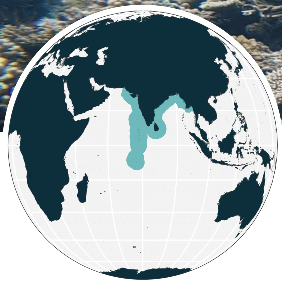

Coral reefs in the Ari Atoll, Maldives
Credit: Irene Pancrazi



SOUTH ASIA

Authors

Ahmad **Ali Khan**[1], Monica **Montefalcone**[2,3], Carlo Nike **Bianchi**[4], Carla **Morri**[4], Laura E. **Richardson**[5], Mohamed F.M. **Fairoz**[6], Patterson J.K. **Edward**[7], Jérémy **Wicquart**[8]

[1]South Asia Cooperative Environment Programme (SACEP), Colombo, Sri Lanka | [2]Seascape Ecology Laboratory, DiSTAV, Department of Earth, Environmental and Life Sciences, University of Genoa, Genova, Italy | [3]National Biodiversity Future Centre (NBFC), Palermo, Italy | [4]Stazione Zoologica Anton Dohrn - National Institute of Marine Biology, Ecology and Biotechnology, Genoa Marine Centre (GMC), Genova, Italy | [5]School of Ocean Sciences, Bangor University, Menai Bridge, UK | [6]Faculty of Fisheries and Ocean Sciences, Ocean University of Sri Lanka, Sri Lanka | [7]Suganthi Devadason Marine Research Institute, Tuticorin, India | [8]Marepolis, Portel-des-Corbières, France

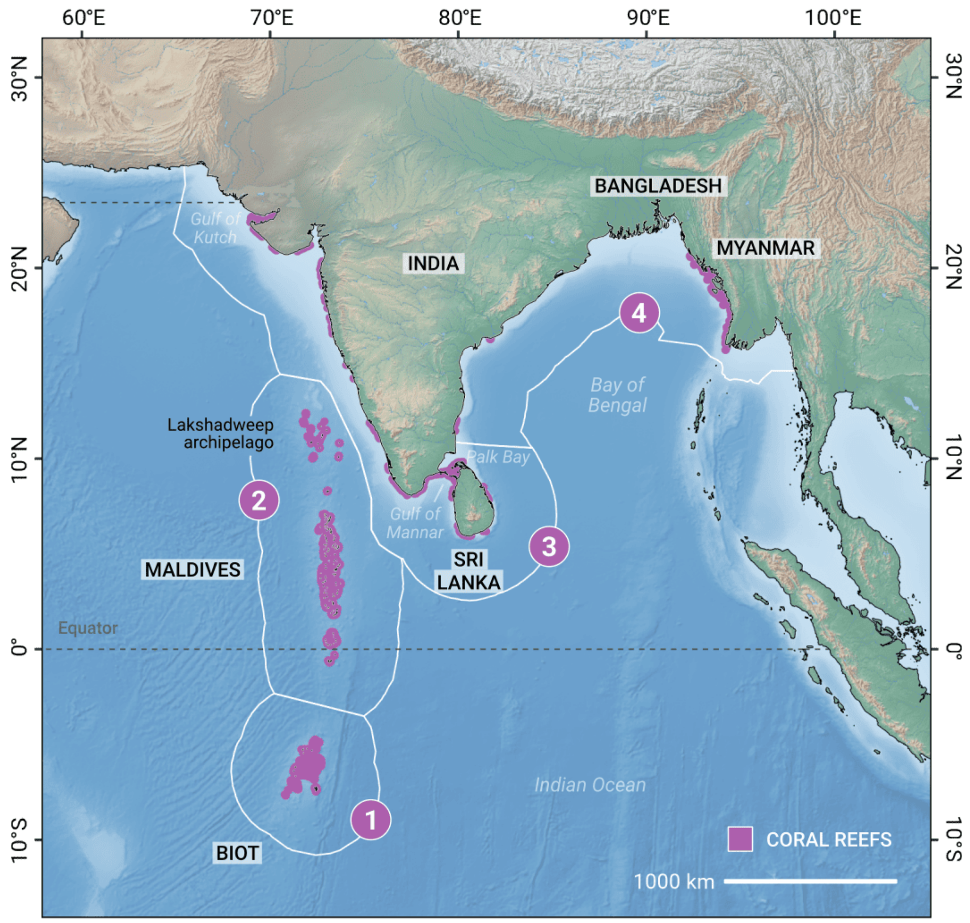
Citation

Ali Khan, A., Montefalcone, M., Bianchi, C. N., Morri, C., *et al.* (2026). Chapter 9 – South Asia. *In González-Rivero, M., et al. Status of Coral Reefs of the World: 2025. Global Coral Reef Monitoring Network and International Coral Reef Initiative.* https://doi.org/10.59387/LFPR6347.SA

On 14 May 2026, while this chapter was still in preparation, our co-author, Professor Monica Montefalcone, tragically passed away following a diving accident. Monica was an esteemed marine scientist whose work made significant contributions to the understanding and conservation of coral reefs in the Maldives. Her passing is deeply mourned by her colleagues, students, collaborators, and the wider marine science community. We dedicate this chapter to the memory of Monica Montefalcone, and the other divers who lost their lives as a result of the accident and the subsequent recovery operation.

INTRODUCTION

The GCRMN South Asia region extends over a maritime area of around 4.1 million km^2, ranging across 36° of latitude and 33° of longitude. The region hosts 10,755 km^2 of coral reefs, which represent 4.3% of the world's coral reef extent, making South Asia the seventh largest GCRMN region in terms of coral reef extent. Coral reefs are found within the exclusive economic zones of six countries and territories within the region, ranging from India in the north to the Chagos Archipelago in the south, and from India in the west to Myanmar in the east (Figure 2.9.1). For the purpose of this report, the GCRMN South Asia region was divided into four subregions (Figure 2.9.1). The Maldives subregion contains the largest proportion of coral reefs in the region, accounting for 58.5% (6,297 km^2) of the regional reef extent, whereas the Bay of Bengal subregion contains the smallest proportion, with only 7.2% (770 km^2, Table A.1).



▲ **Figure 2.9.1.** The distribution of coral reefs within the South Asia region and respective subregions. White polygons and numbers represent subregions. Subregion 1 = Chagos, Subregion 2 = Maldives, Subregion 3 = West and South Indian Shelf, Subregion 4 = Bay of Bengal. Coral reefs are delineated with a 20 km buffer to enhance interpretation, and only coral reefs within the region are represented. The scale bar provides distance at the equator and may not accurately represent distance over the entire latitudinal range of the region. BIOT = British Indian Ocean Territory.

The Chagos subregion contains one of the world's largest atoll structures called the Great Chagos Bank, where reefs are protected from fishing within a no-take MPA (Sheppard *et al.* [419], but see Collins *et al.* [420]). The Maldives subregion comprises the Republic of Maldives, with 26 atolls rising steeply from abyssal depths [421], as well as the Lakshadweep archipelago under India's jurisdiction. The West and South Indian Shelf includes coral reefs in the Gulf of Kutch, the Gulf of Mannar, Palk Bay, and around Sri Lanka (Figure 2.9.1). Finally, the Bay of Bengal subregion mostly includes coral reefs in Myanmar and those around St. Martin's Island in Bangladesh.

As of 2020, approximately 7.7 million people were living within 5 km of South Asia coral reefs. Between 2000 and 2020, the human populations residing within 5 km of coral reefs increased by 21.8%, corresponding to an average annual growth of approximately 70,000 inhabitants. The West and South Indian Shelf subregion exhibited the largest population increase between 2000 and 2020, with an additional 1 million inhabitants, and also accounted for the highest number of inhabitants in 2020 (Table A.2).

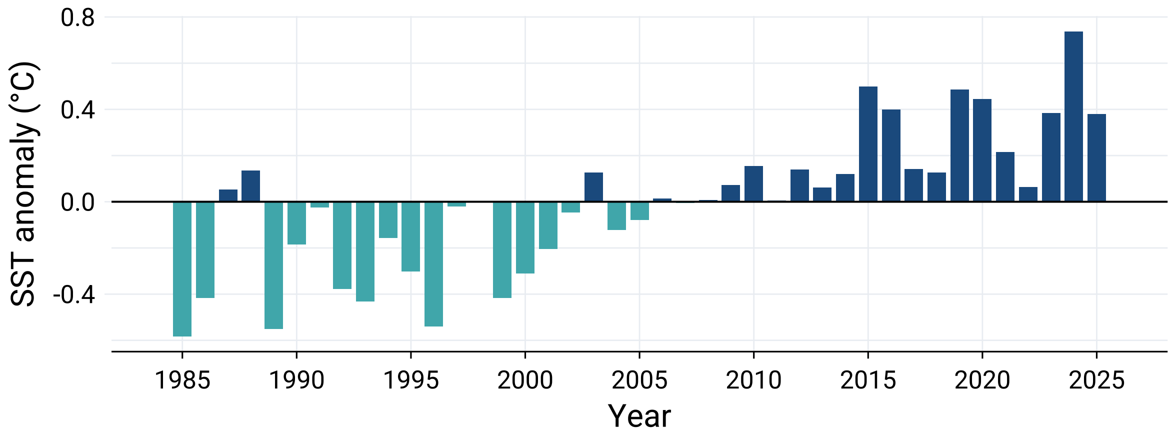
The Chagos subregion has no permanent population, although Diego Garcia hosts a military presence.

THREATS AND DISTURBANCES

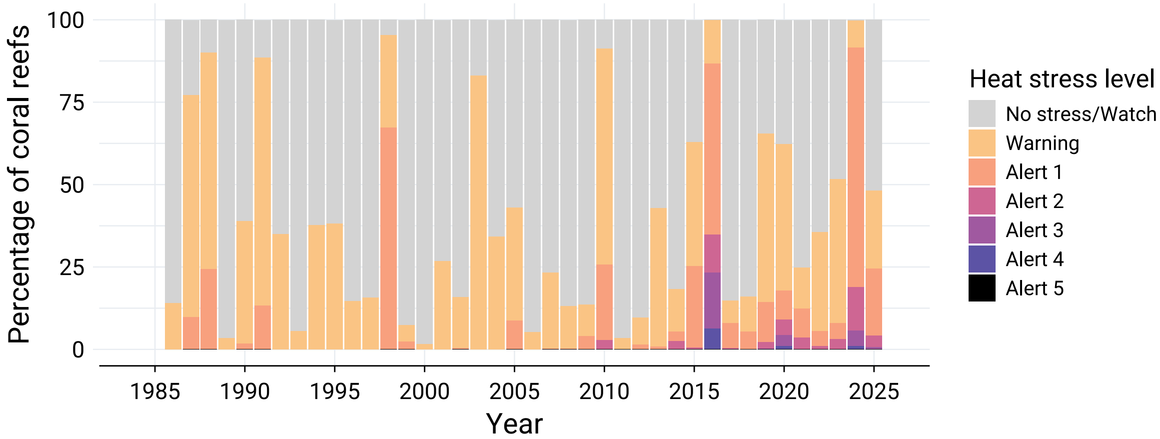
Heat stress

From 1985 to 2025, the long-term average of sea surface temperatures (SST) recorded over coral reefs within the South Asia region was 28.58 °C. During this period, the SST over coral reefs in the region increased by 0.79 °C due to anthropogenic climate change, corresponding to an average warming rate of 0.20 °C per decade (Figure 2.9.2, Table A.3).

Between 1986 and 2025, major episodes of heat stress affecting coral reefs in South Asia occurred in 1998, 2010, 2016, 2020, and 2024 (Figure 2.9.3). The heat stress events in 1998, 2010, 2016, and 2024 coincided with the four global bleaching events. In contrast to the severe impacts observed in 1998 and 2016, the 2010 event resulted in relatively limited hard coral mortality in the region [422–424].



▲ **Figure 2.9.2.** Annual mean sea surface temperature (SST) anomalies (°C) over the coral reefs of the South Asia region from 1985 to 2025. SST anomalies were calculated based on the long-term average over the period 1985–2025. Positive values (red bars) indicate SST warmer than the long-term average, whereas negative values (blue bars) indicate SST cooler than the long-term average. Derived from NOAA Coral Reef Watch data (Skirving *et al.* [107]; see Materials and Methods).



▲ **Figure 2.9.3.** Percentage of the coral reefs within the South Asia region experiencing heat stress levels per year, from 1986 to 2025. No stress/Watch (DHW = 0); Warning (possible bleaching, $0 < \text{DHW} < 4$); Alert 1 (reef-wide bleaching, $4 \leq \text{DHW} < 8$); Alert 2 (reef-wide bleaching and mortality of heat-sensitive corals, $8 \leq \text{DHW} < 12$); Alert 3 (multi-species mortality, $12 \leq \text{DHW} < 16$); Alert 4 (severe multi-species mortality, $16 \leq \text{DHW} < 20$); and Alert 5 (near-complete mortality, $\text{DHW} \geq 20$). Derived from NOAA Coral Reef Watch data (Skirving *et al.* [107]; see Materials and Methods).

More recently, significant declines in hard coral cover have been reported in parts of the Maldives following the fourth global bleaching event [47, 425].

Cyclones and tsunamis

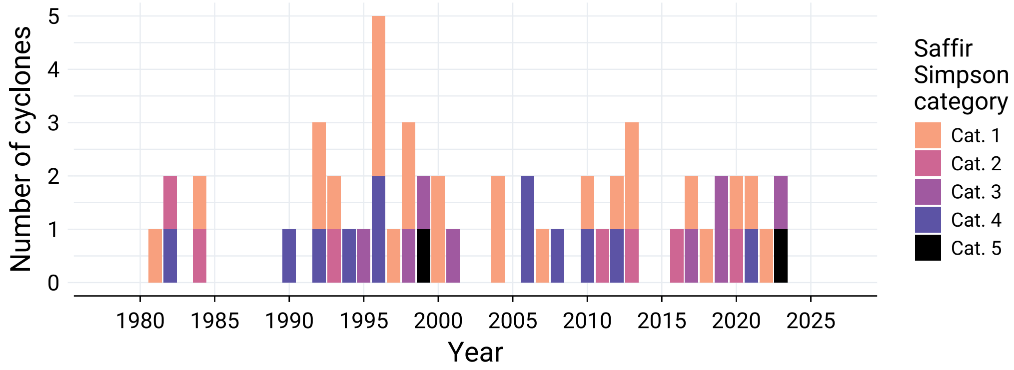
From 1980 to 2025, a total of 54 cyclones passed within 100 km of coral reefs in the South Asia region, representing an average of 1.2 $\pm$ 1.1 SD cyclones per year (Figure 2.9.4). The cyclone with the highest sustained wind speed over the studied period was the cyclone Giri, in October 2010, with sustained wind speed of 250 km.h^{-1} (Figure 2.9.5). Coral reefs located near the equator, such as those in the southern Maldives, are rarely affected by cyclones [108].

In addition to cyclones, tsunamis represent another natural disturbance capable of causing physical damage to coral reefs. In particular, the 2004 Sumatran earthquake and tsunami had limited but spatially heterogeneous impacts on coral reefs, with some of the most significant effects observed in Sri Lanka [426–428].

Regional disturbances

In addition to climatic disturbances, coral reefs in South Asia are also affected by local human pressures linked to growing coastal populations and expanding tourism [429]. While coral mining was historically practiced in the Maldives for construction [430], it has now largely been discontinued. However, land reclamation and dredging continue to pose significant threats by increasing sedimentation and causing habitat destruction [421]. More broadly, with the exception of the uninhabited Chagos Islands, reefs across the region are impacted by coastal development, eutrophication, pollution, and unsustainable fishing [421]. Land-based pollution, particularly from wastewater, remains an understudied but important threat to coral reefs in South Asia [431].

Additional disturbances, partly driven by human activities, have also been reported. In the Gulf of Mannar, blooms of *Noctiluca scintillans* have caused hypoxic conditions and coral mortality [432]. In the Lakshadweep archipelago, coral diseases have been observed alongside the overgrowth of hard corals by algae and sponges [433].



▲ **Figure 2.9.4.** Number of cyclones that passed within 100 km of the coral reefs of the South Asia region from 1980 to 2025. Colors correspond to the Saffir–Simpson category of the cyclone along its entire track. Derived from IBTrACS data (Knapp *et al.* [118]; see Materials and Methods).

Outbreaks of *Acanthaster planci* (crown-of-thorns starfish) have also been documented in the Maldives [434, 435].

Together, these local stressors are likely to weaken the resilience of coral reefs to climate-related impacts, highlighting the urgent need for both improved local management and sustained global climate action [91].

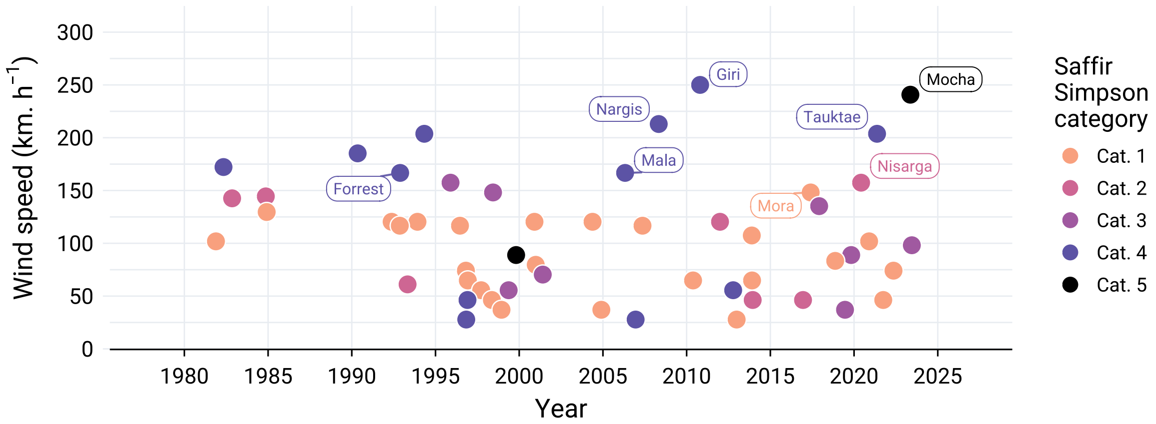
STATUS OF CORAL REEFS IN THE REGION

Hard coral cover

Hard coral cover in the South Asia region increased from 30.1% (credible interval at 95% [CrI $_{95\%}$]: 26.0 – 34.5%) in 1997–2009 to 35.0% (CrI $_{95\%}$: 30.7 – 39.5%) in 2020–2024, a change supported by strong evidence (Figure 2.9.6A). This represents an absolute increase of 4.9 percentage points, corresponding to a relative increase of 16.2% in hard coral cover. Hard coral cover showed two periods of major decline in 1997–1998 and 2015–2016, and two subsequent periods of recovery.

The first period of decline in hard coral cover, which occurred in 1997–1998, led to an absolute loss of 21.3 percentage points (Figure 2.9.6A). This decline was associated with the first global bleaching event, whose impacts were particularly high in the Maldives [422]. Hard coral cover then increased until 2013, when it reached 39.3%, approaching the level of hard coral cover recorded before the impact of the first global bleaching event. However, Montefalcone *et al.* [422] showed that the benthic cover of branching and tabular *Acropora* species only partially recovered, leading to a change in the hard coral assemblage. As reported in previous studies, the second global bleaching event in 2010 had only limited impacts on hard coral cover in the South Asia region, likely because the associated heat stress was less severe than during other major heat stress events [422, 423] (Figure 2.9.3).

The second period of decline in hard coral cover occurred in 2015–2016, due to the third global bleaching event. The absolute loss in hard coral cover was 12.8 percentage points, representing a smaller decline than that observed following the first global bleaching event (Figure 2.9.6A). However, similarly to the first global bleaching event, the heat stress event of 2015–2016 led to a change in the hard coral assemblage, with a relative decline of branching and digitate *Acropora* and a relative increase of massive hard coral species [424, 436].



▲ **Figure 2.9.5.** Maximum sustained wind speed of cyclones that passed within 100 km of a coral reef in the South Asia region between 1980 and 2025. Colors correspond to the Saffir–Simpson category of the cyclone along its entire track. However, the values of sustained wind speed are extracted from the nearest cyclone position from a coral reef. For this reason, some sustained wind speed values are below the lower threshold of category 1 Saffir–Simpson scale (*i.e.* 119 $km.h^{-1}$). Derived from IBTrACS data (Knapp *et al.* [118]; see Materials and Methods).

Macroalgal cover

Macroalgal cover in the region increased from 2.0% ($CrI_{95\%}$: 1.6 – 2.7%) in 1997–2009 to 2.8% ($CrI_{95\%}$: 2.3 – 3.5%) in 2020–2024, a change supported by strong evidence (Figure 2.9.6B). This corresponds to an absolute increase of 0.8 percentage points, or a relative increase of 36.4%. Despite this high relative increase, macroalgae remain minor benthic components in South Asian coral reefs.

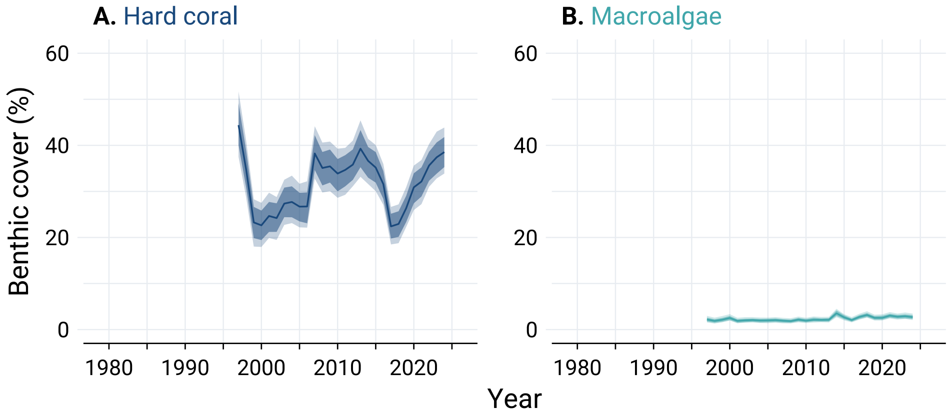
STATUS OF CORAL REEFS IN THE SUBREGIONS

South Asia 1 - Chagos

Coral reefs in the Chagos subregion occur exclusively within the Chagos Archipelago, which comprises seven atolls and several banks located at varying depths. The Archipelago was designated as a no-take marine protected area in 2010 [419].

There is no evidence of a change in hard coral cover in the Chagos subregion between 2010–2014 and 2020–2023 (Figure 2.9.7A). However, this apparent long-term stability masks pronounced interannual variability. Although our estimates do not extend prior to 2010, previous studies indicate that hard coral cover declined by approximately 50 percentage points following heat stress associated with the 1998 global bleaching event [437], before gradually recovering over the subsequent decade [423]. Hard coral cover then declined from 40.9% in 2010 to 13.0% in 2017, with most of the loss occurring in 2015 and 2016 (Figure 2.9.7A). This represents an absolute decline of 27.9 percentage points, largely driven by the third global bleaching event [423, 438, 439]. Hard coral cover subsequently recovered to 37.9% by 2023, approaching levels observed in 2010 (Figure 2.9.7A). Although the available data do not cover this period, a recent study indicates a 23% relative decline in hard coral cover in 2024, following the fourth global bleaching event [440].

Similarly to hard coral cover, there is no evidence of a change in macroalgal cover in the Chagos subregion between 2010–2014 and 2020–2023 (Figure 2.9.8A). Macroalgal cover peaked at around 5.0% in 2018, although the drivers of this increase remain unclear.



▲ **Figure 2.9.6.** Modeled temporal trends of benthic cover in the South Asia region from 1980 to 2024 for hard coral (A) and macroalgae (B). The solid line represents the estimated median benthic cover while darker and lighter ribbons represent 80% and 95% credible intervals, respectively. Grey areas represent periods during which no field data were available.

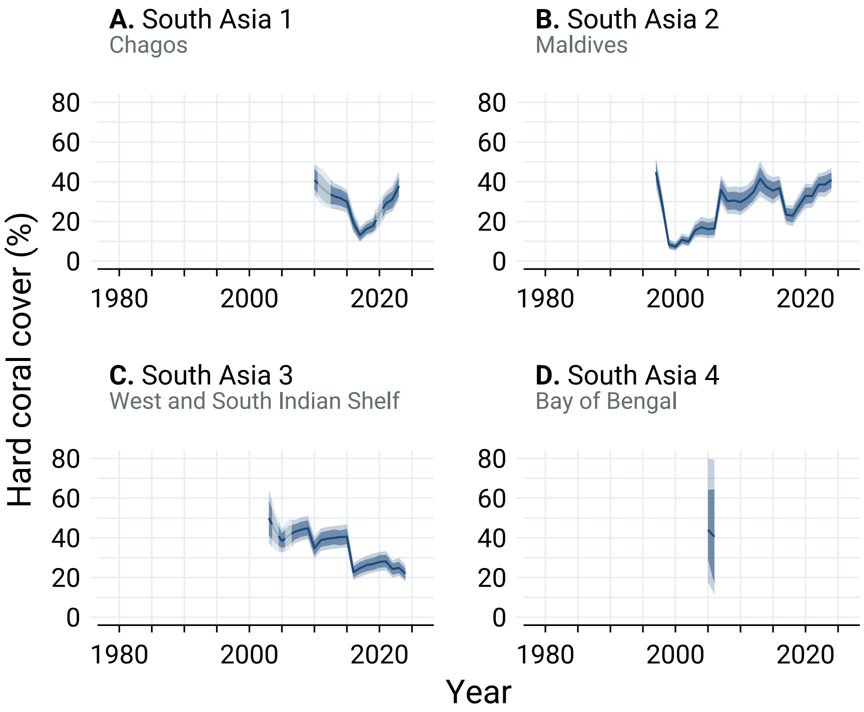
South Asia 2 - Maldives

The Maldives subregion encompasses coral reefs in the Republic of Maldives and the Indian archipelago of Lakshadweep. In this subregion, results provide strong evidence that hard coral cover increased between 1997–2009 and 2020–2024 (Figure 2.9.7B). However, this long-term increase masks pronounced temporal variability, with alternating periods of decline (2000 and 2013–2017) and recovery (2003–2009 and 2018–2024). A major decline followed the first global bleaching event, during which hard coral cover decreased from 44.9% in 1997 to 7.3% in 2000, corresponding to an absolute loss of 37.6 percentage points. In the Lakshadweep archipelago, Arthur [441] reported bleaching prevalence of 82% and hard coral mortality of 26% following this heat stress event. Hard coral cover subsequently increased until 2007 and remained relatively stable until 2015, reaching 35.5% (Figure 2.9.7B). A second decline occurred in 2016 in association with the third global bleaching event [442], although the magnitude of loss was lower than that observed following the first global bleaching event. This event also modified hard coral assemblages, with a relative decline in branching and tabular *Acropora* [422, 436]. As the study period does not include 2025, the impacts of the fourth global bleaching event (2023–2024) could not be assessed. However, Montefalcone *et al.* [425] reported a 40% loss in hard coral cover in the central atolls of the Maldives, but no detectable mortality in the southern part of the archipelago, following the fourth global bleaching event.

Macroalgal cover increased by 0.6 percentage points between 1997–2009 and 2020–2024, a change supported by strong evidence (Figure 2.9.8B). Peaks in macroalgal cover occurred around 3.0% in 2000 and 4.5% in 2014, broadly coinciding with declines in hard coral cover (Figure 2.9.8B).

South Asia 3 - West and South Indian Shelf

Coral reefs in the West and South Indian Shelf subregion occur along the western and southern coasts of India and in Sri Lanka. In this subregion, data provide strong evidence that hard coral cover declined between 2003–2009 and 2020–2024 (Figure 2.9.7C). Although our estimates do not extend prior to 2003, Arthur [441] reported limited bleaching prevalence and mortality following the 1998 global bleach-



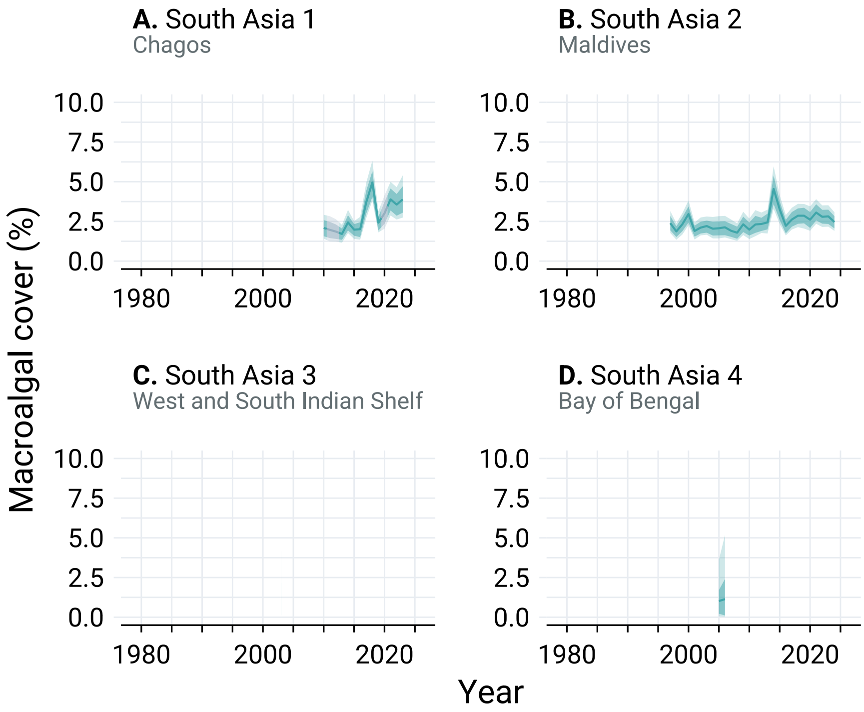
▲ **Figure 2.9.7.** Modeled temporal trends of hard coral cover in South Asia subregions from 1980 to 2024. The solid line represents the estimated median hard coral cover while darker and lighter ribbons represent 80% and 95% credible intervals, respectively. Grey areas represent periods during which no field data were available.

-ing event in the Gulf of Kutch, but 23% bleaching-related coral mortality in the Gulf of Mannar. From 2003 onward, hard coral cover exhibited a stepwise decline, with pronounced absolute decreases in 2003–2005 (-11.5 percentage points), 2009–2010 (-10.2 percentage points), and 2015–2016 (-17.9 percentage points). The first decrease coincides with the Sumatran-Andaman tsunami of December 2004 [443], whereas the 2009 and 2015 declines align with the second and third global bleaching events. Raj *et al.* [444] reported approximately 71% bleaching prevalence and 8% mortality in coral reefs of the Malvan Marine Sanctuary on the western Indian coast following the third bleaching event. In the Gulf of Mannar, this third global bleaching event led to an approximately 50% relative decline in mean hard coral cover [424]. In 2019, an algal bloom of *Noctiluca scintillans* led to a hypoxia phenomenon which caused a mortality of hard coral colonies in the Gulf of Mannar [432].

Owing to the absence of macroalgal cover data integrated into our analyses for this subregion, long-term trends for this benthic category could not be estimated. However, Raj *et al.* [424] reported an increase in total algal cover following the decline in hard coral cover during 2015–2016.

South Asia 4 - Bay of Bengal

The Bay of Bengal subregion encompasses coral reefs along the eastern coast of India, the coast of Myanmar, and around Saint Martin's Island in Bangladesh. Due to the very limited number of surveys available for this subregion, long-term changes in hard coral and macroalgal cover between 1980 and 2024 could not be estimated (Figure 2.9.7D and Figure 2.9.8D). In 2005–2006, hard coral and macroalgae accounted for 42% and 1% of the benthic cover, respectively.



▲ **Figure 2.9.8.** Modeled temporal trends of macroalgal cover in South Asia subregions from 1980 to 2024. The solid line represents the estimated median macroalgal cover while darker and lighter ribbons represent 80% and 95% credible intervals, respectively. Grey areas represent periods during which no field data were available.

DESCRIPTION OF MONITORING DATA

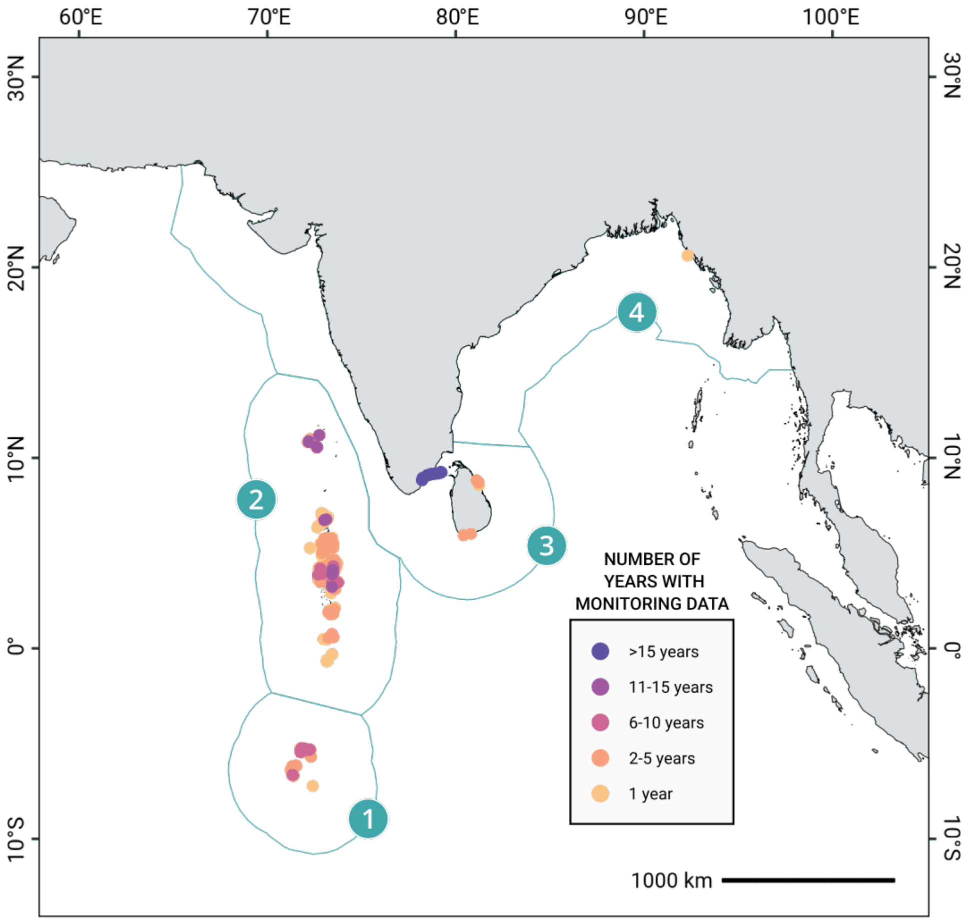
Temporal trends in the percentage cover of benthic categories were estimated using data from 15 datasets encompassing 636 monitoring sites. These data were collected through 2,825 surveys conducted between 1997 and 2024, with 90% of surveys taking place after 2005 (Figure A.1). Of all surveys carried out in the region between 1997 and 2024, 57% (representing 75% of surveyed sites) were conducted in the West and South Indian Shelf subregion, whereas only 0.1% (0.3% of sites) were conducted in the Bay of Bengal subregion (Table A.4). The temporal distribution of surveys shows a substantial increase in monitoring effort over time, reflecting the expansion of reef monitoring programs across the region in the early 2000s (Figure A.1).

CONCLUSIONS

The results indicate a 4.9 percentage point increase in hard coral cover in the South Asia region between 1997–2009 and 2020–2024. However, this increase largely reflects the low baseline values observed during the first period, and the rapid recovery recorded in the second period. Over the full time series, hard coral cover remained highly dynamic, with a difference of 20 percentage points between its lowest and highest values. Macroalgal cover increased by only 0.8 percentage points over the same periods, and continues to represent a minor component of South Asian coral reef benthic communities.

Regional trends, particularly the overall increase in hard coral cover, were largely driven by the Chagos and Maldives subregions, which together account for 83% of the total regional coral reef extent. In contrast, the West and South Indian Shelf subregion shows a decline in hard coral cover from 2003 to 2024, suggesting continental reef systems may be more affected by global and local anthropogenic pressures than oceanic archipelagos such as Chagos, the Maldives, and Lakshadweep. This pattern is consistent with the region's demographic context, as the West and South Indian Shelf subregion concentrates the largest proportion of the human population living within 5 km of coral reefs in South Asia (Table A.2).

While reefs in Chagos, central Maldives, Lakshadweep, and the Gulf of Mannar appear to be sufficiently monitored across space and time to support robust assessments of reef condition, monitoring remains spatially uneven across much of the region. In particular, several coral reef systems within the West and South Indian Shelf remain poorly represented. More concerningly, data from the Bay of Bengal subregion are insufficient to support a long-term assessment of hard coral cover, highlighting a critical need for improved monitoring efforts in this subregion.



▲ **Figure 2.9.9.** Spatio-temporal distribution of benthic cover monitoring sites across the South Asia region and respective subregions. Light blue polygons and numbers represent subregions. Subregion 1 = Chagos, Subregion 2 = Maldives, Subregion 3 = West and South Indian Shelf, Subregion 4 = Bay of Bengal. The scale bar provides distance at the equator and may not accurately represent distance over the entire latitudinal range of the region.

DATA CONTRIBUTORS

Khadeeja Ali, Cassandra E. Benkwitt, Carlo Nike Bianchi, Graham J. Edgar, Ida Elizabeth George, Mohamed F.M. Fairoz, Jan Freiwald, Javier Gonzalez-Barrios, Nicholas Graham, Rachel Gunn, Shaha Aminath Hashim, Titus Immanuel, Vibitha M. A., Jenny Mihaly, Monica Montefalcone, Carla Morri, Radhika Nair, Elizabeth Oh, Edward J.K. Patterson, Morgan Pratchett, Abdul Raheem C. N., Rajkumar Rajan, Laura Richardson, Ronan Roche, Jyodee Sannassy Pilly, Mohamed Shimal, Danielle Spring, Rick D. Stuart-Smith, Nina Tabitha Simon, John Turner, Swetha V. Rajan, Shaun Wilson.

Access to online supplementary materials

The modelled benthic cover data, detailed outputs from the data analyses, and the CRediT author contribution statement are available on Zenodo.

REFERENCES

47. Spady, B. L. *et al.* The 4th global coral bleaching event: ushering in an era of near-annual bleaching. *Coral Reefs* (2026).

91. MacNeil, M. A. *et al.* Water quality mediates resilience on the Great Barrier Reef. *Nature Ecology & Evolution* **3,** 620–627 (2019).

107. Skirving, W. *et al.* CoralTemp and the coral reef watch coral bleaching heat stress product suite version 3.1. *Remote Sensing* **12,** 3856 (2020).

108. Puotinen, M. *et al.* Towards modelling the future risk of cyclone wave damage to the world's coral reefs. *Global Change Biology* **26,** 4302–4315 (2020).

118. Knapp, K. R., Kruk, M. C., Levinson, D. H., Diamond, H. J. & Neumann, C. J. The International Best Track Archive for Climate Stewardship (IBTrACS) - Unifying tropical cyclone data. *Bulletin of the American Meteorological Society* **91,** 363–376 (2010).

419. Sheppard, C. R. *et al.* Reefs and islands of the Chagos Archipelago, Indian Ocean: Why it is the world's largest no-take marine protected area. *Aquatic Conservation: Marine and Freshwater Ecosystems* **22,** 232–261 (2012).

420. Collins, C. *et al.* Changes in illegal fishing dynamics in a large-scale MPA during COVID-19. *Current Biology* **33,** R851–R852 (2023).

421. Stevens, G. M. & Froman, N. in *World Seas: An Environmental Evaluation* 211–236 (Elsevier, 2019).

422. Montefalcone, M., Morri, C. & Bianchi, C. N. Long-term change in bioconstruction potential of Maldivian coral reefs following extreme climate anomalies. *Global Change Biology* **24,** 5629–5641 (2018).

423. Sheppard, C., Sheppard, A. & Fenner, D. Coral mass mortalities in the Chagos Archipelago over 40 years: Regional species and assemblage extinctions and indications of positive feedbacks. *Marine Pollution Bulletin* **154,** 111075 (2020).

424. Raj, K. D. *et al.* Coral reef resilience differs among islands within the Gulf of Mannar, southeast India, following successive coral bleaching events. *Coral Reefs* **40,** 1029–1044 (2021).

425. Montefalcone, M., Bianchi, C. N., Morri, C., Ahmed, H. & Pancrazi, I. Outcomes of the fourth global coral bleaching (2023–2024) in the Maldives. *Coral Reefs,* 1–17 (2026).

426. Wilkinson, C., Souter, D. & Goldberg, J. *Status of coral reefs in tsunami-affected countries: 2005* (Global Coral Reef Monitoring Network, 2005).

427. Gischler, E. & Kikinger, R. Effects of the tsunami of 26 December 2004 on Rasdhoo and northern Ari atolls, Maldives. *Atoll Research Bulletin* **561,** 1–10 (2006).

428. Morri, C. *et al.* Through bleaching and tsunami: Coral reef recovery in the Maldives. *Marine Pollution Bulletin* **98,** 188–200 (2015).

429. Montefalcone, M., Morri, C. & Bianchi, C. N. Influence of local pressures on Maldivian coral reef resilience following repeated bleaching events, and recovery perspectives. *Frontiers in Marine Science* **7,** 587 (2020).

430. Brown, B. E. & Dunne, R. P. The environmental impact of coral mining on coral reefs in the Maldives. *Environmental Conservation* **15,** 159–165 (1988).

431. Wear, S. L. & Thurber, R. V. Sewage pollution: Mitigation is key for coral reef stewardship. *Annals of the New York Academy of Sciences* **1355,** 15–30 (2015).

432. Raj, K. D. *et al.* Low oxygen levels caused by *Noctiluca scintillans* bloom kills corals in Gulf of Mannar, India. *Scientific Reports* **10,** 22133 (2020).

433. Das, R. R. *et al.* Evidence of coral diseases, phase shift, and stressors in the atolls of Lakshadweep islands, Arabian Sea — with geographical notes on their occurrence within the Indian EEZ and Contiguous International Waters. *Diversity* **15,** 382 (2023).

434. Morri, C., Aliani, S. & Bianchi, C. N. Reef status in the Rasfari region (North Malé Atoll, Maldives) five years before the mass mortality event of 1998. *Estuarine, Coastal and Shelf Science* **86,** 258–264 (2010).

435. Saponari, L. *et al.* Monitoring and assessing a 2-year outbreak of the corallivorous seastar *Acanthaster planci* in Ari Atoll, Republic of Maldives. *Environmental Monitoring and Assessment* **190,** 344 (2018).

436. Pancrazi, I., Ahmed, H., Chimienti, G. & Montefalcone, M. The new face of the northernmost coral reefs of the Maldives revisited after 13 years. *Coral Reefs,* 1–8 (2025).

437. Sheppard, C. R. Coral decline and weather patterns over 20 years in the Chagos Archipelago, Central Indian Ocean. *Ambio* **28,** 472–478 (1999).

438. Head, C. E. *et al*. Coral bleaching impacts from back-to-back 2015–2016 thermal anomalies in the remote central Indian Ocean. *Coral Reefs* **38,** 605–618 (2019).

439. Sannassy Pilly, S., Roche, R. C., Richardson, L. E. & Turner, J. R. Depth variation in benthic community response to repeated marine heatwaves on remote Central Indian Ocean reefs. *Royal Society Open Science* **11** (2024).

440. *Coral bleaching and mortality in the Chagos Archipelago, 2024* (2025).

441. Arthur, R. Coral bleaching and mortality in three Indian reef regions during an El Niño southern oscillation event. *Current Science* **79,** 1723–1729 (2000).

442. Nair, R. C., KR, M., S, A. A. & PK, D. K. Relationship between coral bleaching and large-scale oscillations in the Lakshadweep archipelago. *Ocean Dynamics* **73,** 463–474 (2023).

443. Brown, B. E. The fate of coral reefs in the Andaman Sea, eastern Indian Ocean following the Sumatran earthquake and tsunami, 26 December 2004. *The Geographical Journal* **171,** 372–374 (2005).

444. Raj, K. D. *et al*. Climate change-induced coral bleaching in Malvan marine sanctuary, Maharashtra, India. *Current Science* **114,** 384–387 (2018).