



Status of Coral Reefs of the World: 2020

Chapter 3. Status and trends of coral reefs of the Red Sea and Gulf of Aden

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Chapter 3.

Status and trends of coral reefs of the Red Sea and Gulf of Aden

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1. Geographic information and context

Key numbers:

- Total area of coral reefs 13,605 km²
- Proportion of the world's coral reefs: 5.24%
- Number of countries with coral reefs: 9
- Number of Marine Ecoregions of the World (MEOW) ecoregions: 3

Regional Context:

The Red Sea contains the most biologically diverse coral reef communities outside of Southeast Asia's coral triangle. It shares many of the species found elsewhere in the Indo-Pacific, but approximately 10% of species are endemic¹, making this region one of the most valuable repositories for marine biodiversity in the world. Coral reefs within the Red Sea and Gulf of Aden region cover 13,605 km², which is about 5.3% of the total global area of coral reefs.

The Red Sea and Gulf of Aden region is bordered by nine countries: Djibouti, Egypt, Eritrea, Israel, Jordan, Saudi Arabia, Somalia, Sudan and Yemen. Populations in these countries have steadily increased over the last 60 years with the greatest growth occurring in most countries between the 1960s and early 1990s. The region now supports an estimated 240 million people, with an increasing proportion of these people living in urban centres and along the coast to obtain the economic benefits associated with ocean navigation, fisheries, tourism and recreation. Impacts of population growth on marine ecosystems are most intense where growth occurs close to the coast.

The Red Sea is one of the world's major tourist destinations, and reef-associated tourism is a major source of income for some Red Sea countries. For example, coral reef-related tourism contributes 3.5% to Egypt's Gross Domestic Product (GDP)². To date, coastal tourism has been concentrated along Egypt's eastern coastline. However, with the establishment of Saudi Arabia's Vision 2030 economic plan, which seeks to diversify the kingdom's economy and reduce its reliance on revenues from oil^{3,4},

¹ De Vantier, L.; Turak, E.; Al-Shaikh, K. and De'ath, G., (2000). Coral communities of the central-northern Saudi Arabian Red Sea. *Fauna of Arabia*, 18, 23:66.

² Hilmi, N., Safa, A., Reynaud, S., Allemand, D., (2012). Coral reefs and tourism in Egypt's Red Sea topics in middle eastern and African economies.

³ Fattouh, B., Sen, A., (2016). Saudi Arabia's Vision 2030, Oil Policy and the Evolution of the Energy Sector. Oxford Institute for Energy Studies, Oxford Energy Comment, July <https://www.oxfordenergyorg/wpcms/wpcontent/uploads/2016/07/Saudi-Arabias-Vision-2030-Oil-Policy-and-the-Evolutionof-the-Energy-Sectorpdf>.

⁴ Gazette, S., (2016). Full text of Saudi Arabia's vision 2030. *Saudi Gazette* 26.

tourism, including coastal tourism, is considered the most prospective element of the kingdom's diversification plan, particularly given their long coastline and many attractive coral reefs.

While the current contribution of fisheries to national GDP is relatively small (<1%), except in Yemen where this sector accounts for 15% of GDP, the value of the Red Sea and Gulf of Aden fishery resources to the prosperity of the region has long been recognized. Artisanal fisheries provide food and employment for thousands of the region's inhabitants, particularly in Yemen where more than 220,000 people depend on fishing as their principal source of income. Potential to expand marine fisheries in the future exists, but this will depend on the continued upgrading of infrastructure and development of export markets.

The Red Sea and Gulf of Aden region is comprised of three Marine Ecoregions of the World (MEOW) ecoregions⁵ (Tab. 3.1, Fig. 3.1). Data from each ecoregion are reported here.

Table 3.1. The subregions comprising the Red Sea and Gulf of Aden region, the area of reef they support, and the constituent Marine Ecoregions of the World (MEOW)¹.

| Subregion | Reef Area (km ²)* | Proportion of Reef Area within the Red Sea and Gulf of Aden Region(%) | Constituent Marine Ecoregions of the World |
|-----------|-------------------------------|---|--|
| 1 | 7,800 | 57.3 | 87: Northern and Central Red Sea |
| 2 | 4,896 | 36.0 | 88: Southern Red Sea |
| 3 | 911 | 6.7 | 89: Gulf of Aden |

*World Resources Institute. Tropical Coral Reefs of the World (500-m resolution grid), 2011. Global Coral Reefs composite dataset compiled from multiple sources for use in the Reefs at Risk Revisited project incorporating products from the Millennium Coral Reef Mapping Project prepared by IMaRS/USF and IRD. <https://datasets.wri.org/dataset/tropical-coral-reefs-of-the-world-500-m-resolution-grid>

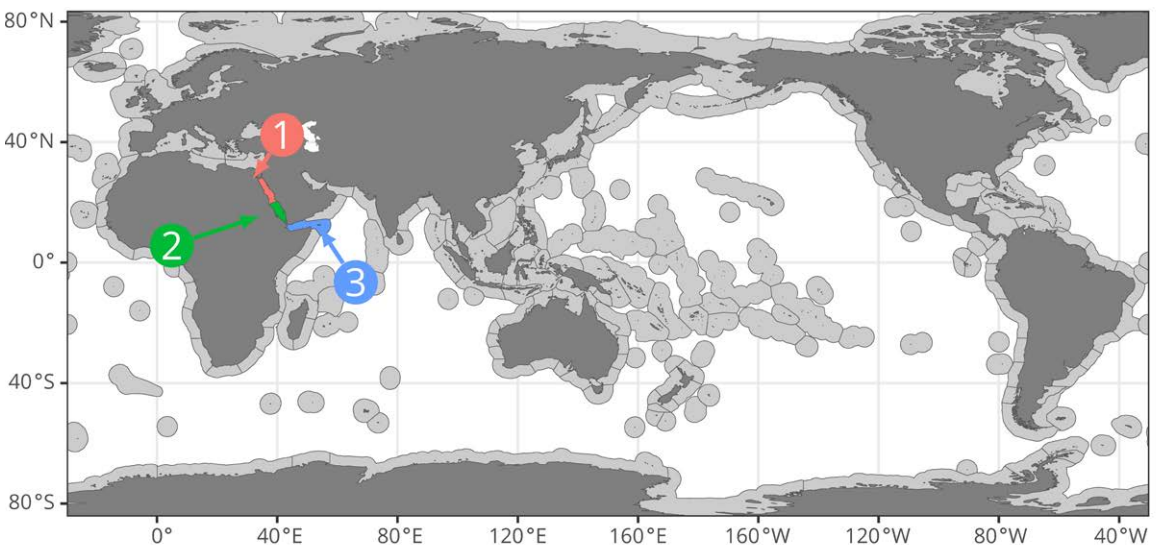


Figure 3.1. Map of each subregion comprising the Red Sea and Gulf of Aden region. The number ascribed to each subregion corresponds with that in Table 3.1.

⁵ Spalding, M. D., E. H. F., Allen, G. R., Davidson, N., Ferdaña, Z. A., Finlayson, M., Halpern, B. S., Jorge, M. A., Lombana, A., Lourie, S. A., Martin, K. D., McManus, E., Molnar, J., Recchia, C. A., & Robertson, J. (2007). Marine Ecoregions of the World: A Bioregionalization of Coastal and Shelf Areas, *BioScience*, Volume 57, Issue 7, Pages 573–583, <https://doi.org/10.1641/B570707>

2. Summary of data contributed to this report

Key numbers:

- Number of countries from which monitoring data were used: 6 (of 9)
- Number of sites: 243
- Number of observations: 6,416
- Longest time series: 15 years

General features:

The great majority of observations (75%) in the Red Sea and Gulf of Aden region were recorded in the northern and central Red Sea (subregion 1) (Fig. 3.2, Tab. 3.2). Approximately one-quarter of all observations were recorded in the southern Red Sea (subregion 2), and a very small number of observations were recorded in the Gulf of Aden (subregion 3). Although fewer reefs occur in the southern Red Sea and Gulf of Aden compared with the northern and central Red Sea (Tab. 3.2), the disproportionately small number of observations recorded in these two subregions means that their condition may not be accurately reflected in the overall regional status and trends.

The vast majority (84%) of sites in the region have been surveyed only once (Fig. 3.3A). Only about 7% of sites were surveyed over periods longer than a decade (Fig. 3.2 & 3.3A). Unfortunately, metadata describing the methods used to conduct many of the surveys were not provided (Fig. 3.4). However, point intercept and line intercept transects were the most common methods when a description of the methods was provided (Fig. 3.4). Although not represented in figure 4, permanent photo-quadrats were used at some sites along the Egyptian coast.

Table 3.2. Summary statistics describing data contributed from the Red Sea and Gulf of Aden region. An observation is a single record within the global dataset (i.e. one row). A site is a unique GPS position where data were recorded. A site was considered a long-term monitoring site if the time between the first survey and the most recent survey was greater than 15 years. Such sites may have been surveyed multiple times during the intervening period.

| Red Sea and Gulf of Aden subregions | Observations | | Sites | | Long term monitoring sites | |
|-------------------------------------|--------------|------------------------------|--------------|------------------------------|----------------------------|------------------------------|
| | Total Number | Proportion of global dataset | Total Number | Proportion of global dataset | Total Number | Proportion of global dataset |
| All | 6,416 | 0.66 | 243 | 2 | 7 | 0.01 |
| 1 | 4,793 | 0.49 | 161 | 1.32 | 7 | 0.01 |
| 2 | 1,583 | 0.16 | 69 | 0.57 | 0 | 0 |
| 3 | 40 | 0 | 13 | 0.11 | 0 | 0 |

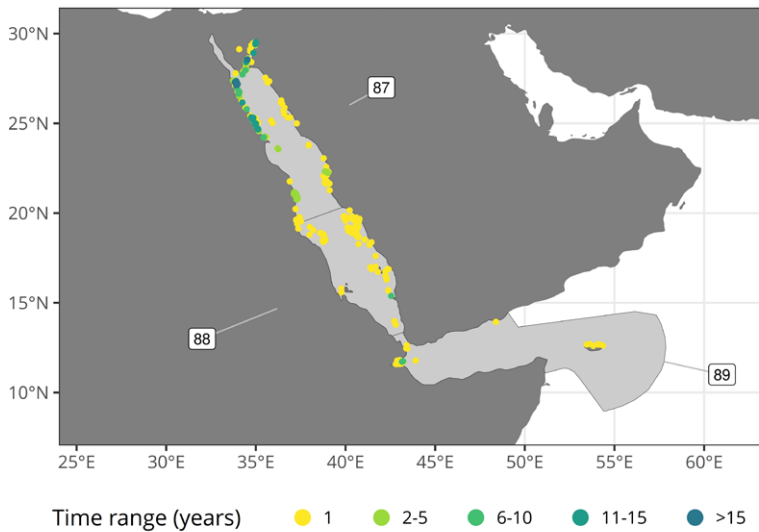


Figure 3.2. The distribution and duration of monitoring at sites across the Red Sea and Gulf of Aden region. The colours of dots represent the time span between the first survey and the most recent survey at each site. Numbers refer to the MEOW ecoregions listed in Table 3.1.

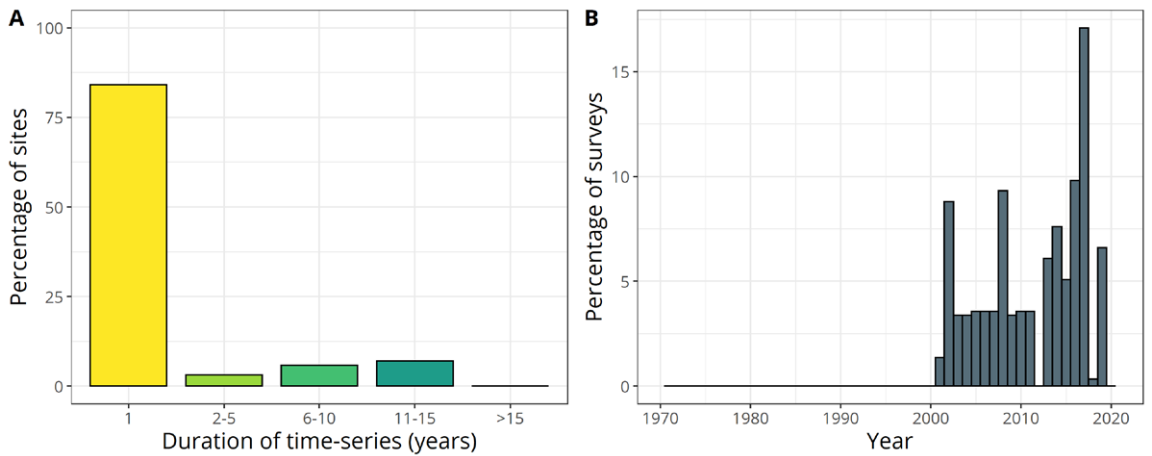


Figure 3.3. The proportion of sites in the Red Sea and Gulf of Aden region within each category describing the time span between the first and most recent surveys (A), and the proportion of the total number of surveys conducted in each year (B). The total number of surveys was 574.

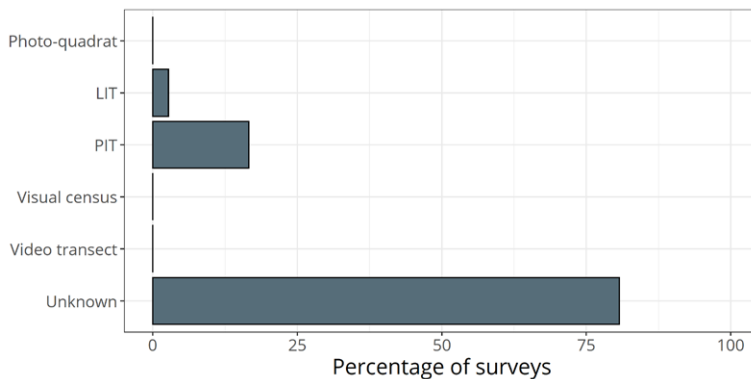


Figure 3.4. The proportion of the total number of surveys conducted in the Red Sea and Gulf of Aden region using each survey method. PIT: Point Intercept Transect; LIT: Line Intercept Transect.

3. Status of coral reefs in the Red Sea and Gulf of Aden region

- Regional trends in the cover of live hard coral and algae

In 1997, when the first data contributed to this analysis were collected, the estimated average cover of hard coral in the region was 36.1%, which was the highest at any point in the 22 year time series (Fig. 3.5A). Between 1997 and 2002, coral cover declined to 32.3% as a consequence of the mass coral bleaching event that occurred in 1998, when one-third of coral reefs in the region were affected⁶. During the next six years, coral cover almost recovered to pre-1998 levels, reaching 35.3% in 2008, but progressively declined again during the next eight years to 30.9% in 2016 . Since 2016, average coral cover has increased again to 34.3% in 2019 (Fig. 3.5A).

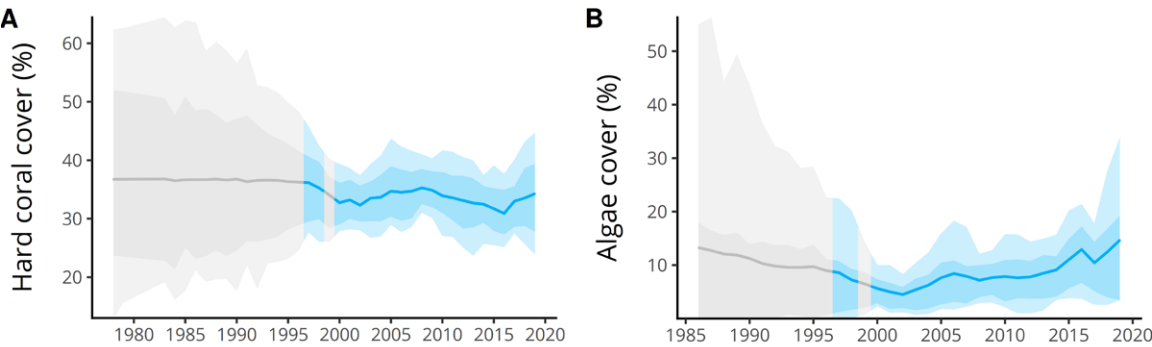


Figure 3.5. Estimated regional average cover of live hard coral (A) and algae (B) for the Red Sea and Gulf of Aden region. The solid line represents the estimated mean and associated 80% (darker shade) and 95% (lighter shade) credible intervals, which represent levels of uncertainty. Grey areas represent periods during which no field data were available.

Comparison of the average hard coral cover between three five-year periods (2005-2009, 2010-2014, 2015-2019) over the last 15 years provided weak evidence (71% probability) of a decline in coral cover between 2005-09 and 2010-14, and no evidence (47% probability) of any change between 2010-14 and 2015-19 (Tab. 3.3). The relatively low probabilities of change were attributable to the timing of fluctuations in coral cover within and between 5-year periods resulting in small absolute and relative changes in coral cover (Tab. 3.3).

Table 3.3. Probability and magnitude of mean absolute and relative change in the percent cover of live hard coral in the Red Sea and Gulf of Aden region between each of the three five-year periods comprising the last 15 years.

| Comparison | Probability of change (%) | Mean absolute change (%) | Mean relative change (%) |
|-------------------|---------------------------|--------------------------|--------------------------|
| 2005-09 - 2010-14 | 76 | -2.0 | -7.6 |
| 2010-14 - 2015-19 | 47 | 0.2 | 1.7 |
| 2005-09 - 2015-19 | 71 | -1.7 | -6.0 |

The average cover of algae on coral reefs in the region was generally low (<8.6%), particularly prior to 2012 (Fig. 3.5B). Between 1997 and 2006, the cover of algae exhibited a similar trend to that of coral cover, with an initial decline from 8.6% in 1997 to 4.5% in 2002, which was followed by a progressive

⁶ PERSGA, 2006. The State of the marine environment report for the Red Sea and Gulf of Aden (SOMER I). Wilkinson, G.; Facey, R. and Hariri, K. (eds), PERSGA, Jeddah, 241 pp.

increase to 8.4% in 2006. The cover of algae varied little during the next six years, but increased from 7.8% in 2012 to 14.7% in 2019, almost doubling the amount of algae on reefs in the region during that time (Fig. 3.5B). The stability in the cover of algae between 2006 and 2012 was confirmed by the low probability of change (68%) when comparing average algal cover between 2005-09 and 2010-14 (Tab. 3.4). However, there was a greater probability (85%) of an increase in the cover of algae between 2005-09 and 2015-19, and a mean relative change of 105.1% (Tab. 3.4) is consistent with the doubling of the amount of algae on the region's coral reefs since 2012 illustrated in figure 5b.

Table 3.4. Probability and magnitude of mean absolute and relative change in the percent cover of algae in the Red Sea and Gulf of Aden region between each of the three five-year periods comprising the last 15 years.

| Comparison | Probability of change (%) | Mean absolute change (%) | Mean relative change (%) |
|-------------------|---------------------------|--------------------------|--------------------------|
| 2005-09 - 2010-14 | 68 | 1.0 | 25.6 |
| 2010-14 - 2015-19 | 81 | 3.8 | 65.7 |
| 2005-09 - 2015-19 | 85 | 4.8 | 105.1 |

- The primary causes of change in the cover of live hard coral and algae

Local-scale causes of coral loss vary across the region. In the northern Red Sea, tourism activities and coastal development are the main causes of coral loss, while in the central region, land runoff, eutrophication and overfishing have degraded coral reefs and stimulated algal growth. In the southern Red Sea, overfishing and poor management are considered the main causes of declines in coral cover.

At a regional scale, one-third of coral reefs in the Red Sea and Gulf of Aden were affected by coral bleaching in 1998. Impacts were most severe in the central-northern Red Sea of Saudi Arabia (especially near Rabigh) and in Yemen (Belhaf, Hadhramaut, Socotra Archipelago). Fortunately, most bleached reefs recovered⁶.

- Changes in resilience of coral reefs within the GCRMN PERSGA region

Increases in the frequency of disturbances to coral reefs in the Red Sea and Gulf of Aden have changed long-term disturbance-recovery patterns, particularly on reefs along the Egyptian coast and submerged reefs, such that many reefs are not recovering completely between one disturbance and the next. The result is a stepwise decline in live hard coral cover. Among the 10 sampling units for which there was greater than 15 years of data (all of which occurred along the Egyptian coast of the Red Sea) and had experienced at least a 20% decline in relative hard coral cover, half did not recover to at least 90% of their pre-disturbance hard coral cover (Tab. 3.5). The average absolute decline in hard coral cover between the first survey and the last survey at these sites was 4% which, in relative terms, means that these sites had 13.6% less hard coral. The average maximum absolute decline in hard coral cover was 20.5%, which equates to 57% less hard coral.

Table 3.5. The mean maximum decline and the mean difference between first and last survey expressed as absolute and relative declines in percent live coral cover. N is the total number of sampling units for which >15 years of data were available and had experienced a relative decline in live coral cover of at least 20 percent. n is the number of sampling units that did not exhibit recovery to 90 percent of the initial live coral cover. Percent is the proportion of the total number of sampling units that did not exhibit recovery to 90 percent of the initial live coral cover. A sampling unit is defined as the specific area that was surveyed repeatedly. Depending on the survey methods used and how the data were provided, a sampling unit could be a transect, a quadrat or even a site.

| N | n | Percent | Mean maximum absolute decline | Mean maximum relative decline | Mean long-term absolute decline | Mean long-term relative decline |
|----|---|---------|-------------------------------|-------------------------------|---------------------------------|---------------------------------|
| 10 | 5 | 50 | 20.5 | 57.1 | 4.1 | 13.6 |

4. Subregional trends in the cover of live hard coral and algae within the Red Sea and Gulf of Aden region

Trends in the cover of hard coral differed among the three subregions comprising the Red Sea and Gulf of Aden region (Fig. 3.6), indicating some variation in disturbance-recovery regimes across the region. This also highlights the need to survey reefs in all subregions. Average hard coral cover on reefs in the northern and central Red Sea (subregion 1) showed an initial decline from 35.2% in 1997 to 29.7% in 2002, attributable to the 1998 mass coral bleaching event. However, after 2002, average coral cover on reefs in this subregion slowly increased, reaching a maximum of 39.1% in 2019 (Fig. 3.6). Fewer data were available from the southern Red Sea (subregion 2) but those that were collected suggested a progressive decline in coral cover on reefs in this subregion, particularly between 2008 (37.3%) and 2016 (24.1%), with the first sign of potential recovery in 2017 (26.7%). Trends in coral cover on reefs in the Gulf of Aden (subregion 3) were difficult to describe as data were collected in only five years between 1998 and 2008. However, those data that were collected indicated that coral cover fluctuated, ranging between 29.6% (2005) and 37.3% (2001).

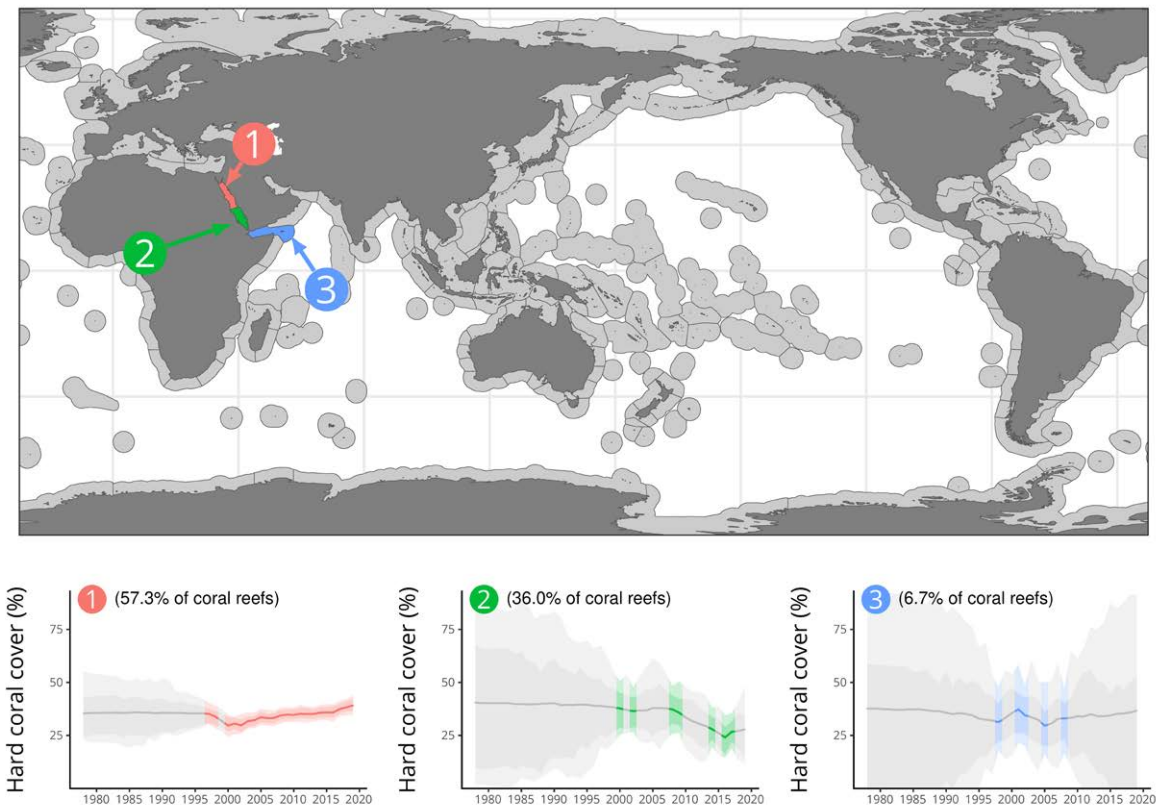


Figure 3.6. Estimated average cover of live hard coral within each subregion comprising the Red Sea and Gulf of Aden region. The solid line represents the estimated mean and associated 80% (darker shade) and 95% (lighter shade) credible intervals, which represent levels of uncertainty. Grey areas represent periods during which no field data were available. The proportion of all coral reefs in the East Asian Seas region within each subregion is indicated by the % of coral reefs.

Similar to hard coral cover, trends in the cover of algae varied among the three subregions (Fig. 3.7). Algal cover on coral reefs in the northern and central Red Sea (subregion 1) exhibited little overall change between 1997 (5.6%) and 2010 (5.2%), but slowly increased to 11.5% in 2019. Despite this increase, algal cover remained low throughout compared with the other two subregions. This may be attributable to bans established by Egypt and Jordan on any discharge into marine waters. Data describing the cover of algae on reefs in the southern Red Sea (subregion 2) were collected in only seven years between 2000 and 2017. These data indicated that algal cover was generally greater on these reefs but varied considerably, ranging between 6.4% (2002) and 25.5% (2016). More abundant algae on these reefs could be attributable to land run-off or discharge, or that waters in the southern Red Sea and Gulf of Aden are naturally more nutrient-rich. The few data collected from reefs in the Gulf of Aden (subregion 3) suggested that the cover of algae in this subregion was low (<6.8%).

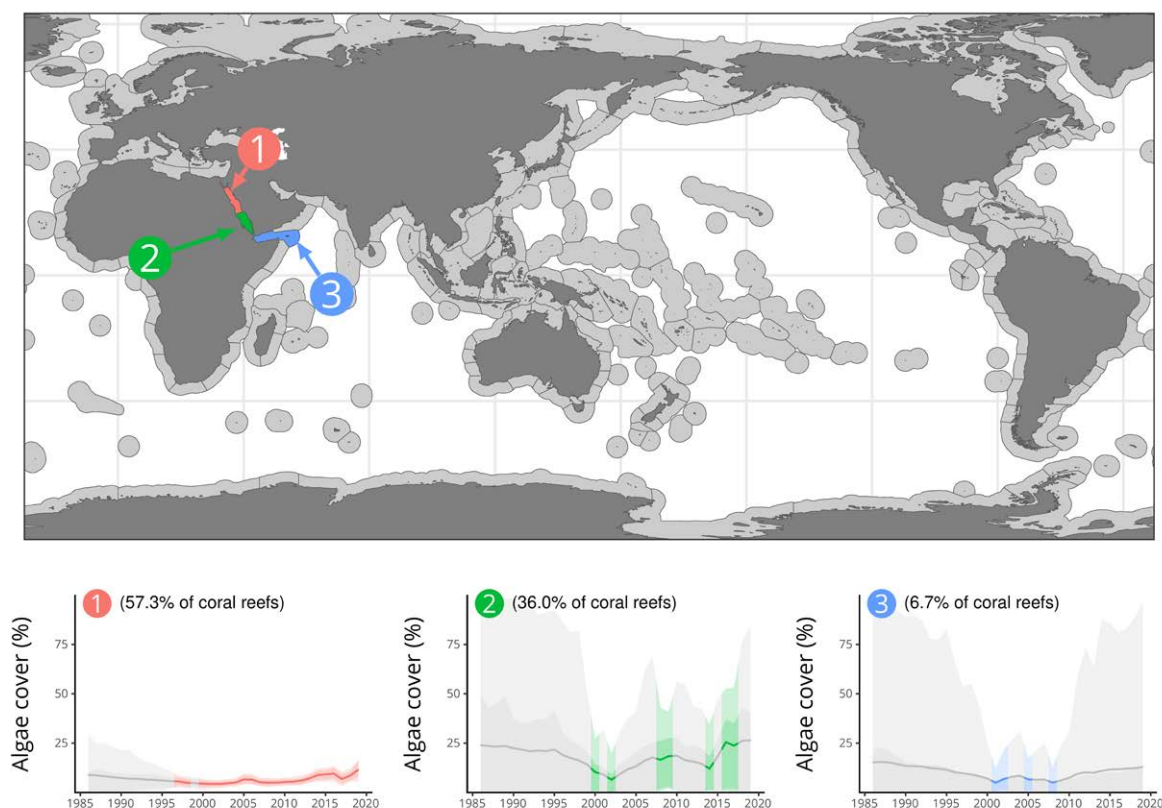


Figure 3.7. Estimated average cover of algae within each subregion comprising the Red Sea and Gulf of Aden region. The solid line represents the estimated mean and associated 80% (darker shade) and 95% (lighter shade) credible intervals, which represent levels of uncertainty. Grey areas represent periods during which no field data were available. The proportion of all coral reefs in the Red Sea and Gulf of Aden region within each subregion is indicated by the % of coral reefs.



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