

# CHELONIAN CONSERVATION AND BIOLOGY

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Cover: A new subspecies of snake-necked chelid turtle (genus *Chelodina*) from eastern Timor-Leste (East Timor), is described in this issue by Kuchling, Rhodin, Ibarrrondo, and Trainor (pp. 213-222). (Photos by GERALD KUCHLING [top] and BONGGI R. IBARRONDO [bottom]).

## A Comprehensive Overview of the Population and Conservation Status of Sea Turtles in China

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**ABSTRACT.** – Five species of sea turtles, including leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and olive ridley turtles (*Lepidochelys olivacea*), were found in the waters east and south of mainland China and the associated islands. Decades of harvesting and habitat degradation have led to a drastic decline in the sea turtle population in the last century. Many foraging grounds and nesting sites have been degraded or have disappeared as a result of human activities. Nowadays, there are only a few nesting sites and even fewer foraging grounds for sea turtles in China. Fishery bycatch is also believed to have been a major cause of sea turtle mortality in recent years. There is an urgent need for more efforts to be focused on the conservation of sea turtles in the region. However, limited information is available, which has impeded the formulation of effective conservation measures. The goal of this paper is to provide an overview on the current population and conservation status of sea turtles, as well as recommendations for their effective management in China.

**KEY WORDS.** – Dermochelyidae; Cheloniidae; *Caretta caretta*; *Chelonia mydas*; *Dermochelys coriacea*; *Eretmochelys imbricata*; *Lepidochelys olivacea*; sea turtle; China; conservation; population status; nesting site; foraging ground.

The People's Republic of China has a total marine area of over 4,700,000 km<sup>2</sup> and a coastline of 32,000 km. The mainland is surrounded by 4 seas in the western Pacific Ocean: the inland Bohai, the Yellow Sea, the East China Sea, and the largest, South China Sea. Except for Bohai, which has an annual sea temperature of 0° to 21°C, the Yellow, East China, and South China seas are relatively warmer, with water temperatures ranging from 15° to 28°C, and they support a large number of subtropical and tropical marine organisms, including the once abundant but now endangered sea turtles. Due to the difficulties to conduct sea turtle research, limited information is available on sea turtles in China. Most sea turtle research has been restricted to particular areas or nesting sites but a comprehensive overview on the existing population and conservation status of sea turtles in China is lacking. In addition, most of the relevant articles have been published in Chinese, which makes access and interpretation of relevant information difficult for the international community. For example, Shanker and Pilcher (2003) made a recent assessment on marine turtle conservation in South and Southeast Asia. However, due to an apparent lack of appropriate information in English, the conservation status of sea

turtles in China was not mentioned. Mistakes, due to translation, have also been found in published materials about sea turtles in China. For example, loggerhead turtles (*Caretta caretta*) are only known to nest in the Xisha Archipelago (Paracel Islands) of China (Ouyang et al. 1992; Cheng 2000c), while Limpus and Limpus (2003) have quoted that this species nests along the coast of mainland China; this was probably due to misinterpretation of the source information.

Sea turtles are migratory species, and successful conservation measures cannot be accomplished without the existence of a tight-knit spirit of cooperation among the concerned parties at the nesting sites, along the migratory routes, and in the foraging grounds. Information exchange, technical support, and cooperative research are all needed, between government agencies, international communities, and research institutions, to enhance sea turtle conservation. It is obvious that these deficiencies are the major obstacles blocking the conservation of sea turtles on both a regional and global scale. This paper provides an overview of the existing population and conservation status of sea turtles in China. It is our fervent hope that this will initiate more holistic conservation efforts to protect sea turtles in China.

## SEA TURTLE SPECIES AND THEIR GEOGRAPHIC DISTRIBUTIONS

Five species of sea turtles occur in China, including loggerheads, green turtles (*Chelonia mydas*), leatherbacks (*Dermochelys coriacea*), hawksbills (*Eretmochelys imbricata*), and olive ridleys (*Lepidochelys olivacea*). They are all listed as Critically Endangered in the China Species Red List (Anonymous, 2004). It is estimated that sea turtles are most abundant in the South China Sea. Investigations conducted along the coast, from Bohai in northern China to Nansha Archipelago (Spratly Islands) in the South China Sea, have indicated that there is an increasing trend in both the numbers and abundance of species, from the north to the south. The waters and islands in the South China Sea have been considered as the major foraging and nesting grounds for sea turtles in China, particularly the Nansha and Xisha Archipelagos (Huang 1979a; Wang 1980; Liang et al. 1990; Wang 1993; Cheng 1995b, 1996). According to Liang et al. (1990), about 90% of sea turtles in China are found in the South China Sea. Based on historical data of direct harvest during the period from 1959 to 1988, the size of this population was estimated to be about 16,800 to 46,300. The estimated proportion of each species was approximately 87% for green turtles, 10% for hawksbill turtles, and the remaining 3% for leatherback, loggerhead, and olive ridley turtles, combined.

Based on information from fishery bycatch and strandings for nesting and nonnesting species, as well as records for the nesting species, the geographic distribution of each species is obtained and described from the following sources (Wang 1966; Anonymous 1975; Huang 1979a, 1979b; Ding et al. 1980; Zhao and Huang 1982; Zhou 1983; Wen 1984; Zheng 1985; Zong 1986; Huang and Zhu 1987; Frazier et al. 1988; Huang et al. 1991; Nishimura and Nakahigashi 1992; Hua and Yin 1993; Cheng 1995c, 1997, 1998b, 2000c; Cheng and Chen 1997; Zhang et al. 1998; Lu et al. 1999; Jiang et al. 2000; Li 2000; Song et al. 2002a; Zhou and Chen 2002; Chan 2004; AFCD 2005; GSTNRR 2005), and as diagrammatically shown in Fig. 1.

*Dermochelys coriacea*. — While an uncommon species in China, the leatherback turtle is distributed throughout the waters of China. The leatherback turtle is a pelagic species, spending most of its life in the offshore waters. Both adults and subadults can be found in China (Frazier et al. 1988). Leatherback turtles are not known to nest in China (Cheng 1997).

*Caretta caretta*. — The loggerhead turtle is also an uncommon species in China. While both adults and subadults are present, subadults seem to occur more frequently (Frazier et al., 1988). Loggerhead turtles are distributed throughout the waters of China. Frazier et al. (1988) observed that there were more at sea sightings of loggerhead turtles in Fujian (Pingtan Island, in particular) during a survey conducted in the Fujian and Guangdong

coastal waters of South China. Zhu (2002) suggested that loggerhead turtles migrate from Xisha Archipelago and the South China Sea to the northern waters, presumably seeking for food, by following the warm ascending currents. Within China, loggerhead turtles are only known to nest in the Xisha Archipelago in the South China Sea (Ouyang et al. 1992; Cheng 2000c).

*Chelonia mydas*. — The green turtle is the most common and abundant of sea turtles found in China. Their distribution ranges from Liaoning in the north, past Taiwan, to the Beibu Gulf in the South China Sea. Existing nesting sites are only located in a few subtropical or tropical beaches in Guangdong and Taiwan as well as several sites in the Dongsha (Pratas Island), Xisha, and Nansha archipelagos in the South China Sea. All life stages can be found in the waters of China (Frazier et al. 1988). According to Frazier et al. (1988), the species is most abundant in the southern waters of China and nearly 80% of the turtles captured during a survey in the South China Sea came from the waters of Hainan Island and the Xisha Archipelago. The remaining turtles were captured from Guangdong and Fujian. Tan and Huang (1988) also reported that the green turtle is most abundant in the waters off Guangdong and Hainan Island, whereas olive ridley and loggerhead turtles are often found in Fujian.

*Eretmochelys imbricata*. — The hawksbill turtle is a common species in China. It can be found in the Yellow, East China, and South China seas, ranging from the waters off Shandong to the Beibu Gulf. Most records of live sightings and strandings were subadults from the East China and South China Seas (Frazier et al. 1988). Hawksbill turtles are known to nest in the Dongsha and Nansha archipelagos (Cheng 1996, 2000c).

*Lepidochelys olivacea*. — The olive ridley turtle is an uncommon species in China. It can be found in the Yellow, East China, and South China seas. Both adults and subadults have been recorded (Frazier et al. 1988). According to Frazier et al. (1988), olive ridley turtles occur more frequently in the waters off Fujian than off Hainan Island, Guangdong, or Zhejiang. Olive ridley turtles are not known to nest in China (Cheng 1997).

A detailed list of the localities of the sighting and nesting records of sea turtles in China in both Chinese and English are available upon request from the corresponding author.

## HABITAT STATUS

### Currently Known Nesting Sites

Only green, loggerhead, and hawksbill turtles are known to nest in China (Cheng 1997). The nesting sites are located in the subtropical and tropical beaches on the mainland and associated islands. Historical records indicate that green turtles used to nest in a number of sites along the coast from Fujian to the Beibu Gulf, as well as some offshore islands in the South China Sea. However,

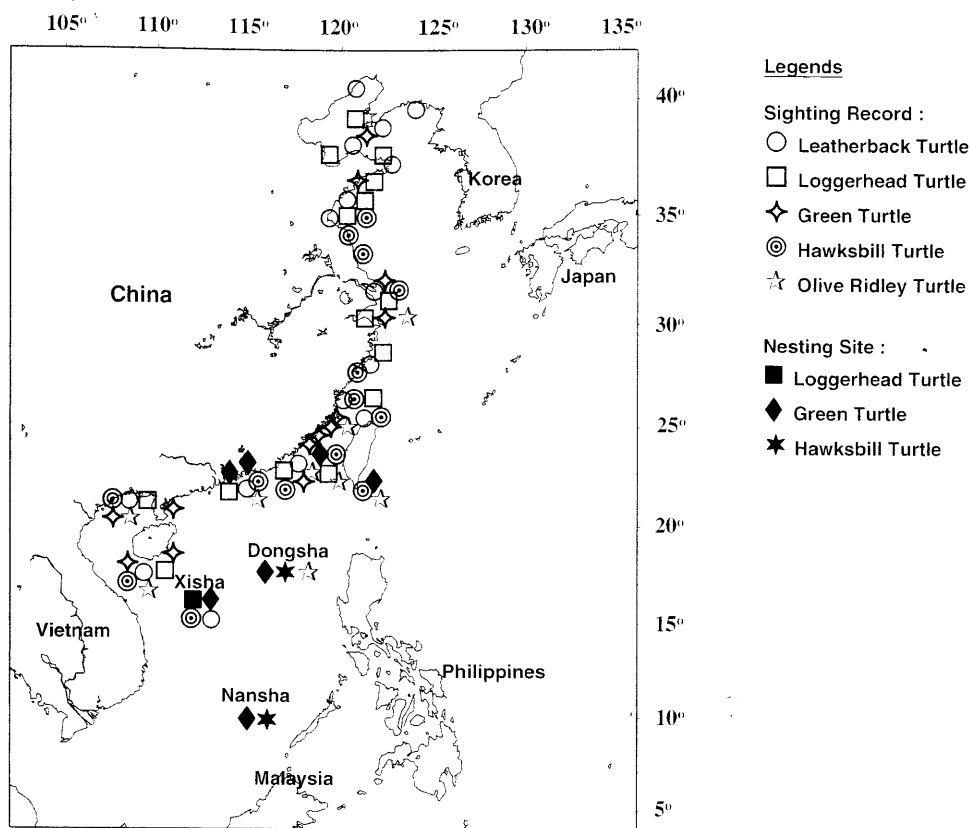


Figure 1. The distribution of sea turtles in China.

most of these sites do not exist due to habitat loss or degradation or turtles no longer nest there over the past few decades (Frazier et al. 1988; Jiang et al. 2000). Nowadays, nesting green turtles are only found in a few sites on the mainland, in Taiwan and in the Dongsha, Xisha, and Nansha archipelagos in the South China Sea. On the other hand, loggerhead and hawksbill turtles only nest on the archipelagos in the South China Sea. The existing nesting sites are described as follows.

*Mainland China.* — Before the 1940s, Chinese fishermen claimed that sea turtles used to nest in a number of beaches along the coast of Guangdong, Hainan Island, and Beibu Gulf (Liang et al. 1990). A more detailed survey, on the distribution and nesting sites of sea turtles, was conducted in Fujian, Guangdong, and Hainan Island in 1985, with 14 nesting beaches being identified, including 7 in Fujian, 1 in Guangdong, and 6 on Hainan Island. Except for the nesting beach at Huidong in Guangdong, no nesting activity was observed at the other sites (Frazier et al. 1988). Based on local anecdotal accounts, unconfirmed reports of historical nesting sites include Chuanshan Island in Guangdong and the Beibu Gulf in Guangxi but these sites seemed to have been abandoned over the past few decades (Jiang et al. 2000). Nowadays, the only known nesting sites on the mainland are in Huidong and Hong Kong. Situated in Huidong, the Gangkou “Sea Turtle Bay” is a well-known nesting site on the mainland. It is the only national nature reserve, designated in 1985, dedicated to the protection of a sea

turtle nesting site in the mainland. The Gangkou nesting beach has an area of 0.1 km<sup>2</sup> but the total area of the nature reserve, including the nesting beach and the surrounding waters, is about 18 km<sup>2</sup> (Jiang et al., 2000). According to historical records, decades ago, sea turtles used to nest in many remote beaches in Hong Kong. However, due to the rapid development and intense human activities, most of these sites do not exist or turtles no longer nest on these sites. At present, the only nesting site in Hong Kong is located on a small sandy beach (about 0.005 km<sup>2</sup>) called Sham Wan on Lamma Island (Romer 1978; Karsen et al. 1998; Chan 2004). The green turtle is the only nesting species in Huidong (Zhang 1992; Jiang et al. 2000) and Hong Kong (Chan 2004).

*Taiwan.* — Among the various nesting sites in Taiwan, Wan-an Island in Penghu Archipelago and Lanyu Island in Taitung County are the 2 main nesting islands. The green turtle is the only nesting species found in Taiwan (Cheng 1995a, 1997, 1998a, 2002; Huang 2000).

*South China Sea.* — Nesting sites include the Dongsha Archipelago, Taipin Island in Nansha Archipelago, and the Xisha Archipelago (on Dong Island, Jinqing Island, Zhongjian Island, and Qilianyu). Nesting species include green turtles at Taipin Island, the Dongsha Archipelago, and the Xisha Archipelago (Anonymous 1975; Liang et al. 1990; Cheng 1996, 2000c); loggerhead turtles at the Xisha Archipelago (Ouyang et al. 1992; Cheng 2002); and hawksbill turtles at the Dongsha Archipelago and Taipin Island (Cheng 1995b, 1996,

2000c). Frazier et al. (1988) seemed to have evidence that the nesting population of green turtles in Xisha Archipelago was large, although no detailed studies have ever been conducted, so far. Of the 3 nesting species, green turtles are the most abundant in Xisha Archipelago (Anonymous, 1975)

### Currently Known Foraging Grounds

Very little is known about the foraging grounds of sea turtles in China. The following section describes the currently known foraging grounds and also identifies potential ones.

*Mainland China Coast.* — Frazier et al. (1988) suggested that there is little feeding habitat for green and hawksbill turtles along the coast of Fujian and Guangdong, due to the lack of nearshore waters. However, the waters surrounding Nanao Island and Dongshan Island, between Guangdong and Fujian, were reported to be important foraging grounds for sea turtles, including green, hawksbill, olive ridley, and leatherback turtles (Xu and Zheng 2000). The coastal waters off Guangdong, and in particular, the waters around offshore islands, such as the Wanshan Archipelago, Shangchuan Island, Xiachuan Island, Donghai Island, and the Qiongzhou Gulf of the Leizhou Peninsula, are also potential foraging grounds for green turtles. Satellite telemetry seems to support the above conclusions (Cheng 2000a, 2000b; Song et al. 2002b; Chan et al. 2003; Chan 2004). Other potential foraging grounds for sea turtles on the mainland may occur along the coastal waters where sea turtles, in particular juveniles or subadults, have been frequently captured or sighted, and where suitable habitats, such as coral reefs and seagrass pastures are present. These sites include the inshore waters of Qingdao in Shandong (Wang 1975); Pingtan Island and Dongshan Island in Fujian (Zheng 1985); the shallow offshore waters of Jiangsu (Zhou 1983; Zong 1986); Guiling Island and the surrounding waters (Liang et al. 2000); and Shanwei in Guangdong (AFCD 2005). Lusi in Jiangsu may also be a suitable foraging ground because Hua and Yin (1993) reported that, during the jellyfish reproduction season in autumn, leatherback turtles were observed feeding on jellyfish in the waters of Lusi; fishermen caught 7 leatherback turtles there in the autumn of 1982. The continental shelves of the South China Sea are also considered as foraging grounds for loggerhead turtles nesting in Japan. Hatase et al. (2002) reported that 3 loggerhead turtles nested at Minabe of Japan migrated to the neritic part of the East China Sea. Further evidence was given by the report that a loggerhead turtle tagged in Japan was recaptured in Vietnam (Sadoyama et al. 1996).

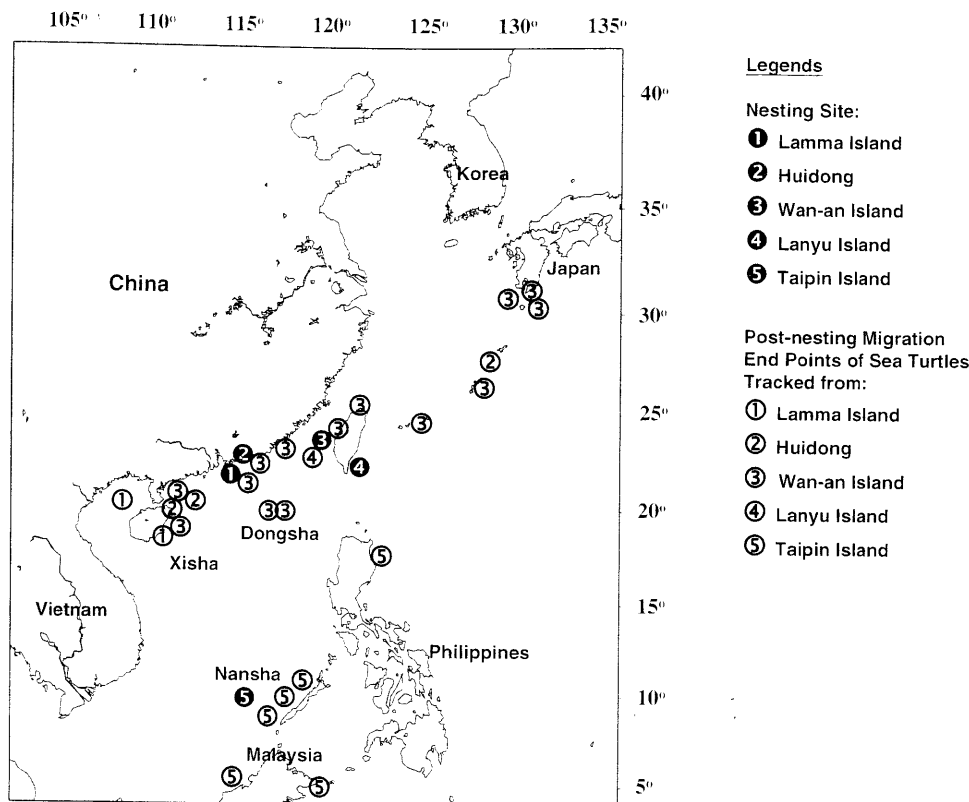
*Hainan Island.* — Satellite telemetry has indicated that the southern coastal waters of Hainan Island, in particular the shallow waters near Wanning and Wenchang, are potential foraging grounds for green turtles (Cheng 2000a, 2000b; Chan et al. 2003). Seagrass pastures

and coral reefs are also found in Qionghai and Sanya, and may provide suitable feeding grounds for green and hawksbill turtles (Frazier et al. 1988).

*Taiwan.* — The foraging grounds include the coastal waters off Taiwan (Cheng et al. 2000). Green, loggerhead, hawksbill and olive ridley turtles have been found there (Cheng and Chen 1997). Satellite telemetry showed that the foraging grounds of adult green turtles that nested at Wan-an Island included the coastal waters off northern Taiwan, Nanao Island, Huidong, Hong Kong, Dongsha Archipelago, Hainan Island, east coast of Leizhou Peninsula, northern Philippines, Ryukyu Archipelago, and Koshiki in southern Japan (Cheng 2000a, 2000b; Cheng et al. 2000). Similarly, satellite telemetry showed that one foraging site for adult green turtles that nested on Lanyu Island is located around the coral reefs in the southern Penghu Archipelago, north of Chimei Island (I.J. Cheng, unpubl. data, 1997). In addition, coastal fishery bycatch showed that the coral reefs in the Penghu waters act as foraging grounds for juvenile and subadult green and hawksbill turtles. Subadult olive ridley and loggerhead turtles have also been infrequently recorded in this region (Chen et al. 2004). Tagged loggerhead turtles, recovered from fishery bycatch, showed that the East China Sea and the coastal waters off Japan are foraging grounds for loggerhead turtles nesting in Japan (Sato et al. 1997).

*South China Sea.* — Satellite telemetry has shown that the foraging grounds of adult green turtles, nesting on Taipin Island of the Nansha Archipelago, are mainly located in the coastal waters off Palawan Island, Philippines, the north coast of eastern Malaysia, and the east coast of Luzon Island, Philippines (Cheng 2003, 2007). Many of these foraging grounds, especially Palawan Island and eastern Malaysia, are shared with those green turtles nesting in western Malaysia (Liew et al. 1995). In 1994, recapture reports from the conventional Inconel tags showed that a green turtle, which nested at Wan-an Island, was found in the northern Philippines (Cheng 2000a). The waters of the Dongsha and Xisha Archipelagos host substantial seagrass pastures and coral reefs (Lin 2001; Li et al. 2004). These habitats may provide suitable foraging grounds for sea turtles. Also, Hamann et al. (2006) reported that loggerhead turtles use the South China Sea as foraging habitat.

*Other Sites.* — Dao Bach Long Vi is a small offshore island within the territorial waters of Vietnam in the Beibu Gulf. A postnesting green turtle from Hong Kong was reported as arriving at Dao Bach Long Vi (Chan 2004). It is possible that the waters around the island are the foraging ground for a subset of green turtles from the rookery in Hong Kong. One postnesting green turtle from Wan-an Island and another from Gangkou Sea Turtle National Nature Reserve were found to spend time in the nearshore waters of Okinawa Island, Japan (Cheng 2000a; Song et al. 2002b). Seagrass beds exist in the northeastern waters of Okinawa Island and the area is known as a



**Figure 2.** Postnesting migration end points of sea turtles tracked from their respective nesting sites in the South China Sea. The end-point of migration is defined as the tagged turtle being stayed in the vicinity of the last position over one month (Cheng 2000a, 2000b, 2007; Song et al. 2002b; Chan et al. 2003; Chan 2004).

foraging ground for green turtles (Kikukawa et al. 1996; Anonymous 2002b).

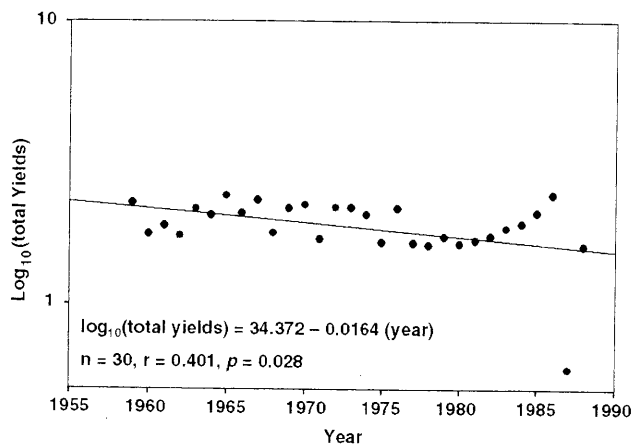
Figure 2 shows the postnesting migration end points of sea turtles tracked by satellites from their respective nesting sites in the South China Sea (Cheng 2000a, 2000b, 2007; Song et al. 2002b; Chan et al. 2003; Chan 2004).

**STATUS AND TREND OF SEA TURTLES**

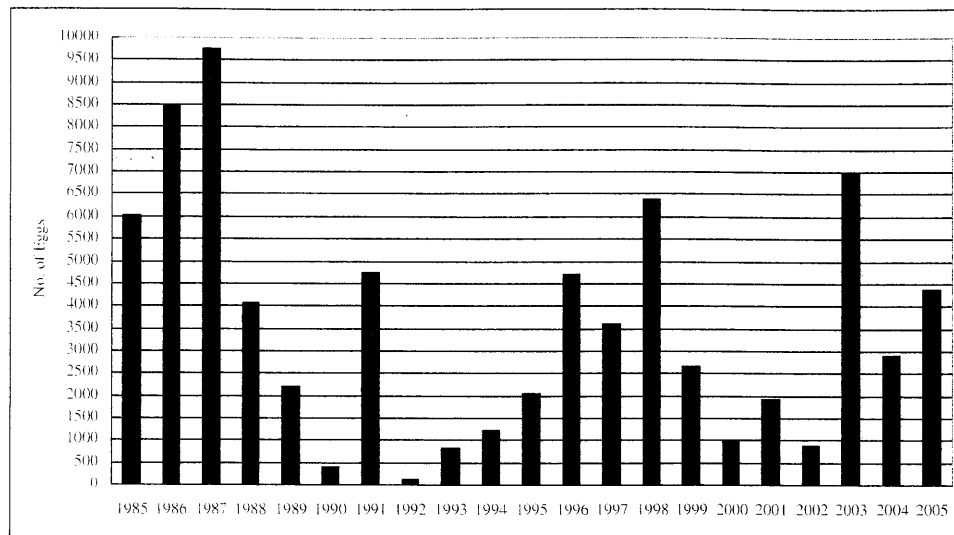
According to Liang et al. (1990), the population size of sea turtles in the South China Sea was estimated to be about 16,800 to 46,300 in the 1980s, including about 14,000 to 40,000 sea turtles in the Xisha and Nansha Archipelagos, 2300 to 5500 in the coastal waters off Guangdong, Hainan Island and Dongsha Archipelago, and 500 to 800 in the Beibu Gulf. From the annual yield of sea turtles harvested directly by fishermen in the South China Sea from 1959 to 1988, Liang et al. (1990) estimated that over 31,800 sea turtles were slaughtered during the period (the mean body weight of harvested turtles was assumed to be 100 kg per turtle). That is, on average, well over 1000 sea turtles were killed each year. There existed an exponential decrease in sea turtle harvest from 1959 to 1988 (Fig. 3). Furthermore, Wang (1980) reported that the size (in straight carapace length, SCL) of loggerhead turtles caught in the coastal waters of Shandong was smaller in the 1980s (SCL ~ 50 to 80 cm) when compared to those in the early 1960s (SCL ~ 90 cm). In Fujian, there

were also fewer numbers of green and loggerhead turtles caught from fishery bycatch in recent years, and the number of leatherback, hawksbill, and olive ridley turtles was also rapidly decreasing (Zheng 1985). All of the above evidence suggests that the sea turtles in China have suffered from overexploitation.

Systematic surveys of the nesting population have been carried out at 4 sites, with the green turtle being the only nesting species identified so far. These sites are Gangkou Sea Turtle National Nature Reserve since 1985 (Jiang et al. 2000; GSTNNR 2005), Lamma Island since



**Figure 3.** The annual yield of sea turtles harvested by fishermen in the South China Sea from 1959 to 1988 (Liang et al. 1990). The Y-axis is on log-scale.



**Figure 4.** The total number of eggs produced by nesting green turtles at Gangkou Sea Turtle National Nature Reserve from 1985 to 2005 (GSTNNR 2005).

1997 (Chan 2004; AFCD 2005). Lanyu Island since 1997, and Wan-an Island since 1992 (Cheng 2003). Some discontinued nesting data were also available from the nesting sites at the Dongsha, Nansha, and Xisha archipelagos (Cheng 1995b, 1996, 1997, 2000c, 2007). Data from these nesting sites indicate that existing nesting populations in China (including green, loggerhead, and hawksbill turtles) are very small.

#### Nesting Population Status

*Mainland China.* — According to Zhang (1992), about 400 green turtles nested in Gangkou Sea Turtle National Nature Reserve every year before the 1950s. From the 1950s to early 1980s, prior to the establishment of the nature reserve, approximately 60 to 80 turtles were slaughtered every year and nearly all the eggs were collected for food. The recruitments were seriously impacted by human intervention. According to the nature reserve's record (GSTNNR, 2005), the number of nestings and eggs laid each year ranged from 1 to 83 and 131 to 9766, respectively, producing a total of over 75,000 eggs from 665 nests from 1985 to 2005. On average, there were about 30 nests, with 3500 eggs, being laid each year. A total of 125 nesting turtles were tagged during this period (range = 1 to 20 tagged females/year). The number of eggs produced fluctuated greatly each year (Fig. 4).

Limited data have shown that each year the number of nesting turtles in Lamma Island ranged from 0 to 5. From 1997 to 2005, the total number of nests was 28 and the estimated total number of eggs laid was about 3000 (AFCD 2005).

*Taiwan.* — Wan-an Island of Penghu Archipelago hosts a small green turtle rookery, with 2 to 19 females each year from 1992 to 2005 (Fig. 5; Chen and Cheng 1995; Wang and Cheng 1999; I.J. Cheng, unpubl. data, 2005). Lanyu Island also hosts a small green turtle rookery

ranging from 5 to 13 females per season. There are 2 nesting beaches on the island; one faces the Pacific Ocean and the other faces eastern Taiwan. No refuge site has been established on this island. Data on annual nesting abundance from 1997 to 2005 shows substantial annual variation (Fig. 6) (Cheng 2002; I.J. Cheng, unpubl. data, 2005).

*South China Sea.* — Due to national security reasons, long-term research on the islands of the Dongsha, Nansha, and Xisha archipelagos has not been possible. Thus, the nesting populations in these regions could only be estimated. On Taipin Island of the Nansha Archipelago, it has been estimated that the nesting population ranges from 30 to 64 females (green and hawksbill turtles) per year, with the peak nesting seasons lasted from June until September and from November until February (Cheng 2007). On Dongsha Archipelago, only a small rookery of hawksbills, with less than 10 females/year, was found (Cheng 1995b). This number was reconfirmed by the report of resident Coast Guards in 2003, which recorded only 4 tagged females. A 10-day field trip, in the summer of 2004, did not find any nesting activity (I.J. Cheng, unpubl. data, 2004). The Xisha Archipelago is a major nesting site for sea turtles in China (Huang 1986; Liang et al. 1990; Wang 1993). Huang (1979a) reported that over 1,100,000 kg or about 11,100 sea turtles (mostly green turtles but also some loggerhead turtles) were caught from 1959 to 1970 within the waters of the Xisha Archipelago, suggesting that there had been a large nesting population. Surveys conducted in 1987 and 1989 in Qilanyu of the Xisha Archipelago recorded a total of 92 females (Liang et al. 1990).

The status of sea turtle nesting populations at various known sites in China are listed in Table 1. The data suggest that the sea turtle population in China is not large. At sites, with relatively systematic and long-term nesting

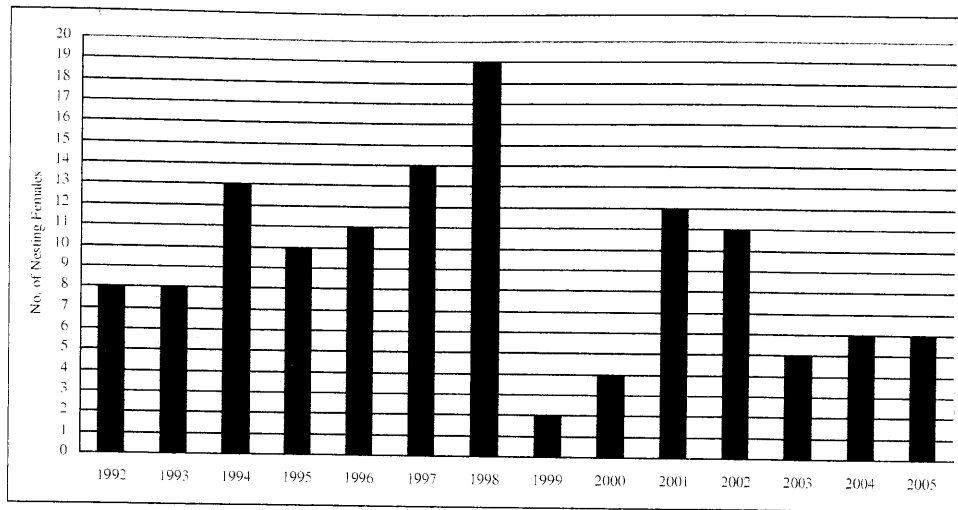


Figure 5. Changes in the number of nesting green turtles in Wan-an Island from 1992 to 2005 (I.J. Cheng, unpubl. data, 2005).

records, such as Gangkou and Wan-an Island, no obvious increasing or decreasing trends are discernable.

**THREATS**

Similar to the other species, the sea turtles in China have faced serious human threats since the last century. The threats include direct harvesting, fishery bycatch, habitat degradation, and pollution (Cheng 1998b).

*Direct Harvesting.* — In China, a considerable number of sea turtles were slaughtered before they were listed as protected species in 1988 (Liang et al. 1990; Zhao 1998). Both the eggs and nesting turtles were harvested for consumption from nesting sites such as Gangkou and the Xisha Archipelago. In Gangkou alone, it has been reported that 60,000 to 200,000 eggs of green turtles were collected each year before the 1950s (Zhang 1992). Gravid females were also slaughtered for human consumption and it was

estimated that 70 to 80 green turtles were harvested each year in Gangkou during the 1950s (Liang et al. 1990). Green turtles were also intensively fished in the Xisha Archipelago and most catches were done during the summer and autumn (Frazier et al. 1988). Direct beach harvesting for meat was common in eastern Taiwan in the early 1970s, especially along the east coast, resulting in the killing of most of the nesting green turtles there (I.J. Cheng, unpubl. data, 1995).

Like the green turtles, the population of hawksbill turtles in China suffered from overharvesting and pollution, resulting in a sharp decline in recent decades (Mao and Zheng 2000). Nowadays, the direct harvesting of sea turtles and egg poaching no longer exists in the protected nesting sites. However, illegal capture of sea turtles still occurs occasionally and the exact extent of the damage to sea turtle populations is unknown.

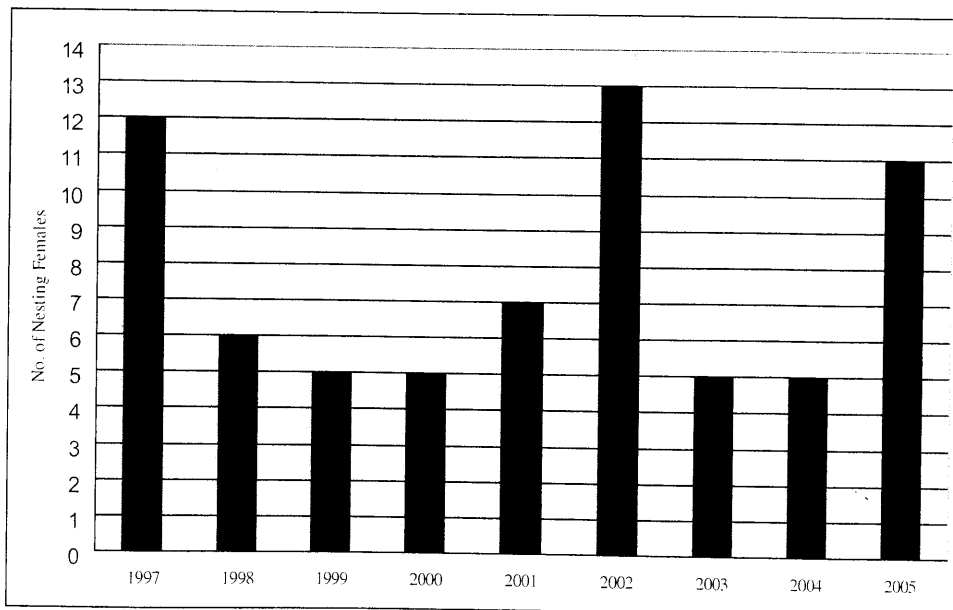


Figure 6. Changes in the number of nesting green turtles in Lanyu Island from 1997 to 2005 (I.J. Cheng, unpubl. data, 2005).



**Table 1.** The status of nesting sea turtle populations at various sites in China.

Nesting site	Species	No. of nesting females per season	Clutch size	No. of clutches per season	Hatching rate (%)	References
Gangkou Sea Turtle National Nature Reserve, Huidong	green turtle	1–20	mean = 113	mean = 5	34–96	GSTNNR (2005)
Lamma Island, Hong Kong	green turtle	0–5	103–152	1–8	40–90	AFCD (2005)
Wan-an Island, Penghu Archipelago	green turtle	2–19	70–154	1–9	50–87	Cheng (1997); I.J. Cheng (unpubl. data, 2005)
Lanyu Island	green turtle	5–13	86–152	1–4	52–86	Cheng (1997); I.J. Cheng (unpubl. data, 2005)
Dongsha Archipelago	green turtle and hawksbill turtle	4–10	no data	no data	no data	Cheng (1995b); I.J. Cheng (unpubl. data, 2004)
Taipin Island, Nansha Archipelago	green turtle and hawksbill turtle	30–64	no data	no data	no data	Cheng (1997, 2007)
Xisha Archipelago	green turtle loggerhead turtle	29–53 no data	26–148 no data	no data no data	no data no data	Huang (1986); Liang et al. (1990); Ouyang et al. (1992); Wang (1993); Cheng (2002)

*Fisheries Bycatch.* — Several studies have identified that fisheries bycatch is a major threat to sea turtles worldwide (e.g. Heppell 1998; Hall et al. 2000; Heppell et al. 2000; Hays et al. 2003; Lewison et al. 2004). Frazier et al. (1988) reported that except for the green turtle, which was fished directly, fisheries bycatch was the main source of mortality for all the other species of turtles in China. According to the record of the nature reserve in Huidong (GSTNNR 2005), sea turtles caught in gill nets and trawler nets from 2001 to 2005 included 11 green turtles, 4 olive ridleys, 2 leatherbacks, and 2 hawksbills. In addition, 5 green turtles, 1 olive ridley, 1 loggerhead, and 1 hawksbill were found stranded on nearby beaches, also perhaps killed as a result of bycatch. The actual number of sea turtles, killed as a result of fisheries bycatch may even be higher when the number of suspected unreported cases is taken into account. Nishimura and Nakahigashi (1990) estimated that Japanese research and training vessels had incidentally captured over 21,200 turtles, with 12,296 being killed, in the Western Pacific and South China Sea. Sato et al. (1997) reported that among 395 loggerhead turtles tagged while nesting on Senri Beach in Japan between 1990 and 1995, 2 were captured by trawler nets in the East China Sea and 7 were captured by set-nets along the coast of Japan.

Set-net fisheries have been the main source of coastal bycatch in Taiwan. A few decades ago, most turtles caught incidentally were slaughtered or sold for release in religious ceremonies. Nowadays, these sea turtles are usually released back into the sea at the scene, due to the enforcement of wildlife conservation laws by Coast Guards (Cheng and Chen 1997; Cheng 2002). However, it is apparent that the potential impact of bycatch on the sea turtle populations of China cannot be underestimated.

*Habitat Degradation.* — In recent years, the rapid coastal development in China has resulted in a serious disturbance to the coastal marine environment, including the foraging and nesting habitats of sea turtles (Tan and Ding 2003; Zhang 2003). Beach developments will

destroy turtle nesting habitats and cause serious beach erosion (Cheng 1995d; Huang 2001). Both tourism development and sand mining have resulted in a serious damage to many sea turtle nesting sites and foraging grounds in China. Xiachuan Island, in Guangdong, used to be a sea turtle nesting site some decades ago. However, it is likely that sea turtles no longer nest there because of tourism development on the island (Liang et al. 1990).

Artificial light discourages the nesting turtles from emerging and also creates an abnormal behavior in the nesting activities (Hsien 2004). In addition, intensive illumination at the back of the beach will disorientate the hatchlings, preventing them from entering the sea, and increase the mortality rate (Hsien 2004). In the Dongsha Archipelago, studies have suggested that dynamite and poison fishing as well as direct harvesting may be the main reasons for the small nesting population there. Besides, beach security fences posed an additional threat to the remaining nesting turtles. Although more marine patrols have been conducted in this atoll to protect the marine ecosystem, and most fences have been removed in recent years, the nesting population has yet to recover (Cheng 1995b). The recent increase in the number of small fishing vessels using trawl nets has caused considerable damage to the benthic habitats in the waters of Guangxi and Nanao in Guangdong, further threatening the survival of sea turtles in this area (Yang and Lin 1999; Tan 2003).

*Pollution.* — The rapid development and population growth in China has released an ever-increasing amount of pollutants that are eventually entering into the coastal ecosystems, leading to the disappearance of the once highly diverse marine organisms in many coastal waters of China (Yu et al. 2000; Zhang 2003). Tan and Ding (2003) reported that water pollution from reclamation and aquaculture has brought about a serious impact on the marine ecosystem, causing a sharp decline in the number of sea turtles in the waters of Zhejiang. In Sanya, Hainan Island, the heavy metal levels were found to be increasing in the coral reefs, indicating the deterioration in water

quality, which poses a long-term potential threat to marine life, including sea turtles, in the area (Huang et al. 2003). Pollution, mainly due to the discharges of untreated domestic sewage, has also occurred in Xisha Archipelago (Li et al. 2004). Solid debris, oil and tar, organochlorine residues, and heavy metals are the major pollutants threatening the survivorship of sea turtles in the Mediterranean Sea (Godley et al. 1999). They may also play an important role in the decline of sea turtle populations in Japan (Sakai et al. 2000). In fact, other studies on heavy metals and organochlorine residues in sea turtles have found that the contaminant burdens are highest in juvenile animals, at levels causing subclinical toxic effects in other vertebrates (Godley et al. 1999; McKenzie et al. 1999). An analysis of the trace element residues in eggs and tissues of adult green turtles from Hong Kong found that the levels of heavy metals such as Hg and Cd were relatively low in the tissues. However, Se and Ni were found to pose a potential health risk to eggs and hatchlings (Lam et al. 2004, 2006). Fibropapillomatosis, which affects green turtles almost worldwide in recent years, has been reported twice in the subadult green turtles in the waters of Northern Taiwan (I.J. Cheng, unpubl. data, 1997).

#### CONSERVATION AND MANAGEMENT

A number of measures were implemented in China with a view to protecting the endangered sea turtles and their habitats. These measures are briefly described as follows.

*Legal Protection Status.* — All 5 species of sea turtles are protected in China. They are listed as "Second Class State Protected Animals" in the "List of State Key Protected Wildlife" under the Law of the People's Republic of China on the Protection of Wildlife. The hunting, catching, or killing of any protected wildlife is prohibited (Anonymous, 1992). China is also a signatory state to the CITES and Bonn Convention. In Taiwan and Hong Kong, sea turtles are also protected under the local ordinances respectively (Anonymous 1997, 1999, 2002a).

*Monitoring and Conservation of Sea Turtles.* — The Gangkou Sea Turtle National Nature Reserve implemented a species conservation program in 1985. Population monitoring and conventional tagging have been employed since then to study the population dynamics and nesting ecology of the sea turtles. In addition, a head-starting program has been conducted to improve the survivorship of sea turtle population. Satellite telemetry on the postnesting migration of green turtles has been carried out to identify the whereabouts of their resident foraging grounds (Song et al. 2002b). In Taiwan, monitoring of the nesting population has been carried out at Wan-an Island since 1992 and at Lanyu Island since 1997 (Cheng 2002). In addition, various studies were carried out on the nesting ecology, satellite telemetry, threats, and incubation environment of sea turtles in these areas (Chen 1998, 2002; Lin 1999; Wang and Cheng 1999; Cheng 2000a,

2000b, 2007; Lai 2000; Jen 2001; Hsien 2004). In Hong Kong, a sea turtle conservation program was implemented since 1997. The program includes regular patrols and management of nesting site, conventional tagging, monitoring of the nesting population, artificial incubation, toxicological studies, satellite telemetry, and public education (Chan et al. 2003; Chan 2004; Lam et al. 2004, 2006). A territory-wide survey was also conducted to assess the status of green turtles in Hong Kong (McGilvray and Geermans 1997).

*Conservation and Management of Habitats.* — In the mainland, the nesting beach at Gangkou, Huidong is a national nature reserve, managed by a dedicated management authority. Entry into the nesting beach and the adjacent waters is restricted, and a 24-hour patrol of the beach is carried out during the nesting season, to protect the nesting turtles. In addition, the reserve's management authority works together with the fisheries management authority to protect the sea turtles from direct harvesting and fisheries bycatch in the surrounding waters. In Taiwan and Hong Kong, the nesting beaches on Wan-an Island and Lamma Island were also designated as a protected area. Entry to the nesting beaches is restricted and patrols are carried out during the nesting season (Cheng and Lin 1996; Chan 2004). Various habitat management measures, including the removal of weeds, collection of refuse, and monitoring of site conditions, are also carried out in Lamma Island during the nesting season (Chan 2004). In Xisha Archipelago, access to the islands and fishing activity in the surrounding waters are prohibited at Qilianyu for the protection of the sea turtles nesting there (Liang et al. 1990). A field station was set up for the sea turtle conservation works (Huang 1987). In Nansha Archipelago, the beaches around Taipin Island are patrolled by Coast Guards during the day. Light and human activities are prohibited on the beaches at night for security reasons. These restrictions provide a suitable environment for nesting turtles on the island (I.J. Cheng, unpubl. data, 2007).

*Regional and International Cooperation.* — A tight-knit spirit of cooperation has developed among the conservation officials and academics of the mainland, Taiwan, Hong Kong, and the United States for information exchange, staff training, and scientific studies (Chan 2004). Joint research endeavors on the satellite telemetry of postnesting migration of green turtles in Gangkou (Song et al. 2002b) and on the bycatch of loggerhead turtles by set-net fisheries in Taiwan (I.J. Cheng, unpubl. data, 1996) have been carried out, in order to obtain a better understanding of sea turtle ecology in the region. An international workshop was held in 2000 in Taipei to promote and foster information exchange on sea turtle research and conservation, with relevant Asian countries sharing the critical habitats of the green turtles nesting in Taiwan (Cheng 2000d; Cheng et al. 2000). In 2006, a Sea Turtle Stranding and Necropsy International Workshop was held in Makung, Penghu County, to foster information

exchange and field experience between Taiwan and the United States, and provided useful recommendations to the current sea turtle stranding report and necropsy procedures in Taiwan (I.J. Cheng et al. 2006).

*Education and Public Awareness.* — The relevant parties have arranged various local programs and published education materials to raise the public awareness on the conservation of sea turtles in mainland China, Taiwan, and Hong Kong respectively. A dedicated website (<http://www.marineturtle.net>), introducing the Gangkou Sea Turtle National Nature Reserve and relevant activities, was set up in 2004. There was also wide mass media coverage, which has attracted much public attention in mainland China, Taiwan, and Hong Kong.

## CONSERVATION RECOMMENDATIONS

In recent years, an increase in work has been done on the conservation of the endangered sea turtles in China. However, there is still insufficient information on the existing population status and distribution of nesting sites and foraging grounds, which poses a major obstacle to the effective conservation management of sea turtles in China (Cheng 1998b). The following recommendations are, therefore, proposed.

*Action Plan.* — In view of their critical status, we urge the development of a national action plan for the protection of sea turtles in China. This action plan must identify specific problems and requirements for the long-term conservation of sea turtles in China and appropriate regional cooperation must be sought to implement this plan.

*Comprehensive Field Surveys.* — There is a lack of up-to-date information on the distribution of sea turtles in China. A comprehensive field survey is needed to identify the existing nesting sites and foraging grounds. Apart from the well-known nesting sites in Gangkou, Wan-an Island, Lanyu Island, and Lamma Island, the status of other known nesting sites, including the Dongsha, Nansha, and Xisha archipelagos, needs to be updated and more in-depth surveys are required. Nesting sites that have disappeared on the mainland and Hainan Island should also be surveyed to identify if there are any signs of recovery. Satellite telemetry is a very useful and cost- and time-effective tool to identify the turtles' resident foraging grounds and migration pathways in the ocean (Cheng 2000a, 2000b, 2007; Song et al. 2002b; Wang et al. 2002; Chan et al. 2003). This technique should be promoted and applied more frequently.

*Education and Public Awareness.* — The conservation of sea turtles is dependent on the support of the public. A widespread public awareness campaign can generate such support, which is urgently needed in China, from both a financial and social perspective. The recently launched website of the Gangkou Sea Turtle National Nature Reserve (<http://www.marineturtle.net>) can serve as a convenient platform for the dissemination of informa-

tion, as well as the coordination of fund-raising for the conservation of sea turtles in China. Ecotourism and environmental education programs may also achieve similar goals.

*Financial Support.* — Necessary funding, as well as resources for the conservation of sea turtles in China, is limited. For example, the Gangkou Sea Turtle National Nature Reserve has limited funds for their routine management work, hampering research there. In addition, large amounts of nesting data, collected since the reserve was established, have yet to be properly analyzed. Sufficient funding should be provided to the nature reserve and other related sea turtle conservation works in China.

*Conservation of Sea Turtles at Xisha, Dongsha, and Nansha Archipelagos.* — Xisha, Dongsha and Nansha Archipelagos are the important nesting and foraging grounds for sea turtles. Due to the complex international political situation, it has been difficult to set up nature reserves in these areas (Gomez, 1996). Perhaps, a regional liaison can be agreed to, among concerned states in the region, as an effective way to promote the protection of sea turtle resources. For example, the relevant governments may coordinate sea turtle surveys in the offshore archipelagos to collect the baseline of nesting and foraging populations there. The Coast Guards on the Dongsha Archipelago and Taipin Island of the Nansha Archipelago should be encouraged to actively protect sea turtle populations, both on land and at sea.

*Fisheries Enforcement.* — Despite being listed as protected species, illegal harvesting of sea turtles still occurs in China occasionally and enforcement needs to be strengthened. Surveys must be carried out to identify the potential threats of fisheries bycatch on sea turtles, and the possibility of applying environmentally friendly gears, such as turtle excluder devices and big circle hooks, etc., to reduce the impact of fisheries bycatch in China. As longline fisheries have been identified as a major cause of sea turtle mortality both on the coast and on the high seas (Lewison et al. 2004), a public awareness campaign, highlighting techniques to reduce longline bycatch, is urgently needed to protect these endangered, and rapidly declining, species.

*Regional and International Cooperation.* — China is not currently a signatory state to the recently concluded Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA MoU). Furthermore, little information on the sea turtles of China is available to international societies. Being a group of transboundary species, more regional and international cooperation is needed for the long-term conservation of sea turtles in China. Consideration should be given to joining the IOSEA MoU and other relevant organizations, in order to cooperate more closely with nearby states for the protection of this shared resource. Opportunities for international and regional cooperation must be sought, particularly joint research into the ecology and manage-

ment of nesting sites and foraging grounds, as well as genetics of the population of sea turtles in the South China Sea by neighboring countries.

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