frontiers

Supplementary Material

1 SUPPLEMENTARY FIGURES

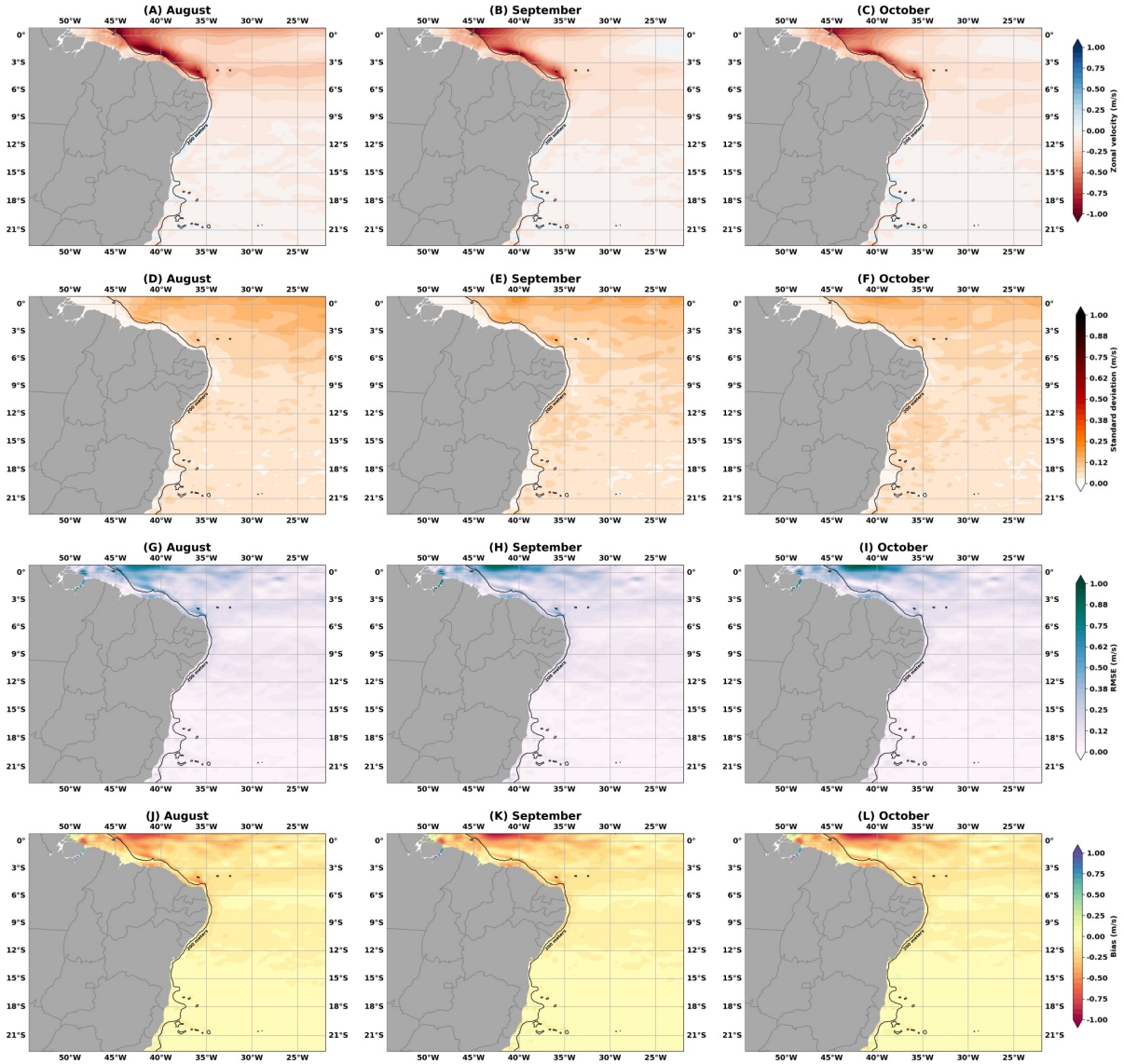

Figure S1. Comparison of GLORYS12V1 and satellite altimetry-derived surface ocean currents products during August, September and October, between 1993 and 2019. (a,b,c) GLORYS12V1 zonal component *u* average; (d,e,f) GLORYS12V1 zonal component standard deviation; (g,h,i) Root Mean Square Error (RMSE) and (j,k,l) Bias.

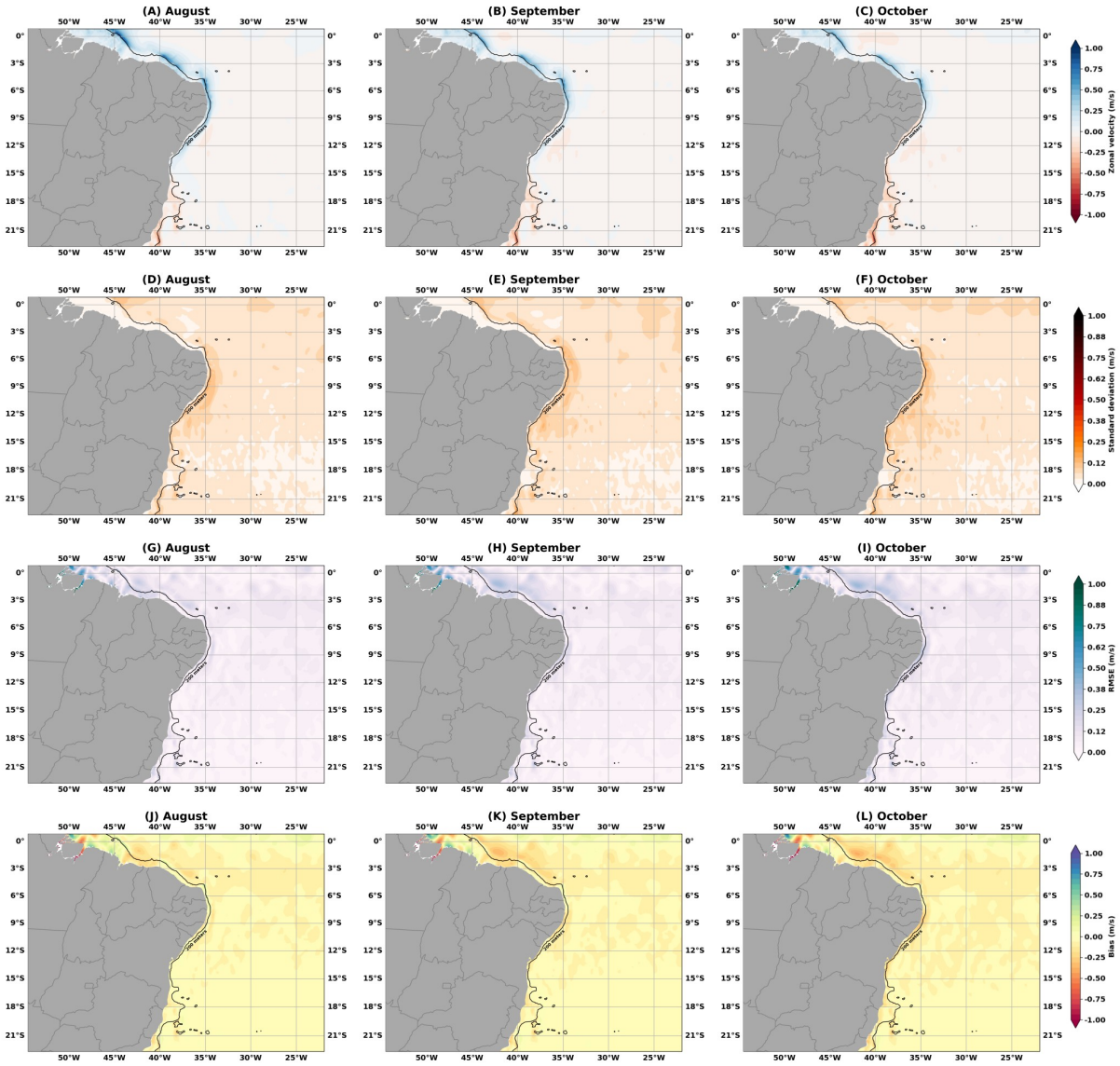

Figure S2. Comparison of GLORYS12V1 and satellite altimetry-derived surface ocean currents products during August, September and October, between 1993 and 2019. (a,b,c) GLORYS12V1 meridional component *u* average; (d,e,f) GLORYS12V1 meridional component standard deviation; (g,h,i) Root Mean Square Error (RMSE) and (j,k,l) Bias.

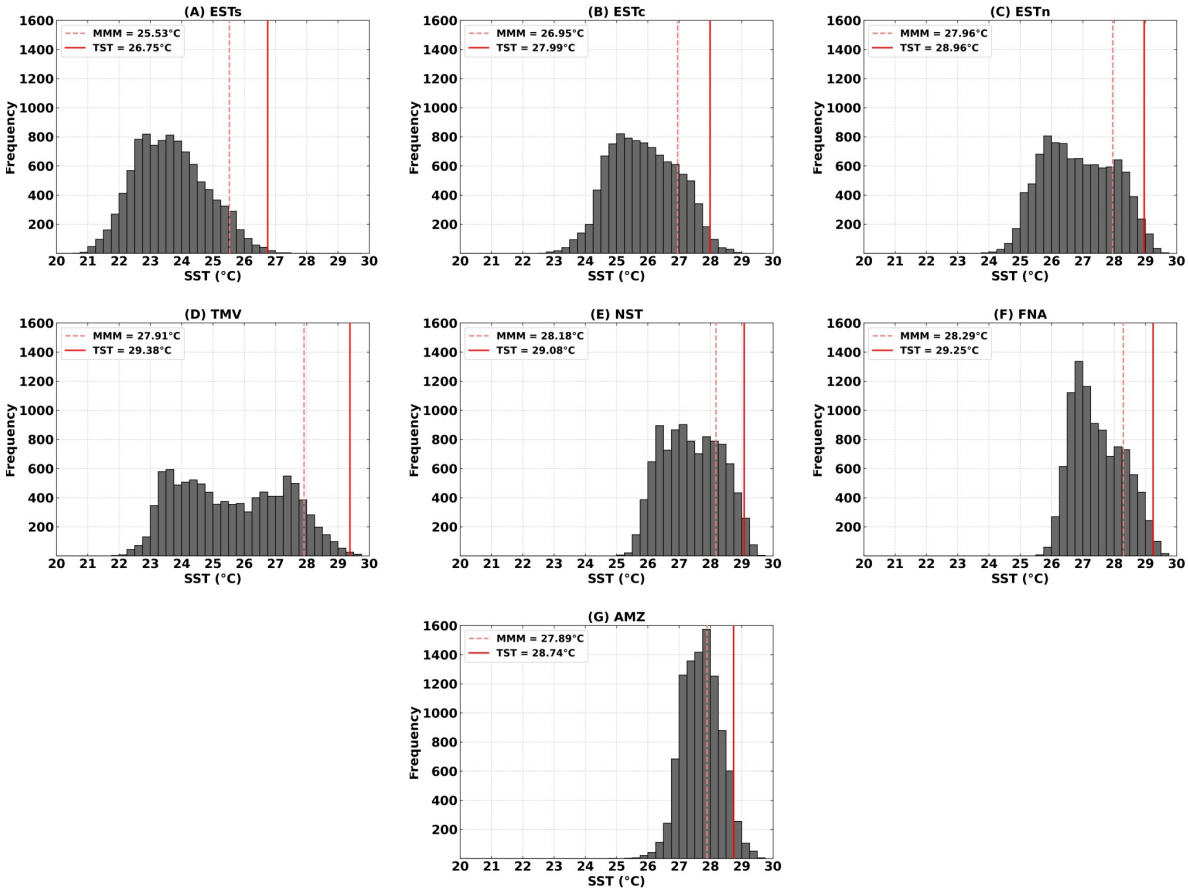

Figure S3. Sea surface temperature histograms obtained by the average of the reef sites within each ecoregion, presenting their respective maximum monthly mean (MMM) and thermal stress threshold (TST) average values (see text for MMM and TST calculation). (A) Eastern-south - ESTs; (B) Eastern-center - ESTc; (C) Eastern-north - ESTn; (D) Trindade-Martim Vaz Islands - TMV; (E) Northeastern - NST; (F) Fernando de Noronha-Atol das Rocas; (G) Amazon - AMZ.

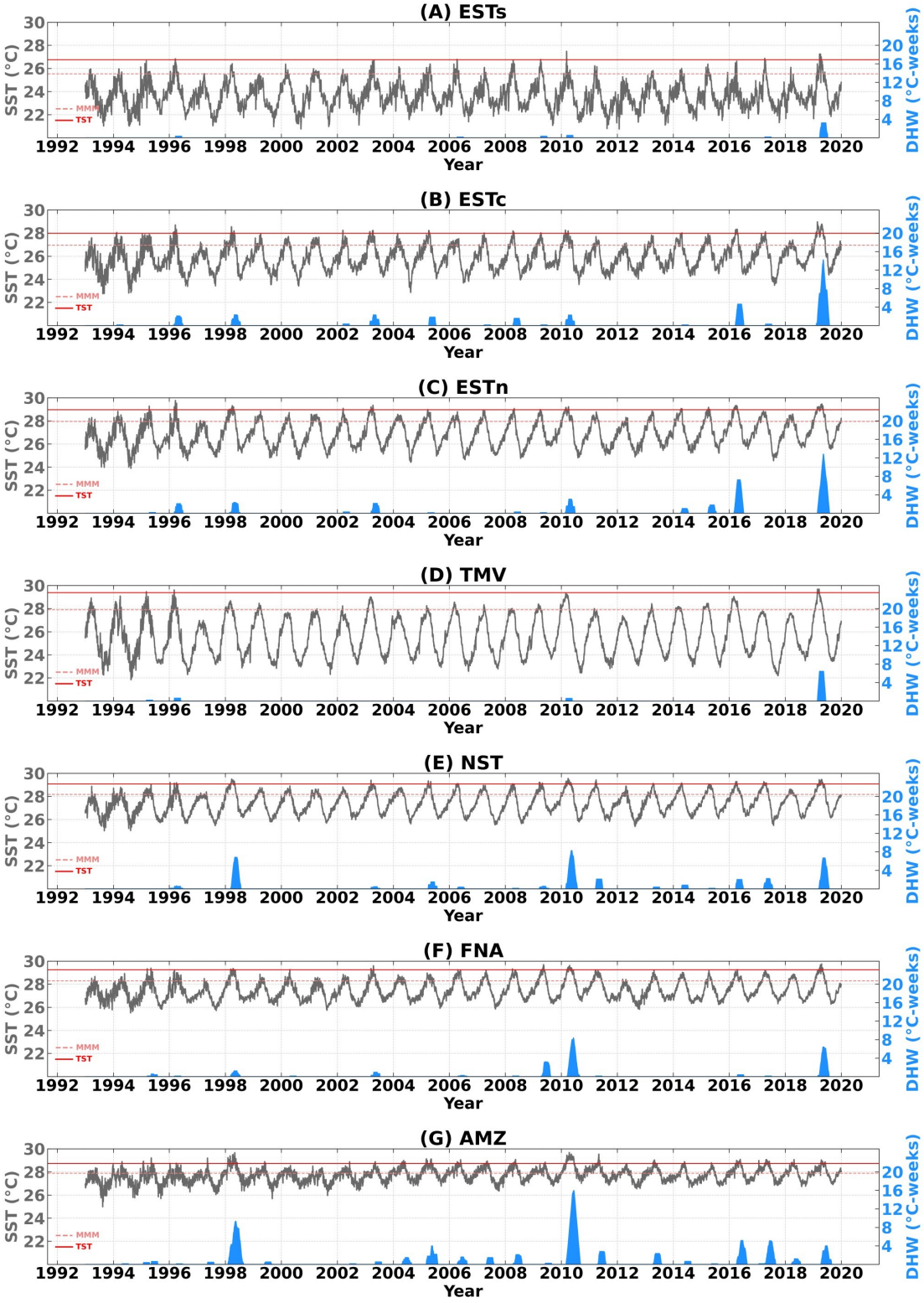

Figure S4. Sea surface temperature daily time-series (in gray) and the 12-week accumulation of SST anomalies by the Degree Heating Week index (in orange) between 1993 - 2019, obtained by the average of the reef sites within each ecoregion (see text for Degree Heating Week index calculation). (A) Eastern-south - ESTs; (B) Eastern-center - ESTc; (C) Eastern-north - ESTn; (D) Trindade-Martim Vaz Islands - TMV; (E) Northeastern - NST; (F) Fernando de Noronha-Atol das Rocas; (G) Amazon - AMZ.

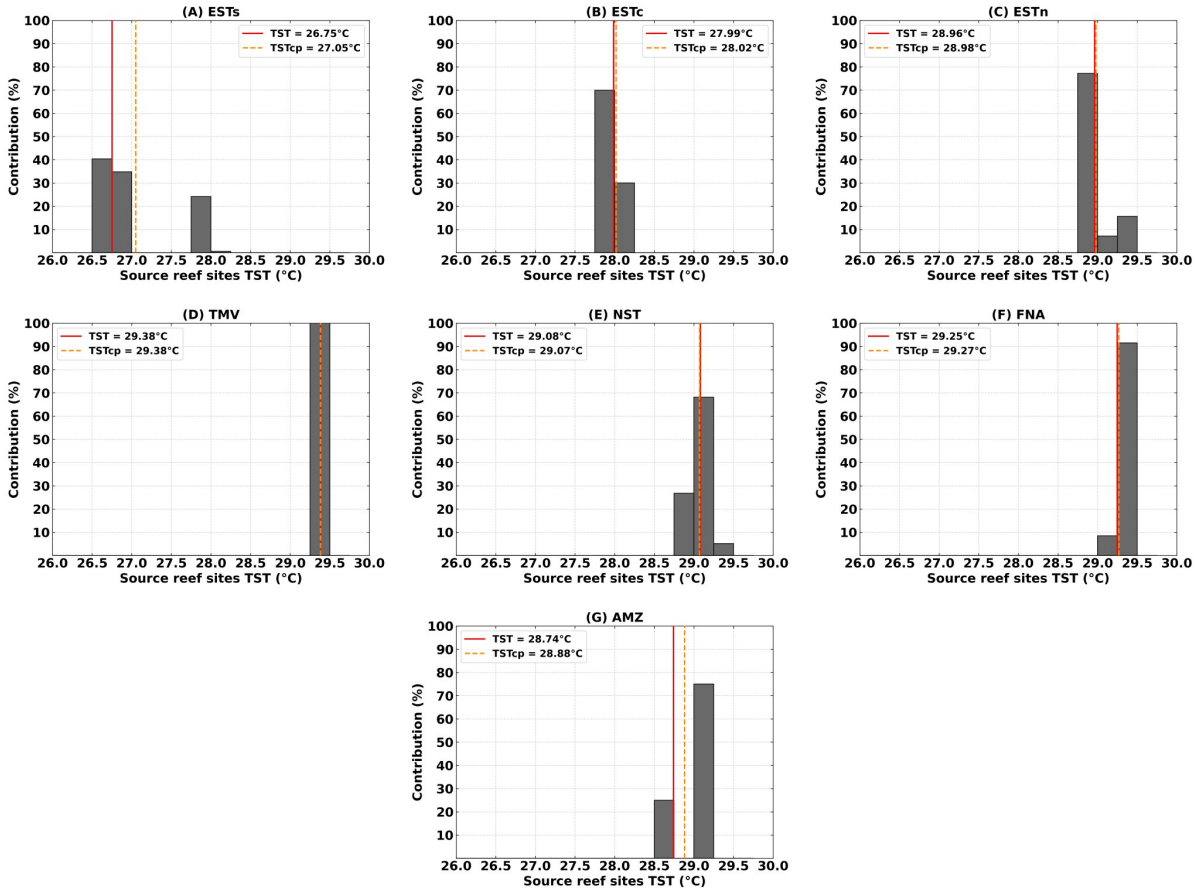

Figure S5. Thermal stress thresholds (TST) contribution (%) histogram from source reef sites to destination reef sites, highlighting the TST and TSTcp average values within each ecoregion (see text for TST and TSTcp calculation). (A) Eastern-south - ESTs; (B) Eastern-center - ESTc; (C) Eastern-north - ESTn; (D) Trindade-Martim Vaz Islands - TMV; (E) Northeastern - NST; (F) Fernando de Noronha-Atol das Rocas; (G) Amazon - AMZ.

2 LIST OF BLEACHING EVENTS REPORTED IN THE LITERATURE ALONG THE BRAZILIAN CONTINENTAL MARGIN, BETWEEN 1993 - 2019

[1] Mayal EM, Neumann-Leitão S, Feitosa FA, Schwamborn R, Silva-Cunha MD. Hydrology, plankton, and corals of the Maracajaú reefs (Northeastern Brazil): an ecosystem under severe thermal stress. Brazilian Archives of Biology and Technology. 2009 Jun;52(3):665-78.

[2] Alves Jr N, Neto OS, Silva BS, De Moura RL, Francini-Filho RB, Barreira e Castro C, Paranhos R, Bitner-Mathé BC, Kruger RH, Vicente AC, Thompson CC. Diversity and pathogenic potential of vibrios isolated from Abrolhos Bank corals. Environmental Microbiology Reports. 2010 Feb;2(1):90-5.

[3] Amaral FD, Costa CF. Zooxantelas dos hidrocorais Millepora alcicornis e Millepora braziliensis e dos corais Favia gravida e Siderastrea stellata de Pernambuco. Trab. Oceanogr. Univ. Fed. PE. 1998;26(1):123-33.

[4] Amaral FM, Farrapeira CM, Lira SM, Ramos CA, Dom R. Benthic macrofauna inventory of two shipwrecks from Pernambuco coast, northeastern of Brazil. Rev. Nordest. Zool. 2010;4(1):24-41.

[5] Amorim T, Costa CF, Sassi R. Branqueamento e doenças em cnidários dos recifes costeiros de Picãozinho, Nordeste do Brasil. Tropical Oceanogr. 2011;40(1):185-201.

[6] Barradas JI, Amaral FD, Hernández MI, Montes MD, Steiner AQ. Spatial distribution of benthic macroorganisms on reef flats at Porto de Galinhas Beach (northeastern Brazil), with special focus on corals and calcified hydroids. Biotemas. 2010 Apr 8;23(2):61-7.

[7] Castro CB, Pires DO. A bleaching event on a Brazilian coral reef. Revista brasileira de Oceanografia. 1999;47(1):87-90.

[8] Cavalcante F, Amaral F. Variação das zooxantelas e branqueamento no hidróide calcário Millepora alcicornis Linnaeus, 1758 nos recifes de Porto de Galinhas-Nordeste brasileiro. Tropical Oceanography. 2013;42:1-1.

[9] Coni EO, Ferreira CM, de Moura RL, Meirelles PM, Kaufman L, Francini-Filho RB. An evaluation of the use of branching fire-corals (Millepora spp.) as refuge by reef fish in the Abrolhos Bank, eastern Brazil. Environmental Biology of Fishes. 2013 Jan;96(1):45-55.

[10] Coni EO, Ferreira CM, Meirelles PM, Menezes R, Santana EF, Moreira AP, Amado-Filho GM, Ferreira BP, Pereira-Filho GH, Thompson FL, Moura RL. Modeling abundance, growth, and health of the solitary coral Scolymia wellsi (Mussidae) in turbid SW Atlantic coral reefs. Marine biology. 2017 Apr;164(4):1-5.

[11] da Costa CF, Amaral FD, Sassi R. Branqueamento em Siderastrea stellata (Cnidaria, Scleractinia) da praia de Gaibu, Pernambuco, Brasil. Revista Nordestina de Biologia. 2001:15-22.

[12] Costa CF, Coutinho CS, Sassi R, Brito LA. Microsymbionts of Siderastraea stellata (Cnidaria, Scleractinia) in coastal reefs of Cabo Branco, State of Paraíba, northeastern Brazil. Trop. Oceanogr. 2004;32(2):173-81.

[13] Cruz I, Leal MC, Mendes CR, Kikuchi RK, Rosa R, Soares AM, Serôdio J, Calado R, Rocha RJ. White but not bleached: photophysiological evidence from white Montastraea cavernosa reveals potential overestimation of coral bleaching. Marine Biology. 2015 Apr;162(4):889-99.

[14] Elliff CI, Kikuchi RK. Ecosystem services provided by coral reefs in a Southwestern Atlantic Archipelago. Ocean Coastal Management. 2017 Feb 1;136:49-55.

[15] Kelmo F, Attrill MJ. Severe impact and subsequent recovery of a coral assemblage following the 1997–8 El Niño event: a 17-year study from Bahia, Brazil. PLoS One. 2013 May 31;8(5):e65073.

[16] Kikuchi RK, Leão ZM, Testa VI, Dutra LX, Spano SA. Rapid assessment of the Abrolhos reefs, eastern Brazil(Part 1: Stony corals and algae). Atoll Research Bulletin. 2003 Jul;496:172-87.

[17, 18] Leão ZM, Kikuchi RK, Oliveira MD, Vasconcellos V. Status of Eastern Brazilian coral reefs in time of climate changes. Pan-American Journal of Aquatic Sciences. 2010;5(2):224-35.

[19, 20] Kikuchi RK, Leão ZM, Oliveira MD. Conservation status and spatial patterns of AGRRA vitality indices in Southwestern Atlantic Reefs. Revista de biologia tropical. 2010 May;58:10-32.

[21, 22] Leão ZM, Kikuchi RK, Oliveira MD. Branqueamento de corais nos recifes da Bahia e sua relação com eventos de anomalias térmicas nas águas superficiais do oceano. Biota Neotropica. 2008;8:69-82.

[23] Leão ZM, Oliveira MD, Kikuchi RK. Os recifes de coral da APA Ponta da Baleia, Bahia. OLAM Ciência Tecnologia. 2008 Jan;8:287.

[24] Lourenço LD, Crispim MC, Eloy CC. Caracterização do parque estadual marinho de Areia Vermelha, Cabedelo, PB, baseado na diversidade e abundância dos cnidários da classe anthozoa, como subsídio para o zoneamento ecológico econômico. Gaia Scientia. 2015 Dec 31;9(1).

[25] Marangoni LF, Mies M, Güth AZ, Banha TN, Inague A, Fonseca JD, Dalmolin C, Faria SC, Ferrier-Pagès C, Bianchini A. Peroxynitrite generation and increased heterotrophic capacity are linked to the disruption of the coral–dinoflagellate symbiosis in a scleractinian and hydrocoral species. Microorganisms. 2019 Oct;7(10):426.

[26] Mayal EM, Sial AN, Ferreira VP, Fisner M, Pinheiro BR. Thermal stress assessment using carbon and oxygen isotopes from Scleractinia, Rocas Atoll, northeastern Brazil. International Geology Review. 2009 Feb 1;51(2):166-88.

[27] Mazzei EF, Bertoncini AA, Pinheiro HT, Machado LF, Vilar CC, Guabiroba HC, Costa TJ, Bueno LS, Santos LN, Francini-Filho RB, Hostim-Silva M. Newly discovered reefs in the southern Abrolhos Bank, Brazil: Anthropogenic impacts and urgent conservation needs. Marine pollution bulletin. 2017 Jan 15;114(1):123-33.

[28] Meirelles PM, Amado-Filho GM, Pereira-Filho GH, Pinheiro HT, De Moura RL, Joyeux JC, Mazzei EF, Bastos AC, Edwards RA, Dinsdale E, Paranhos R. Baseline assessment of mesophotic reefs of the Vitória-Trindade Seamount Chain based on water quality, microbial diversity, benthic cover and fish biomass data. PloS one. 2015 Jun 19;10(6):e0130084.

[29] de Sousa Melo R, Lins RP, Eloy CC. O impacto do turismo em ambientes recifais: caso praia Seixas-Penha, Paraíba, Brasil. REDE-Revista Eletrônica do Prodema. 2014;8(1).

[30] Miranda RJ, Cruz IC, Leão ZM. Coral bleaching in the Caramuanas reef (Todos os Santos Bay, Brazil) during the 2010 El Niño event. Latin American Journal of aquatic research. 2013;41(2):351-60.

[31] de Moura RL, Rodrigues MM, Francini-Filho RB, Sazima I. Unexpected richness of reef corals near the southern Amazon River mouth. Coral Reefs. 1999;2(18):170.

[32] Pereira LC, Jiménez JA, Gomes PB, Medeiros C, da Costa RA. Effects of sedimentation on scleractinian and actinian species in artificial reefs at the Casa Caiada beach (Brazil). Journal of Coastal Research. 2003 Apr 1:418-25.

[33] Pereira NS, Sial AN, Kikuchi RK, Ferreira VP, Ullmann CV, Frei R, Cunha A. Coral-based climate records from tropical South Atlantic: 2009/2010 ENSO event in C and O isotopes from Porites corals (Rocas Atoll, Brazil). Anais da Academia Brasileira de Ciências. 2015 Oct;87:1939-57.

[34, 35] Pereira-Filho GH, Amado-Filho GM, Guimarães SM, Moura RL, Sumida PY, Abrantes DP, Bahia RG, Güth AZ, Jorge RR, Francini Filho RB. Reef fish and benthic assemblages of the Trindade and Martin Vaz island group, southwestern Atlantic. Brazilian Journal of Oceanography. 2011 Sep;59(3):201-12.

[36] Poggio C, Leão Z, Mafalda-Junior P. Registro de branqueamento sazonal em Siderastrea spp. em poças intermareais do recife de Guarajuba, Bahia, Brasil. Interciência. 2009;34(7):502-6.

[37] Ramos CA, de Kikuchi RK, Amaral FD, Fauth JE. A test of herbivory-mediated coral–algae interaction on a Brazilian reef during a bleaching event. Journal of experimental marine biology and ecology. 2014 Jul 1;456:1-7.

[38] Sassi CFC, Sassi R, Gorlach-Lira K, Lima RCP. Pigmentation patterns of Siderastrea Stellata Verrill, 1868 (Cnidaria, Scleractinia) from coastal reefs in northeastern Brazil and its relation with zooxanthellae and other microsymbionts. Pan-American Journal of Aquatic Sciences. 2014;9(3):207-22.

[39] de Oliveira Soares M, Rabelo EF. Primeiro registro de branqueamento de corais no litoral do Ceará (NE, Brasil): indicador das mudanças climáticas?. Geosciences= Geociências. 2014 Apr 25;33(1):1-0.

[40] Steiner AQ, Amaral FM, Amaral JR, Sassi R, Barradas JI. Zonação de recifes emersos da área de proteção ambiental costa dos corais, nordeste do brasil. Iheringia. série zoologia. 2015 Jun 30;105:184-92.

[41] Teixeira CD, Leitao RL, Ribeiro FV, Moraes FC, Neves LM, Bastos AC, Pereira-Filho GH, Kampel M, Salomon PS, Sá JA, Falsarella LN. Sustained mass coral bleaching (2016–2017) in Brazilian turbid-zone reefs: taxonomic, cross-shelf and habitat-related trends. Coral Reefs. 2019 Aug;38(4):801-13.

[42] Vila Nova LLM, Carvalho DMN, Maida M. Estudo da população do Coral-de-Fogo Millepora alcicornis (Linnaeus, 1758) no complex recifal de Tamandaré (Recife da Ilha da Barra – zona de preservação da vida marinha, e Recife do Pirambu) Pernambuco – Brasil. Trop. Oceanogr. 2014;42, 226-237.

[43] Donner SD, Rickbeil GJ, Heron SF. A new, high-resolution global mass coral bleaching database. PLoS One. 2017 Apr 26;12(4):e0175490.

[44] Krug LA, Gherardi DF, Stech JL, De Andrade Nery Leão ZM, De Kikuchi RK. Characterization of coral bleaching environments and their variation along the Bahia state coast, Brazil. International journal of remote sensing. 2012 Jul 10;33(13):4059-74.

[45] Sassi CF, Farias GM, Vasconcelos AD, Macedo RS, França JP, Sassi R. Histopatological effects of bleaching and disease on the coral Siderastrea stellata from coastal reefs of Brazil. Iheringia. Série Zoologia. 2021 May 7;111.

[46] Gaspar TL, Quimbayo JP, Ozekoski R, Nunes LT, Aued AW, Mendes TC, Garrido AG, Segal B. Severe coral bleaching of Siderastrea stellata at the only atoll in the South Atlantic driven by sequential Marine Heatwaves. Biota Neotropica. 2021 Apr 12;21.

[47] Duarte GA, Villela HD, Deocleciano M, Silva D, Barno A, Cardoso PM, Vilela CL, Rosado P, Messias CS, Chacon MA, Santoro EP. Heat waves are a major threat to turbid coral reefs in Brazil. Frontiers in Marine Science. 2020:179.

[48] Ferreira LC, Grillo AC, Repinaldo Filho FP, Souza FN, Longo GO. Different responses of massive and branching corals to a major heatwave at the largest and richest reef complex in South Atlantic. Marine Biology. 2021 May;168(5):1-8.

Table S1. Bleaching events reported in the literature, highlighting the period and/or year of observation, ecoregion and severity code classified according to the ReefBase protocol: Eastern-south (ESTs); Eastern-center (ESTc); Eastern-north (ESTn); Northeastern (NST), Amazon (AMZ), Fernando de Noronha-Atol das Rocas (FNA), Trindade-Martim Vaz Islands (TMV).

References	Period/Year	Ecoregion	Severity code
[1]	2000	NST	3
[2]	2007	ESTc	1
[3]	January/1996 - July/1997	NST	1
[4]	December/2005 - February/2007	NST	1
[5]	2008 - 2009	NST	3
[6]	2004	NST	2
[7]	1993 - 1995	ESTc	3
[8]	2011	NST	1
[9]	2007	ESTc	2
[10]	2006 - 2008	ESTc	2
[11]	April/1996 - July/1996	NST	1
[12]	June/2003 - July/2003	NST	1
[13]	2011	ESTn	1
[14]	2013	ESTn	2
[15]	1995 - 2011	ESTn	2
[16]	March/2000 a April/2000	ESTc	1
[17]	2006 - 2008	ESTn	1
[18]	2006 - 2008	ESTc	1
[19]	2000 - 2005	ESTc	2
[20]	2000 - 2005	ESTn	2
[21]	1998 - 2005	ESTc	2
[22]	1998 - 2005	ESTn	3
[23]	2000	ESTc	1
[24]	2009	NST	1
[25]	2015 - 2016	ESTn	2
[26]	1995 - 1999	FNA	1
[27]	2013 - 2015	ESTc	1
[28]	2009 - 2011	TMV	3
[29]	No information	NST	1
[30]	2009 - 2010	ESTn	2
[31]	July/1998	AMZ	3
[32]	March/1993 - February/1999	NST	2
[33]	2012	FNA	1
[34]	2009	TMV	3
[35]	2009	FNA	3
[36]	March/2005 - March/2006	ESTn	1
[37]	2010	ESTn	3
[38]	2008 - 2009	NST	2
[39]	2010	NST	3
[40]	2004	NST	1
[41]	2016 - 2017	ESTc	3
[42]	2012 - 2014	NST	2
[43]	1998	ESTc	1
[44]	1993 - 2005	ESTc	3
[45]	September/2018 - July/2019	NST	3
[46]	2019	FNA	3
[47]	2019	ESTc	2
[48]	February/2019 - August/2019	ESTc	3