

Review of the current conservation concerns for the whale shark (*Rhincodon typus*)

A regional perspective



Project No. 2127

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Acknowledgements

Appreciation is extended to Dr David from Murdoch University in early stages of developing the plan for this work and review of the final manuscript.

Thankyou to representatives from CALM, AMCS, ECOCEAN volunteers, the whale shark industry and management at Ningaloo Marine Park, Christmas Island, Seychelles, Maldives and Mexico. Thanks also to fellow whale shark researchers and conservationists throughout the world.

This project could not have been completed without the support of the Department of Environment and Heritage (Coast & Clean Seas Program), the Thyne Reid Education Trust, the Feilman Foundation and the Rufford Foundation.

Special thanks to Rhiannon Bennett who has provided invaluable assistance throughout the project.

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Executive Summary

The whale shark is the largest living fish and one of only three filter-feeding sharks. It was first described in 1828 but is rare, with less than 350 confirmed sightings prior to the mid-1980s. The World Conservation Union (IUCN) lists the global conservation status of this shark as *vulnerable to extinction* requiring careful monitoring of the decline and / or recovery of this species.

A lucrative ecotourism industry has developed around swimming with these harmless animals, especially at locations where the sharks aggregate seasonally in response to increases in food abundance. In Australia, the whale shark ecotourism industry is regarded internationally as an example of 'best practice' ecotourism, and whale shark sighting numbers have remained high despite increased tourism pressure. Australia protects these sharks under Commonwealth and state legislation although this is insufficient to protect this species if/when they migrate to locations where they are under threat from legal (and illegal) fishing operations. Whale shark numbers have declined significantly in some areas over the last decade, possibly as a result of fishing pressure combined with a low productivity and low resilience life history.

The global population size of this highly migratory species is yet to be determined, although several research and monitoring programs have been initiated. Mark / recapture studies using a comprehensive database of identified whale sharks (via photo-identification) draws on researchers, dive industry stakeholders and the general community to become actively involved in conservation monitoring through collection of basic sighting information - without harm to individual animals.

A broad international coordinated approach is required to ensure the future conservation of this threatened species. Successful listing on various international conventions (e.g. CITES and the Convention on Migratory Species) is an important first step, although further research on the basic biology and ecology of this species is required to identify *critical habitats* and implement appropriate protection.

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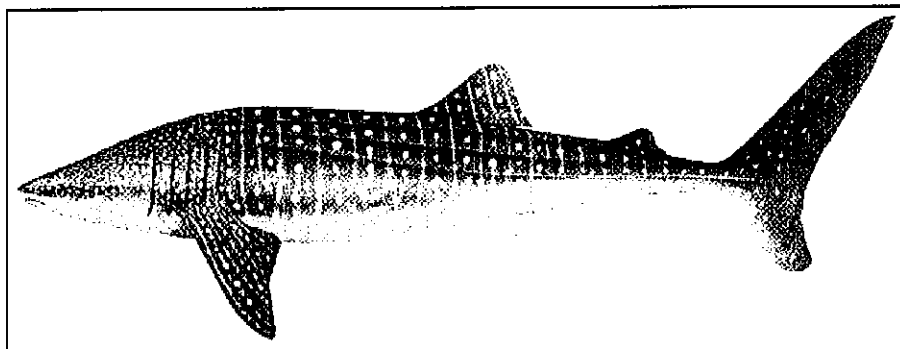
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1. The Whale Shark *Rhincodon typus* (Smith, 1829)

<i>Class</i>	Elasmobranchii
<i>Order</i>	Orectolobiformes
<i>Family</i>	Rhincodontidae
<i>Species</i>	<i>Rhincodon typus</i>

Scientific Synonyms *Rhiniodon typus* Smith, 1828

<i>Common Names</i>	English	whale shark
	Indian	Panai meen, Uravi, Pullian surrow, Pulli-udoombu, Makara sravu, Osman shira, Karaj, Bharait, Bahiri, Vori mas meer, Barrel
	Pakistan	Mhor
	Sri Lanka	Muni-muthu-mora
	Philippines	Butanding, balilan, toki, tawiki, tuki-tuki
	China	Jing Sha, tofu shark
	Japan	Ebisuzame, Jinbei
	France	Requin-baleine
	Mexico	Tiburón ballena
	Spain	Tiburón ballena, pez dama
	Taiwan	Tofusa, tofu shark
	Swahili	Vaame
	Germany	Walhai, rauhhai
	Poland	Rekin wielorybi
	Afrikaans	Walvishaai
	Khmer	Vaak
	Malaysia	Vu paus
	Portugal	Tubarão baleia



Whale sharks (*Rhincodon typus*), first discovered in 1828, are the world's largest living fish (Last & Stevens, 1994). They are widely distributed throughout warm tropical waters, although not regarded as common. However, small to moderate aggregations do occur. They are also rare and vulnerable to extinction (Norman, 2000).

1.1 Introduction

Rhincodon typus is one of approximately 370 species of shark alive today (Last & Stevens, 1994), and is within the order Orectolobiforms, predominately bottom dwelling species (e.g. wobbegong and carpet shark) (Compagno, 1988). It is one of only three filter feeding species, the other two being the megamouth and basking shark. (Last & Stevens, 1984), and is regarded as rare with as few as 320 sightings documented prior to the mid 1980's (Wolfson, 1986).

Although this species has been found in all tropical and warm temperate seas except the Mediterranean (Compagno, 1984; Wolfson, 1986), there are few places in the world where whale sharks are known to aggregate, or appear in large numbers. Ningaloo Marine Park (NMP), adjacent to the Gascoyne region in Western Australia is arguably the best location in the world to regularly find whale sharks at a particular time of the year. Large numbers can be found here during the annual whale shark 'season' (usually between April – June) (Norman, 1999). The Australian External Territory of Christmas Island (Indian Ocean) is less well known as a prime destination for whale sharks, although regular sightings of whale sharks are recorded here between November and January each year.

1.2 Conservation of species

At several locations accurate monitoring and/or anecdotal reports reveal shark appearances have declined dramatically. A decline in whale shark sightings is also evident in some areas where whale sharks have, or are currently being hunted (see Section 3). With the rise in popularity of whale shark ecotourism throughout the world (see Sections 6 & 7) and a marked improvement in the level of public awareness for the conservation concerns facing this species, there is strong support for international protection of the whale shark.

In the first instance, the species must be protected within national waters, which is the responsibility of national governments. In Australia, the Department of Environment and Heritage (DEH) is entrusted to conserve and manage wildlife, lands, waters and resources for the benefit of present and future generations. The Department must ensure that access to natural attractions is well managed, is ecologically sustainable and only occurs where appropriate. In relation to whale shark interaction tours in Australia, DEH take responsibility for the management and protection of the resource in Commonwealth waters (including waters around Christmas Island and the Coral Sea). In state waters of NMP, the Western Australian Department of Conservation and Land Management (CALM) is the management agency responsible for whale shark conservation.

Many countries have already established protection unilaterally (including Australia, India, Philippines, Mexico etc.; see Section 8). Domestic protection enables pressure to be exerted by a nation on neighbouring countries – who are yet to implement similar protection. As the level of international support broadens, it will be possible to discuss the implementation of a regional approach for the protection of this species beyond the jurisdiction of individual range states (see Section 8).

The whale shark is rare but still hunted at a level that is feared unsustainable in many regions, where it provides an income to local fishermen (e.g. Indonesia, Taiwan etc.). In order for protection to succeed, there must be incentives to discourage the killing / hunting of this species. Whale shark ecotourism can provide an economic alternative at locations where whale sharks are sighted regularly (see Section 7). As an example, although only in operation since 1989, the whale shark ecotourism industry at NMP has expanded significantly in recent years. It has the potential to contribute up to AUD \$16 million/yr to the economy of a region (Norman, unpub. data). However, as whale shark tourism continues to grow in popularity any impacts to the sharks attributable to ecotourism activities must be minimised.

To address the declining trend in whale shark numbers, the governments of all whale shark range states must work on international agreements to ensure regional protection for this species (see Section 8).

2. Whale shark ecology

Many aspects of whale shark ecology have received little attention and intensive research on this species restricted by lack of funding and rarity of sightings. Whale sharks are sometimes seen in large groups (Last & Stevens, 1984; Hanfee, 2001) although mainly solitary at most locations throughout their range (Compagno, 1984; Norman, 1999). They are known throughout the water column ($0 > 1000\text{m}$) and undergo large open ocean migrations (Eckert *et al.*, 2001; Rowat, unpub. data; R. Graham, pers. comm.). They are the largest of all the sharks yet feed by sieving plankton and small animals from the water as it passes over their gill rakers (Moss, 1977). This includes eggs released by spawning aggregations of reef fish (Heyman *et al.*, 2001), coral spawn, tropical krill, crab megalopa, small teleosts and mysids (Norman, 1999). The sharks can 'ram feed' as they swim forward or orient themselves vertically to 'suck' prey items.

The filter feeding manta ray (*Manta birostris*) shares some similar prey items and is occasionally seen with whale sharks (Norman 1999; Norman, unpub. data). Whale sharks are however more commonly seen in association with remora, suckerfish, cobia and groups of other smaller teleosts (Norman, 1999; see Figure 2).



Figure 2: A large group of fish in association with whale sharks at Ningaloo Marine Park.

Traditional tuna fishermen also know whale sharks to be associated with schools of tuna (Anderson & Ahmed, 1993; Silas, 1986). Predators, are few and include the killer whale *Orcinus orca* (O'Sullivan & Mitchell, 2000) and, for juveniles, blue marlin *Makaira nigricans* (A. Goorah, pers. comm.) and blue shark *Prionace glauca* (Kukuyev, 1996). Although unconfirmed, it is believed that an attack on a sub-adult whale shark photographed in the North West of Western Australia in 2003 may have been from a great white shark (*Carcharhinus charcharias*) (R. Mau, pers. comm.) (see Figure 3). Humans also represent a major threat through fishing activities, boat strikes and environmental degradation (see Section 3).



Figure 3: Trauma to a whale shark in the North West of Western Australia that may have resulted from a white shark attack (note: circular scars within the wound possibly from a 'cookie cutter' shark).

2.1 Habitat preferences

Compagno (1984) suggests that this species prefers warmer waters, with surface seawater temperatures between 21-25°C. Even warmer water temperatures have been recorded at NMP, with a study between 1995-1997 recording the mean water temperature during each whale shark observation of 27.1°C (Norman, 1999). This corresponds closely with water temperature recorded at the time of whale shark sightings at Christmas Island in 2004 (*i.e.* 28°C) (Norman, unpub. data). There is very little variation in sea surface water temperature during the whale shark season at NMP (see Figure 4), in contrast to fluctuations in ambient air temperatures.

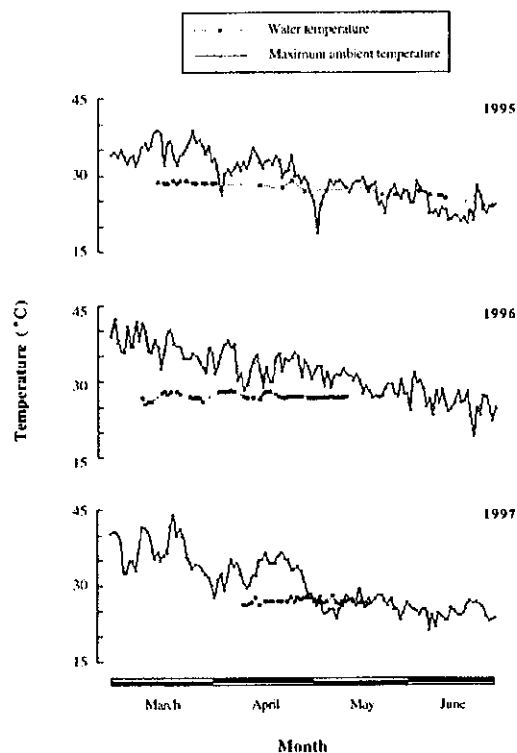


Figure 4: Water temperature as compared to ambient air temperature at Ningaloo Marine Park during the whale shark 'season' (1995-1997).

To date, there has been no study undertaken on the full biology of this species, although some aspects of whale shark biology have been reviewed. At NMP, CALM and researchers have been able to keep excellent records on sighting numbers and sighting conditions during the peak of the whale shark 'season' (Norman, 1999; Chapman, 2001; Chapman, 2002; Fitzpatrick, 2003). However, little information in the shoulder periods (*i.e.* between June and March) is available. This lack of data makes it very difficult to suggest whether parameters such as ambient air pressure, barometric pressure, wind direction and cloud cover, together or in isolation may have an effect on whale shark appearance at the surface. An ecosystem approach to the study of the habits and preferred conditions for whale sharks will enable a greater understanding of this species and assist conservation management.

Areas of increased food abundance (including upwelling locations) often record a substantial number of whale shark sightings. Whale shark aggregations have been linked to the spawning of corals in Western Australia (Taylor, 1994; Norman, 1999) and fishes near Belize (R. Graham, pers. comm.).

At NMP, research by Dr Steven Wilson indicates a complex relationship exists between the abundance of whale sharks and a tropical krill *Pseudeuphausia latifrons*. Dr Wilson suggests that krill abundance and appearance of whale sharks there fluctuate on an annual basis, with greatest prevalence during La Niña conditions as opposed to years when El Niño-Southern Oscillation (ENSO) occurs with its

associated influence on upwellings (<http://www.aims.gov.au/pages/research/boeg2002/boeg-05-1-whale-sharks.html>). The influence on whale shark appearance of the different ocean currents flowing in the north-west of Western Australia (*i.e.* the Leeuwin Current and the Ningaloo Current) has yet to be fully determined.

Whale sharks are also known to appear at Christmas Island following land crab spawning events (Norman, 1999), and in the Coral Sea at the time of myctophid spawning (J. Stevens, pers. comm.). At Bahia de los Angeles, Mexico where the author is working on a conservation strategy with the local community and the management group (see Section 7.2), whale sharks have been known to frequent an enclosed bay where currents appear to aggregate zooplankton that is targeted by the whale sharks (N. Rodriguez-Dowdell, pers. comm.). This species is also known from shallow-water areas near estuaries and river mouths in northern Borneo and the Philippines (Alava *et al.*, 1997; Alava & Kirit, 1994), sometimes during seasonal shrimp blooms. These habitats are however, highly vulnerable to pollution, development and other human activities.

In addition, nursery and mating grounds have yet to be identified for this species. However, habitat availability is not considered to be a constraint, unless associated with seasonal food concentrations. Therefore, *critical habitats* for *R. typus* would presumably include areas of high food abundance. Indeed, to improve survival rates of juveniles (born relatively small with little natural protection), these individuals would likely seek areas of high productivity.

Few seasonal whale shark habitats have been surveyed comprehensively and the key environmental factors that are important to this species have yet to be identified. There are many variables that may influence the appearance of whale sharks at particular locations including those that occur largely out of sight below the sea surface. This basic information is lacking and should be addressed as a priority so that management of whale sharks and their habitats can be enhanced to ensure long-term sustainability.

2.2 Global Distribution

Whale sharks have a broad distribution in tropical and warm temperate seas, usually between latitudes 30°N and 35°S (Last & Stevens, 1994; Norman, 1999; see Figure 5). They are known to inhabit both deep and shallow coastal waters and the lagoons of coral atolls and reefs (Demetrios, 1979; Wolfson, 1983). Australia is one of the most reliable locations to find whale sharks, with large numbers sighted each year at NMP, Western Australia and to a lesser extent at Christmas Island. Regular sightings have also been recorded from India, the Maldives, Taiwan, Seychelles, Honduras, South Africa, Kenya, Belize, Mexico, the Galapagos Islands, Chile, Thailand, the Philippines, northern Borneo, Malaysia, Mauritius and Indonesia.

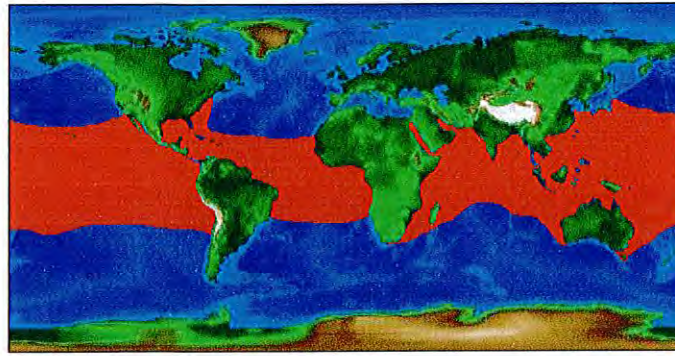


Figure 5: Global distribution of whale sharks (represented by red shading).

The sharks regularly appear in warmer latitudes and at locations where seasonal food ‘pulses’ are known to occur (see Section 2.1). At many sites, there are whale sharks are often observed feeding constantly while searching throughout the water column for areas of increased food abundance. Despite this, and as testimony to its global distribution, the whale shark is known from more than 100 different range states (see Table 1), sometimes in regions with relatively unproductive waters.

Table 1. *Whale shark Range States (Anon, 2002)*

Angola	Guinea Bissau	Philippines
Antigua and Barbuda	Guyana	Portugal
Argentina	Haiti	Qatar
Australia	Honduras	S. Tome and Principe
Bahamas	India	Saudi Arabia
Bahrain	Indonesia	Senegal
Bangladesh	Iran	Seychelles
Barbados	Iraq	Sierra Leone
Belau	Israel	Singapore
Belize	Ivory Coast	Solomon Islands
Brunei Darussalam	Jamacia	Somalia
Cambodia	Japan	South Africa
Cameroon	Jordan	South Yemen
Cap Verd Republic	Kenya	Spain (Canary Islands)
Chile	Kiribati	Sri Lanka
China	Korea	St. Kitts-Nevis
Colombis	Kuwait	St. Lucia
Comoros	Liberia	St. Vincent and the Grenadines
Congo	Madagascar	Sudan
Costa Rica	Malaysia	Surinam
Cote d’Ivoire	Maldives	Swaziland
Cuba	Marshall Islands	Tanzania
Democratic Republic of the Congo	Mauritania	Thailand
Dijbouti	Mauritius	The Gambia
Dominica	Mexico	Togo
Dominican Republic	Morocco	Tokelau
East Timor	Mozambique	Tonga
Ecuador	Myanmar	Trinidad and Tobago
Egypt	Nambia	Philippines
El Salvador	Nauru	Tuvalu
Equatorial Guinea	Netherlands	United Arab Emirates
Eritrea	New Zealand	United Kingdom
Ethiopia	Nicaragua	United Republic of Tanzania
Federated States of Micronesia	Nigeria	Uruguay
Fiji	Northern Marianas Islands	USA
France	Oman	Vanuatu
Gabon	Pakistan	Venezuela
Ghana	Palau	Vietnam
Grenada	Panama	Western Samoa
Guatemala	Papua New Guinea	Yemen
Guinea	Peru	

2.2.1 Tagging studies to track migratory movements

Not only is this species widely distributed, it is also highly migratory, with satellite tracking of individuals demonstrating long-distance and long-term migrations (Eckert & Stewart, 2001; see Figures 6-8). This technology has been trialled in Australia on several occasions (Taylor, 1994; Norman, 1999; J. Stevens, pers. comm.), with some success. There are concerns that whale sharks migrate from Australian waters towards Asia, where whale shark hunting has been reported in some areas.

Satellite tracking work at different locations throughout the whale shark range can significantly increase our knowledge of the species and ultimately assist with their international management for long-term conservation. In 1999, a satellite tag was deployed on a shark off Western Australia and then tracked for approximately 420km as it moved towards Indonesia (Norman, 1999). Another shark was tagged at NMP in 2002, and was tracked for approximately 2000km away from the northwest Western Australian coastline toward Asia (near Christmas Island) (see Figure 6).

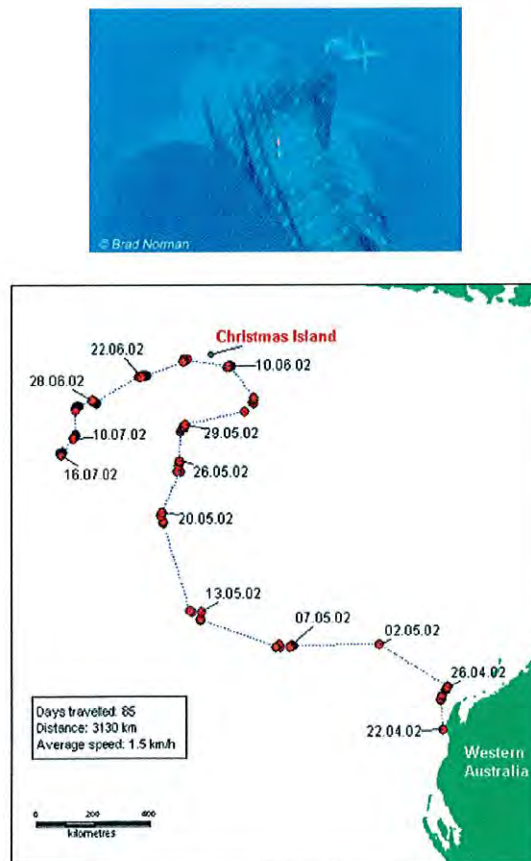


Figure 6: Whale shark with tag attached at Ningaloo Marine Park in 2002 and tracked moving towards Christmas Island

(from: <http://www.marine.csiro.au/research/tagging/hopetraveller/index.html>).

NB: The tag is thought to have detached from the shark near Christmas Island, with subsequent data collected while the tag was adrift at the surface (J. Stevens, pers. comm.).

A second shark was also tracked swimming away from NMP in 2002 where, it travelled approximately 1800km towards south-east Asia (Figure 7) over a 35 day period (J. Stevens, pers. comm.).

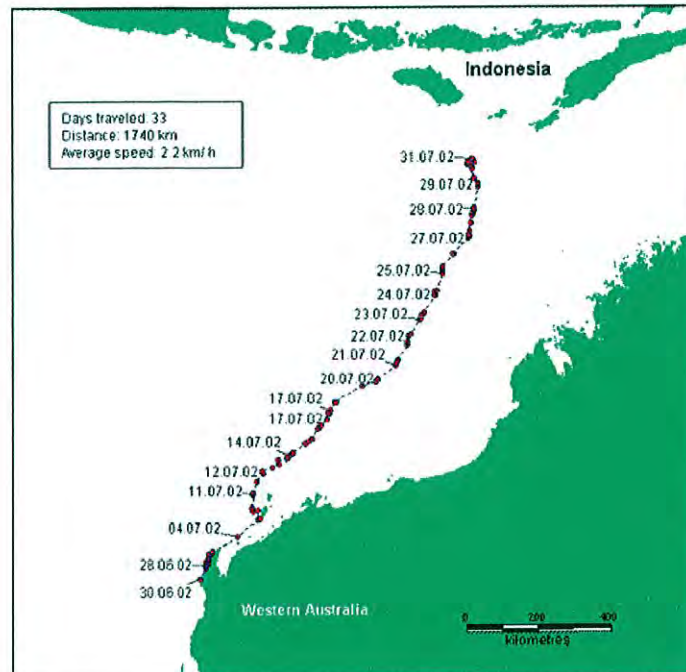


Figure 7: Shark tracked swimming away from Ningaloo Marine Park towards Indonesia in 2002
(from: <http://www.marine.csiro.au/research/tagging/mandu/track.htm>)

At other locations throughout their range, whale sharks have been tracked for varying distances, including a 550km journey completed within a few weeks by a shark tagged off Belize (R. Graham, pers. comm.). Three sharks from the Seychelles were tracked in 2001/02 migrating distances of approximately 700, 1000 and 5000km respectively (see Figure 8) over short time periods (D. Rowat, pers. comm.). A whale shark tagged in the Mindano Sea (inner Philippines) undertook a 2000km migration to a location south of Vietnam in a two-month period, while another travelled 13000km from the Gulf of California, Mexico, to near Tonga over 37 months (Eckert & Stewart, 2001). It can be surmised therefore that the extensive migratory habits of this species may expose the sharks to a variety of different habitats and threats throughout their range, including fishing pressure, irrespective of whether this activity is permitted or unregulated.

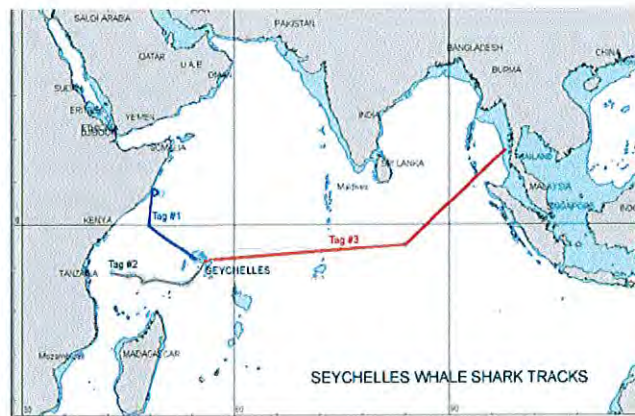


Figure 8: Whale sharks tagged in the Seychelles, with movement either west towards Kenya and Zanzibar, or east towards Sri Lanka and Thailand (courtesy D. Rowat, Marine Conservation Society, Seychelles).

To compliment these studies, less expensive monitoring programmes on whale shark distribution should be encouraged. Current knowledge of this species will be increased through collection and subsequent collation of sighting data on whale sharks throughout the world. Prior to the mid 1980s there had been only 320 whale shark sightings in the literature (Wolfson, 1986) with increased interest in this species (especially through newly developed whale shark ecotourism activities), the potential to document whale shark sightings has also increased. A public online database, (the international *ECOCEAN Whale Shark Photo-identification Library*) provides a simple means by which these data can be stored for future reference by interested groups (see Section 4.3; www.ecocean.org)

Diving behaviour

Using archival tagging, researchers have collected results confirming whale shark diving activity to depths in excess of 1000m, where water temperature is around 8°C (D. Rowat, unpub. data.). These animals are also known to frequent areas where the bottom depth exceeds 5000m (e.g. around Christmas Island), and given their close relationship to the bottom-dwelling sharks (*Orectolobiformes*), it seems reasonable to suggest that whale sharks may in fact travel deeper than current records show. The recent observation of a whale shark that was likely a victim of a white shark attack (see Figure 3) reveals possible ‘cookie-cutter’ shark (*Isistius brasiliensis*) scars. This small shark is known to inhabit depths to 3500m (www.fishbase.org).

Several whale shark research projects are currently underway to further understand the general biology and habits of this species. At NMP in 2003, a total of four pop-off archival tags were deployed in a joint study headed by AIMS, CSIRO, NOAA and CALM. If successful, the results from this work should become available in 2004 (J. Stevens, pers. comm.) In an associated study ECOCEAN teamed up with CALM and the whale shark ecotourism industry at NMP to successfully deploy a further two archival data-logging tags in 2003. Further research on this species in Australian waters included electronic tagging work (archival data-logging and satellite tracking) at Christmas Island, Indian Ocean through a joint ECOCEAN and Parks Australia North (DEH) project. Research at NMP and Christmas Island will continue during

The whale shark is protected in the waters of very few countries (see section 8.1), although it is known to visit more than 100 (see Table 1). At several locations, unregulated fishing for whale sharks continues. The fishing effort expanded considerably in the 1990's, while the number of whale sharks caught (relative to effort) proceeded to decline (see Section 6.1.1).

3.1 Fisheries

Sharks in general are vulnerable to exploitation because of their longevity, delayed maturation and relatively low fecundity (Camhi *et al.*, 1998). With few natural predators, whale shark populations are very vulnerable to targeted fisheries. Populations may decline rapidly as a consequence of unregulated over-exploitation and, as described for other depleted shark populations, may remain low. It seems that the main threat to whale shark populations is from fishing operations (Figure 10) – either targeted, incidental or as bycatch in non-targeted whale shark fisheries (see Section 6.1).

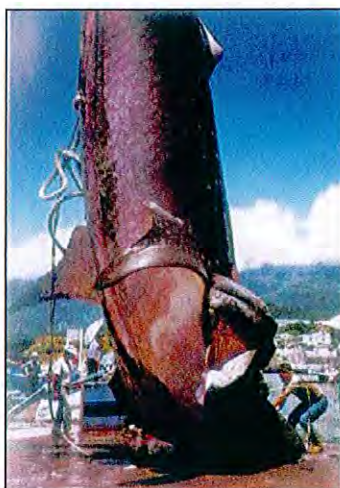


Figure 10: Example of female whale shark captured in Taiwanese whale shark fishery with 300 near-term embryos in twin uteri (from Joung *et al.*, 1996).

Traded products derived from whale sharks include fins, liver oil (see Figure 11), jaws, fresh, frozen or salted meat for human consumption, stomach and intestines, cartilage, and skin for leather products (Hanfee, 2001). The value of whale shark meat depends largely on freshness and section of the shark from which it is cut, with prices of between USD \$4.9 – 17.2/kg recorded by Chen and Phipps (2002) in the Taiwanese marketplace. Whale shark fins are of low quality and demand a low price on the marketplace, (Chen & Phipps, 2002), although there was a report in 1999 of a single whale-shark fin on sale in Beijing for £11,000 (<http://www.bbc.co.uk/nature/animals/features/252feature2.shtml>), indicating high prices are sometimes paid. As a consequence, targeting of whale sharks (legal or illegal) can prove highly lucrative for fishers and may result in increased fishing effort for this species.

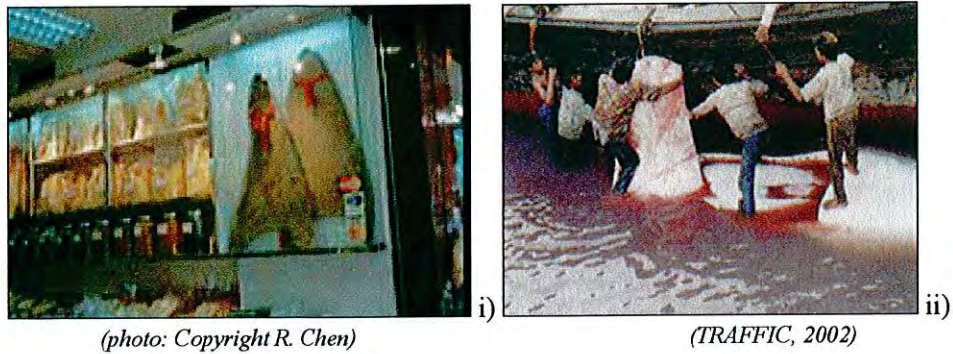


Figure 11: i) Whale shark fins on sale in market; ii) whale shark with large liver that produces high volume of oil.

3.2 Boat collisions

Another threat to the whale shark is from vessel collision (Stead, 1963; Budker, 1971; Norman, 1999). Collisions are now rarely reported, although many sharks have been observed by ecotourists and scientists with scars on caudal and dorsal fins, and near the head and dorsal surfaces that are likely the result of vessel contact (see Figure 12) (Norman, 1999). There are very few records of contact between sharks and vessels resulting in mortality, although this may be because whale sharks sink rapidly after death (Tubb, 1948).

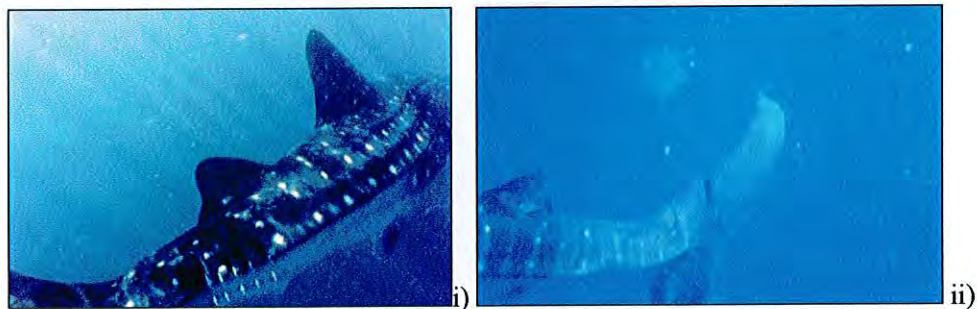


Figure 12: Examples of scarring to whale sharks from boat (propeller) contact i) five vertical cuts on right flank, directly below 2nd dorsal fin; ii) two vertical cuts on the leading edge of the upper lobe of the caudal fin.

Sharks have strong regenerative properties (Reif, 1978) and it appears that, superficial scarring heals very rapidly in *R. typus* (Taylor, 1994; Norman, 1999). As an example, a shark sighted at NMP with fresh white 'scratches' near the caudal fin was resighted (confirmed using photo-identification – see Section 4.3) 40 days later with advanced 'healing' to this wound (see Figure 13).

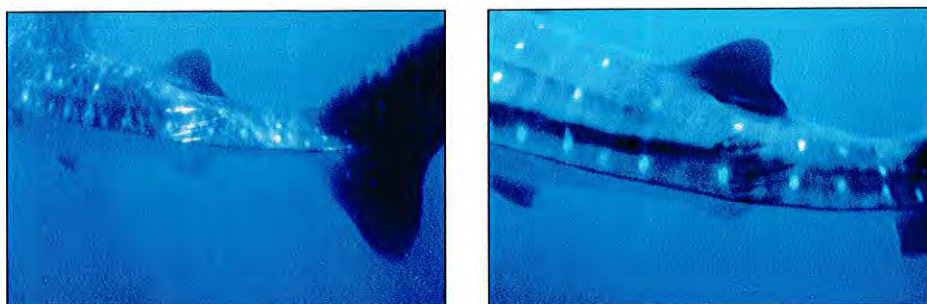


Figure 13: Example of superficial scratches on a whale shark at Ningaloo Marine Park that healed almost completely within 40 days.

3.3 Tourism

Harassment by unregulated shark watching and/or diving operations can also present a localised threat to this species (Norman, 1999). At Bahia de los Angeles, Mexico where a fledgling whale shark ecotourism activity has developed, some local tour boat operators are willing to work with local conservation groups and local authorities to implement sustainable management via a licencing system. The small village of less than 400 people currently survives with limited involvement of the local authorities, and this combined with the fact that local villagers are able to derive a worthwhile income from taking tourists swimming with these sharks (see Figure 14), has resulted in heavy pressure being exerted on this group of animals.

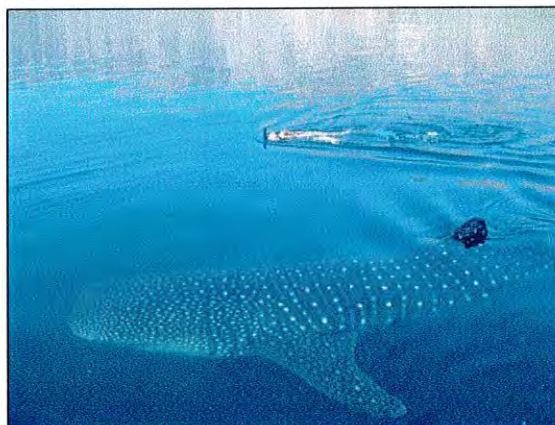


Figure 14: Whale shark ecotourism activity in Bahia de los Angeles, Mexico.

Sharing of information on 'best practice' ecotourism used at other locations where whale shark ecotourism has been implemented successfully (e.g. NMP) can minimise the negative impacts to these animals elsewhere (see Section 7). Even in well-regulated ecotour operations however, management arrangements should be reviewed regularly in order to achieve the objective of minimal impact to the sharks. Importantly, because whale sharks frequent particular locations at specific times of the year to maximise feeding (and possibly breeding) opportunities (see Section 2.1), any negative impact resulting from tourism and/or boating activities may effect the habits, movements and long-term survivability of this species.

3.3.1 *Whale Sharks in Captivity*

Because of their sheer size, non-aggressive nature and general rarity, whale sharks were previously sought for display in aquaria, with the first whale shark on show to the public at the Izumito Sea Paradise Aquarium in 1934 (<http://www.milton.edu/academics/pages/marinebio/whalesrk.html>). In contrast to their expected longevity in the wild (Wintner, 2000), whale sharks rarely survive for long in captivity. Uchida *et al.* (2000) report of 16 whale sharks ranging in length between 3.1m – 6.3m (14 male, 2 female) held at the Okinawa Expo Aquarium, Japan between 1980 and 1998. Survival time for the sharks ranged between three and 2056 days, and seven of the sharks injured during capture (in set nets) survived for less than two months. In India, a newspaper report (*The Hindu*, 27 December 2002) reports on a juvenile whale shark (0.95m TL), that was captured in a net by local fishermen off the Vizhinjam coast, and survived in the Marine Aquarium at Vizhinjam for only one day before dying (<http://www.hinduonnet.com/thehindu/holnus/04271610.htm>).

The Georgia Aquarium (USA) indicated intentions to capture and subsequently display two whale sharks as a main attraction when it opens in 2005 (L. Carne, pers. comm.). Despite the possibility of increased funding to the local marine conservation group at the location where whale sharks were to be captured (Belize), strong public concern may result in the proposal being withdrawn. With the low survival rate of sharks in captivity, and given the unfavourable conservation status of this species, it is anticipated that the appropriateness of such a project will be carefully reviewed as a priority.

3.4 *Other threats*

Although not previously known as a predator of the whale shark, in July 1992, two killer whales (*Orcinus orca*) were seen to attack, kill and feed on an 8 m whale shark in the waters off Bahia de los Angeles (O'Sullivan-Mitchell, 2000). The orcas attacked from below while the whale shark was at the surface, the shark using the defensive strategy of remaining 'upside down', with its only protection (the skin of its tough dorsal surface) turned toward the attacker/s. On this occasion however the force of the orcas was too powerful and the attack proved fatal for the whale shark.

In another report, a whale shark (approx. 6.5m TL) survived an attack by what was thought to be a white shark off Western Australia in 2003 (see Figure 3). Several other whale sharks at NMP have previously been seen with healed 'shark bite' scars (Taylor, 1994; Norman, 1999; see Figure 15), although it is unknown whether these attacks were in coastal or deep ocean environments, nor whether these scars were inflicted when the sharks were very small and vulnerable to attack. As noted in Section 2, the blue marlin and the blue shark are other known predators of juvenile whale sharks.

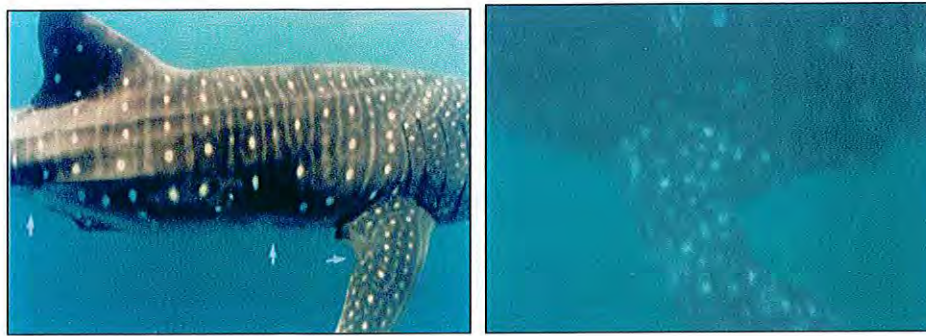


Figure 15: Whale sharks seen in Australian waters with healed 'shark bite' wounds on the fins and body.

4. Population status

4.1 Life History

No detailed study has been undertaken on the life history of the whale shark. The gestation period and interval between births remain unknown. Only one pregnant female with a litter of approximately 300 small near-term pups (between 48-64 cm TL) has ever been recorded. One juvenile survived for a short time in captivity and grew rapidly from 58 to 139cm over 143 days (Joung *et al.*, 1996; Leu *et al.*, 1997). In a separate study, Uchida *et al.* (2000) measured the growth rate of small whale sharks in captivity (see Section 3.3.1). Although under non-natural conditions, growth rates of these sharks were analysed. Rapid growth rate in small whale sharks was evident, with one female (365cm TL at capture) surviving for 2056 days and growing at an average of 29.5cm per year over this period. Another shark grew from 440cm TL to 520cm TL in 630 days at an average rate of 46cm per year (G. Cailliet, pers. comm.). While it is likely that growth rate would slow as the shark reaches maturity, initial rapid growth of pups may explain the scarcity of records of very small whale sharks seen in the wild.

Estimates of age at maturity for this species range from nine (9) to over 20 or 30 years (Wintner, 2000). Norman (1999) studied a group of 275 male whale sharks at NMP in an attempt to determine size at maturity. Mature male whale sharks can be identified through possession of abraded calciferous claspers, while immature males exhibit smooth undeveloped claspers (see Figure 16). In this study, shark length was either directly measured or estimated, with length at maturity in males calculated to be approximately 8.6m TL (Figure 17).

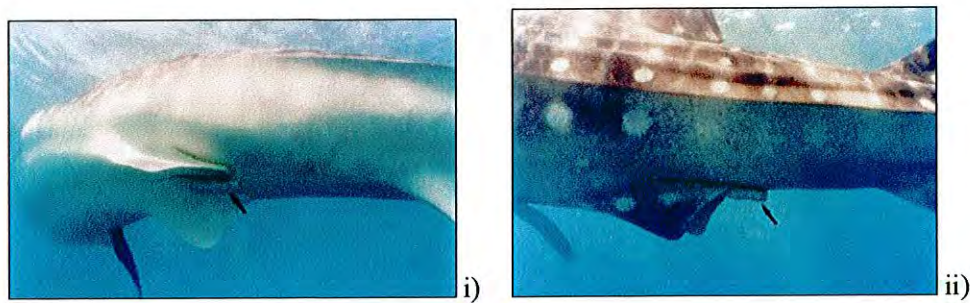


Figure 16: Morphology of male reproductive organs (claspers) indicates maturity in whale sharks i) immature; ii) mature (from Norman, 1999).

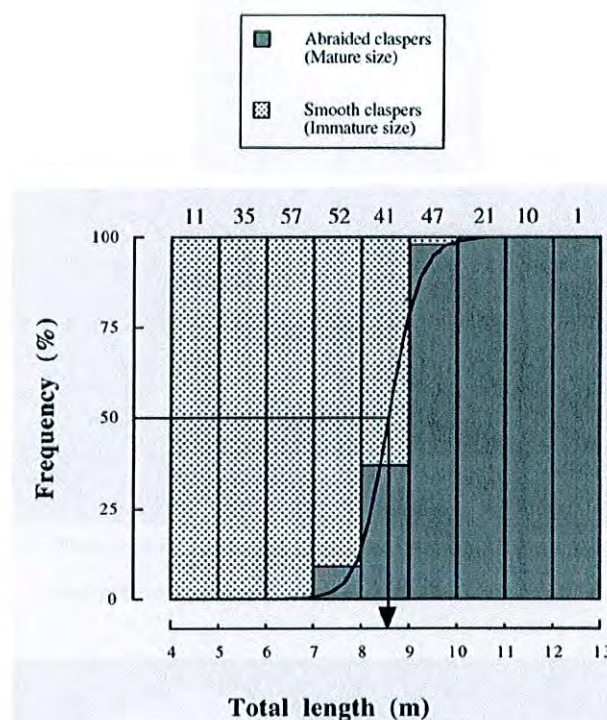


Figure 17: Data collected by Norman (1999) were used to determine length which 50% of male whale sharks are mature (~ 8.6m TL).

It is not possible, however, to determine sexual maturity in females by simple external observation. Pai *et al.* (1983) and Rao (1986) studied two female whale sharks (7.9 and 8.6m TL) and found these specimens to have immature ovaries. This may have been because the sharks were not examined during the breeding season (Norman, 1999). In one of the few analyses of a small female whale shark specimen, Dr Leonard Compagno from the South African Museum worked on a specimen (4.2m TL; 450kg) washed up on the shore near Western Cape, Mossel Bay. The ovaries were analysed and found to be moderately well-developed, 150mm across, with 16-20mm follicles (L. Compagno, pers. comm.) indicating that these sharks may reach maturity at a relatively small size compared to males.

Generation time for this species has been estimated to be from 24 to over 60 years, and longevity from 60 to over 100 years (Wintner, 2000). Even if the most conservative (lowest) estimates are taken, this is a very low-productivity, low-resilience species (Chen & Phipps, 2002). The life history parameters calculated for the 20m long shark reported by Chen *et al.* (2002) yields an estimate of 0.08/year intrinsic rate of population increase (r) using Fishbase (www.fishbase.org).

The preferred breeding (pupping) grounds for this species have yet to be determined. Although there have been several observations of two whale sharks circling ‘nose to tail’ (Norman, 1999; R. Mau, pers. comm.) at NMP in a possible display of courtship behaviour, this remains to be confirmed (see Figure 18). We know however, that newborn whale sharks would be vulnerable in open water (see Section 2 & 3.4) and grow rapidly when very young (Leu *et al.*, 1997). The very few records of either pregnant females or very small / young whale sharks (*i.e.* < 2m) are from either Taiwan, Philippine or Indian waters. In the absence of any data to the contrary, we must assume that these areas are likely critical in the breeding cycle and long-term survival of this threatened species. Those areas of critical importance (e.g. high food productivity, protected breeding areas etc.) must be identified and appropriate protection implemented as a priority.



Figure 18: Aerial photographs of two whale sharks at Ningaloo Marine Park (sex unknown) displaying social interaction (photos courtesy Suzy Quasnichka)

4.2 Mitochondrial DNA studies

While it is known that whale sharks are highly migratory (see Section 2.2), there is very little information on population structure and separation. Whereas satellite tagging can help to document migration and provide information on the geographic overlap of whale shark populations, analysis of genetic information that can be used to test evolutionary relationships at their most basic level and identify whether whale sharks in different parts of the world are in fact interbreeding. Genes are the fundamental and functional unit of heredity, and genetic studies are able to track the movements of genes over many generations. When two populations become isolated (reproductively), gene frequencies change over generations simply through random genetic drift. Reproduction between individuals from different regions results in gene flow ensuring that gene frequencies between regions are similar. It is through analysis of the frequencies of specific genes from different geographic areas that it is possible to estimate the amount of gene flow that has taken place over past generations. However, genetic similarity between regions is not proof that separate stocks do not exist, as populations may not have been isolated long enough for

differences in frequencies of the alternate form of gene (allele) to develop. In addition, an exchange of only a few individuals per generation is enough to maintain the same alleles in different populations (From: Ed Heist, Texas A&M University <http://www.flmnh.ufl.edu/fish/Organizations/SSG/sharknews/sn7/shark7news9.htm>).

There are several whale shark DNA studies underway, although to date there have not been any major results published.

4.3 Mark / Recapture studies

Mark/recapture studies can be used in any situation where animals can be 'marked' (or otherwise identified) and 'recaptured' (or identified later) by resighting (Lettink & Armstrong, 2003). Analysis of any resultant data can be used to estimate abundance, survival, recruitment and population growth rates over time (Thompson *et al.*, 1998). The use of conventional tags on whale sharks has been attempted at several locations in recent years (see Taylor, 1994; D. Rowat, pers. comm.; R. Graham, pers. comm.) with limited success. Often the tags are damaged ('fouled') or, being a foreign object lodged in the skin, are shed quickly as a result of the rapid healing process in whale sharks. In addition, tagging of this type is also invasive and can potentially cause stress to the animals, as whale sharks have been observed 'rubbing' on the sea floor in an attempt to dislodge objects (Norman, unpub. data).

Alternatively, whale sharks can be 'tagged' without any physical contact or interference. Whale sharks are born with unique body patterning on their skin that is retained throughout their life (see Figure 19). Similar to a fingerprint in humans, this natural patterning shows no evidence of change between years and can therefore be used to identify individual sharks without interference to the animal (Taylor, 1994; Norman, 1999).

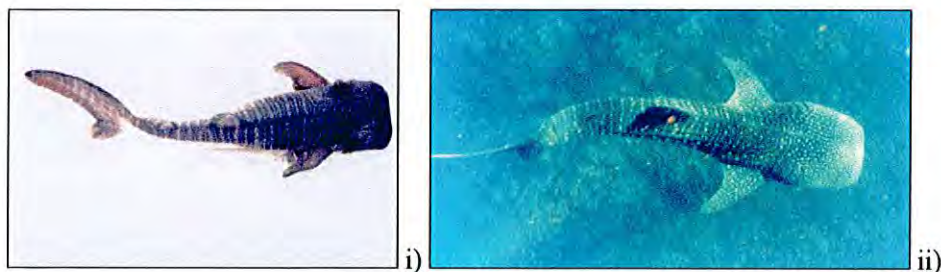


Figure 19: i) juvenile whale shark (~0.5m TL); ii) mature whale shark (~7.5m TL) with body-patterning that remains through development.

Using these natural markings, an international database (the *ECOCEAN Whale Shark Photo-identification Library*) has been developed as a public resource to assist with global monitoring of this threatened species (see Figure 20). The *Library* uses advanced spot extraction methodology to effectively 'map' the pattern of spots on the skin of the shark and then compare this unique patterning with other sharks within the *Library* (see www.ecocean.org). When a match is confirmed, the rate of appearance and movement patterns of identified sharks (especially when sighted at a different location than first registered within the *Library*) can be determined.

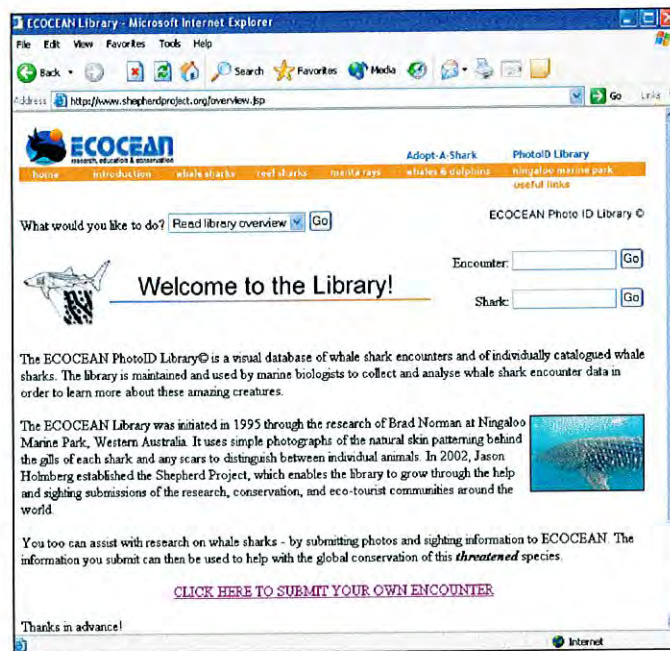


Figure 20: The ECOCEAN Whale Shark Photo-identification Library is an international online database to assist the global monitoring of this species.

As a further example of its benefits for monitoring of this species, utilisation of the *ECOCEAN Library* has enabled researchers to establish the return of many sharks to NMP between 1995 and 2003. Shark A-001 has been confirmed returning to NMP in 1995 and 2003 (and in the years between) using the Library (see Figure 21). Also, submissions to the Library from volunteers in the Maldives have enabled us to prove that at least one identified shark M-001, 'marked' near Ari Atoll and then 'recaptured' there on several occasions over a 10-month period (*i.e.* 20/5/03; 29/8/03; 24/10/03; 12/3/04), is resident to this area.

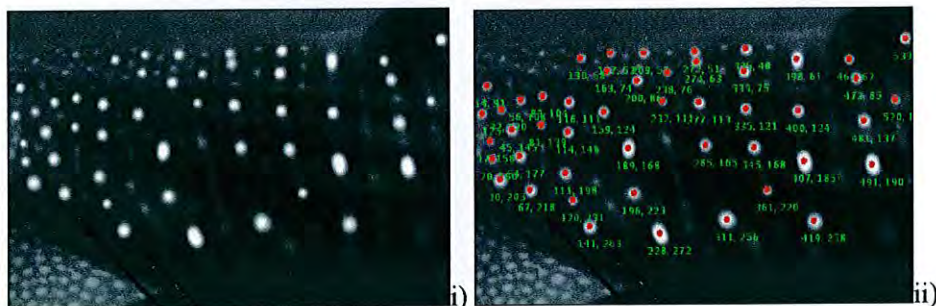


Figure 21: Using the ECOCEAN Library, it has been possible to resight many identified sharks returning to Ningaloo Marine Park in subsequent years, including as an example A-001 who was photographed at Ningaloo Marine Park in 1995 and 2003 (i). The procedure uses 'mapping' (ii) of spots on the skin of the shark from photograph taken during initial encounter – then matching with pattern recorded from photo of shark at a later date.

This mark/recapture program is non-invasive and can be greatly enhanced via input from community volunteers around the world. Ecotourists, industry personnel, scientists and managers can become involved in whale shark conservation monitoring, through submission of whale shark identification photos and sighting data to the international online database (www.ecocean.org). As testimony to its global appeal and ease of use by the variety of stakeholders, to date submissions have been forwarded to the *ECOCEAN Library* with information on whale shark sightings from the Maldives, Seychelles, Bahamas, Mexico, Thailand, the Red Sea, Christmas Island and NMP. Further analysis of these monitoring data will enable an improved understanding of whale shark population size, migratory routes and ultimately assist the future management for conservation of this threatened species.

5. Conservation status

The *World Conservation Union* (IUCN) is an umbrella organization of the world's conservation agencies and institutions, previously noted the uncertain conservation status of the whale shark by listing it as 'Indeterminate – Data Deficient' in the 1996 *Red List of Threatened Species*. The IUCN uses this publication to provide taxonomic, conservation status and distribution information on taxa (in this case the whale shark *R. typus*) that has been evaluated using the [IUCN Red List Categories and Criteria](#). This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN *Red List* is to catalogue and highlight those taxa that are facing a higher risk of global extinction (*i.e.* those listed as Critically Endangered, Endangered and Vulnerable). However, the long-term success in preserving the future conservation of the whale shark is dependent on individual parties monitoring trade and implementing protection as necessary.

The global conservation status of the whale shark was reassessed in 2000 and upgraded to *vulnerable* (A1b,d, A2d) in the revised *IUCN Red List of Threatened Species* (Norman, 2000; <http://www.redlist.org/>). IUCN Criterion A, the basis for this assessment, refers to declining populations. Sub-criterion 1 indicates that population reductions have been observed, estimated, inferred, or suspected in the past, based on b) an index of abundance appropriate for the taxon [in this case declining landings or catch per unit effort] and d) actual levels of exploitation. Sub-criterion 2 indicates that a population decline is projected or suspected in the future, based on d) potential levels of exploitation (likely to occur if directed fisheries, driven at least in part by the demand for fins and meat in international trade, remain unmanaged, and as a result of bycatch). The *vulnerable* assessment indicates that the estimated and projected scale of this population reduction is between 50 and 20% of the population over a ten-year or three-generation period, whichever is the longer.

The *Bonn Convention for the Conservation of Migratory Species of Wild Animals* (CMS) aims to protect migratory species across geographical boundaries in their range. The whale shark was listed on Appendix II of this convention in 1999 (Chen & Phipps, 2000), which identifies the species as having unfavourable conservation status that would benefit from the implementation of international cooperative agreements for its conservation and management.

The convention provides a framework that facilitates negotiation between two or more signatories within the range of the whale shark to tackle any threatening process (Fowler, 2000). The *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) is an international agreement between Governments with an aim to ensure that international trade in specimens of wild animals and plants does not threaten their survival. 'States' (countries) that have agreed to be bound by the Convention (*i.e.* who have 'joined' CITES), are known as 'Parties' and are legally bound to implement the Convention.

There are three appendices of CITES:

- i) Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances.
- ii) Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival.
- iii) Appendix III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade.

Australia unilaterally listed the whale shark on Appendix III and promoted extensive global collaboration in the lead up to the 12th Conference of Parties (Santiago, Chile) in 2002. At this meeting the proposal to list the whale shark on Appendix II was successful in establishing that the whale shark meets the criteria for listing in that 'it is known, inferred or projected that harvesting has or may have, a detrimental impact on the species by exceeding, over an extended period, the level that can be continued in perpetuity'. As a consequence of the successful listing, international trade in whale shark products is still legal, although a permit is required. This allows trade to be monitored and provides a mechanism to verify catches (Chen & Phipps, 2002). Australia was a prominent supporter of the Appendix II nomination, providing expert comment and a *Whale Shark Fin Identification Manual* (see Attachment A) to distinguish whale shark fins from those of other sharks in the marketplace.

6. Exploitation

6.1 Hunting

Targeted whale shark fisheries have previously been reported in the Maldives, China, Taiwan, India, Pakistan, Japan, Indonesia, the Philippines and Senegal, although catch data is lacking in some countries. Records show declining catches (and, where available, declining catch per unit effort) at different locations ranging from 30 to 80% per decade and 20 to 30% annually in some very short-lived fisheries (S. Fowler, pers. comm.). Although banned at certain locations, directed fisheries, high value in international trade, a K-selected life history combined with a highly migratory nature and generally low abundance makes this species vulnerable to exploitation (Norman, 2000).

6.1.1 Catch statistics

China

In China a modified spear was previously used to harpoon large whale sharks in the 1960s. There are, however very few reports of recent catches, with two whale sharks landed in 1995. Fishermen report whale sharks are now seldom caught (Parry-Jones, 1996).

India

Small-scale harpoon fisheries traditionally existed in Pakistan and India for local utilisation (Hanfee, 2001) where the species was harpooned in order for oil to be extracted from the liver (Rao, 1986; Silas, 1986; Vivekanandan & Zala, 1994). Demand in Taiwan stimulated a huge increase in effort and landings in the Veraval (Gujarat, India) fishery in the 1990s (Hanfee, 2001), when the value of landed whale sharks increased steeply, particularly after whale shark meat began to be utilised in 1994. Landings increased in the late 1990s, and Pravin (2000) reports of more than 1000 whale sharks killed in Indian coastal waters in 1998. A total of 279 whale sharks were reported taken during the main January and May whale shark season in 1999, while an additional 145 sharks out of a group of approximately 300-500 were taken between 10-15km offshore (depth 20-26m) in December 1999 off the north west coast near Veraval (Hanfee, 2001). Despite continued high market demand and a possible increase in fishing activity the following year, the whale shark fishery appeared able to take only 160 whale sharks during the following season, January to May 2000. Until it closed in May 2001 when the Ministry of Environment and Forests legally protected the species in Indian territorial waters, up to 150 vessels per day were involved in this fishery (Pravin, 2000).

Maldives

Fishermen throughout the Maldives previously took between 20-30 whale sharks a year, using the liver oil to treat their boats (Anderson & Ahmed, 1993). Since this fishery was closed in 1995 there has been no monitoring to ascertain whether there are signs of population recovery.

Philippines

In the Philippines an artisanal subsistence harpoon or gaff fishery for whale sharks was operational in a small number of former whaling villages in the Bohol Sea (Alava *et al.*, 1993; Alava *et al.*, 1997). The increase in demand for whale shark meat in Taiwan stimulated the development of a targeted fishery for the species in the 1990's, with new whale shark fisheries initiated in several locations to meet export demand in Taiwan. Alava *et al.* (2002) report 450-799 sharks were taken between 1990 and 1997, averaging between 56-100 sharks per site per year in four of the primary fishing sites. This fishery peaked in 1993 when about 180 sharks were landed, then declined at an average of 27% per year in the following years. Catch per boat (used to represent catch per unit effort) in two of the traditional whale shark fishing villages in the Bohol Sea declined steeply from 4.4 to 1.7 sharks per boat in one area and from 10 to 3.8 sharks in another. In 1997, 11 sites were identified, taking on average 13 sharks per sight per year. The Philippine government introduced legal protection for

the species throughout Philippines waters in 1998 after poaching occurred in a locally proclaimed whale shark sanctuary and ecotourism site in Donsol, Sorsogon. Despite this, a significant decline in Donsol whale shark sighting rate (from 8 to 1-2 sharks per trip) was recorded in 1998 and 1999, respectively (Groves, 1999). However, sighting numbers have shown some improvement since 2000, with a total of 115 ecotourist/whale shark encounters recorded in March – April 2001 (J. Freund, pers. comm.).

Taiwan

Demand for whale shark products has increased significantly in Taiwan (Province of China) during the past two decades. Chen *et al.* (1997) estimate that 272 (158 as bycatch in set nets and 114 by harpoon) were taken in Taiwan in 1996. Concern was expressed, however, that landings were declining. Joung *et al.* (1996) previously noted anecdotal reports that captures south of Penghu (off the west coast) had declined significantly during the 1980s. Billfish harpoon fishermen from Hengchun Harbour fishing south of Penghu had reportedly landed some 50-60 whale sharks each spring in the mid-1980s, but landings had declined over the next decade until only about 10 sharks were caught annually. Fewer than 10 were caught in this area in 1994 and 1995. Chen (2002) reports that 94 whale sharks were caught in Taiwan during the 12 months from March 2001 to March 2002. It appears that the catch has declined by 60-70% in the seven years since surveyed by Chen *et al.* (1996), despite increased market demand.

6.1.2 Aerial and vessel-based surveys

The immediate and possible long term effect of fishing on whale shark numbers has yet to be comprehensively reviewed. However, analysis of aerial survey data from areas where whale sharks are commonly seen can provide a crude indication. Aerial survey programs are only possible because the sharks often swim near the surface at particular locations and at certain times of the year. This type of monitoring is however cost-prohibitive and many 'surveys' will ultimately result in zero whale shark sightings, due in part to the fact that whale sharks also spend considerable time away from the surface (see Section 2). In this situation, whale sharks may be present but deep and out of survey sight, and any analysis of results must take this into consideration.

Whale sharks occur seasonally off the east coast of South Africa, although sighting numbers have fluctuated over the years (Bass *et al.*, 1975). Aerial surveys conducted off the KwaZulu-Natal coast in 1994 resulted in 184 sightings from 12 survey flights, with most of these seen within a 110km stretch between Durban and Umhlangeni (Gifford, 1994). In another study, a total of 13 survey flights were undertaken over 4600 km of coastline in 2001/02 at the normally peak time for whale shark sightings, with only 10 sharks sighted throughout (A. Aitken, pers. comm.).

At the Seychelles, the use of a dedicated 'micro-light' aircraft has enabled the collection of important data on whale shark numbers and distribution in recent years. As an example, in 2003, a total of 116 micro-light flights were completed (survey time approx. 200 hrs) during which 765 whale shark sightings were recorded. A maximum of 36 separate sharks were recorded on a single flight. While this type of

aircraft was very successful in locating sharks, it was deemed inappropriate at many locations because of the dangers of flying a very small aircraft offshore in remote areas often frequented by whale sharks (D. Rowat, pers. comm.).

Dedicated aerial survey programs have also been undertaken at NMP to monitor whale shark numbers (Taylor, 1994; Colman, 1997; Norman, 1999; R. Bennett, unpub. data; see Figure 22), although very cost-prohibitive and with limited success. Weather conditions were found to vary considerably and significantly effect sighting opportunities (Norman, 1999). Degree of cloud cover, sun reflection on the water surface at different times of the day, ocean swells, barometric pressure and wind direction had varying effects on survey results. As an alternative, a low-cost survey program utilising support from pilots employed by the whale shark industry to search for sharks at NMP could be developed (R. Bennett, pers. comm.). Pilots have the opportunity to collect important data on whale shark distribution and numbers at NMP while conducting daily searches for the commercial whale shark ecotourism industry.



Figure 22: Community volunteers at Ningaloo Marine Park have previously undertaken aerial surveying, with support from the whale shark ecotourism industry. Whale sharks are usually seen within 5km of the Ningaloo Reef front.

In contrast, independent aerial survey programs are not restricted to only search for sharks in those areas demanded by the industry. This minimises the opportunity for bias and ensures a more structured survey of whale shark sighting numbers in the region. Importantly, as there is considerable evidence to show that whale sharks spend much of the day below sighting depth (see Section 2.2.1 & 6.3.2), in any aerial survey program, only a percentage of the actual number of sharks in the area will be recorded. Therefore, as with any monitoring program, it must be well-planned and the results analysed taking these factors into account.

Unlike cetaceans, whale sharks do not need to break the surface at any time to obtain oxygen for survival. This makes it very difficult to see (survey) these animals from the low vantage height of a vessel. However, because these sharks are often swimming at or near the surface, sighting numbers can be documented, especially at locations where whale shark ecotourism is undertaken. Although less structured, vessel-based monitoring can also provide important information on trends in whale shark sighting numbers over time. Logbook programs, similar to that implemented by management at NMP (with the support of industry) can continue to assist our understanding of whale shark population numbers on a local scale.

6.1.3 Population trends

There have been several documented declines in seasonal catches of the whale shark by directed fisheries with declines in some areas over only a few years (see examples for Philippines, Taiwan and India) [see Section 6.1.1]. Local populations have become reduced, while fishing effort and price have increased for whale shark products in other regions (Hanfoc, 2001; Chen & Phipps, 2002). The majority of these fisheries are however, too recent and/or populations too poorly monitored to determine whether these declines will result in long-term reductions (e.g. over several generations) in local populations.

It is not known to what degree fishing in one area affects population/s in other areas. However, it is known that at least some sharks migrate long distances (see Section 2.2) within ocean basins suggesting that the effects may not be purely local. Thus a fishery in one location may affect numbers sighted in another area or even in a different region. There is increasing concern that unexplained declines in numbers sighted seasonally in apparently unfished areas such as South Africa (see Section 6.1.2) and in Thailand where one dive boat operator reports that sighting numbers have dropped from ~60/year to only two sightings in 1999 (A. Antoniou, pers. comm.), may be the result of fisheries elsewhere impacting these populations. The rapid collapse of localised fisheries for this widely distributed and apparently seasonally migratory species could be explained by the tendency for whale sharks to be site-faithful and to return regularly to the same seasonal feeding locations. Despite their very wide-ranging nature, they may effectively form local stocks that are particularly vulnerable to depletion by fisheries activity.

Anecdotal evidence from certain locations suggest fluctuations in sighting numbers may be explained by natural variation and/or the effect of variable climatic conditions and food resource availability (Norman, unpub. data; Colman, 1997). In the absence of good baseline data at a range of locations however, there is insufficient evidence to determine the cause of this variation in sightings. It is therefore imperative that baseline environmental and shark monitoring be implemented at a range of locations where whale sharks have been known to frequent. When a good time series of data is available for further analysis, it may be possible to identify the driving factors contributing to this variation in sighting numbers.

Ningaloo Marine Park

Although no long-term independent study has yet been undertaken to determine individual whale shark numbers or local population size at NMP, records collected by CALM (the state management agency), indicate that the number of whale sharks there has fluctuated over the last decade (see Figure 23). It was during 1993 that CALM licenced the whale shark ecotourism, with logbook returns indicating that the total number of whale shark sightings was only 348 in that year. The number of sharks recorded during each commercial whale shark season at NMP showed an increasing trend in the early years there, with a peak of 710 in 1996. Sighting numbers declined between 1997 and 1999 but have stabilised somewhat since (Colman, 1997; Norman, 1999; Chapman, 2002; Fitzpatrick 2003).

industry has developed in Belize worth in the region of US\$1.5 million (R. Graham, pers. comm.) and in the Phuket area of Thailand, where the industry is worth a minimum of US\$3 million (Newman *et al.*, 2002), although this industry has declined dramatically in recent years (see Section 6.1.3). In the Gulf of California, Mexico, another whale shark ecotourism industry has been established using spotter planes to direct boats to whale sharks. This is in contrast to the developing industry at Bahia de los Angeles where spotter planes are not used and the sharks are spotted from the boat or shore. The latter is at present providing only limited income to local operators (A. Vasquez, pers. comm.), although with good management this is expected to increase (see Section 7.1.2). Other countries where whale shark ecotourism has been implemented, including the Philippines, Maldives, Honduras, South Africa, Mozambique, Tanzania, Kenya and several Red Sea and Indian Ocean range states, are likely to gain considerable economic benefit from these activities.

6.2.1 *Whale shark ecotourism in Australia*

6.2.1.1 *The economic importance of ecotourism*

As a result of the predictable annual aggregation of whale sharks at NMP, Australia has become a premier destination for whale shark ecotourism. A lucrative whale shark ecotourism industry in Western Australia's northwest (near the towns of Exmouth and Coral Bay) has developed, where ecotourists pay high prices to swim alongside whale sharks in their natural environment (Figure 24).



Figure 24: *Ecotourists swimming with whale sharks at Ningaloo Marine Park.*

The number of ecotourists visiting NMP to swim with whale sharks each commercial 'season' has continued to expand since the mid-1990s (see Figure 24). In addition, previous reviews of the whale shark ecotourism industry there (see Norman, 1999; Chapman, 2001; Chapman 2002) have established 'peak' periods within each 'season' when ecotourism pressure is at its greatest. The industry there has achieved very good 'strike' rates, with the proportion of all tours in which a whale shark was encountered being greater than 80% between 1995 – 2003 (Chapman, 2002; Fitzpatrick, 2003). However, not all vessels operate on all days of the whale shark 'season' i.e. at 41 and 42% capacity in 2002 and 2003 respectively (Fitzpatrick, 2003).

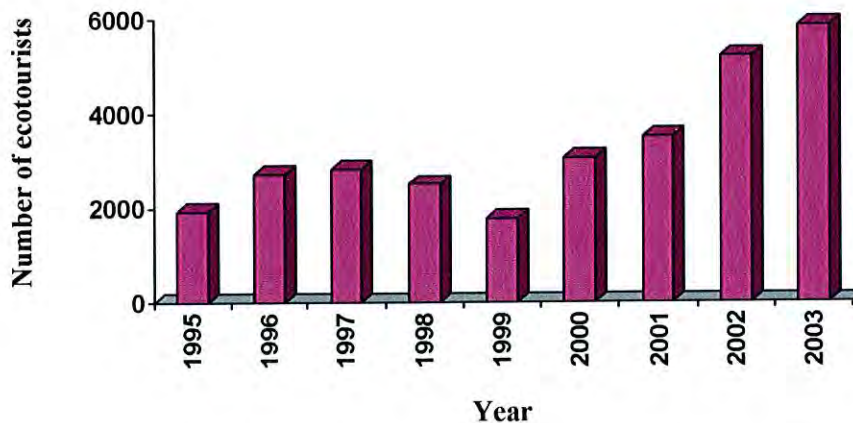


Figure 25: The number of tourists undertaking whale shark interaction tours at Ningaloo Marine Park has shown an increasing trend since 1995 (with the exception of 1999 attributable to the devastation of Exmouth by Cyclone Vance) (from CALM records).

The number of participants in whale shark tours at NMP numbered around 1000 in 1993 (Colman, 1997). Recent figures indicate this number had risen to approximately 4300 tourists in 2002 and almost 5000 in 2003 (Fitzpatrick, 2003). Using an estimated expenditure of AUD \$3198 per person (calculated during an previous survey of paying ecotourists at NMP in 1995 (D. Davis, pers. comm.)), it is possible that the whale shark ecotourism industry at NMP may inject as much as AUD \$16 million to the economy of the region in some seasons. Importantly, sound management practices are implemented and enforced as appropriate to ensure longevity of the industry, economic stability for the local communities, and especially minimisation of any negative impacts on the species.

6.2.1.2 Commissioned research to assist sustainable management

While the whale shark industry at NMP was still in its infancy, the management agency (CALM) consulted with the whale shark industry and Murdoch University to develop a major research project to investigate the whale sharks and associated ecotourism industry at NMP. Initially, the set of behaviours commonly displayed by whale sharks was established. The activities of sharks, tourists and industry throughout whale shark/tourist interactions were also observed and recorded over consecutive whale shark 'seasons'. A comprehensive list of findings is available in the subsequent thesis:

Norman, B.M. (1999). *Aspects of the biology and ecotourism industry of the whale shark Rhincodon typus in northwestern Australia* Master of Philosophy Thesis, Murdoch University, WA.

Significant facts concerning the sharks that visit the northwest of Western Australia include:

- i) the majority of the sharks sighted at NMP are male (85%),

- ii) the largest shark sighted was 12m (mean ~ 7m),
- iii) the length at which a male whale shark is sexually mature is ~ 8.5m,
- iv) time of day when sightings of whale sharks by the tourism industry were most common was between 11am - 1pm,
- v) whale shark behavioural responses in relation to tourism pressure include diving, banking, eye rolling, changes in swimming speed and direction,
- vi) most common water temperature at NMP when sharks were recorded was ~ 27°C,
- vii) most common sighting depth for sharks was between 10 - 30m,
- viii) whale sharks were more prevalent at particular locations within NMP,
- ix) food items taken by the whale shark include tropical krill, mysids, crab megalopae, planktonic copepods and small fish,
- x) fish in regular association with whale sharks include remora, slender suckerfish, juvenile trevally, cobia and (occasionally) manta rays,
- xi) a new species of copepod (*Pandarus rhincodonicus*) living on the skin of the whale shark was collected. This was described in a joint study between Murdoch University and UWA,
- xii) radio tracking provided evidence that the whale sharks remain close to the reef over a 24hr period - with a tagged shark resighted on 14 separate days over a 28 day period,
- xiii) significantly more whale sharks were moving in a northerly direction, parallel to Ningaloo Reef,
- xiv) the methodology for identifying individual whale sharks using photo-identification was proposed and tested. This method was used to establish that sharks return to NMP in successive years.

This study has served to provide baseline information on this species and the associated tour industry. It enabled the establishment of a continuous data set, which updated each successive 'season' with CALM collecting information via industry logbooks at NMP. Additional data can be collected by independent researchers (see Norman, 1999), included with industry collected data and then compared between years (as shown in Section 6.1.3.)

Furthermore, it will be important to continue to review whale shark ecotourism activities at other locations throughout the world, and to then compare different management strategies (and any associated positive or negative effects on whale shark behaviour and sighting numbers) with results collected in Australian waters. However, in each situation the ability to gather information on the behaviour of sharks under *natural* conditions (*i.e.* when there is no tourism pressure) will pose a significant challenge. There will also be little opportunity to test the *natural* level of variability in sighting numbers, because it is usually only through ecotourism or hunting that the majority of data on this species is collected.

Christmas Island, Indian Ocean may provide one of the best opportunities to test the natural variability in whale shark behaviour in the absence of human influence. Less than 1500 people inhabit the island and dive tourism constitutes a very small industry there. During a recent research field trip to Christmas Island in January 2004, very few shark sightings were recorded at the time when shark numbers have previously

been consistent (M. Orchard, pers. comm.). The information provided by dive industry representatives on the island indicates that shark sighting numbers have been declining in recent years (M. Cathrein, pers. comm.). Although unlikely the result of tourism pressure attributable to the fledgling whale shark industry there, it raises the question of whether the sharks at this stage in their long distance migrations have been negatively influenced by hunting pressure in parts of Asia.

6.3 Sustainable development in tourism

Whale shark ecotourism is largely dependant on whale sharks returning to a known location, at a predictable time of year, in numbers sufficient to provide ecotourists with a strong chance of seeing individual sharks. As highlighted in Section 2.2, appearance of whale sharks at a particular location may be influenced by several factors, especially environmental conditions. However, human-related activities, including tourism pressure may also affect shark return rate, the behaviour of individual sharks and/or the 'population' as a whole.

Management of the whale sharks and associated industry in Australia must ensure protection for the resource while allowing for sustainable exploitation (Norman, 2001). Within the state waters of NMP in Western Australia, the management agency CALM has been successful in this role, with management of the whale shark industry internationally regarded as an example of 'best practice' ecotourism. Continued monitoring is required to ensure that if required, management actions can be implemented to ensure a viable industry managed for the conservation of the sharks. CALM manage the industry and whale shark resource through the *Wildlife Conservation Act 1950* and the *CALM Act 1984*. An industry 'Code of Conduct' (see Figure 26) was developed in consultation with industry to ensure the industry continues to develop in an ecologically and economically sustainable manner.

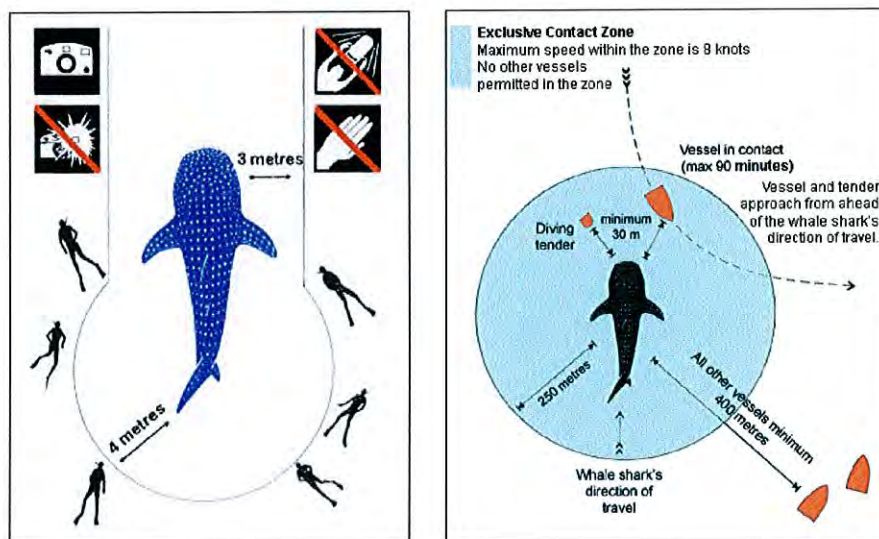


Figure 26: Industry 'Codes of Conduct' for whale shark ecotourism at Ningaloo Marine Park (from: http://www.calm.wa.gov.au/tourism/whalesharks_swimming.html).

Codes of Conduct

Whale sharks are often referred to as '*gentle giants*' (Taylor, 1994; Norman, 1999) although still able to inflict serious injury if they contact a swimmer, especially with their tail. CALM implement the following 'Code of Conduct' at NMP to ensure a safe, enjoyable experience for participants and to prevent the animals from being harmed or adversely disturbed. Both commercial and private vessels must adhere to these rules.

Exclusive Contact Zone

- An exclusive contact zone of a 250 metres radius applies around any whale shark for any single vessel.
- Only one vessel at a time may operate within the zone for a maximum time of 90 minutes and at a speed of 8 knots or less.
- The first vessel within that zone is deemed to be 'in contact'. The second vessel to arrive must keep a distance of 250 metres from the shark, and any other vessels must be 400 metres from the shark.

Vessel Operators in the Contact Zone:

- Must not allow their vessel to approach closer than 30 metres to a shark.
- Should approach from ahead of the shark's direction of travel when allowing swimmers to enter into the water.
- Must display a special commercial *Whale Shark Operator Flag* and a dive flag when swimmers are in the water.

Swimmers in the Contact Zone must not:

- Attempt to touch or ride on a whale shark.
- Restrict the normal movement or behaviour of the shark.
- Approach closer than 3 metres from the head or body and 4 metres from the tail of the whale shark.
- Undertake flash photography.
- Use motorised propulsion aids.
- Exceed more than 10 non-industry people in the water at any one time (an additional industry guide is permitted in the water).
- Remain in the water swimming with a shark for a period exceeding 60 minutes

(from Colman, 1997; www.calm.wa.gov.au/tourism/whalesharks_swimming.html)

The guidelines within this 'Code' have formed the basis of similar management in the Philippines (M. Alava, pers. comm.), and are enforced to reduce the chance that the animals will be negatively affected through human interaction.



Figure 27: Ecotourists and whale shark industry vessel at Ningaloo Marine Park operating to guidelines set out in the CALM 'Codes of Conduct'.

6.3.1 Indicators of whale shark disturbance

In the field of natural resource management, indicators point to an issue or condition, with the purpose to show (or indicate) how a system is working. If there is a problem, an indicator can be used to assist a manager determine which direction to take to address the issue. With this in mind, CALM commissioned a review of whale shark research and applications for sustainable management of the species in 2002. Various aspects of whale shark ecotourism in Western Australia were discussed within this report including impacts, the potential consequences to the sharks and the industry and suggested research priorities (Norman, 2002). Although indices of sustainability for whale shark ecotourism were previously undefined, the review suggested that NMP represented the most suitable location to undertake a dedicated study program to develop and refine appropriate indicators.

6.3.1.1 Short-term consequences

In general, whale sharks move more slowly than the vessels involved in the ecotourism activity (~ 1-2 knots) and so have limited options to avoid interaction when confronted by a vessel (Norman, 1999). The following reactions, when displayed by a shark during a whale shark / ecotour interaction, can indicate that a whale shark has been disturbed:

- An attempt by the shark to leave the area or proximity of a vessel;
- Regular changes in swimming direction and/or speed of a shark;
- Shark rapidly dives away from the surface;
- Banking behaviour (where the shark 'rolls' its body to the side to present only the tough dorsal surface as a defence);
- The eye is rolled within the orbit for protection;
- Increased dive frequency (*i.e.* greater period spent away from the surface).

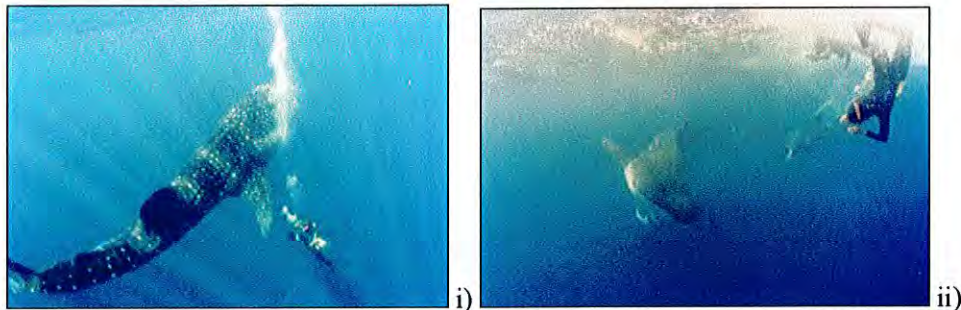


Figure 28: Whale sharks exhibiting a reaction to i) SCUBA bubbles and ii) defensive behaviour to swimmers diving near the sharks head region.

In the short-term, disturbance to whale sharks may result in discomfort to the animal and an attempt by the shark to abort any shark / ecotourist interaction. This would then likely result in a reduced level of satisfaction for ecotourists undertaking whale shark interactions.

6.3.1.2 Long-term consequences

Although any negative long-term consequences of whale shark ecotourism are yet to be fully realised, these may prove significant if not monitored and addressed where necessary. These effects may be minor in isolation, but may become a major problem if built up over an extended period. The following represents potential long term impacts to the whale sharks that may result from human disturbance (Norman, 2002):

- Displacement from important feeding areas;
- Disruption of feeding;
- Disruption of mating, reproductive and other social behaviours;
- Abandonment of preferred breeding sites;
- Changes to regular migratory pathways to avoid human interaction zones;
- Stress;
- Injury;
- Increased mortality.

6.3.2 Research to determine natural behaviour

Although whale sharks can dive to depths below 1000m (see Section 2.2.1), they are only accessible to the ecotourism industry while swimming at or near the surface. The sharks can remain there for extended periods (*i.e.* > 30mins), while at other times these sharks have been known to dive away immediately with the arrival of tour vessels and swimmers in the water (Norman, 1999). At NMP, the mean interaction time (*i.e.* period when ecotourists are swimming at the surface alongside the shark) has fluctuated between 29.9 and 7.0 minutes in recent years (see Figure 29) (Chapman, 2002; Fitzpatrick, 2003). This reduction may indicate that the sharks are becoming less tolerant of ecotourism activity. However, industry logbook data does not distinguish whether the 'end point' to an interaction was the transfer of the shark between operators; the result of the whale shark diving in response to tourism pressure; or if the shark diving away from the surface was simply a natural behaviour of the shark.

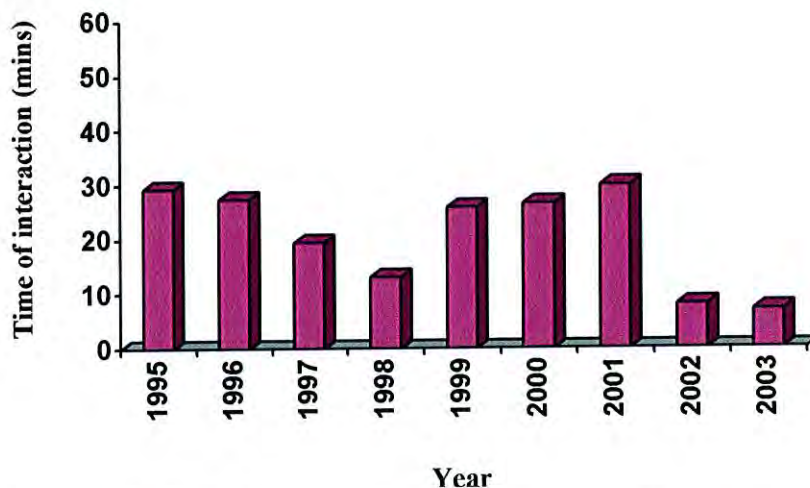


Figure 29: Mean time of ecotourist / whale shark interactions at Ningaloo Marine Park between 1995-2003 (adapted from Chapman, 2002; Fitzpatrick, 2003).

Electronic tagging programs (see Section 2.2.1) have been implemented on several occasions in Australia and can record 'natural' behaviour when ecotourists are not present. Aimed at documenting the short-term natural behaviour in whale sharks, specific studies by Gunn *et al.* (1999) and Norman (1999) have shown that whale sharks do regularly move throughout the water column, swimming at the surface and undertaking dives to the ocean floor in daylight and darkness hours (Figure 30).

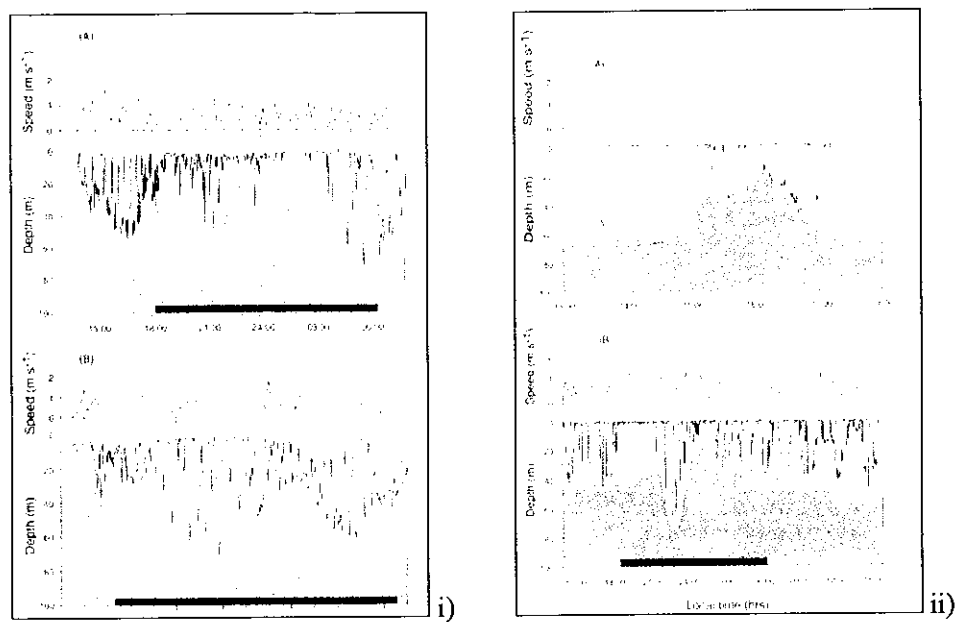


Figure 30: Research undertaken at Ningaloo Marine Park indicates sharks spend considerable periods away from the surface throughout the water column (i = shark tracked over 16hrs in 1997; ii = shark tracked for 12hrs in 1998) [NB. solid grey line represents seabed topography]

In a similar study, staff from CALM Exmouth worked collaboratively with researchers from various institutions (AIMS, CSIRO, NOAA, National Geographic) in 2003 to investigate aspects of the behavior and ecology of whale sharks at NMP. On this occasion, animals were tagged using acoustic tags and tracked for extended periods, ranging from 6 – 20 hours (see Fitzpatrick, 2003). The data collected on swimming depth and location of these sharks at all times throughout the tracking period were important for extending the level of knowledge currently available on whale shark diving behaviour. Researchers are also able to analyse these data further to describe the short-term movements and natural behavior of whale sharks in relation to submarine topography (R. Mau, pers. comm.).

Four pop-up archival tags (PAT) were also deployed at NMP in 2003 as part of this joint study. These tags are able to collect data on shark swimming depth and light intensity (for calculating shark location) over extended periods before timed release (up to 8 months hence). Upon release, the tags transmit summarised data to an overhead satellite that can then be used to document the broad-scale migration of whale sharks (after they leave NMP). One tag detached prematurely in 2003, with data available for the previous 10 day period (Figure 31). These results reinforced earlier studies at NMP (Gunn *et al.*, 1999; Norman, 1999) indicating that whale sharks spend a considerable proportion of their time away from the surface, swimming throughout the water column, possibly in search of higher concentrations of food.

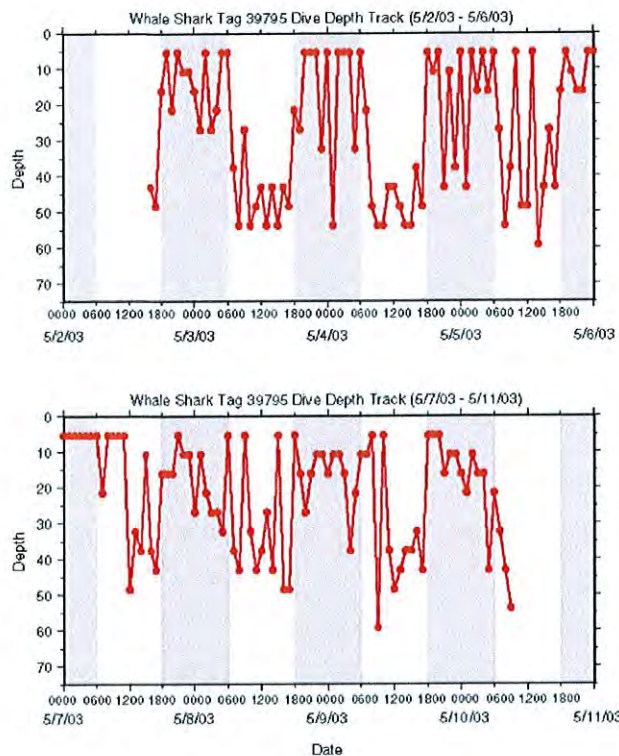


Figure 31: Data on whale shark movements at Ningaloo Marine Park over a 10 hr period in 2003, collected using PAT technology (source: <http://oceanexplorer.noaa.gov/projects/02census/pelagics/pelagics.html>).

In a further attempt to document natural behaviour of these animals, the research team deployed an underwater camera, attached to the dorsal surface of four whale sharks at NMP. Of the four units deployed in 2003, one provided some footage on the behaviour of the shark as it moved throughout the water column, navigating around schools of fish and underwater reef features (R. Mau, pers. comm.).

In another example of successful collaboration between industry, researchers and the management agency, a parallel project (funded through the Natural Heritage Trust), resulted in the deployment of two longer-term archival data-logging tags at NMP in 2003, and a third tag deployed at Christmas Island in 2004. On each occasion, these sharks were photographed for identification purposes during the tagging procedure (with information and photos submitted to the online *ECOCEAN Library*). If/when these sharks are sighted either in Australian waters or at any other international location, licensed management or industry personnel can remove the tags and forward these to scientists at ECOCEAN for further analysis. The data collected will help determine location (from light levels), water temperature and depth (each recorded at one-minute intervals) to provide a very comprehensive outline of the natural habits of this species.

6.3.3 Assessment of impacts and potential responses

In order to assess any impacts to the sharks resulting from ecotourism, the involvement of industry stakeholders must be encouraged. Participants within the industry are able to collect important data throughout each whale shark season while reducing the overall costs attributable to monitoring. Importantly, management for the future conservation of the whale shark (and the sustainability of the associated ecotourism industry) will benefit greatly from continued stakeholder involvement. And, to facilitate the uptake of management responses industry participants are likely to be more supportive if given a sense of stewardship/ownership over the whale shark resource.

In 1995, with the support of CALM, the whale shark industry and Murdoch University a project was initiated at NMP in an attempt to better understand the whale sharks and the effects attributable to the associated ecotourism industry (see Section 6.2.1.2). As a result, an ethology (set of) of whale shark behaviours was produced (see Norman, 1999). Observations recorded within this study indicate the sharks often showed little response to industry activities, whilst on other occasions adverse reactions to ecotourist activity was observed under certain conditions (e.g. when tourists and tour vessels were very close or contacted the shark/s). It will only be through continued monitoring that any obvious long-term effects can be identified.

If the current level of ecotourism pressure is found to be excessive, management may consider a reduction in the total number of days each licence holder is permitted to undertake whale shark tours within the annual 'season' at NMP. Any such response however, would require considerable consultation with industry representatives because of the likely financial repercussions resulting from such an action. In addition, if *critical habitats* for this species can be identified, limited entry/closed areas to protect these habitats may be considered as a management option to ensure the conservation of the species and ensure the future sustainability of the associated ecotourism industry.

At present, there is no clear indication that the industry at NMP is having an adverse effect on the whale shark 'group' that visits NMP each year. Shark sighting numbers have remained relatively high (see Figure 23) although interaction times have declined and require continued monitoring. In addition, the number of whale shark licences and level of utilisation has remained stable over the years since the industry has been in full operation at NMP (see Table 2).

Table 2: *The level of utilisation of whale shark licences over the short whale shark 'season' at Ningaloo Marine Park (1995-2001) (adapted from Chapman, 2002).*

Year	Days in paying season	No. days vessels operated	No. licences issued	Maximum No. tours possible	No. tours conducted	Proportion (tours possible/tours conducted)
1995	61	59	15	915	241	26 %
1996	61	58	14	854	263	31 %
1997	61	55	13	793	270	34 %
1998	61	52	13	793	186	23 %
1999	61	58	13	793	137	17 %
2000	61	57	14	854	255	30 %
2001	61	61	13	793	269	34 %
All Years	427	400	95	5795	1621	28 %

The management agency (CALM) can revoke any licence when reviewed on a five yearly basis. In 2003, CALM revoked the licence of one industry member and called for 'Expressions of Interests' to re-issue this under-utilised licence so that the whale shark ecotourism industry at NMP could operate at maximum capacity (R. Mau, pers. comm.). Any decision to increase or decrease licence numbers must consider the conservation of this threatened species as the first priority.

6.3.4 Socio-economic relevance of ensuring sustainable development

As noted in Section 6.2, whale shark ecotourism can be of significant economic importance to a particular region. Indeed at NMP, where coastal activities are a major source of income to the communities of Coral Bay and Exmouth, it is imperative that industries exploiting natural resources do so in a sustainable manner. This is true for any location where the economy of the region is tightly linked to social well-being.

Management of the commercial whale shark ecotourism industry at NMP has been successful since its inception in the late 1980s / early 1990s. Interest in this activity increased dramatically soon after, with large numbers of international and domestic tourists visiting the isolated region of NMP for the predictable whale shark aggregation in autumn each year. CALM intervened in 1993, introducing regulation and licencing of operators (Fitzpatrick, 2003) to ensure that the whale shark resource and associated ecotourism industry was managed sustainably. The number of commercial whale shark interaction licences granted has fluctuated between 13 and 15 (1995-2003), although not all licences have been utilised at full capacity throughout the short whale shark 'season' (see Table 2; Chapman, 2002; Fitzpatrick, 2003). The peak in ecotourist numbers appears to mimic the peak period of whale shark appearance at NMP (see Figure 24; Norman, 1999; Chapman, 2002). However, the relatively high price of whale shark interaction tours (at ~ AUD \$300/day) combined with the excellent 'strike rate' (~ 86% between 1995-2001), has ensured an economically sound industry to date.

7. Sustainability through a broad collaborative approach

Whale shark ecotourism can play a major role in educating the general public and raising awareness for the current conservation concerns facing this species (Norman, 2001). It also represents a non-consumptive use of what we now know is a threatened natural resource (Norman, 2000).

To ensure the future conservation of this species at both the local and international level, it is imperative that information on all aspects of whale shark biology, ecology and general behaviour (especially in response to human activities) be shared. Australia has the opportunity to further affirm its position at the forefront of whale shark protection and 'best practice' ecotourism management, and continue to assist in the development of global whale shark conservation initiatives. The convening of an international whale shark workshop, previously recommended by Colman (1997) and Norman (2002), will facilitate the sharing of information and lead to the development of an international collaborative approach to the management of this species.

7.1 *Ecotourism as an economic / ecologically sustainable alternative to whale shark hunting*

Whale shark ecotourism has the potential to provide significantly greater economic return than can be gained from whale shark hunting (Norman, 2001). In addition, ecotourism is non-consumptive and ensures whale sharks are available for exploitation in subsequent years, provided appropriate management controls are enforced. However, in the absence of sound data on which to base good management decisions, some level of caution must be applied. This will (hopefully) ensure whale shark feeding and breeding patterns are not disrupted to the point where animals are driven away from habitats, critical to their survival.

7.1.1 *The Philippines Example*

In the Philippines, whale shark ecotourism is actively promoted as a sustainable alternative to whale shark hunting, using similar regulations to those currently employed at NMP (M. Alava, pers. comm.). As mentioned in Section 6.1.1, legislation for the protection of whale sharks was enacted by the Philippines government in 1998 and in one location (Donsol), more than 1700 people took part during the 1998-1999 season alone, with average revenue from tourists registration fees and boat rentals estimated at in excess of US\$8000 per year (Groves, 1999; Alava, 2002). Additional whale shark ecotourism activities have since begun at least four other sites outside Donsol, thereby providing a new source of income for the villagers (M. Alava, pers. comm.).

7.2 *Rufford Foundation project*

The Rufford Foundation is supporting work aimed at promoting good management whale shark ecotourism in Mexico, India and Taiwan. This work is timely given the recent progress with international whale shark protection and conservation, and the concerns aired by many groups (e.g. ecotourism industry participants) in relation to the reduction in whale shark sightings at several locations. The project draws on

information gleaned from whale shark operations throughout the world and encourages sustainable ecotourism practices as an economic and ecological alternative to unsustainable fishing practices.

Taiwan

There has been significant support shown by Taiwanese authorities for improved management of the whale shark resource in this region. The NGO community (including WWF TRAFFIC and WildAid) and the National Taiwan Ocean University have been active in these efforts. A workshop to discuss whale shark management is planned for late-2004. This workshop is particularly relevant because of the potential for whale shark ecotourism in this region. As part of the Rufford Foundation project, advice on the current management successfully employed in Australia for 'best practice' whale shark ecotourism will be provided. In addition, public education materials will be distributed at this time.

India

In 1999, there was a report in a local Indian newspaper that over 1000 whale sharks were killed in a single season (Pravin, 2000). Respected nature documentary filmmaker Mike Pandey, completed a film about the shark slaughter in India. This film, entitled 'Shores of Silence' was awarded the coveted Panda Award – the so called 'green Oscar' at Wildscreen 2000. Soon after, the Indian government implemented legislation banning the hunting of whale sharks.

To ensure the local communities in Indian coastal states have an incentive and the means by which to successfully replace whale shark hunting with sustainable whale shark ecotourism, the author (with support from the Rufford Foundation) will encourage and assist its implementation. The work will enable further explanation of the methodology and management used in Western Australia, where CALM and the industry are known globally to exhibit 'best practice' whale shark ecotourism. Public education is key to ensuring a successful transition from hunting to minimal impact ecotourism.

Mexico

Although whale sharks are not currently subjected to hunting pressure in Mexico, there has been a substantial increase in whale shark ecotourism in several coastal regions, especially at Bahia de los Angeles (see Section 3.3). At Bahia, there have been reports of some local villagers and visitors to the area having negative impacts on the sharks. Many animals exhibit damage from boat propellers and are subject to harassment from over zealous swimmers. There exists little infrastructure to manage the resource in a sustainable manner. With support from the Rufford Foundation, a community workshop was convened in 2003, where information on 'best practice' management guidelines currently used at NMP was discussed, providing the local community with an increased level of understanding on minimal impact ecotourism. This will ultimately facilitate community management of the resource for economic and ecological sustainability.

8. Whale shark protection

The level of protection currently available to the whale shark has increased dramatically in recent years. As this is a low productivity, low resilience species (see Section 4.1), increased protection combined with a better understanding of the conservation concerns facing this species, will (hopefully) stabilise any decline in whale shark abundance.

8.1 National Initiatives

Australia

The whale sharks are identified as both a migratory species and as a threatened species under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act* 1999. As a consequence of this listing, a 'Recovery Plan' must be prepared to set out the management actions necessary to stop the decline and support the recovery of this listed marine species. In Western Australian waters, the whale shark is fully protected under the *Wildlife Conservation Act* 1950 and the *Fish Resources Management Act* 1994. It is also protected under the *Great Barrier Reef Marine Park Act* in those Queensland waters, and under the *Tasmanian Fisheries Regulations* 1996.

Belize

Gladden Spit, on the Belize Barrier Reef is a known feeding ground for whale sharks and was declared a marine reserve in 2000 (*Decree No.68 of 2000*). In addition, although not yet been gazetted, whale shark tour regulations have been drafted and tour guides trained in these regulations (R. Graham, pers. comm.).

Honduras

The whale shark was granted full protection by government decree in 1999 (*Presidential Decree No. 321-900*).

India

In 2001, the whale shark was granted full legal protection in Indian territorial waters by the Indian Ministry of Environment and Forests by adding the species to Schedule I of the *Wildlife (Protection) Act* 1972.

Maldives

Whale sharks have been fully protected in the Maldives since 1995 (*Environment Law* 4/93).

Mexico

There is a whale shark sanctuary under consideration for Bahia de Los Angeles, Gulf of California. Whale sharks were listed in the *NOM-029-PESC-2000*. Which is a Law in Mexico of "Responsible Shark Fishery and alike species". It states that whale shark fishery is prohibited (N. Rodriguez Dowdell, pers. comm.).

Philippines

The whale shark has received full protection under Department of Agriculture *Fishery Administrative Order No. 193*, which prohibited “the taking or catching, selling, purchasing and possession, transporting and exporting of whale sharks and manta rays” since 1998. Some illegal exploitation and export is evident as is difficulty with enforcement.

South Africa

Full legal protection is currently under consideration. Permits are required for ecotourism or scientific interactions with whale sharks from the Department of Marine and Coastal Management.

Taiwan

The *Whale Shark Harvest Reporting System* was implemented by Taiwan’s Fisheries Administration, Council of Agriculture under *Fisheries Law* on 1 July 2002. The system requires fishermen to submit catch data and provides for penalties to be imposed for violation of the provisions of the Law. For 2002/03 and 2003/04, a catch limit was set at 80 whale sharks (Chen & Phipps, 2002). Common Commodity Codes have been assigned for seven whale shark products in order to monitor international trade in the Customs database. Taiwan is now able to apply Article 11 of the *Foreign Trade Law* to regulate imports and exports, as a result of the whale shark listing on CITES Appendix II.

Thailand

This species is protected through a fishery ban under Section 32 (7) of the *Fishing Act* B.E. 2490 on 28 March 2000.

USA

Whale sharks are fully protected in Florida State waters (out to the three mile limit on the east coast, and nine miles on the Gulf coast) and in Atlantic and Gulf of Mexico federal waters (3-200 miles) under the *US Fishery Management Plan*, which prohibits directed commercial fishing and landing or sale.

8.2 International

The Food and Agriculture Organization of the United Nations (FAO) Committee on Fisheries (COFI) is where major international fisheries problems and issues are examined and recommendations made. In February 1999, COFI endorsed the *International Plan of Action for the Conservation and Management of Sharks* (IPOA) (available at www.fao.org) that calls on all member nations to implement this voluntarily. The objective of the IPOA is to ensure the conservation and management of sharks and their long-term sustainable use, although to date few countries have drafted and implemented these plans. In recent years, declining whale shark numbers has encouraged greater attention from the NGO community and the development of international agreements to assist the conservation of this species.

The whale shark is also listed in the *U.N. Fish Stocks Agreement* and the *UN Convention on the Law of the Sea* (UNCLOS) as a highly migratory species requiring

international cooperative management. However, it is through the IUCN, CITES and CMS that improved protection will be further encouraged and implemented on a global scale.

IUCN

As noted in Section 5, according to the IUCN, the global conservation of the whale shark is currently listed as 'Vulnerable to Extinction' (Norman, 2000) having been upgraded from 'Indeterminate – Data Deficient' in 1996. This listing effectively raised the level of awareness globally for the conservation concerns facing this species. It has also resulted in an increased level of interest from non-governmental organisations and government agencies to work collaboratively for the global conservation of this species.

CITES

As a result of CITES Appendix III listing by Australia and subsequent listing on CITES Appendix II by the 12th Conference of Parties in 2002, trade in whale shark products is allowed although strictly monitored (see Section 5). There are more than 150 'parties' (countries) signed up to CITES, and no species protected by CITES has become extinct as a result of trade since the Convention has been in operation.

CMS

Since the successful CMS Appendix II nomination (submitted by the Philippines and ratified in 1999), there has been increased attention for this species on a regional basis, although to date no agreements have been developed. An international whale shark workshop is proposed for the Indian Ocean region in 2004/05 (A. Yaptinchay, pers. comm.) and should provide a forum to establish regional cooperative management to aid the global conservation of this highly migratory species.

An extended program should be implemented as a priority to determine the level (if any) of 'mixing' of whale sharks between the Indian Ocean and Pacific Ocean. Do the shallow waters between Australia and Indonesia / Papua New Guinea serve as a natural barrier, impeding the migration of these large sharks? This will be a major consideration when considering a regional approach for protection of this species.

One of the simplest and most readily accessible tools available to collect information on whale shark movements between countries uses photo-identification. A passive 'mark – recapture' program can be implemented via the international *ECOCEAN Whale Shark Photo identification Library* (see Section 4.3) to also assist population monitoring. Review of this database will assist international management for the conservation of the species.

9. Summary

The whale shark is the largest shark in the ocean; has a global distribution; and travels great distances to appear regularly at certain locations, often corresponding with periods of high food productivity (e.g. coral, fish, copepod spawning/blooms). Although the whale shark is very fecund (producing litters of 300+ individuals),

evidence of pupping was recorded only once from a specimen killed in the Taiwanese fishery, and breeding areas (and breeding season) are presently undefined. The young are small at birth (~0.5m), making this species vulnerable until a substantial size has been attained, hence rapid growth early in life. These animals mature late, with males not reaching sexual maturity until ~8.6m, although in females this may be considerably earlier.

Fishing pressure on this species increased around the mid- 1990s, with up to 1000 sharks killed in one Indian whale shark fishery in a single season. Fearing that this level of exploitation was unsustainable, protection in various range states has been implemented and international protection via CMS, IUCN and CITES is now in place. Despite this, hunting of this species (legal and illegal) still continues and further work must be undertaken to ensure the future conservation of this species.

Studies aimed at documenting whale shark migratory habits have been implemented at various locations around the world. However, success has been limited due in part to the difficulties of working with this rare species in the open ocean environment. Total numbers of this species in the wild are at present unknown, although photo-identification and mark/recapture studies will assist in establishing an estimation of population size. Future research on the whale sharks will only benefit through collaboration between the many international groups currently working on this species.

Whale shark ecotourism is a developing industry that can be both economically and environmentally sustainable (as evidenced in Australia at Ningaloo Marine Park). It has been introduced at several locations throughout the sharks' range and, providing it is well managed, can benefit the conservation of this species. This can be achieved via awareness raising and through promotion of whale shark ecotourism as a non-consumptive alternative to unsustainable whale shark hunting. Importantly, this must be undertaken using similar management guidelines to those developed at NMP where the industry is regarded internationally as an example of 'best practice' whale shark ecotourism.

There are significant gaps in knowledge about this species, and the ecological interactions that may effect their survival. Research to improve our understanding of this species and associated habitats should be undertaken as a priority. In its absence, the precautionary approach for sustainable management must be invoked. It will also be important to continue monitoring whale shark appearance and behaviour at a number of key study sites (including NMP and Christmas Island). Subsequent analysis will enable a robust assessment of impacts resulting from whale shark ecotourism activities and ensure that any management responses are based on sound evidence.

10. Recommendations

In recent times, the whale shark has become an 'icon' species. Increased media attention has been focussed on these sharks in recent years as a result of developing ecotourism industries and declining numbers in the wild. Many television documentaries have resulted in a raised level of community awareness for the

conservation concerns faced by this species. Combined with the desire of ecotourists and communities in general to work for the long-term sustainability of our natural environment, it has enabled a successful community-based whale shark monitoring program to develop using the ECOCEAN *Whale Shark Photo-identification Library* © (www.ecocean.org). Continued development of this global database of whale shark sightings must continue and be used in conjunction with other monitoring programs (e.g. research, management etc.). Further review of data collected will enable a greater understanding of the habits and distribution of individual sharks to assist local and international conservation management.

National and locally driven public awareness campaigns to highlight the conservation concerns faced by this species must continue. All stakeholders involved with the whale shark research, ecotourism and management play a pivotal role in community education and this must continue.

10.1 Priorities for whale shark conservation

International collaboration and data sharing must remain a high priority. To facilitate this, several governmental and non-governmental bodies have indicated support for an international workshop to progress global whale shark conservation (e.g. CMS, ECOCEAN, CALM, DEH, ecotourism industry etc.). Sharing of knowledge and management objectives will only improve the success of any international initiatives to sustainably manage this threatened species.

Basic aspects of whale shark biology and ecology require further research. In particular:

1. *Baseline information on the biological and ecological factors of critical importance (e.g. mating and nursery grounds; generation time; age at maturity etc.).*
2. *Studies to accurately map the global distribution and migratory patterns of whale sharks (e.g. tagging/genetic studies), especially to locate and identify critical habitats e.g. breeding locations etc.*
3. *Study to find carrying capacity of whale shark ecotourism operations*
 - a. *using Ningaloo as a test case, it will be important to initiate a study at another location where there has (to date) been little tourism pressure (e.g. Christmas Island).*
4. *Study to further understand impacts from ecotourism and then test actions / management alterations that will ensure minimisation of any impacts resulting from ecotourism pressure.*
5. *Expansion of the global photo-identification library database (see www.ecocean.org) and work to ensure greater utilisation*
 - a. *to document movements / home range and understand better habits of individuals and species as a whole;*
 - b. *tag / recapture to enable a more accurate assessment of population status of this species and assist with the global conservation initiatives.*

6. *Establish an International Forum to share management skills and information that will minimise pressure on this species in various regions. This level of collaboration will also facilitate the establishment and implementation of international agreements (e.g. CMS) to further efforts aimed at ensuring the global conservation of this species.*
7. *On a domestic scale, the Commonwealth Department of Environment and Heritage must, as a requirement of this species being listed under the Environment Protection and Biodiversity Conservation Act 1999, must develop a Whale Shark Recovery Plan that will ensure appropriate management of this species within Australian waters.*

11. References

- Alava, M.N.R. 2002. Conservation and management of whale shark in the Philippines. Paper presented during Shark Conference 2002: Sustainable Utilization and Conservation of Sharks. WildAid-National Taiwan Ocean University. May 13-16, 2002. Taipei, Taiwan. (Abstract).
- Alava, M.N.R., and R. Kirit, R. 1994. Larger marine vertebrates (cetaceans, sea turtles and whale sharks) in Sogod Bay, southern Leyte. Resource and Ecological Assessment (REA) of Sogod Bay (Fisheries Component). 1993–1994.
- Alava, M.N.R., E.G.Himoya, R. Merto and M.L.J. Dolar. 1993. Resource utilisation of marine mammals in communities along Tanon Strait (central Visayas) and in Camiguin I. (Mindanao), Philippines. Terminal report submitted to the Haribon Foundation.
- Alava, M.N.R., A.A.Yaptinchay, G. Acogido, M.L.J. Dolar, C.J. Wood and S. Leatherwood. 1997. Fishery and trade of whale shark (*Rhincodon typus*) in the Philippines. Paper presented during the 13th American Elasmobranch Society (AES) Annual Meeting, Seattle, WA, USA.
- Anderson, R.C., and H. Ahmed. 1993. *Shark fisheries of the Maldives*. Ministry of Fisheries and Agriculture, Maldives, and FAO, Rome. 73 pp.
- Anon 2002. Proposal to include the Whale Shark (*Rhincodon typus*) on Appendix II of the Convention on International Trade in Endangered Species (CITES). Philippines and India, to the 12th Conference of Parties to CITES, Chile, November 2002. (www.cites.org)
- Bass, A.J., J.D. D'Aubrey and N. Kistnassmy. 1975. *Sharks of the east coast of southern Africa. IV. The families Odontaspidae, Scapanorhynchidae, Isuridae, Cetorhinidae, Alopiidae, Orectolobidae and Rhinodontidae*. Investigation Report No. 39, Oceanographic Research Institute, Durban.
- Budker, P. 1971. The life of sharks. Columbia Univ. Press, New York.
- Camhi, M., S. Fowler, J. Musick, A. Brautigam and S. Fordham. 1998. *Sharks and their relatives*. Occasional paper of the IUCN Species Survival Commission No. 20. IUCN, Gland, Switzerland.
- Chapman, T.F. 2001. The whale shark tourism industry in Ningaloo Marine Park: summary of the 2001 paying season. Occasional Report for the Western Australian Department of Conservation and Land Management, Exmouth, Australia 23pp.
- Chapman, T.F. 2002. Whale shark log sheet data 1995-2001. Occasional Report for the Western Australian Department of Conservation and Land Management, Exmouth, Australia 25pp.
- Chen, C.T., Liu, K.M., Joung, S.J. and Phipps, M.J. 1996. *Shark Fisheries and Trade in Taiwan*. TRAFFIC East Asia, Taipei, Taiwan
- Chen, C.T., Liu, K.M., and Joung, S.J. 1997. *Preliminary report on Taiwan's Whale Shark Fishery* TRAFFIC Bulletin 17 (1): 53-57.
- Chen V.Y. 2002. Whale shark utilisation and management in Taiwan. Paper presented *Shark Conference 2002* 'Sustainable Utilisation and Conservation of Sharks'. WILDAid National.
- Chen, V.Y and Phipps, M.J. 2002. Management and Trade of Whale Sharks in Taiwan. TRAFFIC East Asia-Taipei.

- Chen, C.T., Liu, K.W., and Joung, S.J. 2002. Preliminary report on Taiwan's whale shark fishery. In: Fowler, S.L., Reed, T.M. and Dipper, F.A. (eds). (2002). *Elasmobranch Biodiversity, Conservation and Management: Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997*. IUCN SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. xv + 258 pp.
- Colman, J. 1997. Whale shark interaction management with particular reference to Ningaloo Marine Park. Marine Conservation Branch. Dept. of Conservation and Land Management, Western Australia: pp. 63.
- Compagno, L.J.V. 1984. *FAO species catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species known to date*. FAO Fish Synopsis 125, Vol. 4, Pt. 1, Hexanchiformes to Lamniformes. Rome, Italy.
- Department of Conservation and Land Management (Western Australia) 1993. A Nature Based Tourism Strategy. Public Report. Department of Conservation and Land Management
- Eckert, S.A. and B.S. Stewart. 2001. Telemetry and satellite tracking of whale sharks, *Rhincodon typus*, in the Sea of Cortez, Mexico, and the north Pacific Ocean. *Environmental Biology of Fishes* 60: 299-308.
- Fitzpatrick, B. 2003. Ningaloo Marine Park Whale Sharks Season 2003. Occasional Report for the Western Australian Department of Conservation and Land Management, Exmouth, Australia 42pp.
- Fowler, S.L. 2000. Whale Shark *Rhincodon typus*: Policy and research scoping document. Report to WWF, WildAid and the Shark Trust from the Nature Conservation Bureau.
<http://www.naturebureau.co.uk/whaleshark>
- Groves, N. 1999. Whale shark interaction data 1998 & 1999. In: WWF-Philippines' Southern Luzon whale shark and other elasmobranch research and monitoring project: progress report (February-July 1999).
- Gunn, J.S., J.D. Stevens, T.L.O. Davis and B.M. Norman. 1999. Observations on the short-term movements and behaviour of whale sharks (*Rhincodon typus*) at Ningaloo Reef, Western Australia. *Mar. Biol.* 135: 553-559.
- Hanfee, F. 1997. *Trade in sharks and its products in India*. TRAFFIC India report, New Delhi: pp. 50.
- Hanfee, F. 2001. Trade in Whale shark and its products in the coastal state of Gujarat, India. Report to the Rufford Foundation from TRAFFIC India.
- Heyman, W., R. Graham, B. Kjerfve and R.E. Johannes. 2001. Whale sharks *Rhincodon typus* aggregate to feed on fish spawn in Belize. *Marine Ecology Progress Series* 215: 275-282.
- Joung, S.J., C.T. Chen, C. Eugenie, S. Uchida and W.Y.P. Huang. 1996. The whale shark *Rhincodon typus* is a livebearer: 300 embryos found in one 'megamamma' supreme. *Environmental Biology of Fishes* 46: 219-223.
- Kukuyev, E.I. 1996. The new finds in recently born individuals of the whale shark *Rhincodon typus* (Rhiniodontidae) in the Atlantic Ocean. *Journal of Ichthyology* 36, 203-205.
- Last, P.R. and J.D. Stevens. 1994. *Sharks and Rays of Australia*. CSIRO, Hobart, 513 pp.
- Lettink, M. and Armstrong, D.P. 2003. An introduction to using mark-recapture analysis for monitoring threatened species. New Zealand Department of Conservation *Technical Series* 284 33pp.

- Leu, M.Y., Chang, W.B. and Fang, L.S. 1997. The success of keeping a baby whale shark from its fetal stage in Taiwan. In: *Proceedings of the Fourth International Aquarium Congress Tokyo*, pp.109-111. Tokyo: Congress Central Office of IAC '96.
- Lien, J. 1999. An examination of the captive maintenance of marine mammals in Canada. Report to the Minister of Fisheries and Oceans 31 March 1999. Ottawa, Ontario, Canada. 167pp.
- Moss, S.A. 1977. Feeding mechanisms in sharks. *American Zoologist* 17, 355-364.
- Newman, H.E., J.G. Colman and A.J. Medcraft. 2002. Whale shark tagging and ecotourism. In: Fowler, S.L., Reed, T.M. and Dipper, F.A. (eds). (2002). *Elasmobranch Biodiversity, Conservation and Management: Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997*. IUCN SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. xv + 258 pp.
- Norman, B.M. 1999. Aspects of the biology and ecotourism industry of the whale shark *Rhincodon typus* in north-western Australia. MPhil. Thesis (Murdoch University, Western Australia)
- Norman, B.M. 2000. In: *2000 IUCN Red List of Threatened Species*. IUCN, Gland, Switzerland and Cambridge, UK. xviii+61 pp. (Book & CD) also on <http://www.redlist.org/>
- Norman, B.M. 2001. Whale shark ecotourism = whale shark conservation. Paper presented during World Tourism Convention 2001: Sustainable Wildlife Tourism Convention. Oct 28-30, 2001. Hobart, Tasmania (<http://www.worldtourismconvention.com/program/summary.html#sustain>).
- Norman, B.M. 2002. *Review of current and historical research on the ecology of whale shark (Rhincodon typus), and applications to conservation through management of the species*. Unpublished report for the Department of Conservation and Land Management, Australia.
- O'Sullivan, J.B. and T. Mitchell. 2000. A fatal attack on a whale shark *Rhincodon typus*, by killer whales *Orcinus orca* off Bahia de Los Angeles, Baja California. Abstract: American Elasmobranch Society Whale Shark Symposium, June 2000. La Paz, Mexico.
- Pai, M.V., Nandakumar, G. & Telang, K.Y. 1983. On a whale shark, *Rhincodon typus* Smith landed off Karwar, Karnataka. *Indian Journal of Fisheries* 30, 157-160.
- Parry-Jones, R. 1996. TRAFFIC report on shark fisheries and trade in the People's Republic of China. In: Phipps, M.J. 1996. TRAFFIC Report on shark fisheries and trade in the East Asian Region. The World Trade in Sharks: a compendium of TRAFFIC's Regional Studies. Volume 1. TRAFFIC Network.
- Rao, G.S. 1986. Note on the occurrence of the whale shark off Veraval coast. *Marine Fisheries Information Service, T&E series* No.66. CMFRI, Cochin: pp30.
- Silas, E.G. 1986. The whale shark (*Rhincodon typus* Smith) in Indian coastal waters: is the species endangered or vulnerable? *Marine Fisheries Information Service, Technical and Extension Series* 66: 1-19. CMFRI, Cochin.
- Stead, D.G. 1963. *Sharks and Rays of Australian Seas*. Angus and Robertson, Sydney 278pp.
- Taylor, G. 1994. *Whale Sharks*. Angus & Robertson Publishers, Sydney, Australia.
- Thompson, W.L., White, G.C. and Gowan, C. 1998. *Monitoring vertebrate populations*. Academic Press, Inc., San Diego.
- Tubb, J.A. 1948. Whale sharks and devil rays in North Borneo. *Copeia* 3, 222.

- Uchida, S., Toda, M., Kamei, Y., and Teruya, H. 2000. The husbandry of 16 whale sharks *Rhincodon typus* from 1980 to 1998 at the Okinawa Expo Aquarium. Abstract. American Elasmobranch Society Whale Shark Symposium, La Paz, Mexico, June 15 2000.
- Vivekanandan and Zala. 1994. Whale shark fishery off Veraval. *Indian Journal of Fisheries* 41(1):37-40.
- Wilson, S.G., Taylor, J.G. and Pearce, A.F. 2001. The seasonal aggregation of whale sharks at Ningaloo Reef, Western Australia: currents, migrations and El Nino / Southern Oscillation. *Environmental Biology of Fishes* 61:1-11.
- Wintner, S.P. 2000. Preliminary study of vertebral growth rings in the whale shark, *Rhincodon typus*, from the east coast of South Africa. *Environmental Biology of Fishes* 59: 441-451.
- Wolfson, F.H. 1983. Records of seven juveniles of the whale shark, *Rhincodon typus*. *Journal of Fish Biology* 22: 647-655.
- Wolfson, F.H. 1986. Occurrences of the whale shark, *Rhincodon typus*, Smith. *Indo-Pacific Fish Biology: Proceedings of the Second International Conference on Indo-Pacific Fishes*. Pp. 208-226 (eds Uyeno, T., Arai, R., Taniuchi, T. & Matsuura, K.) Ichthyological Society of Japan, Tokyo.
- Yapinchay, A.A.S.P., R. Uy, and M.N.R. Alava. 1998. Catch and effort data of whale sharks in the Philippines. Paper presented during the 14th American Elasmobranch Society Annual Meeting, Guelph, Ontario, Canada. (Abstract).
- Yapinchay, A. A., M.N.R. Alava. 2000. Philippines community-based whale shark conservation and ecotourism development. Paper presented during the 16th American Elasmobranch Society Annual Meeting, La Paz, B.C.S., México. (Abstract).

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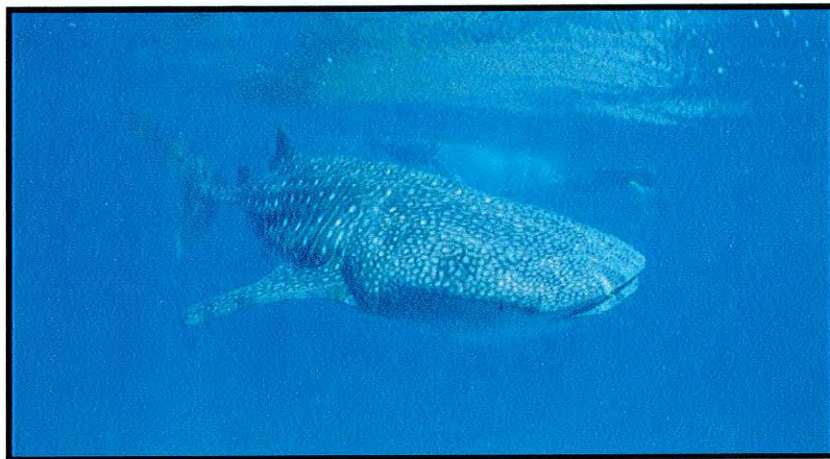
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12. Appendix 1

CITES Identification Manual

Whale Shark

(Rhincodon typus Smith 1829)



by

Brad Norman
ECOCEAN

For

Environment Australia
Marine Species Section

May 2002

CITES Identification Manual for the Whale Shark

***Rhincodon typus* (Smith, 1829)**

Taxonomy

<i>Class</i>	Elasmobranchii
<i>Order</i>	Orectolobiformes
<i>Family</i>	Rhincodontidae
<i>Species</i>	Rhincodon typus

Scientific Synonyms

Rhiniodon typus Smith, 1828

Common Names

English	whale shark
Indian	Panai meen, Uravi, Pullian surrow, Pulli-udoombu, Makara sravu, Osman shira, Karaj, Bharait, Bahiri, Vori mas meer, Barrel
Pakistan	Mhor
Sri Lanka	Muni-muthu-mora
Philippines	Butanding, balilan, toki, tawiki, tuki-tuki
China	Jing Sha, tofu shark
Japan	Ebisuzame
France	Requin-baleine
Spain	Tiburon ballena, pez dama
Taiwan	Tofusa, tofu shark

Conservation status

The whale shark is protected in the waters of very few of the approximately 100 countries where this species is known to visit. While protected in Honduran and some US waters, the Maldives brought in legislation to protect whale sharks in 1995 and the Philippine government banned the hunting of whale sharks in 1998. India followed in mid-2001. However, some illegal hunting still continues.

At several other locations, unregulated fishing for whale sharks is apparent. The effort is expanding, with the number of whale sharks caught (relative to effort) appearing to decline. In Western Australian waters, the whale shark is fully protected under the *Wildlife Conservation Act 1996* and the *Fish Resources Management Act 1994*. The whale sharks are identified as both a migratory species and recently a threatened species on the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*.

The whale shark is listed on the Bonn Convention for the Conservation of Migratory Species (CMS). This identifies the whale shark as a species whose conservation status would benefit from the implementation of international cooperative agreements.

Distribution

Whale sharks have a broad distribution in tropical and warm temperate seas, usually between latitudes 30°N and 35°S. They are known to inhabit both deep and shallow coastal waters and the lagoons of coral atolls and reefs. Australia is one of the most reliable locations to find whale sharks, with large numbers sighted each year at Ningaloo Marine Park (NMP) in Western Australia. Regular sightings have also been recorded from many other regions including India, the Maldives, Taiwan, Seychelles, Honduras, South Africa, Kenya, Belize, Mexico, the Galapagos Islands, Chile, Thailand, the Philippines, northern Borneo, Malaysia, Mauritius and Indonesia.

This species is thought to prefer surface sea-water temperatures between 21 - 25°C. Sightings at NMP, however, are most common in water temperatures around 27°C. The sharks (regularly) appear at locations where seasonal food 'pulses' are known to occur. The predictable annual whale shark aggregation at NMP is closely linked with an increase in productivity of the region, associated with a mass coral spawn which occurs around March/April each year.

Characteristics

WHOLE SPECIMENS:

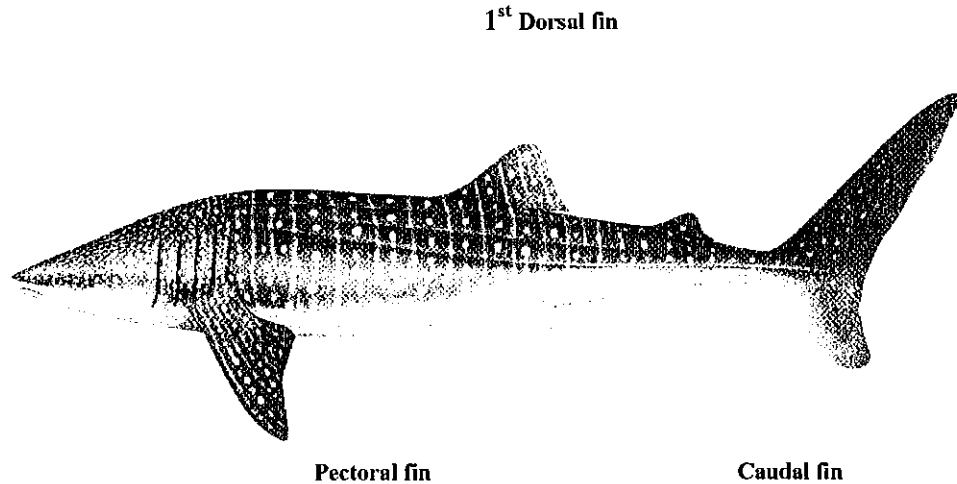
Whale sharks have a moderately stout, fusiform body, with three prominent longitudinal ridges on its upper flanks extending from near the gill region to the caudal peduncle. The head is broad and dorso-ventrally flattened, with a large and nearly terminal transverse mouth. The nostrils have a rudimentary barbell.

The colour of whale sharks has been reported as ranging from blue-grey to grey-brown, with a 'checkerboard' pattern of lines and spots on the dorsal and lateral surfaces. The ventral surface of these sharks typically has a light white colouration.

The size at birth of whale sharks is between 58 – 64 cm. The whale shark is the most fecund of any shark, with

the only pregnant female ever recorded with a litter size in excess of 300 individuals.

Size at maturity for whale shark is suggested at between 8 – 9 m for males and around 9 m for females.



TRADED PRODUCTS: Traded products derived from whale sharks include fins, livers (liver oil), jaws, meat (fresh, frozen or salted for human consumption), stomach and intestines (for food), cartilage (used in health supplements), and skin (for leather products). While processed meat, oil and cartilage are almost impossible to identify without undertaking DNA testing in the laboratory, individual jaws, fins and fin sets can be identified more easily, especially where traded intact or only partly processed.

FINS: Shark fins are among the world's most expensive fishery products. They are processed to yield shark fin needles, a tasteless gelatinous product used, with other ingredients, to prepare shark fin soup, particularly in the Asian markets. Almost every species of shark have commercially valuable fins. However, the value of these is dependant on factors such as colour, size, thickness and fin needle content.

Shark fins are often graded individually according to size and colour (because of the difficulty involved to identify fins to species when imported dried). However, larger fins are worth more than smaller fins, and 'white' fins are generally worth more than 'black' fins because they have a higher needle content. Grading systems differ considerably between countries, and may also

take into account water content, rehydration capacity, number and length of needles, degree of whiteness, presence of blemishes and the general quality of initial processing. Whale and basking shark fins tend to demand high prices in the marketplace because of their relatively large size.

Fins usually enter international trade for the first time intact (dried or frozen) with the skin on, or semi-prepared (with the skin, cartilaginous base plate and remaining meat removed but the fibres intact). Fin shape is unaltered by removal of the skin and base plate. Further preparation of fins may include the removal of the hard cartilage of the dorsal fins and the cartilaginous platelets between the two layers of fin needles before drying.

Fins are then processed to produce fin needles or fin nets. This is carried out by soaking and boiling to remove the gelatinous fin ray membrane and expand and expose the fin needles (which occur as a bundle in the centre of the fin). Fin needles may be further processed to sun-dried fin nets.

Although there has been limited research undertaken on whale shark fins, it appears that the skeletal structure of the pectoral fins is characteristic. However, radiography is required to examine the fin cartilage in intact fins.

With the exception of the anal and pelvic fins (which are small), the fins of whale sharks are large. The 1st dorsal and tail (caudal) fins reach to over one and a half (1.5) metres in height in mature adults. They are generally grey to grey-black in colour, with few white spots distributed randomly. Pectoral fins are generally a dark grey colour on the dorsal surface (again with spots although more concentrated at the leading edge) and are essentially white on the ventral surface. The anal and pelvic fins are essentially white in colour, although the latter has some evidence of white spots on a pale grey background.

The first dorsal fin becomes more triangular as the shark becomes larger, and is approximately triangular when the species reaches maturity (around 8m in males). The caudal fin is semi-lunate, with the upper lobe considerably larger than the lower lobe. The upper lobe has a small sub-terminal notch on the trailing edge near the top of the fin.

The dorsal fin on its own is easy to recognise as a whale shark, despite the size / maturity of the specimen, because of the white spots present. However, the 2nd dorsal fin sometimes lacks these spots in juveniles and would be more difficult to identify as that of a whale shark unless found in conjunction with the caudal, pectoral fin or 1st dorsal fin.

SHARK FIN SETS:

A fin set which has the above features of: 1) a triangular dorsal fin grey to grey-black in colour (with few white spots); 2) a caudal fin that is grey to grey-black (with white spots); and is semi-lunate in shape with a sub-terminal notch; and 3) has pectoral fins that are falcate, dark grey colour on the dorsal surface (with concentrated white spots) and white on the ventral surface – can be confidently identified as being from a whale shark.

Photographs and x-rays of fins are attached to aid in identification.

TEETH AND JAWS:

The most distinctive feature of jaws of the species is their size (up to 1.5 m diameter). The transverse mouth is enormous and houses up to 3000 teeth, aligned in 300 rows which are covered by a velum of skin and not used in the feeding process. The teeth are small (less than 6mm in length), with a singular hooked cusp.

TRADE:

Most of the world trade in shark fins involves imports, exports and re-exports between China, Hong Kong, Taiwan and Singapore. Hong Kong Customs data record shark fin imports from 125 countries and re-exports to 75 countries during the period 1980-1995 (Rose 1996). Many of the fins entering Hong Kong are processed in China before being re-exported in processed form via Hong Kong. There was extensive trade in whale shark fins exported from India and the Philippines to a lesser extent, although this has been reduced significantly since whale shark hunting was banned in both countries recently.

Photograph of whale shark 1st dorsal fin



Photograph of whale shark caudal fin



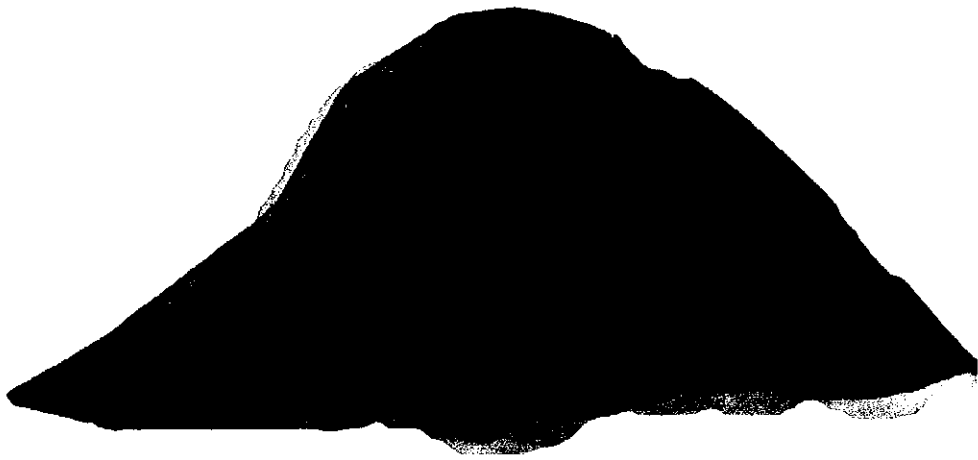
Photograph of caudal fin – base



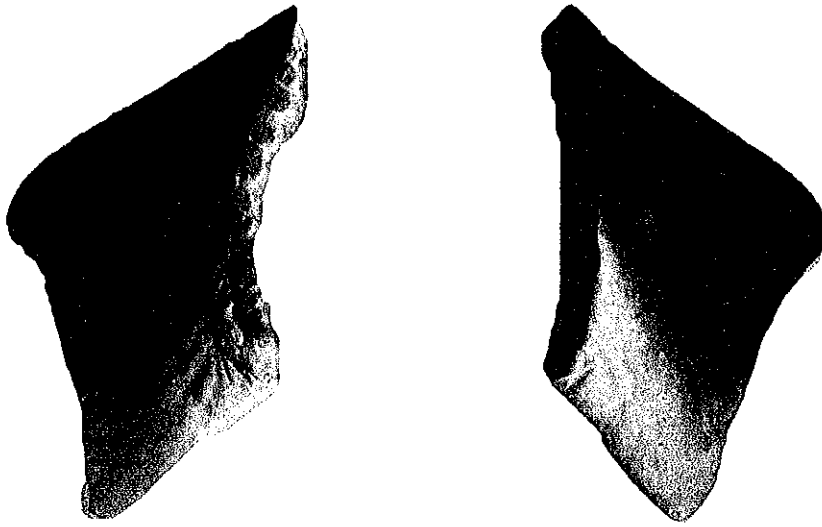
Photograph of whale shark left pectoral fin



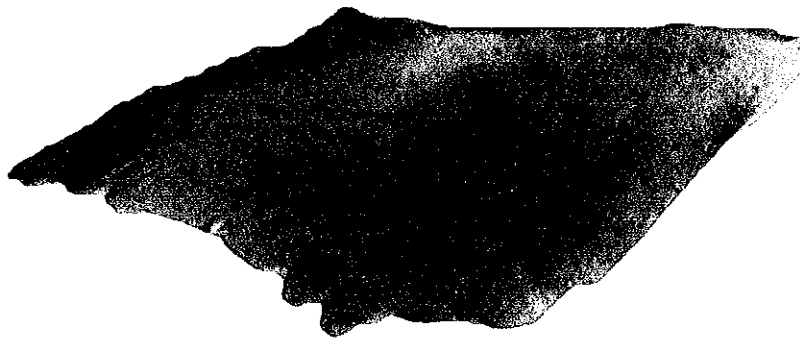
Photograph of whale shark 2nd dorsal fin



Photograph of whale shark pelvic fins



Photograph of whale shark anal fin



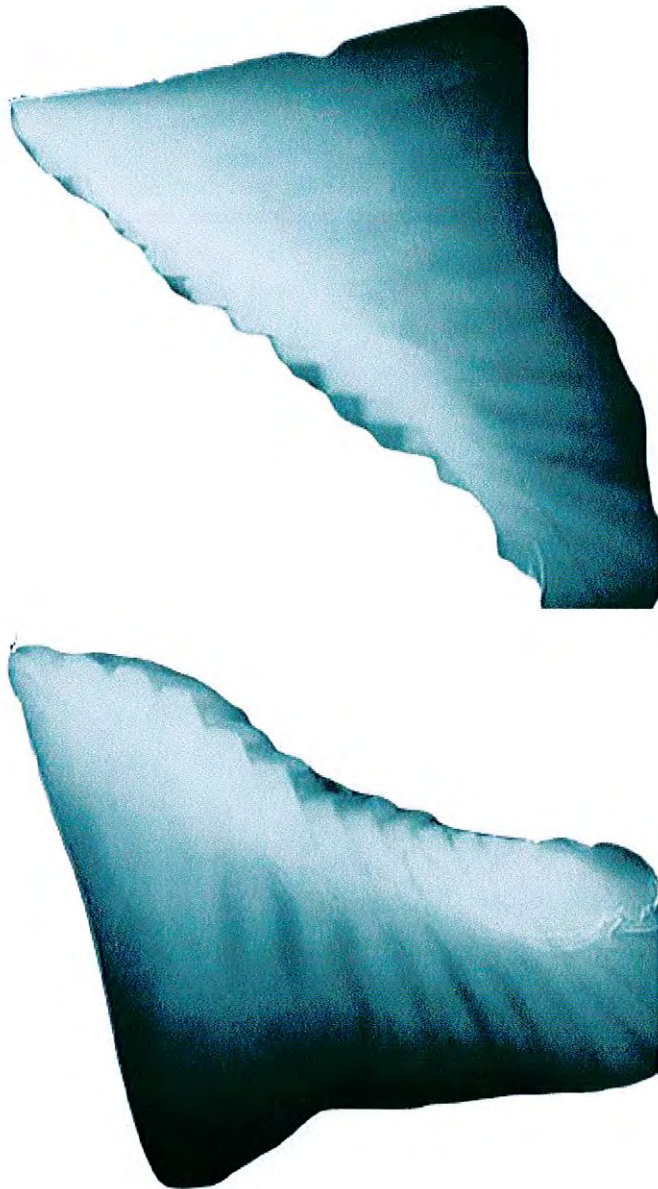
Dorsal fin x-ray image



Pectoral fin x-ray image



Pelvic fin x-ray images



Please note:

Due to the cartilaginous nature of shark fins, the small size and relative immaturity of the shark specimen (<4m TL) used to construct this 'Manual', it is apparent that the x-rays of the fin established a very low level of calcification in the fin rays. As a result, a lower than ideal level of fin ray identification was possible.

However, given the large size of the majority of whale sharks captured and utilised for trade, it will be possible to identify most fins (as originating from a whale shark) through the presence of a unique patterning and colouration on the dorsal and lateral surface of the fins. To increase the chance of a positive identification of products traded from this species, it would be advisable to prepare a simple 'protein fingerprinting' kit. This should then be made available to Customs officials to assist with the accurate determination of the species of shark from which the traded fins originated.