

## **Dong-sha Atoll in the South China Sea: Past, Present and Future**

Chang-feng Dai

Institute of Oceanography, National Taiwan University, Taipei, Taiwan 106, R.O.C.

### **ABSTRACT**

Dongsha Atoll, or Pratas Island, is the northernmost atoll in the South China Sea at 20°35'–47'N and 116°41'–55'E. The atoll is about 28 km wide in diameter and covers an area of about 600 km<sup>2</sup>. The atoll was surveyed in June 1994 and a total of 137 species of corals with approximately 80% coral cover and 369 species of fish in 62 families were recorded. The atoll has been intensively fished during the past decade. In 2001, a total of 7976 boats were fishing around and within the atoll with a peak in March and April. These vessels fish with gill nets, long lines, purse seines, and destructive practices such as dynamite and cyanide. The effect of fishing was devastating as revealed in a survey in April 1998. At one reef site, there were 45 species of corals and 118 species of fish recorded in 1994, but only 3 corals and 32 fishes in 1998. Over 90% of the reef and its inhabitants were killed and replaced by filamentous algae or macroalgae. The food web was virtually collapsed with only low trophic level fish such as algivores and planktivores present. A survey in October 2001 showed that thick beds of dead corals covered all the substrate with no trace of live ones between 1-7 m depth in the lagoon. However, at 10 m depth, about 25% of the substrate was covered by live corals, mostly *Echinopora* spp., fungiids, and poritids. A total of 107 species of corals were recorded and most of them were newly-recruited small colonies. To facilitate the restoration and recovery of reef ecosystems and to protect the marine resources, the government of Taiwan ROC has designated Dongsha Atoll as a marine national park in March 2004. The future and effective management of the Dongsha Marine National Park rely on a comprehensive understanding of the reef ecosystem, enact an exclusive law for MPAs, enforcement of the law, and regional cooperation of resources management.

*Key words:* Dongsha Atoll, South China Sea, Pratas Island, Marine Park, Marine Protected Area

## Introduction

Dongsha Atoll ( $20^{\circ}40' -43' \text{ N}$ ,  $116^{\circ}42' -44' \text{ E}$ ) is the largest and first to be developed atoll in the South China Sea. The atoll is at the mid-point between Taiwan and Hainan Island of mainland China. It is about 340 km southeast of Hong Kong, 260 km south of Shantou on the Chinese mainland, and 850 km southwest of Taipei, Taiwan (Fig. 1). The atoll is about 28 km in diameter and covers an area of about 600 km<sup>2</sup>. Dongsha Island, an island built by coral debris, is located on the west end of the atoll. The island is 2,860 m from east to west and 865 m from north to south with an area of about 1.74 km<sup>2</sup>.

In Chinese, Dongsha Atoll is known as Moon Island because it shapes like the moon. It is also known as Pratas Island to the western world because a British sailor Pratas discovered and reported this island in 1866. However, Dongsha Island became part of ancient China's territory around the time of the Chin and Han Dynasties (approximately 600 B.C.), and the Chinese fisherman visited this island frequently from the Ming Dynasty (about 1380 A.D.) on. This island was occupied by Japanese before and during the World War II and returned to Republic of China in 1946. The island now falls within the jurisdiction of Kaohsiung City, and the Coast Guards Administration of Taiwan is stationed on the island. After 50 years of construction and development, Dongsha Island has become a fortified castle defending the southern frontier of the Republic of China.

Dongsha Island is of strategic importance because it controls the gateway to Taiwan Strait and Bashi Channel, and thus controls the transportation between East and SE Asia. Dongsha Reefs are the major reefs in the northern South China Sea, thus the main breeding and nursery grounds for numerous marine organisms. Reef areas around Dongsha Atoll have traditionally been recognized as an important fishing ground for fishermen from China, Hong Kong, Taiwan, and even Vietnam.

## The Environmental Setting

Geologically, Dongsha Atoll is a part of Dongsha Reefs that covers an area about 150 km long from east to west and 30 km wide from north to south. The whole reef is situated on Dongsha Terrace in the northern South China Sea, with its base at about 1500 m below sea level (Xie 1981). Formation of the reef possibly started in early Tertiary, and the reef is still growing recently.

Dongsha Island is short of soil. Its surface is covered by white sand (i.e., weathered shells and coral); the middle layer is phosphate, in the form of guano; the lower layer is limestone base. Dongsha Island is flat, with no high mountains or valleys. The highest point is only 7.8 m above sea level. Reef limestone outcrops are distributed all over the island, but they do not constitute too great an obstacle to transportation. The island has a subtropical climate, and is influenced by the northeast monsoon in winter. The annual average temperature is 25 °C. The rainy season is in summer and the average temperature is 28.5 °C. It rains less in winter when the average temperature is 20 °C.

## Reef Biota before 1998

### Coral fauna

Research on corals from Dongsha Atoll was traced to Ma (1937) who studied the growth rates of corals from there. Yang et al. (1975) conducted a biological and geological expedition to this atoll and reported 45 scleractinian species in 17 genera. Following surveys by Fang et al. (1990) reported 63 species of scleractinians in 28 genera. A biological survey was conducted in June 1994 and a total of 137 species of corals recorded from its waters and with about 80% coral cover outside it to the northwest, 80-95% to the north but only 15-20% to the south, possibly due to the influence of southeasterly monsoons and prevailing typhoons (Dai et al. 1994). Coral communities of Dongsha Atoll were dominated by scleractinians in which *Acropora* spp. and *Porites* spp. were the most abundant and widely distributed species. Alcyonaceans were distributed on the outer edge of the reef flat on the west and northwest sides of the island. Biogeographically, the coral fauna of Dongsha Atoll is a part of the Indo-West Pacific province and has a close affinity with those of southern Taiwan and Taiping Island in the Spratlys. Coral communities on the reef flat and seaward slope on the west and northwest sides of the island are highly developed where high diversity and coral cover of both scleractinians and alcyonaceans were found. Well-developed coral communities also occurred in the lagoon on north side of the island where many large *Acropora* and *Porites* colonies were found. On the reef flat around the island, there were dense seagrass beds, mainly *Thalassia hemprichii*, with scattered coral colonies.

### Fish fauna

During the survey in 1994, a total of 311 species in 55 families of fishes were found. Together with previous findings, totally 396 species in 62 families of fish have been recorded at Dongsha Atoll (Chen et al. 1994). Among them, 30 species were new to Taiwanese waters. Regarding the number of species, Labridae was the most diverse group, followed by Pomacentridae, Gobiidae, and Chaetodontidae. A further analysis revealed that about 95% of the species were widely distributed tropical fishes (Chen et al. 1994). Since only a small part of the reef areas have been surveyed, the species diversity of fish is apparently underestimated. It is estimated that more than 600 species of fish may exist at Dongsha Atoll (Table 1).

### Other marine biota

In 1994, 114 species of macroalgae were found during field surveys in the shallow reef flat and lagoon around Dongsha Island. These algae were widely distributed but never dominated the benthic community. The most diverse algal flora was found on the northern coast of the island. In addition, there were two species of seagrasses, *Thalassia hemprichii* and *Holodule uninervis*, forming thick meadows on the shallow reef flat around the island. These seagrasses provide abundant food source for green turtles that often feed and breed in the lagoon.

For macrobenthos, 275 species of crustaceans and 141 species of mollusks were recorded during the field survey in 1994 (Table 1). These numbers are also underestimated because only limited areas have been surveyed. The estimated number of species of these animals should exceed 500 species. Among the macrobenthos, spiny lobsters (*Panulirus* spp.) and the giant clams (*Tridacna* spp.) are common and important fishery resources that have been heavily harvested since 1980s by fishermen from Chinese mainland and Taiwan. Only few small individuals of spiny lobsters and giant clams were recorded during the field survey in 1994 indicating that populations of these animals had been severely depleted.

In addition to the fauna and flora mentioned above, there are rich fauna of sponges, sea anemones, polychaetes, echinoderms, ascidians, and cetaceans. However, most of them have never been surveyed and no reliable data is available. Nonetheless, a high species diversity of reef organisms can be expected judging from its biogeographic location and large reef areas.

## Reef Biota after 1998

Dongsha Atoll was surveyed again in 1998 (Li et al. 2000) and 2001 (Soong et al. 2002). Li et al. (2000) used visual census to identify fish and corals and to estimate the cover of living and dead corals. Their study revealed that the number of coral species declined dramatically to less than 50%, and about 60 to 90% of the reef surface was covered by dead corals.

Soong et al. (2002) applied the Reef Check protocol to survey the reefs in addition to the visual censuses. A total of 9 sites distributed in and out of the lagoon were surveyed. At each site, two 50-m line transects were laid haphazardly on the reef surface, and benthic categories were recorded at 20 cm intervals. The survey revealed that, in the lagoon, thick beds of dead branching acroporids covered all the substrate with no trace of live ones between 5-7 m depth. At 10 m depth in the lagoon, about 23% of the substrate was covered by live corals, mostly large foliaceous colonies of *Echinopora gemmacea*, *E. lamellose*, *Echinophyllia aspera*, and other corals, e.g., fungiids (*Sandalolitha robusta*, *Herpolitha limax*, *Fungia* spp.) and poritids (*Porites cylindrica*, *P. negrescens*), with the remaining space taken by thick beds of dead branching acroporids. A total of 107 species of hard corals were recorded in this survey; most of them were newly recruited small colonies or remnants of partially damaged colonies. The selective killing of acroporids in the lagoon was likely due to the 1998 bleaching event. On the reef crest and outer reef slope, live coral coverage ranged from <1 to 6% of the substrate, with the rest represented by coral debris possibly caused by physical forces such as typhoons, dynamite fishing, and cyanide poisoning. Most of the dead coral skeletons on reef surface were covered by filamentous and fleshy macroalgae (Table 2). Due to the almost total (>95%) destruction of the atoll, the food web had virtually collapsed, with only low trophic level fish such as planktivores and algivores present (Morton 2002). The fish community was dominated by herbivores (mostly wrasses and surgeonfish), and large schools of herbivorous fish grazing on algae growing on dead coral skeletons were the common scene on the reef.

### Causes of reef degradation

Dongsha Reefs have long been regarded as an important fishing ground for fishermen from south China, Hong Kong and Taiwan. Fishermen visited this atoll frequently to harvest fish, spiny lobsters, and giant clams about 20 to 30 years ago. Overfishing and destructive fishing practices were apparently the major causes for depletion of biological resources and degradation of coral reefs at Dongsha Atoll. The fishing boat-days within and around the atoll increased rapidly in recent years according to the data recorded by the coastguard at Dongsha Island. For example, 1044 boats were recorded in 1996, 6500 boats in 2000, and 7976 boats in 2001. Most fishing boats (>90%) could be identified as originated from ports in southern China, with the rest originating from Hong Kong, Taiwan, and unidentified. The peak of fishing activity was between March and April when more than 1700 boat-days were recorded per month. The off-season was between November and February (<200 boat-days per month). These boats fish with gill nets, long lines, purse seines, but also with dynamite, and cyanide, and by electrofishing. Based on the record provided by the coastguard, Fang (1998) estimated that about 50 tons of cyanide and 1 ton of dynamite were applied in 1996 by

those 1044 boats. Furthermore, he estimated that more than 9 tons of batteries used by those fishermen during diving were dumped over the atoll. For the 7976 boat-days recorded in 2001, an increase of about 5 times of cyanide, dynamite and mercury batteries could be expected. Obviously, overfishing and destructive fishing played a major for the degradation of coral reefs at Dongsha Atoll (Morton, 2002).

The mass bleaching event in 1998 might also play a significant role for mass mortality of corals at the atoll. The selective killing of almost all acroporids and pocilloporids in the lagoon suggested that seawater warming could be an important cause for widespread coral death since they were more sensitive to temperature rising (Loya et al. 2001). However, the bleaching event might only act as the camel's last straw that led to the collapse of whole reef system (Knowlton 2001).

## **Challenges to the Future of Dongsha National Park**

The destruction of Dongsha Atoll has brought much attention to marine ecologists and environmental protection societies. In the Fourth Conference on the Protected Areas of East Asia sponsored by the IUCN World Commission on Protected Areas in East Asia (WCPA-EA) held in Taipei in February 2002, a group of marine ecologists reported the status of the atoll and reached a petition- "Yangmingshan Declaration" urging the government and all relevant organizations to support the establishment of Dongsha Atoll as a marine protected area (Chiu 2002, Li et al. 2002, Morton 2002, Soong et al. 2002). Recognizing the atoll's importance for the sustainable of fishery resources in the South China Sea and Taiwan Strait, as well as the potential of ecosystem goods and services, the government of Taiwan agreed to designate Dongsha Atoll as the first marine national park, with the same purpose and function as a marine protected area, in March 2004.

It is generally recognized that MPAs are currently the best management tool for conserving coral reefs and many other marine systems (Kenchington 1990, Slam et al. 2000, Hughes et al. 2003) although there are debates on how to establish and manage MPAs. Slam et al. (2000) summarized the typical objectives of establishing MPAs including (1) maintaining a high-quality coastal environment, (2) conserving special habitats and environmental sensitive areas, (3) protecting species and species diversity, (4) conserving critical ecological processes, (5) combining natural hazard protection with nature conservation by protection of natural features, (6) restoring damaged ecosystems and replenishing depleted fisheries, and (7) involving and educating the community to create public awareness of ecological values and needs for coastal and marine conservation. Basically, establishing Dongsha Atoll as a MPA meets most of the above objectives, especially the damaged reef ecosystem need strict protection to facilitate its restoration and recovery. Such a protective measure will help to maintain the environmental quality, species diversity, and natural resources of Dongsha Atoll. The establishment of Dongsha Atoll as a MPA with a conservation priority also initiates the peaceful approach for the stability of the frequently disputed region of the South China Sea (Gomez 1994).

Based on the preliminary management plan for Dongsha Marine National Park (Dai and Chiu 2003), the area encircled by 100 m isobath around the atoll is declared as the "conservation zone", and the area encircled by a distance of 12 nautical miles from the outer edge of the atoll is the "general control zone" (Fig. 2). All resource utilization activities including fisheries, diving, tourism, and mining are prohibited in the conservation zone. The general control zone acts as a buffer zone where only destructive fishing practices are prohibited. Owing to the remoteness, vast reef areas (>600 km<sup>2</sup>), and complicate users of

Dongsha reefs, it is obvious that the future management of Dongsha National Park will be a great challenge for government organizations and marine scientists in Taiwan.

Firstly, there is very limited information on marine environment and biological resources that are essential for the planning and management for Dongsha Marine National Park. Due to the limitation of transportation and support facilities, previous field surveys were constrained to areas adjacent to the island and the vast reef areas to the north, south and east parts of the atoll have rarely been surveyed. More researches on marine environment and natural resources are needed to reach a comprehensive understanding of the reef ecosystem.

Secondly, an exclusive law for the administration of MPAs in Taiwan is needed. MPA is a new concept in Taiwan and there is no law to support this management. There are relevant laws for the administration of several systems of protected areas such as the National Park Act for national parks, Tourism Development Act for national scenic areas, Wildlife Conservation Act for wildlife refuges, and Fisheries Act for fishery resources cultivation areas (Chiu 2002). However, most of the legally protected areas are terrestrial except that a portion of some of them includes a marine component. The above laws may not be applicable to Dongsha due to the fact that they do not encompass a holistic approach or include the comprehensive goals of MPAs. The future management Dongsha Marine National Park will require an exclusive law for MPAs. Furthermore, the enforcement of law is a great challenge for managers. Currently, the atoll is patrolled by the coastguards of Taiwan, ROC. Due to their restricted operation capabilities, they can hardly stop fishermen from operating on the atoll. A well trained and well resourced coastguard is required for future effective management of the atoll.

Thirdly, regional consensus on sustainable fisheries is needed. Since most of the fishing vessels come from mainland China and Hong Kong, an effective management for Dongsha Atoll will require a regional cooperation to stop the operations of destructive fishing. The purposes of establishing Dongsha Marine National Park are to bring about mutual benefit to the region, particularly the fisheries, and to serve as a peaceful solution to mitigate possible conflicts in the South China Sea. The challenges lying ahead are how to reach a regional consensus on sustainable fisheries at Dongsha Reefs as well as elsewhere in the South China Sea. Direct dialogue of governmental organizations among mainland China, Hong Kong, and Taiwan is necessary to reach a mutual agreement on this issue. Meanwhile, the Asian Pacific Economic Cooperation (APEC) Marine Resources Working Group and Fishery Working Group provide an opportunity to facilitate the building of a consensus on sustainable fisheries in this region.

In summary, Dongsha Atoll is a perfect ring-shaped reef with its largely enclosed reef system supporting highly diverse fauna and flora. The recent collapse of the reef ecosystem was mainly resulted from overfishing, destructive fishing practices, and mass bleaching event associated with global warming. The establishment of Dongsha Marine National Park is aimed to restore the damaged reef ecosystems and to replenish depleted biological resources. The future of Dongsha Atoll will rely on effective management of the park and this is a great challenge to government organizations and marine scientists.

## Acknowledgements

This study was carried out in cooperation with the Department of National Parks, Administration of Construction and Planning, Ministry of Interior, Taiwan, R.O.C. I would like to thank Drs. K. Soong, W. Y Chiu, Ms. S. F. Lu and Mr. H. Y. Chang for their support of this study.

## References

- Chen JP, Shao KT, Lin CP (1995) A checklist of reef fishes from Tungsha Tao (Pratas Island), South China Sea. *Acta Zoologica Taiwanica* 6(2): 13-40.
- Chiau W-Y (2002) Establishing the Tungsha (Pratas) Islands as Taiwan's first marine protected area: key issues and challenges. Proceedings of the 4<sup>th</sup> Conference on the Protected Areas of East Asia (IUCN/WCPA/EA-4), p. 387-401, Taipei.
- Dai CF, Chiu WY (2003) The preliminary management plan for the establishment of Dongsha Marine National Park. Department of National Parks, Administration of Construction and Planning, Ministry of Interior, Taiwan ROC, 81 p. (in Chinese)
- Dai CF, Fan TY, Wu CS (1995) Coral fauna of Tungsha Tao (Pratas Island). *Acta Oceanographica Taiwanica* 34: 1-16.
- Fang LS (1998) The marine ecology status of Dongsha Atoll and its management planning. National Museum of Marine Biology and Aquarium, Kaohsiung, Taiwan, 48 p. (in Chinese)
- Gomez ED (1994) The South China Sea: conservation area or war zone? *Mar Pollut Bull* 28: 132
- Hughes TP, Baird AH, Bellwood DR, Card M, Connolly SR, Folke C, Grosberg R, Hoegh-Guldberg O, Jackson JBC, Kleypas J, Lough JM, Marshall P, Nyström M, Palumbi SR, Pandolfi JM, Rosen B, Roughgarden J (2003) Climate change, human impacts, and the resilience of coral reefs. *Science* 301: 929-933
- Kenchington RA (1990) *Managing marine environments*. Taylor & Francis, New York, USA, 248 p.
- Knowlton N (2001) The future of coral reefs. *Proc Natl Acad Sci USA* 98: 5419-5425
- Li JJ, Lee TF, Tew KS, Fang LS (2000) Changes in the coral community at Dong-sha Atoll, South China Sea from 1975 to 1998. *Acta Zoologica Taiwanica* 11: 1-15.
- Li JJ, Fang LS (2002) The management of Dong-sha Atoll as an effective marine protected area. Proceedings of the 4<sup>th</sup> Conference on the Protected Areas of East Asia (IUCN/WCPA/EA-4), p. 403-415, Taipei.
- Loya Y, Sakai K, Yamazato K, Nakano Y, Sambali H, van Woesik R (2001) Coral bleaching: the winners and the losers. *Ecol Lett* 4: 122-131
- Ma TYH (1937) On the growth of reef corals and its relation to the sea water temperature. *Mem Nat Inst Acad Sinica Zool* 1: 1-226
- Morton B (2002) Dong-Sha Atoll, South China Sea: ground zero! *Mar. Pollut. Bull.* 44: 835-837.

- Salm RV, Clark J, Sirila E (2000) Marine and coastal protected areas: a guideline for planners and managers. Washington DC, IUCN, 40 p.
- Soong K, Dai CF, Lee CP (2002) Status of Pratas Atoll in South China Sea. Proceedings of the 4<sup>th</sup> Conference on the Protected Areas of East Asia (IUCN/WCPA/EA-4), p. 739-742, Taipei.
- Xie YX (1981) The features of submarine topography in the South China Sea. *Nanhai Studia Marina Sinica* 2 (2): 1-11
- Yang RT, Huang CC, Lee CS, Tsai HJ, Sun CL (1975) Report on a survey at Dongsha Island and the adjacent area. Spec Publ 8, Institute of Oceanography, National Taiwan University, Taipei, 15 p.

**Table 1** Species diversity of some reef organisms at Dongsha Atoll.

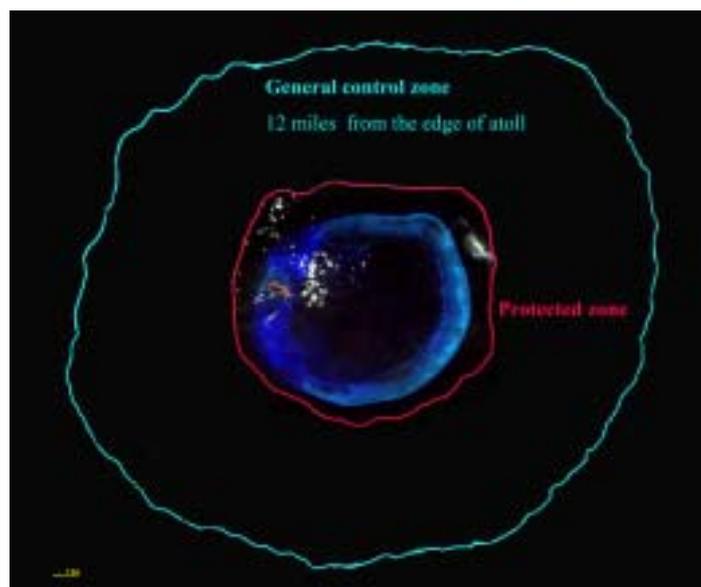
	Hard coral	Fish	Mollusc	Crustacean
Recorded	137	396	141	275
estimated	>300	>600	> 500	> 500

**Table 2** Major changes of Dongsha reef ecosystem between 1994 and 2002.

	Live coral cover	macroalgae	Fish
1994	≈ 80%	<10%	All trophic groups
2002	<5%	>70%	Dominated by herbivorous fish



*Fig. 1* Map of Dongsha Atoll in the northern South China Sea.



*Fig. 2* Zoning of the Dongsha Marine National Park in northern South China Sea.