Journal of Coastal Conservation (2023) 27:39
https://doi.org/10.1007/s11852-023-00961-z

Status and perspectives of blue economy sectors across the Macaronesian archipelagos

Yaiza Fernández-Palacios[1] · Sadasivam Kaushik[1] · Andrej Abramic[1] · Víctor Cordero-Penín[1] · Alejandro García-Mendoza[1] · Alberto Bilbao-Sieyro[2] · Yeray Pérez-González[2] · Pedro Sepúlveda[3,4] · Isabel Lopes[5] · Carlos Andrade[3] · Natacha Nogueira[6] · Gilberto P. Carreira[7] · Maria Magalhães[7] · Ricardo Haroun[1]

Received: 30 January 2023 / Revised: 19 May 2023 / Accepted: 29 July 2023 / Published online: 26 August 2023

Abstract
The global economy is increasingly focusing on the Oceans to meet its needs, for which maritime spatial planning is being fostered to promote this is done sustainably. Thus, assessing the current state and future development trends of the maritime sectors is key to evaluating the performance of the planning process. This is the aim of this study, in which the main maritime sectors related to the blue economy present in the archipelagos of the European Macaronesia Sea Basin, i.e. the Azores and Madeira (Portugal), and the Canary Islands (Spain), were identified and studied. The following maritime sectors were analysed: fisheries, marine aquaculture, marine biotechnology, coastal and maritime tourism, maritime transport, ship repair and maintenance, extraction of aggregates, deep-sea mining, offshore oil and gas, renewable ocean energies, and desalination. As part of the PLASMAR project, partners undertook in 2017–19 a literature review gathering scientific papers, official statistics and reports, which were complemented by interviews with experts from the economic sectors and public administration departments. Results show that while some maritime sectors are well established, others are emerging sectors with varying long-term growth potential. Besides, development patterns vary across the archipelagos. This study represents the first effort in the Macaronesia Sea Basin to set the basis of the current and future development conditions of the blue economy in applicability to maritime spatial planning processes at a regional level. The future post-pandemic context will provide a unique opportunity to promote the blue economy sectors and activities through the support provided by the EU Green Deal and Recovery and Resilience Plans, as well as with the actions envisioned under the United Nations Decade of Ocean Science for Sustainable Development (2021–2030). The European Macaronesia example –given its wide maritime territory, commitment, and capacities in terms of expertise and networking– presents a great potential to act as a good practice to extrapolate the new approach for a sustainable blue economy to other similar geographical settings such as island regions/states.

Keywords Maritime Sectors and Activities · Trends · Blue Growth · Maritime Spatial Planning · Ecosystem Approach · Azores · Madeira · Canary Islands

Introduction

In recent years, much attention is being paid to marine/maritime sectors at Worldwide and European levels as key elements underpinning responsible blue growth strategies (Campbell et al. 2016; Kirkfeldt and Frazão Santos 2021). Coastal and offshore areas have high potential to improve the sustainable uses of their marine resources for the creation of jobs and economic values and, at the same time, preserving the health of marine ecosystems. The interest in these areas is evidenced by the large number of documents produced by major stakeholders providing the bases for the definition, promotion, and adoption of strategies among governmental institutions and sectors (OECD 2016; World Bank and UN-DESA 2017; European Commission 2018). This has led to the development of terms such as Blue Economy, which emerged from the 2012 UN Conference on Sustainable Development (Rio + 20) (Silver et al. 2015) and is now undoubtedly linked to ocean governance (Voyer et al. 2018; Midlen 2021), as well as other variations of this term such as Blue Growth (a broader concept discussed by Eikeset et al. 2018), and more recently Blue Communities, that is

Extended author information available on the last page of the article

putting more emphasis on the societal aspects (Campbell et al. 2021).

The European Union (EU) charted out a long-term *Blue Growth Strategy* (European Commission 2012) to support sustainable growth of the marine and maritime sectors, which linked to the *Integrated Maritime Policy* (European Commission 2007; European Parliament 2021) and contributed to the objectives of the *EU 2020 Strategy* (European Commission 2010). In 2021, a new approach for the sustainable blue economy in the EU was presented (European Commission 2021a; European Union 2021) as a major contribution to the European Green Deal (European Commission 2019a) objectives and support for the transitions envisioned both to attain Europe's 2030 targets and to foster the post-pandemic Recovery Plan for Europe (European Commission 2020a).

A comprehensive definition of the activities that make up the blue economy (from now on, BE) comprises the following: (i) those that take place in the marine environment, (ii) those that use sea resources as an input, and (iii) those which are involved in the production of goods or the provision of services that will directly contribute to activities that take place in the marine environment. This view incorporates a geographic reference (activities occurring in the marine environment) combined with other criteria of process and nature (which also acknowledges the land-sea interaction of the marine sector) (EASME 2017a). There is wide agreement about the sectors considered as key elements of the BE, being: Fisheries, Marine aquaculture, Marine biotechnology, Coastal and maritime tourism, Maritime transport, Shipbuilding and ship repair, Ocean mineral resources, Offshore oil and gas, and Renewable ocean energies.

The present work was mainly developed within the framework of the PLASMAR[1] Interreg project (MAC/1.1a/030, 2017-2020), a cooperation initiative within the European Macaronesian Sea focused on the development of methodologies for Maritime Spatial Planning (MSP) of the BE sectors founded on ecosystem-based management. A review of the main marine / maritime sectors identified in the European Macaronesian Sea Basin (i.e., the archipelagos of Azores, Madeira and the Canary Islands) was conducted with a comparative analysis of the situation, trends, and perspectives for the overall.

The EU recognizes the Macaronesian Sea Basin as an essential part of the EU's Outermost Regions (ORs) as stated in the Treaty on the Functioning of the EU, due to their common characteristics, which act both as constraints and opportunities on their development potential. The marine/maritime sectors, whose associated economies are undoubtedly present in all three archipelagos, show different levels of development and expertise. In recent years, the EU is setting the basis for the development of the maritime economies in the ORs through diverse support actions (EASME 2017b). The main goal of this contribution is to provide an overview of the extant situation of marine / maritime sectors in the Azores, Madeira, and the Canary Islands, describing their trend in recent years, and taking into consideration the European, national and regional blue growth initiatives, outlining their potential development in the coming years.

Materials and methods

Geographic setting

The study area covers the European Macaronesian Sea Basin. The term "Macaronesia" is composed by two Greek words: *makarion* (fortunate) and *neosi* (islands) and mainly refers to four archipelagos located in the Central-East North Atlantic Ocean: Azores, Madeira, Selvagens (Portugal) and the Canary Islands (Spain) (EEA 2002) (Fig. 1). These oceanic archipelagos have a volcanic origin as geological demonstrations of hotspots off the Northwestern Africa coastline with large depths separating the islands. Geologically and geographically speaking, the Azores is the youngest and most isolated archipelago with 1370 km distance between the island of San Miguel and continental Europe (Cabo da Rocha, Portugal). The Canary Islands constitute the largest archipelago (744 km^2) and the nearest to mainland (97 km from Fuerteventura to Punta Stafford, Western Sahara, Africa). Moreover, the Selvagen Islands are the smallest (4–5 km^2) and oldest (27 Ma) archipelago, indicating that they are in the last stages of their erosive dismantling process; these islets are politically considered an integral part of the Madeira Autonomous Region (Fernández-Palacios and Dias 2001; EEA 2002).

The biogeographic position of these archipelagos encompasses among them a large macroclimatic gradient of almost 2500 km of latitudinal extension, from hyperoceanic temperate conditions in the Azores to Mediterranean and subtropical ecosystems in the case of Madeira, Selvagens, and the Canaries (Morton et al. 1998; Haroun 2001). Their marine environments are connected through the Canary Current, a branch of the Gulf Stream in the Eastern Atlantic moving down from the Azores through Madeira, to the Canary Islands, and further south to the Cape Verde Islands (Valdés and Déniz-González 2015). As similar insular systems (Whittaker and Fernández-Palacios 2007), these islands are recognized as endowed with high biodiversity areas and one of Europe's most important biodiversity hotspots (Martín et al. 2008; Myers et al. 2000).

[1] Plasmar project webpage: https://www.plasmar2017.eu/

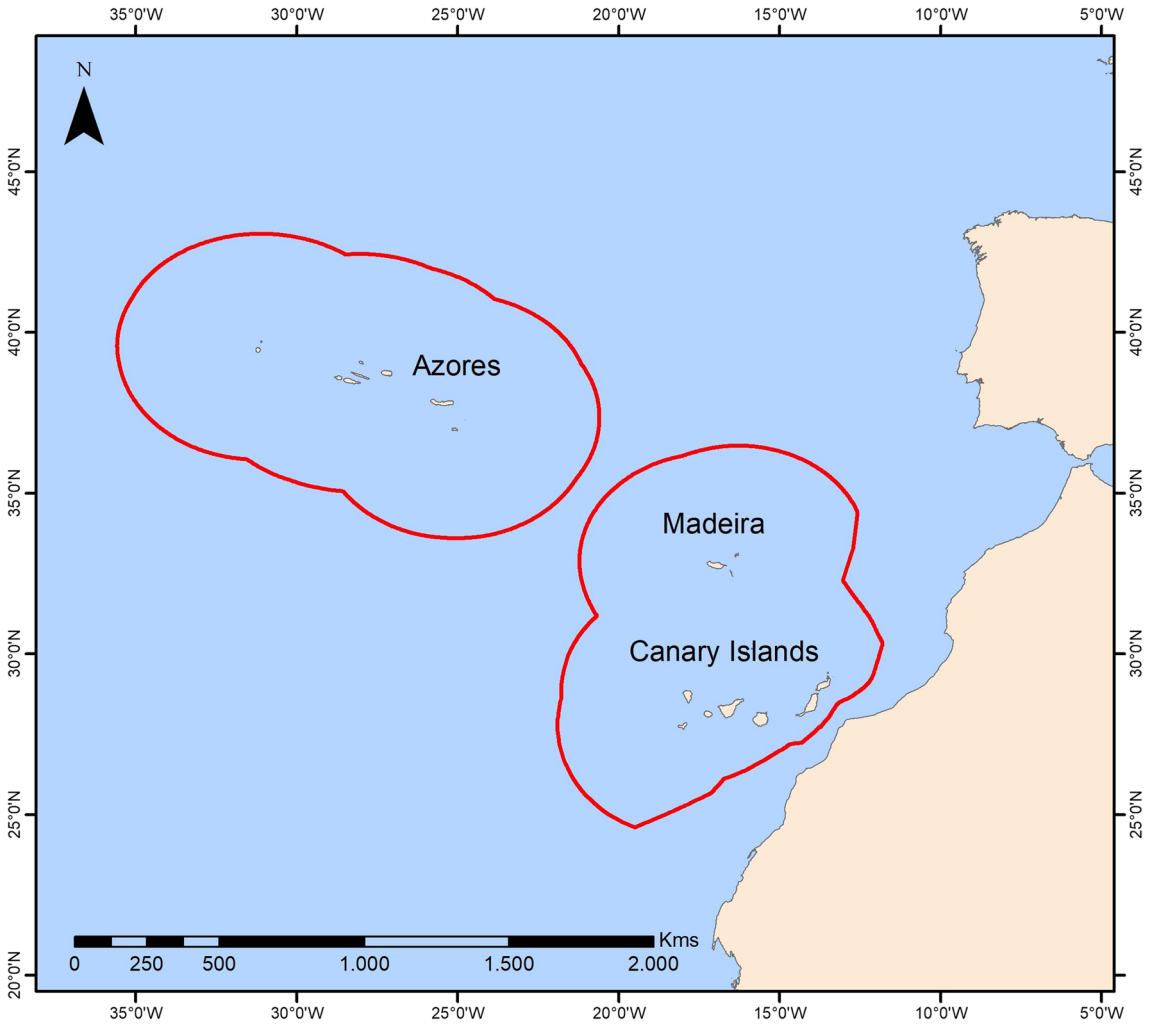

Fig. 1 The European archipelagos of the Macaronesian Sea Basin (Central East Atlantic). The red line shows the PLASMAR project limits, included at the European Environment Information and Observation Network (https://cdr.eionet.europa.eu/) as marine waters where the Marine Strategy Framework Directive 2008/56/EC is of application

Although each archipelago has a different extension, they share common characteristics such as remoteness and isolation, short continental platforms due to their volcanic origin and limited space for land uses that contrast with large maritime territories. Besides, all three have their own autonomous governments but differ greatly from a socioeconomic viewpoint (Table 1), with unequal distribution of population density between islands, economic development, and pressures on the terrestrial and marine ecosystems.

Data collection and sources of information

The BE sectors identified and analysed for each archipelago were: fisheries, marine aquaculture, marine biotechnology, coastal and maritime tourism, maritime transport, ship repair and maintenance, extraction of aggregates, deep-sea

Table 1 Descriptive geographic and social data of the European Macaronesian archipelagos

Indicators	Archipelagos of the European Macaronesia		
	Azores	Madeira	Canaries
Islands (Nº)	9	7	8
Land area (km^2)	2,322	802	7,447
EEZ size (km^2)	930,687	442,248	462,855
Population (2017)	243,862	254,368	2,108,121
GDP (M€, 2017)	4,067	4,353	44,206

Sources: *Azores*: Portuguese National Institute of Statistics (INE): https://ine.pt. *Madeira*: INE: https://ine.pt; Regional Directorate of Statistics of Madeira: https://estatistica.madeira.gov.pt/; EEZ size (Economic Exclusive Zone): Bessa Pacheco (2013). *Canaries*: Canary Islands Statistics Institute (ISTAC): http://www.gobiernodecanarias.org/istac/; EEZ size: http://www.marineplan.es/ES/fichas_kml/eez.html

mining, offshore oil and gas, renewable ocean energies, and desalination.

The collection of data and information on these sectors was mainly undertaken between 2017 and 2019 through an exhaustive review of the most up-to-date relevant sources, i.e. scientific publications, official reports and statistics, grey literature, such as unpublished reports, and expert consultations from the different maritime sectors and regional competent authorities in their management. Thus, general economic indicators such as gross value added, jobs and other specific indicators that could contribute to describing the development magnitude and trends of the maritime sectors, were gathered and analysed.

The use of different sources of information was necessary due to the difficulty in finding disaggregated statistical data specifically for maritime activities and, thus, in an attempt to fill the information gaps. For example, the availability of specific NACE codes (statistical classification of economic activities in the European Community, NACE Rev.2) is very limited for these maritime sectors, existing only for fisheries (A03.11), aquaculture (A03.21), and maritime transport (H50.50; H50.20).

The sources of information consulted varied across the archipelagos according to their availability (Fernández-Palacios et al. 2017). In the case of the Azores, data was compiled from internal and official statistics, technical reports (SRMCT 2014) and peer reviewed publications. In Madeira, the review was based on two main documents: the National Strategy for the Sea 2013–2020,[2] and the Situation Plan of Maritime Spatial Planning[3] (SRA-DROTA 2018) and done by Direção Regional do Ordenamento do Território e Ambiente (Lopes et al. 2017). For the Canary Islands, the assessment was undertaken by Gestión del Medio Rural de Canarias S.A.U., (GMR 2017, Bilbao et al. 2018) through open data (reports, publications, statistics, etc.) and interviews.

Results

The detailed analysis of the diverse sources of information provided a valuable insight of the status and factors affecting the current development as well as the future trends and growth potential of each of the maritime sectors. Tables were made with general and specific economic indicators for most maritime sectors. Then, a final table summarizing the status and trends of the BE sectors in the European Macaronesia was produced to highlight the major findings and trends.

Fisheries

Macaronesian archipelagos have short insular shelf and abyssal depths near (or only a few miles off) the coastlines. Small-scale commercial fishing has a long tradition throughout the region. The implementation of EU's Common Fisheries Policy (CFP) was a turning point on fisheries management in the Macaronesia Sea Basin as in the rest of Europe. The use of destructive and non-selective fishing gears (as bottom trawling or deep-sea gillnets) was prohibited in defined areas of the Macaronesia, for the protection of ecologically sensitive benthic ecosystems (Council Regulation (EC) No.1811/2004; Council Regulation (EC) No.1568/2005). As in other basins around the World, despite recent technological advance, this artisanal sector has seen a pattern of slow generational turnover and fish stock declining.

In the *Azores*, fisheries are small-scaled and artisanal with ~ 87% of vessels < 12 m (Diogo et al. 2015) and with 585 active boats in 2018 (source Azores Regional Directorate for Fisheries). In 2014, the Gross Value Added (GVA) of fisheries in the region was 16.4 M€ for production plus 11.0 M€ for processing (EASME 2017c). In 2016, the sector provided 2,805 full-time jobs (~ 6% of total population; INE[4]), with 5,728 tonnes of landed fish (fresh and chilled) with an economic value of 25.9 M€ (SREA 2018). Boats are generally polyvalent (equipped with different fishing gears) and target four main species groups: small pelagics (blue jack mackerel (*Trachurus picturatus*) and chub mackerel (*Scomber colias*)); pelagics (tunas, swordfish (*Xiphias gladius*) and blue shark (*Plionace glauca*)), and demersal fishes (Morato 2012). Azorean fishers also catch coastal fishes and crustaceans, and collect algae and invertebrates. Fisheries data in the Azores dates back to the 1970s (Fauconnet et al. 2019), leading to the implementation of technical measures for the management of fish stocks (Morato et al. 2010), and attempts to support recognition through ecological certifications (Abecasis et al. 2015). It is currently assumed that high selectivity of the gears used in the Azores assure sustainability (Fauconnet et al. 2019).

In *Madeira*, fisheries rely mainly on a very small number of high trophic level migratory species (tunas and related species) and on the bathypelagic species Black scabbardfish (*Aphanopus carbo*), representing 47% and 33% of total landings, respectively (SRA 2014; STECF 2018). According to STECF (2018) 5,764 tonnes of fresh and chilled fish were traded in 2016, accounting for 15.4 M€ (36% of the total exports value). Of this amount, 58% represents catches, 38% processing activities and 3% related activities. In 2016, there were 100 boats (of which 68 < 12 m) and 603 fishers

[2] https://www.dgpm.mm.gov.pt/enm-en

[3] www.psoem.pt

[4] https://www.ine.pt

Table 2 Descriptive data of Aquaculture as an economic activity in the analysed regions

Indicators	Archipelagos of the European Macaronesia		
	Azores (2018)	Madeira (2015)	Canaries (2016)
Companies (Nº)	1	2	19 (8 + 11)*
Production (tonnes)	–	~400	7,500
Employment (persons)	4	14	222 (151 + 71)*
Turnover (€)	–	690,428	39,000,000
GVA	–	1,631,000 (2016)	6,300,000 (2014)#
Prospect	Increase	Increase	Production limit: 37000 tonnes (2026)

Sources: *Azores*: Regional Directorate for Fisheries. *Madeira*: DREM 2018; INE https://www.ine.pt/

Canaries: * Data added for Las Palmas and Tenerife provinces, respectively; MAPA: https://www.mapa.gob.es/es/estadistica/temas/estadisticas-pesqueras/acuicultura/encuesta-economica-acuicultura/default.aspx; # Estimated by EASME (2017e).

(Direção Regional de Estatística da Madeira[5]). The GVA of the activity was in 2014 of 4.8 M€ for production plus 2.7 M€ for post-harvest (EASME 2017d). Estimates of annual catches from 1990 to 2016 (STECF 2014) recognize a declining trend in abundance of the eighteen identified fishery resources, implying that Madeiran waters are subject to severe overexploitation. Regarding recreational fisheries, until 2016 there was no specific legislation, except for spear-fishing. After publishing of the Ordinance No.484/2016 that regulates the permitted gear and conditions, 7,362 annual licences were issued in 2017 (Martinez-Escauriaza et al. 2018), but there is still no information available regarding biological data and catches of the most common species.

Fisheries in the *Canary Islands* are mainly coastal and artisanal, with a fleet composed greatly (≃85%) of small polyvalent vessels (< 12 m) targeting small pelagic species, demersals and tuna (STECF 2018). In 2012, there were 1,447 professional fishers in the Canary Islands (Castro and Bilbao 2013). Only 4.9% of the fleet (748 vessels; González-Benkovics 2017) fish outside the Canarian waters (STECF 2018). In 2017, 14,008 tonnes (valued 31.4 M€) were landed in Canarian first-sale ports.[6] The GVA of the activity was in 2014 of 13.4 M€ for production and 6.5 M€ for transformation (EASME 2017e). Regarding the state of the fish stocks in the Canary Islands, biological data and resource evaluation have been sporadic and need improvement. According to González (2008), the abundance and state of the coastal pelagic resources (mackerel, sardine) is unknown and the coastal demersal shellfish resources are overexploited, while other deep-water resources could represent an alternative. The pelagic tunas relevant to the Canaries assessed by the ICCAT (International Commission for the Conservation of Atlantic Tunas) are at a maximum exploitation level but, being highly migratory species, should not be used as stock assessment indicators for the region (MAPAMA 2012). The impact of recreational fisheries in the Canaries (101,434 valid licenses in 2016; González-Benkovics 2017) increases the uncertainty about the trends of the resources and stresses the need to improve fisheries knowledge and management.

Marine aquaculture

Aquaculture production can be considered an established maritime sector contributing to the economy both in the Canary Islands and Madeira, while in Azores it is in an early stage of research, development and innovation (RD&I), (Table 2).

In the *Azores*, the regional administration is actively promoting the development of aquaculture sector by supporting investment in the marketing of fishery products and aquaculture (Ordinance no.18/2017 altered by Ordinance no.53/2018); identifying coastal and offshore areas with potential for aquaculture and designating aquaculture production areas (Government Council Resolution no.126/2016); and providing the framework for licencing of aquaculture, including the conditions for the location, establishment and exploitation (Regional Legislative Decree no.22/2011/A). Overall, seventeen indigenous species are allowed for aquaculture production in the Azores (Government Council Resolution no.126/2016), counting crustaceans, molluscs, echinoderms and teleosts (bony fish) including live bait. In the end of 2018 a promising start-up company (Aquazor) was established on-land (pre-growing) and marine cages (growing) for the production of amberjacks (*Seriola*).

High potential for the aquaculture sector development in Madeira and the Canaries is related to some favourable parameters, such as clean oligotrophic seawater, annual high and stable mean sea temperature (average of 22ºC), short

[5] https://estatistica.madeira.gov.pt/

[6] http://www.gobiernodecanarias.org/agricultura/sgt/temas/estadistica/pesca/index.html

variation of the annual photoperiod and availability of a range of marine species suitable for aquaculture purposes (Andrade and Gouveia 2008; Domínguez 2008), together with a historical record of aquaculture research centres. Priority was given in both regions to cage fish farming systems, due to the lack of coastal space for land-based farms (Andrade and Gouveia 2008; Hernández-Cruz 1992).

In *Madeira*, the Regional Government has supported the sector through the Mariculture Centre of Calheta, established in 2000 to promote RD&I. By 2014, the two existing enterprises accounted for a total production of more than 600 tonnes of gilthead seabream (*Sparus aurata*), of which 70% was exported (Lopes et al. 2017). In 2016, the new regulations concerning the identification of marine areas for aquaculture were launched (Resolution no.1025/2016 with Ratification no.2/2017), establishing five zones of aquaculture interest (ZIA), each with 1–4 areas of 1km^2/farm, which could result in an increase of the total production capacity in Madeira (Lopes et al. 2017). In 2018, total installed production of the archipelago increased to 2,350 tonnes due to the installation of a new gilthead seabream farm and expansion of another of gilthead seabream and amberjack (*Seriola dumerili*).

In the *Canary Islands*, better market access, infrastructures, and the close relationship between farmers and researchers are key elements that have sustained the growth of aquaculture since the early 80's (Domínguez 2008). The sector is based on the production of European seabass (*Dicentrarchus labrax*) and gilthead seabream. The economic crisis of 2008–2009 reversed the upward trend of employment and production, although with uneven results in the islands, showing better performance and stability in Las Palmas Province, possibly due to a higher technical and economic capacity of bigger companies (pers. comm. J. Macías, CANAEST). After a break of more than 5 years in which no new aquaculture concessions could be granted, the Regional Plan of Zonification for Aquaculture (PROAC) was approved in 2018 (Regional Decree no.102/2018). The PROAC is the major administrative instrument for management and planning of aquaculture in the archipelago. It has established zoning areas for aquaculture (as forbidden, suitable and of interest), determined the species authorised for production and proposes a maximum global annual production limit of 37,000 tonnes in 8 years.

Marine biotechnology

This is clearly an emerging sector worldwide as well as in the Macaronesian archipelagos. RD&I initiatives and some commercial activities have been reported for all three archipelagos considered.

The *Azores* are known to possess valuable deep-sea resources carrying high potential for biotechnology (Amorim et al. 2017) and cold-water coral aggregations (Braga-Henriques et al. 2013; Tempera et al. 2013). Eight projects for offshore macroalgal production are currently being established and the Regional Directorate for Fisheries is evaluating another one for funding support (source Azores Regional Directorate for Fisheries). Five enterprises are already established in the region, dealing with the production and exploitation of macroalgae, including the extraction of secondary compounds for pharmacological, cosmetic, and biotechnological purposes.

In *Madeira*, the three existing companies, mostly based on RD&I projects, focus on the production of macroalgae (as food supplements and products), microalgae (for biofuel and extraction of specific products), and refined oils from fisheries by-products. The regional government participates in the Oceanic Observatory of Madeira, a consortium established in 2015 where local entities and private companies develop scientific research needed for the development of this emerging sector.

Marine biotechnology is a promising sector in the *Canary Islands*, due to the advantageous environmental conditions of the archipelago and to the presence of internationally recognised research groups and facilities. About seven companies can be classified either as producers or dealers of biotech products (for agriculture or cosmetics) mainly from microalgae species. In this context, the creation of "BIOASIS Gran Canaria" Consortium within the Canary Islands Intelligent Specialization Strategy 2014–2020 (RIS3 Canarias 2013), aims to provide scientific, technological, and logistic support for the establishment of BE activities. BIOASIS Consortium is constructing an experimental and high-technology incubator area on the East coast of Gran Canaria, which will facilitate private initiatives and help unlock administrative obstacles.

Coastal and maritime tourism

For all three archipelagos, tourism is a crucial pillar of the local economy. Besides the direct uses along the coastlines and beaches, a variety of activities, such as sea-trips (excursions), water sports, recreational sailing, recreational fishing, cruise tourism and associated services are linked to the coastal and maritime environments. However, precise statistical data are not available for each of these activities (e.g. employment, economic indicators). In the framework of this contribution, sea-trips and cruise tourism subsectors have been chosen to describe the status and trends of the sector (Table 3).

The *Azores* tourism has become the main tertiary activity (Soukiazis and Proença 2008). Maritime tourism plays a key role and has registered growth since its beginning in

Table 3 Descriptive data of Coastal and maritime tourism as an economic activity in the analysed regions

Indicators	Archipelagos of the European Macaronesia		
	Azores	Madeira	Canaries
Tourists (Nº, 2017)	615,822	1,434,630	15,975,510
Passengers in boat tours (Nº)	Not available	100,000 (2013)	497,837 (2016)
Companies of boat tours (Nº)	113 (2018)	153 (2013)	
Prospect of passengers in boat tours (Nº)		1.4–1.5 million (2025)	
Cruise berthing (Nº, 2017)	152; (Ponta Delgada: 75; Horta and Praia da Vitória: 26) (2017)	299 (Funchal; 43 in November, highest activity month) 4 (Porto Santo)	1087; 554 (Las Palmas) and 533 (Tenerife) (2017)
Total cruise tourists (Nº, 2017)	135,783	539,197 (Funchal); 1,396 (Porto Santo)	2 205 700; (Las Palmas: 1 241 363; Tenerife 964 337)
Prospect of cruise berthing (Nº)		Prospect 2035: 67–91 in November (Funchal)	

Sources: *Azores*: Portos dos Açores, SA: https://www.portosdosacores.pt/outrosdocs.html; Azores Government https://srea.azores.gov.pt/, https://www.azores.gov.pt/Portal/pt/entidades/srtop-drt/textoImagem/Actividade_Marítimo-Turística.htm. *Madeira*: Regional Directorate of Statistics of Madeira: https://estatistica.madeira.gov.pt/download-now/economica/turismo-pt/turismo-serie-pt/turismo-series-longas-pt.html; Regional Legislative Decree No. 15/2017/M approving the Tourism Planning Programme (POT) of the Autonomous Region of Madeira; APRAM: http://www.apram.pt/site/files/estatisticas1/171.pdf. *Canaries*: Canary Islands Statistics Institute (ISTAC): http://www.gobiernodecanarias.org/istac/; Statistics of Canary Islands ports: https://puertoscanarios.es/estadisticas/

the 1990s. Regional policies and legislation regulate and manage eleven sea-trips modalities (Regional Legislative Decree no.23/2007/A), promoting environmental conservation and education (Abecasis et al. 2015). Whale watching, the most successful modality, adds more than 80% of all sea-trips passengers (over 112,000 in 2017; source Regional Directorate for Tourism; Direção Regional dos Transportes 2017). Emerging activities with high potential still need to be regulated, such as swimming or diving with whale sharks (*Rhincodon typus*) and with Jamantas (*Mobula* and *Manta*). Cruise tourism is currently growing in the ports of the region, with 152 calls in all ports in 2017, 25% more than the previous year (Portos dos Açores[7]).

For *Madeira*, tourist sea-trips in 2013 accounted for approximately 100,000 passengers (Regional Legislative Decree No. 15/2017/M approving the Tourism Planning Programme (POT) of the Autonomous Region of Madeira), representing 10% of the total number of tourists who visited the Region in the same year (1,082,750). Future perspective growth predicts a total of 1.4 to 1.5 million tourists buying organized sea trips by 2025 as stated in the Strategic and Integrated Transport Plan for the Autonomous Region of Madeira 2014–2020 (PIETRAM; SRTEC 2016). Cruise tourism takes a prominent position, contributing to the regional economy by around 40.6 M€. In 2015, the port of Funchal achieved the national leadership with 578,492 cruise tourists and 308 scales (APRAM[8]) and further growth is predicted (PIETRAM).

In the *Canary Islands* tourism contributed in 2016 to 34.3% of the GDP (Gross Domestic Product) and 39.7% of employment (312,466 employees) (EXCELTUR 2017). Currently, the sector is in short-term stability, working on its rehabilitation, diversification, and consolidation in the medium and long-term, following the Tourism Infrastructure Plan for the Canary Islands (PITCAN) 2017–2023 and the RIS3 Canarias (2013). In 2016 sea-trips from ports under regional responsibility added 497,837 passengers, being the Port of Corralejo (Fuerteventura) the most relevant with 164,576 users (Puertos de Canarias[9]). These excursions include a varied offer, such as charters and littoral excursions, recreational fishing, etc. Cruise tourism has continued to increase over the last 16 years and suggests further growth perspectives, although calculated prospects have not been identified. Main ports are La Luz y Las Palmas (Gran Canaria), Santa Cruz de Tenerife (Tenerife), and Arrecife (Lanzarote).

Maritime transport

The Macaronesian Archipelagos possess an important external dependence from continental Europe and other World

[7] https://www.portosdosacores.pt/

[8] http://www.apram.pt/site/index.php/pt/estatisticas

[9] https://puertoscanarios.es/estadisticas/

Table 4 Descriptive data of Maritime transport as an economic activity in the analysed regions

Indicators	Archipelagos of the European Macaronesia		
	Azores (2017)	Madeira (2016)	Canaries (2016)
Employment (Nº)	~161	~223*	> 2,900
Enterprises (Nº)		23	
Transport of cargo (Tn, all ports)	Import 1,740,401 Export 630,371	Import 958,198 Export 147,483	Import 21,372,752 Export 12,318,544 Transit 7,512,107
Transport of passengers between islands (Nº)	586,073	300,000	
Total transport of passengers (Nº)			4.25 M Objective: 5 M in 2023
GVA (M€, 2014)#	6.8	10.7	245.4

Sources: *Azores*: https://srea.azores.gov.pt/Conteudos/Relatorios/lista_relatorios.aspx?idc=392&idsc=971&lang_id=1; INE, Integrated accounting system for companies. *Madeira*: INE: https://www.ine.pt/xportal/xmain?xpgid=ine_main&xpid=INE; *The nr. of employees is higher but not disclosed due to confidentiality. *Canaries*: Canary Islands Statistics Institute (ISTAC), http://www.gobiernodecanarias.org/istac/; CCELPA, http://www.ccelpa.org/informe-anual/IA2016/pdf/indicadores/10-2016.pdf; # EASME (2017c, d, e)

areas (for fuel, food, raw material, machinery, etc.), making maritime transport a strategic sector (Table 4).

Marine transport is key for the *Azores* economy, which like other remote islands depends on import and export activities (marine shipping) and passenger traffic (mainly inter-islands), being cargo movement the main activity in the ports of the Archipelago (Abecasis et al. 2015). As a result of the economic crisis, movements of cargo reached a minimum of 2,589 movements in 2014 (Carreira and Porteiro 2015). Maritime passengers transport is one of the activities with a growth potential and is expected to generate new job opportunities in the short term, especially due to the growth of coastal tourism (EASME 2017c).

Madeira is mainly an importing territory. Between 2008 and 2012, the variables related to container shipping, freight shipping and number of ships fell due to economic instability, linked to the reduction in local consumption and construction. This trend continued in 2016 with 1.5 thousand tonnes of goods moved. The PIETRAM (SRTEC 2016) presented an analysis of freight transport in the Port of Caniçal (the main commercial port of the archipelago) and concluded that by 2020, the utilization rate for all the port terminals will be low –just above 50%. Regarding the transport of passengers, according to PIETRAM 2014–2020 (SRTEC 2016), the Madeira-Porto Santo line was considered sustainable only with a minimum traffic of 300,000 passengers/year (achieved in 2016). The Madeira's International Shipping Register[10] is a key maritime service complying with all international conventions ratified by the Portuguese Government.

The *Canary Islands* is a main hub in international maritime transport in the Central Atlantic because of its strategic position between Europe, America, and Africa. As a result, transport is considered a strong and well-developed sector in the Canarian archipelago, with more than 36 M tonnes moved in 2016 (ISTAC[11]). After the economic crisis of 2008, there was a significant recovery of employment between 2013 and 2017, with figures above 2,900 employees since 2016 (ISTAC[12]). No data on GVA of the sector at insular level is available.

Ship repair and maintenance

The long-term growth predicted for seaborne trade reflects in the sector of shipbuilding, ship repair and maintenance (OECD 2016) including strong linkages with the offshore oil and gas industries, offshore wind energy as well as with cruise tourism, fisheries, and aquaculture.

In the *Azores* and *Madeira*, the sector is related to minor builders and ship repair companies dedicated to the construction of small boats (for local fishing or recreation). Due to its privileged situation, both geographical and as base for expertise and dedicated companies, Canarian ports are leaders in maritime maintenance activities, presenting a wide ecosystem of auxiliary companies with accumulated experience. The *Canary Islands* has become a main support area for oil and gas operations in Western Africa. Although there are no regular statistics, trends or projections of the sector, naval repair represented in 2015 some 1,450 direct jobs (Lorenzo Días and Afonso Trujillo 2015) and

[10] https://www.ibc-madeira.com/images/eBrochures/Brochure-MAR-en/

[11] http://www.gobiernodecanarias.org/istac/

[12] http://www.gobiernodecanarias.org/istac/jaxi-istac/menu.do?uripub=urn:uuid:35717f3f-feaf-4be6-8487-722ff4757eec

150 M€ of direct invoicing production, port infrastructures and services provide 6,283 direct jobs and 413 M€ direct production EDEI (2014), whereas the offshore services provide some 3,000 direct jobs and 150 M€ billing (Robaina Calderín 2016).

Extraction of aggregates

This activity is developed mainly in Azores and Madeira archipelagos, with no activity reported in the Canary Islands.

In the *Azores*, the exploitation of marine mineral resources meant a GVA of 233,561€ in 2012 (SRMCT 2014) and relates mainly to sand extraction, which is sold as raw material for the construction industry, making the region self-sufficient in relation to this resource. Authorised sand extraction areas, annual exploitation quotas per island and licensing are regulated (Government Council Resolution no.3/2014 and Government Council Regulation no.105/2013). Decreasing trends in number of extraction licenses agree with the decreasing extracted volumes, with 5 licenses and 84,058 m^3 in 2017 (source Azores Regional Directorate for Sea Affairs). Pebble extraction intended for professional fishing gears (mostly bottom longlines) does not require authorization (Regional Legislative Decree no.9/2010/A, republished by Regional Legislative Decree no.31/2012/A), except when the collection is done in limited areas (Miranda 2018). In 2017 there were 2 licenses (source Azores Regional Directorate for Sea Affairs). Pebbles harvested for ornamental purposes require an authorization from the regional administration.

For *Madeira*, since there are no exploitable deposits on land, marine sand extraction is an important economic activity with a GVA of 1.2 M€ in 2014 (EASME 2017d). The activity, regulated by the Regional Legislative Decree no.22/2018/M, concerns the southwest coast of Madeira Island, and is monitored through on-board GPS devices linked to a computer platform. In 2015, a total of 7 enterprises sharing 3 ships extracted 207,970 tonnes, registering a 77% decline since 2006 (APRAM[13]; Lopes 2016).

In the *Canary Islands*, sandbanks might play an important role within future measures to manage climate change coast effects (MAPAMA 2016). The assessment of the banks of sediments has been done for selected areas of Lanzarote, Fuerteventura, Gran Canaria and Tenerife Islands (DGC_MOPTMA 1995; DGC_MMA 2006).

Deep-sea mining (DSM)

Production of minerals from deep-sea resources has not yet started even in the most prospected areas of the world (OECD 2016) as available technologies are not yet profitable. Inside the Macaronesia, there is some potential for future development, although potential and expected environmental impacts are significant and with yet unknown overall consequences (Van Dover et al. 2017; Fauna & Flora International 2020; Leal Filho et al. 2021) and addressed by different projects (e.g. MIDAS project[14]).

The *Azores* presents seafloor massive sulphides associated to hydrothermal fields, although the extent and economic potential of the deposits is currently unknown and evidence suggests that extraction may imply strong environmental impacts (Abecasis et al. 2015; Lopes et al. 2019).

In *Madeira*, the possibility of exploitation of deep-sea mineral resources has not yet been assessed.

The Canary Island Seamount Province (CISP), mostly outside the Spanish EEZ, presents high concentrations in strategic metals in the thick ferromanganese crusts (Van den Bogaard 2013; Marino et al. 2017). Proposals to increase the EEZ of the *Canary Islands* to the south-west are based on the definition of the continental shelf (United Nations Convention for the Law of Sea, art.76) and related to the presence of these metals (Somoza Losada et al. 2011; Vázquez et al. 2011; Marino et al. 2017).

At present state, none of these are envisaged to be exploited due to the above-mentioned environmental concerns, which have been endorsed by the international community through the recently approved moratorium based on the approved motion on "Protection of deep-ocean ecosystems and biodiversity through a moratorium on seabed mining".[15]

Offshore oil and gas

The exploration of deep and ultra-deep waters led to the growth of the oil industry on the West coast of Africa, mainly after the decline of traditional shallow water drilling zones (as the North Sea). Nevertheless, activity in the Macaronesia is inexistent. In *Azores* and *Madeira,* no permits have been granted. In the *Canary Islands*, prospecting licenses were authorized in 2012 despite strong opposition from the Canarian society given the environmental and economic risks. By 2015 the exploration had ceased after verifying that the deposit had neither the quantity nor the sufficient quality for a profitable commercialization. Recently, the Spanish Government has cancelled the authorization of oil and gas prospects aligned with the EU decarbonization of economy objectives.

[13] www.apram.pt

[14] www.eu-midas.net

[15] https://www.iucncongress2020.org/motion/069

Renewable ocean energies

Regarding ocean renewable sources of energy, diverse experiences are available along the Macaronesian archipelagos.

Although currently there are no ocean-based renewable energies in the *Azores*, pilot experience on wave energy generation is available. The Pico Ocean Wave Center was installed in 1999 as a European demonstration project located on Pico Island.[16] This pioneer experimental unit for electricity production in a small grid carried out 1,300 h of operation by 2010, producing more than 48 MWh of energy (SRMCT 2014). However, after severe technical difficulties the plant was finally disconnected from the grid following partial collapse in April 2018.[17] In the consideration that the objectives as a demonstration project had been fulfilled, the project to dismantle the plant went ahead. No further projects are planned for the Azores in the short and medium term.

For *Madeira*, an Atlas of Marine Waves was produced in 2003, identifying the conditions for the development of renewable energies in the maritime space (Lopes 2016), although presently there are no such installations. According to the proposed situation plan of MSP, in the next 10 years, the development of renewable energies will target only pilot projects. In this sense, ARCWIND project[18] aimed at the reassessment of wind energy potential, identification of locations for wind energy farms, adequacy of different floating structures, and economic feasibility (Diaz et al. 2019).

In the *Canary Islands,* wind and wave potentials and suitable installation areas were determined according to atmospheric-wind, oceanographic-wave, bathymetry, and economic criteria (IDAE 2011), and offshore wind potential areas were also identified (Martín Mederos et al. 2011; Schallenberg-Rodríguez and García Montesdeoca 2018). The "Energy Strategy of the Canary Islands 2015–2025" (Gobierno de Canarias 2017) established that in 2025, 45% of the electricity generation should come from renewable resources, with offshore wind meeting 18% of all renewable energy produced. According to the Spanish Ministry of Ecological Transition, there are three requests for offshore wind farms in Gran Canaria Island, all related to RD&I projects devoted to the study of implementation strategies and testing prototypes, such as the MLRT prototype which includes the "self-installation" of a wind turbine by injection of concrete.[19] Wave-converters have also been tested with favourable small-scale results within UNDIGEN project.[20]

[16] http://www.pico-owc.net/en/

[17] https://tethys.pnnl.gov/project-sites/pico-power-plant

[18] http://www.arcwind.eu/home.aspx

[19] http://www.esteyco.com/projects/elican/sin-categoria/offshore-wind-tower-receives-green-light/

[20] https://www.plocan.net/index.php/en/portfolio-proyectos/1546

Desalination

The presence of desalination in the Macaronesia is related to water supplies' availability and demand. Thus, it is inexistent in the Azores, reduced in Madeira, but well developed in the Canary Islands.

In *Madeira*, desalination is the only potable water supply distributed to the population of Porto Santo island. Porto Santo's desalination plant has three production units, with a total production capacity estimated at 6,900 m^3/day (Águas e Resíduos da Madeira, S.A.). In Madeira Island, although some hotels have incorporated it as a complement, desalination is not used for public water supply.

In the *Canary Islands*, "desalination assumes the guarantee of drinking water for more than 50% of the population", ranging from ~ 100% of the water supply in Lanzarote and Fuerteventura, over 65% in Gran Canaria and ~ 20% in Tenerife: some 340 desalination plants are operational in the region, producing about 600,000 m^3/day (EDEI 2014). At present, the sector has a GVA of 55 M€ (EASME 2017e) and provides over 2,000 direct jobs in the public or private sectors. The achievements and continued efforts of the Canary Islands in the field of desalination place the region in an excellent situation to enhance the experience and knowledge accumulated (EDEI 2014) with a demonstrative and attraction effect for other interested regions. The release of brine discharges back into the marine ecosystem is becoming the main environmental issue (Pérez-Talavera and Quesada-Ruiz 2001) and efforts have focused in the study and minimization of the impact (Proyecto Venturi 2012; Desal+ Project 2017; Portillo et al. 2013, 2014).

The blue economy in the European Macaronesia at a glance

To help navigate through the different results, Table 5 summarizes the state and prospects of the identified BE sectors for each of the three archipelagos.

Discussion

The results of our study showed to be useful to set the basis of the current and future needs of the BE in the European archipelagos of the Macaronesia. The importance of the BE is well recognised internationally, and indeed one of the UN's sustainable development goals (SDG 14), concerning the "conservation and sustainable use of Earth's oceans, seas and marine resources". European actions supporting SDG 14 range from sustainable fisheries (e.g. Common Fisheries Policy and Marine Strategy Framework Directive), environmental protection (e.g. Natura 2000, 7th Environmental Action Programme), research and innovation policy (e.g. Horizon 2020's Blue Growth and Horizon Europe Green

Table 5 Summary of the current state and future trends for the sectors of the blue economy in the Macaronesian archipelagos and in the international context

	Maritime Sectors	International		Archipelagos of the European Macaronesia					
		EU	World	Madeira		Azores		Canaries	
		State	Prospects	State	Prospects	State	Prospects	State	Prospects
1	Fisheries	✓	↗	✓	→	✓	→	✓	→
2	Marine aquaculture	✓	↑	✓	↑	✓	⚙	✓	↑
3	Marine biotechnology	✓	⚙	✓	⚙	✓	⚙	✓	⚙
4	Coastal & maritime tourism	✓	↑	✓	↑	✓	↑	✓	↑
5	Maritime transport	✓	↑	✓	↑	✓	↑	✓	↑
6	Ship repair and maintenance	✓	↑	✗	✗	✗	✗	✓	↑
7	Extraction of aggregates	**NA**	**NA**	✓	→	✓	→	✗	?
8	Deep-sea mining	✓	⚙	✗	✗	✗	?	✗	?
9	Offshore oil & gas	✓	↗	✗	✗	✗	✗	✗	✗
10	Renewable ocean energies	✓	⚙	✓	?	✗	✗	✓	⚙
11	Desalination	✓	↑	✓	→	✗	✗	✓	↗

The nomenclature used in the reports cited as information sources for the international context has been used and translated to symbols. Thus, the state was defined as: ✗ non-existent; ✓ emerging; and ✓ established. The development prospect was defined as: ✗ no development; ? unknown; ⚙ significant long-term potential but not yet at commercial scale; → stable; ↗ modest business and employment growth; ↑ high long-term growth of business and employment

Sources: *Madeira, the Azores and the Canary Islands*: previously cited literature and sources and EASME 2017c, d, e respectively for each archipelago. *European Union (EU)*: the state for each sector has been adapted from "the 2018 annual economic report on the EU blue economy" (European Commission 2018). *World Global*: the prospect for each sector has been adapted from the report "The Ocean Economy in 2030" (OECD 2016).

Deal), and through EU commitments to international conventions like the 'Law of the Sea' and International Ocean Governance.[21] The coastal and maritime activities bear significance not only in terms of economics but also due to their impacts on society and environment, as these provide, among others, food, fuel/energy, fine chemicals, leisure, both currently and for the future. The "Manifesto for the marine social sciences" (Bavinck and Verrips 2020) calls attention upon the importance of engaging with the BE process and its different protagonists. Bennett et al (2021) analyse the risks of building the blue growth framework without considering a real commitment to 'blue justice', which must be central to the blue growth agenda as a requirement for a complete transformation of the blue economy paradigm.

This study represents the first effort in the European Macaronesia to consider the status and look at the prospects of growth of different sectors of the maritime economy aiming to set the bases for responsible MSP processes at a regional level in the three autonomous regions belonging to two different Member States.

We found there are some sectors within the BE which show a common status and trends for all three Macaronesian archipelagos (i.e. fisheries, biotechnology, tourism, and transport) although presenting different magnitudes in line with the different sizes of the regional economies. Others bear specific significance only in one or two of the three archipelagos within the Macaronesia (i.e. aquaculture, ship repair and maintenance, extraction of aggregates, or desalination).

After the identification of the maritime sectors and their development perspective, the datasets and associated information were incorporated in the on-going maritime spatial

[21] https://webgate.ec.europa.eu/maritimeforum/en/node/4205

planning processes in each archipelagic waters. Following the implementation of sectorial regulations defined by the regional/national administrations, the different maritime sectors have a wide range of activities to develop under an ecosystem-based approach.

Progress in data compilation on the BE sectors is underway in the EU (EASME 2017a) and annual results are published (European Commission 2018, 2019b, 2020b, 2021b). Nevertheless, the statistical data for the BE sectors (mainly through NACE codes) is generally collected at the national level. This hampered data collection at the archipelagic level, resulting in multiple knowledge gaps and limiting the comparability between archipelagos. As already stated in Bilbao Sieyro et al. (2018) for the Canary Islands, we reinforce the need to keep the statistical data disaggregated at a regional level for the whole EU Macaronesian Region. This, together with distinguishing between terrestrial and maritime activities, will contribute significantly to monitor and evaluate the BE, especially in the case of isolated archipelagos as these, where the situation differs greatly from continental Europe.

The application of methodologies to measure the progress of the BE sectors in terms of sustainability are very much needed to guide informed decision-making. Specific efforts to improve methodological approaches are being made, such as the Blue Economy Sustainability Framework (European Commission 2021c). The adaptation of methodologies, criteria, and indicators for the specific case of the islands in the Macaronesian Regions is a new line of research contribution that needs to be attended urgently.

The results of the present study show that *maritime transport* is a major economic activity in all the three regions that has long been contributing to the BE and employment in these archipelagos. It is the first activity both in Madeira and the Canary Islands, and the second after fisheries in the Azores. As an example, Madeira's International Shipping Register guarantees adequate measures to ensure efficient surveillance of registered ships. It is worth mentioning here that the implementation of the EU Maritime Transport Strategy 2009–2018 has contributed to improvements in this sector, as reflected in Macaronesia, regarding both the safety of passengers and vessels and the reduction of pollution at sea. Seasonality of the transport services in these isolated archipelagos is another issue which has also been dealt with. For instance, in Madeira, measures to ensure regular general cargo or containerized transport with Continental Portugal guarantee weekly connections (SRA-DROTA 2018), and financial incentives to the residents have been set to promote the usage of maritime transport between islands during off-peak periods. In the Canary Islands, the companies related to the maritime sector rely on the Maritime Cluster of the Canary Islands,[22] which contributes to strengthening maritime transport and related sectors.

Considering food provision, fisheries are the major source, although prospects for the increase of aquaculture are high (SAPEA 2017; FAO 2020). In Macaronesia, artisanal *fisheries* are an active sector in all three regions and the second most developed sector following maritime transport in Madeira and the Canary Islands, while it is the main BE sector in the Azores. The decline in catches over the past three decades observed in almost all the oceans (FAO 2020) is also visible within the Macaronesia (Castro et al. 2015; García-Mederos et al. 2015; Diogo et al. 2015). As mentioned above, most players involved in this activity are small fisheries operators with low carbon footprint and operating at low intensity and selective fishing gears (e.g. bottom trawler gears are banned in the regions). Macaronesia marine ecosystems are very sensitive to imbalances, with oligotrophic waters and a mixing of temperate, tropical, and subtropical species that can easily suffer over-exploitation and environmental deterioration (Manrique de Lara and Corral 2017). It is recognised that a review of the management strategies of overexploited and overfished fisheries should positively differentiate sustainable fisheries with low impact on ecosystems (Oliveira 2012) and, in this context, the three Macaronesian archipelagos can serve as benchmarks for fisheries management in other areas, especially when it comes to small islands around the world. Our analysis showed that in the Azores and the Canary Islands, the sector copes with high transportation costs due to the remoteness of the islands. In Madeira, the limited scientific knowledge on the fish stocks' state and the size and age of the vessels pose challenges for the sector. As another example, in the Canary Islands a key challenge is the regulation and monitoring of recreational fishing (GMR 2017). Despite the existence of common legal tools within the Macaronesia fisheries management under the European CFP, there is still no common strategy for fisheries stock assessment. This is denoted by the lack of standardized data from the different regions regarding the total number of fishing boats and size class, and the sea basin being assigned to two different FAO International Standard Statistical Classification of fishing areas (Rodríguez-Mateos et al. 2019). In this sense, the regionalized vision of a multiannual plan in the context of the Portuguese and Spanish ORs would allow a more focused approach to stocks' sustainability (Valerio 2017).

Tourism was identified as the largest activity within the European BE, adding 40% of all value added and 55% of employment, although it is not a single economic activity, but a wide range of activities (EASME 2017a). Traditional

[22] http://www.clustermc.es

statistics make it difficult to estimate the proportion of *coastal and maritime tourism,* as it aggregates several activities that include cruise tourism, daily sea trips, water sports, recreational sailing, recreational fishing, and associated services. Regarding cruise tourism, there continues to be a clear increasing trend until the arrival of the COVID pandemic, as the sector has not yet reached its maturity (OECD 2016; Cruise Market Watch 2017). Growth strategies include larger capacity new ships, more destinations and local ports, and new on-board/on-shore activities, matching the demands of consumers.

From our study, we have found that the coastal and maritime recreational offer based on natural values (mainly whale-watching) is increasing in Macaronesia, where the existing regulations for the protection of exploited natural resources in all three archipelagos support the stability and predictability of this sub-sector development. Still, this is a dynamic sector with new emerging activities such as diving with sharks and manta rays in the Azores, which also need regulation to be managed sustainably. A good practice to be shared was found in the Azores regarding the overcoming of legal and administrative aspects to promote the fishing tourism activity, which continues to find these barriers in Europe.[23]

Considering the great prospects for future growth of *aquaculture*, we will recommend to foster regulation improvements to deal with environmental externalities and space competition. Also, the incorporation of multi-trophic systems and enlargement of approved species for culture production, are considered key elements to unlock future diversification potential while minimizing the ecological impacts derived from the sector. The challenge for the development of aquaculture in the Azores is that the species earmarked for development are indigenous and for which there is currently limited scientific knowledge. In this sense, the creation of a scientific platform on aquaculture knowledge to promote commercial production of novel indigenous species would be an opportunity to strengthen the cooperation between existent research centres with these capacities in the Macaronesia.

The development of offshore technology, including submersible aquaculture systems has been pointed as critical for the worldwide growth of the sector, and the Macaronesian islands will continue to have the constant and high sea temperature advantage when compared to continental European waters. An issue of concern common to all European countries is the administrative difficulty in the production of different species under the same license or location which if overcome can indeed contribute to a greater development of aquaculture of low trophic species, as was suggested by SAPEA (2017). Although the current market for farmed species is towards the mainland, potential for supply to the local markets can ensure development in a sustainable manner. There is also clear recognition of the complementarity between fishers and farmers subsectors. EASME (2017a) also mentions the importance of simplification of administrative procedures, and better coordination with competing uses of the sea through MSP.

Given the characteristics of the Macaronesian region (biodiversity hotspot, weather, photoperiods, RD&I capacities, etc.), *marine biotechnology* sector has the potential to cover a broad range of products, applications, and services. Synergies with land-based food, feed production and processing, production of bioenergy, chemicals and nutrients have been stressed by Ronzon et al. (2017), being of interest for the Macaronesia as a contribution from a local and circular economy perspective. Given the perception of remote islands as less favourable entrepreneurial ecosystems (Freitas and Kitson 2018), governments have a key role to play in the promotion and establishment of this new sector. As mentioned by EASME (2017a), the present stage of development of marine biotechnology in Europe is "science-rich and cost-heavy, not product-rich and profitable", which could be also applicable to the Macaronesia. We found that there are only about 5, 3 and 7 companies involved in marine biotechnology, respectively in the Azores, Madeira, and the Canaries, connected with food and fine chemicals industries. The presence of technological parks and start-ups incubators in the three Macaronesian archipelagos are worthy of mention, but they do not specifically deal with marine biotechnology per se. The "BIOASIS Gran Canaria" soft-landing initiative is aimed at creating the appropriate logistical conditions and required guarantees for the installation of new companies, while addressing the needs for creation of links between the RD&I phase and an effective take-off of business initiatives. It should also be mentioned the company named NONAGON (São Miguel, the Azores), which aims to be an international reference in the valuation of human, technological, business, and social capital, and sustained in RD&I.

Desalination is an industrial activity located on the coast and mainly in the Canary Islands, although also been present in Madeira archipelago (Porto Santo Island) for the last 40 years. As such, it is not a proper maritime activity although, with regards to MSP, the size of developments and volume of brine discharge needs to be considered regarding site selection for other maritime activities. Desalination is very much in compliance with the UN SDG6 on Clean water and sanitation, especially in the Canary Islands, were 50% of population relies on this sector as their main water supply source.

In the Macaronesia, the shipbuilding sector is only relevant in the Canary Islands, where it is composed by small

[23] European Parliamentary Research Service Blog, https://epthinktank.eu/2016/06/01/marine-fisheries-related-tourism-in-the-eu/

and medium enterprises, specialized in *ship repair and maintenance* mainly for the oil and gas platforms, fishing fleet and nautical sector and, to some extent, supporting transport routes to America and Africa thanks to the privileged geographical situation of the archipelago. According to our results, the added invoicing for naval repair, port infrastructures and services, and offshore services accounts for 713 M€.

Renewable ocean energies are regarded as an opportunity for EU's ORs, although they are not being used to their full potential due to technical, economic, and legislative barriers (Maldonado 2017; European Commission 2017). The shift to clean ocean energies needs to be strengthened much more, in concordance with UN SGD7 (Affordable and clean energy) and specially since the *extraction of oil and gas* is neither ongoing nor foreseen in the Macaronesia. At present, none of the archipelagos has operating companies applying any of the available technologies for production of renewable ocean energy. For Madeira and the Canary Islands, the identification of suitable areas has been undertaken (Abramic et al. 2021), although at present ocean renewables can only be discussed as RD&I pilot projects. Given that wind conditions in the Canaries are classified as having high potential for the offshore wind energy development (IDAE 2011; Martín Mederos et al. 2011; Schallenberg-Rodríguez and García Montesdeoca 2018), there have been 11 licenses demands for nearshore installations, none operating commercially yet. During the final stage of preparation of this contribution, the Spanish Government approved the maritime spatial plans of the five Spanish marine demarcations (POEM) (Royal Decree 150/2023 of 28 February), including the Canary Islands' marine demarcation. This document approved a series of zones with high potential to deploy offshore wind energy and, thus, paving the way for its development. This reinforces our results for renewable energies, showing a significant long-term growth potential, though not being yet at a commercial scale.

The *extraction of aggregates* in Madeira and in the Azores is mainly determined by the demand of cement for the local construction industry, which reduced greatly after the 2008 economic crisis. The priority zones and those of high potential for future development for extraction of marine aggregates in the Canary Islands have been approved within the maritime spatial plan (Royal Decree 150/2023 of 28 February). An increasing demand for beach restoration and coastal infrastructures could maintain the sector in the future, although no major growths have been foreseen.

Deep-sea mining continues to be rather a RD&I sector. Although further effort is needed to quantify the mineral deposits in Macaronesia, no exploration activity is currently taking place. Being oceanic islands located in areas with specific morphologies and physiographic domains (seamounts, abyssal plains, zones of fracture, hydrothermal zones) which imply a recognized potential for the presence of mineral deposits, there are concerns on the possible ecological impacts (Van Dover et al. 2017).

After the review on the different BE sectors of the Macaronesian Sea in 2019, the COVID-19 pandemic modified the dynamics and patterns of the world's economy also affecting the BE sectors and subsectors.[24] The drastic reduction of human activity showed short-term environmental benefits,[25] pointing the need for a change in the production model towards the alignment with the ecosystems approach. In this sense, the Good Environmental Status (GES) proposed by the Marine Strategy Framework Directive (2008/56/EC), could guide the (re)location of current and future maritime activities to minimize their expected impacts on the marine GES. This approach, which has been tested in the Canary Islands to guide the location of offshore wind farms (Abramic et al. 2022), could be extrapolated to the rest of archipelagos and the different maritime sectors.

Furthermore, if MSP processes tend to be driven by BE development interests, i.e. prioritizing economic objectives above environmental ones (Kirkfeldt and Frazão Santos 2021), monitoring this development progress and evaluating the achievement of the economic objectives is key within MSP. However, we advise expanding this type of assessment to include blue justice and equity aspects as well as parallel cumulative impact assessments that may help us differentiate between "sustainable" and "sustained" blue economies (European Commission 2021c).

The EU Blue Economy Report 2021 (European Commission 2021b) presented the severe socio-economic consequences of the COVID-19 pandemic for the EU economy. After an analyses and comparison with the 2008 economic crisis, it explained how the BE increases/decreases faster than the overall economy, i.e. seems to be more sensitive in the face of socio-economic crisis. Thus, upon the recovery of the economy, the BE sectors will grow faster, although sectors will recover at different paces. This report identified how most established maritime sectors (marine living resources, marine non-living resources, port activities, maritime transport) suffered a strong impact from the 2020 pandemic, although both current and the emerging blue biotechnology sector are expected to have a prompt recovery. Other well-established sectors, which also had a strong impact, such as shipbuilding and repair and coastal tourism, are expected to suffer a moderate to large time lag in their recovery, respectively. Finally, emerging sectors such

[24] The ocean and COVID-19. United Nations Development Programme webpage. https://www.undp.org/blog/ocean-and-covid-19

[25] COVID-19 and Europe's environment: impacts of a global pandemic. European Environment Agency, Briefing no. 13/2020. https://www.eea.europa.eu/downloads/18388576f1014e489c1d4c3b05fa9ac6/1616681747/covid-19-and-europes-environment.pdf

as ocean renewable energy or desalination, which underpin strategic basic needs were little impacted and are expected to recover fast.

In the framework of the present study and the analyses of the BE sectors in the EU Macaronesian archipelagos, it is worth considering the relevance of cross-border cooperation and coordination to promote coherent transboundary BE across the three regions. In this sense, García-Sanabria et al. (2021) presented an in-depth analysis for cross-border MSP where representatives of various maritime sectors and MSP competent authorities assessed the main issues around which projects could be developed to foster both coherent planning and BE growth across the European Macaronesia archipelagos. Thus, conservation, research, fisheries and maritime transport were valued as the most important issues to be promoted at a sea basin scale, closely followed by marine biotechnology and coastal and maritime tourism. Our results showed that the mentioned sectors are all well established and present similar long-term trends, which could favour the exchanges of good practices, know-how and strengthen economic bounds across the European Macaronesia promoting coherent MSP and BE development (EASME 2017a, b, c, d, e).

In this context, the need for alliances between sectors that compose the blue growth, and the incorporation of the Circular Economy (CE) approach are key to achieve a sustainable BE (Martínez-Vázquez et al. 2021). Within this new scenario, the BE sectors will be able to provide interesting growth and investment opportunities, which should as well integrate the new EU Circular Economy Action Plan (European Commission 2020c), one of the key instruments linked to the European Green Deal.

In Portugal, the National Action Plan for the Circular Economy[26] and the Portuguese National Strategy for the Sea 2021–2030[27] were approved in 2017 and May 2021, respectively. In Spain, the Spanish Circular Economy Strategy (i.e. Spain Circular 2030[28]) was approved in June 2020. For the regional context of the Canary Islands, the Canary Strategy for Blue Economy (2021–2030) and the Canary Strategy for the Circular Economy (2021–2030), were both approved in July 2021.[29] Thus, the present study established an economic baseline in the EU Macaronesian Regions to promote the implementation of this new paradigm.

Although the future is uncertain and the post-pandemic could be dealt through different pathways (van Tatenhove 2021), the EU is supporting the Member States and regions with the goal of contributing to the recovery through the shift towards more sustainable criteria for the BE (European Commission 2021c).

Conclusions

The European Macaronesian Archipelagos have a good representation of most BE sectors. These differed in volume of financial benefits and level of maturity in their current and expected trends of economic development, depending on the different size of the local economies. Although the strong impact of the COVID-19 pandemic in the BE activities, these are expected to recover at a greater pace than the rest of the economic sectors. The big dependence of the Macaronesian archipelagos' economies on the coastal tourism sector highlighted the need to diversify these local economies.

The available capacities in terms of RD&I in the three archipelagos aligned with a new impetus in terms of policy and regulatory framework under the ecosystem approach would underpin a favourable investment seascape, promoting diverse social and economic benefits. This new approach may result in the true diversification of the local economies towards resilient blue communities. The future post-pandemic context will provide a unique opportunity to promote the BE sectors and subsectors through the support provided by the EU Green Deal and recovery and resilience plans, as well as with the actions envisioned under the United Nations Decade of Ocean Science for Sustainable Development (2021–2030).[30]

The fishing activity has an important socio-economic impact on the small islands comprising the three regions of the Macaronesia, providing both food and jobs. However, increasing concerns exist for the sustainability of the fish stocks, given the environmental sensitivity of its maritime ecosystem. A pluri-annual vision on fisheries stock management at the level of the Macaronesian Sea will be of benefit to all.

The enhancement of the aquaculture production with local indigenous species taking full advantage of the suitable environmental conditions, could benefit through mutual sharing of expertise available within the region to promote long-term aquaculture development under an multitrophic ecosystem-based approach and under the auspices of the EU Farm to Fork Strategy.

[26] https://www.dgae.gov.pt/servicos/sustentabilidade-empresarial/economia-circular.aspx

[27] https://www.dgpm.mm.gov.pt/enm-21-30

[28] https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/economia-circular/estrategia/

[29] https://www.gobiernodecanarias.org/ece/economia-azul-y-circular/index.html

[30] https://en.unesco.org/ocean-decade

The presence of research centres, technological parks, and incubators in the three Macaronesian archipelagos are worthy of mention as key elements to support the development of aquaculture production as well as marine biotechnology products and services.

The reactivation of coastal and maritime tourism activities in a post-pandemic scenario needs to take into consideration the new CE and waste prevention and reduction policies, as well as the conservation of the highly valuable marine natural heritage of these archipelagic systems.

Despite currently being only pilot projects, renewable ocean energies are being supported by the decarbonisation policies, and both regulations and licensing procedures are in progress. However, technological developments are still needed to ensure economic and environmental sustainability.

With the European BE and CE policies transposed into the national and/or regional legal systems, the Macaronesian Regions count on the necessary policy instruments for the promotion of the sustainable use of the existing rich marine natural resources. This process should include the development of science-based methods and geographical information tools aiming to facilitate the decision-making for the public and private sectors. Also, the development of specific criteria and indicators for the monitoring of progress of sustainability and of the contribution to the UNSDG of the BE sectors in the Macaronesia. In this sense, the EU Biodiversity Strategy for 2030 calls for protecting 30% of EU's seas for nature conservation, of which one third must be strictly protected areas by 2030. This should be a top priority in the Macaronesian Sea, both for the conservation of a recognized marine biodiversity hotspot and to support the long-term sustainable (instead of "sustained") development of the BE.

These BE sectors should be a comprehensive part of the Maritime Spatial Planning processes. Here again, the Macaronesian archipelagos –because of their size, actors involved, networking, expertise and interest already expressed– showed to have the capacity to act as major players at the regional, national and international levels. As part of the EU's ORs, the Macaronesia have the potential to be considered natural laboratories for testing and demonstrating the transformation of a sustainable marine economy and, thus becoming best practices to be extrapolated to the rest of Europe and other islander systems, such as Small Island Developing States (SIDS).

Funding This work was mainly developed within PLASMAR Project (MAC/1.1a/030) and finalized within PLASMAR+ Project (MAC2/1.1a/347), with the support of the European Union under the European Regional Development Fund (ERDF) and the INTERREG V-A Spain-Portugal MAC 2014-2020 (Madeira-Azores-Canarias). A. Abramic and S. Kaushik have benefited from research funds provided by the EU ERA-Chair project EcoAqua (Grant #621341). Open Access funding provided thanks to the CRUE-CSIC agreement with Springer Nature.

Data Availability The data used in this paper are available in the source documents which are referenced in Materials and methods, under the subsection Data collection and sources of information. These source documents are available online and in bibliographic repositories.

References

Abecasis RC, Afonso P, Colaço A, Longnecker N, Clifton J, Schmidt L, Santos RS (2015) Marine conservation in the Azores: evaluating marine protected area development in a remote island context. Front Mar Sci 2:104

Abramic A, Cordero-Penin V, Haroun R (2022) Environmental impact assessment framework for offshore wind energy developments based on the marine Good Environmental Status. Environ Impact Assess Rev 97:106862. https://doi.org/10.1016/j.eiar.2022.106862

Abramic A, García Mendoza A, Haroun R (2021) Introducing offshore wind energy in the sea space: Canary Islands case study developed under Maritime Spatial Planning principles. Renew Sust Energ Rev 145:111119. https://doi.org/10.1016/j.rser.2021.111119

Andrade CAP, Gouveia NMA (2008) Ten years of marine aquaculture development in Madeira Archipelago. In: Pham CK, Higgins RM, De Girolano M, Isidro E (eds) Proceedings of the International Workshop: Developing a sustainable Aquaculture Industry in the Azores. Archipelago. Life and Marine Sciences Supp 7:30–32

Amorim P, Perán AD, Pham CK, Juliano M, Cardigos F, Tempera F, Morato T (2017) Overview of the ocean climatology and its variability in the Azores Region of the North Atlantic including environmental characteristics at the seabed. Front Mar Sci 4:56

Bavinck M, Verrips J (2020) Manifesto for the marine social sciences. Marit Stud 19:121–123. https://doi.org/10.1007/s40152-020-00179-x

Bennett NJ, Blythe J, White CS, Campero C (2021) Blue growth and blue justice: Ten risks and solutions for the ocean economy. Mar Policy 125:104387. https://doi.org/10.1016/J.MARPOL.2020.104387

Bessa Pacheco M (2013) Medidas da Terra e do Mar - apontamento. Instituto Hidrográfico, Lisboa (ISBN: 978-989-705-063-3)

Bilbao Sieyro A, Pérez González Y, Couce Montero L, Fernández-Palacios Y, Abramic A (2018) Crecimiento azul en Canarias… ¿Quo vadis? Okeanos. n°7. julio-diciembre 2018, pp 16–21.

Braga-Henriques A, Porteiro FM, Ribeiro PA, de Matos V, Sampaio I, Ocana O, Santos RS (2013) Diversity, distribution and spatial structure of the cold-water coral fauna of the Azores (NE Atlantic). Biogeosciences 10:529–590

Campbell LM, Gray NJ, Fairbanks L, Silver JJ, Gruby RL, Dubik BA, Basurto X (2016) Global oceans governance: new and emerging issues. Annu Rev Environ Resour 41:517–543. https://doi.org/10.1146/annurev-environ-102014-021121

Campbell LM, Fairbanks L, Murray G, Stoll JS, D'Anna L, Bingham J (2021) From Blue Economy to Blue Communities: reorienting aquaculture expansion for community wellbeing. Mar Policy 124:104361. https://doi.org/10.1016/j.marpol.2020.104361

Carreira GP, Porteiro FM (2015) O mar dos Açores e a sua valorização estratégica: descrição do espaço marítimo e socioeconómico. IDN Nação e Defesa 141:79–95

Castro JJ, Bilbao A (2013) Recursos Marinos de Canarias. Una propuesta de ordenación basada en la cogestión. In: Proyecto GESMAR. Programa de Cooperación Transnacional Madeira-Azores-Canarias (PCT-MAC) 2007-2013, mediante fondos FEDER de la Unión Europea y el Gobierno de Canarias, p 110.

Castro JJ, Divovich E, Delgado de Molina Acevedo A, Barrera-Luján A (2015) Over-looked and under-reported: a catch reconstruction of marine fisheries in the Canary Islands, Spain, 1950–2010. Fisheries Centre, University of British Columbia, Vancouver Working Paper #2015-26, p 36

Cruise Market Watch (2017) Growth of the Cruise Line Industry – Statistics. https://www.cruisemarketwatch.com/growth

Desal+ Project 2017. https://www.desalinationlab.com/es/ (10-09-17)

DGC_MMA (2006) Estudio de sondeos marinos, proyecto de explotación y evaluación de impacto ambiental en la costa de la Isla de Tenerife. Investigación en sedimentos en base a sondeos por vibración. Dirección General de Costas. Ministerio de Medio Ambiente. GEOMYTSA

DGC_MOPTMA (1995) Estudio geofísico marino en las Islas de Gran Canaria, Fuerteventura, Lanzarote, Graciosa y Alegranza. Dirección General de Costas. Ministerio de Obras Públicas, Transporte y Medio Ambiente. GEOMYTSA

Diaz HM, Fonseca RB, Guedes Soares C (2019) Site selection process for floating offshore wind farms in Madeira Islands. In: Guedes Soares C (ed) Advances in Renewable Energies Offshore. Taylor & Francis, pp 729–737 (http://www.centec.tecnico.ulisboa.pt/centec_public/ARCWIND/084.pdf)

Diogo H, Pereira JG, Higgins RM, Canha A, Reis D (2015) History, effort distribution and landings in an artisanal bottom longline fishery: an empirical study from North Atlantic Ocean. Mar Policy 51:75–85

Direção Regional dos Transportes (2017) Regional Directorate for Transport, Azores Government. http://www.azores.gov.pt/NR/rdonlyres/59338392-37A7-4A53-B14A-20D0F672EB2A/110461 4/OMTMoradas.pdf (20-12-2018)

Domínguez LM (2008) Aquaculture in the Canary Islands. In Pham CK, Higgins RM, De Girolamo M, Isidro E (eds) Proceedings of the International Workshop: Developing a Sustainable Aquaculture Industry in the Azores. Arquipélago. Life and Marine Sciences. Supp. 7:xiii+81pp, pp 33–34. https://repositorio.uac.pt/bitstream/10400.3/4524/1/Supplement_7_ARQ_LMS_2008.pdf (15-11-2018)

DREM (2018) Statistical Yearbook of Região Autónoma da Madeira 2017. Ed. Direção Regional de Estatística, DREM, Funchal-Portugal, 2018

EASME (2017a) Study on the establishment of a framework for processing and analysing of maritime economic data in Europe. Final Report (Sept.2017). MARE/2014/45. Service contract: EASME/EMFF/1.3.1.13/SI2.718095. 122pp. https://publications.europa.eu/en/publication-detail/-/publication/9c132514-982d-11e7-b92d-01aa75ed71a1/language-en

EASME (2017b) Realising the potential of the Outermost Regions for sustainable blue growth. Final report. https://doi.org/10.2826/074620

EASME (2017c) Realising the potential of the Outermost Regions for sustainable blue growth. Annex 7 to the final report: Azores. https://doi.org/10.2826/765231

EASME (2017d) Realising the potential of the Outermost Regions for sustainable blue growth. Annex 8 to the final report: Madeira. https://doi.org/10.2826/2810

EASME (2017e) Realising the potential of the Outermost Regions for sustainable blue growth. Annex 9 to the final report: Canary Islands. https://doi.org/10.2826/64901

EDEI (2014) Documento de la estrategia marino-marítima de Canarias. EDEI Consultores de Dirección, pp 83 pp

EEA (2002) Europe's biodiversity - biogeographical regions and seas. European Environment Agency, EEA Report 1/2002. http://www.eea.europa.eu/publications/report_2002_0524_154909. Accessed 21 July 2021

Eikeset AM, Mazzarella AB, Davíðsdóttir B, Klinger DH, Levin SA, Rovenskaya E, Stenseth NC (2018) What is blue growth? The semantics of "Sustainable Development" of marine environments. Mar Policy 87:177–179. https://doi.org/10.1016/J.MARPOL.2017.10.019

European Commission (2007) COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS An Integrated Maritime Policy for the European Union. COM(2007) 575 final. Brussels, 10.10.2007. https://www.europarl.europa.eu/RegData/docs_autres_institutions/commission_europeenne/com/2007/0575/COM_COM(2007)0575_EN.pdf

European Commission (2010) COMMUNICATION FROM THE COMMISSION: EUROPE 2020 – A strategy for smart, sustainable and inclusive growth. COM/2010/2020 final. Brussels, 3–3–2010. https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A52010DC2020 (15-11-2018)

European Commission (2012) COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Blue Growth opportunities for marine and maritime sustainable growth. COM/2012/0494 final. Brussels, 13.09.2012. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52012DC0494

European Commission (2017) COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE, THE COMMITTEE OF THE REGIONS AND THE EUROPEAN INVESTMENT BANK. A stronger and renewed strategic partnership with the EU's outermost regions. COM(2017) 623 final. Strasbourg, 24.10.2017. https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52017DC0623

European Commission (2018) The 2018 annual economic report on the EU blue economy. Maritime Affairs and Fisheries, p 200. ISBN: 978-92-79-81757-1. https://doi.org/10.2771/305342

European Commission (2019a) COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS The European Green Deal. COM/2019/640 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640

European Commission (2019b) The EU Blue Economy Report. 2019b. Publications Office of the European Union. Luxembourg. https://doi.org/10.2771/21854

European Commission (2020a) COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS The EU budget powering the

recovery plan for Europe. COM/2020/442 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:442:FIN

European Commission (2020b) The EU Blue Economy Report. 2020b. Publications Office of the European Union. Luxembourg. 165pp + annexes. https://doi.org/10.2771/363293

European Commission (2020c) COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A new Circular Economy Action Plan For a cleaner and more competitive Europe COM/2020/98 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN

European Commission (2021a) COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS on a new approach for a sustainable blue economy in the EU Transforming the EU's Blue Economy for a Sustainable Future. COM/2021/240 final. Brussels, 17.5.2021. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:240:FIN

European Commission (2021b) The EU Blue Economy Report. 2021b. Publications Office of the European Union. Luxembourg. 164pp + annexes. https://doi.org/10.2771/8217

European Commission (2021c) Sustainability criteria for the blue economy : main report, Publications Office, European Climate, Infrastructure and Environment Executive Agency, p 64. https://data.europa.eu/doi/10.2826/399476

European Parliament (2021) Integrated Maritime Policy of the European Union. Fact Sheets on the European Union. https://www.europarl.europa.eu/factsheets/en/sheet/121/integrated-maritime-policy-of-the-european-union

European Union (2021) Putting the Blue into the Green – Sustainable Blue Economy. 17 May 2021. https://ec.europa.eu/oceans-and-fisheries/system/files/2021-05/2021-05-17-sustainable-blue-economy-factsheet_en.pdf

EXCELTUR (2017) Estudio del Impacto Económico del Turismo sobre la Economía y el Empleo de las Islas Canarias. IMPACTUR CANARIAS 2016. 36 pp. http://www.exceltur.org/impactur/

FAO (2020) The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. https://doi.org/10.4060/ca9229en

Fauconnet L, Pham CK, Canha A, Afonso P, Diogo H, Machete M, Silva HM, Vandeperre F, Morato T (2019) An overview of fisheries discards in the Azores. Fish Res 209:230–241

Fauna & Flora International (FFI) (2020) An Assessment of the Risks and Impacts of Seabed Mining on Marine Ecosystems. FFI: Cambridge U.K. Available from: https://www.fauna-flora.org

Fernández-Palacios JM, Dias E (2001) Marco biogeográfico macaronésico. In: Fernández-Palacios JM, Martín-Esquivel JL (eds) Naturaleza de las Islas Canarias. Ecología y Conservación. Editorial Turquesa, pp 39–44

Fernández-Palacios Y, Andrade C, Bilbao A, Carreira G, Haroun Tabraue R, Jorge V, Kaushik S, Lopes M, Oliveira M, Pérez Y, Sepúlveda P, Abramic A (2017) Macaronesian blue growth: current status and future needs. In: PLASMAR Project report (co-financed by ERDF as part of POMAC 2014-2020), p 70. www.plasmar2017.eu/productos/ (2-4-2019)

Freitas C, Kitson M (2018) Perceptions of entrepreneurial ecosystems in remote islands and core regions. Island Stud J 13(1):267–284. https://doi.org/10.24043/isj.44

García-Mederos AM, Tuya F, Tuset VM (2015) The structure of a nearshore fish assemblage at an oceanic island: insight from small scale fisheries through bottom traps at Gran Canary Island (Canary Islands, eastern Atlantic). Aquat Living Resour 28(1):1–10. https://doi.org/10.1051/alr/2015002

García-Sanabria J, García-Onetti J, Cordero Penín V, de Andrés M, Caravaca CM, Verón E, Pallero-Flores C (2021) Marine Spatial Planning cross-border cooperation in the 'European Macaronesia Ocean': A participatory approach. Mar Policy 132. https://doi.org/10.1016/J.MARPOL.2021.104671

GMR, Gestión del Medio Rural de Canarias, S.A.U. (2017) Principales sectores del "Blue Growth" en Canarias: situación y tendencias. Informe. Proyecto PLASMAR (co-financiado por FEDER en el marco de POMAC 2014-2020), p 127. www.plasmar2017.eu/productos/

Gobierno de Canarias (2017) Estrategia Energética de Canarias 2015–2015 (EECan25, doc. preliminar) http://www.gobiernodecanarias.org/ceic/energia/temas/planificacion/EECan25_DocumentoPreliminar_junio2017.pdf (4-12-2018)

González JA (Ed.) (2008) Memoria científico-técnica final sobre el Estado de los Recurso Pesqueros de Canarias (REPESCAN). ICCM–ACIISI, Gobierno de Canarias, pp 210. https://mdc.ulpgc.es/cdm/ref/collection/MDC/id/154543

González-Benkovics A (2017) Consideraciones previas sobre la Pesca en Canarias frente a la Ordenación del Espacio Marítimo. Trabajo Fin de Título para la obtención del título de Máster en Gestión Sostenible de los Recursos Pesqueros. ULPGC, p 34

Haroun R (2001) El Mar Canario. In: Fernández-Palacios JM, Martín-Esquivel JL (eds) Naturaleza de las Islas Canarias. Ecología y Conservación. Editorial Turquesa, pp 103–107

Hernández-Cruz CM (1992) Acuicultura en las Islas Canarias: Desarrollo y perspectiva de futuro. In: I Jornadas de Ictiopatología y Acuicultura 1(11), 3–24. ULPGC. https://www.researchgate.net/profile/Maria_Hernandez-cruz/publication/38182390_Acuicultura_en_las_Islas_Canarias_desarrollo_y_prespectivas_de_futuro/links/5729c39908aef7c7e2c2ed68/Acuicultura-en-las-Islas-Canarias-desarrollo-y-prespectivas-de-futuro.pdf (15-11-2018)

IDAE (2011) Análisis del recurso. Atlas eólico de España. Estudio técnico. PER 2011–2020, p 200

Kirkfeldt TS, Frazão Santos C (2021) A review of sustainability concepts in marine spatial planning and the potential to supporting the UN sustainable development goal 14. Front Mar Sci 8(September):1–12. https://doi.org/10.3389/fmars.2021.713980

Leal Filho W, Abubakar IR, Nunes C, Platje J, Ozuyar PG, Will M, Nagy GJ, Al-Amin AQ, Hunt JD, Li C (2021) Deep seabed mining: a note on some potentials and risks to the sustainable mineral extraction from the oceans. J Mar Sci Eng 2021(9):521. https://doi.org/10.3390/jmse9050521

Lopes CL, Bastos L, Caetano M, Martins I, Santos MM, Iglesias I (2019) Development of physical modelling tools in support of risk scenarios: A new framework focused on deep-sea mining. Sci Total Environ 650(Part 2):2294–2306

Lopes M (2016) Proposta para a constituição de um Cluster do Mar na Região Autonóma da Madeira e o papel desempenhado pelo ordenamento do espaço marítimo. In: Dissertação – Grau de Mestre em Gestão do território, Faculdade de Ciências Sociais e Humanas, Universidade Nova de Lisboa, p 182. https://run.unl.pt/bitstream/10362/20236/2/LOPES%2CM.Isabel%20%282016%29%20%28disserta%C3%A7%C3%A3o%29.pdf (4-12-2018)

Lopes M, Sepúlveda P, Jorge V, Oliveira M, Andrade C (2017) Blue Growth – for a better development of the sea – Report from Madeira Archipelago. ARDITI –Agência Regional para o Desenvolvimento da Investigação, Tecnologia e Inovação; Secretaria Regional do Ambiente e Recursos Naturais – Direção Regional do Ordenamento do Território e Ambiente. PLASMAR Project report (co-financed by ERDF as part of POMAC 2014-2020), p 47. www.plasmar2017.eu/productos/

Lorenzo Días DJ, Afonso Trujillo R (2015) Cuantificación económica del sector marino-marítimo en Canarias: propuesta metodológica del ISTAC. Revista Índice Nº64:19–21p

Maldonado E (2017) Energy in the EU Outermost Regions. FINAL REPORT. http://ec.europa.eu/regional_policy/en/information/publications/reports/2017/expert-group-report-on-energy-for-the-eu-outermost-regions (4-12-2018)

Manrique de Lara DR, Corral S (2017) Local community-based approach for sustainable management of artisanal fisheries on small islands. Ocean Coast Manag 142:150–162

MAPAMA (2016) Estrategia española ante el cambio climático. Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente, p 120

MAPAMA (2012) Estrategia Marina - Demarcación Canaria. Parte IV. Descriptores del Buen Estado Ambiental. Descriptor 3: Especies Marinas Explotadas Comercialmente, p 33. http://cdr.eionet.europa.eu/es/eu/msfd8910/msfd4text/envuhupia/IV_D3_Canarias.pdf (4-12-2018)

Marino E, González FJ, Somoza L, Lunar R, Ortega L, Vázquez JT, Reyes J, Bellido E (2017) Strategic and rare elements in Cretaceous-Cenozoic cobalt-rich ferromanganese crusts from seamounts in the Canary Island Seamount Province (northeastern tropical Atlantic). Ore Geol Rev 87:41–61. https://doi.org/10.1016/j.oregeorev.2016.10.005

Martín JL, Arechavaleta M, Borges PAV, Faria B (eds) (2008) Top 100. Las 100 especies amenazadas prioritarias de gestión en la región europea biogeográfica de la Macaronesia. Consejería de Medio Ambiente y Ordenación Territorial, Gobierno de Canarias, pp 500. http://www.interreg-bionatura.com/pdfs/Top100%20Part%201.pdf (4-12-2018)

Martín Mederos AC, Medina Padrón JF, Feijóo Lorenzo AE (2011) An offshore wind atlas for the Canary Islands. Renew Sustain Energy Reviews 15(1):612–620 (**ISSN 1364-0321**)

Martinez-Escauriaza R, Gouveia N, Gouveia L (2018) Licensing system for the characterization of the recreational maritime fishers' population in the Autonomous Region of Madeira. I International Symposium on Marine Recreational Fishing. Vigo (Spain), 14-15th September 2018. http://proyectosicore.es/wp-content/uploads/2018/10/ISMAREF_2018_Sesion_Posters-3.pdf (4-12-2018)

Martínez-Vázquez RM, Milán-García J, de Pablo Valenciano J (2021) Challenges of the Blue Economy: evidence and research trends. Environ Sci Eur 33:61. https://doi.org/10.1186/s12302-021-00502-1

Midlen A (2021) What is the Blue Economy? A spatialised governmentality perspective. Marit Stud 20:423–448. https://doi.org/10.1007/s40152-021-00240-3

Miranda P (2018) Identificação de zonas de agregados costeiros grosseiros na região e compilação de informação. *SeaExpert*. Report contracted by DRAM under PLASMAR project (co-financed by ERDF as POMAC 2014–2020), pp 49

Morato T, Pitcher TJ, Clark MR, Menezes G, Porteiro F, Giacomello E, Santos RS (2010) Can we protect seamounts for research? A Call for conservation. Oceanography 23(1):190–199

Morato T (2012) Description of Environmental Issues, Fish Stocks and Fisheries in the EEZs Around the Azores and Madeira. Report for the European Commission, Directorate-General Maritime Affairs and Fisheries, B-1049 Brussels, Belgium. https://stecf.jrc.ec.europa.eu/documents/43805/465474/Item+6.2+Report+Morato_Azores_Madeira.pdf

Morton B, Britton JC, De Frias AM, Martins H (1998) *Coastal Ecology of the Azores*. Ponta Delgada, Açores, Portugal: Sociedade Afonso Chaves. Legal Deposit 124 034 / 98, pp 249

Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J (2000) Biodiversity hotspots for conservation priorities. Nature 403:853. https://doi.org/10.1038/35002501

OECD (2016) The Ocean Economy in 2030. OECD Publishing, Paris. https://doi.org/10.1787/9789264251724-en

Oliveira MA (2012) What can Europe do for a better international ocean governance? Peripheral Maritime Regions Perspective. http://searica.eu/fr/documents (4-12-2018)

Pérez-Talavera JL, Quesada-Ruiz JJ (2001) Identification of mixing processes in brine discharges carried out in Precipice of the Toro Beach, south of Gran Canaria (Canary Islands). Desalination 139(2001):277–286

Portillo E, Ruiz de la Rosa M, Louzara G, Quesada J, Ruiz JM, Mendoza H (2013) Desalination and Water Treatment (2013): Dispersion of desalination plant brine discharge under varied hydrodynamic conditions in the south of Gran Canaria. Desalination Water. https://doi.org/10.1080/19443994.2013.795349

Portillo E, Ruiz de la Rosa M, Louzara G, Ruiz JM, Marín-Guirao L, Quesada J, González JC, Roque F, González N, Mendoza H (2014) Assessment of the abiotic and biotic effects of sodium metabisulphite pulses discharged from desalination plant chemical treatments on seagrass (*Cymodocea nodosa*) habitats in the Canary Islands. Mar Pollut Bull 80(1–2):222–233. https://doi.org/10.1016/j.marpolbul.2013.12.048

Proyecto VENTURI (2012) Programa Nacional Español de Proyectos de Desarrollo Experimental. Ministerio del Medio Ambiente y Medio Rural y Marino. http://www.proyectoventuri.com/ (10-09-17)

RIS3 Canarias (2013) Estrategia de Especialización Inteligente de Canarias 2014–2020. Gobierno de Canarias, p 264

Robaina Calderín L (2016) Nota Sectorial OFFSHORE OIL AND GAS Canarias 2016. Breve descripción de la situación del sector Offshore en los Puertos de Canarias en el año 2016. PROEXCA, pp 10

Rodríguez-Mateos JC, Martínez I, Palacios JL, Suárez-de Vivero JL (2019) Macaronesian Geopolitical Atlas. Deliverable - D.6.9., under the WP6 of MarSP: Macaronesian Maritime Spatial Planning project (GA nº EASME/EMFF/2016/1.2.1.6/03SI2.763106). https://www.marsp.eu/result/44

Ronzon T, Lusser M, Klinkenberg M (ed.), Landa L, Sanchez Lopez J (ed.), M'Barek R, Hadjamu G (ed.), Belward A (ed.), Camia A (ed.), Giuntoli J, Cristobal J, Parisi C, Ferrari E, Marelli L, Torres de Matos C, Gomez Barbero M, Rodriguez Cerezo E (2017) Bioeconomy Report 2016. JRC Scientific and Policy Report. EUR 28468 EN

SAPEA (2017) Food from the oceans: how can more food and biomass be obtained from the oceans in a way that does not deprive future generations of their benefits? (Science Advice for Policy by European Academies). https://doi.org/10.26356/foodfromtheoceans

Schallenberg-Rodríguez J, García Montesdeoca N (2018) Spatial planning to estimate the offshore wind energy potential in coastal regions and islands. Practical case: The Canary Islands. Energy 143(2018):91–103 (ISSN 0360-5442)

Silver JJ, Gray NJ, Campbell LM, Fairbanks LW, Gruby RL (2015) Blue economy and competing discourses in international oceans governance. J Environ Dev 24(2):135–160. https://doi.org/10.1177/1070496515580797

Somoza Losada L, Medialdea Cela T, León Buendía R (2011) Ampliación de la Plataforma Continental de España al oeste de las Islas Canarias: Campaña GAROÉ HE-148- BIO-Hespérides Madrid. Instituto Geológico y Minero de España, pp 166. http://info.igme.es/SidPDF/166000/919/166919_0000001.pdf (11-12-2018)

Soukiazis E, Proença S (2008) Tourisme as an alternative source of regional growth in Portugal: a panel data analysis at NUTS II and III levels. Port Econ J 7:43–61

SRA (2014) Estratégia Marinha para a subdivisão da Madeira. Diretiva Quadro Estratégia Marinha, Secretaria Regional do

Ambiente e dos Recursos Naturais. https://www.dgrm.mm.gov.pt/implementacao (4-12-2018)
SRA-DROTA (2018) Plano de Situação do Ordenamento do Espaço Marítimo. Secretaria Regional do Ambiente e Recursos Naturais
SREA (Serviço Regional de Estatística dos Açores) (2018) PESCA (Excel file). https://srea.azores.gov.pt/Conteudos/Media/file.aspx?ida=7672 (4-12-2018)
SRMCT (2014) Estratégia Marinha para a subdivisão dos Açores. Diretiva Quadro Estratégia Marinha. Secretaria Regional dos Recursos Naturais. Outubro de 2014. http://www.azores.gov.pt/Gra/SRMCT-MAR/conteudos/livres/Estrategia_Marinha_para_a_subdivisao_dos_Acores.htm
SRTEC (Secretaria Regional da Economia, Turismo e Cultura) (2016) Plano Integrado Estratégico dos Transportes da Região Autonoma da Madeira (PIETRAM) 2014–2020. Prepared by CONSULMAR and Figueira de Sousa 261p. https://civitas.eu/resources/plano-integrado-estrategico-de-transportes-da-regiao-autonoma-da-madeira-pietram-20142020
STECF (Scientific, Technical and Economic Committee for Fisheries) (2014) Review of an assessment of the stock of black scabbardfish (*Aphanopus spp*.) around Madeira (STECF-14–15). Publications Office of the European Union, Luxembourg, EUR26895EN, JRC92326, 27pp. https://stecf.jrc.ec.europa.eu/documents/43805/254315/STECF+14-15+-+Black+scabbard.pdf (4-12-2018)
STECF (Scientific, Technical and Economic Committee for Fisheries) (2018) The 2018 Annual Economic Report on the EU Fishing Fleet (STECF-18–07). Publications Office of the European Union, Luxembourg, 2018, JRC112940. https://doi.org/10.2760/56158
Tempera F, Atchoi E, Amorim P, Gomes-Pereira J, Gonçalves J (2013) Atlantic area marine habitats. Adding new Macaronesian habitat types from the Azores to the EUNIS habitat classification. MeshAtlantic Technical Report, 4/2013, 126
Valdés L, Déniz-González I (eds) (2015) Oceanographic and biological features in the Canary Current Large Marine Ecosystem. IOC UNESCO, Paris. IOC *Technical Series,* 115: 383 pp
Valerio B (2017) Master thesis: A Política Comum das Pescas e as Regiões Ultraperiféricas: o contributo político/legal para a sustentabilidade das pescas na macaronésia. Azores, Ponta Delgada 116pp
Van den Bogaard P (2013) The origin of the Canary Island Seamount Province —NewAges of Old Seamounts. Sci Rep 3:1–7
Van Dover CL, Ardron JA, Escobar E, Gianni M, Gjerde KM, Jaeckel A, Jones DOB, Levin LA, Niner HJ, Pendleton L, Smith CR, Thiele T, Turner PJ, Watling L, Weaver PPE (2017) Biodiversity loss from deep-sea mining. Nat Geosci 10(7):464–465. https://doi.org/10.1038/ngeo2983
van Tatenhove JPM (2021) COVID-19 and European maritime futures: different pathways to deal with the pandemic. Marit Stud 20:63–74. https://doi.org/10.1007/s40152-021-00216-3
Vázquez JT, Somoza L, Rengel JA, Medialdea T, Millán A, Alcalá C, González FJ, Jiménez P, León R, López-González N, Palomino D, Rodríguez López FJ, García Muñoz M, Martín D, Sánchez-Guillamón O, Correa A, Martínez JC, Corbalán A, Cruces M, García JM, García M (2011) Informe Científico-Técnico de la Campaña Oceanográfica DRAGO 0511. Ampliación de la Plataforma Continental de España al Oeste de las Islas Canarias, pp 273
Voyer M, Quirk G, McIlgorm A, Azmi K (2018) Shades of blue: what do competing interpretations of the Blue Economy mean for oceans governance? J Environ Planning Policy Manage 20(5):595–616. https://doi.org/10.1080/1523908X.2018.1473153
Whittaker RJ, Fernández-Palacios JM (2007) Island Biogeography: ecology, evolution, and conservation, 2nd edn. Oxford University Press, New York, p Xii+401
World Bank and UN-DESA (2017) The Potential of the Blue Economy: Increasing Long-term Benefits of the Sustainable Use of Marine Resources for Small Island Developing States and Coastal Least Developed Countries. World Bank, Washington DC, p 50. https://sustainabledevelopment.un.org/content/documents/15434Blue_EconomyJun1.pdf (11-12-2018)

Authors and Affiliations

Yaiza Fernández-Palacios[1] · Sadasivam Kaushik[1] · Andrej Abramic[1] · Víctor Cordero-Penín[1] · Alejandro García-Mendoza[1] · Alberto Bilbao-Sieyro[2] · Yeray Pérez-González[2] · Pedro Sepúlveda[3,4] · Isabel Lopes[5] · Carlos Andrade[3] · Natacha Nogueira[6] · Gilberto P. Carreira[7] · Maria Magalhães[7] · Ricardo Haroun[1]

✉ Yaiza Fernández-Palacios
yaiza.fernandezpalacios@ulpgc.es

Sadasivam Kaushik
sachi.kaushik@ulpgc.es

Andrej Abramic
andrej.abramic@ulpgc.es

Víctor Cordero-Penín
victor.cordero89@gmail.com

Alejandro García-Mendoza
alejandro.garcia@ulpgc.es

Alberto Bilbao-Sieyro
albertobs@gmrcanarias.com

Yeray Pérez-González
yeraypg@gmrcanarias.com

Pedro Sepúlveda
pedro.sepulveda@madeira.gov.pt

Isabel Lopes
isabellopesg@gmail.com

Carlos Andrade
carlos.andrade@mare.arditi.pt

Natacha Nogueira
natacha.nogueira@madeira.gov.pt

Gilberto P. Carreira
gilberto.mp.carreira@azores.gov.pt

Maria Magalhães
maria.cc.magalhaes@azores.gov.pt

Ricardo Haroun
ricardo.haroun@ulpgc.es

[1] Biodiversity & Conservation Research Group, ECOAQUA, Univ. Las Palmas de Gran Canaria, Scientific & Technological Marine Park, Crta. Taliarte s/n, 35214 Telde, Spain

[2] Fisheries Area, Projects Division, GMR Canarias, S.A.U., Canary Islands, Ingenio, Spain

[3] MARE - Marine and Environmental Sciences Centre, ARNET - Aquatic Research Network, Regional Agency for the Development of Research Technology and Innovation (ARDITI), Autonomous Region of Madeira, Funchal, Portugal

[4] Regional Directorate of Environment and Climate Change (DRAAC), Regional Secretariat for Environment, Natural Resources and Climate Change, Autonomous Region of Madeira, Funchal, Portugal

[5] Regional Directorate for Spatial Planning (DROTe), Regional Secretariat for Environment, Natural Resources and Climate Change, Autonomous Region of Madeira, Funchal, Portugal

[6] Regional Directorate of the Sea (DRM), Regional Secretariat for the Sea and Fisheries, Autonomous Region of Madeira, Funchal, Portugal

[7] Department of Biodiversity and Marine Policy, Regional Directorate for Maritime Policies, Regional Secretariat for the Sea and Fisheries, Azores Government, Horta, Portugal