Chapter 3: RED SEA

Luisa Schramm[1], David Blair[2], Amgad El Shaffai[3], Abdulqader Khamis[4], Len McKenzie[5], Tekle Mengstu[6], Nicolas Pilcher[6], Ahmed Shawky[8], Helene Marsh[2]

[1] Centre for Tropical Water and Aquatic Research TropWATER, Townsville, Queensland, Australia.

[2] College of Science and Engineering, James Cook University, Townsville, Queensland, Australia.

[3] Egyptian Environmental Affairs Agency, Ministry of Environment, Cairo, Egypt.

[4] Faculty of Biology, University of Barcelona, Barcelona, Spain.

[5] Centre for Tropical Water and Aquatic Research TropWATER, Cairns, Queensland, Australia.

[6] Ministry of Marine Resources, Massawa, Eritrea.

[7] National Centre for Wildlife, Riyadh, Saudi Arabia.

[8] EcoPro Training Center, Ismailia, Egypt.

Correspondence to: Helene Marsh helene.marsh@jcu.edu.au.

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Regional Findings

Red Sea: Djibouti, Egypt, Eritrea, Saudi Arabia, Sudan and Yemen.

- The dugong distribution in the Red Sea is fragmented, reflecting the availability of suitable seagrass habitat.
- The dugong population of the Red Sea was estimated to be up to 4,000 animals in the 1980s, an estimate extrapolated from an aerial survey estimate of the number of dugongs in the Saudi Arabian waters of the Red Sea in 1987, plus interview surveys in Yemen in 1988.
- There is a lack of contemporary data on both dugongs and their seagrass habitats for most countries bordering the Red Sea, especially the Range States along the western coast. Recent research assessing the status of dugongs in the region is largely based on local-scale research including interviews with fishers, studies of feeding trails and photo-identification of individual dugongs and unpublished reports of recent aerial surveys along parts of the Saudi Arabian coast.
- The following Important Marine Mammal Areas of relevance to dugongs have been declared in the Red Sea: the 'Northern Red Sea Islands' and the 'Southern Egyptian Red Sea Bays, Offshore Reefs and Islands' in Egypt; and the 'Farasan Archipelago' in Saudi Arabia.
- In addition, there are Important Marine Mammal Areas of Interest, which are still being evaluated, for which the dugong is listed as a supporting species: (1) the 'Golfe de Tadjoura' and (2) 'Seven Brothers Islands and Gondoya', in Djibouti; (3) 'Dhalak and Adjacent Southern Waters' in Eritrea; (4) 'Dungonab Bay–Mukawar Island', and the 'Suakin Archipelago and Sudanese Southern Red Sea' in Sudan.
- The dugong status in the region is currently data deficient.
- It is likely that dugongs have declined in the Red Sea in recent decades due to human-caused mortalities relating to past hunting pressure and current incidental bycatch and habitat loss.
- The Programme for the Environment of the Red Sea and Gulf of Aden (PERGSA) offers an established framework for regional co-operation on the marine environment and conservation in the Red Sea. A constructive way forward might be to invite PERSGA to co-ordinate a regional strategy for dugongs in the Red Sea.
- A key initiative could be a program of coordinated and replicable research on the distribution and abundance of dugongs and their seagrass habitats across the countries of the Red Sea. Such a program should use techniques that are appropriate to the capacity of each country and the known distribution of its dugongs, but enables cross-country comparisons.

3.1 Regional Setting

3.1.1 Geographic Overview

This chapter considers the status of the dugong along the ~ 12,858 km coastline of the Red Sea, from the Somalia-Djibouti border in the southwest, north through the Red Sea to the Gulfs of Suez and Aqaba, and south back to Aden, Yemen in the southeast. The region is divided into three sections: the Red Sea proper, the Gulf of Aqaba, and the Gulf of Suez (and Suez Canal) (Figures 3.1, 3.2). The Red Sea is connected to the Gulf of Aden via the narrow (26 km wide) and relatively shallow (186 m deep) Bab-el-Mandeb Strait, between Djibouti and Eritrea on the coast of the Horn of Africa to Yemen on the Arabian Peninsula.

The Red Sea proper is bordered by coastlines of the following dugong Range States (counter-clockwise from the border with Somalia): Djibouti, Eritrea, Sudan, Egypt, Saudi Arabia, and Yemen. The Gulf of Suez and Suez Canal are entirely within Egyptian waters, and the Gulf of Aqaba is bordered by Egypt, Israel, Jordan and Saudi Arabia. Jordan and Israel are not considered further here as there is no recent evidence of resident dugongs in either country. Nonetheless, Lipkin (1975) studied the stomach contents of three dugongs from the Gulf of Aqaba (Eilat) suggesting that dugongs may have occurred in the Gulf waters of Israel at some time.

The Red Sea is a 2,000 km long, deep, narrow, semi-enclosed sea spanning 16^{o} of latitude. Its maximum width is 306 km, greatest depth 3 km, and its area ~ 450,000 km^2 (Augustin et al. 2014; Rasul et al. 2015). It is likely that the shallow Bab-el-Mandeb Strait causes the Red Sea to act as a standalone body of water, possibly as a barrier to species distributions. Coastal regions have low rainfall and scant vegetation and until recently, human populations along the coast have generally been sparse and centred on a few cities and towns (Carvalho et al. 2019).

The dugong distribution in the Red Sea is fragmented, reflecting the availability of suitable seagrass habitat (Preen 1989; Al-Mansi 2016). In the northern Red Sea, substrates suitable for seagrasses are restricted by the extensive fringing reefs that drop off steeply into deep water (Preen 1989). In other regions of the Red Sea, seagrass beds are largely restricted to the shallow, soft bottom areas of sharms and marsas (inlets and bays) or intertidal and submarine wadi (dry riverbed) outwash plains, and some shallow areas in the lee of offshore islands (Khamis et al. 2022). There are extensive shallows in the Al Wajh Bank (Figure 3.2) and further north in the extreme northeast of the Red Sea, in what is today NEOM (a futuristic, urban area currently under construction by Saudi Arabia, see Section 3.4). The continental shelf is wider and shallower in the southern Red Sea, and the sedimentary substrates suitable for extensive seagrass communities are more abundant (Preen 1989; El Shaffai 2011, 2016).

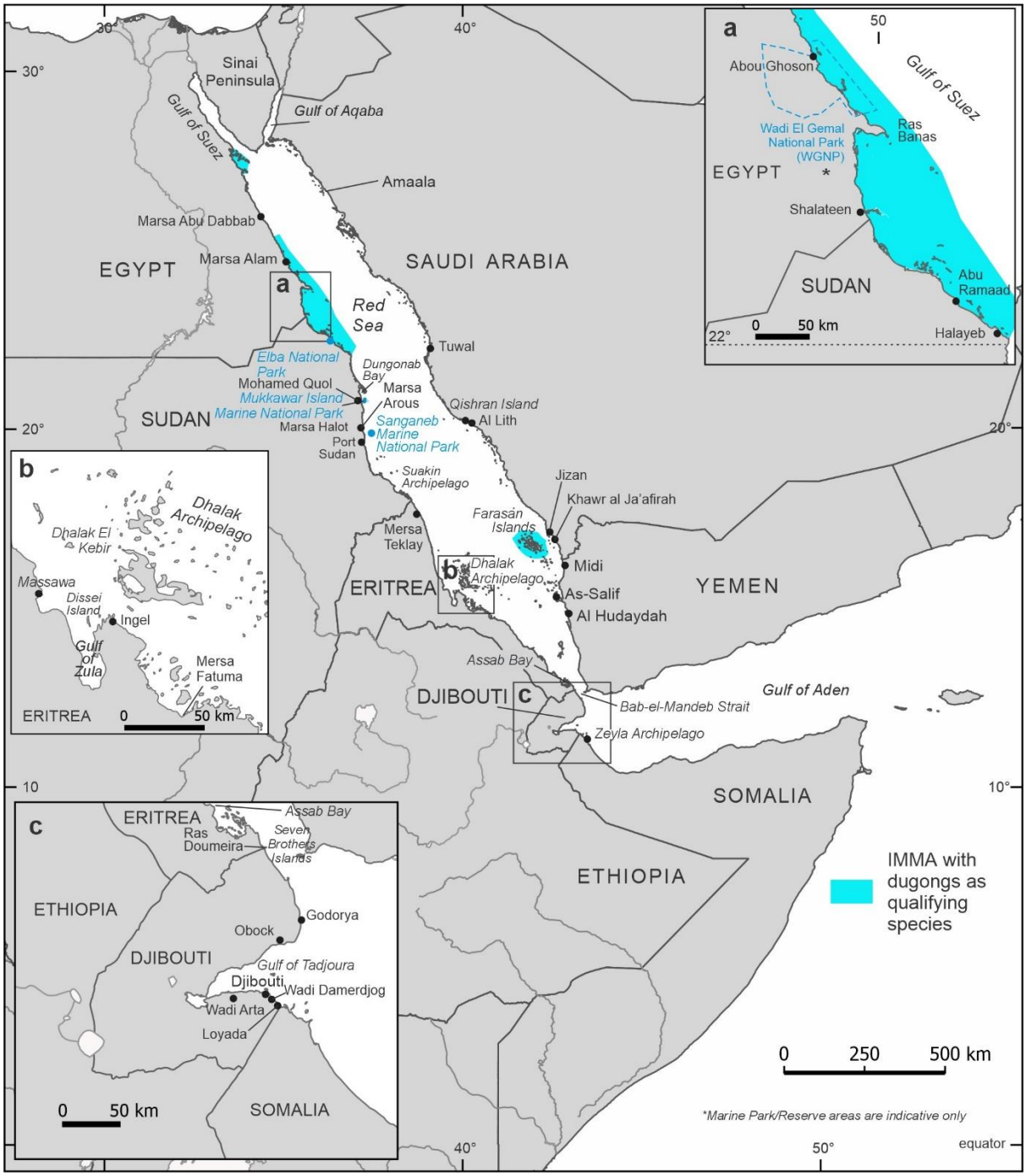

Figure 3.1. Geographic context of the Red Sea showing placenames mentioned in the text. Dugong Range States are ordered clockwise around the region starting with Djibouti: Djibouti, Eritrea, Sudan, Egypt, Saudi Arabia and Yemen. Important Marine Mammal Areas with the dugong as a qualifying species are shown in blue. Insets: (a) Egypt-Sudan border with Wadi El Gemal National Park (WGNP); (b) Dhalak Archipelago in Eritrea; (c) Djibouti. Figure created by Adella Edwards; reproduced with permission.

Figure 3.2. Geographic context of the Gulfs of Suez and Aqaba within the Red Sea with placenames mentioned in the text. Figure created by Adella Edwards; reproduced with permission.

The Red Sea is part of the Tropical Indo-Pacific seagrass bioregion (Short 2007). Twelve seagrass species have been recorded (El Shaffai 2016), most of which usually grow in the shallow subtidal regions (up to 10 m deep) (Lipkin et al. 2003), with some species found as deep as 70 m (El Shaffai 2016). The central Red Sea has the highest diversity of seagrass species, while the northern Red Sea has up to eight species (Jones et al. 1987). The distribution of seagrass meadows progressively increases in extent towards the south, due in part to a shallower, wider shelf; a higher proportion of unconsolidated sediments; and less extreme temperatures and salinities (Bruckner et al 2012). Estimates of the total area of seagrass within the region are as follows (countries ordered counterclockwise, consistent with the chapter, starting with Djibouti): Djibouti 4 km^2 (Allen Coral Atlas 2020); Eritrea: 278 km^2 (Allen Coral Atlas 2020); Sudan: 48 km^2 (Allen Coral Atlas 2020); Egypt: 108 km^2 (Allen Coral Atlas 2020; El-Regal et al. 2012); Saudi Arabia: 117 km^2 (Chalastani et al. 2020; Bruckner et al. 2012); Yemen: 89 km^2 including the Gulf of Aden (Allen Coral Atlas 2020) (all areas are rounded to the nearest km^2, confidence intervals are not available, all estimates were made with moderate to high confidence and are minimum estimates).

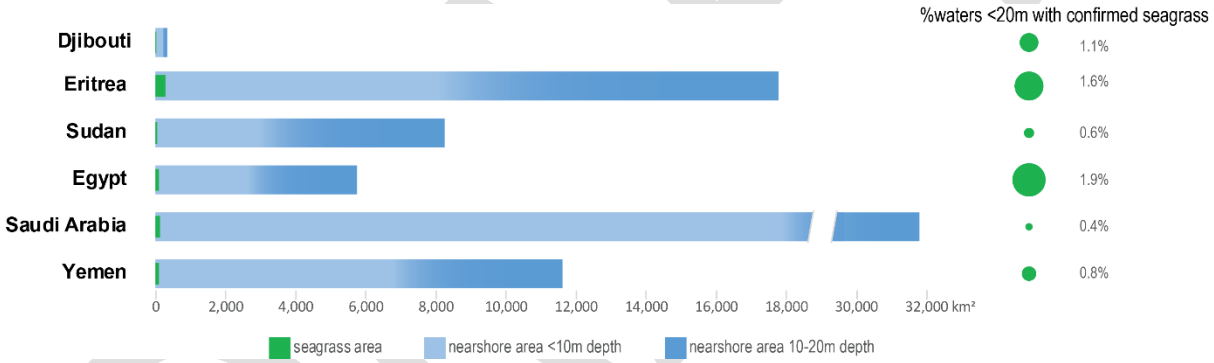

Figure 3.3. Histogram showing the known areas of seagrass and coastal waters < 10m and < 20 m deep for each dugong Range State in the Red Sea region. The areas of seagrass are almost certainly underestimates and do not include reef associated seagrasses. Figure created by Len McKenzie, reproduced with permission.

Aerial surveys of the Saudi Arabian coastline conducted in 1987 by Preen remain the only published large-scale, systematic study of dugongs for the Red Sea region. Preen (1989) used a strip transect technique based on Marsh and Sinclair (1989) and corrected for detection biases. He estimated the total dugong population of the entire Red Sea to be up to 4,000 individuals (Preen et al. 2012), an estimate extrapolated from the survey estimate of 1,820 ± SE 380 in Saudi Arabian waters plus some interview surveys in Yemen in 1988 (Preen 1989). Preen assumed that dugong density on the western coast of the Red Sea would be comparable to that on the eastern coast, given the similarity in geomorphology. Dugong density within his survey area was similar with those of the Arabian Gulf and eastern Australia (0.22–0.047 individuals km^{-2}). Preen's (1989) estimate was much higher than

previous estimates of dugong populations in the Red Sea (Ormond 1978; Frazier et al. 1987), which were based on incidental sightings from boats.

There is a lack of contemporary data on both dugongs and their seagrass habitats for most countries bordering the Red Sea, especially Range States along the western coast. Recent research assessing the status of dugongs in the region has largely been at the local-scale, including interviews with fishers (Hanafy et al. 2006; El Shaffai 2015; Qahtani unpublished data), studies of feeding trails (e.g., Shawky 2018, 2019b; Khamis et al. 2022; Nasif 2022; Shawky 2024) and photo-ID of individual dugongs (e.g., Shawky et al. 2019). There are unpublished reports of recent aerial surveys along parts of the Saudi Arabian coast (see Section 3.2.5 below).

The geography of the region suggests that it is extremely unlikely that the Red Sea dugong population is currently linked to the Arabian/Persian Gulf population, which is ~ 1,600km to the north and separated from the Gulf of Aden by the open Indian Ocean coast of the Arabian Peninsula. The Djibouti population is likely connected to the population in Somaliland (Chapter 2).

3.1.2 Geo-Political and Socio-Economic Overview

This information is provided as an indication of the challenge for each of the Range States in the region to consider the conservation of dugongs and their habitats in the context of their socioeconomic development needs. The Red Sea region is home to ~ 226 million people, increasing at ~ 1.77% p.a. (United Nations Development Programme [UNDP] 2022). The population growth rate around the Red Sea is expected to double in the next 20–30 years (Fine et al. 2019). The Human Development Index (HDI) status and Gross Domestic Product (GDP) of the dugong Range States bordering the Red Sea is diverse (Table 3.1). Saudi Arabia has a Very High Human Development Index (HDI), while its neighbour Yemen had the seventh lowest HDI of any country in 2023. Egypt has a High HDI, Djibouti, Sudan and Eritrea, Low HDIs (UNDP 2022). The per capita GDP data follow a similar pattern (Table 3.1).

There is ongoing geopolitical instability in the Red Sea region (Dunne 2021). As nations across the Horn of Africa push to settle inter- and intra-state disputes, global powers are investing in the region to establish footholds in the emerging market. Even though the region continues to undergo extensive development, the opening of a Northern Sea route across the top of Russia as the climate changes could slow the region's production (Blunden 2012), a situation that may be hastened by the instability in the Middle East Region.

Table 3.1. Human Development Index (HDI) status and Gross Domestic Product (GDP) per capita rank of the Dugong Range States in the Red Sea. Consistent with the remainder of this Chapter, the

countries in this table are ordered counter-clockwise around the Red Sea starting with Djibouti. The ranks are ordered so that countries with the highest HDI or GDP have the lowest ranks. 189 countries were ranked for both indices.

Range State	HDI	HDI Rank 2023[1]	GDP per capita rank[2]
Djibouti	Low	171	133
Eritrea	Low	176	175
Sudan	Low	172	156
Egypt	High	97	92
Saudi Arabia	Very High	35	15
Yemen	Low	183	177

[1] 2023 HDI data from https://hdr.undp.org/data-center/country-insights#/ranks (downloaded from the internet January 2024);

[2]2023 per capita GDP from https://en.wikipedia.org/wiki/List_of_countries_by_GDP_(PPP)_per_capita (downloaded from the internet January 2024)

More than 10% of global trade passes through the Red Sea each year (Dunne 2021). The threat of oil pollution is serious as the region remains a vital route for the global oil trade, connecting oil rich Arabia to Europe. The Suez Canal has undergone recent expansions to combat blockages at bottlenecks, such as the 2021 Ever Given blockage, to increase capacity and minimise waiting time for transiting ships (Suez Canal Authority 2019).

Many of the coastal communities along the largely undeveloped western coast of the Red Sea rely heavily on marine resources, especially fisheries (e.g., in Djibouti and Sudan (Gladstone et al. 2003)). Along the Saudi Arabian Red Sea, the major cities are industry and shipping hubs, with tourism and fisheries comprising less of a financial value. Smaller towns and villages still rely on fisheries as key income sources. Much of the Red Sea consists of clear, oligotrophic environments and is considered a key location for diving and snorkelling tourism (Carvalho et al. 2019; Chalastani et al. 2020). Dugongs are a significant tourist attraction some coastal areas in Egypt (Ayad 2021).

3.1.3 Genetics of Dugong Sub-Populations

For an overview of techniques, relevant genetic studies and general findings, refer to Chapter 1.

The Red Sea has very high levels of species endemism (DiBattista et al. 2016), implying a long evolutionary history. At the last glacial maximum, the Red Sea was almost isolated from the greater Indian Ocean and its waters were hypersaline (DiBattista et al. 2016). It seems unlikely that a dugong

population could have persisted there during glacial maxima, especially as waters less than 60 m in depth were rare (Ludt and Rocha 2015) and therefore seagrasses were likely absent. DiBattista et al. (2016) suggested that the Gulf of Aden might have served as a glacial refugium for many Red Sea endemics. However, this region also had little or no shallow water at glacial maxima (Ludt and Rocha 2015). It therefore seems likely that dugongs dispersed into the Red Sea only after post-glacial sea-level rise.

Plön et al. (2019) have reported the only genetic data for dugongs in the Red Sea. Using DNA from historical museum collections, they generated between 122 and 309 basepairs of sequence from the mitochondrial control region for 26 individuals. Most were compatible with the common Western Indian Ocean haplotype (that from Tanzania and UAE in Figure 1.x) or differed at only 1-3 sites from this haplotype. Two sequences are exceptions to this: MH704339 (from an undated, unregistered specimen in the Natural History Museum, London) seems most similar to sequences of the restricted haplogroup from Australia (Chapter 10), and MH704345, also from the London collection, dated 1946 and from Jordanian waters at Aqaba, is a unique haplotype (placed in the widespread Australian haplogroup in Plön et al.'s (2019) Figure S4). Both sequences include some ambiguities, suggesting technical difficulties in sequencing. The Jordanian sequence might represent an endemic Red Sea/Gulf of Aqaba population, but this is only speculation.

- The genetic data for dugongs from the Red Sea is limited to partial mitochondrial control region sequences.
- The mitochondrial haplotypes are almost identical to the common haplotype from East Africa and the Arabian Gulf (Western Indian Ocean haplogroup).
- Genetic diversity therefore seems to be limited in the Red Sea, as in the Western Indian Ocean more broadly.

3.2 Distribution, abundance and trends in Range States

The accounts in this Section have been arranged counter-clockwise around the Red Sea starting with Djibouti.

3.2.1 Djibouti

There appears to be no contemporary information on dugongs in Djibouti waters. Robineau and Rose (1982) reported 23 observations (mainly dead net captures) between 1966–1980 in the coastal waters of the Gulf of Tadjoura, between the border with Somaliland and Obock (Figure 3.1). In December 1980, they undertook a helicopter flight to explore the coastal waters from Ras Doumeira (12.70° N, 43.13° E) in the Bab-el-Mandeb Strait, down to Loyada (11.45° N, 43.25° E), close to the

border with Somaliland. They saw 32 individuals including calves between Wadi Damerdjog and Wadi Arta, west of Loyada.

Djibouti has two Important Marine Mammal Areas of Interest (IMMA AoIs) for which the dugong is listed as a supporting species: (1) the Golfe de Tadjoura and (2) Seven Brothers Islands and Godorya (IUCN-MMPATF). These IMMA AoIs need to be further evaluated before they can be formally recognised.

- Information on dugongs in Djibouti is extremely dated and limited to a helicopter flight in 1980, which recorded 32 dugongs.

3.2.2 Eritrea

More research is required to determine the distribution and abundance of dugongs in Eritrea, especially given the significant area of known seagrass (278 km^2). Teclemariam et al. (2007) reported the results of survey trips and interviews with fishers and coastal locals between 2004 and 2007. They found dugong remains (bones, skulls, jaws, skin) in fishing camps and villages in almost all the areas surveyed, and reported 34 sites (coastal villages, coastal areas, or islands) where dugongs occurred based on fishers' reports. Dugongs were also sighted during boat surveys (Y. Teclemariam, personal communication 2024). Most of these sites are near-shore, shallow embayment areas supporting seagrass. They concluded that 'It is clear that Eritrea has a significant dugong population', which they estimated to be 300 to 400 individuals based on the apparent stability of catches and effort and an assumed natural rate of increase of 5% per annum. Teclemariam et al. (2007) reported that dugongs were scattered all along the coastal waters, especially in the central part of the Eritrean Sea, north of Massawa to Mersa Teklay, south of Massawa to Mersa Fatuma including the Dahlak archipelago, Assab Bay and surrounding areas (Figure 3.1).

Although there were no historical records to establish trends, Teclemariam et al. (2007) inferred that numbers were likely to be stable because fishers considered that there was no evidence of decline. They estimated that fishers caught ~ 20 individuals $year^{-1}$ incidentally in gillnets. Live animals were released and drowned individuals consumed locally. Some villages (Dissei, Ingel and Dhalak El Kebir; Figure 3.1) reported consuming three to five individuals each year (Teclemariam et al. 2007). Fishers reported rare sightings of dugongs, but all villages interviewed reported slaughtering dugongs, with the exception of two agricultural villages north of Massawa and in the Gulf of Zula (Teclemariam et al. 2007).

Although Lipkin (1987, 2003) reported that seagrass communities were sparse and uncommon in the Dhalak Archipelago, the Dhalak and Adjacent Southern Waters have been listed as an IMMA AoI,

pending more information, with the dugong as a supporting species (IUCN-MMPATF). The Dhalak Archipelago, Hawakil Bay and Offshore Islands have been confirmed as a Key Biodiversity Area (KBA) (Key Biodiversity Areas [KBA] Partnership 2024a).

- Dugong abundance in Eritrea was estimated at ~ 300-400 individuals based on interviews and boat surveys between 2004-2007.

3.2.3 Sudan

Information on the distribution and abundance of the dugong in Sudan is sparse. Ormond (1978) estimated the Sudanese dugong population to be 20-40 animals. Nocturnal vocalisations were heard in Dungonab Bay and Marsa Halot in 1973 by staff of the Fisheries Research Section (Nasr et al. 2019). Nasr et al. (2019) reported that dugongs were found throughout Sudanese waters, from Suakin harbour and archipelago (south of Port Sudan) and in the various wadis to the north of Port Sudan such as Marsa Halot and Marsa Arous, and off Mohammed Quol, which lies south of the wide entrance to Dungonab Bay (Figure 3.1).

Dungonab Bay Mukkawar Island Marine National Park was inscribed on the World Heritage List in 2016 as part of a serial nomination. The Statement of Outstanding Universal Value (OUV) states that Dungonab Bay supports 'a globally significant dugong population, given that the Red Sea and the Persian Gulf [sic] host the last remaining healthy populations of this species in the Indian Ocean' (UNESCO 2016; Claudino-Sales 2019) (but see Chapter 2). Dungonab Bay–Mukawar Island and Suakin Archipelago have been confirmed as KBAs (KBA Partnership 2024b). Dungonab Bay–Mukawar Island, and the Suakin Archipelago and Sudanese Southern Red Sea, have also been declared IMMA AoIs that require further evaluation (IUCN-MMPATF).

- Information on the distribution and abundance of dugongs in Sudan is limited and dated.
- The Dugonab Bay Mukkawar Island Marine National Park was listed as a World Heritage site in 2016 with the dugong listed in the statement of Outstanding Universal Value.

3.2.4 Egypt

Anecdotal information on dugong distribution in Egypt has been obtained using a variety of techniques over many years. Gohar (1957) recorded 16 individuals within the 70 km between Hurghada immediately south of the Gulf of Suez and Ras Gemsha, near Safaga (Figure 3.2). These animals were caught for research over 14 years using fishing nets. Hanafy et al. (2006) reported a low-density population throughout the area with 12 to 17 individuals in the period 2001–2003 based on interview surveys in the area of Hurghada to Shalateen about 200 km north of the border with

Sudan (Figures 3.1, 3.2). These respondents reported eight adults and three juveniles around Marsa Alam and six adults and one juvenile in Wadi El Gemal (Figure 3.1). They also reported five dugong carcasses on the Egyptian Red Sea coast between 1999 and 2004 with injuries consistent with netting entrapment (Hanafy et al 2006). Shawky et al. (2024) estimated the dugong population size in the Egyptian Red Sea as 73-97 animals based on interview questionnaire surveys and photo identification.

Shawky et al. (2024) administered 207 standardised dugong catch/bycatch questionnaires developed by the United Nations Environmental Programme (UNEP) Convention on Migratory Species (CMS) Dugong Memorandum of Understanding (Dugong MOU) (Pilcher et al. 2017) between August 2015 and May 2016. Fishers and some other stakeholders at twenty sites in seven regions were interviewed; Elba Protected Area (EPA, one site), Ras Banas (three sites), Wadi El Gemal National Park (WGNP, seven sites), Marsa Alam (five sites), Qosseir (two sites), Northern Islands Protected Area near Hurghada (NIPA, one site) and Southern Sinai (one site). More than 97% of the respondents were 15–75 years old, and the largest age group was 26–50 years (77%) with a mean age of 35 ± 6 years. Ninety-eight percent of respondents were aware of dugongs and encountered them during fishing (27%) or in transit to fishing areas (>39%). They reported 1,322 dugong sightings 1980–2016; many of these are almost certainly repeat sightings. A total of 24 strandings (five live and 19 dead) were recorded between 1986 and 2023. Of those, 15 cases occurred during the last decade (i.e., since 2013) (12 dead and three live). Over the last three decades, two large dugongs stranded in gillnets in the village of Abou Ghoson when the local fishers left their nets untended near the shore. Those dugongs were eaten, and the skin used as armour.

Based on these fisher interviews, Shawky et al. (2024) reported dugongs from 95 sites along the western coast of the Egyptian Red Sea, including two in south Sinai, nine in Hurghada, three in Safaga, 11 in Qosseir, 31 in Marsa Alam, 17 in Wadi El Gemal National Park, five in Ras Banaas and 17 in Shalateen, Abou Ramaad and Halayeb regions (Figures 3.1 and 3.2). Sixty-one percent of respondents estimated the dugong population to be about 2–10 individuals in key areas. Approximately 89% of the fishers claimed that the trend in the net capture of dugongs was decreasing. This result should be interpreted with caution, as the decrease could reflect both a decrease in captures as a consequence of an overall decrease in population size as pointed out by Plicher et al. (2017). Ninety-six percent of respondents had encountered a dugong at least once in the previous year; > 72% of dugongs were released alive; 13% were reported as eaten. Although 66% of fishers stated that dugongs were not hunted in their village, > 25% claimed that they were captured in other villages. Four percent of the respondents claimed that dugong numbers were declining and > 79% believed that dugongs could be extinct in the future.

A lone male dugong calf was found stranded in Wadi El Gemal National Park in 2015 and released on the same day (Shawky et al 2016). After 12 days the calf was found dead on a reef close to the original stranding site.

Shawky (2018) and Shawky et al. (2019) used photograph identification of permanent notches and scars to estimate dugong numbers at 30 inshore dive sites between December 2015 and October 2017. Thirty individuals including four calves were recognised across 22 sites over 180 km: 14 sites in Marsa Alam, and eight in WGNP (Figure 3.1). Identified males outnumbered females 7:1 at both sites, a possible availability bias. Although eight individuals were recorded undertaking long-and short-distance movements within the study sites, no identified individual was recorded moving between Marsa Alam and Wadi El Gemal National Park. (Figure 3.1).

Two IMMAs have been declared in the coastal waters of the Egyptian Red Sea: The Northern Red Sea Islands (declared in 2020 with the dugong as a supporting species) (IUCN-MMPATF 2020), and the Southern Egyptian Red Sea Bays, Offshore Reefs and Islands (declared in 2021 with the dugong as a qualifying species (IUCN-MMPATF 2021b).

- Small groups of dugongs have been reported from 95 sites along the western coast of the Egyptian Red Sea.
- Shawky et al. (2024) estimated the dugong population size in the Egyptian Red Sea as 73-97 animals based on interview questionnaire surveys and photo identification.
- Two Important Marine Mammal Areas of relevance to dugongs have been declared in the coastal waters of of the Egyptian Red Sea: The Northern Red Sea Islands (in 2020) and the Southern Egyptian Red Sea Bays, Offshore Reefs and Islands (in 2021).

3.2.5 Saudi Arabia

The dugong population along the Red Sea coast of Saudi Arabia was considered to be of global significance on the basis of comprehensive large-scale aerial surveys conducted in 1987 (Preen et al. 2012) but is now data deficient because that information is dated.

Preen (1989) conducted strip-transect quantitative aerial surveys over 22,371 km^2 of dugong habitat in seven zones along about 70% of the Saudi Arabian Red Sea coastline (excluding the Gulf of Aqaba) in the summer of 1987. He concluded that the bathymetry of the remaining coast suggested unsuitable dugong habitat. Preen (1989) estimated that there were 1,818 ± SE 382 dugongs in Saudi Arabian waters, concentrated in three areas: Al Wajh Bank, the Al Lith area and Jizan (Jazan, Gizan).

Although there is no published repeat of Preen's baseline study, there is some unpublished information of relevance. Pilcher (2022) led an aerial survey from the Farasan Islands to the Gulf of Aqaba (Figure 3.1) in 2022 and recorded ~ 40 dugong sightings (including five mother-calf pairs), half

the total number of sightings recorded by Preen in 1987 for the same region. Although the results of the 2022 survey are yet to be analysed; the comparison of sighting numbers with Preen's (1989) results over a vast spatial scale suggest a population decline.

There have also been some local-scale surveys. Gladstone sighted 27 dugongs on an aerial survey in the Jizan area in in 1993 (Gladstone, personal communication in Nasr et al. 2019). A survey in 2009 using underwater SCUBA equipment as well as incidental sightings from vessels recorded two dugongs in shallow onshore waters in the Farasan Islands (Al-Mansi 2016). Baldwin (2018) estimated a population of ~ 98 dugongs (95% CI 54-141) in the NEOM area in the north-eastern Red Sea; it is unclear whether this estimate was corrected for detection biases. There was a further survey of this region in 2023 using an unoccupied aerial vehicle (UAV); the results were not available at the time of writing. No dugongs were sighted in UAV surveys in Al-Wajh Lagoon in Saudi Arabia by Nasif (2022) although feeding trails were observed. There were seven off-effort sightings of dugongs within the study area (Nasif 2022).

Khamis et al. (2022) conducted large-scale in-water surveys of dugong feeding trails across 27 seagrass meadows. They covered ~ 4,061 km^2 of nearshore and offshore waters in the NEOM area and recorded 13 dugong feeding sites based on the presence of feeding trails. Many of the feeding trails were clustered around five main sites: Al-Muwaylih, Sindalah Island, Sanafir Island, Tiran Island and Ras Al-Shaykh Humayd (Figure 3.2).

The Farasan Archipelago, which includes the dugong as a qualifying species, was declared an IMMA in 2021 (IUCN-MMPATF 2021a). The associated Marine Protected area has also been nominated by Saudi Arabia as a tentative World Heritage Site with the dugong as a 'key taxon' (United Nations Educational, Scientific and Cultural Organization [UNESCO] 2019).

- The dugong population along the Red Sea coast of Saudi Arabia was considered to be of global significance on the basis of an aerial survey conducted in the summer of 1987, which resulted in a population estimate of ~ 1,800 animals.
- An aerial survey from the Farasan Islands to the Gulf of Aqaba in 2022 recorded only half the total number of sightings recorded in 1987 for the same region. Although the results of the 2022 survey are yet to be analysed; the comparison of sighting numbers is of concern and suggests a population decline.
- The status of the population is now data deficient.
- The Farasan Archipelago, which includes the dugong as a qualifying species, was declared an Important Marine Mammal Area in 2021.

3.2.6 Yemen

Research concerning dugong status in Yemen is limited to interviews with fishers. The lack of aerial surveys can be attributed to the historical and current conflicts faced by this dugong Range State. At the time of writing in early 2024, Yemen is experiencing a major humanitarian crisis, tormented by civil war and famine. Currently, 80% of the population is in need of humanitarian aid and protection, and 58% of the population lives in extreme poverty. (United Nations Office for the Coordination of Humanitarian Affairs 2021).

Dugongs occur as far south as Al Hudaydah on the eastern coast of the Red Sea (Preen 1989; Nasr et al. 2019) (Figure 3.1). Two Yemeni fishers claimed that the main area for dugongs is between Midi and As-Salif (Figure 3.1), a stretch of coast is known as *taweelah al bahr* – the dugong sea. Preen et al. (2012) estimated that the waters of Yemen supported up to 200 dugongs, based on interviews with fishers in and the extent of shallow water habitat suitable for seagrasses.

- Information on the dugong population of Yemen has not been updated since 1987.
- Population size was estimated to be ~ 200 animals in 1987 based on interviews with fishers in and the extent of shallow water habitat suitable for seagrasses.
- Dugongs occurred as far south as Al Hudaydah on the eastern coast of the Red Sea.
- Fishermen claimed that the main area for dugongs is between Midi and As-Salif, a stretch of coast is known as *taweelah al bahr* – the dugong sea.

3.3 Cultural values

In historic times dugong skin was an important product in the Red Sea region. It is believed that the coverings of the biblical Tabernacle housing the Ark of the Covenant were made from dugong skin (Cansdale 1970). In Eritrea, dugong skin was used for covering of the holy book *Birana* and to protect nets stored on the beach from the sun (Teclemariam et al. 2007). Sandals made from dugong skin are mentioned in the Bible (e.g., The Holy Bible: Numbers 4: 4–6, Exodus 25: 1-9). Egyptians used dugong hide for shoemaking, often purchasing the hides from Al-Wajh, Saudi Arabia (Gohar 1957) (Figure 3.2). Fishers in Yemen sold dugong skins in Aden and Djibouti for use as shields and helmets (Preen 1989). The skin was dried and used by Beja tribesman for shields (Nasr et al. 2019).

Other historical uses of dugongs in the Jizan area were similar to those East African Range States (Chapter 2): oil was used as a treatment for kidney failure and indigestion, bones were used as a treatment for rheumatism (Preen 1989). Dugong meat was also an important source of nutrition (Nasr et al. 2019).

Gohar (1957) claimed that the origin of the mermaid legend may lie in the resemblance of the dugong to human females and speculated that dugongs may have been used as surrogate females by sailors on long voyagers. He did not provide evidence for such claims.

3.4 Threatening processes

3.4.1 Interactions with fisheries

The major current drivers for dugong consumption are poverty and declining fish stocks (Nasr et al. 2019). In the past, dugongs were actively hunted on both sides of the Red Sea. Sudanese fishers speared dugongs and then hammered wooden plugs into their nostrils to drown them (Nasr et al. 2019). Interviews conducted by Preen (1989) confirmed that dugongs were historically hunted in the Al Wajh Bank, up to 'one or two generations' prior to his study. Preen (1989) noted a decreased demand for dugong meat and attributed the decline to the economic development of the region.

In Eritrea, incidental catch in gillnets designed for sharks and large pelagic fish is the main threat for dugongs (Teclemariam et al 2007). Artisanal fishers and members of the navy living along the coast used to hunt dugongs. An extensive awareness was implemented campaign from 2004–2007 aimed at educating locals to avoid the hunting of dugongs and marine turtles. Since, there has been a decrease in deliberate dugong hunting (Y. Teclemariam, personal communication 2024). In addition to this, the Ministry of Marine resources introduced two enforcements: 1) No person may fish any Marine Mammal or other protected species in Eritrean waters; 2) any Marine Mammal or other protected species caught accidentally must be released immediately and returned with the least injury to the waters from which it was taken. Failure to release any bycaught protected species is punishable with a fine of ERN 50,000 (USD $3,333.50). In the case of a subsequent conviction, the fine doubles to ERN 100,000 (USD $6,667) (Eritrean Fisheries proclamation No. 176/2014).

Many coastal residents in Sudan rely on marine resources for their livelihoods. Hand-lining is the most common fishing method (Vine 1986), though large nets used to catch sharks sometimes catch dugongs in the process (Ormond 1976; Gladstone 2000; Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden [PERSGA] 2001). Dugong bycatch has been reported in gillnets in Sudan. Recent reports are few.

In Egypt, more than 50% of the fishers surveyed by Shawky (2018) said that there is no enforcement and penalties are not imposed. Nine percent of the fishers working in the Elbe Marine Park in Egypt interviewed by Rouphael et al. (2013) in 2006 reported catching dugongs in their nets; this percentage had increased to 20% nearly a decade on (Rouphael et al. 2015). Thirty-five percent of Shawky's (2018) interviewees in Egypt believed that fishing nets are the main reason for the

dugong's decline; 11% reported that the accidental capture of dugongs in fishing nets had increased; 72% claimed they released them back to the sea.

Nasr et al. (2019) claim that dugongs are no longer actively hunted by fishers in Saudi Arabia. If a dugong is encountered, the relevant authorities are informed. Enforcement of reporting is extremely strong (N. Pilcher, personal communication 2024). Khamis et al. (2022) reported boats fishing with gillnets around the offshore islands off the Saudi coast in the north-eastern Red Sea. Nasr et al. (2019) consider that it is likely that dugongs accidentally drown in gillnets throughout most of their range in the Red Sea. Fishers in Tuwal (north of Jeddah in Saudi Arabia) do not eat dugong meat and either release dugongs back to the sea or donate the carcass to universities for study (Nasr et al. 2019).

3.4.2 Oil pollution

Red Sea dugongs face serious threats from oil pollution because the region is such an important oil transport route (Preen et al 2012). For example, coastal communities in war-torn Yemen were at serious risk of losing their livelihoods for eight years with a rusting oil supertanker remaining moored in their waters presenting a very significant risk of a major oil spill for several years from 2015 (Huynh et al. 2021). A United Nations-led operation transferred the oil to another vessel in 2023 avoiding what the UN Secretary-General described as 'a potential monumental environmental and humanitarian catastrophe' (United Nations News 2023). Nonetheless oil pollution remains an ongoing threat. In 2023 a tanker sank in international waters of the Red Sea; in 2021, one sank in Yemen (The Maritime Executive 2021).

3.4.3 Port development

There is the potential for port development on the African coast of the Red Sea to damage seagrass communities, due to the region's geo-strategic location at the intersection of shipping lanes of global importance (Styan 2020). The Red Sea is a corridor for Europe's imports and oil and links the Horn of Africa to world markets. At the time of writing Djibouti was expanding its ports with international assistance (Styan 2020). There are geo-political as well as economic reasons for port-development with major powers establishing military bases that require port access and deploying economic assistance and trade deals to achieve influence in the Red Sea African states (Dunne 2021). There is no debate on the environmental impacts of these developments (Styan 2020). Such developments could lead to dugong mortality from vessel strikes and cause seagrass loss.

3.4.4 Tourism

Ecotourism has resulted in the establishment of dugong dive tourism because of the exceptionally clear water in the Red Sea. At Marsa Alam in Egypt, large groups of divers may observe habituated

dugongs for a lengthy period (Shawky 2018) (See Figure 3.3). In Saudi Arabia, NEOM is being constructed as a futuristic mega-city along the north-eastern coast of the Red Sea covering 26,500 km^2, an area only slightly smaller than Belgium (Aly 2019). Khamis et al. (2022) surveyed the coastal waters of NEOM and identified dugong feeding sites close to proposed hotels and fishing harbours subject to high boat traffic fishing and coastal development. Further south the Amaala, Red Sea and Tuwal developments (Red Sea Global) further threaten important dugong feeding and development habitats.

Figure 3.4. A dugong surrounded by snorkelers at Marsa Mobarak, 55 km north of Marsa Alam and close to Port Ghalib on the Red Sea coast of Egypt from where vessels arrive daily bringing tourists. Ahmed Shawky photograph; reproduced with permission.

As in other regions, climate change and severe weather have the potential to impact the seagrass habitats of dugongs. For example, Abu El-Regal et al. (2012) reported that Marsa Abu Dabbab, a popular dive site in Egypt (Figure 3.1) was subject to the runoff from a severe flood in winter 2010, which smothered the seagrass with sediment.

3.5 Conservation initiatives

3.5.1 International conventions

All Dugong Range States bordering the Red Sea are parties to the Convention on Biological Diversity. All except Djibouti are signatories to CMS Dugong MOU. All are signatories to the United Nations Framework Convention on Climate Change (UNFCC), although Yemen had not ratified the agreement as of November 2023.

Many threats to the marine environment of the Red Sea such as pollution and resource depletion including overfishing, are trans-boundary harms requiring regional cooperation. In recognition of this reality, the 'Programme for the Environment of the Red Sea and Gulf of Aden (PERSGA)' was initiated in 1974 in collaboration with the Arab League Educational, Cultural and Scientific Organization (ALECSO) with the support of United Nations Environment Programme (UNEP). In 1982, the program was strengthened by Somalia, Sudan, Djibouti, Egypt, Jordan, Saudi Arabia, and Yemen signing the 'Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment' (Jeddah Convention), the 'Protocol Concerning Regional Cooperation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency' and the 'Action Plan for the Conservation of the Marine Environment and Coastal Areas in the Red Sea and Gulf of Aden'. These three instruments entered into force in August 1985. The Jeddah Convention was further consolidated by the signing and ratifying of two additional regional protocols in 2005: the 'Protocol Concerning the Conservation of Biological Diversity and the Establishment of Network of Protected Areas in the Red Sea and Gulf of Aden' and the 'Protocol Concerning the Protection of the Marine Environment from Land-Based Activities in the Red Sea and Gulf of Aden'. In addition, a 'Protocol Concerning Cooperation in Management of Fisheries and Mariculture in the Red Sea and Gulf of Aden' was finalised in 2017. That protocol provides the legal basis for collaborative and coordinated mechanisms among PERSGA states to regulate fisheries, combat illegal, unreported, and unregulated (IUU) fishing, adopt regional biosecurity and bio-safety systems in aquaculture, and implement ecosystem approach to fishery management and aquaculture development, a very important addendum to the 1982 Jeddah Convention.

The signing of the 'Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas' by PERSGA member states has enabled a regionally coordinated approach to establishment of a Marine Protected Area (MPA) Network. Gladstone et al. (2003) recorded 75 proclaimed and recommended MPAs in the Red Sea. Although theoretically this should bode well for biodiversity conservation in the Red Sea, the level of protection afforded to dugongs is unknown outside Egypt (Rouphael et al. 2015) because it has not been measured. Rouphael et al.

(2015) assessed the capacity of two Egyptian MPAs to protect megafauna including the dugong. They concluded that the Elba and Wadi El Gamal National Parks were not providing comprehensive protection for dugongs; similar proportions of fishers used nets irrespective of whether they lived inside or outside the MPAs. Although a greater proportion of fishers living outside the MPAs had caught dugongs in nets, the proportions of fishers living inside the MPAs who had caught dugongs (20%) in nets was higher than some 10 years earlier (Rouphael et al. 2013), and a greater proportion of fishers were using nets in 2013 than before. Rouphael et al. (2013) concluded that it was unlikely that the MPAs outside Egypt are providing a better level of protection for dugongs, illustrating the challenge of enforcing dugong conservation across the Red Sea.

Due to the lack of enforcement and establishment of most MPAs (Gladstone 2000; PERSGA 1998), the number of MPAs in the Red Sea was reduced to 12 (see Gajdzik et al. 2021 Figure 1). PERSGA and other national initiatives that followed (mainly in Egypt and Saudi Arabia) resulted in a substantial increase in MPA coverage from ~ 2 km^2 prior to 1983 to > 16,600 km^2 in 2014 (One Shared Ocean 2015). Nonetheless, most MPAs in the Red Sea remain paper parks with no implementation, management, or legal enforcement (UNEP-WCMC and IUCN 2020).

More recent 'in-house' protection efforts for dugongs at NEOM and Amaala and Red Sea developments along the Saudi coast bode well for protecting dugong habitat, although concern remains that activities within these developments (e.g., boating) will adversely impact dugongs. Similarly, the development of a Management Plan for the Farasan Islands also presents opportunities for protection of dugongs and their habitat in this fragile ecosystem in the southern Saudi Arabian Red Sea.

3.5.2 Other conservation initiatives

The World Bank Red Sea and Gulf of Aden Strategic Ecosystem Management Global Environment Facility (GEF) Project 2012-2018 had a final project development objective: 'To improve management of selected MPAs by local communities and strengthen information sharing between PERSGA member countries' (World Bank 2019). The project was developed in recognition of the need for the littoral countries of the Red Sea to have the capacity to coordinate and work together to monitor, manage, and protect the region's fragile environmental resources, despite their very different stages of development. The project improved the protection of over 200,000 hectares of marine waters in the pilot sites of Dungonab Bay – Mukkawar Island Marine National Park in Sudan and Wadi El Gemal National Park in Eygpt, which are known dugong areas with updated zoning plans and assigned user rights informed by consultations with community members, and the completion of 10 community-based alternative livelihood sub-projects to reduce pressure on marine resources.

Gajdzik et al. (2021) concluded that Red Sea biodiversity is only nominally protected by the non-cohesive network of small MPAs, most of which are 'barely implemented'. They argued that a large-scale connectivity-informed MPA approach would be an avenue to unite the Red Sea's coastal nations toward acting for the common good of conservation and reverse the global decline in marine biodiversity. They did not suggest the dugong as a flagship species for this approach, but it could be an appropriate candidate.

3.6 Research and monitoring initiatives

3.6.1 Techniques used to date

Aerial surveys conducted for dugongs along the Saudi Arabian coast by Preen (1989) remain the benchmark for systematic survey for megafauna in the region. Pilcher (2022) repeated the survey however, no population estimates have been calculated for these data.

Along the coast of the Red Sea there has also been local and regional scale survey efforts for dugongs and their seagrass habitats using a range of techniques as summarised in Table 3.2. However, apart from the work of Preen (1989), these approaches have rarely been coordinated. In addition, there are assumptions inherent in each approach. These assumptions have rarely been made explicit.

Table 3.2. Summary of research to date on dugongs and their seagrass habitats in the Red Sea ordered by date within survey type.

Technique	Country	Extent	Date of surveys	Reference
Aerial survey qualitative	Djibouti	Ras Dumeira to Loyada	December 1980	Robineau and Rose (1982)
	Saudi Arabia	Al Wajh to Yemen border	June-August 1987	Preen 1989
	Saudi Arabia	Jizan	1993	Gladstone (personal communication in Nasr et al. 2019)
Aerial survey systematic with detection bias correction	Saudi Arabia	22,371 km^2 across approximately 70% of Saudia Arabian coastline	1987	Preen (1989)
Aerial survey systematic without detection bias correction	Eritrea, Sudan, Egypt, Saudi Arabia	Farasan Islands to Gulf of Aqaba (4,250 km^2)	2022	Pilcher (2022)
UAV survey	Saudi Arabia	Al-Wajh Lagoon (4,000 km^2)	July – December 2021	Nasif (2022)
Feeding trail surveys	Egypt	Qosseir, Marsa Alam, WGNP	2018 – 2019 (Autumn 2018 – Summer 2019)	Shawky (2019b) Shawky et al. (2024)
	Saudi Arabia	NEOM – mouth of Gulf of Aqaba to south of Duba Port (4,061km^2)	October – November 2020	Khamis et al. (2022)
	Saudi Arabia	Al-Wajh Lagoon	July – December 2021	Nasif (2022)
Interview surveys	Saudi Arabia	Al Wajh, Jizan	July-August 1987	Preen (1989)
	Yemen	Durhalmi, Al Hudaydah, Urj, Khobha, Luhalyah, Midi, Sanaa	January 1988	Preen (1989)
	Egypt	Hurghada to Shalateen	2001 – 2003	Hanafy et al. (2006)

	Eritrea	34 sites from Mersa Ibrahim Village to Gahro Village	2004 – 2007	Teclemariam et al. (2007)
	Egypt	Suez to Shalateen (735 km^2 area but dugongs only sighted in 1.9 km^2)	2011	El Shaffai (2016)
Fisher surveys using Pilcher et al. (2017) technique	Egypt	Hurghada, Safaga, Qosseir, Marsa Alam, WGNP, Ras Banaas, Shalateen, Abu Ramaad, Halayeb	August 2015 – May 2016 (Reports ranging from 1980-2016)	Shawky in Nasr et al. (2019) Shawky et al. (2024)
Photo-identification	Egypt	180 km shoreline of Marsa Alam & WGNP	December 2015 – October 2017	Shawky (2018) Shawky et al. (2019)
Vocalisations	Sudan	Dungonab Bay, Marsa Halot	1973	Nasr et al. (2019)
	Saudi Arabia	Al-Wajh and Tuwal		Nasr et al. (2019)
	Yemen	Al Hudaydah		Nasr et al. (2019)
Net captures	Eygpt	Hurghada to Ras Gamish	1942 - 1955	Gohar (1957)
	Djibouti	Gulf of Tadjoura	1966 – 1980	Robineau and Rose (1982)
	Egypt	Red Sea coast	1999 – 2004	Hanafy et al. (2006)
Dugong remains	Eritrea	34 sites from Mersa Ibrahim Village to Gahro Village	2004 – 2007	Teclemariam et al. (2007)
Strandings	Egypt	Wadi El Gemal National Park	22 September – 4 October 2015	Shawky et al. (2016)
Vessel & SCUBA	Saudi Arabia	Farasan Bank	5 – 28 April 2009	Al-Mansi (2016)
	Saudi Arabia	Al-Wajh Lagoon	July – December 2021	Nasif (2022)
Underwater Laser Photogrammetry	Egypt	Qosseir, Marsa Alam	2019	Shawky (2019a) Shawky (2019b)

2

3.6.2 Future research

An important initiative would be to develop a program of coordinated and replicable research on the distribution and abundance of dugongs and their seagrass habitats across the countries of the Red Sea. Such a program would need to use techniques that are appropriate to the capacity of each country, but which would enable cross-country comparisons. Once this foundational research has been completed, consideration should be given to understanding the connectivity between dugongs at locations within the region using modern genetics and tracking techniques.

3.7 Regional summary

It is likely that dugongs have declined in the Red Sea in recent decades due to human-caused mortalities relating to past hunting pressure and current incidental bycatch and habitat loss. Nonetheless, the dugong status in the region is currently data deficient. Distribution is patchy due to the distribution of suitable habitat, a serious cause for concern when considering the potential for population recovery.

It is impossible to provide a comprehensive list of contemporary areas of local importance within the Red Sea as seagrasses are sparsely distributed, presenting challenges for surveying these areas. Large areas of the Red Sea are remote, and scientists face many logistical challenges working in the region (Preen et al 2012). Table 3.3. provides a summary of confirmed and possible areas of local importance in the Red Sea region.

There has not been regional co-operation on dugong conservation in the Red Sea to date. PERGSA offers an established framework for regional co-operation on the marine environment and conservation, despite the challenges created by differences in the socio-economic status of the various Dugong Range States bordering the Red Sea. A constructive way forward might be to invite PERSGA to co-ordinate a regional strategy for dugongs in the Red Sea as a component of a regional strategy for megafauna, or for one country to take the lead in promoting dugong conservation and research and bringing together key specialists in the region to initiate such efforts. An essential foundational element in such a strategy would be the co-ordinated regional survey efforts using techniques appropriate to the capacity of the various countries suggested in Section 3.6.2.

Table 3.3: Summary of confirmed and possible dugong areas of local importance in the Red Sea region by country counter-clockwise from the border between Somalia and Djibouti.

Country	Region
Djibouti	Gulf of Tadjoura, Seven Brothers Islands and Godorya
Eritrea	North of Massawa to Marsa Teklay, south of Massawa to Mersa Fatuma, Dahlak archipelago, Assab Bay and surrounding areas
Sudan	Dungonab Bay Mukkawar Island Marine National Park
Egypt	Western coast of the Egyptian Red Sea, including Hurghada, Safaga, Qosseir Marsa Alam, Wadi El Gemal National Park (WGNP), Northern Red Sea Islands, Southern Egyptian Red Sea Bays, Offshore Reefs and Islands, Nabq Protected Area and southern Gulf of Suez at Ras Raya (south of El Tor)
Saudi Arabia	Al-Muwaylih, Sindalah, Sanafir Island, Tiran Island and Ras Al-Shaykh Humayd, Wajh Bank, Al Lith area, Jizan, Farasan Archipelago
Yemen	Between Midi and As-Salif

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