## Title

*Dugong dugon* (East African coastal subpopulation), Dugong

## Assessment by

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## Classification

Critically Endangered

## Taxonomy

| Kingdom | Phylum | Class | Order | Family |
|---|---|---|---|---|
| Animalia | Chordata | Mammalia | Sirenia | Dugongidae |

## Taxon Name

*Dugong dugon* (East African coastal subpopulation)

## Parent Species

*Dugong dugon* (Müller, 1776)

(http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T6909A160756767.en)

## Common Name(s)

- English: Dugong, Sea Cow
- Portuguese: Dugongo,
- Swahili: Nguva
- Xitswa: Nguluve-ndjange

## Assessment Information

*Red List Category & Criteria*

Critically Endangered C2(a)(ii) ver 3.1

*Justification*

The East African coastal subpopulation of Dugongs (*Dugong dugon*) historically ranged from southern Somalia to southern Mozambique in relative abundance. However, the number of mature individuals in the geographically-isolated East African coastal Dugong subpopulation is now estimated to be fewer than 250 mature animals based on aerial surveys of East Africa, including the Bazaruto seascape. That location is estimated to support more than 90% of all mature individuals. Groups of Dugongs in Mozambique, Kenya, and Tanzania outside of this seascape are small (1 - 10 animals) and rarely sighted. Various pressures, including habitat loss and unsustainable fishing techniques, continue to threaten the entire subpopulation, but conservation interventions to reduce rates of unnatural Dugong mortality and the degradation of important dugong habitats will only be effective in the Bazaruto seascape. Indeed, participatory appraisals in coastal communities throughout the region over the past thirty years indicate continuing decline. Given these lines of evidence, we conclude that this subpopulation qualifies as Critically Endangered under Criterion C2a(ii).

**Geographic Range**

*Range Description*

The Dugong is listed as Vulnerable at a global scale (Marsh & Sobtzick, 2019). Dugongs are found in coastal and island waters from East Africa to Vanuatu between approximately 27°N and 27°S (Marsh & Sobtzick, 2019). The western limit of their range includes the Red Sea, Arabian Gulf, continental East Africa, and the islands and archipelagos of the West Indian Ocean including Madagascar, the Comoros, and the Seychelles.

The Dugong's regional status is heterogenous across its huge range (Marsh et al., 2011). Along the East African coastline, large herds (hundreds of individuals) were historically reported off Kenya and southern Somalia (Jarman, 1966; Travis, 1967), and groups of tens were reported from Tanzania and Mozambique (Hughes & Oxley-Oxland, 1971; Muir et al., 2003). Nonetheless, Husar (1975) suggested that Dugong populations in coastal East Africa were discontinuous. Occupied habitats were limited to the following locations: Maputo, Inhambane, and Bazaruto Bays, as well as the Primeiras and Segundas (Angoche) and Quirimbas Archipelagos, in Mozambique (Hughes & Oxley-Oxland, 1971; Cockcroft et al., 1994; Findlay et al., 2011); the Tanga region and Mafia-Rufiji-Kilwa seascape in Tanzania (Hughes, 1969; Muir et al., 2003; Muir et al., 2012); and Ungwana, Manda, and Gazi Bays in Kenya (Fig. 1 in Supplementary Material; Wamukoya et al., 1995; Wamukoya et al., 1996). Observations and strandings of Dugongs are now very rare outside of the Bazaruto seascape (Cockcroft et al., 2018), which includes Bazaruto Bay.

The Bazaruto seascape extends from ~ 21°S to 22°S. Dugongs are usually sighted in shallow, near-shore waters or sheltered areas such as within Bazaruto Bay or in mangrove-fringed estuaries along the mainland coast (Trotzuk et al., 2021). Most individuals are observed in shallow (< 20 m) waters less than ~10 km offshore. We consider that it is possible but unlikely that this subpopulation extends tens of kilometers further north, south, or offshore, because these areas are less suitable for Dugongs due to higher wave action and sediment loads

(Findlay et al., 2011). Furthermore, reports of Dugongs from these adjacent areas are very rare.

Dugongs are seagrass community specialists (Marsh et al., 2018). Ten species of seagrass occur in Bazaruto Bay, where shallow-water meadows cover ~ 90 $km^2$ (Everett & Van der Elst, 2008; K. Allen, pers. comm, 2022). Seagrass also occurs to the north of this bay, although in this area coverage and species composition have not been quantified. Dugongs are also regularly observed over sandy flats that are sometimes covered with macroalgae (E. Trotzuk, pers. obs. 2021). As in some other areas (Keith-Diagne et al., 2022), Bazaruto Dugongs may be feeding on macroalgae, invertebrates, or low density seagrass on these sandy flats.

Dugongs in East Africa are geographically isolated from the Red Sea subpopulation to the north (Marsh et al., 2011). The distance from the northern-most record of Dugongs along the east coast of Africa in Somalia to the southern-most observations of Dugongs in the Red Sea at Al Hudaydah in Yemen is 1650 - 1700 km (Fig. 1 in Supplementary Materials; Travis, 1967; Nasr et al., 2019). The geographic separation is further than documented large-scale movements of Dugongs (Deutsch et al., 2022a), apart from movements of occasional vagrant animals. The exposed, high-energy coastline of central and northern Somalia is unlikely to be suitable Dugong habitat due to lack of seagrass (UNEP-WCMC & Short, 2021). While it may be possible for Dugongs to move along this coast between Somalia to the Red Sea, Dugong abundance appears to be very low in southern Somalia, and it is likely that such movements, if they occur, are very rare.

Similarly, deep water habitats without seagrass are expected to limit the movement of Dugongs from continental East Africa to the islands of the West Indian Ocean such as the Comoros, Madagascar, and the Seychelles. Analysis of mtDNA indicates that Dugongs from the Comoros and Madagascar are a separate genetic lineage from most other West Indian Ocean Dugongs (Plön et al., 2019). Cockcroft et al. (2018) did not observe any Dugongs in the Quirimbas Archipelago, the closest historical Dugong habitat in continental East Africa to the Comoros Archipelago (separated by ~ 400 km), and reported only one (dead) Dugong from northern Mozambique during the past two decades. Regional currents also appear to be unfavorable for Dugong movements from northern Mozambique to these West Indian Ocean islands (Ali & Huber, 2010), with water moving from the east past the Comoros before splitting into northerly and southerly currents that follow the continental coastline (Fig. 2 in Supplementary Materials; Collins et al., 2016). Therefore, regardless of whether displacement between the African continent and these islands is possible, Dugong movements between the two locations are almost certainly infrequent.

*Countries of Occurrence of this Regional Subpopulation*

**Native:** Somalia; Kenya; Tanzania; Mozambique

*FAO Marine Fishing Areas*

**Native:** Indian Ocean – western

**Distribution Map**

*Dugong dugon* (East Africa coastal subpopulation

[create shapefiles and provide when submitting]

**Population**

Surveys over the past two decades suggest that the Bazaruto seascape is the only location in East Africa where robust estimates of Dugong abundance can be obtained (Cockcroft et al., 2018; Trotzuk et al., 2021). Elsewhere in East Africa, Dugongs are likely highly depleted and geographically isolated, and sightings are too infrequent to estimate abundance (Cockcroft et al., 2018). The Bazaruto Dugongs were most recently estimated at 325±SD 145 individuals from aerial surveys carried out in 2021 (Trotzuk et al., 2021). $N_{min}$, the accepted metric for estimating the minimum population size of marine mammal stocks (Wade, 1998), is thus calculated to be 228.

*Proportion of mature individuals*

We use multiple lines of reasoning to support our conclusion that there are fewer than 250 mature individuals throughout East African coastal waters. Deutsch et al. (2008) estimated from population modeling and carcass recovery that ~ 45 – 70% of a Florida manatee, *T. manatus manatus,* population were mature. Assuming a similar proportion of mature individuals in the East African coastal Dugong subpopulation, we estimate that there are 131±SD 30 mature individuals in the Bazaruto seascape (Table 1 in Supplementary Material). Considering that observation rates are so low outside of the Bazaruto seascape and that an estimated 90 - 100% of the East African coastal Dugong subpopulation occurs at this site, we can conclude that the entire East African region supports a maximum of 146±SD 33 mature individuals. In reality, our estimate of the proportion of mature individuals may be high, as manatees reach sexual maturity at a younger age than Dugongs (Marsh et al., 2011).

Even if every other known Dugong habitat in coastal East Africa supported ten Dugongs, which recent aerial surveys demonstrate is extremely unlikely (Cockcroft et al., 2018), we can use similar reasoning as above to conclude that the East African subpopulation would still be less than 250 mature individuals and that > 90% of these animals still occur in the Bazaruto seascape (Fig. 1 in Supplementary Materials).

*Population trend*

Together with historical records, participatory appraisals and aerial surveys indicate that Dugongs have become much rarer throughout coastal East Africa over the past six decades (Marsh et al., 2002; Pilcher et al., 2017; Cockcroft et al., 2018). Severe declines in Kenya, Tanzania, and parts of Mozambique have been inferred from the literature. No data are available for Somalia, but the pressures responsible for declines elsewhere in coastal East Africa have also been present (possibly at exacerbated levels) in that country. Interviews and aerial surveys in the offshore islands of the Comoros and Madagascar suggest similar declines in that region (Muir et al., 2012). Dugongs have become extinct at some locations elsewhere

in the West Indian Ocean, such as the Mascarene Islands (Husar, 1975; Cockcroft & Young, 1998). Estimates from the Bazaruto seascape indicate no significant change over the past two decades, although wide error margins make any conclusion uncertain (Findlay et al., 2011; Trotzuk et al., 2021). The decline observed elsewhere in East Africa, however, is inferred to be substantial and projected to continue over the next few decades (Marsh et al., 2011).

*Population structure*

Husar (1975) suggested that the East African Dugong subpopulation was discontinuous, a pattern that is characteristic of most Dugong subpopulations elsewhere in its range. Most Dugongs occur close to seagrass communities, which are limited to sheltered seascapes, which tend to be interrupted. Despite this geographic discontinuity, mtDNA indicates genetic homogeneity throughout different geographically isolated groups in coastal East Africa (Plön et al., 2019). Given the geographic isolation of the Bazaruto Dugong subpopulation, as well as very low detection rates elsewhere, over 90% of coastal East Africa's Dugongs are likely limited to this one location.

The EOO of the entire East African subpopulation is difficult to estimate given the paucity of recent data. However, assuming historical limits stretching from the Banjuni Archipelago in Somalia to Maputo Bay in Mozambique, as well as an offshore range of waters with a depth of less than or equal to 20 m, the EOO of the East African subpopulation is around 40,000 $km^2$, well over the limits for Criterion B1 (GEBCO, 2020). The area of occupancy (AOO) of this subpopulation is realistically limited to the Bazaruto Archipelago. Observations from 2017 – 2021 suggest that Dugongs occupy ~ 488 $km^2$ in the Bazaruto seascape, mostly in coastal waters shallower than 20 m (Trotzuk et al., 2021). Given that the Bazaruto seascape supports more than 90% of the region's mature individuals and that participatory appraisals in coastal communities indicate continuing decline, the East African coastal subpopulation of the Dugong is eligible for listing as Endangered under Criterion B2(a, b) and Criterion D1. The data are insufficient to determine the eligibility of this subpopulation of Dugongs under Criteria A or E.

**Habitat and Ecology**

Little is known as to how Dugong habitat and ecology differ between the East African coastal subpopulation and better studied subpopulations elsewhere (Marsh & Sobtzick, 2019). It is unlikely that the life history ethology and behavioural ecology are substantially different (Marsh et al., 2011; Marsh, 2022). Only in the Bazaruto seascape have sufficient observations been made to infer any behavioural patterns. As in other areas (Deutsch et al., 2022b), the Dugongs' distribution in the Bazaruto seascape appears to be driven partially by tides, with individuals foraging in the near-shore when tides are high and moving further offshore or into deeper channels as water levels recede. Tidal patterns in the Bazaruto seascape are mixed semidiurnal, with spring tide differences of over 5 m (Sumich, 1996).

Certain areas within the seascape may be associated with specific Dugong behaviors. In the north of this subpopulation's range, herds of over 50 individuals have been observed on multiple occasions as recently as 2021 (E. Trotzuk, pers. obs. 2021). The function of such herds is uncertain, but herding behavior has been associated with feeding or mating elsewhere

(O'Shea et al., 2022). Cow-calf pairs are regularly encountered in the sheltered waters of Bazaruto Bay, suggesting they may selectively occupy these calmer waters (Trotzuk et al., 2021).

**Systems:** Marine

## Use and Trade

As in many other parts of their range (Marsh et al., 2001; Ponnampalam et al., 2022), Dugongs were traditionally harvested for food and medicine in coastal East Africa. Dugong meat was a prized source of protein and according to local beliefs, consuming it would lead to an eternal life (Muir et al., 2012). Taboos around the consumption of Dugong meat were once widespread along the Swahili coast because of the animal's supposed resemblance to humans (Ponnampallam et al., 2022). However, these traditional restrictions were typically flexible, and culturally sanctioned mechanisms existed to allow for consumption (Muir et al., 2012).

Various parts of the Dugong were used in traditional medicine to treat a variety of ailments including asthma, burns and muscle pain (Muir et al., 2012). Dugong oil had many non-medical uses including as a cosmetic product to soften hair (Awadh et al., 2021) and for waterproofing boats (Muir et al., 2012). Parts of the Dugong were also utilized in religious practices, since they were believed to provide protection against evil spirits (Muir et al., 2012).

Take is now banned in all East African countries. Given low densities throughout the region, current trade and use occur primarily as a result of incidental catch. Meat from both live and dead Dugongs is retained for consumption and can fetch a high price (Pusineri et al., 2013). Due to the illegal nature of this activity, meat is often traded rapidly and in secret (L. West, pers. comms. 2022), so it can be challenging to obtain detailed information about current use and trade practices. However, recent participatory appraisals in coastal communities suggest that bycaught animals are traded today.

## Threats

Marsh et al. (2011) and Marsh & Sobtzick (2019) indicated that threats to Dugongs often differ between subpopulations. In East Africa, the major threats include:

- Incidental capture in fishing gear (e.g. gill nets or seine nets); illegal, unreported, and unregulated (IUU) fishing, particularly if "targeted" for later consumption (Pilcher et al., 2017; Cockcroft et al., 2018)
- Hunting and direct fishing: historically legal, currently illegal
- Damage/modification/loss of habitat caused by human settlements or infrastructure development on coasts, oil and gas exploration and production, shipping, trawling, destructive fishing, natural processes (e.g. cyclones and tsunamis)
- Degradation of seagrass habitat (including untreated sewage disposal, coastal dredging and reclamation, inshore commercial trawling, agricultural pollution)
- Chemical pollution (e.g. oil spills and heavy metal loads)

- Climate change impacts on seagrass communities (e. g. extreme weather events, marine heatwaves; Marsh et al., 2022).
- Boat strikes and boating activities (including acoustic pollution)

Dugongs are protected throughout coastal East Africa (Muir et al., 2012). However, low development levels, increased migration to coastal areas due to armed conflict and climate change adaptation strategies, and high human population growth rates along the East African coast have put severe pressure on marine ecosystems to support food provisioning. The use of passive fishing gears that can yield a high catch, such as gill nets, remains relatively widespread throughout East Africa (Marsh et al., 2002; Pilcher et al., 2017; Cockcroft et al., 2018). Marsh & Sobtzick (2019) concluded that unattended gill nets were the most widespread source of anthropogenic mortality for Dugongs at a global scale currently. Declines in Dugong abundance throughout East Africa appeared to correlate with the growing use of these nets over the past few decades (Muir et al., 2012). Gill nets are still used around the Bazaruto Archipelago (Cockcroft et al., 2018). Seine nets, which are always attended, have also caused Dugong mortality in East Africa.

Habitat decline, particularly loss of seagrass, also poses a threat to East Africa's Dugongs. Although the extent of seagrass decline throughout East Africa over the past few decades has not been fully quantified, seagrass coverage across the tropical Indo-Pacific has declined by ~20% over the past century (Dunic et al., 2021). Coastal development and declining water quality are considered as the principle drivers of seagrass loss (Dunic et al., 2021). There are large towns (50,000 + people) and numerous tourism-related facilities around the Bazaruto Archipelago. If development is unmanaged, associated activities may increase sedimentation on seagrass meadows and negatively affect the health of these critical habitats. Such pressures transcend conservation area boundaries. Additionally, the waste associated with urban centers and tourism may decrease water quality and exacerbate declines in seagrass habitat. Finally, while not currently a significant issue, vessel strikes may become more common as tourism- and fishing-related activities increase alongside human population growth.

Resource extraction throughout East Africa also threatens Dugongs across the subpopulation's entire range, including in parts of Kenya and Tanzania where Dugongs are already rare. On-going, large-scale infrastructure development such as port expansions, which have been proposed in at least Lamu and Maputo, as well as the construction of the East Africa Crude Oil Pipeline in northern Tanzania and offshore gas extraction in Mozambique's Rovuma Basin, will probably exacerbate on-going declines in Dugong abundance throughout these areas. Such projects may thus further increase the proportion of mature individuals isolated to the Bazaruto seascape.

Activities associated with the extraction of three commodities (sand, oil, and gas) around the Bazaruto Archipelago could also lead to Dugong mortality in this seascape. Sand mining, involving dredging, can severely disturb seagrass meadows (Erftemeijer & Lewis III, 2006). Indeed, sand mining in Mozambique has been associated with a variety of negative ecological outcomes such as increased sedimentation and decreased coastal resilience (Amnesty

International, 2018). There are currently four coastal mineral concessions adjacent to the Bazaruto seascape, three of which are reserved for heavy sand mining.

The effect of oil and gas extraction on Dugongs and their forage is less certain, but Geraci (2012) suggested that oil may negatively affect *T. m. manatus* health due to potential irritation from direct contact. Similar effects can be inferred for Dugongs. An oil spill in Saudi Arabia in 1991 may have been responsible for an observed decline in local Dugong abundance following the incident, although direct links are unclear (Khan, 1992). Seagrass and other aquatic vegetation may also be vulnerable to oil spills (Geraci, 2012). Acoustic pollution associated with oil and gas exploration may also negatively impact the health of the Bazaruto Dugongs. There are currently two blocks reserved for oil and gas exploration and extraction that cover the entire northern range of Dugongs in the Bazaruto seascape. In addition, two off-shore (50+ km from mainland coast) concessions have recently been offered as a part of an on-going licensing process for potential exploration. The development of any of these projects could adversely affect the Dugongs of the Bazaruto seascape due to aforementioned impacts.

Climate change is likely to adversely impact the East Africa subpopulation in the future (Marsh et al., 2022), particularly given that an estimated >90% of the subpopulation is limited a single location that could be severely disturbed by a single, or series of, natural disaster(s). The Bazaruto seascape is seasonally battered by cyclones, and severe storms can cause widespread seagrass loss (Marsh et al., 2022). Cyclones elsewhere have damaged hundreds of square kilometers of seagrass (Marsh et al., 2008; Groom et al., 2017; Griffiths et al., 2020). A series of floods and storms caused the loss of roughly 1,000 $km^2$ of seagrass in Hervey Bay, Queensland (Preen et al., 1995). A similar event in the Bazaruto seascape would severely affect resident Dugongs, particularly since they apparently lack adjacent suitable habitats to which they could migrate.

**Conservation Actions**

Dugongs are legally protected at a national level throughout the entirety of their East African range, and internationally through the Convention on Biological Diversity (CBD), the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on Migratory Species of Wild Animals (CMS) and the associated Dugong MOU, the African Convention on the Conservation of Nature and Natural Resources (ACCNNR), and the Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (MCEA). Somalia, Kenya, Tanzania, and Mozambique are all signatories to these Conventions and to the Dugong MOU. However, in practice, neither national nor international policy provide meaningful protection for the East African coastal Dugong subpopulation (Muir et al., 2012). Ultimately, inadequate fisheries monitoring and weak enforcement of these laws limit their value along much of the East Africa coast. Further complicating the efficacy of these higher-level protections are complex political realities - Tanzania, Kenya, and Mozambique all rank in the bottom half of Transparency International's 2021 Global Corruption Index (Transparency International, 2022). In Mozambique, for example, at least one resource extraction project that is known to

have caused severe environmental damage advanced without a legally-required environmental impact assessment (Amnesty International, 2018).

Mozambique is ranked as 181 out of 189 countries on the UN Development Programme's 2020 Human Development Index (Conceição, 2020). Approximately 46% of Mozambique's population lives below the national poverty line (Conceição, 2020), and the country is ranked third-to-last out of 113 countries on the Economist Impact's 2021 Global Food Security Index (Economist Impact, 2021). In the Bazaruto seascape, over 90% of community members living inside Bazaruto Archipelago National Park depend exclusively on local marine resources for food security and livelihoods (D'Agata, 2016). Proportions are probably similar throughout the rest of the Bazaruto seascape. Ultimately, these realities put immense pressure on marine resources and habitats, including seagrass meadows, and regularly bring artisanal fishers into contact with Dugongs. This socioeconomic situation demonstrates the importance of developing alternative livelihoods and sustainable fisheries management in order to reduce unnatural Dugong mortality by decreasing by-catch rates and seagrass habitat degradation.

Numerous protected areas exist throughout the East African coastal Dugong subpopulation's range and at least one, Bazaruto Archipelago National Park, was designated partly for Dugong conservation (Husar, 1975). This protected area was subsequently expanded in the early 2000s, again, in part, to protect resident Dugongs. Dugongs are still observed outside of protected areas in the Bazaruto seascape, however. Expanding the boundaries of existing protected areas in this area, and ensuring that these zones are well-managed, could help provide additional protection for the last known viable subpopulation of Dugongs in coastal East Africa.

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**Supplementary Material**

**Table 1:** Sensitivity analysis based on matrix of various estimates of total number of mature individuals using abundance estimates from Bazaruto after calculating the minimum population estimation (228) and assuming the range of similar proportions of mature individuals to Trichechus manatus manatus populations (Wade, 1998; Deutsch et al., 2008; Trotzuk et al., 2021). The range of total number of mature individuals is based the average $N_{min}$ (228) of abundance estimates from three aerial surveys in the Bazaruto seascape conducted throughout 2021. The range of values is based on the standard deviation of the three calculated $N_{min}$ values. The analysis demonstrates the very high likelihood that the East African costal Dugong population numbers < 250, as over 90% of this subpopulation is limited to the Bazaruto seascape.

| | | Percentage of Mature Individuals | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 45 | 50 | 55 | 57.5 | 60 | 65 | 70 |
| Total number of mature individuals in the Bazaruto seascape | 155 | 70 | 78 | 85 | 89 | 93 | 101 | 109 |
| | 169 | 76 | 85 | 93 | 97 | 101 | 110 | 118 |
| | 183 | 82 | 92 | 101 | 105 | 110 | 119 | 128 |
| | 197 | 89 | 99 | 108 | 113 | 118 | 128 | 138 |
| | 211 | 95 | 106 | 116 | 121 | 127 | 137 | 148 |
| | 218 | 98 | 109 | 120 | 125 | 131 | 142 | 153 |
| | 223 | 100 | 112 | 123 | 128 | 134 | 145 | 156 |
| | 228 | 103 | 114 | 125 | 131 | 137 | 148 | 160 |
| | 233 | 105 | 117 | 128 | 134 | 140 | 151 | 163 |
| | 238 | 107 | 119 | 131 | 137 | 143 | 155 | 167 |
| | 245 | 110 | 123 | 135 | 141 | 147 | 159 | 172 |
| | 259 | 117 | 130 | 142 | 149 | 155 | 168 | 181 |
| | 273 | 123 | 137 | 150 | 157 | 164 | 177 | 191 |
| | 287 | 129 | 144 | 158 | 165 | 172 | 187 | 201 |
| | 301 | 135 | 151 | 166 | 173 | 181 | 196 | 211 |

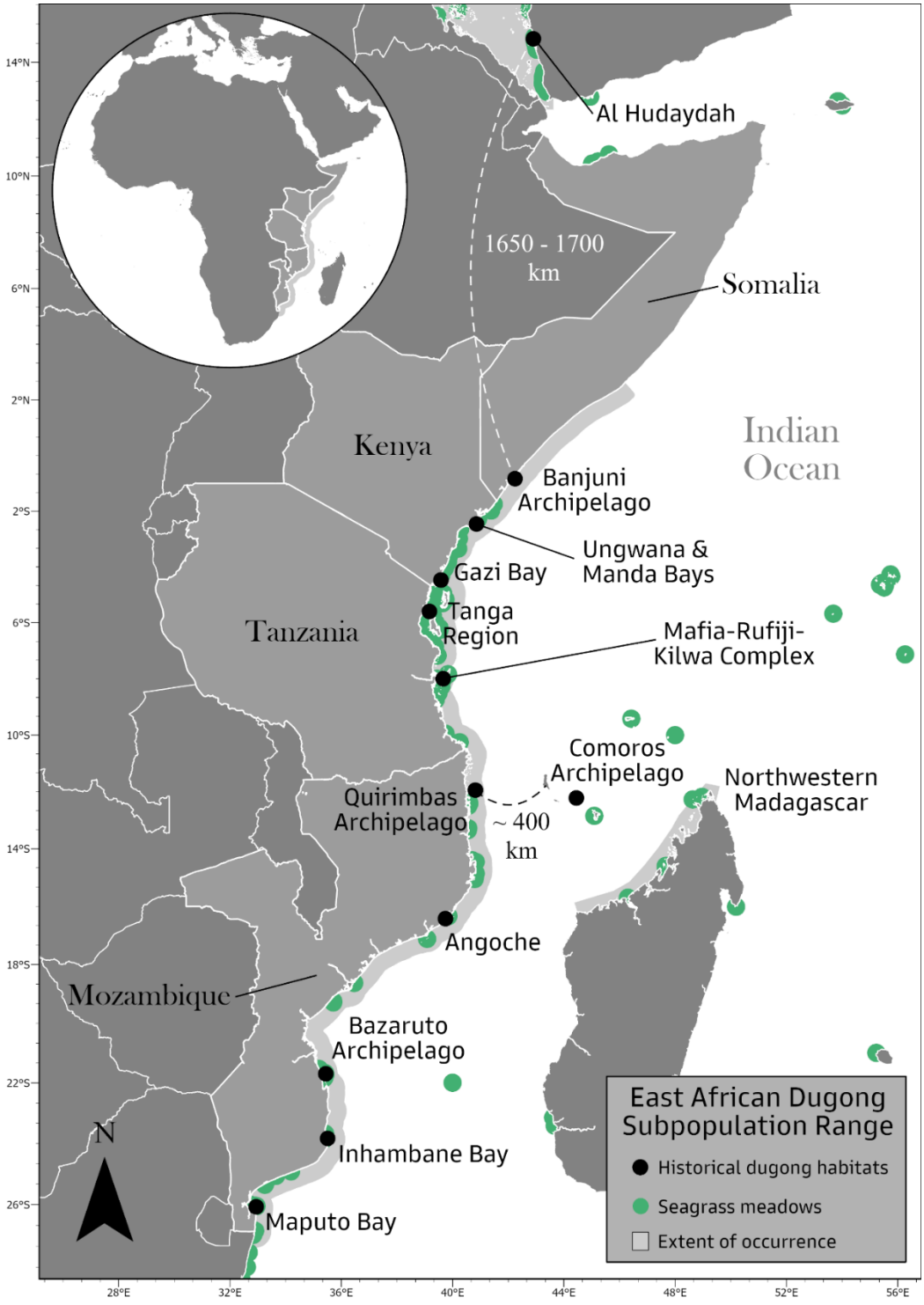


**Figure 1:** Historical Dugong habitats (black dots) and estimated extent of occurrence (EOO) in light grey along the East African coast from Mozambique to Somalia. The lack of seagrass (green dots) along the Somalian coast and between continental East Africa and the Comoros may limit movement between these regions (UNEP-WCMC & Short, 2021).

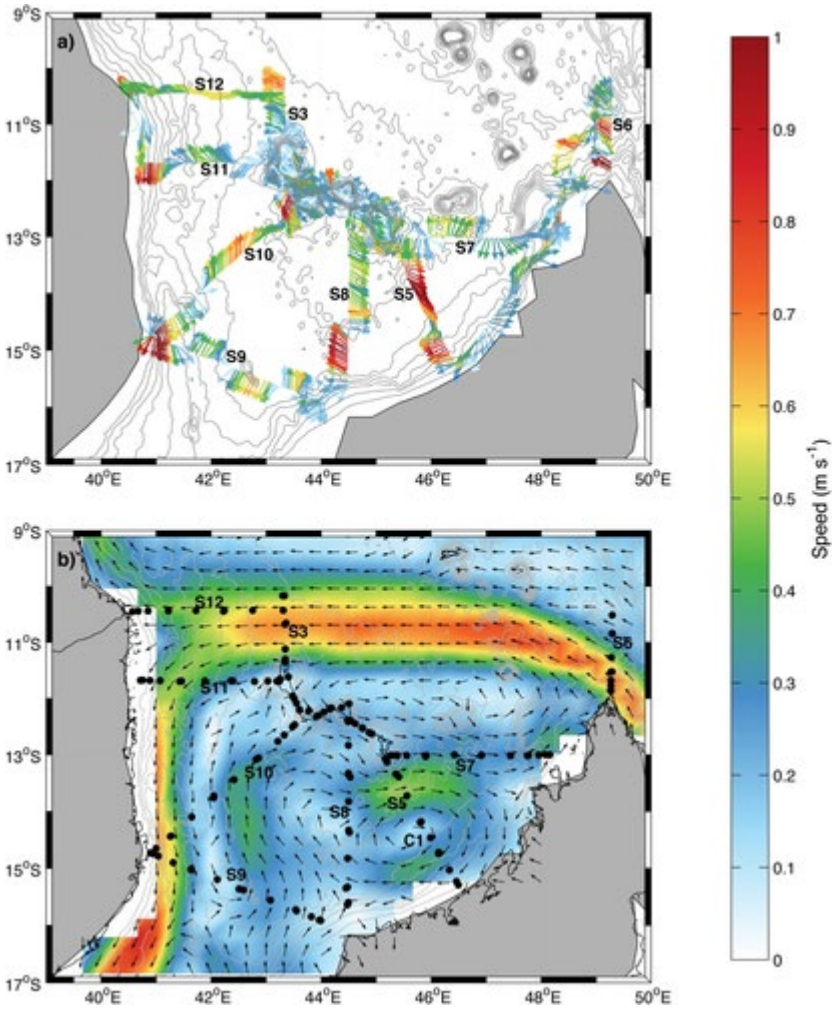


**Figure 2:** Regional currents in the northern Mozambican Channel derived from an Acoustic Doppler Current Profiler (ADCP) mounted on a vessel (top) and accessed from Archiving, Validating and Interpretation of Satellite Oceanographic data (AVISO; bottom; Collins et al., 2016). The ADCP sampling locations (black dots) of Collins et al., 2016 are overlaid on the AVISO currents on the bottom figure. These images illustrate that the strong easterly currents passing Madagascar and the Comoros are unfavorable for movements of Dugongs from the African continent to these West Indian Ocean islands. Therefore, movements between these subpopulations, while possible, are probably infrequent.

## Appendix

*Habitats*

Same as Marsh & Sobtzick (2019).

*Threats*

| Threat | Timing | Scope | Severity | Impact Score |
|---|---|---|---|---|
| 1. Residential & commercial development -> 1.1. Housing & urban areas | Ongoing | Whole | Slow, significant declines | 7 |
| | Stresses | 1. Ecosystem stresses -> 1.1. Ecosystem conversion<br>1. Ecosystem stresses -> 1.2 Ecosystem degradation | | |
| 1. Residential & commercial development -> 1.3. Tourism & recreation areas | Ongoing | Whole | Slow-significant declines | 7 |
| | Stresses | 1. Ecosystem stresses -> 1.1. Ecosystem conversion<br>1. Ecosystem stresses -> 1.2 Ecosystem degradation | | |
| 3. Energy production & mining -> 3.1. Oil & gas drilling | In the past but now suspended and likely to return | Whole | Slow-significant declines | 5 |
| | Stresses | 1. Ecosystem stresses -> 1.1. Ecosystem conversion<br>1. Ecosystem stresses -> 1.2 Ecosystem degradation<br>2. Species stresses -> 2.2. Species disturbance | | |
| 3. Energy production & mining -> 3.1. Mining & Quarrying | In the past but now suspended and likely to return | Whole | Slow-significant declines | 5 |
| | Stresses | 1. Ecosystem stresses -> 1.1. Ecosystem conversion<br>1. Ecosystem stresses -> 1.2 Ecosystem degradation | | |
| 5. Biological resource use -> 5.4. Fishing & harvesting aquatic resources -> 5.4.1. Intentional use (subsistence/small scale) [harvest] | Ongoing | Whole | Unknown | Likely 8 |
| | Stresses | 2. Species stresses -> 2.1. Species mortality | | |
| 5. Biological resource use -> 5.4. Fishing & harvesting aquatic resources -> 5.4.1. Intentional use (subsistence/small scale) [harvest] | Ongoing | Whole | Unknown | Likely 8n |
| | Stresses | 2. Species stresses -> 2.1. Species mortality | | |
| 6. Human intrusions & disturbance -> 6.1 Recreational activities | Ongoing | Whole | Unknown | Unknown |

| | | | | |
|---|---|---|---|---|
| | Stresses | 2. Species stresses -> 2.1. Species disturbance | | |
| 9. Pollution -> 9.1 Domestic & urban waste water -> 9.1.1. Sewage | Ongoing | Whole | Slow, significant decline | 7 |
| | Stresses | 1. Ecosystem stresses -> 1.1. Ecosystem conversion<br>1. Ecosystem stresses -> 1.2 Ecosystem degradation | | |
| 9. Pollution -> 9.2. Industrial & military effluents -> 9.2.1. Oil spills | In the past but now suspended and likely to return | Whole | Slow-significant declines | 5 |
| | Stresses | 1. Ecosystem stresses -> 1.1. Ecosystem conversion<br>1. Ecosystem stresses -> 1.2 Ecosystem degradation<br>2. Species stresses -> 2.2. Species disturbance<br>2. Species stresses -> 2.2. Species disturbance | | |
| 9. Pollution -> 9.3. Agricultural & forestry effluences -> 9.3.4 Type unknown/unrecorded | Future | Whole | Slow, significant declines | 5 |
| | Stresses | 1. Ecosystem stresses -> 1.2. Ecosystem degradation | | |
| 11. Climate change & severe weather -> 11.4. Storms & flooding | Future | Whole | Slow, significant declines | 5 |
| | Stresses | 1. Ecosystem stresses -> 1.1. Ecosystem conversion<br>1. Ecosystem stresses -> 1.2. Ecosystem degradation | | |

*Conservation Actions in Place*

Same as Marsh & Sobtzick (2019).

*Conservation Actions Needed*

| **Conservation Actions Needed** |
|---|
| 1. Land/water protection -> 1.1. Site/area protection |
| 2. Land/water management -> 2.1. Site/area management |
| 4. Education & awareness -> 4.1. Formal education |
| 4. Education & awareness -> 4.2. Training |
| 4. Education & awareness -> 4.3. Awareness & communications |
| 5. Law & policy -> 5.2. Policies & regulations |
| 5. Law & policy -> 5.3. Private sector standards & codes |
| 5. Law & policy -> 5.4. Compliance & enforcement -> 5.4.2. National level |
| 5. Law & policy -> 5.4. Compliance & enforcement -> 5.4.2. Sub-national level |
| 6. Livelihood, economic, & other incentives -> 6.1. Linked enterprises & livelihood alternatives |

| |
|---|
| 6. Livelihood, economic, & other incentives -> 6.2. Substitution |
| 6. Livelihood, economic, & other incentives -> 6.5. Non-monetary values |

*Research Needed*

Same as Marsh & Sobtzick (2019).

*Additional Data Fields*

Same as Marsh & Sobtzick (2019), with the exception of a severely fragmented population.