

New records of whale shark (*Rhincodon typus*), giant manta ray (*Manta birostris*) and Chilean devil ray (*Mobula tarapacana*) for Suriname

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Little is known about elasmobranchs along the northern coast of South America. During five boat surveys in Suriname offshore waters we visually documented the presence and behaviour of the free-ranging whale shark Rhincodon typus and two mobulid rays: the giant manta ray Manta birostris and the Chilean devil ray Mobula tarapacana. Three sightings were made of R. typus at the surface in shallow coastal waters where the water depth measured 46–67 m. One of these sightings was confirmed by photographs. Manta birostris was positively identified on five occasions while at the surface, all in shallow waters of less than 57 m deep. Four additional sightings, not accompanied by photographs, were identified as Manta spp. One devil ray, photographed and identified as Mobula tarapacana, was recorded at the surface in deep waters (2491 m) in July 2012. These records of R. typus, Manta birostris and Mobula tarapacana are the first for Suriname and therefore add to the documented information of these species within the Wider Caribbean Region and contribute to the knowledge of the pelagic distribution of these species.

Keywords: whale shark, *Rhincodon typus*, giant manta ray, *Manta birostris*, Chilean devil ray, *Mobula tarapacana*, Elasmobranchs, Wider Caribbean Region, Atlantic Ocean, geographical range

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INTRODUCTION

The whale shark (*Rhincodon typus* Smith, 1828) and rays of the family Mobulidae are large elasmobranchs found in tropical and temperate seas worldwide (Couturier *et al.*, 2012; Rowat & Brooks, 2012). Despite their wide range, very little is known of their pelagic distribution. *R. typus* are most frequently observed in areas of fish spawning events (Heyman *et al.*, 2001; Hoffmayer *et al.*, 2007; de la Parra Venegas *et al.*, 2011; Robinson *et al.*, 2013) and areas of major zooplankton blooms (Motta *et al.*, 2010; Ramírez-Macías *et al.*, 2012), although surface zooplankton may only be a component of their diet (Rohner *et al.*, 2013). The Mobulidae, comprising manta rays (*Manta* spp.) and devil rays (*Mobula* spp.), are largely planktivorous elasmobranchs. The genus *Manta* has at least two distinct species: the reef manta ray (*Manta alfredi* Krefft, 1868) and the giant manta ray (*Manta birostris* Walbaum, 1792). This genus was recently re-described with a third putative species, *Manta* sp. cf. *birostris* (Marshall *et al.*, 2009). *Manta* spp. are the largest rays and reach between 5 and 7 m disc width (W_D) (Compagno & Last, 1999;

Marshall *et al.*, 2009). The genus *Mobula* comprises nine recognized species attaining 1–5 m W_D and includes the pygmy devil ray (*Mobula eregoodootenkee* Bleeker, 1959), the Atlantic devil ray (*Mobula hypostoma* Bancroft, 1831), the spintail devil ray (*Mobula japonica* Müller & Henle, 1841), the shortfin devil ray (*Mobula kuhlii* Müller & Henle, 1841), the giant devil ray (*Mobula mobular* Bonnaterre, 1788), the Munk's devil ray (*Mobula munkiana* Notarbartolodi-Sciara, 1987), the lesser Guinean devil ray (*Mobula rochebrunei* Vaillant, 1979), the Chilean devil ray (*Mobula tarapacana* Philippi, 1893) and the bentfin devil ray (*Mobula thurstoni* Lloyd, 1908) (Notarbartolodi-Sciara, 1987). The identification of individual species of *Mobula* is often problematic because of the similarities between species within this taxon; these similarities have led to taxonomic ambiguities (Couturier *et al.*, 2012).

Assessment of the current conservation status of *Mobula* is further hampered by a paucity of information, resulting in a 'Data Deficient' status for *Mobula hypostoma*, *Mobula kuhlii* and *Mobula tarapacana* within the IUCN Red List for Threatened Species (Clark *et al.*, 2006a; Bizzarro *et al.*, 2006, 2009). Four species of *Mobula* are listed as 'Near Threatened' (*Mobula eregoodootenkee*, *Mobula japonica*, *Mobula munkiana* and *Mobula thurstoni*), one as 'Vulnerable' (*Mobula rochebrunei*) and one as 'Endangered' (*Mobula mobular*) (Pierce & Bennett, 2003; Bizzarro *et al.*, 2006; Clark *et al.*, 2006b;

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Notarbartolo-di-Sciara *et al.*, 2006; White *et al.*, 2006; Valenti & Kyne, 2007). *R. typus* and *Manta* spp. are listed as ‘Vulnerable’ (Norman, 2005; Marshall *et al.*, 2011a, b) with worldwide distributions.

R. typus are known to seasonally aggregate in near-shore waters off Western Australia (Colman, 1997), Belize (Heyman *et al.*, 2001), northern Mexico (Eckert & Stewart, 2001), the Philippines (Alava *et al.*, 2002), Djibouti (Rowat *et al.*, 2006), Mozambique (Pierce *et al.*, 2010), the Maldives (Anderson & Ahmed, 1993; Riley *et al.*, 2010) and the Seychelles (Rowat, 1997; Rowat & Gore, 2007). Recent records originating from purse-seine fisheries in offshore waters revealed that *R. typus* habitat suitability in the Atlantic, Indian and Pacific Oceans is driven by spatial variation in the bathymetry and sea surface temperatures (Sequeira *et al.*, 2012, 2014). *Mobula* spp. are regarded as pelagic or epipelagic species of coastal waters, and may be encountered in both shallow inshore environments and deeper offshore waters (Bizzarro *et al.*, 2007; Cortés & Blum, 2008; Scacco *et al.*, 2009; Canese *et al.*, 2011). *Manta alfredi*, *Manta birostris*, *Mobula japanica*, *Mobula tarapacana* and *Mobula thurstoni* have been reported from the Pacific, Atlantic and Indian Oceans (Clark *et al.*, 2006a, b; White *et al.*, 2006; Marshall *et al.*, 2009, 2011a, b; Kashiwagi *et al.*, 2011). *Mobula hypostoma* is a widely distributed species endemic to coastal and shelf waters of the western Atlantic Ocean. It can be found from North Carolina in the United States in the north, through much of the Gulf of Mexico and the Greater and Lesser Antilles, to northern Argentina in the south (McEachran *et al.*, 2002; Bizzarro *et al.*, 2009). *Mobula rochebrunei* has a limited distribution along the coastal areas of Western Africa, from Senegal to Angola (Notarbartolo-di-Sciara and Seret, in press).

Without the aid of underwater cameras the identification of aquatic animals to species level from ocean-going vessels is often problematic. However, as both *R. typus* and *Manta* spp. can be observed swimming just below the surface during feeding sessions and as both have unique colouration patterns (*R. typus* has white characteristic spots and stripes

on an overall dark blue body and manta rays have a unique skin pigmentation pattern on the ventral surface, e.g. Marshall *et al.*, 2009; Rowat & Brooks, 2012), then, given good viewing conditions, the positive identification of these species at sea is feasible.

Based on observations made during surveys of free-ranging marine fauna in Suriname offshore waters, we report on the presence and, where possible, the behaviour of *R. typus* and two mobulid rays: *Manta birostris* and *Mobula tarapacana*. Notable gaps exist in the knowledge of these species, particularly with respect to their migration routes and their range (Couturier *et al.*, 2012; Rowat & Brooks, 2012). Our observations therefore add to the documented information on these species within the Wider Caribbean Region (WCR) and contribute to the knowledge of the pelagic distribution of these species.

MATERIALS AND METHODS

Study area

Suriname is located on the north-east coast of South America, bordering the Atlantic Ocean, with French Guiana to the east and Guyana to the west (Figure 1), an area also known as ‘the Guianas’. These largely unexplored coastal areas, together with the eastern Venezuelan coastline, are heavily influenced by the Amazon River and ecosystems typically include estuaries, mudflats, sandy beaches and mangrove forests (Miloslavich *et al.*, 2011).

The North Brazil Current dominates the area and is characterized by large anti-cyclonic eddies. Upon reaching French Guiana this current splits; one branch diverges from the coast and joins the North Equatorial Counter Current, while the other branch continues flowing north-westwards to form the Guiana Current (Condie, 1991). The coastal waters off Suriname are loaded with sediment from the Amazon River carried by this Guiana Current. Between the 30 and 60 m isobath the water is coloured green due to the high abundance

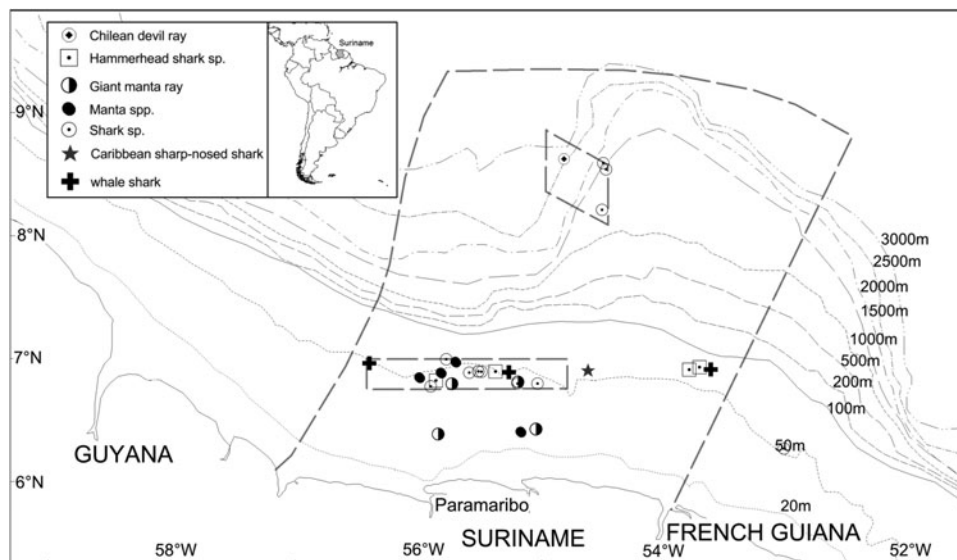


Fig. 1. Map of large elasmobranch sightings recorded during both the marine fauna surveys and during transits outside the study areas. The Exclusive Economic Zone of Suriname (large dashes) and the two main study areas (small dashed boxes) are also shown together with isobaths up to 3000 m.

of algae, whilst beyond the 60 m isobath the water is clear (Lowe-McConnell, 1962; Teunissen, 2000).

Survey design

Effort-related (dedicated) marine fauna observations were carried out within Suriname waters during three surveys from several geophysical survey vessels (surveys 1–3; Table 1). Incidental observations were also contributed from two additional geophysical surveys (surveys 4 and 5; Table 1); the authors were not present during these additional surveys and the methodology for these surveys was not specified.

Survey coverage was determined by the design of the geophysical surveys, which resulted in a series of parallel survey transects. During all surveys the coastal waters were occasionally surveyed opportunistically from supply vessels (*MV Opal*, *MV Maria G* and *MV Elizabeth C*) during transits to and from Paramaribo.

All research vessels operated with a survey speed of ca. 7.4 km h⁻¹. During surveys 1–3, observational efforts were conducted from the bridge wings and foredeck (14 m above sea level) with two observers (survey 1) or one observer (survey 2–3) monitoring ahead and to the side of the vessel (for further information on cetacean survey methodology; De Boer, in press). Observations were carried out during all daylight hours (0900–2200 h UTC). Sightings data included the time (UTC), position (from GPS), water depth, species, group-size and initial range and bearing to the sighting. Environmental observations were collected during the survey, these included wind speed and direction (from the ship's wind instruments), swell height, visibility and Beaufort Sea State (estimated by eye). In surveys 1 and 2, the water depth was measured using an acoustic Doppler current profiler, while in the remaining surveys the vessels' echo sounders were used. When conditions allowed, marine fauna were photographed to confirm the species identification using Sony, Nikon and Canon DSLR cameras with 70–200 mm, 70–300 mm and 100–400 mm zoom lenses respectively.

RESULTS

Most of the dedicated survey efforts in the coastal zones were carried out in waters between 40 and 50 m deep (69.2% of all efforts). A total of three *Rhincodon typus*, nine *Manta* spp. and one *Mobula tarapacana* were recorded (Table 2). Other species of elasmobranchs were also recorded, including four hammerhead sharks (*Sphyrna* sp.), one unconfirmed

Caribbean sharpnose shark (*Rhizoprionodon porosus*) and 12 unidentified sharks.

Whale shark (*Rhincodon typus*)

On 23 June 2013, *Rhincodon typus* was observed and photographed approximately 99 km off the north coast of Paramaribo (Figure 1). During the sighting, *R. typus* swam just below the surface and slowly passed ahead of the bow of the vessel (Figure 2). The shark had an overall darkish colouration with distinct white dots and stripes and a large, broad and rounded head. The dorsal fin and tip of the caudal fin were exposed. The shark was believed to be ram-feeding (Rowat & Brooks, 2012) although it was not possible to see if the mouth was open during the encounter. Two other incidental sighting records were made during surveys 4 and 5, but these were not substantiated by photographs. On both occasions, *R. typus* surfaced approximately 20–30 m away from the vessel but without breaking the surface. Both sharks were described as having an overall dark blue body with distinct white spotting; characteristics were consistent with the observers' identification of these sharks as *R. typus*. No further details were observed regarding any of the *R. typus* sightings due to the irregular sea surface distorting the view.

Giant manta ray (*Manta birostris*)

Of all the *Manta* sightings, *Manta birostris* was sighted on five occasions and verified by photographs (Figure 3). The following identification features were noted: (1) a large body size of 4–5 m W_D; (2) a black dorsal surface; (3) very distinct shoulder patches present in the supra-branchial region; (4) these shoulder patches occurred on either side of a dark midline and were approximately triangular in shape; and (5) long curved pectoral fins. Occasionally the following features were also noted: (6) a distinct pale chevron-shaped patch in the region of the dorsal fin; (7) a white ventral surface visible during breaching events; and (8) white pectoral fins on ventral and dorsal surfaces exposed during surface feeding events. On 17 May 2012, a pair of *M. birostris* was recorded; these rays were following each other, swimming just below the surface and exposing the tips of their dorsal fins. On 5 July 2013, *M. birostris* was seen repeatedly leaping clear of the water. During surveys 4–5, four incidental sightings were made of *Manta* spp. (though they remained unidentified as they were unsubstantiated by photographs). All *M. birostris* sightings were made between 43 and 88 km from the coast and in shallow waters, ranging in depths of between 28 and 42 m. The records of unidentified *Manta* spp. were made in waters depths between 27 and 57 m.

Table 1. Summary of surveys.

Survey	Period	Research vessel	Water depth (m)	Mean distance to coast (km)
1	17 May–3 September 2012	<i>RV Western Regent</i>	1200–3600	280
2	12 June–5 July 2013	<i>RV Polarcus Naila</i>	40–60	80
3	6 August–18 September 2013	<i>RV Polarcus Naila</i>	40–60	80
4	4 December 2008–4 April 2009	<i>RV Geo Celtic</i>	40–60	80
5	9 April–5 June 2009	<i>RV Geo Celtic</i>	40–60	80

Multiple observers were involved with the data collection with MDB and JTS participating in surveys 1–3 and TPL in survey 1. None of the authors were present during surveys 4 and 5. Surveys 1–3 were effort-related (dedicated) marine fauna surveys, whereas observations made during surveys 4 and 5 are regarded as incidental sightings as survey methodology was not specified and no photographs were available.

Table 2. Summary of whale shark and mobulid ray sighting records.

Date	Time (UTC)	Latitude, longitude	Species	Group-size	Estimated size (m)	Water depth (m)	Distance to coast (km)	Beaufort Sea State
17/05/2012	12:54	6°21.78'N, 54°49.74'W	<i>Manta birostris</i>	2	4	30.1	43	4
12/07/2012	15:31	8°39.39'N, 54°47.21'W	<i>Mobula tarapacana</i>	1	2–2.5	2491.0	295	4
12/06/2013	16:19	6°52.43'N, 54°48.08'W	<i>Manta</i> spp.	1	Not recorded	57.0	99	3
23/06/2013	14:54	6°52.89'N, 54°14.92'W	<i>Rhincodon typus</i>	1	7	45.6	99	2
05/07/2013	21:44	6°24.36'N, 54°01.82'W	<i>Manta birostris</i>	1	Not recorded	27.7	43	2
05/07/2013	21:53	6°24.56'N, 54°01.85'W	<i>Manta birostris</i>	1	4	27.7	43	2
18/08/2013	19:51	6°47.74'N, 54°10.46'W	<i>Manta birostris</i>	1	4	41.8	88	4
06/09/2013	10:06	6°46.76'N, 54°42.88'W	<i>Manta birostris</i>	1	4.5	39.9	87	3
28/12/2008	13:18	6°54.50'N, 54°35.90'W	<i>Rhincodon typus</i>	1	Not recorded	67.0	127	2
27/01/2009	18:11	6°23.26'N, 54°09.09'W	<i>Manta</i> spp.	1	Not recorded	27.0	43	Not recorded
18/04/2009	11:15	6°57.25'N, 54°23.35'W	<i>Rhincodon typus</i>	1	Not recorded	50.0	111	4
18/04/2009	15:15	6°58.00'N, 54°40.83'W	<i>Manta</i> spp.	1	Not recorded	57.0	108	4
21/04/2009	15:45	6°50.18'N, 54°58.63'W	<i>Manta</i> spp.	1	2.5	50.0	98	4

Manta spp. were most likely *M. birostris* but no photographs were available to substantiate species' identification.

Chilean devil ray (*Mobula tarapacana*)

On 12 July 2012, a single devil ray was observed and photographed approximately 295 km off the north coast of Paramaribo (Figure 1). The water depth was 2491 m and the Beaufort Sea State was 4. During the sighting the devil ray swam slowly just below the surface and was photographed as it passed down the vessel's portside (Figure 4). The following identification features were noted: (1) the devil ray had a sandy-brown/buff and slightly greenish dorsal colouration; (2) was estimated to be 2–2.5 m W_D ; (3) had an elongated 'neck'; (4) an elongated posterior end to the disc; and (5) the cephalic fins were clearly visible and were pale in colour. No further details were observed due to the distortion of the view by the irregular sea surface.

DISCUSSION

Understanding the distribution and migration patterns of *Rhincodon typus*, *Mobula tarapacana* and *Manta birostris* is essential in identifying important mating, breeding and feeding grounds and migration routes and in understanding the potential effects of fisheries on these iconic species. Our records of free-ranging elasmobranchs contribute to the



Fig. 2. Whale shark *Rhincodon typus* photographed on 23 June 2013 (photograph © M.N. de Boer).

poorly documented pelagic distribution of *R. typus*, *Mobula tarapacana* and *Manta birostris* within the WCR.

Within the WCR, *R. typus* are known to aggregate annually at feeding locations off Gladden Spit in Belize (Heyman *et al.*, 2001; Graham & Roberts, 2007) and off the Yucatan Peninsula in Mexico (Motta *et al.*, 2010; Ramírez-Macías *et al.*, 2012). More recently, dense aggregations of *R. typus* were recorded offshore, to the east of Contoy Island off the Yucatan Peninsula (de la Parra Venegas *et al.*, 2011) and individuals are regularly sighted off Utila (Bay Islands) in Honduras

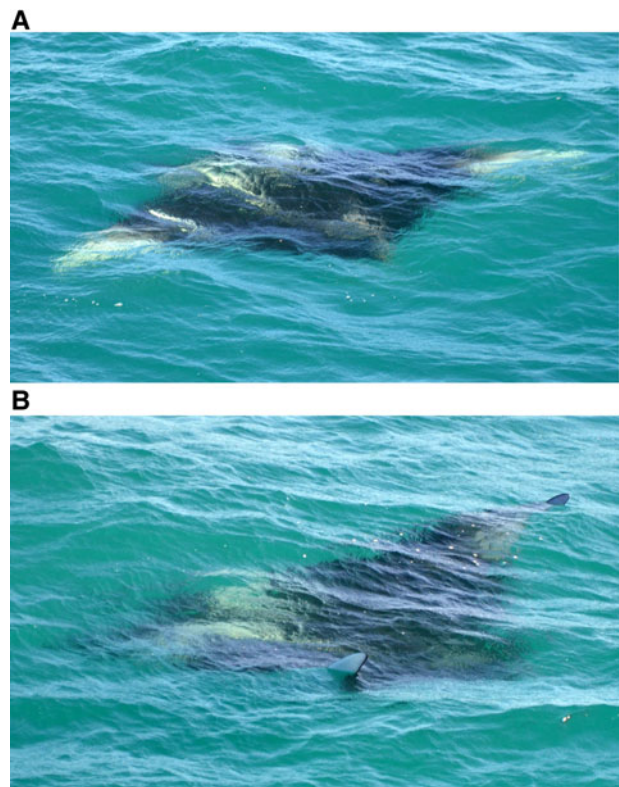


Fig. 3. Giant manta ray *Manta birostris* photographed on 18 August 2013: (A) pale chevron-shaped patch in the region of the dorsal fin; (B) distinct shoulder patches present in the supra-branchial region and exposed pale pectoral fin tips (photographs © J.T. Saulino).

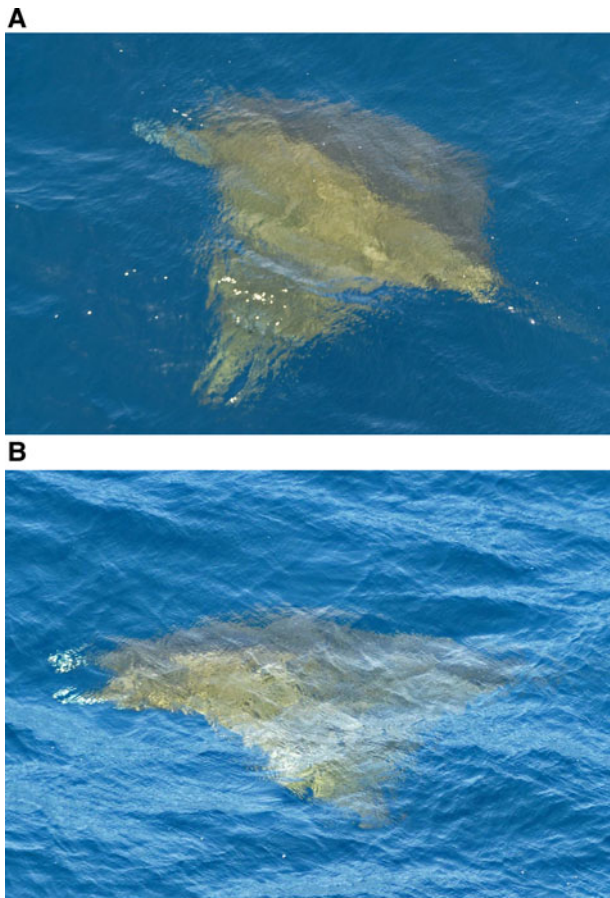


Fig. 4. Chilean devil ray *Mobula tarapacana* photographed on 12 July 2012: (A) sandy-brown/buff and slightly greenish dorsal colouration and elongated 'neck'; (B) elongated posterior end to the disc (photographs © J.T. Saulino).

(Fox *et al.*, 2013). *R. typus* are known to feed on lutjanid snappers, spawning off the coast of Belize between March and May (Graham & Roberts, 2007; Heyman *et al.*, 2001). Off the Yucatan Peninsula in Mexico, *R. typus* feed inshore on zooplankton blooms (Motta *et al.*, 2010; Ramírez-Macías *et al.*, 2012) and further offshore they feed on tuna eggs (de la Parra Venegas *et al.*, 2011). Off Venezuela, the highest concentration of *R. typus* records were from the Gulf of Cariaco, made during August–October, while a lesser peak in *R. typus* records was found in January–February (Romero *et al.*, 2000). The principal peak in occurrence in that study coincided with the period of greatest marine productivity in the area, as governed by wind-driven seasonal upwelling and inflow of freshwater from the Orinoco River. In the southern part of the Dutch Caribbean, *R. typus* have been reported in association with seasonal upwelling-driven productivity (Debrot *et al.*, 2013). *R. typus* has not been documented in Suriname previously. Local fishermen that were interviewed did not appear to be familiar with the species. Since records of shark catches are pooled and not specified by species, no useful information on the three species was forthcoming from fisheries bycatch data (Babb-Echteld *et al.*, 2000; Seijo, 2013). Within the region, *R. typus* are a known bycatch off Venezuela (Romero *et al.*, 2000). One of our *R. typus* sightings coincided with the full moon (23 June 2013), which is when *R. typus* have been reported to aggregate off Belize to forage on snapper spawn (Heyman *et al.*, 2001;

Graham & Roberts, 2007). One of the important commercial species in Suriname is the Caribbean red snapper (*Lutjanus purpureus* Poey, 1866), which spawns from May to August (though this can extend to October; Riley *et al.*, 2004). *R. typus* populating waters off Suriname may be attracted to a local area of high productivity in this coastal region whilst they are migrating through Suriname coastal waters to one of their main aggregation sites within the WCR (e.g. off Belize and off the Yucatan Peninsula). Little is known about the migration of *R. typus* between aggregations. Hueter *et al.* (2013) attached both conventional and satellite tags to *R. typus* off the north-eastern corner of the Yucatan Peninsula in Mexico. These authors found tracks that predominately lead to areas within the Gulf of Mexico and the Caribbean Sea, however they also found one long track that left Mexico in August, continued through offshore waters and ended at the south of the Saint Peter and Saint Paul Archipelago, off the coast of north-eastern Brazil, in January.

Manta birostris is most commonly found in coastal waters with high productivity. Within the WCR, its presence is well documented off Venezuela (Notarbartolo-di-Sciara & Hillyer, 1989) and off the Yucatan Peninsula in Mexico (Graham *et al.*, 2012). During aerial surveys off French Guiana it was the most commonly sighted megavertebate species (Mannocci *et al.*, 2013). Our *Manta birostris* records were made in shallow waters (<42 m), while sightings of *Manta* spp. were made in waters with a depth of 27–57 m. Manta rays were observed mainly in the months of January and April to September. These records coincided with the two rainy seasons that occur in Suriname (short rainy season: early December to early February; and the long rainy season: late April to the middle of August; Amatali, 1993). The outflow of the Amazon and several Suriname rivers contribute nutrient-rich water and lower the salinity in the neritic zone (Eisma & Bennekoum, 1969). The species was recorded off Venezuela between March and December with sightings peaking towards the end of the rainy season (Notarbartolo-di-Sciara & Hillyer, 1989). Similar seasonal patterns were recently described for south-eastern Brazil where the occurrence of *Manta birostris* coincided with a low-salinity front generated by outflow from the La Plata River (Luiz *et al.*, 2009). The authors are unaware of any documented records of *Manta birostris* for Suriname, however, some local Suriname fishermen, interviewed during the present survey, were familiar with *Manta birostris* (using the common name 'batfish'), suggesting that the species occurs regularly in the area. During most of our *Manta birostris* observations the rays were seen swimming just below the surface with their pectoral fins often curled up and protruding from the surface; characteristics we believed to be indicative of feeding. Our sample size is low, which is probably because the majority of the surveys took place in deep waters where this species is less common (Mannocci *et al.*, 2013). Nevertheless, our records suggest that the coastal waters off Suriname may be a feeding ground for this species, particularly during the rainy seasons.

Both *Mobula tarapacana* and *Mobula hypostoma* are known to occur in the tropical and sub-tropical Atlantic and the WCR (Clark *et al.*, 2006a, b; Bizzarro *et al.*, 2009). However, *Mobula hypostoma* reaches a maximum size of only 1.2 m W_D and occurs primarily in coastal waters, although they may occasionally enter oceanic waters (Bizzarro *et al.*, 2009), while *Mobula tarapacana* is larger

(2–3 m W_D) and has been reported in deep waters (>200 m) off Venezuela (Notarbartolo-di-Sciara & Hillyer, 1989). We are confident that our sighting can be identified as *Mobula tarapacana* and we base this identification on the following characteristics: (1) colour and size of the ray (all other *Mobula* rays with a light brown colouration are smaller in size); (2) the overall shape including specifically the elongated ‘neck’ and the elongated posterior end to the disc; and (3) the deep water habitat. *Mobula tarapacana* are predominantly oceanic (Thorrold *et al.*, 2014), but are occasionally recorded in coastal waters. Limited information is available for this broadly distributed ray (Clark *et al.*, 2006a). Records known for this species in the western Atlantic are from Venezuela, Brazil, Mexico and the United States (Texas; Clark *et al.*, 2006a). Sightings off Venezuela (21 records involving 32 animals) were made during aerial surveys between April and November (Notarbartolo-di-Sciara & Hillyer, 1989). Our record was made in July, the same month during which sightings peaked off Venezuela (Notarbartolo-di-Sciara & Hillyer, 1989). This is the first record for Suriname and its presence in the deep oceanic waters contributes to the documented distribution range of the species.

Manta birostris and *R. typus* are internationally classified as ‘Vulnerable’ species and the health of the populations of these species is now being examined accordingly. Shrimp trawling, snapper trawling and snapper long-lining take place in Suriname waters at depths of up to 80 m. In the Guianas there are clear signs of overexploitation of some species in fisheries, including *L. purpureus*, with declining catch rates and a decrease in the size of this species (Plouvier *et al.*, 2012). The pressure from fisheries on sharks and rays in Suriname is largely unknown as details of their catches in fisheries are often pooled and species are not specified (Babb-Echteld *et al.*, 2000; CARICOM, 2000; Seijo, 2013). However, it is known that sharks and rays are caught in trawl-gear and there are also large pelagic long-liners operating within the region that target elasmobranchs (Gillett, 2011; Seijo, 2013). Concerns have been raised over the bycatch of cartilaginous fish, including rays and sharks, in the Atlantic seabob shrimp (*Xiphopenaeus kroyeri* Heller, 1862) fishery off Suriname (Willems *et al.*, 2013). This fishery consists of about 20 vessels that typically operate 15–35 km offshore in Suriname waters. Willems *et al.* (2013) assessed the effectiveness of the recently installed net-adaptations including the Turtle Excluder Devices (TEDs) and Bycatch Reduction Devices (BRDs; square-mesh-window type) in the Suriname seabob shrimp trawling fishery. Fishermen do very occasionally catch *Manta* spp. in these fisheries (Willems, personal communication) but no *Manta birostris* were bycaught in that particular study, either during trawls fitted with TEDs and BRDs or during trawls without these (Willems *et al.*, 2013). It was found that TEDs and BRDs seem effective in reducing the bycatch of large pelagic rays, but less effective in protecting smaller demersal rays, such as *Gymnura micrura* Bloch & Schneider, 1801, *Dasyatis guttata* Bloch & Schneider, 1801 and *Urotrygon microphthalmum* Delsman, 1941.

The seasonal appearance of large elasmobranchs such as mobulids and *R. typus* is often related to temporal variability in the abundance of their prey (Notarbartolo-di-Sciara, 1988; Taylor, 1996; Wilson *et al.*, 2001). Zooplankton often congregates in areas where seasonal upwellings and fronts enhance the plankton productivity (Sims & Quayle, 1998; Wilson,

2004; Etnoyer *et al.*, 2006). The waters off Suriname are highly dynamic with eddies affecting local-scale currents further offshore. Furthermore, the region is influenced by the Amazon and several Suriname rivers (Gyory *et al.*, 2005); this probably creates localized areas of enhanced productivity and perhaps temporal feeding grounds for these large elasmobranchs.

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