The whale shark: Is the species endangered or vulnerable?

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Introduction

Notable contributions summarising our knowledge of the known habits of the whale shark in general, and its occurrence in Indian coastal waters have been made by Gudger (1935), Chevey (1936) and Prater (1941). The monumental work "The Fishes of the Western North Atlantic" by Bigelow and Schroeder (1948) lists several references to *Rhiniodon typus* Smith from various parts of the world, but there are some omissions from Indian coastal waters. Subsequent records and observattions on whale sharks from Indian coastal waters and other parts of the world have added to our knowledge of this leviathan of the open seas. In the light of these, a re-appraisal seems necessary. Herein, are also added a number of records of the whale shark from Indian coastal waters, while attention is drawn to the gaps in our knowledge of the natural history of this shark so that those interested could make constructive observations as and when opportunities arise.

Silas and Rajagopalan (1963) reviewed the position regarding captures of whale shark in Indian waters.

More records of whale sharks from Indian coastal waters

1. During the first week of July, 1960, a whake shark of sizeable proportions was caught in a fishing net, a few miles to the east of Tondi in the Palk Bay. The fish was towed to Thangachimadam on Rameswaram Island where it was cut up and readily sold to be cured and later exported to Sri Lanka, as its flesh is not favoured much locally. Information about the capture was received too late and hence no photographs or measurements are available except the following data. The fish weighed, excluding a part of the cartilaginous skeletal parts and viscera, about 84 maunds (3,123. 7 kg), the weight of the liver alone being 2½ maunds (93.0 kg). The flesh was sold at Rs. 12/- per maund. Besides this information it was possible to collect a few vertebrae of this fish; 14 of which in the dried condition measured 82.5 cm, the average length of each vertebra being 65 mm and the average diameter 84 mm. The vertebral centra are asterospondylous, the outer cartilaginous layer being traversed by four characteristic, outwardly radiating hardened (clacified) areas, the lateral areas being slightly wider than the dorsal and ventral ones as noted by White (1930). Between these four, but extending only very slightly from the cone are four irregular calcified ridges (intercalated calcifications) which are poorly developed in these vertebrae, probably on account of the smaller size of the animal. The centra also show a number of concentric rings of white fibrous tissue, progressively narrower towards the periphery of the centra and whether these rings could help in age determination is not known. There was hardly any way of knowing the exact length of the shark except hearsay which placed it round about six metres.

Although a rarity, the fishermen are familiar with the whale shark which in Tamil is locally known as 'Panai meen'. They recognise it as one of the sharks and their characterisation of it as of large size combined with the broad head, large transverse slit-like terminal mouth, and the slaty grey colour of the dorsal side with numerous large circular white markings and the structure of the vertebrae recovered are but definite clues to its correct identity.

2. Mr. K. Virabhadra Rao, formerly of the CMFRI, kindly informed me of the capture of a 25'3" (7.72 metres) whale shark on 16th May, 1958 at Irumeni on the Palk Bay coast, a few miles from the Central Marine Fisheries Regional Research Centre,

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Mandapam Camp. Reports of this capture appeared in the newspapers at that time. Additional details for the shark are as follows: girth of fish: 13′6″ (4.11 m); sex: female; weight: about 5.5 tonnes.

3. I am also informed by my colleague, Mr. S. Mahadevan about another landing of a whale shark, 28′ (8.5 metres) long, at Periathalai, near Idinthakarai in the Gulf of Mannar on 26th March, 1958. It was four days before the authorities could visit the spot and by that time the animal had become badly decomposed, but parts of the skeleton appeared to have been saved.

The fishermen call the whale shark 'Uravi' (Tamil) at Tuticorin and Idinthakarai, while further south at Cape Comorin it is known as 'Pullian surraw' (Tamil), while the name 'Panai meen' by which it is known at Palk Bay is applied by the Cape fishermen to the baleen whale.

4. On 10th December, 1960 while visiting Pozhikara, a fishing village between Cape Comorin and Colachel on the west coast, I was informed by Mr. A.C. Roche, a local inhabitant, of the capture of a whale shark in a drift net off Pozhikara during the first week of January, 1960. The fishermen who made the catch were there at the time and they had no difficulty in identifying their fish with that of a drawing *Rhiniodon*, from amongst several drawings of cetaceans, sharks and other fishes. The whale shark was said to measure 18 feet (5.48 metres) and the liver of the animal was sold for Rs. 20/-. Since the meat was whitish and very soft, it was considered unpalatable and the carcass was towed back and dumped far into the sea.

Known occurrence of the whale shark in Indian coastal waters

There are two additional records of whale sharks rammed by steamers over deep waters off Sri Lanka but not included in the Table. The last two records are: (1) one specimen rammed by the Dutch ship *Johan van Oldenbarnvelt* on 23rd November, 1932 about 150 miles west of Colombo and reported by Gudger (1940), the estimated length of the shark being 7.62 metres, and (2) one specimen rammed by the Japanese ship *S.S. Katori Maru* on 10th July, 1933 about 300 miles off Colombo and reported by Deraniyagala (1936), the estimated length of the shark being about 12.19 metres.

Season of occurrence

The months of occurrence of 91 captures out of a total of 98 reported herein is known (Table 1). Of these, four are from Pakistan, 63 from the west coast of India and the Gulf of Mannar, 10 from the east coast of India and eight and six respectively from the west and east coasts of Sri Lanka.

Table 1 The month-wise occurrence of whale sharks reported so far

Month	Pakistan	West coast India & Gulf of Mannar	East coast India	West coast Sri Lanka	East coast Sri Lanka	Total
Jan.	..	8	1	3	..	12
Feb.	..	9	2	2	..	13
Mar.	1	6	2	1	..	10
Apr.	2	24	..	..	..	26
May	..	..	2	..	..	2
June	..	1	..	..	..	1
July	..	2	2	..	..	4
Aug.	..	..	..	..	..	..
Sept.	..	..	..	1	3	4
Oct.	..	1	1	..	3	5
Nov.	1	2	..	..	..	3
Dec.	..	10	..	1	..	11
	4	63	10	8	6	91

It will be seen that more than 78% of the captures were during the period December-April. The largest aggregation seen was off Gujarat coast where during April, 1982 the fishermen are reported to have harpooned about 40 sharks, of which 22 were taken to the Veraval fisheries harbour for removing the liver in four days from 12 to 15 April, 1982.

On the whole the occurrences reported as captures are much more along the west coast of India, the Gulf of Mannar and the west coast of Sri Lanka (71) than along the east coasts of Sri Lanka and India (16).

Along the west coast of India and the Gulf of Mannar there are no records during May, August and September, while along the east coast of India, the same is true for six months (April, June, August, September, November and December). These gaps may be partly due to insufficient documentation and captures going unreported. A more effective data acquisition system will be necessary. The National Marine Living Resources Data Centre (NMLRDC) at the Central Marine Fisheries Research Institute should help in such monitoring.

At this stage it is not very clear whether there is a seasonal migration of the whale shark along the coastal waters of the west coast from the south northwards. Nor is it very clear as to whether their incursions from

the offshore to coastal water take place at different latitudes at different times. An annual synoptic picture of their occurrence on more sighting or captures is needed to answer some of these questions.

December to April also coincides with the season for pelagic fisheries such as sardines and anchovies along the west coast. The relationship between occurrence and forage abundance is yet another aspect which needs further study.

So also there is need to understand whether environmental parameters such as temperature and salinity play a role in their aggregation. The three records along the west coast-Gulf of Mannar region of India during June and July are from the Gulf of Mannar. It is not known whether the whale shark generally avoids lower salinities. Whether the absence of records from the coastal waters during May, June, July, August and September along the west coast of India which coincides with the southwest monsoon is not clear.

The records are suggestive that the whale shark is not resident in the coastal waters, but influxes come in from the offshore and high seas influenced by some extraneous factors.

Sex ratio

One of the most frustrating experiences while looking at past records is that often when workers have taken great pains to measure captured whale sharks, the sex is not reported. The known information on this from the west and east coasts of India are given in Table 2.

It will be seen that there is great insufficiency of information, the available data being only from 31 specimens from west and east coasts of India, of which 27 are from the west coast.

Month	West coast of India and Gulf of Mannar		East coast of India		Total	
	Male	Female	Male	Female	Male	Female
Jan.	2	5	1	..	3	5
Feb.	4	1	..	..	4	1
Mar.	..	3	1	..	1	3
Apr.	1	..	..	..	1	..
May	..	..	..	1	..	1
June	1	..	..	..	1	..
July	1	1	1	..	2	1
Aug.	..	..	..	..	..	..
Sept.	..	..	..	..	..	..
Oct.	..	..	..	..	..	..
Nov.	1	1	..	..	1	..
Dec.	4	4	..	..	4	3
	14	15	3	1	17	14

With the present state of knowledge of the species, it is difficult to say whether sexual segregation occurs in the whale shark either of a "behavioural" type as noted in the case of the spiny dog fish (*Squalus acanthias*) by Ford (1921) or of a "geographical" nature as reported in the case of the soupfin shark *Geleorhinus zyopterus* (Ripley, 1946), and the white-tip shark *Pterolamiops longimaness* (Backus *et al.*, 1956). Information such as size at first maturity, maximum size attained by both sexes and reproductive potential are not available.

Mode of development

Until recently speculation was rife as to the mode of development of the whale shark, the general belief being that it was viviparous. In fact, late Dr. Gudger, the greatest authority on whale sharks, once remarked (Gudger, 1935) that "It is my judgement that the whale shark will be found to be viviparous — i.e. a live-bearer. The young when born must be of good size, too large to be hatched from a shelled egg extruded into the water. The just born young must be atleast three to five feet long — perhaps as much as eight to ten. *Quien saba!*" However, the earliest indication that this giant fish could be oviparous was suggestive from Southwell's observation (1912-'13) based on a specimen taken at Dutch Bay, west coast of Sri Lanka in which he found "...very ripe ovary, oviduct full of eggs, 16 cases counted, same form as in dogfish." This observation, although very significant was discounted by Gudger (1933) who opined that Southwell's shark could have been a *Galeocerdo tigrinum,* although Southwell (in litt. see Gudger, 1933) appears to have been quite positive about his identity of the shark. However, based on Southwell's observations, Bigelow and Schroeder (1948) suggested the possibility of the mode of development of *Rhiniodon* being ovoviviparous, and changing his views on the same grounds Gudger (1952) conceded oviparity to be a possibility.

Of exceptional interest is the discovery of an egg case containing a fully developed embryo of the whale shark from the coastal waters of the Gulf of Mexico off Texas (Baughman, 1955). The embryo when released from the egg measured 14½ inches (37 cm) in total length and was bluish grey dorsally with the characteristic white spots, the ventral side of the body being whitish.

The egg case was 12 inches long. 5½ inches wide and 3½ inches thick (35 × 14 × 9 cm) and "presented every appearance of having been in the water for some time, one side of it being worn, as if by sand". Baughman further remarks that the discoverer of the egg, Captain Freeze found a large whale shark, longer than his 65-foot shrimp trawler Doris, on or about 2nd July, 1953, (the day that the egg was taken), swimming on the surface in the same area a number of times. For a redescription and an additional drawing of this embryo, reference is invited to Reid (1957) and Garrick (1964). One point of interest is that the egg was trawled from 51 m in the coastal waters and in this context Southwell's find of a gravid female whale shark in the month of March in coastal waters is significant as it suggests that this shark besides undertaking migratory movements to feeding grounds could also seek sheltered coastal waters for breeding.

However, the controversy as to whether the whale shark is viviparous or oviparous or ovoviviparous still continues. The Gulf of Mexico embryo had an external yolk sac of about 6.3 cm^3 and a stalk 24 cm long and Reid (1957) commented on the context of absorption of yolk and opined that the embryo was close to hatching. Wolfson (1983) examining early juveniles of whale sharks, found in three of the specimens measuring 55.0, 62.0 and 63.0 cm "a faint indentation in all that remains to mark the stalk" a condition seen in some other elasmobranchs where the "umbilical scar" disappears a few months after hatching. Garrick (1964) postulated that the Gulf of Mexico embryo had yolk in its abdomen which was confirmed by Wolfson (1983). The presence of an umbilical scar in a 55.0 cm (TL) juvenile led Nolan and Taylor (1978) to suggest a viviparous mode of reproduction for the whale shark. In pointing out that the whale shark's mode of reproduction is still uncertain, Wolfson (1983) remarks that "The egg case of *Rhiniodon* is light amber in colour and extremely thin.... the corners may have possessed 'rudimentary' tendrils, but that would have been insufficient to allow for anchoring... and that the case does not appear to be well adapted to withstand condtions on the sea floor." Wolfson (1983) further points out that the embryo could have been aborted by that shark. In the light of these it is quite evident that the mode of reproduction of the whale shark is still an open question. The evidence, therefore suggests ovoviviparity.

Size

The size of whale sharks caught or stranded have always been a matter of interest and the smallest known specimen, besides the 37 cm (given by Wolfson, 1983 as 35.5 cm) embryo mentioned earlier, are six specimens 55.0, 56.0 (2), 62.0, 63.0 and 93.0 cm in TL collected in purse seine from the high seas of Eastern Pacific and Tropical Atlantic where the depth was well over 2,600 m. The next may be the 6 feet (1.81 m) specimen from Cuban waters (Bigelow and Schroeder, 1948). The largest on record is one, a few inches over 59 feet (ab. 18 m) from the Gulf of Siam Smith, 1925, not actually measured). I am unable to comment about the plus 65-feet specimen mentioned in Baughman's account (1955) from the Gulf or Mexico. However, the longest actually measured specimen appears to be the one recorded from the Seychelles Islands by Wright (1870) as measuring 45 feet (13.72 m). In Indian coastal waters the smallest on record is 3.15 m and the largest 12.18 m, a male.

Shri Ali Manikfan, formerly of the Central Marine Fisheries Research Institute, who hails from the Minicoy Island in the Lakshadweep Archipelago informs me that he has seen on atleast three occasions whale sharks caught at Minicoy, but none of the specimens was longer than eight feet. Their occurrence is rare, but the local fishermen are well aware of its passive and harmless disposition, and call it 'Vori mas meer.' The name 'Vori mass' is applied by them to species of *Siganus stellatus* (Forskal) which has got a blotched colour pattern, from which probably the name of the shark is also derived.

Out of the 68 records from the Indian seas, the length measurements are available for only 49 specimens and these are given in Table 3.

From the above statement it is apparent that individuals between four and nine metres are more liably to be encountered in Indian coastal waters.

Table 3 Length measurements of whale sharks caught from Indian seas

Sl. No.	TL (m)	No. of specimens	Sl. No.	TL (m)	No. of specimens
1.	3.0–3.9	3	6.	08.0–08.9	3
2.	4.0–4.9	7	7.	09.0–09.9	1
3.	5.0–5.9	15	8.	10.0–10.9	..
4.	6.0–6.9	11	9.	11.0–11.9	..
5.	7.0–7.9	7	10.	12.0–12.9	2

What is intriguing is that we have no information on specimens less than 3 m. The work of Wolfson (1983) points to the occurrence of small whale shark occurring in the high seas and have been taken by the purse seine operated for tuna fishing. The information I have received from Ali Manikfan from the Lakshadweep also suggests that early juvenile whale sharks may be found in oceanic waters. This information gap on early juveniles needs bridging. Similarly our information on specimens 10 m and above is extremely meagre.

Food

But for stray observations which have led to two schools of thought, nothing much is known about the food of the whale shark. Gudger (1939, 1953), Prater (1941) and Deraniyagala (1944) have tried to correlate the occurrence of whale sharks in Indian coastal waters with the abundance of zooplankton in these areas. Von Kampen found shells of small *Sepia* and some small fishes (Gobiids and Saurids) in the stomach of one specimen harpooned in Batavia Bay, Indonesia and on more than one occasion the whale shark has been noticed to feed on tuna bait fish, namely anchovies and sardines (Gudger, 1915, 1918, 1935, 1941a, 1953). On the contrary, Wright (1868, 1870) found large masses of algae as stomach contents of the whale shark he examined in Seychelles and concluded that the whale shark was herbivorous. Later, Pflueger's examination of a 5.5 m whale shark harpooned off the Florida coast showed the stomach to contain nothing but seaweeds and a large quantity of partly digested and consequently unrecognisable food material (Gudger, 1932a). In Indian coastal waters, Mc Cann's (1954) examination of the stomachs of two specimens and the observations of Kaikini show that marine algae could as well form an item of the food of the whale shark during its visits to the coastal waters. It is also possible that the dietary habits of this fish may change with age. Southwell's (1912-'13) remark that the stomach of the gravid female specimen taken at Dutch Bay, west coast of Sri Lanka, was empty, is also of interest. Although, from this it would appear that the whale shark is an omnivorous feeder and not a purely zooplankton feeder or a herbivore, the final word has not yet been said and it is desirable to have more information about the food of this, larger of all fishes.

Natural enemies and longevity

Gudger (1953) mentions intestinal parasites as the only mortal enemies of the whale shark, while ramming by ocean going vessels also accounts for a few others being killed. According to him, if *R. typus* escapes these, only "one end awaits him — Death from Old Age — from the degenerative metabolic changes and processes consequent on aging." To this should be added fishing with gill nets, purse seines and harpoons. Another limiting factor which he overlooked and which Mc Cann (1954) has rightly drawn attention to, is the possibility of younger individuals being more susceptible to dangers of mortality. In fact, now that we know that the newly hatched whale shark is less than half a metre long, it is undoubtedly subject to dangers of predation and only a very fast growth rate could help it minimise mortality rate. In addition, many of the captures of smaller individuals may take place in coastal waters and go unreported or it may not excite curiosity even if reported on account of the smallness of their size. Capture and stranding of larger individuals by themselves may be contributory factors in limiting their ultimate numbers.

Gudger's surmise of intestinal parasites of the whale shark is also based on Southwell's report on the Dutch Bay specimen in which he found "...six huge cestodes in gut ... a number of soft, round, pink, cysts also found on walls of stomach. Spiral valve full of holes, Cestodes numerous, all Tetrahunchides." It is interesting that neither Mc Cann (1954) nor Kaikini found any parasites in the stomach in spite of detailed examination of the stomach of three specimens.

Wilson (1907) has reported on some gill parasites of whale sharks. Wright's record (1877) of a new genus and species of *Pandarina* as parasitic on the whale shark should also be mentioned here. Thus it will be seen that only very scanty information is available regarding external as well as internal parasites of the whale shark.

Apparently only three instances are on record of whale shark carcass being drifted ashore, one near Madras in 1889, the second on the Florida coast in 1902 (Gudger, 1952) and the third recently recorded by Deraniyagala (1955) as having been washed ashore at Colombo on 23rd September, 1953. A few records of dead whale sharks washed ashore, but inspected after a few days or even several days after the

occurrence could represent specimens caught and dragged ashore by fishermen and subsequently dead. In view of the tendency of the whale shark to sink rapidly when killed in open waters (Tubb, 1948), or when rammed and killed by ocean going vessels the three instances cited above are of interest, although in neither case information is available about the cause of death, as whether due to natural causes, injury or infection.

Schooling behaviour

In the open seas as well as in some of the coastal waters of the world, the whale shark has been observed to swim about in small schools, but the reasons for such congregations are least understood, some suggesting a mode of group feeding. Thomas (1887) apparently was the first to observe a school of whale shark with individuals from 25 to 40 feet long in association with other sharks in New Guinea waters. Subsequently, Weber (1902) noted among a school of sharks and rays in the Strait of Buton, between the islands of Buton and Muna, southeast of Celebes, several whale sharks, which appeared least concerned about the expedition ship *Siboga,* but went about playing around the vessel and struck its bow. Other records of whale shark schools are given by Gudger (1935, 1939) and a recent report appears to be the one recorded by Tubb (1948), who observed two small schools of whale sharks, the smallest school consisting of nine sharks ranging in size between 20 and 35 feet (6.09 and 10.66 metres) in Darvel Bay, British North Borneo. The capture of two specimens at the same time at Madapally on the west coast of India is the first indication of such schooling behaviour in our waters. However, more recently we have seen aggregations in Gujarat waters off Veraval which definitely points to their schooling in some parts of our coastal waters.

Association with Tuna

Very significant is the tendency of *Rhiniodon* to associate with large schooling fish. Gudger (1941b) has given a number of instances of associations between *Rhiniodon* and the Bonito in Japan, Cuban waters, off Havana, Manzanillo, Gibara and Vita. In the Bahamas, the whale shark has been seen along with tuna school and the same association has been noted also off Lower California. The behaviour of the whale shark when in association with bonitos and tunas suggests that they might have been together in seeking their food.

In oceanic waters, whale shark is considered as an indicatory of tuna schools and regularly so along North West Africa (Wolfson, 1983). Association of whale sharks and tunas have been also reported by Tubb (1948) from North Borneo; Baughman (1955) from British Honduras; Baughman and Springer (1950) and Springer (1957) from U.S. and Mexican waters; Fourmanoir (1955, 1961) from Malagasy; Iwasaki (1970) from Japan and Cropp (1978) from Australia. The capture of early juveniles in purse seine operations over deep water reported by Wolfson (1983) is also interesting.

On the west coast of India, the period from November-December to April is the time when sardines and mackerel occur in abundance, and as already noted, this period coincides with the occurrence of whale sharks in the coastal waters of that area. This is also the period when schools of bonitos, frigate mackerels, skiperels, skipjack and yellow-fin tunas visit the coastal waters along the west coast of India and it will be worth finding whether any such associations between these larger fish and the whale shark exist in our waters. In fact, off San Diego on the California coast, whenever the whale shark is sighted, fishermen know that it will be invariably surrounded by yellow-fin tuna and head for it (Gudger, 1941a).

Other animal associates

Composite schools of whale sharks and other sharks and rays have been reported by Thomas (1887). Weber (1902), Gudger (1941 a,c), Tubb (1948) and others. Off Sri Lanka waters, Captain James Steuart observed that "...sharks of the ordinary description are frequently seen: and on two occasions my attention has been called to spotted ones of such monstrous size as to make the common ones at their sides appear like pilot-fish."

The sucker fish or remoras are known to be associated with the whale shark (Gudger, 1935) and in the open seas have been observed to freely enter and leave the oral cavity of the shark (Gudger, 1922; Prater, 1940). Jonklass gives a fascinating account of his encounter with a 40-foot whale shark off Sri Lanka coast while aqualung diving, and recollects seeing 'pilotfish' hovering around the mouth of the shark. In fact, one such fish has even been taken from the stomach of a whale shark probably swallowed

inadvertently at the time of capture. In one of the whale sharks landed at Sassoon Docks, Bombay, Prater (1940) found a sucker fish cleaving to its palate, well inside the mouth.

Tubb (1948) also mentions of an interesting association between the whale sharks and small shoals of stromateid fish (young *Stromateus cinereus)*, the latter swimming "almost invariably on their sides, suggesting pleuronectids and although somewhat scattered, each shoal closely followed the movement of its gigantic companion. The stromateids appeared to generally travel about one fathom below the whale shark." When one of the sharks was killed, the accompanying stromateid shoal transferred its allegiance to the launch and stayed beneath it until the speed was increased, suggesting the natural tendency of these smaller fishes to take shelter under or follow in the wake of giant fishes. In Indian coastal waters, only Chacko and Mathew mention of fishermen having seen such an association between *Stromateus cinereus* and the two whale sharks they reported on at Madapally.

Yet, another interesting association is that between the whale shark and enormous shoals of the carangid fish *Caranx gymnostothoides* noted regularly off Seychelles Islands (Gudger, 1932b).

Whale sharks and underwater sound

Are whale sharks capable of producing underwater sound? Hitherto there has been nothing to indicate that they are concerned with purposeful sound production of a biological nature or even mechanical sound production. However, Mr. S. Mahadevan who was connected with the pearl fishing operations in the Gulf of Mannar during the past few years informs me that pearl divers are familiar with the 'Uravi' or whale shark which is not at all uncommon in the Pearl Banks off Tuticorin during the pearl fishing season extending from Novermber to about April. The curious thing is the fishermen while diving recognise the presence of the shark, even when it is quarter of a mile away, by a peculiar intermittent snapping or grating noise, well audible under water. The volume of this crackling noise resembling that made by a heavy disused door moved on its rusted hinges, it appears, if heard at close quarters under water is really deafening. (It sounds very cetacean to me). Once when the divers indicated the presence of an 'Uravi' in the vicinity, Mr. Mahadevan immersed his head under water and sure enough, heard the peculiar grating sound. A few moments later a large swirl in the water a few hundred metres away indicated the place where the animal had sounded. Although the divers are well aware that the shark is harmless in spite of its enormous size, the moment they hear its noise under water they come up and remain in the boats for 5 to 10 minutes by which time the direction of movement of the shark would be known, and when it has passed by they recommence diving.

The absence of air bladder in the whale shark will rule out the sound as being accomplished by the air bladder and associated organs as is the case with many of the sciaenids, perches, etc. For such a large animal with hardly any natural enemies, the purposefulness of any biological sound production as a warning sign may be ruled out. Mechanical sound production appears to be the only possibility and under this category too, as the shark passively swims about, there is no likelihood of its producing such sound as a result of body movements directly involved in swimming. Nor is it likely that the exhalation of water through the gill openings could account for such sound. As such, I feel that the mode of feeding possibly has something to do with the sound produced by this shark. As the oral armature may give a clue, the nature of the dentition as described by Gudger (1953) is given below: "...the very small teeth are in contrast with the 4- or 5-ft wide jaws. They form in each jaw a band (of about 3,600 teeth in a 31.5 ft specimen) extending from angle to angle of the great jaws.... The band is composed of rows of teeth extending from front to back. Each row has from 10 to 12 or 14 teeth pointing backwards. Each tooth has a bulbous base and the tooth proper is sharply recurved flatly to the rear (the interior of the mouth). The cusp of the tooth, that is, the part covered with enamel, is only about three-sixteenths of an inch long. It does not stand upright, as do other sharks' teeth, but it bent flatly backwards and inwards..."

The quick and successive snapping of the jaws and the consequent grinding of the numerous teeth may perhaps produce the grating sound. That this is a possibility is understandable from Dr. Fish's (1954) observation on the mechanical sound produced by the smooth dogfish *Galeorhinus laevis* Valmont.

She remarks that the sounds of five of these fishes "were audible only when they were swimming with fins partly out of water or occasionally when feeding on carbs....However, the noisy grinding of the numerous flat granular teeth of a 'pack of sea hounds' over favourite shoal feeding grounds may be expected to reach considerable volume." It is interesting that in the Pearl Banks off Tuticorin the fishermen should associate this characteristic underwater sound only with the whale shark and not with any other sharks, skates or rays nor with any of the reef fishes or cetaceans.

I have still reservations as to whether this could be the sound produced by the sperm whale or any other cetacean. No doubt, this reported mechanical sound production in the whale shark needs confirmation.

Local names

West Pakistan: 'Mhor'; West coast of India: 'Karanj', 'Bhariat', 'Bahiri' (Marathi), 'Makara sravu', Osman shira' (Malayalam) 'Pulli-udoombu', 'Pullian Surraw (Tamil) Lakshadweep Islands: 'Vori mas meer'; West coast of Sri Lanka: Muni-muthu-mora' (Singhalese); Gulf of Mannar: 'Panai meen', 'Uravi' (Tamil); Palk Bay, east coast of India: 'Panai meen' (Tamil).

Whale shark in the Jataka sculpture of 2nd B.C.

The present discussion also necessitates clarification of any doubtful references to the whale shark, especially from this area. In this connection, two notes by the late Dr. Hora (1955, 1956) referring to the *Timingila Jataka* Medallion of the Bharhut reliefs of the 2nd century B.C. as representing a whale shark and not a whale calls for a re-study. Hora (1956) remarks that "....its food-fishes, such as mullets, sardines and small perches, are shown in the medallion....When the fish inhales water for oxygenating its gills, the power of suction is so great that small boat with three occupants could be sucked into its cave-like mouth as is so clearly shown in the medallion. It is evident, therefore, that even sizeable fish and other animals, besides plankton and small shoaling fishes, could form the food of the whale shark." The *Timingila* is represented as a pisciform animal with the body covered with scales, with a very large head and an enormously large mouth fringed with conspicuous conical teeth, but with the lower jaw shorter. The eyes are large, and still more significant is a spout of water shown cascading from near the anterior end of the snout and seen curving backwards as well as forwards. While it is difficult to imagine that such a creature could in any way be connected with the whale shark, there is no reason why it could not be the product of an artist's imagination of a whale! The enormity of the animal and the known disposition of some whales to even attack or upset a boat in the vicinity with their sudden movements could have given rise to the scene depicted in the medallion, the scales on the body shown again being a matter of imagination and the small fishes only adding flovour to the marine environment and not forming food of the whale. Besides, a whale is known as *Timingilam* in Tamil, *Timingalam* in Malayalam and Thimingilamu in Telugu, while as will be seen from the local names given above, the whale shark is not known to be denoted by the name Timingilam.

A second doubtful identity of the whale shark from Indian waters may also be mentioned here. Burton (1940) remarks of a sight he saw two days after leaving Chetlat Is. in the Lakshadweep Archipelago for Managalore as "...an enormous dorsal fin moved along four or five feet out of the water at a distance of several hundred yeards, but what creature it belonged to we could not make out; perhaps it was a whale shark (*Rhiniodon typicus*) which usually swims near the surface with part of its dorsal fin exposed." It may be mentioned here that *R. typus* besides having a moderately large dorsal fin has also a large upper caudal fin lobe which surely should be partly seen when the fish swims, at the surface. It is not unlikely that the animal sighted could be a solitary killer whale *Orcinus orca* which has a conspicuous dorsal fin and which in a 30 feet specimen may be nearly six feet high.

Centre of origin and dispersal

Gudger (1935) opined that a fish so markedly distinct and circumtropical in distribution should have had only one centre of origin and assigned the Sulu Sea in the south west part of the Philippines as the focal point from where the whale shark originated and subsequently got dispersed. The basis for this postulation was that as on December 31, 1934 for a period of 107 years, out of 76 whale sharks recorded from all seas, 17 were definite records for the general

region of the Sulu Sea "with as many more being checked up." At that time he listed only 10 definite records from Indian coastal waters, which Prater (1941) raised to 20, and I have in this contribution referred to 78+ occurrences. Now, this increase in the number of records from Indian coastal waters has also kept pace with additional records from all seas which to date may add to number a few hundreds. To presume that the abundance of an organism at one place in the present day and its relative scarcity in other areas should indicate the former area to be the centre of origin of a species is a highly controversial subject. For a study of the origin and present day distribution of the whale shark, it will also be necessary to consider conditions existent in the past geological ages (the period of origin of ***Rhiniodon*** is not known, but the closely allied family Orectolobidae is known from the Upper Jurassic to Recent) especially oceanic conditions prevalent then and during the successive ages. While Gudger's thesis is fascinating, and has hardly any facts today to substantiate it, yet it is equally feasible that the whale shark, pelagic and passive as it is having originated from one place (unknown), has at present found suitable niche in the different seas, areas where they are at present found in numbers. The latter may be feeding aggregations and we right now have little information on breeding, migration and behaviour. With our present limited knowledge, any pinpointing of the centre of origin of the whale shark will only be a matter of conjecture.

While describing a recent sensational discovery — the Megamouth — as a new species, genus and family (*Megachasma pelagios*, Family Megachasmidae) Taylor *et al.* (1983) made some pertinent remarks on whale shark, its feeding habits and biology in relation to *Megachasma* and *Cetorhinus*. They have described the filter apparatus of *Rhiniodon* which differs from the latter two genera markedly to form dense screens, and act as more efficient filters for short suction intakes and not as a flow through system. The whale shark's behaviour of generally aligning itself vertically below the prey school which may include small crustaceans (including euphausiids), squids, anchovy and sardines and sucking in the same is reported by these authors. Hence we have some information today about the whale shark when it occurs in its feeding ground.

Deraniyagala advocates Gudger's view when he states that "the newly hatched young ones of this slow swimming, giant pelagic shark are transported from the breeding ground by current and attain a length of about 22 feet by the time they reach Ceylon". Although early juveniles have recently been caught in purse seine in the Atlantic and the Eastern Pacific from oceanic waters, more work is needed before we say anything about breeding ground and growth. Southwell's record of the gravid female from Sri Lanka waters is considered doubtful. Baugman's (1953) record of the egg case of a whale shark from the trawling ground is now considered as most probably an aborted egg. The seasonal migrations of whale shark need closer study.

Its present circumglobular distribution is interesting and its linkage between the Indo-Pacific and the Atlantic shoud be only *via* South African waters. Compagno reports that whale sharks apparently prefer "areas where surface temperature is 21 to 25°C with cold water of 17°C or less upwelling into it and salinity of 34 to 34.5 ppt." This moderately lower temperature tolerance may also enable it to circumvent the Cape of Good Hope. However, it will be worthwhile to see whether any genetic heterogeneity exists in the species along its range of distribution.

Is the whale shark endangered or vulnerable?

Commercial harvesting of whale sharks is practically non-existent. In a very few areas, directed fishing is practised especially for its liver oil which is used as a preservative for the timber used in boat hulls. Gujarat waters along the northwest coast of India is a good example where a small harpoon fishery during certain years exists when the sharks occur in numbers. Off Pakistan also a similar activity is said to occur. In incidental captures, sometimes the meat is marketed fresh or is salt cured.

When there is such a low level of exploitation of this resource, one may question the appropriateness of addressing ourselves to the question whether the whale shark is endangered or vulnerable. My reasons are:

1. Our knowledge today is confined mainly to incidental captures, strandings or rammings by ships or boats.
2. Even so, data on such specimens are grossly insufficent.

3. Many sightings or captures of smaller whale sharks less than 2.5 m or 3 m may go unreported.
4. The data acquisition system is far from adequate in the tropics, except in countries such as India where we follow a multistage stratified random sampling technique for estimating the exploited resources and as such, the enumerators and field staff of the Central Marine Fisheries Research Institute may chance on specimens being caught and file a report. This system has undoubtedly increased the number of records from the Indian coastal waters many fold.
5. Decades of fishing for oceanic pelagics such as tunas and billfishes has resulted in only few sightings and captures of whale sharks.
6. Their occurrence in coastal waters in many places are very sporadic and may often be fortuitous. Rarely do we have captures in two successive years from the same area.
7. The "aggregations of upto hundreds of sharks" which Compagno mentions has not been observed in Indian coastal waters.
8. In the absence of tagging we have hardly any information about their migrations, growth, size at first maturity and longevity.
9. A major critical gap is our lack of knowledge about its reproductive potential and recruitment to juvenile and adult sizes.
10. Many gaps in our knowledge on its life history and biology have been already pointed out.
11. Other than man and his activities we are not aware of its natural enemies and predators. Diseases and internal parasites are practically unknown. Neither are we in a position to say about the effects of toxic pollutants it may assimilate through its food nor the effect of plastics, tar balls and other flotsam it may accidentally imbibe.
12. With so many unknown factors, and apparently limited numbers wherever they are known, any increase in directed effort at capture may result in great imbalance. Hence the dangers that I foresee are:
    a) The more increased small-scale fisheries in island states and mainland coastal waters (neritic) using better fishing craft and gear such as purse seine and gill nets resulting in greater incidental catch or even directed fishing.
    b) The large scale use of tuna purse seine in oceanic waters, especially in the Indian Ocean, where until 1981 this activity was practically nil. An explosive development is taking place now.
    c) The wider use of its meat and oil if more whale sharks are landed.
13. Hitherto, its occurrence has been a rarity.

In the light of these, I would not consider the whale shark as an endangered species at this point of time, but a highly vulnerable one. Both natural and regional co-operative research programmes may be necessary to study more about this, the largest of all fishes.

Mere recordings of occurrence unaccompanied by facts such as the exact location of capture or stranding, the time of occurrence, the length of the shark, sex etc. will be hardly helpful and so in order to facilitate collection of proper data, I have given in the Appendix-I the information most desired (also Fig. 1). The format is the same as that given by Silas and Rajagopalan (1963). Perhaps proper documentation of such data over a period of time will help us understand more about the habits and natural history of this shark. With this in view, I appeal that readers who are able to make any fresh observations on the whale shark from Indian seas, both in coastal as well as offshore waters, communicate their findings, to the National Marine Living Resources Data Centre (NMLRDC) at the Central Marine Fisheries Research Institute, Cochin, so that the information could be collected and published from time to time. Perhaps the time has come when international collaboration in whale shark research will also have to be considered, while taking as a first task a tagging programme. A simultaneous extension programme to educate the coastal and island fishermen for data on whale sharks and the need of releasing the sharks when caught may have to be taken up. In India, this could be done through the CMFRI through its field and research staff and the Department of Fisheries of concerned maritime states and union territories.

The question may be posed as to what will all this prove, especially for a resource which is a rarity. I have no hesitation in saying that aside from our knowing more about the largest of all fishes, already whale sharks have been used as an indicator of aggregations of tuna shoals and no doubt if they are after sardines and anchovy in neritic waters we may find that they could be an equally good indicator of their forage resource or incursion of water masses into the neritic realm — cutting it short, the well being of the ecosystem.

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APPENDIX

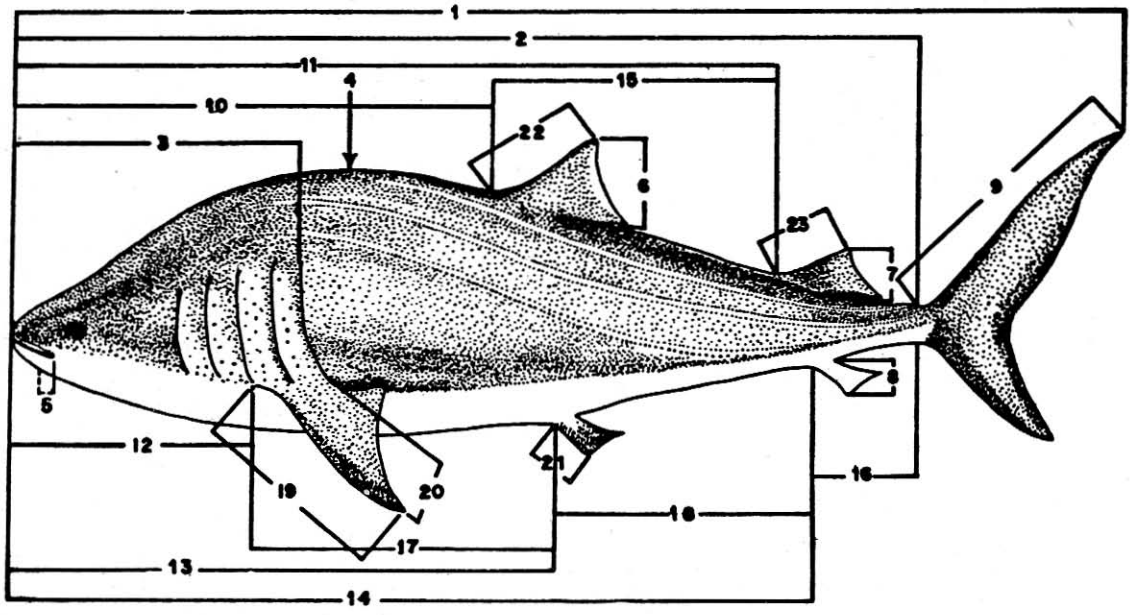

Figure 1. Schematic diagram of lateral view of whale shark showing methodology for measurements (outline drawing after Bigelow and Schroeder, 1948) Nos. are in sequence as given in Appendix.

Data

Date ..... Locality .....

.....

If captured, time and method of capture .....

If stranded, time .....

If stranded, injured or infected .....

If washed ashore, dead, injured or infected .....

If sight record, location (Lat. & Long) .....

Any other animals seen in association with the whale shark .....

Sex ..... Weight .....

If female, any eggs (if so number) .....

Length, width and thickness of egg cases.....

Length of embryos (eggs and embryos to be preserved).....

Contents of stomach (at least sample to be preserved).....

.....(if so, to be preserved)

Any gill parasites.....(if so, to be preserved)

Any external parasites.....(if so, to be preserved)

MEASUREMENTS (in metric system):

(1) Total length.....(2) Standard length.....(3) Head length.....

(4) Girth of body at.....(5) Width of mouth from angle to angle.....

Vertical height of:

(6) First dorsal fin..... (7) Second dorsal fin.....

(8) Anal fin.....

(9) Length of caudal fin along upper margin.....

Snout to:

(10) First dorsal.....(11) Second dorsal.....(12) Pectoral.....

(13) Pelvic.....(14) Anal.....

Interspace between: (15) First and second dorsals.....

(16) Anal and caudal.....

(17) Pectoral and pelvic origins.....

(18) Pelvic and anal origins.....

Length of pectoral fin: (19) Along outer margin.....

(20) From angle of inner base to tip.....

(21) Length of pelvic fin.....

(22) Length of first dorsal.....

(23) Length of second dorsal.....

If male: Length of clasper from inner base of pelvic fin.....

Length of pelvic fin along its inner side.....

Any additional measurements and information available.....

.....

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