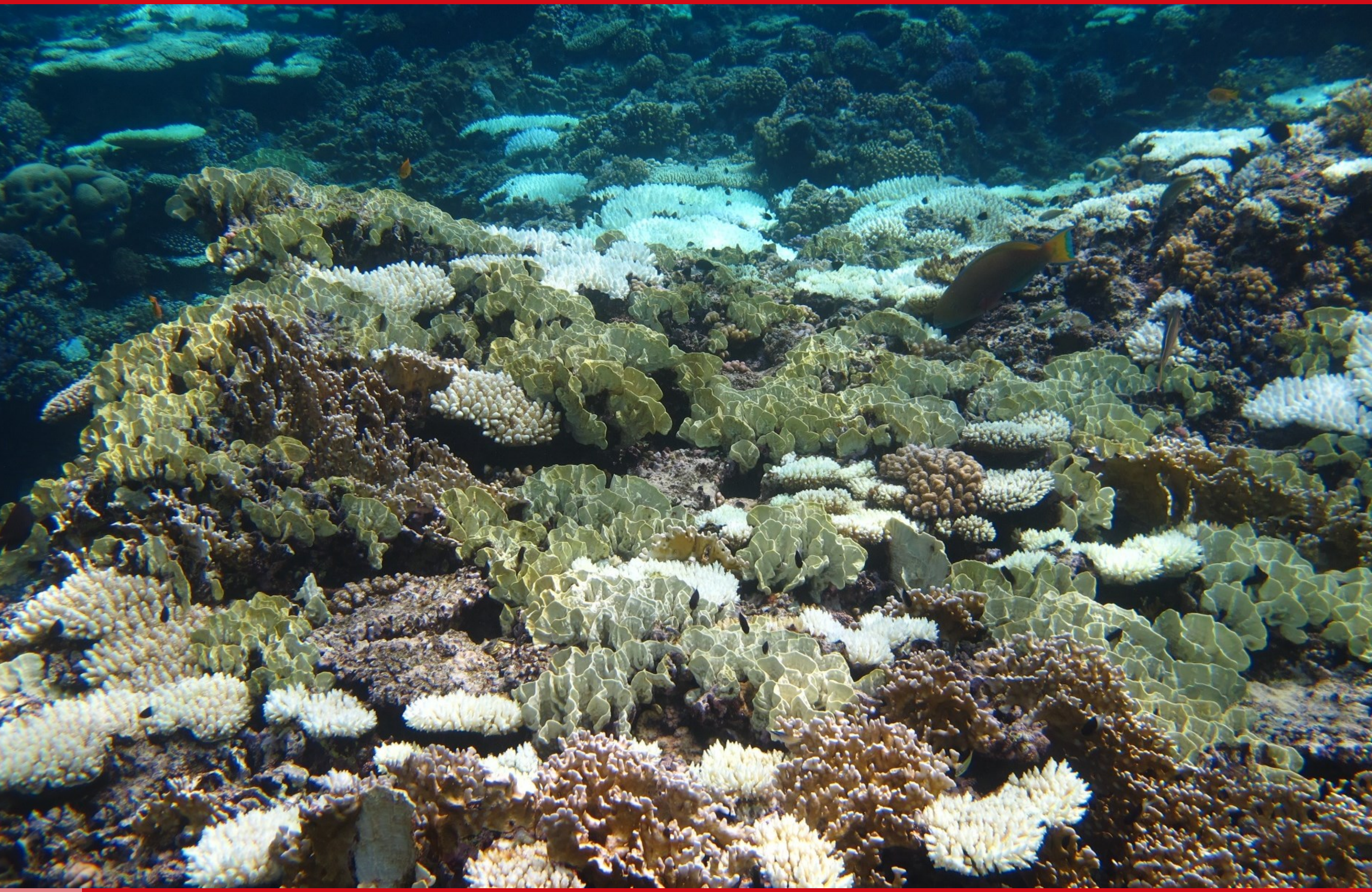
HEPCA's Periodic Report on Coral Reefs Status: Bleach Watch Egypt



SCIENTIFIC NEWS REPORT

Coral Bleaching Event of 2023:

Exploring distribution, sensitivity, and recovery potential on the Egyptian coast of the Red Sea

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Table of Contents

1. Introduction

Coral reefs, facing the compounded challenges of climate change, biodiversity loss, and pollution, serve as the frontline defenders of our planet. Paradoxically, these ecosystems, renowned for their biodiversity and ecological value, are also the most vulnerable. With half of the world's coral reefs already lost, projections indicate a potential further decline of 70-90% even if global warming is limited to the Paris Agreement target of 1.5 degrees Celsius. This alarming scenario underscores the critical need for optimism in the realm of ocean conservation. The Hurghada Environmental Protection and Conservation Association (HEPCA) is committed to the preservation of Egypt's coral reefs, particularly the Great Fringing Reef, due to the following pivotal reasons:

- ***Symbol of Hope:*** The Great Fringing Reef of the Egyptian Red Sea stands as a symbol of hope for the entire ecosystem and serves as a beacon of Nature's Tipping Point. Its significance is unparalleled, and its preservation hinges on achieving the targets outlined in the Paris Climate Agreement, coupled with robust local marine protection measures. Success in safeguarding these reefs holds the key to preventing the irreversible loss of entire ecosystems upon which countless species depend.

- ***Unique Endemism:*** Recent reviews highlight the Red Sea's remarkable endemism, featuring 346 scleractinian coral species, 19 of which are endemic. High rates of endemism extend to polychaetes, echinoderms, ascidians, crustaceans, mollusks, and shore fish. Scientific evidence underscores the Great Fringing Reef's high resilience and tolerance to climate change, positioning it as a potential global refuge for coral reefs and offering hope for future generations and recovery. In essence, the conservation of these reefs carries the promise of averting not only an imminent biodiversity crisis in the ocean but a broader ecological catastrophe for the entire planet.

- ***Socioeconomic Significance:*** Coastal cities and communities along the Great Fringing Reef are intricately linked to the ocean's resources. With tourism emerging as the primary source of income, the reef plays a pivotal role in supporting biodiversity-based tourism.

> *"The Great Fringing Reef of the Egyptian Red Sea stands as a symbol of hope for the entire ecosystem and serves as a beacon of Nature's Tipping Point."*

1.1. Bleach Watch Egypt

HEPCA, in collaboration with the International Union for Conservation of Nature (IUCN), introduced Bleach Watch Egypt in 2010 as part of the Climate Change Project. Drawing inspiration from the Great Barrier Reef Marine Park Authority's coral reef monitoring program, this community-based initiative acts as an early warning system for potential coral bleaching events. Trained volunteers report on local reef health, contributing valuable information to track bleaching events and environmental damage. Bleach Watch Egypt is operational along the Egyptian Red Sea coast, reflecting HEPCA's singular dedication to addressing climate change impacts on coral reefs.

2. Survey Objective

The survey's overarching objective is to comprehensively assess coral bleaching and estimate recovery rates in bleached coral colonies. Specific objectives encompass a range of facets, including:

- Conducting an extensive inventory of coral bleaching compared to the two bleaching events in 2012 and 2020.
- Quantifying the extent of coral bleaching across coral community.
- Evaluating the geographical and depth distribution of coral bleaching patterns along the Egyptian Red Sea coast.
- Determining the sensitivity, tolerance, and resilience of coral species to heat stress induced by climate change.
- Assessing the rate of recovery in tagged bleached colonies, considering various species and genera.
- Comparing survey findings with events documented in 2012 and 2020.

3. Study Area and Method Approach

In June, HEPCA received a bleaching warning from the National Oceanic and Atmospheric Administration (NOAA). The Bleach Watch Egypt network, fueled by member notifications on coral bleaching, was activated, with bleach watch forms distributed to all diving centers along the southern coast of the Egyptian Red Sea. A preliminary survey, guided by notifications received from Bleach Watch members, covered the Gulfs of Suez and Aqaba, as well as the Egyptian coast of the Red Sea.

3.1. Coral Bleaching Field Survey

Following multiple notifications in August 2023 (Fig. 1A), a comprehensive survey was initiated, encompassing the entire coasts of the Egyptian Red Sea, Gulf of Suez, and Gulf of Aqaba. The primary objective of this survey was to identify instances of coral bleaching, with detailed assessments conducted in affected areas (Fig. 1B).

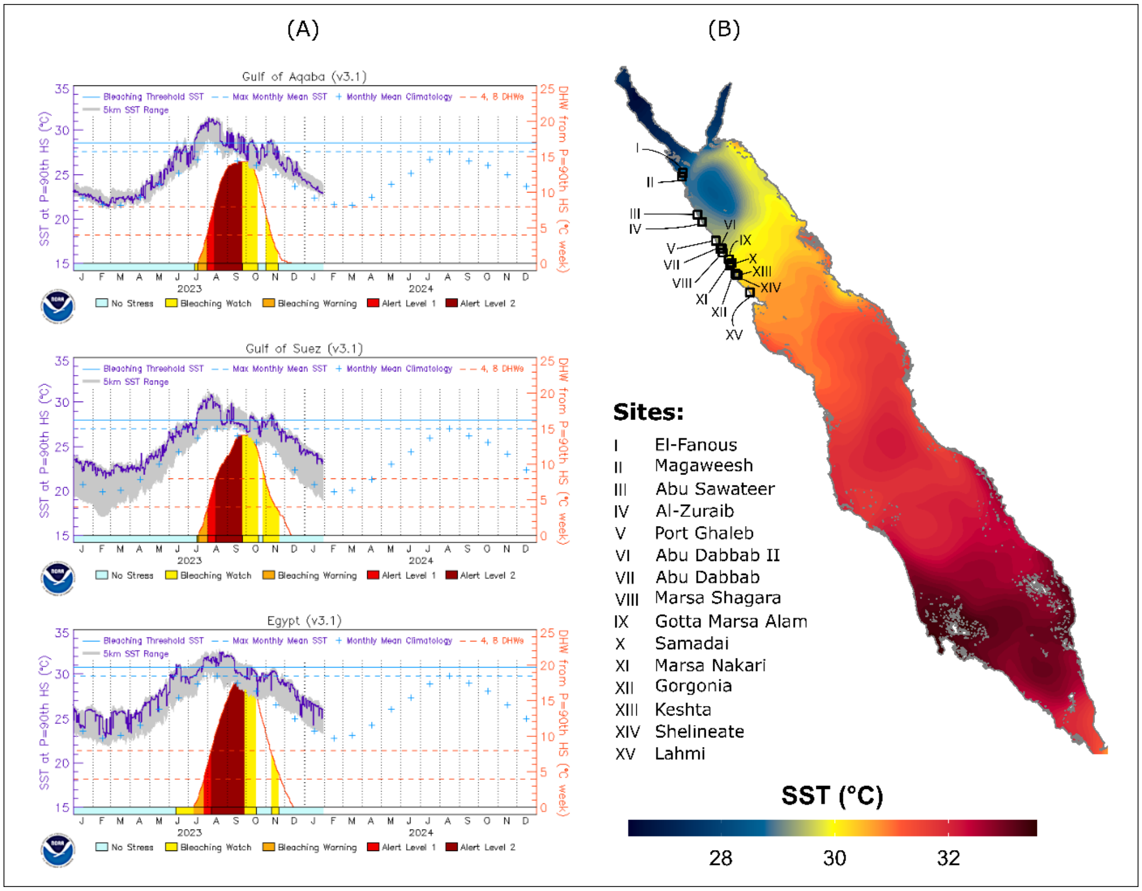


Figure 1. A daily 5 km NOAA Coral Reef Watch (CRW) SST. (A) regional virtual station time series graphs issued by NOAA for the Egyptian coastal zone of the Red Sea. (B) Distribution of 2023 summer heat stress.

Various parameters were examined during the survey, including spatial distribution, depths (specifically 2-5m on the reef edge and 8-10m on the reef slope), offshore versus inshore reefs, coral species and genera, and sheltering conditions. The degree of bleaching severity was measured against different variables. Specifically, the severity of bleaching for each colony was assessed by checking five points on each, determining the bleaching level at each point, and then calculating the average rank per colony. Overall means were computed based on the aggregate rank per species/genus along the transects.

Consequently, the following severity ranks were established:

- ***Unbleached:*** No signs of bleaching, and colony colors are normal.
- ***Slightly Bleached:*** 1-25% of the colony is bleached, with colors ranging from pale to completely white.
- ***Mild Bleached:*** 26-50% of the total colony area is impacted by bleaching.
- ***Moderate Bleached:*** 51-75% of the total colony area is affected by bleaching.
- ***Severely Bleached:*** 76-99% of the colony area is bleached.
- ***Completely Bleached:*** 100% of the colony is bleached.
- ***Partially Dead:*** Part of the colony is dead with no alive polyps.
- ***Totally Dead:*** The entire colony is dead with no alive polyps.

A detailed map of the detailed surveyed areas along the Egyptian Red Sea coast is provided in Fig. 1B.

3.2. Estimation of the Rate of Recovery

During the survey, over 280 tagged bleached colonies representing the most affected species or genera were identified to estimate the rate of recovery (Fig. 2). These colonies were strategically selected to encompass the diverse range of species and genera and were influenced by variables such as geographical range, depths, offshore vs. inshore locations, and sheltering conditions. Approximately 45 days post-bleaching event, the selected colonies were resurveyed, allowing for the estimation of recovery rates, survival rates, and mortality rates across the different variables.

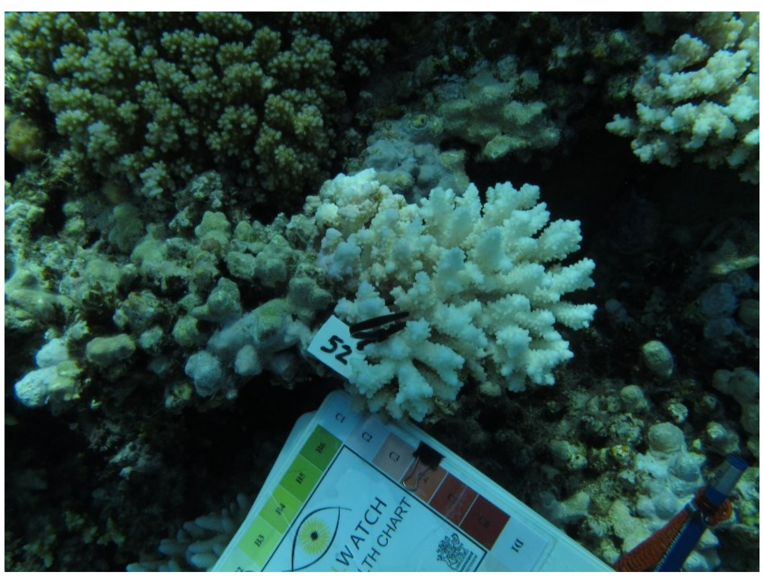


Figure 2. Tagging coral colonies (n= 288) of different genera during the field survey.

4. Summary of the Key Survey Outcomes (2023)

The occurrence and level of bleaching intensity are influence highly significant with both geographical range and the sensitivity and resilience of the coral species/genera. The recovery in bleached colonies varied significantly based on coral species/genera. Following are the main outcomes of the survey of 2023:

4.1. Geographical Range

The survey meticulously examined the intricate relationship between coral bleaching dynamics and its intensity concerning the geographical range, with a particular focus on the Egyptian Red Sea. The findings underscore a highly significant correlation, reminiscent of patterns observed in the 2012 and 2020 bleaching events. Notably, the southern stretch of the Red Sea consistently exhibited heightened coral bleaching (Fig. 3), while the northern regions—encompassing the Gulf of Suez, Gulf of Aqaba, and areas north of Quasier City—displayed only minimal indications of complete bleaching. A discernible gradient in bleaching occurrence emerged from the south of Quasier City, reaching its zenith south of Marsa Alam. The Wadi El-Gimal and Lahmi Bay regions stood out with the highest incidence of bleaching, accentuating the spatial heterogeneity in bleaching severity.

The severity of bleaching was graphically depicted (refer to Fig. 3) to illustrate a clear trend: the further south in the Egyptian Red Sea, the more pronounced the bleaching became. North of Quasier City, the bleaching spectrum ranged from unbleached to mild, contrasting with the escalated severity witnessed southward. The Wadi El-Gimal and Lahmi Bay areas, situated south of Marsa Alam, recorded the highest percentage of mildly to completely bleached coral colonies in comparison to the northern sector of the Red Sea. It is noteworthy that the heightened occurrence of severe bleaching correlated with the presence of the most sensitive coral species/genera, particularly *Porites*, *Millepora*, and *Montipora*, which were prevalent in the Wadi El-Gimal and Lahmi Bay sites.

4.2. Species Sensitivity to Heat Stress

The survey scrutinized the diverse responses of coral species/genera to heat stress, revealing highly significant variations in sensitivity. Identified as the most sensitive were *Millepora*, *Montipora*, *Porites*, *Acropora*, *Pocillipora*, and *Stylophora*. Among these, a non-scleractinian coral *Millepora* followed by *Stylophora*, *Montipora*, and *Porites* emerged as the most affected genera, exhibiting the highest levels of severity in bleaching. The survey's findings, visually represented in figure 4, underscore the pronounced vulnerability of these species to heat stress, particularly in the aforementioned Wadi El Gimal and Lahmi Bay regions.

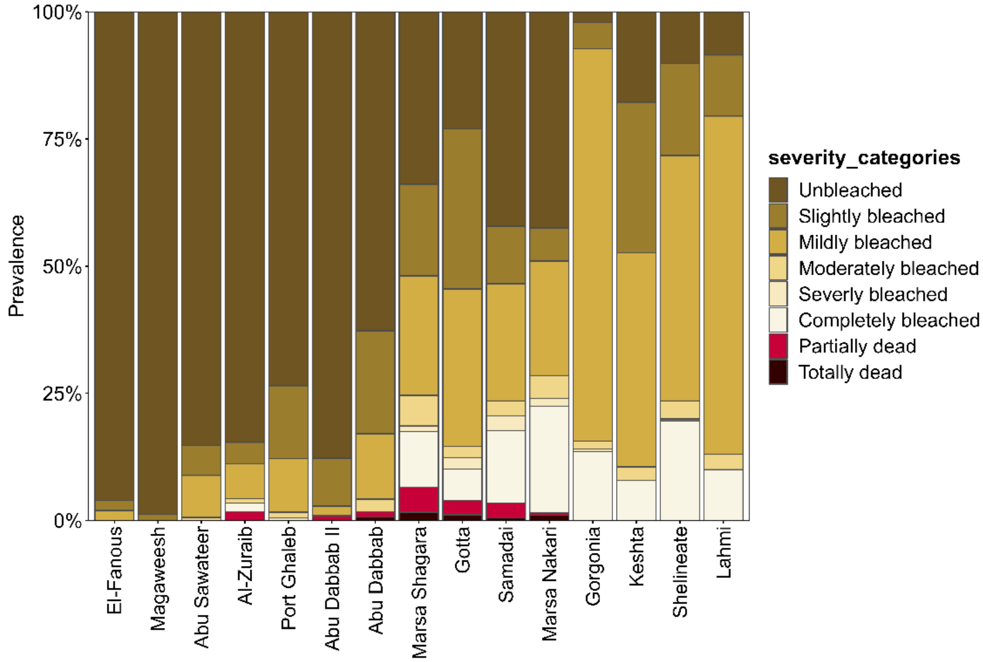


Figure 3. The geographical distribution and intensity pattern of coral bleaching observed in 2023. Southern reefs witnessed significantly higher bleaching severity compared to the north. This highlights priority areas for conservation while also indicating the potential of less-affected northern reefs as a natural refuge for corals.

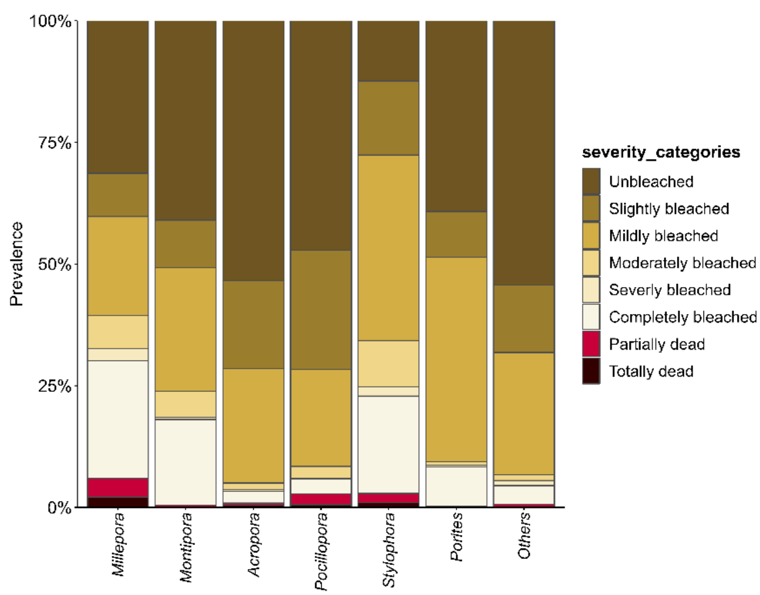


Figure 4. Diverse responses to heat stress across coral genera with *Millepora*, *Stylophora*, *Montipora*, and *Porites* exhibiting the most pronounced response to severe bleaching.

4.3. Comparison Between Inshore and Offshore Reefs

Detailed exploration into the bleaching potentials of inshore and offshore reefs revealed no discernible differences, particularly in coral colonies exhibiting moderate, severe, and complete bleaching (Fig. 5). The data unveiled a consistent pattern, with approximately 50-60% of coral colonies displaying signs of bleaching across all surveyed reefs, regardless of their proximity to the shoreline.

4.4. Comparison Between Depths

The survey delved into the impact of depth on bleaching potential, examining two specific depths: 2-5m (reef edge) and 8-10m (reef slope). The findings illuminated a higher prevalence of affected coral colonies on the reef slope compared to the reef edge. Furthermore, the severity of impact was more pronounced in the deeper studied depth (reef slope) than in the shallower depth (reef edge). Figure 6 visually illustrates this depth-dependent variation, emphasizing the importance of accounting for depth when assessing the repercussions of bleaching on coral colonies in the surveyed areas.

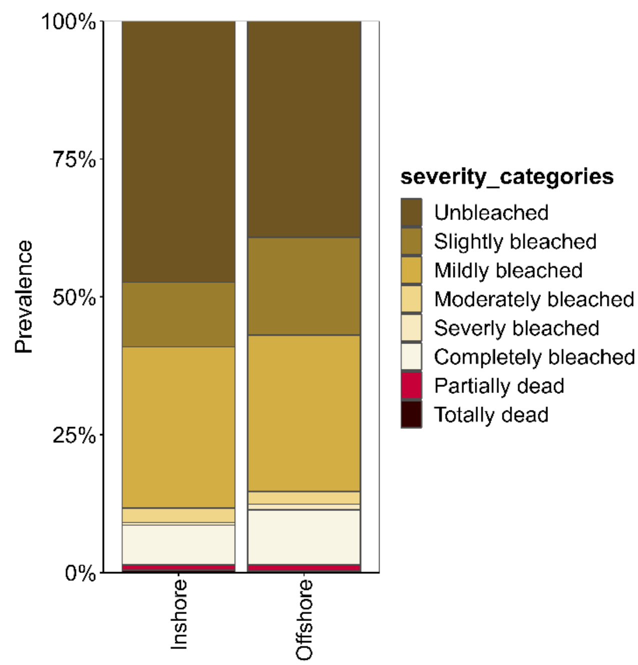


Figure 5. Bleaching patterns across inshore and offshore reefs. No significant differences in bleaching severity were observed between the two reef systems. This consistency suggests that proximity to the shoreline may not be a major factor influencing coral bleaching susceptibility.

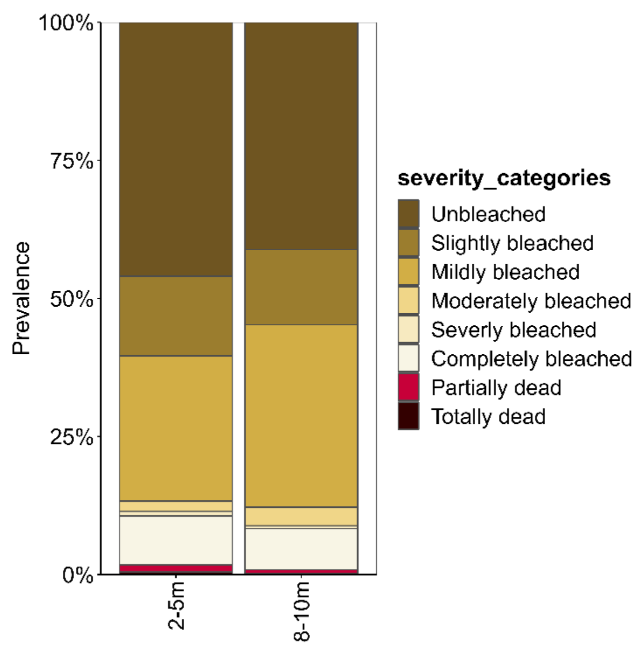


Figure 6. Depth-dependent variations in coral bleaching. Bleaching pattern reveals a higher proportion of affected coral colonies on the deeper reef slope (8-10m) compared to the shallower reef edge (2-5m).

5. Recovery in Bleached Colonies

Results of the recovery study on bleached tagged colonies revealed compelling insights, summarized as follows:

5.1. Overall Recovery Rates

A comprehensive analysis of the nearly 288 bleached tagged colonies unveiled a noteworthy trend. Approximately 72.2% of these colonies exhibited signs of recovery, whether it be total (50.3%) or partial (21.9%) recuperation from the bleaching event. In stark contrast, only 27.8% of the total tagged colonies were deemed completely deceased after an observation period of nearly 45 days post-bleaching (refer to Fig. 7). These findings suggest a promising recovery potential for a majority of the affected colonies.

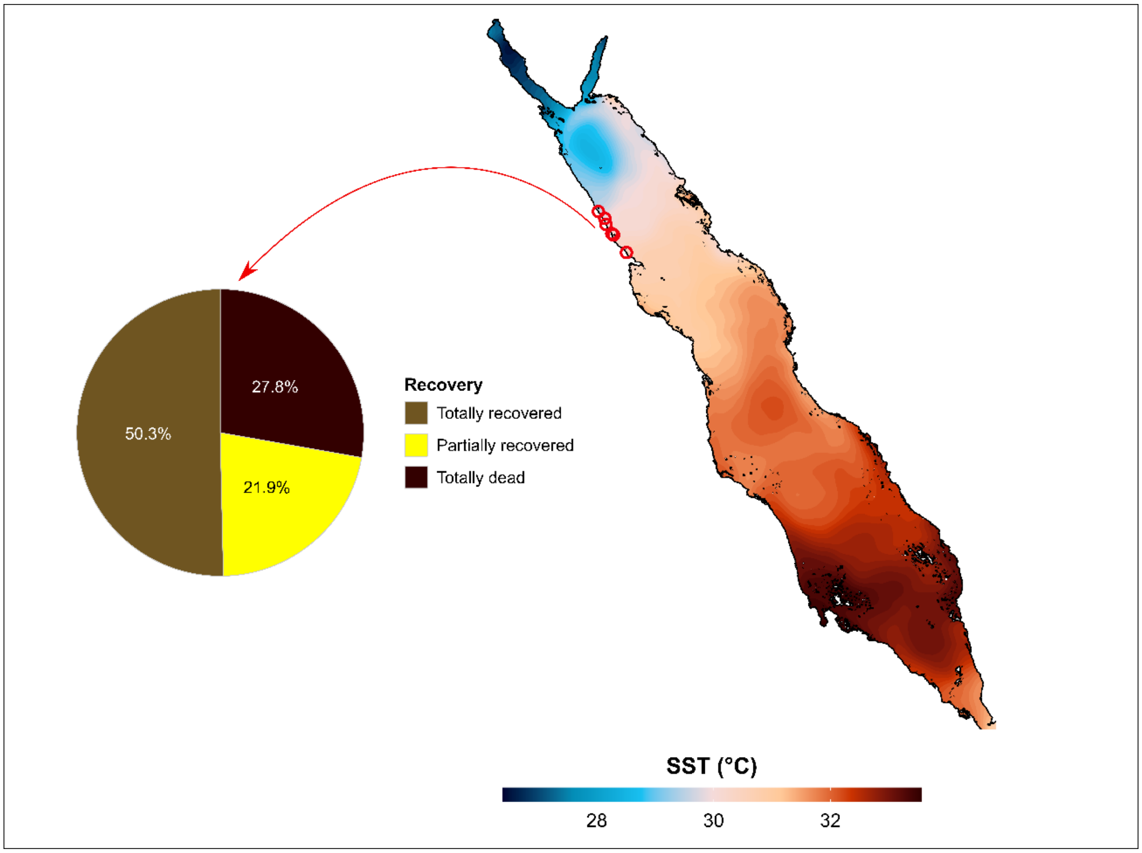


Figure 7. Post-bleaching recovery in tagged coral colonies in seven southern reefs. Notably, 72.2% of these colonies displayed signs of recovery after 45 days, represented by different color intensities. Of these, 50.3% exhibited complete recovery, highlighting their resilience. Additionally, 21.9% showed partial recovery, demonstrating their ability to partially regain health.

5.2. Correlation Between Sensitivity and Recovery

A compelling correlation emerged between the sensitivity of coral species/genera to heat stress and their potential for recovery. Notably, *Porites*, a genus known for its resilience, demonstrated an impressive recovery rate. Approximately 80% of the tagged bleached *Porites* colonies fully recovered, with an additional 8-9% experiencing partial recovery. Intriguingly, even among the partially recovered colonies, it was observed that large colonies, spanning centuries in age, achieved complete recovery through the horizontal growth of polyps. This underscores the high recovery potential of large *Porites* colonies, attributed to their resilience and expected horizontal growth of polyps.

In contrast, coral genera such as *Millepora*, *Montipora*, and *Pocillopora*, which exhibited high sensitivity to heat stress (indicated by severe bleaching, i.e moderately, severely and completely bleached colonies), surpassed expectations with recovery rates exceeding 70% for both partial and complete recuperation (see Fig. 8).

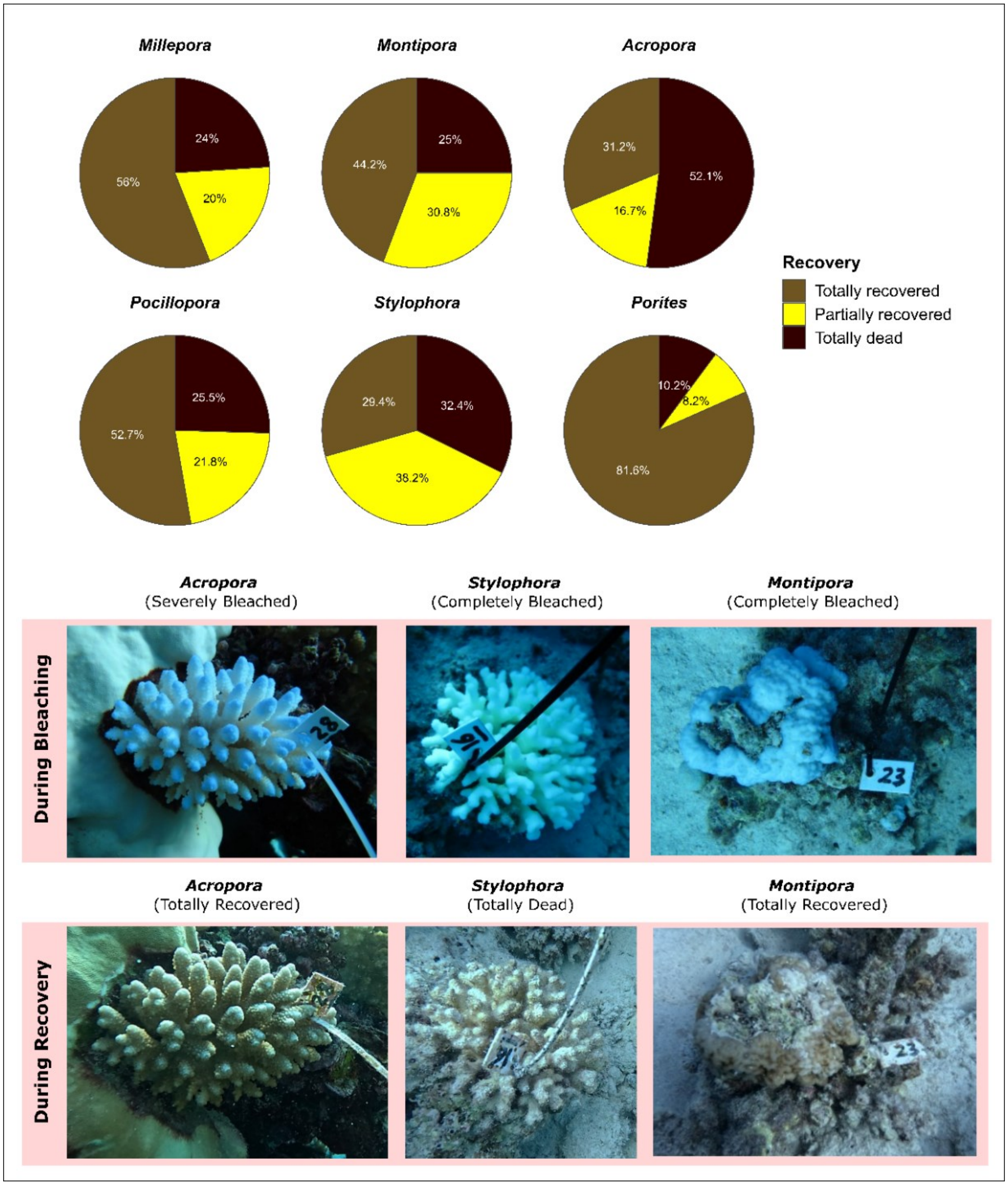


Figure 8. Recovery potential linked to heat stress sensitivity. *Porites*, known for resilience, showed high recovery. Conversely, highly sensitive genera (*Millepora*, *Montipora*, and *Pocillopora*) exceeded expectations with over 70% of different levels of recovery.

Acropora and *Stylophora* showcased a distinct pattern in sensitivity and resilience. Despite lower rates of severe bleaching in *Acropora* compared to other species/genera, this genus exhibited lower recovery rates (see Fig. 8). In essence, *Acropora* demonstrated lower sensitivity to heat stress during bleaching events but was characterized by a diminished resilience or recovery rate, evident in the higher percentage of tagged bleached colonies recorded for this genus.

This nuanced analysis not only underscores the variability in recovery dynamics across coral species and genera but also sheds light on the interplay between sensitivity to stress and subsequent resilience in the face of bleaching events.

6. Conclusion

The results obtained from the comprehensive analysis of bleaching and recovery data unveil four pivotal findings that can be articulated in greater detail:

- ***Consistent Bleaching Trend:*** A persistent pattern akin to the 2012 and 2020 bleaching events emerges along the Egyptian coast of the Red Sea. Notably, the northern section, encompassing the Gulf of Suez, the Gulf of Aqaba, and the Northern part of the Egyptian Red Sea, remains devoid of severe bleaching. Conversely, the potential for bleaching intensifies southward from Qusier City and peaks south of the Marsa Alam City area (Appendix 1).
- ***Coral Species Sensitivity:*** The nuanced sensitivity of coral species/genera to heat stress manifests in pronounced variations. *Porites*, *Montipora*, *Stylophora*, and *Millepora* exhibit a higher potential for severe bleaching, contrasting with the lower occurrences observed in *Pocillopora* and *Acropora*.
- ***Resilience of Sensitive Species:*** Noteworthy is the resilience demonstrated by the most sensitive species/genera, showcasing the highest recovery and adaptability to heat stress.
- ***Prolonged Heat Wave Impact:*** The protracted duration of the 2023 heat wave exerts a more substantial influence on bleaching potential compared to the events of 2012 and 2020. This signals a potential trajectory of increased frequency, duration, and intensity of heat waves in the coming years.

The intriguing question of "why Red Sea corals exhibit a higher tolerance to heat stress" remains a subject of rigorous investigation. While some scientists posit evolutionary or genetic influences, this explanation encounters challenges due to observed disparities in bleaching potential along latitudinal lines. Our hypothesis, formulated since 2008 and bolstered by consistent bleaching trends, posits that the diminished bleaching occurrence along the northern coast of the Egyptian Red Sea is primarily attributable to the region's distinctive hydrodynamic pattern.

As illustrated in Appendix 2, the main current in the Red Sea shifts from south to north at its northern extremity, creating a turbulence/mixing zone in the far north. This alteration directs the main current north-south along the western coast of the Egyptian Red Sea until the Qusier area, acting as a significant mitigating factor against temperature rise. The unique circulation pattern in the northern part forms a temperature-mitigated area, averting temperatures from reaching the threshold for severe bleaching. Moreover, wind patterns in the northern Red Sea, predominantly between the north and north-east, further support this mitigation by propelling surface water southward and facilitating the replacement of warmer surface water with cooler deep water in coral reef areas (Appendix 2).

Both of these factors contribute to the lower temperature levels characterizing the northern region of the Red Sea, as depicted in Appendix. 3.

The influence of evolutionary factors on the sensitivity and resilience of Egyptian Red Sea corals should not be discounted. The region experiences substantial temperature fluctuations between winter and summer, ranging from 13-14°C in winter to 30°C or slightly more in summer. This exposure to temperature variations likely contributes to the heightened tolerance capacity of Egyptian corals. Further in-depth investigations are imperative to validate and deepen our understanding of this perspective.

7. Recommendations

In order to bolster the resilience of coral reefs, we propose a multifaceted conservation strategy that includes limiting fishing activities, redirecting human interactions with coral reef ecosystems towards sustainable practices, promoting coral restoration through sexual reproduction, and progressing towards the designation of the entire Great Fringing Reef of Egypt as a National Park.

1. Sustainable Fisheries Management:

- Implement measures to reduce fishing pressure on coral reef ecosystems, including the establishment of no-take zones and regulated fishing seasons.
- Introduce community-based fisheries management initiatives that involve local stakeholders in sustainable resource utilization.

2. Transitioning to Sustainable Practices:

- Reorient all human activities associated with coral reefs toward sustainable practices, emphasizing eco-friendly tourism, responsible diving, and the adoption of low-impact recreational activities, based on implementing carrying capacity plans.
- Collaborate with local communities to raise awareness about sustainable practices and their role in preserving the health of coral reefs.

3. Coral Restoration through Sexual Reproduction:

- Prioritize coral restoration efforts, focusing on the degraded reefs off Hurghada, by implementing innovative approaches such as sexual reproduction.
- Establish coral nurseries to facilitate the growth of sexually reproduced corals, promoting genetic diversity and resilience in the restored populations.

4. Progressing towards National Park Status:

- Advocate for the declaration of the entire Great Fringing Reef as a National Park to ensure comprehensive protection and conservation.
- Collaborate with relevant authorities, communities, and environmental organizations to formulate and implement the necessary legal frameworks for the National Park designation.

5. Strengthening Collaborative Conservation Initiatives:

- Encourage partnerships between government agencies, non-governmental organizations, and local communities to pool resources and expertise for effective coral reef conservation.
- Establish monitoring and enforcement mechanisms to safeguard against illegal activities and ensure the sustained protection of the coral reef ecosystems.

6. Research and Monitoring:

- Implement regular monitoring programs to assess the health and resilience of the Great Fringing Reef and adjust conservation strategies based on the latest scientific findings.
- Support continuous research and monitoring efforts to inform adaptive conservation measures and ensure the long-term health of the coral reef ecosystem.
- Promote citizen science initiatives to involve the public in data collection and monitoring efforts.
- Establish platforms for public participation in conservation decision-making processes.
- These recommendations aim to create a comprehensive and adaptive strategy to safeguard the Great Fringing Reef of Egypt, recognizing its significance as a potential coral refuge in the face of climate change and coral bleaching.

7. Education and Community Engagement:

- Conduct educational programs targeting local communities, schools, and tourists to foster a deeper understanding of the importance of coral reefs and the role each individual can play in conservation.
- Facilitate community engagement in decision-making processes related to coral reef conservation, ensuring inclusivity and shared responsibility.

This comprehensive approach seeks to safeguard the Great Fringing Reef of Egypt by addressing various aspects of conservation, from sustainable resource management to proactive restoration efforts, all while progressing towards the establishment of a National Park for enduring protection.

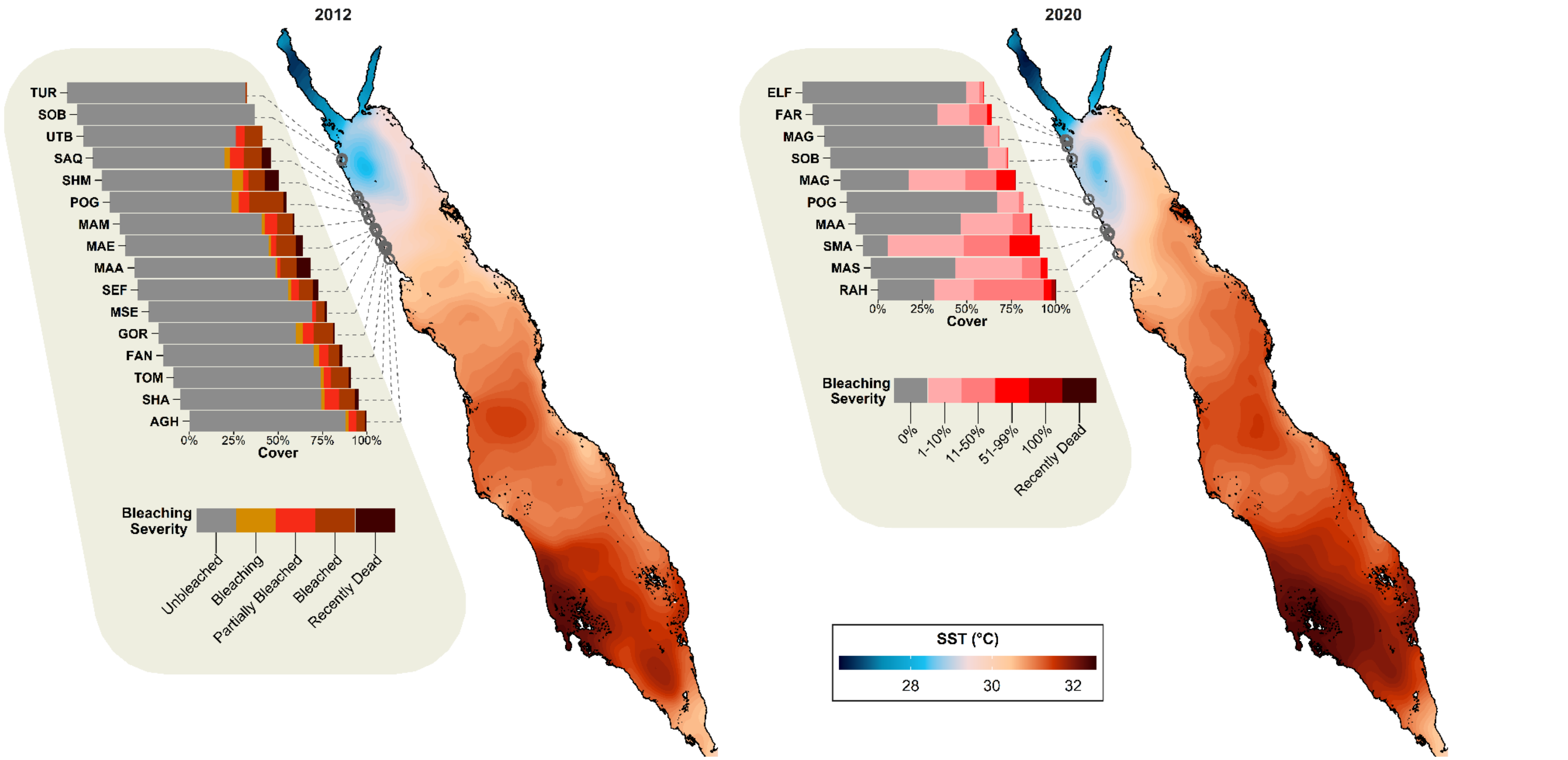
Acknowledgment

The authors extend their 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 the research, HEPCA plays a pivotal role in monitoring the impact of climate change on the precious and distinctive living resources of the Red Sea.

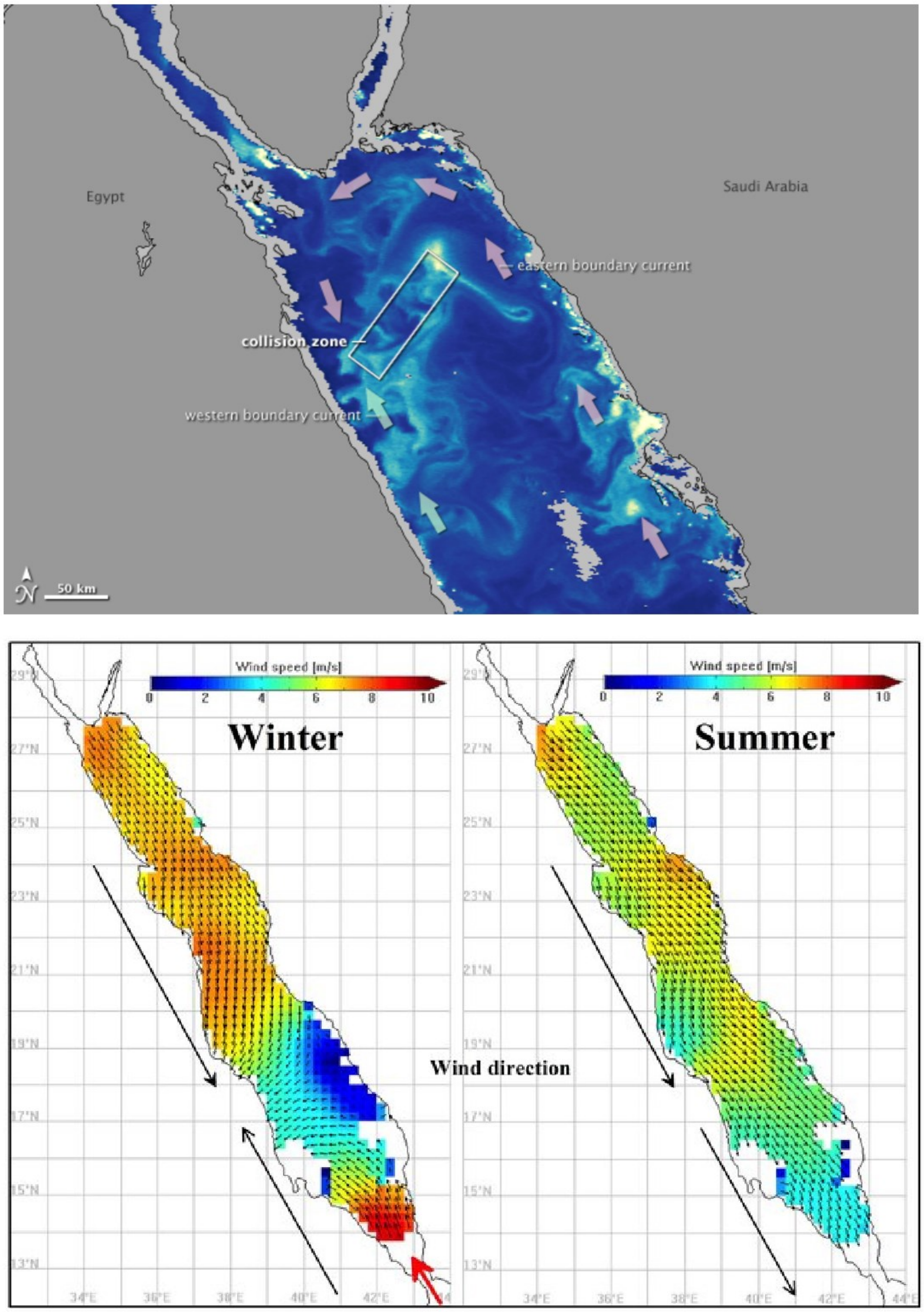
Furthermore, the authors would like to express their deep appreciation to various individuals who supported the field survey. Without their assistance, this investigation would not have been conducted successfully. Special thanks to ***Ms. Mai Mohamed Hussain*** (Suez Canal University), ***Mr. Ayman Nasr*** (Red Sea Protectorate, Hamata), ***Ms. Hadeer Ismail*** (post-graduate student), ***Dr. Ahmed Gallab*** (Red Sea Protectorate, Hurghada), ***Dr. Asmaa Hassan*** (General Authority for Remote Sensing). Their contributions were instrumental in ensuring the thorough and effective execution of the study.

Next step: The authors commit to conducting a comprehensive analysis of the complete dataset, with the aim of generating a scientific publication that assesses the bleaching potential and resilience/recovery of the coral community in the Egyptian reefs of the Red Sea.

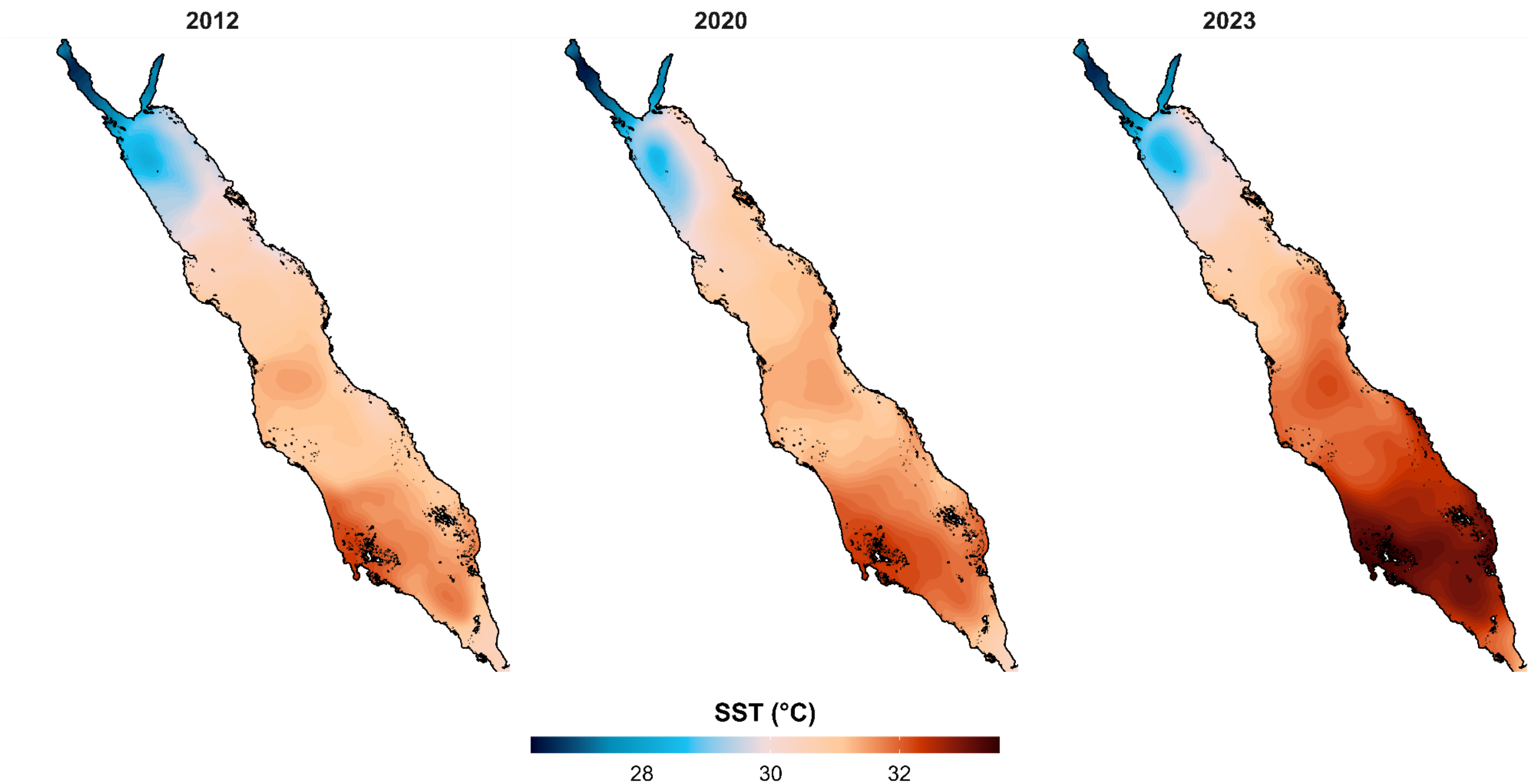
Appendix 1. Spatial distribution of coral bleaching severity along the Egyptian Red Sea coast during the 2012 and 2020 heat stress events.



Appendix 2. Mitigation Factors in the Northern Red Sea. (Top) Circulation dynamics (Adapted from *NASA Earth Observatory story Chlorophyll and Currents in the Red Sea*). (Bottom) Prevailing wind patterns (source: https://doi.org/10.1371/journal.pone.0064909).



Appendix 3. Heat stress distributions along the Red Sea during the bleaching events of 2012, 2020, and 2023.



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The heatwave and subsequent coral bleaching event of Summer 2023 are considered unprecedented in the recent history of the Egyptian Red Sea coast, especially in the southern region. Therefore, 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.