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Seamounts of Cabo Verde: A review of their ecological and economic significance, anthropogenic impacts, and conservation needs

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A B S T R A C T

The deep-sea areas of the Cabo Verde Archipelago remain largely unexplored, with seamounts standing out as the most prominent and abundant geomorphological features. The ecological significance of these underwater structures is well-documented in various regions of the planet, as they often serve as biodiversity hotspots, stepping stones for species connectivity and, in some cases, areas with high levels of endemism. However, the biology and ecology of the seamounts around Cabo Verde are still largely unknown. Preliminary studies of the geomorphology, oceanographic characteristics and ecology of specific features suggest that the Cabo Verde seamount network — comprising 14 known conspicuous seamounts as well as smaller elevations less than 1000 m — harbours high biological diversity. That biodiversity associated with the Cabo Verde seamounts spans a wide range of forms, from microscopic organisms to cetaceans, encompassing both pelagic and benthic communities. Commercial activities associated with seamounts, in particular fishing, are a critical aspect to consider for ecosystem management. Evaluating their current uses, future prospects, and the existing and potential threats the Cabo Verde seamounts face is essential for effective and sustainable marine spatial planning. This study reviews and synthesises the current knowledge on the Cabo Verde seamounts within its Exclusive Economic Zone (EEZ), focusing on their environmental and biological aspects, including geology, oceanography, and associated biological communities. Key topics include primary production, zooplankton communities, benthic organisms, large vertebrates such as elasmobranchs, sea turtles, seabirds, and cetaceans, as well as microbes and trophic linkages. Additionally, this review explores the socio-economic dimensions linked to seamounts, highlighting their importance to the local economy and emphasizing the need for effective marine spatial management plans. These considerations are crucial for balancing conservation efforts with sustainable use, ensuring the long-term health of these vital underwater ecosystems.

1. Introduction

Seamounts are among the most prevalent geological features in the deep sea (Clark et al., 2010). They have traditionally been defined as geomorphological features of volcanic origin, which rise at least 1,000 m above the surrounding seafloor (Consalvey et al., 2010), although newer definitions also include other topographically distinct and completely submerged structures that are higher than 100 m (Consalvey et al., 2010; Staudigel et al., 2010; Kvile et al., 2014; Victorero et al., 2018). Given these varying interpretations, and to ensure clarity and consistency in this review, we adopt the definition proposed by Staudigel et al. (2010): "*any geographically isolated topographic feature on the seafloor taller than 100 m, including ones whose summit regions may temporarily emerge above sea level, but not including features that are located on continental shelves or that are part of other major landmasses*".

Due to the enhanced primary productivity patterns often observed around seamounts (i.e. Morato et al., 2010; Leitner et al., 2020; Wang et al., 2023), they are typically considered areas with high ecological relevance. The interaction between seamount morphology and surrounding ocean circulation can locally result in upwelling, downwelling, tidal amplification (Baines, 2007; White et al., 2007; Mashayek et al., 2024), the formation of closed circulation cells (such as eddies and stratified Taylor columns, e.g., Ma et al., 2021; Liu et al., 2023) or frontal systems (e.g., Morato et al., 2016), which may lead to enhanced primary productivity. These hydrodynamical processes, together with the availability of hard substratum over a large depth range, contribute to increased biodiversity, both in the benthic (e.g., Rowden et al., 2010; Victorero et al., 2018; de la Torriente et al., 2020; Bo et al., 2021) and pelagic domains (Holland and Grubbs, 2007; Morato et al., 2010). Seamounts frequently host a high number of species (Howell et al., 2010) and, in some cases, due to isolation, can be home to unique endemism (Harmelin, 2024). Seamounts are also known as locations of enhanced fish abundance (e.g., O'Driscoll and Clark, 2005; Santos et al., 2020), attracting shallow and deep-sea fisheries that may have a large ecological impact on these ecosystems (Clark and O'Driscoll, 2003; Clark and Koslow, 2007; Morato et al., 2008). Particularly bottom trawling can be extremely destructive, with studies indicating that recovery from disturbances can take several decades (e.g., Williams et al., 2010; Clark et al., 2019; Baco et al., 2023). More recently, the prospect of potential deep-sea mining (e.g. for metal-rich crusts) has added another threat to seamount ecosystems (e.g., Hein et al. 2009; Washburn et al., 2023). Because of their ecological importance and their unique, fragile, and complex ecology seamounts are widely recognized as key conservation priorities. These habitats host organisms such as deep-sea corals and sponges, which make them highly susceptible to human impacts. As a result, in 2009, the United Nations General Assembly (UNGA) (2009), called upon states to implement the FAO guidelines on deep-sea fisheries to sustainably manage fish stocks and protect Vulnerable Marine Ecosystems (VMEs) and VME elements, which included seamounts (United Nations General Assembly (UNGA), 2009). Some Regional Fisheries Management Organizations (RFMOs) recognise seamounts as VME elements, implementing fisheries closures for their protection, based on the precautionary principle. For example, the Northwest Atlantic Fisheries Organization (NAFO) has established closures around all seamounts with summits at or above 4,000 m, and the General Fisheries Commission for the Mediterranean (GFCM) enforces a ban on bottom trawling below 1,000 m, while the South East Atlantic Fisheries Organization (SEAFO) has restricted fishing on 12 seamounts and associated ridges. To date, two of the three areas in Cabo Verde declared EBSAs (Ecologically or Biologically Significant Marine Areas)—namely the North West Region of Santo Antão, the Island of Boa Vista and the Santa Luzia, Raso and Branco complex—include seamounts (Secretariat of the Convention on Biological Diversity, 2020). However, as this review will demonstrate, based on currently available information, several Cabo Verde seamounts meet the EBSA criteria, an aspect that should be taken into account in future assessments.

In this conservation context, the Cabo Verde archipelago in the NE Atlantic hosts a very important, but currently understudied series of seamounts in addition to other smaller features (less than 1,000 m tall) (Kwasnitschka et al., 2024; Fig. 1). Many of these seamounts are isolated and experience upwelling, generating highly productive habitats for various marine fauna ranging from small fish to apex predators (Cardoso et al., 2020; Mohn et al., 2021; Roberts et al., 2002). They also provide habitats for deep-sea benthic species (Vinha et al., 2025), attracting different visitors, including seabirds (Morato et al., 2008), marine mammals (Wenzel et al., 2020) and sea turtles (Santos et al., 2007). The presence of multiple seamounts around Cabo Verde plays a significant role in establishing the archipelago as a unique biodiversity hotspot (Roberts et al., 2002). The seamounts not only serve as refuges for marine species but also support Cabo Verde's artisanal fishing, with local fish populations relying on these ecosystems for breeding and feeding (Monteiro et al., 2008).

Contrary to many other locations, there are indications that many Cabo Verde seamounts are still pristine or have received comparatively little anthropogenic impacts (Hansteen et al., 2014; Orejas et al., 2022), adding to their importance and conservation value. Still, much remains unknown about their biodiversity, ecological function and connectivity. For instance, to the best of our knowledge no studies have been published on seamount endemism in Cabo Verde, although species endemic to Cabo Verde have also been detected at the seamounts (i.e. Hanel et al., 2010). Moreover, no specific studies have been conducted to explore the potential of spillover effects from Cabo Verde seamounts to coastal areas. Spillover refers to the movement of individuals (adults, juveniles, or larvae) from areas of high population density or productivity, such as marine protected areas (MPAs), into adjacent, less-protected or fished areas, leading to increased abundance, biomass or recruitment. Although this effect has not yet been studied in Cabo Verde, clues of this effect have been documented on seamounts from other regions (i.e. Lynham, 2022; Medoff et al., 2022).

In general, an exhaustive overview of the current knowledge of the Cabo Verde seamounts, integrating all ecosystem and socio-economic information, and considering the seamounts as a coherent network, is currently lacking. This hampers an integrated view of their value as well as their management and conservation design. The aim of this paper is therefore to bring together current understanding about the environment, ecology, human activities and conservation status of seamounts in the EEZ of Cabo Verde, to identify knowledge gaps, and to summarise the research and conservation needs for this unique area.

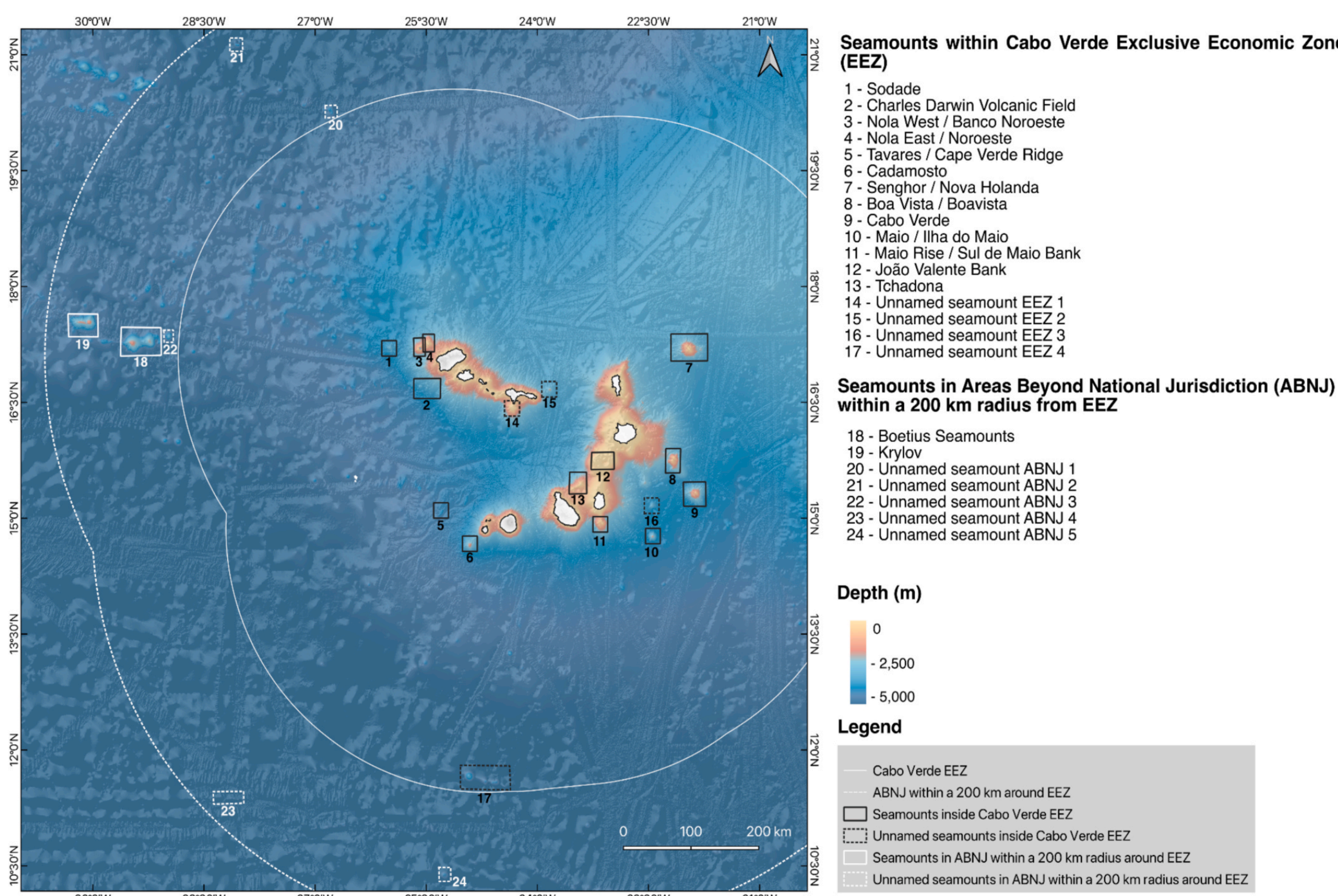

Fig. 1. Seamounts within the Exclusive Economic Zone (EEZ) of Cabo Verde (solid white line) and in the surrounding Area Beyond National Jurisdiction (ABNJ) (dashed white line). The seamounts in dashed lines correspond to unnamed seamounts, identified in Yesson et al., (2021). Officially recognized seamounts refer to seamounts bearing an official name. Seamounts in the ABNJ have been depicted in the map but not included in this review. (Bathymetry data source: Global Multi-Resolution Topography (GMRT), 2024; Ryan et al., 2009; Kwasnitschka et al., 2024)

2. Context of Cabo Verde

2.1. Cabo Verde biogeography

2.1.1. Cabo Verde in Macaronesia

The Macaronesian biogeographical unit comprises several North Atlantic archipelagos (Fig. 2) including the Azores, Madeira, Selvagens Islands, Canary Islands, and Cabo Verde (*sensu* Engler, 1914). Historically, these islands are linked by shared botanic characteristics (Webb and Berthelot, 1836–1850; García-Talavera, 1999) and recent geobotanic studies have reinforced this classification (Fernández-Palacios et al., 2024). However, from a marine biogeographical perspective and community structure, the Macaronesian archipelagos present significant differences in the compositions of the crustacean, molluscan and ichthyological communities (Lloris et al., 1991; Wirtz et al., 2013; Freitas, 2014; González, 2018; Melo et al., 2023), challenging the concept of Macaronesia as a coherent marine biogeographic unit (Freitas et al., 2019). In fact, Cabo Verde exhibits stronger marine faunal associations with the Guinean region and the Canary Islands than with the Northwest-African coast (Morri et al., 2000; Brito et al., 2007; Wirtz et al., 2013). As a result, part of Macaronesia (excluding Cabo Verde) is now included within the marine Lusitanian province, while Cabo Verde and the Sahelian Upwelling ecoregions have been categorised under a peripheral marine ecoregion referred to as the 'West African Transition' (Lloris et al., 1991; Spalding et al., 2007). In addition, Cabo Verde was included in a deep-sea benthic province within the large North Atlantic bathyal region (Watling et al., 2013). However, recent studies highlighted a distinct and rich shallow water benthic community in Cabo Verde, including coastal fishes, echinoderms, gastropods, decapods, and other groups suggesting an evolutionary isolation (Freitas et al., 2019). It was proposed by Freitas et al. (2019) to redefine the Lusitanian biogeographical province, currently including four ecoregions, by coining a new term "Webbnesia" to encompass the Macaronesian archipelagos while excluding Cabo Verde. According to these authors, Cabo Verde should be classified as a distinct sub province.

Despite inconsistencies in the classification of the Macaronesia marine biogeography, Cabo Verde shares many geographical, climatic, geological and ecological similarities with Madeira, Selvagens and the Canary Islands due to their relative proximity (Florencio et al., 2021) and their similar geological formation history (Fernández-Palacios et al., 2024). These characteristics have made them pivotal for studying macroecological patterns and interaction networks on islands, contributing to developing and refining the General Dynamic Model of oceanic island biogeography (see Florencio et al., 2021), including its consideration of sensitivity to sea level changes (Ávila et al., 2019). Sea-Level Sensitive Dynamic Modelling of marine island biogeography is a useful tool that helps to predict how coastlines and islands, among others, change over time. These physical changes affect the distribution of habitats as well as the movements, exchanges or isolation of species. Therefore, these models contribute to understanding dispersal pathways across time, endemism patterns, and in general how environmental changes shape species and habitat distribution over time.

Moreover, the molluscan fauna was analysed to elucidate the biogeographical relationships among the Macaronesian archipelagos during the warmer period of the Last Interglacial (MIS 5e) (Melo et al., 2023). During the MIS 5e, the Canaries and Cabo Verde clustered into a single biogeographic unit. These Macaronesian archipelagos have never been connected with the continental shelf, making Macaronesia an interesting region for studying island ecology, evolutionary processes, radiation of animal taxa, connectivity and conservation needs (Florencio et al., 2021).

2.1.2. Cabo Verde as a marine endemism hotspot

Cabo Verde has a high degree of marine endemism, mostly related to shallow water organisms (e.g. reef fishes; Floeter et al., 2008), but also to some deep-sea echinoderms (Pérez-Ruzafa et al., 2005). This is attributed, after Floeter et al. (2008), to three main factors: geographic isolation (from the mainland and between the islands), high heterogeneity of habitats (Pérez-Ruzafa et al., 2005), and the persistence of warm tropical waters during glacial periods (Floeter et al., 2008 and references therein). Moreover, insular littoral areas, coupled with the impact of glacial-interglacial cycles, are thought to be the key factors that explain the endemic patterns found in this archipelago (Ávila et al., 2019). The geological time dimension is key to understanding the high degree of

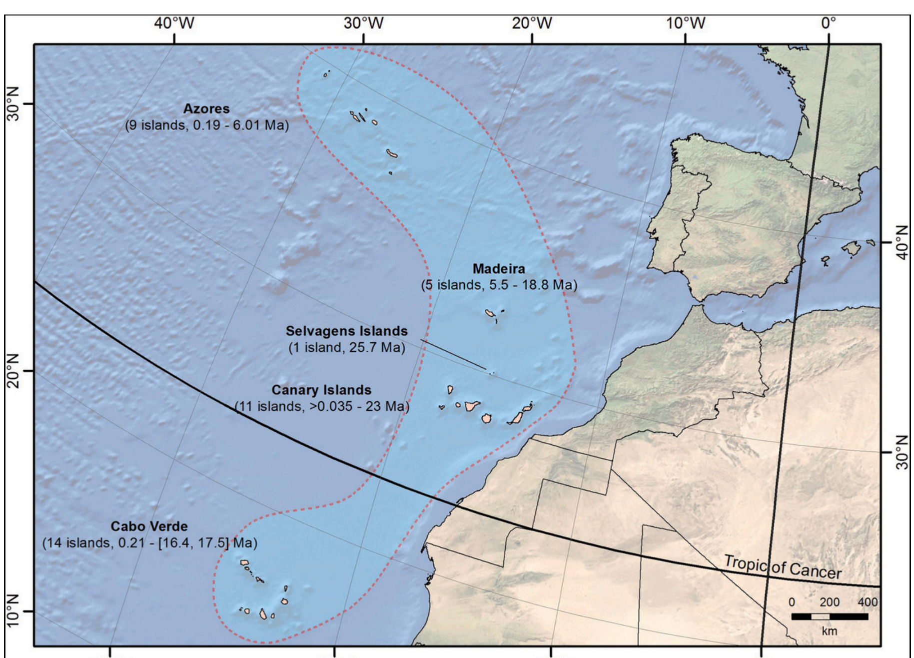

Fig. 2. The archipelagos of Macaronesia, including the different islands as well as the time of formation of the different archipelagos in million years ago (Ma). The ages of the archipelagos include the minimum and maximum age register for the oldest subaerial lavas of the islands (Source: Figure 1 and Table 1 in Florencio et al., 2021).

endemism in Cabo Verde, as Ávila et al. (2019) pointed out. The Pleistocene climate variations impacted the Atlantic archipelagos in different ways depending on their geographical locations. The high- and medium-latitude insular marine life was influenced by glacial episodes, and consequently thermophilic species were extirpated and probably some endemic species completely disappeared due to the reduction of the littoral area and decrease of the sea surface temperature (SST) during the glaciations (Ávila et al., 2018). However, some tropical islands, among those the Cabo Verde archipelago, were buffered from the direct impact of glaciations by their geographical location within the tropical belt, having an estimated average SST fluctuation of only 1 to 3 °C between glacial and interglacial phases (Herbert et al., 2010). Therefore, the several glacial/interglacial cycles that occurred during the last million years in Cabo Verde and other archipelagos may have promoted a high rate of *in situ* speciation during interglacials. The physical isolation of Cabo Verde, driven by distance, habitat heterogeneity, and depth variations between islands, shaped the distribution and evolution of its marine fauna (Medina et al., 2007). In the case of the evolution of benthic communities, habitat characteristics play a major role, but seawater temperature and biological productivity are considered critical (Pérez-Ruzafa et al., 2005).

Endemism in Cabo Verde's marine fauna is significant, with rates including 8.3 % for coastal reef fishes, 9.2 % for marine bivalves, 44 % for keyhole limpets, 50 % for sea slugs, 70–95 % for cone snails, while over 23 species of *Euthria* (marine gastropod) are exclusive to the archipelago; (Floeter et al., 2008; Lopes, 2010; Wirtz et al., 2013; Moro and Ortea, 2015; Fraussen and Swinnen, 2016; Peters et al., 2016; Cunha et al., 2017). Specifically in the case of the shallow water gastropods (0–50 m depth) almost 60 % of all known species are endemic, a proportion far higher than that of other archipelagos (Ávila et al., 2018). The high endemism of many *Euthria* species in the region underscores the importance of the archipelago as a centre of diversity for this group (Fraussen et al., 2025). A recent discovery of more small gastropods in the new genus *Mirpurina* highlights the explosive radiation similar to Cabo Verde's cone snails, further underscoring its unique marine biodiversity, with 20 species to date (Ortea et al., 2019).

2.2. Geological origin and formation of the archipelago and seamounts

2.2.1. The Cabo Verde archipelago and its seamounts

Located in the eastern central Atlantic, approximately 570 km west of Ngor, which is the nearest island outside the archipelago (Senegal, West African coast), the Cabo Verde archipelago consists of ten islands and eight islets. The archipelago has a total land area of 4,033 km^2 and ~ 965 km of coastline (Ramalho, 2011). The surrounding insular marine shelf, at depths less than 200 m, spans about 1,900 km^2, representing only 0.2 % of the total Cabo Verde Exclusive Economic Zone (EEZ) (DGMP, 1998). The total EEZ area of Cabo Verde, excluding the insular shelf area, accounts for approximately 796,000 km^2 (isobaths depth > 200 m) (Figs. 1 and 3).

The Cabo Verde archipelago forms a west-facing horseshoe and consists of two main island groups: the northern Barlovento and the southern Sotavento chains. The northern islands are characterised by shallow inter-island depths with a west–east orientation, while the southern chain includes two separate structures with northeast–southwest alignment (Ramalho, 2011; Cardoso et al., 2020). The northern and northeastern coasts feature cliffs and rocky areas exposed to wave action, while the southern and southwestern coasts are flatter, with beaches, sandy bottoms, and subtidal zones supporting habitats like rhodoliths and corals (Almeida et al., 2015). The insular shelf hosts diverse submarine habitats, including sandy bottoms, lava structures, rhodolith fields, and coral communities (Almada, 1993; Almeida et al., 2015; Vinha et al., 2024, Amaro et al., 2025 – this issue). Beyond the shelf, fishing grounds are located on steep-sided, flat-topped seamounts (guyots), locally known as "fishing banks," which rise from the seafloor and contribute to the islands' marine biodiversity (González et al., 2020).

For this review, we follow the seamount definition from Staudigel et al., (2010), noting that the Cabo Verde archipelago comprises at least 14 major seamounts, as well as other smaller features (Kwasnitschka et al., 2024 and references therein), and at least three "unnamed" seamounts located around the islands and one located on the edge of the EEZ (Yesson et al., 2021) (Fig. 1, Table 1). Furthermore, based on morphology and location, we classify the Cabo Verde seamounts either as (1) guyots: flat-topped seamounts with a summit between 0 and 120 m water depth, or (2) separate volcanic edifices that rise at least several hundred meters above the surrounding seafloor, and have their summit area deeper than 120 m water depth.

The guyots in the archipelago existed as highly eroded islands during the Last Glacial Maximum at about 20 ka, a period of global sea-level low stands, and were drowned during the Late Pleistocene-Holocene sea-level rise of 120 m (Miller, 2009). Amongst the guyots, João Valente represents a special case, as it occurs on the broad, shallow-submarine shelf between Boa Vista and Maio islands. The seamounts in the Cabo Verde archipelago vary significantly in depth and size. Their summits range from just 14 m to about 3,700 m below surface, creating a highly varied and complex topography (see Table 1). The Charles Darwin Volcanic Field at about 3,700 m depth stands out as it comprises more than 10 separate eruption centres, with the largest volcano (Batuku) rising merely 600 m above the seafloor (Kwasnitschka et al., 2024).

In the northern chain, the NW islands of Santo Antão, São Vicente, Santa Luzia and São Nicolau are considered volcanically active, with the youngest activity on Santo Antão recorded at ~90 ± 30 ka (Plesner et al., 2002), 57 ± 38 ka on São Nicolau (Duprat et al., 2007), and ~34–35 ka before present on São Vicente, respectively (Clemmensen and Holm, 2020). Also, Sodade Seamount and the Charles Darwin Volcanic Field in the NW are considered active, as indicated by frequent volcano-tectonic earthquakes (Faria and Fonseca, 2014).

At the western termination of the southern chain, Fogo and Brava islands are volcanically active, with the most recent eruption occurring on Fogo from November 2014 to February 2015. Further, Cadamosto seamount, off Brava, is seismically active (Grevemeyer et al., 2010; Faria and Fonseca, 2014), and the youngest radiometrically dated submarine eruption occurred at about 21 ka (Samrock et al., 2019). Cadamosto seamount also comprises presumably active hydrothermal systems (Fig. 4) (Samrock et al., 2019; Orejas et al., 2022).

To the east, the islands Sal, Boa Vista and Maio are intensely eroded, being almost entirely razed by marine erosion, but were subsequently uplifted during the Quaternary (Ramalho et al., 2010a,b,c). Towards the west, Santiago, Brava and especially Fogo have much higher and steeper relief, as does Santo Antão in the north-west. This reflects their comparatively younger formation ages.

Morphological studies suggest that the age progression of the seamounts follows the same E-W trend as the islands (Kwasnitschka et al., 2024). The variable morphology of the 14 major seamounts is related to their respective evolutionary stages. The concept of evolutionary stages of seamounts and ocean islands was originally based on observations from Hawaiian volcanoes (as summarized in e.g., Clague and Sherrod, 2014). An idealized volcano developing on the seafloor evolves through several eruptive stages, which reflect variations in the amount and rate of heat supplied to the lithosphere as it overrides the mantle hot spot, and is thus related to variations in magma production rates and magma volumes. The respective stages for the seamounts can be summarised as follows: (a) an early growth stage (pre-shield and early shield), (b) a main growth stage (shield), and (c) erosion and rejuvenation stages (Kwasnitschka et al., 2024). Further, the physical sizes and chemical compositions of the seamounts may have influenced their present morphology. In particular, flank collapse events and resulting landslide scars are common on all of the larger seamounts (Senghor, Boa Vista, Cabo Verde, Maio Rise, Tchadona, Cadamosto and Nola seamounts) (Kwasnitschka et al., 2024). Similarly, abundant landslides have also

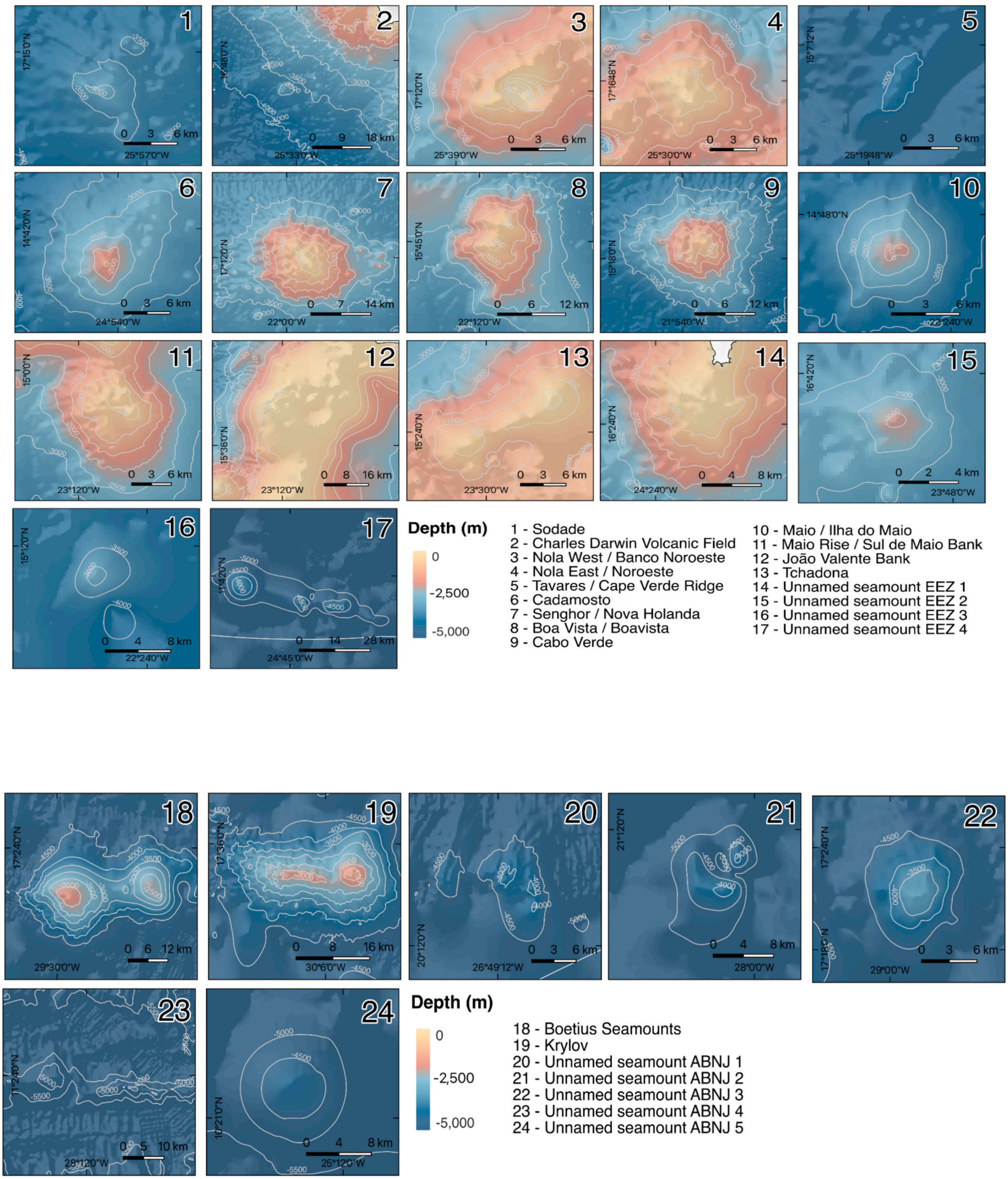

Fig. 3. The top panel displays seamounts and contour lines at 500 m depth intervals within the EEZ of Cabo Verde. The bottom panel presents seamounts and contour lines, also at 500 m intervals, in areas beyond national jurisdiction adjacent to the Cabo Verde EEZ. Seamount polygons were delineated by identifying the deepest isoline encircling each seamount, which represents its base depth. (Bathymetry data source: Global Multi-Resolution Topography (GMRT), 2024; Ryan et al., 2009; Kwasnitschka et al., 2024).

Table 1
Seamounts within the EEZ of Cabo Verde. Location, summit and base depth as well as height are included. Depths and dimensions are approximate and are based on bibliographic references and the latest seamount databases: Sea Around Us Project (https://www.seaaroundus.org/large-seamount-areas/) and Global Marine Environment Database: (https://www.ncei.noaa.gov/maps/marine/). Seamounts are ordered after Fig. 1 numbers. References on the available information for each seamount are included as superscripts after the name of each seamount and listed below the table. It is indicated in which seamounts Remotely Operated Vehicle (ROV) surveys have been conducted.

Seamount number (after Fig. 1)	Seamount name	Special features (bank, guyot…)	Local or alternative names	Location	Summit depth (m)	Base depth (m)	Basis diameter (m)	Available information after research fields
1	Sodade[1,2]	Seamount group		17.20°N, 26.00°W	2,700	3,800	11	Geology Geomorphology Volcanology Mapping
2	Charles Darwin Volcanic Field[1,2,3]	Dispersed volcanoes including one prominent seamount		16.71°N, 25.57°W	3,000	3,700	15	Geology Geomorphology Volcanology Mapping Deep-sea benthos (ROV) Fisheries
3	Nola West[1,3,4,5,6,7,8,9,10,11,12,13,14,15]	Guyot and former island	Noroeste (banco de baixo)	17.20°N, 25.57°W	35	3,000	22	Geology Geomorphology Volcanology Mapping Physical oceanography Deep-sea benthos (ROV) Elasmobranchs Fish biology Fisheries
4	Nola East[1,3,4,5,6,7,8,9,10,11,12,1,13,14,15,16]	Guyot and former island	Noroeste (banco de riba)	17.26°N, 25.47°W	60	3,000	16	Geology Geomorphology Volcanology Mapping Physical oceanography Deep-sea benthos (ROV) Elasmobranchs Fish biology Fisheries
5	Tavares[11]	Seamount ridge		15.10°N, 25.30°W	3,700	4,300	15	Mapping Fisheries
6	Cadamosto[2,11,14,17,18,19, 20,21]	Volcanic edifice		14.67°N, 24.91°W	1,480	3,500	25	Geology Geomorphology Volcanology Mapping Physical oceanography Deep-sea benthos (ROV) Trophic ecology
7	Senghor[1,3,4,5,7,8,9,10,11,13,14,22,23,24,25,26,27,28,29,30,31,32,33,34]	Guyot and former island	Nova Holanda	17.17°N, 21.95°W	90	3,000	51	Geology Geomorphology Volcanology Mapping Physical oceanography Deep-sea benthos (ROV) Zooplankton Elasmobranchs

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Table 1 (*continued*)

Seamount number (after Fig. 1)	Seamount name	Special features (bank, guyot…)	Local or alternative names	Location	Summit depth (m)	Base depth (m)	Basis diameter (m)	Available information after research fields
8	Boa Vista[8, 11, 14,15,35,36,37,38,39]	Volcanic edifice		15.80°N, 22.17°W	450	3,000	28	Fish biology Fisheries Cetaceans Trophic ecology Geology Geomorphology Volcanology Mapping Deep-sea benthos (ROV)
9	Cabo Verde[1,11,14,15,22]	Volcanic edifice		15.33°N, 21.85°W	511	3,600	41	Elasmobranchs Fish Biology Cetaceans Sea turtles Fisheries Geology Geomorphology Volcanology Mapping Deep-sea benthos (ROV)
10	Maio[8,3,35,36,37,38]	Volcanic edifice		14.77°N, 22.44°W	1,800	4,000	16	Cetaceans Geology Geomorphology Volcanology Mapping
11	Maio Rise[1,3,11,24]	Close to the shelf	Sul de maio	14.92°N, 23.15°W	180	3,000	41	Fish biology Sea turtles Fisheries Geology Geomorphology Volcanology Mapping
12	João Valente Bank[3,4,5,6,7,8,9,10,11,12,13,22]	Guyot and former island. Part of a shallow submarine shelf	João Valente	15.64°N, 23.12°W	14	100	20	Fisheries Geology Geomorphology Mapping
13	Tchadona[11]	Guyot and former island. Connected to a shelf		15.43°N, 23.40°W	40	1,520	34	Fish biology Elasmobranchs Cetaceans Fisheries Geology Geomorphology Mapping
14	Unnamed seamount EEZ1[3,11,40,41,42]	Volcanic edifice		16.67°N, 23.83°W	105	2,300	47	Geology Geomorphology Mapping
15	Unnamed seamount EEZ2[3,11,40,41,42]	Volcanic edifice		16.42°N, 24.34°W	1,900	3,000	10	Fisheries Geology Geomorphology

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Table 1 (*continued*)

Seamount number (after Fig. 1)	Seamount name	Special features (bank, guyot…)	Local or alternative names	Location	Summit depth (m)	Base depth (m)	Basis diameter (m)	Available information after research fields
								Mapping Fisheries
16	Unnamed seamount EEZ3[3,11,40,41,42]	Volcanic edifice		15.16°N, 22.46°W	2,795	3,730	10	Geology Geomorphology Mapping Fisheries
17	Unnamed seamount EEZ4[3,11,40,41,42]	Volcanic edifice. This seamount has four summits. Summit depth (S1-S4) is given for each summit		11.64°N, 24.70°W	3,530 (S1) 4,130 (S2) 4,150 (S3) 4,540 (S4)	5,080	87	Geology Geomorphology Volcanology Mapping Fisheries

References: 1 Hansteen et al., 2014; 2 Faria and Fonseca, 2014; 3 Global Fishing Watch, 2025; 4 https://www.ngdc.noaa.gov/mgg/; 5 Strømme et al., 1982; 6 SEPA 1999; 7 Menezes et al., 2004; 8 Monteiro et al. 2008; 9 Graham et al. 2017; 10 Garzón et al. 2023; 11 Kwasnitschka et al. 2024; 12 MAAP, 2004; 13 Seymour et al., 2024; 14 Vinha et al., 2024; 15 CBD-UNEP/CBD/COP/DEC/XII/22, 2014; 16 Queiroz et al., 2019; 17 Grevemeyer et al., 2010; 18 Samrock et al., 2019; 19 Orejas et al., 2022; 20 Vinha et al., 2022; 21 Vinha et al., 2025; 22 Garrigue et al., 2015; 23 Hanel et al., 2010; 24 Christiansen et al., 2011; 25 Christiansen, 2013; 26 Denda and Christiansen, 2014; 27 Denda et al., 2017a; 28 Freitas et al., 2018; 29 Vieira et al., 2016; 30 Hoving et al., 2019; 31 Chi et al., 2021; 32 Mohn et al., 2021; 33 Lüskow et al., 2022; 34 Schütte et al., 2025; 35 Ramalho et al., 2010a; 36 Ramalho et al., 2010b; 37 Ramalho et al., 2010c; 38 Martins et al., 2022; 39 López-Guzmán et al., 2013; 40 Ryan et al., 2009; 41 Yesson et al., 2021; 42 Global Multi-Resolution Topography (GMRT), 2024.

been described from the island flanks (Masson et al., 2008). Thus, both comparatively old and young seamounts and island flanks show major flank collapse events, demonstrating high erosion rates both during growth and erosional stages. For further considerations on the origin and evolution of the archipelago, the interested reader is referred to Doucelance et al. (2003), Holm et al. (2006), and Barker et al. (2010).

2.3. Oceanographic and biogeochemical characteristics of the archipelago

2.3.1. Oceanographic characteristics

The most prominent oceanographic feature in the upper 600 m of the water column in the Cabo Verde Basin, located north and northeast of the archipelago, is the Cabo Verde Frontal Zone (CVFZ). The CVFZ is a well-described central water mass boundary with strong spatial and temporal variability. It separates warmer and more saline North Atlantic Central Water (NACW) of subtropical origin to the north, from colder and less saline South Atlantic Central Water (SACW) originating from the subtropical gyre on the southern Hemisphere (e.g., Zenk et al., 1991; Klein and Siedler, 1995; Fig. 5 a,b,d,e). The Cabo Verde Archipelago is located within the so-called poorly ventilated shadow zone of the east Atlantic bounded in the north (>20°N) by the North Equatorial current (NEC) and the south-westward extension of the Canary Current (CC) and in the south by the eastward flowing North Equatorial Counter Current (NECC). To the east, on the shelf of the African coast, the northward flowing Mauritania Current (MC) (Pelegrí et al., 2017) is transporting in the upper 300 m SACW along the eastern boundary of the tropical North Atlantic, supplying the coastal upwelling (Pelegrí et al., 2017; Klenz et al., 2018; Tiedemann et al., 2018). To the southwest of the Cabo Verde Basin, between the NEC and the NECC, the main feature is the Guinea Dome (GD), a cyclonic region covering a broad latitudinal range (6-15°N, Machín and Pelegrí, 2009), which implies a rising of the isopycnals (Siedler et al., 1992). This wind-driven upwelling is forced by the seasonal changes of the Intertropical Convergence Zone (ITCZ) with a pronounced zonal displacement: offshore in summer-fall and closer to the continent in winter-spring (Pelegrí et al., 2017).

In the Cabo Verde Basin (Fig. 5d), the surface layer is occupied by surface water (SW) with seasonally varying changes in water mass properties (Pelegrí et al., 2017). Sea surface temperatures in Cabo Verde waters range from 20 to 27 °C, experiencing a tropical climate, with two alternating seasons: a moderate mild season (December to June, with an average SST of 22–23 °C) and a warm season (July to November, 26–27 °C) (Almada, 1993; Peña-Izquierdo et al., 2012). Below the surface water, down to 500–600 m, the previously mentioned central waters are located, NACW to the north and SACW to the south, showing a latitudinal gradient of the water properties (Peña-Izquierdo et al., 2012; Pelegrí et al., 2017) (Fig. 5d). Deep water masses at depths > 600 m are dominated by relatively fresh and cold Antarctic Intermediate Water (AAIW) in the depth range 600 to 1000 m and North Atlantic Deep Water (NADW) in the depth range 1,000 to 1,600 m (Zenk et al., 1991; Pelegrí et al., 2017). NADW originates in the northern North Atlantic and is characterized by high oxygen and low nutrient values (Zenk et al., 1991) (Fig. 5c,d).

In contrast to the consistent wind field dominated by the steady trade winds, the average ocean circulation in the immediate vicinity of the Cabo Verde Archipelago is highly variable, relatively weak and sluggish, and occasionally disrupted by westward-propagating mesoscale eddies moving through the region (Schütte et al., 2025 – this issue). The CVFZ, along with seasonal filaments and eddies spreading from the Mauritanian Upwelling Zone, are the primary contributors to the mesoscale variability in the Cabo Verde Basin (Zenk et al., 1991; Vangriesheim et al., 2003; Karstensen et al., 2015) (Fig. 5 b). Mauritanian coastal upwelling is driven by north-easterly trade winds and is particularly strong in winter and spring (Mittelstaedt, 1991). Upwelled water filaments extend westward from the Mauritanian Upwelling Zone source region and interact with mesoscale eddies linked to baroclinic instabilities of the CVFZ (Meunier et al., 2012). Eddy generation along the

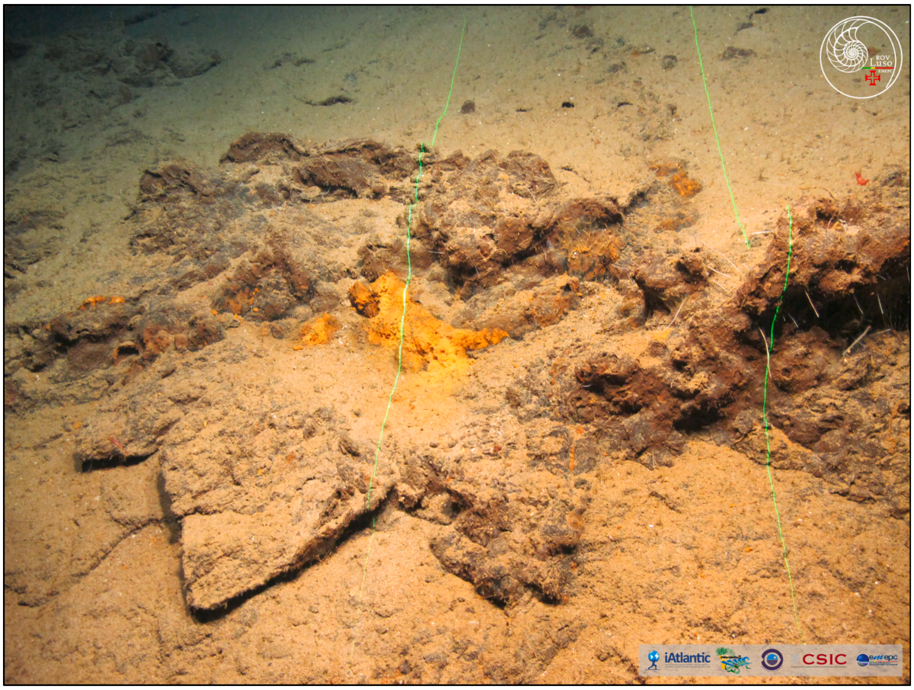

Fig. 4. Illustration of the seabed at the summit of Cadamosto seamount (ca. 1,480 m depth) displaying red–orange hydrothermally-altered rocks with the presence of the white stick-shaped organisms (carnivorous sponges from the family Cladorhizae) (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.) (Source: Luso/iMirabilis2/iAtlantic project).

West African coast is mainly caused by instabilities of Mauritanian coastal currents when encountering abrupt changes in bathymetry at different coastal headlands (Schütte et al., 2016a; Dilmahamod et al., 2022). As a result of coastal upwelling, eddy formation and subsequent westward propagation, the Cabo Verde Basin is a major corridor for the westward propagation of mesoscale instabilities across the tropical North Atlantic (Pérez-Rodríguez et al., 2001; Schütte et al., 2016a).

The mesoscale eddy field in the Cabo Verde Basin consists of three main types: anticyclones characterized by elevated sea level anomaly (SLA) and enhanced SST, cyclones with depressed SLA and reduced SST, and anticyclonic mode-water eddies (ACME) with elevated SLA but reduced SST and sea surface salinity (SSS) (Schütte et al., 2016a). Their average duration varies between 24 to 32 days, with westward propagation speeds varying between 2.7 and 3.3 km/day, depending on the eddy type and the analysis method used (Schütte et al., 2016a). Interactions between the islands of the archipelago and incoming far-field eddies frequently occur, causing various transformations to eddy structure and lifetime, such as deflection, splitting, and dissipation. In contrast, the archipelago can also trigger eddy formation and intensification through atmospheric effects, such as wind-topography interactions that generate wind shear and wake turbulence in the lee of the high mountains particularly on Santo Antão and Fogo (Cardoso et al., 2020; Schütte et al., 2025 – this issue). In addition, observations indicate that passing eddies interact with bathymetry-induced processes like enhanced internal wave activity (Schütte et al., 2025 – this issue).

The barotropic tidal currents in the Cabo Verde Basin are generally weak and dominated by the semidiurnal tides with meridional velocities between 0.03 and 0.05 $m \cdot s^{-1}$ (Siedler and Paul, 1991; Gomes et al., 2015). The islands and seamounts of the Cabo Verde Archipelago serve as obstacles to the tidal flow, redirecting and intensifying it into strong currents over the shallow topography, through narrow passages between the islands, or around the islands and seamounts. As the barotropic tides encounter the topography, they generate internal tides (baroclinic modes) that can either interact further with the seabed or break down into smaller-scale internal waves. These waves, in turn, may dissipate and result in turbulent motions (Schütte et al., 2025 – this issue). Near the continental slopes, both barotropic and baroclinic tides follow a clear spring-neap cycle (Siedler and Paul, 1991). The interaction of barotropic tides with seamount topography in the Cabo Verde archipelago can generate energetic internal waves that propagate into the surrounding areas horizontally and vertically with the potential to distribute plankton and marine organisms over large distances (Mohn et al., 2021).

2.3.2. *Biogeochemical characteristics*

In terms of biogeochemical properties, the Cabo Verde region is characterized by a pronounced oxygen minimum zone (OMZ) with a core depth of approximately 450 m (Karstensen et al., 2008; Brandt et al., 2015) (Fig. 5c). This OMZ is primarily governed by sluggish ventilation along the respective isopycnals (Wyrtki, 1962; Luyten et al., 1983). In addition to this deep OMZ, formed by gyre-scale ventilation, local ventilation and oxygen consumption in the upper layer of the eastern tropical North Atlantic result in a secondary, shallower oxygen minimum, with its core located at around 80 m depth (Brandt et al., 2015; Karstensen et al., 2008). Cyclonic eddies and ACMEs have been identified as eddy types that exhibit enhanced surface productivity compared to surrounding waters and maintain reduced oxygen concentrations at their centres and with this the shallow OMZ. These reduced oxygen levels are a consequence of high respiration rates (Schütte et al., 2016b) and limited exchange or renewal of water masses across the eddy boundaries (Karstensen et al., 2017). This phenomenon has significant implications for zooplankton but also higher trophic levels such as small pelagics or tuna (Karstensen et al., 2015; Hauss et al., 2016).

In general, primary production in the open tropical Atlantic – including the broader oceanic region in which the Cabo Verde archipelago and its seamounts are located, is limited by low nitrate availability and thus the region is considered oligotrophic (Moore et al., 2013). However, the waters directly surrounding the islands and seamounts can show locally elevated productivity by island-induced processes (Schütte et al., 2025 – this issue). In this context, Cabo Verde acts as a productive anomaly within an otherwise oligotrophic larger setting.

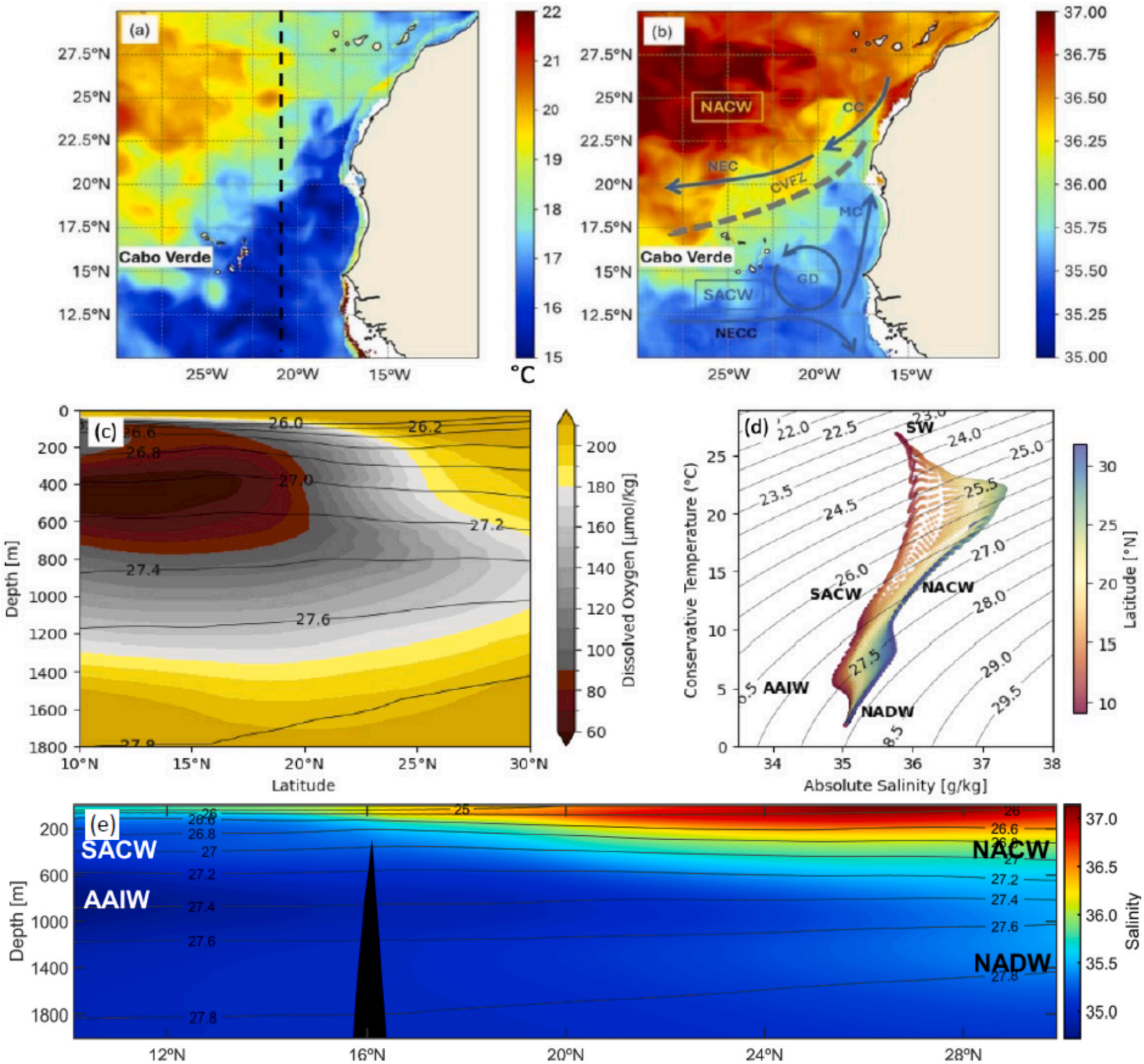

Fig. 5. (a) Mean temperature (°C) and (b) salinity in the depth range 30 to 550 m in the Cabo Verde Basin (January 2020 average) from model output of the Copernicus Global Ocean Physics Reanalysis GLORYS12V1 (DOI, product: https://doi.org/10.48670/moi-00021)(https://data.marine.copernicus.eu/product/GLOBAL_MULTIYEAR_PHY_001_030/description).The main current systems and water masses are overlaid. Vertical sections of dissolved oxygen (c) and salinity (e) at 22.5°W for the first 2,000 m of the water column. The black dotted line in panel (a) indicates the position of the section displayed in panels (c) and (e). (d) Temperature and salinity diagram of the area; colour indicates the latitude. The main water masses presented are: SW (surface Water), NACW (North Atlantic Central Water), SACW (South Atlantic Central Water), AAIW (Antarctic Intermediate Water) and NADW (North Atlantic Deep Water). Data from WOA 2023 (Reagan et al., 2024). The currents shown in (b) are NEC (North Equatorial Current), MC (Mauretania Current), GD (Guinea Dome, approximate mean location), NECC (North Equatorial Counter Current).

On this large scale, primary production in the eastern Tropical North Atlantic is strongly influenced by seasonality (Fig. 6a,b). During boreal winter, when temperatures are at their lowest and winds are strongest, the mixed layer deepens (on average around 70 m depth) and reaches the nitracline (on average around 60 m depth), which facilitates increased large-scale primary production. Conversely, in summer, the mixed layer across the region becomes shallower (on average around 40 m depth) due to warmer sea surface temperatures and reduced wind intensity, while the nitracline is located much deeper than the mixed layer (on average still around 60 m depth), which dampens primary production (Schütte et al., 2025 – this issue).On top of the large-scale seasonality of nitrate availability, around the seamounts nitrate is mainly brought into the upper layers from the deeper ocean through vertical advection or mixing, initiating blooms of primary production. Various processes can drive vertical advection and mixing. In the absence of strong large-scale ocean currents, Schütte et al. (2025 – this issue) identified three physical key forcing mechanisms responsible for vertical nitrate transport in the Cabo Verde Archipelago: (1) atmosphere–ocean interactions, (2) mesoscale eddy-topography interactions, and (3) tide-topography interactions. Since the seamounts investigated in this study do not reach the ocean surface, atmospheric interactions are negligible. Consequently, the dominant drivers of enhanced primary production near the seamounts of Cabo Verde are probably the interaction of mesoscale eddies with seamount topography and tidal processes (for further details on these processes, see Schütte et al., 2025 – this issue).

The described individual physical processes (eddy-seamount / tide-seamount interactions) amplify the background variability and are likewise subject to seasonality. During the boreal summer, mesoscale eddies are most frequently formed near the African coast. These nitrate rich eddies typically reach the Cabo Verde region around the boreal winter months interacting with the topography. This interaction enhances sub mesoscale activity leading to hotspots of vertical advection and mixing. Tidal processes, although influenced to some extent by stratification, exhibit limited seasonality. However, during the winter, the shallower nitracline enhances the effectiveness of tides in transporting nitrate into the euphotic zone, further increasing primary production. As a result, seamounts are hotspots of primary production in the Cabo Verde archipelago (Fig. 6c, d) and around the globe (Demarcq et al., 2020; Leitner et al., 2020).

3. Ecology of Cabo Verde seamounts

3.1. Benthic ecosystems

Research into the benthic ecosystems of the Cabo Verde seamounts has been limited so far. Most of the scientific data available comes from international research expeditions, such as the Meteor M80/3 in 2010 (Hansteen et al., 2014), the iMirabilis2 in 2021 (Orejas et al., 2022), and the NANSEN expedition in 2021. The two more recent research cruises are the OceanX (January-April 2025) and the Meteor M209 (March-April 2025) expeditions, where Remotely Operated Vehicles (ROV) were used to investigate, amongst others, the seamounts' seafloor.

The benthic communities of the seamounts that have been studied show a dominance of cold-water coral (CWC) species, mostly gorgonians and black corals forming coral gardens, but also stony corals depending on depth and orientation (Vinha et al., 2024, 2025 – this issue). Those coral-dominated communities are often accompanied by other associated deep-sea fauna, such as sponges and echinoderms (Fig. 7). The distribution of CWCs on these seamounts seems to be linked to underlying hydrodynamic-topography interactions (Mohn et al., 2014, 2021; Vinha et al., 2024). These interactions lead to a high-quality and abundant food supply to the benthic communities (Vinha et al., 2024), potentially driving higher abundances and diversity of benthic fauna on the seamounts compared to adjacent island slopes (Vinha et al., 2025 – this issue). Nonetheless, finer-scale changes in terrain geomorphology (i.e., substrate type) and water column characteristics contribute to habitat heterogeneity within seamounts (Vinha et al., 2025 – this issue), leading to patchy distributions of species and communities. The sampled seamounts of Cabo Verde present a strong bathymetric zonation (Hansteen et al., 2014; Orejas et al., 2022), which is possibly linked to changes in seawater carbonate saturation state (Tittensor et al., 2010; Lunden et al., 2013) and to water mass distribution (Quattrini et al., 2017; Mosquera et al., 2019; Puerta et al., 2020; Vinha et al., 2024).

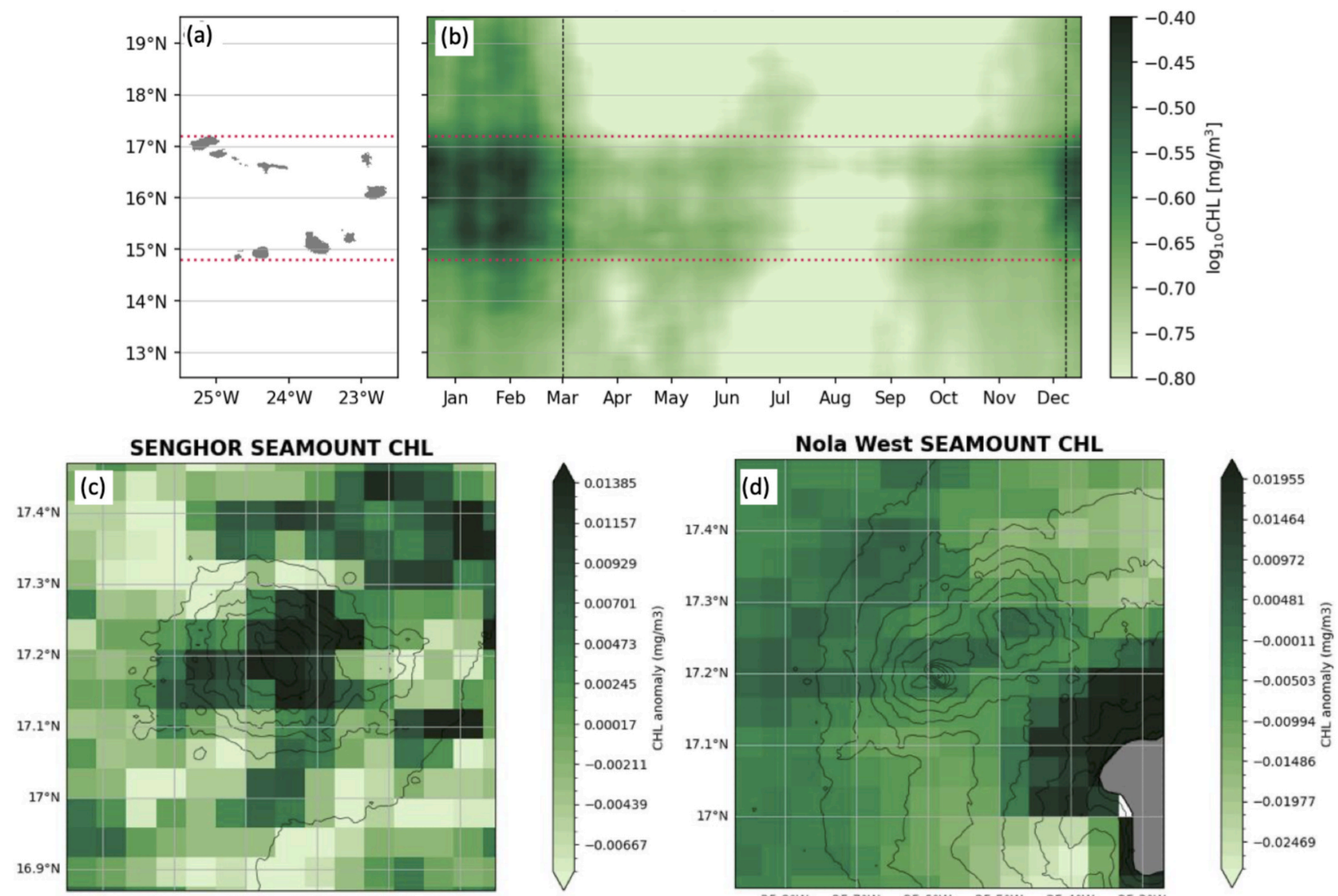

Fig. 6. (a, b) Hovmöller diagram of the latitudinal (between 22°W to 26°W) averaged climatological (2000–2022) Chlorophyll distribution measured by satellites (taken from Schütte et al., 2025-this issue). The vertical dashed lines delineate the period when the mixed layer is deeper than the nitracline. Exemplary zoom of the average Chlorophyll distribution on the (c) Senghor and (d) Nola seamount. The large-scale field has been subtracted in both plots using a box filter (60 km). Black contour lines indicate the bathymetry.

Indeed, on all seamounts of Cabo Verde, various octocoral species are present across a wide bathymetric range (from 550 to 3,600 m), while the presence of scleractinian corals has only been reported at depths shallower than 2,200 m (Hansteen et al., 2014).

For instance, on Cadamosto Seamount, the best studied seamount of the archipelago to date, the presence of octocoral gardens is noted across the whole explored depth range (from 1,400 to 2,100 m) (e.g., Fig. 7), but a coral garden dominated by the scleractinian coral *Enallopsammia rostrata* was only found at approximately 1,600 m depth (Fig. 7e) on the northwest slopes of the seamount (Vinha et al., 2025 – this issue). Similarly, on Nola Seamount, the presence of framework-building scleractinian corals is only noted above 1,600 m, with the presence of *Solenosmilia variabilis* in the upper explored sections of Nola (Fig. 7b,c). Different scleractinian coral species have also been reported on Senghor Seamount (or Nova Holanda) above 2,200 m depth, including *E. rostrata* and *S. variabilis,* as well as *Desmophyllum pertusum* (synonym: *Lophelia pertusa*) and *Madrepora oculata* (Hansteen et al., 2014). On the other hand, below 3,000 m at the Charles Darwin Volcanic Field, bamboo corals, in particular *Keratosis* spp., are the only dominant coral taxa observed (Fig. 7gh).

Indicator taxa for VMEs are present on all the seamounts for which seafloor images are available, with all investigated seamounts presenting suitable habitat for VME indicator species (Fig. 8; Vinha et al., 2024). Like most seamounts (Clark et al., 2010; Rogers, 2018a), the CWC habitats on the seamounts of Cabo Verde host diverse and ecologically significant benthic habitats, potentially composed of long-lived coral species supporting a high number of associated fauna. In fact, estimates based on U-Th dating suggest that the *E. rostrata* colonies at Cadamosto can be as old as 1.3 ka (J. Raddatz. unpublished data). On Cadamosto Seamount, over 180 morphospecies have been reported, including echinoderms and pelagic fauna, as well as the presence of elasmobranch egg cases, lying on the seafloor (Vinha et al., 2022), hinting at the potential supporting and nursery roles of coral-dominated habitats on the seamounts of Cabo Verde. On other seamounts, there are also reports of the occurrence of conspicuous associated bivalve species, such as the deep-sea oyster *Neopycnodonte zibrowii* on Maio Rise or the bivalve *Acesta excavata* on Cabo Verde and Nola Seamounts (Hansteen et al., 2014).

Predictive distribution maps of CWCs cover a limited bathymetric range (750 to 2,100 m) and are available only for a handful of seamounts within Cabo Verde's EEZ (Vinha et al., 2024) (see Fig. 8), while a detailed community characterization and distribution study has only been carried out for Cadamosto Seamount (Vinha et al., 2025 – this issue). For deep seamounts, such as Sodade and seamounts in the Charles Darwin Volcanic Field, only scattered seafloor images are available (Hansteen et al., 2014). For instance, the presence of dense coral areas has been reported around Santo Antão (Hoving, 2019; Amaro et al., unpublished result) and Fogo and Brava Islands (Orejas et al., 2022; Vinha et al. 2025 – this issue) as well as on other seamounts near Cabo Verde in areas beyond national jurisdiction (e.g., Boetius seamounts; Scepanski et al., 2024). Given that seamounts often present intricate connectivity across spatial and vertical gradients (Shank, 2010; Metaxas, 2011), investigating connectivity patterns within seamounts, but also with adjacent islands and the broader regional context, will be essential to understanding and accurately quantifying the level of endemism in the benthic ecosystems of the Cabo Verde seamounts.

Due to their volcanic origin, seamounts are hard substrate dominated. However, the presence of seamounts modifies deep-water currents generating variable local hydrographic conditions. Those frequently result in removal and deposition of soft sediments (e.g. Rogers, 1994; Davies et al., 2015) (Fig. 9). Moreover, it is important to note that studies on seamounts often focus primarily on hard substrate fauna, resulting in sampling efforts that are consequently biased (Vinha et al., 2024). However, some recent studies on Cabo Verde Seamounts revealed the presence of soft substrates. Specifically, Kwasnitschka et al., (2024) presented the most complete study on the geomorphology of Cabo Verde Seamounts. In this study, the authors presented a description of all surveyed seamounts, and provided backscatter data obtained during the multibeam surveys, showing the presence of some sedimentary cover (in different magnitude) for several of the Cabo Verde Seamounts. However, no faunistic studies have been conducted on those more sedimented seamounts.

A recent study by Scepanski et al. (2024) explored the Boetius seamounts, two deep seamounts (> 2,100 m) located in the ABNJ near Cabo Verde (Fig. 1). It showed that the presence of soft substrate increased towards the deeper part of the seamounts, with Echinoidea, Crustacea and Teleosti as the characteristic taxa associated with soft sediment on those seamounts. To the best of our knowledge, no further studies have been conducted in soft sediments of Cabo Verde seamounts. However, recent literature has focused on the abyssal plains near the archipelago. Specifically, De Jonge et al., (2024-this issue) investigated the functionality of the sedimentary benthic community in the Cabo Verde Abyssal Basin, highlighting the mesotrophic characteristics of the area and the important role of bacteria and meiobenthos processing phytodetritus. A further recent work in the same area investigated the taxonomic composition of the Cabo Verde abyssal sediment macrofauna (Gaurisas et al., 2024 – this issue), establishing a baseline for macrofauna characterization as well as for benthic ecosystem functioning in abyssal sediments around Cabo Verde.

3.2. Pelagic fauna

In Cabo Verde, relatively few studies have investigated pelagic communities in relation to seamounts. One exception is Senghor Seamount located to the east of the archipelago, which was the focus of several research campaigns (e.g. Christiansen et al., 2011; Christiansen, 2013). Various components of the pelagic food web have been studied on this seamount (Denda and Christiansen, 2014; Denda et al., 2017a, Mohn et al., 2021).

For example, zooplankton standing stocks and their respiratory carbon demand were six times higher on Senghor Seamount compared to Ampere Seamount (north of Madeira) (Denda and Christiansen, 2014). However, these differences were attributed to differences in the local productivity and oceanographic current system the seamounts are located in rather than direct effects of the seamount itself (Denda and Christiansen, 2014). Seamounts are hypothesized to interact with vertically migrating fauna (zooplankton and micronekton) that are transported over the seamount during the night and are then unable to migrate to deeper layers during the day because they are blocked by the topography of the seamount (Isaacs and Schwartzlose, 1965). There is evidence for this topographic blocking mechanism affecting micronekton and zooplankton distribution on Senghor seamount (Mohn et al., 2021). Senghor seamount furthermore showed a high abundance of benthic invertebrate larvae in the surrounding waters, indicating a retention potential of Senghor Seamount (Denda et al., 2017b).

In a study on distribution and biomass of gelatinous zooplankton in the deep seas of the Cabo Verde EEZ, the highest biomass (39 $mg \cdot C \cdot m^{-2}$) was found at the deepest sample depths (600–1,000 m) at the southeastern flank of Senghor Seamount (Lüskow et al., 2022). Using daytime and nighttime horizontal video transects from 20 to 950 m depth with a pelagic towed camera system, the midwater fauna on the north west flank of Senghor Seamount was investigated and quantified (Hoving et al., 2019). Contrary to the biomass measurements by nets (Lüskow et al., 2022), the abundance of PELAGIOS observed fauna peaked at 300–600 m during the day and night, and peaked also in the upper 100 m during the night (Fig. 10) (Hoving et al., 2019). Gelatinous organisms that were observed were *Praya* and *Apolemia* siphonophores, the polychaetes *Poeobius and Tomopteris*, medusae *Periphylla*, *Halitrephes*, *Haliscera*, *Crossota*, *Colobonema*, *Solmissus* and *Solmundella* and ctenophores *Beroe*, *Cestum*, as well as lobate ctenophores. Many of these were not captured by nets (Hoving et al., 2019). Cephalopods were rarely observed, but cranchiid squid were encountered in the upper 50 m

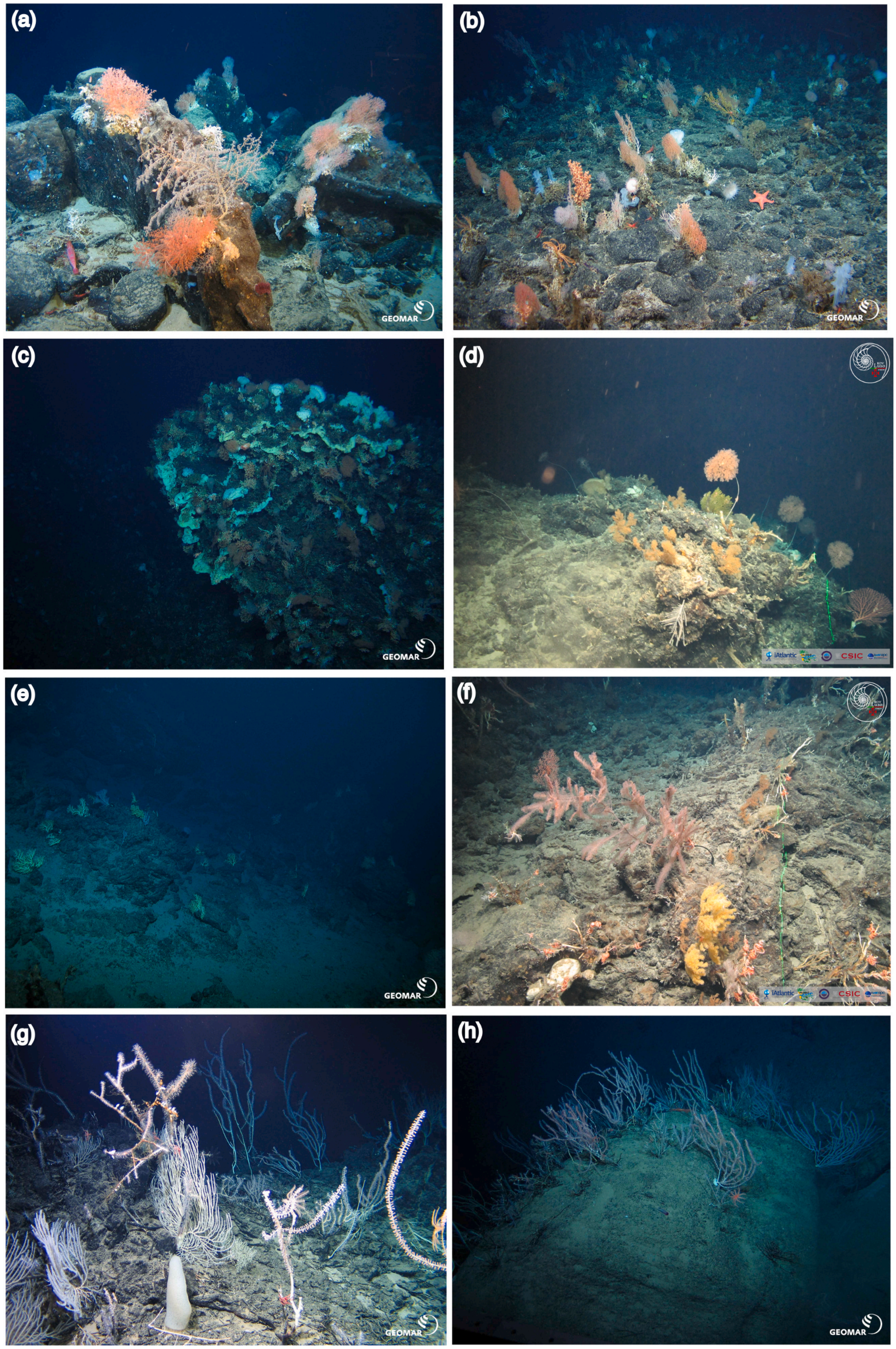

Fig. 7. Cold-water corals and associated species observed on the seamounts of Cabo Verde. (a) Octocorals and some scleractinian coral colonies on Cabo Verde Seamount at 920 m depth. (b) Cold-water coral gardens, with the presence of *Acanella arbuscula* and *Solenosmilia variabilis* on Nola Seamount at 1,030 m depth. (c) Outcrops with dense aggregations of sponges, *Solenosmilia variabilis* and crinoids on Nola Seamount at 980 m depth. (d) Coral garden on Cadamosto Seamount at 1,920 m depth, dominated by *Metallogorgia* spp. with the presence of black corals, octocorals and sponges. (e) Scleractinian coral *Enallopsammia rostrata* on Cadamosto Seamount at 1,730 m depth. (f) Black coral *Parantipathes* spp. at 2,015 m on Cadamosto Seamount. (g) Bamboo corals on Batuku in the Charles Darwin Volcanic Field at 3,000 m depth. (h) Aggregation of bamboo corals on Tabanka at the Charles Darwin Volcanic Field between 3,000 and 3,500 m depth. Photo credits of pictures d and f belong to iMirabilis2/EMEPEC/iAtlantic Project (2021). Photo credits for all the remaining pictures belong to Meteor M80-3/ROV KIEL 6000/ GEOMAR (2010).

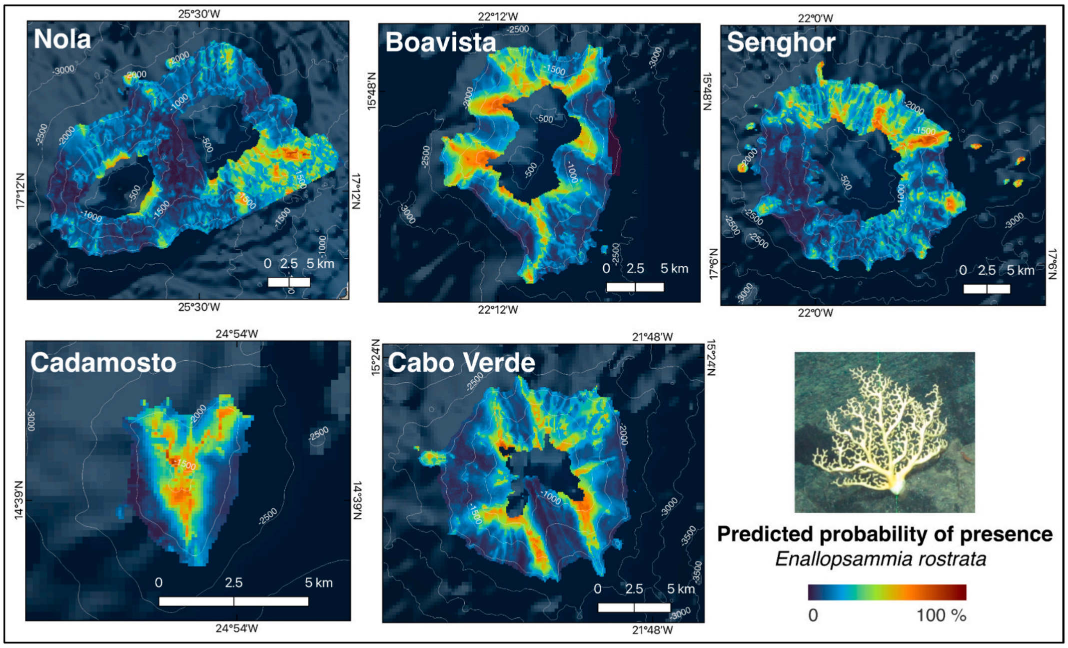

Fig. 8. Predicted distribution of *Enallopsammia rostrata*, one of the modelled VME indicators on the seamounts of Cabo Verde from 750 to 2,100 m depth. Data source: Vinha et al. (2024)

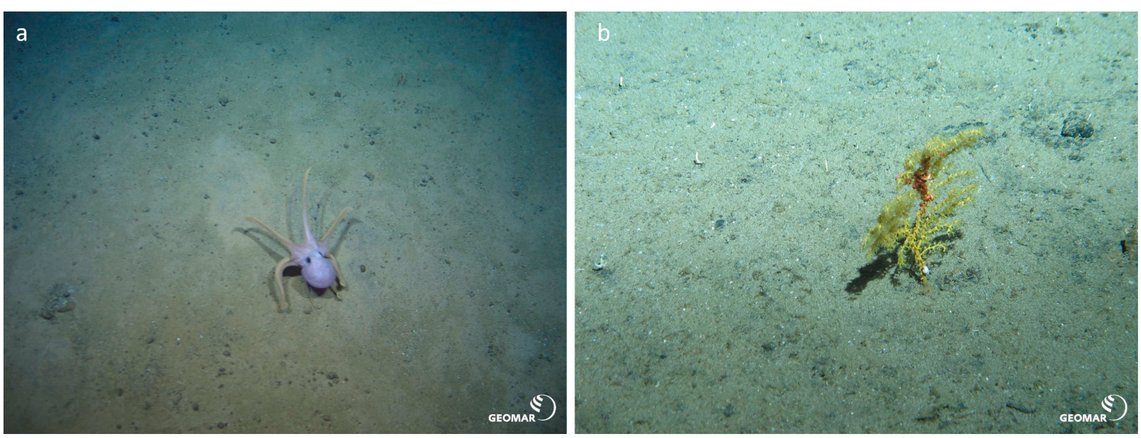

Fig. 9. Example of soft bottoms documented on Cadamosto seamount. a) an octopus on a sedimented seafloor at 1,575 m depth, b) a gorgonian from the family Plexauridae growing on a sandy bottom at 1,734 m depth. (Source of images: Meteor Expedition M80-3 /ROV KIEL 6000/ GEOMAR, 2010).

during night tows. Squids of the family Mastigoteuthidae were observed below 500 m and during a transit between transects, one individual of the bioluminescent squid *Taningia danae* was attracted to the bright lights of the sampling gear PELAGIOS. Other pelagic molluscs that were observed were *Phylliroe* and pteropods. Typical midwater fishes that were seen were myctophids, eels and hatchet fish (Hoving et al., 2019). A comparison of taxa on the north west flank of Senghor Seamount observed during day and night by means of pelagic video transects showed a clear daily vertical migration of pelagic organisms, in particular fishes and crustaceans (Hoving et al., 2019; Fig. 10). The results by Hoving et al., (2019) revealed a clearly higher abundance of fishes, chaetognaths, decapods and mysids, during the night time; whereas this pattern was not so clear for gelatinous zooplankton, except for the first 50 m where all taxa were clearly much more dominant by night.

Diversity studies on ichthyoplankton communities on Senghor Seamount suggest that this seamount is a stepping stone for coastal species (Hanel et al., 2010). The possibility of seamounts acting as stepping stones was also discussed in a diving study on ichthyofauna of two Cabo Verdean seamounts, Nola West and João Valente Bank (Monteiro et al., 2008). Collected fish species from Senghor Seamount also support the potential of seamounts dispersing typical shelf species to oceanic habitats (Vieira et al., 2016). The unexplored nature of Cabo Verde seamounts is illustrated by the relatively high number of new species records that are described in the few studies that exist. A deep-sea lander that was deployed at 119 m depth without bait on Senghor Seamount took time lapse images for 36 h, resulting in a new regional record of fish (Freitas et al., 2018). Of 27 collected species during an expedition in 2009, seven were new records of deep-sea fishes for Cabo Verde (Vieira et al., 2016). The example of Senghor seamount highlights the possibility of Cabo Verdean seamounts structuring and affecting different players of the pelagic food web ranging from zooplankton to ichthyofauna to gelatinous fauna (Chi et al., 2021). It also highlights the need of research efforts focused on other seamounts of the archipelago to increase our knowledge of the influence of these bathymetric features on the pelagic fauna.

3.3. Mobile marine megafauna

In oceanic regions, where food resources for mobile marine megafauna (elasmobranchs, sea turtles, seabirds and cetaceans) are typically sparse and less predictable compared to nutrient-rich neritic regions (Weimerskirch, 2007), seamounts play a critical role in congregating marine productivity (Morato and Clark, 2007). They promote localized, predictable prey aggregations, which provides critical foraging opportunities for mobile marine megafauna and thus influence their abundance and distribution. Cabo Verde hosts a remarkable diversity of marine megafauna (Fig. 11), which encompasses data-poor species (e.g. Cabo Verde skate *Raja herwigi,* Dureuil et al., 2024), often highly sensitive to, and impacted by, human threats (e.g. beaked whales, Feyrer et al., 2024) and with globally concerning conservation status as assessed by IUCN (Table S1, S2, S3 and S4). Elasmobranchs, sea turtles, seabirds and cetaceans species identified within Cabo Verde EEZ are listed in Suppl. Mat. (Tables S1, S2, S3 and S4, respectively).

Despite observation efforts having mainly focussed on coastal areas, marine megafauna occurrence has also been documented over seamounts and adjacent areas, using acoustic and visual census techniques (direct observation, photography and underwater videos), scientific longlining and biologging data.

Most records of sharks and rays have been documented over Nola and Senghor seamounts and near João Valente Bank where census efforts have been comparably more intensive (Strømme et al., 1982; Menezes et al., 2004; Monteiro et al., 2008; Graham et al., 2017; Garzón et al., 2023; Seymour et al., 2024). Furthermore, an ecological niche modelling study on tagged manta rays (*Mobula birostris*) suggested that most seamounts in Cabo Verde exhibited suitable habitat for manta rays for at least 6 months per year (Garzón et al., 2023). Additionally, anecdotal reports from fishers described sightings of several shark species in the seamount areas where they operate (Ratão, unpublished data). However, it remains unclear whether the elasmobranchs present at seamounts are attracted by their natural prey, such as tuna and other fishes, or by feeding opportunities provided by fishing activities occurring in the area.

Tracking data from loggerhead sea turtles (*Caretta caretta*), for which the Cabo Verde islands host one of the world's most important breeding grounds (Marco et al., 2011; Patino-Martinez et al., 2022), revealed only a few positions overlying seamounts (Varo-Cruz et al., 2013; Pikesley et al., 2015), suggesting no strong preference of these organisms for these oceanic features to forage or rest. Similarly, a study in the Azores also failed to find an association of loggerhead turtles with seamounts in that region (Morato et al., 2008). Nevertheless, it is unknown whether seamounts can be used to forage or rest by other sea turtle species occurring in Cabo Verde waters.

Some foraging trips of three out of eight tracked seabird species breeding in Cabo Verde showed a high concentration of GPS fixes above seamounts (Fig. 12; González-Solís and Paiva, unpublished data). These three species, the Cabo Verde petrel (*Pterodroma feae*), white-faced storm petrel (*Pelagodroma marina*) and Bulwer's petrel (*Bulweria bulwerii*) typically do not associate with fishing vessels (Montrond, 2020; Almeida, 2021; Navarro-Herrero et al., 2025). They forage mainly after sunset and during the night (Dias et al., 2016; Ramos et al., 2016; Medrano et al., 2023) and rely on micronekton that perform diel vertical migrations (Carreiro et al., 2023; dos Santos et al., 2023), which are common on certain seamounts (Fig. 10; Denda et al., 2017b). These ecological traits, combined with the GPS fixes of these species over oceanographic features like seamounts, suggest that they may benefit from the surface projections of these structures as foraging grounds. Cabo Verde shearwaters (*Calonectris edwardsii*) were also observed visiting the projection of Maio seamount and João Valente slopes (Fig. 12a; González-Solís and Paiva unpublished data). Nevertheless, this species forages during the day or at crepuscular hours and is known to associate with artisanal and industrial fisheries (Montrond, 2020; Almeida, 2021). Therefore, it is unclear whether shearwaters are profiting from feeding opportunities created by artisanal fisheries operating near seamounts or benefiting directly from prey-aggregations at seamounts. These prey-aggregations, which may be enhanced by the presence of subaquatic predators on seamount summits, such as tunas (Morato et al., 2008). That is, subaquatic predators can drive schooling prey to the surface, creating foraging opportunities for seabirds exploiting predator-mediated prey-aggregations (Clua and Grosvalet, 2001; Miller et al., 2018a). Indeed, tuna fisheries such as pole-and-line and trolling are particularly active around the Cabo Verde seamounts (see Section 4), providing indirect evidence that these predators frequently aggregate in association with seamounts.

The distribution of cetaceans remains as one of the most significant knowledge gaps in Cabo Verde (see section 6.3 on Research needs), leaving their association with seamounts largely unexplored, despite evidence from other regions that seamounts serve as important feeding grounds for cetacean species, many of which are also found in Cabo Verde waters (Pitcher et al., 2007; Giorli et al., 2015; Baumann-Pickering et al., 2016; Romagosa et al., 2019; Cascão et al., 2020;). Most cetacean observations have been opportunistic and thus concentrated near the main islands, leaving seamount areas relatively understudied. Despite these biases, when compiling observations from various sources, a high cetacean species richness over the seamount south of São Nicolau was detected (Fig. 13), which is supported by local surveys and reports from local fishers (Berrow et al., 2015; P. Lopez et al., unpublished data), suggesting that seamounts may be important foraging areas for cetaceans in Cabo Verde.

Most sightings of megafauna on Cabo Verde seamounts are just snapshots with no further behavioural information which makes it difficult to understand how and why these organisms explore the seamounts. Indeed, besides promoting foraging opportunities, seamounts could also provide shelter, stop-over areas during migratory movements or breeding/nursery areas. Seamounts were identified as important refuge areas for sharks and other pelagic predators, such as mahi-mahi (*Coryphaena hippurus*) also present in Cabo Verde, but only when these areas were beyond the range of local human (fishing) pressures (Letessier et al., 2019). In Cabo Verde, most seamounts are close to inhabited islands and within the range of fishing pressures (see section 4.1.1), thus they may not play a refuge/shelter role. Seamounts may also serve as important cleaning stations for marine megafauna (Oliver et al., 2011), as cleaner species are typically found in shallower waters (Sazima et al., 2010). However, no data currently exists to confirm this role for seamounts in Cabo Verde.

Many mobile megafauna species perform long migratory movements through the Atlantic Ocean. Five out of 11 tagged manta rays tracked in Cabo Verde migrated via the Nola Seamount and João Valente Bank (Garzón et al., 2023), the latter showing high space use intensity by this species. The lack of re-encounters and brief residency time within Cabo Verde suggests that the archipelago could serve as a migratory stop-over along a larger movement route (Table S1). Tracking data of blue sharks during their migratory movements showed that Nola East and West seamounts host important relative shark density at Atlantic basin scale (Queiroz et al., 2019), suggesting that these seamounts could have been used as stop-over areas. However, this study was performed at a global scale and studies at the Cabo Verde scale are needed to understand the importance of these seamounts as migratory stop-over areas and their role in maintaining connectivity among different areas in the Atlantic Ocean.

The growing evidence of the importance of seamounts as nursery areas to certain elasmobranch species, such as skates (*Bathyraja smirnovi*, *Bathyraja richardsoni*) and gray reef shark (*Carcharhinus amblyrhynchos*) (Hunt et al., 2011; Henry et al., 2016; Orr, 2019), has also been confirmed for Cabo Verde seamounts, as egg cases have been recently documented on Cadamosto Seamount (Vinha et al., 2022).

Regarding loggerhead turtles in Cabo Verde, tracking data suggest these turtles do not rely on seamounts as stop-over areas during their migratory movements towards the West African Coast (Hawkes et al.,

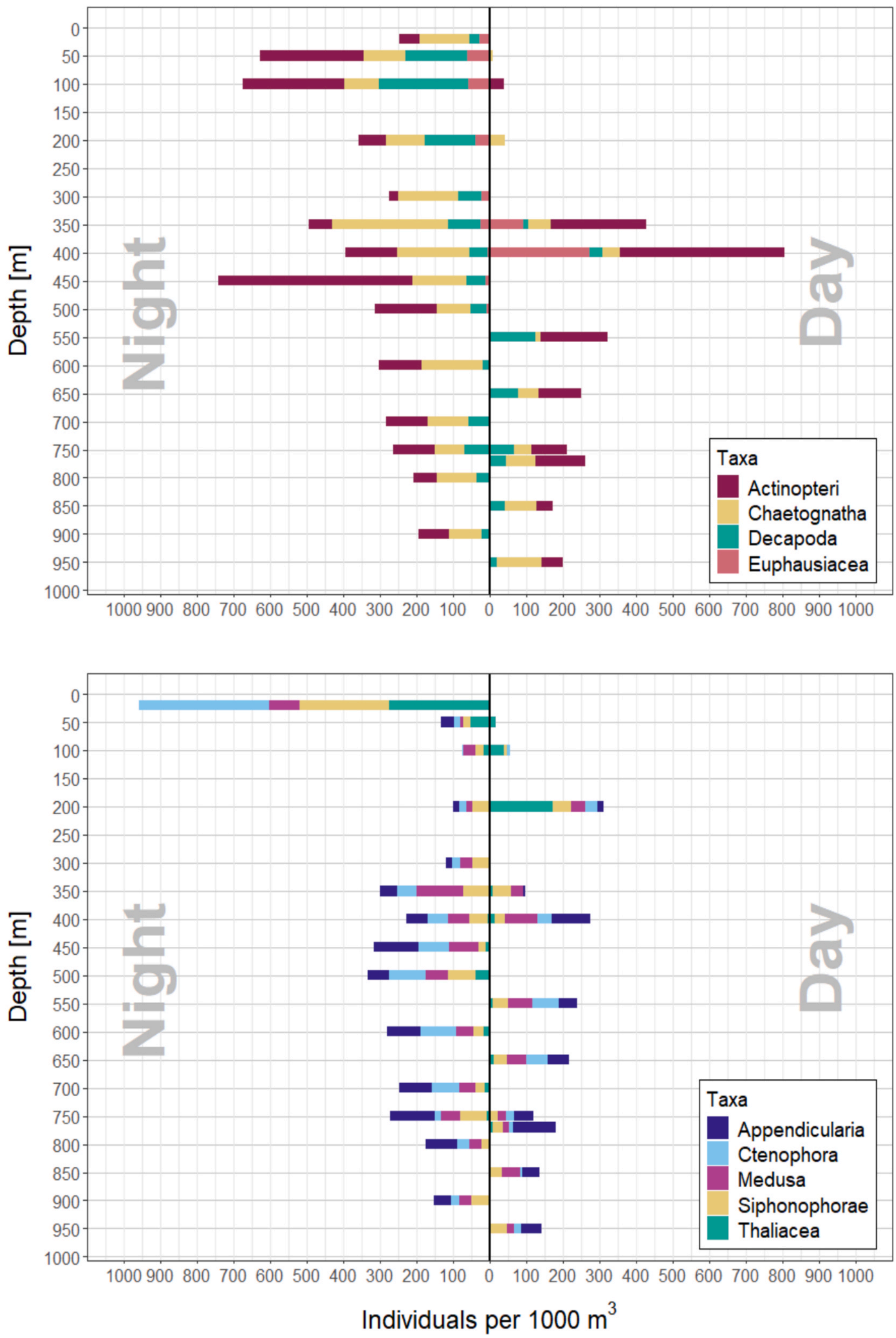

Fig. 10. Vertical distribution of micronekton (top) and macrozooplankton (bottom) taxonomic groups, as observed during horizontal pelagic video surveys down to 950 m with the pelagic in situ observation system PELAGIOS on Senghor Seamount north west flank. The left distribution shows enhanced occurrence of fish and crustaceans at night in the upper 300 m. Abundance is calculated according to the formula elaborated in Hoving et al. (2019). (Source: adapted from Hoving et al., 2019).

Fig. 11. Examples of mobile marine megafauna in Cabo Verde: (a) oceanic manta ray (*Mobula birostris*) captured in underwater video at west of Boa Vista island, (b) loggerhead turtle (*Caretta caretta*) nesting in Cima islet; (c) Cabo Verde petrels (*Pterodroma feae*) breeding on Fogo island; and (d) humpback whale (*Megaptera novaeangliae)* off Boa Vista island, using Sal Rei Bay as a breeding and nursery ground. (Copyright: (a) Sara S. Ratão (MOVE Group, University of Porto), (b-d) Jacob González-Solís).

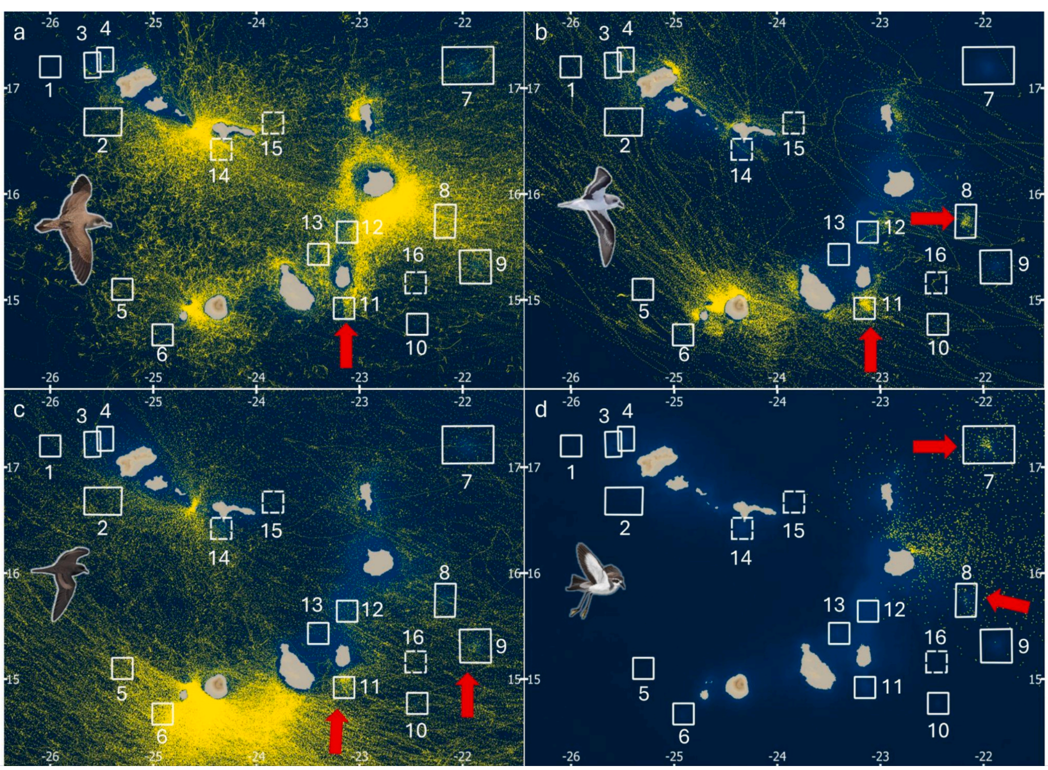

Fig. 12. GPS tracking data of four of the eight seabird species breeding in Cabo Verde, with only these four species foraging on the surface projections of seamounts: (a) Cabo Verde shearwater (*Calonectris edwardsii*), (b) Cabo Verde petrel (*Pterodroma feae*), (c) Bulwer's petrel (*Bulweria bulwerii*), and (d) white-faced storm-petrel (*Pelagodroma marina*). The red arrows highlight the most prominent concentrations of foraging activity on seamounts. White rectangles show seamount locations, with numbers matching those in Fig. 1 and Table 1, where names are listed. Dashed outlines indicate unnamed seamounts. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.) (Source: Unpublished data collected from 2014 to 2023 by Jacob Gonzalez-Solís, Vitor H. Paiva and local NGOs (Associação Projecto Vitó, Biosfera, Bios.CV, Associação Projeto Biodiversidade))

2006; Varo-Cruz et al., 2013; Pikesley et al., 2014). Despite this, loggerhead turtles are occasionally seen on seamounts (i.e. in João Valente's seamount) (S. Ratão unpublished data).

Regarding the importance of the seamounts during migration for seabirds, several seabird species breeding in the North Atlantic, Mediterranean or South Atlantic migrate through and/or overwinter in Cabo

Verde waters (Table S3, Fig. S1), highlighting the region's critical role in connecting the two hemispheres. Nevertheless, it remains unclear whether these transequatorial migratory seabirds (Fig. S1) use seamounts as stopover sites or as non-breeding areas. This uncertainty stems from limitations in current technology, such as global location sensors (geolocators), which exhibit a mean positional error of approximately 300–400 km in radius (Halpin et al., 2021), making it challenging to determine the precise role of seamounts in their migration.

Tagged humpback whales (*Megaptera novaeangliae*) in New Caledonia (South Pacific) suggest seamounts serve as crucial stopover areas to this species (Garrigue et al., 2015), which could also be the case of Cabo Verde seamounts. However, the role of Cabo Verde seamounts as stopover sites or migratory landmarks for cetacean species inhabiting the archipelago waters remains poorly understood. Cabo Verde is the only known breeding ground for humpback whales in the eastern North Atlantic (Wenzel et al., 2020; Chosson et al., 2023) and is also visited by individuals from the southern hemisphere (Hazevoet, 2012; Berrow et al., 2015), making it a unique site in the Atlantic where populations from both hemispheres breed, albeit in different seasons. Since humpback whales prefer shallow waters (< 50 m) for breeding and nursing, they may use shallower seamounts, such as Senghor, João Valente, Cabo Verde, South São Nicolau and Unnamed 1 seamounts (Table 1) for these purposes (Garrigue et al., 2015) (Table 1).

3.4. Microbial diversity

The hydrothermally – altered areas observed in several Cabo Verde seamounts (i.e. Cadamosto) could be an indicator of chemosynthetic hydrothermal communities (i.e. bacterial mats). However, to the best of our knowledge, there are no studies on the marine microbial communities (planktonic and benthic) available for Cabo Verde Seamounts (see section 6.3 Research needs).

Regarding the deep-sea around Cabo Verde, recent research expeditions have revealed significant microbial diversity and ecological functionality in the abyssal habitats surrounding the archipelago. Specifically, the recent expeditions M139 DEEP MICROBES and M209 BASIS METEOR, both conducted on board the German research vessel METEOR, provide novel data and information on the microbial structure and dynamics across depth gradients, from the mesopelagic (~200–1,000 m) to the abyssopelagic and benthic seafloor (> 3,500 m) (Arndt et al., 2017; Hoving et al., 2025). Overall, the microbial communities inhabiting the deep-sea regions of Cabo Verde seem to play key roles in organic matter remineralization, nutrient flux regulation, and benthic-pelagic coupling in an otherwise relatively oligotrophic region. Although hydrothermally-adapted fauna have not yet been documented, the microbial biodiversity exhibits remarkable adaptations to pressure, temperature, and substrate availability, (Arndt et al., 2017; Hoving et al., 2025; Merten et al., 2021).

In a wider context, a comprehensive study in the deep tropical and subtropical North Atlantic Ocean (Morgan-Smith et al., 2013) presents the diversity and distribution of microbial eukaryotes from 100 to 7,000 m depth, mostly from the Romanche Fracture Zone within the Mid-Atlantic Ridge. The authors concluded that the deep-sea eukaryotic community is composed of a few dominant taxa and a large number of scarcely present taxa, many still unidentified, being in agreement with the idea of a "rare biosphere" for deep-sea eukaryotes in the ocean (i.e., a large collection of microbial life that are present in very low concentrations) (Morgan-Smith et al., 2013). The authors also conclude that both abundance and diversity of deep-water eukaryotes reflect surface ocean productivity conditions. This suggests a strong coupling between the microbial food webs of the surface and deep ocean, driven by sinking particles that carry organic matter and bacterial prey to deep-sea eukaryotic communities.

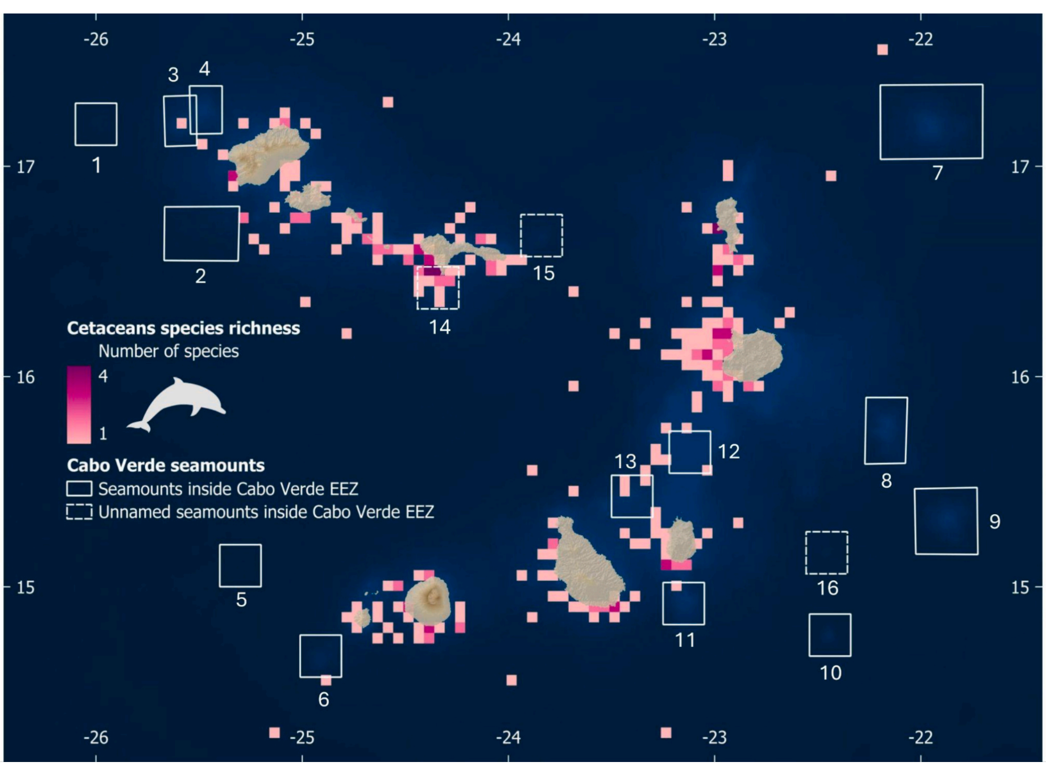

Fig. 13. Cetacean species richness across the Cabo Verde Archipelago and its surrounding oceanic waters. While based on diverse data sources with notable spatial and temporal observation biases, seamount 14 south of São Nicolau appears to host an elevated cetacean richness. White rectangles show seamount locations, with numbers matching those in Fig. 1 and Table 1, where names are listed. Data compiled from literature (Reiner et al., 1996; Hazevoet and Wenzel, 2000; Hazevoet et al., 2010, 2011; Torda et al., 2010; Berrow et al., 2014, 2019; Legrand and Monticelli, 2020), unpublished cetacean surveys (Survey Edmaktub / IWDG 2019; Proyecto Hydrocarpo, 2003–2005; Survey MARCET II, 2022) and databases (GBIF, 2024; Ocean Biodiversity Information System (OBIS), 2024).

3.5. Trophic linkages

Few attempts have been made to investigate the trophic linkages on the seamounts of Cabo Verde. To the best of our knowledge there is a single study (Vinha, 2024) that investigated the benthic trophic net on the Cadamosto seamount and the slopes of the islands of Brava and Fogo, using stable isotopes and lipids as trophic markers. The study revealed similar stable isotopes and lipid composition between seamount and island slopes, indicating that benthic communities at both locations benefit from the high primary productivity in the region, relying on organic matter from phytoplankton production. However, higher lipid concentrations of phytoplankton indices were observed in the investigated seamount CWC, suggesting that enhanced bottom hydrodynamics-topography interactions are delivering higher quantities and fresher food to benthic communities on the seamount, thereby contributing to higher CWC abundances (Vinha et al., 2024, 2025 – this issue). Although not directly related to the seamounts, a recent study by Gaurisas et al. (2024 – this issue) investigated by means of *ex situ* experiments the trophic web and dynamics of the deep-sea macrofaunal assemblages of the Cabo Verde basin bathyal zone, simulating future climate scenarios (i.e., warming and decrease in food quality). The results of the experiments revealed no effects on the incorporation of carbon and nitrogen by macrofauna under warming, and a decrease in organic matter quality not even under the combination of both climate stressors. Therefore, the potential effects of warmer temperatures and Particulate Organic Carbon quality on carbon and nitrogen incorporation by macrofauna remain uncertain.

Beyond benthic studies, other recent investigations focused on zooplankton and micronekton (Hoving et al., 2019) on Senghor Seamount. The authors documented an increase of mid-water biomass (i.e., higher concentration of gelatinous zooplankton, chaetognaths, and small fish), which provide prey for larger predators such as pelagic fish.

The role of seamounts as ecological hotspots and aggregation sites for large pelagics is, well documented on other Macaronesian seamounts (Morato et al., 2008) and is also evident for the Cabo Verde region. This is particularly clear for some seabird species that forage over certain seamounts (Fig. 12), and can further be inferred for tuna, given the concentration of pole-and-line and troller fishing above these features (Fig. 14). Within the Cabo Verde archipelago, stable isotope studies revealed a well-defined trophic structure in the seabird community, characterized by low interspecific isotopic overlap and high trophic positions among the species associated with Cape Verde seamounts (Roscales et al., 2011). There is also evidence of dietary overlap between seabirds and tuna species; particularly the sea birds brown boobies (*Sula leucogaster*) and Cape Verde shearwaters show dietary overlap with yellowfin tuna (*Thunnus albacares*) and, to a lesser extent, skipjack tuna (*Katsuwonus pelamis*) (Carreiro et al., 2023). While this overlap does not necessarily imply co-foraging at seamounts, such features are known to concentrate potential prey for both seabirds and tuna species, which may increase the likelihood of interactions among them. One suggestion would be that diurnal seabirds, such as brown boobies and Cape Verde shearwaters may visit seamounts because tunas can drive prey to the surface, unintentionally benefiting surface-feeding seabirds through predator-facilitated foraging (Clua and Grosvalet, 2001; Miller et al., 2018a). This dynamic reinforces potential trophic linkages between these predators in seamount-associated food webs. Regarding other groups (i.e., elasmobranchs, cetaceans, sea turtles), to the best of our knowledge no studies have yet been conducted in the seamounts of Cabo Verde.

4. Current anthropogenic activities, pressures and impacts on the Cabo Verde seamounts

As an island nation, Cabo Verde has a maritime EEZ that covers over 796,000 square kilometres—almost 200 times its land area. This vast oceanic space makes Cabo Verde heavily reliant on the ocean economy through fisheries, marine transportation of goods, and tourism. These activities can have negative impacts on seamount ecosystems, including overfishing, the introduction of invasive alien species (IAS), as well as noise, plastic and chemical pollution.

4.1. Anthropogenic activities

4.1.1. Fishing

The fishing industry is a cornerstone of Cabo Verde's economy, with estimates of its contribution to the national GDP ranging from about 2 % to 10 % depending on whether only the primary sector is considered or if processing and associated industries are included (DNA, 2020). According to the National Fisheries Institute (IMar), fish landing catches in 2018 totalled 26,588 tons, with tuna, small pelagic species, and demersal fish dominating the composition. However, substantial underreporting has been detected, suggesting catches may greatly exceed this value (Santos et al., 2013). Fish and processed fish products, including canned fish, comprise over 70 % of Cabo Verde's total exports, underscoring their economic importance. The capture of fish has increased significantly since the mid-1990 s due to a growing trend in semi-industrial and industrial national vessels followed since 2005 by intensified efforts from both domestic and foreign fleets, and enhanced data collection methods (Brito, 2022) (Fig. 15).

Both Cabo Verdean and foreign industrial fleets (Council Regulation (EC) No 2027/2006) —primarily from Europe (Portugal, Spain, France), China, and neighbouring sub-regional countries (Global Fishing Watch, 2025)—target high-value fish species in Cabo Verde's EEZ, including tunas, swordfish (*Xiphias gladius*), marlin (*Makaira* spp.), and small pelagics such as scads (*Decapterus macarellus* and *Selar crumenophthalmus*) (Direcção Geral dos Recursos Marinhos, 2019). Additionally, industrial fisheries also target pelagic sharks within the Cabo Verde EEZ, including tiger (*Galeocerdo cuvier*), blue (*Prionace glauca*), mako (*Isurus* spp.) and smooth-hound (*Mustelus mustelus*) sharks. Although shark finning is prohibited, there are no quota restrictions for shark catches (Direcção Geral dos Recursos Marinhos, 2019).

Drifting longlines has been by far the most widely used gear over the last decade, followed at a considerable distance by purse seines (Fig. 15, Fig. S2). However, these fisheries are generally dispersed across the EEZ rather than concentrated on seamount summits (Fig. 16; Table S5; Global Fishing Watch, 2025). A Fisheries Partnership Agreement between the EU and Cabo Verde (2019–2024) prohibited European fleets of these fisheries to operate within 14 nm of the Cabo Verde archipelago, leading to less longline fishing effort within this range. Seamounts beyond the 14 nm mark experienced higher fishing effort between 2012 and 2022, though some activity was still recorded within 14 nm at Unnamed Seamounts 1 and 2 (Figs. 1, 14, Global Fishing Watch, 2025). Global Fishing Watch data showed an annual average of 33 h of drifting longline fishing within 30 km of seamount summits within the Cabo Verde EEZ between 2014 and 2018 (Kerry et al., 2022). Tuna purse seines were recorded only at seamounts beyond the 14 nm mark, notably Charles Darwin, Tavares/Cape Verde Ridge, Boa Vista, and Senghor. Bottom trawling, known to have the most Significant Adverse Impacts (SAI) on seamount ecosystems, in particular on VMEs (Ramirez-Llodra et al., 2011; Taranto et al., 2012), has been forbidden within Cabo Verde's EEZ since 2020 and was not recorded above seamounts but was recorded within Cabo Verde's EEZ (Section 2 of B.O. n° 81 on July 9, 2020; Cabo Verde Republic). However, the practice was still recorded at the Tchadona Seamount by one Spanish vessel in 2020 (Figs. 14, 16; Global Fishing Watch, 2025). The pole-and-line fishery was also part of the Fisheries Partnership Agreement between the EU and Cabo Verde (2019–2024), though in this case, prohibiting European fleets of these fisheries within 12 nm of Cabo Verde. Unlike drifting longlines and purse seines, pole-and-line and trolling are mainly concentrated around seamounts, with national vessels primarily targeting specific seamounts such as Nola E/Noroeste, Nola W/Banco Noroeste, Unnamed 1, Senghor/Nova Holanda, and Maio Rise/Sul de Maio Bank seamounts.

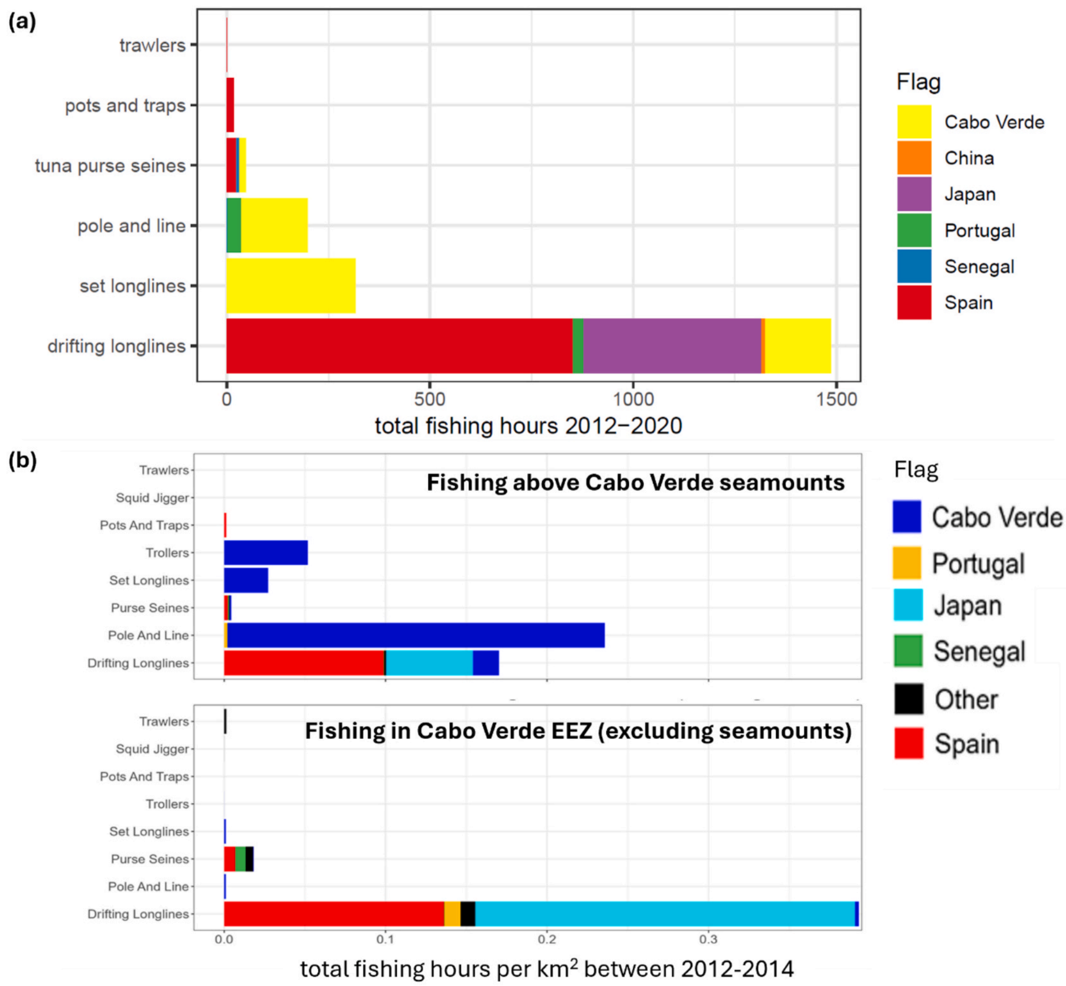

Fig. 14. Total fishing effort (hours of active fishing per km^2) by gear type and flag state in Cabo Verde waters between 2012 and 2024 above Cabo Verde seamounts (a) and within the Cabo Verde Exclusive Economic Zone (EEZ) excluding seamount areas (b). Bars represent stacked contributions from each flag state. The Flag category "other" includes fishing from China, Belize, South Korea, France, Morocco, Côte d'Ivoire, Taiwan, El Salvador, Curaçao, Saint Vincent and the Grenadines, Guatemala, Guinea, Panama, Sierra Leone, Guinea-Bissau, Angola, Russia, Comoros, Falkland Islands, South Africa, United Kingdom, Netherlands, Ghana, Italy, Lithuania, Cuba, Namibia, Cameroon, Poland and Martinique, all with less than 0.005 cumulative fishing hours per km^2 within the Cabo Verde EEZ. (Source: Global Fishing Watch, 2025)

Fishing pressure from these fisheries has notably increased over the past year (Fig. S5), underscoring the importance of seamounts for tuna. Finally, pot-and-trap and set longline fisheries, which are limited to shallow waters, concentrate around João Valente and Tchadona Banks, as well as Unnamed 1 and 2 seamounts. However, their fishing effort is comparatively small, and these gears appear to have been abandoned over the past year (Fig. 16; Global Fishing Watch, 2025, Fig. S2).

Artisanal and semi-industrial fisheries are vital for Cabo Verde's coastal communities, with 1,462 artisanal and 27 semi-industrial boats registered (Correia et al., 2022). Artisanal vessels (3–8 m) primarily use handlines to catch large pelagic and demersal species, while purse seines, beach seines and gillnets target small pelagics for bait or direct consumption (MegaPesca, 2004). Additionally, scuba diving on Nola Seamount or the João Valente Bank is conducted to harvest lobsters, molluscs, and demersal fish exploited for tourism and local markets (SEPA, 1999; MAAP, 2004). Moreover, although currently infrequently used, previous more widespread use of dynamite fishing may have had important impacts on Cabo Verde seamounts (Santos et al., 2013), creating for instance coral damage (Oliver et al., 2011). In Cabo Verde, the use of illegal dynamite fishing has significantly decreased since 1985, after a development programme encouraged the use of purse seines in the artisanal small-scale fishery, as an alternative to the use of explosives (MAAP, 2004; Silva, 2009).

Semi-industrial fleets (8–28 m) target pelagic and demersal species using handlines, pole-and-line, purse seines, and traps (Fonseca, 2000). Tuna landings, which constituted 80 % of large-scale catches before 1991, accounted for just 40 % by 1998. This decrease in proportion likely reflects a combination of factors: the introduction of purse seines targeting small pelagics in 1992 and the impacts of overfishing on tuna stocks (Fonseca, 2000; Dancette, 2019; Brito, 2022).

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Official data about the type and effort of fishing exerted on the Cabo Verde offshore seamounts is scarce. The artisanal fleets contribute to most captures in the region (Benchimol et al., 2009). GPS tracking of artisanal and semi-industrial vessels also highlights the use of Nola East and Nola West, Unnamed 1, Senghor, and Maio Rise seamounts as well as João Valente Bank as common fishing grounds (see Table 1 and

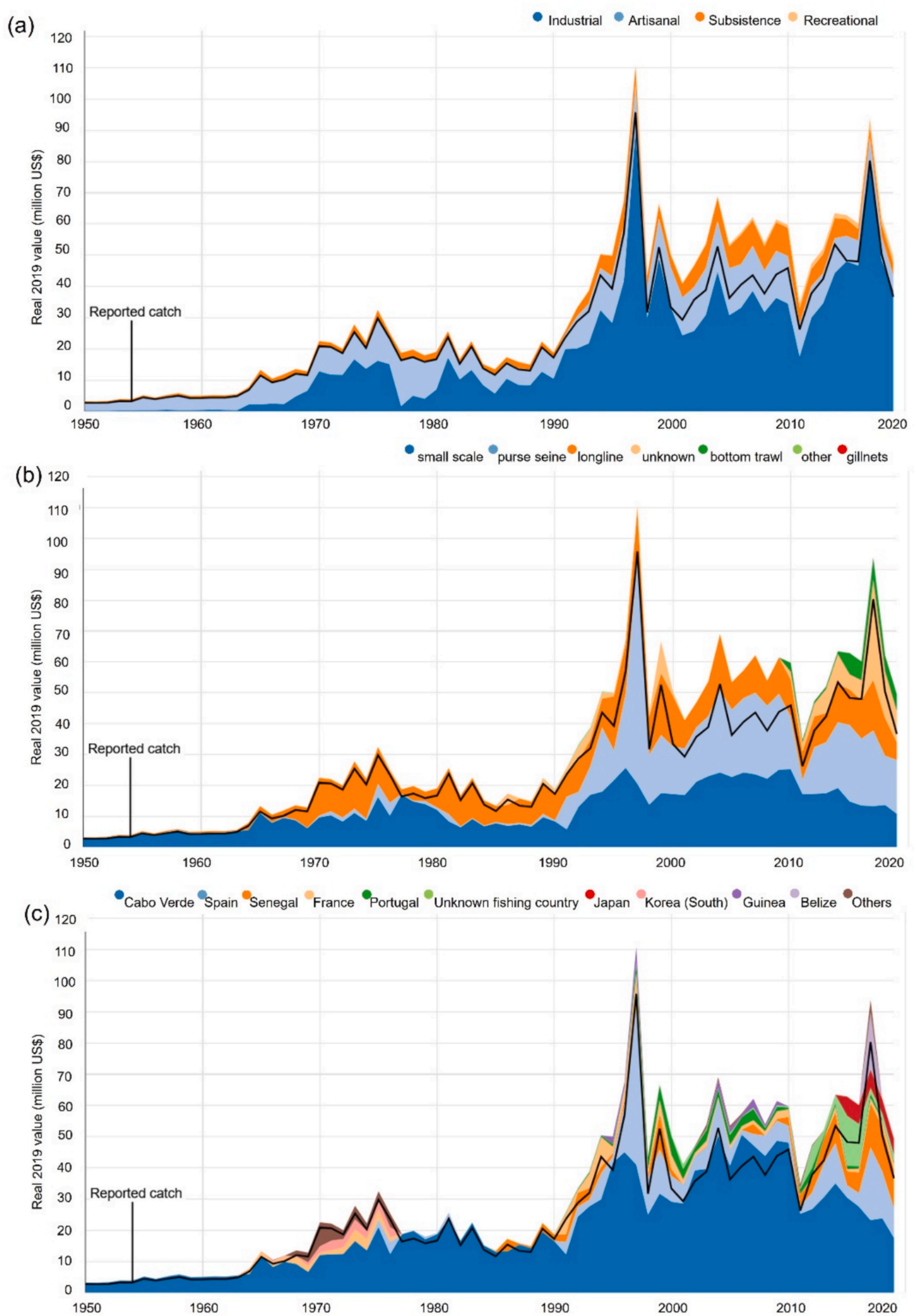

Fig. 15. Overall 'reconstructed' catch and real 2019 value (US$) in the waters of Cabo Verde by (a) the fishing sector, (b) fishing gear and (c) fishing country. The data presented combine official reported data and reconstructed estimates of unreported data (including major discards). The 'Reported catch' line overlaid on the catch graph represents all catches deemed reported (including foreign) and allocated to Cabo Verde's EEZ. (Source: images downloaded with permission from SeaAroundUs, 2024a,b,c; Pauly et al., 2020).

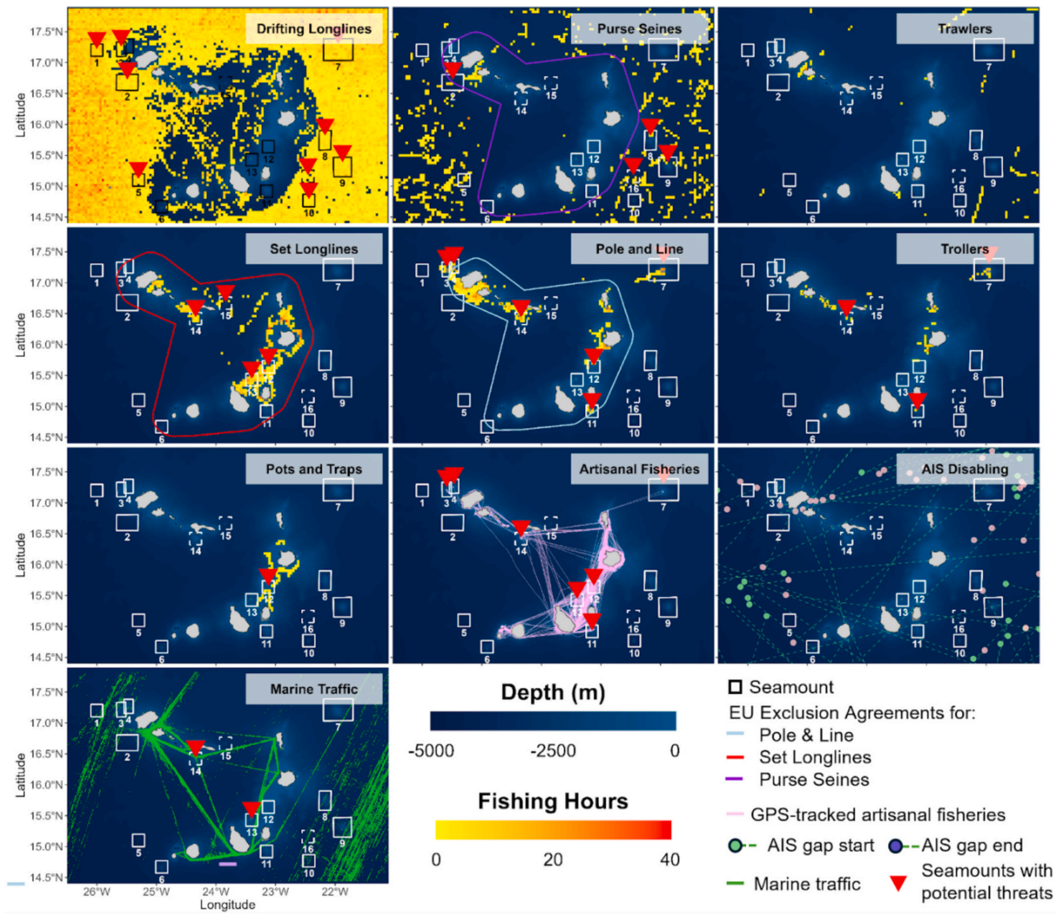

Fig. 16. "Apparent fishing hours" are estimates of the time a vessel is likely engaged in fishing, based on analysis of AIS (Automatic Identification System) data. Global Fishing Watch (GFW) calculates these by using machine learning models to classify each AIS position as "fishing" or "not fishing" based on vessel behaviour such as speed, direction, and movement patterns.) per fishing gear per 0.04 degrees based on AIS data, available from Global Fishing Watch (2025) for the period of 2012–2024, GPS-tracked artisanal fisheries for the period of 2018–2025 (unpublished data), Marine Traffic for 2023 (Global ShipTracking Intelligence, 2024), and AIS disabling events between 2017 and 2019 from Welch et al., (2022), in proximity to the seamounts within the EEZ of Cabo Verde. Red arrows highlight seamounts exhibiting higher apparent fishing hours compared to adjacent areas. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Fig. 16). Of the 341,200 h of artisanal vessel tracking, 1,816 were spent over Cabo Verde Seamounts (0.53 %, González-Solís, Paiva and local NGOs – Associação Projecto Vitó, Biosfera, Bios.CV, Associação Projeto Biodiversidade, unpublished data). Nevertheless, there is a lack of official information on the type of fishing and the volume of catches for all seamounts in Cabo Verde.

4.1.2. Marine traffic

In addition to fisheries, the Cabo Verde EEZ is a region of intense marine traffic, including cargo ships, tankers, and passenger vessels. These vessels travel along well-established shipping routes, which act as "marine highways" and often overlap with habitats frequented by marine megafauna, such as cetaceans and sea turtles (Fig. 16). The high volume of marine traffic increases the risk of vessel strikes with air-breathing vertebrates, particularly slower-moving species such as sea turtles, whale sharks and large whales (Schoeman et al., 2020; Womersley et al., 2022; Nisi et al., 2024). The risk is amplified in areas where vessels travel at high speeds, giving megafauna less time to react and increasing the severity of injuries in collision events (Schoeman et al., 2020). In relation to cruise shipping, Cabo Verde is characterized by the lack of adequate port infrastructure, with direct impact on the quality level of provided services, and a reduced volume (50,000 cruise passengers per year) compared to the rest of the Macaronesia region (Da Luz et al., 2022). Therefore, the marine traffic within Cabo Verde is mainly composed of marine cargo vessels. The volume of marine traffic within Cabo Verde is generally increasing (Kramel et al., 2024), despite an initial decline during the first months after the COVID-19 outbreak (March et al., 2021b). Seamount ecosystems within the marine highways are more likely to be affected by traffic-related collisions, noise pollution, oil spills and accidents, anti-foulants, chemical discharge and ballast water release that can bring invasive species (Walker et al., 2019). Overall, Unnamed Seamount 1 has the highest national marine traffic, while further seamounts such as Sodade, Nola West, Nola East, Charles Darwin Volcanic Field, Senghor, Boa Vista, Unnamed Seamount 3, Cabo Verde, and Maio Seamounts are within international marine highways (Fig. 16).

4.1.3. Tourism

Tourism in Cabo Verde has experienced significant growth, particularly after the European financial crisis in 2008 (González-Gómez, 2022), with an annual average increase of 11 % between 2000 and 2018 (Tavares, 2020). While the majority of tourists are drawn to "beach and sun" especially on the islands of Sal and Boa Vista (López-Guzmán et al., 2013), the archipelago has seen a rise in more diverse forms of tourism, including marine and coastal eco-tourism, as well as adventure tourism. São Vicente and Santo Antão, for example, combine cultural tourism with marine activities, offering diving and fishing opportunities that appeal to a different segment of visitors. Seamounts are central to this tourism boom due to their ecological and economic significance. They harbour diverse marine life, supporting activities like diving and underwater tours, where tourists can observe fish, crustaceans, and coral ecosystems. Whale watching, particularly in areas like Boa Vista Island's Sal-Rei Bay and Santa Monica, focuses primarily on humpback whales during their mating and breeding seasons, a species that may make use of the seamounts in the archipelago (see section 3.3). Indeed recreational activities such as scuba diving and sportfishing are increasingly popular in Cabo Verde, drawing a growing number of tourists eager to explore the region's unique underwater seascapes and abundant marine life, as evidenced by a record of over 1 million visitors in 2023, a 23 % increase from previous years (Amaro, unpublished data; Cabo Verde's Record Tourism Highlights Economic Potential, 2024).

Seamounts also contribute indirectly to tourism through their role in recreational fisheries, which began alongside the tourism industry in 1939 (Fialho, 2011; CVRS, 2012). Game fishing, an increasingly popular activity, is actively encouraged by the government and has developed alongside diving and other marine pursuits (Cabral, 2005; MegaPesca, 2010; ESR, 2011). However, even recreational fisheries may have a potential impact on seamount ecosystems. For instance, certain practices in sportfishing, such as catch-and-release methods or the use of certain heavy tackle, can harm sensitive species or disrupt local habitats (Cooke and Wilde, 2007). Moreover, like in many countries (e.g., Zeller et al., 2008), data on recreational fishing catches in Cabo Verde is limited due to inadequate monitoring, highlighting a gap in understanding the full scope of its economic and ecological impact. Seamounts in Cabo Verde, such as the northwest Bank near Santo Antão and the Bank of João Valente between Boa Vista and Maio, serve as biodiversity hotspots and vital fishing grounds (Monteiro et al., 2008). These underwater features are similar to other regions where marine-based tourism thrives, such as the Condor Seamount in the Azores, where shark-diving alone generates €194,111 annually (Ressurreição and Giacomello, 2013). However, the economic potential of seamount-based tourism in Cabo Verde is largely underexplored.

4.2. Current anthropogenic pressures and impacts on Cabo Verde seamounts

4.2.1. Pressures caused by fishing

4.2.1.1. Overfishing. In Cabo Verde, as in many West African countries, fisheries resources are considered to be overexploited (FAO, 2024); indeed Cabo Verde fish stocks are currently harvested above their maximum sustainable yield (Brito, 2022), with several fish stocks, such as tunas, mackerel scad and groupers (Epinephelidae) showing signs of decline (da Cruz Delgado et al., 2024; Macedo et al., 2025). Spiny lobsters (Palinuridae) caught legally with pots & traps or illegally by diving are also considered overexploited (González et al., 2020). These declines are mirrored by an increase in industrial fishing in the area by foreign fleets within the Cabo Verde EEZ (Dancette, 2019), and locally, for example the decrease in lobsters is likely due to the increase of divers fishing; this activity is often unregulated and not monitored (Fig. 15a). Furthermore, it has been suggested that the João Valente Bank and Nola West Seamount (known locally as Banco Noroeste) may be overexploited by artisanal fisheries (Monteiro et al., 2008). An indirect evidence of overexploitation is the absence of higher trophic-level sharks, as indicated by baited remote underwater video (BRUV) and scientific longline data (Graham et al., 2017). Artisanal and industrial practices, such as mid-water longlining commonly used in tuna and swordfish fisheries, are known to significantly impact mid-water shark populations.

4.2.1.2. Bycatch. Bycatch mortality due to the unintentional capture of non-target species in fishing gear is a significant driver of population declines in marine megafauna such as elasmobranchs, sea turtles, seabirds, and marine mammals (Tasker et al., 2000; Moore et al., 2010; Tuck et al., 2011; Croxall et al., 2012; Roast et al., 2023). These groups are particularly vulnerable due to their long lifespans, late maturity, slow reproduction rates, and wide-ranging movements, exposing them to multiple fisheries and gear types (Lewison et al., 2004; Wallace et al., 2008, 2013; Dulvy et al., 2008). Artisanal fisheries cause an estimated 1,675 loggerhead turtle deaths annually, primarily from handlines near Boa Vista, Sal, and Maio (Martins et al., 2022). Industrial longline and purse-seine fleets also catch turtles, with post-release survival rates as low as 63.5 % (Álvarez de Quevedo et al., 2013; Cardona et al., 2025). Seabirds, including the endemic Cabo Verde shearwater, are at risk from longlines near Santo Antão, São Vicente, and Boa Vista, but shearwaters in particular are also at risk on the African shelf (Navarro-Herrero et al., 2025). Sharks and rays are affected by longline and purse-seine fisheries, with French purse-seiners reporting 376 shark bycatch incidents (2013–2022), including critically endangered species, while pelagic stingrays were recently documented near the Cabo Verde-Mauritania EEZ boundary (de la Hoz Schilling et al., 2024).

4.2.1.3. Illegal, unreported and unregulated fishing. Western Africa is a global hotspot for illegal, unreported and unregulated (IUU) fishing, with 8 % of fishing activity concealed through AIS (Automatic Identification System) disabling events (Welch et al., 2022; Navarro-Herrero et al., 2024, Simataa et al., 2025, Fig. 16). In Cabo Verde, foreign fleets operate under non-transparent licensing agreements and often engage in unreported catches, with enforcement hampered by financial and logistical constraints (Aquino, 2023; da Cruz Delgado et al., 2024). AIS technology has become essential for tracking fishing activities, but its misuse complicates monitoring. Between 2017 and 2019, 752 AIS disabling events were recorded in Cabo Verde's EEZ, some occurring near ecologically significant seamounts, where unauthorized activity may harm vulnerable benthic ecosystems and marine megafauna (Welch et al., 2022). Drifting longlines, tuna purse seines, and trawlers were the primary culprits, with Spanish fleets being responsible for the highest proportion of disabling events, suggesting underestimation of fishing activities near these critical habitats.

4.2.1.4. Overlap between fishing activities and occurrences of vulnerable marine ecosystems. Significant Adverse Impacts (SAI) of fishing on seamount benthic communities vary, with some practices causing significant disruptions while others are less harmful. Bottom trawling, which can cause the biggest SAI on VMEs, by severely disrupting the seabed and reducing habitat complexity (Clark, 2009; Ramirez-Llodra et al., 2011;Taranto et al., 2012; Clark et al., 2016), is currently limited within Cabo Verde (see section 4.1.1). Although the Cabo Verde fishing fleet mainly consists of small-scale artisanal vessels (see section 4.1.1) for which the impact on the seamounts is assumed to be low, other countries' intensive artisanal fisheries have caused significant impacts on benthic communities (Hawkins and Roberts, 2004; Lokrantz et al., 2010). International fleets using drifting longlines are the primary fishing gear used on the seamounts of Cabo Verde (Fig. 14), and while they are expected to cause lower SAIs on VMEs in comparison to other fishing gear (Taranto et al., 2012; Pham et al., 2014a), longline entanglement still poses a physical threat to benthic organisms (Lumsden et al., 2007; Orejas et al., 2009; Fabri et al., 2019). In fact, derelict fishing longlines (Drinkwin, 2022) were observed during ROV dives on Cadamosto Seamount, overlapping the areas with the highest coral densities (Vinha et al., 2025- this issue). Demersal fisheries, such as pots, traps, and set longlines, are common on some Cabo Verde seamounts and can also cause some damage to benthic habitats, though to a lesser extent (Stevens, 2020; Pham et al., 2014a). Dynamite fishing, though now rare and illegal, may have historically affected benthic habitats in Cabo Verde, although the areas in which this fishing practice occurred remain unclear (MAAP, 2004; Santos et al., 2013).

To explore the potential interaction of fishing activities on the Cabo

Verde seamounts with benthic VMEs, we investigated the spatial overlap of fishing effort extracted from AIS data (Global Fishing Watch, 2025) and predicted areas of VME existence as published by Vinha et al. (2024). The seamounts in Cabo Verde with the highest apparent fishing effort are Nola West and Senghor Seamount, particularly at summit depths (Fig. 17, Table S5). As presented in Fig. 17, there is little overlap between areas with predicted presence of VME indicator taxa and areas with high fishing effort. Most likely, this result is due to the limited data on the distribution of VME indicators, available only for depths between 750 and 2100 m, and not available for the summit depth of most of the modelled seamounts (except Cadamosto). In fact, seamount fisheries mainly target commercial species between 250 and 1500 m depth (Clark, 2009). This means that seamounts with deeper summit depths, such as Cadamosto, Maio, Tavares or Sodade, might be less attractive for the fishing industry. At the same time, AIS data may underestimate fishing efforts on these seamounts, given that only large vessels are required to have these systems and IUU fishing is a common problem in West Africa, as discussed above. Furthermore, AIS data is primarily required on large vessels, and most fishing activity within Cabo Verde consists of small-scale artisanal fishing (González et al., 2020). Therefore, understanding the full impact of fishing on VMEs in Cabo Verde remains challenging without the collection of additional data.

4.2.2. Pollution

Seamount communities in Cabo Verde may also be affected by pollution from plastic debris, oil spills, persistent organic pollutants

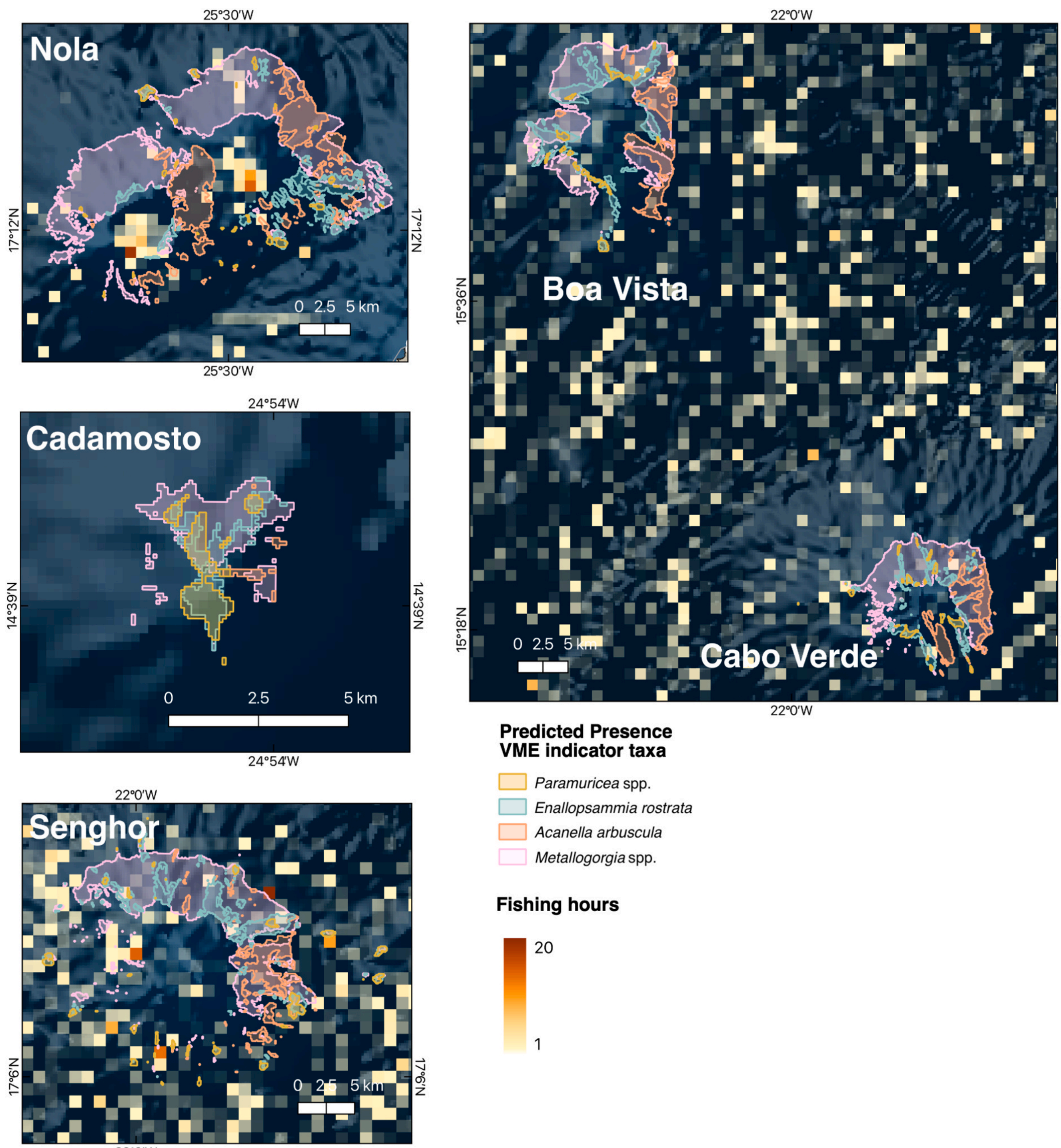

Fig. 17. Apparent fishing effort (mostly from drifting long lines but also from pole and line and tuna purse seines) based on AIS data, available on Global Fishing Watch (Global Fishing Watch, 2025) from2012 to 2022 and predicted distribution of four cold-water coral taxa (*Acanella arbuscula*, *Enallopsammia rostrata*, *Metallogorgia* spp. and *Paramuricea* spp.), that serve as indicators for VMEs from 2100 to 750 m in five seamounts of Cabo Verde (Cadamosto, Nola, Senghor, Cabo Verde and Boa Vista), modelled in Vinha et al., (2024).

(POPs), and heavy metals. Ocean currents bring plastic waste, which harms marine megafauna through ingestion and entanglement, with ghost fishing from abandoned gear posing additional risks (Sousa-Guedes et al., 2007). Microplastics have been documented throughout the water column around seamounts in the Subtropical Northwest Pacific. Smaller particles and surface roughness increased with depth due to degradation and biofouling, suggesting that seamount topography and associated communities can influence microplastic retention, degradation, and vertical transport (Guo et al., 2024). Recent studies have shown that microplastic debris in the Macaronesian region, including Cabo Verde, can act as a vector for emerging contaminants such as UV filters and pharmaceuticals, with notable concentrations of octocrylene observe on uninhabited and protected beaches, indicating long-range oceanic transport (Pacheco-Juárez et al., 2025). Oceanographic modeling also indicates that the Gulf Stream is a major pathway for surface plastics reaching Macaronesian archipelagos, and particles from the Northwestern African coast are a major land-based source of microplastics for Cabo Verde (Cardoso and Caldeira, 2021). Moreover, some plastics eventually sink, accumulating on the seabed and potentially impacting benthic communities as well, though this is less studied (Pantó et al., 2024; Figuerola et al., 2024).

Plastics can also act as vectors for the dispersion of invasive species which may also disrupt seamount communities (García-Gómez et al., 2021). Within Cabo Verde, plastic exposure risk for seabirds is globally rated as medium–low (Clark et al., 2023), although it still remains of concern, especially since research in the North Atlantic has shown seamounts ranking among submarine features with the highest litter density (Pham et al., 2014b). Within the Cabo Verde EEZ, the Gulf Stream is the main pathway through which plastics arrive (Cardoso and Caldeira, 2021) and most litter in the North Atlantic is linked to fishing activities (Pham et al., 2014b). This suggests that Cabo Verde seamounts are likely affected by marine litter, particularly those with high fishing activity and proximity to inhabited islands. For instance, at Cadamosto Seamount, the amount of plastic litter encountered was low; however, observations of lost fishing gear were noted (Vinha et al., 2025 – this issue).

Litter is also associated with marine traffic, and so seamounts below marine highways may risk more accumulation of marine plastics (Woodall et al., 2015). Although oil spills currently do not originate within Cabo Verde's EEZ, simulations aimed to model the spread of hydrocarbons accidentally spilled at offshore oil and gas sites along the coasts of Mauritania and Senegal showed oil could potentially reach Cabo Verde waters within two months, depending on seasonal currents (Merceron et al., 2024). This could have severe impacts on Cabo Verde's seamount ecosystems, affecting a wide range of pelagic fauna as well as benthic communities, such as CWCs. These slow growing corals would take years to recover, as those affected by the Deepwater Horizon oil spill (Girard and Fisher, 2018).

Although no studies have specifically examined their effects on seamount ecosystems, POPs and heavy metals introduced through industrial activities and other pathways bioaccumulate in marine organisms, posing risks to predators such as seabirds, sharks and corals (Camacho et al., 2013; Rainbow and Furness 2018). Recent research with POPs has documented a 'PFAS seamount effect,' where concentrations of per- and polyfluoroalkyl substances (PFAS) in the mesopelagic zone over seamounts were substantially elevated ($\sim$1.4 $\times$ higher) relative to surrounding basins, indicating a distinct seamount-related accumulation pattern (Hou et al., 2025). Similarly, phthalate esters (PAEs), dominated by dibutyl phthalate (DBP), di(2-ethylhexyl) phthalate (DEHP), and diisobutyl phthalate (DiBP), have been detected in seamount waters of the Tropical Western Pacific, with distributions influenced by current–seamount interactions and DEHP posing a medium ecological risk (Zhang et al., 2019).

Regarding studies on fish, unpublished baseline data from the Cabo Verde Abyssal Basin include liver and muscle metal concentrations in abyssal grenadiers (*Coryphaenoides* spp.) and cusk eels (*Ophidiiformes*). Overall, cusk eels exhibited higher mercury (Hg) concentrations in both liver and muscle tissues compared to grenadiers, while hepatic cadmium (Cd) levels were more variable and could reach relatively elevated values in some individuals. For cusk eels, there are no published data currently available for direct comparison of metal concentrations. When compared with published data for grenadiers *Coryphaenoides armatus* and *C. yaquinae* from the Clarion-Clipperton Zone (CCZ) (Anderson et al., under review), Cabo Verde grenadiers appear to have generally higher hepatic Hg and copper (Cu), while Cd concentrations broadly overlap with CCZ data but appear more variable in Cabo Verde specimens. Grenadier muscle Hg concentrations in Cabo Verde are comparable to those reported for *C. armatus* from the CCZ and similar to those in *C. yaquinae*. Relative to previously published data for North Atlantic abyssal grenadiers (e.g., Greig et al., 1976; Vas et al., 1993; Cronin et al., 1998; Oehlenschläger, 2009), Cabo Verde grenadiers show elevated hepatic Hg and Cu but broadly similar concentrations of essential metals (e.g., Zn). Muscle Hg concentrations are higher than historical Atlantic values and approach concentrations reported in Pacific abyssal grenadiers (Moran, 2012; Welty et al., 2018). Regionally, Hg inputs are influenced by atmospheric deposition, including minor contributions from Saharan dust (1–3 % of total deposition; Bailey, 2021), as well as microbial methylation and vertical transport in mesotrophic surface waters (Driscoll et al., 2012). Globally, up to 70 % of Hg deposited in the environment ultimately resides in marine ecosystems (Batrakova et al., 2014), with carrion acting as a significant vector for its transfer into deep-sea habitats (Blum et al., 2020).

In Cabo Verde, POPs have been detected in local mega vertebrates, and heavy metals (e.g. mercury and lead) have been found in the feathers of Cabo Verde shearwaters (Ramos et al., 2009). Recent studies have detected plastic and chemical exposure (POPs) in all seabird species breeding on Raso islet linked to their foraging and trophic ecology (Matos et al., 2023, 2024). Additionally, other contaminants affecting Cabo Verde's marine ecosystems have been reported, including DDT found in seabirds, likely linked to pesticide use in Sub-Saharan Africa (Roscales et al., 2010, 2011), and PCBs and PAHs detected in loggerhead sea turtles (Camacho et al., 2013). Specifically, baseline contaminant data have been reported for sea turtles in the region, with green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) showing detectable levels of organochlorine pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), with green turtles exhibiting comparatively higher total contaminant concentrations and differing contamination profiles relative to hawksbills. These differences were linked to dietary preferences and trophic position, as organic pollutants and metals can bioaccumulate according to feeding ecology and are influenced by physiological processes (Camacho et al., 2014).

4.2.3. Invasive species

One of the indirect impacts of marine traffic is the passive transportation of alien species, especially in ballast water (Bax et al., 2003). These species often disrupt ecosystems, outcompete native species, and cause biodiversity loss (Castro et al., 2024). They are particularly problematic for island and coastal ecosystems, where native species are typically not adapted to competing with or resisting invaders. In the case of Cabo Verde, there is little information available, but 18 maritime alien species have been recorded historically, a lower number than in the other regions within Macaronesia (but also a lower detection rate; Castro et al., 2022). Alien species in Cabo Verde include Bryozoa, Macroalgae, Arthropoda, Tunicata, Cnidaria, Fishes and Porifera (Monteiro, 2012; Freitas et al., 2014; Castro et al., 2022). Most of the alien species have been recorded in the largest harbour of Cabo Verde in São Vicente, but this island is also the only one with research institutions dedicated to marine sciences, which might bias our comprehension of this process (Castro et al., 2022). Rough spatial information provided in the literature indicates the potential for overlap in the distribution of alien species and seamounts (Freitas et al., 2014), but further information is required to fully understand their presence.

5. Marine conservation in Cabo Verde

5.1. Existing legislative framework for protection of marine biodiversity

Cabo Verde's legislative framework includes a hierarchy of environmental legislation and dedicated ministries and government agencies to manage wild species and ecosystems as well as fisheries. Marine spatial planning (MSP) and a National Strategy for the Sea connect conservation and sustainable use of the oceans and marine resources with the Blue Economy strategy. The Policy Charter for the Blue Economy emphasises sustainable and inclusive economic growth with a focus on key economic sectors, all of which are relevant for Cabo Verde's seamounts: fisheries and aquaculture; trade and food security; marine and coastal environment; oceans, climate change and pollution, fight against plastics in the seas; tourism and aquatic ecotourism; maritime transport and port development; MSP and enhancement of coastal areas and bays; services and scientific research; maritime security; and renewable energy (Conselho de Ministros, 2020). Cabo Verde's National Blue Economy Investment Plan (FAO, 2020) highlights the importance of natural capital including: corals, molluscs and other invertebrates, sea turtles, seabirds, cetaceans and fish – including sharks and rays (Table S6).

The competent authority for marine and coastal protection is the Ministry of Maritime Economy (Fig. S3). The Directorate General for Maritime Economy (DGEM) manages economic maritime policies, including developing and coordinating MSP with relevant entities. The Directorate General for Marine Resources (DGRM-CV) supports development of fisheries and aquaculture, and exploitation of living marine resources. The Ministry of Infrastructure, Spatial Planning and Housing and its agency National Institute for Territorial Management (INGT), implements instruments and policies for spatial planning, land use and housing and manages the spatial data infrastructure of Cabo Verde. The National Directorate of Environment (DNA) is the national environmental agency and authority for nature conservation, and is responsible for environmental impact assessments (Guerreiro et al., 2021, 2023).

There is a clear mandate and strong legal basis to develop MSP. For example, the legislation on terrestrial spatial planning includes instruments for integrated coastal zone management of special spatial nature (Table S7). As is typical in MSP processes elsewhere, a major challenge relates to the strength of some sectoral interests compared with others, which tends to hinder progress on creating an ecosystem-based approach to MSP and a more sustainable approach to the blue economy. A more cohesive and coordinated approach within and across government ministries could provide greater clarity regarding authority and responsibility for managing the blue economy (MAHOT, 2014 and references therein).

Although cross-sectoral MSP has not yet been implemented, there is a legally established network of 47 nationally designated terrestrial and marine protected areas (Table S8). This includes: 26 terrestrial and inland waters protected areas covering 25.43 % (1,035.98 km^2) of the total land area (4,073 km^2), and a comprehensive network of 21 marine protected areas (MPAs) covering 0.17 % (1,393.22 km^2) of the marine and coastal area (801,954 km^2) (see section 5.2). None of these MPAs currently include seamounts (Fig. 18) and none have management effectiveness evaluations in place (UNEP-WCMC, 2024). There are also four Ramsar sites, one of which (Salinas de Porto Inglês, Ilha de Maio) extends into the marine environment (Table S9). Fogo, Brava and São Vicente currently have no marine and coastal protected areas. There is ongoing work to improve MPA management in Cabo Verde. For example Fauna and Flora International is supporting two initiatives: a network of five marine protected areas around Maio (Fauna and Flora, 2025); and a project aiming to bring 1,118.49 km^2 across 10 sites under new or more robust protected area management which aims to assist Cabo Verde in advancing toward its global obligations and domestic goals regarding ocean protection, reducing poverty, and building climate resilience, while establishing an example that other island countries can follow (Fauna and Flora, 2024). There are also efforts to update and strengthen MPA management plans through cooperative management initiatives (Projeto Biodiversidade, 2024).

The archipelago also has 33 designated Key Biodiversity Areas (KBA) including the following which have marine or coastal areas (https://www.keybiodiversityareas.org/sites/search): Ilhéu Branco; Ilhéu Raso; Ilhéu de Curral Velho and adjacent coastal area; Ilhéus do Rombo; Beaches of Boa Vista; Santa Luzia Island; Raso / São Nicolau – marine; Volcano area, Ilha do Fogo – marine; Beaches of São Nicolau Island; Ilhéu de Curral Velho – marine; Costa de Fragata (Key Biodiversity Areas Partnership, 2024).

Cabo Verde's latest National Biodiversity Strategic Assessment Plan (NBSAP) 2014–2030 outlines a set of measurable goals aligned with Aichi Targets of the 2020 Convention on Biological Diversity, including marine-related National Targets and Priorities, although progress on achieving these ambitions is slow (MAHOT, 2014; CBD Sixth National Report, 2020) (Table 2). For example, National Priority 4, the 'conservation of priority habitats and sustainable management of marine resources', aims to involve various stakeholders including protected areas management entities, government agencies (e.g. environment, tourism), NGOs and communities, universities and research institutes, international partners, and private sector, to improve the efficiency of protected area management; identify and designate new protected areas; promote inclusion and valuation of protected areas in the context of national development; develop and implement on site conservation programs for main endangered species; develop and implement monitoring programs for priority habitats; and develop and implement national conservation and monitoring plans for threatened species or groups of species, among others (MAHOT, 2014). However, there are significant challenges in tracking the implementation, monitoring and effectiveness of the NBSAP National Targets and actions due to a lack of processes, coordination and organisation, as well as limited human and financial resources in place and dispersion of information on biodiversity. Furthermore, no monitoring systems are in place to check progress on any of the National Targets (CBD Sixth National Report, 2020) (Table 2).

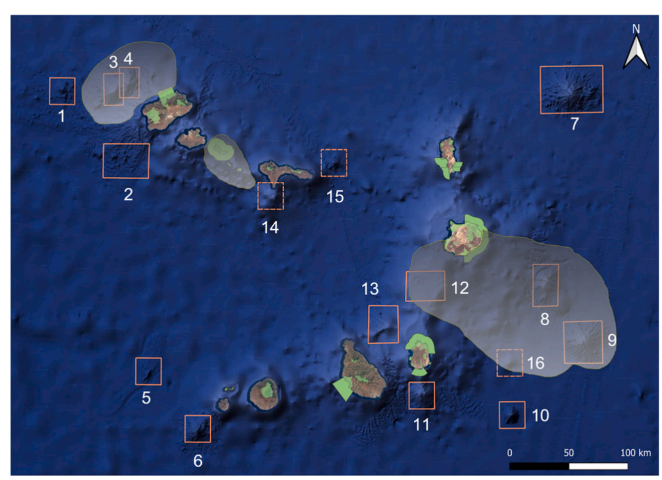

Fig. 18. Zoomed-in view of the Cabo Verde archipelago, highlighting existing protected areas in light green (see detailed information in Table S8, and S9), and the locations of seamounts represented by squares (numbers correspond to Fig. 1). Ecologically or Biologically Significant Marine Areas (EBSAs) are highlighted in grey (see Section 5.3). Notably, none of the seamounts are currently protected. (of Protected Areas' shapefile: Cabo Verde Spatial Data Infrastructure (IDE-CV) (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article. (Source: https://idecv.gov.cv).

Table 2
Selected National Biodiversity Strategic Assessment Plan (NBSAP) National Targets and progress, based on an assessment conducted in 2020 (CBD Sixth National Report, 2020).

National Target	Assessment of progress (score 1–5, where 5 = target achieved)	Indicators used in assessment
By 2015, Cabo Verde will have adopted the NBSAP as a policy instrument and will have commenced implementing it with the broad participation of all key sectors of society.	No clear evaluation (Unknown)	– Approval of NBSAP by the Council of Ministers – Implementation of NBSAP in progress – Inclusion and participation of all partners in the implementation of the NBSAP – % of State budget allocated to NBSAP
By 2018, thus, all approved national conservation strategies and plans will integrate elements of resilience and adaptation to climate change.	No clear evaluation (Unknown)	– Number of Plans that integrate elements of resilience to climate change – 50 % incidence of clean energy use at national level – Number of protected areas identified as being more susceptible to the effects of climate change with mitigation/adaptation projects implemented
By 2020, marine resources of economic interest will be managed sustainably	Progress made towards the target, but too slow (3)	– At least 4 sensitive marine ecosystems monitored (1 AMP in Sal; 1 AMP in Maio; 1 AMP in Boa Vista; AMP Santa Luzia) – At least 6 identified underexploited populations and/or species (large pelagic/small pelagic/lobster/whelk) – 5 destructive practices in fisheries eliminated (explosives; bottle; fining; trawling; catch in closed season) – 4 operational AMP (Santa Luzia/Sal/Boa Vista/Maio) – 8 fishery resources with appropriate management measures (tuna, pink lobster, mackerel, horse mackerel, bent, shark, demersal, whelk)
By 2025, Cabo Verde will have strengthened protection, improved connectivity and recovered key ecosystems so that they will continue to provide essential services to the economy and the welfare of the population.	No clear evaluation (Unknown)	– Number of projects and programs developed in protected areas through participatory management – N° of investment projects evaluated based on pre-defined socio-environmental criteria
By 2025, the ecological, economic and social values of biodiversity will have been integrated into national and local strategies and planning, and poverty reduction processes, and duly incorporated in national accounts.	No notable changes (2)	– Economic assessment of biodiversity in priority ecosystems – Integration of biodiversity values into National Plans and Strategies
By 2025, the government, businesses and civil society will have implemented plans and measures to ensure the sustainable production and consumption, while maintaining the impacts of use of natural resources well within safe ecological limits.	Progress made towards the target, but too slow (3)	– Creation of a legal framework for Strategic Environmental Assessment – SEA – Implementation of SEA at all levels of biodiversity planning – Number of companies with a quality management system and/or environment implemented – Number of plans/strategies submitted to Strategic Environmental Assessment (PDM/PDU/ZDTI) – 50 % national renewable energy penetration – Fisheries/Protected Areas Management Plans Strategically evaluated
By 2025, at least 5 % of coastal and marine areas, especially those of ecological relevance and importance will be conserved through a coherent system of PAs and managed effectively and equitably through the implementation of Special Plans for Management of Protected Areas (SPMPA)	Progress made towards the target, but too slow (3)	– 20 Priority protected areas (marine and terrestrial) with effective management – 80,660 ha of terrestrial protected areas and 1.6 ha of marine protected areas of the country – At least 65 % implementation of the annual plan of the Entity Responsible for the Management of Protected Areas
By 2025, endangered and priority marine species will be conserved and enhanced	Progress made towards the target, but too slow (3)	– Update/New red list of endangered species elaborated – 7 conservation and monitoring plans for priority threatened species (marine 5 (shark, coral, turtle, whale, seabird) and terrestrial 2 (tchota-cana, red heron, reptile) implemented – At least # of invasive species with control program implemented – 2 Pilot projects of sustainable valorisation of the marine or terrestrial biodiversity of Cabo Verde (observation diving, traditional culture of cure) implemented – At least 25 % diversity of endemic species conserved in the ecosystems of origin (most are inserted in the PA) – At least 3 terrestrial endemic species scientifically proven of their healing properties (used in traditional medicine)
By 2025, scientific and empirical knowledge will contribute to the conservation of biodiversity in Cabo Verde.	No clear evaluation (Unknown)	– At least 5 biodiversity research programs implemented – At least 10 studies on species/ecosystems conducted – 1 species database held and updated periodically – At least 2 published red lists – No. of continuous inventories of species used in the implementation of the CBD – At least 5 habitats restored – At least 2 publications on empirical knowledge
By 2025, Cabo Verde will have mobilized 70 % of the financial resources necessary for implementation of the strategy.	No clear evaluation (Unknown)	– % of MAA's annual budget dedicated to the implementation of the Strategy – % of resources mobilized – % of private sector involved in the implementation of the Strategy

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Table 2 (*continued*)

National Target	Assessment of progress (score 1–5, where 5 = target achieved)	Indicators used in assessment
		– % of multilateral cooperation budget involved in the implementation of the Strategy – % of bilateral cooperation budget involved in implementing the Strategy
By 2030, society at large will be aware of the importance and values of Biodiversity and the measures required for its conservation and sustainable use.	On track to achieve the target (4)	– 60 % of sectors (media, NGO, private) trained in biodiversity conservation – Number and quality of education programs and/or materials implemented – Number of people (individuals and groups) participating in biodiversity conservation activities

5.2. *Protection figures, compliance and enforcement*

Cabo Verde has sovereign rights within its EEZ for the purpose of exploring and exploiting, conserving and managing its natural resources, whether living or non-living (ProtectedSeas Navigator, 2024). The level of fishing protection, as assessed by ProtectedSeas Navigator (2024), is 'Least restrictive'. That is, there are no known restrictions on marine life removal beyond national or subnational generally applicable restrictions. Nevertheless, the Policy on Sustainable Exploitation of Fisheries Resources applies fishing restrictions, such as bag limits, seasons, and size restrictions.

In addition, comprehensive measures and prohibitions established under the Fishing Resources Management Plan for 2020–2024 aim to ensure sustainable fisheries management. General measures include the application of the precautionary principle or reinforced control to combat IUU fishing, as well as restrictions on fishing licenses for bottom crustaceans. A series of prohibited practices aims to protect marine ecosystems and promote conservation, including bans on bottom trawling and harmful methods such as explosives, poisons, and electric currents within Cabo Verde's EEZ.

The following is expressly prohibited:

– The capture, possession, simple detention or acquisition, landing, marketing and consumption of sea turtles.

– The hunting and capture of marine mammals in maritime space under national jurisdiction, without any reservation of time or place.

– The use or processing of marine mammals by any facility located in national territory.

– The use in fishing activities of explosive materials or toxic substances likely to weaken, stun, excite or kill species or pollute the marine environment.

The current legislative framework for biodiversity conservation focuses on defence and preservation of the environment; however, its provisions emphasise supervision rather than regulation of activities. Environmental law is organized under a national system with two central authorities the Ministry of Agriculture and Environment in Praia, and the Ministry of the Sea in Mindelo, supported by delegations across all municipalities and islands. However, the system remains weakened by centralization, as legislative power and key decisions are concentrated on the main islands of Santiago (MAHOT, 2014 and references therein; Guerreiro et al., 2021, 2023). A structural weakness in this system is reflected in sectoral policies such as the approval of Decreto Regulamentar n° 2/2021, which authorises commercial dive fishing. The measure runs counter to two decades of awareness-raising and conservation work by government bodies and NGOs, undermines efforts to ensure the sustainability of fisheries resources, and creates direct competition with artisanal fishers. Such inconsistencies raise doubts about the government's commitment to effectively preserving the country's marine biodiversity.

Compliance with biodiversity legislation is very low among local fishers, industrial fishers and tourism companies, partly due to the inadequacy of laws regarding the populations' socio-economic and educational challenges. For instance, limited awareness among local fishers of the current regulations, such as minimum capture sizes or protected species, combined with a weak political system and inadequate oversight, undermines protection of integral reserves such as Rombo and Raso islets (MAHOT, 2014 and references therein). It is suggested that the current environmental legislation framework needs to be more holistically coordinated and integrated to be more effective, since the current arrangement is deemed to hinder a strategic vision for biodiversity management and conservation.

Some challenges arise due to conflicting interests between Ministries, the absence of management and monitoring plans for most protected areas, and the failure to compile and analyse data collected by local NGOs and other international entities, all of which hinder continuous updates on biodiversity status. To illustrate, the Government's national reports on biodiversity (e.g., Cabo Verde, 2018) provide

Table 3
Examples of local conservation initiatives in place in several islands of the Cabo Verde archipelago. The island/s where the initiative takes place is indicated as well as the conservation initiative and the entity promoting and leading the initiative.

Main initiatives of marine conservation in Cabo Verde	Entities leading the initiative and location
Long-term monitoring of nesting sea turtle populations, supported by several international partners.	Cabo Verde Natura 2000 (Boa Vista) BiosCV (Boa Vista) Fundação Tartaruga (Boa Vista) Fundação Maio Biodiversidade (Maio) Associação Projeto Biodiversidade (Sal) Biosfera I (Santa Luzia, Branco and São Vicente) Projecto Vitó (Rombo and Fogo) Associação Varandinha da Povoação Velha (Boa Vista) Associação Fauna e Flora de São Francisco (Santiago) Terrimar (Santo Antão) Lantuna (Santiago) Associação Ambiental Caretta caretta (Santiago) National Directorate of Environment (National)
Educational campaigns and community outreach to promote conservation awareness; beach-cleaning campaigns; training and engagement of local communities, small restaurant owners, fishers, fishmongers and decision-makers on sustainable artisanal fisheries. Surveillance in coordination with local authorities (national police, fisheries inspectors, and environmental agencies).	Biosfera I (São Vicente, Santo Antao and São Nicolau) Fundação Maio Biodiversidade (Maio) Projecto Vitó (Rombo, Fogo and Brava) Associação Projeto Biodiversidade (Sal) BiosCV (Boa Vista) Fundação Tartaruga (Boa Vista) Cabo Verde Natura 2000 (Boa Vista) Lantuna (Santiago) Terrimar (Santo Antão)
Guardians of the Sea (GoS) and other programs in collaboration with artisanal fishers to collect data on megafauna sightings, fishing effort and landing data which can be used to support marine spatial planning. For example, sightings of loggerhead turtles in Sal have informed the creation of the POOCM-Sal (Plano de Ordenação da Orla Costeira e Marinha do Sal). It also includes coastal surveillance and collecting illegal activities. In some cases, following real-time reports, drones have been deployed to record infractions and provide evidence to the authorities.	Fundação Maio Biodiversidade (Maio) Associação Projeto Biodiversidade (Sal) Projecto Vitó (Fogo and Brava) Biosfera I (São Vicente and Desertas) BiosCV (Boa Vista) Lantuna (Santiago) Terrimar (Santo Antão)
Research on sharks and rays in Cabo Verde using BRUV surveys, tracking, and fisher collaboration with international partners to assess populations, map species distributions, identify critical nursery areas and IUCN ISRAs.	Fundação Maio Biodiversidade (Maio) Biosfera I (São Vicente and Desertas) Associação Sphyrna (Boa Vista) Associação Projeto Biodiversidade (Sal) Projecto Vitó (Fogo, Brava, Rombo) BiosCV (Boa Vista) Lantuna (Santiago) Mar Alliance (several islands) Terrimar (Santo Antão)
Long-term monitoring, demographic studies, and seabird tracking are carried out in collaboration with the Seabird Ecology Lab at the Universitat de Barcelona and the Universidade de Coimbra. These tracking data have recently been used to identify marine KBAs and to support a proposal for the protection of waters between and around Fogo, Brava, and the Rombos.	Projecto Vitó (Rombos and Brava) Biosfera I (Desertas, São Vicente and Santo Antão) BiosCV (Boa Vista) Associação Projeto Biodiversidade (Sal) Lantuna (Santiago)

(*continued on next page*)

Table 3 (*continued*)

Main initiatives of marine conservation in Cabo Verde	Entities leading the initiative and location
Long-term monitoring, demographic studies, and tracking of Cape Verde petrels (*Pterodroma feae*) are carried out in collaboration with the Seabird Ecology Lab at the Universitat de Barcelona. Recent tracking data have been used to prepare a proposal to protect the waters between and around Fogo, Brava, and the Rombos, as well as to identify marine Key Biodiversity Areas (KBAs). Recently published demographic data have contributed to the re-evaluation of the species' conservation status.	Projecto Vitó (Fogo, Santo Antão and São Nicolau) Lantuna (Santiago) Parque Natural de Monte Gordo (São Nicolau) Parque Natural de Serra Malagueta (Santiago)
Collaboration with local partners, including Biosfera I, Projeto Vitó, Associação Projeto Biodiversidade, BiosCV and Lantuna, to support sustainable fisheries (including bycatch mitigation) and identify KBAs for seabirds. Biosfera I is its official partner in Cabo Verde.	BirdLife International (several islands)
Collaboration with local partners, including Fundação Maio Biodiversidade, Associação Projeto Biodiversidade, Biosfera I, Terrimar, Projeto Vitó and Biflores, to advance marine conservation, strengthening marine protected areas and promoting sustainable fishing.	Fauna & Flora International (several islands)
A proposal to protect the waters between and around Fogo, Brava, and the Rombos, including the Cadamosto Seamounts, has recently been developed and presented to the Cabo Verde Government.	Projecto Vitó (Fogo, Brava and Rombo)
A proposal for a new MPA in the east of Sal to protect the lemon shark nursery of Parda Reef, and surrounding area, have been submitted with the support of the Association of Workers of Shark Bay and the National Directorate of Environment.	Associação Projeto Biodiversidade (Sal)
A proposal for the creation of an ecological corridor of approximately 90,000 square kilometers was prepared and delivered to the Government of Cabo Verde, with the aim of protecting an essential area for the passage of megafauna and some seamounts, with the support of Fundação Oceano Azul	Biosfera I (Cabo Verde EEZ)
Long-term monitoring, demographic studies, and tracking of Cape Verde petrels (*Pterodroma feae*) are carried out in collaboration with the Seabird Ecology Lab at the Universitat de Barcelona. Recent tracking data have been used to prepare a proposal to protect the waters between and around Fogo, Brava, and the Rombos, as well as to identify marine Key Biodiversity Areas (KBAs). Recently published demographic data have contributed to the re-evaluation of the species' conservation status.	Projecto Vitó (Fogo, Santo Antão, São Nicolau) Lantuna (Santiago) Parque Natural de Monte Gordo (São Nicolau) Parque Natural de Serra Malagueta

current information on lists of species, endemic status, and global conservation status according to the IUCN Red List, but information on the national species status is lacking (e.g., abundance, distribution, general trends).

The government is responsible for ensuring conservation is maintained through regular surveillance and law enforcement and it has recently invested in some public institutions such as IMAR and INIDA. However, it is the local environmental NGOs and international projects, mainly funded by international agencies, which conduct regular fieldwork and collect most biodiversity data across the archipelago. These data are often deficient due to a lack of government resources. Recent local partner initiatives including local authorities and NGOs (Table 3) have aimed to address gaps in government staffing and resources in different islands of the archipelago, and such collaborations, together with the data collected from the NGOs, have already produced important results (e.g. updated monitoring plans using more recent biodiversity data, increased marine surveillance) (Table 3).

In 2014, the Ministry of the Environment, Habitat and Spatial Planning created Protected Areas Advisory Councils (Conselho Assessor das Áreas Protegidas) for the islands of Boa Vista, Fogo, Sal, Santo Antão and São Vicente with the aim of facilitating management, through population participation and cooperation of the various administrative bodies (República de Cabo Verde, 2014). In Boa Vista, Fogo and Maio, collaborative law enforcement initiatives have been implemented to address challenges posed by limited human resources. These efforts involve joint task forces composed of local authorities—such as the National Police, Fisheries Inspectors, and City Council representatives—working in partnership with stakeholders, including NGOs. Furthermore, co-management initiatives that actively engage fishing communities in monitoring of marine biodiversity and illegal activities have been successfully replicated across several islands within the archipelago (Associação Projeto Biodiversidade, unpublished data).

5.3. International treaties and implications for Cabo Verde

Cabo Verde has signed and/or ratified several international agreements, including the Convention on Biological Diversity (CBD), the Convention on Wetlands (Ramsar), the Convention on Migratory Species (CMS), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the International Commission for the Conservation of Atlantic Tunas (ICCAT), and the Biodiversity Beyond National Jurisdiction (BBNJ) treaty. This demonstrates Cabo Verde's interests and commitment to sustainability. In addition, Cabo Verde's national "Ambição 2030 – Agenda Estratégica de Desenvolvimento Sustentável de Cabo Verde, 2021" and national plans such as the National Strategy and Action Plan for Biodiversity Conservation 2015–2030 (MAHOT, 2014), aim to promote and achieve the Sustainable Development Goals (SDG), as well as other specific goals related to conservation, biodiversity and sustainability. To reach some of those goals, Cabo Verde has created its national network of Protected Areas (DNA, 2020), identified and created Ramsar sites (Ramsar – The Convention of Wetlands, 2005), and has implemented two UNESCO Biosphere Reserves (RFI, 2020). Under CBD, Cabo Verde also has three designated Ecologically and Biologically Significant Areas (EBSAs) which encompass Boa Vista, Cabo Verde, and Nola seamounts (Convention on Biological Diversity - UNEP/CBD/COP/DEC/XII/22, 2014) (Fig. 18).

Cabo Verde and the European Commission launched the Mindelo Arrangement in 2018 to encourage cooperation for a coordinated and partnership-based approach based on mutual benefit in key common areas of interest in marine research (All-Atlantic Ocean Research and Innovation Alliance, 2018). The archipelago also belongs to the group of Small Island Developing States (SIDS) (Banque Africaine de Développement, 2014). Like many SIDS, it has a limited domestic market, few resources for export (primarily fish), and minimal agricultural and mineral production, all of which add to the country's vulnerability (Dancette, 2019). Consequently, Cabo Verde depends strongly on global and regional conditions, including factors like import dynamics and transportation costs (United Nations, 2010) and the environment (Allison et al., 2009; Barnett and Campbell, 2010; Lee et al., 2014; Dancette, 2019). Fish—primarily yellowfin, bigeye (*Thunnus obesus*), and skipjack tuna, along with swordfish and blue shark—-make up 85 % of the country's exports (Dancette, 2019).

Cabo Verde's fishing sector is dominated by small-scale artisanal vessels, with no operational distant-water fleet, making it attractive to international fleets (Carneiro, 2011; Pauly et al., 2020; Fig. 15c). The country has maintained fishing agreements with the EU (since 1990) and with countries such as Japan and Senegal, yet challenges persist, including the lack of onboard observer programmes or electronic monitoring systems to oversee fishing activity, insufficient transparency, overfishing, and inadequate compensation (Aquino, 2023). For instance, fleets from the EU and China often exceed allowable catch limits, with actual catches reported to be significantly higher than official figures (Belhabib et al., 2015; Dancette, 2019). The latest EU agreement (2024–2029) allows 56 vessels to harvest 7,000 tonnes of tuna annually for €430,000, equating to just € 0.06 per kilogram; a significantly lower rate than previous agreements (European Commission, 2024). Increased competition from foreign vessels has also pressured semi-industrial boats from larger islands to fish within the 3-mile zones of smaller islands, intensifying strain on local resources (Fig. 15c, 16, 17; Cesarini, 2013; Dancette, 2019). These pressures have further deteriorated the livelihoods of small-scale fishing communities (Carneiro, 2011), which frequently regard competition from industrial fleets as inequitable. Combined with IUU fishing, these practices pose a significant threat to marine biodiversity, local artisanal fisheries, and Cabo Verde's progress toward sustainable fishing and biodiversity conservation goals.

In February 2023, Cabo Verde was approved as a candidate for the Fisheries Transparency Initiative (FiTI) in an attempt to show transparency in fisheries management. Their first report (FiTI, 2024) summarises and pinpoints publicly available information, as well as information not available or lacking that requires improvement. For example, there are no recent studies on the state of biodiversity and a lack of information on the status of species stocks by IMar (Instituto do Mar) and ICCAT (International Commission for Conservation of Atlantic Tuna) for most exploited species. It is also unclear from the report which foreign fleets are fishing in Cabo Verde.

The NBSAP (National Biodiversity Strategic Assessment Plan) is the main tool for the implementation of CBD in Cabo Verde (CBD Sixth National Report, 2020, page 63). With the challenges and limitations seen in implementing the NBSAP (e.g. see Section 5.1), it is important for the country to assess and reconsider this implementation tool and find alternative ways to increase the effectiveness of the action plans highlighted above. This would set the scene and help equip the country to engage with other treaties such as the newly adopted Biodiversity Beyond National Jurisdiction (BBNJ) treaty (3 A/CONF.232/2023/4). Provisions from the Capacity Building and Technology Transfer (CBTT) (Part V) of the BBNJ already exist in the CBD treaty. Cabo Verde became a signatory party to the agreement on September 20, 2023 (High Seas Alliance, 2023), and the government has expressed their plans in ratifying the treaty.

Ratifying the BBNJ treaty would likely strengthen Cabo Verde's capacity to ensure adequate resources for seamount monitoring, including both human resources and financial assets. There are synergies between CBTT and areas within and beyond national jurisdiction. For example, the provisions of CBTT may contribute to closing capacity and technology gaps, access to genetic samples and data, technology for the development of marine genetic resources, vessels, long term funding, and support long term capacity (Leal et al., 2012; Harden-Davies, 2017; Dunn et al., 2018; Minas, 2018; Rabone et al., 2019; Vierros and Harden Davies, 2020). The CBTT provisions could also assist with "introducing new policy measures to ensure that scientific and technological capacity building is planned and delivered to meet nationally determined needs" (Vierros and Harden Davies, 2020). Lastly, SIDS such as Cabo Verde have the potential to benefit from the BBNJ treaty as its effective implementation may support blue economy growth, preserve national ocean resources, and mitigate climate change (Berry, 2024).

6. Discussion

This review summarises the known multidisciplinary research conducted to date on Cabo Verde seamounts, but equally underlines the many knowledge gaps that still need to be filled. Most of the seamounts have not yet been scientifically explored. However, the data reviewed highlight the uniqueness of the Cabo Verde seamount complex and demonstrate their crucial role as biodiversity hotspots.

6.1. Importance of Cabo Verde seamounts for biodiversity and ecosystem services

Based on the current evidence gathered in this review, it is clear that the Cabo Verde seamounts are of high intrinsic and extrinsic value. The term "intrinsic value" is commonly associated with specific species or ecosystems, referring to their "value that exists independently of human valuations" (Dietz et al., 2005, p.340). According to Chan (2008), conservation efforts themselves demonstrate biodiversity's inherent worth as a "protected value" – one that should not be compromised for instrumental benefits like human welfare or rights. Whereas the definition of ecosystem services mainly focuses on direct benefits for human beings, it is important to also consider the intrinsic value of ecosystems to move away from the traditional anthropocentric point of view (i.e. IPBES, 2022; Steyn, 2024; Himes et al., 2024; Perillo et al., 2024).

In terms of "extrinsic value", Cabo Verde seamounts provide a wide range of ecosystem services. Typically defined as "the benefits people obtain from ecosystems", ecosystem services include provisioning, regulating, supporting and cultural services (MEA Millennium Ecosystem Assessment Board, 2005). Regarding provisioning services, it is clear that the fisheries provided and supported by the Cabo Verde seamounts are important for local communities targeting species such as groupers, snappers, and tuna (Monteiro et al., 2008), which tend to aggregate around seamounts (Holland and Grubbs, 2007; Watson et al., 2007; Morato et al., 2010; Aguzzi et al., 2022). The benthic communities found on the seamounts of Cabo Verde have the potential to significantly contribute to provisioning and supporting services provided by the ocean, thereby supporting biodiversity and fisheries. Although they remain largely understudied, these communities dominated by CWCs, such as black corals and octocoral species, are known to act as ecosystem engineers, fostering the productivity and resilience of marine ecosystems (González, 2018; Amaro et al., 2025 – this issue; Vinha et al., 2025 – this issue; Ornelas et al., unpublished results). Additionally, a wide range of other marine animal forests, composed of suspension-feeding organisms such as sponges, gorgonians, stony corals, bryozoans, and bivalves also provide essential supporting services (Rossi et al., 2017; Ornelas et al. unpublished results). These assemblages provide habitat for diverse marine species, support nutrient cycling near the sea floor, contribute to carbon sequestration, and generate economic value through fisheries and tourism support (Paoli et al., 2017; Rossi et al., 2017). Their ecological importance underscores the need for sustainable management of seamount resources (Clark et al., 2012).

The localized ocean mixing and the upwelling induced by the seamounts brings nutrients to the surface and fosters primary production in nutrient-poor waters, thereby providing a series of regulating services (Oliveira et al., 2016; Demarcq et al., 2020). These processes not only support marine biodiversity but also contribute to global climate regulation through carbon sequestration, as the biological activity around seamounts facilitates the storage of carbon in sediments and marine organism skeletons (Silva et al., 2021; Hilmi et al., 2023).

Beside provisioning, fishing resources obtained from the seamounts of Cabo Verde also provide significant cultural services, supporting employment opportunities for fishers and women fish peddlers ("vendedeiras"), while also serving as a vital element of Cabo Verde's gastronomic and cultural heritage (González et al., 2024). Furthermore, these resources are integral to local traditions and community gatherings, where fishing practices and seafood dishes are celebrated, reinforcing social bonds and cultural identity among the island's inhabitants. For example, the annual "Festa de São Pedro," a festival dedicated to the patron saint of fishers, showcases traditional fishing techniques, local seafood dishes, and vibrant cultural performances, highlighting the deep connection between the community and its marine resources.

6.2. Projected increases in anthropogenic impacts

6.2.1. Population growth

The latest UN World Population Prospects predict a 12.5 % population increase in Cabo Verde by 2100, while most West African countries are expected to see a population rise of over 100 % (United Nations Department of Economic and Social Affairs, n.d.). This growth will significantly increase human pressures on the region's marine ecosystems, as many of these countries rely heavily on marine resources. Some potential effects will include increased overfishing, IUU fishing, shipping and marine traffic, unsustainable resource use, pollution, conflicts over resources and vulnerability to climate change impacts.

With more mouths to feed, it is inevitable that fishing activities will increase, under a continuous drive to unlock new stocks. For example, while bottom trawling is currently of little significance in the Cabo Verde EEZ (Figs. 14 and S2), technological advances and the continued exploitation of fishing resources could steadily increase the maximum trawling depth around the globe (Clarke et al., 2015; Victorero et al., 2018). As such, there is potential for this fishery to expand into Cabo Verde waters. Studies indicate that biodiversity increases with increasing water depth, but so does the ratio of discarded to commercial biomass in trawl fisheries, as well as the proportion of elasmobranchs (sharks and rays) within the catch, while commercial value declines. These findings have prompted legislative bodies, such as the EU, to consider imposing depth limits on bottom trawling (Clarke et al., 2015). While bottom trawling is banned in Cabo Verde, there are no depth-related regulations in place to address potential future challenges if the ban were to be lifted.

The predicted population growth will be accompanied by a rapid rate of urbanization, much of it occurring near coastlines (Jambeck et al., 2015). Similar to other regions, Africa's population is transitioning from traditional markets to supermarkets, leading to increased consumption of plastic goods and products packaged in plastic. While these changes reflect infrastructure modernization and improved living standards, they must be accompanied by the modernization of waste management facilities to avoid excessive impacts on the marine environment (Sousa-Guedes et al., 2024). Although benthic surveys over Cadamosto Seamount only registered a low abundance of litter items at present (Vinha et al., 2025 – this issue), under a growing population, increasing marine traffic and increasing fishing pressure, without adequate conservation or management measures, there is a high risk that also the amount of marine litter on Cabo Verde's seamounts will increase.

6.2.2. Marine traffic

In terms of global marine traffic, vessel movements are projected to be 240 % to 1,209 % higher in 2050 than in 2014 (Sardain et al., 2019). African countries are expected to experience more moderate increases compared to other regions, but even moderate growth in maritime traffic could exacerbate issues related to anthropogenic pollution and invasive species, with particularly significant impacts on insular regions. Future projections of shipping activities around Cabo Verde itself have provided varying predictions, depending on the ship type and future climate scenario. Within the Cabo Verde EEZ, shipping is predicted to increase under the SSP1 and SSP2 scenarios (Kramel et al., 2024). Besides the additional pollution risks, these future changes in shipping are expected to drive new biological invasions in West Africa, particularly from Northeast Asia (Sardain et al., 2019).

6.2.3. Tourism

The growth of tourism on islands like Santo Antão and São Vicente highlights the increasing appeal of Cabo Verde as a destination for both adventure and marine tourism. While these activities have the potential to provide significant economic benefits, they also raise concerns about their sustainability in relation to the seamount ecosystems. Increased activity such as diving, game fishing, and cruises could disturb fragile habitats and deplete marine resources. The increase in tourism has driven a growing demand for hotel construction, with many of these developments situated along beaches, leading to the destruction of coastal ecosystems and the degradation of vital habitats for marine and terrestrial species. To mitigate these risks, further research is needed to assess the economic significance and ecological impact of both seamount and terrestrial tourism in Cabo Verde. Sustainable practices, stricter regulations, and comprehensive monitoring are essential to ensure that tourism development aligns with the conservation of the archipelago's unique natural and cultural heritage. Collaboration between tour operators, government agencies, and environmental organizations will be crucial in balancing economic growth with the preservation of Cabo Verde's exceptional landscapes and ecosystems.

6.2.4. Aquaculture

To date, few aquaculture developments exist in Cabo Verde. However, due to its strategic geographic location and infrastructure for seafood processing, new initiatives are currently being developed. In São Vicente, a 50-year land concession including 180 km^2 of ocean was given to the Norwegian company Nortuna Holding CV in 2021 for tuna aquaculture (Noturna, 2024). If this first phase of the project is successful, future expansion is expected. Another initiative funded by PROBLUE and the World Bank, includes a mapping of offshore and onshore area suitability for aquaculture in Cabo Verde published in 2023 (Mapping Cabo Verde aquaculture suitability zones, 2023).These maps suggest that most of the offshore areas that are suitable and highly suitable for aquaculture lie around and between Boa Vista and Maio islands as well as around the group of islands from São Vicente to Raso islet, notably including the areas above the Tchadona and Joao Valente Banks and Maio Rise seamounts.

6.2.5. Mining

Submarine ferromanganese (Fe-Mn) crusts occur globally throughout the oceans, including on seamounts, ridges and marine plateaus (e.g., Hein et al., 2013; Hein and Koschinsky 2014). Such Fe-Mn crusts have comparatively high concentrations of base metals, and strategic and critical elements such as cobalt (Co), vanadium (V), nickel (Ni), titanium (Ti), platinum group elements (PGEs) or rare earth elements (REEs) plus yttrium (REY), and may be considered for future seabed mining efforts (González et al., 2012; Hein et al., 2013). Seabed mining for these rare-earth metals poses a significant threat to communities on seamounts, as it can produce sediment plumes and toxic waste, further degrading these fragile ecosystems (Rogers, 2018b; Washburn et al., 2023). From the subtropical East Atlantic, extensive ferromanganese crusts are described from seamounts in the Canary Island Seamount Province (Marino et al., 2017). However, within the Cabo Verde archipelago, ferromanganese crusts of several centimetres in thickness have only been found locally on the Senghor and Maio Seamounts (Christiansen et al., 2011; Hansteen et al., 2014). These are presumably among the oldest seamounts in the area, as exemplified by one magmatic crystallization age of about 14.9 Ma at Senghor (Kwasnitschka et al., 2024). The younger seamounts occurring towards the west in the area have been extensively sampled by rock dredging and direct sampling by underwater remotely operated vehicles, and samples typically comprise only a thin veneer of ferromanganese crust, if at all (Hansteen et al., 2014). On the Cabo Verde Seamount (n° 9, see Fig. 1) cobalt-rich ferromanganese crusts have been identified, containing minerals essential for batteries (Wang et al., 2011).Thus, although the incentive for seabed mining at the Cabo Verde seamounts appears to be small for the foreseeable future, still they could represent a potential future economic interest.

6.2.6. Renewable energies

Regarding renewable energies, a pre-feasibility study on the electrical interconnection of the Cabo Verde Islands is currently being carried out by the energy data provider TGS in partnership with RTE International and Consultores de Engenharia e Ambiente S.A. (COBA), aiming to increase renewable energy production in Cabo Verde. This falls under Cabo Verde's Energy Master Plan (2018–2040) which aims

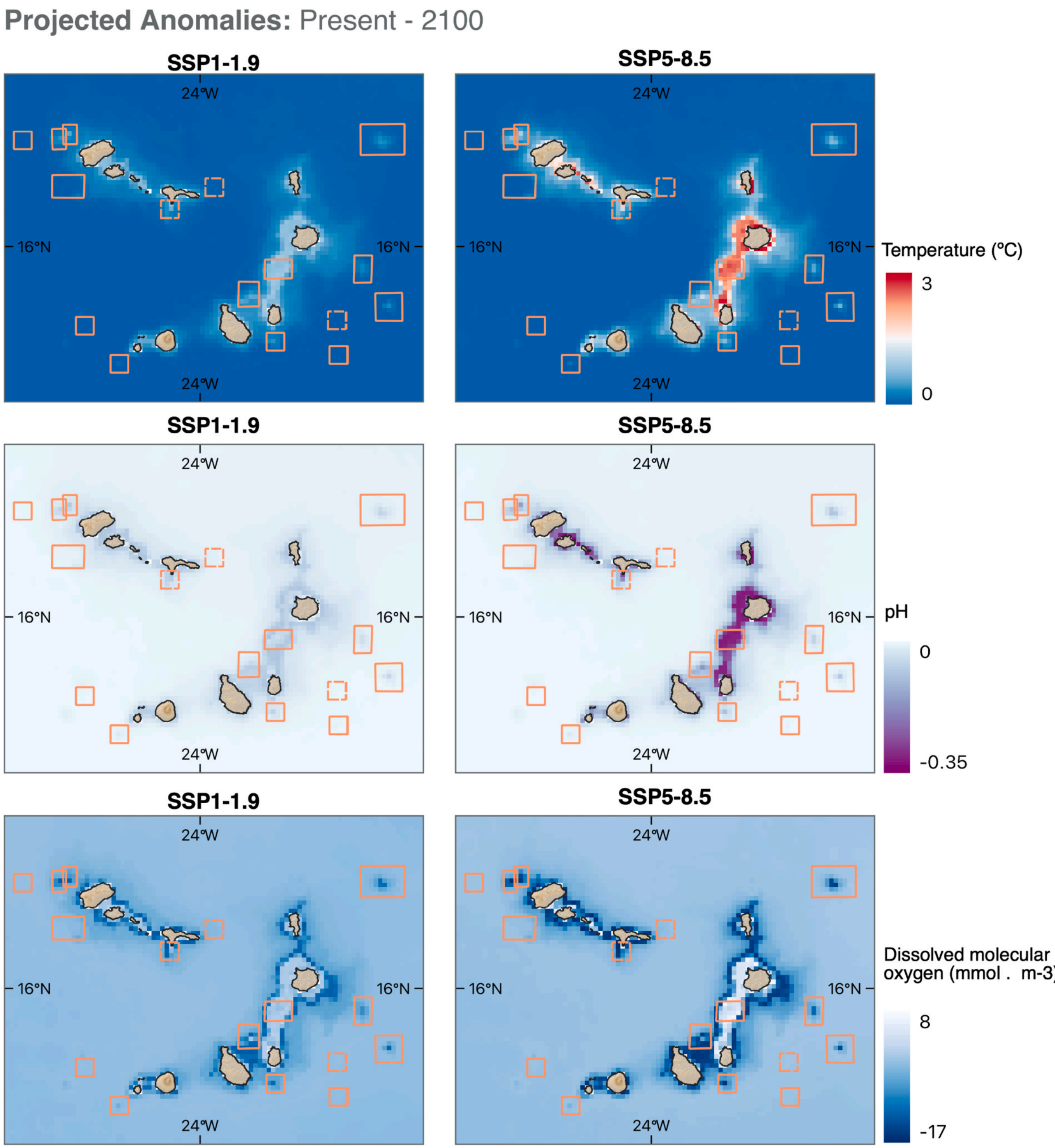

Fig. 19. Projected anomalies from present to 2100 for bottom temperature, pH and dissolved molecular oxygen for Cabo Verde, under two different Shared Socioeconomic Pathway (SSP) scenarios of future climate change: SSP1-1.9 corresponds to a very low GreenHouse Gases (GHG) emissions scenario, where CO_2 emissions are cut to net zero by 2050, while SSP5-8.5 represents a very high GHG emissions scenario, where CO_2 emissions triple by 2075. Orange squares represent the location of the seamounts around Cabo Verde. (Data sources: Tyberghein et al., 2012; Assis et al., 2024). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 4
Research and conservation needs for Cabo Verde Seamounts.

		Needs
Research	Ecology	Increase the number of seamounts investigated
		Improve information on benthic ecosystems, including soft bottoms
		Increase data on species occurrences to develop robust species distribution models
		Increase habitat mapping efforts and studies on spatial distribution patterns
		Increase the use of novel methodologies and advanced technologies (i.e. acoustic monitoring, drone-based surveys, baited remote underwater video stations and eDNA analysis) to enhance knowledge on behavioural patterns
		Increase research on pelagic communities (nekton and zooplankton)
		Increase investigations on functional ecology, including trophic ecology and trophic networks and potential role as foraging hotspots
		Increase data on abundance and movements on cetacean, elasmobranch, turtles (except loggerhead) and non-breeding seabirds, as their distribution and behaviour is still largely unknown
		Develop multidisciplinary studies on the importance of seamounts for large pelagics, cetaceans, elasmobranchs and most sea turtle species, as well as for other ecosystem components
		Further explore the role of seamounts as biodiversity hotspots and potential ecological corridors
		Increase the number of studies on the microbiological community of seamounts (prokaryotes and eukaryotes)
		Investigate the role of seamounts as potential migratory stop-over and nursery areas for mobile megafauna
		Investigate the faunal connectivity patterns within and between seamounts, and with adjacent islands, the African continent and in general, considering the broader regional context
		Implement monitoring programs to increase the frequency of megafauna sightings, year-round data and multi-year data on the spatial and temporal use of seamounts by megafauna
		Standardize methods for monitoring and censusing marine megafauna
	Geomorphology, Volcanism and Oceanography	Increase efforts in seafloor mapping
		Implement long-term and high resolution monitoring of water column characteristics, deployment of moored instrumentation, which provide essential time-series data on physical and biological dynamics
		Conduct systematic research on Cabo Verde underwater volcanic activity, geological deposits and mineral resources
		Investigate the "seamount seascape" as a whole, to obtain insights into the common aspects they might share and specificities of each isolated structure
	Anthropogenic activities	Assess the fishing effort and fishing gears of artisanal, semi-industrial and industrial fishing on seamounts
		Estimate impacts of fishing on seamounts, including bycatch of sea turtles, seabirds, cetaceans, sharks and rays
Conservation		Need to establish robust biodiversity baselines to support conservation objectives and develop effective monitoring programs
		Investigate risks, sources, pathways, and trophic transfer of pollutants in Cabo Verde's seamount ecosystems
		Explore strategies to safeguard the few investigated seamounts, whose relatively pristine ecosystems warrant protection, along with similar, yet unstudied, seamounts
		Incorporate pluralistic values and multiple stakeholder interests into management decision-making processes
		Bottom-up approaches to provide opportunities to the Government to engage with national and international research and advocacy partners to represent local partners' interests in the planning and implementation of marine spatial planning
		Increase the support (political and financial) to the local communities across the islands to promote the sustainable use of marine resources
		Need for collaborative efforts (i.e. throughout a multi-stakeholder knowledge platform) from Government ministries, local industry partners, community- and rights stakeholders
		Extend the MPA network, which is currently limited to the coastal areas, to Cabo Verde's oceanic ecosystems
		Enhance the effectiveness of MPA management by strengthening enforcement, promoting compliance, building management capacity, and supporting alternative livelihoods for local communities
		Seamounts of Cabo Verde need protection:, no seamounts are currently protected in the archipelago
		Area-based management implementation is needed, the process should be: 1) be data-driven, 2) considering seamount scape as a whole and related to the African continent, 3) integrate with development of holistic conservation measures

for 50 % renewably sourced electricity by 2030 (Pombo et al., 2022). The study will include evaluating potential for offshore renewable energy generation (wind, wave, etc.) as well as the possibility and impacts of installing submarine power lines.

6.2.7. Bioprospecting

The bioprospecting industry is another human activity that potentially could lead to threats to benthic communities on seamounts (Synnes, 2007). However, it is expected to primarily target seamounts located in the high seas, areas which until the recently agreed BBNJ agreement (Zhang and Liu, 2024) lacked a regulatory framework. In the case of Cabo Verde, future scenarios could involve the exploration of seamounts for such resources, although no information is currently available on plans to advance this activity in the region.

6.2.8. Climate change

Climate change poses a major threat to marine ecosystems, particularly through ocean warming, deoxygenation and acidification, also known as the "deadly trio" (Hoegh-Guldberg et al., 2018; Pimentel et al., 2023; Alter et al., 2024). Cabo Verde, like other small island nations, is particularly vulnerable to the impacts of climate change (Mycoo et al., 2022), with low-lying islands facing significant risks from rising sea levels (DGMP, 1998; IPCC, 2019).

Recent decades have already seen higher-than-anticipated temperature rises in the Northeast Atlantic, including in the waters around Cabo Verde (Cropper and Hanna, 2014). These changes coincide with global trends, such as the expansion and deepening of oxygen minimum zones (OMZs) (Stramma et al., 2010; Löscher et al., 2016) and the shoaling of carbonate and aragonite saturation horizons (Feely et al., 2012; Perez et al. 2018), that are known to impact benthic species on seamounts, particularly those with slow growth rates and limited mobility, such as CWCs and sponges (Tittensor et al., 2010; Hennige et al., 2020; Morato et al., 2020). Cabo Verde's OMZ, currently at around 340–500 m depth, could experience further expansion, with seamount ecosystems in Cabo Verde mirroring global patterns of vulnerability. For example, seamounts in the North Pacific have experienced a 15 % loss of oxygen in the upper 3,000 m layer over the past 60 years, a trend that is expected to increase in coming years, compromising the distribution, ecophysiological requirements and, ultimately, the survival of key seamount taxa (Ross et al., 2020). Such changes could cascade through the food web, impacting marine predators. For example, climate change projections suggest significant risks to seabird survival in Cabo Verde, even under moderate scenarios (Cruz-Flores et al., 2022).

In Cabo Verde, under worst-case climate scenarios (SSP5-8.5), modelled forecasts (Tyberghein et al., 2012; Assis et al., 2024) indicate that by 2100 bottom temperatures could increase by up to 2.50 °C on the summits of shallow seamounts (i.e., summits > 1,000 m), while deeper seamounts appear to be less affected (Fig. 19). This trend is also observed in ocean acidification (pH) and deoxygenation patterns, highlighting the potential climate refugia role of deep seamounts in Cabo Verde.

While specific information on climate change impacts on most taxonomic groups of the seamounts of Cabo Verde remains limited, climate change is expected to have significant social-economic impacts on Cabo Verde. For instance, seamounts that are important fishing grounds for small-scale local fisheries, such as João Valente and Tchadona, could be especially susceptible to climate-driven changes (see Fig. 19). Fisheries projections for the West African region show that by 2050 climate change could reduce marine fish production, leading to a 21 % drop in annual landed value, a 50 % decline in fisheries-related jobs, and a total economic loss of USD 311 million, with severe implications for food security and economic stability in the region (Lam et al., 2012; Belhabib et al., 2015). Cabo Verde seamounts could become increasingly important for megafauna species in the context of global change and growing coastal development. As coastal species face displacement, they are likely to seek refuge in these habitats, which offer shallower depths, higher productivity, and conditions that may closely resemble coastal environments.

Regarding potential implementation of ocean-based climate remediation techniques there are some plans in place, specifically regarding renewable energies, as well as decarbonized ocean-based transport (see Fig. 13 in Adewumi et al., 2022). Cabo Verde has also signaled interest in advancing carbon storage capacity and design for climate mitigation (Adewumi et al., 2022). Moreover Cabo Verde is also considering studying ocean-based natural carbon sequestration (Ocean-based climate solutions in Nationally Determined Contributions, 2023).

6.3. Research needs for Cabo Verde seamounts

Throughout this review, many outstanding research questions were identified. First of all, given that only a few of Cabo Verde's seamounts have been studied at all, there is a clear need to fill in the blank spots on the map. In the following paragraphs knowledge gaps are highlighted and research needs indicated and summarised in Table 4.

A better understanding of the physical characteristics of the seamounts' environment is needed. In addition to bathymetric mapping and measurement of water column characteristics, observational strategies should prioritize long-term, high-resolution monitoring using moored instrumentation such as acoustic current meters, CTDs, as well as fluorometers, turbidity and oxygen sensors, which provide essential time-series data on physical and biological dynamics. Moored systems are essential to collect continuous time-series data in situ that are crucial to fully understand the variability of physical processes at seamounts (e.g. mixing, upwelling) and their influence on biological distribution patterns. Similarly, there is currently no systematic research on Cabo Verde underwater volcanic activity, geological deposits and mineral resources at its seamounts. Working under the precautionary principle, in order to preserve the seamounts and their surroundings from potential future mining activity, more research on this is needed.

In terms of the benthic ecosystem, as presented in section 3.1, only Cadamosto Seamount has been relatively well explored and mapped so far, while only sparse information has been collected from a handful of other seamounts (Vinha et al., 2024). This lack of information on benthic communities has resulted in species distribution models with high levels of uncertainty, especially for non-surveyed seamounts (e.g., Boa Vista), highlighting the need to collect more data to improve model predictions and mapping efforts in the archipelago. The exploration and implementation of novel research methodologies, such as environmental DNA (eDNA) as currently applied in other ecosystems (including the deep sea: McCartin et al., 2024) is expected to contribute significantly to increasing the knowledge on the biodiversity harboured by Cabo Verde seamounts. However eDNA research needs to rely on a robust and comprehensive reference database, which is currently lacking for many deep-sea areas.

Similarly, the pelagic communities of nekton and zooplankton should be investigated around more of Cabo Verde's seamounts, including Cadamosto and Nola. The distribution, diversity and abundance of pelagic organisms will inform about the potential prey-scapes that exist for commercially important fish species as well as marine megafauna. Identification of such communities will help to define the ecological value and horizontal interconnection of seamounts across trophic levels, and between regions in the Cabo Verde archipelago, as the functional ecology and trophic network of the Cabo Verde seamount communities are still largely unexplored.

For mobile marine megafauna, there is a huge knowledge gap regarding cetacean distribution and limited data on elasmobranch distributions. This lack of data hinders scientific evaluation of the ecological importance of seamounts for these organisms. Similarly, the role of seamounts for sea turtle species present in Cabo Verde waters, aside from loggerheads, remains poorly understood. While loggerhead turtles are known to use Cabo Verde waters extensively, their interaction with seamounts appears minimal for breeding adults. However, the potential use of seamounts as foraging grounds for juvenile or subadult turtles remains an open question (Santos et al., 2007; Vandeperre et al., 2019). The foraging movements of most seabird species and populations breeding in Cabo Verde have been extensively tracked with GPS, providing detailed information on habitat use and seamount association during the breeding season (Fig. 12). However, the role of seamounts, particularly regarding trophic ecology, and as potential non-breeding and stop-over areas for migratory species, remains largely unexplored.

Except for Cabo Verde seabirds, the existing information on megafauna sightings on Cabo Verde seamounts is primarily based on opportunistic observations or isolated studies. These provide only snapshots of presence without accompanying behavioural data, leaving critical gaps in understanding how and why these organisms interact with seamount habitats. For example, whether seamounts serve as key foraging hotspots, migratory stop-overs or nursery areas for different life stages is not yet clear. To address these knowledge gaps, an increased focus on biologging studies is imperative. Such studies could provide year-round and multi-year data on the spatial and temporal habitat use and association with seamounts by various megafauna species. Additionally, incorporating advanced technologies like acoustic monitoring, drone-based surveys, baited remote underwater video stations and eDNA analysis could yield a more comprehensive understanding of species presence and behaviour around these underwater features. Furthermore, establishing marine megafauna census programs and trophic ecology studies using standardized methods would contribute to understanding the ecological importance of seamounts for these organisms. Investigating the distribution, trophic ecology and behavioural patterns of marine megafauna on seamounts, and understanding the role of seamounts as biodiversity hotspots and potential ecological corridors, is crucial not only for enhancing the conservation of marine megafauna, but also for elucidating the connectivity of Cabo Verde's marine ecosystems and guiding conservation priorities to protect their habitats amid changing oceanographic conditions and increasing human pressures, including fishing and climate change.

Regarding microbial diversity, as mentioned in section 3.4 no studies have been yet conducted, therefore there is an important research need on microbial (prokaryots and eukaryots, benthic and planktonic) for the Cabo Verde seamounts and in general for the marine waters of the archipelago where very few studies have been conducted (i.e. Fernandes Soares, 2023; Larrea et al., 2023; Morais et al., 2025).

The investigations on trophic nets and linkages in Cabo Verde seamounts are likewise very scarce as highlighted in section 3.5, as the trophic relations among most biological groups have not been studied. The few investigations conducted refer to some specific communities (i.e. some deep-sea benthic communities) or groups (i.e. some seabirds). The currently available works on this topic, in a broader context of Cabo Verde waters, are focused on trophic interactions in coastal ecosystems (i.e. Araújo, 2005), reef fish (Freitas et al., 2019) and the evaluation of potential impact of fisheries policies in the trophic nets (da Cruz Delgado et al., 2024). The poor knowledge on the trophic relationships in Cabo Verde seamounts and in general in the deep sea, stress the need of increasing research efforts in this field.

The spatial distribution of the Cabo Verde seamounts also invites investigation of not only the specific characteristics of each feature (i.e. local oceanographic conditions, orientations, depths), which will highly influence the species occurrences and ultimately the communities inhabiting the seamounts, but also the "seamount seascape" as a whole, to obtain insights into the common aspects they might share (i.e. geological origin and characteristics). Investigating the faunal connectivity patterns within and between seamounts, and also with adjacent islands, the African continent and in general, considering the broader regional context, will be essential to understanding and accurately quantifying the level of fauna endemism present on Cabo Verde seamounts.

Crucial for defining the exact ecological role of seamounts is to undertake interdisciplinary studies where biological surveys (using optics, acoustics and sampling) are combined with physical oceanography and bathymetric mapping. Seamount specific studies are needed since variability is expected in the biological and temporal dynamics of seamount processes and communities. Including and recognizing the three-dimensional space of the pelagic realm, its relation to the benthic realm, and their diverse and many inhabitants is crucial for integrative marine conservation strategies (Levin et al., 2018).

Regarding the anthropogenic activities on seamounts, an assessment of the intensity of fishing on seamounts is needed to ensure proper management. More research efforts are needed to obtain a more realistic view on the degree of activity of industrial fisheries on Cabo Verde's seamounts. In parallel, more comprehensive information of fishing type and effort operating on seamounts is needed, as AIS data are only required on large vessels, which means that the information regarding the operations of the small-scale artisanal fleet is not well known. The acquisition of these data will contribute to improve, among other things, the knowledge on the current effects of artisanal fisheries (i.e. handlines, long lines, purse-seine) on loggerhead turtle deaths, as well as on seabirds, sharks and rays. On a broader scale, significant socio-economic research is needed to fully understand the ecosystem services, societal importance and economic significance of the seamounts in Cabo Verde to the country's inhabitants and society in general. This should encompass collaborative actions co-produced by marine conservation stakeholders in Cabo Verde that support the implementation of cohesive and equitable policies and practices relating to marine protection, the blue economy and marine spatial planning to adequately address the complex interactions and trade-offs between multiple anthropogenic drivers and their potential impacts on seamount ecosystem health.

These above-mentioned services are fundamental not only at a local and regional level, but also for global biodiversity (Merten et al., 2021; Scepanski et al., 2024). Scientific knowledge about Cabo Verde's seamount benthic and demersal communities, their biodiversity (both taxonomic and functional), and their ecological roles is still limited (Larrea et al., 2023; Vinha et al., 2024). Even less is known about the ecosystem services they provide, although some overview studies have included Cabo Verde as a case study (Larrea et al., 2023). Addressing these knowledge gaps through further research is essential to ensuring the conservation and sustainable use of these vital marine ecosystems.

6.4. Conservation needs for Cabo Verde seamounts

This review has followed an ecosystem-based assessment approach to evaluate the ecological integrity, functioning, and resilience of Cabo Verde's seamount habitats while considering their biotic, abiotic, and socio-economic components. Undertaking a comprehensive review such as this has required the contributions and expert knowledge from an interdisciplinary team of scientists including geologists, biologists, ecologists, oceanographers and social scientists, based in universities, research institutions and NGOs from Cabo Verde and across Europe. Several of the contributors are Cabo Verde nationals whose expertise and community engagement experiences are distributed across the islands, while numerous other contributors have been working in the archipelago on collaborative research projects for many years.

This collaboration is an example of the existing strong level of commitment among the national and international scientific community to preserve the seamounts and their associated biodiversity due to their critical importance to the health and wellbeing of Cabo Verde's oceans, people and blue economy. Much of the evidence upon which this review is based has involved the contribution of Cabo Verdean citizens from many kinds of backgrounds who have participated directly in scientific research programs, volunteered their knowledge, time and other resources, or have supported these efforts in other ways. Their significant contribution reflects the cultural importance of Cabo Verde's habitats and biodiversity to local communities. It also provides an indication of the extent of community support that may be engaged to deliver the Government's strong conservation ambitions in terms of developing a sustainable blue economy, implementing the NBSAPS and achieving its international treaty targets relating to the SDGs, Aichi, CBD, ICCAT, CITES and BBNJ, to name a few.

To move forward with these conservation goals, including the implementation of marine spatial planning to protect marine resources, such as the seamounts, there is an evident need for pluralistic values and multiple stakeholder interests to be incorporated into management decision-making processes (see Table 4 for a summary of Conservation needs). This bottom-up approach provides numerous advantages and opportunities to the Government for engaging with national and

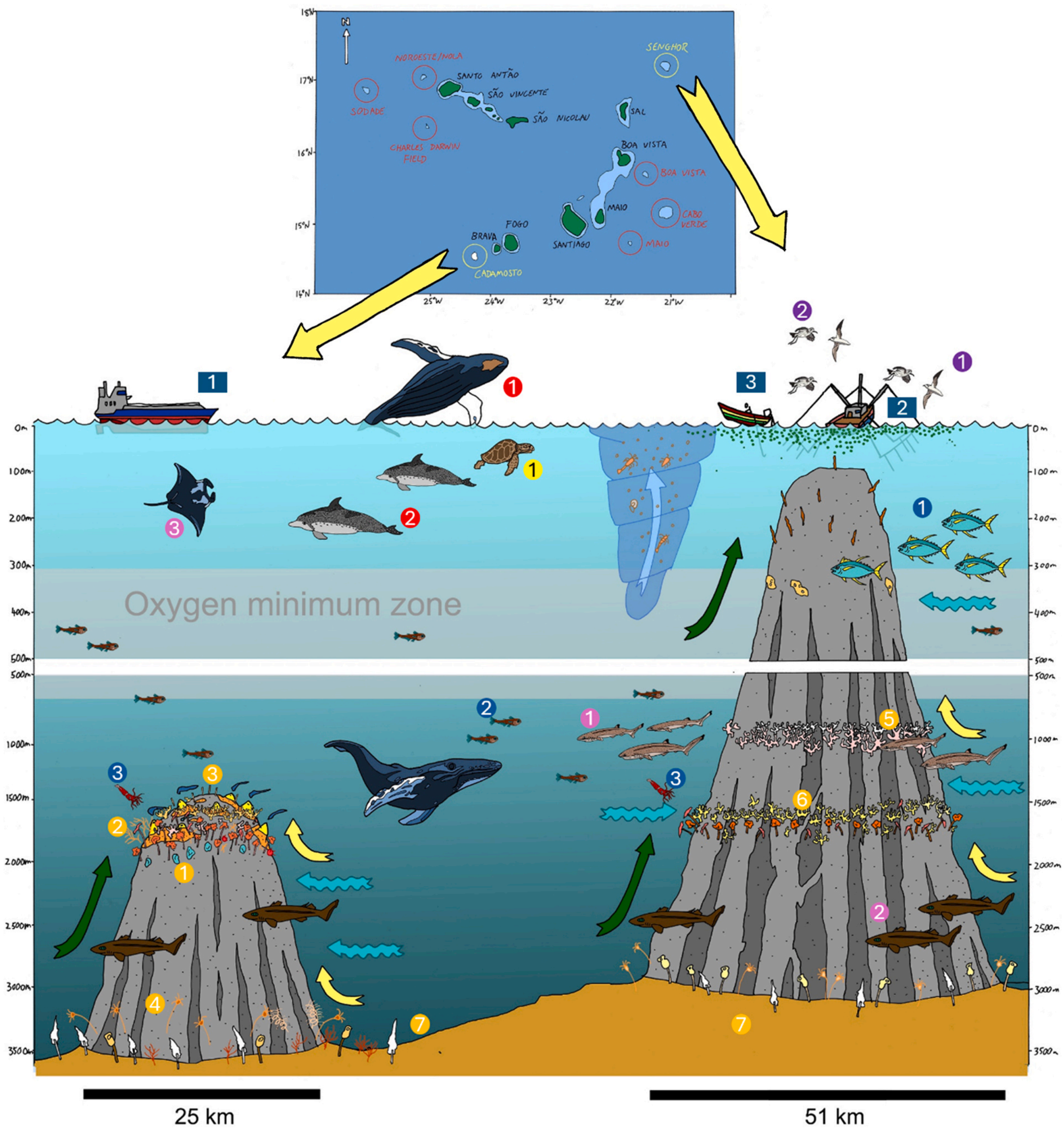

Fig. 20. Idealized representation of the Cabo Verde Seamounts based on the information compiled in this review. On the top of the figure, location of the two most extensively studied seamounts—Cadamosto (southwest of Brava) and Senghor (northeast of Sal). The schematic illustration depict: (1) Main oceanographic processes associated with seamounts. Green arrows indicate upwelling; blue and yellow arrows represent internal waves and turbulence; the grey layer denotes the depth range of the Oxygen Minimum Zone. Near Senghor Seamount, an eddy is shown transporting and concentrating plankton. (2) Colored circles indicate different faunal groups. Orange circles represent benthic fauna: *Cadamosto Seamount:* 1 – Sponges, 2 – Gorgonians (*Metallogorgia* sp., Primnoidae), scleractinians (*Corallium* sp., *Enallopsammia rostrata*), 3 – Stick sponge (*Cladorhiza* spp.) at the summit, where volcanic activity is suggested by the orange substrate and visible hydrothermal venting, 4 – Stalked crinoids, gorgonians, and black corals (*Stichopathes* sp.); *Senghor Seamount:* 5 – *Lophelia pertusa,* 6 – *Enallopsammia rostrata*, *Solenosmilia* sp., 7 – Sea pens and stalked sponges in deeper, soft-sediment areas. Note that different depth zones and seamount flanks host distinct benthic communities. Areas without depicted benthic fauna have not yet been explored. Pink circles indicate elasmobranchs observed around the seamounts: 1 – *Heptranchias perlo,* 2 – *Etmopterus princeps,* 3 – *Mobula birostris.* Blue circles represent fish and cephalopods: 1 – *Thunnus albacares*, 2 – *Myctophum nitidulum,* 3 – *Taningia danae.* Red circles show marine mammals: 1 – *Megaptera novaeangliae,* 2 – *Stenella frontalis.* Yellow circle (1) denotes the sea turtle *Caretta caretta*. Purple circles indicate seabirds: 1 – *Pterodroma feae,* 2 – *Pelagodroma marina.* Blue squares mark human activities in the area: 1 – Oil tanker, 2 – Troller, 3 – Artisanal fishing boat. (Concept: Covadonga Orejas & Jacob González-Solís, Drawing by Autun Purser). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

international research and advocacy partners who already have strong connections with local communities across the islands and can help to represent their interests in the planning and implementation of protected areas. Furthermore, these organisations already have infrastructure and skills in place to collect the data required to fill current knowledge gaps and have demonstrated their capacity to support conservation of important species and habitats in Cabo Verde. However, they require greater financial and political support from the Government to expand their efforts effectively.

This comprehensive review, where a significant amount of the existing data, known challenges and gaps in knowledge about Cabo Verde's seamounts has been centralised, provides an invaluable opportunity to create a cohesive vision for conserving the seamounts. Doing so would require the collaboration of several Government ministries responsible for different interests affected by managing the seamounts (e.g. environment, fisheries, tourism, shipping) as well as local industry partners and community stakeholders and rightsholders. The data presented in this review could serve as the basis for identifying key individuals to be involved and for outlining important discussion points.

This engagement process could also serve as a roadmap for the Government to better understand how these different actors and others could participate and collaborate more effectively to achieve other environmental and social objectives, including the monitoring and implementation of NBSAP priorities and the blue economy strategy. For example, a multi-stakeholder knowledge platform involving stakeholders and policy makers could provide an effective forum for communication and action to achieve sustainability goals in the country.

While our current knowledge about the Cabo Verde seamounts is incomplete and fragmentary, it is sufficiently robust to clearly establish the importance of these ecosystems. As demonstrated in previous sections, the seamounts provide extensive ecosystem services that support the Cabo Verde population and economy. They harbour a high benthic and pelagic biodiversity, and host an extensive range of migratory species. Their unusual position in Macaronesia points to their global importance as a truly unique ecosystem. At the same time, future projections of population growth and increasing human impacts underline the need and urgency for action. Hence, although many knowledge gaps still exist and further research is needed, based on the precautionary principle, this lack of knowledge need should not delay the further development of much-needed conservation plans.

Cabo Verde's current MPA network is limited to coastal regions, while the islands of Fogo and São Vicente have no marine and coastal protected areas at all. This leaves Cabo Verde's oceanic ecosystems unprotected. None of the areas in the current MPA network include seamounts and none have management effectiveness evaluations in place (UNEP-WCMC, 2024). The establishment of Marine Protected Areas (MPA) on seamounts has been recommended, for example by Monteiro et al. (2008), but the effectiveness of MPAs depends on enforcement and management capacities that are still a challenge for marine and coastal areas in Cabo Verde.

When implementing Area-Based Management Tools such as MPAs, we recommend three important considerations: (1) the process should be data-driven, grounded in the best available scientific knowledge, and supported by targeted initiatives to address significant current knowledge gaps (2) rather than approaching the Cabo Verde seamounts as single entities, it is essential they are evaluated as part of an entire system: a connected network that also includes the island flanks of the archipelago, in addition to features further afield, including the continental slope of West Africa. Furthermore, (3) it is recommended to develop holistic conservation measures that incorporate multiple integrated components (e.g. benthic habitats, pelagic species and mobile megafauna) and that consider entire ecosystems and related services at a seascape level (e.g. including abiotic components such as geology and geomorphology). Furthermore, establishing robust biodiversity baselines will be essential to support conservation objectives and develop effective monitoring programs for the future, such as those described in Cabo Verde's National Blue Economy Investment Plan (FAO, 2020) (Section 5.1; Table S6).

7. Conclusions

This review has summarised our current state of knowledge on the seamounts of Cabo Verde. While focused studies on a limited number of seamounts have indicated high faunal abundance and diversity (benthic, pelagic and mobile megafauna), as well as the potential for endemism, the review has also highlighted the lack of data and our limited understanding of these valuable ecosystems. Future research priorities have been listed to address these associated challenges.

As highlighted in the different sections of this review, the Cabo Verde seamounts present some singularities which make them unique in the wider context of the North Atlantic Seamounts. Fig. 20 schematically represents some of the singularities of Cabo Verde Seamounts with Senghor and Cadamosto as paramount examples. These are the two seamounts currently investigated in more detail.

From a geographical and geological point of view the Cabo Verde seamounts are of volcanic origin, formed over the so-called "Cabo Verde hotspot". In contrast, the Mid-Atlantic Ridge seamounts (i.e. Azores seamounts) are associated with the mid-ocean ridge tectonics. As a result, the Cabo Verde seamounts have a unique magmatic composition and geological history and are particularly isolated, with only a few other seamounts within an 800 km radius. Furthermore they can reach shallow depths (see Table 1, Fig. 20), which makes them more accessible for biological colonisation from coastal ecosystems.

From an oceanographic point of view, the permanent Oxygen Minimum Zone at ca. 300–800 m depth affects the faunal composition which should be adapted to low-oxygen concentrations in these specific depth ranges. The seasonal upwelling (mostly localised on the windward sides of the islands) leads to high productivity compared to most of the open ocean seamounts in the North Atlantic, creating remarkable gradients for abiotic factors.

From the biological and ecological point of view, the level of endemism (confirmed for shallow waters but still unexplored for the deep sea and the seamounts) is also particularly high compared to other North Atlantic seamounts. Considering the few surveys conducted over the Cabo Verde seamounts, the dense and well preserved CWC dominated ecosystems make these edifices urgent candidates for conservation. Although the documented hydrothermal activity on several of the seamounts suggests the potential occurrence of chemosynthetic /vent communities, their presence has not yet been confirmed. Regarding pelagic fauna, cephalopods are very diverse, in general, in the archipelago, compared to other archipelagos from Macaronesia (Merten et al., 2021).

Cabo Verde is also a critical seabird hotspot, supporting five endemic taxa among its eight regularly breeding species, with half of them relying on the Cabo Verde seamounts as foraging grounds. This combination of high endemism and remarkable seamount connectivity sets the archipelago apart within the wider North Atlantic.

Fish endemism is remarkable in Cabo Verde (about 7.3 % of coastal fish species are endemic to the archipelago) compared to the other archipelagos of Macaronesia, where endemism is lower and species composition between islands is more similar. Although this information is still unknown for the Cabo Verde seamount's fish fauna, some census conducted on Nola West and João Valente Bank (Monteiro et al., 2008) point to high diversity and a potential role of those seamounts as stepping stones for fish species.

The few available data on sharks indicate the possible role of seamounts as migratory stop-over areas for this group, as well as to maintain connectivity among different areas in the Atlantic. There is also growing evidence of the role of seamounts as shark nursery areas, also supported by recent findings of egg cases on Cadamosto seamount.

Data on cetaceans is one of the most important knowledge gaps in Cabo Verde, including seamounts. The few mostly opportunistic observations on cetaceans around the Cabo Verde seamounts, as well as reports from local fishermen around a seamount south of São Nicolau, suggest the relevance of these underwater features as foraging areas for cetaceans.

Existing tracking data from loggerhead sea turtles (for which Cabo Verde hosts one the world's most important breeding grounds) do not reveal a preference of those animals for seamounts. However, no studies have been conducted to explore the potential role as forage or rest areas for other sea turtles in Cabo Verde. Some opportunistic observations documented the occasional presence of loggerhead turtles in João Valente seamount.

Given the importance of the Cabo Verde seamounts to oceanic and human health and wellbeing in terms of ecosystem services, particularly food provisioning through fisheries, effective conservation and sustainable management of these valuable habitats could contribute to addressing expected increases in anthropogenic impacts caused by predicted population rises. Successfully navigating the opportunities and challenges this review has described will require a holistic approach, considering the entire network of seamounts, their interactions with the wider marine environment, and their socio-economic importance at a national and international level.

Key strategies for success include continuing to build effective stakeholder and rightsholder engagement, implementation and enforcement of appropriate environmental legislation across the archipelago, and sufficient dedicated resources to ensure the long-term monitoring and management of conservation measures for the benefit of future generations of Cabo Verdean people and biodiversity.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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Data availability

The authors do not have permission to share data.

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Further reading

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