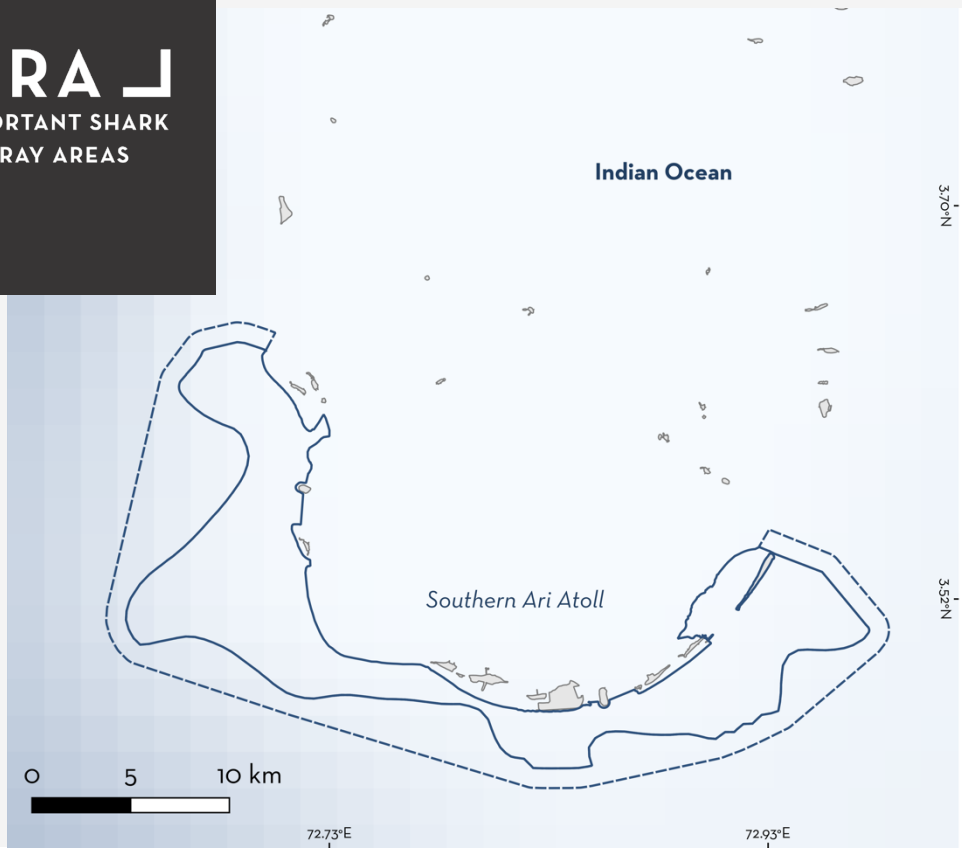
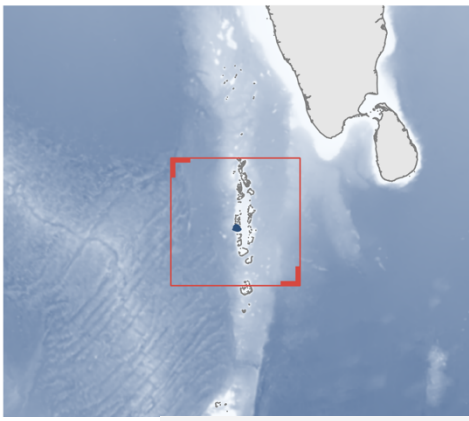
ISRA
IMPORTANT SHARK AND RAY AREAS





Blue lines indicate the area meeting the ISRA Criteria; dashed lines indicate the suggested buffer for use in the development of appropriate place-based conservation measures

SOUTHERN ARI ATOLL

Western Indian Ocean Region

MALDIVES

0–200 metres

182.9 km²

SUMMARY

Southern Ari Atoll is located in the central western part of the Maldivian archipelago. The area covers the outer reef edge of South Ari Atoll including Dhigurah Falhu lagoon on the eastern side, and Rangalli Madivaru channel on the western side. It is characterised by a shallow lagoon with sandy substrates, atoll channels, and outer coral reefs encompassing shallow crests and a wide fore reef platform followed by steep slopes to deep waters. The area overlaps with the South Ari Atoll Marine Protected Area (SAMPA), and Rangali Madivaru Marine Protected Area. Within the area there are: **threatened species** (e.g., Reef Manta Ray *Mobula alfredi*); **reproductive areas** (Reef Manta Ray); **feeding areas** (e.g., Reef Manta Ray); **resting areas** (Whale Shark *Rhincodon typus*); and areas with **distinctive attributes** (Silvertip Shark *Carcharhinus albimarginatus*).

CRITERIA

Criterion A – Vulnerability; Sub-criterion C1 – Reproductive Areas; Sub-criterion C2 – Feeding Areas; Sub-criterion C3 – Resting Areas; Sub-criterion D1 – Distinctiveness

DESCRIPTION OF HABITAT

Southern Ari Atoll is located at the southern edge of Ari Atoll in the central-western Maldives. The area includes the outer reef of the south edge of South Ari Atoll, Dhigurah Falhu lagoon, and Rangali Madivaru Channel.

The weather in the Maldives is strongly influenced by the South Asian monsoon, especially the northern and central atolls as these are closer to the Indian subcontinent (Anderson et al. 2011). Two monsoons occur annually with the southwest monsoon (locally known as *Hulhan'gu*), from May to November, and the northeast monsoon (locally known as *Iruvai*), from January to March, with transitional periods in December and April (Shankar et al. 2002; Anderson et al. 2011). The southwest monsoon increases average rainfall, and wind speeds, causing rougher seas and reduced visibility; in contrast, the northeast monsoon usually brings clear waters (Stevens & Froman 2019). The monsoonal winds generate oceanic currents mirroring the direction and intensity of the winds that interact with the geomorphology of the Maldivian archipelago generating upwellings through Island Mass Effect (Su et al. 2021)

Southern Ari Atoll outer reef consists of wide shallow reef platforms (<20 m deep), rapidly dropping to depths of >1,500 m. Dhigurah Falhu is a large lagoonal area situated along the inner-atoll margin in the east of the atoll, bordering Dhigurah Island (Mancini et al. 2020). It is ~ 5–6 km in length and 1–2 km wide. The inner basin reaches a depth of ~25 m with a benthic cover of fine sands and scattered coral blocks and is enclosed by a shallow barrier reef with a depth of 10–20 m. Dhigurah Falhu is positioned between two large channels, Dhigurah Kandu in the north and Ariyadhoo Kandu in the south. Tidal currents bring plankton-rich water in and out of the atoll lagoons via channels along the outer rim of the atoll. The geomorphology of the shallow Dhigurah lagoon coupled with the tidal movements and Langmuir Circulation may act as a zooplankton trap, especially during the southwest monsoon (May–November) (Hedley et al. 2018; Moloney et al. 2019; Harris et al. 2020; Harris & Stevens 2021).

Sea surface temperatures fluctuate little between 28–30°C, with the highest average temperatures recorded in April and the lowest average temperatures recorded during January/February (Weather Stats 2023).

Rangali Madivaru channel, on the western edge of Southern Ari Atoll, lies between the islands Rangali and Hukurudhoo. The reef area is characterised by plate corals with many reef cavities, overhangs, and caves, as well as sea fans. The channel's downward slope leads to predictable upwelling events and sometimes strong tidal forces. The outer reef bordering the channel has several large coral blocks.

Southern Ari Atoll overlaps with the South Ari Atoll Marine Protected Area (SAMPA) and Rangali Kandu (Madivaru) Marine Protected Area.

This Important Shark and Ray Area is benthopelagic and is delineated from surface waters (0 m) to 200 m based on the distribution of the Qualifying Species in the area and the maximum depth of the area.

ISRA CRITERIA

CRITERION A – VULNERABILITY

Three Qualifying Species considered threatened with extinction according to the IUCN Red List of Threatened Species™ regularly occur in the area. These are the Endangered Whale Shark (Pierce &

Norman 2016) and the Vulnerable Silvertip Shark (Espinoza et al. 2021), and Reef Manta Ray (Marshall et al. 2022).

SUB-CRITERION C1 – REPRODUCTIVE AREAS

Southern Ari Atoll Area is an important reproductive area for one ray species.

Reef Manta Ray young-of-the-year (YOY), juveniles, aggregations of pregnant females, and courtship and mating behaviours have been recorded in this area. Of the 1,418 Reef Manta Rays recorded throughout Ari Atoll, 18% (n = 250) were observed in Dhigurah Falhu (n = 506 surveys; with only 10% of all surveys conducted in Ari Atoll). Overall, 56% (n = 140) of the Dhigurah Falhu individuals were immature: with 89% YOYs and juveniles (n = 125) and 11% subadults (n = 16). Sightings of YOY display a marked seasonal spatial distribution. Dhigurah Falhu is an important site for YOY Reef Manta Rays and sheltering location where juveniles take refuge during early life-stages, with aggregations occurring especially during June and December. Data from photo-identification conducted between 2007–2022 revealed that 20% (n = 15) of all the YOY individuals identified in Ari Atoll (n = 74) were first recorded in Dhigurah Falhu (based on individual estimated size between 150–190 cm disc width [DW]; length of tail, light ventral/spot pattern pigmentation; creases along pectorals, and often a light pink skin pigmentation on first sighting; Stevens 2016; Hedley et al. 2018; Moloney et al. 2019; Hedley 2021; IDtheManta unpubl. data 2022). Reef Manta Rays have low fecundity, reproducing every 5–7 years and giving birth to one offspring at a time (Stevens 2016). This location is one of the main sites where YOY are reported in South Ari Atoll (Hedley et al. 2018; Moloney et al. 2019; IDtheManta unpubl. data 2022).

Of the YOYs recorded in Dhigurah Falhu (n = 15), 80% of animals were repeatedly seen within Dhigurah Falhu over consecutive years, confirming that this area is used repeatedly across years and as a nursery area. This behaviour has been observed in juvenile Reef Manta Rays in other parts of the world (Peel et al. 2019). During the northeast monsoon (December–April), juveniles and YOY are also regularly sighted at Rangali Madivaru. Between 2004 and 2020, a total of 191 confirmed sightings of 76 juveniles have been recorded cleaning at this site.

Courtship, mating behaviour, and pregnant females are also regularly observed between January and April at Rangali Madivaru. The area holds a high abundance of Reef Manta Rays; of the 1,418 individuals recorded throughout Ari Atoll between 1998–2022, 22% were recorded in Rangali Madivaru through photo-identification (IDtheManta unpubl. data 2022). Between 2004–2022, a total of 35 courtship events were recorded with 61 identified individuals participating in courtship (IDtheManta unpubl. data 2022). This area is one of the few global locations where not only courtship, but also mating has been observed and recorded (Stevens et al. 2018).

Between 1998–2022, 21 pregnant Reef Manta Rays were recorded, with the majority (93%) of sightings displaying cleaning behaviour (n = 148). Pregnancy was determined by the presence of extended abdomens by trained researchers (Stevens 2016). The regular occurrence of pregnant Reef Manta Rays at these cleaning stations, typically predictable during the outgoing current (Hedley et al. 2018), suggests that this site is key to maintaining health during gestation (Stevens 2016).

SUB-CRITERION C2 – FEEDING AREAS

Southern Ari Atoll Area is an important feeding area for one shark species and one ray species.

Based on data recorded between 2002–2023 on boat transect surveys (between 8 am and 3 pm), and citizen science from diving and snorkel tourist boats, a total of 6,353 Whale Shark sightings and

399 Whale Shark individuals have been identified through photo-identification (Maldives Whale Shark Research Programme [MWSRP] unpubl. data 2023). Juvenile animals are recorded year-round (size estimates between 316–800 cm total length [TL]), with a marked sex bias of 91% male (Perry et al. 2018). Ram feeding behaviour can be regularly observed and was recorded during 984 sightings (17.1% of the 5,764 sightings where notes on behaviour were recorded). Of these, 49.1% (n = 483) have been recorded by MWSRP trained staff (MWSRP unpubl. data 2023). Additionally, Southern Ari Atoll is one of the locations in the Maldives where bathymetries of >1,650 m are closer to shallow reefs. Telemetry data from tagged Whale Sharks (n = 8) in the area during the year 2008, show regular dives towards plankton-rich deep layers (> 125 m deep), a bathymetry with cold water (Su et al. 2021), after which they ascend to shallower depths (> 50 m) (Steward et al. unpubl. data 2008). These patterns of deep descents by animals inhabiting open waters are thought to be driven by foraging (Brunnschweiler et al. 2009; Copping et al. 2018; Harvey-Carroll et al. 2021).

Southern Ari Atoll is an important feeding area for Reef Manta Rays with a marked seasonality in the spatial distribution of feeding aggregation events. It has been observed in other parts of the world that Reef Manta Ray aggregate to feed in areas where local environmental conditions promote high zooplankton biomass (Dewar et al. 2008; Armstrong et al. 2016; Harris et al. 2021; Harris & Stevens 2021). During the southwest monsoon (May–December) Reef Manta Rays are known to aggregate in a regular and predictable way in Dhigurah Falhu due to the accumulation of zooplankton in the area resulting from monsoonal conditions (Harris et al. 2020). Surveys conducted during snorkelling trips (n = 448) with photo-identification in the area between the years 2007 and 2022 recorded aggregations of an average of 10 individuals (SD = 3.87, minimum = 6, maximum = 22) on 76 different occasions (IDtheManta unpubl. data 2022). Of the 1,418 Reef Manta Rays recorded throughout Ari Atoll, 18% (n = 250) of these individuals have been observed feeding in Dhigurah Falhu. Individuals in the aggregations are observed actively feeding individually or organised in feeding chains (IDtheManta unpubl. data 2022). This is one of the most important and regular feeding locations recorded for Reef Manta Rays in South Ari Atoll (IDtheManta unpubl. data 2022).

When the seasons are reversed and currents are moving from east to west (northeast monsoon), Rangali Madivaru, on the west of Southern Ari Atoll, is also known to support feeding activity by Reef Manta Rays and Whale Sharks, with the enhanced productivity attributed to the Island Mass Effect intercepting current flow through the archipelago and producing upwelling (Su et al. 2021). Reef Manta Rays typically feed inside the channel along the reef near Rangali Finolhu island (G Stevens pers. comm. 2023). Between the years 2003 and 2022, a total of 130 confirmed sightings of feeding animals were recorded at Rangali Madivaru. Of the 1,418 individual Reef Manta Rays recorded throughout Ari Atoll, 6% (n = 78) of these individuals have been observed feeding in Rangali Madivaru (IDtheManta unpubl. data 2022). Individuals in the aggregations are observed actively feeding individually or organised in feeding chains of up to 20 individuals.

SUB-CRITERION C3 – RESTING AREAS

Southern Ari Atoll is an important resting area for one shark species.

Juvenile Whale Sharks use the shallow and sheltered waters along the outer reef crest to thermoregulate and recover after deep dives, showing a strong site fidelity, especially in injured individuals. Data collected during snorkel and diving trips between 2002–2023, recorded a total of 6,353 Whale Shark sighting. Of these, 399 Whale Shark individuals were identified through photo-identification, highlighting the area as an important aggregation site. The aggregation predominantly comprises juvenile male sharks (91%) of 316–800 cm TL (Perry et al. 2018). From mark-recapture data using photo-identification it is known that juvenile Whale Sharks predictably reside in the area for several years before continuing their life cycle (Donati et al. 2016). Whale Sharks in the area are

commonly observed in a lethargic behaviour, cruising slowly along the reef crest in shallow waters a few metres deep with little reactions to disturbances (C Canovas Perez, G Donati, I Zareer, A Batlle-Morera pers. obs. 2014–2023). Telemetry data from tagged animals (n = 8) in the area during the year 2008, show that individuals perform regular deep dives (to > 125 m deep), a bathymetry with cold water (Su et al. 2021), after which they ascend to shallower depths (> 50 m) (Steward et al. unpubl. data 2008), a behaviour pattern known to be linked with thermoregulation in this species (Thums et al. 2013).

Additionally, the effect of major injuries (defined as potential life-threatening, including dorsal, caudal, or pectoral fin amputations, and damage penetration to at least the sub-dermal layer) on residency and apparent survival of Whale Sharks have been investigated in the area, using Capture Mark Recapture (CMR) with photo-identification data of 265 unique individuals (3,445 sightings) between 2006–2019. The study highlights that Whale Sharks with major injuries are most likely to return to the area and reside for longer than those without injuries. Injured sharks showed a higher apparent survival, likely representing lower levels of emigrations (mean value across years: injured = 0.80, non-injured = 0.20; Harvey-Carroll et al. 2021), and a higher probability of returning over time (mean time between encounters: injured = 41.2 ± 1.9 days, non–injured = 137.3 ± 20.2 days; Allen et al. 2021), suggesting that individuals with major injuries reside in the proximity of the area for longer periods of time. When comparing individuals with minor and major injuries, a significant correlation has also been observed, where sharks with major injuries have longer residency periods (mean days: major = 20.1 ± 2.3, minor = 14.8 ± 1.3), shorter absences (mean days: major = 170.1 ± 28.1, minor = 245.0 ± 23.9), higher number of residency periods (mean: major = 14.8 ± 1.9, minor = 88.8 ± 0.8), and faster return rate (mean years: major = 0.4 ± 0.0, minor = 0.6 ± 0.0) than sharks with minor injuries (Allen et al. 2021). Since healing injuries requires significant resources, especially for juveniles during critical growing phases (Harvey-Carroll et al. 2021), these data strongly implicates the vital role of the area in resting and recovery.

SUB-CRITERION D1 – DISTINCTIVENESS

Southern Ari Atoll is an important area for distinctive attributes of one shark species.

Large-bodied Silvertip Sharks aggregate in shallow reefs (<25 m) to visit cleaning stations in the area. Animals are generally found in deep channels out of the reach of recreational scuba diving activities, but Rangali Madivaru is one of the few sites in the Maldives where adult Silvertip Sharks regularly aggregate (in groups of 3–4 individuals) to clean during outgoing currents. Animals are observed slowly cruising a few centimetres away from the reef with regular stops to hover in an upwards swimming motion over the cleaning stations. These events occur year-round but increase during the northeast monsoon season (December–April) (G Stevens pers. comm. 2023).

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QUALIFYING SPECIES

Scientific Name	Common Name	IUCN Red List Category	Global Depth Range (m)	ISRA Criteria/Sub-criteria Met								
				A	B	C1	C2	C3	C4	C5	D1	D2
SHARKS												
Carcharhinus albimarginatus	Silvertip Shark	VU	0–800	X							X	
Rhincodon typus	Whale Shark	EN	0–1,928	X			X	X				
RAYS												
Mobula alfredi	Reef Manta Ray	VU	0–711	X		X	X					

SUPPORTING SPECIES

Scientific Name	Common Name	IUCN Red List Category
SHARKS		
Carcharhinus amblyrhynchos	Grey Reef Shark	EN
Carcharhinus melanopterus	Blacktip Reef Shark	VU
Nebrius ferrugineus	Tawny Nurse Shark	VU
Stegostoma tigrinum	Indo-Pacific Leopard Shark	EN
Triaenodon obesus	Whitetip Reef Shark	VU
RAYS		
Aetobatus ocellatus	Spotted Eagle Ray	EN
Mobula birostris	Oceanic Manta Ray	EN
Mobula kuhlii	Shorthorned Pygmy Devil Ray	EN
Pateobatis fai	Pink Whipray	VU
Taeniurops meyeni	Blotched Fantail Ray	VU

IUCN Red List of Threatened Species Categories are available by searching species names at www.iucnredlist.org Abbreviations refer to: CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient.

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