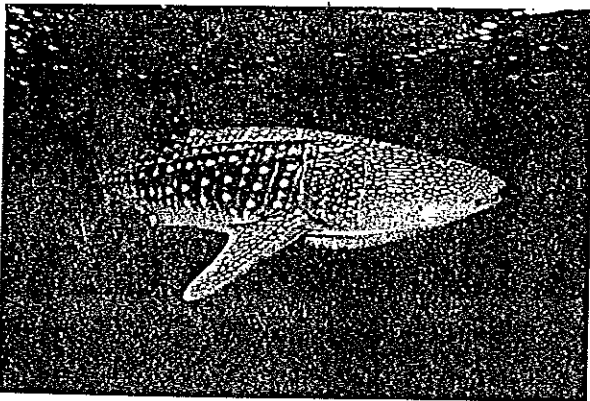


Preliminary Report on Taiwan's Whale Shark Fishery

Chen Che-Tsung, Liu Kwang-Ming and Joung Shoon-Jeng

INTRODUCTION

The Whale Shark *Rhincodon typus* is the largest fish in the world, growing to a length of up to 18 metres (m) or more. However, little is known of the species' biological history, its ecological role, or its conservation status. There is increasing concern that heavy and largely unregulated trade in shark species in general could be contributing to a decline in global shark stocks. Efforts by the IUCN/SSC Shark Specialist Group and relevant national and international authorities to gauge the current level of threat for many species are hindered by a lack of data. Although the Whale Shark is listed in the IUCN 'data deficient' category (IUCN, 1997), there is growing concern that trade may be depleting stocks of this fish.



Whale Shark *Rhincodon typus*

In Taiwan, there appears to be no dedicated Whale Shark fishery and the species is caught mainly as a bycatch of set net fisheries and opportunistically, by harpoon. Referred to as the "Tofu Shark" in Taiwan on account of its soft, white flesh, the species has recently emerged as a delicacy. The last five or six years have seen much interest among Taiwan's media in Whale Shark landings, particularly in details such as the shark's large size, capture methods, its high price, and whether or not the animal poses a danger to humans. Little attention has been paid, however, to potential conservation problems for the species resulting from increasing domestic consumption.

The survey described below was conducted as a first step in collecting information on the distribution and catch of Whale Sharks around Taiwan, as well as in gathering market and trade information for future use as a reference in developing management and conservation

strategies. The data compiled here supplements information on the history of and trends in Taiwan's shark fisheries in Chen *et al.*, 1996. The report hopes to contribute towards other regional research and monitoring efforts such as WWF's 1996 investigation into the Whale Shark fishery in the Bohol Sea (Philippines) (Trono, 1996) and research into the migratory patterns of the species through electronic tagging of specimens in northwest Australia (Taylor, 1996).

Financial support for this project was provided by the Rufford Foundation via WWF-UK.

METHODS

Initial research for this study was conducted from February to July 1996. Information was primarily based on interviews with the crews and owners of harpoon and set net vessels: 58 of a total of 97 set net fishermen (60%) and 32 captains of 98 harpoon vessels (32.7%) operating in Taiwan were interviewed. Questions covered catch volumes, size of specimens caught, capture locations, Whale Shark behaviour, and migratory routes.

Data on numbers of set nets and harpoon vessels in operation were collected from the Taiwan Fishery Bureau, as well as from regional and local fishermen's associations. Local fishermen's associations are responsible for the collection of fisheries catch and sales data in Taiwan. Available data for Whale Shark catch and sales are limited, however, for reasons explained later in the report.

Regional catches were estimated from the average catch per unit of set net or harpoon vessel, as reported in interviews, and multiplied by the total number of set nets and harpoon vessels in operation. Figures for the estimated total annual catches of Whale Sharks may not accurately reflect the catches of those set net operators and harpoon fishers who were not interviewed. Furthermore, catch effort data for the two types of fishery were not collected for this preliminary report.

BIOLOGY AND DISTRIBUTION

Whale Sharks live in epipelagic (waters to a depth of 200 m), oceanic, and coastal areas of tropical and subtropical regions, including the western and eastern Atlantic, west Indian, central Pacific, and eastern Pacific oceans (Compagno, 1984). In the western Pacific, the species is commonly found along the Kuroshio Current. Although few tagging or marking studies documenting their larger migration routes have been published to date, Whale Sharks are believed to be highly migratory, their movements corresponding to plankton blooms and blooms associated with coral spawning, and the changing temperatures of water masses. They are associated with schools of pelagic fishes, especially mackerel Scombridae (Compagno, 1984). Examination of the stomach contents of landed Whale Sharks revealed small fish such as anchovy and shrimp, as well as plankton.

RECOMMENDATIONS

The following steps should be taken to ensure that the illegal trade in raptors is stopped:

- 1) Investigation must be made into the socio-economic aspects of the trade, with alternative employment schemes established for those involved.
- 2) Increased vigilance is required at airports and land borders to foil attempts to smuggle protected species out of the country.
- 3) Local people need to be made aware that trapping and trade in these species is illegal. Personnel at airports, buses and railways should be trained to identify species and be encouraged to check cargo.
- 4) All markets selling wild animals should be monitored regularly by enforcement authorities.

ACKNOWLEDGEMENTS

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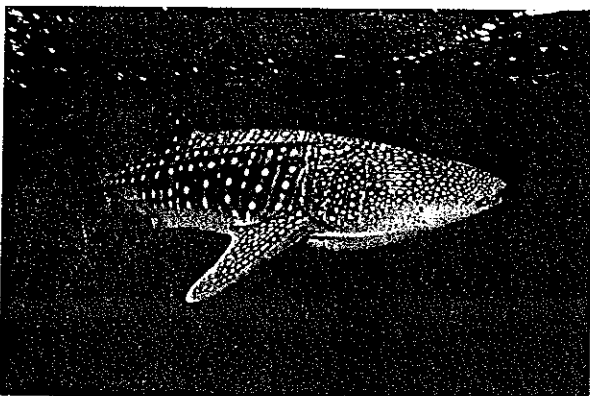
Abrar Ahmed, Consultant, TRAFFIC India; Asad R. Rahmani, Director, Bombay Natural History Society; Gautam Das, Consultant, WWF-India; Manoj Kumar Misra, Director, TRAFFIC India.

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strategies. The data compiled here supplements information on the history of and trends in Taiwan's shark fisheries in Chen *et al.*, 1996. The report hopes to contribute towards other regional research and monitoring efforts such as WWF's 1996 investigation into the Whale Shark fishery in the Bohol Sea (Philippines) (Trono, 1996) and research into the migratory patterns of the species through electronic tagging of specimens in northwest Australia (Taylor, 1996).

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Joung *et al.* (1996) found that the Whale Shark is ovoviviparous (the female produces live offspring from eggs hatched in the uterus) and found one gravid female, 16 t and 10.6 m in length, to contain 300 embryos. This level of fecundity is possibly the highest among elasmobranchs (sharks, skates, and rays). However, even female Whale Sharks larger than 15 t are rarely found to be carrying offspring, which may indicate an extremely late sexual maturity, low reproductive capacity, and high vulnerability to over-exploitation.

Taylor (1994) suggested that Whale Sharks do not reach maturity until they are over 30 years of age at a size of nine metres. Given the body weight and length of a full-term Whale Shark foetus (0.7 kg and 60 cm) (Joung *et al.*, 1996), such a lengthy maturation period is possible. The gestation period is unknown. The species is thought to grow to a maximum of 18 m in length (Compagno, 1984); however, in March 1987, two of the authors recorded one specimen in Lotung fish market (Ilan county) which was approximately 20 m in length and weighed 34 t. This is believed to be the largest Whale Shark ever caught in Taiwan.

Limited population data exist for Taiwan's Whale Sharks. Figures collected for set nets indicate that the species is distributed around Taiwan's coastal area, particularly off the eastern coast (Figure 1), and specimens can be sighted around the island year-round, with winter (December to February) and summer (June to August) being the peak seasons. The fish follow the Kuroshio Current north along the coastline, and are known to enter the waters of southern Japan in spring. The duration and route of their migration south is not known.

FISHING METHODS

In Taiwan, Whale Sharks are caught accidentally by set net or on an opportunistic basis by harpoon; catches by gillnets and longlines are less common. Set nets are nets which are suspended vertically from floats at a fixed location. These are used to target seasonally migratory fish including mackerel Scombridae, scad Carangidae, tuna *Thunnus*, barracuda *Sphyraena japonica*, and bonito *Auxis*. Whale Sharks occasionally swim close to the coastline while in pursuit of prey, and blunder into set nets, making them an easy catch for set net operators.

Harpoon fishers, using three-prong or spear-headed weapons, target billfish Istiophoridae, including Sailfish *Istiophorus platypterus*, Black Marlin *Makaira indica*, marlin *M. mazara* and Striped Marlin *Tetrapturus audax*. Because of the difficulty of handling such large animals, harpoon fishers have previously avoided catching Whale Sharks. However this situation is changing following the growing demand for this fish and the correspondingly high price it fetches. The animal's docility, combined with its habit of swimming slowly and near the surface, make it an easy target for harpoon fishers. After it has been harpooned, the Whale Shark is towed to the harbour.

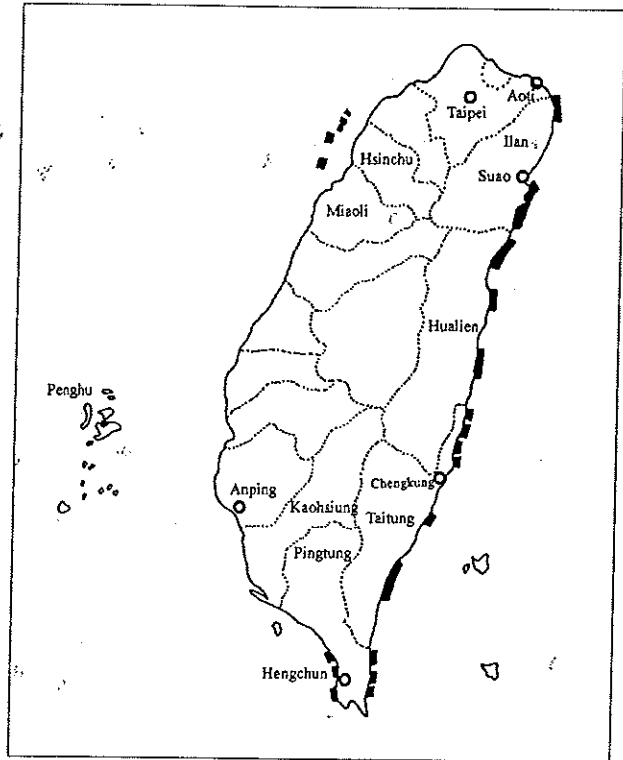


Figure 1. Map of Taiwan with black areas along the coastline showing set net operations in the Hsinchu, Ilan, Hualien, Taitung, Pingtung and Penghu coastal regions.

CATCH VOLUMES

Figure 1 shows the area of operation for set nets in the Hsinchu, Ilan, Hualien, Taitung, Pingtung, and Penghu coastal regions. All but three of the 58 set net operators interviewed have recorded the capture of Whale Sharks. As no set nets or harpoon vessels operate between Hsinchu in the north-west and Pingtung in the south-west, there are no capture records for Taiwan's western coastal region except for the Penghu area. However, the authors believe that Whale Sharks do occur in this region.

It is difficult to estimate the actual catch from local fish market data as the majority of landed Whale Sharks are sold outside the regular fish market system to avoid incurring market fees. Only the markets at Chengkung, in Taitung county, and Suao, in Ilan county, have recorded landing data for Whale Sharks.

A wholesaler in Suao who specializes in Whale Shark meat estimated that about 250 Whale Sharks are landed in Taiwan annually (Y.S. Yu, pers. comm., August 1995). He also estimated that landed specimens range in weight from several hundred kilogrammes to as much as 30 t.

Set net catch

Table 1 shows the distribution for set nets based on data collected from the Taiwan Fishery Bureau and regional fishermen's associations. A total of 97 set nets are in operation in Taiwan's inshore area; 58 set net

fishermen (60%) were interviewed. The main fishing areas for set nets are Taitung, Hualien and Ilan, comprising 84.86% of the total annual catch of Whale Sharks. Ilan has the highest annual catch rate for set nets, with 2.35 animals per set net per year, and Miaoli has the lowest, with 0.83 per set net per year (Table 1). Taking the average annual catch per year in each region and multiplying it by the number of nets gives the estimated total catch of Whale Sharks by set net as 158 specimens.

Harpoon catch

Harpoon fisheries operate in the Hengchun, Taitung, and Ilan coastal areas, with the harpoon-equipped vessels in each region numbering 20, 46, and 32, respectively (Table 2). Based on catch information provided by the harpoon fishermen interviewed (32 of 98, or 32.7%), the total annual catch of Whale Sharks for harpoon fisheries in Taiwan is estimated to be 114 individuals. Three captains of harpoon vessels who were interviewed in the Aoti region had never captured Whale Sharks.

Total combined catch

The current combined annual catch of Whale Sharks from set net and harpoon fisheries is estimated by the authors to be 272 individuals (158 for set net; 114 for harpoon). This estimate is very close to that of 250 specimens mentioned by the wholesaler in Suao. Figures for the estimated total annual catches of Whale Sharks may not completely reflect the catches of those set net operators and harpoon fishers who were not interviewed, given a variety of factors including differing sizes and designs for set nets and harpoon vessels.

Insufficient information exists to estimate catch trends for Taiwan's Whale Shark fishery. However, information provided by the fishermen indicates that, in the mid-1980s, harpoon fishermen from Hengchun harbour were able to harvest between 50 and 60 specimens from the waters south of Penghu each spring. Over the last decade, the catch has declined gradually to approximately 10 individuals annually. Fewer than 10 were captured in this area in 1994 and 1995. The apparent decline in overall Whale Shark numbers could be attributed to environmental factors including changes in water temperature, abundance of prey, or the flow of the Kuroshio current. Changes in catch effort could also be a factor.

	Hengchun	Taitung	Ilan	Total
No. of harpoon vessels in operation ¹	20	46	32	98
No. of captains interviewed ²	14	7	11	32
Average annual catch per vessel ²	1.68	1.36	0.56	1.22
Estimated total annual catch ²	33.64	62.43	17.78	113.85

Table 2. Distribution of harpoon fisheries in Taiwan and estimated minimum number of Whale Sharks caught by harpoon each year. Sources: ¹Regional fishermen's associations; ²based on interviews with fishermen

SALE, MARKETING, AND UTILIZATION OF WHALE SHARKS

Sale

After being towed to the fishing harbour, the Whale Shark is weighed before auction (the weight of large specimens can only be estimated). The auctions usually take place at Suao, Chengkung or Anping fish markets; however, this procedure usually takes place outside the official fish market system in order to avoid market fees which, being a proportion of the total price (0.4%), could result in a substantial amount of money for large specimens. The whole animal, including the fins, is sold intact to one buyer and, in the case of specimens too large to weigh, the price is based on estimated weight.

After auction, the specimen is transported either whole or cut into several pieces, with fins and viscera removed, to processors. The major processing centres for Whale Sharks in Taiwan are located in Lotung, Ilan, and Suao, in Ilan county. Smaller numbers of Whale Sharks are landed in Chengkung and Hengchun. Whale Sharks landed in Chengkung are processed in that district while specimens landed in Hengchun are processed in Anping. Processors handle a range of products and are not specifically set up to handle Whale Shark.

Marketing

In the past, the meat of the Whale Shark was less popular than it is today and the price relatively low; prior to 1985, a specimen weighing several tonnes would fetch between New Taiwan Dollars NT\$5 500 and NT\$8 200 (US\$200 and US\$300) at auction. Since the late 1980s, however, the wholesale price of an ungutted Whale Shark has increased to roughly NT\$190

County	Taitung	Hualien	Ilan	Hsinchu	Miaoli	Pingtung	Penghu	Total
No. of set nets in operation ^{1,2}	11	32	26	12	4	7	5	97
No. of operators interviewed ³	5	14	17	12	3	2	5	58
Average annual catch per set net ³	2.3	1.46	2.35	0.43	0.83	2.0	0.4	1.63
Estimated total annual catch ³	25.3	46.8	61.1	5.17	3.33	14.0	2.0	157.7

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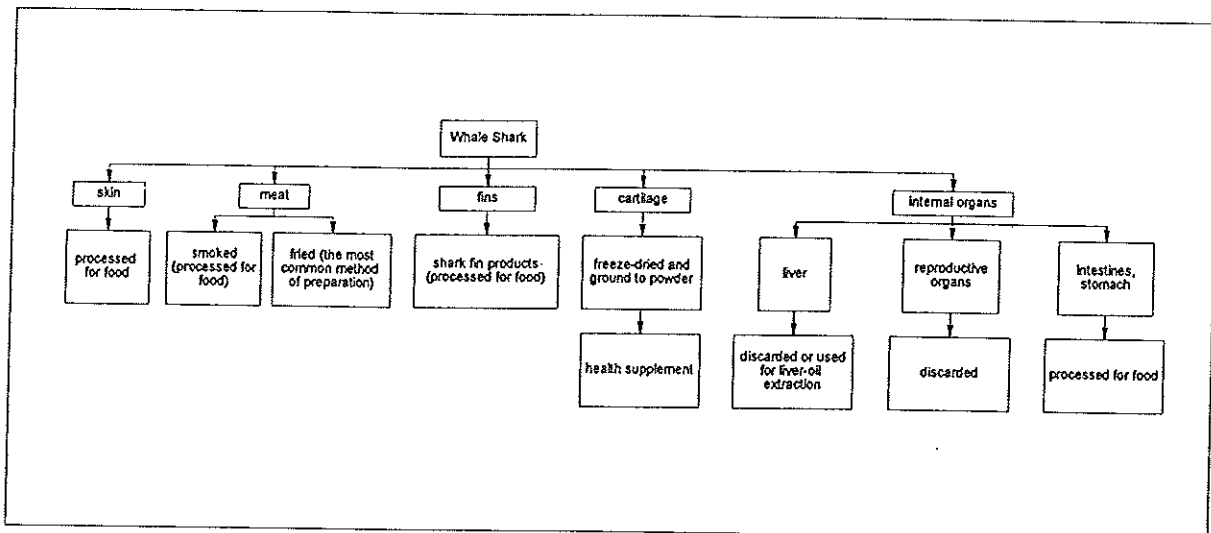


Figure 2. The Whale Shark processing system in Taiwan.

(US\$7) per kg (total price divided by estimated weight) and is now the most expensive of the shark meats available. A small Whale Shark of 2000 kg could fetch NT\$360 000 (US\$14 000) while a larger specimen of 10 000 kg could sell for NT\$ 1.9 million (US\$70 000). Because of these high prices, the number of wholesalers who purchase Whale Sharks is small.

For comparative purposes, Table 3 summarizes the landing price of shark species caught by Taiwan's coastal and offshore fisheries. Prices are those paid at auction after landing at fishery markets (production sites) for whole specimens, including fins and internal organs. The price of shark meat in the market varies according to season and freshness, with prices highest in winter (December through February).

Species	Price range per kg	
	NTS	US\$
Whale Shark <i>Rhincodon typus</i>	70-180	2.56-6.59
Shortfin Mako <i>Isurus paucus</i>	50-80	1.83-2.93
Scalloped Hammerhead <i>Sphyrna lewini</i>	50-70	1.83-2.75
Pelagic Thresher <i>Alopias pelagicus</i>	35-70	1.28-2.56
Silvertip Shark <i>Carcharinus albimarginatus</i>	50-60	1.83-2.20
Dogfish sharks <i>Squalidae</i>	30	1.10
Blue Shark <i>Prionace glauca</i>	15-20	0.55-0.73

Table 3. Range of shark prices in Taiwan's fish markets, 1995.

Exchange rate: US\$:NTS=1:27.322

Source: Chen et al., 1996

Following processing, the meat is distributed through usual channels to retail outlets, supermarkets, and restaurants around the island. The retail price of Whale Shark meat in local fish markets is about NT\$400 (US\$15) per kg. Non-meat products of Whale Sharks are sold by the buyer to individuals who deal in shark viscera and other byproducts.

Utilization

Meat comprises about 45% of the body weight of a Whale Shark. The fins, skin, stomach and intestines are also used for food. As with other shark species, its cartilage can be processed and exported for use in health supplements. The processing system is illustrated in Figure 2.

DISCUSSION

Traditionally, Taiwan has utilized the body parts (fins, meat, skin, cartilage, for example) of a variety of shark species. However, Taiwan's Whale Shark fishery is a recent development. The increasing popularity and high price of Whale Shark meat have made this species a valuable catch for fishermen. This preliminary study has documented a significant annual take of Whale Sharks by Taiwan's fishermen. Although information is too sketchy to conclude with any certainty that Whale Shark populations off Taiwan are declining, anecdotal evidence, paired with recent information on the species' reproductive patterns, give cause for concern. As with a number of other shark species which may be vulnerable to overexploitation, there is a need for more comprehensive, long-term monitoring of Whale Shark populations and catch.

Currently, no international fishery, trade or conservation regime exists for shark fisheries. In Taiwan, Whale Sharks are caught for local consumption predominantly by set net and harpoon. Under these circumstances, a domestic management system based on size limits or a quota system should be created. However, a successful management system for Whale Shark fisheries will require further research into the life history of the species, its population structure, behaviour, migration patterns, and genetics, as well as more in-depth research into current fisheries practices.



W.L. Chen

Landed Whale Shark *Rhincodon typus*, Chengkung fish market, Taitung county.

RECOMMENDATIONS

The authors would like to make the following recommendations to further the management and conservation of Whale Sharks in Taiwan:

1) Education

Fishermen and the general public should be better informed about the behaviour, ecology, limited reproductive capacity, and conservation status of the Whale Shark, by means of the media, public seminars, etc.

2) Establishment of catch and trade databases

Reporting of Whale Shark catch and landing data should be made mandatory. Portside monitoring should be improved. All trade should be required to go through the market system and destinations of catches should be documented to the extent possible. Attention should be paid to possible international trade, both legal and illegal. All these data should be made available to scientists for future study.

3) Scientific research

Further research into the Whale Shark's life history, population structure, behaviour, migration patterns, and genetics should be considered of high priority, as should co-operation with other scientists internationally.

4) Development of a domestic management system

The relevant fisheries agencies in Taiwan should compile and analyse the information gathered from the implementation of recommendations 2) and 3) above. The results should be used to develop a feasible Whale Shark management plan taking account of both the conservation needs of the species and the economic needs of local fishermen. It is comparatively straightforward to establish size and catch limits for Whale Sharks targeted by harpoon. Regulation of set nets is more difficult to control and requires further study, particularly the feasibility of releasing live specimens caught in excess of a quota.

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Chen Che-Tsung, Liu Kwang-Ming and Joung Shouu-Jeng,
National Taiwan Ocean University, Taiwan.