**OCEANS 2021: San Diego – Porto, 2021,**
**Pages 1-6**
Electronic ISBN:978-0-692-93559-0, ISSN: 0197-7385
September 2021,
https://doi.org/10.23919/OCEANS44145.2021.9705993
https://archimer.ifremer.fr/doc/00759/87108/

# Descriptors to characterize acoustic scattered layers: evidence of interest in three Atlantic African Large Marine Ecosystems

Mouget Anne [1], Brehmer Patrice [1], Perrot Yannick [1], Uanivi Uatjavi [2], Diogoul Ndague A Supprimer [1, 3], Ayoubi Salahedine El [4], Jeyid Mohamed Ahmed [5], Sarre Abdoulaye [3], Behagle Nolwenn [1], Kouassi Aka Marcel [6]

[1] ENEGALIRD, Univ Brest, CNRS, Ifremer, Lemar, Délégation régionale IRD ouest, France IUEM, Plouzané, France
[2] Ministry of Fisheries and Marine Resources, MFMR, Swakopmund, Namibia
[3] ISRA, Centre de Recherche Océanographique de Dakar Thiaroye, CRODT, Pôle de recherche de Hann, Institut Sénégalais de Recherche Agricole, Dakar, Sénégal
[4] IMROP, Institut Mauritanien de Recherche Océanographique et des Pêches, Nouadhibou, Mauritania
[5] Institut National de Recherche Halieutique, INRH, Casablanca, Maroc
[6] Centre de Recherches Océanologiques, CRO, BP V 18, Abidjan, Côte d'Ivoire

## Abstract :

Hydroacoustic is now a reliable and often used tool to monitor and study marine ecosystems (Brehmer et al. 2006). This study focus on acoustic scattered layers, which are the echosounder detection of pelagic marine organism of low trophic level, important in ecosystems functioning. Data have been recorded at 38 kHz in the three Atlantic African Large Marine Ecosystems (LME). Layers have been extracted using Matecho (Perrot et al. 2018) at a threshold level of -70 dB. To describe parsimoniously ecosystems, compare them and understand the difference, two descriptors have been used. Some of them are based on already used descriptors and others are new. The aim of this study is to ensure that these descriptors are relevant to monitor and compare systems. Therefore, we first explore temporal and spatial dimension. For such purpose, we use a large acoustic database collected in Canary Current Large Marine Ecosystem 'CCLME' (Diogoul et al., 2020; Brehmer et al. 2018). The temporal dimension is studied by diel comparison and by analysing change over years in each system. Spatial dimension is explored by intra-LME comparison concerning CCLME, which present two systems with different functioning. Results highlight the effectiveness of these descriptors. The methodology presented in this work is innovative, introducing original new descriptors to monitor pelagic compartment of each LME and should be efficiently used for environmental monitoring in case of perturbation as overfishing, climate change or marine pollution. Indeed the acoustic scattered layer are mainly composed of macrozooplankton and ichtyoplankton, which are sensitive to environmental change.

**Keywords** : Climate change, Databases, Perturbation methods, Oceans, Marine pollution, Ecosystems, Acoustics

## 1. Introduction

There is an increasing need to monitor ecosystems and understand the impact of anthropic activities worldwide and even more particularly for marine African countries. Micronektonic layers are a crucial intermediate trophic level in lot of ecosystem because of their intermediate position (Bakun 1996). They are necessary for lot of pelagic fish species. As micronekton biomass can largely vary over spatial and temporal parameters (Cury et al. 2000). Micronekton can be used as sentinel species to efficiently monitor ecosystems (Béhagle et al. 2017). Micronekton aggregate in Sound Scattering Layers (SSLs), which can been observed by fisheries acoustic tools (Ballón et al. 2011). SSL also include macro-zooplankton, micronekton and all pelagic mid-trophic organisms, such as *Sardinella aurita* which can also been used as sentinel to monitor ecosystems (Sarré 2017). Fisheries acoustic is a non-invasive tool and can easily record data over large areas (Brehmer 2006). This study try to set up a methodology to monitor SSL changes over spatio-temporal parameters to efficiently follow ecosystems modifications. We apply this methodology to ecosystems from one of the Atlantic African Large Marine Ecosystems (AALMEs) (Sherman 1991): the Canary Current Large Marine Ecosystem (CCLME). Analyses focused first on the well-known Diel Vertical Migration (DVM) (Brierley 2014) in a homogeneous sub-area, the North CCLME. We then analyse the difference between two sub-areas of the CCLME, *i.e.*, North and South Cape Blanc (Diogoul et al. 2021).

## 2. Material and Methods

The acoustic data set used to test the SSL methodology was recorded in parts of the three AALME, located on the continental shelf of West Africa. The study area in the CCLME extend from 12.2°N to 34.1°N and from 7.2°E to 17.7°E and data have been recorded over 20 years between 1995 and 2015 (14 annual surveys). This area can be divided in two part, separated by the Cape Blanc (Sarré et al. 2016) at 20.7°N. The study part of the GCLME extend from 4.2°N to 6.3°N and from 7.5°E to 2.7°W and surveys have been recorded over 6 years between 1999 and 2006. In BCLME, surveys stand from 17.3°S to 29.3°S and from 11.5°W to 16.6°W during 8 years between 1994 and 2001.

Acoustic data have been cleaned and echo-integrated using Matecho software (Perrot et al. 2018). SSLs were extracted at an echo level threshold of -70 dB re 1 $m^{-1}$ (noted dB from here) to include macro-zooplankton, micronekton and all pelagic mid-trophic organisms (Béhagle et al. 2016). Data have then been statistically analysed using R software (R Core Team 2021).

Fourteen parameters can be extract to characterise SSL organization and monitor their spatial, morphologic and acoustic changes. We present here only two parameters based on SSL position in the water column: (i) the minimal depth of the layer đ, *i.e.* the minimal distance between surface and the SSL (in m) and (ii) the maximal depth Đ, *i.e.* the maximal distance between surface and the SSL bottom (in m). These two parameters present the position of the SSL in the water column and their heights. Only the shallowest SSL was kept for analyse.

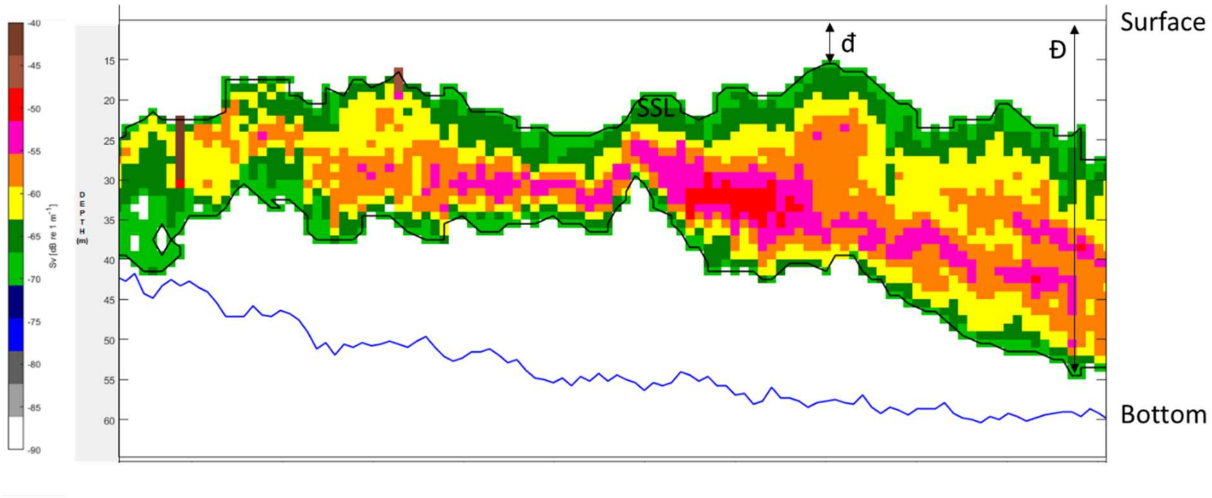

*Figure 1. Presentation of the two classic Sound Scattering Layer (SSL) descriptors: đ, the minimal depth of SSL (in meters) and Đ, the maximal depth of SSL (in meters). The blue line represents the bottom and the black one the surface. The colour scale on the left indicates the backscattering strength, noted $S_v$ expressed in dB. This SSL has been extracted from survey in CCLME in 2015.*

## 3. Results

### 3.1. Diel vertical Migration in CCLME North

Descriptors has been used to compare SSL organisation through Diel Vertical Migration (DVM) in a homogeneous area: the North CCLME. Minimal and maximal depth are significantly different between day and night. Boxplots (Figure 2) present the minimal and the maximal depth of SSLs to get an overview of water column organisation. The maximal depth of SSLs (in light grey) is more stable over time but the minimal depth is different, smaller during nighttime. These results highlight wider and shallower SSL during night than during day, so a rise of SSLs.

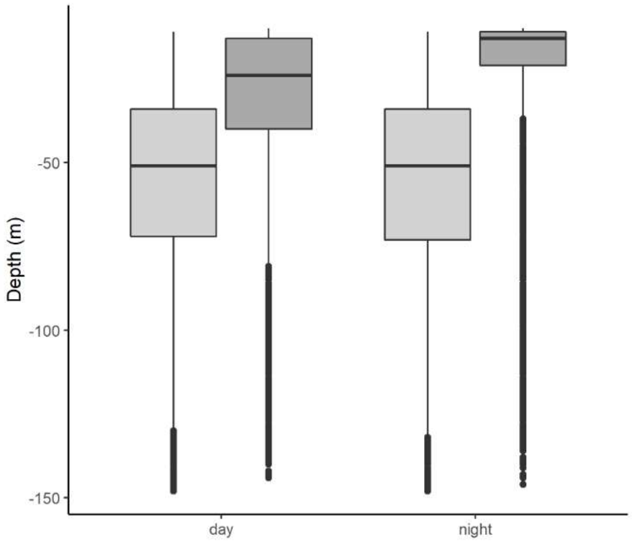

*Figure 2. Boxplots of minimal and maximal depth of sound scattering layers (respectively in light grey and dark grey) in Canary Current Large Marine Ecosystem (CCLME) North during day and night*

### 3.2. Spatial

Descriptors has also been used to compare sub-areas in a LME. Here we compare North and South CCLME, with all data, including day and night. North and South are significantly different for the two variables. The maximal depth of SSL is slightly smaller in CCLME South and SSL are generally shallower and higher than in CCLME North.

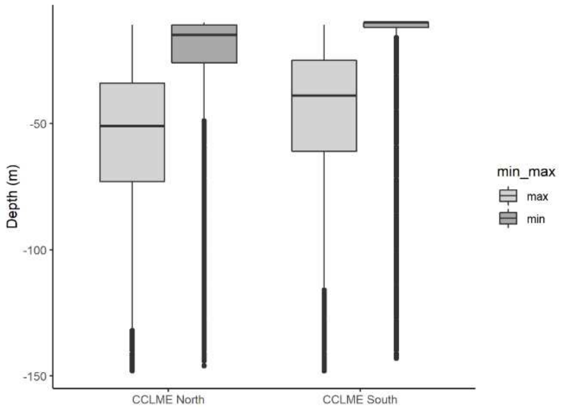

*Figure 3. Boxplots of minimal and maximal depth of sound scattering layers (respectively in light grey and dark grey) in Canary Current Large Marine Ecosystem (CCLME) North and South*

## 4. Discussion

The acoustic analyse of SSL produce numerous descriptors to observe them and follow evolution over spatial and temporal gradient. Here we choose to work with only two of them: minimal depth of SSL đ, and maximal depth of SSL Đ. These two descriptors efficiently transmit a global idea of size and localisation and water column of SSL, which can vary depending of such parameters. Therefore, we found a significant difference between day and night, with SSL higher and shallower during night-time. This observation is convenient with characteristic of typical nocturnal ascendant DVM behaviour (Tiedemann et Brehmer 2017; Brierley 2014). This significant answer confirms that descriptors are efficient to detect changes in SSLs organization.

These two descriptors are then used to compare two sub-areas in the CCLME: North and South CCLME. We also find a significant difference with SSL generally smaller and deeper in the North Cape Blanc. This difference could be explained by specificities of each sub-area and especially upwelling regime. In Southern CCLME, the upwelling is seasonal, whereas it is permanent in Northern CCLME (Arístegui et al. 2009; Benazzouz et al. 2014). Upwelling is known to highly impact ecosystems and biocenoses (Capet et al. 2017), which can explain the different structure of SSL between the two sub-areas. However, as we do not have any information about species identification of SSL during the surveys, we cannot conclude further on change in SSL composition. However, analyse of the fourteen available descriptors could allow a more precise interpretation of changes in SSL organization and use them to monitor spatio-temporal changes.

## References

Arístegui, Javier, Eric D. Barton, Xosé A. Álvarez-Salgado, A. Miguel P. Santos, Francisco G. Figueiras, Souad Kifani, Santiago Hernández-León, Evan Mason, Eric Machú, et Hervé Demarcq. 2009. « Sub-regional ecosystem variability in the Canary Current upwelling ». *Progress in Oceanography*, Eastern Boundary Upwelling Ecosystems: Integrative and Comparative Approaches, 83 (1): 33-48. https://doi.org/10.1016/j.pocean.2009.07.031.

Bakun, A. 1996. « Patterns in the ocean: ocean processes and marine population dynamics, 323 pp ». *University of California Sea Grant, San Diego & Centro de Investigaciones Biológicas del Noroeste, La Paz*.

Ballón, Michael, Arnaud Bertrand, Anne Lebourges-Dhaussy, Mariano Gutiérrez, Patricia Ayón, Daniel Grados, et François Gerlotto. 2011. « Is there enough zooplankton to feed forage fish populations off Peru? An acoustic (positive) answer ». *Progress in Oceanography* 91 (4): 360-81. https://doi.org/10.1016/j.pocean.2011.03.001.

Béhagle, Nolwenn, Cédric Cotté, Anne Lebourges-Dhaussy, Gildas Roudaut, Guy Duhamel, Patrice Brehmer, Erwan Josse, et Yves Cherel. 2017. « Acoustic Distribution of Discriminated Micronektonic Organisms from a Bi-Frequency Processing: The Case Study of Eastern Kerguelen Oceanic Waters ». *Progress in Oceanography* 156 (août): 276-89. https://doi.org/10.1016/j.pocean.2017.06.004.

Béhagle, Nolwenn, Cédric Cotté, Tim E. Ryan, Olivier Gauthier, Gildas Roudaut, Patrice Brehmer, Erwan Josse, et Yves Cherel. 2016. « Acoustic micronektonic distribution is structured by macroscale oceanographic processes across 20–50°S latitudes in the South-Western Indian Ocean ». *Deep Sea Research Part I: Oceanographic Research Papers* 110 (avril): 20-32. https://doi.org/10.1016/j.dsr.2015.12.007.

Benazzouz, Aïssa, Soumia Mordane, Abdellatif Orbi, Mohamed Chagdali, Karim Hilmi, Abderrahman Atillah, Josep Lluís Pelegrí, et Demarcq Hervé. 2014. « An Improved Coastal Upwelling Index from Sea Surface Temperature Using Satellite-Based Approach – The Case of the Canary Current Upwelling System ». *Continental Shelf Research* 81 (juin): 38-54. https://doi.org/10.1016/j.csr.2014.03.012.

Brehmer, Patrice A. J-P. 2006. « Fisheries Acoustics: Theory and Practice, 2nd Edn ». *Fish and Fisheries* 7 (3): 227-28. https://doi.org/10.1111/j.1467-2979.2006.00220.x.

Brierley, Andrew S. 2014. « Diel vertical migration ». *Current Biology* 24 (22): R1074-76. https://doi.org/10.1016/j.cub.2014.08.054.

Capet, Xavier, Philippe Estrade, Eric Machu, Siny Ndoye, Jacques Grelet, Alban Lazar, Louis Marié, Denis Dausse, et Patrice Brehmer. 2017. « On the Dynamics of the Southern Senegal Upwelling Center: Observed Variability from Synoptic to Superinertial Scales ». *Journal of Physical Oceanography* 47 (1): 155-80. https://doi.org/10.1175/JPO-D-15-0247.1.

Cury, Philippe, Andrew Bakun, Robert J. M. Crawford, Astrid Jarre, Renato A. Quiñones, Lynne J. Shannon, et Hans M. Verheye. 2000. « Small pelagics in upwelling systems: patterns of interaction and structural changes in "wasp-waist" ecosystems ». *ICES Journal of Marine Science* 57 (3): 603-18. https://doi.org/10.1006/jmsc.2000.0712.

Diogoul, Ndague, Patrice Brehmer, Hervé Demarcq, Salaheddine El Ayoubi, Abou Thiam, Abdoulaye Sarre, Anne Mouget, et Yannick Perrot. 2021. « On the Robustness of an Eastern Boundary Upwelling Ecosystem Exposed to Multiple Stressors ». *Scientific Reports* 11 (1): 12. https://doi.org/10.1038/s41598-021-81549-1.

Perrot, Yannick, Patrice Brehmer, Jérémie Habasque, Gildas Roudaut, Nolwenn Behagle, Abdoulaye Sarré, et Anne Lebourges-Dhaussy. 2018. « Matecho: An Open-Source Tool for Processing Fisheries Acoustics Data ». *Acoustics Australia*, juin. https://doi.org/10.1007/s40857-018-0135-x.

R Core Team. 2021. *R: A Language and Environment for Statistical Computing*. Vienna, Autria: R Foundation for Statistical Computing. https://www.R-project.org/.

Sarré, Abdoulaye. 2017. « Climate-Driven Shift of Sardinella Aurita Stock in Northwest Africa Ecosystem as Evidenced by Robust Spatial Indicators [Résumé]- Fdi:010072122- Horizon ». Présenté à ICAWA : International Conference AWA, Dakar, Sénégal. http://www.documentation.ird.fr/hor/fdi:010072122.

Sarré, Abdoulaye, Hervé Demarcq, S. Faye, Patrice Brehmer, Jens-Otto Krakstad, D. Thiao, et S. Elayoubi. 2016. « Climate-Driven Shift of Sardinella Aurita Stock in Northwest Africa Ecosystem as Evidenced by Robust Spatial Indicators ». Colloque présenté à ICAWA : International Conference AWA, 3, Dakar, Sénégal, décembre 13. http://www.documentation.ird.fr/hor/fdi:010072122.

Sherman, Kenneth. 1991. « The Large Marine Ecosystem Concept: Research and Management Strategy for Living Marine Resources ». *Ecological Applications* 1 (4): 349-60. https://doi.org/10.2307/1941896.

Tiedemann, Maik, et Patrice Brehmer. 2017. « Larval fish assemblages across an upwelling front: Indication for active and passive retention ». *Estuarine, Coastal and Shelf Science* 187 (mars): 118-33. https://doi.org/10.1016/j.ecss.2016.12.015.