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Core theme 5, Work Package 12: *Task 12.3 Comparative analyses of spatiotemporal macrozooplankton distributions along three LMEs of the West coast of Africa related to environmental parameters*

Lead beneficiary for this deliverable: IRD

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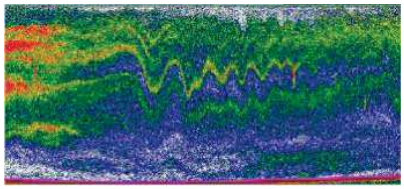
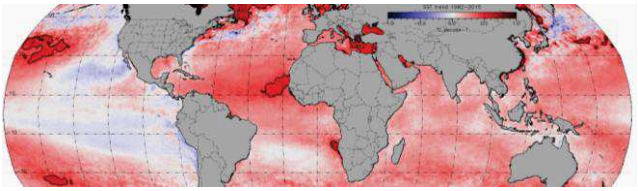
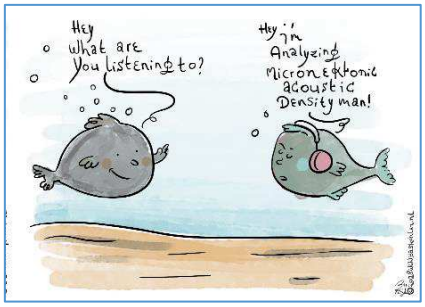
Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the Consortium (including the Commission Services)	
CO	Confidential, only for members of the Consortium (including the Commission Services)	X







Contribution to project objectives – with this deliverable, the project has contributed to the achievement of the following objectives (from Annex I / DOW, Section B1.1.):

N.º	Objective	No	Yes
1	Reduce uncertainties in our knowledge of the functioning of Tropical Atlantic (TA) climate, particularly climate-related ocean processes (including stratification) and dynamics, coupled ocean, atmosphere, and land interactions; and internal and externally forced climate variability.	X	
2	Better understand the impact of model systematic error and its reduction on seasonal-to-decadal climate predictions and on climate change projections.	X	
3	Improve the simulation and prediction TA climate on seasonal and longer time scales, and contribute to better quantification of climate change impacts in the region.	X	
4	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 TA.		X
5	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.	X	

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Comments on deviations: Data and personnel recruitment issues related to Task 12.3 in the three regions under study (Canary Current Large Marine Ecosystem, Gulf of Guinea LME, and Benguela Current LME) delayed this task and achievement of D12.3 by 6 months. For the CCLME, a PhD student only began in month 37 with the analysis of acoustic EAF Nansen survey data. A postdoctoral scientist was recruited around roughly the same time to focus on acoustic data extraction and analysis in the GCLME, while supporting progress in the other LMEs. The late release of the entire acoustic data base (including missing transect in the ICPC first release) was due to the necessary transformation of the EAF Nansen survey acoustic data into classic raw format from an old aggregated Norwegian binary format. Standard extraction of acoustic data was hindered by the lack of *ad hoc* license or software types for common data extraction and standard processing. However, in PREFACE, IRD provided a Matlab algorithm (methodology recently accepted in "Australian Acoustics") for data analysis to all ICPC beneficiaries that enabled the planned comparative analysis within PREFACE but will allow for future data analyses at these and other institutions.

Executive Summary: Zooplankton and micronekton are key groups in ocean foodwebs. Both micronekton and macrozooplankton (here further referred to simply as micronekton) are consumers of primary producers, microzooplankton, and detritus, producing dissolved and particulate organic matter, thereby actively contributing to the remineralisation of nutrients. These biological cycles are also key processes in the maintenance of the oxygen minimum zone in upwelling areas (OMZ). Furthermore, micronekton contribute to the export of matter to the ocean sea floor with fast-sinking faecal pellets, via diel vertical migration (DVM). In turn, micronekton are main prey items for a large variety of exploited and non-exploited fishes. Micronekton therefore perform a critical role in structuring higher and lower trophic levels, influencing the population dynamics of exploited species. In past decades, acoustic methods have enabled the extraction of high-resolution information on the biomass and distribution patterns of micronekton.

To study micronekton interannual variability and trend in the three African Atlantic large marine ecosystems (LME), *i.e*, the Canary Current LME (CCLME), Guinea Current LME (GCLME), and Benguela Current LME (BCLME), particularly over the continental shelf where most fisheries activities occur, we compiled almost 300 000 km of survey transects through 29 surveys carried out by the FRV Fridtjof Nansen. The historical data were converted, cleaned, and echo integrated using *ad hoc* software 'Matecho' developed as open source that enabled collaborative work and applied a standardized method to all surveys.

The environmental data were compiled from remote sensing satellite products. Special analysis was made in the CCLME, making use of a database of vertical probes (water: Temperature, Salinity, and Oxygen). Space-based observations of some major parameters allow a precise synoptic observation of marine ecosystems. Sea surface temperature (SST) has been observed for 36 years and ocean-colour related parameters, such as surface primary productivity, for more than 20 years. The observed spatially heterogeneous time series show that these systems are highly variable, at temporal scales of decades that potentially impact some of their marine resources. Based on this standardized data set, we present the effect of global warming at regional level for the three LMEs of Atlantic Africa on SST, wind stress, and primary production. The CCLME and the BCLME are particularly impacted by global warming, especially in their lower latitudes. The GCLME appears "less" impacted according to satellite data when compared to the two other African LMEs, particularly in comparison with the south CCLME where a high SST warming was found. In this study, no significant changes of micronektonic biomass proxy (*i.e*. micronekton acoustic density (S_v in dB)) were observed from 1999 to 2006. As expected, a difference is observed in the vertical micronektonic acoustic density between day and night. However, we observed an unexpected increase in micronekton acoustic density during night-time. Two hypotheses are proposed: (i) the increase is explained by an offshore horizontal diel migration or (ii) a very high contribution of the micronektonic density occurring at the surface (0-10 m), which corresponds to the blind zone of the research vessel. According to an original descriptor "water column filling rate", a significant change in the GCLME is reported. Indeed, there is an increase over the study period of the water column filling rate. Future investigations should focus on this interesting phenomenon. Such an increase should be monitored to inform on a potential major change in the trophic web in this part of the GCLME. These findings can be interpreted as an early warning signal of climate change and require future study.

When we deal with micronektonic trophic levels, using micronekton acoustic scattering layers characteristics is a relevant alternative. Indeed, preliminary results have shown a significant increase (i) of the minimum depth of such scattering layers and (ii) of the mean layer micronektonic density per sampling unit from 1995 to 2015 in the CCLME. Lower daytime S_v values compared to night-time values suggest either less dense patches of micronekton leading to negative day-night differences in the CCLME and GCLME; the kinematic of micronekton behaviour should play a role. Only a few significant and different DVM descriptors suggest a change in the CCLME and the GCLME over the study period. Boosted Regression Tree classification is well suited to show the importance of the large scale environmental variability on micronektonic acoustic density. The inter-annual variability is not significant, 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 CCLME (consistently cold and windy) and a pronounced effect in the south CCLME 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. 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 BCLME then in the CCLME, particularly when comparing the southern part of the CCLME *vs* its northern part. In all LMEs, the oceanographic factors' relative influence has a significant role, confirming the important changes expected due to global warming on the ecosystems and thus in the fisheries sector. The next step will be to couple our results with climate projections to forecast major changes in African coastal systems.

Lastly the time series of the DVM amplitude at observed depth in the CCLME indicate not only an increase of the amplitude as a function of time but also a general deepening of the day and night position of the micronekton layer above the slope. Climate features of the time series may reveal a correlation between this behavioural change in amplitude and deepening of the micronekton layer. If a climate-driven change in amplitude and depth is found to be significant, it will have a strong impact on the ocean carbon pump and the climate as the biological production along the slope is generally high. It is expected that a deepening of the micronekton and an increase of the DVM amplitude would enhance the carbon sink and consequently may buffer the carbon dioxide (CO_2) emission in the atmosphere.

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