ELSEVIER

PII: S0006-3207(97)00027-X

Biological Conservation **82** (1997) 235–239

0006-3207/97 $17.00+0.00

SHORT NOTE

THE INCIDENTAL CAPTURE OF FIVE SPECIES OF SEA TURTLES BY COASTAL SETNET FISHERIES IN THE EASTERN WATERS OF TAIWAN

I.-Jiunn Cheng[a]* & Tien-Hsi Chen[a,b]

[a]*Institute of Marine Biology, College of Fishery Sciences, National Taiwan Ocean University, Keelung, Taiwan, 202, Republic of China*
[b]*Present address: Department of Biology, National Taiwan Normal University, Taipei, Taiwan, Republic of China*

(Received 14 March 1996; accepted 23 September 1996)

Abstract

The incidental capture of sea turtles by the coastal setnet fisheries in Eastern Taiwan was investigated. Five species of sea turtle were caught — in declining order of abundance, green Chelonia mydas, *loggerhead* Caretta caretta, *hawksbill* Eretmochelys imbricata, *olive ridley* Lepidochelys olivacea, *and leatherback* Dermochelys coriacea. *Green, loggerhead and olive ridley sea turtles used the east coast waters of Taiwan as their benthic habitats. Most of the captured turtles were sold to be subsequently released in religious ceremonies. Although none of the turtles were drowned* in situ, *the setnet fisheries could have a negative impact on their populations. Some mitigating recommendations are made.* © *1997 Published by Elsevier Science Ltd*

Keywords: Incidental captures, sea turtles, setnet fisheries, Eastern coast waters of Taiwan, benthic habitats.

INTRODUCTION

The incidental capture of sea turtles by various types of fishing gear is considered a major threat to the survival of their populations (Carr *et al.*, 1978; Chan *et al.*, 1988; Margaritoulls *et al.*, 1991; Antypas *et al.*, 1993; Bjorndal *et al.*, 1993; Wetherall *et al.*, 1993; Balazs & Pooley, 1994; Balazs *et al.*, 1995; Dodd, 1995; Chan & Liew, in prep.). Higher capture rates were found in foraging or nesting grounds and in areas where bait species were similar to the diet of the sea turtles (Chan *et al.*, 1988; Margaritoulls *et al.*, 1991; Balazs & Pooley, 1994; Bowen *et al.*, 1995). Population model studies have suggested that a reduction of turtle mortalities in subadult and adult stages is crucial to their survival and recovery (Frazer, 1984; Crouse *et al.*, 1987; Crowder *et al.*, 1994; Heppell *et al.*, 1996). Many mitigating methods, such as using TEDs (Turtle Excluder Devices) on shrimp trawls, have been proposed to reduce incidental captures (Crouse *et al.*, 1987; Andrew & Pepperall, 1992; Balazs & Pooley, 1994; Balazs *et al.*, 1995; Weber & Crouse, 1995; Heppell *et al.*, 1996). All these studies, however, concentrated on trawling and longline fisheries, while little has been done on coastal fisheries and none at all on setnet fisheries.

In Taiwan, coastal setnet fisheries provide the second largest total fish yields, after gill nets (Chen, 1991). There are 107 setnets in Taiwan, 80% of these in east coast waters. One area of concentrated use is in the waters of I-Lan County, NE Taiwan (Chen, 1991; Fig. 1) where 25 setnets are located. A preliminary survey revealed substantial capture of sea turtles by this fishing gear, and we decided to choose this area as our study site to evaluate the impact of setnets on the sea turtle population. The species involved were green *Chelonia mydas*, loggerhead *Caretta caretta*, hawksbill *Eretmochelys impbricata*, olive ridley *Lepidochelys olivacea* and leatherback *Dermochelys coriacea*.

MATERIALS AND METHODS

Setnets, 300 m wide, a few tens of meters in length, and 20–30 m in depth, are put out when the fishing season starts in mid to late October and left until the end of June. Fishing activities cease from July to September owing to the shift in coastal currents and the onset of the typhoon season (Liu, 1991). Setnets are near-shore sedentary trap nets, and rarely extend below 20 m, the fishermen lifting the nets and retrieving fishes two or three times a day. This may explain why no dead turtles were found inside the nets, as any entangled turtles have a chance to reach the surface and/or be rescued before drowning.

The fishing grounds including setnets and gill nets in I-Lan County and around Taiwan were visited irregularly from October 1991 to October 1992, usually more than once per month, during the fishing season to

*To whom correspondence should be addressed.

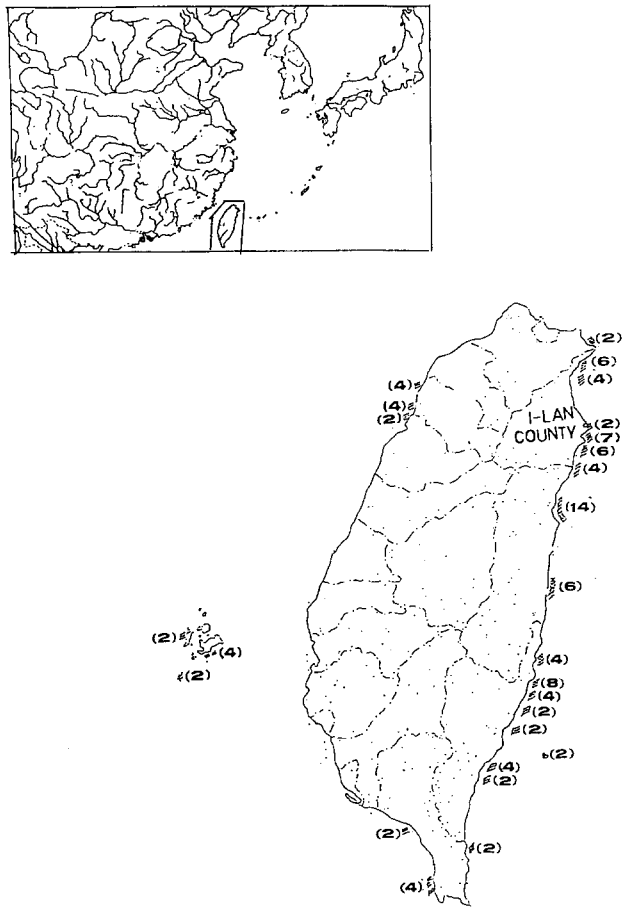

Fig. 1. Distribution map of the 107 setnets in Taiwan. The numbers in parentheses denote the number of setnets in the area.

determine the bycatch of each fishing gear. According to interviews with fishermen from Eastern Taiwan, most of the incidentally caught turtles are sold to dealers in the Nanfango Fish Market, any unsold being slaughtered for meat. Therefore, during the fishing season this market was also visited once or twice per month from October 1991 to April 1995 to corroborate and supplement the monthly bycatch data. The turtle dealers were also interviewed regarding the numbers of turtles brought in during the intervening weeks.

The capture data obtained during interviews included date, condition, sex, location, species, curved carapace length (CCL), and the projected fate of the turtles, either at the scene of capture or in the market. In the literature, the mature sizes of turtles are given as 85 cm for green, 80 cm for loggerhead, 76 cm for hawksbill, 60 cm for olive ridley, and 140 cm for leatherback (Eckert, 1993). Thus, in this study, captured turtles below these sizes were classified as juvenile/subadult. The sex of adult turtles was determined by the external tail sexual character, though some misidentification can occur (Limpus, 1993). The sex of immature turtles was not determined.

RESULTS

The geographic distribution of the five species of sea turtles captured by the gill and setnet fisheries is given in Table 1. Most incidental captures occurred from November to April with peaks in November–December and February–March (Fig. 2). The spatial distribution showed that 88% of the bycatch was on the east coast (Table 1). Setnet fisheries accounted for 92% of the bycatch (Table 1), and 70% of the bycatch was of green turtles (Table 1). Interviews with fishermen, and in a few cases personal observations, showed that no turtle was found drowned or killed at the scene of capture, although a single stranded turtle, dead from unknown causes, comprised 1% of total landings (Table 1). Of the captured turtles 88% were sold to temples for release in Buddhist ceremonies, 8% were stuffed or slaughtered and 3% were released at the site of capture (Table 1).

Incidental captures increased from 1991 to 1995 (Table 1), owing to the improvement of fishing techniques (Chen, 1991).

Green turtle

The capture size ranged from 25 to 115 cm CCL, and had a bimodal distribution, with peaks at 36–55 cm and 76–95 cm (Fig. 3(a)). This suggests that both large juvenile, subadult and adults turtle were caught. Only one adult male was identified.

Loggerhead turtle

Capture size ranged from 46 to 105 cm (Fig. 3(b)). Most captured turtles were either subadults or adult females. Only one male was identified.

Hawksbill turtle

All the captured turtles were juveniles, sizes ranging from 25 to 45 cm (Fig. 3(c)). Two turtles were stuffed and sold to souvenir shops (Table 1).

Olive ridley turtle and leatherback turtle

Most of the captured olive ridley turtles were subadults (Fig. 3(d)). This turtle is rarely seen in the waters of Taiwan. One leatherback turtle was caught by the setnets, and released at the scene. No measurements were made.

DISCUSSION

Most of the incidental captures of sea turtles were in Eastern Taiwan (Table 1), probably on migration via the main Kuroshio Currents. These currents move parallel to the east and northeast coasts of Taiwan, with a branch extending from the south into the Taiwan Strait via the southwest coast. Previous studies on the breeding biology of the green turtles nesting at Wan-An Island, Peng-Hu Archipelago (located in the Southern Taiwan Straits) (Chen & Cheng, 1995), and Satellite

telemetry studies (Cheng, unpublished data), have shown that these turtles migrate along the continental shelves of China (i.e. South China Sea, Yellow Sea, East China Sea, and Taiwan Straits) after their breeding seasons.

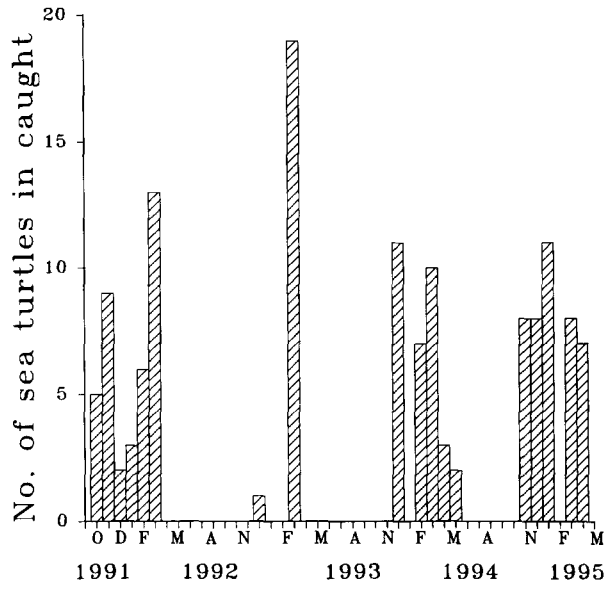

Fig. 2. Monthly incidental captures of sea turtles by the setnet fisheries from 1991 to 1995.

The records of higher catches from November to December and from February to March (Fig. 2) could be related to rough seas in late fall, when low pressure meteorological cells are a frequent occurrence that force marine species to concentrate in the in-shore waters (Liu, 1991). The second and largest catches in late winter and early spring might be due mainly to the onshore shift of the Kuroshio Currents (Liu, 1991).

The increase of incidental captures with the increase of fishing yields suggests that the setnet fishing grounds might overlap with the sea turtle benthic habitats. From 1991 to 1994, for every thousand tonnes of fish caught, the setnets trapped two to four turtles.

Owing to the long life expectancy of sea turtles, they are a symbol of good luck to most Chinese (Morton, 1992; Cheng, in press), so that fishermen prefer to sell those caught. The Buddhists believe that the release of captive animals alive can purify their spirits (Cheng, in press). These captive-release activities, although sounding relatively benign, involve the illegal trading of endangered species (Council of Agriculture, 1990). In addition, the turtles are sometimes kept in captivity for weeks to months in small non-circulating tanks with scant food provided before release. The maltreatment of

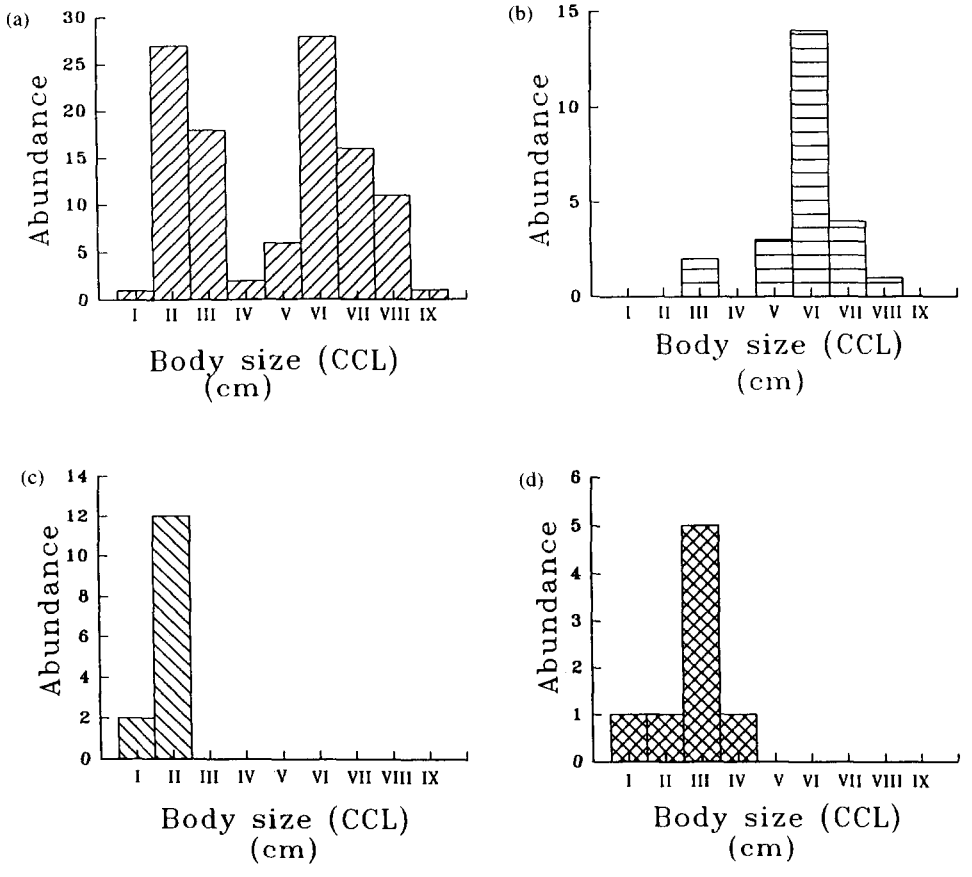

Fig. 3. Size frequency of the incidental captures of (a) green; (b) loggerhead; (c) hawksbill; and (d) olive ridley sea turtles from 1991 to 1995. Size categories: I, 25–35 cm; II, 36–45 cm; III, 46–55 cm; IV, 56–65 cm; V, 66–75 cm; VI, 76–85 cm; VII, 86–95 cm; VIII, 96–105 cm; IX, 106–115 cm.

Table 1. The geographic distribution, numbers and fate of sea turtles accidentally caught in fishing gear in Taiwan from 1991 to 1994

	Green (No.)	Loggerhead (No.)	Olive ridley (No.)	Hawksbill (No.)	Leatherback (No.)	Total (%)
Geographic distribution						
E Taiwan	49	9	8	13	1	88
SW Taiwan	9	1	0	0	0	11
Other areas	1	0	0	0	0	1
Numbers of nets set						
Setnet	55	8	8	11	1	92
Gill net	4	1	0	2	0	8
Number caught						
1991	6	1	9	0	1	
1992	17	4	0	2	0	
1993	28	5	1	4	0	
1994	23	15	0	0	0	
1995	42	1	4	2	0	
Total (%)	70	16	5	8	1	
Fate of caught turtles						
Released	0	1	0	0	1	3
Sold	34	7	4	7	0	88
Stuffed or slaughtered	3	0	0	2	0	8
Mortality	0	1	0	0	0	1

sea turtles may not only cause sublethal threats to the animals, but contravenes the domestic wildlife protection law (Council of Agriculture, 1990).

The greater catch of green turtles (70%, Table 1) might be related to their geographic distribution (Sternberg, 1981; Groombridge, 1982; Eckert, 1993). Rocky shores abound along the east coast of Taiwan, as well as in the vicinity of the setnet. They provide good habitats for macroalgae and thus provide feeding grounds for the green turtle. The juveniles that have ended their pelagic life stages, and adults that nest on the Northwest seaboard of the Pacific, might use these waters as one of their benthic habitats.

The largest specimens of loggerhead turtles were comparable to those nesting in Japan (N. Kamezaki, pers. comm.), which has the largest loggerhead population in the Northwest Pacific (Kamezaki, 1989; Eckert, 1993; Balazs & Pooley, 1994). Thus, it is possible that the mature loggerhead turtles were using the east coast of Taiwan as a temporary shelter during their nesting or feeding migration when they were caught in the setnet fishing gear.

All the captured hawksbill turtles were juveniles (Fig. 3). The closest nesting site is in the southern islands of the Ryukyu Archipelago but the population is small (EXPOSE Memorial Park Foundation, 1984; Kamezaki, 1989; Eckert, 1993). Hawksbill turtles have not been found nesting in Taiwan since 1992, even though Mao (1970) suggested that nesting sites might have existed previously.

Olive ridley and leatherback turtles have never been found nesting in Taiwan or Japan. The only nesting sites in the Western Pacific are in Malaysia, Indonesia and The Arafura Sea (Eckert, 1993). It is possible that Taiwan could be a feeding habitat for the olive ridley during migration, but the leatherback is an oceanic species, and is rarely observed in the coastal waters of islands.

ACKNOWLEDGEMENTS

The authors thank Mr S-H. Tsu for his assistance with the field work. This work is supported by a grant from the Council of Agriculture, Republic of China (No. 84 Conservation-10(12)) to I-J. Cheng.

REFERENCES

Andrew, N. L. and Pepperall, J. G. (1992) The by-catch of shrimp trawl fisheries. *Oceanogr. Mar. Biol. Ann. Rev.* **30**, 527–565.

Antypas, A. P. G., Giannopoulos, Y., Moschonas, S. *et al.* (1993) Incidental catches of loggerhead turtles, *Caretta caretta* in swordfish long lines in the Ionian Sea, Greece. *Archipelagos-Marine and Coastal Mgmt* 7 pp.

Balazs, G. H. and Pooley, S. G. (1994) Research to assess marine turtle hooking mortality: results of an expert workshop held in Honolulu, Hawaii, 16–18 November 1993. *NOAA Tech. Mem.*, No. NMFS-SWFSC-201.

Balazs, G. H., Pooley, S. G. and Murakawa, S. K. K. (1995) Guidelines for handling marine turtles hooked or entangled in the Hawaii longline fishery: results of an expert workshop held in Honolulu, Hawaii, 15–17 March 1995. *NOAA Tech. Mem.*, No. NMFS NOAA-TM-NMFS-SWFSC-222.

Bjorndal, K. A., Bolten, A. B. and Legueux, C. J. (1993) Decline of the nesting population of hawksbill turtle at Tortuguero, Costa Rica. *Conserv. Biol.* 7, 925–927.

Bowen, B. A., Abreu-Grobois, F. A., Balazs, G. H., Kemezaki, N., Limpus, C. J. and Ferl, R. J. (1995) Trans-Pacific migrations of the loggerhead turtle (*Caretta caretta*) demonstrated with mitochlondrial DNA makers. *Proc. Natl Acad. Sci.* **92**, 3731–3734.

Carr, A., Carr, M. and Meylan, A. B. (1978) The ecology and migrations of sea turtle, 7. The west Caribbean green turtle colony. *Bull. Am. Mus. Nat. Hist.* **162**, 1–46.

Chan, E. H., Liew, H. C. and Mazlan, A. G. (1988) The incidental capture of sea turtles in fishing gear in Terengganu, Malaysia. *Biol. Conserv.* **43**, 1–7.

Chen, M.-R. (1991) The training and future perspectives of setnet fisheries in Taiwan. In *Symposium on the Problems of Setnet Fisheries*, ed. S.-C. Ou. Council of Agriculture, Taiwan, ROC, pp. 5–10 (in Chinese).

Chen, T.-H. and Cheng, I.-J. (1995) Breeding biology of the green turtle, *Chelonia mydas* (Reptilia: Cheloniidae) on Wan-An Island, Peng-Hu Archipelago, Taiwan, I. Nesting ecology. *Mar. Biol.* **124**, 9–15.

Cheng, I.-J. (in press) Sea turtle status and research in Taiwan. *International Congress of Chelonian Conservation.*

Council of Agriculture (1990) *Catalogue on the endangered wild-life species and the products.* Council of Agriculture, Taipei, Taiwan, ROC.

Crouse, D. T., Crowder, L. B. and Caswell, H. (1987) A stage-based population model for loggerhead sea turtles and implications for conservation. *Ecology* **68**, 1412–1413.

Crowder, L. B., Crouse, D. T., Heppell, S. S. and Martin, T. H. (1994) Predicting the impact of turtle excluder device on loggerhead sea turtle populations. *Ecol. Appl.* **4**, 437–445.

Dodd, C. K. (1995) Marine turtles in the Southeast. In *Our Living Resources*, ed E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran and M. J. Mac. US Interior–National Biological Service, Washington, DC. pp. 121–123.

Eckert, K. L. (1993) The biology and population status of marine turtles in the North Pacific Ocean. *NOAA Tech. Mem.*, No. NMFS-SWFSC-186.

EXPOSE Memorial Park Management Foundation (1984) A report of the general survey of sea turtle for aquarium exposition. EXPOSE Memorial Park Aquarium, Motobu-chu, Okinawa.

Frazer, N. B. (1984) A model for assessing mean age-specific fecundity in sea turtle populations. *Herpetologica* **40**, 281–291.

Heppell, S. S., Limpus, C. J., Crouse, D. T., Frazer, N. B. and Crowder, L. B. (1996) Population model analysis for the loggerhead sea turtle, *Caretta caretta*, in Queensland. *Wildlife Res.* **23**, 143–159.

Liu, T.-C. (1991) The relationship between the setnet fisheries and coastal oceanography. In *Symposium on the Problems of Setnet Fisheries*, ed. S.-C. Ou. Council of Agriculture, Taiwan, ROC, pp. 11–14 (in Chinese).

Kamezaki, N. (1989) The nesting sites of sea turtles in the Ryukyu Archipelago and Taiwan. *Current Herpetology in East Asia*, 342–348.

Limpus, C. J. (1993) The green turtle, *Chelonia mydas*, in Queensland: breeding males in the Southern Great Barrier Reef. *Wildl. Res.* **20**, 513–523.

Mao, S. H. (1970) *Turtles of Taiwan — a natural history of the turtle.* Commercial Press, Taipei, Taiwan.

Groombridge, B. (1982) *Red data book, Amphibia–Reptilia, Part 1. Testudinae, Crocodylia, Rhynchocephalia.* World Conservation Union, Gland.

Margaritoulls, D., Kousias, N., Nicolopoulou, G. and Teneketzis, K. (1991) Incidental catch of sea turtles in Greece: the case of Lakonikos Bay. *Proc. Ann. Workshop on Sea Turtle Biology and Conservation*, 11th. *NOAA Tech. Mem.*, No. NMFS-SEFSC-302, pp. 168–169.

Morton, B. (1992) China's turtles. *Marine Pollut. Bull.* **24**, 576–577.

Sternberg, J. (1981) *The worldwide distribution of sea turtle nesting beaches.* Center for Environmental Education, Washington, DC.

Weber, M. and Crouse, D. (1995) *Delay and denial, a political history of sea turtles and shrimp fishing.* Center for Marine Conservation, Washington, DC.

Wetherall J. A., Balazs, G. H., Tokunaga, R. A. and Yong, M. Y. Y. (1993) Bycatches of marine turtles in North Pacific high-sea driftnet fisheries and impact on the stocks. In *INPFC symposium on biology, distribution, and stock assessment of species caught in the high sea driftnet fisheries in the North Pacific Ocean*, ed. J. Ito *et al. Bull., Int. N. Pacif. Fish. Commn.* **53**, pp. 519–538.