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# Seasonal dynamics of zooplankton communities in a recent lava delta on an oceanic island in the Central East Atlantic Ocean

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**ABSTRACT**

We examined the structure of the zooplankton community in a Special Area of Conservation affected by the recent formation of lava deltas caused by a volcanic eruption on the island of La Palma (Canary Islands) in the Central East Atlantic Ocean. Seasonal variability in biomass, abundance, and composition of the zooplankton community was analyzed, both in total and within different size ranges. The results showed higher biomass values in winter at 30 m and in spring–summer at 10 m depth, possibly related to seasonal changes in food availability and seawater temperature. Significant differences were observed in the biomass of the smaller size range compared to larger sizes. Similarly, organisms in the smaller size range were the most abundant, primarily due to the community being dominated by copepods, which represented 80.43% of the total abundance in winter, decreasing to 47.14% in spring–summer. At the same time, a significant increase was observed in decapod larvae, gastropods, invertebrate eggs, and cladocerans during the warmer season. An increase in gelatinous organisms, especially siphonophores, was also observed in spring–summer for the largest size range, suggesting potential seasonal changes in the zooplankton trophic structure. This study indicates a limited direct impact of volcanic activity on zooplankton biomass but highlights the importance of understanding seasonal variability in community structure for managing marine conservation. Continuous monitoring of zooplankton dynamics is crucial for detecting potential future impacts on the food web and developing targeted conservation management strategies.

KEYWORDS: abundance; biomass; gelatinous zooplankton; taxonomic composition

## INTRODUCTION

The Canary Islands, a volcanic archipelago in the subtropical East Atlantic Ocean, are known for their oligotrophic waters and exceptional marine biodiversity, with species uniquely adapted to distinct oceanographic conditions (Arístegui *et al.,* 2001; Haroun, 2001). Recently, both submarine and subaerial volcanic activity have significantly disrupted these ecosystems (Fraile-Nuez *et al.,* 2012; Betancor *et al.,* 2014; Torres-González *et al.,* 2020; Amonte *et al.,* 2022), emphasizing the need to understand the impacts of such natural disturbances on marine biodiversity and ecosystem functions at a global scale (Ariza *et al.,* 2014; Fernández de Puelles *et al.,* 2021; Caballero *et al.,* 2023; Herrera *et al.,* 2024).

In September 2021, the island of La Palma experienced a subaerial volcanic eruption, which led to substantial impacts on surrounding marine ecosystems (Escolà-Gascón *et al.,* 2023). Lava flows from this event reached the coastal zone, particularly affecting the Fuencaliente Marine Strip, a protected area designated as a Special Area of Conservation (SAC) under the Natura 2000 network (ES7020122; BOE, 2011). The eruption created two lava deltas on the upper layers of the continental shelf, resulting in a loss of fish biodiversity (Caballero *et al.,*

2023). The spatial extent of this impact reached several 100 m from the coast. However, two months after the eruption, environmental conditions such as seawater temperature, salinity, pH, and oxygen levels began to normalize (González-Santana *et al.,* 2022), allowing the recolonization of benthic flora and fauna in the newly formed volcanic substrates (Sangil *et al.,* 2023; Bosch *et al.,* 2024).

The formation of lava deltas in the Fuencaliente Marine Strip has considerable implications for human activities dependent on a healthy marine environment, such as ecotourism (whale watching, diving), fishing, aquaculture, and scientific research. The sustainability of these activities relies on the good environmental status of the marine ecosystem, emphasizing the need to understand the resilience of pelagic systems in the face of such disturbances (Herrera *et al.,* 2021). Therefore, it is important to examine these processes at the scale of the marine food web.

Zooplankton, a key component of the food web, plays a crucial role in secondary production by transferring energy from primary producers to higher trophic levels (Ratnarajah *et al.,* 2023). This diverse group of organisms is distributed throughout the water column and plays a pivotal role in the biological pump, which transports organic matter to deeper ocean layers (Mojica López and Franco-Herrera, 2019; Castillo *et al.,* 2019). Despite

having relatively short life cycles (weeks to months) (Bode et al., 2012), zooplankton communities are critical biological indicators, as they are highly sensitive to environmental changes, such as fluctuations in water temperature and salinity (Jakhar, 2013; López-Figueroa et al., 2023). Accurately measuring zooplankton abundance, biomass, and taxonomic composition is, therefore, crucial for assessing changes in marine ecosystems and for ecosystem modeling on a global scale (Hjøllo et al., 2021).

Some taxonomic groups of the zooplankton community, particularly gelatinous organisms, have been poorly studied despite their ecological significance. These include jellyfish (Hydrozoa, Scyphozoa and Cubozoa), ctenophores, siphonophores, chaetognaths, appendicularians, and thaliaceans (Jaspers et al., 2023, Jaspers et al., 2015; Ramírez, 1981). These organisms represent various functional groups in marine food webs such as carnivores represented by hydrozoans, ctenophores, and chaetognaths (with some exceptions for the latter; Grigor et al., 2020), and filter feeders represented by pelagic tunicates (appendicularians and thaliaceans), which play a fundamental role as indicators of environmental changes in the ocean (Luo et al., 2022). At the same time, their adaptability to tolerate various adverse environments and withstand wide seawater temperature and salinity ranges makes them effective indicators for identifying and tracking the properties and movement of water masses and currents. These characteristics are particularly relevant in the context of climate change, as they help monitor shifts in oceanographic conditions and ecosystem dynamics (Castillo et al., 2019).

With this study, we aim to contribute to the knowledge of mesozooplankton communities in the oligotrophic waters of the subtropical Atlantic, with a focus on gelatinous organisms (mainly siphonophores), due to their significant role in the marine trophic web (Hetherington et al., 2024). Our specific objectives were to examine their seasonal variations in biomass and abundance, as well as the taxonomic composition of the zooplankton communities along the Fuencaliente Marine Strip (SAC ES7020122) with surveys conducted in winter and spring–summer to gain valuable insights into natural environmental changes.

Given previous studies highlighting the influence of seasonal changes in food availability and environmental factors, we hypothesized that seasonal variations in environmental conditions, such as temperature, would drive significant shifts in both the biomass and composition of zooplankton communities. We expected to observe higher biomass and abundance in spring–summer, coinciding with increased sea surface temperature. Moreover, we anticipated shifts in taxonomic composition, with gelatinous organisms such as siphonophores showing higher occurrence during the warmer season. These findings are expected to provide valuable insights into the natural dynamics of local zooplankton communities in response to environmental changes.

## MATERIAL AND METHODS
### Study site
The study was conducted in the recently formed lava deltas resulting from the volcanic eruption in September 2021 on La Palma Island, located in the subtropical waters of the Atlantic Ocean (28° 37′ 32.63" N, 17° 55′ 57.64" W). This area is part of the Fuencaliente Marine Strip, as referred to above and shown in Fig. 1. Two oceanographic cruises were carried out in 2023 to collect biological samples: one in winter (15 January) and the other in late spring-early summer (June 3). Vertical hauls using a WP2 net with a 200 $\mu$m mesh size (UNESCO, 1968) were performed consecutively at four depth intervals in the water column: 0–10, 0–30, 0–50, and 0–100 m (referred to hereafter as 10, 30, 50, and 100 m) at eight stations in winter (W1-W8) and ten stations in spring–summer (SS1-SS10). For each haul, the WP2 net was lowered to the specified depth and retrieved vertically to the surface, ensuring consistent sampling across depth intervals. The 100 m depth interval was sampled only in the spring–summer season at station SS10.

Additionally, horizontal transects were conducted at a depth of 3 m between stations using an APSTEIN-type net (200 $\mu$m mesh size). Transects covered a distance of approximately 250–500 m in winter (Tr1–Tr3) and 1500 m in spring–summer (Tr4–Tr6) (see Fig. 1). Towing was performed at a speed of 2–3 knots, approximately 25 m behind the boat, avoiding turbulence from the boat engine. The APSTEIN-type net is a lightweight alternative to the WP2 net, designed for both horizontal and vertical sampling (Sambolino et al., 2022).

Station selection varied between cruises due to logistical constraints and the distinct oceanographic conditions present in winter and spring–summer. Stations were spaced according to accessibility, proximity to the eruption site, and depth profiles of interest. Stations sampled during both seasons shared similar bathymetry, allowing for direct comparisons of seasonal data. The two-season sampling enabled analysis of seasonal variability in zooplankton composition and structure in the volcanic eruption-affected region. Winter and spring–summer were chosen based on the region's hydrographic cycles (Arístegui et al., 2001): winter typically corresponds to a mixing period with a less stratified water column, while spring–summer represents the onset of stratification. These sampling points are expected to capture significant seasonal dynamics affecting zooplankton communities in subtropical marine environments.

### Biological variables
Zooplankton samples collected during the oceanographic cruises were divided using a FOLSOM splitter into two equal subsamples. These subsamples were fractionated through 1000 $\mu$m and 500 $\mu$m sieves according to size ranges (200–500, 500–1000, and >1000 $\mu$m) to assess biomass, abundance, and the taxonomic composition of the mesozooplankton community. Biomass of each size range was measured using the method described by Lovegrove (1966), drying the sample at 60°C for 24–48 hours, with the data expressed as dry weight in miligrams per cubic meter (mg DW·m$^{-3}$). Abundance was determined for each size range, by counting individuals using a binocular stereomicroscope (LEICA®, S APO) and expressed as individuals per cubic meter (ind·m$^{-3}$). Gelatinous organisms were individually identified to the lowest taxonomic level possible using a green Janus dye to enhance visibility (Licandro et al., 2017).

### Environmental variables data
Daily average for Sea Surface Temperature (SST, °C), Salinity, Chlorophyll-*a* (Chl-*a*, mg·m$^{-3}$) and Zooplankton biomass
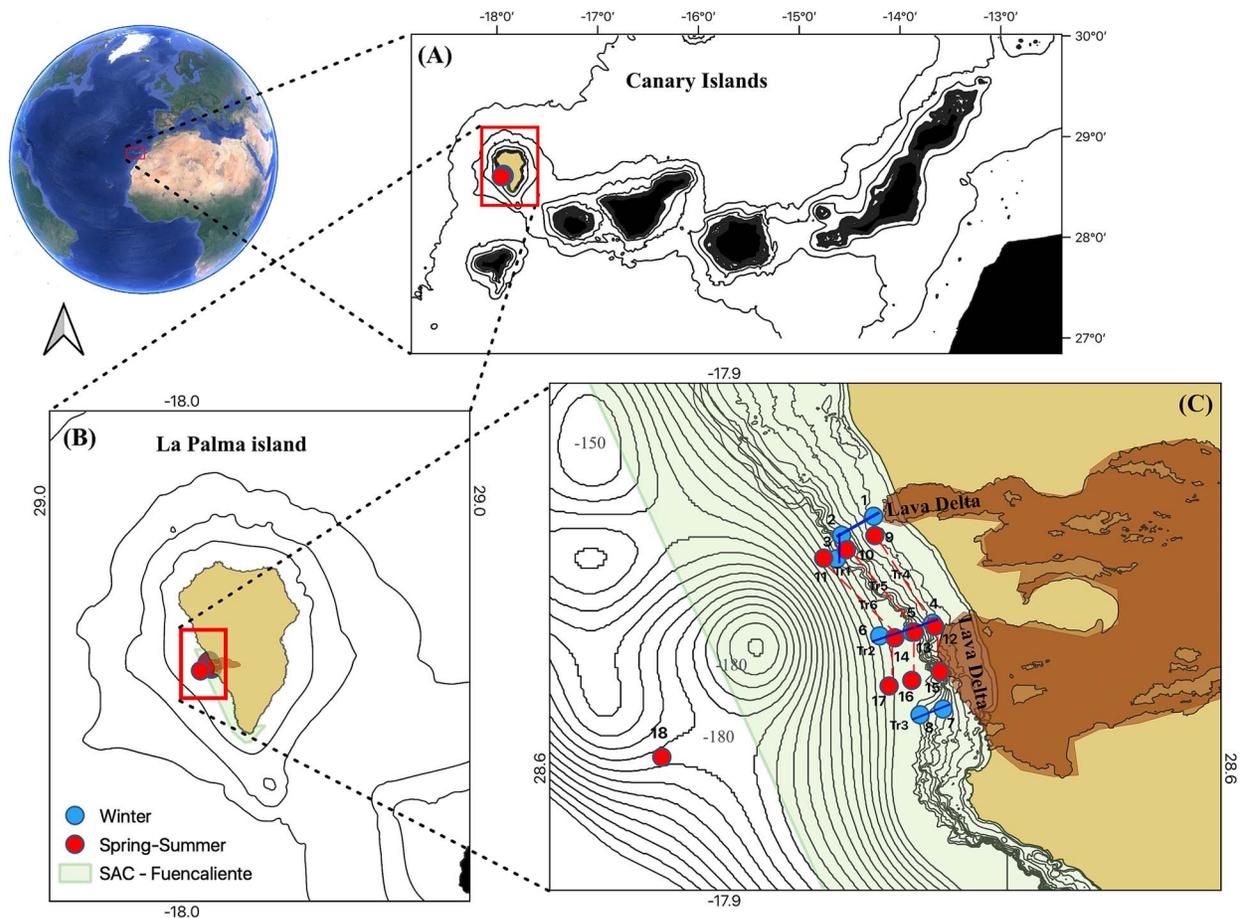
**Fig. 1.** Location of the study area in the waters near the lava deltas of the island of La Palma (Canary Islands, Atlantic Ocean). (**A**) Canary Islands; (**B**) La Palma Island; (**C**) Study stations, in blue circle for the Winter season and in red circle for the Spring–Summer season. Transects, labeled as "Tr," were conducted using an APSTEIN-type net, while circles indicate stations sampled using a WP2 net.

(Mole concentration of zooplankton expressed as carbon in seawater; $mmol \cdot m^{-3}$) were obtained from the Copernicus Marine Service (https://marine.copernicus.eu/) for the period from April 2021 to December 2023. All variables were derived from Level 4 SST data provided by the product IBI_ANALYSISFORECAST_PHY_005_001, with a spatial resolution of $0.028° × 0.028°$. These variables were used to assess the environmental conditions that might influence the structure of zooplankton communities (Fig. S1).

## Data analysis

The total and size-specific zooplankton biomass $(mg\, DW \cdot m^{-3})$ and abundance $(ind \cdot m^{-3})$ values of the specific taxonomic groups observed at each station were obtained using the estimated filtered water volume $(m^3)$. For WP2 net samples, the net area $(0.25\, m^2)$, efficiency (0.94), and depth (m) of each haul were considered. For APSTEIN-type net samples, the net area $(0.05\, m^2)$, efficiency (0.94), and distance in meters of each transect were used to estimate the filtered volume. Taxonomic groups less represented at each station were categorized under "Others".

The QGIS (version 3.26) program was used to represent the study area. Statistical analyses were conducted to examine variability in biomass, abundance, and composition across stations, size classes, and depths. Analysis of variance (ANOVA) was initially employed to detect significant differences between variables. This was followed by a multivariate permutation analysis (PERMANOVA) to explore relationships between zooplankton composition and environmental factors. Factors included in the analysis were size range (Total, 200–500, 500–1000, and >1000 $\mu$m), season (Winter and Spring–Summer), depth (3, 10, 30, 50, and 100 m), and taxonomic group. The analysis was based on modified Euclidean distance dissimilarity, with significance determined using 9999 permutations (Anderson, 2001). A Bonferroni-corrected multiple comparison test was applied to identify taxa groups showing significant seasonal or depth-related differences in abundance. All analyses were conducted using RStudio (R Core Team, 2022) and PAST4 (version 4.10).

## RESULTS

The study examined mesozooplankton communities in the oligotrophic waters of the subtropical Atlantic Ocean, near the recent lava deltas on La Palma Island. Seasonal variations in zooplankton biomass, composition, and abundance were identified in the SAC under the Natura 2000 network, specifically in the Fuencaliente Marine Strip (ES7020122).
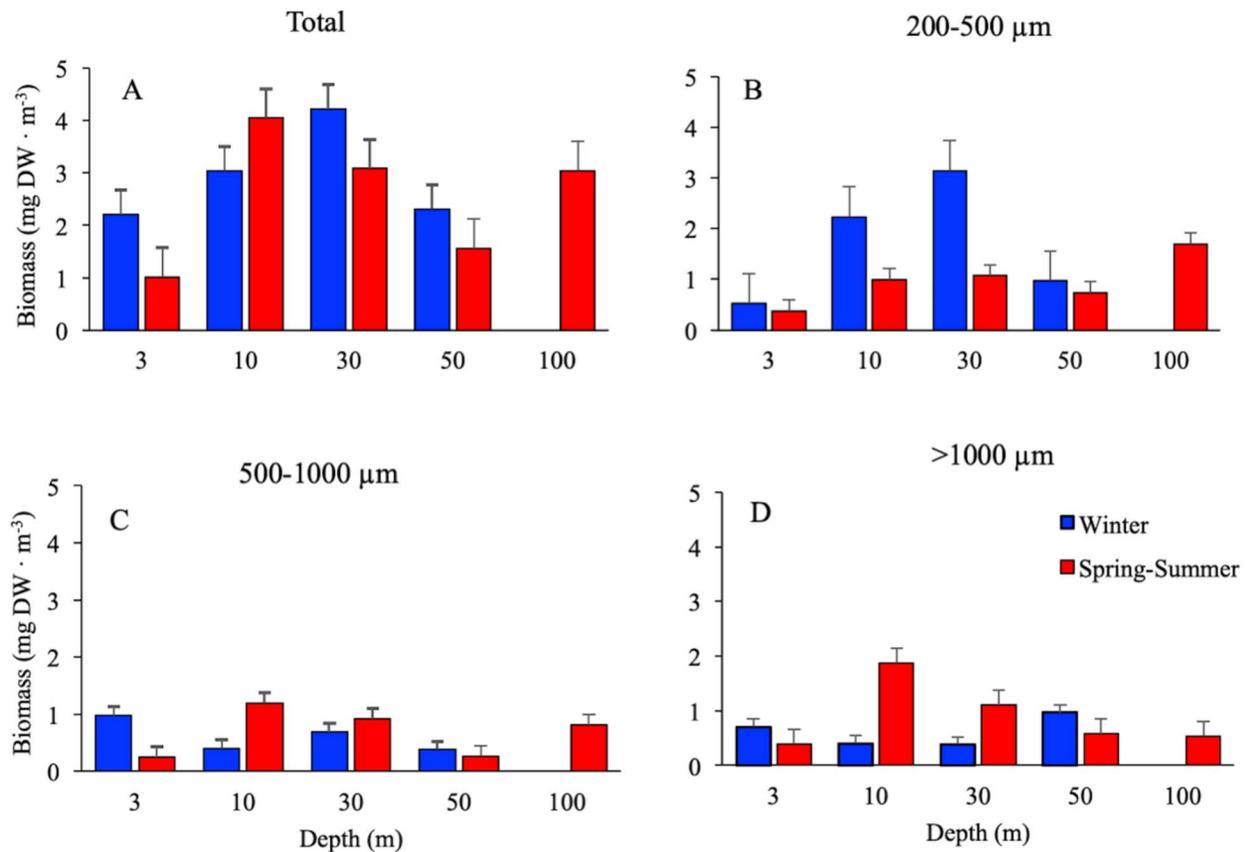
**Fig. 2.** Biomass of the mesozooplankton community (mg DW·m$^{-3}$) at different depth intervals (m) during Winter (blue) and Spring–Summer (red). Biomass is presented for (**A**) Total zooplankton, (**B**) 200–500 $\mu$m size range, (**C**) 500–1000 $\mu$m size range, and (**D**) >1000 $\mu$m size range. The biomass at 3 m was sampled using an Apstein-type net, while a WP2 net was used for all other depths.

## Biomass

Values obtained for biomass (mg DW·m$^{-3}$; Fig. 2) did not show significant seasonal differences (ANOVA; $P > 0.05$). During winter, total zooplankton biomass (Fig. 2A) fluctuated along the water column, ranging from a minimum of 2.21 mg DW·m$^{-3}$ at 3 m depth, increasing to a maximum of 4.22 mg DW·m$^{-3}$ at 30 m intervals, then decreasing to 2.31 mg DW·m$^{-3}$ at 50 m depth interval. In spring–summer, total biomass ranged from a minimum (1.01 mg DW·m$^{-3}$) at 3 m, to a maximum (4.06 mg DW·m$^{-3}$) at 10 m depth, decreasing toward deeper layers (3.09–1.56 mg DW·m$^{-3}$) before increasing again at 100 m (3.05 DW·m$^{-3}$). The PERMANOVA analysis showed significant size structure differences, primarily in the smaller size range ($P < 0.05$).

Biomass showed variations in the community structure according to the size range, with significant differences observed in the small size range compared to the larger size ranges (500–1000 and >1000 $\mu$m). For the 200–500 $\mu$m size range (Fig. 2B), winter values ranged from a minimum (0.52 DW·m$^{-3}$) at 3 m to a maximum (3.14 mg DW·m$^{-3}$) at 30 m, decreasing to 0.96 mg DW·m$^{-3}$ at 100 m. In spring–summer, values ranged from a minimum (0.37 mg DW·m$^{-3}$) at 3 m to a maximum (1.70 mg DW·m$^{-3}$) at 100 m. The larger size ranges (500–1000 and >1000 $\mu$m) did not show significant seasonal differences (Fig. 2C and D).

## Abundance

During both seasons, 13 taxonomic groups were identified in the community in waters near the lava deltas. In winter, the community was dominated by Copepoda (80.43%), crustacean eggs (hereafter "eggs"; 9.27%), Chaetognatha (3.09%), Gastropoda (2.41%), Decapod larvae (1.70%), Ostracoda (1.15%), and gelatinous organisms (Siphonophores and Salps; 0.64%). The "Others" category (1.28%) included other mollusks, polychaetes, amphipods, and fish larvae (Fig. 3).

In spring–summer, the community composition did not show significant differences (ANOVA, $P > 0.05$) compared to winter, except for gastropods and decapod larvae (ANOVA, $P < 0.05$). Copepods remained dominant but decreased their contribution to 47.14% in spring–summer, while other groups, such as eggs (20.04%) and decapod larvae (22.76%), increased their presence. Other groups included Gastropoda (4.64%), Chaetognatha (2.03%), Cladocera (order Diplostraca; 1.35%), gelatinous organisms (0.78%), Ostracoda (0.48%), and the "Others" category (0.75%) (Fig. 3).

The present study also examined the relative abundance (%) of various taxonomic groups and total abundance (ind·m$^{-3}$), categorized by size range, depths in the water column (3, 10, 50, and 100 m), and seasons (winter and spring–summer) (Fig. 4). Variability was observed between winter and spring–summer in the relative abundance (%) of total mesozooplankton, with
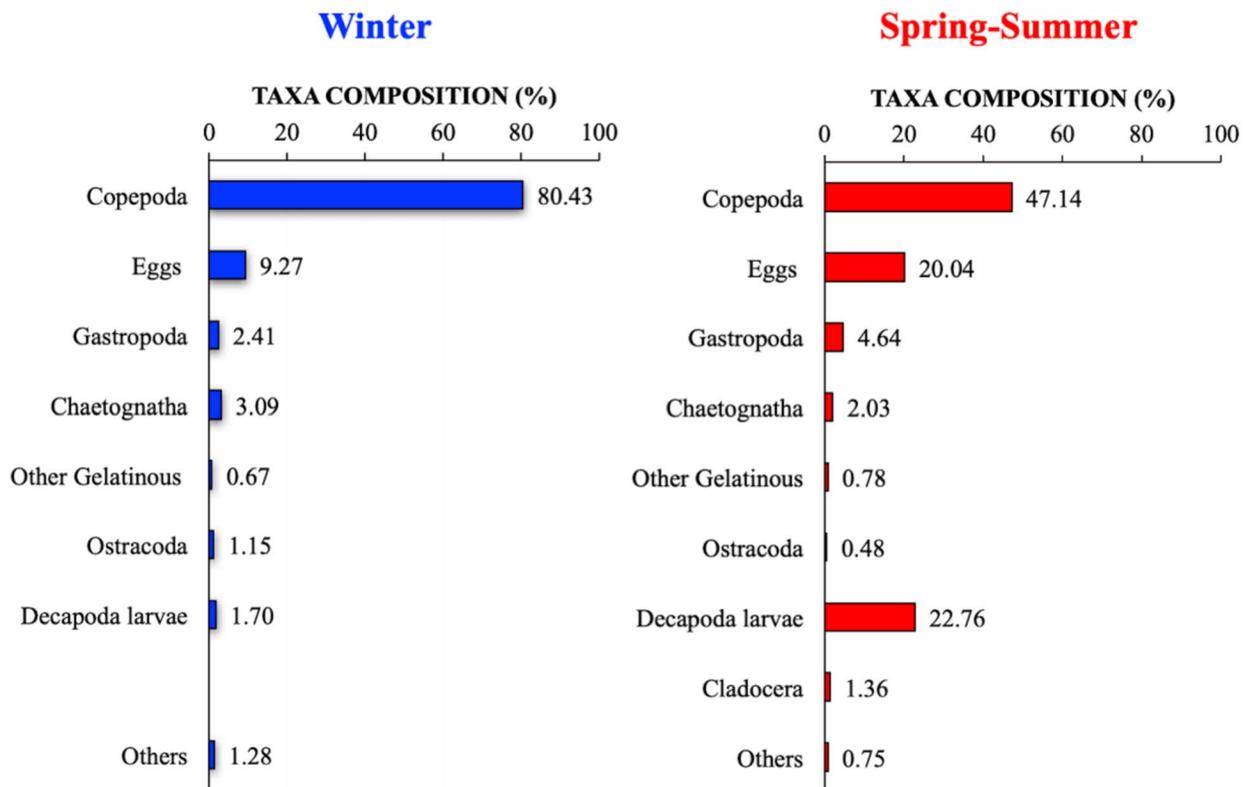
**Fig. 3.** Taxa composition (%) for Winter and Spring–Summer in the waters near the lava deltas in the Atlantic Ocean, including all samples.

winter showing a total abundance of 179.90 ind·m$^{-3}$ ($\pm$147.45 SD; standard deviation), and spring–summer 262.99 ind·m$^{-3}$ ($\pm$142.73 SD). Minimum abundances were found at 3 m (8 ind·m$^{-3}$ in winter and 36.53 ind·m$^{-3}$ in spring–summer), with maximum abundances at 30 m (368.22 ind·m$^{-3}$ in winter and 420 ind·m$^{-3}$ in spring–summer).

The seasonal composition of the mesozooplankton community, particularly the copepods, showed significant changes (ANOVA, $P < 0.05$), especially for the 200–500 $\mu$m size range (Fig. 4B). During spring–summer, cladocerans became more abundant at 3 m (23.77% of total abundance), while copepods decreased to 41.03% at 10 m and decapod larvae increased to 24.44%.

### Gelatinous organisms

The gelatinous components (Table I), comprised mainly of siphonophores and salps, showed higher abundances for siphonophores. In winter, siphonophores ranged from a minimum abundance (0.17 ind·m$^{-3}$; 4.50%) at 50 m depth, to a maximum (2.55 ind·m$^{-3}$; 42.34%) at 30 m. In spring–summer, siphonophore abundance ranged from 0.10 ind·m$^{-3}$ (3.10%) at 3 m to 14.75 ind·m$^{-3}$ (40.31%) at 30 m. Salps, in contrast, showed lower abundances, ranging from 0.19 ind·m$^{-3}$ (3.60%) in winter to a maximum of 1.99 ind·m$^{-3}$ (10.85%) in spring–summer at 30 m depth (Table I).

The siphonophore families, Diphyidae and Abylidae, belonging to the Suborder Calycophorae, were identified during both seasons (Fig. 5). No significant differences (ANOVA $P > 0.05$) were observed between seasons or families. In spring–summer,

Diphyidae decreased to 20% at 10 m, while Abylidae increased to 80%.

### DISCUSSION

In this study, we analyzed the zooplankton community structure in the Fuencaliente Marine Strip (SAC ES7020122), a SAC near the newly formed lava deltas on La Palma Island in the Atlantic Ocean. Our results revealed significant seasonal variations in zooplankton biomass, abundance, and taxonomic composition, with distinct patterns observed in both size ranges and depth distribution within the mesozooplankton community.

The total biomass near the lava deltas was consistent with values observed near our study sites (Hernández-León and Miranda-Rodal, 1987) and in other regions of Canary Islands waters (e.g. north of Gran Canaria, Hernández-León *et al.,* 2004; Herrera *et al.,* 2017; post-eruption phase of the Tagoro submarine volcano, Fernández de Puelles *et al.,* 2021). These findings are in accordance with previous studies on the effects of volcanic eruptions, such as Tagoro, a submarine volcano on El Hierro Island close to the study site, which also caused damage to pelagic ecosystems (Ariza *et al.,* 2014). In the Tagoro submarine volcano, significant changes occurred in the diel vertical migratory biota due to altered scattering patterns from temperature and water chemistry changes. Similarly, environmental disturbances appear to have played a key role in shaping the seasonal variability observed in zooplankton biomass within the Fuencaliente Marine Strip SAC.

While no significant differences in biomass were observed with depth, seasonal peaks occurred above 30 m during winter
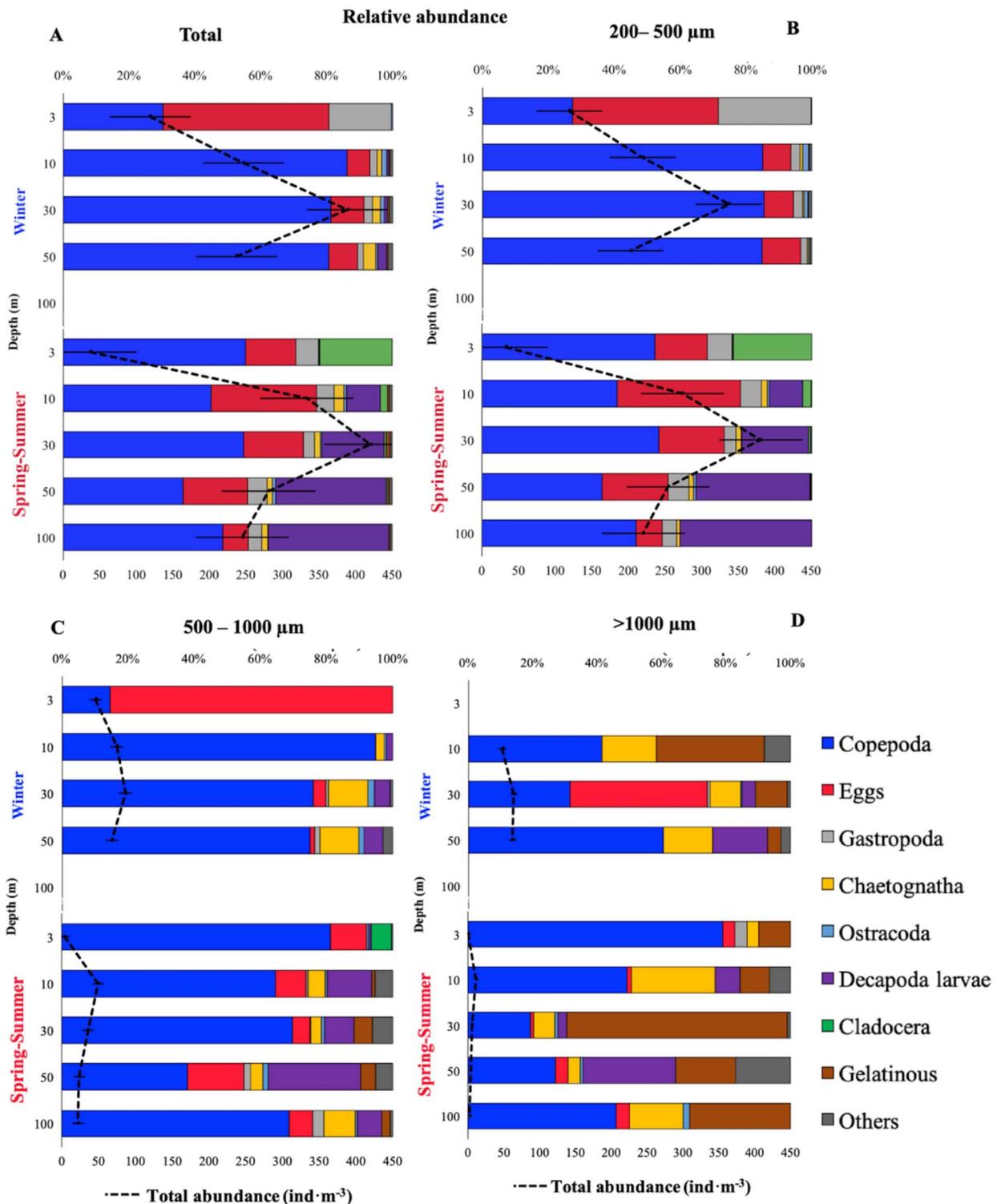
**Fig. 4.** Relative abundance (%) for each taxonomic group in the mesozooplankton community and Total abundance (ind·m$^{-3}$; dashed line) as a function of depth. (**A**) Total; (**B**) 200–500 $\mu$m; (**C**) 500–1000 $\mu$m; and (**D**) >1000 $\mu$m, for Winter and Spring–Summer. The biomass at 3 m was sampled using an Apstein-type net, while a WP2 net was used for all other depth intervals. Sampling at 100 m was conducted only during the spring–summer season. *No organisms were found at 3 m in the >1000 $\mu$m size range.

and at 10 m during spring–summer. These patterns were primarily driven by the dominance of specific size ranges, particularly 200–500 $\mu$m organisms in winter and >1000 $\mu$m

organisms in spring–summer. The winter biomass increase may have been influenced by bathymetric changes from the new lava deltas and nutrient-rich upwelling, which enhanced primary

**Table I:** *Mean abundance values (ind·m⁻³) and percentage (%) of total gelatinous component and by group (siphonophores and salps) for each depth (m) and season (Winter and Spring–Summer)*

| Depth (m) | Winter | | | Spring–summer | | |
|---|---|---|---|---|---|---|
| | Siphonophores ind·m⁻³ (%) | Salps ind·m⁻³ (%) | Total gelatinous ind·m⁻³ (%) | Siphonophores ind·m⁻³ (%) | Salps ind·m⁻³ (%) | Total gelatinous ind·m⁻³ (%) |
| 3 | | | | 0.10 (3.10) | | 0.10 (3.10) |
| 10 | 1.28 (6.31) | 0.43 (3.60) | 1.71 (9.91) | 2.98 (2.71) | 1.70 (3.10) | 4.68 (5.81) |
| 30 | 2.55 (42.34) | 3.12 (39.64) | 5.67 (81.98) | 14.75 (40.31) | 1.99 (10.85) | 16.74 (51.16) |
| 50 | 0.17 (4.50) | 0.19 (3.60) | 0.36 (8.11) | 4.09 (20.54) | 1.28 (11.63) | 5.38 (32.17) |
| 100 | | | | 1.11 (10.07) | 0.09 (1.55) | 1.20 (11.63) |
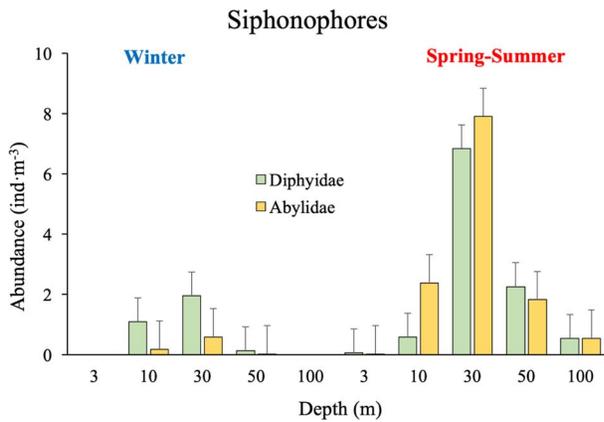


**Fig. 5.** Abundance (ind·m⁻³) of siphonophores identified to the family level (Abylidae and Diphyidae), per depth (m) for Winter and Spring–Summer.

production. This observation is consistent with findings from other volcanic regions, where thermocline disruptions caused by atmospheric cooling promoted nutrient influx into the euphotic zone, boosting zooplankton biomass (Hernández-León *et al.,* 2001; Herrera *et al.,* 2017). Similar trends have been reported in the South Atlantic Bight, where variability in sea surface temperature and nutrients influenced zooplankton dynamics (López-Figueroa *et al.,* 2023). This is further supported by increased Chlorophyll-*a* (Chl-*a*) levels, as depicted in Fig. S1. Conversely, during spring–summer, water stratification limited surface nutrient availability (Bode *et al.,* 2012; Villalba *et al.,* 2017; Couret *et al.,* 2023a), resulting in higher zooplankton abundance at deeper depths due to organic matter remineralization (Fernández de Puelles, 1994; Román *et al.,* 2019; Couret *et al.,* 2023b). This could explain the second biomass increase found over the 100 m depth during the warmer season.

Copepods consistently dominated the zooplankton community across seasons, contributing between 60 and 90% of total abundance, consistent with earlier studies in Canary Island waters (Hernández-León, 1988; Fernández de Puelles, 1994). The increased presence of decapod larvae and eggs observed during spring–summer (e.g. Campillo *et al.,* 2023) may be attributed to higher temperatures conducive to egg development coinciding with their life cycle (Landeira, 2010; Bode *et al.,* 2012). Cladocerans (order Diplostraca) also appeared during

spring–summer, likely due to optimal warmer conditions for growth and reproduction (Castro, 1991; Lavaniegos *et al.,* 2012). Siphonophores were particularly abundant during this season, as observed in previous studies (Palma and Apablaza, 2004), with higher abundances during warmer periods. These seasonal changes reflect the complex interactions between zooplankton and environmental factors such as temperature and nutrient availability. Specifically, the rise in sea surface temperatures during spring–summer in Atlantic waters, depicted in Fig. S1, seems to have significantly influenced these shifts.

Total zooplankton abundances observed in this study were similar to those reported during the post-eruptive stage of the submarine volcano, Tagoro, off the coast of El Hierro island (Ariza *et al.,* 2014; Fernández de Puelles *et al.,* 2021). Variations in relative abundances across seasons, taxonomic groups, and size ranges reflect complex interactions between zooplankton and their environment (Bode *et al.,* 2012). Copepods were present in all size ranges and depths, supporting their significant dominance, which could be influenced by various factors, such as seasonal changes in seawater temperature, nutrient availability, and primary productivity, consistent with previous studies (Álvarez-Cadena *et al.,* 2007; Hernández-León *et al.,* 2020). The presence of early larval stages of gastropods in the surface layers, mainly within the size range of 200–500 μm, could reflect their transport to the surface through ocean currents, where they can be more easily dispersed, as well as being favored by environmental conditions on the surface, such as the availability of food and sunlight (Campos and Díaz, 2007). The results are derived from an area undergoing changes, which could influence the zooplankton community structure and abundance. A higher contribution from the smaller size organisms compared to larger ones (500–1000 μm; > 1000 μm) was observed, consistent with previous studies in the Atlantic Ocean (Fernández de Puelles *et al.,* 2021). Contrasting results have been reported in other studies (Hernández-León *et al.,* 2004), where the dominant size range was >1000 μm. This difference may reflect depth-related effects, as our study was conducted in coastal neritic waters. In contrast, higher abundances of larger organisms are typically observed in deep oceanic waters, which provide environmental conditions such as greater depth and pressure that favor larger zooplankton (Angel, 1993; Hernández-León *et al.,* 2004).

Moreover, in this study, the presence of gelatinous organisms was during spring–summer, especially siphonophores, consistent with findings from previous studies (Mapstone, 2014).

The observed abundances suggest that warmer temperature conditions during the spring–summer period (Fig. S1) may promote the growth of these gelatinous organisms, indicating a seasonal shift in the trophic structure of zooplankton (Molinero et al., 2009). While the presence of siphonophores implies more intense predatory pressure on other organisms, such as copepods, it restricts the flow of energy to fish and other higher trophic-level consumers (Bode et al., 2012). Siphonophores were classified into two families, Diphyidae and Abylidae, which are commonly found above 100 m in the Atlantic Ocean (e.g. Lo and Biggs, 1996). Our results showed that both observed families were present in both seasons (winter and spring–summer). The Diphyidae family was more prevalent during winter, while the Abylidae family was more dominant in the spring–summer period. This result contrasts with what was reported by Andrade Ruiz (2012), where a higher presence of Diphyidae was observed under warm temperature conditions, and Abylidae appeared to thrive better under cooler conditions. However, according to Alvariño (1971), it depends on the species, as species within the same family may be more or less present depending on environmental conditions. This discrepancy highlights the need for a more continuous, long-term study across both temporal and spatial scales to obtain more comprehensive results. Additionally, it is crucial to advance research on gelatinous organisms in pelagic food webs due to their role as central predators in marine ecosystems. This can greatly enhance our understanding of trophic relationships and help predict how these food webs will respond to environmental pressures (Hetherington et al., 2024).

Understanding these seasonal variations in zooplankton dynamics provides a foundation for aligning local findings with broader ecological patterns observed in other volcanic and oligotrophic marine regions, providing a basis for designing effective management and conservation strategies to ensure the long-term sustainability of marine ecosystems and associated biodiversity. Identifying seasonal patterns in zooplankton distribution and abundance could also serve as an early indicator of potential changes in the marine ecosystem due to natural stressors, such as volcanic eruptions. Therefore, continuous monitoring of the zooplankton community in this protected area is needed to detect and mitigate any future negative impacts.

## CONCLUSION

This study showed stable zooplankton biomass and abundance in waters near the newly formed lava deltas at an oceanic island in the Central East Atlantic Ocean, indicating limited impact from the volcanic activity. Seasonal changes were primarily observed in community structure, with smaller size ranges predominating in both seasons. Copepods remained the dominant group, although their relative abundance decreased in spring–summer as decapod and gastropod larvae increased. The rise in siphonophores during warmer months suggests good environmental conditions for gelatinous zooplankton, taking into account the seasonal shifts in trophic interactions.

These results underscore the importance of understanding seasonal variations in local zooplankton dynamics for the effective management of marine conservation areas. Continuous monitoring is essential for a better understanding of the marine food web in oligotrophic waters and for mitigating potential future impacts, particularly in light of natural environmental disturbances such as volcanic eruptions.

## SUPPLEMENTARY DATA

Supplementary Data can be found *Journal of Plankton Research* online.

## CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Inés Sastre-Estarellas: Methodology, Formal analysis, Investigation, Data curation, Writing—original draft, Writing—review & editing. Ricardo Haroun: Writing—review & editing and Funding acquisition. Inma Herrera: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Supervising, Writing—original draft, Writing—review & editing and Funding acquisition.

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