

Spatial analysis of coral bleaching in the Western Indian Ocean in January-June 2010

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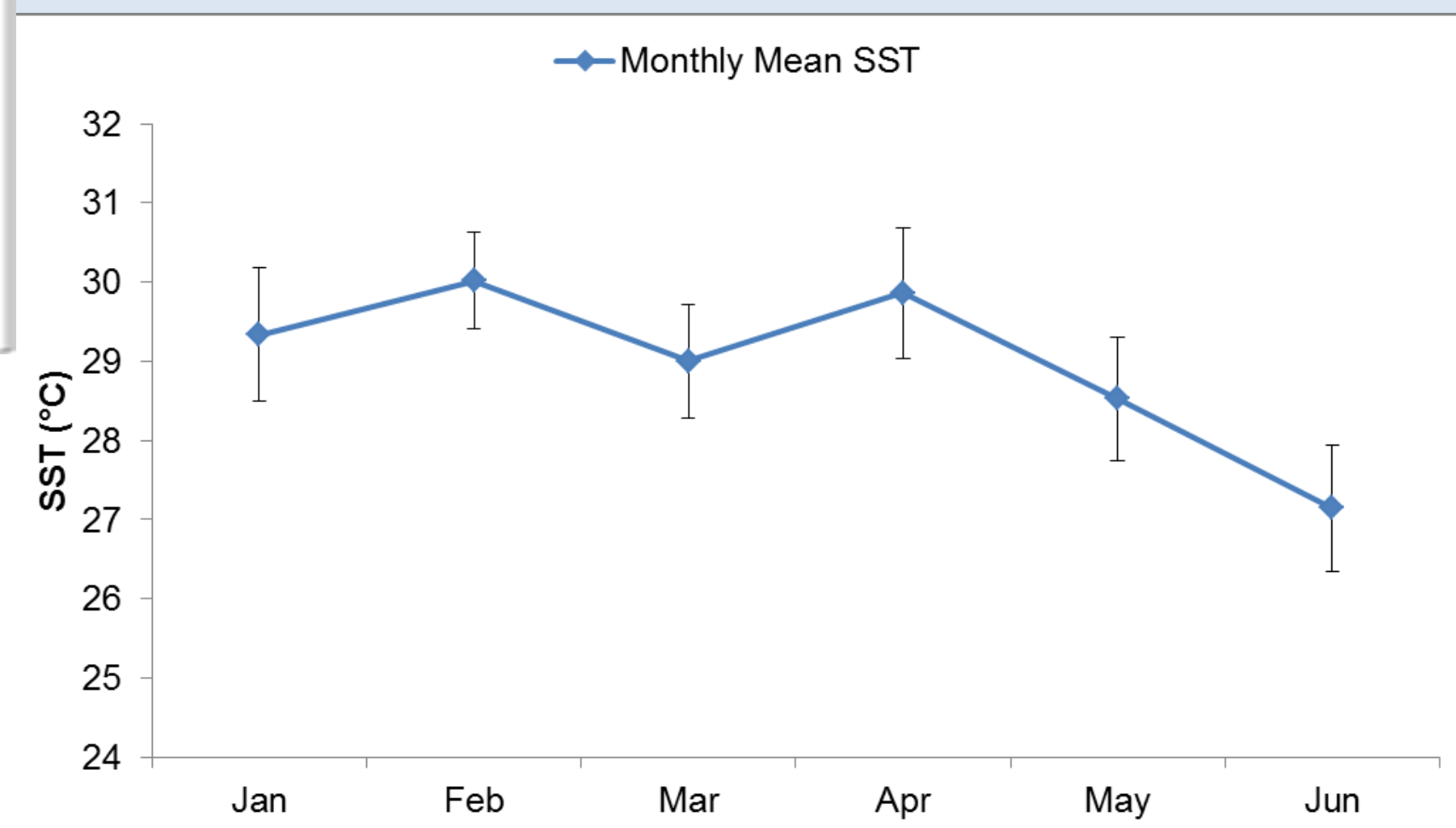


Abstract

Coral reefs in the Western Indian Ocean (WIO) are a critical ecosystem that supports the livelihoods of millions of people and provides protection and infrastructure for coastal development and tourism. Globally, reefs are threatened by climate change as corals are vulnerable to increasing sea surface temperatures (SST). During the local summer season when SSTs are hottest, (January to June in the WIO), corals may bleach or whiten, then die if temperatures increase above a threshold. In this study we compare satellite-derived SST data and field observations of coral bleaching in the unusually hot season of January – June 2010 to better understand bleaching patterns in the region and their vulnerability to degradation. During the survey period, widespread low level coral bleaching and mortality was observed in most reefs of the WIO, with ~10% of corals being affected, and ~5% levels of mortality. However bleaching levels were higher on reefs in Mayotte and SW Madagascar, with maximum bleaching levels in SW Madagascar and high levels of mortality in Mayotte.

Results

January, February and April were the hottest months in 2010 with peaks in February and April (Data source: AquaMODIS daytime 4km monthly means)



Study sites

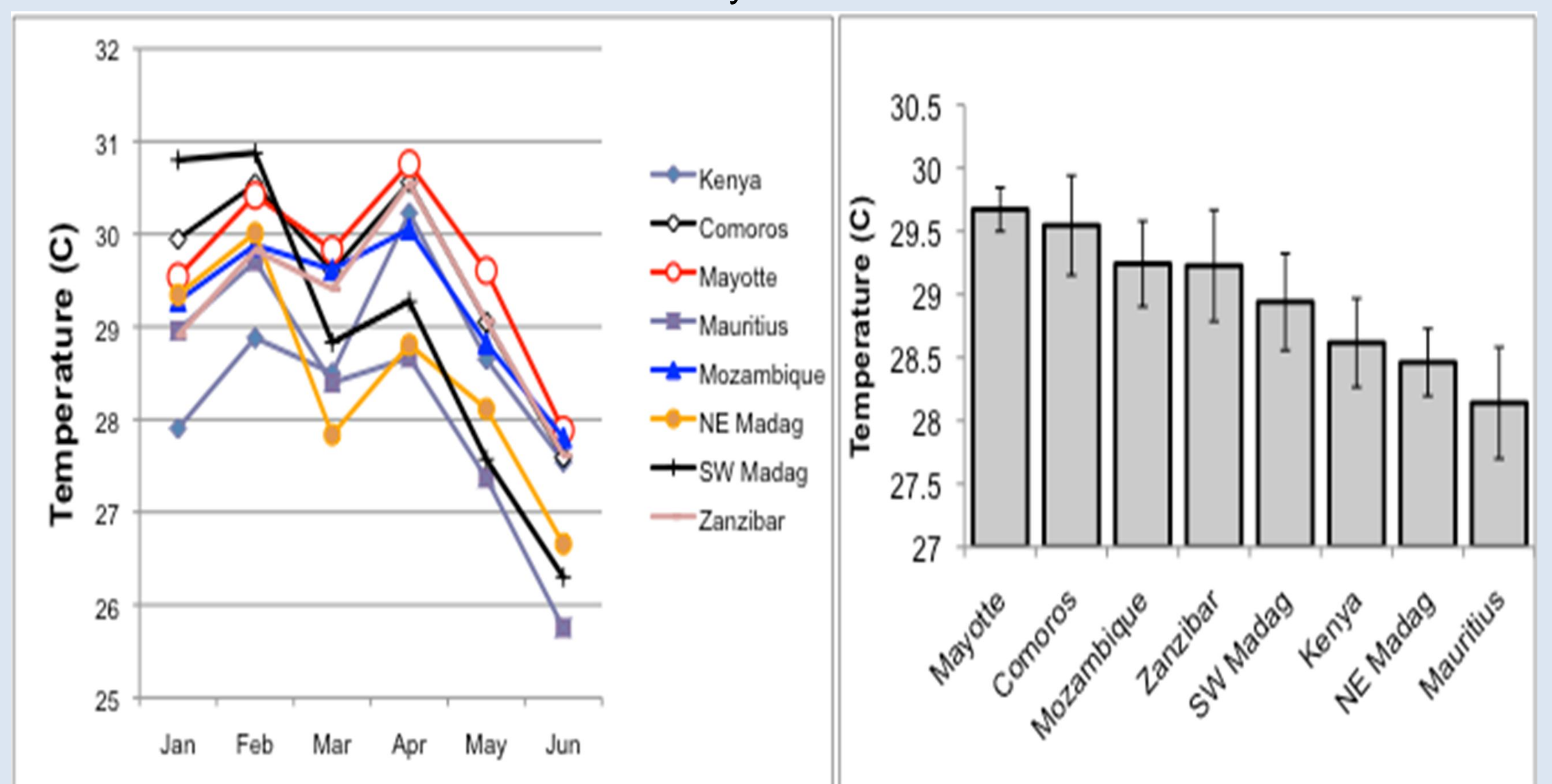


Methods

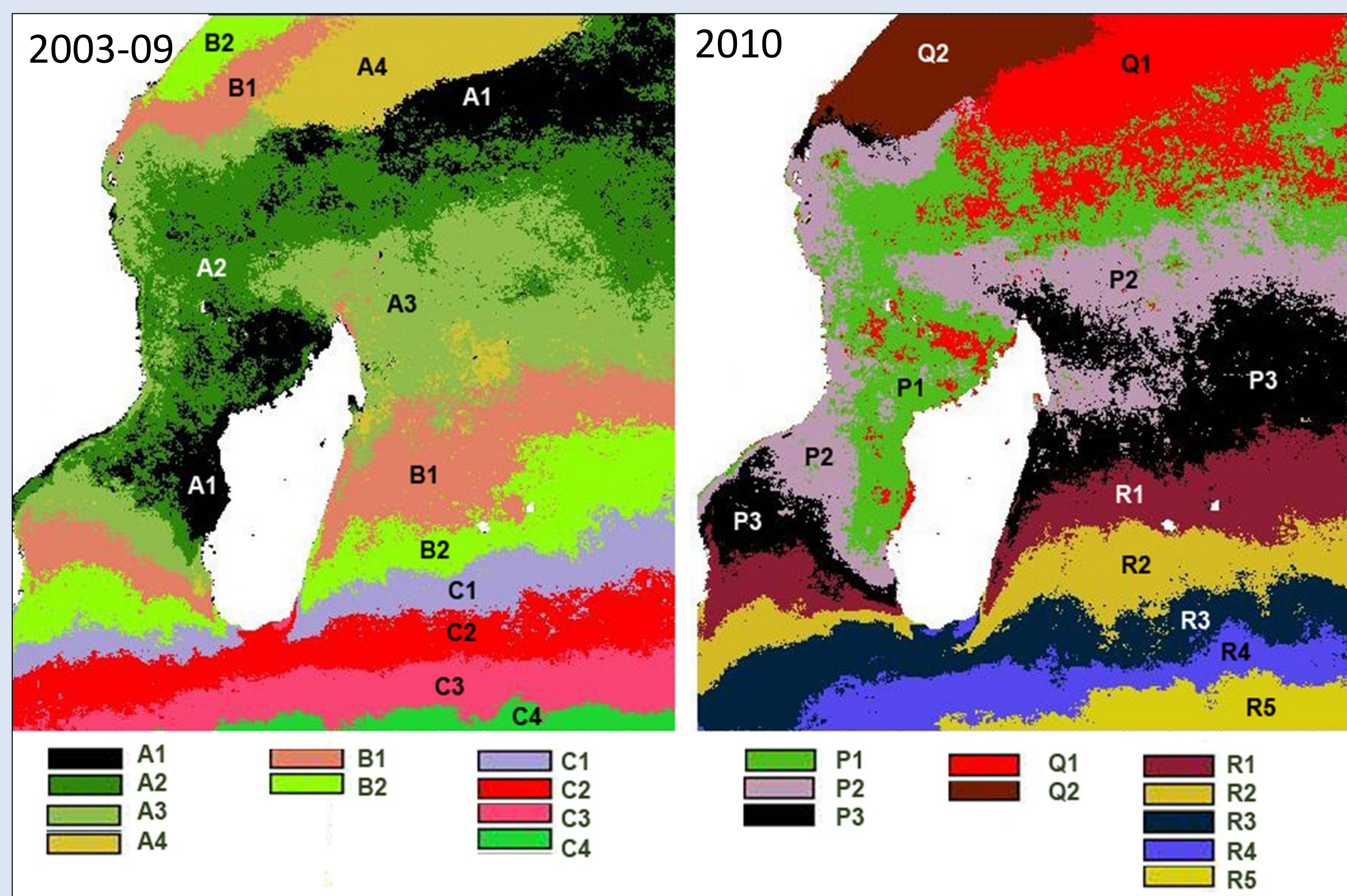
GIS capability at CORDIO is being built up through a range of licensed and open source software, with interactions and capacity building obtained through ODINAFRICA/UNESCO-IOC workshops and collaborations. The degree of bleaching and mortality was assessed against environmental variables that could be derived for all sites in the region. These included SST, wind strength and cloud cover. The AquaMODIS SST at 4 km pixel resolution was resampled to 1 km using an interpolation algorithm to enable distinctions among sites to be made including monthly means and maxima, SST anomaly in 2010 over the previous three years (2007-9), and accumulated stress in a Degree Heating Month-like index (DHM). Wind data used was the NOAA/NCDC Blended Monthly 0.25-degree Sea Surface Winds with monthly mean windspeed calculated for all sites.

| | SSTMax | SSTMonthBI | SSTano | dhm | Febwind | MinWind |
|----------------|--------|------------|--------|-------|---------|---------|
| Pale | 0.528 | 0.533 | 0.120 | 0.343 | -0.303 | -0.527 |
| Bleached | 0.634 | 0.617 | 0.258 | 0.662 | 0.068 | -0.149 |
| Pale + beached | 0.658 | 0.648 | 0.229 | 0.603 | -0.075 | -0.317 |
| Dead | 0.386 | 0.377 | 0.140 | 0.217 | -0.401 | -0.441 |
| Impact | 0.685 | 0.674 | 0.240 | 0.585 | -0.189 | -0.409 |

Paling and bleaching of corals were highly correlated with the maximum SST as well as SST during or just prior to the bleaching month, while mortality was less strongly correlated with these. Bleaching (but not paling or mortality) was very strongly correlated with DHM ($r > 0.6$) but not with SST anomaly ($r < 0.26$). Mortality was most strongly, and negatively, correlated with minimum wind. In a multivariate analysis



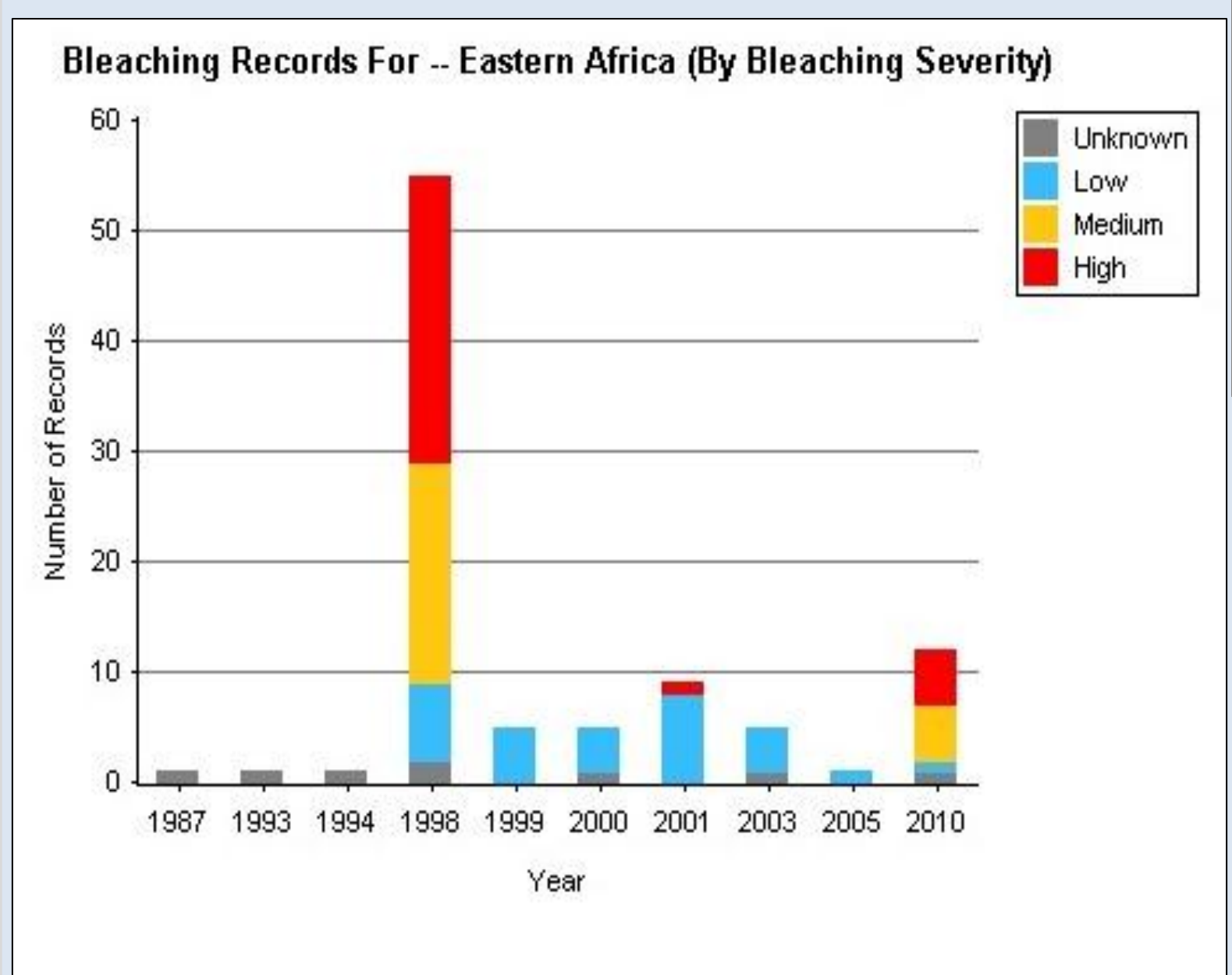
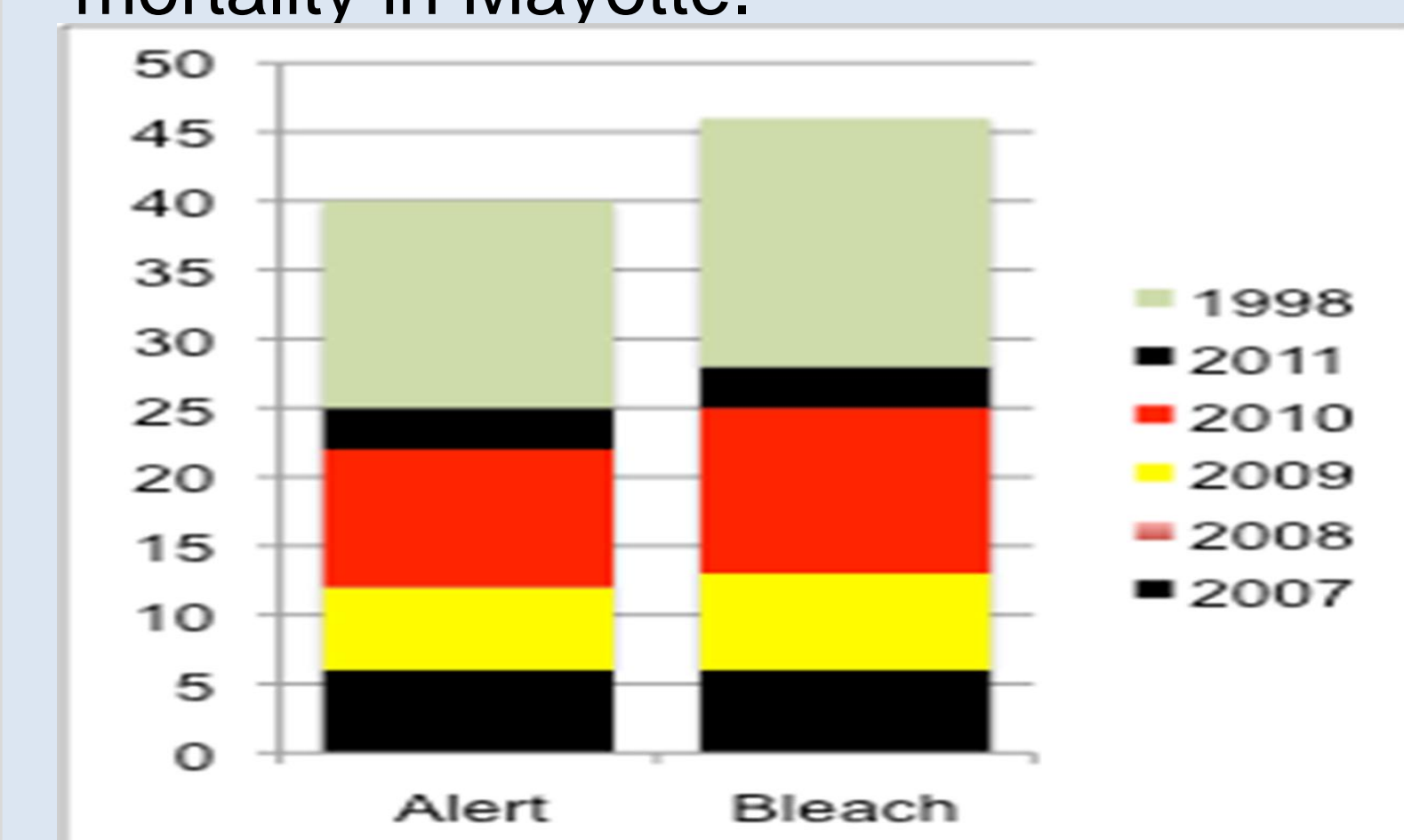
SSTs ranged from 29.7 to 28.6 °C with most areas experiencing bimodal temperatures with warm conditions in February and April. An exception to this was SW Madagascar, which experienced warmest conditions in January and February.



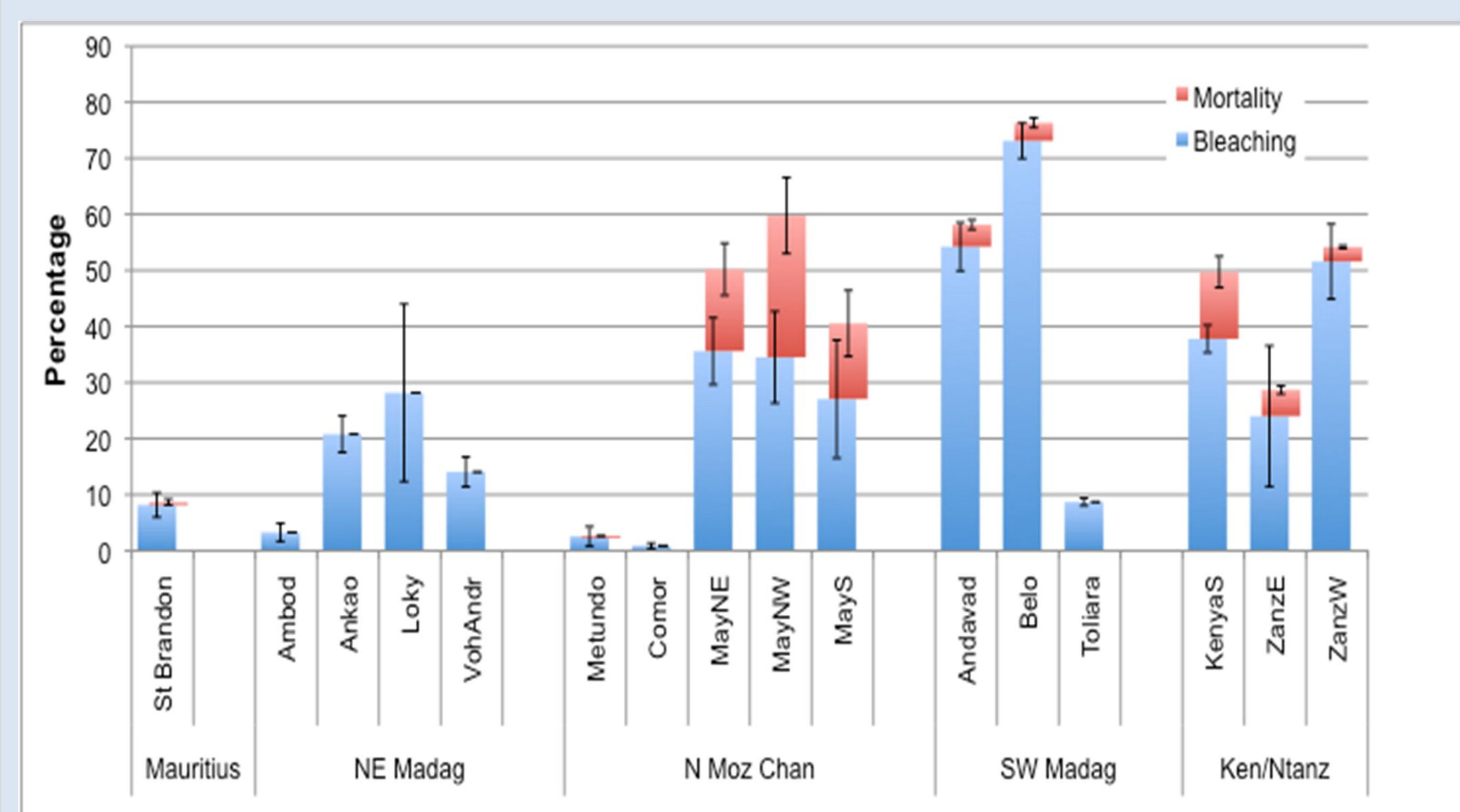
Temperature patterns in April-June 2010 were broadly similar to 2003-9, including the latitudinal extent of the main tropical waters east and west of the Seychelles, cooler mixed waters off the Somali and northern Kenya coasts, and latitudinal bands of cooler water extending southwards from the southern Mozambique channel and Madagascar.

Conclusion

The western parts of the N and central Mozambique channel and the offshore equatorial belt north of about 4°S were the warmest zones of the WIO in January-April. Temperature patterns in 2010 during a time of high thermal stress showed a number of notable features: the main centers of reef development in the WIO (western Madagascar, Mozambique, Tanzania and most of the Seychelles islands) are the hottest regions in both 'normal' and bleaching years. The highest level of bleaching and mortality were reported from Mayotte with up to 35% bleaching and 25% mortality recorded in NW Mayotte. In the 2010 event, the strongest relationship between bleaching and mortality on the one hand, and environmental parameters on the other was a positive correlation between bleaching and both maximum temperatures and DHM. Spatial analysis of ocean climate, climate event forecasting and communications linked to key vulnerabilities to climate change can feed into national and regional programmes on social and socio-economic welfare and adaptation to marine and climate threats.



2010 was reported to be the hottest year since 1998 and predictions for coral bleaching in the region were high. CORDIO has run bleaching alerts for the WIO region since 2007. Cumulative bleach alerts (2007-2011 and a reconstruction of 1998) vs. reported bleaching is shown in (Top graph above; source: CORDIO E.A) and the reported bleaching from 1987 to 2010 for the Eastern Africa region (Bottom graph above; source: www.reefbase.org).



Bleached corals were recorded at all sites, from St. Brandons Island (Mauritius) in the path of the South Equatorial Current, to the length of the Madagascan and African coasts (fig. 6a), though there was considerable variation from the lowest (<10% in St. Brandons, northern Mozambique and Tulear, SW Madagascar) to the highest (70%, Belo sur Mer, SW Madagascar). By region, bleaching was least east of Madagascar (NE coast and St. Brandons Island), high along the central and northern parts of the East African coast and in the Comoros archipelago in the northern Mozambique channel, and highest at the most southern sites in SW Madagascar. Mortality as a result of bleaching was only recorded in the East African and Mozambique channel regions (Kenya, northern Tanzania, Comoros and SW Madagascar), and not on the oceanic sides of Madagascar and at St. Brandons. Though SW Madagascar experienced the highest bleaching, it showed low levels of mortality, similar to northern Tanzania (Zanzibar) and less than in Kenya. Sites in the northern Mozambique channel showed differential levels of mortality.