SEA TURTLE SURVEY, MONITORING AND AWARENESS PROMOTION PROGRAMME IN MAINLAND CHINA

Final Report

Prepared By Wang Yamin and Li Wei

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Shandong University Email: wangyamin@sdu.edu.cn

Acknowledgment

Personnel involved in this project included:

Wang Yamin	Associate professor, Shandong University at Weihai
Zheng Fengying	Associate professor, Shandong University at Weihai
Zhu Lixin	Lecturer, Shandong University at Weihai
Sun Xiaohong	Lecturer, Shandong University at Weihai

Students

Li Wei	Wang Lijian	Tao Shiyu
Li Bin	Zai Mingyao	Jian Lihua
Wen Guoqin	Li Lele	Zhang Xuejing
Zhang Dianjiang	Li Haibo	Cheng Shaojie

Cooperating agencies

Oceanic and Fisheries Administrator of Guangdong Province

Hainan Fisheries Administration Commanding Center

Working Committee of Xisha, Zhongsha and Nansha Archipelagoes

Working Station at Sanya, Fisheries Bureau, Ministry of Agriculture

Oceanic and Fisheries Environmental monitoring Center of Guangdong Provine

Guangdong Oceanic and Fisheries Nature Reserves

Sea Turtle 911

Huidong Gangkou Sea Turtle Nature Reserve

Aquatic wildlife rescuing and rehabilitation center of Hainan province

Hainan Normal University

Hainan Provincial Fisheries Research Institute

South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences

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Table of contents

Introduction 6

Species composition and distribution 6

Threats to sea turtle populations in China 6

Current laws and legislations pertaining to sea turtle conservation in China 7

Chapter 1 Huidong Gangkou Sea Turtle Nature Reserve monitoring and satellite tracking of green and loggerhead turtles 9

1. Sea turtle monitoring in Huidong Gangkou Sea turtle Nature reserve 9

2 Satellite tracking post-nesting movement of female turtles 13

Chapter 2 Sea Turtle Nesting habitat Survey in Daya Bay and Xisha Archipelagos 17

1. Field survey in the islands and beaches within Daya Bay 17

2. Field survey in the remote islands of South China Sea 21

Chapter 3 Public awareness promotion and partnership building with local sea turtle conservation NGO 37

1. Public awareness promotion 37

1.1 Fishermen 37

1.2 Market vendors 39

1.3 Local fishery enforcement 39

1.4 Tourists 40

2. Partnership establishment with Governmental agencies and local Non-governmental organizations 41

2.1 Cooperation with governmental organization 41

2.2 Cooperation with sea turtle conservation NGO - Sea Turtle 911, in Hainan province 42

Chapter 4 Improving student learning in sea turtle conservation techniques 43

Reference 44

Appendix 1 46

Consensus of sea turtles nesting, tagging, hatchling and releasing in Huidong Sea Turtle Nature Reserve from 1985 to 2008 46

Appendix 2 47

Investigation form of the distribution of sea turtles in South China Sea 47

List of Figures

Fig. 1 Map of the eight cities investigated in Hainan province

Fig. 2 Changes in the number of female turtles ashore and nests from 1985 to 2008

Fig. 3 Changes in the total number of green turtle eggs and successful hatchlings from 1985 to 2008

Fig. 4 Changes in the percentage of false crawls from 1985 to 2008

Fi.g 5 Changes in the number of newly tagged turtles from 1985 to 2008

Fig. 6 Changes in the hatching success rate of sea turtle eggs (natural and artificial incubation)1985 to 2008

Fig. 7 Satellite tracking map of 3 female green turtles in 2001

Fig. 8 Satellite tracking map of 7 sea turtles' movements after being released in Zhuhai, 2009

Fig. 9 Historical sea turtle nesting sites and our survey sites in Daya Bay

Fig.10 Numbers of suspected sea turtle nesting pits in 10 islands of Xisha Archipelagos

List of Tables

Table. 1 Information of 7 female turtle tracked by satellite telemetry in 2009 at Zhuhai

Table. 2 Numbers of ashore turtles, nesting pits and eggs spotted in Daya Bay from 1987 to 2005

Table. 3 Scale of marine aquaculture in Daya Bay from 1985 to 2004

Table. 4 The amounts of sea turtle captured in South China Sea from 1959 to 1988

Table. 5 The amounts of sea turtle captured in South China Sea from 1959 to 1988

Table. 6 Abundance of zooplankton groups in Northeast water of Xisha Archipelagos (0.505mm mesh size)

Table. 7 Abundance of zooplankton groups in Northeast water of Xisha Archipelagos (0.160mm mesh size)

Table. 8 Dominance of 9 different zooplankton groups (0.505 mm mesh size)

Table. 9 Dominance of 10 different zooplankton groups (0.160 mm mesh size)

Table. 10 Diversity Index of zooplankton(collected by net of 0.505 mesh size and 0.16 mesh size)

Table. 11 Exact locations of 13 suspected nesting pits in South Shoal

Table. 12 Exact locations of 6 suspected nesting pits in Middle Shoal

Table. 13 Exact locations of 3 suspected nesting pits in North Shoal

Table. 14 Exact locations of two suspected nesting pits in South Island

Table. 15 Exact locations of 6 suspected nesting pits in North Island

Table. 16 Exact locations of one suspected nesting pits in West Shoal

Table. 17 Exact locations of 14 suspected nesting pits in Woody Island

Table. 18 Exact locations of 4 suspected nesting pits in Woody Island

List of Plates

Plate. 1 Huidong Gangkou Sea Turtle Nature Reserve

Plate. 2 One nesting green sea turtle on the beach of nature reserve in 2010/ Photo by nature reserve

Plate. 3 Green and loggerhead turtles equipped with satellite tracking transmitters and to be released in Zhuhai

Plate. 4 Plate 4 Sandy beach of Pinghai Bay

Plate. 5 Beach of Fuchao Bay

Plate. 6 Plate 6 Dongchong Beach

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Plate. 7 Dalajia Island

Plate. 8 Xiaolajia Island

Plate. 9 Beach condition of South Shoal, Xisha Archipelagos

Plate. 10 Beach condition of Middle Shoal, Xisha Archipelagos

Plate. 11 Beach condition of North Shoal, Xisha Archipelagos

Plate. 12 Beach condition of South Island, Xisha Archipelagos

Plate. 13 Beach condition of Middle Island, Xisha Archipelagos

Plate. 14 Beach condition of North Island, Xisha Archipelagos

Plate. 15 Beach condition of West Shoal, Xisha Archipelagos

Plate. 16 Beach condition of Zhaoshu Island, Xisha Archipelagos

Plate. 17 Beach condition of Woody Island, Xisha Archipelagos

Plate. 18 Beach condition of East Island, Xisha Archipelagos

Plate. 19 Sea turtle conservation brochure that we designed

Plate. 20 Awareness promotion activities in fishing port of Qionghai, Hainan

Plate. 21 Awareness promotion activities in Dongmen food market, Sanya

Plate. 22 Awareness promotion activities in Fishery enforcement in Hainan province

Plate. 23 Awareness promotion activities for the tourists in Hainan province

Plate. 24 Sea turtle tissue sampling for DNA analysis

Plate. 25 Sea turtle to be released in “Beibu gulf marine biological resources proliferation and release festival”

Plate. 26 Sea turtles cultured in Sea Turtle 911 for rehabilitation

Plate. 27 Participation in “Workshop on regional cooperation to address direct capture of sea turtles”

Introduction

Species composition and distribution

Five out of seven species of sea turtles are found in China – green (*Chelonia mydas)*, hawksbill (*Eretmochelys imbricata)*, loggerhead (*Carette carette)*, leatherback (*Dermochelys coriacea)* and olive ridley (*Lepidochelys olivacea)*. Most are documented from the South China Sea, with the greatest abundance reported from Xisha and Nansha Archipelagos and Hainan Island. Historically, estimated 14,000 to 40,000 sea turtles migrated to the Xisha Archipelagos (a group of low coral islands and reefs in the South China Sea, 280 km southeast of Hainan Island) and to the Nansha Archipelagos annually, whereas about 2300 to 5000 migrated to Hainan Island and Guangdong Province. These migrations are species assemblages, mixed by 87% Green, 10% Hawksbill, and 3% other species (Wang, 1993).

Sea turtle populations have been sharply reduced in China over the past 50 years. Fifty years ago there were several identifiable sea turtle nesting sites at Hainan Island, e.g. Qionghai, Wanning and Dongfang, and in Guangdong Province, e.g. Nan'ao, Huilai, Haifeng, Huidong, Wanshan, Taishan, Yangjiang, Dianbai. Today**,** only Huidong Gangkou Sea turtle Nature Reserve is known to have sea turtle nesting in China**.** The only hope is to survey some remote and desolate islands in the South China Sea, which may still have potential nesting beach.

Threats to sea turtle populations in China

The major factors threatening our sea turtle populations are: (1) fisheries accidental and opportunistic capture; (2) harvesting of nesting females and the collection of eggs for sale and consumption; (3) loss of foraging and nesting habitats due to coastal development. Today's population remains only a fraction of what it once was, but there is still a general lack of awareness of its endangered status among our national populations and domestic market for sea turtle products is substantial, although it is strictly prohibited by national laws. Here we would like to present the results of our preliminary investigation into the illegal trade of sea turtle products in Hainan - the trading center of China.

We chose eight cities: Haikou, Wenchang, Qionghai, Lingshui, Sanya, Dongfang, Danzhou and Lingao, based on the background information we collected, including sea turtle bycatch and stranding records, public reports on sea turtle illegal trade by medium and fishery enforcement.

Market and Source

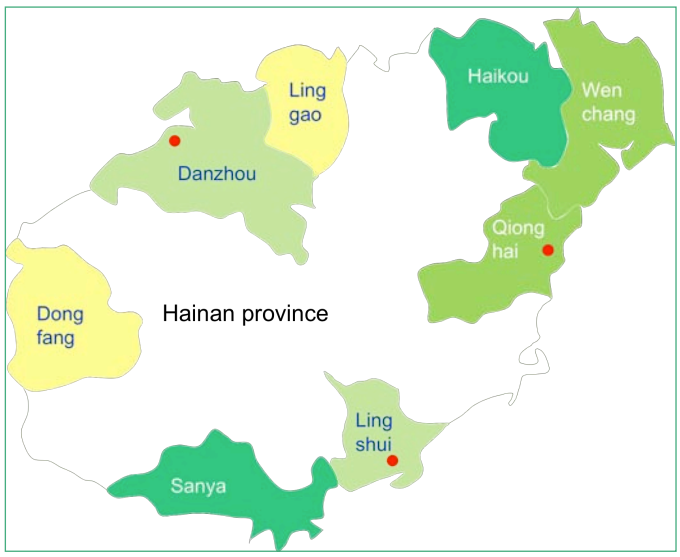

Fig. 1 Map of the eight cities investigated in Hainan province

As the capital of Hainan, Haikou has relatively strict law enforcement. Sea turtle products were not common, but we still saw a few hawksbill turtle specimens, live turtle hatchlings in the pet stores and green turtle meat in Dongmen Market. Sanya is the biggest tourism destination in Hainan province, and was also found to be the most thriving market for sea turtle trade. However, only hawksbill turtle products could be found in stores and also it was hard to distinguish the real ones from fakes. Other turtle products such as stuffed specimens could only be found in the private premises of the owners. There were three big shops dealing with sea turtle products. One shop was far from the center of Sanya city, about 50miles away. The other two shops were in Huichun, which had the longest history and complete sales network,

stretching to Beijing and Shanghai, one of which had been reported to the local authorities by a tourist and seized by local fisheries enforcement.

Although Hainan and Sanya own biggest markets for sea turtle products, the products originated from other places. The most important source is Qionghai city, especially Tanmen Town. The reason for its large amount of supply was due to their specific activities of hawksbill turtle capture. Twice a year, 3-month trips were undertaken in which they travel through the sea area between Malaysia and Philippines, and even to islands near Australia. During this period of time, sea turtles are stored with preservatives. Another city which has specific activities of direct capture is Wenchang, and the target was also hawksbill turtles. As far as we know, all the specimen here were processed by the fishermen themselves.

Apart from direct captures, Vietnam is also an important supplier, turing Lingshui and Danzhou into another trading centers. Fishermen in Lingshui often exchange their agriculture products for hawksbill shell from fishermen of Vietnam, and Baimajiang fishing harbor in Danzhou is the major entrance of hawksbill turtle specimens and shells from Vietnam.

Prices

The main market demands in sea turtles are for hawksbill turtles, with green turtles occurring as bycatch, not main target. The main reason can be found in their price difference. The specimen of hawksbill turtles fetch RMB 1,000 to 8,000, varying according to source region and time, but specimens longer than 70cm can reach up to RMB10,000, while green turtle specimen are always between RMB1,000 to 5,000. Hawksbill turtle shell can also be made into accessories whose price range from several to several hundred RMB. The shell of green turtles never reaches that high. Demand for green turtle hatchlings for aquarium trade is expanding in some big cities of China. The green turtle hatchings cost several hundred RMB each. Sea turtle meat is from green turtle caught incidentally and sold by fishermen to the food marker vendors at RMB 14-16 per kg and sold to consumers at RMB 90 per kg at the market.

Trade processes

Apart from jewelry made from hawksbill turtle shell. customers require intermediaries for access to turtle products. An order can be made for a specimen of any size required. After confirming the products, the business transection can be completed directly or by mail. As far as we know most sea turtle products were transported by one company called “Lulutong”. Turtle specimen were concealed under dried fish or squid and sent to other provinces labelled as sea food.

Current laws and legislations pertaining to sea turtle conservation in China

International treaties to which China has acceded

China is a signatory state to the CITES and Bonn Convention.

Laws and regulations issued by the government of China

1) Fisheries Law of the People’s Republic of China (1996) - The state carries out key protection in aquatic wild animals which are valuable or in severe danger in order to prevent their extinction(Including sea turtle). Protection shall be provided to rare aquatic animals whose capture is banned by the state. In case there is a special need to catch them, the matter shall be handled in accordance with the relevant laws and regulations.

2) Laws of the People’s Republic of China on the protection of wildlife (1998) - The state shall protect wild life and the environment for its survival, and shall prohibit the illegal hunting, catching or destruction of wildlife by any unit or individual. In nature reserves and areas closed to hunting, and during seasons closed to hunting, the hunting and catching of wildlife and other activities which are harmful to the living and breeding of wildlife shall be prohibited. If anyone, in violation of the provisions of this Law, sells,

purchases, transports or carries wildlife under special state or local protection or the products thereof, such wildlife and products and his unlawful income shall be confiscated by the administrative authority for industry and commerce and he may concurrently be fined.

3) Protection of Breeding Habitats of Fishery Resources Ordinance(1979)
4) Enforcement of Fisheries Law(1987)
5) Enforcement of Aquatic Wildlife Protection Law (1993)
6) Regulations on Nature Reserves(1994)
7) Management Measures on Aquatic Flora and Fauna in the Nature Reserve(1997)
8) Special Measures on Aquatic Fauna(1996)

Although all five species of sea turtles has been included in the list of national second class protected animals under the Law of the People's Republic of China on the Protection of Wildlife, there are no specific regulations specifically pertaining to the conservation of sea turtles.

A number of measures has been undertaken in the recently years on sea turtle conservation, including setting up nature reserve, regional and international cooperation on scientific research and public education. However, insufficient information is still the major obstacle to the effective management of sea turtles in China (Cheng 1998). For instance, there is a lack of un-to-date information on the distribution of sea turtles in China, as well as their nesting and foraging habitats(Chan et al 2007). Except well-known Gangkou sea turtle nature reserve, very few studies has been conducted in Dongsha, Nansha and Xisha Archipelagos, which are the most important habitats in the South China Sea according to historical records. Moreover, the fact that markets for sea turtles products was still substantial indicates a urgent need for more efforts on public awareness promotion and fisheries enforcement. Also being a group of transboundary species, more regional and international cooperation is needed for the long-term conservation of sea turtles in China (Chan et al.,2007).

In responds to these conservation needs of sea turtles in China and to fill the information gap, the author initiated this sea turtle survey, monitoring and public awareness promotion programme in China in 2008. This project is made possible by the financial support of U.S. Fish and Wildlife Service, Department of Interior. It is also supported by a partnership of governmental agencies at different levels, environmental organizations and student volunteers.

This project is comprised of four parts:

1) A continued monitoring of Huidong Gangkou Sea Turtle Nature Reserve to analyze the trend of nesting female turtles; research on the foraging grounds of green and loggerhead turtles by means of satellite tracking;

2) Surveying and identifying remaining sea turtle nesting habitats along Guangdong coastline and in Xisha Archipelagos in the South China Sea, providing scientific basis for setting new sea turtle nature reserve;

3) Education to raise public awareness, targeting fishermen, food market vendors, fisheries enforcement, and tourists in Hainan province, and partnership establishment with governmental agencies and environmental organization;

4) Improving student learning in sea turtle conservation techniques and international communication on sea turtle issues.

Chapter 1 Huidong Gangkou Sea Turtle Nature Reserve monitoring and satellite tracking of green and loggerhead turtles

1. Sea turtle monitoring in Huidong Gangkou Sea turtle Nature reserve

1.1 Introduction

Huidong Gangkou sea turtle nature reserve (22°33′15" － 22°33′20 " E, 114°52′50"－ 114°54′ 33" N) is situated in the southernmost tip of Renping peninsular, the border of Daya Bay and Honghai Bay, Huidong County, Guangdong province. It's also called "Sea turtle Bay" due to its significance as sea turtle nesting habitats. The total area of this reserve is 18km^2, with 2km^2 of terrestrial area and 16km^2 of sea area.

Reserve has a typical subtropical marine climate. The average air temperature is 22.3°C, with highest record of 37°C and lowest 4.5°C. Annual average rainfall is 1402 to 2085mm, concentrating in April to September. The temperature of surface sea water ranges between 22°C to 26°C, averaged a variance of 5.55°C between day and night. The sea water transparency is 2.5 to 3.5m. The beach for turtle nesting is flat with incompact sand grains of 0.05 to 0.2 diame-ter. Beach vegetation compo-sition is relatively simple. *Ipomoea pescaprae* grow in block shape before high-tide line, followed by common shrubs and arboreal forest, mainly *Casuarina equisetifo-lia*, making this beach a quite and hidden place. Sea areas around the reserve is known to support a large variety and abundance of biological re-sources. In short, environ-mental conditions of this nature reserve is quite suit-able for nesting female tur-tles.

Plate1 Huidong Gangkou Sea Turtle Nature Reserve

Gangkou sea turtle nature reserve is the only confirmed nesting habitat for green sea turtles now along the 180 km coastline of mainland China. Except routine monitoring during nesting season, it also carries out research work such as artificial incubation and culture techniques and organizes education activities. We have initiated a long-term cooperation with the administrative department of the reserve, with the common aim to analyze the trend of green turtle populations in China and evaluate their threatening factors in order to protect sea turtle resources in China. Following content summarized the monitoring results in the past 25 years.

1.2 Method

Staring from April, the beach was consistently monitored at daily and nightly basis by staff of sea turtle nature reserve and student volunteers in search of turtle crawls and nesting activity. When encountered, the stuff would quietly follow the sea turtles and observe the digging of the nest, which prepare for conducting egg counting. During this period human induced pressure such as illuminations are reduced into minimum. After laying eggs, the female sea turtle was checked whether or not she has been tagged. New encounters were fitted with sequentially numbered mental tag either on the hind flipper (leatherback) or front flipper (other species). Then all nesting turtles were measured for carapace length and width, weight. The nest location, number of eggs deposited and other general conditions were also recorded. Microenvironmental factors such as sand moisture and temperature were examined. Turtle eggs were left in place other than relocated for artificial incubation

Plate 2 One nesting green sea turtle on the beach of nature reserve in 2010/ Photo by nature reserve

unless they were laid below the high tideline that would receive frequent tidal inundation. Monitoring was also conducted in the protected sea area to expel fishing boats, which may cause mortality, bycatch or disorientation of sea turtles.

1.3 Results and discussion

Only green turtles is known to have nested within sea turtle nature reserve. We made a detailed inventory of total landing green turtles, newly tagged turtles, nests, eggs, hatchlings and released turtle numbers in Gangkou Sea Turtle Nature Reserve from 1985 to 2008.

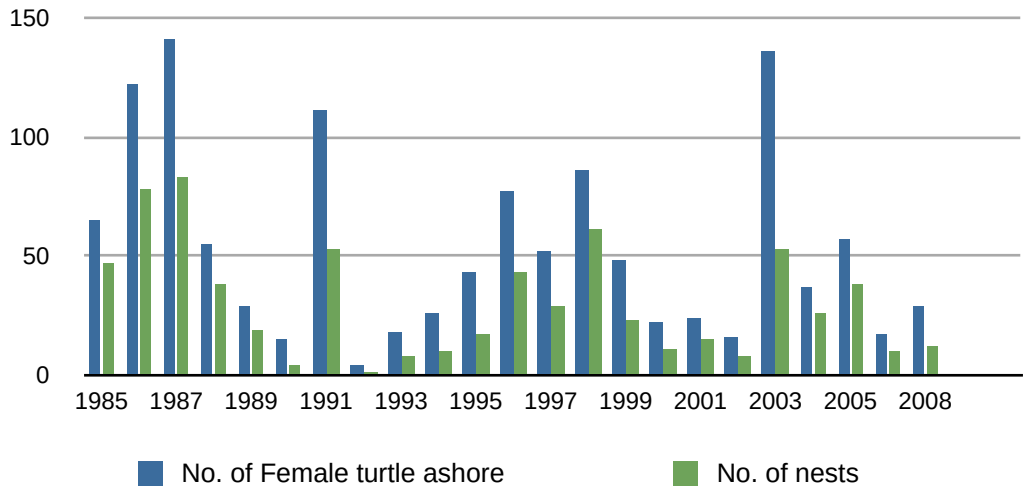

Fig.2 Changes in the number of female turtles ashore and nests from 1985 to 2008

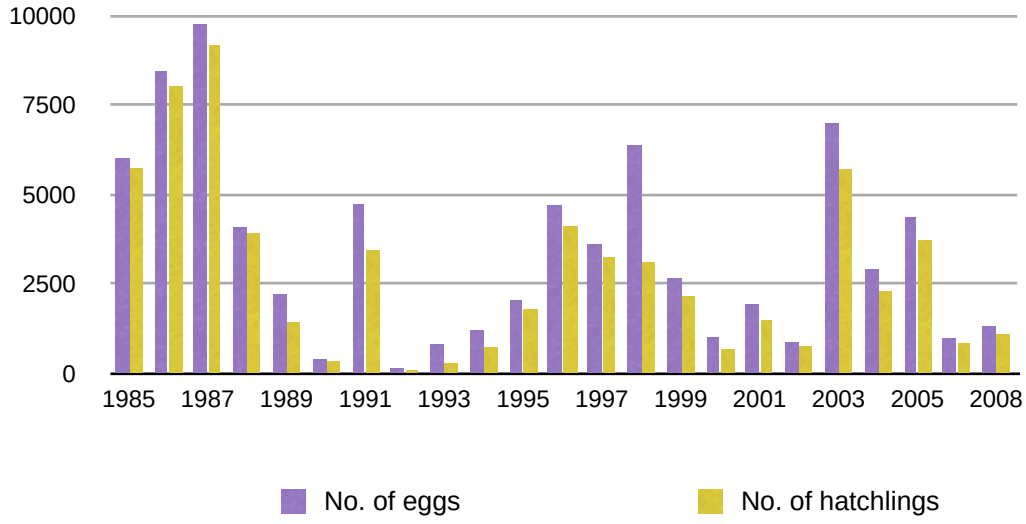

Fig.3 Changes in the total number of green turtle eggs and successful hatchlings from 1985 to 2008

In the past 25 years, there is a considerable year to year variation in the female turtles coming shore, with largest record of 141 in 1987 and 0 records in 2006 and 2009. Averaged annual number of landing female

turtles has declined from 57 for years between 1985 to 1995 to 50 for years between 1996 to 2005, however, it's not significant (P>0.05). 2006 and 2009 were found to have no records of landing female turtles. However, it did not necessary indicate that this beach became an less important rookeries for green turtles in China. There may be gap years for they need about 20-50 years for green sea turtles to reach maturity. And so far as we know, there's already 8 females coming to nest here by July 7 this year. However, it's also possible that there are some other factors causing this phenomenon, e.g. direct or incidental capture before entering the protected area, offshore human disturbance, boat collisions. Investigation should be carried out to identify whether they are any increasing threatening factors inside and outside the protected area of sea turtle nature reserve.

"False crawls" have been observed every year. It means that females laden with eggs emerge from the surf, but decide no to nest. For beach in the nature reserve, in average about 47% of all emergences were non-nesting. This percentage of non-nesting behavior was comparable to those observed in some of other areas. The reasons for false crawls are not understood, but it may be caused by sand texture and compactness, erosion processes that affect beach width and slope, and with additional development on this island, an increase in human activities on the beach at night. The frequency of false crawls, therefore, may be an indicator of changes in beach suitability to nesting turtles. If it is the case, the decrease of false crawl from 49.86%, which is the average value from 1985 to 1995, to 39.19%, the average value from 1996 to 2006, may suggest that the environment of nature reserve become more suitable for green turtles, probably due to the improved management of Gangkou sea turtle nature reserve.

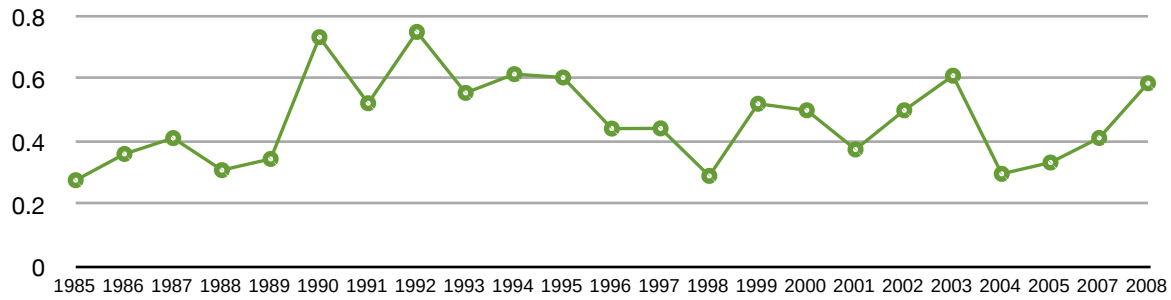

Fig.4 Changes in the percentage of false crawls from 1985 to 2008

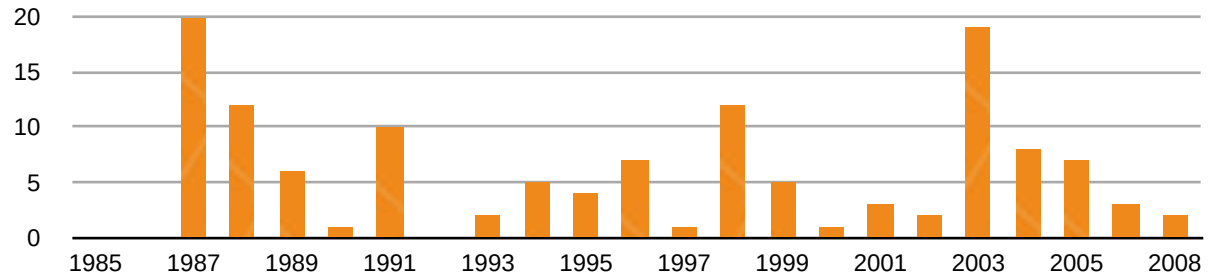

Fig.5 Changes in the number of newly tagged turtles from 1985 to 2008

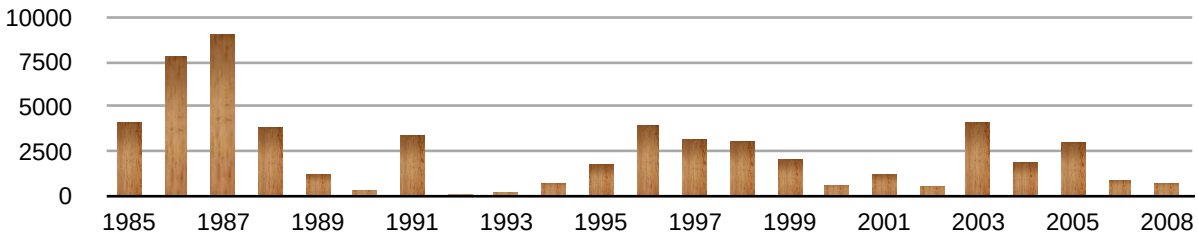

Fig.6 Changes in the number of released green turtles from 1985 to 2008

Clutch size was calculated by averaging the number of eggs counted per nest from post-hatch nest excavation. Mean clutch size was 112 eggs (97-132, N=23). This mean clutch size was exactly the same with one research conducted in a beach of Lattakia, City of Syria and comparable to results in other researches. Some researchers has found that size of the clutches laid in the later season was larger than that in the early breeding season. Due to inadequate data on each day's clutch size in the early years, we haven't compared the size difference between early and later seasons.

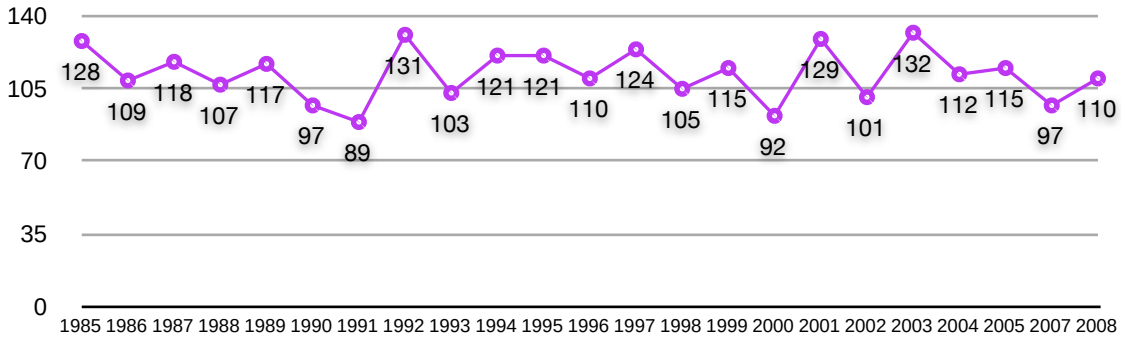

Fig.7 Changes in the average clutch size of green sea turtles from 1985 to 2008

The mean hatching success rate was 78.5% (34%-96%, N=23). Because we do not know the percentage of hatchlings that came from in situ incubation or artificial incubation, we cannot compare the successful rates between these two methods. However, according to the records of nature reserve, for in situ hatching, the highest successful rate was 97.3% and lowest 0%, 46.4% in average. Mean successful rate by artificial incubation can reach 82.13%, with highest of 94% and lowest 66% (Chen, et al. 2007). Although artificial incubation produced higher mean successful hatching rates than in situ incubation, it is conducted only when the nests are in unsuitable conditions, e.g lower than high-tide line. Moreover, artificial incubation requires financial support and techniques and should be based on well understanding of microenvironment needed for successful incubation, e.g. temperature, sand moisture and ventilation.

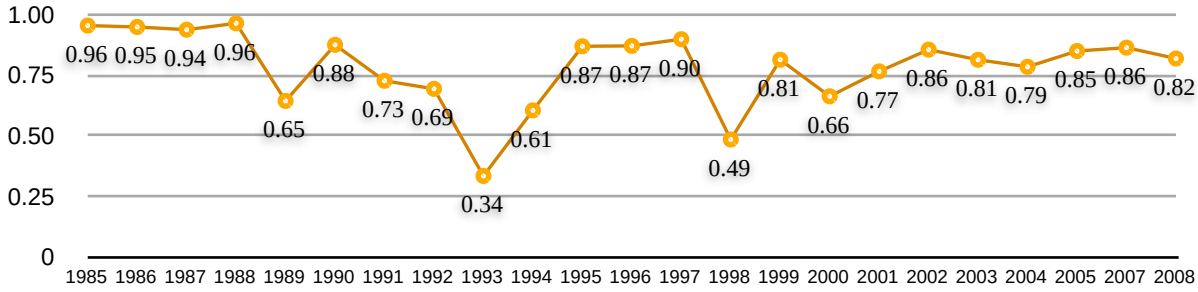

Fig.8 Changes in the hatching success rate of sea turtle eggs (natural and artificial incubation)1985 to 2008

In conclusion, we have not observed a clear trend of nesting green turtle population in the beach of Gangkou Sea Turtle Nature Reserve since year to year variety is large since the monitoring began. Clutch size and hatchling success rates are within the normal range as the results found in other areas of the world. In the past few years, phenomenon of no nesting turtles in the entire season was observed. Although it may be a gap year of turtle nesting, it may be also an indicator of intensified threatening factors. It is worthy of note that this year (2010) the staff of the nature reserve were endowed with the authority of fishery enforcement and able to better manage the sea areas around the nesting beach, e.g. driving off fishing boats. And this year's nesting individual has largely increased. Whether it's coincidence or not requires further investigation.

2 Satellite tracking post-nesting movement of female turtles

2.1 Introduction

Sea turtles are highly migratory animals whose life history typically span large temporal and spatial scales (B. J. Godley, 2007). In most cases, the location of their feeding grounds and migratory paths is not known (Anonymous, 1994). However, this information is getting increasingly important in perspective of conservation issue. Adult turtles are often harvested or incidentally captured during their migration journey, thus understanding their routes can help to provide scientific basis of reducing fishing activities in the hotspot of interaction between turtles and fisheries. Historically, marine turtles have been tracked with flipper tags (Caldwell, 1962), tethered floats (Carr,1974), and radio beacons (Carr et al.1972). Flipper tag returns rely on the chance returns by others and make a study very unreliable. Tethered floats and balloons are extremely expensive for they require a continuous support vessel to maintain visual contact(TIMKO, 1982). It was until the late 1980s that the development of satellite tracking using Argos System allowed the first in-depth studies of animal move patterns (Parmelee et al. 1985, Duron- DeFrenne 1987, Fancy et al. 1988).

Service Argos, a joint venture between the Centre National d'Etudes Spatiales (CNES, the French space agency), the National Aeronautics and Space Administration (NASA, USA) and the National Oceanic and Atmo- spheric Administration (NOAA, USA), has emerged as the predominant satellite-based system for tracking wildlife (Argos 1996). Polar orbiting satellites can locate Platform Terminal Transmitters (PTTs) , allowing the generation of geographic location and limited transmission of sensor data (M.S. Coyne, 2005). There are several advantages of utilizing this tracking method. Firstly, satellite tracking allows us to follow turtles in near real time and find out what routes they take and what nesting sites they choose, in global range(B. J. Godley, 2007). Secondly, it integrates the marine animal movement with informations of both individuals and environmental factors, such as speed, current, water depth and temperature, providing behavioral and other important data that contribute to the sound management decisions. Moreover, in conjunction with environmental, geomagnetic and other factors, tracking data will provide insight into the navigational mechanisms of sea turtles(Balazs and Ellis, 2000). Thirdly, tracking data can be gathered quickly and data collection, management and mapping can be undertaken in a standardized way by the Satellite Tracking and Analysis tool(STAT) (B. J. Godley, 2007).

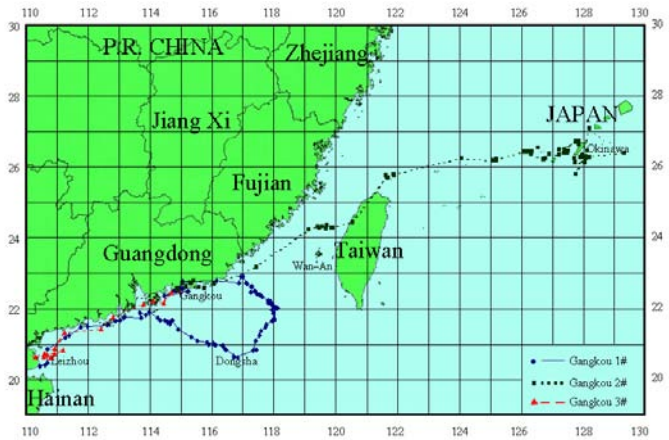

Fig. 9 Satellite tracking map of 3 female green turtles in 2001

Sea turtle post-reproductive movement tracking in China was first conducted in 2001 by Gangkou Sea Turtle Nature Reserve. Three female green turtles were attached with ST-6/A-1600satellite transmitter, which was used to conduct real-time location tracking, as well as collect information of water temperature and depth. This study showed 3 different routes selected by three green turtles. Gangkou No.1 first swam to the open ocean, but then turned back and swam along the coast of Guangdong to the sea areas around Hainan Province. While Gangkou No.3 journeyed on a direct path to the southernmost tip of Guangdong province, close to Hainan. Gangkou No.2, on the contrary, crossed the Taiwan strait, stayed in the western coast of Taiwan for a while and then headed northeast directly to the Okinawa Islands, Japan. The average minimum speed of No.1 was fastest, with 30% of time keeping 2-3km/h and 20% of 3-4m/h. Turtle No. 3 spent about 38% of time keeping 0-1m/h but also stayed at 2-3m for about 32% of time. Tracking the depth of green turtle No.1 indicated that it was at the depth in average between 8m and surface for 45% of the time. (Wang Huajie, 2002)

2.2 Method

We made a cooperation with Guangdong Oceanic and Fisheries Environment monitoring Center to conduct this satellite tracking research. 7 female turtles, from adults to juveniles were released and tracked. The largest turtle was an female green turtle over 100 years old and weighted 140kg. There were four green sea turtles, including 2 adults and 2 juveniles and three young female loggerheads. They were all once caught incidentally by fishermen and then sent to sea turtle nature reserve for rehabilitation. This was the first time that loggerhead in China was tracked by satellite telemetry. Transmitter (platform transmitter terminal, PTT) linked to the Argos System was fixed on the top of each turtle's carapace. The longest tracking period was estimated to be two and half year. Besides tracking the location of movement, the transmitters also sent information about the turtle's diving parameters, e.g. water temperature and depth. The turtles were released in Zhuhai at about 10:30 on 10 July, 2009 (Beijing standard time). Then the turtles were located using the Argos System and the migration routes were reconstructed on the basis of quality controlled location data. In the analysis of the turtles' routes, we considered they had reached their feeding grounds when they were localized for more than 1 month in the same limited area and displayed a characteristic diving pattern consisting in few and long submergences(Papi, 2003). We aimed to obtain information about its migratory route and foraging area destination.

Table 1 Information of 7 female turtle tracked by satellite telemetry in 2009 at Zhuhai

NAME	SPECIES	WEIGHT(KG)	SIZE(CM)	ARGOS ID	PTT
H1	Adult green turtle	140	98*94	94967	SPLASH AM-L203F
H2	Adult green turtle	110	84*78	94969	SPOT5 AM-S244A
H3	Young loggerhead	80	79*76	94968	SPOT5 AM-S244A
H4	Young loggerhead	80	78*74	94970	SPOT5 AM-S244A
H5	Young loggerhead	75	76*74	94971	SPOT5 AM-S244A
H6	Juvenile green turtle	10	42*42	95903	SPOT5 AM-174-00S
H7	Juvenile green turtle	10	42*42	95902	SPOT5 AM-174-00S

2.3 Results and discussion

This satellite tracking map showed the migratory routes of 7 turtles(H1 to H7) from July 10 to December 21, 2009. Almost all turtles immediately departed the location they released, which was the mouth of Pearl River, swimming in a northern direction and primarily along the coastal waters of Guangdong Province, except H6, which spent about one month heading south and then transmissions ceased abruptly on August 1. When reached close to the boarder between Guangdong and Fujian province, turtles seemed to head to distinct directions. Turtle H2 swam to southwestern edge of Fujian and then lost transmissions on August 3. H7 journeyed on a direct east path, turned northeast on July 31 and reached the southernmost part of Taiwan and then lost transmissions on August 12.

Turtle H1 swam along the coastline of Guangdong province, then stayed at the waters in the boarder of Guangdong and Fujian for about 15 days before it turned southeast at the direction of southern Tainan, but lost signals on August 23. Turtle H5, chose a northeast path along the coastline of Guangdong province, crossed half of the Taiwan strait, and migrated to the eastern coast of northern Taiwan. It didn't stay here for long but turned back and resided in the middle of Taiwan Strait for nearly four months until the last tracking date of this map, which indicated that it has found the foraging habitats in this area.

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Plate 3 Green and loggerhead turtles equipped with satellite tracking transmitters and to be released in Zhuhai

H3, one female young loggerhead turtle, first swam east to the direction of southern Taiwan, then turned back, lingering along the coastal area of Guangdong province, finally arrived the sea area close to the place where it was released on December 17, which indicated that H3 has found its foraging grounds in the coastal area of Guangdong Province. H4, another young loggerhead turtle displayed a quite different journey from all other 6 turtles: it didn't show to stay at certain areas for long but directly swam northwesterly and crossed Taiwan strait on August 13. Without orient immediately towards north, it first headed easterly until reached Diaoyu Island of China on August 19, then swam back towards western direction until August 21. Then it headed northeast, which seemed to be the direction of Japan according to the last fix on October 9, and finally lost transmission. The migratory path of this turtle in China was very similar to Gangkou No.2, the tur-

tle which was tracked in 2001.

4 satellite transmitters lost signals definitely only one month after releasing, a time well before the normal duration. The reason for this has no simple answers. One possible reason is the drop off of the transmitters due to bad attachment or mortalities of turtles, for nature or anthropogenic reasons. It's worthy of note that after being released, almost all turtles swam in the neritic waters along the coast of Guangdong from Pearl River Estuary. Sea traffic in this area is especially intense, posing severe threats to these turtles. And although the time that turtle were released coincided with closing fishing season, there were still plenty of illegal fishing boats working at all days. There has been several cases before that turtles released here was found stranded as well as injured on the beach after one or several days, with obvious traumas associated with fishing activities. Therefore, these turtles' movement would make them vulnerable to commercial fisheries and maritime transportation. The lost of satellite transmissions thereby may be an indicator of their conditions which was not good.

According to former records , many post-nesting movement of sea turtles include migration to Japan, Okinawa Islands in particular, where is the known important feeding ground and breeding area for many sea turtles. This is also observed in last two satellite tracking results, one for green turtle and one for loggerhead turtle. During their journey, and also other turtles' migration routes, Taiwan Strait (117°10 ～125°00 E，22°00 ～27°10 N) is an important pathway and also some of them visited eastern waters of Taiwan, probably on migration via the main Kuroshio Currents. There are many upwelling regions in the Taiwan Strait, which bring water with high extents of nutrients and create 5 major fishing grounds of a total area of 213, 237 km^2 (Dai, 2005). Intensive fishing activities in this area poses a big threat to migrating sea turtles and former studies has revealed that substantial capture of sea turtles by setnet fisheries occurred in this area(Cheng, 1997). More researches are needed to elucidate the seasonal pattern and migratory corridors in Taiwan Strait for sea turtles, which could provide scientific information for further conservation management to reduce fishing activities in certain time at the area where sea turtle migration occurs.

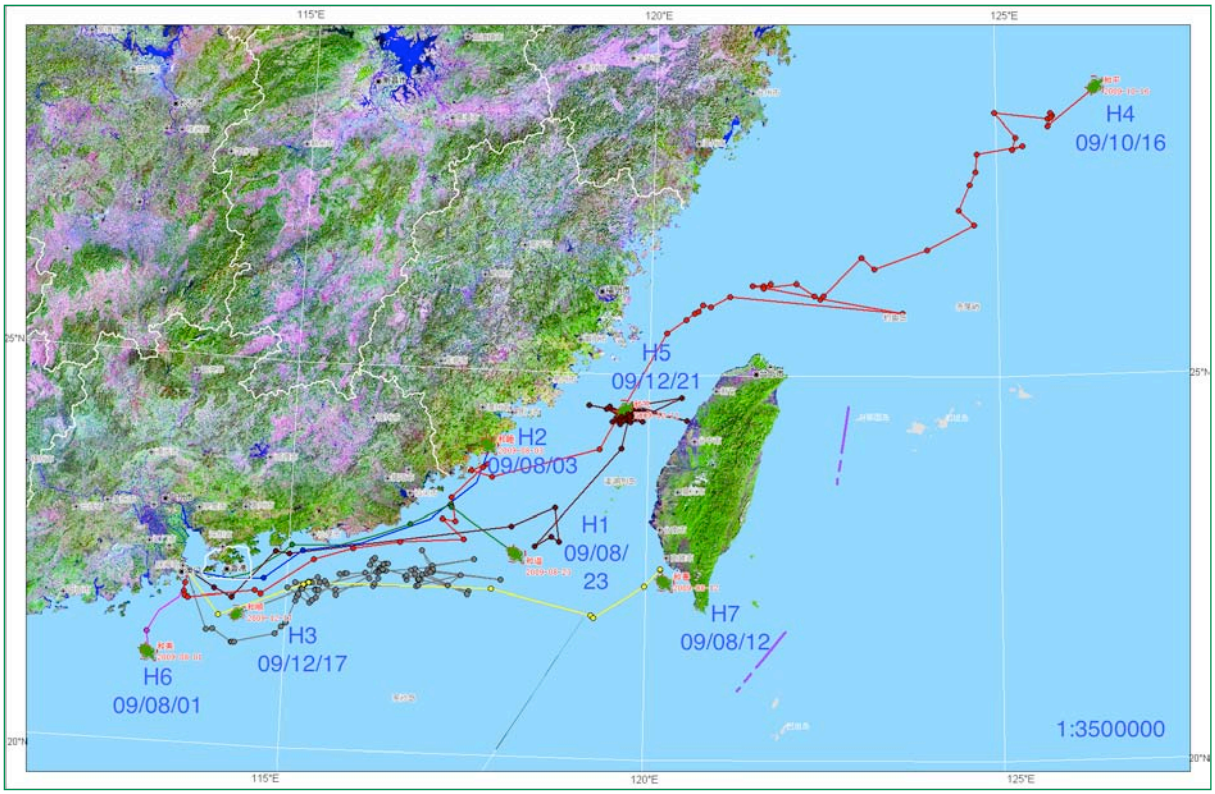

Fig. 10 Satellite tracking map of 7 sea turtles' movements after being released in Zhuhai, 2009

Chapter 2 Sea Turtle Nesting habitat Survey in Daya Bay and Xisha Archipelagos

1. Field survey in the islands and beaches within Daya Bay

1.1 Introduction

The Daya Bay (113°29′42" － 114°49′42 " E, 23°31′12 "－ 24°50′ 00 " N) is a semi-enclosed bay located in the northern South China sea, east to the Pearl River Estuary. It's one of the most important subtropical bays in China, boasting in great richness of biological resources and biodiversity. According to historical records and literature, it also creates the most important habitats for sea turtles in the mainland China. There are many flattened and wide beaches comprised of fine sand along the coastal area, providing plenty of suitable nesting habitats for female turtles. All nesting turtles recored were green sea turtles, but hawksbills, loggerheads, leatherbacks and olive Ridley had also shown up in the waters of Daya Bay.

However, human disturbance, coastal development in particular, has been intensified in the past few decades. Beaches suitable for turtles become more and more rare. Fig. 9 shows the existing records of sea turtle sightings in the past 15 years, including foraging, mating, nesting ones and also turtle eggs. This eastern coast of the Daya Bay, the last potential habitat for nesting turtles, are now crowed by aquaculture factories, power plant, all-purpose wharf and holiday resorts. The aboriginal environment of most beaches have changed and former researches indicated that the ecosystem of the Daya Bay is undergoing rapid deterioration, with some parts eutrophicated, biodiversity and abundance of biological resources declined and coral bleaching appeared.

Fig. 11 Historical sea turtle nesting sites and our survey sites in Daya Bay

Sea turtle sighting locations in the past 15 years: (1)Fuchao Bay; (2)Pinghai Bay; (3)Da'ao mountain; (4) Yudidian; (5)sea waters around Dalajia Island.

Red balloons showed our survey sites: (A) Pinghai Bay; (B) Fuchao Bay; (C) Xichong; (D) Dongchong; (E) Yangmeikeng; (F) Dalajia Island; (G) Xiaolajia Island.

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Table 2 Numbers of ashore turtles, nesting pits and eggs spotted in Daya Bay from 1987 to 2005(Cite from Ke D. S,et al. 2009)

Year	No. of turtles ashore	No. of nesting pits	No. of eggs
1987	20	58	7656
1996	11	31	4092
2001	4	10	1320
2003	19	53	6996
2005	4	15	1800

1.2 Method

The aim of our survey on the islands and coastal area of Daya Bay is to collect existing sea turtle nesting information and investigate the status of coastal development in order to assess whether there is still hope to protect potential sea turtle nesting habitats in Daya Bay. The survey was conducted in January, 2010 by a group of student volunteers. Based on former records of turtle presences, we chose 7 potential sites, as shown in Fig. 9 from A to G. They are Pinghai Bay, Fuchao Bay, Xichong Beach, Dongchong Beach, Yangmeikeng Beach and two islands - Dalajia Island and Xiaolajia Island. Environmental conditions and development status of surveyed areas were carefully recorded, for the purpose of analyzing their suitableness as sea turtle nesting habitat.

1.3 Results

1.3.1 Pinghai Bay

Plate 4 Sandy beach of Pinghai Bay

The beach of Pinghai Bay is flat and wide, comprised of fine sand. Vegetated zone is 14m distant from high-tide line, including *Ipomoea pescaprae, Hedyotis auricularia, Spinifex littoreus, Zoysia sinica, Casuarina equisetifolia*. Pinghai Bay has not been highly developed and its beach profile was quite similar to that of Sea Turtle Bay, without many newly constructed buildings and densely populated people.

Pinghai Bay has long been a sea turtle nesting habitat. From 1996 there were one to two nests of turtle eggs every year and up to four nests in 2004 and 5 in 2005. However, in recent years there was no such reports. During our interview and observation, we identified two main factors that may prevent Pinghai Bay being a destinations for female sea turtles.

Firstly, marine aquaculture and fishing activities around Pinghai Bay become quite common, making the paths to the beaches deliberately blocked. For instance, in every year's August to October, local residents adopt a quite destructive fishing method - "the maze" to capture baby mangrove crab *Scylla serrata*. This fishing tool is composed of vertical and connected cylindrical nets. When animals enter the cylindrical nets

they can only move forward entering a narrower space, finally caught by fishermen. It's destructive not only because it targets animals from water surface to ground without selection, not also its extremely small pore size could capture over 80 percent baby or young fishes, making it also a highly unsustainable fishing practice. Secondly, artificial lights in nearby aquaculture and breeding grounds could cause disorientation of adult turtles. Sand mining has also been observed now and then in this area.

1.3.2 Fuchao Bay

Plate 5 Beach of Fuchao Bay. Left: Vocational facilities on the beach; Right: Natural bath areas under construction

Fuchao Bay is located within Daya Bay Provincial Level Nature reserve of aquatic resources. Former studies recorded nesting green turtles in Fuchao Bay from 2004 to 2006. Currently, the entire area is undergoing a large scale construction of holiday resorts as well as relevant facilities. Nature vegetations have been removed, replaced by ornamental plants. Many parts of coastal areas are used as bathing beaches. In short, beach profile suitable for sea turtles before has been modified and anthropogenic disturbance is expected to increase in the future. Since nesting season of sea turtles is overlapping with the peak time of vacationing people, Fuchao Bay become increasingly unsuitable habitats for nesting turtles unless special conservation measures are taken.

1.3.3 Dongchong, Xichong and Yangmeikeng beaches

Plate 6 Dongchong Beach

Dongchong, Xichong and Yangmeikeng beaches are generally flat and wide, along with some rocky area. Vegetation zone in Dongchong is relatively distant from high-tide line, comprised of many cactus, screw pine *Pandanus tectorius* and sea holly *Acanthus ilicifolius.* we also observed a sewage outlet. Vegetations in Xichong beach is mainly *lpomoea pescaprae and bea*ch grass was sparse and had been cleaned obviously, while in Yangmeikeng, *Casuarina equisetifolia* is the constructive species.

These beaches has long been vocational destinations for local people and camping zones and resorts are systematically managed. Generally anthropogenic disturbance along with coastal development is still the biggest problem concerning suitable habitats for nesting sea turtles.

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1.3.4 Dalajia Island

Plate 7 Left: Satellite image of Dalajia Island Right: Vocational facilites under the construction on the beach of Dalajia Island

Dalajia Island is located at Middle of Daya Bay. The total area is 1.8168km^2 and the coastal line is 11.40km. Vegetation coving the island are mainly shrubs, small area of secondary forest and artificial forest, without primeval forest. The beach is fine and flat, and vegetation coverage is high. Although this island has no records regarding nesting sea turtles, mating turtles and a injured green turtles was found before, which make it a potential habitat. This island now is a popular holiday destinations, providing a lot of holiday flats and entertainment facilities. Human disturbance is still the biggest problems if the beach is served as turtle nesting habitats.

1.3.5 Xiaolajia Island

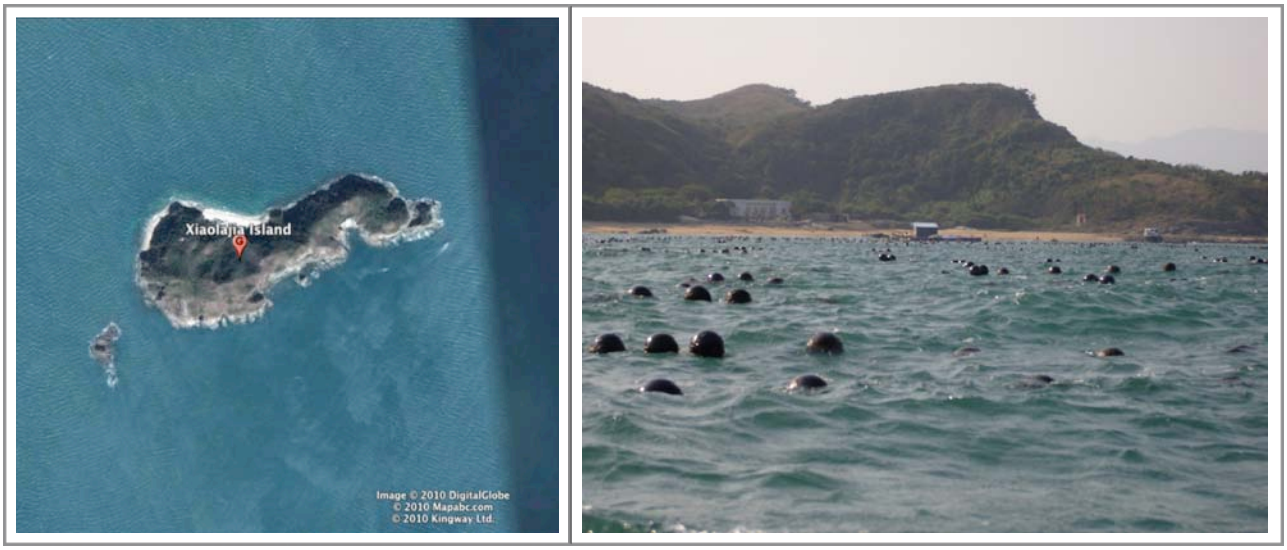

Plate 8 Left: Satellite image of Xiaolajia Island Right: Scallop farm in the sea waters around Xiaolajia Island

Xiaolajia Island is not a holiday destinations for local people, but fishermen conduct marine aquaculture in the surrounding sea waters. Plate 5 showed one part of the large area of scallop farm, which adopt raft culture method. This structures in the coastal waters makes the access of sea turtles to the beaches of the island extremely difficult. It’s not hard for us to predict from following data that foraging area for sea turtles will be diminished and access to suitable nesting habitats will be further blocked by more and more aquaculture sites. Moreover, unshaded lights equipped in aquaculture sites are possible to deter nesting females.

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Table 3 Scale of marine aquaculture in Daya Bay from 1985 to 2004 Cite from Ke D. S,et al. 2009)

Year	Cage culture / No. of cage	Raft culture/ hm^2	Bottom sowing culture/ hm^2	Total product value/million
1985	16	40	133	211
1990	3004	127	347	227.3
1995	12892	173	1800	279.69
2000	16110	547	4400	730.15
2004	16500	713	7557	851.60

1.4 Discussion and conclusion

During our survey on the coastal area of Daya Bay, which is the most important sea turtle habitat along the coastline of mainland China in the past, we cannot find out any information pertaining to nesting turtles in the past 3 years (2007-2010), whether it was by interviews to local people, fishermen or fishery enforcement department. We identify two major factors that may prevent the beaches of these islands or coastal area serving as suitable turtle habitats: the first is marine aquaculture and the second is coastal development, as holiday resorts in particular. Marine aquaculture is usually conducted in shallow coastal waters around relatively undeveloped beaches. The beach profile including vegetation composition is still remaining at nature state. However, the fishing structures such as “the maze” or rafts culture seriously block turtles’ way to these beaches. On the other hand, there are many problems caused by coastal development: vegetation devastation, noise, artificial lights, pollution and so on, creating an environment usually avoided by female turtles. It’s not realistic to persuade government to stop their plan of coastal develop and reserve beaches for potential female sea turtles. But we do think that the issue of balancing development and turtle conservation should be considered in the beginning of environmental impact assessment. We also suggest more work should be done to raise local people’s conservation, so that if turtles do show up they can be best protected from direct capture, slaughtering or bycatch.

2. Field survey in the remote islands of South China Sea

2.1 Introduction

Nest site selection represents a crucial aspect of sea turtles’ reproductive process, because the position of the nest may strongly influence the probability of offspring survival(Serafini T. Z. et al. 2009). When study the microenvironment that turtles choose to nest, researchers usually try to identify the relationship between nests and several environmental variables such as substrate property, vegetation coverage, slope, human disturbance extent and so on. The results are often contradictory and inconclusive and interspecies difference is also quite high (Bjorndal and Bolten, 1992). Until now we still don’t know whether it’s a random behavior or selection after integrative analysis by female turtles. However, it’s important to know the preference of turtle nest selection, especially for conservation purpose, for instance, in setting the environmental conditions for relocated eggs.

Nest site selection behavior is best studied on loggerhead turtles. Studies on varies beaches indicates that it nests preferentially in the sandy, soft, wide, open and flat zone and penetration into the vegetation zone was limited, which was presumably due to roots that impeded digging (Garmestani, et al 2000; G.C. Hays, et al 1995; Bjorndal and Bolten, 1992). It also prefers those beaches distant from the nearest human settlement.

Leatherbacks are laying predominantly in open sand and adopt a scatter nesting strategy that ensures that at least some of their nests will be appropriately sited(Mrosovsky, 1983; Whitmore and Dutton, 2003). It use wide beaches that inherently have less slope and e less shells (low amounts of calcium carbonate) in the nesting substrate (Garmestani, et al 2000. In addition, nest sites are located within or in close proximity to the supra-littoral vegetation zone of beaches.

In contrast to these two species, green turtles like vegetated areas (Whitmore and Dutton, 2003). It could crawl up to 80m to reach this area through uneven beach(Hays, et al 1995). Individual green turtles are more

likely to conform to the population's pattern of nest distribution each year than to maintain their own individual pattern between years (Bjorndal and Bolten, 1992). In addition, green turtles prefer the salinity of the sand moisture at nesting depth lower, the salt content of surface sand lower, and the beaches sheltered from prevailing winds(Özdilek et al. 2007; Johannes and Rimmer, 1984).

While hawksbill turtles demonstrated no preferences for either sand or vegetation zone. Some researches found that hawksbill turtles preferentially selects vegetated and shade places for egg laying, but high densities of beach vegetation cover are avoided by hawksbills (Kamel et al. 2006; Serafini et al. 2009).

As there is only one nesting habitat left for female sea turtles in coastal area of mainland China, the only hope is those remote islands in South China Sea, of which historical records of sea turtle numbers were large, mainly in Hainan province, Xisha Archipelagos, Nansha Archipelagos and Zhongsha Archipelagos. According to former investigation in Hainan, turtle capturing amount was about 31,841 between year 1959 and 1988 (See Table 4). Zhongjian Island, East Island and “Seven-connected islets”, which were known to have hundreds of nesting turtles every year in 80s, now can rarely see turtles due to excessive slaughtering and consumption. Interviews with local fishermen indicated that currently there was about 1 to 3 turtles nesting on each islands of “Seven connected Islets”. As illegal trades of sea turtle products still occur in Hainan province and the sources of these turtles are not known, it’s important to identify whether there are eggs poaching or turtle capturing from those islands . The information can be utilized to initiative further conservation efforts.

Table 4 The amounts of sea turtle captured in South China Sea from 1959 to 1988 (Cite from Wang, 1993)

Year	Acquisition(t)	Consumes of fishermen(t)	Total(t)
1959	144.5	43.4	187.9
1960	44.8	13.4	58.2
1961	59.6	17.9	77.5
1962	42.7	12.8	55.5
1963	113.5	34.1	147.6
1964	87.3	26.2	114.5
1965	199.9	60.8	260.7
1966	95.8	28.7	124.5
1967	165.3	49.6	214.9
1968	46.8	14.0	60.8
1969	115.5	34.7	150.2
1970	135.1	40.5	175.6
1971	38.8	11.6	50.4
1972	120.5	36.2	156.7
1973	118.4	35.5	153.9
1974	90.8	27.2	118.0
1975	34.6	10.4	45.0
1976	115.6	34.7	150.3
1977	34.0	10.2	44.2
1978	32.0	9.6	41.6
1979	41.0	12.3	53.3
1980	33.0	9.9	42.9
1981	37.0	11.1	48.1
1982	42.5	12.8	55.3
1983	55.0	16.5	71.5
1984	65.0	19.5	84.5
1985	97.0	29.2	126.2
1986	208.4	62.5	270.9
1987	3.0	0.9	3.9
1988	31.4	9.4	40.8
Total	2448.8	735.6	3184.4

Table 5 The amounts of sea turtle captured in Seven-connected Islets from 1959 to 1988(Cite from Wang, 1993)

Seven-connected islets	Female turtles	Nesting pits	Hatchlings	Tagged turtle
1987	329	148	6064	53
1989	98	26	736	29
total	427	174	6800	82

The aim of our survey of potencial nests on the remote islands of South China Sea is to (1) understand the number and distribution of sea turtle nesting sites in each islands as well as the relationship between sites selection and key environmental factors; (2) investigate whether egg poaching or turtle capturing activities still occur in these islands or nearby waters; (3) evaluate the conservation needs of each island based on our investigation.

We chose 10 islands, including Zhaoshu Island, Woody Island, Easter Island and “seven connected islands”, which are the only known nesting habitats for loggerheads. They are all historically destinations for a great number of nesting female turtles. Moreover, some of them are military restricted area where fishermen are not allowed entering, thereby are probably still suitable habitats for turtles.

2.2 Methods

Field survey

Species composition, dominant species and diversity of zooplankton in waters around Xisha Archipelagos

Zooplankton samples were collected at coastal waters of 9 sites: S1 East Island; S2 North Island Island; S3 Zhaoshu Island; S4 Middle Island; S5 South Island; S6 North Shoal; S7 Middle Shoal; S8 South Shoal S9 Woody Island. Two plankton nets were adopted, with mesh size of 0.505mm and 0.160mm. Zooplankton samples were collected from 15 m depth to the surface and fixed in buffered 5% formaldehyde. The abundance, dominant species and diversity of zooplankton were studied using aliquots under the inverted microscope.

Abundance is defined as the number of individuals per unit volume of water.

$C_B = \frac{N_B}{V}$ N_B (ind) is the total number in the sample; V(m^3) is the water filtered.

Dominant species is determined by its dominance:

$Y = \frac{n_i}{N} \cdot f_i$ n_i (ind/m^3) is the density of this species; f_i is the frequency of occurrence in all stations; N (ind/m^3) is the density of all zooplankton species. For dominant species, Y≥0.02.

Species Diversity Index

Margalef's richness index: D=*(S-1)/*ln*(n)*, where *S* is the number of taxa, and *n* is the number of individuals.

Shannon-Wiener Index: H’=-sum((n_i/n)ln(n_i/n)), where ni is the number of one species and n is the number of total individuals.

Pielou’s evenness Index:

$J' = \frac{H'}{H'_{max}} = \frac{H'}{\log_2 S}$, where H’ is derived from Shannon diversity Index, S is the total number of species.

Beach survey

The survey for turtle remains was carried out by foot patrols on every beach of the islands to look for any evidence of the presence, including the nesting pits, eggs, crawl marks, shells and other specimen. Nesting pits were confirmed as turtles' only when egg shells or hatchlings were found, otherwise they were potencial or suspected nests. We also made the detailed inventory of all the beaches, including fauna, flora, geomorphology and level of development in order to assess the suitableness for nesting ses turtles. Every island was visited at least 10 times to check whether there was any sea turtle ashore.

Interview

we designed questionnaires (see appendix) for local fishermen and garrison, collection information on turtles ashore, *e.g.* location,time, number and fluctuation between years, as well as accidental catches and stranding cases.

2.3 Results

2.3.1 Sea water

Composition and abundance

Table 6 Abundance and percentage of zooplankton groups in Northeast water of Xisha Archipelagos (0.505mm mesh size)

Group		Sampling Station									
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	Mean
Copepoda	Ni	20.67	2.67	2.00	1.00	1.33	2.33	3.67	4.67	4.00	4.70
	P	0.50	0.21	0.24	0.05	0.33	0.14	0.11	0.25	0.17	0.22
Chaetognatha	Ni	2.33	1.00	0.33	0.00	0.00	0.00	1.67	0.67	4.67	1.19
	P	0.06	0.08	0.04	0.00	0.00	0.00	0.05	0.04	0.19	0.05
Euphausiids	Ni	9.00	5.00	2.33	1.33	0.00	1.33	2.67	2.33	1.33	2.81
	P	0.22	0.38	0.28	0.07	0.00	0.08	0.08	0.13	0.06	0.14
Tunicata	Ni				0.67	0.00	0.00	0.00	0.00	0.67	0.22
	P				0.04	0.00	0.00	0.00	0.00	0.03	0.01
Acalephe	Ni	3.33	1.00	2.33	0.67	1.00	0.00	0.67	0.67	5.00	1.63
	P	0.08	0.08	0.28	0.04	0.25	0.00	0.02	0.04	0.21	0.11
Cladocera	Ni	0.33	1.33	0.33	0.33	0.33	0.00	1.33	1.00	2.67	0.85
	P	0.01	0.10	0.04	0.02	0.08	0.00	0.04	0.05	0.11	0.05
Polychaeta	Ni	0.67	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.11
	P	0.02	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.01
Noctiluca	Ni			0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.05
	P			0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Planktonic larvae	Ni	4.67	2.00	0.67	14.67	1.00	12.67	24.00	9.33	5.67	8.30
	P	0.11	0.15	0.08	0.79	0.25	0.78	0.71	0.50	0.24	0.40

Notes：P means percentage；Ni means the abundance of zooplankton (unit: ind/ m^3)

9 main group of zooplankton were identified in the samples collected by plankton net with 0.505 mesh size. Copepods took up the greatest proportion in most sampling stations. The highest percentage was found in S1 as 50%. However, in S3 and S9, the number of Acalephe was higher than copepods, while in S4, Euphausiids was also more abundant than copepods. However, the occurrence of copepod in all stations(f_i) was one, thus it was the dominant species at all sites. The percentage of planktonic larvae in S4, S6 and S8 was quite high, over 50%. Tunicata, Polychaeta, and Noctiluca were least abundant, less then 10% in all sampling stations.

Table 7 Abundance and percentage of zooplankton groups in Northeast water of Xisha Archipelagos (0.160mm mesh size)

Group		Sampling Stations								
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S9**	Mean
Copepoda	Ni	373.33	155.83	916.67	213.33	316.67	243.33	326.67	173.33	339.90
	P	0.71	0.89	0.93	0.92	0.83	0.88	0.64	0.67	0.81
Chaetognatha	Ni	47.50	10.00	13.33	3.33	20.00	10.83	10.00	19.17	16.77
	P	0.09	0.06	0.01	0.01	0.05	0.04	0.02	0.07	0.04
Euphausiids	Ni	8.33	3.33	5.83	7.50	2.50	2.50	2.50	1.67	4.27
	P	0.02	0.02	0.01	0.03	0.01	0.01	0.00	0.01	0.01
Tunicata	Ni					4.17	0.00	6.67	5.00	3.96
	P					0.01	0.00	0.01	0.02	0.01
Acalephe	Ni	3.33	0.83	0.00	0.00	3.33	0.00	4.17	5.00	2.08
	P	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.01
Mollusk	Ni			5.83	3.33	4.17	0.00	0.00	0.00	2.22
	P			0.01	0.01	0.01	0.00	0.00	0.00	0.01
Rotifer	Ni	2.50	0.00	0.00	0.83	0.00	0.83	1.67	0.00	0.73
	P	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cladocera	Ni	70.00	0.00	6.67	0.00	2.50	5.00	9.17	27.50	15.11
	P	0.13	0.00	0.01	0.00	0.01	0.02	0.02	0.11	0.04
Polychaeta	Ni	2.50	0.83	2.50	0.83	0.83	0.00	4.17	4.17	1.98
	P	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00
Planktonic larvae	Ni	19.17	3.33	40.00	2.50	26.67	14.17	148.33	23.33	34.69
	P	0.04	0.02	0.04	0.01	0.07	0.05	0.29	0.09	0.08

10 main groups of zooplankton were identified in the sampling collected by plankton nets of 0.160 mesh size. Copepods were the dominant species in all sites, taking 64% to 93% of total numbers. The highest proportion were found in S3 and S4 as 93% and 92%, respectively. The mean abundance of copepods was 339.9 ind/m^3.

Dominance and dominant species

Table 8 Dominance of 9 different zooplankton groups (0.505 mm mesh size)

Group	Dominance **Y**								
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
Copepoda	0.50	0.21	0.24	0.05	0.33	0.14	0.11	0.25	0.17
Chaetognatha	0.04	0.05	0.03	0.00	0.00	0.00	0.03	0.02	0.13
Euphausiids	0.20	0.34	0.25	0.06	0.00	0.07	0.07	0.11	0.05
Tunicata				0.01	0.00	0.00	0.00	0.00	0.01
Acalephe	0.07	0.07	0.25	0.03	0.22	0.00	0.02	0.03	0.19
Cladocera	0.01	0.09	0.04	0.02	0.07	0.00	0.03	0.05	0.10
Polychaeta	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Noctiluca			0.00	0.00	0.00	0.00	0.00	0.00	0.00
Planktonic larvae	0.11	0.15	0.08	0.79	0.25	0.78	0.71	0.50	0.24

The dominance Y of copepods was bigger than 0.02, thus it was the dominant species of all sampling sites. The dominance Y of Chaetognatha, Euphausiids and Acalephe were larger than 0.02 at some stations, thereby they were dominant species at the corresponding stations. While the dominance Y of Tunicata and Noctiluca were less than 0.02 at all stations, thus they were not dominant species.

Table 9 Dominance of 10 different zooplankton groups (0.160 mm mesh size)

Groups	Dominance **Y**							
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S9**
Copepoda	0.71	0.89	0.93	0.92	0.83	0.88	0.64	0.67
Chaetognatha	0.09	0.06	0.01	0.01	0.05	0.04	0.02	0.07
Euphausiids	0.02	0.02	0.01	0.03	0.01	0.01	0.00	0.01

Tunicata					0.00	0.00	0.00	0.01
Acalephe	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01
Mollusk			0.00	0.01	0.00	0.00	0.00	0.00
Rotifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cladocera	0.10	0.00	0.01	0.00	0.00	0.01	0.01	0.08
Polychaeta	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Planktonic larvae	0.04	0.02	0.04	0.01	0.07	0.05	0.29	0.09

Copepods were dominant species at all sampling sites, ranging from 0.64 to 0.93. Chaetognatha and Euphausiids were dominant species in certain sites, and other groups of zooplankton were not dominant. In both the samples collected by net of 0.505mm and 0.160mm, high dominance of planktonic larvae were observed in S7.

Biodiversity Index

Table 10 Diversity Index of zooplankton(collected by net of 0.505 mesh size and 0.16 mesh size)

		Station								
	Index	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
0.505 mesh size	**S**	7	6	7	6	5	3	6	6	7
	D	2.00	1.35	1.96	1.18	2.00	0.50	0.98	1.18	1.31
	H′	2.03	2.32	2.37	1.21	2.13	0.98	1.49	1.95	2.57
	J′	0.72	0.90	0.84	0.47	0.92	0.62	0.58	0.75	0.92
0.160 mesh size	**S**	8	6	7	7	9	7	9	8	8
	D	0.77	0.67	0.60	0.76	0.93	0.74	0.89	0.87	0.77
	H′	1.44	0.68	0.52	0.58	1.03	0.75	1.41	1.69	1.44
	J′	0.48	0.26	0.19	0.21	0.32	0.27	0.44	0.56	0.48

Notes: S means Number of zooplankton taxa； H′ means diversity; D means richness; J′ means evenness

Compared to the zooplankton samples by nets of 0.16mm mesh size, zooplankton collected by nets of 0.505 showed higher diversity, richness and evenness. Diversity index was relatively homogenous and was about 2.00. The smallest diversity value was 0.98, found in S6, which also had the smallest richness-0.5. It was due to only 3 zooplankton groups observed in this sites. The diversity, richness and evenness value for zooplankton samples collected using nets of smaller size were homogenous. Diversity index ranged from 0.52 to 1.69, richness index ranged from 0.67 to 0.93 and evenness index ranged from 0.21 to 0.56 in all sampling sites.

2.3.2 Islands

2.3.1.1 South Shoal

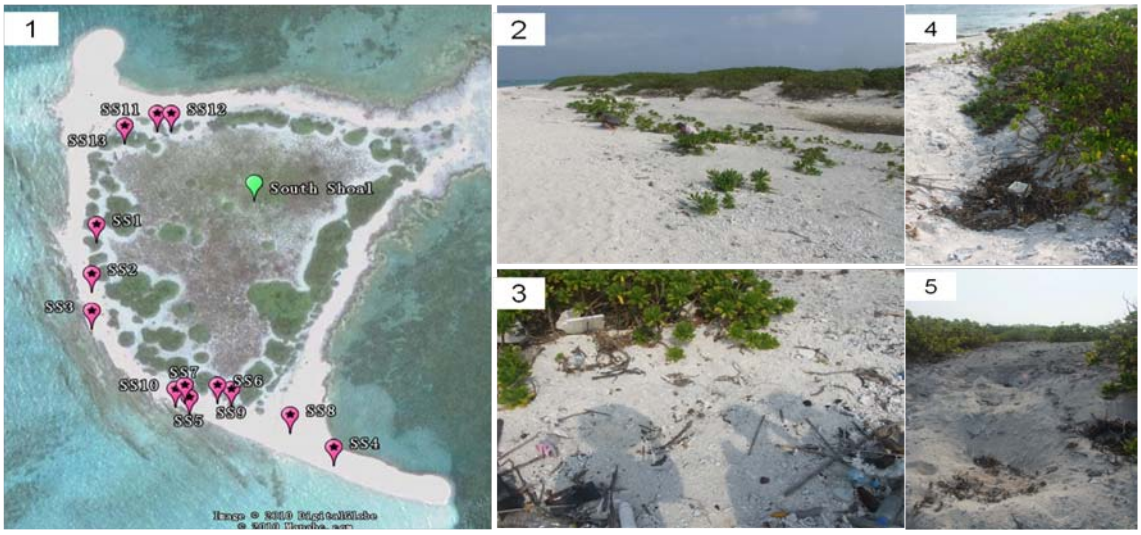

Plate 9 Beach condition of South Shoal, Xisha Archipelagos

Area: South Shoal locates at the southernmost among the "seven connected islets". It forms an equilateral triangle with sides of 300 m, and stretches a 100 m long beach in the southern corner. The total area is about 0.061km^2.
Vegetation: Dominant plants are the shrub *Scaevola frutcscen* and others are some spare beach grasses.
Freshwater: No freshwater is found in this shoal.
Beach condition: Generally calcareous. Surrounding beaches are flat and own a much higher percentage of fine sand than the middle area, which is composed mainly of dark rocklike coral deposit. The beach is littered by a variety of plastic debris, such as plastic bottles, foams, scandals and so on.

Table 11 Exact locations of 13 suspected nesting pits in South Shoal

Nesting sites	Exact location	
	N	E
SS1	16°55′46.7"	112°20′41.4"
SS2	16°55′45.5"	112°20′41.3"
SS3	16°55′44.6"	112°20′41.3"
SS4	16°55′41.3"	112°20′46.5"
SS5	16°55.4′42.5"	112°20′43.4"
SS6	16°55′42.8"	112°20′44"
SS7	16°55′42.8"	112°20′43.3"
SS8	16°55′42.08"	112°20′45.56"
SS9	16°55′42.7"	112°20′44.3"
SS10	16°55′42.7"	112°20′43.1"
SS11	16°55′49.4"	112°20′42.7"
SS12	16°55′49.4"	112°20′43"
SS13	16°55′49.1"	112°20′42"

Consensus of turtle nesting pits
No apparent sea turtle tracks, *e.g.* crawls, eggs or shells were spotted during field surveys. There are neither residents nor visiting tourists, however, fishermen are known to conduct fishing activities nearby and are likely to take away the eggs, plus consistent strong wind likely to bury the shell debris quickly. However, 13 suspected sea turtle nesting pits were found along the western beach. SS2 had the highest elevation, but flat, wide and lower-elevated beach around SS8 seemed to attract more female turtles. This is consistent with one study which indicated that beach width was a critical habitat variable affecting nest-site selection. However, little is known about the relationship between wind direction, slope and nest-site selection.

2.3.1.2 Middle Shoal

Area: The length of this shoal was 300 m and the widest place was about 200 m. The total area was about 0.052km^2, however, the area changes now and then due to frequent storm and violent storms.
Vegetation: Very low vegetation coverage, only spare beach grasses.
Freshwater: No freshwater is found in this shoal.
Beach condition: Generally calcareous. Coral deposits are mixed with rough sand grains; plastic debris are easy to see in some area of the shoal.

Table 12 Exact locations of 6 suspected nesting pits in Middle Shoal

Nesting sites	Exact location	
	N	E
MS1	16°56′2.6"	112°20′35.2"
MS2	16°56′0.6"	112°20′30.2"
MS3	16°56′0.2"	112°20′36.4"
MS4	16°55′59.6"	112°20′37"
MS5	16°55′58.9"	112°20′38.3"
MS6	16°55′58.7"	112°20′38.4"

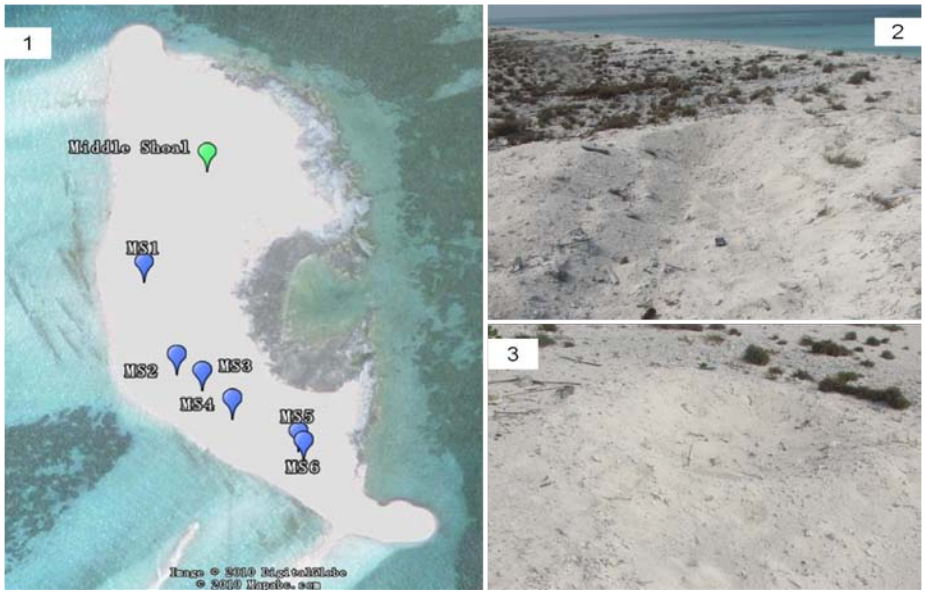

Plate 10 Beach condition of Middle Shoal, Xisha Archipelagos

Consensus of turtle nesting pits

There were also no apparent turtle lefts such as shells or eggs. Like the South Shoal, all the suspected nesting pits found were along the western beach. The highest elevation of nesting pits was 3m higher than the lowest, but pits didn't show aggregation at certain locations. Although this shoal is composed by large areas of beach, but low vegetation coverage, rough sand grains or other environmental variables may limit the suitableness of this beach as nesting habitats for more female sea turtles. Three of the six pits showed to be excavated by humans.

2.3.1.3 North Shoal

Plate 11 Beach condition of North Shoal, Xisha Archipelagos

Area: the length of this shoal was 300m and the widest place was about 200m.
Other conditions such as vegetation and beach condition was quite similar to that of Middle Shoal.
Consensus of turtle nesting pits
Only three nesting pits were found, of which two showed the signs of being excavated.

Table 13 Exact locations of 3 suspected nesting pits in North Shoal

Nesting sites	Exact location	
	N	E
NS1	16°56'17.10"	112°20'28.80"
NS2	16°56'17.63"	112°20'28.10"
NS3	16°56'18.20"	112°20'28.60"

2.3.1.4 South Island

Plate 12 Beach condition of South Island, Xisha Archipelagos

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Table 14 Exact locations of two suspected nesting pits in South Island

Nesting sites	Exact location	
	N	E
SI1	16°56′57.5"	112°19′56.6"
SI2	16°56′41.1"	112°20′10.3"

Area: South Island stretches 1.2km from northwest to southeast and widest place is 260m. Total area is 0.17km^2.
Vegetation: Shrubs like *Scaevola frutcscen* are flourishing, covering about 80 percent of island's surface and make the habitats for various seabirds. The ground under the tree is thereby covered by a thin layer of birds' droppings.
Freshwater: There was once a small lake in the middle of the island, but it has dried out.
Beach condition: The beach is quite flat and sand grains in this island are much finer than other shoals mentioned above.
Consensus of turtle nesting pits
Although South Island has a wide and flat beach with fine sand grains and flourishing vegetation, only 2 pits were suspected to be nesting sites of female turtles.

2.3.1.5 Middle Island

Plate 13 Beach condition of Middle Island, Xisha Archipelagos

Area: The length of this island is 0.6km and width is about 0.26m and total area is 0.2km^2.
Conditions of the island: This island is surrounded by sandy beach and the former lagoon in the middle has dried out. Sand quality and vegetation are quite similar to that of South Island.
Consensus of turtle nesting pits: No pits were found for turtle nesting purpose or maybe the trails has been modified by strong winds or anthropogenic factors.

2.3.1.6 North Island

Plate 14 Beach condition of North Island, Xisha Archipelagos

Table 15 Exact locations of 6 suspected nesting pits in North Island

Nesting sites	Exact location	
	N	E
NI1	16°57′53.1"	112°18′35.3"
NI2	16°57′53.5"	112°18′34"
NI3	16°57′53.8"	112°18′33.9"
NI4	16°57′58.3"	112°18′18.4"
NI5	16°57′55.8"	112°18′15"
NI6	16°57′51.4"	112°18′22.5"

Area: The length of North Island is 1.5km and widest place is 0.35m. Total area is 0.25km^2.
Vegetation: Vegetation covers over 90 percent of the island, including *Scaevola frutcscen, Pisonia Grandis, Morinda citrifolia* and beach grasses.
Freshwater: There was a lagoon whose size was about half of the island. However, it has dried out during the time we visited. Since the ground was covered by a layer of birds' droppings, freshwater here was not suitable for drinking.
Environmental conditions: Strong and consistent northeastly wind brings more oxygen to the seawaters at this side, which makes the coral reef here grows particularly well. It harbors great biodiversity and emerges from seawater in low tides. Great richness of fish and other economic species also attracts a lot of fishermen and temporary shelters can be seen on the island.
Consensus of turtle nesting pits
Six nesting pits were found during the survey and most of them distributed in the northern part. Three pits were over 1 year old and had been covered by tangling weeds and broken branches. Two new pits showed the sign of being excavated. The difference between the highest and lowest elevation of these turtle pits was 5m.
Consensus of turtle nesting pits:
No suspected nesting pits were found.

2.3.1.7 West Shoal

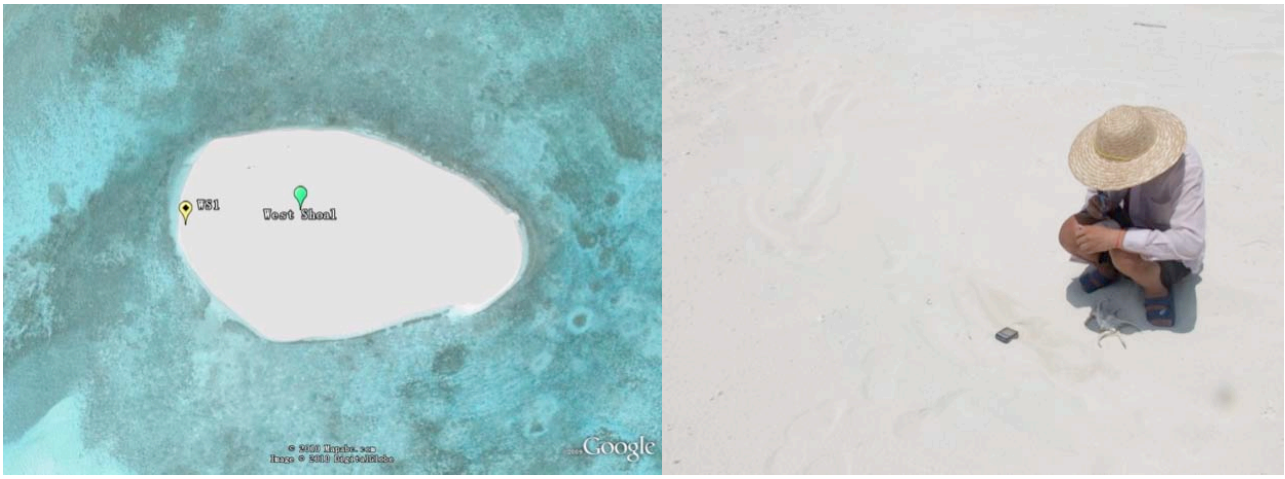

Plate 15 Beach condition of West Shoal, Xisha Archipelagos

Table 16 Exact locations of one suspected nesting pits in West Shoal

Nesting sites	Exact location	
	N	E
WS	16°58′40.3"	112°12′30.5"

Area: length-600m, width-400m
Vegetation: Very few grass or trees.
Freshwater: Since the sand layer in this shoal is quite thick, freshwater is kept underground.
Consensus of turtle nesting pits:
Only one pit was spotted in the western corner of the island. Due to strong wind and quite low vegetation coverage, the trails of nesting sites may be easily lost.

2.3.1.8 Zhaoshu Island

Plate 16 Beach condition of Zhaoshu Island, Xisha Archipelagos

Area: Length-0.6km, width-0.3m, area- 0.19km^2.
Vegetation: Except common shrub and grasses, there are also coconut tree of 10m’s height.
Freshwater: Sand layer here is quite thin and underground water is contaminated by birds' dropping, thus not suitable for drinking.

Other conditions: There was a 20-meter-high lighthouse in the western corner of the island. Local residents are not army but migrated fishermen. About 200 fishermen reside in this area and use processed dried fish or economic sea food to exchange for freshwater and other food items. Domestic dumping and sewage is of particular concern in this island: plastic debris form a continuous band along the beach line. Dumping are partially buried underground without any technical treatment, and abandon abalone shells and other sea food waste are gradually overwhelming.

Consensus of turtle nesting pits:

No suspected nesting pits were found.

2.3.1.9 Woody Island

Area: Length-1.8km, width-1.16km, area-2.1km^2. Woody Island is the largest island among Xisha archipelago and also among islands in the South China Sea.

Vegetation: "Woody Island" is named for its flourishing trees. 148 species of plants can be found in the island, namely *Eriobotrya japonica, Scaevola frutcscen, Cocos nucifera, canna indica, Anemone vitifolia, Datura metel* and so on, some of which has been used as habitats for sea birds like red-footed booby, frigate birds and terns.

Freshwater: Rainfall in Woody Island is plenty and it's easy to find water underground. However, due to birds' dropping's contamination and high mineralization, freshwaters are not suitable for drinking. Sea water desalination has now been able to satisfy local residents' freshwater's needs.

Other environmental conditions: Woody Island has a flat topography, rising about five meters in average above sea level. Entire island is surrounded by sandy beach and there's a 870m long, 100m wide beach along southwest coast. Coral coverage and diversity in nearby waters is quite high but undergoes serious degeneration in recently years. Great richness of fishing resources has attracted plenty of fishermen, who often adopt destructive fishing activities such as explosion and bottom trawling. Former studies has shown that explosive fishing for once would destroy coral reefs here of 3-5 diameters or 10m^2(Huang, 2008). Another anthropogenic environmental problem is associated with trashes and sewage. Dumping on Woody Island is about 1000 t per day and sewages 300t per day. Without proper treatment, organic matters, heavy metal and infested pathogenic microorganisms in landfills are easily penetrating to underground waters and nearby sea waters through loose ground.

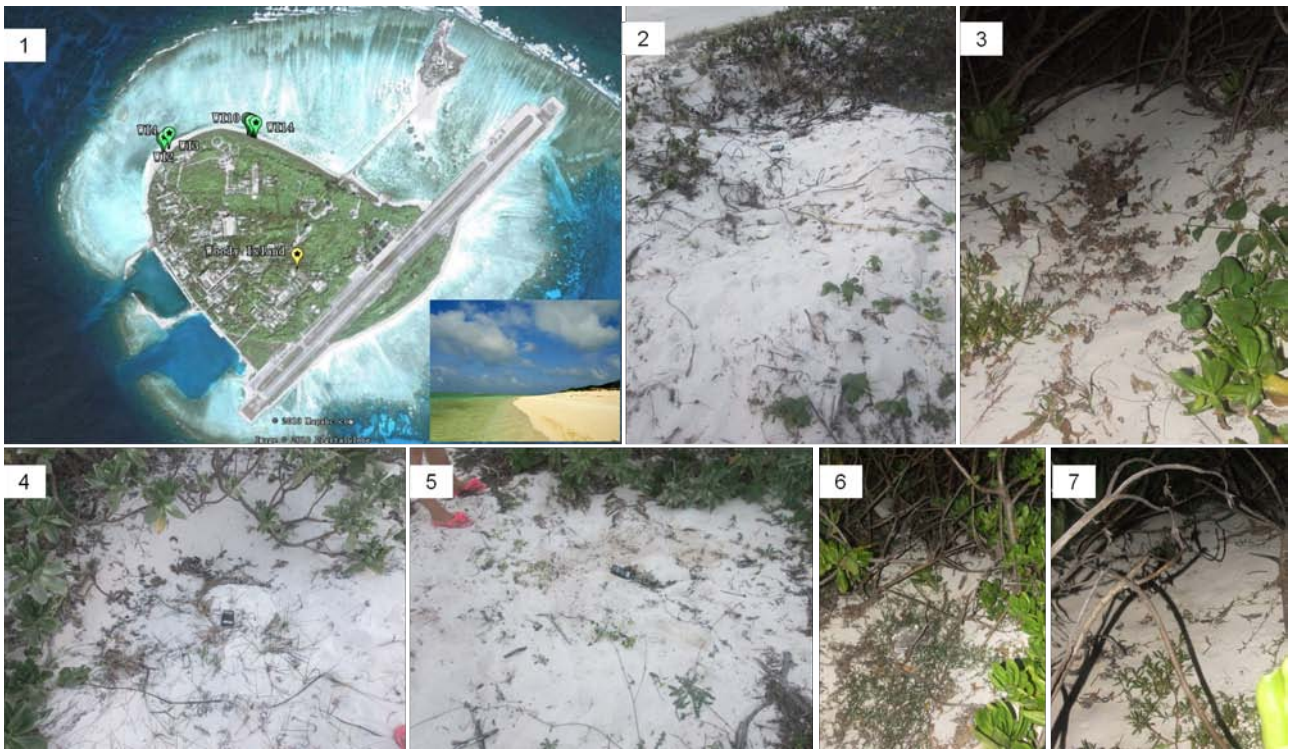

Plate 17 Beach condition of Woody Island, Xisha Archipelagos

Table 17 Exact locations of 14 suspected nesting pits in Woody Island

Nesting sites	Exact location	
	N	E
WI1	16°50′21.6"	112°19′52.6"
WI2	16°50′21.8"	112°19′53"
WI3	16°50′22.6"	112°19′53.8"
WI4	16°50′22.6"	112°19′54"
WI5	16°50′25.3"	112°20′10.3"
WI6	16°50′25.4"	112°20′10.2"
WI7	16°50′25.1"	112°20′10.7"
WI8	16°50′25.1"	112°20′10.9"
WI9	16°50′25.1"	112°20′10.9"
WI10	16°50′25.0"	112°20′11"
WI11	16°50′24.9"	112°20′11.3"
WI12	16°50′24.9"	112°20′11.4"
WI13	16°50′24.8"	112°20′11.6"
WI14	16°50′24.7"	112°20′11.9"

Consensus of turtle nesting pits

Total 14 turtle nesting pits has been spotted in Woody Island. They aggregated in two sites of “New port” area, which is the northwest corner of the island. This place is in the upper reaches of a water way, which may make it easier for turtles to arrive. Soft fine sand, suitable elevation and vegetation coverage were also believed to create suitable microenvironment for female sea turtles. Moreover, compared to western and southwestern area, new port area is less disturbed by human activities, for western area is much more densely populated and there is a airport in southern area.

2.3.1.10 East Island

Plate 18 Beach condition of East Island, Xisha Archipelagos

Area: With 2.4km long and 1km width, total area of East Island is about 1.6km^2, ranking the second largest island among Xisha Archipelagos. The average elevation is four to five meters. It's a military restricted area, not open to any visitors unless permitted.
Vegetation: Over 95% of the island is covered by original plants, *e.g.* arbors *Pisonia grandis*, *Guettarda speciosa*, shrubs *Scaevola frutecens*, *Messerschmidia argentea* and grasses *Sesuvium portulacastrum*, *Atriplex repens*, *Ipomoea pescaprae*, *Zoysia matrella* or artificial vegetation like coconut trees, loquat trees and coastal oaks.
Freshwater: There is a small lake in the southeast of the island, which is mainly utilized as drinking water tank for stocks. Although typical tropical weather brings plenty of rain, it's usually contaminated by birds' droppings and only used for washing.

Table 18 Exact locations of 4 suspected nesting pits in Woody Island

Nesting sites	Exact location	
	N	E
EI1	16°40'25.4"	112°43'30.5"
EI2	16°40'24.2"	112°43'33.1"
EI3	16°40'24.7"	112°43'31.9"
EI4	16°40'24.8"	112°43'31.8"

Other environmental conditions: East Island is also called "Birds' Island ", for it owns the highest biodiversity and numbers of sea birds among Xisha Archipelagos, with over forty species. An area of 180 acre in the island has been set as nature reserve for 50-100 thousand inhabited red-footed booby *Sula sula.* Other birds include egret, golden eagle, helmeted hornbill, brown booby, great frigatebird, black-naped tern, great crested-tern and japanese white-eye and so on.
Consensus of turtle nesting pits:
only 4 suspected turtle nesting pits were found in the East Island. Although the average elevation of this island is 4-5 meters, not all the surrounding beaches are flat. Beach rocks are often present outside and sometimes form a low cliff about 2-3m high. Particularly, some parts of the northern coast has developed into wave-cut terrace, which are made of hard coral sandstone and coral limestone. Therefore, those beaches are not suitable for sea turtles to nest.
2.3.2 Interview

During our interview, we found that most people prefer talking to filling the questionnaires. People interviewed were pleased to respond, however, many information provided was hard to believe. For instance, one fishermen on Woody Island said that turtle were so many that they entered his house at night. It's also possible that they would not tell the truth if they were themselves involved in turtle capturing. Thus, we only presented some valuable results of our interview, other then all the words of the interviewee.

Interview with Mr Wu Qingzhi, who has been working over 30 years in Propaganda Department of Woody Island working committee

He told us that between 1978 and 1986 thousands of sea turtles would come ashore to deposit eggs during June or July. At this time fishermen would catch them in large quantity and sell to local market for food. These turtles caught weighted in average between 160 to 180kg and largest ones could reach 260kg. However, local people usually ate turtle of 220kg and refused that less than 120kg. Sea turtles captured by fishermen were mainly green turtles, with few hawksbill turtles. It was until 1995 when laws and regulations on sea turtle conservation were issued in China, this excessive slaughtering was ceased. Nowadays, Woody Island has been developed like other cities in the mainland, over 2000 people including fishermen and army reside here, and sightings of sea turtles become very rare.

Interview with fishermen in Woody Island
Most fishermen we interviewed showed fully understanding of the laws and regulations on sea turtle conservation. They told us that fishermen now no longer caught sea turtles due to its rarity and relevant regulations.

2.4 Discussion and conclusion

Although potential or suspected sea turtle nesting pits were spotted during our survey, more convincing evidence such as crawling marks, egg shells, hatchlings or other specimen were not found. Also there was no turtle showing up during our 10 times' visits. Our survey lasted for two months, but frequent strong wind blows and also financial problems prohibited us to undergo everyday's patrol. There was also probable that the time we visited was not turtle nesting season. In order to test this possibility, the second survey is now undergoing in July and August, 2010.

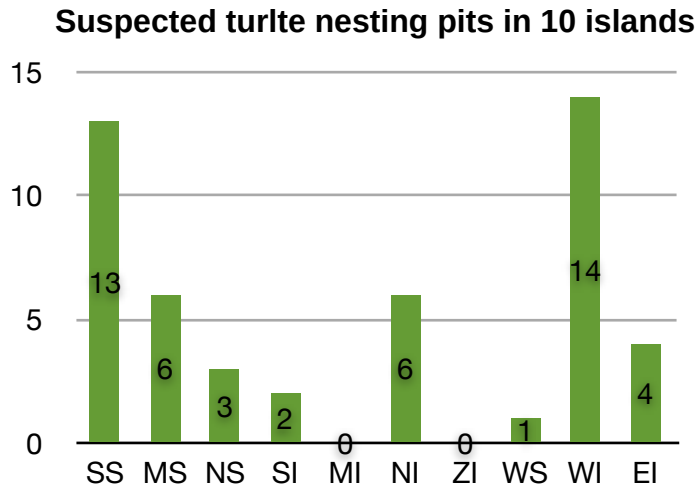

Fig.12 Numbers of suspected sea turtle nesting pits in 10 islands of Xisha Archipelagos

Numbers of suspected sea turtle nests were highest in South Shoal (n=13) and Woody Island (n=14). Compared to other islands, these two islands share similar features in that the beaches are wide and flat, composed of larger percentage of fine sands; and high vegetation coverage. Former studies have shown beach width is an important variables and hatchling mortality is positively correlated with mean particle diameter of the sand. Nests on these two islands seemed to congregate at wide beaches with fine and soft sand. High percentage of vegetation usually provides cooler environment and help to shelter from strong wind, but not all turtles prefer high vegetation coverage zones. Green turtles are willing to crawling through 80m to penetrate, but for hawksbills beach vegetation cover negatively influenced hatching success and loggerhead typically tend to nest at sandy open beaches. It's not easy to tell the owner of each pit solely by its location. We believe there are other factors attracting female turtles than beach profile and vegetation coverage, for some of other islands also have similar conditions but have few turtle nests.

Islands with little or no vegetation such as West Shoal, North Shoal and Middle Shoal were found to have no or only a few suspected nests. It's possible that these zone of low vegetation coverage and strong wind blow was avoided by green turtles, which are the main species nesting in China. For green turtles, avoidance of Middle Island could be explained by its quite low elevation, for this species always try its best to prevent eggs inundation. As for Zhaoshu Island, although nearby water could provide satisfying foraging grounds for turtles, it's highly disturbed by local residents and fishing activities.

Our monitoring efforts on remote islands of South China Sea is still continuing in order to collect information in July and August, which is believed to be the most important season for female turtles' nesting. We expect to see turtles coming ashore and record whether there is any poaching and capturing activities. Recommendations on conservation management will be provided based on the integrated information.

Chapter 3 Public awareness promotion and partnership building with local sea turtle conservation NGO

1. Public awareness promotion

There were several reasons for us to conduct public awareness promotion in Hainan. During our undercover investigations to sea turtle products illegal trade in Hainan province, we found that direct capture, incidental take and egg poaching were still common among fishermen in Hainan. Local markets sell green turtle meat secretly despite that they know it's illegal. Some turtles captured alive have been sold to high grade restaurants for display, and hatchlings were sold as aquarium pets. It's also the center of turtle product processing and the source for the market of other places in China. Moreover, Sanya is one of the greatest vocational destinations in China, attracting over twenty million visitors annually, which create large markets for sea turtle products as souvenirs. In chinese culture, decoration items made from hawksbill scutes are symbol of safety and happiness and turtle soup is a great delicacy. Many tourists are still not aware that sea turtles are protected animals. Therefore, our public awareness programme, with consideration to time and financial strain, was determined to conducted in Sanya, Haikou and Qionghai city, targeting fishermen, local markets, fishery enforcement and tourists.

We prepared a brochure on sea turtle conservation, which introduced briefly the basic biology of sea turtles, laws and regulations, their threatened situation and current conservation efforts of both China and other countries. The targets of 12 student volunteers were including fishermen, local market vendors, fishery enforcement and tourists, respectively. Based on one of our former studies which showed that stakeholder would be convinced only by the awareness messages that match their interests and point of view, we have organized a small workshop to improve volunteer's communication skills with their targets and analyze the information which they should emphasize to different group of people.

Plate 19 Sea turtle conservation brochure that we designed

1.1 Fishermen

Fishing activities have posed the biggest threat to sea turtles in China. Firstly, fishing boats are numerous and even in closed fishing season there are still secret fishing activities conducted by boats without license. Operation of longlines, trawls and gillnets, as well as other destructive methods of fishermen such as poisoning, electrocution and blasting have greatly endangered sea turtles in migratory routes. Along with various nets set in large areas, the chance of incidental capture of sea turtles is quite high. When there is a bycatch, it's a common practice of them to sell it to the market rather than return it back to water, since it's low cost and high profit. Secondly, Hainan is a sea turtle products' trading center which has a group of fishermen harvesting sea turtles intentionally in sea waters around Hainan, as well as setting fishing nets around coral reefs and catch mating and nesting turtles in remote islands of South China Sea.

Thus , it was said that fishermen were at the very heart of the problem. Without their involvement and cooperation, we can not succeed. In order to raise the awareness of fishermen in Hainan, 4 student volunteers visited the largest fishing port of Tanmen Town, Qionghai City, which is so far as we know the most important entrance of sea turtles in Hainan and has a complete and secret chain comprising of turtle harvesting, proc-

essing and transportation. There was a case in June 2000 that the Fishery Monitoring Team of Hainan Province seized 9 living and 3 dead green turtles in Tanmen Town, Qionghai City. And another case was in in December 2007 that the border officers in Qionghai seized 54 sea turtles in a fishing vessel, which were confessed to be harvested from South China Sea area.

Plate 20 Awareness promotion activities in fishing port of Qionghai, Hainan

When communicating with fishermen in fishing ports of Qionghai, our volunteers explained to them that sea turtles were endangered animals and belong to the second class national protected animals. We then shared several cases of illegal acquisition, slaughtering, trading and domestication and elaborated laws and regulations pertaining to these activities. They were also encouraged to report such events to fishery enforcement. The information we expected them to receive most was that they played an important role in sea turtle conservation. We provided a general guidelines for them to perform under certain circumstances. For instance,

techniques of tackling with turtles incidentally captured by longlines, trawls and gillnets, measures of tackling with injured and stranded sea turtles, as well as how to record the maximum information of turtles encountered for the scientific research. Most fishermen welcomed our visits and listened to our information carefully. They responded to us actively and asked questions frequently. They said that they would also protect sea turtles in the future and were willing to tell this to more fishermen.

1.2 Market vendors

We conducted our awareness promotion activity for market vendors in the Dongmen Market, Haikou, which is the largest food market located in the center of Haikou city and often found to sell green sea turtle meat. Green sea turtle meat, so far as we know, was usually sold to market vendors at about RMB14-16 per kg, and sold to consumers at about RMB 90 per kg. In fact, most vendors were aware of the illegality of selling sea turtle meats and refused us to take photos. Although it's of high risk, revenues generated are apparently sufficiently high to warrant the risks for these vendors.

Plate 21 Awareness promotion activities in Dongmen food market, Sanya

Brochures were first distributed to vendors selling animal products, especially wildlife and sea food. There were many vendors selling freshwater turtles, snakes, birds and mammals in open view, some of which were illegal. We explained to them of sea turtles' endangered status and laws and regulations regrading sea turtle conservation. They were also strongly encouraged to report cases of selling sea turtles to local fishery enforcement. Most vendors read the brochures carefully and promised that they would support sea turtle conservation in China.

1.3 Local fishery enforcement

Plate 22 Awareness promotion activities in Fishery enforcement in Hainan province

Fishery enforcement in China performs the duty of protecting aquatic biological resources. As for sea turtle conservation, firstly, fishery enforcement carries out investigation and combat of illegal trading of sea turtle products, including acquisition, processing, transportation, sales and illegal domestication and exhibition in both sea areas and local markets; secondly, it was their responsibility to rescue injured and stranded turtles upon reporting; thirdly, fishery enforcement patrol in the marine protected areas for sea turtles, driving off fishing boats, especially in breeding seasons, to reduce incidental capture and negative effects on sea turtles. Therefore, their work is closely linked to the well-being of sea turtles in China. The sea turtle population could benefit best from effective enforcement of existing domestic and international measures to protect sea turtles.

In order to promote greater conservation efforts on sea turtles, our student volunteers visited Fishery Enforcement and Administration Bureau, Hainan Province. Since they are already aware of the endangered status of sea turtle in China and also familiar with related laws and regulations, we concentrated our efforts on sharing the case studies of successful conservation measures of sea turtles in other countries, e.g. Malaysia, Philippine, U.S. and the like. We analyzed several cases, discussing both the advantages and limitations of each practices and feasibility of performing similar measures in China. We also listened to their ideas and plan of raising fishermen's awareness of sea turtle conservation, for instance, setting up bulletin board in large fishing ports and fishermen resided area. Finally we built a long-term cooperation with Fishery Enforcement and Administration Bureau, Hainan and we prepared sea turtle information collection form for them, which aimed to obtain the first hand and maximum information on sea turtles spatial and seasonal distribution, bycatch and illegal trading. Protocols of sea turtle tissue sampling and preservation was also provided, which will be conducive to reveal the genetic biodiversity of sea turtles in China.

1.4 Tourists

Plate 23 Awareness promotion activities for the tourists in Hainan province
Upper: Sea turtle sampling in Sanya, Hainan
Lower:Turtle to be released in Sanya

Hainan is one of the biggest holiday destinations in China, visited by over 200 million tourists annually, of which most are heading to Haikou and Sanya city. They are the main consumers and customers of sea turtle products. Jewelry and other ornamentation items made from hawksbill turtle shells have long been regarded as special and precious souvenirs and many people are not aware of its illegality. In order to raise the awareness of tourists and reduce the market demand of sea turtle products, our volunteers were divided into two groups, with one group staying close to Sanya Fenghuang Airport and the other group staying in one of the most famous vocational areas -Yalong Bay. Volunteers first distributed brochures of sea turtle conservation, then explained to people why sea turtle products should be refused. A lot of people said that it was their first time to know that purchasing sea turtle products were illegal and in the future they would support sea turtle conservation and were willing to tell more people not to buy sea turtle products.

2. Partnership establishment with Governmental agencies and local Non-governmental organizations

2.1 Cooperation with governmental organization

In the past few years, Guangdong and Hainan government have made several specific efforts on sea turtle conservation, including strengthening law enforcement on illegal trade of sea turtle products, carrying out public awareness promotion activities and supporting related scientific research. During these activities, we have established long-term cooperative relationship with them. Here we would like to present some of our cooperation work in 2009 briefly.

Firstly, when fishery enforcement seized sea turtles captured illegally in fishing boats or encounter stranded and injured ones in sea areas or on the beach, they transfer those turtles in nurturing center for rehabilitation. If the condition turns suitable, they will be released. These turtles, therefore, provide us with an important source to know the genetic diversity of the seat turtle population in China. For instance, on June 29, 2009, “ Beibu Gulf marine biological resources proliferation and release festival” organized by Fishery Bureau, China fishery law enforcement command, Department of Ocean and Fisheries of Hainan Province and Sanya government was hold in Sanya. Among many creatures released, there were 19 adult sea turtles, most of which were once captured incidentally by the fishermen or found and seized in fishing boats. We then took the samples on flippers using biopsy punch, which is a simple, quick and relatively non-invasive sampling procedure{Dutton PH, 1996 #12}. Skin tissues were stored in 90% ethanol. The author was also interviewed by the journalists of China Central Television to introduce the principle of satellite tracking technology. And on 11 July, “ South China Sea marine biological resource proliferation and release festival”

Upper: Plate 24 Sea turtle tissue sampling for DNA analysis

Lower: Plate 25 Sea turtle to be released in “Beibu gulf marine biological resources proliferation and release festival”

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hosted by Ministry of Agriculture and Guangdong government, Department of Oceanic and Fisheries of Guangdong province and Environmental protection foundation of Guangdong province was hold in Zhuhai, Guangdong. This event has released 666 sea turtles, most of which were juveniles hatched and bred in Sea Turtle nature reserve. We also sampled several adults and young turtles. On the other hand, survey and monitoring in the remote islands of South China Sea, such as Xisha Archipelagos are made possible when we get permission of government, since many of them are military restricted area. Our transportation was also assisted partially by supply vessels of Hainan government.

2.2 Cooperation with sea turtle conservation NGO - Sea Turtle 911, in Hainan province

Sea Turtle 911(http://www.seaturtles911.org/) is an non-profit organization targeting sea turtle conservation based in Hainan. Their work generally includes undercover investigations into restaurants and report illegal displaying and domesticating cases to fishery enforcement; rescuing sea turtles from food market and fishermen; cooperation with other permitted rehabilitation facility to provide medical care to injured turtles until they rehabilitate, as well as providing oversea volunteer activities to interested people.

Plate 26 Sea turtles cultured in Sea Turtle 911 for rehabilitation

We first visited the working center of Sea Turtle 911 in 2009, then we became partners on sea turtle conservation work in China by sharing information and co-organizing future research and education activities.
Firstly, we together made an information collection sheet to obtain maximum data of each sea turtles encountered, including species, morphology, spotting sites and date, condition and so on, so that we can build a better understanding of their species composition, spatial and seasonal distribution, migratory patterns and various threatening factors, which are the essential basis for the development of effective conservation measures. Secondly, we made an agreement in studying the genetic diversity. Every time when there is a new turtle rehabilitating or cultured temporarily in Sea Turtle 911, its DNA sample will be collected and preserved, from skin or blood, after its condition turns well. Thirdly, we facilitated communication and coordination between Sea Turtle 911 and governmental organizations in Hainan province, which would make the work of Sea turtle 911 more efficient. Finally, we are planning to hold a workshop on ecotourism in 2010.

In conclusion, we have successfully carried out awareness promotion activities in 2009 in Hainan and also built a long-term cooperation with Guangdong and Hainan government, as well as one of the most important non-profit sea turtle conservation organizations in Hainan. We are going to continue this public education activities and expand its scale in the following years.

Chapter 4 Improving student learning in sea turtle conservation techniques

One of the aims of this project is to create learning opportunities for students interested in sea turtle conservation, especially for those determined to develop a professional career in marine conservation. This project is comprised of both public education and field research, some parts of which is conducted for the first time in China, e.g. undercover investigation of illegal trade of sea turtle products in China and surveys of sea turtle nesting habitats in Xisha Archipelagos. Thus, it provides a precious opportunity for the students to get first-hand information and experience in various aspects of sea turtle conservation work. Each student has their own responsibilities and together make up a team contributing to the success of the whole projects.

First-hand experience on research and outreach activities

For instance, by monitoring females turtles nesting in Gangkou Sea Turtle Nature Reserve, our student helpers have received the supervision of the specialists in Gangkou Sea Turtle Nature Reserve to learn the process of sea turtle eggs depositing, standard measurement of their morphological features, tagging skills, eggs relocation and artificial incubation techniques. When sea turtles finishing depositing eggs, the microenvironment of the nests such as moisture, temperature, sand grain size and depth will be measured and whether the location of nests is safe or not for hatchlings will also be identified. Students under the guidance then were able to gain an understanding of the environmental requirements of successful hatchings and assess whether it is necessary to relocate eggs for artificial incubation in their own work in the future. Student helpers have also learnt the basic techniques of sea turtle culturing by observing how technicians took care of hatchlings and injured adult turtles.

Furthermore, surveying in the remote islands of South China Sea, Xisha Archipelagos for this time, has provided student helpers with a precious opportunity to acquire skills and experience on field survey under the supervision of the author. Techniques on the exploration and recording of the environmental factors of potential beaches were practiced, species composition of vegetation near the beach were identified and possible anthropogenic threats were noted. They have also conducted the research on the species composition and abundance of zooplankton community in the sea areas around Xisha Archipelagos, in order to understand the marine environment of potential sea turtle foraging grounds. Other important techniques training they received included turtle tissue sampling for DNA analysis and basic medical care for injured turtles.

Finally, during outreach activities, student helpers contributed to the programme design, implementation and final evaluations. Their communication skills with people from governmental agencies and non-profit organizations, as well as general public have been practiced.

Other academic opportunities for students

We also provided oversea learning opportunities for students. In June, 2009, one student was supported by this project's fund to participate the "workshop on regional cooperation to address direct capture of sea turtles" in Malaysia, which was to discuss the problem of illegal taking of sea turtles in South East Asian waters. Participants from Malaysia, Indonesia, Philippine and China have exchanged information on this issue. Our students gave a presentation on the investigation of illegal trade of sea turtle products in Hainan province.

Plate 27 Participation in "Workshop on regional cooperation to address direct capture of sea turtles" in Malaysian State of Terengganu, 5 June, 2009

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Appendix 1

Consensus of sea turtles nesting, tagging, hatchling and releasing in Huidong Sea Turtle Nature Reserve from 1985 to 2008

Year	Turtles ashore	New tagging	No. of nests	No.of eggs	No. of hatchlings	No. of releasing
1985	65	0	47	6016	5747	4149
1986	122	0	78	8463	8036	7843
1987	141	20	83	9766	9164	9069
1988	55	12	38	4076	3932	3829
1989	29	6	19	2217	1430	1214
1990	15	1	4	387	339	315
1991	111	10	53	4734	3446	3386
1992	4	0	1	131	91	85
1993	18	2	8	822	276	200
1994	26	5	10	1208	732	690
1995	43	4	17	2054	1787	1772
1996	77	7	43	4713	4108	3980
1997	52	1	29	3597	3234	3154
1998	86	12	61	6387	3104	3084
1999	48	5	23	2648	2157	2050
2000	22	1	11	1015	674	621
2001	24	3	15	1928	1478	1200
2002	16	2	8	876	750	564
2003	136	19	53	6996	5697	4100
2004	37	8	26	2912	2287	1898
2005	57	7	38	4373	3719	2994
2007	17	3	10	973	841	886
2008	29	2	12	1320	1082	687
Total	1184	125	665	75319	62188	53203

Appendix 2

Investigation form of the distribution of sea turtles in South China Sea

Investigator：
Location：
Date：

Basic information of interviewee

Gender：Male[ ]　　Female[ ]

Age：10—20[ ]　20—30[ ]　30—40[ ]　40—50[ ]　50—60[ ]　60—70[ ]　over 70[ ]

Occupation：
Contact:

Information on sea turtles

Species：Green turtle[ ]　Loggerhead[ ]　Hawksbill[ ]　Leatherback[ ]　Olive ridley[ ]　others[ ]

Spotting sites:(Island or sea water area)：

Numbers of nesting turtles and Date：_____

Threats：marine pollution[ ] coastal development[ ] Fishery bycatch[ ] direct capture[ ] loss of nesting habitat[ ] Others[ ]

Changes in the number of capture or nesting turtles

Time	0	1－2	3－5	6－10	10－20	＞20
1970s						
1980s						
1990s						
Now						

Changes in the seasonal distribution of nesting turtles

No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0												
1－2												
3－5												
6－10												
10－20												
＞20												

Other relevant information: