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Biophysical Modeling as a tool to predict marine organisms behavior in climate change scenarios

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INTRODUCTION

The main purposes of Marine Protected Areas (MPA) are to ensure the conservation of biodiversity patterns, biological connectivity and mitigate regime shifts due to climate change. Projections of future climate change scenarios point to alterations in ocean circulation and sea surface temperature (SST), affecting the life cycle of marine organisms. These changes directly affect the reproduction and dispersal capacity of marine organisms, including changes in egg and larvae survival conditions, as well as in the trajectory imposed by the surface circulation. Sea surface temperature and ocean currents affect reef fishes reproduction and survival, principally in the first stages of life.

METHODOLOGY

Future projections from global coupled numerical models will be used to model the ecological connectivity and acclimation patterns of the reef fishes into Brazilian oceanic islands and the continental shelf. The selected future scenarios are from the HadGEM2-ES, ensemble r2i1p1, RCP8.5, which are based on the premise that no mitigation action is fulfilled. It will be simulated the dispersion of egg and larvae of reef fishes from nine regions that correspond to Marine Protected Areas (Figure 1).

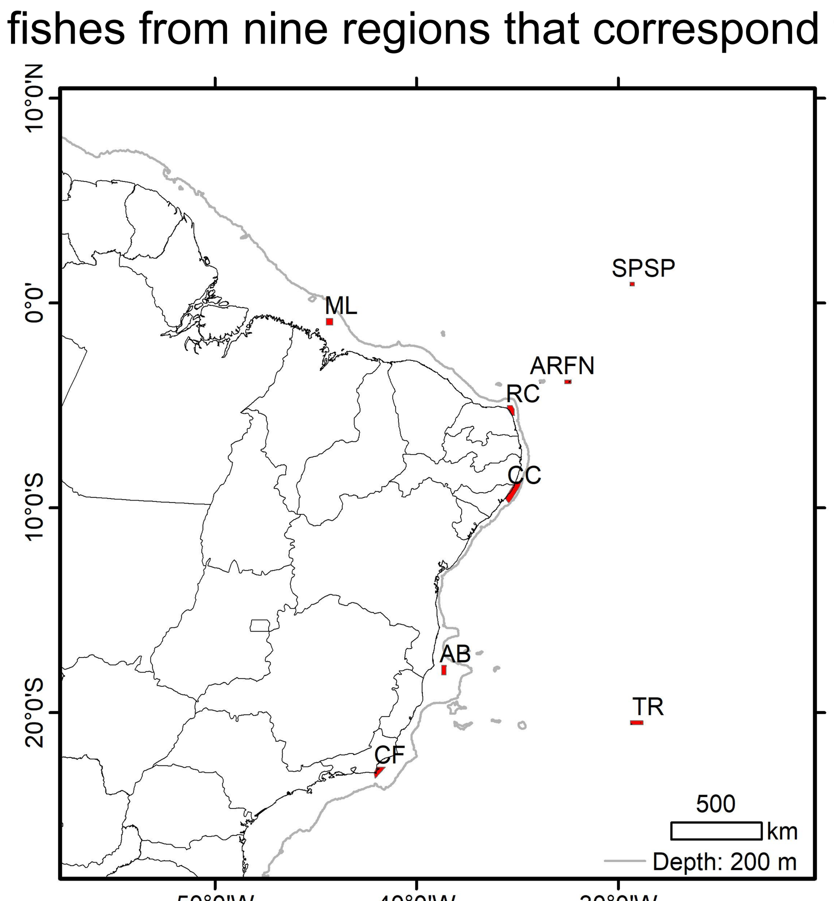

Figure 1: Marine Protected Areas used as egg release and larvae recruitment sites (**SPSP** – São Pedro and São Paulo Archipelago; **ML** – Manuel Luis; **FN** – Fernando de Noronha; **AR** – Rocas Atol; **RC** - Recife de Corais; **CC** - Costa de Corais; **AB** – Abrolhos; **TR** – Trindade and Martim Vaz; **CF** – Cabo Frio).

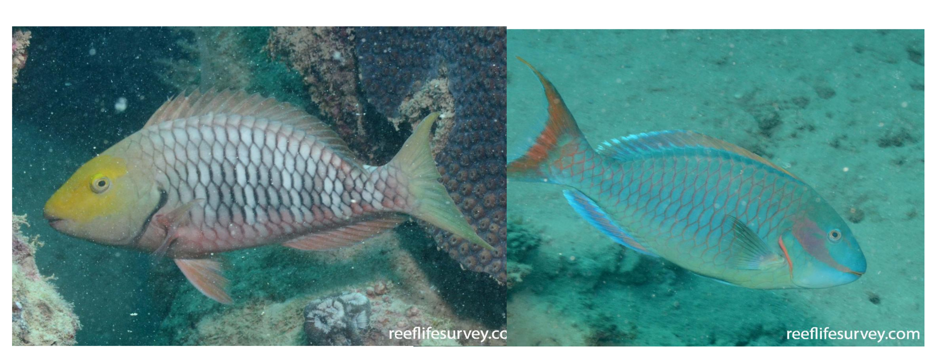

Figure 2: *Sparisoma* sp. Endemic to Brazil where can be found in all reef environments defined in this study. Photo credits: Graham Edgar, Reef Life Survey.

The oceanic downscaling of these scenarios will be carried out using the Regional Oceanic Model System (ROMS) for the hydrodynamic modeling of the tropical Atlantic Ocean, and the lagrangean model ICHTHYOP (Lett et al, 2008) for the individual-based biological modeling (Figure 3). It will be used to evaluate egg release and larvae recruitment sites reef fishes of genus *Sparisoma* (Scaridae) (Figure 2), like a target scenario in the IBM simulation.

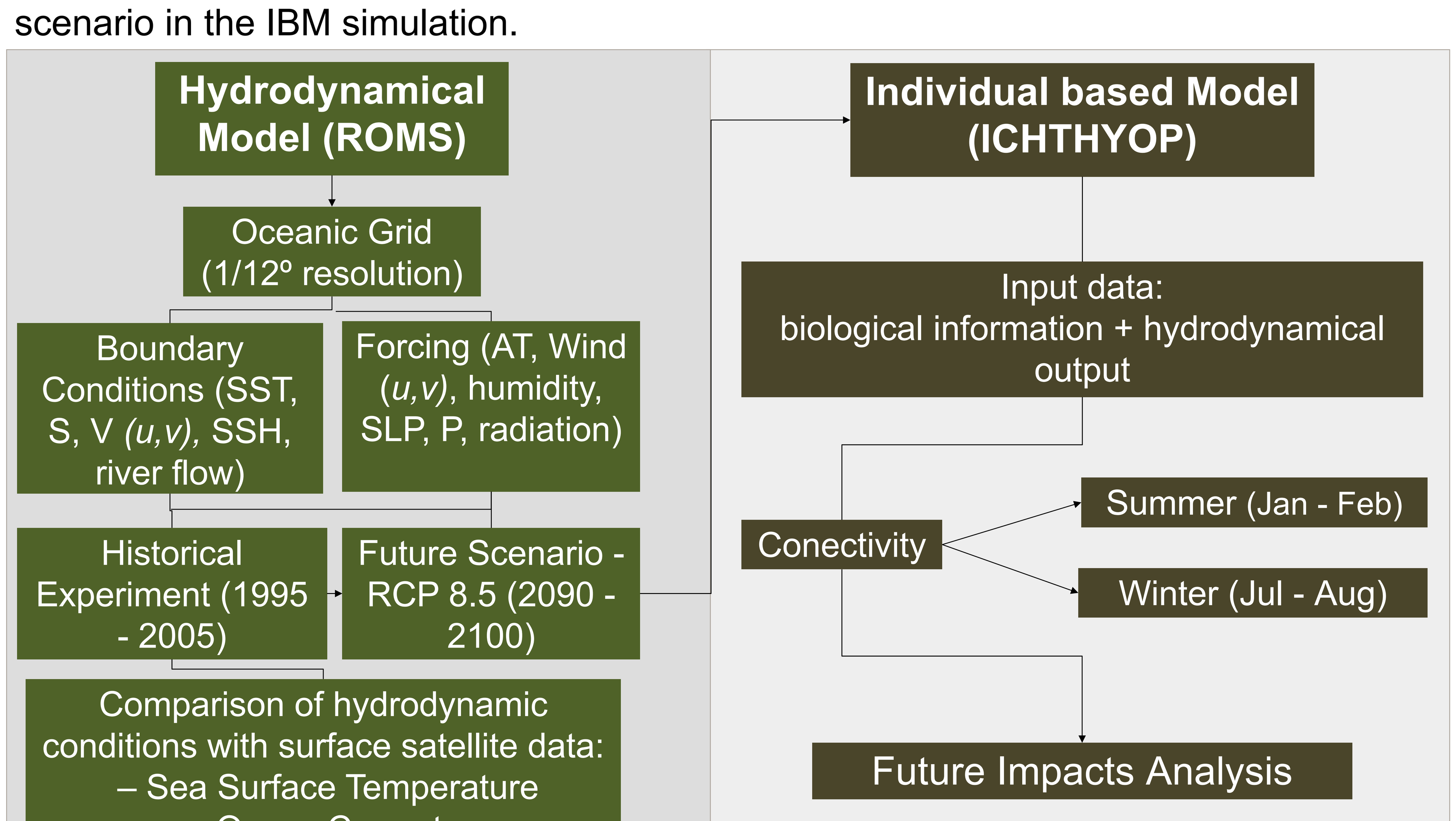

Figure 3: Experimental scheme for this study. SST – Sea Surface Temperature; S – Salinity; V(*u,v*) – ocean currents; SSH – Sea Surface Height; AT – Air Temperature; SLP – Sea Level Pressure; P – Precipitation.

PRELIMINARY ANALYSIS

Figure 4 shows the mean winter and summer SST for all nine MPAs. Visually, it is possible observe that the SST in HadGEM2-ES/RCP 8.5 is warmer than Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) and HadGEM2-ES near the Equator and in subtropical areas warming is less intense.

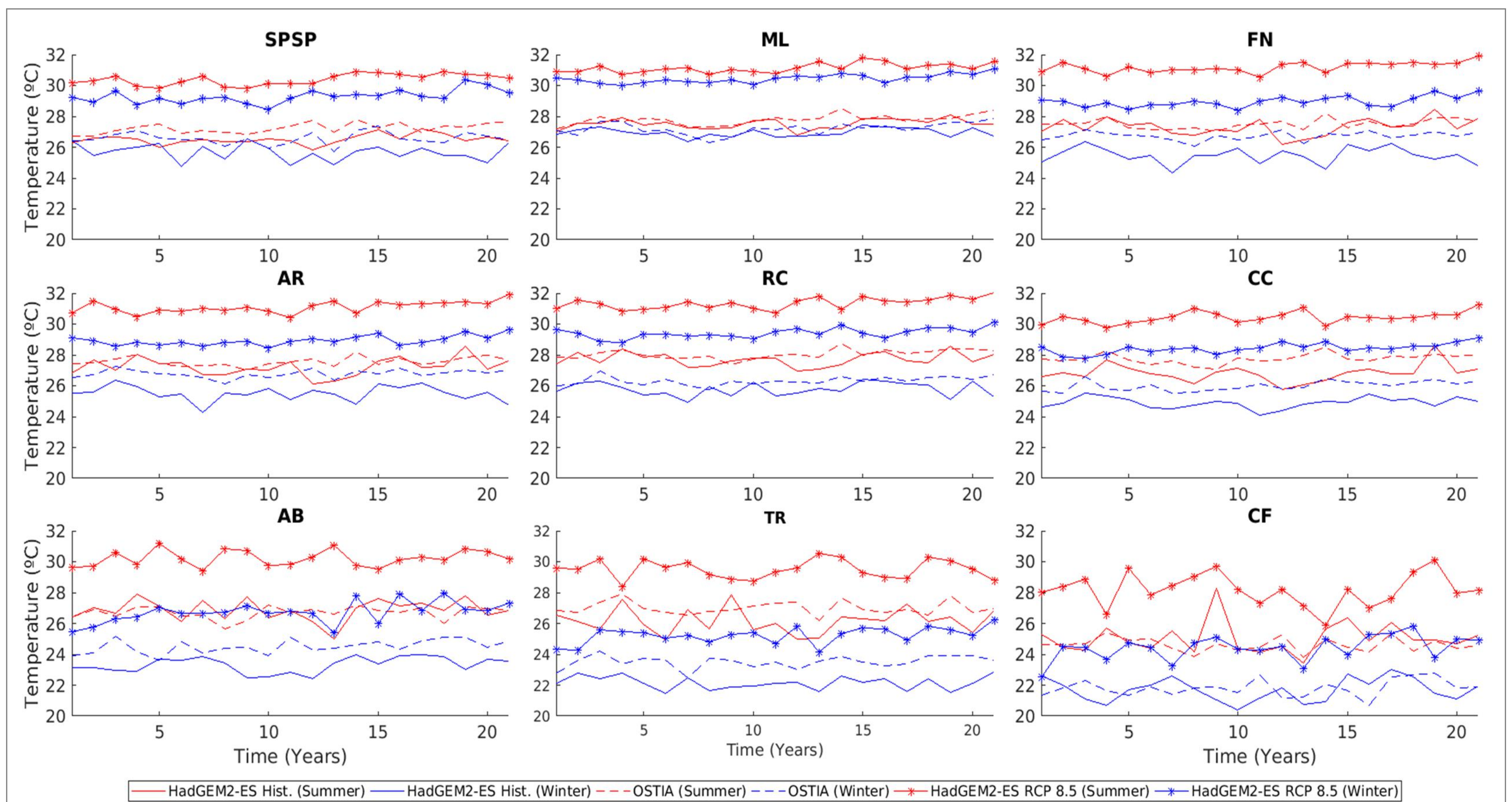

Figure 4: Comparison between HadGEM2-ES (present-day/Hist. (1985- 2005), RCP8.5 (2080-2100)) and satellite (OSTIA) summer and winter mean SST.

Figure 5 presents HadGEM2-ES and ROMS SST output comparisons with OSTIA data. The period analysis is between 1997-01-01 and 2004-12-31.

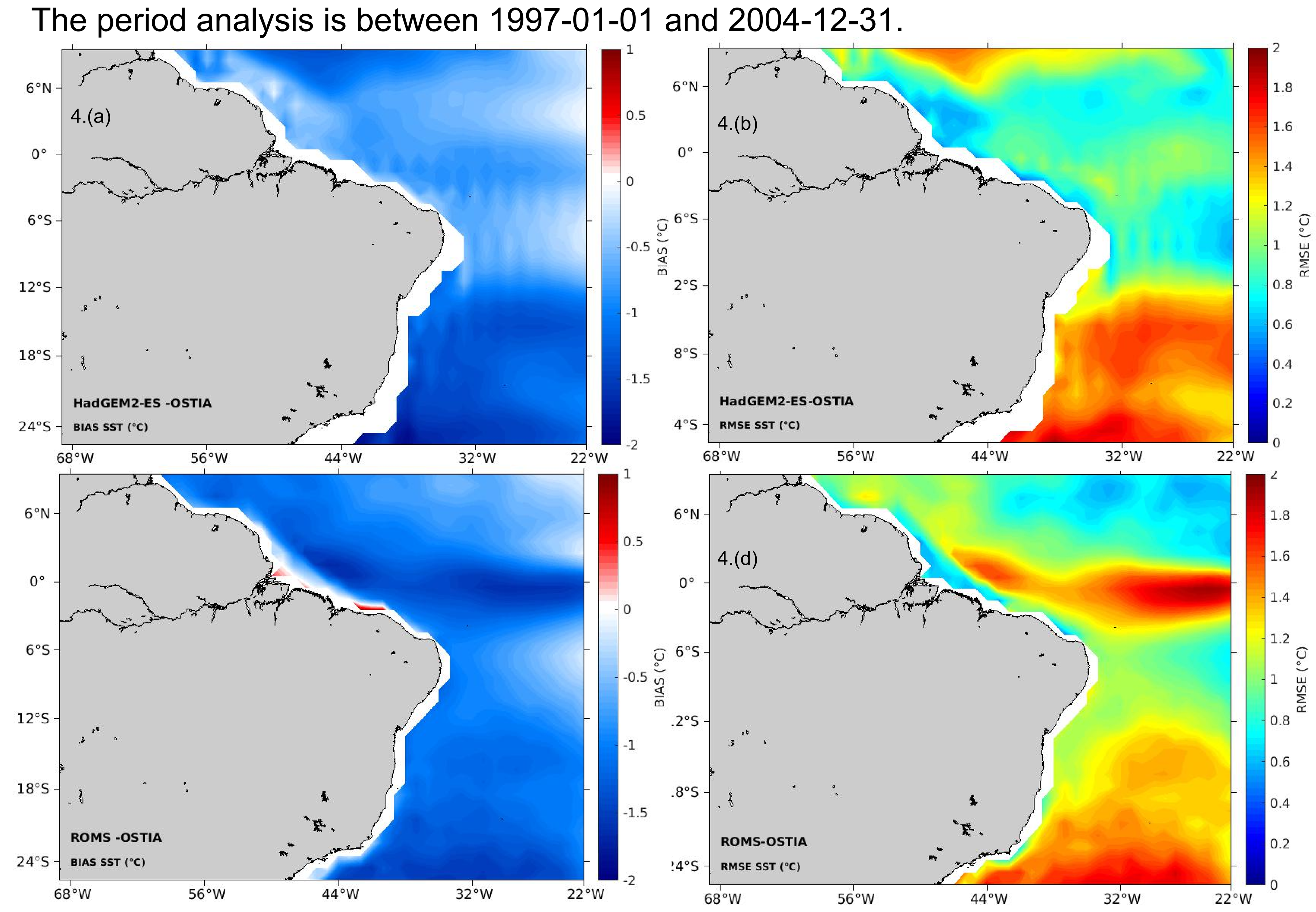

Figure 4: (a) Bias SST (HadGEM2-ES – OSTIA) ; (b) RMSE(HadGEM2-ES – OSTIA); (c) Bias SST (ROMS – OSTIA) ; (d) RMSE(ROMS – OSTIA).

Spatially, the historical data (1997 - 2004) presents negative bias (Figure 4.a and 4.c), reaching -1,87ºC to HadGEM2-ES and -1,64ºC to ROMS. Although, RMSE (Figure 4.b and 4.d) resulted with maximum error of 1,91ºC to HadGEM2-ES and 1,93ºC to ROMS, compared with OSTIA.

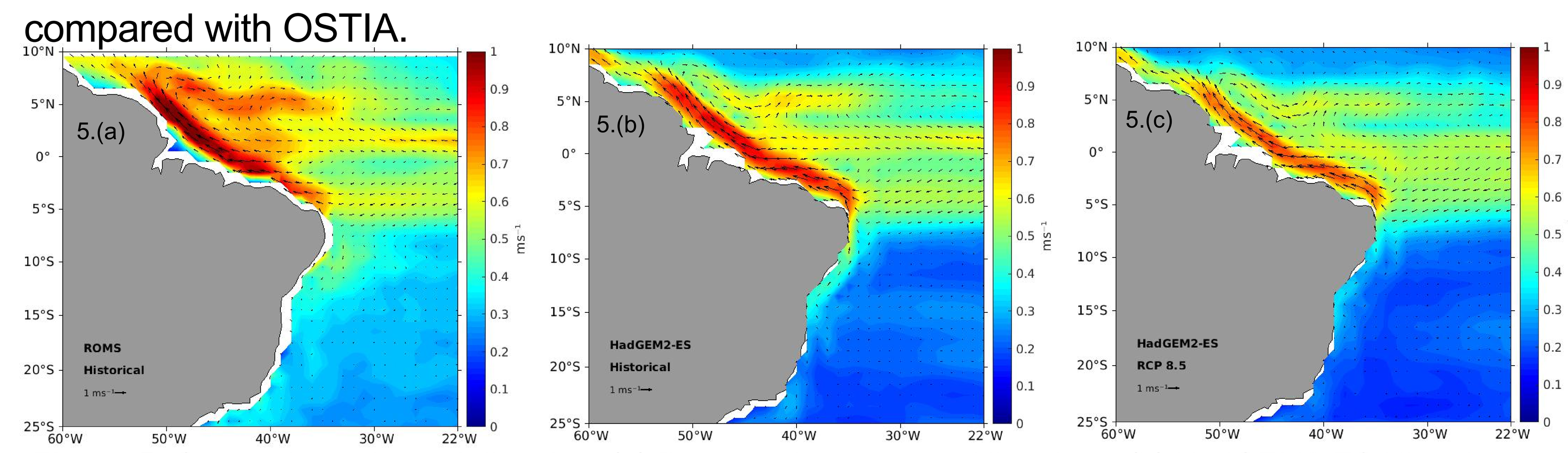

Figure 5: Current intensity and direction: (a) Downscaling results – Historical; (b) HadGEM2-ES Historical; (c) HadGEM2-ES RCP 8.5.

According to HadGEM2-ES RCP 8.5 (Figure 5.c), Brazilian North current speed will be less intense, compared with historical scenario (Figure 5.b). In view of this setting, in the biological simulation is expected seasonal changes of the expected survival and dispersion of eggs and larvae. The downscaling experiments are hoped provide a better representation of mesoscale ocean processes in the study area and their impact on the reproduction of reef fishes.

REFERENCES

DONELSON, J.M.; MCCORMICK, M.I.; BOOTH, D.J.; MUNDAY, P.L. (2014) Reproductive Acclimation to Increased Water Temperature in a Tropical Reef Fish. **PLoS ONE,** 9(5): e97223.

LETT, C., VERLEY, P., MULLON, C., PARADA, C., BROCHIER, T., PENVEN, P., & BLANKE, B. (2008). A Lagrangian tool for modelling ichthyoplankton dynamics. **Environmental Modelling & Software**, 23(9), 1210-1214

SHCHEPETKIN, A. F., AND J. C. MCWILLIAMS (2005), The Regional Ocean Modeling System: A split-explicit, free-surface, topography following coordinates ocean model, **Ocean Modelling**, 9, 347-404.

SHCHEPETKIN, A. F., AND J. C. MCWILLIAMS (2003), A method for computing horizontal pressure-gradient force in an oceanic model with a nonaligned vertical coordinate, **J. Geophys. Res.**, 108(C3), 3090, doi:10.1029/2001JC001047.

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