



# Fishing resources of the traditional gastronomy of Macaronesia: A navigation through the intangible food heritage in the Azores, Madeira, Canary Islands and Cabo Verde

José Antonio González<sup>a,\*</sup>, Ana L. Álvarez-Falcón<sup>b</sup>, Ricardo Sousa<sup>c</sup>, Mafalda Freitas<sup>c</sup>, Sandra Correia<sup>d</sup>, José M.N. Azevedo<sup>e</sup>

<sup>a</sup> EMAP–Applied Marine Ecology and Fisheries, i-UNAT, University of Las Palmas de Gran Canaria (ULPGC), HUB GastroFood ULPGC, Las Palmas de Gran Canaria, Canary Islands, Spain

<sup>b</sup> Research Institute of Biomedical and Health Sciences (UIBS), University of Las Palmas de Gran Canaria, HUB GastroFood ULPGC, Dietetics Unit - University Hospital of Gran Canaria Dr. Negrín, Las Palmas de Gran Canaria, Canary Islands, Spain

<sup>c</sup> OOM - Funchal Marine Biology Station; Marine and Environmental Sciences Centre (MARE) and Direção Regional do Mar, Funchal, Madeira, Portugal

<sup>d</sup> Instituto do Mar, Mindelo, São Vicente, Cabo Verde

<sup>e</sup> cE3c - Centre for Ecology, Evolution and Environmental Changes/Azorean Biodiversity Group, Faculdade de Ciências e Tecnologia, Universidade dos Açores. Ponta Delgada, Azores, Portugal

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## ABSTRACT

Artisanal fishing is a vital activity in the Macaronesia archipelagos (Azores, Madeira, Canaries, and Cabo Verde) within the Northeast Atlantic (15°–39°N). It has historically played a pivotal role in poverty alleviation, employment generation, and the fortification of food security and sovereignty. This sector faces chronic threats from resource overexploitation, poaching, and the rising trend of recreational fishing. Recent decades have witnessed the growth of mass tourism, primarily reliant on processed fish from distant sources, exacerbating the situation alongside the impact of warming seas. Traditional fishing resources and their connection to regional gastronomy form a crucial part of the intangible cultural heritage of these archipelagos. Therefore, promoting local production and fostering education around smarter, healthier, and more sustainable consumption are imperative. Data on traditional fishery resources in Macaronesian gastronomy have been collated from diverse sources, including literature, specialised websites, interviews, and the extensive expertise of the authors. This information has been categorised by environmental resource groups for each archipelago. The biodiversity exploited by Macaronesia's artisanal fleets, integral to classic regional cuisine, encompasses over 220 marine species, with around 330 culinary dishes and seafood preparation methods catalogued. While there exists substantial similarity in the fishery resources utilised in the traditional cuisines of these four archipelagos, the Canaries have historically incorporated additional species from the Northwest African coasts. Meanwhile, Cabo Verde has integrated more tropical elements and has had limited developed in its deep-water fisheries. Macaronesia's gastronomic heritage, rooted in Portuguese and Spanish traditions, reflects a Mediterranean Diet characterised by lifestyle and the utilization of traditional recipes.

## 1. Introduction

Regional gastronomy is determined by the availability of raw materials and is the result of interactions between natural conditions (geological, geographical, biological) and historical events (Almenar, 2020; Coll et al., 2010; Espino et al., 2022; Sousa et al., 2023). This idea

applies to both traditional and creative cuisine, including that based on products derived from local and regional coastal fisheries over the past centuries, such as black scabbardfish, *Aphanopus carbo* Lowe, 1839 (Maul, 1950) and cod, *Gadus morhua* Linnaeus, 1758 (Kurlansky, 2013). Seafood products caught by small-scale fisheries in nearshore waters are usually carried out by small or medium-sized vessels with little or

\* Corresponding author: Universidad de Las Palmas de Gran Canaria, Edif. Ciencias Básicas, Campus de Tafira, 35207 Las Palmas de Gran Canaria, Canary Islands, Spain

E-mail address: [pepe.solea@ulpgc.es](mailto:pepe.solea@ulpgc.es) (J.A. González).

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moderate power; this is the case of the Northeast Atlantic oceanic archipelagos, such as, from north to south, the Azores (Gallagher et al., 2012), Madeira (Nunes, 1994; Alves et al., 2008), Canary Islands (González, 1991; González et al., 2020a) and Cabo Verde (González et al., 2020b), i.e., Macaronesia sensu lato. As a result, a seafood gastronomy based on local products can somehow reflect the availability of species (fish, crustaceans, molluscs, and others) and tradition (consumption habits and cultural patterns) through multiple generations (Espino et al., 2022; Hermida and Costa, 2020; da Silva et al., 2015).

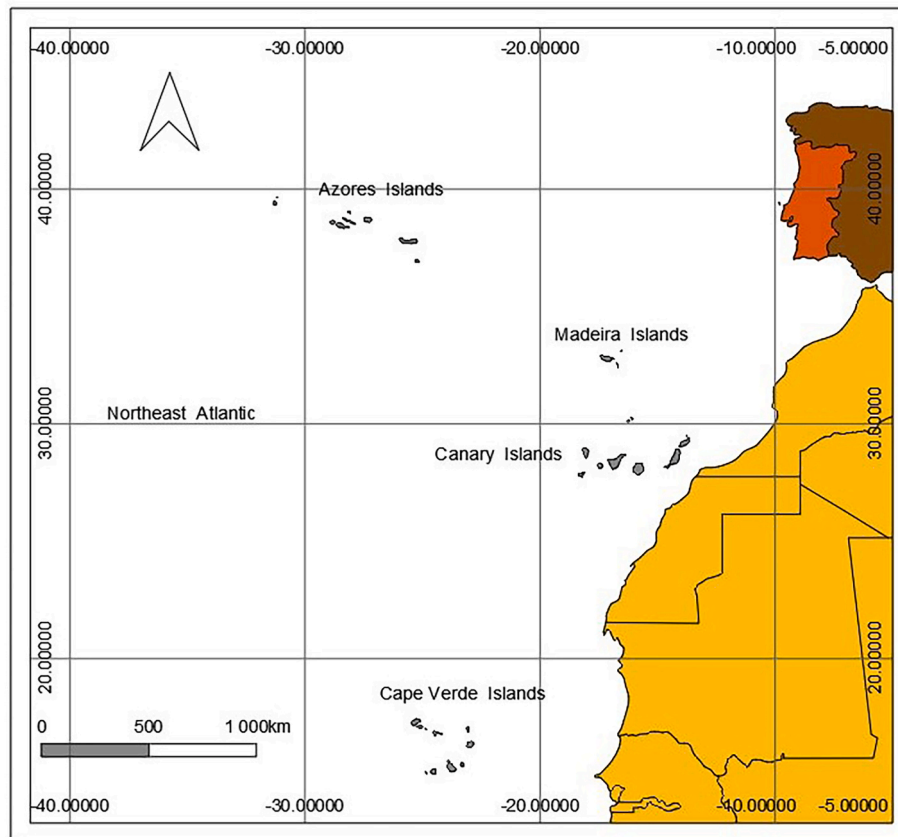
When ecological data are sparse, difficult, and expensive to obtain, citizen science (CS) and indigenous or local ecological knowledge (LEK) are receiving increasing attention to provide an alternative in ecosystem stewardship and conservation, which has proven successful for several marine species neglected by current fisheries (González et al., 2020a), emerging (González and Mojo, 2019), or even threatened or endangered species (Otero-Ferrer et al., 2017). CS and LEK approaches are often based on surveys (to collect and/or verify information) targeting sectors of the population that interact directly with species from small-scale fisheries or aquaculture, e.g., fishermen, fish farmers, fishmongers, restaurateurs, home cooks, or researchers (Espino et al., 2022; González et al., 2022). However, the social knowledge imprint may arise from activities that do not directly interact with species and transcend multiple human generations (Almenar, 2020; Coll et al., 2010; González et al., 2022).

Over the last 60 years, Madeira and especially the Canary Islands have progressively developed and implemented an economic model strongly based, and highly dependent, on mass tourism. The average contribution of the tourism industry in the Canary Islands to regional GDP in the five-year period 2014–2018 was 33.54%, showing an increasing annual trend, compared to 0.20% for the regional artisanal fisheries, as a primary sector, in the same period (González et al., 2020a,

2021). The authors' observations indicate that Cabo Verde seems to be adopting the same model with a strong presence of large hotel chains which, as is well known, are usually very difficult and reluctant to incorporate local products into their buffets and menus due to their purchasing mechanics. The Azores, perhaps because of their greater distance from the continents, seem to be more of a nature tourism model with an acceptable range of local products.

A recent study (González and Mojo, 2019), just before the pandemic crisis, pioneering in the description and analysis of the Canary Islands fisheries market (MPC) as a whole, estimated for the first time that the contribution in weight of the local aquatic products was 22.945%, proposing this value as an indicator of regional food sovereignty in the primary sub-sector of fisheries and aquaculture. Such an indicator arises from comparing the 20,593 tonnes produced in 2019 by small-scale fisheries and aquaculture farms against the 89,753 tonnes marketed by the MPC in the same year (González and Mojo, 2019; González et al., 2020a). However, how can an economy such as that of the Canary Islands with a growing degree of tourists (close to 16 million per year, impacting a territory of about 7445 km<sup>2</sup> fragmented into eight islands with a resident population of about 2,200,000 inhabitants) maintain or increase that degree of local production (and consumption)? In Cabo Verde (with about 4000 km<sup>2</sup> of island territories, with barely 450,000 residents spread over nine islands), which has not yet developed its potential demersal fisheries below 80/100 m depth and has not yet satisfactorily exploited its potential for tuna and allied (González et al., 2020b), it is obvious that this economic model, already heavily based on food imports and the massive influx of low-cost charter flights, will have serious difficulties in meeting the expected growing demand.

In this scenario, generalised in the four archipelagos of Macaronesia and aggravated by numerous situations of overexploitation of fish and shellfish stocks, poaching and even subsistence fishing, and by the



**Fig. 1.** The study area: Macaronesia in its broad historical and biogeographical island concept, including the Azores, Madeira, Canary, and Cabo Verde islands in the northeastern Atlantic. Map prepared by the authors.

significant growth of recreational fishing (including spearfishing impact), some recent studies propose the implementation of strategic and structured ad-hoc actions to mitigate these imbalances (Castro et al., 2019; González et al., 2012a, 2020a, 2020b; Jiménez-Alvarado et al., 2020; Martínez-Escariuza et al., 2020; Tuya et al., 2006a, 2006b). In this regard, most of the recommendations of researchers call for a greater sustainable exploitation of the potential fishery resources of the EEZs of the four archipelagos, with greater emphasis on large pelagic fish and demersal resources in semi-deep and deep waters (Carvalho et al., 2007; González et al., 2009, 2020a, 2020b; Menezes et al., 1998; Oddsson and Monteiro, 1998).

However, another strategic measure that is receiving recent attention, with strong support in CS and LEK, is based on studies that revitalise and reinforce the gastronomic heritage through actions such as culinary recipe books that differentiate between local and foreign products, between those from nearby and those from distant origins, between sustainable and those with a high ecological footprint, and which highlight forgotten and emerging species from artisanal fishing in Macaronesia, and that such actions are intensively disseminated to raise consumer awareness (M. Freitas et al., 2014; González and Mojo, 2019; González et al., 2012b, 2019a, b).

A recent study conducted in Lanzarote (Canary Islands) has delved into rescuing the islands' intangible food heritage through approaches that combine several innovative elements. One of these has been based on culinary traditions: that of the home in the hands of popular wisdom, which practised on board traditional fishing boats and inherited from several generations, and that offered by traditional restaurants. A second element has been substantiated on interviews with primary producers and restaurateurs who prioritise local produce, with special attention to their role as social voices that contribute to preserving the rich cultural heritage of their territory (land and sea) and, ultimately, to the care and conservation of natural resources, as key elements of collective prosperity and integral sustainability. A third novel element has been the inclusion in the study of a seasonal calendar of local fish and seafood, to inform consumers and facilitate the prioritisation of fresh local products (González et al., 2022).

In the above context and with the aforementioned issues, this study aimed to identify the native fish and shellfish resources that have served as raw material for the traditional gastronomy of the oceanic islands of the Azores, Madeira, Canary Islands and Cabo Verde, while compiling the titles/modalities of culinary dishes of each archipelago, thus contributing to the conservation of the species involved, to the improvement of food sovereignty and to the revitalisation of the regional gastronomic heritage linked to them, in a scenario of loss of identity, a high level of imports of aquatic products from distant countries and the strong influence of mass tourism. In the case of the Canaries, which are closer to the mainland, the fishing species of the historical fishing grounds of northwest Africa since the 14th century are identified by the authors and their influence on the islanders' dietary habits is analysed.

## 2. Material and methods

### 2.1. Study area

The Macaronesian region has historically been recognised as a group of biogeographically related oceanic archipelagos (Sjogren, 2000). Located in the northeast Atlantic Ocean, between 15 and 39°N latitude, it includes, from north to south, the Azores, Madeira, Savage Islands, the Canary Islands and Cabo Verde (Fig. 1). Macaronesia is renowned for its biodiversity, with extraordinarily important levels of species diversity and endemism in both terrestrial and marine environments (R. Freitas et al., 2019). Currently, these five volcanic archipelagos, with island ages ranging from 0.27 Ma (Pico, Azores) to 29.5 Ma (Savage) (R. Freitas et al., 2019), represent about 15,061 km<sup>2</sup> of emerged territories with 3.2 million inhabitants (2017 data) spread over 28 islands with large depths between nearby islands (Fernández-Palacios et al., 2018) and with an



Fig. 2. Fish market in Ponta Delgada, São Miguel, Azores. Photograph taken by Rui Martins.



Fig. 3. Fish market in Funchal, Madeira. Photograph taken by Paulo Camacho.



Fig. 4. Fish market in Las Palmas de Gran Canaria, Canary Islands. Photograph taken by the first author.





Fig. 5. Fish market in Mindelo, São Vicente, Cabo Verde. Photograph taken by the first author.

EEZ estimated at about 2,800,000 km<sup>2</sup>. The high number of archipelagos and islands, their latitudinal gradient, and the corresponding climatic and water temperature differences, as well as the fact that these oceanic islands have never been related to any continent, make Macaronesia an ideal region to test biogeographical and evolutionary theories (Ávila et al., 2018; Fernández-Palacios et al., 2011; R. Freitas et al., 2019; González, 2018; Rijdsdijk et al., 2014).

To provide a global system for the conservation and sustainable use of marine resources, Spalding et al. (2007) established a classification of coastal and shelf areas that includes a series of marine ecoregions characterised by common biogeographical elements. In this classification, the three archipelagos of the Azores-Madeira-Canary Islands were given the status of an ecoregion, which falls within the Lusitanian province of the Temperate Northern Atlantic realm. Such biogeographical similarities in the littoral benthic fauna (up to the insular shelf boundary) of these archipelagos have been widely assimilated to 'Macaronesia', or Macaronesian region, in the scientific literature. In addition, Spalding et al. (2007) also gave the Cabo Verde islands the status of an ecoregion, albeit within the West African Transition province of the Tropical Atlantic realm.

Closely aligned to the above classification, although now referring to pelagic surface waters, Spalding et al. (2012) proposed a series of pelagic provinces of the world based on the state of natural resources and threats that require improved management and conservation. That classification synthesises knowledge of biogeographic taxonomy and oceanographic forces that define the broad ecological patterns of the world ocean. Within this global system emerges the Canary Current province – with boundaries from the Straits of Gibraltar to Guinea-Conakry and including the Canary and Cabo Verde islands – nested within the Atlantic Warmwater realm. In addition, Spalding et al. (2012) included Madeira and the Azores in the North Central Atlantic province, which, bordering the Canary Current province, extends to the vicinity of the Bahamas and Cuba.

Based on a biogeographical approach using eight marine taxa from the benthic littoral environment, R. Freitas et al., 2019 proposed a restructuring of the classical biogeographical unit called 'Macaronesia'. All marine groups studied suggest the exclusion of Cabo Verde from the

remaining Macaronesian archipelagos and, therefore, Cabo Verde should be given the status of a biogeographic subprovince within the West African Transition province. They also proposed to redefine the Lusitanian biogeographic province, in which they included four ecoregions: the South European Atlantic Shelf, the Saharan Upwelling, the Azores, and a new ecoregion, named Webbnesia, comprising the archipelagos of Madeira, Savage and the Canaries.

The study area of this paper covers Macaronesia in its broad historical and biogeographical island concept, including the Azores, Madeira, Canary, and Cabo Verde islands in the northeastern Atlantic (Figs. 1–5). Furthermore, given that the purpose of this article is to identify the fishery resources used as raw material for traditional cuisine in these archipelagos, to our concept of 'Macaronesia' we add the element of a socio-economic, cultural (gastronomy is culture) and cooperative space, with Portuguese and Spanish roots, endowed with a unique natural heritage (in this case, marine) that must be used in a rational and sustainable way, valued, conserved and disseminated.

It is important to note that the Canary archipelago is relatively close to the African mainland (ca. 95 km), and it has long been considered to be the result of large-scale oceanographic variation associated with the proximity of the Canary Islands to the continental coasts of Africa, with the eastern islands (Fuerteventura and Lanzarote) regularly influenced by seasonal upwelling off the African coast and exhibiting relatively high productivity (ca. 237 g C m<sup>-2</sup> yr<sup>-1</sup>) (Davenport et al., 2002).

## 2.2. Data analysis

Data were analysed by four widely accepted environmental categories and higher taxa of fishery resource species: oceanic pelagic fish, coastal pelagic fish, demersal fish (both benthic and benthopelagic), and shellfish (crustaceans, molluscs, and echinoderms), the latter two categories including both coastal and deepwater species. For each of these ecological groups, we indicate the most representative species of the food heritage in the four archipelagos, providing information on the capture techniques and information of general interest (on feeding habits and other).

We also provide examples of the traditional culinary dishes in each archipelago and point out the fat profile (data published by the authors, submitted or in preparation) of the fishery resources involved (fatty, with mean values of total lipids in their edible portion higher than 5%; semi-fat, between more than 1.75 and 5%; lean, up to 1.75%).

We have compiled in an extensive table (Supplementary Material 1) the main and secondary fisheries resources (with their scientific name and the zoological family) that have served as raw material in traditional Macaronesian gastronomy, indicating the English name, as well as their vernacular names used (in Portuguese or Spanish) in each archipelago. We have also compiled in a separated table (Supplementary Material 2) the names/modalities of the culinary dishes of the traditional seafood gastronomy of Macaronesia, indicating their names in the native languages to facilitate their identification and reach a wider audience, and indicating the archipelago and island of origin. The column of English names in the table of Supplementary Material 1 links to the traditional culinary recipes or modes of preparation from the Azores, Madeira, Canary Islands and Cabo Verde compiled in the table of Supplementary Material 2.

Taxonomic nomenclature of the fisheries families and species follows FishBase (Froese and Pauly, 2023), Eschmeyer's Catalog of Fishes (Fricke et al., 2023), and World Register of Marine Species (WoRMS Editorial Board, 2023). Common names of fishery species in English follow FishBase (fishes, Froese and Pauly, 2023) and SeaLifeBase (invertebrates, Palomares and Pauly, 2022).

## 3. Results

The biodiversity exploited by these artisanal fishing vessels and used in classic regional cuisine involves more than 220 primary and secondary marine species (grouped into 95 current zoological families) in

**Table 1**

Number and percentage of main and secondary species of fish and shellfish (and families to which they belong) traditionally utilised in the cuisine of Macaronesia and each of its archipelagos.

Fishery product	Macaronesia		Azores		Madeira		Canaries		Cabo Verde	
	Species	Families	Species	Families	Species	Families	Species	Families	Species	Families
Oceanic pelagic fish	20	9	13	6	17	10	18	8	15	7
Coastal pelagic fish	15	9	4	4	4	5	9	7	9	6
Demersal fish	146	50	47	24	66	29	96	40	74	26
Shellfish	41	27	17	15	19	15	31	22	16	14
Total	222	95	81	51	105	59	154	78	113	53
%	100	100	36	54	47	62	69	82	51	56

the Macaronesian region (Table 1 and Supplementary Material 1). Table 1 shows the numerical and percentage distribution of the fish and shellfish species and their families for the different archipelagos studied. About 330 culinary dishes or seafood preparation methods have been compiled (Supplementary Material 2).

### 3.1. Oceanic pelagic fish

These medium to large oceanic pelagic fishes are caught, one-by-one, with very specialised hook-and-line or pole-and-line artisanal methods. In Macaronesia, landings of tuna and tuna-like species by local fleets account for the largest volume by weight and the largest economic contribution (Alves et al., 2008; Bas et al., 1994; Gil Pereira, 1984; Santana et al., 1987; González et al., 2009, 2020a, 2020b; Westhaus, 1981). These fish are to be qualified as fatty products (González, 2013; González et al., 2004, 2020c).

Among the tunas, skipjack tuna (*Katsuwonus pelamis*), bigeye tuna (*Thunnus obesus*), yellowfin tuna (*T. albacares*), albacore (*T. alalunga*) and, to a lesser extent, Atlantic bluefin tuna (*T. thynnus*) are the main resources (Alves et al., 2008; Gil Pereira, 1984; González et al., 2009, 2020a, 2020b; Westhaus, 1981). However, in Cabo Verde, catches of *T. alalunga* and *T. thynnus* are scarce, while bullet tuna (*Auxis rochei*) and, to a lesser extent, frigate tuna (*A. thazard*) are frequent and abundant, supplying a cannery on the island of São Vicente which supports some 1500 jobs (particularly women) (González et al., 2009, 2019a, 2020b). Among the tuna-like and other related species, the fishing of wahoo (*Acanthocybium solandri*) is significant in Cabo Verde (Monteiro, 2008), constituting one of the most typical traditional culinary resources of the country (Chantre, 2001; Lopes, 1990). Catches of wahoo are of some importance (fishing and culinary) in the western Canaries (Mena et al., 1993; González et al., 2020c). However, in Madeira and the Azores, the species is a recreational/sport fishery and is not consumed in these archipelagos. Catches of Atlantic bonito (*Sarda sarda*) are increasingly abundant in the Canary Islands, especially in the eastern islands, where yellowmouth barracuda (*Sphyræna viridensis*) is also caught by hook-and-line gear in surface waters and culinary appreciated (Cabrera, 2008; González et al., 2022). Swordfish (*Xiphias gladius*), caught by hand line and surface longlines, is popular in the Azores (Gallagher et al., 2012) and Madeira, where it lends itself to many culinary preparations (Nunes, 1994), and to a lesser extent in the Canary Islands and Cabo Verde. Finally, dolphinfishes (*Coryphaena hippurus* and *C. equiselis*) are occasionally fished in the four archipelagos (Gallagher et al., 2012; González et al., 2022; Nunes, 1994; Monteiro, 2008) and, according to Nunes (1994), lending themselves to all kinds of culinary modalities (we have verified that specimens under about 10 kg are lean, while larger specimens are fatty). See Supplementary Material 1.

Tuna and related species are an extraordinarily versatile raw material in Macaronesian seafood cuisines. These products are prepared as appetizers, starters, salads, and main courses. Fresh or marinated, their loins, fillets, and belly fillets are traditionally grilled, broiled/griddle-grilled, oven-roasted and cocked in mixed cooking (fish stews or casseroles), also fried (Chela, 1997–1999; Fernández-Gil et al., 2014; M. Freitas et al., 2019; Gallagher et al., 2012; González, 2021; González

et al., 2004; Nunes, 1994; Pereira, 2007). Examples of culinary dishes include tuna patties in the Azores; fried tuna fillets or dry salted skipjack tuna in pickled sauce (“petisco”) in Madeira; marinated tuna on the griddle in the Canary Islands; grilled tuna belly or tuna stew (“cachupa”, very typical of classic Cabo Verdean cuisine) (Barrera Álamo, 1989; González et al., 2019a, 2020c, 2022; Millares, 2006). In Madeira and the Azores, it was traditional to salt tuna belly fillets, after two days in brine, which were then cooked and served in a spicy Portuguese sauce (“molho de vilão”) (Nunes, 1994). In the Canary Islands, tuna belly fillets and roe are fried or stewed for hodgepodge or medley (“salpicón”, a cold dish of chopped fish) (González et al., 2004). See Supplementary Material 2.

### 3.2. Coastal pelagic fish

These small, coastal, and gregarious pelagic fishes are caught by means of purse seines and other minor techniques. In Macaronesia, landings of these small blues by local fleets represent an important volume by weight of certain economic contribution (Alves et al., 2008; González et al., 2009, 2020a, 2020b; Westhaus, 1981). These fish are to be qualified as fatty food (González, 2013; González et al., 2004, 2020c).

Blue jack mackerel (*Trachurus picturatus*) is fished in the four archipelagos, especially in the Canary Islands and Madeira, where it is more popular than the other species in this ecological group (Alves et al., 2008; Gallagher et al., 2012; González et al., 2020a, 2020b; Nunes, 1994; Westhaus, 1981). In the Canary Islands, catches of this species are accompanied by Atlantic horse mackerel (*T. trachurus*) in the eastern-most islands (Fuerteventura and Lanzarote), close to the African continent (González et al., 2020a). Atlantic chub mackerel (*Scomber colias*) is traditionally fished in the Azores, Madeira and especially in the Canary Islands, where it is very popular in cuisine (Alves et al., 2008; Gallagher et al., 2012; González et al., 2020a; Nunes, 1994; Westhaus, 1981). The older (and therefore larger) individuals have benthic habits and, in the Canary Islands, are fished with hand lines (González et al., 2020a). The significant appearance of this species, against all odds, in Cabo Verde waters in recent years suggests a north-south migration that has not yet been explained (R. Freitas, pers. comm.). The European pilchard (*Sardina pilchardus*) and the anchovy (*Engraulis encrasicolus*) fisheries are of relative importance in the eastern Canaries where they are highly popular culinary products (González et al., 2004, 2020a), and of minor importance in Madeira (Alves et al., 2008). Round sardinella (*Sardinella aurita*) has a high level of catches in the Canary Islands, accompanied by Madeiran sardinella (*Sardinella maderensis*) (González et al., 2004, 2020a), and to a lesser extent in Madeira (Alves et al., 2008; Nunes, 1994) and Cabo Verde (González et al., 2020b). Fishing of sand smelt (*Atherina presbyter*) with small seines has had a long tradition in Madeira (Nunes, 1994) and the Canary Islands, where it can nowadays only be used as bait, as its commercialisation has been banned for many years (Báez et al., 2014; González et al., 2004). Bogue (*Boops boops*), although of lesser commercial importance, is also fished in all four archipelagos (Alves et al., 2008; Gallagher et al., 2012; González et al., 2020a, 2020b; Nunes, 1994). Other coastal pelagic fishes with tropical affinity are fished in Cabo Verde. The two species that enjoy great social and economic importance are bigeye scad *Selar crumenophthalmus* and, above

all, mackerel scad (*Decapterus macarellus*) which is the subject of an annual cultural and gastronomic festival (“Kavala fresk”) in São Vicente. To a lesser extent, these species are occasionally accompanied by round scad (*Decapterus punctatus*). See [Supplementary Material 1](#).

This group of small coastal pelagics can be prepared in a variety of ways. Fresh, marinated or salted, whole fish or fillets are traditionally grilled, broiled/grilled, baked and cocked in mixed cooking (stews), as well as fried, filled or in meatballs (Chela, 1997–1999; Fernández-Gil et al., 2014; Gallagher et al., 2012; González, 2021; González et al., 2004; Massieu, 1995; Mújica, 1982; Nunes, 1994; Pereira, 2007). Examples include blue jack mackerels fried in flour in the Azores; chub mackerel with villain sauce (“molho de vilão”) or fried with cooked corn in Madeira; fried sardines, mackerel noodles or a stew with noodles, pulses, and grains (“rancho canario”) in the Canaries; bigeye scad fillets in tomato sauce or mackerel scad with bean rice in Cabo Verde (Fonseca et al., 2014; González et al., 2019a, 2020c, 2022; Nunes, 1994). In the Canary Islands, the chub mackerel roe in oil and salt, canned and preserved under the name “caviar gomero” (caviar from the island of La Gomera), was a delicious snack for three decades until the factories closed. Also, anchovy pieces, together with sand smelt and small, salted-dried sardines and sardinella, were a popular snack (“pejines”) in the Canaries consumed by simply sprinkling them with alcohol, schnapps or rum and burning them (Franquet and Brito, 1995; González et al., 2004). See [Supplementary Material 2](#).

### 3.3. Demersal fish

A significant number of benthic and benthopelagic species (estimated at 150) are exploited in Macaronesia by traps, gill nets, hook-and-line, and other minor fishing gear (Alves et al., 2008; González et al., 2009, 2020a, 2020b; Silva, 1987; Westhaus, 1981). This varied fish larder includes species ranging from lean to semi-fat (Belín González, 2016; González, 2013; González et al., 2004, 2020c; 2021b; Lorenzo Perera et al., 1999; Massieu, 1995; Mújica, 1982). See [Supplementary Material 1 and 2](#).

#### 3.3.1. Coastal and shelf species

Numerous benthic species belonging to around twenty families are exploited in Macaronesia from shallow waters to the limit (at a depth of 180/200 m) of the small island platforms (Alves et al., 2008; González et al., 2009, 2020a, 2020b; Oddsson and Monteiro, 1998; Westhaus, 1981). Several studies have shown that the composition of the macrofauna (both crustaceans and fishes) inhabiting these habitats has more tropical or warm-water affinities in Cabo Verde than in the Canary Islands-Madeira (Freitas et al., 2019; González, 2018; González et al., 2021a). In sum, several species of labrids, sparids, serranids, epinephelids, muraenids, congrid, carangids, balistids, mullids, haemulids, priacanthids, pomacentrids and/or scorpaenids, among others, are the target of artisanal fisheries in the four volcanic archipelagos, with some differences in number of species, volume of catches, fishing techniques and other parameters of the extractive activity.

At species level, the parrotfish (*Sparisoma cretense*) is by far the demersal resource most caught by the Canarian artisanal fisheries, with a value historically stabilised at around  $200 \text{ t y}^{-1}$  (González et al., 2020a). In addition to its economic value, this species (a lean food) forms a very important part of the food and cultural heritage – literary works, folklore, popular sayings – of the region. There is a regional debate on whether it should be cooked with or without scales. Unfortunately, the tradition of preparing salted and dried parrotfish (“jarea”) is disappearing. With an Atlanto-Mediterranean biogeographical pattern, the parrotfish is undoubtedly the most representative and emblematic common fishery species of Macaronesia, in whose archipelagos it has reached important levels of abundance (Cabrera, 2008; Franquet & Brito, 1995; Gallagher et al., 2012; González, 1991; González et al., 2009; Nunes, 1994). Although fishing for this species began late in the Azores, this region “exports” parrotfish to its

neighbours in Madeira, where it has a good level of consumption. In Cabo Verde it is a very popular resource (González et al., 2020b; Monteiro, 2008), although unfortunately it appears in the markets gutted and damaged, as it is usually fished with spearguns together with the West-African parrotfish (*Sparisoma choati*) and Guinean parrotfish (*Scarus hoefleri*). Examples include roasted parrotfish in the Azores; fried/boiled/grilled parrotfish in Madeira (Nunes, 1994); parrotfish (fresh or salted-dried) boiled in the Canary Islands (Chela, 1997–1999; González et al., 2020c; Millares, 2006); breaded and fried parrotfish in Cabo Verde.

Pink dentex (*Dentex gibbosus*), red porgy (*Pagrus pagrus*) and other sparids of the genera *Pagellus* and *Diplodus* (pandoras and seabreams) show high levels of catches and culinary appreciation in the Canary Islands, Madeira, and the Azores (Alves et al., 2008; González, 1991; González et al., 2009, 2020a, 2020b, 2022; Nunes, 1994; Silva, 1987; Westhaus, 1981); within this group, only *Diplodus* are well represented in Cabo Verde (González et al., 2009, 2020b; Monteiro, 2008). The red porgy fisheries, with bottom longline/handline, are among the most traditional in the Azores (Silva, 1987; Westhaus, 1981) and Madeira, where common pandora fishing is also common (Alves et al., 2008). Fishing for black seabream (*Spondyliosoma cantharus*) is of some importance in the Canary Islands and, to a lesser extent, in Cabo Verde (González et al., 2020a, 2020b). In addition, fishing with beach seines, gillnets and/or handlines for the endemic blackspot picarel (*Spicara melanurus*) and bulldog dentex (*Virididentex acromegalus*) is traditional in Cabo Verde (González et al., 2009, 2020b; Monteiro, 2008). Examples include oven-roasted blackspot seabream in Azores; red porgy/pink dentex cooked/fried/grilled/oven in Madeira; baked Moroccan white seabream with vegetables or pink dentex in onion in the Canaries (Chela, 1997–1999; González, 2013; González et al., 2004, 2020c); common pandora or blackspot picarel stew (“caldeirada”) in Cabo Verde (Silva et al., 2021). In general, sparids are lean or semi-fatty foods, depending on the species and their annual cycle phase (González, 2013; González et al., 2004, 2020c, 2022).

Blacktail comber (*Serranus atricauda*) and comber (*S. cabrilla*) are commonly fished in Macaronesia (Alves et al., 2008; González et al., 2020a, 2020b; Monteiro, 2008; Silva, 1987; Westhaus, 1981); also, the moth-winged comber (*S. papilionaceus*) is regularly caught in the Canaries (González-Lorenzo et al., 2021). Catches of dusky grouper (*Epinephelus marginatus*) and island grouper (*Mycteroperca fusca*) are relatively frequent in Macaronesia (González et al., 2020a, 2020b). However, since 2022 *E. marginatus* is protected in Madeira archipelago (Resolução do Conselho do Governo Regional no. 604/2022). The bluespotted seabass/African hind (*Cephalopholis taeniops*) is one of the most important target species in Cabo Verde, where it is a popular culinary staple (González et al., 2020b; Monteiro, 2008). Examples include grilled wreckfish in the Azores; fried blacktail comber in Madeira; grouper casserole or island grouper in green sauce in the Canaries; grilled African hind in Cabo Verde (González et al., 2019a, b). Serranids and epinephelids are semi-fatty foods (González, 2013; González et al., 2004, 2020c, 2022).

Moray eel fishing and consumption is very common in Cabo Verde, the Canary Islands and, to a lesser extent, Madeira, and the Azores (González et al., 2021a). The quantity and variety of moray eels caught in Cabo Verde throughout the year have made these resources very popular and it is the most common gastronomic starter in the country, where they have also been associated with music festivals (e.g., ‘Baia das Gatas Festival’ in São Vicente, ‘Gamboa Festival’ in Santiago). The Mediterranean moray (*Muraena helena*) and the black moray (*M. augusti*, endemic to Macaronesia) are very common and popular in the region (Barrera Álamo, 1989). However, three species of tropical moray eels historically yield the largest catches in Cape Verde: purplemouth moray (*Gymnothorax vicinus*), stout moray (*Muraena robusta*), and honeycomb moray (*M. melanotis*) (González et al., 2021a). Conger eels (mainly European conger, *Conger conger*) are also fished and consumed in Macaronesia (González et al., 2004, 2009, 2020a, 2020b; Monteiro, 2008;



Silva, 1987). Examples include poached conger eel medallion in the Azores; conger eel and shellfish in stew in Madeira; fried moray eel in the Canary and Cabo Verde islands (González et al., 2009). Moray and conger eels are semi-fatty foods (González, 2013; González et al., 2004, 2020c, 2022).

Medium-sized benthic carangids are also caught in relative abundance in Macaronesia. Amberjacks (*Seriola* spp.), white trevally (*Pseudocaranx dentex*) and pompano (*Trachinotus ovatus*) are common to all four archipelagos, although Cabo Verde also obtains tropical jacks (*Caranx* spp.) and rainbow runner (*Elagatis bipinnulata*). Examples include baked white trevally in the Azores; fried pompano in Madeira; grilled amberjack in the Canary and Cabo Verde islands (González et al., 2019a, 2020c, 2019b, 2022). Jacks and pompanos are semi-fatty products (González, 2013; González et al., 2004, 2020c, 2022).

Forkbeard (*Phycis phycis*) fishing is also traditional in the Azores and the Canary Islands, to a lesser extent in Madeira (González et al., 2020a; Silva, 1987). Examples of this lean fish (González, 2013; González et al., 2020c) include forkbeard rump or fried forkbeard in the Azores; oven-roasted forkbeard in Madeira; forkbeard open and griddled in the Canaries (M. Freitas et al., 2014; González et al., 2004, 2012b, 2020c).

The planehead filefish (*Stephanolepis hispidus*) fishery in the eastern Canary Islands, and to a lesser extent in Cabo Verde, is worth noting (González et al., 2020a). Examples of this lean food include fried planehead filefish with its livers (González et al., 2020c).

A curious case is carried out by the bright glasseye (*Heteropriacanthus fulgens*), a fish endemic to Madeira, the Canary and Cabo Verde islands. In Cabo Verde it is usually consumed (along with the Atlantic bigeye *Priacanthus arenatus*) salty-dry (in times and locations without ice or refrigeration) and fresh in stews or breaded (González et al., 2019a, 2019b, 2020b; Silva et al., 2021). In some coastal towns in the Canary Islands, this fatty fish (González and Mojo, 2019) was a common raw material for the fishermen's own soups and stews, however, this product has fallen into disuse and is very rarely present in the markets. In Madeira, despite its white and rich flesh, it appears little in the markets and at low prices (Nunes, 1994). This author pointed out some of the possible causes of the low popularity of this fish. Upon being captured, the bright glasseye emits an odour reminiscent of urine. They frequently have several ectoparasitic isopods, attached to their fins and caudal region, which can cause disgust in the buyer due to their resemblance to cockroaches.

### 3.3.2. Deepwater species

Other benthic species belonging to a dozen families are exploited, to a greater or lesser extent, in semi-deep and deep waters of the Macaronesia. In summary, several species of sparids, polyprionids, scorpaenids, muraenids, congrid, berycids, epigonids, merluccids, morids, phycids and/or trichiurids, among others, are subject to artisanal fisheries in the Azores, Madeira, and the Canary Islands (Alves et al., 2008; González, 1991; González et al., 2020a; 2012b; Nunes, 1994; Silva, 1987; Westhaus, 1981), while fishing for these species is underdeveloped in Cabo Verde due to technical and financial investment constraints (González et al., 2009, 2020b).

Other sparids such as blackspot seabream (*Pagellus bogaraveo*) and large-eye dentex (*Dentex macrophthalmus*) (accompanied by Moroccan dentex *D. maroccanus* in the eastern Canaries) show moderate levels of catches and culinary appreciation in the Azores, Madeira, and the Canaries (Alves et al., 2008; González et al., 2020a; Nunes, 1994; Silva, 1987), large-eye dentex being relatively abundant in experimental fisheries in Cabo Verde. The blackspot seabream fishery, with bottom longline, is one of the most traditional in the Azores (Silva, 1987; Westhaus, 1981) and Madeira (Alves et al., 2008). Examples include oven-roasted blackspot seabream in the Azores, blackspot seabream stew with onion and tomato in Madeira. These fish are semi-fatty foods (González et al., 2020c).

The wreckfish (*Polyprion americanus*) fishery is traditional in the Azores (Silva, 1987; Westhaus, 1981), where wreckfish cuisine is very

popular, and to a lesser extent in Madeira and the Canary Islands (Alves et al., 2008; González et al., 2020a). Examples of this semi-fatty fish include grilled or rump wreckfish in the Azores; boiled/fried/cooked wreckfish in Madeira; wreckfish fillets or broth in the Canaries (González et al., 2020c).

Blackbelly rosefish (*Helicolenus dactylopterus*), red scorpionfish (*Scorpaena scrofa*) and offshore rockfish (*Pontinus kuhlii*) are frequently caught in the Azores, Madeira, and the Canary Islands (Alves et al., 2008; González et al., 2020a; Silva, 1987), and to a lesser extent in Cabo Verde where, in addition, experimental fisheries indicate a higher potential than at present (González et al., 2020b). Examples of these semi-fatty fish include grilled/fry fillet of blackbelly rosefish in the Azores; grilled/fry fillet of offshore rockfish; red scorpionfish soup in the Canary and Cabo Verde islands (M. Freitas et al., 2014; González et al., 2012b, 2020c). These fish are lean to semi-fatty foods (González, 2013; González et al., 2004, 2020c).

Fishing for splendid alfonsino (*Beryx splendens*) and, to a lesser extent, for alfonsino (*B. decadactylus*), with longlines and handlines, is of great importance in the Azores, Madeira, and the Canary Islands (González et al., 2020a, 2020b; Schönhuth et al., 2005). Examples include alfonsino rump in the Azores; oven-roasted splendid alfonsino in Madeira; griddled open splendid alfonsino in the Canaries (M. Freitas et al., 2014; González et al., 2012b, 2020c). The splendid alfonsino is a lean fish with delicate flesh that blackens quickly, while the alfonsino, surprisingly, is a fatty product (González, 2013; González et al., 2004, 2020c).

Fishing for benthopelagic black scabbardfishes (*Aphanopus carbo* and *A. intermedius*), practised by the Madeiran mid-water drifting longline fleet in the deep waters off Madeira, Canaries, and nearby seamounts, is an artisanal activity that dates back some 150 years (Biscoito et al., 2011). This activity has recently spread on a much smaller scale to the Azores and the island of La Palma. To date, no experimental fishery has been conducted to verify the existence of *Aphanopus* in Cabo Verde waters. Examples of these lean products – undoubtedly the most appreciated by native Madeiran consumers – include a wide variety of culinary preparations, including their fried roe (M. Freitas et al., 2014; González, 2013; González et al., 2012b, 2020c; Nunes, 1994). The main by-catch species in this fishery is leafscale gulper shark (*Centrophorus squamosus*) (M. Freitas et al., 2018) which, salted and dried as cod, has been one of the traditional starters (“xara”) in Madeira's gastronomy (Nunes, 1994; Pereira, 2007).

Other artisanal bottom longline shark fisheries, which are currently being abandoned, targeted shortnose spurdog (*Squalus megalops*) in the Canary Islands and smooth-hound (*Mustelus mustelus*) in the Canary and Cabo Verde islands (Espino et al., 2022; Monteiro, 2008) as well as kitefin shark (*Dalatias licha*) in the Azores and Madeira (Silva, 1987; Westhaus, 1981). The lean flesh of these sharks was consumed fresh in traditional dishes and, in the Canary Islands, cut into long strips, salted and then dried (“tollos”) as a classic appetizer (Brito et al., 1998; Espino et al., 2022; González et al., 2020c).

Fishing for European hake (*Merluccius merluccius*), with longlines and handlines, is of great importance in the eastern Canary Islands (Franquet and Brito, 1995; González et al., 2020a). Examples include a wide variety of culinary preparations, including its fried roe (González, 2013; González et al., 2004, 2020c). In Macaronesia, bottom longline fishing for ling (*Molva macrophthalma*) is exclusive to the Azores (Gallagher et al., 2012), where it functions as a substitute species for hake.

Fishing for common mora (*Mora moro*), with longlines and handlines, has gained some notoriety in the Azores and Madeira, although it has been practically abandoned in the Canary Islands (González et al., 2020a). This lean product has the same culinary versatility as hake, although it is usually prepared fried or cooked with onions (M. Freitas et al., 2014; González, 2013; González et al., 2004, 2012b).

### 3.4. Shellfish

Macaronesian shellfish are collected by a range of small-scale harvesting methods (including gaffs) and with some selective traps and handlines (Biscoito et al., 2021; Franquet and Brito, 1995; González, 1991, 2013; González et al., 2012a, 2020a, 2020b). This ecological group includes generally lean species, although some crabs show a semi-fatty profile (González, 2013; González et al., 2004, 2020c). See Supplementary Material 1 and 2.

#### 3.4.1. Molluscs

The most representative mollusc of the Macaronesian fauna and gastronomy is undoubtedly the group of limpets (*Patella* spp.), with one species exploited in Cabo Verde and between two and four species in the remaining archipelagos (Biscoito et al., 2021; Delgado et al., 2019; Franquet and Brito, 1995; Gallagher et al., 2012; González et al., 2020a, 2020b, Sousa et al., 2023). The systematics of this group in Macaronesia has traditionally been controversial and, at present, several research groups are studying morphological, bioecological, and genetic aspects of their populations, with the presence of endemic subspecies being identified (Quinteiro et al., 2016, 2022; Sousa et al., 2020, 2021). Other gastropods traditionally collected and used in Macaronesian cuisine are the group of marine topshells/periwinkles (*Phorcus*) with one species exploited in Madeira (*P. sauciatus*) (Biscoito et al., 2021; Delgado et al., 2019; Sousa et al., 2018, 2019) – served usually as an entrée – and two (the former and *P. atratus* endemic to Madeira, the Canary Islands and Cabo Verde) in the Canary Islands (Franquet and Brito, 1995; González et al., 2012a). The tuberculate abalone (*Haliotis tuberculata*) is exploited, to varying degrees, in all four archipelagos (Franquet and Brito, 1995; Gallagher et al., 2012; González et al., 2012a), but its harvesting is currently prohibited in the Canaries. In the Triton group, knobbed Triton (*Charonia lampas*) is harvested on a small scale in the Azores (Gallagher et al., 2012) and Canary Islands (Franquet and Brito, 1995), while exploitation of *Charonia* spp., redmouth purpura (*Stramonita haemastoma*) and other similar snails is currently banned in the Canaries (Báez et al., 2014; González et al., 2020a). Examples of these lean products include soupy rice with limpets, grilled limpets/abalones, boiled periwinkles in any of the archipelagos studied (Chela, 1997–1999; González et al., 2019a; 2020c). In the island of El Hierro we have observed the use of purged periwinkles in salads or to obtain a blackish soup.

Among the cephalopods, the common octopus (*Octopus vulgaris*) and, to a lesser extent, the European squid (*Loligo vulgaris*) and the flying squids (Ommastrephidae) are caught and used, to varying degrees, for culinary preparations in the four archipelagos (Biscoito et al., 2021; Franquet and Brito, 1995; Gallagher et al., 2012; González et al., 2019a, 2020a, 2020b, 2020c).

#### 3.4.2. Crustaceans

The lobster group is perhaps the most representative of Macaronesia, both in terms of catches and gastronomy. In Cabo Verde, the main coastal target species are hand caught royal or green spiny lobster (*Panulirus regius*) and brown spiny lobster (*Panulirus echinatus*) (Palinuridae) and Mediterranean slipper lobster (*Scyllarides latus*) (Scyllaridae). A deepwater species, the Cape Verde spiny (or pink) lobster (*Palinurus charlestoni*), endemic to this archipelago, is being subject to commercial exploitation in the region by means of specialised bottom traps (González et al., 2009a; 2020b). In the Azores, there is a traditional trap fishery for *S. latus* and common spiny lobster (*Palinurus elephas*), although hand harvesting is also practised (Gallagher et al., 2012; Rost Martins, 1985). In Madeira only sporadic catches of *S. latus* occur (Biscoito et al., 2021), while very recent (unpublished) experimental fisheries in their usual fishing grounds do not find *P. elephas* or any other palinurids. In coastal waters of the Canary Islands, *P. echinatus* (in the western islands), *S. latus*, and *P. elephas* were sporadically caught by different methods; nowadays only semi-deep-water catches of the latter species are allowed as bycatch with fish-traps (Báez et al., 2014;

González et al., 2020a). Examples include slipper lobster cooked with grilled green corn in Azores; cooked regional slipper lobster in Madeira; sweated spiny lobster in local style in Cabo Verde (González et al., 2019a).

Perhaps the second most important group in Macaronesia are the pandalid shrimps. A traditional fishery for narwal shrimp (*Plesionika narval*), with specialised benthic traps, exists in the Azores, Madeira and especially in the Canaries (González et al., 2012a). Over the last twenty-five years, a fishery for striped soldier shrimp (*P. edwardsii*) with benthic and epibenthic (semi-floating) shrimp-traps has progressively consolidated, at different levels of development, in the four archipelagos (González et al., 2012a), with the Canary Islands standing out with a good level of catches and high consumer demand (Gallagher et al., 2012; González, 2013, 2021; González et al., 2020a, 2020b). Examples include boiled or grilled shrimps in any of the archipelagos surveyed (M. Freitas et al., 2014; González et al., 2012a, 2020c).

Crabs are also fished and consumed in Macaronesia. Among the intertidal species, red rock crab (*Grapsus adscensionis*) is harvested in all four archipelagos and grey rock crab (*Plagusia depressa*) are harvested by hand or with a specialised rod. Among the traditional deep-water crab, only toothed rock crab (*Cancer bellianus*), caught with traps, can be found in the Azores, Madeira, and the Canary Islands. Generally used boiled as an appetizer, for broth or in casseroles and rice dishes, also as a main dish in the case of, for example, toothed rock crab velouté with sugarcane syrup in Madeira (Biscoito et al., 2021; M. Freitas et al., 2014; González, 2013; González et al., 2012a, 2020c).

Among the cirripedes, the harvest and consumption of Azorean barnacle (*Megabalanus azoricus*) in the four archipelagos studied (Quinteiro et al., 2015) and goose barnacles in the Canary Islands (*Pollicipes pollicipes*, currently protected) and Cabo Verde (*P. caboverdensis*, endemic) are noteworthy (Báez et al., 2014; Franquet and Brito, 1995; Gallagher et al., 2012; González et al., 2020b). Examples include boiled Azorean/goose barnacles as an appetizer in Cabo Verde.

#### 3.4.3. Echinoderms

Among the echinoderms, we only know of the traditional use of the roe of the rock sea urchin (*Paracentrotus lividus*), a semi-fatty product (González and Mojo, 2019), which is consumed in some parts of the Canary Islands (Franquet and Brito, 1995), as in the case of raw consumption with kneaded “gofio” (= a sort of Canarian flour made from roasted grains – typically wheat or certain varieties of maize – or another starchy plant) at the sea urchin festival in Tenesar (Tinajo, Lanzarote) (González et al., 2022).

### 3.5. Other Cabo Verdean tropical fish and shellfish

A variety of demersal species with tropical or subtropical affinity, native to the Cabo Verde, are usually fished by hand and consumed by the islanders. See Supplementary Material 1 and 2.

Among the fish families not represented in the native fauna of the Canary Islands or Madeira, lutjanids (with four species of snappers of the genera *Lutjanus* and *Apsilus*), acanthurids (especially Monrovia doctorfish *Acanthurus monroviae*), lethrinids (Atlantic emperor *Lethrinus atlanticus*), holocentrids (blackbar soldierfish *Myripristis jacobus* and squirrelfish *Holocentrus adscensionis*) and polynemids (lesser African threadfin *Galeoides decadactylus*) stand out. Among the families represented in the native fauna of the Canaries or Madeira, haemulids (especially the pignout grunt *Pomadasyds rogerii*) and mullids (West African goatfish *Pseudupeneus prayensis* and yellow goatfish *Mulloidichthys martinicus*) stand out (González et al., 2020b; Monteiro, 2008). These are products between lean and semi-fat, used in traditional soups, stews and fried foods (Befín González, 2024; González et al., 2019a, 2019b; Silva et al., 2021).

Among the shellfish families not represented in the native fauna of the Canary Islands or Madeira, *Thetystrombus latus* (Strombidae) is the



only whelk species subject to intensive commercial exploitation by hand (apnoea), towed dredge, and mainly by scuba-diving in Cabo Verde (González et al., 2020b). This gastropod, along with moray eels, is the most popular appetizer (stewed welk) in the country (González et al., 2019a). Mixed with true limpets (*Patella*), keyhole limpet (*Fissurella alabastrites*) and other fissurellids are subject to commercial exploitation by hand (González et al., 2020b).

### 3.6. Northwest-african species traditionally present in the gastronomy of the Canaries

Already in the 14th century and especially in the 15th with the annexation of the Canary Islands to Castile, the new islanders settled in the Canaries practiced an incessant and growing fishing activity until the 17th century in the neighbouring NW coast of Africa. Several war events resulted in the Canary fishing fleet continuing to operate exclusively in the area, expanding its fishing grounds to the entire Saharan coast (Rumeu de Armas, 1977). In those times, fish was preserved salty on board and their primary target was large demersal fish they caught with hook and gill gear (Balguerías, 1993). The two world wars occurred in the 20th century closed the North Atlantic fishing grounds and this forced Spanish and some European fleets to move to the Saharan bank (Balguerías, 1993). Since the abandonment of the Sahara by Spain in 1975 and especially since Spain's entry into the EU in 1986, bilateral fishing agreements have allowed some Spanish fleets to continue operating from Morocco to Senegambia. In short, because of the historical interactions between the Canary Islands and this region of the African continent over some 550 years, numerous and diverse products of fishing (first artisanal and then industrial) in Africa have traditionally been present in Canarian markets and have formed part of its intangible food heritage (Bas et al., 1994; Espino et al., 2022; García Cabrera, 1970; González, 2021; González et al., 2004). See Supplementary Material 1 and 2.

Undoubtedly, the most outstanding fish species has been the white grouper (*Epinephelus aeneus*), to the point of becoming the emblematic dish of the gastronomy of the four eastern Canary Islands: the “sancho” (González et al., 2004, 2020c). It is a dish that combines this product (salted) cooked with vegetables (Chela, 1997–1999). Today, however, white grouper from Mauritania and Senegal, a semi-fatty food, is also consumed fresh by the islanders in various culinary forms throughout the year (González et al., 2004, 2020c). Other epinephelids (groupers) of northwest-African origin have reinforced the Canary Islands catches of dusky grouper (*E. marginatus*) and have brought new traditional products to the islands market: goldblotch grouper (*Epinephelus costae*) and mottled grouper (*Mycteroperca rubra*) (González et al., 2004).

A second group of products from the NW African coast has traditionally and uninterruptedly consisted of cephalopods, basically common octopus (*O. vulgaris*), veined squid (*Loligo forbesi*) and common cuttlefish (*Sepia officinalis*) (González, 2021). These lean products are the basis of starters and main dishes (roasted or in stews) (González, 2013; González et al., 2022c).

Meagre (*Argyrosomus regius*) and other sciaenids of the genus *Pseudotolithus* (croakers), traditionally from Western Sahara, Mauritania, and Senegal, are the third largest group of products originating from the African coasts (González, 2021; González et al., 2004). They are semi-fatty foods that are eaten grilled, breaded or onioned, and their roe fried or in salads. They are the raw material for the popular fish fritters (“churros de pescado”) (González et al., 2004).

A fourth group has traditionally been made up of large sparids (“sama”), including species that are fished in Canary waters (pink dentex, red porgy, redbanded seabream (*Pagrus auriga*) and common dentex (*Dentex dentex*)) as well as others that are rare or non-existent in this archipelago: bluespotted seabream (*Pagrus caeruleostictus*), gilthead seabream (*Sparus aurata*) and Canary dentex (*Dentex canariensis*) (González, 2021; González et al., 2004).

Various species of flatfishes from NW Africa have traditionally been

present in Canarian markets: bastard sole (*Microchirus azevia*), Senegalese sole (*Solea senegalensis*), tonguesoles (*Cynoglossus* spp.) and spottail spiny turbot (*Psettodes* spp.), which are usually eaten fried or roasted on the grill (González, 2021; González et al., 2004).

## 4. Discussion

Fishing (in terms of small-scale fisheries) is a primary activity of great economic and social importance in Macaronesia sensu lato (the Azores, Madeira, Canary, and Cabo Verde islands) and has traditionally played an important role in reducing poverty, in job creation, strengthening food security and sovereignty, balance of payments equilibrium and increase in gross domestic product (Espino et al., 2022; González et al., 2020a, 2020b). Furthermore, fishing activity has a prominent place in the regional/country's strategic economic development plans, whose importance is greater in the archipelagos furthest from the mainland and less touristic (Azores and Cabo Verde) and lesser in the archipelagos closer to the continent and more touristic (Canary Islands and Madeira) (González et al., 2020a, 2020b). Fresh fish constitutes an important source of animal protein commonly consumed by the Macaronesian population. Women fish peddlers, especially the “vendedeiras” of Cabo Verde (González et al., 2009) have played a fundamental role in the exchange or barter economy. They have brought fish to the inland areas of the islands and brought vegetables, cereals, seasonal fruit and sometimes some money to the coastal communities. They have been the link between the products of the fishery and those of the land. Another example: in the Azores, limpets were generally sold door-to-door by fishermen's wives who carried them in baskets.

The fleets based in the Macaronesian archipelagos carry out artisanal and semi-industrial fishing activities, with a rotation strategy aimed at resources with a seasonal pattern. This characteristic gives the fishery products spatial/temporal proximity, quality, and a certain degree of sustainability (González, 2016). Fishing trips generally take place in nearby waters, are of short duration and the product is landed fresh, usually within the day or a few days (González et al., 2020a, 2020b, 2020c, 2022).

A clear north (Azores) - south (Cabo Verde) pattern is observed, reflecting a gradual increase in the number of species used in traditional culinary arts (Table 1). The higher values in the Canary Islands, compared to Cabo Verde, can be attributed to two main factors. Firstly, the Canary Islands' closer proximity to the African continent has led to the incorporation of around twenty African species, which have historically been available in the Canarian market. Secondly, Cabo Verde has seen limited development in its deep-water fisheries. In conclusion, we can say that, both overall and in each archipelago, there has traditionally been a wide and varied pantry of products (local or of nearby origin) available to consumers in these islands of the north-eastern Atlantic.

Many of these fish and shellfish caught and consumed by Macaronesian people form a crucial part of their cultural heritage. For this reason, encouraging local production and educating in smarter, healthier, and more sustainable consumption based on local products must be a priority and urgent strategy. However, this promotional task is more difficult to implement in regional economies strongly based on mass tourism, as is the case in Madeira and especially the Canary Islands, and apparently in Cabo Verde, where the import of foreign products from distant origins is gradually taking over. In addition, the use of clean, gutted, and filleted products is also gaining in importance in the HORECA channel (hotels - restaurants - catering) in these archipelagos where there is a shortage of fish processing industries. On the other hand, a high percentage of European tourists are not familiar with the handling of fish with head and spines.

The cuisine of the four Macaronesian archipelagos studied uses similar or equivalent marine raw materials, although Cabo Verde incorporates a greater number of tropical and even endemic species. The use of fatty fish (which we refer to as “blue fish”) is particularly important: tunas, tuna-like, and small and medium-sized pelagic fish.

The semi-fatty fish (“green fish”) include serranids, epinephelids, muræenids, congrid, carangids and sparids, among others. Among the lean fish (“white fish”), parrotfishes and related fishes stand out. Shellfish (from lean to semi-fat products) includes mainly coastal species: molluscs (chiefly cephalopods and gastropods) and decapod crustaceans (mainly crabs, shrimps, and lobsters in Cabo Verde).

Due to a greater development in fishing technology, semi-deep and deepwater species are more present in the Azores and Canary culinary, although Madeira (black scabbardfishes) and Cabo Verde (the endemic pink lobster) also have some specificities with a strong traditional character.

Due to its proximity to the continent and secular fishing and commercial activity with the neighbouring coastal countries, the gastronomy of the Canary Islands enjoys many species from NW Africa: cephalopods, groupers, meagre and croakers, flatfishes, sparids and triakids.

The results of the present study suggest a substantial similarity in the fishery resources utilised in the traditional cuisines of these four Macaronesian archipelagos and, moreover, at least between the Canary Islands and the Spanish Mediterranean (see [González, 2016](#)).

In most households across Macaronesia, traditional cooking used lard (ES “manteca de cerdo”) for frying and in home baking, especially among the lower social classes. However, the middle and upper classes in the Canaries, Madeira, and the Azores also used sunflower oil and even corn and olive oil, especially for baking fish and fish salads (hodgepodge/medley, ES “salpicones”). We attest to the use of such oils (which came from the Iberian Peninsula, in 50-L drums) based on the authors’ family backgrounds and old recipe books from Gran Canaria and La Gomera (1930–1960). A reference to olive oil, as a luxury alternative to lard, can be found in Lorenzo Perera et al. (1999: 170) for frying eels. In Cabo Verde, lard (PT “banha de porco”) was also primarily used, with sunflower oil and homemade butter to a lesser extent, while olive oil has always been reserved for salads. Additionally, in the warmer (southernmost) archipelagos, it has been customary to rest after lunch: lying down (in bed or on the sofa) for a nap in the Canaries (“siesta”) or sitting (in a typical rocking chair, “a cadeira de baloiço”) to rest in Cabo Verde. Furthermore, the limitation in the use of pork lard also stemmed from a historical factor: the religious affiliation of the new European settlers of the Macaronesia islands, which received significant settlements in the late 15th and especially the 16th centuries.

The classic (and the updated classic) cuisine of the four Macaronesian archipelagos is based on traditional recipes that form a very important part of their intangible food heritage, which must be preserved, disseminated, and passed on to current and future generations.

In the case of the Azores ([Gomes, 2019](#)) and the Canary Islands ([Caballero Martel et al., 2009](#); [González, 2016](#)), we are heirs to a gastronomy with Portuguese-Spanish roots, resulting from the Mediterranean Diet. And this statement is perfectly applicable to Madeira and, to a lesser extent, to Cabo Verde, which inherited a large part of Portuguese cuisine. In sum, Macaronesia’s gastronomic heritage, rooted in Portuguese and Spanish traditions, reflects a Mediterranean Diet characterized by lifestyle and the utilization of traditional recipes.

## 5. Implications for gastronomy

The traditional cuisine of the Macaronesian archipelagos (including the Azores, Madeira, Canary, and Cabo Verde islands) is deeply rooted in time-honored recipes, forming a vital element of their intangible culinary heritage. As advocated by the FAO, promoting local production and fostering education for smarter, healthier, and more sustainable consumption based on local products should be an urgent and top-priority strategy in any region, particularly in oceanic archipelagos with economies heavily reliant on mass tourism. Beyond cultural reasons, consuming local products contributes to environmental preservation, enhances food security and sovereignty, and promotes the health and well-being of consumers, among other social and economic benefits.

## CRedit authorship contribution statement

**José Antonio González:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Ana L. Álvarez-Falcón:** Writing – review & editing, Investigation, Data curation. **Ricardo Sousa:** Writing – review & editing, Writing – original draft, Investigation, Data curation. **Mafalda Freitas:** Writing – original draft, Investigation. **Sandra Correia:** Writing – original draft, Investigation. **José M.N. Azevedo:** Writing – original draft, Investigation.

## Declaration of competing interest

The authors declare that they have no conflicts of interest associated with this work.

## Data availability

Data will be made available on request.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijgfs.2024.100942>.

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