Effect of environmental variables on the vertical structure of micronektonic layers over the continental shelf

Ndague DIOGOUL[1,2,4] (diogoulndague@yahoo.fr), Patrice BREHMER[2,4], Yannick PERROT[2], Maik TIEDEMAN[3] , Salaheddine EL AYOUBI[4], Chloé MIGAYROU[3] Abou THIAM[1], Abdoulaye Sarré[5]

(1) Institute of Environmental Sciences (ISE), Cheikh Anta Diop University of Dakar (UCAD), B.P. 5005 Dakar, Sénégal
(2) Research Institute for Development (IRD), UMR 195, Laboratory of Marine and Environmental Sciences (LEMAR), Brest, France
(3) Thunen-Institute (TI), Institute of Sea Fisheries, Federal Research Institute for Rural Areas, Forestry and Fisheries, Pamaille 9, 22767 Hamburg, Germany
(4) Senegalese Institute of Agricultural Research (ISRA), Center for Oceanographic Research of Dakar Thiaroye (CRODT), BP 2221 Dakar, Sénégal
(5) National Institute of Halieutic Research (INRH), Agadir, Morocco

Introduction

- ✓ Micronektonic compartment remain under studied while they represent a key intermediate level;
- ✓ Acoustics method allow to describe some key biotic and abiotic environment parameters;
- ✓ Micronekton are presented as scattering layers on the echogram of a scientific sounder;
- ✓ During ECOAO cruise over "la petite côte" Senegal in March 2013, acoustic and environmental data were collected to study the pelagic ecosystem ;

Goal

Study the effect of environment on the structure of biological scattering layer ➡

- Description of physico-chemical and biological characteristics of the study area: "la petite côte";
- Study of spatio-temporal variations of the biological scattering layers observed by acoustics;
- Study of relationships between these biological layers and physico-chemical parameters.

Material & methods

1. Oceanic Cruise ECOAO (Fig.1):

✓Acoustic data (38 kHz)
✓CTD data (temperature, density, O_2, and CHL)
✓SST data

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 (threshold =-75dB)

3. Echogram/profile coupling (Fig.3)

4. Mapping and Statistic analysis with R

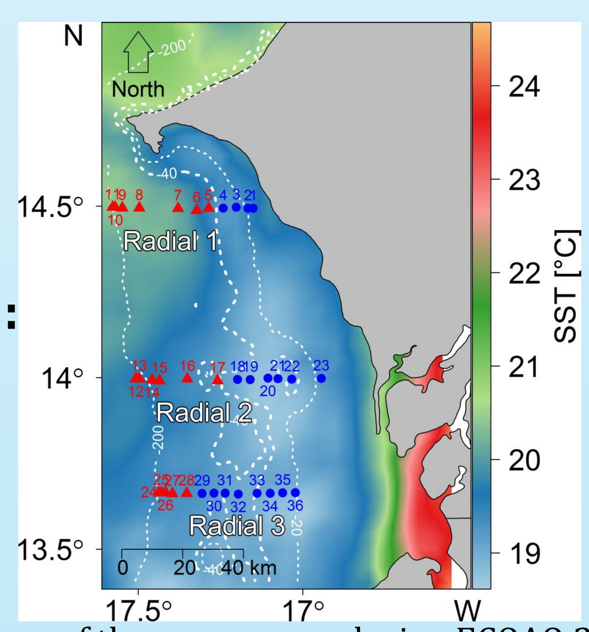


Fig. 1: Maps of the survey area during ECOAO 2013 (6th – 08th March 2013), showing the positions of the CTD; Stations of group 1 (stations in inshore area) in blue and stations of group 2 (stations in offshore area) in red.

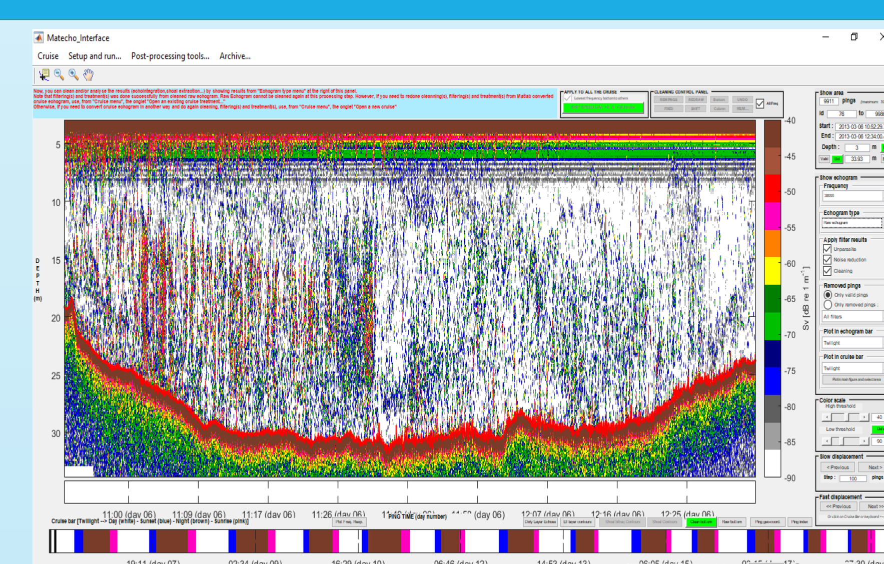


Fig.2: Matecho, main interface when a cruize is loaded

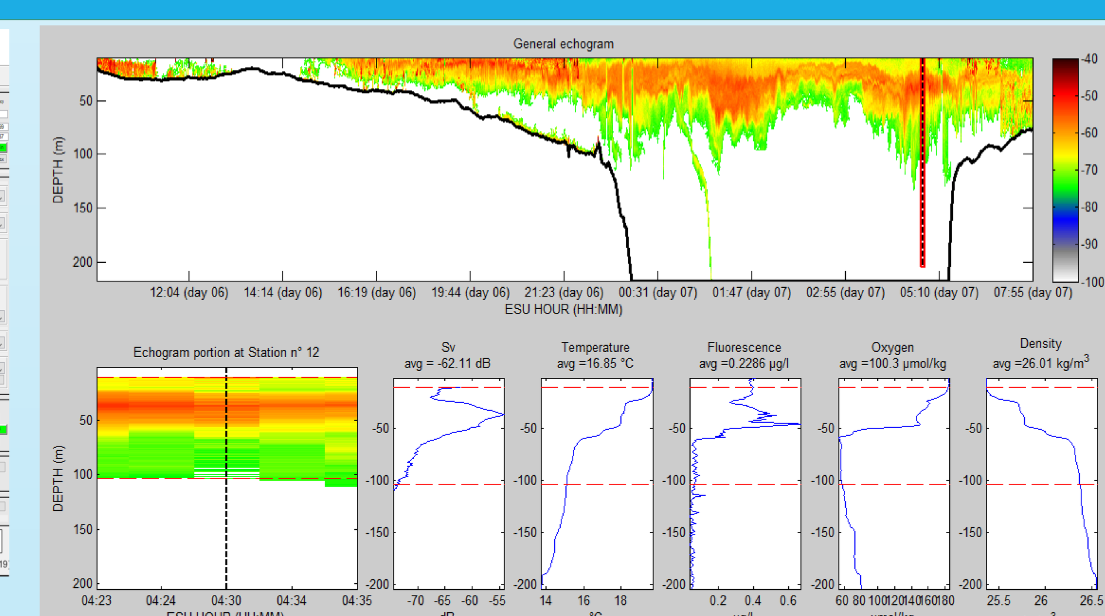
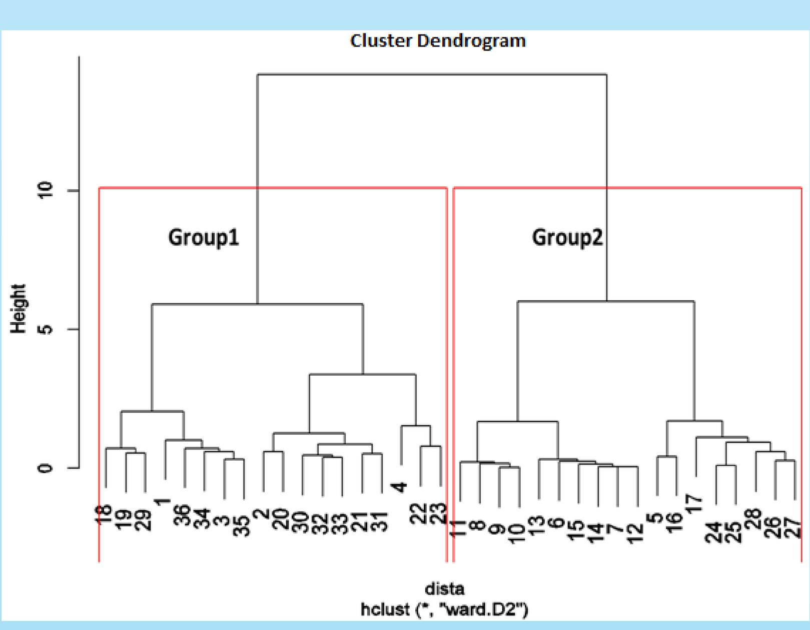


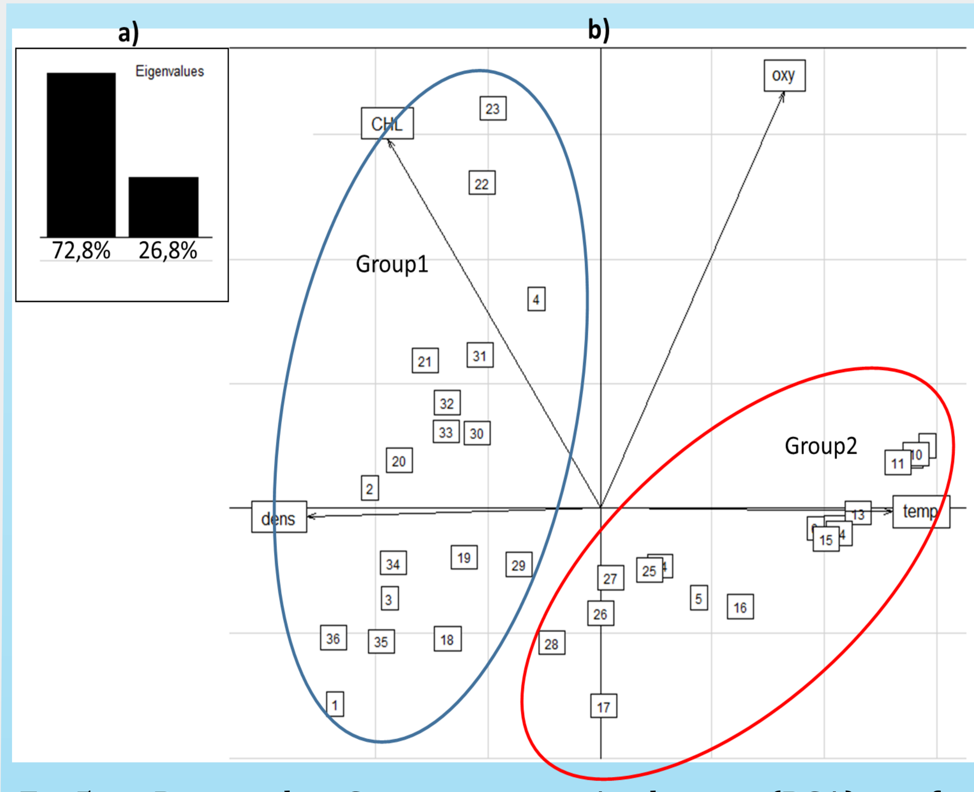
Fig. 3: Echogram and profiles of station n°12: (i) general echogram ;(ii) echogram portion of CTD station; (iii) Profile of S_v in layer (dB) ; (iv) Profile of mean temperature in layer (°C) ; (v) Profile of mean CHL in layer (µg l^{-1}); (vi) Profile of mean oxygen in layer (µmol kg^{-1}); (vii) Profile of mean density in layer (kg/m^{-3}).

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 inshore area (n = 18), Group 2: stations in 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 inshore area , Group 2: stations in offshore area.

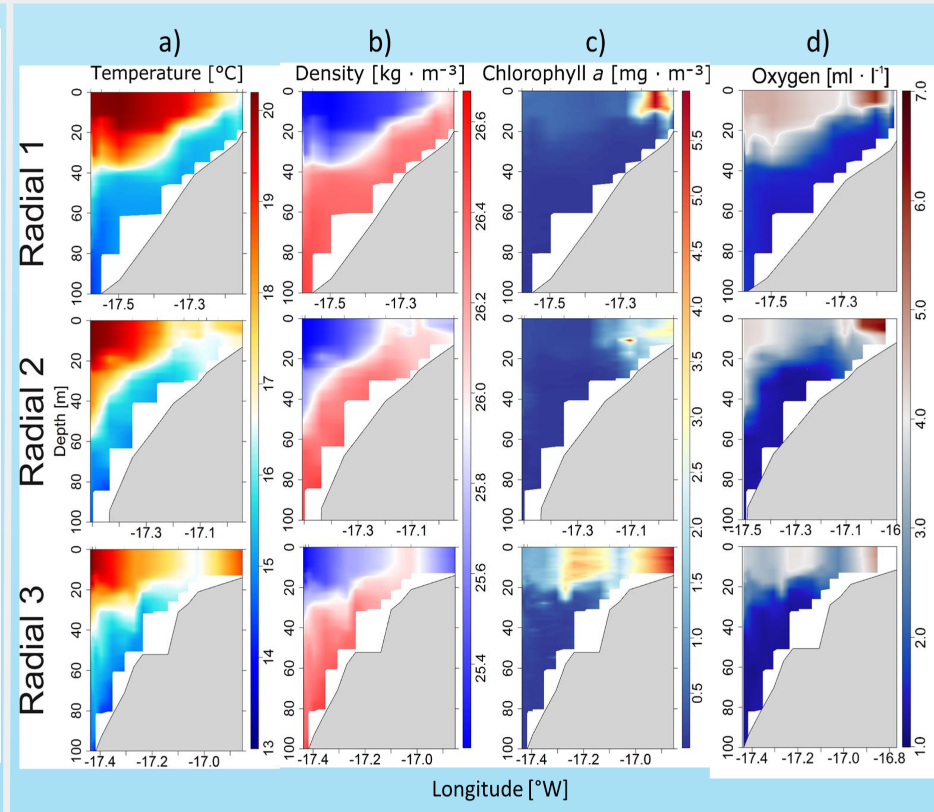


Fig.6: (a) Mean vertical profile of temperature, (b) density, (c) chlorophyll 'a' concentration, and (d) oxygen along the 3 radials (R1 to R3).

Spatial-temporal variability of SL

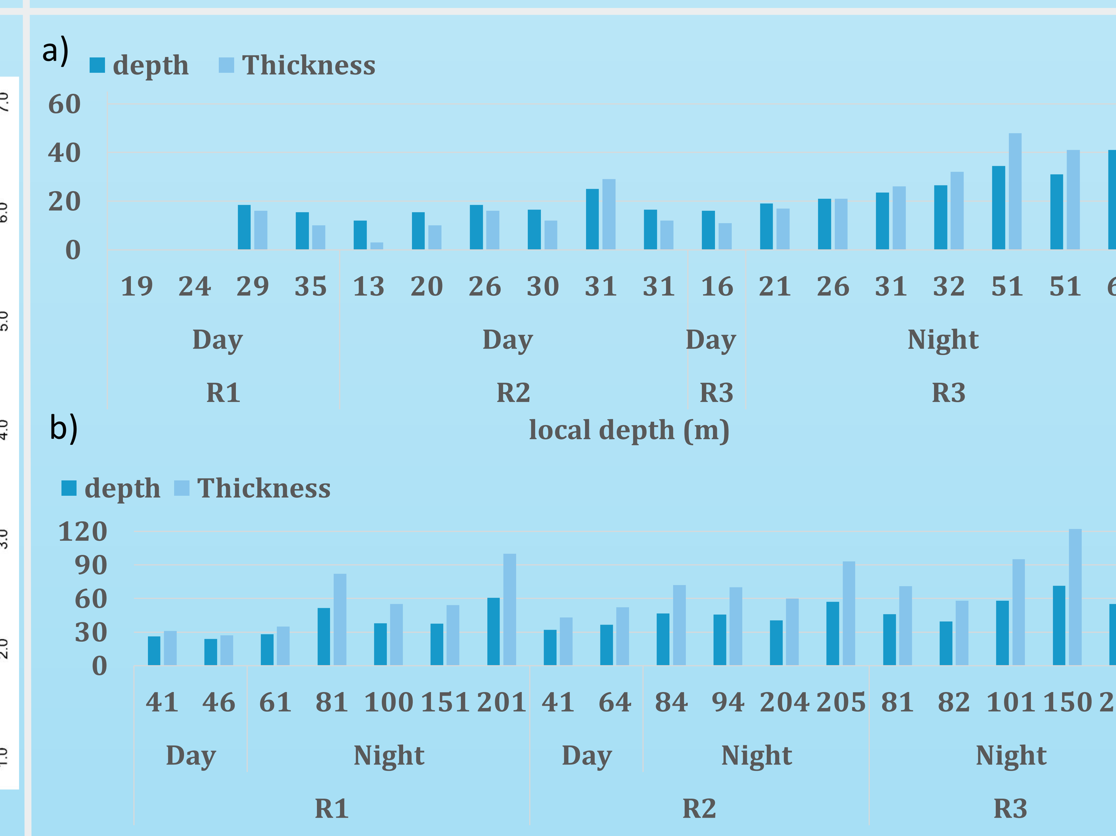


Fig. 7: Variation of mean layer's thickness (black) and depth (grey) *vs* local depth on the radial R1, R2, and R3 during day and night. (a) in the inshore area; (b) in the offshore area.

Influences of environmental parameters (temperature, density, O_2 and CHL) on the biological scattering layers (SL)

Analyses of echograms and CTD profiles

- ✓ Scattering layers (SL) are located partially or totally in zones of strong vertical gradient (thermocline, pycnocline, and oxycline);
- ✓ In the inshore area, the peak of CHL is always located above the scattering layer.;
- ✓ In the offshore area, the peak of CHL is either above layer (50 % of stations) or in the middle of layer (50 % of stations);

Correlation tests (SL thickness and Depth *vs* environmental parameters

Inshore area

- **Day:**

no correlation

- **Night**

CHL (p-value = 0,014, , R^2 = - 0,8)

Local Depth (p-value = 0,000, R^2 = 0,9)

Offshore area

- **Day**

CHL (p-value=0,016, R^2 = -0,9)

- **Night**

Temp (p-value = 0,010, R^2 = 0,4)

Dens (p-value = 0,013, R^2 = 0,4)

Oxy (p-value = 0,031, R^2 = 0,3)

Regression models (SL thickness and depth)

Inshore area (night)

$SL_{thickness}$ = -296, 8 + (0.9 * **Local Depth**)

SL_{depth} = -155, 34 + (00.4 * **Local Depth**)

Offshore area (night)

$SL_{thickness}$ = 422.6 + (0.2 * **Local Depth**) - (21 * **temp**)

SL_{depth} = 221,8 + (0, 09 * **Local Depth**) - (10,5 * **temp**)

Discussion

SL thickness and depth increases with local shelf depth from inshore to offshore which also correspond to the difference of water mass, the fresh upwelled water is not yet abundant in micronekton, as in the first time mainly phytoplankton abundance increase. Furthermore SL are formed and persist under stable conditions allowing physical stratification, i.e. in the absence of turbulence or upwelling (Aoki and Inagaki, 1992; Baussant et al., 1992). The diel variation of layer's thickness and depth is related to diel vertical migration which is a characteristic of zooplanktons and micronektons organisms (Bianchi et al., 2013; Haney, 1988);

In the inshore area Local Depth appear as the main parameter that contribute on SL thickness, while in the offshore area more stratified, the water temperature also contribute to SL vertical structuration. Local depth controls vertical distribution of SLs in the water column (Gausset and Turrel, 2001; Torgersen et al., 1997). SL distribution has also been shown to be a function primarily of temperature (Marchal et al., 1993, Hazen and Johnston, 2010). In more stratified area, SL vertical distribution is limited by strong thermocline and when thermocline were not very marked, SL occupied the entire water column during night (Lee et al., 2013)

The unexpected correlation between SL thickness/depth and CHL observed during daytime in offshore area reveal a probable inverse diel vertical migration of a part of the micronektonic communities in the offshore area over the Senegalese shelf.