Policy Brief

AWA and PREFACE policy session

Key findings and recommandations

December 2018

Enhancing Prediction of Tropical Atlantic Climate and its impact

Enhance cooperation between European and African researchers working on Tropical Atlantic climate and its impacts, by fostering existing collaborations and improving project synergy

UNION EUROPEENNE SEVENTH FRAMEWORK PROGRAMME

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 Daïm 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).

Contents

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.

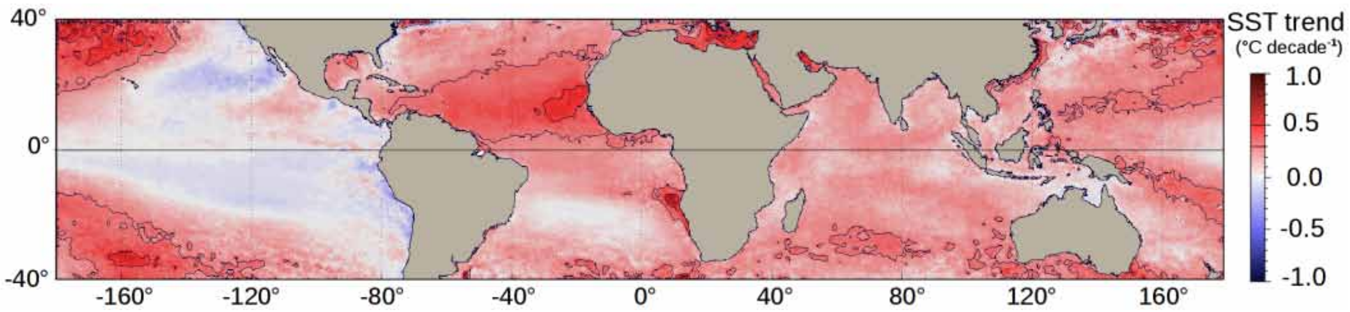


Figure 1: Space-based measurements provide fine spatial scale observations of key parameters for marine ecosystems. Sea surface temperature (SST) has been observed for 36 years. Based on this standardized data set, we present the regional effects of global warming. Of the three African Atlantic LMEs, 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

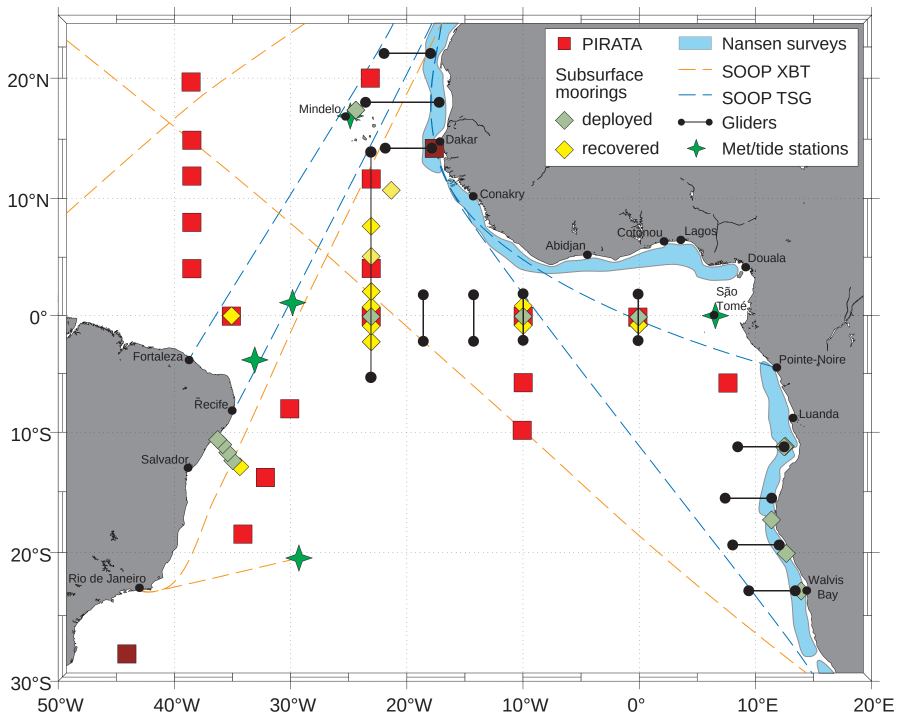


Figure 2: Key elements of the present tropical Atlantic observing system: The Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) network of oceanographic-meteorological buoys; fisheries and oceanographic survey regions from the EAF-Nansen Programme; Surveys Ship Of Opportunity Program (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

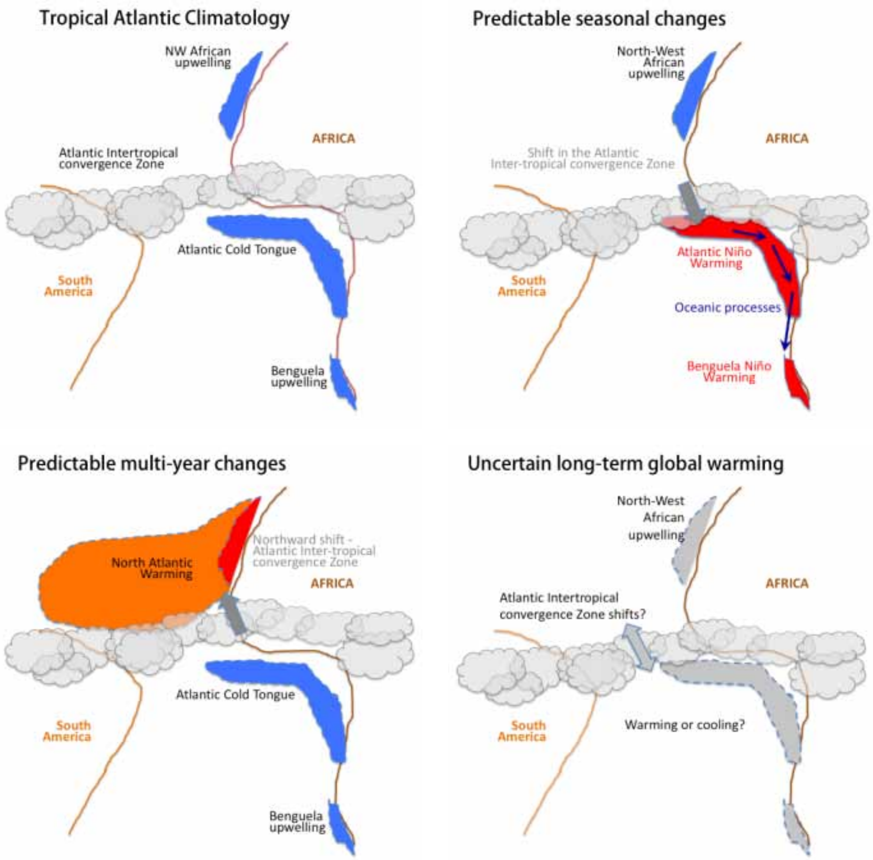


Figure 3: Schematic of tropical Atlantic climate and its key patterns of change. The Atlantic ITCZ links continental climate to the Atlantic Ocean on seasonal, multi-year, and longer time scales. Changes in the position of the ITCZ are reflected in changes in rainfall as well as equatorial and fisheries-important 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

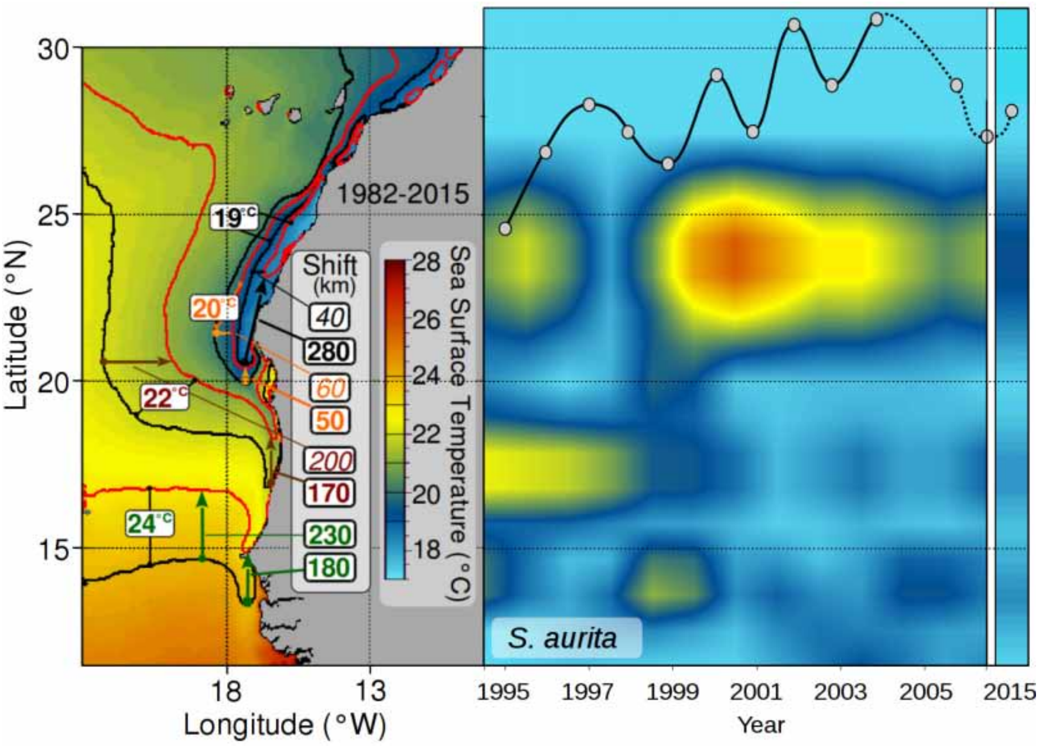


Figure 4: The increase in sea temperatures in the north (e.g. the 24°C isotherm shift of around 230 km in 20 years) appear linked to the northern shift of a key finfish species (Sardinella aurita) for food security in West Africa, whereas the spatial distribution of another species of the same family (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

Scan me

Scan me

Special thanks to:

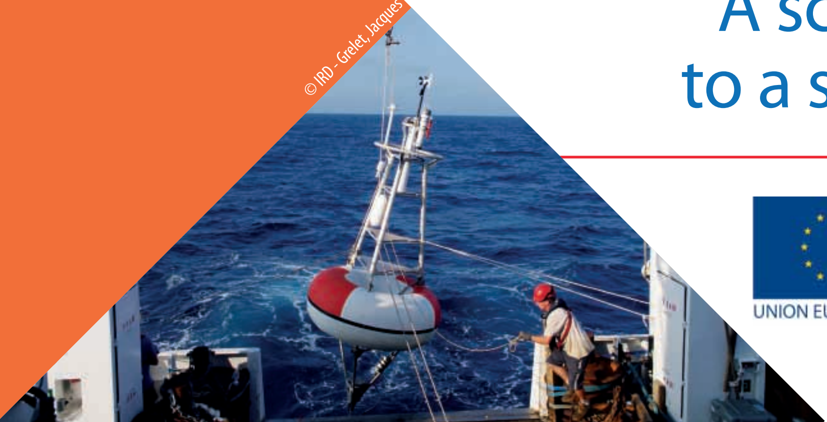
Federal Ministry of Education and Research

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

BJERKNES CENTRE for Climate Research

OCEAN UNIVERSITY INITIATIVE WITH CAMPUS MONDIAL DE LA MER

KIEL MARINE SCIENCE CONNECTED RESEARCH



© IRD - Grelet, Jacques

A science committed to a sustainable future

French National Research Institute for Sustainable Development
IRD Institut de Recherche pour le Développement FRANCE

UNION EUROPEENNE

SEVENTH FRAMEWORK PROGRAMME

CSRP SRFC

AWA

PREFACE