasing marine tourism. The most severe epidemic is black disease at northern Green Island caused by a sponge, *Terpios hoshinota*, that proliferates in polluted waters. More than 50% of corals were overgrown by the sponge, irrespective of the coral species. Corals in Kenting reefs were infected by an unknown pathogen with the surface covered in pink spots. The linkage between polluted waters and declining coral health and growth is becoming much more evident. In Japan, high temperature coral bleaching occurred in Ogasawara in 2004 and Sekisei Lagoon in 2005 and 2006 but the damage was not serious. Moderate to severe coral bleaching was observed in Iki, Miyako and Ishigaki islands, Yabiji and Sekisei Lagoon in 2007. The most severe losses were in Sekisei Lagoon with a 14% loss in coral cover from 2006. This was much more serious than the 1998 bleaching damage. In 2004 and 2005 bleaching caused by low temperature was recorded in Sekisei Lagoon during winter when coral colonies on the upper-reef flat bleached and died during the low tide at night when the air temperature went down to 14°C. Low temperature bleaching also occurred in Kushimoto in 2005 at 14.4°C: the highest bleaching rate was 90% with 50% mortality at the upper reef. Coral diseases have been frequent in Sekisei Lagoon since 2003, and recorded at the Kerama Islands, Miyako Island and Kushimoto in 2007. Korea has no record of coral bleaching.
The incidence of observed disease on coral colonies on reefs in Japan has increased between 2003 and 2007. The data combines reports of 3 coral diseases: white syndrome, black band disease and coral tumors.

These graphs compare average coral cover (as %) and the number of crown-of-thorns starfish (average of observations during a 15 minute swim) at the Japanese monitoring sites in the Sekisei Lagoon, south of Ishigaki Island, and in the Kerama Islands, west of Okinawa from 2004 to 2007. The decline in coral cover at both sites was largely due to the COTS predation.

Coral predators and Invasive Organisms: Outbreaks of COTS in 2005 were recorded at Sanya (Yalong Bay in particular) and Xisha Islands in China, as well as at Da Donghai and Xiao Donghai and Yalong Bay (especially at Xipai) in 2006. There are fewer COTS in Dongpai, Yalong Bay, but Drupella was often found in these areas. Fortunately, COTS are rarely observed on reefs in Taiwan. A previous outbreak of a sea anemone, *Condylactis nanwanensis*, in Nanwan Bay, southern Taiwan, overgrew and killed corals; this has now greatly diminished. An outbreak of COTS started around 2000 at Amami Islands at the northern end of the true coral reefs in Japan. COTS have increased and coral cover has shown a clear decline between 2004 and 2007: with large numbers of COTS observed at Kerama Islands, Miyako Island, Yabiji, Ishigaki Island and Sekisei Lagoon. The outbreak continued in those areas during 2007 except on Kerama Island when numbers diminished in parallel with the loss of coral colonies. In Sekisei Lagoon, large numbers of a second generation of COTS were observed in 2007, as well as at the Daito Islands (ocean islands 340 km east of Okinawa Island). These COTS outbreaks spread northwards with the Kuroshio Current to Amakusa, Shikoku and Kushinoto; there was a significant drop in coral cover between 2004 and 2005 in Kushimoto. No outbreaks of invasive organisms have been reported in Korea.
Natural disturbance on coral reefs: Coral reefs in Taiwan are battered frequently by typhoons from May to October, especially on southern, eastern and offshore island reefs where corals are broken or covered with sediment. Increasing sea surface temperatures will threaten all coral reefs in the region, especially those under other stresses. Japan also has several typhoons every year, with major damage to corals in northern Sekisei Lagoon in 2004. Strong typhoons destroyed corals at Ishigaki Island, Sekisei Lagoon and Ogasawara in 2005 and 2006. Typhoons reach as far as the Korean peninsular but there are no records of serious coral damage from 2005 to 2007.

Coral Reef Management Status in East and North Asia

In the East and North Asian region Taiwan and Okinawa, Japan, have actively conducted coral reef research and conservation activities since the 1980s with regular monitoring including an Integrated Coastal Zone Management project at Sekisei Lagoon in Okinawa. Hong Kong has also had active coral monitoring and conservation in MPAs. On mainland China there had been limited coral reef research (for specific interests) in 1980s and 1990s, but in the early 2000s China focused coral studies on conservation and management of coastal resources especially at Hainan Island which is a National Coral Reef Reserve. However, effective MPA management has not been established. On the other hand, coral reef management has improved in South-east Asia since 2002 with the World Commission on Protected Areas SEA Marine Working Group developing a Regional Action Plan for 2002–2012; however, progress in implementation varies considerably between countries. Therefore, in 2008 the Japanese government launched a new initiative on MPA enhancement to support the goal for MPA networks throughout Asia. A series of workshops on MPA networking has been planned to develop strategies towards meeting the 2012 goal. Japan also produced an MPA database of East Asia and Micronesia in 2007 as a part of the ICRI Plan of Action 2005–2007 (available on http://www.reefbase.org/key_topics/coralreefmpas.aspx).

Marine Protected Areas: Most of China’s 47 MPAs were established more than 20 years ago (only 10 have been created in the last 10 years), 16 of which contain coral reefs as the dominant habitat. The following major MPAs have been established: Sanya National Coral Reefs Nature Reserve, Hainan Province in 1990 (the most studied MPA in China); Dongshan Bay Provincial Coral Reef Nature Reserve in Fujian Province in 1998; Xuwen Large Yellow Croaker in 2000; Wailuohaiwan Bay’s Limuloid Nature Reserve in 2001; Dengloujiao Provincial Coral Reefs Nature Reserve, Guangdong Province in 2002, and Leizhou Liushawan Bay’s Coral Reefs Nature Reserve in 2003. The upgraded Xuwen National Coral Reef Reserve, Guangdong Province was approved in April 2007. The Dongshan Coral Reserve (Fujian Province) is currently being upgraded.

There are 21 MPAs in Hong Kong, but only 2 contain coral reefs as the dominant habitat. Most of these MPAs are well-established, having been implemented over 20 years ago and managed by the Agriculture, Fisheries and Conservation Department. MPAs in Hong Kong are administered and managed at the national and country level to provide some protection for reef fish; however, they are not completely no-take zones as local inhabitants are still allowed to fish with non-destructive gear under a licensing system. No pre-protection data on fish diversity and abundance are available, thus the benefits of MPA designation are difficult to assess.
Most reef areas in Taiwan were already designated within national parks or national scenic areas; however, management was ineffective with inadequate laws and enforcement. Monitoring has revealed that most coral reefs are deteriorating, and possibly undergoing a phase shift from coral-dominated to algae-dominated communities. Fortunately, awareness is increasing the need for reef protection to sustain their marine resources. New holistic approaches to conservation and ecosystem-based management are being implemented to increase the resilience of the reefs in the face of climate change. Protection of the Dongsha Atoll was declared in 2004, and the Dongsha Marine National Park was established in 2006. Since then, the diversity of marine organisms has increased, including new species records. The Dongsha International Marine Research Station was commissioned to undertake comprehensive research on the diverse marine communities. This is the first national park in Taiwan with a theme of protecting the marine environment, covering all aspects of marine and terrestrial conservation, research, and environmental and ecological education. Coastal marine resources in Taiwan are declining, indicating that previous government regulations have not yielded effective results. Therefore a long-term ecosystem-based management plan integrating social, economical and ecological issues is being drafted for Kenting National Park, encompassing the next 25 years. The visions are to achieve sustainable fishery, well-managed protection of marine habitats, limited damage from human activities, and mitigation of the effects of climate change.

Japan has established 78 MPAs, 18 of which contain coral reefs as the dominant habitat. Most of these parks are well-established, having been implemented over 20 years ago, with only 4 established within the last decade. Administration is primarily at the national level (31 MPAs), although there are 24 MPAs managed at municipality level with the remaining MPAs managed at state/provincial level (11) and region/county level (8). The no-take area of Japanese MPAs was only 118.5 km², or less than 1% of the total MPA area; this is likely to be a gross underestimation. The various measures to conserve the coral reefs in Japan are insufficient, especially the poor coordination in the conservation of adjacent land and sea areas. Environmental conservation is virtually ignored outside protected areas – development has priority over conservation. The ‘Coral Reef MPAs of East Asia and Micronesia’ database was a collaborative effort between The WorldFish Center (ReefBase Project) and Japan Wildlife Research Center (JWRC), and funded by the Ministry of the Environment, Japan, as part of the Japan-Palau ICRI Secretariat Plan of Action for 2005–2007. It contains information and GIS maps on MPAs in South-east, East and North Asia and Micronesia (http://www.reefbase.org/key_topics/coralreefmpas.aspx).

The southern part of Jejudo in Korea was designated as a Natural Monument Protection Area by the Ministry of Maritime Affairs and Fisheries in 2001; the first MPA that includes corals and is also a Man in the Biosphere (MAB) Reserve Area within UNESCO. There are also 10 Wetland Protected Areas with the draft management plan, developed by the Korea Environment Institute, being reviewed for budget allocation. Many ministries with different names in Korea are involved (Natural Monument Protection Areas; Wetland Protection Area; Seogwipo City Marine Park; and MAB): these overlaps emphasize environmental conservation to the public, local stakeholders and local government as well as central government. The coral MPAs were designated recently and management plans are under progress or review. However, evaluation of management effectiveness has not been conducted. A ‘Hot Spot’ Program started in 2006 to select MPAs for corals and endemic species.
Monitoring Capacity in East and North Asia: The long-term monitoring program for Sanya National Coral Reef Natural Reserves in China in 2007 is based on the Survey Manual for Tropical Marine Resources and the Reef Check manual and has 26 sites for corals, 9 for reef fish and 9 sites for plankton in West Island of Sanya Bay, Xiaodonghai and Xipai of Yalong Bay. In addition a 2 year extensive survey project was made for other reefs in South China and Xisha Islands (Paracel Islands) in 2005 and 2006. All data will be stored on the Marine Development Planning and Design Academy of Hainan database and GIS system. The Chinese University of Hong Kong has conducted regular monitoring at 3 Marine Parks (Tung Ping Chau, Hoi Ha Wan and Yan Chau Tong) funded by the Agriculture, Fisheries and Conservation Department (AFCD), Hong Kong Special Administration Region (SAR). The Taiwanese Coral Reef Society has conducted regular monitoring since 1997, sponsored by the Administration of Fisheries of the Taiwanese government, with the first long-term project in Kenting National Park, southern Taiwan, to monitor coral reef changes since 2001. Japan started a national coral reef monitoring program in 2003, with 24 sites from Sekisei Lagoon northward to Tokyo Bay. Surveys are conducted by local scientists or NGO members with data stored in the database of Biodiversity Center of Japan, Ministry of the Environment. Reef Check is active and formed the Coral Network, Okinawa Reef Check and Research Group, Reef Check Kushimoto. A coral mapping program by the Ministry of the Environment has been using remote sensing to find hot spots of biodiversity since 2007; for example, WWF-Japan is surveying biodiversity at the south-west islands including Osumi, Tokara and Ryukyu islands to assist in management planning. Although no regular socioeconomic monitoring has been implemented in Japan, some surveys were conducted on Ishigaki Island to provide reliable data for management planning of Sekisei Lagoon. A regular monitoring program by the Ministry of Marine Affairs will report on management of Wetland Protected Areas in Korea, including coral monitoring for Jeju Island in 2008.

Management Activities: The ‘Sanya-Biodiversity surveys, data management and monitoring, and related training’ in China from 2006 to 2008 was supported by UNDP, GEF and SOA (State Ocean Administration) to generate data and analysis for policy decisions and to build capacity for long-term biodiversity surveys and data management. Taiwan plans to participate in the Integrated Coral Observing Network by establishing coral reef early warning systems to understand the impacts of climate change on coral reefs. The local association of dive operators in Japan has tried to eradicate COTS in specific areas and the outbreak seemed to end at Kerama Islands in 2007; however the outbreak in Sekisei Lagoon continued into 2007, despite efforts by the Ministry of the Environment. Local stakeholders have formed a local committee for integrated management of the Sekisei Lagoon with the Ministry; similarly Okinawa has a prefectural committee to improve coral conservation. The Korean Oceanology Research and Development Institute (KORDI) established a research station on Chuuk, Micronesia in 2000 for coral research and resource surveys.

Reef Restoration: Acknowledging that coral degradation is continuing, local managers have considered coral restoration as a quick solution. Coral relocation was attempted in Daya Bay, Guangdong Province, China, in September 2007 because an oil pipeline was being constructed. About 15 000 m² of coral communities were relocated 7 km to the east side of Guoqaizhou Island, south of Chizhou Island, where water quality is better and monitoring is planned. In Taiwan coral reef restoration is being examined following strong demand. The Ministry of the Environment, Japan, has trialed reef restoration in Sekisei Lagoon and the Akajima Marine Science Laboratory has studied mass spawning at Kerama Islands for possible coral restoration.
Coral transplantation is a popular tourist attraction in Okinawa, organised by tourist operators and NGOs, and the Okinawa Prefectural Government is developing appropriate guidelines, similar to those produced by the Japan Coral Reef Society. Coral restoration research is still experimental with no proven success.

**Conclusions**

Frequent bleaching and COTS outbreaks have been damaging to reefs of the region and slowed recovery after the mass bleaching in 1998. Land-based activities, over-fishing, destructive fishing, tourism, coastal development, sedimentation, sewage pollution, and global climate change are reducing coral resilience, further threatening these reefs. A possible phase shift from coral-dominated to algal-dominated reef communities is a concern in this region. Regular coral reef monitoring and research on corals occur in China, Hong Kong, Taiwan and Japan; Korea now recognizes an urgent need to implement monitoring. Socioeconomic monitoring has not been implemented to assist reef management. Integrated Coastal Zone Management is more focused in the region as an effective approach to conserve coral reefs and communities. All countries and states are planning to increase MPAs in number and efficiency; however, networks of effective MPAs have not been established. There is a high demand for reef restoration in China, Taiwan and Japan, and some commercial coral transplanting programs, with funding from companies, are operating in Japan to raise awareness: there is, however, no evidence of restoration success.

**Recommendations**

- Increase the focus on socioeconomic monitoring as well as ecological monitoring to provide reliable data and information for better coastal management;
- Develop mechanisms for ensuring and extending the network of monitoring scientists to start a dialogue with managers and decision makers to recommend appropriate coral conservation;
- Implement programs of MPA enhancement in the region to identify gaps between the current situation and the WSSD 2012 goals;
- Improve coordination and cooperation within the region and between the regions of ENA and SEA as a wider regional initiative to share information and lessons learned;
- Conduct more research on reef restoration for reef managers to assess the effectiveness or otherwise of current methods.

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Data for this chapter were taken from papers and reports prepared in Japanese by the Biodiversity Center of Japan and the Ministry of the Environment and the Subtropical Research Institute; these are available on Japanese government websites or from Tadashi Kimura, tkimura@jwrc.or.jp.


THE CORAL REEFS OF EILAT, ISRAEL

The coral reefs of Eilat (northern Gulf of Eilat/Aqaba, Red Sea) are exposed to continual human pressures including water pollution, sedimentation, and recreational snorkel and scuba diving. Urban sewage and phosphate dust pollution have recently been reduced while groundwater inputs and port-ballast water contamination have increased. One major positive management step has been the complete cessation of sewage pollution from the city of Eilat since 1995. Another major corrective action was the cessation of fish farms of sea bream, Sparus aurata, that had been a major source of nutrient enrichment since 1991. The Government of Israel decided to close these farms in 2007–2008 based on extensive scientific data and recommendations (summarised in Status 2004 report). These increased nutrient concentrations were considered to be the main cause for the decline in the corals between 1986 and 2000. As a result of deep water mixing (increased nutrients were carried into surface water) in recent years (1995, 2007), the settlement and growth of macro-algae increased, but algal grazing fish reduced the algae and maintained the ecological balance of the reef. However, a negative sign is that more than 40 species of reef fish have been found to carry the exotic pathogen Mycobacterium marinum, introduced to the Gulf by the previous fish farm industry, including main grazing fish such as Acanthurus nigrofuscus, Diplodus noct and Siganus rivulatus. Five years of monitoring found that numbers of coral recruits were negatively correlated with algal biomass. The amount of healthy coral tissue decreased 2004–2006, while in 2007 more tissue looked healthy during the Israel National Monitoring Program at the northern Gulf of Aqaba. Concentrations of nutrients in the sediments is expected to decline in the future as there are no major human sources of nutrient pollution. There has been a recent increase in populations of crinoids (feather stars) on reefs which appears to be an indication of recovery. (from Noga Stambler, Bar Ilan University, Israel; David Zakai, Israel Nature and National Parks Protection Authority, Israel; Yonathan Shaked and Amatzia Genin).