*Kuroshio Science* 10-1, 23-27, 2016

# Dongsha Atoll Research Station – A steady research platform in South China Sea

**Yalan Chou**
Department of Oceanography
National Sun Yat-sen University

## Introduction

Dongsha Atoll locates on the northern part of the South China Sea (20° 41'15" N; 116° 48'42"E). The shortest distance between this remote atoll and the mainland is 250 km, and is over 450 km away from Kaohsiung, Taiwan (Fig. 1). The Atoll is about 25 km in diameter and the coverage is about 500 km$^2$. Dongsha Island is the only islet on the Atoll; it locates at the western side of the atoll lagoon. Northern and southern channels at the northern and southern sides of the islet are the only routes for bigger boats to enter Dongsha Lagoon.

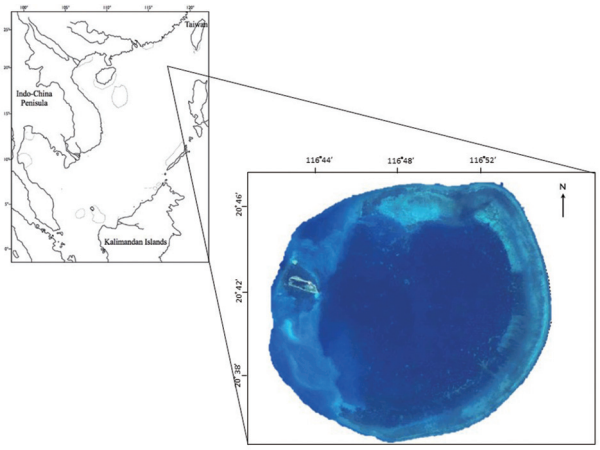


**Fig. 1. Geographic location and satellite image of Dongsha Atoll**

Dongsha Atoll is a place with various scientific interests because of the unique environments:

1. A fast acidified ocean (Liu *et al*., 2013). The pH value is 0. 1 lower than other oceans (the pH value is decreasing 0.1 in the past 200 years in world oceans)
2. The strongest internal waves (IWs) that are generated by intrusions of the Kuroshio Current into the Luzon Strait pass by Dongsha area.
3. With remote and independent coral reef and seagrass ecosystems. The ecosystems are mostly influenced by global changes and with very few anthropogenic effects.
4. Typhoons often pass through Dongsha area.
5. Dongsha Atoll encompasses both oceanic and island ecosystems, and with high biodiversities.

The Atoll is composed of three parts including fore-reefs, back reefs and lagoon that can easily be identified from satellite imagery (Fig. 1). Lagoon-open ocean water exchange rate is lowered due to the semi-closed ring shape of the atoll. Water temperature in the lagoon is usually 1-2℃ higher than fore-reefs in spring and summer (March to October), but with lower water temperatures in winter (Fig. 2). IWs that bring the deep waters up to surface could be the main reason to influence water temperatures in fore-reefs and may introduce a daily water temperature fluctuation for almost 8℃ (Wang et al. 2007; Fig. 2). On the other hand, weather condition may be the main factor controlling the water temperatures in Dongsha lagoon because of the small water mass and low exchange rate in the semi-closed system.

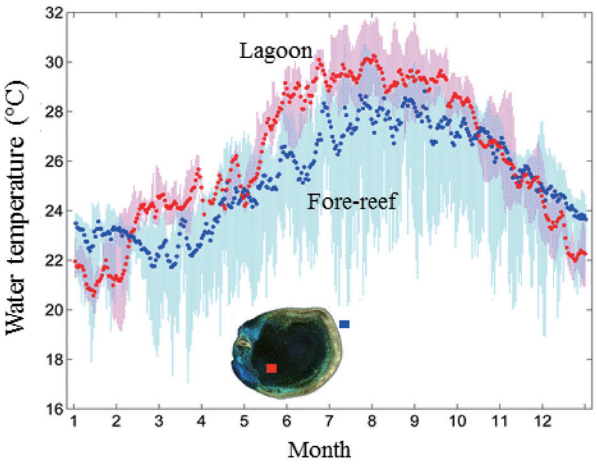


**Fig. 2. Yearly water temperature records of fore-reef (blue) and lagoon (red).**

Field surveys conducted at north, west, southern fore-reefs and lagoon patch reefs recorded 290 coral species in 78 genera and 22 families (Dai et al. 2013) . The results indicate a

*e-mail: ylchou@gmail.com

large variance of the habitats among the 11 sampling sites at Dongsha Atoll, especially between the fore-reefs and lagoon patch reefs. For example, none of the soft corals were observed in the lagoon, but with high abundance in fore-reefs.

## Fore-reefs

The fore-reefs on Dongsha Atoll is defined from the edge of reef crest toward reef slope, and its well-developed spur-and-groove structure could be seen from aero photos (Figure 3a and b). Reef slope extended smoothly to the water depth of 25 m at a horizontal distance about 1 km from shore. Reef cliffs usually appear below the water depth of 25 m, and extend to deeper ocean basin. The corals on fore-reefs may benefit from the IWs through which the nutrient rich in the cold water was brought to surface and hit the fore-reefs (Wang et al. 2007). For example, the corals on the fore-reefs were not affected by the 1998 worldwide bleaching event, while the lagoon corals experienced almost complete mortality at the same time (Dai 2004). The reef slopes contain abundance of Scleractinia (stony) and Octocorallia (soft) corals (Fig. 3c and d). The coverage are 34-74% and 2.5-30% of stony and soft corals, respectively at the investigated sites (Dai et al. 2013). Expeditions to the reef slopes have become more intensive because the research vessels on Dongsha have improved in recent years. With more effort put into investigating the outer atoll, the distribution of the corals and other organism would be clearer and could provide more information in near future.

## Atoll lagoon

In Dongsha lagoon, the most eye-catching features are the patchy reefs (Fig. 4a). From satellite imagery and drone photos, hundreds of patch reefs distributed in the lagoon with variety depths and diameters of reef tops (Fig. 4a, b). An east-westward shallow to deep trend of the top depth of the patch reefs was observed as judged from 166 individual patch reefs in the lagoon; the phenomenon indicates the lagoon patch reefs may be influenced by certain factors, e.g. current erosion from western water channels or coral growth rates (Wei 2016, NSYSU, unpublished data).

Another significant feature is the high density of *Porites* spp. on the tops of the patch reefs in the atoll's lagoon (Fig. 4b, c). Most of the corals were observed bleaching in the summer of 2015, when water temperatures became too high (i.e., over 32° C in 2015; Fig. 4d, e). Most symbionts had returned to the corals when observed in the spring of 2016, but mortality was also recorded in some areas (Personal observation). Drone photos are also developing to understand the details of the patch reefs in Dongsha.

There are at least 3 shark species recorded in Dongsha lagoon. The most abundant one is the sharp-teeth lemon shark (*Negaprion acutidents*), which could be observed easily around Dongsha Island in spring. This species may use the seagrass beds around Dongsha Island as a nursing area (Wang et al. 2013). Tiger shark (*Galeocerdo cuvier*) with body size of

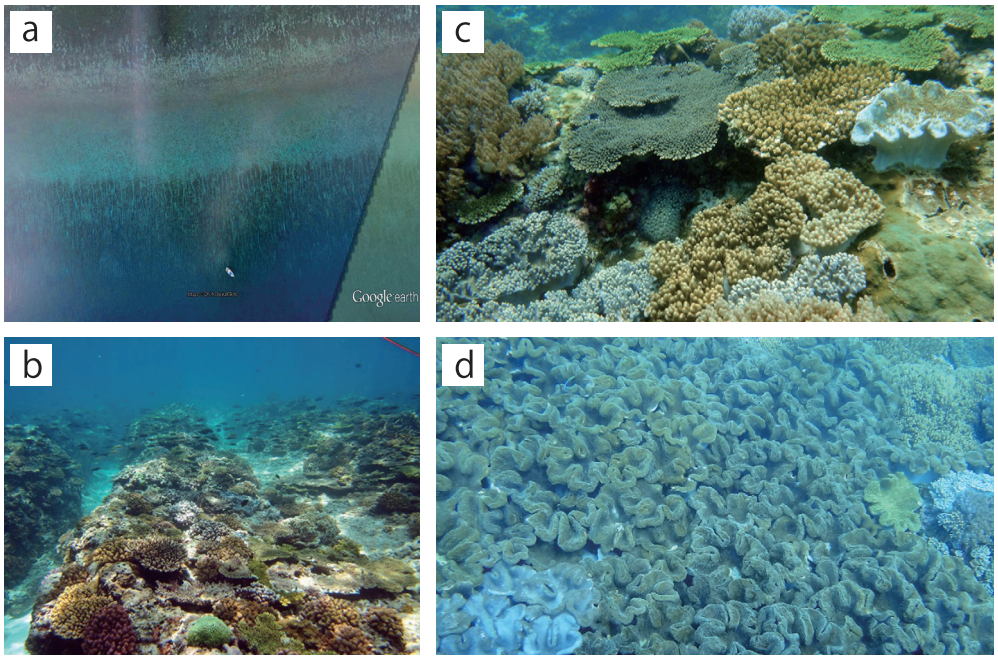


**Fig. 3. Fore-reef photos.** a. The aerophoto presents significant areas of reef crest, spur-and grooves (from photo top to bottom) of Dongsha fore-reef. White spot indicates Atoll II. High coral densities could be found in b. spur. c-d. fore-reef slope.

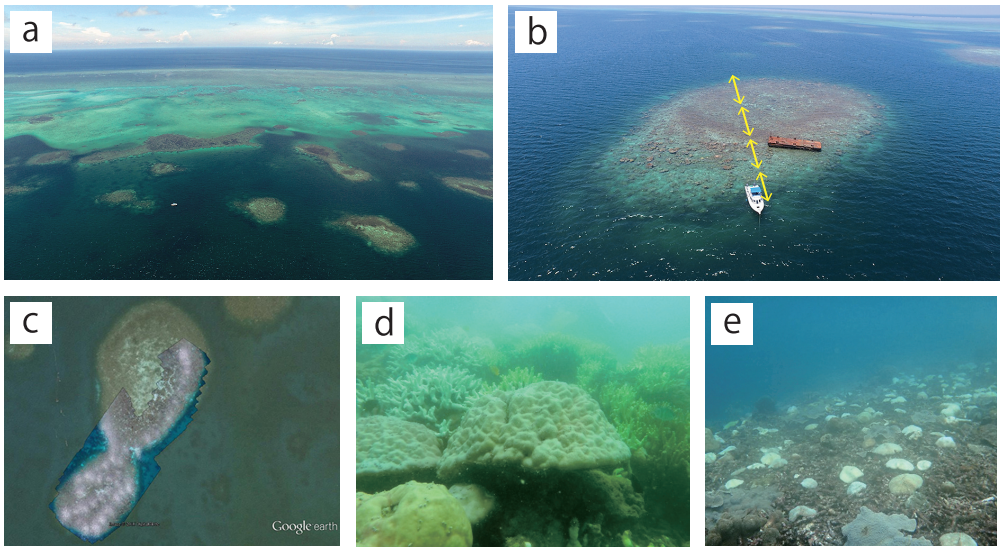


**Fig. 4. Patch reefs of various sizes and shapes in the lagoon (deep green area in a).**
b, these patch reefs differ in meters to hundreds meters. c. stitched patch reef aero photos. The stitched file can be imported into google earth to see the detail of the patch reefs. d. *Porites* spp. and e. *Fungia* spp. are easy to find on patch reefs. The last two photos were taken after a mass bleaching in the summer of 2015.

1.2 m was recorded once around Dongsha Island in May of 2015, and groups of blacktip shark(*Carcharhinus limbatus*) were observed in northeastern and southeastern sites at the edge of patch reefs.

## Reef crest

Satellite imagery and ground truth data provide practical information for reef crest on Dongsha Atoll. The reef crest could be roughly separated into 2 parts of shallow outer reef crest and seagrass beds in inner crest (Kao et al. 2013). The outer reef crest is around 1-2 km in width from the edge of the fore-reef toward lagoon with water depth of 1-2 m and may expose to air when in spring tides (Fig. 5a). High abundance of sea stars, sea urchins, small stony corals and sea anemone distributed on the hard substratum (Fig. 5b). From the shallow crest toward the lagoon, 80 $km^2$ area of seagrass beds could be observed at inner ring (Fig. 5c). The water depths are around 3-5 m in the seagrass beds. Stony corals, mostly *Porites* spp., and usually in the form of micro-atolls distribute among the seagrass beds (Fig. 5d).

Seagrasses are mainly composed by three species on the whole reef crest: *Thalassia hemprichii, Cymodocea serrulata* and *Cymodocea rotundata*; and at least three other species have been observed around Dongsha Island in restricted areas: *Halodule univervis, Halodule ovalis* and *Syringdodium isoetifolium*. The satellite imagery taken from 1994 to 2016 indicates a mass seagrass die-off in recent years (Ren et al., 2014). About 25 and 5 $km^2$ seagrass beds were denuded in 2014 and 2015, respectively, judging by the satellite imagery (Fig. 5e; Kao and Ren, unpublished data). The macroalgae *Halimeda* spp. were found in high abundance in the die-off areas in April of 2015, and no seagrass has been observed after the die-off (Fig. 5f). High water temperature and hypoxia induced high sulfide environment may be the main reason to kill the large area of seagrass at east and north arc in Dongsha Atoll reef crest (Chou *et al*., unpublished data)

## Vessels and Facilities

The Dongsha Atoll Research Station (DARS), founded in 2012, is located on Dongsha Island; it provides variety of research facilities to visiting scientists. DARS is like a boat staying in the South China Sea; it will continuously serve to promote researches resolving the scientific questions relating to atoll and South China Sea. In addition to assist the on-going studies, further international co-operations are welcome to be conducted at Dongsha Atoll Research Station. Accommodations and vessels that suitable for various destinations on Dongsha Atoll are ready for researches. R/V Atoll I, Atoll II (since 2014), Atoll V and Atoll VI (2016) are equipped for different destinations on Dongsha Atoll and nearby areas. R/V Atoll I and Atoll V are convenient for operating at reef crest, but with smaller space and capacity. R/V Atoll II and Atoll VI are able to travel around fore-reefs, and the waterline of Atoll VI is 40 cm that makes this boat easy to travel in the lagoon and shallow patch reefs. Kayak and dinghy are also available for

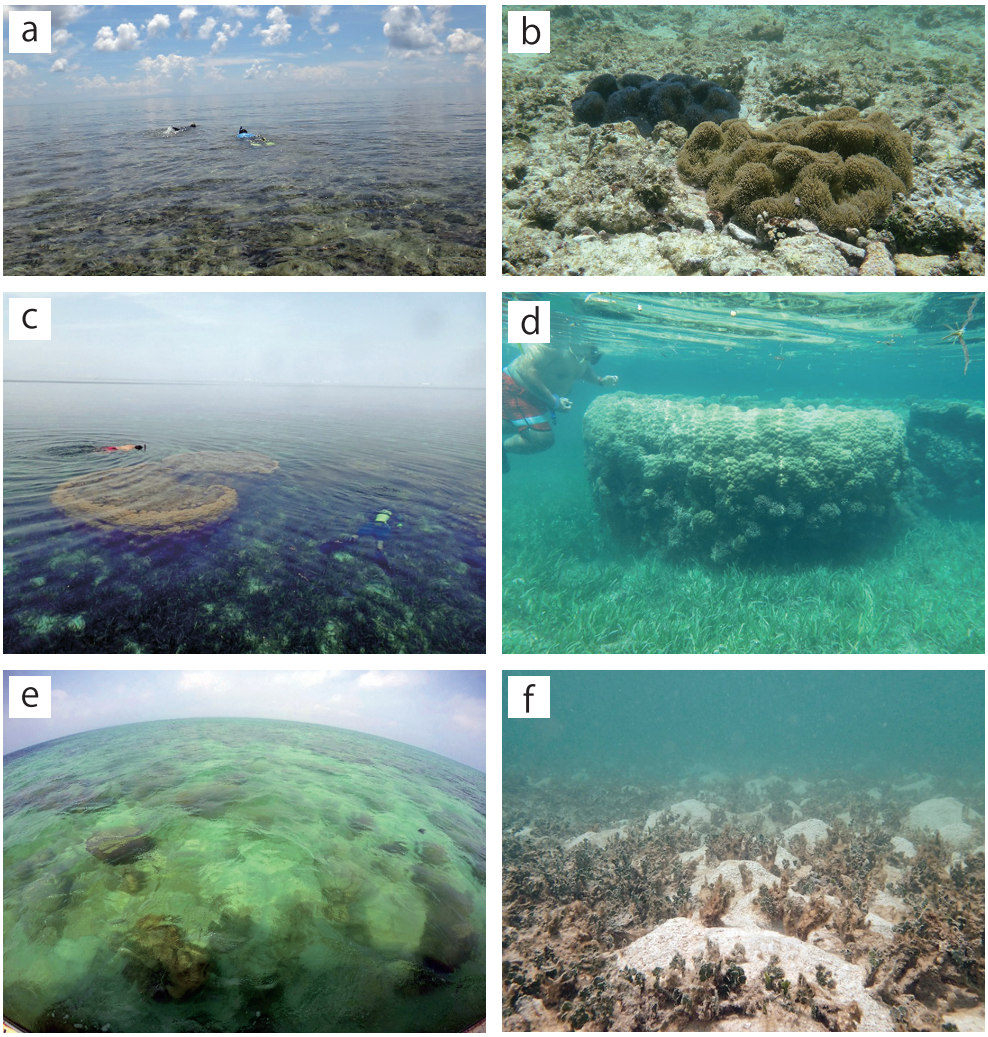


**Fig. 5. Reef crest.** a. outer reef crest. b. organisms growth on hard substratum. c. inner reef crest (reef flat) with micro-atoll distributed on seagrass bed. d. seagrass bed. e. corals on sand substratum after seagrass die-off. f. *Halimeda* spp. became dominant species on the sand area after the die-off event

trips in Dongsha Island small lagoon.

The information on facilities are available on the DARS website (http: //dongsha. mr. nsysu. edu. tw/files/11-1253-100. php?Lang = zh-tw). Scientists who are interested to Dongsha Atoll please contact our PI and co-PIs listed on the website http://dongsha.mr.nsysu.edu.tw/bin/home.php.

## References

Dai, C. F. (2004) Dong-sha Atoll in the South China Sea: Past, present and future ISLANDS of the WORLD VIII International Conference Kinmen Island (Quemoy), Taiwan

Dai, C.F. et al. (2013) 東沙環礁珊瑚生長關鍵因子之探討-珊瑚群聚組成分析暨生態圖鑑製作. Marine National Park Headquarters, Kaohsiung, Taiwan

Kao, H.M. et al. (2013) 東沙環礁礁台生物多樣性及棲地組成調查-以衛星影像應用於底質型態之分析. Marine National Park Headquarter, Kaohsiung, Taiwan

Liu, Y. et al. (2014) Acceleration of modern acidification in the South China Sea driven by anthropogenic CO2. Sci. Rep. 4, 5148; DOI:10.1038/srep05148.

Ren, H. et al. (2014) 遙測影像運用於東沙環礁棲地變遷及圖譜建置之研究. Marine National Park Headquarters, Kaohsiung, Taiwan

Wang, J. P. et al. (2013) 東沙海域大型獵食性生物資源調查-東沙島周邊檸檬鯊及其他軟骨魚類調查. Marine National Park Headquarters, Kaohsiung, Taiwan

Wang, Y. H. et al., (2007) The physical and ecological processes of internal waves on an isolated reef ecosystem in the South China Sea. Geophysical Research Letters 34: L18609


**Fug. 6. Dongsha Atoll Research Station (DARS) owned research vessels.** a. Atoll-I, b. Atoll-II, c. Atoll-V, d. Atoll-VI, e. kayak, f. dinghy.