Biophysical modeling of the Brazilian sardine: from reproduction to your table

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Ocean and Atmosphere Research Laboratory

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Dr Douglas F.M. Gherardi - OBT/INPE - Biophysical Modeling
Dr. Jana Del Favero - PósDoc FAPESP/INPE - Regime Shift
Dr. Leonardo Lima - OBT/INPE - Data Assimilation
MSc Nelson Gouveia - PGSER/INPE - Continent-Ocean Interactions
MSc Mainara Gouveia - PGSER/INPE - Oil Spill Modelling
MSC Leilane Gonçalves - PCI/OBT - Model downscalling
BSc Luciana S. Lima -PGSER/INPE - Biophysical Modeling
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Dr Ronald Buss de Souza - CRS/INPE - Brazil
Dr. Carlos E. L Ferreira - Dept. Biologia Marinha/UFF - Brazil
Dr. Mario Katsuragawa - IO/USP
Dr. Luiz P. Assad - COPPE/UFRJ - Brazil
Dr. Akinori Takasuka - Fisheries Research Agency - Japan
Dr Kevin Rodges - University of Reading – UK
Dr Takemasa Mioshi - University of Maryland – USA
Dr Scott Miller - University of Albany
Other collaborations: GOAL-FURG, IO-USP, Petrobrás.

Presentation layout

- Statistics: *is this it?*
- From *patterns* to *processes*: biology and ocean physics.
- Modelling in a western boundary current:
  - ✓ Brazilian sardine reproduction strategy.
- The highs and lows of sardine production:
  - ✓ don't blame ocean variability.
- What's next? MPAs connectivity.

WHAT IS A BIOPHYSICAL MODEL?

A biophysical model is a simulation of a biological system using mathematical formalizations of the physical properties of that system to predict the influence of biological and physical factors on complex systems.

Nature.com

WHY SHOULD IT BE USED?

Marine ecosystems are affected by multiple factors, natural and anthropogenic, interacting together (non linear) and making ecosystem dynamics difficult to understand and predict.

Travers-Trolet et al., 2014 (PlosOne)

WHAT IS IT USED FOR?

Connectivity of marine populations (ocean physics), describing essential habitats, inpacts of climate change, Marine carbon cycling, testing ecological hypotheses...

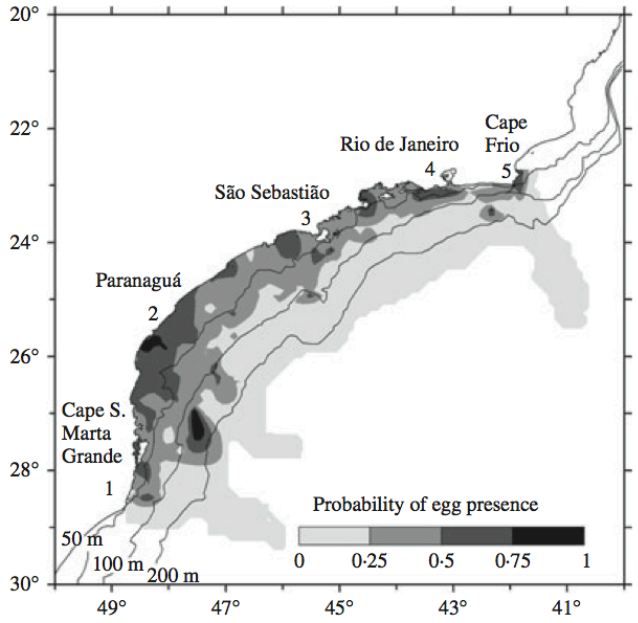

FIG. 3. Summary map of the average probabilities calculated from the indicative kriging of all cruise representing the spawning distribution of *Sardinella brasiliensis*.

Journal of FISH BIOLOGY
Published for the Fisheries Society of the British Isles

Journal of Fish Biology (2010) **77**, 2248–2267
doi:10.1111/j.1095-8649.2010.02802.x, available online at wileyonlinelibrary.com

Spatial analysis of egg distribution and geographic changes in the spawning habitat of the Brazilian sardine *Sardinella brasiliensis*

E. S. GIGLIOTTI*, D. F. M. GHERARDI*†, E. T. PAES*, R. B. SOUZA* AND M. KATSURAGAWA‡

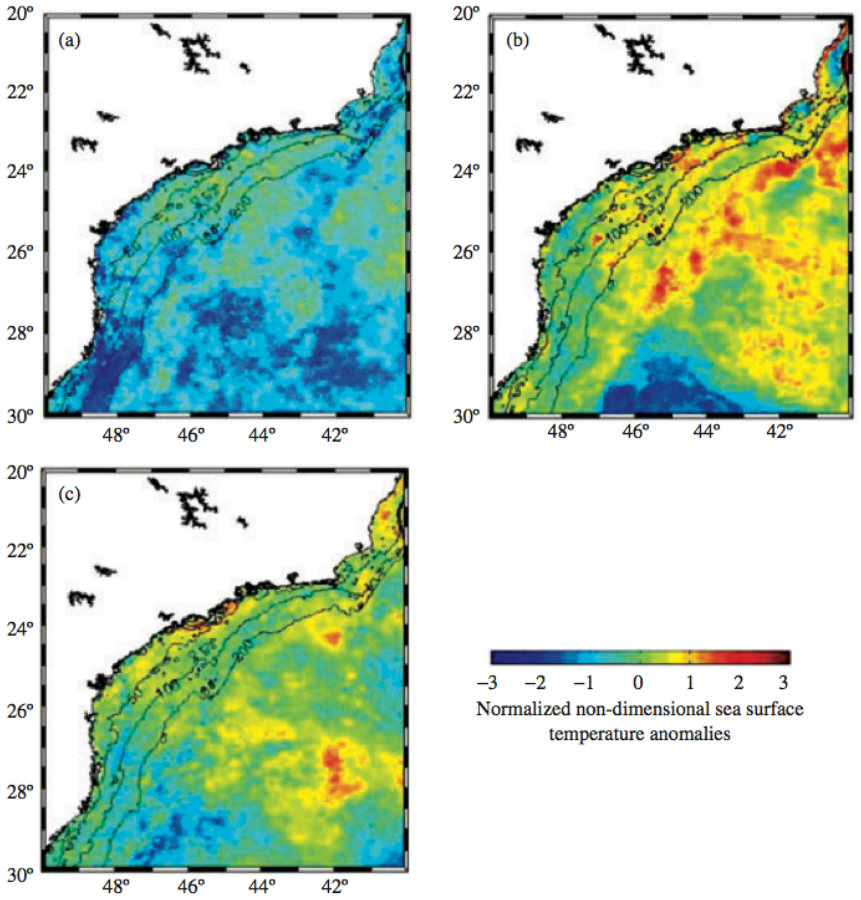

FIG. 10. Normalized (non-dimensional) sea surface temperature anomalies (SSTA) maps derived from satellite data for the spawning habitat relative to: (a) 1993 (case representing a habitat expansion), (b) 1988 and (c) 1991 (cases for the habitat contraction).

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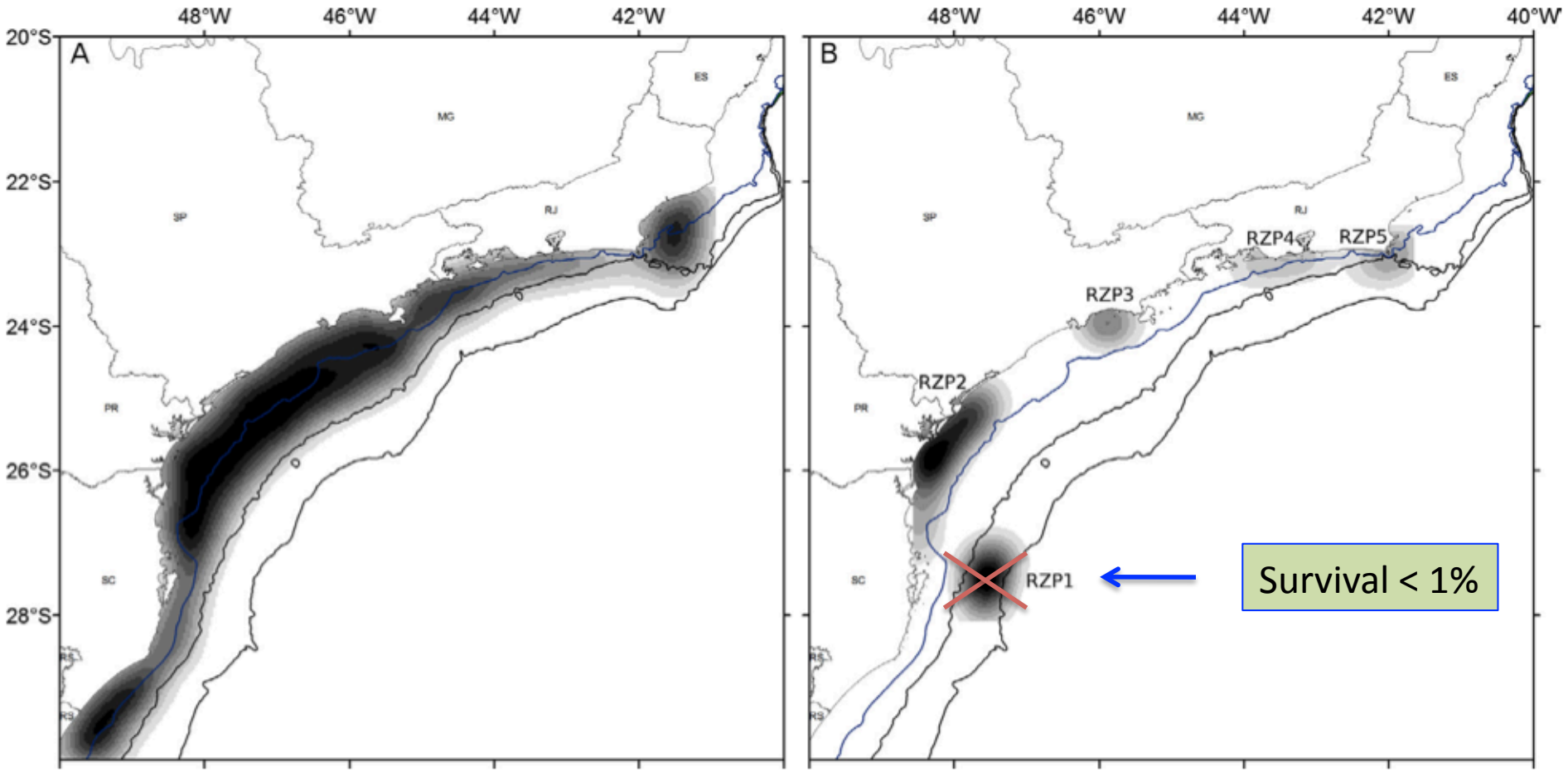
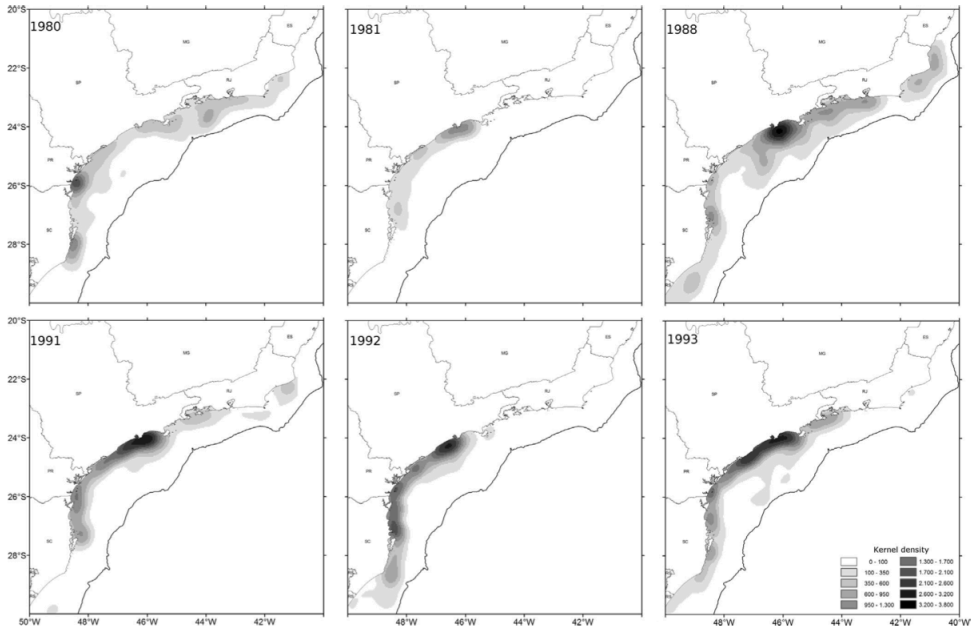
Modeling the spawning strategies and larval survival of the Brazilian sardine (*Sardinella brasiliensis*)

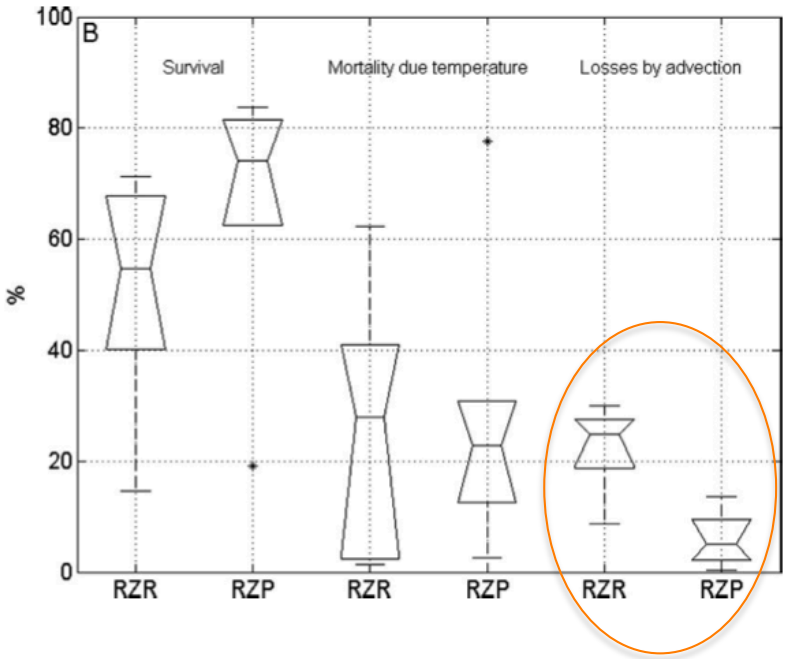
Daniela Faggiani Dias [a,*], Luciano Ponzi Pezzi [a], Douglas Francisco Marcolino Gherardi [a], Ricardo Camargo [b]



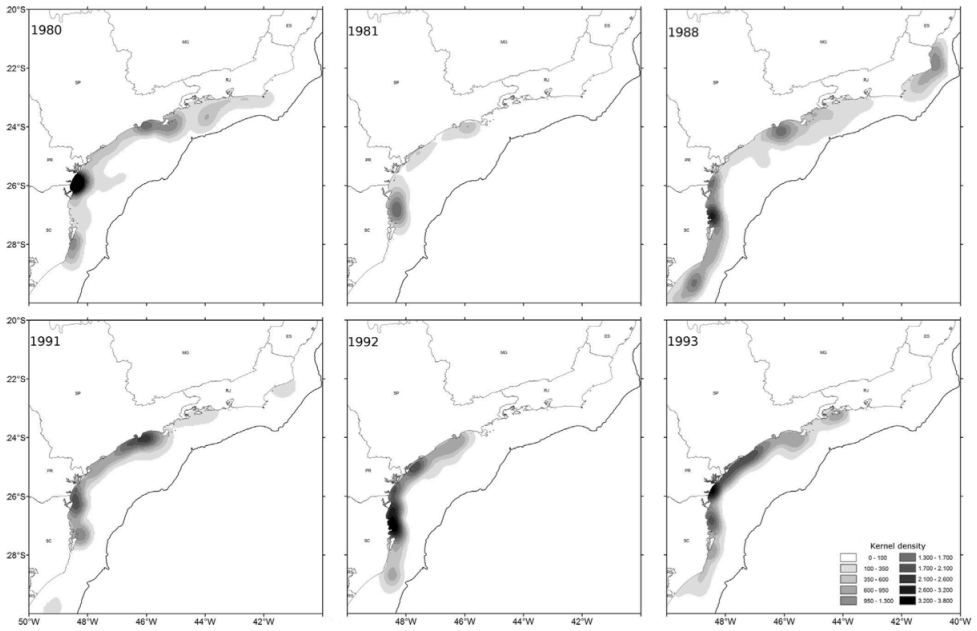
Survival kernel: random spawning



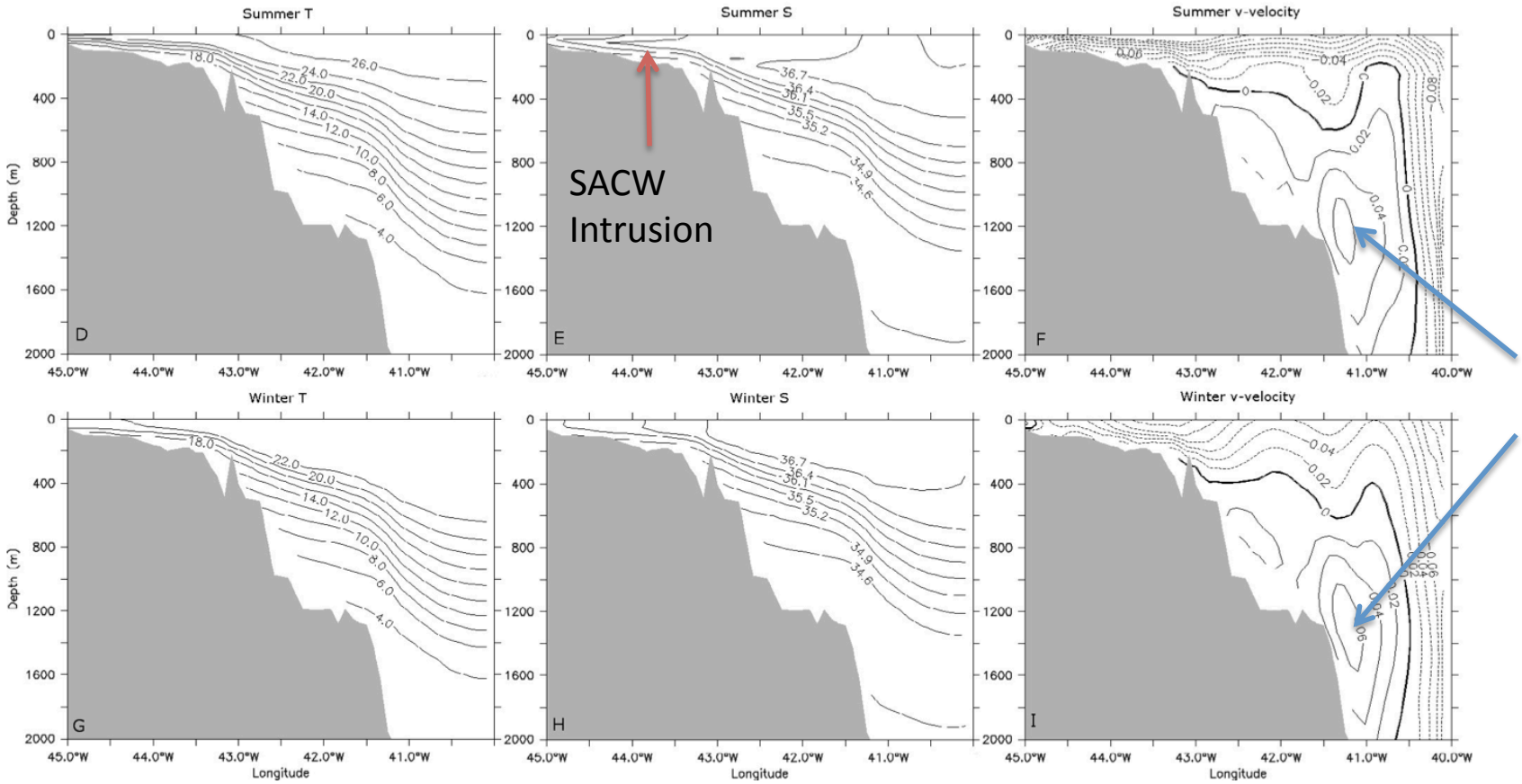
ROMS and ICHTHYOP:
horizontal resolution: 1/12° (~ 9.2 km)
30 sigma levels; 27 yrs; 10,000 eggs.



Survival kernel: spawning habitats



Modeled mean water temperature, salinity and meridional current velocities at 24°S latitude



- Summer stratification of temperature and salinity in the upper 200 m.
- The low salinity and high temperature Coastal Water.
- The warmer and more salinity Tropical Water.
- Cold (3°C to 6°C) Antarctic Intermediate Water.

PLOS ONE

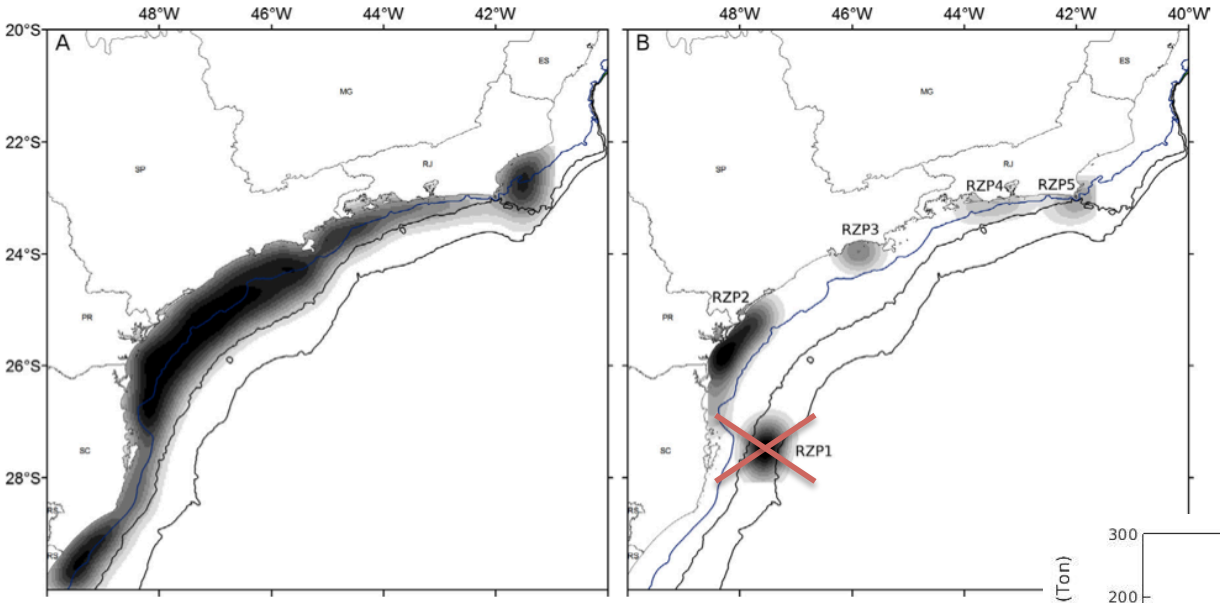
Time series of sardine landings: 1980 – 2007
Selected years: 12 min.; 6 max.

RESEARCH ARTICLE

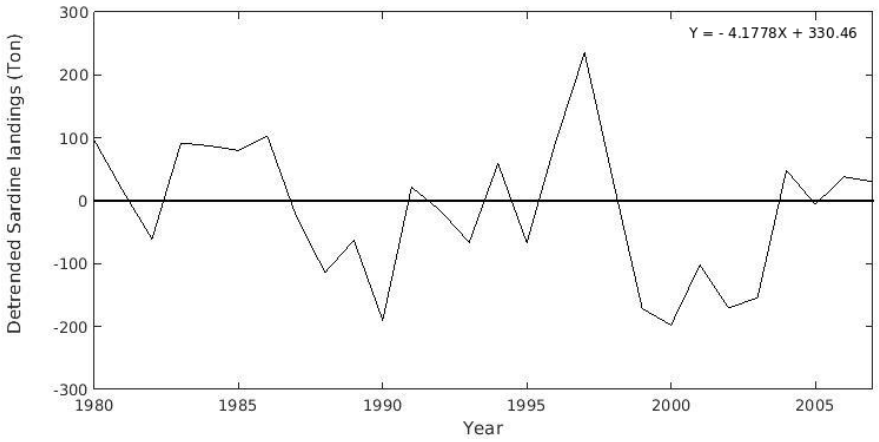
Do the Brazilian sardine commercial landings respond to local ocean circulation?

Mainara B. Gouveia[1]*, Douglas F. M. Gherardi[1], Carlos A. D. Lentini[2,3], Daniela F. Dias[1], Paula C. Campos[1]

1 National Institute for Space Research (INPE), Remote Sensing Division, São José dos Campos, São Paulo, Brazil, **2** Instituto de Física – Departamento de Física da Terra e do Meio Ambiente, Universidade Federal da Bahia - UFBA, Salvador, Bahia, Brazil, **3** GOAT - Grupo de Oceanografia Tropical, Universidade Federal da Bahia - UFBA, Salvador, Bahia, Brazil



GEV: select years of max/min landings.
Weibull distribution was chosen based on the GEV shape parameter and tested with the one-tailed K–S statistic test (α = 0.05, n = 27).



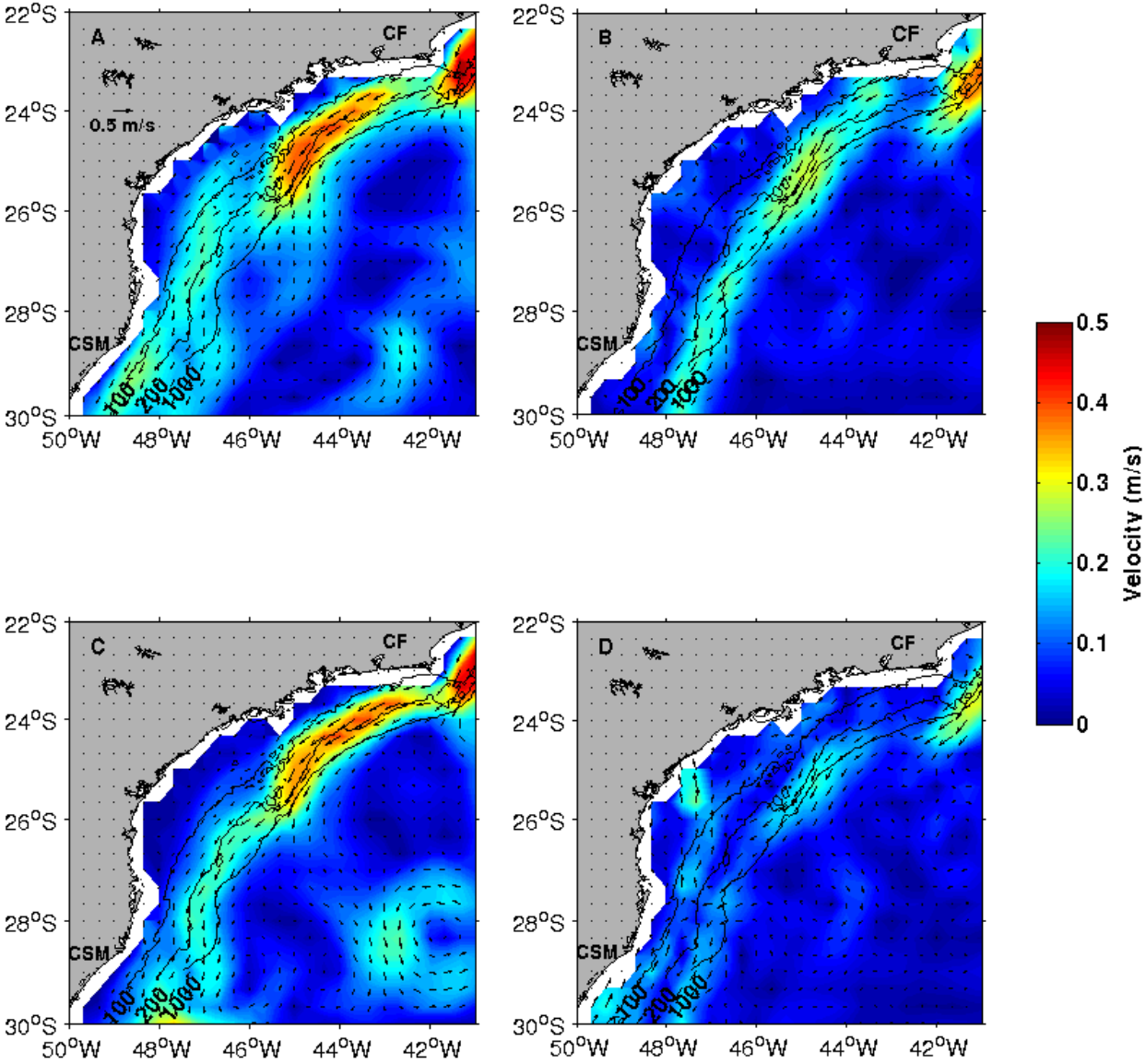
ROMS

OSCAR

Summer

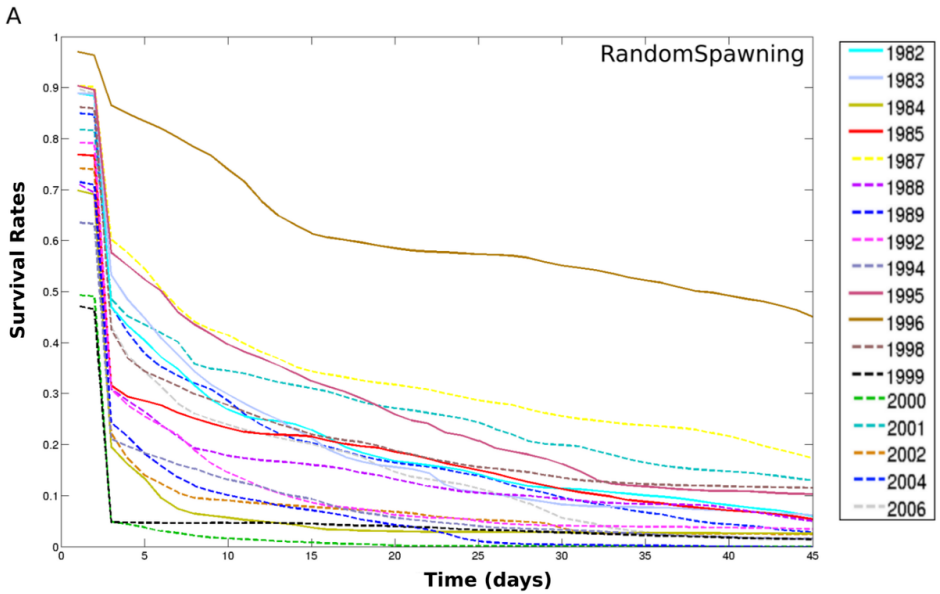
Winter

ROMS: 1/12° (~ 9.2 km).
OSCAR: 1/3° (~ 36.7 km).

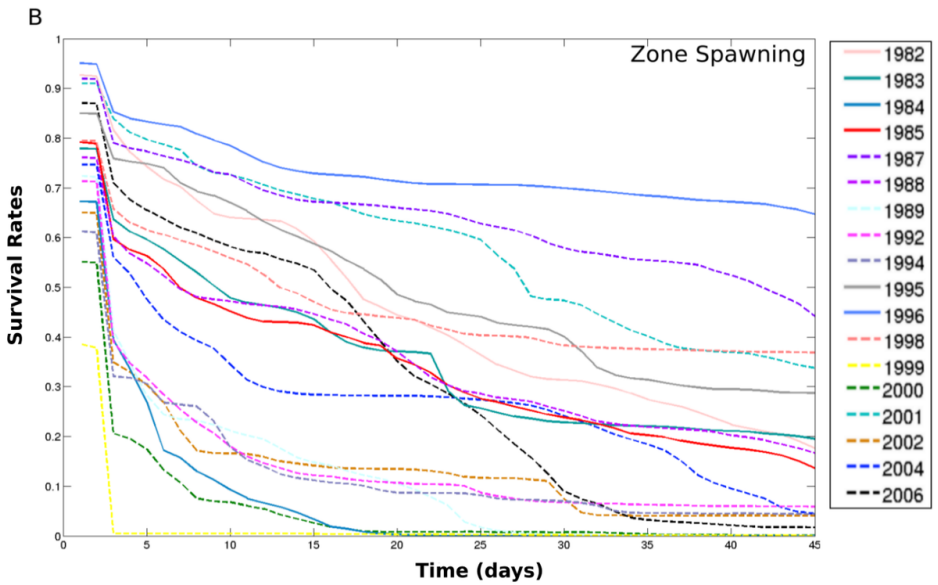


ROMS and ICHTHYOP:
horizontal resolution: 1/12° (~ 9.2 km)
30 sigma levels; 27 yrs; 30,000 eggs.

Random spawning

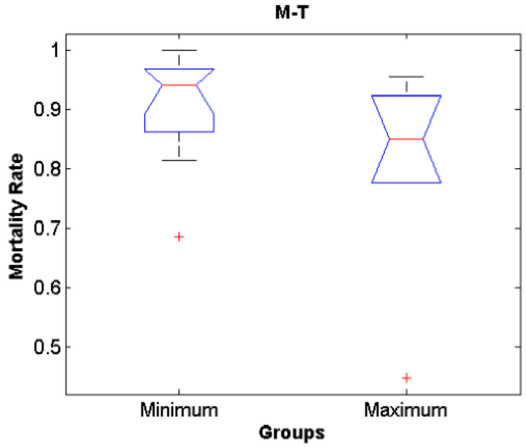


Zone spawning

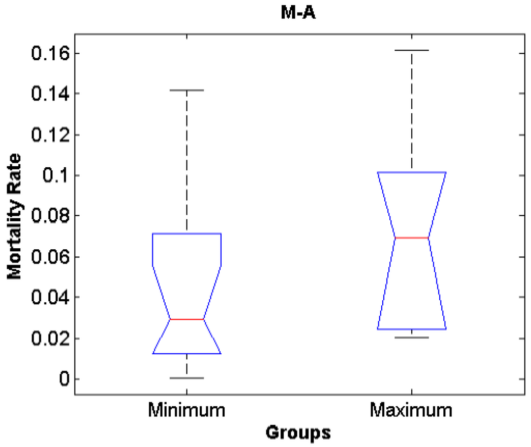


High early mortality consistent with observation.

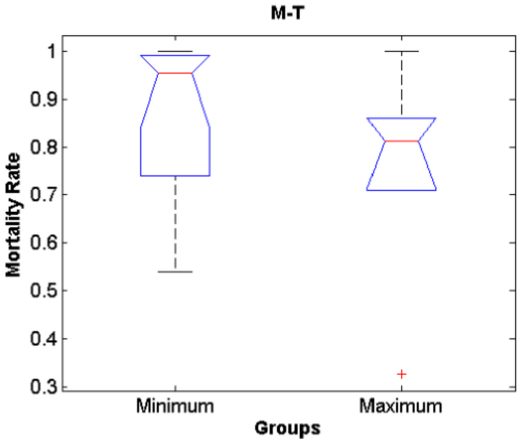
Mortality temperature

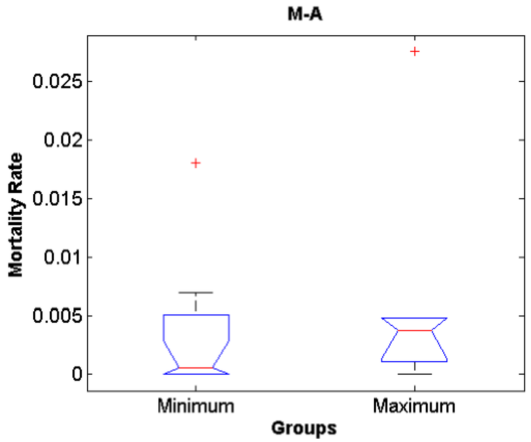


Mortality advection



Random spawning: maximun and minimun landings.

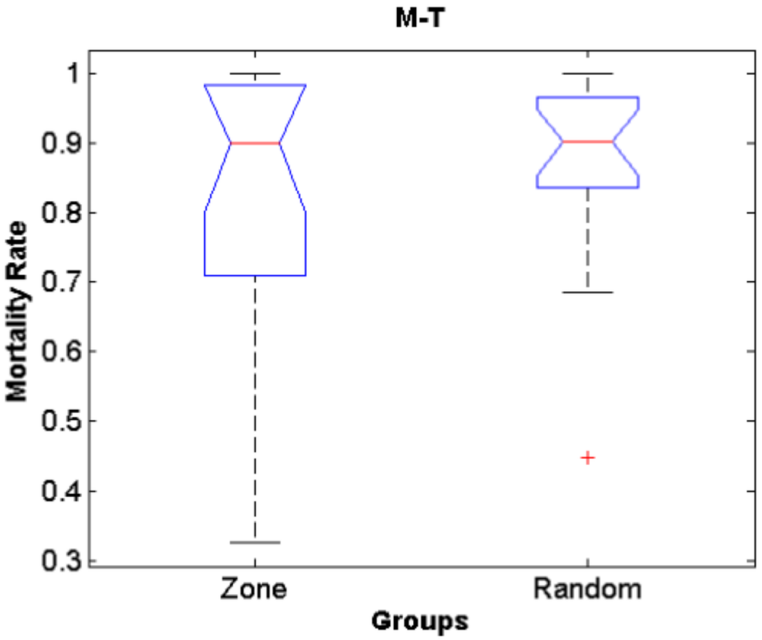


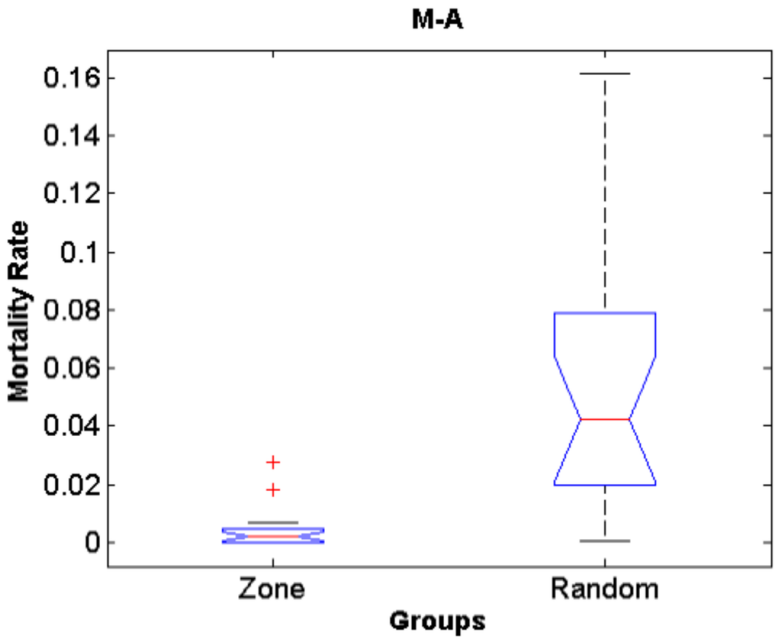


Zones spawning: maximun and minimun landings.

All years grouped: no differences between mortalities by temperature, but significant diffferences for advection.

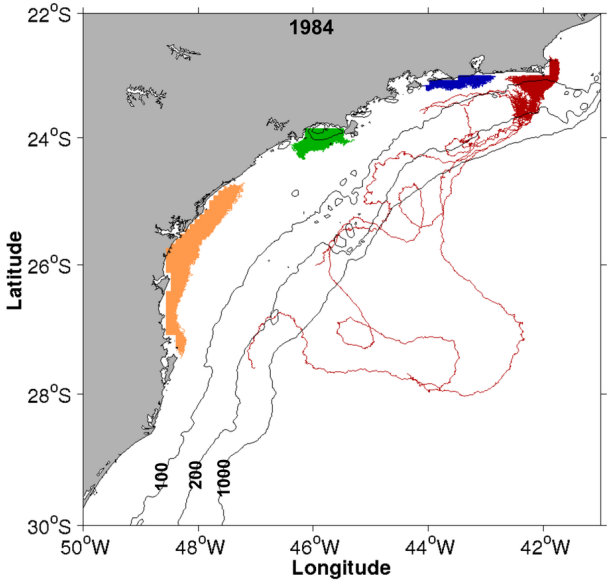
WHY?

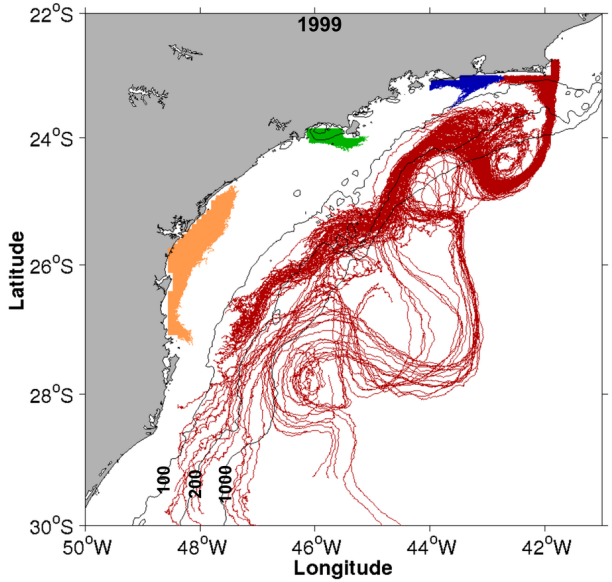




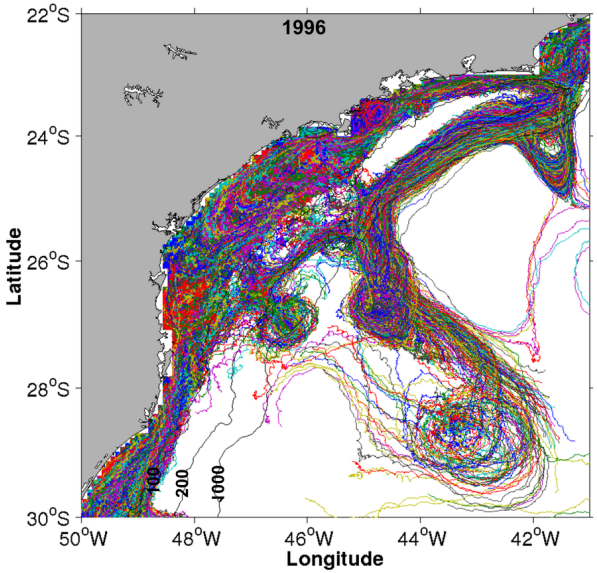
ICHTHYOP simulations

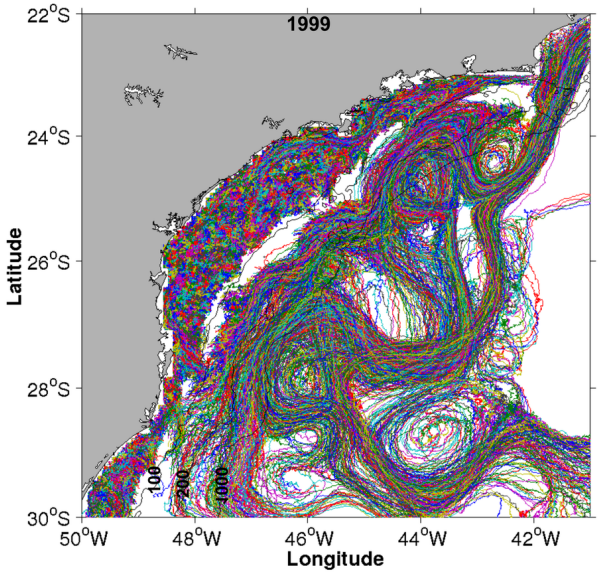
Zone spawning





Random spawning





What's next?

Mycteroperca sp. (grouper)

RESEARCH ARTICLE

Connectivity of Marine Protected Areas and Its Relation with Total Kinetic Energy

Andressa D'Agostini*, Douglas Francisco Marcolino Gherardi, Luciano Ponzi Pezzi

Remote Sensing Department (DSR), National Institute for Space Research (INPE), São José dos Campos, São Paulo, Brazil

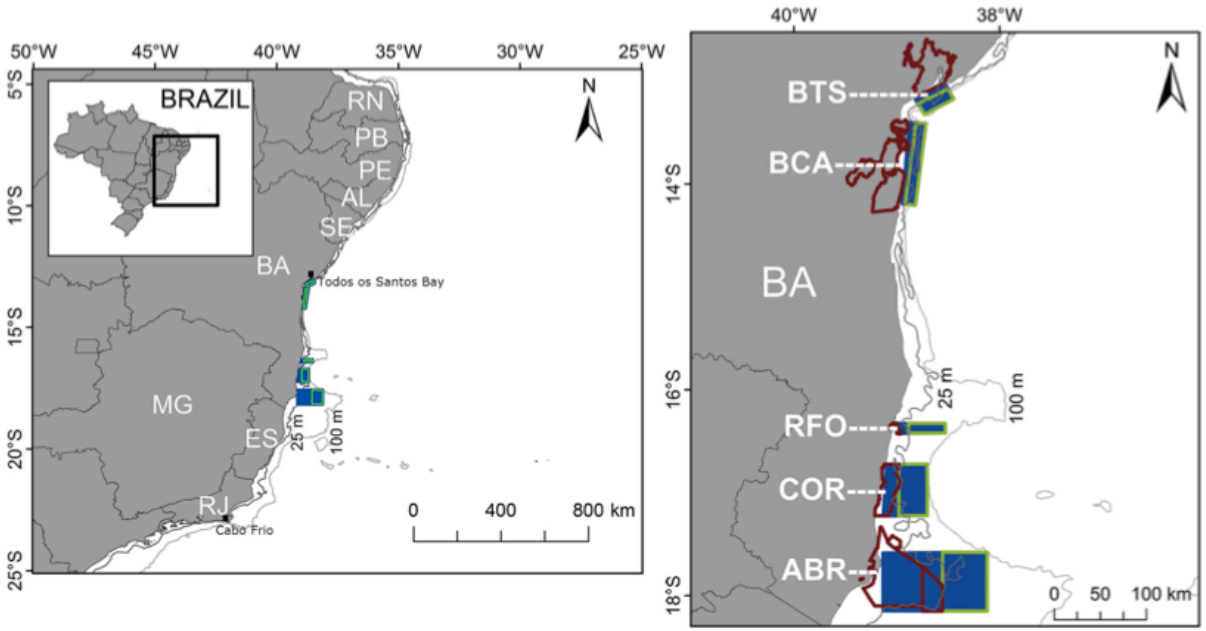


Fig 1. Study area map with the domain of the hydrodynamic model on the left map. The right map presents with detail the spawning areas (polygons outlined in light green), recruitment areas (polygons in navy blue), and MPAs shapes (polygons outlined in dark red). ABR = Marine National Park of Abrolhos and the Area of Environmental Protection (EPA) of Ponta da Baleia; COR = Marine Extractive Reserve of Corumbau; RFO = Municipal Park of Recife de Fora; BCA = EPA of Pratigi, EPA of Tinharé Islands and EPA of Camamu Bay; BTS = EPA of Todos os Santos Bay.

doi:10.1371/journal.pone.0139601.g001

ROMS:
horizontal resolution: 1/24° (~ 4.5 km)
30 sigma levels; 25 yrs.; 30,000 eggs.

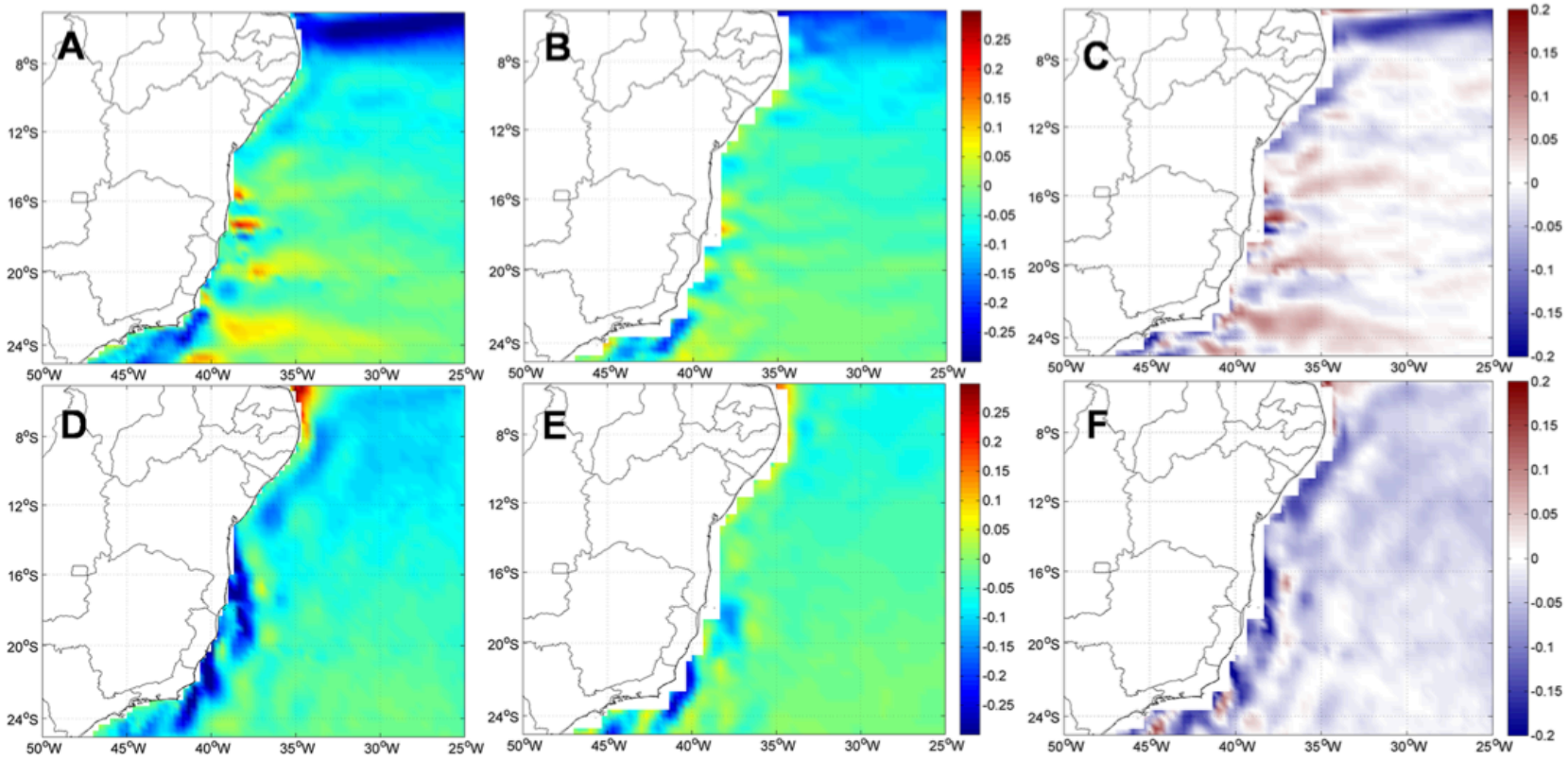


Fig 3. Annual SSC means, in m.s^{-1}, of zonal component (U, above) and meridional component (V, below) from ROMS (A, D) and OSCAR (B, E), and their differences (ROMS—OSCAR, zonal C, meridional F).

doi:10.1371/journal.pone.0139601.g003

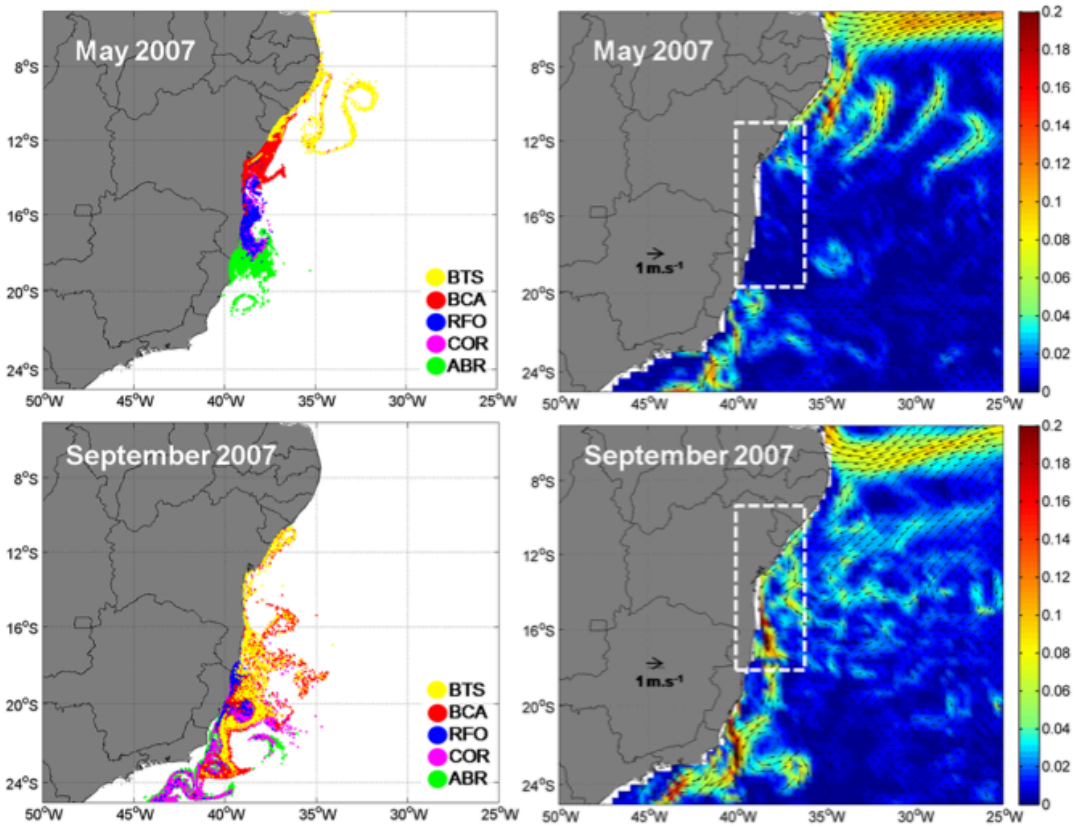


Fig 8. Larval dispersal (left), KE ($m^2.s^{-2}$, right) and surface current vectors for May (top) and September (bottom) of 2007. The dashed areas highlight the region where the spawning and recruitment areas are located.

R = 0.46 (p = 0.0047)

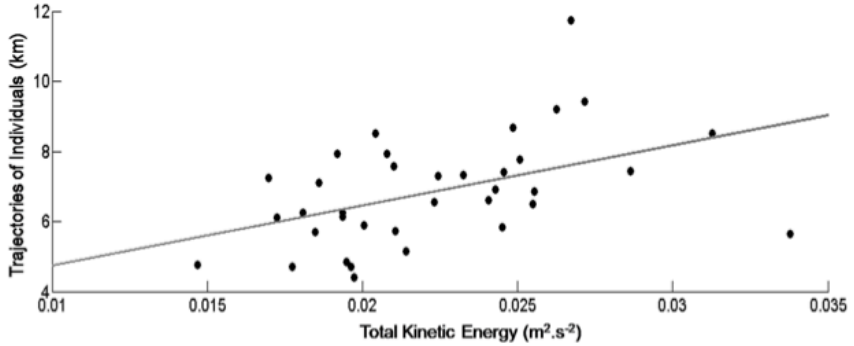
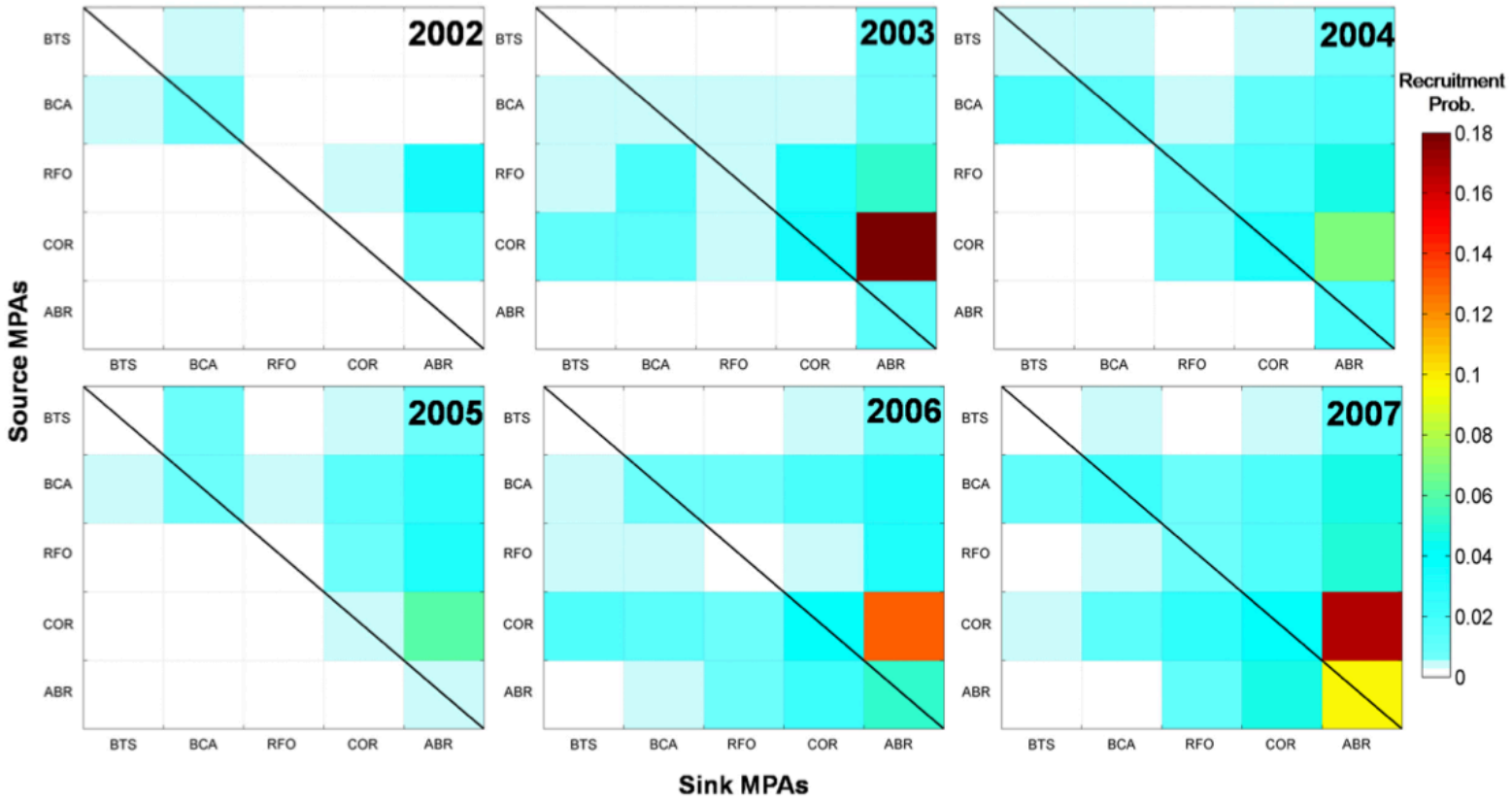


Fig 10. Monthly means of KE, in $m^2.s^{-2}$ and larvae total dispersal distance, in km.

	Kruskal-Wallis ANOVA significance level of 5%	
	self-recruitment	recruitment
Months	0.4489	0.4606
Interannual	0.546	***0.0072***

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Thank you!