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RESPIRATION IN THE MESO- AND BATHYPELAGIC LAYERS IN THE NORTH ATLANTIC OCEAN

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Abstract:

Estimating zooplankton respiration in the mesopelagic layer is crucial for understanding carbon transport in the ocean. The diurnal respiration of vertical zooplankton migrants contributes to the downward flux of carbon in the oceans. Thus, zooplankton respiration directly influences the export and sequestration of organic carbon in the mesopelagic layer, which influences global carbon dynamics. However, measuring specific values of zooplankton respiration in the meso- and bathypelagic zones is challenging. This study examines the respiration of several zooplankton groups in the meso- (200-1000 m) and bathypelagic (>1000 m) layers during the most productive season (winter) in the subtropical Atlantic Ocean due to maximum mixing of the water column. Sampling was conducted at two different latitudinal and longitudinal stations in the North Atlantic Ocean during day and night. The results highlight the importance of incorporating the active transport of large zooplankton migrants in the assessment of the biological carbon pump.

Introduction

Since 1850, human activities have released about 650±65 Gt of carbon into the atmosphere. Approximately 30% has been absorbed by the oceans (Friedlingstein et al., 2020;Gruber et al., 2019;Khatiwala et al., 2013). Causing a continuous increase in the concentration of inorganic atmospheric carbon (Caínzos et al., 2022) in the oceans.

Zooplankton convert a significant portion of the fixed carbon to CO_2 in the upper ocean, where it can be reused or released back into the atmosphere. A fraction of this fixed carbon is exported to the deep ocean, where it can remain sequestered for centuries (Nowicki et al., 2022). Understanding the distinct roles of zooplankton in carbon transport is crucial for predicting future changes in this community (Steinberg and Landry, 2017). Therefore, investigating carbon fluxes from surface waters to the deep ocean provides valuable information on how the oceans absorb and store carbon, offering effective strategies to cope with climate change.

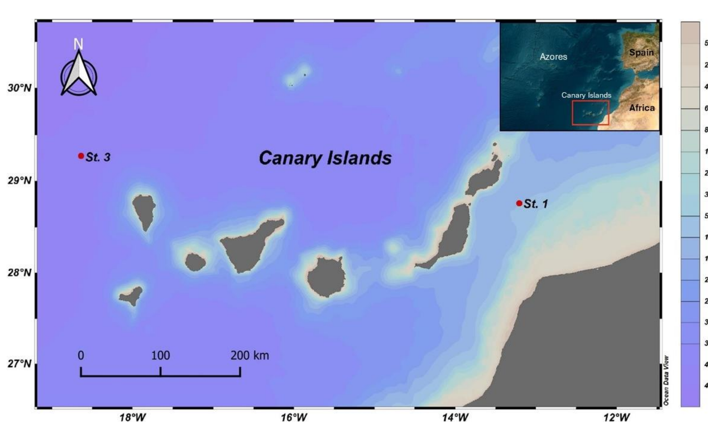

Figure 1. Location of the sampled stations (stations 1 and 3) during the DESAFIO-1 cruise. Background colors correspond to the bathymetry.

Objectives

- ✓ To compare the variability of the active zooplankton flux in two stations located in the productive zone of the African upwelling and in the oligotrophic zone in the west of the island of La Palma.
- ✓ To investigate the carbon transported to the deep ocean due to migratory zooplankton in the mesopelagic and bathypelagic layers at a eutrophic station (st. 1) and at an oligotrophic station (st. 3).
- ✓ Examine the vertical distribution of zooplankton, migrating biomass and respiratory flux along with active flux by an analysis of electron transport system (ETS) enzyme activity.

Methodology

Zooplankton biomass estimations

- Taxonomic characterization of biomass using a representative subsample of the zooplankton community from samples fixed on board. Images were scanned, processed in ZooProcess and classified with ecotaxa.
- Body area was converted to biomass in terms of dry weight (DW) using empirical relationships given by Hernández-León & Montero, (2006) and improved by Lehette & Hernández-León, (2009). DW was converted to carbon units
- The biomass of migrant organisms at station 1 was calculated in the epipelagic layer, taking the difference between nighttime and daytime biomass values. At station 3, the difference in biomass between day and night in the mesopelagic zone was estimated.

Enzymatic activity of the electron transfer system (ETS)

It was measured following the method of Packard (1971) as modified by Owens & King (1975), Kenner & Ahmed (1975) and Gómez et al., (1996). ETS activity was estimated spectrophotometrically at 490 nm. Protein content was determined by the method of Lowry et al., (1951) as modified by Rutter (1967). Protein content was converted to DW using the ratio of 2.49 given by Hernandez-Leon (2019) for zooplankton from subtropical waters.

Active flux

- The respiratory flux in the mesopelagic layer is determined using the average ETS activity (μlO_2/mg prot·h) multiplied by the obtained migrant biomass. A ratio between respiration and ETS of 0.5 and a residence time at depth of 12 hours were used. To convert respiration to carbon units, a respiration ratio (CO_2 respired/O_2 consumed) of 0.97 was used (Omori & Ikeda, 1984).
- Mortality was calculated assuming a steady-state condition in the mesopelagic zone, where growth equals mortality.
- Intestinal flux was estimated assuming that feeding is 2.5 times respiration (Ikeda & Motoda, 1978), and that migrating zooplankton egested 50% of the intestinal content at depth (Ariza et al., 2015).

Results

1. Spatial distribution and productivity.

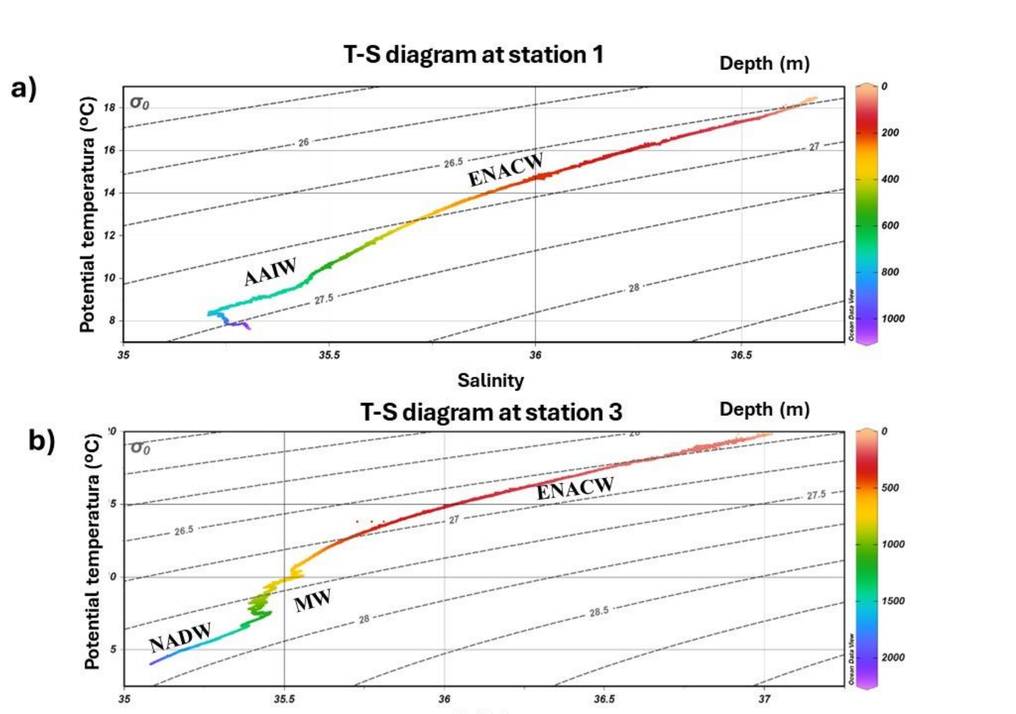

Figure 2. Temperature-salinity (T-S) diagram at a) station 1 and b) at station 3. ENADW stands for Eastern North Atlantic Deep Water, MW for Mediterranean Water, NADW North Atlantic Deep Water, and AAIW for Antarctic Intermediate Water.

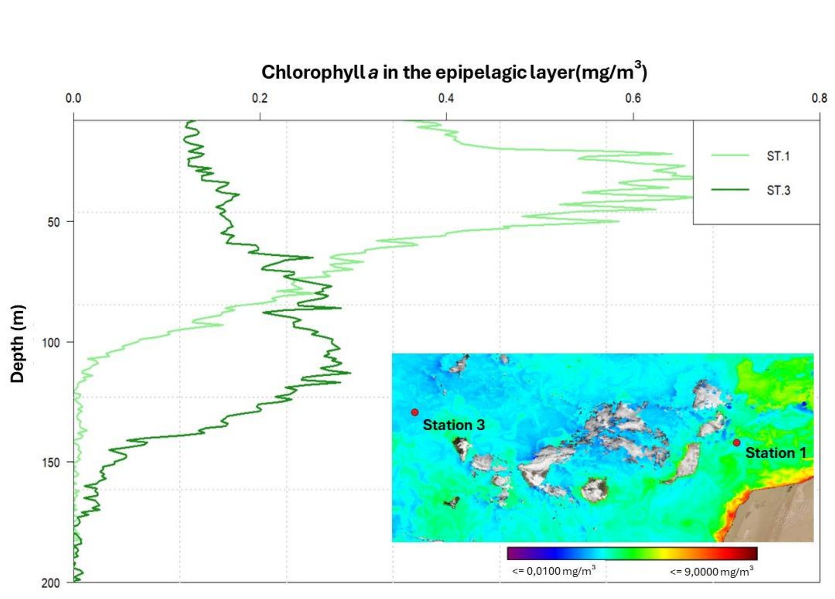

Figure 3. Vertical profiles of chlorophyll a (mg/m3) at station 3 (dark green) and at station 1 (light green). In the lower right corner there is a map of chlorophyll a (mg/m3) around the Canary Islands (Worldview, 2024).

2. Zooplankton biomass

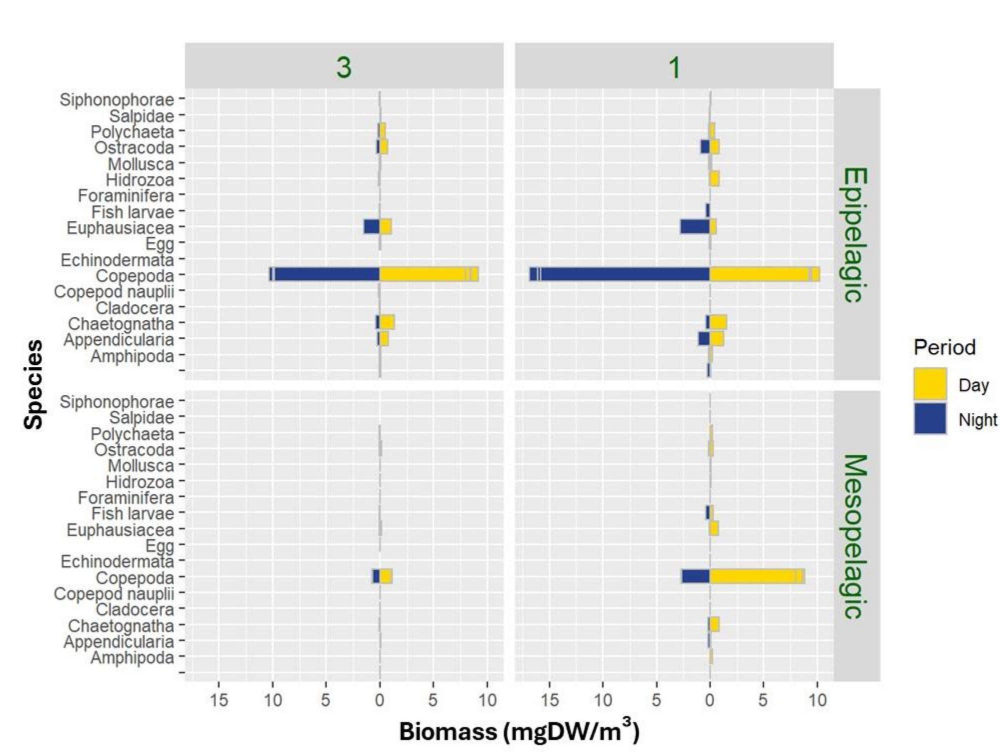

Figure 4. Zooplankton biomass (mgDW/m3) by species at station 3 (left panel) and at station 1 (right panel) for the epipelagic and mesopelagic layer.

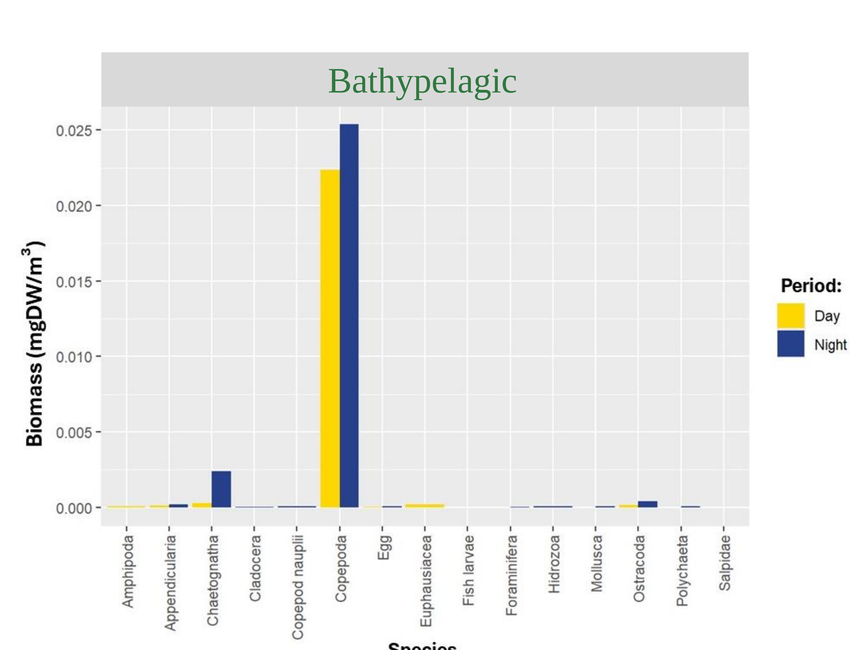

Figure 5. Zooplankton biomass (mgDW/m3) by species at station 3 for the bathypelagic layer.

3. Electron transfer system (ETS)

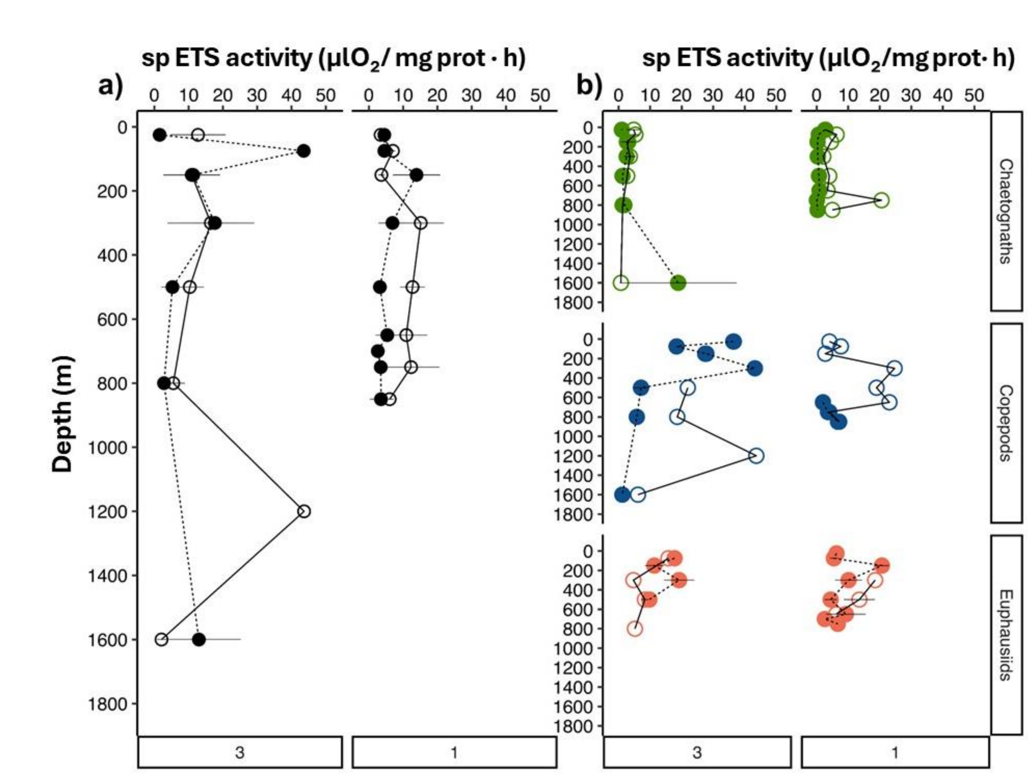

Figure 6. a) Vertical profiles of zooplankton specific ETS activity (μlO_2/mg prot·h) at station 3 (left panel) and station 1 (right panel). **b)** Vertical profiles of specific ETS activity (μlO_2/mg prot·h) for chaetognaths (in green), copepods (in blue), and euphausiids (in orange) at station 3 (left panel) and station 1 (right panel). White dots stand for the daytime activity and the filled dots the nighttime activity if the specific ETS.

4. Total active flux and migrant biomass

Table 1. Total active flux estimated as the sum of the respiratory flux and the estimated mortality, migrant zooplankton biomass, excretion and gut fluxes performed by diel vertical zooplankton migrants at station 1 and at station 3.

Station	Depth layer	Respiratory flux (mgC/m2 · 12h)	Migrant biomass (mgDW/m2)	Mortality flux (mgC/m2 ·12h)	Exeretion flux (mgC/m2 ·12h)	Gut flux (mgC/m2 ·12h)	Total active flux (mgC/m2 ·12h)
1	Epipelagic	6.36	430.53	4.77	1.53	7.95	20.62
3	Epipelagic	1.74	129.48	1.30	0.42	2.17	5.63
	Mesopelagic	0.03	2.22	0.02	0.01	0.04	0.09

Conclusion

In summary, we observed higher mesozooplankton migrant biomass and respiratory flux in areas of high productivity compared to oligotrophic areas, with important consequences on the biological carbon pump. Active flux estimated in the mesopelagic layer showed low values of migrant biomass but similar ETS activities in the meso- and bathypelagic layers. Future projects could study the role played by micronekton in the flux of active carbon in the bathypelagic layers, in addition to knowing the time that carbon sequestration remains in the different water masses.

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