Identifying and characterizing biodiversity hotspots in the BCLME: its relevance in the light of climate change

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REPUBLIC OF SOUTH AFRICA

NansClim
Climate effects on biodiversity, abundance and distribution of marine organisms
A PROJECT FUNDED BY NORAD

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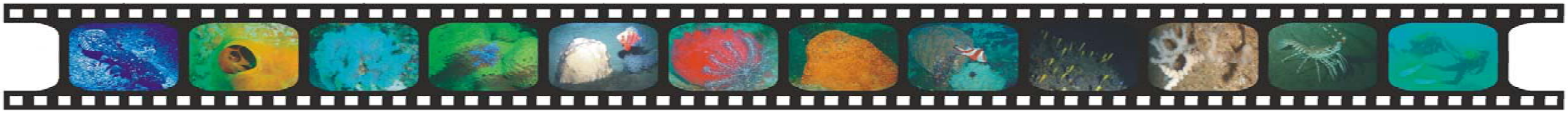
Climate effects on biodiversity, abundance and distribution of marine organisms

A PROJECT FUNDED BY NORAD

- Collaborators: Norway, Angola, Namibia, South Africa
- Aims: Identifying and describing possible trends in ocean climate and corresponding changes in marine biodiversity and fisheries (Benguela Current Large Marine Ecosystem)
- 3 components: Environmental, Pelagic, Demersal

INTRODUCTION

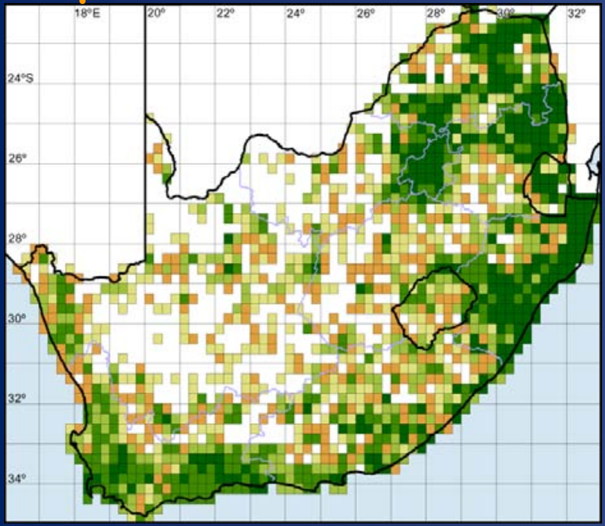
- Biological "hotspots" in the marine realm generally refer to localised areas of biological importance, associated with key processes e.g. spawning, nursery or feeding areas, or with significantly elevated levels of productivity/biodiversity relative to surrounding seascape
- Given their potential (supporting human livelihoods / conservation of biodiversity and natural processes), identifying biological hotspots and determining which factors govern and maintain them is a growing area of research
- In this study, biodiversity characteristics used to define hotspots, in accordance with the definition of a biodiversity hotspot as a biogeographic area with a significant reservoir of biodiversity



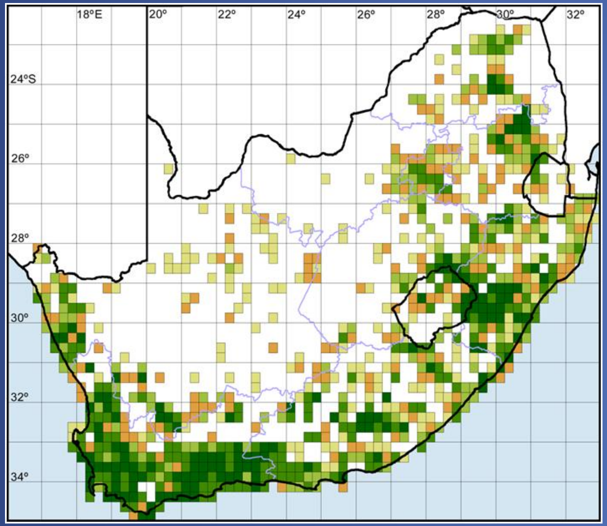
- Species abundance and distributional data frequently employed to identify biodiversity hotspots for prioritising conservation, especially in terrestrial realm

- Biodiversity criteria such as peaks in species richness/ endemism/ rarity have generally been considered

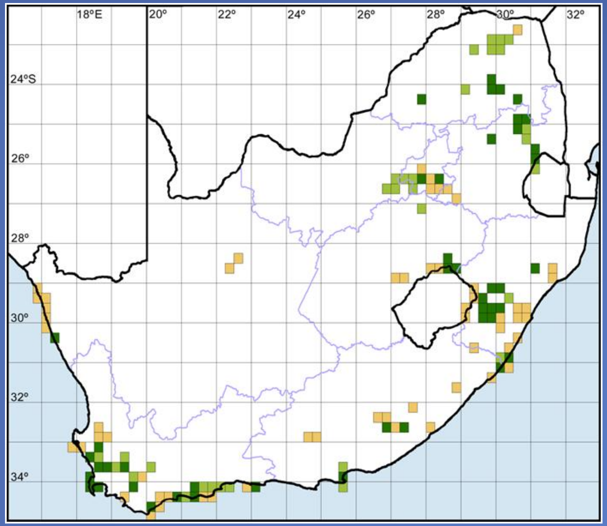
Species richness



Endemic taxa



Threatened taxa



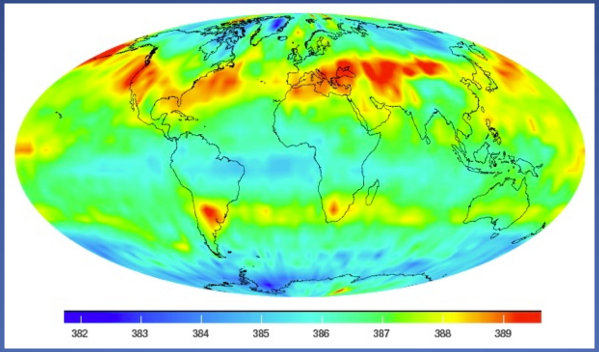
Southern Africa Butterfly Conservation Assessment

- In the marine realm, relatively little consideration has been given to benthic/ demersal communities in the identification biodiversity hotspots to prioritise conservation (notwithstanding coral reefs and some other features)
- Pelagic species (mainly top predators) are frequently focused on either because they are of conservation concern or are relatively easy to study and can be used as a surrogates for wider biodiversity



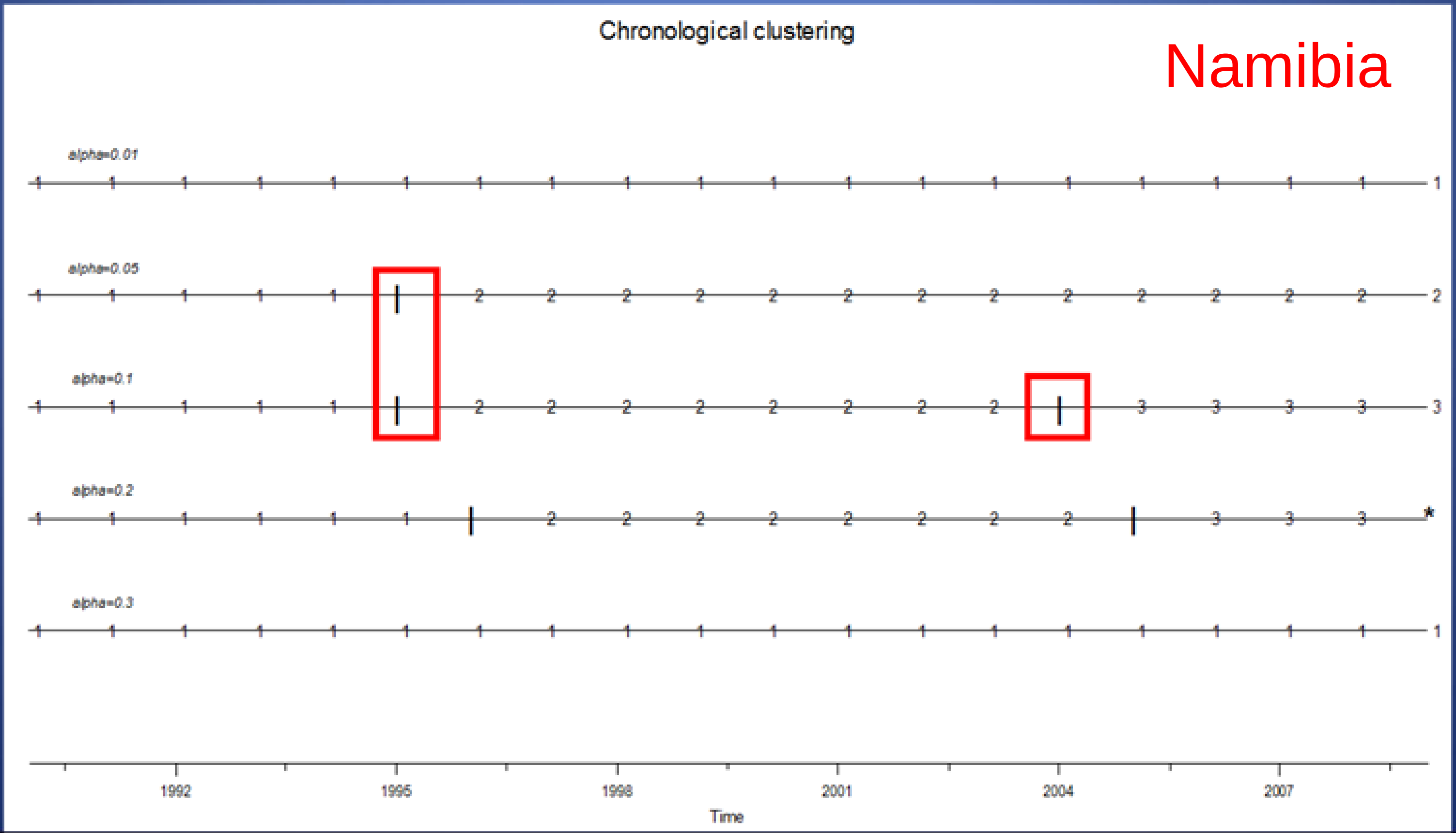


- However, biodiversity hotspots based on top predators or other pelagic species may not be applicable for much of the fauna existing at or near the ocean bottom



- Climate change regarded as major threat to global biodiversity: localized/regional reductions in biodiversity levels , and distributional change, range expansion and contraction of many organisms, have been associated with climatic stress
- Spatio-temporal changes in biodiversity hotspots may provide useful indication of climate change effects
- Understanding of hotspots including spatial and temporal determinants is potentially key for biodiversity conservation especially in light of climate and other global changes

- Recent studies have shown long-term warming of SST in large areas of BCLME
- In a parallel study (Samaai et al.), preliminary multivariate analyses indicated shifts in demersal community composition Namibia (~1995, ~2004), Angola (~1995) and South Africa (~1986, ~1992, ~2004)
- Yemane et al. changes in distribution and range sizes of demersal species in BCLME
- Are such shifts reflected in spatio-temporal changes of biodiversity hotspots?

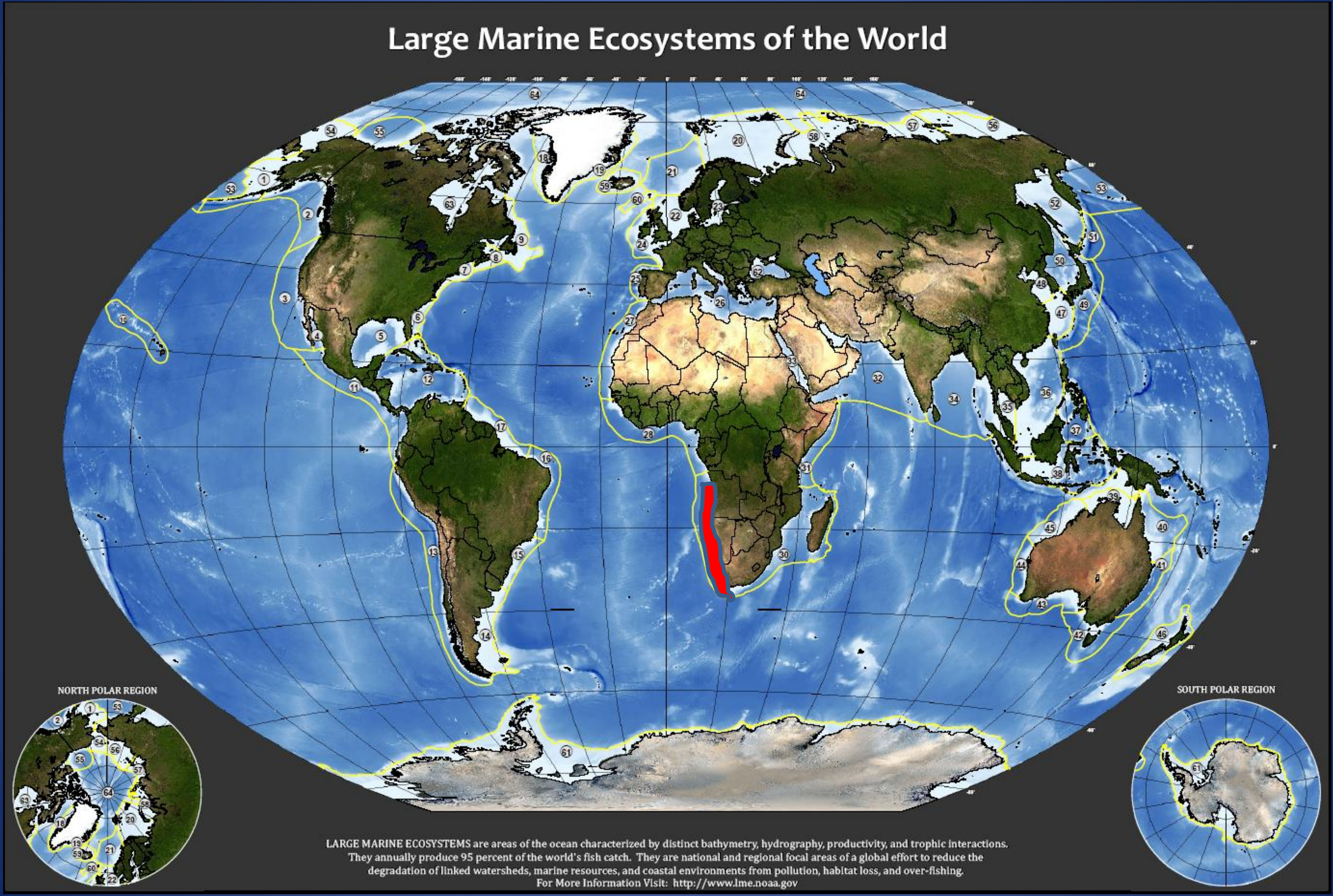


AIMS

1. Identifying demersal biodiversity hotspots in BCLME
   -Comparison of methods for identifying and characterising hotspots
2. Assessing the persistence of hotspots in space and time
3. Assessing relationships between biodiversity levels and physical, environmental variables
4. Assessing the implications of potential future climate change effects for the spatio-temporal variability of biodiversity hotspots



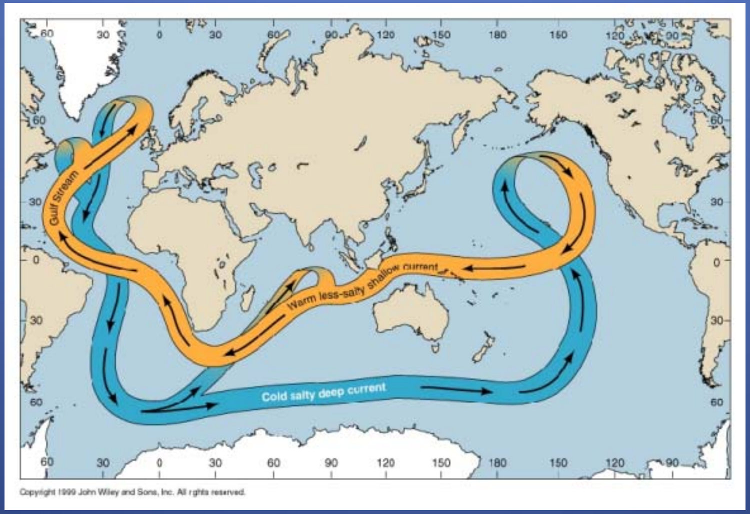

STUDY AREA



Large Marine Ecosystems of the World
NORTH POLAR REGION
SOUTH POLAR REGION
LARGE MARINE ECOSYSTEMS are areas of the ocean characterized by distinct bathymetry, hydrography, productivity, and trophic interactions. They annually produce 95 percent of the world's fish catch. They are national and regional focal areas of a global effort to reduce the degradation of linked watersheds, marine resources, and coastal environments from pollution, habitat loss, and over-fishing.
For More Information Visit: http://www.lme.noaa.gov

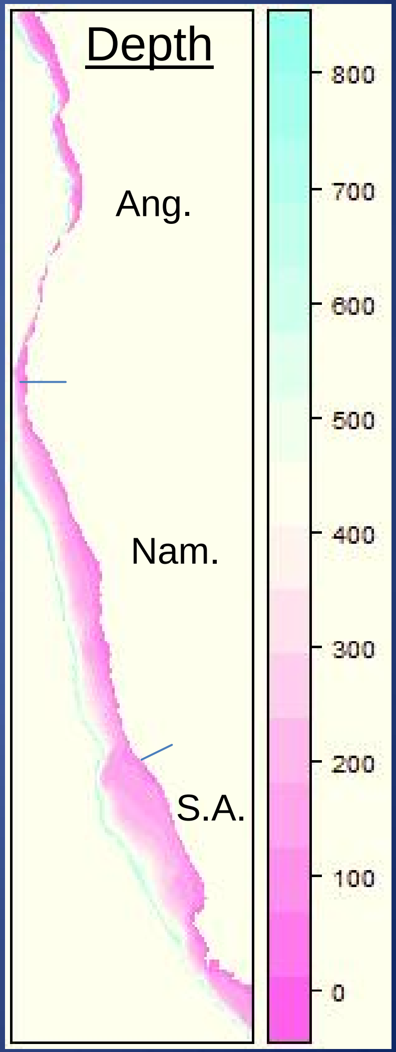
- The BCLME is one of four major eastern boundary coastal upwelling ecosystems of the world; supports important reservoir of biodiversity and biomass of zooplankton, fish, seabirds, marine mammals

- Given the key situation of its southern extent with regard to the Global Climate Conveyor Belt and other interactions with neighbouring ocean systems, the BCLME is considered to be critically located in terms of the global climate system, but also critically vulnerable to any future climate change or variability in climate



Survey Methods

- Use of fishery-independent data from routine demersal biomass assessment surveys – Nansen Programme and related survey programmes in the region – summer surveys only
  - Angola: 1985-2010 (RV Dr Fridtjof Nansen): 2768 stations
  - Namibia: 1990-1999 (RV Dr Fridtjof Nansen), 1999-2010 (Blue Sea II) : 4219 stations
  - South Africa: 1984-2010 (RV Africana): 2528 stations
- Angola and Namibia: bottom trawls at depths 20-800 m, locations followed a semi-random distribution based on a 10x10 min grid
- South Africa: bottom trawls at depths 30-500 m, locations followed a pseudo-random distribution based on a 5x5 min grid



Data collection and analysis

- Used demersal fish data only
  - Most reliable data
  - The heterogeneous nature of fish distributions can make them relatively effective surrogates for other marine taxa including molluscs, echinoderms, crustaceans and higher predators
- Catch rate for the study was defined as the biomass caught per standard trawl (i.e. standardised to 30 min tow duration)




- Using species composition and catch rate (kg) of each species, two diversity indices estimated per trawl station
  Species richness (*S*)
  Shannon-Wiener index (*H'*)

- Inverse Distance Weighting (IDW) used to interpolate diversity indices over entire study grid, for the entire period or for sequential shorter periods to assess time dynamics (~5 y)

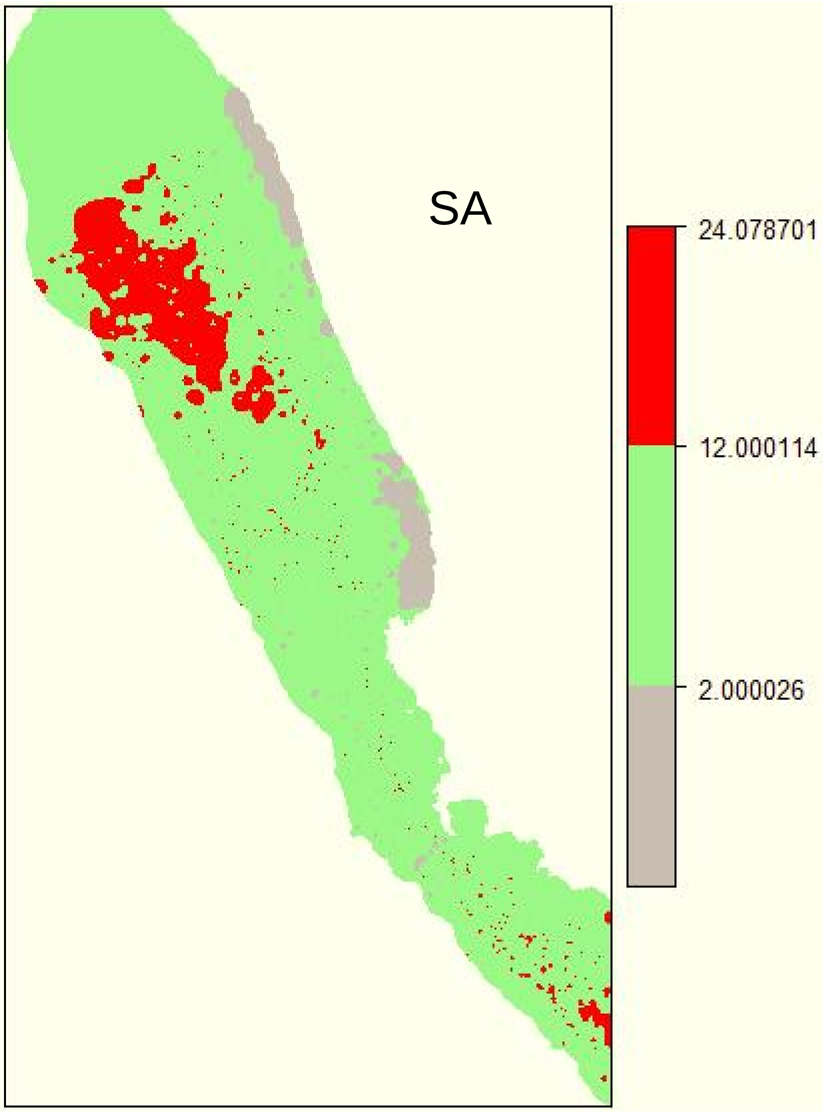
- Generalized Additive Models (GAM)/ Generalized Linear Models (GLM) used to model diversity indices over study grid, using gridded bathymetry data (GEBCO), lat and long positions as predictors.
  - Model selection using AIC

- Spatial areas were considered hotspots if their diversity was in the top 5% (diversity >=95% quantile)

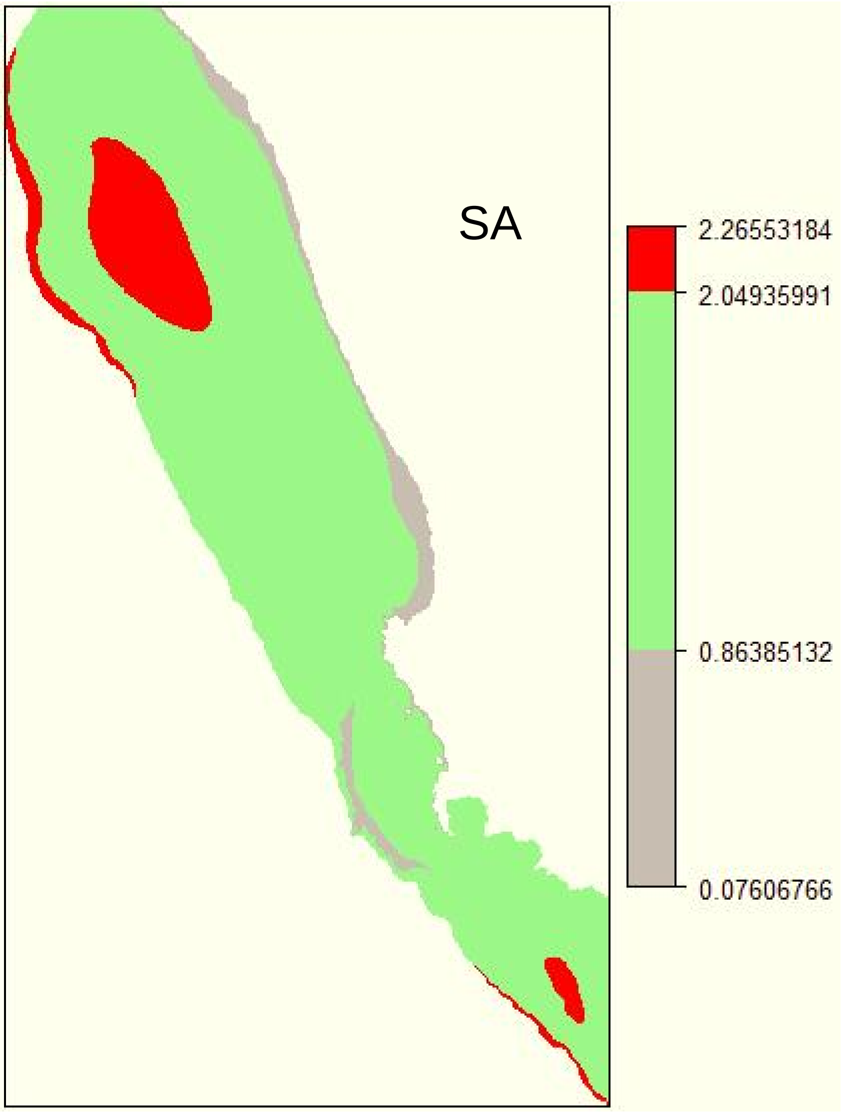
- Analyses in PRIMER - E 5P (Warwick and Clark 1991) and R 2.14.0 (R Development Core team)

Results

Species richness quantiles

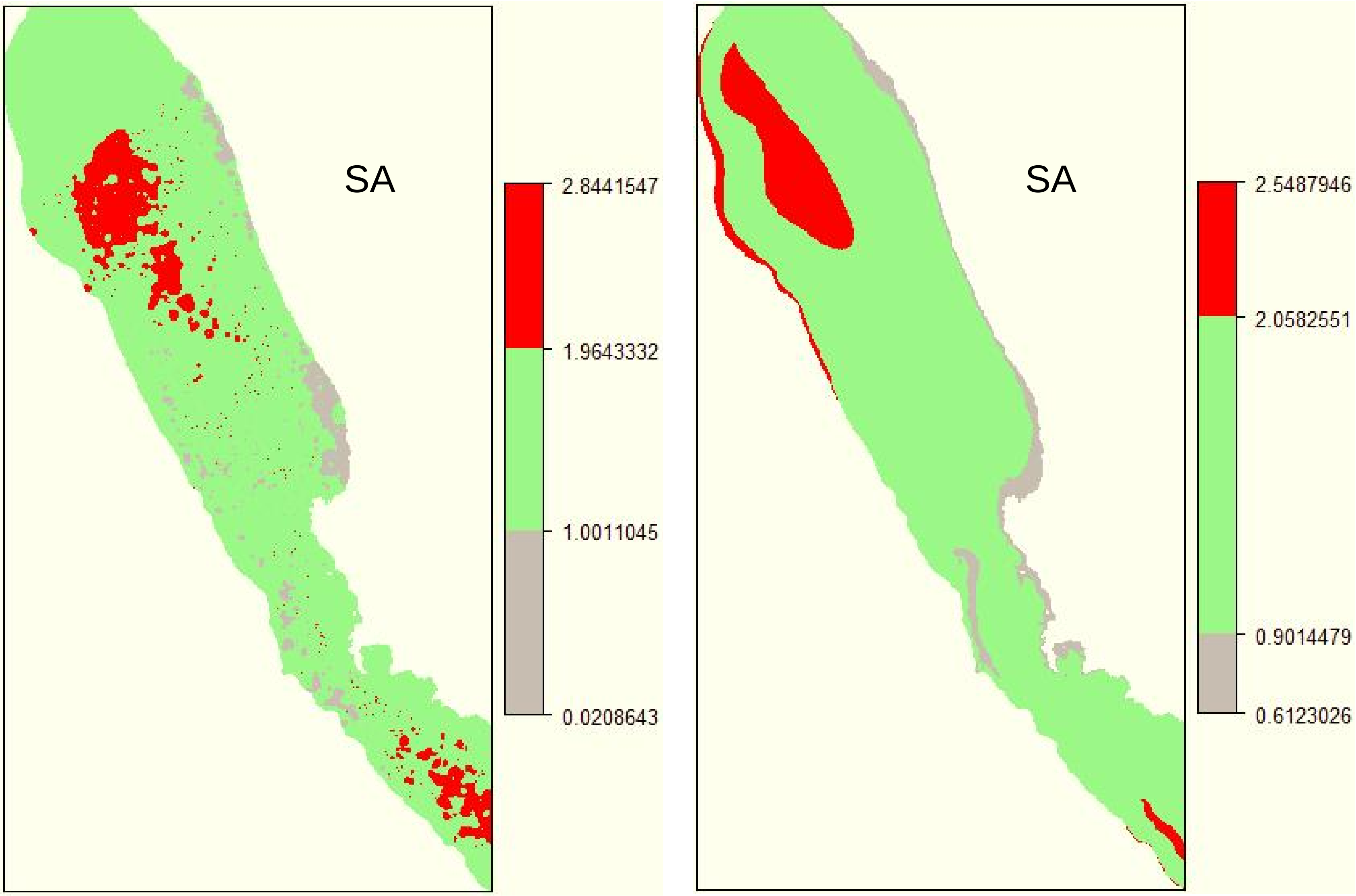


IDW interpolation



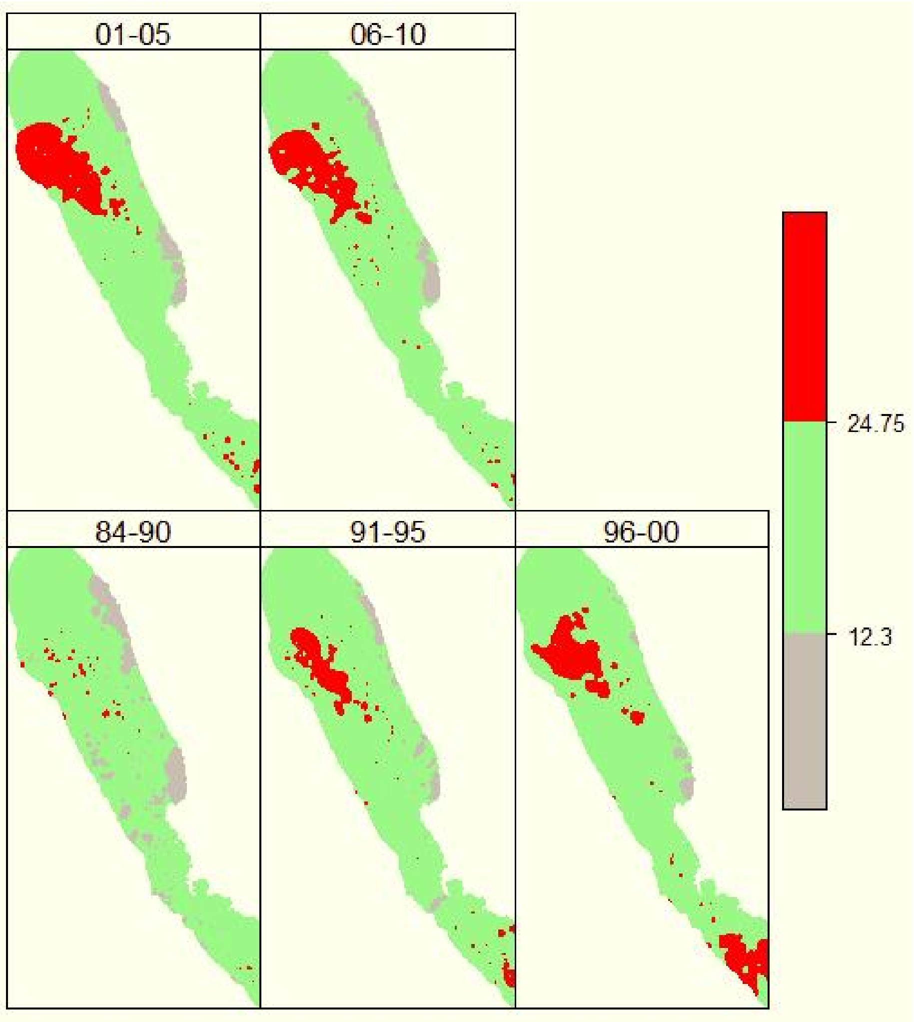
GAM model (Poisson) predictions

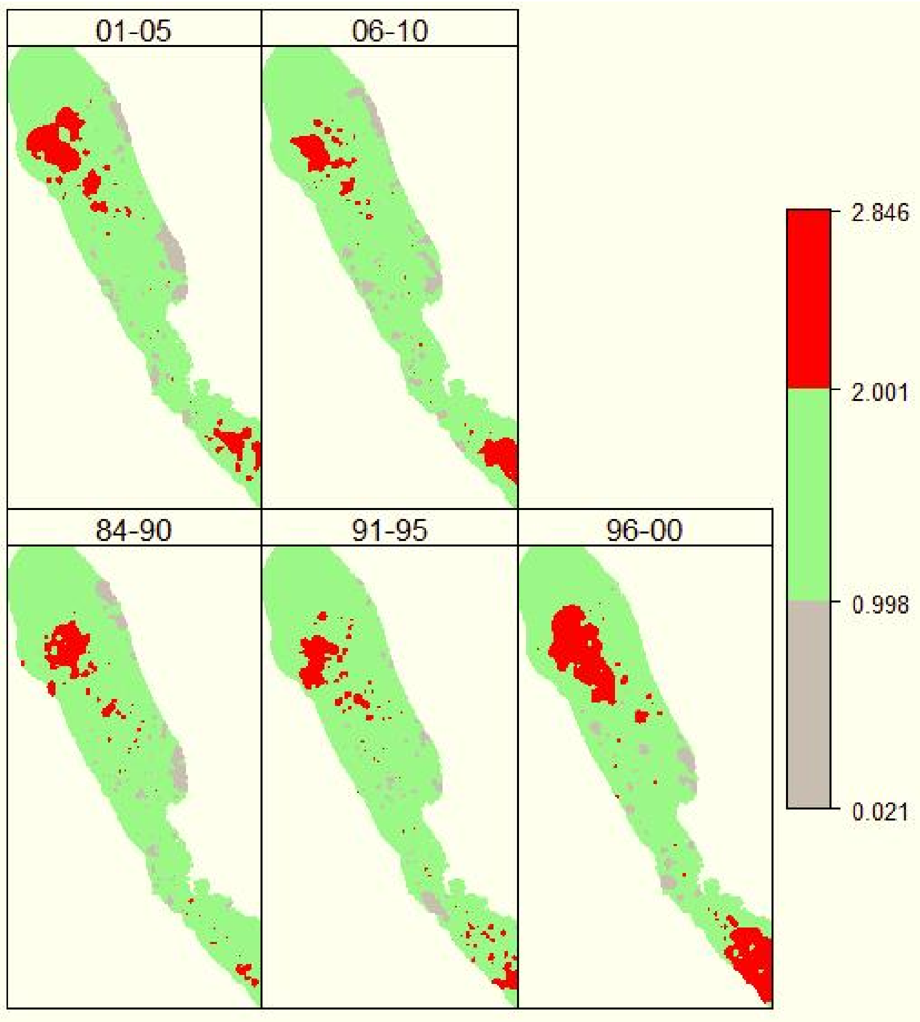
Shannon-Wiener index quantiles



IDW interpolation **GAM model (Gaussian) predictions**

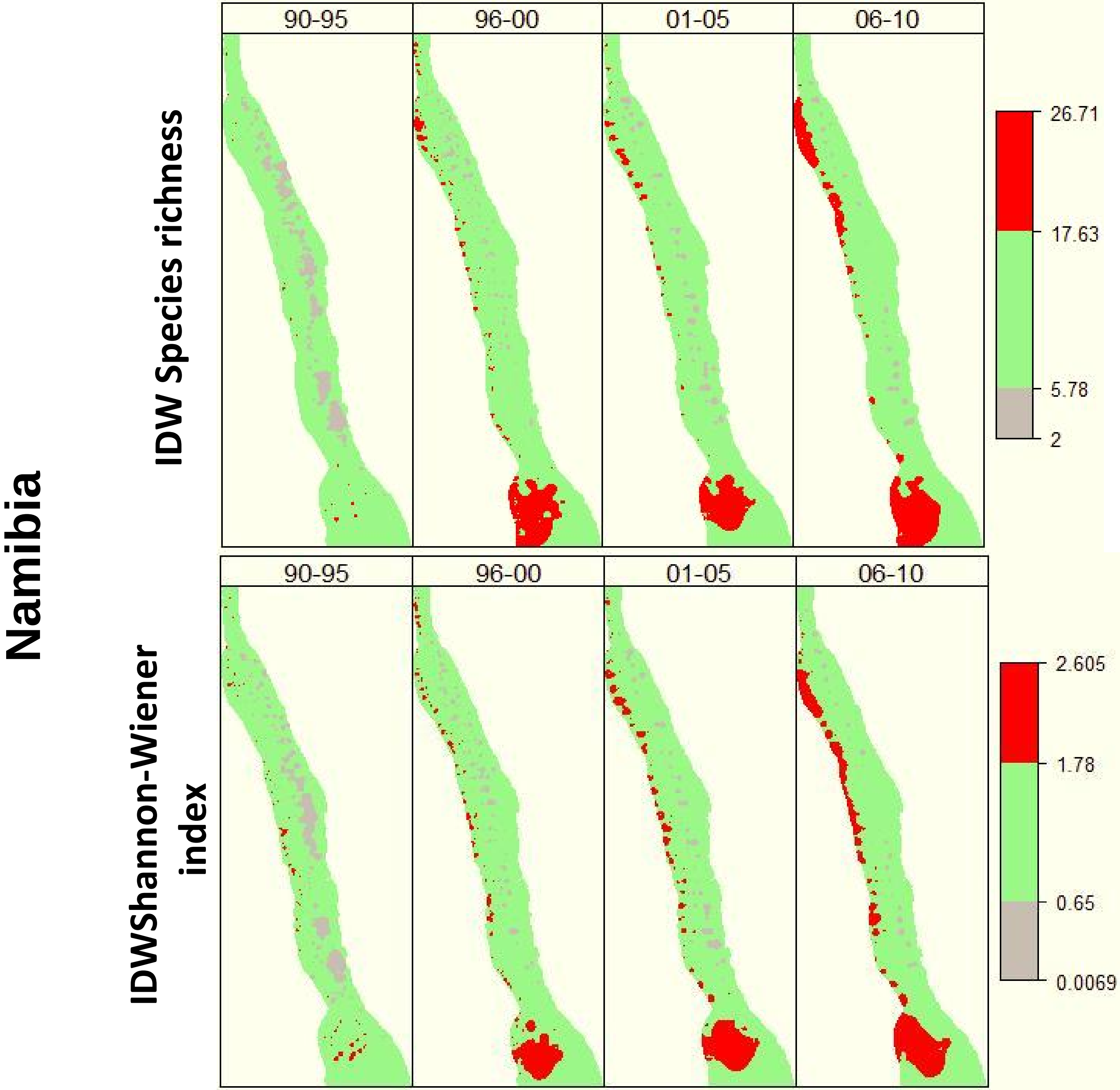
South Africa



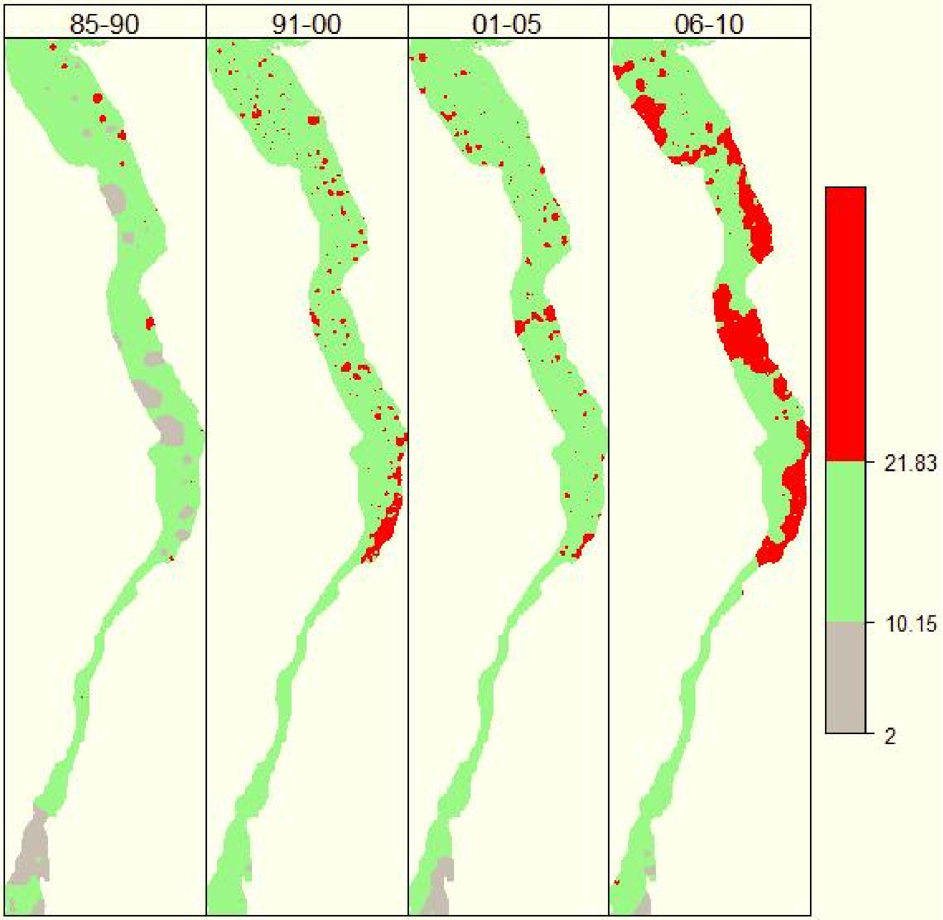


IDW Species richness

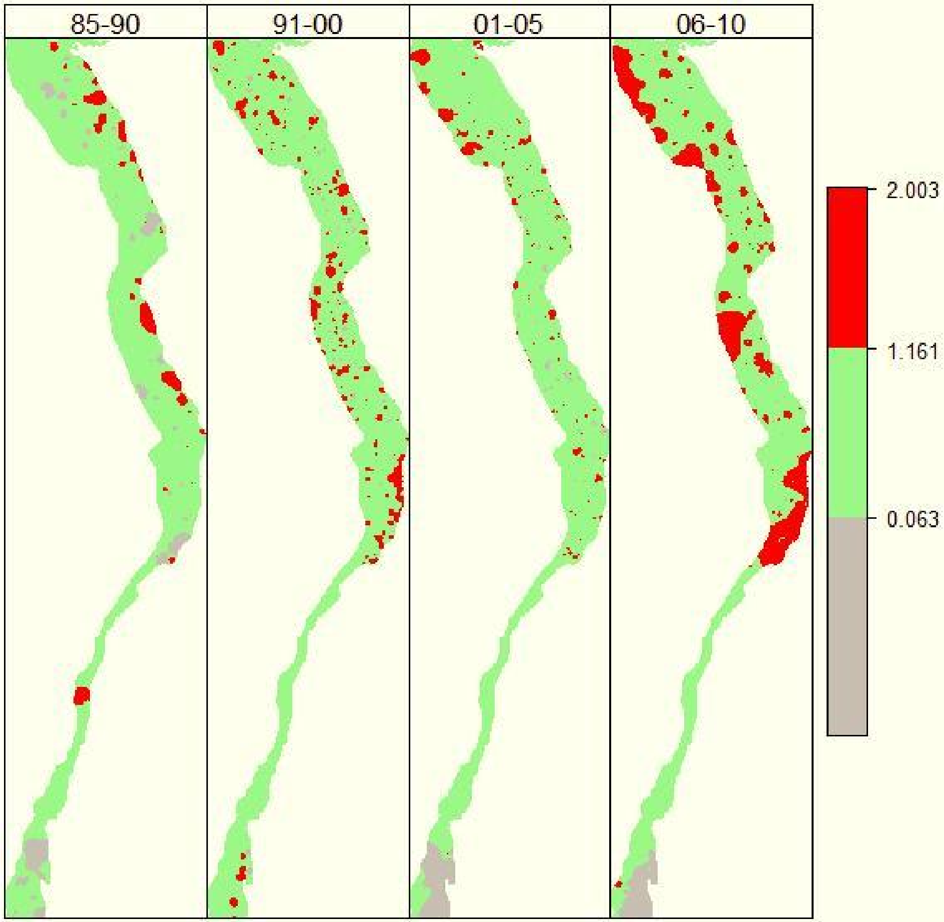
IDW Shannon-Wiener index


Namibia
IDW Species richness
90-95
96-00
01-05
06-10
26.71
17.63
5.78
2
IDWShannon-Wiener index
90-95
96-00
01-05
06-10
2.605
1.78
0.65
0.0069

Angola

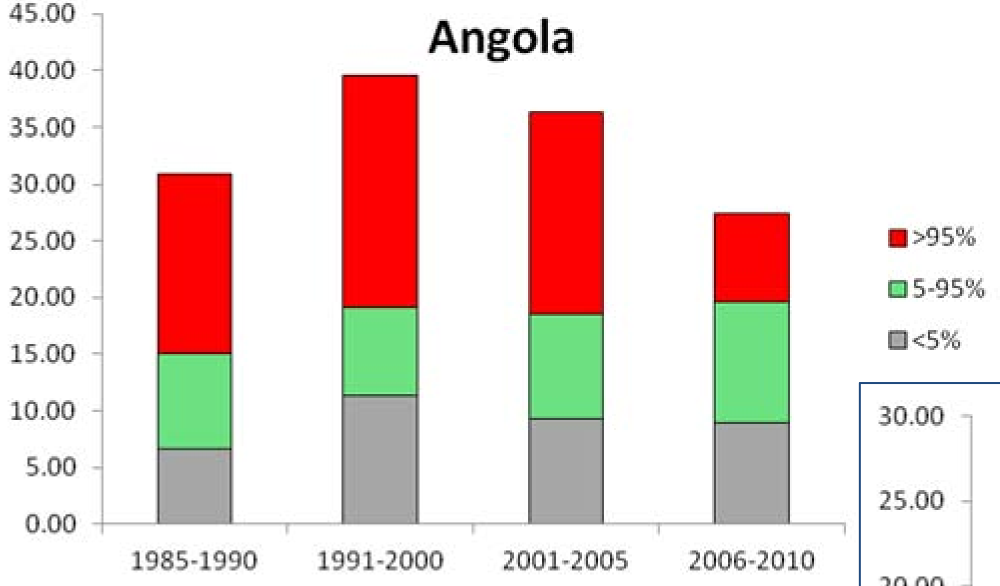


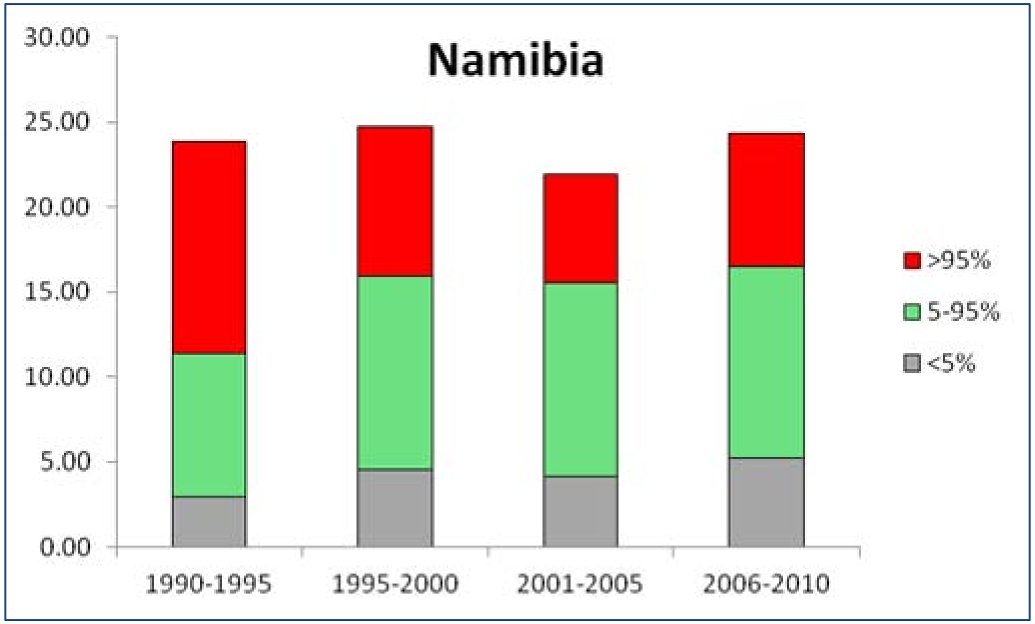
Species richness

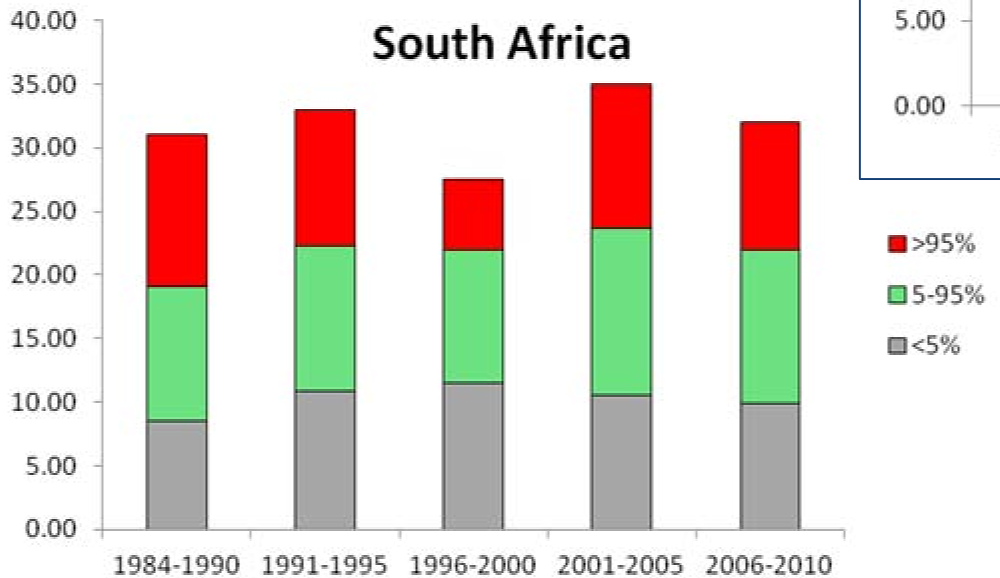


Shannon-Wiener index

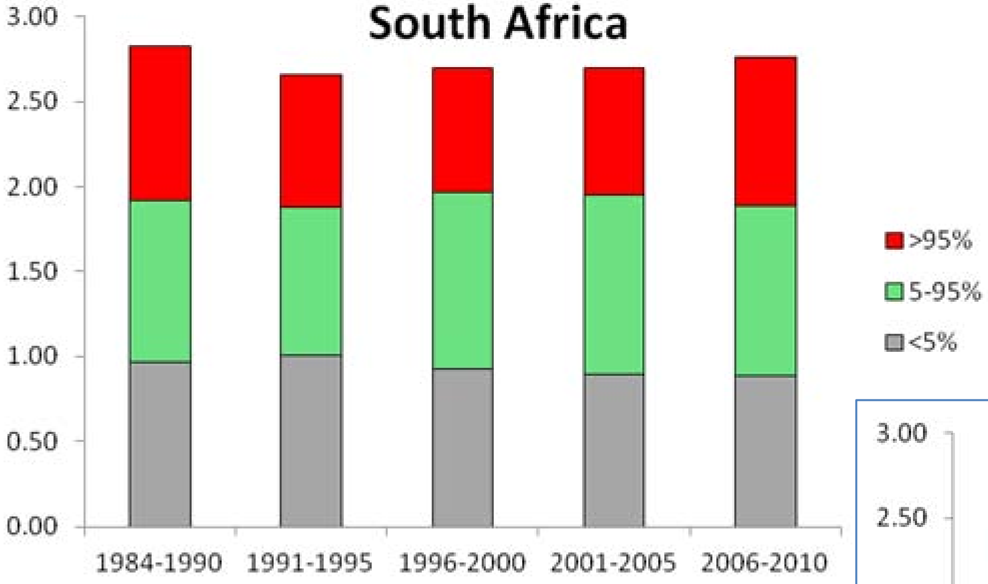
Species richness quantiles

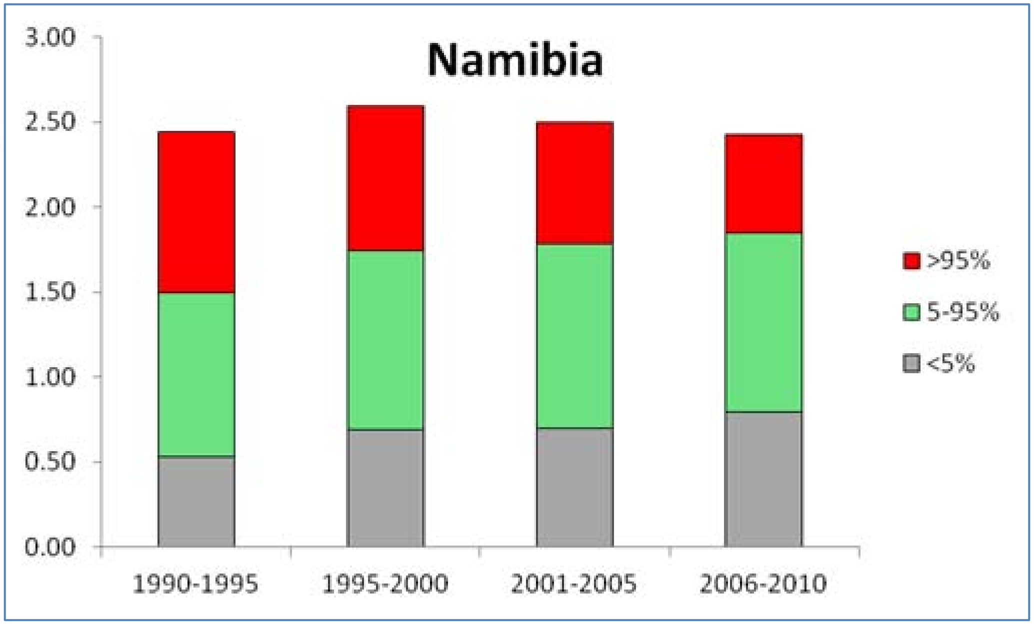


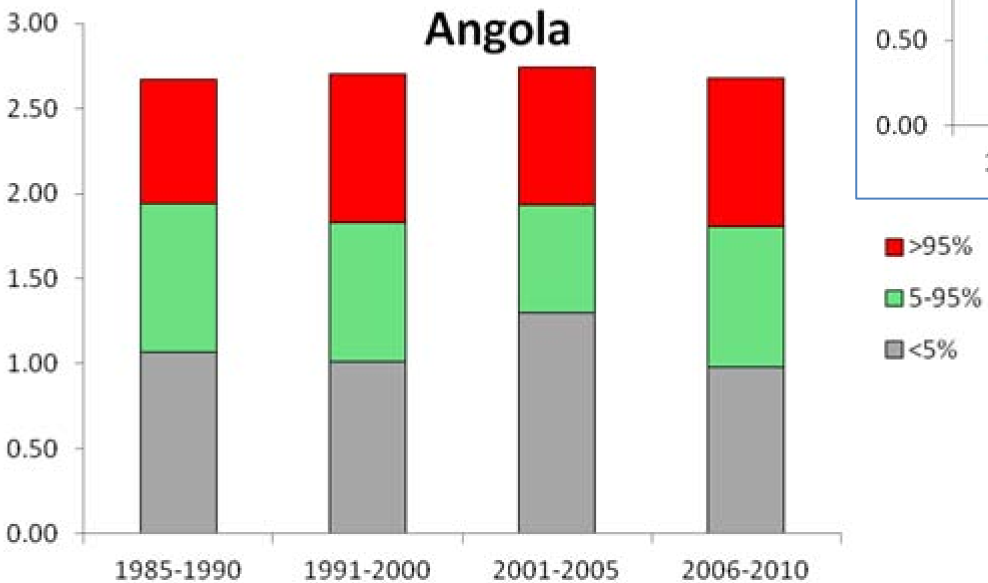




Shannon-Wiener index quantiles







Discussion

- Despite apparent changes in the structure of communities in the BCLME during the study period, identified locations of hotspots were generally persistent in space and time (in Namibia and South Africa)
- Generally associated with areas of heterogeneity including seamounts and also shelf break
- Further work is required to assess relationships between biodiversity levels and physical and environmental variables, and to assess whether variability in the former may be attributable to environmental changes
- The usefulness of biodiversity hotspots based on free-swimming organisms to identify priority conservation areas in the marine realm has been questioned because animals may move extensively between areas
- However, this study has shown the presence of consistent hotspot areas
- Could be considered for spatial protection of representative biodiversity – requires regional coordination considering transboundary occurrence of hotspots

Acknowledgements

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- South Africa’s Department of Agriculture Forestry and Fisheries, Namibia’s Ministry of Fisheries and Marine Resources and Angola’s Instituto Nacional de Investigação Pesqueira for their data
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- The Department of Environmental Affairs for supporting my participation here

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