

# First photographic evidence of oceanic manta rays (*Mobula birostris*) at two locations in the Fiji islands

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## Abstract

We present the first unequivocal evidence of oceanic manta ray (*Mobula birostris*) occurrence in Fijian waters. In November 2018, two individuals were sighted foraging in Laucala Bay, a large lagoon adjacent to Suva, the capital city of Fiji. Subsequently, three more individuals were sighted in December 2018, two individuals in July 2020 and at least six individuals were observed in November 2021, all foraging in the same geographical area. Unique ventral identification patterns could be obtained for six individuals, and three of these have been re-sighted since first identification, with one individual being documented in 2018, 2020 and 2021. Two additional individuals were recorded in the Yasawa Island Group in the west of Fiji while passing through and foraging in a channel between Drawaqa and Naviti Island in April and September 2020. We provide photographic identification of seven *M. birostris* individuals from two sites and discuss our findings in the context of local environmental parameters and other recorded sightings in the South Pacific region. In light of the global extinction risk of *M. birostris* and the recent reclassification from Vulnerable to Endangered on the Red List of Threatened Species, the expansion of their known distribution range to Fijian waters and the recurrence of individuals over consecutive years in the same location adds valuable information for the development of effective and data-driven conservation strategies.

## Introduction

Manta rays (*Mobula* spp.) are large and charismatic zooplanktivorous elasmobranchs found in tropical and subtropical waters throughout the world (Marshall *et al.*, 2020; Marshall *et al.*, 2019). The two recognised species, *Mobula birostris* (oceanic manta ray) and *Mobula alfredi* (reef manta ray) belong to the family Mobulidae together with seven other ray species. *M. alfredi*

is generally observed in nearshore areas or in the vicinity of continental coastlines, exhibiting small home ranges and a high degree of site fidelity (Couturier *et al.*, 2011) albeit exceptions have been observed, such as a reef manta ray recorded at Cocos Island nearly 6000km from the nearest confirmed sighting (Arauz *et al.*, 2019). The more widely distributed species, *M. birostris*, occurs in all three major oceans (Marshall *et al.*, 2020) often observed in pelagic environments, such as offshore seamounts, pinnacles or oceanic islands (Marshall *et al.*, 2009). Similar to other elasmobranchs, targeted and untargeted fisheries coupled with life-history traits, such as slow growth, late maturation, long gestation periods and low fecundity render both manta species particularly vulnerable to overexploitation (Couturier *et al.*, 2012; Dulvy *et al.*, 2014; Pardo *et al.*, 2016). Declining populations due to the aforementioned factors led to conservation concerns for both species, with *M. alfredi* listed as Vulnerable, and *M. birostris* listed as Endangered to Extinction on the IUCN Red List of Threatened Species (Marshall *et al.*, 2019, Marshall *et al.*, 2020).

On a national level, both manta ray species are legally protected in Fiji by the ‘Endangered and Protected Species Act (EPS)’ adopted in 2002, which requires permits to trade or land species listed in Appendix I, II or III of CITES, the ‘Convention on International Trade on Endangered Species of Wild Fauna and Flora’ (Fiji Government, 2002). Similarly, Fiji’s ‘Offshore Fisheries Management Act (OFMA)’ adopted in 2012 forbids the killing, taking, landing, selling and transporting of species listed in Appendix I and II of CITES (Fiji Government, 2012). Besides introducing national legislation, Fiji has repeatedly advocated for more protection on an international level. For example, in 2014 Fiji led the successful proposal for inclusion of all *Mobula* species in Appendix II of the ‘Convention on the Conservation of Migratory Species’ (Convention of Migratory Species, 2014), and in 2016, the successful proposal for inclusion of the same group in Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2016). Fiji reaffirmed their domestic ambitions at the UN Ocean Conference in New York in 2017 by committing to the “conservation and management of all species of sharks and rays and their critical habitats within Fijian waters” (United Nations, 2017).

Surprisingly, to date, there are no official records of *M. birostris* in Fiji’s waters besides brief mentions in the catch statistics of Fijian longline pelagic fisheries (Piovano & Gilman, 2016). While some reliable reef manta aggregation sites are known throughout the country and opportunistic *Mobula* spp. sightings are commonly reported by recreational divers, fishermen and tourism operators, detailed information on habitat preferences and distribution within the country is generally lacking. Several Fiji-based tourism operators offer reef manta ray snorkeling activities, most notably Barefoot Manta, an ecotourism resort based on Drawaqa island in the Yasawa Island Group, approximately 40 km north-west from Viti Levu. The island group consists of 11 main volcanic islands running 90 km to the north-east (Ward *et al.*, 2007). A 250 m long, 300 m wide and approx. 7 m deep channel located towards the southern end of Drawaqa Island and the largest island in the chain, Naviti Island, is a known reef manta ray aggregation site. During May to October aggregations of up to 15 reef manta rays can be observed in the

channel (Shannon *et al.*, 2018). In addition to feeding on plankton, the manta rays also opportunistically utilise a cleaning station in the passage. Similarly, the waters off Kokomo Private Island Fiji, a luxury resort based in the south of the country on Yaukuve Levu Island, part of an island chain to the North of Kadavu Island, are home to several foraging sites and cleaning stations with regular sightings from April-December and a peak in sightings from May-October. Large aggregations have been recorded at these sites with 65+ individuals foraging at the same time, currently the largest aggregation of reef manta rays known in Fiji (Luke Gordon, 2020, unpublished data). Manta Project Fiji (MPF), established in 2012 as an affiliate of the Manta Trust, has been cataloguing reported manta ray sightings across the country and currently manages a database containing 407 identified *M. alfredi* individuals. Prior to this study, no oceanic manta rays had been reliably confirmed through photographs or video in Fijian waters and were absent from the database.

The country's capital city Suva is home to an estimated population of 256,000 (incl. the Greater Suva area; Pratap *et al.*, 2019) and is located on southern Viti Levu, Fiji's largest island. The surrounding coastal area has been investigated in a number of studies of various disciplines (e.g. Morrison *et al.*, 2001; Koliyavu *et al.*, 2021; Paris *et al.*, 2022), including some publications that looked at elasmobranch occurrence and distribution. For example, the Rewa delta and river located to the east of the city have been documented to constitute important pupping habitats for elasmobranch species, such as scalloped hammerhead sharks *Sphyrna lewini* and bull sharks *Carcharhinus leucas* (Brown *et al.*, 2016; Glaus *et al.*, 2019). In addition, reef manta rays (*Mobula alfredi*) have been observed within the neighbouring Laucala Bay area, a relatively flat coastal lagoon enclosed by a barrier reef located adjacent to Suva, with one individual being captured here by local fisherman in August 2021 (Luke Gordon, 2021, unpublished data) and an additional video record of one foraging individual ~~was captured~~ in October 2021. Laucala Bay lies between the Suva peninsula in the west (where a hilly environment separates it from Suva Harbour) and the delta of Fiji's largest river, the aforementioned Rewa, in the east (Fig. 1). The tidal range of the bay lies between 0.9-1.33 m, with an average depth of 9-15 m and a maximum depth of 30-40 m (Morrison *et al.*, 2001; Koliyavu *et al.*, 2021). During high tide, Laucala Bay's surface area extends to 4500 ha, with several emerging mudflats and sandbanks shrinking it to 3900 ha during low tide (Morrison *et al.*, 2001). Besides being located adjacent to the Rewa delta, several rivers feed into the Bay area shedding large amounts of freshwater into the area with limited exchange towards the oceans due to the reef system sheltering it from the open ocean (Koliyavu *et al.*, 2021). Additionally, the bay receives treated domestic, commercial and industrial wastewater discharged from the Kinoya sewage treatment plant into the northern part of the bay (Fig. 1; Ferreira *et al.*, 2020). This paper discusses all recorded *M. birostris* sightings in Fijian waters to date, presenting photographic evidence of six *M. birostris* individuals foraging in Laucala Bay near Suva and two additional *M. birostris* sightings in the Yasawa Island Group and explores the sightings in relation to local environmental parameters. It thus provides the first unequivocal evidence of oceanic manta ray occurrence within Fijian waters.

# Material & Methods

While sightings of rays in Laucala Bay off Suva, Fiji's capital ~~and largest city in the country~~, were relatively frequently reported by local citizens over the years, ~~unequivocal species identification was lacking~~. Thus, the main author of this study and project manager of MPF, started opportunistic surveys in 2018 within the reported area and continued these surveys when possible, throughout the next two years mostly within November, December and July, the months with the highest ray sighting reportings. At the end of November 2021, after several recreational boaters had sent videos of rays in Laucala Bay, targeted surveys were undertaken on eight consecutive days. Utilising a fibreglass boat, the Laucala Bay area was systematically explored by slowly cruising parallel to the coast and scanning the horizon for signs of *Mobula* spp. activity. Surveys were timed to coincide with the arrival of high tide, as manta ray activity and sightings seem to be limited to high tide and the first 45-60 minutes thereafter (Luke Gordon, 2021, unpublished data). Additionally, a drone was utilised to monitor a larger area and to attempt taking aerial photographs and/or videos of their ventral side while feeding below the surface. Besides the opportunistic surveys in the Laucala Bay area, daily manta ray surveys were also undertaken from April to October in the channel between Drawaqa and Naviti Island within the Yasawa Island Group (17.16335°S 177.19270°E; Fig. 2) to coincide with high tide when reef manta ray foraging activity peaks at this site (Manta Project Fiji, unpublished data, 2021). Collected photographs and video frame grabs were colour and contrast-enhanced utilising Adobe Lightroom and subsequently analysed for unique *M. birostris* identification marks using the key provided in Marshall *et al.* (2009): Coloration of the dorsal shoulder patches and pectoral fins (1), Chevron-shaped marking anterior to the dorsal fin (2), dark spots anterior to the 5th gill slit (3), coloration of ventral pectoral fin margins (4) and coloration of ventral mouth region (5). Individuals were then added to Manta Project Fiji's database, which currently encompassed more than 4075 unique identifications of *M. alfredi* and the seven identifications of *M. birostris* presented in this paper.

# Results and Discussion

During opportunistic sampling of Laucala Bay spanning from December 2018 to December 2021, at least eight different *M. birostris* individuals were observed, with six individuals being photographically identified (Fig. 3). Notably, one of the six individuals was subsequently re-sighted at the same site in December 2018, July 2021 and December 2021 (FJ-MB-0001, Fig. 3). All specimens presented in this study displayed repeated somersault and surface feeding before leaving the area approx. 45-60 minutes after high tide. In addition to the Laucala Bay sightings, in April and September 2020 two *M. birostris* individuals were filmed by Mathjis Carmen in the channel between Drawaqa and Naviti Island in Fiji's Yasawa Island Group, a known feeding and cleaning site for reef manta rays *M. alfredi* (Fig. 4). Only the individual recorded in September 2020 was identified while foraging in the channel and was re-sighted foraging at the same location the next day. Notably, this was the first time observing *M. birostris* in this area despite daily sampling between April and October for the past nine years, suggesting this location was

visited opportunistically and does not represent a reliable observation site for *M. birostris*. Contrastingly, repeated sightings in Laucala Bay over at least three years indicate a reliable observation area further corroborated by one individual being identified three times within three years. While ray activity in the bay reported by recreational users or fishermen may be attributed to visually similar *M. alfredi* individuals, either scenario provides interesting insights, as shared foraging grounds between *M. birostris* and *M. alfredi* add to the knowledge of existing locations where both species occur in micropsympatry (co-occurrence at the same site; Kashiwagi *et al.*, 2011). A recent study focusing on nutrient measurements in Laucala Bay reported high chlorophyll-a concentrations (phytoplankton biomass), especially in the coastal areas (Koliyavu *et al.*, 2021). The authors of the study attribute the high values to the accumulation of nutrients from high riverine discharges and anthropogenic inputs, such as the effluents discharged from the Kinoya wastewater treatment plant in the north of the bay coupled with a low water outflow due to the barrier reefs restricting water exchange to and from the open ocean (Fig. 1). Notably, study sites within the inner bay zone that displayed the highest mean chlorophyll-a measurements are consistent with the observed foraging areas of *M. birostris* suggesting the individuals are specifically targeting these areas to maximise their foraging success. While more surveys are needed to confirm the presence of *M. birostris* consistently over a longer time frame than the three years presented here, the current observational data and the spatio-temporal overlap of chlorophyll-a concentrations with manta occurrences suggests that Laucala Bay might be visited annually in at least November, December and July, presumably for feeding on zooplankton blooms following high phytoplankton concentrations (Koliyavu *et al.*, 2021). However, future research should incorporate sampling over the entire year to elucidate the temporal distribution of this species in the region and the population dynamics of the mantas that visit the area. Unpublished tagging data from Conservation International Aroterea, Manta Watch New Zealand and the New Zealand Department of Conservation suggest that the South Pacific population of *M. birostris* may undertake seasonal migrations between Fiji/Tonga and New Zealand (and possibly further afield). Additionally, a recent study on *Mobula spp.* phylogenomics found no evidence of population structure in *M. birostris* across ocean basins, suggesting homogeneity within the global *M. birostris* population (Hosegood *et al.*, 2020). Considering the migratory nature of this species, national and regional policies to protect this endangered species need to be coherent to maximise potential conservation benefits. In light of Fiji's commitment to protect and manage critical habitats for rays and sharks at the UN Ocean Conference in New York in 2017 (United Nations, 2017) coupled with the extinction threat of oceanic manta rays, our findings provide valuable information to develop and advance protective measures to safeguard this species within Fijian waters. While the national 'Endangered and Protected Species Act' and the 'Offshore Fisheries Management Act' provide a legal framework for the protection for both manta species, the logistical difficulty of monitoring and enforcement remains to be solved. The occurrence of *M. birostris* in such close proximity to Fiji's capital city Suva makes this discovery especially noteworthy as increasing urban development will inevitably cause increasing pollution and boat traffic. Both factors have been shown to pose risks



to foraging mantas (Couturier *et al.*, 2012; Marshall *et al.*, 2020). Besides confirming *M. birostris* occurrence in Fijian waters for the first time, our findings suggest that Laucala Bay may represent a critical foraging habitat for the species on longer journey migrations, rendering it an area of interest not only for Fiji but for the wider South Pacific region.

## Conclusions

This study provides the first unequivocal photographic evidence of *M. birostris* occurrence at two locations within Fiji's Exclusive Economic Zone (six individuals recorded in Laucala Bay and two individuals recorded near Drawaqa Island) with one of the observed mantas visiting over at least a three-year period and being sighted three times (2018, 2020, 2021). Although the currently available information is insufficient to draw concise conclusions, these sightings indicate that *M. birostris* individuals may use the Laucala Bay area near Fiji's capital Suva as a regular foraging site. Future studies should incorporate visual sampling throughout the entire year and over a longer time frame to test this hypothesis and monitor manta ray activity in the bay. We also suggest that increased local awareness of these findings could be helpful in obtaining additional data on ray sightings from recreational users of the above-mentioned areas.

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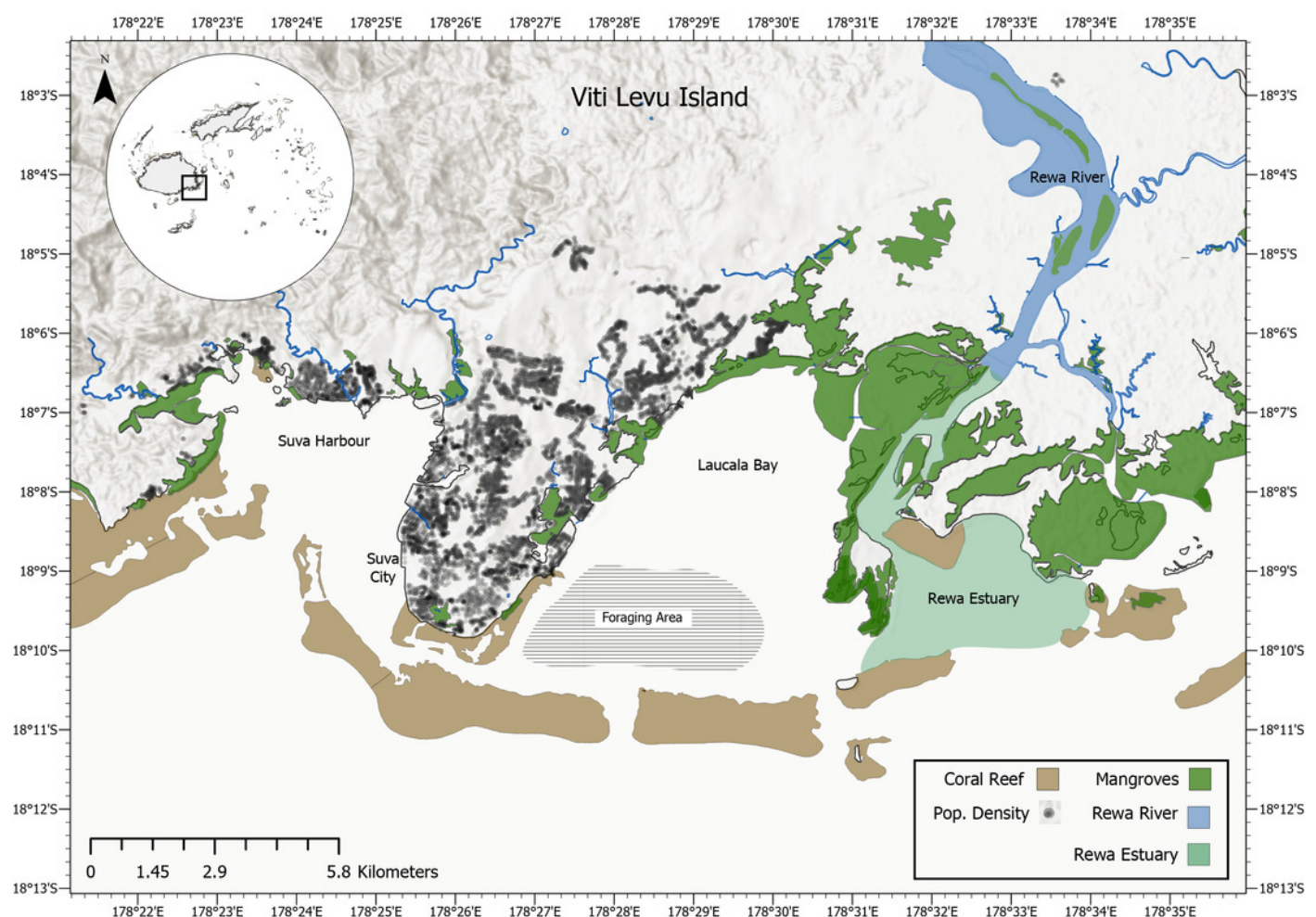


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# Figure 1

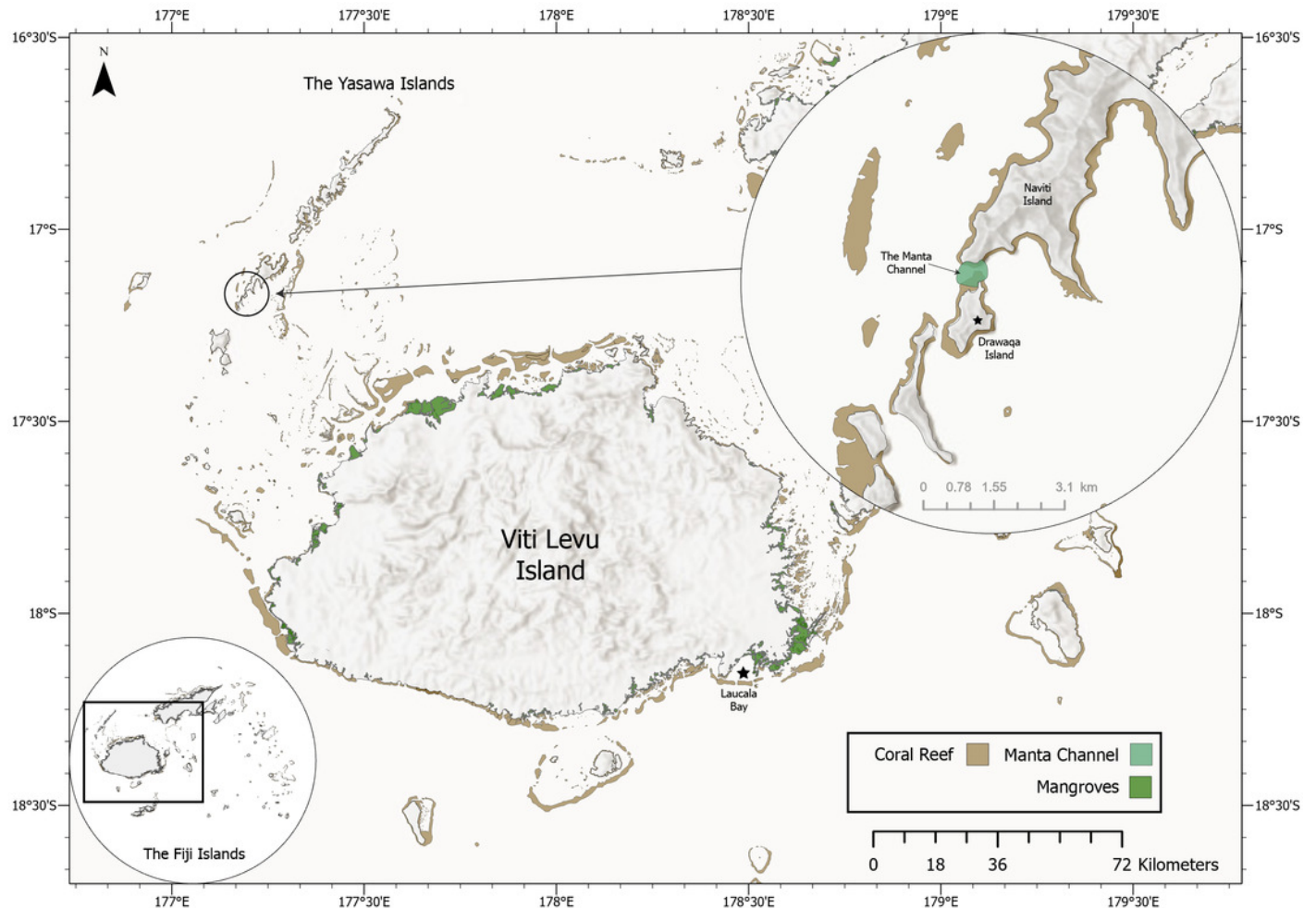
Map of the greater Suva area which includes Laucala Bay, Suva city, Suva Harbour, the Rewa River and the Rewa Estuary.

The foraging area of the observed oceanic manta rays is located at the southern-western end of Laucala Bay (highlighted) near one of the channels in the barrier reef.



# Figure 2

Map of the Yasawa Islands and Viti Levu, Fiji's main island. Inset (top right) displays a close-up map of 'The Manta Channel' between Drawaqa Island and Naviti Island.

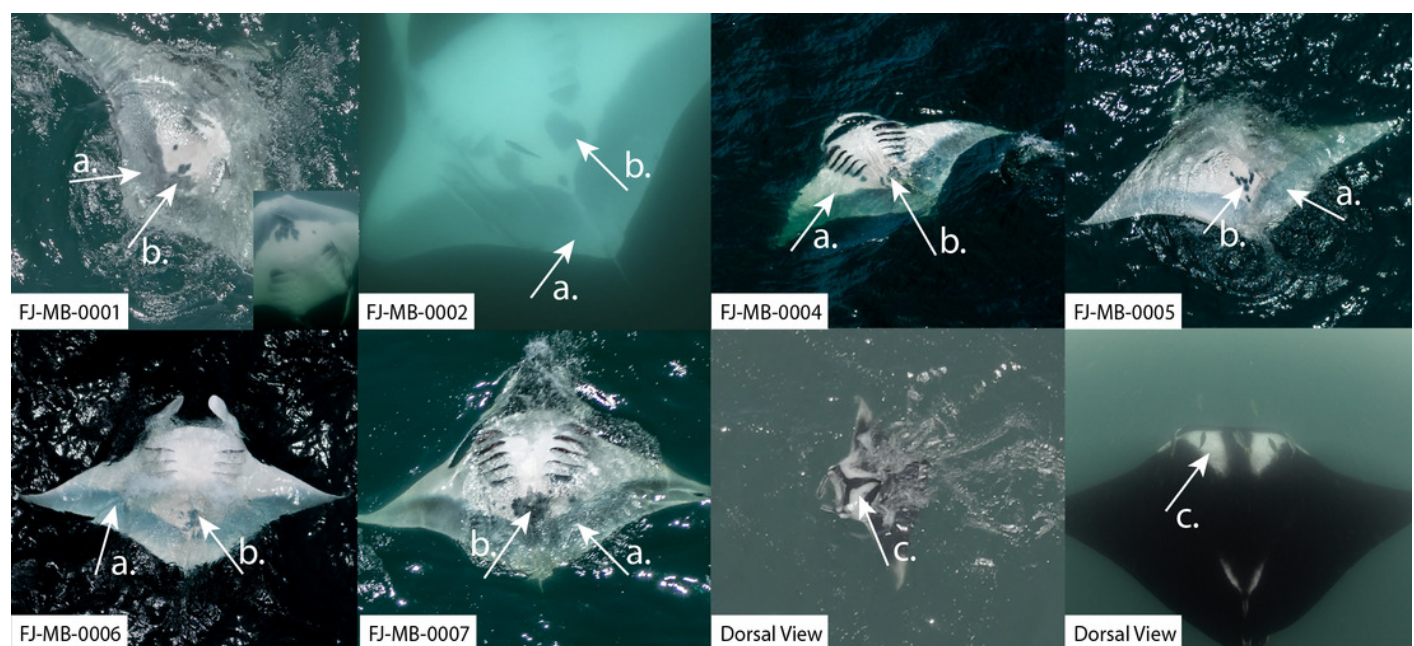




# Figure 3

Identification photographs of six *M. birostris* individuals sighted in Laucala Bay adjacent to Suva, Fiji's capital city.

Manta identification names are shown at the bottom left. e.g. 'FJ-MB-0001'. Two individuals (FJ-MB-0001, FJ-MB-0002) were identified underwater while the remaining four were photographed or filmed utilising a drone. White arrows (a) and (c) indicate key morphological features for *M. birostris*: (a) shows the distinctive grey V-shaped margin along the posterior edge of the pectoral fins; and (c) shows the white dorsal shoulder markings that form two mirror image right-angled triangles. Ventral spots clustered around the lower abdomen region which are used for identification are indicated by (b). FJ-MB-0001 image shows two sightings, the original sighting (inset, bottom right) from 02.12.2018 and the most recent from 24.11.2021. Photographs taken by Tom Vierus, Luke Gordon and Cliona O'Flaherty.



# Figure 4

*M. birostris* individuals sighted in the channel between Drawaqa and Naviti Island in the Yasawa Group in north-western Fiji.

Only one individual could be filmed from below revealing its unique identification pattern (FJ-MB-0003). White arrows (a) and (c) indicate key morphological features for *M. birostris*: (a) shows the distinctive grey V-shaped margin along the posterior edge of the pectoral fins; and (c) shows the white dorsal shoulder markings that form two mirror image right-angled triangles. Ventral spots clustered around the lower abdomen region which are used for identification are indicated by (b).

