# Citizen-based Observations on Shark and Mobulid Species in Tobago,West Indies

**Lanya Fanovich[1*], Neil D. Cook[1], Ryan S. Mohammed[1,2] and Aljoscha Wothke[1]**

1. Environmental Research Institute Charlotteville (ERIC)
2. Department of Life Sciences, The University of the West Indies (UWI)
*corresponding author: *ericecologist@eric-tobago.org*

**ABSTRACT**

Recreational dive operators in Tobago have indicated that shark and mobulid species sightings have become increasingly rare. However, in the absence of documentation these trends are difficult to verify. We engaged nine dive operators and collated the sightings of sharks and mobulid rays for the period November 2015 to January 2017 in Tobago. From the data, we conclude that nurse sharks,*Ginglymostoma cirratum* are the most commonly sighted and widely distributed shark species both spatially and temporally. Overall, eight shark species and two mobulid species were recorded. This report highlights the importance of citizen-based science in identifying key areas for future research into Tobago's shark and mobulid populations.

**Key words**: *Ginglymostoma*, *Sphyrna*, *Carcharhinus*, *Mobula*, *Squalus*, *Negaprion*, Tobago dive site, citizen science

## INTRODUCTION

Historical accounts of recreational diving in Tobago describe flourishing coral reefs with diverse and plentiful fish assemblages, fields of gorgonians and widespread hard coral cover. Sightings of hammerhead sharks (*Sphyrna* spp.), reef sharks (*Carcharhinus* spp.) and manta rays (*Mobula* spp.) were common throughout the year (A. Wothke, pers. obs.). In recent years the chances of observing sharks and mantas during recreational dives have consistently diminished to the point where nurse sharks (*Ginglymostoma cirratum*) are the most commonly encountered, albeit in small numbers (Authors and dive tour operators, pers. obs.).

There is growing global concern regarding shark and manta declines, and the future ramifications of their removal and consequential trophic cascades (Heithaus *et al.*, 2008). Furthermore, ethical considerations associated with shark finning have been highlighted in the media. Economically speaking, studies of the global socio-economic benefits of manta ray dive and snorkel tours estimate a direct revenue of US$73 million annually, in contrast to the value of the international manta ray gill plate trade of US$5 million annually (O'Malley, Lee-Brooks and Medd 2013). Shark-based tourism in Palau generates US$18 million in business and tax revenue per year, (Vianna *et al.* 2012). Similarly, Anderson and Ahmed (1993) determined that grey reef sharks (*Carcharhinus amblyrhynchos*) are a magnitude of 100 times more valuable alive than dead in the Maldives. There has been research on the willingness to pay for turtle sightings by recreational divers, which indicated a significant non-use value of these species (see Cazabon-Mannette *et al.* 2017), but as yet there are are no similar studies estimating the value of sharks and mantas to tourism in Tobago.

Sharks rank fourth in Trinidad and Tobago's artisanal fisheries estimated landings, primarily as bycatch from gill-nets, and hook and line fisheries (Shing 2006). International long liners use Trinidad and Tobago's ports as transhipment points, resulting in the country being listed among the top 15 suppliers of dried and frozen fins, according to the Hong Kong 2011 Census Trade Statistic (Pew Environment Group 2012; Solomon 2017). Data indicating the quantity of sharks caught in Trinidad and Tobago's waters are limited.

Mobulid rays (*Mobula* spp.) and sharks such as hammerhead (*Sphyrna* spp.) and silky sharks (*Carcharhinus falciformis*) have been documented in Tobago's waters (FAO 2002), and are listed under CITES Appendix II (CITES 2017). These inclusions and the development of International and National Plans of Action (Shing 2006) towards regulating shark fisheries, are intended to improve and develop shark and manta conservation, and sustainable resource use.

A growing number of studies have focused on the ecological role of sharks as meso- and apex predators, both in oceanic and coral reef ecosystems, and the potential ecological and economic consequences of their decline due to direct and indirect fishing pressure (Heithaus *et al.* 2008). Studies on the roles of mobulid rays have lagged behind somewhat, although recent isotopic analyses and electronic tag studies suggest that *Mobula birostris* may be a primarily mesopelagic forager, contradicting historic reports of a predominantly surface zooplankton diet (Burgess *et al.* 2016). Continued research is needed to further understand the ecological role of mobulid rays in marine ecosystems (Sobral 2013).

While fisheries data are important for establishing trends in elasmobranch populations, the use of citizen-based observations plays an increasingly valuable role in elucidating distribution patterns of sharks and mobulid rays (Ward-Paige *et al.* 2010a; Ward-Paige and Lotze

2011). Citizen observers increase the number of observations by visiting a greater number of sites at a higher frequency than would be possible for scientific divers (Ward-Paige *et al.* 2010b).

For this study, the Environmental Research Institute Charlotteville (ERIC) collaborated with Tobago's dive operators to determine spatial and temporal trends for species of shark and mobulid rays using observations made during their recreational dive activities.

## METHODOLOGY

On a weekly basis, nine dive operators submitted data for all shark and manta sightings from their recreational dives. The submitted data included date, location, species, estimated total length (TL) of sharks (from snout to tip of caudal fin), and estimated wingspan of mobulid rays (width across body from tips of pectoral fins). The data collection covered a 14-month period from November 2015 to January 2017.

Hammerhead sharks were classified as *Sphryna* sp. since identification to species level was not possible from all diver operators. Manta rays were historically classified as *Manta* spp., however recent phylogenetic research determined significant morphological and genetic similarities between *Manta* spp. and mobula rays *Mobula* spp. (White *et al.* 2017). As a result, a single genus, *Mobula* spp. is now recognised (White *et al.* 2017). Since mantas and other mobula rays (also known as devil rays) were reported as separate species by dive operators, due to their distinct diagnostic features they are treated separately and are referred to by their common names. The description "mobulid ray" refer to both species collectively. This study does not include rays outside of the family Mobulidae.

## RESULTS

### Dive operator sightings

Eight species of sharks from four families (Carcharhinidae, Ginglymostomatidae, Sphrynidae and Squalidae) and at least two species of mobulid rays (*Mobula* spp.) were identified. Nurse (*G. cirratum),* blacktip (*Carcharhinus limbatus*) and Caribbean reef sharks (*Carcharhinus perezi*) were the most frequently reported among the shark species while manta rays were most often sighted among the mobulid species (Table 1).

The highest number of recreational dive events with affirmative shark and mobulid ray sightings occurred in November 2015 (40) and 2016 (27). Consequently, these two months also represented the highest number of reported sharks and mobulid rays with 85 and 74 individuals respectively.

Overall, 352 individual sightings of *G. cirratum* were recorded, with numbers peaking in November 2015 (72) and 2016 (69) in contrast to other months (Table 1). *C. limbatus* was the second most reported shark species with

**Table 1.** Total number of sightings of each species per month from November 2015 to January 2017

| Month | Number of dives | Species | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Carcharhinus falciformis* | *Carcharhinus leucas* | *Carcharhinus limbatus* | *Carcharhinus perezi* | *Ginglymostoma cirratum* | *Mobula* sp. (Manta) | *Mobula* sp. (Devil ray) | *Negaprion brevirostris* | *Sphyrna* spp. | *Squalus cubensis* | Total number of sightings |
| Nov-15 | 40 | 0 | 0 | 5 | 0 | 72 | 6 | 1 | 1 | 0 | 0 | 85 |
| Dec-15 | 22 | 0 | 0 | 2 | 4 | 27 | 1 | 0 | 0 | 1 | 0 | 35 |
| Jan-16 | 11 | 0 | 0 | 1 | 0 | 10 | 2 | 0 | 0 | 0 | 0 | 13 |
| Feb-16 | 12 | 0 | 0 | 1 | 0 | 17 | 3 | 0 | 0 | 0 | 0 | 21 |
| Mar-16 | 15 | 0 | 0 | 0 | 5 | 20 | 4 | 0 | 0 | 0 | 0 | 29 |
| Apr-16 | 12 | 1 | 0 | 1 | 1 | 10 | 2 | 0 | 0 | 0 | 0 | 15 |
| May-16 | 10 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 11 |
| Jun-16 | 10 | 0 | 0 | 2 | 0 | 14 | 1 | 0 | 0 | 0 | 0 | 17 |
| Jul-16 | 23 | 0 | 0 | 0 | 0 | 19 | 7 | 3 | 0 | 2 | 0 | 31 |
| Aug-16 | 13 | 0 | 0 | 1 | 0 | 14 | 4 | 0 | 0 | 0 | 0 | 19 |
| Sep-16 | 8 | 0 | 1 | 0 | 1 | 6 | 4 | 0 | 0 | 0 | 0 | 12 |
| Oct-16 | 8 | 0 | 0 | 0 | 0 | 29 | 0 | 0 | 0 | 0 | 0 | 29 |
| Nov-16 | 27 | 0 | 0 | 0 | 1 | 69 | 4 | 0 | 0 | 0 | 0 | 74 |
| Dec-16 | 8 | 0 | 0 | 15 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 28 |
| Jan-17 | 12 | 0 | 1 | 0 | 4 | 21 | 0 | 0 | 0 | 0 | 1 | 27 |
| Total | 231 | 1 | 2 | 28 | 16 | 352 | 38 | 4 | 1 | 3 | 1 | 446 |

28 sightings during the study period. An unusual spike in sightings of this species in December 2016 was observed (Table 1). Manta sightings were consistent throughout the study period with 38 individuals reported over 14 months, and no record of their presence for four months (Table 1). The remaining five species, bull shark (*Carcharhinus leucas*), Cuban dogfish (*Squalus cubensis*), hammerhead shark (*Sphyrna* spp.), lemon shark (*Negaprion brevirostris*) and silky shark (*Carcharhinus falciformis)* made very rare appearances (Table 1).

**Length estimates of *G. cirratum***

*G. cirratum* were reported ranging from estimates of 0.6m total length (TL) to 3.0m TL (Fig. 1). Eighty percent of all individuals were between 1.1m TL and 2.5m TL wherein 131 individuals were estimated between 1.1m TL and 1.5m TL. 10% of individuals were small, ranging between 0.6m TL and 1.0m TL whereas only 21 were greater than 2.5m TL (Fig. 1). The estimated total lengths of 11 *G. cirratum* were unrecorded.

**Shark and mobulid ray distribution**

Dive sites with reported sharks and mobulid rays were combined into five geographical regions around Tobago (Fig. 2). The fifth region, approximately 46km south of Scarborough and 33km east of Toco, Trinidad, is not shown on the map.

Dive operators reported shark and mobulid ray sightings at 28 recreational dive sites in Region 3, in the northern Atlantic. This region also showed the greatest diversity with five species of shark including, *N. brevirostris* and *C. falciformis*, and two species of mobulid rays (Table 2).

There were three species each in Regions 1 and 2 in the south and north Caribbean respectively (Fig. 2) and these were the only areas with sightings of *Sphyrna* spp. (Table 2). *G. cirratum* was present in the four regions surrounding Tobago. No sightings of *G. cirratum* were made in Region 5, however this represents the lone site at which *S. cubensis* was reported (Table 2). *C. leucas* sightings were confined to south Tobago in Regions 4 and 5 (Table 2).

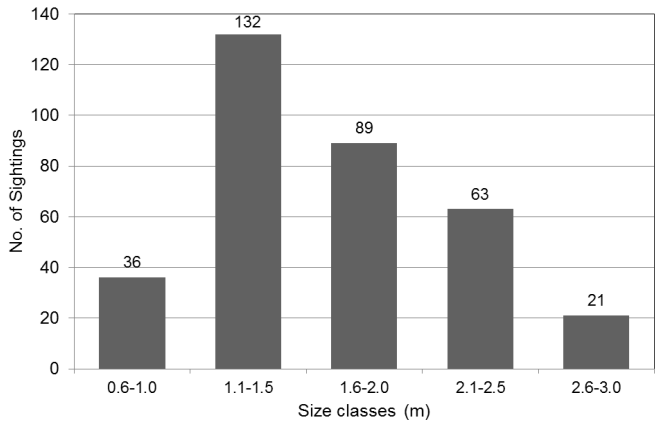


**Fig. 1** Estimated total lengths (TL) of *G. cirratum* recorded from November 2015 to January 2017.

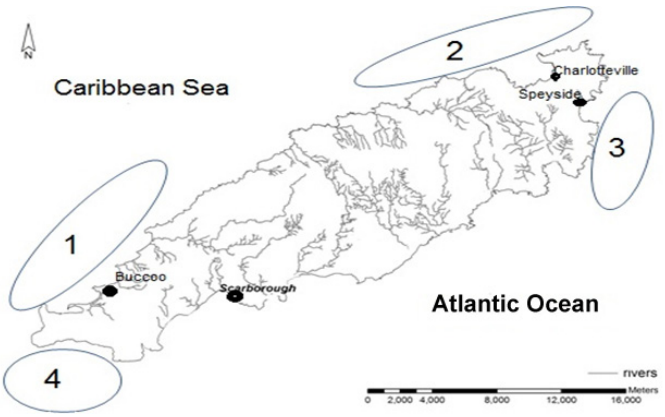


**Fig. 2.** Location of four of the five dive regions. The fifth region is located 46km south of Scarborough and is not shown on this map.

**Table 2.** Number of encounters of each species at the five dive regions in Tobago (Number of reported dive sites per region in parentheses)

| Species | Region 1 (13 sites) | Region 2 (6 sites) | Region 3 (28 sites) | Region 4 (14 sites) | Region 5 (1 site) |
|---|---|---|---|---|---|
| *Carcharhinus falciformis* | 0 | 0 | 1 | 0 | 0 |
| *Carcharhinus leucas* | 0 | 0 | 0 | 1 | 1 |
| *Carcharhinus limbatus* | 0 | 0 | 23 | 5 | 0 |
| *Carcharhinus perezi* | 0 | 4 | 3 | 4 | 5 |
| *Ginglymostoma cirratum* | 15 | 8 | 61 | 267 | 0 |
| *Mobula* sp. (Manta) | 13 | 0 | 19 | 7 | 0 |
| *Mobula* sp. (Devil ray) | 0 | 0 | 3 | 0 | 0 |
| *Negaprion brevirostris* | 0 | 0 | 1 | 0 | 0 |
| *Sphyrna* spp. | 2 | 1 | 0 | 0 | 0 |
| *Squalus cubensis* | 0 | 0 | 0 | 0 | 1 |
| Total number of species seen | 3 | 3 | 7 | 5 | 3 |

## DISCUSSION

The information provided in this report relies on diver reports of sightings of sharks and mobulid rays. It does not take into account the effort required at each site for successful sightings, specifically the number of visits per site, as these data were unavailable. However, we do know that Regions 1, 3 and 4 are generally areas frequented by more tourists and as such they support more dive operators. The effort of data collection was dependent on operation of dive shops and influenced by client availability, diver experience, site preference and conditions and is therefore highly variable.

Shark and manta identifications rely on the dive operators' cumulative decades of experience, however there are shark species with very subtle diagnostic traits that are easily missed. Species identification can be improved by providing dive tour operators with photographs highlighting these features. Marine turtle monitoring using recreational divers by Williams *et al.* (2015), demonstrated the validity of incorporating both photographic and non-photographic data recording, further emphasising the usefulness of citizen science.

Several other species of sharks and mobulid rays, not recorded in this report, are known from Tobago waters (FAO Keys 2002). However, these may not have been present at these specific dive sites since these sites are selected based on criteria of dive operators and not to cover a representative coverage of Tobago's marine habitats.

Anecdotal evidence from diver operators suggests that the chance of encountering large sharks during recreational dives around Tobago has decreased over time, perhaps with the exception of nurse sharks (*G. cirratum*). Unlike more mobile shark and manta species, *G. cirratum* has been documented as having strong site fidelity, often resting during the day and within possible aggregations (Rosa *et al.* 2006), arguably increasing the probability of diver encounter over a period of time. We suggest that spikes in *G. cirratum* sightings in November 2015 and 2016 (Table 1) may be due to larger aggregations at dive sites, more frequent dive activities, or repeated visits to sites with aggregations. Region 4 (Fig. 2), had the highest number of *G. cirratum* sightings.

No trends were observed with respect to aggregations among other species, with the exception of *C. limbatus* in December 2016, where a school of 15 individuals were present at a single dive site (Table 1). Mantas were recorded only in Regions 1, 3 and 4 (Table 2) perhaps due to lower dive frequency and frequently visited dive sites in Region 2, reducing the probability of encountering individuals. Contrary to anecdotal evidence that March and April were the ideal months for manta sightings, dive operator reports showed that individuals were present throughout the year. The four months with no sightings were scattered and since no pattern is apparent, it is likely that this species is present year-round.

Anecdotal evidence (dive tour operators) also describes aggregations of hammerhead sharks (*Sphyrna* spp.) migrating from the Gulf of Paria in Trinidad to the Caribbean coastline of Tobago, particularly from January to March. However, there were only three sightings in December 2015 and July 2016 (Table 1). Their location in Regions 1 and 2 (Table 2) supports previous reporting of their presence along the Caribbean coast.

There has been similar anecdotal evidence of bull shark (*C. leucas*) encounters along the eastern coast of Trinidad. Their presence in only Regions 4 and 5 (Table 2), located in the southern Atlantic end of Tobago (Fig. 2) and to the east of Trinidad reflects this. To prevent possible exploitation of the information by thrill-seekers and fishers, specific dive sites are not identified in this article.

Investigations in Florida indicated that male and females *G. cirratum* attain sexual maturity greater than 2.1m and 2.2m TL respectively, and juveniles at birth are between 28 to 30cm (Castro 2000). Based on the provided total length estimates of *G. cirratum*, 73% of individuals in our study were estimated under 2.1m. It seems likely that only a small percentage of those individuals sighted, and by projection the local population, are reproductively capable. A Belize survey (Pikitch *et al.*, 2005) indicated the reported TL range was 1.85m to 2.0m. However, in Brazil, Santander-Neto *et al.* (2011) noted a wider range of 0.73 to 2.74m TL, which closely matches the range found in our study (0.6 - 3m TL).

There is a lack of local data on elasmobranch diversity, abundance, distribution, biology and ecology. This study is a first step towards rectifying this situation. By gathering data using citizen-based observations, we capitalised on a cost-effective means of collecting preliminary baseline data that would not otherwise be economically or logistically feasible. Resources can now be deployed focusing on specific regions for further work, such as deployment of baited remote underwater video (BRUV) for data collection. Additionally, an assessment of the economic value of elasmobranchs to Trinidad and Tobago both as a consumptive and non-consumptive resource is necessary to formulate adequate shark fisheries management, including regulations and conservation measures such as the establishment of marine protected areas or shark sanctuaries.

Our study confirmed the presence and distribution of ten species of elasmobranchs and also highlights the importance of citizen-based science in identifying key areas for future surveys. These subsequent surveys should involve rigorous scientific techniques such as BRUV deployment,

and underwater visual census specific to all elasmobranchs to fill the much-needed information gaps.

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