

Opinions count: decline in abundance of Silky Sharks in the central Indian Ocean reported by Maldivian fishermen

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Abstract

The silky shark *Carcharhinus falciformis* is probably the most important species of oceanic shark in terms of catch weight taken in fisheries in the Arabian Sea and tropical Indian Ocean. However, both catch and biological data are scarce, while catch per unit effort time series are almost completely lacking. It is therefore difficult to make informed judgements about the status of this species in this ocean. Nevertheless, it is clear that silky sharks have been heavily exploited in other oceans, where populations appear to have been reduced to a fraction of their former abundance. There is no reason to suppose that the same is not happening in the Indian Ocean. In the Maldives there is a small directed fishery for silky sharks but no catch data. We conducted a series of five small surveys of Maldivian islanders and fishermen, recording their opinions of the status of the local shark longline fishery and of the silky shark resource. Remarkably consistent results were obtained: islanders and shark fishermen reported a decline in the shark longline fishery; all fishermen reported declines in the abundance and average size of silky sharks. It is difficult to quantify these declines, but the available information is not inconsistent with silky shark abundance currently being less than 50% and perhaps just 10% of what it was 20 years ago. Since silky sharks are highly migratory, this implies that they have been grossly overexploited on an oceanic scale.

Introduction

The silky shark (*Carcharhinus falciformis*) is one of the commonest pelagic shark species, and is widespread in tropical oceans (Compagno, 1984). It is fished throughout much of its range, and because of its biological characteristics it does have a high risk of overexploitation (Cortés *et al.*, 2008). Indeed, there is growing evidence that its abundance has declined globally over recent decades as a result of high and sustained levels of fishing activity. For example, silky shark bycatch in the eastern tropical Pacific purse seine fishery is estimated to have declined by something of the order of 60-80% during the period 1994-2004 (Minami *et al.*, 2007). Bycatch on tuna on tuna longlines in the Gulf of Mexico may have fallen by some 90% over 40 years (Baum and Myers, 2004), and in the western and central Pacific by some 60% during the period 1995-2006 (WCPFC, 2008). While there is debate over some such

assessments and over the exact scale of declines (Burgess *et al.*, 2005a, 2005b; Baum *et al.*, 2005) it is clear that widespread stock depletion has occurred. As a result, this species is now considered to be Near Threatened globally by the World Conservation Union (IUCN), while populations in the eastern Pacific and western Atlantic are listed as Vulnerable (Camhi *et al.*, 2009; Dulvy *et al.*, 2008).

In the Indian Ocean, there are important directed fisheries for silky sharks off Oman (Henderson *et al.*, 2007 & 2008), Yemen (Bonfil, 2008), Sri Lanka (Joseph, 1999) and probably other countries too. In addition, significant quantities are believed to have been taken as bycatch in the purse seine and longline tuna fisheries (Amandé *et al.*, 2008; Bonfil, 2008; Smale, 2008).

In the Maldives, the pole and line tuna fishery for skipjack (*Katsuwonus pelamis*) and juvenile yellowfin tuna (*Thunnus albacares*) has continued for centuries. Maldivian fishermen are very familiar not only with tunas, but also with other epipelagic species including sharks. In recent years, new fisheries have developed in the country, including pelagic longlining for oceanic sharks and handlining for large yellowfin tuna. Silky sharks are common in Maldivian waters and are particularly well-known to Maldivian fishermen. For shark longline fishermen, silky sharks make up some 85% of their catch (Anderson, 2002). Juvenile silky sharks aggregate under floating objects, where they associate with juvenile skipjack and yellowfin tunas, and are frequently taken as by-catch by pole and line fishermen (Anderson *et al.*, 1998). Larger individuals associate with free-swimming tuna schools, and are again regularly encountered by Maldivian tuna fishermen. These associations are reflected in the several local names given to silky sharks, including for juveniles *oivaali miyaru* (drifting object shark), and for adults *ainu* or *ainumathi miyaru* (tuna school shark) or *mas miyaru* (skipjack shark), or simply *aadhaige miyaru* (common shark).

Despite the local importance of silky sharks in the Maldives there has been no regular catch or biological data collection for this species. Similarly, for the Indian Ocean as a whole, most catches are unreported, and there are no published, long-term data series. It is therefore difficult to make informed judgements about the status of this species in this ocean.

In the absence of such information, the Indian Ocean Tuna Commission has recognised the need to identify and monitor other indicators of shark stock status (IOTC, 2007:11). In other regions, experienced fishermen have proved to be important sources of insights into major trends in fish abundance (Johannes *et al.*, 2000; Sáenz-Arroyo *et al.*, 2005). This paper reports the results of five small polls of opinion (four of experienced fishermen, one of householders on a small shark fishing island) in the Maldives relating to the status of the local shark fishery and to silky shark abundance in particular.

Methods

Information was obtained by interviews during the course of five surveys. In three surveys interviewees were selected at random; in another two surveys knowledgeable and experienced fishermen were recommended by authoritative locals. Interviewees' opinions about changes (in state of the shark fishery, abundance of sharks, or size of

sharks, over a specified number of years) were recorded on a five-point scale (e.g. much better, better, same, worse, much worse). Questions about changes were asked in a non-leading fashion (e.g. had there been a change, if so for better or worse, if so a bit better or much better?). In four surveys pre-printed questionnaires were used; in one survey (no. 3 below) questions were asked without a questionnaire as part of a wider-ranging interview. In all cases additional questions not related to the shark fishery were asked; these included at least two questions to which we had some independent means of assessing reliability of responses (e.g. about the status of the skipjack fishery, for which official catch and effort statistics are available). A summary of some major features of the surveys is given in Table 1, and details are given below:

(1) Householders at H.Dh. Kulhudhuffushi

As part of a regional development project, RCA made three visits to the island of Kulhudhuffushi in Haa Dhaalu Atoll in the north of Maldives, during Oct-Nov 2000, May-June 2002 and Oct 2002. This island is a major centre of shark longlining. During the second of these visits, during a period of bad weather when most fishermen were at home, a household survey was conducted to assess the socio-economic importance of the shark fishery to the island (Anderson, 2002a). From a register of all households on the island (n=1120), 10% were chosen at random. Six of these were empty when visited, and so 106 households (9.5%) were surveyed. The survey was conducted, using printed forms, by Hussein Ahmed (MRC, Malé), Aminath Nileesha (Environmental Research Centre, Malé) and Ibrahim Hassan (Northern Regional Development Programme Management Office, Kulhudhuffushi) under the supervision of RCA. Householders were asked a number of questions, including their opinion of the status of the shark fishery, and the major sources of household income, both at the time and 4-5 years before.

(2) Shark longline fishermen at H.Dh. Kulhudhuffushi

During the course of the household survey (1, above), when a household included a shark fisherman (n=44), either active (n=17) or recently 'retired' (n=27) he was asked additional questions. These included his opinion of the status of the shark fishery compared to 4-5 years earlier, his earning at the time and 4-5 years before, and, for those who had left the fishery, their reason(s) for doing so. These questions were posed by the same team as in survey (1), using an additional printed questionnaire.

(3) Tuna fishermen in four northern atolls

During the course of a bait fisheries survey in June 2009, the opportunity was taken to ask livebait pole and line fishermen in Noonu, Raa, Baa and Lhaviyani Atolls their opinions about the status of silky shark resources. 23 fishermen were interviewed by RJ and RCA on 10 islands. Interviewees were experienced master-fishermen (typically over the age of 40) recommended by a senior figure on each island (typically the island chief or school headmaster). They were asked mainly about the livebait fishery, but also about the relative abundance and the relative size of silky sharks at the time, compared to 20 years ago.

(4) Tuna fishermen telephone survey

During September and early October 2009 a telephone survey was conducted of 21 tuna fishermen on 15 islands in 10 atolls. The survey was conducted by RJ and

Yousuf Rilwan of the Marine Research Centre. Experienced fishermen were selected on the basis of recommendations of MRC field officers based in 12 atolls.

(5) Tuna fishermen at Malé market

During September and early October 2009, 31 tuna fishermen at Malé market were interviewed. These fishermen were from eleven islands in six atolls. Malé is the island capital of Maldives; it is the only major town in the country and has the largest fish market in the country. Older, experienced-looking fishermen were asked the same questions, using the same form, as in survey 4. Interviews were conducted by two-man teams, from among three MRC staff who are responsible for regular length frequency sampling at the market (Hassan Hamid, Ali Yashau and Mohamed Azan, Azan), under the supervision of RCA and RJ.

Table 1. Summary of major attributes of surveys
(LL = longline, PL = pole and line, HL = handline)

Survey	Date	Atoll	Island	No. interviewees	Occupation
1	May-June 2002	HDh	Kulhudhuffushi	106	Householders
2	May-June 2002	HDh	Kulhudhuffushi	44	Shark LL
3	June 2009	N, R, B, Lh	10 islands	23	Tuna PL
4	Sept-Oct 2009	10 atolls	12 islands	21	Tuna PL & HL
5	Sept-Oct 2009	7 atolls	11 islands	31	Tuna PL & HL

Results

(1) Householders at H.Dh. Kulhudhuffushi

The shark longline fishery was a major source of income for just 11% of households in 2002, down from 28% of households 4-5 years previously. 42% of households had included shark fishermen at some time, but only 15% included shark fishermen in 2002. Householders' opinions on the status of the shark fishery are summarized in Table 2. Most householders (81%) felt that the shark fishery was worse or much worse than it was 4-5 years previously. In general, interviewees whose households included or had included a shark fisherman thought that the fishery was in a worse state than households that had no such connection with the shark fishery. 90% of shark-fishing householders thought that the fishery was worse than 4-5 years before, whereas 26% of non-shark-fishing householders thought that the fishery was better or much better (despite evidence to the contrary).

Table 2. Opinions of H.Dh. Kulhudhuffushi islanders and fishermen on the status of the shark longline fishery in 2002 compared to 4-5 years before

Survey	Interviewees	Relative status of shark fishery					N
		Much better	Better	Same	Worse	Much worse	
1	Non-shark fishing households	20.6%	5.9%	0	8.8%	64.7%	34
	Shark fishing households	2.8%	5.6%	2.8%	11.1%	77.8%	36
	All households	11.4%	5.7%	1.4%	10.0%	71.4%	70
2	Lapsed shark fishermen	4.5%	4.5%	0	4.5%	86.4%	22

Active shark fishermen	0	0	6.3%	12.5%	81.3%	16
All shark fishermen	2.6%	2.6%	2.6%	7.9%	84.2%	38

(2) Shark longline fishermen at H.Dh. Kulhudhuffushi

The majority of shark fishermen (both active and retired) felt that the fishery was much worse than it was 4-5 years earlier (Table 2). No active fisherman felt that the fishery was better than it had been. Among men who had recently stopped shark fishing (n=23) only two cited a decline in the shark fishery as the main reason for leaving. However, 19 (83%) of these stated that they left because of low income or better opportunities elsewhere. Few fishermen were able (or willing) to give precise information on earnings, and the responses received showed that earnings were highly variable. Nevertheless, reported average earnings during the high season (when fishermen made most of their income) were about 34% lower in 2002 than they were 4-5 years previously, dropping from MRf 6208 (n=33, range MRf 300-18000) to MRf 4115 (n=12, range MRf 800-8000).

(3) Tuna fishermen in four northern atolls

All pole and line tuna fishermen were familiar with silky sharks, and saw them regularly both as juveniles under drifting objects and fish aggregating devices (FADs) and as adults associated with free-swimming tuna schools. Nearly all reported that silky sharks were very much less abundant than they had been about 20 years earlier (Table 3), and that silky sharks were much smaller than they had been (Table 4).

Table 3. Opinions of fishermen on the **abundance** of the silky sharks in 2009 compared with 20 years before

Survey	Interviewees	Sharks	Relative abundance of silky sharks					N
			Much more	More	Same	Fewer	Much fewer	
3	Tuna fishermen	Silky	0	0	4.3%	0	95.6%	23
4	Tuna fishermen	S. silky	0	4.8%	4.8%	57.1%	33.3%	21
4	Tuna fishermen	L. silky	0	0	0	23.8%	76.2%	21
5	Tuna fishermen	S. silky	0	0	0	19.4%	80.6%	31
5	Tuna fishermen	L. silky	0	3.2%	3.2%	41.9%	51.6%	31

Table 4. Opinions of fishermen on the **size** of the silky sharks in 2009 compared with 20 years before

Survey	Interviewees	Sharks	Relative size of silky sharks					N
			Much larger	Larger	Same	Smaller	Much smaller	
3	Tuna fishermen	Silky	0	0	0	9.5%	90.5%	21
4	Tuna fishermen	S. silky	0	0	14.3%	52.4%	33.3%	21
4	Tuna fishermen	L. silky	0	0	23.8%	23.8%	52.4%	21
5	Tuna fishermen	S. silky	0	0	3.3%	56.7%	40.0%	30
5	Tuna fishermen	L. silky	0	3.4%	10.3%	27.6%	58.6%	29

(4) Tuna fishermen telephone survey

Tuna fishermen from 12 islands were interviewed by telephone. Over 90% thought small silky sharks were less abundant than they had been 20 years earlier, while 100% thought large sharks were less abundant. About 85% of interviewees thought that both large and small silky sharks were smaller than 20 years before.

(5) Tuna fishermen at Malé market

Tuna fishermen interviewed at Malé market came from a range of islands scattered throughout the country. 100% thought that small silky sharks were less abundant than they had been 20 years earlier, and 90% thought the same for large silky sharks. 96% thought that small silky sharks were smaller than 20 years before, while 86% thought large silky sharks were smaller.

Discussion

The responses given by fishermen and householders present a remarkably consistent picture of decline in the abundance of silky sharks around the Maldives. Tuna fishermen interviewed in 2009, overwhelmingly reported a decline in the abundance of silky sharks (be it all, small or large) over the past 20 years (Table 3). In every case more than 90% of fishermen reported that silky sharks were less or much less abundant than they had been.

Nearly all tuna fishermen also reported a decline in the average size of silky sharks over the past 20 years (Table 4). One fisherman wryly stated that he could not comment on size as he never saw silky sharks any more.

Nevertheless, the responses are subjective and qualitative. To what extent are they a reliable reflection of silky shark status, and can they be used to provide a quantitative index of change?

Reliability of responses

Most fishermen have extensive traditional or local knowledge about the biology of the species that they exploit (e.g. Johannes, 1981; Zann, 1985). There is a growing body of evidence demonstrating that this knowledge can provide valuable insights into the status of exploited fish populations that might not be available from other sources (e.g. Johannes *et al.*, 2000; Sáenz-Arroyo *et al.*, 2005), providing, among other things, that due care is taken in the choice of knowledgeable informants (Davis and Wagner, 2003).

In our experience (which includes working with Maldivian fishermen over a combined total of more than 40 years), Maldivian fishermen will, when approached in an appropriate way, give accurate answers to factual questions based on their own observations (e.g. is species X more or less abundant than before?). In contrast, when asked to give explanations for their observations (e.g. why has species X changed in abundance?), they may give almost any answer. Often they will give local explanations for something with a regional cause, and these explanations often appear to be based on the flimsiest of evidence or preconceived notions. This agrees with Zann (1985) who, working in the Pacific, noted that “atoll fishermen are astute

observers of natural phenomena. While many of their explanations may be steeped in spiritualism and folk lore, their actual observations are highly reliable.”

In the case of this survey, questions were limited to the factual, e.g. what is the change in the abundance or size of silky sharks over a set time period. While interviewees were also asked for their opinions on the causes of these changes (which were mainly related to local observations, not regional activities), these are not included here.

To provide some check on the reliability of responses, we included questions in our interviews unrelated to silky sharks and shark fishing, for which we had some prior knowledge. In almost every case interviewees gave responses that were compatible with our existing understanding. For example, during survey 3 we asked pole and line tuna fishermen about the seasonality of different livebait species. All answers received were consistent with our existing knowledge. For these shark surveys, nearly all fishermen gave ‘expected’ answers for questions relating to both sharks and other species. However, in surveys 3 and 5, one fisherman in each case did give eccentric answers to several questions (relating to both sharks and other species), suggesting that they were not reliable informants. We nevertheless include their responses here (Tables 3 and 4). All other fishermen gave responses that were consistent both internally and with other interviewees.

Another indication of reliability was provided by results from the shark-fishing island of Kulhudhuffusi in 2002, where the best-informed interviewees gave the most pessimistic assessments (Table 2). Thus, the percentage of interviewees who thought that the shark fishery was worse or much worse than it had been 4-5 years previously increased with increased knowledge:

Householder (non-shark fishing house)	73.5%
Householder (shark fishing house)	88.9%
Shark fisherman (lapsed)	90.9%
Shark fisherman (active)	93.8%

Quantification

Nearly all fishermen report a decline in the abundance of silky sharks around the Maldives, over both 4-5 and 20 year time periods. Most say not just that there are fewer sharks now, but that there are much fewer sharks. It seems clear that there has been a significant decline in abundance. However, putting a value on the magnitude of that decline is not straightforward.

The earnings data collected during the survey of shark longline fishermen (survey 2) provide one perspective. Those fishermen reported that average earnings were about MRf 4100 in 2002 and MRf 6200 about 4-5 years earlier, a fall of 34%. During this same period, the value of shark fins increased by 48%, from MRf 374 in 1997-98 to MRf 554 in 2002 (source: Maldives Customs data compiled by Ministry of Fisheries and Agriculture). Since income is based directly on catches, and most of the value of the catch is in the fins, this suggests that shark catch rates may have declined by at least 50% over that 4-5 year period.

Although fishermen were not asked to put a quantitative value on the decline in the abundance of silky sharks that they had experienced, several did volunteer opinions. Among those who did comment, all said that numbers had decreased by more than 50%. Several said quite independently that numbers were now only about 10% of what they had been 20 years earlier. Two stated that there were next to no sharks now compared to earlier years.

In addition, several fishermen volunteered information about catch sizes, recalling instances in the past when a few hundred silky sharks were taken during one day's fishing; such catches are now unthinkable. Several fishermen stated that they typically see just a handful of sharks each year now. One fisherman reported that he had seen just one shark at a FAD (where they used to aggregate in numbers) during the whole of last year.

These reports are consistent with our own observations. For example, during Maldivian tuna tagging activities conducted during December 2008 to April 2009 MRC tagging teams saw only four sharks during 52 days at sea. And during a survey in January-May 2009, a total of 24 dives were made on 8 separate FADs, with specific aims of surveying and tagging sharks; only 4 small sharks (all silky sharks) were seen and none could be tagged. These numbers were very much less than expected based on our previous experience.

Conclusions

Based on the data presented here, it is clear that silky shark numbers are now much smaller than they were in the waters around the Maldives. We are hesitant to put a precise figure on the scale of decline reported by Maldivian fishermen. But from their reports, silky shark abundance is almost certainly less than 50% of what it was 20 years ago, and perhaps as little as 10%.

The silky shark is a highly migratory species; it occurs throughout the tropical Indian Ocean; and there is believed to be just one stock in the Indian Ocean (Bonfil, 2008). It is clear from the reports of experienced Maldivian fishermen that silky shark abundance has declined significantly in the waters around the Maldives. The implication is that the population of this species has been grossly overfished right across the ocean.

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