Aerial surveys of whale sharks (*Rhincodon typus*) off the East Coast of Southern Africa

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Abstract

From 1993 to 1998, the Shark Research Institute conducted aerial surveys of whale sharks (*Rhincodon typus*) along the coast of KwaZulu-Natal, South Africa. Three types of aircraft were used: two different Cessna fixed-wing aircraft and a delta-wing microlight. The microlight proved to be the better choice for this survey due to its slow flight speed, manoeuvrability, portability, and low cost of maintenance and fuel. During 114 survey flights of the entire KwaZulu-Natal coast over 5 whale shark seasons, a total of 452 whale sharks were observed. These individuals were predominantly swimming in a south to north direction, often along the clearly defined perimeter separating clean water from that discoloured due to siltation by rivers. The aerial survey indicated that the sector north of Cape Vidal, with no major rivers discharging silt into the sea, was the most suitable for a tagging study of whale shark that was ongoing during this period.

Keywords: aerial survey, whale shark, abundance, distribution, South Africa, Indian Ocean

1. Introduction

The whale shark (*Rhincodon typus,* Smith 1828) is a filter-feeding, coastal and oceanic orectoloboid shark, found in all tropical and warm-temperate seas (Compagno, 2001). This shark was first reported from Table Bay, Western Cape, South Africa (Smith, 1828) but was eventually recorded from the southwest and east coasts of southern Africa to Mozambique and northward to East Africa (Barnard, 1925, 1935; Fowler, 1941; Bigelow and Shroeder, 1948; Smith, 1949; Bass *et al.,* 1975; Compagno, 1984, 2001; Bass, 1986; Wolfson, 1986; Compagno *et al*. 1989). The occurrence of whale sharks off the KwaZulu-Natal province on the east coast of southern Africa is a seasonal phenomenon that has been sporadically investigated and documented. This has resulted in limited data regarding the annual abundance and movements of this species in the area based on records of strandings, diver surveys, aerial surveys, and surface sightings (Bass *et al*., 1975; Beckley *et al*. 1997, Compagno, 1999).

Starting in December 1993 and ending 30 April 1998, the Shark Research Institute (SRI) initiated, developed and implemented an aerial survey program of whale sharks in order to support their ongoing whale shark tagging program (Gifford, 1994, 1995, 1997, 1998). Further information about this tagging program is given in Gifford *et al.* (2007). Surveys were conducted from Port Edward (31º02'5"S, 30º13'6"E; 158 kilometres southwest of Durban) to Kosi Bay (26º41'60"S, 32º53'60"E, 392 kilometres northeast of Durban) covering the KwaZulu-Natal coastline (Fig. 1). Anecdotal reports from divers and sport fishermen, suggested the area north of Cape Vidal was routinely visited by large numbers of whale sharks. Thus, one objective of this study was to confirm these observations, and possibly locate other areas suitable for the tagging program. It was also anticipated that data collected from the survey might prove useful in the development of local management plans of the species.

2. Methods

Aerial surveys were conducted along the KwaZulu-Natal coast of South Africa between December 1993 and January 1999 (Fig. 1). Reconnaissance flights were conducted randomly throughout the winter months, and no whale sharks were observed. Each year, the study period began when the sharks appeared off the KwaZulu-Natal coast, and ended when the sharks left the area, thus the study seasons were as follows: 31 December 1993 to 14 April 1994; 3 December 1994 to 30 April 1995; 1 October 1995 to 30 April 1996; 1 October 1996 to 30 April 1997; and 1 October 1997 to 30 April 1998.

Each survey flight encompassed the coast of KwaZulu-Natal from Kosi Bay in the north to Port Edward in the south (Fig. 1). In order to determine

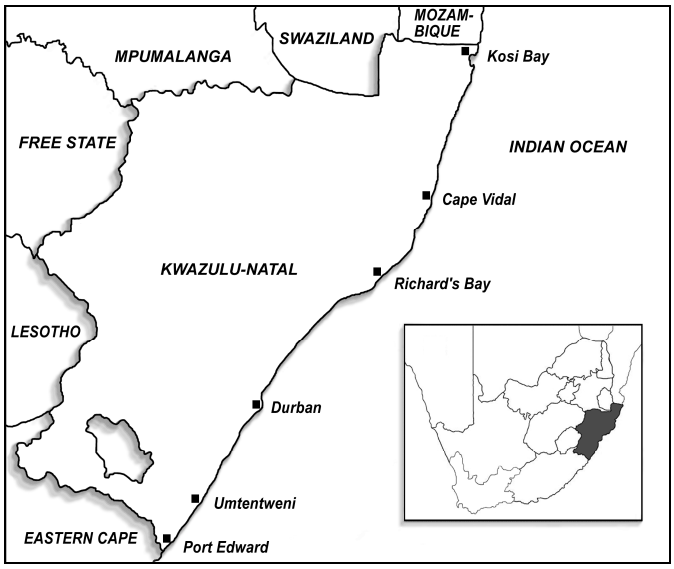

Figure 1. The study area off the KwaZulu-Natal coast in South Africa.

the optimum flight level for observation, test flights were flown at heights of 500, 750, 1000 and 1500ft above sea level. It was determined that flight levels between 500 and 850ft were the most productive relative to the wind direction and velocity, haze, and glare from the sea surface.

Three types of aircraft were used during the survey period (Table 1). During the 1993/1994 whale shark season, surveys were conducted using a Cessna 182; it facilitated three dedicated observers in addition to the pilot and was able to travel the entire survey area without refuelling. However, to reduce costs, a Cessna 172 was used for two of survey flights. The disadvantages of a reduced number of observers and limited fuel capacity outweighed the economical savings. In addition, the cruising and stall speeds of both Cessna aircraft were too high and their respective safe turning circles too wide to ensure that all whale sharks were counted. In order to accommodate the highly specialized needs of the tagging project, a Solo Wings delta-wing microlight aircraft was bought into service in October 1994. Although only capable of carrying the pilot and one observer, its speed and manoeuvrability proved ideal and the lack of any fuselage structure made visibility from the aircraft almost unlimited. A single pilot flew all Cessna surveys, while this and one additional person alternated as pilots of the microlight throughout the study.

Due to the prevalence of choppy sea conditions and reduced visibly resulting from sunlight reflecting off the sea surface, aerial surveys were performed as often as sea and weather conditions permitted rather than on a fixed schedule. On each survey flight, the aircraft was flown above the backline of breaking waves at 500 to 850 feet above sea level for the entire length of the KwaZulu-Natal coast. Whale sharks were counted only in one direction of each survey flight, the direction dependent on the sun's glare from the sea surface. A minimum of two experienced observers were deployed on each Cessna flight, one at port and one starboard, and whenever possible a third person recorded data. The microlight aircraft accommodated only one observer who also recorded data. The shallow sandy bottom of the coast and the use of low-altitude aircraft ensured whale sharks were easily observed and recognised.

On each flight, standard flight charts were used with a plastic overlay for recording the position and direction of travel of each whale shark. This information was transferred in a master log for each season.

Table 1. Evaluation of aircraft used in whale shark aerial surveys.

Aircraft	Engine	Cruising Speed (km/h)	Stall Speed (km/h)	Range (km)	Capacity *	Cost (US$/hr)
Cessna 182	Single	244	92	1600	3	45
Cessna 172	Single	205	92	860	2	32
Microlight Trike	Single	65-100	40-50	400	1	7

* in addition to pilot

3. Results

The greatest number of whale sharks sighted in a single day was on 15 January 1994 when 95 individuals were observed between Durban and Umtentwini on the south coast of KwaZulu Natal, a distance of 110km; this was during the season using Cessna aircraft. During the course of conducting the aerial surveys, it was found that the majority of whale sharks were swimming alone as fairly wide-spaced individuals. Occasionally a pair was observed, and only once were more than two seen together, when on 15 January 1994 five sharks were recorded in close proximity off Turton on the south coast.

Significantly more whale sharks were seen during the initial survey season using Cessna aircraft compared to subsequent seasons utilising microlight aircraft (Table 2). Overall 452 whale sharks were observed during the 114 flights of the entire KwaZulu-Natal coast. The 30% of coastal

Table 2. Results of aerial surveys along the KwaZulu-Natal coast, South Africa.

Season	No. Flights	No. Flights in S to N Direction	No. Flights in N to S Direction	Total Flight Time (hr)	Total No. Whale Sharks (550 km)	% Whale Sharks Durban to Port Edward (169 km)	% Whale Sharks Durban to Kosi Bay (381 km)
1993/1994	12	5	7	25.33	184	63.6	36.4
1994/1995	10	6	4	19.67	31	19.4	80.6
1995/1996	36	9	27	82.17	79	19.0	81.0
1996/1997	42	10	32	96.30	93	29.0	71.0
1997/1998	14	8	6	40.25	65	29.2	70.8
Total for Microlight	102	33	69	238.39	268	25.0	75.0
Total for All Surveys	114	38	76	263.72	452	40.7	59.3

length south of Durban contained 25.0% of the whale sharks observed on microlight surveys and 40.7% of all whale sharks for 5 seasons. This increase when including Cessna surveys is due to the majority of whale sharks observed in the 1993/1994 season being in this southern region compared to the opposite for all other seasons. For the 4 microlight survey seasons it is apparent that a relatively proportionate number of whale sharks were seen north and south of Durban.

The average number of whale sharks observed per flight for all seasons was 4.0, however this reduced to 2.6 when excluding the Cessna surveys of 1993/1994 (Table 3). The average number of whale sharks per flight was relatively consistent throughout the seasons of similar methodology. An average of 1 whale shark per 100km coastline was observed for all 5 seasons (Table 3).

During the five year survey period in KwaZulu-Natal, the directions of travel of each individual shark was recorded and the results are summarized in Table 4. Almost all whale sharks were swimming along the South African coastline rather than heading east or west. In all but the final year of study, the majority of individuals were heading in a south to north direction.

Aerial surveys revealed that the area south from Port Edward to Durban, a length of 169km, suffers from seasonal reduced water visibility due to silt discolouration resulting from swollen rivers that discharge directly into the sea, particularly after the summer rains. Observations showed that the whale sharks tended to avoid this turbid water and were often seen swimming along the clearly defined perimeter that separates the clean from the silt discoloured water.

Table 3. Mean number of whale sharks per flight and per kilometre of coastline in KwaZulu-Natal, South Africa.

Season	Whale Sharks per Flight	Whale Sharks per 100km Coastline
1993/1994	15.3	2.79
1994/1995	3.1	0.56
1995/1996	2.2	0.40
1996/1997	2.2	0.40
1997/1998	4.6	0.84
Microlight Surveys	2.6	0.55
All Surveys	4.0	1.00

Table 4. Direction of travel of whale sharks.

Season	South to North	North to South	West to East	East to West
1993/1994	59%	36%	4%	1%
1994/1995	68%	32%	--	--
1995/1996	61%	37%	2%	--
1996/1997	54%	46%	--	--
1997/1998	48%	52%	--	--

4. Discussion

Ideally, an aerial survey would be most useful if a set number of flights could be flown at the same dates and times each season, but the reality is that an aerial survey is dependent on weather and sea conditions. Thus it is not possible to assess the impact of adverse weather and sea conditions, if any, on the abundance of whale sharks during the study period. Although recorded and shown in table 2, the hours flown are not relevant to the objectives or results of this survey because headwinds and tailwinds vary with each flight and

may slow the aircraft or increase its speed, and the objective was not to fly a specific number of hours but to record the numbers of whale sharks per kilometre of coastline. A better indicator of whale shark abundance is the number of individuals observed per flight of the coastline or the number per 100km of coastline as given in Table 4. These results show significantly more whale sharks seen in the 1993/1994 season using Cessna aircraft compared to subsequent seasons which used microlights. It may be that there were more whale sharks during this season, but given the change in methodology analysis must be cautious.

Since the completion of this 5 year survey, a study was conducted from 2001 to 2005 by Cliff *et al.* (2007). This research surveyed the northern 350km of the KwaZulu-Natal coast by light aircraft. Over the seasons the sighting rates of flights varied from 0-4.35 whale sharks per 100km coastline with seasonal means ranging 0.21-0.69 sharks per 100km. These figures are comparable to the average number of whale sharks per 100km coastline for each season assessed by microlight aircraft in this survey. Additionally, in the surveys by Cliff *et al.* (2007) the majority of whale sharks were seen in the northern most 150 km of the KwaZulu-Natal coast. This contrasts the work shown here in which numbers of whale sharks were found along the entire coastal length.

South of Durban 34 rivers empty into the sea. Of these, the mouths of eight rivers are always open, and another five are open more than 80% of the year. Along the 209 km from Durban to St Lucia Estuary which is located 32 km south of Cape Vidal, 18 rivers or estuaries empty into the sea. Of these, five rivers or estuaries are always open and another three rivers are open 80% or more of the year. However, no major rivers empty into the sea between St Lucia Estuary and Kosi Bay, a distance of 172 km (Jackson and Lipschitz, 1984). As the whale shark distribution is relatively even along the coastline north and south of Durban (Table 2), no particular area was better for the Shark Research Institute's whale shark tagging program in regard to this. However, as the SRI's tagging program was to utilise divers to attach the tags, good underwater visibility was essential, and thus the area north of Cape Vidal was considered suitable for such work. Additionally, the beaches from Cape Vidal to Kosi Bay are generally wide and flat, making them conducive to take-off and landings of microlight aircraft used to support the tagging program.

No whale shark fisheries existed along the coast of East Africa during the course of this study. However, it was considered possible that the decrease in sightings from 1993/1994 to 1994/1995 might be related to the whale shark fishery then operating to the north in the Arabian Sea (Sreenivas, 1999; Hanfee, 2001). In 2000 and 2001, in efforts to determine if the sharks observed during this study period, including those tagged by the Shark Research Institute, were among those harvested at Gujarat on the Saurashtra coast of India, researchers from SRI visited the whale shark fisheries and processing plants at Veraval, India (Patil, 2002). Posters were distributed in Hindi, Gujarati and English, depicting the tags placed on whale sharks along the South African coast and offering a substantial monetary reward for the return of a tag. However, no tags were recovered.

5. Conclusion

Based on the continued sightings of whale sharks and the generally good water visibility in the area north of Cape Vidal, it was decided to concentrate the efforts of the tagging program in those areas with aerial support from microlight aircraft.

At the conclusion of this study period, an aerial study was commenced in KwaZulu-Natal by South Africa's Marine and Coastal Management using fixed-wing aircraft. Their results were presented at the Whale Shark Conference at Perth in May 2005.

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