2024 BLEACHING EVENT

SCIENTIFIC REPORT
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HEPCA's Periodic Report on Coral Reefs Status in the Red Sea

Red Sea Coral Bleaching Event

The 2024 Coral Bleaching Event and Recovery along the Egyptian Coast

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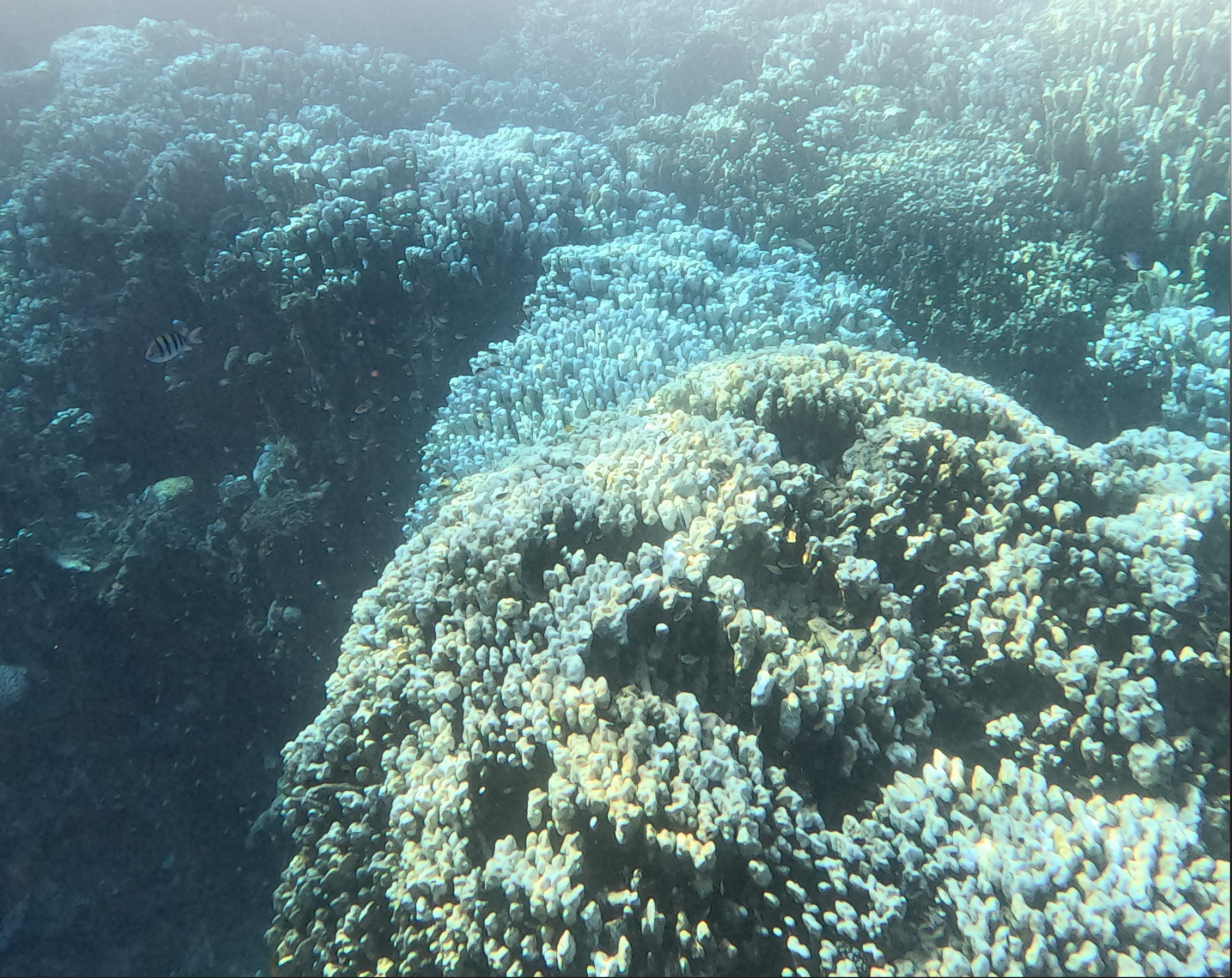

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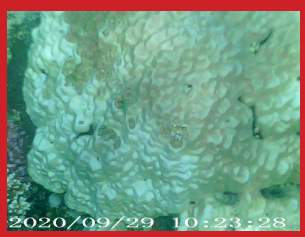
Bleach Watch Egypt

In 2010, HEPCA launched Bleach Watch Egypt in partnership with the International Union for Conservation of Nature (IUCN), and in collaboration with the Red Sea Protectorates Sector, as part of its Climate Change Project. This initiative was inspired by the successful coral reef monitoring program run by the Great Barrier Reef Marine Park Authority in Australia. Bleach Watch Egypt is a community-based early warning system designed to monitor and report signs of coral bleaching. Trained volunteers regularly check the health of coral reefs and submit reports, helping scientists track bleaching events and assess environmental changes. The program operates along the Egyptian Red Sea coast and shows HEPCA's strong commitment to protecting coral reefs from the impacts of climate change.

2011

2012

2020



2023

2024

Survey Objectives

The main goal of the survey is to understand how coral bleaching is affecting reefs and how well the corals are recovering afterward. More specifically, the survey aims to:

1. Monitor and document the current state of coral bleaching and compare it with previous bleaching events in 2012, 2020, 2023 and 2024.
2. Measure how widespread the bleaching is within coral communities.
3. Study how bleaching varies in different locations and at different depths along the Egyptian Red Sea coast.
4. Identify which coral species are more sensitive or more tolerant to heat stress.

Study Area and Method Approach

In June, the National Oceanic and Atmospheric Administration (NOAA) issued a coral bleaching alert (Fig. 1). In response, HEPCA with the Red Sea Protectorate authority (RSPs) activated the Bleach Watch Egypt network. Bleach Watch members quickly began reporting signs of bleaching, and special reporting forms were sent out to all dive centers along the southern part of the Egyptian Red Sea coast. Based on these reports, HEPCA and RSPs carried out a preliminary survey covering key areas including the Gulfs of Suez and Aqaba, and the entire Egyptian Red Sea shoreline.

After several alerts in July 2024, a large field survey was carried out along the entire Egyptian Red Sea coast, including the Gulf of Suez and the Gulf of Aqaba. The main goal was to identify areas where coral bleaching had occurred and to measure how badly the corals were affected.

The survey looked at many factors, such as how bleaching was spread across different areas, water depth (both shallow areas at 2–5 meters and deeper areas at 8–10 meters), the difference between inshore and offshore reefs, the types of coral species and groups, and whether reefs were in exposed or sheltered locations.

To measure the severity of bleaching, five spots were checked on each coral colony. The level of bleaching at each spot was recorded, and an average score was calculated for each colony. Then, averages were worked out for each coral species or group along the survey lines. Based on this, bleaching was sorted into these categories:

1. **Unbleached:** Coral looks healthy with normal colors.
2. **Slightly Bleached:** Only 1–25% of the coral is pale or white.
3. **Mildly Bleached:** About 26–50% of the coral is affected.
4. **Moderately Bleached:** 51–75% of the coral is pale or white.
5. **Severely Bleached:** Most of the coral (76–99%) is affected.
6. **Completely Bleached:** The whole coral colony is white, showing full bleaching.
7. **Partially Dead:** Some parts of the coral are dead, with no living polyps.
8. **Totally Dead:** The entire coral colony is dead.

A map showing the areas that were surveyed along the Red Sea coast is included in Figure 2.

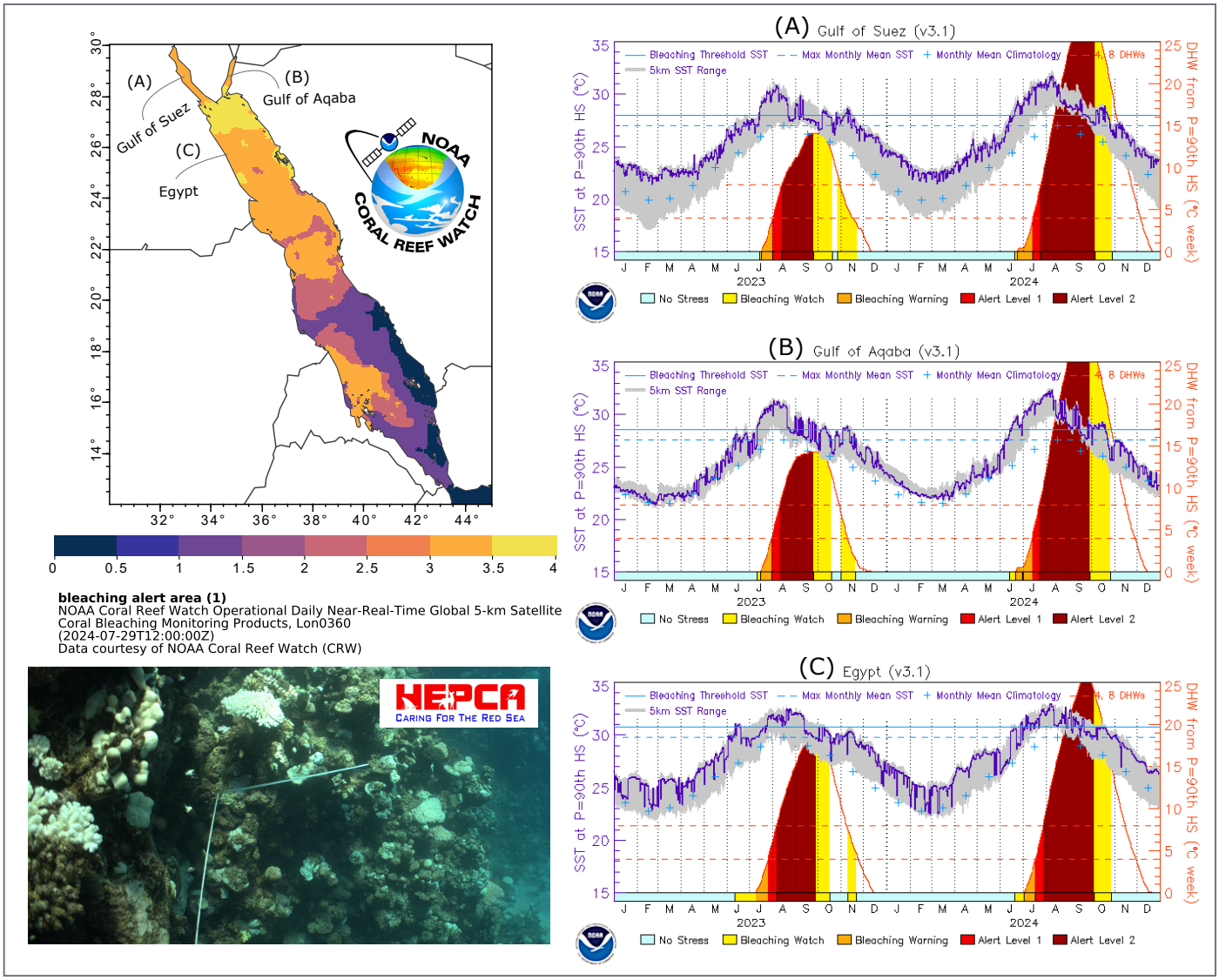


Figure 1. Key coral reefs heat stress metrics along the Egyptian Red Sea coast during the summer of 2024. The map on the top left highlights areas within the Red Sea that received coral bleaching alerts from NOAA as in July 29, 2024. The right regional virtual station time series graphs (A-C) compares the accumulated heat stress, measured in Degree Heating Weeks (DHWs), during the summer of 2024 against the levels recorded in the summer of 2023.

The underwater survey was conducted in the summer of 2024 at various locations along the Egyptian Red Sea coast. The study sites were chosen to represent the different coral reef environments present along the Egyptian coastline. For systematic analysis, the study area was partitioned into several geographical zones, extending from north to south (Fig. 2). Furthermore, site selection within each of these geographical regions was based on three basic criteria: exposure to wave action (differentiating between sheltered and exposed sites), proximity to the shoreline (categorizing sites as inshore or offshore), and their documented resilience during previous bleaching events.

At each study site, a 100m transect was surveyed using SCUBA diving across two depth ranges: 0–5m and 5–10m. Each transect was systematically divided into four 20m segments, with a 5m interval separating each segment. Transects were laid parallel to the depth contour, originating from haphazardly or randomly selected starting points along the reef slope. Benthic assemblages were recorded at 0.5m intervals along each transect, resulting in 160 data points per transect.

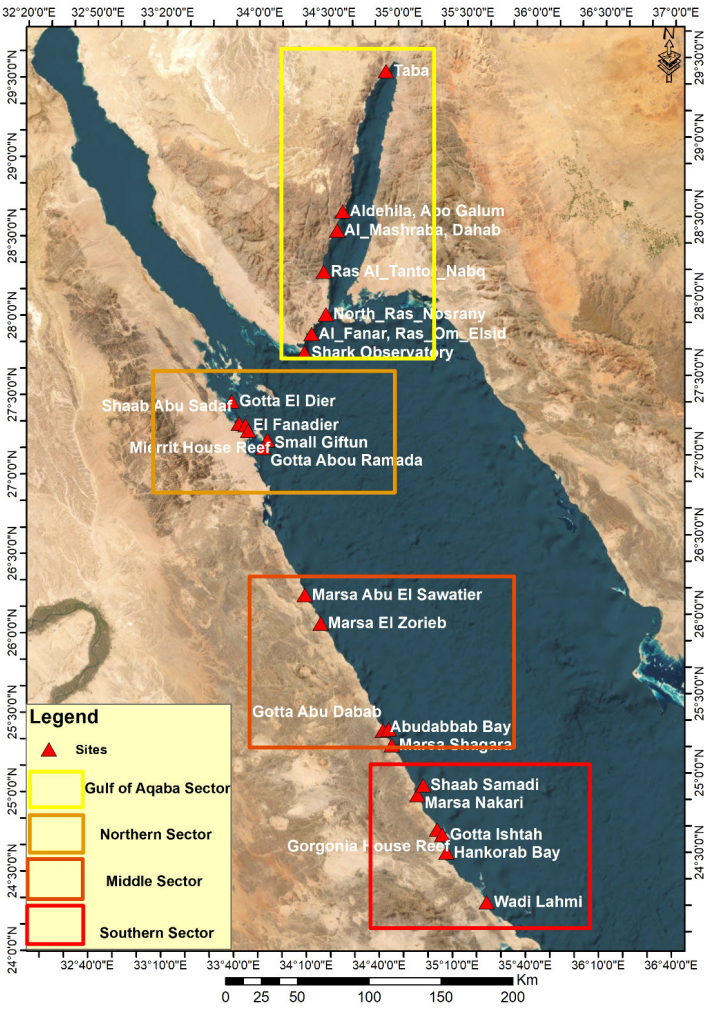


Figure 2. Location of the study sites along the Egyptian Red Sea coast. These sites were surveyed to assess the impacts of the 2024 coral bleaching event.

Estimating How Well Corals Recovered

To understand how well the corals might recover, over 280 bleached coral colonies were marked and tracked (Fig. 3). These corals were chosen to represent different species, depths, locations (north and south), inshore and offshore reefs, and both exposed and sheltered sites. About 45 days after the bleaching event, researchers went back to check the same tagged colonies. This helped estimate how many corals had recovered, how many had survived, and how many had died. These results gave valuable information about which coral types were more resilient, and how different reef areas were recovering after the bleaching.

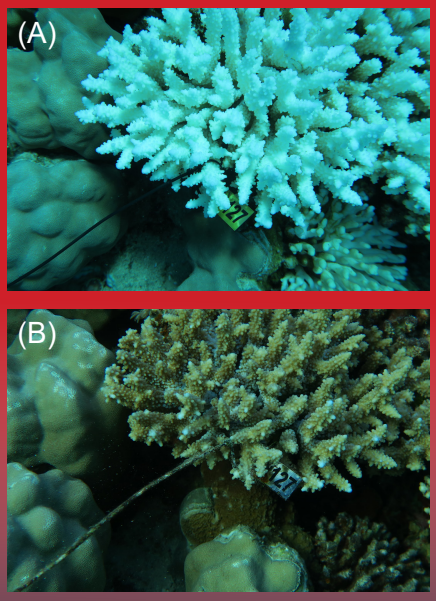


Figure 3. Monitoring recovery rate of some coral colonies. (A) A Colony of *Acropora* (tag_ID: 127) exhibits a complete bleaching severity. (B) The same colony was re-examined in November to assess the recovery potential.

Summary of the Key Survey Outcomes

The occurrence and level of bleaching intensity are significantly influenced by both geographical range and the sensitivity and resilience of the coral species/genera. The recovery of bleached colonies varied significantly based on coral species/genera. The main outcomes of the 2024 survey, in comparison to the findings of 2023, are as follows:

The overall pattern of coral bleaching across the Egyptian Red Sea shows a clear trend: the potential for bleaching increases progressively as we move southward. In general, the lowest levels of bleaching were observed in the northern sector of Hurghada, particularly across all three surveyed reef zones—namely, the reef flat, the 5-meter depth, and the 10-meter depth. The Gulf of Aqaba also recorded relatively low bleaching levels. In contrast, the highest levels of coral bleaching were documented in the southern sector, as illustrated in Figure 4.

The severity of bleaching—defined by the percentage of completely bleached coral colonies and those showing fluorescence (a sign of stress)—followed the same geographical trend. The lowest severity levels were recorded in the northern Hurghada area and the Gulf of Aqaba, as presented in Figure 4.

During this study, the southern Red Sea regions (Marsa Alam and Wadi El Gemal) experienced higher coral bleaching than the northern regions (Hurghada and Gulf of Aqaba). Wadi El Gemal had the highest incidence at 50.1% bleached and 7.7% fluorescent, irrespective of local conditions. In contrast, Hurghada showed the lowest bleaching at 9% (1.6% fluorescent), with other regions falling between these extremes (Fig. 4).

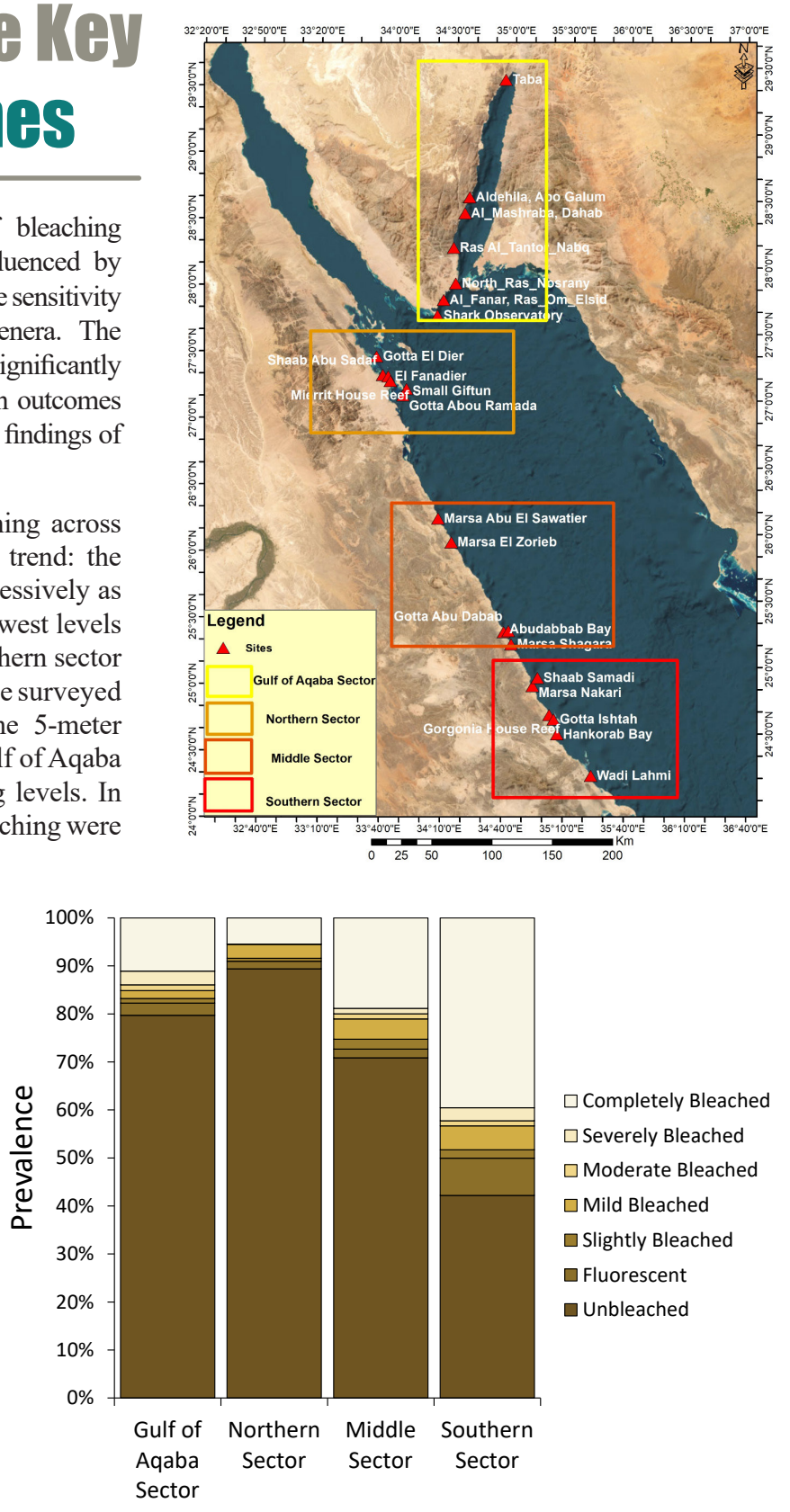


Figure 4. Impact of the 2024 bleaching event on coral cover across four sectors of the Egyptian Red Sea. (A) Map illustrating the four defined sectors with their respective study sites. (B) Prevalence of coral bleaching (% cover) within each of the surveyed sectors.

This general pattern of increased bleaching in southern regions has also been observed during previous bleaching events, such as those in 2012, 2020, and 2023. However, the 2024 bleaching event showed some unusual and noteworthy differences:

1 **Geographical Expansion:** For the first time, significant bleaching was detected in the northern parts of the Red Sea, including the Hurghada and Gulf of Aqaba sectors. Furthermore, bleaching tended to increase with depth, with more pronounced bleaching observed at the 10-meter depth compared to shallower zones (Fig. 5).

2 **Timing Shift:** Unlike earlier events that typically peaked in August, the 2024 bleaching occurred mainly in July.

3 **Tidal Influence:** The bleaching event coincided with exceptionally low tides throughout July, which likely intensified the stress on shallow corals.

4 **Sea Conditions:** June and July were marked by prolonged heatwaves coupled with extremely calm sea conditions. These calm conditions may have resulted in weak or nearly stagnant water circulation, reducing the natural cooling effect of ocean currents and contributing to the severity and spread of the bleaching.

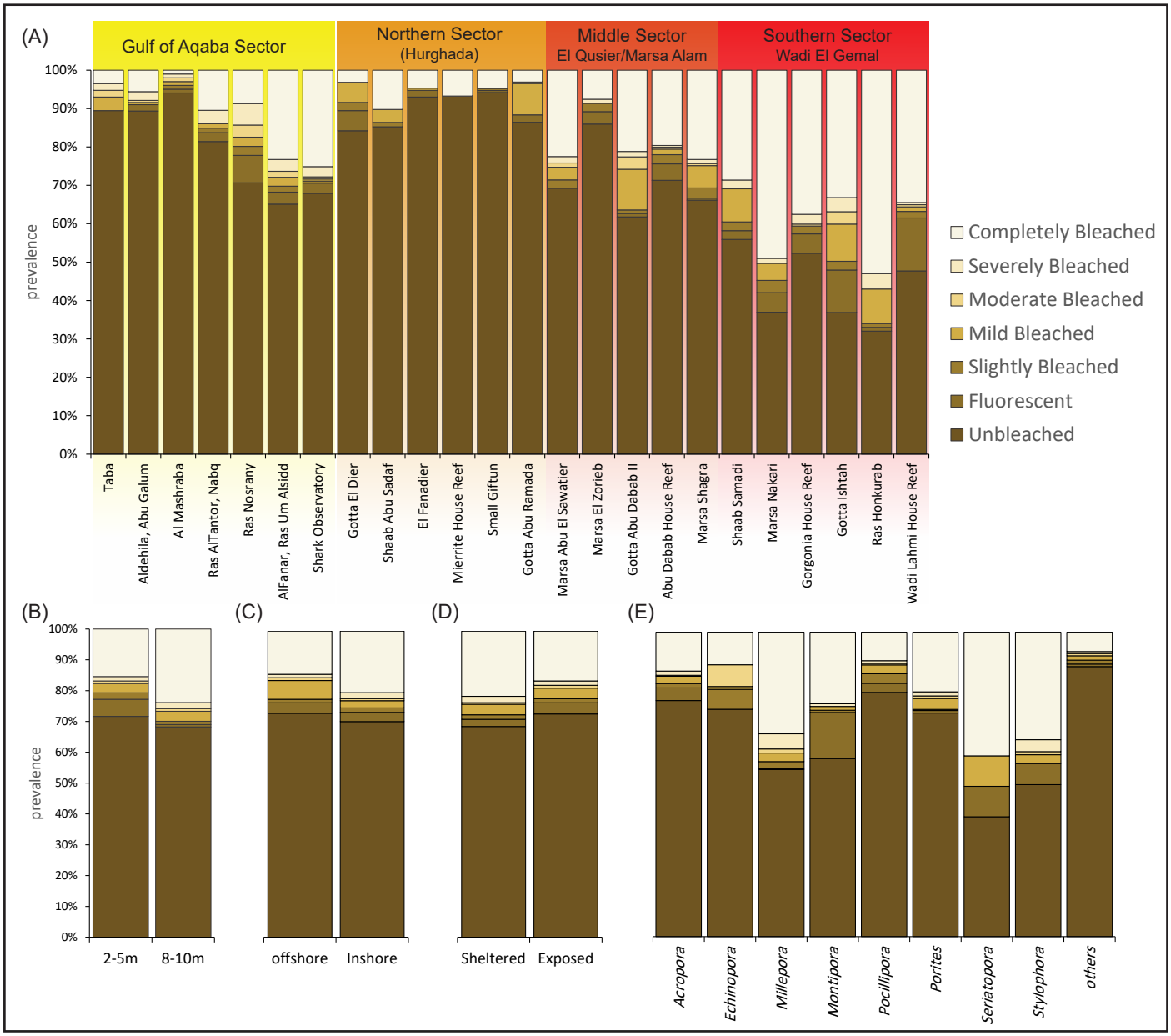


Figure 5. Coral bleaching pattern along the Egyptian Red Sea coast during the summer of 2024. (A) The geographical pattern of bleaching across all sites from nortrh (Taba) to the south (Wadi Lahmi House Reef). (B) Effect of depth on bleaching severity. (C) The pattern of coral bleaching across inshore and offshore reefs. (D) Extent of bleaching in sheltered and exposed reefs. (E) Susceptibility of different coral genera to bleaching.

Previous bleaching events along the Egyptian coast (1998, 2007, 2012, 2020) were predominantly characterized by slight to mild colony bleaching. In contrast, the 2023 event saw complete colony bleaching and mortality due to thermal stress, primarily in the southern Red Sea (Marsa Alam to Wadi El Gemal). The current study, however, reveals a more severe impact in the same southern region, with average totally bleached colonies ranging from 7.6% to 53% (Fig. 7).

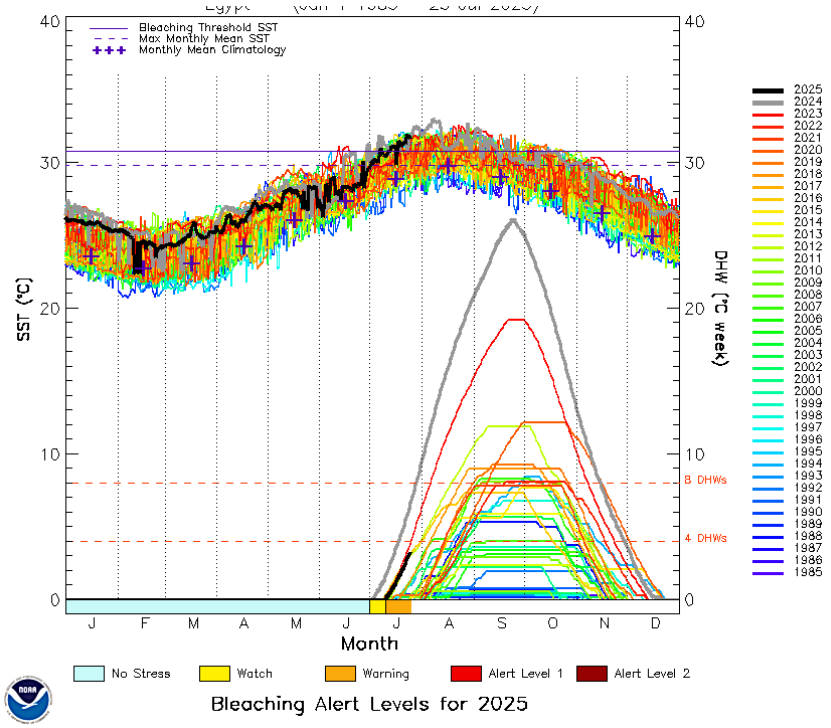


Figure 6. A regional virtual station time series graph, illustrates the magnitude of thermal stress over approximately four decades, from 1985 to 2024. This time series provides a historical context for current conditions.

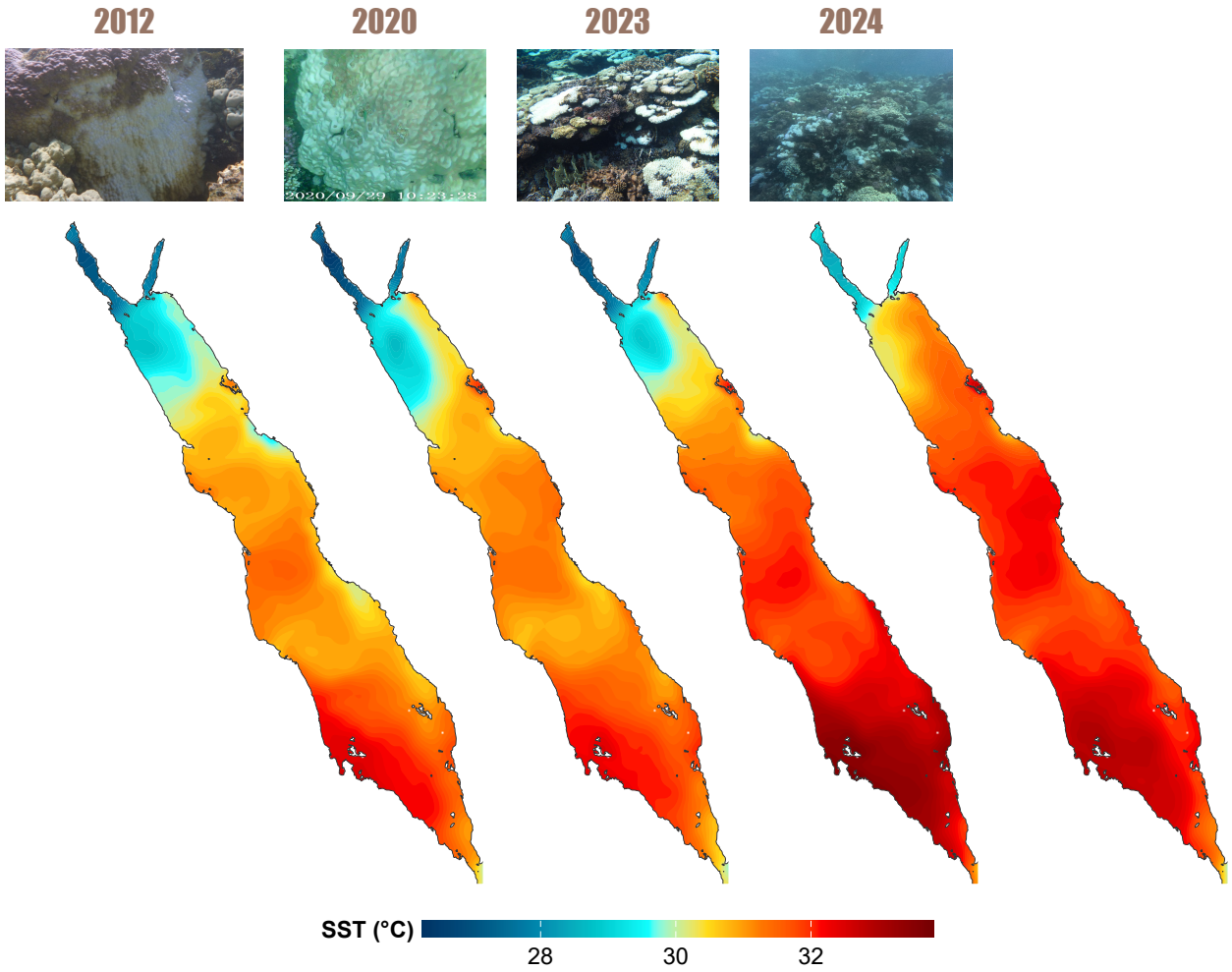


Figure 7. Historical overview of coral bleaching events documented by the HEPCA's Bleach Watch Egypt program. The upper panel presents photographic evidence illustrating the extent of bleaching recorded since 2012. The lower panel provides corresponding maps depicting the average sea surface temperature during the summer season (June-September) associated with these bleaching events along the Egyptian coast.

The bleaching occurrence and severity

The occurrence of different severity categories in Figure 5 indicated that the highest bleaching occurrence and severity were recorded in the southern sites (South of Marsa Alam) and the lowest occurrence of bleaching and severity in the Northern sector of Hurghada and the sector of the Gulf of Aqaba. Figure 5 provides a clear picture of how total coral bleaching occurrence varies across different regions of the Egyptian Red Sea and at different depths. In general, the data shows a noticeable trend: coral bleaching increases as we move southward along the coastline. Among the four sectors surveyed, Gulf of Aqaba, Northern, Middle, and Southern—the southern sector shows the highest levels of bleaching across all reef zones.

In the southern sector, bleaching is especially severe at the 10-meter depth, where over 60% of coral colonies were affected. Even at shallower levels like the reef flat and 5 meters, bleaching levels remain high, around 30% and nearly 50% respectively. This suggests that corals in the south are experiencing significant stress at all depths, but the problem intensifies deeper down.

In contrast, the northern sector shows the lowest bleaching levels. Here, the percentage of affected corals is minimal—especially at the 10-meter depth, where bleaching barely exceeds 5%. The 5-meter zone in the north shows only slight bleaching, and the reef flat is similarly low. This indicates that corals in the northern Red Sea are currently less exposed or more resilient to bleaching conditions.

The Gulf of Aqaba also follows this pattern, with bleaching levels gradually increasing with depth, from about 10% at the reef flat to roughly 25% at 10 meters. The middle sector, on the other hand, presents more consistent bleaching between 5 and 10 meters, both reaching nearly 30%, while the reef flat shows a moderate 15% level. Overall, the histogram supports two important trends: bleaching becomes more severe as we go south, and it tends to increase with depth. These patterns may be linked to factors like rising sea temperatures, reduced water circulation, and prolonged exposure to heat stress, especially in deeper reef zones.

In comparison to the event of the 2023, the latest data from the 2024 coral bleaching assessments reveals a clear escalation in both the severity and geographic extent of bleaching compared to 2023. Notably, bleaching in 2023 was primarily concentrated in the southern Red Sea, with limited impacts observed in northern sites such as Hurghada. However, in 2024, the situation has changed markedly.

Starting with El-Fanous, the northernmost station in Hurghada, the chart shows that this site remains mostly unbleached, mirroring its status in 2023 and suggesting some resilience in the far north. However, moving just slightly southward, sites like Magawesh, Abu Sawatier, and Al-Zurab exhibit increased levels of bleaching across multiple categories—including mild, moderate, and even severe bleaching, which were either absent or negligible in 2023. This indicates that the bleaching front has advanced northward for the first time. Further south, the prevalence and severity of bleaching become more alarming. Sites such as Abu Dabbab, Marsa Shagara, and Gotta show a much higher proportion of colonies affected, with noticeable segments of completely bleached, severely bleached, and even partially dead coral.

These levels represent a significant intensification compared to the 2023 event, when the majority of colonies in these areas were either slightly or mildly bleached, with very few recorded as dead. In Samadai, Marsa Nakari, and Gorgonia, a large portion of the coral population now falls into the moderately to severely bleached

categories, with some presence of mortality—indicating that the thermal stress of 2024 not only persisted longer but also hit deeper. At the southernmost sites—Shileniate and Lahmi—which were among the hardest hit in 2023, bleaching in 2024 remains severe. However, the distribution has shifted slightly, with an increased proportion of completely bleached and dead corals (both partially and totally dead) compared to last year, implying degradation and possible reduced recovery capacity.

These findings underline the intensifying nature of thermal stress events in the Red Sea, highlighting both the spatial expansion and biological toll of the 2024 bleaching episode. The combination of earlier onset, calm sea conditions, and prolonged heat exposure likely played a key role in this shift.

Conclusion

The comprehensive analysis of bleaching and recovery data reveals several critical findings:

► **Consistent Bleaching Pattern:**
A recurring pattern of bleaching—similar to events in 2012, 2020, and 2023—is observed along the Egyptian coast of the Red Sea. In contrast to the intensifying bleaching southwards from Quseir City (peaking near Marsa Alam), the northern section—including the Gulf of Suez, Gulf of Aqaba, and the northern Egyptian Red Sea—has historically escaped severe bleaching.

► **Differential Species Sensitivity:**
Heat stress affects coral species differently. In particular, Porites, Montipora, Stylophora, Millepora, and, notably in 2024, Acropora show a higher risk of severe bleaching. Meanwhile, species such as Pocillopora exhibit lower incidences of bleaching, highlighting a spectrum of vulnerability among coral genera.

► **Remarkable Resilience in Sensitive Species:**
Despite their susceptibility, the most sensitive coral species have demonstrated significant resilience, recovering well from heat stress. Their capacity to bounce back under challenging conditions underscores an innate adaptability that may be key to the region's future coral survival.

► **Impact of the 2024 Prolonged Heat Wave:**
The extended heat wave in 2024 has had a more pronounced effect on bleaching intensity compared to past events. This prolonged exposure to elevated temperatures likely foreshadows a future of more frequent, longer, and potentially more intense heat waves.

► **Hydrodynamic Influence on Bleaching Trends:**
The central question driving our ongoing research is: Why do Red Sea corals, particularly in the northern sectors such as the Gulf of Aqaba and Hurghada, exhibit both a higher tolerance to heat stress and an unusual extension of bleaching in 2024? Although some researchers suggest evolutionary or genetic factors may be involved, our findings indicate that regional hydrodynamics play a crucial role.

Our hypothesis, established in 2008 and continually supported by observed trends, proposes that the lower bleaching incidence along the northern Egyptian Red Sea is primarily due to unique water circulation patterns. At the far northern end, the Red Sea's principal current shifts from south to north, creating a turbulence/mixing zone. This mixing promotes a north-south flow along the western Egyptian coast, especially up to the Quseir area, which helps prevent surface temperatures from reaching levels that trigger severe bleaching. Additionally, prevailing wind patterns—mostly from the north and northeast—assist by propelling cooler deep water to replace warmed surface layers, further supporting lower temperatures in the northern region.

► **Specific Changes Recorded in 2024:**
The unusual extension of bleaching into the northern sectors, including areas such as the Gulf of Aqaba and Hurghada, appears to be linked to three main factors accompanying the July 2024 heat wave:

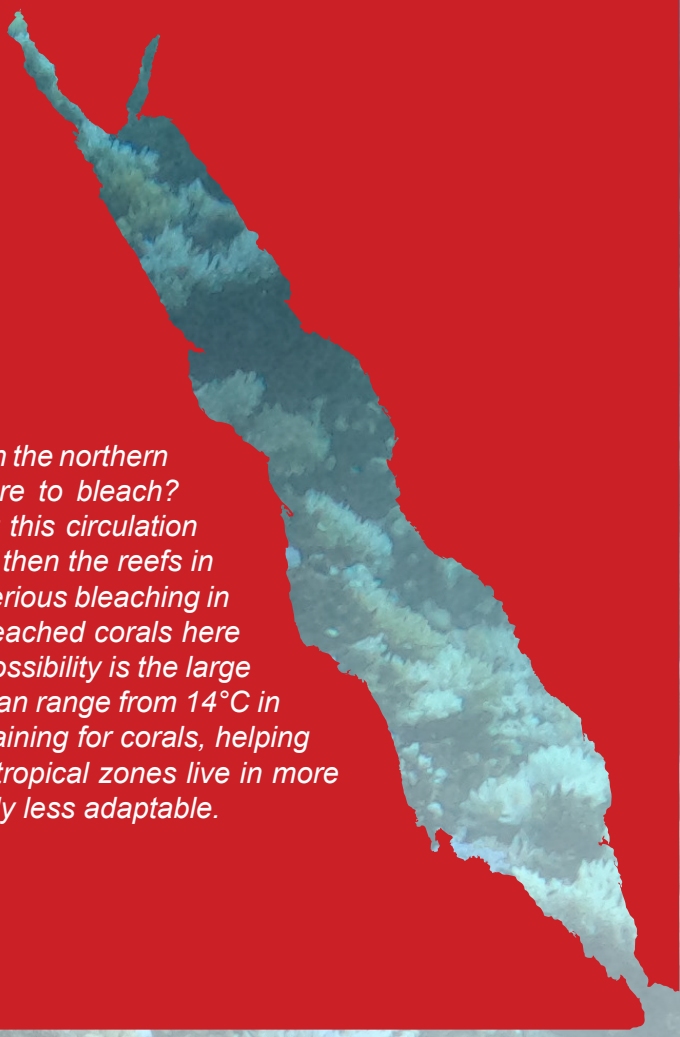
1. *Altered Water Currents:* A noticeable change in the direction and strength of water currents disrupted the usual mixing of cold deep water with the surface layer. This reduced the natural moderation of surface temperatures, impacting even regions like Quseir.

2. *Decline in Sea Level:* For the first time, an unprecedented drop in sea level was recorded. This decline exposed shallow coral colonies to intense sunlight and air during low tide, directly contributing to increased bleaching.

3. *Reduced Wind Intensity:* From the end of June until the beginning of August, wind speeds dropped to their lowest levels. This sustained reduction, combined with the sea level decline, severely curtailed the replacement of warm surface water with cooler deep water over an extended period.

The combined influence of these factors in 2024 underscores a dual dynamic: while certain coral species continue to demonstrate resilience and recovery after heat stress, the altered physical environment—marked by changes in current dynamics, sea level, and wind intensity—has exacerbated bleaching events beyond historical norms. Further research is essential to fully understand these interactions and to develop strategies that might mitigate future bleaching risks.

Questions from the 2024 Bleaching Event



Can the way water moves—its hydrodynamic pattern—in the northern part of the Egyptian Red Sea affect how likely corals are to bleach? And more importantly, could climate change actually shift this circulation pattern? We hope the answer is no. But if it does happen, then the reefs in Egypt's northern waters might face a much higher risk of serious bleaching in the future. That brings us to another question: Why do bleached corals here seem to recover better than anywhere else? One strong possibility is the large seasonal swings in temperature. In this region, the water can range from 14°C in winter to 30°C in summer. This wide range may act like training for corals, helping them build tolerance to heat stress. In contrast, corals in tropical zones live in more stable temperatures all year round, making them potentially less adaptable.

Acknowledgments

We extend our sincere gratitude to the Board Members of HEPCA for their unwavering commitment to advancing scientific research on the marine resources of the Red Sea through their Strategic Agenda. HEPCA's invaluable support encompassed funding for all expeditions and efficient management of logistics during field activities and data collection. As the sole sponsor of this work, HEPCA plays a pivotal role in monitoring the impact of climate change on the precious and distinctive living resources of the Red Sea.

Furthermore, we wish to express our deep appreciation to the members of the underwater survey team. Their dedication during the field work and survey execution were truly exceptional. The significant effort they invested was instrumental in successfully completing this work.

HEPCA

CARING FOR THE RED SEA

This report serves as a news update within the periodic reports issued by HEPCA on the status of the Red Sea natural resources on the Egyptian side.