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STATUS CONFERENCE RESEARCH VESSELS 2024

Conference transcript

SCHRIFTENREIHE PROJEKTTRÄGER JÜLICH

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SCHRIFTENREIHE PROJEKTTRÄGER JÜLICH

POSTER

SO287

Planktonic and Micronektonic Scattering Layer distribution along latitudinal section: from North East Atlantic to Eastern Tropical Pacific Oceans

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Pelagic Sound Scattering Layers (SSLs) are ubiquitous in all oceans (Tont, 1976; Boswell et al., 2020; Geoffroy et al., 2019) and the result of acoustic scattering from extensive aggregations of micronekton and large zooplankton (Proud et al., 2015; Behagle et al., 2017). SSLs appear continuous on the echogram from scientific echosounder (Simmonds and MacLennan, 2006) vertically narrow, tens to hundreds of meters, and horizontally extensive for tens to thousands of kilometers (Proud et al., 2015). In this study, we explore acoustic and environmental data obtained along a cross Atlantic sea survey ending in the Eastern Tropical Pacific Ocean. In our research, we described the distribution patterns of SSLs along the transport pathway of water from the Northwest African EBUS to the Sargasso Sea and, subsequently, to the Caribbean Sea and the Eastern Tropical Pacific Ocean. On this basis, we scrutinized the SSLs spatial variability in response to key environmental factors taking advantage of the contrasted area surveyed.

Our dataset, collected during the SO287 Connect cross-tropical Atlantic cruise, encompassed acoustic and environmental data. We used a Simrad EK60 echosounder to collect acoustic data, as well as Acoustic Doppler Current Profilers (ADCP) to measure backscatter and water velocities. Coupled with this, hydrographic data, including temperature, salinity, and chlorophyll-a concentration, were obtained from a calibrated CTD (Conductivity, Temperature, Depth) rosette-sampler. We used Matlab open source tool (Matecho) to extract SSLs based on echo levels, allowing us to calculate descriptors such as minimum and maximum depth, width, length, and mean Sv (acoustic backscatter).

Data processing involved advanced techniques, including the use of Matlab open source tool (Matecho) to extract SSLs based on echo levels, allowing us to calculate SSLs descriptors. The Weighted Mean Depth (WMD) as a proxy for vertical distribution was also computed. The diel vertical migration (DVM) of SSLs was analyzed, and generalized additive mixed models (GAMMs) were applied to examine the relationships between SSLs metrics and environmental variables.

SSLS ACOUSTIC CHARACTERIZATION

The clustering of SSLs acoustic data (38 kHz) resulted in four clusters, spatially distributed across the survey area (Figure 1). These clusters corresponded to four regions with different SSLs features: Eastern Tropical North Atlantic Ocean, Sargasso Sea, Caribbean Sea and Eastern Tropical Pacific Ocean. The Atlantic and Pacific cluster exhibited the thickest and longest SSLs. The Pacific Ocean cluster also displayed the shallowest SSLs, which corresponded to the areas of greatest acoustic density. The Sargasso Sea had the deepest, shortest and thinnest SSLs, with the lowest acoustic density. The SSLs in the Caribbean Sea exhibited similar characteristics to those of the Sargasso Sea, with the exception of a higher acoustic density.

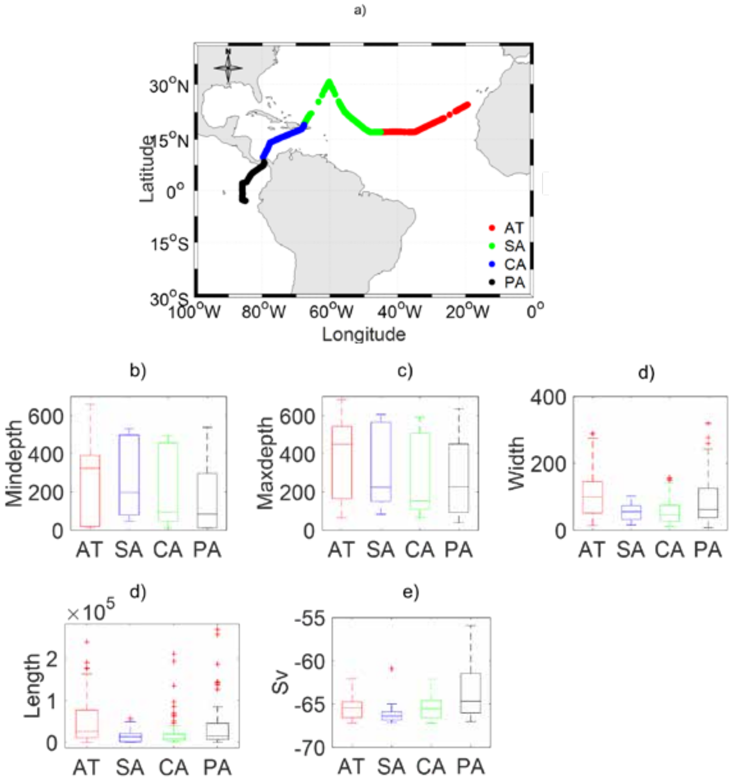

Figure 1: k-means clustering of (38 kHz) discriminated four area along the vessel survey part (Fig 1). a) Map of the daytime survey track with each day colored by its resulting cluster: Atlantic (red); Sargasso (blue); Caribbean (green); Pacific (black). b-f) Boxplots of Sound Scattering Layer (SSLs) metrics for each identified cluster: minimal depth (m), maximal depth (m), width (m) length (m) and Acoustic backscattering strength Sv (dB) used as a micronektonic biomass proxy. AT (Eastern Tropical North Atlantic Ocean), SA (Sargasso Sea), CA (Caribbean Sea) and PA (Eastern Tropical Pacific Ocean).

SSLS VERTICAL DISTRIBUTION

SSLs vertical structuration also differed from region to region (Figure 2). Throughout the studied areas, two main SSLs were observed: epipelagic SSLs between 10–200 m depth and mesopelagic SSLs located between 300–600 m depth during day and at shallower depths during night. The Pacific region, particularly, exhibited a singular feature showing an intermediate SSL appearing at 350–450 m depth between the epilapegic and mesopelagic SSLs.

The vertical profile of mean acoustic volume backscattering strength (Sv in dB) recorded at 38 kHz (Figure 3) exhibited diverse patterns from the surface down to 800 m. Daytime and nighttime effects on the vertical distribution consistently emerged, with elevated values of acoustic backscatter (Sv) generally observed in the epipelagic zone (0–200 m) during the night and in the mesopelagic zone (200–800 meters) during the day. However, there were exceptions, particularly in the Pacific region, where the diel difference is less clear in the epipelagic layer with day and night profiles overlapping. Notably, in the Sargasso Sea, the daytime biomass slightly exceeded the nocturnal biomass in the mesopelagic zone, occasionally overlapping with the latter.

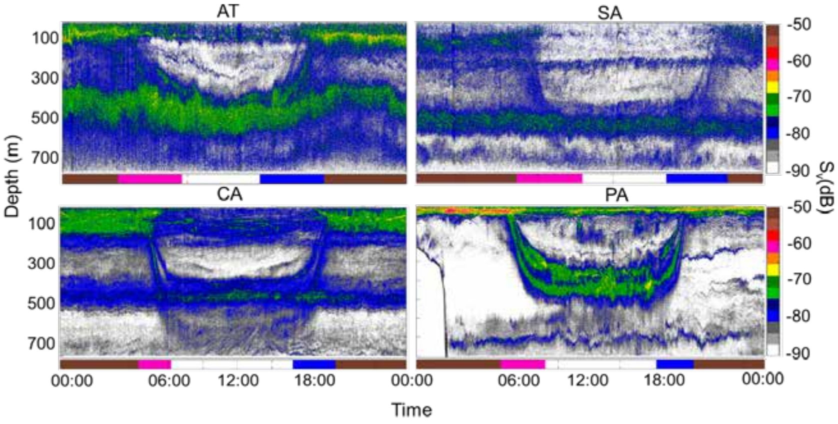

Figure 2: TPM (transcript per million) value of each nitrogen metabolism in the metagenome datasets from Tara Ocean samples and SO287, and their correlations (excluding Tara Ocean datasets) with physiochemical parameters (p<0.05, |r|>0.5).

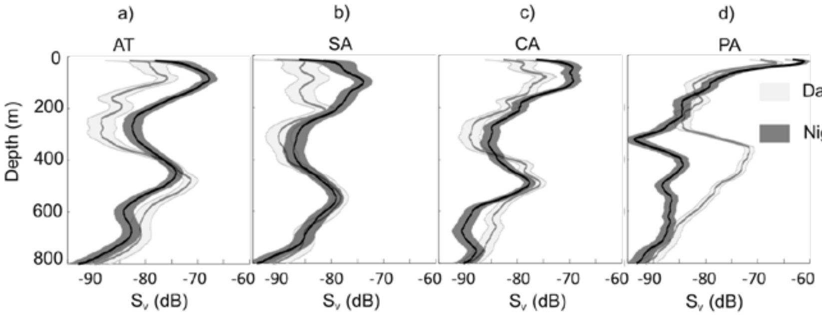

Figure 3: Diel difference of mean acoustic volume backscattering strength (Sv in dB) within the water column in AT (Tropical Atlantic Ocean), SA (Sargasso Sea), CA (Caribbean Sea) and PA (Eastern tropical Pacific Ocean).

ENVIRONMENTAL CONDITIONS ACROSS THE STUDY AREA

Vertical variability of temperature, salinity, dissolved oxygen, and chlorophyll-a along the transects performed in the North Atlantic and in the Pacific Ocean are shown in Figure 4. The variability of the environmental parameters clearly reflects the transport pathway of water from the upwelling zones off Africa into the Sargasso Sea, further to the Caribbean and to the equatorial Pacific. Our results are indicative of the properties of the water masses and the influence of ocean circulation in the tropical Atlantic and Pacific.

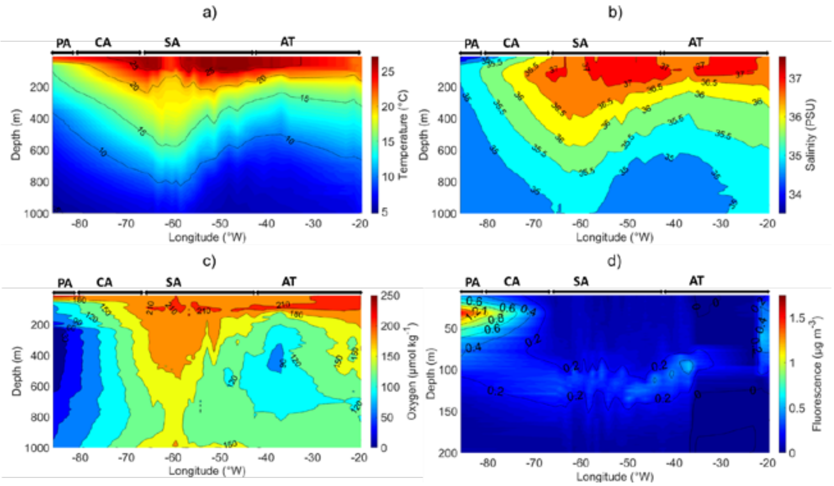

Figure 4: Contour plots of (a) temperature, (b) salinity, (c) dissolved oxygen, and (d) fluorescence in the entire surveyed area, i.e., AT (EasternTropical Atlantic Ocean), SA (Sargasso Sea), CA (Caribbean Sea) and PA (Eastern tropical Pacific Ocean).

EFFECT OF ENVIRONMENTAL PARAMETERS ON SSLS

The relationships between the vertical distribution of SSLs and the physical environment are depicted in Figure 5. The vertical variability of temperature, salinity, and dissolved oxygen was found to influence the vertical distribution of the SSLs WMD, shaping their vertical distribution. Thus, the observed variability of WMD seems to be drifted by the water masses characteristic despite no obvious environmental constraint or gradient limiting their vertical extend. The influence of water masses characteristics on SSLs vertical distribution are corroborated by the depenning of the SSLs (Figure 6) in the Sargasso sea coinciding with the depening of thermocline, oxycline and halocline. Numerous previous studies have investigated the potential environmental factors, including primary production, dissolved oxygen levels, light intensity, temperature, wind-induced mixing and predation pressure, that drive the spatial distribution of SSLs (Escobar-Flores et al., 2013; Diogoul et al., 2020; Irigoien et al., 2009; Klevjer et al., 2016a; Aksnes et al., 2017; Balino and Aksnes, 1993; Proud et al., 2017; Receveur et al., 2019). Our research findings suggest that sea temperature fluorescence and oxygen play a predominant role in determining the vertical distribution of the SSLs while salinity and diel period exerted less influence. On a global or basin scale, the primary influencing factors for SSLs include sea surface temperature, primary productivity, and dissolved oxygen levels (Bianchi et al., 2013; Irigoien et al., 2014a; Escobar-Flores et al., 2013; Klevjer et al., 2016b). The combination of salinity, light, temperature, nutrients, circulation, carbon dioxide, and oxygen collectively determines the physiology of life, ultimately impacting the composition, structure, and functioning of the ecosystem (Röthig et al., 2023)

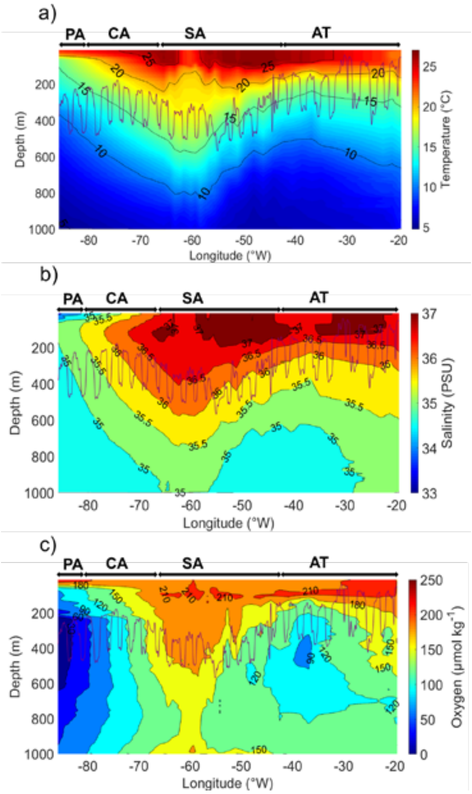

Figure 5: Vertical section along the vessel pathway from CTD probe for (a) sea water temperature, (b) salinity, and (c) dissolved oxygen in the AT (EasternTropical Atlantic Ocean), SA (Sargasso Sea), CA (Caribbean Sea) and PA (Eastern tropical Pacific Ocean). Purple line depict the Weighted Mean Depth (WMD) on each panel.

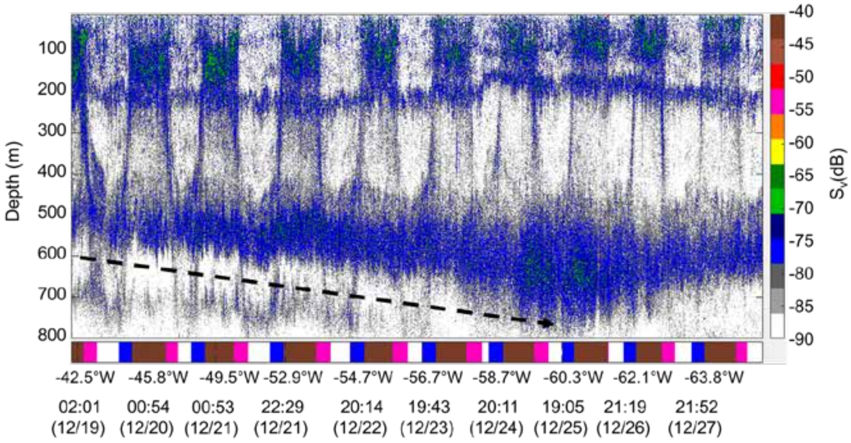

Figure 6: Echogram (38 kHz) in the Sargasso sea depicting the deepening of the mesopelagic layer from 19/12 to 26/12/2021.

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DATA

Acoustic observations:
https://portal.geomar.de/group/so287-connect/data

Physical oceanography (CTD):
https://portal.geomar.de/group/so287-connect/data