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Contribution to the Special 'Global status of wedgefish and guitarfish'

NOTE

Notable abundance of two Critically Endangered elasmobranch fishes near an area of intensive coastal development in the Arabian Gulf

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ABSTRACT: The Pakistan whipray *Maculabatis arabica* and the halavi guitarfish *Glaucostegus halavi* are Critically Endangered elasmobranch species that are endemic to areas of the northern Indian Ocean. An unexpectedly high abundance of both species in a shallow, nearshore area of Abu Dhabi, United Arab Emirates, is described here. Both species were found to utilise this area year-round, although seasonal fluctuations in abundance were evident. Male and female *G. halavi* were encountered at sizes that suggest a mix of immature and mature individuals; however, all except 1 *M. arabica* were female, indicating sexual segregation in this species. Further studies are required to learn more about the importance of the study area in the life history of these Critically Endangered species, but it is a matter of considerable concern that the wider Khor Faridah area is currently undergoing intensive coastal development.

KEY WORDS: Chondrichthyes · Guitarfish · Whipray · Conservation · Habitat loss

1. INTRODUCTION

The Arabian or Persian Gulf (henceforth 'the Gulf') is a 241 000 km^2 semi-enclosed marine sea bordered by the United Arab Emirates (UAE), Saudi Arabia, Qatar, Bahrain, Kuwait, Iraq, Iran and Oman (Musandam Peninsula). It is characterised by high summer water temperatures, high salinity and limited freshwater inflow, as well as extensive coastal development (Burt 2014). Historically, fisheries within the Gulf have been intensive and unregulated, leading to high levels of overfishing and habitat degradation (Ben-Hasan & Christensen 2019).

The ichthyofauna of the region includes a number of endemic species, and this is particularly true of the elasmobranch fishes (Elasmobranchii). Of the ca. 48 species that have been reported from the Gulf, 14 are known only from the northern Indian Ocean (including the Arabian Sea, Red Sea, Gulf of Aden, Gulf of Oman and Arabian Gulf) (Last et al. 2016, Ebert et al. 2021). Given the relative paucity of historical scientific research in this region, there are numerous knowledge gaps regarding the general biology and ecology of these endemics. Indeed, the taxonomy of some lineages remains poorly resolved (Henderson 2020).

This combination of unregulated fishing, habitat loss and lack of biological data has resulted in elevated extinction risks for many of the region's elasmobranchs (IUCN 2023). Two such species, which

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have been categorised as Critically Endangered, are the halavi guitarfish *Glaucostegus halavi* (Kyne & Jabado 2019) and the Pakistan whipray *Maculabatis arabica* (Dulvy et al. 2017). A preliminary survey of the elasmobranch fauna of the Khor Faridah region of Abu Dhabi, UAE, in 2019 uncovered an area with a notable occurrence of both species (Fig. 1). Following this discovery, a study was initiated to describe their demographics within this focal area.

2. MATERIALS AND METHODS

2.1. Study area

The study area under consideration is located between Ras Ghurab and Al Weheil islands, approximately 21 km north-east of Abu Dhabi Island, and is characterised by a combination of fringing mangrove forest, shallow (<1.5 m deep) sand flats and seagrass meadows. Numerous, slightly deeper (<2 m) channels run through the area, coalescing into a main channel (3 to 4.5 m deep) that connects the area to the open waters of the Gulf (Fig. 2).

2.2. Data collection

An 800 m bottom-set longline with 1.5 m branchlines terminating in either 13/0 or 10/0 circle hooks (equal numbers of each size) was employed to capture the target species. Deployment locations were generated randomly within the open-source QGIS software, and soak times were determined based on tidal conditions within the study area. Bait consisted mostly of pharaoh cuttlefish *Sepia pharaonis*, supplemented with Arabian scad *Trachurus indicus*, bigeye scad *Selar crumenophthalmus*, Indian scad *Decapterus russelli* and Indian mackerel *Rastrelliger kanagurta*, depending on market availability. Latitude and longitude of the longline start and end points were recorded with a Garmin GPSMAP 78sc handheld GPS unit, and water depth at these points was determined to the nearest 0.1 m with a Vexilar LPS-1 portable sounder. When a catch was encountered during the hauling of the longline, latitude, longitude and depth were recorded at that location in the same manner.

Captured animals were brought aboard the vessel, measured to the nearest cm (total length, TL, in the case of *Glaucostegus halavi*; disc width, DW, in the case of *Maculabatis arabica*), tagged sub-dermally with a passive integrated transponder (PIT) tag, and sexed based on the presence or absence of claspers. Species identities were determined following characteristics described by Last et al. (2016). In particular, *G. halavi* was distinguished from potentially sympatric congeners based on rostral profile and denticle/thorn patterns, while *M. arabica* was distinguished from potentially sympatric congeners based on a combination of anterior disc margin profile, mid-shoulder denticles, tail colouration and ventral disc margin colouration. A small (5 mm diameter) fin-clipping was collected for gen-

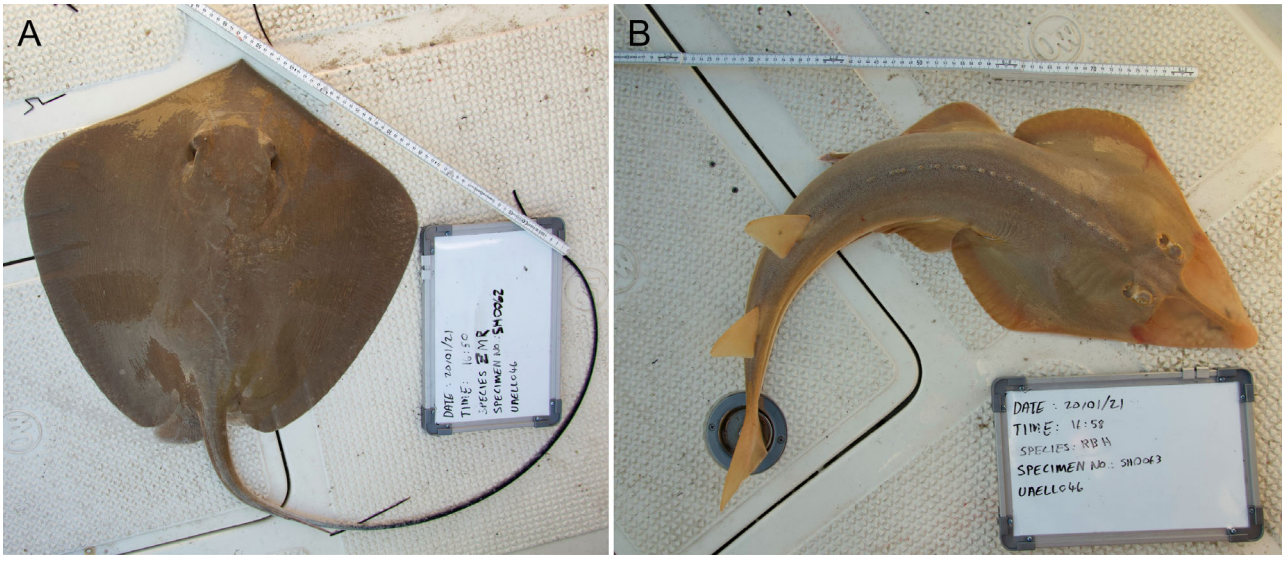

Fig. 1. (A) Pakistan whipray *Maculabatis arabica* and (B) halavi guitarfish *Glaucostegus halavi* from the Khor Faridah region of Abu Dhabi, UAE

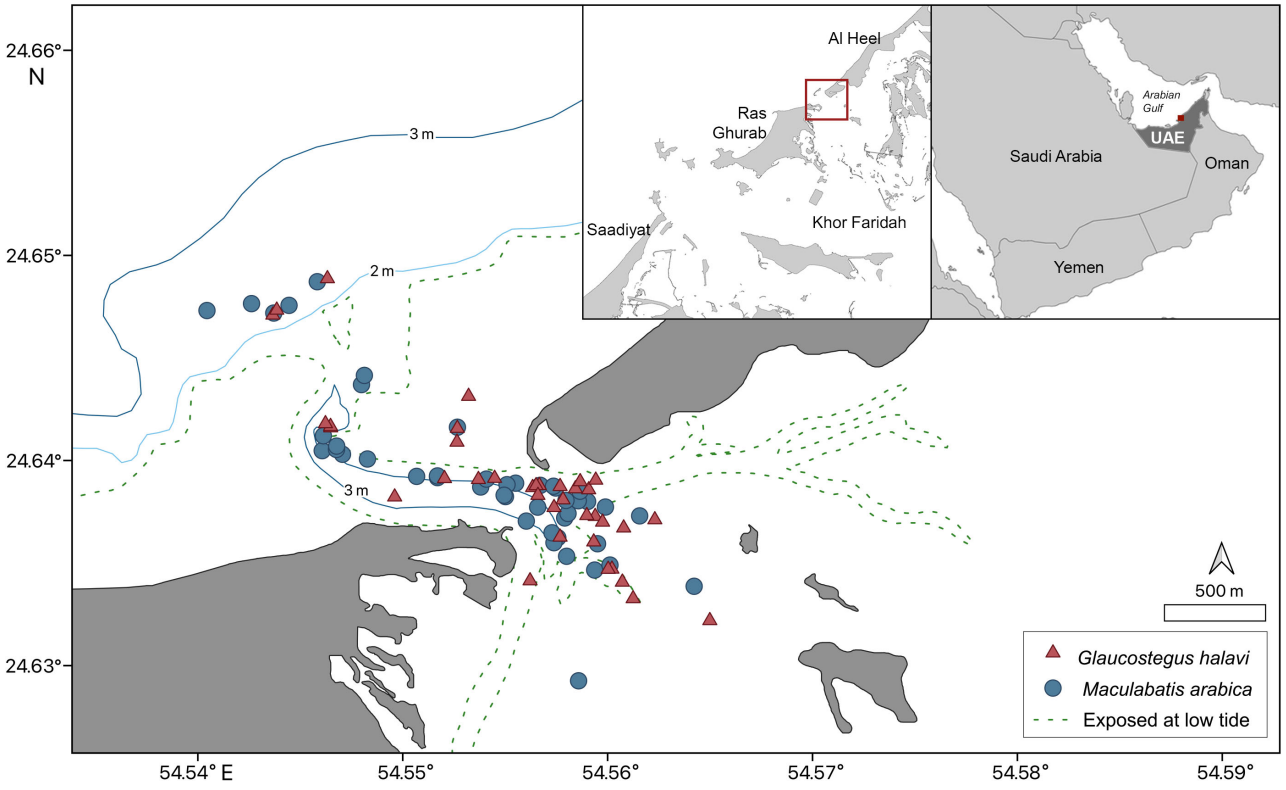

Fig. 2. The study area within the Khor Faridah region of Abu Dhabi showing the capture locations of *Maculabatis arabica* and *Glaucostegus halavi*

etic analysis and placed in 95% ethanol, after which the animal was released.

2.3. Data analysis

Data were pooled by season, with seasons delineated based on a multi-year water temperature dataset provided by the Environment Agency — Abu Dhabi. Consequently, spring is March, April, May; summer is June, July, August; autumn is September, October, November; winter is December, January, February. Relative abundance was estimated by catch per unit effort (CPUE), calculated as the number of individuals caught per hook per hour (ind. hook-hour^{-1}). Because of the relatively small sample size under consideration, non-parametric tests were employed in statistical analyses. Specifically, Spearman's rank correlation was used to investigate the relationship between animal size and depth of capture, while the Mann-Whitney *U*-test assessed intersex differences in both size and depth of capture. Similarly, central tendency is reported as median with interquartile range (IQR). All analyses were performed in Jamovi (version 1.6.15).

2.4. DNA extraction and sequencing

For the purpose of molecular-assisted species identification, total genomic DNA was extracted with Thermo Scientific GeneJET Genomic DNA Purification Kits following the protocol for mammalian tissue. From this, the cytochrome c oxidase subunit 1 gene (CO1) was amplified via the polymerase chain reaction (95°C for 3 min; followed by 35 cycles of 95°C for 30 s, 54°C for 30 s and 72°C for 60 s; followed by 72°C for 10 min and infinite hold at 4°C) and Sanger-sequenced with FishF1 and FishR1 primers (Ward et al. 2005).

3. RESULTS

A total of 65 longline deployments were performed between October 2019 and December 2021, providing a total fishing effort of 12171.05 hook-hours. Median soak time was 3.4 h (IQR = 1.5 h). However, this effort was temporally uneven due to periodic travel limitations imposed within the UAE during the COVID-19 pandemic. Consequently, there were 7 deployments in spring, 13 in summer, 31 in autumn and 14 in

winter. Bycatch was minimal and consisted of coach whipray *Himantura uarnak*, leopard whipray *Himantura leoparda*, orange spotted grouper *Epinephelus coioides*, hound needlefish *Tylosurus crocodilus*, talang queenfish *Scomberoides commersonnianus*, spangled emperor *Lethrinus nebulosus*, slender sharksucker *Echeneis naucrates* and cobia *Rachycentron canadum*, all of which were released alive.

Maculabatis arabica was the more common of the 2 focal species, with 48 individuals captured (0.0039 ind. hook-hour^{-1}) versus 39 *Glaucostegus halavi* (0.0032 ind. hook-hour^{-1}). Both species were encountered year-round, but *M. arabica* displayed a notable decline in abundance during winter, whereas the abundance of *G. halavi* was lowest during summer and autumn (Fig. 3).

A single male *M. arabica* was captured at a depth of 2.1 m during autumn 2021, and this 29 cm DW individual possessed uncalcified claspers. All of the remaining *M. arabica* were female, ranged in size from 28 to 72 cm DW (Fig. 3) and were captured at depths ranging from 0.4 to 4.4 m (median = 2.1 m, IQR = 1.3 m). Size was positively correlated with depth of capture (Spearman's rank correlation, n = 47, ρ = 0.425, $p < 0.01$). When viewed by season, median size remained relatively consistent throughout the year

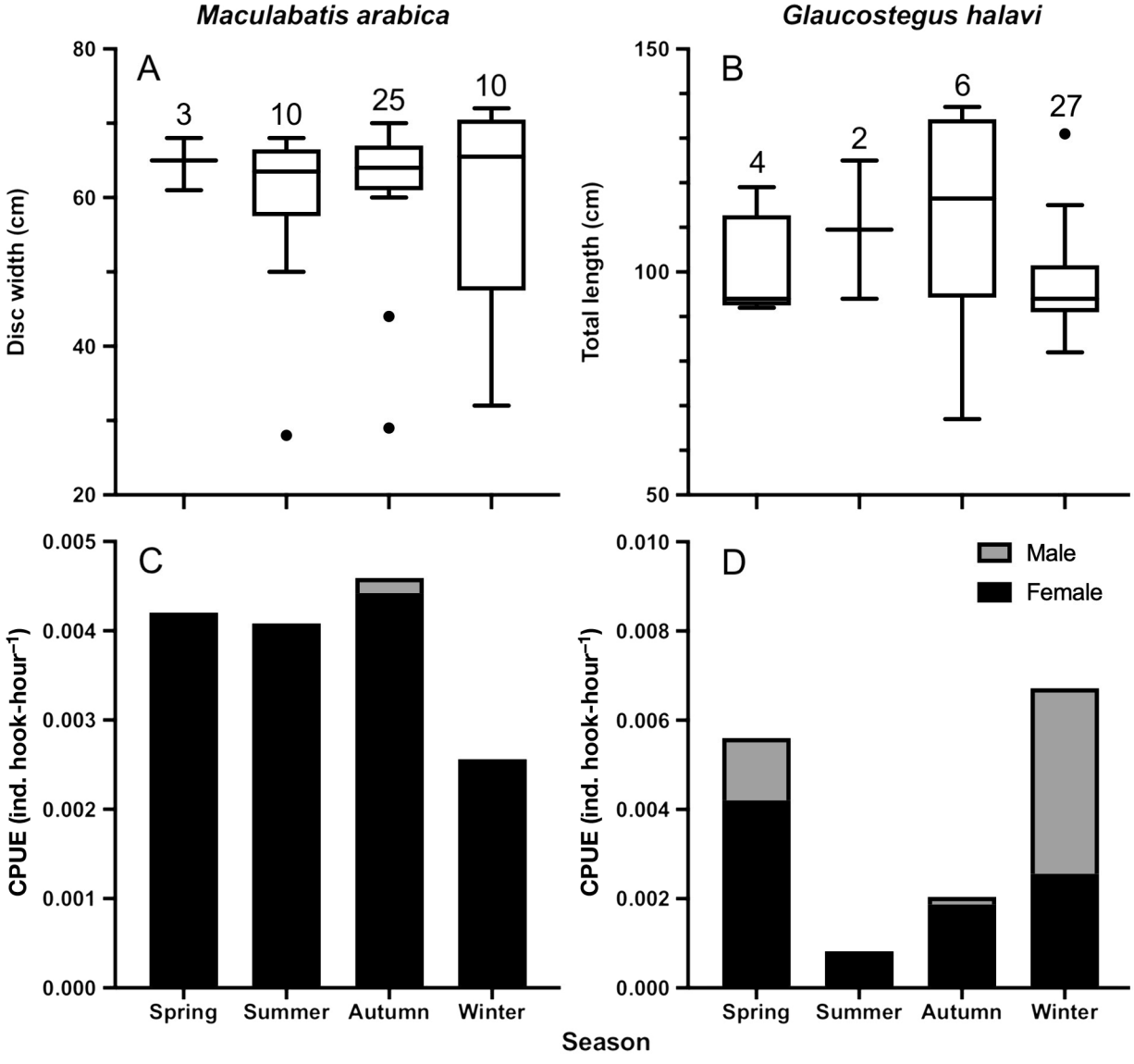

Fig. 3. Seasonal (A,B) size and (C,D) catch per unit effort trends of *Maculabatis arabica* and *Glaucostegus halavi* in the Khor Faridah region of Abu Dhabi, UAE. Boxplots display medians and quartiles; points beyond the whiskers are outliers. Values above the boxplots are the numbers of individuals captured

(Fig. 3); however, the small sample size in spring precluded any statistical comparison of these data. It is notable though, that the smallest individuals were encountered during summer and autumn, and there was a downward extension of the IQR in winter.

One female *M. arabica* was recaptured during the study. The initial capture took place in October 2019, at which time the animal's size was 60 cm DW. On recapture in August 2021 after 665 d at liberty, it had grown to 65 cm DW. The linear, overwater distance between the 2 capture points was 1.93 km.

Although the sex ratio of *G. halavi* was less pronounced, it was still dominated by females (1.6:1), which were encountered in all seasons. Males, by contrast, were not encountered during summer and were uncommon during autumn. Females ranged in size from 67 to 137 cm TL (Fig. 3) and were captured at depths ranging from 0.4 to 3.6 m (median = 1.7 m, IQR = 0.9 m), but there was no correlation between size and depth of capture (Spearman's rank correlation, $n = 25$, $\rho = 0.056$, $p > 0.05$). Males were significantly smaller than females (Mann-Whitney *U*-test, $n = 39$, $p < 0.01$), ranging in size from 87 to 107 cm TL, all with calcified claspers. Male capture depth ranged from 0.5 to 3.0 m (median = 2.2. m, IQR = 1.6 m). As in the case of females, there was no correlation between size and depth of capture (Spearman's rank correlation, $n = 14$, $\rho = 0.152$, $p > 0.05$), nor was there any difference in depth of capture between males and females (Mann-Whitney *U*-test, $n = 39$, $p > 0.05$).

When viewed by season, there was a notable fluctuation in *G. halavi* median size, with a winter minimum, intermediate spring and summer values, and an autumn maximum (Fig. 3). However, as in the case of *M. arabica*, the small sample size precluded any statistical comparison of these data.

Representative 633 bp CO1 sequences generated for *M. arabica* and *G. halavi* were submitted to GenBank, with accession numbers OR195432 and OR195435, respectively. The Basic Local Alignment Search Tool (BLAST) did not recover any pre-existing CO1 submissions for either species. However, the current *M. arabica* sequence displayed a 100% match (100% query cover) with a '*Maculabatis* sp.' submission from Thailand (accession no. MZ407818.1) and high similarity (>99% with 100% query cover) with '*Himantura* sp. A' sequences from the west coast of India (accession nos. KF899466.1, KF899465.1). The most similar sequence from a fully identified specimen was a *M. randalli* from Qatar (accession no. GU673593.1) (95.77% with 97% query cover).

Existing *Glaucostegus* spp. CO1 sequences exhibited a relatively low similarity with the current *G. halavi* sequence, none exceeding 92%. The closest matches were '*Glaucostegus* sp.' sequences from the Bay of Bengal (e.g. accession no. MW431027.1) at 90.98% (99% query cover), *G. cemiculus* from the Mediterranean Sea (accession no. KY176593.1) at 91.17% (98% query cover) and *G. granulatus* from Bangladesh (accession no. MH230954.1) at 91.03% (98% query cover).

4. DISCUSSION

This study provides the first record of *Maculabatis arabica* in the Gulf waters of the UAE. The reported range of *M. arabica* is the northern Indian Ocean off Pakistan and western India (Last et al. 2016), but it has also been recorded from Fujairah on the Gulf of Oman coast of the UAE (although, reported as *Himantura* sp. at the time) (Henderson et al. 2016), and from both Iraqi and Iranian waters within the Arabian Gulf (Al-Faisal & Mutlak 2020, Golzarianpour et al. 2020). These records, combined with the results of the present study, suggest a much broader *M. arabica* distribution than previously thought. Moreover, if the matching *Maculabatis* sp. CO1 sequence from Thailand (accession no. MZ407818.1) was captured in that locality, this further indicates that the distribution of *M. arabica* may extend into areas of the eastern Indian Ocean and western Pacific Ocean.

The maximum size previously reported for this species is 61 cm DW (Last et al. 2016), 11 cm smaller than the largest individual encountered here. Therefore, in addition to extending the known geographic range of *M. arabica*, the present study increases its known maximum size.

Glaucostegus halavi is known to occur around the Arabian Peninsula, including the waters of the Gulf (Randall 1995). However, the species remains poorly studied. It is thought to mature at around 83 cm TL (Last et al. 2016), which would suggest that the females encountered during the present study were a mix of mature and immature individuals, while all males were mature. This is supported by the fact that all males in the present study possessed calcified claspers. The species is known to grow larger than the individuals encountered here, with sizes up to 187 cm TL reported from Bahrain (Moore & Peirce 2013) and up to 207 cm TL reported from Oman (Jabado 2018). This may mean that larger individuals avoid shallow, nearshore waters, or it could reflect a possible decrease in the abundance of large individuals within the Gulf, as a consequence of the par-

ticularly heavy levels of exploitation that shark-like batoids (Rhinopristiformes) have experienced in the region (Jabado 2018).

The seasonal changes in abundance and size distribution exhibited by both species point to a dynamic situation regarding their demographics in nearshore waters. That all except 1 of the *M. arabica* encountered were female is indicative of sexual segregation in this species, with the winter decline in abundance possibly reflecting an offshore breeding migration. The summer/autumn decline in *G. halavi* abundance is more likely explained by environmental conditions, with summer water temperatures exceeding 35°C and not falling below 30°C until late autumn (Environment Agency — Abu Dhabi unpubl. data). The fact that *M. arabica* abundance did not decline during this period is somewhat surprising and may indicate a particularly high temperature tolerance in this species.

Despite a year-round occurrence within the study area, only 1 animal was recaptured. It is unlikely that this was due to excessive tag loss, as subdermal PIT tags are commonly used in elasmobranch studies and are known to have a high rate of retention (Feldheim et al. 2002). It seems more likely that individual *M. arabica* and *G. halavi* may have only a transient association with the area under consideration. If this is indeed the case, it follows that there must be additional areas of importance to their respective populations elsewhere. Further studies will be required to assess residency and movement patterns in both species.

The current findings come with important caveats. Sampling effort was not consistent across the duration of the study, due to the impact of COVID-19 travel restrictions. Spring, in particular, was underrepresented compared to other seasons. Similarly, the use of 2 hook sizes was intended to minimise the inherent catch size bias associated with hooks (Løkkeborg & Bjordal 1992). Although a broad size range was captured during the study, smaller size classes may have been under-represented. It is envisaged that on-going research will provide a more detailed assessment of the demographic characteristics of both species in due course. Additionally, the lack of existing CO1 reference sequences in GenBank from verified *M. arabica* and *G. halavi* specimens should be borne in mind.

The findings of the current study indicate that sheltered, shallow nearshore environments are an important habitat for both *M. arabica* and *G. halavi*. Henderson et al. (2022) showed that baited hook assessments consistently underestimate shark abundance due to a combination of factors, and it seems likely that this would hold true for other elasmobranch lineages. Hence, *M. arabica* and *G. halavi* abundance within the present study area may be even greater than the data suggest. Consequently, it is a matter of considerable concern that the wider Khor Faridah area is currently undergoing intensive coastal development, including land reclamation and channel dredging. The highly localised occurrence of 2 Critically Endangered elasmobranch species within this area should be given due consideration by local planning and conservation authorities.

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