Historical occurrences of marine heatwaves over Southwestern Atlantic reef environments

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1. Extended abstract

1.1 Introduction

The occurrence of marine heatwaves (MHWs) has intensified its frequency and intensity over the past years due to climate change and ocean warming (Oliver et al., 2019). This phenomenon is characterized by abnormal sea surface temperature (SST) conditions, where SST stays above a climatological temperature threshold for at least five consecutive days (Hobday et al., 2018). This anomaly pattern is associated with various impacts on marine ecosystems such as an increase in coral bleaching events, mass mortality of organisms, and loss of benthic habitat. Historically, Southwestern Atlantic coral reefs seem less susceptible to heat stress, where predictability of heat-induced mortality events is not as accurate as worldwide (Mies et al., 2020). However, recent MHWs events along the Brazilian continental margin had lead to major coral bleaching and mortality episodes, threatening reef conservation in the region (Duarte et al., 2020). Here we present an atlas of marine heatwaves in Southwestern Atlantic reef environments, tracking its spatiotemporal distribution, intensity variability and relationships with historical episodes of coral decline from 1985-present.

1.2 Methodology

1.2.1 MHWs detection NOAA Coral Reef Watch (CoralTemp) daily global 5 km sea surface temperature product (Skirving et al., 2020) was extracted for coral reef sites along the Brazilian continental margin from 1985-present. The CoralTemp SST product was validated against in situ data in order to verify its accuracy in representing local temperature conditions along the Brazilian continental margin. SST timeseries were decomposed in order to obtain its trend, seasonal and residual components. We then performed a normalization procedure by subtracting the seasonal component from the original time series, removing the influence of periodical variability in order to detect only anomalous events. Daily positive SST anomalies were calculated considering the deviation from the climatological mean at each coral reef site. MHWs were identified on the basis of the 90th percentile threshold if presenting a minimum duration of five consecutive days (Hobday et al., 2016). In addition, intervals of two or less days between continuous events above 90th percentile were considered as part of the same MHW.

1.2.2 MHWs analysis After the MHW identification, we calculated the intensity, duration and cumulative intensity (ºC days) for each event. These events were also classified according to their severity, considering the maximum intensity and the 90th percentile deviation from the climatological mean. In order to verify the potential relationship with coral bleaching events, the identified MHWs were grouped into five marine ecoregions according to the location of the coral reef sites: Eastern (EST), Trindade-Martim Vaz Archipelago (TMZ), Northeastern (NST), Fernando de Noronha Archipelago (FNA) and Amazon (AMZ). The identified MHWs were matched with the bleaching events reported in the literature and registered in public databases.

1.3 Preliminary results

Preliminary results indicates that the CoralTemp SST product accurately reproduces the local SST conditions along the study area, showing a high correlation coefficient (R = 0.99), moderate root mean square error (RMSE = 0.55ºC) and low bias (-0.06ºC) when compared to in situ buoys from the PNBOIA program (Figure 1).

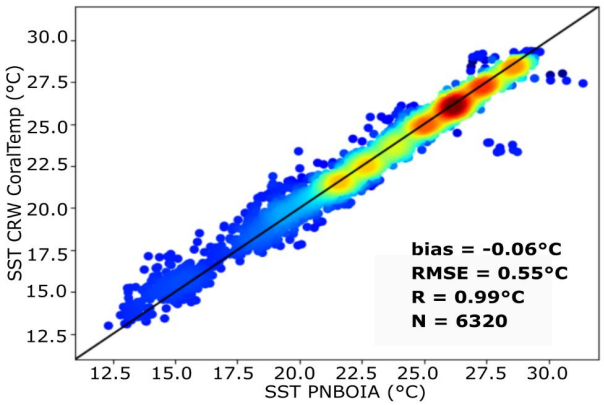

Figure 1. Scatter-plot distribution of sea surface temperature data from NOAA Coral Reef Watch (CoralTemp) product versus in-situ data from PNBOIA program, highlighting its bias, root mean square error (RMSE), coefficient of determination (R) and number of samples (N).

The average occurrence and intensity of MHWs on Brazilian coral reef sites varied greatly according to their marine ecoregion (Figure 2). An average of 78, 58, 70, 48, 63 MHWs were spotted at EST, TMV, NST, FNA and AMZ ecoregions, respectively. The intensity of MHWs was greater at coral reef sites further from the equatorial region, reaching a maximum anomaly peak of 2.70 ºC at TMV and 2.62 ºC at EST (Table 1). The maximum cumulative intensity observed for TMV and EST were also $>10^4$ ºC days. Although northern coral reef sites also

presented severe MHWs, their maximum anomaly peak and cumulative intensity were <2 ºC and $<10^4$ ºC days. Also, 50% of the MHWs here identified were detected in the last 10 years, indicating a strong increase in the probability of occurrence of these events.

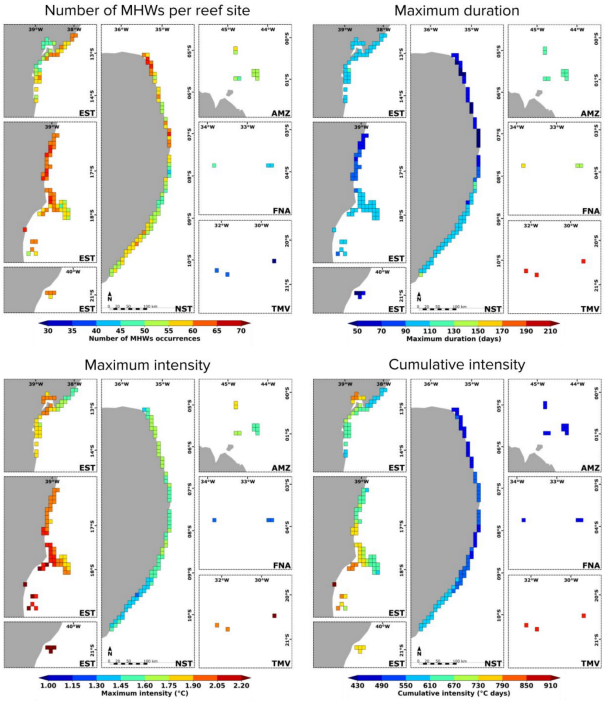

Figure 2. Spatial distribution of marine heatwaves (MHWs) attributes over reef sites along the Brazilian continental margin: number of MHWs per reef site; maximum duration of MHWs (days); maximum intensity (°C); and cumulative intensity (°C days)

Table 1. Summary of Marine Heatwaves (MHWs) occurrences per region along the Brazilian continental margin.

Region	Number of MHWs	Average duration of MHWs (days)	Average intensity (°C)	Average cumulative intensity (°C days)	Number of bleaching events reported
EST	59 ± 5.4	90 ± 15.5	2.45 ± 0.19	688.21 ± 74.7	25
NST	56 ± 5.0	82 ± 26.9	1.74 ± 0.12	515.80 ± 42.0	16
AMZ	52 ± 1.8	122 ± 3.2	1.82 ± 0.13	446.55 ± 15.6	1
FNA	43 ± 2.5	144 ± 5.7	1.29 ± 0.01	479.94 ± 13.7	4
TMV	35 ± 5.0	184 ± 19.3	2.27 ± 0.15	860.90 ± 8.5	2

Regarding coral bleaching, all the most intense and persistent MHWs occurrences seem to be associated with at least one reported bleaching event per marine ecoregion (Figure 3), indicating that although South Atlantic coral reefs are more resistant to positive temperature anomalies, periods of extreme and persistent warming are still threatening their health and conservation. Finally, our results show that the occurrence of MHWs on e Brazilian coral reefs is increasing over the years, especially in the southern communities. Further analysis is also underway to better understand the impact of less severe MHWs on these ecosystems.

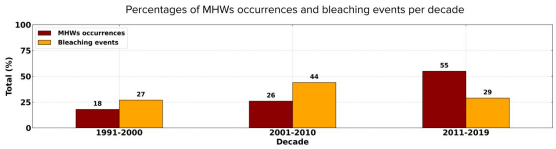

Figure 3. Comparison between the percentage of occurrence of marine heatwaves (MHWs) and coral bleaching events per decade.

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