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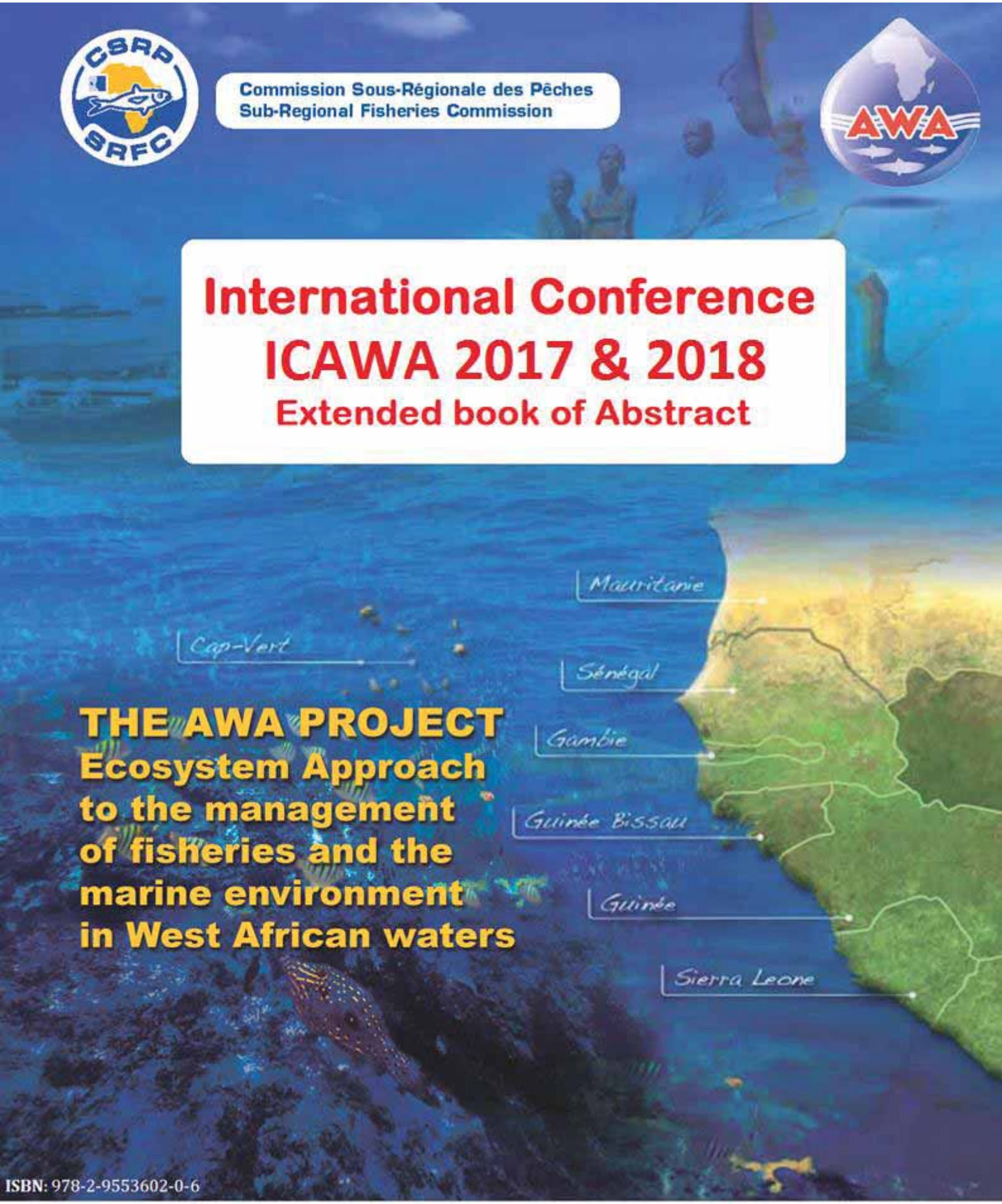

THE AWA PROJECT
Ecosystem Approach to the management of fisheries and the marine environment in West African waters

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für Bildung
und Forschung

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Trilateral German-French-African research initiative

Edited by

Patrice BREHMER (IRD, France)

Technical support: Ndague DIOGOUL (IRD, Sénégal), Cordula Zenk (Geomar, Germany) and Mahaut de Vareilles (UiB, Norway)

With the collaboration of

Noel Keenlyside (Norway), Jorge M. NASCIMENTO (CABO VERDE), Vito Melo RAMOS (CABO VERDE), Bamol Ali SOW (SENEGAL), Heino FOCK (GERMANY), Joern SCHMIDT (GERMANY), Werner EKAU (GERMANY), Adama MBAYE (SENEGAL), Assane FALL (MAURITANIA), Ivanice MONTEIRO (CABO VERDE), Aka Marcel KOUASSI (IVORY COAST), Osvaldina SILVA (CABO VERDE), Timothée BROCHIER (FRANCE), Moussa SALL (SENEGAL), Mohamed MAYIF (MAURITANIA), Vamara KONÉ (IVORY COAST), Thomas GORGUES (FRANCE), Carlos FERREIRA SANTOS (CABO VERDE), Idrissa Lamine BAMY (GUINEA), Iça Barry (GUINEA BISSAU), Momodou Sidibe (THE GAMBIA), Hamet Diaw DIADHIOU (SENEGAL)

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The both last ICAWA edition, 2017 and 2018, was done as a joint event with other closely related meeting. In 2017 with the inauguration of the OSCM in Cabo Verde underlining AWA cooperation with INDP and UNICV as well as Geomar and collaborators. In 2018 ICAWA was join to Preface final meeting following the memorandum of understanding signed a couples of years before between the two consortium and which have led at the end to a common policy session followed by the redaction of a policy brief taking advantage of the results of the both projects. Some abstract aside ICAWA joint session are missing see the orgniser to get more information.

Sponsors ICAWA 2017 and IACAWA 2018

These two edition of ICAWA were joint with OSCM inauguration and the final meeting of the European preface project, respectively in 2017 and 2018.

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The AWA project

« Ecosystem **A**pproach to the management of fisheries and the marine environment in the **W**est **A**frican Waters »

Build the Foundation of a West African observatory

Create a sub-regional task force on the ecosystem approach to the management of fisheries and the marine environment in the West African Waters under the effect of climate change

Group pictures & Conference Banners

Acknowledgments

On behalf of all organizers and participants from Europe and Africa, we would like to thank the sponsors of 2017 and 2018 edition the ICAWA. Special thanks to:

- SRFC: Sub Regional Fisheries Commission;
- IRD : Institut de Recherche pour le Développement ;
- The Univeristy pof bergen and the Bjerknes center (Norway)
- The Preface EU Project (DG Env, FP7)
- The OSCM, INDP (Cabo Verde) and Geomar (Germany)
- Greenpeace Africa
- Lanzarote city

Core funding

Additonal funding

Synopsis on the AWA tripartite project

The Consortium

The AWA consortium includes ten (10) countries (including the 15 associated partners) and forty (40) laboratories.

Joint proposals by the Federal Ministry of Education and Research (BMBF/Germany) and the Institut de Recherche pour le Developpement (IRD/France) under the patronage of the French Ministry for Higher Education and Research (MESR) and the French Ministry of Foreign and European Affairs (MEDI ex-MAEE).

Locally implemented by the SRFC Sub Regional Fisheries Commission (Dakar, Senegal).

A trilateral German-French-African Research initiative in Sub-Sahara Africa.

To add a new dimension to the long history of cooperation in Science and Technology (S&T) between Europe and Africa, Germany and France have decided to join their efforts to strengthen S&T cooperation with Sub-Sahara Africa, building on mutual strengths and interests.

Goal

AWA project is a strategic partnership among Germany, France and West African countries that will be capable of developing a vision and the scientific basis for an ecosystem approach to the management of fisheries and the marine environment ('EAMME') in West African with a long-term endeavor focusing on small pelagic.

Combining process studies of ecosystem functioning, long-term biological and physical monitoring and modeling, the final goal is to develop indicator-based management and adaptive decision support tools for EAMME in the context of global change and regional cooperation, since the same stocks are shared by several member States of the Sub-regional Fisheries Commission (SRFC).

To achieve this goal, the laboratories involved will work in two main areas of research: the monitoring of oceanic biological resources (assessment) and the functioning and modeling (ecological processes) of their environment. These are both research areas of outstanding importance in the broader scientific context of the analysis of global climate change, and of paramount relevance of their impacts on fisheries resources for West Africa. Both research activities will be done with a particular interest in capacity building of West African.

Project structure

WP 0: Project coordination and management

WP 1: Observations and modeling of ocean physics and biogeochemistry supporting the ecosystem approach to marine management

The lack of historical perspectives, continuous monitoring and regular forecasts of ocean physics and biochemistry parameters increase the vulnerability of the fragile economies of West African Countries. WP1 will concentrate on the observation and modeling of four key parameters that are at the heart of the assessment, understanding and anticipation of the ocean response to ongoing future changes: upper ocean temperature, sea level, chlorophyll concentration and dissolved oxygen.

Tasks

Task 1.1. Assessing a highly variable oceanic environment
Task 1.2. Modeling the variability of the environment
Task 1.3. Observation and simulation synthesis: towards prescription and early warning tools.

WP 2: Variability of pelagic productivity in West-African waters

Pelagic productivity in the West African upwelling sustains one of the world's largest small pelagic fisheries. However, key ecosystems processes and stock dimensions are still not clearly understood. WP2 will link process data and operational observational data (e.g. satellite data, physical oceanography) in order to establish long-term modeling and forecasting capabilities of pelagic productivity and exchange processes in the West African upwelling and estuarine interface.

Tasks

Task 2.1. Indicators of productivity of oceanic small pelagic in nurseries, shelf and deep water/oceanic habitats.
Task 2.2. Pelagic key components at the interface between subtropical gyre and coastal upwelling
Task 2.3. Exchange processes and pelagic productivity at the estuarine interface.

WP 3: Physical-biogeochemical coupling: processes and small pelagic fish control

Within the eastern boundary currents, pelagic fish are strongly dependent on their environment, which defines their habitat, the availability of food and probably also drives their spawning, growth recruitment success, spatial distribution and health. WP3 will increase understanding of the physical/biochemical environment of small pelagic fish in West Africa in order to apprehend the bottom up processes that impact on their life cycle and also identify useful indices in a context of climate change.

Tasks

Task 3.1. Key biogeochemical processes: control of primary production and oxygen minimum zone
Task 3.2. The spatio-temporal variability of small pelagic spawning
Task 3.3. Recruitment of *Sardinella aurita*
Task 3.4. Temporal evolution of fish habitat defined from coupled modeling approach

WP 4: Economics integrated into the ecosystem approach to marine management

WP4 goal is to determine the optimal management of key fish species, taking into account economic (including profits by fleet) and ecological drivers and needs. A special focus will be on the effects of environmental variability and climate change on economics performance and indicators.

Tasks

Task 4.1. Optimal economic-ecological management of selected key-species under environmental uncertainty.

Task 4.2. Spatial economic-ecological approaches

Task 4.3. Ecosystem, economic, and fish based indicators of global change in West Africa

WP 5: Education, Training and Capacity-building

There is a strong demand for capacity building strategies as well as strategic partnerships between institutions and universities in the sub region of West Africa. WP5 will encourage the development of common data formats and sampling protocols, as well as communication to exchange data and information between project partners and other institutions. WP5 will also develop the advancement of local scientific expertise in marine environment management. In each WP, individual training opportunities are provided to PhD students and MSC candidates from African partners. In particular MSC require a high degree of mentoring as envisaged under WP2 and WP4 (in Task 4.2 with the questionnaire work) and therefore require a strong component of capacity building. The goal is to achieve 17 graduations with funding from AWA (European MSC do not need funding)

Tasks

Task 5.1. To coordinate and reinforce existing training capacities in the oceanography field

Task 5.2. Enforcement of local scientific expertise

Synopsis on the PREFACE European project

The European Preface project

The AWA and Preface project was associated trough a consortium agreement. The project Enhancing Prediction of Tropical Atlantic Climate and its Impacts (PREFACE) is funded by the European Union 7th Framework Programme (FP7-Environment) to improve our understanding of the functioning of the tropical Atlantic climate and our capabilities to predict it and its impacts, with a particular focus on Atlantic African fishing communities. It is a large project (~€12M) bringing together 28 partners across 18 countries in Europe and Africa with expertise in oceanography, climate modelling and prediction, and fisheries science, and 3 associate partners directly involved in the sustainable management of the three Eastern boundary large marine ecosystems (LME) of the Tropical Atlantic. PREFACE forms part of a cluster of projects funded by the European Union to investigate climate-related ocean processes and combined impacts of multiple stressors on the marine environment, as a contribution to the pan-European and international goal of achieving the sustainable management of the environment and its resources. See: https://preface.w.uib.no/ . The information and views set out here are those of PREFACE and do not necessarily reflect the official opinion of the European Union.

Synopsis

The tropical Atlantic experienced persistent climate change during the last century together with pronounced multi-decadal shifts. The largest oceanic changes were in the eastern boundary upwelling systems (EBUS). African countries bordering the Atlantic depend strongly upon their ocean for societal development, fisheries, and tourism. They were strongly affected by these climatic changes and will face important adaptations associated with future global change. Fisheries in the region are crucially important for the livelihoods of these countries and experience additional pressure through foreign, including EU, fishing fleets. These upwelling regions, among the most productive around the world, are also of great climatic importance, as here cloud feedbacks involving marine stratocumulus are key to regulating global climate. Furthermore, tropical Atlantic sea surface temperature (SST) variations have been linked to climatic extremes, including droughts in Africa, Europe, America, and Asia, as well as changes in Atlantic Hurricanes. They may also influence the El Niño Southern Oscillation (ENSO).

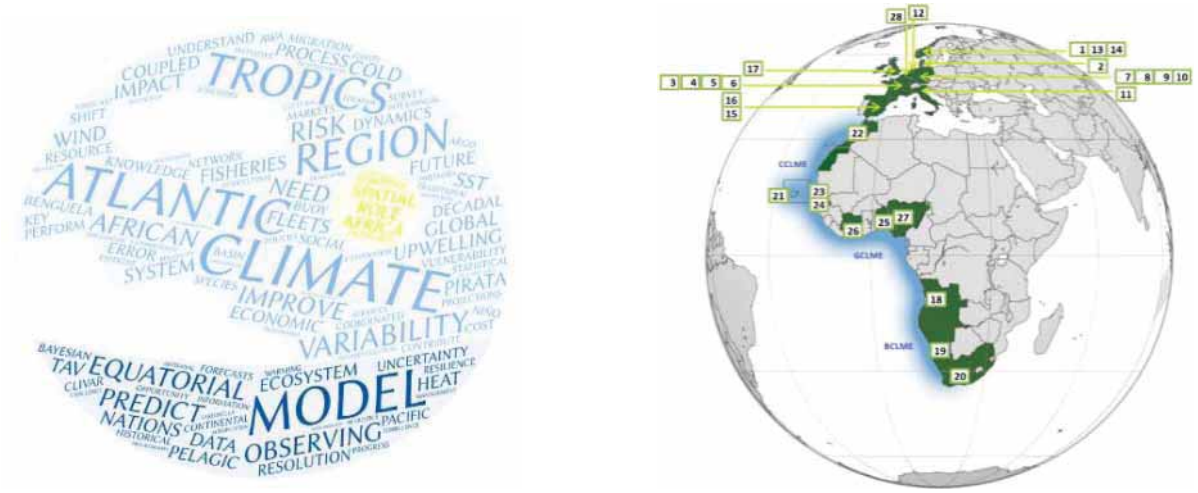
Unfortunately, the tropical Atlantic is a region of key uncertainty in the climate system: state-of-the-art climate models exhibit large systematic error; large uncertainties exists in the relative roles of internal and external factors in shaping climate change; and it is largely unknown how marine ecosystems respond to climate variability and how climate change will impact them. As a consequence, model based prediction of tropical Atlantic climate and its global socio-economic impacts are highly uncertain on all timescales. The magnitude of the problem and the need to resolve it is internationally recognised. PREFACE takes on the challenge to redress this situation through the first comprehensive assessment of the Tropical Atlantic. Together European and African expertise will combine regional and global scale modelling capabilities, field experiments and observation systems to address the following objectives

Goals

- To reduce uncertainties in our knowledge of the functioning of tropical Atlantic climate, particularly of climate-related ocean processes and dynamics, coupled ocean, atmosphere, and land interactions; and internal and externally forced climate variability;
- To better understand the impact of model systematic error and its reduction on seasonal-to-decadal climate predictions and on climate change projections;
- To improve the simulation and prediction of tropical Atlantic climate on seasonal, and longer time scales, and contribute to better quantification of climate change impacts in the region;
- To improve understanding of the cumulative effects of the multiple stressors of climate variability, greenhouse gas induced climate change (including warming and deoxygenation), and fisheries on marine ecosystems, functional diversity, and ecosystem services (e.g., fisheries) in the tropical Atlantic;
- To assess the socio-economic vulnerabilities and evaluate the resilience of the welfare of West African fishing communities to climate-driven ecosystem shifts and global markets.

Expected Results

- Improved understanding of variability in the Eastern Boundary Upwelling regions and the Gulf of Guinea;
- Improved climate modelling and prediction capabilities;
- Better understanding of the function of marine ecosystem so that socio-economic impacts can be better predicted;
- Enhance cooperation between European and African researchers working on Tropical Atlantic climate and its impacts, by fostering existing collaborations and improving project synergy.



PREFACE[1] Consortium and Associate Partners. The PREFACE consortium consists of 28 partners distributed across 18 countries and 2 continents, and 3 associate partners directly involved in the sustainable management and protection of three of the Earth's Large Marine Ecosystems

[1] A new project EU H2020 project TriAtlas « Tropical and South Atlantic climate-based marine ecosystem predictions for sustainable management » have been launch the 1st June 2019 following Preface and AWA projects, coordinated by Pr Noel Kleenlyside (UiB, Norway) https://cordis.europa.eu/project/rcn/223210/factsheet/en

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Ocean Science Centre Mindelo Cabo Verde, Nov 13th to 17th, 2017

Book of abstract

Atlantic Observatories session.
Monday, Nov. 13, 2017

Biogeochemical time-series observations at CVOO

Björn FIEDLER [1,*]

[1]GEOMAR, Helmholtz Centre for Ocean Research Kiel, Kiel, Germany

*Correspondance: Tél : (+43) 31 600 4203; Courriel: bfiedler@geomar.de (B. FIEDLER)

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Abstract

Not communicated

Contact the author

Coastal dynamic at Salamansa Bay, São Vicente, Cabo Verde

Corrine ALMEIDA [1]

[1] Departamento de Engenharias e Ciências do Mar, Universidade de Cabo Verde (UNI-CV), CP 163 Mindelo, Cabo Verde

*Correspondance: Tél : (00) 238 232 11 13; Courriel: corrine.almeida@docente.unicv.edu.cv (C. ALMEIDA)

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Abstract

Not communicated

Contact the author

Observations of physical ocean properties in the eastern tropical North Atlantic

Florian SCHÜTTE [1], Peter BRANDT [1], J. KARSTENSEN[1] and Gerd KRAHMANN [1]

[1]GEOMAR Helmholtz-Centre for Ocean Research Kiel, Wischhofstr, 24148 Kiel, Germany

*Correspondance: Tél: (00) 494316004103; Courriel: fschuette@geomar.de (F.SCHÜTTE)

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Abstract

In the last decade the Cap Verdean Islands, especially Mindelo on São Vincente, developed into an important ocean research center. Since 2002 more than 30 GEOMAR research cruises and in addition 19 Glider deployments were either conducted in Cap Verdean Islands waters or headed towards the eastern tropical North Atlantic from here. Another important basis for ocean research in the area is a deep sea mooring, called the Cape Verde Ocean Observatory (CVOO), which is deployed at a depth of about 3600 m 60 km northeast of São Vincente (nominal mooring position is 17°36'N, 24°15'W). Up to now this mooring has collected a unique time series of more than 10 years of continuous measurements, which also emphasizes the importance of the ocean research location Mindelo. An example is the unexpected low (< 2 $\mu molkg^{-1}$) oxygen environments just below the mixed layer, which were recorded by the CVOO mooring in February 2010. Within the tropical North Atlantic the oxygen concentration does normally not fall below 40 $\mu molkg^{-1}$. The extremely oxygen depleted waters could be associated to eddy cores of cyclones and anticyclonic-mode-water eddies. These eddies show enhanced primary production at the surface (enhanced chlorophyll) and have associated elevated respiration rates (3-5 times higher than the background) within their isolated cores. The emerging oxygen minimum in the eddy cores has profound impacts on sensible metazoan communities and marine life. The compression of the habitable volume in the mixed layer above the eddy core (strong increase in integrated zooplankton abundance) increases the abundance of higher trophic levels (such as small pelagic forage fish and their predators), which benefit from the dense prey field. Other important research interests in the tropical North Atlantic, which strongly benefit from the research location Mindelo over the last years, are the upwelling areas off the West African coast, the oxygen minimum zones, Open Ocean mixing and equatorial dynamics.

The warming of the Eastern Atlantic

Peter LEMKE [1,*], Subrata SARKER[1,*], Annette WILSON[1], Karen Helen WILTSHIRE[1] and Pauhla MCGRANE[1]

[1]Alfred Wegener Institute for Polar and Marin Research, Bremerhaven, Germany

*Correspondance: Tél: Courriel: peter.lemke@awi.de (P. LEMKE)

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Abstract

Since 1982, the German research icebreaker Polarstern is transiting twice a year between both Polar Regions. More than half of these transits took place in the Eastern Atlantic between Bremerhaven and Cape Town. On many transects temperature data were taken from XBT and CTD casts. To date, this data set has not been exploited in detail. A preliminary analysis concerning the heat content is presented, indicating a significant warming.

Dinitrogen fixation in the Atlantic Ocean

Debany FONSECA-BATISTA[1,*], Frank DEHAIRS[1], and Marc ELSKENS[1]

[1]Analytical, Environmental and Geo-Chemistry (AMGC), Vrije Universiteit Brussel (VUB)

*Correspondance: Tél: ; Courriel: dbatista8@hotmail.com (D. FONSECA)

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Abstract

Dinitrogen (N_2) gas is the largest N reservoir in the ocean, but it can only be drawn and converted into bioavailable N (or fixed-N) by a small community of marine microorganisms, namely the diazotrophs. Marine primary production (*i.e.*, biological fixation of atmospheric carbon dioxide, CO_2) is limited by the availability of dissolved inorganic nitrogen (*e.g.*, nitrate, ammonium) over large areas of the world's ocean. Therefore, in these nutrient depleted regions biological N_2 fixation contributes considerably in maintaining marine primary productivity and atmospheric CO_2 sequestration into the deep ocean. In addition, N_2 fixation also contributes to counterbalancing the loss of bioavailable N from natural biological processes (denitrification and anaerobic ammonium oxidation) occurring in oxygen depleted zones of the global ocean. Recent discoveries suggested that field measurements of oceanic N_2 fixation from the past decades may have underestimated in situ activities due to a methodological bias in the incubation protocol. The present work investigated the importance of community N_2 fixation as a source of N to the Atlantic Ocean, using the lately-adapted "$15N_2$ dissolution method". Our work has confirmed the widespread occurrence of biological N_2 fixation across the North and South Atlantic Ocean, including regions where the process had previously been considered as negligible, for instance the temperate Northeast Atlantic and the eastern South Atlantic. We discuss the potential environmental drivers of N_2 fixation activity, including iron supply from atmospheric dust deposition and nitrate deficit relative to phosphorus (P) in comparison to the common ratio of N to P requirements for the marine microalgae (*i.e.*, Redfield stoichiometry). Finally, we re-assess the annual basin-wide N input via N_2 fixation, compare it with earlier estimates.

Conservation of sea turtles: a country-wide approach

Christophe EIZAGUIRRE[1]

[1]Queen Mary University of London, School of Biological and Chemical Sciences 6.04, Fogg Building Mile End Road London E1 4NS, United Kingdom

*Correspondance: Tél : +44 (0) 207 882 6982; Courriel: c.eizaguirre@qmul.ac.uk (C. EIZAGUIRRE)

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Abstract

Located in the middle of the Atlantic, Cape Verde is a unique biodiversity hotspot. This archipelago supports the third largest nesting aggregation of the loggerhead sea turtle, Caretta caretta, in the world, making it of local and global conservation priority. There, turtles are poached on land, and slaughtered in the Sea for meat consumption. Interestingly, this rookery was discovered ~20 years ago by scientists and is strongly data deficient. Intense pressure and lack of data have forced the IUCN Red List to classified turtles of this rookery as endangered. Conceived in 2010, The Turtle Project originated from a collaboration between scientists, international and national NGOs. Here, I will report of the conservation success at the whole Archipelago level as well as the major discoveries about the distribution of genetic diversity, feeding ecology strategy and movement ecology of this species. This citizen science project demonstrates how we can tackle key conservation questions building on a robust network of collaborators and improve the state of this endangered population.

Zooplankton-mediated fluxes in the Eastern Tropical North Atlantic

Rainer KIKO [1,*], Helena HAUSS[1], Svenja CHRISTIANSEN[2], Jannik FAUSTMANN[1], and Elizandro RODRIGUES[3]

[1]GEOMAR Helmholtz-Centre for Ocean Research Kiel, Wischhofstr. 1-3, 24148 Kiel, Germany
[2]Department of Biosciences, University of Oslo P.O. box 1066 Blindern 0316 Oslo
[3]Instituto Nacional de Desenvlvimento das pescas, Cabo Verde

*Correspondance: Tél : (+49) 431 600-4524 ; Courriel: rkiko@geomar.de (R. KIKO)

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Abstract

Zooplankton occupies an important role in pelagic ecosystems as it provides the link between primary producers and higher trophic levels and to a large extent shapes elemental cycles. Zooplankton organisms feed on all kinds of small particulate matter (*e.g*. phytoplankton, detritus, smaller zooplankton organisms) and egested fecal pellets contribute substantially to the passive sinking flux out of the surface layer. Some zooplankton species also conduct diel vertical migrations (DVMs) between the surface layer where they feed at nighttime and midwater depth below the sunlit euphotic zone where they hide at daytime from predation. These DVMs result in the active export of organic and inorganic matter from the surface layer as zooplankton organisms excrete, defecate, respire and get eaten at depth. In the Eastern Tropical North Atlantic (ETNA), the daytime depth (300-600 m) coincides with an oxygen minimum zone (OMZ) that was observed to expand and intensify in the past decades. We here constrain zooplankton impacts on the nitrogen and oxygen budget in the upper 1000 m of the ETNA using a comprehensive set of day and night catches with a Hydrobios Multinet, analysed using the Zooscan method. We estimate that about 13 to 28 % of the external nitrogen supply (diapycnal diffusion, atmospheric deposition, nitrogen fixation) to the upper 100 m of the water column is lost via DVM activity of zooplankton. Likewise, zooplankton contributes about 20 % to oxygen consumption in the 300 to 600 m depth layer. Changes in zooplankton abundance and migration behavior due to decreasing oxygen levels at midwater depth could therefore considerably alter the elemental cycling of oxygen and carbon in the ETNA OMZ, but might also impact the removal of nitrogen from the surface layer.

Biological exploration of the deep water column around the Cape Verde islands

Henk-Jan HOVING[1,*]

[1]GEOMAR Helmholtz-Centre for Ocean Research Kiel, Wischhofstr. 1-3, 24148 Kiel, Germany

*Correspondance: Tél : 0431 600 4566 ; Courriel: hhoving@geomar.de (H-J. HOVING)

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Abstract

Most of the exclusive economic zone of Cape Verde consists of Open Ocean. The largest part of the ocean is deep sea: the water column and seafloor in depths exceeding 200 m. Deep-sea biodiversity remains largely unknown, and we are only at the start of understanding the behavior and ecology of deep-sea organisms. To increase our knowledge on deep-sea ecosystems in the era of global change, we are performing biological baseline studies in the epi- and mesopelagic zone of the Cape Verde region, using a combination of biological in situ observations and net sampling. These efforts have resulted in one of the first insights in the vertical distribution and abundance of gelatinous zooplankton in relation to the oxygen minimum zone in the Cape Verde region, which is rapidly expanding as a result of climate change. Striking differences were found between the diversity and abundance of gelatinous fauna observed during video transects, and specimens captured in nets. Pelagic video surveys revealed previously undocumented gelatinous fauna, some of which have an important role in the oceanic foodweb. Biological exploration of the bathypelagic zone (1000-4000) is required to understand the biological and biogeochemical connections between the ecological zones of the ocean and the seafloor, and ongoing and future research activities contributing to this mission are presented.

Surface ocean Lower atmosphere International Campaign (SLIC) : A new SOLAS Time Series Concept for Cabo Verde

Christa MARANDINO[1,*] and Anja ENGEL[1]

[1]GEOMAR Helmholtz-Centre for Ocean Research Kiel, Wischhofstr. 1-3, 24148 Kiel, Germany

*Correspondance: Tél : 0431 600 4219 ; Courriel: cmarandino@geomar.de (C. MARANDINO)

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Abstract

The sea surface microlayer (SML) is one of the Earth's vast interfaces and is the gateway to all air-sea interactions. Despite its importance, detailed information on how this area of the ocean functions is highly undercharacterized and underquantified. There is laboratory, as well as indirect evidence, that the SML greatly impacts air-sea exchange of energy and matter. However, the underlying field evidence is elusive. If we are to understand and model the Earth system, especially with respect to air-sea interactions, we need a more comprehensive grasp on this important interface. Based on the results of an international SOLAS workshop discussion group led by A. Engel and C. Marandino in 2017, we propose a time-series station devoted to better understand ocean-atmosphere interactions and the role of the SML. We would like to build on the existing time-series stations/infrastructure at Cape Verde, namely the Cape Verde Ocean Observatory, the Ocean Science Center Mindelo, and the Cape Verde Atmospheric Observatory, to create this one-of-a-kind time series station.

Reactive trace gases at the Cape Verde Observatory: What have we learnt - and what next?

Lucy CARPENTER[1,*], James LEE[1], Chris REED[1], Katie READ[1], Shalini PUNJABI[1], Jim HOPKINS[1], Ally LEWIS[1], Tomas SHERWEN[1], Mat EVANS[1]

[1]Wolfson Atmospheric Chemistry Laboratories (WACL), Department of Chemistry, University of York, United Kingdom

*Correspondance: Courriel: lucy.carpenter@york.ac.uk (L. CARPENTER)

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Abstract

The chemistry of the remote marine boundary layer, containing low NOx levels and a small abundance of reactive volatile organic compounds (VOCs), has historically been thought to be well represented by a relatively small number of well established reaction mechanisms. Recent studies at the Cape Verde Observatory (CVO) however show that exchange of chemical species across the ocean-air interface can be a rich source of many climate-active species including halogens and VOCs. Further, new observations potentially overturn the long held view that peroxyacetyl nitrate (PAN) is the dominant source of NOx in the marine atmosphere and that HNO3 / nitrate production is a permanent sink, suggesting instead that photolysis of particulate nitrate to generate gaseous NOx ("renoxification") could be a major source. This talk gives an overview of how measurements of reactive gases at the CVO have generated new understanding of key processes, and points to how we might focus our efforts in the coming years.

A decade of greenhouse gas measurements from the Cape Verde Atmospheric Observatory "Humberto Duarte Fonseca"

Martin HEIMANN[1,*], Helder TIMAS[2] and Elena HOZLOVA[3]

[1]Max-Planck-Institute for Biogeochemistry, Jena, Germany
[2]Instituto National de Meteorologia e Geophysica, Mindelo, Cape Verde
[3]College of Life and Environmental Sciences, University of Exeter, United Kingdom

*Correspondance: Tél : (+49) 151 120 359 46 ; Courriel: martin.heimann@bgc-jena.mpg.de (M. HEIMAN)

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Abstract

The Cape Verde Atmospheric Observatory "Humberto Duarte Fonseca" (CVAO) fills a critical gap in the global observation network of long-lived well mixed greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The location of the station on the north-eastern coast of Sao Vicente near Calhau is ideally suited to sample air masses from the prevailing north-eastern trade winds. These originate from the open North Atlantic Ocean, Europe, northern Africa and the north-western African coastal upwelling region off Morocco and Mauritania. The decade-long observations from the CVAO document the long term evolution and seasonal cycle of these gases over the subtropical North Atlantic Ocean. While these follow pretty much the increasing concentration patterns as seen elsewhere on the global observation network, subtle differences to the global trends as well as synoptic short term variations provide insight into location and magnitude of regional sources and sinks of these gases, in particular from the coastal upwelling areas. Additional information is provided by measurements of their isotopic composition (*e.g*. 13C/12C ratio in CO_2 and CH_4), as well as by concurrent high-precision measurements of the oxygen/nitrogen ratio.

Chemical composition of aerosol particles at the CVAO

Khanneh wadinga FOMBA[1,*], Konrad MÜLLER[1], and Hartmut HERRMANN[1]

[1]Leibniz Institute for Tropospheric Research (TROPOS), Permoser str. 15, 04318 Leipzig, Germany

*Correspondance: Courriel: fomba@tropos.de (K. FOMBA)

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Abstract

Chemical analysis was performed on both bulk and size-resolved aerosol particles collected at the CVAO at both 24 h and 72 h intervals. The samples were analyzed for their organic and inorganic compositions. The aerosol particles were mainly dominated by sea salt and mineral dust with the relative contributions varying according to seasons. Other aerosol chemical components were sulfates, ammonium, nitrate, organic matter, elemental carbon and trace metals. Observations showed strong seasonal variation in the chemical compositions of most aerosol components with mineral dust showing strong winter peaks while ammonium and non-sea salt sulfate show spring and summer peaks, respectively. Trace metals such as iron was mainly deposited by mineral dust with the soluble content of iron found to be very low (< 0.5%) under near to marine atmospheric conditions. The main sources of trace metals were mineral dust, ship emissions and biomass combustion while elemental carbon mainly originated from long-range transport.

ICAWA-4: International Conference, "Ecosystem Approach to the management of fisheries and the marine environment in West African waters". Tuesday, Nov. 14th (afternoon)

Session ICAWA- 4

Variability of pelagic productivity in West-African waters

Heino FOCK [1,*]

[1]Thünen Institute, Institute of Sea Fisheries, Germany

*Correspondance: Tél: (+49) 471 94460 366; Courriel: heino.fock@thuenen.de (H. FOCK)

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Abstract

Tasks within AWA WP 2 were to identify (1) pelagic key components in relation to water mass structure and bottom topography, (2) ichthyoplankton stock components (*e.g. S. aurita*) and link to environmental factors, and (3) exchange processes and pelagic productivity at the estuarine interface. The analysis in WP2 was based on the concept of fisheries thematic mapping (Caddy and Garcia, 1986) recognizing that "…Mapping the fishery and the resource should be among the priority tasks when planning for fisheries management"

Results from 10 studies are presented, indicating good agreement between models and observations with regards to inshore retention mechanisms in nursery areas (Mbaye et al., 2015; Tiedemann and Brehmer, 2017). The estuarine interface is also an important spawning area and nursery for clupeid larvae in the Sine Saloum estuary, Senegal (*e.g*. Sloterdijk et al., 2017). Fish egg distributions were investigated in 2 different seasons, allowing to indicate spawning habitats for small pelagics *e.g. Sardinella aurita* (Badji et al., 2018), also presenting the first record for spawning for European anchovy *Engraulis encrasicolus* in southern Senegal. Statiscal analysis of stock components for *Sardienlla aurita* and *S. maderensis* were presented from Thiaw et al. (2017) and Diankha et al. (2017).

Session ICAWA-4

Remarks on confirmed records of ten fish species to Cabo Verde Archipelago based on photographic and genetic data

Rui FREITAS [1,*], Jesus M. FALCÓN[2], José A. GONZÁLEZ[3], Kirsti Ann BURNETT[4], Manuel DUREUIL[5], John CARUSO[6], Henk Jan HOVING[7] and Alberto BRITO[2]

[1]Departamento de Engenharias e Ciências do Mar, Universidade de Cabo Verde, CP 163 Mindelo, Cabo Verde
[2]Brito, Grupo de investigación BIOECOMAC, Unidad Departamental de Ciencias Marinas Facultad de Ciencias, Universidad de La Laguna, ES-38206 La Laguna (Tenerife), Spain
[3]Ecología Marina Aplicada y Pesquerías, i-UNAT, Universidad de Las Palmas de Gran Canaria (ULPGC), ES-35017 Las Palmas de Gran Canaria, Spain
[4]Sharks of the Atlantic Research and Conservation Centre ShARCC, B3L2Y5 Halifax, Canada
[5]ShaRCC and Dalhousie University, B3H 4R2 Halifax, Canada
[6]Department of Ecology and Evolutionary Biology, Tulane University, New Orleans, Louisiana 70118, USA
[7]GEOMAR, Helmholtz Centre for Ocean Research Kiel, Düsternbrooker Weg 20, DE-24105 Kiel, Germany

*Correspondance: Tél: (+238) 99 189 09; Courriel: rui.freitas@docente.unicv.edu.cv (R.FREITAS)

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Abstract

In recent decades the Cabo Verde ichthyofauna has been studied more extensively, and nowadays photo-recording is employed as a valuable asset under special caution and consideration. Four species reported here are new records for Cabo Verde: *Carlarius sp., sea catfish; Serranus cabrilla, comber; Branchiostegus semifasciatus, African tilefish* and *Lutjanus dentatus*, African coastal snapper. The presence in Cabo Verde of *Glaucostegus cemiculus, blackchin guitarfish, Elops senegalensis*, Senegalese ladyfish, *Lophius spp*., bathydemersal monkfishes, *Rachycentron canadum*, cobia, *Pagrus auriga*, African seabream, *Lutjanus dentatus*, African coastal snapper and Mugil cephalus, mullet, was re-confirmed by photo-records. Squalus megalops, cosmopolitan spurdog, was identified by genetic fingerprinting. The two littoral species, *P. auriga* and *M. cephalus*, are firmly established in the archipelago and additional information on their occurrence is given. The findings reported in the present contribution may well be the result of a wider sharing of information between fishermen and other seafarers and scientists, rather than an indicator of recent faunal changes.

Keywords: Marine fishes, new photo-records, Cabo Verde Islands, Eastern Atlantic.

Physical-biogeochemical coupling: processes and control of small pelagic fish

Vamara KONE [1,*] and Thomas GORGUES[2]

[1]IRD-Centre de recherches océanologiques (CRO), Abidjan/Ivory Coast
[2]Université de Brest, Plouzané, France

*Correspondance: Tél: (+225) 01 74 64 67; Courriel: kvamara@hotmail.com (V.KONE)

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Abstract

Not communicated

Contact the author

Session ICAWA-4

Economics integrated into the ecosystem approach to marine management

Jörn SCHMIDT[1]

[1]University of Kiel, Germany (CAU), Department of Economics, Germany

*Correspondance: Tél: (+49) 431 880-5632 ; Courriel: jschmidt@economics.uni-kiel (J. SCHMIDT)

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Abstract

Artisanal fisheries still play a large role in many economics, especially in developing countries. These fishers and the coastal communities in general, face various risks in their everyday life including uncertainty about the success of fishing, uncertain prices for fish and uncertain costs for inputs such as fuel, and many more. In addition, foreign fleets, changing world markets and other global factors including climate change in particular can put additional pressures on top of this. We have used field surveys and economic experiments among fishing communities to assess how fisher perceive these risks and how they cope with them. The surveys were carried out in Senegal, Cabo Verde and Nigeria, with 691, 671 and 1479 valid interviews, respectively. In this presentation, we give an overview on the general framwork of ecosystem based fisheries management (EBFM), including the links to new international frameworks like the Sustainable Development Goals (SDGs) and why economic and social these aspects need to be integrated with ecological knowledge to support sustainable development of the fishing sector.

Session ICAWA-4

Indicators for an ecosystem Approach to the management of fisheries and the marine environment in West Africa waters

Didier JOUFFRE[1,*], and Ibrahima DIALLO[2]

[1]Institut de Recherche pour le Développement, UMR 248 MARBEC, Université Montpellier, Place E. Bataillon, Bât 24, CC 093, 34095 Montpellier cedex 5, France

[2]Centre National des Sciences Halieutiques de Boussoura, 814, Rue MA 500, Corniche Sud, Boussoura Port, BP 3738, Conakry, République de Guinée

*Correspondance: Tél: (+33) 0626 6789 38; Courriel: didier.jouffre@ird.fr (D. JOUFFRE)

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Abstract

Several activities have been conducted on the thematic of « ecosystem indicators, sensu lato» during the AWA project (www.awa-project.org). This communication reports those related to the Tasks 3 of the WP4.

Its first part introduces the indiAWA network which has emerged as a result of the AWA project. IndiAWA is a research and expertise network focussing on indicators and ecosystem approaches for fisheries and global change in West Africa. Started in the AWA context, IndiAWA has the ambition to continue on the long term, after AWA phase 1 funding period, as well as to be an open network, with the addition of extra AWA contributors, and to constitute a growing task force for West Africa. With AWA's consortium and extended collaborations, the general and long-term objective of indiAWA is to develop ecosystem indicators and to promote regional solutions for an Ecosystem Approach to the management of fisheries and the marine environment in West Africa waters. In line with AWA's philosophy, this long-term objective of indiAWA comes in three main components, including scientific research, capacity building and communication objectives. These components are presented and their sub-components or particular objectives are specified in the first part of the communication.

The second part brings then an illustration of the indiAWA's approach applied to the Guinean shelf case study. In this study, the ecosystem indicators calculated on the basis on three decades of national scientific trawling surveys, coupled with others indicators from commercial fishing activities on the same period, allows now to detect some of the fisheries ecosystem effects that were not perceptibles in former studies, based on both shorter data series and period of exploitation.

The third and last part of the communication concludes with some perpectives and work to be continued and developped on this thematic on the future by the AWA/indiAWA consortium.

Keywords: Indicators, modelling, fisheries, marine environment, ecosystem status, global change, management, research network, West-Africa.

Session ICAWA-4

Profitability and economic drivers of small pelagic fisheries in West Africa: a twenty year perspective

Aliou BA[1,*]

[1]Cheikh Anta Diop University (UCAD), Institute of Research for Development (IRD), ISRA / Research Centre Dakar - Thiaroye Oceanographic (CRODT), Senegal

*Correspondance: Tél: (+221) 705 910 585; Courriel: aliou.ba@ird.fr (A. BA)

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Abstract

Small pelagics are the main fish resource in North West Africa. In Senegal, these are mainly sardinellas and bonga shad. The fisheries, mainly encircling gillnets and purse seins, are predominantly performed by artisanal fisherfolk and have a great importance for the Senegalese economy and for food security in the region. However, in recent years, the main conditions for these fisheries have changed and recent observations have shown a decline of profit. A retrospective analysis over twenty years (1993-2013) has been done and the fisheries show a loss in profit between 65 and 100% and an increase in operating costs of 25 and 90%, respectively for encircling gillnet and purse seine. While the fuel price dominates as determining factor during the survey period, important other drivers during the last five years are a decrease in biomass and an increase in fishing effort.

Keywords: Small scale fisheries, small pelagic, income, management, Senegal.

Session ICAWA-4

Capacity building in the AWA consortium

Werner EKAU[1,*] and Heino FOCK[2]

[1]Leibniz Center for Tropical Marine Ecology (ZMT), GmbH- Fahrenheitstraße 6, 28359 Bremen, Germany
[2]Thünen Institute, Institute of Sea Fisheries, Germany

*Correspondance: Tél: (+49) 421 23800 - 23; Courriel: wekau@zmt-bremen.de (W. EKAU)

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Abstract

A short overview of capacity building activities in AWA WP5 was presented featuring summer schools, fisheries management course at AIMS , Senegal, sea-going training onboard RVs Antea, Thalassa, Meteor and FRV Walther Herwig III, a 1-day fisheries biology excursion for the University of Dakar postgraduate program, post-graduate minisymposium in Bremen, 2016, M.Sc and Ph.D promotions accomplished within all workpackages and the role of the ICAWA conference as a network of West African researchers working on their local marine resources in their associated habitats.

Session ICAWA-4

Contribution of mathematical modeling to the ecosystem approach to fisheries management and the marine environment (EAMME): the AWA experience

Timothée BROCHIER[1,*], Pierre-Amael AUGER[2,3], Philippe ESTRADE[4], Aliou BA[2,5], Vamara KONE[6], Baye Cheikh MBAYE [4], Siny NDOYE [4], Modou THIAW[6], Hieu Nguyen TRONG[7], Rachid MCHICH[8], Pierre AUGER[1], Alassane BAH[9], Djiga THIAW[6], Eric MACHU[10], Xavier CAPET[11], Laure PECQUERIE[2], Christophe LETT[1], Thomas GORGUES[10], and Patrice BREHMER[2,5]

[1] Institut de Recherche pour Développement (IRD), UMI 209, UMMISCO, Sorbonne Universités, Bondy, France
[2] IRD, Laboratoire des sciences de l'Environnement MARin (Lemar), UMR 195, F-93143, ISRA-CRODT, BP 1386, Hann, Dakar, Senegal
[3] Instituto Milenio de Oceanografia (IMO), Escuela de Ciencias del Mar, Pontificia Universidad Católica de Valpara íso, Av. Altamirano 1480, Valpara íso, Chile
[4] Laboratoire de Physique de l'Atmosphère et de l'Ocean Siméon Fongang, ESP/UCAD, Dakar, Senegal
[5] Institut Sénégalais de Recherche Agronomique (ISRA), Centre de Recherche Océographique Dakar-Thiaroye (CRODT), Dakar, Senegal
[6] Centre de Recherches Océanologiques (CRO), 29 Rue des Pêcheurs, BPV 18, Abidjan, Cote d'Ivoire
[7] *Faculty of Mathematics, Mechanics, and Informatics, Vietnam National University, Hanoi, 334 Nguyen Trai, Thanh Xuan, Hanoi, Viet Nam*
[8] Equipe de Recherche ERMEG, Ecole Nationale de Commerce et de Gestion de Tanger, B.P. 1255, 90000 Tangier, Morocco
[9] Université Cheikh Anta Diop (UCAD), Département Génie Informatique, Ecole Supérieure Polytechnique, BP 15915 Dakar, Senegal
[10] Univ. Brest, CNRS, IRD, Ifremer, Laboratoire d'Océanographie Physique et Spatiale (LOPS), IUEM, Brest, France
[11] CNRS, Laboratoire d'Océanographie et du Climat Expérimentation Et Approche Numériques (LOCEAN), Université Pierre et Marie Curie, Paris, France

*Correspondance: Tél: (+33) 688663742; Courriel: Timothee.brochier@ird.fr (T. BROCHIER)

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Abstract

Since the onset of AWA, a number of studies have focused on the management and ecology in West Africa. Here we provide a short insight of the main highlights on a selection of contrasted modelling case studies. Understanding the functioning of the ecosystem is essential to promote ecosystem approach to fisheries management and the marine environment (EAMME) and path providing advices to decision makers and managers. In the EAMME, the civil society addressed various questions to AWA on which specific models have been developed to provide at least first insight to the answers, e.g., on the effect of artificial reef implementation in marine protected area; the possible equilibriums between national fisheries sharing a same trans-boundary fish stock; the feedback between local exploitation, fish market and fisheries mobility, the responses of a fishery to economic, biologic and management parameters, the spatial variability of primary productivity as well oceanographic circulation at regional level or the fish egg advection over the continental shelf. More complex modelling exercise have also been conducted taking advantage of previous research led on sardinella aurita. In this way a coupled model taking into account environmental variability, fish growth and spatial behaviour was developed. We present as example new hypothesis on adult mediated connectivity between EEZ, inter-annual variability

and interest to work on climate change with such model. We propose a prospective of what further research could be conducted to continue to bring up relevant information for a sub-regional EAMME in North West Africa fostering exchanges between modellers and marine scientists and all stakeholders.

Session ICAWA-4

Industrie de farine et d'huile de poisson en Mauritanie entre 2004 et 2016 : «transit», «point de chute» ou «refuge» des candidats à l'immigration clandestine vers les Canaries"

Assane D. FALL[1,*]

[1]Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), BP 22, Nouadhibou, Mauritania

*Correspondance: Tél: (+222) 22 4210 46; Courriel: assanefallus@gmail.com (A. D. FALL)

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Abstract

La Mauritanie connait un dynamisme migratoire des pêcheurs Saint-Louis de «Guet-Ndar » (Sénégal) à destination de la Mauritanie pays dans leur quête d'espace halieutique de production. Mais la ville de Nouadhibou a été classé et médiatiser comme « ville de Transit » à la fin des années 2004 en tant que point de passage ou relais pour des milliers de candidats à l'immigration vers l'Europe via les Canaries par les pirogues sénégalaises.

Dans ce texte, nous allons d'abord relater le cursus migration des pêcheurs de «Guet-Ndar » jusqu'à leur arrivée en Mauritanie. Nous allons ensuite montrer comment ses pêcheurs migrants participer à la qualification de la fonction de de ville ou d'espace de transit qui lui est assigné. Après, nous allons évoquer la réinstallation de l'industrie de la farine et de l'huile de poisson à partir des années 2004 pour expliquer comment cette industrie a constitué un point de chute ou un refuge pour des milliers de migration à cause du renforcement du contrôle de l'entrée aux frontières de l'espace Schengen par voie maritime à partir de Nouadhibou.

Keywords : migration, pêcherie pélagique ; farine ; huile de poisson ; pêcheurs, Guet-Ndar ; Mauritanie, Transit, refuge, Saint-Louis, Sénégal.

Session ICAWA-4

Impact of subsidies on the dynamics of pelagic small-scale fishery in Senegal

Aliou BA[1,4,*], Jörn SCHMIDT[2], Christian CHABOUD[3], Malick Diouf[4] and Patrice BREHMER[1]

[1]Institut de Recherche pour le Developpement (IRD) /Institut Sénégalais de Recherches agricoles (ISRA), Centre de Recherches Océanographiques de Dakar Thiaroye (CRODT), PRH, BP 2241, Dakar, Sénégal
[2]University of Kiel, Germany (CAU), Department of Economics
[3]Institut de Recherche pour le Développement (IRD), UMR 248 MARBEC (Marine Biodiversity, Exploitation and Conservation), CS 30171, 34203 Sète, France
[4]Université Cheikh Anta Diop de Dakar, Institut Universitaire de Pêche et d'Aquaculture (IUPA), BP 206, Dakar, Sénégal

*Correspondance: Tél: (+221) 705 910 585; Courriel: aliou.ba@ird.fr (A. BA)

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Abstract

Small pelagic fish are the main fish resource in North West Africa. In Senegal, they are mainly represented by the sardinellas (Sardinella aurita and S. maderensis). The fishery, mostly composed by purse seins and encircling gill nets, is predominantly performed by artisanal fishers and is of great importance for the Senegalese economy and for food security in the region. However this fisheries is totally (engine fuel and fishing gear) subsidized by the state. Because of these effects, sometimes negative, this subsidy is the subject of severe criticism in the world. In such context, the operating conditions for this fishery have changed during the recent years, thus a bioeconomic model is developed to simulate the dynamics of sardinella exploitation and analyze the impact of subsidies on the dynamics of the fishery. This model may also allow managers and decision makers to analyze the responses of the fishery to economic (price, costs), biologic (growth, mortality, recruitment) and management (tax, subsidies, licenses, spatial regulations) parameters.

Keywords: bioeconomics, small pelagic fish, West Africa, fishing policy, subsidies.

Session ICAWA-4

Reaching milestones of public regulations in marine environment: Toward an integrative way of marine management

Marie BONNIN [1,*]

[1] Institut de recherche pour le développement (IRD), UMR LEMAR-IUEM, Rue Dumont d'Urville, Technopole Brest Iroise, 29280 Plouzané, France

*Correspondance: Tél: +33 (0)29 0915 554; Courriel: marie.bonnin@ird.fr (M. BONNIN)

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Abstract

Marine environmental law has been emerging in West Africa in 70's. International convention has been ratified and national law progressively developed. This communication will show the development of marine environmental law in West African countries using examples from Senegal, Mauritania and Cabo-Verde. This field of law use to be very sectorial. However, the development of integrative ways of regulations at international level impacts West African national law on marine environment. Lastly, examples of first steps toward an integrative way of regulation are underlined in West African countries.

Keywords: Marine law, regulation, integrative approach, Tropical Atlantic, West Africa.

Session ICAWA-4

Climatic benchmarks among Senegalese fishermen: what has changed

Adama MBAYE[1,*], Marie-Christine Cormier-SALEM[2], Jörn SMITH[3], and Patrice BREHMER[4]

[1]Institut Sénégalais de Recherches agricoles (ISRA), Centre de Recherches Océanographiques de Dakar Thiaroye (CRODT), PRH, BP 2241, Dakar, Sénégal
[2]Institut de Recherche pour le Developpement (IRD) /Patrimoines locaux, Environnement et Globalisation (PALOC), UMR 208, 75231 Paris cedex 05
[3]University of Kiel, Germany (CAU)
[4]Institut de Recherche pour le Developpement (IRD) /Institut Sénégalais de Recherches agricoles (ISRA), Centre de Recherches Océanographiques de Dakar Thiaroye (CRODT), PRH, BP 2241, Dakar, Sénégal

*Correspondance: Tél: (+221) 77 656 57 83; Courriel: ambayeskr@yahoo.fr (A. MBAYE)

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Abstract

Senegalese artisanal fishermen, in their fishing activity, cut the year into four fishing seasons (autumn, winter, spring, and summer). Each of these seasons is characterized by a type of regular natural phenomena that they observe for decades that serve as benchmarks for determining their duration (beginning, middle and end). The benchmarks on these four fishing seasons are the presence of stars (types of stars) the presence of certain species (types of fish types of birds), the temperature of the air and water, types of winds, the nature of the sea. It is from these benchmarks that they measure the evolutions (variation and change) observed in each season in order to be able to adapt their activities accordingly. The changes noted by the fishermen concern the disturbances on noted the duration of the periods of cold and periods of heat such as initially recorded according to the seasons, the disturbances on the marks on the movement of the fish according to the seasons. Thus, through the expression "there are no more seasons as before", the fishermen note the appearance of discrepancies between the current seasonal cycles and the seasonal cycles of the 60s attesting to a loss of benchmarks due to irregularities of certain phenomena that characterized each season. Climate change thus appears through the "ruptures" between what the old fishermen now live compared to what they used to live.

Keywords: climate change-empirical knowledge-landmarks-artisanal fisheries-Senegal.

Session ICAWA-4

The influence and fluctuating trends of ocean variables in surface mixed layer of the south atlantic ocean, Nigeria

Francis E. ASUQUO[1,*], Nsikak BENSON[2] and Nsisong DANIEL[1]

[1]Physical Oceanography Department, Faculty of Oceanography, University of Calabar, Nigeria
[2]Department of Chemistry, College of Science and Technology, Covenant University, Nigeria

*Correspondance: Courriel: fe.asuquo@unical.edu.ng (F. ASUQUO)

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Abstract

An assessment of the behavior of the surface mixed layer in relation to the variations of sea surface salinity, sea surface temperature and pH in coastal waters of Nigeria revealed that surface heat fluxes and dominating coastal winds contributed remarkably to the observed trends in the physicochemical anomaly. The sea surface salinity (SSS) fluctuated with change in lunar tides. A unimodal trend occurred at spring while bimodal symmetry ensued at neap tide. Generally, changes in salinity was directly related to changes in sea level where high salinity corroborated with increasing sea level, and low salinity with reduction in sea level. The SSS ranged from 17–32 ppt during the period. The sea surface temperature (SST) varied from 23–30°C increasing during flood tide and with a decrease at ebb tide with a maximum hourly mean of 29.5°C during spring tide. The Tmax and Tmin occurred at spring tide high water slack respectively. The pH patterns (range 7.3–9.5) during the study were strikingly different. The diurnal patterns were highly irregular and differed at each tide. A haphazard pattern dominated during the spring tide except at the onset of neap tide where a unimodal fluctuation existed. Peak SSS coincided with peak pH during spring tide indicating minimal influence from freshwater drainage.

Keywords: Ocean variables, surface mixed layer, fluctuating trends, South Atlantic Ocean, Nigeria.

Session ICAWA-4

The Future of West Africa fisheries under threat: Learning from the 2017 Greenpeace Expedition in the SRFC States Members

Ahmed DIAME[1,*]

[1]Greenpeace, Africa, BP 3788 – Dakar Sénégal

*Correspondance: Tél : (+221) 77 332 89 93 ; Courriel: ahmed.diame@greenpeace.org (A. DIAME)

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Abstract

Not communicated

Contact the author

Session ICAWA-4

Towards improved climate prediction for West Africa

Noel Keenlyside[1,2*], Mahaut DE VAREILLES[1,2], Peter BRANDT[3], Timothée BROCHIER[4,5] Teferi DEMISSIE[6,2], Shunya KOSEKI[1,2], Elsa MOHINO[7], Jorge LOPEZ-PARAGES[7], Chloé PRODHOMME[8], AND Abdoulaye SARRÉ[9]

[1] Geofysisk Institutt, Universitetet i Bergen, Bergen, Norway
[2] Bjerknes Centre for Climate Research, Bergen, Norway[3] GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany
[4] IRD, UMMISCO, Bondy, France
[5] IRD, Univ Brest, CNRS, Ifremer, Lemar, Dakar Senegal
[6] Uni Research Climate, Bergen, Norway
[7] Departamento de Fisica de la Tierra, Astronomia y Astrofisica I, Geofisica y Meteorologia, niversidád Complutense de Madrid, Madrid, Spain
[8] Barcelona Supercomputing Centre, Barcelona, Spain[9] ISRA, Centre de Recherche Océanographique de Dakar-Thiaroye, Dakar, Senegal

*Correspondance: Tél: (+47) 55 58 20 32; Courriel: noel.keenlyside@uib.no (N. KEENLYSIDE)

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Abstract

The project "Enhancing Prediction of Tropical Atlantic Climate and its Impacts – PREFACE» (www.preface-project.eu) is a 4.5 year research project funded by the European Union under FP7- Environment. The project gathers 28 partners from 18 countries across Africa and Europe, with expertise in oceanography, climate modelling and prediction, and fisheries science, targeting climate prediction and marine-ecosystem changes in the eastern boundary and equatorial upwelling regions of the tropical Atlantic. Since 2013 and in a spirit of strong international cooperation, PREFACE has made important contributions towards improving the Atlantic observational network and climate prediction models – whilst enhancing local capacity and harvesting the synergy from inter-projects collaboration – such that we can now usefully forecast climate from a season to a decade in advance over large regions of the tropical Atlantic Ocean, and over parts of continental South America and Africa. A particular example is the skill in predictions of ocean surface temperature and Sahel rainfall a season to several years ahead. There is also a potential to predict stock biomass from a season to years in advance. We showed that the upwelling intensity in North West Africa and consequent marine productivity are redistributed due to warming trends, and we report a northern spatial shift of round sardinella. In the southeast Atlantic, a similar shift is reported on the same species. Such potentially predictable changes impact food security management and demand adequate policy measures. However, more work is required to make the most use of these predictions. Climate model errors and modelling of biophysical relations continue to be a major challenge. These introduce uncertainties in future projections of climate change and its impacts in this region. They also limit shorter-term climate prediction. Thus much more work is needed to improve models. Collaborative climate research on the Atlantic remains a key priority.

Session ICAWA-4

Isotopic niche plasticity in mesopelagic fish assemblages of the Eastern tropical North Atlantic under different productivity environments

Stephanie CZUDAJ[1,*] and Heino FOCK[2]

[1]Thünen Institute, Institute of Sea Fisheries, Germany

*Correspondance: Tél: (+49) 471 94460 101; Courriel: stephanie.czudaj@thuenen.de (S. CZUDAJ)

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Abstract

The present study investigates the spatial variability in the isotopic niches of the same mesopelagic fish species assemblage (eight myctophids, one gonostomatid, one sternoptychid) of the Eastern tropical North Atlantic along a productivity gradient. We use appendicularians caught at 0 – 50 m as regional baseline indicators. Our results demonstrate an inconsistent non-linear relationship of the different species' δ15N values to the appendicularian proxy of regional surface productivity, exhibiting two main patterns: one group showing correspondence to the significant differences in regional appendicularian signal, while mean δ15N values of other species do not change across regions. We discuss implications of the interplay of environmental factors, multiple resource pools, biochemical composition and inter-species competition on the trophic interpretation of nitrogen isotopes in complex open ocean mesopelagic ecosystems. Using dispersion metrics and standard ellipses the present study quantifies the relative change in the realized isotopic niche space of individual mesopelagic species in response to different productivity regimes under competition pressure.

Session ICAWA-4

Habitat and catch rates of Yellowfin tuna in Cape Verdian waters linked to ocean surface processes

Heino FOCK[1,*]

[1]Thünen Institute, Institute of Sea Fisheries, Germany

*Correspondance: Tél: (+49) 471 94460 366; Courriel: heino.fock@thuenen.de (H. FOCK)

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Abstract

This report covers the main aspects of the WP 12 analysis of Yellowfin tuna (YFT) dynamics with regards to temporal trends and spatial distribution of catches around Cape Verde and covers a first analysis of size classes of forage fish. Results on tuna stable isotope analysis are not included, since they were not fully analysed. Tagging results indicated that YFT in line with literature results, mainly occupy the epipelagic layer of the ocean, rarely extending dives beyond 150 m. Catch-per-unit-effort trends as indicators of abundance in the Cape Verde region indicated a strong effect of subtropical wind stirring with a subsequent cooling of the surface layer, which led to an increase in abundance, evidenced in negative correlations to January SST in the area. A calming down of longitudinal wind in May and June was also significant. SST effect is interpreted as conditions of enhanced ecosystem productivity, with subsequent attraction and aggregation of this migratory species. Spatially significant factors extending the center of gravity of catches were positive SST anomalies (with regards to longitude) and positive NAO and NAO with a lag of 1 year (with regards to latitude). Positive NAO is linked to less wind stirring, so that the ocean surface layer is not cooled down. This is in line with published results, indicating that YFT did not show any range contraction. The epipelagic swimming characteristics of YFT augment the interpretation of surface features associated with wind stirring and surface cooling which were indicated as significant factors in the analysis of CPUE and spatial distribution of catches.

Session ICAWA-4

Sardinella aurita growth parameters variability under climate change and fishing pressure

Bocar Sabaly BALDÉ[1,2,*] , Fambaye NGOM[2], Kamarel BA[1,2], Werner EKAU[3], Modou THIAW[2], Massal FALL[2], Justin KANTOUSSAN[4], Jean FALL[1], Malick DIOUF[1], and Patrice BREHMER[2]

[1]Université Cheick Anta Diop (UCAD), Institut Universitaire des Pêche et de l'Aquaculture, UCAD II, Dakar–Fann, Senegal

[2]Insitut Sénégalais de Recherche Agricole (ISRA), Centre de Recherche Océanographique de Dakar-Thiaroye (CRODT), BP 2241, Centre PRH, Dakar, Senegal
[3]Leibniz Center for Tropical Marine Ecology (ZMT), GmbH- Fahrenheitstraße 6, 28359 Bremen, Germany
[4]Université Gaston Berger de Saint-Louis (UGB), UFR des Sciences Agronomiques, de l'Aquaculture et des Technologies Alimentaires (S2ATA), BP 234, Saint-Louis, Sénégal

*Correspondance: Tél: (+221) 77 2346 421; Courriel: bocarbalde2005@hotmail.com (B. BALDE)

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Abstract

Sardinella aurita is an overexploited fish and a key species in Senegal at socioeconomics level, nevertheless the growth parameters have not been updated since 30 years. The study of growth parameters is a good indicator of fish stressors. In this work, we analyzed *S. aurita* (n = 32 300) age and growth in Senegal according to von Bertalanffy model taking into account the seasonality. Growth parameters are then compared with those previously obtained in the literature on the same geographical area (since 60 to 34 years) and more widely in different locations in Atlantic and Mediterranean Sea. The results show a significant difference of growth parameters in Senegal since 30 years, indeed growth of *S. aurita* became slower and its maximum size has significantly decreased. The comparison of *S. aurita* variability in growth performance reported in the literature in Mauritania-Senegal coast, as well as in Mediterranean Sea and Eastern/Western Atlantic Ocean show significant influence of environmental parameters and/or the level of exploitation. In one hand in tropical Atlantic, *S. aurita* growth in Northwest Africa is similar to the one reported in Western Atlantic, while *S. aurita* growth is rather slow in Mediterranean Sea where, vs tropical Atlantic, temperatures and preys availability are lower. On the other hand, in the Western Atlantic Ocean, where the fishing pressure has declined over the 50 years, an increase in asymptotic length is reported. However, in the Mediterranean and Norwest Africa, where the fishing pressure is high, the asymptotic length has drastically decreased during its last years.

Keywords: Small pelagic, round sardinella, size structure, stock management, West Africa.

Session ICAWA-4

Effect of environmental variables on the structure of micronectonic layers over the Senegalese continental shelf

Ndague DIOGOUL[1,6*], Patrice BREHMER[2,3,6], Yannick PERROT[3], Maik TIEDEMANN[4], Abou THIAM[1], Salaheddine EL AYOUBI[5], Anne MOUGET[3], Chloé MIGAYROU[3], Oumar SADIO[2], and Abdoulaye SARRÉ[6]

[1] University Cheikh Anta Diop UCAD, Institute of Environmental Science (ISE), Dakar, Senegal
[2] IRD, Univ Brest, CNRS, Ifremer, LEMAR, Campus UCAD-IRD de Hann, Dakar, Senegal
[3] IRD, Univ Brest, CNRS, Ifremer, LEMAR, DR Ouest, Plouzané, France
[4] Institute of Marine Research IMR, Pelagic Fish, PO Box 1870 Nordnes, 5817 Bergen, Norway
[5] Institut National de Recherche Halieutique INRH, Agadir, Morocco
[6] Institut Sénégalais de Recherches agricoles ISRA, CRODT, BP 2221 Dakar, Senegal

*Correspondance: Tél: (+221) 77 623 3520; Courriel: diogoulndague@yahoo.fr (N. DIOGOUL)

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Abstract

The micronectonic organisms aggregate at specific depths and occur as scattering layer on echosounder records. They constitute an important component in the marine food web in direct contact with primary producers. We characterized the Senegalese water masses of the “Petite côte” on physicochemical and biological criteria using an in situ data set collected during an acoustics survey. Then we described at fine scale spatial and temporal variation of micronektonic layers in relation with their environment. Two areas with different characteristics have been discriminated: the upwelling’s cell area and the upwelling’s offshore area more stratified, warm and sharply separated from the other area by a strong thermal boundary. The spatio-temporal variation of scattering layer’s thickness of micronectonic is strongly influenced by depth and the time of the day. The continental shelf scattering layer’s thickness increases with depth, but no variation is reported in longitudinal plane. In both areas nocturnal layers are thicker and deeper than diurnal ones. The hydrological structure of the water column also influence the micronectonic scattering layer. The scattering layer requires "stable" physical conditions which support vertical stratification. In the upwelling’s area cell, the chlorophyll-a (CHL) concentration is correlated to scattering layer thickness during night time. In the upwelling’s offshore area, sea temperature, water density and oxygen have a significant effect on the scattering layer’s thickness during the nightime. However, during the daytime, CHL has a significant effect on the scattering layer’s thickness. This correlation between CHL and scattering layer thickness in the upwelling’s offshore area during day could be explained by an inverse diel vertical migration of a micronectonic group. On this basis we assume that trophic relationship between phytoplankton and micronecton operate during the day at the surface in this area.

Keywords: sound scattering layer, plankton, fish, upwelling, ecosystem, ECOAO, West Africa.

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AWA - PREFACE Policy Workshop, Wednesday, Nov. 15 (afternoon)

Socioeconomics and Regulation perceptions in the small scale fishing sector - Findings from the PREFACE surveys in Cabo Verde and Senegal

Jörn SCHMIDT[1,*] Lancker Kira[1], Hoffmann Julia[1], Ba Aliou[2], Mbaye Adama[2], and Fricke L[1]

[1]University of Kiel (CAU), Department of Economics, Germany
[2] ISRA, centre de recherche oceangoraphique de Dakar Thiaroye (CRODT), Dakar, Senegal

*Correspondance: Tél: (+49) 431 880-5632 ; Courriel: jschmidt@economics.uni-kiel (J. SCHMIDT)

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Abstract

Artisanal fisheries still play a large role in many economics, especially in developing countries. These fishers and the coastal communities in general, face various risks in their everyday life including uncertainty about the success of fishing, uncertain prices for fish and uncertain costs for inputs such as fuel, and many more. In addition, foreign fleets, changing world markets and other global factors including climate change in particular can put additional pressures on top of this. We have used field surveys and economic experiments among fishing communities to assess how fisher perceive these risks and how they cope with them. The surveys were carried out in Senegal and Cape Verde, with 691 and 671 valid interviews, respectively. In this presentation, we will provide insights into some parts of our results including the general situation of the fisheries and fishers, climate change perceptions, and on coping mechanisms.

Session ICAWA-4

Socioeconomics and Regulation Perceptions of Artisanal Fisherfolk in the Marine Fisheries Sector in Nigeria

Nnaemeka Andegbe CHUKWUONE[1,*], Jörn SCHMIDT[2], Kira LANCKER[2], and Ebele Chinelo AMAECHINA[3]

[1]Department of Agricultural Economics and Centre for Entrepreneurship and Development Research (CEDR), University of Nigeria, Nsukka, Enugu State, Nigeria
[2]University of Kiel (CAU), Department of Economics, Germany
[3]Department of Agricultural Economics, University of Nigeria, Nsukka, Enugu State, Nigeria

*Correspondance: Tél: (+234) 805 1242 411 ; Courriel:nmaemeka.chukwuone@unn.edu.ng (N. CHUKWUONE)

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Abstract

Despite the high level of artisanal fishing in the marine fisheries sector in Nigeria, marine fisheries regulation, although limited, is mainly focused on industrial fishing. Artisanal marine fishing in Nigeria is open access with regulation, although not monitored, limited to mesh size and use of explosives and poisonous matter in fishing. This among others has resulted in overfishing, reduced fish catch and catches dominated by juveniles. Considering the role of effective regulation in controlling overfishing, this study determines the perception of fisher folks as regards the use of regulation in marine fisheries in Nigeria. A total stratified sample of 1105 fisherfolks from 17 core fishing grounds in eight coastal states across Nigeria, 65 fishermen in each fishing ground, were interviewed. The result of descriptive statistics shows that the most common fishing method, across all vessels, is the drift net (28.25%) while 82.93% of all vessels are motorized. The main species caught are croakers, bonga shad and barracudas. The majority (60.77%) of fisherfolks indicated that there was need for regulation in artisanal fishing in the marine sector. The majority (67.56%) that supports regulation are captains/persons responsible for boat. Also, the majority (75.92%) that supports regulation are of the opinion that government should be responsible for issuing and controlling regulations in the marine fisheries sector. Only 5.5% of the fisherfolks indicated that they currently have rules as regards fishing in their coastal communities. The most effective rules in their communities are restriction on fish size (47.49%) and restriction on fishing gears (27.63%). The findings suggest that government can implement some regulations in artisanal fishing in Nigeria marine sector in order to help reduce overfishing and improve catch.

Session ICAWA-4

The artisanal hand line fishery in Cabo Verde: A regional analysis of weather impacts on harvest and income

Kira LANKER[1,*]

[1]University of Kiel (CAU), Department of Economics, Wilhelm-Seelig-Platz 1, 24118, Kiel, Germany

*Correspondance: Tél: (+49) 431 880-4978; Courriel: lancker@economics.uni-kiel.de (K. LANKER)

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Abstract

As part of the PREFACE project, we undertake to model the artisanal hand line fishery in Cabo Verde targeting Yellowfin tuna. We use monthly data on catch, effort and weather conditions in conjunction with yearly biomass and price data to model the supply system. Using a quadratic cost function and a harvest production function, we estimate the effect of biomass changes and price changes on harvest. Due to the mostly localized nature of artisanal fishing, we can use the model for a comparison of the three regions Barlavento east, Barlavento west and Sotavento. Secondly, we use weather conditions such as sea surface temperature (SST), wind speed and precipitation to analyze their impact on yellowfin catchability. Productivity in Cape Verde waters has been shown to depend particularly on wind regime and SST. In addition, precipitation may influence salinity and may lead to a nutrient increase, washed from the islands into the sea. Our model allows us not only to look at the influence of these variables on yellowfin availability, but also to quantify the economic impact of it for the separate three island regions. Therefore, in a second step, it will serve to forecast the economic consequences from future changes in weather conditions, as predicted by fellow PREFACE workpackages, for artisanal fisherfolk.

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Book of abstract and recommendations

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Session 1: « Ocean modelling»

Oral presentation

Session 1

Eastern boundary circulation and hydrography off Angola – building Angolan oceanographic capacities

Pedro TCHIPALANGA[1,*], Marcus DENGLER[2], Peter BRANDT [2,3], Robert KOPTE [2], Marisa MACUÉRIA [4], Paulo COELHO [4], Marek OSTROWSKI [5] and Noel KEENLYSIDE [6]

[1]Instituto Nacional de Investigação Pesqueira, Departamento do Ambiente e Ecossistemas Aquáticos, Moçâmedes, Angola
[2]GEOMAR Helmholtz Centre for Ocean Research Kiel, FB1: Ocean Circulation and Climate, Physical Oceanography, Kiel, Germany
[3]Christian-Albrechts-Universität zu Kiel, Mathematisch-Naturwissenschaftliche Fakultät, Kiel, Germany
[4]Instituto Nacional de Investigação Pesqueira, Luanda, Angola
[5]Institute of Marine Research, Oceanography and Climate, Bergen, Norway
[6]Geophysical Institute, University of Bergen, & Bjerknes Center for Climate, Norway

*Correspondance: courriel : mdengler@geomar.de (M. Dengler)

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Abstract

The eastern boundary region off Angola encompasses a highly productive ecosystem important for the food security of the coastal population. The fish-stock distribution, however, undergoes large variability on intraseasonal, interannual and longer time scales. These fluctuations are partly associated with large-scale warm anomalies that are often forced remotely from the equatorial Atlantic and propagate southward reaching the Benguela upwelling off Namibia. Such warm events, named Benguela Niños, occurred in 1995 and in 2011. Here we present results from an under-explored extensive in-situ dataset that was analysed in the framework of a capacity strengthening effort. The dataset was acquired within the Nansen Programme executed by the Food and Agricultural Organization of the United Nations and funded by the Norwegian government. It consists of hydrographic and velocity data from the Angolan continental margin acquired bi-annually during the main downwelling and upwelling seasons over more than 20 years. The mean seasonal changes of the Angola Current from 6°S to 17°S are presented. During austral summer the southward Angola Current is concentrated in the upper 150 m. It strengthens from north to south reaching a velocity maximum just north of the Angola Benguela Front. During austral winter the Angola Current is weaker, but deeper reaching. While the southward strengthening of the Angola Current can be related to the wind forcing, its seasonal variability is most likely explained by coastally trapped waves. On interannual timescales, the hydrographic data reveals remarkable variability in subsurface upper ocean heat content. In particular, the 2011 Benguela Niño was preceded by a strong subsurface warming of about 2 year duration.

Session 1

Role of Equatorial Basin-Mode Resonance for the Seasonal Variability of the Angola Current at 11°S

Robert KOPTE [1,*], Peter BRANDT [1,2], Martin CLAUS [1,2], Richard J. GREATBATCH [1,2] and Marcus DENGLER [1]

[1]GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Kiel, Germany
[2]Christian-Albrechts-Universität zu Kiel, Kiel, Germany

*Correspondance: courriel rkopte@geomar.de (R. KOPTE)

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Abstract

Multi-year moored velocity observations of the Angola Current near 11°S reveal a weak southward mean flow superimposed by substantial intraseasonal to seasonal variability, including annual and semiannual cycles with distinct baroclinic structures. In the equatorial Atlantic these oscillations are associated with basin-mode resonances of the fourth and second baroclinic modes, respectively. Here, the role of basin-mode resonance and local forcing for the Angola Current seasonality are investigated. A suite of linear shallow-water models for the tropical Atlantic is employed, each model representing a single baroclinic mode forced at a specific period. The annually and semiannually oscillating forcing is given by 1) an idealized zonally uniform zonal forcing restricted to the equatorial band corresponding to a remote equatorial forcing or 2) realistic, spatially-varying Fourier components of wind stress data that include local forcing off Angola, particularly alongshore winds. Model-computed modal amplitudes are scaled to match moored velocity observations from the equatorial Atlantic. The observed annual cycle of alongshore velocity at 11°S is well reproduced by the remote equatorial forcing. Including local forcing slightly improves the agreement between observed and simulated semiannual oscillations at 11°S compared to the purely equatorial forcing. However, the model-computed semiannual cycle lacks amplitude at mid-depth. This could be the result of either underestimating the strength of the second equatorial basin-mode of the fourth baroclinic mode or other processes not accounted for in the shallow-water models. Overall, our findings underline the importance of large-scale linear equatorial wave dynamics for the seasonal variability of the boundary circulation off Angola.

Session 1

Sources and Propagation Pathways of Water Masses to the Northern Benguela Upwelling System

Martin SCHMIDT [1,*], Lydia SIEGFRIED [1], Volker MOHRHOLZ [1], Tim JUNKER [1], Anja van DER PLAS [2], Pascal NARDINI [3], Gerik SCHEUERMANN [3] and Michael BÖTTINGER [4]

[1]Leibniz-Institute for Baltic Sea Research Warnemünde, Germany
[2]National Marine Information and Research Centre, Namibia
[3]Universität Leipzig, Institute for Computer Science, Germany
[4]Deutsches Klimarechenzentrum GmbH, Germany

*Correspondance: courriel martin.schmidt@io-warnemuende.de (M. SCHMIDT)

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Abstract

We investigate sources and propagation pathways of water masses determining the hydrographic conditions in the Northern Benguela Upwelling System (NBUS). Our results challenge the common view on the water mass variability in the NBUS as derived from a classical water mass analysis and limited field data. From in-situ temperature and salinity measurements two major source water masses are well known, South Atlantic Central Water (SACW) and Eastern South Atlantic Central Water (ESACW). Both have different oxygen and nutrient characteristics. Mooring data have shown the direct relation between poleward SACW transport with a coastally trapped undercurrent and the oxygen conditions in the NBUS. Hence, the coastal wave guide is considered as the major pathway and direct link for poleward spreading SACW from the equatorial area into the NBUS. Based on a numerical tracer release experiment, we present a more comprehensive view on the origin of the water mass variability in the NBUS. We could identify three major source areas for water masses determining the hydrographic, oxygen and nutrient variability in the NBUS. In addition to the coastal wave guide, the South Equatorial Counter Current (SECC) and the South Equatorial Under Current (SEUC) reveal as major pathways of tropical SACW into the NBUS. Near the northern rim of the NBUS in the Kunene upwelling cell, south-eastward extensions of the SECC merge with the coastal flow (Angola current) and feed the poleward undercurrent. Away from the coast and on a decadal scale the simulated ocean current field partly resembles a Sverdrup balanced flow, indicating the importance of the large scale wind stress curl over the south-eastern Atlantic for the variability of the water mass composition, oxygen and nutrient conditions in the NBUS. We discuss seasonal cycle and interannual variability of conservative model tracers, oxygen and nutrient conditions in the NBUS in response to the wind field variability.

Session 1

Coastal trapped wave propagation along the southwest African shelf as revealed by moored observations

Tim JUNKER [1,*], Volker MOHRHOLZ [1], Martin SCHMIDT [1], Lydia SIEGFRIED [1] and Anja van DER PLAS[2]

[1]Leibniz-Institut fur Ostseeforschung Warnemünde (IOW), Germany
[2]National Marine Information and Research Centre (NatMIRC), Swakopmund, Namibia

*Correspondance: courriel Tim.Junker@io-warnemuende.de (T. JUNKER)

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Abstract

Coastal trapped waves (CTWs) that propagate poleward along the south west African shelf potentially leak energy from lower latitudes into the Benguela Upwelling System (BUS). Thus, in addition to the local winds, these waves provide an important remote forcing mechanism for the upwelling region.

The present study aims at elucidating the basic nature of CTWs in the northern BUS. To this end we make use of unique, multi-site velocity observations from the Namibian shelf (18°S, 20°S, 23°S). By means of wavelet methods, we examine the alongshore velocity signal for signatures of CTWs. We found that a substantial amount of energy is concentrated within a sub monthly to sub seasonal frequency band (10-50 d). Based on the coherence and phase spectra of the alongshelf currents, we provide evidence for a predominant southward phase propagation and establish typical time and length scales of CTWs in the region. It turns out that their properties differ significantly within a few hundred kilometres along the coast. A comparison of the results with theoretical dispersion curves shows that this difference is most likely explained by variations in the cross-shelf topography. Finally, we investigate the coupling of the alongshore currents with the coastal and equatorial wind stress and highlight regions of potential wave generation.

Session 1

Benguela Niño and Niña events from 1958 to 2015

Rodrigue Anicet Imbol KOUNGUE [1,2,*], Serena ILLIG [1,3], and Mathieu ROUAULT [1,2]

[1]Department of Oceanography, MARE institute, University of Cape Town, South Africa
[2]Nansen-Tutu Centre for Marine Environmental Research, University of Cape Town, South Africa
[3]Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS), Université de Toulouse, CNES, CNRS, IRD, UPS, part of the International Mixed Laboratory ICEMASA, Toulouse, France

*Correspondance: courriel Mathieu.Rouault@uct.ac.za (M ROUAULT)

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Abstract

Benguela Niños and Niñas are intermittent, extreme warm and cold events that develop near the border between Angola and Namibia. These extreme events have been intensively studied these past years because of their significant impacts on the regional rainfall and the local marine ecosystem. Recently, Imbol Koungue et al. [2017], evidenced the role played by the Interannual Equatorial Kelvin waves during the onset of Benguela Niños and Niñas over 15 years (1997-2012). The present study is an update of the recent paper by Imbol Koungue et al. [2017]. We aim to revisit most of the Benguela Niños and Niñas developing before 1998 along the Angolan and Namibian coastlines using monthly averaged from an Ocean General Circulation Model (OGCM) for the period 1958 - 2015 which has been validated using available observation datasets. Preliminary results show the occurrences of 55 anomalous coastal events (29 warm and 26 cold) over the period 1958 – 2015. In agreement with recent studies, most of these anomalous coastal events are remotely forced via Interannual Equatorial Kelvin Wave (IEKW) propagations at interannual timescales with equatorial variability leading coastal SST variability by 1 month. Meridional transport anomalies across the ABF seem to contribute to the development of these anomalous coastal warm events. We show that October to April appears to be the favourable season in which anomalously warm or cold coastal events in the South-east Atlantic Ocean peak and are also linked to the remote oceanic forcing (IEKW).

Session 1

How does the low-frequency Equatorial Kelvin Wave activity, local ocean stratification, and coastal winds modulate the south-eastern interannual Atlantic variability?

Marie-Lou BACHELERY [1,2,*], Serena ILLIG [1,3,4] and Mathieu ROUAULT [1,2]

[1]Department of Oceanography, University of Cape Town, Cape Town, Rondebosch, South Africa
[2]Nansen-Tutu Centre for Marine Environmental Research, University of Cape Town, South Africa
[3]Laboratoire d'Etude en Géophysique et Océanographie spatiale (LEGOS), CNRS/IRD/CNES, Toulouse, France
[4]MARE Institute, LMI ICEMASA, University of Cape Town, Cape Town, Rondebosch, South Africa

*Correspondance: courriel Mathieu.Rouault@uct.ac.za (M ROUAULT)

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Abstract

The objective of this study is to describe the low-frequency modulation of the Equatorial Kelvin Wave (EKW) activity in the tropical Atlantic as well as the low-frequency modulation of the local stratification and coastal winds along the coast of south-western Africa. We aim at investigating the control of these forcings in modulating the oceanic interannual variability off the coasts of Angola/Namibia and the phenomenology of Benguela Niño/Niña events. The methodology is based on the development of a high resolution (1/12°) long-term (1958 - 2008) numerical simulation of the South-Atlantic Ocean using the Regional Ocean Modeling System (ROMS). The evaluation of the model performances show that the model is skilful in reproducing the mean state and the interannual variability. The evaluation of the equatorial forcing reveals a low-frequency modulation of the EKW activity with a significant reduction of the EKW energy from 1958 to 1990, then re-energized up to 2008. Variations are associated with change in EKW baroclinic mode contribution to interannual sea level anomalies: from 1958 the second baroclinic mode dominate, and is then balance by the third baroclinic mode after the late 1990's. Concomitantly, further analyses show a decrease of the wind stress forcing and a modulation of the magnitude of wind projection coefficients according to the oceanic baroclinic modes in the Guinea gulf with in particular a strong increase of the third EKW mode. Changes are associated with the increase (decrease) of the intensity (maximum depth) of the equatorial stratification. Our results suggest that the change in the remote equatorial forcing may play an important role in the modulation of the variability off the coasts of South-West Africa. These results will be confronted to the low frequency modulation of local wind variations and Coastal Trapped Waves (CTW) signature due to different stratification state along the south-eastern coast of Africa. Indeed, modulation of the coastal stratification will most likely impact the characteristics of CTW propagation and their efficiency to imprint the coastal interannual variability in the Benguela Upwelling System.

Session 1

Monitoring Rossby waves along 6 degree south in the tropical Atlantic

Mathieu ROUAULT [1,2,*], Rodrigue Anicet Imbol KOUNGE [1,2] and Serena ILLIG [1,3]

[1]Department of Oceanography, MARE Institute, University of Cape Town, South Africa
[2]Nansen Tutu Center for Marine Environmental Research, Ma-re Institute, University of Cape Town, South Africa
[3]ICEMASA, LEGOS, IRD, France

*Correspondance: Tél: (0)21 650 3607; Courriel: Mathieu.rouault@uct.ac.za (M. ROUAULT)

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Abstract

The PREFACE program allowed the deployment and annual maintenance of an ATLAS mooring at 6° S, 8° E during PREFACE cruises. A first mooring was bought by South Africa in 2006 and was deployed successfully for a year during a pilot project. PREFACE allowed to buy a second mooring needed to establish a permanent location as one replaced a mooring by a complete calibrated one. This is an extension of the PIRATA array of moorings in the tropical South-East Atlantic and an African contribution to the global observing system. PREFACE acquired an ATLAS mooring which is equipped with an extra currentmeter at 10 m depth and an extra short wave radiation sensor which allows calculation of the radiative flux and the net heat budget at a 10 minute temporal resolution. Turbulent sensible and latent heat fluxes can also be calculated at a 10 minute resolution. Sensible and Daily average is available in real time. A CO_2 sensor is also deployed on the mooring. The strategic location of the mooring in the stratocumulus deck which is a problem to coupled models, offshore of the Congo River plume and upstream of the Angola Current make this mooring a unique measuring platform which has continuously worked in real time since May 2013. Mooring data and satellite remote sensing estimates of salinity indicates numerous intrusions of low salinity water from the Congo River since 2013. While the air and sea surface temperature (SST) distribution is unimodal, the upper ocean subsurface temperature and dynamic height is bi-modal and seems to be a seasonal Rossby wave triggered by a seasonal kelvin waves along the equator. PIRATA mooring, altimetry and SST allow monitoring the passage of Rossby waves all the way to Brazil modifying the SST in a region that is known to impact the regional Brazilian climate.

Reference

Rouault, M., Servain J., Reason C.J.R., Bourles B., Rouault M.J., Fauchereau N., 2009: Extension of PIRATA in the tropical South-East Atlantic: an initial one-year experiment. African Journal of Marine Science 2009, 31(1): 63–71.

Session 1

Equatorial Deep Jets in the Atlantic Ocean studied by observations and ocean general circulation models

Peter BRANDT [1,2,*], Richard J. GREATBATCH [1,2], Martin CLAUS [1,2], Jan-Dirk MATTHIEßEN [1], Franz Philip TUCHEN [1], François ASCANI [3], Marcus DENGLER [1], John TOOLE [4], Christina ROTH [1] and J. Thomas FARRAR [4]

[1]GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany
[2]Christian-Albrechts-Universität zu Kiel, Germany
[3]Department of Oceanography, University of Hawai`i, Hawai`i, USA
[4]Woods Hole Oceanographic Institution, Woods Hole, MA, USA

*Correspondance: Tél: (+49) 431 600 4105; Courriel: pbrandt@geomar.de (P. BRANDT)

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Abstract

With the first few years of full-depth moored velocity observations in the central equatorial Atlantic at 23°W at hand showing the upward energy propagation of high vertical mode interannual zonal velocity oscillations, an impact of these so called Equatorial Deep Jets (EDJs) on sea surface temperature and climate was suggested. Much effort was devoted during the PREFACE period to the understanding of the dynamics, the energy sources and maintenance as well as the upward influence of EDJs. Here we will summarize the knowledge gained from the analysis of observational data and model output on the intricate chain of mechanisms and processes starting with the generation of intraseasonal equatorial waves by the instability of the mean wind-driven circulation via their downward energy propagation, the transfer of intraseasonal energy to maintain EDJs and the upward energy propagation of the EDJs. EDJs are composed of high vertical mode equatorial Kelvin and Rossby waves forming resonant equatorial basin modes. In the observational record of the Atlantic Ocean, oscillations of these basin modes have a quasi-steady period of about 4.5 years. EDJs are maintained against dissipation due to energy supply from intraseasonal variability with time scales of tens of days via the convergence of the meridional flux of intraseasonal zonal momentum. The energy transfer observed in the central equatorial Atlantic at 23°W is associated with downward and eastward beams of intraseasonal Yanai waves generated by Tropical Instability Waves (TIWs) near the surface west of 23°W. These Yanai waves interact with the pre-existing EDJs resulting in the energy transfer from high to low frequency variability. This observational evidence confirms results obtained by idealized and realistic simulations with ocean general circulation models. Moreover, model simulations show the quasi-steady oscillation of EDJs with a decadal modulation and an upward influence at the sea surface manifesting in enhanced variability of the North Equatorial Counter Current (NECC) with the same time scale.

Session 1

Deep Intraseasonal Variability in the Central Equatorial Atlantic

Franz Philip TUCHEN [1,*], Peter BRANDT [1,2] and Martin CLAUS [1,2]

[1]Geomar Helmholtz Centre for Ocean Research Kiel, Kiel, Germany
[2]Christian-Albrechts-Universität zu Kiel, Germany

*Correspondance: Tél: 0431 600-4158 ; Courriel: ftuchen(at)geomar.de (F. P. TUCHEN)

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Abstract

Besides the zonal flow that dominates the seasonal and long-term variability in the equatorial Atlantic, energetic intraseasonal meridional velocity fluctuations are observed in large parts of the water column. 15 years of full-depth velocity data from an equatorial mooring at 23°W are used to investigate intraseasonal variability and specifically the downward propagation of intraseasonal energy from the surface into the deep ocean. Near the surface (20 to 50 m), intraseasonal variability at 23°W peaks at periods between 30 to 40 days. It is associated with westward propagating Tropical Instability Waves, which undergo an annual intensification in August. Enhanced energy levels of equatorial intraseasonal variability are observed down to about 2000 m. A frequency-vertical mode decomposition shows that meridional velocity fluctuations are more energetic than the zonal ones for periods < 50 days. The energy peak at 30 to 40 days and vertical modes 2 to 5 excludes equatorial Rossby or gravity waves and suggests Yanai waves to be associated with the observed intraseasonal energy. Yanai waves that are considered to be generated by Tropical Instability Waves propagate their energy from near the surface west of 23°W down- and eastward to eventually reach the mooring location. The distribution of intraseasonal energy depends largely on the dominant frequency and the time, depth, and longitude of excitation with the dominant vertical mode of the Yanai waves playing only a minor role. Observations also indicate the presence of weaker intraseasonal variability at 23°W below 2000 m that is not associated with Tropical Instability Waves.

Session 1

Inertial wave induced mixing in the tropical Atlantic: observations, parameterizations and impacts

Markus JOCHUM [1,*]

[1] Niels Bohr Institute (NBI), Denmark

*Correspondance: Tél: (+ 45) 24851562 Courriel: mjochum@nbi.ku.dk (M. JOCHUM)

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Abstract

The strength of inertial wave induced mixing is estimated from the PIRATA array in the tropical Atlantic, and its impact is parameterized in the two different mixed layer models of CESM and NorESM. Despite the differences in their mixed layer models, the climate response is quite similar in both models: a northward shift of the Atlantic ITCZ, which represents a significant improvement for both models. A surprising challenge, however, is the exact quantification of the mixing: it turns out that most of the mixing is done during a few short events, which makes for rather poor statistics even with record lengths of several years. Based on our experience we provide some strategies with which future observational campaigns can improve our understanding of inertial wave induced mixing.

Session 1

Mixed Layer Heat Budget in the North-eastern Tropical Upwelling System: Two paradoxes of the temperature control in the Senegalese upwelling

Saliou FAYE [1,*], Alban LAZAR [2] and Gregory FOLTZ [3]

[1]Centre de Recherche Océanographique Dakar-Thiaroye (CRODT/ISRA), Dakar, Senegal
[2]Laboratoire d'Océanographie et du Climat: Expérimentations et Approches Numériques (LOCEAN/UPMC), Paris, France
[3]NOAA/Atlantic Oceanographic and Meteorological Laboratory, Miami, FL, USA

*Correspondance: Tél: (+221) 772349741; Courriel: saliou.faye@ucad.edu.sn (S. FAYE)

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Abstract

An oceanographic and meteorological buoy has been set up and dedicated to monitoring and analysis of the short and long-term changes in climate, atmosphere and marine environment within the Senegal coastal upwelling. The buoy ""MELAX"" was deployed early 2015 in the heart of the Senegalese upwelling by 35m-depth at (14,20'N, 17,14'W). Data collected are, for the atmosphere, surface wind, solar radiation, humidity and rain, and for the ocean, temperatures, salinity, and currents (from the surface to the bottom) and oxygen.

We present the first two years of observations, in particular the relationship between wind, sea surface temperature and currents. We also show the reconstruction of the heat budget which highlights the relative role of oceanic and atmospheric processes in the evolution of sea surface temperature. Buoy and model mixed layer budget are compared to provide a better understanding of thermodynamics within Senegalese upwelling.

International PREFACE International Conference on Ocean, Climate and Ecosystems joint with ICAWA 5th, editon 2018

Session 1: « Ocean modelling»

Poster presentation

Session 1

Mixed layer heat/salt budget and Equatorial Under-Current dynamics in the tropical Atlantic from a joint model-observations approach

Olivia KOM [1,*], Gaël ALORY [2], Casimir DA-ALLADA [1] and Julien JOUANNO [2]

[1]CIPMA, Université d'Abomey Calavi, Cotonou, Bénin
[2]IRD, UMR LEGOS, Toulouse, France

*Correspondance: courriel gael.alory@legos.obs-mip.fr (G. Alory)

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Abstract

Climatological mixed layer heat/salt budget terms derived from a NEMO 1/4° forced model simulation and from a PREFACE observation-based product are compared in the eastern tropical Atlantic. Mean spatial patterns of mixed layer depth, SST and SSS are in good agreement despite some local biases. For the annual mean heat balance, atmospheric fluxes are quite different along the coasts, while horizontal advection mostly differs around the equator, maybe due to the low resolution of the observations (2.5°) that cannot resolve small meridional scales. The seasonal heat balance is compared in boxes off Angola, in the northeast Gulf of Guinea and in the Atlantic cold tongue. Seasonal variations of heat fluxes are correlated except in the last box, while advection is everywhere poorly correlated. For the annual mean salt balance, model and observations show similar freshwater fluxes, with larger spatial contrasts in the model, while advection mostly differs around the ITCZ. In the Benguela region, model and observations roughly agree on freshwater fluxes and advection seasonal variations. Off Angola, SSS variations are uncorrelated. The observed product does not explicitly resolve vertical diffusion, an important process for the heat/salt balance in the Gulf of Guinea.

The seasonal characteristics of the simulated EUC transport are compared to observations based on cruises and moorings at 23°W. In the model, the EUC transport is slightly larger than observed on average, while its seasonal cycle is of comparable amplitude and shows a maximum around September and minimum in November, leading the observations by one month. The maximum velocity is also biased high but seasonal cycles are consistent and roughly phased with the transport seasonal cycle. The EUC core in the model is shallower than observed but with a similar seasonal cycle and coinciding maxima in depth and transport. Its latitudinal position is more south of the equator, with a seasonal cycle opposite in phase and larger than observed. A test simulation with interannual wind forcing but climatological fluxes forcing is compared to the reference simulation to identify the respective role of dynamic and thermodynamic forcing on the EUC characteristics, in particular its salinity maximum.

Session 1

Seasonal variations of tidally generated internal waves in the eastern boundary upwelling system off Angola

Peter BRANDT [1,2,*], Kevin LAMB [3], Marcus DENGLER [1], Robert KOPTE [1], Volker MOHRHOLZ [4], Pedro TCHIPALANGA [5], and Marek OSTROWSKI [6]

[1]GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany
[2]Christian-Albrechts-Universität zu Kiel, Germany
[3]Department of Applied Mathematics, University of Waterloo, Canada
[4]Leibniz-Institut für Ostseeforschung, Rostock, Germany
[5]Instituto Nacional de Investigação Pesqueira, Departamento do Ambiente e Ecossistemas Aquáticos, Moçâmedes, Angola
[6]Institute of Marine Research, Oceanography and Climate, Bergen, Norway

*Correspondance: Tél: (+49) 431 600 4105; Courriel: pbrandt@geomar.de (P. BRANDT)

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Abstract

The eastern boundary upwelling system of the South Atlantic Ocean is one of the most productive marine ecosystems. It is separated by the Angola-Benguela frontal zone at about 16°S into a permanent wind-driven upwelling system to the south and a tropical upwelling system to the north. Here we study the seasonal upwelling at 11°S using shipboard hydrographic and current data, microstructure data as well as temporally high-resolution moored velocity data acquired during several field experiments since July 2013. Additionally we use hydrographic data taken in the frame of the Norwegian Nansen Programme during biannual cruises covering the main downwelling and upwelling seasons over more than 20 years. The seasonal upwelling is strongly influenced by the propagation of semiannual coastally trapped waves leading to a dynamical change in the stratification at the shelf. Local wind forcing plays only a minor role in driving the near-coastal upwelling. Moored velocity observations at the shelf break at about 500 m water depth show a seasonal enhancement of internal wave energy near the buoyancy frequency during the main upwelling system. An on-shore propagation of internal waves as observed during the field campaigns implies enhanced mixing on the shelf, which is in general agreement with sparse microstructure measurements. To better understand the processes at work, a 2-D very high-resolution non-hydrostatic model is applied to simulate the generation of internal waves at the shelf break by a barotropic tidal flow and their onshore propagation. Simulations performed using mean observed stratifications of the main upwelling and downwelling seasons show significant differences in the onshore propagation of internal waves induced by both differences in slope criticality and near surface stratification.

Session 1

An elevated turbulent mixing event caused by a near-inertial wave in the mixed layer

Marcus DENGLER [1,*], Rebecca HUMMELS [1], Tim FISCHER [1], Gerd KRAHMANN [1], Willi RATH [1] and Peter BRANDT [1]

[1] GEOMAR Helmholtz Centre of Ocean Research Kiel, Kiel, Germany

*Correspondance: Tél: (+49) 431 600 4107; Courriel: mdengler@geomar.de (M. DENGLER)

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Abstract

Between 2005 and 2016, an extensive shipboard and autonomous microstructure measurement program was carried out in the proximity of PIRATA sites in the central and northeastern tropical Atlantic. The data reveal regional variability of upper ocean mixing processes from diurnal to seasonal time scales. Here, we discuss an elevated turbulent mixing event below the mixed layer caused by surface near-inertial waves and address the impact of these mixing events on the mixed-layer heat balance at the PIRATA site at 11.5°N, 23°W. Altogether, microstructure data at this site was collected during 8 different cruises. During one incident, sampling was conducted during the presence of an elevated near inertial wave. Velocities associated with the NIW were above 0.6m/s in the mixed layer and decreased to near zero below the stratification maximum at 30m depth. Mixing during the presence of the NIW was strongly elevated and dissipation rates of turbulent kinetic energy exceeded 1x10^(-5) m^3 s^(-2) in the stratified region below the mixed-layer in some profiles. Associated cooling of the sea surface temperature was also elevated. Diapycnal heat flux was above 140Wm^(-2) 10m below the mixed layer and more than 300Wm^(-2) in the region 5m below the mixed layer. Near-Inertial wind stress magnitude (NIWSM) during the period war particularly high. Using the PIRATA winds, it was found that in general, the seasonal cycle of NIWSM has a very similar shape as the residual from the heat balance. Wind energy flux to NIWs from a slab ocean model is used to estimate the frequency of the occurrence of the elevated NIW ocean velocity.

Session 1

The variability of the Cape Boujdor upwelling and its relationship with the cape Blanc frontal zone

Ahmed MAKAOUI [1,*], Aziz. AGOUZOUK [1], Bessa ISMAIL [1,2], Jamila LARISSI [1], Mohamed IDRISSI [1], Y. BELEBCHI [1], Omar ETTAHIRI [1] and Karim HILMI [1]

[1]Oceanography Department, National Institute of Fisheries Research (INRH), Casablanca, Morocco
[2]Laboratory of Engineering and Materials, Faculty of Sciences Ben M'Sik, Hassan II Casablanca University, Morocco

*Correspondance: courriel omarettahiriomar@gmail.com (O ETTAHIRI)

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Abstract

The southern zone is in permanent supply of water enriched in nutrient, allowing a high primary productivity of its marine ecosystem. However, inputs of hot water deficit in dissolved oxygen, deriving from the south, are manifested exceptionally from one year to another under the effect of global warming on the ocean. Using in situ data and a model data from marine Copernicus with a resolution of 0.083-degree x 0.083 degree, we evaluated the relationship between ocean mixed layer depth (MLD), the sea surface temperature, sea surface salinity, and sea surface chlorophyll-a concentration. In our study, we found that coastal areas are related generally to a shallower MLD all the year in the Cape Boujdor region. In addition, we proved that the source of the upwelling is between 25°N and 26°N, and it is permanent in this region except during the fall season when the northern east wind are weaker in the north of Dakhla. However, we observed that the sea surface chlorophyll richness is located in the region between 24.5°N and 22°N, and corresponding to the south of cape Boujdor. We suggested that the upwelled water is derived to the south by a coastal south current forming a filament in this region. When upwelling is relatively active in the south of Dakhla, the area is fed more by mineral-enriched South Atlantic Central Waters (SACW). These waters (ECSA) are accompanied, exceptionally by waters less saturated in dissolved oxygen and can be an indicator of the impact of climate change on the area.

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Session 2: « Climate variability and teleconnections». Wednesday 18th April 2018

Session 2.1-Atlantic variability: ITCZ and atmosphere-ocean feedbacks

Oral presentation

Session 2

Do SST gradients drive the monthly climatological surface wind convergence over the tropical Atlantic?

Moussa DIAKHATE [1,2,*], Alban LAZAR [2], Gaëlle DE COËTLOGON [3] and Amadou T. GAYE [1]

[1]Laboratoire de Physique de l'Atmosphère et de l'Océan-Siméon Fongang (LPAO-SF), Université Cheikh Anta Diop, Dakar, Senegal
[2]Laboratoire d'Océanographie et Climat, Expérimentations et Approches Numériques (LOCEAN),
[3]Université Pierre et Marie Curie, France
[4]Laboratoire Atmosphère, Milieux, et Observations Spatiales (LATMOS), Université Pierre et Marie Curie, France

*Correspondance: courriel pmdiakhate@gmail.com (M DIAKHATE)

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Abstract

We present a climatological study of the tropical Atlantic surface wind convergence, one of the main drivers of the marine intertropical convergence zone (ITCZ) precipitations, including coastal northeastern Brazilian and West African rainfalls. Climatological monthly mean surface wind convergence budget, as well as that of their month-to-month variations, is analysed over the 2000– 2009 decade, using ocean–atmosphere reanalyses and satellite-derived data sets. Sea surface temperature (SST) influence is particularly investigated via comparison of its Laplacian with that of sea level pressure. Results for monthly means reveal that the Lindzen-Nigam paradigm does hold in regions of deep convection but only on their flanks. In deep convection regions, the budget analysis suggests the entrainment due to elevated heating by cumulus convection as the leading term. Elsewhere, over the 'open ocean ITCZ' meridional flanks, as well as over the 'coastal one' (Gulf of Guinea and northeastern Brazilian coasts), the pressure contribution is positive and largely dominated by its component below the boundary layer closely related to the SST. Horizontal advection is also found important over these areas, but with the pressure as the first-order driver. Otherwise, month-to-month variations of ITCZ are controlled by the geostrophy within the pressure contribution tightly dominated by the free tropospheric component.

Session 2

Equatorial Atlantic interannual variability and its relation to dynamic and thermodynamic processes

Julien JOUANNO [1,*], Olga HERNANDEZ [2,1] and Emilia SANCHEZ-GOMEZ [3]

[1]LEGOS, Université de Toulouse, CNES, CNRS, IRD, UPS, Toulouse, France
[2]Mercator-Océan, Ramonville Saint Agne, France
[3]CECI-CERFACS, Toulouse, France

*Correspondance: Tél: (+33) 05 61 33 27 95; Courriel: julien.jouanno@legos.obs-mip.fr (J. JOUANNO)

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Abstract

The contributions of the dynamic and thermodynamic forcing to the interannual variability of the equatorial Atlantic sea surface temperature (SST) are investigated using a set of interannual regional simulations of the tropical Atlantic Ocean. The ocean model is forced with an interactive atmospheric boundary layer, avoiding damping toward prescribed air temperature as is usually the case in forced ocean models. The model successfully reproduces a large fraction (R2 = 0.55) of the observed interannual variability in the equatorial Atlantic. In agreement with leading theories, our results confirm that the interannual variations of the dynamical forcing largely contribute to this variability. We show that mean and seasonal upper ocean temperature biases, commonly found in fully coupled models, strongly favour an unrealistic thermodynamic control of the equatorial Atlantic interannual variability.

Session 2

The coupling between the ocean and the atmosphere in the equatorial Atlantic seasonal cycle

Lander R. CRESPO [1,*], Noel KEENLYSIDE [1] and Shunya KOSEKI [1]

[1]Geophysical Institute, Bjerknes Centre for Climate Research, University of Bergen, Norway

*Correspondance: courriel noel.keenlyside@gfi.uib.no (N KEENLYSIDE)

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Abstract

We investigate the ocean-atmosphere interactions in driving the seasonal cycle of the atmosphere in the tropical Atlantic basin. We force an atmospheric general circulation model with three different sea surface temperature (SST): (1) globally observed daily-climatological SST, (2) globally annual-mean SST, and (3) annual-mean SST in the equatorial Atlantic and daily-climatological SST elsewhere. The comparison between the three atmospheric model runs show that seasonal variations in SST strongly influence the seasonal evolution of the West African Monsoon and ITCZ over the equatorial Atlantic Ocean. Forcing the model with annual mean SST (globally and in the equatorial Atlantic) considerably reduces the seasonal variance in the atmosphere, except for the zonal winds in the central and eastern equatorial Atlantic. Equatorial Atlantic SST contributes to the seasonal cycle in precipitation and meridional winds over the entire equatorial Atlantic, but only strongly influences zonal winds in the western equatorial Atlantic. We conclude that the coupling between ocean and atmosphere is stronger in the western than in the eastern equatorial Atlantic. We are now using the output of the atmospheric model simulations to force an ocean general circulation model. We will use this to assess the role of active ocean-atmosphere interaction in the seasonal cycle in the equatorial Atlantic.

Session 2

Sea Surface Salinity signature of the tropical Atlantic interannual climatic modes

F. Mesmin AWO [1,2,4,*], Gael ALORY [2], Casimir Y. DA-ALLADA [1,3,4,5], T. DELCROIX [2], Julien JOUANNO[2], and Ezinvi BALOÏTCHA [1]

[1]CIPMA, Université d'Abomey Calavi, Cotonou, Bénin
[2]LEGOS, UMR CNES, CNRS, IRD, Université de Toulouse, Toulouse, France
[3]IRD/LOPS, IFREMER, CNRS, Université de Brest, IUEM, Brest, France
[4]LHMC/IRHOB, IRD, Cotonou, Benin
[5]ESTBR/UNSTIM, Abomey, Benin

*Correspondance: courriel gael.alory@legos.obs-mip.fr (G. Alory)

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Abstract

A consistent Sea Surface Salinity (SSS) signature of the tropical Atlantic meridional and equatorial interannual modes is extracted from in situ observations and a regional numerical simulation, by a statistical analysis on the 1980-2012 period. Oceanic and/or atmospheric processes responsible for the signature of each mode are identified through a mixed-layer salt budget in the validated model. The meridional mode is associated in spring with a meridional SSS dipole in the equatorial band, due to changes in fresh water flux related to a meridional shift of the Inter-Tropical Convergence Zone (ITCZ). It is also associated with large SSS anomalies in the north and south west tropical Atlantic, due to advection of relatively fresh equatorial waters by strengthened western boundary currents, and off the Congo River where both meridional and vertical advection are involved. The equatorial mode is associated in summer with 3 zonal bands of alternating SSS anomalies between 5°S and 10°N. The southernmost band is due to vertical advection and diffusion at the mixed layer base, the two others to a shift of the ITCZ-related rainfall maximum, with additional contribution of meridional advection in the northernmost band. The equatorial mode also leads to large SSS anomalies in the North Brazil Current retroflection region, mainly due to horizontal advection of equatorial SSS anomalies. The SSS signatures of the meridional and equatorial modes are well captured by the SMOS satellite during particular events.

Session 2

Climates in oceanic regions characterized by low-level clouds

Carlos Roberto MECHOSO [1,*]

[1]Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles

*Correspondance: courriel mechoso@atmos.ucla.edu (CR MECHOSO)

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Abstract

This presentation focuses on the tropical climate and addresses the fundamental subject of the influence of low-level (MLB) clouds over the oceans. Studies based on observational data and numerical models suggest that warmer sea-surface temperature (SST) reduces overlying cloudiness, thereby acting as a positive feedback on SST by increasing the amount of solar radiation reaching the ocean surface. Colder SST enhances MBL cloudiness, which similarly acts as a positive feedback. The clouds are generated and sustained by complex interplays among microphysical, radiative and turbulent processes, which are very challenging to parameterize in comprehensive global climate models (CGCMs).

We start by demonstrating that MLB clouds may amplify modes of interannual to interdecadal climate variability by means of a positive cloud-SST feedback. Typical summertime patterns of SST variability over the North Atlantic and Pacific and springtime patterns of interhemispheric SST variability over the tropical Atlantic in the observation are associated with co-located anomalies of shortwave cloud radiative effect, low-level cloud fraction, SST, and estimated inversion strength. These associations are consistent with a positive cloud-SST feedback. The simulation of such a feedback varies widely among CGCMs participating in phase 5 of the Coupled Model Intercomparison Project (CMIP5). We examine the impact of the feedback on model-to-model differences in the representation of patterns of coupled atmosphere-ocean variability. Models that simulate a cloud feedback magnitude that is too weak compared to that estimated from observations substantially underestimate the amplitudes of SST and cloudiness associated with these patterns of variability. Such models also underestimate the amplitude of atmospheric circulation associated with typical interhemispheric tropical Atlantic variability. Models with a more realistic feedback magnitude generally produce higher and more realistic amplitudes. The amplitudes of patterns of coupled atmosphere-ocean variability in simulations, therefore, are sensitive to the simulation of MLB cloud processes.

Next, we narrow down on the case of the anomalous high-magnitude warming of SST in the subtropical northeast Pacific, the marine low cloud region off Baja California, between January 2014 and September 2015, when SST sharply increased and the PDO shifted to its warm phase. It is shown that anomalously positive cloud-induced radiative flux was the dominant component of the energy budget of the ocean mixed layer during this period of warming off Baja California.

Session 2

Characterization of Rainfall Extreme Events by Dry Spell and Wet spell Analysis in Senegal

Cheikh Modou Noreyni FALL [1,*], Amadou Thierno GAYE [1], Christophe LAVAYSSE [2], Cheikh DIONE [3] and Mamadou Simina DRAMÉ [4]

[1]Laboratory of Atmospheric and Oceanic Physics Simeon FONGANG, UCAD, Senegal
[2]JRC European commission, Ispra, Italy
[3]Laboratoire d'aérologie/Centre de recherches atmosphériques, Toulouse, France
[4]Department of physics, UCAD, Senegal

*Correspondance: courriel: atgaye@ucad.sn (A.T. GAYE)

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Abstract

In West Africa, rainfall is a mean socio-economic factor for the people. For example in Senegal, we have 60% of the people who live from agriculture. At this time, the World Food Program (WFP) in his 2018 report said that Senegal is one of the seven Sahelian countries where the number of food-insecure people will increase significantly, from 314,600 people currently to 548,000 people during the 2018 lean season. While in this area, the water cycle has a high variability on all spatial and temporal scales and depends on the dynamics of the complex system of the West African monsoon. Rainfall is generated by Mesoscale convective systems and squall lines (Mesoscale convective systems multicellular) but also with local storm systems of any size, such as isolated thunderstorms. The spatial and temporal distribution of the seasonal cumulative rainfall depends on the number of occurrence of these various convective systems. This work highlights the rainfall intraseasonal characteristics of Senegal. Using the synoptic observation network of ANACIM (National Agency of Civil Aviation and Meteorology) to and IRD (Institute of Research for Development) with 86 stations in Senegal, from 1990 to 2010. We have analysed many descriptors of the rainy season including wet and dry spells.This high spatiotemporal variability is observed between stations separate by a few kilometres. Indeed, Diourbel recorded a rain deficit in 2007 season, while for the same year was in surplus Kaolack. The high frequency character with spatial variability of short Dry spell DS1 (1 to 3 days) an DS2 (4 to 7 days) is shown at the South of Senegal. While the DS3 (8 to 14 days) and the extreme dry spell DS4 (up to 14 days) show a low occurrence at the North but with more spatial variability. We have also observed that DS3 and DS4 reflect often the false start and early end of the season, while for the wet spell we have shown a dipolar shape, with a South-North gradient. The strong and long Wet Spell modulate meanly the seasonal accumulation rain but with a high spatial variability.

Session 2

Interdecadal changes in ocean teleconnections with the Sahel. Modulating role of the multidecadal SST background

Roberto SUÁREZ-MORENO [1,*], Belén Rodríguez DE FONSECA [1,2], Jesús A. BARROSO [1] and Andreas H. FINK [3]

[1]Universidad Complutense de Madrid (UCM), Department of Geophysics and Meteorology, Madrid, Spain
[2]Instituto de Geociencias, IGEO-CSIC, Madrid, Spain
[3]Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology (KIT), Germany

*Correspondance: Tél:; Courriel: roberto.suarez@fis.ucm.es (R. SUÁREZ-MORENO)

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Abstract

The atmospheric response to global sea surface temperatures (SSTs) is the leading cause of rainfall variability in the West African Sahel. On interannual periodicities, the El Niño-Southern Oscillation, the Atlantic equatorial mode and Mediterranean warm/cold events primarily drive variations of summer rainfall over the Sahel. Nevertheless, the rainfall response to these modes of interannual SSTs variability has been suggested to be unstable throughout the observational record. This study explores changes in the leading patterns of co-variability between Sahel rainfall and SSTs, analysing the dynamical mechanisms at work to explain the non-stationary relationship between anomalies in these two fields. A new network of rain-gauge stations across West Africa is used for the first time to investigate these instabilities during the period 1921-2010. A hypothesis is raised that the underlying SSTs background seems to favour some interannual teleconnections and inhibit others in terms of the cross-equatorial SSTs gradients and associated impacts on the location of the Inter-tropical Convergence Zone. Results of this study are relevant for improving the seasonal predictability of summer rainfall in the Sahel.

Session 2: « Climate variability and teleconnections». Wednesday 18th April 2018

Session 2.2- External drivers of tropical Atlantic variability

Oral presentation

Session 2

Oceanic Forcing on Interannual Variability of Sahel Heavy and Moderate Daily Rainfall Events

Hyacinth C. NNAMCHI[1,*] and Mojib LATIF[1]

[1]Universidad Complutense de Madrid, Madrid 28040, Spain

*Correspondance: courriel hyacinth.nnamchi@unn.edu.ng (H. HYACINTH)

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Abstract

The equatorial Atlantic cold tongue is characterized by intense seasonal upwelling peaking during the boreal summer, which plays import roles in regional and global climate fluctuations. However, climatic trends in the cold tongue remain poorly understood due to poor observational coverage and biases in climate models. Here we analyse the past 35 years with generally improved observations, including satellite data, to show cooling trends in the cold tongue. Consistent with the annual cycle of the upwelling, the cooling trends are seasonally phase-locked to the summer months. The trends are associated with shifts in the latitudinal location of the inter-tropical convergence zone and consequently summer precipitation over West Africa. The underlying mechanism for the cooling trends appears linked to the intrusion of cold waters from beneath the thermocline. Greenhouse forcing experiment with a high-resolution version of the Kiel Climate model, with substantially reduced biases in the cold tongue, suggests that the cooling may be related to increases in atmospheric greenhouse gases.

Session 2

South Atlantic Anti-Cyclone as a driver of Atlantic Niño variability

Noel KEENLYSIDE [1,2,*], William Cabos NARVAEZ [3], Dmitry SEIN [4], Shunya KOSEKI [1,2], and Hyacinth NNAMCHI [5]

[1] Geophysical Institute, University of Bergen, Norway
[2]Bjerknes Center for Climate Research, Bergen, Norwayand Bjerknes Centre, Bergen, Norway
[3]University of Alcalá, Alcalá de Henares, Madrid, Spain
[4]Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
[5]University of Nigeria, Nsukka, Nigeria

*Correspondance: Tél: (+47) 55 58 20 32; Courriel: l noel.keenlyside@uib.no (N. KEENLYSIDE)

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Abstract

Atlantic Niño variability remains poorly understood and predicted, despite exhibiting some apparent similarities to the El Niño Southern Oscillation. Here we show that extra-tropical influences play a dominant role in driving Atlantic Niño variability, bringing a new dimension to our understanding. We assess the role of extra-tropical atmospheric variability in driving observed Atlantic variability by comparing ensemble simulations with two configurations of a regional coupled climate model. In one case the South Atlantic Anticyclone is prescribed at the southern boundary of the regional atmospheric model, while in the other it is simulated within the domain. In both configurations, atmospheric reanalysis drive the global ocean model outside of the coupled domain and are prescribed as boundary conditions to the regional atmospheric model. Extra-tropical southern hemisphere variability can explain around 50% of the observed Atlantic Niño variability. The greatest impact is from boreal spring and autumn. Comparing models different resolution and parameterisations shows the importance of representing the link between SAA and equatorial Atlantic variability in capturing the observed Atlantic Niño variability. The link between the two regions appears related to thermodynamic ocean-atmosphere interaction.

Session 2

Conciliating tropical Atlantic impact on ENSO

Belén Rodríguez DE FONSECA [1,2,*], Irene POLO [3], Elsa MOHINO [1], Teresa LOSADA [1], Marta Martín DEL REY [1,2], Noel KEENLYSIDE [4] and C. Roberto MECHOSO [5]

[1]Dto Fisica de la Tierra y Astrofisica, UCM, Madrid, Spain
[2]IGEO, Madrid, Spain
[3]Department of Meteorology, University of Reading, Reading, UK
[4]University of Bergen and Bjerknes Centre for Climate Research, Bergen, Norway
[5]Department of Atmospheric and Oceanic Sciences, UCLA, Los Angeles, USA

*Correspondance: courriel brfonsec@fis.ucm.es (B.R. de FONSECA)

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Abstract

Recent studies have found, in observations, windows of enhanced ENSO predictability from the tropical Atlantic variability. Thus, during some periods, Atlantic Niño is able to influence from previous summer in the atmospheric processes that trigger Pacific Niño. Other studies point to decades in which is the spring north tropical Atlantic anomalous sea surface temperature the optimal predictor of ENSO. These windows of predictability occur at multidecadal timescales, and studies put forward the Atlantic Multidecadal Variability as modulator. Nevertheless, no physical explanation has been found so far to explain the mechanisms behind this modulation. Here we analyse both connections in observations and Pi-control simulations from Phase 5 of the Climate Modelling Intercomparison Project (CMIP5). Results show how both, observations and CMIP5 models presents multidecadal modulation of the Atlantic-Pacific interbasin connection. Nevertheless, models are not realistic at reproducing the north tropical Atlantic-ENSO teleconnection and overestimated the influence on ENSO on equatorial Atlantic. While north tropical Atlantic –ENSO connection enhances 2-yr cycle El Niño, the Atlantic Niño-ENSO teleconnection presents a 4 year cycle. This last feature is also shown in models. For those periods in which the connection is enhanced, simulations present a negative interhemispheric gradient of sea surface temperature in the Atlantic and an meridional shifts of tropical rainfall. It has been concluded that the switch for the interbasin connections coincides with displacements of the Intertropical Convergence Zone, which can be associated with Atlantic Multidecadal Oscillation but also to other factors. Despite in models ENSO influence on the Atlantic is stronger than in observations and the Atlantic leading on the Pacific is weaker, the shift is found for all models. The present study confirms the existence of this connection, its periodicity and the causes leading to its emergence. Our results are of great interest for the seasonal to decadal prediction system.

Session 2

Role of the ocean dynamics in ENSO-tropical Atlantic teleconnection under warmer climate

Marta MARTIN-REY [1,*], Christophe CASSOU [1] and Emilia SANCHEZ-GOMEZ [1]

[1] CECI-CERFACS, Toulouse, France

*Correspondance: courriel mmrey@cerfacs.fr (M. MARTIN-REY)

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Abstract

El Niño-Southern Oscillation (ENSO) is the leading air-sea coupled mode of inter-annual variability in the tropical Pacific with worldwide climate impacts. Recent studies have reported that the Global Warming (GW), induced by GHG external forcing, could affect the ENSO phenomena in a long-term future climate (i.e. the frequency, intensity, spatial pattern) and consequently the ENSO teleconnections and impacts. In addition, the role of the internal climate variability seems to be crucial to amplify or attenuate the GW effect in the near-term horizon.

In the present study, we use a pacemaker protocol in a perfect model framework by using the coupled model CNRM-CM5 to investigate the influence of the mean background state (pre-industrial vs RCP85) on the ENSO teleconnection over the tropical Atlantic (TA). Two pacemaker experiments have been performed by restoring the SSTs anomalies, issued from a pre-industrial control simulation, over the eastern Tropical Pacific. Both experiments, consisting of an ensemble of 30 members each, only differ in the prescribed GHG forcing: Pre-industrial versus RCP85.

In a warmer climate, the mean Walker circulation is debilitated in the tropical band, causing anomalous subsidence over the eastern equatorial Atlantic during winter-spring. Additionally, the Atlantic Subtropical Highs are weakened and the ocean surface-subsurface connection is enhanced in the tropical Atlantic basin. Under the RCP85 scenario, the ENSO-TA teleconnection is reinforced, activating the ocean wave activity. In particular, the El Niño event originates a negative NAO-like pattern and in turn an anomalous reduction of the north-eastern trades in TA. This wind pattern at the surface is able to excite an oceanic Rossby wave north of equator that is reflected in the western boundary and propagates as an equatorial Kelvin wave from boreal spring to summer. The latter ENSO-TA teleconnection mechanism is much more prominent in a warmer climate, suggesting the importance of the background state in modulating the atmospheric ENSO signal and TA mean conditions, key elements for the effectiveness of the ENSO impact.

Session 2.3: « Climate variability and teleconnections». Wednesday 18th April 2018

Poster presentation

Session 2

Boreal spring equatorial Sea Surface Salinity as a potential predictor of Atlantic Cold Tongue events

Casimir Y. DA-ALLADA [1,2,3,*], Julien JOUANNO [4], Nicolas KOLODZIEJCZYK [5], C. MAES [1], Bernard BOURLÈS [4], Gael ALORY [4] and F. GAILLARD [6]

[1]IRD/LOPS, IFREMER, CNRS, Univ. Brest, IUEM, Brest, France
[2]LHMC/IRHOB, IRD, Cotonou, Benin
[3]ESTBR/UNSTIM, Abomey, Benin
[4]Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS), Université de Toulouse, CNES, CNRS, IRD, UPS, Toulouse, France, Brest, France
[5]IUEM/LOPS, IFREMER, CNRS, IRD, Univ. Brest, Brest, France
[6]IFREMER/LOPS, CNRS, IRD, Univ. Brest, IUEM, Brest, France

*Correspondance: courriel gael.alory@legos.obs-mip.fr (G. Alory)

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Abstract

The link between the boreal spring sea surface salinity (SSS) and the May-June-July (MJJ) sea surface temperature (SST) in the equatorial Atlantic Cold Tongue (ACT) region is investigated at interannual time scales from 1990-2012 using observations and model. Results reveal a significant correlation between April-May-June (AMJ) interannual SSS anomalies (SSSA) and the MJJ SST anomalies (SSTA). Most of extreme interannual SSSA appear the years of extreme interannual SSTA in the ACT region. Thus, major salty and desalted ACT events are followed by 1-month major warm and cold ACT events and confirms the idea that boreal spring SSSA could be used as a predictor of ACT events. Based on the model mixed-layer salinity budget and sensitivity experiments, we found that the interannual variability of the SSS is mainly controlled by horizontal advection during salty and desalted ACT events and changes in the horizontal advection are largely due to changes in winds.

Session 2

Oceanic Forcing on Interannual Variability of Sahel Heavy and Moderate Daily Rainfall Events

Moussa DIAKHATE [1,*], Belén Rodríguez DE FONSECA [2], Iñigo GÓMARA [2], Elsa MOHINO [2], Abdou Lahat DIENG [1] and Amadou Thierno GAYE [1]

[1]Université Cheikh Anta Diop, BP 5085, 10700 Dakar, Senegal
[2]Universidad Complutense de Madrid, Madrid 28040, Spain

*Correspondance: courriel pmdiakhate@gmail.com (M DIAKHATE)

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Abstract

Sahelian rainfall variability is strongly influenced by atmospheric teleconnections triggered by anomalous sea surface temperatures (SST). The remote SST forcing on seasonal precipitation rainfall over West Africa has been extensively analysed in the literature. However, their impact on the variability of Sahelian daily rainfall events, stratified by intensity, has received little attention so far. This article analyses SST remote forcing on Sahel summer months (June to September) moderate (below 75th percentile) and heavy (above 75th percentile) daily precipitation events interannual variability during the period 1981-2016. Evidence is given that interannual variabilities of these events are markedly different. Occurrence of moderate daily rainfall events appears to be enhanced by positive SST anomalies over the Tropical North Atlantic and Mediterranean, which act to increase low-level moisture advection towards the Sahel from the adjacent oceanic waters (the opposite holds for negative SSTs anomalies). While heavy/extreme daily rainfall events seem to be linked to El Niño-Southern Oscillation (ENSO) and Mediterranean variability. Under La Niña conditions and a warmer Mediterranean, vertical atmospheric instability is increased over the Sahel and low-level moisture supply from the Equatorial Atlantic is enhanced over the area (the reverse is found for opposite sign SST anomalies). Attending to the total rainfall index, these results indicate that interannual variability of Sahel rainfall is mainly dominated by the extreme events. These results may have strong implications on seasonal forecasting of Sahel moderate and heavy/extreme precipitation events based on SST predictors, as significant predictability has been found from 1-4 months in advance.

Session 2

Longitudinal variations of SST event characteristics in the tropical Atlantic and Pacific oceans

Tina DIPPE [1,*], Richard J. GREATBATCH [1] and Joke F. LÜBBECKE [1]

[1] GEOMAR Helmholtz Center for Ocean Research Kiel, Germany

*Correspondance: courriel : tdippe@geomar.de (T. DIPPE)

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Abstract

Sea surface temperature (SST) variability in the tropical Atlantic and Pacific oceans is characterized by strong, interannual modes, whose warm and cold events are referred to as Atlantic and Pacific Niños and Niñas, respectively. While the basins are comparable in terms of their principal physical set-up, the characteristics of their SST events differ substantially from each other. One well-researched aspect of the Pacific El Niño-Southern Oscillation (ENSO) is its asymmetry. Although the term refers to a number of known non-linearities within the ENSO phenomenon in general - such as differences in the spatial and temporal evolution between warm and cold events -, we focus here specifically on the length and strength of events. We use a simple event identification method that isolates events within a time series of anomalies, relative to a threshold that is based on its standard deviation. We then apply this method along the equator and quantify how length and strength asymmetries between warm and cold events vary in dependence of longitude, both in the tropical Atlantic and Pacific. We show that for the period 1958-2016, events tend to be of statistically indistinguishable length in the entire tropical Pacific, while warm events are significantly longer than cold events in the Atlantic cold tongue region. In agreement with previous research, we find that the strength of events is highly asymmetrical in the Pacific, with cold events being significantly stronger than warm events in the western basin and vice versa in the eastern basin, where mean magnitudes differ by roughly 1K. In contrast, event strengths are statistically equal in the entire tropical Atlantic.

Session 2

Abrupt transitions in the NAO control of explosive North Atlantic cyclone development

Iñigo GÓMARA [1,2,3,*], Belén Rodríguez DE FONSECA [1,2], Pablo ZURITA-GOTOR [1,2], Sven ULBRICH [4] and Joaquim G. PINTO [5]

[1]Dept. of Geophysics and Meteorology, Universidad Complutense de Madrid, Madrid, Spain
[2]Instituto de Geociencias (IGEO), UCM-CSIC, Madrid, Spain
[3]CEIGRAM, AgSystems, Universidad Politécnica de Madrid, Madrid, Spain
[4]Institute for Geophysics and Meteorology, University of Cologne, Cologne, Germany
[5]Institute of Meteorology and Climate Research (IMK-TRO), Karlsruhe Institute of Technology (KIT), Germany

*Correspondance: Tél: (+34) 913944513; Courriel: i.gomara@ucm (I. GÓMARA)

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Abstract

Explosive cyclones are intense extra-tropical low-pressure systems featuring large deepening rates. In the Euro-Atlantic sector, they are a major source of life-threatening weather impacts due to their associated strong wind gusts, heavy precipitation and storm surges. The wintertime variability of the North Atlantic cyclonic activity is primarily modulated by the North Atlantic Oscillation (NAO). In this study, we investigate the interannual and multi-decadal variability of explosive North Atlantic cyclones using track density data from two reanalysis datasets (NCEP and ERA-40) and a control simulation of an atmosphere/ocean coupled General Circulation Model (GCM—ECHAM5/MPIOM1). The leading interannual and multi-decadal modes of variability of explosive cyclone track density are characterized by a strengthening/weakening pattern between Newfoundland and Iceland, which is mainly modulated by the NAO at both timescales. However, the NAO control of interannual cyclone variability is not stationary in time and abruptly fluctuates during periods of 20–25 years long both in NCEP and ECHAM5/MPIOM1. These transitions are accompanied by structural changes in the leading mode of explosive cyclone variability, and by decreased/enhanced baroclinicity over the sub-polar/sub-tropical North Atlantic. The influence of the ocean is apparently important for both the occurrence and persistence of such anomalous periods. In the GCM, the Atlantic Meridional Overturning Circulation appears to influence the large-scale baroclinicity and explosive cyclone development over the North Atlantic. These results permit a better understanding of explosive cyclogenesis variability at different climatic timescales and might help to improve predictions of these hazardous events under present and projected greenhouse gas forcing scenarios. Available as: Gómara et al. (2016) Clim Dyn 47, 3091. https://doi.org/10.1007/s00382-016-3015-9

Session 2

Equatorial Atlantic interannual variability in a CGCM

Shunya KOSEKI [1,2], and Noel KEENLYSIDE [1, 2]

[1]Geophysical Institute, University of Bergen, Norway
[2]Bjerknes Center for Climate Research, Bergen, Norway

*Correspondance: Tél: +47 55 58 98 24; Courriel: Shunya.Koseki@uib.no (S. KOSEKI)

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Abstract

We have investigated the CGCM-simulated equatorial Atlantic interannual variability in sea surface temperature (SST) focusing on its dynamical and thermodynamical processes. We compare an anomaly-coupled model, with its mean state corrected to observations by prescribing the observed air-sea flux correction of climatology to a standard model with large biases in the tropical Atlantic. A benchmark simulation of the CGCM (without the anomaly coupling) overestimates the equatorial SST variability from summer to early winter and the area of high variability extends more westward compared to the observations. The Bjerknes Feedback is held in the standard simulation as observed, but the coupling between zonal wind and Atlantic SST anomalies and its seasonality is poorly represented. While the anomaly coupling somewhat underestimates the amplitude of SST interannual variability with respect to the observations, there are some improvements in seasonality and location of the SST variability. The Bjerknes Feedback loop is also ameliorated; in particular, the communication between zonal wind stress and SST anomalies shows a better seasonal march in the western basin. Additionally, the thermodynamical process for the SST variability is also well reproduced with the anomaly coupling. Lag-composite analysis elucidates that the anomaly coupling leads to a more realistic evolution in the Atlantic modes and better symmetry between the SST warm and cold SST anomalies. On the other hand, both experiments without and with the anomaly coupling fail to simulate the South Atlantic Anticyclone variability in February to April, which possibly triggers and enhances the equatorial Atlantic SST anomalies. We conclude that the anomaly coupling can improve the equatorial mechanism for the SST variability. Such improvement of the processes responsible for the variability should influence the skill of seasonal prediction.

Session 2

Is the boreal spring Tropical Atlantic SST variability a precursor for the Equatorial Mode?

Marta MARTÍN-REY [1,2,*] and Alban LAZAR [2]

[1]CERFACS, Toulouse, France
[2]Université Pierre et Marie Curie (UPMC), Sorbonnes Universités, Paris, France

*Correspondance: courriel mmrey@cerfacs.fr (M. MARTIN-REY)

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Abstract

The boreal spring-to-summer tropical Atlantic variability is driven by two air-sea coupled modes: the Meridional (MM) and Equatorial Mode (EM), respectively. Previous studies have suggested a possible interaction between them, but without reaching a consensus about its existence, type (destructive or constructive) and frequency (inter-annual to decadal). Here, we present a set of sensitivity experiments with the medium-resolution regional ocean model NEMO-ATLTROP025, aimed to investigate the air-sea and ocean processes responsible of the development of the MM and its connection to the equatorial SST anomalies. The reference experiment is forced with a 1.5-year composite air-sea fluxes associated with a typical Meridional Mode event from July (year -1) to December (year 0). It confirms that during the growing phase, the reduction (intensification) of the trades in NTA (STA) activate the latent heat fluxes, warming (cooling) the underneath region. In contrast, ocean processes are crucial to generate the equatorial SST signal. North and close to the equator, the wind anomaly excites a downwelling equatorial Rossby wave that propagates from winter to spring. It is reflected at the western boundary, becoming a downwelling Kelvin wave traveling and warming up the equator from July to September. Two additional sensitivity experiments have been performed to isolate the contribution of the oceanic waves *vs* the local wind forcing at the equator. The present study suggests that the oceanic wave connecting the MM and the EM is modulated by the local wind forcing, establishing a competition between both phenomena. Depending on the constructive or destructive nature of this interaction, the EM event will take place after a MM event.

Session 2

Atlantic control of the late-19th century Sahel humid period

Julián VILLAMAYOR [1,2,*], Elsa MOHINO [1], Myriam KHODRI [3], Juliette MIGNOT [3] and Serge JANICOT [3]

[1]Universidad Complutense de Madrid (UCM), Madrid, Spain
[2]Instituto de Geociencias (IGEO), Spain
[3]LOCEAN/IPSL, Sorbonne Universités, UPMC-CNRS-IRD-MNHN, Paris, France

*Correspondance: Courriel: julian.villamayor@ucm.es (J. VILLAMAYORI)

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Abstract

Precipitation regime shifts in the Sahel have dramatic humanitarian and economic consequences such as during the 1970's and 1980's severe droughts. Though Sahel precipitation changes during the late 20th century have been extensively studied, little is known about the decadal variability prior to the 20th century. Some evidences suggest that during the second half of the 19th century the Sahel was as much or even more rainy than during the 1950's and 1960's. Here, we reproduce such anomalous Sahel humid period in the late-19th century by means of climate simulations. We show that this increase of rainfall was associated with an anomalous supply of humidity and higher-than-normal deep convection in the middle and high troposphere. We present evidence suggesting that Sea Surface Temperatures (SSTs) in the Atlantic basin played the dominant role in driving decadal Sahel rainfall variability in this early period.

Session 2

The coupling between tropical Pacific and Atlantic basins in a recharge oscillator framework

Lander R. CRESPO [1,*], Belen Rodríguez DE FONSECA [2,3], Irene POLO [4] and Noel KEENLYSIDE [1]

[1]Geophysical Institute, Bjerknes Centre for Climate Research, University of Bergen, Bergen, Norway
[2]Departamento de FTAAI, Facultad de Ciencias Físicas, Universidad Complutense de Madrid, Madrid, Spain
[3]Instituto de Geosciencias (CSIC-UCM), Facultad de Ciencias Físicas, Universidad Complutense de Madrid, Madrid, Spain
[4]NCAS-Climate, Department of Meteorology, University of Reading

*Correspondance: courriel lander.crespo@gfi.uib.no (L. CRESPO)

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Abstract

We implement a conceptual recharge oscillator model for the tropical Pacific coupled with a linear damped model based on tropical Atlantic SST anomalies to study the interbasin teleconnections. The parameters of the model are fit to the observations for the first and the second half of the 20th century and for the following two cases: (1) non-seasonally, non-interannually varying parameters and (2) seasonally, non-interannually varying parameters. The simulated Pacific thermocline and SST show a strong coupling for the period 1951-2001 with the thermocline and SST leading by 12 and 10 months, respectively, with a correlation of 0.5, while in the observations they lead by 10 and 8 months, respectively. For the period 1900-1950, the thermocline leads the SST by 5 months both in the model and observations but the SST does not feedback onto the thermocline. The comparison between the simple recharge oscillator model with and without Atlantic feedback shows that the Atlantic SST does not affect the coupling between Pacific thermocline and SST, but clearly impacts the Pacific SST. Observations show that Atlantic SST leads Pacific SST by 8 months, while in our model the correlation maximum occurs for a leadtime of 15 months. The impact of Atlantic SST on Pacific SST is stronger for the second period of the study, in agreement with the observations. The leadtime of Atlantic SST onto Pacific SST is slightly reduced, and hence, closer to the observed when we fit the model for seasonally varying parameters.

Session 2

Large scale mechanisms associated with heat wave occurrences in Senegal

Marie Jeanne Gnacoussa SAMBOU [1,*], Serge JANICOT [2], Benjamin POHL [3], Daouda BADIANE [1], Amadou T. GAYE [1] and Abdou L. DIENG [1]

[1]LPAOSF/ ESP / Univ. Cheikh Anta Diop, Dakar,Senegal
[2]LOCEAN, UMR7159 Sorbonne Univ. UPMC-CNRS-IRD-MNHN, Paris, France
[3]CRC, UMR6282 Biogéosciences, CNRS / univ. Bourgogne Franche-Comté, Dijon, France

*Correspondance: courriel: atgaye@ucad.sn (A.T. GAYE)

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Abstract

The coastal location of the Senegal induces specific heat wave (HW) events. HWs are defined as daily temperature (daily maximum or minimum temperature, or mean apparent temperature) higher than the 95th moving percentile during at least three consecutive days over the boreal spring period (Mars-April-May, 1979-2014). A hierarchical classification enables to define three homogeneous regions in terms of HW occurrences over Senegal (Zone #1, #2 and #3, from West to East). In order to study how atmospheric circulation is linked to these HW occurrences, composites of anomaly fields of ERA-Interim reanalysis have been computed using as reference date the starting day of each HW detected in GSOD (Global Summary of the Day) observations database. Results show that two patterns control the occurrence of HWs: regional-scale positive pressure anomalies centred around 35°N-10°W, and more local negative anomalies around 20°N-15°W. This structure leads to enhanced north-easterly winds advecting higher temperatures and moister air over the three zones of Senegal, and lower temperatures and drier air over the central Sahel. The intensity of this relationship is the largest for Zone #1, intermediate for #2 and the weakest for #3. The increased moisture signal over Senegal is highest for the composites associated with minimum and apparent temperature. Indices linked to this structure can be used to evaluate the predictability of such HW events.

Session 2

The connection between Atlantic multi-decadal variability and the Indian summer monsoon in CMIP5 models

Lea SVENDSEN [1], Feifei LUO [2], Shuanglin LI [2,3], Yongqi GAO [2,4], Noel KEENLYSIDE [1,4], and Tore FUREVIK [1]

[1]Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research, Bergen, Norway
[2]Nansen-Zhu International Research Centre and Climate Change Research Center, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China
[3]Department of Atmospheric Science, China University of Geoscience, Wuhan, China
[4]Nansen Environmental and Remote Sensing Center and Bjerknes Centre for Climate Research, Bergen, Norway

*Correspondance: Tél: (+47) 55 58 25 90 ; Courriel: Lea.Svendsen@uib.no (L. SVENDSEN)

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Abstract

Instrumental records show a significant positive correlation between the Atlantic multi-decadal variability (AMV) and the Indian summer monsoon (ISM) rainfall, where warm (cold) sea surface temperatures (SSTs) in the North Atlantic are associated with more (less) ISM rainfall on multi-decadal timescales. However, discrepancies among the models make the robustness of this link debated. We have analysed the link between AMV and ISM rainfall in 66 historical 20th century all-forcing simulations from 22 models from the Coupled Model Intercomparison Project Phase 5 (CMIP5). There is a considerable range in the correlation between AMV and the ISM in the CMIP5 between -0.39 to 0.66, and only 10 out of 66 members (~ 15%) show a significant positive correlation close to the observations. The ensemble members with positive AMV-ISM correlations show an AMV-related atmospheric teleconnection that involves an extratropical-tropical SST gradient in the North Pacific, as well as a regional temperature difference between the Indian subcontinent and the tropical Indian Ocean. Moreover, the models with higher climatological precipitation over the tropical Atlantic and smaller SST biases the North Pacific and the tropical Atlantic better reproduce the observed teleconnections. Further analyses of the preindustrial control simulations of the only two models that capture these teleconnections across all the historical ensemble members (HadGEM2-ES and GFDL-CM3), reveal that the while both these models capture the AMV-ISM teleconnection in externally forced simulations, only HadGEM2-ES reproduces a link in the preindustrial control simulation, where the concurrent SST anomalies in the Pacific seem to be pivotal in reproducing the AMV-ISM link.

Session 2

Meridian Seasonal Variability of the Tropical Atlantic Warm Pool Associated with the Inter-Tropical Convergence Zone (ITCZ)

Dahirou WANE [1,*], Alban LAZAR [2], Malick WADE [3] and Amadou T. GAYE [1]

[1]Laboratoire de Physique de l'Atmosphère et de l'Océan Siméon-Fongang, ESP/UCAD, Senegal
[2]Laboratoire d'océanographie et du climat: expérimentations et approches numériques (LOCEAN) / UPMC, Sorbonne Universités, France
[3]Laboratoire des sciences de l'atmosphère et des océans (LSAO) / UGB, Senegal

*Correspondance: courriel: atgaye@ucad.sn (A.T. GAYE)

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Abstract

The Atlantic Warm Pool (AWP) is an ocean system strongly coupled to the Marine Inter-Tropical Convergence Zone (ITCZ) and its precipitation, and to a lesser extent to adjacent coastal precipitation. In our study, the Ocean Mix Layer (MLD) heat budget equation is used to identify and quantify the mechanisms controlling seasonal AWP meridional migration. We define the latter as the region with SST ≥ 27 ° C, and identify the terms of the budget that explain the migrations of the two isotherms 27 ° C north and south (respectively FN and FS). The results show that north-side meridional migration (FN) is mainly controlled by air-sea flux, while oceanic processes are opposed. The ocean plays an important role in the meridional migration of the FS in the west except in the Gulf of Guinea, where movement is controlled by air-sea flux. We will present a detailed analysis of the mechanisms of these migrations, detailing the contributions of ocean processes and heat fluxes at the air-sea interface.

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Session 3: « Climate prediction».
Wednesday 18th April (afternoon)

Oral presentation

Session 3

Reducing climate model systematic error in the tropical Atlantic sector by enhancing

Mojib LATIF [1,*], Jan HARLAß [1], Sebastian STEINIG [1] and Wonsun PARK [1]

[1]GEOMAR - Helmholtz Centre for Ocean Research Kiel, Düsternbrooker Weg 20, 24105 Kiel, Germany

*Correspondance: Tél: (+49) 431 600 40 50 ; Courriel: mlatif(at)geomar.de (M. LATIF)

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Abstract

We investigate the influence of atmosphere model resolution on tropical Atlantic sector mean climate, seasonal to interannual variability and its predictability in the Kiel Climate Model (KCM). Biases typical for state-of-the-art climate models such as large errors in the sea surface temperature (SST) over the eastern tropical Atlantic can be strongly reduced in the KCM by employing high atmospheric resolution, horizontal and vertical. At high atmospheric resolution, simulation of the mean three-dimensional atmospheric circulation over the tropical Atlantic and the adjacent continents is much enhanced, which in turn improves simulation of tropical Atlantic Ocean circulation and SST. Companion uncoupled atmosphere model simulations with observed SST reveal that the errors in the mean atmospheric circulation are systematic to the atmosphere model. The enhanced mean state and seasonal cycle improves the simulation of tropical Atlantic interannual SST variability and its seasonal phase locking. Further, monthly to seasonal predictability of tropical Atlantic SST is enhanced at high atmospheric circulation, as well as the representation of the West African Monsoon and its relationship to the cold tongue development in the tropical Atlantic. We conclude that sufficiently high atmospheric resolution is a prerequisite to reduce climate model biases in the tropical Atlantic sector.

Session 3

Prediction of Short-term Tropical Atlantic Climate Fluctuations using A Coupled Climate Model with Different Atmosphere Model Resolutions

Xuewel LI [1,2*], M. H. BORDBAR [1], Mojib LATIF [1,3], W. PARK [1] and Jan HARLA[1]

[1]GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany
[2]Physical Oceanography Laboratory, Ocean University of China, Qingdao, China
[3]Excellence Cluster "The Future Ocean" at Kiel University, Kiel, Germany

*Correspondance: Tél: (+49) 431 600-1533 ; Courriel: xli(at)geomar.de (X. LI)

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Abstract

The Tropical Atlantic features several competing modes of climate variability such as those fluctuations which are similar to the El Niño/Southern Oscillation (ENSO) but with weaker amplitude and different seasonal phase locking. In contrast to the tropical Pacific, climate models generally fail to realistically simulate the climate mean state and the ENSO-like variability in the Tropical Atlantic due to model bias. The crucial role of atmosphere model resolution in refining ocean–atmosphere exchanges and thus improving climate mean state and variability over the Tropical Atlantic has been previously shown. However, the impact on the predictive skill is still under debate. Utilizing three commonly used approaches to predict short-term climate fluctuations, we examine the skill in predicting sea surface temperature anomalies (SSTAs) over the tropical Atlantic in a fully coupled climate model with identical oceanic model but different atmospheric resolutions.

In perfect model experiments, i.e. when predicting the model SSTAs, our analysis reveals a significant skill over much of the tropical Atlantic at lead times of one to two seasons and up to three seasons in the western Tropical Atlantic for forecasts initialized in boreal summer and fall, whereas it is the most skilful over the eastern sector when initialized in boreal spring.

Overall, our findings suggest that, in the presence of identical oceanic component, the skill in predicting Tropical Atlantic SSTAs is significantly enhanced when using high resolution in the atmospheric component which can be potentially related to the enhanced representation of ENSO-like dynamics in the model version with higher atmospheric resolution. This further supports the widespread efforts to refine the spatial and temporal resolutions in the climate models.

Session 3

Relationships among Inter-model Spread and Biases in Tropical Atlantic sea surface temperatures

Elsa MOHINO[1], Belén Rodríguez DE FONSECA [1,2], Teresa LOSADA [1], Irene POLO [1,3] and C. Roberto MECHOSO [4]

[1]Dto Fisica de la Tierra y Astrofisica, UCM, Madrid, Spain
[2]IGEO, Madrid, Spain
[3]Department of Meteorology, University of Reading, Reading, UK
[4]Department of Atmospheric and Oceanic Sciences, UCLA, Los Angeles, USA

*Correspondance: Tel.: 91 394 4390; courriel : emohino@fis.ucm.es (E. MOHINO)

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Abstract

In this work we explore the reasons for spread in the simulation of monthly-mean sea surface temperature (SST) in the Tropical Atlantic (70ºW-20ºE; 20ºS - 20ºN) by 24 models participating in CMIP5. We use the output of piControl simulations and estimate the modes of inter-model variability by applying Principal Component (PC) analysis to the long-term climatological SSTs simulated in the Atlantic Ocean for the selected region. The first mode of inter-model variability is related to generally cooler SSTs, especially over the southern basin. A regression between the PC of this mode and the global SST field reveals worldwide connections with same-signed loads over most of the tropics, especially in the eastern Pacific. The mode is also connected with higher low cloud cover over the main upwelling regions of the world. The second mode of inter-model variability is restricted to the Atlantic basin with a north-south dipole of SST (defined by negative and positive loads to the north and south of the equator, respectively), with strongest loads in the subpolar gyre region. This mode is connected to a too weak Atlantic Meridional Overturning Circulation. The third mode is related to the double Intertropical Convergence Zone bias in the Pacific and to an interhemispheric asymmetry in the net radiation at the top of the atmosphere. Our results suggest that the main contributor to the mean bias pattern in the Tropical Atlantic is the second mode. Accordingly, those models that simulate weaker AMOCs tend to show stronger biases in the Tropical Atlantic. For those models, particular attention should be paid to the correct simulation of the Antarctic sea ice, as its underrepresentation is a potential cause for weakening the upwelling branch of the AMOC.

Session 3

The April Transition between Easterly and Westerly Wind Bias in the Tropical Atlantic in Hindcasts Using the ECMWF IFS

Jon SHONK [1], Teferi DEMISSIE [2] and Thomas TONIAZZO [2]

[1]University of Reading, Department of Meteorology, University of Reading, PO Box 243, UK
[2]Uni Research Climate and Bjerknes Centre for Climate Research, Bergen, Norway

*Correspondance: Tél: (+44) 118 378 7144 ; Courriel: jon.shonk@ncas.ac.uk (J. SHONK)

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Abstract

Seasonal forecasting using coupled general circulation models is heavily affected by model drift that can dominate the forecasts. This is the case in the tropical Atlantic where equatorial westerly errors have a large impact particularly on the representation of coastal upwelling in the Benguela region (Voldoire et al. 2018).

Operational and non-operational forecasts with ECMWF's Integrated Forecasting System (IFS) atmosphere model, used in System 4 and EC-Earth, show that equatorial westerlies appear during a sudden transition in boreal spring corresponding to the establishment of a spurious southern ITCZ in the Atlantic. We analyse this transition in System 4, in parallel uncoupled (atmosphere-only) hindcasts prescribing observed SSTs, and in hindcasts run using EC-Earth version 2.3.

We find that the initial easterly and the subsequent westerly "bias regimes" are very different in terms of how the biases interact, and also that they originate from different components of the coupled model. The easterly regime shows strong trade winds that are associated with the development of a cold tongue bias and a double ITCZ, that develop in all models independent of the presence of coupling. The sharp weakening of the trade winds in the westerly regime occurs during April and is associated with the intensification of rainfall in the erroneous southern branch of the ITCZ in the coupled models. The excess convergence steers the trade winds away from the equatorial band, creating a windless zone between the two branches of the ITCZ. The establishment of a double ITCZ in the Atlantic is not dependent on a cold model bias over the Equator, and it cannot be explained by a traditional wind-induced surface heat exchange mechanism (Xie and Philander 1994) or by excessive convection over land (Richter and Xie 2008). We speculate that excessive boundary-layer stability in the transitional regime between marine stratocumulus and trade cumulus (Schreier et al. 2014), together with the geometry of the basin, tends to favour moisture convergence south of the Equator (Pauluis 2004) and associated convective precipitation in the tropical Atlantic.

Session 3

Role of wind stress in driving coupled model SST biases in the Tropical Atlantic

Aurore VOLDOIRE [1,*], Teferi DEMISSIE [2], Anna-Lena DEPPENMEIER [3], Eleftheria EXARCHOU [4], Claudia FRAUEN [1,10], Katerina GOUBANOVA [5,9], Noël KEENLYSIDE [6], Shunya KOSEKI [6], Chloé PRODHOMME [4], Emilia SANCHEZ-GOMEZ [5], Mao-Lin SHEN [6], Jon SHONK [7], Thomas TONIAZZO [2], and Abdoul-Khadre TRAORÉ [8]

[1]Centre National de Recherches Météorologiques (CNRM), France
[2]Uni Klima, Uni Research AS, Bergen, Norway
[3]Wageningen University, The Netherlands
[4]Barcelona Supercomputing Center, Spain
[5] Centre Europeen De Recherche Et De Formation Avancee En Calcul Scientifique (CERFACS), France
[6]University of Bergen, Norway
[7] University of Reading, Department of Meteorology, University of Reading, PO Box 243, UK
[8]LMD, France
[9] Centro de Estudios Avanzados en Zonas Áridas (CEAZA), Chile
[10] Leibniz Institute for Baltic Sea Research (IOW), Germany

*Correspondance: courriel: aurore.voldoire@meteo.fr (A. VOLDOIRE)

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Abstract

Coupled climate models used for long-term future climate projections as well as seasonal forecasts models share a systematic warm sea surface temperature (SST) bias in the tropical Atlantic. One of the objectives of the EU-FP7 PREFACE project is to better understand physical mechanisms responsible for the development of such systematic biases in the Tropical Atlantic using the Transpose-CMIP protocol. Six climate models have participated to the coordinated analysis: CNRM-CM-LR (CNRM), CNRM-CM-HR (CERFACS), EC-Earth v3.1 (WU, BSC), ECMWFS4 (UREAD), IPSL-CM (IPSL), and NorESM (UiB). Seasonal hindcasts simulations have been run starting in May and February over the period 2000-2009. In all models, 80% of the long term bias is reached in 6 months, confirming the rapid development of Atlantic warm SST biases. From these control experiments, it is shown that the equatorial SST bias is not driven by surface heat fluxes biases in all models whereas in the southeast the solar heat flux could explain the set-up of an initial warm bias in the first days. Several sensitivity experiments to the wind stress allow disentangling the role of wind in driving the SST bias. These confirm the leading role played by wind stress bias in driving the equatorial SST bias, even if the amplitude of the bias depends on the model. The reduced SST bias lead to reduced precipitation locally but there is no remote effect on the West African Monsoon rainfall. Over the southeast, the local wind biases tend to have a local impact on the SST bias (except in the higher resolution model). However, there is also a non-local effect of equatorial wind correction in 2 models explained by sub-surface advection of water from the equator that is colder when the equatorial wind stress is corrected. It is also shown that improving the mean state in the equatorial Atlantic lead to an intensification of the Bjerknes feedback loop.

Session 3

Bias development and its impact on prediction skill as examined from daily mean output of a full-field initialization hindcast

Ingo RICHTER [1,*] and Takeshi DOI [1]

[1]APL, JAMSTEC, Japan

*Correspondance: Tél: (+81) 45-778-5523; Courriel: richter@jamstec.go.jp (I. RICHTER)

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Abstract

Current prediction systems struggle to skilfully predict sea-surface temperature (SST) variations in the tropical Atlantic, particularly in the equatorial and coastal upwelling regions. It is often assumed that this poor prediction skill is due to the severe SST biases that most models feature there. Some recent studies, however, indicate that the role of biases maybe less important than previously thought and that inherent predictability limits are one major reason for the poor skill in the tropical Atlantic compared to the tropical Pacific.

The present study uses a hindcast experiment with the SINTEX-F coupled general circulation model (GCM) for the period 1983-2016 to examine both the impact of biases on prediction skill and the root causes of the model biases in the tropical Atlantic. For this purpose, we analyse the bias evolution (the forecast drift) and its relation to prediction skill at daily time-scales. Since the model is initialized with the observed state, the forecast starts out with zero bias and gradually drifts towards its biased attractor during the forecast period.

Preliminary results suggest that the link between drift and prediction skill is not very strong. A good example is the Angola-Benguela upwelling region off the coast of southwestern Africa, were SST biases of up to 5 K gradually develop over the 6-month forecast period but the prediction skill often deteriorates within a few weeks. Other regions, such as the equatorial Atlantic and the northern tropical Atlantic, also exhibit relatively little sensitivity to SST bias. This suggests that forecast drift is not the main reason for the poor tropical Atlantic prediction skill of SINTEX-F.

Regarding the origins of eastern equatorial Atlantic SST biases, we find that, irrespective of initialization month, there are two periods of rapid development: July through August and December through February. The former period appears related to westerly wind biases in the western equatorial Atlantic, while the latter period is associated with a weakening of the local cross-equatorial winds.

Session 3

Seasonal prediction skill in the tropical Atlantic using anomaly coupling

Lea SVENDSEN [1], Francois COUNILLON [1,2], Noel KEENLYSIDE [1,2], Shunya KOSEKI [1], Teferi DEMISSIE [3], Thomas TONIAZZO [3], Yiguo WANG [2] and Ingo BETHKE [3]

[1]Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research, Bergen, Norway
[2]Nansen Environmental and Remote Sensing Center and Bjerknes Centre for Climate Research, Bergen, Norway
[3]Uni Research Climate and Bjerknes Centre for Climate Research, Bergen, Norway

*Correspondance: Tél: (+47) 55 58 25 90 ; Courriel: Lea.Svendsen@uib.no (L. SVENDSEN)

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Abstract

Current state-of-the-art models exhibit large climatological errors in the tropical Atlantic. To what extent this contributes to the poor seasonal prediction of these models in the tropical Atlantic remains unclear. Here we investigate this issue by comparing seasonal predictions with a standard and an anomaly coupled configurations of the Norwegian Climate Prediction Model (NorCPM), which aims at providing seasonal-to-decadal prediction by assimilating data into the Norwegian Earth system model (NorESM) with the Ensemble Kalman Filter. In the anomaly coupled configuration the climatological errors are reduced and the mechanisms for equatorial Atlantic variability are better represented. We also find significant prediction skill of equatorial Atlantic SSTs in August in the anomaly coupled configuration. Here we discuss the possible mechanisms for the improved prediction skill in August, and why the skill has not improved earlier in the year when Atlantic Niño events are initiated.

Session 3

Impact of Tropical Atlantic variability on Tropical Pacific predictability

Eleftheria EXARCHOU [1], Maria Belén Rodríguez DE FONSECA [2], Irene POLO [2,3] and Teresa LOSADA [2]

[1]Barcelona Supercomputing Centre, Bercelona, Spain
[2]Universidad Complutense de Madrid, Facultad de Físicas, Geofísica y Meteorología, Madrid, Spain
[3]National Centre for Atmospheric Science Department, Department of Meteorology, University of Reading, Reading, UK

*Correspondance: courriel brfonsec@fis.ucm.es (B.R. de FONSECA)

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Abstract

Previous studies indicate the influence of Atlantic variability on ENSO frequency and variability (Wu and Kirtman, 2004; Dommenget et al. 2006; Jansen et al., 2009). Rodriguez-Fonseca et al (2009) shows that summer equatorial Atlantic anomalous SSTs are highly anticorrelated with the equatorial Pacific in the next winter months. The mechanism of the Atlantic/Pacific teleconnection involves an anomalous Walker circulation triggered by the anomalous SST over the eastern Tropical Atlantic, which results in anomalous easterly winds over western Pacific and thermocline perturbations that propagate eastward thus favouring the development of ENSO conditions (Losada et al., 2010; Polo et al., 2015). Here, we use the NMME and EUROSIP multi-model seasonal prediction systems for the period 1981-2014. In order to investigate the impact of the summer Atlantic variability on the predictability of ENSO, we compare retrospective forecasts initialized in February to forecasts initialized in June. We find that the June initialized forecasts have consistently higher skill in predicting ENSO than the February initialized at longer lead times, indicating a source of ENSO predictability in the initialization of June. We further find that models with high prediction skill over the summer Tropical Atlantic tend to both better reproduce the connection between the summer Tropical Atlantic SST and the winter Tropical Pacific SST, and also have higher skill in predicting the winter Tropical Pacific SST. Given that the Tropical Atlantic is an area of large and systematic biases and poor prediction skill (*i.e.* Richter et al., 2017) this study emphasizes the importance of correctly representing the Tropical Atlantic mean state and variability in order to improve Tropical Pacific predictability.

Session 3

Quantifying systematic climate model errors in the simulation of interannual and decadal climate variability in the tropical Atlantic region

Davide ZANCHETTIN [1], Carlo GAETAN [1], Maeregu Woldeyes ARISIDO [1,2], Jorge Lopez PARAGES[1,3], and Angelo RUBINO [1]

[1]University Ca'Foscari of Venice, Dept. of Environm. Sc., Informatics and Statistics, Mestre, Italy
[2]University of Milano Bicocca, School of Medicin and Surgery, Milano, Italy
[3]Universidad Complutense de Madrid, Departamento de Física de la Tierra, Astronomía y Astrofísica, Madrid, Spain

*Correspondance: Tél: (+41) 234 8952; Courriel: davidoff@unive.it (D. ZANCHETTIN)

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Abstract

The climatology simulated by current coupled climate models is affected by systematic errors compared to observations regarding mean state, seasonal cycle and interannual internal variability. Of these, the warm bias affecting south-eastern tropical Atlantic sea-surface temperatures is among the most critical. In this contribution, we will illustrate two state-of-the-art statistical models for the quantification of the impact of climate model biases on the simulation of interannual and decadal climate variability in the tropical Atlantic region. Both models were developed within Work Package 10 of PREFACE and build on the state-space approach and share a Bayesian hierarchical framework, but are targeted at different aspects of the problem: The first model is focused on estimation of the purely temporal component of systematic model errors through structural decomposition, and uses the evolution of sea-surface temperature drifts in the Tropical Atlantic region from decadal climate predictions as a test bed; the second model is focused on the spatio-temporal assessment of the bias in a multi-model ensemble, and uses near-surface air temperatures over the Tropical Atlantic region from CMIP5 historical simulations as a test bed. We will provide illustrative examples to demonstrate how the proposed methodology can help improving the characterization and understanding of the temporal as well as spatio-temporal evolution of systematic climate model errors, and hence for a more reliable interpretation of simulated interannual-to-decadal tropical climate variability.

Session 3

Revisiting the CMIP5 Thermocline in the Tropical Pacific

Antonio castaño-TIERNO [1,*], Elsa MOHINO [1], Belén Rodríguez DE FONSECA [1] and Teresa LOSADA[1]

[1] Universidad Complutense de Madrid, Madrid, Spain

*Correspondance: Tél: (+34) 23 48 95 24; Courriel: antcasta@ucm.es (A. CASTAÑO-TIERNO)

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Abstract

The thermocline is defined as the ocean isotherm in which the vertical thermal gradient is maximum. In the Pacific Ocean, observations have led to the use of the 20 degree Celsius isotherm as an estimate of the thermocline. Nevertheless, such estimate is not necessarily as good a proxy in coupled models as in observational datasets. This work presents a comparison of the depth of the 20 °C isotherm and the depth of the layer of maximum temperature gradient for the equatorial Pacific Ocean. It is shown that there are significant differences between them in the CMIP5 preindustrial simulations. This is due to the 20 °C isotherm not being able to follow the thermocline correctly, mainly in the eastern region of the Pacific, where the cold tongue develops. A strong correlation between the depth of the 20 °C isotherm and the model sea surface temperature is found in the eastern boundary of the ocean, while in the western region the 20 °C isotherm is located below the thermocline. It is found that using the depth of the 20 °C isotherm as a proxy for thermocline depth for the whole of the Pacific Ocean might lead to errors in the assessment of the model ability to reproduce ocean-atmosphere interactions. These results might have implications in the study of model thermocline biases and their relationship with model sea surface temperature bias.

Session 3: « Climate prediction».
Wednesday 18th April 2018 (afternoon)

Poster presentation

Session 3

Influence of sea surface temperature (SST) bias in North West Africa upwelling system in CMIP5 models

Antonio CASTAÑO-TIERNO [1,*], Belén Rodríguez DE FONSECA [1,2], Teresa LOSADA [1] and Elsa MOHINO [1]

[1]Departamento de Física de la Tierra, Astronomía y Astrofísica I, Geofísica y Meteorología. UCM, Av. Complutense s/n, 28040 Madrid, Spain
[2]Instituto de Geociencias (CSIC-UCM), Facultad de CC. Físicas, Plaza de Ciencias 1, 28040 Madrid, Spain

*Correspondance: Tél: (+34) 23 48 95 24; Courriel: antcasta@ucm.es (A. CASTAÑO-TIERNO)

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Abstract

Using different diagnostic variables, we study the relation between SST bias in CMIP5 PI control simulations and the representation of North West Africa upwelling. Upwelling variability is studied using the meridional wind stress, temperature profiles and thermocline depth defined as the depth of maximum temperature vertical gradient. Both seasonal cycle and interannual variability are analysed. Applying regression analysis and Empirical Orthogonal Functions (EOFs), a link is stablished between the global SST bias and coastal upwelling representation. Consistence between thermocline depth and wind stress divergence is assessed.

Session 3

Climate projections with bias-reduced CGCMs in Tropical Atlantic

Teferi DEMISSIE [1,*], Noel KEENLYSIDE[2], Shunya KOSEKI[2], Thomas TONIAZZO[1] and Ingo BETHKE[1]

[1]Uni Research Climate and Bjerknes centre for climate research, Bergen, Norway
[2]Geophysical Institute, University of Bergen and Bjerknes centre for climate research, Bergen, Norway

*Correspondance: Tél: (+47) 55 58 87 78; Courriel: Teferi.Demissie@uni.no (T. DEMISSIE)

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Abstract

Current state-of-the-art models exhibit large climatological errors in the tropical Atlantic. The consequence of these errors for climate projections is undocumented. Here we compare climate change projections with a standard and an anomaly coupled configurations of the Norwegian Climate Prediction Model (NorCPM). Anomaly coupling greatly reduces the simulated climatological errors. This leads to greatly differing climate change projections (present to 2100). The standard model shows a rather uniform warming of around 2.5 degrees Celsius over the equatorial Atlantic. In contrast, the corrected model shows greater warming in the east, reaching 3 degrees Celsius in the eastern equatorial Atlantic. These changes are reflected in quite different rainfall response patterns. The standard model shows that climate change will lead to wetter conditions over central Africa and the western Atlantic, and drier conditions over eastern equatorial South America and the south equatorial Atlantic. The corrected model, in contrast, shows greater rainfall changes in the east and over central Africa, and less drying over South America. The underlying mechanisms causing these differences will be discussed. This result illustrates the potential impact of mean state errors in future climate change in this region.

Session 3

Impact of dynamical regionalization on precipitation biases and teleconnections over West Africa

Iñigo GÓMARA [1,2,3,*], Elsa MOHINO [1], Teresa LOSADA [1], Marta DOMÍNGUEZ [1], Roberto SUÁREZ-MORENO [1,2] and Belén Rodríguez DE FONSECA [1,2]

[1]Dept. Geophysics and Meteorology, Universidad Complutense de Madrid, Madrid, Spain
[2]Instituto de Geociencias (IGEO), UCM-CSIC, Madrid, Spain
[3]CEIGRAM, AgSystems, Universidad Politécnica de Madrid, Madrid, Spain

*Correspondance: Tél: (+34) 913944513; Courriel: i.gomara@ucm (I. GÓMARA)

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Abstract

West African societies are highly dependent on the West African Monsoon (WAM). Thus, a correct representation of the WAM in climate models is of paramount importance. In this article, the ability of 8 CMIP5 historical General Circulation Models (GCMs) and 4 CORDEX-Africa Regional Climate Models (RCMs) to characterize the WAM dynamics and variability is assessed for the period July-August-September 1979–2004. Simulations are compared with observations. Uncertainties in RCM performance and lateral boundary conditions are assessed individually. Results show that both GCMs and RCMs have trouble to simulate the northward migration of the Intertropical Convergence Zone in boreal summer. The greatest bias improvements are obtained after regionalization of the most inaccurate GCM simulations. To assess WAM variability, a Maximum Covariance Analysis is performed between Sea Surface Temperature and precipitation anomalies in observations, GCM and RCM simulations. The assessed variability patterns are: El Niño-Southern Oscillation (ENSO); the eastern Mediterranean (MED); and the Atlantic Equatorial Mode (EM). Evidence is given that regionalization of the ENSO–WAM teleconnection does not provide any added value. Unlike GCMs, RCMs are unable to precisely represent the ENSO impact on air subsidence over West Africa. Contrastingly, the simulation of the MED–WAM teleconnection is improved after regionalization. Humidity advection and convergence over the Sahel area are better simulated by RCMs. Finally, no robust conclusions can be determined for the EM–WAM teleconnection, which cannot be isolated for the 1979–2004 period. The novel results in this article will help to select the most appropriate RCM simulations to study WAM teleconnections under current and future climate scenarios.

Reference

Gómara et al. (2017) Clim Dyn 1-26, https://doi.org/10.1007/s00382-017-3886-4

Session 3

Impact of the anomaly coupling in the simulation of the interannual variability of the Tropical Atlantic Ocean in a simulation

Teresa LOSADA [1,2], Antonio CASTAÑO-TIERNO [1], Elsa MOHINO [1], Belén Rodríguez DE FONSECA [1,2], and Carlos R MECHOSO [3]

[1]Departamento de Física de la Tierra, A. A. I, Facultad de Ciencias Físicas, UCM. Madrid (Spain)
[2]Instituto de Geociencias (CSIC-UCM), Facultad de Ciencias Físicas, UCM. Madrid (Spain)
[3]Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, (USA)

*Correspondance: Tél: (+34) 91 394 5007; Courriel: tldoval@fis.ucm.es (T. LOSADA)

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Abstract

It is well known that coupled global climate models show important systematic errors that can preclude our confidence in their results. One important open question in this regard, is the relation between biases and variability in global climate models.

In this work, we evaluate the impact of the implementation of an anomaly coupling technique, in which the only information exchanged by the atmospheric and oceanic components of the model is the anomalous part of the fluxes and the SST, in the simulation of the interannual variability in the UCLA CGCM model.

Session 3

Impact of the reduction of the southern extratropical incoming radiation on the simulation of the tropical Atlantic variability

Teresa LOSADA [1,2,*], Belén Rodríguez DE FONSECA [1,2], Antonio CASTAÑO-TIERNO [1] and Carlos R. MECHOSO [3]

[1]Departamento de Física de la Tierra, Astronomía y Astrofísica I, Facultad de Ciencias Físicas, UCM. Plaza de las Ciencias 1, 28040 Madrid, Spain
[2]Instituto de Geociencias (CSIC-UCM), Facultad de Ciencias Físicas, UCM. Plaza de las Ciencias 1, 28040 Madrid, Spain
[3]Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, CA, 90095, USA

*Correspondance: Tél: (+34) 91 394 5007; Courriel: tldoval@fis.ucm.es (T. LOSADA)

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Abstract

Coupled global climate models (CGCMs) show important biases in the simulation of SST, not only in the tropics, but also over the Southern Ocean. A recent work has shown that improving the errors in the Southern Ocean SST can result in an improvement of the tropical biases in the UCLA CGCM. In this work, we analyse how this model simulates the tropical Atlantic Niño mode in a control run and we compare the results with the variability of a second simulation in which we apply an idealized reduction of the incoming shortwave radiation over the Atlantic sector of the Southern Ocean. Our results show an improvement of the simulation of the tropical Atlantic variability at interannual timescales in the idealized simulation. The representation of the Atlantic Equatorial Mode is improved and the variability in the tropical Atlantic is enhanced.

Session 3

Relationship between inter-annual tropical variability and mean state in CMIP5 models

Irene POLO [1,2,*], Belén Rodríguez DE FONSECA [1], Elsa MOHINO [1], Teresa LOSADA [1], Julian VILLAMAYOR [1] and Carlos R. MECHOSO [3]

[1]Dto Fisica de la Tierra, Astronomia y Astrofisica I, UCM, Madrid, Spain
[2]Department of Meteorology, University of Reading, Reading, UK
[3]Department of Atmospheric and Oceanic Sciences, UCLA, Los Angeles, USA

*Correspondance: courriel brfonsec@fis.ucm.es (B.R. de FONSECA)

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Abstract

Previous studies on systematic errors of coupled atmosphere-ocean general circulation models have generally focused on long-term-averaged features. The way in which these mean errors impact the variability of the coupled system has received less attention. The present study examines the relationships in CMIP5 models among inter-model differences in the simulation of the mean climate and the individual models' success in reproducing the observed tropical climate variability at inter-annual time-scales. Our approach is based on comparing the leading inter-annual modes of sea surface temperature (SST) variability for each model, and on correlating defining characteristics of these modes with their representations of the mean state. In the tropical Pacific, the success in simulating the spatial structure of the first mode of inter-annual variability (El Niño) is higher in models that capture the observed location of mean convection over the western Pacific and Maritime Continent. This appears together with a southward shift of the Intertropical Convergence Zone in both the Pacific and Atlantic basins. Such a shift is noted in models for which the mean SST is warmer than average over the southern hemisphere and the equatorial Pacific and Atlantic. In the Tropical Atlantic, the success with the first mode of inter-annual variability (Atlantic Niño) is higher in models that are able to reproduce the intensity of observed westerly winds around 40S as well as the cooler SST/lower Ocean Heat Content over 40S and the Southern Ocean, which are themselves linked to the deep ocean circulation and Atlantic Meridional Overturning Circulation. A stronger North Brazil Current is associated with reduced explained variance by the Atlantic Niño, through the increased ocean heat transport convergence in the deep tropics and the warming of the subsurface in the equatorial Atlantic. Thus, this work contributes to set metrics for assessment of predictions of inter-annual variability in climate projections by CMIP5 models.

Session 3

Impact of the ocean stochastic parameterization on the simulated mean state and variability of a coupled model

Emilia SANCHEZ-GOMEZ [1,*], Marta Martin DEL REY [1], G. RUGGIERO [2] and R. MSADEK [1]

[1]CECI-CERFACS, Toulouse, France
[2]Mercator-Ocean, Toulouse, France

*Correspondance: Tel: +33 (0) 5 61 19 31 29; courriel Emilia.Sanchez@cerfacs.fr (E. SANCHEZ-GOMEZ)

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Abstract

The ocean component in state-of-the-art coupled models operates in general at a coarse horizontal resolution (~100 km) that does not allow resolving the ocean mesoscale dynamics. These unresolved processes provide a great degree of uncertainty in forced ocean and also coupled simulations. To tackle with this uncertainty, parameterisations emulating the average effect sub-grid scale processes have been developed. These parameterisations are implemented either on the advection terms or in the equation of state of the primitive equations of the ocean model. In a recent work, Brankart 2013 has developed a new parameterization aimed at simulating the uncertainties in the computation of the large-scale horizontal density gradient from the large-scale temperature and salinity fields. On this purpose, a stochastic term was added in the seawater equation of state to mimic the sub-grid random fluctuations of temperature and salinity fields. In a ocean forced simulation, they showed that this parameterization has a considerable impact on the ocean large-scale circulation, especially in the regions of intense mesoscale activity (i.e. the western boundary currents). Following this idea, in this work we study the impact of the stochastic parametrization in the low-resolution coupled model CNRM-CM6 (1.4o for the atmosphere, and 1o for the ocean). Given the uncertainties related to this parameterization, we built 3 ensembles of 3 members each in which different values of the stochastic parameters have been tested. The effect of the stochastic ocean on the mean state and variability is analysed in the ensembles. Preliminary results show slight, but significant impacts over the heat and salt content in the Atlantic Ocean (North Atlantic and Tropical Atlantic), associated with the Subpolar and Subtropical gyres transports, and also over the mixed layer and deep convection the Labrador and Greenland-Irminger-Norwegian seas.

Session 3

Tropical Atlantic low-cloud biases in CNRM-CM6: evaluation of the new atmospheric physics

Florent BRIENT [1,*], Romain ROEHRIG [1] and Aurore VOLDOIRE [1]

[1] CNRM, Météo-France/CNRS, Toulouse, France

*Correspondance: Tel.: +33 5 61 07 96 62; courriel : florent.brient@meteo.fr (F. BRIENT)

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Abstract

Most state-of-the-art coupled general circulation models have serious biases in the tropical Atlantic, which strongly impact their representation of the regional climate. The CMIP5 version of CNRM-CM has been shown to suffer from these typical biases, namely a westerly wind bias over the Equatorial Atlantic and a excess of solar radiation in the southeastern region. Since CMIP5, a new atmospheric physics has been developed and implemented in the CNRM-CM model. It includes a new boundary-layer scheme based on a TKE prognostic equation, a detailed microphysics scheme prognostically describing liquid and ice cloud condensates as well as liquid and solid precipitating hydrometeors, and a new convective scheme aiming at representing in a continuous way dry, shallow and deep convection. The representation of clouds and convection in the tropics is strongly impacted. In the present study, its realism is further assessed in the south-eastern part of the tropical Atlantic. Low-level cloud biases in the new version of CNRM-CM are first assessed in AMIP-type simulations. We focus on how the model represents the vertical development of boundary-layer clouds and the transition from stratus to cumulus regimes, using a zonal transect between the Namibian coast and South America. In particular, the representation of this transition is related to biases of the surface energy budget. Then, short-term hindcasts (Transpose-AMIP framework) are used to better understand the mechanisms at play. Low-level cloud biases are shown to be associated with fast processes (a few hours to a few days). Specifically, the drivers for this low-cloud underestimate are further discussed to show that they are likely to arise from errors in cloud scheme input coming from the boundary-layer thermodynamics (e.g. turbulence) and structural errors from the cloud parameterization itself (e.g. assumptions of sub-grid variance of thermodynamical variables). This study provides guidance for future improvements of stratocumulus representation in the CNRM-CM model.

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Oral presentation

Session 4

Spatial and temporal variability of primary production in the north-west African upwelling: A modelling approach.

Pierre-Amaël AUGER [1,3,*], Thomas GORGUES [3], Eric MACHU [3], Timothée BROCHIER [5], Patrice BREHMER [2] and Olivier AUMONT [4]

[1]Millenium Institute of Oceanography, Concepción, Chile
[2]Institut de recherche pour le développement (IRD), UMR Lemar, Campus Ifremer, Délégation régionale IRD ouest France, 29280, Plouzané, France
[3]Laboratoire d'Océanographie Physique et Spatiale, Brest, France
[4]Laboratoire d'Océanographie et du Climat : Expérimentations et Approches Numériques, Paris, France
[5]UMMISCO, Univ Sorbonne, Paris, France

*Correspondance: courriel pierreamael.auger@gmail.com (PA AUGER)

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Abstract

An analysis based on a multi-decadal physical–biogeochemical hindcast simulation (1980– 2009) was conducted to characterize the drivers of the spatial distribution of phytoplankton biomass and production in the north-west (NW) African upwelling system. To that end, a comparative box analysis representing homogeneous sub-regions in the NW African upwelling system has been conducted. The sub-regions have been defined using the near-surface horizontal circulation patterns. In each box, we analysed the dynamics of primary productivity and nutrients with regard to advective and diffusive matter fluxes at the boundaries and local biological production and/or uptake. The nature and variability of the matter exported from the coastal margin to the adjacent open ocean were also subsequently depicted. This variability of the primary production may impact the distribution and abundance of fish populations, and their associated fisheries, on a large range of timescales.

Session 4

Synthesis of prey field dynamics and the analysis of tuna dynamics to qualitatively evaluate the prospect for future fisheries in the tropical eastern central Atlantic

Heino O. FOCK [1,*], Stephanie CZUDAJ [2], Ivanice MONTEIRO [2] and Péricles SILVA [2]

[1]Thünen-Institute (TI), Institute of Sea Fisheries, Federal Research Institute for Rural Areas, Forestry and Fisheries, Palmaille 9, 22767 Hamburg, Germany
[2]Instituto Nacional de Desenvolvimento das Pescas (INDP) and Ocean Science Centre Mindelo (OSCM), Mindelo, Sao Vincente, Cabo Verde

*Correspondance: Tél: (+49) 471 94460 366; Courriel: heino.fock@thuenen.de (H. FOCK)

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Abstract

The evaluation is based on the analysis of prey length spectra and biomass size spectra on the one side and tuna catch rate dynamics on the other side. The production of tuna is determined by the amount of primary production PP transferred to higher trophic levels TL by PP × TE (TL − 1), where TE is trophic efficiency. TE is determined by TE=exp((b-0.25)*lg PPMR), where b is the slope of biomass spectrum and PPMR is the size ratio of predators to prey. The analysis of prey dynamics revealed no change in minimum or maximum sizes of the species indicating no change in PPMR. However, significant differences in size structure were indicated in 20 out 28 species. Slopes of normalized biomass size spectra steepened in 2015 for the tropical (-0.88 to -1.4) and subtropical region (-1.08 to -1.28). The slope for the temperate region was -0.44 in 1966-79. Maximum sizes for all species were smaller in the oxygen minimum region, associated with significant changes in size structure. Local dynamics of Yellowfin tuna (*Thunnus albacares*, YFT) catch rates covering the area 10-20°N latitude and 10-30°W longitude indicate a positive dependency on cooling in the tropical North Atlantic in springtime and a weakening of autumn winds in September and October. The evaluation shows that negative effects due to changes in TE can be counterbalanced by improved stock management.

Session 4

Yellowfin tuna catch opportunities in Cape Verde – coping with uncertainties of local CPUEs

Ivanice MONTEIRO [1,*], Pericles SILVA [1] and Heino O. FOCK [2]

[1]Instituto Nacional de Desenvolvimento das Pescas (INDP) and Ocean Science Centre Mindelo (OSCM), Mindelo, Sao Vincente, Cabo Verde
[2]Thünen-Institute (TI), Institute of Sea Fisheries, Federal Research Institute for Rural Areas, Forestry and Fisheries, Palmaille 9, 22767 Hamburg, Germany

*Correspondance: Tél: (+238) 2321373/74; Courriel: ivanice.monteiro@indp.gov.cv (I. MONTEIRO)

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Abstract

One of the aims of the PREFACE project (EU FP7 GA. N. 603521) work package WP12.1 is to analyse Yellowfin tuna (Thunnus albacares, YFT) catch opportunities in the waters of Cabo Verde and to investigate the effect of climate. Local catch-per-unit-effort (CPUEl) is treated as a function of stock size, Ns, and environmental factors, Vi, the latter at local scale or in terms of climate indices. For tuna stocks, no fisheries independent information is available. This limits the potential to calculate unbiased abundance and distribution indices. We analyse local YFT catches with different statistical models to account for uncertainty in local abundance data. Catch data both from artisanal and industrial fisheries were acquired for the area 10-20°N latitude and 10-30°W longitude to indicate catch opportunities in Cape Verde waters. In this presentation, we emphasize on the assumptions underlying the calculation of local CPUE and model weighting to take account of for instance aggregation behaviour both of fishermen and tuna.

Session 4

Hydrographic control on larval fish assemblages: Lessons from the Canary Current Ecosystem

Maik TIEDEMANN [1,2,6,*], Heino FOCK [1], Patrice BREHMER [2], Julian DÖRING [3], Gregor BÖRNER [4], Shawn DOVE[5], Werner EKAU [3], and Christian MÖLLMANN [6]

[1]Thünen-Institute (TI), Institute of Sea Fisheries, Federal Research Institute for Rural Areas, Forestry and Fisheries, Palmaille 9, 22767 Hamburg, Germany
[2]Institut de recherche pour le développement (IRD), UMR Lemar, Campus Ifremer, Délégation régionale IRD ouest France, 29280, Plouzané, France
[3]Leibniz Centre for Tropical Marine Research (ZMT), Fahrenheitstraße 6, 28359 Bremen, Germany
[4]Humboldt University, Albrecht Daniel Thaer-Institute of Agricultural and Horticultural Sciences, 12587 Berlin, Germany
[5]GEOMAR, Helmholtz Centre for Ocean Research Kiel, Düsternbrooker Weg 20, 24105 Kiel, German
[6]Institute for Hydrobiology and Fisheries Science, Center for Earth System Research and Sustainability (CEN), Klima Campus, University of Hamburg, Grosse Elbstrasse 133, D-22767 Hamburg, Germany

*Correspondance: Tél: (+ 49) 531 596 1099; Courriel: tiedemann.maik@gmail.com (M. TIEDEMANN)

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Abstract

Fronts, eddies, and upwelling shape larval fish habitats in the Canary Current Ecosystem. In the last five years, five sea-going expeditions have been undertaken to investigate the influence of these ocean processes on the life of fishes and their early life stages. The use of different sampling techniques (*e.g*. midi/maxi multinet, GULF VII, and CTD) allowed us to understand horizontal and vertical larval fish distribution patterns. Frontal zones that function as natural barrier for plankton drift were identified enabling the formation of spatially segregated larval fish assemblages. Mesoscale eddies compensated an offshore drift of water masses during the upwelling process retaining fish larvae at the shelf break. An upwelling intensity driven spatio-temporal niche partitioning was observed between larval round sardinella (*Sardinella aurita*) and larval European sardine (*Sardina pilchardus*). While climate models predict a change of the upwelling intensity in upwelling ecosystems, we suggest that dominance relationships of small pelagic fishes will fluctuate according to upwelling intensity variation. The results of our studies improve the understanding of how fishes avail the dominant physical features in upwelling ecosystems and aid to comprehend population dynamics.

Session 4

Sardinella aurita growth parameters variability under the balanced effects of climate change and fishing pressure

Bocar Sabaly BALDE [1,2,3,4,*], Fambaye Ngom SOW [2], Kamarel BA [2], Werner EKAU [3], Justin KANTOUSSAN [5], Massal FALL [2], Patrice BREHMER [5], and Malick DIOUF [1]

[1]Université Cheikh Anta Diop (UCAD), Institut Universitaire de Pêche et d'Aquaculture, UCAD II
[2]Bâtiment Pédagogique / Rez-de-chaussée, BP 45784, Dakar–Fann, Sénégal
[3]Institut Sénégalais de Recherche Agricole (ISRA), Centre de Recherche Océanographique de Dakar-Thiaroye (CRODT), BP 2241, Centre PRH, Dakar, Senegal
[4]Leibniz Center for Tropical Marine Ecology (ZMT), GmbH- Fahrenheitstraße 6, 28359 Bremen, Germany
[5]Institut de Recherche pour le Développement - France (IRD), UMR 195 Lemar (UBO, CNRS, IRD, Ifremer), BP 1386, Dakar, Sénégal
[6]Université Gaston Berger (UGB), Unité de Formation et de Recherche des Sciences Agronomiques, de l'Aquaculture et des Technologies Alimentaires (UFR S2ATA), Saint-Louis, Senegal

*Correspondance: Tél: (+221) 77 2346421; Courriel: bocarbalde2005@hotmail.com (B. BALDE)

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Abstract

Sardinella aurita is an overexploited small pelagic fish and a key species in Senegal at socioeconomics level, nevertheless the growth parameters which is a good indicator of fish stressors, have not been updated since 30 years. In this work, we analysed *S. aurita* (n = 32 300) age and growth in Senegal taking into account the tropical seasonality. Growth parameters are then compared with those previously obtained in the literature on the same geographical area (since 60 to 34 years) and more widely in different locations in tropical North Atlantic and Mediterranean Sea. The results show a significant difference of growth parameters in Senegal since thirty years, indeed growth *of S. aurita* became slower and its maximum size has significantly decreased. The comparison of *S. aurita* variability in growth performance reported in Mauritania-Senegal coast, as well as in Mediterranean Sea and Eastern/Western Atlantic Ocean reveals a significant influence of environmental parameters and/or the level of exploitation. In one hand in tropical Atlantic, *S. aurita* growth in Eastern Central is similar to the one reported in Western Central, while *S. aurita* growth is rather slow in Mediterranean Sea where, *vs* tropical Atlantic, Sea temperature and prey availability are lower. On the other hand, in the Atlantic Western Central, where the fishing pressure on the stock is lower over the last decade *vs* Atlantic Eastern Central, an increase in asymptotic length is observed, while in the Mediterranean Sea and Atlantic Eastern Central, where the fishing pressure is higher, the asymptotic length has drastically decreased. We assume that the fishing pressure and the climate change, or a combination of both, have an effect on the biological parameters of *S. aurita*.

Session 4

On the role of equatorial warm events in expanding the southward range of *Sardinella aurita* along Angolan coast.

Marek OSTROWSKI [1,*], Antonio BARRADAS [2] and Jens Otto KRAKSTAD [1]

[1]Institute of Marine Research, Nordnesgaten 50, 5817 Bergen, Norway
[2]Instituto Nacional de Investigacaõ Pesqueira, C.P.2061, Luanda, Angola

*Correspondance: Tél: (+47) 93833564; Courriel: mareko@hi.no (M. OSTROWSKI)

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Abstract

Sardinella caught in Angolan waters belongs the southeastern sardinella stock inhabiting coastal waters from Cape Lopez in Gabon (0.5°S) to the Angola Benguela Front (ABF,17°). Since mid 2000s, a growth of the sardinella biomass is observed in the southernmost regions of Angola, in the Central Region (9°-13°S) where recently 70% of the stock is observed compared to 30 % during 1990s and in the ABF region (13°-17°) where there had not been a full annual life cycle presence of sardinella before 2006. The analysis of fish length data suggests that the observed biomass increase occurs due the migration of adult fish from the more northerly, warmer areas along the coast. A hypothesis is proposed that warm equatorial events increase availability of *S. aurita* to fisheries along the southern Angolan coast. Austral summer (October to March) is the season prompting southward migrations of sardinella in Angolan waters. Coastally trapped waves of equatorial origin depress the thermocline inhibiting upwelling. The Congo River flooding waters that have been accumulated in the open ocean during past fluvial discharge events intrude onto the Angolan shelf driven by the seasonally accelerated Angolan Current. With the upwelling inhibited, poor feeding conditions set in and cue the southward fish migration. The period 1995-1999 was characterized by a strong interannual equatorial activity with a seasonally locked episodes occurring every summer, but then stock was dominated by the climate resistant S. maderensis. Seasonal migrations along the coast were observed but these did not expand the geographical range of the stock. In 2004, S. aurita first appeared in significant numbers in Angolan waters, coincident to the decadal minimum of the Congo River discharge (2004-2005). S. aurita reacts to the summertime food scarcity with a much longer migration range compared to S. maderensis. In 2006, it expanded to the ABF region (13°-17°S); at the same time its numbers were substantially reduced along the Gabonese and Congolese coasts (0.5°-5°S). In the summer 2012, one year after the major 2011 Benguela Niño event, the biomass of *S. aurita* in the ABF contributed the highest proportion to the total biomass in Angola.

Session 4

A promising effect of El Niño on sardinella distribution along the northwest African coast: a potential source of seasonal predictability?

Jorge LÓPEZ-PARAGES [1,*], Belén Rodríguez DE FONSECA [1], Timothée BROCHIER [2,*], Pierre-Amael AUGER [3], Davide ZANCHETTIN [4], Angelo RUBINO [4], Carlo GAETAN [4] and Noel KEENLYSIDE [5]

[1]Dpto. de Fısicá de la Tierra y Astrofisicá, UCM-IGEO, Complutense University of Madrid, Spain
[2]Institute of Research for Development, Paris, France
[3]Milenio Oceanographic Institute, Valparaısó, Chile
[4]Dpto di Scienze Ambientali, Informatica e Statistica, Ca Foscari University of Venice, Italy
[5]Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research, Norway

*Correspondance: courriel Timothee.Brochier@ird.fr; (T. BROCHIER)

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Abstract

Many questions remain open concerning the effect of environmental variability on abundance and distribution dynamics of round sardinella (*Sardinella aurita*) over the Canary upwelling system. This issue is of special relevance due to the great role that sardinella plays in northwest African fisheries and marine ecosystems. Here, the possible climate drivers of sardinella population migration along the northwest Africa are addressed. To this aim, we have used data provided by the coupled model compounded by the Regional Oceanic Modelling System ROMS, configured for the northwest African upwelling system, and by the biogeochemical model PISCES, which simulates plankton productivity and carbon biomass based upon the main nutrients. This coupled model has been run over the period 1980-2009 using an atmospheric reanalysis and consistent oceanic boundary conditions. Finally, an evolutionary individual-based Lagrangian model has been used to simulate the spatio-temporal behaviour of sardinella according to the environmental constraints obtained from ROMS-PISCES. Strikingly, a robust anomalous increase (decrease) of sardinella biomass has been identified from early to late winter off Cape Blanc (Saharan coast) in response to the Pacific El Niño conditions. This dipolar pattern reflects an alteration of the normal migration of sardinella between the Saharan and the Mauritanian waters and seems to be primarily mediated by the effect that El Niño-related anomalous winds has on the meridional currents along the northwest African coast. This sardinella response to El Niño is reinforced in late winter through an anomalous warming of the Mauritanian waters due to an anomalous weakening of coastal upwelling also forced by the aforementioned El Niño-related anomalous winds. According to our results this anomalous response of sardinella biomass might be predicted, for El Niño years, few months in advance from the El Niño-related SST patterns. This fact opens the possibility to the development of predictive tools, which should be necessarily assessed in further works.

Session 4

Intense warming causes a spatial shift of small pelagic fish: early warning for food security in North-West Africa

Abdoulaye SARRE [1,*], Hervé DEMARCQ [2], Noel KEENLYSIDE [3], Jens-Otto KRAKSTAD [4], Saliou FAYE [1], Djiga THIAO [1], Salaheddine EL AYOUBI [5], Ould Taleb Mohamed AHMED [6], Ebou Mass MBAYE [7], Adama MBAYE [1], and Patrice BREHMER [8]

[1]Centre de Recherche Océanographique de Dakar-Thiaroye, BP 2241, Dakar, Senegal
[2]Institut de Recherche pour le Développement, UMR-248 MARBEC, Centre de Sète, Avenue Jean Monnet, CS 30171, 34203 Sète cedex, France
[3]Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research, Norway,
[4]Institute of Marine Research, P.O. Box 1870 Nordnes, N-5817 Bergen, Norway
[5]Institut National de Recherche Halieutique (INRH), Casablanca, Morocco
[6]Institut Mauritanien de Recherche Océanographique et des Pêches (IMROP), BP 22, Nouadhibou, Mauritania
[7]Fisheries department (FD), Banjul, The Gambia
[8]Institut de Recherche pour le Développement, Campus IRD-UCAD, UMR-195 LEMAR, BP 1386, Hann, Dakar, Senegal

*Correspondance: Tél: (+221) 77 632 05 32; Courriel: ablaysarrey@yahoo.fr (A. SARRE)

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Abstract

Along the coast of North-West Africa, fish supply is important at both socio-economic and cultural levels. Reports by fishermen emphasise changes in the distribution of fish species important for food security. Northward shifts in the distribution of sardinella and other species have been attributed to a warming trend and the redistribution of upwelling intensity and productivity. As a result, the abundance of sardinella along the coast has increased in the subtropics and fallen in the intertropical region. Independent observational time series confirm a robust northward shift in Sardinella aurita since 1995, which we attribute to the intense warming of this region, where the greatest increase in sea surface temperature of all tropical regions is found. The spatial shifts in biomass of several hundred kilometres observed during the last 20 years are of the same order of magnitude as those recorded for surface isotherms in the sub-regional pelagic habitat of sardinella. Such changes are an important policy consideration for food security management in several West African countries.

Session 4

Climate change and seasonality of small pelagics: impacts on their value chain in Senegal

Adama MBAYE [1,*], Aliou BA [2], Jörn SCHMIDT [3], Fambaye NGOM [1], Modou THIAW [1], Patrice BREHMER [2], Abdoulaye SARRÉ [1], and Djiga THIAO [1]

[1]ISRA, centre de recherche Oceanographique de Dakar Thiaroye CRODT, Dakar, Sénégal
[2]Institut de recherche pour le développement (IRD), UMR Lemar, Campus Ifremer, Délégation régionale IRD ouest France, 29280, Plouzané, France
[3]Kiel université, CAU, Germany

Correspondance: Tél: (+221) 77 656 57 83; Courriel: ambayeskr@yahoo.fr (A. MBAYE)

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Abstract

Factors influencing landed prices and those of processed products (fish and processed) are mainly landed quantities and product quality. The latter are in turn influenced by the seasonality of sardinella conditioned by the temperature of the water. It is usually in cooroon periods (April to June) that sardinella landings are more important and it is at this time also that the prices of fresh fish and processed products are the lowest. On the other hand sardinella is rare in lolli most often (October to December) and it is at this period also that the prices are generally higher. Nevertheless, depending on whether one is on the Petite Côte or on the Grande Côte, fishermen's appreciations of the periods of abundance of sardinellas differ. However, from the analysis of fishermen's knowledge on sardinella migration and bioecological models, it appears that sardinella are present on Senegalese coasts during periods of low temperature. As the cold water periods are later and shorter, the sardinella will be increasingly rare on the coast in Senegal, its higher price, accessibility is more difficult and consequently the animal protein deficit of the populations more accentuated.

Session 4

The economic impacts of Marine Protected Area on Senegalese small pelagic fisheries

Aliou BA [1,5,*], Christian CHABOUD [2], Jörn SCHMIDT [3], Malick DIOUF [4], Massal FALL [5], Moustapha DÈME [5], and Patrice BREHMER [1,5]

[1]Institut de Recherche pour le Développement - France (IRD), UMR 195 Lemar (UBO, CNRS, IRD, Ifremer), BP 1386, Dakar, Sénégal
[2]Institut de Recherche pour le Développement - France (IRD), UMR Marbec, Sète, France
[3]University of Kiel (CAU), Department of Economics, Wilhelm-Seelig-Platz 1, 24118, Kiel, Germany
[4]Université Cheikh Anta Diop (UCAD), Institut Universitaire de Pêche et d'Aquaculture, UCAD II, BP 45784, Dakar, Sénégal
[5]Institut Sénégalais de Recherche Agricole (ISRA), Centre de Recherche Océanographique de Dakar-Thiaroye (CRODT), BP 2241, Centre PRH, Dakar, Sénégal

*Correspondance: Tél: (+221) 70 591 05 85; Courriel: aliou.ba@ird.fr (A. BA)

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Abstract

In the early 2000s, Senegal set up several Marine Protected Areas (MPAs) along its coastal zone for the purpose of biodiversity conservation and the sustainably of fisheries. However, the impact of MPAs may vary depending on the types of fishing. In Senegal, the sardinella fishing accounts for 70% of total catches. This fishery is of crucial for food security and employment. Given this importance, it is necessary to evaluate the impact of the MPAs often considered as a tool for fisheries management. An analytical, dynamic and spatial bio-economic model of sardinella fishery has been developed and simulations over 40 years were carried out. The model takes into account the migration of the resource and that of fishermen. The main results show that the fishery is economically overexploited and that the society loses about 15 billion CFA over 40 years of exploitation, i.e. 375 million CFA per year. To reach an optimal level of exploitation, it would be necessary to halve the current fishing capacity. The closure rates of 10, 20 and 30% lead to increases in biomass (8 to 28%) and rent (5 to 11%). Spatio-temporal closure measures lead inevitably to overcapacity in unclosed areas. The objective 11 of the Aichi Convention will have a reserve effect on the resource but also weak improvements in economic indicators for this fishery. Lastly we show that if we expect that the MPAs provide a significant impact on sardinella fishery in Senegal, they should be accompanied by a limitation of fishing capacity.

Keywords*:* Marine Protected Area, MPA, Senegal, sardinella, bio-economic model, migration, optimal level of exploitation, overcapacity, Aichi.

Session 4

Empirical bio-economic modelling of small-scale artisanal fisheries under climate change: A new approach and application to the Senegalese purse-seine fishery

Kira LANCKER [1,*], Lorena FRICKE [1], and Jörn SCHMIDT [1]

[1]Department of Economics, Christian Albrechts University of Kiel, Wilhelm-Seelig-Platz 1, 24118 Kiel, Germany

*Correspondance: Tél: (+49) 431 880-4978; Courriel: lancker@economics.uni-kiel (K. LANKER)

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Abstract

Artisanal open access fisheries are an important source of protein in many developing regions, and they provide livelihoods for millions of people. They are, however, challenged by changing environmental and local market conditions. Quantitative bio-economic models of such fisheries are needed to inform resource management and climate adaptation policies. The empirical estimation of model parameters faces issues of endogeneity, as local markets provide significant links between quantities and prices, and data is often scarce and of poor quality. Here, we present a bio-economic model based on standard resource economics assumptions, which is able to explain non-linear impacts of environmental variations (climate and catchable biomass) on output and prices. We present an estimation approach that efficiently utilizes scarce data by directly estimating dynamic model equations and that averts endogeneity bias by means of a two-step estimation procedure. The ensuing exogenous environmental impact estimates can be used for robust prediction beyond the currently observed environmental state. In addition, the approach is able to analyse a fisheries vulnerability to environmental variations by disentangling regional supply and demand particularities. An application to the Senegalese purse seine fishery targeting small pelagics illustrates the link between environmental impacts and economic outcomes. An analysis of welfare effects quantifies consequences for livelihoods and food security.

Session 4

Managing environmental impacts and decrease in Marine Fish Catch: perceptions and strategies by fisher folks in coastal Nigeria

Nnaemeka Andegbe CHUKWUONE [1,*], Jorn SCHMIDT [2], kira LANCKER [2] and Ebele Chinelo AMAECHINA [3]

[1]Centre for Entrepreneurship and Development Research (CEDR) and Department of Agricultural Economics, University of Nigeria, Nsukka, Enugu State, Nigeria
[2]University of Kiel (CAU), Department of Economics, Germany
[3]Department of Agricultural Economics, University of Nigeria, Nsukka, Enugu State, Nigeria

*Correspondance: Courriel: nnaemeka.chukwuone@unn.edu.ng (N. CHUKWUONE)

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Abstract

Despite the significant level of dependence on the resources from Nigeria coastal areas, it has become highly degraded due to lack of proper management and the additional threat of environmental and climate variability. There has been unprecedented decline in fish stocks, over harvesting and over fishing in Nigeria coast. In fact, catch by artisanal fishermen manifest the degrading stock as landings are dominated by juveniles while certain valued species are disappearing. For example, the result of a short day survey in areas of Nigeria's coastal waters under the Gulf of Guinea Large Marine Ecosystem survey revealed a high proportion of under-sized fish species or juvenile to the tune of 70-90% in each haul, less than 15 cm in size. This situation persists despite the fact that one of the central goals of the government is to achieve a substantial, but sustainable increase in production. In order to find ways to reverse this ugly situation, this study determined the perceptions and strategies employed by artisanal fisher folks in coastal Nigeria in managing environmental impacts and decline in fish catch and estimated the socioeconomic factors that influence management strategies. A total of 1105 fishermen from 17 core fishing grounds in eight coastal states across Nigeria, 65 fishermen in each fishing ground, were interviewed. Weights were applied to the fishermen in the artisanal sector and in the semi-industrial sector to reflect the population of fishermen in coastal Nigeria. Descriptive statistics and multinomial logit model was applied in achieving the objectives. The findings revealed that petroleum pollution was the major environmental issue that impacts on fish and fishing gear causing death of fish resources. The major coping strategy to petroleum pollution was changing fishing grounds or doing nothing. The findings also revealed that the majority of the fishermen experienced decrease in fish catch in the last 10 years. The major reason for decrease in demersal and pelagic species catch was due to encroachment by industrial fleet and petroleum pollution. Reduction of expenditure on household consumption, increase in income from non-fishing activities and using savings as buffer were the main financial management strategies employed by fishermen in coping with decline in fish catch. Some socioeconomic and social capital factors influenced the management strategies employed by the fishermen. We recommend that policies to check petroleum pollution of the marine area; and increased surveillance to check the encroachment of industrial fleet in areas within the five nautical miles as in Nigeria fisheries regulation should be encouraged. Also providing financial incentives to the fisher folk especially middle aged and poorer ones

through their associations would help them cope with decline in catch and also reduce their extent of fishing as they would invest in non-fishing activities and thus help in ensuring sustainable fisheries.

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Poster presentation

Session 4

Variabilité hydrobiologique de la région de Dakhla (24°N-23°30°N et 23°N) et biodiversité du micro-phytoplancton

Tarik BAIBAI [1,*]

[1] Institut National de Recherche Halieutique, Casablanca, Maroc

*Correspondance: courriel : baibaitarik@gmail.com (T BAIBAI)

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Abstract

La présente étude concerne la zone située au large de la région de Dakhla (23° - 24°N). C'est une synthèse des paramètres du milieu (volets océanographie physique et océanographie biologique) des campagnes océanographiques réalisées par l'INRH durant les périodes estivales 2000-2015, tout en mettant l'accent sur la période juillet 2015 (en terme de production et de biodiversité du microphytoplancton). Cette zone de la région de Dakhla (23° - 24°N) connaît une variabilité hydrologique et biologique dans l'espace et dans le temps. Elle dépend étroitement des résurgences des eaux situées au niveau du Cap Boujdor dont les origines se situent au large, entre 250 à 300 m de profondeur. En terme de biodiversité du phytoplancton (période juillet 2015), la zone située à 23°-23°30' et 24°N, révèle la présence de six groupes rituels des côtes atlantiques marocaines (diatomées, dinoflagellés, silicoflagellés, raphidophycés et coccolithophoridés), dominés quasiment par le groupe des diatomées avec un pourcentage d'abondance relatif de 88%. La majorité des taxons dominants le peuplement microalgal durant cette période estivale en 2015 sont fréquemment abondants au niveau des côtes atlantiques marocaines et connus comme indicateurs ou accompagnateurs de l'activité des upwellings, tels Pseudonitzschia, Leptocylindrus danicus, Thallassiosira et Gymnodinium. Toutefois, d'autres taxons, habituellement observés avec une faible fréquence et abondance au niveau de ces radiales, se sont rencontrées fréquemment avec une abondance élevée, tels : Lithodismium (11%) et Cochlodinium (5%).

Session 4

Modelling and management options in a context of increase fishing effort and efficiency: Case of *Ethmalosa fimbriata* in Southern Senegal

Bocar Sabaly BALDE [1,2,3,4,*], Patrice BREHMER [4], Fambaye Ngom SOW [2], Werner EKAU [3], Justin KANTOUSSAN[5], Massal FALL [2], and Malick DIOUF [1]

[1]Université Cheikh Anta Diop (UCAD), Institut Universitaire de Pêche et d'Aquaculture, UCAD II Bâtiment Pédagogique / Rez-de-chaussée, BP 45784, Dakar–Fann, Sénégal
[2]Institut Sénégalais de Recherche Agricole (ISRA), Centre de Recherche Océanographique de Dakar-Thiaroye (CRODT), BP 2241, Centre PRH, Dakar, Senegal
[3]Leibniz Center for Tropical Marine Ecology (ZMT), GmbH- Fahrenheitstraße 6, 28359 Bremen, Germany
[4]Institut de Recherche pour le Développement - France (IRD), UMR 195 Lemar (UBO, CNRS, IRD, Ifremer), BP 1386, Dakar, Sénégal
[5]Université Gaston Berger (UGB), Unité de Formation et de Recherche des Sciences Agronomiques, de l'Aquaculture et des Technologies Alimentaires (UFR S2ATA), Saint-Louis, Senegal

*Correspondance: Tél: (+221) 77 2346 421; Courriel: bocarbalde2005@hotmail.com (B. BALDE)

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Abstract

The bonga shad (*Ethmalosa fimbriata*) is the third exploited of the small pelagics (after *Sardinella aurita* and *S. maderensis*) in the Senegalese waters and is commonly consumed locally. This fishery is mainly practiced by artisanal fishermen and is of great importance for the Senegalese economy as for food security in the region. Our investigations are aimed to inform the selection of management tools based on the dynamics of bonga shad exploitation to increase the likelihood of fishermen. The current rate of exploitation (E) was estimated (0.8), updating current statute (fully exploited) and indicating that the bonga shad in Senegal is over-fished. Moreover, we report a seasonal variability in recruitment and biomass of the Senegalese bonga shad, and a downward trend over the study period as well as a maximum size decrease of -8.8 cm (18 %) in 63 years. Such changes are attributed to increase in fishing capacity. To reverse the overexploitation status of the bonga shad stock, it is necessary to put the mesh of encircling nets from 40mm to 60 mm, to reduce the fishing effort drastically, apply regulations on the capture, sale and processing of juveniles and exclusion of seiners and monofilaments on the Senegalese Southern Coast.

Keywords: Fisheries, rate of exploitation, overfishing, small scale fisheries, West Africa.

Session 4

Estimating dynamics of population fecundity to understand spawning tactics in *Ethmalosa fimbriata* (Bowdich, 1825) in an upwelling environment

Bocar Sabaly BALDE [1,2,3,4,*], Julian DÖRING [3], Saliou FAYE [2], Werner EKAU [3], Patrice BREHMER [4], and Malick DIOUF [1]

[1]Université Cheikh Anta Diop (UCAD), Institut Universitaire de Pêche et d'Aquaculture, UCAD II
[2]Bâtiment Pédagogique / Rez-de-chaussée, BP 45784, Dakar–Fann, Sénégal
[3]Institut Sénégalais de Recherche Agricole (ISRA), Centre de Recherche Océanographique de Dakar-Thiaroye (CRODT), BP 2241, Centre PRH, Dakar, Senegal
[4]Leibniz Center for Tropical Marine Ecology (ZMT), GmbH- Fahrenheitstraße 6, 28359 Bremen, Germany
[5]Institut de Recherche pour le Développement - France (IRD), UMR 195 Lemar, BP 1386, Dakar, Sénégal

*Correspondance: Tél: (+221) 77 2346 421; Courriel: bocarbalde2005@hotmail.com (B. BALDE)

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Abstract

Fluctuations in abiotic factors, e.g., temperature, salinity, food availability, will result in specific spawning tactics. This drives some populations to create reproductive strategies to ensure the survival of their offspring. The analysis of comparative functional responses can be used in different contexts to improve the understanding and prediction of the environmental impact on small pelagic population fecundity (PF). Successful recruitment into a population is subject to variations in fecundity. Significant seasonal and inter-annual differences in PF of *Ethmalosa fimbriata* in southern Senegalese coastal waters could be observed. Here we show that the population is able to fit its spawning tactic to variable conditions in an upwelling environment. It appears that *E. fimbriata* aims at spawning in water temperatures of around 24°C and at an upwelling intensity of 3 m^3 s^{-1} m^{-1}. Understanding the spawning tactics of an highly exploited fish species is important in the context of climate change to get efficient forecast in countries where fisheries is crucial at socio-economical level, in order that decision maker can provide ad hoc adaptation plan for the fisheries sector.

Session 4

The effect of oceanographic factors on micronektonic acoustic density in the three African Atlantic large marine ecosystems

Patrice BREHMER [1,*], Hervé DEMARCQ [2], Anne MOUGET [1], Chloé MIGAYROU [1], Najib CHAROUKI [3], Vamara KONÉ [4], Uatjavi UANIVI [5], Abdoulaye SARRÉ [6], Mohamed Ahmed JEYID [7], Aka Marcel KOUASSI [4], Yannick PERROT [1], Nolwenn BEHAGLE [1], Jens-Otto KRAKSTAD [8], Ibrahima DIALLO [9] and Ndague DIOGOUL [10,1]

[1]Institut de recherche pour le développement (IRD), UMR Lemar (UBO, CNRS, IRD, Ifremer), Campus Ifremer, Délégation régionale IRD ouest France, 29280, Plouzané, France
[2]Institut de recherche pour le développement (IRD), UMR Marbec, Avenue Jean Monnet, 34280, Sète, France
[3]INRH, Route de Sidi Abderrahmane, Casablanca, Maroc
[4]Centre de Recherche Océanologiques (CRO) 29, rue des Pêcheurs (Treichville) B. P. V. 18 Abidjan Côte d'Ivoire
[5]Ministry of Fisheries and Marine Resources (MFMR), P.O. 25305 Windhoek / P.O. 912 Swakopmund, Namibia
[6]Institut Sénégalais de Recherche Agricole (ISRA), Centre de Recherche Océanographique de Dakar Thiaroye (CRODT), Pôle de recherche de Hann, Dakar, Sénégal
[7]Institut mauritanien de recherche océanographique et des pêches (IMROP), BP 22, Nouadhibou, Mauritanie
[8]Institute of Marine Research (IMR), Nordnesgaten 50, 5005 Bergen, Norway
[9]Centre National des Sciences Halieutiques de Boussoura (CNSHB), BP 3738, Boussoura, Guinea
[10]Université Cheikh-Anta-Diop (UCAD), BP5005, Dakar, Sénégal

*Correspondance: Tél: (+221) 78 122 16 15; Courriel: patrice.brehmer@ird.fr (P. BREHMER)

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Abstract

The interest of modelling the effect of oceanographic factors on micronektonic acoustic densities and its variability is relevant in the context of climate change to better understand the environmental processes controlling ecosystem productivity. Ultimately for the stakeholders, we plan to forecast changes induced by climate change effects and study inter annual variability. Satellite data have been processed using the same time steps as the time series of fisheries acoustic surveys carried out by the R/V Dr. Fridtjof Nansen along the Atlantic African coasts, overlapping three Large Marine Ecosystems. The observed split at Cape Blanc (21°N) separates the coastal upwelling into a strong and stable dynamic upwelling, and a highly seasonal one. Because of the highly non-linear nature of the relationships the BRT modelling accounts for a considerably higher part of the environmental variability, compared to classic multivariate approaches. Environmental data are extracted from daily series of AVHRR (SST), MODIS (SST and Chl-a) and others at spatial resolution between 4 and 25 km. Boosted Regression Tree classification is well suited to show the importance of the large scale environmental variability, despite a limited set of variables. It is interesting to note that the inter-annual variability is not significant in the model, showing that the underlying environmental forcing is associated with relatively stable processes. The structural variables, *i.e.,* bathymetry and distance to the coast, consistently explain a large part of the variability. SST has a minor influence in the north (consistently cold and windy) and a pronounced effect in the south where seasonality is high and variable. Especially in Senegal and Guinea, the detrimental effects of the coastal upwelling (mostly offshore drifts due to strong winds) are strongly attenuated by the wider continental shelf which favour retention processes. The next step will be to couple our

results with climate projections to forecast major changes in African coastal systems as the micronektonic compartment is essential at mid-trophic level in all marine ecosystems. Considering the oceanographic factors relative influence, and under the assumption of similar warming in the three Atlantic African LMEs, a stronger ecosystem perturbation is expected in BBCLME, then in the CCLME and particularly when comparing the southern part of the CCLME *vs* North part. In all LME *i.e.* including GCLME, the oceanographic factors relative influence get a significant role confirming the important changes expected due to climate change on the ecosystems and thus in the fisheries.

Keywords: modelling, micronektonic, acoustic densities, variability, climate change, environmental processes, ecosystem productivity, fisheries.

Session 4

Micronektonic acoustic density variations along Canary Current Large Marine Ecosystem over 20 years

Nolwenn BEHAGLE [1,*], Abdoulaye SARRÉ [2], Mohamed Ahmed JEYID [3], Salahedine El-AYOUBI [4], Anne MOUGET [1], Yannick PERROT [1], Chloé MIGAYROU [1], Jens-Otto KRAKSTAD [5], Ndague DIOGOUL [2,1], Ebou Mass MBYE [6], and Patrice BREHMER [2]

[1]Institut de recherche pour le développement (IRD), UMR Lemar, Campus Ifremer, 29280, Plouzané, France
[2]Institut Sénégalais de Recherche Agricole (ISRA), CRODT, Pôle de recherche de Hann, Dakar, Sénégal
[3]Institut mauritanien de recherche océanographique et des pêches (IMROP), BP 22, Nouadhibou, Mauritanie
[4]INRH, Route de Sidi Abderrahmane, Casablanca, Maroc
[5]Institute of Marine Research, Bergen, Norway
[6]Fisheries Department, Marina road, Banjul, The Gambia

*Correspondance: Courriel: nolwenn.behagle@gmail.com (N. BEHAGLE)

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The Canary Current Large Marine Ecosystem (CCLME) extends from the Strait of Gibraltar (36°N, 5°W) to the South of Guinea-Bissau (11°N, 16°W) and includes the study zone, from 34°N, 7°W to 12°N, 17°W. This area was divided in two parts: north vs. south of Cape Blanc. North of Cape Blanc has a permanent upwelling while in the south it is seasonal. This LME is of crucial importance at socio-economic level for millions of West African citizens and for food security. Acoustic data were recorded with a 38 kHz echosounder, from 10 to 500 m depth over 14 surveys totaling 99 274 nmi from 1995 to 2015. To get homogenous data (i) only off-upwelling season surveys (October to May) were studied and (ii) only continental shelf data were considered (10-150 m). The mean volume backscattering strength (S_v in dB) was used as a micronektonic biomass proxy to assess its spatial inter-annual variability. Diel transition periods were removed from analyses to avoid micronektonic density changes bias due to diel vertical migrations. Data were echointegrated at a spatial resolution of 0,1 nmi*1 m depth using Matecho tool. (i) On horizontal dimension, the variability in annual micronektonic densities was assessed using the mean Sv value for each 0,1 nmi Elementary Sample Unit (ESU). Then, hot- and cold spots were computed from the combined analysis of the spatial correlation and the Morans' I index of these values. (ii) On vertical dimension, the change of micronektonic spatial structure between north and south, and day and night was assessed using the mean Sv value for each 1 m depth step. The inter-annual variability inside the east border upwelling ecosystem of the CCLME was scrutinized. (i) No significant change in micronektonic density was highlighted over the study period. (ii) Hot and cold spots were clearly discriminated in this area; hot spots were mostly situated in the south, whereas cold spots were mostly in the north. (iii) A different diel vertical migration was reported between north and south, suggesting a different composition in micronektonic communities. Considering analyses by acoustic sound scattering layers will be important when we deal with this micronektonic trophic level. Indeed, preliminary results have shown from 1995 to 2015 (i) a significant increase of the minimum depth of such layer and (ii) a significant increase of the mean micronektonic density per ESU of such layer.

Keywords: climate change, Fisheries acoustics, Upwelling, LME, fisheries acoustics, West Africa.

Session 4

Complex small pelagic fish population patterns arising from individual behavioural responses to their environment

Timothée BROCHIER [1,4,*], Pierre-Amaël AUGER [3], Laure PECQUERIE [4], Eric MACHU [5], Xavier CAPET [6], Modou THIAW [7], Baye Cheikh MBAYE [5], Cheikh-baye BRAHAM [8], Omar ETTAHIRI [9], Najib CHAROUKI [9], Ousseynou Sene NDAW [10], Francisco WERNER [11], and Patrice BREHMER [4,7]

[1]IRD, Unité de Modélisation Mathématique et Informatique des Systèmes COmplexes (UMMISCO), UMI 209, Univ Paris 06, Sorbonne Universités, Bondy, France
[2]CNRS/IFREMER/IRD/UBO, Technopole Brest Iroise, 29280 Plouzané, France; Present address: Instituto Milenio de Oceanografia (IMO), Escuela de Ciencias del Mar, Pontificia Universidad Católica de Valparaíso, Av. Altamirano 1480, Valparaíso, Chile
[3]IRD, Laboratoire d'Océanographie Physique et Spatiale (LOPS), UMR 6523
[4]IRD, Laboratoire des sciences de l'Environnement MARin (Lemar), UMR 195 Lemar (UBO, CNRS, IRD, Ifremer), F-93143, ISRA-CRODT, BP 1386, Hann, Dakar Sénégal
[5]UCAD, Laboratoire de Physique de l'Atmosphère et de l'Océan Siméon Fongang, BP 5085 Dakar-Fann, Senegal
[6]CNRS, Laboratoire d'Océanographie et du Climat Expérimentation Et Approche Numériques (LOCEAN), Université Pierre et Marie Curie, Paris, France
[7]Centre de Recherche Océanographique de Dakar-Thiaroye, ISRA-CRODT, BP 2241, Hann, Dakar, Senegal
[8] Institut Mauritanien de Recherche Océanographique et des Pêche (IMROP), BP 22, Nouadhibou, Mauritania
[9] Institut Nationale de Recherche Halieutique (INRH), Bd Sidi Abderrahmane 2, Ain Diab 20180 Casablanca, Morocco
[10]Groupe Interdisciplinaire de Recherche sur l'Éducation et les Savoirs (GIRES), Dakar, Senegal
[11]NOAA Fisheries, 1315 East West Highway, Silver Spring, MD 20910, USA

*Correspondance: Tél: (+33) 688663742; Courriel: timothee.brochier@ird.fr (T. BROCHIER)

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Abstract

Small pelagic fish (SPF) species are heavily exploited in eastern boundary upwelling systems (EBUS) as their transformation products are increasingly used in the world food chain. Management relies on regular monitoring, but there is a lack of robust theories for the emergence of the populations' traits and their evolution in highly variable environments. This work aims to address existing knowledge gaps by combining physical and biogeochemical modelling with an individual life-cycle based model applied to round sardinella (Sardinella aurita) off northwest Africa, a key species for regional food security. Our approach focused on the processes responsible for seasonal migrations, spatio-temporal size-structure, and interannual biomass fluctuations. Emergence of preferred habitat resulted from interactions between natal homing behaviour and environmental variability that impacts early life stages. Exploration of the environment by the fishes was determined by swimming capabilities, mesoscale to regional habitat structure, and horizontal currents. Fish spatio-temporal abundance variability emerged from a complex combination of distinct life-history traits. An alongshore gradient in fish size distributions is reported and validated by in situ measurements. New insights into population structure are provided, within an area where the species is abundant year-round (Mauritania) and with latitudinal migrations of variable (300 to 1200 km) amplitude. Interannual biomass fluctuations were linked to modulations of fish recruitment over the Sahara Bank driven by variability in alongshore current intensity. The identified processes constitute an analytical

framework that can be implemented in other EBUS and used to explore impacts of regional climate change on SPF.

Keywords: pelagic fish, model, DEB, Icthyop, ROMS, Pisces, CCLME.

Session 4

Spatial Environmental trends in the three Atlantic African Large Marine Ecosystems in a context of global warming

Hervé DEMARCQ [1,*], Abdoulaye SARRÉ [2], Aka Marcel KOUASSI [3], Uatjavi UANIVI [4], Mohamed Ahmed JEYID [5], Salahedine el AYOUBI [6], Idriss Lamine BAMY [7] and Patrice BREHMER [8,*]

[1]Institut de Recherche pour le Développement (IRD), UMR 248 MARBEC (Marine Biodiversity, Exploitation and Conservation), CS 30171, 34203 Sète, France
[2]Institut Sénégalais de Recherches agricoles (ISRA), Centre de Recherches Océanographiques de Dakar-Thiaroye, PRH, BP 2241, Dakar, Sénégal
[3]IRD-Centre de recherches océanologiques (CRO), Abidjan/Ivory Coast
[4]Ministry of Fisheries and Marine Resources (MFMR), P.O. 25305 Windhoek / P.O. 912 Swakopmund, Namibia
[5]Institut Mauritanien de Recherche Océanographique et des Pêche (IMROP), BP 22, Nouadhibou, Mauritanie
[6]Institut National de Recherche Halieutique (INRH), Bd Sidi Abderrahmane, Ould Jmel-Casablanca, Morocco
[7] Centre National des Sciences Halieutiques de Boussoura (CNSHB) BP: 3738, Conakry Republique de Guinée
[8]Institut de Recherche pour le Développement (IRD), Délégation régionale France Ouest, UMR Lemar (UBO-CNRS-IRD-Ifremer), BP70, 29 280, Plouzané, France

*Correspondance: Courriel: herve.demarcq@ird.fr (H. DEMARCQ)

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Abstract

In Atlantic Africa there is a crucial need to better assess the effect of climate change on marine ecosystems, particularly over the continental shelf and inside the national exclusive economic zones. Nevertheless there is a lack of observation carried out in the African ecosystems and the times series are often short or disrupted. Space-based observations allow precise synoptic observation of marine ecosystem and is often use to monitor, *e.g.*, Eastern boundary upwelling ecosystems, from 36 years of constant monitoring from some major parameters as Sea Surface Temperature and more than twenty years for Ocean-Colour related parameters as surface primary productivity. The spatially heterogeneous trends observed show that these systems are highly variable, at temporal scales decades) that potentially impact some of their marine resources at rates that compete with the decline of human activities, beyond over-fishing. In this work we will present the effect of global warming at regional level for the three large marine ecosystems of Atlantic Africa on the sea surface temperature, wind stress and chlorophyll concentration as a proxy of primary production. The Canary and the Benguela systems are particularly impacted by the global warming, especially in their tropical parts, while Pacific systems show a more stable trend, due to their constantly high activity that partly counteracts some effects of the global warming.

Keywords: remote sensing, tropical Atlantic, climate change, staelitte, MODIS, LME, CCLME, BCLME, GCLME.

Occurrence spatiale et biodiversité des méduses dans l'écosystème Atlantique marocain entre (35°N) et (21°N)

Hounaida Farah IDRISSI [1,*], Souad KEFFANI[1,*], Hamid CHFFIRI[1], Abdekrim KALMONI[1], and Najib CHAROUKI[1]

[1]Institut National de Recherche Halieutique (INRH), Boulevard Sidi Abderrahmane, Ould Jmel-Casablanca, Morocco

*Correspondance: courriel souad.kifani@gmail.com (S. KEFFANI)

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Abstract

Les méduses figurent parmi les premiers métazoaires apparus dans l'hémisphère bleu. En Atlantique marocain entre les parallèles (35°N) et (21°N), durant la période allant du 1998 à 2017, les apparitions massives de ce macro-plancton gélatineux sont de plus en plus fréquentes et qui inclus divers groupes, comme les cténaires, les méduses et les tuniciers. Dans la zone d'étude, l'occurrence des méduses calculée dans les stations de pêche a été pondérée par rapport au nombre moyen des stations par campagne en mer de chaque navire de recherche déployé. A l'échelle spatiale, le poids total des méduses capturées cumulé sur toute la série des campagnes disponibles montre que le maximum des captures a été enregistré entre les latitudes 22°N et 23°N, suivi par une apparition bien prononcée au niveau de la zone centrale entre 33, 50°N et 31°N pendant les années 2007, 2009, 2011, 2015 et 2016. Cette présente étude dresse en partie l'éventuelle interaction entre l'abondance des méduses et la variabilité de la concentration de l'oxygène dissous (O2) en (mol/l) dans toute la colonne d'eau à l'échelle spatiale et aussi interannuelle. En terme de biodiversité du macro-plancton gélatineux, l'écosystème atlantique marocain a révélé la présence de six groupes (Salpes, Cténaires, Pyrosomes, Rhizostomes, Siphonophores, et scyphozoaires), représentés par 15 espèces identifiées et recensées.

Session 4

Micronektonic acoustic density variations in Guinea Current Large Marine Ecosystem continental shelf from 1999 to 2006

Aka Marcel KOUASSI [1,*], Nolwenn BEHAGLE [2], Vamara KONÉ [1], Yannick PERROT [2], Maik TIEDEMANN [2], Anne MOUGET [2], Chloé MIGAYROU [2], Jens-Otto KRAKSTAD [4], Abdoulaye SARRÉ [3], Désiré Kouamé KANGA [1], Benjamin KOUADIO [1], Ndague DIOGOUL [5,3,2], and Patrice BREHMER [1,*]

[1] IRD-Centre de recherches océanologiques (CRO), Abidjan/Ivory Coast
[2] Institut de Recherche pour le Développement (IRD), Délégation régionale France Ouest, UMR Lemar (UBO-CNRS-IRD-Ifremer), BP70, 29 280, Plouzané, France
[3] Institut Sénégalais de Recherches agricoles (ISRA), Centre de Recherches Océanographiques de Dakar-Thiaroye, PRH, BP 2241, Dakar, Sénégal;
[4] Institute of Marine Research (IMR), P.O. Box 1870 Nordnes, N-5817 Bergen, Norway
[5] Institut des Sciences de l'Environnement (ISE), Université Cheikh Anta Diop de Dakar (UCAD), B.P. 5005 Dakar, Sénégal

*Correspondance: Courriel: aka.marcel.kouassi@gmail.com (A. M. . KOUASSI)

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Abstract

The Guinea Current Large Marine Ecosystem (GCLME) extends from Bissagos Island (Guinea Bissau) in the north (11°N, 16°W) to Cape Lopez (Gabon) in the south (0°S, 8°E) and includes the study zone, from 4°N, 8°W to 6°N, 3°E. Acoustic data were recorded with a 38 kHz echosounder, from 10 to 500 m depth over 7 surveys, 6 were selected here, totalling 16 618 nmi from 1999 to 2006. To get homogenous data, (i) only off-upwelling season surveys (April to September) were studied and (ii) only continental shelf data were considered (10-150 m). The mean volume backscattering strength (Sv in dB) was used as a micronektonic biomass proxy to assess its spatial inter-annual variability. Diel transition periods were removed from analyses to avoid micronektonic density changes bias due to diel vertical migrations. Data were echointegrated at a spatial resolution of 0,1 nmi*1 m depth using Matecho tool (Perrot et al., 2018). (i) On horizontal dimension, the variability in annual micronektonic densities was assessed using the mean Sv value for each 0,1 nmi Elementary Sample Unit (ESU). (ii) On vertical dimension, the water column variation (%) filled by micronektonic acoustic layer (filling rate) across years was estimated using a linear regression and the change of micronektonic spatial structure between day and night was assessed using the mean Sv value for each 1 m depth step. GCLME have a narrow continental shelf vs. other African Atlantic LMEs. No significant change of micronektonic biomass proxy has been observed from 1999 to 2006 in this study (Fig. 1). As expected, a difference is observed in the vertical micronektonic acoustic density between day and night (Fig. 3). However, there is a paradoxical process, indeed there is an increase in Sv during nighttime. Two hypotheses are proposed: (i) the increase in density could be explained by an offshore horizontal diel migration or (ii) a very high contribution of the micronektonic density occurring in surface (0-10 m) is suspected, which corresponds to the blind zone of the research vessel. According to the new descriptor "water column filling rate", a significant change in the system is reported. Indeed there is an increase in five years.

Future investigations should focus on this interesting phenomenon, which could be link to an effect of global change. We have to take care that such increase could also inform on a major change in the trophic web in this part of the GCLME. These findings can be interpreted as an early warning signal and encourage for future study.

Characterization of micronektonic spatial structure using ecosystemic acoustics descriptors applied in three Atlantic African Large Marine Ecosystems

Anne MOUGET [1,*], Nolwenn BEHAGLE [1], Yannick PERROT [1], Maik TIEDEMANN [1], Chloé MIGAYROU [1], Abdoulaye SARRÉ [2], Uatjavi UANIVI [3], Elizandro RODRIGUEZ [4], Mohamed Ahmed JEYID [5], Salahedine El AYOUBI [6], Aka Marcel KOUASSI [7], Adrien BERNE [1], Ebou Mass MBYE [8], and Patrice BREHMER [1]

[1]Institut de Recherche pour le Développement (IRD), Délégation régionale France Ouest, UMR Lemar (UBO-CNRS-IRD-Ifremer), BP70, 29 280, Plouzané, France
[3]Institut Sénégalais de Recherche Agricole (ISRA), Centre de Recherche Océanographique de Dakar Thiaroye (CRODT), BP 2221, Dakar, Sénégal
[3]Ministry of Fisheries and Marine Resources (MFMR), P.O. Box 25305 Windhoek / P.O. Box 912 Swakopmund, Namibia
[4]Instituto Nacional de Desenvolvimento das Pescas (INDP) and Ocean Science Centre Mindelo (OSCM), Mindelo, Sao Vincente, Cabo Verde
[5]Institut Mauritanien de Recherche Océanographique et des Pêche (IMROP), BP 22, Nouadhibou, Mauritanie
[6]Institut National de Recherche Halieutique (INRH), Boulevard Sidi Abderrahmane, Ould Jmel-Casablanca, Morocco
[7]Centre de Recherche Oceanologique, Abidjan, Côte d'Ivoire
[8]Fisheries Department, Banjul, The Gambia

*Correspondance: Tél : (+33) 628385130; Courriel: anne.mouget@ird.fr (A. MOUGET)

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Abstract

Using the segmentation algorithm within Matecho (Perrot *et al*., 2018) we are able to deliver 15 descriptors to characterize the acoustic micronektonic layers in the water column. Even if the species composition is not known, these descriptors which are obtained using the same methodology allow for comparison between ecosystems and to study inter-annual variability. Some of these descriptors are new and others are based on the ones usually used to characterize pelagic fish schools using echointegration per shoal (Weill *et al*., 1993). In this work we will focus on the new ones and show some application cases in the three Atlantic African Large Marine Ecosystems, to monitor potential perturbations due to global change. All layer descriptors are estimated per layer and per elementary sampling unit of 0.1 nautical miles (ESU) with an accuracy of 1 meter depth. In this study we present four classes of descriptors: spatial (*e.g*. altitude, mean depth, minimal depth); morphological (*e.g*. width, ESU number, filling rate of water column); acoustic (*e.g*. mean volume backscattering strength S_v (dB)) and the layer number per ESU. In this study we focus on the original descriptors: (i) Filling rate of the water column (%): this indicator is based on the calculation of the width of the micronektonic layer vs. the local bottom depth. (ii) Filling rate contribution of first layer (%): this indicator shows the contribution of the first layer (the closest layer of surface) in the global filling rate. It is computed by dividing the filling rate of first layer by the filling rate of all layers. (iii) Number of layers: this indicator is calculated for each ESU, giving the number of layers in this water column. The descriptors have been computed over more than 1 million of ESUs, 992 737 in the CCLME, 166 183 in the GCLME and 462 807 in the BCLME. Such descriptors

allow classification of micronekton layers and appear relevant to monitor changes in the ecosystem. Next step will be to use multifrequency or even wide-band data to improve the quality of descriptors. They were efficiently applied to study diel vertical behaviour as well as the effect of water mass characteristics on the spatial structure of the layers. In future applications it should help in the classification of the layers per functional group as well as to improve our knowledge on ecosystem organization and functioning.

Keywords: ecosystem descriptor, sound scattering layer, tropical Atlantic, fisheries acoustics.

Unsupervised functional classification applied on high resolution oceanographic data in Canaries current large marine ecosystem: toward fine scale analysis

Mamadou NDIAYE [1,3,*], Sophie Dabo-NIANG [2], Mohamed Salem AHMED [2], Abdoulaye SARRÉ [3], Ahmed TALEB [4], Salahedine El AYOUBI [5], Ndague DIOGOUL [6, 1], Elizandro RODRIGUEZ [7], Ebou Mass MBYE [8], Maik TIEDEMANN [1], Yannick PERROT [1], Chloé MIGAYROU [1], Nolwenn BEHAGLE [1], Louis MARIÉ [9], Eric MACHU [9], Xavier CAPET [10] and Patrice BREHMER [1]

[1]Institut de Recherche pour le Développement (IRD), DR Ouest, Lemar (UBO-CNRS-IRD-Ifremer), Plouzané, France
[2]Univ-Lille, LEM, INRIA, France
[3]Institut Sénégalais de Recherche Agricole (ISRA), CRODT, BP 2221, Dakar, Sénégal
[4]Institut Mauritanien de Recherche Océanographique et des Pêche (IMROP), BP 22, Nouadhibou, Mauritanie
[5]Institut National de Recherche Halieutique (INRH), Boulevard Sidi Abderrahmane, Morocco
[6]Institut de Recherche pour le Développement - France (IRD), UMR 195 Lemar, BP 1386, Dakar, Sénégal
[7]Instituto Nacional de Desenvolvimento das Pescas (INDP) and Ocean Science Centre Mindelo (OSCM), Mindelo, Sao Vincente, Cabo Verde
[8]Fisheries Department, The Gambia
[9]Institut de Recherche pour le Développement - France (IRD), -Ifremer, LOPS, France
[10]CNRS, UPMC, France

*Correspondance: Tél: (+33) 754010667; Courriel: mamadoundiaye397@gmail.com (M. NDIAYE)

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Abstract

The understand of the fine scale process occurring in the ocean needs high resolution data and ad hoc analysis approach to improve the knowledge of ecosystem functioning. During an international survey carry out in 2014 'AWA' on-board the research vessel Thalassa (Ifremer, Brest) along the coast of Mauritania and Senegal we have used simultaneously multifrequency scientific echosounder and a Scanfish, both system allow a continuous acquisition of high- quality data at high spatial and temporal resolution over long distance. The functional data analyses have recently raising in serval field of statistics and appear to be well suited for the analysis of this dataset. In fact such data has spatial-functional nature and may be considered as observations of a stochastic process X in space of continuous functions over an interval T. Let X1(t), X2(t),.., Xn(t), t T, be the collection of n observations from X. First, we study an eventual horizontally or vertically variation of the acoustic intensity, we consider for a given frequency (here 200 kHz) and one vessel radial the two cases: vertical and horizontal variations of the acoustic intensity. Unsupervised functional classification used, shows a horizontal and vertical variation of acoustic intensity for a given frequency and a given radial. The approach can led to scrutinized at fine scale the processes occurring in three dimensions in the pelagic environment. The statistical functional classification applied to this case study appears powerful, ad hoc for ecological studies of marine ecosystem and will be extend to model the spatial structuration of the pelagic ecosystem according to the physcio-chemical parameters of the water mass which will allow to improve the forecast of the effect of the environment on marine ecosystem organization.

Methanogenic potential of aquaculture waste a smart initiative for green aquaculture in the framework of blue growth

Hamet Diaw DIADHIOU [2,*] ,NDeye Aida NDIAYE [1,] Halima Magouzou DIAGNE [1], Waly ndiaye [2], Fulgence DIEDHIOU [2], Mamadou NIANG [2], Matar sylla [3], Mouhamed Lamine GAYE [4], Saliou FALL [1], and Patrice BREHMER [5,2,*]

[1]Institut Sénégalais de Recherche Agricole (ISRA), LCM, Bel air, Dakar, Sénégal
[2]Institut Sénégalais de Recherche Agricole (ISRA), Centre de Recherche Océanographique de Dakar Thiaroye (CRODT), BP 2221, Dakar, Sénégal
[3]Programme Nationale de Biogaz du Sénégal (PNB Sn), Dakar, Sénégal
[4]Université Cheikh Anta Diop (UCAD), Département de Chimie, Dakar, Sénégal
[5]Institut de Recherche pour le Développement (IRD), Délégation régionale France Ouest, Lemar (UBO-CNRS-IRD-Ifremer), BP70, 29 280, Plouzané, France

*Correspondance: Tél:; Courriel: hamet_diadhiou@yahoo.fr H. DIADHIOU)

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Abstract

All predictions agree that tilapia is destined to become the major aquaculture species of tomorrow. Tilapia is grown in more than 100 countries and production reaches 4.3 million tonnes making this fish group the second largest for global aquaculture, after that of carp. The modern development of its breeding requires energy for production systems *e.g.* to supply oxygen equipment or automatic food vending machines or the heating of livestock ponds. This work proposes to valorise the waste resulting from the activities in fish farming by the processes of anaerobic digestion to produce energy. For this, faeces of Tilapia Oreochromis niloticus were sampled periodically and their methanogenic potential (BMP test) determined and compared to a reference substrate (poultry droppings); with or without inoculum. The µCG analysis made it possible to determine the relative proportions of methane (CH_4) in the biogas as a function of the duration of production. Biochemical methane potential (BMP) tests showed rapid kinetics of biogas production of fish faeces in the presence of inoculum (+ inoculum) compared with the production of biogas in faeces alone. This kinetics of biogas production is reversed between the third and fourth week. In both cases, the proportion of methane is generally greater than 60% from the second week of incubation, which shows the quality of the biogas produced. The composition of CH_4 and CO_2 does not change with or without inoculum. However, there is a significant difference in total CH_4 volume which is twice as large with inoculated fish faeces than uninoculated fish or poultry droppings. Our results show that fish droppings are good methanogenic substrates and the use of the inoculum allows for a quick start of biogas production and avoids MO losses. Realized on a large scale, the valorisation of aquaculture fish faeces could constitute a source of green energy for the development of fish farming in Africa. And thus a smart initiative to fight against climate impact on small pelagic fish stock displacement in tropical areas.

Matecho: an open-source tool for processing fisheries acoustics data to facilitate collaborative development

Yannick PERROT [1,*], Patrice BREHMER [1,3], Jérémie HABASQUE [1], Gildas ROUDAUT [1], Nolwenn BEHAGLE [1], Abdoulaye SARRÉ [2], Ndague DIOGOUL [3,1], and Anne LEBOURGES-DHAUSSY [1]

[1]Institut de Recherche pour le Développement (IRD), UMR 195 Lemar (Laboratoire des sciences de l'environnement marin ; CNRS, UBO-IUEM, IRD, Ifremer), Plouzané, France
[2]Institut Sénégalais de Recherches Agricoles (ISRA), Centre de Recherches Océanographiques de Dakar Thiaroye (CRODT), Pôle de Recherches de Hann, Sénégal
[3]Université Cheikh Anta Diop (UCAD), Dakar, Senegal

*Correspondance: Tél: (+33) 2 98 22 46 71; Courriel: yannick.perrot@ird.fr (Y. PERROT)

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Abstract

Matecho is a free, open-source and automated processing method to extract information and perform echo-integration and fish shoal extraction from various echo sounder sources providing digital acoustic data on fisheries and aquatic ecosystem. The open-source initiative helps foster collaboration and technological transfer. Matecho supports various formats, such as the international standard format for the exchange of fisheries acoustics raw and edited data. The procedure allows the cleaning of semi-automatic echogram data and the application of automatic data filters, *i.e.,* transient noise, attenuated signal and impulsive noise removal and background noise reduction. Echo-integration processing is executed for each depth layer and integrates their characteristics per elementary sampling unit. Scattered layers are automatically detected by segmentation from the echo-integrated echogram, and shoals are extracted according to an iterative process of aggregation of filtered echogram echoes that allows, in both cases, the calculation of the *ad hoc* parameters describing morphological, spatial location and acoustic characteristics of scattered layers and shoals. Matecho is open-source software for researchers and provides end-users with a user-friendly, free executable program.

Keywords: echo-integration, fisheries acoustics, software, open access, Movies 3D, Matecho.

Echo level segmentation on echo-integration of fisheries acoustics data

Yannick PERROT [1,*], Patrice BREHMER [1,3], Nolwenn BEHAGLE [1], Anne MOUGET [1], Chloé MIGAYROU [1], Gildas ROUDAUT [1], Ndague DIOGOUL [2,1], Abdoulaye SARRÉ [2], and Anne LEBOURGES-DHAUSSY [1]

[1]Institut de Recherche pour le Développement (IRD), UMR 195 Lemar (Laboratoire des sciences de l'environnement marin ; CNRS, UBO-IUEM, IRD, Ifremer), Plouzané, France
[2]Institut Sénégalais de Recherches Agricoles (ISRA), Centre de Recherches Océanographiques de Dakar Thiaroye (CRODT), Pôle de Recherches de Hann, Sénégal
[3]Université Cheikh Anta Diop (UCAD), Dakar, Senegal

*Correspondance: Tél: (+33) 2 98 22 46 71; Courriel: yannick.perrot@ird.fr (Y. PERROT)

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Abstract

In fisheries acoustics the analysis of data usually often concern biomass assessment mainly for small pelagic fish stocks using the well-known echointergration approach. Other can concern the analysis of single fish using their target strength (TS in dB) and more seldom analysis can also be done with the fish school descriptors using *e.g.* shoal extraction method (Movies+, Ifremer Software). In the framework of the Preface project we have focused on the micronektonic layers observed by scientific echosounder. Matecho, a friendly automatized processing method to extract information and perform echo-integration, fish shoal extraction and also performs a segmentation, on each zone of a cruise with a constant twilight, of the echointegrated echogram from an echo level threshold fixed by user to extract micronektonic layers in the water column. Here we describe this methodology which allows an accurate description of the spatial organisation and structuration of the marine ecosystem. The process is based on three main steps which consist in : (i) adjust the echo level threshold in dB, (ii) the extraction of the echoes inside each contours and the calculation of the layer descriptors, (iii) and then the correction of the extraction. Finally the echo segmentation, setup to extract micronektonic sound scattered layer, allows to get 34 layers descriptors, *e.g.*, minimum/maximum depth (m), geographical position in 3D, maximum depth width (m), duration of the layer, surface covered by the layer, mean volume backscattering strength "S_v" (dB re 1 m^{-1})': mean nautical area scattered coefficient "S_a" (or NASC m^2 nmi^{-2}), to characterise their spatial position in the water column and acoustics properties. Moreover, a second class of descriptors, classified by elementary sampling unit (ESU), are estimated *e.g.* number of layer per ESU, layer depth per ESU. An innovative descriptor is also computed using this methodological approach: the water column fulling rate per layer and per ESU. Both classes of descriptors are then available for ecological studies.

Keywords: sound scattering layer, deep scattering layer, fisheries acoustics, acoustics shoal, Matecho.

Analysing tortuosity in diving behaviour of yellowfin tuna, *Thunnus albacares*, in Cabo Verde

Péricles SILVA [1,*], Ivanice MONTEIRO [1], Victor STIEBENS [2], Matthias SCHABER [3] and Heino O. FOCK [3]

[1]Instituto Nacional de Desenvolvimento das Pescas (INDP) and Ocean Science Centre Mindelo (OSCM), Mindelo, Sao Vincente, Cabo Verde
[2]Marine Biological Consultancy, Cape Verde
[3]Thünen-Institute (TI), Institute of Sea Fisheries, Federal Research Institute for Rural Areas, Forestry and Fisheries, Palmaille 9, 22767 Hamburg, Germany

*Correspondance: Tél: ; Courriel: pericles.silva@indp.gov.cv (P. SILVA)

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Abstract

Habitat quality changes with climate change, affecting water temperature and oxygen contents, and this change in habitat quality could trigger a shift in spatial distributions of the tuna species, i.e. yellowfin (YFT) and bigeye tuna (BET), in Cabo Verde with subsequent effects for the fisheries. The aim of WP 12-2 is to investigate habitat use of these species. In 2016 and 2017, five specimens of YFT were tagged with External pop-up satellite tags (WildlifeComputers MiniPAT). Diving depth rarely was deeper than 80 m. No deep dives were undertaken. Tags were deployed at the islands of Maio, São Vincente, São Nicolau and Boa Vista of Cabo Verde. We developed 2 different approaches to analyse tortuosity in diving behaviour. The index τ1 describes the ratio between depth differences to vertical swimming speed for 9 consecutive time steps, i.e. about 10 minutes. The index τ2 is the inverse of the depth difference weighted by the swimming speed. Values for τ1 range from 0 – 1, and values ~ 1 indicate straight diving and searching. Intermediate values are assumed to indicate hunting activities with a series of short up and downward directed strokes, and low values would indicate horizontal activities only. Whereas τ1 is a relative measure, τ2 is indicative of absolute activity levels. Relatively high levels indicate low absolute vertical activity and could indicate either horizontal moves or resting. In particular the specimens associated with dolphins showed a significant difference for τ2 during night-time.

Comparative Analysis of Diel Vertical Migration between three Atlantic African Large Marine Ecosystems

Maik TIEDEMANN [1,*], Patrice BREHMER [1], Anne MOUGET [1], Salahedine el AYOUBI [2], Vamara KONE [3], Nolwenn BÉHAGLE [1], Yannick PERROT [1], Najib CHAROUKI [2], Chloé MIGAYROU [1], Uatjavi UANIVI [4], Mohamed Ahmed JEYID[5] , Ebou Mass MBYE [6], Elizandro RODRIGUEZ [7] and Abdoulaye SARRÉ [8]

[1]France Institut de Recherche pour le Développement (IRD), UMR 195 Laboratoire des sciences de l'Environnement Marin (LEMAR), Brest, France
[2]Morocco INRH, Bd Sidi Abderrahmane 2, Ain Diab 20180 Casablanca, Morocco
[3]Ocean Research Center (CRO), Ivory coat
[4]Ministry of Fisheries and Marine Resources (MFMR), P.O. Box 25305 Windhoek / P.O. Box 912 Swakopmund, Namibia
[5] Intitut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), Mauritania
[6]Fisheries Department (FD), The Gambia
[7] Instituto Nacional do Desenvolvimento das Pescas (INDP), Cabo Verde
[8]Institut Sénégalais de Recherches agricoles (ISRA), Centre de Recherches Océanographiques de Dakar-Thiaroye, PRH, BP 2241, Dakar, Sénégal

*Correspondance: Tél: (+ 49) 531 596 1099; Courriel: tiedemann.maik@gmail.com(M. TIEDEMANN)

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Abstract

Diel vertical migration (DVM) of micronekton is a behavioural mechanism driven by a trade-off between predator avoidance and access to prey. This trade-off is controlled by environmental forcing that can lead to changes of DVM pattern under changing environmental conditions. Time series of hydro acoustic surveys between 1995 – 2015 of three large Atlantic ecosystems (Canary Current - CCLME, Guinea Current - GCLME, and Benguela Current - BCLME) were analysed to calculate DVM patterns based on volume backscattering strength (S_v). DVM related descriptors (n=15) were calculated for areas according to bathymetric definitions (shelf = 10 – 150 m bottom depth, slope = 150 – 500 m bottom depth, and plain > 500 m bottom depth). Typical DVM I pattern, with micronekton descending during daytime and ascending during night-time, were observed on the slope and plain in all three ecosystems, but not on the shelf with only negative day-night values in the CCLME and BCLME. Lower daytime S_v values during the day compared to night-time suggest either less dense patches of micronekton leading to negative day-night differences in the CCLME and GCLME or insufficient measurements of certain depth strata (*e.g.*, 0 – 10 m surface). Only a few significant and different DVM descriptors suggest a change in the CCLME and the GCLME in the last 20 years. All other insignificant descriptors assume natural variability in large Atlantic ecosystems. Our results provide insight into inter-annual variability in micronekton DVM patterns.

Keywords: LME, CCLME, GCLME, BCLME, West Africa, climate change, DVM, fisheries acoustics, pelagic ecosystem.

Micronektonic acoustic density variations along Benguela Current Large Marine Ecosystem continental shelf from 1994 to 2001

Uatjavi UANIVI [1,*], Anne MOUGET [2], Yannick PERROT [2], Nolwenn BEHAGLE [2], Chloé MIGAYROU [2], Abdoulaye SARRÉ [3], Jens-Otto KRAKSTAD [4], Ndague DIOGOUL [5,2,3], Hervé DEMARCQ [6], and Patrice BREHMER [2]

[1]Ministry of Fisheries and Marine Resources (MFMR), P.O. Box 25305 Windhoek / P.O. Box 912 Swakopmund, Namibia
[2]Institut de recherche pour le développement (IRD), UMR Lemar, Campus Ifremer, Délégation régionale IRD ouest France, 29280, Plouzané, France
[3]Institut Sénégalais de Recherche Agricole (ISRA), Centre de Recherche Océanographique de Dakar Thiaroye (CRODT), Pôle de recherche de Hann, Dakar, Sénégal
[4]Institut of Marine Research (IMR), Nordnesgaten 50, 5005 Bergen, Norway
[5]Université Cheikh-Anta-Diop (UCAD), BP5005, Dakar, Sénégal
[6]Institut de recherche pour le développement (IRD), UMR Marbec, Avenue Jean Monnet, 34280, Sète, France

*Correspondance: Tél: (+264) 81 256 0303; Courriel: uatjavi@yahoo.co.uk (U. UANIVI)

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Abstract

The Benguela Current Large Marine Ecosystem (BCLME) is situated along the coast of south-western Africa, stretching from Tombua (Angola) in the north (16°N, 11°W) southwards to the east of the Cape of Good Hope (South Africa) (29°S, 17°E) and includes the study zone, from 17°S, 9°E to 31°S, 17°E. In this work, we focused on the Namibian continental shelf where fishing activities are mostly due to industrial fishing. Acoustic data were recorded with a 38 kHz echosounder, from 10 to 500 m depth over 8 surveys totalling 46 302 nmi from 1994 to 2001. To get homogenous data (i) only off-upwelling season surveys (October to June) were studied and (ii) only continental shelf data were considered (10-150 m). The mean volume backscattering strength (Sv in dB) was used as a micronektonic biomass proxy to assess its spatial inter-annual variability. Diel transition periods were removed from analyses to avoid micronektonic density changes bias due to diel vertical migrations. Data were echointegrated at a spatial resolution of 0,1 nmi*1 m depth using the Matecho tool. (i) On horizontal dimension, the variability in annual micronektonic densities was assessed using the mean Sv value for each 0,1 nmi Elementary Sample Unit (ESU). Then, hot and cold spots were computed from the combined analysis of the spatial correlation and the Morans' I index of these values. (ii) On vertical dimension, the change of micronektonic spatial structure between day and night was assessed using the mean Sv value for each 1 m depth step. The inter-annual variability inside the eastern boundary upwelling ecosystem of the BCLME was analysed. (i) No significant change in micronektonic density was observed over the study period. Mean micronektonic acoustic density values observed were lower than in other African Atlantic large marine ecosystems. (ii) Hot and cold spots were spatially stable over time. Further analysis of physico-chemical parameters should improve the understanding of this pattern. (iii) A different vertical structure was reported between day and night, suggesting a migration from bottom to surface at dusk, as in the well-known diel vertical migrations. In perspective, physical processes occurring in the water column from turbulence to mesoscale activities should be considered in future studies.

International Workshop on Marine & Atmospheric Sciences Joint with ICAWA 4th in West Africa Ocean Science Centre Mindelo Cabo Verde,

November 13th to 17th, 2017

Agenda and Program

Sunday, Nov. 12

Icebreaker

Ocean Science Centre Mindelo, Hangar

17:00 – 20:30 Registration & Icebreaker

Monday, Nov. 13

Atlantic Observatories – Results & Perspectives

Ocean Science Centre Mindelo, Hangar

08:00 Registration

09:00 – 13:00 Morning Session (OSCM Hangar)

09:00 Arne Körtzinger, GEOMAR, Germany: *Welcome Address*

09:10 Björn Fiedler, GEOMAR, Germany: *Biogeochemical time-series observations at CVOO*

09:32 Corrine Almeida, Uni CV, Cabo Verde: Coastal dynamic at Salamansa Bay, São Vicente, Cabo Verde

09:54 Florian Schütte, GEOMAR, Germany: *Observations of physical ocean properties in the eastern tropical North Atlantic*

10:16 Annibal Medina, PRAO-CV, Cabo Verde: Cabo Verde Archipelago as a natural center for a better understanding of regional climate changes

10:38 Coffee break

11:10 Peter Lemke, AWI, Germany: *The warming of the Eastern Atlantic*

11:32 Debany Fonseca, Vrije Universiteit, Belgium: *Dinitrogen fixation in the Atlantic Ocean*

11:54 **Christophe Eizaguirre**, QMUL, United Kingdom: *Conservation of sea turtles: a country-wide approach*

12:16 **Rainer Kiko**, GEOMAR, Germany: *Zooplankton-mediated fluxes in the Eastern Tropical North Atlantic*

12:38 **Henk-Jan Hoving**, GEOMAR, Germany: *Biological exploration of the deep water column around the Cape Verde islands*

13:00 Lunch break

14:00 – 16:30 Afternoon Session (OSCM Hangar)

14:00 Christa Marandino & Anja Engel, GEOMAR, Germany: Surface ocean Lower atmosphere International Campaign (SLIC): A new SOLAS Time Series Concept for Cabo Verde

14:22 Lucy Carpenter Univ. of York, UK: Reactive gases at the Cape Verde Observatory

14:44 **Martin Heimann**, MPG-BGC Jena, Germany: *A decade of greenhouse gas measurements from the Cape Verde Atmospheric Observatory "Humberto Duarte Fonseca"*

15:06 Coffee & Water

5:40 **Wadinga Fomba**, TROPOS, Germany: *Chemical composition of aerosol particles at the CVAO*

16:02 **Andrew Watson**, Univ. of Exeter, UK: *Observational constraints on the global carbon cycle from SOCAT ocean pCO_2*

16:24 **Andrew Peters**, BIOS, Bermuda: *Marine Atmospheric Research in Bermuda*

17:00 – 19:30: Posters & Drinks

Joint poster session for all topics. Poster will be up throughout the week.

Mindelo, Cabo Verde, Nov. 12-17, 2017

Tuesday, Nov. 14

Inauguration of Ocean Science Centre

Ocean Science Centre Mindelo, Hangar

OSCM
Ocean Science Centre

09:00 – 12:30 Inauguration Ceremony

09:00 Arrival and Welcome of Delegations

09:53 Introduction to OSCM (short video)

10:00 Speeches of Courtesy

- Dr. Osvaldina Silva, President of INDP
- Prof. Dr. Peter Herzig, Director of GEOMAR
- Mr. Augusto Neves, Mayor of Sao Vicente
- Mr. Wilfried Kraus, Deputy Director General of the BMBF Directorate 72 "Sustainability, Climate ,Energy" (video message)
- Dr. José Goncalves – Minister of Economy and Employment of the Republic of Cabo Verde

11:00 Ceremonial Inauguration Acts

11:20 Reception, Music & Group Picture

14:00 – 17:00 Field trip with site visits (departing from OSCM with shuttle busses)

- R/V Islandia in Mindelo harbor (Porto Grande)
- "Cape Verde Atmosphere Observatory" in Calhau, São Vicente

18:00 – 20:00 Reception on R/V Maria S. Merian in Mindelo harbor (Porto Grande)

--- By Invitation Only ---

Tuesday, Nov. 14 (afternoon)

ICAWA-4: International Conference

"Ecosystem Approach to the management of fisheries and the marine environment in West African waters"

INDP, Auditorium

13:00 Registration

14:00 – 18:001st ICAWA-4 Session

14:00 Osvaldina Silva, President of INDP: *Welcome Address*

14:05 Njeri Kabeberi , Excecutive Director Greenpeace Africa: *Welcome Address*

14:10 His Excellency James F.P. GOMEZ, Minister of Fisheries, Water Resources and National Assembly

Matters, Banjul/ The Gambia: *Welcome Address & Official Opening*

14:20 Patrice Brehmer, IRD, Plouzané/France: AWA consortium: Toward West African Observatory – project overview

14:35 Abdoulaye Sarré, CRODT, Dakar/Senegal: Keynote speech

15:15 Heino Fock, vTI, Hamburg/Germany & **Carlos Santos**/Cabo Verde: *Variability of pelagic productivity in West-African waters*

15:35 Rui Freitas, Uni-CV, Mindelo/Cabo Verde: *Remarks on confirmed records of ten fish species to Cabo Verde Archipelago based on photographic and genetic data*

15:50 Vamara Koné, IRD-CRO, Abidjan/Ivory Coast & **Thomas Gorgues**, Univ. Brest, and Plouzané/France: *Physical-biogeochemical coupling: processes and control of small pelagic fish*

16:05 Coffee break

16:35 Jörn Schmidt, CAU, Kiel/Germany: *Economics integrated into the ecosystem approach to marine management*

16:55 **Didier Jouffre**, IRD, Montpellier/France & **Ibrahima Diallo**, CNSHB, Conakry/Guinea: *IndiAWA: Indicators for an Ecosystem Approach to the Management of Fisheries and the Marine Environment in West African Waters*

17:15 Aliou Ba, IRD-CRODT, Dakar/Senegal: Profitability and economic drivers of small pelagic fisheries in West Africa: a twenty year perspective

17:30 **Werner Ekau**, ZMT, Bremen/Germany: *Capacity building in the AWA consortium*

17:40 AWA Poster teaser

Wednesday, Nov. 15 (morning)

ICAWA-4 (continued):

Ocean Science Centre Mindelo, Hangar

08:00 Registration

09:00 – 12:30 2nd ICAWA-4 Session

09:00 Idriss Lamine Camara, CNSHB, Guinea: *Speech of Courtesy*

09:05 Timothée Brochier, IRD, Bondy/France: *Contribution of mathematical modeling to the ecosystem* approach to fisheries management and the marine environment (EAMME): the AWA experience

09:20 Thomas Gorgues, IUEM, LabexMer, Plouzané/France: *Spatial and Temporal variability of primary production in the north-west African upwelling. A modelling approach*

09:35 Assane Fall, IMROP, Nouadhibou/Mauritania: *Industrie de farine et d'huile de poisson en Mauritanie entre 2004 et 2016 : «transit», «point de chute» ou «refuge» des candidats à l'immigration clandestine vers les Canaries"*

09:50 PREFACE – AWA Poster teaser

10:00 Aliou Ba, IRD-CRODT, Dakar/Senegal: *Impact of subsidies on the dynamics of pelagic small-scale fishery in Senegal*

10:10 Coffee break

10:25 Marie Bonnin, IRD, Plouzané/France: *Reaching milestones of public regulations in marine environment: Toward an integrative way of marine management*

10:45 Adama Mbaye, CRODT: Climatic benchmarks among Senegalese fishermen: what has changed

11:05 Francis Asuquo, University of Calabar, Nigeria: *The influence and fluctuating trends of ocean variables in surface mixed layer of the South Atlantic Ocean*

11:15 Ahmed Diamé, Greanpeace, South africa: *The Future of West Africa fisheries under threat: Learning from the 2017 Greenpeace Expedition in the SRFC States Members.*

11:50 Lunch break

12:30 – 14:00 POGO Lunch (see separate invitation)

INDP, Foyer & Auditorium

Call for Oceanographic Research Institutions in Africa to join the International Ocean Observing Community

Wednesday, Nov. 15 (afternoon)

ICAWA-4 (continued) & PREFACE side-event

Ocean Science Centre Mindelo, Hangar

14:00 – 16:30 3rd ICAWA-4 Session

14:00 Open Discussion (Moderator: CSRP): *AWA observatory and scientific council for SFRC member's states*

14:30 Open Discussion (Moderator: Patrice Brehmer): *On-going Project proposal following AWA and PREFACE experiences*

15:00 Open Discussion (Moderator: Adama Mbaye & Assane Fall): *Human migration in West Africa*

15:15 Coffee break

15:30 **Patrice Brehmer**, IRD & **Jörn Schmidt**, CAU: *Opening: Impacts of climate change on pelagic functional diversity in the tropical Atlantic with effects on western African fisheries economies*

15:35 **Noel Keenlyside & Mahaut de Vareilles,** University of Bergen and Bjerknes Centre for Climate Research, Bergen/Norway: *Towards improved climate prediction for West Africa.*

15:55 **Stephanie Czudaj** & **Heino Fock**, vTI, Hamburg/Germany: *WP12.1 Isotopic niche plasticity in mesopelagic fish assemblages of the Eastern tropical North Atlantic under different productivity environments*

16:10 **Heino Fock**, vTI, Hamburg, Germany: *Habitat and catch rates of Yellowfin tuna in Cape Verdian waters linked to ocean surface processes*

16:20 **Bocar Sabaly Baldé**, UCAD, IRD, ZMT, Dakar/Senegal: *WP12.2 Sardinella aurita growth parameters variability under climate change and fishing pressure*

16:25 **Ndague Diogoul**, ISRA/CRODT, IRD, Dakar/Senegal: *WP12.3*

16:30 – 18:30 PREFACE Policy Workshop

16:30 **Jörn Schmidt**, CAU, Kiel/Germany: *Socioeconomics and Regulation perceptions in the small scale fishing sector - Findings from the PREFACE surveys in Cabo Verde and Senegal*

17:55 **Nnaemeka Chukwuone**, University of Nigeria, Nsukka/Nigeria: *Socioeconomics and Regulation perceptions of the marine fisheries sector in Nigeria*

17:15 Open Discussion

17:25 **Kira Lanker**, CAU, Kiel/Germany: *The artisanal hand line fishery in Cabo Verde: A regional analysis of weather impacts on harvest and income*

17:45 Open Discussion

18:30 **Jörn Schmidt**, CAU, Kiel/Germany: Policy Workshop Wrap-up

Thursday, Nov. 16

Macaronesia Matters (Workshop)

Ocean Science Centre Mindelo, Hangar

09:00 – 12:301st Session (presentations)

9:00 **Vito Ramos**, INDP, Mindelo/Cabo Verde: *Oceanographic Tools for Fisheries Management in Cabo Verde. The case of MESA project*

9:20 **Marina Cunha**, Univ. Aveiro, Aveiro/Portugal: *LO3CAted - Looking out for deep-sea connectivity in Atlantic observatories*

9:40 **Eduardo Azevedo**, Univ. Azores, Angra do Heroísmo/Azores: *Eastern North Atlantic (ENA) Azores Islands ARM facility - an opportunity for international cooperation on ocean/atmospheric sciences*

10:00 **João Canning-Clode**, MARE, Funchal, Madeira/Portugal: *The foundations for a student exchange programme seeking to contribute to marine ecological patterns in Macaronesia*

10:20 **Rui Caldeira**, ARDITI/OOM, Funchal, Madeira/Portugal: *The Oceanic Observatory of Madeira*

10:40 Coffee break

11:10 **Manuel Dureil**, Dalhousie Univ., Halifax, Canada: *Prospects for Cabo Verde as a shark research hub in West Africa*

11:30 **Carlos Barrera**, PLOCAN, Las Palmas, Gran Canaria/Spain: *Improving ocean-observation with autonomous platforms in the Macaronesian region*

11:50 **Silvana Neves**, PLOCAN, Las Palmas, Gran Canaria/Spain: *MARCET project*

12:10 **Andres Cianca**, PLOCAN, Las Palmas, Gran Canaria/Spain: *Overview about two decades of ESTOC and the repercussions in the Macaronesia*

12:30 **Isabel Sousa Pinto**, Univ. Porto, Porto/Portugal: *Marine Biodiversity Observation Network: establishing a Macaronesian team*

12:50 Lunch break

14:00 – 17:00:2nd session (discussion)

The session will be moderated by Joaquin Brito, PLOCAN, Las Palmas, Gran Canaria, Spain

15:30 Coffee break

WASCAL – West African Science Service Center on Climate Change and Adapted Land Use

INDP, Auditorium

14:00 – 17: 30: Planning Workshop for WASCAL Graduate School

14:00 Janet Olatundun Adelegan, WASCAL Director of Capacity Building, Accra/Ghana: *Welcome and*

Introduction

14:10 João Canning-Clode, MARE, Funchal, Madeira/Portugal: *GAME – Global Approach by Modular*

Experiments

14:20 Avan Antia, CAU, Kiel/Germany: *"One Planet – One Ocean" – Massive Open Online Course*

14:30 Karen Wiltshire, AWI, Bremerhaven/Germany *: POGO-PML AMT Fellowships*

14:40 Open discussion and planning

19:00 – 22:00 Conference Dinner

Restaurant Le Goût de Grills, Mindelo, Avenida Marginal, opposite Belém Tower. Further information will be provided during the Workshop.

Friday, Nov. 17

Blue Growth and the 'Cabo Verde RealityLab'

Ocean Science Centre Mindelo, Hangar

09:00 – 10:00 Opening of Future Ocean Dialogue Exhibition

09:00 Arne Körtzinger, GEOMAR, Kiel/Germany: *Opening*

09:10 Frederike Tirre, Kiel University, Cluster of Excellence "Future Ocean", Kiel/Germany: *Understanding the ocean – Sustaining our future*

With this motto the travelling exhibition of the Cluster of Excellence "The Future Ocean", based on six scientific topics, presents the challenges with which modern ocean research is confronted and the opportunities that arise from these. The exhibits cover the topics fisheries, coastal research, ocean observation, waste in the oceans, ocean acidification and marine resources. Together they offer visitors the possibility to gain a comprehensive overview of the current issues in the marine sciences.

09:30 Press tour

10:00 Coffee break

10.30 – 12.30 Case Studies for Applied Sciences (Plenary session)

Keynotes:

10:30 George Wiafe, University of Ghana, Legon/Ghana: *Earth Observation (EO) services in support of combatting Illegal, Unregulated and Unreported (IUU) fishing in West Africa*

10:45 **Tatiana Cabral**, Fazenda de Camarão de Cabo Verde, Mindelo/Cabo Verde: *Aquaculture as a tool for Blue Growth Initiative – The Sustainable Shrimp-Tilapia Juveniles Farm, A Vision to a New Horizon, Island of S.Vicente, Cabo Verde*

11:00 **Christine Merk**, IfW, Kiel/Germany: *Impacts of regional changes in beach wrack composition on visitors' valuation of visits to the beach*

11:15 **Malte Winkler**, IfW, Kiel/Germany: *Wave Energy Conversion in the North Sea - An analysis of the economically most feasible locations and technologies with regard to energy output*

11:30 **Oscar Melicio**, RME, Mindelo/Cabo Verde: *Resolute Marine Energy – At the nexus of energy and water - Implementing the Wave2O in Cabo Verde for improved access to potable water and sustainable energies*

11:45 **Sören Harrs**, IfW, Kiel/Germany: *Stakeholder Engagement on Marine Litter – How to carry out a survey*

12:00 **Carlos Evora Rocha,** DNEM, Mindelo/Cabo Verde –Cabo Verde - Blue Growth and Blue Economy

12:30 Lunch Break

14:00 – 16:30 Cabo Verde Reality Lab (Discussion Session)

Ocean Science Centre Mindelo, Hangar

The session will be moderated by Jörn Schmidt, Kiel University - Cluster of Excellence “Future Ocean”

14:00 Discussion Session

16:00 Wrap-Up

Mindelo, Cabo Verde, Nov. 12-17, 2017

ACRONYMS / AFFILIATIONS

oAWI – Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Germany

oBIOS – Bermuda Institute of Ocean Sciences – Bermuda, USA

oBMBF – German Federal Ministry of Education and Research, Bonn, Germany

oCAU – University of Kiel, Germany

oCIPA – Centro de Investigação Pesqueira Aplicada, Guinea-Bissau

oCNSHB – Centre National des Sciences Halieutiques de Boussoura, Guinea

oCRO – Centre de Recherches Océanologiques, Ivory Coast

oCRODT – Centre de Recherches Océanografiques de Dakar-Thiaroye, Senegal

oDal – Dalhousie University, Canada

oDNEM – Direccao Nacional de Economia Marítima, Cabo Verde

oFazenda de Camarao de Cabo Verde, Calhau, Cabo Verde

oFURG – Federal University of Rio Grande, Brazil

oGreenpeace Africa, South Africa

oGEOMAR – GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany

oIfW – Institute for the World Economy, Germany

oINDP – Insituto Nacional de Desenvolvimento das Pescas, Cabo Verde

oINMG – Instituto Nacional de Meteorologia e Geofísica, Cabo Verde

oIMROP – Institut Mauritanien de Recherches Océanographiques et des Pêches, Mauritania

oIRD – Institut de Recherche pour le Développement, France

oISRA – Institut Sénégalais de Recherche Agricole, Senegal

oIUEM – Institut Universitaire Européen de la Mer, France

oMARUM – Centre for Marine Environmental Sciences, Germany

oMAVA – MAVA Fondation pour la Nature, Switzerland

oMPI-BGC – Max-Planck-Institute for Biogeochemistry Jena, Germany

oPLOCAN – Plataforma Oceanica de Canarias, Spain

oPRAO-CV – Projeto Regional das Pescas em África Ocidental, Cabo Verde

oQMUL – Queen Mary University of London, United Kingdom

ovTI-IFÖ – von Thünen Institute – Institute of Fisheries Ecology, Germany

ovTI-IFS – von Thünen Institute – Institute of Sea Fisheries, Germany

oTROPOS – Leibniz-Institute for Troposheric Research in Leipzig, Germany

oRME – Resolute Marine Energy, Mindelo, Cabo Verde

oSP – CSRP – Commission Sous-Régionale des Pêches, Senegal

oUni CV – Universidade de Cabo Verde, Cabo Verde

oUniversity of Exeter, United Kingdom

oUFPE – Universidade Federal de Pernambuco, Brazil

oUniversity of Ghana, Legon, Ghana

oULPGC – Universidade de Las Palmas de Gran Canaria, Spain

oUniversity of York, United Kingdom

oVrije Universiteit Brussels, Belgium

oZMT – Leibniz Centre for Tropical Marine Research, Germany

International PREFACE International Conference on Ocean, Climat and Ecosystems joint with ICAWA 5th, editon 2018 and AWA-Preface Policy session

17th to 20th APRIL 2018

Agenda and Program

	Monday (16/04/18)	Tuesday (17/04/18)	Wednesday (18/04/18)	Thursday (19/04/18)	Friday (20/04/18)
08:00		Reception desk & poster hanging	Reception desk	Reception desk	
08:45		Welcome by Geoparque, PREFACE Coordinator and IRD			
09:00		Overview of PREFACE achievements and lessons learnt, by Research Core Theme	Session 2: Climate variability and teleconnections (6x 15min)	Session 3: Climate Prediction (3x 15min)	PREFACE Reporting: management, science and dissemination
				Session 4: Marine ecosystems, fisheries management and climate change (3 x 15min)	
10:30		Coffee break	Coffee break	Coffee break	
11:00		Session 1: Ocean Processes (6x 15min)	Session 2: Climate variability and teleconnections (4x 15min)	Session 4: Marine ecosystems, fisheries management and climate change (6 x 15min)	
			Session 3: Climate Prediction (2x 15min)		
12:30		Lunch & Poster Session (1h45min	Lunch & Poster Session (1h45min	Lunch & Poster Session (1h30min	End (13:00)
14:00				Session 4: Marine ecosystems, fisheries management and climate change (3 x 15min)	
14:15		Session 1: Ocean Processes (5 x 15min)	Session 3: Climate Prediction (5x 15min)		
14:45				PREFACE appreciation by ESAP	
15:30		Coffee break	Coffee break	Coffee break	
16:00		Poster Session (2h) / *Preparation for Science-Policy session*	Sight-seeing excursion to Timanfajo	Science-Policy Session	
		Adjourn (18:00)	Adjourn (18:00)	Adjourn (18:00)	
		Welcome Reception 19:30-21:30		**Networking Dinner (20:30)**	

Session 1	Presenter	Affiliation	Title
Tuesday 17.04.18	**Convenors: Marie-Lou Bachélery and Mathieu Rouault (UCT & Nansen Tutu Center, South Africa)**		
11:00-11:15	Pedro Tchipalanga	INIP, Angola	Eastern boundary circulation and hydrography off Angola – building Angolan oceanographic capacities
11:15-11:30	Robert Kopte	GEOMAR, Germany	Role of Equatorial Basin-Mode Resonance for the Seasonal Variability of the Angola Current at 11°S
11:30-11:45	Martin Schmidt	IOW, Germany	Sources and propagation pathways of water masses to the northern Benguela upwelling system
11:45-12:00	Tim Junker	IOW, Germany	Coastal trapped wave propagation along the southwest African shelf as revealed by moored observations
12:00-12:15	Rodrigue Anicet Imbol Koungue	UCT, South Africa	Benguela Niño and Niña events from 1958 to 2015
12:15-12:30	Marie-Lou Bachélery	UCT, South Africa	How the low-frequency equatorial Kelvin wave activity, local ocean stratification, and coastal winds modulate the south-eastern interannual Atlantic variability?
Tuesday 17.04.18	**Convenors: Gael Alory (IRD, France) and Marcus Dengler (GEOMAR, Germany)**		
14:15:14:30	Mathieu Rouault	Nansen Tutu Centre, South Africa	Monitoring Rossby waves along 6 degree south in the tropical Atlantic
14:30-14:45	Peter Brandt	GEOMAR, Germany	Equatorial Deep Jets in the Atlantic Ocean studied by observations and ocean general circulation models
14:45:15:00	Franz Tuchen	GEOMAR, Germany	Deep intraseasonal variability in the central equatorial Atlantic
15:00-15:15	Markus Jochum	NBI, UCPH, Denmark	Inertial wave induced mixing in the tropical Atlantic: observations, parameterizations and impacts
15:15:15:30	Sailou Faye	ISRA-CRODT, Senegal	Mixed layer heat budget in the north-eastern tropical upwelling system: Two paradoxes of the temperature control in the Senegalese upwelling

Session 2	Presenter	Affiliation	Title
Wednesday 18.04.18	**Convenors: Lea Svendsen (UiB, Norway) and Aurore Voldoire (CNRM, France)**		
09:00-09:15	Moussa Diakhate	UCAD, Senegal	Do SST gradients drive the monthly climatological surface wind convergence over the tropical Atlantic?
09:15-09:30	Julien Jouanno	IRD-LEGOS, France	Equatorial Atlantic interannual variability and its relation to dynamic and thermodynamic processes
09:30-09:45	Lander R. Crespo	UiB, Norway	The coupling between the ocean and the atmosphere in the equatorial Atlantic seasonal cycle
09:45-10:00	Gael Alory	IRD-LEGOS, France	Sea Surface Salinity signature of the tropical Atlantic interannual climatic modes
10:00-10:15	C. Roberto Mechoso	UCLA, USA	Climates in oceanic regions characterized by low-level clouds
10:15-10:30	Roberto Suárez-Moreno	UCM, Spain	Interdecadal changes in ocean teleconnections with the Sahel. Modulating role of the multidecadal SST background.
Wednesday 18.04.18	**Convenors: Lea Svendsen (UiB, Norway) and Aurore Voldoire (CNRM, France)**		
11:00-11:15	Hyacinth Nnamchi	GEOMAR, Germany	A warming hole in the equatorial Atlantic cold tongue region during the satellite era (cancelled)
11:15-11:30	Noel Keenlyside	UiB, Norway	South Atlantic Anti-Cyclone as a driver of Atlantic Niño variability
11:30-11:45	Belén Rodríguez-Fonseca	UCM, Spain	Conciliating tropical Atlantic impact on ENSO
11:45-12:00	Marta Martín-Rey	CERFACS, France	Role of the ocean dynamics in ENSO-tropical Atlantic teleconnection under warmer climate

Session 3	Presenter	Affiliation	Title
Wednesday 18.04.18	**Convenors: Eleftheria Exarchou (BSC, Spain) and Jorge-Lopez Parages (UCM, Spain)**		
12:00-12:15	Sebastian Steining	GEOMAR, Germany	Reducing climate model systematic error in the tropical Atlantic sector by enhancing atmospheric resolution: implications for seasonal to interannual variability and predictability
12:15-12:30	Xuewei Li	GEOMAR, Germany	Prediction of Short-term Tropical Atlantic Climate Fluctuations using A Coupled Climate Model with Different Atmosphere Model Resolutions
Wednesday 18.04.18	**Convenors: Eleftheria Exarchou (BSC, Spain) and Marta Martin-Rey (CERFACS, France)**		
14:15:14:30	Elsa Mohino	UCM, Spain	Relationships among Inter-model Spread and Biases in Tropical Atlantic sea surface temperatures
14:30-14:45	Jon Shonk	UREAD, UK	The April Transition between Easterly and Westerly Wind Bias in the Tropical Atlantic in Hindcasts Using the ECMWF IFS
14:45:15:00	Aurore Voldoire	CNRM, France	Role of wind stress in driving coupled model SST biases in the Tropical Atlantic
15:00-15:15	Ingo Richter	JAMSTEC, Japan	Bias development and its impact on prediction skill as examined from daily mean output of a full-field initialization hindcast
15:15:15:30	Lea Svendsen	UiB, Norway	Seasonal prediction skill in the tropical Atlantic using anomaly coupling
Thursday 19.04.18	**Convenors: Marta Martin-Rey (CERFACS, France) and Jorge-Lopez Parages (UCM, Spain)**		
09:00-09:15	Eleftheria Exarchou	BSC, Spain	Impact of Tropical Atlantic variability on Tropical Pacific predictability
09:15-09:30	Davide Zanchettin	UNIVE, Italy	Quantifying systematic climate model errors in the simulation of interannual and decadal climate variability in the tropical Atlantic region
09:30-09:45	Antonio Castaño-Tierno	UCM, Spain	Revisiting the CMIP5 Thermocline in the Tropical Pacific

Session 4	Presenter	Affiliation	Title
Thursday 19.04.18	**Convenors: Uatjavi Uanivi (MFMR, Namibia) and Aliou Ba (IRD & ISRA-CRODT, Senegal)**		
09:45-10:00	Thomas Gorgues	IFREMER-LOPS, France	Spatial and Temporal variability of primary production in the north-west African upwelling: A modelling approach.
10:00-10:15	Heino Fock	Thuenen Institute, Germany	Synthesis of prey field dynamics and the analysis of tuna dynamics to qualitatively evaluate the prospect for future fisheries in the tropical eastern central Atlantic
10:15-10:30	Ivanice Monteiro	INDP & OSCM, Cape Verde	Yellowfin tuna catch opportunities in Cape Verde – coping with uncertainties of local CPUEs
Thursday 19.04.18	**Convenors: Uatjavi Uanivi (MFMR, Namibia), Ivanice Monteiro (INDP&OSCM, Cape Verde) and Aliou Ba (IRD & ISRA-CRODT, Senegal)**		
11:00-11:15	Maik Tiedemann	IRD, France	Hydrographic control on larval fish assemblages: Lessons from the Canary Current Ecosystem
11:15-11:30	Bocar Sabaly Balde	IRD, France	*Sardinella aurita* growth parameters variability under the balanced effects of climate change and fishing pressure
11:30-11:45	Marek Ostrowski	IMR, Norway	On the role of equatorial warm events in expanding the southward range of *Sardinella aurita* along the Angolan coast
11:45-12:00	Jorge López-Parages	UCM, Spain	A promising effect of El Niño on sardinella distribution along the northwest African coast: a potential source of seasonal predictability?
12:00-12:15	Abdoulaye Sarré	ISRA-CRODT, Senegal	Intense warming causes a spatial shift of small pelagic fish: early warning for food security in North-West Africa
12:15-12:30	Adama Mbaye	ISRA-CRODT, Senegal	Climate change and seasonality of small pelagics: impacts on their value chain in Senegal
Thursday 19.04.18	**Convenors: Uatjavi Uanivi (MFMR, Namibia) and Ivanice Monteiro (INDP&OSCM, Cape Verde)**		
14:00-14:15	Aliou Ba	IRD, France	The economic impacts of Marine Protected Area on Senegalese small pelagic fisheries
14:15-14:30	Kira Lancker	CAU, Germany	Empirical bio-economic modelling of small-scale artisanal fisheries under climate change: A new approach and application to the Senegalese purse-seine fishery
14:30-14:45	Nnaemeka Chukwuone	UNN, Nigeria	Managing Environmental Impacts and Decrease in Marine Fish Catch: Perceptions and Strategies by Fisher Folks in Coastal Nigeria

POSTERS
ALL SESSIONS:
TUE 17.04.18 12:30-14:15 and 16:00-18:00
WED 18.04.18 12:30-14:15
THU 19.04.18 12:30-14:00

Session 1		
Presentor	**Affiliation**	**Title**
Karim Hilmi	INRH, Morocco	The variability of the Cape Boujdor upwelling and its relationship with the cape Blanc frontal zone
Marcus Dengler	GEOMAR, Germany	An elevated turbulent mixing event caused by a near-inertial wave in the mixed layer
Gael Alory	IRD-LEGOS, France	Mixed layer heat/salt budget and Equatorial Under-Current dynamics in the tropical Atlantic from a joint model-observations approach
Peter Brandt	GEOMAR, Germany	Seasonal variations of tidally generated internal waves in the eastern boundary upwelling system off Angola
Session 2		
Presentor	**Affiliation**	**Title**
Casimir Da-Allada	CIMPA, Benin	Boreal spring equatorial Sea Surface Salinity as a potential predictor of Atlantic Cold Tongue events
Moussa Diakhate	UCAD, Senegal	Oceanic Forcing on Interannual Variability of Sahel Heavy and Moderate Daily Rainfall Events
Tina Dippe	GEOMAR, Germany	Longitudinal variations of SST event characteristics in the tropical Atlantic and Pacific oceans
Iñigo Gómara	UCM, Spain	Abrupt transitions in the NAO control of explosive North Atlantic cyclone development
Shunya Koseki	UiB, Norway	Equatorial Atlantic interannual variability in a CGCM
Marta Martín-Rey	CERFACS, France	Is the boreal spring Tropical Atlantic SST variability a precursor for the Equatorial Mode?
Elsa Mohino	UCM, Spain	Atlantic control of the late-19th century Sahel humid period.
Lander R. Crespo	UiB, Norway	The coupling between tropical Pacific and Atlantic basins in a recharge oscillator framework
Marie-Jeanne Sambou	UCAD, Senegal	Large scale mechanisms associated with heat wave occurrences in Senegal
Roberto Suarez-Moren	UCM, Spain	Interdecadal changes in ocean teleconnections with the Sahel. Modulating role of the multidecadal SST background.
Lea Svendsen	UiB, Norway	The connection between Atlantic multi-decadal variability and the Indian summer monsoon in CMIP5 models
Dahirou Wane	UCAD, Senegal	Meridian Seasonal Variability of the Tropical Atlantic Warm Pool Associated with the Inter-Tropical Convergence Zone (ITCZ)
Session 3		
Presentor	**Affiliation**	**Title**
Antonio Castaño-Tierno	UCM, Spain	Influence of SST bias in North West Africa upwelling system in CMIP5 models
Teferi Dejene Demissie	UniResearch, Norway	Climate projections with bias-reduced CGCMs in Tropical Atlantic
Iñigo Gómara	UCM, Spain	Impact of dynamical regionalization on precipitation biases and teleconnections over West Africa
Teresa Losada	UCM, Spain	Impact of the anomaly coupling in the simulation of the interannual variability of the Tropical Atlantic Ocean in a simulation.

Session 3		
Presentor	**Affiliation**	**Title**
Teresa Losada	UCM, Spain	Impact of the reduction of the southern extratropical incoming radiation on the simulation of the tropical Atlantic variability
Irene Polo	UCM, Spain	Relationship between inter-annual tropical variability and mean state in CMIP5 models
Emilia Sanchez	CERFACS, France	Impact of the ocean stochastic parameterization on the simulated mean state and variability of a coupled model
Aurore Voldoire	CNRM, France	Tropical Atlantic low-cloud biases in CNRM-CM6: evaluation of the new atmospheric physics
Session 4		
Presentor	**Affiliation**	**Title**
Tarik Baibai	INRH, Morocco	Variabilité hydrobiologique de la région de Dakhla (24°N-23°30°N et 23°N) et biodiversité du micro-phytoplancton
Bocar Sabaly Balde	ISRA-CRODT, Senegal	Modelling and management options in a context of increase fishing effort and efficiency: Case of Ethmalosa fimbriata in Southern Senegal
Bocar Sabaly Balde	ISRA-CRODT, Senega	Estimating dynamics of population fecundity to understand spawning tactics in Ethmalosa fimbriata (Bowdich, 1825) in an upwelling environment
Patrice Brehmer	IRD, France	The effect of oceanographic factors on micronektonic acoustic density in the three African Atlantic large marine ecosystems
Nolwenn Behagle	IRD, France	Micronektonic acoustic density variations along Canary Current Large Marine Ecosystem over 20 years
Timothée Brochier	IRD, France	Complex small pelagic fish population patterns arising from individual behavioural responses to their environment
Hervé Demarcq	IRD, France	Spatial Environmental trends in the three Atlantic African Large Marine Ecosystems in a context of global warming
Hamet D. Diadhiou	ISRA-CRODT, Senega	Methanogenic potential of aquaculture waste a smart initiative for green aquaculture in the framework of blue growth
Farah Hounaida Idrissi	INRH, Morocco	Occurrence spatiale et biodiversité des méduses dans l'écosystème Atlantique marocain entre (35°N) et (21°N)
Aka Marcel Kouassi	CRO, Ivory Coast	Micronektonic acoustic density variations in Guinea Current Large Marine Ecosystem continental shelf from 1999 to 2006
Anne Mouget	IRD, France	Characterization of micronektonic spatial structure using ecosystemic acoustics descriptors applied in three Atlantic African Large Marine Ecosystems
Mamadou Ndiaye	ISRA-CRODT, Senegal	Unsupervised functional classification applied on high resolution oceanographic data in Canaries current large marine ecosystem: toward fine scale analysis
Yannick Perrot	IRD, France	Matecho: an open-source tool for processing fisheries acoustics data to facilitate collaborative development
Yannick Perrot	IRD, France	Echo level segmentation on echointegration of fisheries acoustics data
Péricles Silva	INDP, Cape Verde	Analysing tortuosity in diving behaviour of yellowfin tuna, *Thunnus albacares*, in Cabo Verde
Maik Tiedemann	IRD, France	Comparative Analysis of Diel Vertical Migration between three Atlantic African Large Marine Ecosystems
Uatjavi Uanivi	MFMR, Namibia	Micronektonic acoustic density variations along Benguela Current Large Marine Ecosystem from 1994 to 2001

Science-Policy Session to prepare Policy Brief

19th April 2018, 16:00-18:00, Centro Cívico de Arrecife, Lanzarote, Spain

Context

The EU FP7 funded PREFACE – *Enhancing prediction of tropical Atlantic climate and its impacts* project has successfully developed cooperation between European and African research communities in natural and social sciences and initiated South-South cooperation to study climate change in the tropical Atlantic off the African coast. It forged agreements with other local and international programs, such as the ones of the Benguela Current Commission, Sub-regional Fisheries Commission, and the German-French-African tripartite project AWA – *Ecosystem Approach to the Management of Fisheries and the Marine Environment in West African waters*.

High-quality and long-term observations are key to understand and anticipate the changes in the tropical Atlantic. The project has extended the Tropical Atlantic Observing System and improved access to, and analysing capacity of, data for African countries. This has led to improved understanding of the tropical Atlantic Ocean, especially at the eastern boundary and the equator.

Accurate climate models and deep understanding of predictability bring us one step closer to the development of climate services for the regions. PREFACE has vastly improved our understanding of climate variations and change in the tropical Atlantic. It has contributed to improve the ability of numerical models to simulate and predict climate in the regions. Climate services for the African-Atlantic regions can now be developed by combining improved predictions with marine ecosystem and bio-economic models.

Climate change is impacting the structure and the organization of the ecosystems in the tropical Atlantic with effects on western African fisheries economies. PREFACE has successfully investigated the impact of climate change on marine ecosystems, particularly on commercially important fish stocks (e.g. Sardinella, Bonga shad, and

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Tuna). It also successfully analysed the economic impact on the fishing sector in selected West African countries and investigated the perception of environmental change. Developed methodologies are available and can now be applied in other countries of the region.

Potential recommendations to be refined and tailored to stakeholder perspective

- Weather and ocean forecasts are important for many maritime sectors and coastal activities and communities. Improved observation systems are needed to improve the data basis for model forecasts and enable short-, medium- and long-term forecasts for strategic policy development and tactical management decision.

- Further developments in climate modelling are also required to improve the accuracy of these forecasts.

- South-South cooperation, especially in social and economics sciences, is strongly needed to evaluate effects of climate change as well as societal, economic and technological change on maritime activities, and fisheries in particular.

- Fisheries play a crucial role for many African coastal communities in terms of income generation as well as for the provision of animal protein and micronutrients for coastal as well as inland communities. Thus, the management of fisheries in light of external pressures, including climate change, overfishing, pollution, and market drivers as well as illegal, unreported, and unregulated fisheries is crucial. Locally, climate change can already have severe direct effects, namely the redistribution of stocks and changes in migration, as well as indirect effects through salinization of fertile coastal agricultural land and redistribution of labour into fisheries. Even though not specifically analysed within the project, the data shows evidence for an important role of human

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migration between fisheries and into fisheries, especially in terms of community stability.

Session programme and aim

Aim: to discuss and refine the content of the policy brief.

Programme draft:

16:00-16:45 Series of short 5 minute presentations on key findings and recommendations

- Dr Patrice Brehmer, Institute of Research and Development (IRD, France): ***Recommendations on the need for regional and international cooperation***
- Dr Abdoulaye Sarre, Oceanographic Research Centre Dakar-Thiaroye at the Senegalese Institute of Agricultural Research (ISRA-CRODT): ***Long-term warming impact on fish stock in West Africa waters***
- Dr Aka Marcel Kouassi, Centre of Ocean Research of Abidjan (CRO, Ivory Coast): ***The contribution of research for fisheries management***
- Dr Noel Keenlyside, University of Bergen and Bjerknes Centre for Climate Research (UiB & BCCR, Norway): ***Climate Prediction and Climate Services***
- Mr Pedro Tchipalanga, National Institute of Fisheries Research (INIP, Angola): ***Long-term observations, and the benefits of capacity strengthening and international cooperation***
- Dr Jörn Schmidt, Christian-Albrechts University of Kiel (CAU, Germany): ***Socio-economic aspects, possible future impacts in coastal fishing communities***

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- Dr Osvaldina Silva, National Institute for Fisheries Research and Development (INDP, Cape Verde): ***User-demand for economic forecast in the fisheries sector***

16:45-18:00 Moderated discussion (Moderator: Patrice Brehmer. Logistical support: https://www.sli.do/)

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Some picture of last ICAWA editons (2017-2018)

Edition 2017

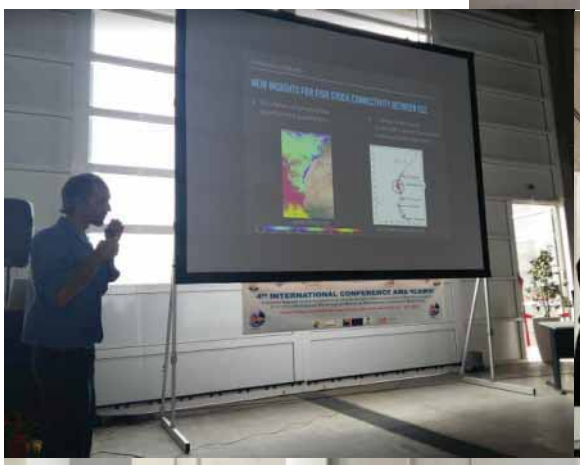
Inuaguration by the officials of the OSCM during the conference

His Excellency Dr. José da Silva Gonçalves, both Minister of Tourism and Transport and Minister of Maritime Economy of the Republic of Cabo Verde

The Executive director of greenpeace Africa with the AWA coordinator

The ICAWA 2017 Scientific Award Winners, in the presence of the Menbra of the Jury, the Director of INDP, the Director of Greenpeace Africa and the Deputy Director of the CRO of Abidjan


CONFERENCE AWA 'ICAWA'



Edition 2018











The AWA
consortium
Ocean-Fisheries-Littoral-Climat


The AWA
SALIDA


The AWA
consortium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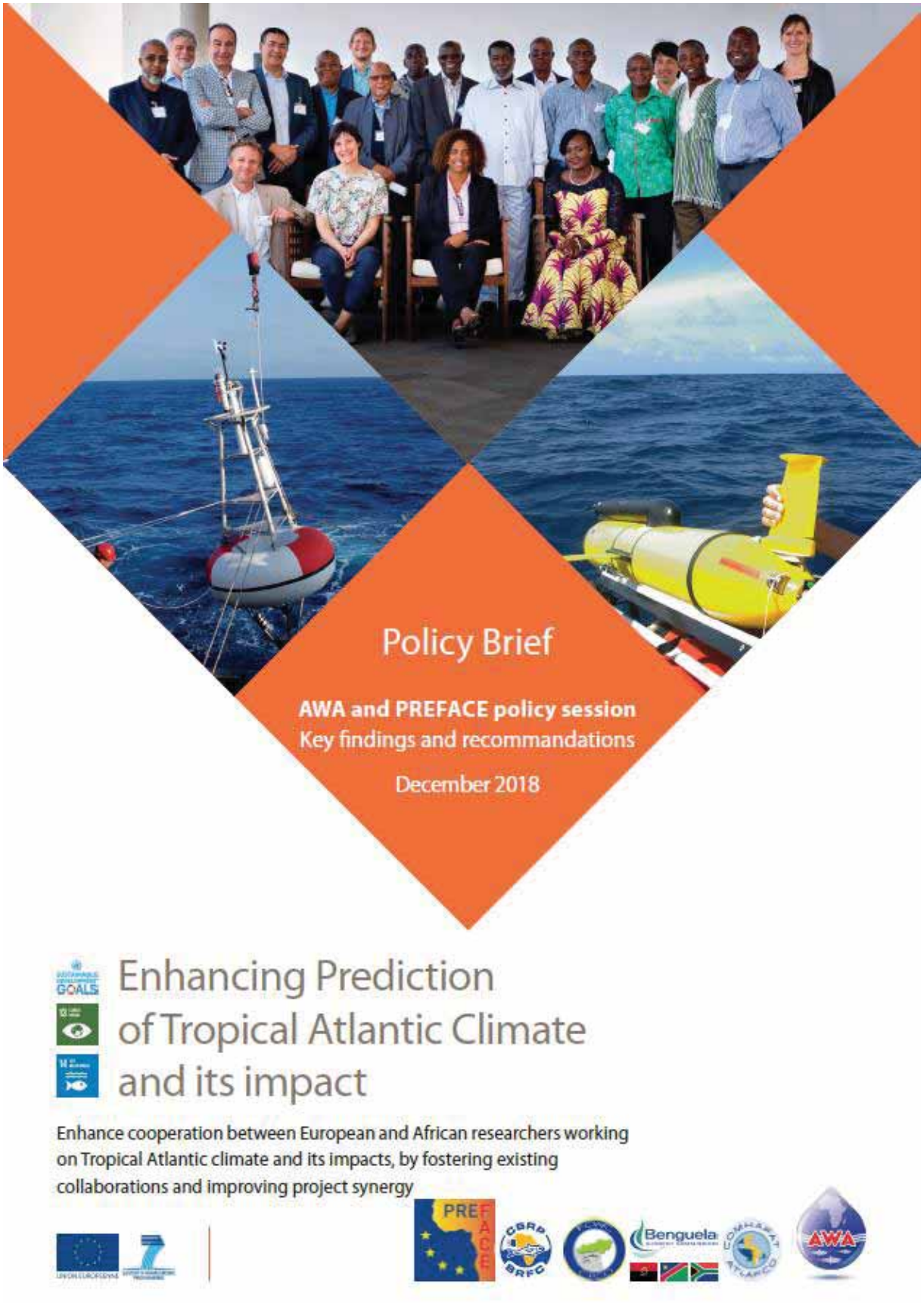
consortium

AWA-Preface Policy brief



Available at :

http://www.documentation.ird.fr/hor/fdi:010076724

https://preface.w.uib.no/files/2019/07/Policy_Brief_Preface_AWA.pdf

PREFACE-AWA science-policy session (April 2018)

Organisers: The Preface (Enhancing Prediction of Tropical Atlantic Climate and its Impact) and AWA (Ecosystem approach to the management of fisheries and the marine environment in West African waters) consortiums, with support of the Sub Regional Fisheries Commission (SRFC), the Fisheries Committee for the West Central Gulf of Guinea (FCWC), the Benguela Current Commission (BCC) and the Ministerial Conference on fisheries cooperation among African States bordering the Atlantic Ocean (ATLAFCO).

Funding: From the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 603521 for Preface, and the Institute of research for sustainable development (IRD, France) and Bundesministerium für Bildung und Forschung (BMBF, Germany) under grant agreement no. 01DG12073B and 01DG12073E, for AWA.

Cite as: Preface and AWA 2018. Enhancing Prediction of Tropical Atlantic Climate and its Impact: keys findings and recommendations. 12p. IRD, Marseille.

This report has been produced by the participant of the Science-Policy Session held in Lanzarote in 2018 during the PREFACE International conference on Ocean, Climate and Ecosystems. The session began with seven brief presentations by Dr Patrice Brehmer on «Recommendations on the need for regional and international cooperation», Dr Abdoulaye Sarre on «Long-term warming impact on fish stock in West Africa waters», Dr Aka Marcel Kouassi on «The contribution of research for fisheries management», Dr Noel Keenlyside on «Climate Prediction and Climate Services», Mr Pedro Tchipalanga on «Long-term observations, and the benefits of capacity strengthening and international cooperation», Dr Jörn Schmidt on «Socio-economic aspects, possible future impacts in coastal fishing communities», and Dr Osvaldina Silva on «User demand for economic forecast in fisheries sector». This provided valuable input for the policy brief and in particular to identify the most relevant recommendations to be drawn from these 4.5 years of intense collaboration, scientific progress and capacity strengthening enabled by the European Commission's 7th Framework Programme (FP7), French National Research Institute for Sustainable Development (IRD) and the German Federal Ministry of Education and Research (BMBF). The reflexion continued during 6 months, before arriving at this final product with : Abdelouahed Benabbou, Executive Secretary of the Ministerial Conference on Fisheries Cooperation among African States Bordering the Atlantic Ocean (COMHAFAT/ATLAFCO), Morocco; Abdennaji Laamrich, Secretary of the Ministerial Conference on Fisheries Cooperation among African States Bordering the Atlantic Ocean (COMHAFAT/ATLAFCO), Morocco; Abdou Daim Dia, Technical Advisor to the Director of the Mauritanian Institute of Ocean and Fisheries Research (IMROP), Mauritania; Abou Bamba, Executive Secretary of the Abidjan Convention (UNEP), Côte d'Ivoire; Ahmed Mahmoud Lemhaba, Scientific Advisor at the Parc National du banc d'Arguin (PNBA), Mauritania; Aka Marcel Kouassi, Director of the Centre for Ocean Research of Abidjan, Côte d'Ivoire; Angaman Konan, Technical Advisor to the Ministry of Fisheries, Côte d'Ivoire; Arsène D'Almeida, Technical Advisor at the Ministry of Agriculture, Aquaculture and Fisheries, Benin; Carlos Ferreira Santos, Head of the Ocean Science Center Mindelo (OSCM) and German Consul of Cabo Verde, Cabo Verde; Emma M. Glassco, Director General of the National Fisheries and Aquaculture Authority (NaFAA), Liberia; Jörn Schmidt, Senior Researcher at the University of Kiel, Germany; Maika Müller, German Society for International Collaboration (GIZ), Germany; Mark Prein, German Society for International Collaboration (GIZ), Germany; Mohamed Mayif, Programmes Director at the Sub-Regional Fisheries Commission (SRFC/CSRP), Senegal; Moussa Sall, Regional Coordinator of the West African Coast Observation Mission (WACOM/MOLOA), Senegal; Nnaemeka Chukwuone, Professor at the Department of Climate Change, University of Nsukka, Nigeria; Noel Keenlyside, Professor at the Geophysical Institute, University of Bergen, Norway; Osvaldina Silva, Director of the National Institute for Fisheries Research and Development, Cabo Verde; Patrice Brehmer, Senior Researcher at the French National Research Institute for Sustainable Development (IRD), France; Pedro C.M. Tchipalanga, Representative for the Director of the National Institute of Fisheries Research, Angola; Uatjavi Uanivi, Representative for the Permanent Secretary of the Ministry of Fisheries and Marine Resources, Namibia; Wesseh D. Kay, EAF Nansen Focal person and Senior Research Officer at NaFAA, Liberia; Zacharie Sohou , Director of the Fisheries and Ocean Research Institute (IRHOB/CNDO/CBRSI), Benin. The session was moderated in French and English (simultaneous translation) including stakeholders and scientist by Dr Patrice Brehmer, Institute of Research for sustainable Development (IRD, France).

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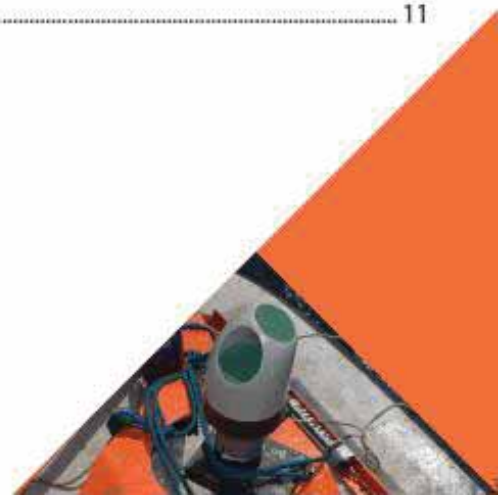

The PREFACE project was funded by the European Union 7th Framework Programme (FP7-Environment) to improve our understanding of the functioning of the tropical Atlantic climate and our capabilities to predict it and its impacts, with a particular focus on Atlantic African fishing communities. PREFACE brought together 28 partners across 18 countries in Europe and Africa with expertise in oceanography, climate modelling and prediction, and fisheries science, and three associate partners directly involved in the sustainable management of the three African Atlantic large marine ecosystems (LMEs). There was also close interaction with the tripartite French-German-African project AWA (Ecosystem Approach to the management of fisheries and the marine environment in West African waters). This policy brief summarises the project's key achievements and findings for the African-Atlantic region, with a focus on the fisheries sector. The brief includes recommendations arising from an interactive exchange with stakeholders during PREFACE-AWA science-policy session in Lanzarote, Spain, April 2018, and has sections devoted to the observing system, climate prediction, and fisheries system.

AWA/PREFACE (2013-2018)

58 Laboratories

24 Countries

7 Organization of International conference

2 Organization of summer school

4 Organization of High Level meeting

> 70 African student trained (PhD, M Sc.)

>400 Scientific communications

>200 Papers published at high scinetific level

>18 Research surveys at sea in African waters

Key achievements

PREFACE successfully developed cooperation among European and African research communities in natural and social sciences to study climate change and its impacts in the tropical Atlantic Ocean off the African coast. It initiated and strengthened North-South and South-South cooperation on this topic forging agreements with regional commissions and other local and international programs, such as the ones of the Benguela Current Commission, Sub-regional Fisheries Commission, and the AWA project. This cooperation contributed to the improvement of the scientific ocean observations network and climate prediction models such that it is now possible to usefully forecast climate from a season to a decade in advance over large regions of the tropical Atlantic Ocean, and over parts of continental South America and Africa. We showed that the upwelling intensity off North West Africa and consequent marine productivity are redistributed due to warming trends, and we report a northern spatial shift of round sardinella, one of the most important species for local fisheries. In the Benguela region, a similar shift is reported on the same species. Such potentially predictable changes are highly relevant for food security management, demanding adequate policy measures. We expect global warming will cause important changes in the micronekton species in all African Atlantic LMEs. Micronekton are essential to marine ecosystem functioning and these changes will affect the fisheries sector. PREFACE participated in high level meetings throughout the project lifetime and contributed to the training of many researchers in the region. Specifically, it enabled these researchers to perform applied sciences in the region, publish in high impact, international, peer-reviewed journals and interact with the international scientific community dealing with climate change impact. Such success in capacity strengthening significantly improves these researchers' advisory skills in this field for their local governments.

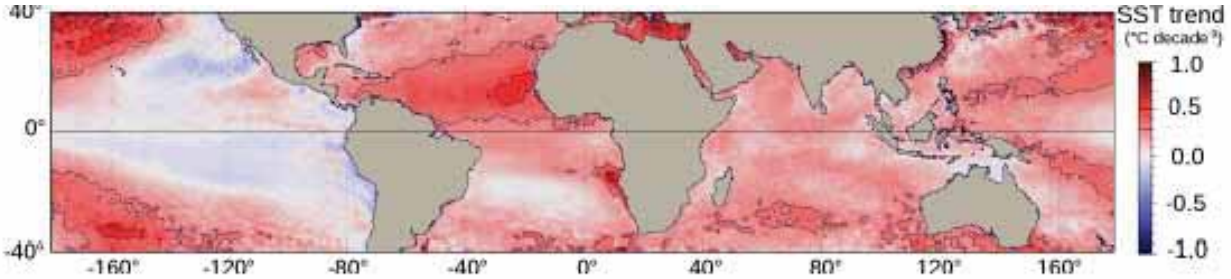

Figure 1: Space-based measurements provide fine spatial scale observations of key parameters for marine ecosystems. Sea surface temperature (SST) has been observed for 36 years. Based on this standardized data set, we present the regional effects of global warming. Of the three African Atlantic LMEs, the Canary Current Large Marine Ecosystem (CCLME) and Benguela Current Large Marine Ecosystem (BCLME) are particularly impacted by global warming, especially towards the equator (red area) (Source: Demarcq et al., 2018; AWA-PREFACE projects).

Recommendations arising from interactive exchanges with stakeholders

The development of climate services for the marine sectors should be made a priority, in order to provide accurate information on climate in a timely and accessible form to stakeholders, including policy- and decision-makers and society. The information, including current status short- medium- and long-term forecasts, can be used not only to foresee changes in the state of marine ecosystems and related services and goods, but also changes in environmental conditions affecting coastal urbanisation and agriculture, for example. This can contribute to the sustainable development of regions where not enough is known on the impact of climate change. The development of climate services fitting user demand requires stakeholder engagement, which requires trans-disciplinary teams involving scientists, users and beneficiaries of such services, and policy makers, who all speak a common language. More dialogue among different stakeholder groups to balance objectives is needed to strengthen (and implement) policy measures in the face of climate change.

AWA and PREFACE helped reveal much hidden expertise in the study regions. **Capacity building is no longer needed** but rather**, but about capacity strengthening** and making use of the expertise in national and regional institutes: funding for science needs to increase in these countries. Specifically, we recommend to increase local funding for marine science actions.

We strongly **emphasise the benefit of cooperation and specifically training and capacity strengthening**. PREFACE and AWA strongly contributed to intra-European and Europe-Africa collaborations, and also notabley to enhanced intra-African collaborations. This type of **cooperation** should be consolidated and common cruises, technology and skill transfers, scholarships for Masters and PhD students and **joint publications must be promoted**.

We recommend **clustering of international programmes and projects to increase their impact**, by fostering synergy and dialogue, and by empowering users and decision-makers through training and education. Such clustering of activities is particularly well illustrated by the close interaction of the AWA and PREFACE projects. The integration of efforts provides added value to the funders, the beneficiaries and the wider scientific community.

To **increase awareness of the societal benefit of global observations and climate models** is important. It can lead to the meaningful integration of the variety of observing and monitoring systems (physical, chemical, biological, social, and economic) and climate change information. To understand and detect long-term changes in the marine ecosystems, it is important to **continue the time series of acoustic surveys** using standardised protocols and survey designs and to **make environmental observations together with routine stock assessment exercises.** We emphasise the need to also collect more data on human local perception of environmental change and on the general economic situation and options for adaptation, as this allows local and traditional knowledge assessments of changes in marine resources and the environment. Thus, while observations in natural sciences are a prerequest, we also need **more economic and social sciences research linked to specific sectors and integrated management demand**.

Data sharing is important for progress in many scientific domains. However, creating local data centres is not conceivable in the near future due to lack of sufficient infrastructure and manpower. **Publishing data via scientific publications or international repositories** are the chosen solution for

data sharing. We **encourage historical data recovery** and its publication particularly for coastal observations. Likewise we recommend South-South scientific community, including across institutions in the same country (*e.g.* clusters of excellence) through changes in funding priorities (locally and internationally).

It is necessary to consider the impacts of climate change on the abundance and spatial distribution of fish stock that can extend beyond national boundaries. Climate change can also impact other sectors, such as agriculture and aquaculture. A better understanding of societal and economic needs, together with improved tools such as state-of-art economic modelling, is important for the development of conflict-free, adaptive strategies. **Regional collaboration should be supported and encouraged** to foster initiatives in this topic. Needless be said, regional and sub-regional policy must be prioritised, particularly for the integrated management of shared resources.

The governance should be considered as one central. We emphasize the importance of a structured approach to communicate and for dialogue, including defining mandates and roles of actors. Best practice in **communication between producers of scientific results** (*e.g.*, **researchers**) **and users** (*e.g.*, **managers**) should be defined. Moreover, we recommend **good coordination among research institutes**, fisheries administrations and professionals, and sometimes even between fisheries and fisheries research institutes and other relevant scientific institutes. Such governance will allow to develop research programs that address the most important fisheries problems occurring in the developing countries.

Tropical Atlantic Observing System

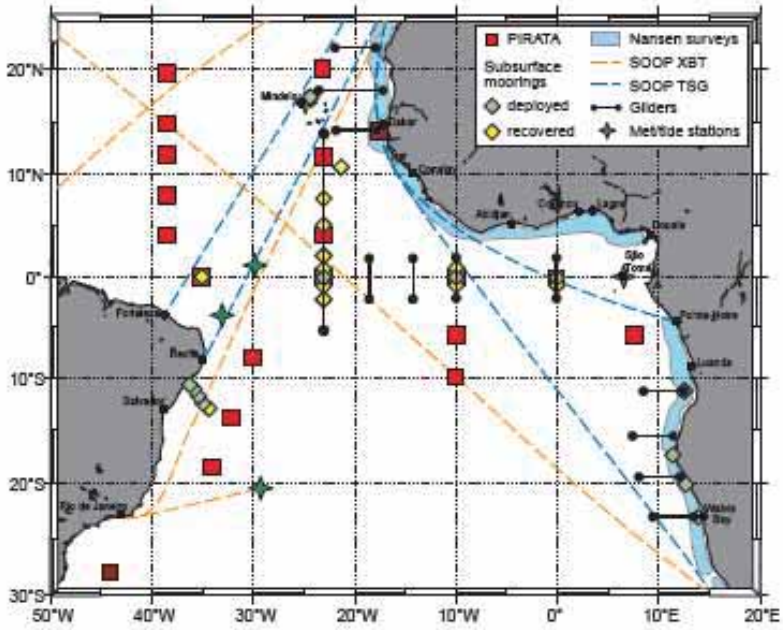

Figure 2: Key elements of the present tropical Atlantic observing system: The Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) network of oceanographic-meteorological buoys; fisheries and oceanographic survey regions from the EAF-Nansen Programme; Surveys Ship Of Opportunity Program (SOOP) Expendable Bathythermograph (XBT) and Thermosalinograph (TSG); deployed and recovered subsurface moorings; and recent surface glider measurement campaigns. (Source: Brandt et al., 2016; PREFACE project).

Sustained critical observations of environmental variables within the ocean are crucial for understanding the ocean's major role in the Earth's climate system and improving climate models. They also contribute to better understanding the functioning of marine ecosystems, to ultimately achieve a sustainable ecosystem-based and integrated management of our oceans. During the last decade much progress was made in understanding tropical Atlantic variability. This was particularly due to the enhancement of the tropical Atlantic observing system within different international and national programs. Among these, PREFACE contributed particularly to enhancing the ocean observing system in the eastern tropical Atlantic, a region of key uncertainty in the Earth's climate system and that encompasses 3 LMEs of great socioeconomic importance.

Selected key achievements

Within a larger landscape of national and international initiatives to enhance the critical observing system for the Atlantic, AWA and PREFACE added observations in the eastern tropical Atlantic including previously less explored near-coastal regions. Within PREFACE, new time series stations were established to enhance the PIRATA (Fig. 2) network in the south-eastern tropical Atlantic, to complement continuous measurements along the equatorial and coastal regions with subsurface moorings crucial for detecting climate signals propagating from the equatorial Atlantic towards the biologically productive south-eastern boundary upwelling region, and to establish near-coastal atmospheric and oceanographic measurements in the biologically productive region off Senegal within the CCLME. Due to the intense cooperation and capacity strengthening activities within PREFACE, historical datasets from near-coastal regions off Africa, particularly including hydrographic data from the Nansen programmes, could be made available for scientific analysis thereby drastically enhancing the climate record of the tropical Atlantic. Dedicated shipboard and glider observations carried out within PREFACE complemented the available database.

Specific recommendations

We recommend maintaining the PREFACE funded eastern boundary extensions to the observing system. These are especially critical to the monitoring and prediction of future Benguela Niño events.

We also stress the **importance in maintaining continuous time series**, as these are essential to monitoring and detecting long-term changes.

Joint oceanographic and marine-ecosystem observations and fisheries statistics are critical for improving our understanding of environmental and anthropogenic driven ecosystem changes.

Tropical Atlantic Climate Prediction

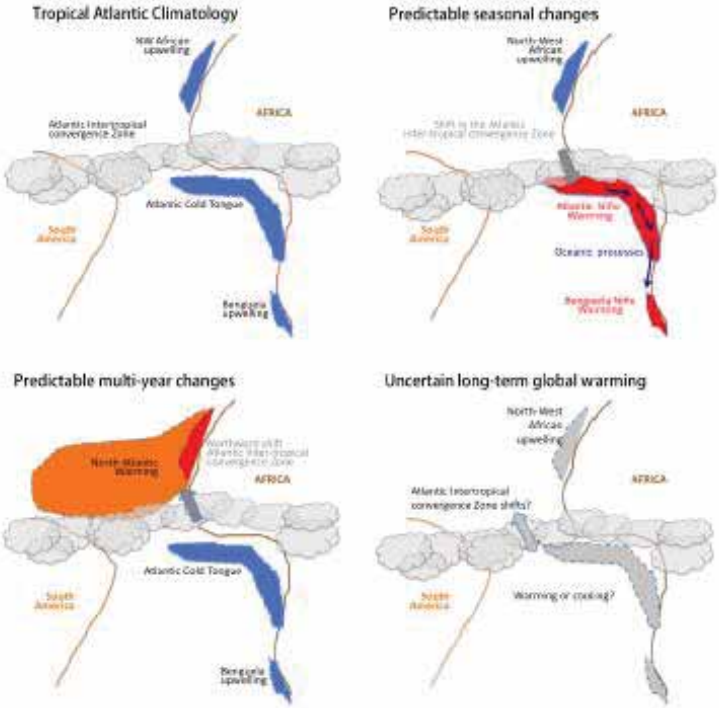

Figure 3: Schematic of tropical Atlantic climate and its key patterns of change. The Atlantic ITCZ links continental climate to the Atlantic Ocean on seasonal, multi-year, and longer time scales. Changes in the position of the ITCZ are reflected in changes in rainfall as well as equatorial and fisheries-important coastal upwelling. Reliable prediction of these changes can be of great socio-economic benefit for countries in Africa and South America, but also for Europe and other parts of the world (Source: Keenlyside et al., 2018; PREFACE project).

African and South American climate is closely tied to the tropical Atlantic Ocean through its interaction with the overlying rain band, known as the Atlantic Intertropical Convergence Zone (ITCZ), that extends from equatorial South America to North Africa. Over the ocean the rain band is collocated over the warmest surface waters and where the surface trade winds from the northern and southern hemispheres meet. The surface winds cause upwelling of cold and nutrient rich waters to the surface in the eastern equatorial Atlantic (known as the Atlantic cold tongue), in the Benguela region, and along the north West African coast. These cold surface waters are very biologically productive.

The rainfall patterns, winds, and the ocean undergo large seasonal variations that are linked to the West African and South American Monsoons.

Shifts in these large-scale atmospheric and oceanic patterns occur on both short and long-time scales and can have great impact on climate, locally and globally. PREFACE has used observations and numerical models to improve our understanding and ability to simulate and predict climate variability and change in the tropical Atlantic, and its global impacts.

Selected key achievements

Atlantic Niño events are characterised by warming of the eastern equatorial Atlantic Ocean and by a south eastward shift of ITCZ affecting rainfall over the Gulf of Guinea. These events occur mainly during June to August. We have better explained how ocean circulation is the primary cause of these anomalous ocean temperatures and rainfall patterns. We have also decisively shown that Atlantic Niño variability influences the Pacific El Niño phenomenon. Our results indicate that Atlantic Niño events in austral winter can be predicted one to two months ahead.

Benguela Niño events are characterised by a sudden warming of the ocean in the Benguela region that is often associated with collapse of local fisheries. PREFACE has clarified that most Benguela Niño events are connected to Atlantic Niño events. Oceanic processes along the eastern boundary of the Atlantic connect these events and provide the potential to predict Benguela Niño events up to two months in advance. However, some Benguela Niño events, such as the one in 2016, result from local atmospheric and oceanic conditions and are much less predictable. The PREFACE extensions to the tropical Atlantic observing system were critical to obtaining these results.

The tropical Atlantic Ocean also undergoes large changes from one decade to another. This variability is referred to as Atlantic multidecadal variability or the Atlantic Multidecadal Oscillation. PREFACE has shown how this variability is most likely caused by processes internal to the climate system, *i.e.*, natural, not driven by global warming. This oceanic variability can be predicted 5-10 years in advance, and because of it we are able to predict the rainfall conditions over the Sahel. Current forecasts indicate that during the next decade Sahel rainfall will be above its long-term average.

Climate models clearly show that the anthropogenic driven increase in greenhouse gases has caused long-term warming of the tropical Atlantic Ocean (Fig. 1), and that this warming will continue and intensify. However, climate models need to be improved, as they poorly predict changes in temperature and rainfall at regional scales. PREFACE has contributed to improve models for the tropical Atlantic and outlined strategies to even improve them further.

Specific recommendations

PREFACE has shown that **prediction of climate in the tropical Atlantic is possible** in certain cases for a season to several years in advance. We recommend to invest in the further development of climate services so that society in the region can benefit from these predictions.

To achieve more skilful climate predictions and reduce uncertainties in climate change projections, we recommend continued research on **improving the understanding of tropical Atlantic climate variability** and on improving climate prediction models. Sustained observations at sea are critically important to both.

We recommend that research on understanding and modelling the influence of environmental factors on the marine ecosystem be prioritised. This will increase the value of climate predictions.

Tropical Atlantic Fisheries Systems

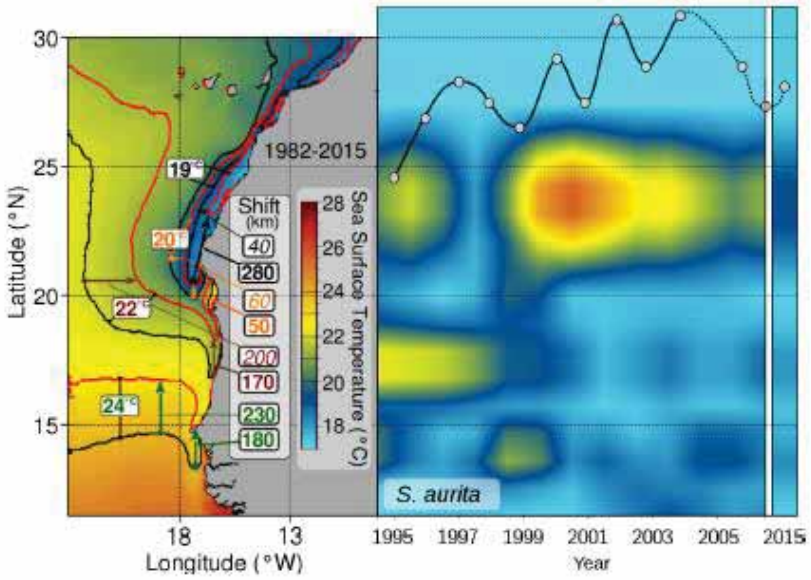

Figure 4: The increase in sea temperatures in the north (e.g. the 24°C isotherm shift of around 230 km in 20 years) appear linked to the northern shift of a key finfish species (Sardinella aurita) for food security in West Africa, whereas the spatial distribution of another species of the same family (Sardinella maderensis) is not impacted (Source: Sarré , 2018; AWA-PREFACE projects).

For African countries of the tropical Atlantic, the dependence on fish for development, food security, and poverty alleviation is comparatively high. In these regions, to support the proper ma¬nagement of marine resources, fisheries research has so far focused mainly on commercially exploited stocks and on measuring single stock population dynamics and life history traits. In recent years, however, uncertainty associated with effects of changing environmental conditions on marine ecosystems has prompted scientists to urge for the adoption of a precautionary approach with a shift in policy focus towards an ecosystem-based management. This is particularly difficult to implement in these regions as basic information of a single stock is often missing. Compounding this, many stocks are also highly migratory and their transboundary nature require transnational management schemes. Nevertheless, the effect of envi¬ronmental changes in combination with other stressors such as fishing pressure needs to be assessed to inform a sustainable resources management. In addition, fish consumption per capita is high and many fisheries are artisanal. Hence the societal and economic impacts of changes in the resources, as well as additional social and economic drivers, need to be understood to ensure the sustainable development and well-being of coastal communities.

Selected key achievements

The analysis of Yellowfin tuna catches in Cape Verde revealed that climate and fish stock are both important factors determining catch. This highlights the impact of local climate on local fisheries with important implications for fisheries economics. In terms of prey fish dynamics, the first long-term and large scale comparison of mesopelagic fish data in terms of biomass spectra revealed significant changes in terms of trophic efficiency in oceanic food webs. We identified a possible link between the dominant large-scale weather pattern in the North Atlantic - the North Atlantic Oscillation - and biomass production and fisheries in the Canary Current LME (CCLME).

We have observed the poleward expansion of tropical Atlantic finfish species during the last 25 years in both hemispheres. Off northwest Africa, the northern range of the *Sardinella aurita* stock has shifted by two degrees to the north, to regions previously inhabited almost exclusively by subtropical sardines. Off southwest Africa, the adult sardinella exhibited a strong interannual variation in the seasonal migration cycle, synchronized with the strength of the interannual equatorial climatic events. In the southern range of sardinella distributions, a change in fish age structure was observed, from a majority of adult migratory fish during the 1990s to an increasing proportion of locally born juveniles during the current decade.

For the analysis of interannual variability and long-term trends in micronekton micronekton – a key component of marine food webs – in the three African Atlantic LMEs, we compile acoustic data from almost 300 000 km of surveys covering the past 20 years and environmental data from satellite remote sensing. The analysis revealed the three LMEs are highly variable systems, with the CCLME and the BCLME being particularly impacted by global warming, particularly towards the Equator. From 1995 to 2015, in the CCLME there was a significant increase of the minimum depth of micronektonic layers and of their mean density. The environmental forcing shown less impact than expected on their variability. Sea surface temperature has a minor influence on micronektonic distribution in the north CCLME, whereas it has a pronounced effect in the south CCLME. Considering the relative importance of oceanographic factors, stronger ecosystem perturbations are expected in BCLME than in the CCLME. Global warming is expected to cause important changes in the three LMEs and hence many ecosystem service-dependent sectors, such as fisheries. Additionally, if a cli¬mate-driven change in amplitude and depth of micronekton is found to be significant, it will have a strong impact on the ocean carbon pump and climate. Particularly, for the deepening trend observed in the CCLME, this could enhance the carbon sink and consequently buffer the carbon dioxide emission in the atmosphere.

The socio-economic surveys conducted in Senegal and Cabo Verde show that impacts of weather changes on the fisheries resource are clear. For Senegal, this is mainly apparent in the perception on rainfall pattern effects, while for Cabo Verde, wind changes may prove more important, on the resource as well as on fishing effort in the artisanal sector. The data also shows the sensitivity and adaptive capacity of the fishing sector in the two countries. While in Senegal specialization is at the individual level but on a rather diverse range of target species and gears used, the Cabo Verde fisheries depend precariously on only six species, and most importantly, tuna. This is true on individual, fishing sector and total-fishery level. In that regard, while only individual sensitivity is high in Senegal and the artisanal sector itself is likely too diverse to be hard hit by single species changes, the Cabo Verde fishery is very sensitive to certain species changes.

The economic analysis of the Senegalese fisheries on small pelagic species showed however that this sector is indeed vulnerable to changes in catchability, affected by changes in sea surface temperature. A sea surface temperature shock during summer can increase the catchability by one third. However, long term effects can be negative due to decrease in population biomass. In addition, economic drivers like fuel prices also have a significant negative effect on the profitability of the purse seine and encircling net fisheries. For the Senegalese purse seine fishery, operating costs have increased by 90% over the last twenty years, mainly due to an increase in fuel prices.

Specific recommendations

We recommend to **improve the communication and coordination between producers of scientific results** validated by their peers (high level scientific production) **and end-users as fishermen, managers, and decision-makers**.

We recommend the **improvement of economic and social science research** linked to specific sector and management demand, including the collection of respective sectoral data as well as data related to community well-being. As prerequisite the key fisheries must be monitored to get time series of basic information such as landing, fishing effort, size class, etc., by the national institution of the fisheries sector and if possible share the logistical, financial and human resources at national, sub-regional or even at regional levels.

We recommend the **inclusion of local or traditional knowledge** to assess changes in the resource base and the environment in general.

Abbreviations

ATLAFCO - The Ministerial Conference on fisheries cooperation among African States bordering the Atlantic Ocean

AWA - Ecosystem Approach to the management of fisheries and the marine environment in West African waters

BCC - Benguela Current Commission

BCLME - Benguela Current Large Marine Ecosystem

CCLME - Canary Current Large Marine Ecosystem

FCWC - Fisheries Committee for the West Central Gulf of Guinea

GCLME - Guinea Current Large Marine Ecosystem

ITCZ - Intertropical Convergence Zone

LME - Large Marine Ecosystem

PREFACE - Enhancing Prediction of Tropical Atlantic Climate and its Impacts

SRFC - Sub Regional Fisheries Commission

SST - Sea Surface Temperature

Contacts

Patrice Brehmer patrice.brehmer@ird.fr

Noel Keenlyside noel.keenlyside@gfi.uib.no

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Les notes politiques de l'ISRA - BAME - Juillet - 2019

Bureau d'analyses macro-économiques
Institut sénégalais de recherches agricoles

Dynamique du Yaboy mërëg et du Cobo au Sénégal dans un contexte de changement climatique : diagnostic et synthèse bioécologiques

Bocar Sabaly BALDÉ, Hamet Diaw DIADHIOU, Fambaye Ngom Sow, Massal FALL, Patrice BREHMER

MESSAGES CLES

1. Améliorer les avis scientifiques nécessaires pour une gestion durable de deux principaux stocks de petits pélagiques côtiers exploités dans la zone sénégalaise (Yaboy mërëg et Cobo).
2. Les petits poissons pélagiques occupent une part importante dans l'approvisionnement en protéines animales des populations sénégalaises et sont d'une importance vitale pour leurs besoins nutritionnels (notions de sécurité alimentaire).
3. Encourager les gestionnaires à considérer l'existence de différents stocks de Cobo dans la sous-région et au Sénégal, dans leur évaluation de stock et leur plan de gestion.
4. Le Yaboy mërëg et le Cobo sont en état de surexploitation.
5. La taille de première capture constatée au Sénégal pour le Yaboy mërëg et le Cobo est inférieure à la taille de première maturité sexuelle ; ce qui est préjudiciable aux pêcheries.
6. Nous recommandons de réviser la législation sur la taille légale de capture des Yaboy mërëg et des Cobo afin d'améliorer la productivité du système pêche.
7. Pour une meilleure compréhension des processus en cours dans le système d'upwelling Sénégalo-mauritanien nous plaidons pour une collaboration scientifique sous régionale accrue, qui peine à se mettre concrètement en place.
8. Une réflexion sur des concepts d'agro-écologie à appliquer aux pêcheries ouest africaines est à mener.

CONTEXTE

En Afrique de l'Ouest (Sénégal, Gambie, Guinée Bissau, Mauritanie et Maroc), les ressources pélagiques côtières, les plus importantes, ont une caractéristique commune : elles sont situées dans une zone d'upwelling. L'upwelling côtier est la caractéristique océanographique la plus frappante de la région. Qu'il soit permanent ou saisonnier, celui-ci affecte profondément les structures physiques et biologiques des écosystèmes et sont à l'origine de la productivité biologique élevée de ces régions côtières (Thiaw et collaborateurs, 2017 ; Baldé 2019).

Ainsi, il est important d'approfondir notre connaissance sur les adaptations des petits pélagiques aux modifications de l'environnement, d'estimer les impacts de ces changements sur les écosystèmes et de développer des instruments (indicateurs fiables et durables) et des modèles permettant d'évaluer et de prédire l'évolution des stocks et des écosystèmes dans des contextes divers dont celui de la surexploitation combinée au changement climatique.

Le dynamisme de la pêche artisanale réside dans sa capacité à s'adapter en permanence aux modifications du contexte de l'activité (disponibilité qualitative et quantitative de la ressource, conditions économiques du moment en référence aux possibilités d'écoulement des produits et les niveaux de rémunération des marchés).

Dans ce contexte, la principale préoccupation des scientifiques (photo 1) et des gestionnaires des pêches au cours des dernières années a été d'essayer d'éviter la surcapacité (Baldé 2019). Or, pour gérer cette ressource de façon durable, il faut pouvoir évaluer la variabilité dans le temps et dans l'espace de ces ressources et évaluer le niveau d'exploitation. Ces résultats permettront d'estimer le potentiel de ces ressources afin d'identifier les mesures de gestion les plus appropriées face aux attentes des décideurs et des acteurs.

LES PECHERIES

Le Yaboy mërëg (sardinelle ronde) fait déjà l'objet d'une exploitation intensive par des flottes artisanales (photo 2) au Sénégal (Baldé 2019) et en Mauritanie par des flottes de pêche industrielles étrangères dans le cadre d'accords de pêche (ex : Turquie, Union Européenne et Fédération Russe) ainsi qu'au Maroc qui fait partie d'un ensemble écologique commun. Il faut aussi noter l'augmentation des usines de farine de poisson qui ciblent les sardinelles en Mauritanie et au Sénégal. Par exemple, en Mauritanie, l'augmentation de l'effort de pêche est liée à l'expansion de l'industrie de la farine à Nouadhibou et Nouakchott. En effet, les débarquements de Sardinelle ronde dans les

minoteries sont passés de 30% en 2012 à 45% en 2013 et à 62% en 2014 (FAO, 2016). Le nombre de sociétés de farine en activité est passé de 18 usines en 2012 à 22 en 2013. Le même scénario est observé au Sénégal où la production à Saint-Louis et particulièrement le long de la Petite Côte (Mbour et Joal) est toujours stimulée par l'existence du marché sous régional et la mise en place d'usines de production de farine de poisson selon le récent rapport de Greenpeace (2019).

En raison de la demande croissante de sardinelle ronde pour la consommation humaine locale et internationale, l'effort de pêche des flottes artisanales au Sénégal (photo 3) et en Mauritanie a régulièrement augmenté ces dernières années. Cependant, le précédent accord de pêche qui liait Dakar à Nouakchott n'avait pas été renouvelé depuis janvier 2016 en raison du refus de la partie sénégalaise d'observer l'obligation de débarquement des prises en Mauritanie, prévue par une nouvelle réglementation mauritanienne. Le nouvel accord signé par les ministres sénégalais et mauritanien de la pêche le 19 décembre 2018, d'une durée d'un an renouvelable, permet aux pêcheurs sénégalais de bénéficier de 400 licences pour capturer 50 000 tonnes de poissons pélagiques avec 400 pirogues. Les espèces concernées par cet accord sont notamment les deux sardinelles, les chinchards, l'ethmalose et l'anchois.

Compte tenu de la pression de pêche importante subie par la sardinelle ronde, les gestionnaires des pêches ont cherché à modéliser les séries chronologiques des prises comparées à la densité, au recrutement ou à la production (Baldé 2019). En effet, appliquer ces indicateurs (ex. indices d'abondances) à des stocks tels que la sardinelle ronde pour démontrer leur utilité et permettre aux acteurs de la pêche (p.ex. pêcheurs, gérants de supermarchés, consommateurs et politiciens) de participer à la gestion des pêches et de renverser le schéma mondial de la surpêche (Baldé 2019).

Photo 2 : Flottes artisanales au Sénégal.
Crédit photo : Dr Massal Fall (2018)

Photo 3 : Débarquements de la flotte artisanale sur les côtes sénégalaises.
Crédit photo : Dr Massal Fall (2017)

Photo 1 : Navire de recherches halieutiques, ITAF DEME du CRODT de l'ISRA.
Crédit photo : Dr Patrice Brehmer (2015)

Le Coko (ethmalose) est principalement exploitée par les pêcheries artisanales en Gambie, au Sénégal et récemment en Mauritanie. Elle est surtout pêchée au moyen de la senne tournante en Mauritanie, et de filets maillants encerclant au Sénégal et en Gambie. Les captures de l'ethmalose au Sénégal ont légèrement fluctué, mais ont chuté à partir de 2010 d'environ 45 % en 2011 et 34 % en 2012 avant de remonter en 2013 et 2014 (79 %). Au Sénégal, l'effort de pêche des filets maillants encerclant est passé de 22 553 sorties en 2013 à 30 513 sorties en 2014 soit une hausse de 35 % (Baldé et collaborateurs, 2018). La production, surtout le long de la Petite Côte du Sénégal (Mbour et Joal), est stimulée par l'existence du marché sous régional et l'implantation d'usines de production de farine de poisson.

CONNAISSANCES SCIENTIFIQUES SUR LES RESSOURCES

Sur la base des données de fréquences de taille des poissons et d'un indice d'upwelling côtier, nous avons observé que le recrutement de la sardinelle ronde a tendance à se produire pendant les périodes d'upwelling les plus intenses (mars-avril au large du Sénégal), ce qui est conforme aux résultats obtenus par

Diankha et collaborateurs en 2018. Le pic de reproduction correspond aux périodes de basse température de la surface de la mer (en février ou mars ; Baldé et collaborateurs. 2019). Le sex-ratio était remarquablement constante pendant une période d'étude de 30 ans (entre 1995 et 2014) et n'a pas été affecté par les changements environnementaux subits dans leur habitat (Baldé et collaborateurs, 2019). La performance de croissance est fortement dépendante des conditions environnementales (Baldé et collaborateurs, 2019). Les périodes de reproduction semblent s'établir lorsque la nourriture (proies zooplanctonique et phytoplanctonique) est la plus abondante et disponible, ce qui permet de fournir les besoins énergétiques nécessaires aux adultes pour la reproduction, mais aussi le développement de leurs larves. Les changements environnementaux semblent avoir un effet significatif positif sur la croissance et la reproduction de la sardinelle ronde, ce qui confirme leur forte plasticité phénotypique (Baldé et collaborateurs, 2019).

En ce qui concerne l'ethmalose, au large des côtes sénégalaises, elle présente un pic de fécondité lorsque la température de l'eau est d'environ 24°C et que la disponibilité alimentaire est moyenne (Baldé 2019). Auparavant on se basait sur des travaux historiques de deux français qui dataient de presque un demi-siècle qui signalait une température de reproduction maximale de 30°C. L'espèce se serait apparemment adaptée aux changements environnementaux pour profiter de conditions environnementales optimales qui se produisent au large de cette côte.

LA GESTION ET L'AMENAGEMENT DES PECHERIES

Compte tenu des grandes (sardinelle ronde) et faibles (ethmalose) amplitudes migratoires des espèces étudiées, deux approches peuvent être développées pour la gestion durable des petits pélagiques. Il est, en effet, urgent de prendre des mesures d'aménagement par une régulation basée sur la distribution transfrontalière des stocks. La responsabilité de la réduction des stocks de petits pélagiques au niveau sous régional, ainsi que du fléchissement du rendement économique et du marché de l'emploi dans les pêcheries, doit être partagée entre les pays concernés, les pêcheurs, les autorités d'aménagement des pêcheries, les gestionnaires des pêcheries et les experts des pêches. Toute politique d'aménagement des sardinelles doit être concertée et devrait se faire par l'intermédiaire d'un organisme commun aux pays intéressés doté de moyen adapté, et ne pas se contenter de se réunir annuellement pour constater les problèmes liés au suivi de la ressource entre chaque pays.

La gestion de la pêcherie de l'ethmalose est nécessaire pour améliorer le renouvèlement des stocks au Sénégal. De ce fait, afin de de préserver le potentiel de reproduction de l'ensemble du stock d'ethmalose nous recommandons aussi de: (1) augmenter la taille à la première capture, afin de permettre aux individus de grandir et d'assurer la survie à long terme des populations et donc d'une pêche durable, (2) recourir à une réduction drastique de la capacité de pêche, (3) sanctionner, préalablement à une campagne de sensibilisation-information *ad hoc*, la capture, la vente et la transformation de juvéniles et (4) diminuer le nombre des filets maillants en activité du fait de leur faible sélectivité qui induit un fort potentiel de capture accessoire.

LIMITES ET PERSPECTIVES

Les analyses des données historiques ont permis de dégager des facteurs potentiellement responsables de la variabilité de l'abondance, de la migration et de la fluctuation des captures de sardinelle ronde et de l'ethmalose (Baldé et collaborateurs, 2019 & 2018). Cependant, elle comporte des limites. La limite principale de cette étude réside dans l'étude de la biologie et de la dynamique de la sardinelle ronde. La sardinelle ronde est une espèce migratrice (du sud Marocain à la Guinée Bissau en passant par le Sénégal et la Mauritanie), cependant les données environnementales et biologiques de cette étude provenaient essentiellement du Sénégal. Les sardinelles exploitées au Sénégal ne peuvent être isolées de celles capturées dans les pays voisins et toute exploitation faite en dehors des frontières maritimes du Sénégal à des répercussions importantes sur la production dans les eaux sénégalaises (Nguyen 2018). Les captures annuelles peuvent varier de façon considérable et toute perspective de développement de la pêche dans les pays riverains doit tenir compte de cette situation.

Aux données de température, de salinité, il semble désormais nécessaire de combiner celles sur l'oxygène dissout. Ainsi l'effet potentiellement limitant, notamment sur la croissance et la reproduction et la migration des espèces de petits pélagiques de l'oxygène dissout, mériterait d'être étudié dans notre zone d'étude. En effet l'existence d'épisode hypoxie sur le plateau sénégalais a été mise en évidence dans le projet AWA (2013-2017). Est-il envisageable que la teneur en oxygène puisse être contraignante dans la migration des espèces de petits pélagiques et leur distribution spatiale ? Est-il possible que dans l'habitat pélagique de notre système d'étude des phénomènes d'hypoxie, voire d'anoxie, aient un effet sur les chances de survie des œufs et larves des petits pélagiques ? etc.

De nombreuses études sont encore à mener pour affiner nos connaissances relatives aux petits pélagiques côtiers. Dans le cadre de notre travail, il nous est apparu essentiel d'en prioriser quatre qui auraient permis une meilleure compréhension : (1) étude et suivi *in situ* de la ponte (en batch) à l'éclosion des larves de sardinelles, l'influence de la température sur le développement des différents stades larvaires, ainsi que d'autres paramètres environnementaux (ex. : concentration en chlorophylle[1], la salinité de l'eau de mer, l'oxygène dissous) sur ces différents stades. Il faut noter que la survie des premiers stades de développement du poisson est l'un des processus les plus complexes en milieu marin et difficile à estimer ; (2) Réalisation d'une étude génétique pour statuer sur la controverse relative au nombre de stocks et de métapopulation de sardinelles dans la sous-région ; (3) Conduire des études bioéconomiques afin de voir l'impact des fluctuations des prix sur les prises selon les périodes de reproductions des espèces et de forte abondance. (4) Elargir les études de la stratégie démographique des petits pélagiques côtiers à l'échelle de l'aire de distribution des espèces et enfin, (5) valider puis intégrer les résultats issus des analyses biologiques et écologiques récentes dans les procédures d'évaluation des stocks

[1] Indicateur de la production primaire à la base de chaine alimentaire marine.

(mettre à jour), voire de mettre en place de nouvelles procédures. Il est aussi bon de rappeler l'importance de pouvoir disposer de données fiables et exhaustives pour formuler de bon avis scientifique sur ces deux espèces indépendamment de partenaires technique et financiers étrangers.

POUR EN SAVOIR PLUS

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INFORMATIONS SUR LES AUTEURS

Bocar Sabaly BALDE, est chercheur au *Centre de Recherche Océanographique de Dakar-Thiaroye (CRODT) l'Institut Sénégalais de Recherche Agricole (ISRA), Dakar, Sénégal.* bocarbalde2005@hotmail.com

Hamet Diaw Diadhiou, est chercheur, chef de centre au *Centre de Recherche Océanographique de Dakar-Thiaroye (CRODT) l'Institut Sénégalais de Recherche Agricole (ISRA), Dakar, Sénégal.* hamet_diadhiou@yahoo.fr

Fambaye Ngom Sow est chercheur en charge des pélagiques au *Centre de Recherche Océanographique de Dakar-Thiaroye (CRODT) l'Institut Sénégalais de Recherche Agricole (ISRA), Dakar, Sénégal.* ngomfambaye2015@gmail.com

Massal Fall est colonel vétérinaire et enseignant chercheur à *l'Université du Sine Saloum El-Hâdj Ibrahima NIASS, Fatick, Sénégal.* massal.fall@yahoo.com

Patrice Brehmer est chercheur à *l'Institut de Recherche pour le Développement (IRD-France), et accueillie au sein du Centre de Recherche Océanographique de Dakar-Thiaroye (CRODT) l'Institut Sénégalais de Recherche Agricole (ISRA), Dakar, Sénégal.* patrice.Brehmer@ird.fr

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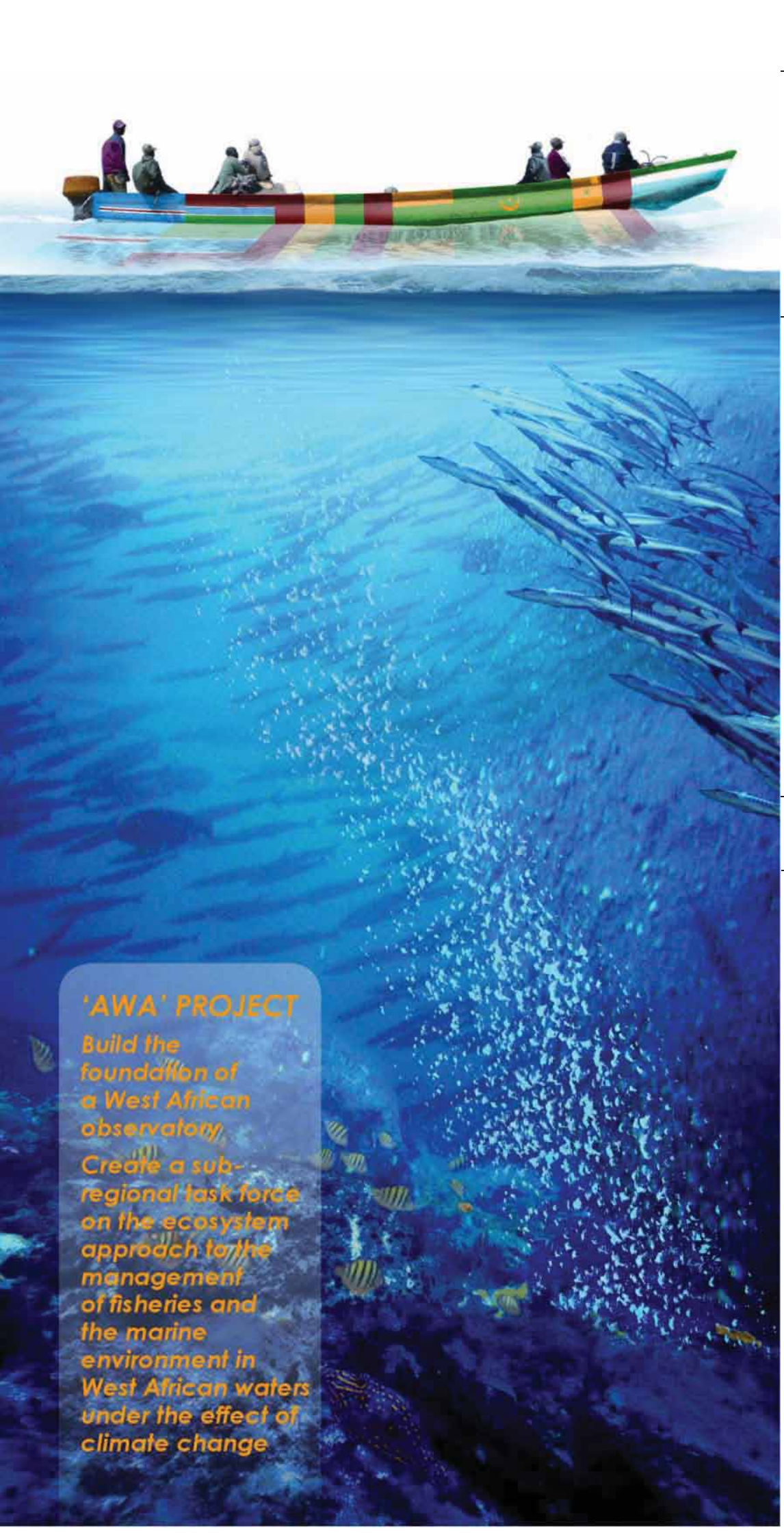

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