Insight from PREFACE & AWA on Tropical Atlantic Tuna ecology and effects on western African fisheries economies

Patrice Brehmer[1,*], Joern Schmidt[2], Heino Fock[3], Carlos Ferreria Santos[4], Timothée Brochier[1], Fambaye Ngom[5], Vanda Monteiro[4], Pierre-Amael Auger[6], Eric Machu[6], Xavier Capet[7], Gerd Kraus[3], Noel Keenlyside[8]

[1] *IRD UMR Lemar, ISRA-CRODT, Dakar, Senegal*
[2] *University of Kiel, Kiel, Germany*
[3] *TI, Hamburg, Germany*
[4] *INDP, Mindelo, Capo-Verde*
[5] *ISRA-CRODT, Dakar, Senegal*
[6] *IRD LPO, IUEM, Plouzané, France*
[7] *CNRS, UMR Locean, Paris, France*
[8] *University of Bergen, Bergen, Norway*

* Correspondance Patrice.Brehmer@ird.fr , Tel.: (+221) 78 1221615

Two on-going projects, Preface (EU DG Env. FP7) and AWA (BMBF & IRD-MESR-MAEE) both ending in 2017 will work on the ecosystem functioning and to enhance prediction of Tropical Atlantic climate and its impact. In Africa, fisheries play an important economic, social and environmental role. Historically, in South Africa and other countries, research and data collection pertaining to the oceans mainly focused on exploited fish populations and their management. In recent years, however, uncertainty associated with effects of changing environmental conditions on marine ecosystems has prompted scientists to suggest the adoption of a precautionary approach with a shift in policy focus towards an ecosystem-based approach. Although distant water fleets are currently a major pressure on stocks in West Africa and thus the local fisheries, global warming will be an important and likely irreversible additional pressure. 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. African countries bordering the Atlantic depend strongly upon their ocean - 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, the most productive around the world, are also of great climatic importance. The Tropical Atlantic is a region of key uncertainty in the earth-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. We take 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: (i) reduce uncertainties in our knowledge of the functioning of Tropical Atlantic climate, climate predictions and on climate change projections; (ii) 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; (iii) to improve understanding of the cumulative effects of the multiple stressors of climate variability, greenhouse induced climate change, and fisheries on marine ecosystems, functional diversity, and ecosystem services in the Tropical Atlantic; (iv) 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. Critical situations for stocks appear at times when severe environmental impacts coincide with impacts from fisheries. With fisheries mortality as density controlling factor, changes in the spatial distribution and utilization of habitat should be the effect of changing habitat quality, when at low densities key habitats should be preferred whereas at high densities also habitats of low quality should be utilized according to the ideal free distribution. First analyses on BET (*Thunnus obesus*) and YFT (*Thunnus albacares*) show no significant changes in range distributions (Worm and Tittensor, 2011), but both species have different habitat preferences with BET utilizing depths below the thermocline and tolerating low oxygen concentrations whereas YFT needs highly oxygenated waters above the thermocline, although occasional deep dives have been reported. Hence the analysis of habitat properties (including acoustic approach, see Bertrand *et al*., 2002; Moreno *et al*. 2008) in the area is suggested a promising approach to track differential changes in horizontal and vertical habitat utilization. Methodically, pop-up tags that provide detailed behavioural data and allow for controlled experimental design without depending on uncertain fisheries tag return rates are applied (Weng et al., 2009). In time series analysis, amongst others partial moving time window analysis or analysis of residuals from population models may be applied to figure out the effects of different simultaneous impacts. Based on longline logbooks (and catch statistics from the Cap Verde region and the eastern central Atlantic, shifts in the center of gravity of catches will be analyzed applying a stepwise climate envelope model including shifts in temperature, changes in OMZ, long-term fisheries data and ocean productivity. Strong cooperation with CECAF and ICCAT authorities is envisaged. Parallel to the analysis of predator dynamics, meso- and bathypelagic food web components will be analysed to obtain a description of the prey field and quantify and model changes in vertical and horizontal distribution of these food web components. Differential responses may be expected with water depth, with higher rates of change in warmed surface waters vertically disconnecting food webs and thus effecting also mid-water and deep-sea habitats. Comparative data will be obtained along meridional transects resampling historical transects from the 1960' and 1970's to indicate both OMZ and climate related shifts in distribution and abundance. We also propose to use state-of-the art dynamic (ROMS) and biogeochemical (PISCES) models that are able to represent the structure of the planktonic community and the iron cycle, and conduct "test cases". A set of simulations using different sources of iron will be run in order to highlight the new processes (and their interplay) that influence primary production.

Comparisons with available datasets will provide an assessment of the relative role of the processes highlighted in our model simulations. Lastly, the main objective of our bioeconomics works is to understand the effect of climate change on small scale fisheries and coastal communities in selected West African countries and to derive an understanding of the effect of uncertainty in projections and possible implications for management. Using historic oceanographic data or model hind cast data to identify the environmental effect on the stock development of key species and derive environmental sensitive single-stock models for those, and as well as to compare the environmental effect on key species from different coupled climate-ocean models to understand the uncertainty of projections. Lastly to understand (i) the potential effect of different model projections on management of key species with focus on small scale fisheries by developing coupled ecological-economic models, and (ii) the perceived and realized threats to small scale fisheries communities. The Preface and AWA project have build a consortium agreement and would like to develop collaboration with ICCAT institution and partners in (i) Tagging experiment (pop-up) on YFT and BET, (ii) Dynamics of tuna prey and habitat in the context of climate change, (iii) the development of bio-economics models on tropical tuna, (iv) the retrospective analysis of time series of tuna landing (mainly Skipjack), (iv) the capacity building in West Africa for students, technicians and scientists and obviously try to create synergy with current and future project related to ICCAT communities.