TRIATLAS

Fine-scale vertical structure of sound-scattering layers over an east border upwelling system and its relationship to pelagic habitat characteristics

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Introduction

- ✓ Aggregations of marine pelagic organisms (Zooplanktonic and micronektonic) in ocean water can be observed acoustically as sound-scattering layers (SSL);
- ✓ Zooplanktonic and micronektonic components are fundamental to ecosystem functioning, particularly in productive upwelling areas (e.g., off south Senegal, in "the Petite côte"), providing the main trophic link between primary producers and higher trophic levels.;
- ✓ During ECOAO cruise of "Small coast" Senegal in March 2013, acoustic and environmental data were collected to study specifically the pelagic ecosystem .
- ✓ We investigate the fine-scale vertical structure of SSLs to understand how the pelagic environment influences SSLs in the EBUS off Senegal during an upwelling event.

Goal

Effect of environment on the structure of SSL sound-scattering layers i.e. pelagic biological layer

- **Description of physico-chemical and biological characteristics of the study area**
- **Spatio-temporal variations of the SSL observed by acoustics;**
- **Relationships between SSL and key physico-chemical parameters.**

Material & methods

1. Survey at sea ECOAO (Fig.1) **led in Senegal**

✓Acoustic data (38 kHz)
✓CTD data (water temperature, density, O_2, and CHL)
✓Sea Surface Temperature (SST) from space

2. Acoustic data processing with " Matecho " (Fig.2)

- ✓ Conversion from raw to HDF5 format
- ✓ Manual corrections of echogram;
- ✓ Echogram filtering
- ✓ Echo-integration, and Extraction of layers SSL (threshold =-75 dB)

3. Echogram/profile coupling (Fig.3)

4. Mapping and Statistic analysis

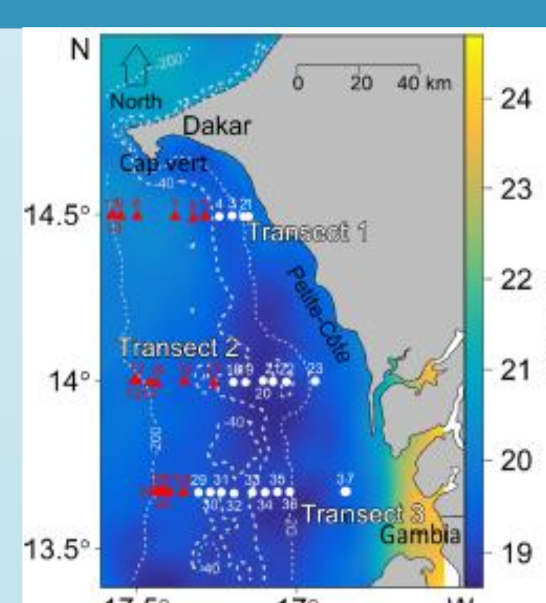


Fig.1: Location of the survey area off the Petite cote. CTD probes collected at stations along three transects. Stations of Group 1 (white circles) were located in the inshore zone, whereas stations of Group 2 (red triangles) were situated further offshore.

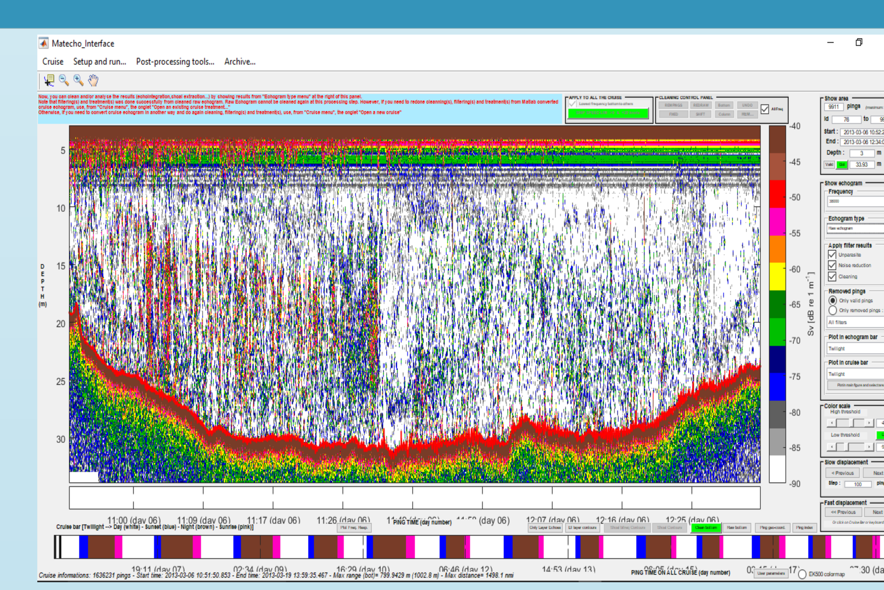


Fig.2: Matecho (Perrot et al. 2018), interface developed within AWA and Preface projects, used to analysis raw acoustics data delivered from scientific echo sounders.

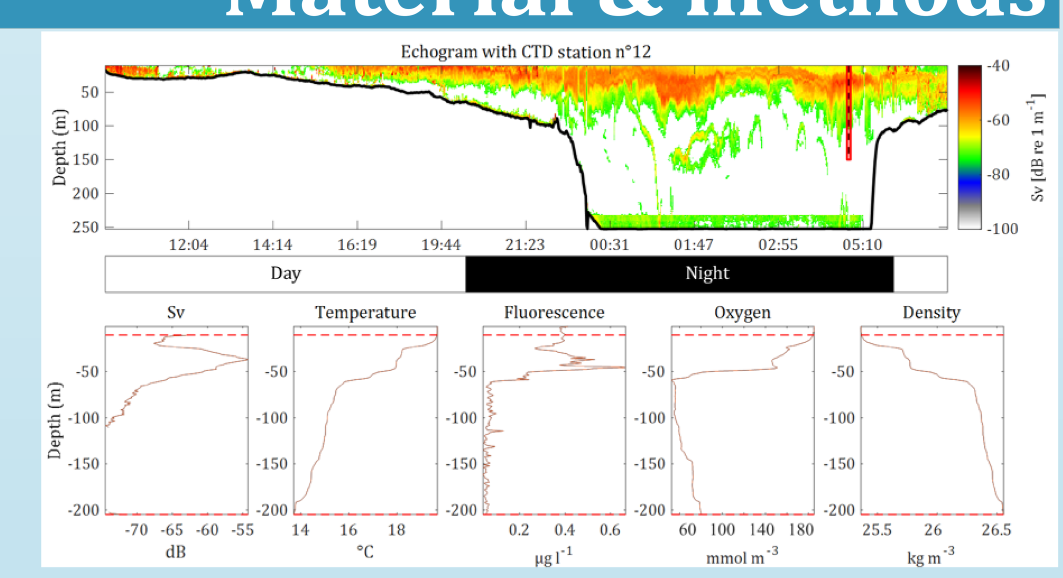
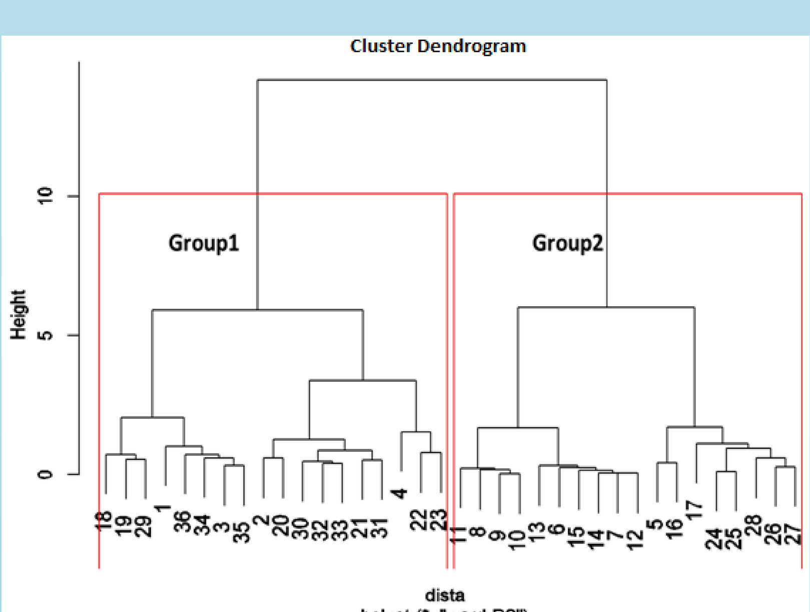


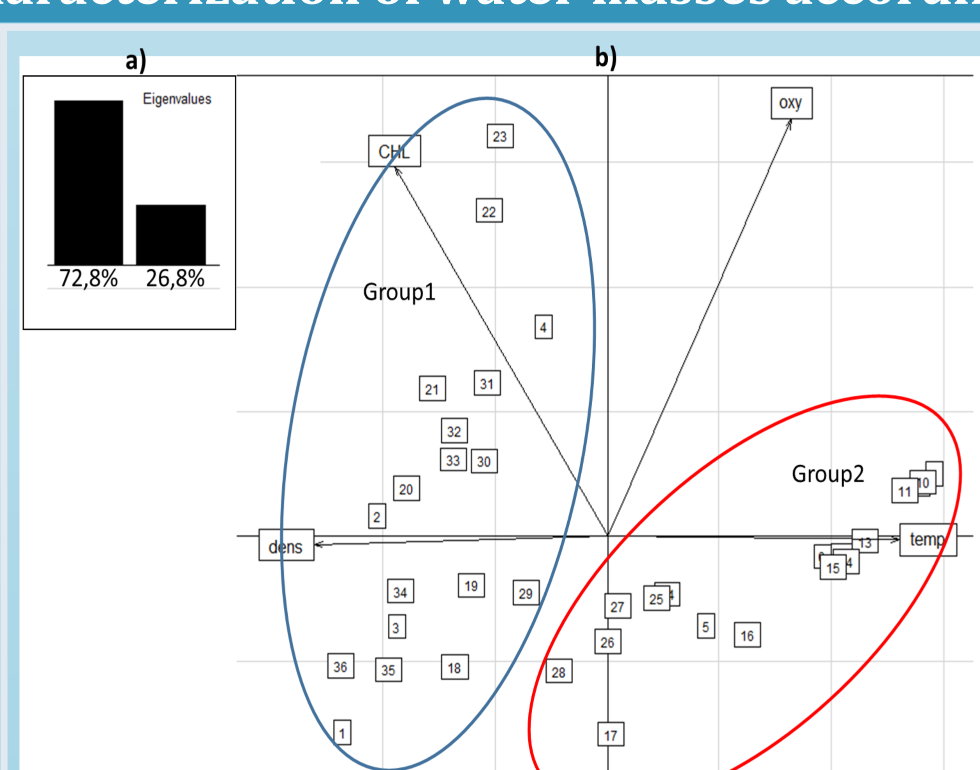
Fig. 3: Echograms and associated vertical acoustic profiles as well as CTD data for stations 12 in the offshore area (location depicted by the vertical red line). Data represent mean conditions collected within an area of 0.1 nmi around the station : acoustic volume backscattering strength (Sv), temperature profile, CHL profile, oxygen profile, and density profile. The horizontal dashed lines in all profiles represent the SSL thickness.

Results

Physico-chemical characterization of water masses according to environmental parameters



Fig,4: Dendrogram discriminating CTD stations during ECOAO campaign according to temperature, fluorescence, dissolved oxygen and density; Group 1: stations in the inshore area (n = 18), Group 2: stations in the offshore area (n = 18).



Fig,5: Principal Components Analysis (PCA) of environmental parameters for all 36 CTD stations during the ECOAO campaign. (a) Eigenvalue diagram; (b) Factor plane, Group 1: stations in the inshore area , Group 2: stations in the offshore area).

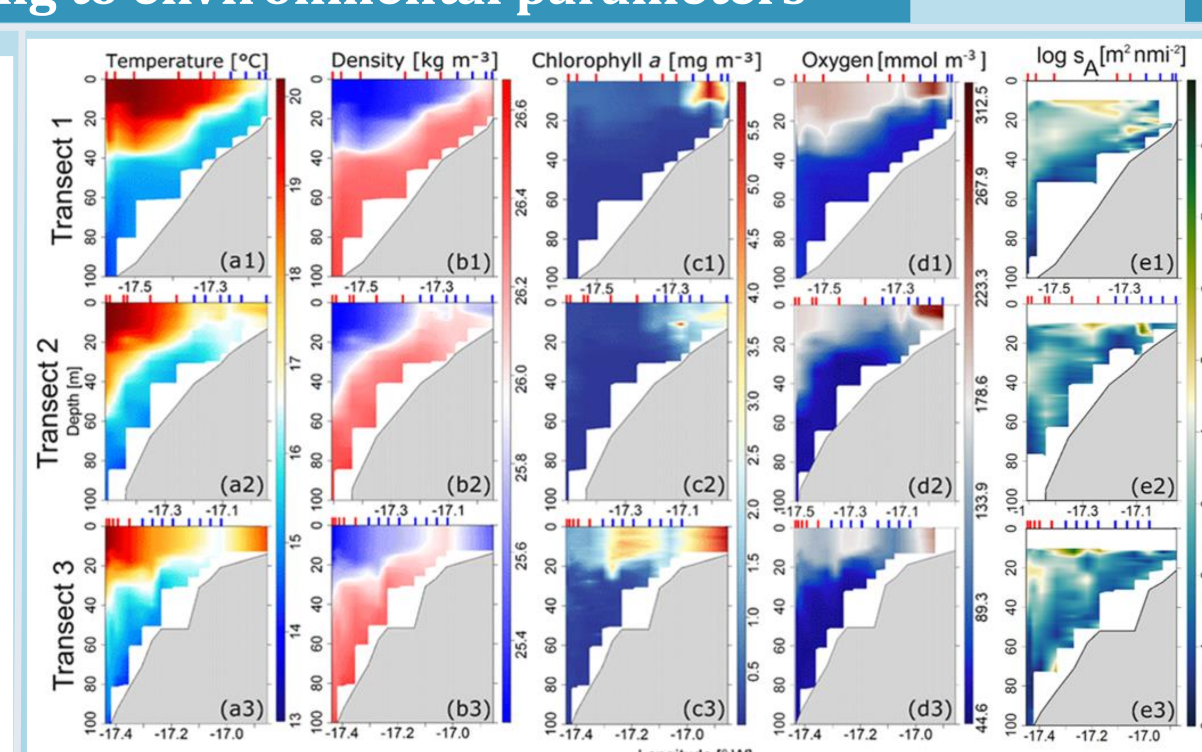


Fig.6: Contour plots of (a) temperature, (b) density, (c) chlorophyll-a concentration, (d) dissolved oxygen, and (e) square rooted nautical area scattering coefficient (s_A) in the three transects (T1, T2, T3; see Fig. 1) with positions of vertical probe stations CTD in the inshore area (vertical line in blue (G1)) and the offshore area (vertical line in red (G2)).

Spatial-temporal variability of SSL

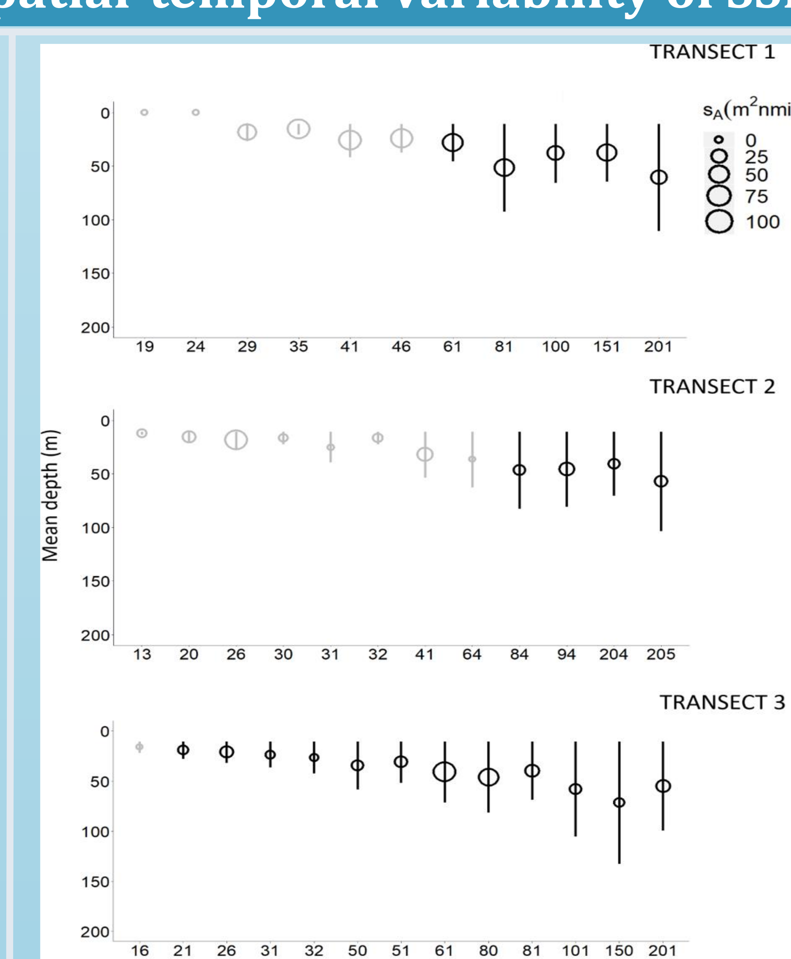


Fig. 7: Sound-scattering layer (SSL) mean depths (empty circle) according to their bottom depth, with their associated thickness (line, in meters) and SSL mean nautical area scattering coefficient (NASC or sA in m^2 nmi^{-2}), along transect 1 (south), transect 2 (intermediary), and transect 3 (north) during nighttime (black) and daytime (gray) sampling periods..

Vertical dimension of SSLs related to physicochemical profile (temperature, density, O_2 and CHL)

In both areas, **SSLs were** partially or completely **located in areas of strong vertical gradients of temp., density, and diss. Oxygen**

In the inshore area the peak of CHL concentration was always located above the SSLs (Fig. 2a), whereas **in the offshore area, the peak of CHL concentration was either above the SSLs or in the middle of the SSLs** (Fig. 3).

Behavior of the SSLs relative to pelagic habitat characteristics

Inshore area (G1)

The ANCOVA models to predict SSL thickness and SSL depth can be expressed as:

$$SSL_{thickness} = -11.865 + (0.916 * B_d) + (11.492 * D_p)$$

$$SSL_{depth} = -4.223 + (0.954 * B_d) + (12.864 * D_p)$$

Offshore area (G2)

The ANCOVA models to predict SSL thickness and SSL depth can be expressed as:

$$SSL_{thickness} = 56030 + (0.21 * B_d) + (27.35 * D_p) + (-383.80 * T) - (1898 * D) - (1.76 * O_2)$$

$$SSL_{depth} = 56040 + (0.21 * B_d) + (27.35 * D_p) + (-383.80 * T) - (1898 * D) - (1.76 * O_2)$$

With B_d= Bottom depth in m; D_p = Diel period in night; T = Water Temperature in °C; D = Water Density in kg m^{-3}; O_2= oxygen in mmol m^{-3}

Discussion & Conclusion

We had discriminated a cold upwelling-influenced inshore area sharply separated by a strong thermal boundary from a deeper, warmer, stratified offshore area over the Senegalese shelf; SSLs were influenced by turbulence level in the upwelling, which led to an offshore advection of SSL organisms. SSL acoustic density variation suggested different diel migrations: a normal and reverse DVM, and/or a DHM. SSL distributions were mainly structured by bottom depth, diel period, and the level of vertical stratification in water column. Although chlorophyll-*a* concentration insignificantly affected SSL characteristics, the peak of chlorophyll-*a* was always located above or in the middle of the SSLs, regularly matching with the peak of SSL biomass. Such observations indicate trophic relationships, suggesting SSLs to be mainly composed of phytoplanktivorous zooplankton and micronekton.

References: N. Diogoul, P. Brehmer, Y . Perrot…. and A. Sarré. Fine-scale vertical structure of sound-scattering layers over an east border upwelling system and its relationship to pelagic habitat characteristics Ocean Sci., 16, 65–81, 2020 https://doi.org/10.5194/os-16-65-2020; Perrot et al 2018. Matecho: An Open-Source Tool for Processing Fisheries Acoustics Data. Acou. Aus. 46, 241–248, 2018. https://doi.org/10.1007/s40857-018-0135-x